2015 All-Hazards Mitigation Plan Update

Kent County, Delaware

Prepared for:
Kent County Department of Public Safety
Emergency Management Division
911 Public Safety Boulevard
Dover, DE 19901

Prepared by:
Vision Planning and Consulting, LLC
7572 Morris Street
Fulton, MD 20759

May 2015

TABLE OF CONTENTS

1. INTRODUCTION

2. PLANNING PROCESS

3. COMMUNITY PROFILE

4.1 HAZARD IDENTIFICATION

TABLE OF CONTENTS

TABLE OF CONTENTS

Table of Contents

1. INTRODUCTION

1.1 Introduction

In an effort to reduce the Nation's mounting natural disaster losses, the United States Congress passed the Disaster Mitigation Act of 2000 (DMA 2000) to provide new and revitalized approaches to mitigation planning. Section 322 of DMA 2000 emphasizes the need for state and local entities to closely coordinate mitigation planning and makes the development of a hazard mitigation plan a specific eligibility requirement for any local government applying for Federal mitigation grant funds. These funds include the Hazard Mitigation Grant Program (HMGP) and the Pre-Disaster Mitigation (PDM) program, both of which are administered by the Federal Emergency Management Agency (FEMA). Communities with an adopted and Federally approved hazard mitigation plan thereby become pre-positioned and more apt to receive available mitigation funds before and after the next disaster strikes.

This 2015 Plan Update is conducted in coordination with the Federal Emergency Management Agency (FEMA) and the Delaware Emergency Management Agency (DEMA) to ensure that it meets all applicable DMA 2000 planning requirements. A Local Mitigation Plan Review Tool, included in the Plan Update, provides a summary of FEMA's current minimum standards of acceptability and notes the location within the Plan where each planning requirement is met.

This Chapter provides a general introduction to the 2015 Kent County Multi-jurisdictional Hazard Mitigation Plan Update. It is comprised of the following sections: Background, Purpose, Scope, Authority, and Organization of the Plan.

1.2 Background

The occurrence of natural hazards, such as floods, tornadoes and severe winter storms is inevitable, and while there is little that can be done to control their force and intensity, a lot can be done to be better prepared to face these hazards.

Kent County is vulnerable to a wide range of natural hazards, including flooding, drought, tropical storms and hurricanes, and winter storms. It is also vulnerable to a variety of human-caused hazards, including chemical releases, spills or explosions associated with the fixed storage or mobile transport of hazardous materials. These hazards threaten the life and safety of county residents, and have the potential to damage or destroy both public and private property and disrupt the local economy and overall quality of life.

While the threat from hazardous events can never be fully eliminated, there is much we can do to lessen their potential impact upon our community and our citizens. By minimizing the impact of hazards upon our built environment, we can prevent such events from resulting in disasters. The concept and practice of reducing risks to people and property from known hazards is generally referred to as hazard mitigation.

Hazard Mitigation is defined by the Federal Emergency Management Agency (FEMA) as “sustained action taken to reduce or eliminate long-term risk to people and property from hazards and their effects”. The hazard mitigation planning process involves the coordination of actions taken to reduce injuries, deaths, property damage, economic losses, and degradation of natural resources caused by natural and man-made disasters. Hazard mitigation is considered one of four phases in the emergency management cycle. Others include: emergency preparedness, emergency response, and recovery.

- Hazard mitigation activities involve actions that reduce or eliminate the probability of an occurrence or reduce the impact of a disaster. The goal of the mitigation phase is to make communities more resistant to disasters and thereby decrease the need for a response. Mitigation occurs long before a disaster.
- Preparedness activities include planning and preparing for when a disaster strikes and includes response capability actions to ensure an effective and efficient use of resources and efforts to minimize damage. Preparedness occurs just before a disaster.
- Emergency response activities include providing emergency assistance to victims and minimizing property loss. The response phase begins during or immediately after the onset of a disaster.
- Recovery activities include short and long-term projects that help return individuals and communities to normalcy as soon as possible. Recovery actions involve clean-up efforts, temporary housing, and replacement of infrastructure. Recovery activities typically commence several days or weeks after a disaster and are long-term.

Hazard mitigation techniques include both structural measures, such as strengthening or protecting buildings and infrastructure from the destructive forces of potential hazards, and non-structural measures, such as the adoption of sound land use policies and the creation of public awareness programs. It is widely accepted that the most effective mitigation measures are implemented at the local government level, where decisions on the regulation and control of development are ultimately made. A comprehensive mitigation approach addresses hazard vulnerabilities that exist today and in the foreseeable future. Therefore it is essential that projected patterns of future development are evaluated and considered in terms of how that growth will increase or decrease a community’s overall hazard vulnerability.

One of the most effective means that a community can implement a comprehensive approach to hazard mitigation is to develop, adopt, and update as needed, a local hazard mitigation plan. A mitigation plan establishes the broad community vision and guiding principles for reducing hazard risk, and further proposes specific mitigation actions to eliminate or reduce identified vulnerabilities.

The 2015 Kent County Hazard Mitigation Plan Update (hereinafter referred to as “Hazard Mitigation Plan Update” or “Plan Update”) is a logical first step toward continuing to incorporate hazard mitigation principles and practices into the routine government activities and functions of Kent County and its municipalities. The Plan Update recommends specific actions to combat the forces of nature and/or human-caused threats and protect its residents from losses to those hazards that pose the greatest risk. These mitigation actions go beyond simply recommending structural solutions to reduce existing vulnerability, such as elevation, retrofitting and acquisition projects. Local policies on community growth and development, incentives for natural resource protection, and public awareness and outreach activities are examples of other actions considered to reduce Kent County's future vulnerability to identified hazards.

The Plan Update is designed to be a living document, with implementation and evaluation procedures included to help achieve meaningful objectives and successful outcomes. The original Plan, created in 2004 and promulgated in January 2005, was updated first in 2009 and is subsequently being updated in 2015.

1.3 Purpose

The purpose of this Hazard Mitigation Plan Update is:

- To protect life, safety and property by reducing the potential for future damages and economic losses that result from natural or human-caused hazards
- To qualify for additional grant funding, in both the pre-disaster and post-disaster environment
- To speed recovery and redevelopment following future disaster events
- To demonstrate a firm local commitment to hazard mitigation principles
- To comply with Federal legislative requirements for local hazard mitigation plans.

The 2015 Plan is to serve as an update to the 2009 Plan and various hazards and vulnerabilities have been investigated and mitigation actions revisited, as part of the 2015 Plan Update. The Plan Update is intended to enable the County and its municipalities to effectively respond to hazards as they occur and reduce the potential risks of these hazards to the health, safety and welfare of the residents. The overall goal for the Update is to continue to allow Kent County and its municipalities to be eligible for a range of financial assistance following hazard events.

The 2015 Plan Update consists of a thorough review of the 2009 Plan, which was used as a base document. Each chapter in the 2015 version has been updated and a summary is included at the beginning of each chapter to indicate how this Plan was updated from the 2009 version.

- The Plan Update involves the review of data on potential hazards and reprioritization of these hazards in terms of frequency and severity.
- The Plan Update includes a review of mitigation actions, which were revised, deleted, or modified to address the high priority hazards.
- The Plan Update includes Plan Maintenance and Monitoring sections.

1.4 Scope

In November of 2014, the Kent County Emergency Management Agency contracted with the Vision Planning and Consulting Team (comprised of Vision Planning and Consulting (VPC) from Fulton, Maryland and the Eastern Shore Regional GIS Cooperative from Salisbury University in Salisbury, Maryland) to develop the Plan Update in compliance with the requirements of the Disaster Mitigation Act of 2000. The Hazard Mitigation Plan Update was funded by Hazard Mitigation Assistance (HMA) funds from the Federal Emergency Management Agency (FEMA) and administered by the Delaware Emergency Management Agency (DEMA).

It must be noted that future funding for mitigation projects will be contingent upon having each jurisdiction in Kent County adopt the 2015 Plan Update after the County has adopted it. Any jurisdiction that does not adopt the 2015 Plan Update will become ineligible for pre- and post-disaster mitigation funds.

The overall planning area for the Plan Update includes the all incorporated and unincorporated areas of Kent County. This includes the following 20 jurisdictions:

- Town of Bowers Beach
- Town of Camden
- Town of Cheswold
- Town of Clayton
- City of Dover
- Town of Farmington
- Town of Felton
- Town of Frederica
- City of Harrington
- Town of Hartly
- Town of Houston
- Town of Kenton
- Town of Leipsic
- Town of Little Creek
- Town of Magnolia
- City of Milford
- Town of Smyrna
- Town of Viola
- Town of Woodside
- Town of Wyoming

Note: The Towns of Smyrna and Clayton has portions of territory that are within New Castle County, however, since the majority of these towns are located within Kent County their plan components are in the Kent County Mitigation Plan Update.

This Hazard Mitigation Plan Update addresses those hazards determined to be “high risk” and “moderate risk” through a detailed hazard risk assessment for Kent County (see Section 4: Risk Assessment). Other hazards that pose a low or negligible risk will continue to be evaluated during future updates to the Plan, but they will not be fully addressed until they are determined to be of high or moderate risk to Kent County.

1.5 Authority

This Plan Update has been adopted by the Kent County Levy Court under the authority granted to counties under Title 9 (Counties) of the Delaware Code and by Kent County’s participating incorporated jurisdictions under the authority granted to municipalities under Title 22 of the Delaware Code (Municipalities). Copies of all local resolutions to adopt the Plan are included in the Appendix.

This Plan was developed in accordance with current Federal rules and regulations governing local hazard mitigation plans. The Plan shall be routinely monitored to maintain compliance with the following legislation:

Section 322, Mitigation Planning, of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, as enacted by Section 104 of the Disaster Mitigation Act of 2000 (P.L. 106-390) and by FEMA's Interim Final Rule published in the Federal Register on February 26, 2002, at 44 CFR Part 201.

1.6 Organization of the Plan

The 2015 Hazard Mitigation Plan Update comprises seven chapters. Chapter 1 provides an introduction to the Plan Update process and includes the background, scope, process, and authority. Chapter 2 includes an overview and update of the socio-economic and demographic characteristics. Chapter 3 discusses the planning process. Chapter 4 comprises the hazard identification and risk assessment and examines vulnerability and the potential losses from the top priority hazards. Chapter 4 also includes a historic profile of hazard types and associated losses, and a vulnerability assessment. Chapter 5 contains a municipal capability assessment. Chapter 6 discusses the mitigation strategy including updated mitigation goals and objectives, mitigation actions, and the method for prioritization and implementation of mitigation actions. Chapter 7 outlines how the County and its municipalities will implement the Plan once it is adopted and ways to monitor progress and ensure continued public involvement.

2. PLANNING PROCESS

2.1 Plan Update Summary

This Chapter describes the planning process undertaken by Kent County and the VPC Team in preparation of the 2015 All Hazard Mitigation Plan Update. Specific topics include:

- Overview of hazard mitigation planning
- Preparing the Plan Update
- Hazard Mitigation Steering Committee
- Meetings and workshops
- Involving the public
- Involving stakeholders
- Multi-jurisdictional participation

2.2 Overview of Hazard Mitigation Planning

Typically, mitigation planning is described as having the potential to produce long-term and recurring benefits by breaking the repetitive cycle of disaster loss. A core assumption of hazard mitigation is that pre-disaster investments will significantly reduce the demand for post-disaster assistance by lessening the need for emergency response, repair, recovery and reconstruction. Furthermore, mitigation practices will enable local residents, businesses and industries to re-establish themselves in the wake of a disaster, getting the community economy back on track sooner and with less interruption.

The benefits of mitigation planning go beyond solely reducing hazard vulnerability. Measures such as the acquisition or regulation of land in known hazard areas can help achieve multiple community goals, such as preserving open space, maintaining environmental health and enhancing recreational opportunities. Thus, it is vitally important that any local mitigation planning process be integrated with other concurrent local planning efforts, and any proposed mitigation strategies must take into account other existing community goals or initiatives that will help complement or hinder their future implementation.

2.3 Preparing the Plan Update

44 CFR 201.6(c)(1): *The plan shall include documentation of the planning process used to develop the plan, including how it was prepared, who was involved in the process and how the public was involved.*

The Plan Update process included six tasks that were completed over the course of four months, each of which, resulted in critical elements, which collectively make up the Plan Update. The following sub-tasks were conducted as part of the 2015 Kent County Plan Update process:

Task 1: Organize Resources – Planning Process

- Participation in planning process meetings which included the public, neighboring communities, agencies, businesses, academia, nonprofits and other interested parties involved in the process.
- Communication with key stakeholders and agencies to obtain information on any related mitigation efforts: Delaware Emergency Management Agency, Delaware Office of State Planning, Delaware Department of Natural Resources and Environmental Control, Delaware Department of Transportation, and Delaware Geological Survey.
- Mitigation strategy workshop with the Committee and municipalities to update existing and identify new mitigation strategies.
- Review and update of the Community Profile

Task 2: Hazard Identification and Risk Assessment

- Review and update of the Hazard Analysis for incidents since 2009.
- Update of Hazard Vulnerability.
- Identification of development trends and areas that may be proposed for intense development that are located in high hazard areas.

Task 3: Goals and Objectives

- Review and update of mitigation goals and objectives of the current plan to reduce or avoid long term vulnerabilities to the identified hazards.

Task 4: Mitigation Strategy

- Alignment of the Plan Update with FEMA revisions to regulations governing these plans.
- Reissue of the mitigation capability assessment to identify how the fiscal, administrative, and local mitigation capabilities have changed since 2009 to illustrate each jurisdiction's overall hazard risk in comparison to their overall capacity.
- Mitigation strategy workshop to update existing and collect new mitigation strategies.
- Update of the mitigation actions to include a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure including actions related to continued compliance with the National Flood Insurance Program (NFIP).
- Update of the action plan describing how the actions will be prioritized, implemented, and administered by the local jurisdiction.
- Identification of the completed, deleted or deferred mitigation actions as a benchmark for progress, and if activities are unchanged or deferred.

Task 5: Plan Maintenance

- Update of the method and schedule of monitoring, evaluation, and update of the mitigation plan within a five-year cycle.
- Review and update of the process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms such as comprehensive or capital improvements plans, when appropriate.

- Identification of any additional local planning mechanisms available for incorporating the mitigation requirements of the mitigation plan.
- Continued public participation.

Task 6: Plan Adoption

- Submittal of the draft Plan Update to the Delaware Emergency Management Agency and Federal Emergency Management Agency Region III.
- Draft Plan Update approval by FEMA Region III.
- Plan adoption by the County and municipalities.

2.4 Hazard Mitigation Steering Committee

Kent County reconvened its 2009 Steering Committee for this Plan Update. Stakeholders, residents, and local government officials played a major role in reviewing the Plan. Table 2.1 includes the members of the Kent County Steering Committee, the make-up of which, was similar to that of the previous Planning Committee, especially for those communities with multiple representatives. Those members who were no longer with the County or municipality were replaced on the Committee.

Table 2.1 – Kent County 2015 Hazard Mitigation Steering Committee

Name	Agency	Name	Agency
Robert Devitt	Bowers	Nancy Goodfellow	Leipsic
Aaron Chaffinch	Camden	Glenn Gauvry	Little Creek
Harold Scott Jr.	Camden	Ed Strouse	Little Creek
Theon Callender	Cheswold	James Frazier	Magnolia
Shadina Jones	Cheswold	Diane Cahall	Magnolia
Jeff Hurlock	Clayton		Milford City Manager
Kay Sass	Dover	David Hugg III	Smyrna
Ronald Vincent	Farmington	Gina Miserendino	Viola
Rebecca Greene	Felton	Michael Warren	Woodside
Ricky Maddox	Frederica	Pamela Haddick	Wyoming
Teresa Tieman	Harrington	Nicole Armour	Wyoming
Alan Moore	Harrington	Brandon Olenik	Kent County
Raymond Morris Jr.	Hartly	Michael Scott	ESRGC
Connie Morgan	Houston	Deepa Srinivasan	Vision Planning and Consulting
Jessica Penawell	Kenton Mayor	Craig Pugh	Leipsic

2.5 Community Meetings and Workshops

The planning process for the most part, was similar to the process followed during the 2009 Plan Update as it was deemed effective. It comprised a series of meetings and workshops for facilitating discussion and initiating data collection efforts with state and local municipal and county officials as well as stakeholders. Two Steering Committee meetings and one public meeting were held for the County and municipalities in addition to one mitigation planning workshop that was held specifically for municipal input and awareness.

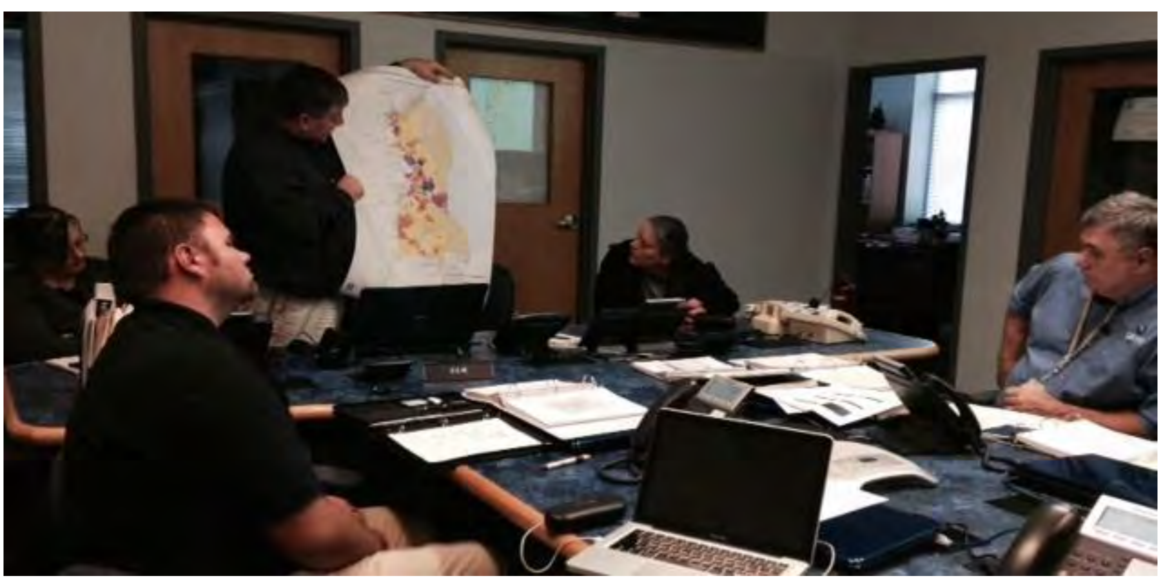
Initial Project Kickoff Meeting

The initial kick off meeting was held on 30th October 2014, with the Kent County Emergency Management staff. The purpose of this meeting was to finalize the contract as well as discuss the specific steps in the project including schedule and deliverables.

Steering Committee Meeting #1

The first Steering Committee meeting was held on 10th December 2014 at the Kent County Public Safety Building in Dover. At this meeting, VPC Consultants:

- Discussed schedule and deliverables
- Reviewed sections of the 2009 Plan with the Committee and identified sections that needed to be updated
- Reviewed data on the hazard identification and ranked risks
- Solicited input on risks from various hazards
- Discussed data from the hazard vulnerability and risk assessment
- Reviewed goals and objectives



First Steering Committee Meeting held on 10 December 2014 at the EMA

Steering Committee Meeting #2

The second Committee Meeting was held on 10th March 2015 at the Kent County Public Safety Building in Dover. At this meeting, VPC Consultants:

- Discussed and updated mitigation actions
- Discussed loss estimates
- Prioritized mitigation actions
- Developed an implementation strategy for each mitigation action.

Second Steering Committee Meeting held on 10 March 2015 at the EMA

Municipal Workshop

Meeting invitations and reminders for the Municipal Mitigation Workshop were sent via e-mail and follow up calls were made to further urge municipal participation. The Municipal Mitigation Workshop was held on the same evening as the first Steering Committee Meeting and was facilitated by the Consultants, providing an opportunity for municipal officials to attend and become educated on various aspects of the planning process including the hazard identification, vulnerability assessment, and mitigation strategy.

A series of exhibits were developed for the workshop, which include maps of the northern, central, and southern segments of the County. Attendees were encouraged to partake in discussion and mark up maps to indicate missing data with respect to problematic/vulnerable areas. Examples of potential mitigation projects were shared and municipalities were encouraged to recommend additional mitigation projects based on past hazard experiences.

Municipal Workshop held on 10 December 2015 at the County Public Safety Building in Dover

At the workshop, municipal officials:

- Reviewed maps and identified high-hazard areas by marking up maps;
- Identified critical facilities within their municipality;
- Discussed risks and vulnerabilities within their municipality;
- Identified past mitigation projects and discussed potential mitigation projects; and
- Discussed future participation opportunities and next steps.

2.6 Involving the Public

44 CFR Part 201.6(b) (1): *The planning process shall include an opportunity for the public to comment on the plan during the drafting stage and prior to plan approval.*

Community-based input enables a greater understanding of local concerns and ensures a higher degree of mitigation success promoting community "buy-in" from those directly affected by the decisions of public officials. As citizens become more involved in decisions that affect their safety, they are more likely to gain greater knowledge of the natural hazards present in their community and take personal steps to reduce their potential impact. Public awareness is a key component of an overall mitigation strategy aimed at making a home, neighborhood, school, business, or city safer from the potential effects of natural hazards.

The structure of the public meeting was kept simple and advertised in the local newspapers. It was held following the second Committee meeting prior to the completion of the draft Plan. The public meeting was held to present the findings of the risk and capability assessments, and verify any unique hazard concerns and possible mitigation actions to address those concerns.

Public Meeting

The countywide planning workshop for Kent County was held on 10th March 2015 at the Public Safety Building in Dover. At this meeting, an overview of the planning process was presented and the mitigation actions for the County and municipalities were discussed while soliciting comments from the public. The meeting was advertised through the local newspaper and the County's website.

Following the release of the draft Plan Update, it was made available for public review comment through the Kent County website. Copies of the Draft Plan were also available in the public library and with the Office of Emergency Management.

Public Meeting held on 10 March 2015 at the County Public Safety Building in Dover

2.7 Involving Stakeholders

44 CFR Part 201.6(b)(2): *The planning process shall include an opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have authority to regulate development, as well as businesses, academia and other private and non-profit interests to be involved in the planning process.*

The development and coordination of County's and municipal risk and mitigation actions involved the assistance of several state agencies, including Delaware Emergency Management Agency, Office of State Planning Coordination, Department of Natural Resources and Environmental Control, Delaware Geological Survey, Delaware Department of Transportation, Office of the Delaware State Climatologist and Department of Environment Observing System, and American Red Cross, in order to obtain input on their activities with respect to hazard mitigation. A summary of each of these departments' services related to mitigation activities is elaborated below:

Delaware Emergency Management Agency

The Delaware Emergency Management Agency in involved in all aspects of emergency management – preparedness, mitigation, response, and recovery. The State agency prepares and updates the State Hazard Mitigation Plan every five years. The State Plan informs and is informed by the three county plans. DEMA officials are closely involved in the local plan update processes and also review and approve the plan before it is submitted to FEMA Region III for final review and approval. The agency has a successful working relationship with the Department of Natural Resources and Environmental Control and the Department of Transportation, two important stakeholders in mitigation activities around the State.

Office of State Planning Coordination

The Office of State Planning Coordination has been involved in planning activities as well as a neighborhood buyout project in Kent County. This Office is responsible for developing the State as well as the counties' comprehensive plans. These plans are used to provide guidelines for development and growth throughout the State and continue to be sources of information for the local hazard mitigation plans. This Office has a very strong interest in being involved in the mitigation planning process and has conducted several environmental and other studies, and developed plans that could be valuable resources for local mitigation planning and be used to develop mitigation strategies and activities. The Office also has a successful working relationship with the Department of Natural Resources and Environmental Control and the Department of Transportation, two important stakeholders in mitigation activities around the State.

Department of Natural Resources and Environmental Control (DNREC)

DNREC has worked closely with the State on various mitigation activities, as well as being responsible for floodplain mapping activities. DNREC provided the necessary information regarding National Flood Insurance Program (NFIP) compliance, and repetitive loss information for the Local Mitigation Plans. DNREC's primary mitigation activities include overseeing NFIP ordinances and regulations, and guiding local jurisdictions on developing and adopting regulations to manage development in floodplains. They also conduct inspections of construction in floodplains to ensure compliance with NFIP guidelines. Specifically, DNREC worked with DelDOT on a FEMA funded buy-out of several properties that were demolished and turned in to open space, where DelDOT then became the landowner. DNREC is interested in having an active role in the development of the current mitigation plans and is willing to work with the three counties and the City of Wilmington on the development of their hazard identification and risk assessments, and mitigation strategies, as well as providing any available NFIP data.

Office of the Delaware State Climatologist and the Delaware Environmental Observing System (DEOS)

The Office of the Delaware State Climatologist works with various State agencies including DEMA, DelDOT and DNREC on mitigation projects and activities. The Office of the Delaware State Climatologist also monitors and maintains DEOS. DEOS is a support tool for decision makers involved with emergency management, natural resource monitoring, transportation, and other activities throughout the State of Delaware. Their primary goal is to provide state agencies and the citizens of Delaware with immediate information about environmental conditions in and around the State. DEOS also archives data for historical environmental studies and research. This agency has been invaluable in categorizing and quantifying rainfall, flood, and wind activities during storms. Some of this information is reflected in Vulnerability Assessment section of this plan. This information has also been critical to justifying many of the mitigation projects and actions completed in the past.

American Red Cross

While the primary role of the Red Cross is to serve as a source of information and education, the organization participates in mitigation, wherever possible. The Red Cross also participates in mitigation through the creation and distribution of preparedness brochures to educate the public and teach the importance of being prepared, and the steps to take before a hazardous event such as a flood or a hurricane. The Red Cross indicated a continued interest in being involved in the hazard mitigation planning process.

Delaware Geological Survey

Delaware Geological Survey provides funding for coastal monitoring and the development of alert systems for the City of Bowers Beach in Kent County. They also monitor stream gauges on the Red Clay and White Clay creeks and the Brandywine River that provide real time information on flood stages, water quality, and potential drought conditions. Due to limited staffing and time constraints, the Delaware Geological Survey is unable to take on an in-depth role in the current mitigation planning process. However, they are interested in providing technical assistance and input during the planning process by reviewing plan sections, particularly those dealing with flood, drought, and earthquakes. Delaware Geological Survey has worked closely with DEMA and other State agencies on mitigation and continues to indicate an interest in being involved in the hazard mitigation process.

Delaware Department of Transportation

The Delaware Department of Transportation works closely with all three Delaware counties on transportation related issues. Part of the agency's recent efforts includes coordination to test traffic flow impedances due to flooding and testing some of their existing plans to deal with such issues. They continue to engage in opportunities to improve their relationship and collaborate with local governments as well as with DNREC on mitigation related issues.

2.8 Multi-Jurisdictional Participation

44 CFR Part 201.6(a) (3): *Multi-jurisdictional plans may be accepted as long as each jurisdiction has participated in the planning process.*

This Plan Update includes the participation of Kent County and all of its incorporated municipalities. In order to involve the municipalities in the planning process as well as to satisfy the multi-jurisdictional participation requirements, the local jurisdictions were required to perform various tasks as part of the 2015 Plan Update. The level of participation varied between the jurisdictions during the planning process and is documented in Table 2.2.

Public Meeting held on 10 March 2015 at the County Public Safety Building in Dover

The message that "each jurisdiction must participate on their own, adhere to the hazard mitigation planning process, or they cannot adopt the Plan and will not be eligible for pre- and post-disaster funding" was emphasized to all jurisdictions to solicit their participation in the Plan Update process. An extensive municipal participation strategy was established to allow for maximum participation throughout the process.

A Letter of Intent to Participate was mailed to all jurisdictions in that explained the hazard mitigation process, Federal requirements, and deliverables. Municipalities were required to sign onto or opt-in to the County planning process (and commit to participation) or opt-out of the process (in which case, they would be responsible for developing their own plan in order to obtain Federal funding following a disaster). Those who decided to opt-in were required to identify and provide information for a local point of contact.

Table 2.2 – Municipal Participation in the Planning Process

Municipality	Capability Assessment Review	Mitigation Actions Review	Attendance at Municipal Workshop (10 Dec 2014)	Attendance at Public Meeting (10 Mar 2015)	Draft Plan Review
Bowers Beach	1	1		1	1
Camden	1	1	1	1	1
Cheswold	1	1	1		1
Clayton	1	1			1
Dover		1			1
Farmington					1
Felton		1			1
Frederica					1
Harrington		1			1
Hartly					1
Houston					1
Kenton	1	1			1
Leipsic	1			1	1
Little Creek	1	1		1	1
Magnolia	1	1			1
Milford		1			1
Smyrna	1	1			1
Viola					1
Woodside					1
Wyoming					1

In October 2014, an introduction letter for the Plan Update was sent to all jurisdictions in the County that explained the plan update process, Federal requirements, and expected level of participation. Feedback on the mitigation capabilities was sent to all municipalities. The feedback forms include questions related to: past hazard events; critical facilities in high hazard areas; mitigation projects, and municipal mitigation capabilities (technical and staffing). The Consultants sent reminder emails and made follow-up phone calls to encourage municipalities to complete their municipal capability updates and attend a Municipal Mitigation Workshop scheduled for 10 December 2014. A total of 9 municipalities completed and returned their questionnaires and two municipalities were represented at the workshop. All municipalities reviewed the draft plan and those how had any comments provided them to the County via email. A total of 8 communities participated actively in the Plan Update process. The remaining 12 communities will need to review the HIRA, update the mitigation strategy, and complete the Mitigation Capability Assessment questionnaire in order to be considered eligible for pre- and post-disaster funding.

Municipal Workshop held on 10 December 2014 at the County Public Safety Building in Dover

Meeting invitations and reminders for the Municipal Mitigation Workshop were sent via e-mail and follow up calls were made to further urge municipal participation. The Municipal Mitigation Workshop was held at the Emergency Management Agency in Dover on the same evening as the first Steering Committee Meeting and was facilitated by the Consultants, providing an opportunity for municipal officials to attend and become educated about the plan update, planning process, hazard identification, and vulnerability assessment.

A series of exhibits were developed for the workshop including maps of critical facilities, and floodplains. Attendees were encouraged to stimulate discussion and mark up maps to indicate updated or missing data. Examples of potential mitigation projects were shared and municipalities were encouraged to recommend additional mitigation projects based on past hazard experiences.

- Update the local Capability Assessment
- Attend the Municipal workshop
- Attend the Steering Committee and Public meeting
- Update municipal actions

- Review the draft plan
- Adopt the Hazard Mitigation Plan Update, once the County has adopted the Plan Update.

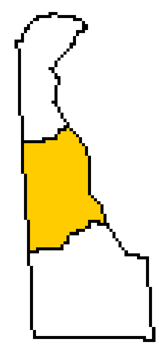
3. Community Profile

3.1 Introduction

This Chapter provides a general overview of Kent County's unincorporated areas as well as its incorporated municipal jurisdictions. It is broken down into the following five sections:

- Geography and the Environment
- Population and Demographics
- Housing, Infrastructure and Land Use
- Employment and Industry
- Disaster Declarations.

3.2 Geography and the Environment



Kent County is the central county in Delaware and is bordered by New Castle County, Delaware to the north, Maryland to the west, Sussex County, Delaware to the south, and Delaware Bay to the east. The County's location affords easy access to the major metropolitan areas of the Northeast United States — the cities of Baltimore, New York, Philadelphia and Washington, D.C. are all approximately within a two-hour drive or less. The county seat is the City of Dover, Delaware's state capital, which has a population of 37,366 residents.

Kent County has a total area of 594 square miles. The area's topography is generally flat, ranging from sea level along the shores of Delaware Bay to approximately 80 to 85 feet above sea level.

Kent County has a moderate climate, with an average annual temperature of 57 degrees Fahrenheit, and a mean daily temperature ranges from 35 degrees in January to 78 degrees in July. Normal annual rainfall is 46 inches per year and annual snowfall totals approximately 16 inches.

