CITY OF WOBURN
ENGINEERING DEPARTMENT

NATURAL HAZARD MITIGATION PLAN

REPORT
MAY 2007

Contents

Section 7 – Conclusion

Section 8 - Appendices

Section 1
Planning Stage

1.1 INTRODUCTION

The City of Woburn has developed this Natural Hazard Mitigation Plan with funds provided through a Hazards Mitigation Assistance Grant from the Massachusetts Emergency Management Agency (MEMA). A team of city officials who have a broad spectrum of knowledge and experience of the city's infrastructure palyed a critical role in developing this plan.

1.2 PURPOSE

Natural hazard mitigation is a sustained attempt to lessen the impact that a natural hazard poses to life, property, infrastructure and other valuable resources. A plan to mitigate natural hazards includes a variety of preventive actions in the form of policies and capital improvement projects targeted at minimizing the impact of future severe weather occurrences. The purpose of this plan is to identify both known and potential risks and to develop a mitigation action plan.

The benefits to the City of Woburn from the implementation of an effective Natural Hazard Mitigation Plan could include:

- Reduction in public and private property damage
- Increased access to funding sources for hazard mitigation projects.
- Increased access to funding sources for post disaster recovery projects.

1.3 HAZARD MITIGATION TEAM

Hazard Mitigation Team includes:

- Thomas L. McLaughlin – Mayor
- Frederick W. Russell – Superintendent of Public Works
- John E. Corey, Jr. City Engineer
- Chief Phillip Mahoney – Police Chief
- Chief Paul Tortolano – Fire Chief
- John Fralick – Health Agent
- Anthony Blazejowski – Water Treatment Plant Manager

1.4 HAZARD MITIGATION PLANNING PROCESS

The purpose of the Hazard Mitigation Planning Process is to identify and determine the corrective actions of know and potential hazard mitigation areas.

The process is as follows.

- Step 1: Map known and potential hazard locations
- Step 2: Determine the potential damage of these locations
- Step 3: Identify which mitigative measures are already in place
- Step 4: Identify areas of mitigative measures that need improvement
- Step 5: Evaluate Feasible Mitigation Actions
- Step 6: Prioritize Mitigation Actions
- Step 7: Develop a strategy to implement mitigative actions
- Step 8: Adopt and monitor plan

Section 2
Current Hazard Risks

2.1 INTRODUCTION

The City of Woburn is approximately 12 miles north of Boston; it has two major interstates bisecting the city. Woburn supplies approximately 60% of its residence and businesses with municipal water from it wells and 40 % from the MWRA water. Its proximity to points in New England makes it a desirable place to live and work and with 37, 600+ residents and 80,000 commuters who enter the city to work, this can create significant hazards in storm and emergency related events.

The City of Woburn's Geographical Information Systems (GIS) mapping delineates areas throughout the city that pose a potential natural hazard. They include Flood Insurance Rate Maps (FIRM) which delineate 100 and 500 year flooding, Horn Pond Dam, Water Treatment facilities, Water distribution tanks, communication towers and power transmission lines and the Anderson Regional Transportation commuter railway.

This information along with pictures of flooding prone areas was used to determine potential risks and associated hazards.

2.2 FLOODING

Flood hazard as identified in the Federal Emergency Management Agency (FEMA) and Flood Insurance Rate Maps 1980 (FIRM) as well as the revised 2005 Draft Flood Study divides the areas into zones, these zones, (A, B and C) determine the potential impact to flooding where as Zones A and B are most like to have flooding issues in a major rain event and Zone C is an area that is least likely to have flooding.

The primary water body in the city is Horn Pond; it has a controlled outlet structure which discharges into the Horn Pond Brook, and then flows directly into the Town of Winchester.

In severe storm events where the water in the pond reaches elevation 42.0 Water will over top the emergency spillway increasing flow downstream, at elevation 42.0 Water overtops the roadway causing flooding to the nearby houses and apartment complexes, and closes off the local roadway to and from Winchester. In the event of a dam failure this could result in a catastrophic flooding problem for areas down gradient.

Another area of concern is the Halls Brook Holding Area. This is located in the Northeast section of the City on Commerce Way. This area is prone to flooding in sever conditions and has closed down the north and south bound lanes and the Commerce Way interchange from Interstate 93.

Localized flooding occurs throughout the city where water impounds onto local streets and properties thus causing areas of impassable roads and bridges. Improvements have been made to help alleviate areas of flooding; these mitigation measures include stream maintenance and resized culverts and drainage lines.

The average annual snowfall for the city of Woburn is approximately 48 to 72 inches. Heavy snow fall or blizzard conditions, where snow amounts fall too rapidly to be cleared can trigger a state of emergency in which vehicles will need to be cleared of major roadways would need to be cleared of vehicles.

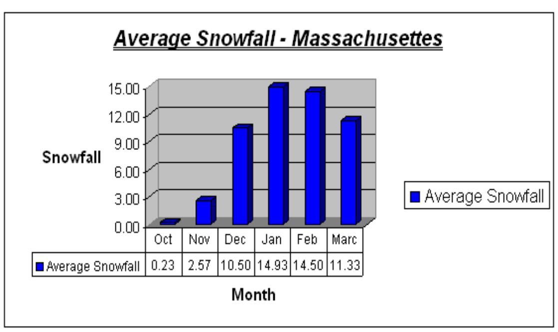
WINTER WEATHER GLOSSARY

Blizzard - A blizzard means that the following conditions are expected to prevail for a period of 3 hours or longer: Sustained wind or frequent gusts to 35 miles an hour or greater and considerable falling and/or blowing snow (i.e., reducing the visibility frequently to less than a quarter mile).

Heavy Snow - This generally means snowfall accumulating to 4" or more in depth in 12 hours or less or snowfall accumulating to 6" or more in depth in 24 hours or less In forecasts, snowfall amounts are expressed as a range of values, (i.e., "8 to 12 inches). However, in heavy snow situations where there is considerable uncertainty concerning the range of values, more appropriate phrases are used, such as "...up to 12 inches..." or alternatively "...8 inches or more...".

Ice Storm- An ice storm is used to describe occasions when damaging accumulations of ice are expected during freezing rain situations. Significant accumulations of ice pull down trees and utility lines resulting in loss of power and communication. These accumulations of ice make walking and driving extremely dangerous. Accumulations are called significant when they amount to a quarter inch or more.

Nor'easter- A strong low pressure system that affects the Mid Atlantic and New England States. It can form over land or over the coastal waters. These winter weather events are notorious for producing heavy snow, rain, and tremendous waves that crash onto Atlantic beaches, often causing beach erosion and structural damage. Wind gusts associated with these storms can exceed hurricane force in intensity. A nor'easter gets its name from the continuously strong northeasterly winds blowing in from the ocean ahead of the storm and over the coastal areas.



Wind Advisory- Sustained winds 25 to 39 mph and/or gusts to 57 mph. Issuance are normally site specific.

Wind Chill- Increased wind speeds accelerate heat loss from exposed skin, and the wind chill is a measure of this effect. No specific rules exist for determining when wind chill becomes dangerous. As a general rule the threshold for potentially dangerous wind chill conditions is about -20 degrees Fahrenheit.

Winter Storm Warning - This announcement is issued by the National Weather Service when a winter storm is producing or is forecast to produce heavy snow or significant ice accumulations. The criteria for this warning can vary from place to place.

Winter Storm Watch- This product is issued by the National Weather Service when there is a potential for heavy snow or significant ice accumulations, usually at least 24 to 36 hours in advance.

2.4 TROPICAL STORMS AND HURRICANES

In the event of a hurricane or tropical storm, the associated winds and heavy rains can wreak havoc on the community and low lying areas and poor drainage facilities can result to sever flooding conditions. Fortunately Woburn has not seen very many of these storms, the exception was Hurricane Bob in 1991. Preparedness for these types of storms are critical for ensuring safety for the community.

Hurricane Bob hit Rhode Island and southeastern Massachusetts as a moderate hurricane in 1991. Bob was small in size - but concentrated great power in isolated areas. Fortunately, a northeasterly track kept most of Long Island, Connecticut, and western Rhode Island on the weaker side of the hurricane. This was fortunate, since Bob was stronger than Gloria in 1985. Unlike Gloria, which arrived at low tide - the storm surge from Bob was more significant, and several areas reported extensive wind and storm-surge damage. However, the effects of Bob were in small beach towns in Rhode Island and southeastern Massachusetts, thus media coverage was minimal. Nevertheless - damage in several areas *was at levels not seen since Hurricane Carol in 1954*.

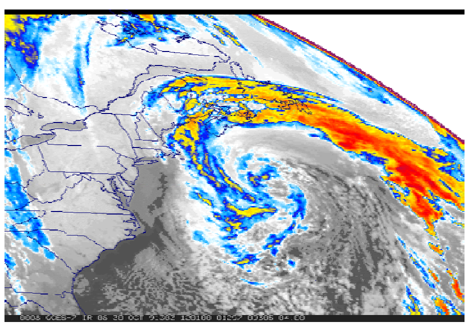
Hurricane Bob developed from a persistent area of clouds just to the east of the Bahamas. By August 17th, Bob was located about 200-miles east of the central Florida coast, with winds of 75-mph. By the 18th, Bob begin turning in a more northerly direction, continuing to intensify. As the storm swept past the North Carolina Outer Banks - the Diamond Shoals Light buoy recorded sustained winds of 99-mph and a peak gust of 123-mph. Bob continued to intensify early on August 19th - reaching major hurricane strength about 80-miles east of Virginia Beach, with sustained winds of 115-mph and a barometric pressure measured at 28.05 inches (950 mb).

Six hours later (1:30 p.m.) the eye of Hurricane Bob passed just to east of Montauk Point, New York, then passed right over Block Island, Rhode Island. After passing over Block Island - the eye of Bob become disorganized and begin to fill with clouds. Bob crossed the coast of the United States mainland near Newport, Rhode Island about 45-minutes after striking Block Island. Bob moved through eastern Rhode Island and southeastern Massachusetts, the center passing over Fall River and Plymouth, and then passing just off the tip of Cape Cod near Provincetown. As Bob passed the over Provincetown and moved over the cooler waters off New England, the storm quickly weaken to tropical storm strength before crossing the coast of Maine. Although Bob's track spared most of the region, coastal Rhode Island, Buzzards Bay, and the lower Cape took the brunt of the storm.

No Named Storm

On October 28, 1991, a extra-tropical cyclone developed along a cold front which had moved off the Northeast coast of the U.S. By 1800 UTC, this low was located a few hundred miles east of the coast of Nova Scotia. With strong upper air support, the low rapidly deepened and became the dominant weather feature in the Western Atlantic. Hurricane Grace, which had formed on October 27 from a pre-existing subtropical storm and was initially moving northwestward, made a hairpin turn to the east in response to the strong, westerly deep-layer mean flow on the southern flank of the developing extratropical low. Grace was a large system and it was already generating large swells ranging in size from about 15 feet offshore of North Carolina to about 10 feet near the Florida coastline.

As the low pressure continued to deepen on October 29, Grace became only a secondary contributor to the phenomenal sea conditions which developed over the Western Atlantic during the next few days. At 1800 UTC on the 29th, the vigorous cold front from the extra-tropical low undercut and quickly destroyed Grace's low level circulation east of Bermuda (Note the red and yellow area east of Charleston, SC in Figure 1). The remnant mid- and upper-level moisture from Grace became caught up in the outer part of the extra-tropical storm center's circulation, far from the storm's center. By the next day these remnants had become indistinguishable. The center of the extra-tropical low drifted southeastward and then southwestward, deepening all the time. It reached peak intensity of 972 mb and maximum sustained winds of 60 knots at 1200 UTC on October 30, when it was located about 340 n mi south of Halifax, Nova Scotia (See Event Discussion image above). After reaching peak intensity on October 30, the low retrograded southwestward on October 31 (Note swirl off Delmarva Peninsula in Figure 2), and then southward as the central pressure rose to about 998 mb by 0000 UTC on November 1.



During the early phase of the storm's history, a strong high pressure center extended from the Gulf of Mexico northeastward along the Appalachians into Greenland. Strong winds were generated from the tight pressure gradient between a strong high pressure center in eastern Canada (1043 mb) and the surface low. Phenomenal seas and strong winds and waves along the eastern U.S. coastline occurred at this time. Several vessels passed close to the extra-tropical storm center on October 30 and reported winds of 50-60 knots. NOAA buoy 44011 located at 41.1 degrees N, 66.6 degrees W reported maximum sustained winds of 49 kt with gusts to 65 kt and a significant wave height of 39 feet near 1500 UTC. Buoy 44008 located at 40.5 degrees N, 69.5 degrees W reported maximum sustained winds of 53 kt with gusts to 63kt and a significant wave height of 31 feet near 0000 UTC on October 31. Other unsubstantiated observations reported winds and waves considerably higher.

North Carolina's coast was lashed with occasional winds of 35 to 45 mph for five consecutive days. In New England on October 30-31, wind gusts of above hurricane force pounded the Massachusetts coastline. Representative peak gusts included: 78 mph at Chatham NWS, 74 mph at Thatcher Island, 68 mph at Marblehead, 64 mph at Blue Hill Observatory (all in Massachusetts) and 63 mph at Newport, RI. Even more damaging were the heavy surf and coastal flooding caused by the tremendous seas and high tides caused by the long over water fetch length and duration of the storm. Waves 10 to 30 feet high were common from North Carolina to Nova Scotia. High tides pushed from three to seven feet above normal. In New Jersey, the greatest tidal departures of winter storms of record occurred during this event, with tide heights exceeded only by the Great Atlantic Hurricane of 1944. In Delaware, Maryland and Virginia the highest water levels were comparable to those of the nor'easter of March, 1962. A record high tide of 7.8 feet occurred at Ocean City, MD on the 30th, which eclipsed the old record of 7.5 feet recorded during the March 1962 storm. In Massachusetts, 25-foot waves reached the shoreline atop high tides already 4 feet above normal. At Boston, the tide reached 14.1 feet above mean low water or about 1 foot less than the tides associated with the "Blizzard of 1978." Elsewhere, treacherous swells, surf and associated coastal flooding occurred along portions of the Atlantic shoreline extending from Puerto Rico and the Dominican Republic, to the Bahamas, along the U.S. and Canada and in Bermuda.

Section 3

Hazard Areas

3.1 INTRODUCTION

Woburn has identified areas throughout the city as potential hazard areas; these areas are flood and fire prone areas. These areas are susceptible to excessive water or extreme dry weather conditions.

This section outlines those specific areas identified by the city that has a high risk of occurrences and impacts on the community.

3.2 CRITICAL FACILITIES – FLOODING

Critical facilities are those areas that are public and or private facilities that posses added value to the community.

The list of critical facilities was identified and compiled using the city's GIS system and overlaying the flood prone areas as well as the critical infrastructure. Schools, elderly housing and shelters are included in this to ensure the health and safety of the residents of Woburn.

Horn Pond Dam

Horn pond is approximately 120 acres and a watershed area of 10 square miles. The primary outlet control structure is controlled by a weir and slide gate with a secondary emergency riprap spillway that handles elevated water levels. The spillway is located on the southerly side of Horn Pond and outlets into Horn Pond Brook which flows through the Town of Winchester.

In severe weather events and anticipation of rainfall 4 inches or greater, the city notifies the down gradient cities and towns that Woburn would be lowering the pond for storm water runoff storage. When the capacity exceeds the storage volume, the pond begins to crest at elevation 45 (NGVD). Thus creating flooding of the local roadway and impacting the residences and apartments that directly abut Horn Pond Brook.

Commerce Way

There is an existing 48" culvert that traverses the median between the north and southbound lanes of Commerce Way.

The northerly portion on Commerce Way near the Marshall distribution facility (83 Commerce Way) is prone to flooding in sever rain events. Runoff from the Aberjona River flows into a series of underground culverts and then discharges into Halls Brook holding area. When the capacity of the open channels are exceeded, the stormwater runoff surcharges onto Commerce way. This adversely impacts this area by making the roadway impassable in both directions and blocking access from the Commerce Way interchange. There have been improvements in the upstream portion of the channel. As a part of the drainage improvements in 2000, approximately 400 feet of new 4'x8' box culvert was installed from Atlantic Avenue southerly. These drainage improvements have helped alleviate the flooding problem in the area.

Washington Street (Staples)

The Staples & CompUSA building at #335 Washing Street expierences substancial flooding in sever rain events. As seen in the depicted photo, the water elevation reaches the elevated entrances to the businesses. Runoff from the resource area behind 369 Washington Street (WR Grace site) flows through the local business on Washington and Cedar Streets, collects in a series of underground drainage network to Washington Street and discharges to a 18" CMP culvert under the roadway to a resource area at the rear of #10 Cedar Street. The amount of runoff that is collected in the parking lot and roadway is far greater than the capacity of the main drain line. This inturn causes a significant flooding problem in moderate and sever storm events.

Richard Circle

The Richard Circle area had always been prone to localized flooding. The flooding is caused by a drainage runoff that is impounding on the southerly side of Interstate 95 near the Stoneham Woburn corporate limits. The roadway runoff discharges through a series of catch basins and outlets through a 12" drain line to a swale that runs along Interstate 93. The this swale reaches capacity, runoff discharge backs up through the drain lines and onto the roadway causing the flooding condition.

Four Corners (Cambridge Road & Russell Street)

The Four Corners is located on the west side of Woburn which is a low point for the convergence of 3 major roadways. Cambridge Road, Lexington Street and Russell Street. In a sever rain event, the Shaker Glen Brook, which runs in a North Easterly direction along Russell Street and then crosses under Cambridge Road via an old stone box culvert Swells and over flows on to the roadway. Due to the topography and the low lying areas, storm water runoff collects from several directions. One is via a 60" line under Cambridge Road.

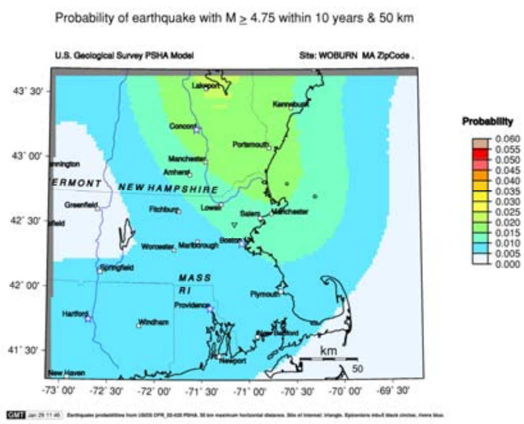
Water ponds around the neighboring properties and causes impassible conditions and flooding of the local businesses in the area. These properties flood in moderate rain events and have been a recuring problem in past years

The city has determined several areas around the city as shown on out Hazard Mitigation Plan that have significant impacts to buildings and properties that are affected by flooding.

Listed below are the buildings and parcels that are affected

- Buildings in FEMA Flood Plane - 129 Building Value $152,717,900.00
- Buildings in Local 100 yr Flood Plane - 79 -Building Value $36,350,500.00
- Parcels in FEMA Flood Plane - 455
- Parcels in Local 100 yr Flood Plane – 407

One area that that has a systemic flooding problem



Massachusetts was the sixth state of the original thirteen to enter the Union (1788). However, the region was visited by English explorers as early as 1602, followed by the arrival of the Pilgrims at Plymouth in 1620. The early settlers compiled the extensive historical accounts that are now available. Nineteen earthquakes, intensity V or greater, have centered in Massachusetts. A number of other earthquakes were centered off the coast of Massachusetts and affected the eastern portion of the State. A shock in 1755 reached intensity VIII at Boston and was felt across the State. In addition, Massachusetts was affected by some of the more severe Canadian shocks plus the earthquake of 1929 that centered on Grand Banks of Newfoundland.

Strong earthquakes in the St. Lawrence Valley in 1638, 1661, 1663, and 1732 were felt in Massachusetts. The 1638 and 1663 shocks damaged chimneys at Plymouth, Salem, and Lynn. On June 11, 1643, Newbury, Massachusetts, was strongly shaken. Again in 1727 (November 9) an earthquake described as "tremendous" in one report and "violent" in another caused much damage at Newbury. The shock was felt from the Kennebec River to the Delaware River and from ships at sea to the extreme western settlements. Several strong aftershocks were reported from the area through February 1728.

Eastern Massachusetts was shaken moderately on February 17, 1737, and June 24, 1741. Then on June 14, 1744, large numbers of bricks were shaken from tops of chimneys in Boston and other towns and stone walls were shaken down. Many persons in Newbury and Ipswich were alarmed. The earthquake was reported as felt severely at Falmouth, Maine.

On November 18, 1755, one of the most significant earthquakes in the northeastern region occurred off Cape Ann. At Boston, walls and chimneys were thrown down and stone fences were knocked down (intensity VIII, Modified Mercalli scale). Some descriptions mentioned violent movement of the ground, like waves of the sea, making it necessary to cling to something to prevent being thrown to the ground. At Pembroke and Scituate small chasms opened in the earth through which fine sand reached the surface. Large numbers of fish were killed and many people on vessels felt shocks as if the ships were striking bottom. This earthquake was felt from Lake George, New York, to a point at sea 200 miles east of Cape Ann, and from Chesapeake Bay to the Annapolis River, Nova Scotia, about 300,000 square miles. Reports of a seismic sea wave reaching the West Indies following the earthquake appear to be erroneous. A tsunami had occurred in the West Indies on November 1, 1755, following the great Lisbon earthquake, which apparently led to a report of its association with the Cape Ann earthquake.

Little information is known about an earthquake that occurred on October 5, 1817. Walls were reported thrown down at Woburn (VII - VIII), but additional details are lacking.

Moderate earthquakes in 1847 (August 8), 1852 (November 27), 1854 (December 10), 1876 (September 21), 1880 (May 12), 1903 (January 21 and April 24), 1907 (October 15), 1925 (January 7 and April 24), 1940 (January 28), and 1963 (October 16 and 30), were felt over limited areas of eastern Massachusetts. The epicenter of the January 7, 1925, shock was off Cape Ann; the reported felt area extended from Providence, Rhode Island, to Kennebunk, Maine. The October 16, 1963, shock caused some plaster to fall at Somerville; in addition a wall was reported cracked and stones fell from a building foundation (intensity VI). Dishes were broken and many persons were alarmed at Amesbury, and a window was cracked at Winthrop. The other earthquakes did not exceed intensity V.

The residents of Nantucket Island were jolted by a moderate earthquake on October 24, 1965. Very slight damage, mostly to ornaments, was reported. Doors, windows, and dishes rattled, and house timbers creaked.

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

Synopsis of Seismic Design Criteria For Structures Located within The City of Woburn

Purpose: 780 CMR presents design criteria for design and construction of buildings and structures subject to earthquake ground motions. The purpose of 780 CMR is to minimize the hazard to life of occupants of all buildings and non building structures, to increase the expected performance of higher occupancy structures as compared to ordinary structures, and to improve the capability of essential facilities to function during and after an earthquake.

Design: Because of the complexity of and the great number of variables involved in seismic design (e.g. variability in ground motion, soil types, and dynamic characteristics of the structure, material strength properties and construction practices) 780 CMR presents only minimum criteria in general terms. These criteria are considered to be prudent and economically justified for the protection of life safety in buildings subject to earthquakes. It must be emphasized that absolute safety and prevention of damage, even in an earthquake event with a reasonable probability of occurrence, cannot be achieved economically for most buildings. The “design earthquake” ground motion levels specified by 780 CMR may result in both structural and non structural damage. For most structures designed and constructed in compliance with 780 CMR, it is expected that structural damage from a major earthquake may be repairable, but the repair may not be economical. For ground motions larger than the design levels, the intent of 780 CMR is that there be a low likelihood of collapse.

Event Occurrence: In the event of a major earthquake the Building Department would mobilize and begin inspections of properties based upon their seismic hazard exposure group rating (e.g. Group I, Group II, Group III). Inspections would begin with all Group III buildings, Group II and lastly Group I.

- *Group III:* Are those buildings having essential facilities which are required for post earthquake recovery such as: Fire and Police stations, Institutional uses having emergency surgery and treatment facilities, Emergency preparedness centers, Power generating facilities, Primary communication facilities.

- *Group II*: Are those buildings which have a substantial public hazard due to occupancy or use such as: Buildings within an assembly use group were more than 300 people congregate, Buildings within an educational use group with an occupancy greater than 250, Buildings within a Business use group which are used for colleges or adult education and have an occupancy greater than 500, Buildings within an institutional use group and having an occupancy greater than 50 and not having any emergency or surgery treatment facilities.

- *Group I*: Are all occupancies other than those listed above.

3.4 EARTHQUAKE PRONE AREAS

Rag Rock Water Tower (Rag Rock Drive)

Rag Rock water tank is located on Hillside Avenue and is part of the city's water distribution system. It was built in 1960's and holds approximately 4.4 million gallons of water. At the time of construction, earthquake design standards did not exist and therefore was not incorporated into its construction, thus making this structure vulnerable to seismic activity which could have an adverse impact to the water distribution system and dwellings down gradient. In addition to the water tank, the city has commercial and residential buildings that are 5 stories and taller that were built before 1985. The reason for this concern is that buildings that were constructed before 1985 did not conform to today's earthquake design standards. In the event of a significant earthquake, these structures are susceptible to some type of structural failure. Listed below are locations of buildings that are 5 stories and greater and that were built prior to 1985.

