HAZARD MITIGATION PLAN FOR THE NORTHERN MIDDLESEX REGION

2015 Update

Prepared by:
Northern Middlesex Council of Governments
40 Church Street
Lowell, Massachusetts 01852

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This plan was prepared with the input and guidance of a regional Multiple Hazard Community Planning Team comprised of representatives from the nine communities in the Northern Middlesex Region. Community representatives included the following:

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- Tony Fields, Director of Planning, Town of Billerica;
- Deputy Chief Michael Donoghue, Chelmsford Fire Department;
- Walter Hedlund, Emergency Services Coordinator (former), Chelmsford;
- Stephen Maffetone, Emergency Management Director, Chelmsford
- Evan Belansky, Director of Community Development, Chelmsford;
- Deputy Richard Patterson, Dracut Fire Department;
- Glen Edwards, Assistant Town Manager/Town Planner, Dracut;
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- John Crandall, Emergency Manager Director, Dunstable;
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- George Rose, Emergency Management Director, Lowell;
- George Ux, Emergency Management Director, Pepperell;
- Peter Shattuck, Highway Superintendent; Pepperell;
- Michael Sitar, Emergency Management Director (former), Tewksbury;
- Steve Sadwick, Community Development Director, Tewksbury;
- Captain Wes Russell, Director of Emergency Management, Tyngsborough;
- Chief Joe Targ, Fire Department, Westford; and
- Tim Whitcomb, Emergency Management, Police Department, Westford.

Many additional municipal staff, state officials, citizens and volunteers participated in the meetings and contributed to this report. Among them were the following:

- Daniel Rosa, Police Chief, Billerica;
- Daniel Doyle, Deputy Police Chief, Billerica;
- Anthony Capaldo, Fire Chief (former), Billerica;
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EXECUTIVE SUMMARY

A natural hazard is defined as "an event or physical condition that has the potential to cause fatalities, injuries, property damage, infrastructure damage, agricultural losses, damage to the environment, interruption of business, or other types of harm or loss.[1] The Northern Middlesex region is susceptible to many types of natural hazards including floods, severe thunderstorms, winter storms, earthquakes, and hurricanes. The economic cost of these disasters can be staggering. In addition, disasters can bring social and emotional devastation to our communities. This Regional Hazard Mitigation Plan outlines actions that can be taken now to reduce the impact of natural disasters when and if they occur later. Regional mitigation breaks the costly cycle of recurrent damage and increasing reconstruction costs.

In 2006, the Northern Middlesex Council of Governments developed a regional multi-hazard mitigation plan encompassing the communities of Billerica, Chelmsford, Dracut, Dunstable, Lowell, Pepperell, Tewksbury, Tyngsborough and Westford. This document represents the first five-year update to the 2006 Plan. The update has been prepared in accordance with the federal Disaster Mitigation Act (DMA) of 2000.

The *Hazard Mitigation Plan for the Northern Middlesex Region* contains goals and objectives for developing the Plan, provides an assessment and inventory of natural hazard risks, as well as a vulnerability analysis based on the geographic location of critical infrastructure and facilities, and delineates an existing protection matrix for the region and its nine member communities. Through discussions with local officials and the Multi Hazard Community Planning Team, a list of hazard mitigation actions and projects has been developed for future implementation. Unlike the 2006 regional hazard mitigation plan, this update also takes into account the potential impacts of climate change.

The completion of this update will maintain the region's eligibility for certain types of federal funds to implement mitigation initiatives under the Pre-Disaster Mitigation (PDM), Flood Mitigation Assistance (FMA), and Hazard Mitigation Grant (HMGP) programs. The update has a strong emphasis on integrating local, regional and state planning initiatives. The updated document will also serve as the local annexes for the nine NMCOG communities, and is a multi-jurisdictional document.

The region's vulnerability to natural hazards can be viewed as having three components[2]:

- Exposure to a hazard – for example, a community located in proximity to a natural hazard, such as a geological fault line, is more likely to be impacted by an earthquake;

[1] MEMA and DCR PowerPoint presentation, 2010.
[2] Cutter, S.L., Burton, C.G. & Emrich, C.T. *Disaster Resilience Indicators for Benchmarking Baseline Conditions*, Journal of Homeland Security and Emergency Management, 2010

- Sensitivity or the ability to mitigate a threat – a community that has not permitted development in the floodplain is less sensitive to flooding than a community that has not protected low-lying lands; and

- Capacity to adapt – a community with the resources to plan for, prevent, limit and recover from a natural disaster event is less vulnerable than one that has little capacity to respond.

Vulnerability can vary from community to community. For example, communities that are close to hazard-prone areas, such as riverine floodplains, are vulnerable to flooding depending on the magnitude, intensity and frequency of an event. Vulnerability is also greatest where buildings are poorly constructed or maintained, or where critical infrastructure, such as bridges, roads and water and sewer lines, is susceptible to damage. Social vulnerability may occur in areas with high poverty, minority status, gender inequality, an aging population or a high percentage of individuals with a disability. These factors tend to affect access to governmental and social service resources both before and after a disaster.

The updated plan will continue to reduce the region's vulnerability to natural disasters by effectively identifying appropriate projects for the limited amount of funding that is made available in the future. Development of a regional mitigation plan before disaster strikes will result in the most efficient and effective means of reducing the loss of life and property. Mitigation assists in helping minimize or prevent damage to structures, infrastructure, and other resources. The regional nature of this plan helps to ensure that mitigation initiatives, measures and strategies are coordinated across municipal boundaries. Ultimately, such regional integration of the plan will also improve the ability of the local communities to implement post-disaster recovery projects in a cooperative and coordinated manner. Implementing the mitigation measures identified in the plan will also help reduce short-term and long-term recovery and reconstruction costs.

Many tools have been analyzed within the planning process for their applicability in mitigating natural hazards, including the following:

- Land use planning and regulation of development in hazard-prone areas, such as prohibiting construction in a floodplain;
- Enforcement of building codes and environmental regulations;
- Public safety measures, such as routine and ongoing maintenance of roadways, culverts and dams;
- Acquisition or relocation of properties, e.g. purchasing repetitive flood loss properties;
- Retrofitting of structures and careful design of new construction, such as elevating buildings; and
- Comprehensive emergency planning, preparedness and recovery.

PREFACE

Congress enacted the Disaster Mitigation Act of 2000 (DMA 2000) on October 10, 2000. Also known as the Stafford Act Amendments, the bill was signed into law by President Clinton on October 30, 2000, creating Public Law 106-390. The law established a national program for regional mitigation and streamlined the federal administration of disaster relief. Specific rules on the implementation of DMA 2000 were published in the Federal Register in February 2002 and required that all communities must have a Multiple Hazards Mitigation Plan in place in order to qualify for future federal disaster mitigation grants following a Presidential disaster declaration.

According to federal regulations, every five years regional and local jurisdictions must review and revise their plan to reflect changes in development, progress in mitigation efforts, and changes in priorities. The updated plan must be resubmitted to MEMA and FEMA for review and approval in order to continue to be eligible for mitigation project grant funding. Plan updates must demonstrate that progress has been made in the last five years through a comprehensive review of the previous plan.

The regional and local plans emphasize measures that can be taken to reduce or prevent future disaster damages caused by natural hazards. Mitigation, in the context of natural hazard planning, refers to any action that permanently reduces or eliminates long-term risks to human life and property. In 2006, FEMA performed a cost-benefit analysis based on a sampling of hazard mitigation grants and determined that every dollar spent on mitigation saved society an average of four dollars.[3]

A variety of mitigation actions are available to reduce the risk of losses from natural hazards. These activities, which can be implemented at the local and state levels, include hazard mitigation planning, the adoption and enforcement of development codes and standards, the use of control structures such as floodwalls and culverts, and the protection of wetlands, floodplain and open space. Many of the strategies identified in hazard mitigation planning are implemented through land use planning tools and development regulations that can prevent or limit development in hazard-prone areas. Where development has already occurred in hazard-prone areas buildings can be retrofitted or modified to increase the chances of surviving a known hazard. Enforcement of the state building code is critical in order to effectively minimize natural hazard losses. For example, studies have shown that inadequate code enforcement resulted in significant losses from Hurricane Andrew in 1992.

In addition to addressing natural hazard mitigation, this updated hazard mitigation plan includes an overview of non-natural hazards and assesses the interrelationship of climate change and hazard mitigation.

[3] National Institute of Building Sciences, *Natural Mitigation Saves: An Independent Study to Assess Future Savings from Mitigation Activities*, 2006.

SECTION 1: THE PLANNING PROCESS

The Massachusetts Emergency Management Agency (MEMA) has encouraged the regional planning agencies to act as facilitators of local hazard mitigation planning efforts. The development of the multi-jurisdictional Hazard Mitigation Plan update was conducted under the overall direction of the Northern Middlesex Council of Governments (NMCOG). NMCOG is one of thirteen regional planning agencies in Massachusetts and was established in 1963 under Chapter 40B of the Massachusetts General Laws. NMCOG is the official area-wide planning agency for the region and engages in comprehensive planning in the areas of land use, transportation, economic development, historic preservation, emergency response, housing, municipal service delivery and environmental planning.

NMCOG completed the region's initial Hazard Mitigation Plan in 2006, and this update builds upon that planning initiative. Updated data regarding natural hazard events, demographics, non-natural hazards, and critical infrastructure have been incorporated into the document. Recently developed plans, including comprehensive community plans and master plans, open space and recreation plans, economic development plans, housing production plans and emergency management plans have been consulted. The *Regional Strategic Plan*, *Greater Lowell Comprehensive Economic Development Strategy 2009-2013* and the *2012-2035 Regional Transportation Plan* have also been considered in formulating the updated document. New information regarding changes in development patterns, progress in local mitigation efforts and changes in local and regional priorities have been incorporated into the update. The State's Hazard Mitigation Plan has been considered in the preparation of this document as well.

In completing the planning process for the Hazard Mitigation Plan update, NMCOG staff met with MEMA and FEMA staff, consulted with other regional planning agencies, attended conferences, and consulted state and federal guidance and regulations relative to development of a regional hazard mitigation plan. During the development of the *Hazard Mitigation Plan for the Northern Middlesex Region,* NMCOG and local staff have taken numerous steps to coordinate all aspects of emergency management planning. Each municipality has a Comprehensive Emergency Management Plan (CEMP) and a Regional Homeland Security Plan is also in place. Each of these emergency management plans has a slightly different focus, but many of the components within each are common, such as the inventory of critical facilities, roles and responsibilities, and protocols for response. The intent of this hazard mitigation plan is to reflect existing conditions, as cited in previous work, and to complement and augment efforts already undertaken. Accordingly, this Hazard Mitigation Plan update includes goals and objectives that meet local needs and complement local and regional goals established in the CEMPs and Homeland Security Plan.

A Multiple Hazard Community Planning Team (MHCPT) was formed and input was solicited from the MHCPT, local officials, local residents, the business community, neighborhood organizations and other interested stakeholders. The MHCPT reviewed and commented on the plan update during its formulation, and served as a liaison with other local boards and committees. The MHCPT members included:

- William Laurendeau, Emergency Management Director, Billerica;
- Peter Kennedy, Director of Planning (former), Town of Billerica;
- Tony Fields, Director of Planning, Town of Billerica;
- Deputy Fire Chief Michael Donoghue, Chelmsford Fire Department;
- Walter Hedlund, Emergency Services Coordinator (former), Chelmsford;
- Steve Maffetone, Emergency Manager, Chelmsford;
- Evan Belansky, Director of Community Development, Chelmsford;
- Deputy Richard Patterson, Dracut Fire Department;
- Glen Edwards, Assistant Town Manager/Town Planner, Dracut;
- William Ahern, Emergency Management Director (former), Dunstable;
- John Crandall, Emergency Management Director, Dunstable
- Mark Boldrighini, Emergency Management Director (former), Lowell;
- George Rose, Emergency Management Director, Lowell;
- Brian Gilbert, DPW Director, Tewksbury;
- Kevin Hardiman, Town Engineer, Tewksbury
- Michael Sitar, Tewksbury Fire Department (former);
- Steve Sadwick, Community Development Director, Tewksbury;
- Captain Wes Russell, Director of Emergency Management, Tyngsborough;
- Chief Joseph Targ, Emergency Management, Westford Fire Department
- Tim Whitcomb, Emergency Management, Westford Police Department

The process for developing the updated document included the following steps:

- Update the identification of natural hazards for the region and the nine member communities;

- Update all demographic, land use, economic and other data, as needed;

- Re-evaluate and update the Existing Protection Matrix for the region and each community;

- Review and update the risk assessment/vulnerability section of the Plan, by identifying critical infrastructure and repetitive flood loss structures, and estimating potential losses;

- Review the action plan from the 2006 hazard mitigation plan to identify those measures that were implemented, and to determine whether the remaining measures are still relevant and should be carried into the updated plan;

- Develop and prioritize mitigation strategies and create an action plan for the region and each municipality based on current and future conditions.

Once the draft plan is approved by MEMA and FEMA, and is adopted by NMCOG and all nine communities, final approval will be sought and plan maintenance will be initiated.

A. Planning Team Meetings

The first MHCPT meeting was held on March 1, 2011 at the NMCOG offices. The purpose of the meeting was to introduce the planning team members to the plan update process and to provide an overview of the Disaster Mitigation Act of 2000. The meeting outlined the roles of the MHCPT and NMCOG in assisting each community in meeting in its obligations under the DMA of 2000. The meeting began with a PowerPoint presentation that described the DMA of 2000 and the need for local communities to have an approved updated plan in place. It then proceeded to a general discussion of the types of natural disasters common to the area, and solicited participant input based on local experience in responding to recent disasters. Further discussion focused on disaster mitigation and appropriate steps each community may take prior to a disaster in order to mitigate its potential impact.

On May 4, 2011, an additional meeting of the MHCPT was held at the NMCOG offices in Lowell. The MHCPT reviewed the goals of the plan update, examined updated critical infrastructure data and mapping for their respective communities, and identified the priorities for each municipality. In addition, FEMA staff provided an overview of FEMA's expectations in terms of the plan update process, public involvement and the content of the updated document. Meeting summaries are included in Appendix A. The MHCPT met again on June 13, 2012 to review the draft document before release to the local communities for full review and comment. The draft plan was then released to the communities, the public and all project stakeholders. Copies of the document were made available through the NMCOG website and at all City/Town Halls. NMCOG staff responded to comments received from the public and the local communities and forwarded the final draft to MEMA in July 2012. Comments were received from MEMA in April 2013 and were subsequently addressed by NMCOG staff. The revised draft plan was resubmitted to MEMA in November 2013, was approved by MEMA staff, and then transmitted to FEMA. Review comments on the draft plan were received from FEMA in June 2014.

The MHCPT met on August 1, 2014 to discuss FEMA's review comments regarding the first draft *Hazard Mitigation Plan for the Northern Middlesex Region* sent to FEMA in November 2013. Meeting attendees discussed the schedule, responsibilities for completing the revisions, the FEMA approval process, and the local adoption process.

B. Municipal Meetings

In the period between March 2011 and May 2012, individual meetings were held with the representatives of each community. Draft community base maps with flooding related hazards and critical facility locations were presented for review and discussion. In addition, possible mitigation strategies for individual communities were discussed.

NMCOG staff also contacted each of the nine jurisdictions by phone and e-mail. The Planning Committee members were the primary contacts for the planning process. Meetings were attended by the primary contacts and other key municipal staff including, where possible: the community planner, city/town engineer, public works director, emergency management director, conservation agent, local board of health, fire and police chief and other interested parties. These meetings were useful in facilitating the local natural disaster mitigation planning process. In some cases, NMCOG met with the local Planning Committee staff alone, if other staff was unable to attend. Overall these meetings generally formed the heart of the planning process, given the importance of local participation and the fact that natural disaster mitigation activities are typically locally initiated.

NMCOG staff contacted other stakeholders to gather their input on the region's hazards and possible mitigation actions. Among the stakeholders were the University of Massachusetts Lowell (UML), the Merrimack River Watershed Council (MRWC), the Lowell Parks and Conservation Trust, the Greater Lowell Chamber of Commerce, and local neighborhood organizations.

In addition to correcting the local hazard maps, meetings focused on updating the "Existing Protection Matrix", and identifying projects that have been completed since the original Plan was approved. In addition, the discussions provided an opportunity for city/town staff to identify gaps in natural disaster mitigation programs. NMCOG staff encouraged municipal staff to discuss specific needs within each community and to identify appropriate mitigation projects.

A meeting was held with the Town of Chelmsford Planning Committee on September 9, 2014 to discuss revisions to the draft document and request additional data. NMCOG staff met with the City of Lowell's Emergency Manager on August 27, 2014 to discuss the comments provided by FEMA, and to review the community's responsibility in providing information needed to address the comments. NMCOG staff also met with the municipal managers and administrators from all nine communities on August 20, 2013 and on June 25, 2014 to discuss the status of the plan, outline the information required from each municipality in order to develop an approved document, and to solicit their input on revisions to the draft document.

NMCOG staff participated in the Hazard Mitigation planning process for the University of Massachusetts Lowell. Staff attended meetings with the University on February 3, 2013, June 17, 2013, and on December 16, 2013. NMCOG also represented the Massachusetts Association of Regional Planning Agencies (MARPA) on the State Hazard Mitigation Interagency Committee and attended meetings of that body on May 22, 2013, December 3, 2013, February 3, 2014, May 5, 2014, August 12, 2014, and December 5, 2014. Staff also attended meetings of MEMA's Local Hazard Mitigation Planning Subcommittee on February 27, 2014 and on June 5, 2014.

C. Public Meetings and Opportunities for Community Involvement

Efforts to adopt new mitigation activities can be constrained by the general public's lack of awareness and understanding about natural hazards and risks. Collaboration aimed at clarifying priorities, goals and desired outcomes is essential to an effective hazard mitigation planning process. A comprehensive public involvement process was utilized to encourage governmental entities, local residents, businesses and nonprofit sector participation in the process. During the drafting of the plan and prior to plan approval, a wide range of stakeholders were engaged, including neighborhood and environmental groups, local elected officials, the University of Massachusetts Lowell and area businesses. The stakeholders assisted in identifying the most vulnerable populations and facilities, assessing the potential extent of each hazard, providing data and identifying mitigation goals, objectives and strategies.

NMCOG staff discussed the Plan during a public meeting held in each community. In most cases either the Board of Selectmen or Planning Board acted as the meeting host, with exception of the Lowell meeting, which was hosted by the NMCOG Council. In most cases, the meetings were broadcast on local cable. All public meetings were advertised in the local newspaper and posted in the City/Town Clerk offices, as required under Massachusetts Open Meeting law. Table 1 below details the dates and locations of these meetings.

Table 1: Public Meetings Conducted in the Communities during Plan Development

5/25/11	Dracut – Harmony Hall	Planning Board
6/6/11	Westford – Town Hall	Planning Board
6/8/11	Chelmsford – Town Offices	Planning Board
6/13/11	Billerica – Town Hall	Planning Board
6/15/11	Lowell-NMCOG Office	NMCOG Council
6/16/11	Tyngsborough – Town Hall	Planning Board
6/20/11	Dunstable – Town Hall	Planning Board
6/21/11	Tewksbury – Town Hall	Board of Selectmen
7/18/11	Pepperell –Town Hall	Planning Board
9/8/14	Lowell-Wang School	FEMA and ACOE sponsored meeting on NFIP revisions and flood mitigation

The meetings provided additional opportunities to engage the community and educate the public on the importance of mitigation planning. Meeting notes are included in Appendix A.

In addition to the public meetings outlined above, NMCOG staff performed public outreach to the various neighborhood organizations within the City of Lowell. The following table contains a list of neighborhood meetings held throughout the plan development process.

Table 2: Lowell Neighborhood Meetings Conducted During the Plan Development Process

Date	Neighborhood Organization
2/6/12	Pawtucketville Citizens Council
3/12/12	Highlands Circle/Highlands Neighborhood Association
3/19/12	Centraville Neighborhood Action Group (CNAG)
4/11/12	Belvidere Neighborhood Council
4/18/12	Acre Coalition to Improve Our Neighborhood (ACTION)
4/23/12	Downtown Neighborhood Association
4/25/12	Lower Highlands Neighborhood Group
6/11/12	East Pawtucketville Neighborhood Group
10/14/13	Highland Neighborhood Association

The neighborhood level meetings provided for direct grassroots participation. NMCOG staff members went to regular monthly meetings of the neighborhood organizations, and were able to educate residents on the importance of mitigation planning and gain an in depth understanding of the residents' issues and concerns. The neighborhood groups were very engaged in the process given that they were directly impacted by the 2006 and 2007 floods.

In order to gain input from the business community, NMCOG staff presented the draft Hazard Mitigation Plan to the region's Comprehensive Economic Development Strategy Committee on April 10, 2012 and on June 12, 2012. In addition, NMCOG reached out to the local business community through the Greater Lowell Chamber of Commerce and the Greater Lowell Workforce Investment Board.

The Draft Plan, and other work products and informational items related to development of the plan, were also posted on the NMCOG website: www.nmcog.org. The public was encouraged to review the document and provide comments through the website via an email link. The Regional Hazard Mitigation Plan was also discussed at monthly NMCOG meetings and information was provided through NMCOG's quarterly newsletter, *Regional Perspectives*.

NMCOG conducted a public meeting on July 25, 2012 at the Tewksbury Town Hall to receive comments on the draft Regional Hazard Mitigation Plan. NMCOG staff gave a PowerPoint presentation summarizing the hazard mitigation planning process and the contents of the draft plan. Staff then solicited input and feedback relative to potential mitigation projects and strategies that were included in the draft plan. Participants discussed several natural disaster and mitigation topics of interest. The agenda for the meeting is included in Appendix A.

On June 20, 2013 NMCOG staff presented the Hazard Mitigation Plan to the Greater Lowell Workforce Investment Board (GLWIB) and discussed the planning process and community and business resiliency principles. On June 27, 2013 the Northern Middlesex Metropolitan Planning Organization discussed the integrating hazard mitigation and resiliency into the regional transportation planning process.

D. Other Local and Regional Planning Initiatives

As previously mentioned, recently developed local plans, such as comprehensive plans and master plans, open space and recreation plans, economic development plans, housing production plans, and emergency management plans were consulted in formulating this document. In addition, hazard mitigation has been included and considered in many planning documents and initiatives. In 2010 NMCOG assisted the Town of Chelmsford in preparing its Master Plan, which included discussion of hazard mitigation issues and references to the 2006 Hazard Mitigation Plan. Over the past several years, NMCOG has prepared Open Space and Recreation Plans for the communities of Billerica, Dracut, Tyngsborough and Westford. Each of those documents incorporated hazard mitigation planning, and contained recommendations regarding flood control, stormwater management, and other mitigation issues.

In 2011, NMCOG completed the *Regional Strategic Plan (RSP) for Greater Lowell*. The RSP assisted NMCOG and its member communities in planning for future development initiatives and for the preservation of open space and natural resources. The RSP focuses on smart growth and sustainable development principles that promote compact development in those areas with available infrastructure, and fosters the protection and preservation of the region's most vulnerable and valuable environmental and cultural resources. Several of the goals outlined in the Strategic Plan are beneficial in mitigating natural hazards and addressing climate change, including the following:

- Use land efficiently and protect sensitive resource areas by directing growth to priority development areas and locations with adequate infrastructure;
- Support the transformation of key underutilized lands, such as brownfields, to productive uses that complement the community and enhance existing neighborhoods;
- Minimize the environmental impact of future development by encouraging mixed-use and compact development patterns, and by promoting the use of low impact development techniques;
- Care for the natural environment by protecting and restoring natural systems, conserving habitat, improving water quality, and reducing air pollution, thereby ensuring that all residents, regardless of social and economic status, live in a healthy environment;
- Promote the use of innovative, environmentally sensitive development practices, including design, materials, construction, and on-going maintenance;
- Encourage the use of low impact development techniques and other best management practices (BMPs) for managing stormwater;
- Preserve, protect and enhance the region's remaining agricultural lands;

- Preserve significant historic, visual and cultural resources, including public views, landmarks, archaeological sites, historic and cultural landscapes and areas of special character; and

- Promote the production and use of alternative energy.

The *2011-2035 Regional Transportation Plan* incorporates hazard mitigation planning in that it addresses stormwater management, climate change and reductions in greenhouse gas emissions, air quality, transportation safety, and traffic management along evacuation routes. The regional transportation plan is updated every four years.

In addition to the above efforts, NMCOG received an Urban Waters Small Grant from EPA. Under this grant program, NMCOG is working in partnership with the Merrimack River Watershed Council to educate residents of Lowell, Chelmsford, Dracut and Tewksbury on the importance of managing stormwater. In addition, a train-the-trainer program is being developed for local officials and staff.

Through the District Local Technical Assistance (DLTA) program, NMCOG worked with its member communities to establish a regional entity that would provide assistance to municipalities in implementing certain BMPs outlined in their MS-4 permits. In 2012, NMCOG received a Community Innovation Challenge grant from the Executive Office of Administration and Finance (A&F) to form the Northern Middlesex Stormwater Collaborative comprised of the nine NMCOG communities. The intent of the Collaborative is to utilize new approaches to solve stormwater problems across the region in a way that reduces costs for local governments and taxpayers, and promotes regional communication and cooperation. The principal goals are to effectively manage stormwater and improve water quality, while engaging in resource sharing among local governments, thereby minimizing costs and improving the quality of service provided to residents. Although stormwater management isn't a new concept for our region, this is the first initiative that has successfully brought nine political jurisdictions together to address the problem in a comprehensive and cohesive manner. The participating municipalities and NMCOG have signed an MOU forming the collaborative and outlining roles and responsibilities of the participants.

In 2014 NMCOG received additional funding to expand the Collaborative to include the communities of Burlington, Carlisle, Littleton and Wilmington, creating a Collaborative of fourteen communities in total. The funding is also being used to address the public education, procurement, management, administrative, and mapping tasks necessary for implementing municipal stormwater management plans and meeting EPA requirements. Expansion of the Collaborative will remove geographic and jurisdictional obstacles to maximizing efficiencies in these areas. Such collaboration at the regional level will also benefit hazard mitigation planning, particularly in addressing flood hazards. Most recently, the Collaborative was awarded the STORMY Award for municipal innovation by the New England Water Works Association.

Projects that benefit hazard mitigation are also incorporated within the region's Comprehensive Economic Development Strategy (CEDS) prepared by the Northern Middlesex Council of Governments in partnership with the Economic Development Administration (EDA) of the U.S. Department of Commerce. Some of these projects are listed in the document's Priority Projects list.

E. Hazard Identification and Assessment Process

The MHCPT and NMCOG staff updated the natural hazards inventory for the region and grouped the hazards in a format consistent with the State Hazard Mitigation Plan. Specific discussions were held regarding recent hazards, local natural hazard issues, current protection measures, and potential action items that could benefit the communities. Consequently, an updated discussion of each individual hazard is provided, as well as an assessment and history of the occurrence of the hazard in the region, and an evaluation of the likelihood of future occurrence.

Comprehensive hazard maps were updated using the best available data for each of the nine local jurisdictions. The maps include natural hazard zones such as flood zones or other high-risk areas. The maps also include the location of critical facilities such as emergency operation centers, city or town offices, police and fire stations, schools, daycare centers, nursing homes and hospitals, emergency shelters, power plants and power substations, bridges, access roads, evacuation routes and other critical facilities. In addition, the base maps include roads, rail lines, streams, ponds, lakes, wetlands, and other data. The maps depict the location of structures within flood zones, including repetitive loss structures, and form the basis for estimating probable losses from potential natural disasters, such as severe flooding.

The hazard identification and assessment process included compiling information regarding high-risk dams and structurally deficient bridges. This information was culled from state data sources, including the Department of Conservation and Recreation's Office of Dam Safety and MassDOT, and further refined with input from the local municipalities. Part of the risk assessment consisted of the development of loss estimates and area vulnerability assessments. Through input from the local communities and the regional MHCPT, it was concluded that flooding was the most prevalent natural disaster impacting the region. Furthermore, potential flooding impacts can be identified and predicted within flood zones such as the 100-year event flood plain, for which maps are readily available. The most recent tax assessor's data was evaluated to estimate the value of structures located within the 100-year flood plain. The mapping incorporated the most recent FIRM map updates. The figures derived provide an estimate of losses that might result from a severe flood event. The methodology utilized is described in more detail in a later section of this document.

F. Updating the Existing Protection Matrix

The existing protection matrix is a summary of measures, programs, and projects that have been implemented locally to mitigate natural hazards. The matrix is essentially a listing of the items already in place which work toward solving hazard problems or preventing future losses, as outlined in FEMA's *Local Multi-Hazard Mitigation Planning Guidance*.[4] In order to update the matrix, NMCOG interviewed municipal staff members in each of the nine NMCOG

[4] Local Multi-Hazard Mitigation Planning Guidance, FEMA, July 2008

communities. These interviews were used to examine the adequacy of each community's programs, policies and bylaws, and to determine what has been accomplished since the original plan was approved in 2006. The information gathered from these interviews is outlined in the meeting summaries in Appendix A and is also detailed in the updated existing protection matrix.

G. Development of Hazard Mitigation Strategies and Preparation of the Plan

The MHCPT and NMCOG staff worked together to develop the hazard mitigation strategies. In local meetings, municipal staff members were asked to identify possible projects, programs, and strategies that would become part of the updated local and regional mitigation plans. The meetings served to stimulate discussion relative to appropriate mitigation measures. In addition, the MHCPT also generated valuable suggestions that were incorporated into the Plan. Public input and comments provided by the project stakeholders were seriously weighed and considered in crafting appropriate mitigation strategies for the region and for each municipality.

SECTION 2: PLAN PURPOSE

The process utilized by the planning team focused on identifying vulnerabilities to future disasters and formulating mitigation strategies to avoid or minimize losses. The Plan contains data and information that can be utilized to increase public awareness and promote improved mitigation planning at the local, regional, and state levels of government. Developing a mitigation plan before disaster strikes will result in the most efficient and effective means for reducing loss of life and property.

FEMA, within the Department of Homeland Security, is responsible for leading the country's efforts to prepare for, prevent, respond to, and recover from disasters. FEMA has made hazard mitigation a primary goal in its efforts to reduce the long-term effects of natural hazards. FEMA provides guidance to state, regional and local governments in developing their hazard mitigation plans, reviews and approves the plans, and administers a number of hazard mitigation grant programs to fund mitigation activities.

A number of state and federal grant programs and related regulations, mandate that local governments develop and maintain natural hazard mitigation plans. The Federal Disaster Mitigation Act of 2000 requires that all communities have such plans in place in order to be eligible for future federal post disaster mitigation funds under the Federal Emergency Management Agency's (FEMA) Hazard Mitigation Grant Program (HMGP), Pre-Disaster Mitigation (PDM) grant program and the Flood Mitigation Assistance (FMA) program. This plan is intended to assist the region and the local communities in complying with these requirements. The mitigation planning process is also directed at ensuring that proposals for mitigation projects and initiatives are coordinated among the communities within the Northern Middlesex Council of Governments' planning district.

Hazard Mitigation Plans must be updated and resubmitted to FEMA for approval every five years. Plan updates must demonstrate that progress has been made in fulfilling the commitments made in the previous plan. This requires a review and update of each section of the plan and a discussion of the progress made over the past five-year period. This document represents the first full update to the region's 2006 Pre-Disaster Mitigation Plan, and it describes occurrences of hazards included in the previous plan, as well as new occurrences of hazard events and changes in the region's vulnerability to such hazards. The Plan has also been revised to include changes in development patterns and changes in local and regional priorities. The goals contained in the prior plan have been reviewed and either reaffirmed or revised to reflect new information and priorities.

SECTION 3: REGIONAL PROFILE

The Greater Lowell region consists of the City of Lowell and its eight suburbs – Billerica, Chelmsford, Dracut, Dunstable, Pepperell, Tewksbury, Tyngsborough and Westford – and has a land area of approximately 196 square miles and an inland water area of 5.76 square miles. The City of Lowell serves as the central city and economic center of the region. According to the U.S. Census Bureau, the Greater Lowell region had a population of 286,901 in 2010, which represented an increase of 2.2% since 2000. This growth rate was one-third of what the region experienced between 1990 and 2000.

The region is tied together by the Merrimack River and is located in the northeastern section of Massachusetts, abutting the New Hampshire state line. The City of Lowell is approximately forty-five minutes from the City of Boston and Manchester, New Hampshire and an hour from the City of Worcester and Portsmouth, New Hampshire.

A. Population and Housing

Presently, Lowell accounts for 37% of the region's population and continues to have the highest population density, at over 7,325 persons per square mile. Billerica, Chelmsford, Dracut and Tewksbury, the early suburbanizing communities with population densities over 1,000 persons per square mile, collectively account for 46% of the region's population. The remaining communities, where much of the development activity occurred during the 1990s, account for 17% of the region's population. Table 3 below summarizes the population characteristics of the region's communities.

Table 3: 2000 and 2010 Population in the Northern Middlesex Region

Community	2000 Population	2010 Population	% Change
Billerica	38,981	40,243	3.24%
Chelmsford	33,858	33,802	-0.17%
Dracut	28,562	29,457	3.13%
Dunstable	2,829	3,179	12.37%
Lowell	105,167	106,519	1.29%
Pepperell	11,142	11,497	3.19%
Tewksbury	28,851	28,961	0.38%
Tyngsborough	11,081	11,292	1.90%
Westford	20,754	21,951	5.77%
Total	**281,225**	**286,901**	**2.02%**

Source: U.S. Census Bureau, 2000 and 2012 U.S. Census Data

The total number of housing units in the region increased from 101,973 units in 2000 to 109,446 units in 2010, an increase of 7,473 units or 7.3%. The City of Lowell accounted for the largest share of housing units in the region, however, its percentage share of the total housing units in the region decreased slightly from 38.7% in 2000 to 37.9% in 2010. The number of vacant units in the region nearly doubled from 2.6% in 2000 to 5 % in 2010. In terms of housing unit density, the City of Lowell was the only community in 2010 that had more than 600 housing units per square mile at 2,849.45 housing units, with the next highest community being

Chelmsford at 593.08 housing units per square mile. Table 4 below, provides population density and housing density data for the region and for each community.

Table 4: Housing and Population Density in the Northern Middlesex Region

Community	Population	Housing Units	Land Area (Sq. Mi.)	Population Density (Per Sq. Mi.)	Housing Unit Density (Per Sq. Mi.)
Billerica	40,243	14,481	26.38	1,525.51	548.94
Chelmsford	33,802	13,807	23.28	1,451.98	593.08
Dracut	29,457	11,351	21.36	1,379.07	531.41
Dunstable	3,179	1,098	16.74	189.90	65.59
Lowell	106,519	41,431	14.54	7,325.93	2,849.45
Pepperell	11,497	4,348	23.17	496.20	187.66
Tewksbury	28,961	10,848	21.06	1,375.17	515.10
Tyngsborough	11,292	4,206	18.50	610.38	227.35
Westford	21,951	7,876	31.33	700.64	251.39
Total	**286,901**	**109,446**	**196.36**	**1,461.10**	**557.37**

Source: U.S. Census Bureau, 2010 U.S. Census

B. Land Use Characteristics

The most recent land use data for the Greater Lowell region was compiled in 2005 using aerial photogrammetric data. According the McConnell land use data provided by the University of Massachusetts Amherst, the communities of Lowell, Billerica, Chelmsford and Tewksbury had the greatest acreage currently in commercial use, followed by Dracut, Tyngsborough and Westford. Of the nine Greater Lowell communities, the Town of Billerica clearly had the largest land area devoted to industrial development (1,071 acres), followed by Lowell (632 acres), Tewksbury (586 acres), Chelmsford (561 acres) and Westford (416 acres). In 2005, the overall region had 2,470 acres of land being utilized for commercial development and 3,612 acres devoted to industrial development. Nearly one-quarter of the region's land area used for commercial and industrial development (1,491 acres) was located within the Town of Billerica. As shown in Table 5 below, this land use pattern is very different from that seen in 1971, when the City of Lowell had the largest land area devoted to commercial and industrial uses, and reflects a continued trend in the suburbanization of employment centers.

Table 5: Land Use Patterns and Trends in the Region (1971-2005)

Community	Land Use Category	Acres				Percentage Change (1971 -2005)	Percent of Region (2005)
		1971	**1985**	**1991**	**2005**		
Billerica	Commercial	216.6	283.80	397.00	419.81	93.82	16.99
	Industrial	324.6	692.28	1,083.57	1,071.70	230.16	29.67
	Residential	4,747.58	5,670.02	6,665.34	7,265.28	53.03	16.46
	Developed	5,288.78	6,646.10	8,145.91	9,831.96	85.90	16.67
	Undeveloped	11,608.93	10,251.61	8,751.80	6,983.72	-39.84	10.55
	Total	**16,897.71**	**16,897.71**	**16,897.71**	**16,815.68**	**N/A**	**13.43**

Table 5 (cont'd): Land Use Patterns and Trends in the Region (1971-2005)

Community	Land Use Category	Acres				Percentage Change (1971 -2005)	Percent of Region (2005)
		1971	1985	1991	2005		
Chelmsford	Commercial	158.39	216.55	376.89	410.70	159.30	16.62
	Industrial	310.07	503.97	637.32	560.91	80.90	15.53
	Residential	3,249.10	3,914.34	6,866.71	7,162.52	120.44	16.22
	Developed	3,717.56	4,634.86	7,880.92	9,286.53	149.80	15.75
	Undeveloped	11,110.09	10,192.79	6,946.73	5,463.36	-50.83	8.25
	Total	**14,827.65**	**14,827.65**	**14,827.65**	**14,749.89**	**N/A**	**11.78**
Dracut	Commercial	115.88	176.87	215.36	256.82	121.63	10.39
	Industrial	228.49	277.73	425.91	125.47	-45.09	3.47
	Residential	2,159.37	3,024.00	4,502.61	4,837.59	124.03	10.96
	Developed	2,503.74	3,478.60	5,143.88	5,525.23	120.68	9.37
	Undeveloped	11,241.50	10,266.64	8,601.36	8,121.81	-27.75	12.27
	Total	**13,745.24**	**13,745.24**	**13,745.24**	**13,647.04**	**N/A**	**10.90**
Dunstable	Commercial	2.77	2.77	0.00	1.79	-35.38	0.07
	Industrial	26.8	62.75	189.11	0	0	0
	Residential	368.59	586.81	1,064.48	1,725.27	368.07	3.91
	Developed	398.16	652.33	1,253.59	1,850.79	364.84	3.14
	Undeveloped	10,346.39	10,092.22	9,490.96	8,866.62	-14.30	13.39
	Total	**10,744.55**	**10,744.55**	**10,744.55**	**10,717.41**	**N/A**	**8.56**
Lowell	Commercial	424.91	466.57	493.97	549.55	29.33	22.24
	Industrial	465.99	638.01	797.94	632.04	35.63	17.50
	Residential	2,455.18	2,645.16	4,453.35	3,548.46	44.53	8.04
	Developed	3,346.08	3,749.74	5,745.26	8,125.43	142.83	13.78
	Undeveloped	5,990.99	5,587.33	3,591.81	1,174.06	-80.40	1.77
	Total	**9,337.07**	**9,337.07**	**9,337.07**	**9,299.48**	**N/A**	**7.43**
Pepperell	Commercial	44.56	55.49	62.13	46.23	3.75	1.87
	Industrial	46.37	131.79	196.12	87.58	88.87	2.42
	Residential	1,041.51	1,801.37	2,595.19	4,013.63	285.37	9.09
	Developed	1,132.44	1,988.65	2,853.44	4,397.52	288.32	7.46
	Undeveloped	13,754.62	12,898.41	12,033.62	10,449.41	-24.03	15.78
	Total	**14,887.06**	**14,887.06**	**14,887.06**	**14,846.93**	**N/A**	**11.862**
Tewksbury	Commercial	194.63	284.85	274.18	342.64	76.05	13.87
	Industrial	338.63	442.83	656.03	586.22	73.12	16.23
	Residential	2,803.53	3,555.56	4,876.41	5,472.25	95.19	12.39
	Developed	3,336.79	4,283.24	5,806.62	7,264.22	207.61	12.32
	Undeveloped	10,234.58	9,288.13	7,764.75	6,247.17	-38.96	9.44
	Total	**13,571.37**	**13,571.37**	**13,571.37**	**13,511.40**	**N/A**	**10.79**
Tyngsborough	Commercial	24.83	82.13	178.98	225.79	809.34	9.14
	Industrial	149.43	256.78	309.28	132.08	-11.61	3.66
	Residential	819.27	1,459.02	2,245.08	3,561.95	334.77	8.07
	Developed	993.53	1,797.93	2,733.34	4,599.05	362.90	7.80
	Undeveloped	10,626.49	9,822.09	8,886.68	6,946.92	-34.63	10.49
	Total	**11,620.02**	**11,620.02**	**11,620.02**	**11,545.96**	**N/A**	**9.225**
Westford	Commercial	71.23	137.91	172.71	217.73	205.67	8.81
	Industrial	477.56	572.81	719.90	416.31	-12.83	11.52
	Residential	2,504.62	3,642.93	4,930.98	6,562.39	162.01	14.86
	Developed	3,053.41	4,353.65	5,823.59	8,086.59	164.84	13.71
	Undeveloped	17,013.72	15,713.48	14,243.54	11,949.75	-29.76	18.05
	Total	**20,067.13**	**20,067.13**	**20,067.13**	**20,036.33**	**N/A**	**16.00**

Table 5 (cont'd): Land Use Patterns and Trends in the Region (1971-2005)

Community	Land Use Category	Acres				Percentage Change (1971 -2005)	Percent of Region (2005)
		1971	**1985**	**1991**	**2005**		
Region	Commercial	1,253.80	1,706.94	2,171.22	2,471.06	97.09	100
	Industrial	2,367.94	3,578.95	5,015.18	3,612.31	52.55	100
	Residential	20,148.75	26,299.21	38,200.15	44,149.34	119.12	100
	Developed	23,770.49	31,585.10	45,386.55	58,967.31	148.07	100
	Undeveloped	101,927.31	94,112.70	80,311.25	66,202.82	-35.05	100
	Total	**125,697.80**	**125,697.80**	**125,697.80**	**125,170.13**	**N/A**	**100**

Source: McConnell Land Use Data, University of Massachusetts

Land consumption will likely continue at an alarming rate for as long as large lot zoning remains the norm in the suburbs. The largest category of developed land use in the region was residential. This included all residential dwelling types, from large lot, single-family homes to multi-family apartments and condominiums. Recent development across the region has been largely in the form of large lot, single family subdivisions, although there have been several multi-family projects constructed under Chapter 40B. A significant amount of undeveloped land remains, although it is not evenly distributed throughout the region. This undeveloped land includes land that is vacant and developable, as well as land that may be classified as undevelopable due to various development constraints, such as wetlands.

Commercial development continues to be dispersed beyond traditional centers to locations along state numbered routes and major travel corridors, such as Route 110 in Lowell, Chelmsford and Westford, Route 3A in Billerica, Lakeview Avenue in Dracut, Route 38 in Tewkbury, and Middlesex Road in Tyngborough. The greatest concentration of industrial areas also tends to be in technology parks built near highway interchanges and along major corridors, such as Route 110 in Westford, Route 129 in Chelmsford and Billerica, Concord Road and the Middlesex Turnpike in Billerica, and Route 133 in Tewksbury. Such industrial parks are often built in a campus-like setting with large fields of paved parking, resulting in higher land consumption rates than would occur in an urban or compact development setting where higher floor area ratios are typically allowed.

The trend toward urbanization/suburbanization of the region has implications for natural hazard planning. As more land is developed, additional impervious surface is created, potentially increasing the flood risk and decreasing the area available for flood storage. As population and housing density increases, the potential for property damage and economic loss as a result of a natural disaster also increases.

C. Open Space/Conservation Land

Presently, there are 16,497 acres of permanently protected open space within the Northern Middlesex region, as shown in Table 6 on the following page. These lands range from large tracts of state-owned land located across multiple communities, to small tracts held by private land trusts and municipalities. Table 16 on the following page shows the acreage of protected open space in each community. Region-wide, nearly 3,000 acres are held by the Commonwealth, while the municipalities own more than 7,600 acres collectively. Approximately, 828 acres are under agricultural preservation restrictions, and another 680 acres have been set aside for water supply protection. Over 1,550 acres are owned and protected through non-profit organizations, such as the local land trusts.

Table 6: Permanently Protected Open Space by Community

Community	Total Acreage							
	State	**Municipality**	**Land Trusts**	**Conservation Restriction**	**Water Supply**	**Agricultural Preservation Restriction (APR)**	**Other**	**Total**
Billerica	448.57	1,114.12	60.33	77.40	0	19.65	122.25	1,842.32
Chelmsford	56.00	798.00	80.00	66.00	2.77	0	0	1,004.00
Dracut	554.88	358.58	68.80	85.82	99.65	222.90	0	1,390.63
Dunstable	228.14	845.69	700.07	475.01	14.39	210.00	0	2,473.30
Lowell	347.16	360.72	8.41	0	0	0	11.74	728.03
Pepperell	445.79	592.29	318.39	1	132.63	315.13	62.10	1,867.33
Tewksbury	412.53	974.76	0	0	0	0	0	1,387.29
Tyngsborough	480.43	536.82	68.70	65.13	71.7	20.00	0	1,242.78
Westford	13.00	2,040.51	251.26	1,715.00	358.90	39.97	142.79	4,561.34
Total	**2,986.50**	**7,621.49**	**1,555.96**	**2,485.36**	**681.27**	**827.65**	**338.88**	**16,497.11**

Source: Regional Strategic Plan, NMCOG

D. Water Resources and Water Quality

The region possesses an abundance of water resources, including rivers, streams, brooks, lakes, ponds, reservoirs, marshes and wetlands. The entire region falls within the drainage basin of the Merrimack River, the second largest in New England. The Concord, Nashua, Nissitissit and Shawsheen Rivers are other rivers in the region and are tributaries of the Merrimack River. More than fifty streams and brooks, including Beaver Brook, Black Brook, River Meadow Brook, Stony Brook and Trull Brook, are tied into this river system and connect with the lakes, ponds and wetlands in an elaborate hydrologic system.

More than twenty-five (25) major lakes and ponds are found in the region. Most are natural water bodies over ten (10) acres in area and, therefore, are defined as “Great Ponds”, according to DEP. The larger bodies of water in the region include Forge Pond in Westford and Mascuppic Lake in Tyngsborough, which are greater than 200 acres in area. Long Pond in Tyngsborough and Dracut, and Long Sought For and Nabnasset Ponds in Westford and Pepperell Pond in Pepperell and Groton are greater than one hundred (100) acres in area. In general, the ponds with the best water quality are Long Pond in Tyngsborough, Burgess Pond in Westford, and Massapoag Pond in Dunstable. Two swamps, the Great Swamp in Tewksbury and Tadmuck Swamp in Westford, are more than one hundred (100) acres in area as well.

Abundant, high quality water sources are essential to the region's long term growth and economic vitality. According to the *Massachusetts 2012 Integrated List of Waters*, the section of the Concord River within the Greater Lowell region is impacted by a number of impairments due to the presence of fecal coliform, invasive plant species, mercury in fish, phosphorus, and algal growth. Similarly, the Merrimack River suffers from several impairments including fecal coliform, Escherichia coli, phosphorus, and mercury and PCB in fish. The Nashua River in Dunstable and Pepperell is impacted by mercury in fish tissue, non-native aquatic plants, nutrient/eutrophication biological indicators and phosphorus. The Shawsheen River in Billerica and Tewksbury is impaired due to low dissolved oxygen levels and the presence of fecal coliform. Ongoing efforts by environmental groups, such as the Merrimack River Watershed Council, the Nashua River Watershed Association, and the Northern Middlesex Stormwater Collaborative focus on water quality addressing problems through a watershed or regional approach.

Wetlands are protected from development by the state Wetlands Protection Act and, in some cases, by local wetlands protection bylaws. Freshwater wetlands support high biodiversity, including unique plant communities and many animal species that are dependent on wetlands for various lifecycle needs. Wetlands also capture heavy rains and prevent flooding downstream, absorb greenhouse gases from the atmosphere, and store and purify groundwater. Despite federal, state and local regulations, wetland destruction, habitat fragmentation, unsustainable water withdrawals, pollution, invasive species and climate change threaten the quantity and quality of the region's wetland resources.

The region contains a number of municipal water supply sources, including the Merrimack River and Concord River which supply drinking water to the communities of Billerica, Chelmsford, Dracut, Lowell, and Tewksbury. Surface water reservoirs and groundwater aquifers meet the daily water supply needs of the remainder of the region.

It is essential that the region protect both the quantity and quality of its water supply through effective land use controls and health regulations. Toward this end, most municipalities have adopted water supply protection district regulations consistent with DEP drinking water source protection requirements. These regulations prohibit high-risk commercial and industrial uses within the protection district. The following table provides an overview of the region's primary water supply lands (Zone A and Zone II), as mapped by DEP and summarized in Table 7 on the following page. Zone A is an area delineated 400' from a surface water supply (200' from tributaries). Zone II is a wellhead protection area that has been determined by hydro-geologic modeling and approved by the Massachusetts Department of Environmental Protection (DEP). In cases where hydro-geologic modeling studies have not been performed and there is no approved Zone II, an Interim Wellhead Protection Area (IWPA) is established based on DEP well pumping rates or default values. Certain land uses may be either prohibited or restricted in both approved (Zone II) and interim (IWPA) wellhead protection areas.

Table 7: Municipal Drinking Water Supplies – Primary Protection Zones

Municipality	Zone A (acres)	Zone II (acres)	Zone A and Zone II protected area (acres)	% Permanently Protected	
				Zone A	Zone II
Billerica	710.85	1055.00	1765.85	67.41	10.24
Chelmsford	173.22	4704.58	4877.80	15.21	21.11
Dracut	115.02	128.00	243.02	0.00	30.52
Dunstable	0	443.28	443.28	0.00	21.13
Lowell	882.15	83.23	965.38	7.29	1.08
Pepperell	0	702.34	702.34	0.00	61.01
Tewksbury	56.57	2562.19	2618. 76	2.26	16.87
Tyngsborough	547.83	428.59	976.42	11.52	20.20
Westford	0	4298.64	4298.64	0.00	39.21
Region	2485.64	14408.92	16894.56	25.52	26.85

Source: Massachusetts Department of Environmental Protection

E. The Regional Economy

The economic conditions in the Greater Lowell region have been negatively impacted by the national recession, which began as of December 2007. The full impact of the national recession was not felt in this region until a year later when the unemployment rate in the City of Lowell increased from 7.7% in November 2008 to 8.3% in December 2008. The unemployment rate in the City of Lowell continued to increase steadily until it reached 11.7% in September 2009 and finally reached its peak of 11.8% in January 2010. As of June 2013, the unemployment rate for the City of Lowell had decreased to 9.4%.

During the twenty-four month period from July 2011 to June 2013, the unemployment rate in the City of Lowell decreased slightly from 9.7% to 9.4%, while the average unemployment rate for this twenty-four month period was 8.8%. This average unemployment rate was .7% greater than the average national unemployment rate for the same period. During the period from July 1, 2012 to June 30, 2013, the average unemployment rate for the City of Lowell was 8.6%, which was .4% higher than the nation's average unemployment rate for the same period of time.

The unemployment rate for the Greater Lowell region experienced a nearly 3% increase, from 5.8% in September 2008 to 8.6% in August 2010. Since August 2010, the unemployment rate for the region decreased to 7.5% as of June 2013. The City of Lowell and the suburban communities experienced a significant increase in the unemployment rates between December 2009 and January 2010. The unemployment rates as of August 2010 showed that the suburban communities had been impacted as well, such as in Dracut (9.1%), Tyngsborough (8.5%), Billerica (7.8%) and Tewksbury (7.8%). However, these unemployment rates have decreased to 7.1% in Dracut and 6.6% in Billerica, Tewksbury and Tyngsborough 6.6% as of June 2013.

The Greater Lowell region experienced 1,984 layoffs from July 1, 2009 to June 30, 2013. These layoffs directly impacted six of our nine communities – Billerica (824 employees in 14 businesses), Chelmsford (321 employees in 8 businesses), Dracut (54 public employees), Lowell (469 employees in 14 organizations), Tewksbury (183 employees in 5 organizations) and Westford (133 employees in 5 businesses). For instance, the 315 layoffs at Jabil Circuits, located in North Billerica, directly impacted Lowell residents, who comprised one-third of the workforce, in 2009.

Additionally, the housing crisis, which initially impacted this region in 2008, continued to negatively impact the economy through 738 foreclosure petitions, 577 foreclosure auctions and 200 bank-owned/REO properties between April 2008 and March 2010. During 2011, the region experienced 561 foreclosure petitions, 955 auctions and 428 foreclosure deeds. The City of Lowell has generally accounted for 40% of the foreclosure petitions, 45-50% of the auctions and 41-48% of the foreclosure deeds in the region. These statistics illustrate that the Greater Lowell region is still slowly recovering from the national recession. According to the Warren Group, foreclosure petitions statewide fell to the lowest monthly level in June 2013 since they started compiling foreclosure statistics in 2006. A total of 245 foreclosure petitions were recorded in June, which represented an 84% decrease from the 1,548 foreclosure petitions filed in June 2012. From January to June 2013 2,943 foreclosure petitions were filed statewide, which represented a decrease of 69% from the same time period in 2012.

During the recession in the early 2000s, this region's computer manufacturing and information technology industries were significantly impacted. During the most recent recession, layoffs occurred in high tech manufacturing, information technology and retail industries, but the impact on these industries wasn't as severe and the economic downturn has affected every industry. Due to the diverse and high tech nature of the Massachusetts economy, industries in this region have been able to recover more readily than industries in other parts of the country. Recent statistics show that the Commonwealth of Massachusetts has done better than most states in creating new jobs as we continue to emerge from the national recession.

F. Historic and Cultural Resources

The preservation of historic and cultural resources must be carefully considered in order to protect the character of the region's city, town, and village centers. Many colonial era residences, mill structures, and village greens are already protected to some extent through the establishment of historic districts, however, additional consideration should be given to protecting such resources from potential natural hazards. Historic inventories and plans are essential in guiding historic preservation initiatives, and such plans should consider hazard mitigation. Effective preservation of these resources requires active stewardship and support of the overall community. Table 8 on the following page provides a listing of the National Register Historic Districts and the Local Historic Districts in each community.

COSTEP-MA promotes proactive steps to reduce losses from natural hazards, especially flooding or water damage following fires, through cooperative, team-building activities in communities and through educational activities within the cultural heritage and emergency management communities. COSTEP-MA has worked to develop an Annex to the state's CEMP to promote education and cooperation in communities and to enhance the protection of cultural resources from natural disasters.

Table 8: National Register Districts and Local Historic Districts

Community	National Register Districts	Local Historic Districts
Billerica	Billerica Mills Historic District	Billerica Mills Historic District
	Town Hall	Corner Historic District
	Middlesex Canal Historic and Archaeological District	Howe School
	Two Brothers Rocks	Richardson’s Mill Historic District
		Sabbath Day House
Chelmsford	Chelmsford Center Historic District	Chelmsford Center Historic District
	Old Town Hall	Old Town Hall
	Fiske House	Fiske House
	Forefathers Cemetery	Forefathers Cemetery
	J.P. Emerson House	J.P. Emerson House
	Middlesex Canal Historic and Archaeological District	
Dracut	None	None
Dunstable	None	None
Lowell	Belvidere Hill Historic District	City Hall District
	Andrew J. Calef Building	Downtown Lowell Historic District
	City Hall District	Warren Fox Building
	Colburn School	Hamilton Manufacturing Co.-Counting House
	Eliot Presbyterian Church	Hamilton Manufacturing Co.- Storage House
	Warren Fox Building	Hill Brothers Carriage House
	Hamilton Manufacturing Co.-Counting House	Holy Trinity Greek Orthodox Church
	Hamilton Manufacturing Co. –Storage House	Howe Building
	Hill Brothers Carriage Factory	Hoyt-Shedd Estate
	Holy Trinity Church	Lawrence Manufacturing Co.-Mill #12

Table 8 (Cont'd): National Register Districts and Local Historic Districts

Community	National Register Districts	Local Historic Districts
Lowell (Continued)	Howe Building	Lawrence Manufacturing Co. – Storehouse #14
	Hoyt-Shedd Estate	Lawrence Manufacturing Co. –Agent's House
	Lawrence Manufacturing Co.-Mill #12	Locks and Canal District
	Lawrence Manufacturing Co. – Storehouse #14	Merrimack-Middle Street Historic District
	Lawrence Manufacturing Co. –Agent's House	Peter Powers Double House
	Locks and Canal District	Saint Anne's Episcopal Church
	Lowell National Historical Park Canal System	Lawrence Manufacturing Co.- Mill #12
	Merrimack-Middle Street Historic District	Lawrence Manufacturing Co. – Storehouse #14
	Middlesex Canal Historic and Archaeological District	Wentworth Block
	John Nesmith House	Whistler House
	Peter Powers Double House	
	Roger Fort Hill Park Historic District	
	Round House	
	Saint Anne's Episcopal Church	
	Saint Patrick's Church	
	South Common Historic District	
	Dr. Joel Spalding House	
	Tyler Park Historic District	
	U.S. Post Office Historic District (Appleton)	
	U.S. Post Office Historic District (Kearney Square)	
	Wamesit Canal-Whipple Mill Industrial Complex	
	Wannalancit Street Historic District	
	Washington Square Historic District	
	Wentworth Block	
	Whistler House	
	Wilder Street Historic District	
	Worcester House	
Pepperell	Pepperell Center Historic District	None
	Pepperell Town Hall	
Tewksbury	Tewksbury State Hospital	None
Tyngsborough	None	None
Westford	Brookside Historic District	
	Forge Village Historic District	
	Graniteville Historic District	
	Parker Village Historic District	
	Westford Center Historic District	

Source: 2010 State Register of Historic Places, Massachusetts Historical Commission

G. Demographic Data and Projections

In considering exposure to natural hazards it is important to assess population and development trends. As more land is developed, additional impervious surface is created increasing the flood risk and decreasing available flood storage area. The population, household and employment projections for the Northern Middlesex Region were developed utilizing a methodology developed by the Massachusetts Department of Transportation (MassDOT). Over the past ten years, the region has continued to grow, albeit less dramatically than in past decades. Based upon population projections developed by MassDOT with input from NMCOG, the region is expected to grow by an additional 10,099 residents (3.52%) between 2010 and 2020 and by another 23,000 residents (7.74%) between 2020 and 2035. The region, as a whole, is projected to grow by 8.88% between 2010 and 2035, which represents a much greater growth rate than that experienced between 2000 and 2010 (2.02%). The data summarized in Table 9 below reflects anticipated population trends over the next two decades.

Table 9: Current and Projected Population in the Northern Middlesex Region

Community	2010	2020	2025	2030	2035
Billerica	40,243	40,690	41,340	41,810	42,560
Chelmsford	33,802	34,750	35,260	35,880	36,480
Dracut	29,457	32,080	33,140	34,630	36,160
Dunstable	3,179	3,560	3,950	4,370	4,800
Lowell	106,519	106,920	108,220	109,820	111,360
Pepperell	11,497	13,070	13,680	14,660	15,360
Tewksbury	28,961	30,000	31,020	31,820	32,640
Tyngsborough	11,292	12,470	13,070	13,740	14,400
Westford	21,951	23,460	24,320	25,270	26,240
Total	**286,901**	**297,000**	**304,000**	**312,000**	**320,000**

Source: U.S. Census for 2010; MassDOT projections in consultation with NMCOG

Between 2010 and 2035, the towns of Dunstable and Pepperell are expected to increase their total populations significantly with growth rates of 50.99% and 33.6%, respectively. For those communities that are more developed, such as Billerica, Chelmsford, Tewksbury and the City of Lowell, less dramatic population growth is expected over the next twenty-five years. In general, the growth rates for the remaining towns will range between 12.7% (Tewksbury) and 19.5% (Westford) for this same period of time.

Notwithstanding the current housing slump, the number of households in the region is projected to increase from 104,022 in 2010 to 118,900 households in 2035, an increase of 14.3%. The principal areas of household growth will be in Dunstable (55.2%), Pepperell (38.2%), Tyngsborough (33.8%), Westford (25.8%), and Dracut (25.7%), as outlined in Table 10 below. The more developed communities, such as the City of Lowell (5.7%), Billerica (10.6%), Chelmsford (11.6%) and Tewksbury (15.8%), will experience more restrained household growth between 2010 and 2035.

Table 10: Current and Projected Households in the Northern Middlesex Region

Community	2010	2020	2025	2030	2035
Billerica	14,034	14,350	14,700	14,950	15,250
Chelmsford	13,313	13,900	14,180	14,550	14,850
Dracut	10,956	12,000	12,490	13,150	13,770
Dunstable	1,063	1,210	1,350	1,500	1,650
Lowell	38,470	38,650	39,370	39,920	40,650
Pepperell	4,197	4,850	5,130	5,500	5,800
Tewksbury	10,492	10,980	11,450	11,800	12,150
Tyngsborough	3,999	4,550	4,800	5,080	5,350
Westford	7,498	8,310	8,630	9,050	9,430
Total	**104,022**	**108,800**	**112,100**	**115,500**	**118,900**

Source: U.S. Census for 2010; MassDOT projections in consultation with NMCOG

As mentioned previously, the Northern Middlesex Region has experienced its worst economy since the end of World War II. Although the Commonwealth performed better economically than many other states, the national recession has created the worst unemployment rates in more than thirty years. However, the state projects 21,000 jobs will be added for the region between 2010 and 2035, as shown in Table 11 below.

Table 11: Current and Projected Employment in the Northern Middlesex Region

Community	2010	2020	2025	2030	2035
Billerica	20,583	22,620	22,590	22,810	22,810
Chelmsford	20,736	23,200	23,520	23,710	23,920
Dracut	4,826	5,720	5,970	6,210	6,420
Dunstable	255	320	350	360	390
Lowell	33,204	36,520	36,680	37,460	37,960

Table 11 (cont'd): Current and Projected Employment in the Northern Middlesex Region

Community	2010	2020	2025	2030	2035
Pepperell	1,379	1,750	1,950	2,170	2,300
Tewksbury	15,213	17,190	17,610	18,050	18,400
Tyngsborough	4,123	5,040	5,160	5,380	5,650
Westford	11,681	13,640	14,170	14,850	15,150
Total	**112,000**	**126,000**	**128,000**	**131,000**	**133,000**

Source: U.S. Census for 2010; MassDOT projections in consultation with NMCOG

This employment growth of 18.75% is expected to be fueled by employment growth principally in the City of Lowell (4,756 jobs), Westford (3,469 jobs), Tewksbury (3,187 jobs), Chelmsford (3,184 jobs) and Billerica (2,227 jobs). The expected employment growth in Pepperell (66.8%), Dunstable (52.9%), Tyngsborough (37%) and Dracut (33%) will occur between 2010 and 2035.

H. Assessed Valuations

The Massachusetts Department of Revenue (DOR) requires all communities to value all property each year and every third year a complete recertification is required. Both a recertification and an interim year adjustment (the two years in between the triennial re-certification) include a detailed analysis of the appropriate sales data as a basis for adjusting the property values. The goal is to keep the values as close as possible to 100% of market value and avoid an excessive swing in the assessments in one year. Table 12 below contains the FY 2013 Assessed Values for all property classes in each community.

Table 12: 2013 Assessed Values by Class

COMMUNITY	RESIDENTIAL	OPEN SPACE	COMMERCIAL	INDUSTRIAL	PERSONAL PROPERTY	TOTAL
Billerica	$4,006,737,103	0	$268,594,743	$782,113,174	$224,326,400	$5,281,771,420
Chelmsford	$3,603,918,180	0	$353,189,440	$334,358,600	$187,203,250	$4,478,669,470
Dracut	$2,504,925,425	0	$142,870,485	$50,039,590	$80,555,623	$2,778,391,123
Dunstable	$443,558,300	0	$4,271,791	$3,103,100	$8,962,380	$459,895,571
Lowell	$5,005,369,487	0	$526,424,699	$344,529,092	$206,194,580	$6,082,517,858
Pepperell	$1,044,751,604	0	$26,817,879	$23,800,500	$17,841,030	$1,113,211,013
Tewksbury	$3,063,903,096	0	$375,205,114	$206,961,040	$157,198,370	$3,803,267,620
Tyngsborough	$1,171,902,140	0	$101,051,779	$51,961,105	$38,939,717	$1,363,854,741
Westford	$3,283,472,825	0	$243,588,224	$217,461,440	$94,723,861	$3,839,246,350

Source: Massachusetts Department of Revenue, Division of Local Services

SECTION 4: HAZARD IDENTIFICATION

In the context of this plan, a "hazard" is defined as an extreme natural event that poses a risk to people, infrastructure, or resources. Hazard identification details the geographic extent, the significance, and the probability of a particular natural hazard affecting the region. Federal regulations for hazard mitigation plans include a requirement for a risk assessment, in order to provide communities with information needed to prioritize mitigation strategies. Hazard mitigation is commonly defined as any sustained action that permanently reduces or eliminates long-term risk to people, property, and resources. It is important to note that one particular category of hazard can be caused by several different types of events. For example, flooding can be the result of a hurricane, a nor'easter, a thunderstorm or a winter storm.

In an urbanized area, such as the Northern Middlesex region, natural hazards can result in disaster. Hazard mitigation planning is a process directed at reducing the impact that natural disasters may have on the built environment and the lives of area residents. As the region grows and population increases, the risk of disaster caused by natural hazards becomes greater. It is impossible to predict exactly when and where such a disaster might occur; however, careful planning can help minimize the losses that may result. Hazards can be exacerbated by human behavior and practices, such as building in a floodplain, along steep slopes, or on a fault line.

A. Natural Hazards Inventory

Natural hazards that are likely to occur in Northern Middlesex region are summarized in this section of the report. These include flood-related hazards, wind-related hazards, winter-related hazards, fire-related hazards, and geologic hazards. In addition, some information is provided regarding non-natural hazards such as pandemics, chemical and hazardous materials, transportation accidents, nuclear incidents, infrastructure failure, terrorism, and commodity shortages. Including such information within this updated document provides consistency with the Commonwealth's most recent Hazard Mitigation Plan completed in 2010.

This section provides a regional summary of the hazards and assesses the potential for occurrence based on historic records and information available from local, state and national sources. Where cumulative data is available for the region, or is aggregated from the information gathered from the individual communities, it is presented herein. Section 5 of this report presents community-by-community information relative to the hazard identification process.

1. Flood-Related Hazards

Floods are the most common hazard to affect New England. Most floods are caused by spring rains, thunderstorms, hurricanes, or rapid snowmelt. Inland floods are most likely to occur in Spring due to increased rains and snowmelt. Riverine flooding consists of the overbank flooding of rivers and streams, typically resulting from either extremely rapid snowmelt or a large-scale weather event that generates an unusual amount of precipitation. In areas of urban flooding, heavy rainfall collects and flows quickly across impervious surfaces. During periods of urban flooding, roadway flooding is common and basements may fill with water.

Flooding poses a danger to life and property. Two types of flooding typically affect the Northern Middlesex region: riverine flooding and urban flooding. In addition, there are several low-lying areas that have the potential to flood. According to the National Climatic Data Center, fifty-three (53) flood events were reported in Middlesex County from January 1, 1950 to July 2010. Floodwaters can be extremely dangerous, as the force of six inches of rapidly moving water can knock people off their feet. Flash flood waters move very quickly and often happen unexpectedly. Flash floods usually result from an intense storm, typically a thunderstorm that drops a large amount of rainfall over a short period of time. Flash floods can destroy buildings and obliterate bridges.

While the Merrimack River is generally prone to minor flooding, on May 15, 2006 rainfall raised the river to more than 8 feet (2.4 m) above flood stage, forcing evacuations and damaging property. Reports of total rainfall vary, but most areas appear to have received around a foot of rain, with some areas receiving as much as 17 inches. According to the Boston Globe, around 1,500 people evacuated their homes to escape the flood. This flood also prompted the City of Lowell, Massachusetts to install a modern (albeit temporary) flood control gate comprised of square steel beams at the site of the historic Francis Gate, a 19th and 20th century wooden flood gate. When lowered, the Francis Gate seals the city's canal system off from its source on the Merrimack. The Mother’s Day 2006 flood caused $25 million in damage to infrastructure in the City of Lowell alone, and approximately 400 homes in the City were damaged from the floodwaters.

The most significant flood in the recorded history of the Merrimack River was in March 1936, when rain, melting snow and ice swelled the Merrimack in Lowell to 68.4 feet (20.8 m), 10 feet (3 m) higher than the 2006 flood. In addition to the 1936 flood, the 1852 flood, the Mother's Day Flood of 2006, the New England Hurricane of 1938, and April 2007 flood are among the River's most serious flood events in Lowell. Most recently, from March 14 through 21, 2010, a major rain event caused all seven gauged mainstream rivers in Middlesex County to rise above flood stage.

Flooding at the Lawrence Mills in Lowell in 2007

Since 1985, there have been twelve federal Disaster Declarations for flood events, most of which were the result of severe weather. Table 13 below summarizes the details of each declaration.

Table 13: Flood-related Disaster Declarations (1985-present)

Disaster #	Disaster Type	Declaration Date	Incident Period
DR-1895	Severe Storm and Flooding	3/29/10	3/12/10-4/26/10
DR-1813	Severe Winter Storm and Flooding	1/05/09	12/11/08-12/18/08
DR-1642	Severe Storms and Flooding	5/25/06	5/12/06-5/23/06
DR-1614	Severe Storms and Flooding	11/10/05	10/7/05-10/16/05
DR-1512	Flooding	4/21/04	4/1/04-4/30/04
DR-1364	Severe Storms and Flooding	4/10/01	3/5/01-4/16/01
DR-1224	Heavy Rain and Flooding	6/23/98	6/13/98-7/6/98
DR-1142	Severe Storms/Flooding	10/25/96	10/20/96-10/25/96
DR-975	Winter Coastal Storm	12/21/92	12/11/92-12/13/92
DR-914	Hurricane Bob	8/26/91	8/19/91
DR-790	Severe Storms, Flooding	4/18/87	3/30/87-4/13/87
DR-751	Hurricane Gloria	10/28/85	9/27/85

Source: FEMA

Methodology

Flood hazard identification is the first phase of flood-hazard assessment. Identification is the process of estimating the geographic extent of the floodplain, the intensity of flooding that can be expected in specific locations, and the probability of occurrence of flood events.

Flood-related hazards were identified in each of the nine communities in the region. The methodology employed in assessing the hazard presented by flooding involved mapping the 100-year flood plain in each of the nine communities. Vulnerable critical infrastructure, including dams and bridges, was then mapped relative to proximity to streams, rivers and flood prone areas. Map 17 on page 157 shows the location of all critical infrastructure located within the 100-year flood plain.

