PCR-56-12

THE CITY OF WARWICK
STATE OF RHODE ISLAND AND PROVIDENCE PLANTATIONS

RESOLUTION OF THE CITY COUNCIL

No. ...**R-12-54**..... *Date* 5/22/12

Approved.....*Mayor*

RESOLUTION IN SUPPORT OF CITY OF WARWICK, LOCAL MULTI-HAZARD MITIGATION PLAN

RESOLVED, that

WHEREAS, the Federal Emergency Management Agency ("FEMA") has established that municipalities review and revise their local multi-hazard mitigation plan every five years to reflect changes in development, progress in local hazard mitigation efforts, and changes in mitigation priorities and submit their revised multi-hazard mitigation plan for review and approval by FEMA to remain eligible for mitigation project grant funding; and

WHEREAS, the City of Warwick Hazard Mitigation Committee (the "Committee") was formed to compose revisions and updates to the City of Warwick's Local Multi-Hazard Mitigation Plan (the "Plan"); and

WHEREAS, the Committee, assisted by Department of City Plan personnel and professional consultants, meet regularly to perform it's task to review and revise the existing Plan; and

WHEREAS, the Committee's updated Plan was submitted to FEMA for review, comment and approval; and,

WHEREAS, FEMA approved the City's updated Plan on November 29, 2011; and,

WHEREAS, the Committee hereby forwards the Plan to the City Council for their review and seeks their approval to allow the City to remain eligible for mitigation project funding.

NOW, THEREFORE, BE IT RESOLVED, that the City Council of the City of Warwick hereby adopts this resolution and grants its approval of the Plan, as approved by FEMA on November 29, 2011.

This Resolution shall take effect upon passage.

SPONSORED BY: COUNCILMAN COLANTUONO
ON BEHALF OF MAYOR AVEDISIAN

COMMITTEE: Intergovernmental

City of Warwick, Rhode Island
Local Multi-Hazard Mitigation Plan

February 2011

Warwick Hazard Mitigation Strategy

As per FEMA Guidance (07/01/08), adoption will take place within one calendar year of receipt of FEMA's Approval Pending Adoption

A copy of the City Executive Order adopting the Updated Hazard Mitigation Strategy will be inserted into the final document, and the approved plan published in final version

FORWARD

This Plan was updated under the guidance of Kevin Sullivan, Fire Department Chief and City of Warwick EMA Director with the assistance of *Crossman Engineering, Weston & Sampson Engineers* and the City of Warwick Hazard Mitigation Committee. The update was funded via a Federal Emergency Management Agency Pre-Disaster Mitigation Grant administered by the Rhode Island Emergency Management Agency.

The purpose of the Warwick Hazard Mitigation Strategy is to advocate the concepts of disaster resilient and sustainable communities. Warwick is committed to building a disaster resistant community and achieving sustainable development through the commitment of state and local government and its policymakers to mitigate hazard impacts before disaster resilient, and therefore, safer community, through the implementation of mitigation programs and policies. The City will have the capability to implement and institutionalize hazard mitigation through its human, legal and fiscal resources, the effectiveness of intergovernmental coordination and communication, and with knowledge and tools at hand to analyze and cope with hazard risks and the outcome of mitigation planning.

2010 Updates
Strategy for Reducing Risks from Natural Hazards in Warwick, Rhode Island

A Multi-Hazard Mitigation Strategy

ACKNOWLEDGEMENTS

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CITY OF WARWICK HAZARD MITIGATION COMMITTEE

Chair: Chief Kevin Sullivan, Emergency Management Director
Assistant Chief Ed Armstrong, Dep. Emergency Mgmt. Director
Col. Stephen McCartney, Warwick Police
Janine Burke, Warwick Sewer Dept.
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ACKNOWLEDGEMENTS – 2005 PLAN

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This project has proceeded thanks to the support and resources provided by the Rhode Island Emergency Management Agency and funding from Rhode Island Sea Grant.

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Strategy for Reducing Risks from Natural Hazards in Warwick, Rhode Island

A Multi-Hazard Mitigation Strategy

TABLE OF CONTENTS

SUBJECT

Acronyms

ASCE	American Society of Civil Engineers
BFE	Base Flood Elevations
CDBG	Community Development Block Grant
CRMC	Coastal Resource Management Council
CRMP	Coastal Resource Management Program
CRS	Community Rating System
DOT	Department of Transportation
EMA	Emergency Management Assistance
EMPG	Emergency Management Performance Grant Program
FEMA	Federal Emergency Management Agency
FIA	Flood Insurance Agency
FIMA	Federal Insurance and Mitigation Administration
FIPM	Flood Insurance Program Maps
FIS	Flood Insurance Studies
FIRM	Flood Insurance Rate Map
FMA	Flood Mitigation Assistance
GIS	Geographic Information System
HMGP	Hazard Mitigation Grant Program
HMPC	Hazard Mitigation Plan Committee
HMS	Multi-Hazard Mitigation Strategy
HUD	Housing and Urban Development
IBHS	Institute for Business and Home Safety
MAP	Mitigation Assistance Program
NESEC	Northeast States Emergency Consortium
NFIP	National Flood Insurance Program
NIMS	National Incident Management System
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
PDM	Pre-Disaster Mitigation
RIDEM	Rhode Island Department of Environmental Management
RIEMA	Rhode Island Emergency Management Agency
RVA	Risk and Vulnerability Assessment
SAMP	Special Area Management Plan
SBA	Small Business Administration
SFHA	Special Flood Hazard Area
SLOSH	Sea, Lake, and Overland Surges from Hurricanes
SRF	State Revolving Fund
SRL	Severe Repetitive Loss
STAPLEE	Social, Technical, Administrative, Political, Legal, Economic, and Environmental
TF	Theodore Francis
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WWTF	Wastewater Treatment Facility
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System

Chapter 1. Introduction

The Cost of Disasters

Property damage resulting from natural hazards has become exceedingly costly, for both the disaster victims, and the American taxpayer. Between 1980 and 2008, a recorded 601 natural disasters caused over 12,000 fatalities and an estimated total of $483 billion in economic damage (source: PreventionWeb).

In 2010, Warwick experienced one of its worst natural disasters on record, and a Major Disaster Declaration was issued on March 29, 2010 as a result of extreme storms and flooding. Beginning on March 13th, a multi-day storm event dropped almost four inches of rainfall over the Pawtuxet River Basin, bringing the Pawtuxet River to crest at over 15 feet. Only two weeks later on March 29th, a second event dropped over eight inches of additional rainfall over the Pawtuxet River Basin. The week of March 28, 2010 is now considered the flood of record for the main channel of the Pawtuxet River, with peak discharges estimated at 10,400 cubic feet per second and flood elevations reaching 20.79 feet (11.79 feet above the 9-foot flood stage)(source: Cranston/Coventry HMPs).

Substantial flooding and extraordinary damages occurred along the Pawtuxet River, and a Major Disaster Declaration was issued by President Obama on March 29th. The Pawtuxet River crested at elevations in excess of the existing levee surrounding the City of Warwick Wastewater Treatment Facility (WWTF) and the WWTF was completely inundated, rendering the facility inoperable. The Warwick Mall was also fully inundated (see above photo), with all stores suffering significant losses. Although final damage assessments were not yet available at the time of this hazard mitigation plan update, FEMA estimated that as of July 7, 2010, nearly $79 million had been paid out in federal grants and loans.

The estimated costs associated with major disasters experienced in Rhode Island are presented in Table 1-1. Aside from the direct costs of property damage, Americans also suffer from indirect costs, most of which may take much longer to recover from. Recovery from disasters requires resources to be diverted from other public and private programs, adversely affecting the productivity of the economy. Business interruption insurance only covers a small part of actual losses. Loss of economic productivity and downtime in tourism is not fully accounted for by the public or private sector.

Table 1-1

Costs of Disasters in Rhode Island
1938 - present

Date	Disaster	Amount of Damage*
1938	Storm of '38	$306 million
1954	Hurricane Carol	$461 million
1991	Hurricane Bob	$115 million
2010	Severe Storms & Floods	$79 million**

*dollars given in the year damage occurred
**based on available data from FEMA through July 7, 2010

Source: NOAA & FEMA

What is Hazard Mitigation?

Hazard mitigation is action taken to permanently reduce or eliminate long-term risk to people and their property from the effects of natural hazards. As the direct and indirect costs of disasters continue to rise, it becomes particularly critical that preparing for the onslaught of damage from these events must be done in order to reduce the amount of damage and destruction. This strategy is commonly known as *mitigation.* The purpose of multi-hazard mitigation is twofold: 1) to protect people and structures from harm and destruction; and 2) to minimize the costs of disaster response and recovery.

To ensure the national focus on mitigation, the Federal Emergency Management Agency (FEMA) introduced a National Mitigation Strategy in 1995. The strategy promotes the partnership of government and the private sector to "build" safer communities. Hazard mitigation encourages all Americans to identify hazards that may affect them or their communities and to take action to reduce risks.

Mitigation Benefits

Mitigation actions help safeguard personal and public safety. Retrofitting bridges, for example, can help keep them from being washed out, which means they will be available to fire trucks and ambulances in the event of a storm. Installing hurricane clips and fasteners can reduce personal and real property losses for individuals and reduce the need for public assistance in the event of a hurricane. Increasing coastal setbacks reduces the risk of deaths and property losses from storm surge and coastal erosion.

The purpose of this Hazard Mitigation Strategy is to set forth guidelines of short term and long-term actions, which will reduce the actual or potential loss of life or property from the wide variety of hazardous events such as winter storms, flooding, thunderstorms, droughts, hurricanes and earthquakes.

The following is stated under Section 322 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended by Section 104 of the Disaster Mitigation Act of 2000:

> *"To obtain Federal assistance, new planning provisions require that each state, local and tribal government prepare a hazard mitigation plan to include sections that describe the planning process, an assessment of the risks, a mitigation strategy, and identification of the plan maintenance and updating process."*

Therefore, this plan is a directive of FEMA and conforms specifically to 44 CFR Parts 201 and 206 Hazard Mitigation Planning. Upon FEMA approval and formal adoption of this Hazard Mitigation Strategy by the City on March 21, 2005, the City became an eligible applicant for the following hazard mitigation assistance programs currently available through FEMA: Hazard Mitigation Grant Program (HMGP), Pre-Disaster Mitigation (PDM), Flood Mitigation Assistance (FMA), and Severe Repetitive Loss (SRL). These programs provide resources that may be used to mitigate the effects of natural hazards on both public and private property.

Pre-disaster planning will also help post-disaster operations become more efficient. For instance, procedures and necessary permits can be identified prior to the disaster and therefore, permit streamlining procedures can be put into place. Priorities for mitigation during reconstruction can also be identified, helping to reduce the high costs of recovery after a disaster. The State emergency response effort will run more smoothly because of the guidance provided in this strategy.

Sustainable Communities

"Disaster resilient" communities employ a long range, community-based approach to mitigation. Mitigation advocates communities to proactively address potential damage that could occur from hurricanes, coastal erosion, earthquakes, flooding and other natural hazards. When natural hazard mitigation is combined with the standards of creating sustainable communities, the long-term beneficial result is smarter and safer development that reduces the vulnerability of populations to natural disasters while reducing poverty, providing jobs, promoting economic activity, and most importantly, improving people's living conditions (Munasinghe & Clarke 1995). In addition to a community's sustainability criteria for social, environmental and economic protection, there is also the criterion that development must be disaster resistant (FEMA 1997; Institute for Business & Home Safety 1997).

Resilient communities may bend before the impact of natural disaster events, but they do not break. They are constructed so that their lifeline systems of roads, utilities, infrastructure, and other support facilities are designed to continue operating in the midst of high winds, rising water and shaking ground. Hospitals, schools, neighborhoods, businesses and public safety centers are located in safe areas, rather than areas prone to high hazards. Resilient and sustainable communities' structures are built or retrofitted to meet the safest building code standards available. It also means that their natural environmental habitats such as wetlands and dunes are conserved to protect the natural benefits of hazard mitigation that they provide.

The Warwick Hazard Mitigation Strategy advocates the concepts of disaster resilient and sustainable communities. Warwick is committed to building a disaster resistant community and achieving sustainable development through the commitment of state and local government and its policymakers to mitigate hazard impacts before disaster strikes. Additionally, Warwick will achieve a disaster resilient, and therefore, safer community, through the process of completing its Hazard Risk and Vulnerability Assessment (RVA), and Multi-Hazard Mitigation Strategy (HMS) and through the implementation of mitigation programs and policies. The City will have the capability to implement and institutionalize hazard mitigation through its human, legal and fiscal resources, the effectiveness of intergovernmental coordination and communication, and with the knowledge and tools at hand to analyze and cope with hazard risks and the outcomes of mitigation planning.

Mitigation versus Emergency Response

The Emergency Management model ascribed to by FEMA, as well as the City of Warwick, has four phases:

- Mitigation: those activities designed to either prevent the occurrence of an emergency, or minimize the potentially adverse effects of an emergency.

- Preparedness: those activities, programs, and systems that exist prior to an emergency used to support and enhance response including, but not limited to planning, training, and exercising.

- Response: those activities designed to address the immediate and short-term effects of the onset of an emergency; thereby reducing casualties and damage, and facilitating recovery. Response activities include direction and control, warning, evacuation, shelter, and other similar operations.

- Recovery: those activities designed to restore system to normal including short-term actions to assess damage and return vital life support systems to minimal operating standards, and long-term actions that may continue for many years and take into consideration appropriate mitigation measures.

Each of these phases is an integral part of effective emergency management and no phase is more important than another. However, it is difficult to address all four phases in one written document. In addition, the federal government currently has different guidelines with respect to these phases. For example, emergency response typically follows the National Incident Management System (NIMS) and plans are written and updated in accordance with this program; whereas mitigation must follow FEMA requirements in order to maintain eligibility for grant funding and plans are written and updated in accordance with FEMA guidance documents.

The activities of emergency response and short-term recovery are typically those handled by municipal departments tasked with Public Safety (i.e., fire and police), and the activities associated with mitigation and long-term recovery are often those handled by departments tasked with planning and capital improvements.

For this reason, the City of Warwick maintains two comprehensive Emergency Management documents, which include:

- Hazard Mitigation Strategy: generally identifies potential hazards, assesses the risks associated with each hazard, and develops capital and other action plans aimed at mitigating the impacts of these potential hazards in advance of their occurrence.

- Emergency Operations Plan: describes emergency response activities; briefly discusses potential hazards, associated risks, and anticipated impacts; outlines federal, state, and Warwick response policies and procedures; assigns responsibilities and responsible parties; and provides other specific information about actions to be taken once the onset of a hazard has been realized.

Many City departments maintain detailed standard operating procedures for emergency response specific to their individual facilities. For example, the Warwick School Department has a written Emergency Response Plan outlining actions to be taken in the schools in response to natural hazards, but

also education-related incidents such as suicides or other staff/student deaths, intruders, student unrest or violence, disease outbreaks, etc. The Warwick Sewer Authority also maintains standard operating procedures for response to emergencies in the collection and treatment of wastewater such as sewer main collapses, equipment failures, and chemical releases.

These plans and procedures are intended to work together to address each of the four phases of emergency management and thereby ensure that the City of Warwick properly anticipates and minimizes the impacts of potential hazards to public health and property.

Chapter 2. Mission and Goals

Mission

The purpose of the Warwick multi-hazard Mitigation Strategy is to:

1. Provide a coordinated consistent set of goals for reducing or minimizing: human and property losses; major economic disruption; degradation of ecosystems and environmental critical habitats; destruction of cultural and historical resources from natural disasters;

2. Provide a basis for intergovernmental coordination in natural hazard mitigation programs at the state and local level;

3. Develop partnerships between the City and private sector, local communities and non-profit organizations in order to coordinate and collaborate natural hazard mitigation programs;

4. Identify and establish close coordination with local government departments and agencies responsible for implementing the sound practices of hazard mitigation through building standards and local land use development decisions and practices; and to

5. Provide for a continuing public education and awareness about the risks and losses from natural disasters, in addition to natural hazard mitigation programs, policies and projects.

Goals

The goals of the Warwick Multi-hazard Mitigation Strategy are to:

1. Protect public health, safety and welfare;

2. Reduce property damages caused by natural disasters;

3. Minimize social dislocation and distress;

4. Reduce economic losses and minimize disruption to local businesses;

5. Protect the ongoing operations of critical facilities;

6. Reduce the dependence and need for disaster assistance funding after natural disasters;

7. Expedite recovery disaster mitigation efforts during the recovery phase;

8. Promote non-structural flood and coastal erosion measures to reduce the risk of damage to the surrounding properties and environmental habitats;

9. Establish a local Hazard Mitigation Committee to support, implement and revise the Warwick multi-hazard mitigation strategy and to provide the support necessary for an ongoing forum for the education and awareness of multi-hazard mitigation issues, program, policies and projects; and to

10. Provide for adequate financial and staffing resources to implement the Warwick Hazard Mitigation Strategy.

11. Maintain an updated, FEMA-approved Local Mitigation Plan in accordance with 44 CFR 201 such that the City of Warwick is eligible to apply and receive assistance under federal hazard mitigation assistance programs.

Chapter 3. Methodology

The Need for Updates

According to 44 CFR 201, the City of Warwick must review and revise its plan to reflect changes in development, progress in local mitigation efforts, and changes in priorities, and resubmit it for approval within five years in order to continue to be eligible for mitigation project grant funding. The general scope of this effort in Warwick was to update the 2005 document to address required elements as dictated in FEMA's July 1, 2008 Local Multi-Hazard Mitigation Guidance document, and to ensure compatibility with the Rhode Island Emergency Management Agency (RIEMA) State Hazard Mitigation Plan, dated March 2008. In addition, although no new hazards were identified during the update process, the severe storms and flooding experienced by the City in March 2010, and resulting federal major disaster declaration, presented a real-life situation with which to truly assess the effectiveness of past mitigation efforts and more accurately project future needs.

The Update Process

It is a recognized fact that the process of developing, and regularly updating, a Hazard Mitigation Plan is perhaps more important than the actual written plan itself. Taking the time to perform a comprehensive assessment of risks, resources, and capabilities based on past history, current conditions, and future projections is an important step in mitigating hazards. Participation in the process by a wide range of stakeholders, each tasked with identifying and implementing mitigation measures, is also a critical component.

For the 2010 plan, selected individuals were tasked with making the updates. The City retained the services of outside consultants to assist with the bulk of the research and document revisions. Consultants from Crossman Engineers and Weston & Sampson Engineers assisted the 2010 Hazard Mitigation Plan Committee (HMPC), which included representatives from the following:

- City's Emergency Management Agency
- Warwick Engineering Department
- Warwick Highway Department
- Warwick Sewer Authority
- Warwick Planning Department
- Warwick Economic & Community Development
- Warwick Municipal Building Maintenance
- Warwick Building Department
- Warwick Police Department
- Warwick Fire Department
- Warwick Management Information Services
- Warwick Water Department

On-site Committee/stakeholder meetings were held on September 27, October 27 and November 5, 2010. A summary of participants and discussion topics is appended to this document. A great deal of Committee and stakeholder input was also collected via email and telephone communications.

In addition, the Planning Department published a notice of the plan revision process on the City's website, provided a copy of the 2005 plan for review, and requested public comments. The Planning

Department also prepared and posted a questionnaire to solicit information in support of the mitigation plan updates. A copy of the public notice and questionnaire are appended at the end of this document.

Summary of Updates

Each section of Warwick's 2005 plan was reviewed by the consultant and the Hazard Mitigation Committee. Current regulations and guidance documents, as well as the Rhode Island State Hazard Mitigation Plan, were reviewed to ensure that updates to all chapters of the Warwick plan addressed any new requirements.

The forward and chapters 1 and 4 were revised to address needed updates. The City's Mission and Goals for hazard mitigation were revisited (Chapter 2) and determined to require only the addition of the City's commitment to assuring continued FEMA funding eligibility through updates to this plan at a minimum of once every five years. In addition, local geography and demographics sections were reviewed (Chapter 4); however, no changes were found to be necessary since 2010 Census data had not yet been published. Substantial additions were made to Chapter 3 to document the 2010 update process.

Local and regional hazard data for occurrence and impacts of various natural hazards was researched through online data searches and other available resources including, but not limited to: FEMA, RIEMA, Rhode Island Department of Environmental Management (RIDEM), United States Geologic Survey (USGS), the Northeast States Emergency Consortium (NESEC), and recently updated/approved Hazard Mitigation Plans for neighboring communities. A complete list of references and resources is appended to this document. No new hazards were identified; however, minor revisions to statistical data were performed in applicable sections of the plan (Chapter 5 & 6).

Based upon the current hazard data, each type of hazard was revisited and updates made to the hazard profiles to ensure that the location, extent, historical occurrences, and probability was addressed as now required by FEMA (Chapter 6). Resulting risk scores were re-evaluated; however, only one risk score was recommended for adjustment - flood. After the extreme storms and riverine flooding experienced by the City of Warwick in March 2010, the area of impact for this hazard type was increased from 10 to 50 square miles. This was done to account for the fact that riverine flooding occurs in a different geographical area than previously identified coastal flood hazards. Although first impression is that the risk score for flooding should have increased substantially, this wasn't the case, since the risk of flooding in Warwick is already high due to tropical cyclones, nor'easters, and storm surge. The addition of riverine flooding was of relatively little impact to the overall flood risk score.

Warwick's current assets and vulnerabilities were also reviewed and minor revisions made as necessary to provide updates to information such as climate and hazard occurrence statistics. Although the majority of the assets and vulnerabilities remained substantially unchanged, Chapters 6-12 were significantly re-organized to make them more in concert with FEMA guidance, including the following specific modifications:

- The title of Chapter 8 was revised to "Assessing Vulnerability," and all section headers revised accordingly.

- The entirety of former Chapter 9, Development Trends, was moved to become a section of Chapter 8 entitled Assessing Vulnerability: Development Trends.

- A number of sections in former Chapter 10 were deleted because they exactly duplicated sections from Chapter 6.

- Former Chapters 10 through 12 were combined and re-organized into a single Chapter entitled *Mitigation Strategies*, and the majority of the sections re-titled accordingly. Mitigation Strategies is now Chapter 9.

- Former Chapter 13, Evaluation & Implementation of Actions, was updated to reflect changes in the mitigation actions, as well as supplemented to ensure compliance with new FEMA plan requirements. This is now Chapter 10 entitled "Evaluation & Implementation."

- Former Chapter 14, Plan Monitoring, Evaluating, and Updating, was revised to provide more detailed milestones for plan monitoring and evaluation. This is now Chapter 11.

- Former Chapter 16, Definitions and Acronyms, was deleted, since terms are defined at the time of use throughout the document. The list of acronyms was updated and moved to a more standard location following the Table of Contents.

- Chapters 14 and 17 were supplemented to provide new references and appendices in support of the 2010 updates, and re-numbered as a result of the modifications above.

Using the updated vulnerability assessment, and the wealth of input from stakeholders, revisions were made to the mitigation strategies (former Chapters 11 through 14), outlining existing and future mitigation strategies and their associated implementation. A large majority of the revisions to these sections came from observations and lessons learned from the severe storms and flooding that plagued the City of Warwick in March and April of 2010. Institutional knowledge gained by local, regional, and state personnel who experienced this disaster first hand was captured in these updates.

Additional discussion was also added to new Chapter 9 to detail Warwick's continued participation in the National Flood Insurance Program (NFIP), as is now required for approval of this hazard mitigation plan by FEMA.

It is important to note that some sections of the 2005 Hazard Mitigation Strategy were left untouched in order to provide historic record of the development of the original plan, demonstrate implementation progress, and preserve references and data sources. In addition, a great deal of effort was put into preparation of the first plan, and it was deemed important to maintain the acknowledgements and accolades earned by these individuals, departments, institutions, and agencies throughout the plan maintenance process.

Copies of the draft 2010 Hazard Mitigation Strategy were published for public comment on the official City website, and hard copies made available for review at the Planning Department. In addition, specific requests for review of the 2010 draft plan were forwarded via email (or hard copy upon request) to each of the Committee/stakeholders listed above. Comments received within the allotted comment period were considered and incorporated as appropriate.

In addition to conducting advertised public hearings, providing hard copies of the draft plan for review in the Warwick Planning Department and posting the 2005 and draft 2010 plan on the City website for review and comment the City also directly reached out to neighboring communities and business

organizations. Specifically, the City of Warwick contacted the following abutting communities Planning Offices for comment via direct telephone communication and/or email: City of Cranston, Town of West Warwick, Town of East Greenwich and the Town of North Kingstown. No comments were received other than requests for a copy of the final, approved plan. Additionally, the City of Warwick also reached out to the business community at large via the Central Rhode Island Chamber of Commerce whose purpose is to support and advance the business community in Rhode Island by providing leadership initiatives in economic and human development. Copies of the Plan were emailed directly to the Director of the Chamber and a brief conversation took place regarding the Plan and its purpose. Nonprofits and academia were welcome to participate in the planning process via the two website postings, through the advertised public comment period and the public hearing.

2005 Hazard Mitigation Committee

(This information is being provided to detail the framework of the original plan and to ensure consistency with plan development).

The development of the 2005 mitigation strategy resulted from countless hours of work by all parties involved over approximately a two-year period. In order to assure the plan fully encompassed all the aspects of the City of Warwick, a working group was formed in January of 2003 consisting of members of City Government, affiliates of major institutions located in the City, and the general public. This allowed for the demographics of the group to be in line with the overall demographics of the City. Planning in this fashion created a mitigation strategy that fully encompassed all aspects of disaster impact, from concerns of the residency, business continuity, and local disaster response and recovery activities. The general public was invited to join the planning process by way of general public notice to the populace. As a part of the planning process, concerned members from T.F. Green airport, Kent County Hospital, Kent County Court House, and the Community College of Rhode Island, were also invited to attend meetings and play a part in the formulation of the local mitigation strategy. The following is a list of all parties involved in the creation of the Warwick mitigation strategy published in 2005.

City of Warwick Hazard Mitigation Committee (2005)

Chief Jack Chartier, Emergency Management Director
Assistant Chief Michael Walsh, Deputy Emergency Management Director
Col. Stephen McCartney, Warwick Police
Barbara Caniglia, Mayor's Office
Joel Burke, Warwick Sewer Dept.
Juan Mariscal, Warwick Sewer Dept.
John Delucia, Warwick Engineering Dept.
Charles Sapcoe III, Warwick Engineering Dept.
Mark Carruolo, Warwick Planning Dept.
Daniel Geagan, Warwick Planning Dept.
William Facente, Warwick Economic Development
Linda Sullivan, Warwick Human Services Dept.
Daniel O'Rourke, Warwick Water Dept.
John Pagliaro, Warwick Building Dept.

David Picozzi, Warwick Public Works Dept. Michael Rooney, Warwick Recreation Dept.

The committee met on a monthly basis and discussed any issues encountered in the development of the strategy. Tasks were assigned to appropriate group members and meetings were scheduled to discuss developments as they were made. Although the project was completed by the group as a whole, Assistant Chief Michael E. Walsh of the Warwick Fire Department coordinated the group. Jarrett W. Devine, an emergency management planning specialist, was also brought in to assist in the plan development.

2005 Methodology

The first step in completing a multi-hazard mitigation strategy is to identify all of the hazards that have the potential to impact the City of Warwick. The second step is to perform a risk assessment. Risk assessment is a systematic way to quantify the effects of the identified hazards and provides a way to recognize and compare risks. These tasks were assigned to Jarrett Devine and Michael Walsh, the Emergency Management Coordinator for the City, during the early stages of the planning process.

After quantifying the risk, data about population, property, economic and environmental resources were gathered in order to determine how and where Warwick is vulnerable to the impact of various hazards. To more accurately understand the community's vulnerability it was also important to gather information on the existing protection systems, both physical and regulatory currently in place within Warwick. This process was assigned in the October 2003 meeting, where it was decided that each member of the committee shall maintain responsibility of reviewing the impacts of hazards within each of their areas of expertise. The planning department was responsible for gathering data on the impacts to all other areas of the City not publicly owned.

Once the results from the risk assessment and vulnerability analysis were known and an understanding of how and where Warwick is vulnerable to the impacts of these hazards in terms of damage to public infrastructure, critical facilities, as well as environmental, societal and economic components was gained, a clearer picture of the areas at risk was depicted using Geographic Information System (GIS) maps.

Based on the results of the risk assessment and vulnerability analysis, mitigation actions were identified in order to address the various hazards which have the potential to impact Warwick. These actions were designed to allow Warwick to reduce the City's vulnerability to natural hazard losses. This process began in February 2004, once all information was known regarding the potential impact of the hazards. In June 2004, all information that was required to write the plan had been gathered and the group worked on creating the final draft.

Chapter 4. Climate, Geography, and Demographics

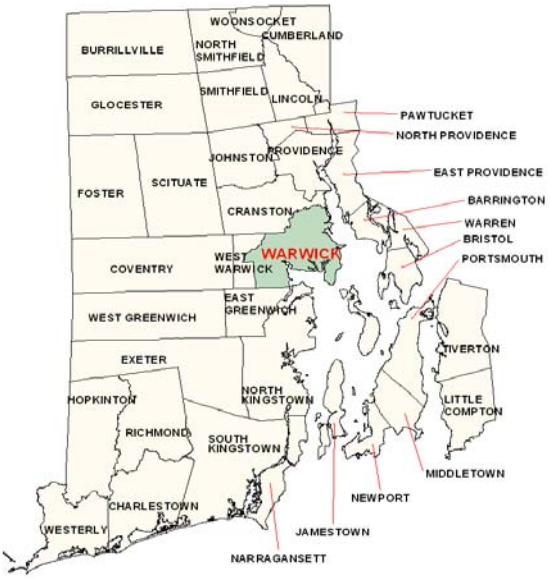
When preparing a mitigation strategy it is imperative to assure that the plan encompasses all aspects of the City. In order to assure that this was the case, the hazard mitigation committee first studied the current situation of the City of Warwick, namely the climate, geography, and demographics. A historical review was also performed in order to assure that the City of Warwick Mitigation Strategy brings together every aspect of the City. This section will serve as a summary of the foundation upon which the Warwick Mitigation Strategy was written.

City of Warwick – General Information

Warwick is located in east-central Rhode Island along the western coast of Narragansett Bay (Figure 4-1) and is comprised of approximately 35 square miles of land area, 39 miles of coastline, and hosts a population of 85,808.

Warwick is the second largest city in Rhode Island. The city is situated at the center of the state's super-highway system. Theodore Francis (T.F.) Green State Airport is located in Warwick and is the state's largest commercial air terminal. Warwick offers many educational, recreational, and cultural opportunities. The Knight Campus of the Community College of Rhode Island, a state supported facility, is located in Warwick.

Warwick's central location in Rhode Island as well as the easy access for air travel, has made the city a prime area for further industrial, commercial and population growth.



Geography and Climate

Summer temperatures tend to be in the 53-76 F / 12-24 C range. There are some 90+ F / 32+ C days, mostly in the inland areas of the city in July, but the afternoon sea breeze keeps most summer highs in the low 80s F/27 C. September and October are generally clear, with highs in the mid 60s to mid 70s F/17-23 C. Winter is wet, sometimes snowy, sometimes icy and chilly (18 to 37 F/-8 to -3 C).

Government

Established: 1642
Incorporated: 1931
Form of Government: Mayor and a nine member City Council
Fiscal Year Begins: July 1
Address: City Hall; 3275 Post Road; Warwick, RI 02886

General Demographic Characteristics

Although the 2010 Census is currently underway, this data will not be published in final form in time to be incorporated into this mitigation plan revision and will be addressed during the next revision cycle. Should the 2010 Census data be available after FEMA approval, but prior to local approval of this Plan, the updated numbers will be incorporated.

Based on 2000 census data, the following general demographic facts are presented for the City of Warwick:

- **Population**: The population count for The City of Warwick as of April 1, 2000, was 85,808. This represented a 0.45% increase (381 persons) from the 1990 population of 85,427.

- **Rank**: In 2000 Warwick ranks 2nd in population among Rhode Island's 39 cities and towns.

- **Median Age**: In 2000 the median age of the population in Warwick was 40.

- **Age Distribution**: In 2000, 78.1% or 67,028 persons residing in Warwick were 18 years of age or older. 64,478 were 21 and over, 16,664 were 62 and over, and 14,558 were 65 and over.

- **Population Density**: The 2000 population density of Warwick is 2,417 persons per square mile of land area. Warwick contains 35.50 square miles of land area (91,940,953 Sq. meters) (22,719.28 acres) and 14.12 square miles of water area (36,574,361 square meters) (9,036.76 acres).

- **Housing Units**: The total number of housing units in the The City of Warwick as of April 1, 2000, was 37,085. This represented an increase of 1,944 units from the 35,141 housing units in 1990. Of the 37,085 housing units 1,568 were vacant. 493 of the vacant units were for seasonal of recreational use.

- **Households**: In 2000, there are 35,517 households in Warwick with an average size of 2.39 persons. Of these, 22,971 were family households with an average family size of 2.99 persons.

- **Race**:
  > White: 81,695
  > Black of African American: 996
  > American Indian and Alaska Native: 213
  > Asian: 1,281
  > Native Hawaiian and Other Pacific Islander: 15
  > Some Other Race: 506
  > Total Population of two or More Races: 1,102
  > Hispanic or Latino: 1,372

Chapter 5. Hazard Identification

Identifying the hazards is the first step in any effort to reduce community vulnerability. For multi-hazard identification, all hazards that may potentially occur in the community should be identified including both natural hazards and cascading emergencies – situations when one hazard triggers others sequentially. For example, severe flooding that damaged buildings storing hazardous water-reactive chemicals could result in critical contamination problems that would dramatically escalate the type and magnitude of events.