Map	Block	Lot	St. No.	Street Name	Yr. Blt.	No Stories
21	1	9	19	COMMERCE WAY	1964	5
51	6	17	59	CAMPBELL ST	1970	7
59	1	1	21	WARREN AVE	1974	5
73	9	2	304	CAMBRIDGE RD	1979	5
50	8	22		LIBRARY PL	1980	5
74	1	2	3	REHAB WAY	1980	7

20	1	16	1	LINSCOTT RD	1984	5
54	3	1	1	MACK RD	1984	5
26	1	1	311	MISHAWUM RD & 315	1984	5
25	9	4	285	MISHAWUM RD	1985	5

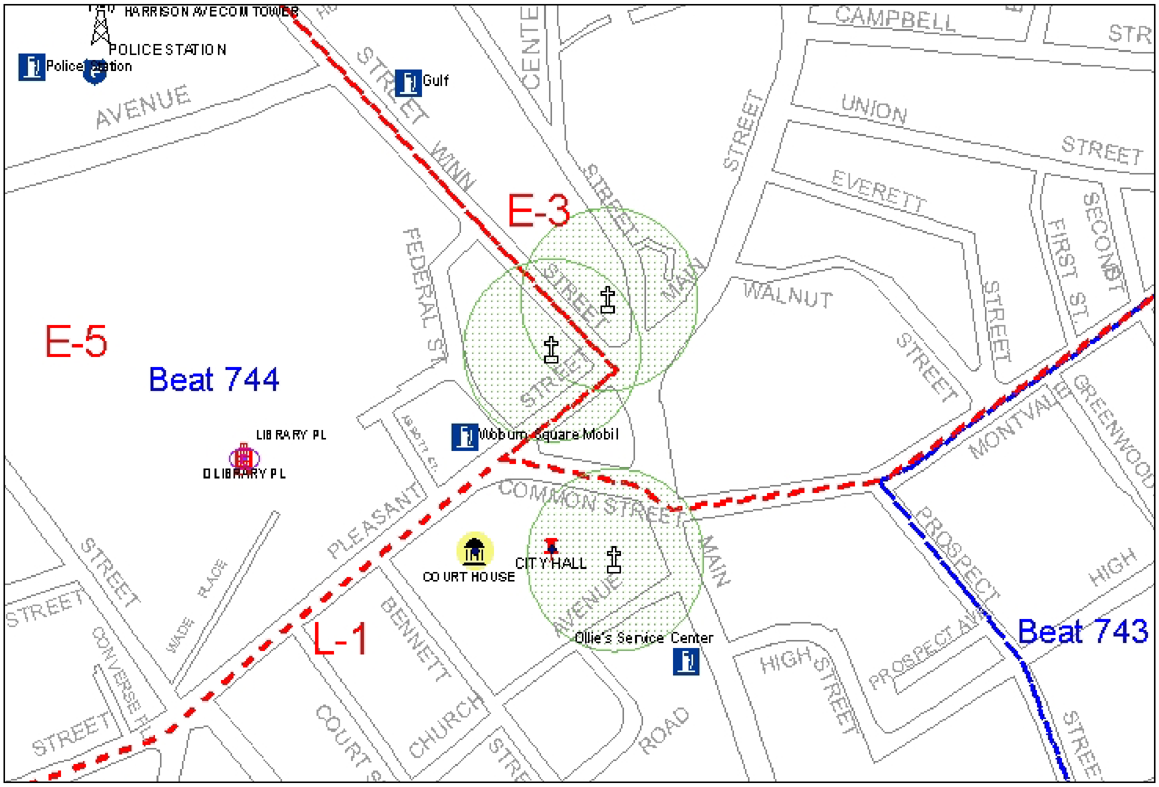
Rehabilitation Way

Library Place

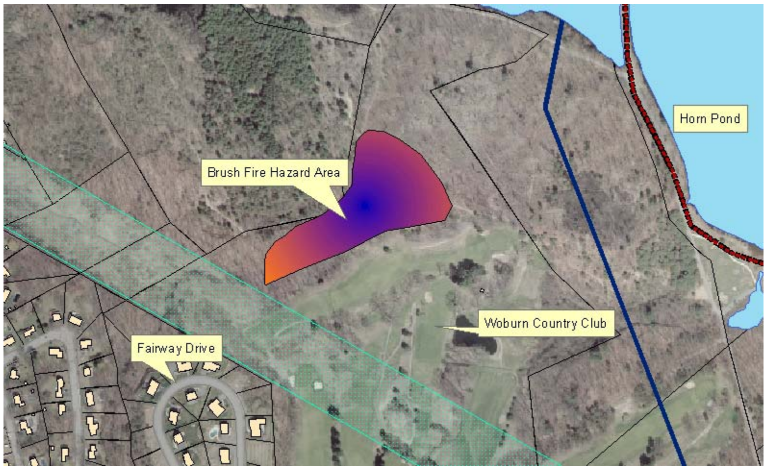
Woburn has several churches with steeples in excess of 100 feet. These buildings could pose a potential hazard in a significant earthquake. The spires could shear off and have adverse impacts to the surrounding buildings, roadways and pedestrians.

#322
Main Street 1st Congregational Church

#3 Winn Street First Baptist Church



Portion of a GIS location map showing churches with steeples



The city has designated an area on the westerly side of Horn Pond and just north of Woburn Country Club golf course as a Brush Fire Hazard Area due to the numerous fires that have occurred over the years. This area is prone to brush fires due to its proximity to walking trails which bisect the fire hazard area and carelessness of pedestrians with cigarettes and children playing with matches. The city has a ban on outdoor burning. The fire department does allow controlled permitted burning in the spring during favorable conditions. On Average, the fire department issues 150 burn permits per year. The amount of permits issued varies on weather conditions in the spring.

Brush Fire Statistics:

2003-83 Fires	2004-87 Fires	2005-90 Fires	2006-109 Fires	2007-8 Fires

The Fire Department maintains records for over 150 underground and aboveground fuel storage tank locations. Each station is required to file paperwork with the Fire Department documenting the volume capacity as well and the number of storage tanks that are on site as per Chapter 527 CMR 9.00 of the Commonwealth of Massachusetts Fire Services Regulations.

Section 4

Current Hazard Mitigation Activities

4.1 INTRODUCTION

The City of Woburn initiates hazard mitigation policies and procedures to promote the safety of its residents and minimize risk to city assets. This section outlines a brief description of each procedure.

4.2 MASS EMERGENCY MANAGEMENT AGENCY

The Emergency Management Agency has developed the Comprehensive Emergency Management Plan (CEMP) to properly respond to emergency situations such as flooding and other natural disasters. The CEMP is a report that outlined the policies and procedures in case of an incident or disaster occurs.

4.3 HORN POND EMERGENCY MANAGEMENT PLAN

Prior to a significant storm event, the Department of Public Works superintendent lowers the water elevation of Horn Pond. The amount of rainfall that is predicted determines the elevation that the pond is lowered. Communities that are downstream from Woburn, such as The Town of Winchester and City of Medford are notified and water at their control points are adjusted accordingly.

4.4 NEW DEVELOPMENT AND CONSTRUCTION POLICY

New developments in the city of Woburn that are near water courses and wetland areas have to adhere to strict guidelines to site runoff. The developments must match or decrease post development runoff from predevelopment conditions. This helps maintain or reduce the amount of stormwater runoff from exacerbating the municipal drainage network. This requirement also applies to subdivisions that do not have any direct out let to a watercourse.

4.5 EMERGENCY SHELTERS

In the event of a natural disaster, Woburn residents have access to designated shelters throughout the city. The shelters are located as follows: Woburn Senior Center on School Street, Joyce Jr. High School on Locust Street and the White Elementary School on Bow Street.

Senior Center – School St

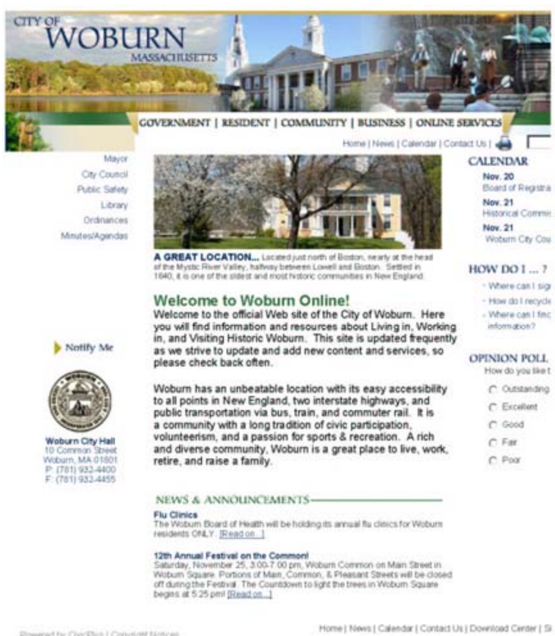
Joyce Jr. High School - Locust Street

4.6 WINTER SNOW STORMS

In the winter months (November 15th to April), the city institutes a parking ban on the odd numbered side of the street. This ban helps keep the roadways clear for snow removal and emergency apparatus.

4.7 CITY OF WOBURN WEB SITE

The City of Woburn has revised its website which allows the individual departments to publish critical information and emergency response procedures in an instant. The website has links to all municipal departments and emergency phone numbers and contacts.



Section 5

Planned Mitigation Activities

5.1 INSTODUCTION

The City of Woburn is in the process of reviewing all areas of critical concern to determine what steps need to be implemented to ensure the safety and well being of the residents of the city.

City of Woburn Goals

- Improve ability to notify residents in the event of a natural disaster.
- Increase reliability of city departments and emergency shelters to function effectively during a natural disaster.
- Establish measures to reduce and / or correct each known flood hazard area.
- Enhance the reliability of public utilities during a natural disaster.
- Increase public education
- Expand communications with state and abutting communities.

5.2 PLANNED PROJECTS

Washington Street

The Washington Street area in the vicinity of Cedar Street and #335 Washington Street has a history of flooding in rain events, due to in part of insufficient capacity in the drainage system in the area. During rain events storm water runoff from an upstream resource area behind #32 Cedar Street and adjacent private properties sheet flows overland and into the inadequate drainage system causing flooding conditions. The Engineering Department has a preliminary design that has twin 18” drain lines connecting into a proposed 24” RCP drain line which will act as a relief line to the existing 18” drain under Washington Street. This will help reduce the amount of water that accumulates in the roadway as well as the Staples parking lot during rain events.

Hart Street Drain

The City is reviewing the feasibility of installing a 24” drain line from the old Middlesex Canal and running along the abandoned Railroad right of way bed crossing Kilby Street and Winn Streets. In moderate and sever rain storms, storm water runoff from Hamilton Road and Hart Street collects in an undersized drainage network through several back yards and outlets in the old Middlesex Canal. Several areas of the canal have been culverted but few areas are still open channel. In the areas that are open, the water collects and overflows onto several properties on hart street causing flooding of basements and back yards. The installation of the proposed 24" drain line will reduce the amount of water that ponds in the old canal alleviating the standing water that occurs in the back yards of Hart Street and Hamilton Road.

Section 6

City Department Cooperation

6.1 ENGINEERING DEPARTMENT

Over the past10 years, the Engineering Department has developed a fully functioning Geographical Information System (GIS) which contains the city's infrastructure in a graphical format. The city has also scanned approximately 20, 000 record plans and documents. The record plans are stored on a server with backups performed four times a week. The department has created "Grab and Go" kits which contain a laptop computer, external hard drives which contain all the GIS and scanned drawings as well as cables and power cords that would be needed to set up and emergency command center at a moment's notice. The engineering van with the help of the Woburn police department is equipped to support a mobile command center if needed with GPS capabilities. The technology is extremely useful in the event that utilities need to be located that have been obstructed by flooding or some other hazard. The GPS combined with our GIS on the laptop can be used to locate these utilities.

The GIS system is updated on a monthly basis and the data is available to the general public, engineering firms etc. via a license agreement. The department has installed a kiosk at the front counter for the general public. The use of this system has help residents to see properties around the city and obtain any information and or plans.

6.2 BUILDING DEPARTMENT - INSPECTIONAL SERVICES

The purpose of the Department of Inspectional Services is to protect the public health and safety by overseeing all types of construction in the City of Woburn. The Inspectional Services Department is responsible for the enforcement of all laws and related City Ordinances which pertain to the Massachusetts State Building Code. More specifically, these responsibilities encompass the administration of the State Building, Plumbing and Gas and Mechanical Codes. In addition, the Department of Inspectional Services is responsible of the interpretation and the enforcement of the City Zoning Ordinance and for the provision of administrative support for the Zoning Board of Appeals.

The Department of Inspectional Services reviews applications for building permits to construct alters, repair, remove or demolish a structure. Once applications have been approved by the building official a building permit will be issued. The building Inspectors will then make the appropriate periodic inspections. Plumbing and Gas permits are also issued from this department. Once approved the plumbing/ gas inspector will conduct the appropriate inspections. This department also fields numerous complaints from various City departments as well as the public. Examples of these complaints range from unregistered vehicles, abandoned buildings and working without permits.

6.3 BOARD OF HEALTH

The Board of Health provides the following functions and services. Food Service Permits, Infectious Diseases Surveillance and Outbreak Investigation, Epi investigations and reporting, operation of emergency dispensing site(s), Medication Dispensation, Restaurant Licenses, Trash Collection, Vaccination and prophylaxis for staff and their families, Small-scale immunization and prophylaxis operations, Guidance to the community on protective actions to be taken against public health hazards.

Maintains vital operational records (emergency plans and directives, Orders of Succession, Delegations of Authority, staffing assignments, records of a policy or procedural nature, contracts for goods and services, contracts for support staff, personnel files, Inventory records, emergency time logs, emergency logs of actions taken, emergency expenditures.

Maintains vital health records (morbidity and mortality data, isolation orders and records, quarantine orders and records, immunization and prophylaxis records, records of other public health directives) Computer support, Behavioral health support, Building security, food inspections specific to emergency needs, environmental sampling, emergency complaints, sanitary/environmental code.

6.4 DEPARTMENT OF PUBLIC WORKS

The Highway Department is responsible for the maintenance of Woburn's public ways.

Highway personnel paint crosswalks, center and parking lines, and repair and replace numerous signs and street signs during the year. All public roads are plowed and sanded by the Highway Department during snow and ice conditions.

The City of Woburn's Horn Pond Treatment Facility allows the city to meet US EPA requirements for lead and copper. The plant also provides disinfection of the city's wells and prevents mineral deposits in the piping system.

The Horn Pond water treatment facility is designed to treat six million gallons of water per day. Sodium Hydroxide is used to adjust the PH level of the water making it less corrosive. Sodium Hypochlorite is used for disinfection.

Sequestering Agents
A sequestering agent is used to prevent iron and manganese from depositing in the distribution system. A combination of sequestering agents provides a mixture that manages the PH, Iron and Manganese that are inherent in the wells. This adjustment when in contact with the MWRA water will result in minimized discoloration of the water.

The city's water supply comes from an underground aquifer within the Horn Pond area. This series of wells, delivers approximately 60% of the city's daily supply, the remaining 40% is supplied by the MWRA.

The Water Department installs and maintains the water distribution system network throughout the city, and provides coordination of the flushing programs, water main cleaning and relining projects, domestic water main tap installations, hydrant flow testing and water main pressure tests.

The Sewer Department is responsible for the installation, maintenance and repair of the sanitary common sewer and storm drain systems. If you have any questions or require service, contact the Highway Department Monday through Friday from 7:30 am to 4:30 pm.

The city has separate sanitary sewer and storm water system. The sewerage system is collected through underground piping network and ultimately discharges into the MWRA sewer.

The city has approximately 130 miles of common sewer main excluding building service connections.

Sewer System

The sewer system was constructed in 1898 and a majority installed in the late 1960's. There about 350 properties that are on septic systems or cess pools.

Task of Woburn

The City of Woburn has undertaken the daunting task of removing extraneous I/I (inflow and infiltration) from the sewer system. Illegal sump pumps and drain connections contribute to the overtaxing of the sewer system.

General Storm water Permit

The Department of Public Works operates the City's storm water drainage system under a Phase II General Storm Water Permit issued by the U.S. Environmental Protection Agency as part of its National Pollutant Discharge Elimination System (NPDES) Storm Water Permitting program. The City's permit number is MAR041073.

The Phase II NPDES Storm water Permit is part of a federally mandated program to address water pollution from storm water under the Clean Water Act. The Phase II Stormwater Management Program page provides more information on this program and the City's permit.

Snowplow Operations

During the winter months, the City of Woburn Department of Public Works applies salt to the public ways when surfaces are deemed hazardous by the Superintendent of Public Works or his designee. During non-business hours, the Woburn Police Department will advise the Superintendent or his designee of hazardous conditions. Typical salting operations require the deployment of 13 trucks to cover the entire City. The DPW's priority is to salt main roads and hills first, followed by the secondary and other through roads. Dead-ends and cul-de-sacs are salted last. Given the intensity of a storm, it may take up to 4 hours for a truck to apply salt to a street. Pre-treatment of major roads prior to a snow event is also typical.

Due to environmental concerns and economics issues, the trend in snow and ice control has been to reduce the volume of sand that is mixed with salt. The City of Woburn Department of Public Works has phased out the use of sand. There has also been a concerted effort to reduce the volume of salt used during snow operations, by supplementing the application of salt with chemical enhancement such as calcium-chloride and/or "Magic Salt"©.

Although each snow storm varies considerably, snow removal/plowing operations typically commence when at least two inches of snow has fallen, with the expectation that more snow fall will occur. The DPW has subdivided the City into 28 distinct plow routes. Within each route, streets are plowed and treated in order of priority, in concert with salt operations. It is extremely important that major roads remain open to vehicular traffic, especially for Emergency Services. It is also important to note that at any time DPW personnel and equipment are ready to respond to assist Emergency Vehicles for passage on any street.

The DPW clears approximately 60 miles of sidewalks along major roads, in the downtown area and around schools. Currently the City of Woburn has no specific ordinance that requires homeowners to remove snow from sidewalk areas in front of their homes, however some residents do take it upon themselves to clear the remaining sidewalks. City of Woburn ordinances do prohibit residents and others from blocking a sidewalk with snow once it has been cleared.

The DPW dispatching office is active during plowing and salting operations, and calls are answered throughout the duration of the storm. Although every effort is made to clear streets and sidewalks in a timely manner, unforeseen problems may occur. Equipment breakdowns, other emergencies during storms, the intensity of the storm, etc. all can contribute to delays in clearing snow.

6.5 POLICE DEPARTMENT

The duties and responsibilities of the Woburn Police Department during natural or manmade disasters within the city are outlined in the ***City of Woburn's Emergency Management Plan*** that is on file with the Massachusetts Emergency Management Agency (MEMA). In general, the overall responsibilities associated with the police department during these events remain unchanged. The departments' primary function is that of protecting life and property. As the primary law enforcement agency in the city we are also charged with maintaining public order, directing and maintaining the flow of traffic and providing security for critical facilities including mass care shelters. In most instances, the police department will provide a support role to the lead agency directing the overall operations. In the event that a Unified Command is established, the police department will be represented by its Chief Executive or one of its division commanders. (i.e.: Patrol Division, Services Division or Investigations Division).

During unusual events, whether scheduled or unanticipated, the Woburn Police Department operates according to protocols set forth in the departments ***Emergency Operations Manual***. This Manual is divided into five distinct sections or parts. Part I of the manual contains general information regarding the role of the police department during city wide emergency operations. It also describes how the command structure will be set up and outlines the general duties associated with each of the command positions established.

Part II of the document; includes information on how to initially activate the General Emergency Operations Plan. The three stages or phases of emergency activation (Alert, Rapid Recall and Deployment) are covered. This plan is based on the Incident Command System and the related function based sections associated with this system. (Command, Operations, Logistics, Finance etc.) Also included in this section, are the duties and responsibilities associated with each section during the various phases of activation. Part II concludes with information regarding special assignments and considerations that may need to be addressed throughout the event.

The information in Part III is event specific. The department recognizes that severe weather and civil disturbances bring with them their own unique set of problems. These two, event-specific plans, attempt to address some of these issues.

Part IV is a list of resources that the department can draw upon during an emergency event. The table of contents at the beginning of the document directs you to the location of the various categories of resources available.

The manual concludes with Part V. Part V contains Action Guides for the most common Incident Command Positions. The guides walk the reader through each phase of the Emergency Operations Plan. They describe the tasks that should be performed during each phase of activation by those persons assigned to head each operational section. There are three sets of guides. One set is for General Emergency Operations, a second is specific to severe weather and the third is specific to civil disturbances and mass arrests.

Section 7

Conclusion

7.1 CONCLUSION

The city of Woburn had made great strides in determining areas throughout the city which are prone to flooding and other natural disasters. The city has several projects that are under the design phase that will help alleviate flooding conditions in key areas.

In the event of a natural disaster, major snow storm, hurricane or other natural disaster, the city can be mobilized in a short period of time and have an emergency command center set up and operational. The command center could be located at the police department, veterans school or be a mobile unit in the engineering van.

The different city agencies come together to coordinate emergency management and public safety concerns throughout the event. Each event is logged and after-action reports prepared so that the department learns from what went smoothly and what areas needs improvement.

With the ability of being able to remotely connect to our SCADA and GIS systems via laptop computers, gives us the ability to effectively function in emergency situations.

The city's natural hazard plan will continue to evolve when new issues arise and when existing conditions are corrected. With continuing table top exercises, the city continues to refine operating procedures to maximize department coordination.

Section 8

APPENDIX A- HAZARD AREA MAPS

FIGURE 1-1

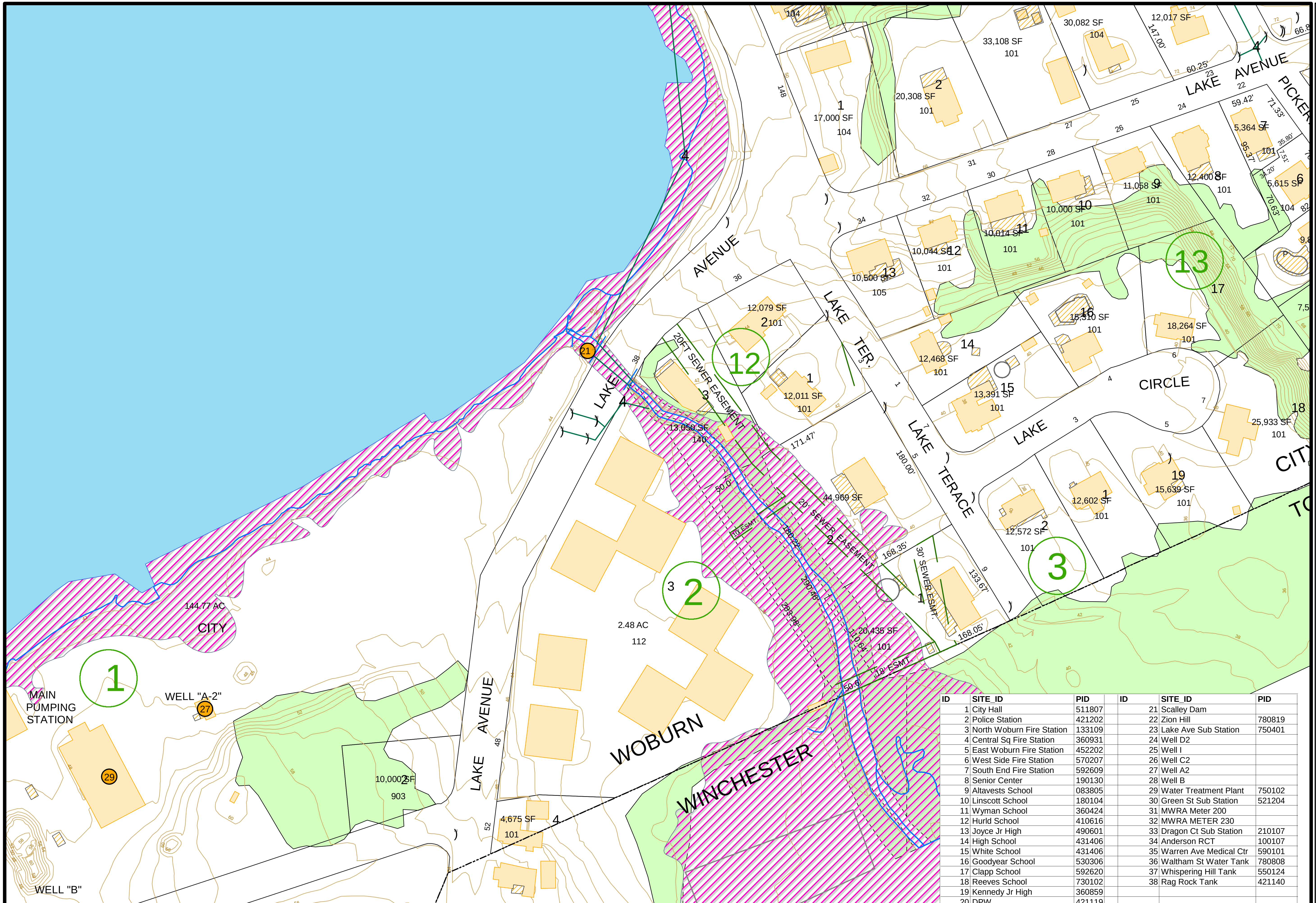
LOCATION MAP

Conversion Date:
Revision Date: September 1, 2006

City of Woburn
Engineering Department

FIGURE 2-1

HORN POND FLOOD HAZARD AREA



ID	SITE_ID	PID		ID	SITE_ID	PID
1	City Hall	511807		21	Scalley Dam	
2	Police Station	421202		22	Zion Hill	780819
3	North Woburn Fire Station	133109		23	Lake Ave Sub Station	750401
4	Central Sq Fire Station	360931		24	Well D2	
5	East Woburn Fire Station	452202		25	Well I	
6	West Side Fire Station	570207		26	Well C2	
7	South End Fire Station	592609		27	Well A2	
8	Senior Center	190130		28	Well B	
9	Altavests School	083805		29	Water Treatment Plant	750102
10	Linscott School	180104		30	Green St Sub Station	521204
11	Wyman School	360424		31	MWRA Meter 200	
12	Hurld School	410616		32	MWRA METER 230	
13	Joyce Jr High	490601		33	Dragon Ct Sub Station	210107
14	High School	431406		34	Anderson RCT	100107
15	White School	431406		35	Warren Ave Medical Ctr	590101
16	Goodyear School	530306		36	Waltham St Water Tank	780808
17	Clapp School	592620		37	Whispering Hill Tank	550124
18	Reeves School	730102		38	Rag Rock Tank	421140
19	Kennedy Jr High	360859				
20	DPW	421119				