Floodplains and Repetitive Loss Structures

The communities of Billerica, Dracut, Chelmsford, Lowell, Pepperell, Tewksbury and Tyngsborough have repetitive loss structures located within their boundaries. Table 14 on the following page graphically displays the number of repetitive losses and the money paid out by FEMA in insurance claims under the National Flood Insurance Program (NFIP) in each community as of May 2013. Billerica had the most repetitive losses (139) impacting fifty (50) properties and totaling $1,799,982.79 in claims, the most recent of which occurred in 2010. Since 1979, there have been a total of 266 repetitive claims for flood insurance payments across the region, as shown in Table 14. Dracut had the fewest number of claims, with only four claims totaling $181,947.24. Monetarily, the largest losses occurred in the Town of Tyngsborough which had claims totaling $2,129,486.05. The total monetary payout for the region under the NFIP was $5,352,590.34. As shown in Table 14 on the following page, most of the repetitive flood loss properties (98) are residential. There are only six repetitive flood loss properties in the region that are non-residential in terms of use classification.

Table 14: Repetitive Flood Loss Properties under the NFIP by Community (as of May 2013)

Community	Number of Repetitive Flood Loss Properties	Number of Losses	Single-Family Residential Properties	2-4 Family Residential	Other Residential Properties	Non – Residential Properties	Total Paid
Billerica	50	139	48	0	0	2	$1,799,982.79
Chelmsford	7	22	7	0	0	0	344,702.28
Dracut	2	4	1	0	0	1	181,947.24
Lowell	24	55	17	7	0	0	584,907.11
Pepperell	2	6	1	0	0	1	123,945.05
Tewksbury	8	24	8	0	0	0	187,619.82
Tyngsborough	8	16	3	0	3	2	2,129,486.05
Region	**101**	**266**	**85**	**7**	**3**	**6**	**$5,352,590.34**

Source: Massachusetts Department of Conservation and Recreation

Severe repetitive loss properties are located in Billerica and Chelmsford. A Severe Repetitive Loss property is a residential property that is covered under an NFIP flood insurance policy and:

a. That has at least four NFIP claim payments (including building and contents) over $5,000 each, and the cumulative amount of such claims exceeds $20,000; or
b. For which at least two separate claim payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building.

At least two of the referenced claims must have occurred within any ten year period and must be greater than ten days apart. There are two properties in Billerica and two in Chelmsford that fall under this designation. All four properties are impacted by riverine flooding.

In addition to threatening building structures, flood events pose risks to critical infrastructure, such as dams and bridges. The ability of these structures of withstand flood events depends in part on the current maintenance and repair status. Dam failure during a flood event can pose a serious threat to downstream properties by releasing a surge of water that was stored behind the dam prior to its failure.

With the exception of Dunstable and Westford, most communities in the region are at risk of being impacted by flood events. The floodplain boundaries provide a reasonable approximation of where the risk is greatest within each community.

National Flood Insurance Program

The National Flood Insurance Program (NFIP) is a federal program administered by FEMA. The NFIP provides subsidized flood insurance within communities that agree to adopt corrective and preventative floodplain management regulations that will reduce future flood damages. Congress created the NFIP in 1968, with the passing of the National Flood Insurance Act. The Act was passed to benefit homeowners whose insurance does not cover flood damage.

In general, flood insurance from private companies is either not available or extremely expensive. NFIP flood insurance is available anywhere within a participating community, regardless of the flood zone in which a property is located. Federal law requires that flood insurance be purchased as a condition of federally insured financing used for the purchase of buildings in the Special Flood Hazard Area (SFHA). Table 15 below summarizes the NFIP policy data for those communities in the Northern Middlesex region:

Table 15: National Flood Insurance Policies in the Northern Middlesex Region (as of 9/30/13)

Community	Policies In-force	Insurance In-force (whole $)	Written Premium In-force
Billerica	246	$59,712,000	$359,879
Chelmsford	302	76,218,400	320,593
Dracut	64	15,050,800	60,486
Dunstable	10	3,025,900	7,091
Lowell	1,269	242,748,900	896,359
Pepperell	36	8,441,500	41,607
Tewksbury	110	27,906,700	107,161
Tyngsborough	129	20,906,900	118,643
Westford	102	27,099,600	79,864
Region	2,268	$421,398,700	$1,631,804

Source: FEMA

FEMA produces Flood Insurance Rate Maps, commonly known as FIRMs, to support the National Flood Insurance Program. The FIRMs depict Special Flood Hazard Areas, the areas subject to inundation from the 1% annual chance flood (also known as the Base Flood or the 100-Year Flood). The SFHA determines where flood insurance is required as a condition of a federally insured loan through the NFIP mandatory purchase requirement. This requirement is intended to shift flood damage and recovery costs away from the general taxpayer and on to those who live in floodplains. The risk zones and flood elevations shown on the FIRMs within the SFHA are used to determine flood insurance rates. The SFHA also determines where NFIP floodplain management requirements must be enforced by communities that participate in the program. These include land use and building code standards. In addition to the NFIP, the FIRMs are also used within FEMA's Individual and Public Disaster Assistance programs and FEMA's Mitigation Grant Programs, in emergency management, and they are also used to identify areas where certain State Building Code and Wetland Protection regulations must be enforced. Massachusetts State Building Code covers the entire state, applies to both public and private construction, and is administered through the local building inspectors with state oversight. Section 3107 of the State Building Code contains most of the construction requirements related to buildings or structures.

In 2010, new FEMA floodplain maps were released for the communities located in the Northern Middlesex region. The updated FIRM maps indicate a net increase of approximately 532 acres now determined to be located in the flood plain. The greatest increases are in the towns of Chelmsford, Lowell and Dunstable, as shown in Table 16 on the following page.

Table 16: Floodplain Area by Community

Community	Acres of floodplain as shown on 1979 FIRM maps	Acres of floodplain as shown on 2010 FIRM maps	Difference in acres (1979-2010 FIRM maps)	% Change 1979-2010	Total Land Area in Acres	% Land Area in Flood Plain (according to the 2010 FIRM maps)
Billerica	2,267.94	2,284.43	16.49	0.73	16,815.68	13.58
Chelmsford	1,947.67	2,076.28	128.61	6.60	14,749.89	14.08
Dracut	1,128.86	1,144.05	15.19	1.35	13,647.04	8.38
Dunstable	1,847.58	1,960.73	113.15	6.12	10,717.41	18.29
Lowell	1,226.20	1,285.33	59.13	4.82	9,299.48	13.82
Pepperell	1,470.85	1,518.10	47.25	3.21	14,846.93	10.23
Tewksbury	1,602.31	1,617.72	15.41	0.96	13,511.40	11.97
Tyngsborough	1,731.76	1,814.20	82.44	4.76	11,545.96	15.71
Westford	2,991.97	3,045.77	53.80	1.80	20,036.33	15.20
Regional Total	**16,215.14**	**16,746.61**	**531.47**	**3.28**	**125,170.10**	**13.38**

Source: GIS Analysis of the FEMA FIRM maps

It is important to note that the term "100-year flood" is misleading. It is not a flood that will occur only once every 100 years. Rather, it is a flood that has a one percent chance of being equaled or exceeded each year. Thus, the 100-year flood could occur more than once in a relatively short period of time. The 100-year flood, which is the standard used by most federal and state agencies, is used by the National Flood Insurance Program (NFIP) as the standard for floodplain management and to determine the need for flood insurance. A structure located within a Special Flood Hazard Area (SFHA) shown on an NFIP map has a 26 percent chance of suffering flood damage during the term of a 30-year mortgage.

All nine Northern Middlesex communities participate in the National Flood Insurance Program. To join the program each community adopted a resolution of intent to participate and cooperate with FEMA. Each community agreed to "maintain in force…adequate land use and control measures consistent with the NFIP criteria" and to:

- Assist the Administrator in the delineation of the floodplain;
- Provide information concerning present uses and occupancy of the floodplain;
- Maintain for public inspection and furnish upon request, for the determination of applicable flood insurance risk premium rates within all areas having special flood hazards, elevation and floodproofing records on new construction;
- Cooperate with agencies and firms which undertake to study, survey, map, and identify floodplain areas, and cooperate with neighboring communities with respect to the management of adjoining floodplain areas in order to prevent aggravation of existing hazards; and
- Notify the Administrator whenever the boundaries of the community have been modified by annexation or the community has otherwise assumed or no longer has authority to adopt and enforce floodplain management regulations for a particular area.

National Flood Insurance Program Compliance

Although the NFIP is a federal program, its successful implementation and management depends on the participation of a variety of partners, including local communities, MEMA, DCR and FEMA. Participating communities agree to adopt and enforce compliant floodplain management regulations as a condition of making federal flood insurance available. FEMA, MEMA and DCR support local communities by providing technical assistance and monitoring and enforcing compliance with the requirements of the NFIP.

Communities must enforce the ordinances or bylaws that they adopt. This means that all development in a community's Special Flood Hazard Area (SFHA as mapped by FEMA) must be reviewed and permitted. The local permitting process ensures that all construction and development is adequately designed, located, constructed and anchored to minimize flood damage and is fully compliant with the local bylaw or ordinance. Communities can grant exceptions, called variances, to the NFIP requirements under limited circumstances.

In the Greater Lowell region, all communities have adopted a local floodplain management bylaw or ordinance which is enforced according to FEMA requirements. Each community conducts inspections during the construction process to detect violations and remedies such violations prior to completion of the project.

Each community in the region has a designated floodplain manager who is responsible for ensuring the community's compliance with NFIP. This person is responsible for understanding NFIP regulations, reviewing permit applications, conducting inspections (or designating a staff member to perform inspections), taking enforcement actions against non-compliant projects, monitoring and participating in the variance process, and maintaining the community's floodplain records.

Each community periodically reviews its floodplain bylaw/ordinance and makes necessary revisions as needed. Communities work to identify potential and actual violations of the bylaw/ordinance and take necessary steps to avert them or enforce compliance. In addition, municipal staff in each community takes advantage of training opportunities offered by MEMA and FEMA, as a means of staying up-to-date with changes in the NFIP program and requirements. Most recently, the communities assisted with the revision of the FIRM maps, and helped residents understand the changes that were made and how such changes impacted their properties. Each community has identified action items related to their NFIP program. These actions are identified in Section 8 of this document.

Community Rating System

The Community Rating System is part of the NFIP. The CRS program encourages communities to reduce their flood risk by engaging in floodplain management activities. CRS provides discounts on flood insurance for communities that establish floodplain management programs that go beyond the minimum requirements of the NFIP. Depending on the level of activities that communities undertake in four areas – public information, mapping and regulatory activities, flood damage reduction, and flood preparedness - communities are categorized into 1 to 10 CRS classes. A Class 1 rating provides the largest flood insurance premium reduction, while a community with a Class 10 rating receives no insurance premium reduction.

Although communities are not required to participate in CRS to receive approval of a hazard mitigation plan, FEMA encourages jurisdictions to integrate the CRS planning steps in their multi-hazard mitigation plans. Tewksbury is the only CRS community in the Northern Middlesex region, however their designation was rescinded in 2009.

Bridges

Bridges in Massachusetts are rated in accordance with standards set by the American Association of State Highway and Transportation Officials (AASHTO). AASHTO standards rate bridges on a scale of 1 to 100, with one being the least compliant with the ideal and 100 being the most compliant. Bridges with an AASHTO rating lower than 50 are considered in need of improvement and are placed on a state bridge repair list. In some cases, a bridge may have an AASHTO rating greater than 50 but is considered deficient due to a specific key structural problem with a particular component. A bridge may also be considered functionally obsolete, meaning that the roadway carried by the bridge does not meet current design standards for things such as roadway width. For the purpose of flood related hazards, the designation of structurally deficient is the most critical. Bridges in the region which are classified as structurally deficient and located over water are listed by community in Table 17 on the below.

Table 17: Structurally Deficient Bridges Over Water

Community	Roadway	Water Body	Owner	Year Built/ Rebuilt	Status	AASHTO Rating
Lowell	Bridge St.	Eastern Canal	MassDOT	1937	Preliminary design	49.2
Lowell	Lawrence St.	Concord River	City of Lowell	1850/1951	No activity	51.1
Lowell	VFW Parkway	Beaver Brook	MassDOT	1949	Under Design	19.0
Lowell	Market St.	Western Canal	City of Lowell	1920	Preliminary design	31.2
Lowell	Beaver St.	Beaver Brook	City of Lowell	1971	Local responsibility	53.1
Tewksbury	Mill St.	Shawsheen River	Town of Tewksbury	1998	Local responsibility	59.9
Westford	Bridge Street	Stony Brook	Town of Westford	1870	Local responsibility	48.1
Westford	Beaver Brook Rd.	Beaver Brook	Town of Westford	1957	Local responsibility	38.1

Source: MassDOT

Dams

A *dam* is an artificial barrier that has the ability to impound water, wastewater, or any liquid for the purpose of storage or control. Dam failure can be defined as a catastrophic failure characterized by the sudden, rapid, and uncontrolled release of impounded water. Dams can fail for several reasons:

- Overtopping caused by floods that exceed the capacity of the dam;
- Deliberate acts of sabotage;
- Structural failure of materials used in dam construction;

- Movement and/or failure of the foundation supporting the dam;
- Settlement and cracking of concrete or embankment dams;
- Piping and internal erosion of soil in embankment dams; or
- Inadequate maintenance and upkeep.

Dam failures potentially represent the worst of flood events. When a dam fails, huge volumes of water are often released, causing widespread destruction and potential loss of life. Floods due to dam failures have occurred in New England in the past. On May 16, 1874, in Williamsburg, Massachusetts, a landslide destroyed a 43-foot dam on Mill Creek, a tributary of the Connecticut River, resulting in the deaths of 144 people.

Pawtucket Dam on the Merrimack River in Lowell

Dams are classified by the Massachusetts Department of Conservation and Recreation, Office of Dam Safety, according to their "hazard potential". Dams are classified as *High Hazard* (Class I), *Significant Hazard* (Class II), and *Low Hazard* (Class III). Each level of classification has an associated hazard potential. Class I dams are located in areas where "failure or mis-operation will likely cause loss of life and serious damage to home(s), industrial or commercial facilities, important public utilities, main highway(s) or railroad(s)". Class II dams are located in areas "where failure or misoperation may cause loss of life and damage home(s), industrial or commercial facilities, secondary highway(s) or railroad(s) or cause interruption of use or service of relatively important facilities". Class III dams are located in areas "where failure or misoperation may cause minimal property damage to others". Loss of life is not expected from the failure of Low Hazard dams. See Appendix B for a complete description of Massachusetts' Dam Hazard Classification system.

It is important to note that a dam's hazard classification is not an assessment of its potential for failure. For example, a Class I – High Hazard Dam does not have a higher potential for failure than a Class III – Low Hazard Dam. The hazard classification identifies the potential damage that would be caused if failure did occur. However, because of the greater risk posed by higher hazard dams, the state requires more frequent inspections of such dams. The higher the hazard classification the more frequently dam inspections must be performed. There are four high hazard dams located in the region, as shown in Table 18 below. Only the dams in Tewksbury have been inspected within the past two years, as required by state regulation. The Turner Dam on the Nissitissit River in Pepperell has not been inspected since 1998.

The current dam regulations, dated June 29, 2009, were promulgated in accordance with 2002 revisions to the Dam Safety Statute (MGL Chapter 253, Sections 44-50) and identify the responsibilities of dam owners to register, inspect, develop emergency action plans for high hazard dams, and maintain dams in good operating condition. Amendments to Dam Safety Regulations (302 CMR 10.00-10.16) became effective November 4, 2005 with minor revisions in 2009, and are reflective of the 2002 statutory changes.

In accordance with MGL Chapter 235, Section 45, and 302 CMR 10.05, dam owners must add their dam(s) to the public record by completing a Dam Registration form provided by the Office of Dam Safety, which in turn issues a Dam Registration Certificate to a dam owner. The dam owner must record the certificate at the applicable Registry of Deeds as an attachment to the record deed and provide the Office with a copy of the recorded certificate. When land ownership is transferred, a revised form must be submitted to the Office to initiate an updated registration certificate. Owners of dams are required by 302 CMR 10.07 to hire a qualified engineer to inspect high hazard dams every two years. Significant dams must be inspected every five years, while low hazard dams must be inspected every ten years.

Table 18: High Hazard (Class I) Dams in the Northern Middlesex Region

Community	Dam Name	Impoundment Name	Downstream Population**	Last Inspection Date	Next Inspection Due
Lowell	Lowell Reservoir Dam	Lowell Reservoir	400	8/25/2009	8/25/2011*
Pepperell	Turner Dam	Nissitissit River	0	6/24/1998	6/24/2000*
Tewksbury	Ames Pond Dike A	Ames Pond	5,000	10/7/2010	10/7/2012
Tewksbury	Ames Pond Dam	Ames Pond	5,000	10/7/2010	10/7/2012

*Dam inspection overdue.
**Downstream population estimates are from the 2005 CEMP on file with MEMA

2. Wind-Related Hazards

As wind speed increases, the pressure against an object increases at a disproportionate rate. For example, a 25-mile per hour wind causes about 1.6 pounds of pressure per square inch. When the wind speed increases to 75 miles per hour, the force on that object increases to 450 pounds per square inch. At a wind speed of 125 miles per hour, the force increases to 1,250 pounds per square inch. High winds can cause considerable damage to structures, infrastructure and trees. Winds sustained at 31 to 39 mph for at least one hour, or any gusts of 46 to 57 mph, cause the National Weather Service to issue a Wind Advisory. While winds 58 mph or higher would lead to the issuance of a High Wind Warning. Local communities in the Northern Middlesex region do not monitor or record wind speed data, and no other local source for this information has been identified. There are no airports or National Weather Service stations located within the region.

Effects from high winds can include downed trees and/or power lines and damage to roofs, windows, etc. High winds can cause scattered power outages, and are also a hazard for the boating, shipping, and aviation industry sectors. The region is susceptible to high wind from several types of weather events: before and after frontal systems, hurricanes and tropical storms, severe thunderstorms, and Nor'easters. The State Building Code has incorporated engineering standards for wind loads. Calculating wind load is important in the design of the wind force-resisting systems (including structural members, components, and cladding) to ensure against shear, sliding, overturning, and uplift actions.

Two major wind-related hazards that occur in the region include hurricanes and tornadoes. (Nor'easters are discussed under winter-related hazards). The entire region is at equal risk for wind-related hazards. Though these are not frequent events on an annual or seasonal basis, the chance of occurrence and the extent of damage associated with each are of concern to disaster mitigation planners. Unlike flooding, where historical river flow records allow the potential extent of flooding to be delineated with some accuracy within each community, delineating the exact area where a hurricane or tornado will strike is not possible. A brief description of hurricanes and tornadoes, along with the general risks associated with each follows.

Hurricanes

A hurricane is a type of tropical cyclone; an organized rotating weather system that develops in the tropics. Tropical cyclones are classified as follows:

Tropical depression: An organized system of persistent clouds and thunderstorms with a low-level circulation and maximum sustained winds of 39 mph or less.

Tropical storm: An organized system of strong thunderstorms with a well-defined circulation and maximum sustained winds of 39-73 mph.

Hurricane: An intense tropical weather system with a well-defined circulation and maximum sustained winds of 74 mph or higher.

The typical hurricane moves at an average speed of approximately twelve (12) miles per hour. While in the lower latitudes, hurricanes tend to move from east to west. However, when a storm drifts further north, the westerly flow at the mid-latitudes tends to cause the storm to curve toward the north and east. When this occurs, the storm may accelerate its forward speed. This explains why some of the strongest hurricanes have reached New England.

Tropical depressions and tropical storms, while generally less dangerous than hurricanes, can be deadly. The winds of tropical depressions and tropical storms are usually not the greatest threat. Heavy rains, flooding and severe weather associated with tropical storms and depressions can cause significant problems in the region. Serious power outages can be associated with hurricanes and other tropical storms. After Hurricane Gloria in 1985, some area residents were without power for five days. When the remnants of Hurricane Irene passed through the region as a tropical storm in late August 2011, much of the region was without power for 3 to 5 days.

Hurricanes can occur along the East Coast of the United States anytime in the period between June and November. However, from 1900-2013, there are no records of a land falling hurricane in New England during the months of June or July. August, September, and the first half of October have the most frequent hurricane occurrences for New England. This is due to the fact that it takes a while for the waters south of Long Island to warm up enough to sustain storms this far north. In addition, as Fall approaches, the upper level jet stream contains more dips, which means that the steering winds may flow from the Great Lakes southward to the Gulf states and then back northward up the eastern seaboard. This pattern is conducive for capturing a tropical system over the Bahamas and accelerating it northward.

Hurricane intensity and the potential property damage posed by a hurricane are rated from 1 to 5, according the Saffir-Simpson Hurricane Scale. Hurricanes reaching Category 3 and higher are considered major hurricanes, given the potential for loss of life and property damage. The wind intensity and potential damage for each category is summarized as follows:[5]

Category 1 – Winds 74 to 95 miles per hour (mph). Damage potential to unanchored mobile homes, trees, shrubbery, and poorly constructed signs.

Category 2 – Winds 96 to 110 mph. Damage to roofing material, doors, and windows. Considerable damage to mobile homes and poorly constructed signs. Significant damage to trees and shrubs, with some trees blown down.

Category 3 – Winds 111 to 130 mph. Small residences and buildings may experience some structural damage. Minor curtain wall failure is possible. Destruction of mobile homes and poorly constructed signs. Foliage is blown off trees and trees may be blown down.

Category 4 – Winds 131 to 155 mph. Small residences may experience complete roof structure failures. Mobile homes completely destroyed. All signs, trees, and shrubs blown down. Doors and windows extensively damaged.

Category 5 – Winds greater than 155 mph. Many residences and industrial buildings

[5] References to coastal surges are not included as there is no coast line within the Northern Middlesex region.

experience complete roof failure. Complete building failures possible. Small utility buildings are blown over or away. All signs, trees, and shrubs blown down. Mobile homes completely destroyed. Windows and doors severely and extensively damaged.

Hurricane force winds can destroy buildings and mobile homes. According to NOAA, the strongest sustained 1-minute wind speed and wind gust ever recorded in Massachusetts from a hurricane was at the Blue Hill Observatory in Milton, MA, during the Great New England Hurricane in 1938. A sustained wind of 121 mph with a peak gust to 186 mph was recorded. In hurricane conditions, debris such as signs, roofing materials, siding and lawn furniture can become missiles. Hurricanes can also spawn tornadoes that generally occur in thunderstorms embedded in rain bands well away from the center of the hurricane. Tornadoes can also occur near the eye wall.

A hurricane watch is issued when a hurricane or hurricane conditions pose a threat to an area within the next thirty-six (36) hours. A hurricane warning is issued when hurricane winds of 74 mph or higher are expected in the next twenty-four (24) hours. If a hurricane's path is erratic or unusual, the warning may be issued only a few hours before the beginning of hurricane conditions.

While there have been relatively few direct hits from hurricanes in New England, peripheral effects from offshore hurricanes and tropical storms that track inland are not uncommon. In the period of time since records have been kept for hurricanes, Massachusetts has experienced forty-seven (47) wind-related occurrences associated with hurricanes. Of those, seven have had a direct impact and forty (40) have had an indirect impact. Each community in the Northern Middlesex region is at equal risk of being impacted by a hurricane. Table 19 on the following page provides a summary of hurricanes that have affected New England since 1938.

The most recent hurricane to significantly affect the region was Hurricane Irene in August 28, 2011, which became a tropical storm as it passed over the region. The Commonwealth of Massachusetts and federal government issued a Pre-Landfall Emergency Declaration on August 26, 2011 and local states of emergency were declared on August 27, 2011. The local emergency managers were in constant communication with National Grid, MEMA and FEMA. Local DPW crews supported power restoration efforts and the LEPCs participated in MEMA's daily conference calls from August 26th through September 1st. In the Northern Middlesex region, local communities communicated with residents through reverse 911 phone calls, emails and web postings.

Table 19: New England Hurricanes and Tropical Cyclones (1938-2012)

DATE	STORM/ EVENT	DESCRIPTION	FATALITIES	INJURIES	PROPERTY DAMAGE
09/21/1938	New England Hurricane	Highest sustained winds-121 mph, Forward motion in excess of 50 mph. 17 inches of rain; extensive flooding.	564	1700+	9,000 homes and businesses destroyed, 15,000 damaged.
09/15/1944	Great Atlantic Hurricane	Forward motion in excess of 40 mph.	390	NA	$925 million
09/12/1950	Hurricane Dog	Center passed offshore Cape Cod. 4.42 inches of rain in 24 hours.	0	0	$2 million
09/07/1953	Hurricane Carol	Moved through the Bay of Fundy with only minor damage.	0	0	
08/31/1954	Hurricane Carol	First of three devastating hurricanes of 1954. Forward motion in excess of 50 mph. Category 3. Extensive flooding and damage.	60	NA	$438 million
09/11/1954	Hurricane Edna	Over 7 inches of rainfall. Extensive flooding.	29	NA	$40.5 million
10/15/1954	Hurricane Hazel	Forward motion over 50 mph.	600	NA	$350 million
08/00/1955	Hurricane Connie	Extensive flooding with 4-6 inches of rainfall	43	NA	$40 million
08/18/1955	Tropical Storm Diane	20 inches of rainfall caused devastating floods	184	NA	$832 million
08/29/1958	Hurricane Daisy	New England felt only periphery gales.	0	0	NA
09/12/1960	Hurricane Donna	Category 2. Forward motion of 39 mph.	133	NA	$387 million
09/21-25/1961	Hurricane Esther	Did unusual loop-de-loop southeast of Cape Cod. 7-8 inches of rainfall. Forward motion slowed approaching New England.	0	NA	NA
10/10/1961	Hurricane Frances	Category 3 storm, 110 mph winds. Some wind damage in New England	NA	NA	NA
08/29/1962	Hurricane Alma	Minor damage only.	NA	NA	NA
10/06-07/1962	Hurricane Daisy	14.25 inches of rainfall over 48 hours in Wakefield, MA. Significant flooding occurred throughout New England. Set record for 24-hour precipitation which remained unbroken until Hurricane Bob in 1991.	24	NA	NA

Table 19 (cont'd): New England Hurricanes and Tropical Cyclones (1938-2012)

DATE	STORM/ EVENT	DESCRIPTION	FATALITIES	INJURIES	PROPERTY DAMAGE
10/29/1963	Hurricane Ginny	Famous snow hurricane in Maine with up 18 inches falling in the Maine mountains.	0	0	$300,000
09/14/1964	Hurricane Dora	Moderate rainfall.	3	NA	$200 million
09/24/1964	Hurricane Gladys	Moderate to heavy precipitation.	2	NA	$6.7 million
06/13/1966	Hurricane Alma	Minor damage.	5	NA	$1.5 million
09/09/1969	Hurricane Gerda	Center passes directly over Nantucket with gusts to 140 mph.	NA	NA	NA
08/28/1971	Tropical Storm Doria	Wind gusts to 80 mph. Heavy rains, flooding.	3	NA	NA
09/14/1971	Tropical Storm Heidi	Moderate rainfall, little damage.	0	0	NA
09/03-04/1972	Tropical Storm Carrie	Hurricane force wind gusts. Heavy rainfall	1	NA	$1.2 million
07/27/1975	Hurricane Blanche	Most heavy weather remained offshore	0	NA	NA
08/09-10/1976	Hurricane Belle	Category 1. Forward motion 32 mph. Heavy rainfall causes some flooding.	3	3	NA
09/06/1979	Tropical Storm David	Minor effects	1,100 (Virgin Islands)	NA	$60 million
09/25/1985	Tropical Storm Henri	Minor effects	0	0	NA
09/27/1985	Hurricane Gloria	Category 2. Forward motion of 72 mph. Gusts to 80 mph.	NA	3	$ 1 billion
08/07/1988	Tropical Storm Alberto	Winds of 50 mph.	31	NA	$500 million
08/19/1991	Hurricane Bob	Category 2. Forward motion of 51 mph. Wind speeds of up to 60 mph. Set new 24- hour precipitation record. Major flooding and power outages	18	NA	$1.5 billion
10/30-11/01/1991	Unnamed "Halloween" storm	Huge storm surge caused extensive damage along the coast	12	NA	$210 million
07/13/1996	Hurricane Bertha	Forward motion of 48 mph. Very heavy rainfall and strong gusty winds. Spawned one tornado in Massachusetts	12	NA	$275 million
09/02/1996	Hurricane Edouard	Left 40,000 residents without power, 3 inches of rain fell	0	0	$3.5 million

Table 19 (cont'd): New England Hurricanes and Tropical Cyclones (1938-2012)

DATE	STORM/ EVENT	DESCRIPTION	FATALITIES	INJURIES	PROPERTY DAMAGE
07/25/1997	Tropical Storm Danny	Dropped 3-5 inches of rain	0	0	
09/16-17/1999	Tropical Storm Floyd	Forward motion of 56 mph. No significant damage in Massachusetts.	0	0	$4.5 billion
09/03/10	Hurricane Earl	Tropical Storm passed 98 miles east of New England with winds of 40+ mph producing high surf, heavy rain and coastal flooding	1	0	NA
08/28/11	Hurricane Irene	Hurricane Irene, became a tropical storm as it moved inland over New York, Connecticut, Massachusetts, New Hampshire and Maine	42	NA	7-10 Billion (est.)
10/30/12	Hurricane Sandy	Major impacts caused by flooding of roads and bridges in Massachusetts; widespread power outages	160	NA	$50 billion

Source: National Climatic Data Center, NOAA, U.S. Dept. of Commerce

Since there are no coastal areas within the region, the risk of storm surge associated with a hurricane is not a factor. However, inland flooding resulting from intense rain is a serious threat and is often responsible for more deaths than wind. In the past 30 years, inland flooding has been responsible for more than half the deaths associated with tropical cyclones in the United States. There is no direct correlation between wind speed and rain intensity. Less intense hurricanes can deliver the highest amount of rainfall, especially if a storm stalls over an area.

Though heavy rains associated with hurricanes probably present the highest recurrent risk in the Northern Middlesex region, high winds are also a risk. Blowing objects carried by the wind pose a threat to people stranded outside in a hurricane. Hurricanes can also spin off small, localized tornadoes outside the center of the storm. Though typically weaker than other tornadoes, those associated with hurricanes still pose an additional threat outside the primary track of the hurricane. Downed trees and tree limbs, blocked roads, and downed telephone and power lines can disrupt transportation routes and communication channels.

Since 1954, there have been five hurricane-related Presidential Disaster Declarations affecting the region, as shown in Table 20 below.

Table 20: Hurricane-related Presidential Disaster Declarations (1954-2012)

Disaster Number	Date	Storm/incident
4028	09/03/2011	Tropical Storm Irene
914	08/26/1991	Hurricane Bob
751	10/28/1985	Hurricane Gloria
43	8/20/1855	Unnamed hurricane
22	09/02/1954	Unnamed hurricane

Source: FEMA

The National Oceanic and Atmospheric Administration (NOAA) Coastal Services Center provides a searchable database that allows one to query hurricane records dating back to as early as 1851. Query results show historical storm tracks by storm intensity within a specified radius of a site. Query results for this region for hurricanes of Category 1 or above, passing within a 75-mile radius, show eight Category 1-5 hurricanes, as depicted in Figure 4 on the following page. These include six unnamed storms for the years 1858, 1869, 1874, 1893, 1916, and 1944, as well as Hurricane Donna (1960) and Hurricane Bob (1991). The figure that follows shows the tracks of these storms. [1] As noted above, however, a hurricane's wind intensity alone does not speak to the threat posed by intense rains that can cause serious inland flooding. Less intense hurricanes or tropical storms, can carry higher rainfall amounts independent of wind speed. Map 2 on page 42 shows Category 1-5 hurricanes whose centers have passed within ten (10) nautical miles of the Massachusetts state boundary from 1851 to 2010.

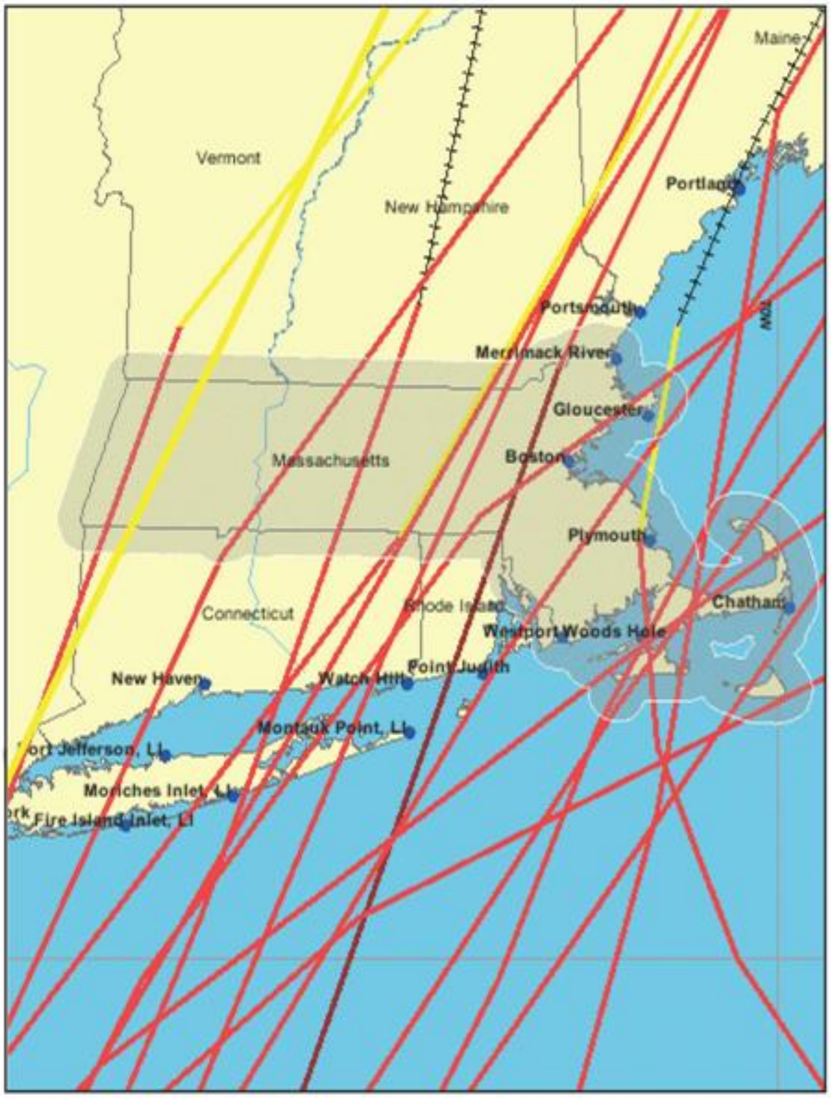
Map 1: Typical Historical Cyclone Tracks over Massachusetts
Source: NOAA

The Comprehensive Emergency Management Plans prepared for the nine communities in the Northern Middlesex region indicate that an estimated 108,700 people may be affected by a possible hurricane. Potentially, 9,732 people may lack access to transportation. The regional population potentially affected by a hurricane, as identified in the CEMPs on file with MEMA, is outlined by community in Table 21 below.

Table 21: Estimated Population Impacted by a Possible Hurricane in the Northern Middlesex Region

Community	Maximum Population Affected	Maximum Number of People Without Transportation
Billerica	38,981	3,696
Chelmsford	20,000	2,000
Dracut	3,000	3 00
Dunstable	400	40
Lowell	15,000	3,000
Pepperell	80	10
Tewksbury	28,644	314
Tyngsborough	2,100	120
Westford	500	50
Total	**108,705**	**9,732**

Source: Comprehensive Emergency Management Plans for the NMCOG communities



Source: NOAA

MAP 2: CATEGORY 1-5 HURRICANES (1851-2010)

Legend:

- Category 3-5 storm track
- Category 1-2 storm track
- Tropical storm track
- Tropical depression track
- Subtropical storm track
- Extratropical storm track
- Tropical low track
- Tropical wave track
- Tropical disturbance track

Tornadoes

According to the American Meteorological Society's Glossary of Meteorology, a tornado is "a violently rotating column of air, pendant from a cumuliform cloud or underneath a cumuliform cloud, and often (but not always) visible as a funnel cloud". The most deadly and destructive tornado forms from a super cell, which is a rotating thunderstorm with a well-defined circulation called a mesocyclone.

Tornadoes can appear from any direction, but most move from southwest to northeast, or west to east. Tornadoes can last from several seconds to more than an hour. Most last less than ten minutes, and over 80% of strikes occur between noon and midnight. "Tornado season" is generally from March through August, although a tornado may occur any time of the year. Some ingredients for tornado formation include:

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

The most devastating tornado to occur in New England was the Worcester tornado of July 9, 1953, which killed ninety-six people and injured over thirteen hundred. The most recent tornado to strike New England occurred on June 1, 2011, pummeling sections of Springfield and West Springfield. This event included seven confirmed tornadoes, the worst of which was a category F3. The storm killed three, injured hundreds and left over 48,000 people without electricity. As a result, President Obama declared Springfield and the surrounding region a Federal Disaster Area. Governor Patrick also activated National Guard troops to assist with rescue and recovery efforts.

On average, six tornadoes per year touch down somewhere in New England. Those at risk include people in automobiles, anyone not in a secure structure, and those residing in mobile homes. Since 1951, there have been 156 tornadoes in Massachusetts, which resulted in 105 fatalities and 1,559 injuries.

Within the Northern Middlesex region, there have been eight tornadoes since 1955. As shown in Table 22 below, the most recent tornado impacting the region occurred in September 1974 and was classified as an F3. The oldest record of a tornado in the region is from July 24, 1857, when a powerful tornado swept through Tewksbury, MA. The town was sparsely populated at the time, and there were no injuries or fatalities. The tornado tore up fields and orchards, and destroyed barns and sheds, as it headed south to Wilmington. In July 1890, a tornado touched down for three minutes in North Billerica, destroying the roofs on some buildings and damaging trees. On July 21, 1972 an F2 tornado sliced a 7.6 mile long, 35-yard path from Tyngsborough, along the Merrimack River, into North Chelmsford and over Robin Hill into South Chelmsford. There have been no tornadoes reported in the region since 1974. Each community in the Northern Middlesex region is at equal risk of being impacted by a tornado.

Table 22: Tornadoes in the Northern Middlesex Region

Date	Category	Injuries/fatalities
10/24/55	F1	0
8/21/57	F2	1 injury
7/11/58	F2	0
7/18/63	F1	0
10/3/70	F3	1fatality
7/1/71	F1	1 injury
7/21/72	F2	4 injuries
9/29/74	F3	1injury

Source: www.tornadohistoryproject.com

As outlined in the Commonwealth's 2010 Hazard Mitigation Plan, the Reported Tornado Occurrence map shows tornado risk based on the historic past occurrence of tornadoes. The density per 25 square miles indicated the probable number of tornado touchdowns for each square mile cell within the contoured zone that can be expected over a similar timeframe (fifty years). The analysis shows that the area of the state at greatest risk runs from central to northeastern Massachusetts and includes the Northern Middlesex region.

The National Weather Service (NWS) issues tornado forecasts through each local NWS office. In predicting severe weather, meteorologists look for the development of instability, lift and wind shear for tornadic thunderstorms. Real-time weather observations from satellites, weather stations, weather balloons, and radar become highly important as a storm approaches. A tornado watch defines an area where tornadoes and other types of severe weather are possible in the next several hours. A tornado warning means that a tornado has been spotted, or that Doppler radar indicates a thunderstorm with circulation that can spawn a tornado.

Tornado damage severity is measured by the Fujita Tornado Scale, in which wind speed is not measured directly but rather estimated from the amount of damage. As of February 01, 2007, the National Weather Service began rating tornados using the Enhanced Fujita-scale (EF-scale). It is considerably more complicated than the original F-scale, and it allows surveyors to create more precise assessments of tornado severity. Tables 23 and 24 illustrate the EF-scale and the damage indicators. It uses three-second gusts estimated at the point of damage as judged by eight levels of damage to the 28 indicators listed in Table 24. These estimates vary with height and exposure.

Table 23: The Enhanced F-Scale

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

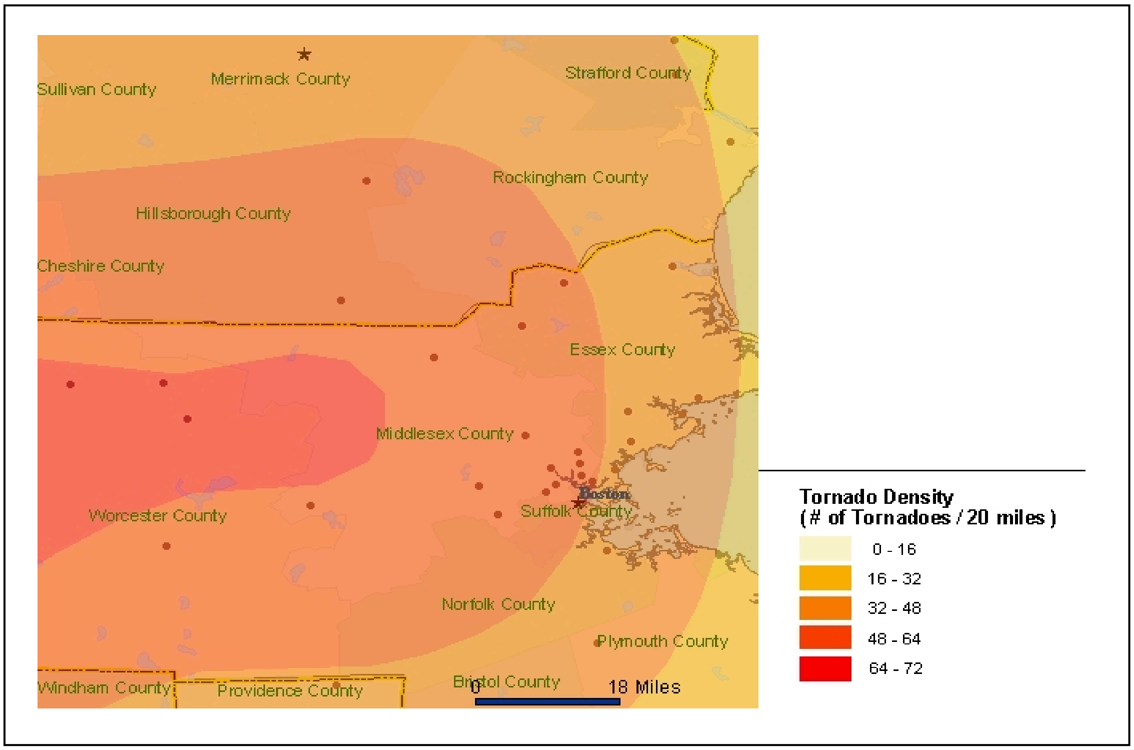
Source: www.noaa.gov

Table 24: Enhanced F-Scale Damage Indicators

Number	Damage Indicator	Abbreviation
1	Small barns, frames outbuildings	SBO
2	One or two-family residences	FR12
3	Single-wide mobile home	MHSW
4	Double-wide mobile home	MHDW
5	Apt, Condo, townhouse (3 stories or less)	ACT
6	Motel	M
7	Masonry Apt. or motel	MAM
8	Small retail building (fast food)	SRB
9	Small professional (Doctor office, Bank)	SPB
10	Strip Mall	SM
11	Large shopping mall	LSM
12	Large, isolated (big box) retail building	LIRB
13	Automobile showroom	ARS
14	Automobile service building	ASB
15	School – 1-story elementary (interior or exterior halls)	ES
16	School – jr. or sr. high school	JHSH
17	Low-rise (1-4 story) building	LRB
18	Mid-rise (5-20) building	MRB
19	High-rise (over 20 stories	HRB
20	Institutional bldg. (hospital, govt. or university)	IB
21	Metal building system	MBS
22	Service station canopy	SSC
23	Warehouse (tilt-up walls or heavy timber)	WHB
24	Transmission line tower	TLT
25	Free-standing tower	FST
26	Free standing pole (light, flag, luminary)	FSP
27	Tree - hardwood	TH
28	Tree - softwood	TS

Source: www.noaa.gov

The Disaster Center evaluated tornado statistics from 1950-1995 by state. When compared with other states across the country, Massachusetts ranked 35th in frequency, 16th in the number of tornado-related deaths, 21st in the number of injuries, and 12th for the cost of tornado-related damages. In terms of tornado frequency per square mile, Massachusetts ranked 14th in overall frequency, and first in terms of fatalities, injuries, and cost per area. Map 3 on the following page shows tornado density for Middlesex County.



Map 3: Tornado Density for Middlesex County
Source: NOAA

Severe Thunderstorms

The National Weather Service considers a thunderstorm to be severe if it produces hail at least ¾ inch in diameter, has winds of 58 mph or higher, or has the potential to produce a tornado. Lightning accompanies all thunderstorms and can cause death, injury and property damage. Straight-line winds can exceed 100 mph and are responsible for most thunderstorm wind damage. A downburst, a small area of rapidly descending air beneath a thunderstorm, can reach speeds equal to that of a strong tornado.

Three basic ingredients are required for a thunderstorm to form: moisture, rising unstable air (air that keeps rising when given a nudge), and a lifting mechanism to provide the impetus. The sun heats the surface of the earth, which warms the air above it. When this warm surface air begins to rise, such as in areas with hills or mountains, or areas where warm/cold or wet/dry air bump together, it will continue to rise as long as it weighs less and stays warmer than the air around it. As the air rises, it transfers heat from the surface of the earth to the upper levels of the atmosphere (a process known as convection). The water vapor in the air begins to cool, releases heat and condenses into a cloud. The cloud eventually expands upward into areas where the temperature is below freezing. Some of the water vapor turns to ice, and some of it turns into water droplets. Both ice particles and water droplets have electrical charges. Ice particles usually have positive charges, and rain droplets usually have negative charges. When the charges build up they are eventually discharged in a bolt of lightning, which causes the sound waves we hear as thunder.

An average thunderstorm is 15 miles in diameter and lasts an average of 30 minutes. *Severe* thunderstorms can be much larger and last much longer. Southern New England typically experiences about 10-15 days per year in which there are *severe* thunderstorms. It is not unusual for the region to experience a few severe thunderstorms over the course of the spring and summer. The greatest hazard caused by this type of storm is flash flooding. In addition, hail can cause substantial damage to property and crops. Large hailstones can fall faster than 100 mph, and can be very costly in terms of economic losses.

A thunderstorm over Westford

Every thunderstorm has an updraft (rising air) and a downdraft (sinking air, usually with the rain). However, sometimes, there are extremely strong downdrafts, known as downbursts, which can cause tremendous straight-line wind damage at the ground, similar to that of a tornado. A small (< 2.5 mile path) downburst is known as a "microburst" and a larger downburst is called a "macroburst." An organized, fast-moving line of embedded microburst that travels across large portions of a state is known as a "derecho" and this can occasionally occur in Massachusetts. The strongest downburst ever recorded was 175 mph, near Morehead City, North Carolina. Winds exceeding 100 mph have been measured in Massachusetts from downbursts.

One hazard specifically associated with thunderstorms is lightning. Fatalities, although rare, can occur from lightning. In the United States, 99 percent of fatalities have occurred outside of a large substantial building or fully-enclosed metal-topped vehicle. For all of the United States, approximately 34 people were killed by lightning per year from 2003 to 2012 or 349 total fatalities, and Massachusetts accounted for just four of those incidents.

There have been several damaging thunderstorms in Massachusetts. In June of 1998, a very slow moving and complex storm system moved through southeast New England. The combination of its slow movement and presence of tropical moisture across the region produced rainfall of 6 to 12 inches over much of eastern Massachusetts. This led to widespread urban, small stream, and river flooding. As a result, the counties of Suffolk, Essex, Middlesex, Norfolk and Bristol received a Presidential Disaster Declaration for the Individual Household Program (Individual Assistance) on June 23, 1998. Each community in the Northern Middlesex region is at equal risk of being impacted by a severe thunderstorm and it is not possible to predict where damage from such a storm might occur.

On May 22, 2006 a severe thunderstorm toppled trees in Tyngsborough, Chelmsford and Lowell and left 5,000 residents without power. Wind gusts reached 45 mph.

3. Winter-Related Hazards

Severe winter storms can produce a wide variety of hazardous weather conditions, including heavy snow, freezing rain, sleet, and extreme wind and cold. A severe winter storm is one that results in four or more inches of snow over a twelve-hour period, or six or more inches over a twenty four-hour period. The leading cause of death during winter storms is from an automobile or other transportation accidents. Exhaustion or heart attacks caused by overexertion are the second most likely cause of winter storm-related deaths.

The National Weather Service issues outlooks, watches, warnings and advisories for all winter weather hazards. These statements are defined as follows:

Outlook: Winter storm conditions are possible in the next 2-5 days
Watch: Winter storm conditions are possible in the next 36-48 hours
Warning: Life-threatening severe winter conditions have begun or will begin
Advisory: Winter weather conditions are expected to cause significant inconveniences and may be hazardous.

The most severe winter storm to ever strike New England was the Blizzard of 1888. The storm that occurred from March 11-14, 1888, deposited up to 50 inches of snow. The Blizzard of 1978 dumped 24-36 inches of snow on the eastern part of the state and paralyzed the area for several days. The winter of 2010-2011 produced some of the largest snowfall totals in the region's and state's history, and included two blizzards, both occurring in January 2011. According to the National Weather Service, Boston received 80.1 inches of snow that winter, while the Northern Middlesex region received 79.6 inches.

Since 1983, the most significant winter snowfall in the region occurred during the winter of 1995, when snowfall measurements in the City of Lowell reached 126.5 inches. Most recently, the October 2011 snowstorm left 640,000 Massachusetts homes and residents without power, according to MEMA. Table 25 on the following page outlines the number of power outages by community as a result of the early season snow storm, which left 79,296 customers, or 67% of the region, in the dark.

Table 25: Power Outages in the Region During the October 2011 Snowstorm (10/30/11)

Community	Customers without power	% of Customers without power
Billerica	13,444 out of 16,112	83.44
Chelmsford	13,898 out of 15,372	90.41
Dracut	12,096 out of 12,672	95.45
Dunstable	1,176 out of 1,220	96.39
Lowell	13,441 out of 41,526	32.37
Pepperell	3,470 out of 4,824	71.93
Tewksbury	8,954 out of 12,442	71.97
Tyngsborough	4,935 out of 4,966	99.37
Westford	7,882 out of 9,010	87.48
Region	**79,296 out of 118,144**	**67.12**

Source: National Grid

Table 26 below details the annual snowfall totals for the City of Lowell, from 1983-2011. This data was compiled by the University of Massachusetts Lowell, Department of Environmental and Atmospheric Sciences.

Table 26: Annual Snowfall Totals for Lowell, MA – 1983-2011

Winter season starting	Annual Snowfall Total (inches)
1983	28.9
1984	18.4
1985	41.2
1986	40.6
1987	49.6
1988	8.2
1989	55.5
1990	25.9
1991	21.0
1992	90.3
1993	81.1
1994	23.3
1995	126.5
1996	55.5
1997	46.6
1998	38.2
1999	32.5
2000	85.3
2001	32.7
2002	84.9
2003	41.2
2004	94.6
2005	55.7
2006	38.1
2007	79.1
2008	80.6
2009	46.0
2010	87.1
2011	23.9
2012	92.1
Average	**63.1**

*Source: University of Massachusetts Lowell, Department of Environmental and Atmospheric Sciences; based on snowfall measurements taken every 24 hours.

Since 2005, there have been several disaster declarations related to winter weather, as well as specific "snow emergency" declarations. Each community in the Northern Middlesex region is at equal risk of being impacted by a severe winter storm. As an example, the *Lowell Sun* published the following snowfall totals for the February 9, 2013 snowstorm. Every community in the region received significant snow ranging from 19 inches in Chelmsford to 28 inches in Tyngsborough. Temperature, wind direction, and banding of precipitation impact where the highest snowfall totals occur, but these factors are unpredictable, as shown in the case of the snowfall from the February 9, 2013 storm where each community received the following:

- Billerica-23.8 inches
- Chelmsford-19 inches
- Dracut-24.9 inches
- Dunstable-25 inches
- Lowell-20 inches
- Tewksbury-27 inches
- Tyngsborough-28 inches
- Westford-24 inches

A summary of the winter weather related disaster declarations for Middlesex County is provided in Table 27 below.

Table 27: Winter Weather-Related Federal Disaster and Emergency Declarations for Middlesex County 2005-2013

Disaster Name (Date of Event)	Disaster Number (Type of Assistance)	Declared Areas
Severe Winter Storm, Snowstorm and Flooding February 8-9, 2013	FEMA DR 4110	All 14 counties
Severe Storm and Snow storm (October 29-30, 2011)	FEMA DR 4051	Counties of Berkshire, Franklin, Hampden, Hampshire, Middlesex, and Worcester.
Severe Storm (Jan. 11-12, 2011)	FEMA DR 1959 (Public)	Counties of Berkshire, Essex, Hampshire Hampden, Hampshire, Middlesex, Norfolk and Worcester
Severe Winter Storm and Flooding (December 11 – December 18, 2009)	FEMA-1813 (Public and individual)	Counties of Berkshire, Essex, Franklin, Hampden, Hampshire, Middlesex, and Worcester
Severe Winter Storm (Dec. 11, 2008 – Dec. 18, 2008)	FEMA 3296 (Public)	Counties of Berkshire, Essex, Franklin, Hampden, Hampshire, Middlesex, Bristol, Suffolk and Worcester
Severe Winter Storm (January 22, 2005 – January 23, 2005)	FEMA 3201 (Public)	All 14 Counties

Source: www. fema.gov

Nor'easters

Nor'easters occur in New England more frequently than hurricanes and typically have a longer duration than hurricanes. A nor'easter is a large New England storm formed from a weather system traveling from South to North, passing along or near the seacoast. The nor'easter derives its name from the northeasterly direction of its counterclockwise cyclonic winds. It is not unusual for the sustained winds of a nor'easter to meet or exceed hurricane force. The duration of a nor'easter may outlast a hurricane event by many hours or even days. High winds associated with a nor'easter can last from 12 hours to 3 days, while the duration of a hurricane ranges from 6 to 12 hours.

Nor'easters pose a threat to infrastructure, including critical facilities. During the height of a storm, blizzard conditions present a hazard to driving or any other outdoor activity. A blizzard is defined as a storm with winds in excess of 35 mph, with falling and blowing snow reducing visibility to less than ¼ mile for at least three hours. Heavy snow disrupts transportation and may impede the passage of emergency vehicles. Heavy snow may also bring down power lines and trees, and lead to roof collapses. The Blizzard of 1978 dumped 24-48 inches of snow on eastern Massachusetts, paralyzing the region for several days.

The region experienced a significant nor'easter on March 5-7, 2001, that resulted in a Presidential Disaster Declaration on April 10, 2001. Two feet of snow fell over a three-day period (March 5-7). Wind gusts to 64 miles per hour were reported in some areas. The combination of heavy wet snow and high winds resulted in broken tree limbs that blocked roadways and downed power lines. More than 16,000 people in the Merrimack Valley were left without power on March 6, 2001. The late season snow set the stage for flooding. Two subsequent rainstorms, on March 20-22 and 29-30, 2001 resulted in the flooding of more than 10,000 residences and businesses in northeastern Massachusetts. Most of the damage due to flooding occurred along smaller tributary streams and rivers.

Most recently, the region experienced a significant Nor'easter, known as the Halloween Nor'easter, on October 29-30, 2011. The storm produced a snow fall in excess of 30 inches in some parts of the state, and, due to the amount of foliage still on the trees, resulted in power outages for hundreds of thousands of electrical customers for up to seven days. (The National Weather Service estimated that approximately 3 million electrical customers were without power at the height of the event.) As a result of the storm, a Presidential disaster declaration was approved on November 1, 2011.

The October 2011 snowstorm downed trees and power lines in Chelmsford

Recovery during the aftermath of a snowstorm poses its own challenges. Prolonged curtailment of all forms of transportation can have significant adverse impacts for people stranded at home, preventing the delivery of critical services such home heating fuel supplies or the ability to get to a local food store. The cost of snow removal, repairing damages, and the loss of business can have severe economic impacts on local communities. Each community in the region is at equal risk of being impacted by a Nor'easter, and the impact of such a storm is widespread and consistent across the region.

While the Fujita and Saffir-Simpson Scales characterize tornadoes and hurricanes respectively, there is no widely used scale to classify snowstorms. NOAA's National Climatic Data Center is now producing the Regional Snowfall Index (RSI) for significant snowstorms that impact the eastern two thirds of the U.S. The RSI differs from these other indices because it includes population. RSI is based on the spatial extent of the storm, the amount of snowfall, and the juxtaposition of these elements with population. Including population information ties the index to societal impacts. Currently, the index uses population based on the 2000 Census. The RSI is an evolution of the Northeast Snowfall Impact Scale (NESIS), which NCDC began producing operationally in 2005. While NESIS was developed for storms that had a major impact in the Northeast, it includes the impact of snow on other regions as well. It can be thought of as a quasi-national index that is calibrated to Northeast snowstorms. By contrast, the RSI is a regional index; a separate index is produced for each of the six NCDC climate regions in the eastern two-thirds of the nation. The RSI is important because of the need to place snowstorms and their societal impacts into a historical perspective on a regional scale.

Table 28: Regional Snowfall Index Values

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

http://www.ncdc.noaa.gov/snow-and-ice/rsi/societal-impacts

Table 29 shows the RSI values of winter storms for the Northeast area. Twelve storms were rated as "Crippling" or "Extreme" through the winter of 2013.

Table 29: Regional Snowfall Index and Societal Impacts for the Northeast

Start Date	End Date	Category	RSI	Area of Snow	Population
1969-02-21	1969-02-27	5	26.42	174,690	57,062,630
1993-03-11	1993-03-14	5	20.465	174,690	57,062,622
1996-01-05	1996-01-08	5	20.281	162,082	56,617,484
1950-11-21	1950-11-29	4	11.182	149,147	55,898,440
1969-12-24	1969-12-28	4	10.284	174,690	57,062,568
1978-02-03	1978-02-07	4	15.675	174,690	57,062,560
1966-01-27	1966-01-31	4	10.655	174,680	57,048,708

Table 29 (cont'd): Regional Snowfall Index and Societal Impacts for the Northeast

Start Date	End Date	Category	RSI	Area of Snow	Population
1902-03-02	1902-03-05	4	11.272	140,008	27,993,083
2010-02-20	2010-02-28	4	15.853	174,690	57,062,541
1900-02-25	1900-03-02	4	13.879	143,073	28,985,495
2013-02-07	2013-02-09	4	10.089	174,229	58,816,885
2003-02-13	2003-02-17	4	14.452	162,812	56,921,974
1947-12-24	1947-12-26	3	8.138	174,066	57,055,783
1971-02-25	1971-03-05	3	9.479	174,680	57,059,895
1971-03-02	1971-03-05	3	9.674	174,690	57,062,629
1925-01-27	1925-01-30	3	7.421	173,883	57,053,814
1920-02-03	1920-02-06	3	6.246	174,335	57,058,468
1947-02-26	1947-03-03	3	9.752	174,575	57,061,379
1964-01-08	1964-01-13	3	6.081	171,442	57,027,901
1961-01-31	1961-02-04	3	8.567	152,241	56,690,510
1960-02-28	1960-03-04	3	7.024	174,037	57,055,440
1958-03-17	1958-03-22	3	6.821	174,469	57,060,215
1958-02-11	1958-02-17	3	7.894	174,469	57,060,252
2010-02-03	2010-02-07	3	8.438	90,161	48,490,403
2007-02-10	2007-02-15	3	7.316	174,690	57,062,546
1915-12-09	1915-12-14	3	6.244	173,681	57,046,880
1914-02-11	1914-02-14	3	9.708	173,941	57,053,757
2003-12-03	2003-12-07	3	9.024	174,690	57,062,588
1983-02-09	1983-02-12	3	7.875	141,180	53,610,038
1952-02-16	1952-02-17	2	3.53	166,743	52,742,331
1972-02-15	1972-02-19	2	5.401	174,690	57,062,566
1971-11-22	1971-11-26	2	3.267	170,711	55,967,850
1969-02-07	1969-02-09	2	4.528	173,306	56,875,979

Table 29 (cont'd): Regional Snowfall Index and Societal Impacts for the Northeast

Start Date	End Date	Category	RSI	Area of Snow	Population
1978-01-16	1978-01-20	2	5.555	174,690	57,062,585
1956-03-13	1956-03-16	2	3.323	174,488	57,060,279
1927-02-15	1927-02-20	2	3.401	172,345	57,039,670
1926-02-02	1926-02-04	2	4.539	173,354	56,998,419
1924-03-31	1924-04-03	2	3.02	173,277	57,049,340
1924-02-16	1924-02-20	2	3.123	173,018	57,046,918
1922-01-25	1922-01-29	2	3.632	102,471	51,341,410
1921-02-17	1921-02-21	2	3.997	163,446	56,723,855
1947-02-19	1947-02-23	2	5.114	174,575	57,061,339
1966-02-22	1966-02-25	2	3.752	174,680	57,061,955
1966-01-20	1966-01-23	2	4.147	167,944	56,939,500
1961-01-17	1961-01-20	2	3.986	172,768	57,008,892
1960-12-09	1960-12-12	2	4.279	174,181	57,057,113
1935-01-20	1935-01-24	2	4.379	173,748	57,052,314
1910-02-09	1910-02-12	2	3.493	172,989	57,044,222
1910-01-11	1910-01-14	2	3.363	140,978	55,947,687
1909-12-22	1909-12-26	2	4.349	172,999	57,044,725
1907-02-03	1907-02-05	2	3.911	173,374	57,048,198
1903-02-13	1903-02-17	2	4.06	173,018	57,041,030
1902-02-12	1902-02-18	2	3.365	167,406	56,975,091
1959-03-11	1959-03-13	2	4.077	172,191	56,714,016
1946-02-14	1946-02-20	2	3.958	172,816	56,825,942
1941-03-06	1941-03-09	2	4.613	174,575	57,061,330
1940-02-12	1940-02-14	2	4.278	153,942	56,715,406
1938-11-22	1938-11-24	2	3.72	174,575	57,061,300
1936-01-17	1936-01-20	2	4.227	173,326	56,966,638

Table 29 (cont'd): Regional Snowfall Index and Societal Impacts for the Northeast

Start Date	End Date	Category	RSI	Area of Snow	Population
2011-01-08	2011-01-12	2	3.495	174,680	57,057,940
2010-12-23	2010-12-27	2	3.272	174,690	57,062,573
2010-02-04	2010-02-10	2	3.368	147,138	56,328,325
2010-02-07	2010-02-10	2	3.117	146,081	56,302,907
1917-12-11	1917-12-14	2	4.49	172,682	57,041,084
1917-03-01	1917-03-05	2	4.802	173,422	56,988,232
1916-03-01	1916-03-08	2	4.672	173,940	57,053,760
1933-12-25	1933-12-26	2	3.024	174,220	57,057,400
2008-12-20	2008-12-22	2	3.095	174,661	57,059,860
2007-03-15	2007-03-17	2	3.351	173,614	56,930,626
1995-02-01	1995-02-05	2	4.535	174,690	57,062,563
1994-02-27	1994-03-03	2	4.448	174,690	57,062,623
2006-02-09	2006-02-13	2	5.128	174,690	57,062,590
2005-02-27	2005-03-01	2	3.159	174,690	57,062,575
2005-01-21	2005-01-23	2	4.349	174,623	59,091,926
2009-12-27	2010-01-03	2	3.636	174,123	57,008,734
1987-01-20	1987-01-23	2	4.916	174,690	57,062,574
1992-12-08	1992-12-12	2	4.882	161,274	56,695,670
1988-02-08	1988-02-13	2	3.242	174,690	57,062,638
2002-12-22	2002-12-25	2	3.75	170,048	56,788,225
2000-12-27	2000-12-31	2	3.369	168,174	52,797,525
1982-04-03	1982-04-07	2	3.66	174,181	56,955,431
1997-03-30	1997-03-31	2	4.666	172,730	57,025,596
1996-03-02	1996-03-08	2	3.259	174,681	57,050,954
1995-12-17	1995-12-21	2	3.551	174,680	57,061,297
1967-02-05	1967-02-07	2	3.209	169,933	56,960,500

Table 29 (cont'd): Regional Snowfall Index and Societal Impacts for the Northeast

Start Date	End Date	Category	RSI	Area of Snow	Population
1966-12-21	1966-12-25	2	3.686	174,690	57,062,573
1951-12-12	1951-12-15	1	2.311	174,680	57,062,517
1950-02-10	1950-02-16	1	2.613	166,070	51,673,631
1949-01-28	1949-01-31	1	1.553	174,690	57,062,568
1948-01-22	1948-01-24	1	2.799	171,019	57,022,580
1974-01-07	1974-01-11	1	2.771	174,075	56,992,170
1973-12-14	1973-12-17	1	1.727	174,652	57,052,520
1970-12-30	1971-01-01	1	1.791	170,837	57,021,076
1970-12-08	1970-12-13	1	1.021	157,402	49,280,790
1969-02-24	1969-03-03	1	1.263	162,476	55,960,968
1977-03-20	1977-03-24	1	2.182	162,831	50,380,369
1977-01-06	1977-01-10	1	2.099	174,680	57,060,970
1978-01-13	1978-01-18	1	2.919	174,690	57,062,534
1978-01-10	1978-01-14	1	2.228	174,690	57,062,563
1957-12-02	1957-12-04	1	1.233	122,969	54,570,440
1956-03-17	1956-03-19	1	2.816	171,797	56,931,226
1956-03-02	1956-03-08	1	1.256	155,499	41,155,971
1929-02-19	1929-02-21	1	2.289	174,574	57,061,360
1926-01-06	1926-01-09	1	2.211	169,731	57,011,569
1924-12-30	1925-01-02	1	2.014	119,067	51,492,402
1923-02-02	1923-02-06	1	1.038	139,940	55,494,710
1964-02-17	1964-02-20	1	2.498	174,690	57,062,486
1963-12-20	1963-12-23	1	1.757	174,690	57,062,539
1962-03-07	1962-03-13	1	1.029	154,432	46,895,982
1962-03-04	1962-03-08	1	1.828	142,218	55,752,214
1962-02-27	1962-03-06	1	1.764	142,228	55,753,745

Table 29 (cont'd): Regional Snowfall Index and Societal Impacts for the Northeast

Start Date	End Date	Category	RSI	Area of Snow	Population
1962-02-12	1962-02-15	1	2.26	155,268	56,758,999
1960-02-11	1960-02-14	1	1.999	174,181	57,056,961
1910-02-15	1910-02-17	1	1.399	161,130	50,009,110
1909-03-01	1909-03-04	1	1.701	170,932	57,024,650
1909-01-26	1909-01-30	1	1.311	171,365	56,992,536
1909-01-09	1909-01-14	1	1.173	170,270	56,656,050
1908-02-15	1908-02-19	1	1.767	170,279	57,014,817
1908-02-02	1908-02-06	1	2.086	173,056	57,044,423
1908-01-28	1908-02-01	1	2.099	173,316	57,047,562
1906-03-16	1906-03-19	1	2.72	174,334	57,058,700
1906-03-11	1906-03-16	1	1.862	174,027	57,055,420
1904-01-26	1904-01-29	1	1.219	141,017	55,940,756
1902-12-10	1902-12-13	1	1.728	151,463	55,548,200
1901-01-31	1901-02-05	1	1.939	166,522	56,758,490
1929-12-18	1929-12-23	1	1.597	173,883	57,053,837
1918-01-24	1918-01-28	1	1.295	171,413	57,036,845
1918-01-20	1918-01-22	1	1.105	164,522	56,944,000
1918-01-11	1918-01-15	1	2.266	170,625	56,557,158
1945-12-16	1945-12-19	1	2.837	162,966	56,910,640
1945-01-12	1945-01-16	1	2.683	174,114	57,017,145
1944-12-07	1944-12-12	1	2.287	174,161	56,969,568
1944-02-07	1944-02-12	1	2.088	173,633	57,004,760
1943-01-24	1943-01-28	1	2.751	154,432	56,625,618
1942-03-27	1942-03-30	1	2.377	169,548	57,009,586
1942-02-27	1942-03-03	1	1.892	168,280	55,511,724
1936-02-09	1936-02-14	1	1.593	167,992	56,971,249

Table 29 (cont'd): Regional Snowfall Index and Societal Impacts for the Northeast

Start Date	End Date	Category	RSI	Area of Snow	Population
1932-12-15	1932-12-17	1	1.293	121,902	53,126,620
1931-03-03	1931-03-11	1	1.782	164,648	51,398,896
2012-01-11	2012-01-13	1	1.067	167,137	53,414,773
2011-10-24	2011-10-30	1	1.969	157,459	54,140,301
2011-02-23	2011-02-26	1	1.85	155,720	42,991,280
2011-01-25	2011-01-26	1	2.652	174,431	57,059,999
2010-02-11	2010-02-18	1	1.16	174,421	57,029,770
1900-03-14	1900-03-15	1	2.301	167,089	56,971,290
1917-12-05	1917-12-08	1	1.349	170,163	56,868,400
1915-04-02	1915-04-04	1	2.175	119,442	49,424,275
1915-03-01	1915-03-07	1	1.507	107,833	49,168,120
1915-01-28	1915-02-02	1	1.784	173,902	57,053,360
1934-02-22	1934-02-26	1	2.865	174,459	57,060,080
2012-12-27	2012-12-30	1	1.173	175,199	58,917,659
2012-12-23	2012-12-27	1	2.24	175,891	59,050,400
1999-03-11	1999-03-15	1	1.913	164,907	54,530,770
1999-01-12	1999-01-15	1	2.554	172,653	56,794,660
2009-02-28	2009-03-02	1	1.58	174,411	57,038,130
2009-02-25	2009-03-02	1	1.515	170,865	56,437,990
2009-02-21	2009-02-23	1	1.56	169,232	55,409,126
2009-01-08	2009-01-11	1	1.059	168,809	54,332,392
2008-12-17	2008-12-21	1	2.792	174,671	57,060,880
2008-02-20	2008-02-23	1	1.005	174,603	57,061,670
2007-12-13	2007-12-16	1	1.844	166,195	53,716,405
2007-11-29	2007-12-03	1	1.393	169,674	55,864,530
2007-04-02	2007-04-05	1	1.162	161,380	46,978,423

Table 29 (cont'd): Regional Snowfall Index and Societal Impacts for the Northeast

Start Date	End Date	Category	RSI	Area of Snow	Population
1994-02-21	1994-02-24	1	1.917	173,345	56,885,145
1994-01-15	1994-01-17	1	2.995	174,680	57,062,212
1994-01-03	1994-01-08	1	2.62	173,393	56,887,967
1993-12-31	1994-01-04	1	2.911	173,556	56,914,705
2009-12-17	2009-12-20	1	2.743	130,407	54,528,591
2009-12-06	2009-12-10	1	1.805	169,501	55,845,477
2013-03-16	2013-03-19	1	1.781	175,113	58,748,374
2013-03-02	2013-03-08	1	1.441	158,555	58,817,789
2000-01-23	2000-01-31	1	1.469	173,787	56,932,414
2000-01-23	2000-01-26	1	2.567	174,680	57,060,450
1987-12-12	1987-12-16	1	1.112	163,869	51,435,470
1987-11-09	1987-11-11	1	1.114	168,828	56,871,600
1987-02-21	1987-02-23	1	1.441	139,451	55,806,361
1987-01-07	1987-01-11	1	1.711	170,490	56,359,527
1986-12-31	1987-01-02	1	2.8	173,460	56,907,542
1985-02-28	1985-03-04	1	1.144	156,652	48,965,830
1985-01-28	1985-02-02	1	2.04	174,690	57,062,552
1984-02-23	1984-02-29	1	2.285	168,511	55,355,457
1993-02-19	1993-02-23	1	2.291	174,690	57,062,555
1993-02-13	1993-02-17	1	2.223	174,671	57,059,500
1990-12-26	1990-12-28	1	1.724	174,085	57,056,014
1988-01-21	1988-01-26	1	2.295	174,681	57,062,330
1988-01-04	1988-01-08	1	1.696	174,575	57,061,380
2002-12-31	2003-01-03	1	2.968	169,039	57,800,788
2000-02-15	2000-02-19	1	1.395	172,730	57,041,310
1982-01-19	1982-01-23	1	1.227	174,690	57,062,566

Table 29 (cont'd): Regional Snowfall Index and Societal Impacts for the Northeast

Start Date	End Date	Category	RSI	Area of Snow	Population
1982-01-11	1982-01-14	1	2.059	174,690	57,062,540
1979-02-16	1979-02-19	1	2.868	135,318	53,049,251
1979-02-05	1979-02-08	1	1.441	154,317	56,740,391
1997-01-07	1997-01-11	1	1.597	174,690	57,062,621
1996-04-08	1996-04-10	1	1.726	174,498	57,033,178
1996-01-31	1996-02-03	1	1.349	128,600	52,977,105
1967-03-19	1967-03-22	1	1.361	168,828	56,995,870

Source: http://www.ncdc.noaa.gov/snow-and-ice/rsi/societal-impacts

Ice Storms

Ice storms occur when a mass of warm moist air collides with a mass of cold Arctic air. As the less dense warm air rises moisture may precipitate as rain. The rain falls through the colder, denser air and comes in contact with cold surfaces where ice forms. Ice may continue to form until the ice is several inches thick.