Kent County has a total water area of 210 square miles, and has numerous waterways flowing through it; including Murderkill River, Choptank River, the Saint Jones River, Marshy Hope creek, and Silver Lake. Kent County lies within six watersheds: Delaware Bay, Chesapeake Bay, Broadkill-Smyrna, Chester-Sassafras, Choptank, and Nanticoke.

Most of Kent County lies within the Delaware River Basin, which drains 13,539 square miles in Delaware, New Jersey, New York and Pennsylvania. The River's main stem is 330 miles long and extends from the confluence of its east and west branches at Hancock, New York to the mouth of the Delaware Bay just south of Wilmington. It is the longest free-flowing (un-dammed) river east of the Mississippi.

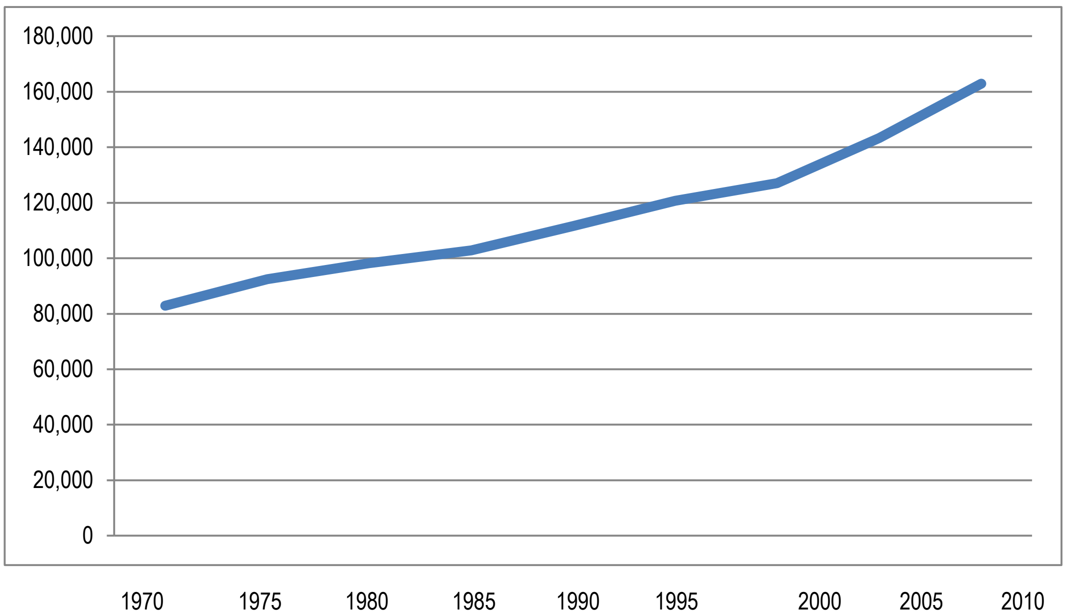
Geologically, Kent County is a part of the "Coastal Plain Province" composed of overlapping beds of unconsolidated or semi-consolidated clay, silt, sand and gravel. Delaware Bay is the area's most marked natural feature. About one-third of the region is wooded with about equal divisions between soft and hard woods.

3.3 Population and Demographics

Recent data from the 2013 U.S. Census estimates and other sources has been included where available. In cases where more recent data was not available, information from the 2000 Census has been retained.

Population growth in Kent County had leveled off until the 1950s, but in recent decades the population has been steadily climbing. **Figure 3.1** shows the population growth of Kent County from 1970 to 2010.

Figure 3.1
Population Growth of Kent County, 1970-2010



Source: U.S. Census Bureau

The 2013 U.S. Census estimates the population of Kent County at 169,416, which is a 25.2 percent increase over the 2006 census population. In comparison, the State's population has increased by 15.9 percent during this period. Kent County has continually exhibited a high growth rate since 1950 and this trend continues. According to the Delaware Population Consortium (DPC) Kent County is expected to grow to approximately 189,431 persons by 2030 (Figure 3.2). While the population is projected to continue to increase through 2030, the rate of increase is projected to decrease markedly.[1]

There are 20 incorporated municipalities in Kent County. The County is approximately 590 square miles and includes the City of Dover. The City of Dover indicated a population of 37,366 persons (2013 estimate) and a 7 percent increase between 2006 and 2013. Dover's land area is approximately 22 square miles.

[1] 2007 Kent County Comprehensive Plan

Figure 3.2
Population Growth of Kent County, 2000-2030

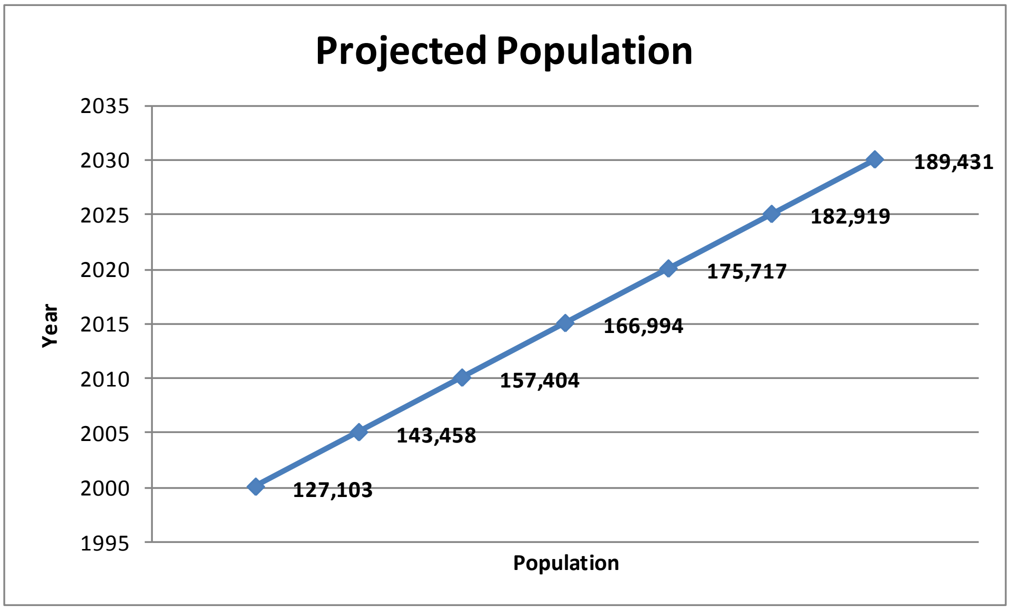


Table 3.1 shows the population for each of the incorporated municipalities in Kent County and the unincorporated area according to U.S. Census 2013.

According to the 2010 U.S. Census , the median age for persons in Kent County is 36.6 years, slightly younger than the statewide average of 36.7 years. Persons 65 years old and over make up 14.5 percent of the total population and those under five years of age comprise 3.4 percent. Approximately 53.7 percent of the population is married, and 72.3 percent own their own homes. Of all persons more than 25 years of age, approximately 85.5 percent are high school graduates and 21.4 percent have a Bachelor's degree or higher. In terms of race, 2013 estimates indicated that the County is comprised 68.1 percent White, a decrease from the 2000 figure of 72.4 percent.

Table 3.1
Municipal Populations for Kent County, 2010

Jurisdiction	Population
Kent County Unincorporated Area*	70,629
Bowers Beach	349
Camden	3,510
Cheswold	1,423
Clayton	3,037
Dover	37,366
Farmington	112
Felton	1,362
Frederica	806
Harrington	3,715
Hartly	76
Houston	391
Kenton	271
Leipsic	193
Little Creek	235
Magnolia	237
Milford	10,122
Smyrna	10,960
Viola	165
Woodside	192
Wyoming	1,406
TOTAL	**169,416**

*Includes Census Designated Places (CDP)
Source: U.S. Census Bureau

3.4 Housing, Infrastructure and Land Use

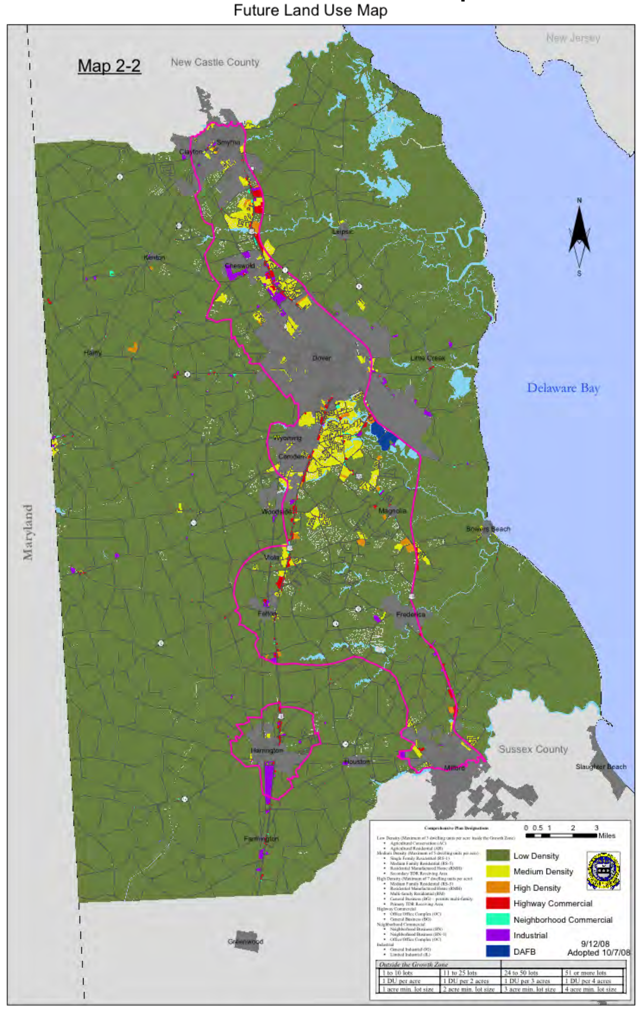
As of 2013, there were 66,839 housing units, an increase of 7 percent from the 61,640 housing units 2007. 2014 census figures indicate 92.2 percent of these housing units as occupied, of which, 64.4 percent were owner-occupied. The average household size for the county is 2.62 persons in 2014. Median home values in Kent County are $199,500 for owner-occupied units and 13.3 percent of all housing units were located in multi-unit structures between 2009 - 2013. Source: http://www.census.gov/quickfacts

Kent County is a hub of transportation ways. These include U.S. Highways 13,113, and 9; and State Route 1. State Route 1, the largest project in the history of the Delaware Department of Transportation, has relieved congestion on the state's major north-south corridor, Route 13. The County is located approximately a one-hour drive south of the Port of Wilmington, providing access to Atlantic shipping lanes. Norfolk Southern and Maryland and Delaware Shortline railroads provide service to Kent County.

Kent County has undergone significant growth over the past few decades and typical land use patterns are no longer predominately agricultural as they were in the earlier part of the 1900s. The County experienced significant residential development between 2000 and 2007 when the average annual single-family dwelling building permits issued was 1,153. However this has declined since 2007. While the County has experienced significant residential development in the past several years, commercial and industrial development has been evident mostly in the municipalities. The County continues to maintain the 2002 Growth Zone Overlay that encourages residential and nonresidential development and infrastructure investments around existing developed areas including municipalities. The predominant land use outside the Growth Zone Overlay is agriculture. Other sensitive environmental features such as wetlands, woodlands, and critical habitat exist outside the Growth Zone.

Figure 3.2
Future Land Use Map

Future Land Use Map



The goals from the 2007 Comprehensive Plan build on the concept of community centers at central locations that provide greater access to employment, services, and recreation. The Comprehensive Plan also supports green infrastructure and encourage the protection of the rural character of the County and the preservation of its open spaces.

3.5 Land Use Development Trends

The attached Future Land Use Map shows the Kent County Growth Zone. It was designated because services exist already or are planned. The following development applications were approved in the past five years: 7 applications in 2009 (4 telecommunications towers, 2 childcare centers, and a county recreation center); the Landingsa and Lahey &Mensch Property/Calico Circle in 2010; Loganberry Village and Norty Nine Pines Phase 2/Easter Pines in 2011; Villages at Nobles Pond Phases 3A and 4A and Cherrington in 2012; and Big Oak in 2014. It should be noted that while these plans have been approved, there is no guarantee they will be constructed (particularly the subdivisions). The County has development restrictions within natural areas and floodplains.

3.6 Employment and Industry

Delaware has one of the strongest state economies in the region and remains an above average performer in comparison to the national economy. With lower than average unemployment, a fair and equitable tax system and a well-trained workforce, the State's economic climate has shown dramatic improvement since the early 1980s, partially in response to stable fiscal policies, careful debt management, conservative spending programs, and personal income tax reductions. Delaware's economy continues to have increasing levels of job growth, although more moderate than in previous years.

In 2010, the median household income for Kent County was $55,149, a 14 percent increase from $47,407 in 2007. The State's median income also increased from $55,988 to $59,878 in 2014. The County's per capita income in 2014 was $24,851, compared with a statewide average of $29,818. In 2014, Kent County had an unemployment rate of 6.1 percent, the statewide average was 7.9 percent. The County's poverty rate increased from 12.1 percent in 2007 to 12.9 percent in 2014 (statewide average in 2014 was 11.7%).

Kent County sustains a diversified economy, with most firms concentrated in the government and services-related sectors. In 2014, health care and social assistance, Government, and retail and wholesale trade were the leading industries in the region. **Table 3.2** provides an overview of firms in Kent County by sector.

Table 3.2
Firms by Sector for Kent County, 2014

Industry Description	# of Firms	Average Employment
Agriculture, forestry, fishing and hunting	35	*
Mining	2	*
Utilities	7	189
Construction	389	2,385
Manufacturing	70	4,624
Wholesale trade	145	1,116
Retail trade	509	9,077
Transportation and warehousing	99	2,108
Information	36	412
Finance and insurance	165	1,135
Real estate and rental and leasing	121	477
Professional and technical services	306	1,813
Management of companies and enterprises	11	212
Administrative and waste services	244	1,914
Educational services	28	474
Health care and social assistance	468	8,616
Arts, entertainment, and recreation	53	2,753
Accommodation and food services	265	5,194
Other services, except public administration	328	1,642
Total Government	174	18,805
Total Industries	3,455	63,193

Industry Description	# of Firms	Average Employment
Agriculture, forestry, fishing and hunting	35	*
Mining	2	*
Utilities	7	189
Construction	389	2,385
Manufacturing	70	4,624
Wholesale trade	145	1,116
Retail trade	509	9,077
Transportation and warehousing	99	2,108
Information	36	412
Finance and insurance	165	1,135
Real estate and rental and leasing	121	477
Professional and technical services	306	1,813
Management of companies and enterprises	11	212
Administrative and waste services	244	1,914
Educational services	28	474
Health care and social assistance	468	8,616
Arts, entertainment, and recreation	53	2,753
Accommodation and food services	265	5,194
Other services, except public administration	328	1,642
Total Government	174	18,805
Total Industries	**3,455**	**63,193**

Note: * indicates non-releasable data
Source: Delaware Department of Labor

Kent County's largest employer is the State of Delaware and Dover Air Force Base. Among the County's largest private employers are the Bayhealth Medical Center, Dover Downs Casino and Kraft Foods. **Table 3.3** lists Kent County's top private employers.

Table 3.3
Kent County's Top Ten Private Employers

Employer
Bayhealth Medical Center (Kent General)
Dover Downs Inc.
Harrington Raceways & Slots
Kent-Sussex Industries
Kraft Foods Inc.
Perdue Farms
University of Delaware
Delaware Home & Hospital For the Chronically Ill
Safeway Inc.
Wal-Mart Associates Inc.

Source: Delaware Economic Development Office

3.6 Disaster Declarations

Since 1965, Kent County has experienced a total of five Presidential disaster declarations, shown in **Table 3.4**. Prior to 1965, any presidential declarations did not have county designations. The county has also experienced additional emergencies and disasters that were not severe enough to require Federal disaster relief through a presidential declaration. This includes a blizzard in March 1993 that resulted in an emergency declaration (3111-EM) for Kent County that made limited Federal assistance available through the Public Assistance program for snow removal. The most recent declaration for the County was in 2012 during the Hurricane Sandy.

Table 3.4
Presidential Disaster Declarations for Kent County, 1965– 2014

Event	Declaration Date	Type of Assistance	Declaration Number
Water Shortage	08/15/65	Individual Assistance Public Assistance	DR-207
Blizzard of '96 (Severe Snow Storm)	01/12/96	Public Assistance	DR-1082
Hurricane Floyd	09/21/99	Public Assistance	DR-1297
Hurricane Isabel	09/20/03	Individual Assistance Public Assistance	DR-1494
Tropical Storm Henri	09/23/03	Individual Assistance Public Assistance	DR-1495
Hurricane Jeanne	11/15/04	Public Assistance	DR-1572
Hurricane Katrina	09/30/05	Individual Assistance Public Assistance	DR-3263
Severe Storms and Flooding	06/23/06	Public Assistance	DR- 1654
Severe Winter Storms and Snow	02/05/11	Public Assistance	DR-1896
Hurricane Irene	08/26/11	Public Assistance	DR - 4037
Hurricane Sandy	10/27/12	Public Assistance	DR-4090

Source: Federal Emergency Management Agency

4.1 Hazard Identification

4.1.1 Introduction

Requirement §201.6(c)(2)(i): *[The risk assessment **shall** include a] description of the type … of all natural hazards that can affect the jurisdiction*

The United States and its communities are vulnerable to a wide array of natural and human-caused hazards that threaten life and property. These hazards include:

Natural

- Flood
- Hurricanes and Coastal Storms
- Severe Thunderstorms and Tornadoes
- Wildfire
- Drought/Extreme Heat
- Winter Storms and Freezes
- Hail
- Erosion
- Dam/Levee Failure
- Earthquakes, Sinkholes and Landslides
- Tsunami
- Volcano

Human-caused

- Terrorism
- Hazardous Materials (HazMat)
- Energy Pipeline Failures

Some of these hazards are interrelated (i.e., hurricanes can cause flooding and tornadoes), and some consist of hazardous elements that are not listed separately (i.e., severe thunderstorms can cause lightning; hurricanes can cause coastal erosion). In addition, terrorist-related incidents or accidents involving chemical, radiological or biological agents can coincide with natural hazard events, such as flooding caused by destruction of a dam or an accidental chemical release caused by a tornado. It should also be noted that some hazards, such as severe winter storms, may impact a large area yet cause little damage, while other hazards, such as a tornado, may impact a small area yet cause extensive damage. This section provides a general description for each of the hazards listed above along with their hazardous elements, written from a national perspective.

4.1.2 Flood

Flooding is the most frequent and costly natural hazard in the United States, a hazard that has caused more than 10,000 deaths nationwide, since 1900. Nearly 90 percent of presidential disaster declarations have resulted from natural events in which flooding was a major component.

Floods are generally the result of excessive precipitation, and can be classified under two categories: general floods, precipitation over a given river basin for a long period of time; and flash floods, the product of heavy localized precipitation in a short time period over a given location. The severity of a flooding event is determined by the following: a combination of stream and river basin topography and physiography; precipitation and weather patterns; recent soil moisture conditions; and the degree of vegetative clearing.

General floods are usually long-term events that may last for several days. The primary types of general flooding include riverine, coastal, and urban flooding. Riverine flooding is a function of excessive precipitation levels and water runoff volumes within the watershed of a stream or river. Coastal flooding is typically a result of storm surge, wind-driven waves, and heavy rainfall produced by hurricanes, tropical storms, nor'easters, and other large coastal storms. Urban flooding occurs where man-made development has obstructed the natural flow of water and decreased the ability of natural groundcover to absorb and retain surface water runoff.

A total of 534 counties in nine states were declared for Federal disaster aid as a result of the Midwest Floods in June 1994. Homes, businesses and personal property were all destroyed by the high flood levels; 168,340 people registered for Federal assistance. (FEMA News Photo)

Flash flooding events usually occur from a dam or levee failure within minutes or hours of heavy amounts of rainfall, or from a sudden release of water held by an ice jam. Most flash flooding is caused by slow-moving thunderstorms in a local area or by heavy rains associated with hurricanes and tropical storms. Although flash flooding occurs often along mountain streams, it is also common in urbanized areas where much of the ground is covered by impervious surfaces. Flash flood waters move at very high speeds—"walls" of water can reach heights of 10 to 20 feet. Flash flood waters and the accompanying debris can uproot trees, roll boulders, destroy buildings, and obliterate bridges and roads.

The periodic flooding of lands adjacent to rivers, streams, and shorelines (land known as floodplain) is a natural and inevitable occurrence that can be expected to take place based upon established recurrence intervals. The recurrence interval of a flood is defined as the average time interval, in years, expected between a flood event of a particular magnitude and an equal or larger flood. Flood magnitude increases with increasing recurrence interval.

Floodplains are designated by the frequency of the flood that is large enough to cover them. For example, the 10-year floodplain will be covered by the 10-year flood and the 100-year floodplain by the 100-year flood. Flood frequencies such as the 100-year flood are determined by plotting a graph of the size of all known floods for an area and determining how often floods of a particular size occur. Another way of expressing the flood frequency is the chance of occurrence in a given year, which is the percentage of the probability of flooding each year. For example, the 100-year flood has a 1 percent chance of occurring in any given year.

Table 4.1-1 shows flood loss values by fiscal year from a national perspective.

Table 4.1-1
National Flood Losses by Fiscal Year (Oct.-Sept.), 1983-2013

Fiscal Year	Damage (Billions of Current Dollars)	Inflation Adjustment	Damage (Billions of 2013 Dollars)	U.S. Population (Millions)	Damage Per Capita (2013 Dollars)
1983	4.014	2.34	9.392	233.79	40.17
1984	3.866	2.24	8.635	235.82	36.62
1985	0.524	2.17	1.137	237.92	4.78
1986	6.261	2.13	13.337	240.13	55.54
1987	1.526	2.05	3.129	242.29	12.91
1988	0.242	1.97	0.476	244.5	1.94
1989	1.190	1.88	2.236	246.82	9.06
1990	1.855	1.78	3.302	249.62	13.23
1991	1.961	1.71	3.354	252.98	13.26
1992	0.880	1.66	1.461	256.51	5.70
1993	18.63	1.61	29.997	259.92	115.41
1994	1.259	1.57	1.977	263.13	7.51
1995	5.829	1.53	8.918	266.28	33.49
1996	7.026	1.48	10.399	269.39	38.60
1997	9.866	1.45	14.306	272.65	52.47
1998	2.816	1.43	4.027	275.85	14.60
1999	6.119	1.40	8.596	279.04	30.81
2000	1.521	1.35	2.054	282.16	7.28
2001	8.334	1.32	11.001	284.97	38.60
2002	1.371	1.29	1.769	287.63	6.15
2003	2.787	1.27	3.540	290.11	12.20
2004	15.241	1.23	18.746	292.81	64.02
2005	45.264	1.19	53.864	295.52	182.27
2006	3.976	1.16	4.612	298.38	15.46
2007	2.552	1.12	2.858	301.23	9.49
2008	6.082	1.08	6.569	304.09	21.60
2009	0.982	1.09	1.070	306.77	3.49
2010	5.108	1.07	5.466	309.33	17.67
2011	8.521	1.04	8.862	311.59	28.44
2012	0.511	1.01	0.516	313.59	1.65
2013	2.152	1.00	2.152	316.98	6.79

Source: Hydrologic Information Center, National Weather Service

4.1.3 Hurricanes and Coastal Storms

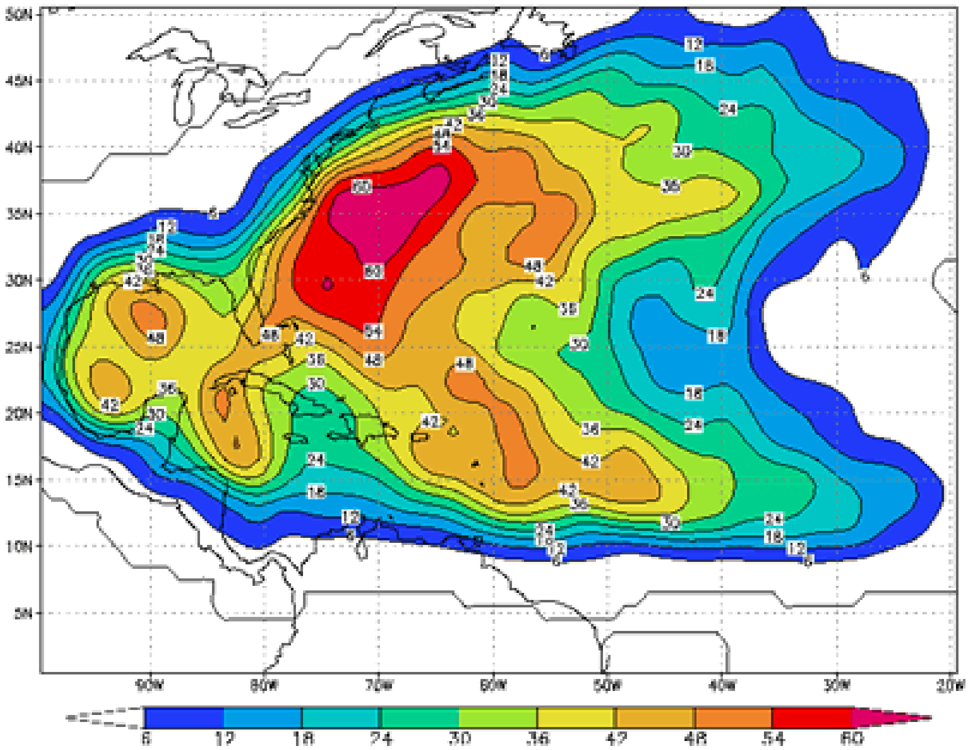
Hurricanes, tropical storms, nor'easters and typhoons, also classified as cyclones, are any closed circulation developing around a low-pressure center in which the winds rotate counter-clockwise in the Northern Hemisphere (or clockwise in the Southern Hemisphere) and whose diameter averages 10 to 30 miles across. A tropical cyclone refers to any such circulation that develops over tropical waters. Tropical cyclones act as a "safety-valve," limiting the continued build-up of heat and energy in tropical regions by maintaining the atmospheric heat and moisture balance between the tropics and the pole-ward latitudes. The primary damaging forces associated with these storms are high-level sustained winds, heavy precipitation, and tornadoes. Coastal areas are also vulnerable to the additional forces of storm surge, wind-driven waves, and tidal flooding which can be more destructive than cyclone wind.

The key energy source for a tropical cyclone is the release of latent heat from the condensation of warm water. Their formation requires a low-pressure disturbance, warm sea surface temperature, rotational force from the spinning of the earth, and the absence of wind shear in the lowest 50,000 feet of the atmosphere. The majority of hurricanes and tropical storms form in the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico during the official Atlantic hurricane season, which encompasses the months of June through November. The peak of the Atlantic hurricane season is in early to mid-September and the average number of storms that reach hurricane intensity per year in this basin is about six (6).

Wind and rain from Hurricane Lili damage road signs along I-10 in Louisiana October 3, 2002. (Photo by Lauren Hobart/FEMA News Photo)

Figure 4.1-1 shows for any particular location what the chance is that a tropical storm or hurricane will affect the area sometime during the whole June to November Atlantic hurricane season. The figure was created by the National Oceanic and Atmospheric Administration's Hurricane Research Division using data from 1944 to 1999 and counting hits when a storm or hurricane was within approximately 100 miles (165 km) of each location.

Figure 4.1-1
Empirical Probability of a Named Storm



Source: National Oceanic and Atmospheric Administration, Hurricane Research Division

As an incipient hurricane develops, barometric pressure (measured in millibars or inches) at its center falls and winds increase. If the atmospheric and oceanic conditions are favorable, it can intensify into a tropical depression. When maximum sustained winds reach or exceed 39 miles per hour, the system is designated a tropical storm, given a name, and is closely monitored by the National Hurricane Center in Miami, Florida. When sustained winds reach or exceed 74 miles per hour the storm is deemed a hurricane. Hurricane intensity is further classified by the Saffir-Simpson Scale, which rates hurricane intensity on a scale of 1 to 5, with 5 being the most intense.

The Saffir-Simpson Scale is shown in **Table 4.1-2**.

Table 4.1-2
Saffir-Simpson Wind Scale

Category	Maximum Sustained Wind Speed (mph)
1	74-95 mph
2	96-110 mph
3	111-129 mph
4	130-156 mph
5	157 mph or higher

Source: National Hurricane Center

The Saffir-Simpson Scale categorizes hurricane intensity linearly based upon maximum sustained winds, barometric pressure, and storm surge potential, which are combined to estimate potential damage. Categories 3, 4, and 5 are classified as "major" hurricanes, and while hurricanes within this range comprise only 20 percent of total tropical cyclone landfalls, they account for over 70 percent of the damage in the United States. **Table 4.1-3** describes the damage that could be expected for each category of hurricane.

Table 4.1-3
Hurricane Damage Classification

Category	Damage Level	Description
1	MINIMAL	**Very dangerous winds will produce some damage:** Well-constructed frame homes could have damage to roof, shingles, vinyl siding and gutters. Large branches of trees will snap and shallowly rooted trees may be toppled. Extensive damage to power lines and poles likely will result in power outages that could last a few to several days.
2	MODERATE	**Extremely dangerous winds will cause extensive damage:** Well-constructed frame homes could sustain major roof and siding damage. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks.
3	EXTENSIVE	**Devastating damage will occur:** Well-built framed homes may incur major damage or removal of roof decking and gable ends. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to weeks after the storm passes.
4	EXTREME	**Catastrophic damage will occur:** Well-built framed homes can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last weeks to possibly months. Most of the area will be uninhabitable for weeks or months.
5	CATASTROPHIC	**Catastrophic damage will occur:** A high percentage of framed homes will be destroyed, with total roof failure and wall collapse. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Most of the area will be uninhabitable for weeks or months.

Source: National Hurricane Center

A storm surge is a large dome of water often 50 to 100 miles wide and rising anywhere from four to five feet in a Category 1 hurricane up to 20 feet in a Category 5 storm. The storm surge arrives ahead of the storm's actual landfall and the more intense the hurricane is, the sooner the surge arrives. Water rise can be very rapid, posing a serious threat to those who have not yet evacuated flood-prone areas. A storm surge is a wave that has outrun its generating source and become a long period swell. The surge is always highest in the right-front quadrant of the direction in which the hurricane is moving. As the storm approaches shore, the greatest storm surge will be to the northeast of the hurricane eye. Such a surge of high water topped by waves driven by hurricane force winds can be devastating to coastal regions, causing severe beach erosion and property damage along the immediate coast.

Storm surge heights, and associated waves, are dependent upon the shape of the continental shelf (narrow or wide) and the depth of the ocean bottom (bathymetry). A narrow shelf, or one that drops steeply from the shoreline and subsequently produces deep water close to the shoreline, tends to produce a lower surge but higher and more powerful storm waves.

Damage during hurricanes may also result from spawned tornadoes and inland flooding associated with heavy rainfall that usually accompanies these storms. Hurricane Floyd, as an example, was at one time a Category 4 hurricane racing towards the North Carolina coast. As far inland as Raleigh, the state capital located more than 100 miles from the coast, communities were preparing for extremely damaging winds exceeding 100 miles per hour. However, Floyd made landfall as a Category 2 hurricane and will be remembered for causing the worst inland flooding disaster in North Carolina's history. Rainfall amounts were as high as 20 inches in certain locales and 67 counties sustained damages.

Hurricane Floyd brought a devastating 15 feet of storm surge that damaged or destroyed hundreds of houses along the ocean front of Long Beach on Oak Island, North Carolina in September 1999. A prime example of successful hazard mitigation, the elevated home (right) survived while the older, ground-level block foundation of the home on the left was crushed. (Photo by Dave Gatley/FEMA News Photo)

Similar to hurricanes, nor'easters are ocean storms capable of causing substantial damage to coastal areas in the Eastern United States due to their associated strong winds and heavy surf. Nor'easters are named for the winds that blow in from the northeast and drive the storm up the East Coast along the Gulf Stream, a band of warm water that lies off the Atlantic coast. They are caused by the interaction of the jet stream with horizontal temperature gradients and generally occur during the fall and winter months when moisture and cold air are plentiful.