As a New England coastal community, Warwick's primary hazards are related to severe storms and flooding. However, as part of developing and updating this mitigation strategy, upwards of 25 different potential hazards were reviewed. Through online and other data searches, and in accordance with FEMA guidance, the following natural hazards were found to be a relatively low risk for Warwick and do not require a risk assessment at this time:

Avalanche	Land Subsidence	Tsunami	Windstorm
Expansive Soils	Levee Failure	Volcano	Wildfire
Landside			

Two of these exclusions require additional explanation. First, although there is a levee in Warwick, this levee was constructed for the purpose of protecting the municipal wastewater treatment facility from flooding. As such, assessment of risks related to this levee is included under flood hazard discussions and not separately under Levee Failure. The other exclusion is Windstorms. The FEMA Wind Zone map indicates that Warwick lies within Zone II, which is not a high threat for windstorms; however, Warwick is in a special wind region due to its susceptibility to hurricanes. Assessment of wind risks due to hurricanes is discussed under hurricanes, and not separately under Windstorm.

Therefore, the following natural hazards will be addressed as part of the Warwick Hazard Mitigation Strategy:

Atmospheric		
Hailstorms	Temperature Extremes	Tornados
Nor'easters	Thunderstorms & Lightning	Tropical Cyclones
Severe Winter Storms		

Hydrologic	Seismic
Coastal Erosion	Earthquakes
Droughts	
Floods / Storm Surges	

Due to their potentially catastrophic nature, this plan also addresses the Technological Hazards of Dam Failure and Hazardous Materials Events. These hazards, as identified above, are the events that have the greatest potential for impacting the City of Warwick and serve as the cornerstone for this mitigation strategy. Please note that this updated list contains no new hazards identified since the 2005 plan.

PART 1 - NATURAL HAZARDS

SUBPART A – ATMOSPHERIC HAZARDS


Hurricane Bob Making Landfall in

A.1 Tropical Cyclones

Hurricanes, tropical storms, and typhoons, collectively known as tropical cyclones, are among the most devastating naturally occurring hazards in the United States and its territories. More than 36 million people live in the States along the Gulf of Mexico and Atlantic Ocean coast; they are of the conterminous United States most susceptible to tropical cyclones. These are also the regions with the highest growth rates and rising property values. The trend of increasing development in coastal zones magnifies the exposure of those areas to catastrophic losses from tropical cyclones.

A tropical cyclone is defined as a low pressure area of closed circulation winds that originates over tropical waters. Winds rotate counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere. A tropical cyclone begins as a tropical depression with wind speeds below 39 mph. It may develop into a tropical storm as it intensifies, with further development producing a hurricane or typhoon. Tropical cyclones with wind speeds between 39 mph and 74 mph are commonly known as tropical storms. When winds speeds exceed 74 mph they are commonly known as hurricanes. The eye, the storm's core, is an area of low barometric pressure that is generally 10 to 30 nautical miles in diameter. The surrounding storm may be 100 to 500 nautical miles in diameter, with intense windfields in the eastern and northern quadrants.

Hurricanes are classified as Categories 1 through 5 using the Saffir/Simpson Hurricane Scale (see Table 5-1 on the following page). The analysis is based on central pressure, wind speed, storm surge height, and damage potential. These storms involve both atmospheric and hydrologic characteristics. Those commonly associated with tropical cyclones include severe winds, storm surge flooding, high waves, coastal erosion, extreme rainfall, thunderstorms, lightning, and, in some cases, tornados.

The wind speed of a hurricane decreases as it moves inland for two reasons. First, the major source of storm energy (warm water) is no longer available to fuel the storm. Second, the land, vegetation, and structures offer frictional resistance to the storm winds. A hurricanes' peak wind speed distribution is a direct function of its rotational wind speed and forward speed. Storms that have a higher traveling speed do not stay in one place for long, minimizing the possibility of damaging buildings and other stationary structures. However, faster moving storms tend to be more destructive further inland. Because they travel further inland causing higher storm surge and stronger winds (IIPLR, 1994).

Table 5-1 SAFFIR-SIMPSON HURRICANE SCALE

Category	*Pressure*	*Wind Speed*	*Storm Surge*	*Damage Potential*
1 Weak	> 28.94" > 980.02 mb	75 - 95 mph 65 - 82 kt	4 - 5 ft.	Minimal damage to vegetation. No real damage to other structures. Some damage to poorly constructed signs. Low-lying coastal roads inundated, minor pier damage, some small craft in exposed anchorage torn from moorings.
2 Moderate	28.50" - 28.93" 965.12mb - 979.68mb	96 -110 mph 83 - 95 kt	6 - 8 ft.	Considerable damage to vegetation; some trees blown down. Major damage to exposed mobile homes. Moderate damage to houses. Considerable damage to piers; marinas flooded. Small craft in unprotected anchorages torn from moorings. Evacuation from some shoreline residences and low-lying areas required.
3 Strong	27.91" - 28.49" 945.14mb - 964.78mb	111 - 130 mph 96 -113 kt	9 - 12 ft.	Large trees blown down. Mobile homes destroyed. Extensive damage to small buildings. Poorly constructed signs blown down. Serious coastal flooding; larger structures near coast damaged by battering waves and floating debris.
4 Very Strong	27.17" - 27.90" 920.08mb - 944.80mb	131 - 155 mph 114 - 135 kt	13 -18 ft.	All signs blown down. Complete destruction of mobile homes. Extreme structural damage. Major damage to lower floors of structures due to flooding and battering by waves and floating debris. Major erosion of beaches.
5 Catastrophic	> 27.17" > 920.08 mb	> 155 mph > 135 kt	> 18 ft.	Catastrophic building failures. Devastating damage to roofs of buildings. Small buildings overturned or blown away.

A.2 Nor'easters

A Nor'easter is defined as a large weather system traveling from South to North, passing along or near the seacoast. As the storm approaches, and its intensity becomes increasingly apparent, the resulting counterclockwise cyclonic winds impact the coast and inland areas from a northeasterly direction. In the winter months, oftentimes blizzard conditions accompany these events. The added impact of the masses of snow and/or ice upon infrastructures often affects transportation and the delivery of goods and service for an extended period of time.

A.3 Thunderstorms and Lightning

Thunderstorm and lightning events are generated by atmospheric imbalance and turbulence due to a combination of conditions. These include unstable warm air rising rapidly into the atmosphere, sufficient moisture to form clouds and rain, and an upward lift of air currents caused by colliding weather fronts (cold and warm), sea breezes, or mountains.

Thunderstorms are recorded and observed as soon as a peal of thunder is heard by an observer as a NWS first-order weather station. A thunder event is composed of lightning and rainfall, and can intensify into a more severe thunderstorm with damaging hail, high winds, tornados, and flash flooding. Strong, concentrated, straight-line winds called downbursts are created by falling rain and sinking air that can

reach speeds of 125 mph. Microburst winds, which are more concentrated than downbursts, contain speeds up to 150 mph. These downbursts and microbursts generally last 5 to 7 minutes.

The National Weather Service classifies a thunderstorm as severe if its winds reach or exceed 58 mph, produces a tornado, or drops surface hail at least 0.75 inches in diameter (NWS, National Oceanic and Atmospheric Administration).

Lightning occurs during all thunderstorms. It can strike anywhere and at anytime during the storm. Generated by the buildup of charged ions in a thundercloud, the discharge of a lightning bolt interacts with the best conducting object or surface on the ground. The air in the channel of a lightning strike reaches temperatures higher than 50,000 degrees F. The rapid heating and cooling of the air near the channel causes a shock wave which produces thunder (NOAA, 1994).

Many hazardous weather events are associated with thunderstorms. Fortunately, the area affected by any one of them is fairly small and, most of the time, the damage is fairly light. Lightning is responsible for many fires around the world each year, as well as causing deaths when people are struck. Under the right conditions, rainfall from thunderstorms causes flash flooding, which can change small creeks into raging torrents in a matter of minutes, washing away large boulders and most man-made structures. Hail up to the size of softballs damages cars and windows, and kills wildlife caught out in the open. Strong (up to more than 120 mph) straight-line winds associated with thunderstorms knock down trees and power lines.

A.4 Tornados

Tornados are violently rotating columns of air extending from within a thundercloud down to ground level. The strongest tornadoes may sweep houses from their foundations, destroy brick buildings, toss cars and school buses through the air, and even lift railroad cars from their tracks. Tornadoes vary in diameter from tens of meters to nearly 2 km (1 mi), with an average diameter of about 50 m (160 ft). Most tornadoes in the northern hemisphere create winds that blow counterclockwise around a center of extremely low atmospheric pressure. Peak wind speeds can range from near 120 km/h (75 mph) to almost 500 km/h (300 mph). The forward motion of a tornado can range from a near standstill to almost 110 km/h (70 mph).

Many tornadoes, including the strongest ones, develop from a special type of thunderstorm known as a supercell. A supercell is a long-lived, rotating thunderstorm 10 to 16 km (6 to 10 mi) in diameter that may last several hours, travel hundreds of miles, and produce several tornadoes. Supercell tornadoes are often produced in sequence, so that what appears to be a very long damage path from one tornado may actually be the result of a new tornado that forms in the area where the previous tornado died. Sometimes, tornado outbreaks occur, and swarms of supercell storms may occur. Each supercell may spawn a tornado or a sequence of tornadoes.

Direct measurements of tornado wind speeds are difficult (and dangerous) to obtain. In 1971 Theodore Fujita, a meteorology professor at the University of Chicago, devised a classification system based on damage to manmade structures (see Table 5-2). His Fujita-scale classification system (F-scale) ranks tornado damage as weak (F0 and Fl), strong (F2 and F3), or violent (F4 and F5). The weakest tornadoes (F0) may damage chimneys and signs, whereas the most violent tornadoes (F5) can blow houses completely off their foundations.

Scientists are able to correlate F-scale values roughly using only wind speeds. For instance, a wind speed of 145 km/h (90 mph) might do minor F0 damage to a well-constructed building but significant

F2 damage to a poorly constructed building. Scientists estimate that F0 tornadoes may have wind speeds up to 110 km/h (70 mph), while F5 tornadoes may have wind speeds somewhere in the range of 420 to 480 km/h (260 to 300 mph). Despite its drawbacks, the F-scale system is a convenient means for scientists to classify and discuss the intensity of tornadoes. In the United States, it is the official tornado classification system of the National Weather Service.

Table 5-2 TORNADO CLASSIFICATIONS

SCALE	WIND ESTIMATE (MPH)	TYPICAL DAMAGE
F0	< 73	**Light damage.** Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.
F1	73-112	**Moderate damage.** Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.
F2	113-157	**Considerable damage.** Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
F3	158-206	**Severe damage.** Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.
F4	207-260	**Devastating damage.** Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.
F5	261-318	**Incredible damage.** Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 meters (109 yds); trees debarked; incredible phenomena will occur.

A.5 Severe Winter Storms

Winter storms and blizzards originate as mid-latitude depressions or cyclonic weather systems, sometimes following the path of the jet stream (Weather Defined, 1992). A blizzard combines heavy snowfall, high winds, extreme cold, and ice storms. The origins of such weather patterns are primarily from four sources in the continental United States.

In the northeast, lake effect snowstorms develop from the passage of cold air over the relatively warm surfaces of the Great Lakes, causing heavy snowfall and blizzard conditions. The Eastern and Northeastern States are affected by extra-tropical cyclonic weather systems in the Atlantic Ocean and the Gulf of Mexico that produce snow, ice storms, and occasional blizzards.

A.6 Hailstorms

A hailstorm is an outgrowth of a severe thunderstorm in which balls or irregularly shaped lumps of ice greater than 0.75 inches in diameter fall with rain (Gokhale, 1975). In the earliest developmental stages of a hailstorm, ice crystals form within a low-pressure front due the rapid rising of warm air into the upper atmosphere, which then causes a subsequent cooling of the air mass. Frozen droplets gradually accumulate on the ice crystals until, having developed sufficient weight, they fall as precipitation.

The size of hailstorms is a direct function of determining the size and severity of the storm. High velocity updraft winds are required to keep hail in suspension in thunderclouds. The strength of the updraft is a function of the intensity of heating at the earth's surface. Higher temperature gradients relative to the elevation above the surface result in increased suspension time and hailstone size (Encarta Online, 2002).

A.7 Temperature Extremes

Extreme summer weather is characterized by a sometimes dangerous combination of very high temperatures and exceptionally humid conditions. When such a pattern persists over an extended period of time, it is known as a heat wave. The National Weather Service uses a heat index that includes the combined effects of high temperature and humidity when measuring the severity of a heat wave. They also gather and compile information used to estimate the index and then distribute the determined value to the public and the weather broadcasting industry.

The estimation of the heat index is a relationship between dry bulb temperatures (at different humidities) and the skin's resistance to heat and moisture transfer. Because skin resistance is directly related to skin temperature, a relation between ambient temperature and relative humidity versus skin temperature can be determined. If the relative humidity is higher or lower than the base value, then the apparent temperature is higher or lower than the ambient temperature (National Weather Service, 1997).

Extreme winter weather is characterized by very low temperatures and low humidity. When such a pattern persists over an extended period, it is known as a cold snap. The average number of deaths

attributed to cold is 770 yearly, substantially higher than the number attributed to heat (Kilbourne, 1997).

When extreme cold temperatures are combined with high winds an effect called wind chill can increase the severity of the temperature extreme. The formula for winds in mph and Fahrenheit temperatures is:

*Wind chill temperature = 35.74 + 0.6215T - 35.75V (**0.16) + 0.4275TV (**0.16)*

In the formula, V is in the wind speed in statute miles per hour, and T is the temperature in degrees Fahrenheit.

SUBPART B - HYDROLOGIC HAZARDS

B.1 Floods

Flooding is the accumulation of water within a body of water and the overflow of excess water onto adjacent floodplain lands. The flood plain is the land adjoining the channel of a river, stream, ocean, lake, or other watercourse or water body that is susceptible to flooding (FEMA, Multi Hazard Identification and Risk Assessment, 1997). Flooding is the result of large-scale weather systems generating prolonged rainfall or on-shore winds. Other causes of flooding include locally intense thunderstorms, and dam failures.

Overbank flooding of rivers and streams known as riverine flooding is the most common type of flooding event. Riverine floodplains range from narrow, confined channels in the steep valleys of hilly areas, and wide, flat areas in low-lying coastal regions. Annual spring floods result from snowmelt, and the extent of this flooding depends on the depth of winter snowpack and spring weather patterns.

Coastal flooding can originate from a number of sources. Coastal storms such as hurricanes can generate the most significant flood damage to the outlining coastal areas.

Some other types of floods include flash floods, ice-jam floods, and dam-break floods that occur due to structural failures or overtopping of embankments during flood events.

Flash floods are characterized by a rapid rise in water level, high velocity, and large amounts of debris. Flash floods are capable of tearing out trees, undermining buildings and bridges, and scouring new channels. Warwick is more prone to flash flood events in areas where there is a predominance of clay soils that do not have high enough infiltration capacities to absorb water fast enough from heavy precipitation events.

Flash floods may also result from dam failure, causing the sudden release of a large volume of water in a short period of time. In urban areas, flash flooding is an increasingly serious problem due to the removal of vegetation, and replacement of ground cover with impermeable surfaces such as roads, driveways and parking lots. In these areas, and drainage systems, flash flooding is particularly serious because the runoff is dramatically increased.

The greatest risk involved in flash floods is that there is little to no warning to people who may be located in the path high velocity waters, debris and/or mudflow. The major factors in predicting potential damage are the intensity and duration of rainfall and the steepness of watershed and stream

gradients. Additionally, the amount of watershed vegetation, the natural and artificial flood storage areas, and the configuration of the streambed and floodplain are also important

There is often no sharp distinction between these separate types of floods; however, they are widely recognized and helpful in considering not only the range of flood risk but also appropriate responses.

Storm water runoff and debris flows also negatively impacts public infrastructure such as roads and bridges as water collects typically the result of inadequate drainage systems in the immediate area, creating ponding conditions oftentimes making roads impassible. Standing surface water develops after intense rainfall events where poor soil permeability and urbanization prevent adequate water drainage. This may interrupt road transportation and damage low elevation buildings.

B.2 Storm Surges

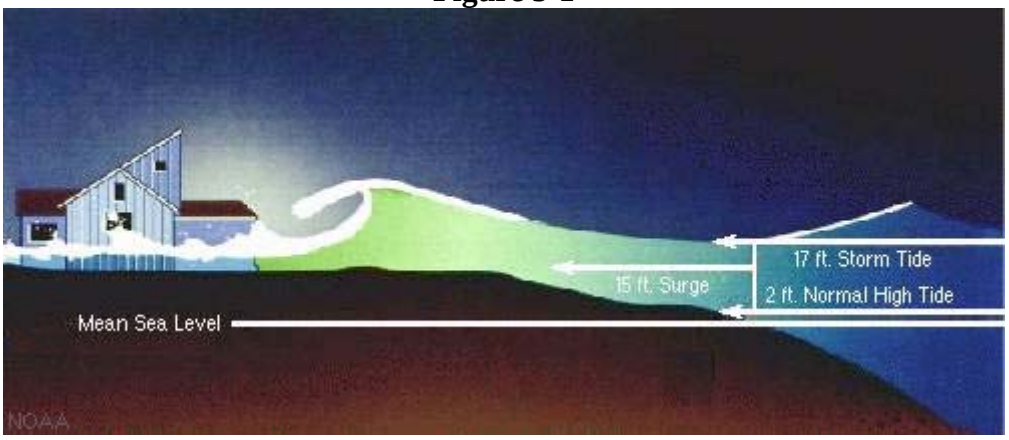
Storm surges occur when the water level of a tidally influenced body of water increases above the normal astronomical high tide. Storm surges commonly occur with coastal storms caused by massive low-pressure systems with cyclonic flows that are typical of hurricanes, nor'easters, and severe winter storms.

Storm surges caused by hurricanes usually begin over deep ocean waters wherein low pressure and strong winds around the hurricane's center raise the ocean surface 1-2 feet higher than the surrounding ocean. This rise in water lever forms a dome of water as wide as 50 miles across (National Science Foundation, 1980). As the storm moves into shallow coastal waters, decreasing water depth transforms the dome of water into a storm surge that can rise 20 feet or more above normal sea level, and cause massive flooding and destruction along the shoreline in its path.

There are certain factors associated with and controlled by coastal storms that attribute to the generation of such storm surges. The low barometric pressures experienced during coastal storms cause the water surface to rise, further increasing the height of storm surges; storms hitting land during peak astronomical tides have higher surge heights and more extensive flood inundation limits; coastal shoreline configurations with concave features or narrowing bays create a resonance within the area as a result of the winds forcing the water higher than experienced along adjacent areas of open coast (FEMA, Multi Hazard Identification and Risk Assessment, 1997).

Those areas most susceptible to storm surge are coastlines that are uniformly flat or only a few feet above mean sea level, the storm surge will spread water rapidly inland. Typically, storm surge diminishes one to two feet for every mile it moves inland. For example, a 20 foot surge in a relatively flat coastal area, where the land may only be 4 to 6 feet above mean sea level, would be felt 7 to 10 miles or more inland.

Figure 5-1



B.3 Coastal Erosion

Coastal erosion is the wearing away of land and loss of beach, shoreline, or dune material as a result of natural coastal processes or manmade influences. Actions of winds, waves, and currents are natural processes that can cause coastal erosion. Human influences include construction of seawalls, groins, jetties, navigation inlets and dredging, boat wakes, and other interruption of physical processes.

Erosion patterns and severity vary regionally as they result from local geological and environmental factors such as wind, tide, and frequency and intensity of coastal storms. Some coasts, such as those of the barrier islands in the Southeast, are retreating 25 feet per year, and sections of the Great Lakes coastline have receded as much as 50 feet per year.

Some scientists believe that global warming will make storms stronger and more frequent. But no one can say yet for sure. It is known, however, that sea level is rising in many regions and that global warming may increase the rate of rise. The sea level has increased by 10 to 25 cm over the past 100 years and NASA scientists predict that the sea level could rise 40 to 65 cm by the year 2100. Such a sea level rise would threaten coastal cities, forcing them to attempt to hold back the sea or to retreat.

Humans have also significantly increased the rate of coastline erosion. Population pressures, through economic development and recreational use, have exploited even the most remote coastal lands. In the last century, confidence in American technology's ability to engineer solutions has led many coastline property developers to risk placing structures closer and closer to the water (ScienCentral-Coastal Erosion, 2000). Protecting these structures from eroding away with the shoreline is both expensive and difficult, as is rebuilding or replacing damaged structures.

B.4 Droughts

A drought is defined as "a period of abnormally dry weather sufficiently prolonged for the lack of water to cause serious hydrologic imbalance in the affected area." -Glossary of Meteorology (1959). It is a normal part of virtually all climatic regimes, including areas with high and low average rainfall.

A drought is a period of unusually persistent dry weather that persists long enough to cause serious problems such as crop damage and/or water supply shortages. The severity of the drought depends upon the degree of moisture deficiency, the duration, and the size of the affected area.

There are four different ways that drought can be defined.

1. Meteorological- a measure of departure of precipitation from normal. Due to climatic differences, what might be considered a drought in one location of the country may not be a drought in another location.

2. Agricultural- refers to a situation where the amount of moisture in the soil no longer meets the needs of a particular crop.

3. Hydrological- occurs when surface and subsurface water supplies are below normal.

4. Socioeconomic- refers to the situation that occurs when physical water shortages begin to affect people.

SUBPART C - SEISMIC HAZARDS

C.1 Earthquakes

One of the most frightening and destructive phenomena of nature is a severe earthquake and its terrible aftereffects. An earthquake is a sudden movement of the Earth, caused by the abrupt release of strain that has accumulated over a long time. For hundreds of millions of years, the forces of plate tectonics have shaped the Earth as the huge plates that form the Earth's surface slowly move over, under, and past each other. Sometimes the movement is gradual. At other times, the plates are locked together, unable to release the accumulating energy. When the accumulated energy grows strong enough, the plates break free. If the earthquake occurs in a populated area, it may cause many deaths and injuries and extensive property damage.

The theory of plate tectonics, introduced in 1967, holds that the Earth's crust is broken into several major plates. These rigid 50 to 60 mile thick plates move slowly and continuously over the interior of the earth, meeting in some areas and separating in others (FEMA, Multi Hazard Identification and Risk Assessment). As the tectonic plates move together they bump, slide, catch, and hold. Eventually, faults along or near plate boundaries slip abruptly when the stress exceeds the elastic limit of the rock, and an earthquake occurs. Surface faulting, ground failure, and tsunamis are dangerous secondary hazards that can occur after an earthquake.

Although earthquakes have caused much less economic loss annually in the United States than other hazards such as floods, they have the potential for causing great and sudden loss. Within 1-2 minutes, an earthquake can devastate part of an area through ground-shaking, surface fault ruptures, and ground failures.

PART 2 - TECHNOLOGICAL HAZARDS

Dam Failures

A dam is defined as a barrier constructed across a watercourse for the purpose of storage, control, or diversion of water (Dam Safety Manual). A dam impounds water in the upstream area, or reservoir. The amount of water impounded is measured in acre-feet referring to the volume of water that covers an acre of land to a depth of one foot (FEMA, Multi-Hazards Risk Assessment, 1997). Two factors influence the potential severity of a full or partial dam failure: the amount of water impounded, and the density, type, and value of development and infrastructure located downstream.

Disastrous floods caused by dam failures, may cause great loss of life and property damage, primarily due to their unexpected nature and release of a high velocity wall of debris-laden water rushing downstream destroying everything in its path. The 1997 FEMA Multi-hazards Identification and Risk Assessment Publication reports that dam failures can result from any one or a combination of the following factors: prolonged periods of rainfall and flooding; inadequate spillway capacity, resulting in excess overtopping flows; internal erosion caused by embankment or foundation leakage or piping; improper maintenance, including failure to remove trees, repair internal seepage problems, replace lost material from the cross section of the dam, or maintain gates, valves and other operational components; improper design, including the use of improper construction material; negligent operation; failure of upstream dams on the same waterway; landslides into reservoirs; high winds causing significant wave action; and earthquakes.

Hazardous Materials Events

Hazardous materials are chemical substances, which if released or misused can pose a threat to the environment or health. These chemicals are used in industry, agriculture, medicine, research, and consumer goods. Hazardous materials come in the form of explosives, flammable and combustible substances, poisons, and radioactive materials.

Hazardous materials in various forms can cause death, serious injury, long-lasting health effects, and damage to buildings, homes, and other property. Many products containing hazardous chemicals are used and stored in homes routinely. These products are also shipped daily on the nation's transportation corridors.

Varying quantities of hazardous materials are manufactured, used, or stored at an estimated 4.5 million facilities in the United States--from major industrial plants to local dry cleaning establishments or gardening supply stores.

Under the Emergency Planning and Right to Know Act of 1986, the Unites States Department of Transportation (DOT) identified as hazardous 308 specific chemicals from 20 chemical categories. In small doses, these chemicals may have minimal or no affects on humans. During transportation, DOT classifies HAZMAT in one or more of the following categories: explosive; blasting agent; flammable liquid; flammable solid; oxidizer; organic peroxide; corrosive material; compressed gas; flammable compressed gas; poison (A and B); irritating materials; inhalation hazard; etiological agent; radioactive materials; and other regulated material (FEMA and DOT, 1989).

Chapter 6. Hazards Risk Assessment

What Is Risk Assessment?

Risk assessment is the determination of the likelihood of adverse impacts associated with specific natural hazards to the built, natural, business, and social environments. (Heinz Coastal Hazards Panel Report, 1999, p.110) In order to assess the risk of the City of Warwick to the hazards previously identified, the NOAA Community Risk Assessment Tool was used to determine the frequency, area of impact and potential damage magnitude of each hazard.

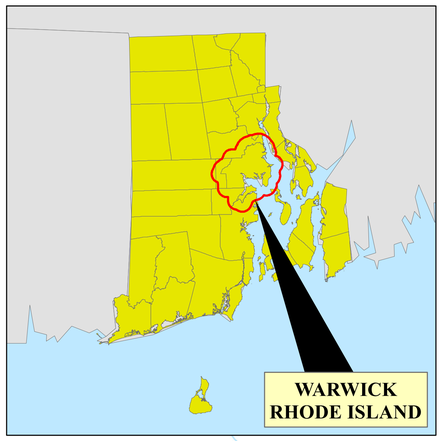
Occurrence Frequency

Evaluating the number of times that the natural hazard has impacted Warwick or a region within Rhode Island in the past provides a measure of the likelihood of the event occurring again in the future. This rating, presented in Table 6-1, is derived from an investigation of trends over the long-term, a minimum of 30 years of data. Examination of past events helps to determine the likelihood of similar events occurring in the future.

TABLE 6-1 FREQUENCY SCORE

Approx. Recurrence (years)	Approx. Annual Probability	Subjective Description	Frequency Score
1	100.0%	Frequently recurring hazards, multiple recurrences in one lifetime	5
50	2.0%	Typically occurs at least once in lifetime of average building	4
250	0.40%	25% chance of occurring at least once in lifetime of average building	3
500	0.20%	10% chance of occurring at least once in lifetime of average building	2
1000	0.10%	Highly infrequent events, like maximum considered earthquake	1
2500	0.04%	Unlikely event	0

Source: David Odeh, Odeh Engineers, North Providence, Rhode Island



T.F. Green
State Airport

GREENWICH
BAY

Legend

Critical Facilities

- FEMA Key Facilities
- Fire Stations
- Police Stations
- Sewer Facilities
- Water Facilities
- Schools
- Day Care Center
- Home Daycare Facility
- dams
- bridges
- Interstate Highway
- US Highway
- State Highway
- Other Road
- FEMA Evacuation Routes

Risks

- 100 Year Flood Zone
- 500 Year Flood Zone

SLOSH (Hurricane) Evacuation Areas

- A (Category 1 and 2 hurricane with forward wind speeds up to 40 mph and category 3 hurricane with forward wind speeds up to 20 mph)
- B (All other categories and forward wind speeds)

- Streams
- Municipal Boundary

N

1,600 0 1,600
Scale In Feet

FIGURE 1

CITY OF WARWICK, RHODE ISLAND
2010 EMERGENCY ACTION PLAN

CRITICAL FACILITIES AND RISKS
IN WARWICK
HAZARD MITIGATION

DECEMBER, 2010 SCALE: NOTED

Weston&Sampson®

Area of Impact (location)

A second criteria used in evaluating the risk of Warwick to natural hazards is to determine the area of impact (see Table 6-2). Some hazard events impact only a small region, while others can affect the entire area. The area of impact determination indicates how much of the immediate area is impounded by a single event. Again, historical data is used to investigate damage and loss records of previous hazard events to develop an estimate of where expected impacts or the amount of property damage may occur from future events.

TABLE 6-2 AREA OF IMPACT SCORE

Mean Affected Area (sq. miles)/event	Subjective Description	Area Impact Score
0	No affected area	0
1	Highly localized (city block scale)	1
10	Single zip code impact	2
50	City scale impact	3
100	County scale impact	4
500	Regional impact (e.g. statewide)	5

Extent

Extent (intensity or magnitude) criteria are used to determine the range of the severity of damage, from minor to devastating, expected from a single event (see Table 6-3). Previous damage reports and other historical data (e.g. newspaper articles, personal accountings, video clips, etc,) are used.

TABLE 6-3 MAGNITUDE SCORING

Magnitude Score	Earthquake MMI	Hurricane SSI	Average Flood Elevation
0	3	0	0
1	4	1	1
2	5	2	8
3	7	3	12
4	9	4	14
5	12	5	24

Based on the results of the cumulative scores, the following formula is used to prioritize the potential threat each hazard poses on Warwick:

(FREQUENCY + AREA OF IMPACT) X POTENTIAL DAMAGE MAGNITUDE = TOTAL SCORE

Table 6-4 presents the hazard risk score for the City of Warwick. The sections following discuss in depth the evidence in support of the risk scores for each of the City's identified hazards. As part of preparing the 2010 updates to this hazard mitigation plan, the frequency, area of impact, and magnitude associated with each hazard were reviewed. Although updates were made to historical data sets, review of this data did not find evidence of any notable changes in the risks associated with the majority of the hazards. Therefore, no changes were made to the calculated risk scores.

TABLE 6-4 RISK SCORE FOR WARWICK, RI

Hazard	Frequency	Area Impact	Magnitude	Total
Tropical Cyclone	4	5	4	36
Nor'easters	4	5	4	36
Thunderstorms	5	4	2	18
Tornado	1	2	4	12
Severe Winter Storms	4	5	4	36
Hail Storms	4	4	2	16
Temperature Extremes	5	5	1	10
Flood	3	3	5	30
Storm Surge	3	2	5	25
Coastal Erosion	4	2	1	6
Droughts	4	5	3	27
Earthquake	1	4	4	20
Dam Failures	1	1	4	8
Hazardous Materials	2	2	2	8

Total Score = (Frequency + Area Impact) x Potential Damage Magnitude

It is important to note that, after the extreme storms and riverine flooding experienced by the City of Warwick in March 2010, first impression is that the risk score for flooding should have increased substantially. However, since the risk of flooding in Warwick is already high due to tropical cyclones, nor'easters, and storm surge, the addition of riverine flooding was of relatively little impact to the overall flood risk score. The area of impact was increased to 50 square miles to account for the fact that riverine flooding occurs in a different geographical area than previously identified coastal flood hazards.

PART 1 NATURAL HAZARDS

Weather-related events account for almost all of the natural hazards recorded in the Warwick area. A summary of these events occurring in Kent County over the past 60 years is provided in Table 6-5 below.

TABLE 6-5 NATURAL HAZARD EVENTS RECORDED IN KENT COUNTY (January 1950-July 2010)
Source: National Climate Data Center

Hazard Type	No. of Events	Est. Damage ($M)	Deaths	Injuries
Floods	28	$28.83	0	0
Hail	24	$0	0	0
Rain	25	$0	0	0
Lightning	8	$0.42	0	9
Extreme Temperature	27	$0	0	0
Thunderstorm Wind	29	$0.07	0	2
Tornado	2	$0.25	0	0
Funnel Cloud	2	$0	0	0
Wind (with storm event)	85	$6.19	0	0
Winter Storm	57	$11.68	0	2
Total	**287**	**$47.44**	**0**	**13**

A detailed profiling of these and other natural hazards is presented in the following sections. For each type of hazard, the plan identifies the estimated:

- Past Occurrences: historical data on actual occurrences of the hazard event
- Location: geographical areas likely to be affected by the hazard event
- Extent: likely magnitude or severity of the hazard event
- Probability: likelihood that the hazard event would occur

In addition, the profiling includes information regarding known conditions that may exacerbate or mitigate the hazard, illustrates the hazard information in graphical form where readily available, and identifies the data source(s) on which the profile was created.