Ice storms may strain tree branches, power lines and even transmission towers to the breaking point and often create treacherous conditions for highway travel and aviation. The weight of formed ice (especially with a following wind) may cause power and phone lines to snap and the towers that support them to collapse under the load, and may break tree limbs. Debris impacted roads make emergency access, repair and cleanup extremely difficult.

The most recent ice storm in New England and the region occurred in December 2008. The storm resulted in one fatality and left over one million people without power, some for as long as two weeks. Damage from the storm was measured in millions of dollars in property damage, lost business and clean up costs. For example, The Town of Westford alone spent $650,000 in responding to this storm, according to Town Manager Jodi Ross. Many of the expenses incurred were related to debris cleanup. Given the magnitude of damage, the storm resulted in a Presidential Disaster Declaration.

Ice storms equally as severe have been recorded in New England since 1929. The U.S. Army Corps of Engineers, Cold Regions Research and Engineering Laboratory estimates a 40 – 90 year return period for an event with a uniform ice thickness of between .75 and 1.25 inches. In other words, on average, a one-inch ice storm is likely every fifty years. Middlesex County has experienced 22 ice storms since 1971.[6] Each community in the region is at equal risk of being impacted by an ice storm and impacts are consistent across the region, with the exception of Lowell, where tree damage and power outages are often lessened due to the community's urban nature and the fact that utilities within the downtown are located underground.

[6] NCDC Database

Utility company responds to the aftermath of the December 2008 ice storm in Westford, MA

Ice Jams

Ice jams occur when warm temperatures and heavy rain cause rapid snow melting. The melting snow combined with the heavy rain, causes frozen rivers to swell, breaking the ice layer into large chunks that float downstream and pile up near narrow passages or near obstructions, such as bridges and dams. Historically, there have been hundreds of ice jams in New England. Within the Northern Middlesex region, ice jams have been recorded on the Merrimack River in Lowell and on the Nashua River in the Town of Pepperell. According to the U.S. Army Cold Regions Research Lab's database, [7] an ice jam occurred along the Nashua River on March 19, 1968, and along the Nashoba Brook on March 18, 1972 and on February 17, 2008. The major hazard associated with an ice jam is flooding. Given that sizable rivers traverse every community in the region, each municipality is at equal risk of being impacted by an ice jam, however, based on historical occurrences, the probability of such an event occurring is relatively low.

4. Fire-Related Hazards

Fire poses a danger to developed and urbanized areas of the region, as well as to forested areas. A wildland fire can be defined as any non-structure fire that occurs in the wildland. Three distinct types of wildland fire have been defined and include wildfire (naturally occurring or human caused), and prescribed fire. Many of these are highly destructive and can be very uncontrollable. They occur in forested, semi-forested or less developed area.

[7] http://www.crrel.usace.army.mil/

Drought

Drought is a normal recurrent feature of climate, occurring in virtually all climatic zones. Drought originates from a deficiency in precipitation over an extended period of time, typically two winter seasons or more, and should be considered relative to the long-term average condition based on precipitation and evapo-transpiration. The first evidence of drought is usually seen in rainfall records. Within a short period of time, soil moisture can begin to decrease. The effects on stream and river flow, or water levels in lakes and reservoirs, may not be noticed for several weeks or months. Water levels in wells may not be impacted for a year or more after the drought begins.

Massachusetts is often considered to be a water-rich state, receiving an average of 45 inches of precipitation each year. The region can experience extended periods of dry weather, from single season events to multi-year events, such as occurred in the mid-1960s. Historically, droughts in Massachusetts have started with dry winters, rather than summers.

During the summer of 2002, one-third of the nation, including New England, experienced drought conditions. Massachusetts has experienced multi-year drought episodes in 1879-1873, 1908-1912, 1929-1932, 1939-1944, 1961-1969 and 1980-1983. The most recent drought advisory for the state was issued in April 2012 when a number of days had “red flag” wildfire warnings due to warm and dry weather, high winds, and low fuel moisture. DCR placed an increased emphasis on wildfire detection and suppression during this period of time.

A serious drought occurred in Massachusetts during the Spring and Summer of 1999. Cumulative deficits in precipitation reached 8-12 inches below normal over a one-year period. Stream flows routinely fell below the 25th percentile of historical flows for the month. Ground water levels were also below normal throughout the summer over nearly the entire state. During this period, the Massachusetts Emergency Management Agency developed a Massachusetts Drought Management Plan. The Plan includes ground water, surface water, reservoir, and precipitation data, and stream flow conditions, as well as a report on fire danger and agricultural conditions. The Drought Management Plan provides specific action items to be implemented during a drought watch, drought warning and drought emergency. A drought emergency is one in which state-mandated water restrictions or use of emergency water supplies is necessary. Each community in the region is at equal risk of being impacted by a drought emergency. Communities within the Northern Middlesex region have imposed outdoor watering restrictions during times of drought.

Wildfires

A wildfire is an uncontrolled fire that spreads due to the presence of vegetative fuel. These fires often begin unnoticed and spread quickly. In this area of the country, wildfire season generally begins in March and ends in late November. Human beings start four out of every five wildfires through arson or carelessness; lightning strikes account for the remainder. If heavy rain follows a major wildfire, other natural disasters can occur, including landslides and floods. Once groundcover is burned away, there is little left to hold soil in place on steep slopes. Water supplies can also be affected. The loss of ground cover materials and the chemical transformation of burned soils can make some watersheds more susceptible to erosion.

A surface fire is the most common type of wildfire, burning slowly along the floor of a forest, destroying or damaging trees. Lightning typically starts a ground fire, and burns on or below the forest floor; such fires are difficult to detect and extinguish. Crown fires spread quickly along the tops of trees, and are driven by wind. Crown fires are seen when high-intensity surface fire spreads or “ladders” upward through the lower foliage to the canopy.

The Massachusetts Office of Fire Services reported 45,486 wildfires in the Commonwealth from 2000-2009. In 2011, there were 1,116 human-caused fires that consumed 545.5 acres across the state.[8] The Massachusetts Department of Conservation and Recreation (DCR), Fire Control Division maintains monthly records of the number of wildfires. The Northern Middlesex region is located in Massachusetts Fire Control District 6. Each municipal Fire Department in the region has provided wildfire data for a nine-year period ending in 2010, which is shown in Table 30 below. This is the most recent data available. It should be noted that the Town of Dracut was only able to provide data for the years 2008-2010.

TABLE 30: Brush Fires/Wildfires in the Northern Middlesex Region (2002 to 2010)

Community	*Number of Events*
Billerica	549
Chelmsford	325
Dracut	78*
Dunstable	115
Lowell	631
Pepperell	106
Tewksbury	400
Tyngsborough	206
Westford	171
Total	2,503

* 2008-2010

Source: Municipal Fire Departments

The early detection of forest fires is critical to preventing a large wildfire. The sooner suspicious smoke is located and units are dispatched for investigation the less likely there will be needless damage to homes and property. Early detection is achieved by trained DCR observers who staff the statewide network of operating fire towers. From their high vantage points, observers utilize alidade tables, binoculars, and topographic maps to triangulate the precise location of any fire. This information is then given to local community fire departments for prompt response. There is a fire tower on Robbin Hill in Chelmsford that is manned by DCR staff during periods of high fire danger.

While the communities of Dunstable, Pepperell, Tyngsborough, and Westford have the most forested land and large tracts of remaining open space, the incidence of brush fire is lower in these communities than in the more urbanized communities. This is primarily due to there being less human activity, which is often the catalyst for such events. Input received from the region’s communities indicates that there are no specific geographic patterns related to brush fire incidents, although brush fires along major highways were noted to be frequently caused by careless disposal of cigarette materials by passing motorists. Local communities do not maintain data on the areas impacted by brush fire events or on the extent of such events. The Town of

[8] www.northeastwildfire.org

Chelmsford has identified specific locations that the Fire Department considers to be at risk for wildfire. Please refer to pages 107-108 for a list of the locations.

Wildland/Urban Interface

Wildland/urban interface areas exist wherever homes and businesses are built among trees and other combustible vegetation. The wildland/urban interface problem stems from two different sources of fire and their impact on the community. Fire can move from forest, brush or pastureland into the community or from the community into adjacent wild areas. In temperate areas vegetative decay is a slow process, and logs, leaves and evergreen needles pile up on the forest floor. This accumulation of fuel increases the probability of large fires that are difficult to control. Ignitions are more frequent in the wildland/urban interface because of the increased presence of people - carelessness, recreation, damaged power lines, and industrial activity are potential ignition sources.

Interface fire can move rapidly through agricultural landscapes. Drought conditions, high winds, and accumulation of fine fuels, such as grass or stubble, set the stage for interface fires far away from any forests. In addition to building and equipment loss, crops, feed, soil, livestock and farm infrastructure are also at risk.

Typically, wildland/urban interface fires do tremendous damage, resulting in large economic losses and severe social impacts. The impact to residents can include the loss of, or damage to, homes and irreplaceable items, and even death or serious injury. Financial costs include building and infrastructure loss or damage, and business interruptions, as well as suppression and evacuation costs.

Wildland fires produce firebrands that are lofted into the air and travel great distances, often igniting spot fires ahead of the main fire. Firebrands that land on a combustible roof will usually start a fire that will consume a building, if not suppressed in time. The reality of firebrand-caused ignitions is that buildings located in relatively urban settings, some distance inside the community interface boundary, are still vulnerable to wildland fires. Additionally, direct flame contact or radiant heat can ignite vulnerable buildings. Ignitions can result from both vegetation-to-structure spread and structure-to-structure spread.

Within the Northern Middlesex region there are some locations where forests interface with urban and suburban neighborhoods. Most notable are the areas adjacent to the Dracut-Tyngsborough-Lowell State Forest, Manning State Forest in Billerica, Thanksgiving Forest and the Cranberry Bog in Chelmsford, the Town Forest in Pepperell, and the Town Forest and East Boston Camp/Stepinski parcels in Westford.

Urban Fire

The probability of an urban fire increases with population density. This is due to human error and carelessness, which are primary factors contributing to urban fires. The elderly (age 65 and older) tend to be more vulnerable to fires than any other age group. They also experience the highest number of deaths per fire. The second most vulnerable age group is those age 14 years and younger. Many homes destroyed by urban fires are often older homes in the community. Fire can spread faster in areas with high concentrations of housing, compared to less densely developed suburban and rural areas. The potential secondary effects of an urban fire include utility failures and hazardous materials releases. The City of Lowell is the only community in the region at high risk for urban fire. During 2013, 323 structure fires were reported in the City. Tragically, seven people perished in an apartment fire in Lowell in 2014.

5. Geologic Hazards

Earthquakes

Earthquakes in the Northeast are not associated with specific known faults, as they are in California. In New England, the immediate cause of most earthquakes is the sudden release of stress along a fault or fracture in the earth's crust. Much of the research on earthquakes in the northeast has involved attempts to identify pre-existing faults and other geological features that may be susceptible to such stress, but this has proven to be quite difficult. Unlike the situation in the western part of the country where many plate boundary earthquakes occur, it is unclear whether faults mapped at the earth's surface in the northeast are the same faults along which earthquakes are occurring.

It is impossible to predict the time and location of future earthquakes in New England. The U.S.G.S. has produced a series of earthquake hazard maps for the United States. These maps show the amount of earthquake generated ground shaking that is predicted to have a specific chance of being exceeded over a certain period of time. Ground shaking caused by earthquakes is often expressed as a percentage of the force of gravity. Due to the difficulty of identifying specific seismically active geological features in the Northeast, the level of seismic hazard is based primarily on past seismic activity. These maps generally show that there is a 1 in 10 chance that in any given fifty-year period a potentially damaging earthquake will occur.

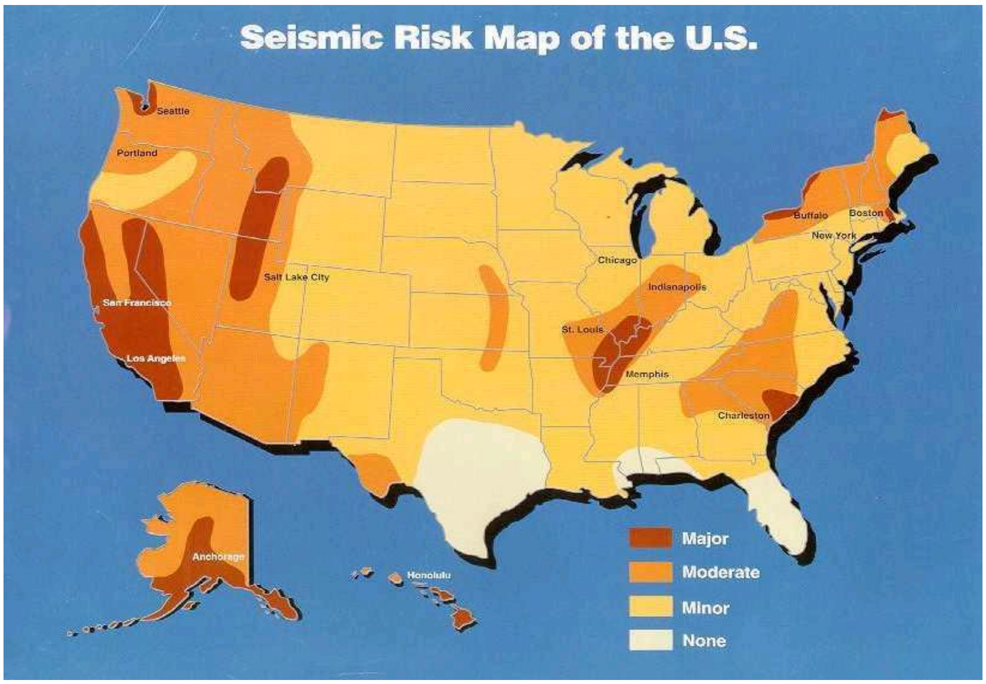
From 1924-1989 there were eight earthquakes with a magnitude of 4.2 or greater in New England. The Northeast States Emergency Consortium (NESEC) documented 165 earthquakes within 250 miles of the NESEC northeast region, from January 1 through December 5, 2012. These earthquakes ranged from magnitude 0.3 to 4.5, and 30 were magnitude 2.5 or greater. NESEC also noted that in 2012 there was a sequence of 12 offshore earthquakes that occurred off the continental slope east of Massachusetts, ranging from magnitude 0.5 to 4.5. New England experiences 30-40 earthquakes each year, although most are not felt. Potential earthquake losses total $4.4 billion annually in the United States, with the Northeast ranking third in the nation for annualized losses, according to FEMA. The $4.4 billion estimate includes only losses to buildings and business interruption. It does not include damage and losses to critical facilities, transportation infrastructure and services, utilities, or indirect economic losses.[9]

The Northern Middlesex region is considered to be at moderate risk of experiencing an earthquake. Moderate risk means that there is a relatively long period of time between strong earthquakes. Since 1985 there has been a small earthquake approximately every 2 ½ years within a few miles of Littleton and Westford, Massachusetts. It is not clear why some localities experience such clustering of earthquakes, but one possibility suggested by Prof. John Ebel of Weston Observatory of Boston College is that these spatial clusters are sites where strong

[9] www.nesec.org

earthquakes were centered in the prehistoric past. These spatial clusters may indicate locations where there is an increased likelihood of future earthquake activity.

The area's vulnerability to a devastating earthquake is based primarily on two elements: the density of the population in the region, and the age of the region's buildings and lack of earthquake proof design. Additionally, seismic waves travel further in the eastern U.S. than in other parts of the country. Seismologists have determined that the likelihood of an earthquake with a magnitude of 5.0 or greater occurring in New England area by the year 2043 is 41-56%.[10] Map 4 on the following page shows the earthquake risk for each region of the United States.



Source: New Hampshire Office of Emergency Management website: www.nhoem.state.nh.us

MAP 4

Earthquake magnitude is measured on two scales, the Richter Scale and the Mercali Scale. The Richter Scale (expressed as "mb") is an open-ended logarithmic scale that measures the amount of energy released by an earthquake. An earthquake registering 1.5mb on the Richter Scale represents that point at which some disturbance may be felt. At 4.5mb slight damage may be caused. An 8.5mb is considered a devastating earthquake. The Mercali Scale is measured on a Scale of I to XII and expresses more directly the damaged caused by an earthquake. A Scale I earthquake on the Mercali Scale would barely be felt, whereas a Scale XII quake would result in total destruction of all buildings. The intensity of the quake is evaluated according to observations at specific locations. Appendix C outlines the full impact for each level.

Ground movement during an earthquake is seldom the direct cause of injury or death. Collapsing walls, falling objects and flying glass cause most casualties. Buildings with foundations resting on unconsolidated landfill, old waterways, or other unstable soils are most at risk. Buildings, trailers, and manufactured homes not tied to a reinforced foundation anchored to

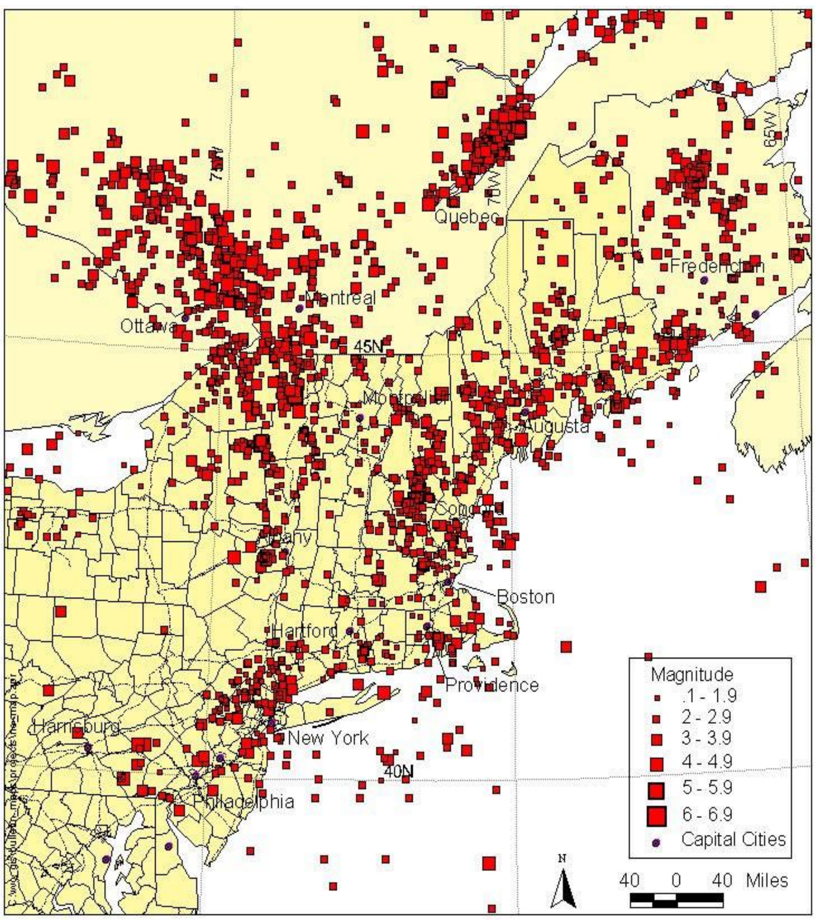
[10] www.earthquake.usgs.gov

the ground are also at risk, since they can be shaken off their mountings during an earthquake. In the eastern part of the U.S. a magnitude 5.5 earthquake can be felt as far as 300 miles from where it occurred, and can cause damage out to 25 miles from the epicenter.

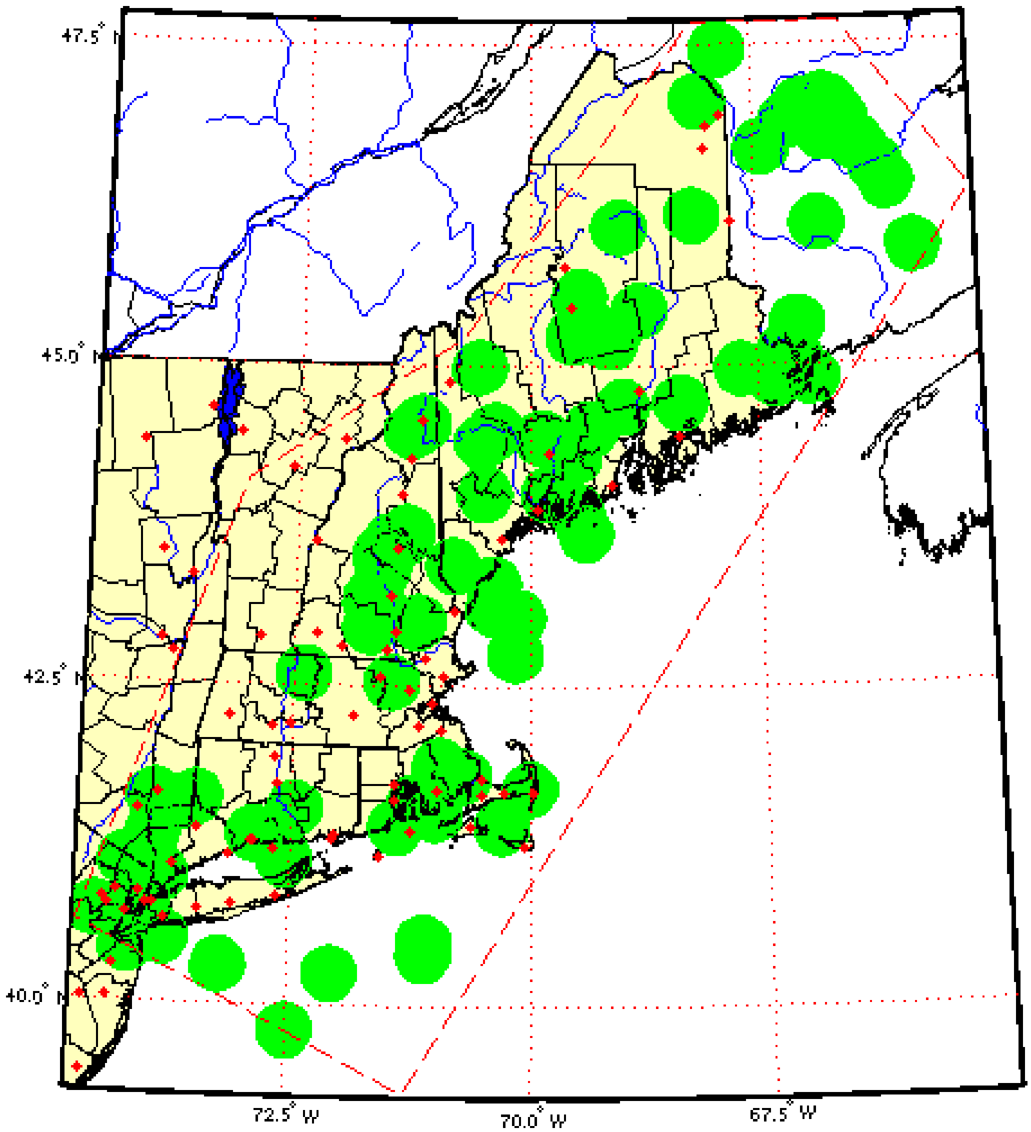
Based on past records, the maximum experienced earthquake intensities on the Mercali Scale in Northern Middlesex County have been in the range of VI (where there is damage to objects indoors, the tremor is felt by all people indoors and outdoors, movement is unsteady, moderately heavy furniture moves, and pictures fall off walls) to VII (where there is damage to architecture, the tremors are frightening, it is difficult to stand, cracks occur in chimneys and plaster, bricks may fall, and stream banks may cave in).

Figure 1 below shows earthquake activity in the northeast from October 1975 to March 2010. Map 5 on the following page shows the results of an earthquake probability analysis conducted by the Weston Observatory at Boston College. The study examined earthquake activity of magnitude greater than 2.7. According to the analysis, there is a 66% chance that the next earthquake of magnitude greater than 2.7 will occur in the green areas shown on Map 5 on the following page. Map 7 on page 74 shows the seismic activity in Massachusetts since 1973.

Figure 1: Earthquake Activity in the Northeast from October 1975 – March 2010



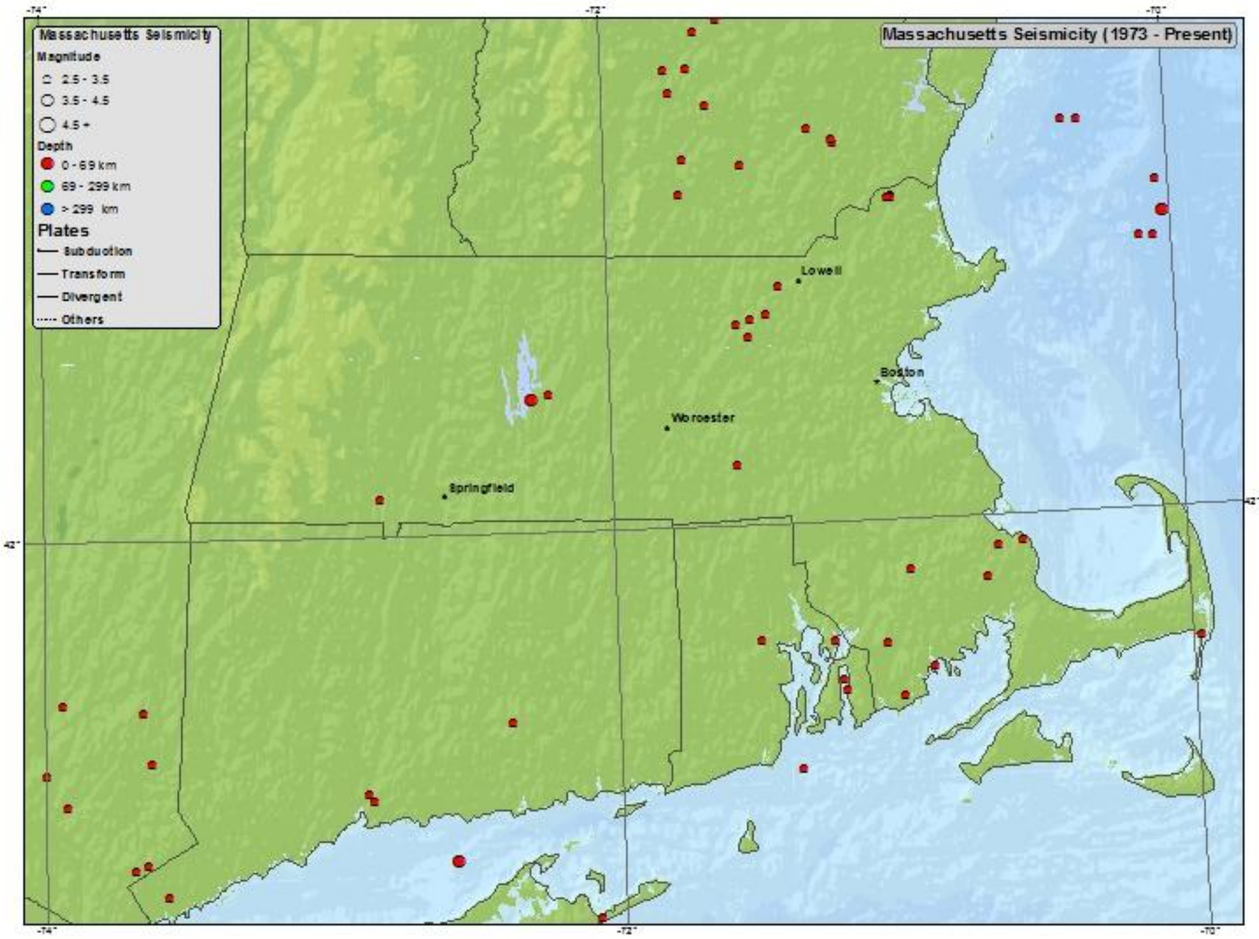
Source: Weston Observatory



MAP 5: NEW ENGLAND EARTHQUAKE PROBABILITY

Source: Weston Observatory, Boston College

Map 6: Seismicity in Massachusetts, 1973 to present



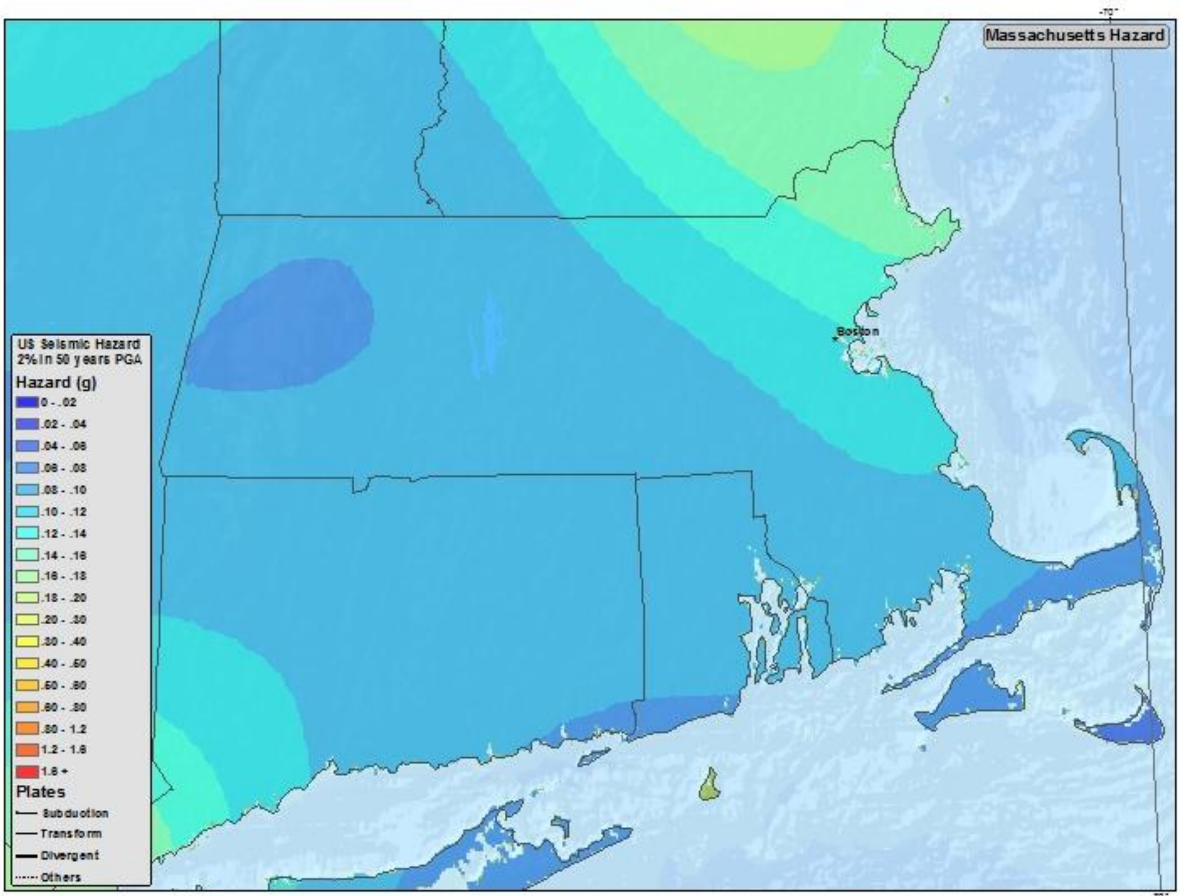
Source: www.earthquake.usgs.gov

The CEMPs on file with MEMA for the nine communities in the Northern Middlesex region indicate that a significant earthquake in the region would affect 277,000 people; 13,000 of whom do not have access to transportation. The number of people potentially affected in each community is summarized in the Table 31 below and essentially includes the entire population of the region.

TABLE 31: PERSONS AT RISK TO EARTHQUAKES		
Community	**Maximum Population Affected**	**Maximum Number of People without Transportation (est.)**
Billerica	38,981	1,169
Chelmsford	33,858	1,157
Dracut	28,562	1,102

TABLE 31 (cont'd): PERSONS AT RISK TO EARTHQUAKES		
Community	**Maximum Population Affected**	**Maximum Number of People without Transportation (est.)**
Dunstable	2,829	91
Lowell	105,167	8,090
Pepperell	11,142	300
Tewksbury	28,851	314
Tyngsborough	11,081	308
Westford	20,754	246
REGIONAL TOTAL	**281,225**	**12,777**

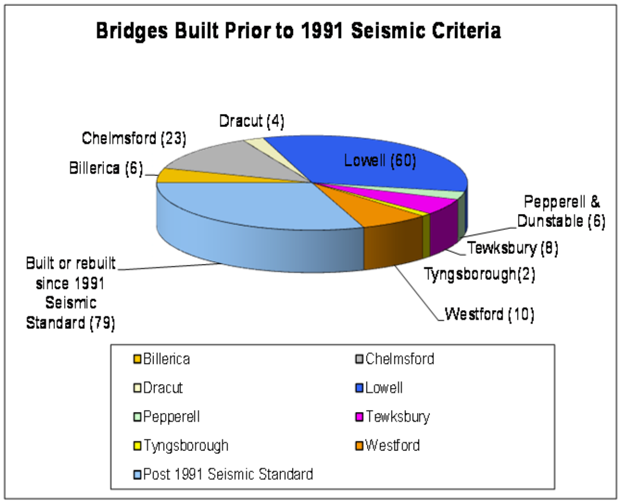
Map 8: Seismic Hazard in Massachusetts



Source: *http://earthquake.usgs.gov/earthquakes/states/massachusetts/hazards.php*

Failure to design structures with earthquakes in mind will also affect the potential damage caused by an earthquake. Map 8 on the previous page shows seismic hazard for the state of Massachusetts. Regulations that require buildings and structures to meet some minimum seismic criteria were only put in place over the past three decades. For example, the Commonwealth of Massachusetts began requiring new or rehabilitated bridges to meet minimum seismic criteria in 1991. Therefore, many bridges in the region have an elevated risk of failure during a significant earthquake. Figure 2 below indicates that 119 of the 198 bridges (60%) have not been subject to any specific seismic evaluation because they were built or rebuilt prior to state seismic requirements.

Figure 2: Seismic Status of Northern Middlesex Bridges



Source: MassDOT 2010

Little is understood about the occurrence of earthquakes in this area, as mentioned previously. The earthquake cluster identified in the vicinity of Littleton and Westford may indicate a pattern that is likely to continue. Overall, the region is at a moderate risk for earthquakes, and the greatest damage is likely to occur where structures were designed prior to seismic standards being incorporated into the state building code. Such structures are scattered throughout the region. In addition, many older structures in the region, such as schools, hospitals and fire stations, are built of un-reinforced masonry (i.e., "red brick") and are particularly vulnerable to damage or collapse in the event of an earthquake.

Landslides

A landslide is the downward movement of a slope and its materials under the force of gravity. Human activity such as construction and mining, and natural factors such as topography, geology and precipitation influence landslides. Landslides often develop when water rapidly accumulates in the ground, such as during periods of heavy rainfall or rapid snowmelt. Other factors contributing to a landslide include earthquakes, and erosion by rivers and streams. Landslides commonly occur with other major natural disasters, such as earthquakes and floods that exacerbate relief and reconstruction efforts.

Nationally, landslides constitute a major geologic hazard, as they are widespread, occur in every state, cause an estimated 25 fatalities annually, and result in $1-2 billion in property damage each year. Landslides are common throughout New England, but are generally limited to mountainous or hilly terrain. The Northern Middlesex region is not considered to be at risk for this type of natural hazard.

6. Other Natural Hazards

Extreme Temperatures

A heat wave is a period of three consecutive days during which the air temperature reaches or exceeds 90 degrees Fahrenheit on each day. Temperatures that hover ten degrees or more above the average high for the region and last for several weeks are defined as extreme heat. Humid or muggy conditions, which add to the discomfort of high temperatures, occur when a dome of high pressure traps hazy, damp air near the surface.

Heat kills by pushing the human body beyond its limits. Most heat disorders occur because the victim has been overexposed to heat or has over-exercised for his or her age and physical condition. The most severe heat-induced illnesses are heat exhaustion and heat stroke. If left untreated, heat exhaustion can progress to heat stroke and possible death. Young children, the elderly and those with existing illnesses are more likely to become victims. Other conditions that can cause heat-related illness include stagnant atmospheric conditions and poor air quality.

Recent statistics in the United States indicate that approximately 200 deaths per year are attributable to heatstroke. In 1980, high summer temperatures in Central and Southern States caused an estimated 1,700 excess deaths directly attributable to the heat. In July 1995, a heat wave in the mid-west caused 670 deaths, 375 in the Chicago area alone. High cooling demands also increase the risk of utility black outs as transmission systems are stretched to their limits. The combination of a loss of air conditioning due to a black out, along with a heat wave could have catastrophic results for the region.

The hottest temperature ever recorded in the region was 105 degrees measured in Dunstable and Pepperell during August 1948.[11] In recent years, temperatures over 100 degrees were recorded in the region in July 1995, June 2008, and July 2011. Although the entire region is at risk for extreme heat, it is of particular concern in Lowell where the built environment contributes to the phenomenon of urban heat-island effect. Heat islands develop when built surfaces replace a large portion of natural land, keeping nighttime air temperatures high, relative to temperatures in less urbanized areas. According to meteorologists, a heat island is a well-defined area where temperatures are higher than the surrounding region, sometimes as much as 15º F higher.

[11] www.intellicast.com

Extreme cold events are days where the mean daily temperature (average of the high and low recorded temperatures over a 24-hour period) falls below 32° F. Prolonged exposure to extreme cold temperatures can lead to serious health problems such as hypothermia, cold stress, frostbite, or freezing of the exposed extremities such as fingers, toes, noses and earlobes. Infants, seniors, people who are homeless, and those living in a home without adequate heat are most susceptible to such conditions. As the temperature drops and wind speed increases, heat can leave the body more rapidly. This phenomenon is known as the wind-chill effect, which can exacerbate an extreme cold event. The coldest temperature ever recorded in the region was -29 degrees, as recorded in Dunstable and Pepperell in January 1957.[12]

The entire region is at risk for extreme cold and heat, although the City of Lowell contains a higher percentage of the most vulnerable populations, such as the elderly and those who are homeless. The record high and low temperatures for the communities within the Northern Middlesex region are shown in Table 32 below.

Table 32: Record High and Low Temperatures by Community

Community	Record High Temperature (degrees F)	Month and Year Recorded	Record Low Temperature (degrees F)	Month and Year Recorded
Billerica	101	August 1975	-19	January 1961
Chelmsford	103	August 1948	-17	January 1994
Dracut	103	August 1948	-17	January 1994
Dunstable	105	August 1948	-29	January 1957
Lowell	103	August 1948	-17	January 1994
Pepperell	105	August 1948	-29	January 1957
Tewksbury	102	July 1926	-20	December 1993 and January 1984
Tyngsborough	103	August 1948	-17	January 1994
Westford	103	August 1948 and July 2011	-17	January 1994

Source: www.intellicast.com and data reported by the Town of Westford

7. Climate Change

Scientific assessments indicate that climate change is expected to alter the frequency or severity of weather-related natural hazards, increasing the vulnerability to such hazards. These assessments suggest that the potential effects of climate change on weather-related events could be significant. For example, increasing temperatures may impact communities by altering the frequency or severity of hurricanes, tornadoes, and severe thunderstorms. There is growing evidence that the warming surface temperatures in the sea have increased the destructive potential of Atlantic tropical storms since 1970.

Massachusetts' climate is already changing – ambient temperature has increased by approximately 1.8°F since 1970 and sea surface temperature has increased by 2.3° F between 1970 and 2002. These warming trends have also been associated with more frequent days with temperatures above 90°F, reduced snowpack, and earlier snow melt and spring peak flows.[13] The

[12] Ibid.

[13] Frumhoff, P.C., J.J. McCarthy, J.M. Melillo, S.C. Moser and D.J. Wuebbles, 2006. Climate Change in the U.S. Northeast: A Report of the Northeast Climate Change Impacts Assessments, Union of Concerned Scientists, Cambridge, MA.

Intergovernmental Panel on Climate Change predicts that, by the end of the century, Massachusetts will experience a 5° to 10°F increase in average ambient temperature, with several more days of extreme heat during the summer months. Days with temperatures above 90°F are predicted to increase from 5 to 20 days annually presently, to 30 to 60 days annually. Sea temperatures are expected to increase by 8°F. Winter precipitation (generally in the form of rain) is expected to increase by 12% to 30%, while the number of snow events is expected to decrease.[14]

New England is expected to experience changes in the amount, frequency and timing of precipitation. Since 1900, precipitation recorded at the U.S. Historical Climatology Network weather stations located across the northeast has increased by 5 to 10 percent. By the end of the century, annual precipitation is expected to increase 14% with a slight decrease in the summer.[15] The shift toward more rainy and icy winters would have serious implications in terms of possible damaging ice storms, similar to the storm that severely impacted the region in December 2008. In addition, more winter rain is expected to cause more high-flow and flooding events during the winter, earlier peak flows in the spring, and extended low-flow periods in the summer months. Such hydrologic changes would impact water resources, including an increase in flooding, pollutant laden overflows from stormwater and wastewater systems during high periods of flow, and increased stress on surface and groundwater drinking sources during periods of low flow or drought. Figure 4 below shows the annual precipitation totals for Boston over the past four decades.

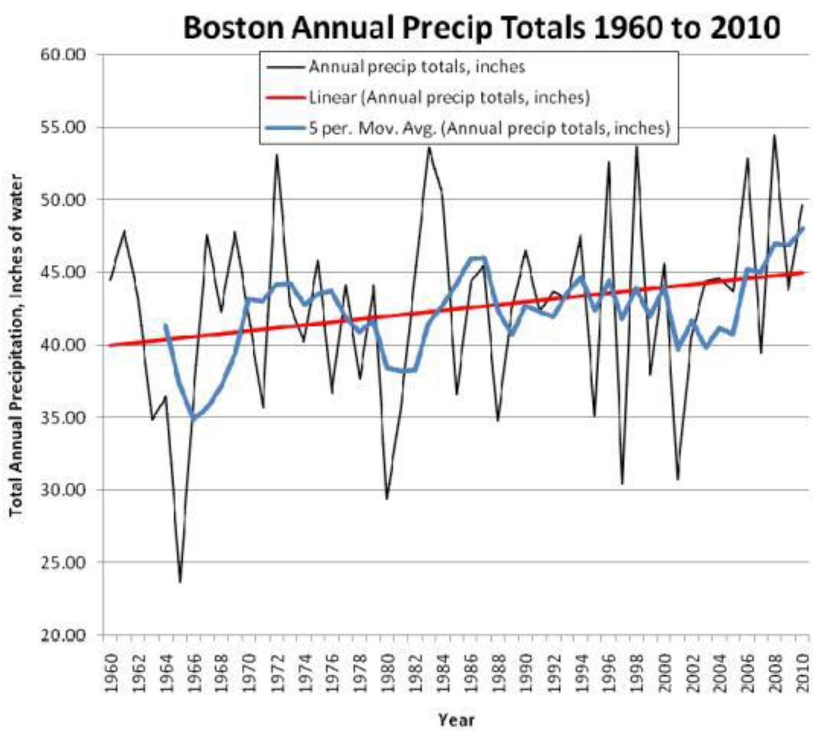


Figure 3

Source: National Weather Service

[14] Massachusetts Climate Adaptation Report, Executive Office of Energy and Environmental Affairs and the Adaptation Advisory Committee, September 2011.
[15] Ibid.

Higher temperatures will have a negative effect on air quality and human health. Increased rates of respiratory illness, worsening of allergies and asthma, increased vector borne diseases, and degraded water quality are expected. Floods caused by high intensity precipitation will also impact the region and the state. Should these events occur with greater frequency as many climate expert predict, future damage may be severe and cumulative, straining local and state resources. Extreme weather events can disrupt power, limit access to safe and nutritious food, damage property, and impact health care services.

Climate change is also expected to impact the state and local economy. Among the sectors most likely to be affected are agriculture, forestry, fisheries, manufacturing and service industries, tourism, recreation and health care. Establishing redundant supply routes and sources, developing renewable energy sources, and protecting facilities and sites which are vulnerable to flooding, will help minimize the potential economic impact to businesses. With these higher temperatures, electricity demand in Massachusetts could increase by 40% in 2030, most of the increase would occur during the summer months, requiring significant investment in peak load capacity and energy efficiency measures.[16]

Given the known natural hazard risks and the projected impacts of climate change, there are several reasons to integrate hazard mitigation and climate change adaptation. First, the decisions and choices made today will shape the future of our communities and impact their ability to be resilient. Second, given significant time is required to develop adaptive strategies and implementation capacity, acting now will allow the time needed for communities to work toward achieving long-term adaptation goals. Third, proactive planning is far less costly than reacting and responding to a disaster created by a hazard that has been exacerbated by the effects of climate change.

By creating an engaged community and taking a proactive approach to reducing the region's vulnerability, the region will be better positioned to deal with the increased threats posed by climate change. Some solutions that address climate change can also be viewed as hazard mitigation strategies in that they achieve reductions in greenhouse gas emissions that contribute to global warming and exacerbate the severity and impacts of natural hazards.

Developing effective and efficient initiatives to address climate change will require communication, coordination, and collaboration among government bodies, the private sector, non-profit organizations, academic institutions and other stakeholders. Neither adaptation nor mitigation alone can address the impacts of climate change, but taken together the two programs can reduce the risks of climate change and result in more resilient communities.

The Region's Vulnerability to Climate Change

The most significant vulnerability to structures in the region is that they were designed and constructed based on historic weather conditions. This puts infrastructure at an increased risk of future damage from increased precipitation and flooding. It is expected that increased frequency of extreme weather events will raise the risk of damage to transportation systems, energy-related facilities, communications systems, and water supply and wastewater management

[16] Ibid.

systems. Improving siting and design of new structures to include consideration of the impacts of climate change will minimize the region's vulnerability and allow communities to be more resilient. The Insurance Institute for Business & Home Safety (IBHS) has released a new report which provides an analysis of residential building codes in the 18 hurricane-prone coastal states along the Gulf of Mexico and the Atlantic Coast. Massachusetts rated fourth with a score of 87 out of 100.[17]

Municipalities and the State should adjust traditional maintenance and inspection schedules for roadways, bridges and drainage structures to take into account the impacts of climate change. Short-term measures for publicly-owned water and wastewater treatment facilities could include flood-proofing by increasing the elevation of structures, installing water-tight doors and windows, replacing wet/dry well pumps with submersible pumps, increasing emergency back-up provisions to keep key equipment operational, and relocating vulnerable equipment.

There are similar vulnerabilities across ecosystems based on projected temperature changes, increased storm intensity, precipitation changes, drought, and sea level rise. Different organisms have different rates of response to climate change. It is expected that climate change will cause changes in species composition and forest structure. Climate change, in conjunction with other stressors, will alter forest function and its ability to provide wildlife habitat, and could reduce the ability of forests to provide ecological services such as air and water cleansing. In addition, the negative impacts of invasive species may increase, as native forests are increasingly stressed. In general adaptive strategies for natural resources and habitats include land and water protection, land and water resource management, regulation changes and increased monitoring.

Higher summer temperatures, less summer precipitation, and an increase in drought frequency will impact water quality and quantity. Intermittent streams will cease flowing earlier in the season and some coldwater habitat will be replaced with warm water habitat. The predicted changes in precipitation patterns will also increase stormwater discharge. Hydrologic changes from increased flooding will lead to increased erosion, stream scouring and sedimentation. Overbank floods that once spilled across the floodplain can become confined within the channel and disconnect the waterway from the floodplain. Adaptation strategies should integrate the protection of rivers, streams, lakes, floodplain, and wetlands with land use, watershed and floodplain management.

The entire region is vulnerable to impacts of climate change. The areas most at risk include those located in the floodplain, near wetlands and along waterways. In order to help protect existing structures and minimize or prevent exposure, sound land use decisions should be promoted through technical support to local communities on effective land use standards, model bylaws and permitting processes. Hazard mitigation, evacuation and emergency response plans should be evaluated and updated to reflect changing climate conditions and new development patterns.

[17] "Rating the States: An Assessment of Residential Building Codes and Enforcement Systems for Life Safety and Property Protection in Hurricane Prone Regions", IBHS, 2012.

Climate Change Planning and Adaptation at the State Level

Massachusetts is actively working to reduce greenhouse gas emissions and address climate change adaptation. The Global Warming Solutions Act, passed by the Massachusetts Legislature and signed by Governor Deval Patrick in 2008, directed the Secretary of Energy and Environmental Affairs to convene an advisory committee charged with developing a report that analyzed strategies for adapting to the predicted impacts of climate change. The *Massachusetts Climate Change Adaptation Report* was published in September 2011. The report provides an overview of the observed and predicted changes to Massachusetts' climate and the anticipated impacts, outlines key findings, sets guiding principles, and identifies key adaptation strategies that could help increase resilience and preparedness.

B. Non-Natural Hazards

The Massachusetts Emergency Management Agency (MEMA) is the state agency responsible for coordinating federal, state, local, voluntary, and private resources during emergencies and disasters in the Commonwealth of Massachusetts. MEMA provides leadership in developing plans for effective response to all hazards, disasters or threats; trains emergency personnel; provides information to the public; and assists individuals, families, businesses, and communities to mitigate against, prepare for, respond to, and recover from emergencies caused by both nature and humans.

Each municipality has a Comprehensive Emergency Management Plan (CEMP) in place. The CEMP combines the four phases of emergency management: mitigation, preparedness, response and recovery. In the interest of holistically addressing mitigation and its interrelationship with emergency management overall, this Hazard Mitigation Plan provides an overview of several hazards that are non-natural and pose a threat to the state, the region and individual municipalities. This section of the regional Hazard Mitigation Plan is intended to complement the state's Hazard Mitigation Plan. Strategies will not be provided for addressing these hazards at the regional and local levels. MEMA and the communities maintain Comprehensive Emergency Management Plan s (CEMPs), as well as other documents that outline the specific response and mitigation associated with non-natural disasters, crime, and other emergencies.

According to the *National Preparedness Report* published by the Department of Homeland Security (DHS) in March 2012, the Nation's preparedness capabilities have improved considerably since 9/11. Areas of overall strength include:

- Planning: All hazards planning considers routine emergencies and catastrophic events, integrating local perspectives;
- Operational Coordination: The National Incident Management System (NIMS) provides a common doctrine for incident management;
- Intelligence and information sharing: A national network of fusion centers and Joint Terrorism Task Forces (JTTFs) brings together federal, state and local law enforcement, intelligence community, and other public safety officials and private sector partners;

- Environmental Response/Health and Safety: A diverse set of federal, state and local assets have the capabilities to address a wide range of routine and large-scale hazardous material and chemical, biological, radiological, nuclear, and explosive incidents;
- Mass Search and Rescue Operations: Federal, state and local resources comprise a comprehensive rescue network;
- Operational communication: Government partners have established communication capabilities tested through exercises and real events; and
- Public Health and Medical Services: A wide range of partners provide a responsive public health and medical network.

1. Public Health Emergencies and Hazards

A community or region may face serious illness due to a communicable disease which threatens to overwhelm the public health system. Infectious disease emergencies are extremely rare - while the Massachusetts Department of Public Health (MDPH) receives 10,000 case reports of infectious disease annually, only a small fraction are considered public health infectious disease emergencies. Health care providers, local boards of health, and the MDPH handle most infectious diseases routinely. However, when an infectious disease spreads undetected or undeterred through a community, especially an easily communicable disease with high morbidity and mortality, it is considered an emergency. The longer this type of disease goes unrecognized and untreated, the more severe the impact will be on human health and mortality.

Worldwide travel and the re-emergence of infectious diseases in more virulent forms may increase the rate of public health infectious disease emergencies in the future. The Massachusetts Department of Public Health is the primary agency responsible for the study, planning, isolation/quarantine and actions, surveillance, and reporting for all public health emergencies. Any cluster or outbreak of any unusual disease or illness must be reported to the local board of health (or to MDPH if the local board of health is not available). The H1N1 flu (also referred to as the swine flu) caused by a new virus first recognized in April of 2009, and was the most recent public health emergency. The H1N1 flu quickly spread to many parts of the world and was identified as a pandemic, or global outbreak impacting Massachusetts.

Bioterrorism is the intentional use of (or threat to use) biological agents including but not limited to: anthrax, botulism, brucellosis, cholera, pandemic influenza, plague, ricin, smallpox, tularemia, and viral hemorrhagic fevers.

2. Transportation Accidents

Transportation accidents can occur in any community. Automobile accidents occur with great frequency across the region, while rail accidents occur less frequently and are isolated to areas where active lines exist. Aircraft accidents occur with the least frequency but have the potential to affect the region, given current flight paths and patterns for local and regional airports.

NMCOG has an ongoing safety program aimed at identifying, reducing and mitigating motor vehicle crashes within the region. Using crash data collected by MassDOT and the Registry of Motor Vehicles, the top 100 most hazardous intersections within the region were identified. Over a three-year period extending from 2008-2010, a total of 19,485 crashes were reported within the Northern Middlesex region. Table 33 provides a summary of the total crashes reported in each of the Northern Middlesex communities.

Table 33: Total Crashes by Community, 2008 – 2010

Community	Total Crashes	Roadway Miles	Crashes per Roadway Mile per year	Percent of Crashes for the Region
Billerica	1,782	449.74	1.3	9%
Chelmsford	1,967	449.63	1.5	10%
Dracut	1,346	301.28	1.5	7%
Dunstable	141	62.55	0.8	1%
Lowell	9,670	503.12	6.4	50%
Pepperell	621	144.64	1.4	3%
Tewksbury	1,943	293.41	2.2	10%
Tyngsborough	750	158.83	1.6	4%
Westford	1,265	333.2	1.3	6%
Total	**19,485**	**2,696.40**	**2.4**	100%

Source: MassDOT; Massachusetts Registry of Motor Vehicles

3. Nuclear Event

As described in the joint Nuclear Regulatory Commission and Federal Emergency Management Agency publication "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants" (NUREG-0654 REMA-REP-1 Rev.1), a radioactive plume released from a nuclear power plant consists of gaseous and/or particulate material. Three dominant modes of exposure have been identified from atmospheric releases: external whole body irradiation, inhalation, and ingestion. External whole body irradiation is direct exposure from gamma radiation in or from the plume. Internal exposure occurs primarily through the inhalation of airborne radioactive material in the plume or from breathing re-suspended material deposited from a passing plume. Ingestion is exposure to radiation following the consumption of contaminated food or water by mouth.

Exposure to radiation is measured on a dose equivalent basis. Dose equivalent (or effective dose) combines the amount of radiation absorbed and the medical effects of that type of radiation. For beta and gamma radiation, the dose equivalent is the same as the absorbed dose. By contrast, the dose equivalent is larger than the absorbed dose for alpha and neutron radiation, because these types of radiation are more damaging to the human body. Units for dose equivalent are the roentgen equivalent man (rem) and sievert (Sv), and biological dose equivalents are commonly measured in 1/1000th of a rem (known as a millirem or mrem). [18] Linear no-threshold (LNT) dose-response relationship is used to describe the relationship between radiation dose and the occurrence of cancer. This dose-response model suggests that any increase in dose, no matter how small, results in an incremental increase in risk. The U.S. Nuclear Regulatory Commission (NRC) accepts the LNT hypothesis as a conservative model for estimating radiation risk. The greater the dose received the greater the potential for biological effect. However, it is impossible to predict precisely how an individual will respond to a particular dose, as effects will vary from one person to another.

[18] http://www.nrc.gov/about-nrc/radiation/health-effects/measuring-radiation.html

The average annual whole body dose equivalent from all natural sources of radiation in the U.S. is estimated to be approximately 360 millirems. This dose results from exposure to cosmic and terrestrial radiation sources and radiation from internally deposited radio nuclides. Additionally, the use of x-rays and radioactive materials in medicine and dentistry add to overall population doses.

Radiation effects can be classified in two categories, early or delayed, but these categories are not mutually exclusive. Early acute effects of radiation exposure generally occur within 90 days from exposure, and may include fatalities, symptoms of acute radiation syndrome, or clinically detectable changes in blood and chromosomes. However, emergency protective actions can be taken to prevent or minimize these effects. Delayed effects of radiation exposure (i.e., biological effects that can only be observed on a statistical basis) could occur in some members of a population that has been exposed to radioactive materials. The effects may include fatalities or disabilities of anatomical or genetic origin.

The Nuclear Regulatory Commission (NRC) and the Environment Protection Agency (EPA) utilize the emergency planning zone (EPZ) concept. EPZs are designated areas for which plans are prepared to ensure that prompt and effective actions can be taken to protect the public in the event of an incident at a nuclear power plant. There are three EPZs that impact Massachusetts. The Pilgrim Nuclear Power Station located in Plymouth and operated by Entergy Nuclear Northeast is the only nuclear power generation facility located within the borders of Massachusetts. Two other licensed facilities are located just over the border from Massachusetts. These include the Vermont Yankee Nuclear Power Station (Vermont Yankee) located in Vernon, Vermont, and operated by Entergy Nuclear Northeast; and Seabrook Nuclear Power Station, located in Seabrook, New Hampshire, and operated by NextEra Energy.

Within the Northern Middlesex region, the University of Massachusetts Lowell (UML) operates a small nuclear reactor that is utilized for educational purposes. The UML Nuclear Reactor is water cooled and operates at a maximum power level of one megawatt. It is used primarily for training and research in the fields of nuclear science, radiochemistry and engineering. The reactor is housed in a containment building which is part of the UML Radiation Laboratory.

Radiation sources at the University of Massachusetts Lowell (UML) are regulated by the U.S. Nuclear Regulatory Commission (NRC) and the Commonwealth of Massachusetts Department of Public Health (DPH). Through these agencies, the University has been granted three broad scope licenses to manage its campus radiation safety program. As part of the requirements of the broad scope licenses, the University is required to appoint a Radiation Safety Committee (RSC) and a Radiation Safety Officer (RSO) to develop and manage the university radiation safety program. This program is subject to periodic audits by the NRC and DPH to verify regulatory compliance and to ensure the safety of university personnel and members of the public.

4. Infrastructure Failure

Infrastructure failure includes technological emergencies that result in an interruption or loss of a utility service, power source, life support system, information system or equipment needed to keep the businesses in operation. Examples include:

- Utilities such as electric power, gas, water, hydraulics, compressed air, municipal sewer systems, water treatment plants, and wastewater treatment plants;
- Security and alarm systems, elevators, lighting, life support systems, heating, ventilation and air conditioning systems, and electrical distribution systems;
- Manufacturing equipment and pollution control equipment;
- Communication systems, both data and voice computer networks; and
- Transportation systems including air, highway, railroad and waterways.

Technological emergencies have the potential to occur in every community. Communities with limited infrastructure are more vulnerable to experiencing an incident because of the lack of redundant systems. Communities should consider mitigation measures such as installing emergency generators, burying cable, installing back-up systems, and undertaking vegetation management and pruning to help reduce risks.

The New York Blackout of 2003, the December 2008 Ice Storm and the October 2011 Snowstorm resulted in widespread power outages of up to five days in duration. These outages significantly impacted the delivery of services, the regional economy, and the quality of life for the region's residents.

5. Commodity Shortages

Commodities are goods that are in demand in an emergency, such as food, fuel and medicine. For example, petroleum shortages in Massachusetts may be caused by natural disasters in the Commonwealth itself or in those parts of the world which supply petroleum. The shortage may be created by geopolitical events such as revolutions, embargoes, or war, or by economic factors that drive up prices or reduce available supply.

Petroleum Shortages

Massachusetts is particularly vulnerable to petroleum shortages during the winter months due to a combination of high demand for home heating oil and severe weather that may impact regional distribution mechanisms. Massachusetts and New England in general are logistically isolated from major U.S. refineries and pipelines, and depend on imports, chiefly by water, from domestic and foreign sources.

Historically, there have been several events that have impacted the price and availability of petroleum. The Arab Oil Embargo in 1973 led to increased fuel prices and rationing throughout the United States. In 1979, the Iranian Revolution caused a steep decline in that country's oil exports, which in turn caused a spike in fuel prices in the United States. Severe weather in January and February of 2000 not only increased demand in Massachusetts, but limited supply as weather conditions slowed the docking and unloading of barges and tankers. In 2005, Hurricane Katrina shut down refineries and oil rigs in the Gulf of Mexico, leading to price spikes in Massachusetts due to limited supplies. In the summer of 2008, oil prices skyrocketed to almost $150 per barrel, creating concern that residents would have difficulty affording the oil needed to heat their homes in winter.

The Regional Strategic Plan for Greater Lowell calls for policies that will result in reducing fossil fuel use in buildings, power generation, and transportation. The use of renewable energy sources would help to reduce greenhouse gas emissions, manage energy costs, and reduce reliance on fossil fuels, thereby creating a sustainable energy future for the region. Increased reliance on local solar, wind and geothermal energy sources would provide a buffer against the fluctuations in supply and prices of traditional fossil fuel markets.

Natural Gas Shortages

Natural gas shortages may be caused by a natural disaster, disruptions to pipelines and other facilities which transport natural gas, geopolitical events such as revolutions, embargoes or war, or by economic factors that drive up prices or reduce available supply. New England receives 80% of its natural gas supply from the Gulf Coast, western Canada, and eastern Canada via interstate pipelines. Liquefied natural gas (LNG) is also imported through the Distrigas facility in Everett. LNG presently meets 20 to 25% of New England's demand, spiking to 30% in winter months. Concern for natural gas supply reliability is almost exclusively confined to the winter months when demand for natural gas for space heating increases. During the three winter months, interstate pipelines feeding Massachusetts operate at over 90% of capacity.[19] Nearly half of all homes in Massachusetts are heated with natural gas.

Severe winter weather can cause increased demand for natural gas for heating and electric power generation, along with delays of over-the road transportation of LNG to satellite facilities. Hurricanes in the Gulf of Mexico may shut down or damage natural gas infrastructure in that area. Intensely cold weather in January 1981, combined with disruptions in the supply of liquefied natural gas created by storm off the coast of Algeria which disrupted tanker shipments, caused the Governor to declare an energy emergency in Massachusetts. Schools heated by natural gas were closed, non-residential buildings were ordered to lower thermostats to 55 degrees, and residential customers were urged to lower their thermostats by ten degrees.

Electricity Shortage

Electricity shortage may be caused by a sudden increase in demand due to weather conditions, a shortfall in generating capacity, or by power issues in neighboring regions that decrease available electricity reserves. An electricity shortage is distinguished from a power failure in that the electric transmission infrastructure has suffered little or no damage.

All areas are vulnerable to electricity shortages. Shorter-duration heat waves (2-3 days) may cause demand surges, generator stresses/outages, and transmission problems. A prolonged heat wave may lead to electricity supply problems, rolling blackouts, and health and safety risks if priority users cannot be supplied with power. Electricity problems in neighboring power pools may deplete available electricity reserves, leading to supply problems if conditions in New England deteriorate.

[19] 2010 State Hazard Mitigation Plan, Massachusetts Emergency Agency, p. 95.

Disruptions in the supply of natural gas or petroleum may impact generating capacity in the region. Disruptions to generation plants or key transmission lines due to natural disasters, mechanical failure, or deliberate action may reduce the supply of electricity. Most electricity in Massachusetts is produced by gas- or oil-fired power plants, with coal-fired plants accounting for about 25% of net electricity production. National Grid is the delivery company for the region.

6. Food Contamination / Foodborne Illnesses

Foodborne illnesses are caused by more than two hundred different pathogens, including viruses, bacteria, parasites, toxins, chemical contaminants, and metals. Symptoms of foodborne illness range from mild stomach upset to life-threatening neurological conditions, liver and kidney syndromes, or even death. All communities are vulnerable to foodborne illness. According to the Centers for Disease Control (CDC), there are approximately 76 million cases per year of illness from foodborne agents, including about 325,000 hospitalizations and 5,000 deaths.[20] Most cases of foodborne illness are natural or accidental in nature, but deliberate contamination of food for financial gain or as an act of terrorism is possible.

In addition to illnesses and deaths, food contamination can cause significant economic impact to the food industry through the effects of recalls and decreased consumer confidence. Changes in demographics and consumption patterns have increased susceptibility to food-borne pathogens and contamination. Approximately 25% of the population is in a high-risk category from foodborne illness (e.g. young, elderly, pregnant, immune compromised). Furthermore, people are increasingly consuming ready-to-eat and prepared foods, and these "convenience foods" are at higher risk of cross-contamination from other foods and/or from food workers. Consumers are also eating a greater variety of foods year-round, particularly those consumed raw or with minimal processing, which are often associated with foodborne illness. In addition, a greater proportion of foods are imported now than in the past, some of which come from countries with less well-developed food safety systems.

In September 2011, Colorado's state health department reported to CDC an outbreak of listeriosis. From August to October, the outbreak reached 28 states, and 146 cases of invasive listeriosis were confirmed and reported to public health officials. Ultimately, thirty patients died. The outbreak made national headlines as the deadliest outbreak of foodborne illness since 1924.

7. Water Contamination / Waterborne Illnesses

Water supplies in the region may be contaminated by pathogens, such as *E. coli* or *Giardia*, or by chemicals from stormwater runoff or point sources such as industrial sources or storm sewers. Infants, young children, the elderly, pregnant women, and the immune compromised are particularly vulnerable to water contamination and waterborne illness. There is also an economic impact if public water supplies are unusable for extended periods, as businesses which rely on these supplies must remain closed and bottled water is substantially more expensive per gallon than tap water.

[20] Ibid.

When water supply contamination is suspected, boil water orders are issued by MassDEP to local public water suppliers, who in turn issue advisories to their consumers advising them that they should boil their tap water for drinking and other human-consumption uses like cooking, hand washing, brushing teeth, etc. Boil water orders are preventative measures issued to protect public health from waterborne infectious agents that could be or are known to be present in drinking water. When a boil order is issued by MassDEP to the local public water supplier (PWS), the PWS must take appropriate corrective action, notify/advise its customers, continue to monitor its water supply, and notify customers when it has remedied the problem and the boil water order is lifted.

8. Chemical/Hazardous Materials

Chemical agents are poisonous vapors, aerosols, liquids, and solids that have a toxic effect on people, animals, or plants. Such agents can be released by accident, by bombs or sprayed from aircraft, boats, and vehicles. They can have an immediate effect (a few seconds to a few minutes) or a delayed effect (2 to 48 hours). While potentially lethal, chemical agents are difficult to deliver in lethal concentrations. Outdoors, the agents often dissipate rapidly. Chemical agents also are difficult to produce. A chemical attack could come without warning. Symptoms of a chemical release include difficulty breathing, eye irritation, a loss of coordination, nausea, or burning sensation in the nose, throat, and lungs. The presence of many dead insects or birds may also indicate a chemical agent release.

Chemicals are found throughout our communities. They are used to purify drinking water, increase crop production, and simplify household chores. But chemicals can be hazardous to humans or the environment if used or released improperly. Hazards can occur during production, storage, transportation, use, or disposal processes. Hazardous materials come in the form of explosives, flammable and combustible substances, poisons, and radioactive materials. These substances are most often released as a result of transportation accidents or because of chemical accidents at industrial plants. A hazardous material spill or release can pose a risk to life, health or property. An incident can result in the evacuation of a few people, a section of a facility or an entire neighborhood.

There are a number of Federal laws that regulate hazardous materials, including: the Superfund Amendments and Reauthorization Act of 1986 (SARA), the Resource Conservation and Recovery Act of 1976 (RCRA), the Hazardous Materials Transportation Act (HMTA), the Occupational Safety and Health Act (OSHA), the Toxic Substances Control Act (TSCA) and the Clean Air Act. Title III of SARA regulates the packaging, labeling, handling, storage and transportation of hazardous materials. The law requires facilities to furnish information about the quantities and health effects of materials used at the facility, and to promptly notify local and State officials whenever a significant release of hazardous materials occurs.

Communities with a large industrial base may be more likely to experience a hazardous materials release due to the number of facilities that use such materials in their manufacturing processes. Communities with major highways or rail corridors may also be at a greater risk due to the number of trucks or trains transporting hazardous materials.

9. Terrorism

Terrorism is the use of force or violence against persons or property in violation of the criminal laws of the United States for purposes of intimidation, coercion or ransom. Terrorists bypass established institutions (such as courts), using violence against citizens to force changes in society or to force governments to change policies in support of their cause. Terrorists might use weapons of mass destruction, such as toxic or poisonous chemicals, disease causing organisms, dangerous radiation, explosive, incendiary or poison gas bombs, grenades, rockets or missiles, mines or similar devices. Terrorists may also use traditional weapons such as automatic guns or grenades in armed attacks on targets.