Nor'easters are known for dumping heavy amounts of rain and snow, producing hurricane-force winds, and creating high surfs that cause severe beach erosion and coastal flooding. There are two main components to a nor'easter: (1) a Gulf Stream low-pressure system (counter-clockwise winds) generated off the southeastern U.S. coast, gathering warm air and moisture from the Atlantic, and pulled up the East Coast by strong northeasterly winds at the leading edge of the storm; and (2) an Arctic high-pressure system (clockwise winds) which meets the low-pressure system with cold, arctic air blowing down from Canada. When the two systems collide, the moisture and cold air produce a mix of precipitation and have the potential for creating dangerously high winds and heavy seas. As the low-pressure system deepens, the intensity of the winds and waves will increase and cause serious damage to coastal areas as the storm moves northeast.

Table 4.1-4 shows an intensity scale proposed for nor'easters that is based upon levels of coastal degradation.

Table 4.1-4
Dolan-Davis Nor'easter Intensity Scale

Storm Class	Beach Erosion	Dune Erosion	Overwash	Property Damage
1 (Weak)	Minor changes	None	No	No
2 (Moderate)	Modest; mostly to lower beach	Minor	No	Modest
3 (Significant)	Erosion extends across beach	Can be significant	No	Loss of many structures at local level
4 (Severe)	Severe beach erosion and recession	Severe dune erosion or destruction	On low beaches	Loss of structures at community-scale
5 (Extreme)	Extreme beach erosion	Dunes destroyed over extensive areas	Massive in sheets and channels	Extensive at regional-scale; millions of dollars

Source: North Carolina Division of Emergency Management

4.1.4 Severe Thunderstorms and Tornadoes

According to the National Weather Service, more than 100,000 thunderstorms occur each year, though only about 10 percent of these storms are classified as "severe." Although thunderstorms generally affect a small area when they occur, they are very dangerous because of their ability to generate tornadoes, hailstorms, strong winds, flash flooding, and damaging lightning. While thunderstorms can occur in all regions of the United States, they are most common in the central and southern states because atmospheric conditions in those regions are most ideal for generating these powerful storms.

Multiple cloud-to-ground and cloud-to-cloud lightning strokes observed during a nighttime thunderstorm. (Photo courtesy of NOAA Photo Library, NOAA Central Library; OAR/ERL/ National Severe Storms Laboratory)

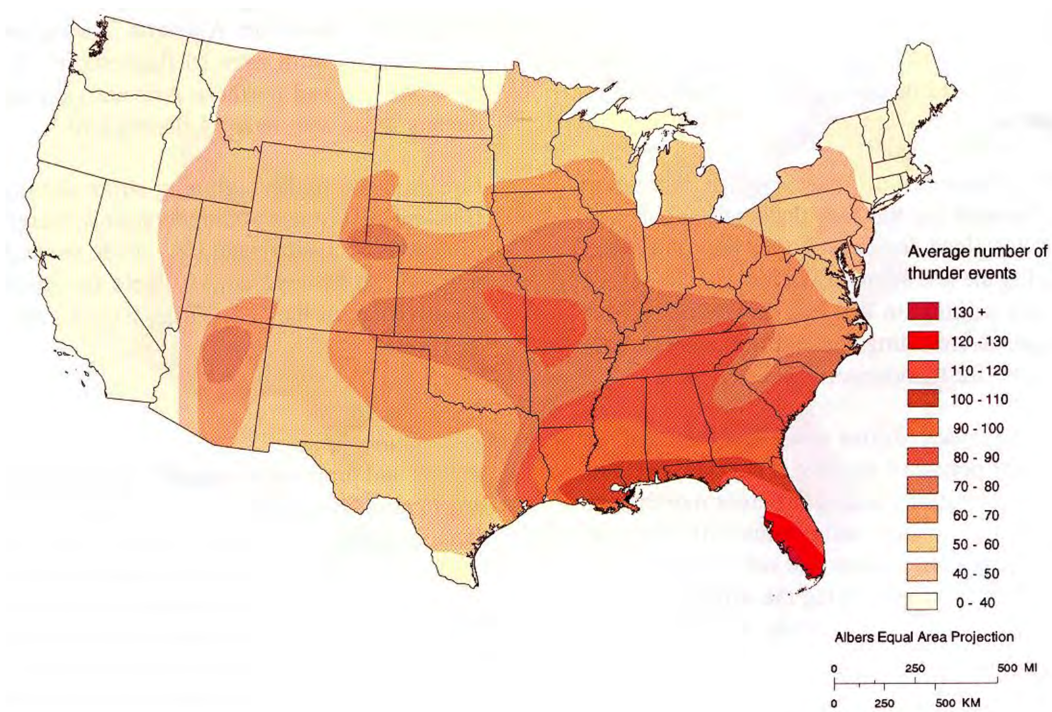
Thunderstorms are caused when air masses of varying temperatures meet. Rapidly rising warm moist air serves as the "engine" for thunderstorms. These storms can occur singularly, in lines, or in clusters. They can move through an area very quickly or linger for several hours.

Lightning is a discharge of electrical energy resulting from the buildup of positive and negative charges within a thunderstorm, creating a "bolt" when the buildup of charges becomes strong enough. This flash of light usually occurs within the clouds or between the clouds and the ground. A bolt of lightning can reach temperatures approaching 50,000 degrees Fahrenheit. Lightning rapidly heats the sky as it flashes but the surrounding air cools following the bolt. This rapid heating and cooling of the surrounding air causes thunder. On average, 89 people are killed each year by lightning strikes in the United States.

The National Weather Service collected data for thunder days, number and duration of thunder events, and lightening strike density for the 30-year period from 1948 to 1977. A series of maps was generated showing the annual average thunder event duration, the annual average number of thunder events, and the mean annual density of lightning strikes.

Figure 4.1-2 illustrates thunderstorm hazard severity based on the annual average number of thunder events from 1948 to 1977.

Figure 4.1-2
Annual Average Number of Thunder Events



Source: Federal Emergency Management Agency

The most comprehensively observed tornado in history, this tornado south of Dimmitt, Texas developed June 2, 1995 curving northward across Texas Highway 86 where it entirely removed 300 feet of asphalt from the road tossing it more than 600 feet into an adjacent field. It also caused F4 damage at an isolated rural residence just north of the road. (NOAA Photo Library, NOAA Central Library; OAR/ERL/National Severe Storms Laboratory)

A tornado is a violent windstorm characterized by a twisting, funnel-shaped cloud extending to the ground. Tornadoes are most often generated by thunderstorm activity (but sometimes result from hurricanes and other coastal storms) when cool, dry air intersects and overrides a layer of warm, moist air forcing the warm air to rise rapidly. The damage caused by a tornado is a result of the high wind velocity and wind-blown debris, also accompanied by lightning or large hail. According to the National Weather Service, tornado wind speeds normally range from 40 to more than 300 miles per hour. The most violent tornadoes have rotating winds of 250 miles per hour or more and are capable of causing extreme destruction and turning normally harmless objects into deadly missiles.

Each year, an average of over 800 tornadoes is reported nationwide, resulting in an average of 80 deaths and 1,500 injuries (NOAA, 2002). They are more likely to occur during the spring and early summer months of March through June and can occur at any time of day, but are likely to form in the late afternoon and early evening. Most tornadoes are a few dozen yards wide and touch down briefly, but even small short-lived tornadoes can inflict tremendous damage. Highly destructive tornadoes may carve out a path over a mile wide and several miles long.

Waterspouts are weak tornadoes that form over warm water and are most common along the Gulf Coast and southeastern states. Waterspouts occasionally move inland, becoming tornadoes that cause damage and injury. However, most waterspouts dissipate over the open water causing threats only to marine and boating interests. Typically a waterspout is weak and short-lived, and because they are so common, most go unreported unless they cause damage.

The destruction caused by tornadoes ranges from light to inconceivable depending on the intensity, size, and duration of the storm. Typically, tornadoes cause the greatest damages to structures of light construction such as residential homes (particularly mobile homes), and tend to remain localized in impact. The Fujita-Pearson Scale for Tornadoes (**Table 4.1-5**) was developed to measure tornado strength and associated damages.

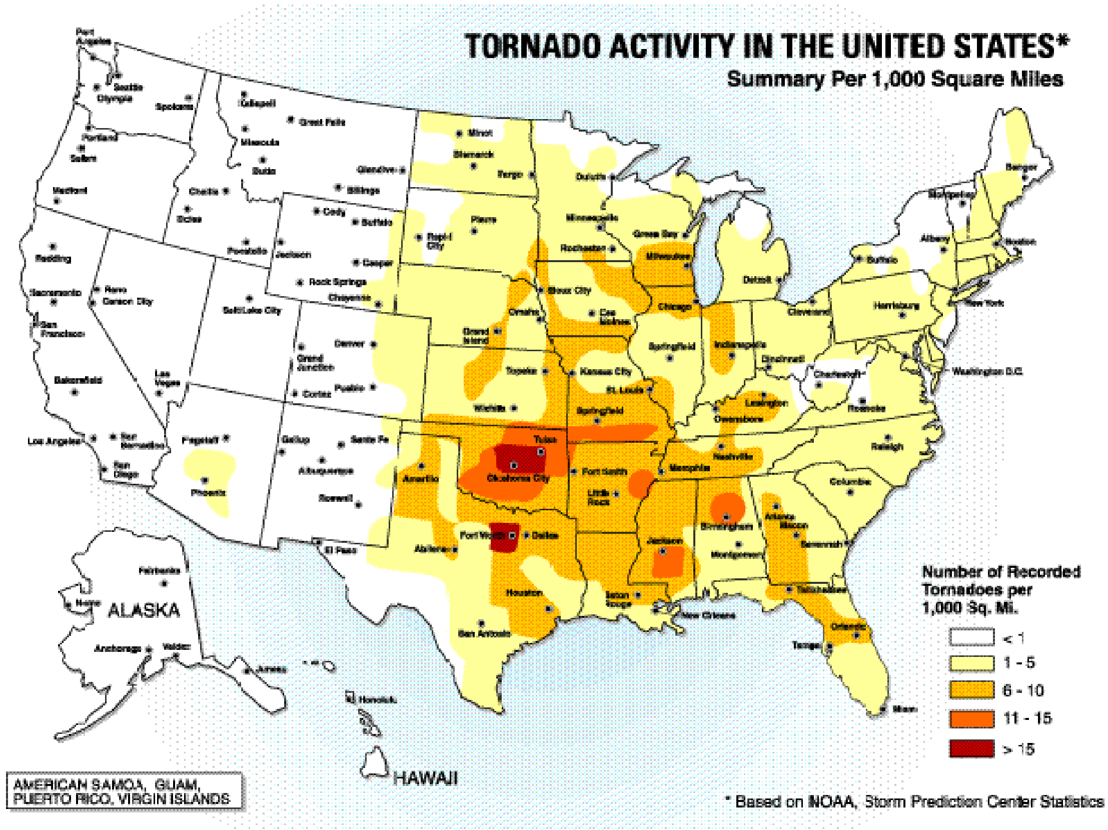
Table 4.1-5
Enhanced Fujita Scale for Tornadoes

EF-Scale Number	3 Second Gust (mph)	Type of Damage Done
EF0	65-85	Light Damage: Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over.
EF1	86-110	Moderate Damage: Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.
EF2	111-135	Considerable Damage: Roofs torn off well-constructed houses; mobile homes demolished; large trees snapped or uprooted; light object missiles generated; cars lifted off ground.
EF3	136-165	Severe Damage: Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some distance.
EF4	166-200	Devastating Damage: Whole frame houses, well-constructed houses and whole frame houses completely leveled; cars thrown and small missiles generated.
EF5	>200	Incredible Damage: Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100m (109 yd); high-rise buildings have significant structural deformation; incredible phenomena will occur.

Source:NOAA's NWS Storm Prediction Center

According to the NOAA Storm Prediction Center (SPC), the highest concentration of tornadoes in the United States has been in Oklahoma, Texas, Kansas and Florida respectively. Although the Great Plains region of the Central United States does favor the development of the largest and most dangerous tornadoes (earning the designation of "tornado alley"), Florida experiences the greatest number of tornadoes per square mile of all U.S. states (SPC, 2002). **Figure 4.1-3** shows tornado activity in the United States based on the number of recorded tornadoes per 1,000 square miles.

Figure 4.1-3
Tornado Activity in the United States

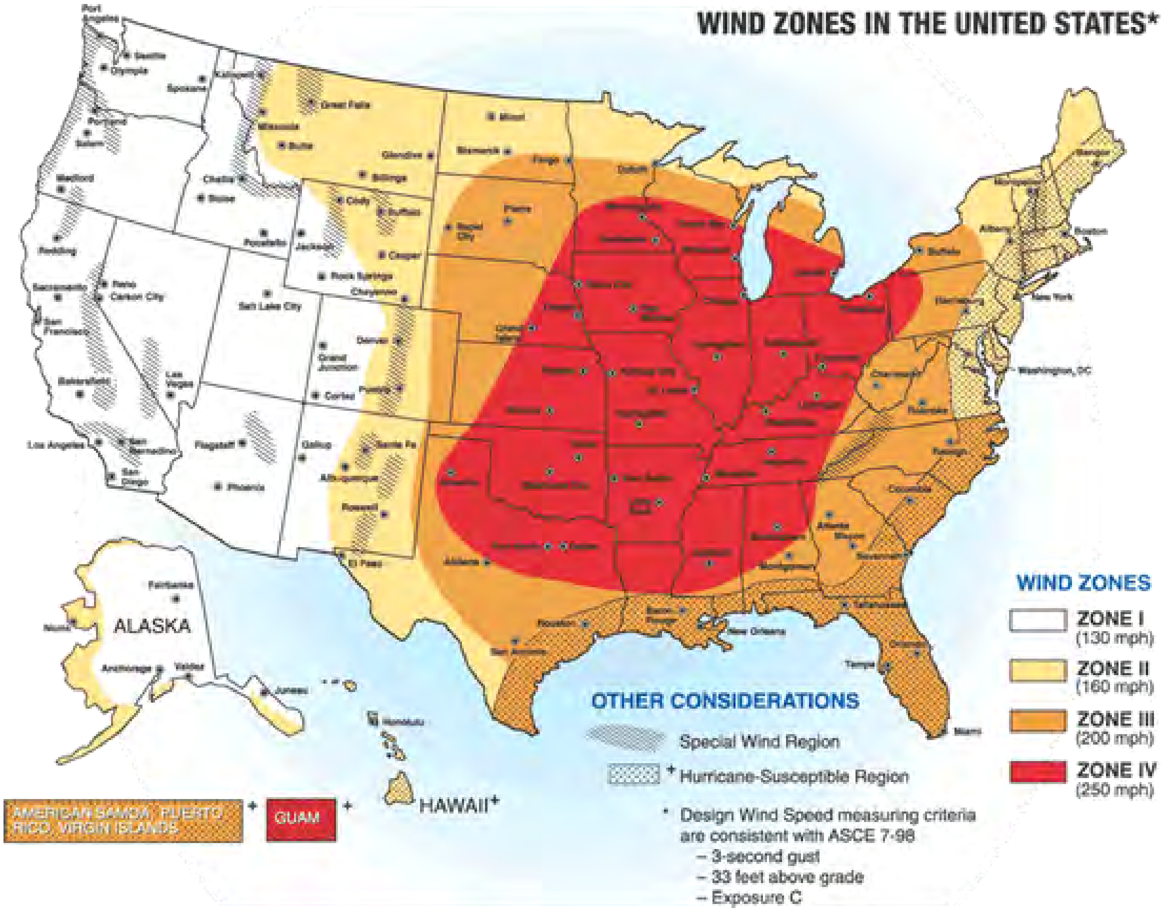


Source: American Society of Civil Engineers

The tornadoes associated with tropical cyclones are most frequent in September and October when the incidence of tropical storm systems is greatest. This type of tornado usually occurs around the perimeter of the storm, and most often to the right and ahead of the storm path or the storm center as it comes ashore. These tornadoes commonly occur as part of large outbreaks and generally move in an easterly direction.

Figure 4.1-4 shows how the frequency and strength of extreme windstorms vary across the United States. The map was produced by the Federal Emergency Management Agency and is based on 40 years of tornado history and over 100 years of hurricane history. Zone IV, the darkest area on the map, has experienced both the greatest number of tornadoes and the strongest tornadoes. As shown by the map key, wind speeds in Zone IV can be as high as 250 MPH.

Figure 4.1-4
Wind Zones in the United States



Source: Federal Emergency Management Agency

4.1.5 Wildfire

A wildfire is any fire occurring in a wildland area (i.e., grassland, forest, brush land) except for fire under prescription. Wildfires are part of the natural management of the Earth's ecosystems, but may also be caused by natural or human factors. Over 80 percent of forest fires are started by negligent human behavior such as smoking in wooded areas or improperly extinguishing campfires. The second most common cause for wildfire is lightning.

There are three classes of wildland fires: surface fire, ground fire, and crown fire. A surface fire is the most common of these three classes and burns along the floor of a forest, moving slowly and killing or damaging trees. A ground fire (muck fire) is usually started by lightning or human carelessness and burns on or below the forest floor. Crown fires spread rapidly by wind and move quickly by jumping along the tops of trees. Wildland fires are usually signaled by dense smoke that fills the area for miles around.

On Sunday, August 6, 2000, several forest fires converged near Sula, Montana, forming a firestorm that overran 100,000 acres and destroyed 10 homes. Temperatures in the flame front were estimated at more than 800 degrees. Note the elk gathering near the East Fork of the Bitterroot River. (Photo by John McColgan/U.S. Forest Service Firefighter)

State and local governments can impose fire safety regulations on home sites and developments to help curb wildfire. Land treatment measures such as fire access roads, water storage, helipads, safety zones, buffers, firebreaks, fuel breaks, and fuel management can be designed as part of an overall fire defense system to aid in fire control. Fuel management, prescribed burning, and cooperative land management planning can also be encouraged to reduce fire hazards.

Fire probability depends on local weather conditions, outdoor activities such as camping, debris burning, and construction, and the degree of public cooperation with fire prevention measures. Drought conditions and other natural disasters (tornadoes, hurricanes, etc.) increase the probability of wildfires by producing fuel in both urban and rural settings. Forest damage from hurricanes and tornadoes may block interior access roads and fire breaks, pull down overhead power lines, or damage pavement and underground utilities.

Many individual homes and cabins, subdivisions, resorts, recreational areas, organizational camps, businesses, and industries are located within high fire hazard areas. The increasing demand for outdoor recreation places more people in wildlands during holidays, weekends, and vacation periods. Unfortunately, wildland residents and visitors are rarely educated or prepared for the inferno that can sweep through the brush and timber and destroy property in minutes.

4.1.6 Drought/Extreme Heat

Drought is a natural climatic condition caused by an extended period of limited rainfall beyond that which occurs naturally in a broad geographic area. High temperatures, high winds, and low humidity can worsen drought conditions, and can make areas more susceptible to wildfire. Human demands and actions can also hasten drought-related impacts.

Droughts are frequently classified as one of following four types:

- Meteorological
- Agricultural
- Hydrological
- Socio-economic.

Meteorological droughts are typically defined by the level of “dryness” when compared to an average, or normal amount of precipitation over a given period of time. Agricultural droughts relate common characteristics of drought to their specific agricultural-related impacts. Emphasis tends to be placed on factors such as soil water deficits, water needs based on differing stages of crop development, and water reservoir levels. Hydrological drought is directly related to the effect of precipitation shortfalls on surface and groundwater supplies. Human factors, particularly changes in land use, can alter the hydrologic characteristics of a basin. Socio-economic drought is the result of water shortages that limit the ability to supply water-dependent products in the marketplace.

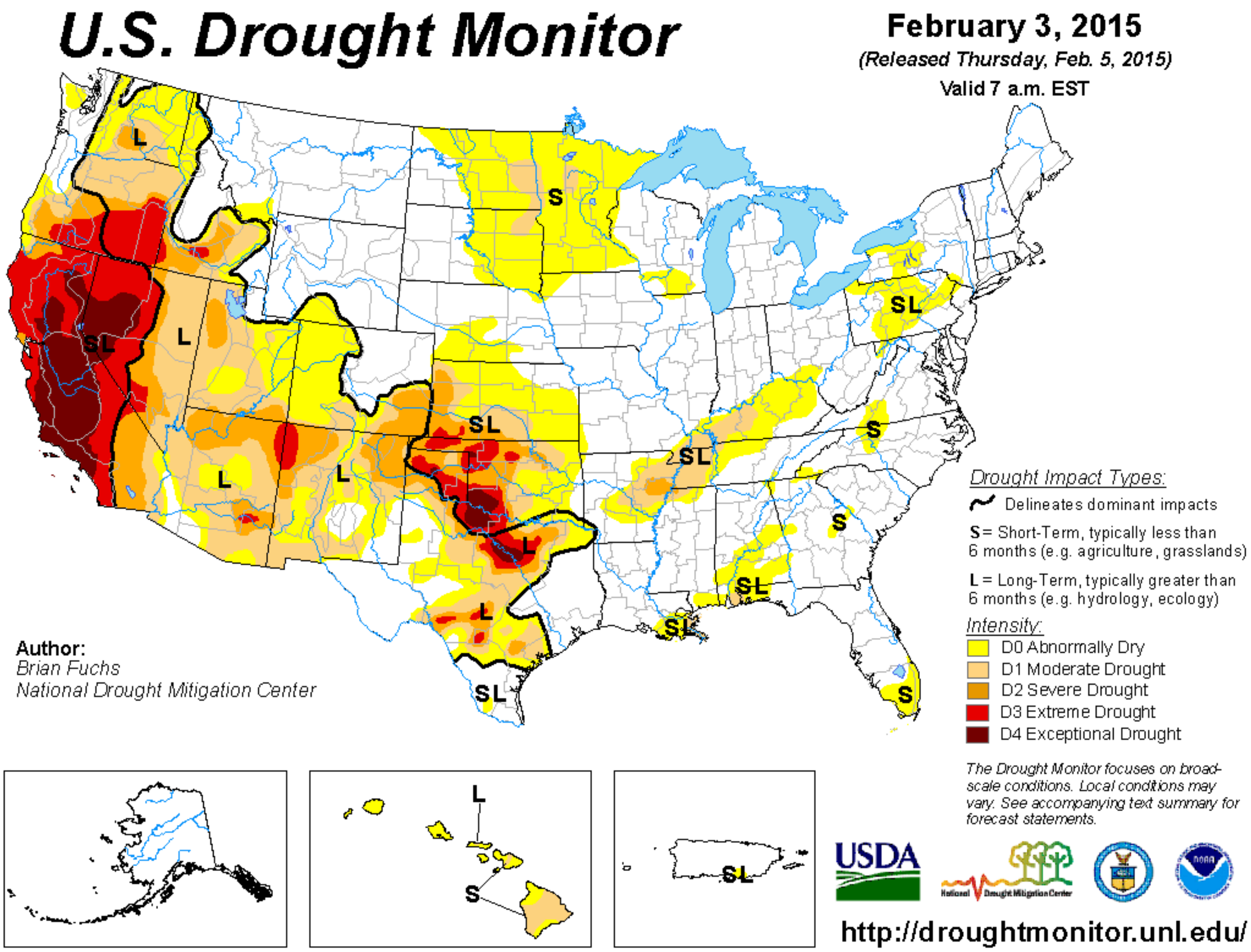
A USGS streamflow gaging station at the Ogeechee River near Eden, Georgia in July 2000 illustrates the drought conditions that can severely affect water supplies, agriculture, stream water quality, recreation, navigation, and forest resources. (Photo courtesy of the United States Geological Survey)

While drought mostly impacts land and water resources, extreme heat can pose a significant risk to humans. Extreme heat can be defined as temperatures that hover 10 degrees or more above the average high temperature for the region, last for prolonged periods of time, and are often accompanied by high humidity. Under normal conditions, the human body’s internal thermostat produces perspiration that evaporates and cools the body. However, in extreme heat and high humidity, evaporation is slowed and the body must work much harder to maintain a normal temperature. Elderly persons, young children, persons with respiratory difficulties, and those who are sick or overweight are more likely to become victims of extreme heat. Because men sweat more than women, they are more susceptible to heat-related illness because they become more quickly dehydrated. Studies have shown that a significant rise in heat-related illness occurs when excessive heat persists for more than two days. Spending at least two hours per day in air conditioning can significantly reduce the number of heat-related illnesses. Therefore, cooling stations are often an effective emergency response, as well as warnings in the media about the danger of over-exposure to the extreme heat.

Extreme heat in urban areas can create health concerns when stagnant atmospheric conditions trap pollutants, thus adding unhealthy air to excessively hot temperatures. In addition, the “urban heat island effect” can produce significantly higher nighttime temperatures because asphalt and concrete (which store heat longer) gradually release heat at night.

Figure 4.1-5 shows a U.S. Drought Monitor summary map from the United States Department of Agriculture for August 25, 2009. Drought Monitor summary maps identify general drought areas and label droughts by intensity, with D1 being the least intense and D4 being the most intense.

Figure 4.1-5
U.S. Drought Monitor



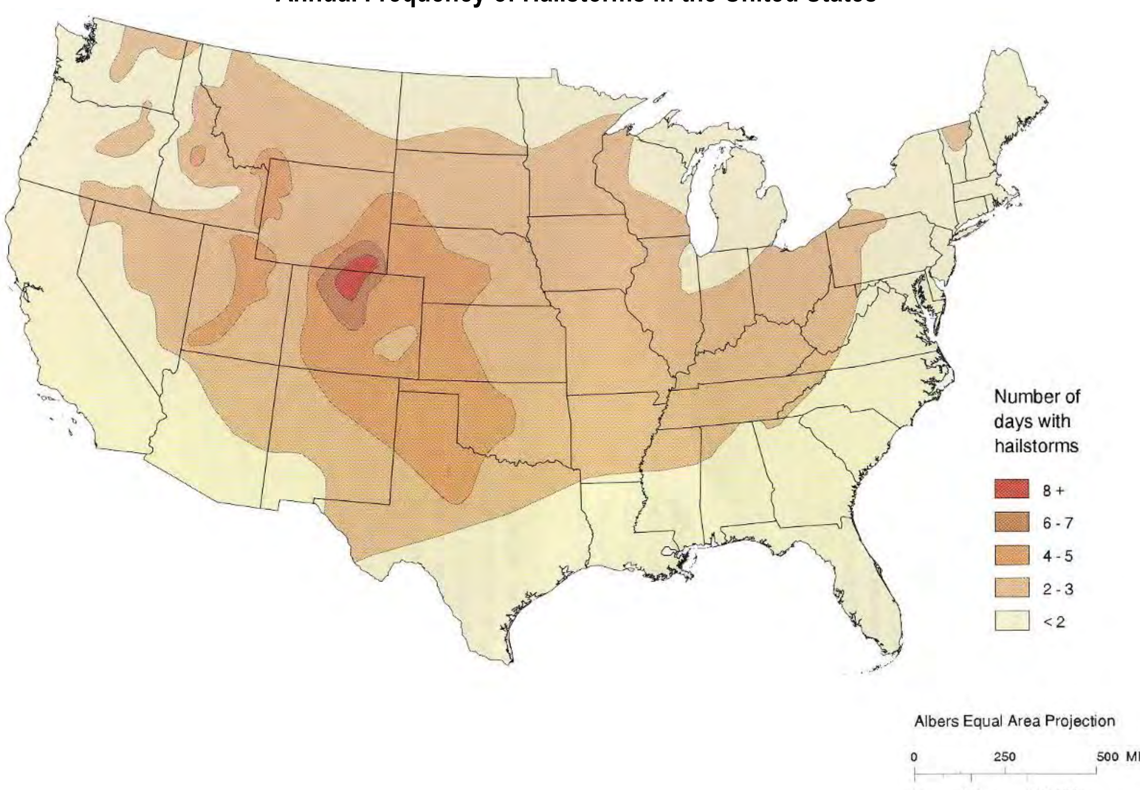
Weekly-updated maps may be obtained online from The Drought Monitor Web site, maintained by the National Drought Mitigation Center, located at the following Web address: http://drought.unl.edu/dm.

4.1.7 Hail

Hailstorms are an outgrowth of severe thunderstorms. Early in the developmental stages of a hailstorm, ice crystals form within a low-pressure front due to the rapid rising of warm air into the upper atmosphere and the subsequent cooling of the air mass. Frozen droplets gradually accumulate on the ice crystals until, having developed sufficient weight, they fall as precipitation—as balls or irregularly shaped masses of ice greater than 0.75 in. (1.91 cm) in diameter. The size of hailstones is a direct function of 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 elevation above the surface result in increased suspension time and hailstone size. **Figure 4.1-6** shows the annual frequency of hailstorms in the United States.

Large hail collects on streets and grass during a severe thunderstorm. Larger stones appear to be nearly two to three inches in diameter. (NOAA Photo Library, NOAA Central Library; OAR/ERL/National Severe Storms Laboratory)

Figure 4.1-6
Annual Frequency of Hailstorms in the United States



Source: Federal Emergency Management Agency

4.1.8 Winter Storms and Freezes

A winter storm can range from a moderate snow over a period of a few hours to blizzard conditions with blinding wind-driven snow that lasts for several days. Some winter storms may be large enough to affect several states, while others may affect only a single community. Many winter storms are accompanied by low temperatures and heavy and/or blowing snow, which can severely impair visibility.

Winter storms may include snow, sleet, freezing rain, or a mix of these wintry forms of precipitation. Sleet—raindrops that freeze into ice pellets before reaching the ground—usually bounce when hitting a surface and do not stick to objects; however, sleet can accumulate like snow and cause a hazard to motorists. Freezing rain is rain that falls onto a surface with a temperature below freezing, forming a glaze of ice. Even small accumulations of ice can cause a significant hazard, especially on power lines and trees. An ice storm occurs when freezing rain falls and freezes immediately upon impact. Communications and power can be disrupted for days, and even small accumulations of ice may cause extreme hazards to motorists and pedestrians.

A heavy layer of ice was more weight than this tree in Kansas City, Missouri could withstand during a January 2002 ice storm that swept through the region bringing down trees, power lines and telephone lines. (Photo by Heather Oliver/FEMA News Photo)

A freeze is weather marked by low temperatures, especially when below the freezing point (zero degrees Celsius or thirty-two degrees Fahrenheit). Agricultural production is seriously affected when temperatures remain below the freezing point.

Winter storms and extreme cold snaps affect certain populations disproportionately, namely the impoverished, the elderly, and those with acute (and sometimes chronic) health conditions. This disproportionate outcomes are a result of the sensitivity to populations to the cold and their inability to get warm, but also because these conditions are often accompanied with power loss, and a general lack of mobility. Evacuation shelters with independent power generation can be a effective mitigation measure. Additionally, education of social service providers to be extra vigilant during times of winter storms can make a difference in the potential mortality rate.

4.1.9 Erosion

Erosion is the gradual breakdown and movement of land due to both physical and chemical processes of water, wind, and general meteorological conditions. Natural, or geologic, erosion has occurred since the Earth's formation and continues at a very slow and uniform rate each year.

There are two types of soil erosion: wind erosion and water erosion. Wind erosion can cause significant soil loss. Winds blowing across sparsely vegetated or disturbed land can pick up soil particles and carry them through the air, thus displacing them. Water erosion can occur over land or in streams and channels. Water erosion that takes place over land may result from raindrops, shallow sheets of water flowing off the land, or shallow surface flow, which is concentrated in low spots. Stream channel erosion may occur as the volume and velocity of water flow increases enough to cause movement of the streambed and bank soils. Major storms such as hurricanes may cause significant erosion by combining high winds with heavy surf and storm surge to significantly impact the shoreline.