SUBPART A – ATMOSPHERIC HAZARDS

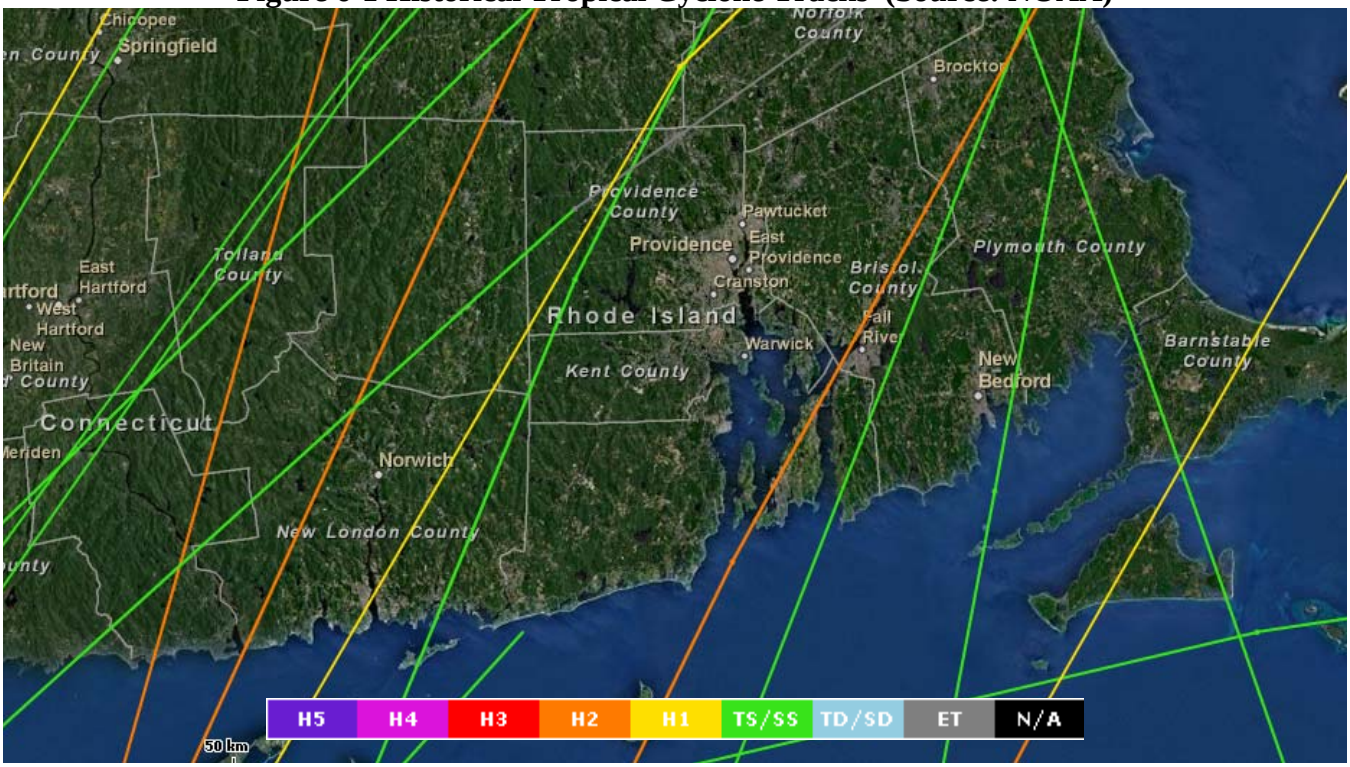
A.1 Tropical Cyclones – Risk Score 36

Storm Tracks in Rhode Island

Tropical cyclones, including hurricanes and tropical storms, impact Rhode Island from the south and southwest during the summer and fall from June through November. Although an average of 10 storms form each hurricane season in the Atlantic, most do not impact the northeast. Over the past 100 years, a variety of topical cyclones have hit or passed near Rhode Island (Figure 6-1).

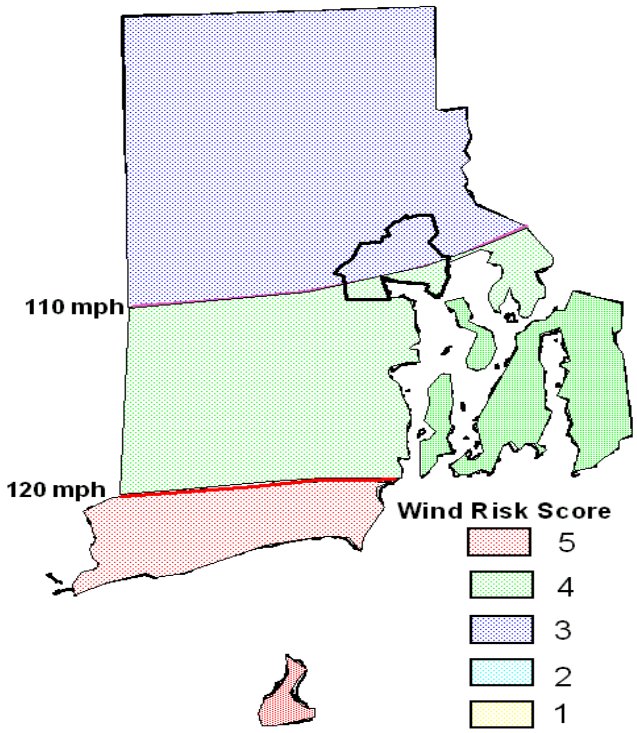
In addition, hurricanes tracking through the Atlantic Ocean that do not make a direct hit on Rhode Island still generate large swell, storm surge, and moderately high winds, causing varying degrees of damage. Impacts from these "near misses" frequently result in severe beach erosion, large waves, high winds, and marine overwash.

Figure 6-1 Historical Tropical Cyclone Tracks (Source: NOAA)



TS/SS = Tropical Storm/Subtropical Storm

Figure 6-2 Wind Risk Score



Tropical Cyclone Wind Potential

The hurricane events that represent much of the wind hazard for Warwick are coastal systems. As such, wind hazard areas can be prioritized based on the distance from the coast. Figure 6-2 shows the relative wind hazard ranking for Warwick and all of Rhode Island. These rankings are based on the American Society of Civil Engineers (ASCE) *Minimum Design Loads for Buildings and Other Structures, ASCE 7-98.* Coastal regions of Warwick are in the risk category 4, while the remainder of the City is in category 3.

Hurricanes Events

While there is only a 0.50% probability of one or more hurricanes making landfall in Kent County based on climatology, and the 50-year probability of an intense hurricane making landfall is just under 12% (landfalldisplay.geolabvirtualmaps.com), these storms have the potential to cause large amounts of damage over a widespread area. In coastal Warwick, damage would likely be city wide. A total of six notable storms have caused damage in Rhode Island since 1900 (Table 6-6).

TABLE 6-6 - HISTORICAL HURRICANE LOSSES FOR RI (NOAA)

Date	Name	Category of Storm	Magnitude (MPH)	Forward Motion	Property Damage ($ million *Actual)*	Deaths
9/21/1938	-	3	121	82	306	262
8/31/1954	Carol	3	110	56	461	19
8/19/1955	Diane	TS	45	24	170	0
9/12/1960	Donna	2	58	39	2.4	0
9/27/1985	Gloria	2	81	72	19.8	2
8/19/1991	Bob	2	100	51	115	18

The Great New England Hurricane of 1938, originating in the far-eastern Atlantic, was one of the most powerful and devastating storms in New England history. The wind speed of this hurricane reached record highs of over 120 mph and resulted in flood tides of more than 12 feet above the normal high water line in Greenwich Bay (Journal-Bulletin, 1979). The phase of the moon and the autumnal equinox combined to produce one of the highest tides of the year and the storm surge coincided almost exactly with it from ebb to flood (Brown, 1979), exacerbating the impact of the storm (Boothroyd's hurricane figure showing quadrant hits).

Property losses in and around Greenwich Bay from the Great New England Hurricane of 1938 were substantial. Among these were the loss of more than 700 permanent residences and hundreds of summer homes in Warwick, the devastation of Rocky Point (the oldest resort in Rhode Island), and the destruction of Scalloptown in East Greenwich (Journal-Bulletin, 1979). The Warwick Point lighthouse, which sits on a 20-foot cliff, was undermined by a 38-foot recession due to heavy erosion (Brown, 1979). After the hurricane of 1938, the Warwick Light was moved landward 75 feet. The erosion and changing coastline not only impacted the local infrastructure but has also had an impact on various habitats within the Bay.

Hurricane Carol (1954) was the most destructive storm to hit New England since the Great New England Hurricane of 1938. Sustained winds of 80 to 110 mph resulted in $3 million worth of property damage in Warwick; flash flooding in Apponaug; and an estimated $250,000 worth of damages to Rocky Point. Storm surges were just below the 1938 Hurricane levels. Oakland Beach was the most heavily battered section along the upper Narragansett Bay due to its exposure to southeast winds. Many observers noted that the destruction to Oakland beach was identical to what occurred in the 1938 storm. Apponaug, Chepiwanoxet, and Potowomut shores were littered with "houses, industrial structures, docks and stately trees" (Providence Journal Company, 1954). Greenwich Cove escaped the full force of the hurricane due to its location, and fishing and pleasure boats survived the storm with minor battering. The entire State lost electrical power during this storm (Journal-Bulletin, 1979).

Hurricane Bob reached Rhode Island on August 19, 1991 after developing in the Central Bahamas three days earlier. This hurricane caused a storm surge of 5 to 8 feet along the Rhode Island shore. Bob's damage in Rhode Island was primarily from the sustained winds of 75 to 100 mph. The winds caused over 60% of the residents across Rhode Island and Southeast Massachusetts to loose electricity due to tree and power line damage. Agricultural losses in peach and apple orchards were substantial. Boat damage from this hurricane was significant, as many were torn from their moorings (Vallee and Dion, 1998). The storm path of Bob was quite similar to Hurricane Carol (1954). Though the storm hit at high tide as a Category 2 hurricane, its center passed over Massachusetts. Rhode Island suffered over $115 million dollars in damage, with spillage of 100 million gallons of untreated sewage into Narragansett Bay and a resulting nine day shellfish bed closing (RIEMA 1995). Each of these major storms had significant northward acceleration. The average forward speed at time of landfall was 51 km/hr. The Great New England Hurricane of 1938 registered 82 km/hr.

A.2 Nor'easters – Risk Score 36

Nor'easters are similar to hurricanes in that they are coastal storms that bring heavy precipitation and very powerful winds. However, nor'easters are winter storms often accompanied by dramatic temperature drops and the possibility of frozen precipitation. Southern New England is impacted by nor'easters of varying sizes and intensity once every few years. The area impact of large nor'easters can be dramatic, with some notable storms affecting many hundreds of miles of coastline.

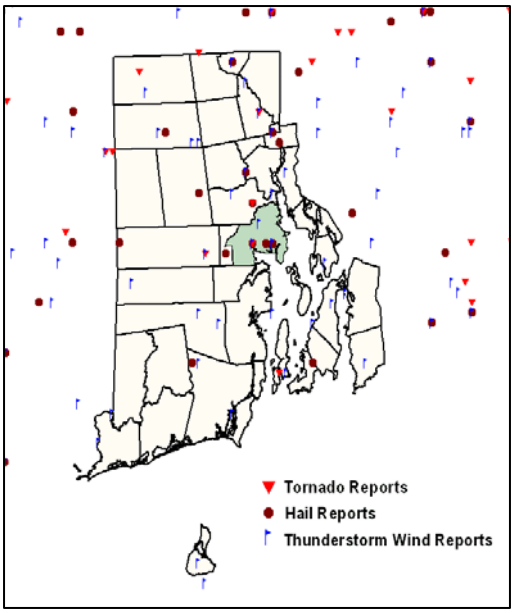
Nor'easter Events

The property damage from serious Nor'easters can be greater than that from hurricanes (Table 6-7).

TABLE 6-7 HISTORICAL NOR'EASTER LOSSES IN RI
Source: NOAA

Year	Deaths	Total Losses (Actual)
1888	400+	Unknown
1978	99	$202M
1991	33	$200M
1992	19	$1,000M-2,000M
1993	270	$3,000M-6,000M
1996	187	$3,000M

Figure 6-3
Historical severe weather reports in RI
Source: NOAA



A.3 Thunderstorms – Risk Score 18

Severe thunderstorms occur across southern New England during the spring and summer months. Accompanied with winds in excess of 75 mph, these storms develop an average of once or twice each year (Figure 6-3).

Each severe thunderstorm affects approximately 25 square miles. The winds in these storms are capable of damaging both buildings and vegetation. However, only the strongest of these storms cause physical damage to well-built structures.

A.4 Tornadoes – Risk Score 12

Tornadoes do not occur frequently across New England, and the Warwick area is no exception. In the almost 60 years (January 1950–July 2010) of available data from the National Climatic Data Center, only ten tornadoes were reported in Rhode Island, and only two of these were reported in Kent County. An F1 tornado was recorded in Kent County in October 1990, causing an estimated $250,000 in damage, and an F0 tornado touched down in Coventry in August 1994, but damage was minimal (NCDC). The probability that a tornado will occur in Warwick is relatively low, and the probability of a strong tornado is even lower.

Although the probability of a tornado touching down in Warwick is low (RI ranks 49th amongst the states in its frequency of tornado occurrence), these hazards are among the most destructive. Even minor tornadoes have the ability to destroy property and cause injuries or death. While tornadoes can occur anywhere in and around the Warwick area, the events are typically small in geographical area. The average tornado impacting the Rhode Island area affects only 2 square miles.

A.5 Severe Winter Storms – Risk Score 36

Warwick lies outside the heavy snow regions of the northeast. Located along the southern New England coast, Warwick has a maritime climate that is cooler in the summer and warmer in the winter than many inland locations. As a result, Warwick experiences less snowfall, on average, than cities to the northwest (Figures 6-4 and 6-5). Based on almost 50 years of data from the National Climate Data Center, during an average year, coastal regions of Rhode Island receive nearly 36 inches of snow. Conversely, Worcester, Massachusetts receives over 68 inches of snow annually.

Severe winter storms are spatially expansive. While individual locations can receive varying amounts of snow in a single event, few areas escape the impact entirely.

The two major threats from severe winter storms are snow loading on rooftops, and loss of power due to ice on power lines. The impact of major storms can be quite extreme, with power being out for several days.

Within the City of Warwick, the immediate coastal areas may experience less snow than inland areas. However, local terrain, combined with the size and variability of individual storms makes it difficult to assign relative rankings to the snow and ice hazard.

Figure 6-4 Heavy Snowstorm Probability of Occurrence.
Source: NOAA

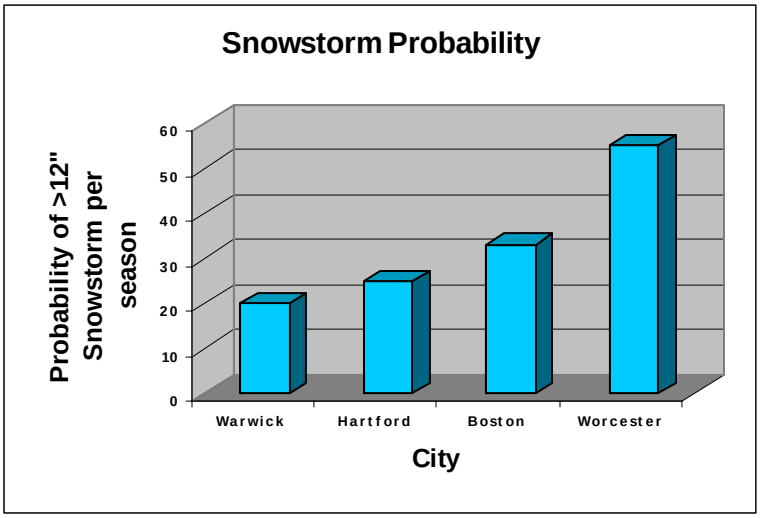
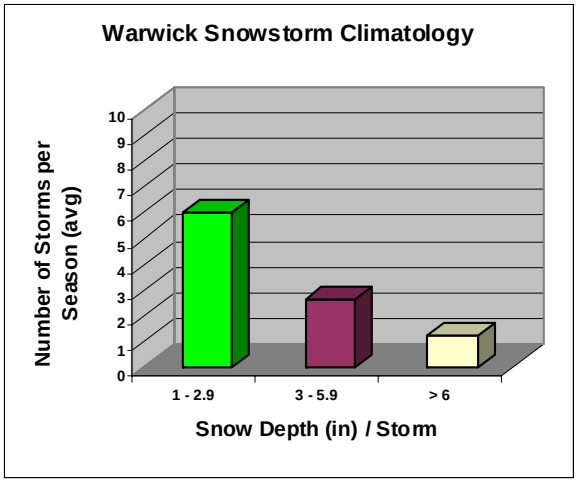
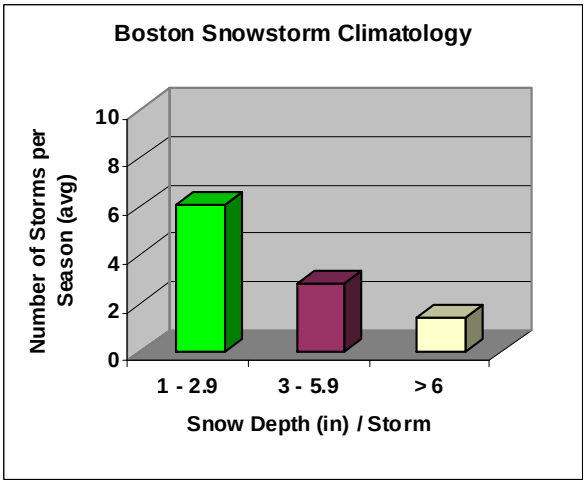
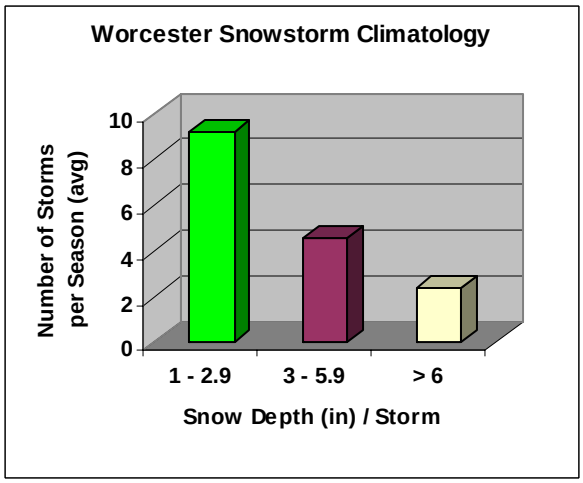
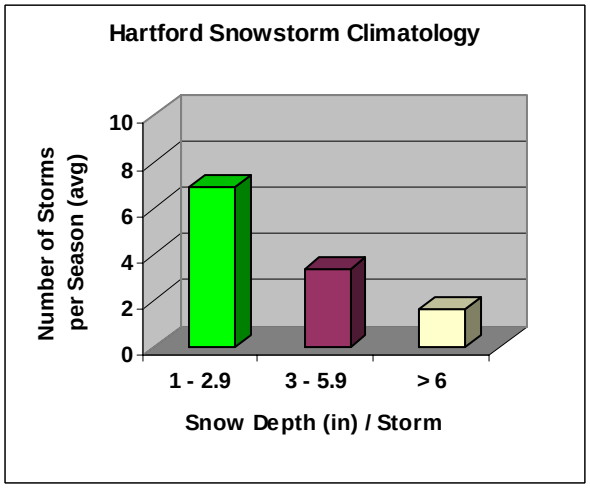


Figure 6-5 New England Seasonal Snowfall.
Source: NWS Boston, MA









A.6 Hail – Risk Score 16

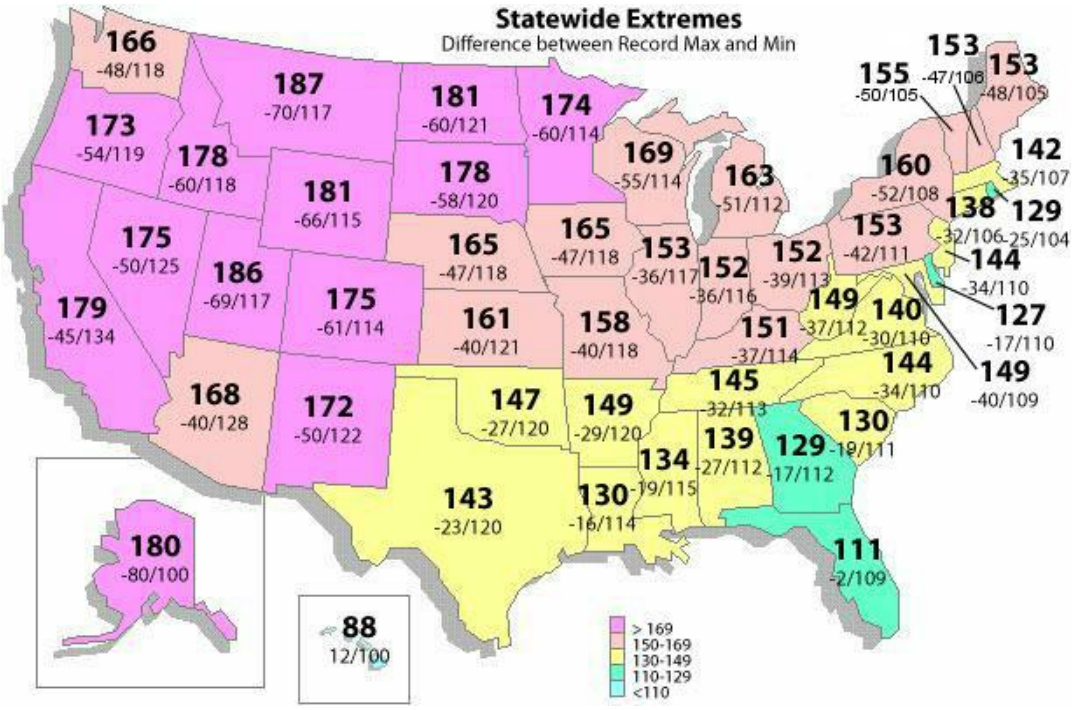
Hail occasionally accompanies severe thunderstorms in Rhode Island. Based on 52 years of data (1955 – 2007), hail of at least 0.75 inches diameter was reported in Rhode Island a total of 59 times (NOAA). This equates to an average of just under once per year. The actual range of hail storms per year recorded since 1955 ranged from zero events to a maximum of 10 hail events in any given year.

The portion of a thunderstorm that contains hail is relatively small. Less than half of the area impacted by a thunderstorm will experience hail. Hail can cause damage to automobiles and buildings. Unprotected roofing systems can be damaged by hail greater than one inch in diameter.

A.7 Temperature Extremes – Risk Score 10

An examination of historical temperature records reveals that Rhode Island lies in an area of varying temperature. Summers can have brief periods of extreme heat, while winters are often quite cold. The record high temperature for the City of Warwick is 104 degrees Fahrenheit and the record low temperature is minus 25 degrees Fahrenheit (Figure 6-6). The potential impacts of such extremes include health concerns (particularly in vulnerable populations) and power outages due to excessive heating or cooling load. These impacts are region-wide, but are typically short in duration. In addition, there are potential economic impacts due to elevated heating/cooling expenses and commercial downturns.

Figure 6-6 Rhode Island Temperature Extremes (ggweather.com)



SUBPART B – HYDROLOGIC HAZARDS

B.1 Flood – Risk Score 30

Storms
Major flooding events in Rhode Island are caused by storms, storm surge, high surf, and river flooding. The following storms hold the greatest potential to impact the City of Warwick:

- *Nor'easters* - Nor'easters are similar to tropical cyclones in that they are coastal storms that bring heavy precipitation and very powerful winds. However, nor'easters are winter storms often accompanied by dramatic temperature drops and the possibility of frozen precipitation.

- *Hurricanes* - Hurricanes or tropical storms hitting or passing by the New England coast cause heavy rains, storm surge, high winds and surf. Impacts from these events have included coastal erosion, severe inland and coastal flooding. Extensive wind damage can occur from the stronger tropical cyclones (hurricanes and tropical storms).

Flood Prone Areas
The City of Warwick utilizes the FEMA Flood Insurance Rate Map's (FIRM's) to determine the location of flood zones and flood prone areas. New FIRM maps were adopted by the City on December 3, 2010. These new maps were reviewed as part of updating this hazard mitigation strategy. There were only minor changes to the maps covering Warwick; therefore, revisions to this section on hazards are not needed at this time.

In Warwick, approximately 3,379 acres, and hundreds of structures are located within a FEMA designated Special Flood Hazard Area (SFHA). A special flood hazard area is delineated on a Flood Insurance Rate Map. The SFHA is mapped as Zone A. In coastal situations, Zone V is also part of the SFHA. The SFHA may or may not encompass all of the community's flood problems.

Under the National Flood Insurance Program (NFIP), FEMA is required to develop flood risk data for use in both insurance rating and floodplain management. FEMA develops this data through Flood Insurance Studies (FIS). In FISs, both detailed and approximate analyses are employed. Generally, detailed analyses are used to generate flood risk data only for developed or developing areas of communities. For areas where little or no development is expected to occur, FEMA uses approximate analyses to generate flood risk data.

Using the results of the FIS, FEMA prepares a FIRM that depicts the SFHAs within the studied community. SFHAs are areas subject to inundation by a flood having a one percent chance or greater occurring in any given year. This type of flood, which is referred to as the 100-year flood or base flood, is the national standard on which the floodplain management and insurance requirements of the NFIP are based.

The FIRMs show base flood elevations (BFEs) and flood insurance risk zones. The FIRM also shows areas designated as a regulatory floodway. The regulatory floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 100-year flood discharge can be conveyed without increasing the BFE more than the specified amount. Within the SFHAs

identified by approximate analyses, the FIRM shows only the flood insurance zone designation. The FEMA FIRM designations are defined as follows:

- *VE Zone* is the flood insurance rate zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

- *Zone A* is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the FIS by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no base flood elevations or depths are shown within this zone.

- *Zone AE* is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the FIS by detailed methods. In most instances, whole foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

- *Zone AH* is the flood insurance rate zones that correspond to the areas of 100-year shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

- *Zone AO* is the flood insurance rate zone that corresponds to the areas of 100-year shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. Average whole-depths derived from the detailed hydraulic analyses are shown within this zone

- *500-Year Flood Zone (or Zone X)* is the flood insurance rate zone that corresponds to areas outside the 500-year floodplain, areas within the 500-year floodplain, and to areas of 100-year flooding where average depths are less than 1 foot, areas of flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 100-year flood by levees. No base flood elevations or depths are shown within this zone.

The estimated acres of land in Warwick associated with each of these designations is presented in Table 6-7.

TABLE 6-7 REPRESENTATION OF WARWICK BY FEMA FLOOD ZONES

FEMA Flood Zone	Acreage	Square Miles	Percent
AE Zones	2,410	3.76	10.5
VE Zones	681	1.06	3.0
X500 Zones	3,835	5.99	16.7
X Zone	15,731	24.57	68.5
A Zone	288	0.449	1.25
City of Warwick	22,945	35.88	100

Within the established flood risk areas in Warwick, certain regions are more susceptible to damaging floods than others. In order to identify such regions, the Warwick flood risk areas can be prioritized based on a relative flood risk ranking. The relative risk rankings, illustrated in Figure 6-2, and presented in Table 6-8 are based on the FEMA flood zones. Zone VE designates areas along coasts subject to inundation by a 100-year flood event in addition to storm-induced velocity wave action. Such areas require mandatory flood insurance. Zones A, AE, AH, and AO are also subject to inundation by the 100-year flood event and also require mandatory flood insurance. However, regions in these zones are susceptible to shallow flooding from ponding and/or sloping terrain. The Zone X500 designation is given to those areas subject to flooding by severe, concentrated rainfall coupled with poor drainage systems.

Figure 6-7 Warwick Flood Hazard Risk Scores
Source: FEMA

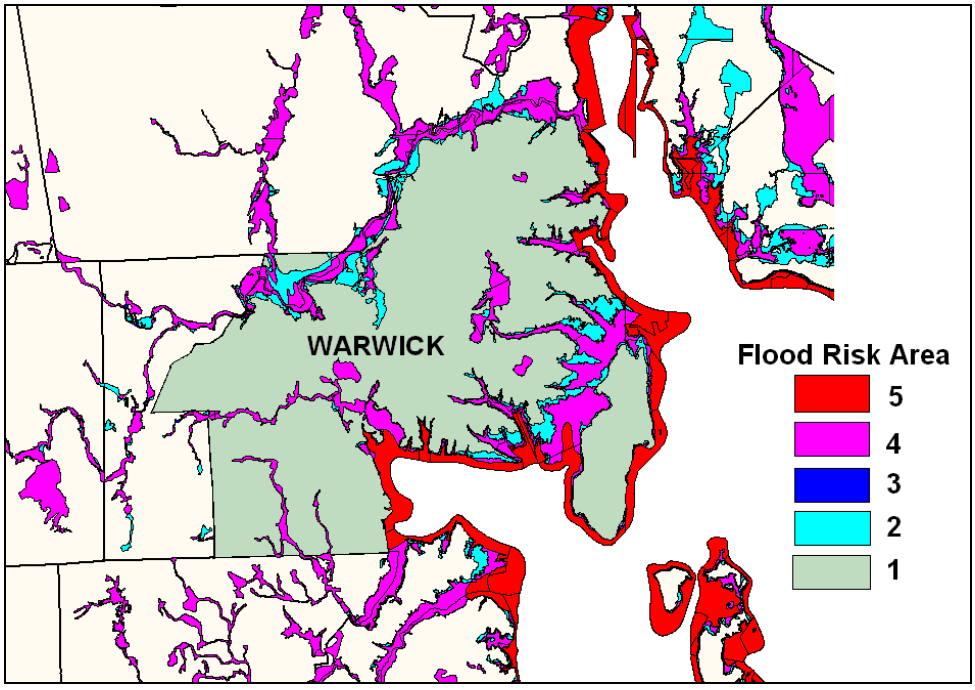


TABLE 6-8 FEMA FIRM FLOOD HAZARD RISK SCORES FOR WARWICK

FEMA Flood Zone	Amount of Land	Risk Score
VE zones	681	5
A and AE zones	2,698	4
AH and AO zones	288	3
500 year	3,835	2
Remainder of City	22,945	1

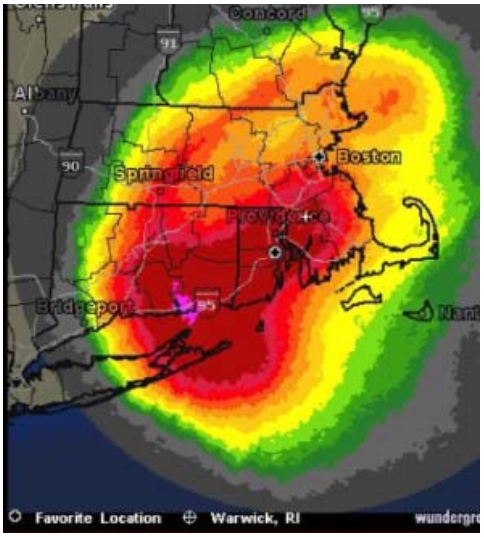
Flash Floods, Sheet Flow, and Ponding

Flash floods are characterized by a rapid rise in water level, high velocity, and large amounts of debris. Flash floods are capable of tearing out trees, undermining buildings and bridges, and scouring new channels. Warwick is more prone to flash flood events in areas where there is a predominance of clay soils that do not have high enough infiltration capacities to absorb water fast enough from heavy precipitation events.

Flash floods may also result from dam failure, causing the sudden release of a large volume of water in a short period of time. In urban areas, flash flooding is an increasingly serious problem due to the removal of vegetation, and replacement of ground cover with impermeable surfaces such as roads, driveways and parking lots. In these areas, and drainage systems, flash flooding is particularly serious because the runoff is dramatically increased.

The greatest risk involved in flash floods is that there is little to no warning to people who may be located in the path high velocity waters, debris and/or mudflow. The major factors in predicting potential damage are the intensity and duration of rainfall and the steepness of watershed and stream gradients. Additionally, the amount of watershed vegetation, the natural and artificial flood storage areas, and the configuration of the streambed and floodplain are also important.

Storm water runoff and debris flows also negatively impacts public infrastructure such as roads and bridges as water collects typically the result of inadequate drainage systems in the immediate area, creating ponding conditions oftentimes making roads impassible. Standing surface water develops after intense rainfall events where poor soil permeability and urbanization prevent adequate water drainage. This may interrupt road transportation and damage low elevation buildings. Road closures can be a critical issue in Warwick - when these events have the potential to isolate communities.



Flash flooding events, resulting from heavy precipitation, sometimes equaling the average annual rainfall, have occasionally occurred throughout the historical record. In Warwick, these events are concentrated around the Pawtuxet River watershed.

River Flooding

Although not a new hazard, major flooding as a result of rivers swollen from rainfall had previously not been given much attention in Warwick before March 2010. Beginning on March 13th, a multi-day storm event dropped almost four inches of rainfall over the Pawtuxet River Basin, bringing the Pawtuxet River to crest at over 15 feet. Only two weeks later on March 29, a second event dropped over eight inches of additional rainfall over the Pawtuxet River Basin. The week of March 28, 2010 is now considered the flood of record for the main channel of the Pawtuxet River, with peak discharges estimated at 10,400 cubic feet per second and flood elevations reaching 20.79 feet (11.79 feet above the 9-foot flood stage)(source: Cranston/Coventry HMPs).

Major flooding and significant damages occurred to properties, buildings, roadways, and other infrastructure along the Pawtuxet River and well inland, including the entire Warwick Mall. A significant and largely unanticipated impact was that the River crested at elevations in excess of the existing levee surrounding the City of Warwick Wastewater Treatment Facility (WWTF). The facility was completely inundated, rendering inoperable. A Major Disaster Declaration was issued by President Obama on March 29th. Although final damage assessments were not yet available at the time of this hazard mitigation plan update, FEMA estimated that as of July 7, 2010, nearly $79 million had been paid out in federal grants and loans.

Although the probability of this type of major river flood event is very low, the extent of the damage was substantial (and has yet to be fully determined). A river flood event similar to that experience in March 2010, also impacts the geographical area along the river's alignment, rather than the coastal flood areas typically flooded from tropical cyclones and winter storms.