The terrorist attacks of September 11, 2001 had a profound impact on the nation, the state and the region. A series of four suicide attacks were carried out by nineteen terrorists from the Islamist militant group al-Qaeda. The attacks involved the hijacking of four passenger jets. Two of the planes were flown into the towers of the World Trade Center in New York City, a third plane hit the Pentagon just outside Washington, D.C., and the fourth plane crashed in a field in Pennsylvania. The two passenger jets that struck the World Trade Center, American Airlines Flight 11 and United Airlines Flight 175, originated from Logan Airport in Boston. Following this attack, a presidential disaster declaration was made that provided $1.5 million in FEMA Individual Household Program funds for Massachusetts residents who requested crisis counseling.

Depending on the severity and type of a terrorist attack, many things can impact a community or the region overall:

- There could be casualties;
- Significant damage to buildings and the community’s infrastructure;
- Health and mental health resources in the affected communities could be strained to the limit or overwhelmed;
- There could be heavy involvement of law enforcement at local, state and federal levels, due to the event's criminal nature;
- Evacuation may be necessary;
- Workplaces and schools may be closed;
- There may be restrictions on domestic and international travel;
- Cleanup could take months; and
- Public fear could continue for a prolonged period.

High-risk targets for acts of terrorism include military and civilian government facilities, and high-profile landmarks. Terrorists might also target large public gatherings, water and food supplies, utilities, public transportation facilities and corporate centers.

Since 1995, MEMA has conducted multiple anti-terrorism programs, training thousands of local, state, and federal public safety officials, hospital emergency room personnel, and emergency management personnel, through classes in Anti-Terrorism, Incident Command, and Hazmat Awareness, including chemical-biological threats. To ensure adequate preparedness, MEMA has conducted hundreds of exercises in conjunction with local communities and other state and federal agencies.

The MEMA Planning Department works closely with communities to ensure that the all hazards Comprehensive Emergency Management Plans (CEMP) are current. These local plans include a Terrorism Annex, which helps local officials focus on specific potential terrorist threats to their particular community. The Massachusetts Statewide Anti-Terrorism Unified Response Network (SATURN) is an information sharing and first responder network created to enhance the existing public security delivery system. SATURN brings together fire, emergency management, and police personnel from each municipality, and provides a process for receiving and exchanging information during a terrorist threat.

The Commonwealth maintains a fusion center which is defined by the Global Justice Information Sharing Initiative as: “a collaborative effort of two or more agencies that provide resources, expertise, and/or information to the center with the goal of maximizing the ability to detect, prevent, apprehend and respond to criminal and terrorist activity.” The Commonwealth Fusion Center (CFC) operates around the clock and provides terrorist-related intelligence and public safety and security information to state, local and federal public safety interests. The CFC also serves as a clearinghouse for information and information requests between the state’s public and private safety and security entities, as well as DHS.

SECTION 5: COMMUNITY PROFILES, CRITICAL FACILITIES, AND RISK AND VULNERABILITY ASSESSMENTS

A. Natural Hazard Risks for the Northern Middlesex Communities

The natural hazard risks in each community are detailed in the following report sections. Each section provides information regarding flood prone areas, repetitive loss structures, structurally deficient bridges over waterways, and the hazard potential of local dams. A database containing information relative to critical facilities has also been developed for each municipality in the region. These facilities are vital to the delivery of key government services, and may significantly impact the public during a time of emergency or while recovering from an emergency. The primary sources of information relative to critical facilities were the Emergency Managers, and the Fire, Police and Public Works Departments within each municipality. During individual community meetings, the list of critical facilities was reviewed and updated to reflect the most current information. Several schools have been built and/or upgraded since completion of the 2006 Pre-Disaster Mitigation Plan. These upgraded facilities typically have emergency backup generators, and are therefore a good choice for emergency shelter locations.

The list of critical facilities inventoried for each community included the following:

a) emergency operations center
b) city or town offices
c) water and wastewater treatment plants
d) water pumping stations and tanks
e) municipal wells
f) sewage pumping stations
g) police and fire stations
h) schools and colleges
i) hospitals
j) daycare facilities with greater than 5 children
k) electric power substations
l) public works garages
m) nursing homes/elderly housing/senior centers
n) correctional facilities
o) emergency shelters
p) dams
q) power plants
r) access roads to all listed facilities
s) evacuation routes
t) bridges
u) communication facilities
v) nuclear sites
w) gas pipelines/storage sites
x) flood gates
y) transportation hubs
z) problem areas based on local knowledge

The critical facilities information is contained within a digital database which has been graphically displayed on maps for each community. The maps can be found in Appendix D of this document. A CD containing the electronic database files is included in Appendix E. In addition to providing information relative to critical facilities, each community was asked to identify areas that are of local concern or are known problems areas, although they may not currently be identified on state, regional, or even town-wide inventories.

Finally, a risk assessment was performed for each community, taking into consideration the historic occurrence of natural hazard events, and utilizing data available through the municipalities, MEMA and other sources. The risks identified by each individual community were averaged to quantify the overall risk to the region. Ratings were applied to each hazard based on frequency, severity, extent of impact, and probability as follows:

- Low – 1 point
- Medium – 2 points
- High – 3 points

The criteria for each category were weighted as follows:

- Frequency (weight factor = 2) is based on the record of previous occurrences.
  -Low: 0-1 event has occurred over the past 100 years
  -Medium: 2-3 events have occurred over the past 100 years
  -High: 4 or more events have occurred over the past 100 years

- Severity (weight factor = 5) is based on the percentage of population and property likely to be affected by the hazard under an average occurrence of the event.
  -Low: less than 1% affected
  -Medium: 1-10% affected
  -High: greater than 10% affected

- Extent of Impact (weight factor = 7) is the highest percentage if population and property that could be impacted under the worst case scenario.
  -Low: less than 5% affected
  -Medium: 5-25% affected
  -High: greater than 25% affected

- Probability (weight factor = 7) is the likelihood of future occurrence within a specified time period.
  -Low: one incident likely within 75 to 100 years
  -Medium: one incident likely within 26 to 74 years
  -High: one incident likely within the next 25 years.

Based on this methodology, scores may range from 24 to 75. With the exception of flooding, urban fire and dam failure, all of the region's communities are equally at risk for the remaining hazards.

B. Natural Hazard Risk Assessment for the Town of Billerica

Community Profile

The Town of Billerica covers a land area of 26.38 square miles, and has a resident population of 40,243 persons, according to the 2010 U.S. Census. The town's population density was 1,525.51 persons per square mile in 2010. Billerica's population increased 3.24% between 2000 and 2010, compared to a population increase of 2.02% for the Greater Lowell region overall. In 2010, the median age in Billerica was 40.1 years, with 25.3% of the resident population under the age of 20, 62.5% between the ages of 20 and 64, and 12.2% of the population was 65 years of age or older. Approximately, 2.46% of the population lives below the poverty line, according the 2010 American Community Survey.

There are 5,720 students enrolled in the Billerica public school system, which includes six elementary schools, two middle schools, and one high school, and there is one new school under construction. Billerica is also home to Shawsheen Valley Regional Technical School, which has an enrollment of 1,268 students.

One hundred percent of the town is served by the municipal drinking water supply which is drawn from the Concord River, and passes through the town's water treatment plant. The water system pumps approximately 4.7 million gallons per day (MGD). The Billerica Wastewater Treatment Facility treats wastewater from all homes, businesses, and industries connected to the sewer system in Billerica. The facility is located in the north end of town near the Concord River. It is a Grade 7 plant with a capacity of 5.4 million gallons per day (MGD) and an average flow of 4.0 MGD.[21] The plant operates 24-hours-a-day, every day of the year and currently serves 75% of the town's population.

In 2010, there were 14,481 housing units in the town, with the average housing unit sheltering 2.78 persons. There is an average of 548.94 housing units per square mile.[22] Forty percent (40%) of the town's land is used for residential housing, eight percent of the land is in commercial and industrial use, three percent (3%) is used for agriculture, forty-three (43%) percent is in open space, recreation, or water use, and four percent (4%) is used for transportation, mining, or waste disposal. The Town of Billerica has twice the acreage zoned for industrial use as any community in the region.

There are 151 public safety personnel in Billerica, including 66 uniformed police officers, 73 fire fighters and 12 EMS personnel.[23] In addition, the town has an emergency civil defense force comprised of volunteers who are under the direction of the Emergency Management Division. The Force acts as an auxiliary police force and receives emergency management, emergency response, and some police training.

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[21] http://www.billericadpw.org/divisions_wastewater.asp
[22] 2010 U.S. Census
[23] *NMCOG Feasibility Study for a Regional Emergency Communications Center*, Final Report, December 2011, Page 7.

Critical Facilities

The most recent CEMP on file with the MEMA for the Town of Billerica is dated 2009. The list of critical care facilities has been extracted from that document and updated based on input received from the Town during the development of this Plan. This listing includes emergency operations centers, health care facilities and shelters. Map 8 in Appendix D shows the location of all critical facilities in the Town of Billerica. Table 34 below provides information concerning the Town's Emergency Operations Center, health care facilities and shelters.

Table 34: Emergency Operations Center, Health Care Facilities and Shelters – Billerica

Facility Type	Common Name	Street Address	Health Facility Type	Average Daily Patient Capacity	Capacity	Feeding Capability	Emergency Generator Available
Emergency Operations Center	Police Station	6 Good St.				No	Yes
Health Facilities	Life Care Center of the Merrimack Valley	80 Boston Road	Level		124	No	
	New England Pediatric Care	78 Boston Road	Level			No	
Shelters	Marshall Middle School	Floyd Street			1,400	Yes	Yes
	Ditson School	Cook Street			1,000	Yes	Yes
	Billerica Memorial High School	365 Boston Road			800	Yes	Yes

Hazard Risk Assessment

Using the methodology outlined on page 91, an assessment of hazard risk was performed based on frequency, severity, extent of impact and the probability of a future event. The result of the analysis is outlined in Table 35 on the following page.

Table 35: Billerica Hazard Risk Assessment

Hazard	**Frequency-** (Weight factor=2)	**Severity- (**Weight factor=5)	**Extent of Impact – (**Weight factor=10)	**Probability-** (weight factor=7)	**Total Score**
Flood	3x2=6	2x5=10	3x10=30	3x7=21	67
Wildfire	3x2=6	1x5=5	3x10=30	3x7=21	62
Urban Fire	2x2=4	1x5=5	2x10=20	2x7=14	43
Earthquake	3x2=6	3x5=15	3x10=30	2x7=14	65
Tornado	1x2=2	2x5=10	3x10=30	1x7=7	49
Dam Failure	1x2=2	1x5=5	2x10=20	1x7=7	34
Drought	2x2=4	3x5=15	3x10=30	1x7=7	56
Nor'easter/severe storm	3x2=6	3x5=15	3x10=30	3x7=21	72
Hurricane	3x3=9	3x5=15	3x10=30	3x7=21	75
Snowstorm/ blizzard	3x2=6	3x5=15	3x10=30	3x7=21	72
Landslide	1x2=2	1x5=5	1x10=10	1x7=7	24
Ice Storm	3x2=6	3x5=15	3x10=30	3x7=21	72
Ice Jam	1x2=2	1x5=5	1x10=10	1x7=7	24

Based on this analysis, Billerica is at a high risk for flooding, wildfire, earthquake, nor'easters, hurricanes, ice storms, snowstorms and blizzards. The town is at a moderate risk for urban fire and drought, and at low risk for ice jams, dam failure, and tornadoes.

Flood Prone Areas

The Concord and Shawsheen Rivers run in a south to north direction through Billerica. The Concord River flows 9.6 miles roughly through the geographic center of the town, while the Shawsheen River flows through the southeastern end of town. Historically, the western bank of the Concord River, between Route 4 and Route 3A, has been subject to flooding that affects residential development, especially in the area along Elsie Avenue. Due to the fact that the

Concord River generally has a broad, flat floodplain, it is relatively slow to respond to flood events. The Concord generally crests at flood stage (8 feet) up to three days after the related rain event has ceased. This allows some time to react; however, the River also tends to stay at flood stage for a long period of time. In the flood of 1955, the river remained at a flood elevation of 11.7 feet for eight days. In the flood of 1936, it stayed at flood elevations for fourteen days. In 1979, flood elevation reached 11.8 feet in the vicinity of the town's water treatment plant. The River has reached or exceeded the 10-year flood elevation of 11.4 feet almost every year since 1957.

The Shawsheen River passes through the southern portion of town. The banks of the river are bordered by wetlands which, for the most part, have prevented development in the floodplain. Unlike the Concord River, the Shawsheen River is quick to react to rain events. Floodwater velocities in the main channel exceed hazardous levels. The Army Corps of Engineers estimated that during the October 1962 storm, maximum velocities of the Shawsheen River approached four feet per second in the channel. These high velocities are hazardous to structures close to the river channel. More importantly, they have a greater capacity to break loose and carry ice and debris, which can clog bridge openings and result in higher flood crests upstream. In January 1979, and again in March 2010, flood levels exceeded the 100-year flood elevation. The latter storm resulted in numerous repetitive loss claims as indicated on page 82. At the peak of the 2006 flood, the river reached 8.94 feet. Flood stage on the Shawsheen River is seven feet.

During the 2010 flood, the town's wastewater plant was overwhelmed causing overflows at some manholes. The Pinehurst section of town, near the intersection of Boston Road and Shawsheen Street, was hardest hit after the Shawsheen River overflowed. Several roads were closed, including Boston Road, Cook Street and Pinedale Avenue, and the Whipple Road Bridge was damaged.

Multiple tributaries flow into the Concord and Shawsheen Rivers. Major streams flowing into the Shawsheen include Jones Brook, Content Brook, Webb Brook, and McKee Brook. Mill Brook is the major tributary running into the Concord River. In addition, Lubber Brook, located in the eastern corner of Billerica, flows into the Ipswich River in Wilmington.


A duck swims across Elsie Avenue in Billerica during the March 2010 flood (photo by Yoon Byun)

Billerica's floodplain zoning prohibits buildings within the floodplain district, unless a special permit is granted by the Zoning Board of Appeals, as reviewed by the Board of Health and the Building Inspector. Approval is required for new fill or paving within the 100-year flood plain. The boundaries of the Flood Plain Districts are defined by adjusted borders of the 1973 Green Engineering Floodplain Index Map, and include any land shown in the 2010 Flood Insurance Rate Map. Beginning in 1990, a Board of Health regulation prohibited new construction within 100 feet of the 100-year floodplain without a variance. A permit from the Conservation Commission is also required for any activity in this area.

Repetitive Flood Loss Structures

Billerica has more repetitive loss structures than any other community in the region. It ranks eleventh in the state in terms of National Flood Insurance Program repetitive flood loss properties. Fifty (50) structures have experienced repetitive losses due to flooding (please see Table 14 on page 30). Figure 4 on the following page shows the number of flood losses experienced along both the Concord River and the Shawsheen River.

Flooding along Elsie Avenue in Billerica

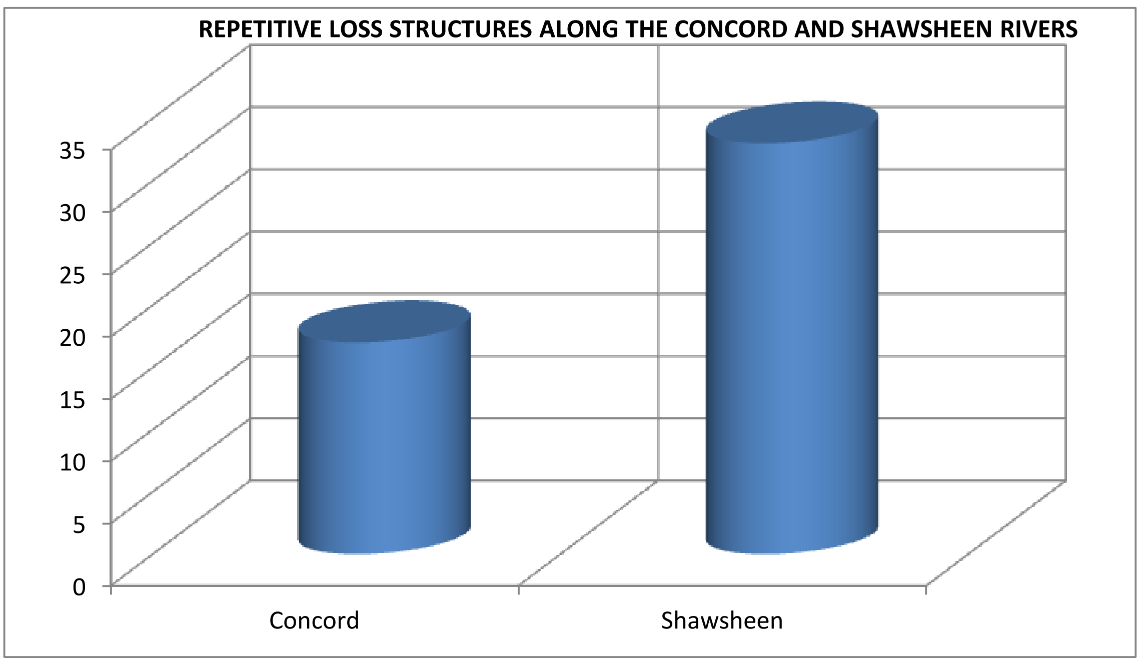


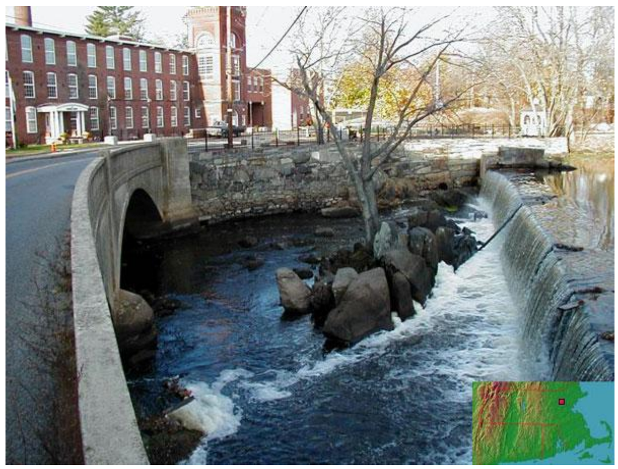
Figure 3

The National Flood Insurance Program (NFIP) has paid out $1,799,982 in repetitive flood loss claims in the Town of Billerica as of May 2013. Of the fifty properties that have suffered repetitive losses, seventeen (17) are in the Concord River watershed and thirty-three (33) are in the Shawsheen River watershed. Two of these are severe repetitive flood loss properties. The most vulnerable areas of the town are along the Shawsheen and Concord Rivers within the floodplain (please refer to Appendix D).

Structurally Deficient Bridges Over Waterways

Since completion of the 2006 Pre-Disaster Mitigation Plan, MassDOT has rehabilitated or replaced all structurally deficient bridges on the federal aid system within Billerica. While the Brown Street/Whipple Road Bridge is under local control, improvements were undertaken through a cooperative agreement with the towns of Billerica, Tewksbury and Wilmington, with funding assistance from MassDOT.

Hazard Potential of Dams



Talbot Dam, North Billerica

There are three dams in Billerica listed with the Massachusetts Department of Conservation and Recreation's (DCR) Office of Dam Safety. Detailed information concerning the characteristics and hazard classification of each dam is provided in Table 36 below. The dam on Winning Pond has not been inspected since 1992, according to the data provided by DCR.

Table 36: Hazard Classification of Billerica Dams

Dam Name	Impoundment Name	Hazard Class	Last Inspection Date	Next Inspection Due
Millbrook	Mill Brook	Low	4/30/2009	4/30/2019
Faulkner Mills/Talbot Dam	Concord River	Significant	5/22/2009	5/22/2014
Winning Pond	Winning Pond	Low	1/18/1982	1/18/1992*

Source: Massachusetts Department of Conservation and Recreation, Office of Dam Safety
* Dam inspection overdue.

Winter Storms (ice storms, snowstorms, nor'easters)

As stated in this Plan previously, severe winter storms can produce a wide variety of hazardous weather conditions, including heavy snow, freezing rain, sleet, and extreme wind and cold. A severe winter storm is one that results in four or more inches of snow over a twelve-hour period, or six or more inches over a twenty-four hour period. The leading cause of death during winter storms is from an automobile or other transportation accident. Exhaustion or heart attacks caused by overexertion are the second most likely cause of winter storm-related deaths. Billerica, like the rest of the region, is at risk for winter storms.

Since 1983, the most significant winter snowfall in the region occurred during the winter of 1995, when snowfall measurements in the City of Lowell reached 126.5 inches. Snowfall totals in Billerica were similar, however the Town does not maintain its own records. During the Halloween Snowstorm of 2011 (10/29-11/03), the Billerica Police Department communication center answered 365 9-1-1 calls and another 5,503 business line calls. Since many hardwood trees were still retaining their leaves, the wet snow added a tremendous amount of weight to the branches. For many trees in town, it was too much to bear and many split and fell and brought wires and utility poles down with them. The end result was a widespread power outage affecting over 80% of Billerica's National Grid customers. This power outage was so widespread that National Grid needed to mobilize hundreds of line crews from out of state to restore power. In many cases, this restoration process took several days.

Recovery from a winter storm poses a number of challenges. Prolonged curtailment of all forms of transportation can have significant adverse impacts for people stranded at home, preventing the delivery of critical services such home heating fuel supplies or the ability to get to a local food store. Extended power outages, the cost of snow removal, repairing damages, and the loss of business can have severe economic impacts on local communities. The elderly and infirmed are populations of particular concern during these events. The map in Appendix D shows the nursing facilities and senior housing locations within the town.

Hurricanes

Hurricanes can occur along the East Coast of the United States anytime in the period between June and November. Hurricane force winds can destroy buildings and mobile homes. Debris, such as signs, roofing materials, siding and lawn furniture, can become missiles. Hurricanes can also spawn tornadoes that generally occur in thunderstorms embedded in rain bands well away from the center of the hurricane. Tornadoes can also occur near the eye wall. Heavy rain associated with the storm may cause flooding. Flooding events in Billerica tend to be most severe along the Concord and Shawsheen Rivers.

The most recent hurricane to affect the region and the town was Hurricane Irene in August 2011, which became a tropical storm as it passed over the region. Irene caused localized flooding and knocked out power for thousands of local residents. Although heavy rains associated with hurricanes present the highest recurrent risk, high winds are also a risk. Downed trees and tree limbs, blocked roads, and downed telephone and power lines can disrupt transportation routes and communication channels. It is impossible to predict where these things might occur during a hurricane event, therefore the entire town is considered to be equally vulnerable. The areas vulnerable to flooding have been discussed above. Table 19 on page 41 contains a list of hurricanes that have hit New England over the past decades. The entire Northern Middlesex region is equally impacted by these events.

Wildfire

A wildfire is an uncontrolled fire that spreads due to the presence of vegetative fuel. These fires often begin unnoticed and spread quickly. In this area of the country, wildfire season generally begins in March and ends in late November. Human beings start four out of every five wildfires through arson or carelessness; lightning strikes account for the remainder. Over a three-year period, over five hundred brush fires were reported in the Town of Billerica. The area surrounding the Manning State Forest is vulnerable, as it is one of the most heavily forested areas of the town. This facility is managed by the Massachusetts Department of Conservation and Recreation (DCR), and is located in the north section of town. Other areas prone to such fires include the Pan Am/MBTA railroad rights-of-way and the area along the Route 3 corridor.

On June 2, 2013, Billerica firefighters battled both fire and heat exhaustion after a brush fire near Iron Horse Park spread to a nearby building, the *Lowell Sun* reported. The fire broke out around 5 p.m. near the park, with high winds spreading the blaze. With temperatures in the 90s, keeping the firefighters in their heavy suits from overextending themselves in the heat was quickly a concern. Billerica Deputy Fire Chief Tom Ferraro stated that the collapsed building was an old storage building for the railroad, owned by Pan Am Railways.

Earthquake

In New England the immediate cause of most earthquakes is the sudden release of stress along a fault or fracture in the earth’s crust. Much of the research on earthquakes in the northeast has involved attempts to identify pre-existing faults and other geological features that may be susceptible to such stress, but this has proven to be quite difficult. It is unclear whether faults mapped at the earth’s surface in the northeast are the same faults along which earthquakes are occurring. It is impossible to predict the time and location of future earthquakes in New England. There is a 1 in 10 chance that in any given fifty-year period a potentially damaging earthquake will occur.

From 1924 to 1989 there were eight earthquakes with a magnitude of 4.2 or greater in New England. According to the Weston Observatory, the last earthquake to hit the New England Region with a magnitude of 3.0 or greater occurred on September 26, 2010, in the area of Contoocook, New Hampshire. New England experiences 30-40 earthquakes each year, although most are not felt.

The area’s vulnerability to a devastating earthquake is based primarily on the following elements: the density of the population in the region, and the age of the region’s buildings and lack of earthquake proof design. In the Town of Billerica, concentrations of older buildings can be found in the North Billerica Historic District and in the area around the Town Center, although older buildings can also be found throughout other areas of town.

C. Natural Hazard Risk Assessment for the Town of Chelmsford

Community Profile

The Town of Chelmsford covers a land area of 23.28 square miles and has a population of 33,802 persons, according to the 2010 U.S. Census. Just over sixteen percent (16%) of the town's population is 65 years of age or older. Approximately four percent (4%) of the town's residents live below the poverty level, according to the 2005-2009 American Community Survey.

There are approximately 5,211 students enrolled in the public school system, which includes five elementary schools, two middle schools, and one high school. Ninety-five percent of the town is served by a public drinking water supply. Drinking water comes from groundwater wells and is distributed by three independent water districts – the Chelmsford Water District, the North Chelmsford Water District, and the East Chelmsford Water District. Approximately, 95% of the Town is served by one of the three water districts. Nearly 100% of the Town is served by sewer, which is treated at the Greater Lowell Wastewater Treatment Facility.

There are 13,807 housing units in town, with the average housing unit sheltering 2.45 people. Forty-seven percent of the town's land is used for residential housing, six percent is in commercial and industrial use, four percent is used for agriculture, 39 percent is in open space, recreation, or water use, and five percent is used for transportation, mining, or waste disposal. Since 1999, there has been almost no change in land use within Chelmsford, which can be attributed to the slowing economy and the nearly built-out nature of the community.

There are 111 public safety personnel in Chelmsford, including 49 uniformed police officers and 62 fire fighters.[24]

Critical Care Facilities

The list of critical care facilities includes emergency operation centers, health care facilities and shelters. It has been extracted from the Town's CEMP, and was updated based on input received from the Town during the development of this Plan. This information is shown in Table 37 on the following page. Map 9, contained in Appendix D, shows the location of all critical facilities in the community.

[24] *NMCOG Feasibility Study for a Regional Emergency Communications Center*, Final Report, December 2011, Page 10.

Table 37: Emergency Operations, Health Care Facilities and Shelters – Chelmsford							
Facility Type	**Common Name**	**Street Address**	**Health Facility Type**	**Average Daily Patient Capacity**	**Capacity**	**Feeding Capability**	**Emergency Generator Available**
Emergency Operations Center	Police Headquarters (Primary)	North Road				No	Yes
	Town Offices (Secondary)	50 Billerica Road				No	Yes (7-days fuel)
Health Facilities	Harvard Pilgrim Health Plan	228 Billerica Road	General	50		No	No
	Lowell General Hospital Surgical Center	10 Research Place					
	Chelmsford Walk-in	Parkhurst Road	General	25		No	No
	Palm Manor Nursing	Parkhurst Road	Level III	85		No	No
	Sunny Acres Nursing	254 Billerica Road	Levels I-IV	75		No	No
Shelters	McCarthy Middle School	250 North Road			400	Yes	Yes
	Chelmsford High School	200 Richardson Road			800	Yes	Yes
	Parker Jr. High School	75 Graniteville Road			200	Yes	Yes
	Byam School	25 Maple Road			200	Yes	Yes
	South Row School	250 Boston Road			150	Yes	Yes
	Town Hall	One North Road			150	Yes	No
	Town Offices	50 Billerica Road			200	No	Yes
	Senior Citizen Center	75 Groton Road			500	Yes	Yes
	St. John's Church	Middlesex Street			250	Yes	No
	St. Mary's Church	North Road			250	Yes	No
	North Chelmsford Congregational Church	Princeton Street			150	Yes	No
	Central Congregational Church	Worthen Street			200	Yes	No

Areas with Limited Access or of Local Concern

One area of concern was identified during the project meetings with Chelmsford town staff and officials. Emergency access to the Williamsburg Condominium complex, located off Route 3A in the northern area town, is limited by two at-grade railroad crossings which carry an active freight line. The complex has an estimated population of 2,500 residents, and much of the area lies within the floodplain of the Merrimack River. Freight trains that use the rail line on a regular basis are often 100 or more cars in length. During normal train travel, emergency vehicle access to the Williamsburg area can be blocked for critical periods of time. Complete stoppage of a train along the line for extensive periods of time is possible during extreme weather events, or as a result of damage to the rail line. There is a secondary gravel access road to this area but the roadway has fallen into disrepair. In addition, the bank of the Merrimack River in this area is eroding. Bank stabilization is needed to protect nearby homes that are located in the floodplain.

Hazard Risk Assessment

Using the methodology outlined on page 91 an assessment of hazard risk was performed based on frequency, severity, extent of impact and the probability of a future event. The result of the analysis is outlined in Table 38 on the following page.

Table 38: Chelmsford Hazard Risk Assessment

Hazard	**Frequency-** (Weight factor=2)	**Severity-** **(**Weight factor=5)	**Extent of Impact – (**Weight factor=10)	**Probability-** (weight factor=7)	**Total Score**
Flood	3x2=6	2x5=10	3x10=30	3x7=21	67
Wildfire	3x2=6	1x5=5	3x10=30	3x7=21	62
Urban Fire	2x2=4	1x5=5	2x10=20	2x7=14	43
Earthquake	3x2=6	3x5=15	3x10=30	2x7=14	65
Tornado	1x2=2	2x5=10	3x10=30	1x7=7	49
Dam Failure	1x2=2	1x5=5	1x10=10	1x7=7	24
Drought	2x2=4	3x5=15	3x10=30	1x7=7	56
Nor’easter/severe storm	3x2=6	3x5=15	3x10=30	3x7=21	72
Hurricane	3x3=9	3x5=15	3x10=30	3x7=21	75

Snowstorm/ blizzard	3x2=6	3x5=15	3x10=30	3x7=21	72
Landslide	1x2=2	1x5=5	1x10=10	1x7=7	24
Ice Storm	3x2=6	3x5=15	3x10=30	3x7=21	72
Ice Jam	1x2=2	1x5=5	1x10=10	1x7=7	24

Based on this analysis, Chelmsford is at a high risk for flooding, wildfire, earthquake, nor'easters, hurricanes, ice storms, snowstorms and blizzards. The town is at a moderate risk for urban fire and drought and at low risk for ice jams, dam failure, and tornadoes.

Flood Prone Areas

Chelmsford has an extensive hydrological system that includes groundwater, wetlands and surface water. Surface water accounts for 2.3% (328 acres) of the town's area. The town also contains 1,379 acres of wetlands and floodplain, accounting for nearly 9.3% of the town's total land area.[25] The Town is located within the Merrimack River basin, and falls within two sub-watersheds: the Merrimack and the Sudbury, Assabet and Concord (SuAsCo). The Merrimack River forms a portion of Chelmsford's northern border, and the Concord River runs 2/3 of a mile along its eastern border. Eleven named streams run through Town including Beaver Brook, Stony Brook, Crooked Spring Brook, Scotty Hollow Brook, Farley Brook, Putnam Brook, Black Brook, Hales Brook, Cold Spring Brook and River Meadow Brook.

Stony Brook is a tributary of the Merrimack River located in the north end of town. It has a 100-year flood plain that extends back from its confluence with the Merrimack River and under Route 3. River Meadow Brook runs south to north, draining much of the eastern third of the town, and has several tributaries that flow into it from the west. There is flood plain throughout large portions of River Meadow Brook's watershed, much of it extending upstream from where it crosses under Interstate 495.

Flood zones are located adjacent to the rivers, streams, and wetlands within Town, many of which were flooded during the Mother's Day in 2006 and Patriot's Day Storms of 2007. In addition, there were other areas of localized flooding caused by heavy rains in the spring of 2010. The Town has reported recurrent flooding problems along Tyngsborough Road (Route 3A) in North Chelmsford when the Merrimack River is at flood stage. In 2006, Dunshire Avenue also flooded. During past years, this flooding has been severe enough to require closure of the roadway along with Butterfield and Sleeper Streets for days at a time. These are the most vulnerable areas of Chelmsford, in terms of flooding. The Town also has concerns that access to the sewer pump station located on Wotton Street could become blocked during a severe flooding event.

[25] *Chelmsford Master Plan, Vision Quest 2020*, Town of Chelmsford and Northern Middlesex Council of Governments, October 2010, p.259.

During the May 2006 flood, which followed a week of precipitation that dumped over a foot of rain on the Merrimack Valley, a half mile of Tyngsborough Road in Chelmsford was closed. At 81 Tyngsborough Road, the Mobil gas station was forced to close after flood waters caused the station's tanks to leak gasoline. Workers were forced to cap the tanks to prevent further environmental damage. East of Tyngsborough Road residents of Sleeper and Butterfield Streets were evacuated by boat. Gas service to several homes on Dunshire Drive was also shut off. The gauging station on the Merrimack River recorded 59.7 feet, approximately 10 feet over flood stage. In 2010, Route 110 was closed from Chelmsford Center to Hunt Road due to flooding of an adjacent brook that washed out 15 feet of roadway.

Stony Brook has a 100-year floodplain that extends back from its confluence with the Merrimack River and under Route 3. There is also significant floodplain throughout a large portion of the River Meadow Brook watershed, much of it extending upstream from where it crosses I-495. In 2002, the River Meadow Brook floodplain elevation was increased from 106 feet to 108 feet through the FEMA amendment process.

According to the town's 2010 Open Space and Recreation Plan Update, several other areas have reportedly been observed to flood regularly during storm events or after an extended period of heavy rain:

- Littleton Road, west of Chelmsford Center;
- Turnpike Road at River Meadow Brook;
- Portions of Southwell Park near the Merrimack River;
- High Street at Beaver Brook;
- Warren Avenue at River Meadow Brook;
- Crooked Spring Road and Meadowbrook Road; and
- Meadowbrook Road at Stony Brook.

Initially adopted in 1997, Chelmsford's Floodplain Overlay District is similar to that of other communities across the Commonwealth. It includes all areas within the 100-year floodplain and floodways, as shown in the Flood Insurance Rate Maps. The 100-year flood zones are Special Flood Hazard Areas (SFHA), with a 1% annual chance of flooding. All development in the district, including structural and non-structural activities, whether permitted by right or special permit, must be in compliance with M.G.L. c.131, §40. The Zoning Board of Appeals can grant a special permit for new construction in the floodplain, as long as the applicant demonstrates that a proposed project conforms to the State Building Code and provides an engineer's certification that it will not increase the flood levels during the 100-year flood.

The Town enacted a local wetlands bylaw in 1996, and the bylaw was updated in 2009 to strengthen areas of jurisdiction and setbacks. The purpose of Chapter 187 is to "protect the wetlands, water resources, flood prone areas, and adjoining uplands...by controlling activities deemed by the Conservation Commission as likely to have a significant or cumulative effect on Resource Area values, including but not limited to the following: public or private water supply, groundwater supply, flood control, erosion and sedimentation control, storm damage prevention, water quality, prevention and control of water pollution, fisheries, fresh water shellfisheries, wildlife habitat, rare species habitat, agriculture, aquaculture, recreation and aesthetic values deemed important to the community". The local wetlands bylaw includes a 50-foot no build zone, a 30-foot no impervious surface restriction, and a 25-foot no-disturbance zone.

Repetitive Flood Loss Structures

There seven (7) repetitive flood loss properties in the Town of Chelmsford and two of these are severe repetitive flood loss properties, as shown on Table 14 on page 30. All of the repetitive flood loss properties in Chelmsford are single-family homes. As of May 2013, the National Flood Insurance Program paid out $344,702 for twenty-two (22) claims. The most vulnerable locations in town for flooding are along the Merrimack River.

Town Programs to Address Stormwater, Flooding and Drainage Issues

The town currently maintains drainage swales, retention and detention basins, culverts and ponds within its jurisdiction. The town has a dredging permit for this purpose and regularly sweeps street, empties catch basins, cleans inlet screens, and cleans blocked culverts as a flood prevention measure.

NFIP Compliance

Chelmsford participates in the NFIP and has an NFIP compliant floodplain bylaw (Chapter 195, Article XV). The Town participates in training opportunities provided by MEMA and FEMA, and work with neighboring communities during major storm events or other natural disasters.

Structurally Deficient Bridges Over Waterways

There are no structurally deficient bridges over waterways in Chelmsford.

Hazard Potential of Dams

There are seven dams located within the Town of Chelmsford. None are classified as high hazard dams but inspections are overdue for two of the dams: the Stony Brook Dam and the Russell Mill Pond Dam. Since completion of the last Plan, the Town has worked with DCR to reclassify the Swain Pond Dam, Crooked Spring Dam and Heart Pond Dam as "Non-jurisdictional". The hazard classification for each dam is provided in Table 39 below.

Table 39: Hazard Classification of Chelmsford Dams

Dam Name	Impoundment Name	Hazard Class**	Downstream Population	Last Inspection Date	Next Inspection Due
Stony Brook Dam***	Stony Brook	Significant	500	3/31/1998	3/31/2003*
Crooked Spring Dam	Crooked Spring Pond	Non-jurisdictional	NA		
Lowell Sportsman's	Scotty Hollow Brook	Non-jurisdictional	NA		

Table 39: Hazard Classification of Chelmsford Dams					
Dam Name	**Impoundment Name**	**Hazard Class****	**Downstream Population**	**Last Inspection Date**	**Next Inspection Due**
Club Dam***					
Swain Pond Dam	Swains Pond	Non-jurisdictional	NA		
Heart Pond Dam	Heart Pond	Non-jurisdictional	NA		
Russell Mill Pond Dam***	Russell Mill Pond	Significant	300	3/31/1998	3/31/2003*
Freeman Lake Dam	Freeman Lake	Significant	200	1/19/2012	1/19/2017

Source: Massachusetts of Conservation and Recreation, Office of Dam Safety
* Dam inspection overdue.
**Non-jurisdictional dams are not regulated by Office of Dam Safety
*** These dams are not owned or operated by the Town of Chelmsford

Winter Storms (ice storms, snowstorms, nor'easters)

As stated in this Plan previously, severe winter storms can produce a wide variety of hazardous weather conditions, including heavy snow, freezing rain, sleet, and extreme wind and cold. A severe winter storm is one that results in four or more inches of snow over a twelve-hour period, or six or more inches over a twenty four-hour period. The leading cause of death during winter storms is from an automobile or other transportation accident. Exhaustion or heart attacks caused by overexertion are the second most likely cause of winter storm-related deaths. Chelmsford, like the rest of the region, is at risk for winter storms.

Since 1983, the most significant winter snowfall in the region occurred during the winter of 1995, when snowfall measurements in the City of Lowell reached 126.5 inches. Snowfall totals in Chelmsford were similar, however the Town does not maintain its own records.

Recovery from a winter storm poses a number of challenges. Prolonged curtailment of all forms of transportation can have significant adverse impacts for people stranded at home, preventing the delivery of critical services such home heating fuel supplies or the ability to get to a local food store. Extended power outages, the cost of snow removal, repairing damages, and the loss of business can have severe economic impacts on local communities. The elderly and infirmed are populations of particular concern during these events. The map in Appendix D shows the nursing facilities and senior housing within the town. Residents residing in the mobile home park located on Route 110 are also vulnerable due to the weight of snow and the possibility of roof collapses.

Hurricanes

Hurricanes can occur along the East Coast of the United States anytime in the period between June and November. Hurricane force winds can destroy buildings and mobile homes. Debris, such as signs, roofing materials, siding and lawn furniture can become missiles. Hurricanes can also spawn tornadoes that generally occur in thunderstorms embedded in rain bands well away from the center of the hurricane. Tornadoes can also occur near the eye wall. Heavy rain associated with the storm may cause flooding. Flooding events in Chelmsford tend to be most severe along the Merrimack River.

The most recent hurricane to affect the region and the town was Hurricane Irene in August 2011, which became a tropical storm as it passed over the region. Although heavy rains associated with hurricanes present the highest recurrent risk, high winds are also a risk. Downed trees and tree limbs, blocked roads, and downed telephone and power lines can disrupt transportation routes and communication channels. It is impossible to predict where these things might occur during a hurricane event, therefore the entire town is considered to be vulnerable. Given the likelihood of high winds, residents in the mobile home park on Route 110 are considered to be particularly vulnerable. The Town appropriates capital funds each year to have a certified arborist remove any hazardous tree limbs in order to protect property and prevent injuries.

Table 19 on page 41 contains a list of hurricanes that have hit New England over the past decades. The entire Northern Middlesex region is equally impacted by these events.

Wildfire

A wildfire is an uncontrolled fire that spreads due to the presence of vegetative fuel. These fires often begin unnoticed and spread quickly. In this area of the country, wildfire season generally begins in March and ends in late November. Human beings start four out of every five wildfires through arson or carelessness; lightning strikes account for the remainder. Over a three year period, over 325 brush fires were reported in the Town of Chelmsford. The area surrounding the Thanksgiving Forest is vulnerable, as it is one of the most heavily forested areas of the town.

The Chelmsford Fire Department has identified the following open space and forested parcels as areas of potential risk:

Private Areas

- Sportsman Club, Swain Road - 51.50 acres
- Kent Farm, Elm Street - 31 acres
- Visnewski Land, Concord Road -17.25 acres
- Bridge Street Realty Trust - 13.72 acres
- Hennessy Misty Meadow - 41.16 acres
- Chelmsford Swim & Tennis, Robin Hill Rd - 17.30 acres
- Russell Mill Swim & Tennis, Mill Road - 10.60 acres

Water District Properties inclusive of pump station sites

- Center Water District - 255.41 acres
- North Water District - 53.75 acres
- East Water District - 32.93 acres

Conservation Commission properties

- Crooked Spring Reservation - 37.44 acres
- Lime Quarry - 64.37 acres
- Wright Reservation - 57.17 acres
- Bill Edge Deep Brook Reservation -15.67 acres
- Red Wing Farm - 12.56 acres
- Cranberry Bog (Chelmsford portion) - 180 acres
- Thanksgiving Forest - 45.67 acres
- Greenwood Wildlife Reserve - Concord Rd 13.20 acres
- Russell Mill, 105 Mill Rd - 132 acres
- Town of Chelmsford Landfill - 16.76 acres

There is no specific data available detailing the greatest number of acres burned during a wildfire. The collective memory of the current Fire Department Command Staff places the amount in the 2-3 acre range. The Department has experienced brush fires in the Sportsman Club and in the Cranberry Bog recently.

Earthquake

In New England, the immediate cause of most earthquakes is the sudden release of stress along a fault or fracture in the earth's crust. Much of the research on earthquakes in the northeast has involved attempts to identify pre-existing faults and other geological features that may be susceptible to such stress, but this has proven to be quite difficult. It is unclear whether faults mapped at the earth's surface in the northeast are the same faults along which earthquakes are occurring. It is impossible to predict the time and location of future earthquakes in New England. There is a 1 in 10 chance that in any given fifty-year period a potentially damaging earthquake will occur.

From 1924to1989 there were eight earthquakes with a magnitude of 4.2 or greater in New England. According to the Weston Observatory, the last earthquake to hit the New England Region with a magnitude of 3.0 or greater occurred on September 26, 2010, in the area of Contoocook, New Hampshire. New England experiences 30-40 earthquakes each year, although most are not felt.

The area's vulnerability to a devastating earthquake is based primarily on the following elements: the density of the population in the region, and the age of the region's buildings and lack of earthquake-proof design. In the Town of Chelmsford, concentrations of older buildings can be found in the North Chelmsford and Vinal Square neighborhoods and in the area around the Town Center. Older buildings can also be found throughout other areas of town, for example the Old Chelmsford Garrison House, located off Route 110, dates back to 1691.

D. Natural Hazard Risk Assessment for the Town of Dracut

Community Profile

The Town of Dracut covers a land area of 21.36 square miles and has a population of 29,457 persons, according to the 2010 U.S. Census. Nearly sixteen percent (16) of the town's population is 65 years old or older. Approximately 2.95% of the population lives below the federal poverty line, according to the 2005-2009 American Community Survey. There are 11,351 housing units in the town, with the average housing unit sheltering 2.69 people.

There are approximately 3,953 students enrolled in the Dracut public school system, which includes four elementary schools, one junior high school, and one high school. Ninety percent of the town is on public drinking water supply distributed by the Dracut Water Supply District or Kenwood Water District. The Dracut Water Supply District serves the neighborhoods of Dracut Center, the Navy Yard, and Collinsville. The District's main well fields are located off Hildreth Street in Dracut and off Frost Road in Tyngsborough. The District also purchases water from the City of Lowell. The District supplies approximately 9,000 households, including about 1,000 residents in Tyngsborough. The Kenwood Water District distributes water to approximately 1,500 households in East Dracut. The Kenwood District has no water supply of its own but instead purchases water from the City of Lowell and the Town of Methuen.

The municipal sewer system services about 90% of the town. Existing sewered areas include most of Dracut Center, East Dracut, Collinsville, the Navy Yard, and the Peters Pond area. Discharge from the sewer system is either sent to the Greater Lowell Wastewater Utility or the Greater Lawrence Wastewater Facility. The sections of the community not served by public sewer utilize on-site septic systems.

Thirty-two percent of the town's land use is for residential housing, two percent is in commercial and industrial use, fourteen percent is used for agriculture, 46 percent is classified as open space, recreation, or water, and five percent is used for transportation, mining, or waste disposal.

There are 76 public safety personnel in Dracut, including 39 uniformed police officers and 37 fire fighters.

Critical Facilities

The list of critical care facilities, shown in Table 40 on the following page, has been extracted from the Town's CEMP and updated based on input received from the Town during the development of this Plan. Map 10, contained in Appendix D, shows the location of all critical facilities in the Town of Dracut.

Table 40: Emergency Operations Centers, Health Care Facilities, and Shelters - Dracut							
Facility Types	**Common Name**	**Street Address**	**Health Facility Type**	**Average Daily Patient Capacity**	**Capacity**	**Feeding Capability**	**Emergency Generator Available**
Emergency Operations Centers	Central Fire (Primary)	488 Pleasant Street				No	Yes
	Broadway Road (Route 113) Fire Station (Secondary)	Broadway Road (Route 113)				No	Yes
Fire Stations	Central Fire	488 Pleasant Street				No	Yes
	Station 2	15 Jones Avenue				No	Yes
	Station 3	1990 Lakeview Avenue				No	Yes
Police Stations	Police Station	110 Loon Hill Road				No	No
Shelters	Dracut Junior High School	1580 Lakeview Avenue			125	Yes	Yes
	Campbell School	1021 Methuen St			125	Yes	Yes
	Dracut Middle School	1560 Lakeview Avenue			150	Yes	Yes

Areas with Limited Access or of Local Concern

The risk of wildfire in the Lowell/Dracut/Tyngsborough State Forest, located in the southwest corner of Town, is of concern to fire and emergency management officials. There are several regional truck transfer facilities in the east end of town along Broadway Road (Route 113). The terminals generate a high volume of truck traffic that may carry significant quantities of hazardous cargo, but the transient nature of the traffic makes it difficult to quantify the risk.

Hazard Risk Assessment

Using the methodology outlined on page 91 an assessment of hazard risk was performed based on frequency, severity, extent of impact and the probability of a future event. The result of the analysis is outlined in Table 41 below.

Table 41: Dracut Hazard Risk Assessment

Hazard	**Frequency-** (Weight factor=2)	**Severity-** **(**Weight factor=5)	**Extent of Impact – (**Weight factor=10)	**Probability-** (weight factor=7)	**Total Score**
Flood	2x2=4	2x5=10	3x10=30	2x7=14	58
Wildfire	3x2=6	1x5=5	3x10=30	3x7=21	62
Urban Fire	2x2=4	1x5=5	2x10=20	2x7=14	43
Earthquake	3x2=6	3x5=15	3x10=30	2x7=14	65
Tornado	1x2=2	2x5=10	3x10=30	1x7=7	49
Dam Failure	1x2=2	1x5=5	2x10=20	1x7=7	34
Drought	2x2=4	3x5=15	3x10=30	1x7=7	56
Nor'easter/severe storm	3x2=6	3x5=15	3x10=30	3x7=21	72
Hurricane	3x3=9	3x5=15	3x10=30	3x7=21	75
Snowstorm/ blizzard	3x2=6	3x5=15	3x10=30	3x7=21	72
Landslide	1x2=2	1x5=5	1x10=10	1x7=7	24
Ice Storm	3x2=6	3x5=15	3x10=30	3x7=21	72
Ice Jam	1x2=2	1x5=5	1x10=10	1x7=7	24

Based on this analysis, Dracut is at high risk for wildfire, earthquake, nor'easters, hurricanes, ice storms, snowstorms and blizzards. The town is at a moderate risk for flooding, urban fire, and drought and at low risk for ice jams, dam failure and tornadoes.

Flood Prone Areas

The Merrimack River forms much of Dracut's southern border. The riverbank is relatively steep in this area and the floodplain is quite narrow. Other perennial streams in Dracut include Beaver Brook, Trout Brook, Richardson Brook, Bartlett Brook, Peppermint Brook, and Double Brook, all of which flow into the Merrimack River. Areas prone to flooding and identified in FEMA's Flood Insurance Rate Maps (FIRM) for the Town include:

- Peter's Pond and Cedar Pond Shorelines
- Bartlett Brook
- Richardson Brook
- Trout Brook
- Double Brook
- Shore of Lake Mascuppic, and
- Beaver Brook

During the 2006 flood, the E. Butterworth Mill on Lakeview Avenue sustained significant flood damage and water flooded the Lakeview Avenue Bridge when Beaver Brook topped its banks. During local meetings, the Town identified a section of Peabody Avenue and Lakeview Avenue as areas of concern. Flooding on Tennis Plaza Road is also particular concern for public safety, given that 303 condominiums and 69 single-family homes are accessed via this roadway. Flooding on Kelly Road has been severe enough to warrant evacuations. According to local officials, other areas where flooding has historically been reported include the following:

- Tennis Plaza Road, Vinal and Cook Streets
- Loon Hill Road
- Peters and Cedar Pond shorelines
- Lake Mascuppic shoreline
- Cricket Lane
- Bridge Street
- Nottingham Road and Dean Avenue

The Town also expressed concern over the lack of coordination between New Hampshire and Massachusetts government officials relative to dam releases upstream on Beaver Brook. Such releases have caused flooding in Dracut in the past.

Since completion of the 2006 Plan, the town has replaced or upgraded several culverts and drainage structures to reduce flash flooding problems. The following locations have been addressed: Varnum Road near Florence Street; Lakeview Avenue near Florence Street; Methuen Street near Stuart Avenue; Pleasant Street, Lakeview Avenue, and Burdette Road at Peppermint Brook; Cheever Avenue near Robbins Road, Salem Road and Loon Hill Road.

The Town has a Flood Plain and Floodway Overlay District in place that regulates land use in flood prone areas designated as A, A1-30, AE, AH, and A99 on the Flood Insurance Rate Maps (FIRM). In the interest of maintaining the flood storage capacity of floodplains and avoiding property damage, all new construction or earthmoving is prohibited in this district, except certain agricultural and conservation uses, repairs to pre-existing structures, and new structures that have been shown by an engineer not to be subject to flooding. The Conservation Commission also has jurisdiction in all flood plains. In addition, the town, in conjunction with the Northern Middlesex Council of Governments, has developed a draft Low Impact Development By-law that will be presented to Town Meeting in the future.

Repetitive Flood Loss Structures

As of May 2013, there were two repetitive loss structures in Dracut, one residential and one non-residential (see Table 14 on page 30). Four NFIP claims were paid out totaling $181,947.

The Town of Dracut has participated in the NFIP for many years. The Building Inspector is currently working on becoming a certified flood plain manager. The Town has taken steps to monitor and ensure compliance with the program through the permitting process. Information is available to the public at the Building Department regarding flood plain building regulations, flood insurance and code requirements. All foundations are inspected regardless of possible floodplain infringement, as part of the building permit process and checked for BFE compliance. The use of elevation certificates is required. Cause of submit to rate structure is addressed through the town bylaws. The FIRM is included in the Town's GIS mapping tool and is available online to assist builders, officials, citizens and developers.

Structurally Deficient Bridges Over Waterways

According to MassDOT, there are currently no structurally deficient bridges in the Town of Dracut.

Hazard Potential of Dams

There are four dams located within the Town of Dracut, all of which are overdue for inspection. Three of the dams are classified as a significant hazard. The hazard classification of each dam is detailed in Table 42 on the following page.

Table 42: Hazard Classification of Dracut Dams

Dam Name	Impoundment Name	Hazard Class**	Downstream Population	Last Inspection Date	Next Inspection Due
Old Tub & Dye Printing Works Dam	NA	Non-jurisdiction	NA		
Beaver Brook Dam / Collinsville Dam	Beaver Brook	Significant	500	4/30/1998	4/30/2003*
Peters Pond Dam	Peters Pond	Non-jurisdictional	NA		
Beaver Brook Dam)	Beaver Brook	Significant	250	3/30/1998	3/30/2003*

Source: Massachusetts Department of Conservation and Recreation, Office of Dam Safety

Winter Storms (ice storms, snowstorms, nor'easters)

As stated in this Plan previously, severe winter storms can produce a wide variety of hazardous weather conditions, including heavy snow, freezing rain, sleet, and extreme wind and cold. A severe winter storm is one that results in four or more inches of snow over a twelve-hour period, or six or more inches over a twenty four-hour period. The leading cause of death during winter storms is from an automobile or other transportation accidents. Exhaustion or heart attacks caused by overexertion are the second most likely cause of winter storm-related deaths. Dracut, like the rest of the region, is at risk for winter storms.

Since 1983, the most significant winter snowfall in the region occurred during the winter of 1995, when snowfall measurements in the City of Lowell reached 126.5 inches. Snowfall totals in Dracut were similar, however the Town does not maintain its own records.

Recovery from a winter storm poses a number of challenges. Prolonged curtailment of all forms of transportation can have significant adverse impacts for people stranded at home, preventing the delivery of critical services such home heating fuel supplies or the ability to get to a local food store. Extended power outages, the cost of snow removal, repairing damages, and the loss of business can have severe economic impacts on local communities. The elderly and infirmed are populations of particular concern during these events. The map in Appendix D shows the location of senior housing within the town.

Hurricanes

Hurricanes can occur along the East Coast of the United States anytime in the period between June and November. Hurricane force winds can destroy buildings and mobile homes. Debris, such as signs, roofing materials, siding and lawn furniture can become missiles. Hurricanes can also spawn tornadoes that generally occur in thunderstorms embedded in rain bands well away from the center of the hurricane. Tornadoes can also occur near the eye wall. Heavy rain associated with the storm may cause flooding. Dracut is at moderate risk for flooding and, as previously mentioned, the areas most prone to flooding include:

- Peter's Pond and Cedar Pond Shorelines
- Bartlett Brook
- Richardson Brook
- Trout Brook
- Double Brook
- Shore of Lake Mascuppic, and
- Beaver Brook

The most recent hurricane to affect the region and the town was Hurricane Irene in August 2011, which became a tropical storm as it passed over the region. Although heavy rains associated with hurricanes present the highest recurrent risk, high winds are also a risk. Downed trees and tree limbs, blocked roads, and downed telephone and power lines can disrupt transportation routes and communication channels. It is impossible to predict where these things might occur during a hurricane event, therefore the entire town is considered to be vulnerable. Table 19 on page 41 contains a list of hurricanes that have hit New England over the past ten decades. The entire Northern Middlesex region is equally impacted by these events.

Wildfire

A wildfire is an uncontrolled fire that spreads due to the presence of vegetative fuel. These fires often begin unnoticed and spread quickly. In this area of the country, wildfire season generally begins in March and ends in late November. Human beings start four out of every five wildfires through arson or carelessness; lightning strikes account for the remainder. Dracut averages about 80 brush fires per year. The area surrounding the Lowell-Dracut-Tyngsborough State Forest is vulnerable, as it is one of the most heavily forested areas of the town. This facility is managed by the Massachusetts Department of Conservation and Recreation (DCR). On July 5, 2012, Dracut firefighters responded to a brush fire in the State Forest which was brought under control and extinguished.

Earthquake

In New England, the immediate cause of most earthquakes is the sudden release of stress along a fault or fracture in the earth's crust. Much of the research on earthquakes in the northeast has involved attempts to identify pre-existing faults and other geological features that may be susceptible to such stress, but this has proven to be quite difficult. It is unclear whether faults mapped at the earth's surface in the northeast are the same faults along which earthquakes are occurring. It is impossible to predict the time and location of future earthquakes in New England. There is a 1 in 10 chance that in any given fifty-year period a potentially damaging earthquake will occur.

From 1924 to1989 there were eight earthquakes with a magnitude of 4.2 or greater in New England. According to the Weston Observatory, the last earthquake to hit the New England Region with a magnitude of 3.0 or greater occurred on September 26, 2010, in the area of Contoocook, New Hampshire. New England experiences 30-40 earthquakes each year, although most are not felt.

The area's vulnerability to a devastating earthquake is based primarily on two elements: the density of the population in the region, and the age of the region's buildings and lack of earthquake proof design. In the Town of Dracut concentrations of older buildings can be found in the Navy Yard area, the Town Center, and in East Dracut, although older buildings can also be found throughout other areas of town.

E. Natural Hazard Risk Assessment for the Town of Dunstable

Community Profile

The Town of Dunstable covers a land area of 16.7 square miles and has a population of 3,179 persons, according to the 2010 U.S. Census. Nearly ten percent (9.9%) of the town's population is 65 years of age or older. Approximately 5.27% of the population lives below the federal poverty level, according the 2005-2009 American Community Survey. There are 1,098 housing units in the town, with the average housing unit sheltering 2.89 persons.

There are 864 Dunstable students enrolled in the public school system. Dunstable is part of the Groton-Dunstable Regional School which includes two elementary schools, one middle school, and one high school. With the exception of the Swallow Union Elementary School, the school buildings are all located in Groton.

Five percent of the town is served by a public drinking water supply, using water pumped from the Salmon Brook aquifer. The average public water supply consumer uses 25,000 gallons per day. The remainder of the Town extracts its water from private wells. There is no public sewer system in Dunstable. All wastewater treatment is done through onsite septic systems. Most 2-acre lots must provide their own water source and their own wastewater treatment onsite.

Dunstable has numerous ponds, rivers, brooks, wetlands, aquifers and other groundwater resources. All water which falls on Dunstable eventually drains into the Merrimack River to the east of town. The town's drainage pattern, however, can be divided into three smaller watershed areas: 1) the Nashua River watershed, 2) the Salmon Brook watershed, and 3) the Eastern Upland watershed.

Eleven percent (11%) of the town’s land is used for residential housing; less than one percent of the land is in commercial and industrial use; twelve percent is used for agriculture; 74 percent is in open space, recreation, or water use; and two percent is used for transportation, mining, or waste disposal. There are 43 public safety personnel in Dunstable, including seven full-time and seven reserve uniformed police officers, 29 volunteer fire fighters and a part-time paid chief.

Critical Facilities

The list of critical care facilities, shown in Table 43 on the following page, has been extracted from the Town’s CEMP and updated based on input received from the Town during the development of this Plan. Map 11, contained in Appendix D, shows the location of all critical facilities in the Town of Dunstable.

Table 43: Emergency Operations Centers, Health Care Facilities and Shelters- Dunstable

Facility Type	Common Name	Street Address	Health Facility Type	Average Daily Patient Capacity	Capacity	Feeding Capability	Emergency Generator Available
Emergency Operations Centers	Police Station (Primary)	23 Pleasant Street	No	No			

Table 43: Emergency Operations Centers, Health Care Facilities and Shelters- Dunstable							
Facility Type	**Common Name**	**Street Address**	**Health Facility Type**	**Average Daily Patient Capacity**	**Capacity**	**Feeding Capability**	**Emergency Generator Available**
	Fire Station (Secondary)	28 Pleasant Street					
Fire Stations	Fire Station	28 Pleasant Street					
Police Station	Police Station	23 Pleasant Street					
Shelters	Swallow Union School	518 Main St.			200	Yes	No
	Dunstable Congregational Church	516 Main St			50	Yes	No
	Town Hall	511 Main Street			25	No	No

Areas with Limited Access or of Local Concern

Local officials have reported that the growing beaver population poses the greatest challenge for the community in terms of the worsening of existing flooding problems. The increased cost of hiring licensed trappers to deal with this problem is impacting the Town's budget, and its ability to respond in a timely fashion.

Hazard Risk Assessment

Using the methodology outlined on page 91 an assessment of hazard risk was performed based on frequency, severity, extent of impact and the probability of a future event. The result of the analysis is outlined in Table 44 on the following page.

Table 44: Dunstable Hazard Risk Assessment

Hazard	**Frequency-** (Weight factor=2)	**Severity-** **(**Weight factor=5)	**Extent of Impact –** **(**Weight factor=10)	**Probability-** (weight factor=7)	**Total Score**
Flood	1x2=2	1x5=5	2x10=20	2x7=14	41
Wildfire	3x2=6	1x5=5	3x10=30	3x7=21	62
Urban Fire	1x2=3	1x5=5	1x10=10	1x7=7	24
Earthquake	3x2=6	3x5=15	3x10=30	2x7=14	65
Tornado	1x2=2	2x5=10	3x10=30	1x7=7	49
Dam Failure	1x2=2	1x5=5	2x10=20	1x7=7	34
Drought	2x2=4	3x5=15	3x10=30	1x7=7	56
Nor'easter/severe storm	3x2=6	3x5=15	3x10=30	3x7=21	72
Hurricane	3x3=9	3x5=15	3x10=30	3x7=21	75
Snowstorm/ blizzard	3x2=6	3x5=15	3x10=30	3x7=21	72
Landslide	1x2=2	1x5=5	1x10=10	1x7=7	24
Ice Storm	3x2=6	3x5=15	3x10=30	3x7=21	72
Ice Jam	1x2=2	1x5=5	1x10=10	1x7=7	24

Based on this analysis, Dunstable is at high risk for wildfire, earthquake, nor'easters, hurricanes, ice storms, snowstorms and blizzards. The town is at a moderate risk for flooding, and drought and at low risk for ice jams, dam failure, landslides, urban fire and tornadoes.

Flood Prone Areas

The Nashua River forms the western boundary of the Town of Dunstable. Its embankments are relatively steep and no town roads cross or closely approach the River. Therefore, impacts on the Town are minimal when the River is at flood stage. The principal cause of flooding along the Nashua River is runoff from spring snowmelt. This melting is greatest during heavy spring rains, when the still frozen ground cannot absorb the runoff. The worst such storm was recorded in 1936, but flooding occurs yearly with varying severity. Hurricanes are also a source of flooding conditions, especially when accompanied by wet autumns, when the soil is already saturated. Severe storms of this nature occurred in 1938, 1954, and 1958.

Unkety Brook, a tributary to the Nashua River, is prone to flooding caused primarily by backwater from the Nashua. The brook itself has an extensive floodplain, however, there is no development located in the floodplain considered to be at risk.

Salmon Brook runs south to north through the geographic center of the Town. Its main tributaries in Dunstable are Joint Grass Brook, Hauk Brook, and Black Brook. The Brook is bordered by adjoining marshes and during flood stage no man-made structures are considered to be at risk.

The upland till area of Dunstable is drained by three intermittent streams which flow into Locust and Flint Ponds in Tyngsborough. Because soils in this watershed are generally slowly permeable, wetlands small in area, and slopes generally steep, water runoff characteristics are relatively fast. As the area develops, the impacts of heavy rain will be felt more quickly in this area than in the other watersheds. Because of this, and because soils in this area tend to be hardpan types with limitations for septic systems and complicated by slopes, protection strategies emphasized in the town's *2010 Open Space and Recreation Plan* include:

- Development controls which limit construction to hazard-free areas;
- Controls which regulate peak discharge of storm water; and
- Preservation of wetlands as natural storage basins and pollutant modifiers.

During meetings with local officials flooding problems were identified at the following locations:

- River Street: Repeatedly flooding has occurred in this location, even after replacing a problematic culvert on several occasions. The low profile of the roadway, along with beaver activity, has caused washouts of the roadway a few times. The local highway department is considering elevating the roadway in an attempt to rectify the problem.
- Main Street: Repeated flooding has occurred in the vicinity of Sweets Pond.
- Lowell and Forest Street: Local officials are concerned about potential flood problems that may impact new homes being constructed in this area.

The Town's *2010 Open Space and Recreation Plan* prioritizes the protection of the Nashua River watershed within Dunstable through:

- The protection of the river embankment and adjoining flood prone areas;
- Preservation and protection of those watershed characteristics which reduce flooding, especially of wetlands adjoining Unkety Brook and its tributaries; and
- Adoption of development controls which will modify peak runoff and lessen the danger of pollution.

Repetitive Flood Loss Structures

There are no repetitive flood loss structures in the Town of Dunstable.

Structurally Deficient Bridges Over Waterways

The Main Street Bridge over Salmon Brook is the only structurally deficient bridge in the community, with an AASHTO rating of 21.7, according to MassDOT. MassDOT is currently designing a bridge replacement for this location.

Hazard Potential of Dams

There are three dams located within the Town of Dunstable, one of which is overdue for inspection. The Massapoag Pond Dam is classified as a significant hazard, potentially impacting a downstream population of 200 persons. The hazard classification of each dam is detailed in Table 45 below.

Table 45: Hazard Classification of Dunstable Dams

Dam Name	Impoundment Name	Hazard Class	Downstream Population	Last Inspection Date	Next Inspection Due
Woodward's Mill/James Shaw Dam	Black Brook	Low	NA	1/28/2010	1/28/2020
Massapoag Pond Dam	Massapoag Pond	Significant	200	6/26/2007	6/26/2012
Joint Grass Brook Dam	Joint Grass Brook	Low	NA	5/2/2001	5/2/2011*

Source: Massachusetts Department of Conservation and Recreation, Office of Dam Safety
* Dam inspection overdue

Winter Storms (ice storms, snowstorms, nor'easters)

As stated in this Plan previously, severe winter storms can produce a wide variety of hazardous weather conditions, including heavy snow, freezing rain, sleet, and extreme wind and cold. A severe winter storm is one that results in four or more inches of snow over a twelve-hour period, or six or more inches over a twenty-four hour period. The leading cause of death during winter storms is from an automobile or other transportation accidents. Exhaustion or heart attacks caused by overexertion are the second most likely cause of winter storm-related deaths. Dunstable, like the rest of the region, is at risk for winter storms.

Since 1983, the most significant winter snowfall in the region occurred during the winter of 1995, when snowfall measurements in the City of Lowell reached 126.5 inches. Snowfall totals in Dunstable were similar, however the Town does not maintain its own records.

Recovery from a winter storm poses a number of challenges. Prolonged curtailment of all forms of transportation can have significant adverse impacts for people stranded at home, preventing the delivery of critical services such home heating fuel supplies or the ability to get to a local food store. Extended power outages, the cost of snow removal, and repairing damages, can have severe economic impacts on local communities. The elderly and infirmed are populations of particular concern during these events. Given its rural nature, there are no senior housing or medical facilities within Dunstable, however, most Dunstable residents are on private wells and have no access to drinking water during a power outage.

Hurricanes

Hurricanes can occur along the East Coast of the United States anytime in the period between June and November. Hurricane force winds can destroy buildings and mobile homes. Debris, such as signs, roofing materials, siding and lawn furniture can become missiles. Hurricanes can also spawn tornadoes that generally occur in thunderstorms embedded in rain bands well away from the center of the hurricane. Tornadoes can also occur near the eye wall. Heavy rain associated with the storm may cause flooding. Historically, flooding has occurred on River Street, Main Street (near Sweets Pond), Lowell Street and Forest Street.

The most recent hurricane to affect the region and the town was Hurricane Irene in August 2011, which became a tropical storm as it passed over the region. Although heavy rains associated with hurricanes present the highest recurrent risk, high winds are also a risk. Downed trees and tree limbs, blocked roads, and downed telephone and power lines can disrupt transportation routes and communication channels. It is impossible to predict where these things might occur during a hurricane event, therefore the entire town is considered to be vulnerable. Table 19 on page 41 contains a list of hurricanes that have hit New England over the past ten decades. The entire Northern Middlesex region is equally impacted by these events.

Wildfire

A wildfire is an uncontrolled fire that spreads due to the presence of vegetative fuel. These fires often begin unnoticed and spread quickly. In this area of the country, wildfire season generally begins in March and ends in late November. Human beings start four out of every five wildfires through arson or carelessness; lightning strikes account for the remainder. Over a three-year period, over 115 brush fires were reported in the Town of Dunstable. Given its rural nature, the entire community is considered to be vulnerable, given the abundance of forested areas.

Earthquake

In New England, the immediate cause of most earthquakes is the sudden release of stress along a fault or fracture in the earth's crust. Much of the research on earthquakes in the northeast has involved attempts to identify pre-existing faults and other geological features that may be susceptible to such stress, but this has proven to be quite difficult. It is unclear whether faults mapped at the earth's surface in the northeast are the same faults along which earthquakes are occurring. It is impossible to predict the time and location of future earthquakes in New England. There is a 1 in 10 chance that in any given fifty-year period a potentially damaging earthquake will occur.

From 1924 to1989 there were eight earthquakes with a magnitude of 4.2 or greater in New England. According to the Weston Observatory, the last earthquake to hit the New England Region with a magnitude of 3.0 or greater occurred on September 26, 2010, in the area of Contoocook, New Hampshire. New England experiences 30-40 earthquakes each year, although most are not felt.

The area's vulnerability to a devastating earthquake is based primarily on the following elements: the density of the population in the region, and the age of the region's buildings and lack of earthquake proof design. Dunstable is a rural community with a low population density, however, there a significant number of older buildings that can be found throughout the town.

F. Natural Hazard Risk Assessment for the City of Lowell

Community Profile

The City of Lowell covers a land area of 14.54 square miles, and has a population of 106,519 persons, according to the 2010 U.S. Census. Just over ten percent (10%) of the City's population is 65 years of age or older. There are 41,431 housing units in the City, with the average housing unit sheltering 2.57 persons. Approximately 17.67% of the City's population lives below the federal poverty level, according to the 2005-2009 American Community Survey.