An area's potential for erosion is determined by four factors: soil characteristics, vegetative cover, topography climate or rainfall, and topography. Soils composed of a large percentage of silt and fine sand are most susceptible to erosion. As the content of these soils increases in the level of clay and organic material, the potential for erosion decreases. Well-drained and well-graded gravels and gravel-sand mixtures are the least likely to erode. Coarse gravel soils are highly permeable and have a good capacity for absorption, which can prevent or delay the amount of surface runoff. Vegetative cover can be very helpful in controlling erosion by shielding the soil surface from falling rain, absorbing water from the soil, and slowing the velocity of runoff. Runoff is also affected by the topography of the area including size, shape and slope. The greater the slope length and gradient, the more potential an area has for erosion. Climate can affect the amount of runoff, especially the frequency, intensity and duration of rainfall and storms. When rainstorms are frequent, intense, or of long duration, erosion risks are high. Seasonal changes in temperature and rainfall amounts define the period of highest erosion risk of the year.

During the past 20 years, the importance of erosion control has gained the increased attention of the public. Implementation of erosion control measures consistent with sound agricultural and construction operations is needed to minimize the adverse effects associated with increasing settling out of the soil particles due to water or wind. The increase in government regulatory programs and public concern has resulted in a wide range of erosion control products, techniques, and analytical methodologies in the United States. The preferred method of erosion control in recent years has been the restoration of vegetation.

4.1.10 Dam/Levee Failure

Worldwide interest in dam and levee safety has risen significantly in recent years. Aging infrastructure, new hydrologic information, and population growth in floodplain areas downstream from dams and near levees have resulted in an increased emphasis on safety, operation and maintenance.

Dam failure can result from natural events, human-induced events, or a combination of the two. Failures due to natural events such as hurricanes, earthquakes or landslides are significant because there is generally little or no advance warning. The most common cause of dam failure is prolonged rainfall that produces flooding. (Photo: Michael Baker Corporation)

There are about 80,000 dams in the United States today, the majority of which are privately owned. Other owners include state and local authorities, public utilities, and federal agencies. The benefits of dams are numerous: they provide water for drinking, navigation, and agricultural irrigation. Dams also provide hydroelectric power, create lakes for fishing and recreation, and save lives by preventing or reducing floods.

Though dams have many benefits, they also can pose a risk to communities if not designed, operated, and maintained properly. In the event of a dam failure, the energy of the water stored behind even a small dam is capable of causing loss of life and great property damage if development exists downstream of the dam. If a levee breaks, scores of properties are quickly submerged in floodwaters and residents may become trapped by this rapidly rising water. The failure of dams and levees has the potential to place large numbers of people and great amounts of property in harm's way.

4.1.11 Earthquakes, Sinkholes and Landslides

Earthquake

An earthquake is the motion or trembling of the ground produced by sudden displacement of rock in the Earth's crust. Earthquakes result from crustal strain, volcanism, landslides, or the collapse of caverns. Earthquakes can affect hundreds of thousands of square miles; cause damage to property measured in the tens of billions of dollars; result in loss of life and injury to hundreds of thousands of persons; and disrupt the social and economic functioning of the affected area.

Many roads, including bridges and elevated highways, were damaged by the 6.7 magnitude earthquake that impacted the Northridge, California area January 17, 1994. Approximately 114,000 structures were damaged and 72 deaths were attributed to the event. Damage costs were estimated at $25 billion. (FEMA News Photo)

Most property damage and earthquake-related deaths are caused by the failure and collapse of structures due to ground shaking. The level of damage depends upon the amplitude and duration of the shaking, which are directly related to the earthquake size, distance from the fault, site and regional geology. Other damaging earthquake effects include landslides, the down-slope movement of soil and rock (mountain regions and along hillsides), and liquefaction, in which ground soil loses the ability to resist shear and flows much like quick sand. In the case of liquefaction, anything relying on the substrata for support can shift, tilt, rupture, or collapse.

Most earthquakes are caused by the release of stresses accumulated as a result of the rupture of rocks along opposing fault planes in the Earth's outer crust. These fault planes are typically found along borders of the Earth's ten tectonic plates. These plate borders generally follow the outlines of the continents, with the North American plate following the continental border with the Pacific Ocean in the west, but following the mid-Atlantic trench in the east. As earthquakes occurring in the mid-Atlantic trench usually pose little danger to humans, the greatest earthquake threat in North America is along the Pacific Coast.

The areas of greatest tectonic instability occur at the perimeters of the slowly moving plates, as these locations are subjected to the greatest strains from plates traveling in opposite directions and at different speeds. Deformation along plate boundaries causes strain in the rock and the consequent buildup of stored energy. When the built-up stress exceeds the rocks' strength, a rupture occurs. The rock on both sides of the fracture is snapped, releasing the stored energy and producing seismic waves, generating an earthquake.

Earthquakes are measured in terms of their magnitude and intensity. Magnitude is measured using the Moment Magnitude (M_w) Scale and is equal to the rigidity of the Earth multiplied by the average amount of slip on the fault and the size of the area that slipped. (see **Table 4.1-6**). Each unit increase in magnitude on the M_w Scale corresponds to a logarithmic increase in energy released. Intensity is most commonly measured using the Modified Mercalli Intensity (MMI) Scale based on direct and indirect measurements of seismic effects. The scale levels are typically described using roman numerals, with a I corresponding to imperceptible (instrumental) events, IV corresponding to moderate (felt by people awake), to XII for catastrophic (total destruction). A detailed description of the Modified Mercalli Intensity Scale of earthquake intensity and its correspondence to the M_w Scale is given in **Table 4.1-7**.

Table 4.1-6
Moment Magnitude Scale

Moment Magnitude (M_w)	Earthquake Effects
2	Felt indoors, but may not be recognized as an earthquake
3	Felt by most; some windows, dishes break; tall objects may fall
4	Very noticeable, damage to weaker buildings on fill; driving automobiles notice
5	Walls, monuments, chimneys, bookcases fall, liquefaction; driving is difficult
5 – 6	Buildings shifted off foundations, cracked and twisted; ground is cracked and underground pipes are broken
6 – 7	Most structures severely damaged to destroyed; ground is cracked, rails are bent, landslides on steep slopes
7 – 8	Total damage; can see the earthquake wave move through the ground; gravity overcome and objects thrown into the air

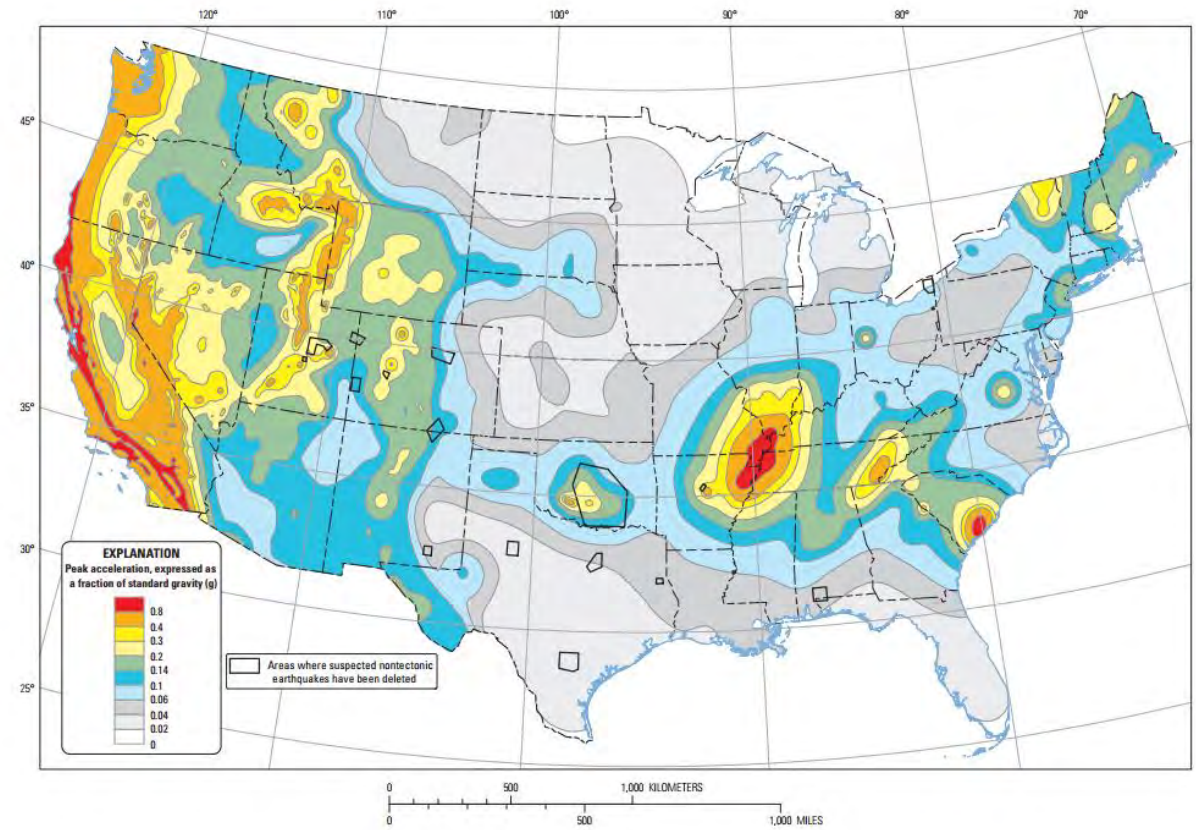
Table 4.1-7
Modified Mercalli Intensity Scale for Earthquakes

Scale	Intensity	Description of Effects	Corresponding M_w Scale Magnitude
I	Instrumental	Detected only on seismographs	
II	Feeble	Some people feel it	
III	Slight	Felt by people resting; like a truck rumbling by	2
IV	Moderate	Felt by people walking	
V	Slightly Strong	Sleepers awake; church bells ring	3
VI	Strong	Trees sway; suspended objects swing, objects fall off shelves	
VII	Very Strong	Mild Alarm; walls crack; plaster falls	4
VIII	Destructive	Moving cars uncontrollable; masonry fractures, poorly constructed buildings damaged	5
IX	Ruinous	Some houses collapse; ground cracks; pipes break open	5.5 – 6
X	Disastrous	Ground cracks profusely; many buildings destroyed; liquefaction and landslides widespread	6 – 6.5
XI	Very Disastrous	Most buildings and bridges collapse; roads, railways, pipes and cables destroyed; general triggering of other hazards	6.5 – 7
XII	Catastrophic	Total destruction; trees fall; ground rises and falls in waves	7+

Source: North Carolina Division of Emergency Management

Figure 4.1-7 shows the probability that ground motion will reach a certain level during an earthquake in the Eastern US. The data show peak horizontal ground acceleration (the fastest measured change in speed, for a particle at ground level that is moving horizontally due to an earthquake) with a 2 percent probability of exceedance in 50 years. The map was compiled by the U.S. Geological Survey (USGS) Geologic Hazards Team, which conducts global investigations of earthquake, geomagnetic, and landslide hazards.

Figure 4.1-7
2% probability of exceedance in 50 years map of peak ground acceleration



Source: United States Geological Survey, 2014

Sinkholes

Sinkholes are a natural and common geologic feature in areas with underlying limestone and other rock types that are soluble in natural water. Most limestone is porous, allowing the acidic water of rain to percolate through their strata, dissolving some limestone and carrying it away in solution. Over time, this persistent erosional process can create extensive underground voids and drainage systems in much of the carbonate rocks. Collapse of overlying sediments into the underground cavities produces sinkholes.

The three general types of sinkholes are: subsidence, solution, and collapse. Collapse sinkholes are most common in areas where the overburden (the sediments and water contained in the unsaturated zone, surficial aquifer system, and the confining layer above an aquifer) is thick, but the confining layer is breached or absent. Collapse sinkholes can form with little warning and leave behind a deep, steep sided hole. Subsidence sinkholes form gradually where the overburden is thin and only a veneer of sediments is overlying the limestone. Solution sinkholes form where no overburden is present and the limestone is exposed at land surface.

Sinkholes occur in many shapes, from steep-walled holes to bowl or cone shaped depressions. Sinkholes are dramatic because the land generally stays intact for a while until the underground spaces get too big. If there is not enough support for the land above the spaces, then a sudden collapse of the land surface can occur. Under natural conditions, sinkholes form slowly and expand gradually. However, human activities such as dredging, constructing reservoirs, diverting surface water, and pumping groundwater can accelerate the rate of sinkhole expansions, resulting in the abrupt formation of collapse sinkholes.

Although a sinkhole can form without warning, specific signs can signal potential development:

- Slumping or falling fence posts, trees, or foundations;
- Sudden formation of small ponds;
- Wilting vegetation;
- Discolored well water; and/or
- Structural cracks in walls, floors.

Collapses, such as the sudden formation of sinkholes, may destroy buildings, roads, and utilities. (Photo: Bettmann)

Sinkhole formation is aggravated and accelerated by urbanization. Development increases water usage, alters drainage pathways, overloads the ground surface, and redistributes soil. According to the Federal Emergency Management Agency (FEMA), the number of human-induced sinkholes has doubled since 1930, insurance claims for damages as a result of sinkholes has increased 1,200 percent from 1987 to 1991, costing nearly $100 million.

Landslides

A landslide is the downward and outward movement of slope-forming soil, rock, and vegetation, which is driven by gravity. Landslides may be triggered by both natural and human-caused changes in the environment, including heavy rain, rapid snow melt, steepening of slopes due to construction or erosion, earthquakes, volcanic eruptions, and changes in groundwater levels.

There are several types of landslides: rock falls, rock topple, slides, and flows. Rock falls are rapid movements of bedrock, which result in bouncing or rolling. A topple is a section or block of rock that rotates or tilts before falling to the slope below. Slides are movements of soil or rock along a distinct surface of rupture, which separates the slide material from the more stable underlying material. Mudflows, sometimes referred to as mudslides, mudflows, lahars or debris avalanches, are fast-moving rivers of rock, earth, and other debris saturated with water. They develop when water rapidly accumulates in the ground, such as heavy rainfall or rapid snowmelt, changing the soil into a flowing river of mud or "slurry." Slurry can flow rapidly down slopes or through channels, and can strike with little or no warning at avalanche speeds. Slurry can travel several miles from its source, growing in size as it picks up trees, cars, and other materials along the way. As the flows reach flatter ground, the mudflow spreads over a broad area where it can accumulate in thick deposits.

Landslides are typically associated with periods of heavy rainfall or rapid snow melt and tend to worsen the effects of flooding that often accompanies these events. In areas burned by forest and brush fires, a lower threshold of precipitation may initiate landslides. Some landslides move slowly and cause damage gradually, whereas others move so rapidly that they can destroy property and take lives suddenly and unexpectedly.

Among the most destructive types of debris flows are those that accompany volcanic eruptions. A spectacular example in the United States was a massive debris flow resulting from the 1980 eruptions of Mount St. Helens, Washington. Areas near the bases of many volcanoes in the Cascade Mountain Range of California, Oregon and Washington are at risk from the same types of flows during future volcanic eruptions.

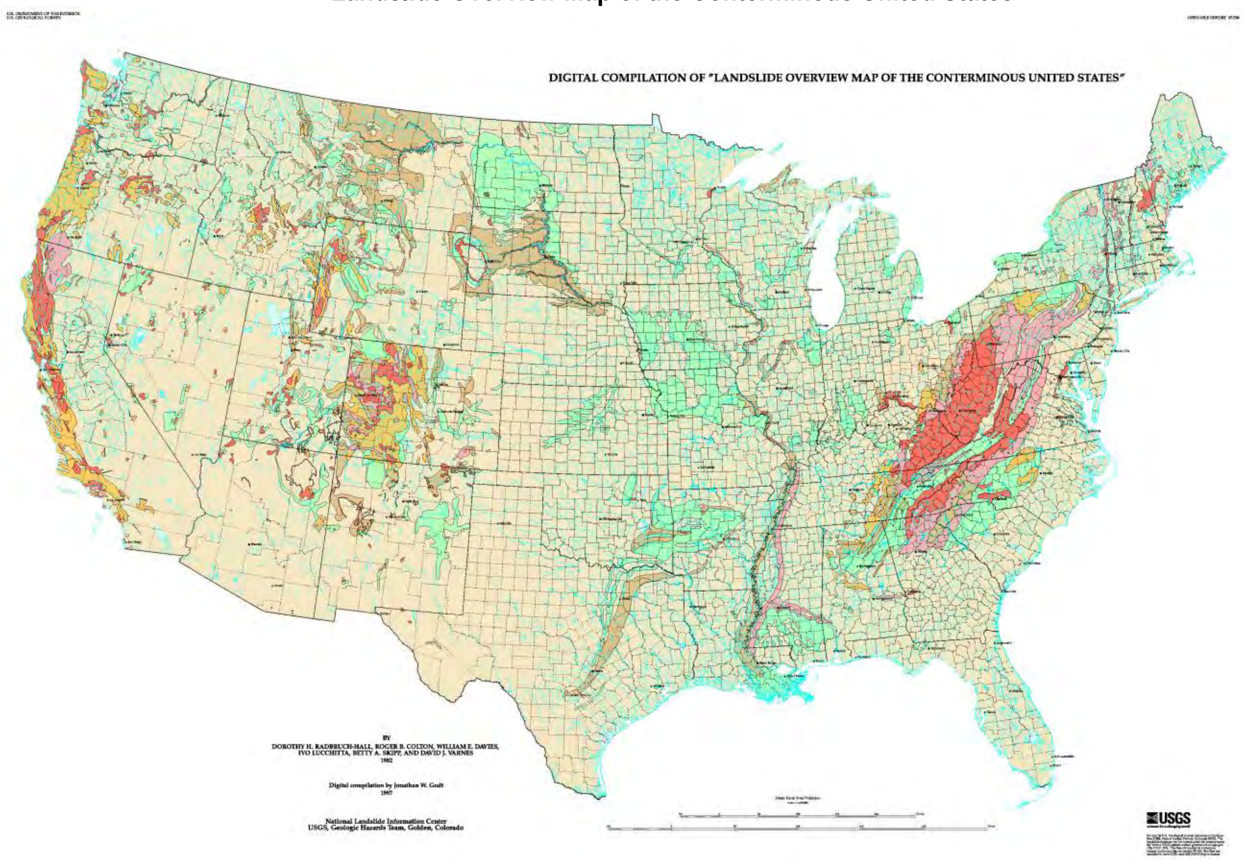
Areas that are generally prone to landslide hazards include previous landslide areas; the bases of steep slopes; the bases of drainage channels; and developed hillsides where leach-field septic systems are used. Areas that are typically considered safe from landslides include areas that have not moved in the past; relatively flat-lying areas away from sudden changes in slope; and areas at the top or along ridges, set back from the tops of slopes.

Landslides can damage or destroy roads, railroads, pipelines, electrical and telephone lines, mines, oil wells, buildings, canals, sewers, bridges, dams, seaports, airports, forests, parks, and farms. (Photo by Lynn Forman)

In the United States, it is estimated that landslides cause up to $2 billion in damages and from 25 to 50 deaths annually. Globally, landslides cause billions of dollars in damage and thousands of deaths and injuries each year.

Figure 4.1-8 delineates areas where large numbers of landslides have occurred and areas, which are susceptible to landsliding in the conterminous United States. This map layer is provided in the U.S. Geological Survey Professional Paper 1183, Landslide Overview Map of the Conterminous United States, available online at http://landslides.usgs.gov/html_files/landslides/nationalmap/national.html.

Figure 4.1-8
Landslide Overview Map of the Conterminous United States



EXPLANATION

LANDSLIDE INCIDENCE

- Low (less than 1.5% of area involved)
- Moderate (1.5%-15% of area involved)
- High (greater than 15% of area involved)

LANDSLIDE SUSCEPTIBILITY/INCIDENCE

- Moderate susceptibility/low incidence
- High susceptibility/low incidence
- High susceptibility/moderate incidence

Susceptibility not indicated where same or lower than incidence. Susceptibility to landsliding was defined as the probable degree of response of [the areal] rocks and soils to natural or artificial cutting or loading of slopes, or to anomalously high precipitation. High, moderate, and low susceptibility are delimited by the same percentages used in classifying the incidence of landsliding. Some generalization was necessary at this scale, and several small areas of high incidence and susceptibility were slightly exaggerated.

Source: United States Geological Survey

4.1.12 Tsunami

The word tsunami is Japanese and means "harbor wave." A tsunami is a series of great waves that are created by undersea disturbances such as earthquakes or volcanic eruptions. From the area of disturbance, tsunami waves will travel outward in all directions. Tsunamis can originate hundreds or even thousands of miles away from coastal areas.

The time between wave crests may be five to 90 minutes and the open ocean wave speed may average 450 miles per hour. As tsunami waves approach shallow coastal waters, they appear normal size and the speed decreases until the waves near the shoreline, where it may grow to great height and crash into the shore. Areas at greatest risk are less than 50 feet above sea level and within one mile of the shoreline. Rapid changes in the ocean water level may indicate that a tsunami is approaching. Most deaths during a tsunami are the result of drowning. Associated risks include flooding, polluted water supplies, and damaged gas lines.

Tsunami Hazard Zone signs are posted at coastal access points or other low-lying areas that would clearly be vulnerable to a large, locally generated tsunami. Signs are placed at locations agreed upon by local and state governmental authorities. Tsunami Evacuation Route markers are used to designate the evacuation routes established by local jurisdictions in cooperation with emergency management officials. (Photos courtesy of Washington State Department of Transportation)

In the United States, tsunamis have historically affected the West Coast, but the threat of tsunami inundation is also possible on the Atlantic Coast. Pacific Ocean tsunamis are classified as local, regional, or Pacific-wide. Regional tsunamis are most common. Pacific-wide tsunamis are much less common, with the last one being recorded in 1964, but are larger waves, which have high potential to cause destruction.

In 1949 the Pacific Tsunami Warning Center was established at Ewa Beach, Hawaii to monitor conditions in the Pacific Ocean and to provide warnings in case of tsunamis. According to the Pacific Tsunami Warning Center, 796 tsunamis were observed or recorded in the Pacific Ocean between 1900 and 2001. Approximately 117 caused casualties and damage and at least nine caused widespread destruction throughout the Pacific. The greatest number of tsunamis during any one-year was 19 in 1938, but all were minor and caused no damage. There was no single year of the period that was free of tsunamis.

4.1.13 Volcano

Over 75 percent of the Earth's surface above and below sea level, including the seafloors and some mountains, originated from volcanic eruption. Emissions from these volcanoes formed the Earth's oceans and atmosphere. Volcanoes can also cause tsunamis, earthquakes, and dangerous flooding.

A volcano is a vent in the Earth's crust that emits molten rock and steam. They are evidence that the physical makeup of our planet is ever-changing. Volcanoes are relatively site specific, but the molten rock, steam, and other gases they release can have an impact on much larger areas.

The May 18, 1980 eruption of Mount St. Helens created an eruptive cloud that rose to an altitude of more than 12 miles in 10 minutes. The swirling ash particles in the eruptive cloud generated lightning, which in turn ignited forest fires. Other fires were ignited by the initial blasts and later pyroclastic flows. Nearly 550 million tons of ash fell over a 22,000 square mile area. (Photo courtesy of Department of Natural Resources, State of Washington)

Lahar is the mudflow of debris and water caused by a volcano. It is also known as debris flow or volcanic mudflow. Lahar is most often triggered by rainfall washing down the debris from the slopes of volcanoes. However, lahar flows can also be triggered by rapidly melting snow and ice, debris avalanches and breakouts of lakes that were dammed by volcanic debris.

Tephra is the general term used to describe the ash and other materials that are released into the air after a volcanic eruption. Tephra ranges in size from fine powder to larger rock-sized particles. Volcanic ash can contaminate water supplies, cause electrical storms, and collapse roofs, and can affect people hundreds of miles away.

Volcanic explosions, which are directed sideways, are called lateral blasts. Lateral blasts can throw large pieces of rock at very high speeds for several miles. These explosions can kill by impact, burial, or heat and may have enough force to knock down entire forests of trees. The majority of deaths attributed to the Mount St. Helens volcano were a result of lateral blast and tree blow-down.

There are more than 500 active volcanoes in the world. More than half of these volcanoes are part of the "Ring of Fire," a region that encircles the Pacific Ocean. More than 50 volcanoes in the United States have erupted one or more times in the past 200 years. The most volcanically active regions of the nation are in Alaska, Hawaii, California, Oregon and Washington. The danger area around a volcano covers approximately a 20-mile radius. Some danger may exist 100 miles or more from a volcano.

4.1.14 Terrorism

The Federal Emergency Management Agency, in its guidance on integrating human-caused hazards into state and local hazard mitigation plans (FEMA Publication 386-7), has established a set of categories that can be applied to the profiling of intentional acts of terrorism. These categories are: contamination; energy release (i.e., explosives, arson, etc.); and disruption of a service.

4.1.15 Contamination

Contamination, as it relates to terrorist activity, refers to the intentional release of **chemical**, **biological** or **radiological** agents, as well as **nuclear** hazards. Contamination can apply to human and animal life, a geographic area, agriculture/food supplies (as in "agriterrorism"), and even the electronic world of computers and information via the Internet and e-mail (as in "**cyberterrorism**.")

Cleanup of hazardous materials and contaminated debris following a terrorist attack can be an arduous 24-hour-a-day operation, as captured in this photo of debris removal from Ground Zero of the 9/11 attack to the Staten Island landfill. (Photo by Andrea Booher/FEMA News Photo)

According to Jane's Chem-Bio Handbook, **chemical** agents are liquid or aerosol contaminants that can be dispersed using sprayers or other aerosol generators, by liquids vaporizing from puddles or containers, or munitions. Chemical agents may pose viable threats for hours to weeks depending on the agent used and the conditions, which exist at the exposed area. This type of hazard is especially volatile as contamination can be carried beyond the initial target zone by persons, vehicles, water and even the wind. Chemicals may also be corrosive or otherwise damaging *over time*, if not dealt with appropriately. **Biological** agents are liquid or solid contaminants that can be dispersed using sprayers or aerosol generators, or by point or line sources such as munitions, covert deposits or moving sprayers. Biological hazards may pose a danger for a period of hours to years, depending on the type of agent used and the conditions in which it exists. Contamination can be spread via water and/or wind, and infection can be spread via humans and/or animals.

FEMA's Radiological Emergency Management Course states that **radiological** agents can also be dispersed using sprayers or aerosol generators, or by point or line sources such as munitions, covert deposits and moving sprayers. Radiological contaminants may remain hazardous for seconds to years depending on the material used. The initial effects of a radiological attack are likely to be localized to the site of the attack; however, depending on meteorological conditions, the subsequent behavior of contaminants may become more dynamic. **Nuclear** hazards include the detonation of a nuclear device underground, on the Earth's surface, in the air, or at a high altitude. Heat flashes and blast waves resulting from a detonation would last for seconds, however nuclear radiation and fallout hazards can continue on for years. In addition, an electromagnetic pulse, resulting from a high-altitude detonation and lasting for a few seconds, can affect unprotected electronic systems. The initial light, heat and blast effects of a subsurface, ground or air burst are static and are determined by the device's characteristics. The fallout of radioactive contaminants may be dynamic depending on meteorological conditions.

Cyberterrorism is a relatively new concept. According to the National Strategy for Homeland Security, terrorists may seek to cause widespread disruption and damage, including casualties, by attacking electronic and computer networks which are linked to critical infrastructures such as energy, financial and securities networks. In addition, terrorist groups are known to exploit information technology and the Internet to plan attacks, raise funds, circulate propaganda, gather information and communicate. In terms of hazard mitigation, cyberterrorism is often explored as a component in business continuity planning.

4.1.16 Energy Release

Energy release refers primarily to the use of explosive devices, such as conventional bombs, and incendiary operations such as arson attacks. The detonation of an explosive device whether on or near a target has an instantaneous effect, which can be compounded and/or prolonged by the use of multiple devices. The extent of damage caused by an explosion is, of course, determined by the type and quantity of explosive used. It should be noted that explosive incidents can result in cascading effects, such as the incremental failure of a structure or system.

Arson and other incendiary attacks refer to the initiation of fire (which can be of an explosive nature) on or near a target. This type of event can last for minutes or hours, and possibly longer depending on the type and quantity of device or accelerant used and the materials (fuels) present at the location of the attack. This type of attack can also result in cascading failures of structures or systems.

4.1.17 Disruption of Service

Disruption of service refers to the interruption, failure or denial of a service due to terrorist attack, such as the sabotage or designed breakdown of infrastructure as with an attack on transportation facilities, utilities and other public services. While the Federal Bureau of Investigation found no evidence of terrorism or criminal activity in its investigation of the August 2003 blackout in the Northeast United States, and the paralyzing blackout in London, England the same month has been labeled a “freak event,” it is clear to see the potential damage and disruption that could be caused by intentional terrorist attack on a nation’s power grids.

4.1.18 Weapons of Mass Destruction

The term “Weapons of Mass Destruction” (WMD) has various definitions, however common to all is the assumption that WMDs may consist of any of the agents discussed above: chemical, biological, radiological, nuclear, explosive or incendiary. The purpose of a WMD is to cause death or serious injury to persons or significant damage to property, typically assumed to be of a scale, which has the potential to overwhelm the capabilities of many local and state governments.

4.1.19 Hazardous Materials (HazMat)

Hazardous materials (HazMat) incidents can apply to fixed facilities as well as mobile, transportation-related accidents in the air, by rail, on the Nation's highways and on the water. Approximately 6,774 HazMat events occur each year, 5,517 of which are highway incidents, 991 are railroad incidents and 266 are due to other causes (FEMA, 1997). In essence, HazMat incidents consist of solid, liquid and/or gaseous contaminants that are released from fixed or mobile containers, whether by accident or by design as with an intentional terrorist attack. A HazMat incident can last hours to days, while some chemicals can be corrosive or otherwise damaging over longer periods of time. In addition to the primary release, explosions and/or fires can result from a release, and contaminants can be extended beyond the initial area by persons, vehicles, water, wind and possibly wildlife as well.

Propane tanks, gasoline, oil and other hazardous materials and debris in Princeville, North Carolina were cleaned up by Environmental Protection Agency crews following Hurricane Floyd in September 1999. The town remained off limits to residents for some time due to health-related concerns. (Photo by Dave Saville/FEMA News Photo)

HazMat incidents can also occur as a result of or in tandem with natural hazard events, such as floods, hurricanes, tornadoes and earthquakes, which in addition to causing incidents can also hinder response efforts. In the case of Hurricane Floyd in September 1999, communities along the Eastern United States were faced with flooded junkyards, disturbed cemeteries, deceased livestock, floating propane tanks, uncontrolled fertilizer spills and a variety of other environmental pollutants that caused widespread toxological concern.

4.1.20 Energy Pipeline Failures

The energy infrastructure of the United States is comprised of many components, including the physical network of pipes for oil and natural gas, electricity transmission lines, and other means for transporting energy to the Nation's consumers. This infrastructure also includes facilities that convert raw natural resources into energy products, as well as the rail network, trucking lines and marine transportation. (U.S. Department of Energy, 2003) Much of this infrastructure is aging, and in addition to the challenges of keeping the infrastructure up-to-date with the latest technological advances and consumer needs, the potential for an energy pipeline failure to become a hazard in-and-of-itself must be considered.

Virtually all natural gas in the United States is moved via pipeline. (Photo courtesy of the Department of Energy)

The two million miles of oil pipelines in the United States are the principal mode for transporting oil and petroleum products such as gasoline, and virtually all natural gas in the United States is moved via pipeline as well. (DOE, 2003) Much of this oil pipeline infrastructure is old, requiring regular safety and environmental reviews to ensure its safety and reliability. The potential risk of pipeline accidents is a significant national concern.

The energy infrastructure is vulnerable to physical and cyber disruption, either of which could threaten its integrity and safety. (DOE, 2003) Disruptions could originate with natural events such as geomagnetic storms and earthquakes, or could result from accidents, equipment failures or deliberate interference. In addition, the Nation's transportation and power infrastructures have grown increasingly complex and interdependent—consequently, any disruption could have far-reaching consequences.