B.2 Storm Surge – Risk Score 25

One of the most dangerous aspects of a hurricane is a general rise in sea level called storm surge. It begins over the deep ocean; low pressure and strong winds around the hurricane's center ("eye") raise the ocean surface a foot or two higher than the surrounding ocean surface forming a dome of water as much as 50 miles across (National Science Foundation, 1980). As the storm moves into shallow coastal waters, decreasing water depth transforms the dome of water into a storm surge that can rise 20 feet or more above normal sea level and cause massive flooding and destruction along the shoreline in its path. This problem is even more critical when there is additional impact caused by high, battering waves that occur on top of the surge.

Those areas most susceptible to storm surge are coastlines that are uniformly flat or only a few feet above mean sea level, where the storm surge will spread water rapidly inland. Typically, storm surge diminishes one to two feet for every mile it moves inland. For example, a 20 foot surge in a relatively

flat coastal area, where the land may only be 4 to 6 feet above mean sea level, would be felt 7 to 10 miles or more inland.

Storm surge floods and erodes coastal areas, salinizes land and groundwater, contaminates the water supply, causes agricultural losses, results in loss of life, and damages structures and public infrastructure. Warwick has over 39 miles of shoreline much of which is susceptible to storm surge. Flooding from storm surge in the immediate coastal areas occurs primarily as a result of tropical storms, hurricanes, and seasonal high waves, and its probability of occurrence is similar. During these events, high winds and surf can push water several feet and even hundreds of yards inshore. Conditions can be exacerbated by large waves that form on top of rising water. The degree of damage caused by storm surge depends on the tidal cycle occurring at the time of the event. During high tides, water levels can be significantly higher than at low tide. This will cause the surge to push further inland and cause more extensive damage. The area of impact of storm surge flooding is confined to regions along the immediate coastline and typically extends to a few hundred feet inland.

Sea, Lake, and Overland Surges from Hurricanes (SLOSH)

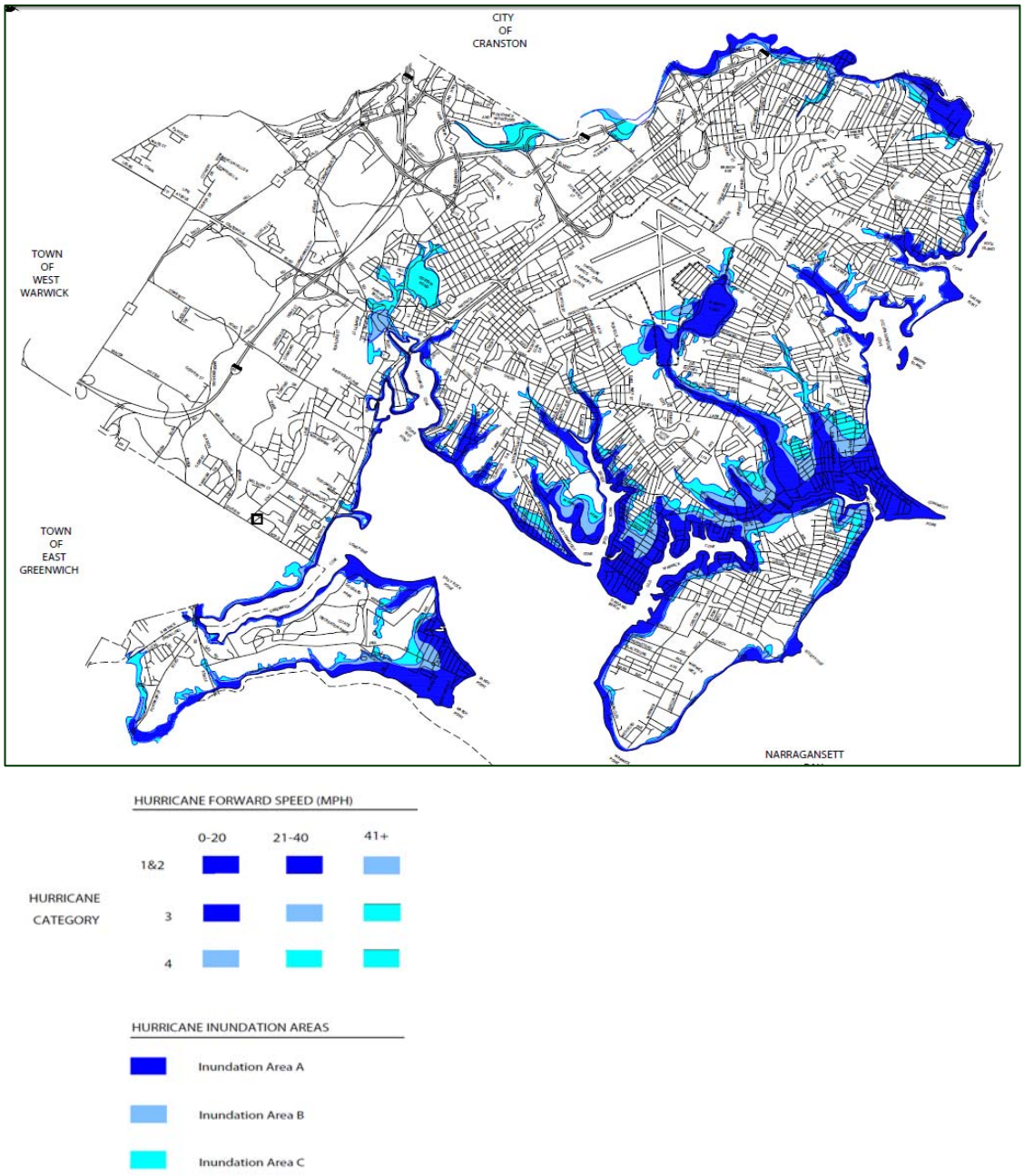
At present, the only widely used inundation model by state and federal agencies to determine the potential of storm surge is the Sea, Lake, and Overland Surges from Hurricanes (SLOSH). The SLOSH model is a computer model developed by the National Weather Service, designed to forecast surges that occur from wind and pressure forces of hurricanes. The National Hurricane Center used the SLOSH model, the bathymetry of Narragansett Bay and the Rhode Island coastal topography to model coastal flooding effects from hurricanes that could be experienced in the region. Combinations of four hurricanes categories (from the Saffir Simpson scale), five storm directions (NW, NNW, N, NNE, and NE), three forward speeds (20, 40 and 60 mph), and storm tracks selected at 15-mile intervals enabled 536 hypothetical situations to be simulated by the SLOSH model.

Maximum envelopes of water for each hurricane category and forward speed were calculated to reduce SLOSH model results to only those surge elevations that could potentially cause the greatest flooding. Further classification of maximum surges enabled three categories and forward speed dependent inundation areas to be developed and presented on each map. The inundation matrix of each community map can be used to determine the corresponding inundation area (A, B, or C) for a given hurricane category and forward speed. The classification of inundation areas by this matrix suggests that, in this region, Worst Case hurricane surges are predominantly a function of a hurricane's category and forward speed, and that a hurricane's track and direction have less of an effect on resulting storm surge.

Worst Case surge tide estimations were based on maximum storm surge elevations derived for each inundation area within each community. The SLOSH model provides estimates of Stillwater surge elevations only and does not consider additional flooding from wave run up. Separate analyses showed that wave run-up effects based on the derived Stillwater estimates do not significantly increase the limits of flooding. Surge elevations corresponding to Worst Case surge tides were superimposed on Rhode Island Department of Transportation base maps using U.S. Geological Survey 7.5 minute quadrangle maps. Community specific hurricane surge tides [referenced to the National Geodetic Vertical Datum] that are depicted for each inundation area are shown in the surge tide profiles provided on Plate iii of the U.S. Army Corps 1993 SLOSH Study.

In 2009, the U.S. Army Corps of Engineers updated the inundation maps for Rhode Island using the results of the SLOSH model, and FEMA LiDAR data. Figure 6-8 presents the projected areas that would be inundated by hurricane surge, as produced for the State of Rhode Island Hurricane Evacuation Study.

Figure 6-8 Estimated Warwick Storm Surge
Source: State of Rhode Island Hurricane Evacuation Study



For the Warwick area, based on the SLOSH model, storm surges are predicted to range from 18 to 23 feet high (U.S. Army Corps of Engineers, SLOSH Study, 1993, p.ii). Aside from a number of bridges, none of Warwick's critical facilities are located in a flood or SLOSH zone within the Greenwich Bay watershed. There are approximately 1,400 at-risk structures in the City of Warwick. Most of these structures are located in the Oakland Beach area, although Buttonwoods Cove is at-risk as well. In the event of a severe hurricane, over 3,379 acres of land in Warwick would be inundated, causing over $50 million in property damage. Such an event would knock out key assets such as the lumberyard, marinas, and several warehouses.

The Great New England Hurricane of 1938 produced the greatest storm tides this century in southern New England. The storm tide reached 19.01 feet (MLLW) at the State Street Station Dock on the upper part of Narragansett Bay during the 1938 Hurricane, associated with a 13.7 foot storm surge. Hurricane Carol brought a slightly higher storm surge, 14.4 feet over the upper portions of Narragansett Bay, but produced a slightly lower storm tide of 17.51 feet (MLLW), due to its arrival shortly after high tide. Hurricane Bob caused a storm surge of 5 to 8 feet along the Rhode Island shore.

B.3 Coastal Erosion – Risk Score 6

The glacially derived sediments found in the bluffs surrounding Greenwich Bay are highly susceptible to the erosion that occurs when a major storm surge elevates the water level 10 to 20 feet above mean sea level and subjects the unconsolidated sediments of glacial headland bluffs to the direct attack of waves (Providence Journal 1938). The beaches are sand-starved, leaving them susceptible to storm-surge and overwash processes. Oakland Beach and Buttonwoods Cove are especially vulnerable to erosion as they are relatively exposed to waves generated by southwesterly winds (Boothroyd, Personal Communication).

Oakland Beach is designated as a Class A critical erosion area in the Coastal Resource Management Program (CRMP). Setbacks are required in this area. The CRMP defines a setback as the minimum distance from the inland boundary of a coastal feature at which an approved activity or alteration may take place. Setbacks should extend a minimum of either 50 feet from the inland boundary of the coastal feature or 25 feet inland of the edge of a Coastal Buffer Zone, whichever is further landward. In areas designated by the Coastal Resource Management Council (CRMC) as Critical Erosion Areas, the minimum distance of the setback shall be not less than 30 times the calculated average annual erosion rate for less than four dwelling units and not less than 60 times the calculated average annual erosion rate for commercial, industrial or dwellings of more than 4 units. Due to site conditions over time, field verification of a coastal feature or coastal buffer zone may result in a setback determination different than that calculated using a shoreline change rate.

The impacts from coastal erosion are primarily due to the retreat of the shoreline inland and include damage to waterfront properties, buildings, and public infrastructure (i.e., roads, bridges, and buried utilities). Buildings become uninhabitable, and structures become structurally unsound, and some are even eventually swallowed by the sea. It is estimated that erosion may claim 25% of houses within 500 feet of the shore over the next 60 years (Heinz Center Report). Impacts are generally limited to coastal areas subject to wind and wave action from storm events.

B.4 Droughts – Risk Score 27

By definition, a drought is a "period of abnormally dry weather sufficiently long enough to cause a serious hydrological imbalance" (American Meteorology Society). It is a normal, recurrent effect of

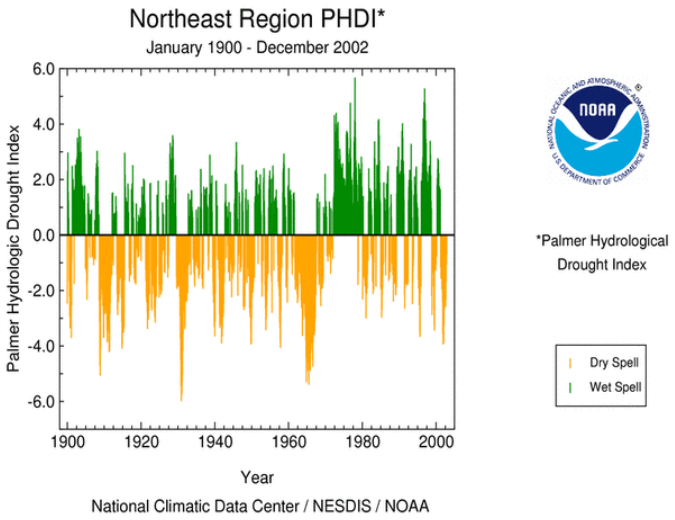
climate variation. As shown in Table 6-9, Rhode Island has had at least seven major droughts since 1929.

TABLE 6-9 RHODE ISLAND HISTORICAL DROUGHTS AND LOCATION OF IMPACT
Source: RI Hazard Mitigation Plan

Date	Area Affected	Recurrence	Remarks
1930-31	Statewide	Unknown	Stream flow of 70% normal.
1941-45	Statewide	20-50 years	Stream flow of 70% normal in Pawtuxet River.
1949-50	Statewide	15-20 years	Stream flow of 70% normal.
1963-67	Statewide	Over 50 years	Water restrictions/well replacements common.
1980-81	Statewide	10-25 years	Considerable crop damage.
1987-88	Southern RI	Unknown	$25 million crop damage.
1999	Statewide	Unknown	Spring through Summer the State experienced 75% of normal flow.

The potential for drought is best projected by the Palmer Index. The Palmer Index was developed by Wayne Palmer in the 1960s and uses temperature and rainfall information in a formula to determine dryness. It has become the semi-official drought index. The Palmer Index is most effective in determining long term drought—a matter of several months—and is not as good with short-term forecasts (a matter of weeks). It uses a 0 as normal, and drought is shown in terms of minus numbers; for example, minus 2 is moderate drought, minus 3 is severe drought, and minus 4 is extreme drought. The Palmer Index can also reflect excess rain using a corresponding level reflected by plus figures (i.e., 0 is normal, plus 2 is moderate rainfall, etc.). Figure 6-9 presents the Palmer Hydrological Drought Index for the Northeast Region over the past 100 years.

Figure 6-9



Review of available data indicates that droughts occur in Rhode Island approximately once every 20 years and the probability of occurrence is around 5%. Since droughts are regional in occurrence, the entire City of Warwick would be impacted. These impacts include, but are not limited to reduced flow in rivers and streams, low water levels in reservoirs and associated potable water shortages, dried up surface waters, crop and livestock losses, and increased fire danger.

SUBPART C - SEISMIC HAZARDS

C.1 Earthquakes – Risk Score 20

In general, the region around Warwick does not suffer from frequent earthquakes; however historical events in New England have been of moderate to high intensity and impact area. Between 1776 and 2007, a total of 38 earthquakes were recorded in Rhode Island; however, only two were considered significant (see Table 6-10). Advances in technology now detect an average of 40-50 earthquakes of varying magnitude and intensity in each year (NESEC).

TABLE 6-10 SIGNIFICANT RHODE ISLAND EARTHQUAKES (1638 – 2007)

Source: Northeast States Emergency Consortium

Date	MMI	Magnitude
June 10, 1951	4	4.6
February 28, 1883	Not rated	Not rated

Seismologists have estimated that there is a 40% to 60% likelihood of experiencing an earthquake of magnitude 6.0 or greater on the Richter scale in the eastern United States over the next 30 years. The quake would be felt throughout the City. The majority of the damage would be structures falling under the stress created by the earth's movement, and thus, not in any particular geographical location. The anticipated damage associated with earthquakes in Warwick (and throughout the northeast) are thought to be higher than other parts of the country due to several factors including, but not limited to:

- Densely populated areas that place more people at risk.
- Lack of a distinct fault line with which to predict location.
- Geology of the northeast magnifies the effects.
- Prevalence of older and un-reinforced masonry structures is higher, increasing the amount of damage.

The primary risk from earthquakes is structural failures in buildings, bridges, utilities, and other infrastructure that can cause injuries, death, and loss of function.

PART 2 TECHNOLOGICAL HAZARDS

Dam Failures – Risk Score 8

Disastrous floods caused by dam failures, may cause great loss of life and property damage, primarily due to their unexpected nature and release of a high velocity wall of debris-laden water rushing downstream destroying everything in its path. Past FEMA Multi-hazards Identification and Risk Assessment Publication reports state that dam failures can result from anyone or a combination of factors:

- Prolonged periods of rainfall and flooding;
- Inadequate spillway capacity;
- Internal erosion resulting in structural failure
- Improper maintenance
- Improper design;
- Negligent operation;
- Failure of upstream dams on the same waterway;
- Landslides into reservoirs which may cause surges resulting in overtopping;
- High winds which can cause significant wave action resulting in substantial erosion; and
- Earthquakes, which cause longitudinal cracks and weaken the entire structure.

With the exception of landslides into reservoirs, all of these factors could potentially lead to a dam failure in Warwick. The level of potential hazard associated with a dam failure can also be classified, as shown in Table 6-11.

TABLE 6-11 DAM HAZARD POTENTIAL CLASSIFICATION

Category	Loss of Life	Property Damage
Low	None expected	Minimal (undeveloped to occasional structures or agriculture)
Significant	Few (no urban structures)	Appreciable (notable developments and or inhabitable no more than a small number of inhabitable structures, agriculture, industry
High	More than a five	Excessive (extensive community, industry, or agriculture)

As indicated in Table 6-12, the latest inventory report from the Rhode Island Department of Environmental Management (Feb. 2009) states that there are a total of 20 dams in Warwick. Of these dams, three are listed as high hazard dams, where failure or misoperation would result in a probable loss of human life. An additional dam is listed as a significant hazard dam, where failure or misoperation would result in no probable loss of human life but can cause major economic loss, disruption of lifeline facilities or impact other concerns detrimental to the public's health, safety or welfare. However, since high hazard dams are regulated and inspected on a regular basis, catastrophic failure is a relatively low risk.

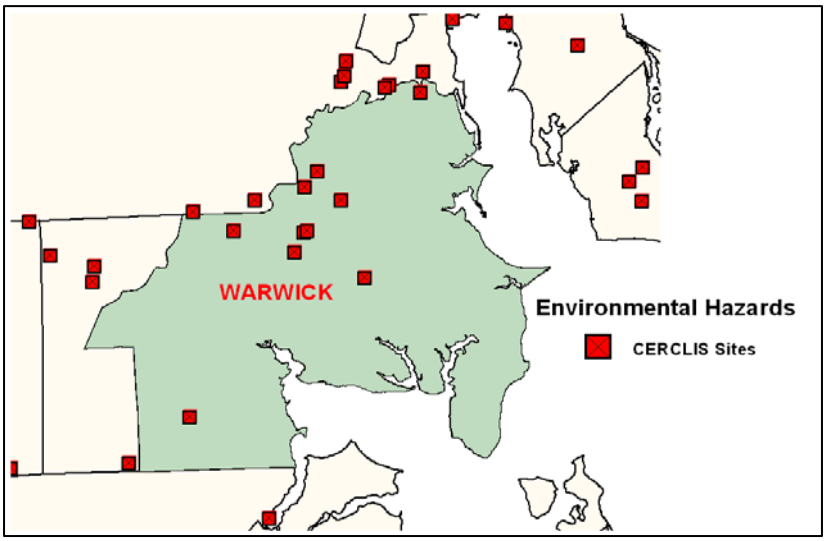
TABLE 6-12 RIDEM LISTING OF DAMS IN WARWICK, RI

State ID#	Dam Name	River	Hazard	Regulated
462	Camp Warwick Pond	Hardig Brook - Tributary	High	Yes
764	Grist Mill Apartments	Hardig Brook	High	Yes
548	Cranberry Bog	Hardig Brook - Tributary	Low	Yes
544	Feiring Farm Pond	Maskerchugg River	Low	Yes
144	Fruit of the Loom	Pawtuxet River	Low	Yes
559	Gorton Pond	Apponaug Brook	Low	Yes
450	Keith Farm Pond	Hardig Brook - Tributary	Low	Yes
143	Pawtuxet Reservoir Lower	Pawtuxet River	Low	Yes
431	Valley Country Club Pond	Hardig Brook - Tributary	Low	Yes
664	Three Ponds	Pawtuxet River - Tributary	Low	Yes
665	Manor Drive Ext. Pond	Providence River - Tributary	Low	Yes
666	Squantum Drive	Providence River - Tributary	Low	Yes
667	Gorton Pond/Rt. 5	Apponaug Brook	Low	Unknown
668	Unnamed	Hardig Brook	Low	Unknown
670	Royal Crest Apartments Upper	Hardig Brook	Low	Yes
671	Royal Crest Apartments Lower	Hardig Brook	Low	Unknown
678	Valley Country Club #2	Hardig Brook - Tributary	Low	Yes
302	Silver Hook	Pawtuxet River	Low	Unknown
669	Daves Marketplace	Tuscatucket Brook	Significant	Yes
145	Natick Pond	Pawtuxet River	High	Yes

Hazardous Materials Events – Risk Score 8

There are many sources of Hazardous Materials in and around Warwick. Many of these sources have been documented in government records. Figure 6-10 below depicts the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) sites. These sites have been identified as hazardous sites that have been investigated or are in the process of investigation for contamination risk.

Figure 6-10 Warwick CERCLIS sites
Source: VISTAinfo



Past Hazard Events That Have Impacted Warwick

Within the past 60 years, a number of natural hazards have impacted Warwick and the surrounding region. The following is a list of all storm events on record that have occurred in the Kent County area between January 1950 and July 2010. The number of deaths/injuries, and amount of property damage associated with each event is also provided.

TABLE 6-13 HISTORICAL STORM DATA

Location or County	Date	Type	Magnitude	Deaths	Injuries	Property Damage
118 Warwick	6/14/1998	Flood	N/A	0	0	$0
119 Coventry	6/19/1998	Flood	N/A	0	0	$0
155 Warwick	9/16/1999	Flood	N/A	0	0	$0
165 West Warwick	4/22/2000	Flood	N/A	0	0	$0
222 RIZ001-001-001-001-001>002-002-002-002>003-003>004-004-006-006-006-006-006	10/15/2005	Flood	N/A	0	0	$1,600,000
233 Coventry	10/28/2006	Flood	N/A	0	0	$4,000
234 Coventry	10/28/2006	Flood	N/A	0	0	$4,000
240 Coventry	4/16/2007	Flood	N/A	0	0	$25,000
248 Coventry	2/13/2008	Flood	N/A	0	0	$20,000
262 River Pt	8/8/2008	Flood	N/A	0	0	$25,000
264 Coventry	12/12/2008	Flood	N/A	0	0	$2,000
270 Coventry	7/1/2009	Flood	N/A	0	0	$0
280 Lakewood	3/14/2010	Flood	N/A	0	0	$1,300,000
281 Lakewood	3/29/2010	Flood	N/A	0	0	$25,700,000
282 Lakewood	4/1/2010	Flood	N/A	0	0	$0
232 RIZ004	10/28/2006	Flood - Coastal	N/A	0	0	$5,000
238 RIZ002 - 004	4/15/2007	Flood - Coastal	N/A	0	0	$5,000
241 RIZ002 - 004	4/16/2007	Flood - Coastal	N/A	0	0	$5,000
18 West Warwick	4/1/1993	Flood - Flash	N/A	0	0	$0
72 Coventry	7/13/1996	Flood - Flash	N/A	0	0	$0
200 East Greenwich	8/13/2003	Flood - Flash	N/A	0	0	$10,000
219 West Warwick	9/15/2005	Flood - Flash	N/A	0	0	$7,000
220 Coventry	9/15/2005	Flood - Flash	N/A	0	0	$25,000
244 Coventry	7/30/2007	Flood - Flash	N/A	0	0	$0
256 Warwick	6/24/2008	Flood - Flash	N/A	0	0	$0
260 Coventry Center	7/23/2008	Flood - Flash	N/A	0	0	$90,000
271 Coventry	7/1/2009	Flood - Flash	N/A	0	0	$0
58 RIZ001>005	1/12/1996	Flood - Urban	N/A	0	0	$0
1 KENT	7/14/1956	Hail	1.75 in.	0	0	$0
4 KENT	7/2/1964	Hail	1.75 in.	0	0	$0
8 KENT	5/30/1979	Hail	1.75 in.	0	0	$0
46 West Warwick	6/20/1995	Hail	0.75 in.	0	0	$0
48 Warwick	8/4/1995	Hail	0.75 in.	0	0	$0
89 Coventry	6/22/1997	Hail	1.00 in.	0	0	$0
120 West Greenwich	6/19/1998	Hail	0.75 in.	0	0	$0
149 West Greenwich	7/25/1999	Hail	1.00 in.	0	0	$0
150 Warwick	7/25/1999	Hail	1.00 in.	0	0	$0
168 West Greenwich	5/24/2000	Hail	0.75 in.	0	0	$0
169 Warwick	6/11/2000	Hail	0.75 in.	0	0	$0
170 West Warwick	7/18/2000	Hail	1.75 in.	0	0	$0

172 Coventry	8/16/2000	Hail	0.75 in.	0	0	$0
190 Coventry	6/19/2002	Hail	0.75 in.	0	0	$0
205 Coventry	7/2/2004	Hail	1.00 in.	0	0	$0
206 Warwick	7/2/2004	Hail	0.75 in.	0	0	$0
216 Coventry	6/22/2005	Hail	0.75 in.	0	0	$0
243 West Warwick	6/28/2007	Hail	0.88 in.	0	0	$0
255 Coventry Center	6/24/2008	Hail	0.75 in.	0	0	$0
257 River Pt	6/24/2008	Hail	1.00 in.	0	0	$0
258 Apponaug	6/24/2008	Hail	0.88 in.	0	0	$0
259 Coventry Center	7/23/2008	Hail	1.00 in.	0	0	$0
261 Apponaug	7/23/2008	Hail	0.75 in.	0	0	$0
272 Apponaug	7/3/2009	Hail	0.75 in.	0	0	$0
20 RIZ001>007	12/4/1993	Heavy Rain	N/A	0	0	$0
28 RIZ001>007	1/28/1994	Heavy Rain	N/A	0	0	$0
32 RIZ001>007	3/10/1994	Heavy Rain	N/A	0	0	$0
70 Countywide	7/13/1996	Heavy Rain	N/A	0	0	$0
73 Countywide	9/18/1996	Heavy Rain	N/A	0	0	$0
74 Eastern Portions	10/8/1996	Heavy Rain	N/A	0	0	$0
76 RIZ001>007	10/20/1996	Heavy Rain	N/A	0	0	$0
79 Countywide	12/7/1996	Heavy Rain	N/A	0	0	$0
96 RIZ001>007	11/1/1997	Heavy Rain	N/A	0	0	$0
103 RIZ002>007	2/18/1998	Heavy Rain	N/A	0	0	$0
104 RIZ001>005 - 007	2/23/1998	Heavy Rain	N/A	0	0	$0
106 RIZ001>007	3/8/1998	Heavy Rain	N/A	0	0	$0
116 RIZ001>005	5/9/1998	Heavy Rain	N/A	0	0	$0
117 Countywide	6/13/1998	Heavy Rain	N/A	0	0	$0
122 Coventry	9/22/1998	Heavy Rain	N/A	0	0	$0
124 Warwick	10/8/1998	Heavy Rain	N/A	0	0	$0
130 Coventry	1/3/1999	Heavy Rain	N/A	0	0	$0
132 Warwick	1/15/1999	Heavy Rain	N/A	0	0	$0
134 Coventry	2/2/1999	Heavy Rain	N/A	0	0	$0
141 Warwick	5/23/1999	Heavy Rain	N/A	0	0	$0
152 Coventry	9/10/1999	Heavy Rain	N/A	0	0	$0
153 Countywide	9/16/1999	Heavy Rain	N/A	0	0	$0
175 RIZ004	11/10/2000	Heavy Rain	N/A	0	0	$0
186 Warwick	3/30/2001	Heavy Rain	N/A	0	0	$0
199 Countywide	3/29/2003	Heavy Rain	N/A	0	0	$0
33 West Warwick	6/14/1994	Lightning	N/A	0	0	$50,000
34 W. Warwick	8/5/1994	Lightning	N/A	0	0	$5,000
90 Warwick	6/22/1997	Lightning	N/A	0	0	$250,000
97 Warwick	11/9/1997	Lightning	N/A	0	0	$2,000
107 West Warwick	3/9/1998	Lightning	N/A	0	0	$50,000
254 Nooseneck	6/24/2008	Lightning	N/A	0	0	$10,000
274 Coventry	8/5/2009	Lightning	N/A	0	9	$0
287 Coventry Center	7/24/2010	Lightning	N/A	0	0	$50,000
26 RIZ001>007	1/15/1994	Temp Extreme-Cold	N/A	0	0	$0
27 RIZ001>007	1/18/1994	Temp Extreme-Cold	N/A	0	0	$0
145 RIZ004	7/14/1999	Temp Extreme-Cold	N/A	0	0	$0
173 RIZ004	10/9/2000	Temp Extreme-Cold	N/A	0	0	$0
174 RIZ004	10/29/2000	Temp Extreme-Cold	N/A	0	0	$0
40 RIZ001>007	1/13/1995	Temp Extreme-Heat	N/A	0	0	$0
47 RIZ002>005	7/15/1995	Temp Extreme-Heat	N/A	0	0	$0
101 RIZ004	1/3/1998	Temp Extreme-Heat	N/A	0	0	$0

112 RIZ004	3/27/1998	Temp Extreme-Heat	N/A	0	0	$0
113 RIZ004	3/28/1998	Temp Extreme-Heat	N/A	0	0	$0
114 RIZ004	3/31/1998	Temp Extreme-Heat	N/A	0	0	$0
123 RIZ002 - 004	9/27/1998	Temp Extreme-Heat	N/A	0	0	$0
127 RIZ004	12/4/1998	Temp Extreme-Heat	N/A	0	0	$0
128 RIZ004	12/7/1998	Temp Extreme-Heat	N/A	0	0	$0
139 RIZ002 - 004	3/18/1999	Temp Extreme-Heat	N/A	0	0	$0
142 RIZ004	6/7/1999	Temp Extreme-Heat	N/A	0	0	$0
143 RIZ004	7/5/1999	Temp Extreme-Heat	N/A	0	0	$0
144 RIZ004	7/6/1999	Temp Extreme-Heat	N/A	0	0	$0
146 RIZ004	7/17/1999	Temp Extreme-Heat	N/A	0	0	$0
147 RIZ004	7/18/1999	Temp Extreme-Heat	N/A	0	0	$0
151 RIZ004	9/7/1999	Temp Extreme-Heat	N/A	0	0	$0
166 RIZ004	5/9/2000	Temp Extreme-Heat	N/A	0	0	$0
187 RIZ004	5/3/2001	Temp Extreme-Heat	N/A	0	0	$0
188 RIZ004	5/4/2001	Temp Extreme-Heat	N/A	0	0	$0
189 RIZ004	5/12/2001	Temp Extreme-Heat	N/A	0	0	$0
286 RIZ004	7/6/2010	Temp Extreme-Heat	N/A	0	0	$0
285 RIZ004	7/6/2010	Temp Extreme-Heat	N/A	0	0	$0
2 KENT	7/14/1956	Thunderstorm Wind	0 kts.	0	0	$0
3 KENT	9/14/1956	Thunderstorm Wind	64 kts.	0	0	$0
5 KENT	3/24/1969	Thunderstorm Wind	0 kts.	0	0	$0
6 KENT	8/9/1969	Thunderstorm Wind	0 kts.	0	0	$0
7 KENT	9/6/1973	Thunderstorm Wind	50 kts.	0	0	$0
9 KENT	8/10/1979	Thunderstorm Wind	0 kts.	0	0	$0
10 KENT	6/27/1983	Thunderstorm Wind	0 kts.	0	0	$0
11 KENT	6/30/1987	Thunderstorm Wind	70 kts.	0	0	$0
12 KENT	9/23/1989	Thunderstorm Wind	70 kts.	0	0	$0
14 KENT	10/18/1990	Thunderstorm Wind	50 kts.	0	0	$0
15 KENT	6/12/1991	Thunderstorm Wind	0 kts.	0	0	$0
16 KENT	7/14/1992	Thunderstorm Wind	0 kts.	0	0	$0
17 KENT	7/14/1992	Thunderstorm Wind	0 kts.	0	0	$0
43 KENT	4/4/1995	Thunderstorm Wind	0 kts.	0	0	$0
45 West Greenwich	6/20/1995	Thunderstorm Wind	0 kts.	0	0	$0
49 Warwick	8/4/1995	Thunderstorm Wind	0 kts.	0	0	$0
69 Warwick	5/21/1996	Thunderstorm Wind	52 kts.	0	0	$0
91 Warwick	6/22/1997	Thunderstorm Wind	65 kts.	0	0	$0
148 Coventry	7/23/1999	Thunderstorm Wind	50 kts.	0	0	$0
171 West Warwick	7/18/2000	Thunderstorm Wind	50 kts.	0	0	$0
191 Coventry	7/23/2002	Thunderstorm Wind	50 kts.	0	0	$2,000
201 East Greenwich	8/13/2003	Thunderstorm Wind	50 kts.	0	0	$15,000
217 Coventry	8/5/2005	Thunderstorm Wind	50 kts.	0	0	$5,000
229 Warwick	7/18/2006	Thunderstorm Wind	50 kts.	0	0	$5,000
230 Coventry	8/20/2006	Thunderstorm Wind	50 kts.	0	0	$10,000
242 Warwick	6/1/2007	Thunderstorm Wind	50 kts.	0	0	$0
249 Warwick	3/5/2008	Thunderstorm Wind	63 kts.	0	0	$0
273 Coventry Center	7/31/2009	Thunderstorm Wind	50 kts.	0	0	$1,000
284 Coventry Center	6/5/2010	Thunderstorm Wind	50 kts.	0	0	$30,000
13 Kent	10/18/1990	Tornado	F1	0	0	$250,000
35 Coventry	8/13/1994	Tornado	F0	0	0	$0
93 Warwick	8/20/1997	Tornado - Funnel Cloud	N/A	0	0	$0
207 West Greenwich	8/7/2004	Tornado - Funnel Cloud	N/A	0	0	$0
92 RIZ004>007	7/25/1997	Wind - Gusty	N/A	0	0	$0
19 Rizall	11/28/1993	Wind - High	0 kts.	0	0	$50,000
21 RIZ001>007	12/26/1993	Wind - High	0 kts.	0	0	$0
23 RIZ002 - 004>007	1/4/1994	Wind - High	0 kts.	0	0	$0
29 RIZ001>007	1/28/1994	Wind - High	0 kts.	0	0	$0
36 RIZ001>007	11/2/1994	Wind - High	0 kts.	0	0	$0
37 RIZ001>007	11/6/1994	Wind - High	0 kts.	0	0	$0