There are approximately 13,421 students enrolled in the Lowell public school system, which includes twenty-six schools. In addition, total enrollment in the City's two charter schools, the Middlesex Academy Charter School and the Lowell Community Charter School, was 784 students in 2011. There are additional 2,842 student enrolled in eleven private schools within the City.[26]

Lowell sits at the confluence of the Merrimack and Concord Rivers. The Merrimack River flows easterly through the northern portion of the City and drops approximately sixty feet in its eight-mile course through the City. The three-mile stretch of the Pawtucket Falls accounts for 30 feet of the elevation drop. The Concord River flows northerly through Billerica and enters the Merrimack River near Bridge Street in the central business district of the City. The floodplain for the Concord River tends to be broad, and the river drops significantly in Lowell as evidenced by three sets of falls.

Surface water discharges to the Merrimack River and its tributaries results from both public and private sources. Recent survey data compiled by the Lowell Regional Wastewater Utility (LRWU) indicates that there are more than 300 stormwater outfalls in the city, not including those located along the canals. Fifty percent of Lowell's sewer pipes are part of a combined sewer and stormwater system. Approximately fifty percent of the system is also over one hundred years old. The LRWU is a secondary facility, which receives wastewater from Lowell, Chelmsford, Dracut and Tewksbury. The nine combined sewer overflow structures that regulate flow to the LRWU discharge excess stormwater flows directly to the Merrimack River and its tributaries.

[26] Lowell Master Plan Existing Conditions Report, 2011, City of Lowell Department of Planning and Development.

One hundred percent of the city is served by the municipal drinking water supply. Water is withdrawn from the Merrimack River and treated by the City's water treatment plant. The water system pumps an average of 15 million gallons per day (mgd) with a maximum capacity of 30 mgd. The utility also supplies water to the Dracut, Tyngsborough and Chelmsford on a daily basis, and to Tewksbury, North Chelmsford, and Chelmsford Center on an as-needed basis.

Forty-eight percent of the City's land use is used for residential housing; thirteen percent of the land is in commercial and industrial use; one percent is used for agriculture; 32 percent is in open space, recreation, or water use; and five percent is used for transportation, mining, or waste disposal.

There are 428 public safety personnel in Lowell, including 228 uniformed police officers and 200 fire fighters. The Fire Department operates nine fire stations throughout the City.

Critical Facilities

The list of critical care facilities for Lowell has been extracted from the City's CEMP and updated based on input received from City officials during the development of this Plan, as shown in Table 46 below. Critical care facilities include emergency operations centers, health care facilities, and shelters. Map 12, contained in Appendix D, shows the location of critical facilities in the City and has been reviewed by the appropriate department heads within City government for accuracy.

Table 46: Emergency Operations Centers, Health Care Facilities and Shelters– Lowell

Facility Type	Common Name	Street Address	Health Facility Type	Average Daily Patient Capacity	Capacity	Feeding Capability	Emergency Generator Available
Emergency Operations Centers	Police Station (Primary)	JFK Plaza				No	Yes
	Lowell Wastewater Treatment Plant (Secondary)	451 First Street (Lowell/Lawrence Boulevard – route 110)				No	Yes
	Portable EOC						
Health Facilities	Northwood Manor	1010 Varnum Avenue	Level II & III	134		No	No
	Lowell General Hospital	Varnum Avenue	General	200		No	No
	Saints Medical Center	Stackpole Street	General	200		No	No
	Walk-in Clinic	1230 Bridge Street	First Aid			No	No
	Highland Medical	660 Middlesex Street	First Aid			No	No

Table 46: Emergency Operations Centers, Health Care Facilities and Shelters– Lowell							
Facility Type	**Common Name**	**Street Address**	**Health Facility Type**	**Average Daily Patient Capacity**	**Capacity**	**Feeding Capability**	**Emergency Generator Available**
	Lowell Community Health Center	597 Merrimack Street	First Aid			No	No
	D'Youville Manor Nursing Home	Varnum Avenue	Level II & III	200		No	No
	Heritage Nursing Home	Merrimack Street	Level II & III	142		No	No
Shelters	Lowell High School	50 Father Morrisette Boulevard			1000	Yes	No
	Lowell Senior Center	Broadway Street			500	Yes	No
	Robinson School	110 June Street			800	Yes	No
	Rogers School	43 Highland Street			500	Yes	No
	Reilly School	115 Douglas School			1000	Yes	No
	Pawtucket Memorial School	West Meadow Road			700	Yes	No
	Pyne School	Boylston Street			500	Yes	No
	Lowell Memorial Auditorium	East Merrimack Street			2000	No	No
	UMass Lowell – North	University Avenue			1000	Yes	No
	UMass Lowell – South	Wilder Street			1000	Yes	No
	Lowell Catholic	530 Stevens Street			500	Yes	No
	Middlesex Community College	East Merrimack Street			500	No	No
	St. Joseph's Parish Hall	500 Merrimack Street			500	No	No
	St. Margaret's Parish Hall	500 Stevens Street			1000	No	No
	St. Michael's Parish Hall	537 Bridge Street			500	No	No
	St. Jeanne D'Arc Parish Hall	4th Avenue			600	No	No
	St. Patrick's Parish Hall	Suffolk Street			1000	No	No
	Sacred Heart Parish Hall	Moore Street			1000	No	No
	Immaculate Conception Parish Hall	East Merrimack Street			500	No	No

Areas with Limited Access or of Local Concern

The City of Lowell has a number of abandoned buildings that add to the risk of urban wildfires. The concentration of these buildings relative to each neighborhood is presently being analyzed in order to assess the risk potential. The City Fire Department is undertaking this analysis. Since 2007, the rising number of foreclosed and vacant properties has increased this risk.

Hazard Risk Assessment

Using the methodology outlined on page 91 an assessment of hazard risk was performed based on frequency, severity, extent of impact and the probability of a future event. The result of the analysis is outlined in Table 47 below.

Table 47: Lowell Hazard Risk Assessment

Hazard	**Frequency-** (Weight factor=2)	**Severity- (**Weight factor=5)	**Extent of Impact – (**Weight factor=10)	**Probability-** (weight factor=7)	**Total Score**
Flood	3x2=6	2x5=10	3x10=30	3x7=21	67
Wildfire	2x2=4	1x5=5	2x10=20	3x7=21	50
Urban Fire	3x2=6	1x5=5	3x10=30	3x7=21	62
Earthquake	3x2=6	3x5=15	3x10=30	2x7=14	65
Tornado	1x2=2	2x5=10	3x10=30	1x7=7	49
Dam Failure	1x2=2	1x5=5	2x10=20	1x7=7	34
Drought	2x2=4	3x5=15	3x10=30	1x7=7	56
Nor'easter/severe storm	3x2=6	3x5=15	3x10=30	3x7=21	72
Hurricane	3x3=9	3x5=15	3x10=30	3x7=21	75
Snowstorm/ blizzard	3x2=6	3x5=15	3x10=30	3x7=21	72
Landslide	1x2=2	1x5=5	1x10=10	1x7=7	24

Table 47 (cont'd): Lowell Hazard Risk Assessment

Hazard	**Frequency-** (Weight factor=2)	**Severity- (**Weight factor=5)	**Extent of Impact – (**Weight factor=10)	**Probability-** (weight factor=7)	**Total Score**
Ice Storm	3x2=6	3x5=15	3x10=30	3x7=21	72
Ice Jam	1x2=2	1x5=5	1x10=10	1x7=7	24

Based on this analysis, Lowell is at high risk for flooding, urban fire, earthquake, nor'easters, hurricanes, ice storms, snowstorms and blizzards. The City is at a moderate risk for wildfire, and drought, and at low risk for ice jams, dam failure, landslides, and tornadoes.

Flood Prone Areas

Lowell sits at the junction of two major rivers, the Concord and the Merrimack. The United States Geological Survey (USGS) maintains a gauge on the Merrimack River, just above the Hunts Falls Bridge. This gauge also accounts for water received from the Concord River, the major tributary to the Merrimack. Average flow at this site is 7,610 cubic feet per second.

Periodic flooding in Lowell has caused extensive property damage in some locations. As in many urban areas, Lowell's floodplains, which generally form a corridor along the waterways, have been built upon. This has exacerbated flooding problems, as wetlands that provide valuable flood storage have been filled to allow for development.

Flooding is a problem along the Concord River during heavy rain periods, and is also a problem along the northern banks of the Merrimack River near the water treatment plant. Other areas of chronic flooding include land around Black Brook and the Trull Brook tributary between Phoenix Avenue and Clark Road. There are several other areas that are located in the 100-year floodplain along major waterways within the City, including the Concord River, Marginal Brook, River Meadow Brook, Beaver Brook, and Clay Pit Brook.

The Wentworth Avenue/Douglas Road area includes a significant drainage area tributary to Trull Brook that has been the focus of several past studies. Major street flooding and sewer backup problems have occurred in the area behind the Wentworth Health Care Facility and along Douglas Road near the Janas Skating Rink. The City has reported 1-3 feet of flooding on these roadways during a significant storm. In addition, an adjacent marsh along Wentworth Avenue encroaches on the roadway during heavy rain events. The City has tried to reduce this impact by placing berms at the end of the street along the marsh, however, this approach has not been completely effective.

Flooding during May 2006 in Downtown Lowell

In 1980 and 1983, the City completed the *South Lowell Drainage and Sewer Facilities Study*. Problems in the area were evaluated by an outside consultant, and recommendations were made to help alleviate the flooding. These past reports noted that the existing drainage channels and culverts had significant sedimentation that filled the channels and reduced the overall drainage capacity. Major recommendations included dredging and re-channelization of the existing marshy areas between Phoenix Avenue and Wentworth Avenue, and between Douglas Road and Clark Road in Tewksbury.

Local flooding at the intersection of Gorham Street (Route 3A) and Moore Street during intense rainstorms is a common occurrence. Intense rain in the summer of 2003 filled the intersection with up to four feet of water. Gorham Street is a major evacuation route for the City. Other areas that have been identified by the City as being susceptible to flooding due to poor drainage include the following:

- Hadley and Pratt Streets;
- North of Princeton Street along Black Brook;
- The mouth of Black Brook;
- Area north of Varnum Avenue and east of Laurel Lane;
- Area south of Varnum Avenue and east of Lebanon Street;
- Area west of Bridge Street and North of Billings Street;
- The mouth of Marginal Brook;
- Area north of Cawley Stadium; and
- Area south of Hollis Avenue.

The City participates in FEMA's National Flood Insurance Program. The Flood Insurance Rate Map and the City profile map are used to determine if a property is within the floodplain. Section 9.1 of the Lowell Zoning Ordinance addresses development within the floodplain, covering all areas designated as Zone A, AO, AH, A1-30, AE, A99,VO,V1-30, VE or V. The precise boundaries are dictated by the 100-year flood elevation on the FIRM maps.

Sections 5 through 120 of the Municipal Code of Ordinances specifically state that no person, "shall remove, fill, dredge, alter or build upon or within 100 feet of any bank; upon or within 100 feet of any lake, river, pond, stream; upon or within any land under said waters; or upon any land subject to flooding or inundation by groundwater or surface water." During local meetings, some Conservation Commission members suggested that enforcement of this ordinance be improved, given that the City currently relies solely on reports and complaints by residents.

Pursuant to an EPA Administrative Order, the City prepared a Long-Term Control Plan in February 2002 that evaluated a range of alternatives to reduce the City's CSO discharges. Since 2001, the Greater Lowell Wastewater Utility has spent more than $90 million to implement Phase 1 of the Control Plan which focused on upgrades to: the treatment plant, the CSO diversion stations along the interceptor system, and the sewerage and drainage collection systems. These improvements have been necessary to separate sanitary wastewater and stormwater flows and relieve the existing interceptor system, which has in turn reduced street flooding and sewer surcharging.

The City owns and operates a flood protection system in the Centraville neighborhood. The Local Protection Project (LPP) for flood control was constructed by the US Army Corps of Engineers (USACE) in 1944, under the 1936 US Flood Control Act. The project was undertaken in response to the historic 1936 and 1938 flooding events that the devastated the City and other communities along the Merrimack River. After construction, the City was required to operate and maintain the LPP system.

As part of the LPP system, the USACE constructed a system of earthen levees and concrete I-walls along both Beaver Brook and the Merrimack River to protect low-lying areas of the Centralville Neighborhood. The earthen levee extends for about 2,700 feet along the River adjacent to the VFW Highway. There is also a 900-foot long I-wall near Bridge Street and a 790-foot I-wall near Beaver Street, as well as an 810-foot earthen levee along Beaver Brook. These structures were utilized in 2006 a 2007 floods to protect the area from high stream levels.

Lowell has made substantial improvements in its flood protection system in the past several years. In January 2007, the US Army Corps of Engineers completed an inspection and identified the following deficiencies that needed to be addressed in order to maintain an "active" status of the flood protection system:

- Removal of brush and trees from the earthen levees;
- Fortification of the levee and I-wall system; and
- Replacement of the inoperable West Street Flood Pump Station.

The City completed the brush and tree removal immediately, but the remaining improvements require significant funding.

Concurrent with the Lowell LPP ACOE report, FEMA revised the FIRM mapping for the area. Given that the USACE deemed the LPP "inactive", FEMA determined that the Centraville area behind the LPP was unprotected from flood hazards. Residents in this area are now required to obtain flood hazard insurance until the LPP can be recertified by USACE and FEMA.

The City is actively working to address levee stability and the pumping station. An engineering assessment that included field testing and computer modeling was completed that recommended fortification of the levee and I-wall along Beaver Brook. In the Spring 2011, the stability improvements were completed the along Beaver Brook portion of the LPP. Efforts are now underway to replace the West Street Flood Pumping Station.

Repetitive Flood Loss Structures

There have been repetitive flood losses along Black Brook and Clay Pit Brook. These losses are associated with floodwater backup into the tributaries from the Merrimack River. All of the losses have affected single-family homes. There are 24 repetitive flood loss properties within the City. As of May 2013, a total of $584,907 has been paid out by the National Flood Insurance Program for fifty-five (55) claims. All of the repetitive flood loss properties are residential (please see Table 14 on page 30).

In 2006, the City experienced significant flooding requiring evacuations in some areas, and requiring officials to find permanent housing for twenty evacuees. The Merrimack River reached 58.6 feet during this flood, although the record flood occurred in March 1936 when the river reached 68.4 feet. Many residents in the Beaver Brook area were also flooded out. The National Guard and local public safety officials canvassed 2,300 addresses within the floodplain to assess damage. In Lowell damages from the flood were estimated at $25 million, including damage to forty city streets and eight bridges. Approximately 400 homes sustained damage.

During the aftermath of the May 2006 flood, several infrastructure needs were identified that could help prevent such severe flooding in the future:

- Currently, the West Street CSO Station diverts to the Merrimack River by gravity only. A pump station is needed to assure that Lakeview Avenue does not flood when the height of the Merrimack River prevents gravity discharge from the station. These improvements are in progress.

- The Greater Lowell Wastewater Treatment Plant emergency effluent pumps could not pump all treated flows to the River during the height of the flood. Modifications to the effluent pumping station to allow direct pumping to the River could prevent river water from backing up into the plant and flooding the unit processes. Most of these modifications have been made.

- "Duck Bill Backflow" prevention valves on some CSO and stormwater outlets would prevent backflow from the River from inundating the pump stations, gravity division stations and local streets. These devices are needed at the Tilden and West Street CSO stations and at stormwater discharge lines on Sparks Street and Rosemont Street. Work on these improvements has been partially completed.

- Given the proximity of the Walker Street and Tilden Street CSO stations and the Rosemont Street Sewer Pump Station to the River and Beaver Brook, flood-proofing through the construction of berms/levees is needed to prevent flooding of these areas.

- A backflow prevention valve is needed at the Alma Street outfall pipe to prevent flood water from the Merrimack River and Beaver Brook from backing up into the neighborhood via the stormwater drainage pipe.

- The existing Merrimack River Erosion/Flood Control Walls along the Merrimack River in Pawtucketville and along Pawtucket Street need to be repaired, reconstructed and elevated. These walls, which are designed to hold the riverbanks and prevent erosion due to flooding, have deteriorated substantially as a result of recent flood events. Repair is needed over approximately 3,300 linear feet on the south side of the river and 9,300 linear feet on the north side. Reconstruction may entail increasing the height of these walls to prevent flooding of adjacent properties and roadways. The City is currently awaiting the completion of a study on the flood walls.

NFIP Compliance

The City has participated in the NFIP since 1974. Since that time, the City staff has taken advantage of training opportunities provided by MEMA. To improve compliance with NFIP, the City adopted a Wetlands Ordinance in 2003 which was amended in 2012. A Floodplain Overlay District was incorporated in 1991 and amended in 2010. The City has continued to provide NFIP information to its residents.

Building foundations are inspected before framing to ensure that the lowest floor is at or above base elevation (BFE). This is coordinated through the issuance of building permits and through the Conservation Commission's approval process. Elevation certificates are required for LOMA applications and all work proposed on jurisdictional area of the Wetlands Protection Act. The City staff provides guidance to property owners regarding this process. City staff has provided information to neighborhood organizations on the NFIP program and have reviewed FIRM with interested residents and property owners.

In 2011, DCR's Office of Water Resources conducted a Community Assistance Visit to monitor community floodplain management programs. In 2012, the City coordinated with the NFIP Region I office to incorporate the 2012 revisions of the NFIP Flood Insurance Manual.

Structurally Deficient Bridges Over Waterways

Presently, there are five bridges in Lowell considered by MassDOT to be structurally deficient, as show in Table 48 on the following page. The two bridges that are considered to be the most structurally deficient are: (1) the bridge over Beaver Brook on the V.F.W. Highway, with an AASHTO rating of 21.0, and (2) the Western Canal Bridge on Market Street, with an AASHTO rating of 31.2. The rehabilitation of both bridges is currently under design. The Route 38 Bridge over the Merrimack River was recently reconstructed. In addition, construction work on the replacement structure for the University Avenue Bridge was completed in November 2013. MassDOT has initiated design work for reconstruction of the Bridge Street Bridge over the Eastern Canal.

Table 48: Structurally Deficient Bridges in Lowell

Community	Roadway	Water Body	Owner	Year Built/ Rebuilt	Status	AASHTO Rating
Lowell	Bridge St.	Eastern Canal	MassDOT	1937	Preliminary design	49.2
Lowell	Lawrence St.	Concord River	City of Lowell	1850/1951	No activity	51.1
Lowell	VFW Parkway	Beaver Brook	MassDOT	1949	Under Construction	19.0
Lowell	Market St.	Western Canal	City of Lowell	1920	Preliminary design	31.2
Lowell	Beaver St.	Beaver Brook	City of Lowell	1971	Local responsibility	53.1

Source: MassDOT 2013

Hazard Potential of Dams

There are nine dams located within the City of Lowell, all of which are overdue for inspection. Five of the dams are classified as a significant or high hazard, potentially impacting downstream populations. The hazard classification of each dam is detailed in Table 49 below.

Table 49: Hazard Classification of Lowell Dams

Dam Name	Impoundment Name	Hazard Class	Downstream Population	Last Inspection Date	Next Inspection Due
Guard Locks**	Pawtucket Canal	Significant	400	6/1/2006	6/1/2011*
Northern Canal Head Gates**	Northern Canal	Significant	8,000	6/1/2006	6/1/2011*
Lower Locks Dam**	Pawtucket Canal	Low	200	6/1/2006	6/1/2011*
Swamp Locks Dam**	Upper Pawtucket Canal	Significant	500	6/1/2006	6/1/2011*
Pawtucket/ Great Dam**	Merrimack River	Significant	6,000	9/21/2000	9/21/2005*
Lowell Reservoir Dam	Lowell Reservoir	High	400	8/25/2009	8/25/2010*

Table 49: Hazard Classification of Lowell Dams					
Dam Name	**Impoundment Name**	**Hazard Class**	**Downstream Population**	**Last Inspection Date**	**Next Inspection Due**
Middlesex*** Dam	Concord River	Non-jurisdictional	1,000		
Wamesit Power Company / Centennial Island Dam**	Concord River	Low	750	8/30/1999	8/20/2009*
Hickey Hall Structure***	Western Canal	Non-jurisdictional	NA		

Source: Massachusetts Department of Conservation and Recreation, Office of Dam Safety
* Dam inspection overdue
** Federal Energy Regulatory Commission (FERC) Regulated Dam
***Non-jurisdictional dams are not regulated by Office of Dam Safety

The possible replacement of the Pawtucket Dam flashboard system with an inflatable crest gate system has been approved by FERC. The U.S. Department of Interior has filed a legal appeal of the approval based on the impacts to the Pawtucket Dam which is an historic structure located within the Lowell National Historical Park. The dam is also listed in the Historic Engineering Record and is a designated National Landmark.

Aftermath of a January 2011 snowstorm in Lowell

Winter Storms (ice storms, snowstorms, nor'easters)

As stated in this Plan previously, severe winter storms can produce a wide variety of hazardous weather conditions, including heavy snow, freezing rain, sleet, and extreme wind and cold. A severe winter storm is one that results in four or more inches of snow over a twelve-hour period, or six or more inches over a twenty-four hour period. The leading cause of death during winter storms is from an automobile or other transportation accidents. Exhaustion or heart attacks caused by overexertion are the second most likely cause of winter storm-related deaths. Lowell, like the rest of the region, is at risk for winter storms.

Since 1983, the most significant winter snowfall in the region occurred during the winter of 1995, when snowfall measurements in the City of Lowell reached 126.5 inches. Recovery from a winter storm poses a number of challenges. Prolonged curtailment of all forms of transportation can have significant adverse impacts for people stranded at home, preventing the delivery of critical services such home heating fuel supplies or the ability to get to a local food store. The City of Lowell imposes an on-street parking ban during snow events and often removes snow within the downtown area and at major intersections to address public safety concerns.

Extended power outages, the cost of snow removal, repairing damages, and the loss of business can have severe economic impacts on local communities. The elderly and infirmed are populations of particular concern during these events. The map in Appendix D shows the location of senior housing and medical facilities (hospitals and nursing homes) within the City.

Hurricanes

Hurricanes can occur along the East Coast of the United States anytime in the period between June and November. Hurricane force winds can destroy buildings and mobile homes. Debris, such as signs, roofing materials, siding and lawn furniture can become missiles. Hurricanes can also spawn tornadoes that generally occur in thunderstorms embedded in rain bands well away from the center of the hurricane. Tornadoes can also occur near the eye wall. Heavy rain associated with the storm may cause flooding. As mentioned previously, the area along the Merrimack River is particularly vulnerable to flooding.

The most recent hurricane to affect the region and the city was Hurricane Irene in August 2011, which became a tropical storm as it passed over the region. Although heavy rains associated with hurricanes present the highest recurrent risk, high winds are also a risk. Downed trees and tree limbs, blocked roads, and downed telephone and power lines can disrupt transportation routes and communication channels. It is impossible to predict where these things might occur during a hurricane event, therefore the entire city is considered to be vulnerable. Electric utilities within the Downtown Historic District are underground, helping to prevent power outages in this area.

Table 19 on page 41 contains a list of hurricanes that have hit New England over the past ten decades. The entire Northern Middlesex region is equally impacted by these events.

Urban Fire

The probability of fire occurring increases with population growth and concentration, due to human error and carelessness, which are factors that contribute to urban fires. The elderly (aged 65 and older) tend to be more vulnerable to fires than any other age group. They also experience the highest number of deaths per fire. The second most vulnerable age group is those 14 years and younger. The City of Lowell is at high risk for urban fire due to the density of development.

For calendar year 2013, the City of Lowell reported 552 fires to the Massachusetts Fire Incident Reporting System (MFIRS). The 323 structure fires, 44 vehicle fires, and 160 other fires resulted in $4.8 million dollars in losses. While four people were injured, fortunately there was no loss of life. Tragically, seven people perished in an apartment fire in 2014. Generally, about 80% of building fires in Lowell occur in residential properties, with apartments accounting for most of the fires. The leading cause of residential building fires in Lowell is cooking, followed by smoking.

Many of Lowell's neighborhoods are very dense, and a significant portion of the housing stock is multi-family, of significant age and of wood construction. Many older structures lack sprinkler systems due to their age. Neighborhoods within the City most at risk include the Acre, South Lowell and Centralville, due to their dense nature.

Earthquake

In New England, the immediate cause of most earthquakes is the sudden release of stress along a fault or fracture in the earth's crust. Much of the research on earthquakes in the northeast has involved attempts to identify pre-existing faults and other geological features that may be susceptible to such stress, but this has proven to be quite difficult. It is unclear whether faults mapped at the earth's surface in the northeast are the same faults along which earthquakes are occurring. It is impossible to predict the time and location of future earthquakes in New England. There is a 1 in 10 chance that in any given fifty-year period a potentially damaging earthquake will occur.

From 1924 to 1989 there were eight earthquakes with a magnitude of 4.2 or greater in New England. According to the Weston Observatory, the last earthquake to hit the New England Region with a magnitude of 3.0 or greater occurred on September 26, 2010, in the area of Contoocook, New Hampshire. New England experiences 30-40 earthquakes each year, although most are not felt.

The area's vulnerability to a devastating earthquake is based primarily on two elements: the density of the population in the region, and the age of the region's buildings and lack of earthquake proof design. In the City of Lowell older buildings can be found throughout. The Downtown Historic District, including its many mill structures, are predominantly of brick construction, which may make them vulnerable during a significant earthquake. There are three high-rise buildings that may be difficult to evacuate in such an event: Cross Point Towers, the Fox Hall dormitory at UMass Lowell and the River Place Towers.

G. Natural Hazard Risk Assessment for the Town of Pepperell

Community Profile

The Town of Pepperell covers a land area of 23.17 square miles and has a population of 11,497 persons, according to the 2010 U.S. Census. Approximately 9.8% of the Town's population is 65 years of age or older. There are 4,348 housing units in Town, with the average housing unit sheltering 2.64 people. Approximately 3% of the town's residents live below the federal poverty line, according to the 2005-2009 American Community Survey.

Pepperell is part of the North Middlesex Regional School District, which includes the towns of Townsend and Ashby. There is one public elementary school located in Pepperell which has an enrollment of 709 students, and one middle school with an enrollment of 645 students. There is also one private elementary school in town, with an enrollment of 26 students.

Eighty-five percent of the Town is served by public drinking water supplied by four groundwater wells located on Jersey Street and Bemis Road. The water system pumps an average of 1.2 million gallons per day. The areas not currently served by public water are primarily located in the northwest and southern areas of town. The Pepperell Wastewater Treatment Plant at 47 Nashua Road went on line in 1979. In 2009, the town expanded the system, installing 2,600 ft. of new main line on Nashua Road and Mill Street. The plant processes approximately 178 mgd and has over 1,500 connections. About 40% of the community is currently sewered. The town has an intermunicipal agreement in place with Groton to supply 120,000 gpd of capacity. Approximately 60% of the town is supported by on-site septic.

Eighteen percent of the town's land use is used for residential housing; two percent is in commercial and industrial use; fifteen percent is used for agriculture; 63 percent is open space, recreation, or water; and four percent is used for transportation, mining, or waste disposal.

There are 64 public safety personnel in Pepperell, including 18 uniformed police officers, a full time paid fire chief and 45 volunteer firefighters.

Critical Facilities

The list of critical care facilities has been extracted from the Town's CEMP and updated based on input received from Town officials during the development of this Plan, as shown in Table 50 below. Critical care facilities include emergency operations centers, health care facilities and shelters. Map 13, contained in Appendix D, shows the location of critical facilities within the Town of Pepperell.

Table 50: Emergency Operations Center, Health Care Facilities and Shelters – Pepperell							
Facility Type	**Common Name**	**Street Address**	**Health Facility Type**	**Average Daily Patient Capacity**	**Capacity**	**Feeding Capability**	**Emergency Generator Available**
Emergency Operations Center	Public Safety Complex (Primary)	Main Street				No	Yes
	Varnum Brook School (Secondary)	Hollis Street				Yes	Yes
Health Care Facilities	Fire Station	Park Street	First Aid	30		No	Yes
	Fire Station	Jersey Street	First Aid	20		No	Yes
Shelters	Peter Fitzpatrick School	Main Street			250	No	Yes
	Nissitissit Middle School	End of Chase and Tucker Avenues			200	Yes	Yes
	Varnum Brook Middle School	Hollis Street			250	Yes	Yes
	Senior Center	37 Nashua Road			100 (no overnight)	Yes	Yes
	Community Center	4 Hollis Street				No	No

Areas with Limited Access or of Local Concern

The intersection of Main Street, River Road, and Hollis Street has experienced local flooding when the culvert under Hollis Street, east of the intersection, has become obstructed. The intersection is critical, as it is part of an emergency evacuation route. The paved surfaces of Brookfield Street and Lowell Road tend to ice over in the winter due to drainage issues, which presents a traffic safety concern.

Hazard Risk Assessment

Using the methodology outlined on page 91 an assessment of hazard risk was performed based on frequency, severity, extent of impact and the probability of a future event. The result of the analysis is outlined in Table 51 on the following page.

Table 51: Pepperell Hazard Risk Assessment

Hazard	**Frequency-** (Weight factor=2)	**Severity-** **(**Weight factor=5)	**Extent of Impact –** **(**Weight factor=10)	**Probability-** (weight factor=7)	**Total Score**
Flood	3x2=6	1x5=5	1x10=10	3x7=21	42
Wildfire	3x2=6	1x5=5	2x10=20	3x7=21	52
Urban Fire	1x2=2	1x5=5	1x10=10	1x7=7	24
Earthquake	3x2=6	3x5=15	3x10=30	2x7=14	65
Tornado	1x2=2	2x5=10	3x10=30	1x7=7	49
Dam Failure	1x2=2	1x5=5	2x10=20	1x7=7	34
Drought	2x2=4	3x5=15	3x10=30	1x7=7	56
Nor'easter/severe storm	3x2=6	3x5=15	3x10=30	3x7=21	72
Hurricane	3x3=9	3x5=15	3x10=30	3x7=21	75
Snowstorm/ blizzard	3x2=6	3x5=15	3x10=30	3x7=21	72
Landslide	1x2=2	1x5=5	1x10=10	1x7=7	24
Ice Storm	3x2=6	3x5=15	3x10=30	3x7=21	72
Ice Jam	2x2=4	1x5=5	1x10=10	2x7=14	33

Based on this analysis, Pepperell is at high risk for flooding, earthquake, nor'easters, hurricanes, ice storms, snowstorms and blizzards. The Town is at a moderate risk for wildfire, drought, and ice jams, and at low risk for dam failure, landslides, urban fire and tornadoes.

Flood Prone Areas

Pepperell lies entirely within the watershed of the north-flowing Nashua River, and has almost eight miles of riverfront. U.S. Geological Survey maintains a gauging station that shows an average flow of 546 cubic feet per second. Historically, the Nashua River has been prone to flooding. The 1936 flood destroyed the Main Street Bridge in East Pepperell. This flood resulted from a series of interrelated weather events: above average snowfall with cold temperatures and frozen ground, followed by a storm that brought warmer temperatures, snowmelt and successive days of rain, resulting in rapid runoff and massive flooding. Roads were awash, and factories and homes were inundated. The peak flow on the Nashua River during the March 1936 flood was 20,900 cubic feet per second (compared with an average flow of 546 cfs), as measured by USGS.

In the May 2006 flood, the Nashua River crested at 9.38 feet, which is 1.38 feet over flood stage. Historically, flood damage has been concentrated in East Pepperell on the Nashua River. Since the Town's early beginnings, activity has concentrated around east Pepperell on the banks of the Nashua River, so that portions of the floodplain have been developed residentially, commercially, and industrially. Low-lying areas of Pepperell Center are subject to periodic flooding in the area near the confluence of the Nashua River, Nissitissit River, and Reedy Meadow Brook.

Pepperell has four miles of riverfront on the Nissitissit River. The Nissitissit River is protected under the Squannacook and Nissitissit Rivers Sanctuary Act (MGL Chapter 132A, section 17). Its confluence with the Nashua River is approximately one mile north of the East Pepperell Dam, near the covered bridge.

Varnum Brook and Green's Brook, both tributaries of the Nashua, are prone to flooding. Green's Brook joins the Nashua through the former mill yard. Just upstream, the area between Main Street and River Road is also prone to flooding. Varnum Brook joins Green's Brook further upstream behind the communications center. Upstream it crosses under the Route 111/113 Rotary, where is collects runoff from both sides of Park Street. The combined area drained by Green's Brook and Varnum Brook is 600 acres in size.

Further downstream of the Green's Brook confluence with the Nashua, is a flood prone area on the west bank of the Nashua River, between the Nashua and the Nissitissit Rivers. The area is known as "The Land between the Rivers" and extends about one-half mile upstream from the confluence. On the opposite bank, the Nashua is joined by Reedy Meadow Brook to form a complex hydrological dynamic.

There are two significant dams in Pepperell. The Main Street or Pepperell Pond Dam is located on the Nashua River. The Turner's Dam impounds the Nissitissit River just upstream from the Hollis Street Bridge.

A marshy basin bounded by East Street and Lowell Road receives runoff from more than 300 acres. A small culvert through the railroad embankment channels the flow toward the Nashua River. At flood stage the River backs up through this culvert, exacerbating flooding in this area. In recent years, beaver activity has caused extensive impoundment of water, flooding buried sewer lines and street storm drains. Attempts by the Town and the Massachusetts Department of Conservation and Recreation to manage the beaver population have resulted in some improvement.

During meetings with local officials it was reported that significant flooding has occurred along Route 119 near the Nashua River, requiring closure of the roadway. The Town attributes this problem, in part, to the collection of debris on the upstream side of the Route 119 Bridge across the River. It may be possible to lessen the severity of the flooding through improved maintenance of the bridge structure by MassDOT.

2010 Roadway flooding along Route 119 in Pepperell

There are no flood control works on the rivers and streams in the Town of Pepperell. The dams on the Nashua and Nissitissit Rivers offer no flood protection. In 1974, Pepperell entered the NFIP, making residents eligible to buy subsidized flood insurance. As a result, a floodplain bylaw was enacted as part of the town's General Bylaw.

In 1981, FEMA published flood maps for Pepperell showing 100-year flood zones for the Town. However, the flooding along the Nashua River, lower sections of the Reedy Meadow Brook, and the Nissitissit River, as shown on the FEMA maps, was less than the actual flooding experienced during the 1936 flood in those locations. Therefore, in November 1984, Town Meeting incorporated into the town's Zoning Bylaws, the 1936 Nashua River flood elevations, as shown by the Raytheon Company's mapping of U.S. Army Corps of Engineers flood data. Wherever applicable, these actual flood records provide the base flood elevation for local regulatory purposes. The FEMA maps were updated again in 2010 to more closely reflect the actual flooding conditions seen historically.

Repetitive Flood Loss Structures

There are two repetitive flood loss structures in the Town of Pepperell, one residential and one non-residential, as shown on Table 14 on page 30. Six flood insurance claims totaling $123,945 were paid by the NFIP, as of May 2013.

Flooding along Groton Street in Pepperell during the 2010 flood

Structurally Deficient Bridges Over Waterways

Currently, there are no structurally deficient bridges within the Town of Pepperell.

Hazard Potential Dams

Turner Dam on the Nissitissit River

Table 52 lists the Pepperell dams that are included on the Office of Dam Safety's hazard classification list. Based on the data provided, all of the dams in Pepperell are overdue for inspection. Three of the five dams are classified as significant or high hazard dams. Initiatives are underway to remove or partially breach the Turner Dam and the Town is working with the dam owner to secure the appropriate permits and approvals.

Table 52: Hazard Classification of Pepperell Dams					
Dam Name	**Impoundment Name**	**Hazard Class**	**Downstream Population**	**Last Inspection Date**	**Next Inspection Due**
Turner Dam	Nissitissit River	High	0	6/24/1998	6/24/2000*
Pork Barrel Dam	Pork Barrel Pond	Low	NA	1/11/1945	1/11/1955*
Nashua River Dam**	Nashua River	Low	NA	1/11/1945	1/11/1955*
Pepperell Paper Co. Dam	Nashua River	Significant	85	12/8/2009	12/8/2014
Guarnottas Dam***	Breached	Non-jurisdictional	0		

Source: Massachusetts Department of Conservation and Recreation, Office of Dam Safety
* Dam inspection overdue
** FERC Regulated Dam
*** Non-jurisdictional dams are not regulated by the Office of Dam Safety

Winter Storms (ice storms, snowstorms, nor'easters)

As stated in this Plan previously, severe winter storms can produce a wide variety of hazardous weather conditions, including heavy snow, freezing rain, sleet, and extreme wind and cold. A severe winter storm is one that results in four or more inches of snow over a twelve hour period, or six or more inches over a twenty-four hour period. The leading cause of death during winter storms is from an automobile or other transportation accidents. Exhaustion or heart attacks caused by overexertion are the second most likely cause of winter storm-related deaths. Pepperell, like the rest of the region, is at risk for winter storms.

Since 1983, the most significant winter snowfall in the region occurred during the winter of 1995, when snowfall measurements in the City of Lowell reached 126.5 inches. Snowfall totals in Pepperell were similar, however The town does not maintain its own records.

Recovery from a winter storm poses a number of challenges. Prolonged curtailment of all forms of transportation can have significant adverse impacts for people stranded at home, preventing the delivery of critical services such home heating fuel supplies or the ability to get to a local food store. Extended power outages, the cost of snow removal, repairing damages, and the loss of business can have severe economic impacts on local communities. The elderly and infirmed are populations of particular concern during these events. Appendix D shows the location of all senior housing and medical facilities within Pepperell. Those residing within the mobile home park are also vulnerable due to the threat of roof collapse as a result of heavy snow loads.

Hurricanes

Hurricanes can occur along the East Coast of the United States anytime in the period between June and November. Hurricane force winds can destroy buildings and mobile homes. Debris, such as signs, roofing materials, siding and lawn furniture can become missiles. Hurricanes can also spawn tornadoes that generally occur in thunderstorms embedded in rain bands well away from the center of the hurricane. Tornadoes can also occur near the eye wall. Heavy rain associated with the storm may cause flooding.

The most recent hurricane to affect the region and the town was Hurricane Irene in August 2011, which became a tropical storm as it passed over the region. Although the heavy rains associated with hurricanes present the highest recurrent risk, high winds are also a risk. Downed trees and tree limbs, blocked roads, and downed telephone and power lines can disrupt transportation routes and communication channels. It is impossible to predict where these things might occur during a hurricane event, therefore the entire town is considered to be vulnerable. Those residing within the mobile home park are considered to be particularly vulnerable.

Table 19 on page 41 contains a list of hurricanes that have hit New England over the past ten decades. The entire Northern Middlesex region is equally impacted by these events.

Wildfire

A wildfire is an uncontrolled fire that spreads due to the presence of vegetative fuel. These fires often begin unnoticed and spread quickly. In this area of the country, wildfire season generally begins in March and ends in late November. Human beings start four out of every five wildfires through arson or carelessness; lightning strikes account for the remainder. Pepperell is considered to be at moderate risk for wildfire. Over a three year period, over 100 brush fires were reported in the Town of Pepperell. Given its rural nature, the entire community is considered to be vulnerable given the abundance of forested areas, but special attention is paid to the Town Forest.

Earthquake

In New England, the immediate cause of most earthquakes is the sudden release of stress along a fault or fracture in the earth's crust. Much of the research on earthquakes in the northeast has involved attempts to identify pre-existing faults and other geological features that may be susceptible to such stress, but this has proven to be quite difficult. It is unclear whether faults mapped at the earth's surface in the northeast are the same faults along which earthquakes are occurring. It is impossible to predict the time and location of future earthquakes in New England. There is a 1 in 10 chance that in any given fifty-year period a potentially damaging earthquake will occur.

From 1924 to 1989 there were eight earthquakes with a magnitude of 4.2 or greater in New England. According to the Weston Observatory, the last earthquake to hit the New England Region with a magnitude of 3.0 or greater occurred on September 26, 2010, in the area of Contoocook, New Hampshire. New England experiences 30-40 earthquakes each year, although most are not felt.

The area's vulnerability to a devastating earthquake is based primarily on the following elements: the density of the population in the region, and the age of the region's buildings and lack of earthquake proof design. In the Town of Pepperell, concentrations of older buildings can be found along Main Street, Route 111 and Route 119, and throughout much of the town.

H. Natural Hazard Risk Assessment for the Town of Tewksbury

Community Profile

The Town of Tewksbury covers a land area of 21.06 square miles and has a population of 28,961 persons, according to the 2010 U.S. Census. Approximately 14.5% of the Town's population is 65 years of age or older. Approximately 3.79% of the town's population lives below the federal poverty level, according to the 2005-2009 American Community Survey. There are 10,848 housing units in Town, with the average housing unit sheltering 2.67 people.

There are approximately 4,646 students enrolled in the public school system, which includes one preschool, five elementary schools, two middle schools, and one high school. Ninety-eight percent (98%) of the Town is served by the community's public drinking water supply. Water is withdrawn from the Merrimack River and treated at the Town's water treatment plant. In 2002, the Town increased the capacity of its water treatment plant from 3.5 to 7.0 mgd. Nearly the entire town (98%) uses the public water system. Total water consumption is about 3.5 mgd, with residential water use accounting for 65% of the demand. Approximately 98% of the town is supported by municipal sewer. The sewage is treated the Greater Lowell Wastewater Utility in Lowell.

Thirty-six percent of the town's land use is used for residential housing; six percent is in commercial and industrial use; two percent used for agriculture; 49 percent for open space, recreation, or water use; and seven percent is used for transportation, mining, or waste disposal.

The Tewksbury Police Department is comprised of 57 sworn police officers, 50 part-time officers and 5 civilian dispatchers. The Town also employs 50 fire fighters.

Critical Facilities

The list of critical care facilities has been extracted from the Town's CEMP and updated based on input received from Town officials during the development of this Plan, as shown in Table 53 on the following page. Critical care facilities include emergency operations centers, health care facilities, and shelters. Map 14, contained in Appendix D, shows the location of all critical facilities within Tewksbury.

Table 53: Emergency Operations Center, Health Care Facilities, and Shelters – Tewksbury							
Facility Type	**Common Name**	**Street Address**	**Health Facility Type**	**Average Daily Patient Capacity**	**Capacity**	**Feeding Capability**	**Emergency Generator Available**
Emergency Operations Center	Tewksbury Fire Department (Primary)	21 Town Hall Avenue				No	Yes
	Tewksbury Police Department(Secondary)	918 Main Street				No	Yes
Health Care Facilities	Blair House	10 Erlin Avenue	Level 1 – 4	200		No	No
	The Emeritus	2580 Main Street	Level 4	50	No	No	
	North Fire Station	830 North Street	First Aid	0			
	Center Fire Station	21 Town Hall Avenue	First Aid	0			
	South Fire Station	2342 Main Street	First Aid	0			
Shelters	High School	20 Pleasant Street		0	1000	Yes	Yes
	Dewing School	1469 Andover Street		0	500	Yes	Yes
	Wynn Middle School	1 Griffin Way		0	1000	Yes	No
	Ryan School	141 Pleasant Street		0	800	Yes	Yes
	Trahan School	12 Salem Street		0	500	Yes	No
Shelters	Heath Brook School	165 Shawsheen Street		0	600	Yes	No
	North Street School	133 North Street		0	500	Yes	No
	Senior Drop In Center	300 Chandler Street		0	50	Yes	Yes

Areas with Limited Access or of Local Concern

There are two intersections in Tewksbury that are subject to local flooding, creating access problems. Both involve roadways or intersections that are affected by the Shawsheen River. Brown Street and Whipple Road are periodically flooded, necessitating roadway closures. Shawsheen Street, south of Main Street (Route 38) and north of Kenneth Lane, also experiences flooding which blocks a critical evacuation intersection at Main Street (Route 38) and Shawsheen Street.

A major railroad freight line crosses four arterials within the Town: North Street, Livingston Street, East Street, and Shawsheen Street. An emergency affecting railroad traffic could impair traffic circulation and evacuation routes. The northwest central section of town, which includes an extensive wetland area, is subject to occasional brush fires.

The Town is trying to address the need for back-up emergency generators for its sewer pump stations. Presently, the Tewksbury's town-wide sewer collection system utilizes 47 sewer pumping stations. If there is a power outage, the sewer pumping stations would rely on back-up power in order to continue pumping the wastewater flows. Without emergency generators, the wastewater flows to the pump station would then backup into the homes that are tributary to those specific pump stations. This back-up would create a health hazard, and result in costly cleanup and repair costs. Environmental impacts may also result from such overflow events. The town estimates that it will cost $483,000 to address this issue.

The sewer collection system in the Town of Tewksbury has been growing with the Town. The existing sewer system consists of over roughly 877,000 linear feet of sewers (166 miles) of public sewers and 46 pumping stations. The earliest sanitary sewer system was constructed in August 1973, and additions to the sewer system have been constructed in intervals. The existing collection system now services the entire population of the town.

A review of the system, indicates that extensive infiltration and inflows (I/I) are occurring. Due to the increasing wastewater conveyance and treatment costs, this infiltration and inflow has created a financial burden on the Town and its residents. Infiltration and inflow problems are more evident in high groundwater months and rain/wet weather events, during which flooding occurs. The sewer collection systems within flood prone areas are hit the hardest, with excessive flows during these events. The I/I influences are partly attributed to leaky pipe joints and manholes in high groundwater and flood prone areas. Significant flow increases are well documented in spring/flood prone months and baseline I/I is also evident entering the system in wet areas of the Town.

The Town has initiated a project to flood proof the existing sewer manhole structures located within the 100-year flood plain. Sewer piping in this area will be tested and sealed due to the degradation of the joints caused by flooding conditions. Sewer manhole structures will be assessed on a case-by-case basis and the appropriate waterproofing technology will be selected based on manhole field conditions. If this project is implemented, it is expected to reduce the effects of infiltration and inflow by roughly 75% to 80% in the treated areas, greatly reducing the conveyance and treatment costs. It will provide protection of existing sewer infrastructure during 100-year flood events. The cost estimate for this project is $517,400.

Hazard Risk Assessment

Using the methodology outlined on page 91, an assessment of hazard risk was performed based on frequency, severity, extent of impact and the probability of a future event. The result of the analysis is outlined in Table 54 below.

Table 54: Tewksbury Hazard Risk Assessment

Hazard	**Frequency-** (Weight factor=2)	**Severity-** **(**Weight factor=5)	**Extent of Impact – (**Weight factor=10)	**Probability-** (weight factor=7)	**Total Score**
Flood	3x2=6	2x5=10	3x10=30	3x7=21	67
Wildfire	1x2=2	1x5=5	2x10=20	2x7=14	41
Urban Fire	1x2=2	1x5=5	2x10=20	1x7=7	34
Earthquake	3x2=6	3x5=15	3x10=30	2x7=14	65
Tornado	1x2=2	2x5=10	3x10=30	1x7=7	49
Dam Failure	1x2=2	1x5=5	1x10=10	1x7=7	24
Drought	2x2=4	3x5=15	3x10=30	1x7=7	56
Nor'easter/severe storm	3x2=6	3x5=15	3x10=30	3x7=21	72
Hurricane	3x3=9	3x5=15	3x10=30	3x7=21	75
Snowstorm/ blizzard	3x2=6	3x5=15	3x10=30	3x7=21	72
Landslide	1x2=2	1x5=5	1x10=10	1x7=7	24
Ice Storm	3x2=6	3x5=15	3x10=30	3x7=21	72
Ice Jam	1x2=2	1x5=5	1x10=10	1x7=7	24

Based on this analysis, the Town of Tewksbury is at high risk for flooding, earthquake, nor'easters, hurricanes, ice storms, snowstorms and blizzards. The Town is at a moderate risk for drought, and at low risk for wildfire, dam failure, landslides, ice jams, urban fire and tornadoes.

Flood Prone Areas

The Town of Tewksbury lies within three watersheds – the Concord, Merrimack and Shawsheen – and within four watershed basins – the Concord, Ipswich, Merrimack and Shawsheen. Tewksbury is bordered by the Merrimack River on the northeast, and the Concord River touches the western most portion of Town. The Shawsheen River runs southwest to northeast through the southeastern portion of the Town. There are four major streams in Town: Heath Brook, Sutton Brook, Strongwater Brook (which flow into the Shawsheen River) and Trull Brook (which flows into the Merrimack River) All of these waterways are prone to flooding, blocking many major roadways in Town. Both the Shawsheen River and Strongwater Brook have significant flood plains. GIS analysis has shown that over 20% of the town's area is comprised of wetlands.

During meetings with the Town, the following locations were identified as having recurring flooding and/or drainage problems:

- Bridge Street and South Street;
- Shawsheen Street and Mohawk Street;
- East Street near Strong Water Brook;
- Pinnacle Street;
- Shawsheen Street near Main Street/Route 38;
- Brown Street at Whipple Road;
- Pond Street; and
- Bonnie Lane.

River Road in Tewksbury sustained considerable damage in the floods of March 2010 and is now being reconstructed through funding received from MassDOT and MEMA.

DPW crews work to control roadway undermining created by flooding on River Road in Tewksbury in March 2010

The existing Trull Brook culvert crossing on River Road is a large nine (9) foot diameter corrugated metal pipe with tapered end sections. The culvert is in relatively good condition except on the bottom plates at entrance and exit points, where scouring velocities have accelerated corrosion and some undermining is present. The culvert has marginal entrance and exit flow characteristics causing some backwater conditions which result in toe erosion of the abutting slope. The backwater conditions causes erosion of the Trull Brook channel and also of the supporting slope at River Road. Wet weather conditions and some roadway runoff can significantly and quickly degrade the roadway side slopes as it washes down the steep bank causing erosion and slope failure. These conditions have resulted in recurring and periodic slope failure with a significant failure occurring in the spring of 2010. Although the Town continues to add trap rock slope protection, the existing angle of repose is insufficient to maintain the slope under saturated or wet weather conditions. Such damages occur with an estimated 10-year frequency storm event.

The town is proposing to install Storm Sewer Pipe into the existing culvert, and inject grout into the annular area between the new pipe and the existing deteriorated pipe, and supplement the slope material to create a more stable roadway side slope. Rip rapping of slope toes near the culvert will also be enhanced. This project, if implemented, will help reduce further damages due to the increased stability for the slope. This project is estimated to cost $279,000.

The existing roadway on Shawsheen Street at Heath Brook is prone to flooding during peak storm events due to its low elevation. This causes periodic closures of Shawsheen Street during peak storm events, restricting access for emergency vehicles and causing significant increases in response times. Additionally, closure of this roadway has a significant impact to residential and commercial traffic and to abutting communities, as the roadway is often used as a connector between Route 129 in Billerica and I-93. The town is proposing reclamation of the existing roadway and sidewalk. Fill material will be installed and graded to raise the final roadway grade to at least Elevation 86.0. If this project is implemented, it will be an improvement over the existing conditions due to the fact that the roadway grade will be raised to the 100-year flood elevation level. The estimated cost for this project is $400,000.

During peak storm events, the Shawsheen River crests and overtops South Street and back feeds into Sutton Brook, causing flow to exceed its hydraulic capabilities further down South Street. As a result, the overtopping of this intersection causes full isolation of several residential units lying between Bridge Street and Sutton Brook. The adjacent Shawsheen River has a 100-year flood elevation of 85.0 which can overtop the existing roadway (existing elevation of approximately 83.9). The flood elevation of the upper Sutton Brook is about 77.0 feet, so back-feeding by the Shawsheen River at elevation 85.0 can have a significant impact. Past flooding events have closed off the northern end of South Street, with a flood event in June 1998 requiring National Guard vehicles to shuttle residents to and from their homes. This event affected approximately 500 residents. In addition, the closing of this intersection causes significant traffic re-routing, thereby delaying emergency response from the South Street Fire Station and impacting commerce. The Town is proposing to raise the roadway to an elevation of 85.0+ over a distance of several hundred feet. It is estimated that this project will cost $400,000.

Pinnacle Street is a residential road which serves as access to the Town of Andover and to Route 93. The roadway accommodates local traffic and feeds many residential homes in both towns. An existing culvert was constructed with concrete block and stone set on top of a single barrel 65” X 40” corrugated metal arch pipe. In recent years, during intense storm events, flooding has occurred due to an undersized culvert, which exacerbates upstream flooding conditions, surcharging into abutting residential properties and occasionally overtopping the road. Up-gradient forested areas also contribute debris and branches, which can quickly accumulate during storm events to block the relatively small-sized culvert. The Town is proposing to install a 5' x 6' box culvert to mitigate this situation. Flooding conditions can necessitate closing of the roadway, limiting emergency service access to residential homes in Tewksbury. The detours also create additional traffic impairments for commuters in the area. Construction of the culvert is estimated to cost $50,000.

Tewksbury has taken some steps to protect its wetland resource and floodplain areas, notably by establishing a Flood Plain District in the Zoning Bylaw, and by adopting a local (non-zoning) wetlands bylaw in 1986 which is administered by the Conservation Commission. The local wetlands bylaw augments M.G.L. c. 131 § 40, the Massachusetts Wetlands Protection Act. It establishes a minimum continuous 25-foot wide buffer strip of undisturbed, natural vegetation around wetland resources and requires that any proposed structure be at least 50 feet from the resource. In effect, the bylaw intends to create a 25-foot “no disturbance zone” and a 50-foot “no build zone” around wetland resources.

The town’s Flood Plain (FP) District is typical of flood plain bylaws in other communities. It is triggered by uses in flood hazard areas identified on the Flood Insurance Rating Map (FIRM), and in areas within the 100-year floodplain as identified by the Federal Emergency Management Agency (FEMA). The bylaw does not prohibit uses allowed in the underlying districts, but bans construction activity that encroaches on a floodway. For development in the Flood Plain District, the bylaw specifies submission requirements for permits from local authorities and incorporates compliance with other laws, e.g., the Wetlands Protection Act, the State Building Code and Title V.

Tewksbury has received disaster relief funds from the Federal Emergency Management Agency for several floods over the past ten years. The Town is particularly concerned about flooding impacts in South Tewksbury which is densely populated, has narrow roadways and older housing stock, with a significant elderly population and a number of young families. In the past, the Town has created emergency access ways in order to evacuate the neighborhood.

Repetitive Flood Loss Structures

There are eight repetitive flood loss structures located along the Shawsheen River within the Town of Tewksbury and in the Devonshire Road area. All of the repetitive flood loss properties are residential. As of May 2013, twenty-four (24) claims were paid under the National Flood Insurance Program which totaled $187,619.

The Town of Tewksbury has been part of the NFIP for well over a decade. The Town has adopted Chapter 40, Section J relative to Public Safety Mutual Aid and Chapter 40, Section K relative to Public Works Mutual Aid. NFIP monitoring and compliance is accomplished through the building permit process, whereby the Building Department requires certified plat plans for all proposed structures. NFIP educational materials are available at the Building Department and the Town Clerk’s office.

Monitoring is accomplished through standard reconnaissance of potential zoning, wetland and stormwater violations. Non-compliant structures are known through the Building Department's institutional knowledge and have also been identified through previous flooding studies. The Building Commissioner has been certified through MEMA to rate structures. The Building Department requires foundation as-builts stamped by an engineer prior to framing permits being issued for properties located in the floodplain. The Building Department, through the Building Commissioner and the Permit Technicians, assists residents and officials on how to read and interpret the FIRMs.

Structurally Deficient Bridges Over Waterways

The Mill Street Bridge over the Shawsheen River is the only structurally deficient bridge located over a waterway in Tewksbury. The Town has plans to address this bridge in FY 2015.

Hazard Potential of Dams

Table 55 below lists the dams in Tewksbury that are included in the Office of Dam Safety's hazard classification list. Based on the data provided in the state's list, Ames Pond Dike B is overdue for inspection. Two of the three dams are classified as high hazard.

Table 55: Hazard Classification of Tewksbury Dams

Dam Name	Impoundment Name	Hazard Class	Downstream Population	Last Inspection Date	Next Inspection Due
Ames Pond Dike A	Ames Pond	High	5,000	10/7/2010	10/7/2012
Ames Pond Dam	Ames Pond	High	5,000	10/7/2010	10/7/2012
Ames Pond Dike B	Ames Pond	Low	5,000	4/30/2003	4/30/2008*

Source: Massachusetts Department of Conservation and Recreation, Office of Dam Safety
* Dam inspection overdue

Winter Storms (ice storms, snowstorms, nor'easters)

As stated in this Plan previously, severe winter storms can produce a wide variety of hazardous weather conditions, including heavy snow, freezing rain, sleet, and extreme wind and cold. A severe winter storm is one that results in four or more inches of snow over a twelve hour period, or six or more inches over a twenty-four hour period. The leading cause of death during winter storms is from an automobile or other transportation accident. Exhaustion or heart attacks caused by overexertion are the second most likely cause of winter storm-related deaths. Tewksbury, like the rest of the region, is at risk for winter storms.

Since 1983, the most significant winter snowfall in the region occurred during the winter of 1995, when snowfall measurements in the City of Lowell reached 126.5 inches. Snowfall totals in Tewksbury were similar, however the Town does not maintain its own records.

Recovery from a winter storm poses a number of challenges. Prolonged curtailment of all forms of transportation can have significant adverse impacts for people stranded at home, preventing the delivery of critical services such home heating fuel supplies or the ability to get to a local food store. Extended power outages, the cost of snow removal, repairing damages, and the loss of business can have severe economic impacts on local communities. The elderly and infirmed are populations of particular concern during these events. The senior housing and medical facilities located within Tewksbury are identified in Appendix D.

Hurricanes

Hurricanes can occur along the East Coast of the United States anytime in the period between June and November. Hurricane force winds can destroy buildings and mobile homes. Debris, such as signs, roofing materials, siding and lawn furniture can become missiles. Hurricanes can also spawn tornadoes that generally occur in thunderstorms embedded in rain bands well away from the center of the hurricane. Tornadoes can also occur near the eye wall. Heavy rain associated with the storm may cause flooding.

The most recent hurricane to affect the region and the town was Hurricane Irene in August 2011, which became a tropical storm as it passed over the region. Although the heavy rains associated with hurricanes present the highest recurrent risk, high winds are also a risk. Downed trees and tree limbs, blocked roads, and downed telephone and power lines can disrupt transportation routes and communication channels. It is impossible to predict where these things might occur during a hurricane event, therefore the entire town is considered to be vulnerable. Those residing within the mobile home park are considered to be particularly vulnerable.

Table 19 on page 41 contains a list of hurricanes that have hit New England over the past ten decades. The entire Northern Middlesex region is equally impacted by these events.

Wildfire

A wildfire is an uncontrolled fire that spreads due to the presence of vegetative fuel. These fires often begin unnoticed and spread quickly. In this area of the country, wildfire season generally begins in March and ends in late November. Human beings start four out of every five wildfires through arson or carelessness; lightning strikes account for the remainder. Tewksbury is considered to be at moderate risk for wildfire. Over a three period, 400 brush fires were reported in the town. The town's Community Development Director has identified the land around the Tewksbury State Hospital and the Great Swamp area along I-495 as locations that are particularly vulnerable.

In April 2012, a field on Main Street caught fire and the flames quickly spread. The flames, he said, were concentrated beneath the power lines with the potential to race across the field and damage houses and businesses. Firefighters were able to prevent the fire from spreading. A lack of precipitation during the winter and spring exacerbated the fire.

Earthquake

In New England, the immediate cause of most earthquakes is the sudden release of stress along a fault or fracture in the earth's crust. Much of the research on earthquakes in the northeast has involved attempts to identify pre-existing faults and other geological features that may be susceptible to such stress, but this has proven to be quite difficult. It is unclear whether faults mapped at the earth's surface in the northeast are the same faults along which earthquakes are occurring. It is impossible to predict the time and location of future earthquakes in New England. There is a 1 in 10 chance that in any given fifty-year period a potentially damaging earthquake will occur.

From 1924 to1989 there were eight earthquakes with a magnitude of 4.2 or greater in New England. According to the Weston Observatory, the last earthquake to hit the New England region with a magnitude of 3.0 or greater occurred on September 26, 2010, in the area of Contoocook, New Hampshire. New England experiences 30-40 earthquakes each year, although most are not felt.

The area's vulnerability to a devastating earthquake is based primarily on the following elements: the density of the population in the region, and the age of the region's buildings, and lack of earthquake proof design. In the Town of Tewksbury concentrations of older buildings can be found in the Town Center area and along East Street, as well as throughout the rest of the town.

I. Natural Hazard Risk Assessment for the Town of Tyngsborough

Community Profile

The Town of Tyngsborough covers a land area of 18.5 square miles and has a population of 11,292 persons, according to the 2010 U.S. Census. Approximately 8.9% of the town's population is 65 years of age or older. There are 4,206 housing units in the town, with the average housing unit sheltering 2.69 people. Approximately 2.02% of the population lives below the federal poverty line, according to the 2005-2009 American Community Survey.

There are 2,300 students enrolled in the public school system, which includes three elementary schools and one junior/senior high school. Additionally, Tyngsborough is home to Greater Lowell Technical High School, a public vocational school which serves the towns of Tyngsborough, Dracut, and Dunstable as well as the city of Lowell. There is one private school, the Academy of Notre Dame, and the town also has one public charter school, Innovation Academy, serving over 400 students in grades five through twelve.

Thirty percent (30%) of the town is currently serviced by public drinking water. The remaining seventy percent (70%) is served by on-site private wells. There are three water districts that operate a total of five distribution systems which access various supply sources in neighboring communities, including Dracut, Chelmsford, Lowell and Nashua, NH. The town's public sewer service covers only 25% of the town, while the remainder of the town is supported by on-site septic systems.

Twenty percent of the town's land is used for residential housing; two percent is in commercial and industrial use; five percent is used for agriculture; 63 percent is in open space, recreation, or water use; and five percent is used for transportation, mining, or waste disposal.

There are 66 public safety personnel in Tyngsborough, including 23 uniformed police officers and 40 on-call fire fighters, who are overseen by a Fire Chief and two additional paid fire officers.

Critical Facilities

The list of critical care facilities, as shown in Table 56 below, has been extracted from the Town's most recent CEMP, and updated based on input received from Town officials and staff during the development of this Plan. Critical care facilities include emergency operations centers, and shelters. Map 15, contained in Appendix D, shows the location of all critical facilities for the Town of Tyngsborough.

Table 56: Emergency Operations Center, Health Care Facilities and Shelters – Tyngsborough

Facility Types	Common Name	Street Address	Health Facility Type	Average Daily Patient Capacity	Capacity	Feeding Capability	Emergency Generator Available
Emergency Operations Centers	Fire Station (Primary)	26 Kendall Road				No	Yes
	Police Station (Alternate)	20 Westford Road				No	Yes
	Town Hall (Alternate)	25 Bryants Lane				No	Yes
Health and Medical Facilities	None						
Shelters	Tyngsborough High School	50 Norris Road			100	Yes	Yes
	Tyngsborough Elementary School	205 Westford Road			100	Yes	Yes
	Greater Lowell Vocational High School	250 Pawtucket Boulevard			100	Yes	Yes

Areas with Limited Access or of Local Concern

The primary access to the Tyngsborough Elementary School, which is located off Westford Road, is subject to flooding from Bridge Meadow Brook. This flooding can obstruct the primary access to the School. Although a secondary gated access point is available north of the school via Diamond Road, it adds travel time for school buses, and can affect school schedules, etc.

Hazard Risk Assessment

Using the methodology outlined on page 91 an assessment of hazard risk was performed based on frequency, severity, extent of impact and the probability of a future event. The result of the analysis is outlined in Table 57 below.

Table 57: Tyngsborough Risk Assessment

Hazard	**Frequency-** (Weight factor=2)	**Severity- (**Weight factor=5)	**Extent of Impact – (**Weight factor=10)	**Probability-** (weight factor=7)	**Total Score**
Flood	3x2=6	1x5=5	3x10=30	3x7=21	62
Wildfire	3x2=6	1x5=5	3x10=20	3x7=21	52
Urban Fire	1x2=2	1x5=5	1x10=10	1x7=7	24
Earthquake	3x2=6	3x5=15	3x10=30	2x7=14	65
Tornado	1x2=2	2x5=10	3x10=30	1x7=7	49
Dam Failure	1x2=2	1x5=5	1x10=10	1x7=7	24
Drought	2x2=4	3x5=15	3x10=30	1x7=7	56
Nor’easter/severe storm	3x2=6	3x5=15	3x10=30	3x7=21	72
Hurricane	3x3=9	3x5=15	3x10=30	3x7=21	75
Snowstorm/ blizzard	3x2=6	3x5=15	3x10=30	3x7=21	72
Landslide	1x2=2	1x5=5	1x10=10	1x7=7	24
Ice Storm	3x2=6	3x5=15	3x10=30	3x7=21	72
Ice Jam	2x2=4	1x5=5	2x10=20	2x7=14	43

Based on this analysis, Tyngsborough is at high risk for flooding, earthquake, nor'easters, hurricanes, ice storms, snowstorms and blizzards. The Town is at a moderate risk for wildfire, drought, and ice jams, and at low risk for dam failure, landslides, urban fire and tornadoes.

The 2008 Ice Storm brings down tree limbs in Tyngsborough (photo by Mark Wilson)

Flood Prone Areas

The Merrimack River bisects the Town of Tyngsborough, running from north to south for a distance of five miles. When the Merrimack River is at flood stage it overtops its bank and floods a section of Route 113 near the Vesper Country Club. Flooding from the River occurs in the vicinity of Bridgeview Circle. In addition, as previously stated, Bridge Meadow Brook floods the access road to the Tyngsborough Elementary School, which has the greatest impact on the community. Repetitive flooding also occurs on Riverbend Road, River Road, and Red Gate Road and Larson Avenue.

There are five other perennial streams within the Town, including the following:

- Bridge Meadow Brook –originates on Scribner Hill and flows into Flint Pond;
- Lawrence Brook- flows from Norris Corner, along Lawndale Road, and into the Merrimack River just upstream from the Tyngsborough Country Club;
- Limit Brook – flows out of Hudson, New Hampshire and enters the Merrimack River near Frost Road;
- Scarlett Brook – flows out of wetlands located between Althea Lake and the State Forest, and enters the Merrimack River near the Greater Lowell Vocational Technical High School; and
- Locust Brook – flows from Locust Pond, along Locust Avenue, and enters the Merrimack River near Farwell Road.

Repetitive Flood Loss Structures

There are eight repetitive flood loss properties within the Town of Tyngsborough. Most of these properties are located adjacent to the Merrimack River. All of the repetitive flood loss structures are residential. As of May 2013, the National Flood Insurance Program paid out $2,129,486 for sixteen claims.

Structurally Deficient Bridges Over Waterways

Presently, there are no structurally deficient bridges over water bodies in Tyngsborough.

Hazard Potential of Dams

Table 58 below lists the dams in Tyngsborough included in the Department of Conservation and Recreation, Office of Dam Safety's hazard classification list. Based on the data provided, two of the dams in Tyngsborough are overdue for inspection and three of the five dams are classified as significant hazard dams.

Table 58: Hazard Classification of Tyngsborough Dams

Dam Name	Impoundment Name	Hazard Class	Downstream Population	Last Inspection Date	Next Inspection Due
Lower Flint Pond Dam	Lower Flint Pond	Low	450	10/13/2007	10/13/2012
Locust Pond Dam	Locust Pond	Significant	100	NA	NA
Mascuppic Lake Dam	Mascuppic Lake	Non-jurisdictional	NA	NA	NA
Upper Flint Pond Dam	Upper Flint Pond	Significant	0	10/13/07	10/13/2012
Cow Pond Brook Dam	Cow Pond Brook	Significant	100	6/26/2007	6/26/2012

Source: Massachusetts Department of Conservation and Recreation, Office of Dam Safety

Winter Storms (ice storms, snowstorms, nor'easters)

As stated in this Plan previously, severe winter storms can produce a wide variety of hazardous weather conditions, including heavy snow, freezing rain, sleet, and extreme wind and cold. A severe winter storm is one that results in four or more inches of snow over a twelve-hour period, or six or more inches over a twenty-four hour period. The leading cause of death during winter storms is from an automobile or other transportation accident. Exhaustion or heart attacks caused by overexertion are the second most likely cause of winter storm-related deaths. Tyngsborough, like the rest of the region, is at risk for winter storms.

Since 1983, the most significant winter snowfall in the region occurred during the winter of 1995, when snowfall measurements in the City of Lowell reached 126.5 inches. Snowfall totals in Tyngsborough were similar, however the Town does not maintain its own records.

Recovery from a winter storm poses a number of challenges. Prolonged curtailment of all forms of transportation can have significant adverse impacts for people stranded at home, preventing the delivery of critical services such home heating fuel supplies or the ability to get to a local food store. Extended power outages, the cost of snow removal, repairing damages, and the loss of business can have severe economic impacts on local communities. The elderly and infirmed are populations of particular concern during these events. Senior housing within Tyngsborough is shown in Appendix D.

Hurricanes

Hurricanes can occur along the East Coast of the United States anytime in the period between June and November. Hurricane force winds can destroy buildings and mobile homes. Debris, such as signs, roofing materials, siding and lawn furniture can become missiles. Hurricanes can also spawn tornadoes that generally occur in thunderstorms embedded in rain bands well away from the center of the hurricane. Tornadoes can also occur near the eye wall. Heavy rain associated with the storm may cause flooding. Historically, flooding has occurred along a section of Route 113 near the Vesper Country Club, in the vicinity of Bridgeview Circle, on the the access road to the Tyngsborough Elementary School, and on Riverbend Road, River Road, Red Gate Road and Larson Avenue.

The most recent hurricane to affect the region and the town was Hurricane Irene in August 2011, which became a tropical storm as it passed over the region. Though heavy rains associated with hurricanes present the highest recurrent risk, high winds are also a risk. Downed trees and tree limbs, blocked roads, and downed telephone and power lines can disrupt transportation routes and communication channels. It is impossible to predict where these things might occur during a hurricane event, therefore the entire town is considered to be vulnerable.

Wildfire

A wildfire is an uncontrolled fire that spreads due to the presence of vegetative fuel. These fires often begin unnoticed and spread quickly. In this area of the country, wildfire season generally begins in March and ends in late November. Human beings start four out of every five wildfires through arson or carelessness; lightning strikes account for the remainder. Over a three year period, over 206 brush fires were reported in the Town of Tyngsborough. The area around the Dracut-Lowell-Tyngsborough State Forest is particularly vulnerable. This property is managed by the Massachusetts Department of Conservation and Recreation (DCR).

Earthquake

In New England, the immediate cause of most earthquakes is the sudden release of stress along a fault or fracture in the earth's crust. Much of the research on earthquakes in the northeast has involved attempts to identify pre-existing faults and other geological features that may be susceptible to such stress, but this has proven to be quite difficult. It is unclear whether faults mapped at the earth's surface in the northeast are the same faults along which earthquakes are occurring. It is impossible to predict the time and location of future earthquakes in New England. There is a 1 in 10 chance that in any given fifty-year period a potentially damaging earthquake will occur.

From 1924 to 1989 there were eight earthquakes with a magnitude of 4.2 or greater in New England. According to the Weston Observatory, the last earthquake to hit the New England Region with a magnitude of 3.0 or greater occurred on September 26, 2010, in the area of Contoocook, New Hampshire. New England experiences 30-40 earthquakes each year, although most are not felt.