The preceding section included data about and description of environmental hazards from a wide variety of sources. Every attempt has been made to include the most accurate and up-to-date information about the hazards that Kent County faces and how those hazards are distributed nationwide to help provide context for the following sections. The data sources used for the preceding hazard identification are as follows:

Data Sources

American Society of Civil Engineers (ASCE), "Facts About Windstorms."
Web site: www.windhazards.org/facts.cfm

Bureau of Reclamation, U.S. Department of the Interior
Web site: www.usbr.gov

Federal Emergency Management Agency (FEMA)
Web site: www.fema.gov

National Climatic Data Center (NCDC), U.S. Department of Commerce, National Oceanic and Atmospheric Administration
Web site: http://lwf.ncdc.noaa.gov/oa/ncdc.html

National Drought Mitigation Center, University of Nebraska-Lincoln
Web site: www.drought.unl.edu/index.htm

National Severe Storms Laboratory (NSSL), U.S. Department of Commerce, National Oceanic and Atmospheric Administration
Web site: www.nssl.noaa.gov

National Weather Service (NWS), U.S. Department of Commerce, National Oceanic and Atmospheric Administration
Web site: www.nws.noaa.gov

Storm Prediction Center (SPC), U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service
Web site: www.spc.noaa.gov

The Tornado Project, St. Johnsbury, Vermont
Web site: www.tornadoproject.com

United States Department of Energy
Web site: www.energy.gov

United States Geological Survey (USGS), U.S. Department of the Interior
Web site: www.usgs.gov

4.2 Hazard Analysis

4.2.1 Introduction

Requirement §201.6(c)(2)(i): *[The risk assessment **shall** include a] description of the … location and extent of all natural hazards that can affect the jurisdiction. The plan **shall** include information on previous occurrences of hazard events and on the probability of future hazard events.*

The *Hazard Analysis* chapter provides information on historical hazard occurrences in Kent County for the hazards listed below. This listing differs slightly in terminology, order and grouping from the *Hazard Identification* section as those hazards affecting Kent County are more fully explored.

Natural

- Flood
  - Storm Surge/ Tide
  - Coastal Flooding
- Severe Winds
  - Hurricanes
  - Coastal Storms
- Thunderstorms
- Tornadoes
- Wildfire
- Drought
- Extreme Temperatures
- Hail
- Winter Storms
- Coastal Erosion
- Dam/Levee Failure
- Earthquakes
- Tsunami
- Volcano

Human-caused

- Terrorism
- Hazardous Materials (HazMat)
- Energy Pipeline Failures

Historical records, such as those available from the National Oceanic and Atmospheric Administration's National Climatic Data Center (NCDC), are used to identify the level of risk. The methodological assumption is that the data sources cited are the best data available, however not always complete. To the extent possible, other sources have been used to supplement NCDC records.

4.2.2 Flood

According to the National Climatic Data Center, 59 flood events were reported in Kent County between March 13, 1993 and July 31, 2014. These 59 events resulted in (0) deaths, (0) injuries and a total of approximately $1,874,000 in property damage (NCDC, 2014). Descriptions of major flooding events that have impacted people, property and the environment are below

Kent County, October 29, 2012, 10:00 a.m. ET through October 30, 2012, 5:00 a.m. ET
Post Tropical Storm Sandy caused an estimated $5.5 million dollars of damage across the three counties in Delaware. The damage estimates from the state were broken down to $2.8 million in New Castle County, $832,000 in Kent County and $1.9 million in Sussex County. Damages were due to tidal flooding as significant wave action resulted during multiple high tide cycles, due to increasing onshore winds prior to landfall. Damages were also due in part to inland flooding caused by excessive rainfall, as up to 10 inches of rain were reported. In addition, high winds resulted in many trees and wires coming down statewide. This created 100,000 power outages and resulted in many road closures due to downed trees and flooding. The hardest hit county was New Castle County. All power was restored by November 2nd. No direct deaths or injuries were reported in Delaware due to the storm and the overall number of traffic accidents was low because of driving restrictions.

Kent County, August 27, 2011, 8:00p.m. ET through August 28, 2011, 5:00 a.m. ET
Hurricane Irene produced heavy flooding rain, widespread tropical storm force wind gusts, a confirmed tornado near Lewes in Sussex County, moderate to severe coastal flooding and beach erosion and caused two flooding related deaths, forced evacuations near the coast over the weekend of August 27th and 28th in Delaware. About 100,000 people were evacuated from the Atlantic Coast. Numerous roadways were flooded and closed and thousands of trees were knocked down. About 100,000 utility customers lost power. In addition, chickens were killed by flooding and agricultural crops were damaged by the flooding. Delaware received federal disaster declaration.

Central Kent County, August 22, 2009, 4:15 p.m. ET
A strong cold front was approaching from the west during the 22nd, while Hurricane Bill passed well to our east. An abundance of moisture in place combined with enough instability, which resulted in showers and thunderstorms with locally torrential rainfall and flooding. Two day event precipitation totals ranged from around 1.5 to around 6.5 inches, highest in Kent County.

Southern Kent County, July 6, 2008, 2:10 p.m. ET
Thunderstorms with torrential downpours caused roadway, stream and poor drainage flooding along the Milford and Mispillion border in southern Kent County. Doppler radar storm total estimates reached 3.1 inches within an hour in that area.

Kent County, May 12, 2008, 3:00 – 6:00 a.m. ET
Early on the morning of the 12th, a storm was centered over the southern Delmarva. The prolonged northeast flow combined with higher than normal tides, caused widespread minor to moderate tidal flooding along the coast of Delaware. Heavy rain also impacted the state, especially central and southern sections. In South Bowers (Kent County), the dunes that were between the surf's edge and the elevated homes were essentially wiped away. Several boats appeared to have been missing as a result of the wind and storm surge. The homes on Route 36 before the bridge were those that were primarily affected by the flooding. West Milford (Kent County) was covered with between one and two feet of water during the storm that roared through the region on the morning of the 12th. Several downtown structures suffered minor water damage, including the Department of Health and Social Service building

on Southeast Front Street, which was closed until the 16th. In Milford (Kent County), police evacuated employees from two state service centers, one on Church Street and the other on Walnut Street, as the Mispillion River overflowed its banks starting the night of the 11th. Bicentennial Park was under water, as were portions of Washington Street, Park Avenue and North East Front Street. The flooding persisted until early on the 13th. Some 150 residents of Kent County along the Delaware Bay were evacuated from their homes early on the 12th as high winds and heavy rains from a Nor'easter caused severe coastal flooding. Some took shelter at the Little Creek Fire Hall. The coastal regions of Kitts Hummock and Pickering Beach received the brunt of the high water, with reports of flooding nearing 6 feet. About 175 people were evacuated from Kitts Hummock and about 50 from Pickering Beach

Dover and Cheswold, April 15, 2007, 11:00 a.m. ET through April 16, 2007, 6:00 a.m. ET
The heavy rain caused flooding in and around Dover. Flooding occurred along the Saint Jones River, Silver Lake and Puncheon Run within Dover. Flood waters encroached about four to five homes in the Pinewood Acres development between Dover and Cheswold. The higher than normal tides and the heavy rain caused flooding of roadways in Woodland and Bowers Beach as well as Kitts Hummock.

Coastal Kent County, November 22, 2006, 8:00 a.m. through November 23, 2006, 12:00 0a.m. ET
A northeaster brought heavy rain, strong winds, rough surf and tidal flooding to Delaware on the 22nd and 23rd (Thanksgiving Day). The rain and strong winds arrived together, just before sunrise on the 22nd. The rain fell at its steadiest and heaviest for about a 24 hour period from 7 a.m. EST on the 22nd through 7 a.m. EST on the 23rd. Storm totals averaged around two inches. The strong onshore flow caused minor tidal flooding during the morning high tides on the 22nd and 23rd. This extended into the back bays and in Delaware Bay. The strong winds also caused a pounding, heavy surf on both days.

Coastal Kent County, September 1, 2006, 1:00 p.m. through September 2, 2006, 9:00 a.m. ET
The combination of the remnants of Tropical Storm Ernesto and a large high pressure system over eastern Canada produced heavy rain and flooding, strong and in some cases damaging winds, tidal flooding and beach erosion in Delaware. Delmarva Electric reported that 151,000 of its customers along the peninsula lost power (including Delaware). All power was restored in Delaware by the night of the 4th. About 17,500 Delaware Electric Cooperative customers also lost power in Kent and Sussex Counties. Ten to twelve foot waves were crashing along the shore line and enhanced rip currents and rough surf persisted through the 5th.. In Kent County, many trees were knocked down especially in and around Dover and Smyrna. One home was damaged by a downed tree. Along Delaware Bay, a Sports Utility Vehicle was struck by large waves at Woodland Beach.

Northern Kent County, July 12, 2004, 3:30 p.m. through July 13, 2004, 2:00 a.m.
A series of thunderstorms with torrential downpours caused flooding from Clayton and Smyrna southeast through Dover. Hardest hit was Smyrna, which declared a state of emergency after 11.10 inches of rain fell. This represents approximately a once in five hundred year storm. Major roads were closed, hundreds of homes were flooded, drivers were stranded and had to be rescued, horses were rescued, fields and yards became ponds, wells became compromised and over 100 people were evacuated. Both U.S. Route 13 and Delaware State Route 1 were closed near Smyrna. The damage was estimated at $625,000. In Smyrna, a state of emergency was declared because of the flooding. Even Lake Como overflowed. The worst damage occurred along Locust Street and West North Street. Four homes were condemned (two on each street) because of collapsed basements. Over 50 families were evacuated by boat from the Holly Hill Trailer Park to the local hospital and school. Only minor damage occurred at the trailer park. Over 100 homes were flooded. Floating propane tanks were secured. Many well heads were submerged in flood waters and homeowners were urged to boil their well water before drinking or cooking. Duck Creek Shopping Plaza also flooded. Lake Como was closed to swimmers because of high bacteria count. Wheatley's

Pond overflowed. The Southern States apartment building suffered the most damage as up to eight feet of water amassed in about 20 basements. In Cheswold, there were several stranded vehicles and residents.

Dover, June 25, 2004, 4:45 p.m. ET
Thunderstorms with very heavy rain caused poor drainage and small stream flash flooding within Dover. Several vehicles became stranded on flooded roadways. Flooding affected several roadways including southern parts of Governor Avenue (U.S. Route 13A). Doppler Radar storm total estimates reached 4 inches just southwest of Dover.

Coastal Kent County, October 14, 2001, 5 p.m.-10 p.m. ET
The combination of spring astronomical tides caused by the new moon and a strong southeast onshore flow preceding a cold front produced minor tidal flooding at the time of high tide during the evening of the October 14 along the Delaware Coast and Bay. Minor tidal flooding extended into Delaware Bay and on the Delaware River as far north as New Castle County. High tide at Reedy Island (New Castle County) reached 7.49 feet above mean lower low water. (Minor tidal flooding begins at 7.2 feet above mean lower low water.) No deaths, injuries or property damage was reported.

Central Kent County, August 19, 2001, 7 p.m. ET
Thunderstorms with very heavy downpours produced flash flooding of streams and creeks in central Kent County, along with flood problems associated with poor drainage. Doppler Radar storm total estimates reached between four (4) and five (5) inches, all of which fell within three hours. Flooding from the Pratt and Hudson Branches covered U.S. Route 13 north of Felton. No deaths, injuries or significant damages were reported.

Kent County, September 16, 1999, 8:30 a.m. ET
Hurricane Floyd battered the State of Delaware with damaging winds and torrential rains that caused widespread flash flooding. Storm totals averaging around nine (9) inches fell within a 12-hour period from early morning through late afternoon. Dover Air Force Base recorded 8.44 inches. Reported property damage was $224,000.

Eastern Kent County, August 20, 1999, 12:15 p.m. ET
Thunderstorms with torrential downpours dropped as much as five (5) inches of rain, most of which fell within an hour across sections of eastern Kent County. The heaviest rain fell just northeast of Dover around Little Creek and also around Thompsonville in the southeast part of the county. Numerous roads were flooded and closed in Little Creek. Storm totals included five (5) inches in Little Creek, 1.75 inches in Milford and 1.17 inches in Dover. The latter two were west of the torrential rain bands. No deaths, injuries or significant damages were reported.

Northwest Kent County, August 10, 1998, 4:30 p.m. ET
Slow moving thunderstorms brought torrential downpours and flash flooding in the northern half of Kent County, impacting the northwestern part of the county the most severely. Doppler Radar storm total estimates reached 11.4 inches between Kenton and Hartly. Other storm totals included 8.80 inches at 2.5 miles west of Cheswold, 7.93 inches in Smyrna, 3.44 inches in Dover and 2.83 inches at the Dover Air Force Base. Streams flooded in Cheswold threatening several homes, and firefighters were forced to pump water from a number of basements in Smyrna. One foot of water was recorded on U.S. Route 13 near Smyrna. Stream flooding resulted in the closure of several roads within the county, but no washouts or damage occurred. No deaths or injuries were reported.

Coastal Kent County, February 4, 1998, 1 p.m. through February 9, 1998, 9 a.m. ET
The strongest nor'easter of the winter of '98 battered Kent County with damaging winds, severe coastal flooding, extensive beach erosion and heavy rain. Several dune breaches were reported, and tidal flooding inundated bayside homes in Woodland Beach, Port Mahon, Kitts Hummock and South Bowers. Flooding was also observed along

Delaware State Routes 6 and 9 inland. Five injuries were reported, with no known deaths. Property damage was reported at $1.7 million.

Coastal Kent County, January 28, 1998, 6 a.m. ET through January 29, 12 p.m. ET
An intense nor'easter pounded Kent County with tidal flooding, beach erosion, strong winds and heavy rain. Conditions were progressively worse closer to the coast. All roadways in beach areas were covered with water during high tide on the 28th. About 10 roads were closed due to tidal flooding near the bay. Several inland roads were closed due to heavy inland rain and flooding. Three roads were still closed through the morning high tide on the 29th. Hardest hit were the townships of Bowers Beach along the shore and Frederica inland. About 500 homes and businesses in Clayton lost power due to strong winds. No deaths or injuries were reported. Property damage was reported as $1.3 million.

Northern Kent County, June 19, 1996, 5 p.m. ET
Slow moving thunderstorms with torrential downpours washed out two bridges, caused widespread street and highway flooding, and closed many roads in the northern part of the county. The two bridges, Massey's Mill Pond Bridge and one near Cheswold, were washed out overnight. Workers labored through the night to save the U.S. Route 13 Bridge at Garrison's Lake—the lake itself had begun flooding at 7 p.m. on the 19th. Four persons were rescued from flooded cars. Flooding also forced the evacuation of a mobile home park near Hartley. The City of Dover reported 3.11 inches of rain from the event. No deaths or injuries were reported. Damages were estimated to have been $300,000 in property damage and $0 in crop damage.

City of Harrington, July 3, 1994, 5 p.m. ET
Two feet of standing water was reported, along with several road closures due to the flooding. Damages were reported to have been $100,000 in property damage and $0 in crop damage.

Coastal Kent County, March 13, 1993, 12 p.m.-3:30 p.m. ET
A major winter storm that had developed over the Gulf of Mexico moved northeast across the Mid-Atlantic region on March 13 and 14 producing a variety of inclement weather conditions. Minor coastal flooding occurred at times of high tide Saturday and early Sunday morning. Sea water, with pizza-sized chunks of ice, flooded roads in Bowers Beach. Property damage was reported as $50,000.

4.2.3 Hurricanes and Tropical Storms

Severe wind events resulting from hurricanes, tropical storms and nor'easters can cause widespread damage and loss of life, as evidenced by the numerous coastal events that have impacted the State of Delaware. Although Delaware has not experienced a direct strike from a major hurricane in more than two decades (a fact often attributed to the geographic position of North Carolina), Delaware has experienced the effects of as many as 16 hurricanes and at least one significant tropical storm since the 1920s. Details of these events are presented below. **Figure 4.2-1** graphically illustrates the paths of nine (9) storms that passed directly through Kent County since 1861.

Hurricanes and Tropical Storms[1]

Hurricane Sandy (2012)

Post Tropical Storm Sandy caused an estimated $5.5 million dollars of damage across the three counties in Delaware. The damage estimates from the state were broken down to $2.8 million in New Castle County, $832,000 in Kent County and $1.9 million in Sussex County. Damages were due to tidal flooding as significant wave action resulted during multiple high tide cycles, due to increasing onshore winds prior to landfall. Damages were also due in part to inland flooding caused by excessive rainfall, as up to 10 inches of rain were reported. In addition, high winds resulted in many trees and wires coming down statewide. This created 100,000 power outages and resulted in many road closures due to downed trees and flooding. The hardest hit county was New Castle County. All power was restored by November 2nd. No direct deaths or injuries were reported in Delaware due to the storm and the overall number of traffic accidents was low because of driving restrictions.

Hurricane Irene (2011)

Hurricane Irene Hurricane Irene produced heavy flooding rain, widespread tropical storm force wind gusts, a confirmed tornado near Lewes in Sussex County, moderate to severe coastal flooding and beach erosion and caused two flooding related deaths, forced evacuations near the coast over the weekend of August 27th and 28th in Delaware. About 100,000 people were evacuated from the Atlantic Coast. Numerous roadways were flooded and closed and thousands of trees were knocked down. About 100,000 utility customers lost power. In addition, chickens were killed by flooding and agricultural crops were damaged by the flooding. Delaware received federal disaster declaration.

Tropical Storm Hanna (2008)

Tropical Storm Hanna brought heavy rain and strong winds in Delaware and some minor tidal flooding in Delaware Bay on the 6th. Rain moved into the region during the morning, fell heavy at times in the afternoon and ended during the early evening. Storm totals ranged from around 1 to around 3.5 inches. The strongest winds occurred during the late morning and afternoon with peak gusts as high as 53 mph. About 10,000 homes and businesses lost power on the Delmarva Peninsula. All power was restored by the 7th. Minor tidal flooding occurred in Delaware Bay during the afternoon as the surge averaged two to three feet. Many planned outdoor activities were cancelled. The heavy rain caused minor roadway and low lying area flooding. The unseasonably dry weather leading into Hanna prevented stream and river flooding from occurring. The pounding surf caused about a three foot vertical cut to occur at Rehoboth Beach. Peak wind gusts included 44 mph in Dover (Kent County).

Hurricane Isabel (2003)

Isabel developed as a tropical storm September 6 about 600 miles west of the Southern Cape Verde Islands. The following day the storm was upgraded to a hurricane and within five days Isabel became the first Category 5 hurricane in the Atlantic since Hurricane Mitch in 1998. Isabel made landfall along the U.S. East Coast on September 18 as a Category 2 storm. Seven federal disaster declarations were issued as a result of Isabel, including the State of Delaware. Isabel may become best known for the wide-spread

[1] Photos courtesy of the National Aeronautics and Space Administration (NASA). Historic hurricane track graphics courtesy of the National Hurricane Center.

power outages it caused. Two days after Isabel lashed Delaware with wind and rain, approximately 60,000 of Conectiv's 280,000 customers were without power. A spokesperson for the power company said that trees falling across power lines caused most of the outages.

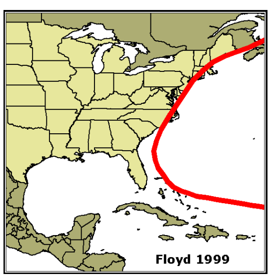
Tropical Storm Henri (Remnants—2003)

The National Weather Service reported that over a two-day period remnants of Tropical Storm Henri dumped eight (8) to 10 inches of rain in a narrow, slow-moving band that included central and northern Delaware, with 7.08 inches reported in Hockessin over a period of a few hours. Much of the region already had received above-normal rainfall in recent weeks.

Tropical Storm Allison (Remnants—2001)

Showers and thunderstorms associated with the remnants of Tropical Storm Allison dropped heavy rain across New Castle County from the mid-afternoon through the early evening of the 16th. The heavy rain caused flooding on some of the smaller steams in the county as well as some urban and poor drainage flooding. As the low moved east of the New Jersey coast during the morning of the 17th, heavy rain fell again for a couple of hours near dawn. Storm totals averaged between two (2) and four (4) inches and included 3.94 inches at the Dover Air Force Base. No serious damages or injuries were reported.

Hurricane Floyd (1999)



According to the National Climatic Data Center, one notable hurricane has impacted the State of Delaware in recent history—Hurricane Floyd, which brought torrential rains and damaging winds on September 16, 1999. The hurricane caused widespread flash flooding as storm totals averaged around nine inches (10.58 inches in Sussex County). Most of this rain fell within a 12-hour period establishing a new state record. A total of $8 million in property damage was reported, along with two fatalities—the first hurricane-related deaths in the state since Hurricane Hazel in 1954. In addition, there were a number of injuries, at least two of which were serious. Overall, the event most heavily affected New Castle County, Kent County's neighbor to the north.

Hurricane Dennis (1999)

The combination of swells from Hurricane Dennis and a stiff northeast flow caused by a strong high pressure system building over the New England States produced rip currents and minor tidal flooding. Rip currents from Dennis started along the Delaware Beaches on Sunday August 29th. About 100 rescues occurred with a few minor injuries. On the 30th, swimming was banned at most of the Delaware Beaches. As Dennis pulled east of North Carolina on the 31st and weakened, the rip currents slowly ceased. A major contributing factor to the winds and rip currents was a very strong high pressure system that built into eastern Canada and the New England States on the 30th and 31st. The northeast flow around it and Hurricane Dennis produced wind gusts up to 50 MPH on the 30th and caused some minor tidal flooding from around noon on the 30th into the afternoon of the 31st. Minor tidal flooding extended into the back bays and inlets as the northeast winds prevented the tide from receding. As both Dennis and the high pressure system weakened, tides subsided after the afternoon of the 31st. The constant pounding and strong winds did cause beach erosion.

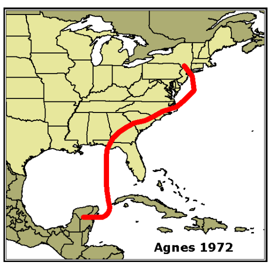
Hurricane Edouard (1996)

On August 30, 1996, a hurricane watch and tropical storm warning was issued from Cape Lookout, North Carolina northward to Cape Henlopen, Delaware (including the Pamlico and Albermarle Sounds) in preparation for the approach of Hurricane Edouard. The hurricane watch was extended northward the following day to include north of Cape Henlopen, Delaware to Plymouth, Massachusetts. Early on September 2, Edouard veered sharply toward the northeast and the center of the hurricane passed about 75 nautical miles southeast of Nantucket Island, its closest point of approach to the United States.

Tropical Storm Bertha (1996)

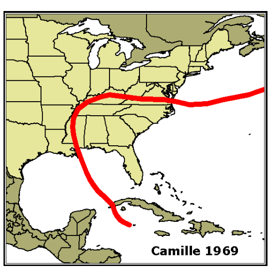
A weakening Tropical Storm Bertha passed across the state on July 13, 1996. While the long trip over land from Wilmington, North Carolina through Virginia to Delaware did weaken Bertha, some wind-related damage did occur in Kent and Sussex counties. The only tidal flooding reported was minor and occurred on Delaware State Route 54 near Fenwick Island, one of the most flood-prone roads in the state. Beach erosion was minor. The storm dropped between 1.5 and three inches of rain across most of the state, with locally higher amounts of around four inches reported in Sussex County just south of Kent County. This caused some poor drainage flooding, but the only river to flood was the Christina in New Castle County to the north.

Hurricane Agnes (1972)



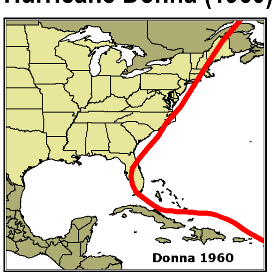
No description/details available.

Hurricane Camille (1969)



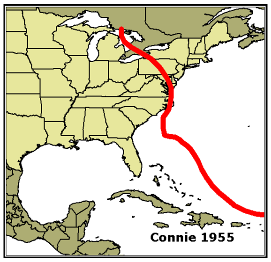
No description/details available.

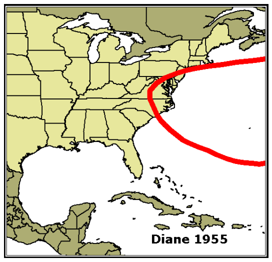
Hurricane Donna (1960)



No description/details available.

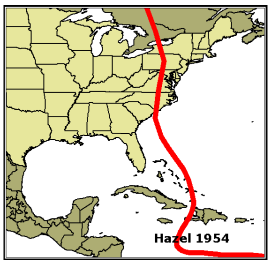
Hurricanes Connie and Diane (1955)





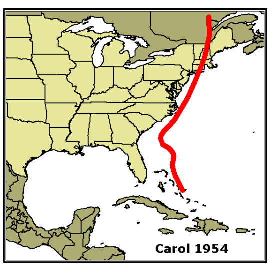
No description/details available.

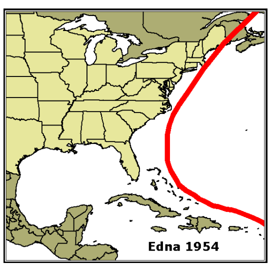
Hurricane Hazel (1954)



Hurricane Hazel was first spotted east of the Windward Islands on October 5, 1954 and by October 15 the storm had turned north and accelerated—making landfall as a Category 4 hurricane near the North Carolina-South Carolina border. Subsequent rapid motion over the next 12 hours took the storm from the coast across the eastern United States and into southeastern Canada as it became extratropical. High winds occurred over large portions of the eastern United States. Washington, D.C. reported 78 MPH sustained winds, and peak gusts of over 90 MPH occurred as far northward as inland New York State. A storm surge of up to 18 feet inundated portions of the North Carolina coast. Heavy rains of up to 11 inches occurred as far northward as Toronto, Canada resulting in severe flooding. Hazel was responsible for 95 deaths (including at least one death in Delaware) and $281 million in damage in the United States; 100 deaths and $100 million in damage in Canada; and an estimated 400 to 1,000 deaths in Haiti.

Hurricanes Carol and Edna (1954)



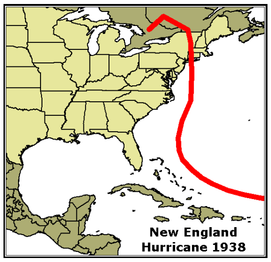


No description/details available.

Great Atlantic Hurricane (1944)

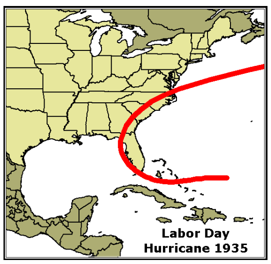
No description/details available.

New England Hurricane (1938)



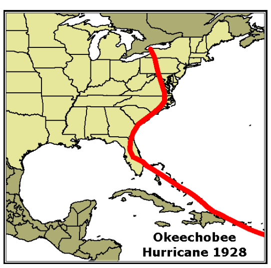
No description/details available.

Florida Keys Labor Day Hurricane (1935)



The Labor Day Hurricane of 1935 caused a bridge to collapse in the City of Milford.

San Felipe-Okeechobee Hurricane (1928)



No description/details available.

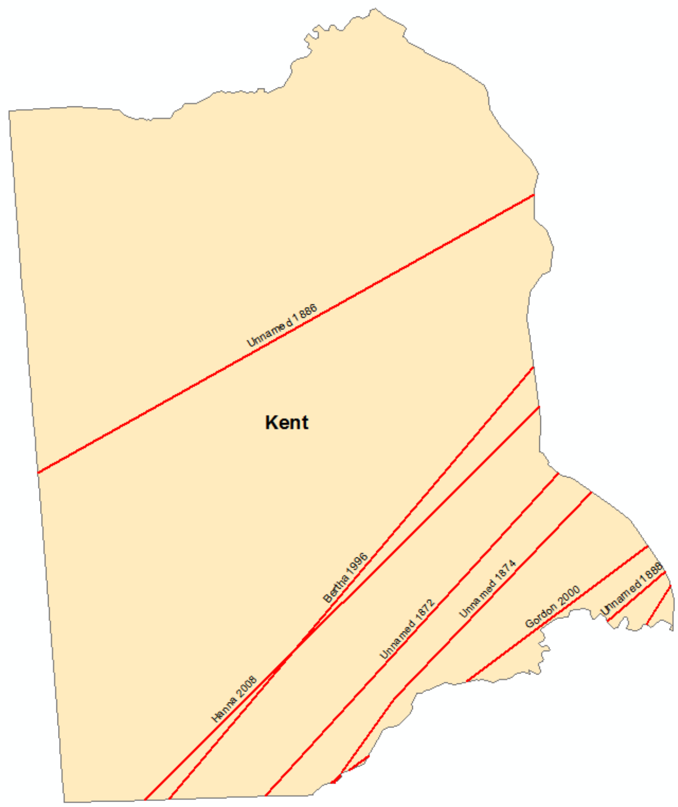
Unnamed Hurricane (1904)

The effects of this storm are known to have impacted the City of Milford to some extent.

Unnamed Tropical Storm (1877)

All that is known about this unnamed event is that it passed directly through Sussex County on October 4, 1877, just south of Kent County, with wind speeds estimated to have been in excess of 55 MPH. No information is available with regard to any property damages, injuries or deaths that may have occurred as a result of this storm.

Figure 4.2-1
Historical Coastal Storm Tracks Directly Through Kent County



4.2.4 Thunderstorms

According to the National Climatic Data Center, Kent County experienced 286 thunderstorm events, including thunderstorm wind, strong wind, lightning, and high wind for the period January 1950 through July 2014. These events resulted in 0 deaths, (1) injuries and a total of approximately $3,273,000 in property damage and $100,000 in crop damage (NCDC, 2014). **Table 4.2-1** provides a breakdown of this thunderstorm activity.