Legend

- Beco_Easements
- Block Circles
- Buildings
- City_Boundry
- Easements
- drainage
- PorchDecks
- Contours
- ParkingLots
- Driveways
- EdgeofPvmt
- Paper_Streets
- Parcels
- Treed Area
- roadsnew
- Zoning Lines
- Local100yrFloodPlain
- R-1 Zoning Text
- 12 Parcel Number
- 8 Block Number
- 5,500 SF Acreage
- 100.00' Dimensions

Scale 1 Inch = 100 feet

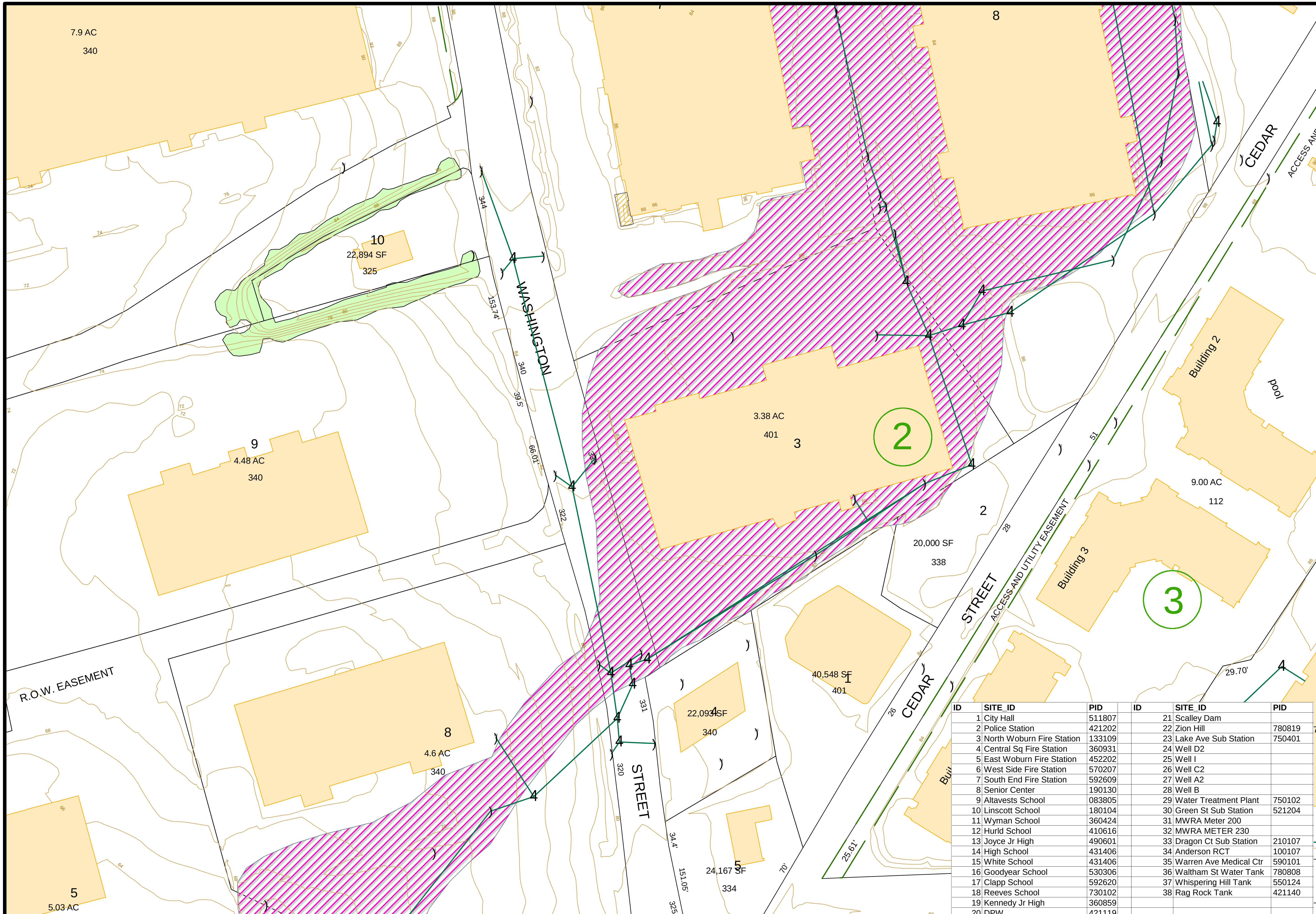
0 50 100 200 Feet

Conversion Date:
Revision Date: September 1, 2006

City of Woburn
Engineering Department

FIGURE 2-2

WASHINGTON STREET FLOOD HAZARD AREA



ID	SITE_ID	PID	ID	SITE_ID	PID
1	City Hall	511807	21	Scalley Dam	
2	Police Station	421202	22	Zion Hill	780819
3	North Woburn Fire Station	133109	23	Lake Ave Sub Station	750401
4	Central Sq Fire Station	360931	24	Well D2	
5	East Woburn Fire Station	452202	25	Well I	
6	West Side Fire Station	570207	26	Well C2	
7	South End Fire Station	592609	27	Well A2	
8	Senior Center	190130	28	Well B	
9	Altavests School	083805	29	Water Treatment Plant	750102
10	Linscott School	180104	30	Green St Sub Station	521204
11	Wyman School	360424	31	MWRA Meter 200	
12	Hurld School	410616	32	MWRA METER 230	
13	Joyce Jr High	490601	33	Dragon Ct Sub Station	210107
14	High School	431406	34	Anderson RCT	100107
15	White School	431406	35	Warren Ave Medical Ctr	590101
16	Goodyear School	530306	36	Waltham St Water Tank	780808
17	Clapp School	592620	37	Whispering Hill Tank	550124
18	Reeves School	730102	38	Rag Rock Tank	421140
19	Kennedy Jr High	360859			
20	DPW	421119			

Legend

- Beco_Easements
- Block Circles
- Buildings
- City_Boundry
- Easements
- drainage
- PorchDecks
- Contours
- ParkingLots
- Driveways
- EdgeofPvmt
- Paper_Streets
- Parcels
- Treed Area
- roadsnew
- Zoning Lines
- Local100yrFloodPlain
- R-1 Zoning Text
- 12 Parcel Number
- 8 Block Number
- 5,500 SF Acreage
- 100.00' Dimensions

Scale 1 Inch = 100 feet

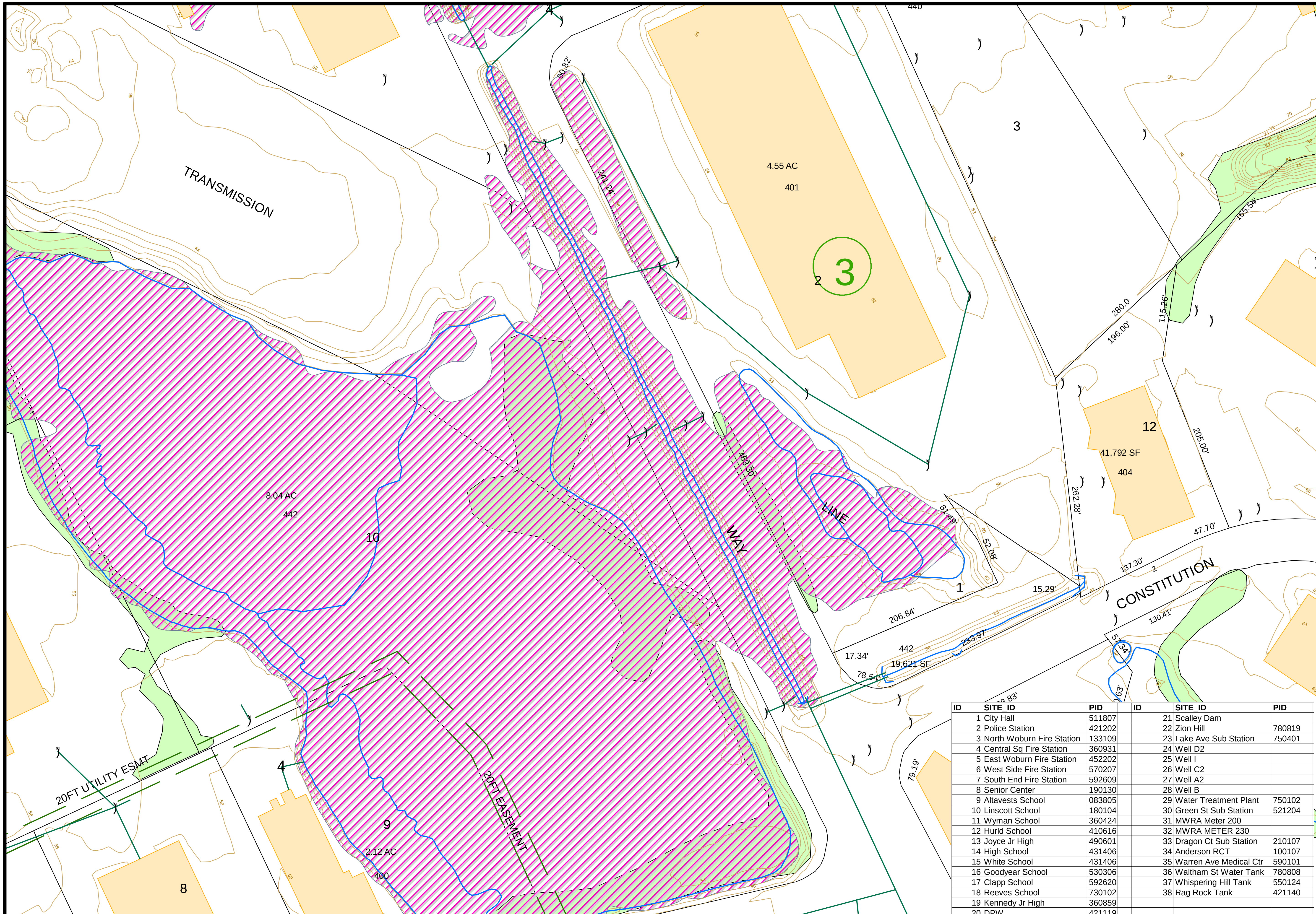
0 50 100 200 Feet

Conversion Date:
Revision Date: September 1, 2006

City of Woburn
Engineering Department

FIGURE 2-3

COMMERCE WAY FLOOD HAZARD AREA



Legend

- Beco_Easements
- Block Circles
- Buildings
- City_Boundry
- Easements
- drainage
- PorchDecks
- Contours
- ParkingLots
- Driveways
- EdgeofPvmt
- Paper_Streets
- Parcels
- Treed Area
- roadsnew
- Zoning Lines
- Local100yrFloodPlain
- R-1 Zoning Text
- 12 Parcel Number
- 8 Block Number
- 5,500 SF Acreage
- 100.00' Dimensions

ID	SITE_ID	PID	ID	SITE_ID	PID
1	City Hall	511807	21	Scalley Dam	
2	Police Station	421202	22	Zion Hill	780819
3	North Woburn Fire Station	133109	23	Lake Ave Sub Station	750401
4	Central Sq Fire Station	360931	24	Well D2	
5	East Woburn Fire Station	452202	25	Well I	
6	West Side Fire Station	570207	26	Well C2	
7	South End Fire Station	592609	27	Well A2	
8	Senior Center	190130	28	Well B	
9	Altavests School	083805	29	Water Treatment Plant	750102
10	Linscott School	180104	30	Green St Sub Station	521204
11	Wyman School	360424	31	MWRA Meter 200	
12	Hurld School	410616	32	MWRA METER 230	
13	Joyce Jr High	490601	33	Dragon Ct Sub Station	210107
14	High School	431406	34	Anderson RCT	100107
15	White School	431406	35	Warren Ave Medical Ctr	590101
16	Goodyear School	530306	36	Waltham St Water Tank	780808
17	Clapp School	592620	37	Whispering Hill Tank	550124
18	Reeves School	730102	38	Rag Rock Tank	421140
19	Kennedy Jr High	360859			
20	DPW	421119			

Scale 1 Inch = 100 feet

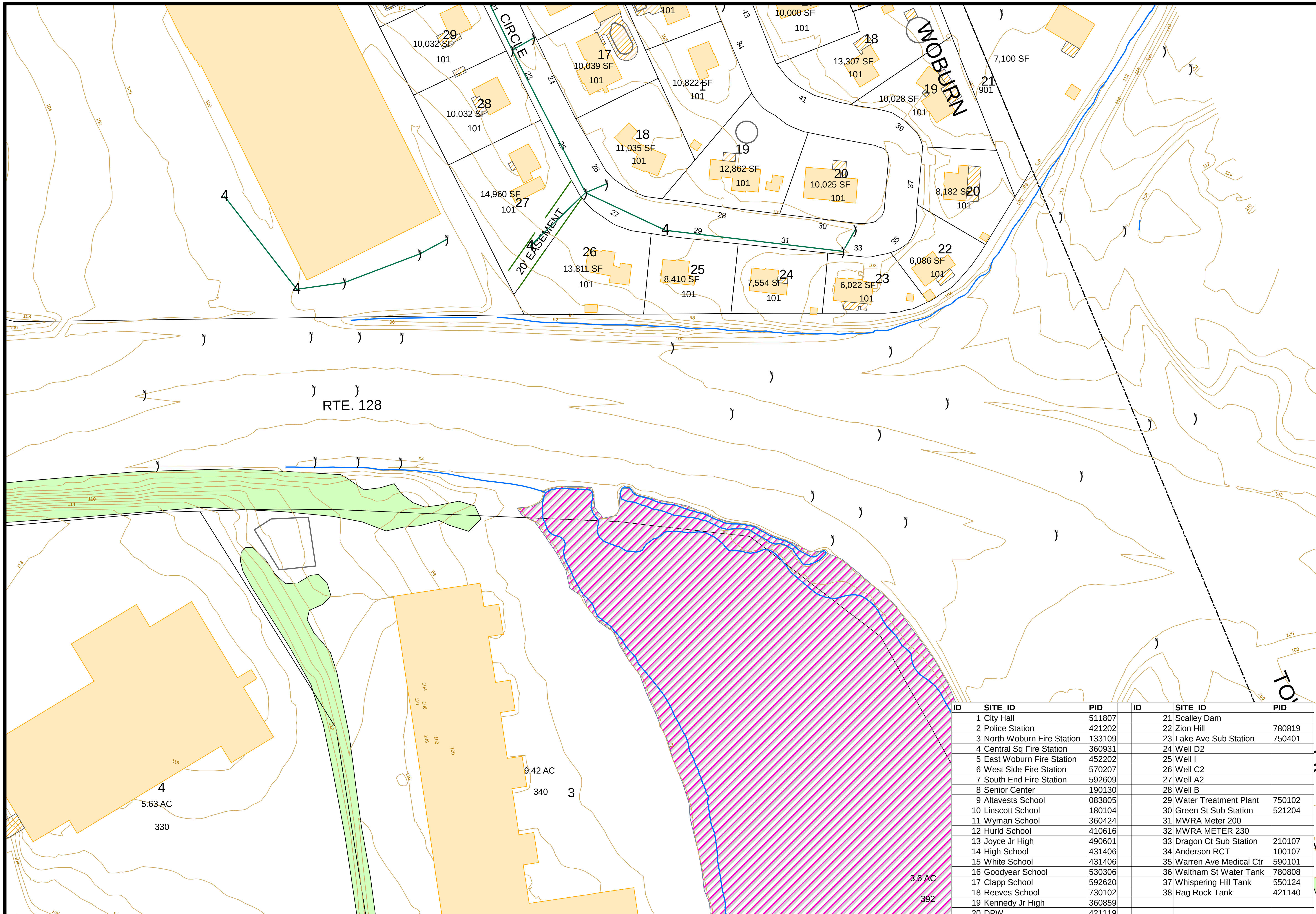
0 50 100 200 Feet

Conversion Date:
Revision Date: September 1, 2006

City of Woburn
Engineering Department

FIGURE 2-4

RICHARD CIRCLE FLOOD HAZARD AREA



ID	SITE_ID	PID	ID	SITE_ID	PID
1	City Hall	511807	21	Scalley Dam	
2	Police Station	421202	22	Zion Hill	780819
3	North Woburn Fire Station	133109	23	Lake Ave Sub Station	750401
4	Central Sq Fire Station	360931	24	Well D2	
5	East Woburn Fire Station	452202	25	Well I	
6	West Side Fire Station	570207	26	Well C2	
7	South End Fire Station	592609	27	Well A2	
8	Senior Center	190130	28	Well B	
9	Altavests School	083805	29	Water Treatment Plant	750102
10	Linscott School	180104	30	Green St Sub Station	521204
11	Wyman School	360424	31	MWRA Meter 200	
12	Hurld School	410616	32	MWRA METER 230	
13	Joyce Jr High	490601	33	Dragon Ct Sub Station	210107
14	High School	431406	34	Anderson RCT	100107
15	White School	431406	35	Warren Ave Medical Ctr	590101
16	Goodyear School	530306	36	Waltham St Water Tank	780808
17	Clapp School	592620	37	Whispering Hill Tank	550124
18	Reeves School	730102	38	Rag Rock Tank	421140
19	Kennedy Jr High	360859			
20	DPW	421119			

Legend

- Beco_Easements
- Block Circles
- Buildings
- City_Boundry
- Easements
- drainage
- PorchDecks
- Contours
- ParkingLots
- Driveways
- EdgeofPvmt
- Paper_Streets
- Parcels
- Treed Area
- roadsnew
- Zoning Lines
- Local100yrFloodPlain
- R-1 Zoning Text
- 12 Parcel Number
- 8 Block Number
- 5,500 SF Acreage
- 100.00' Dimensions

Scale 1 Inch = 100 feet

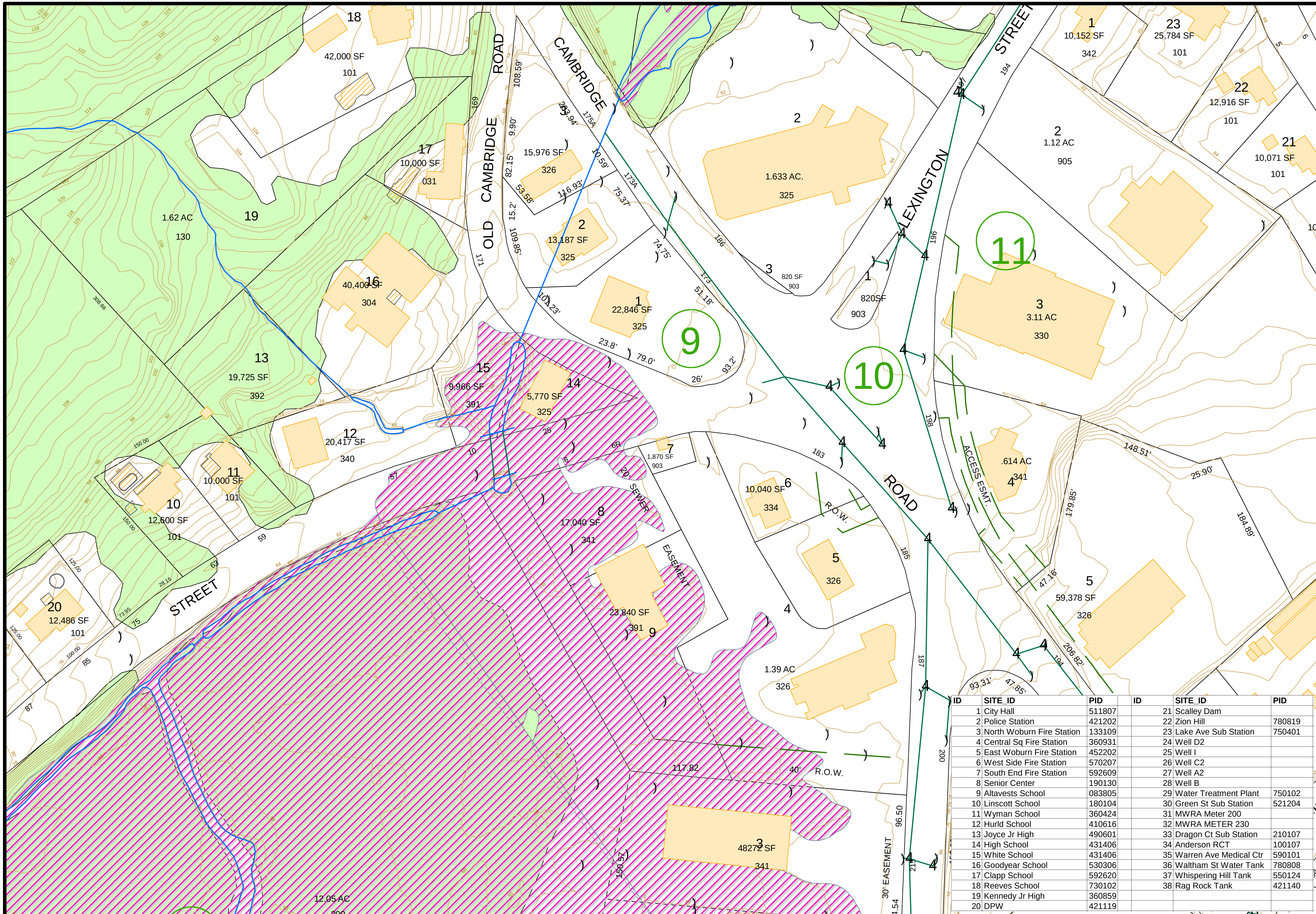
0 50 100 200 Feet

Conversion Date:
Revision Date: September 1, 2006

City of Woburn
Engineering Department

FIGURE 2-5

FOUR CORNERS FLOOD HAZARD AREA



ID	SITE_ID	PID	ID	SITE_ID	PID
1	City Hall	511807	21	Scalley Dam	
2	Police Station	421202	22	Zion Hill	780819
3	North Woburn Fire Station	133109	23	Lake Ave Sub Station	750401
4	Central Sq Fire Station	360931	24	Well D2	
5	East Woburn Fire Station	452202	25	Well I	
6	West Side Fire Station	570207	26	Well C2	
7	South End Fire Station	592609	27	Well A2	
8	Senior Center	190130	28	Well B	
9	Altavests School	083805	29	Water Treatment Plant	750102
10	Linscott School	180104	30	Green St Sub Station	521204
11	Wyman School	360424	31	MWRA Meter 200	
12	Hurld School	410616	32	MWRA METER 230	
13	Joyce Jr High	490601	33	Dragon Ct Sub Station	210107
14	High School	431406	34	Anderson RCT	100107
15	White School	431406	35	Warren Ave Medical Ctr	590101
16	Goodyear School	530306	36	Waltham St Water Tank	780808
17	Clapp School	592620	37	Whispering Hill Tank	550124
18	Reeves School	730102	38	Rag Rock Tank	421140
19	Kennedy Jr High	360859			
20	DPW	421119			

Legend

- Beco_Easements
- Block Circles
- Buildings
- City_Boundry
- Easements
- drainage
- PorchDecks
- Contours
- ParkingLots
- Driveways
- EdgeofPvmt
- Paper_Streets
- Parcels
- Treed Area
- roadsnew
- Zoning Lines
- Local100yrFloodPlain
- R-1 Zoning Text
- 12 Parcel Number
- 8 Block Number
- 5,500 SF Acreage
- 100.00' Dimensions