The area's vulnerability to a devastating earthquake is based primarily on the following elements: the density of the population, and the age of the buildings and lack of earthquake proof design. In the Town of Tyngsborough concentrations of older buildings can be found in the vicinity of the Town Center and along Farwell Road, and older buildings are also scattered throughout town.

J. Natural Hazard Risk Assessment for the Town of Westford

Community Profile

The Town of Westford covers a land area of 31.33 square miles and has a population of 21,951 persons, according to the 2010 U.S. Census. Approximately 9.9 percent of the Town's population is 65 years of age or older. There are 7,876 housing units in the town, which shelter an average of 2.79 people per unit. Approximately 1.14 % of the population lives below the federal poverty line, according to the 2005-2009 American Community Survey.

There are approximately 5,350 students enrolled in the public school system, which includes six elementary schools, two middle schools, and one high school. Seventy-five percent of the town is on public drinking water supply. Water is withdrawn from eight municipal wells, and the distribution system delivers 1.764-MGD to Westford residents and businesses. All wastewater is disposed of through private on-site systems.

Twenty-five percent of the town's land use is used for residential housing; two percent is in commercial and industrial use; five percent is used for agriculture; sixty-five percent is in open space, recreation, or water use; and three percent is used for transportation, mining, or waste disposal.

There are 91 public safety personnel in Westford, including 39 uniformed police officers and 52 fire fighters.

Critical Facilities

The list of critical care facilities, as shown in Table 59 on the following page, has been extracted from the Town's CEMP and updated based on input received from Town officials during the development of this Plan. Critical care facilities include emergency operations centers, health care facilities and shelters. Map 17, contained in Appendix D, shows the location of all critical facilities for the Town of Westford. It should be noted that not all of the shelter facilities identified by the Town have feeding capabilities and back-up emergency power generators.

Table 59: Emergency Operations Center, Health Care Facilities, and Shelters – Westford							
Facility Types	**Common Name**	**Street Address**	**Health Facility Type**	**Average Daily Patient Capacity**	**Capacity**	**Feeding Capability**	**Emergency Generator Available**
Emergency Operations Centers	Police Station (Primary)	53 Main St.				No	Yes
	Fire Station # 3 (Secondary)	37 Town Farm Road				No	Yes
Health Facilities	Police Station	55 Main Street	First Aid				Yes
	Fire Station	55 Main Street	First Aid			No	Yes
	Westford Nursing and Rehab Center	3 Park Drive	Skilled Nursing	50		Yes	
	Emerson Hospital Medical Clinic	Littleton Road	Outpatient facility				
Shelters	Blanchard Middle School	15 West Street			700	Yes	Yes
	Westford Academy	30 Patten Road			500	Yes	Yes
	Norman Day School	75 East Prescott Street			300	Yes	Yes
	Stony Brook Middle School	9 Farmer Way			700	Yes	Yes
	Senior Center	20 Pleasant St.					
	Abbott Elementary School	25 Depot St.					
	Nabnasset Elementary School	99 Plain St.					
	Crisafulli Middle School	13 Robinson Road			300	Yes	Yes
	Rita Miller Elementary School	1 Mitchell Way			300	Yes	Yes

Using the methodology outlined on page 91 an assessment of hazard risk was performed based on frequency, severity, extent of impact and the probability of a future event. The result of the analysis is outlined in Table 60 below.

Table 60: Westford Hazard Risk Assessment

Hazard	**Frequency-** (Weight factor=2)	**Severity-** **(**Weight factor=5)	**Extent of Impact –** **(**Weight factor=10)	**Probability-** (weight factor=7)	**Total Score**
Flood	1x2=2	1x5=5	1x10=10	1x7=7	24
Wildfire	3x2=6	1x5=5	2x10=20	3x7=21	52
Urban Fire	1x2=2	1x5=5	1x10=10	1x7=7	24
Earthquake	3x2=6	3x5=15	3x10=30	2x7=14	65
Tornado	1x2=2	2x5=10	3x10=30	1x7=7	49
Dam Failure	1x2=2	1x5=5	1x10=10	1x7=7	24
Drought	2x2=4	3x5=15	3x10=30	1x7=7	56
Nor'easter/severe storm	3x2=6	3x5=15	3x10=30	3x7=21	72
Hurricane	3x3=9	3x5=15	3x10=30	3x7=21	75
Snowstorm/ blizzard	3x2=6	3x5=15	3x10=30	3x7=21	72
Landslide	1x2=2	1x5=5	1x10=10	1x7=7	24
Ice Storm	3x2=6	3x5=15	3x10=30	3x7=21	72
Ice Jam	2x2=4	1x5=5	2x10=20	2x7=14	43

Based on this analysis, Westford is at high risk for earthquakes, nor'easters, hurricanes, ice storms, snowstorms and blizzards. The Town is at a moderate risk for wildfire, drought, and ice jams, and at low risk for dam failure, landslides, urban fire and tornadoes.

The 2008 Ice Storm brought down trees and power lines across most of the community

Flood Prone Areas

Westford falls within two major drainage basins or watersheds: The Merrimack River basin and the Sudbury-Assabet-Concord (SuAsCo) basin. Seven sub-basins drain most of Westford's surface area: the Snake Meadow Brook/Keyes Brook sub-basin; the Nabnasset Lake sub-basin; the Stony Brook sub-basin; the Forge Pond sub-basin; the Tadmuck Swamp sub-basin; and the Heart Pond sub-basin. There are also four sub-basins that lie largely outside of Westford: Bridge Meadow Brook (Tyngsborough); Deep Brook (Chelmsford; Beaver Brook (Littleton); and a small section of the Massapoag Pond basin (Groton/Tyngsborough). By virtue of the size of its drainage sub-basin, Stony Brook is Westford primary watercourse.

In 1983, flood hazards in Westford were mapped as part of the Federal Emergency Management Act. The FIRM flood plain map was later updated in 2010. Westford has a Flood Zone Overlay District (FOD) that restricts uses within mapped floodplains. The purpose of the FOD is to protect public health and safety, to preserve natural flood control characteristics and flood storage capacity of the floodplain, and to protect the groundwater recharge areas within the floodplain. No construction or earthmoving activities are permitted in the FOD without a special permit from the Planning Board. The applicant must demonstrate that a proposed project conforms to the State Building Code and provide an engineer's certification that it will not increase flood levels. The town has also adopted a Water Resource Protection Overlay District (WRPOD) in order to protect drinking water supply areas. Within the overlay districts, Westford prohibits certain land uses and allows others only by special permit. The WRPOD also imposes limits on total impervious cover.

Historically, roadways and areas that have experienced chronic flooding include:

- Bridge Street at Stony Brook Crossing and at "Blacksmith Pond";
- Gould Road;

- Wing Road near Keyes Road;
- Tenney Road;
- Route 40 near Keyes Road; and
- Concord Road at Vine Brook

During meetings with Town, concern was expressed regarding flooding problems on Route 110 in the vicinity of Tadmuck Swamp. This problem has been due to failure to maintain culverts in the area. Route 110 is a state-owned and maintained highway under the jurisdiction of the MassDOT. A similar problem exists on Boston Road, also a state highway. Flooding is also a problem along Route 40 just west of Keyes Road due to culvert issues, and the town has applied for mitigation funds to address this issue.

Repetitive Flood Loss Structures

There are no repetitive loss structures in the Town of Westford.

NFIP Compliance

The Town participates in the NFIP and their policies require that foundations be inspected prior to framing for those structures located in the floodplain. An elevation certificate is also issued for such properties. The Town's GIS department and Engineering Department participates in MEMA NFIP training. The Town has established a Public Works Mutual Aid agreement and is working on a similar agreement for building inspectors. The town staff provides NFIP information to residents at the Building Permit counter. The building permit process is used to identify non-compliant structures.

Structurally Deficient Bridges Over Waterways

There are two structurally deficient bridges over a waterway in Westford: the Beaver Brook Road Bridge over Beaver Brook with an AASHTO rating of 38.1, and the Bridge Street Bridge over Stony Brook with an AASHTO rating of 48.1. The Beaver Brook Road Bridge is rated structurally deficient, due to the fact that the two steel culverts have corroded bottom sections. Westford Highway Department is currently seeking funding from the Town's capital appropriation to realign both culvert pipes. This realignment process consists of slipping a PVC pipe into the existing culvert and grouting around the pipe, providing a structural repair without tearing out the entire structure or disrupting traffic. The Town is further evaluating the condition of the Bridge Street Bridge to determine the extent of the repairs that are needed.

Hazard Potential of Dams

Table 61 on the following page lists the dams in Westford that are included in the Department of Conservation and Recreation, Office of Dam Safety's hazard classification list. Based on the data provided, the Brookside Station Dam is overdue for inspection. Six of the eight dams are classified as significant hazard dams.

Table 61: Hazard Classification of Westford Dams					
Dam Name	**Impoundment Name**	**Hazard Class**	**Downstream Population**	**Last Inspection Date**	**Next Inspection Due**
Commodore Foods Company/Brookside Station Dam	Stony Brook	Significant	7,000	6/2/1998	6/2/2008*
Westford Depot Dam	Stony Brook	Significant	0	9/2/2010	9/2/2015
Stony Brook Dam At Graniteville	Stony Brook Pond	Significant	0	12/8/2011	12/8/2016
Fletcher Pond Dam	Fletcher Pond	Significant	500	4/10/2008	4/10/2013
Murray Printing Company Dam/ Forge Pond Dam	Forge Pond	Significant	125	10/16/2008	10/16/2013
Flushing Pond Dam	Flushing Pond	**Non-jurisdictional	NA		
Nabnasset Pond Dam	Nabnasset Pond	Significant	25	12/8/2011	12/8/2016
Long-Sought-For Pond Dam	Long-Sought-For Pond	**Non-jurisdictional	NA		

Source: Massachusetts Department of Conservation and Recreation, Office of Dam Safety and the Town of Westford
* Dam inspection overdue
**Non-jurisdictional dams are not regulated by the DCR Office of Dam Safety

Winter Storms (ice storms, snowstorms, nor'easters)

As stated in this Plan previously, severe winter storms can produce a wide variety of hazardous weather conditions, including heavy snow, freezing rain, sleet, and extreme wind and cold. A severe winter storm is one that results in four or more inches of snow over a twelve-hour period, or six or more inches over a twenty-four hour period. The leading cause of death during winter storms is from an automobile or other transportation accidents. Exhaustion or heart attacks caused by overexertion are the second most likely cause of winter storm-related deaths. Westford, like the rest of the region, is at risk for winter storms.

Since 1983, the most significant winter snowfall in the region occurred during the winter of 1995, when snowfall measurements in the City of Lowell reached 126.5 inches. Snowfall totals in Westford were similar. The Town has provided the following information regarding winter precipitation totals from 2009-2013, as shown in Table 62 on the following page.

Table 62: Westford Winter Precipitation: 2009-2013

Date	Precipitation Amount (inches)	Precipitation Type
12/5/2009	3	Snow
12/9/2009	8	Snow/sleet
12/13-14/2009	0	Snow/rain
12/20/2009	8	Snow
12/28/2009	0	Snow showers
1/1 – 1/3/2009	7	Snow
1/8/2010	0	Light snow
1/18/2010	7	Snow/rain
1/19/2010	3	Light snow
1/29/2010	0.5	Snow squall
2/10/2010	0	Snow
2/16/2010	7	Snow
2/24/2010	5	Wet snow
2/27/2010	0	Snow/black ice
12/11-12/2010	0	Black ice
12/15-16/2010	1	Light snow
12/20-21/2010	Dusting	Light snow
12/26/2010	Dusting	Light snow
12/26-27/2010	12	Snow
1/8/2011	Dusting	Light snow
1/12/2011	20	Snow
1/15/2011	Dusting	Snow
1/18/2011	6	Snow/freezing rain
1/19/2011	1	Snow
1/21/2011	7	Snow
1/25/2011	1	Snow
1/26-27/2011	11	Snow
2/1/2011	7	Snow
2/2/2011	7.5	Snow
2/5/2011	0	Freezing rain
2/8/2011	3	Snow
2/21/2011	2	Snow
2/25/2011	3	Snow/freezing rain
2/27/2011	7	Wet snow
2/28/2011	1	Freezing rain
3/1/2011	0	Black ice
3/5/2011	0	Black ice
3/8/2011	0	Black ice
3/17/2011	0	Black ice
3/22/2011	1	Snow
4/1/2011	5	Wet snow
10/30/2011	12	Wet snow
1/12-13/2012	2	Snow/freezing rain
1/16/2012	2	Snow
1/19/2012	2	Snow
1/21/2012	3	Snow
1/26/2012	0	Snow/freezing rain
2/29/2012	7	Snow
3/3/2012	1	Wet snow/freezing rain
3/4/2012	0	Black ice
11/7-8/2012	1.5	Snow
12/1/2012	0.5	Light snow
12/2/2012	0	Black ice

Table 62 (cont'd): Westford Winter Precipitation: 2009-2013

Date	Precipitation Amount (inches)	Precipitation Type
12/16-17/2012	1	Snow/freezing rain
12/26-27/2012	3	Wet snow/freezing rain
12/29-30/2012	8	Snow
1/6/2013	0	Trace snow
1/16/2013	4	Snow
1/17/2013	0	Black ice
1/21/2013	0.5	Snow
1/28-29/2013	1.5	Wet snow/freezing rain
1/30/2013	0	Freezing rain/black ice
2/3/2013	0.5	Light snow
2/6/2013	0	Light snow
2/8-9/2013	27	Snow
2/11/2013	0	Snow/freezing rain
2/16/2013	1	Wet snow
2/17/2013	2	Snow
2/24-25/2013	5	Wet snow
2/27/2013	0	Wet snow/freezing rain
3/6/2013	1	Light snow
3/7-8/2013	16	Wet snow
3/18-20/2013	12	Snow/freezing rain
11/26/2013	0	Light snow
12/1/2013	0	Ice/freezing rain
12/6/2013	Dusting	Light snow/ice
12/9/2013	1	Snow/freezing rain
12/14-15/2013	9	Snow
12/17/2013	8	Snow
12/23/2013	0	Freezing rain
12/24/2013	0	Black ice
12/26/2013	1	Snow
12/30/2013	0	Black ice

Source: Westford Highway Department

The October 29, 2011 snowstorm was among the most devastating that the town has experienced. The storm produced 6 inches of heavy wet snow that resulted in extensive tree damage and the loss of power for 8,790 households (87% of the town). More than 2,000 households were without power for six days. School was cancelled for four days due to downed wires. A fiber optic line located at the corner of Forge Village Road and Flagg Road was destroyed by fire during power restoration efforts. This line is the primary connection to Town Hall. More than 60 roads were closed as a result of the downed wires and trees.

Recovery from a winter storm poses a number of challenges. Prolonged curtailment of all forms of transportation can have significant adverse impacts for people stranded at home, preventing the delivery of critical services such home heating fuel supplies or the ability to get to a local food store. Extended power outages, the cost of snow removal, repairing damages, and the loss of business can have severe economic impacts on local communities. The elderly and infirmed are populations of particular concern during these events. Senior housing within Westford is shown in Appendix D.

Hurricanes

Hurricanes can occur along the East Coast of the United States anytime in the period between June and November. Hurricane force winds can destroy buildings and mobile homes. Debris, such as signs, roofing materials, siding and lawn furniture can become missiles. Hurricanes can also spawn tornadoes that generally occur in thunderstorms embedded in rain bands well away from the center of the hurricane. Tornadoes can also occur near the eye wall. Heavy rain associated with the storm may cause flooding. Historically, flooding has occurred at the following locations:

- Bridge Street at Stony Brook Crossing and at "Blacksmith Pond";
- Gould Road;
- Wing Road near Keyes Road;
- Tenney Road;
- Route 40 near Keyes Road; and
- Concord Road at Vine Brook.

The most recent hurricane to affect the region and the Town was Hurricane Irene in August 2011, which became a tropical storm as it passed over the region. Tropical Storm Irene reached Westford on August 28th at 10 pm with heavy rain and wind gusts. The storm created widespread power outages as trees and tree limbs fell onto power lines. Some National Grid customers went days without power and the first day of school was postponed due to the presence of downed lines.

As a result of Irene, the Frost School and J.V. Fletcher Library sustained roof damages which led to interior damage. Roof top equipment on Westford Academy was damages as a result of power surges. A fiber optic line connected to Westford Academy was damaged by a fallen tree. Tree damage caused wires to be disconnected from utility poles in 40 locations throughout town, impacting 2,600 residents who lost power. Given that many town residents rely on private wells for their drinking water, it is estimated that 1,000 households were without water as a result of the power outage.

The following roadways were closed during Irene as a result of flooding: Plain Road, Tenney Road, and Powers Road at Concord Road. Though heavy rains associated with hurricanes present the highest recurrent risk, high winds are also a risk. Downed trees and tree limbs, blocked roads, and downed telephone and power lines can disrupt transportation routes and communication channels. It is impossible to predict where these things might occur during a hurricane event, therefore the entire town is considered to be vulnerable. Table 19 on page 41 contains a list of hurricanes that have hit New England over the past decades. The entire Northern Middlesex region is equally impacted by these events.

Though heavy rains associated with hurricanes present the highest recurrent risk from a hurricane, high winds are also a risk. Downed trees and tree limbs, blocked roads, and downed telephone and power lines can disrupt transportation routes and communication channels. It is impossible to predict where these things might occur during a hurricane event, therefore the entire town is considered to be vulnerable.

Wildfire

A wildfire is an uncontrolled fire that spreads due to the presence of vegetative fuel. These fires often begin unnoticed and spread quickly. In this area of the country, wildfire season generally begins in March and ends in late November. Human beings start four out of every five wildfires through arson or carelessness; lightning strikes account for the remainder. Over a three year period, 171 brush fires were reported in the Town of Westford. The forested areas, including the Town Forest and the East Boston Camps/Stepinski parcels, are particularly vulnerable.

In February 2007, firefighters knocked down a quick moving brush fire in the Forge Village section of town by Forge Pond. The fire spread to about an 80' x 100' area but was quickly contained by firefighters on the scene. In May 2007, firefighters battled a large brush/wildland fire on Keyes Road. The fire was spread by the intense wind across several acres and a nearby home. Two firefighters were transported to a local Hospital for treatment for smoke inhalation and heat exhaustion. The Tyngsborough, Chelmsford, Groton, Carlisle, Lowell, and Littleton Fire Departments provided mutual aid for the fire.

In April 2009 firefighters were called to a report of a brush fire at the end of Trail Side Road. Once firefighters arrived on scene, they discovered a large area of brush burning between Trail Side Road and Preservation Way. Multiple mutual aid units were requested and all shifts were called back to work due to the fire being over such a large area and moving quickly up a hill. Command declared the fire contained in about two hours and all units left the scene three hours after the initial call.

On May 7, 2010, firefighters responded to reports of smoke in the area of Farmers Way and discovered smoke pluming out of the woods in the East Boston Camps. After walking a mile, a brush fire was found burning over an acre. Access to the area was very difficult, as was access to water. All stations were utilized to fight the fire. Firefighters were able to get the fire under control. In June 2010, firefighters battled a large hay field fire off Old Lowell Road. The field burned over an acre, bringing firefighters from all companies and a mutual aide engine from Littleton.

Earthquake

In New England, the immediate cause of most earthquakes is the sudden release of stress along a fault or fracture in the earth’s crust. Much of the research on earthquakes in the northeast has involved attempts to identify pre-existing faults and other geological features that may be susceptible to such stress, but this has proven to be quite difficult. It is unclear whether faults mapped at the earth’s surface in the northeast are the same faults along which earthquakes are occurring. It is impossible to predict the time and location of future earthquakes in New England. There is a 1 in 10 chance that in any given fifty-year period a potentially damaging earthquake will occur.

From 1924 to1989 there were eight earthquakes with a magnitude of 4.2 or greater in New England. According to the Weston Observatory, the last earthquake to hit the New England Region with a magnitude of 3.0 or greater occurred on September 26, 2010, in the area of Contoocook, New Hampshire. New England experiences 30-40 earthquakes each year, although most are not felt.

The area's vulnerability to a devastating earthquake is based primarily on the following elements: the density of the population, and the age of the buildings and lack of earthquake proof design. In the Town of Westford concentrations of older buildings can be found in the vicinity of the Town Center, in Forge Village, Graniteville, Parkerville, and in the Brookside neighborhood of Nabnasset. Older buildings are also scattered throughout town.

SECTION 6: DEVELOPING THE EXISTING PROTECTION MATRIX

The existing protection matrix is a summary of current measures, programs, projects and activities already in place that are related to hazard mitigation. Compiling such an inventory allows gaps and deficiencies to be identified. In preparing the region's 2006 Pre-Disaster Mitigation Plan, a detailed questionnaire was developed and distributed to each local community. As part of the plan update process, the 2006 information was reviewed and revised through a series of meetings, email communications, and conversations with local officials. In addition, local zoning bylaws, rules and regulations, Master Plans, and Open Space and Recreation Plans were consulted. The updated existing protection matrix reflects current conditions and incorporates new measures that have been put in place over the last five years, as shown in Tables 63 through 71. These tables have been prepared using the format suggested in FEMA guidelines.

Table 63: Existing Protection Matrix for the Town of Billerica

TYPE OF EXISTING PROTECTION	DESCRIPTION	AREA COVERED	EFFECTIVENESS OR ENFORCEMENT	IMPROVEMENTS OR CHANGES NEEDED
Town participation in the National Flood Insurance Program (NFIP)	Provides flood insurance for structures located in flood-prone areas.	FEMA flood zones	Effective	None
Floodplain zoning bylaw is in place.	Floodplain zoning by-law prohibits construction in the floodplain, except by special permit issued by the ZBA.	Zone A town-wide.	Effective	None
Subdivision regulations address erosion control and stormwater management.	Subdivision regulations are consistent with EPA Phase II stormwater requirements.	Town-wide	Enforced by the Planning Board, Conservation Commission and Board of Health.	None.

Table 63 (cont'd): Existing Protection Matrix for the Town of Billerica

TYPE OF EXISTING PROTECTION	DESCRIPTION	AREA COVERED	EFFECTIVENESS OR ENFORCEMENT	IMPROVEMENTS OR CHANGES NEEDED
Stormwater Management Plan	The town has a stormwater management plan in place that complies with existing EPA Phase II requirements	Town-wide	Implemented and monitored by the Conservation Commission, Planning Board, Building Inspector and Public Works Department.	Changes will be needed when new EPA stormwater regulations go into effect.
Town has a local wetlands zoning bylaw.	Local bylaw is more restrictive than the MA Wetlands Protection Act. Requires 100-foot buffer in wetland resource areas.	Town-wide	Enforced by Conservation Commission.	None.
Local regulations address limitations on impervious surface.	Local bylaw includes limitations on expansion of impervious surfaces.	Town-wide	Enforced by the Planning Board and Conservation Commission.	Conservation Commission advocates increased public education and awareness.
Town's Open Space Plan targets protection and acquisition of parcels for flood mitigation.	Plan advocates acquisition of parcels within the 100-year floodplain and other environmentally sensitive area.	Town-wide	Moderately effective. Town is pursuing acquisition of parcels along the Shawsheen and Concord Rivers.	None.
Community has a Capital Improvement Program that includes projects with natural hazard mitigation benefits.	The town has an ongoing sewer construction program, and is designing roadway improvement projects that will address drainage issues in targeted locations.	Town-wide	The Department of Public Works is responsible for implementing these projects.	None.
Maintenance program for stormwater drainage structure	The Town has a maintenance program for cleaning drainage structures, culverts, and detention basins. Streets are swept on a regular basis.	Town-wide	Program is implemented by the Department of Public Works and is effective.	None.

Table 63 (cont'd): Existing Protection Matrix for the Town of Billerica

TYPE OF EXISTING PROTECTION	DESCRIPTION	AREA COVERED	EFFECTIVENESS OR ENFORCEMENT	IMPROVEMENTS OR CHANGES NEEDED
Town has a Stormwater Management Bylaw	Mandates use of structural and non-structural BMPs in construction projects	Town wide	Enforced by the Board of Health	None.
The Community has a program to notify residents of potential wildfire hazard during drought conditions.	The Fire Department utilizes local media, including cable TV and radio, to educate residents regarding wildfire danger.	Town-wide	Effective	None.
Enforcement of State Building Code	The town's building inspector enforces the state building code, including those sections that relate to the NFIP requirements.	Town-wide	Effective	None.
Town utilizes CodeRED emergency notification system	Allows for emergency notification on a town-wide basis or on a specific area basis	Town wide	Effective	None

Table 64: Existing Protection Matrix for the Town of Chelmsford

TYPE OF EXISTING PROTECTION	DESCRIPTION	AREA COVERED	EFFECTIVENESS OR ENFORCEMENT	IMPROVEMENTS OR CHANGES NEEDED
Community participates in the National Flood Insurance Program.	NFIP provides flood insurance to property owners in exchange for community compliance with floodplain management.	FEMA Zones A and AZ (100-year floodplain)	Moderately effective	Improved zoning enforcement needed.

Table 64 (cont'd): Existing Protection Matrix for the Town of Chelmsford

TYPE OF EXISTING PROTECTION	DESCRIPTION	AREA COVERED	EFFECTIVENESS OR ENFORCEMENT	IMPROVEMENTS OR CHANGES NEEDED
Town has floodplain zoning in place	The Town adopted DCR's model floodplain bylaw in April 2004.	Covers Zones A and AZ (100-year floodplain)	Effective	None.
Stormwater and erosion control measures	The Planning Board requires adherence to DEP's Stormwater policy town wide. The town also has a stormwater management plan as required under its MS4 Permit.	Town-wide	Regulations should be reviewed; although a major revision is not needed.	Improved coordination is needed between the Planning Board, Conservation Commission, and ZBA (as 40B permit granting authority). Implementation of a Low Impact Development (LID) bylaw should be evaluated.
The Town has a wetlands protection and aquifer protection bylaw and district.	The Conservation Commission has a general (non-zoning) wetlands bylaw; the zoning bylaw includes a section regarding the Aquifer Protection District.	Town-wide	Both wetland and aquifer protection bylaws are effective.	No improvements needed.
The Town has impervious surface limitations.	The Aquifer Protection District limits impervious surface to 2,500 square feet, or 15%.	Within the Aquifer Protection District	Routine review is warranted.	Better enforcement would be beneficial.
Open Space Plan includes measures aimed at natural hazard mitigation.	Identifies improvements to open space properties and protection of resource areas; includes a seven year action plan.	Town-wide	Open Space Plan is updated every 7 years.	OSRP has been approved by the State. Implementation will be ongoing.

Table 64 (cont'd): Existing Protection Matrix for the Town of Chelmsford

TYPE OF EXISTING PROTECTION	DESCRIPTION	AREA COVERED	EFFECTIVENESS OR ENFORCEMENT	IMPROVEMENTS OR CHANGES NEEDED
Master Plan addresses Natural Hazard Mitigation	The town's 2010 Master Plan contains recommendations relative to natural hazard mitigation.	Town-wide	The town has an established Master Plan Implementation Committee charged with implementing the recommendations contained within the Plan.	The Implementation Committee should contain to its work to implement the plan recommendations; progress will be reported to town meeting on an annual basis.
The Town has local stormwater regulations in place.	Zoning and subdivision regulations require limiting the rate of runoff to pre-development rates. Culverts are sized for 10-year storms, detention basins for 25-year storms with damage avoidance for the 100-year event.	Town-wide	Stormwater controls are generally effective; Town relies on closed stormwater systems. Best management practices required for new commercial developments and subdivisions.	Town should evaluate and consider Low Impact Development (LID); improved coordination between the Planning Board, Conservation Commission, and ZBA.
A response plan is in place for dams located within Town.	There are emergency plans in place for the Freeman Lake and Heart Pond Dams.	Area in vicinity of dams	Plans adequately assess potential damage and provide response measures.	Response plans should be routinely reviewed and updated.
Town performs limited maintenance of drainage infrastructure.	The Town clears several small streams, swales, etc. each year.	Town-wide	In general, stormwater systems are maintained only when there is a failure/emergency.	A plan for routine maintenance should be established.
Town has program to sweep streets, clean out catch basins, and clear blocked culverts	Town sweeps streets and cleans each catch basin yearly. Culverts are cleaned as needed.	Town-wide	Marginally effective. More frequent maintenance is necessary to protect resource areas and meet DEP standards.	Financial constraints limit more frequent maintenance.

Table 64 (cont'd): Existing Protection Matrix for the Town of Chelmsford

TYPE OF EXISTING PROTECTION	DESCRIPTION	AREA COVERED	EFFECTIVENESS OR ENFORCEMENT	IMPROVEMENTS OR CHANGES NEEDED
Green Community Designation	The Town has been designated by the Department of Energy Resources as a Green Community. Hence, the community works toward improving energy efficiency and reducing greenhouse gas emissions, which benefits climate change.	Town-wide	Effective	None. Ongoing program.
Enforcement of State Building Code	The town's building inspector enforces the state building code, including those sections that relate to the NFIP requirements.	Town-wide	Effective	None.
Town has active program to address tree hazards	Street trees are monitored, cut and pruned as needed. Town relies on abutters to report problem locations.	Town-wide	Generally effective	None

Table 65: Existing Protection Matrix for the Town of Dracut

TYPE OF EXISTING PROTECTION	DESCRIPTION	AREA COVERED	EFFECTIVENESS OR ENFORCEMENT	IMPROVEMENTS OR CHANGES NEEDED
Community participates in the National Flood Insurance Program.	NFIP provides flood insurance to property owners in exchange for community compliance with floodplain management.	FEMA Zones A and AZ (100-year floodplain)	Effective	None
The Town has a wetland and water conservancy overlay district	Construction of a new structure, new impervious surface or enlargement of an existing structure or impervious surface is prohibited.	Town-wide	Effective	None

Table 65 (cont'd): Existing Protection Matrix for the Town of Dracut

TYPE OF EXISTING PROTECTION	DESCRIPTION	AREA COVERED	EFFECTIVENESS OR ENFORCEMENT	IMPROVEMENTS OR CHANGES NEEDED
Community has a stormwater control policy	Planning Board reviews projects for compliance with DEP stormwater regulations. Subdivision and zoning regulations require peak runoff for development to be less than or equal to pre-development runoff rates; require that drainage systems be sized for the 25-year storm and detention basins for 100-year storm.	Applied to new development projects town-wide	Effective	None.
Erosion and sediment control bylaw	The Town has an erosion and sediment control bylaw to promote groundwater recharge, limit impervious surface, and remove suspended solids and contaminants from stormwater.	Town-wide	Effective	None
Maintenance plan for drainage and stormwater infrastructure.	The Town maintains all detention/ retention basins, culverts, swales and other drainage infrastructure under its control.	Town-wide	Effective	None
Emergency generators for water supply/other capital improvements	The Dracut Water Supply District has installed new booster pumps with emergency generators and has plans for other capital projects. The Kenwood Water Dept. is constructing a new pump station with an emergency generator.	Dracut Water Supply District and the Kenwood Water Dept. district	Effective	None
The Town has a street sweeping program in place.	Streets are swept and culverts are cleaned annually.	Town-wide	Effective	None

Table 65 (cont'd): Existing Protection Matrix for the Town of Dracut

TYPE OF EXISTING PROTECTION	DESCRIPTION	AREA COVERED	EFFECTIVENESS OR ENFORCEMENT	IMPROVEMENTS OR CHANGES NEEDED
Tree maintenance program.	The town has a full-time tree program to address dead and diseased trees that pose a public safety hazard and may impact utility lines	Town-wide	Effective	None
Enforcement of State Building Code	The town's building inspector enforces the state building code, including those sections that relate to the NFIP requirements.	Town-wide	Effective	None.
Drainage Improvement/culvert replacement program	The town has replaced/upgraded several culverts and drainage structures to reduce flash flooding problems. The following locations have been addressed: Varnum Road near Florence Street; Lakeview Avenue near Florence Street; Methuen Street near Stuart Avenue; Pleasant Street, Lakeview Avenue, and Burdette Road at Peppermint Brook; Cheever Ave, near Robbins Rd., and Salem Rd.	Town-wide	Effective	Additional locations need to be addressed

Table 66: Existing Protection Matrix for the Town of Dunstable

TYPE OF EXISTING PROTECTION	DESCRIPTION	AREA COVERED	EFFECTIVENESS OR ENFORCEMENT	IMPROVEMENTS OR CHANGES NEEDED
Town participation in the National Flood Insurance Program (NFIP).	Provides flood insurance for structures located in flood-prone areas.	FEMA 100-year flood zones	Effective	None.

Table 66 (cont'd): Existing Protection Matrix for the Town of Dunstable

TYPE OF EXISTING PROTECTION	DESCRIPTION	AREA COVERED	EFFECTIVENESS OR ENFORCEMENT	IMPROVEMENTS OR CHANGES NEEDED
The Town has a local wetlands bylaw.	Prohibits construction of a new structure or alteration of an existing structure within 100 feet of a wetland.	Town-wide	Effective	None.
Floodplain Overlay District	The Town's zoning bylaw includes a floodplain overlay district. No building or structure may be erected within the 100-year floodplain.	Town-wide within the 100-year floodplain.	Effective	None.
Enforcement of State Building Code	The town's building inspector enforces the state building code, including those sections that relate to the NFIP requirements.	Town-wide	Effective	None.
Open Space Plan addresses hazard mitigation	The Town has a state-approved Open Space and Recreation Plan that contains goals and recommendations relative to flood protection and open space acquisition.	Town-wide	Effective.	Implementation is ongoing.

Table 67: Existing Protection Matrix for the City of Lowell

TYPE OF EXISTING PROTECTION	DESCRIPTION	AREA COVERED	EFFECTIVENESS OR ENFORCEMENT	IMPROVEMENTS OR CHANGES NEEDED
The City participates in the National Flood Insurance Program (NFIP).	NFIP provides flood insurance to property owners in exchange for community compliance with floodplain management.	FEMA 100-year flood zones	Effective	None.
Floodplain zoning overlay district ordinance is in place.	Section 9.1 of the zoning ordinance requires that all development, including structural and nonstructural activities, be in compliance with state building code requirements for construction in floodplains.	Covers all FIRM zones in the 100-year floodplain	Effective	None.
City Wetlands Ordinance	Sections 5 through 120 of the Municipal Code of Ordinances states that no person shall remove, fill, dredge, alter or build upon or within 100 feet of any bank, lake, river, pond, or stream, or upon any land subject to flooding.	City-wide	Effective	Improve enforcement.
Program to reduce Combined Sewer Overflows	The City of Lowell is implementing a program to separate wastewater and stormwater that will reduce sewer backups and relieve street flooding.	City-wide	Long-term program is being implemented as funds become available, highly effective over the long-term.	Additional funding sources will be needed to implement the overall program within a reasonable timeframe.

Table 67 (cont'd): Existing Protection Matrix for the City of Lowell

TYPE OF EXISTING PROTECTION	DESCRIPTION	AREA COVERED	EFFECTIVENESS OR ENFORCEMENT	IMPROVEMENTS OR CHANGES NEEDED
Street tree program in place.	The City has a program in place to remove problem trees and plant replacements.	City-wide	Effective	None.
Ongoing flood protection system improvement program	The City has made substantial improvements to its flood protection system since the floods of 2006 and 2007	Merrimack River and Beaver Brook flood zones	Effective	City is currently working to address levee stability, the West Street Pumping station, and the I-wall along Beaver Brook.
Brush thin and fuel reduction program for the State Forest.	The City of Lowell and DCR have implemented a fuel reduction program for the Lowell-Dracut-Tyngsborough State Forest to reduce the risk of wildfire.	Lowell-Dracut-Tyngsborough State Forest	New Program, effectiveness cannot yet be rated.	None.
Open Space Plan that address protection of the floodplain	The City has a state-approved Open Space and Recreation Plan in place that addresses flood protection.	City-wide	Effective	None.
Master Plan addresses natural hazards	The City's 2011 Master Plan addresses flood risk and flood zone protection.	City-wide	Implementation will be ongoing over the next several years	None.

Table 67 (cont'd): Existing Protection Matrix for the City of Lowell

TYPE OF EXISTING PROTECTION	DESCRIPTION	AREA COVERED	EFFECTIVENESS OR ENFORCEMENT	IMPROVEMENTS OR CHANGES NEEDED
Green Community Designation	The Town has been designated by the Department of Energy Resources as a Green Community. Hence, the community works toward improving energy efficiency and reducing greenhouse gas emissions, which benefits climate change.	Town-wide	Effective	None. Ongoing program.
Enforcement of State Building Code	The City's Building Department enforces the state building code, including those sections that relate to the NFIP requirements.	Town-wide	Effective	None.
Plan to notify residents in the event of a natural disaster.	The City has implemented reverse E911 as one means of notifying residents in an emergency.	City-wide	Effective.	None.

Table 68: Existing Protection Matrix for the Town of Pepperell

TYPE OF EXISTING PROTECTION	DESCRIPTION	AREA COVERED	EFFECTIVENESS OR ENFORCEMENT	IMPROVEMENTS OR CHANGES NEEDED
The Town participates in the National Flood Insurance Program (NFIP).	NFIP provides flood insurance to property owners in exchange for compliance with floodplain management.	FEMA 100-year flood zones	Effective	None.

Table 68 (cont'd): Existing Protection Matrix for the Town of Pepperell

TYPE OF EXISTING PROTECTION	DESCRIPTION	AREA COVERED	EFFECTIVENESS OR ENFORCEMENT	IMPROVEMENTS OR CHANGES NEEDED
Local Wetlands Protection Bylaw	In addition to the requirements of the state's Wetlands Protection Act, the local bylaw states that a 50-foor wide undisturbed, vegetated strip of naturally occurring plant species must be maintained between a certified vernal pool or wetland resource area.	Town-wide	Moderately effective	Bylaw should be reviewed and modifications considered.
Zoning bylaw addresses erosion control.	The Town's zoning bylaw states that site design, materials, and construction processes shall be employed to avoid erosion damage, sedimentation, or uncontrolled surface water runoff.	Town-wide	Effective	None.
Zoning bylaw contains a Water Resource Protection Overlay District.	The Water Resource Protection Overlay District consists of three zones: Water Source Protection Zone (Zone I); Well Protection Zone (Zone II) and an Aquifer-Watershed Protection Zone (Zone III). Activities within each of these zones are regulated to protect groundwater from degradation.	Town-wide	Effective	None.
Local Flood Control Bylaw (Chapter 95)	The Town bylaws contain a local floodplain bylaw consistent with the requirements of the National Flood Insurance Program.	Town-wide	Effective.	None.

Table 69: Existing Protection Matrix for the Town of Tewksbury

TYPE OF EXISTING PROTECTION	DESCRIPTION	AREA COVERED	EFFECTIVENESS OR ENFORCEMENT	IMPROVEMENTS OR CHANGES NEEDED
The Town participates in the National Flood Insurance Program.	NFIP provides flood insurance for property owners in exchange for community compliance with floodplain management.	Town-wide	Effective	None.
Tewksbury participates in the Community Rating System (CRS).	The federal CRS program encourages communities to undertake activities that exceed the minimum NFIP floodplain management standards.	Town-wide	Effective. The Town has adopted an improved stormwater management program as a result of its participation in the CRS program.	None.
Floodplain overlay district zoning bylaw	The Town's floodplain overlay district zoning bylaw was revised in 2002. All development in the district must comply with Chapter 131, Section 40 MGL; 780 CMR (State Building code) for flood resistant construction which addresses floodplain; 310 CMR Section 10.00; and 302 CMR 6.00, as well as DEP Title V regulations for subsurface disposal of sanitary sewage.	Town-wide	Effective	None.
Discharges to municipal storm sewers by-law has been adopted	Includes enforcement by the DPW on illicit connections to prevent pollutant from entering the system.	Town wide	Effective	None

Table 69 (cont'd): Existing Protection Matrix for the Town of Tewksbury

TYPE OF EXISTING PROTECTION	DESCRIPTION	AREA COVERED	EFFECTIVENESS OR ENFORCEMENT	IMPROVEMENTS OR CHANGES NEEDED
Local Wetlands Protection Bylaw	The Town has a local wetlands protection bylaw which states that no person shall alter a resource area including within 100 feet of any vegetated wetland, meadow, swamp, or bog; or within 100 feet of any river, brook, stream (intermittent or otherwise), pond of lake; any land under water; or within 100 feet of bordering or isolated land subject to flooding or inundation by groundwater or surface water.	Town-wide	Effective	None
Subdivision regulations address drainage, erosion and sediment control, and have additional standards for the floodplain district.	The peak rate of stormwater runoff shall not exceed the rate prior to construction based on a 2, 10, 25, 50 and 100-year storm design. Street drainage cannot be channeled into a wetland or water body without first going to a vegetated detention basin in accordance with DEP stormwater regulations. Where possible, streets must be laid out so that filling or construction in the flood plain district is not required.	Town-wide	Effective. New stormwater management requirements are in place.	None.

Table 69 (cont'd): Existing Protection Matrix for the Town of Tewksbury

TYPE OF EXISTING PROTECTION	DESCRIPTION	AREA COVERED	EFFECTIVENESS OR ENFORCEMENT	IMPROVEMENTS OR CHANGES NEEDED
Green Community Designation	The Town has been designated by the Department of Energy Resources as a Green Community. Hence, the community works toward improving energy efficiency and reducing greenhouse gas emissions, which benefits climate change.	Town-wide	Effective	None. Ongoing program.
Open Space and Recreation Plan addresses Natural Disaster Mitigation.	The Town's most recent Open Space and Recreation Plan targets open space acquisition for natural hazard mitigation especially those in the flood plain.	Key parcels town-wide.	Effective.	None.
Capital Improvement Program	The town has a capital improvement program that contains projects that will benefit natural hazard mitigation. These include implementation of the town's sewer facilities plan, and stormwater management infrastructure improvements.	Town-Wide.	Effective. The Sewer Program Will Address The Failed Septic Systems That Have Been Monitored By The Board Of Health.	None.
Repair of the Ames Pond Dam and Dikes	Within the past five years, the Town funded the cost of repairs for the Ames Pond Dam and dikes, which are privately owned.	Ames Pond Dam and Dikes A and B	Effective	Future maintenance responsibilities for these facilities need to be addressed.

Table 69 (cont'd): Existing Protection Matrix for the Town of Tewksbury

TYPE OF EXISTING PROTECTION	DESCRIPTION	AREA COVERED	EFFECTIVENESS OR ENFORCEMENT	IMPROVEMENTS OR CHANGES NEEDED
Street Sweeping Program	The Town has a program to sweep streets, and clean catch basins and culverts.	Town-wide	Effective	None.
DPW Forestry Department Tree Maintenance Program	The Town DPW has a program for removing diseased and dead trees which pose a risk to public safety and utility lines.	Town-wide	Effective	None.
Measures to address wildfire risk.	The Town requires fireproof roofing shingles. Vegetative fuel under power lines is also removed to reduce fire risk.	Town-wide	Effective	None.
Groundwater Protection Overlay District	The Groundwater Overlay District bylaw protects the wellhead for the Tewksbury State Hospital drinking water supply.	Wellhead area for the Tewksbury State Hospital water supply.	Effective	None.
FMA and HMGP Grants	Two repetitive flood loss structures were elevated above base flood elevation, and culverts were installed on East Street to address flooding.	Two repetitive flood loss properties, and East Street/Strong water Brook crossing	Effective	None.
Stormwater Management and erosion control bylaw.	Approved by town meeting in October 2010	Town wide.	Effective.	None.

Table 70: Existing Protection Matrix for the Town of Tyngsborough

TYPE OF EXISTING PROTECTION	DESCRIPTION	AREA COVERED	EFFECTIVENESS OR ENFORCEMENT	IMPROVEMENTS OR CHANGES NEEDED
Subdivision regulations address drainage and stormwater.	Subdivision regulations state that the quantity of runoff shall be less or equal to the predevelopment condition. The system must be designed for the 25-year storm event. Detention basins must be designed for the 100-year storm.	Town-wide	Effective	None.
The Town participates in the National Flood Insurance Program.	NFIP provides flood insurance for property owners in exchange for community compliance with floodplain management.	Town-wide	Effective	None.
The Town's zoning bylaw includes a Floodplain and Floodway Overlay District.	The Floodplain Overlay District bylaw states that no new building shall be erected, and no existing structure shall be altered, enlarged or moved; no dumping, filling, or earth transfer or relocation shall be permitted; nor any land, building or structure used for any purpose, except by special permit. The Floodway Overlay District bylaw states that all encroachments, including fill, new construction, substantial improvements to existing structures, and other development are prohibited, except by special permit.	The Floodplain Overlay District includes FIRM Zones A and A1-30.	Effective	None.

Table 70 (cont'd): Existing Protection Matrix for the Town of Tyngsborough

TYPE OF EXISTING PROTECTION	DESCRIPTION	AREA COVERED	EFFECTIVENESS OR ENFORCEMENT	IMPROVEMENTS OR CHANGES NEEDED
Zoning bylaw includes a Wetlands Overlay District.	The following uses are prohibited in the Wetlands Overlay District: the erection of any new building or structure, or impervious surface, or enlargement of an existing structure; dumping, filling, earth removal; sewage/septage disposal systems, refuse dumping or sanitary landfills; the storage of chemicals, manure or toxics.	Boundaries of the district are coterminous with the bounds contained in MGL Chapter 131: banks, bordering vegetated wetlands, land under water and waterways, and certain land subject to flooding including bordering and isolated areas. The draining, damming or relocation of any water feature is prohibited.	Effective	None.
Local Wetlands Protection Bylaw	The Town's Wetlands Protection Bylaw states that no person shall remove, fill, dredge, build upon, degrade, discharge into, or otherwise alter any freshwater wetlands; marsh; wet meadow; bog; swamp; vernal pool; bank; reservoir; lake; pond of any size; river; stream; creek; beach; land under water; land subject to flooding; and land abutting any of the aforementioned resource areas.	Lands within 200 feet of a river, and lands within 100 feet of other resource areas, are covered by this bylaw.	Effective	None.
Green Community Designation	The Town has been designated by the DOER as a Green Community. Hence, the community works toward improving energy efficiency and reducing greenhouse gas emissions, which benefits climate change.	Town-wide	Effective	None. Ongoing program.

Table 70 (cont'd): Existing Protection Matrix for the Town of Tyngsborough

TYPE OF EXISTING PROTECTION	DESCRIPTION	AREA COVERED	EFFECTIVENESS OR ENFORCEMENT	IMPROVEMENTS OR CHANGES NEEDED
Stormwater Management By-law and Stormwater Management Plan	The Town has a bylaw to regulate stormwater runoff, non-point source pollution, illicit connections, illegal discharges and obstructions to the storm sewer system. The Town also has a stormwater management plan as part of its MS4 permit.	Town-wide	Effective	None.

Table 71: Existing Protection Matrix for the Town of Westford

TYPE OF EXISTING PROTECTION	DESCRIPTION	AREA COVERED	EFFECTIVENESS OR ENFORCEMENT	IMPROVEMENTS OR CHANGES NEEDED
Zoning bylaw includes a Floodplain Overlay District.	The Town's Floodplain Overlay District Bylaw states that no structure or building shall be erected, constructed, substantially improved, or otherwise created or moved, except by special permit granted by the Planning Board By-law updated in 2010 to reflect updated FIRMs.	FIRM 100-year flood elevations designated as Zone A and Zones A1-A30.	Effective	None.
Zoning Bylaw includes a Water Resource Protection Overlay District.	The Town's Water Resource Overlay District (WRPD) includes WRPD I through III locations.	Town-wide	Effective	Master Plan calls for addition of quantitative standards, such as related to nitrogen loading, into the existing WRPD by-law

Table 71 (cont'd): Existing Protection Matrix for the Town of Westford

TYPE OF EXISTING PROTECTION	DESCRIPTION	AREA COVERED	EFFECTIVENESS OR ENFORCEMENT	IMPROVEMENTS OR CHANGES NEEDED
The Town participates in the National Flood Insurance Program.	NFIP provides flood insurance for property owners in exchange for community compliance with floodplain management.	Town-wide	Effective	None.
Zoning bylaw includes a Conservation Overlay District.	The Conservation Overlay District is comprised of land set aside from development for agriculture, open space, and passive recreation.	Seven locations across Town, including a portion of: Pine Ridge Estates; Vine Brook Estates; Pilgrim Village at Keyes Pond; and Hildreth Hills; land off Lucille Avenue (2.5 acres); and land off Tenney Road (15.3 acres).	Effective	None.
Local Wetlands Bylaw	The Town's local wetlands bylaw states that no person shall remove, fill, dredge, alter or build upon or within 100 ft. of any bank, wetland, marsh, bog, swamp, vernal pool or beach; brook, stream, pond, or lake; or FEMA 100-year flood plain.	Town-wide	Effective	None.
Stormwater Management Plan and By-law	Applies to all land disturbances greater than 1 acre and all subdivisions.	Town-wide	Need to develop regulations, enforced via Planning Board permitting and Engineering Dept. review of proposals	Regulations are being developed by the town
Discharges to municipal storm sewers by-law has been adopted	Includes enforcement by the Board of Health relative to illicit connections to prevent pollutants from entering the system.	Town-wide	Effective	None

Table 71 (cont'd): Existing Protection Matrix for the Town of Westford

Regular maintenance of Dam Structures	The Town has an active program to maintain town-owned dams.	Recent improvement projects include the Commodore Foods/Brookside Station Dam and the Stony Brook Dam.	Effective	None.
Maintenance Program for town-owned outfall structures.	The Town routinely maintains sluice gates for outfalls for lakes/ponds.	Program covers town-owned structures.	Effective	None.
Street Sweeping Program	The Town sweeps all roadways on an annual basis.	Town-wide	Effective	None.
Drainage infrastructure maintenance program.	The Town maintains and cleans all drainage structures including catch basins and culverts on a regular schedule.	Town-wide	Effective	None.
Prevention	Ensure erosion control through Planning Board and subdivision regulations.	Town-wide	Effective	None
Tree Maintenance Program	The Town Highway Dept.-has a program for removing diseased and dead trees which pose a risk to public safety and utility lines.	Town-wide	Effective	None.
Wildfire mitigation measures	The Fire Department initiated a program to address the potential for wildfire in forested areas of Town, in conjunction with the District 6 Fire Warden.	Town-wide	To be determined; new program.	None
Plan for public information dissemination to warn of possible natural disaster.	The Town has a plan in place to provide residence with warning information utilizing cable TV, the internet, and reverse 911.	Town-wide	Effective	None.

SECTION 7: VULNERABILITY/RISK ASSESSMENT

A. Overview of Natural Hazards Vulnerability

Previous sections of this report describe the natural hazards that have occurred, or are most likely to occur in the region. Since 1991, there have been twenty-three Presidential disaster declarations that included Middlesex County, as summarized in Table 72 below. Since 2006, there have been seven Presidential disaster declarations in Middlesex County, four of which were the result of flooding, while the remaining three were the result of severe winter storms. The vulnerability and risk assessment has been based on: the frequency of disasters, the potential extent of the impact from each hazard and the probability of the event occurring. The *2010 Massachusetts State Hazard Mitigation Plan* was consulted for this analysis. The Hazard Assessment analysis is outlined in Section 4 of this document.

According to the State's 2010 Hazard Mitigation Plan, the 2010 Hazard Mitigation Index Rating for Middlesex County was 22. This represents a minimal change from 2007, when the county received an index score of 20. For comparison, in 2010 the lowest index rating of 9 was found in Hampshire County and the highest rating of 25 was in Essex County. The higher the index rate the greater the potential vulnerability to a natural disaster. The greatest hazard risk in Middlesex County is from flooding. In fact, Middlesex County is rated at the greatest risk for flooding of all counties in Massachusetts.

Table 72: Disaster Declarations for Middlesex County (1991-2013)

Disaster Name (Date of Event)	Disaster Number (Type of Assistance)	Declared Areas
Hurricane Bob (August 1991)	FEMA -914-DR-MA (PA); FEMA-914-DR-MA (HMGP)	Counties of Barnstable, Bristol, Dukes, Essex, Hampden, Middlesex, Plymouth, Nantucket, Norfolk, and Suffolk
Severe Coastal Storm (October 1991)	FEMA-920-DR-MA (PA); FEMA-920-DR-MA IMA); FEMA-920-DR-MA (HMGP)	Counties of Barnstable, Bristol, Dukes, Essex, Middlesex, Plymouth, Nantucket, Norfolk, and Suffolk
Blizzard (March 1993)	FEMA-3103-EM (PA)	All 14 Massachusetts counties
Blizzard (January 1996)	FEMA-1090-EM (PA)	All 14 Massachusetts counties
Severe Storms/Flood (October 1996)	FEMA – 1142 –DR-MA (PA); FEMA -1142 – DR-MA (IFG); FEMA-1142-DR-MA (HMGP); and FY 1997 CDBG	Counties of Essex, Middlesex, Plymouth, Norfolk, and Suffolk
Heavy Rain/Flood (June 1998)	FEMA-1224-DR-MA (IFG); FEMA-1224-DR-MA (HMGP); 1998 CDBG	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth and Worcester
Severe Storms and Flooding	FEMA-1364-DR-MA (IFG); FEMA-1364-DR-MA (HMGP)	Counties of Bristol, Essex, Middlesex, Norfolk, Suffolk, Plymouth, and Worcester
Snowstorm (March 2001)	FEMA-3164-DR-MA (IFG)	Counties of Berkshire, Essex, Franklin, Hampshire, Middlesex, Norfolk, and Worcester
Terrorist Attack (September 11, 2001)	FEMA-1391 (IFG)	Massachusetts residents who requested crisis counseling services following September 11th.
Snowstorm (February 2003)	FEMA-3175-EM (PA)	All 14 Massachusetts counties.

Table 72 (cont'd): Disaster Declarations for Middlesex County (1991-2013)

Disaster Name (Date of Event)	Disaster Number (Type of Assistance)	Declared Areas
Snowstorm (December 2003)	FEMA-3191-EM (PA)	Counties of Barnstable, Berkshire, Bristol, Essex, Franklin, Hampden, Hampshire, Middlesex, Norfolk, Plymouth, Suffolk, and Worcester
Flooding (April 2004)	FEMA-1512-DR (IFG); FEMA-1512-DR (HMGP)	Counties of Essex, Middlesex, Norfolk, Suffolk and Worcester
Severe Winter Storm (January 2005)	FEMA-3201-EM (PA)	All 14 Massachusetts counties.
Hurricane Katrina (August 2005)	FEMA- 3252-EM (PA)	All 14 Massachusetts counties.
Severe Storms and Flooding (October 2005)	FEMA-1614-DR (IHP); FEMA -1614-DR-MA (HMGP)	Counties of Berkshire, Bristol, Franklin, Hampden, Hampshire, Middlesex, Norfolk, Plymouth and Worcester (HMGP funds were available to all 14 Massachusetts counties)
Severe Storms and Flooding (May 2006)	FEMA-1642- DR-MA (PA)	Essex and Middlesex Counties
	FEMA-1642-DR-MA (IHP)	Essex, Middlesex and Suffolk
	FEMA-1642-DR-MA (HMGP)	All 14 Massachusetts counties
Severe Storms and Flooding (April 2007)	FEMA-1701-DR-MA (PA); FEMA-1701-DR-MA (HGMP)	All 14 Massachusetts counties
Severe Winter Storm (December 2008)	FEMA-3296-EM-MA (Public)	Counties of Berkshire, Bristol, Essex, Franklin, Hampden, Hampshire, Middlesex, Suffolk and Worcester
Severe Storms and Flooding (December 2008)	FEMA-1813-DR-MA (PA); FEMA-1813-DR-MA (HMGP)	Counties of Berkshire, Essex, Franklin, Hampden, Hampshire, Middlesex, and Worcester. (HGMP funds were made available to all 14 counties.
Severe Storm and Flooding (March-April 2010)	FEMA-1895-DR-MA (PA); FEMA-1895-DR-MA (IHP)	Counties of Essex, Suffolk. Plymouth, Middlesex, Norfolk, and Worcester
Severe Storm and Snowstorm (January 2011)	FEMA-1959-DR-MA (PA); FEMA-1959-DR-MA (HGMP)	Counties of Berkshire, Essex, Hampden, Hampshire, Middlesex, Norfolk, and Suffolk. (HGMP funds were made available in all 14 Massachusetts counties)
Severe Storm/snowstorm (October 2011)	FEMA – 4051-DR-MA (PA); FEMA-4051-DR-MA (HMGP)	Counties of Berkshire, Franklin, Hampden, Hampshire, Middlesex, and Worcester. (HMGP funds are available in all 14 counties)
Severe Winter Storm, snowstorm and flooding (April 2013)	FEMA-4110-DR-MA	All 14 Massachusetts counties

Key:

PA-Public Assistance Project Grants: Supplemental disaster assistance to states, local governments, certain private non-profit organizations resulting from declared major disasters or emergencies.

HMGP – Hazard Mitigation Grant Program: Project grants to prevent future loss of life or property due to disaster. A presidential declaration of a major disaster or emergency is needed to designate HMGP assistance.

IHP – Individual Household Program: Formerly named IFG, this program provides grants and loans to individual disaster victims to address serious needs and necessary expenses, under the FEMA Disaster Housing, State IFG Program, and/or SBA Home and Business Loan Programs.

CDBG – Community Development Block Grant: Project grants for community development –type activities to assist with long-term recovery needs related to both residential and commercial buildings.

Source: FEMA

B. Potential Flood Damage as a Measure of Vulnerability

All jurisdictions within the region have hazard-prone areas. Clearly, the most common hazard is flooding. Estimates of the potential losses from flooding were calculated as one means of measuring the region's vulnerability. Methodologies to measure the geographic impact of flood events are well developed, and mitigation practices to reduce flood impacts are well understood.

NMCOG staff estimated the value of buildings within the 100-year flood plain using assessed value data from the tax assessor records in each community. The 100-year flood plain is a well-defined geographical area for which up-to-date maps are readily available. These maps, which were updated in 2010, were overlaid with the building location data for each municipality.

Flood Insurance Rate Map (FIRM) data was obtained from MassGIS showing the 100-year floodplain (Zones A, A1-30, and AE). The 100-year flood plain map was then overlain on MassGIS Level~2 parcels for eight of the communities. Dunstable, with sixteen properties in the 100-Year Flood Plain, was visually checked using 1:5000 orthophotos, and a point file of these properties was created. The parcel maps of the other eight communities were intersected with the 100-year flood plain and all parcels in the 100-year flood plain were identified.

The identified parcels were then visually compared to the orthophotos to determine if the actual building structure fell within the 100-year floodplain. Given the level of accuracy of the 100-year flood plain data, it was decided that if any part of a building lie outside the 100-year flood plain, that structure would not be included in the calculation.

After visually being checked for accuracy, the parcel files were merged with each community's assessor database. Given that these databases are in various formats, a merger into a regional database was not undertaken. Therefore, individual town files were used for the mapping, rather than one regional file. It is also important to note that the individual map objects do not equal the number of buildings. The building count will be far higher than the parcel count, due to the inclusion of condominiums. In two cases, there were large parcels that were recently developed containing condominium buildings located within and outside of the flood plain. The building values were generally quite similar. Based on visual inspection of the floodplain maps, the number of units that were not within the floodplain was subtracted from the total for those parcels. Buildings were grouped together by land use category: residential (all types), commercial, industrial and institutional.

The final output shows the total value of buildings within the 100-year flood plain for each community. Given the limitations of funding and methodology, there was no attempt made to estimate the probable amount of damage from the 100-year storm event. Hence, the value of each building is the upper limit of potential damage and would not be exceeded, except in an exceedingly rare catastrophic storm event far exceeding a 100-year storm. Table 71 on the following page summarizes by community the value of properties located in the 100-year floodplain by land use code.

Table 73: Assessed Value of Buildings in the 100-Year Flood Plain by Community and Use Code

	Number of Structures	Residential	Commercial	Industrial	Governmental /Institutional	Total Value
Billerica	321	$46,852,100	$5,771,300	$1,779,200	$3,682,400	$58,085,000
Chelmsford [1]	400	50,197,574	8,959,400	8,307,900	1,191,600	89,301,774
Dracut	68	9,811,200	3,342,900	8,092,700	100,000	21,346,800
Dunstable	28	5,230,900	0	0	0	5,230,900
Lowell	451	113,199,600	16,304,900	9,084,500	8,744,800	147,333,800
Pepperell	30	4,082,885	187,600	81,100	87,900	4,439,485
Tewksbury	246	26,027,600	5,211,200	1,837,200	810,400	33,886,400
Tyngsborough	111	16,852,800	7,466,800	383,400	221,200	24,924,200
Westford	113	20,645,300	5,883,100	9,366,600	0	50,733,300
Total	1788	$292,899,959	$53,127,200	$38,932,600	$14,838,300	$435,281,659 [2]

[1]Includes 118 Condo units, representing $28,506,204 in the Williamsburg Condominium Complex
[2]Based on assessed value of structures and adjusted for condo units when majority of building is out of the flood zone.

While Table 73 above provides an estimate of the building values, the figures do not include the estimated cost of replacing building contents. According to HAZUS, the value of building contents depends on the type of building. The contents of residential buildings have a replacement cost of approximately 50% of the building value. Commercial building contents cost approximately 100% of the building value to replace and industrial building contents cost about 125%. For purposes of this analysis, the commercial rate was applied to governmental and institutional buildings. The estimated costs of contents replacement for structures located in the 100-year floodplain by community can be found in Table 74 below. As can be seen from the Tables 73 and 74, replacement costs for building contents total over $263 million, while building value exceeds $435 million. Therefore, the estimated value of property and contents located within the 100-year floodplain exceeds $698 million for the region overall.

Table 74: Estimated Contents Replacement Costs for Buildings in the 100-Year Floodplain

Community	Residential Contents Value	Commercial Contents Value	Industrial Contents Value	Governmental/ Institutional Contents Value	Total Contents Value
Billerica	$23,426,050	$5,771,300	$2,224,400	$3,682,400	$35,104,150.
Chelmsford[1]	25,098,787	8,959,400	10,384,875	1,191,600	45,634,662
Dracut	4,905,600	3,342,900	10,115,875	100,000	18,464,375
Dunstable	2,615,450	0	0	0	2,615,450
Lowell	56,599,800	16,304,900	11,355,635	8,744,800	93,005,135
Pepperell	2,041,279	187,600	101,375	87,900	2,418,154
Tewksbury	13,013,800	5,211,200	2,296,500	810,400	21,331,900
Tyngsborough	8,426,400	7,466,800	479,250	221,200	16,593,650
Westford	10,322,650	5,883,100	11,708,250	0	27,914,000
Total	$146,449,816	$53,127,200	$48,666,160	$14,838,300	$263,081,476.

Source: Local Assessor records, FIRM maps, contents value calculations utilize HAZUS methodology.

It is important to note that loss of property does not reflect the entire cost of a region-wide flood event where there may be rescue and evacuation costs, infrastructure repair/replacement, clean up costs, personnel costs, and economic costs related to business closures and damage. Utilizing GIS, critical infrastructure that is located within the 100-year flood plain was identified and mapped. This information is shown below in Table 75 below and displayed on Maps 17 and 18, located on pages 196 and 197. Specific geographic locations subject to flooding have been discussed in previous chapters of this document. The locations of vulnerable populations are shown in the maps contained in Appendix D. These locations include elderly services and housing, medical facilities and other critical locations.

Table 75: Critical Infrastructure in the 100-Year Flood Plain by Community

Community	Infrastructure/Structures Located in the 100-year Flood Plain
Billerica	Nursing Home, sewage pumping stations, child care facility, fire station, bridges, hazardous material site, helicopter landing zone
Chelmsford[1]	Water supply wells, water storage tank, drinking water pumping station, bridges, dams
Dracut	Bridges
Dunstable*	Electrical substation, dams, child care facility
Lowell	Electrical substation, Co-Generation Plant, bridges, dams, child care facilities, helicopter landing zone, elderly housing, fire station, hazardous material site
Pepperell	Water supply well, hazardous material site, bridges, and a dam
Tewksbury	Child care facility, helicopter landing zone, sewerage pumping stations, bridges, water pumping station
Tyngsborough	Water pumping stations, bridges, dams, hazardous material site
Westford	Water supply well, water pumping station, dams, bridges

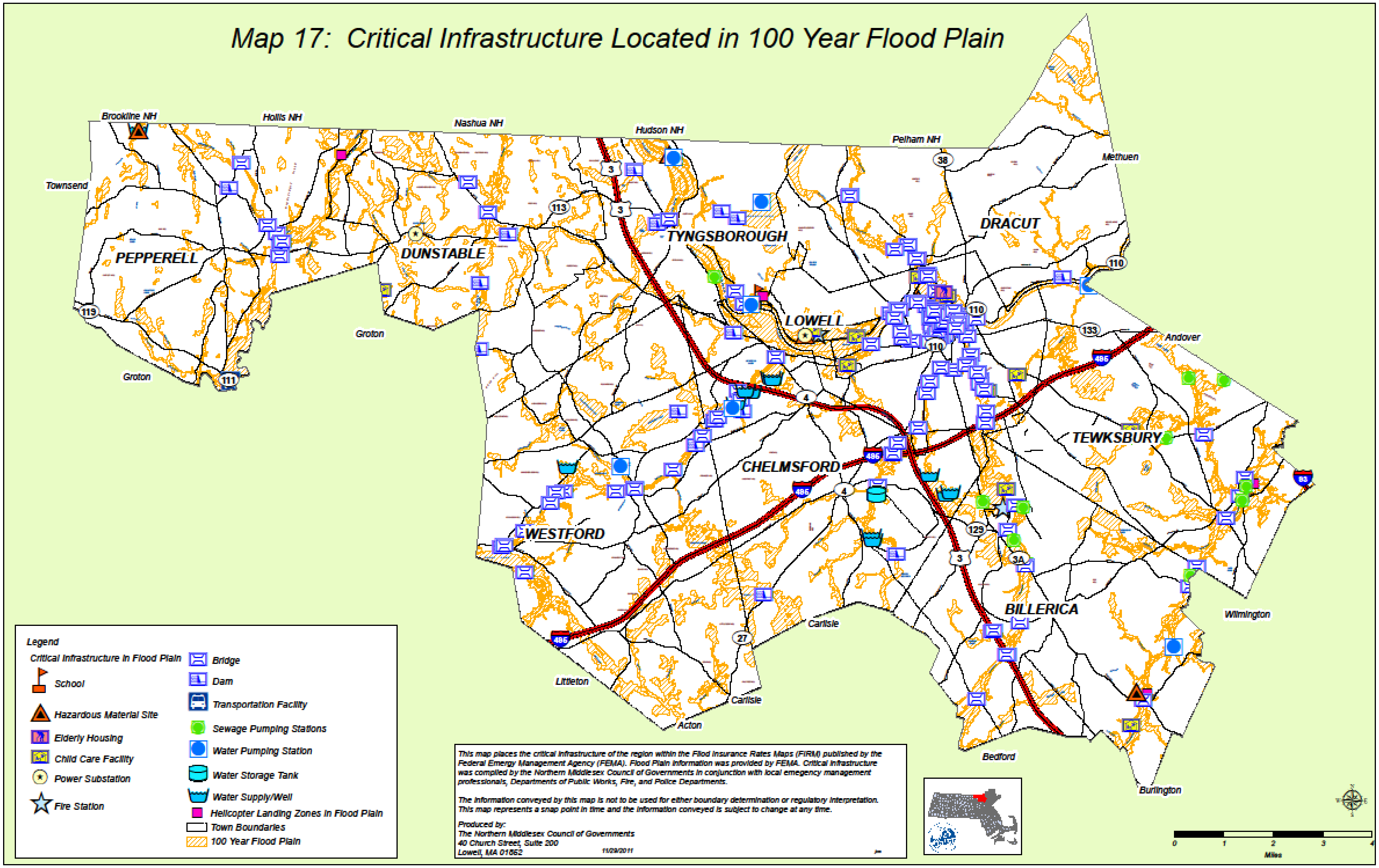
C. Vulnerability to Other Natural Hazards

The vulnerability to natural hazards for the overall region is the same from community to community for the following hazards: earthquake, tornado, winter storms (snow storm, blizzard, ice storm), drought, landslide, and hurricane. However, there are differences among the region's communities for flooding, wildfire and urban fire. These differences have been discussed in Section 4A and throughout Section 5. The region's critical infrastructure is mapped in Appendix D and is shown relative to the 100-year flood plain.

D. Vulnerability to Future Natural Hazards

Based on the identification and profile of the natural hazards that have occurred throughout the region over time, a vulnerability table has been developed. The matrix, adapted from the *2010 Massachusetts Hazard Mitigation Plan* developed by MEMA, was used to categorize each hazard based on frequency, severity, extent of impact, and area of occurrence. The analysis included input from the MHCPT, the local hazard mitigation committees, MEMA, and other stakeholders that were engaged during the plan development process, as discussed in previous chapters of this document. Historical data was utilized, as well as the best available scientific assessments, published literature and input from subject area experts. The criteria were formulated based on the hazard identification profile and assessment performed for the region. There have been no significant changes in the region's vulnerability since the completion of the 2006 Plan.

Table 76 on the page 201 lists the hazards to which the region is vulnerable, describes the expected frequency of occurrence, and the potential severity of the damage resulting from each individual hazard. The methodology utilized was outlined on page 91. As a means of assessing the region's vulnerability, the regional hazard score was calculated based on the average of those scores assigned to each hazard within each community.