38 RIZ001>007	12/23/1994	Wind - High	0 kts.	0	0	$5,000,000
39 RIZ002>007	1/7/1995	Wind - High	0 kts.	0	0	$0
42 RIZ001>007	2/5/1995	Wind - High	0 kts.	0	0	$0
44 RIZ001>007	4/5/1995	Wind - High	0 kts.	0	0	$0
50 RIZ001>007	10/21/1995	Wind - High	0 kts.	0	0	$0
51 RIZ001>007	10/28/1995	Wind - High	0 kts.	0	0	$0
52 RIZ001>007	11/12/1995	Wind - High	0 kts.	0	0	$0
53 RIZ001>007	11/14/1995	Wind - High	0 kts.	0	0	$0
59 RIZ001>007	1/19/1996	Wind - High	63 kts.	0	0	$0
60 RIZ001>007	1/27/1996	Wind - High	55 kts.	0	0	$0
63 RIZ001>007	2/25/1996	Wind - High	70 kts.	0	0	$0
71 RIZ001>007	7/13/1996	Wind - High	64 kts.	0	0	$0
158 RIZ001>003	11/2/1999	Wind - High	52 kts.	0	0	$0
178 RIZ001>007	12/17/2000	Wind - High	50 kts.	0	2	$0
192 RIZ001>003	9/11/2002	Wind - High	0 kts.	0	0	$55,000
195 RIZ004	12/25/2002	Wind - High	35 kts.	0	0	$0
202 RIZ001>007	11/13/2003	Wind - High	50 kts.	0	0	$350,000
208 RIZ001>002 - 004	12/1/2004	Wind - High	58 kts.	0	0	$60,000
213 RIZ001 - 004>007	3/8/2005	Wind - High	62 kts.	0	0	$150,000
215 RIZ003>004	5/25/2005	Wind - High	50 kts.	0	0	$20,000
221 RIZ001 - 004	9/29/2005	Wind - High	58 kts.	0	0	$25,000
223 RIZ001>002 - 002>003 - 006>007	10/25/2005	Wind - High	60 kts.	0	0	$35,000
226 RIZ001 - 001 - 003>004	1/18/2006	Wind - High	58 kts.	0	0	$110,000
231 RIZ004	10/28/2006	Wind - High	50 kts.	0	0	$150,000
236 RIZ003	12/1/2006	Wind - High	50 kts.	0	0	$8,000
239 RIZ004	4/16/2007	Wind - High	53 kts.	0	0	$10,000
245 RIZ004	11/3/2007	Wind - High	50 kts.	0	0	$22,000
247 RIZ004	12/23/2007	Wind - High	36 kts.	0	0	$0
250 RIZ004 - 007	3/8/2008	Wind - High	66 kts.	0	0	$11,000
252 RIZ004	3/8/2008	Wind - High	50 kts.	0	0	$10,000
263 RIZ004 - 005	10/25/2008	Wind - High	51 kts.	0	0	$0
275 RIZ004	12/3/2009	Wind - High	38 kts.	0	0	$0
277 RIZ003	1/25/2010	Wind - High	50 kts.	0	0	$50,000
278 RIZ004 - 006	1/25/2010	Wind - High	50 kts.	0	0	$0
75 RIZ004>007	10/8/1996	Wind - Strong	N/A	0	0	$0
80 RIZ002>007	12/24/1996	Wind - Strong	0 kts.	0	0	$0
83 RIZ001>007	3/6/1997	Wind - Strong	0 kts.	0	0	$0
84 RIZ002>007	3/26/1997	Wind - Strong	0 kts.	0	0	$0
86 RIZ001>007	3/31/1997	Wind - Strong	0 kts.	0	0	$0
88 RIZ001>007	4/1/1997	Wind - Strong	0 kts.	0	0	$0
94 RIZ002>007	8/21/1997	Wind - Strong	0 kts.	0	0	$0
95 RIZ002>007	11/1/1997	Wind - Strong	0 kts.	0	0	$0
98 RIZ001>007	11/27/1997	Wind - Strong	0 kts.	0	0	$0
99 RIZ001>007	12/2/1997	Wind - Strong	0 kts.	0	0	$0
100 RIZ001>007	12/14/1997	Wind - Strong	0 kts.	0	0	$0
102 RIZ002>007	2/4/1998	Wind - Strong	0 kts.	0	0	$0
105 RIZ001>007	2/24/1998	Wind - Strong	0 kts.	0	0	$0
108 RIZ001>007	3/9/1998	Wind - Strong	0 kts.	0	0	$0
109 RIZ001>007	3/12/1998	Wind - Strong	0 kts.	0	0	$0

110 RIZ002>007	3/21/1998	Wind - Strong	0 kts.	0	0	$0
111 RIZ002>006	3/26/1998	Wind - Strong	0 kts.	0	0	$0
115 RIZ002>007	4/9/1998	Wind - Strong	0 kts.	0	0	$0
121 RIZ004>007	6/27/1998	Wind - Strong	0 kts.	0	0	$0
125 RIZ001>007	11/11/1998	Wind - Strong	0 kts.	0	0	$0
126 RIZ004>007	11/26/1998	Wind - Strong	0 kts.	0	0	$0
129 RIZ001>007	1/3/1999	Wind - Strong	0 kts.	0	0	$0
131 RIZ001>007	1/15/1999	Wind - Strong	0 kts.	0	0	$0
133 RIZ001>007	1/18/1999	Wind - Strong	0 kts.	0	0	$0
135 RIZ002>007	2/2/1999	Wind - Strong	0 kts.	0	0	$0
137 RIZ001>007	3/4/1999	Wind - Strong	0 kts.	0	0	$0
140 RIZ001>007	3/22/1999	Wind - Strong	0 kts.	0	0	$0
154 RIZ001 - 003>005 - 007	9/16/1999	Wind - Strong	0 kts.	0	0	$0
156 RIZ003>007	9/30/1999	Wind - Strong	0 kts.	0	0	$0
157 RIZ001>007	10/14/1999	Wind - Strong	0 kts.	0	0	$0
159 RIZ004>007	11/2/1999	Wind - Strong	0 kts.	0	0	$0
160 RIZ004	1/4/2000	Wind - Strong	0 kts.	0	0	$0
162 RIZ001 - 003>006	2/14/2000	Wind - Strong	0 kts.	0	0	$0
164 RIZ001>002 - 004 - 006>007	4/8/2000	Wind - Strong	0 kts.	0	0	$0
167 RIZ004 - 006>007	5/18/2000	Wind - Strong	0 kts.	0	0	$0
177 RIZ002>005 - 007	12/12/2000	Wind - Strong	0 kts.	0	0	$0
182 RIZ001>007	2/10/2001	Wind - Strong	0 kts.	0	0	$0
183 RIZ001>002 - 004>005 - 007	2/17/2001	Wind - Strong	0 kts.	0	0	$0
218 RIZ004	8/31/2005	Wind - Strong	40 kts.	0	0	$5,000
225 RIZ004 - 006>007	1/15/2006	Wind - Strong	31 kts.	0	0	$15,000
235 RIZ004	11/23/2006	Wind - Strong	30 kts.	0	0	$7,000
251 RIZ004 - 007	3/8/2008	Wind - Strong	40 kts.	0	0	$5,000
253 RIZ003	3/8/2008	Wind - Strong	45 kts.	0	0	$1,000
283 RIZ003	4/29/2010	Wind - Strong	40 kts.	0	0	$45,000
196 RIZ001>007	2/7/2003	Winter Storm	N/A	0	0	$0
197 RIZ001>007	2/17/2003	Winter Storm	N/A	0	0	$0
198 RIZ001>007	3/6/2003	Winter Storm	N/A	0	0	$290,000
203 RIZ001>007	12/5/2003	Winter Storm	N/A	0	0	$0
204 RIZ003 - 006	1/27/2004	Winter Storm	N/A	0	0	$0
209 RIZ001>007	12/26/2004	Winter Storm	N/A	0	0	$0
210 RIZ001>007	1/22/2005	Winter Storm	N/A	0	0	$0
212 RIZ001>007	3/1/2005	Winter Storm	N/A	0	0	$0
224 RIZ003	12/9/2005	Winter Storm	N/A	0	2	$100,000
227 RIZ001>007	2/12/2006	Winter Storm	N/A	0	0	$70,000
237 RIZ001>003 - 006	3/16/2007	Winter Storm	N/A	0	0	$0
279 RIZ003 - 006 - 007	2/10/2010	Winter Storm	N/A	0	0	$0
82 RIZ001>005	1/31/1997	Winter Storm - Freezing Drizzle	N/A	0	0	$0
176 RIZ001 - 003	11/26/2000	Winter Storm - Freezing Rain	N/A	0	0	$0
181 RIZ001 - 003	1/30/2001	Winter Storm - Freezing Rain	N/A	0	0	$0
184 RIZ001>007	2/25/2001	Winter Storm - Freezing Rain	N/A	0	0	$0
22 RIZ001>007	12/29/1993	Winter Storm - Heavy Snow	N/A	0	0	$0
24 RIZ001>005	1/7/1994	Winter Storm - Heavy Snow	N/A	0	0	$5,000
30 RIZ001>007	2/8/1994	Winter Storm - Heavy Snow	N/A	0	0	$0
31 RIZ001>007	2/11/1994	Winter Storm - Heavy Snow	N/A	0	0	$0
41 RIZ001>007	2/4/1995	Winter Storm - Heavy Snow	N/A	0	0	$0
54 RIZ001>004	12/14/1995	Winter Storm - Heavy Snow	N/A	0	0	$0
55 Rizall	12/19/1995	Winter Storm - Heavy Snow	N/A	0	0	$0
56 RIZ001>004	1/2/1996	Winter Storm - Heavy Snow	N/A	0	0	$0
57 RIZ001>007	1/7/1996	Winter Storm - Heavy Snow	N/A	0	0	$0
61 RIZ001>007	2/2/1996	Winter Storm - Heavy Snow	N/A	0	0	$0
62 RIZ001>004 - 006	2/16/1996	Winter Storm - Heavy Snow	N/A	0	0	$0
64 RIZ001>007	3/2/1996	Winter Storm - Heavy Snow	N/A	0	0	$0
66 RIZ001>005	3/7/1996	Winter Storm - Heavy Snow	N/A	0	0	$0
67 RIZ001>002 - 004	4/7/1996	Winter Storm - Heavy Snow	N/A	0	0	$0

68 RIZ001>006	4/9/1996	Winter Storm - Heavy Snow	N/A	0	0	$0
77 RIZ001>003	12/6/1996	Winter Storm - Heavy Snow	N/A	0	0	$0
78 RIZ001 - 003	12/7/1996	Winter Storm - Heavy Snow	N/A	0	0	$0
81 RIZ001>005	1/11/1997	Winter Storm - Heavy Snow	N/A	0	0	$0
85 RIZ001>007	3/31/1997	Winter Storm - Heavy Snow	N/A	0	0	$0
87 RIZ001>007	4/1/1997	Winter Storm - Heavy Snow	N/A	0	0	$700,000
136 RIZ001>007	2/25/1999	Winter Storm - Heavy Snow	N/A	0	0	$0
138 RIZ001>007	3/15/1999	Winter Storm - Heavy Snow	N/A	0	0	$0
163 RIZ001>006	2/18/2000	Winter Storm - Heavy Snow	N/A	0	0	$0
179 RIZ001 - 003	12/30/2000	Winter Storm - Heavy Snow	N/A	0	0	$0
180 RIZ001>007	1/20/2001	Winter Storm - Heavy Snow	N/A	0	0	$0
185 RIZ001>004	3/5/2001	Winter Storm - Heavy Snow	N/A	0	0	$10,000,000
193 RIZ001>004	11/27/2002	Winter Storm - Heavy Snow	N/A	0	0	$0
194 RIZ002>007	12/5/2002	Winter Storm - Heavy Snow	N/A	0	0	$0
211 RIZ001>007	2/24/2005	Winter Storm - Heavy Snow	N/A	0	0	$0
214 RIZ001 - 003	3/23/2005	Winter Storm - Heavy Snow	N/A	0	0	$0
246 RIZ001>005	12/13/2007	Winter Storm - Heavy Snow	N/A	0	0	$0
265 RIZ003	12/19/2008	Winter Storm - Heavy Snow	N/A	0	0	$0
266 RIZ004	12/19/2008	Winter Storm - Heavy Snow	N/A	0	0	$0
267 RIZ004	12/31/2008	Winter Storm - Heavy Snow	N/A	0	0	$0
268 RIZ001 - 004	1/18/2009	Winter Storm - Heavy Snow	N/A	0	0	$0
269 RIZ003 - 006	3/1/2009	Winter Storm - Heavy Snow	N/A	0	0	$0
276 RIZ003 - 006	12/19/2009	Winter Storm - Heavy Snow	N/A	0	0	$0
25 RIZ001 - 003 - 004 - 006 - 007	1/7/1994	Winter Storm - Ice Storm	N/A	0	0	$500,000
228 RIZ004	2/12/2006	Winter Storm - Nor'easter	N/A	0	0	$10,000
161 RIZ001>004	1/13/2000	Winter Storm - Snow	N/A	0	0	$0
65 RIZ001>007	3/3/1996	Winter Storm - Snow Squalls	N/A	0	0	$0
TOTALS:				0	13	$47,431,000

This table, along with the discussions throughout this Chapter, provides evidence that Warwick indeed has risks associated with natural hazards. It is obvious from the discussion that weather hazards top the list, with flood-related impacts causing the most common and severe risk. Map 6-1, included in the map pocket at the end of this document, illustrates this risk in Warwick, as well as the geographical areas most vulnerable to them.

Chapter 7. Asset Identification

The analysis, assessment, and identification of assets within a community are integral to determining what may be at risk for loss from a natural disaster. This chapter examines the assets in five separate categories: Critical Facilities, Vulnerable Populations, Economic Assets, Special Considerations, and Historic/Other Considerations.

Each category lists the address and telephone number(s) where applicable. Also supplied is the hazard to which each particular asset is most susceptible. The hazards listed are primarily natural disasters, but can also include secondary disasters such as sewer/water line rupture, or human-made disasters/emergencies such as automobile accidents.

In Warwick, each asset can be damaged by all of the hazards listed in the Hazard Identification Chapter. The Critical Facilities have been plotted on the large map at the end of this plan. When the asset was not specifically vulnerable to one or more particular hazards, the term "All" was used to signify the asset's vulnerability to all possible hazards.

Critical Facilities

Critical Facilities are categorized as those city or state buildings or services that are the first responders in a disaster. Fire departments, police departments, highway departments, and city/state offices play a pivotal roll in coordinating and implementing emergency services in the event of a disaster. Other critical facilities include hospitals, airports, and schools (schools may be used as shelters). The offices of the Department of Public Works, Water Department, and the Warwick Sewer Authority are also included as critical facilities, as utility maintenance plays a key role in disaster response. The Water Department is located at the Department of Public Works facility, and is not listed separately. Tables 7-1 through 7-10 list the identified Critical Facilities located within the City of Warwick

Table 7-1 FEMA Key Facilities

FACILITY	PLAT	LOT	FEMA MAP #	EDITION	HAZARD
CITY HALL	245	61	5E	6/16/1992	WIND, SNOW
T.F. GREEN AIRPORT	321	4	2D	4/16/1991	WIND, SNOW
KENT HOSPITAL	256	80	2D	4/16/1991	WIND, SNOW
PUBLIC WORKS	349	1	6E	6/16/1992	WIND, SNOW
SEWER DEPT.	280	3	2D	4/16/1991	WIND, SNOW, FLOOD
VETERANS H.S. PRIMARY SHELTER	349	585	6E	6/16/1992	WIND, SNOW
WINMAN J.H. PRIMARY SHELTER	255	2	2D	4/16/1991	WIND, SNOW

Table 7-2 Fire Stations

NAME	ADDRESS	PHONE	Hazard
FIRE ALARM	915 SANDY LANE	N/A	WIND
STATION 1	140 VETS. MEM. DR.	468-4021	WIND
STATION 2	771 POST RD.	468-4022	WIND
STATION 3	2373 W. SHORE RD.	468-4023	WIND
STATION 4	1501 W. SHORE RD.	468-4024	WIND, FLOODING
STATION 5	450 COWESETT RD.	468-4025	WIND
STATION 6	456 W. SHORE RD.	468-4026	WIND
STATION 8	1651 POST RD.	468-4028	WIND
STATION 9	314 COMMONWEALTH AV.	468-4029	WIND

Table 7-3 Police Stations

ID	FACILITY	ADDRESS	PHONE	Hazard
1	POLICE HEADQUARTERS	99 VETERANS MEM. DR.	468-4200	ALL
2	POLICE OUTDOOR FIREARMS RANGE	190 RANGE RD.	468-4325	ALL
3	CONIMICUT POLICE CTR.	759 W. SHORE RD.	468-4373	ALL
4	OAKLAND BEACH POLICE CTR.	732 OAKLAND BEACH AV.	468-4375	ALL

Note: the RI Mall Police Center listed in the 2005 plan has been closed.

Table 7-4 Schools

ID	SCHOOL	PHONE	ADDRESS	HAZARD
1	CEDAR HILL ELEM.	734-3535	35 RED CHIMNEY DR.	ALL
2	DRUM ROCK EARLY CHILDHOOD CTR.	734-3490	575 CENTERVILLE RD.	ALL
3	FRANCIS ELEM.	734-3340	325 MIANTONOMO DR.	ALL
4	WPS GREENE ADMINISTRATION	734-3440	51 DRAPER AVE.	ALL
5	GREENWOOD ELEM.	734-3290	93 SHARON ST.	ALL
6	HOLDEN ELEM.	734-3455	61 HOXSIE AVE.	ALL
7	HOLLIMAN ELEM.	734-3170	70 DEBORAH RD.	ALL
8	HOXSIE ELEM.	734-3555	55 GLENWOOD DR.	ALL
9	LIPPITT ELEM.	734-3240	30 ALMY ST.	ALL
10	NORWOOD ELEM.	734-3525	266 NORWOOD AVE.	ALL
11	OAKLAND BEACH ELEM.	734-3420	383 OAKLAND BEACH AVE.	ALL
12	PARK ELEM.	734-3690	40 ASYLUM RD.	ALL
13	POTOWOMUT ELEM.	734-3545	225 POTOWOMUT RD.	ALL
14	RHODES ELEM.	734-3515	110 SHERWOOD AVE.	ALL
15	ROBERTSON ELEM.	734-3470	70 NAUSAUKET RD.	ALL
16	SCOTT ELEM.	734-3585	833 CENTERVILLE RD.	ALL
17	SHERMAN ELEM.	734-3565	120 KILLEY AVE.	ALL
18	WARWICK NECK ELEM.	734-3480	155 ROCKY POINT AVE.	ALL
19	WICKES ELEM.	734-3575	50 CHILD LANE	ALL
20	WYMAN ELEM.	734-3180	1 COLUMBIA AVE.	ALL
21	ALDRICH J.H.S.	734-3500	789 POST RD.	ALL
22	GORTON J.H.S.	734-3350	69 DRAPER AVE.	ALL
23	WINMAN J.H.S.	734-3375	575 CENTERVILLE RD.	ALL
24	PILGRIM S.H.S.	734-3250	111 PILGRIM PKWY.	ALL
25	TOLL GATE S.H.S.	734-3300	575 CENTERVILLE RD.	ALL
26	VETERANS S.H.S.	734-3200	2401 WEST SHORE RD.	ALL
27	CAREER & TECHNICAL CTR.	734-	575 CENTERVILLE RD.	ALL
28	WPS ADMINISTRATION	734-3000	34 LAKE AVE.	ALL
29	WPS BLDS & GROUNDS	734-3400	69 DRAPER AVE.	ALL

Table 7-5 Sewer Facilities

DEPARTMENT	ADDRESS	OCCUPANCY	HAZARD
SEWER	34 ALTEIRI WAY	ALTERI WAY GENERATOR BUILDING	ALL
SEWER	34 ALTEIRI WAY	ALTERI WAY PUMP STATION (#20)	ALL
SEWER	36 CENTERVILLE ROAD	APPONAUG PUMP STATION (#13)	FLOODING
SEWER	2 WEST PONTIAC ST	BALLFIELD (EAST NATICK 2) PUMP STATION (#30)	FLOODING
SEWER	BARBERRY ST (END)	BARBERRY PUMP STATION (#46)	FLOODING
SEWER	38 BELLOWS ST	BELLOWS ST PUMP STATION (#2)	FLOODING
SEWER	115 WINCHELL RD	BROOKWOOD PUMP STATION (#15)	FLOODING
SEWER	CAPRON FARMS	CAPRON FARMS PUMP STATION (#47)	FLOODING
SEWER	902 CEDAR SWAMP RD.	CEDAR SWAMP PUMP STATION (#7)	FLOODING
SEWER	180 COVE AVE	COVE AVE PUMP ST ATION (#40)	FLOODING
SEWER	50 CREEKWOOD DR	CREEKWOOD PUMP STATION (#32)	ALL
SEWER	120 DAVIDSON RD	DAVIDSON PUMP STATION (#33)	FLOODING
SEWER	75 RIVERDALE CT	EAST NATICK PUMP STATION (#23)	FLOODING
SEWER	6 EMMONS AVE	EMMONS AVE PUMP STATION (#6)	FLOODING
SEWER	195 SPRING GREEN RD	GASPEE 1 PUMP STATION (#21)	ALL
SEWER	271 GORTON LAKE BLVD	GORTON LAKE BLVD PUMP STATION (#28)	ALL
SEWER	GULF STREET (POLE #4)	GULF PUMP STATION (#42)	FLOODING
SEWER	131 HILTON RD	HILTON PUMP STATION (#8)	ALL
SEWER	3 VERNON ST	HOXIE EAST PUMP STATION (#24)	ALL
SEWER	150 INGERSOLL AVE (P372/L1)	INGERSOLL PUMP STATION (#39)	ALL
SEWER	160 IRVING RD	IRVING RD PUMP STATION (#9)	FLOODING
SEWER	1 JUNIPER AVE	JUNIPER PUMP STATION (#31)	ALL
SEWER	171 KERRI LYNN DR	KERRI LYNNE DRIVE PUMP STATION (#38)	FLOODING
SEWER	440 KILVERT ST	KILVERT ST PUMP STATION (#11)	FLOODING
SEWER	176 KNIGHT ST	KNIGHT ST PUMP STATION (#12)	FLOODING
SEWER	409 LAKESHORE DR	LAKESHORE NORTH PUMP STATION (#16)	FLOODING
SEWER	223 LAKESHORE DR	LAKESHORE SOUTH PUMP STATION (#14)	FLOODING
SEWER	380 ATLANTIC AVE	LAKEWOOD PUMP STATION (#27)	ALL
SEWER	51 OAK TREE RD	LOCKWOOD PUMP STATION (#35)	ALL
SEWER	6 LOVEDAY ST	LOVEDAY PUMP STATION (#1)	ALL
SEWER	172 MIDGET AVE	MIDGET PUMP ST (#34)	ALL
SEWER	227 SUBURBAN PKWY	OAKLAND BEACH PUMP STATION (#10)	FLOODING
SEWER	OJANICE DR (P12-1)	OLD BUTTONWOODS PUMP STATION (#45)	FLOODING
SEWER	ORMSBY AVE (P-00)	ORMSBY PUMP STATION (#43)	FLOODING
SEWER	PAISLEY ST (POLE 2)	PAISLEY PUMP STATION (#44)	FLOODING
SEWER	203 POSNEGANSETT AVE	POSNEGANSETT PUMP STATION (#17)	ALL
SEWER	4322 POST RD	POST RD PUMP STATION (#36)	ALL
SEWER	500 NARRAGANSETT PKWY	SALTER GROVE (GASPEE 2) PUMP STATION (#22)	FLOODING
SEWER	167 SEFTON AVE	SEFTON AVE PUMP STATION (#25)	ALL
SEWER	187 EDGEHILL RD	STANMORE PUMP STATION (#4)	ALL
SEWER	29 TIDEWATER DR	TIDEWATER DR PUMP STATION (#41)	FLOODING
SEWER	BAYONE AVE 1 (P361/L302)	VETS PUMP STATION (#37)	ALL
SEWER	1849 WARWICK AVE	WARWICK AVE PUMP STATION (#5)	ALL
SEWER	641 MEADOWVIEW AVE	WARWICK COVE PUMP ST (#29)	ALL
SEWER	248 WARWICK NECK AVE	WARWICK NECK PUMP STATION (#18)	FLOODING
SEWER	45 WATERVIEW AVE (600 SANDY LN)	WATERVIEW AVE PUMP STATION (#26)	ALL
SEWER	125 ARTHUR W. DEVINE BLVD	WWTF - ADMIN BLDG	FLOODING
SEWER	125 ARTHUR W. DEVINE BLVD	WWTP - BLOWER	FLOODING
SEWER	125 ARTHUR W. DEVINE BLVD	WWTP - CONTROL/LABORATORY	ALL
SEWER	125 ARTHUR W. DEVINE BLVD	WWTP - DIGESTION FACILITY	ALL
SEWER	125 ARTHUR W. DEVINE BLVD	WWTP - DISINFECTION BLDG	FLOODING
SEWER	125 ARTHUR W. DEVINE BLVD	WWTP - NORTH PUMP STATION	ALL
SEWER	125 ARTHUR W. DEVINE BLVD	WWTP - PRIMARY TREATMENT HOUSE	ALL
SEWER	125 ARTHUR W. DEVINE BLVD	WWTP - SEPTAGE/INLET FACILITY	ALL
SEWER	125 ARTHUR W. DEVINE BLVD	WWTP - SOUTH PUMP STATION (CENTER)	ALL
SEWER	125 ARTHUR W. DEVINE BLVD	WWTP - UTILITY BUILDING	ALL

Note: The Thrush Road Pump Station listed in the 2005 plan has been decommissioned.

Table 7-6 Water Facilities

DEPARTMENT	ADDRESS	OCCUPANCY	HAZARD
WATER	165 PETTACONSETT AVE	METER STATION / INTERCONNECTION	ALL
WATER	NATICK AVE/WAKEFIELD ST	METER STATION / INTERCONNECTION	ALL
WATER	STATE ST/OAK SIDE	BOOSTER PUMP STATION	ALL
WATER	WARWICK NECK AVE	500,000 GAL WATER STG TANK	ALL
WATER	BALD HILL RD/UNIVERSAL RD	5.5 MG WATER STORAGE TANK	WIND
WATER	BALD HILL RD/UNIVERSAL RD	6.5 MG WATER STORAGE TANK	WIND

Economic Assets

Although the City of Warwick contains hundreds of businesses, typically several businesses stand out prominently in a City. These businesses employ the most people in the city (both from Warwick and from outside) and are places where large numbers of people are located and may need to evacuate from in the event of a disaster. In other cases, some large businesses can provide critical services or products to residents in need or may be able to sustain their employees for duration of time.

Table 7-7 Economic Assets

ECONOMIC ASSETS	ADDRESS	PHONE	HAZARD
COMFORT INN AIRPORT	1940 POST ROAD	732-0470	WIND
COURTYARD BY MARRIOTT	55 JEFFERSON PARK ROAD	467-6900	WIND
CROWNE PLAZA AT THE CROSSINGS	801 GREENWICH AVENUE	732-6000	WIND
EXTENDED STAY AMERICA	245 WEST NATICK ROAD	732-2547	WIND
FAIRFILED INN BY MARRIOTT	36 JEFFERSON BLVD.	941-6600	WIND
HAMPTON INN & SUITES	2100 POST ROAD	739-8888	WIND
HILTON GARDEN INN	1 THURBER STREET	734-9600	WIND
HOLIDAY INN EXPRESS HOTEL & SUITES	901 JEFFERSON BLVD.	736-5000	WIND
HOMEWOOD SUITES BY HILTON	33 INTERNATIONAL WAY	738-0008	WIND
HOMESTEAD STUDIO SUITES	268 METRO CENTER BLVD.	732-6667	WIND
MASTER HOSTS INN	2138 POST ROAD	737-7400	WIND
MOTEL 6	20 JEFFERSON BLVD.	467-9800	WIND
OPEN GATE MOTEL	840 QUAKER LANE	884-4490	WIND
RADISSON AIRPORT HOTEL	2081 POST ROAD	739-3000	WIND
RESIDENCE INN BY MARRIOTT	500 KILVERT STREET	737-7100	WIND
SHERATON AIRPORT HOTEL	1850 POST ROAD	738-4000	WIND
WARWICK MALL	400 BALD HILL ROAD	739-7500	WIND
RL MALL	650 BALD HILL ROAD	828-2700	WIND
MICKEY STEVENS SPORTS COMPLEX	975 SANDY LANE	738-2000	WIND, FLOOD
TF GREEN AIRPORT	1000 POST ROAD	734-4000	WIND

Vulnerable Populations

Areas or neighborhoods that are densely populated, buildings that house people who may not be self-sufficient in a disaster or areas that include homes which are not very resistant to natural disasters are considered vulnerable. Vulnerable populations include manufactured home parks and elderly housing developments or care facilities.

Table 7-8 Vulnerable Populations

NAME	ADDRESS	TYPE	HAZARD
PILGRIM SENIOR CTR.	27 PILGRIM PKWY.	SENIOR CENTER	ALL
BUTTONWOODS SENIOR CTR.	3027 WEST SHORE RD.	SENIOR CENTER	ALL
CARROULO COMMUNITY CTR.	830 OAKLAND BEACH AVE.	SENIOR CENTER	ALL
HOUSE OF HOPE SHELTER	65 SHIPPEN AVE.	HOMELESS SHELTER	ALL
WARWICK TERRACE	2215 ELMWOOD AVENUE	SENIOR HOUSING	ALL
WEST SHORE TERRACE	3070 WEST SHORE ROAD	SENIOR HOUSING	ALL
WARWICK TERRACE ANNEX	124 TENNESSEE AVENUE 6	SENIOR HOUSING	ALL
MEADOWBROOK TERRACE	2220 WARWICK AVENUE	SENIOR HOUSING	ALL
FATHER OLSEN TERRACE	2432 POST ROAD	SENIOR HOUSING	ALL
CHARLES FORD TERRACE	25 EASTON AVE	SENIOR HOUSING	ALL
CRANBERRY POND	955 POST ROAD	SECTION 8 SENIOR HOUSING	ALL
GREENWOOD TERRACE	2426 POST ROAD	SECTION 8 SENIOR HOUSING	ALL
GREENWICH VILLAGE	300 LAMBERT LIND HIGHWAY	SECTION 8 SENIOR HOUSING	ALL
HARDIG BROOK VILLAGE	331 CENTERVILLE ROAD	SECTION 8 SENIOR HOUSING	ALL
MATTHEW XXV	359 GREENWICH AVENUE	SECTION 8 SENIOR HOUSING	ALL
SHALOM APARTMENTS	1 SHALOM DRIVE	SECTION 8 SENIOR HOUSING	ALL
SHAWOMET TERRACE	1305 WEST SHORE ROAD	SECTION 8 SENIOR HOUSING	ALL
SPARROWS POINT I	311 HARDIG ROAD	SECTION 8 SENIOR HOUSING	ALL
SPARROWS POINT II	777 COWESETT ROAD	SECTION 8 SENIOR HOUSING	ALL
SPARROWS POINT III	355 HARDIG ROAD	SECTION 8 SENIOR HOUSING	ALL
WARWICK REST HOME	348 WARWICK NECK AVENUE	NURSING HOMES	ALL
WEST BAY MANOR	2783 WEST SHORE ROAD	NURSING HOMES	ALL
ETHAN PLACE	85 ETHAN PLACE	NURSING HOMES	ALL
GASPEE MANSION	69 FAIR STREET	NURSING HOMES	ALL
GREENWOOD OAKS RETIREMENT CTR.	14 LAKE STREET	NURSING HOMES	ALL
ROOSEVELT MANOR	57 FAIR STREET	NURSING HOMES	ALL
AVALON NURSING HOME	57 STOKES STREET	NURSING HOMES	ALL
BRENTWOOD NURSING HOME	3986 POST ROAD	NURSING HOMES	ALL
BURDICK CONVALESCENT HOME	57 FAIR STREET	NURSING HOMES	ALL
BUTTONWOODS CREST HOME	139 HEMLOCK AVENUE	NURSING HOMES	ALL
GREENWOOD HOUSE NURSING HOME	1139 MAIN AVENUE	NURSING HOMES	ALL
GREENWOOD OAKS REST HOME	14 LAKE STREET	NURSING HOMES	ALL
KENT NURSING HOME	660 COMMONWEALTH AVENUE	NURSING HOMES	ALL
PAWTUXET VILLAGE NURSING HOME	270 POST ROAD	NURSING HOMES	ALL
SUNNY VIEW NURSING HOME	83 CORONA STREET	NURSING HOMES	ALL
WARWICK HEALTH CENTER •	109 WEST SHORE ROAD	NURSING HOMES	ALL
WARWICK REST HOME	348 WARWICK NECK AVENUE	NURSING HOMES	ALL
SENIOR CITY	911 TOLEGATE RD.	MOBILE HOME PARK	ALL
TOLLGATE VILLAGE	979 TOLLGATE RD.	MOBILE HOME PARK	ALL

Special Considerations

Churches are special considerations for their unique contributions to society. Churches are often natural gathering places for people in disasters and can temporarily provide shelter and accommodation. In addition, businesses that potentially store or use hazardous materials are listed as special considerations due to the potential for leaking or combustion in the event of a disaster.