μ

Scale 1 Inch = 100 feet

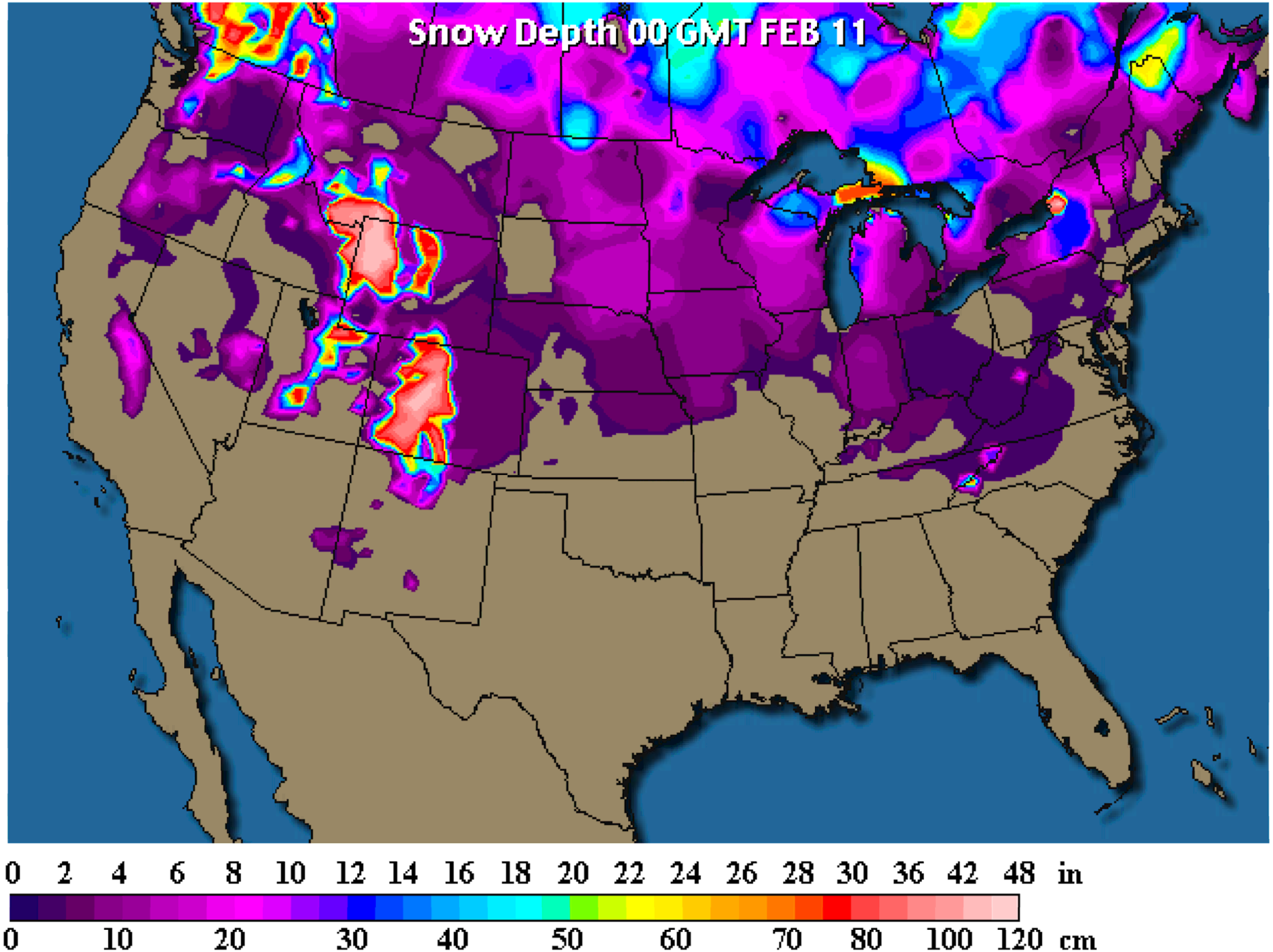
0 50 100 200 Feet

Conversion Date:
Revision Date: September 1, 2006

City of Woburn
Engineering Department

FIGURE 2-6

SNOWFALL DEPTHS



Legend

- Beco_Easements
- Block Circles
- Buildings
- City_Boundry
- Easements
- drainage
- PorchDecks
- Contours
- ParkingLots
- Driveways
- EdgeofPvmt
- Paper_Streets
- Parcels
- Treed Area
- roadsnew
- Zoning Lines
- Local100yrFloodPlain
- R-1 Zoning Text
- 12 Parcel Number
- 8 Block Number
- 5,500 SF Acreage
- 100.00' Dimensions

N W E S

Scale 1 Inch = 100 feet

0 50 100 200 Feet

Conversion Date:
Revision Date: September 1, 2006

City of Woburn
Engineering Department

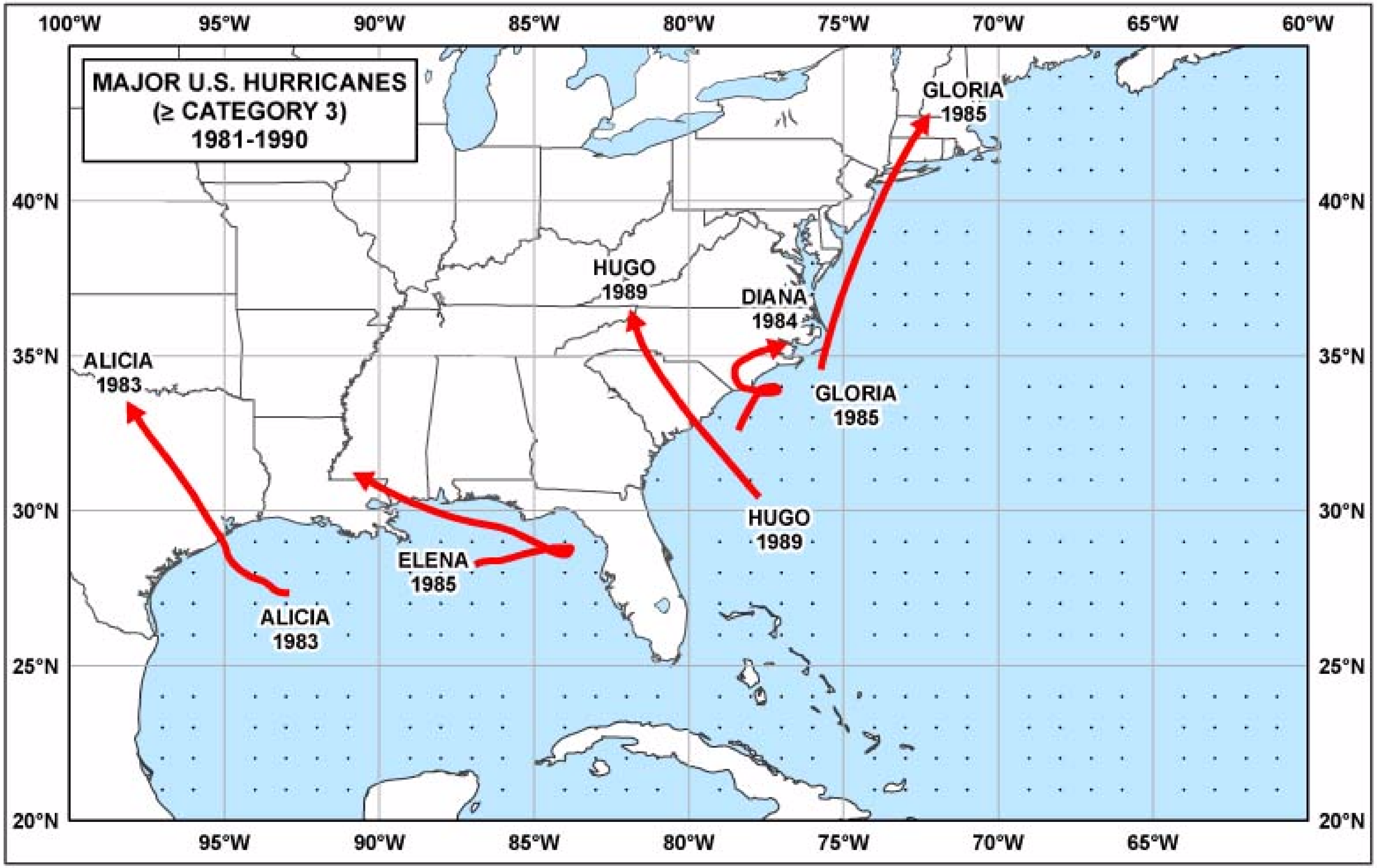


Figure 14. Landfalling United States major hurricanes (stronger than or equal to a category 3) during the period 1981-1990.

FIGURE 3-1

HURRICANE PATHS

Legend
- Beco_Easements
- Block Circles
- Buildings
- City_Boundry
- Easements
- drainage
- PorchDecks
- Contours
- ParkingLots
- Driveways
- EdgeofPvmt
- Paper_Streets
- Parcels
- Treed Area
- roadsnew
- Zoning Lines
- Local100yrFloodPlain
- R-1 Zoning Text
- 12 Parcel Number
- 8 Block Number
- 5,500 SF Acreage
- 100.00' Dimensions

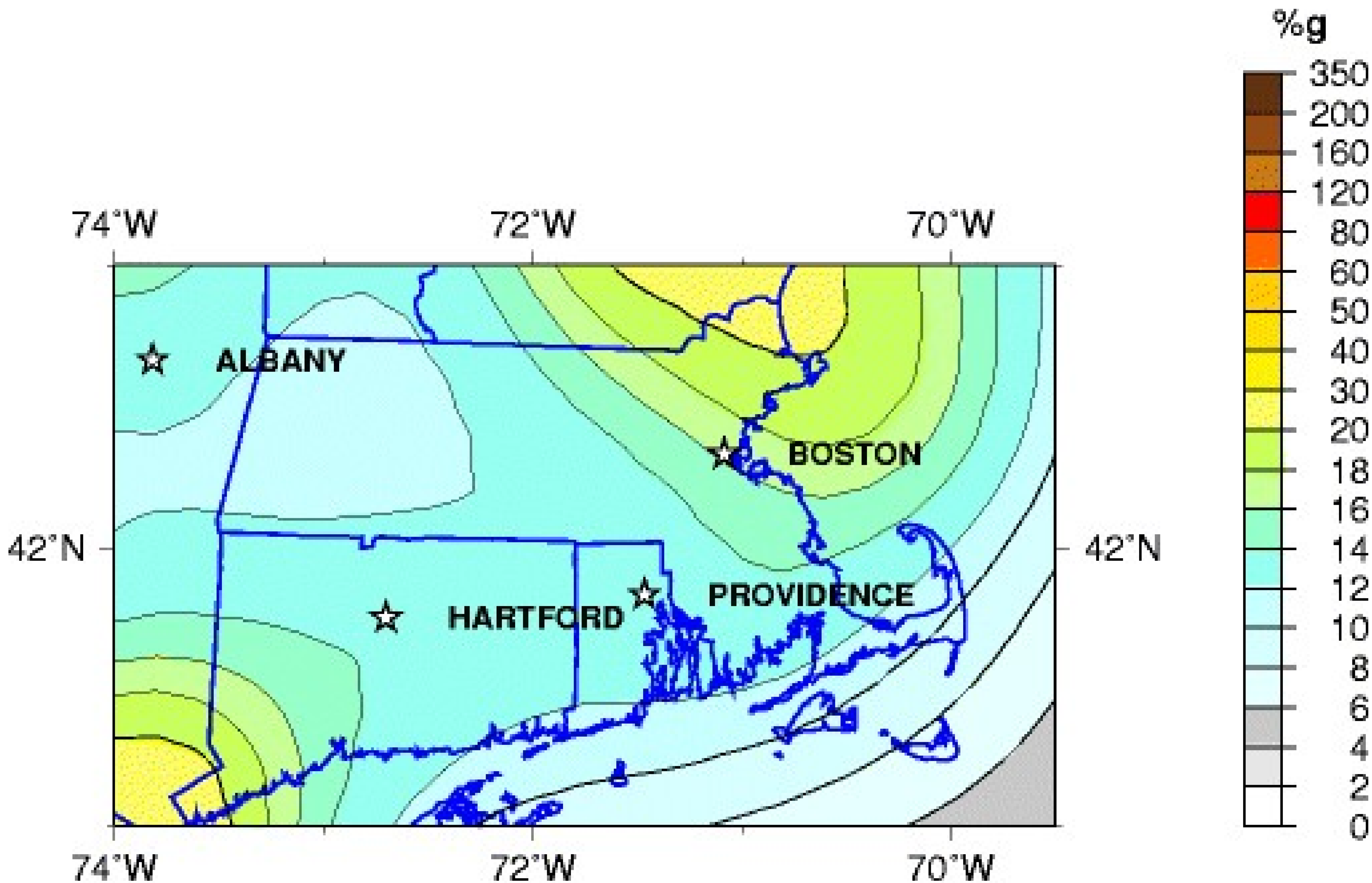
μ

Not to Scale

0 50 100 200 Feet

Conversion Date:
Revision Date: September 1, 2006

City of Woburn
Engineering Department



Peak Acceleration (%g) with 2% Probability of Exceedance in 50 Years
site: NEHRP B-C boundary
National Seismic Hazard Mapping Project

FIGURE 3-2

EARTHQUAKE PROBABILITY ZONES

Legend
Beco_Easements
Block Circles
Buildings
City_Boundry
Easements
drainage
PorchDecks
Contours
ParkingLots
Driveways
EdgeofPvmt
Paper_Streets
Parcels
Treed Area
roadsnew
Zoning Lines
Local100yrFloodPlain
R-1 Zoning Text
12 Parcel Number
8 Block Number
5,500 SF Acreage
100.00' Dimensions

Scale 1 Inch = 100 feet
0 50 100 200 Feet

Conversion Date:
Revision Date: September 1, 2006

City of Woburn
Engineering Department

FIGURE 3-3

BRUSH FIRE AREA HAZARD MAP

Legend

- Beco_Easements
- Block Circles
- Buildings
- City_Boundry
- Easements
- drainage
- PorchDecks
- Contours
- ParkingLots
- Driveways
- EdgeofPvmt
- Paper_Streets
- Parcels
- Treed Area
- roadsnew
- Zoning Lines
- Local100yrFloodPlain
- R-1 Zoning Text
- 12 Parcel Number
- Block Number
- 5,500 SF Acreage
- 100.00' Dimensions

μ

Scale 1 Inch = 100 feet

0 50 100 200 Feet

Conversion Date:
Revision Date: September 1, 2006

City of Woburn
Engineering Department

FIGURE 4-1

SNOW PLOW ROUTE MAP

Legend

- Beco_Easements
- Block Circles
- Buildings
- City_Boundry
- Easements
- drainage
- PorchDecks
- Contours
- ParkingLots
- Driveways
- EdgeofPvmt
- Paper_Streets
- Parcels
- Treed Area
- roadsnew
- Zoning Lines
- Local100yrFloodPlain
- R-1 Zoning Text
- 12 Parcel Number
- 8 Block Number
- 5,500 SF Acreage
- 100.00' Dimensions

Scale 1 Inch = 100 feet

0 50 100 200 Feet

Conversion Date:
Revision Date: September 1, 2006

City of Woburn
Engineering Department

FIGURE 4-2

SANDING ROUTE MAP

Legend

- Beco_Easements
- Block Circles
- Buildings
- City_Boundry
- Easements
- drainage
- PorchDecks
- Contours
- ParkingLots
- Driveways
- EdgeofPvmt
- Paper_Streets
- Parcels
- Treed Area
- roadsnew
- Zoning Lines
- Local100yrFloodPlain
- R-1 Zoning Text
- 12 Parcel Number
- 8 Block Number
- 5,500 SF Acreage
- 100.00' Dimensions

μ

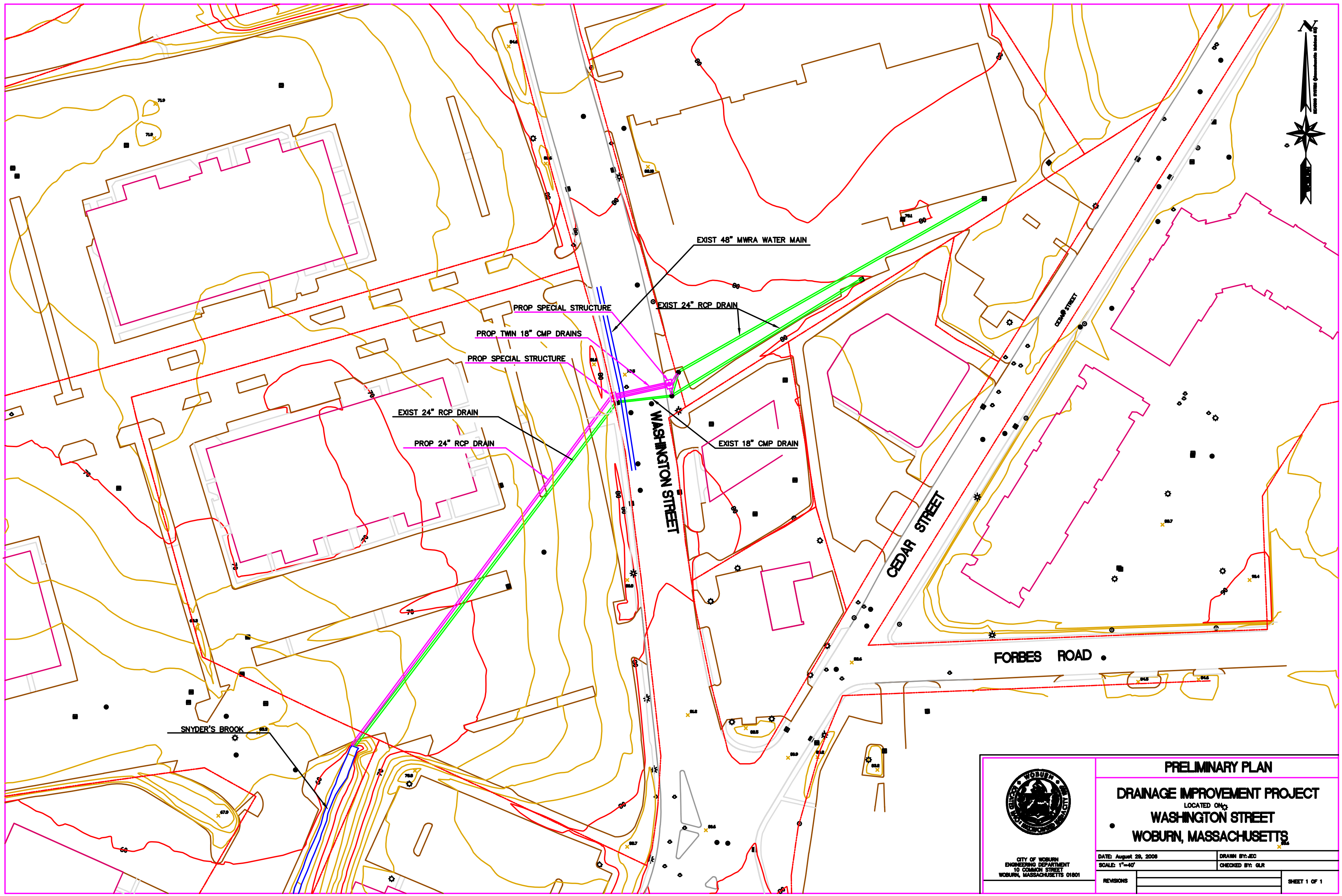
Scale 1 Inch = 100 feet

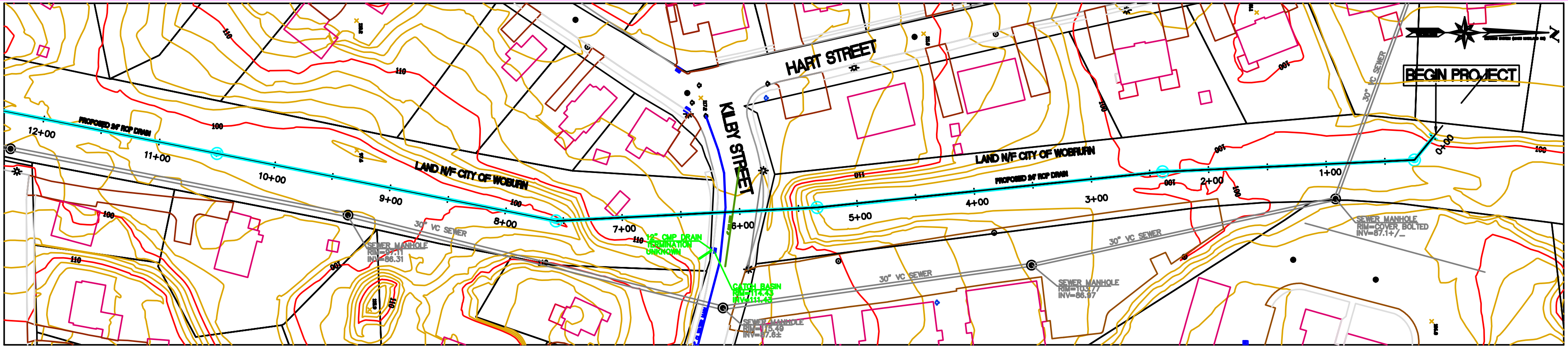
0 50 100 200 Feet

Conversion Date:
Revision Date: September 1, 2006

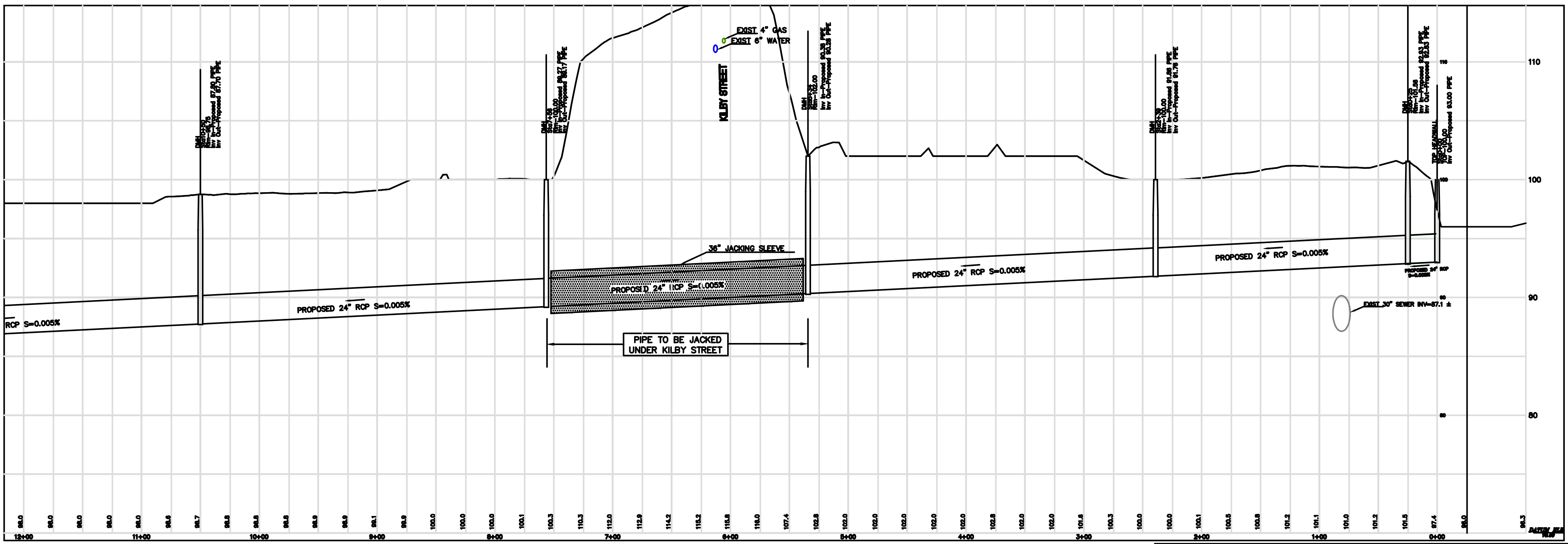
City of Woburn
Engineering Department

APPENDIX B – DRAINAGE IMPROVEMENT PLANS


EXIST 48" MWRA WATER MAIN
PROP SPECIAL STRUCTURE
EXIST 24" RCP DRAIN
PROP TWIN 18" CMP DRAINS
PROP SPECIAL STRUCTURE
EXIST 24" RCP DRAIN
EXIST 18" CMP DRAIN
PROP 24" RCP DRAIN
WASHINGTON STREET
CEDAR STREET
CEDAR STREET
FORBES ROAD
SNYDER'S BROOK
PRELIMINARY PLAN
DRAINAGE IMPROVEMENT PROJECT
LOCATED ON
WASHINGTON STREET
WOBURN, MASSACHUSETTS
CITY OF WOBURN
ENGINEERING DEPARTMENT
10 COMMON STREET
WOBURN, MASSACHUSETTS 01801
DATE: August 29, 2006
DRAWN BY: JEC
SCALE: 1"=40'
CHECKED BY: GLR
REVISIONS
SHEET 1 OF 1



SCALE: 1"=40'



SCALE: 1"=40' HORZ.
1"=4' VERT.