Map 17: Critical Infrastructure Located in 100 Year Flood Plain
Brookline NH
Hollis NH
Nashua NH
Hudson NH
Pelham NH
Methuen
Townsend
PEPPERELL
DUNSTABLE
TYNGSBOROUGH
DRACUT
LOWELL
Andover
TEWKSBURY
CHELMSFORD
WESTFORD
BILLERICA
Wilmington
Groton
Groton
Carlisle
Littleton
Carlisle
Acton
Bedford
Burlington
Legend
Critical Infrastructure in Flood Plain
School
Hazardous Material Site
Elderly Housing
Child Care Facility
Power Substation
Fire Station
Bridge
Dam
Transportation Facility
Sewage Pumping Stations
Water Pumping Station
Water Storage Tank
Water Supply/Well
Helicopter Landing Zones in Flood Plain
Town Boundaries
100 Year Flood Plain
This map places the critical infrastructure of the region within the Filod Insurance Rates Maps (FIRM) published by the Federal Emergy Management Agency (FEMA). Flood Plain information was provided by FEMA. Critical infrastructure was compiled by the Northern Middlesex Council of Governments in conjunction with local emegency management professionals, Departments of Public Works, Fire, and Police Departments.
The information conveyed by this map is not to be used for either boundary determination or regulatory interpretation. This map represents a snap point in time and the information conveyed is subject to change at any time.
Produced by:
The Northern Middlesex Council of Governments
40 Church Street, Suite 200
Lowell, MA 01852
11/29/2011
Miles

Map 18: Lowell Critical Infrastructure Located in 100 Year Flood Plain

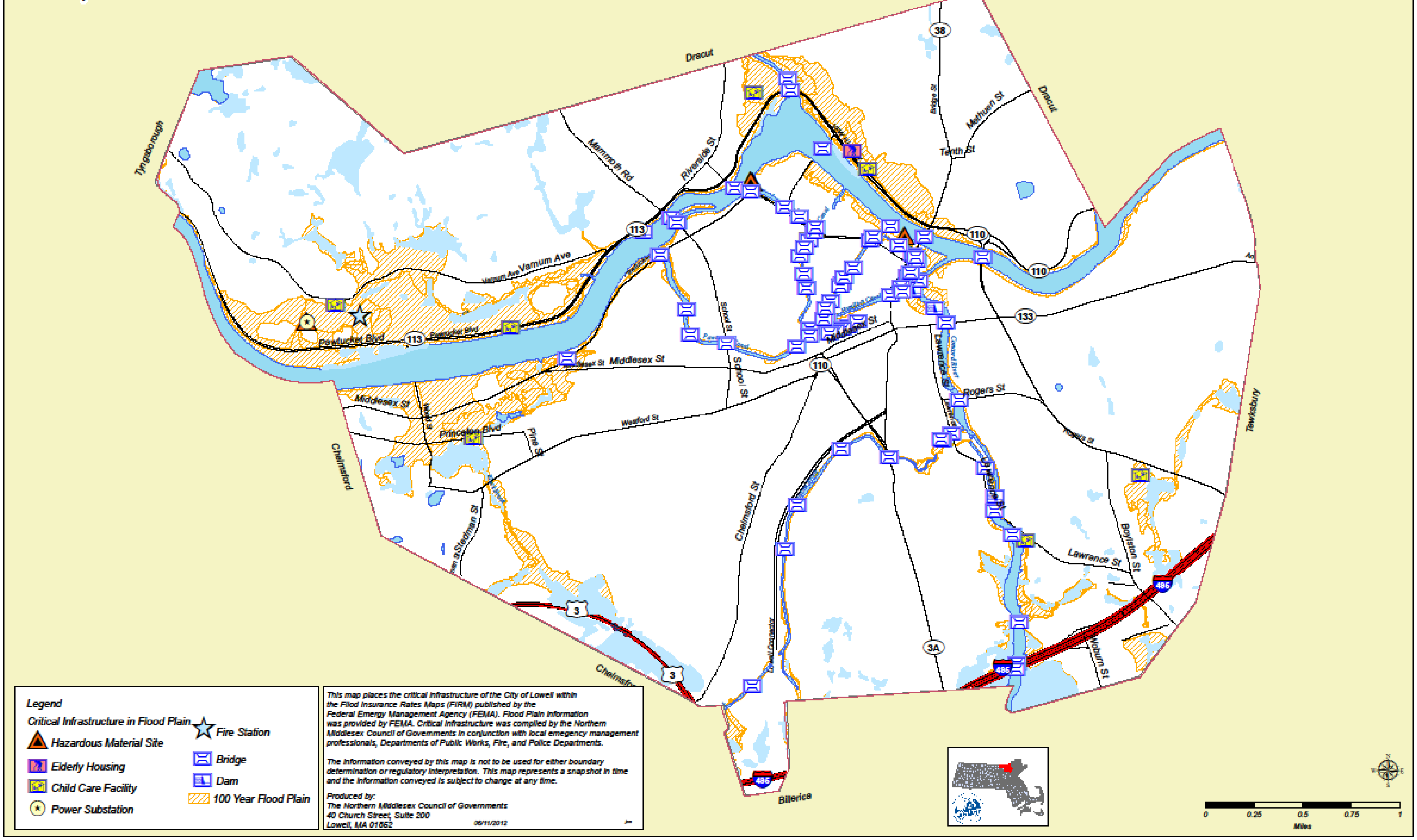


Table 76: The Region's Potential Vulnerability to Future Natural Hazards

HAZARD	FREQUENCY			SEVERITY			EXTENT OF IMPACT			PROBABILITY OF OCCURENCE		
	LOW	MEDIUM	HIGH	LOW	MEDIUM	HIGH	LOW	MEDIUM	HIGH	LOW	MEDIUM	HIGH
FLOOD			X		X				X			X
HURRICANE	X				X				X		X	
WILDFIRE		X		X				X			X	
URBAN FIRE		X		X				X			X	
EARTHQUAKE		X		X					X			X
TORNADO	X			X					X	X		
DROUGHT	X				X			X			X	
NOR'EASTER			X		X				X			X
SNOWSTORM/ BLIZZARD			X		X			X				X
SEVERE THUNDERSTORM		X		X				X			X	
LANDSLIDE	X		X				X			X		
ICE STORM		X			X				X			X
ICE JAM	X			X			X			X		

Hazards can be interrelated and the impacts of one hazard can create the occurrence of another. For example, an earthquake might trigger fires or landslides, and the impacts of climate change are known to increase the frequency and severity of storm events. Table 77 on the following page graphically outlines the potential secondary effects of each natural hazard.

Table 77: Secondary Impacts from Primary Natural Hazards

	SECONDARY IMPACTS													
PRIMARY HAZARD	**Structural damage**	**Utility outage**	**Chemical release**	**Commodity shortage**	**Emergency communications failure**	**Erosion**	**Structural fire**	**Disease**	**Flooding**	**Landslide**	**Dam failure**	**Tornado**	**Hail**	**Wildfire**
FLOOD	X	X	X			X		X		X	X			
DAM FAILURE	X	X	X			X		X	X					
HURRICANE	X	X	X	X	X	X		X	X			X		
TORNADO	X	X	X										X	
THUNDERSTORM		X					X					X	X	X
NOR'EASTER	X	X		X		X	X		X					
SNOWSTORM/ BLIZZARD	X	X		X			X							
ICE STORM	X	X	X	X	X		X							
ICE JAM	X								X		X			
DROUGHT				X										X
WILDFIRE	X		X				X							
EARTHQUAKE	X	X	X	X	X		X			X	X			
LANDSLIDES	X					X								

Source: Derived from the 2010 Massachusetts State Mitigation Plan, MEMA

D. Impacts of New Growth on Vulnerability

As outlined in earlier sections of this report, there has been very modest growth throughout the region over the past ten years. The U.S. Census data shows that the region's population increased by 2.02% between 2000 and 2010. Most of that growth occurred in the suburban communities of Dunstable (12.37%), Westford (5.77%), Billerica (3.24%) and Pepperell (3.19%). The trend is not expected to change remarkably over the next several years, particularly in light of the struggling economy. This suggests that there will be minimal changes in risk in the region overall. The losses that have been seen over the last several years have occurred in existing structures. New construction has not been significantly impacted given the regulatory requirements in place within the Northern Middlesex communities.

To provide a sense of the development activity in the region since completion of the 2006 Plan, Table 78 on the following page details the number of residential building permits issued in each community from 2007 through 2011, along with the total construction costs associated with these permits. For the region overall, a total of 1,820 residential building permits were issued, with associated construction costs of $359,004,486. Over the previous five years, Westford clearly had the most residential development activity of the nine Northern Middlesex communities.

Table 78: Residential Building Permits and Construction Costs (2007-2011)

Community	2007		2008		2009		2010		2011		5-Year Total	
	Number of Permits	Construction Costs	Number of Permits	Construction Costs	Number of Permits	Construction Costs	Number of Permits	Construction Costs	Number of Permits	Construction Costs	Number of Permits	Construction Costs
Billerica	55	$8,872,706	39	$4,722,458	44	$10,566,236	98	$15,764,669	34	$5,283,646	270	$45,209,715
Chelmsford	23	4,307,000	12	2,510,000	14	2,885,000	10	1,764,040	23	4,759,500	82	16,225,540
Dracut	66	13,950,000	33	7,350,000	50	11,425,000	55	12,375,000	33	7,375,000	237	52,475,000
Dunstable*	18	2,066,532	12	1,377,685	11	1,262,877	12	1,377,684	9	1,033,263	62	7,118,041
Lowell	45	3,365,400	87	13,838,923	26	2,662,600	40	4,102,000	46	10,081,250	244	34,050,173
Pepperell	14	3,767,000	9	2,229,400	20	4,006,760	22	3,831,500	13	2,636,500	78	16,471,160
Tewksbury	40	6,749,460	65	40,101,737	57	16,576,185	41	7,067,080	28	5,963,520	231	76,457,982
Tyngsborough	80	7,902,980	16	2,977,000	115	11,121,000	23	10,309,000	13	2,537,000	247	34,846,980
Westford	101	18,879,080	50	9,875,777	55	12,356,437	82	18,254,011	81	16,514,490	369	76,149,795
Regional Total	442	$69,860,158	323	$84,982,980	392	$72,862,095	383	$74,844,984	280	$56,184,169	1,820	$359,004,386

*Estimated with imputation
Source: U.S. Census Bureau

To better understand the monetary implications of natural disaster to residential properties, Table 79 below outlines the average residential property value by community for 2010. For each disaster event, damage and associated financial losses are assessed by state and local officials. The most costly disasters to strike the region since completion of the 2006 Plan were the 2007 flood, the Ice Storm of 2008, and the October 2011 snowstorm.

Table 79: Average Residential Property Values by Community, 2010

Community	Number of Housing Units, 2010	Average Residential Property Value
Billerica	14,481	$325,397
Chelmsford	13,807	$347,659
Dracut	11,351	$284,026
Dunstable	1,098	$416,275
Lowell	41,431	$231,515
Pepperell	4,348	$301,105
Tewksbury	10,848	$321,473
Tyngsborough	4,206	$324,403
Westford	7,876	$450,723

Source: U.S. Census Bureau

Given the economic recession that has gripped the nation and the region over the past few years, commercial and industrial development activity has been fairly slow. Table 80 on the following page provides information relative to the most significant development projects that have been initiated since completion of the previous Plan. None of these projects were located within the 100-year floodplain, although some projects required an Order of Conditions from the Conservation Commission due to wetland impacts. In fact, with the exception of the two Westford projects, they were all located on land that had been previously disturbed. Building code, zoning regulations, and environmental regulations have been fairly effective in keeping development out of the floodplain.

Table 80: Significant Commercial, Institutional and Industrial Development Projects (2007-present)

Community	Project/location	Gross Floor Area(square feet)
Chelmsford	Stop and Shop Route 110	60,000
Lowell	Shopping Center at 1235 Bridge Street	110,500
Lowell	Hamilton Canal District	2,200,000
Lowell	Lowell General Hospital expansion/renovation	170,000
Lowell	UMass Lowell Emerging Technology Center	82,000
Lowell	UMass Lowell Health and Social Sciences Building	69,000
Lowell	1088-1100 Gorham Street-redevelopment and new construction	42,000
Lowell	Lowell Community Health Center Jackson Street (mill redevelopment)	100,000
Lowell	Lowe’s 790 Chelmsford Street	153,000
Lowell	Jeanne D’Arc Headquarters 225 Father Morrisette Blvd.	53,000
Lowell	Target 119 Plain Street	137,000
Westford	Cornerstone Square Route 110	246,000
Westford	Boch Honda Route 110	59,000
Westford	7 Lyberty Way (commercial)	32,000
Westford	Red Hat, 314 Littleton Road	175,000
Westford	108 Littleton Road	43,000

In Chelmsford, construction at the Lighthouse School located at 25 Wellman Avenue required that compensatory storage be provided. In addition, improvements at 1 and 2 Executive Drive required approximately 11 cubic feet of compensatory storage and two wet ponds were built for this purpose. The Chelmsford Water District project at 55 Richardson Road resulted in approximately 2,300 cubic feet of compensatory storage, while a project located at 103 Tyngsborough Road required approximately 3,900 cubic feet of compensatory storage on site.

There have been four significant development projects within Dracut since 2007: Meadow Creek Golf Course, Great Woods (off Mammoth Road), Farm Gate Estates (off Parker Road) and Dadak Estates (off Methuen Road). Given the recession, all of the projects are still under development. Two single-lot developments impacted the floodplain and both obtained Planning Board Special Permits as required by the town’s bylaw. One project involved a parking area and the other a landscaped area. No structures were included and compensatory storage was provided.

Within the City of Lowell, the following projects were approved by the Conservation Commission with effective mitigation:

- Lowe’s- 790 Chelmsford Street
- 1519-1527 Middlesex Street – retail development
- 211 Plain Street – retail center
- Rita Street extension- single-family subdivision
- 10-76 Eckland Drive and 56-140 Adies Way – residential subdivision
- 270 Lawrence Street - multi-family development
- 1857 Middlesex Street –charter school

Within the Town of Tewksbury, two projects were permitted within the floodplain with appropriate mitigation. The first project was a 20 unit townhouse complex located on 13 acres at 130 Pinnacle Street. The second project consisted of a 8,000 square foot addition to an existing building located at 1201 Main Street.

SECTION 8: ACTION PLAN AND STRATEGIES

The following categorizes mitigation actions that will serve to minimize risks or reduce losses from natural hazards. The actions have been organized into the following categories, as recommended in the FEMA Local Multi-Hazard Mitigation Planning Guide (7/1/08) and the Multi-Jurisdictional Mitigation Planning Guide, (August 2006):

- Prevention: Prevention actions are intended to address future development and guide development away from natural hazards. Many of the hazards that impact the region can be reduced by addressing them upfront through code enforcement and regulatory measures. Prevention activities include planning, zoning, building ordinances, subdivision regulations, and requirements to bury utilities;

- Property Protection: Property protection actions address individual buildings and reduce risk through modification. Activities include acquisition, building relocation, building elevation, retrofitting, barriers, flood-proofing, utility relocation or flood-proofing, and insurance;

- Public Education and Awareness: Public educations and awareness actions will inform and remind the public about natural hazards and actions that can be taken to avoid potential damage and injury resulting from a hazard. Activities include providing informational mailings or workshops, community outreach, real estate disclosure of hazards, environmental education, and technical assistance provided on disaster management issues;

- Natural Resource Protection: Natural resource protection reduces the intensity of hazard effects and improves the quality of the environment. Activities include preservation or restoration of natural systems, open space preservation, state and local floodplain and wetland regulations, stormwater management, watershed protection measures and best management practices, and soil erosion and sediment control;

- Structural Projects: Structural projects are actions that control the hazard and directly protect people and property. Such activities include construction and maintenance of berms, dams, floodwalls, channel improvements, drainage improvements, and detention/retention basins; and

- Emergency Services Protection: Emergency services protection actions are aimed at protecting emergency services before, during and immediately after an occurrence. Activities include hazard recognition, emergency warning systems, emergency response training, evacuation planning, protection of critical facilities, protection of public facilities, and health and safety maintenance.

These actions will be coordinated with other regional and community priorities, as well as with mitigation goals of state and federal agencies. Such coordination will improve access to technical assistance; provide broader support for implementation; and reduce duplication of effort. The actions have been further categorized by timeframe into on-going, immediate, short-term projects and long-term measures.

A. Mitigation Goals

In updating the Action Plan, the regional Multiple Hazard Community Planning Team (MHCPT) reviewed the hazard identification and analysis, the regional vulnerability assessment, and the existing protection matrix and measures. The goals in the 2006 Plan were reviewed and affirmed. In addition, a new goal was added to address the impacts of climate change. The following goals were considered in the development of the Action Plan Update:

- Increase coordination between the Federal, State, regional and local levels of government;
- Discourage future development in hazard prone areas, such as flood plains;
- Protect and preserve irreplaceable cultural and historic resources located in hazard prone areas;
- Ensure that critical infrastructure is protected from natural hazards;
- Develop programs and measures that protect residences and other structures from natural hazards;
- Protect electric power delivery infrastructure from natural hazards;
- Provide alternative drinking water supplies for local communities in the event of contamination or disruption from a natural hazard;
- Increase awareness and support for natural hazard mitigation among municipalities, private organizations, businesses, and area residents through outreach and education;
- Implement a broad range of mitigation measures that protect the region’s vulnerable population and infrastructure;
- Protect critical public facilities and services from damage due to natural hazards;
- Develop a mitigation strategy that considers area businesses and protects the economic vitality of the region;

- Update and maintain the Plan as resources permit;

- Increase the number of communities participating in the Community Rating System;

- Provide communities with information concerning hazard mitigation funding opportunities, and assist the communities in the identification and development of specific mitigation projects;

- Increase each community's capacity for responding to a natural hazard event by promoting the adequate provision of emergency service capabilities; and

- Implement adaptation strategies and modify local emergency plans to protect critical infrastructure and property from the impacts of climate change.

B. Mitigation Progress Since 2007

Since completion of the last Plan, the region's municipalities have made significant progress in implementing additional measures to mitigate natural hazards. The following table lists the measures that have been implemented within each municipality since 2007. All other actions were pulled into this plan update (see Table 82).

Table 81: Mitigation Actions Implemented Since Completion of the Previous Plan

Billerica	
Action Implemented	**Hazard Addressed**
Maintained compliance with the National Flood Insurance Program	Flooding
Enforced the town's floodplain bylaw	Flooding
Enforced the erosion control and stormwater management standards with the town's subdivision regulations	Flooding
Implemented BMPs within the town's Stormwater Management Plan	Flooding
Enforced the local wetlands bylaw, the Massachusetts Wetlands Protection Act, and the Rivers Protection Act	Flooding
Pursued acquisition of open space parcels along the Concord and Shawsheen Rivers	Flooding

Table 81 (cont'd): Mitigation Actions Implemented Since Completion of the Previous Plan

Action Implemented	Hazard Addressed
Completed additional phases of the town's sewer program	Flooding
Constructed drainage improvements on Cook Street, Alexander Road and Concord Road, and at many other locations throughout town	Flooding
Routinely maintained the town's stormwater infrastructure (cleaned culverts, catch basins, detention basins)	Flooding
Enforced the town's Stormwater Management Bylaw	Flooding
Implemented CodeRED emergency notification system	All hazards
Developed a fire hydrant maintenance and replacement policy	Urban fire and wildfire
Chelmsford	
Action Implemented	**Hazard Addressed**
Maintained compliance with the National Flood Insurance Program	Flooding
Enforced the town's floodplain bylaw	Flooding
Enforced the erosion control and stormwater management standards with the town's subdivision regulations	Flooding
Implemented BMPs within the town's Stormwater Management Plan	Flooding
Enforced the local wetlands bylaw, the Massachusetts Wetlands Protection Act, and the Rivers Protection Act	Flooding
Acquired open space adjacent to Heart Pond	Flooding
Completed the final phases of the town's sewer program	Flooding

Table 81 (cont'd): Mitigation Actions Implemented Since Completion of the Previous Plan

Action Implemented	Hazard Addressed
Routinely maintained the town's stormwater infrastructure (cleaned culverts, catch basins, detention basins)	Flooding
Enforced the town's Stormwater Management Bylaw	Flooding
Constructed drainage improvements at Hunt Road/High Street	Flooding
Constructed a secondary access to Chelmsford High School	Fire, severe storms, snowstorm, blizzard, flooding
Drainage improvements were installed on Buckman Drive, Mill Road, Alpine Lane, Elizabeth Drive, Golden Cove Road, and Scientia Drive, Garrison Road, Elm Street, Smith Street, Warren Avenue, Dunstable Road, Lauderdale Road, Nobel Drive, Frank Street, Brick Kiln Road, Riverneck Road, Boston Road, Acton Road, Purcell Drive, Bartlett Park, Parker Road, Muriel Ave, Marina Road, Wilson Street, Brook Street, Derringer Road, Marshall Street, Pine Hill Road, Ruthellen Street, Porter Street, Washington Street, Wildes Street, Meetinghouse Road, Burning Tree Lane, Graniteville Road, Groton Road, Elm Street, Ledge Road, Hazen Street, Concord Road, Smokerise Drive, Courtland Drive, Lisa Lane, Harvey Road, Canter Road, Jonathan Lane, Thomas Drive, Mill Road and Sierra Road	Flooding
The following initiative were completed by the Sewer Department: -SCADA remote monitoring installation -Generator upgrade at Miland Pump Station and Mill Road -Pump rebuilds for 54 pump stations -Two new pump stations (Hunt Road and Singlefoot Road) -Replaced two main channel grinder pumps -Upgraded the Central Square main sewer gravity line	Flooding
The sewer system for the Lighthouse School was expanded	Flooding

Table 81 (cont'd): Mitigation Actions Implemented Since Completion of the Previous Plan

Action Implemented	Hazard Addressed
Catch basins were repaired on Harold Street, North Road, Old Stage Road, Sonora Drive, Freeman Road, Burning Tree Lane, Turnpike Road, and Poplar Lane. In addition, basins were installed on Merilda Avenue, QueenStreet and Proctor Road, plus 85 other locations	Flooding
Significant progress was made on the burial of overhead utility lines within the Town Center	All hazards
Maintained compliance with the Office for Dam Safety for four town-controlled dams. Three of the dams were re-designated as non-jurisdictional since the completion of the last plan.	Flooding
Performed drainage work at the Parker School, High School, South Row School and Harrington School	Flooding
Beaver baffles were inserted at various locations throughout town	Flooding
Updated the Town Master Plan to include consideration of hazard mitigation	All hazards
Worked with National Grid to clear trees branches from power lines	All hazards
Updated the Open Space and Recreation Plan	All hazards
Repaired the School Street Bridge	Flooding and Earthquake
Addressed flooding in the Swain Road area through the sewer program	Flooding
Improved coordination between the Planning Board, Conservation Commission, and Zoning Board of Appeals regarding stormwater management and erosion control measures	Flooding
Purchased generator for the Senior Center	All Hazards
Implemented CodeRED emergency notification	All Hazards

Table 81 (cont'd): Mitigation Actions Implemented Since Completion of the Previous Plan

Dracut	
Action Implemented	**Hazard Addressed**
Maintained compliance with the National Flood Insurance Program	Flooding
Enforced the town's floodplain bylaw	Flooding
Enforced the erosion control and stormwater management standards with the town's subdivision regulations	Flooding
Replacement of the emergency generator at the Methuen Street pumping station.	All Hazards
Rehabilitate Parker Avenue Bridge.	Flooding, earthquake
Implemented BMPs within the town's Stormwater Management Plan	Flooding
Enforced the local wetlands bylaw, the Massachusetts Wetlands Protection Act, and the Rivers Protection Act	Flooding
Routinely maintained the town's stormwater infrastructure (cleaned culverts, catch basins, detention basins)	Flooding
Enforced the town's Stormwater Management Bylaw	Flooding
Constructed additional phases of its sewer program	Flooding
Completed the Loon Hill Road culvert project	Flooding
Contracted with a vendor for the provision of emergency notification message town-wide	All hazards
Replaced a culvert on Lakeview Avenue	Flooding
Constructed a floodwall to protect the Turtle Hill Sewer Pump station	Flooding
Installed emergency power supply at the New Boston Well Field.	All hazards

Table 81 (cont'd): Mitigation Actions Implemented Since Completion of the Previous Plan

Action Implemented	Hazard Addressed
Replacement of emergency generator at the Methuen Street pump station.	All hazards
Completion of police station with full emergency power	All hazards
Implemented an erosion and sediment control bylaw	Flooding
Completed Arlington Street pump station improvements	Flooding
Installed emergency power supply at the New Boston Well Field	All Hazards
Dunstable	
Action Implemented	**Hazard Addressed**
Elevated River Street to mitigate flooding	Flooding
Repaired retaining wall and replaced culvert along Route 113	Flooding
Maintained compliance with the National Flood Insurance Program	Flooding
Enforced the Town's floodplain ordinance	Flooding
Enforced the erosion control and stormwater management standards within the town's subdivision regulations	Flooding
Enforced the local wetlands bylaw, the Massachusetts Wetlands Protection Act, and the Rivers Protection Act	Flooding
Routinely maintained the town's stormwater infrastructure (cleaned culverts, catch basins, detention basins)	Flooding
The town installed a second water supply well with a generator.	Wildfire
The town revised Section 15.2 of its Zoning Bylaw adding a new Floodplain District	

Table 81 (cont'd): Mitigation Actions Implemented Since Completion of the Previous Plan

Lowell	
Action Implemented	**Hazard Addressed**
Staff participated in various MEMA training sessions, including cost-benefit training (associated software is now on the City's system).	All hazards
Established a DPW mutual aid program,	All hazards
Amended the City's wetland ordinance	Flooding
Maintained compliance with the National Flood Insurance Program	Flooding
Enforced the City's floodplain ordinance	Flooding
Enforced the erosion control and stormwater management standards within the City's subdivision regulations	Flooding
Implemented BMPs within the City's Stormwater Management Plan	Flooding
Enforced the local wetlands bylaw, the Massachusetts Wetlands Protection Act, and the Rivers Protection Act	Flooding
Routinely maintained the City's stormwater infrastructure (cleaned culverts, catch basins, detention basins)	Flooding
Completed stormwater separation projects at various locations across the City	Flooding
Replaced the University Avenue Bridge	Flooding and earthquakes
Made repairs to the Central Bridge	Flooding and earthquakes
Rehabilitated the Hunt's Fall Bridge	Flooding and earthquakes
Amended the City's Flood Plain Overlay District	Flooding

Table 81 (cont'd): Mitigation Actions Implemented Since Completion of the Previous Plan

Action Implemented	Hazard Addressed
Created a department of Development Services in 2012 with three staff members directly supporting Boards and Commission with permitting and enforcing ordinances regulating development in the floodplain.	Flooding, earthquakes, wind-related hazards, severe storms and urban fire
Established a Driveway permit to regulate existing and proposed driveways to improve stormwater management	Flooding
Distributed information about NFIP Grandfather rules and Floodplain Management Bulletin to Historic Buildings in 2012	Flooding
With direction from EPA and MADEP, initiated the Combined Sewer Overflow (CSO) Long term Control Plan Phase 2. (Will supplement improvements made during Phase 1)	Flooding
Invested $77M in upgrades to the Greater Lowell Wastewater Treatment Facility, improvements to the CSO diversion stations, rehabilitation of the sewer system, and construction of new drainage systems.	Flooding
Instituted an annual brush clearing program along the bank of the Merrimack River levee, and a slope stabilization project along the Beaver Brook branch of the levee.	Flooding
As part of a $35M plant upgrade, the Greater Lowell Wastewater Utility increased its wet weather capacity at the plant	Flooding
Pepperell	
Action Implemented	**Hazard Addressed**
Removed derelict mill building from a 10.4 acre site adjacent to the Nashua River and remediated active contamination	Flooding
Replaced the Groton Street Bridge	Flooding and earthquakes
Replaced the Mill Street Bridge	Flooding and earthquakes

Table 81 (cont'd): Mitigation Actions Implemented Since Completion of the Previous Plan

Action Implemented	Hazard Addressed
Swift River Hydro worked with the Town and the State to replace the penstock on the Pepperell Dam located on the Nashua River	Flooding
Reconstructed numerous culverts and headwalls to decrease flooding on public ways and open land. Locations included Chestnut Street, Brookline Street, and the headwall at the Main Street rotary	Flooding
Installed beaver control devices on Shawnee Road and Oak Hill Street	Flooding
Rebuilt drainage at 12 Lowell Road to eliminate flooding from the Nashua River	Flooding
Removed a derelict building from174 River Road which bordered a perennial stream and was located in the floodplain	Flooding
Participated in NERAC programs to acquire emergency response equipment and training	All hazards
Procured three utility trailers to address emergency response needs for the Highway Department, Emergency Management and Board of Health	All hazards
Tewksbury	
Action Implemented	**Hazard Addressed**
Replaced the East Street and Strong Brook culvert.	Flooding
Maintained compliance with the National Flood Insurance Program	Flooding
Enforced the town's floodplain bylaw	Flooding
Enforced the erosion control and stormwater management standards with the town's subdivision regulations	Flooding
Implemented BMPs within the town's Stormwater Management Plan	Flooding

Table 81 (cont'd): Mitigation Actions Implemented Since Completion of the Previous Plan

Action Implemented	Hazard Addressed
Enforced the local wetlands bylaw, the Massachusetts Wetlands Protection Act, and the Rivers Protection Act	Flooding
Routinely maintained the town's stormwater infrastructure (cleaned culverts, catch basins, detention basins)	Flooding
Enforced the town's Stormwater Management Bylaw	Flooding
Revised the Planning Board regulations in 2008 to address some drainage concerns, and erosion control regulations and were revised in 2011.	Flooding
Groundwater protection district was expanded in 2008	Flooding
Revised the Floodplain Overlay District within the Zoning Bylaw in May 2010 to reflect the revised FIRM maps	Flooding
The Town participates in the CRS and was most recently evaluated in April 2012	Flooding
Replaced Brown Street Bridge	Flooding, earthquake
Complete reconstruction of River Street to address washout and drainage issues	Flooding
Constructed a 5 million gallon water tank	Wildfire, urban fire
Constructed Dascomb Road water interconnection	Wildfire, urban fire
Installed wireless fire alarm system	Wildfire, urban fire
Installed Livingston Street and Kendall Road drainage improvements	Flooding
Installed Bridge Street culvert replacement	Flooding
Installed the Foster Road culvert replacement/Heath Brook channelization	Flooding

Table 81 (cont'd): Mitigation Actions Implemented Since Completion of the Previous Plan

Tyngsborough	
Action Implemented	**Hazard Addressed**
Maintained compliance with the National Flood Insurance Program	Flooding
Enforced the town's floodplain bylaw	Flooding
Enforced the erosion control and stormwater management standards with the town's subdivision regulations	Flooding
Implemented BMPs within the town's Stormwater Management Plan	Flooding
Enforced the local wetlands bylaw, the Massachusetts Wetlands Protection Act, and the Rivers Protection Act	Flooding
Routinely maintained the town's stormwater infrastructure (cleaned culverts, catch basins, detention basins)	Flooding
Enforced the town's Stormwater Management Bylaw	Flooding
Rehabilitation of the Tyngsborough Bridge (opened in 2012)	All Hazards (evacuation route)
Drainage work completed through the Pawtucket Blvd. relocation project	Flooding
Participated in conversations with private dam owners to check on the status of Dam Safety Orders	Flooding
Tree removal for electric reliability-Implemented in Winter 2012-2013 –hazard trees are inspected and removed	All hazards
Procured a Portable 100kVA Backup Generator for Sewer Pump stations	All hazards that may create a power failure
Implemented CodeRED emergency notification system	All hazards
Amended the floodplain bylaw in May 2012 to satisfy 44 CFR, Section 60.3	Flooding

Table 81 (cont'd): Mitigation Actions Implemented Since Completion of the Previous Plan

Action Implemented	Hazard Addressed
Installed riverbank stabilization at the Frost Road Riverfront Park along the Merrimack River	Flooding
Westford	
Action Implemented	**Hazard Addressed**
Updated subdivision regulations to reflect Phase II stormwater requirements	Flooding
Developed an erosion control bylaw	Flooding
Installed drainage improvements along Route 110	Flooding
Installed catch basins and drainage improvements on Tenney Road	Flooding
Installed an emergency generator at the Senior Center	All hazards
Replaced the emergency communications tower at the Center Fire Station	All hazards
Implemented CodeRED and town meeting appropriated money for an AM radio station to be used on an emergency basis	All hazards
The town revised its subdivision regulations and standards and its Floodplain overlay district to improve floodplain management at the request of DCR/NFIP	Flooding
Regional Projects	
Action Implemented	**Hazard Addressed**
Provided technical assistance to local communities in the development and maintenance of the multi-jurisdictional plan	All hazards
Encouraged municipalities to include hazard mitigation planning in Open Space and Recreation Plans and Master Plans	All hazards

Table 81 (cont'd): Mitigation Actions Implemented Since Completion of the Previous Plan

Action Implemented	Hazard Addressed
Participated in the Discovery Meetings for the Concord River watershed	Flooding
Formed a regional stormwater collaborative to encourage communities to work together in addressing stormwater and flooding issues	Flooding
Secured an EPA Urban Waters grant to study stormwater messaging and develop a regional public education program	Flooding
Worked with MassDOT to prioritize and advance improvements to structurally deficient bridges	Flooding and earthquakes
Served as a liaison between the communities and MEMA relative to hazard mitigation	All hazards
Provided technical assistance to the municipalities in the development of HMGP applications	Flooding
NMCOG staff served on the State Hazard Mitigation Interagency Committee	All hazards
Incorporated mitigation planning into the Regional Strategic Plan, Regional Transportation Plan, and the Greater Lowell Comprehensive Economic Development Strategy	All hazards
Programmed ITS-related transportation projects on the regional Transportation Improvement Program	All hazards
Worked with the communities to develop evacuation routes across the region	All hazards
Worked with our local communities to complete a feasibility study and implementation plan for regionalizing 911 dispatch services	All hazards
Completed a feasibility study relative to constructing a permanent replacement for the temporary Rourke Bridge	Flooding, earthquake
Notified local communities of HMGP grant opportunities	All hazards

Table 81 (cont'd): Mitigation Actions Implemented Since Completion of the Previous Plan

Action Implemented	Hazard Addressed
Drafted a Low Impact Development Bylaw for the Town of Dracut which can be used as a model by other communities	All hazards

C. The Action Plan

The Action Plan has a regional component and also outlines action items for individual communities within the region, as presented in Tables 82 through 91. The priorities were established through a consensus building process that consisted of meetings and discussions among local policymakers, boards and commissions, municipal staff and the MHCPT. The following factors were considered in establishing the timeframe/priority for each action:

- The cost of the measure vs. the mitigation benefits;
- The availability of funding;
- The lead time required for design and implementation;
- Political feasibility and acceptability;
- The need for institutional and interagency agreements;
- Consistency with local and regional plans and priorities; and
- Whether the measure has been through a public process, needs Town Meeting or City Council action, or action by a permitting agency.

The benefit and cost of each project has been weighed using a qualitative method outlined in FEMA's guidance provided in *Using Benefit-Cost Review in Mitigation Planning*.[1] Method A: Simple Listing Technique was utilized and the Planning Team chose to express their priorities through timeframe designations. Projects categorized as "annual" will be undertaken each year. "Short-term" projects are those which can go forward with little or no cost, or for which a funding source has been identified, and these projects are of high priority. Projects identified as long-term are either costly, funding is not readily available, the project may not be ready for implementation due to permitting issues or the need for design, or the project requires a long lead time, or new governmental processes need to be established. It is envisioned that short-term projects will be implemented within 2 years; while long-term projects will be implemented in 3 or more years. The timeframe assigned to each project is indicative of local and regional project priorities.

This Action Plan is an update of the 2006 Action Plan. The matrices note whether each particular action was included in the 2006 Plan. Many of the actions contained in the 2006 Plan remain in the updated plan and are still a priority for the region. The actions delineated in this Plan will be implemented as resources are made available.

[1] *Using Benefit Cost Review in Mitigation Planning, State and Local Mitigation Planning How-To Guide Number Five*, FEMA 386-5, May 2007.

Table 82: Proposed Regional Mitigation Actions

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Prevention	Provide technical assistance to local communities in the implementation, update and maintenance of local multi-hazard mitigation plans.	NMCOG and local emergency managers and hazard mitigation teams. NMCOG provides technical assistance to the local communities on an ongoing basis.	All hazards	Annual	DCR/MEMA competitive grant programs and local general funds to finance NMCOG staff time	Yes
Natural Resource Protection	Assist the municipalities in including hazard mitigation in the development of local Open Space and Recreation Plans and Master Plans.	NMCOG and local planning board and conservation commissions; Many of the region's Open Space Plans incorporate hazard mitigation. NMCOG will continue to encourage such inclusion in future updates. In addition, NMCOG will encourage consideration of hazard mitigation in the Master Plan process.	All Hazards	Annual	DLTA funding from NMCOG, and CPA and local general funds. NMCOG staff to work with Planning Boards, Conservation Commissions and Recreation Departments, and their staffs.	Yes, but action item has been modified to include Master Plans as well as Open Space Plans.
Prevention	Work with the federal and state agencies and local communities to improve mapping and estimates of structures located within the 100-year flood plain. Continue to participate in Discovery Meetings for the Concord River watershed.	FEMA, MEMA, DCR, NMCOG, and local public safety and GIS staff; NMCOG staff continues to participate in the Discovery Meetings and has worked cooperatively with FEMA staff and their consultants on the floodplain map updates.	Flooding/ Climate Change	Short-term.	State and Federal agencies, local communities and NMCOG. NMCOG staff to utilize MassGIS, MassDOT and local general funds to provide GIS assistance.	Yes

Table 82 (cont'd): Proposed Regional Mitigation Actions

Category Of Action	**Description Of Action**	**Implementation Responsibility and Status**	**Hazard Addressed**	**Timeframe/ Priority**	**Resources/ Funding**	**Was the action included in the 2006 Plan?**
Prevention	Facilitate the development of an agreement between Massachusetts and New Hampshire state officials, and local communities to coordinate dam operations and flood control activities in order to prevent downstream flooding.	Massachusetts and New Hampshire state agencies, local communities and NMCOG. These negotiations appear to be at an impasse. Issues related to the proposed crest gate system on the Pawtucket Dam have reactivated these conversations.	Flooding	Short-term.	Massachusetts and New Hampshire state agencies, NMCOG and local communities. NMCOG and NRPC staff to work with local Public Works and Engineering Departments, ACOE and DCR. Staff time will be the only expense	Yes.
Prevention/ Natural Resource Protection	Study the formation of a regional Stormwater Utility to fund implementation of local stormwater management plans.	NMCOG and Municipalities. NMCOG is currently using DLTA funds to support the regional stormwater utility effort.	Flooding/ Climate Change	Long-term	DLTA funds from NMCOG; local general funds to be utilized for support. NMCOG staff works with Public Works Departments. .	No, new action item
Public Education and Awareness	Complete the Restoring the Merrimack River by Connecting Communities" project.	NMCOG and the Merrimack River Watershed Council. NMCOG recently received EPA funds through the Urban Water grant program for a training and outreach program designed to educate community member, municipal staff and officials about the effects of stormwater on water quality.	Flooding/ Climate Change	Short-term	EPA Urban Waters Grant funding to finance this initiative. NMCOG staff to work with local communities, particularly Public Works employees.	No, new action item

Table 82 (cont'd): Proposed Regional Mitigation Actions

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Public Education and Awareness	Through public education materials, increase public awareness regarding the dangers of winter storms, such as automobile accidents, exposure, hypothermia, frost bite, overexertion, and downed power lines.	NMCOG, local public safety officials	Winter storms, ice storms, severe snow storms	Annual	Federal and state grants (MassDOT), as well as local general funds. NMCOG staff to identify funding options and work with local public safety agencies.	No, new action item
Structural project	Work with MassDOT and the MPO to prioritize structurally deficient bridges through the Transportation Improvement Program process.	MassDOT, and the Northern Middlesex MPO; several structurally deficit bridges have been rehabilitated and reconstructed since completion of the 2006 Plan.	Earthquake, flooding	Annual.	FHWA and MassDOT funds and State transportation bond funds through the MPO process. NMCOG staff to work with municipalities and MPO members.	Yes
Prevention/ Public Education and Awareness	Serve as a liaison between FEMA, MEMA/DCR, and local communities, and to educate municipalities on the importance of mitigation planning.	NMCOG, MEMA, DCR, FEMA and local communities; NMCOG staff continues to work with its member communities and the public relative to hazard mitigation. NMCOG will continue to partner with MEMA on workshops following Presidential disaster declarations.	All hazards	Annual.	FEMA, MEMA, DCR, NMCOG and local general funds. NMCOG staff to work directly with designated local staff.	Yes

Table 82 (cont'd): Proposed Regional Mitigation Actions

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Prevention	Identify and seek public and private sector funding for residents, businesses, and municipalities to implement sound hazard mitigation measures throughout the region.	NMCOG and local emergency managers, engineers and public works staff. NMCOG staff has worked with its member communities by informing them of available grant opportunities for implementing mitigation measure. NMCOG has hosted workshops for local communities and MEMA staff has made a presentation to NMCOG's policy board relative to the various grant programs.	All hazards	Annual.	NMCOG, FEMA competitive grant programs and and local general funds. NMCOG staff to identify funding opportunities	Yes
Prevention	Incorporate natural hazard mitigation and best planning practices into NMCOG's planning work and activities.	NMCOG. Since the completion of the 2006 Plan, NMCOG has incorporated hazard mitigation into the Regional Strategic Plan, the Regional Transportation Plan, the Comprehensive Economic Development Strategy, and the various local Master Plan and Open Space documents that it has prepared on behalf of municipalities.	All hazards	Annual.	NMCOG annual work plan which is funded through local assessments, local contracts, and state and federal grants.	Yes

Table 82 (cont'd): Proposed Regional Mitigation Actions

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Prevention	Develop a Renewable Energy Siting Plan, in partnership with the Montachusett Regional Planning Commission to encourage renewable energy and reduce greenhouse gas emissions.	NMCOG and MRPC have initiated work on this project	Climate Change	Short-term	EDA technical assistance funds. NMCOG and MRPC staff to develop the Siting Plan and to be reviewed by the Energy Committees.	No, this is a new action item
Property Protection	Develop a mitigation plan for protecting all cultural and historic resources from natural hazard damage.	NMCOG, local historic commissions, libraries, Mass Historical Commission, National Park Service. To date, an appropriate funding mechanism for this action item has not been identified for work at the local level. However, the Massachusetts Board of Library Commissioners is preparing a statewide mitigation plan, which will be available to local communities.	All hazards	Short-term.	Massachusetts Historical Commission and Board of Library Commissioners. NMCOG staff to identify funding options and work with local historic commissions and National Park Service.	No, this is a new action item
Emergency Services	Improve emergency communications and interoperability through the formation of a Regional Emergency Communications Center (RECC)	NMCOG, the State 911 Department and the local public safety officials. Since completion of the 2006 Plan, NMCOG has completed an RECC feasibility study and has applied for funding from the State 911 Department to undertake an implementation study.	All hazards	Long-term	DLTA and State 911 Department funds. NMCOG staff to work with local public safety agencies and Chief Administrators. Bonding may be needed for the building construction which will be repaid with state grant funds.	No, this is a new action item

Table 82 (cont'd): Proposed Regional Mitigation Actions

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Prevention	Work with MassDOT, local highway departments and public safety officials to ensure that the regional and state Intelligent Transportation System (ITS) considers the needs of hazard mitigation and emergency response.	NMCOG, MassDOT, local highway departments and public safety officials. The regional ITS architecture now incorporates emergency response and hazard mitigation concerns. NMCOG staff will work with MassDOT and various stakeholders on future ITS architecture updates.	All hazards	Annual	MassDOT and local general funds. NMCOG staff to work with local highway and public safety officials to incorporate ITS in all projects. No additional funding involved as the work will be part of the overall project design.	Yes
Public Education and Awareness	Organize and conduct a workshop on the Community Rating System for City/ Town Planners, City/Town Managers, Emergency Managers, and Conservation Administrators	NMCOG. NMCOG staff has hosted hazard mitigation workshops for its local communities. To date, Tewksbury was the only CRS community in the region. NMCOG staff will continue to encourage its communities to participate in CRS.	Flooding	Short-term	NMCOG, MEMA/DCR- Utilize planning funds to sponsor the workshop for Chief Administrators, Planners, Emergency Managers, Building inspectors and Conservation Administrators.	Yes.
Public Education and Awareness	Notify eligible applicants of available hazard mitigation project grant funding through the FMA, PDM, HMGP, and SRL programs.	NMCOG. Since completion of the 2006 Plan, NMCOG has notified its member communities of grant opportunities.	All hazards	Annual	NMCOG, MEMA/DCR. Utilize admin funding to complete this task. Work with Chief Administrators and municipal staff.	No, this is a new action item.

Table 82 (cont'd): Proposed Regional Mitigation Actions

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Prevention/ Natural Resource Protection	Work with the NMCOG communities to incorporate Low Impact Development Techniques in local subdivision and zoning regulations.	NMCOG, local planning boards and conservation commissions. NMCOG assisted the towns of Dracut and Westford in crafting draft LID bylaws. To date, the bylaws have not yet been approved by town meeting. The newly adopted Regional Strategic Plan encourages local communities to embrace LID techniques.	Flooding	Short-term.	NMCOG, local communities, environmental agencies. Utilize NMCOG funds to implement this project through work with the local planners and conservation agents.	Yes
Prevention/ Structural	Through the NMSC, assist communities in procuring services to routinely clean and maintain drainage infrastructure.	NMCOG, local communities, MassDOT. The local action plans denote the status of municipal stormwater infrastructure maintenance activities. MassDOT has an ongoing stormwater maintenance program, and is in the process of expanding the extent of its program.	Flooding	Annual.	NMCOG, local communities, MassDOT. Utilize NMCOG funds and work with MassDOT and public works officials.	Yes
Prevention	Reduce the risk of power outages by identifying and trimming branches that could down power lines during a storm event. Particular attention should be paid to protecting the power supply for critical infrastructure and emergency services.	National Grid, municipal DPW crews. The significant and widespread outages that occurred as a result of the December 2008 Ice Storm and the October 2011 snowstorm suggests that there is considerable room for improvement in this area.	Hurricanes, tornadoes, winter storms, thunderstorms	Annual.	National Grid, municipalities. Utilize National Grid tree program and local general funds to address this issue.	Yes.

Table 82 (cont'd): Proposed Regional Mitigation Actions

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Prevention/ Structural	Work with the DCR Office of Dam Safety, dam owners and the local communities to ensure that significant and high hazard dams are inspected according to the prescribed schedule, that up-to-date evacuation plans are in place, and that needed repairs are implemented in a timely fashion.	NMCOG, DCR Office of Dam Safety, dam owners, municipalities. Repairs have been made to several dams throughout the region. However, as mentioned in earlier sections of this document, several dams are overdue for inspection.	Flooding, earthquakes	Short-term.	DCR Office of Dam Safety, NMCOG, local communities. Utilize available funding and work with DCR, dam owners and public works officials. Private dams to be funded with private funds. Municipal projects to be funded with general funds.	Yes.
Prevention	Work with DCR, Bureau of Fire Control and the local communities to develop a uniform reporting system for wildfires.	DCR, local fire departments, and NMCOG. While NMCOG was able to acquire wildfire data for this plan, it does not seem that there is a central collection vehicle or repository for such data.	Wildfire	Short-term	Utilize DCR staff and local public safety staff to implement this project . Requires staff time only	Yes.
Prevention/ Emergency Response	Assist municipalities in developing emergency access and evacuation plans for neighborhoods subject to isolation from flooding using NMCOG GIS.	NMCOG, municipal public safety officials. Since completion of the 2006 Plan, NMCOG staff has worked with each of its municipalities to identify and map evacuation routes.	Flooding	Short-term	NMCOG, municipalities. Utilize local general funds to develop plans. Will work with local public safety officials.	Yes

Table 82 (cont'd): Proposed Regional Mitigation Actions

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Property Protection	Flood-proof or relocate any critical facility sited in the floodplain.	Municipal public safety, DPW, and engineers, and EOPSS. Since the completion of the 2006 Plan, flood proofing of water and sewer infrastructure elements has been undertaken in Dracut and Lowell.	Flooding	Long-term.	Municipalities, State, and Federal agencies. FEMA competitive grant funds or local general funds will be used.	Yes.
Structural / Property Protection	Ensure that any new or existing critical facilities meet state building code for high winds, earthquakes, fire and snow loading.	Municipal building departments. New police stations in Chelmsford and Tewksbury were constructed to meet these codes, as was the renovation of Westford Town Hall.	Hurricane, tornado, earthquake, urban fire, wildfire, winter storms	Long-term.	Municipalities. State and Federal agencies. Work with the state and local building officials to ensure that new facilities meet the building code. Retrofits would be funded through state grant monies or local general fund.	Yes.
Prevention/ Emergency Services	Develop standards for emergency shelters; require that every new and existing shelters comply with all requirements, including the provision of emergency generators or backup power.	Municipal emergency managers, MEMA. Emergency generators have been installed at a number of emergency shelters and at the renovated Westford Town Hall.	All hazards	Long-term.	Municipal general fund or HMGP funds	Yes.

Table 82 (cont'd): Proposed Regional Mitigation Actions

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe / Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Prevention	Provide training to local Conservation Commissions to increase enforcement of the state and local wetland and stormwater regulations and bylaws.	NMCOG, Municipal conservation commissions, DEP. Municipalities have participated in the MACC, APA and CPTC workshops.	Flooding	Short-term.	Municipalities, DEP - Utilize DEP funding or the CPTC program to implement this task. .	Yes.
Prevention/ Property Protection	Educate local communities on how to revise local regulations to require fire-proof roofing materials in areas adjacent to forested land.	Municipal planning boards, building departments, fire departments. No work has begun on this project.	Wildfire	Short-term.	Municipalities NMCOG will utilize its admin funds to reach out to the Planning Boards, fire officials and building departments	Yes.
Prevention/ Property Protection	Conduct a workshop to encourage municipalities to participate in the DCR/ Fire Wise Program	Municipal fire departments, DCR. A number of NMCOG communities now participate in the Fire Wise program, but not all.	Wildfire, urban fire	Annual.	Municipalities, DCR- NMCOG staff will reach out to non-participating communities. Requires staff time only	Yes
Prevention	Encourage local officials to work cooperatively with the District 6 Fire Warden to inventory, map and characterize all access roadways through the state forests.	DCR, District 6, local municipalities. The roadways and trails through the Lowell-Tyngsborough-Dracut State Forest have been mapped.	Wildfire	Short-term.	DCR, District 6 and local communities. NMCOG staff to work with planners and public safety officials. DCR and municipal staff time will cover this task.	Yes
Prevention/ Public Education and Outreach	Educate landowners concerning the importance of removing fuel in forested areas to reduce the risk of wildfire.	NMCOG, DCR and local fire departments.	Wildfire	Annual	Municipalities, DCR- NMCOG staff to work with DCR and public safety officials . Local general funds will be used	Yes

Table 83: Proposed Mitigation Actions -Town of Billerica

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Property Protection	Reduce repetitive flood losses along the Concord and Shawsheen Rivers through flood-proofing or property acquisition.	Board of Selectmen and Conservation Commission, MEMA, FEMA. No work has begun on this task.	Flooding	Long-term.	FEMA/MEMA competitive grant programs. Billerica land bank funds or general funds may be used to acquire property along the rivers.	Yes
Prevention	Work with the DCR Office of Dam Safety and Dam owners to ensure that inspections of the three dams within the Town of Billerica are brought up to date.	DCR, Town Engineer and DPW, Dam owners. A recent inspection of the Talbot Dam was performed.	Flooding, earthquake	Short-term	Dam owners, DCR. Public Works Department to work with DCR and dam owners.	Yes.
Property Protection	Purchase additional land along the Concord and Shawsheen Rivers and protect as open space.	Board of Selectmen. The town has purchased significant property along the Concord River, including the 40-acre Cabot property.	Flooding	Long-term.	Town land bank funds or general funds may be used or the town may apply for state and federal grants.	Yes
Public Education and Awareness	Educate town residents and developers regarding the Town's local bylaw limiting increases in impervious surface.	Town Conservation Commission and Planning Board. The town continues to educate developers and residents.	Flooding	Short-term.	Town Planning Director and Conservation Agent will utilize general funds to complete this task	Yes

Table 83 (cont'd): Proposed Mitigation Actions - Town of Billerica

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Structural project/ Natural Resource Protection	Complete future phases of the Town's sewer facilities plan.	DPW and Engineering.	Flooding	Annual	State SRF funds and town bonding.	Yes
Natural Resource Protection	Increase enforcement of the Town's flood plain bylaw.	Town conservation agent and building inspector	Flooding	Short-term.	Town Conservation Agent and building inspector to complete this task utilizing general funds.	Yes
Prevention / Natural Resource Protection	Revise Stormwater and erosion control regulations; improve coordination between the Planning Board, Conservation Commission, and Zoning Board of Appeals.	Town Planning Director and Engineering Dept. Since the completion of the 2006 Plan, the town has streamlined its permitting process and improved coordination among departments and boards.	Flooding	Short-term	Town general funds.	Yes
Prevention / Natural Resource Protection	Incorporate Hazard Mitigation into the town's Open Space Plan Update and Master Plan Update	Planning Board and Conservation Commission. The town will be updating their Open Space Plan and Master Plan in the future	All hazards	Long-term	Utilize town general funds.	No, this is a new action item.
Prevention / Natural Resource Protection	Update the town's Stormwater Management Plan to address new MS4 permit	DPW and Engineering-The town will address EPA's new requirements as part of its MS4 permit	Flooding	Short-term	Town general funds and competitive grant programs.	No, this is a new action item.

Table 83 (cont'd): Proposed Mitigation Actions - Town of Billerica

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Prevention	Work with NMCOG and the NMSC in investigating the feasibility of forming a stormwater utility.	NMCOG and the Board of Selectmen and DPW	Flooding	Short-term	DLTA and CIC funds The Public Works Director will participate in the NMSC and offer the town's perspective on the need for a stormwater utility.	No, this is a new action item.
Prevention / Property Protection	Participate in DCR's Fire Wise Program.	DCR and Fire Department	Wildfire, Drought	Annual	DCR - Fire Chief to work with DCR on the Fire Wise Program. No town funds needed beyond the operating budget.	Yes
Structural	Upgrade Sewer Treatment Plant to meet regulatory requirements	Board of Selectmen and DPW	Flooding/ hurricanes	Long-term	Town funds and State grant programs (SRF). Bonding is likely.	No, this is a new action item
Prevention	Revise Planning Board, Conservation and Board of Health regulations to improve floodplain management.	Planning Board, Conservation Commission and Board of Health	Flooding	Short-term	Town general funds will be used to complete this task	No, this is a new action item
Prevention	Study the Community Rating System to determine appropriateness for Billerica	Town Emergency Manager	Flooding	Short-term	Emergency Manager, utilizing general funds, will work with MEMA to complete this task.	No, this is a new action item

Table 83 (cont'd): Proposed Mitigation Actions - Town of Billerica

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Public education	Increase public awareness of the dangers of extreme temperatures and outline locations where vulnerable populations (elderly, homeless and those with health issues) can have access to air conditioning or shelter from the cold	Town Emergency Manager	Extreme Temperatures	Short-term	Emergency manager will implement this recommendation using general funds.	No
Public education	Distribute educational information to residents and businesses on protecting life and property from severe winter storm events	Emergency Manager	Winter storms – snowstorms, blizzards, ice storms	Short-term	This task will be implemented by the Emergency Manager using general funds	No
Emergency Services Protection	Ensure that administrators of schools, businesses, medical facilities, and the mobile home park have a shelter plan in the event of a tornado or hurricane warning	Emergency Manager and public safety	Tornado, hurricane	Long-term	This task will completed by the Emergency Manager and public safety personnel using general funds	No

Table 83 (cont'd): Proposed Mitigation Actions - Town of Billerica

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Property Protection	Inspect public buildings to evaluate the capacity to withstand snow loads and prevent roof collapse. Develop plans to clear roofs of excessive snow accumulations to prevent collapse.	Building inspector and Emergency Manager	Severe winter storm/ snowstorm, blizzard	Short-term	This task will be completed by the Building inspector and Emergency Manager using local operating funds	No
Emergency Services	Identify locations for snow storage farms for utilization in severe winters with heavy snowfall	Highway Department	Severe winter storm/snowstorm, blizzard	Short-term	This task will be implemented by the highway department using local operating funds	No
Property protection	Evaluate public buildings and critical facilities for the potential to withstand high winds	Building inspector and emergency manager	Hurricane, tornado, blizzard	Long-term	This task will be implemented by the Building Inspector and Emergency manager using local general funds	No
Emergency services	Assess bridges and roadways to ascertain their capability to support fire apparatus and develop alternative routing plans where deficiencies are noted	Fire Department and Highway Department	Structural fire/ wildfire	Long-term	This task to be undertaken by the Fire Department and Highway Department using operating funds	No
Property Protection	Develop an inventory of public buildings that do not currently meet seismic standards	Building inspector and emergency manager	Earthquake	Long-term	This task is to undertaken by the Building Inspector and emergency manager using general funds	No

Table 83 (cont'd): Proposed Mitigation Actions - Town of Billerica

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Public education	Provide information to homeowners on how to protect their property from brush fire or wildfire during times of drought	Fire Department	Drought, Brush fire/wildfire	Short-term	This task is to be undertaken by the Fire Department using general funds	No

Table 84: Proposed Mitigation Actions - Town of Chelmsford

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Prevention/ Property Protection	Elevate, flood-proof and maintain the alternate access roadway for the Williamsburg Condominium complex and stabilize riverbank.	Town DPW Department. Minor maintenance was performed following the 2006 Plan, however, more extensive work is needed.	Flooding/ hurricanes	Short-term.	Combination of town general funds and HMGP funds	Yes, but the language has been modified
Prevention	Work with DCR Office of Dam Safety to ensure that the inspections of all dams are current.	DCR Office of Dam Safety, dam owners, Town engineer- Since completion of the 2006 Plan the Swain and Crooked Spring dams have been reclassified.	Flooding, earthquakes	Short-term	DCR Office of Dam Safety, dam owners, and town engineer. Work will be performed within existing budget.	Yes

Table 84 (cont'd): Proposed Mitigation Actions - Town of Chelmsford

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Structural project/ Property Protection	Address flooding and bank erosion in the vicinity of Willliamsburg Condos and along Tyngsborough Road in North Chelmsford.	Town DPW and condo association. This issue is currently being studied.	Flooding/ hurricanes	Short-term	HMGP grant program--Public Works Department to work with MEMA and condo association.	No, this is a new action item.
Structural project	Address the Meadowbrook Road culvert and associated flooding.	Town DPW.	Flooding/ hurricanes	Short-term	Town general funds and competitive FEMA grant program	No, this is a new action item
Emergency Services	Install emergency vehicle pre-emption at signalized intersections.	Town and MassDOT	All hazards	Long-term	Billerica Public Works Department budget, Chapter 90 and MassDOT funds will be used.	No, this is a new action item.
Emergency services	Install a generator at the new fire station.	Fire department	All hazards	Short-term	HMGP funds or town general funds	No, this is a new action item.
Prevention	Strengthen enforcement of the town's floodplain zoning bylaw.	Planning Board, Conservation Commission and Building inspector. Since the completion of the 2006 Plan, the town has improved its process for enforcement of the floodplain bylaw.	Flooding, climate change	Annual	Town general funds to be used; falls within existing budget	Yes, but language has been modified

Table 84 (cont'd): Proposed Mitigation Actions - Town of Chelmsford

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Prevention/ Natural Resource Protection	Increase enforcement of impervious surface limitations within the Aquifer Protection District.	Town Planning Board and Conservation Commission-still relevant.	Flooding, climate change	Short-term.	Town Planner and Conservation Agent to complete this task utilizing general funds.	Yes
Prevention/ Natural Resource Protection	Propose a Low Impact Development bylaw for consideration of local officials and town meeting	Town Planning Board and Conservation Commission. This recommendation was also in the town's 2010 Master Plan.	Flooding, climate change	Short-term.	Community Development Director and Conservation Agent to complete this task utilizing general funds.	Yes
Prevention/ Property Protection	Update the response plan for the Freeman Lake and Heart Pond dams.	Town emergency manager and engineer. The town has been addressing minor compliance issues related to the dam.	Flooding, earthquakes	Annual.	Town emergency manager and engineer to complete this task utilizing general funds. .	Yes
Prevention/ Natural Resource Protection	Perform maintenance on drainage/ stormwater structures.	Town DPW. The action is being implemented as part of the town's MS4 permit.	Flooding	Annual.	Department of Public Works to address this issue utilizing general funds.	Yes, but language has been modified
Prevention/ Public Education and Awareness	Conduct outreach program to encourage the purchase of flood insurance by private property owners.	The town's Community Development Department to provide guidance and education to property owners.	Flooding	Short-term.	Community Development Director to address this issue utilizing general funds. .	Yes.
Prevention	Conduct a study to examine measures to mitigate flooding along Tyngsborough Road.	State-MassDOT District 4	Flooding	Short-term	State funding. Public Works Director to work with MassDOT to secure funding.	Yes

Table 84 (cont'd): Proposed Mitigation Actions - Town of Chelmsford

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Structural Project	Improve dam maintenance at the School Street Dam on Stony Brook where stones have been dislodged.	Dam Owner at the behest of the town	Flooding, earthquakes	Short-term	Dam Owner- Private funds used to maintain privately-owned dams.	Yes
Emergency Services	Continue to work with NMCOG in studying the establishment an RECC.	NMCOG and the Town public safety officials	All hazards	Short-term	State 911 Department funds- Public safety officials to work with NMCOG through 911 Work Group.	No, this is a new action item.
Public education	Increase public awareness of the dangers of extreme temperatures and outline locations where vulnerable populations (elderly, homeless and those with health issues) can have access to air conditioning or shelter from the cold	Town Emergency Manager	Extreme Temperature	Short-term	Emergency manager will implement this recommendation using general funds.	No
Emergency Services	Establish an emergency shelter to care for pets during a natural disaster.	Town Emergency manager and animal control officer	All hazards	Short-term	Utilizing town general funds, the Emergency Manager and animal control officer will address this issue.	No, this is a new action item.
Prevention	Revise Planning Board, Conservation Commission, and Board of Health regulations to improve floodplain management	Planning Board, Conservation Commission and Board of Health	Flooding	Short-term	Community Development Director, Board of Health Director and Conservation Agent will address this issue utilizing general funds.	No, this is a new action item

Table 84 (cont'd): Proposed Mitigation Actions - Town of Chelmsford

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Prevention	Study the Community Rating System to determine appropriateness for Chelmsford	Town Emergency manager and building inspector, MEMA	Flooding	Short-term	Emergency Manager, utilizing general funds, will work with MEMA to complete this task.	No, this is a new action item
Prevention	Enhance the knowledge of local officials, builders, developers, citizens and other stakeholders on how to read and interpret the FIRM.	Community Development Director	Flooding	Short-term	Community Development Director to address this issue utilizing general funds. No bonding funds needed.	No, this is a new action item
Public education	Distribute educational information to residents and businesses on protecting life and property from severe winter storm events	Emergency Manager	Winter storms – snowstorms, blizzards, ice storms	Short-term	This task will be implemented by the Emergency Manager using general funds	No
Emergency Services Protection	Ensure that administrators of schools, businesses, medical facilities, and mobile home park have a shelter plan in the event of a hurricane or tornado warning	Emergency Manager and public safety	Tornado, hurricane	Long-term	This task will completed by the Emergency Manager and public safety personnel using general funds	No
Property Protection	Inspect public buildings to evaluate the capacity to withstand snow loads and prevent roof collapse. Develop plans to clear roofs of excessive snow accumulations to prevent collapse.	Building inspector and Emergency Manager	Severe winter storm/ snowstorm, blizzard	Short-term	This task will be completed by the Building inspector and Emergency Manager using local operating funds	No

Table 84 (cont'd): Proposed Mitigation Actions - Town of Chelmsford

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Emergency Services	Identify locations for snow storage farms for utilization in severe winters with heavy snowfall	Highway Department	Severe winter storm/snowstorm, blizzard	Short-term	This task will be implemented by the highway department using local operating funds	No
Property protection	Evaluate public buildings and critical facilities for the potential to withstand high winds	Building inspector and emergency manager	Hurricane, tornado, blizzard	Long-term	This task will be implemented by the Building Inspector and Emergency manager using local general funds	No
Emergency services	Assess bridges and roadways to ascertain their capability to support fire apparatus and develop alternative routing plans where deficiencies are noted	Fire Department and Highway Department	Structural fire/ wildfire	Long-term	This task to be undertaken by the Fire Department and Highway Department using operating funds	No
Property Protection	Develop an inventory of public buildings that do not currently meet seismic standards	Building inspector and emergency manager	Earthquake	Long-term	This task is to undertaken by the Building Inspector and emergency manager using general funds	No
Public education	Provide information to homeowners on how to protect their property from brush fire or wildfire during times of drought	Fire Department	Drought, Brush fire/wildfire	Short-term	This task is to be undertaken by the Fire Department using general funds	No

Table 85: Proposed Mitigation Actions - Town of Dracut

Category Of Action	**Description Of Action**	**Implementation Responsibility and Status**	**Hazard Addressed**	**Timeframe/ Priority**	**Resources/ Funding**	**Was the action included in the 2006 Plan?**
Structural project	Replace the Kelly Road culvert and construct drainage improvements.	Town DPW. No work has commenced	Flooding, climate change, hurricanes	Long-term.	Town Public Works Director to use local general funds to complete the project.	Yes.
Emergency Services	Continue to work with NMCOG in exploring the possibility of establishing an RECC.	NMCOG, Dracut public safety officials and State 911 Department	All hazards	Long-term	State 911 Department and Public safety officials to work with NMCOG through the 911 Work Group.	No, this is a new action item.
Structural project	Study mitigation options to address riverine flooding on Nottingham Road.	Town Engineer and DPW. Project has not yet been initiated	Flooding, climate change, hurricanes	Long-term.	Town Public Works Director and Town Engineer to use general funds to complete the project	Yes
Public education	Increase public awareness of the dangers of extreme temperatures and outline locations where vulnerable populations (elderly, homeless and those with health issues) can have access to air conditioning or shelter from the cold	Town Emergency Manager	Extreme Temperatures	Short-term	Emergency manager will implement this recommendation using general funds.	Public education

Table 85 (cont'd): Proposed Mitigation Actions - Town of Dracut

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Structural project	Continue system upgrades and water main replacements, as funds allow.	Dracut Water Supply and Kenwood Water Districts	Wildfire, urban fire	Annual	Dracut Water Supply and Kenwood Water Districts will utilize District funds. Bonding may be utilized to complete the project.	Yes
Prevention/ Property Protection	Study overflow/flooding issues created by restricted stormwater outfall on private property which result in significant flooding during heavy rain events	Engineering Department and DPW	Flooding	Short-term	Town and private property owners will need to work together. Public Works Director to use general funds to complete the project.	Yes
Prevention	Identify and remove hazardous trees in the town-owned right-of-way.	Town DPW	Hurricanes, thunderstorms, winter storms	Annual.	Town Public Works Director to use general funds to complete the project.	Yes
Prevention/ Property Protection	Work with DCR Bureau of Fire Control to complete mapping of the state forest for public safety purposes.	Town and DCR Bureau of Fire Control. Some work has been undertaken, but more tasks remain.	Wildfire	Short-term.	Dracut fire and engineering to work with DCR through the use of general funds.	Yes

Table 85 (cont'd): Proposed Mitigation Actions - Town of Dracut

Prevention/ Property Protection	Develop a joint Fire Wise Program in cooperation with DCR, the City of Lowell and the Town of Tyngsborough.	Town of Dracut, City of Lowell, Town of Tyngsborough fire departments, and DCR. Work is underway on this initiative.	Wildfire, urban fire	Short-term.	Fire Chief to work with DCR and other communities utilizing general funds.	Yes
Prevention/ Property Protection	Continue to identify NFIP non-compliant structures and submit to rate structures.	Town engineer and building commissioner, and MEMA	Flooding	Annual	Town building Commissioner and engineer to work with MEMA utilizing general funds.	No
Prevention/ Property Protection	Continue to work toward certification of the Building Commissioner as the town's flood plain manager	Town building commissioner, MEMA and FEMA	Flooding	Short-term	Town building Commissioner to work with MEMA and DCR, FEMA utilizing general funds.	No
Prevention/ Property Protection	Work with federal and state officials to address existing compliance issues relative to the NFIP.	Town building commissioner and emergency manager, MEMA, FEMA	Flooding	Short-term	Town Emergency Manager and building commissioner to work with MEMA and FEMA utilizing general funds.	No
Emergency Services Protection	Ensure that administrators of schools, businesses, and medical facilities have a shelter plan in the event of a tornado warning	Emergency Manager and public safety	Tornado	Long-term	This task will completed by the Emergency Manager and public safety personnel using general funds	No

Table 85 (cont'd): Proposed Mitigation Actions - Town of Dracut

Prevention/ Natural Resource Protection	Complete remaining phases of the sewer program.	Town DPW	Flooding	Long-term	Town funds and SRF funds. Public Works Director to utilize grants, as well as local general funds for match. Project may use bonding as a finance mechanism.	No, this is a new action item
Public education	Distribute educational information to residents and businesses on protecting life and property from severe winter storm events	Emergency Manager	Winter storms – snowstorms, blizzards, ice storms	Short-term	This task will be implemented by the Emergency Manager using general funds	No
Property Protection	Inspect public buildings to evaluate the capacity to withstand snow loads and prevent roof collapse. Develop plans to clear roofs of excessive snow accumulations to prevent collapse.	Building inspector and Emergency Manager	Severe winter storm/ snowstorm, blizzard	Short-term	This task will be completed by the Building inspector and Emergency Manager using local operating funds	No
Emergency Services	Identify locations for snow storage farms for utilization in severe winters with heavy snowfall	Highway Department	Severe winter storm/snowstorm, blizzard	Short-term	This task will be implemented by the highway department using local operating funds	No
Property protection	Evaluate public buildings and critical facilities for the potential to withstand high winds	Building inspector and emergency manager	Hurricane, tornado, blizzard	Long-term	This task will be implemented by the Building Inspector and Emergency manager using local general funds	No

Table 85 (cont'd): Proposed Mitigation Actions - Town of Dracut

Emergency services	Assess bridges and roadways to ascertain their capability to support fire apparatus and develop alternative routing plans where deficiencies are noted	Fire Department and Highway Department	Structural fire/ wildfire	Long-term	This task to be undertaken by the Fire Department and Highway Department using operating funds	No
Property Protection	Develop an inventory of public buildings that do not currently meet seismic standards	Building inspector and emergency manager	Earthquake	Long-term	This task is to undertaken by the Building Inspector and emergency manager using general funds	No
Public education	Provide information to homeowners on how to protect their property from brush fire or wildfire during times of drought	Fire Department	Drought, Brush fire/wildfire	Short-term	This task is to be undertaken by the Fire Department using general funds	No

Table 86: Proposed Mitigation Actions -Town of Dunstable

Category Of Action	**Description Of Action**	**Implementation Responsibility/ Status**	**Hazard Addressed**	**Timeframe/ Priority**	**Resources/ Funding**	**Was the action included in the 2006 Plan?**
Prevention	Prepare study of flooding problems along Main Street near Sweets Pond.	Town Board of Selectmen and Conservation Commission	Flooding, hurricanes	Short-term	Town Board of Selectmen and Conservation Commission to complete this task utilizing general funds.	Yes

Table 86 (Cont'd): Proposed Mitigation Actions -Town of Dunstable

Prevention	Study the Community Rating System to determine appropriateness for Dunstable	Town Emergency Manager and building inspector, MEMA and FEMA	Flooding	Short-term	Town emergency manager and building inspector, FEMA and MEMA will address this task. Town will utilize general funds to complete this task.	No, this is a new action item
Public education	Increase public awareness of the dangers of extreme temperatures and outline locations where vulnerable populations (elderly and those with health issues) can have access to air conditioning or shelter from the cold	Town Emergency Manager	Extreme Temperatures	Short-term	Emergency manager will implement this recommendation using general funds.	Public education
Prevention	Work with DCR Office of Dam Safety to ensure that the inspections of all dams are current.	Town Administrator, DCR Office of Dam Safety, dam owners	Earthquake, flooding	Short-term	Town Administrator to work with DCR and dam owners. General funds to be used.	Yes
Prevention / Natural Resource Protection	Incorporate Hazard Mitigation into subdivision regulations, Master Plan and Open Space Plan Updates.	Town Planning Board and Conservation Commission. The town's Open Space Plan currently addresses hazard mitigation.	All Hazards	Short-term	Town Planning Board and Conservation Commission will utilize general funds.	No, this is a new action item