Table 7-9 Churches

CHURCH	ADDRESS	PHONE	HAZARD
WARWICK CHRISTIAN FELLOWSHIP	430 BUTTONWOODS AVENUE	732-1961	WIND, SNOW
ALL SAINTS EPISCOPAL CHURCH	111 GREENWICH AVENUE	739-1238	WIND, SNOW
AMAZING GRACE CHURCH	334 KNIGHT STREET	732-5335	WIND, SNOW
APPONAUG PENTECOSTAL CHURCH	75 PROSPECT STREET	739-2499	WIND, SNOW
ASBURY UNITED METHODIST CHURCH	143 ANN MARY BROWN DRIVE	467-5122	WIND, SNOW
ASSEMBLY OF GOD CHURCH	425 SANDY LANE	732-0634	WIND, SNOW
BAHAI FAITH	80 WALNUT GLEN DRIVE	738-8702	WIND, SNOW
BUTTONWOODS BIBLE CHAPEL	311 BUTTONWOODS AVENUE	739-2556	WIND, SNOW
CALVARY CHAPEL CHRISTIAN FELLOWSHIP	475 ARNOLD'S NECK DRIVE	739-8555	WIND, SNOW
CHAPEL BY THE SEA	29 ELGIN STREET	739-1620	WIND, SNOW
CHURCH OF CHRIST	934 GREENWICH AVENUE	737-1714	WIND, SNOW
CHURCH OF JESUS CHRIST OF LATTER DAY SAINTS	1000 NARRAGANSETT PARKWAY	463-9308	WIND, SNOW
COMMUNITY OF CHRIST CHURCH	292 WEST SHORE ROAD	738-0586	WIND, SNOW
CORNERSTONE CHURCH	1990 ELMWOOD AVENUE	781-6121	WIND, SNOW
FAITH BAPTIST CHURCH	765 COMMONWEALTH AVENUE	738-7664	WIND, SNOW
FIRST BAPTIST CHURCH	550 COWESETT ROAD	885-3010	WIND, SNOW
FIRST CONGREGATIONAL CHURCH OF WARWICK	715 OAKLAND BEACH AVENUE	738-3377	WIND, SNOW
FRIENDSHIP BAPTIST CHURCH	2945 WEST SHORE ROAD	737-8564	WIND, SNOW
FULL LIFE CHRISTIAN FELLOWSHIP	64 DEWEY AVENUE	734-9790	WIND, SNOW
GREENWOOD COMMUNITY CHURCH, PRESBYTERIAN	805 MAIN AVENUE	737-1230	WIND, SNOW
HERITAGE BAPTIST CHURCH	618 OAKLAND BEACH AVENUE	738-9409	WIND, SNOW
HILLSGROVE UNITED METHODIST CHURCH	35 KILVERT STREET	737-8522	WIND, SNOW
JEHOVAH'S WITNESSES OF WARWICK	544 LONG STREET	739-1781	WIND, SNOW
KOREAN CENTRAL CHURCH	336 NORWOOD AVENUE	941-5075	WIND, SNOW
LAKEWOOD BAPTIST CHURCH	255 ATLANTIC AVENUE	781-1136	WIND, SNOW
NORWOOD BAPTIST CHURCH	48 BUDLONG AVENUE	941-7040	WIND, SNOW
PILGRIM LUTHERAN CHURCH	1817 WARWICK AVENUE	739-2937	WIND, SNOW
SHAWOMET BAPTIST CHURCH	1642 WEST SHORE ROAD	739-7184	WIND, SNOW
SPRING GREEN MEMORIAL BAPTIST CHURCH	1350 WARWICK AVENUE	463-8328	WIND, SNOW
ST. BARNABAS EPISCOPAL CHURCH	3257 POST ROAD	737-4141	WIND, SNOW
ST. BENEDICT'S CHURCH	135 BEACH AVENUE	737-9492	WIND, SNOW
ST. CATHERINE CHURCH	3252 POST ROAD	737-4455	WIND, SNOW
ST. CLEMENT CHURCH	111 LONG STREET	739-0212	WIND, SNOW
ST. FRANCIS CHURCH	596 JEFFERSON BLVD.	737-5191	WIND, SNOW
ST. GREGORY THE GREAT CHURCH	360 COWESETT ROAD	884-1666	WIND, SNOW
ST. KEVIN CHURCH	333 SANDY LANE	737-2638	WIND, SNOW
ST. MARK'S EPISCOPAL CHURCH	111 WEST SHORE ROAD	737-3127	WIND, SNOW
ST. MARY'S EPISCOPAL CHURCH IN WARWICK	358 WARWICK NECK AVENUE	737-6618	WIND, SNOW
ST. PAUL EVANGELICAL LUTHERAN CHURCH	389 GREENWICH AVENUE	737-6758	WIND, SNOW
ST. PETER CHURCH	350 FAIR STREET	467-4895	WIND, SNOW
ST. RITA'S CHURCH	722 OAKLAND BEACH AVENUE	738-1800	WIND, SNOW
ST. ROSE & CLEMENT'S CHURCH	171 INMAN AVENUE	739-0212	WIND, SNOW
ST. TIMOTHY'S CHURCH	1799 WARWICK AVENUE	739-9552	WIND, SNOW
ST. WILLIAM CHURCH	PETTACONSETT AVENUE	781-7226	WIND, SNOW
TEMPLE AM DAVID	40 GARDINER STREET	463-7944	WIND, SNOW
WARWICK CENTRAL BAPTIST CHURCH	3270 POST ROAD	739-2828	WIND, SNOW
WARWICK CONGREGATION COMMUNITY OF CHRIST	292 WEST SHORE ROAD	738-0586	WIND, SNOW
WOODBURY UNION PRESBYTERIAN CHURCH	58 BEACH AVENUE	737-8232	WIND, SNOW

Table 7-10 Hazardous Materials Facilities

FACILITY	ADDRESS	Hazard
ADVANCED CHEMICAL	105 AND 131 BELLOWS ST.	ALL
CELLINI INC.	215 JEFFERSON BLVD	ALL
HAB TOOL INC	50 COLORADA AVE	ALL
INTERPLEX METALS	1280 JEFFERSON BLVD	ALL
LEVITON MANUFACTURING	745 JEFFERSON BLVD	ALL
PEASE AND CURREN	75 PENSYLVANIA AVE	ALL
PRIME TIME MANUFACTURING	185 JEFFERSON BLVD	ALL
US ARMY RESERVE	885 SANDY LANE	ALL
WARWICK SEWER AUTHORITY	125 AUTHER W DEVINE BLVD	ALL
WOLVERINE JOINING TECH. INC.	235 KILVERT ST.	ALL

Historic/Other Considerations

Historic resources and structures provide that link to the cultural history of a town. They may also be more vulnerable to certain hazards since they often have fewer safety devices installed or have limited access. Recreational facilities are places where large groups of people can and do gather.

Table 7-11 Historic Structures

NAME	ADDRESS	HAZARD
APPONAUG HISTORIC DISTRICT	POST ROAD	ALL
BUTTONWOODS BEACH HISTORIC DISTRICT	COOPER AND PROMENADE AVENUES	ALL
EAST GREENWICH HISTORIC DISTRICT	GREENWICH COVE	ALL
FORGE ROAD HISTORIC DISTRICT	FORGE ROAD	ALL
MEADOWS ARCHAEOLOGICAL DISTRICT	790 IVES ROAD	ALL
PAWTUXET VILLAGE HISTORIC DISTRICT	PAWTUXET RI	ALL
WARWICK CIVIC CENTER HISTORIC DISTRICT	POST RD	ALL
BUDLONG FARM	595 BUTTONWOODS AVENUE	ALL
GREENE-BOWEN HOUSE	698 BUTTONWOODS AVENUE	ALL
CALEB GREEN HOUSE	15 CENTERVILLE ROAD	ALL
COWESETT POUND	COWESETT ROAD	ALL
LAMBERT FARM SITE	287 COWESSET ROAD	ALL
KNIGHT ESTATE	486 EAST AVENUE	ALL
MOSES GREENE HOUSE	11 ECONOMY AVENUE	ALL
TRAFALGAR SITE	FORGE ROAD AND ROUTE 1	ALL
FORGE FARM	40 FORGE ROAD	ALL
ELIZABETH SPRING	FORGE RD	ALL
CALEB GORTON HOUSE	987 GREENWICH AVENUE	ALL
RICHARD WICKES GREENE HOUSE	27 HOMESTEAD AVENUE	ALL
GREENWICH COVE SITE	IVES RD	ALL
PONTIAC MILLS	KNIGHT ST	ALL
OLIVER WICKES HOUSE	MAJO POTTER RD	ALL
GASPEE POINT/NAMQUID POINT	NAMQUID DRIVE	ALL
TERMINAL BUILDING, R.I. STATE AIRPORT	572 OCCUPASSTUXET ROAD	ALL
JOHN R. WATERMAN HOUSE	100 OLD HOMESTEAD AVENUE	ALL
CHRISTOPHER RHODES HOUSE	25 POST RD	ALL
CAPTAIN OLIVER GARDINER HOUSE	4451 POST RD	ALL
CONIMICUT LIGHTHOUSE	PROVIDENCE RIVER	ALL
JOHN WATERMAN ARNOLD HOUSE	11 ROGER WILLIAMS AVENUE	ALL
HOPELANDS/ROCKY HILL SCHOOL	WAMPANOAG RD	ALL
SENATOR NELSON W. ALDRICH ESTATE	836 WARWICK NECK AVENUE	ALL

WARWICK LIGHTHOUSE	1350 WARWICK NECK AVENUE	ALL
PETER GREENE HOUSE	1124 WEST SHORE ROAD	ALL
GREENE-DURFFEE HOUSE	1272 WEST SHORE ROAD	ALL
DISTRICT FOUR SCHOOL	1515 WEST SHORE ROAD	ALL

Table 7-12 Recreational Facilities

MAP #	NAME	PLAT	LOT	ADDRESS	HAZARD
1	OAKLAND BEACH BIKE PATH	375	549	STRAND AV.	FLOODING
2	PONTIAC PLAYGROUND	273	438	145 GREENWICH AV.	FLOODING
3	DELGIUDICE PARK	380	69	PALMER AV.	FLOODING
4	PASSEONQUIS BOAT RAMP	304	29	GASPEE POINT DR.	FLOODING
5	BAY LAWN BOAT RAMP	292	235	BAY LAWN AV.	FLOODING
6	PAWTUXET VILLAGE PARK	292	366	2 E. VIEW ST.	FLOODING
7	O'DONNELL PARK	262	108	PROVIDENCE ST.	FLOODING
8	PORTER FIELD	330	12	4 VERNON ST.	FLOODING
9	POTOWOMUT FISHING AREA	212	9	POTOWOMUT RD.	FLOODING
10	SANDY POINT BEACH	201	188	IVES RD.	FLOODING
11	RUBERY FIELD	296	147	10 FREDERICK ST.	FLOODING
12	SALTER'S GROVE PARK	304	187	470 NARRAGANSETT PKWY.	FLOODING
13	SAND POND BEACH	298	4	SAND POND RD.	FLOODING
14	BARTON FARM	251	18	1351 CENTERVILLE RD.	FLOODING
15	SPRAGUE FIELD	294	90	600 POST RD.	FLOODING
16	WINSLOW PARK	345	304	89 GERTRUDE AV.	FLOODING
17	WARWICK POND RAMP	327		WELLS AV. R.O.W.	FLOODING
18	WHITAKER FIELD	301	375	257 N. COUNTRY CLUB DR.	FLOODING
19	WARWICK COVE BOAT RAMP	376	549	100 BAY AV.	FLOODING
20	WELLS PLAYGROUND	321	4	WELLS AV. [AIRPORT]	FLOODING
21	ADAMS PLAYGROUND	263	670	60 WASHINGTON ST.	FLOODING
22	BELMONT PARK	287	159	FIRST AVE.	FLOODING
23	JOHNSON FIELD	337	439	20 BEND ST.	FLOODING
24	BEND ST. COMPLEX	337	353	76 BEND ST.	FLOODING
25	CHAMPLIN FIELD	360	789	390 OAKLAND BEACH AV.	FLOODING
26	CHEPIWANOXET PARK	221	94	25 JOHN WICKES AV.	FLOODING
27	WARWICK CITY PARK	371	4	185 ASYLUM RD.	FLOODING
28	CLEGG FIELD	332	470	140 WINTER AV.	FLOODING
29	CONIMICUT BEACH	334	459	60 POINT AV.	FLOODING
30	DODGE PLAYGROUND	270	445	221 DODGE ST.	FLOODING
31	DUCHESS PLAYGROUND	238	56	101 DUCHESS ST.	FLOODING
32	FATHER TIROCCHI PLAYGROUND	263	22	7 W. PONTIAC ST.	FLOODING
33	PETRARCA PARK	263	44	BAKER ST.	FLOODING
34	BOYD FIELD	350	586	35 WATERVIEW AV.	FLOODING
35	GODDARD PARK	206	1	1095 IVES RD.	FLOODING
36	GORTON POND BEACH	245	260	33 VETERANS MEMORIAL DR.	FLOODING
37	STANMORE PARK	328	415	187 EDGEHILL RD.	FLOODING
38	LINCOLN PARK	310	1	KENTUCKY AV.	FLOODING
39	LITTLE POND BEACH	349	585	1 ALBERT RD.	FLOODING
40	LONGMEADOW BEACH	355		LONGMEADOW R.O.W.	FLOODING
41	DORR ST. BEACH	355		1 SAMUEL GORTON AV.	FLOODING
42	MASTHEAD WALK	222	139	NEPTUNE ST.	FLOODING

43	MICKEY STEVENS COMPLEX	349	1	176 RANGE RD.	FLOODING
44	VETERANS MEMORIAL PARK	349	551	2435 W. SHORE RD.	FLOODING
45	BIRCHES PARK	346	303	NORMANDY DR.	FLOODING
46	O'BRIEN FIELD	245	61	120 VETERANS MEMORIAL DR.	FLOODING
47	OAKLAND BEACH	376	549	900 OAKLAND BEACH AV.	FLOODING

Chapter 8. Assessing Vulnerability

What is Vulnerability?

The impacts of natural hazard events are measured in terms of the costs that result from the impacts on society. The potential for future costs can be measured through risk and vulnerability assessments. In the Warwick Hazard Mitigation Strategy, *vulnerability* refers to the predicted impact that a hazard could have on people, services, specific facilities and structures in the community.

Vulnerability assessment is concerned with the qualitative or quantitative examination of the exposure of some component of society, economy or the environment to natural hazards. There are several factors to consider when assessing vulnerability, and these include: time, coastal and inland geography, location of community development and whether or not protective measures have been put into place to reduce future vulnerability to disasters.

The vulnerability of the built environment in Warwick to hazards, combined with trends in population growth and the value of insured property, suggests that there is a potential problem of a first order magnitude. Obviously one cannot prevent the storm from occurring; therefore the forces accompanying the hazard –storm surge, wind and flooding—will result in significant damage and destruction. However, much of the coastal hazard vulnerability can be attributed to inappropriately designed, built and located communities—often the result of not using the best available knowledge and practices. (Heinz, 1999) Almost every planning and development decision made at the local level has implications for the vulnerability to, and impact of, a natural hazard event.

A critical first step in assessing the risk and vulnerability of Warwick to natural hazards is to identify the links between the built environment vulnerability and the community's vulnerability to hazard-related business interruptions, disruptions of social structure and institutions, and damage to the natural environment and the flow of economic goods and services.

Assessing Vulnerability: Repetitive Loss Properties

As defined by FEMA, repetitive loss properties are those for which two or more losses of at least $1,000 each have been paid under the NFIP within any ten-year period since 1978. There are about 40,000 buildings across the country currently insured under the NFIP that have been flooded on more than one occasion and that have received flood insurance claims payments of $1000 or more for each loss.

As part of the 2010 updates to this hazard mitigation plan, the City contacted the Rhode Island NFIP Coordinator to request information on repetitive loss properties. It is important to note that much of the information associated with the NFIP is protected by the Privacy Act of 1974; therefore, this section contains discussion that cannot be fully supported by detailed documentation. Review of NFIP claims data indicated that 42 properties meet the definition of repetitive loss, 38 of which are residential and four are commercial. The areas of Warwick with the highest frequency of repetitive loss properties are Warwick Cove, Brush Neck Cove, Conimicut, and Pawtuxet Cove. Losses at these properties have been due to flooding and due to their location in flood prone areas.

FEMA mitigation funds are available to States so that the riskiest repetitive flood loss properties can be targeted offering the owners financial help to get their buildings high and dry – either moved to a safer location or elevated well above flood elevations. In Warwick, mitigation has been completed at 11 of the 42 properties listed above. Consistent with the grandfather provisions of the flood insurance

program's authorizing legislation, the FIA charges the owners of properties built before we developed detailed flood risk information less than full-risk premiums. These older, less-safe buildings that have been eligible for the reduced premiums account for nearly all of the repetitive loss properties insured under the flood insurance program.

Assessing Vulnerability: Critical Facilities

Hurricanes, storms and other natural events become "hazards" when they affect human society in adverse ways. Communities are vulnerable to these hazards to the extent that they are subject to potential damage to, or disruption of, normal activities. Societal conditions reflect human settlement patterns, the built environment, and day-to-day activities. These conditions include the institutions established to deal with natural hazards during both preparations and response.

The vulnerability of a community includes the potential for direct damage to residential, commercial, and industrial property as well as schools, government, and critical facilities. It also includes the potential for disruption of communication and transportation following disasters. Any disruption of the infrastructure, such as a loss of electric power or a break in gas lines, can interrupt business activity and cause stress to affected families, particularly if they are forced to evacuate their residences and are subject to shortage of basic supplies. If destruction of the infrastructure causes additional damage (e.g., property destroyed by fires caused by breaks in the gas lines), then this vulnerability needs to be taken into consideration. One also has to consider the exposure of the population to each hazard type and the potential number of fatalities and injuries to different socioeconomic groups.

Each jurisdiction classifies "critical facilities" based on the relative importance of that facility's assets for the delivery of vital services, the protection of special populations, and other important functions. If flooded, the loss of that critical facility would present an immediate threat to life, public health, and safety. Protection of critical facilities is also important for rapid response and recovery of a community, its neighborhoods and its businesses. In the City of Warwick, critical facilities are classified under the following subsections (see list in Chapter 7):

Public infrastructure:

Fire stations, Police Stations, Schools, Town Hall, Hospitals and Bridges with Utilities

Utilities:

Sewer treatment plants, Sewer lift stations, Water distribution system and Water tanks

Preparedness:

Red Cross approved shelters, Evacuation routes and Traffic control points

The Critical Facilities in Warwick are illustrated on Map 8-1, provided in the map pocket at the end of this document. Aside from a number of bridges, only one of Warwick's critical facilities is located in a flood or SLOSH zone within the Greenwich Bay watershed. This structure is fire station 4. In the event of a 100 year flood, this fire station would be completely unusable and apparatus would have to be relocated. This would impact the residents in the first response district of this fire station by increasing response times dramatically.

The City of Warwick has a total area of 35 square miles and a population of 85,808. There are approximately 1,400 at-risk structures. In the event of a severe hurricane, over 3,379 acres of land in Warwick could be inundated, causing over $50 million in property damage. Such an event would knock out key assets such as the lumberyard, marinas, and several warehouses (Raford, 1999).

Assessing Vulnerability: Evacuation and Mass Care

Evacuation

An evaluation of a number of factors effecting evacuation of the West Bay area, including the roadway system, likely evacuation destinations, traffic, seasonal population, severity of storm, etc., was conducted by the Army Corps of Engineers for the Hurricane Evacuation Study (ACOE 1995). A search for additional data was performed during the 2010 update of this hazard mitigation plan; however, it was found that the 1995 report was still the governing document. Population data utilized to prepare the estimates in this section were based on the 1990 Census; 2000 Census data showed a population increase in Warwick of only 381 and therefore it was determined that utilizing the "worst case" estimates from the 1990 population study was adequate for the purpose of assessing vulnerability.

The 1995 ACOE transportation analysis was utilized to compose an evacuation route map that illustrates evacuation zones and shelters for each affected community. Municipal and state emergency management officials have the Inundation Map Atlas and the Evacuation Map Atlas, both products of this study, for each community. This information would be most useful if it resulted in municipal signs posting appropriate evacuation routes on roadways.

It is recommended by FEMA that coastal communities use an 8 hour clearance time estimate for well-publicized daytime evacuations. Night time evacuations should allot 10 hours for clearance. In addition to the actual evacuation time, officials must add the time required for dissemination of information to the public, which can vary from community to community. It is a community decision to conduct an evacuation based on information made available to municipal officials. The ACOE recommends that the evacuation be complete before the arrival of gale-force winds.

The ACOE, under a weak hurricane scenario, estimates based on 1990 census data that 86,000 people in affected inundation areas for the state. In the Warwick area, estimates for people in vulnerable areas under a weak hurricane scenario are 16,270 people, with an estimated population of 18,990 likely to evacuate the City (Table 8-1). Estimates for strong hurricane scenarios raised the number to 28,760 people vulnerable, with 28,580 likely to evacuate. Recognizing the population increase in these towns since 1990, slight adjustments need to be made to the estimates by ACOE.

TABLE 8-1
TOWN POPULATIONS, EVACUATION PREDICTIONS, & SHELTER CAPACITIES DATA
(Source: ACOE 1995)

Hazard Event	Vulnerable Population	Population Evacuating		Shelter	
		Surge Areas	Non-Surge Areas	Demand	Capacity
Weak Hurricane	16,270	17,840	1,150	2,420	3,980
Severe Hurricane	28,760	25,700	2,880	3,770	3,980

The Warwick Police Department has a severe weather plan in its emergency operations manual. Emergency transportation and traffic control is a key component of the Department's response to natural disasters. In the event of a disaster, the Police Department's efforts to facilitate evacuation would be coordinated through Emergency Management, and assisted by the Department of Public Works, Fire Department, and Narragansett Electric and Providence Gas as necessary to maintain access and exit routes throughout the City.

Based on the SLOSH maps, the following areas would need to be evacuated during a hurricane: Warwick Neck, Oakland Beach, Buttonwoods, Apponaug Cove, and Potowomut. The primary evacuation routes in Warwick would be be: Post Road, Warwick Avenue, Elmwood Avenue, Bald Hill

Road/Route 2, Centerville Road, Toll Gate Road, Division Road, as well as I-95, Route 37 west, Route 4 and Route 295 north. Within Warwick, West Shore Road would be a primary connector route to any of the above mentioned roadways.

The Warwick Department of Public Works compiled the following list of critical roads being used for evacuation routes. These roads are identified in Table 8-2, listed according to the shelter that they serve.

TABLE 8-2 EVACUATION ROUTES PER SHELTER LOCATION

SWIFT GYM - P.E.S.	WINMAN J.H.S.	VETERANS MEM. H.S.	GORTON J.H.S.	PILGRIM H.S.
DIVISION RD.	BALD HILL RD.	BUTTONWOODS AV.	DRAPER AV.	AIRPORT RD.
IVES RD.	CENTERVILLE RD.	MAIN AV.	LONGMEADOW AV.	ELMWOOD AV.
LOVE LN.	COMMONWEALTH AV.	OAKLAND BEACH AV.	PALMER AV.	LAKE SHORE DR.
POST RD.	DIAMOND HILL RD.	SANDY LN.	SAMUEL GORTON AV.	NARRAGANSETT PKWY.
	GREENWICH AV.	STRAWBERRY FIELD RD.	WARWICK NECK AV.	POINT AV.
	QUAKER LN.	WEST SHORE RD.		POST RD.
	TOLL GATE RD.			WARWICK AV.
				WEST SHORE RD.

Any of the above listed roads may be flooded in areas where the routes pass over bridges if there are within the floodplain. Table 8-3, on the following page, provides a list of those bridges located on evacuation routes and which also lie within the 100 year flood plain.

Mass Care

There are three Red Cross approved emergency shelters in the Warwick's section of the Greenwich Bay watershed (Toll Gate, Pilgrim, and Warwick Veterans high schools). Each of these is capable of accommodating approximately 1,000 people. In the event that the capacity of these shelters is not sufficient during a disaster, other facilities could be used for additional accommodation.

TABLE 8-3 BRIDGES ON EVACUATION ROUTES

BRIDGE #	NAME	LOCATION	RIVER	OWNED BY:	DOT#
4	MALL BRIDGE	BALD HILL RD. RT 2	PAWTUXET RIVER	*STATE*	264
9	HARDIG I95 CULVERT	CENTERVILLE RD. RT 117	HARDIG BROOK	*STATE*	247
11	HERITAGE CULVERT	DIVISION ST. RT 401	MASKERCHUGG RIVER	*STATE*	217
12	DRAPER CULVERT	DRAPER AV.	WARNER BROOK	*CITY*	354
13	EAST NATICK BRIDGE	EAST AV. RT. 113	PAWTUXET RIVER	*CITY*	263
14	ELMWOOD BRIDGE	ELMWOOD AV. US 1	PAWTUXET RIVER	*STATE*	287
17	GORTON CULVERT	GREENWICH AV. RT 5	GORTON POND OUTLET	*STATE*	246
18	PONTIAC BRIDGE	GREENWICH AV. RT 5	PAWTUXET RIVER	*STATE*	271
23	LAKESHORE CULVERT	LAKE SHORE DR.	WARWICK POND INLET	*CITY*	327
24	LARCHWOOD CULVERT	MAJOR POTTER RD.	DARK ENTRY BROOK	*CITY*	223
25	PAWTUXET BRIDGE	NARRAGANSETT PKWY.	PAWTUXET COVE	*STATE*	292
26	FORGE BRIDGE	OLD FORGE RD.	HUNT RIVER	*STATE*	211
30	CONIMICUT CULVERT	POINT AV.	SHAWOMET CREEK	*CITY*	334
31	APPONAUG BRIDGE	POST RD US 1	APPONAUG COVE	*STATE*	245
33	QUIDNESSET BRIDGE	POST RD. US 1	HUNT RIVER	*STATE*	214
34	NORWOOD CULVERT	POST RD. US 1A	CRANBERRY BROOK	*STATE*	295
41	RIVERVIEW BRIDGE	TIDEWATER DR.	OLD MILL COVE	*CITY*	336
42	HARDIG BRIDGE	TOLLGATE RD. RT 115	HARDIG BROOK	*STATE*	246

47	BUCKEYE BRIDGE	W. SHORE RD. RT 117	BUCKEYE BROOK	*STATE*	337
49	CARPENTER BRIDGE	W. SHORE RD. RT 117	TUSCATUCKET BROOK	*STATE*	348
52	COTTAGE BRIDGE	WARWICK AV. RT 117A	BUCKEYE BROOK	*STATE*	351
54	SILVER HOOK BRIDGE	WARWICK AV. US 1A	PAWTUXET RIVER	*STATE*	290
55	BAYSIDE CULVERT	WARWICK NECK AV.	MEADOWVIEW CREEK	*CITY*	357

According to the American Red Cross, 25% of an evacuated population will seek public shelters in the event of most disasters. FEMA requires that a community provide shelters to accommodate 15% of an evacuated population. In order to evaluate the likely shelter populations for various areas in a jurisdiction, a behavioral analysis is performed by ACOE on the population located within projected inundation zones. This "vulnerable population" categorization obviously varies depending on the strength of the storm. As stated under evacuation information, in the Warwick area, estimates are in a weak hurricane 18,990 people will evacuate and 28,580 in a severe hurricane (Table 8-1). The likely demand on public shelters is 2,420 persons under weak storm conditions, and 3,770 under severe storm conditions. The total shelter capacity for the City of Warwick is 3,980 people.

Assessing Vulnerability: Transportation

The City of Warwick evolved from a scattered group of agricultural and maritime settlements. As the industrial revolution developed, factories and textile mills were constructed along the principal waterway, the Pawtuxet River, and resort communities sprang up along the Bay Shore. The scattered maritime, agricultural, industrial, and resort communities were connected by a transportation system of roads, and later in the early 20th century, by a system of trolleys and roads. Although the trolleys have disappeared, the network of roads is very much what is in place today for the City's circulation system (see Figure 8-1).

The construction of the interstate highway system through Warwick has also had a major impact on land use and circulation. Interstate 95 was completed in 1966 and I-295, which connects to I-95 in Warwick, was completed in 1968. Interchanges were established in the City to connect major arterials to the interstates at Routes 2, 37, 113 and 117. The airport connector tied the interstate system to the airport, and the Jefferson Boulevard exit connected the interstate to the City's industrial heartland. The interstates created access to Warwick in a totally new manner and the advantages of this were captured by the quick construction on Route 2 of the Rhode Island and Warwick Malls. This commercial focus on Route 2 continued, creating a nearly continuous strip of development from Cranston to East Greenwich.

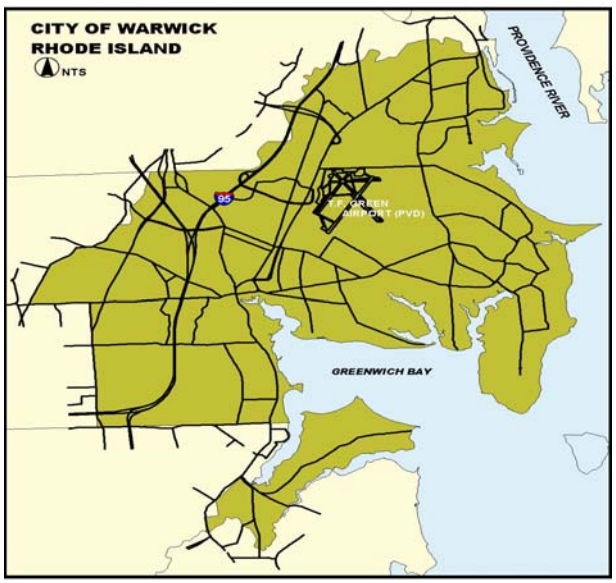


Figure 8-1 Warwick Major Road Systems

The 1985 inventory of land uses prepared for the 1986-1991 Land Use Plan for Warwick determined that roads totaled more than 3000 acres of the city's land area, or 14.5 percent of the city. This represents the third largest single category of use after single-family housing and vacant/undeveloped land. This is not unusual, especially in a suburban community where the primary means of travel is the automobile.

There are 70 state numbered bridges in Warwick. This represents nearly 10% of the 705 bridges statewide. All bridges in Rhode Island greater than 20 feet in length are assigned a number by the State Department of Transportation for the purposes of inspection. Although not owned by the state, they are inspected by the state.

TABLE 8-4 LENGTH OF ROADWAY IN WARWICK BY FUNCTIONAL CLASSIFICATION

Classification	*Length (miles)*
Interstate (Urban)	*9.20*
Other Freeway (Urban)	*2.75*
Connecting Rural Principal Arterials (Urban)	*11.45*
Connecting Rural Minor Arterials (Urban)	*2.20*
Principal Urban Arterials	*21.55*
Minor Urban Arterials	*11.70*
Urban Collectors	*36.90*
Total	*95.75*
Local	*450.00*

As indicated in Table 8-4, there is approximately 450 miles of local streets and roads under the responsibility of the City of Warwick. The Department of Public Works maintains these streets including: pavement repair, striping, shoulder maintenance, vegetation clearing, winter operation, and drainage system maintenance. If the road is on the functional classification, then the City's responsibilities for repair and/or reconstruction of the roadway may be assisted through funding from the state aid system.

Assessing Vulnerability: Social Conditions

A number of demographic and societal factors influence an area's potential risks from natural hazards. These include population growth and density, poverty, the number of renters, the numbers of disabled or elderly, non-English speakers, non-mobile people, and homes lacking insurance.

It is estimated that there are approximately 30,000 seniors living in the City of Warwick. As part of the services offered to the senior population, the City of Warwick has 3 Senior Centers (2 municipally operated and 1 privately operated) conveniently located throughout the City. These Centers provide various services to those that participate - including meal programs, transportation, health and wellness programs, and many other recreational and community programs.

Other General Demographic Characteristics:

- **Population**: The population count for The City of Warwick as of April 1, 2000, was 85,808. This represented a 0.45% increase (381 persons) from the 1990 population of 85,427.
- **Rank**: In 2000 Warwick ranks 2nd in population among Rhode Island's 39 cities and towns.
- **Median Age**: In 2000 the median age of the population in Warwick was 40.
- **Age Distribution**: In 2000, 78.1% or 67,028 persons residing in Warwick were 18 years of age or older. 64,478 were 21 and over, 16,664 were 62 and over, and 14,558 were 65 and over.
- **Population Density**: The 2000 population density of Warwick is 2,417 persons per square mile of land area. Warwick contains 35.50 square miles of land area (91,940,953 Sq. meters) (22,719.28 acres) and 14.12 square miles of water area (36,574,361 square meters) (9,036.76 acres).
- **Housing Units**: The total number of housing units in the City of Warwick as of April 1, 2000, was 37,085. This represented an increase of 1,944 units from the 35,141 housing units in 1990.