NOTE:
PLANIMETRICS DERIVED FROM THE CITY OF WOBURN GIS SYSTEM.
DATUM: NGVD 88

GRAPHIC SCALE
1"=40'

CITY OF WOBURN
ENGINEERING DEPARTMENT
10 COMMON STREET
WOBURN, MASSACHUSETTS 01801

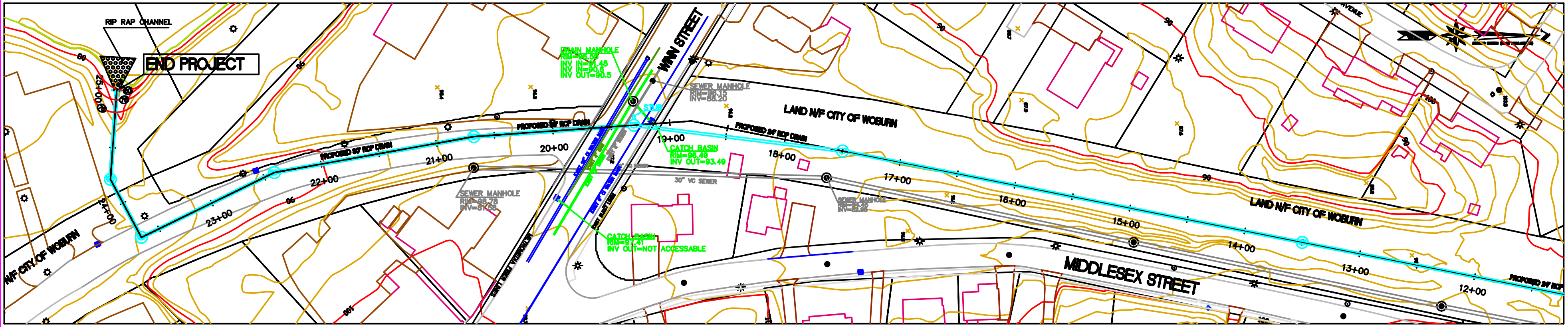
DRAINAGE IMPROVEMENT PLAN AND PROFILE

FLOOD HAZARD MITIGATION PROJECT

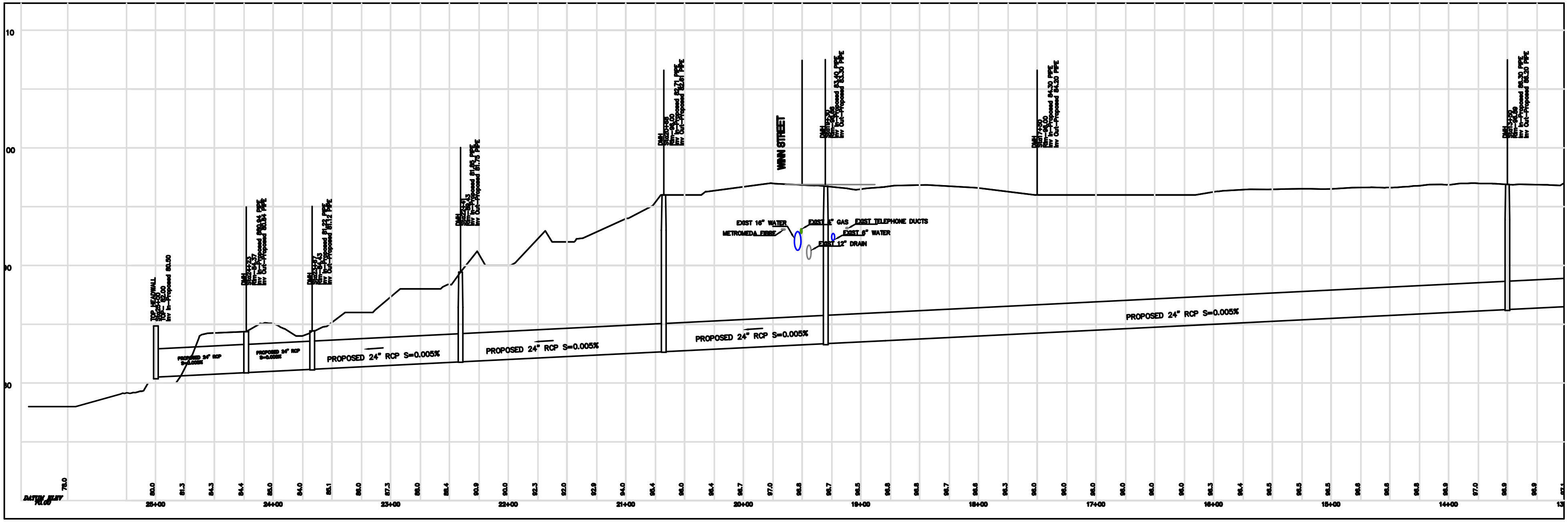
LOCATION

HART STREET - WINN STREET
WOBURN, MASSACHUSETTS

DATE: DECEMBER 4, 2006	DRAWN BY: BFG
SCALE: 1"=40'	CHECKED BY: JEC
REVISIONS	SHEET 2 OF 4



SCALE: 1"=40'



SCALE: 1"=40' HORZ.

NOTE:
PLANIMETRICS DERIVED FROM THE CITY OF WOBURN GIS SYSTEM.
DATUM: NGVD 88

GRAPHIC SCALE 1"=40'

CITY OF WOBURN
ENGINEERING DEPARTMENT
10 COMMON STREET
WOBURN, MASSACHUSETTS 01801

DRAINAGE IMPROVEMENT PLAN AND PROFILE

FLOOD HAZARD MITIGATION PROJECT

LOCATION

HART STREET - WINN STREET WOBURN, MASSACHUSETTS

DATE: DECEMBER 4, 2006	DRAWN BY: BFG
SCALE: 1"=40'	CHECKED BY: JEC
REVISIONS	SHEET 3 OF 4

APPENDIX C – PUBLIC MEETING NOTICE

CITY CLERKS OFFICE

City of Woburn Massachusetts

OFFICE OF THE CITY CLERK

Notice of Hearing

Notice is hereby given that there will be a **Public Hearing** on **May 1, 2007 at 7:30 p.m.** in the City Council Chambers, City Hall, Woburn, Massachusetts, **concerning a natural hazards mitigation plan to meet FEMA guidelines**. Any persons interested may review said petition and appear at the hearing. If special services, assistance or accommodations are required to participate in this meeting, please contact the City Clerk within sufficient time prior to the scheduled meeting time.

William C. Campbell
City Clerk and Clerk of the City Council

April 24, 2007

LEGAL NOTICE

CITY OF WOBURN OFFICE OF THE CITY CLERK

NOTICE OF PUBLIC HEARING

Notice is hereby given that there will be a **Public Hearing** on **May 1, 2007 at 7:30 p.m.** in the City Council Chambers, City Hall, Woburn, Massachusetts, **concerning a natural hazards mitigation plan to meet FEMA guidelines**. Any persons interested may review said petition and appear at the hearing. If special services, assistance or accommodations are required to participate in this meeting, please contact the City Clerk within sufficient time prior to the scheduled meeting time.

William C. CampbellCity Clerk and Clerk of the City Council
April 24, 2007

City of Woburn, Massachusetts

OFFICE OF THE CITY CLERK

City Hall
10 Common Street
Woburn, MA 01801
781-932-4450

WILLIAM C. CAMPBELL
City Clerk

May 8, 2007

To: John E. Corey, Jr., P.E., City Engineer

From; William C. Campbell, City Clerk

Re: Natural Hazards Mitigation Plan

At its Regular Meeting on May 1, 2007, the City Council conducted a public hearing concerning a natural hazards mitigation plan to meet FEMA guidelines. As a result of that meeting the City Council voted as follows:

"Motion made and 2nd that the natural hazards plan be adopted, all in favor, 9-0."

Please note that no specific plan was submitted as part of the record and therefore a specific date of the plan adopted is not available. However, the plan that was presented as part of a Powerpoint presentation by the Office of the City Engineer at the public hearing would be the plan referred to in the City Council vote.

If you have any questions, please feel free to contact this office.

William C. Campbell, City Clerk

cc: All Aldermen

City of Woburn
Massachusetts

Engineering Department

John E. Corey Jr., PE
City Engineer

Email jcorey@ci.woburn.ma.us
Tel (781) 932-4488
Fax (781) 932-4439

Memo to: City Council Members, William Campbell
From: John E. Corey, Jr., PE

Date: April 17, 2007

Subject: Natural Hazards Mitigation Plan – Public Hearing

The engineering department is preparing a Natural Hazards Mitigation Plan in conjunction with the City public safety to meet FEMA guidelines. This plan is required to obtain FEMA and MEMA funding and a public hearing is a necessary component of the plan.

As the plan must be submitted no later than May 15, 2007, it would appear that the May 1 City Council meeting would be the best date for holding the hearing. The engineering department will be the presenter at the hearing.

I trust the foregoing request meets with your approval. Should you have any questions or comments regarding this matter, please do not hesitate to contact this office.

Cc: Mayor Thomas McLaughlin

May 1, 2007 – In City Council – Attest: [signature] **City Clerk**

On the petition by City Engineer John Corey concerning a natural hazards mitigation plan to meet FEMA guidelines. PUBLIC HEARING OPENED. Appearing was City Engineer John Corey and he stated that in order to obtain FEMA grants there must be a natural hazards mitigation plan, that he is working with the Police Department, Fire Department, Board of Health and Department of Public Works to prepare a plan, that the plan will circulate to the City Council within the next week or two, that this public hearing is required as part of the process, that most of the critical databases with sensitive information are secured by the particular departments, that the Massachusetts Area Planning Council receives the document but not the critical documents behind the plan. IN FAVOR: None. OPPOSED: None. Motion made and 2nd that public hearing be closed, all in favor 9-0. Motion made and 2nd that the natural hazards plan be adopted, all in favor, 9-0.

****

APPENDIX D – HAZUS EARTHQUAKE & HURRICANE REPORT

HAZUS-MH: Earthquake Event Report

Region Name: ***Woburn***

Earthquake Scenario: ***Historic 7.0***

Print Date: ***July 31, 2006***

Disclaimer:

The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, geotechnical, and observed ground motion data.

Table of Contents

General Description of the Region

HAZUS is a regional earthquake loss estimation model that was developed by the Federal Emergency Management Agency and the National Institute of Building Sciences. The primary purpose of HAZUS is to provide a methodology and software application to develop earthquake losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from earthquakes and to prepare for emergency response and recovery.

The earthquake loss estimates provided in this report was based on a region that includes 1 county(ies) from the following state(s):

Massachusetts

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 12.87 square miles and contains 7 census tracts. There are over 14 thousand households in the region and has a total population of 37,258 people (2000 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 10 thousand buildings in the region with a total building replacement value (excluding contents) of 3,078 (millions of dollars). Approximately 95.00 % of the buildings (and 63.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 759 and 0 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

HAZUS estimates that there are 10 thousand buildings in the region which have an aggregate total replacement value of 3,078 (millions of dollars) . Appendix B provides a general distribution of the building value by State and County.

In terms of building construction types found in the region, wood frame construction makes up 87% of the building inventory. The remaining percentage is distributed between the other general building types.

Critical Facility Inventory

HAZUS breaks critical facilities into two (2) groups: essential facilities and high potential loss (HPL) facilities. Essential facilities include hospitals, medical clinics, schools, fire stations, police stations and emergency operations facilities. High potential loss facilities include dams, levees, military installations, nuclear power plants and hazardous material sites.

For essential facilities, there are 1 hospitals in the region with a total bed capacity of 210 beds. There are 19 schools, 1 fire stations, 1 police stations and 1 emergency operation facilities. With respect to HPL facilities, there are 1 dams identified within the region. Of these, 0 of the dams are classified as 'high hazard'. The inventory also includes 15 hazardous material sites, 0 military installations and 0 nuclear power plants.

Transportation and Utility Lifeline Inventory

Within HAZUS, the lifeline inventory is divided between transportation and utility lifeline systems. There are seven (7) transportation systems that include highways, railways, light rail, bus, ports, ferry and airports. There are six (6) utility systems that include potable water, wastewater, natural gas, crude & refined oil, electric power and communications. The lifeline inventory data are provided in Tables 2 and 3.

The total value of the lifeline inventory is over 759.00 (millions of dollars). This inventory includes over 85 kilometers of highways, 20 bridges, 497 kilometers of pipes.

Table 2: Transportation System Lifeline Inventory

System	Component	# locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	20	286.00
	Segments	4	454.50
	Tunnels	0	0.00
		Subtotal	**740.50**
Railways	Bridges	0	0.00
	Facilities	0	0.00
	Segments	7	18.80
	Tunnels	0	0.00
		Subtotal	**18.80**
Light Rail	Bridges	0	0.00
	Facilities	0	0.00
	Segments	0	0.00
	Tunnels	0	0.00
		Subtotal	**0.00**
Bus	Facilities	0	0.00
		Subtotal	**0.00**
Ferry	Facilities	0	0.00
		Subtotal	**0.00**
Port	Facilities	0	0.00
		Subtotal	**0.00**
Airport	Facilities	0	0.00
	Runways	0	0.00
		Subtotal	**0.00**
		Total	**759.30**

Table 3: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	5.00
	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal	**5.00**
Waste Water	Distribution Lines	NA	3.00
	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal	**3.00**
Natural Gas	Distribution Lines	NA	2.00
	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal	**2.00**
Oil Systems	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal	**0.00**
Electrical Power	Facilities	0	0.00
		Subtotal	**0.00**
Communication	Facilities	0	0.00
		Subtotal	**0.00**
		Total	**10.00**

Earthquake Scenario

HAZUS uses the following set of information to define the earthquake parameters used for the earthquake loss estimate provided in this report.

Scenario Name	Historic 7.0
Type of Earthquake	Historical
Fault Name	NA
Historical Epicenter ID #	244
Probabilistic Return Period	NA
Longitude of Epicenter	-70.80
Latitude of Epicenter	42.80
Earthquake Magnitude	7.00
Depth (Km)	10.00
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	CEUS Event

Building Damage

Building Damage

HAZUS estimates that about 2,094 buildings will be at least moderately damaged. This is over 21.00 % of the total number of buildings in the region. There are an estimated 94 buildings that will be damaged beyond repair. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS technical manual. Table 4 below summaries the expected damage by general occupancy for the buildings in the region. Table 5 summaries the expected damage by general building type.

Table 4: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Commercial	104	2.12	92	3.05	138	8.67	72	17.90	23	24.00
Education	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Government	1	0.02	1	0.02	1	0.06	0	0.12	0	0.14
Industrial	21	0.43	17	0.58	29	1.84	17	4.18	5	5.49
Other Residential	548	11.21	360	11.92	269	16.84	109	26.95	31	33.05
Religion	1	0.03	1	0.03	1	0.06	1	0.13	0	0.18
Single Family	4,217	86.20	2,547	84.39	1,158	72.53	205	50.72	35	37.14
Total	**4,892**		**3,018**		**1,596**		**404**		**94**	

Table 5: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	4,580	93.63	2760	91.43	1,206	75.54	172	42.52	12	12.90
Steel	71	1.45	53	1.74	100	6.27	55	13.59	16	17.18
Concrete	18	0.37	15	0.48	30	1.87	17	4.16	4	4.36
Precast	3	0.05	2	0.06	5	0.28	4	1.07	1	1.31
RM	46	0.93	23	0.76	47	2.95	36	8.78	5	5.35
URM	173	3.53	164	5.43	204	12.77	118	29.20	55	58.36
MH	2	0.04	3	0.09	5	0.32	3	0.68	1	0.54
Total	**4,892**		**3,018**		**1,596**		**404**		**94**	

*Note:

RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 210 hospital beds available for use. On the day of the earthquake, the model estimates that only 51 hospital beds (25.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 44.00% of the beds will be back in service. By 30 days, 79.00% will be operational.

Table 6: Expected Damage to Essential Facilities

Classification	Total	# Facilities		
		At Least Moderate Damage > 50%	Complete Damage > 50%	With Functionality > 50% on day 1
Hospitals	1	1	0	0
Schools	19	19	0	0
EOCs	1	1	0	0
PoliceStations	1	1	0	0
FireStations	1	1	0	0

Transportation and Utility Lifeline Damage

Table 7 provides damage estimates for the transportation system.

Table 7: Expected Damage to the Transportation Systems

System	Component	Number of Locations				
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality > 50 %	
					After Day 1	After Day 7
Highway	Segments	4	0	0	4	4
	Bridges	20	0	0	20	20
	Tunnels	0	0	0	0	0
Railways	Segments	7	0	0	7	7
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Light Rail	Segments	0	0	0	0	0
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Bus	Facilities	0	0	0	0	0
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	0	0	0	0	0
	Runways	0	0	0	0	0

Note: Roadway segments, railroad tracks and light rail tracks are assumed to be damaged by ground failure only. If ground failure maps are not provided, damage estimates to these components will not be computed.

Tables 8-10 provide information on the damage to the utility lifeline systems. Table 8 provides damage to the utility system facilities. Table 9 provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, HAZUS performs a simplified system performance analysis. Table 10 provides a summary of the system performance information.

Table 8 : Expected Utility System Facility Damage

System	# of Locations				
	Total #	With at Least Moderate Damage	With Complete Damage	with Functionality > 50 %	
				After Day 1	After Day 7
Potable Water	0	0	0	0	0
Waste Water	0	0	0	0	0
Natural Gas	0	0	0	0	0
Oil Systems	0	0	0	0	0
Electrical Power	0	0	0	0	0
Communication	0	0	0	0	0

Table 9 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	249	41	10
Waste Water	149	33	8
Natural Gas	100	35	9
Oil	0	0	0

Table 10: Expected Potable Water and Electric Power System Performance

	Total # of Households	Number of Households without Service				
		At Day 1	At Day 3	At Day 7	At Day 30	At Day 90
Potable Water	14,997	0	0	0	0	0
Electric Power		1,662	774	185	20	3

Induced Earthquake Damage

Fire Following Earthquake

Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. HAZUS uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be 3 ignitions that will burn about 0.03 sq. mi 0.23 % of the region's total area.) The model also estimates that the fires will displace about 61 people and burn about 6 (millions of dollars) of building value.

Debris Generation

HAZUS estimates the amount of debris that will be generated by the earthquake. The model breaks the debris into two general categories: a) Brick/Wood and b) Reinforced Concrete/Steel. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 0.00 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 40.00% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 0 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Social Impact

Shelter Requirement

HAZUS estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. The model estimates (693 households to be displaced due to the earthquake. Of these, 152 people (out of a total population of 37,258 will seek temporary shelter in public shelters.

Casualties

HAZUS estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four (4) severity levels that describe the extent of the injuries. The levels are described as follows;

· Severity Level 1: Injuries will require medical attention but hospitalization is not needed.
· Severity Level 2: Injuries will require hospitalization but are not considered life-threatening
· Severity Level 3: Injuries will require hospitalization and can become life threatening if not promptly treated.
· Severity Level 4: Victims are killed by the earthquake.

The casualty estimates are provided for three (3) times of day: 2:00 AM, 2:00 PM and 5:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residential occupancy load is maximum, the 2:00 PM estimate considers that the educational, commercial and industrial sector loads are maximum and 5:00 PM represents peak commute time.

Table 11 provides a summary of the casualties estimated for this earthquake

Table 11: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	3	1	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	1	0	0	0
	Industrial	6	1	0	0
	Other-Residential	52	12	2	3
	Single Family	30	5	0	1
	Total	**92**	**20**	**3**	**5**
2 PM	Commercial	174	42	6	11
	Commuting	0	0	0	0
	Educational	20	5	1	1
	Hotels	0	0	0	0
	Industrial	42	10	1	3
	Other-Residential	9	2	0	1
	Single Family	5	1	0	0
	Total	**250**	**60**	**8**	**16**
5 PM	Commercial	118	29	4	8
	Commuting	6	7	13	2
	Educational	3	1	0	0
	Hotels	0	0	0	0
	Industrial	26	6	1	2
	Other-Residential	21	5	1	1
	Single Family	12	2	0	0
	Total	**186**	**50**	**19**	**14**

Economic Loss

The total economic loss estimated for the earthquake is 412.73 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.

The total building-related losses were 397.54 (millions of dollars); 19 % of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 38 % of the total loss. Table 12 below provides a summary of the losses associated with the building damage.

Table 12: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Loses							
	Wage	0.00	0.64	23.48	1.15	0.36	25.63
	Capital-Related	0.00	0.27	23.88	0.68	0.07	24.90
	Rental	2.00	7.78	12.17	0.63	0.09	22.67
	Relocation	0.21	0.17	0.60	0.06	0.04	1.08
	Subtotal	**2.21**	**8.87**	**60.12**	**2.52**	**0.56**	**74.28**
Capital Stock Loses							
	Structural	11.49	8.26	32.30	7.13	1.13	60.30
	Non_Structural	52.23	41.11	70.06	19.60	2.68	185.68
	Content	17.50	10.04	31.96	12.92	1.31	73.72
	Inventory	0.00	0.00	1.27	2.26	0.02	3.55
	Subtotal	**81.23**	**59.40**	**135.59**	**41.90**	**5.14**	**323.26**
	Total	**83.44**	**68.27**	**195.71**	**44.43**	**5.70**	**397.54**

Transportation and Utility Lifeline Losses

For the transportation and utility lifeline systems, HAZUS computes the direct repair cost for each component only. There are no losses computed by HAZUS for business interruption due to lifeline outages. Tables 13 & 14 provide a detailed breakdown in the expected lifeline losses.

HAZUS estimates the long-term economic impacts to the region for 15 years after the earthquake. The model quantifies this information in terms of income and employment changes within the region. Table 15 presents the results of the region for the given earthquake.

Table 13: Transportation System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	454.52	$0.00	0.00
	Bridges	285.98	$14.69	5.14
	Tunnels	0.00	$0.00	0.00
	Subtotal	**740.50**	**14.70**	
Railways	Segments	18.79	$0.00	0.00
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**18.80**	**0.00**	
Light Rail	Segments	0.00	$0.00	0.00
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Bus	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Ferry	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Port	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Airport	Facilities	0.00	$0.00	0.00
	Runways	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
	Total	**759.30**	**14.70**	

Table 14: Utility System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Distribution Line	5.00	$0.19	3.75
	Subtotal	**4.98**	**$0.19**	
Waste Water	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Distribution Line	3.00	$0.15	4.94
	Subtotal	**2.99**	**$0.15**	
Natural Gas	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Distribution Line	2.00	$0.16	7.93
	Subtotal	**1.99**	**$0.16**	
Oil Systems	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**$0.00**	
Electrical Power	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**$0.00**	
Communication	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**$0.00**	
	Total	**9.96**	**$0.49**	

Table 15. Indirect Economic Impact with outside aid
(Employment as # of people and Income in millions of $)

	LOSS	Total	%
First Year			
	Employment Impact	0	0.00
	Income Impact	(3)	-0.28
Second Year			
	Employment Impact	0	0.00
	Income Impact	(9)	-0.84
Third Year			
	Employment Impact	0	0.00
	Income Impact	(12)	-1.08
Fourth Year			
	Employment Impact	0	0.00
	Income Impact	(12)	-1.08
Fifth Year			
	Employment Impact	0	0.00
	Income Impact	(12)	-1.08
Years 6 to 15			
	Employment Impact	0	0.00
	Income Impact	(12)	-1.08

Appendix A: County Listing for the Region

Middlesex,MA

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Massachusetts					
	Middlesex	37,258	1,944	1,134	3,078
Total State		**37,258**	**1,944**	**1,134**	**3,078**
Total Region		**37,258**	**1,944**	**1,134**	**3,078**

Debris Summary Report:

August 02, 2006

All values are in tons.

	Brick, Wood and Other	Reinf. Concrete and Steel	Tree Debris	Total
Massachusetts				
Middlesex	14,839	51	68,292	83,182
Total State	**14,839**	**51**	**68,292**	**83,182**
Study Region Total	**14,839**	**51**	**68,292**	**83,182**

Debris Summary Report:

August 02, 2006

All values are in tons.

	Brick, Wood and Other	Reinf. Concrete and Steel	Tree Debris	Total
Massachusetts				
Middlesex	368,482	6,477	101,257	476,216
Total State	**368,482**	**6,477**	**101,257**	**476,216**
Study Region Total	**368,482**	**6,477**	**101,257**	**476,216**

HAZUS-MH: Hurricane Event Report

Region Name: Woburn

Hurricane Scenario: Scenario-05Jul2006-Cat2

Print Date: Wednesday, August 02, 2006

Disclaimer:
The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific Hurricane. These results can be improved by using enhanced inventory data.

Table of Contents

General Description of the Region

HAZUS is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency and the National Institute of Building Sciences. The primary purpose of HAZUS is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

The hurricane loss estimates provided in this report are based on a region that includes 1 county(ies) from the following state(s):

- Massachusetts

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 12.87 square miles and contains 7 census tracts. There are over 15 thousand households in the region and has a total population of 37,258 people (2000 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 10 thousand buildings in the region with a total building replacement value (excluding contents) of 3,079 million dollars (2002 dollars). Approximately 95% of the buildings (and 63% of the building value) are associated with residential housing.

Building Inventory

General Building Stock

HAZUS estimates that there are 10,005 buildings in the region which have an aggregate total replacement value of 3,079 million (2002 dollars). Table 1 presents the relative distribution of the value with respect to the general occupancies. Appendix B provides a general distribution of the building value by State and County.

Table 1: Building Exposure by Occupancy Type

Occupancy	Exposure ($1000)	Percent of Total
Residential	1,944,046	63.1%
Commercial	856,481	27.8%
Industrial	242,794	7.9%
Agricultural	4,269	0.1%
Religious	16,016	0.5%
Government	5,089	0.2%
Education	10,017	0.3%
Total	3,078,712	100.0%

Essential Facility Inventory

For essential facilities, there are 1 hospitals in the region with a total bed capacity of 210 beds. There are 19 schools, 1 fire stations, 1 police stations and 1 emergency operation facilities.

Hurricane Scenario

HAZUS used the following set of information to define the hurricane parameters for the hurricane loss estimate provided in this report.