Table 4.2-1
Summary of Thunderstorm Activity in Kent County (1950-2014)

Storm Location	Date	Time	Event Specifics	Magnitude	Deaths	Injuries	Property/Crop Damage
Countywide	08/25/1958	1400	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	07/16/1961	1500	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	07/21/1962	2000	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	07/21/1962	2030	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	04/23/1963	1900	Thunderstorm/Wind	53 kts.	0	0	0
Countywide	08/26/1964	1500	Thunderstorm/Wind	58 kts.	0	0	0
Countywide	06/16/1966	2100	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	08/25/1968	2055	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	06/18/1970	1730	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	07/04/1970	1550	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	01/26/1971	1245	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	01/26/1971	1400	Thunderstorm/Wind	50 kts.	0	0	0
Countywide	05/12/1974	1545	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	09/03/1974	1817	Thunderstorm/Wind	52 kts.	0	0	0
Countywide	12/01/1974	1852	Thunderstorm/Wind	53 kts.	0	0	0
Countywide	04/03/1975	0830	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	06/19/1975	2100	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	03/13/1976	1100	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	07/06/1977	1700	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	06/03/1980	1533	Thunderstorm/Wind	58 kts.	0	0	0
Countywide	06/03/1980	1540	Thunderstorm/Wind	60 kts.	0	0	0
Countywide	06/15/1980	1900	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	08/03/1980	1700	Thunderstorm/Wind	52 kts.	0	0	0

Storm Location	Date	Time	Event Specifics	Magnitude	Deaths	Injuries	Property/Crop Damage
Countywide	08/11/1980	2100	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	07/21/1981	1500	Thunderstorm/Wind	50 kts.	0	0	0
Countywide	04/03/1982	1720	Thunderstorm/Wind	55 kts.	0	0	0
Countywide	06/16/1982	2215	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	06/16/1982	2230	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	06/16/1982	2245	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	06/16/1982	2300	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	05/15/1983	1430	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	05/15/1983	1430	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	07/21/1983	1905	Thunderstorm/Wind	62 kts.	0	0	0
Countywide	07/21/1983	1930	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	08/11/1983	1800	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	08/22/1983	1930	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	11/15/1983	1730	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	05/08/1984	1620	Thunderstorm/Wind	55 kts.	0	0	0
Countywide	09/03/1984	1830	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	09/03/1984	1830	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	07/31/1985	1640	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	07/12/1987	1110	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	07/21/1987	1700	Thunderstorm/Wind	70 kts.	0	0	0
Countywide	06/07/1988	1449	Thunderstorm/Wind	57 kts.	0	0	0
Countywide	08/15/1988	1800	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	08/15/1988	1800	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	03/18/1989	1515	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	06/15/1989	1815	Thunderstorm/Wind	57 kts.	0	0	0
Countywide	11/16/1989	0800	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	02/23/1990	2130	Thunderstorm/Wind	0 kts.	0	1	0
Countywide	06/08/1990	1708	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	07/10/1990	1820	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	07/10/1992	1743	Thunderstorm/Wind	0 kts.	0	0	0

Storm Location	Date	Time	Event Specifics	Magnitude	Deaths	Injuries	Property/Crop Damage
Harrington	04/26/1993	1445	Thunderstorm Wind	N/A	0	0	$50,000
Dover/Cheswold	06/27/1994	1200	Thunderstorm Wind	N/A	0	0	0
Felton	07/27/1994	1850	Thunderstorm Wind	N/A	0	0	$200,000
Countywide	11/11/1995	1900	High Wind	0 kts.	0	0	0
Countywide	01/19/1996	08:00 AM	High Wind	52 kts.	0	0	0
Countywide	03/19/1996	05:10 PM	High Wind	0 kts.	0	0	0
Dover	04/30/1996	04:00 PM	Thunderstorm/Wind	0 kts.	0	0	0
Smyrna	02/22/1997	01:20 PM	Thunderstorm/Wind	0 kts.	0	0	0
Camden	02/22/1997	01:35 PM	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	03/06/1997	05:00 AM	High Wind	0 kts.	0	0	0
Countywide	03/31/1997	08:00 AM	Wind	N/A	0	0	0
Countywide	04/01/1997	12:00 AM	Wind	N/A	0	0	0
Smyrna	06/22/1997	04:30 PM	Thunderstorm/Wind	0 kts.	0	0	0
Smyrna	06/22/1997	04:30 PM	Lightning	N/A	0	0	0
Milford	08/17/1997	05:30 PM	Lightning	N/A	0	0	0
Countywide	01/28/1998	04:00 AM	Wind	N/A	0	0	0
Countywide	02/04/1998	10:00 AM	High Wind	70 kts.	0	0	0
Countywide	02/25/1998	06:00 AM	Wind	N/A	0	0	0
Harrington	05/06/1998	04:30 PM	Lightning	N/A	0	0	0
Countywide	06/01/1998	12:30 AM	Thunderstorm/Wind	50 kts.	0	0	0
Hartly	06/13/1998	04:33 PM	Thunderstorm/Wind	50 kts.	0	0	0
Milford	06/16/1998	07:45 PM	Thunderstorm/Wind	50 kts.	0	0	0
Dover	06/26/1998	04:00 PM	Thunderstorm/Wind	70 kts.	0	0	$1,500,000
Marydel	06/26/1998	05:25 PM	Thunderstorm/Wind	50 kts.	0	0	0
Smyrna	08/10/1998	03:30 PM	Lightning	N/A	0	0	0
Viola	08/18/1998	04:50 PM	Thunderstorm/Wind	50 kts.	0	0	0
Camden	09/02/1998	08:20 AM	Thunderstorm/Wind	50 kts.	0	0	0
Countywide	12/22/1998	07:00 AM	Wind	N/A	0	0	0
Countywide	12/30/1998	07:00 AM	Wind	N/A	0	0	0
Countywide	01/03/1999	05:00 AM	Wind	N/A	0	0	0

Storm Location	Date	Time	Event Specifics	Magnitude	Deaths	Injuries	Property/Crop Damage
Countywide	03/04/1999	04:00 AM	Wind	N/A	0	0	0
Countywide	03/07/1999	04:00 AM	Wind	N/A	0	0	0
Countywide	03/18/1999	09:00 AM	Wind	N/A	0	0	0
Cheswold	04/09/1999	06:45 PM	Lightning	N/A	0	0	0
Countywide	09/16/1999	03:00 AM	High Wind	57 kts.	0	0	0
Countywide	11/02/1999	02:00 PM	High Wind	50 kts.	0	0	0
Countywide	01/11/2000	11:00 AM	Wind	N/A	0	0	0
Countywide	01/13/2000	01:00 PM	Wind	N/A	0	0	0
Canterbury	02/25/2000	06:00 PM	Thunderstorm/Wind	0 kts.	0	0	0
Countywide	04/08/2000	11:00 AM	Wind	N/A	0	0	0
Countywide	04/09/2000	04:00 AM	Wind	N/A	0	0	0
Dover	05/13/2000	07:45 PM	Thunderstorm/Wind	50 kts.	0	0	0
Petersburg	05/13/2000	08:00 PM	Thunderstorm/Wind	50 kts.	0	0	0
Dover	06/02/2000	07:20 PM	Thunderstorm/Wind	50 kts.	0	0	0
Smyrna	06/26/2000	01:00 AM	Thunderstorm/Wind	52 kts.	0	0	0
Dover	08/16/2000	04:30 AM	Lightning	N/A	0	0	0
Marydel	09/19/2000	02:15 PM	Thunderstorm/Wind	50 kts.	0	0	0
Countywide	11/10/2000	04:45 AM	High Wind	0 kts.	0	0	0
Countywide	12/12/2000	08:30 AM	High Wind	50 kts.	0	0	0
Countywide	12/17/2000	03:00 AM	Wind	N/A	0	0	0
Countywide	02/10/2001	06:00 AM	Wind	N/A	0	0	0
Smyrna	04/09/2001	08:10 PM	Thunderstorm/Wind	52 kts.	0	0	0
Countywide	09/04/2001	07:15 PM	Thunderstorm/Wind	52 kts.	0	0	0
Countywide	01/13/2002	07:00 AM	Wind	N/A	0	0	0
Countywide	02/04/2002	03:00 PM	Wind	N/A	0	0	0
Countywide	03/10/2002	06:00 AM	Wind	N/A	0	0	0
Countywide	03/21/2002	08:00 PM	Wind	N/A	0	0	0
Leipsic	04/28/2002	09:25 PM	Thunderstorm/Wind	50 kts.	0	0	0
Blackiston	05/12/2002	05:12 PM	Thunderstorm/Wind	50 kts.	0	0	0
Dover AFB	05/12/2002	07:09 PM	Thunderstorm/Wind	74 kts.	0	0	0

Storm Location	Date	Time	Event Specifics	Magnitude	Deaths	Injuries	Property/Crop Damage
Countywide	01/20/2003	12:00 PM	Strong Wind	N/A	0	0	$100
Countywide	02/04/2003	01:00 PM	Strong Wind	N/A	0	0	$250
Countywide	02/12/2003	08:00 AM	Strong Wind	N/A	0	0	$250
Countywide	02/23/2003	12:00 PM	Strong Wind	N/A	0	0	$250
Countywide	05/12/2003	11:00 AM	Strong Wind	N/A	0	0	$2,000
Frederica	06/21/2003	06:15 PM	Lightning	N/A	0	0	$80,000
Hartly	08/17/2003	12:45 AM	Lightning	N/A	0	0	$10,000
Countywide	10/15/2003	09:00 AM	Strong Wind	40 kts.	0	0	$1,000
Countywide	11/13/2003	07:00 AM	High Wind	61 kts.	0	1	$25,000
Countywide	11/19/2003	01:00 PM	Strong Wind	40 kts.	0	0	$4,000
Countywide	11/29/2003	12:00 PM	Strong Wind	40 kts.	0	0	$1,000
Countywide	04/04/2004	08:00 PM	Strong Wind	40 kts.	0	0	$1,000
Felton	05/25/2004	08:30 PM	Lightning	N/A	0	0	$10,000
Smyrna	07/12/2004	02:30 PM	Lightning	N/A	0	0	$10,000
Countywide	11/05/2004	04:00 AM	Strong Wind	41 kts.	0	0	$1,000
Countywide	12/01/2004	09:00 AM	Strong Wind	46 kts.	0	0	$20,000
Countywide	12/19/2004	11:00 PM	Strong Wind	45 kts.	0	0	$1,000
Countywide	03/02/2005	07:00 AM	Strong Wind	31 kts.	0	0	$50,000
Countywide	03/08/2005	11:00 AM	Strong Wind	45 kts.	0	0	$1,000
Countywide	04/02/2005	12:00 PM	Strong Wind	40 kts.	0	0	$2,000
Milford	06/22/2005	07:30 PM	Lightning	N/A	0	0	$3,000
Countywide	11/10/2005	03:00 AM	Strong Wind	40 kts.	0	0	$1,000
Countywide	11/22/2005	10:00 AM	Strong Wind	40 kts.	0	0	$1,000
Countywide	01/14/2006	05:00 PM	High Wind	62 kts.	0	0	$5,000
Countywide	01/18/2006	05:00 AM	Strong Wind	40 kts.	0	0	$50,000
Countywide	01/18/2006	05:00 AM	High Wind	50 kts.	0	0	$5,000
Countywide	02/12/2006	01:00 AM	Strong Wind	40 kts.	0	0	$2,000
Countywide	02/17/2006	07:00 AM	Strong Wind	40 kts.	0	0	$3,000
Countywide	02/24/2006	07:00 AM	Strong Wind	40 kts.	0	0	$2,000
Countywide	03/14/2006	10:00 AM	Strong Wind	40 kts.	0	0	$1,000

Storm Location	Date	Time	Event Specifics	Magnitude	Deaths	Injuries	Property/Crop Damage
Countywide	03/15/2006	07:00 AM	Strong Wind	40 kts.	0	0	$1,000
Countywide	04/05/2006	07:00 AM	High Wind	51 kts.	0	0	$5,000
Countywide	09/01/2006	02:00 AM	Strong Wind	41 kts.	0	0	$50,000
Countywide	09/01/2006	01:00 PM	Strong Wind	54 kts.	0	0	$50,000
Countywide	09/01/2006	10:00 PM	High Wind	54 kts.	0	0	$100,000
Countywide	10/20/2006	12:00 PM	Strong Wind	40 kts.	0	0	$1,000
Countywide	10/29/2006	03:00 AM	Strong Wind	44 kts.	0	0	$1,000
Countywide	11/16/2006	12:00 PM	Strong Wind	40 kts.	0	0	$1,000
Countywide	12/01/2006	03:00 PM	Strong Wind	40 kts.	0	0	$3,000
Countywide	01/20/2007	07:00 AM	Strong Wind	40 kts.	0	0	$1,000
Countywide	02/14/2007	03:00 PM	Strong Wind	40 kts.	0	0	$2,000
Countywide	02/23/2007	12:00 AM	Strong Wind	40 kts.	0	0	$1,000
Countywide	03/02/2007	05:30 AM	Strong Wind	41 kts.	0	0	$1,000
Countywide	03/05/2007	02:00 PM	Strong Wind	40 kts.	0	0	$1,000
Countywide	04/16/2007	03:00 AM	Strong Wind	43 kts.	0	0	$1,000
Countywide	12/03/2007	10:00 AM	Strong Wind	47 kts.	0	0	$1,000
Countywide	12/16/2007	06:00 PM	Strong Wind	40 kts.	0	0	$1,000
Countywide	01/30/2008	09:00 AM	Strong Wind	43 kts.	0	0	$2,500
Countywide	02/10/2008	11:00 AM	Strong Wind	48 kts.	0	0	$5,000
Countywide	03/08/2008	04:00 PM	Strong Wind	42 kts.	0	0	$50,000
Countywide	03/20/2008	04:00 AM	Strong Wind	40 kts.	0	0	$1,000
Countywide	05/12/2008	03:00 AM	High Wind	52 kts.	0	0	$50,000
Dover	09/09/2008	11:32 AM	Lightning	N/A	0	0	$5,000
Countywide	10/28/2008	12:00 PM	High Wind	55 kts.	0	0	$5,000
Countywide	12/07/2008	10:00 AM	Strong Wind	40 kts.	0	0	$1,250
Countywide	12/11/2008	10:00 PM	Strong Wind	40 kts.	0	0	$1,000
Countywide	12/21/2008	09:00 PM	Strong Wind	40 kts.	0	0	$4,000
Countywide	12/24/2008	08:00 PM	Strong Wind	40 kts.	0	0	$250
Countywide	12/31/2008	12:00 PM	High Wind	64 kts.	0	0	$25,000
Countywide	02/12/2009	07:00 AM	High Wind	50 kts.	0	0	$25,000

Storm Location	Date	Time	Event Specifics	Magnitude	Deaths	Injuries	Property/Crop Damage
Countywide	02/19/2009	02:00 PM	Strong Wind	40 kts.	0	0	$500
Countywide	02/22/2009	01:00 PM	Strong Wind	40 kts.	0	0	$250
Countywide	03/02/2009	12:00 AM	High Wind	54 kts.	0	0	$10,000
Countywide	04/03/2009	07:00 PM	Strong Wind	40 kts.	0	0	$1,250
Little Creek	04/06/2009	06:15 AM	Lightning	N/A	0	0	$1,000
Countywide	04/15/2009	01:00 PM	Strong Wind	40 kts.	0	0	$1,000
Blackiston	06/09/2009	05:13 PM	Thunderstorm Wind	56 kts.	0	0	$100,000
Vernon	06/13/2009	04:00 PM	Thunderstorm Wind	70 kts.	0	0	$100,000
Countywide	09/10/2009	11:00 PM	Strong Wind	40 kts	0	0	$10,000
Countywide	10/07/2009	08:00 AM	Strong Wind	40 kts	0	0	$1,000
Countywide	12/09/2009	06:00 AM	Strong Wind	40 kts	0	0	$1,250
Countywide	01/02/2010	10:00 PM	Strong Wind	42 kts	0	0	$6,250
Countywide	01/25/2010	06:00 AM	Strong Wind	45 kts	0	0	$5,000
Countywide	03/13/2010	05:00 AM	High Wind	50 kts	0	0	$10,000
Countywide	05/08/2010	02:00 PM	Strong Wind	42 kts	0	0	$2,500
Harrington	06/28/2010	03:10 PM	Thunderstorm Wind	50 kts	0	0	$10,000
Countywide	09/30/2010	09:00 AM	Strong Wind	35 kts	0	0	$1,250
Countywide	11/17/2010	09:00 AM	Strong Wind	40 kts	0	0	$1,250
Countywide	12/01/2010	07:00 AM	Strong Wind	40 kts	0	0	$1,250
Countywide	12/26/2010	05:00 PM	Strong Wind	42 kts	0	0	$6,250
Countywide	02/08/2010	09:00 AM	Strong Wind	40 kts	0	0	$1,250
Countywide	02/14/2011	01:00 PM	Strong Wind	42 kts	0	0	$1,250
Countywide	02/19/2011	12:00 PM	High Wind	50 kts	0	0	$10,000
Countywide	02/25/2011	03:00 PM	High Wind	55 kts	0	0	$25,000
Countywide	03/10/2011	04:00 PM	Strong Wind	40 kts	0	0	$3,000
Countywide	04/05/2011	04:00 AM	Strong Wind	43 kts	0	0	$1,250
Countywide	04/16/2011	03:00 PM	Strong Wind	40 kts	0	0	$6,250
Countywide	04/28/2011	08:00 AM	Strong Wind	45 kts	0	0	$1,330
Farmington	06/10/2011	12:00 AM	Lightning	N/A	0	0	$200,000
Clayton	08/19/2011	02:00 PM	Thunderstorm Wind	52 kts	0	0	$10,000

Storm Location	Date	Time	Event Specifics	Magnitude	Deaths	Injuries	Property/Crop Damage
Countywide	10/29/2011	09:00 AM	Strong Wind	41 kts	0	0	$10,000
Countywide	12/07/2011	09:00 PM	Strong Wind	40 kts	0	0	$5,000
Countywide	12/27/2011	04:00 PM	Strong Wind	40 kts	0	0	$5,250
Countywide	12/28/2011	09:00 AM	Strong Wind	40 kts	0	0	$1,250
Countywide	01/02/2012	04:00 AM	Strong Wind	40 kts	0	0	$1,250
Countywide	01/03/2012	10:00 AM	Strong Wind	40 kts	0	0	$1,330
Countywide	01/13/2012	04:00 AM	Strong Wind	40 kts	0	0	$1,000
Countywide	01/18/2012	02:30 AM	Strong Wind	40 kts	0	0	$1,250
Countywide	01/27/2012	02:00 PM	Strong Wind	40 kts	0	0	$1,000
Countywide	02/24/2012	10:00 PM	Strong Wind	40 kts	0	0	$2,500
Countywide	03/08/2012	11:00 AM	Strong Wind	40 kts	0	0	$250
Countywide	03/26/2012	11:00 AM	Strong Wind	40 kts	0	0	$500
Sandtown	06/29/2012	10:57 PM	Thunderstorm Wind	61 kts	0	0	$50,000
Smyrna	07/18/2012	05:07 PM	Thunderstorm Wind	52 kts	0	0	$1,000
Marydel	09/08/2012	04:25 PM	Thunderstorm Wind	52 kts	0	0	$1,000
Countywide	09/18/2012	10:00 AM	Strong Wind	40 kts	0	0	$2,500
Countywide	10/29/2012	04:00 PM	High Wind	51 kts	0	0	$132,000
Countywide	12/21/2012	01:00 AM	Strong Wind	40 kts	0	0	$1,000
Countywide	12/22/2012	09:00 AM	Strong Wind	40 kts	0	0	$1,250
Countywide	12/26/2012	06:00 PM	High Wind	56 kts	0	0	$5,000
Countywide	12/27/2012	10:00 AM	Strong Wind	40 kts	0	0	$1,250
Countywide	12/30/2012	09:00 AM	Strong Wind	40 kts	0	0	$1,000
Countywide	01/30/2012	11:00 PM	Strong Wind	49 kts	0	0	$2,500
Countywide	02/09/2012	01:00 AM	Strong Wind	41 kts	0	0	$1,000
Countywide	02/17/2012	12:00 PM	Strong Wind	40 kts	0	0	$1,250
Countywide	03/06/2012	11:00 AM	High Wind	50 kts	0	0	$10,000
Countywide	05/25/2012	09:00 AM	Strong Wind	40 kts	0	0	$1,250
Countywide	11/24/2013	06:00 AM	Strong Wind	40 kts	0	0	$2,500
Countywide	01/06/2014	07:30 AM	Strong Wind	40 kts	0	0	$1,000
Countywide	02/13/2014	05:30 AM	Strong Wind	45 kts	0	0	$2,000

Storm Location	Date	Time	Event Specifics	Magnitude	Deaths	Injuries	Property/Crop Damage
Dover	02/21/2014	01:40 PM	Thunderstorm Wind	50 kts	0	0	$1,000
Countywide	02/27/2014	02:00 PM	Strong Wind	40 kts	0	0	$500
Countywide	03/12/2014	08:00 PM	Strong Wind	43 kts	0	0	$2,000
Countywide	04/15/2014	03:00 PM	Strong Wind	40 kts	0	0	$1,000
Marydel	07/02/2014	11:21 PM	Thunderstorm Wind	52 kts	0	0	$1,000
Hartly	07/02/2014	11:29 PM	Thunderstorm Wind	52 kts	0	0	$25,000
Smyrna	07/02/2014	11:35 PM	Thunderstorm Wind	56 kts	0	0	$25,000
				TOTALS:	**0**	**1**	**$3,273,010**

Source: National Climatic Data Center

4.2.5 Tornadoes

In an assessment conducted by the National Weather Service Storm Prediction Center covering the 30 year period from 1980 to 2009, the State of Delaware ranked #45 in the Nation for number of tornadoes (31), #30 in number of fatalities (2), #36 in number of F2 or greater tornadoes (7)

Independent of the Storm Prediction Center state ranking project, the National Climatic Data Center indicates that the geographic area of the State of Delaware experienced 60 tornado events from January 1, 1950 through July 31, 2014. NCDC data supports the statistics of two deaths and (74) injuries, and reflects a total of approximately $13 million in property damage, with an additional $5,000 in crop damage. In addition, The Tornado Project (www.tornadoproject.com) has identified 16 tornadoes that occurred prior to 1950, dating as far back as 1789.

Table 4.2-2 lists 20 tornadoes that were reported to the National Climatic Data Center as having touched down in Kent County. These events are responsible for (2) deaths, (56) injuries and $5,158,000 in property damages in the county.

Table 4.2-2
Summary of Tornado Activity in Kent County (1950-2014)

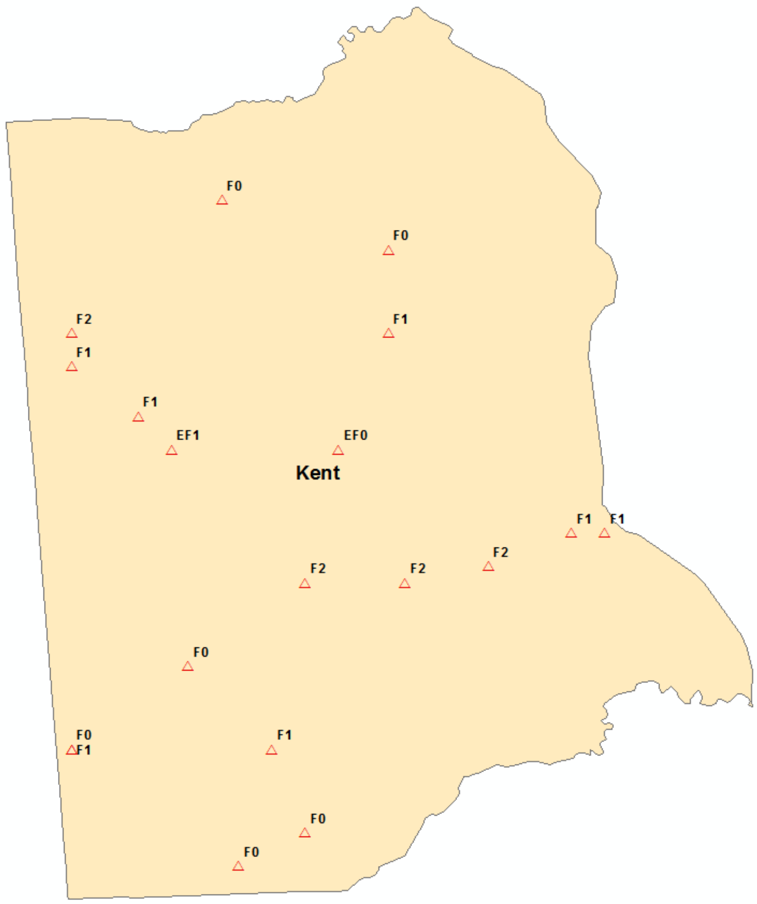
Tornado Location	Date	Time	Magnitude	Deaths	Injuries	Property Damage
County	03/26/1964	02:00 PM	F1	0	0	$3,000
County	01/27/1967	01:30 PM	F2	0	7	$250,000
County	04/03/1975	09:30 AM	F1	0	3	$250,000
County	08/04/1975	06:30 PM	F0	0	0	0
County	03/13/1977	06:20 PM	F1	0	0	$25,000
County	06/09/1977	09:57 AM	F2	0	1	$250,000

Tornado Location	Date	Time	Magnitude	Deaths	Injuries	Property Damage
County	07/21/1983	06:50 PM	F2	2	9	$250,000
County	06/07/1988	02:35 PM	F1	0	30	$2,500,000
County	07/08/1991	01:15 PM	F0	0	0	$250,000
County	07/31/1992	05:00 PM	F1	0	0	$25,000
County	07/31/1992	05:20 PM	F2	0	0	$250,000
Harrington	04/01/1993	07:20 PM	F0	0	0	$5,000
Bowers Beach	04/01/1993	07:47 PM	F1	0	0	$50,000
Petersburg	06/27/1994	12:00 PM	F1	0	0	0
Farmington	07/27/1994	06:35 PM	F0	0	4	$200,000
Harrington	07/27/1994	06:40 PM	F1	0	0	$400,000
County	07/27/1994	06:47 PM	F0	0	0	$200,000
Leipsic	07/12/2004	03:10 PM	F0	0	0	0
Wyoming	09/03/2012	02:20 PM	EF0	0	0	$100,000
Marydel	05/22/2014	03:54 PM	EF1	0	2	$150,000
			TOTALS	**2**	**56**	**$5,158,000**

Source: National Climatic Data Center

Figure 4.2-2 illustrates graphically historical tornado occurrences within Kent County.

Figure 4.2-2
Historical Tornado Occurrences (1950 – 2014)



4.2.6 Wildfire

According to the Delaware Fire Service, the greatest wildfire danger is in those marshes along the Delaware Bay that contain large amounts of phragmites. One such example is the 400 acre fire that occurred at Prime Hook in 2002. Otherwise, the climate, forest types and terrain (flat, interspersed with cropland, ditches, roads, etc.) in Delaware do not promote large wildfires. Most of the wildfires within the state are small, ground fires that are fairly easily extinguished and seldom do much damage. (Austin Short, Delaware Forest Service, austin.short@state.de.us).

Table 4.2-3
Summary of Wildfire Events in Kent County (1950-2014)

Location	Date	Time	Area(s) Affected	Acres Affected	Injuries
Farmington	08/22/2002	01:00 PM	Along Flatiron Road in Farmington	500	0
Little Creek	04/17/2005	09:20 AM	Port Mahon Road	400	0

Source: National Climatic Data Center

4.2.7 Drought

According to the National Climatic Data Center, Kent County has experienced 53 reported droughts and/or periods of unseasonably dry weather from 1950 through July 2014, most of which affected the entire forecast zone of New Castle, Kent and Sussex counties.

All crop damage reported for this period ($8 million) is tied to a single event—the drought that gripped the Middle Atlantic States throughout much of the growing season of 1999, which eased in mid-August of that year. Normal, and in some cases heavier than normal, rainfall returned, and on September 8 Governor Thomas Carper lifted the mandatory watering restrictions in northern Delaware. The drought, for all intents and purposes, ended with the arrival of the record-breaking rain associated with Hurricane Floyd on September 16. As much as 10.5 inches of rain (or about three months worth of normal rainfall) fell from Floyd across Delaware. The drought emergency was lifted by Governor Carper on September 21, however the heavy rain came too late to help farmers. Agricultural losses throughout the state were estimated at $29.1 million. The 1999 corn harvest was 2.6 million bushels less than 1998 and the smallest crop since 1988. The soybean harvest in 1999 was 1.9 million bushels less than 1998 and the smallest harvest since 1995. The drought also greatly affected pastures and produced a later and smaller than usual pumpkin crop.

4.2.8 Extreme Temperature

According to the National Climatic Data Center, Kent County has experienced 95 reported cases of either extreme heat or extreme cold, including cold/wind chill, excessive heat, extreme cold/ wind chill, freezing fog, frost/ freeze, and heat, from 1995 through July 2014 (**Table 4.2-4**). These heat waves and cold snaps have caused 3 deaths, 6 injuries, and no reported damage.

Table 4.2-4
Summary of Extreme Temperature Occurrences in Kent County (1995-2014)

Storm Location	Date	Time	Type	Deaths	Injuries	Property Damage
Countywide	02/04/1996	06:00 PM	Extreme Cold	0	0	0
Countywide	05/19/1996	10:00 AM	Excessive Heat	0	0	0
Countywide	01/03/1997	10:00 AM	Unseasonably Warm	0	0	0
Countywide	01/17/1997	01:00 AM	Extreme Cold	0	0	0
Countywide	02/19/1997	11:00 AM	Unseasonably Warm	0	0	0
Countywide	02/26/1997	12:00 PM	Unseasonably Warm	0	0	0
Countywide	02/28/1997	11:59 PM	Unseasonably Warm	0	0	0
Countywide	03/01/1997	12:00 AM	Unseasonably Warm	0	0	0
Countywide	04/09/1997	01:00 AM	Unseasonably Cold	0	0	0
Countywide	06/21/1997	09:00 AM	Excessive Heat	0	0	0
Countywide	07/12/1997	10:00 AM	Excessive Heat	0	0	0
Countywide	08/16/1997	09:00 AM	Excessive Heat	0	0	0
Countywide	01/04/1998	10:00 AM	Unseasonably Warm	0	0	0
Countywide	01/31/1998	11:59 PM	Unseasonably Warm	0	0	0
Countywide	02/28/1998	11:59 PM	Unseasonably Warm	0	0	0
Countywide	03/27/1998	10:00 AM	Unseasonably Warm	0	0	0
Countywide	06/25/1998	09:00 AM	Hot Spell	0	0	0
Countywide	07/20/1998	09:00 AM	Excessive Heat	0	0	0
Countywide	08/22/1998	10:00 AM	Heat Wave	0	0	0
Countywide	09/27/1998	09:00 AM	Unseasonably Hot	0	0	0
Countywide	09/30/1998	11:59 PM	Unseasonably Warm And Dry	0	0	0
Countywide	11/28/1998	10:00 AM	Unseasonably Warm	0	0	0
Countywide	12/01/1998	12:00 AM	Unseasonably Warm	0	0	0
Countywide	12/31/1998	11:59 PM	Unseasonably Warm And Dry	0	0	0
Countywide	06/07/1999	09:00 AM	Excessive Heat	0	0	0
Countywide	07/04/1999	08:00 AM	Excessive Heat	0	0	0
Countywide	07/16/1999	09:00 AM	Excessive Heat	0	0	0
Countywide	07/23/1999	09:00 AM	Excessive Heat	0	3	0

Storm Location	Date	Time	Type	Deaths	Injuries	Property Damage
Countywide	07/31/1999	11:59 PM	Unseasonably Warm And Dry	0	0	0
Countywide	08/01/1999	12:00 AM	Excessive Heat	0	0	0
Countywide	11/30/1999	11:59 PM	Unseasonably Warm	0	0	0
Countywide	01/02/2000	10:00 AM	Unseasonably Warm	0	0	0
Countywide	01/23/2000	08:30 PM	Freezing Fog	0	0	0
Countywide	03/08/2000	10:00 AM	Unseasonably Warm	0	0	0
Countywide	03/31/2000	11:59 PM	Unseasonably Warm/wet	0	0	0
Countywide	05/02/2001	11:00 AM	Unseasonably Hot	0	0	0
Countywide	08/06/2001	09:00 AM	Excessive Heat	0	0	0
Countywide	11/30/2001	11:59 PM	Unseasonably Warm	0	0	0
Countywide	12/01/2001	08:00 AM	Unseasonably Warm	0	0	0
Countywide	12/31/2001	11:59 PM	Unseasonably Warm	0	0	0
Countywide	01/27/2002	06:00 PM	Unseasonably Warm	0	0	0
Countywide	02/28/2002	11:59 PM	Unseasonably Warm	0	0	0
Countywide	06/24/2002	09:00 AM	Excessive Heat	0	0	0
Countywide	07/01/2002	09:00 AM	Excessive Heat	0	0	0
Countywide	07/15/2002	09:00 AM	Excessive Heat	0	0	0
Countywide	07/28/2002	09:00 AM	Excessive Heat	0	0	0
Countywide	08/01/2002	12:00 AM	Excessive Heat	0	0	0
Countywide	08/11/2002	11:00 AM	Excessive Heat	0	0	0
Countywide	01/14/2003	03:00 AM	Extreme Cold/wind Chill	0	0	0
Countywide	06/24/2003	09:00 AM	Excessive Heat	0	0	0
Countywide	01/09/2004	06:00 PM	Extreme Cold/wind Chill	0	0	0
Countywide	01/15/2004	12:00 PM	Extreme Cold/wind Chill	0	0	0
Countywide	12/20/2004	12:00 AM	Extreme Cold/wind Chill	0	0	0
Countywide	01/18/2005	04:00 AM	Extreme Cold/wind Chill	0	0	0
Countywide	01/23/2005	06:00 PM	Extreme Cold/wind Chill	0	0	0
Countywide	01/28/2005	12:00 AM	Extreme Cold/wind Chill	0	0	0
Countywide	07/25/2005	09:00 AM	Excessive Heat	0	0	0
Countywide	08/02/2005	09:00 AM	Excessive Heat	0	0	0

Storm Location	Date	Time	Type	Deaths	Injuries	Property Damage
Countywide	08/11/2005	09:00 AM	Excessive Heat	0	0	0
Countywide	08/01/2006	09:00 AM	Excessive Heat	2	0	0
Countywide	01/26/2007	03:00 AM	Cold/wind Chill	0	0	0
Countywide	02/05/2007	03:00 AM	Extreme Cold/wind Chill	0	0	0
Countywide	02/06/2007	03:00 AM	Extreme Cold/wind Chill	1	1	0
Countywide	03/06/2007	03:00 AM	Cold/wind Chill	0	0	0
Countywide	06/26/2007	11:00 AM	Excessive Heat	0	0	0
Countywide	07/08/2007	11:00 AM	Excessive Heat	0	0	0
Countywide	08/07/2007	11:00 AM	Excessive Heat	0	0	0
Countywide	08/25/2007	10:00 AM	Excessive Heat	0	0	0
Countywide	06/07/2008	09:00 AM	Excessive Heat	0	0	0
Countywide	07/16/2008	09:00 AM	Excessive Heat	0	0	0
Countywide	01/16/2009	12:00 AM	Cold/wind Chill	0	0	0
Countywide	08/10/2009	09:00 AM	Excessive Heat	0	0	0
Countywide	06/23/2010	09:00 AM	Excessive Heat	0	0	0
Countywide	06/27/2010	09:00 AM	Excessive Heat	0	0	0
Countywide	07/05/2010	09:00 AM	Excessive Heat	0	0	0
Countywide	07/23/2010	09:00 AM	Excessive Heat	0	0	0
Countywide	08/10/2010	09:00 AM	Heat	0	0	0
Countywide	06/09/2011	09:00 AM	Heat	0	2	0
Countywide	07/21/2011	09:00 AM	Excessive Heat	0	0	0
Countywide	06/20/2012	11:00 AM	Heat	0	0	0
Countywide	06/29/2012	11:00 AM	Heat	0	0	0
Countywide	07/01/2012	11:00 AM	Heat	0	0	0
Countywide	07/04/2012	11:00 AM	Heat	0	0	0
Countywide	07/17/2012	11:00 AM	Heat	0	0	0
Countywide	07/18/2013	09:00 AM	Excessive Heat	0	0	0
Countywide	01/04/2014	01:00 AM	Extreme Cold/Wind Chill	0	0	0
Countywide	01/22/2014	12:00 AM	Extreme Cold/Wind Chill	0	0	0
Countywide	06/18/2014	11:00 AM	Heat	0	0	0

Storm Location	Date	Time	Type	Deaths	Injuries	Property Damage
Countywide	07/01/2014	10:00 AM	Heat	0	0	0
			TOTALS:	**3**	**6**	**0**

Source: National Climatic Data Center

4.2.9 Hail

According to the National Climatic Data Center, Kent County experienced 24 hail events from 1950 through July 2014 (see **Table 4.2-5**), with no hail stones exceeding 1.75 inches in diameter. These events total approximately $105,000 in property damage (NCDC, 2014).