Of the 37,085 housing units 1,568 were vacant. 493 of the vacant units were for seasonal of recreational use.

- **Households**: In 2000, there are 35,517 households in Warwick with an average size of 2.39 persons. Of these, 22,971 were family households with an average family size of 2.99 persons.
- **Race**:
  > Total Population of One Race: 84,706
  > White: 81,695
  > Black of African American: 996
  > American Indian and Alaska Native: 213
  > Asian: 1,281
  > Native Hawaiian and Other Pacific Islander: 15
  > Some Other Race: 506
  > Total Population of two or More Races: 1,102
  > Hispanic or Latino: 1,372

When preparing this mitigation plan the aforementioned demographic information was taken into consideration in order to assure that the plan is as comprehensive as possible. Only then can we assure that all of our residents enjoy equal benefit from our proposed mitigation actions.

Assessing Vulnerability: Economic

Approximately 85% of the City of Warwick's revenue is generated from property tax (roughly 60% residential and 25% commercial). Boating-related business real estate in Greenwich Bay also generates between $500,000 and $1 million in tax revenue. In the event that a natural hazard destroys a portion of the tax base, even those property owners not directly impacted by the event would carry the financial burden of increased property taxes. A substantial portion of the revenue generated by Warwick is also from tourism. In this context, it is important that potential economic impacts of a natural disaster be assessed in the hazard mitigation plans so that the resulting policy accounts for these potential impacts. In a declared disaster area, FEMA will only cover those who have addresses in that area. This translates to mean that those who work in the area but don't have real estate, like shell fishermen, will not be covered by FEMA.

Another key element in mitigating possible economic impact in Greenwich Bay is to improve disaster preparedness for businesses – especially small businesses – by creating an alliance among businesses and the public sector. Research shows that 43% of businesses that close after a disaster never reopen, and an additional 29% close for good within two years (IBHS 2003). The Rhode Island Joint Reinsurance Association, Narragansett Electric and AT&T Wireless Services all contributed to efforts in 1999 to determine small business disaster recovery needs. The Institute for Business and Home Safety (IBHS) used the results of this research to produce Open for Business: A Disaster Planning Toolkit for the Small Business Owner. The toolkit includes preparedness checklists and an employee safety poster.

Assessing Vulnerability: Natural Conditions

Major climatic events, such as severe storms, are part of the natural and ecological processes that constantly shape coastal lands and vegetation. According to the 2000 Heinz Center Study on the costs of coastal hazards, the extent of the risk that coastal hazards pose to natural systems and the built environment is related directly to the degree that land uses alter and degrade the environment. To analyze this risk, it is necessary to assess the characteristics and resilience of the natural environment. More specifically, natural features such as soils, elevations above sea level, and vegetative cover need to be inventoried. The intensity of land use, and the extent that hydrology, water quality, and habitats are

altered, must also be evaluated in order to understand vulnerability. Land uses that extensively modify natural systems make these systems much more vulnerable to coastal hazards than do those that preserve and perpetuate natural ecological processes. The natural environment may be affected adversely immediately after the disaster as well as over the long term. Some of the damage may be irreversible, whereas other adverse impacts may be only temporary.

Assessing Vulnerability: Special Considerations

Marinas

The marine trades are a significant economic and social asset to Warwick. Greenwich, Apponaug, and Warwick Coves contain some of the densest marina and boating facilities in the state. There are an estimated 30 marinas/yacht clubs with almost 4,000 boat slips. In addition, a substantial proportion of the shoreline around the Bay is characterized by high-density residential development. Personal safety concerns and economic damage could be substantial for both the in water and nearshore land areas. Recreational and commercial boats are at great risk since most of them are located in high velocity (VE) zones. These boats are located at marinas, on moorings, on land, and at yacht clubs. Other facilities of concern include the diesel tanks used to fill boats in Greenwich Cove.

It is also important to note that in advance of major storms such as hurricanes, boat owners are advised to remove their boats from the water in order to minimize damage. These boats are typically removed and stored at local marinas. Unfortunately, marinas are located in floodplains and inundation areas and, thus, the majority of the boats are still subject to damage. Although not as convenient, it would be far more preferable to have a boat storage site outside of the floodplain.

Debris

The removal, storage, and disposal of debris accumulated, especially along shorelines and riverbanks during major flood and wind events are an important consideration. Massive amounts of debris accumulated along coastal areas during the 1938 and 1954 hurricanes, specifically the shores of Oakland Beach, Apponaug Cove, and Potowomut (Providence Journal Company, 1954). In each event, the result was a large and costly clean up. Highly developed areas have a lower capability to address this consequence, since the capacity of local landfills tends to be exceeded. Warwick stores their debris at several schools, athletic fields and parks locations. The Warwick Harbor Management Plan policy on derelict vessels and debris is for the harbormaster to notify RIDEM of needed cleanups. The plan also recommends that CRMC require tagging of all dock sections in order to determine ownership of debris for cost recovery (Warwick Harbor Plan, 1996).

Assessing Vulnerability: Identifying Structures

Vulnerability can be assessed in terms of the type and numbers of existing and future buildings, infrastructure, and critical facilities located in each identified hazard area. FEMA suggests that these would include:

- Building stock
- Critical facilities
- Transportation systems
- Lifeline utilities
- Communication systems
- Historic, cultural, and natural resource areas
- High potential loss facilities
- Hazardous material sites
- Economic centers
- Other special consideration areas

In Warwick, the primary vulnerability is due to storm events and flooding, so essentially structures located in flood-prone areas. As stated previously, there are approximately 1,400 at-risk structures, located primarily in the Oakland Beach and Conimicut areas. Warwick has participated in a variety of studies aimed at identifying buildings, critical facilities, and roadways located in flood-prone areas, and these vulnerabilities are discussed throughout this hazard mitigation plan. New development, re-development, and substantial renovations in these areas are strictly governed under zoning and building codes; therefore, any future structure will be less vulnerable to damage from flood-related hazards. The City's goals, objectives, and projections for future development are also detailed in the *Comprehensive*

Plan of the City of Warwick, which works in tandem with this hazard mitigation plan to minimize repetitive losses to structures in flood-prone areas.

Assessing Vulnerability: Estimating Potential Losses

This section estimates the potential loss for each of the hazards identified in the City's Hazard Identification. It is difficult to ascertain the amount of damage caused by a natural hazard because the damage will depend on the hazard's extent and severity, making each hazard event somewhat unique. In addition, human loss of life was not included in the potential loss estimates, but could be expected to occur, depending on the severity of the hazard. It is also important to note that only property values were included. These figures do not include contents of the structures or any other property besides values which are included in the City's tax levy.

Tropical Cyclone

Damage causes by hurricanes can be both severe and expensive. In the past, Warwick has been impacted by wind and flooding as a result of hurricanes. The assessed value of all residential, commercial, and industrial structures in Warwick is $9,012,859,870. Assuming 1% to 5% city-wide damage, a hurricane could result in $90,128,599 to $450,642,994 in damage.

Nor'easter

Damage causes by Nor'easter's can be both severe and expensive. In the past, Warwick has been impacted by wind and heavy snowfall as a result of Nor'easters. The assessed value of all residential, commercial, and industrial structures in Warwick is $9,012,859,870. Assuming 1% to 5% city-wide damage, a nor'easter could result in $90,128,599 to $450,642,994 in damage.

Thunder and Lightning

In the past, severe thunderstorms that include dangerous lightning activity have caused mild to severe damage to individual residences in Warwick depending on the severity of the storm, and the location of the lightning strikes. In the future, damages will vary according to the value of the home and the contents inside.

Tornados

Damage from tornados is difficult to predict as the damage is fully dependent upon where the tornado touches down. In Warwick we can estimate that a tornado may cause 1% to 2% city-wide damage. The assessed value of all residential, commercial, and industrial structures in Warwick is $9,012,859,870. Assuming 1% to 2% damage, a tornado could result in $90,128,599 to $180,257,197 in damage. This damage estimate may increase if a heavily populated area was impacted by the storm.

Severe Winter Storms

Heavy snow storms typically occur during January and February. New England usually experienced at least one or two nor'easters with varying degrees of severity each year. Power outages, extreme cold, and impacts to infrastructure are all effects of winter storms that have been felt in Warwick in the past. All of these impacts are a risk to the community, including isolation, especially of the elderly, and increased traffic accidents. Damage caused as a result of this type of hazard varies according to wind velocity, snow accumulation, and duration. The assessed value of all residential, commercial, and industrial structures in Warwick is $9,012,859,870. Assuming 1% to 5% city-wide damage, a severe winter storm could result in $90,128,599 to $450,642,994 in damage.

Hail Storms
Hail storms often cause widespread power outages by downing power lines, making power lines at risk in Warwick. They can also cause severe damage to trees. Hail storms in Warwick could be expected to cause damage ranging from a few thousand dollars to several million, depending on the severity of the storm. The assessed value of all residential, commercial, and industrial structures in Warwick is $9,012,859,870. Assuming 1% to 5% city-wide damage, a hail storm could result in $90,128,599 to $450,642,994 in damage.

Temperature Extremes
Temperature extremes have a limited impact on the infrastructure of the City of Warwick. The best estimate for potential damage would be no greater than one percent of the total value of all commercial and residential structures in the City. This would mean that temperature extremes are expected to cause a loss no greater than $90,128,599.

Flooding and Storm Surge
Flooding is often associated with hurricanes, nor'easters, rapid springtime snow melt, and heavy rains. It can be in the form of inland or coastal flooding. In the following calculations, the average replacement value was calculated by adding up the assessed values of all structures in the 100- and 500-year floodplains and then dividing by the number of structures. There are approximately 5,550 residential structures located in the flood hazard area in Warwick. The average assessed value of those structures is approximately $150,000. There also are approximately 50 non-residential structures in the flood hazard area. The average assessed value for those structures is $370,000. These figures were used to determine the impact a flood would have on the City of Warwick.

FEMA has developed a process to calculate potential loss for structures during flooding. The potential loss was calculated by multiplying the average replacement value by the percent of damage expected from the hazard event, and then by multiplying that figure by the number of structures. Residential and non-residential structures were separated. The cost for repairing or replacing bridges, railroads, power lines, telephone lines, natural gas pipelines, and the contents of structures have not been included in this estimate. All of the following estimates were found in the following reference: *Understanding Your Risks, Identifying Hazards and Estimating Losses, FEMA page 4-13.*

TABLE 8-5 EIGHT FOOT FLOOD

The following calculation is based on eight-foot flooding and assumes that, on average, one or two story buildings with basements receive 49% damage.

Structure Type	# of Structures	Avg. Replacement Value	Percent Damage	Total Damage
Residential	5,550	$150,000	49%	$407,925,000
Non-Residential	50	$365,000	49%	$8,942,500

TABLE 8-6 FOUR FOOT FLOOD

The following calculation is based on four-foot flooding and assumes that, on average, a one or two story building with a basement receives 28% damage.

Structure Type	# of Structures	Avg. Replacement Value	Percent Damage	Total Damage
Residential	5,550	$150,000	28%	$233,100,000
Non-Residential	50	$365,000	28%	$5,110,000

TABLE 8-7 TWO FOOT FLOOD

The following calculation is based on two-foot flooding and assumes that, on average, a one or two story building with a basement receives 20% damage.

Structure Type	# of Structures	Avg. Replacement Value	Percent Damage	Total Damage
Residential	5,550	$150,000	20%	$166,500,000
Non-Residential	50	$365,000	20%	$3,650,000

Coastal Erosion

Coastal Erosion causes very little impact on the City of Warwick on its own as it only makes ocean front structures more vulnerable to storm surge damage. If this erosion is severe enough then the City may choose to rebuild the dunes and coastline in order to protect those homes. It is impossible to estimate the cost of such a project without a complete engineering study.

Droughts

Droughts can be costly to agricultural communities, but in Warwick there is little cost associated with these disasters. Water preservation and supplying alternative sources of water during a severe drought may be the only action required. Supplying emergency water would be a costly endeavor; however the scenario is an unlikely one.

Earthquake

Within one to two minutes, an earthquake can devastate part of an area such as Warwick through ground-shaking, surface fault ruptures, and ground failures. It can also cause buildings and bridges to collapse, disrupt gas lines which can lead to explosions and fires, down power and phone lines, and are often associated with landslides and flash floods. In addition, buildings that are not built to a high seismic design level would be susceptible to severe structural damage. The assessed value of all residential, commercial, and industrial structures in Warwick is $9,012,859,870. Assuming 1% to 5% city-wide damage, an earthquake could result in $90,128,599 to $450,642,994 in damage.

Dam Failure
A dam failure could flood 0.5% to 1% of the structures in Warwick. The assessed value of all residential and commercial structures in Warwick is $9,012,859,870; therefore, a dam failure could result in $45,064,299 to $90,128,599 in property damage.

Hazardous Materials Incident
There is no way to estimate the potential damage from a Hazardous Materials Incident.

Assessing Vulnerability: Development Trends

The City of Warwick has seen significant growth over the past 50 years; however that growth shows signs of stabilizing over the past 30 years. Census information provides us with the best view of the overall growth of the City. By examining the development trends in the City of Warwick we can gather a clearer picture of the potential for future growth and create a mitigation strategy that take these trends into account.

Populations and Housing Growth
Although the updated Census data was collected in 2010, published data was not available at the time of the 2010 updates to this mitigation plan. Therefore, revisions were not made to population data. As indicated in Table 8-8, population growth in the City of Warwick grew 0.45 % between 1990 and 2000, while housing growth increased 5.5%. In 2000, there was an average of 2.3 people in each housing unit, down significantly from 2.9 in 1950.

TABLE 8-8 POPULATION 1950-2000 (Source: 2000 Census)

Census Year	Population	Net Change		Housing Units	Net Change	
		#	%		#	%
1950	43,028	NA	NA	14,790	NA	NA
1960	68,504	25,476	59.21%	21,747	6,957	47.04%
1970	83,694	15,190	22.17%	26,219	4,472	20.56%
1980	87,123	3,429	4.10%	32,450	6,231	23.77%
1990	85,427	-1,696	-1.95%	35,141	2,691	8.29%
2000	85,808	381	0.45%	37,085	1,944	5.53%
Total change 1950 - 2000	NA	42,780	99.42%	NA	22,295	150.74%

As displayed in Table 8-9, the population density increased significantly in terms of persons per square mile, from 1,212 in the year 1950 to 2,417 in 2000.

TABLE 8-9 POPULATION DENSITY (Source: 2000 Census)

2000 Population	Area in Square Miles	Persons per square mile					
		1950	1960	1970	1980	1990	2000
85,808	35.5	1,212	1,930	2,358	2,454	2,406	2,417

In the ten-year period between 1999 and 2009, the number of residential and commercial building permits issued for new construction has declined substantially as demonstrated in Table 8-10.

TABLE 8-10 HISTORICAL BUILDING PERMITS

Housing Type	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	10-Yr Total
Single Family	119	94	91	101	77	70	75	54	49	32	23	785
Multi-Family	9	19	15	5	1	4	3	9	17	1	0	83
Commercial	15	21	14	18	13	17	7	15	13	6	7	146
Total	143	134	120	124	91	91	85	78	79	39	30	1,014

A total of 263 new residential structures were permitted in the period between 2005 and 2009, with an estimated combined value of $36.8 million. A total of 48 new commercial structures were permitted in this same period, with an estimated combined value over $60 million. Any of these structures located within flood-prone areas were required to follow local and state building codes to minimize losses.

Land Use

According to geographic information system calculations, the City of Warwick is made up of 49 square miles, to include a land area of 35 square miles and an inland water area of 14 square miles. Warwick has an estimated 39 miles of shoreline. Approximately 3,379 acres in Warwick area located within a FEMA designated Special Flood Hazard Area.

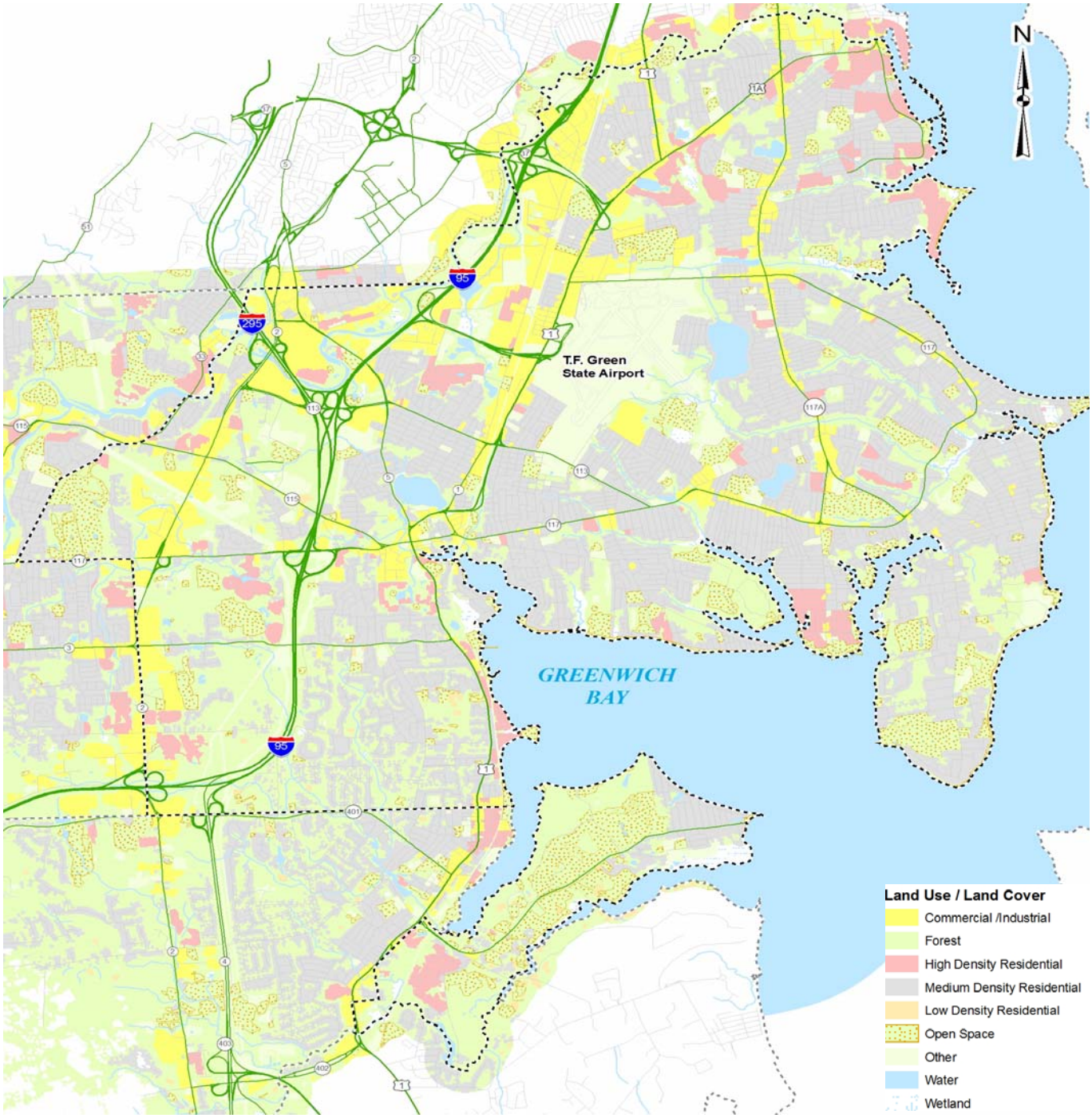
Figure 8-2, on the following page, illustrates the current land uses in Warwick. Based on information from the Warwick Assessor's Office, an estimated 44% of the City is in residential use, with an additional 6% of residentially zoned vacant land. Commercial/industrial uses account for approximately 18% of current land use, primarily limited to arterial road corridors, and approximately 22% of land use is public such as municipal, college/university, utility/railroad, state (including the airport), and federal property. Almost 6% is forest, open space, and coastal beaches.

Development & Land Use - Relation to Natural Hazards

Warwick is primarily comprised of suburban neighborhoods. There is limited open space and undeveloped land. Commercial development lines most of the main roads in the City with the densest commercial area being located along Route 2. The coastal areas of Warwick are developed primarily with residential properties. Out of these coastal areas, Connimicut Beach and Oakland Beach, are most susceptible to coastal flooding and storm surge. As clearly demonstrated during the extreme storm events of March 2010, the City of Warwick is also susceptible to inland riverine flooding in the areas surrounding the Pawtuxet River basin.

As previously indicated, population growth has stabilized over the past 30 years. For this reason, planning for substantial growth is not necessary. Major population increases will only become an issue if there is trend of increased multi-family housing development within the City. If population in the City of Warwick does increase dramatically, evacuation routes and emergency shelters may be taxed.

Figure 8-2
Warwick Land Use



Addressing Vulnerabilities

Recognizing the importance of balancing all of these factors - public safety the built environment, social institutions, and natural ecosystems – the Warwick multi-hazard mitigation strategy identifies the risk and vulnerability potential of these components as well as balance the relationships among them. In taking these issues into consideration, the Warwick Hazard Mitigation Committee created a matrix which outlines the areas in the City of Warwick where mitigation actions should be taken to reduce the impacts of natural hazards. These mitigation actions are discussed in later chapters of this mitigation plan.

Chapter 9. Mitigation Strategies

Local Hazard Mitigation Goals

The City of Warwick's Mission and Goals related to hazard mitigation were detailed in a separate chapter, earlier in this document. As encouraged by FEMA, the purpose of these goals is to help the City avoid, or minimize, vulnerabilities to the hazards identified in this document through implementation of mitigation strategies. Discussion regarding Warwick's identified mitigation strategies, both prior and new in 2010, are detailed in this Chapter.

Identification of Mitigation Actions

Risk management is the process by which the results of an assessment are integrated with political, economic, and engineering information to establish programs, projects and policies for reducing future losses and dealing with the damage after it occurs (Heinz Center, 1999). Managing risks involves selecting various approaches that when applied to the risk area, will reduce the vulnerability. In order to effectively evaluate the true costs associated with natural hazards, the vulnerability of the built environment, social, health and safety, business and natural resources and ecosystems' vulnerability must be determined.

Existing Mitigation Strategies

In preparing the 2005 mitigation plan, the Hazard Mitigation Committee identified a number of pro-active protection mechanisms that were already in place in the City of Warwick that could reduce damage and loss in the event of a natural disaster or secondary disaster. These strategies were also reviewed during the 2010 plan updates, and a few items added. These strategies include actions that address both existing structures and those to be built or substantially changed in the future. Each strategy identified by the Committee as part of the 2005 plan and 2010 updates is listed in Table 9-1 (on the following page), including the area covered by the strategy and the department responsible for administering it. The Committee's recommendations for further improvement are also included.

Status of 2005 Mitigation Action Plan

As part of the 2010 updates, each of the action plan activities from the 2005 plan was reviewed in an effort to determine its level of completion. The current status of each of the 15 items listed in the 2005 Action Plan is presented in Table 9-2, on the following page. Where an Action had not been completed, the table also indicates whether the project is in progress or has been deferred or deleted, and why. In some cases, alternative measures were found to accomplish the same outcome for the listed Action. For example, the City identified relocation of Fire Station #4 as a priority in 2005; however, relocation of this station was found not to be in the City's best interest at this time and, instead, a plan was developed for temporary relocation of personnel, equipment, and apparatus to achieve the same goals of improved response capability and minimized equipment damage.

TABLE 9-1 EXISTING MITIGATION STRATEGIES

Existing Strategies	Description	Coverage Area	Responsible Department	Recommended Improvements
Drain Maintenance	Repair/Clean Infrastructure	City-wide	DPW HWY	Increase Budget/Personnel
Drainage Inventory	Hardcopy Maps w/Project List	City-wide	DPW ENG	Digital Conversion
Road Inventory	List of Road Lengths/Condition	City-wide	DPW ENG	Digital Conversion
Road Reconstruction	Annual Paving Program	City-wide	RIDOT Stds	Increase Budget
Signage Inventory	List of Traffic Regulations at DPW	City-wide	WPD	Add Work Orders; Digital Conversion
Slope Protection	Soil Erosion & Sediment Control Permits	City-wide	Ordinance	None
Snow Plowing	Plowing City Streets during Snow Storms	City-wide	DPW HWY	None
Stormwater	Design & Install Drainage Systems	City-wide	RIDEM Permit	Seek More Grants
Vehicle Maintenance	Maintain Municipal Vehicles; Staff Call List	City-wide	DPW Auto	Additional Garage Space?
Soil/Slope Protection Regs.	Removal of Soil or Change Contour	City-wide	BLDG DEPT	None
Building Code - Multi-Family, Commercial, and Industrial	Adopted 1CC Plumbing, Mechanical, Energy, Gas, & Electric Code	City-wide	BLDG	Code Update Every 3 Years
Building Code - Residential 1 & 2 Family	Adopted INTL 1 & 2 Family Code	City-wide	BLDG	Code Update Every 3 Years
Zoning Ordinance – Max. Building Height	Max. 35-ft Height for Residential Structures	City-wide	BLDG	Follow National Code
Housing Code – Minimum Property Maintenance	Adopted INTL Property Maintenance Code	City-wide	Code Enforcement	Code Update Every 3 Years
Participation in NFIP	Comply with NFIP Min. Requirements	Floodplains	EMA / Planning	Encourage Flood Insurance/Mitigation
Public Education - Flood	Distribute Education Materials for Hazard Mitigation/Recovery	City-wide	EMA	Continue to Update Material as Necessary
Hazard Mitigation Planning	Maintain Current Plan & FEMA Funding Eligibility	City-wide	EMA	Plan Update Every 5 Years

TABLE 9-2 STATUS OF 2005 MITIGATION ACTIONS

Mitigation Strategy	Current Status
Drainage Inventory - GPS to GIS	Stormwater outfalls located; no additional mapping completed to date. Deferred due to funding.
Road Inventory – tie database to GIS map	Inventory complete; not linked to GIS. Link deferred to allow for additional GIS upgrades prior to proceeding.
Infrastructure Inventory – all structures in floodplain	All municipal structures completed. Private structures deferred until GIS capabilities are improved.
Repair Roof of Thayer Arena	Completed: roof repaired.
Road Reconstruction – Critical Roads	Completed: as needed through Annual Capital Program.
Debris Removal – Pawtuxet River	In Progress: Federal assistance secured for project; planned for 2011.
Relocation of Fire Station 4 (Sandy Lane)	Alternative completed: New EMA procedures established.
Debris Removal – Narragansett/Greenwich Bay	Completed: annual cooperative program implemented.
Increase Boat Ramp Inventory	Alternative completed: public preparedness education distributed, which reduced bottlenecks at existing ramps.
Elevate Rt. 117 @ Tuscatucket Brook	Deleted: Roadway is RIDOT responsibility.
Elevate Draper Avenue	In Progress: Tidewater bridge replacement under design.
Annual Mailing – Hurricane Preparedness	Alternative completed: materials published on City website.
Protect Sewer Pumping Stations	In Progress: Phased engineering evaluations on-going.
Protect Conimicut Lighthouse from Storm Surge	In Progress: Additional rock placed on shoreline; additional restoration grant secured but awaiting funding (est. 2015).
Elevate Structures – Financial Aid to Conimucut/Oakland Beach Residents	Deferred: Building code requires new/renovated structures to be elevated. No funding has been successfully secured to date to elevate existing structures.

For those Actions from the 2005 plan that had not yet been completed, the continued applicability and priority of these Actions based on updated assets and risks was reviewed as part of the 2010 updates. Since experiencing the extreme floods of March 2010, projects and priorities have changed in many of the City departments. Any Actions found to be still applicable, were added to the recommended 2010 Actions discussed later in this Chapter.

2010 Mitigation Actions

In addition to those programs and activities that the City of Warwick has previously identified to protect its residents and property from natural hazards, a number of potential new actions were identified by stakeholders during the 2010 updates. *A comprehensive range of potential mitigation actions* were considered when identifying new programs and activities that Warwick could implement including, but not limited to the following:

- Flood Prevention
- Property Protection
- Structural Protection
- Repetitive Loss Reduction
- Emergency Services
- Facilitating Short-Term Recovery
- Continuity of Basic Utility Service
- Public Information & Involvement

In addition to these types of potential actions, various hazards were also considered. As described in detail in earlier chapters, the types of natural hazards in Warwick include:

- Tropical Cyclone
- Nor'easter
- Thunderstorm/Lightning
- Severe Winter Storm
- Hailstorm
- Temperature Extreme
- Tornado
- Flood
- Storm Surge
- Coastal Erosion
- Drought
- Earthquake

With few exceptions, the primary vulnerability associated with these hazards is flooding. Therefore, although other hazards were considered as part of identifying and analyzing mitigation actions, flooding was determined to be the primary hazard on which the City of Warwick would focus its mitigation resources. The resulting newly identified mitigation actions for this 2010 plan update, in no particular order, are listed in Table 9-3.

In developing these Actions, stakeholders considered different projects and activities to reduce the impacts of hazards on existing structures and utilities, but also looked at the future of Warwick with respect to capital improvements, development, re-development, and substantial renovation to assure that mitigation Actions prevent new problems from being built and continue to work towards improving existing ones.

TABLE 9-3 NEWLY IDENTIFIED MITIGATION ACTIONS (2010)

Hazard Type	Potential Action	Description of Action	Affected Location	Type of Activity
Flood	Voluntary Acquisitions	Purchase/demolish/restore an estimated 25 high risk residential properties to prevent further repetitive losses	Various	Repetitive Loss Reduction
Flood	Dam Management Plan	Develop a plan to manage floodwaters in the Pawtuxet River through coordinated flow control at existing public/private dams	Pawtuxet River Floodplain	Flood Prevention
Flood	WWTF Levy Evaluation	Evaluate the feasibility of upgrading the existing levy to prevent repetitive losses of equipment/facilities, and interruptions in critical sewage collection/treatment	City-wide	Loss Reduction/ Continuity of Utility Services
Flood	Boat Relocation Sites	Identify and secure agreements with owners of properties outside flood plain where boats could be relocated during major storm events	Flood/ SLOSH Areas	Property Protection
Flood	Water Valve Relocation	Relocate 42-inch water main valve subject to inundation to allow 1) access to the valve during flooding and, 2) ability to isolate 42-inch main under Pawtuxet River during flood events	City-wide	Property Protection/ Continuity of Utility Services
Flood	Bellows Street Mitigation Study	Develop and evaluate alternatives for flood mitigation in the industrial park area on Bellows Street	Bellows Street	Repetitive Loss Prevention
All	Alternate EMA Site	Identify/secure/equip alternate location for Emergency Management command in case primary is inaccessible/damaged during a disaster	City-wide	Emergency Services
Flood	Bellows Street Pump Station Relocation	Relocate the Bellows Street sewer pump station out of flood-prone area	Sewer Tributary Area	Loss Reduction/ Continuity of Utility Services
Flood	Knight Street Pump Station Relocation	Relocate the Knight Street sewer pump station out of flood-prone area	Sewer Tributary Area	Loss Reduction/ Continuity of Utility Services

National Flood Insurance Program (NFIP) Compliance

Floodplain Management

The City of Warwick Risk Assessment ranked flooding as one of the City's greatest potential risk. Flooding is most likely to occur in the spring due to the melting of snow and the increase in rainfall. However, flooding events can occur at anytime of the year as a result of heavy rains, hurricanes, and nor'easters. Flood mitigation is an essential step in preventing flood damage. A comprehensive discussion regarding Warwick's vulnerability to various types of flood events was provided in Chapter 6 of this hazard mitigation plan. Supplemental discussion specific to floodplain management and the City's participation in the NFIP is provided in this Chapter.

According to FEMA's definition, floodplain management is the operation of a community program of corrective and preventative measures for reduction of flood damage, such as requirements for zoning, subdivision or building, and special-purpose floodplain ordinances. A major objective for floodplain management is participation in the NFIP. Communities that agree to manage Special Flood Hazard Areas shown on the NFIP maps participate in the NFIP by adopting minimum standards, including the adoption of a Floodplain Ordinance and Subdivision/Site Plan Review requirements for land designated as Special Flood Hazard Areas.

The National Flood Insurance Program (NFIP)

In 1968, Congress created the National Flood Insurance Program (NFIP) in response to the rising cost of taxpayer funded disaster relief for flood victims and the increasing amount of damage caused by floods.

The Federal Insurance and Mitigation Administration (FIMA) a component of FEMA manages the NFIP, and oversees the floodplain management and mapping components of the program.

Flood damage is reduced by nearly $1 billion a year through partnerships with communities, the insurance industry, and the lending industry. Further, buildings constructed in compliance with NFIP building standards suffer approximately 80 percent less damage annually than those not built in compliance. Additionally, every $3 paid in flood insurance claims saves $1 in disaster assistance payments. The NFIP is self-supporting for the average historical loss year, which means that operating expenses and flood insurance claims are not paid for by the taxpayer, but through premiums collected for flood insurance policies. The program has borrowing authority from the U.S. Treasury for times when losses are heavy; however, these loans are paid back with interest.

Communities participate in the NFIP by adopting and enforcing floodplain management ordinances to reduce future flood damage. In exchange, the NFIP makes federally subsidized flood insurance available to homeowners, renters, and business owners in these communities. Flood insurance, Federal grants and loans, Federal disaster assistance, and Federal mortgage insurance is unavailable for the acquisition or construction of structures located in the floodplain shown on the NFIP maps for those communities that do not participate in the program.