Table 86 (Cont'd): Proposed Mitigation Actions -Town of Dunstable

Category Of Action	Description Of Action	Implementation Responsibility/ Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Prevention/ Property Protection	Participate in DCR's Fire Wise Program for the forested sections of town.	DCR and Town Fire Department	Wildfire	Annual	DCR and Town Fire Chief to work with DCR on the Fire Wise Program. Part of current budget, no town funds needed.	Yes
Structural Project	Upgrade and expand the Route 113 water line, which will improve fire suppression capabilities.	Town Water Department	Wildfire, urban fire	Short-term	Town and State funds- The Town Water Department is responsible for this project. State grant funds and local water department funds will be used. Project may be bonded.	No, this is a new action item
Emergency Services	Purchase communication equipment with interoperability capabilities.	Town police and fire departments	All Hazards	Long-term	Town Public Safety officials will utilize general funds and/or State 911 Department funds.	Yes, but item has been modified.
Structural Project	Replace Main Street/Salmon Brook Bridge.	Highway department and MassDOT. The bridge replacement project is currently under design	Flooding, earthquake	Short-term	Federal and state funds through MassDOT	Yes

Table 86 (Cont'd): Proposed Mitigation Actions -Town of Dunstable

Category Of Action	Description Of Action	Implementation Responsibility/ Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Emergency Services	Study regional consolidation of 911 dispatch services by establishing an RECC	Town public safety officials, NMCOG and the State 911 Department	All Hazards	Short-term	State 911 Department funds will be used. Public safety officials to work with NMCOG through 911 Work Group.	No, this is a new action item.
Structural Project/ Emergency Response Services	Repair the next phase of the Route 113 retaining wall in order to keep the roadway open, and replace culvert.	MassDOT and the Town Highway Department. This project is currently under design	All Hazards	Short-term	Town Highway Dept. will work with MassDOT to design and construct the project. Construction will be funded through the TIP..	No, this is a new action item
Emergency Services Protection	Ensure that administrators of schools, businesses, and municipal buildings have a shelter plan in the event of a tornado warning	Emergency Manager and public safety	Tornado	Long-term	This task will completed by the Emergency Manager and public safety personnel using general funds	No
Prevention	Study the establishment of a mutual aid agreement with neighboring communities to administer NFIP following a major storm event.	Town Emergency manager, Board of Selectmen, and building inspector	All Hazards	Long-term	Town Emergency Manager will implement this project using general funds. The Board of Selectmen must approve the agreement and the building inspector is responsible for the NFIP program.	No, this is a new action item

Table 86 (Cont'd): Proposed Mitigation Actions -Town of Dunstable

Category Of Action	Description Of Action	Implementation Responsibility/ Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Prevention	Revise subdivision regulations, erosion control regulations, and Board of Health regulations to improve floodplain management as needed	Town Planning Board, Conservation Commission and Board of Health	Flooding	Annual	Planning Board, Conservation Commission, and Board of Health to utilize general funds to complete this task.	No, this is a new action item
Public education	Distribute educational information to residents and businesses on protecting life and property from severe winter storm events	Emergency Manager	Winter storms – snowstorms, blizzards, ice storms	Short-term	This task will be implemented by the Emergency Manager using general funds	No
Property Protection	Inspect public buildings to evaluate the capacity to withstand snow loads and prevent roof collapse. Develop plans to clear roofs of excessive snow accumulations to prevent collapse.	Building inspector and Emergency Manager	Severe winter storm/ snowstorm, blizzard	Short-term	This task will be completed by the Building inspector and Emergency Manager using local operating funds	No
Emergency Services	Identify locations for snow storage farms for utilization in severe winters with heavy snowfall	Highway Department	Severe winter storm/snowstorm, blizzard	Short-term	This task will be implemented by the highway department using local operating funds	No

Table 86 (Cont'd): Proposed Mitigation Actions -Town of Dunstable

Category Of Action	Description Of Action	Implementation Responsibility/ Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Property protection	Evaluate public buildings and critical facilities for the potential to withstand high winds	Building inspector and emergency manager	Hurricane, tornado, blizzard	Long-term	This task will be implemented by the Building Inspector and Emergency manager using local general funds	No
Emergency services	Assess bridges and roadways to ascertain their capability to support fire apparatus and develop alternative routing plans where deficiencies are noted	Fire Department and Highway Department	Structural fire/ wildfire	Long-term	This task to be undertaken by the Fire Department and Highway Department using operating funds	No
Property Protection	Develop an inventory of public buildings that do not currently meet seismic standards	Building inspector and emergency manager	Earthquake	Long-term	This task is to undertaken by the Building Inspector and emergency manager using general funds	No
Public education	Provide information to homeowners on how to protect their property from brush fire or wildfire during times of drought	Fire Department	Drought, Brush fire/wildfire	Short-term	This task is to be undertaken by the Fire Department using general funds	No

Table 87: Proposed Mitigation Actions - City of Lowell

Category Of Action	Description of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Structural project	Dredge and re-channel marsh between Phoenix Avenue and Wentworth Avenue and between Douglas Road and Clark Road (Tewksbury).	City Public Works Department	Flooding	Long-term.	City general fund, with possible State or Federal grant assistance	Yes, but the timeframe has been revised
Structural project/ Natural Resource Protection	Implement stormwater/CSO separation measures citywide.	Lowell Wastewater Treatment Utility. Some stormwater separation projects have been completed since the 2006 Plan was adopted. However, there are many future phases remaining.	Flooding, hurricanes	Long-term	City will implement with rate payer funds, and Federal and State grant assistance. Bonding may be used.	Yes
Structural project	Install drainage improvements at various locations to reduce roadway flooding.	City DPW. A number of drainage improvement projects have been completed since the 2006 Plan was adopted.	Flooding	Annual	City Public Works Director will utilize local funds to complete this project.	Yes.
Prevention/ Property Protection	Pursue mitigation funding to reduce repetitive flood losses along Black Brook and Clay Brook.	City Manager, DPW and Emergency Manager, private property owners, MEMA, FEMA	Flooding, hurricanes	Long-term	With City Council approval, the City will apply for FEMA competitive grant funds or use local general funds	Yes

Table 87 (Cont'd): Proposed Mitigation Actions –City of Lowell

Category Of Action	Description of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Structural project/ Emergency Services	Work with MassDOT to repair or replace structurally deficient bridges.	City Engineer and DPW, and MassDOT. A number of bridge improvement projects have been completed since the adoption of the 2006 Plan. However, there are still several structurally deficient bridges that need to be addressed, as outlined in earlier sections of this document.	Earthquake, flooding	Long-term	The DPW Director and City Engineer will work with MassDOT to secure federal and state funds.	Yes
Prevention	Work with DCR Office of Dam Safety to ensure that the inspections of all dams are current.	City Engineer, DCR Office of Dam Safety, dam owners	Earthquake, flooding	Short-term	City Engineer to work with DCR and dam owners. General funds to be used.	Yes
Prevention	Develop a joint Fire Wise Program in cooperation with DCR and the Towns of Dracut and Tyngsborough.	City of Lowell, Towns of Dracut and Tyngsborough, and DCR will work together in addressing issues within the state forest.	Wildfire, urban fire	Short-term.	Fire Departments of Dracut and Tyngsborough, City of Lowell, and DCR will complete work within annual budgets.	Yes
Prevention	Work with DCR Bureau of Fire Control to complete mapping of the state forest for public safety purposes.	City Fire Department and GIS staff, and DCR Bureau of Fire Control. Some work has been completed, but additional tasks remain.	Wildfire, urban fire	Short-term	Fire Chief and GIS staff to work with DCR and other communities utilizing general funds.	Yes

Table 87 (cont'd): Proposed Mitigation Actions - City of Lowell

Category Of Action	Description of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Prevention	Participate in the Community Rating System or undertake activities to increase the grade level of the community's current CRS participation.	City Emergency Manager and building inspector, MEMA, FEMA	Flooding	Short-term	City Emergency Manager and building inspector will utilize general funds and work with FEMA and MEMA to complete this task.	No
Prevention	Revise subdivision regulations, erosion control regulations, and Board of Health regulations to improve floodplain management.	City Planning and Development Department, Conservation Commission, and Health Department	Flooding	Short-term	DPD Director, Conservation Agent and Health Department will address this issue utilizing general funds.	No
Emergency Services	Upgrade all shelter facilities to meet Red Cross standards; includes plumbing upgrades, air conditioning, and generators.	City Emergency Manager. Some progress has been made since the completion of the 2006 Plan.	All Hazards	Long-term	City general funds with state and federal grant funding assistance.	Yes

Table 87 (cont'd): Proposed Mitigation Actions - City of Lowell

Category Of Action	Description of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Structural project	Repair erosion/flood control walls and levees to ensure structural integrity.	City Wastewater Utility. Trees have been removed from the levee and engineering studies have been initiated.	Flooding, hurricanes	Long-term	City will work with MEMA, FEMA, and the Army Corps of Engineers. LWU Director will address this issue utilizing federal, state and local funds. Bonding may be used to finance project.	Yes
Structural project	Repair Canal Walls throughout system	City Engineering Department, DCR and National Park Service. Some repairs have been made, but this is a long-term project. DCR owns the canal walls.	Flooding	Long-term	City Engineer and the National Park Service will work with DCR to address this issue. A combination of federal, state and local funds will be used.	Yes
Prevention	Clean debris from canals and control structures. Clean out idle overflow canals.	City DPW and non-profits, with consent of Enel, the hydropower company that retains control of the canals. Their cooperation is needed to complete this action item.	Flooding	Short-term	Donated time from non-profit volunteers and private funds from Enel. City DPW will fund disposal costs.	Yes

Table 87 (cont'd): Proposed Mitigation Actions - City of Lowell

Category Of Action	Description of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Emergency Services	Study regional consolidation of 911 dispatch services by establishing an RECC	City public safety officials, NMCOG and the State 911 Department. Feasibility study completed, with implementation study to follow.	All Hazards	Short-term	City Public safety officials to work with NMCOG through 911 Work Group. Using State 911 Department funds	No, this is a new action item.
Structural project	Enlarge undersized culverts to alleviate flooding at key locations.	City Engineer and DPW. Some culvert replacement projects have been undertaken since the completion of the 2006 Plan, while others are needed.	Flooding, climate change, hurricanes	Short-term	City Engineer and DPW Director will address this issue utilizing general funds. Bond funds may be needed for large projects.	Yes
Emergency Services	Replace obsolete snow plow equipment with modern, more reliable snow removal apparatus. Add two snow throwing apparatus for two new multi-purpose trucks.	City DPW. Since the completion of the 2006 Plan, some snow removal equipment has been replaced, but there is still a need to replace other aging vehicles.	Winter Storms	Short-term	DPW Director will address this issue through the City's capital budget	Yes
Emergency Services	Purchase a regional snow melting apparatus.	City DPW. Budgetary constraints have prevented this purchase since the 2006 plan was completed.	Winter storms	Long-term	City with assistance from MEMA/ FEMA DPW Director will address this issue utilizing federal, state and local general funds. .	Yes

Table 87 (cont'd): Proposed Mitigation Actions - City of Lowell

Category Of Action	Description of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Public education	Increase public awareness of the dangers of extreme temperatures and outline locations where vulnerable populations (elderly, homeless and those with health issues) can have access to air conditioning or shelter from the cold	Town Emergency Manager	Extreme Temperatures	Short-term	Emergency manager will implement this recommendation using general funds.	Public education
Public education	Distribute educational information to residents and businesses on protecting life and property from severe winter storm events	Emergency Manager	Winter storms – snowstorms, blizzards, ice storms	Short-term	This task will be implemented by the Emergency Manager using general funds	No
Prevention/ Public Education and Awareness	Conduct outreach program to provide information on flood hazards and methods of protecting property located in the floodplain. Will use multi-lingual brochures, website and social media	City Emergency Manager. No action taken to date	Flooding	Short-term.	City Emergency Manager will address this issue utilizing general funds. .	No, this is a new action item.

Table 87 (cont'd): Proposed Mitigation Actions - City of Lowell

Category Of Action	Description of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Structural Project	Add secondary water supply for the City through tie-in with the Billerica system on the Concord River.	City Water Department. No action has been taken	Wildfire, urban fire	Long-term	City Water Department budget with state and/or federal funding assistance. Director of the Water Department will address this issue.	Yes
Emergency Services	Add portable water supply units for emergencies.	City Water Department and Emergency Manager. No action has been taken to date.	All Hazards	Short-term	Director of the Water Department will address this issue using competitive state or federal grant funds, or using Water Department resources.	Yes
Structural Project/ Property Protection	Construct pump station at West Street CSO station to protect Lakeview Avenue from flooding.	Lowell Wastewater Utility, state and federal agencies. These improvements are under design.	Flooding, hurricanes	Short-term	Lowell Wastewater Utility funds with state and federal funding assistance. Bonding may be needed to finance construction.	Yes, timeframe has been changed and some work has been completed

Table 87 (cont'd): Proposed Mitigation Actions - City of Lowell

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Structural Project/ Natural Resource Protection/ Property Protection	Modify the effluent pump system at the Greater Lowell Wastewater Treatment Plant to prevent the river from backing up into the plant and flooding the unit processes.	Lowell Wastewater Utility (LWU). Many of the needed modifications have been completed, but additional work is needed.	Flooding, hurricanes	Short-term	LWU funds with state and federal funding assistance	Yes, significant improvements have been made since completion of the 2006 Plan,
Structural Project/ Property Protection	Install "Duck Bill" backflow prevention valves on CSO and stormwater outlets to prevent river backflow from inundating pump stations, gravity division stations and local roadways. Locations in need include Tilden, West, Sparks and Rosemont Streets.	Lowell Wastewater Utility	Flooding, hurricanes	Short-term	LWU funds with state and federal funding assistance	Yes, work has been partially completed

Table 87 (cont'd): Proposed Mitigation Actions - City of Lowell

Category Of Action	Description of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Structural Project/ Property Protection	Construct berms/levees along the western bank of Beaver Brook to flood proof the Walker Street and Tilden Street CSO stations and the Rosemont Street sewer. pump station	City Engineer, DPW, and Emergency Manager, state and federal agencies. Engineering studies have been undertaken.	Flooding, hurricanes	Long-term	City with state and federal funding assistance DPW Director is responsible for this item.	Yes
Emergency Services Protection	Ensure that administrators of schools, businesses, medical facilities, and municipal buildings have a shelter plan in the event of a tornado warning	Emergency Manager and public safety	Tornado	Long-term	This task will completed by the Emergency Manager and public safety personnel using general funds	No
Structural Project/ Property Protection	Install a backflow prevention valve on the Alma Street outfall pipe to prevent floodwater from the Merrimack River and Beaver Brook from backing up into the neighborhood. This project includes a structure to house the valve.	City Engineer and state and federal agencies. Engineering studies have been undertaken.	Flooding, hurricanes	Short-term	City capital funds with state and federal funding assistance. City Engineer is responsible for this item.	Yes

Table 87 (cont'd): Proposed Mitigation Actions - City of Lowell

Category Of Action	Description of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Property Protection	Inspect public buildings to evaluate the capacity to withstand snow loads and prevent roof collapse. Develop plans to clear roofs of excessive snow accumulations to prevent collapse.	Building inspector and Emergency Manager	Severe winter storm/ snowstorm, blizzard	Short-term	This task will be completed by the Building inspector and Emergency Manager using local operating funds	No
Emergency Services	Identify locations for snow storage farms for utilization in severe winters with heavy snowfall	Highway Department	Severe winter storm/snowstorm, blizzard	Short-term	This task will be implemented by the highway department using local operating funds	No
Property protection	Evaluate public buildings and critical facilities for the potential to withstand high winds	Building inspector and emergency manager	Hurricane, tornado, blizzard	Long-term	This task will be implemented by the Building Inspector and Emergency manager using local general funds	No

Table 87 (cont'd): Proposed Mitigation Actions - City of Lowell

Category Of Action	Description of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Emergency services	Assess bridges and roadways to ascertain their capability to support fire apparatus and develop alternative routing plans where deficiencies are noted	Fire Department and Highway Department	Structural fire/ wildfire	Long-term	This task to be undertaken by the Fire Department and Highway Department	No
Property Protection	Develop an inventory of public buildings that do not currently meet seismic standards	Building inspector and emergency manager	Earthquake	Long-term	This task is to undertaken by the Building Inspector and emergency manager using general funds	No
Public education	Provide information to homeowners on how to protect their property from brush fire or wildfire during times of drought	Fire Department	Drought, Brush fire/wildfire	Short-term	This task is to be undertaken by the Fire Department using general funds	No

Table 88: Proposed Mitigation Actions - Town of Pepperell

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Structural project	Replace undersized culvert under Hollis Street to mitigate flooding problem at the intersection of Main, River and Hollis Streets.	Town DPW, MassDOT. No work has begun on this task.	Flooding, hurricanes, climate change	Short-term	DPW Director, working with MassDOT, is responsible for this item, utilizing federal, state and/or general local funds. Bonding funds may be needed.	Yes
Prevention	Work with MassDOT to improve debris removal at the Route 119 bridge over the Nashua River.	Town DPW and MassDOT. MassDOT owns this bridge.	Flooding, hurricane	Short-term	DPW Director, working with MassDOT, is responsible for this item. Work will be performed with existing budget.	Yes
Structural project	Work with MassDOT to replace/ rehabilitate any structurally deficient bridges identified in the future.	Town, MassDOT. Since the completion of the 2006 Plan, the Groton Street Bridge and the Mill Street Bridge has been reconstructed.	Earthquake, flooding	Short-term	MassDOT DPW Director, working with MassDOT, is responsible for this item. Will utilize federal and state funding through MassDOT.	Modified- The action item in the 2006 Plan included the replacement of the Groton Street Bridge and the Mill Street Bridge. The Groton Street and Mill Street bridges and Mill have been reconstructed.
Prevention	Work with DCR Office of Dam Safety to ensure that the inspections of all dams are current.	Town Engineer, DCR Office of Dam Safety, dam owners	Earthquake, flooding	Short-term	Town Engineer to work with DCR and dam owners. General funds and private monies to be used.	Yes

Table 88 (cont'd): Proposed Mitigation Actions - Town of Pepperell

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Prevention	Modify local wetlands bylaw to better address hazard mitigation.	Town Conservation Commission	Flooding	Short-term	Town Conservation Agent, working with the Conservation Commission, is responsible for this item, utilizing local general funds.	Yes
Prevention	Undertake an assessment of what is needed to eliminate the flooding problem at Canal and Main Streets.	Town Engineer and MassDOT. MassDOT owns the bridge and adjoining road on Main Street at the Nashua River. No work has commenced to date.	Flooding, hurricane	Short term	Town Engineer, working with MassDOT, is responsible for this item. Work will be performed through the DPW Department budget.	Yes
Prevention	Participate in DCR's Fire Wise Program for the forested sections of town.	Fire Department and DCR	Wildfire	Ongoing	Fire Chief to work with DCR on the Fire Wise Program. No additional town funds needed.	Yes
Public education	Increase public awareness of the dangers of extreme temperatures and outline locations where vulnerable populations (elderly, homeless and those with health issues) can have access to air conditioning or shelter from the cold	Town Emergency Manager	Extreme Temperatures	Short-term	Emergency manager will implement this recommendatio n using general funds.	Public education

Table 88 (cont'd): Proposed Mitigation Actions - Town of Pepperell

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Public education	Distribute educational information to residents and businesses on protecting life and property from severe winter storm events	Emergency Manager	Winter storms – snowstorms, blizzards, ice storms	Short-term	This task will be implemented by the Emergency Manager using general funds	No
Emergency Services Protection	Ensure that administrators of schools, businesses, medical facilities, and the mobile home park have a shelter plan in the event of a tornado warning	Emergency Manager and public safety	Tornado	Long-term	This task will completed by the Emergency Manager and public safety personnel using general funds	No
Emergency Services	Study regional consolidation of 911 dispatch services by establishing an RECC	Town public safety officials, NMCOG, and the State 911 Department and the municipalities	All Hazards	Short-term	Public safety officials to work with NMCOG through 911 Work Group using State 911 Department funding.	No, this is a new action item.
Property Protection	Develop a mitigation plan for protecting properties on Yale Road from repetitive flooding.	Town Emergency manager, town engineer, conservation commission and area homeowners	Flooding, hurricanes	Short-term.	Town Engineer and the emergency manager are responsible for this item, utilizing local general funds.	Yes

Table 88 (cont'd): Proposed Mitigation Actions - Town of Pepperell

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Prevention	Incorporate hazard mitigation into the town's Master Plan and Open Space Plan updates.	Town Planning Board and Conservation Commission. The Open Space Plan be updated in 2015	All hazards	Long-term	Utilizing general funds, the Planning Administrator and Conservation Agent will oversee this task.	No, this is a new action item.
Prevention	Delineate the limits of the ROW on Brookline Street and Lowell Road and develop a plan to remove pine trees that shade the road to decrease icing problems in the winter.	Town DPW	Winter storm	Short- term	DPW Director is responsible for this item, utilizing local general funds.	Yes
Prevention	Study the establishment of a mutual aid agreement with neighboring communities to administer NFIP following a major storm event.	Town Emergency Manager and building inspector	All Hazards	Long-term	Town Emergency Manager, utilizing general funds, will oversee this project.	No, this is a new action item
Prevention	Revise subdivision regulations, and erosion control regulations to improve floodplain management as needed.	Town Planning Board, and Conservation Commission.	Flooding	Annual	Town Planning Administrator and Conservation Agent will address this issue utilizing general funds.	No, this is a new action item

Table 88 (cont'd): Proposed Mitigation Actions - Town of Pepperell

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Property Protection	Inspect public buildings to evaluate the capacity to withstand snow loads and prevent roof collapse. Develop plans to clear roofs of excessive snow accumulations to prevent collapse.	Building inspector and Emergency Manager	Severe winter storm/ snowstorm, blizzard	Short-term	This task will be completed by the Building inspector and Emergency Manager using local operating funds	No
Emergency Services	Identify locations for snow storage farms for utilization in severe winters with heavy snowfall	Highway Department	Severe winter storm/snowstorm, blizzard	Short-term	This task will be implemented by the highway department using local operating funds	No
Property protection	Evaluate public buildings and critical facilities for the potential to withstand high winds	Building inspector and emergency manager	Hurricane, tornado, blizzard	Long-term	This task will be implemented by the Building Inspector and Emergency manager using local general funds	No
Emergency services	Assess bridges and roadways to ascertain their capability to support fire apparatus and develop alternative routing plans where deficiencies are noted	Fire Department and Highway Department	Structural fire/ wildfire	Long-term	This task to be undertaken by the Fire Department and Highway Department	No

Table 88 (cont'd): Proposed Mitigation Actions - Town of Pepperell

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Property Protection	Develop an inventory of public buildings that do not currently meet seismic standards	Building inspector and emergency manager	Earthquake	Long-term	This task is to undertaken by the Building Inspector and emergency manager using general funds	No
Public education	Provide information to homeowners on how to protect their property from brush fire or wildfire during times of drought	Fire Department	Drought, Brush fire/wildfire	Short-term	This task is to be undertaken by the Fire Department using general funds	No

Table 89: Proposed Mitigation Actions - Town of Tewksbury

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Structural project/ Natural Resource Protection	Stabilize stream bed at Bridge Street culvert.	Town DPW. No work has commenced.	Flooding, hurricane	Short-term.	DPW Director will oversee project using MassDOT-Chapter 90.	Yes
Structural project	Elevate Bridge and South Streets to address flooding issues.	Town DPW. No work has commenced to date.	Flooding, hurricane	Short-term.	DPW Director will pursue funding through HMGP program	Yes

Table 89 (cont'd): Proposed Mitigation Actions - Town of Tewksbury

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Structural project	Construct drainage improvements on Main Street (Route 38) at the I-495 ramps.	DPW Director will work with MassDOT as it owns this location	Flooding, hurricane	Long-term.	DPW Director will pursue MassDOT funding to address this area, given that MassDOT owns this location.	Yes
Emergency Services	Purchase emergency generators for schools.	Town - School Department	All Hazards	Long-term; will be implemented as schools are renovated.	School Department will pursue state funding through the SBAB.	Yes
Structural Project	Construct culvert improvements on Pinnacle Street.	Town DPW. No work has commenced on this project to date	Flooding, hurricane	Short-term	DPW Director is responsible for this item, utilizing local general funds or competitive state or federal grant funds.	No, this is a new action item
Emergency Services	Construct boat ramp to the Merrimack River at the end of Merrimack Drive to respond to emergencies.	Fire Department/DPW	Flooding and other emergencies	Short-term	Fire Chief and DPW Director will address this item, utilizing local general funds.	No, this is a new action item
Structural project	Replace Brown Street bridge and raise approach ramps.	Town DPW and MassDOT. Project is under design.	Earthquakes, flooding	Long-term	DPW Director will work with MassDOT to address this item, utilizing federal and state funds.	Yes

Table 89 (cont'd): Proposed Mitigation Actions - Town of Tewksbury

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Prevention	Purchase large back-up pump and generator for East Street pump station.	DPW	All hazards	Long-term	DPW Director is responsible for this item, utilizing federal, state and local general funds.	No, this is a new action item
Structural project/ Natural Resource Protection	Install culvert improvements and stabilize slopes at Trull Brook on River Road.	DPW. Improvements are under design	Flooding	Short- term	Hazard Mitigation Grant funds. DPW Director will work with MEMA and FEMA to address this item	Yes, project description has been revised to provide clarity
Structural project	Flood proof Shawsheen Street at Heath Brook Road.	Town DPW	Flooding, hurricane	Long-term	State and Federal Hazard Mitigation Grant funds DPW Director will work with MEMA and FEMA to address this item.	Yes
Structural project	Replace Mill Street Bridge.	Town DPW	Earthquakes, flooding	Long-term	Town DPW Director will work with MassDOT to address this item, utilizing federal and state funds.	Yes

Table 89 (cont'd): Proposed Mitigation Actions - Town of Tewksbury

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Structural Project	Flood proof sewer manholes and sewer collection system.	Town DPW	Flooding, hurricanes	Short-term	DPW Director to complete this item, utilizing federal and state funds including HMGP.	No, this is a new action item
Structural project	Install emergency back-up generators for sewer pump stations.	Town DPW	Flooding	Short-term	DPW Director to complete this item, utilizing federal and state funds.	Yes, however the timeframe has been adjusted
Prevention/ Public Outreach and Awareness	Incorporate hazard mitigation into the Master Plan process.	Town Community Development Director. Work has commenced on the Master Plan update.	All hazards	Short-term	Utilizing general funds, the Community Development Director will complete this task using CPA funds and general funds.	No, this is a new action item
Emergency Services	Study regional consolidation of 911 dispatch services by establishing an RECC	Town public safety officials, NMCOG and the State 911 Department	All Hazards	Short-term	Public safety officials to work with NMCOG through 911 Work Group. State 911 Department funding will be utilized.	No, this is a new action item.

Table 89 (cont'd): Proposed Mitigation Actions - Town of Tewksbury

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Prevention	Study the establishment of a mutual aid agreement with neighboring communities to administer NFIP following a major storm event.	Town Emergency Manager, building inspector and Board of Selectmen	All Hazards	Long-term	Town Emergency Manager, utilizing general funds, will implement this project. Board of Selectmen must approve agreement and building inspector implements NFIP.	No, this is a new action item
Prevention	Revise subdivision regulations, erosion control regulations, and Board of Health regulations to improve floodplain management as needed.	Town Planning Board, Conservation Commission and Board of Health	Flooding	Annual	Town Community Development Director, Conservation Agent and Board of Health will address this issue utilizing general funds.	No, this is a new action item
Emergency Services Protection	Ensure that administrators of schools, businesses, medical facilities, and the mobile home park have a shelter plan in the event of a tornado warning	Emergency Manager and public safety	Tornado	Long-term	This task will completed by the Emergency Manager and public safety personnel using general funds	No

Table 89 (cont'd): Proposed Mitigation Actions - Town of Tewksbury

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Structural project	Address drainage issues on East Street by upgrading and improving infrastructure.	Town DPW	Flooding, hurricane	Long-term	DPW Director to complete this item, utilizing Chapter 90 funds.	No, this is a new action item
Emergency Services	Purchase GPS Units for DPW vehicles and new messaging board system for emergency management.	Town DPW and Emergency manager	All hazards	Short-term	DPW Director to work with Emergency Manager to complete this item, utilizing federal and state funds.	The 2006 Plan action item has been modified to include the messaging board component
Emergency Services	Install an emergency generator at the Water Treatment Plant.	Town DPW	All hazards	Short-term	DPW Director to complete this task utilizing federal and state competitive grant funds or local funds.	No, this is a new action item
Emergency Services	Install emergency generators for Senior Housing.	Town Emergency Manager and Housing Authority	All hazards	Short-term	DPW Director and Housing Authority Director will work together to complete this item with HMGP or DHCD funds	No, this is a new action item

Table 89 (cont'd): Proposed Mitigation Actions - Town of Tewksbury

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Prevention	Develop dam maintenance plan outlining future responsibilities for inspection, maintenance, and repair of all dams and related structures.	Town DPW, DCR and private dam owners	Earthquakes and flooding	Short-term	Public Works Director to work with DCR and dam owners. Town general funds to be used.	Yes
Public education	Increase public awareness of the dangers of extreme temperatures and outline locations where vulnerable populations (elderly, homeless and those with health issues) can have access to air conditioning or shelter from the cold	Town Emergency Manager	Extreme Temperatures	Short-term	Emergency manager will implement this task using general funds	Public education
Public education	Distribute educational information to residents and businesses on protecting life and property from severe winter storm events	Emergency Manager	Winter storms – snowstorms, blizzards, ice storms	Short-term	This task will be implemented by the Emergency Manager using general funds	No
Property Protection	Inspect public buildings to evaluate the capacity to withstand snow loads and prevent roof collapse. Develop plans to clear roofs of excessive snow accumulations to prevent collapse.	Building inspector and Emergency Manager	Severe winter storm/ snowstorm, blizzard	Short-term	This task will be completed by the Building inspector and Emergency Manager using local operating funds	No

Table 89 (cont'd): Proposed Mitigation Actions - Town of Tewksbury

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Emergency Services	Identify locations for snow storage farms for utilization in severe winters with heavy snowfall	Highway Department	Severe winter storm/snowstorm, blizzard	Short-term	This task will be implemented by the highway department using local operating funds	No
Property protection	Evaluate public buildings and critical facilities for the potential to withstand high winds	Building inspector and emergency manager	Hurricane, tornado, blizzard	Long-term	This task will be implemented by the Building Inspector and Emergency manager using local general funds	No
Emergency services	Assess bridges and roadways to ascertain their capability to support fire apparatus and develop alternative routing plans where deficiencies are noted	Fire Department and Highway Department	Structural fire/ wildfire	Long-term	This task to be undertaken by the Fire Department and Highway Department	No
Property Protection	Develop an inventory of public buildings that do not currently meet seismic standards	Building inspector and emergency manager	Earthquake	Long-term	This task is to undertaken by the Building Inspector and emergency manager using general funds	No

Table 89 (cont'd): Proposed Mitigation Actions - Town of Tewksbury

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Public education	Provide information to homeowners on how to protect their property from brush fire or wildfire during times of drought	Fire Department	Drought, Brush fire/wildfire	Short-term	This task is to be undertaken by the Fire Department using general funds	No

Table 90: Proposed Mitigation Actions: Town of Tyngsborough

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Structural project	Work with MassDOT to mitigate flooding problems along Pawtucket Blvd. (Route 113)	Town Highway Department, MassDOT. Improvements to the stormwater system are currently being designed by MassDOT, as it owns the roadway.	Flooding, hurricanes	Short-term	Highway Department to work with MassDOT to complete this item, utilizing federal and state transportation funds.	Yes
Prevention	Work with DCR Office of Dam Safety to ensure that the inspections of all dams are current.	Assistant Town Administrator, DCR Office of Dam Safety, and dam owners.	Earthquakes and Flooding	Short-term	Assistant Town Administrator will work with DCR and dam owners to ensure timely inspections. Town operating funds to be used. Private dam owner responsible for funding inspections.	Yes
Prevention	Participate in NFIP Training offered by the MEMA and FEMA to address flood hazard planning and management.	Assistant Town Administrator, emergency manager, building inspector, MEMA, FEMA	Flooding	Short-term	Assistant Town Administrator will ensure training of building inspector and Emergency Manager using general funds	No, this is a new action item

Table 90 (cont'd): Proposed Mitigation Actions: Town of Tyngsborough

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Prevention	Require use of elevation certificate.	Town building inspector	Flooding	Short-term	Town Building Inspector to complete this item utilizing local general funds.	No, this is a new action item
Prevention	Incorporate Hazard Mitigation planning into subdivision regulations, Master Plan and Open Space and Recreation Plan Update.	Town Planning Board and Conservation Commission	All hazards	Short-term	Planning Board and Conservation Agent will address this issue utilizing general funds.	Yes, description was modified to include the Master Plan
Prevention	Correct flooding problems on the access road to the elementary school through culvert installation.	Town School Department	Flooding, hurricanes	Short term	School Department and Assistant Town Administrator to work with MEMA and FEMA to complete this item utilizing HMGP funds.	No, this is a new action item
Prevention	Correct flooding problems on Sherburne Avenue and on Westford Road.	Town Highway Department	Flooding, hurricanes	Long-term	Highway Department to undertake this project using Chapter 90 funds or competitive grant monies.	No, this is a new action item
Public education	Distribute educational information to residents and businesses on protecting life and property from severe winter storm events	Emergency Manager	Winter storms – snowstorms, blizzards, ice storms	Short-term	This task will be implemented by the Emergency Manager using general funds	No

Table 90 (cont'd): Proposed Mitigation Actions: Town of Tyngsborough

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Public education	Increase public awareness of the dangers of extreme temperatures and outline locations where vulnerable populations (elderly, homeless and those with health issues) can have access to air conditioning or shelter from the cold	Town Emergency Manager	Extreme Temperatures	Short-term	Emergency manager will implement this recommendation using general funds.	Public education
Emergency Services Protection	Ensure that administrators of schools, businesses, medical facilities, and municipal buildings have a shelter plan in the event of a tornado warning	Emergency Manager and public safety	Tornado	Long-term	This task will completed by the Emergency Manager and public safety personnel using general funds	No
Prevention	Address areas of severe icing on roadways by delineating the limits of the ROW for tree removal to allow greater solar access	Town Highway Department	Winter storms	Long-term	Town Highway Department to complete this item, utilizing local general funds.	No, this is a new action item
Prevention	Work with cable and communication companies and the electric utility to develop a tree trimming program for above ground utility lines.	Town Highway Department and utilities	Hurricanes, tornadoes, thunderstorms, winter storms	Long-term	Highway Department to work with utilities to complete this item utilizing local general funds and funding from the utility companies.	No, this is a new action item

Table 90 (cont'd): Proposed Mitigation Actions: Town of Tyngsborough

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Property Protection	Inspect public buildings to evaluate the capacity to withstand snow loads and prevent roof collapse. Develop plans to clear roofs of excessive snow accumulations to prevent collapse.	Building inspector and Emergency Manager	Severe winter storm/ snowstorm, blizzard	Short-term	This task will be completed by the Building inspector and Emergency Manager using local operating funds	No
Emergency Services	Identify locations for snow storage farms for utilization in severe winters with heavy snowfall	Highway Department	Severe winter storm/snowstorm, blizzard	Short-term	This task will be implemented by the highway department using local operating funds	No
Property protection	Evaluate public buildings and critical facilities for the potential to withstand high winds	Building inspector and emergency manager	Hurricane, tornado, blizzard	Long-term	This task will be implemented by the Building Inspector and Emergency manager using local general funds	No
Emergency services	Assess bridges and roadways to ascertain their capability to support fire apparatus and develop alternative routing plans where deficiencies are noted	Fire Department and Highway Department	Structural fire/ wildfire	Long-term	This task to be undertaken by the Fire Department and Highway Department	No

Table 90 (cont'd): Proposed Mitigation Actions: Town of Tyngsborough

Category Of Action	Description Of Action	Implementation Responsibility and Status	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Property Protection	Develop an inventory of public buildings that do not currently meet seismic standards	Building inspector and emergency manager	Earthquake	Long-term	This task is to undertaken by the Building Inspector and emergency manager using general funds	No
Public education	Provide information to homeowners on how to protect their property from brush fire or wildfire during times of drought	Fire Department	Drought, Brush fire/wildfire	Short-term	This task is to be undertaken by the Fire Department using general funds	No

Table 91: Proposed Mitigation Actions - Town of Westford

Category Of Action	Description Of Action	Implementation Responsibility	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Prevention /Public Outreach and Awareness	Implement Master Plan recommendations advocating public education on hazard mitigation and refinement of regulatory measures.	Planning Board, Conservation Commission and emergency managers	All Hazards	Short-term	Director of Land Use and Town Planner to address this task utilizing local general funds.	No, this is a new action item
Prevention/ Natural Resource Protection	Provide training to Town staff and board members relative to stormwater regulations.	Engineering Department, Highway Department, Planning Board and Conservation Commission	Flooding	Annual	Engineering Department, working with DEP and NMCOG, will address this task utilizing town operating funds	Yes

Table 91 (cont'd): Proposed Mitigation Actions - Town of Westford

Category Of Action	Description Of Action	Implementation Responsibility	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Prevention	Participate in updates to the regional hazard mitigation plan and assist in developing the local annex.	Town Engineering Department, Emergency Managers, Planning staff and NMCOG	All Hazards	Long-term	Emergency Managers, working with NMCOG, town departments and MEMA will complete this task utilizing local general funds and HMGP/PDM funding.	Yes, however the description has been amended for clarity
Prevention/ Property Protection	Update Building Department policies and practices to include further consideration of natural hazards, such as wind, snow and seismic loads.	Building Department	All Hazards	Short-term	Building inspector to complete this project utilizing local general funds.	Yes, but description has been amended for clarity
Prevention/ Property Protection	Complete town-wide Stormwater Master Planning	Engineering Department and Stormwater Master Plan Committee. Town has hired a consultant to prepare the Plan	Flooding	Short-term	Engineering Department will oversee this project using general funds.	No
Prevention/ Natural Resource Protection	Adopt stormwater regulations to implement stormwater by-law.	Planning Board and Conservation Commission. The town has retained a consultant to update its stormwater regulations.	Flooding	Short-term	Planning Board and Conservation Commission to address this item using local general funds.	Yes
Prevention	Conduct hydrological/ drainage studies at problem locations throughout Town.	Engineering/Public Works Department	Flooding	Short-term	Engineering/Public Works Department to address this issue utilizing local general funds.	Yes
Public Outreach and Awareness	Conduct outreach campaign to encourage residents to purchase flood insurance.	Emergency Management and Building Departments	Flooding	Annual	Town Emergency Managers and building department, will implement this project using general funds.	Yes

Table 91 (cont'd): Proposed Mitigation Actions - Town of Westford

Category Of Action	Description Of Action	Implementation Responsibility	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Public Outreach and Awareness	Conduct an ongoing hazard mitigation community outreach program for residents, through the schools and at town events.	Emergency Management, School Department, Conservation Commission, Board of Health	All hazards	Short-term	Town Emergency Managers, working with the School Department, Conservation Commission and Board of Health will implement this project utilizing general funds.	Yes
Public Outreach and Awareness	Utilize internet based technology and cable TV to better distribute information concerning natural hazards.	Town Emergency managers, IT staff and local cable media	All hazards	Short-term	Town Emergency Manager, utilizing general funds, will implement this project.	Yes
Property Protection	Flood-proof electric transmission lines and substations in flood-prone areas of Town.	National Grid at the request of the Town Emergency managers and Board of Selectmen	Flooding, hurricane	Short-term	Work to be completed by National Grid using utility funds. Effort to be coordinated by the Emergency Managers using local general funds.	Yes
Property Protection	Regularly inspect and maintain all Town-owned dams	Engineering Department and DCR. The town has completed improvements to its dams since the 2006 Plan was adopted.	Earthquakes and flooding	Annual	Engineering Department to work with DCR, utilizing local general funds or CPA monies.	Yes
Property Protection	Participate in DCR's Fire Wise program to reduce wildfire risk.	Fire Department	Wildfire, urban fire	Annual	Fire Chief to work with DCR on the Fire Wise Program. No additional funds needed.	Yes
Structural Projects	Replace undersized culverts and drainage structures at problem locations, as described in earlier sections of this Plan	Highway/ Engineering Department, and MassDOT. Drainage problems have been addressed at numerous location since the completion of the 2006 Plan	Flooding/ hurricanes	Annual	Highway/Engineering Department, working with MassDOT, will complete this task using federal, state and local general funds. HMGP will be used at Route 40 and possibly other locations.	Yes
Emergency Services	Interconnect traffic signals and equip with advance vehicle detection (Opticom)	Highway Department, MassDOT	All Hazards	Short-term	Highway Department, working with MassDOT and the Police and Fire Chiefs, will address this task utilizing federal, state and local general funds.	Yes

Table 91 (cont'd): Proposed Mitigation Actions - Town of Westford

Category Of Action	Description Of Action	Implementation Responsibility	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Prevention	Incorporate disaster mitigation into the Open Space and Recreation Plan update process	Conservation Commission-the town's Open Space Plan currently addresses hazard mitigation	All Hazards	Long-term	Conservation Agent, working with the Conservation Commission, will address this issue utilizing CPA and general funds.	Yes
Prevention	Study the possibility of establishing a mutual aid agreement with neighboring communities to administer NFIP following a major storm event	Town Emergency Managers, building inspector and Board of Selectmen	All Hazards	Long-term	Emergency Manager, utilizing general funds, will implement this project. The agreement must be approved by the Board of Selectmen and the Building Inspector enforces NFIP.	No, this is a new action item
Public education	Increase public awareness of the dangers of extreme temperatures and outline locations were vulnerable populations (elderly and those with health issues) can have access to air conditioning or shelter from the cold	Town Emergency Manager	Extreme Temperatures	Short-term	Emergency manager will implement this recommendation using general funds.	Public education
Prevention	Revise subdivision regulations, erosion control regulations, and Board of Health regulations to improve floodplain management as needed	Town Planning Board, Conservation Commission and Board of Health	Flooding	Annual	Town Director of Land Use, Town Planner, Conservation Agent and Board of Health will address this task utilizing general funds.	No, this is a new action item

Table 91 (cont'd): Proposed Mitigation Actions - Town of Westford

Category Of Action	Description Of Action	Implementation Responsibility	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Public education	Distribute educational information to residents and businesses on protecting life and property from severe winter storm events	Emergency Manager	Winter storms – snowstorms, blizzards, ice storms	Short-term	This task will be implemented by the Emergency Manager using general funds	No
Emergency Services Protection	Ensure that administrators of schools, businesses, medical facilities, and municipal buildings have a shelter plan in the event of a tornado warning	Emergency Manager and public safety	Tornado	Long-term	This task will completed by the Emergency Manager and public safety personnel using general funds	No
Property Protection	Inspect public buildings to evaluate the capacity to withstand snow loads and prevent roof collapse. Develop plans to clear roofs of excessive snow accumulations to prevent collapse.	Building inspector and Emergency Manager	Severe winter storm/ snowstorm, blizzard	Short-term	This task will be completed by the Building inspector and Emergency Manager using local operating funds	No
Emergency Services	Identify locations for snow storage farms for utilization in severe winters with heavy snowfall	Highway Department	Severe winter storm/snowstorm, blizzard	Short-term	This task will be implemented by the highway department using local operating funds	No
Property protection	Evaluate public buildings and critical facilities for the potential to withstand high winds	Building inspector and emergency manager	Hurricane, tornado, blizzard	Long-term	This task will be implemented by the Building Inspector and Emergency manager using local general funds	No

Table 91 (cont'd): Proposed Mitigation Actions - Town of Westford

Category Of Action	Description Of Action	Implementation Responsibility	Hazard Addressed	Timeframe/ Priority	Resources/ Funding	Was the action included in the 2006 Plan?
Emergency services	Assess bridges and roadways to ascertain their capability to support fire apparatus and develop alternative routing plans where deficiencies are noted	Fire Department and Highway Department	Structural fire/ wildfire	Long-term	This task to be undertaken by the Fire Department and Highway Department	No
Property Protection	Develop an inventory of public buildings that do not currently meet seismic standards	Building inspector and emergency manager	Earthquake	Long-term	This task is to undertaken by the Building Inspector and emergency manager using general funds	No
Public education	Provide information to homeowners on how to protect their property from brush fire or wildfire during times of drought	Fire Department	Drought, Brush fire/wildfire	Short-term	This task is to be undertaken by the Fire Department using general funds	No

D. Mitigation Success Stories in the Northern Middlesex Region

Since completion of the 2006 Plan a number of mitigation projects have been designed and implemented. This section describes two of the most successful mitigation projects that have been completed over the past five years.

Dracut Sewer Lift Station

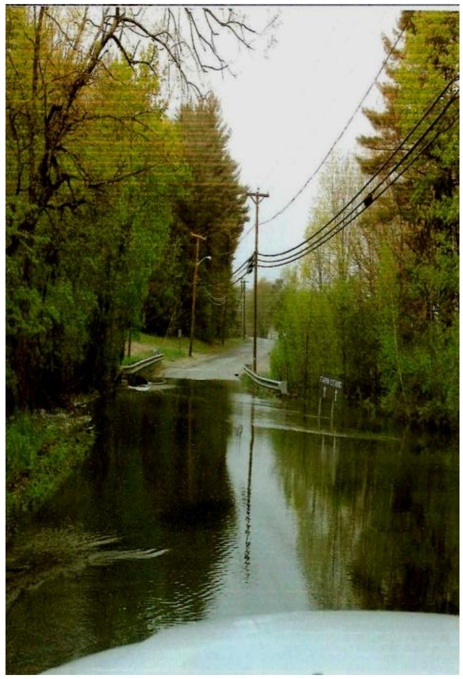
Concerned over ongoing flooding at the 150 Turtle Hill Road sewer lift station, the Town of Dracut applied for and received a grant through FEMA's Hazard Mitigation Grant Program. The lift station serves over 300 residences and was originally built ½ foot above base flood elevation. However, the lift station was threatened by flooding from Beaver Brook as the flood hazard appeared to have increased since the original Flood Insurance Study was published. If the pump were to sustain flooding the pump and electrical components would fail. The failure would cause sewage to back up into homes posing a significant public health threat.

The funding provided by FEMA allowed the town to build a 12-inch thick concrete wall surrounding the station. The wall is 10 feet high with 6'6" below grade and 3'6" above grade, to prevent floodwaters from damaging the electrical components. There is a 4-foot wide service opening to allow access to the station. The opening is closed with stop logs, already stored at the site, when the station is at risk of flooding. The $48,000 project was completed in November 2008.

East Street Culvert Improvements, Tewksbury

Flooding and closure of East Street just east of Tewksbury Town Center, had been an annual event. Over the past several decades, flooding along the Shawsheen River and its tributary, Strongwater Brook, has overtopped stream crossings on major streets in town. As a result, parts of the town were isolated, requiring traffic detours along alternate routes which quickly became congested, limiting access for emergency vehicles. To mitigate the extent and duration of disruptions caused by flooding, town officials proposed installing new, larger culverts at the East Street-Strongwater Brook crossing.

Using HMGP funds totaling $281,250 (the town provided $93,750 in matching funds), two new concrete box culverts (5' feet high x 10' wide) were installed, providing an opening four times larger than the old culverts. In addition, the roadway was elevated by three feet so that it is now higher than the 100-year flood elevation at the crossing. Because this section of Strongwater Brook lies within a wetland, drainage improvements had to be designed to accommodate issues related to wetland protection. The design incorporated maintenance of natural water levels and velocities, including fluctuations during periods of low flow, and the accommodation of high flood flows. This was accomplished by incorporating two features into the design and installation: (1) the bottoms of the culverts were set at one foot below the natural channel of the brook and then backfilled to establish a natural channel within the culverts; and (2) the culverts were sized so that during a flood, water would back up and be temporarily stored in the large wetland area on the upstream side of the roadway, allowing water to rise above the tops of the culverts yet not overtop East Street.



East Street/Strongwater Brook crossing before project completion

East Street/Strongwater Brook crossing after project completion

SECTION 9: PLAN ADOPTION AND MAINTENANCE

Under 44 CFR Part 201 mitigation plans must be sent to the State Hazard Mitigation Officer (SHMO) for initial review and coordination. The State then forwards the plan to FEMA for formal review and approval. The final draft is submitted to the State and FEMA prior to seeking formal adoption of the plan by the local communities and the NMCOG governing board. FEMA reviewers document their evaluation of the Plan using the Plan Review criteria. A copy of the Crosswalk provided for the 2006 Hazard Mitigation Plan is included in Appendix H.

Mitigation plans are approved when they receive a "satisfactory" for all requirements outlined under 44 CFR Section 201.6. Once a final plan is submitted, the FEMA Regional Office generally completes the review within 45 days. In the event that the plan is not approved, the FEMA Regional Office will provide comments on the areas that need improvement. FEMA will the complete review of the re-submittal within 45 days of receipt.

Once FEMA determines that the Plan is "approvable pending adoption", the local adoption process is initiated. The adoption of the Hazard Mitigation Plan update provides continued written guidance for all local governments within the region, and signifies that the plan's recommendations have been considered and approved in accordance with state and federal requirements. Copies of the Certificates of Adoption are provided in Appendix G for each community covered by the Plan.

The Disaster Mitigation Act of 2000 stipulates that regions and municipalities must not only develop a Regional Mitigation Plan, but also take steps to ensure that the plan is implemented, maintained and updated as needed. The following steps will be taken to maintain the plan in each community, assuming that funding is provided:

- Each community will monitor this plan by a combination of an annual meeting with the local team and by responsible department staff following up on specific projects. Within each municipality, an annual review of the plan by the hazard mitigation team will be conducted at one of the monthly interdepartmental meetings. At that time, the hazard mitigation team will review the hazard mitigation measures that have been implemented to date and determine if these measures have impacted the overall hazard. This review may include site visits to appropriate locations where measures have been implemented. Mitigation measures that have not been implemented will be reviewed to determine if they will still minimize natural hazards or if they are no longer a viable option. Additionally, the hazard mitigation team will determine if there are new options that should be included in an update of the plan. Within each community, the Emergency Manager will be responsible for overseeing and coordinating the update process, if needed. In addition to the Emergency Manager, the hazard mitigation team within each community is comprised of public safety officials, the chief administrative officer, planning staff, the conservation, engineering, public health departments and public works.

- The public will have opportunities to submit feedback and solicit comments from the municipality regarding the Plan and the mitigation projects. Residents and businesses will be notified when hazard mitigation issues are brought to the Board of Selectmen or City Council. Notification by each municipality will occur through the Lowell Sun, the local newspapers, the municipal website, the City Clerk or Town Clerk bulletin board, and local cable television community bulletin boards, and social media feeds, such as Facebook and Twitter.

- As a facilitator, NMCOG will meet with members of the regional Multiple Hazard Community Planning Team, local emergency managers, city/town planners, public works departments, city/town engineers, Conservation Commissions and Chief Administrative Officers on an annual basis to discuss each community's progress in implementing the local and regional Mitigation Plans;

- Should the Region or a municipality experience a significant disaster, the Multi-jurisdictional Mitigation Plan will be updated and revised to reflect the technical information gleaned from the event and to outline the mitigation needs that have stemmed from the disaster. Appropriate mitigation strategies will then be added to an amended Plan document; In addition, should Federal or State regulations and requirements change, the Regional and municipal Plans will be updated accordingly. In order for communities to qualify for mitigation funding, it is necessary that the Regional and local plans be amended to incorporate new mitigation projects as they are identified by the local communities;

- The ongoing monitoring and updates of this Plan will include public participation utilizing the media, the community bulletin board on the local cable channels, the municipal websites, and the NMCOG website to facilitate the public's involvement;

- Evaluation of the hazard mitigation plan in its entirety will be done on a 5-year basis in accordance with the Disaster Mitigation Act of 2000 or any significant natural hazard disaster. Any new problems that arise will be reviewed by the hazard mitigation team and incorporated into the hazard mitigation plan. The evaluation will include a review of the goals and objectives and a determination will be as to whether each still addresses current and expected conditions. Local fiscal issues, administrative challenges or major regulation changes will be discussed during the evaluation process. The plan will be updated with possible new mitigation measures and plans of action as determined from the review. This allows for updates to be made as each municipality or the region grows and changes. Within the municipalities, the Emergency Managers will oversee the hazard mitigation team's involvement in the review and updating process; and

- The Northern Middlesex Council of Governments intends to update this multi-jurisdictional plan five years from the date of approval, as resources allow. The next update will be completed in 2020. The update will focus on the successes and failures of the current plan as documented through surveys, meetings and reports from the local communities. Any new information, such as new or changing hazard conditions or vulnerability assessments, will be incorporated into the update The Plan revision will follow the same planning and outreach process that was utilized to develop this plan.

(Please refer to Section 1.) The latest guidance available from FEMA and MEMA will be consulted to ensure that the process meets all state and federal requirements. Members of the community will be invited to provide input into the plan revisions and stakeholders will be kept apprised of the revision process. The public process will be tailored to fit the needs of each community within the region. The residents and businesses in each community will be notified when hazard mitigation issues are brought to the Board of Selectmen or City Council in each community. Such public involvement opportunities will be noticed in the Lowell Sun and posted in the City/Town Clerk office in each community. All public meetings will conform with the Massachusetts Open Meeting Law. The official update process will commence 18 months prior to this plan's expiration date.

SECTION 10: PLAN IMPLEMENTATION

The implementation of the Regional Mitigation Plan will take place at the State, Regional and local levels of government. Local governments play a pivotal role in hazard mitigation, particularly in floodplain management. The municipal Planning Boards, Conservation Commissions, and Boards of Health have legal responsibilities to implement local floodplain bylaws, floodplain guidelines incorporated into the Wetlands Protection Act, the Rivers Protection Act and Title 5 of the State Environmental Code (wastewater disposal). Local Building Departments enforce the National Flood Insurance Program (NFIP) construction standards incorporated into the Massachusetts State Building Code. Local public works and highway departments are responsible for local roadways, and municipal drainage, sewer and stormwater management systems. Each municipality has an emergency manager who is responsible for local preparedness, mitigation response and recovery for natural and manmade hazards. Table 92 below provides a summary of local boards and departments and their corresponding roles in implementing the action items contained in the Regional and Local Mitigation Plans.

The incorporation of the hazard mitigation actions outlined in this Plan Update within other local and regional planning documents and procedures is highly encouraged. Such documents include community master plans, capital improvement plans, Open Space and Recreation Plans, stormwater plans and regulations, emergency management plans, the University of Massachusetts Lowell Hazard Mitigation Plan, zoning bylaws, subdivision regulations, and local wetland bylaws and ordinances. Elected officials should be directly involved in the implementation of the updated Plan, as they set policy and can provide direction in establishing timeframes, assigning implementation responsibility, and providing implementation funding.

Table 92: Role of Local Boards, Departments and Committees in Plan Implementation

Department, Board or Committee	Function	Effect on Loss Reduction
Building Department/Inspector	The building inspector enforces the Massachusetts State Building Code that incorporates NFIP construction standards. The building inspector also enforces locally adopted bylaws. The state building code also contains sections on wind, snow, structural loads and seismic retrofitting.	Insures that NFIP standards and other mitigation standards are uniformly applied throughout the region
Public Works Department and/or City/Town Engineer	The Public Works Department and/or engineer are primarily responsible for municipal drainage and stormwater management issues, taking the lead in insuring compliance with EPA Phase II Stormwater Regulations.	Ongoing maintenance and upgrading of local stormwater systems is crucial to reducing and managing flood risks.

Table 92 (Cont'd): Role of Local Boards, Departments and Committees in Plan Implementation

Department, Board or Committee	Function	Effect on Loss
Conservation Commission	The Conservation Commission is responsible for implementing the Rivers Protection Act of 1996 (MGL Chapter 258, 310 CMR 10.58), and the Wetlands Protection At (MGL Chapter 131, Section 40, 310 CMR 10.00). The Conservation Commission reviews, approves or denies applications for projects in the 100-year floodplain, in the floodplain of a small water body not covered by a FEMA study, within 100 feet of any wetland or 200 feet of any river or stream (except in the case of Lowell, where it is within 25 feet of any river or stream).	These regulations contain performance standards which address flood control and storm damage prevention.
Planning Board and Planning Department	The Planning Board has authority under MGL Chapter 41, and implements local subdivision regulations. The Planning Board ensures that new development incorporates state and federal stormwater management "best management practices". In most communities the Planning Board is responsible for maintaining local floodplain bylaws and ordinances.	In many communities the Planning Department coordinates the hazard mitigation planning process and the implementation of hazard mitigation plans.
Board of Health	The Board of Health implements the State Environmental Code, Title 5, and 310 CMR 15: Minimum Requirements for the Subsurface Disposal of Sanitary Sewage. Some communities opt to adopt local board of health requirements that are more stringent than the state requirements.	Title 5 protects public health and mitigates losses due to adverse effects of improper sewage treatment in high hazard areas. The Board is also involved in issues related to water quality and infectious diseases following a disaster.
Board of Selectmen or City Council	The City of Lowell is governed by a City Council, and the Towns by a Board of Selectmen.	The City Council or Board of Selectmen must adopt the local Regional Mitigation Plan. In addition, their approval is necessary for hazard mitigation grant applications and potential projects.
Emergency Management Department	Each community has an emergency manager who is responsible for local response and recovery, as well as mutual aid.	Emergency managers play a primary role in the development of the Comprehensive Emergency Management Plan (CEMP), as well as in other plans required by MEMA and FEMA.

SECTION 11: FUNDING SOURCES

Appropriate action is needed to ensure that financial resources are available to implement hazard mitigation projects. Such projects need to be included in capital improvement programs at the state and local levels. Federal funding programs are available to qualifying municipalities. The availability of current federal funding sources changes regularly and is dependent upon Congress' ongoing budget appropriations process. In 2003, the federal government established two comprehensive websites that track available funding from all the federal agencies at www.fedgrants.gov or www.grants.gov. In addition, it may also be helpful to check current federal appropriations from Congress through the Federal Register at www.thomas.loc.

The following table provides a summary of FEMA programs which fund hazard mitigation projects and activities. These programs are the primary source of federal hazard mitigation funding in Massachusetts:

Table 93: FEMA Hazard Mitigation Funding Programs

Program	Type of Assistance	Availability	Managing Agency	Funding Source
National Flood Insurance Program (NFIP)	Flood Insurance	Any time (pre- and post- disaster)	DCR Flood Hazard Management Program	Property Owner, Federal Emergency Management Agency
Severe Repetitive Loss (SRL) (Part of the NFIP)	Grants to state emergency management offices to reduce damage to insured severe RLPs	Varies	MEMA	Up to 90% FEMA/ 10% state government
Repetitive Flood Claims Program (RFC) (Part of the NFIP)	Grants to states and municipalities to reduce damage to insured RLPs	Any time	FEMA	100% FEMA
Community Rating System (CRS) (Part of the NFIP)	Disaster Insurance Discounts	Any time (pre and post disaster)	DCR Flood Hazard Management Program	Property Owner, Federal Emergency Management Agency
Flood Mitigation Assistance (FMA) Program	Cost share grants for pre-disaster planning and projects	Annual pre-disaster grant program	DCR & MEMA	75% FEMA/25% local government or organization
Hazard Mitigation Grant Program (HMGP)	Post-disaster Cost-Share Grants	Post disaster program	DCR & MEMA	75% FEMA/25% local government or organization
Pre-Disaster Mitigation Program	National, competitive grant program for multiple hazard mitigation projects and "all hazards"	Annual, pre-disaster mitigation program	DCR & MEMA	75% FEMA/25% local government or organization
Small Business Administration (SBA) Mitigation Loans	Pre- and Post- disaster loans to qualified businesses	Ongoing	MEMA	Small Business Administration
Public Assistance Program	Post-disaster aid to state and local governments	Post- Disaster	MEMA	FEMA

The Federal Emergency Management Agency (FEMA), which is part of the Department of Homeland Security, administers the National Flood Insurance Program, the Community Rating System, the Flood Mitigation Assistance Program (FMA)., the Hazard Mitigation Grant Program (HMGP) and the Pre-Disaster Mitigation Program (PDM). All of these programs are administered in coordination with DCR and MEMA. FEMA also prepares and revises flood insurance studies and maps as well as information on past and current acquisition, relocation and retrofitting programs. The Mitigation Division provides expertise in other natural and technological hazards, including hurricanes, earthquakes and hazardous materials, to state and local government agencies.

Immediately following a Presidential declaration, FEMA's Response and Recovery Division works closely with state agencies, especially MEMA, in assisting in the short-term and long-term recovery effort. FEMA assists disaster-affected communities through emergency funding programs, such as Infrastructure Support and Human Services. In coordination with its Mitigation Division, Response and Recovery distributes information on hazard mitigation methods and acquisition/relocation initiatives as well as coordinating HMGP grants for mitigation projects to protect eligible damaged public and private nonprofit facilities through the Public Assistance Program. In addition to these programs, FEMA also provides disaster recovery and hazard mitigation training at its Emergency Management Institute in Emmitsburg, Maryland.

For the latest information on these funding programs, go to FEMA's website at www.fema.gov. More detailed information regarding the mitigation funding options is provided in the following sections.

NATIONAL FLOOD INSURANCE PROGRAM (NFIP)

The National Flood Insurance Program (NFIP), established by Congress in 1968, provides flood insurance to property owners in participating communities. This program is a direct agreement between the federal government and the local community that flood insurance will be made available to residents in exchange for community compliance with minimum floodplain management requirements. Since homeowners' insurance does not cover flooding, a community's participation in the NFIP is vital to protecting property in the floodplain, as well as ensuring that federally backed mortgages and loans can be used to finance property within the floodplain.

Pursuant to the Flood Disaster Protection Act of 1973, any federal financial assistance related to new construction or substantial improvements (greater than 50% of a structure's market value) of existing structures located in the 100-year floodplain is contingent on the purchase of flood insurance. Such federal assistance includes not only direct aid from agencies, but also from federally insured institutions. Thus, in order for property owners to be eligible for purchasing flood insurance, their respective community must be participating in the NFIP and in compliance with the NFIP.

Communities participating in the NFIP must:

- Adopt the Flood Insurance Rate Maps as an overlay regulatory district;

- Require that all new construction or substantial improvement to existing structures in the flood hazard area will be elevated; and
- Require design techniques to minimize flood damage for structures being built in high hazard areas, such as floodways or velocity zones.

The NFIP standards are contained in the Massachusetts State Building Code (Section 3107), which is implemented at the local level by municipal building inspectors. In Massachusetts, 344 out of 351, or 98%, of Massachusetts municipalities participate in the NFIP.

SEVERE REPETITIVE LOSS PROGRAM (SRL)

The Severe Repetitive Loss Program was authorized by the Bunning-Beruter-Blumaneauer Flood Insurance Reform Act of 2004 with amended the National Flood Insurance Act of 1968 to provide funding to reduce or eliminate the long-term risk of flood damage to severe repetitive loss structures.

MEMA must apply for these funds but may work with other state agencies or local governments. Priority is given to programs that will have the greatest cost-benefit ratio in keeping with the purpose of the program. Grants may be used for acquisition, demolition and relocation but cannot be used for maintenance or repair.

Funds are allocated to the state based on the percentage of validated SRL properties and may be up to 90 percent federal and 10 percent local.

REPETITIVE FLOOD CLAIMS PROGRAM (RFC)

The Repetitive Flood Claims Program was authorized by the Bunning-Beruter-Blumaneauer Flood Insurance Reform Act of 2004 with amended the National Flood Insurance Act of 1968 to provide funding to reduce risk of flood damage to repetitive loss structures.

The program is 100 percent federal funded and the applicant must demonstrate that the proposed activities cannot be funded under the Flood Assistance Program. (See below.)

COMMUNITY RATING SYSTEM (CRS)

A voluntary initiative of the NFIP, the Community Rating Systems (CRS) encourages communities to undertake activities that exceed the minimum NFIP floodplain management standards. Communities participating in CRS can reduce flood insurance premiums paid by policyholders in that community by performing such activities as: maintaining records of floodplain development, publicizing the flood hazard, improving flood data, and maintaining open space. Communities can gain additional credit under CRS by developing a flood mitigation plan.

FLOOD HAZARD MITIGATION PROGRAM (FMA)

Authorized by the National Flood Insurance Reform Act of 1994, the Flood Mitigation Assistance (FMA) program makes cost-share grants available for flood mitigation planning and projects, such as property acquisition, relocation of residents living in floodplains, and retrofitting of existing structures within a floodplain. Flood hazard mitigation plans, approved by the state and FEMA, are a pre-requisite for receiving FMA project grants. Communities contribute a minimum of 25% of the cost for the planning and project grants with an FMA match of up to 75%.

HAZARD MITIGATION GRANT PROGRAM (HMGP)

Established pursuant to Section 404 of the Stafford Disaster Relief and Emergency Relief Act (PL 100-707), this program provides matching grants (75% Federal, 25% Local) for FEMA-approved hazard mitigation projects following a federally declared disaster. These grants are provided on a competitive basis to state, local and tribal governments as well as non-profit organizations. The grants are specifically directed toward reducing future hazard losses, and can be used for projects protecting property and other resources against the damaging effects of floods, hurricanes, earthquakes, high winds, and other natural hazards. HMGP in Massachusetts encourages non-structural hazard mitigation measures, such as:

- The acquisition of damaged structures and deeding the land to a community for open space or recreational use;
- Relocating damaged or flood prone structures out of a high hazard area; and
- Retrofitting properties to resist the damaging effects of natural disasters. Retrofitting can include wet- or dry-flood proofing, elevation of the structure above flood level, elevation of utilities, or proper anchoring of the structure.

Proposals for funding are submitted for review by Massachusetts' Interagency Hazard Mitigation Committee with final approval given by the Commissioner of the DCR, the Director of MEMA and FEMA's Region I office.

PRE-DISASTER MITIGATION PROGRAM

The Pre-Disaster Mitigation Program (PDM) was authorized by §203 of the Robert T. Stafford Disaster Assistance and Emergency Relief Act (Stafford Act), 42 USC, as amended by §102 of the Disaster Mitigation Act of 2000. Funding for the program is provided through the National Regional Mitigation Fund to assist States and local governments (to include Indian Tribal governments) in implementing cost-effective hazard mitigation activities that complement a comprehensive mitigation program. All applicants must be participating in the National Flood Insurance Program (NFIP) if they have been identified through the NFIP as having a Special Flood Hazard Area (a Flood Hazard Boundary Map (FHBM) or Flood Insurance Rate Map (FIRM) has been issued). In addition, the community must not be suspended or on probation from the NFIP.

44 CFR Part 201, Hazard Mitigation Planning, establishes criteria for State and local hazard mitigation planning authorized by §322 of the Stafford Act, as amended by §104 of the DMA. The development of State and local multi-hazard mitigation plans is key to maintaining eligibility for future PDM funding.

SMALL BUSINESS ADMINISTRATION (SBA) MITIGATION LOANS

The SBA's Regional Mitigation Loan Program was developed in support of FEMA's Regional Mitigation program. Businesses proposing mitigation measures to protect against flooding must be located in a Special Flood Hazard Area (SFHA). Businesses may consult FIRM maps to find out if the business is located in a SFHA. For information pertaining to hazard identification mapping and floodplain management, contact the local community floodplain administrator or the State floodplain manager. To apply for a regional mitigation loan, a business must submit a complete Regional Mitigation Small Business Loan Application within the 30-day application period announced by the SBA. SBA will publish a Notice of Availability of Regional Mitigation Loans in the Federal Register announcing the availability of Regional mitigation loans each fiscal year. The Federal Register notice will designate a 30-day application period with a specific opening date and filing deadline, as well as the locations for obtaining and filing loan applications. In addition, SBA will coordinate with FEMA, and will issue press releases to the local media to inform potential loan applicants where to obtain loan applications.

PUBLIC ASSISTANCE

The Federal Emergency Management Agency's Public Assistance Program is triggered for counties declared major disaster areas by the President. Communities and public agencies in designated counties are eligible for partial reimbursement (75%) of expenses for emergency services and removal of debris, and partial funding (75%) for repair and replacement of public facilities that were damaged by the declared disaster. Massachusetts funds an additional 12.5% of these projects. Eligible applicants for Public Assistance include:

- State government agencies/departments;
- Local governments (county, city, town, village, district, etc.); and
- Certain private non-profit organizations.

Typical federal/state aid can include:

- Reimbursable payment of 87.5%of the approved costs for emergency protective measures deployed in anticipation of the storm;
- Reimbursable payment of 87.5% of the approved costs for emergency services and debris removal;
- Payment of 75% of the costs for the permanent repair or replacement of damaged public property; and
- Funding for repair/construction of damaged highways other than those on the Federal Aid System.

VOLUNTEER FIRE ASSISTANCE GRANTS

Volunteer Fire Assistance (VFA) is a Federal grant program that provides funds for fire equipment, training, and initial fire department organization to fire departments serving small communities under 10,000 in population. Congressionally appropriated VFA funds are provided to the State forestry agencies through the USDA Forest Service. The State forestry agencies pass this money on to needful fire departments within their states. A fire department may buy equipment, pay for training or training materials, or cover the cost of department incorporation, as long as the funds are matched. VFA funds are granted on a 50/50 matching basis.

SPECIAL APPROPRIATIONS FOLLOWING STATE DISASTERS

Although there is no separate state disaster relief fund in Massachusetts, the state legislature will enact special appropriations for those communities sustaining damages following a natural disaster that are not large enough for a presidential, disaster declaration. Since 1995, there have been 15 state disaster declarations and has provided over $7,177,251 in funding to aid communities affected by natural disasters

STATE REVOLVING FUND

This statewide loan program through the Executive Office of Energy and Environmental Affairs assists communities in funding local stormwater management projects which help to minimize and/or eliminate flooding in poor drainage areas.

MASSACHUSETTS LAND AND WATER CONSERVATION FUND

Land and Water Conservation Funds provide 50 percent of the total project cost to purchase land for conservation or recreation purposes. Massachusetts has spent $95.6 million dollars since 1965 to purchase almost 4,000 acres of land under this program. The program is administered by DCR.

MAJOR FLOOD CONTROL PROJECTS

The state provides 50% of the non-federal share on the costs of major flood control projects developed in conjunction with the U.S. Army Corps of Engineers. This program is managed by DCR.

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