4.2.10 Winter Storms

According to the National Climatic Data Center, Kent County experienced 110 distinct winter storm events, including blizzards, heavy snow, ice storm, winter storm, and winter weather, from 1993 through July 2014 (see **Table 4.2-6**). In recent history, the three most powerful and costly storms to affect Delaware were the Blizzard of 1996, a storm over President's Day Weekend 2003, and the winter storm on February 9, 2010. The 110 Kent County events resulted in $3,650,000 in property damage, (0) deaths, and (5) reported injuries.

Table 4.2-5
Hail Activity in Kent County (1950-2014)

Location	Date	Time	Type	Magnitude	Deaths	Injuries	Property Damage	Crop Damages
Countywide	07/02/1968	1545	Hail	1.75 in.	0	0	0	0
Countywide	04/19/1969	1400	Hail	1.50 in.	0	0	0	0
Countywide	03/21/1974	0915	Hail	1.00 in.	0	0	0	0
Countywide	06/19/1975	2100	Hail	1.75 in.	0	0	0	0
Countywide	06/03/1980	1533	Hail	1.75 in.	0	0	0	0
Countywide	08/11/1983	1800	Hail	1.75 in.	0	0	0	0
Countywide	04/24/1991	1400	Hail	1.75 in.	0	0	0	0
Dover	04/01/1993	1830	Hail	1.75 in.	0	0	$5,000	0
Blackiston	04/09/1999	06:30 PM	Hail	0.75 in.	0	0	0	0
Smyrna	04/28/2002	09:15 PM	Hail	1.00 in.	0	0	$100,000	0
Smyrna	06/06/2002	03:55 PM	Hail	1.50 in.	0	0	0	0
Dover	06/06/2002	04:25 PM	Hail	0.75 in.	0	0	0	0
Hartly	06/19/2002	02:45 PM	Hail	0.75 in.	0	0	0	0
Bowers	06/21/2003	05:05 PM	Hail	0.75 in.	0	0	0	0
Felton	07/22/2003	04:15 PM	Hail	0.88 in.	0	0	0	0
Wyoming	04/24/2006	12:30 AM	Hail	0.75 in.	0	0	0	0
Dover	04/24/2006	12:40 AM	Hail	0.75 in.	0	0	0	0
Dover	09/30/2008	10:22 PM	Hail	0.75 in.	0	0	0	0
Houston	05/29/2009	04:27 PM	Hail	1.00 in.	0	0	0	0
Milford	05/29/2009	04:40 PM	Hail	1.00 in.	0	0	0	0
Clayton	06/09/2009	05:13 PM	Hail	0.88 in.	0	0	0	0
Hazletsville	06/09/2009	05:40 PM	Hail	0.88 in.	0	0	0	0
Smyrna	05/19/2011	01:06 PM	Hail	0.75 in.	0	0	0	0
Clayton	06/11/2011	03:25 PM	Hail	0.88 in.	0	0	0	0
				TOTALS:	**0**	**0**	**$105,000**	**$0**

Source: National Climatic Data Center

Table 4.2-6
Winter Storm Activity in Kent County (1993-2014)

Location	Date	Time	Type	Deaths	Injuries	Property Damage
Countywide	01/06/1996	11:00 PM	Winter Storm	0	0	$500,000
Countywide	02/02/1996	03:00 AM	Winter Storm	0	0	0
Countywide	02/16/1996	06:00 AM	Heavy Snow	0	0	0
Countywide	01/09/1997	10:00 AM	Freezing Rain	0	0	0
Countywide	01/11/1997	01:00 AM	Snow	0	0	0
Countywide	02/08/1997	06:00 AM	Heavy Snow	0	0	0
Countywide	12/23/1998	04:00 PM	Wintry Mix	0	0	0
Countywide	01/02/1999	10:00 PM	Wintry Mix	0	0	0
Countywide	01/08/1999	08:00 AM	Wintry Mix	0	0	0
Countywide	01/14/1999	04:00 AM	Wintry Mix	0	0	0
Countywide	03/09/1999	12:00 PM	Snow	0	0	0
Countywide	01/20/2000	04:00 AM	Heavy Snow	0	0	0
Countywide	01/23/2000	09:30 PM	Freezing Drizzle	0	0	0
Countywide	01/25/2000	01:00 AM	Winter Storm	0	0	0
Countywide	01/30/2000	02:00 PM	Wintry Mix	0	0	0
Countywide	02/18/2000	06:00 AM	Snow	0	0	0
Countywide	12/19/2000	09:00 PM	Snow	0	0	0
Countywide	12/22/2000	01:00 AM	Snow	0	0	0
Countywide	01/05/2001	11:00 AM	Snow	0	0	0
Countywide	01/20/2001	09:00 PM	Wintry Mix	0	0	0
Countywide	02/12/2001	09:00 PM	Wintry Mix	0	0	0
Countywide	02/22/2001	12:00 PM	Heavy Snow	0	0	0
Countywide	03/26/2001	03:00 AM	Snow	0	0	0
Countywide	01/19/2002	09:30 AM	Wintry Mix	0	0	0
Countywide	12/05/2002	02:00 AM	Winter Storm	0	0	0
Countywide	01/05/2003	11:00 AM	Winter Weather/Mix	0	0	0
Countywide	01/29/2003	03:00 AM	Winter Weather/Mix	0	0	0
Countywide	01/30/2003	03:00 PM	Winter Weather/Mix	0	0	0

Location	Date	Time	Type	Deaths	Injuries	Property Damage
Countywide	02/06/2003	08:30 PM	Heavy Snow	0	0	0
Countywide	02/10/2003	08:00 AM	Winter Weather/Mix	0	0	0
Countywide	02/15/2003	12:00 AM	Winter Weather/Mix	0	0	0
Countywide	02/16/2003	03:00 AM	Winter Storm	0	0	$1,300,000
Countywide	02/27/2003	04:30 PM	Heavy Snow	0	0	0
Countywide	12/06/2003	12:00 AM	Winter Weather/mix	0	0	0
Countywide	01/17/2004	07:00 PM	Winter Weather/mix	0	0	0
Countywide	01/25/2004	09:00 PM	Heavy Snow	0	0	0
Countywide	01/27/2004	06:00 PM	Winter Weather/mix	0	0	0
Countywide	02/05/2004	10:00 PM	Winter Weather/mix	0	0	0
Countywide	02/17/2004	03:00 PM	Winter Weather/mix	0	0	0
Countywide	12/19/2004	01:00 AM	Winter Weather/mix	0	0	0
Countywide	12/19/2004	07:00 PM	Winter Weather/mix	0	0	0
Countywide	01/19/2005	11:00 AM	Winter Weather/mix	0	0	0
Countywide	01/22/2005	09:00 AM	Winter Storm	0	0	0
Countywide	01/29/2005	09:00 PM	Winter Storm	0	0	0
Countywide	02/07/2005	08:00 PM	Winter Weather/mix	0	0	0
Countywide	02/24/2005	06:00 AM	Heavy Snow	0	0	0
Countywide	02/28/2005	10:00 AM	Winter Weather/mix	0	0	0
Countywide	03/01/2005	12:00 AM	Winter Weather/mix	0	0	0
Countywide	03/08/2005	10:30 AM	Winter Weather/mix	0	0	0
Countywide	12/06/2005	04:00 AM	Heavy Snow	0	0	0
Countywide	12/09/2005	03:00 AM	Winter Weather	0	0	0
Countywide	01/25/2006	05:00 AM	Winter Weather	0	0	0
Countywide	02/12/2006	02:00 AM	Winter Storm	0	0	0
Countywide	01/21/2007	04:30 PM	Winter Weather	0	0	0
Countywide	01/25/2007	07:00 PM	Winter Weather	0	0	0
Countywide	02/13/2007	07:00 AM	Winter Storm	0	0	0
Countywide	02/13/2007	07:00 AM	Winter Weather	0	0	0
Countywide	02/25/2007	12:00 PM	Winter Storm	0	0	0
Countywide	02/25/2007	12:00 PM	Winter Weather	0	0	0

Location	Date	Time	Type	Deaths	Injuries	Property Damage
Countywide	03/07/2007	08:00 AM	Winter Weather	0	0	0
Countywide	03/16/2007	06:00 PM	Winter Weather	0	0	0
Countywide	12/05/2007	10:00 AM	Winter Weather	0	0	0
Countywide	01/24/2008	11:00 AM	Winter Weather	0	0	0
Countywide	02/12/2008	12:00 PM	Winter Weather	0	0	0
Countywide	02/14/2008	12:00 AM	Winter Weather	0	0	0
Countywide	02/20/2008	01:00 PM	Winter Weather	0	0	0
Countywide	02/22/2008	12:00 AM	Winter Weather	0	0	0
Countywide	11/21/2008	06:00 PM	Winter Weather	0	0	0
Countywide	12/21/2008	03:00 AM	Winter Weather	0	0	0
Countywide	01/18/2009	05:15 PM	Winter Weather	0	0	0
Countywide	01/27/2009	03:30 AM	Winter Storm	0	5	$50,000
Countywide	02/03/2009	03:00 AM	Winter Weather	0	0	0
Countywide	03/01/2009	04:30 PM	Winter Storm	0	0	0
Countywide	12/19/2009	12:00 AM	Winter Storm	0	0	0
Countywide	12/31/2009	04:00 AM	Winter Weather	0	0	0
Countywide	01/08/2010	01:30 AM	Winter Weather	0	0	0
Countywide	01/30/2010	10:00 AM	Heavy Snow	0	0	0
Countywide	02/02/2010	08:00 PM	Winter Weather	0	0	0
Countywide	02/05/2010	03:00 PM	Winter Storm	0	0	0
Countywide	02/09/2010	06:00 PM	Winter Storm	0	0	$1,800,000
Countywide	02/10/2010	12:00 PM	Blizzard	0	0	0
Countywide	02/25/2010	02:00 AM	Winter Weather	0	0	0
Countywide	12/16/2010	01:00 PM	Winter Weather	0	0	0
Countywide	12/26/2010	09:00 AM	Heavy Snow	0	0	0
Countywide	01/08/2011	04:00 AM	Heavy Snow	0	0	0
Countywide	01/11/2011	03:00 PM	Winter Weather	0	0	0
Countywide	01/17/2011	07:00 PM	Winter Weather	0	0	0
Countywide	01/26/2011	04:00 AM	Winter Weather	0	0	0
Countywide	02/01/2011	01:00 AM	Winter Weather	0	0	0
Countywide	02/09/2011	10:30 PM	Winter Weather	0	0	0

Location	Date	Time	Type	Deaths	Injuries	Property Damage
Countywide	02/21/2011	08:00 PM	Winter Weather	0	0	0
Countywide	01/04/2012	11:00 PM	Winter Weather	0	0	0
Countywide	01/09/2012	03:00 PM	Winter Weather	0	0	0
Countywide	01/21/2012	01:00 PM	Winter Weather	0	0	0
Countywide	02/11/2012	06:00 PM	Winter Weather	0	0	0
Countywide	01/25/2013	03:00 PM	Winter Weather	0	0	0
Countywide	01/28/2013	06:00 AM	Winter Weather	0	0	0
Countywide	02/01/2013	05:30 AM	Winter Weather	0	0	0
Countywide	02/02/2013	07:30 PM	Winter Weather	0	0	0
Countywide	03/25/2013	04:00 AM	Winter Weather	0	0	0
Countywide	12/08/2013	11:30 AM	Winter Weather	0	0	0
Countywide	01/02/2014	06:00 PM	Heavy Snow	0	0	0
Countywide	01/10/2014	06:30 AM	Winter Weather	0	0	0
Countywide	01/21/2014	11:17 AM	Heavy Snow	0	0	0
Countywide	01/25/2014	12:00 PM	Winter Weather	0	0	0
Countywide	01/28/2014	09:00 PM	Heavy Snow	0	0	0
Countywide	02/04/2014	10:00 PM	Winter Weather	0	0	0
Countywide	02/09/2014	05:30 PM	Winter Weather	0	0	0
Countywide	02/12/2014	08:30 PM	Winter Storm	0	0	0
Countywide	02/18/2014	02:00 AM	Winter Weather	0	0	0
Countywide	02/25/2014	07:00 AM	Winter Weather	0	0	0
Countywide	02/26/2014	06:00 AM	Winter Weather	0	0	0
Countywide	03/03/2014	03:00 AM	Winter Storm	0	0	0
Countywide	03/16/2014	05:00 PM	Heavy Snow	0	0	0
Countywide	03/25/2014	12:00 PM	Heavy Snow	0	0	0
			TOTALS:	**0**	**5**	**$3,650,000**

Source: National Climatic Data Center

4.2.11 Coastal Erosion

An evaluation of erosion hazards in the United States was conducted as a collaborative project of The H. John Heinz III Center for Science, Economics and the Environment in April 2000, a study prepared for the Federal Emergency Management Agency (www.heinzcenter.org). The Heinz Center evaluation provides an assessment of coastal erosion and the potential loss of property along U.S. shorelines.

In 1990, the State of Delaware had an estimated 1,000 people living within 500 feet of the Atlantic shoreline, according to data derived from analyzing U.S. Census Block Groups. Sussex County, south of Kent County and one of the 18 counties studied in The Heinz Center's evaluation, is known to experience an average annual erosion rate of three (3) to four (4) feet per year. And, according to the study, an estimated 25 percent of those homes within 500 feet of U.S. coastlines and Great Lakes coastlines are likely to be lost to erosion by 2060.

Figure 4.2-4 shows one Delaware community, South Bethany in Sussex County, and the expectation that the beach will erode inland approximately 60 feet over the next 60 years resulting in the hypothetical loss of three rows of housing.

Figure 4.2-4
The Heinz Center Evaluation of Erosion Hazards (Delaware)

A further, separate study of sea level and the resulting coastal erosion was not conducted as part of this Hazard Mitigation Plan Update. With regard to the sea level rise impact on flooding, the hazard and vulnerability analysis conducted for riverine and coastal flooding will suffice as it goes above and beyond all reasonable estimates of the sea level rise, and therefore creating mitigation actions that deal with periodic flooding will also benefit those areas vulnerable to sea level rise. With regard to the coastal erosion impacts, a separate analysis was conducted as part of the preparation of the report *Preparing for Tomorrow's High Tide: Sea Level Rise Vulnerability Assessment for the State of Delaware* in 2012. Many of the mitigation actions from that report from DNREC have been incorporated into this plan by reference.

4.2.12 Dam/Levee Failure

According to National Inventory of Dams, there are 16 regulated dams in Kent County. Fourteen (14) are considered High Hazard and two (2) are considered Significant Hazard. Overall, nearly 60 percent of the dams within the state are considered to be high or significant hazard facilities.

Dam hazard definitions, as accepted by the National Interagency Committee on Dam Safety, are as follows:

1. Low Hazard Potential — Dams assigned the low hazard potential classification are those where failure or mis-operation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

2. Significant Hazard Potential — Dams assigned the significant hazard potential classification are those dams where failure or mis-operation results in no probable loss of human life but can cause economic loss, environment damage, disruption of lifeline facilities, or impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

3. High Hazard Potential — Dams assigned the high hazard potential classification are those where failure or mis-operation will probably cause loss of human life.

Table 4.2-7
County Dam Hazard Data

Name of Dam	General Location	Owner	Year Built	Hazard Potential
Duck Creek Pond Dam	Green Spring Branch	Duck Creek Investment Corp	N/A	Low
Wheatley Pond Dam	Green's Branch	Wheatley Pond HOA	N/A	High
Cartanza/ez Farms Dam	Little River	Cartanza/ez Farms	N/A	Low
Wyoming Lake Dam	Isaac Branch	Carlton Fifer	1925	Low
Blairs Pond Dam	Tantrough Br-Mispillion River	DNREC	N/A	High
Tub Mill Pond Dam	Swan Creek Trib Mispillion R.	DNREC	N/A	High
Denoname 2	Browns Branch	City of Harrington	1971	Significant
Lake Como Dam	Mill Creek-Smyrna River	DelDOT	1938	High
Masseys Mill Pond Dam	Little Duck Creek - Leipsic River	DelDOT	1933	Low

Garrisons Lake Dam	Leipsic River	DNREC	1964	Significant
Haven Lake Dam	Mispillion River	DNREC	1956	High
Silver Lake Dam - Dover	St. Jones River	City of Dover	1900	High
Silver Lake Dam - Milford	Mispillion River	DNREC	1964	High
Killen Pond Dam	Murderkill River	DNREC	1969	Low
Coursey Pond Dam	Murderkill River	DelDOT	1967	High
Derby Pond Dam	Tidbury Creek	DNREC	1967	High
Voshell Pond Dam	Tidbury Creek- St. Jones River	Margaret Lingo and H. Kline	1969	High
Wyoming Lake Dam	Isaac Branch- St. Jones River	Papen and Feifer (?)	1925	Significant
Moores Lake Dam	Isaac Branch of St Jones	DNREC	1967	High
Andrews Lake Dam		DelDOT; DNREC DFW		Significant

Source: National Inventory of Dams, USACE

4.2.13 Earthquakes

According to the Delaware Geological Survey, 58 earthquakes have been impacted the State of Delaware during a period from 1638 through 2014. The greatest of these, in terms of the Modified Mercalli Intensity (MMI) scale for earthquakes, was the October 9, 1871 earthquake reported to have had an intensity of VII on the MMI scale in New Castle County, Kent County's neighbor to the north.. An event registering 7 would correspond to a ranking between 5.4 and 6.1 on the Richter Scale, and would be considered a "very strong" earthquake. The lower end of the spectrum for Delaware consists of several earthquakes classified as a II on the MMI scale, for instance the October 20, 1985 earthquake documented in the City of Wilmington in New Castle County. No damage estimates are currently available for these events.

Table 4.2-8 lists all recorded earthquakes in the State of Delaware for the period 1638 through 2014, along with their intensity. Earthquake events specifically associated with Kent County are highlighted in bold typeface for quick reference. For some events, the intensity appears as a range due to variations in distances across the impacted areas.

Table 4.2-8
Recorded Earthquakes in the State of Delaware (1638-2014)

Date of Occurrence	Felt Area	Modified Mercalli Intensity (If Known)
October 9, 1871	Wilmington	VII
March 25, 1879	**Dover**	**IV-V**
May 8, 1906	Seaford	IV
December 3, 1937	Georgetown	IV
January 8, 1944	Wilmington	< V
July 14, 1971	SW Wilmington	III-IV
December 29, 1971	SW Wilmington	IV-V
January 2, 1972	SW Wilmington	III-IV

Date of Occurrence	Felt Area	Modified Mercalli Intensity (If Known)
January 2, 1972	SW Wilmington	III-IV
January 6, 1972	SW Wilmington	III-IV
January 22, 1972	SW Wilmington	III-IV
January 22, 1972	SW Wilmington	III-IV
January 23, 1972	SW Wilmington	III-IV
February 10, 1972	ENE Newark	V
February 11, 1972	SW Wilmington	III
August 13, 1972	SW Wilmington	III-IV
August 13, 1972	SW Wilmington	III-IV
November 25, 1972	SW Wilmington	III-IV
November 27, 1972	SW Wilmington	III-IV
February 28, 1973	**Entire State**	**V-VI**
March 1, 1973	Claymont	I
March 2, 1973	Claymont	I
March 2, 1973	Claymont	I
March 3, 1973	Claymont	I
March 3, 1973	Claymont	I
March 3, 1973	Claymont	I
March 3, 1973	Claymont	I
July 10, 1973	Wilmington-Claymont	IV
April 28, 1974	Wilmington	V
February 10, 1977	Wilmington	V
June 5, 1977	Georgetown	-
August 2, 1977	Georgetown	-
February 25, 1980	Wilmington	I
November 17, 1983	Trolley Square area of Wilmington	V
November 17, 1983	Trolley Square area of Wilmington	-
December 12, 1983	NW Wilmington	IV
December 12, 1983	NW Wilmington	I-II
January 19, 1984	Wilmington	I-II
January 19, 1984	Wilmington	IV
February 15, 1984	N Wilmington	I-II
October 10, 1985	N Wilmington	III-IV
October 20, 1985	Wilmington	III-IV
November 8, 1993	Wilmington	I-II
February 11, 1994	Wilmington Area	II

Date of Occurrence	Felt Area	Modified Mercalli Intensity (If Known)
April 23, 1994	Wilmington	II-III
October 16, 1995	Wilmington	I-II
October 17, 1995	Wilmington	II-III
December 20, 1995	Wilmington	I-II
June 13, 1996	Wilmington	II-III
June 23, 1996	Wilmington	I-II
January 28, 1997	Wilmington	II
April 15, 1997	Wilmington	III-IV
March 15, 1998	Wilmington	III
March 19, 1998	Wilmington	I-II
March 19, 1998	Wilmington	III
October 27, 1998	Near Montchanin	II
August 13, 2003	Near Newark	II
April 9, 2005	North Wilmington	I-II

Source: Delaware Geological Survey

4.2.14 Landslides and Sinkholes

Landslides and sinkholes, discussed in the *Hazard Identification* section, were not analyzed in detail due to extremely low probability of occurrence within the State of Delaware.

4.2.15 Tsunami

Though tsunamis are more likely to affect Pacific Rim states, historical evidence does show that tsunamis have affected the Eastern United States and Gulf of Mexico, including Delaware. Forty tsunamis and tsunami-like waves have been documented in the Eastern United States since 1600. To cite one commonly referred to example in terms of Atlantic tsunamis, a severe earthquake (7.2 on the Richter Scale) on November 18, 1929 in the Grand Banks of Newfoundland generated a tsunami that caused considerable damage and loss of life at Placentia Bay, Newfoundland and is also known to have impacted upon the Maine shoreline to some degree. Due to the relatively low probability of a tsunami significantly impacting the State of Delaware, no further analysis or vulnerability assessment will be conducted for this hazard at this time.

4.2.16 Volcanoes

There are no active volcanoes in the State of Delaware, thus no historical evidence of volcanic eruption exists within the planning area. There is also no indication that this hazard is a significant enough threat to the state to warrant further analysis or a vulnerability assessment at this time.

4.2.17 Terrorism

Because of the relevantly recent, or heightened, focus being placed on managing terrorism and consequences of terrorism in the United States, no historical database is currently available for cataloging acts of terrorism. However, at the time of this Plan's development, no significant historical occurrences of terrorism were known to have taken place within Kent County planning area.

4.2.18 Hazardous Materials (HazMat)

Table 4.2-9 shows National Response Center (NRC) data for Kent County for the last 5 years with regard to number of incidents, injuries, deaths and damages incurred as the result of hazardous materials incidents. From 2009 to 2014, there were 42 incidents, 0 injuries, 1 death, and no damage.

Table 4.2-9
NRC HazMat Data for Kent County

Year	Type of Incident							Injuries	Fatalities	Damages
	Fixed	Mobile	Rail	Tank	Vessel	Pipeline	Other			
2009	0	1	4	0	3	0	0	0	0	0
2010	4	1	2	1	2	0	0	0	0	0
2011	4	0	2	1	0	0	2	0	0	0
2012	2	0	3	0	1	0	0	0	0	0
2013	1	1	3	1	2	1	0	0	1	0
Total	11	3	14	3	8	1	2	0	1	0

4.2.19 Energy Pipeline Failures

A history of hazards is not currently available for energy pipeline failures in Kent County.

4.2.20 Probability of Future Events in Kent County

The final step of any hazard analysis is calculating the likelihood of future events. Given the number of events that have occurred in the past and the time period over which those events have occurred, one can calculate the number of events that occur per year. This gives a sense of the probability of future occurrences. The results of this calculation for Kent County are presented in **Table 4.2-10**. For floods, the events that are tallied are generally nuisance events without a great deal of damage. The probability of a 100-year flood (and its predicted extent) is 1% in any given year. Earthquakes require a similar explanation. While 59 total events have taken place according to the historical record, only one of those was capable of causing any damage at all, however slight. Finally, there is no historical record of occurrence for several hazards.

Table 4.2-10
Probability of Future Events (All Hazards)

Hazard	Number of Events	Time Period	Events per Year	Probability of Future Occurrence
Flood	59	1993 – 2014	2.810/0.0100	High/Low
Tropical Storm	24	1877 – 2014	0.175	Low
Severe Thunderstorm	286	1950 – 2014	4.469	High
Tornado	20	1950 – 2014	0.313	Medium
Wildfire	2	1993 – 2014	0.095	Low
Drought	53	1995 – 2014	2.789	High
Extreme Temperature	95	1995 – 2014	5.000	High
Hail	24	1950 – 2014	0.375	Medium
Winter Storm	110	1993 – 2014	5.238	High
Coastal Erosion	Unknown	N/A	Unknown	Low
Dam Failure	Unknown	N/A	Unknown	Low
Earthquake	58 (1 MMI >= VI)	1871 – 2014	0.406/0.007	Medium/Low
Sinkhole/Landslide	Unknown	N/A	Unknown	Low
Tsunami	Unknown	N/A	Unknown	Low
Volcano	Unknown	N/A	Unknown	Low
Terrorism	Unknown	N/A	Unknown	Low
Hazardous Material Release	42	2009-2014	8.400	High
Energy Pipeline Failure	Unknown	N/A	Unknown	Low

The preceding section included data about and description of environmental hazards from a wide variety of sources. Every attempt has been made to include the most accurate and up-to-date information about the type and frequency of hazards that Kent County faces. The data sources used for the preceding hazard identification are as follows:

Data Sources

American Society of Civil Engineers (ASCE), "Facts About Windstorms."
Web site: www.windhazards.org/facts.cfm

Bureau of Reclamation, U.S. Department of the Interior
Web site: www.usbr.gov

Federal Emergency Management Agency (FEMA)
Web site: www.fema.gov

National Climatic Data Center (NCDC), U.S. Department of Commerce, National Oceanic and Atmospheric Administration
Web site: http://lwf.ncdc.noaa.gov/oa/ncdc.html

National Geophysical Data Center, "Tsunamis and Tsunami-Like Waves of the Eastern United States"
Web site: http://www.ngdc.noaa.gov/seg/hazard/tsu.shtml

National Inventory of Dams, U.S. Department of the Interior
Web site: http://crunch.tec.army.mil/nid/webpages/nid.cfm

National Hurricane Center, National Oceanic & Atmospheric Administration (NOAA)
Web site: http://www.nhc.noaa.gov/http://www.nhc.noaa.gov/HAW2/english/history/opal_1995_map.gif

National Severe Storms Laboratory (NSSL), U.S. Department of Commerce, National Oceanic and Atmospheric Administration
Web site: www.nssl.noaa.gov

National Weather Service (NWS), U.S. Department of Commerce, National Oceanic and Atmospheric Administration
Web site: www.nws.noaa.gov

Storm Prediction Center (SPC), U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service
Web site: www.spc.noaa.gov

The Tornado Project, St. Johnsbury, Vermont
Web site: www.tornadoproject.com

United States Geological Survey (USGS), U.S. Department of the Interior
Web site: www.usgs.gov

4.3 VULNERABILITY ASSESSMENT

Requirement §201.6(c)(2)(ii): *[The risk assessment shall include a] description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i) of this section. This description shall include an overall summary of each hazard and its impact on the community*

4.3.1 Introduction

A high-level, detailed vulnerability assessment was completed for Kent County for flood (riverine and coastal), severe winds (hurricanes and coastal storms), thunderstorms, tornadoes, drought, hail, winter storms, dam/levee failure, earthquakes, terrorism, hazardous materials and energy pipeline failures, due to the higher level of vulnerability for these hazards compared to others. It is important to note that this vulnerability assessment is based on best available data and represents a base-level assessment for the planning area. Additional work could be done on an ongoing basis to enhance, expand and further improve the accuracy of the baseline established here.

The loss estimates provided in this section have resulted in an *approximation* of vulnerability. These estimates should be used to understand relative vulnerability from hazards and potential losses. However, it is important to understand that uncertainties are inherent in any loss estimation methodology, arising in part from incomplete scientific knowledge concerning natural hazards and their effects on the built environment. Uncertainties also result from approximations and simplifications that are necessary for a comprehensive analysis (such as abbreviated inventories, demographics or economic parameters).

To conduct the vulnerability assessment effort, two distinct hazard vulnerability assessment methodologies were applied; utilizing both HAZUS-MH® version 2.2 (FEMA's loss estimation software) and a statistical vulnerability assessment methodology. Both approaches provide estimates for the potential impact by using a common, systematic framework for evaluation.

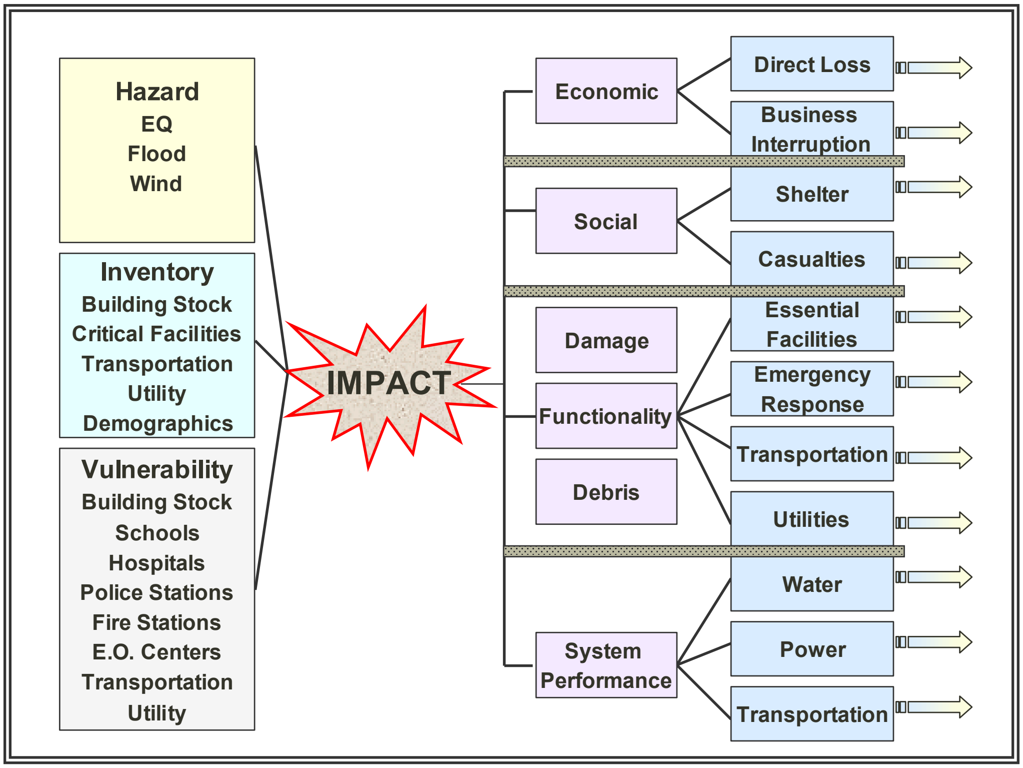
The HAZUS-MH vulnerability assessment methodology is parametric, in that distinct hazard and inventory parameters (for example, wind speed and building types) were modeled using the HAZUS-MH software to determine the impact (damages and losses) on the built environment. The HAZUS-MH software was used to estimate losses from coastal winds, earthquake and flood hazards.