Scenario Name:	Scenario-05Jul2006-Cat2
Type:	Deterministic
Maximum Peak Gust in Study Region:	109 mph

User Defined Storm Track Input Data

Point	Latitude	Longitude	Time Step (hour)	Translation Speed (mph)	Radius To Max Winds (miles)	Max. Sustained Wind Speed (mph @ 10m)	Cental Pressure (mBar)	Profile Parameter	Radius to Hurricane Force Winds (miles)
1	42.33	-70.87	--	25.00	60.00	110.00	965.00	--	--
2	42.35	-70.99	--	25.00	60.00	110.00	965.00	--	--
3	42.37	-71.11	--	25.00	60.00	110.00	965.00	--	--
4	42.40	-71.20	--	25.00	60.00	110.00	965.00	--	--
5	42.43	-71.30	--	25.00	60.00	110.00	965.00	--	--
6	42.46	-71.39	--	25.00	60.00	110.00	965.00	--	--
7	42.49	-71.44	--	25.00	60.00	110.00	965.00	--	--
8	42.53	-71.50	--	25.00	60.00	110.00	965.00	--	--
9	42.60	-71.58	--	25.00	60.00	110.00	965.00	--	--

Building Damage

General Building Stock Damage

HAZUS estimates that about 776 buildings will be at least moderately damaged. This is over 8% of the total number of buildings in the region. There are an estimated 29 buildings that will be completely destroyed. The definition of the 'damage states' is provided in Volume 1: Chapter 6 of the HAZUS Hurricane technical manual. Table 2 below summarizes the expected damage by general occupancy for the buildings in the region. Table 3 summarizes the expected damage by general building type.

Table 2: Expected Building Damage by Occupancy

Occupancy	None		Minor		Moderate		Severe		Destruction	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Commercial	297	69.25	80	18.66	41	9.54	11	2.53	0	0.02
Education	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Government	2	69.67	1	19.79	0	9.37	0	1.17	0	0.00
Industrial	63	69.89	16	18.31	8	9.37	2	2.27	0	0.16
Religion	3	71.32	1	21.13	0	6.84	0	0.71	0	0.00
Residential	6,456	68.11	2,310	24.37	640	6.75	45	0.47	28	0.30
Total	**6,821**		**2,408**		**690**		**58**		**29**	

Table 3: Expected Building Damage by Building Type

Building Type	None		Minor		Moderate		Severe		Destruction	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Concrete	68	69.72	19	19.33	10	10.06	1	0.89	0	0.00
Masonry	563	64.92	168	19.39	126	14.49	9	1.09	1	0.10
MH	11	92.12	1	4.84	0	2.39	0	0.07	0	0.58
Steel	205	69.89	47	16.07	31	10.47	10	3.53	0	0.04
Wood	6,077	69.62	2,195	25.15	393	4.50	37	0.43	27	0.31

Essential Facility Damage

Before the hurricane, the region had 210 hospital beds available for use. On the day of the hurricane, the model estimates that 0 hospital beds (only 0.00%) are available for use. After one week, 100.00% of the beds will be in service. By 30 days, 100.00% will be operational.

Table 4: Expected Damage to Essential Facilities

		# Facilities		
Classification	Total	Probability of at Least Moderate Damage > 50%	Probability of Complete Damage > 50%	Expected Loss of Use < 1 day
EOCs	1	0	0	0
Fire Stations	1	0	0	0
Hospitals	1	0	0	0
Police Stations	1	0	0	0
Schools	19	0	0	0

Induced Hurricane Damage

Debris Generation

HAZUS estimates the amount of debris that will be generated by the hurricane. The model breaks the debris into three general categories: a) Brick/Wood, b) Reinforced Concrete/Steel, and c) Trees. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 83,182 tons of debris will be generated. Of the total amount, Brick/Wood comprises 18% of the total, Reinforced Concrete/Steel comprises of 0% of the total, with the remainder being Tree Debris. If the building debris tonnage is converted to an estimated number of truckloads, it will require 596 truckloads (@25 tons/truck) to remove the debris generated by the hurricane.

Social Impact

Shelter Requirement

HAZUS estimates the number of households that are expected to be displaced from their homes due to the hurricane and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 215 households to be displaced due to the hurricane. Of these, 47 people (out of a total population of 37,258) will seek temporary shelter in public shelters.

Economic Loss

The total economic loss estimated for the hurricane is 107.5 million dollars, which represents 3.49 % of the total replacement value of the region's buildings.

Building-Related Losses

The building related losses are broken into two categories: direct property damage losses and business interruption losses. The direct property damage losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the hurricane. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the hurricane.

The total property damage losses were 108 million dollars. 1% of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 74% of the total loss. Table 4 below provides a summary of the losses associated with the building damage.

Table 5: Building-Related Economic Loss Estimates

(Thousands of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
Property Damage						
	Building	57,550.17	11,440.24	3,700.43	418.52	73,109.37
	Content	13,207.75	4,485.16	2,577.59	152.85	20,423.35
	Inventory	0.00	188.73	395.80	6.27	590.81
	Subtotal	**70,757.91**	**16,114.14**	**6,673.82**	**577.65**	**94,123.52**
Business Interruption Loss						
	Income	0.00	810.20	44.14	27.17	881.52
	Relocation	5,194.31	1,875.16	398.43	79.26	7,547.17
	Rental	3,162.30	782.01	60.95	5.24	4,010.51
	Wage	0.00	743.36	73.57	161.30	978.23
	Subtotal	**8,356.62**	**4,210.74**	**577.09**	**272.97**	**13,417.43**
Total	**Total**	**79,114.53**	**20,324.88**	**7,250.91**	**850.62**	**107,540.95**

Appendix A: County Listing for the Region

Massachusetts
- Middlesex

Appendix B: Regional Population and Building Value Data

		Building Value (thousands of dollars)		
	Population	Residential	Non-Residential	Total
Massachusetts				
Middlesex	37,258	1,944,046	1,134,666	3,078,712
Total State	**37,258**	**1,944,046**	**1,134,666**	**3,078,712**
Total Study Region	**37,258**	**1,944,046**	**1,134,666**	**3,078,712**

HAZUS-MH: Earthquake Event Report

Region Name: ***Woburn***

Earthquake Scenario: ***MA 1963***

Print Date: ***July 31, 2006***

Disclaimer:

The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific earthquake. These results can be improved by using enhanced inventory, geotechnical, and observed ground motion data.

Table of Contents

General Description of the Region

HAZUS is a regional earthquake loss estimation model that was developed by the Federal Emergency Management Agency and the National Institute of Building Sciences. The primary purpose of HAZUS is to provide a methodology and software application to develop earthquake losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from earthquakes and to prepare for emergency response and recovery.

The earthquake loss estimates provided in this report was based on a region that includes 1 county(ies) from the following state(s):

Massachusetts

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 12.87 square miles and contains 7 census tracts. There are over 14 thousand households in the region and has a total population of 37,258 people (2000 Census Bureau data). The distribution of population by State and County is provided in Appendix B.

There are an estimated 10 thousand buildings in the region with a total building replacement value (excluding contents) of 3,078 (millions of dollars). Approximately 95.00 % of the buildings (and 63.00% of the building value) are associated with residential housing.

The replacement value of the transportation and utility lifeline systems is estimated to be 759 and 0 (millions of dollars) , respectively.

Building and Lifeline Inventory

Building Inventory

HAZUS estimates that there are 10 thousand buildings in the region which have an aggregate total replacement value of 3,078 (millions of dollars) . Appendix B provides a general distribution of the building value by State and County.

In terms of building construction types found in the region, wood frame construction makes up 87% of the building inventory. The remaining percentage is distributed between the other general building types.

Critical Facility Inventory

HAZUS breaks critical facilities into two (2) groups: essential facilities and high potential loss (HPL) facilities. Essential facilities include hospitals, medical clinics, schools, fire stations, police stations and emergency operations facilities. High potential loss facilities include dams, levees, military installations, nuclear power plants and hazardous material sites.

For essential facilities, there are 1 hospitals in the region with a total bed capacity of 210 beds. There are 19 schools, 1 fire stations, 1 police stations and 1 emergency operation facilities. With respect to HPL facilities, there are 1 dams identified within the region. Of these, 0 of the dams are classified as 'high hazard'. The inventory also includes 15 hazardous material sites, 0 military installations and 0 nuclear power plants.

Transportation and Utility Lifeline Inventory

Within HAZUS, the lifeline inventory is divided between transportation and utility lifeline systems. There are seven (7) transportation systems that include highways, railways, light rail, bus, ports, ferry and airports. There are six (6) utility systems that include potable water, wastewater, natural gas, crude & refined oil, electric power and communications. The lifeline inventory data are provided in Tables 2 and 3.

The total value of the lifeline inventory is over 759.00 (millions of dollars). This inventory includes over 85 kilometers of highways, 20 bridges, 497 kilometers of pipes.

Table 2: Transportation System Lifeline Inventory

System	Component	# locations/ # Segments	Replacement value (millions of dollars)
Highway	Bridges	20	286.00
	Segments	4	454.50
	Tunnels	0	0.00
		Subtotal	**740.50**
Railways	Bridges	0	0.00
	Facilities	0	0.00
	Segments	7	18.80
	Tunnels	0	0.00
		Subtotal	**18.80**
Light Rail	Bridges	0	0.00
	Facilities	0	0.00
	Segments	0	0.00
	Tunnels	0	0.00
		Subtotal	**0.00**
Bus	Facilities	0	0.00
		Subtotal	**0.00**
Ferry	Facilities	0	0.00
		Subtotal	**0.00**
Port	Facilities	0	0.00
		Subtotal	**0.00**
Airport	Facilities	0	0.00
	Runways	0	0.00
		Subtotal	**0.00**
		Total	**759.30**

Table 3: Utility System Lifeline Inventory

System	Component	# Locations / Segments	Replacement value (millions of dollars)
Potable Water	Distribution Lines	NA	5.00
	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal	**5.00**
Waste Water	Distribution Lines	NA	3.00
	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal	**3.00**
Natural Gas	Distribution Lines	NA	2.00
	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal	**2.00**
Oil Systems	Facilities	0	0.00
	Pipelines	0	0.00
		Subtotal	**0.00**
Electrical Power	Facilities	0	0.00
		Subtotal	**0.00**
Communication	Facilities	0	0.00
		Subtotal	**0.00**
		Total	**10.00**

Earthquake Scenario

HAZUS uses the following set of information to define the earthquake parameters used for the earthquake loss estimate provided in this report.

Scenario Name	MA 1963
Type of Earthquake	Historical
Fault Name	NA
Historical Epicenter ID #	4292
Probabilistic Return Period	NA
Longitude of Epicenter	-70.80
Latitude of Epicenter	42.70
Earthquake Magnitude	5.00
Depth (Km)	10.00
Rupture Length (Km)	NA
Rupture Orientation (degrees)	NA
Attenuation Function	CEUS Event

Building Damage

Building Damage

HAZUS estimates that about 12 buildings will be at least moderately damaged. This is over 0.00 % of the total number of buildings in the region. There are an estimated 0 buildings that will be damaged beyond repair. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS technical manual. Table 4 below summaries the expected damage by general occupancy for the buildings in the region. Table 5 summaries the expected damage by general building type.

Table 4: Expected Building Damage by Occupancy

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Agriculture	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Commercial	422	4.25	5	8.93	2	13.48	0	16.54	0	12.21
Education	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Government	3	0.03	0	0.05	0	0.08	0	0.09	0	0.07
Industrial	89	0.89	1	1.84	0	2.82	0	3.34	0	2.20
Other Residential	1,299	13.08	14	22.33	4	32.96	0	38.98	0	40.23
Religion	4	0.04	0	0.10	0	0.16	0	0.21	0	0.21
Single Family	8,115	81.71	41	66.75	6	50.50	0	40.84	0	45.08
Total	**9,931**		**61**		**11**		**1**		**0**	

Table 5: Expected Building Damage by Building Type (All Design Levels)

	None		Slight		Moderate		Extensive		Complete	
	Count	(%)	Count	(%)	Count	(%)	Count	(%)	Count	(%)
Wood	8,692	87.52	35	57.09	3	22.99	0	0.00	0	0.00
Steel	292	2.94	2	3.92	0	4.26	0	3.58	0	0.00
Concrete	83	0.83	1	1.24	0	1.22	0	0.38	0	0.00
Precast	14	0.14	0	0.46	0	1.24	0	1.87	0	0.00
RM	154	1.55	2	2.77	1	5.66	0	6.73	0	0.00
URM	684	6.89	21	33.92	7	63.79	1	87.31	0	100.00
MH	13	0.13	0	0.60	0	0.83	0	0.13	0	0.00
Total	**9,931**		**61**		**11**		**1**		**0**	

*Note:

RM Reinforced Masonry
URM Unreinforced Masonry
MH Manufactured Housing

Essential Facility Damage

Before the earthquake, the region had 210 hospital beds available for use. On the day of the earthquake, the model estimates that only 209 hospital beds (100.00%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 100.00% of the beds will be back in service. By 30 days, 100.00% will be operational.

Table 6: Expected Damage to Essential Facilities

		# Facilities		
Classification	**Total**	**At Least Moderate Damage > 50%**	**Complete Damage > 50%**	**With Functionality > 50% on day 1**
Hospitals	1	0	0	1
Schools	19	0	0	19
EOCs	1	0	0	1
PoliceStations	1	0	0	1
FireStations	1	0	0	1

Transportation and Utility Lifeline Damage

Table 7 provides damage estimates for the transportation system.

Table 7: Expected Damage to the Transportation Systems

System	Component	Number of Locations				
		Locations/ Segments	With at Least Mod. Damage	With Complete Damage	With Functionality > 50 %	
					After Day 1	After Day 7
Highway	Segments	4	0	0	4	4
	Bridges	20	0	0	20	20
	Tunnels	0	0	0	0	0
Railways	Segments	7	0	0	7	7
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Light Rail	Segments	0	0	0	0	0
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	0	0	0	0	0
Bus	Facilities	0	0	0	0	0
Ferry	Facilities	0	0	0	0	0
Port	Facilities	0	0	0	0	0
Airport	Facilities	0	0	0	0	0
	Runways	0	0	0	0	0

Note: Roadway segments, railroad tracks and light rail tracks are assumed to be damaged by ground failure only. If ground failure maps are not provided, damage estimates to these components will not be computed.

Tables 8-10 provide information on the damage to the utility lifeline systems. Table 8 provides damage to the utility system facilities. Table 9 provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, HAZUS performs a simplified system performance analysis. Table 10 provides a summary of the system performance information.

Table 8 : Expected Utility System Facility Damage

System	# of Locations				
	Total #	With at Least Moderate Damage	With Complete Damage	with Functionality > 50 %	
				After Day 1	After Day 7
Potable Water	0	0	0	0	0
Waste Water	0	0	0	0	0
Natural Gas	0	0	0	0	0
Oil Systems	0	0	0	0	0
Electrical Power	0	0	0	0	0
Communication	0	0	0	0	0

Table 9 : Expected Utility System Pipeline Damage (Site Specific)

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	249	0	0
Waste Water	149	0	0
Natural Gas	100	0	0
Oil	0	0	0

Table 10: Expected Potable Water and Electric Power System Performance

	Total # of Households	Number of Households without Service				
		At Day 1	At Day 3	At Day 7	At Day 30	At Day 90
Potable Water	14,997	0	0	0	0	0
Electric Power		0	0	0	0	0

Induced Earthquake Damage

Fire Following Earthquake

Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. HAZUS uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be 1 ignitions that will burn about 0.01 sq. mi 0.08 % of the region's total area.) The model also estimates that the fires will displace about 15 people and burn about 2 (millions of dollars) of building value.

Debris Generation

HAZUS estimates the amount of debris that will be generated by the earthquake. The model breaks the debris into two general categories: a) Brick/Wood and b) Reinforced Concrete/Steel. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 0.00 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 78.00% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 0 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Social Impact

Shelter Requirement

HAZUS estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. The model estimates (2 households to be displaced due to the earthquake. Of these, 0 people (out of a total population of 37,258 will seek temporary shelter in public shelters.

Casualties

HAZUS estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four (4) severity levels that describe the extent of the injuries. The levels are described as follows;

- Severity Level 1: Injuries will require medical attention but hospitalization is not needed.
- Severity Level 2: Injuries will require hospitalization but are not considered life-threatening
- Severity Level 3: Injuries will require hospitalization and can become life threatening if not promptly treated.
- Severity Level 4: Victims are killed by the earthquake.

The casualty estimates are provided for three (3) times of day: 2:00 AM, 2:00 PM and 5:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residential occupancy load is maximum, the 2:00 PM estimate considers that the educational, commercial and industrial sector loads are maximum and 5:00 PM represents peak commute time.

Table 11 provides a summary of the casualties estimated for this earthquake

Table 11: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	Commercial	0	0	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	0	0	0	0
	Industrial	0	0	0	0
	Other-Residential	0	0	0	0
	Single Family	0	0	0	0
	Total	**0**	**0**	**0**	**0**
2 PM	Commercial	1	0	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	0	0	0	0
	Industrial	0	0	0	0
	Other-Residential	0	0	0	0
	Single Family	0	0	0	0
	Total	**1**	**0**	**0**	**0**
5 PM	Commercial	0	0	0	0
	Commuting	0	0	0	0
	Educational	0	0	0	0
	Hotels	0	0	0	0
	Industrial	0	0	0	0
	Other-Residential	0	0	0	0
	Single Family	0	0	0	0
	Total	**1**	**0**	**0**	**0**

Economic Loss

The total economic loss estimated for the earthquake is 5.04 (millions of dollars), which includes building and lifeline related losses based on the region's available inventory. The following three sections provide more detailed information about these losses.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.

The total building-related losses were 5.04 (millions of dollars); 7 % of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 41 % of the total loss. Table 12 below provides a summary of the losses associated with the building damage.

Table 12: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Single Family	Other Residential	Commercial	Industrial	Others	Total
Income Loses							
	Wage	0.00	0.00	0.11	0.00	0.00	0.12
	Capital-Related	0.00	0.00	0.11	0.00	0.00	0.12
	Rental	0.01	0.04	0.06	0.00	0.00	0.11
	Relocation	0.00	0.00	0.00	0.00	0.00	0.01
	Subtotal	**0.01**	**0.04**	**0.29**	**0.01**	**0.00**	**0.36**
Capital Stock Loses							
	Structural	0.06	0.06	0.15	0.03	0.01	0.32
	Non_Structural	0.70	0.57	0.94	0.39	0.03	2.63
	Content	0.41	0.21	0.71	0.29	0.03	1.65
	Inventory	0.00	0.00	0.03	0.05	0.00	0.08
	Subtotal	**1.17**	**0.84**	**1.84**	**0.76**	**0.07**	**4.68**
	Total	**1.18**	**0.89**	**2.13**	**0.77**	**0.07**	**5.04**

Transportation and Utility Lifeline Losses

For the transportation and utility lifeline systems, HAZUS computes the direct repair cost for each component only. There are no losses computed by HAZUS for business interruption due to lifeline outages. Tables 13 & 14 provide a detailed breakdown in the expected lifeline losses.

HAZUS estimates the long-term economic impacts to the region for 15 years after the earthquake. The model quantifies this information in terms of income and employment changes within the region. Table 15 presents the results of the region for the given earthquake.

Table 13: Transportation System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Segments	454.52	$0.00	0.00
	Bridges	285.98	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Subtotal	**740.50**	**0.00**	
Railways	Segments	18.79	$0.00	0.00
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**18.80**	**0.00**	
Light Rail	Segments	0.00	$0.00	0.00
	Bridges	0.00	$0.00	0.00
	Tunnels	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Bus	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Ferry	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Port	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
Airport	Facilities	0.00	$0.00	0.00
	Runways	0.00	$0.00	0.00
	Subtotal	**0.00**	**0.00**	
	Total	**759.30**	**0.00**	

Table 14: Utility System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Distribution Line	5.00	$0.00	0.01
	Subtotal	**4.98**	**$0.00**	
Waste Water	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Distribution Line	3.00	$0.00	0.01
	Subtotal	**2.99**	**$0.00**	
Natural Gas	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Distribution Line	2.00	$0.00	0.02
	Subtotal	**1.99**	**$0.00**	
Oil Systems	Pipelines	0.00	$0.00	0.00
	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**$0.00**	
Electrical Power	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**$0.00**	
Communication	Facilities	0.00	$0.00	0.00
	Subtotal	**0.00**	**$0.00**	
	Total	**9.96**	**$0.00**	

Table 15. Indirect Economic Impact with outside aid
(Employment as # of people and Income in millions of $)

	LOSS	Total	%
First Year			
	Employment Impact	0	0.00
	Income Impact	0	0.00
Second Year			
	Employment Impact	0	0.00
	Income Impact	0	-0.01
Third Year			
	Employment Impact	0	0.00
	Income Impact	0	-0.01
Fourth Year			
	Employment Impact	0	0.00
	Income Impact	0	-0.01
Fifth Year			
	Employment Impact	0	0.00
	Income Impact	0	-0.01
Years 6 to 15			
	Employment Impact	0	0.00
	Income Impact	0	-0.01

Appendix A: County Listing for the Region

Middlesex,MA

Appendix B: Regional Population and Building Value Data

State	County Name	Population	Building Value (millions of dollars)		
			Residential	Non-Residential	Total
Massachusetts					
	Middlesex	37,258	1,944	1,134	3,078
Total State		**37,258**	**1,944**	**1,134**	**3,078**
Total Region		**37,258**	**1,944**	**1,134**	**3,078**

Debris Summary Report

July 31, 2006

All values are in thousands of tons.

	Brick, Wood & Others	Concrete & Steel	Total
Massachusetts			
Middlesex	77	114	191
Total State	**77**	**114**	**191**
Study Region Total	**77**	**114**	**191**

HAZARD MITIGATION PLAN
BIBLIOGRAPHY OF FLOOD AND DRAINAGE STUDIES

Allen & Major Associates, Inc., *Drainage Report for Salem Place Site Redevelopment* February 2, 2005

Allen & Major Associates, Inc., *Definitive Drainage Calculations for Rose Farm Subdivision* March 23, 1995

Allen & Major Associates, Inc., *Drainage Calculations for Trade Center Park – Sylvan Road* March, 1999

Allen & Major Associates, Inc., *100 Sylvan Road - Notice of Resource Delineation* August 3, 2006

Allen & Major Associates, Inc., *100 Sylvan Road Drainage Report*, August11, 2006 revised on September 14, 2006

Allen & Major Associates, Inc., *9 Forbes Road Proposed Site Redevelopment Notice of Intent* June 28, 2001

Allen & Major Associates, Inc., *Flood Plain Study for Showcase Cinema Complex and Middlesex Canal*, May, 1995

Allen & Major Associates, Inc., *Hydrological Analysis, Cinema Deluxe Proposed Site Redevelopment* March 11, 2005

B L Companies, *Whole Foods Market, Inflow/Infiltration Study* December 20, 2004

Benchmark Survey, *Development Impact Statement and HydroCAD Summary for 5 Crescent Avenue* October 24, 2005

Borselli Engineering & Development, Inc., *Drainage Report for Proposed 15-Lot Subdivision – Spence Farm Property – 84 Lowell Street*, September 6 2005

Camp, Dresser & McKee, Inc., *Upper Mystic River Watershed Board, Horn Pond Brook Flood Control Evaluation*, October, 2003

Carter Burgess, Inc. and Greenman Pedersen, Inc., *Draft EIR Report, MVP Sports dba Decathlon Sports369 Washington Street*, March 14, 2006

Coler & Colantonio, Inc., *Proposed Meetinghouse, Cambridge MA Stake, 71 Wyman Street*, September 12, 2005

Commonwealth Engineering, Inc., *Notice of Filing for Wetlands Permit/Determination, A.G. Pernokas Drive*, June 27, 1994

John E. Corey, Jr., P.E., *May 14-16 Flooding Event – Post Incident Report*, City of Woburn Engineering Department, May 25 2006.