Federally subsidized flood insurance is available to any property owner located in a community participating in the NFIP. Communities that fail to comply with NFIP are put on probation and/or suspended. Probation is a first warning where all policyholders receive a letter notifying them of a $50 increase in their insurance. In the event of suspension, the policyholders lose their NFIP insurance and are left to purchase insurance in the private sector, which is of significantly higher cost. If a community is having difficulty complying with NFIP policies, FEMA is available to meet with staff and volunteers to work through the difficulties and clear up any confusion before placing the community on probation or suspension.

To get Federally secured financing to buy, build, or improve structures in Special Flood Hazard Areas, it is required by federal law to purchase flood insurance. Lending institutions that are federally regulated or federally insured must determine if the structure is located in a SFHA and must provide written notice requiring flood insurance. Flood insurance is available to any property owner located in a community participating in the NFIP.

An essential step in mitigating flood damage is participation in the NFIP. The City of Warwick works to consistently enforce NFIP compliant policies in order to continue its participation in this program. Warwick has and will continue to demonstrate its commitment to participating in the NFIP by meeting the following minimum requirements:

- Adopt Floodplain Maps: The City of Warwick has adopted a new Flood Ordinance and the new Digital Flood Insurance Rate Maps (DFIRMs) effective December 3, 2010 (FEMA).

- Adopt & Enforce Floodplain Regulations: The City of Warwick has implemented floodplain regulations designed to mitigate flood losses in new and substantially improved structures. These regulations are primarily enforced through the City's Building Department and strict compliance with Rhode Island State Building Code. The Planning and Building Departments also ensure continued compliance with the NFIP for development and re-development through subdivision and site plan review process.

- Participation in NFIP: The City of Warwick has been a participant in the NFIP since 1978. FEMA data through September 30, 2010, indicates a total of 1,864 policies are in force and 537 losses have been paid and closed since 1978 (see Table 9-4).

TABLE 9-4 SUMMARY OF NFIP PARTICIPATION
Source: FEMA

City	NFIP Policies	NFIP Insurance In-Force	Total Premiums	Claims since 1978	Total Payments since 1978
Warwick	1,864	$407,427,200	$2,335,560	537	$8,958,769

The City also has and will continue to provide public education and assistance to property owners regarding the NFIP, FEMA requirements/benefits/claims, and other flood-related issues. The City has developed and published a substantial amount of educational and guidance material on their website, and maintains a variety of documents for public reference in the offices of the Planning and Building Departments. In addition, the City recently published online information to educate and advise the public regarding the 2010 flood map updates, demonstrating their continued commitment to compliance with the requirements of the NFIP.

According to NFIP policies, when an applicant files a request for a building permit in the floodplain, the applicant must include an elevation certificate in order to be in compliance. In addition, if an applicant intends to fill onsite, a letter of map of revision must be submitted along with the application. According to NFIP requirements in the Floodplain Ordinance, building permits are reviewed to assure sites are reasonably safe from flooding and construction is completed utilizing flood resistant materials and proper anchoring to prevent flotation, collapse, or lateral movement. The Code Enforcement Officer/Building Inspector is familiar with the Floodplain Ordinance and the NFIP. Additionally, the Planning Board is familiar with NFIP policies, especially those regulations that are required to be incorporated into the Subdivision/Site Plan Review regulations.

Community Rating System (CRS)
When communities go beyond the minimum standards for floodplain management, the FEMA NFIP Community Rating System (CRS) provides discounts up to 45% off flood insurance premiums for policyholders in that community. Formal adoption and implementation of this strategy will help Warwick gain credit points under the CRS. For example, points are given to municipalities that form a Local Hazard Mitigation Committee. Communities also receive points if they involve the public in the planning process, coordinate with other agencies, assess the hazard and their vulnerability, set goals, draft an action plan (local hazard mitigation strategy), and adopt, implement and revise the plan.

To encourage communities to establish sound floodplain management programs, FEMA administers the Community Rating System (CRS). CRS is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements by providing discounts on flood insurance. The community must meet three goals:

- Reduce flood losses
- Facilitate accurate insurance rating
- Promote the awareness of flood insurance

There are many categories to gain credit for public education and awareness activities regarding floodplain management and mitigation. The maintenance of non-federally owned open space land in

floodplains can also help a municipality gain credit points under the CRS program. In addition, vegetated open-space land enhances the natural beauty and the beneficial functions that floodplains serve while helping to prevent flood damage.

The CRS has many benefits, the most obvious being financial. Table 9-5, on the following page, shows the credit points earned, classification awarded, and premium reductions given for CRS communities. However, not only do CRS activities save money, they protect the environment and improve the quality of life – even when there is no flood. For example, when the City of Warwick preserves open space in the floodplain, the residents will get to enjoy the natural beauty of the land. If there is a flood, here are some of the many benefits CRS activities bring:

- CRS activities prevent property damage.
- Avoid lost jobs and economic devastation caused by flooding in offices, factories, farms, stores, and other businesses.
- Prevent damage and disruption to roads, schools, public buildings, and other facilities you rely on every day.
- May reduce casualties if setbacks decrease impact of physical structures.

TABLE 9-5 SUMMARY OF CRS BENEFITS (Source: FEMA)

Credit Points	Class	Premium Reduction SFHA*	Premium Reduction Non-SFHA**
4,500+	1	45%	10%
4,000 – 4,499	2	40%	10%
3,500 – 3,999	3	35%	10%
3,000 – 3,499	4	30%	10%
2,500 – 2,999	5	25%	10%
2,000 – 2,499	6	20%	10%
1,500 – 1,999	7	15%	5%
1,000 – 1,499	8	10%	5%
500 – 999	9	5%	5%
0 – 499	10	0%	0%

*Special Flood Hazard Area

**Preferred Risk Policies are available only in B, C, and X Zones for properties that are shown to have a minimal risk of flood damage. The Preferred Risk Policy does not receive premium rate credits under the CRS because it already has a lower premium than other policies. The CRS credit for AR and A99 Zones are based on non-Special Flood Hazard Areas (non-SFHAs) (B, C, and X Zones). Credits are: classes 1-6, 10% and classes 7-9, 5%. Premium reductions are subject to change.

The City of Warwick recognizes the benefits of an improved CRS rating. Since the CRS "ten-step planning process" for developing a CRS Plan is consistent with the multi-hazard planning regulations, the City intends work toward creation of this plan upon completion of this hazard mitigation plan update.

Chapter 10. Evaluation & Implementation

Once all the possible actions are on the table, there must be a way to determine whether they are appropriate measures to solve the identified problems. Using some basic evaluation criteria can help to decide which actions will work best. The most important criterion is whether the proposed action mitigates the particular hazard or potential loss. Each action should also be examined for conflict with other community programs or goals: How does this action impact the environment? It is very important to consider whether the proposed action will meet state and local environmental regulations. Does the mitigation action affect historic structures or archeological areas? Does it help achieve multiple community objectives? Another important issue is timing: How quickly does the action have to take place to be effective? Which actions will produce quick results? It is particularly important to consider if funding sources have application time limits, if it's the beginning of storm season, or if the community is in the post-disaster scenario, where everyone wants to recover at maximum speed.

STAPLEE

STAPLEE is an acronym for a general set of criteria common to public administration officials and planners. It stands for the Social, Technical, Administrative, Political, Legal, Economic, and Environmental criteria for making planning decisions. The specific applications of these terms are further described as follows:

- (S) Social: Is the proposed action socially acceptable to the Community? Are there equity issues involved that would mean that one segment of the Community is treated unfairly? Will the action cause social disruption?
- (T) Technical: Will the proposed action work? Will it create more problems than it solves? Does it solve a problem or only a symptom? Is it the most useful action in light of other Community goals?
- (A) Administrative: Can the Community implement the action? Is there someone to coordinate and lead the effort? Is there sufficient funding, staff, and technical support available? Are there ongoing administrative requirements that need to be met?
- (P) Political: Is the action politically acceptable? Is there public support both to implement and to maintain the project? Will the Mayor, his Cabinet, County Council and other decision-making political bodies support the mitigation measure?

- (L) Legal: Is the Community authorized to implement the proposed action? Is there a clear legal basis or precedent for this activity? Is enabling legislation necessary? Are there any legal side effects? (e.g., could the activity be construed as a taking?) Will the Community be liable for action or lack of action? Will the activity be challenged?
- (E) Economic: What are the costs and benefits of this action? Does the cost seem reasonable for the size of the problem and the likely benefits? Are maintenance and administrative costs taken into account as well as initial costs? How will this action affect the fiscal capability of the Community? What burden will this action place on the tax base or the local economy? What are the budget and revenue effects of this activity? Does the action contribute to other community goals, such as capital improvements or economic development? What benefits will the action provide?
- (E) Environmental: What is the action's impact on the environment? Does the action promote a sustainable and environmentally healthy community? Does implementation of the action cause temporary or permanent negative impacts on the environment? Does the action result in benefits to the environment?

Warwick Hazard Mitigation Committee selected the STAPLEE criteria as the best method to prioritize mitigation actions, and each of the mitigation strategies was evaluated by utilizing these criteria. The Committee asked and then answered questions in order to determine how acceptable the proposed mitigation action is when being viewed in terms of seven criteria. A numeric score of "1" (indicating poor acceptance), "2" (indicating average acceptance), or "3" (indicating good acceptance) was assigned to each criterion. These numbers were then totaled and developed into an overall priority score. The results of the evaluation are presented in Table 10-1.

TABLE 10-1 STAPLEE EVALUATION OF IDENTIFIED MITIGATION ACTIONS

Proposed Action	S	T	A	P	L	E	E	Total
Drainage Inventory - GPS to GIS	3	2	2	1	3	1	2	14
Road Inventory – tie database to GIS map	3	1	2	1	3	1	2	13
Infrastructure Inventory (private structures)	2	2	2	1	2	2	2	13
Protect Sewer Pump Stations - Needs Eval.	3	2	2	2	2	2	3	16
Elevate Structures (Financial Aid)	3	3	3	3	3	3	3	21
Voluntary Property Acquisitions	3	3	3	2	3	2	3	19
Dam Management Plan	3	2	2	2	2	2	2	15
WWTF Levy Evaluation	2	2	2	2	2	2	2	14
Boat Relocation Sites	2	3	3	3	2	3	3	19
Water Valve Relocation	2	3	3	2	3	1	3	15
Bellows Street Mitigation Study	2	2	2	2	3	2	2	15
Alternate EMA Command Site	3	2	2	2	3	1	2	15
Bellows Street Pump Station Relocation	3	2	2	2	2	1	3	15
Knight Street Pump Station Relocation	3	2	2	2	2	1	3	15

Benefit-Cost Analysis

Although the mitigation actions selected for this 2010 plan update have many obvious benefits, the cost of implementing these actions must also be considered. It is important to weigh the anticipated mitigation benefits versus the implementation cost as a justification of both the project itself and the cost of that project. Such a cost-benefit analysis is essential for selecting one project over another when resources are limited. A simple benefit-cost examination is included in the STAPLEE method and is, thus, factored into the priorities established by the City of Warwick through its analysis.

A more thorough review of the costs associated with each mitigation action proposed in this plan was also performed in an effort to provide a cost justification for each action. These cost justifications are summarized in Table 10-2. The table presents the planning-level costs for each proposed mitigation action, a description of the primary benefits of the proposed action, an estimate of the potential losses that the action could prevent, and a benefit-cost conclusion. Since the benefits of a mitigation project were not always a clear relationship to cost, additional conclusions were considered in the evaluation. The benefit-cost conclusions considered for the purposes of this hazard mitigation plan, and presented in Table 10-2, on the following page, were as follows:

- Beneficial: The cost of losses over the long-term clearly exceeds the cost of implementing the action.
- Justifiable: The cost of losses does not exceed the cost of the action, or the benefits cannot be quantified in terms of cost, but the value of the benefits is not in question.
- Evaluate: Data on the cost of the losses and/or the cost of the action is currently insufficient, or a more detailed benefit-cost analysis is required, to draw a conclusion.

Although a formal FEMA benefit-cost analysis for each proposed mitigation action is beyond the scope of this plan, it is important to note that the City of Warwick will be completing this type of analysis for many of the actions as part of securing the funding to implement them.

TABLE 10-2 BENEFIT-COST SUMMARY

Proposed Action	Est. Cost	Benefits	Est. Losses (per event)	Benefit vs. Cost
Drainage Inventory	$100,000	Increased knowledge/maintenance of drains; more capacity; less flooding	No direct	Justifiable
Road Inventory	$2,000	Digital access to data by all departments; quicker response	No direct	Justifiable
Infrastructure Inventory	Staff Time	Increased knowledge of at risk structures; improved mitigation efforts	No direct	Beneficial
Protect Sewer Stations – Needs Evaluation	$17,625 per station	Continues on-going effort to Identify/recommend mitigation measures to reduced equipment losses & critical utility interruptions	$130,000 (3)	Beneficial
Elevate Structures	Staff Time (2)	Secures FEMA grants for mitigation	Note 1	Beneficial
Voluntary Acquisitions	$6,400,000	Eliminates repetitive losses; adds pervious areas for flood protection	$1,300,000	Justifiable
Dam Management Plan	$75,000	Maximizes flood storage/conveyance; reduces flooding along Pawtuxet River	Note 1 & 3	Justifiable
WWTF Levy Evaluation	$75,000	Identifies feasibility of upgrades for flood protection, and prevention of critical utility interruptions/health & environmental risks	$10M (3)	Beneficial
Boat Relocation Sites	Staff Time (2)	Removes property from flood zone; reduces damage & debris	Note 1	Justifiable
Water Valve Relocation	$250,000	Prevents catastrophic system failure & critical utility interruption	Note 1	Evaluate
Bellows Mitigation Study	$25,000	Identifies mitigation measures to reduce repetitive losses	Note 1 & 3	Justifiable
Alternate EMA Site	$500,000	Prevents loss of EMA incident command during disaster	Note 1	Evaluate
Bellows Street Pump Station Relocation	$1,750,000	Relocate the Bellows Street sewer pump station out of flood-prone area	$70,000	Justifiable
Knight Street Pump Station Relocation	$2,000,000	Relocate the Knight Street sewer pump station out of flood-prone	$70,000	Justifiable

1 Not quantifiable in terms of cost at this time; additional evaluation required.
2 Initial stage is personnel time to coordinate effort at local level; however, additional cost or cost-share may be required to implement actual mitigation.
3 This action is a study needed to identify and recommend mitigation measures; this phase will not mitigate losses.

Implementation of Actions

While each of the actions above will help mitigate hazards, minimize damage and distress, and/or speed recovery, the availability of funding is a driving factor in determining what and when new mitigation strategies are implemented. The STAPLEE assessment and benefit-cost analyses helped evaluate the proposed actions and assign priorities; however, some projects fell into the same priority score and further evaluation was required to assign a final priority to the mitigation actions. In the end, the Hazard Mitigation Committee set science aside and used their best judgment based on their knowledge of the magnitude and frequency of the impacts that would be mitigated by each action. The resulting 2010 Mitigation Action Plan is presented in Table 10-3, on the following page, listed in order of final priority. A responsible department was also identified to add accountability for implementation of the proposed actions.

TABLE 10-3 MITIGATION ACTION PLAN (2010 UPDATE)

Priority Score	Proposed Action	Description of Action	Responsible Department
21	Elevate Structures	Assist in obtaining financial aid for mitigation for Conimucut & Oakland Beach property owners	Planning
19	Boat Relocation Sites	Identify and secure agreements with owners of properties outside flood plain where boats could be relocated during major storm events	Planning
19	Voluntary Acquisitions	Purchase/demolish/restore an estimated 25 high risk residential properties to prevent further repetitive losses	Planning
16	Protect Sewer Pump Stations – Needs Evaluation	Identify & implement flood protection improvements, or relocate, sewer pump stations located in flood prone areas	Sewer
15	Dam Management Plan	Develop a plan to manage floodwaters in the Pawtuxet River through coordinated flow control at existing public/private dams	Engineering
15	Bellows St. Mitigation Study	Develop and evaluate alternatives for flood mitigation in the industrial park area on Bellows Street	Planning
15	Bellows Street Pump Station Relocation	Relocate the Bellows Street sewer pump station out of flood-prone area	Sewer
15	Knight Street Pump Station Relocation	Relocate the Knight Street sewer pump station out of flood-prone area	Sewer
15	Water Valve Relocation	Relocate 42-inch water main valve subject to inundation to allow 1) access to the valve during flooding and, 2) ability to isolate 42-inch main under Pawtuxet River during flood events	Water
15	Alternate EMA Site	Identify/secure/equip alternate location for Emergency Management command in case primary is inaccessible/damaged during a disaster	EMA
14	Drainage Inventory	Complete a comprehensive drainage inventory & prepare digital map (GIS)	Public Works
14	WWTF Levy Evaluation	Evaluate feasibility of upgrading the existing levy to prevent repetitive losses of equipment/facilities, and interruptions in critical sewage collection/treatment	Sewer
13	Infrastructure Inventory	Inventory all private structures in floodplain	Building
13	Road Inventory	Tie existing road database to GIS map	Public Works

Together with the on-going efforts of the City of Warwick, and many other agencies and organizations, this Mitigation Action Plan provides a comprehensive set of activities designed to help the City of Warwick prepare in advance for the impacts of natural disasters. Once implemented, the Action Plan should guide future hazard mitigation efforts. These updated Actions also reflect the needs and priorities of the City of Warwick based on the lessons learned from the unparalleled knowledge of having actually experienced a natural disaster within the City of Warwick.

Funding for Implementation

Funding for implementation of mitigation actions will be sought through a wide variety of sources. A large portion of the actions will need to be funded through the City's operating and capital budgets, and implemented over a period of several years according to the priorities established herein and as determined by local economic, social, and political factors. In addition to local funding sources, many hazard mitigation actions are eligible for grant and loan programs, under which Warwick intends to seek supplemental funding.

The primary source of grant funding for hazard mitigation is through FEMA. FEMA has a variety of grants for mitigation including the Hazard Mitigation Grant Program (HMGP), Pre-Disaster Mitigation Program (PDM) and Flood Mitigation Assistance (FMA) Planning & Project Grants. HMGP provides funding for FEMA-approved hazard mitigation projects following a Presidential declared disaster, PDM provides funding for hazard mitigation planning initiatives and projects, and FMA provides annual funding for developing local flood mitigation plans and projects. Each of these programs is a matching grant, with a 75% Federal portion and 25% non-Federal portion.

Community Development Block Grant (CDBG) grant monies are also available for low and moderate income families for retrofitting of dwelling homes for health or safety purposes, as well as tie-downs for mobile homes.

The Clean Water State Revolving Fund (SRF) program provides low-interest loans to communities for planning and construction of capital improvements to infrastructure. The SRF program has a focus on improvements that will provide environmental benefits, but may be utilized for wide-scale wastewater and stormwater planning, as well as construction of infrastructure replacement projects.

These are just a few examples of ways Warwick can fund its implementation of its 2010 Action Plan. The key component in funding the implementation is to assign responsibility for each action, as listed above, and to regularly monitor and evaluate implementation progress, as discussed in the next chapter.

Implementation Schedule

Implementation of the 2010 Mitigation Action Plan will occur over a period of several years according to the priorities established herein, but also largely dependent upon a wide range of external economic, social, and political factors. However, based on the scope and cost of the proposed actions, estimated implementation goals are presented in Table 10-4.

Implementation of the Action Plan in accordance with this aggressive schedule will be difficult due to financial constraints and economic conditions, but can be achieved if the City is successful in seeking and obtaining outside funding sources. Without outside funding, the schedule would be extended over a 10-15 year period.

TABLE 10-4 ESTIMATED IMPLEMENTATION SCHEDULE (2010 ACTION PLAN)

Priority Score	Proposed Action	Estimated Implementation Schedule	Responsible Department
21	Elevate Structures	One street/area per year	Engineering
19	Boat Relocation Sites	FY2012	EMA/Planning
19	Voluntary Acquisitions	Purchase FY2012 & 2013; Demolish/Restore FY2013 & 2014	EMA/Planning
16	Protect Sewer Pump Stations – Needs Evaluation	FY2014	Sewer
15	Dam Management Plan	FY2013	Engineering
15	Bellows St. Mitigation Study	FY2014	Engineering
15	Bellows St. Pump Station Relocation	Design FY2012; Construct FY2013	Sewer
15	Knight St. Pump Station Relocation	Design FY2013; Construct FY2014	Sewer
15	Water Valve Relocation	Design FY2013; Construct FY2014	Water
15	Alternate EMA Site	FY2013	EMA
14	Drainage Inventory	FY2013	Public Works
14	WWTF Levy Evaluation	FY2015	Sewer
13	Infrastructure Inventory	FY2012	Building
13	Road Inventory	FY2013	DPW

Incorporation of Mitigation into Planning Mechanisms

In 1988, the *Rhode Island Comprehensive Planning and Land Use Regulation Act* strengthened requirements for municipal plans and created stronger connections between State and local plans. All Rhode Island Cities and Towns must now have a locally approved Comprehensive Community Plan that must be updated at least once every five years. Municipal plans are required to be reviewed by the State for consistency with State goals and policies; in turn, State agency projects and activities are to conform to local plans that have received State approval *(certification).* Approved local plans also set the basis for the exercise of key local implementing powers for land use – zoning and development review ordinances.

In writing the 2005 Hazard Mitigation Strategy, the City's Comprehensive Community Plan was read, in addition to existing policies and on-going programs. Details of these plans were incorporated into the Hazard Mitigation Strategy along with all other pertinent planning and implementation tools available such as local zoning, building and subdivision ordinances. This is intended to allow Warwick to focus on strengthening existing plans, programs, policies and procedures by incorporating mitigation as part of the on-going process of Community Development.

As per the State Land Use Act, the City's Comprehensive Plan is updated approximately every five-years. As part of each update, the Comprehensive Plan is amended to include relevant risk reduction measures and recommendations from this Hazard Mitigation Strategy. The two Plans will function independently, but will remain consistent with each update.

In addition, the Hazard Mitigation Strategy will be incorporated into several other City plans. Any activity listed in the Hazard Mitigation Strategy that is of a relatively long lasting nature and greater than $20,000 in expense is eligible to be included in the City's Capital Improvement Program and Budget. The City Planning Department sees that these items are incorporated into the annual Capital Improvement Plan.

Additionally, the Hazard Mitigation Strategy will be forwarded for incorporation into the Greenwich Bay Special Area Management Plan (SAMP). This plan is specific to the Greenwich Bay watershed and it includes an element on natural hazards. The Hazard Mitigation Strategy is referenced in the Greenwich Bay SAMP and some of the policies and risks found in the plan are incorporated into the SAMP.

Finally, the City of Warwick Harbor Management Plan is updated every five year per Rhode Island law. As part of the required future updates, the Natural Hazards Element of the Harbor Management Plan will also be drafted to be consistent with the Hazard Mitigation Plan.

Incorporation of Mitigation into Emergency Management

The Emergency Management Program in the City of Warwick is directed by the City's Fire Chief and coordinated through an Assistant Chief (Deputy EMA Director) that serves under the Chief. The roll of the director is to coordinate the City's emergency management and homeland security program. The position is funded through the City with financial assistance from FEMA's Emergency Management Performance Grant Program (EMPG). The City's Emergency Operation Plan was rewritten to include Mitigation as a principal means for protecting the City from the impact of Natural Hazards. The use of the mitigation plan in conjunction with the City's Emergency Operation Plan will allow the City to develop response priorities based upon expected damage that is derived from solid research and not just educated guesses.

Once approved, this Hazard Mitigation Strategy and subsequent updates will be incorporated into the City's emergency management program. This will strengthen the comprehensive nature of the City's Emergency Management Program. Implementation of mitigation actions will allow for a more effective program by protecting the critical infrastructure of the City and increasing the likelihood that this infrastructure will remain functional throughout a hazard event. Further the actions identified in the plan will reduce the possibility of responders becoming victims themselves. Essentially, this plan will allow mitigation to move into the foreground as the best means to reduce disaster impact on the community and to ensure an effective response to damages that are unavoidable.

Chapter 11. Plan Monitoring, Evaluating, and Updating

The completion of a planning document is merely the first step in its life as an evolving tool. The Hazard Mitigation Plan is a dynamic document which should be reviewed on a regular basis as to its relevancy and usefulness and to add new tasks as old tasks are completed. This Chapter will discuss the methods by with the City of Warwick will review, monitor, and update its Hazard Mitigation Plan.

Maintenance and Update Schedule of the Hazard Mitigation Plan

The City of Warwick Emergency Management Director will be responsible for maintenance of this hazard mitigation plan. The method to accomplish this will be to maintain a permanent local Hazard Mitigation Plan Committee (HMPC), chaired by the Emergency Management Director. This Committee will be tasked with ensuring implementation and monitoring of the Actions, evaluating potential revisions, and ensuring that future updates are made to this plan in a timely fashion. Table 11-1 outlines the specific tasks and timelines for this maintenance process.

Table 11-1 Hazard Mitigation Plan Maintenance Schedule

Milestone Date	Task
February 28, 2011	Ensure approval 2010 updates through FEMA.
March 31, 2011	Ensure adoption of the FEMA-approved plan by the City.
July 1, 2011	Distribute mitigation Actions to applicable Department heads & discuss plans to implement.
October 31, 2011	Year 1 Annual Plan Review & meeting by HMPC.
August 31, 2011	Coordinate with Department heads on submission of implementation budgets.
July 1, 2012	Check progress on Year 1 Actions.
August 31, 2012	Coordinate with Department heads on submission of implementation budgets.
October 31, 2012	Year 2 Annual Plan Review & meeting by HMPC.
July 1, 2013	Check progress on Year 2 Actions.
August 31, 2013	Coordinate with Department heads on submission of implementation budgets.
October 31, 2013	Year 3 Annual Plan Review & meeting by HMPC.
July 1, 2014	Check progress on Year 3 Actions.
August 31, 2014	Coordinate with Department heads on submission of implementation budgets.
October 31, 2014	Year 4 Annual Plan Review & meeting by HMPC.
July 1, 2015	Check progress on Year 4 Actions.
July 1, 2015	Begin 2015 Updates.
October 1, 2015	Submit 2015 updates to FEMA for approval.

The Emergency Management Director will invite all departments to participate in each of the above listed HMPC reviews/meetings. Public notice of the annual review/meetings will be published on the City of Warwick website, which will allow for continued public involvement in the planning process.

The Hazard Mitigation Plan will be reviewed annually in accordance with the schedule set forth in Table 11-1. Should review indicate the need for specific updates at this interval, these will be undertaken. Otherwise, a comprehensive update will be undertaken in year five as required by FEMA.

Continued Public Involvement

The EMA Director and the Hazard Mitigation Committee will be responsible for insuring that all City departments and the public have adequate opportunity to participate in the planning process. Other administrative staff may be utilized to assist with the public involvement process.

For each meeting and for the update process, techniques that may be utilized for public involvement include:

- Provide personal invitations to Budget Committee members.
- Provide personal invitations to City Department heads.
- Post notice of meetings at the City Hall, Fire Departments, Police Departments, and Library.
- Submit newspaper articles for publication to the Warwick Beacon.
- The Local Hazard Mitigation Committee will ensure that the City website is updated with the Hazard Mitigation meeting notices.

Evaluation of Mitigation Actions

During the annual review process and after any disaster situation that may test those actions that have already been implemented, the Warwick Hazard Mitigation committee, under the direction of the emergency management director, will review all proposed and already implemented strategies to determine their effectiveness. The review criteria will test each implemented action to determine the degree of which the action has reduced the vulnerability to the structures it was meant to protect. This review is critical after a hazard event, as the degree of protection offered by the strategy is especially apparent. At this time the original information regarding cost-to-benefit analysis of each action will be reviewed to determine which actions were the most cost effective. If the actions failed, then new actions will be explored to correct the vulnerability. This type of evaluation will help to shape future actions proposed by the hazard mitigation committee. Table 12-2 details the project evaluation process.

Table 11-2 Project Evaluation Process

Project Name and Number:		
Project Budget:		
Project Description:		
Associated Goals:		
Associated Objectives:		
Indicator of Success (eg., losses avoided):		
Was the action implemented?	**Yes** □	**No** □
If NO		
Why not?		
Was there political support for the action?	**Yes** □	**No** □
Were there enough funds available?	**Yes** □	**No** □
Were workloads equitably or realistically distributed?	**Yes** □	**No** □
Was new information discovered about the risks or community that made implementation difficult or no longer sensible?	**Yes** □	**No** □
Was the estimated time of implementation reasonable?	**Yes** □	**No** □
Were there sufficient resources available?	**Yes** □	**No** □

Table 11-2 Project Evaluation Process Continued

If Yes		
What were the results of the implemented action?		
Were the outcomes as expected? If no please explain:	**Yes** □	**No** □
Did the results achieve the goals and objectives? Explain how:	**Yes** □	**No** □
Was the action cost effective? Explain how or how not:	**Yes** □	**No** □
What were the losses avoided after having completed the project?		
If it was a structural project, how did it change the hazard profile?		
Additional comments or other outcomes:		
Date:		
Prepared by:		

Chapter 12. References & Resources

References

1. David M. Ludlum, The American Weather Book, Boston, MA Houghton Mifflin Company, 1982, p.57

2. "Planning for Post-Disaster Recovery and Reconstruction", Federal Emergency Management Agency and American Planning Association, December 1998.

3. “State and Local Mitigation Planning how-to-guide, Version 1.0”, Federal Emergency Management Agency, August 2001.

4. “State and Local Plan Interim Criteria Under the Disaster Mitigation Act of 2000”, Federal Emergency Management Agency, March 26, 2002.

5. “Understanding Your Risks, Identifying Hazards and Estimating Losses”, FEMA, August 2001.

6. Developing the Mitigation Plan (FEMA 386-3), Step 2, Worksheet #1 Identify Alternative Mitigation Actions, Job Aid #1: Alternative Mitigation Actions by Hazard, Worksheet #2 State Mitigation Capability Assessment, Worksheet #3 Local Mitigation Capability Assessment, Job Aid #2: Local Hazard Mitigation Capabilities, and Worksheet #4 Evaluate Alternative Mitigation Actions.

7. Integrating Manmade Hazards into Mitigation Planning (FEMA 386-7), Phase 3.

8. Mitigation Resources for Success CD (FEMA 372).

9. Mitigation Success Stories and Case Studies at www.fema.gov/fima/success.shtm.

10. "Multi-Hazard Identification and Risk Assessment" Document, FEMA

11. Rebuilding for a More Sustainable Future: An Operational Framework (FEMA 365).

12. The Natural Hazards Center at www.colorado.edu/hazards.

13. Flood mitigation success stories from the Association of State Flood-plain Managers at www.floods.org.

14. National Climatic Data Center. National Oceanic and Atmospheric Administration. Accessed through http://www.4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent -Storms.

15. American Red Cross Disaster Services Regulations and Procedures, Mass Care Preparedness and Operations, ARC 3031

16. David R. LaVallee 1997. Rhode Island Hurricanes and Tropical Storms: A Fifty-Six Year Summary 1936 to 1991. National Weather Service Office. Providence, Rhode Island.

Resources

A substantial portion of the research for the 2010 updates to this hazard mitigation plan was completed through online data searches. A list of web sites accessed during this research is provided below.

City of Warwick: http://www.warwickri.gov/

Dams: http://www.dem.ri.gov/programs/benviron/compinsp/pdf/damlist.pdf

Disaster Statistics: http://www.preventionweb.net/english/countries/statistics/?cid=185

Earthquake Data:
http://earthquake.usgs.gov/hazards/products/conterminous/2008/maps/ceus/ceus.10pc50.1hz.jpg

http://www.nesec.org/hazards/earthquakes.cfm#history

Federal Regulations (44 CFR 201): http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&tpl=/ecfrbrowse/Title44/44cfr201_main_02.tpl

Greenwich Bay Special Area Management Plan:
http://www.crmc.ri.gov/regulations/SAMP_GreenwichBay.pdf

Hurricane probability: http://landfalldisplay.geolabvirtualmaps.com/

Kent County Water Authority: http://www.kentcountywater.org/default.aspx

Landslides: http://landslides.usgs.gov/learning/nationalmap/index.php

Land subsidence map: http://ga.water.usgs.gov/edu/gwsubside.html

Northeast State Emergency Consortium: http://www.nesec.org/about.cfm

Precipitation map: http://www.prism.oregonstate.edu/pub/prism/state_ppt/rhodeisland300.png

Record temps: http://ggweather.com/climate/extremes_us.htm

Rhode Island Data: http://www.worldatlas.com/webimage/countrys/namerica/usstates/riland.htm

Storm Occurrences: http://www.ncdc.noaa.gov/oa/ncdc.html

Tornado (wind): http://www.fema.gov/plan/prevent/saferoom/tsfs02_wind_zones.shtm

Tornado history: http://www.spc.noaa.gov/climo/historical.html

Tropical cyclone tracks: http://www.csc.noaa.gov/beta/hurricanes

US Fish & Wildlife Service Fire Program Statistics:
http://www.fws.gov/fire/program_statistics/1995/index.shtml

USGS: http://ma.water.usgs.gov/

Warwick Harbor Management Plan:
http://www.warwickri.gov/index.php?option=com_content&view=article&id=929:harbor-management-plan-for-warwick-rhode-island&catid=67:planning-department&Itemid=159

http://www.warwickri.gov/pdfs/planning/Harbor%20Management%20Plan.pdf

Rainfall: http://www.wunderground.com/history/airport/KPVD/2010/3/15/MonthlyHistory.html

Volcanoes: http://vulcan.wr.usgs.gov/LivingWith/VolcanicPast/Places/volcanic_past_rhode_island.html

Wildfire: http://www.fs.fed.us/land/wfas/fd_class.png

http://www.dem.ri.gov/programs/bnatres/forest/pdf/riforest.pdf

http://www.nifc.gov/fire_info/historical_stats.htm