Corey & Donahue, Inc., *Drainage Calculations and Remedial Measures, Old Farm Road and Bedford Road*, May 13, 1997

Corey & Donahue, Inc., *Cummings Brook Park Subdivision, Coventry Lane, Notice of Intent,* October 28, 1998

Daylor Consulting Group, Inc., *Abbreviated Notice of Resource Area Delineation, Archstone Woburn*, November 29, 2000

Duran Associates, Inc., *Notice of Intent, 27 Normac Road Site Renovation*, August 31,1998

GEI Consultants, Inc., *Scalley Dam, Emergency Inspections* August 4, 1998

Hamway Engineering, Inc., *Drainage Calculations for Woburn Council for Social Concern, 2 Merrimac Street*, February 26, 2002

Hayes Engineering, Inc., *Revised Mitigative Drainage Study, Inwood Drive*, September 14, 2004

LEC Environmental Consultants, Inc., *Abbreviated Notice of Resource Area Delineation and Wetland Resource Area Analysis, Canal Condominiums, Merrimac Street*, June 12, 2003

Massachusetts Area Planning Council, *Urban Watershed Management in the Mystic River Basin, spy Pond, Arlington and Horn Pond, Woburn*, July, 2002, 2 vols

H. W. Moore Associates, Inc., *Kimball Place Stormwater Runoff Analysis*, March 9, 2006

U. S. Army Corps of Engineers, *Scalley Dam Report*, January 16, 1997

Vanasse Hangen Brustlin, Inc., *Stormwater Management Report, Target Store* July, 1997

Vanasse Hangen Brustlin, Inc., *Commerce Way Drainage Improvements – Hydrologic and Hydraulic Report*, September, 1999
Vanasse Hangen Brustlin, Inc., *Notice of Intent, Woburn Wetlands Ordinance for Main Street Shopping Center*, February 10, 2000

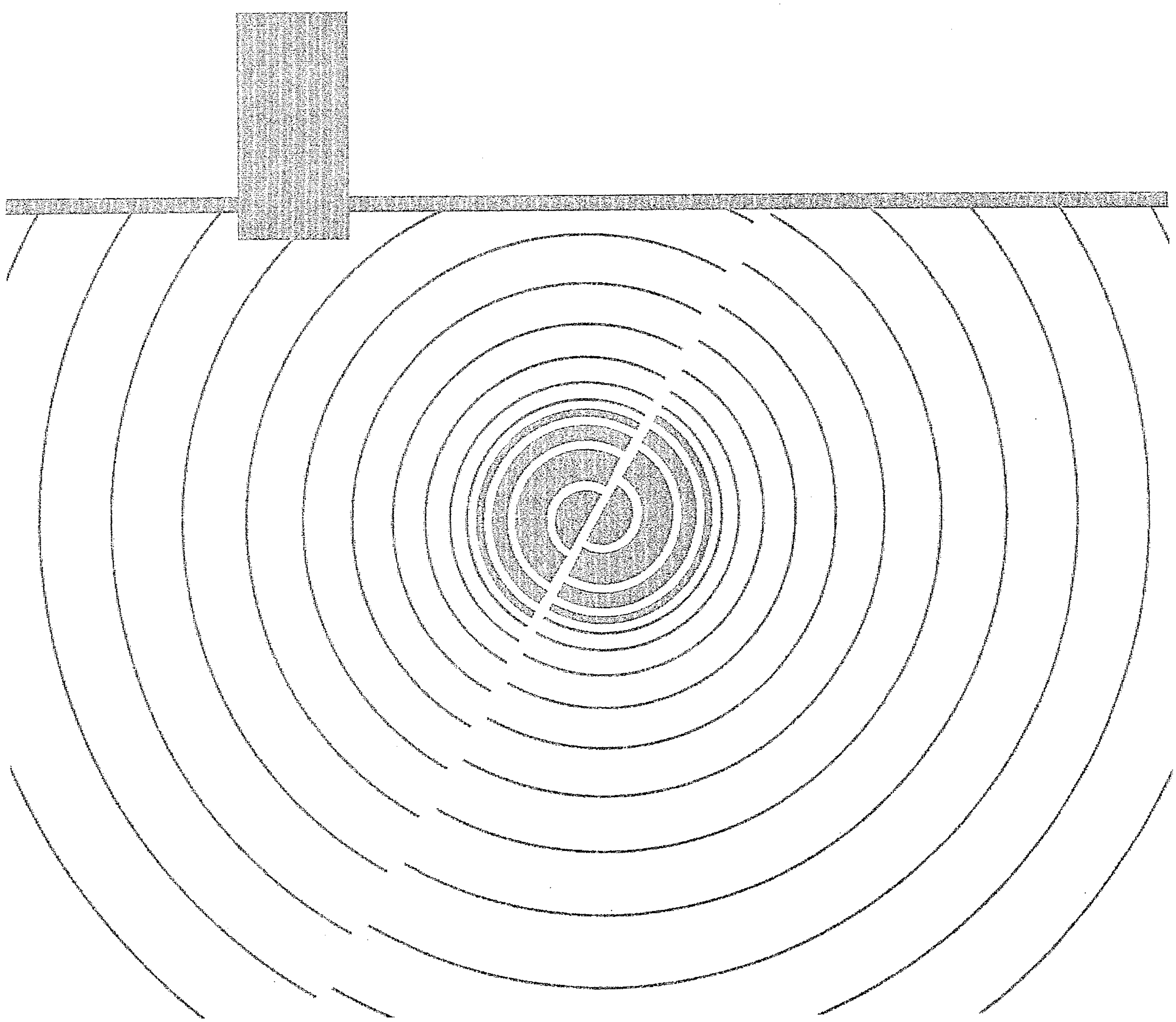
Vanasse Hangen Brustlin, Inc., *Aberjona River Industri-Plex Flooding Study*, March, 1998

Vanasse Hangen Brustlin, Inc., *Middlesex Canal/Halls Brook Hydrologic/Hydraulic Analysis*, U. S. Army Corps of Engineers, January, 2003

Westcott Site Services, *Alfred Street Brook Flooding Study* February 10, 1989

Wright & Company, Inc., *Application for a Special Permit and Site Plan Review for Woodbridge Station, 36-38 Cambridge Road*, July 12, 1996

Appendix A: History and Principles of Seismic Design



Appendix A
History and Principles of Seismic Design

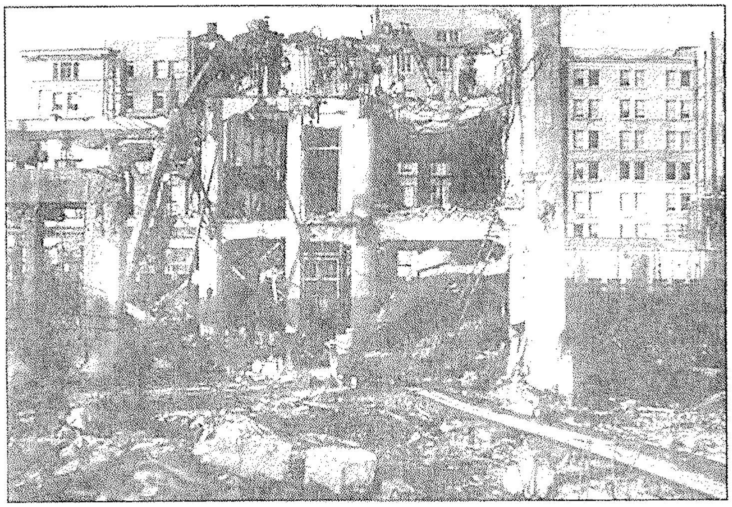


FIGURE A.1 *This 8-story reinforced concrete building was one of scores that collapsed during the 1923 Tokyo (Kanto) earthquake. The disaster prompted a limit on building heights. (Source: Carl V. Steinbrugge Collection, Earthquake Engineering Research Center)*

History of Seismic Standards

The first quantitative seismic code was developed by an Italian commission following the 1908 Messina-Reggio earthquake, which killed 160,000 people. Following the 1923 earthquake in Kanto, Japan, which killed 140,000 people, the Home Office of Japan adopted a seismic coefficient and a limit on building heights.[1]

First U.S. Seismic Codes: UBC and SEAOC in California

The earliest seismic design provisions in the United States were introduced in the appendix to the 1927 Uniform Building Code (UBC), as a result of the 1925 Santa Barbara earthquake.[2] The 1930 edition included strict specifications for mortar and workmanship on masonry (brick) buildings. However, damage from the Long Beach earthquake of 1933 (Richter magnitude 6.8) proved that unreinforced mortar is unstable in earthquakes. Eighty-six percent of unreinforced masonry buildings in the city of Long Beach experienced either collapse or extensive damage, rendering the buildings useless. Seventy-five percent of schools were heavily damaged. Soon after this earthquake California enacted the Field Act, which specified seismic design forces for school buildings, and the Riley Act, which mandated seismic design for most public buildings throughout the state.

By the 1950s some California municipalities had adopted additional seismic-resistant design and material specifications. UBC was the first model building code to incorporate comprehensive seismic design requirements, though they remained in the appendix for many years. The 1949 edition of the UBC contained the first national seismic hazard map.

In 1957 the Structural Engineers Association of California (SEAOC) began to develop seismic standards for use throughout the state. SEAOC in 1959 published the first edition of *Recommended Lateral Force Requirements and Commentary*, commonly called the *Blue Book*. The *Blue Book* reflected the latest knowledge of seismic design and was used throughout California. The seismic design provisions remained in an appendix to the UBC until the International Conference of Building Officials (ICBO) adopted the *Blue Book* provisions into the main code in 1961. The seismic requirements of the UBC remained largely unchanged, except for some map revisions, until after the 1971 San Fernando earthquake. Revisions were made to the 1973 UBC, and new requirements, based on the work of SEAOC, were introduced in the 1976 edition.

Federal Involvement Expands: The ATC Project

Early in the 1970s the National Science Foundation (NSF) funded a project, under the guidance of the National Bureau of Standards (NBS, now the National Institute of Standards and Technology), to evaluate existing earthquake-resistant design provisions. In 1974 the NBS contracted the project to the Applied Technology Council (ATC). The ATC is a nonprofit corporation established in 1971 to assist the design practitioner in structural engineering. It is guided by a Board of Directors with representatives from various structural and civil engineering organizations. ATC also identifies and encourages research and develops consensus opinions on structural engineering issues.

Over three years ATC published several drafts, which received extensive peer review. In 1978 ATC published the final report titled *Tentative Provisions for the Development of Seismic Regulations for Buildings (ATC 3-06)*. The SEAOC and UBC used the ATC 3-06 report to revise their recommendations and building code.

The NBS in the late 1970s published a *Plan for the Assessment and Implementation of Seismic Design Provisions for Buildings*. This plan analyzed ATC 3-06 and facilitated its development into design standards and building codes.

Further Federal Involvement: NEHRP and the BSSC

In the late 1970s the U.S. Congress passed the Earthquake Hazards Reduction Act of 1977 (PL 95-124), establishing the National Earthquake Hazards Reduction Program (NEHRP), a multi-agency program to fund research and improve practice in reducing earthquake hazards. Since 1977 NEHRP has been the primary source of funding for earthquake research. In 1979 the Federal Emergency Management Agency (FEMA) was established as the lead federal agency for coordinating NEHRP.

The Building Seismic Safety Council (BSSC) was established in 1979 as an independent voluntary body under the auspices of the National Institute of Building Science (NIBS). The purpose of the BSSC is to provide a national forum to foster seismic safety. The concept of the BSSC was developed by the ATC, SEAOC, NIBS, NSF, National Bureau of Standards (now the National Institute of Science and Technology), FEMA, and American Society of Civil Engineers (ASCE). Currently, members of BSSC come from more than fifty organizations, such as the American Consulting Engineers Council, Masonry Institute of America, and American Iron and Steel Institute, all having interest in seismic-related issues.

Under a contract with FEMA, BSSC revised ATC 3-06 through a consensus process of its members. After balloting BSSC members twice and receiving approval, FEMA released the recommendations in 1985 under the title *NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings*, commonly called the *NEHRP Provisions*. The BSSC, with FEMA funding, continues to update the seismic recommendations using a consensus process. The most current edition was published by FEMA in 1994, and the 1997 edition will be published in early 1998.

Federal Buildings: EO 12699 & EO 12941

The federal government, under presidential Executive Order 12699 (January 5, 1990), now requires seismic design for its new buildings. According to the executive order, titled *Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction*, federal agencies must by February 1993 require appropriate seismic design and construction standards for new federal and federally assisted,

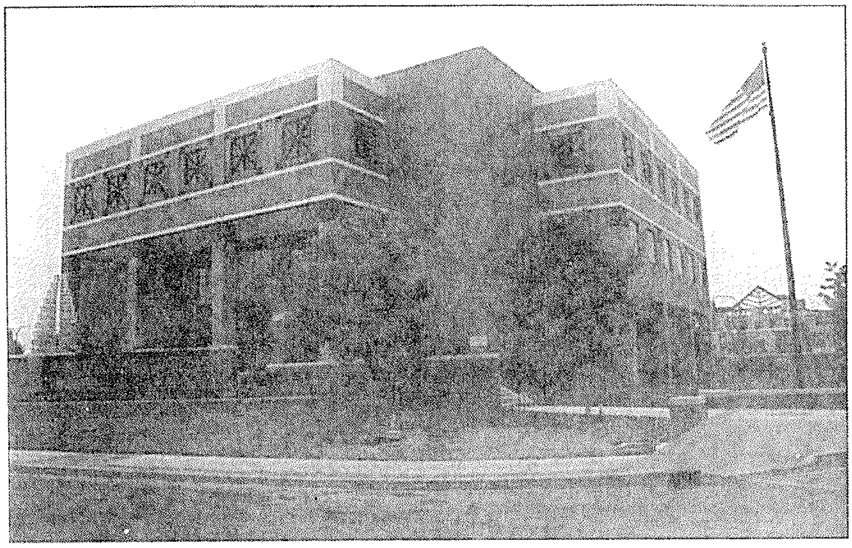


FIGURE A.2 All new federal buildings, such as this federal courthouse in Urbana, Illinois, must be built with seismic design appropriate to the region. (Photo: R. Walker)

leased, and regulated buildings. EO 12699 is significant for state and local governments, because it makes seismic design more prevalent throughout the nation and increases the number of experienced seismic designers and contractors.

Executive Order 12699 is far-reaching, because all new buildings that are owned, leased, or receive federal assistance now must have seismic-resistant design. Also covered are federally regulated or assisted buildings, including single-family homes with Federal Housing Administration or Veterans Administration mortgages.[3]

Under Executive Order 12699, the seismic design provisions used may be those of the municipality or state in which the building is built, so long as the responsible agency or the Interagency Committee on Seismic Safety in Construction (ICSSC) finds that they provide adequately for seismic safety.[4] Accordingly, the ICSSC in 1992 recommended the use of standards and practices that are substantially equivalent to the seismic safety levels in the 1988 *NEHRP Provisions*. Each of the following model codes has been found to provide a level of seismic safety substantially equivalent to the 1988 *NEHRP Provisions*: the 1991 ICBO *Uniform Building Code*, the 1992 *Supplement to the BOCA National Building Code*, and the 1992 *Amendments to the SBCCI Standard Building Code*.

In a May 17, 1995, Recommendation, the Interagency Committee on Seismic Safety and Construction updated this finding. They found that the 1994 UBC, 1993 BNBC, and 1994 SBC provide a level of seismic safety substantially equivalent to that of the 1991 *NEHRP Provisions*. In addition, they found that the National Consensus Standard ASCE 7-93 also provides an acceptable level of seismic safety. Any locality that enforces the current seismic requirements of one of the model codes meets this condition.

The American Society of Civil Engineers' *Minimum Design Loads for Buildings and Other Structures* (ASCE 7-95; see Appendix E for address of ASCE), which supersedes the American National Standards Institute A58.1 standards and subsequent maps adopted for federal use in accord with the order, may be used to determine the seismic hazards in various parts of the country. ASCE 7-95 includes specifications for calculating forces that the building must support, such as earthquake, wind, snow, and building material forces.

Because of EO 12699, it is in the best interests of local governments to adopt seismic codes. To best facilitate the possibility of federal financial assistance for new buildings, local governments would be well advised to adopt one of the model codes that have been found to be seismically adequate. For example, the federal agencies providing financial assistance for housing construction (VA, FHA, HUD) all now require adequate seismic design and construction.

EO 12941, by adopting the *Standards of Seismic Safety for Existing Federally Owned or Leased Buildings*, by the Interagency Committee on Seismic Safety and Construction (ICSSC), promulgates a set of seismic standards for federally owned or leased buildings. It also establishes five triggers for evaluation and possible mitigation of risks in a building. For example, when there is a change of building function, a building is significantly altered, or it has to be rebuilt following a disaster, the building must be evaluated according to the ICSSC standards.[5]

Federal Agency Practices Prior to EO 12699: Some Examples

Prior to EO 12699, many agencies of the federal government had promulgated their own building regulations for federally owned and funded projects. Because of the influence of the federal agencies' standards, increasing numbers of structures throughout the United States have been built to seismic-resistant standards.

The recognized authorities for highway bridge earthquake-resistant design are the American Association of State Highway and Transportation Officials (AASHTO) and the Federal Highway Administration (FHWA). AASHTO has published *The Standard Specifications for Highway Bridges* since 1931 (see Appendix E for address of AASHTO). AASHTO's expressed purpose for publishing these specifications is to guide the preparation of state specifications. The latest edition was published in 1995, and supplements are released yearly. Although seismic design standards were not incorporated into AASHTO's specifications until 1991, they had been adopted as guidelines since 1983. States must use AASHTO specifications in order to receive federal highway funds.

The federal government, through the Interagency Committee on Dam Safety, has published *Federal Guidelines for Earthquake Analysis and Design of Dams*. These guidelines were created to develop consistency among federal agencies involved in the planning, design, construction, operation, maintenance, and regulation of dams.

The 1971 San Fernando, California, earthquake caused a Veterans Administration hospital to collapse. Since then the VA has required its facilities to be designed with earthquake-resistant provisions, in accordance with a seismic design manual published by the VA Office of Facilities.

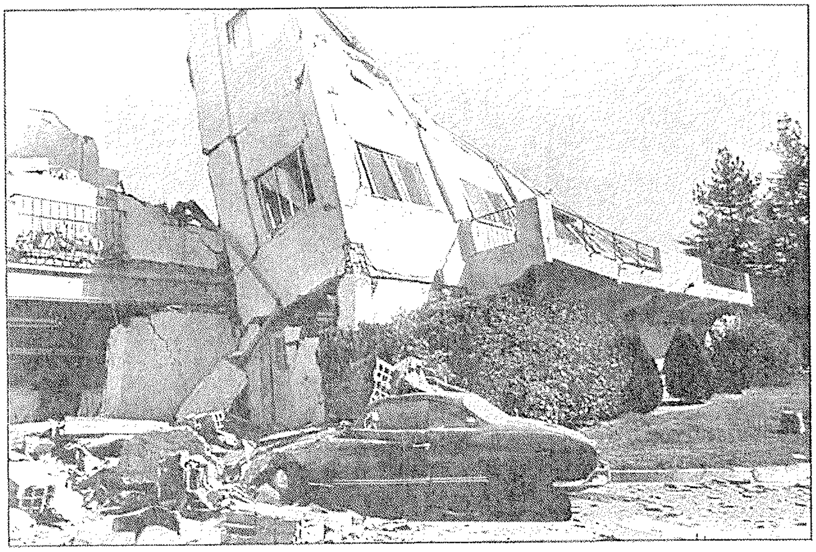


FIGURE A.3 Following the collapse of the Veteran's Administration hospital in the San Fernando earthquake of 1971, the VA has required seismic design for all its facilities. The hospital building shown in this photo was constructed in 1925 with concrete frames and concrete floors, and hollow-tile walls. This type of building is known to be hazardous in the event of a strong earthquake. (Source: Engineering Features of the San Fernando Earthquake, California Institute of Technology, EERL, 1971)

Principles of Seismic Design[6]

The Goals of Seismic Design

Seismic design provisions are intended to protect the safety of a building's occupants during and immediately following an earthquake. Building codes are primarily designed to save lives and reduce injuries, not to eliminate property loss. Their purpose is to allow for safe evacuation of a building. Seismic provisions attempt to prevent general failures (total collapse), but allow for local damage (damage to noncritical sections). Therefore, a building in compliance with the code probably will not collapse, but it may be rendered unfit for continued use. According to the Structural Engineers Association of California, structures built according to a seismic code should resist minor earthquakes undamaged, resist moderate earthquakes without significant structural damage even though incurring nonstructural damage, and resist severe earthquakes without collapse. Building codes are only minimum design standards.

Lateral Earthquake Forces

Today's seismic provisions specify how to calculate the unique earthquake-induced *lateral force*. These are horizontal forces generated by the ground's side-to-side movement in an earthquake.

The purpose of earthquake engineering and earthquake-resistant design is to construct buildings that can resist horizontal forces. This notion is central to seismic building design. All buildings are designed to stand under the vertical forces of gravity, an obvious constraint because it is always present. Less apparent is the need to design for the occasional occurrence of horizontal forces. Many cities have learned the hard way, after it is too late, that their brick or adobe buildings (or concrete and steel buildings not seismically designed) cannot withstand earthquake ground-shaking.

In designing a building, a structural engineer combines the earthquake-induced lateral force with other code-specified forces, such as wind or snow load, to obtain the maximum probable force. The structure is designed based on the maximum combination. The calculated earthquake forces may be less than the wind or snow force.

Buildings that are tall or have unusual shapes require more extensive design analysis. When a building has a complex shape the designer must employ a dynamic structural response analysis, a computer analysis that simulates the building's swaying (side-to-side movement) during an earthquake. The model reflects the building's behavior, conceptually similar to a vibrating string. The dynamic analysis is more accurate than the simple or "static" analysis but is more time-consuming and costly; therefore it is only used for large-scale structures in which many people could be hurt.

The Council of American Building Officials (CABO) has incorporated construction specifications that increase earthquake resistance for one- and two-family dwellings. The CABO *One- and Two-Family Dwelling Code* contains specific requirements for reinforcing chimneys and fireplaces, tying the building frame to the foundation, and providing walls more resistant to earthquake motion (shear walls). These provisions help to prevent chimneys from falling and homes from shifting off their foundation.

Ductility

Another aspect of seismic design is called *ductility*, the flexibility of buildings. In simple terms, buildings are designed to bend rather than break under earthquake forces. Ductility is the ability of a material to deform without fracturing. For example, ductility is an inherent property of steel. Steel will bend significantly before it ultimately fails, which is called ductile failure. Designing an entire structure to be ductile allows for the parts of a building to deflect in an earthquake before they fail.

In contrast to ductile failure, *brittle failure* occurs without prior visual indication. Unreinforced masonry and unreinforced concrete structures are inherently brittle materials. Steel reinforcement transforms concrete's behavior from brittle to ductile. The American Concrete Institute (ACI) through its *Building Code Requirements for Reinforced Concrete (ACI 318-89)* provides specific criteria for structural design of reinforced concrete structures. One provision is the specification of a minimum amount of reinforcing steel to provide for ductile behavior.

Drift

The codes also try to limit the sway of buildings. This is to prevent nonstructural damage and equipment and inventory damage. Although the structural frame can resist stresses and strains created by *drift*, or horizontal movement of one floor relative to the other, items that are attached to the frame or within its interior may not. The John Hancock Building in Boston in the 1970s had problems caused by excessive drift. Windows crashed to the ground as the building swayed in the wind, until the building was retrofitted to reduce the amount of sway. Damage occurred in Mexico City's 1985 earthquake when swaying buildings pounded into each other. Pounding was a significant factor in 40 percent of the collapsed buildings.[7] The drift was due to inadequate stiffness in building frames and the small distances separating buildings.

Seismic Hazard Maps

All the model codes include a seismic hazard map that indicates likely levels of earthquake ground-shaking and, therefore, potential structural damage in every part of the United States. The hazard map is based on the probability that a specified earthquake intensity will occur during a defined time period.

First Seismic Hazard Map Was Based on Maximum Historic Earthquakes[8]

The first seismic hazard map was published in 1948 by the U.S. Coast and Geodetic Survey and was adopted in the 1949 edition of the UBC, as well as subsequent editions until 1970. In 1969 S.T. Algermissen of the U.S. Geological Survey (USGS) published a seismic hazard map for the contiguous forty-eight states. The original map was created by plotting historical earthquake occurrences and was based only on the recorded maximum earthquake intensities. Because of this, portions of the northeast United States were assigned the same hazard and design requirements as areas in California. This map was the basis for the zoning map in the 1970 UBC, which divided the United States into four zones numbered 0 through 3. A zone 4 was added to California in the 1976 UBC.

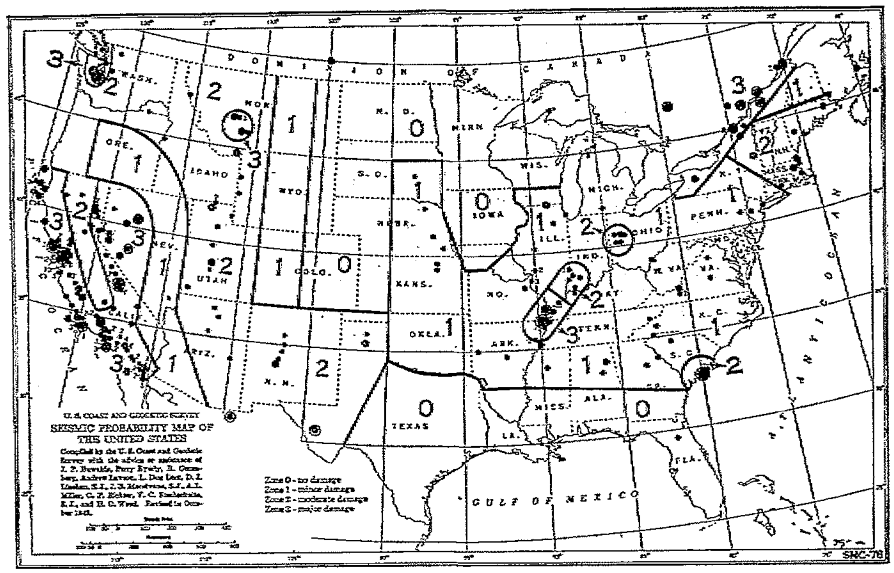


FIGURE A.4 The 1948 seismic hazard map. (Source: U.S. Coast and Geodetic Survey)

1976 Map: Probabilities of Ground-Shaking

In 1976 Algermissen and coworkers refined the map to incorporate the probable frequency of various earthquake intensities. Thus, areas with more frequent earthquakes would be subject to stricter standards of design. They mapped the peak ground acceleration, a measure of the maximum force of earthquake ground-shaking, according to different earthquake intensities expected across the United States. The 1976 map by Algermissen and others depicts the peak ground acceleration that has a 10 percent probability of being exceeded every fifty years. The fifty-year period is typically used as a structure's design lifespan, and 10 percent is consid-

Table A.1 State Codes and Code Influence

State	State Code Name	Basis*	Edition
Alabama	Alabama State Code	SBC	1994
Alaska	Alaska State Code	UBC	1994
Arizona	None		
Arkansas	Arkansas Fire Prevention Code	SBC	1991
California	California Building Code	UBC	1994
Colorado	UBC	UBC	1991
Connecticut	Connecticut State Building Code	BNBC	1992
Delaware	None (done at county level)		
Dist. of Columbia	DC Building Code Supplement	BNBC	1990
Florida	SBC, EPCOT, So. Florida Bldg. Code		1994
Georgia	Georgia State Minimum Std. Bldg. Code	SBC	1994
Hawaii	None (done at county level)		
Idaho	UBC	UBC	1994
Illinois	State (plumbing only)	State	1993
Indiana	Indiana Building Code	UBC	1991
Iowa	Iowa State Building Code	UBC	1991
Kansas	None (uses UBC)	UBC	1991
Kentucky	Kentucky Building Code	BNBC	1993
Louisiana	State Uniform Construction Code	SBC	1991
Maine	None		
Maryland	Model Performance Code	BNBC	1993
Massachusetts	Massachusetts State Building Code	BNBC	1987
Michigan	Building Code Rules	BNBC	1993
Minnesota	Minnesota State Building Code	UBC	1994
Mississippi	None		
Missouri	None		
Montana	Admin. Rules of Montana, Ch. 70	UBC	1994
Nebraska	State Fire Marshall Act	UBC	1979
Nevada	Nevada State Fire Marshall Regulation	UBC	1991
New Hampshire	State Statute	BNBC	1990
New Jersey	State Uniform Construction Code	BNBC	1993
New Mexico	New Mexico Building Code	UBC	1991
New York	Uniform Fire Prevention & Bldg. Code	State	1995
North Carolina	State Building Code	SBC	1994
North Dakota	Century Code	UBC	1994
Ohio	Ohio Basic Building Code	BNBC	1993
Oklahoma	Title 61, Oklahoma Statutes	BNBC	1993
Oregon	Oregon Structural Specialty Code	UBC	1991
Pennsylvania	None		
Rhode Island	State Building Code	BNBC	1990
South Carolina	SBC	SBC	1991
South Dakota	Fire Safety Standards	UBC	1991
Tennessee	SBC	SBC	1994
Texas	None		
Utah	Utah Uniform Building Standards Act	UBC	1994
Vermont	Vermont Fire Prevention & Bldg. Code	BNBC	1987
Virginia	Virginia Uniform Statewide Bldg. Code	BNBC	1993
Washington	State Building Code	UBC	1994
West Virginia	State Building Code	BNBC	1990
Wisconsin	Bldg., Heating, Ventilation & A/C Code	State	
Wyoming	State Code, Ch. 9, Fire Prevention	UBC	1994
Guam	UBC	UBC	
Puerto Rico	Puerto Rico Building Code		
Virgin Islands	UBC	UBC	1994

*Model code on which state code is based.
Sources: Insurance Institute for Property Loss Reduction (now IBHS), April 1996; information on territories was collected by the authors from FEMA and NCSBCS.

ered to be a large enough probability to warrant concern.

It is important to appreciate the probabilistic nature of the Algermissen map. We cannot justify the expense of designing for large but highly improbable events. So we select an event (called the *design event*) that, although large and rare, has a reasonable chance (10 percent) of being exceeded during a building's lifetime (fifty years). The probability selected reflects society's attitude toward risk. This risk acceptance may vary for different uses. Nuclear power plants, for example, are built to much more stringent seismic standards.

It is also important to realize that there is always a chance that an event will exceed the design event—indeed, there is a 10 percent chance of an earthquake that exceeds the design standard. Seismic design standards represent society's balancing of the risks and the costs of designing to withstand that risk.

Finally, one must realize that the zone boundaries themselves are based on probability. There is nothing sacred about the lines on the map; a structure on one side of a zone line is not markedly safer than a structure immediately on the other side. But these maps do represent a consensus of informed scientific opinion of the likelihood of earthquake ground-shaking and its effects. By using these maps as guides to design, we reduce the overall chances of damage to buildings in a region.

ATC Adaptation of the Probabilistic 1976 Map

The ATC revised the 1976 Algermissen map by converting the peak ground acceleration values to effective peak acceleration (EPA) values, another way of describing earthquake ground-shaking. There is no single perfect measure. However, in making the map more user-friendly, it lost accuracy. The effective peak acceleration maps depict peak ground acceleration that has a 5 to 20 percent probability of occurring in a fifty-year period.

From effective peak acceleration, ATC also developed an effective peak velocity map. Effective peak velocity measures the sustained ground movement during an earthquake and is more suitable for building code application to taller buildings. In addition, the ATC maps were revised to follow the boundaries of political jurisdictions to clarify the zones for local building code administration. These maps in ATC 3-06 were used as the basis for the zone map in the *NEHRP Provisions*. A more refined map by the U.S. Geologic Survey appeared in the 1988 *NEHRP Provisions* and has since been adopted by BOCA and SBCCI. The current UBC model building uses similar information for its seismic zone map. The map divides the United States into six earthquake risk zones: 0, 1, 2a, 2b, 3, and 4.

Current Efforts by USGS

The U.S. Geological Survey has recently developed a new generation of seismic hazard maps. These maps are based on the more complete spectrum of ground response to seismic waves, rather than the traditional acceleration and velocity maps. They also use shaking exceedance probabilities of 2 percent and 5 percent in 50 years, in addition to the probability of 10 percent in 50 years that has traditionally formed the basis of seismic hazard maps.[9] The maps currently being balloted for inclusion in the *NEHRP Provisions* are based on the 2 percent in 50 year USGS map, with some changes in high-seismic near-fault areas. The maps will be published with the 1997 edition of the *NEHRP Provisions* and will ultimately be used in the 2000 International Building Code.

NOTES

1 Building Seismic Safety Council, *Improving the Seismic Safety of New Buildings: A Community Handbook of Societal Implications*, FEMA #83, July 1986 edition.

2 This history of seismic codes comes from a number of sources, most notably: Beavers, James E., "Perspectives on Seismic Risk Maps and the Building Code Process," in *A Review of Earthquake Research Applications in the National Earthquake Hazards Reduction Program: 1977–1987*, Walter Hays, ed., U.S. Geological Survey Open-File Report 88-13-A, 1988, 407-432; Whitman, R.V., and Algermissen, S.T., "Seismic Zonation in Eastern United States," *Proceedings, Fourth International Conference on Seismic Zonation*, Vol. I, Earthquake Engineering Research Institute, 1991, 845-869; Martin, H.W., "Recent Changes to Seismic Codes and Standards: Are They Coordinated or Random Events?" *Proceedings, 1993 National Earthquake Conference*, Vol. II, Central U.S. Earthquake Consortium, 1993, 367-376.

3 National Institute of Standards and Technology, *Guidelines and Procedures for Implementation of the Executive Order on Seismic Safety of New Building Construction*, ICSSC RP2.1A, NISTIR 4852, June 1992.

4 Ibid.

5 Todd, Diana, ed., *Standards of Seismic Safety for Existing Federally Owned or Leased Buildings, National Institute of Standards and Technology Report NISTIR 5382*, Interagency Committee of Seismic Safety and Construction Recommended Practice 4 (ICSSC RP 4), February 1994.

6 This summary of seismic design comes from a number of sources, most notably from the Building Seismic Safety Council: *Improving the Seismic Safety of New Buildings: A Community Handbook of Societal Implications*, FEMA #83, July 1986 edition; *Seismic Considerations for Communities at Risk*, FEMA #83, September 1995 edition; and *Nontechnical Explanation of the NEHRP Recommended Provisions*, FEMA #99, September 1995. Also see EERI Ad Hoc Committee on Seismic Performance, *Expected Seismic Performance of Buildings*, Earthquake Engineering Research Institute, February 1994; and Lagorio, Henry J., *Earthquakes, An Architect's Guide to Nonstructural Seismic Hazards*, John Wiley and Sons, Inc., 1990.

7 Geis, Donald A., et al., "Architectural and Urban Design Lessons from the 1985 Mexico City Earthquake," *Lessons Learned from the 1985 Mexico Earthquake*, Earthquake Engineering Research Institute, 1989, 226-230.

8 The information on seismic hazard maps comes from a number of sources, most notably: Beavers, James E., "Perspectives on Seismic Risk Maps and the Building Code Process," in *A Review of Earthquake Research Applications in the National Earthquake Hazards Reduction Program: 1977–1987*, Walter Hays, ed., U.S. Geological Survey Open-File Report 88-13-A, 1988, 407-432; Whitman, R.V., and Algermissen, S.T., "Seismic Zonation in Eastern United States," *Proceedings, Fourth International Conference on Seismic Zonation*, Vol. I, Earthquake Engineering Research Institute, 1991, 845-869; U.S. Department of the Interior, Geological Survey, *USGS Spectral Response Maps and Their Relationship with Seismic Design Forces in Building Codes*, Open-File Report 95-595, 1995; and Leyendecker, Edgar V., Algermissen, S.T., and Frankel, Arthur, *Use of Spectral Response Maps and Uniform Hazard Response Spectra in Building Codes*, Fifth National Conference on Earthquake Engineering, July 1994.

9 Leyendecker, E.V., et al., *USGS Spectral Response Maps and Their Relationship with Seismic Design Forces in Building Codes*, U.S. Geological Survey Open-File Report 95-596, 1995. The most recent versions are available at http://gldage.cr.usgs.gov/eg/

City of Woburn
Critical Facilities List

Site_ID	Site_Name	PID
1	City Hall	511807
2	Police Station	421202
3	North Woburn Fire Station	133109
4	Central Sq Fire Station	360931
5	East Woburn Fire Station	452202
6	West Side Fire Station	570207
7	South End Fire Station	592609
8	Senior Center	190130
9	Altavesta School	083805
10	Linscott School	180104
11	Hurld School	410616
12	Wyman School	360424
13	Reeves School	730102
14	Clapp School	592620
15	Goodyear School	530306
16	White School	431406
17	High School	431406
18	Joyce Jr High	490601
19	Kennedy Jr High	360859
20	DPW	421119
21	Scalley Dam	
22	Zion Hill Communications	780819
23	Dragon Ct Sub Station	210107
24	Lake Ave Sub Station	750401
25	Green St Sub Station	521204
26	Warren Ave Medical Ctr.	590101
27	Anderson Regional RTC	100107
28	Water Treatment Plant	750102
29	MWRA Meter 230	
30	MWRA Meter 200	
31	Well A2	
32	Well B	
33	Well C2	
34	Well D2	
35	Well I	

City of Woburn
Day Care Facilities

Id	Name	Street	Town	Zip	Region	Description	Phone	Exp Date
390718	B&G Club of Woburn/Project Learn @ Hurld	BEDFORD RD	WOBURN	1801	4	Greater Boston	781 424-1204	8/20/2007
390717	B&G Club/Woburn/Project Learn @ Linscott	ELM ST	WOBURN	1801	4	Greater Boston	781 933-1661	8/20/2007
7024799	Bickford, Stacey M.	115 PINE ST	WOBURN	1801	4	Greater Boston	781 281-1798	5/15/2008
700449	Cabral, Edna Patricia Moniz	1 MARLBORO RD	WOBURN	01801-3408	4	Greater Boston	781 266-6535	2/24/2008
618749	Chamberlain, Pauline J.	32 DAVIS ST	WOBURN	1801	4	Greater Boston	781 935-3794	4/23/2009
201430	Children's Center	2 MERRIMAC ST	WOBURN	1801	4	Greater Boston	781 933-5984	5/15/2007
691866	Courtney, Diane	3 LAURENCE RD	WOBURN	1801	4	Greater Boston	781 933-4261	5/11/2009
600442	Fee, Susan M.	16 SQUANTO RD	WOBURN	1801	4	Greater Boston	781 938-8141	12/9/2009
7024147	Gibson, Christy	10 ALICE RD	WOBURN	1801	4	Greater Boston	781 935-4885	9/9/2007
700026	Greekwood, Susan M.	88 EASTERN AVE	WOBURN	01801-5216	4	Greater Boston	781 933-2929	7/26/2007
290663	Hammond Square Children's School	533 MAIN ST	WOBURN	1801	4	Greater Boston	781-376-9009	7/12/2007
700817	Hibbard, Margaret J.	51 WASHINGTON ST	WOBURN	01801-4654	4	Greater Boston	781 938-8948	3/27/2008
692714	Houle, Paula	7 SHERMAN PLACE	WOBURN	1801	4	Greater Boston	781 932-9957	12/17/2008
696709	Kenney, Michelle	14 AUBURN ST	WOBURN	1801	4	Greater Boston	781 354-6991	3/23/2008
201431	Kinder Care Learning Center	225 WASHINGTON ST	WOBURN	01801-3367	4	Greater Boston	781 935-7040	3/1/2007
618286	LaFlamme, Deborah L	47 MONTVALE AVE	WOBURN	1801	4	Greater Boston	781 933-9182	1/24/2009

City of Woburn
Day Care Facilities

Id	Name	Street	Town	Zip	Region	Description	Phone	Exp Date
7025421	Lentine, Tina M.	50 CENTRAL ST	WOBURN	01801-4642	4	Greater Boston	781 935-5228	12/7/2008
201435	Little Folks Day School	600 WEST CUMMINGS PARK	WOBURN	1801	4	Greater Boston	781 935-9697	7/30/2008
200617	Little Hands Big Hearts Lutheran Preschool	60 FOREST PARK ROAD, LUTHERAN CHURCH	WOBURN	1801	4	Greater Boston	781 937-5645	11/22/2008
290278	Little Professional, Inc.(Woburn)	304 CAMBRIDGE RD	WOBURN	01801-6040	4	Greater Boston	781 937-9933	7/7/2007
701023	Lochrie, Kerstin	110 PEARL ST	WOBURN	01801-1545	4	Greater Boston	781 932-7944	5/8/2008
698900	Magro, Rosemary	26 BRIARWOOD RD	WOBURN	01801-1265	4	Greater Boston	781 938-4337	10/30/2009
7024539	Mcardle, Christine P.	18 ALFRED ST	WOBURN	01801-1902	4	Greater Boston	781 933-6487	5/3/2008
698686	McLaughlin, Deborah	4 MAYWOOD TER	WOBURN	1801	4	Greater Boston	781 933-7229	11/8/2009
700598	Newell, Sharyn	50 DAY CIR	WOBURN	01801-5442	4	Greater Boston	781 935-0189	1/6/2008
390132	North Suburban Family YMCA/Plympton Site	33 PLYMPTON ST	WOBURN	1801	4	Greater Boston	781 935-3270	4/2/2008
600467	O'Hearn, Kim L.	13-15 ARLINGTON ST	WOBURN	1801	4	Greater Boston	781 938-9217	1/25/2009
612459	Packard, Mary J.	101 MONTVALE AVE	WOBURN	1801	4	Greater Boston	781 935-8493	10/28/2007
695395	Palacio, Rosa	14 BORDER ST	WOBURN	1801	4	Greater Boston	781 491-8040	6/25/2007
390889	Project Learn Extended Day Program	CHARLES GARDNER LN	WOBURN	1801	4	Greater Boston	781 935-3777	10/24/2008
211781	Puddle Duck Day Care, Inc.	21 X OLYMPIA AVE	WOBURN	1801	4	Greater Boston	781 932-8226	6/26/2007
7026238	Reynoso, Gisela	26 CLINTON ST	WOBURN	1801	4	Greater Boston	781 937-4962	9/20/2009
701527	Rodriguez, Maria	11 BAMBERG DR	WOBURN	01801-3523	4	Greater Boston	781 281-1222	6/7/2008

City of Woburn
Day Care Facilities

Id	Name	Street	Town	Zip	Region	Description	Phone	Exp Date
600473	Serafino, Sally E.	708 MAIN ST	WOBURN	1801	4	Greater Boston	781 935-9227	9/5/2009
7024148	Simpson, Carrie	90 BEDFORD RD	WOBURN	01801-3917	4	Greater Boston	781 935-8363	10/14/2007
7023098	Sullivan, Nancy	37 SYLVANUS WOOD LN	WOBURN	1801	4	Greater Boston	781 935-3893	9/29/2009
625208	Szweda, Marie	36 MAPLE AVE	WOBURN	1801	4	Greater Boston	781-933-7704	11/18/2008
290642	Teddy Bear University, Inc.	23 WARREN AVE STE 180	WOBURN	01801-4987	4	Greater Boston	781 933-8183	1/16/2009
200553	The Children's House	8 SUMMER ST	WOBURN	1801	4	Greater Boston	781-933-6133	12/20/2008
2911916	The Children's Space @ UMC	523 MAIN ST	WOBURN	01801-2941	4	Greater Boston	781 935-6824	4/27/2008
291140	Turtlefun's	237 WINN ST	WOBURN	1801	4	Greater Boston	781 933-0924	11/29/2007
694482	Vander Brug, Wendy L.	10 ROSE FARM LN	WOBURN	1801	4	Greater Boston	781 937-3073	12/1/2009
211448	Woburn Creative Start	4G GILL ST	WOBURN	1801	4	Greater Boston	781 932-0260	10/3/2007
211311	Woburn Montessori School	33 PLYMPTON ST	WOBURN	1801	4	Greater Boston	781 935-6168	4/27/2008
211312	World of Wonder Preschool	905 MAIN ST	WOBURN	1801	4	Greater Boston	781 933-2393	4/27/2008
7024521	Yang, Jane	56 MILL ST. APT. 1	WOBURN	1801	4	Greater Boston	781 935-4866	12/15/2007
290502	YMCA Children's Center	100 SYLVAN RD	WOBURN	1801	4	Greater Boston	781 938-9622	9/1/2007

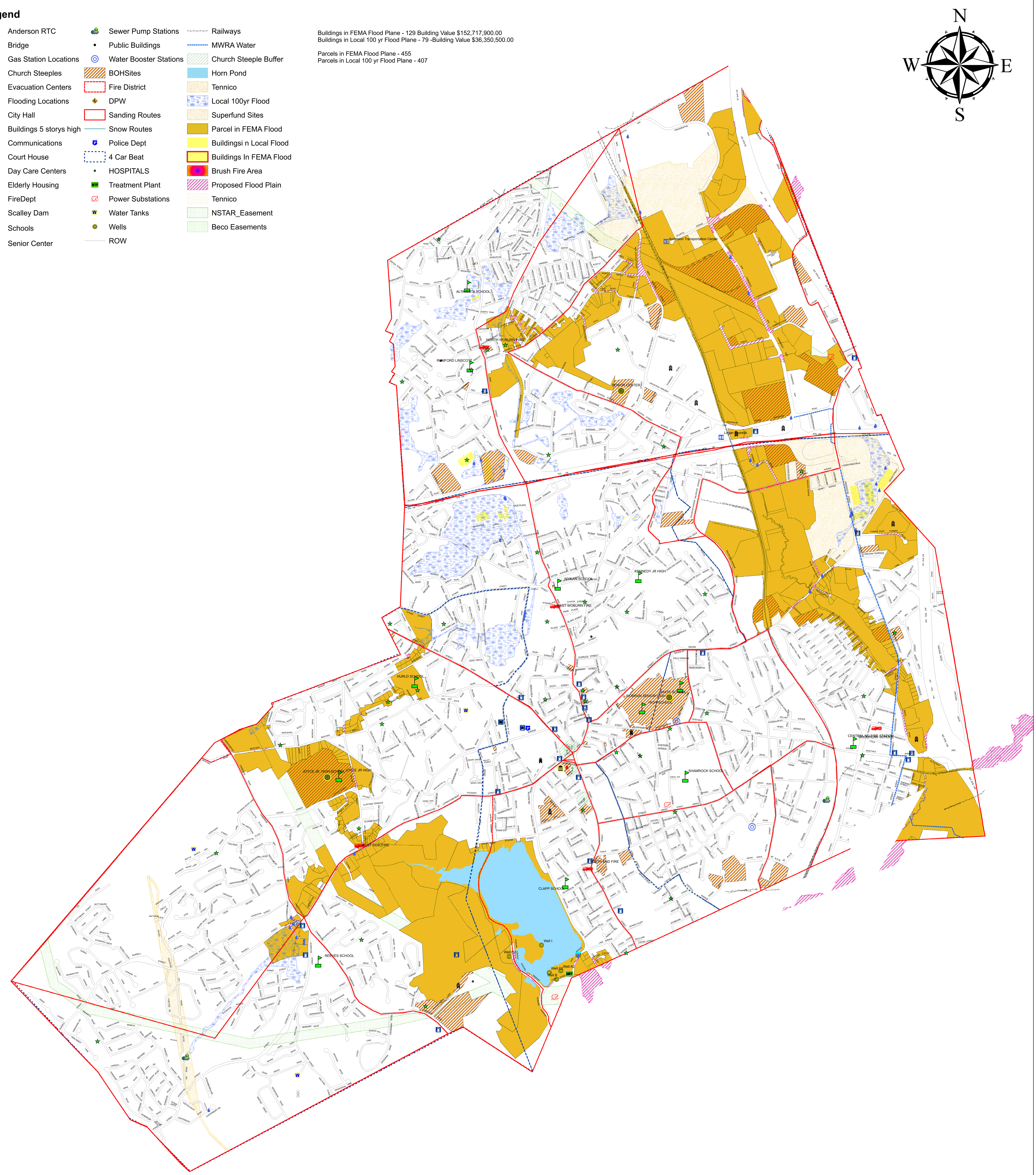
NATURAL HAZARD AND CRITICAL FACILITIES PLAN

Legend

- Anderson RTC
- Bridge
- Gas Station Locations
- Church Steeples
- Evacuation Centers
- Flooding Locations
- City Hall
- Buildings 5 storys high
- Communications
- Court House
- Day Care Centers
- Elderly Housing
- FireDept
- Scalley Dam
- Schools
- Senior Center
- Sewer Pump Stations
- Public Buildings
- Water Booster Stations
- BOHSites
- Fire District
- DPW
- Sanding Routes
- Snow Routes
- Police Dept
- 4 Car Beat
- HOSPITALS
- Treatment Plant
- Power Substations
- Water Tanks
- Wells
- ROW
- Railways
- MWRA Water
- Church Steeple Buffer
- Horn Pond
- Tennico
- Local 100yr Flood
- Superfund Sites
- Parcel in FEMA Flood
- Buildingsi n Local Flood
- Buildings In FEMA Flood
- Brush Fire Area
- Proposed Flood Plain
- Tennico
- NSTAR_Easement
- Beco Easements

Buildings in FEMA Flood Plane - 129 Building Value $152,717,900.00
Buildings in Local 100 yr Flood Plane - 79 -Building Value $36,350,500.00

Parcels in FEMA Flood Plane - 455
Parcels in Local 100 yr Flood Plane - 407



PREPARED BY THE CITY OF WOBURN
ENGINEERING DEPARTMENT FOR THE
METROPOLITAN AREA PLANNING COUNCIL
APRIL 4, 2007

The enclosed Natural Hazard Mitigation plan depicts the City of Woburn's critical facility infrastructure as well as areas throughout the city which are prone to natural hazards. This plan has been created by a combination of actual events, historical records and interdepartmental corporation.

The legend denotes key facilities including the city's 100 year local flood zone and Federal Emergency Management Association (FEMA) 100 year flood zone and the parcels and buildings that are directly affected by each flood zone.

The plan also includes the following:

Commuter Transportation locations
Bridges
Churches
Municipal Buildings
Municipal and Private utilities
Municipal Snowplowing and Sanding routes
Schools
Daycare centers
Police and Fire districts
Local 100 year Flood Zones
FEMA 100 year Flood Zones
Buildings and Parcels that are located in their respective Flood Zones

The Engineering Department has worked diligently over several months with the city departments to complete this plan and develop a document for disaster planning. This plan has been prepared in conjunction with the city's Natural Hazard Mitigation report dated May 2007.

Legend

- Anderson RTC
- Bridge
- Gas Station Locations
- Church Steeples
- Evacuation Centers
- Flooding Locations
- City Hall
- Buildings 5 storys high
- Communications
- Court House
- Day Care Centers
- Elderly Housing
- FireDept
- Scalley Dam
- Schools
- Senior Center
- Sewer Pump Stations
- Public Buildings
- Water Booster Stations
- BOHSites
- Fire District
- DPW
- Sanding Routes
- Snow Routes
- Police Dept
- 4 Car Beat
- HOSPITALS
- Treatment Plant
- Power Substations
- Water Tanks
- Wells
- ROW
- Railways
- MWRA Water
- Church Steeple Buffer
- Horn Pond
- Tennico
- Local 100yr Flood
- Superfund Sites
- Parcel in FEMA Flood
- Buildingsi n Local Flood
- Buildings In FEMA Flood
- Brush Fire Area
- Proposed Flood Plain
- Tennico
- NSTAR_Easement
- Beco Easements

ACKNOWLEDGMENTS

This plan is the result of a cooperation effort of the City of Woburn Engineering Department working in conjunction with the various public safety departments. We wish to thank the following individuals for their efforts in bringing this plan to fruition:

- Chief Paul Tortolano and William Sweeney of the Woburn Fire department
- Chief Philip Mahoney and Sergeant Paul Tenney of the Woburn Police Department
- Health Agent John Fralick and Lori Scalesse of the Woburn Board of Health
- Superintendent Frederick Russell and Highway Foreman Christopher Doherty of the Woburn Department of Public Works

We also wish to acknowledge Joan Blaustein and Allen Bishop of the Metropolitan Planning Commission for their sharing of information and resources as well as their technical support.

Lastly, the efforts of the Assistant City Engineer, Brett Gonsalves must be noted for collecting the data and compilation of the information to form this plan. Of particular note is the Geographical information system component of the plan on which Brett spent long hours of tireless effort to populate the various data bases in conjunction with information obtained from the contributing departments.

This plan is considered a living document which will periodically be updated and used in training exercises with others. During a recent potential flooding problem the GIS portion of the plan was set up and tested in an Incident Command Center environment and its inner most workings and information utilized. This gives us a confidence level that in the event of an actual emergency, the plan will be a useful tool in dealing with natural hazards.

John E. Corey, Jr., PE

City Engineer