The second methodology, a statistical vulnerability assessment methodology, was applied to analyze hazards of concern that are outside the scope of the HAZUS-MH software. The methodology uses a statistical approach and mathematical modeling of vulnerability to predict a hazard's frequency of occurrence and estimated impacts based on recorded or historic damage information.

4.3.2 Explanation of HAZUS-MH Risk Assessment Methodology

HAZUS-MH is FEMA's standardized loss estimation software program, built upon an integrated geographic information system (GIS) platform (**Figure 4.3-1**). This vulnerability assessment applied HAZUS-MH to produce regional profiles and estimate losses for three of the seven hazards addressed in this section: flood, hurricane winds and earthquake.

Figure 4.3-1
Conceptual Model of HAZUS-MH Methodology



4.3.3 Explanation of Regional Vulnerability Assessment Methodology

Vulnerabilities associated with other natural hazards were analyzed using a regional assessment methodology developed and used specifically for this effort. This approach is based on the principal that any spatially-nonspecific hazard event is essentially a random occurrence within a region and had just as much chance of occurring within the study area as outside. Historical data for each hazard are used and statistical evaluations are performed using manual calculations. The general steps used in the statistical vulnerability assessment methodology are summarized below:

- Buffer the study area to determine the regional assessment area;
- Compile hazard occurrence data for the regional area from national and local sources;
- Categorize hazard parameters for each hazard to be modeled (e.g., tornado);
- Calculate the annualized occurrence and loss estimates for each regional subdivision;
- Normalize the annualized occurrence and loss estimates by land area and number of housing units respectively; and
- Determine the overall regional average of annualized occurrence and loss

The economic loss results are presented here using two interrelated vulnerability indicators:

1) The Annualized Loss (AL), which is the estimated long-term value of losses to the general building stock in any single year in a specified geographic area (i.e., city or county)

2) The Annualized Loss Ratio (ALR), which expresses estimated annualized loss as a fraction of the building inventory replacement value

The estimated Annualized Loss (AL) addresses the two key components of vulnerability: the probability of the hazard occurring in the study area and the consequences of the hazard, largely a function of building construction type and quality, and of the intensity of the hazard event. By annualizing estimated losses, the AL factors in historic patterns of frequent smaller events with infrequent but larger events to provide a balanced presentation of the vulnerability.

The Annualized Loss Ratio (ALR) represents the AL as a fraction of the replacement value of the local building inventory. This ratio is calculated using the following formula:

"ALR = ANNUALIZED LOSSES / TOTAL EXPOSURE AT RISK"

The annualized loss ratio gauges the relationship between average annualized loss and building replacement value. This ratio can be used as a measure of relative vulnerability between areas and, since it is normalized by replacement value, it can be directly compared across different geographic units such as metropolitan areas or counties.

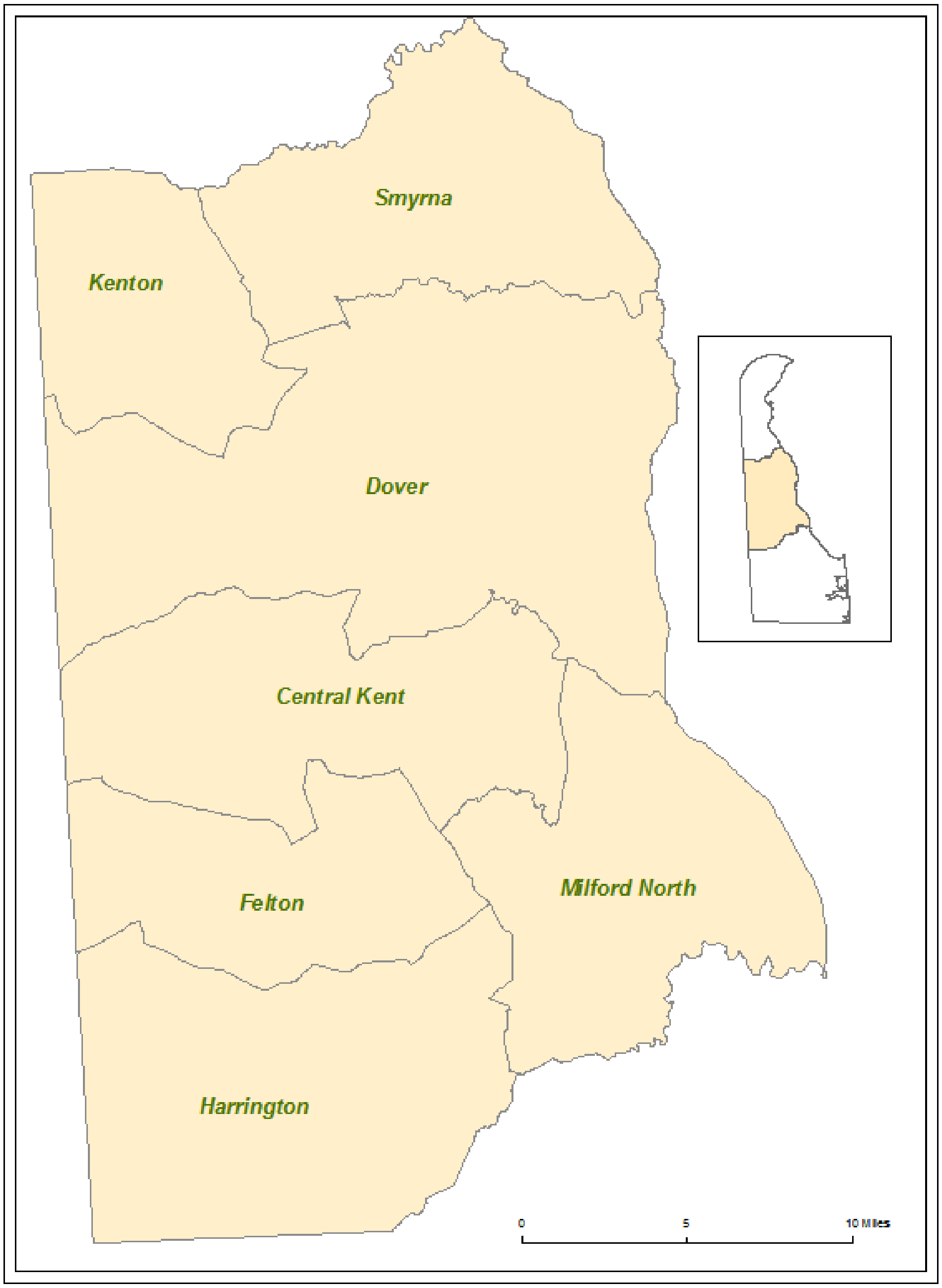
It is important to note that HAZUS-MH was used to produce "worst case scenario" results. The outputs in this document are considered to be the result of a worst case scenario event for each hazard, and it is understood that any smaller events would most likely create fewer losses than those calculated here.

Census County Divisions (CCDs)

Many of the tables presented in the Vulnerability Assessment use Census County Divisions (CCDs), which are defined by the US Census Bureau as areas delineated in cooperation with state, tribal, and local officials for statistical purposes. CCDs have no legal function and are not governmental units. CCD boundaries usually follow visible features and usually coincide with census tract boundaries. The name of each CCD is based on a place, county, or well-known local name that identifies its location (illustrated right). CCDs are recognized by the U.S. Census Bureau and are a national standard by which HAZUS-MH results are prepared (due in part to the reliance of HAZUS on U.S. Census data.)

In the studies conducted for Kent County, cities—such as Dover and Milford, for example—are separated from the CCDs in jurisdiction-level analyses. This was done in order to provide a more detailed cross section of the planning area and eliminate tendencies to double-count available information.

Figure 4.3-2
Census County Divisions (CCDs)



4.3.4 County Overview

Requirement §201.6(c)(2)(ii): *[The risk assessment shall include a] description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i) of this section. This description shall include an overall summary of each hazard and its impact on the community*

Population and Dollar Exposure

According to the U.S. Census Bureau, the total population of Kent County in 2010 was 162,922. (The total population in 2010 for the state of Delaware as a whole was 899,673.) **Figure 4.3-3** shows the distribution of this population across the county's geographic area.

The latest value from HAZUS-MH of total dollar exposure within Kent County is estimated to be approximately $29,312,397,000. This modeled estimate consists of single-family residential buildings, multi-family residential buildings and commercial facilities. Fortunately, for the flood vulnerability analysis, actual tax parcel boundaries and their assessed valuations were available to be used. Using the data from the Kent County Government, the actual total dollar exposure in the county is $3,284,595,900. It was the consensus of the Steering Committee, however, that the assessed valuations are, in some cases, considerably lower than the actual market value of the property.

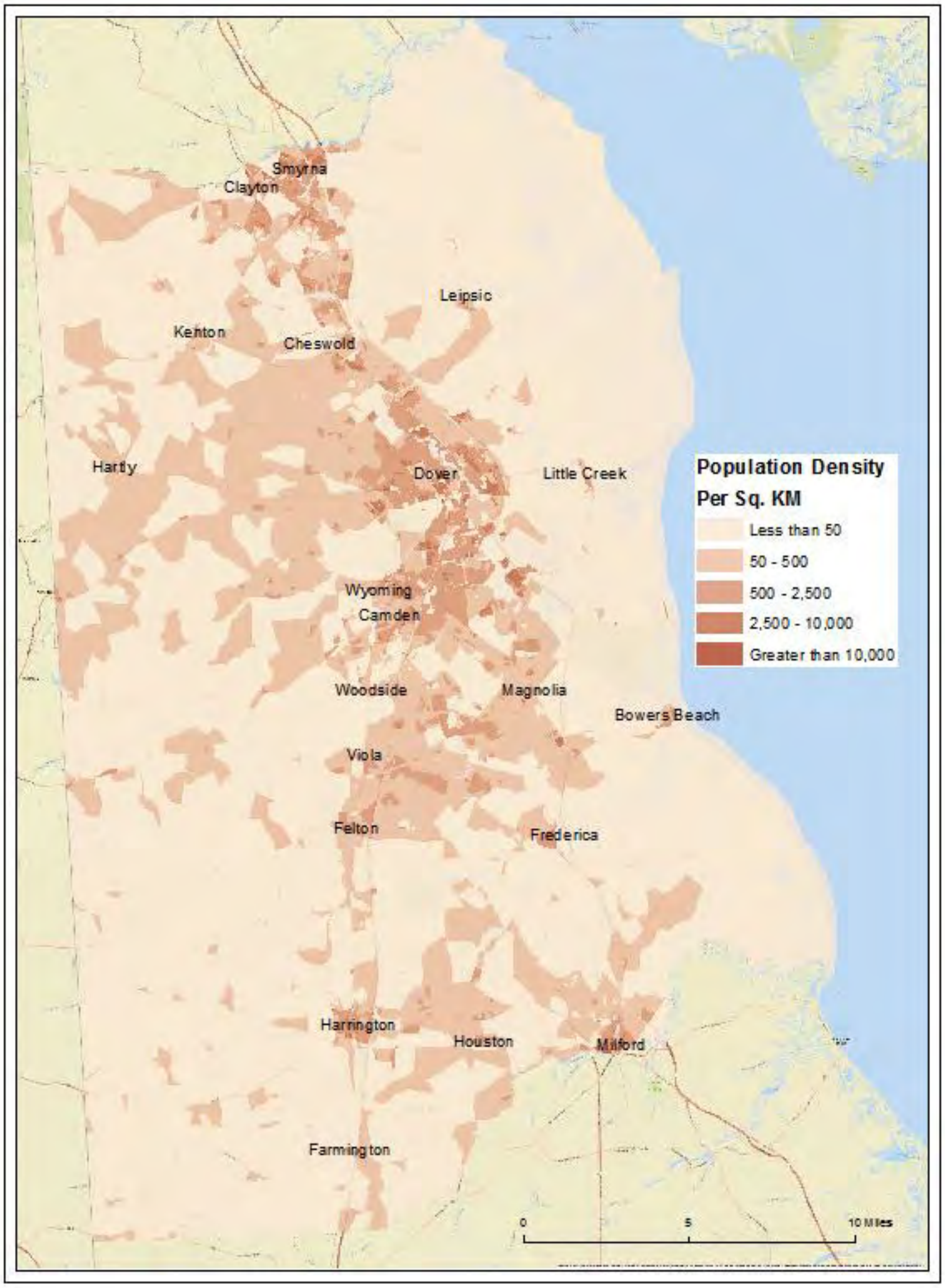
Development Trends

The resident population of the State of Delaware is projected to increase from 899,673 in 2010 to approximately 1,068,155 by 2040 (Delaware Population Consortium, October 2014). From April 1, 2000 to April 1, 2010, Delaware's rate of population change was 14.6% and rate of change in housing units was 18.3% (U.S. Census Bureau). These trends demonstrate that Delaware's population is increasing, and consequently the number of residential structures and the associated exposure of residential buildings will increase as well. Assuming a multiplier of 1.008[1], the total residential exposure of Kent County could reach an estimated dollar value of $3,585,484,089 by 2025. This estimate does not of course take into account many other development factors, such as available land for new residential construction. Future Plan updates will address development trends in more detail through assessments, historical data analysis, and discussions with the County Planning Department, in particular for hazards with a physical hazard boundary (i.e., flood, storm surge, etc.) The planning department will be involved in addressing development trends and ensuring that future development is not planned in high hazard areas. This information will be reviewed and incorporated in the 5-year update.

.

[1] Based on the percent change in housing units for a two-year period and weighted for Kent County.

Figure 4.3-3
Population Distribution (U.S. Census 2010)



Critical Facilities

For the purposes of this risk assessment, the label "critical facility" refers to five categories of locations that will be very important during the response and recovery phase of a hazard event. Those categories are: Medical Care Facilities, Emergency Operations Centers, Fire Departments, Police Departments and Schools. According to HAZUS-MH 2.2, there are a total of 100 critical facilities in Kent County, Delaware

4.3.5 Flood

In May 2014, FEMA released a new coastal flood study of Kent County, complete with a 1% chance per year depth grid that was created with state-of-the-art methods. Because this data was available and determined by the Hazard Mitigation Plan Update Steering Committee to be authoritative, it was directed to be used as the basis for the flood vulnerability assessment. Because only coastal flooding depths were predicted in the May 2014 study, additional analysis was conducted, using the HAZUS-MH Flood Information Tool and the Digital Flood Insurance Rate Maps, to calculate the predicted depths from a 1% chance per year riverine flooding event. Unfortunately, only a 1% chance per year flood depth grid was available, rather than the typical range of various return periods.

Because the actual property parcels with assessed values were available from Kent County, there was an opportunity to examine the potential damage from flooding at the parcel level, rather than the census tract level available in HAZUS-MH. The GIS process used to accomplish this is:

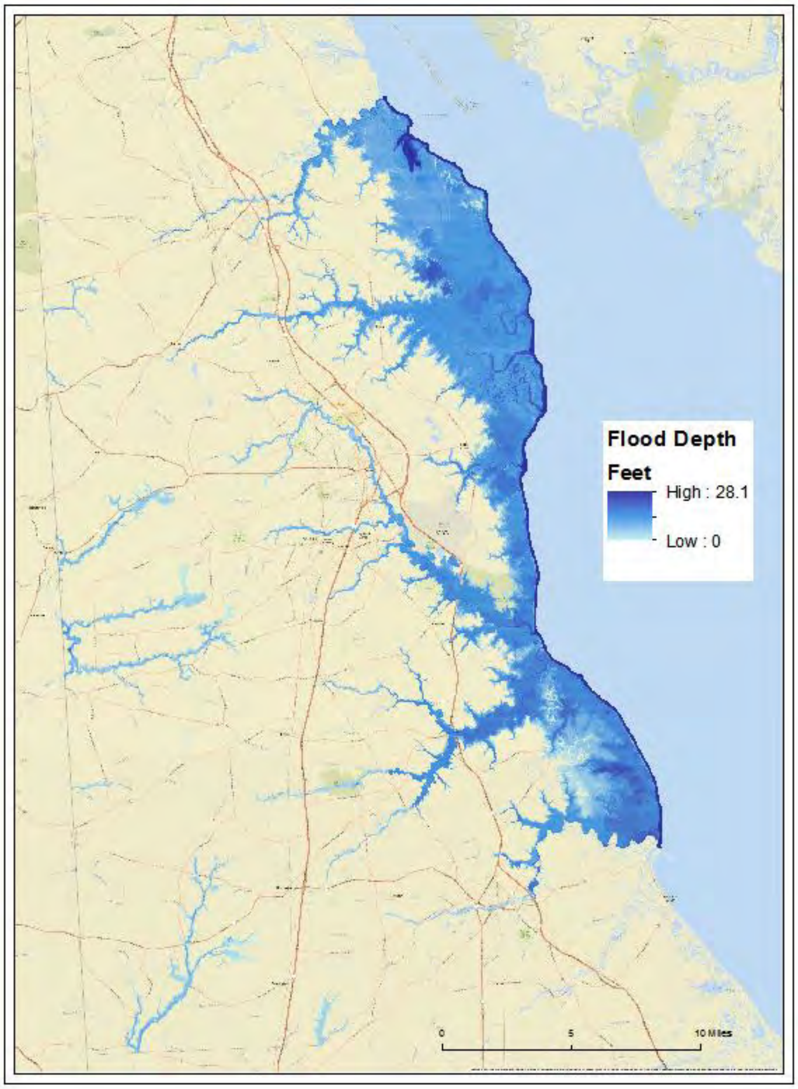
1. Select all of the property parcels in Kent County that intersect the 1% chance per year flood extent.
2. Reduce the assessed value of the parcel's structures by the percentage that the parcel is flooded. This assumes that the impact of a flood would be even across a parcel. This is a best practice in GIS analysis generally when the specific configuration of buildings on a parcel is not known.
3. Convert the raster flood depth grid into polygons for every 6" of flood depth.
4. For each property parcel, determine the flood depth polygon with the greatest intersecting area. In other words, pick the flood depth polygon value that intersects each property parcel the most.
5. Using the type of property, assume the height of the building foundation and remove this value from the flood depth. For example, if a parcel is predicted to be flooded by 3 ft of water in a 1% chance per year scenario, and the primary structure is assumed to have an 18 inch foundation (crawl space), then one can assume 1.5 ft of flood water impacting the structure.
6. Finally, use the depth-damage curves from HAZUS-MH to relate the depth of the floodwater to the percent damaged. This damage percent, for both the building and its content, is multiplied by the reduced assessed value to calculate the estimated damage amount.

The result of this process is parcel-based map of the potential flood damage from both riverine and coastal flood events in Kent County. This parcel-based vulnerability map may now be used to identify which properties are the most at risk from flooding in the County, what are their characteristics, and whom to contact to discuss potential mitigation options. It could also now be used to track the change in vulnerability over time as either the data regarding individual properties improves, or more up-to-date assessment valuations are considered.

Approximately 20.1% of Kent County land area falls within the 1% chance per year flood zone (**Figure 4.3-4**). Also, 5,503 out of 84,657 property parcels (6.5%) intersect the flood zone. The predicted depth of flood water is between 0 and 28.1 ft (**Figure 4.3-5**). However, the upper end of the predicted depths includes portions of the grid that lie just off the coast, exaggerating the depths. The deepest values on land are found in the northern coastal part of the county and average about 12 ft deep.

Figure 4.3-4
FEMA 100-Year Flood Zone in Kent County

Figure 4.3-5
Modeled 1%-chance Flood Depth

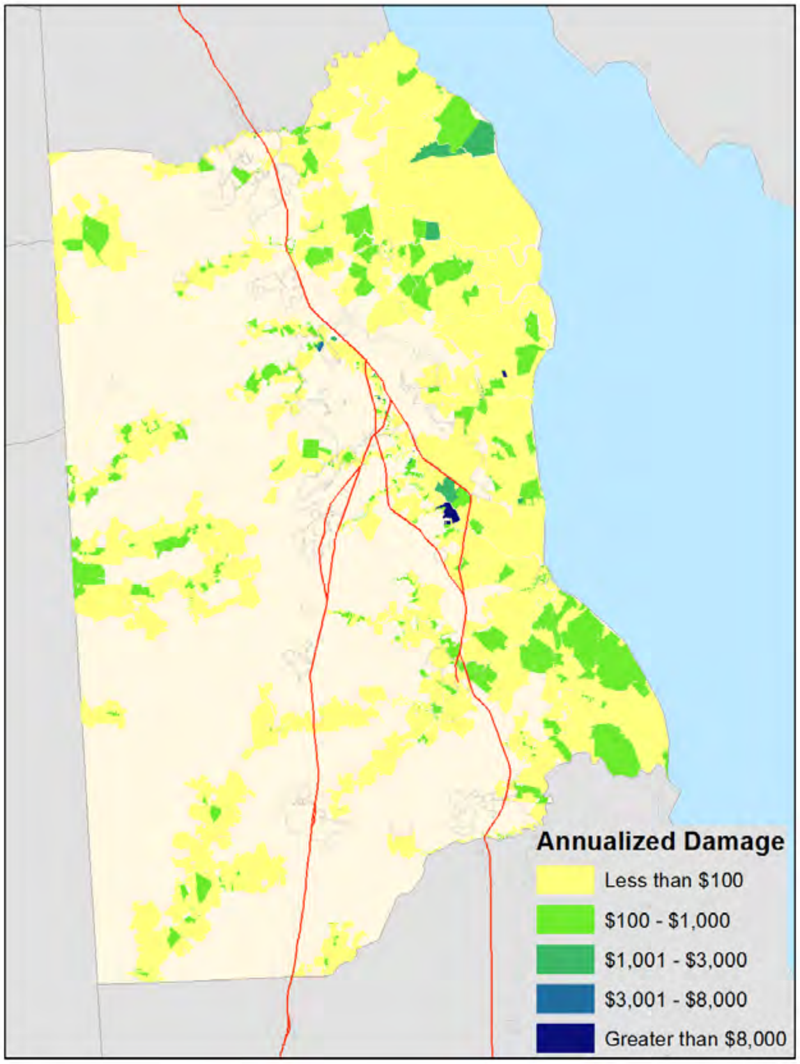


The total built property exposure (both building and contents) in the county is $91,646,903 (**Table 4.3-1**). The total estimated annualized losses equal $406,999, yielding a loss ratio of 0.0044. Loss ratios in the county's municipalities range from 0.0000 in Houston and Kenton to 0.0067 in Bowers Beach. Among the CCDs, Kenton is most vulnerable to flooding (0.0051). Again, this analysis has only used a 1% chance per year flood; including the 10%, 4%, 2%, and 0.2% chance per year flood depths would increase the loss ratio significantly.

Table 4.3-1
Potential Annualized Losses from Flooding

Jurisdiction	Assessed Value	Estimated Losses	Loss Ratio
Bowers Beach	$7,182,154	$47,822	0.0067
Camden	$501,113	$1,820	0.0036
CCD Central Kent	$12,515,068	$51,842	0.0042
CCD Dover	$26,091,393	$125,421	0.0048
CCD Felton	$748,624	$2,173	0.0029
CCD Harrington	$3,804,884	$9,456	0.0025
CCD Kenton	$787,557	$4,055	0.0051
CCD Milford North	$9,860,679	$48,347	0.0049
CCD Smyrna	$5,678,818	$27,206	0.0048
Cheswold	---	---	---
Clayton	$24,776	$84	0.0034
Dover	$10,024,425	$44,658	0.0045
Farmington	---	---	---
Felton	---	---	---
Frederica	$732,038	$4,353	0.0059
Harrington	---	---	---
Hartly	---	---	---
Houston	$1	$0	0.0000
Kenton	$10	$0	0.0000
Leipsic	$1,476,303	$6,209	0.0042
Little Creek	$1,086,487	$5,481	0.0050
Magnolia	---	---	---
Milford	$8,075,453	$17,901	0.0022
Smyrna	$1,819,447	$4,937	0.0027
Viola	---	---	---
Woodside	---	---	---
Wyoming	$1,168,544	$4,773	0.0041
TOTAL	**$91,646,903**	**$406,999**	**0.0044**

Figure 4.3-6
Losses per Parcel from 1% chance per year Flood in Kent County



Another means of gauging the vulnerability within Kent County to flooding was determined to be the vulnerability of critical facilities to the 1% chance per year flood return periods. Within the county, 100 critical facilities were assessed with regard to flood risk (**Table 4.3-2**). In summary, during a 1% chance per year flood event, 4 facilities (South Bowers Fire Company in the Milford North CCD, North Dover Elementary School in Dover, Leipsic Volunteer Fire Company in Leipsic, and the Milford Police Department in Milford) are predicted to sustain slight damage (1 to 5 percent damage) and 1 facilities (Bowers Volunteer Fire Department in Bowers Beach) are predicted to sustain moderate damage (5 to 30 percent damage).

Table 4.3-2
Potential Damage to Critical Facilities from Flood[2]

Jurisdiction	Total Number of Critical Facilities	1% chance per year Flood		
		Moderate Damage	Slight Damage	Negligible Damage
Bowers Beach	1	1	0	0
Camden	9	0	0	9
CCD Central Kent	5	0	0	5
CCD Dover	17	0	0	17
CCD Felton	2	0	0	2
CCD Harrington	1	0	0	1
CCD Kenton	2	0	0	2
CCD Milford North	1	0	1	0
CCD Smyrna	1	0	0	1
Cheswold	1	0	0	1
Clayton	3	0	0	3
Dover	24	0	1	23
Farmington	N/A	0	0	N/A
Felton	3	0	0	3
Frederica	2	0	0	2
Harrington	5	0	0	5
Hartly	1	0	0	1
Houston	1	0	0	1
Kenton	N/A	0	0	N/A
Leipsic	1	0	1	0
Little Creek	1	0	0	1
Magnolia	2	0	0	2
Milford	5	0	1	4
Smyrna	8	0	0	8
Viola	N/A	0	0	N/A
Woodside	1	0	0	1
Wyoming	3	0	0	3
TOTAL	**100**	**1**	**4**	**95**

[2] The definitions used are as follows. Negligible: less than 1 percent damage. Slight: 1 to 5 percent damage. Moderate: 5 to 30 percent damage. Extensive (where applicable): 30 to 60 percent damage.

Requirement §201.6(c)(2)(ii): *[The risk assessment shall include a] description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i) of this section. This description shall include an overall summary of each hazard and its impact on the community*

A repetitive loss property is an NFIP-insured property that has had at least four paid flood losses of more than $1,000, or has had two paid flood losses within 10 years that, in aggregate, equal or exceed the value of the property, or has had three or more paid losses that, in aggregate, equal or exceed the value of the property. Addressing repetitive loss properties through the implementation of specific mitigation projects represent one of the most effective ways to reduce future flood losses. **Table 4.3-3** contains a tally of the number of repetitive loss properties in the County and individual municipalities, the number of flood insurance policies currently in force (as of April 2014), and the percentage of current policies that represent repetitive loss properties. Of the two repetitive loss properties in Kent County, one is a single-family residential property and one is a non-residential property. The one repetitive loss property in the Town of Bowers is a single-family residential property. **Table 4.3-4** contains the same information but for the severe repetitive loss properties in Kent County. A severe repetitive loss property is one that has had at least four claim payments greater than $5,000, or the cumulative amount of the four payments exceeds $20,000, or has had two cumulative claim payments that exceed the value of the property. Of the six severe repetitive loss properties in Kent County, five are single-family residential properties and one is a non-residential property. Both of the severe repetitive loss properties in the Town of Bowers and the Town of Smyrna are single-family residential properties. The location of the repetitive loss properties in relation to the dFIRM floodplain may be found in **Figure 4.3-7**.

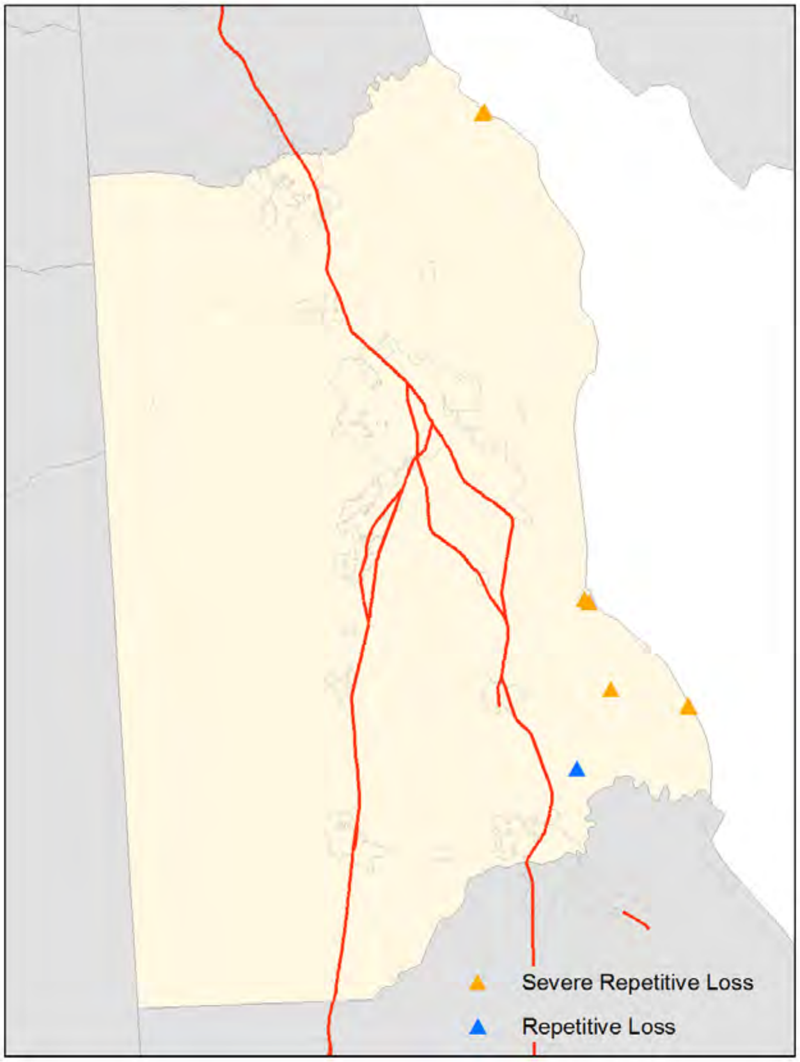
Table 4.3-3
Repetitive Loss Properties as of April 2014

Jurisdiction	Number of Properties	Total Number of Policies per Jurisdiction	Total Payments	Average Payment per Claim
Kent County	2	699	$218,060	$54,515
Town of Bowers	1	119	$107,019	$53,509

Table 4.3-4
Severe Repetitive Loss Properties as of April 2014

Jurisdiction	Number of Properties	Total Number of Policies per Jurisdiction	Total Payments	Average Payment per Claim
Kent County	6	699	$625,752	$36,499
Town of Bowers	2	119	$147,943	$36,986
Town of Smyrna	1	30	$133,366	$33,342

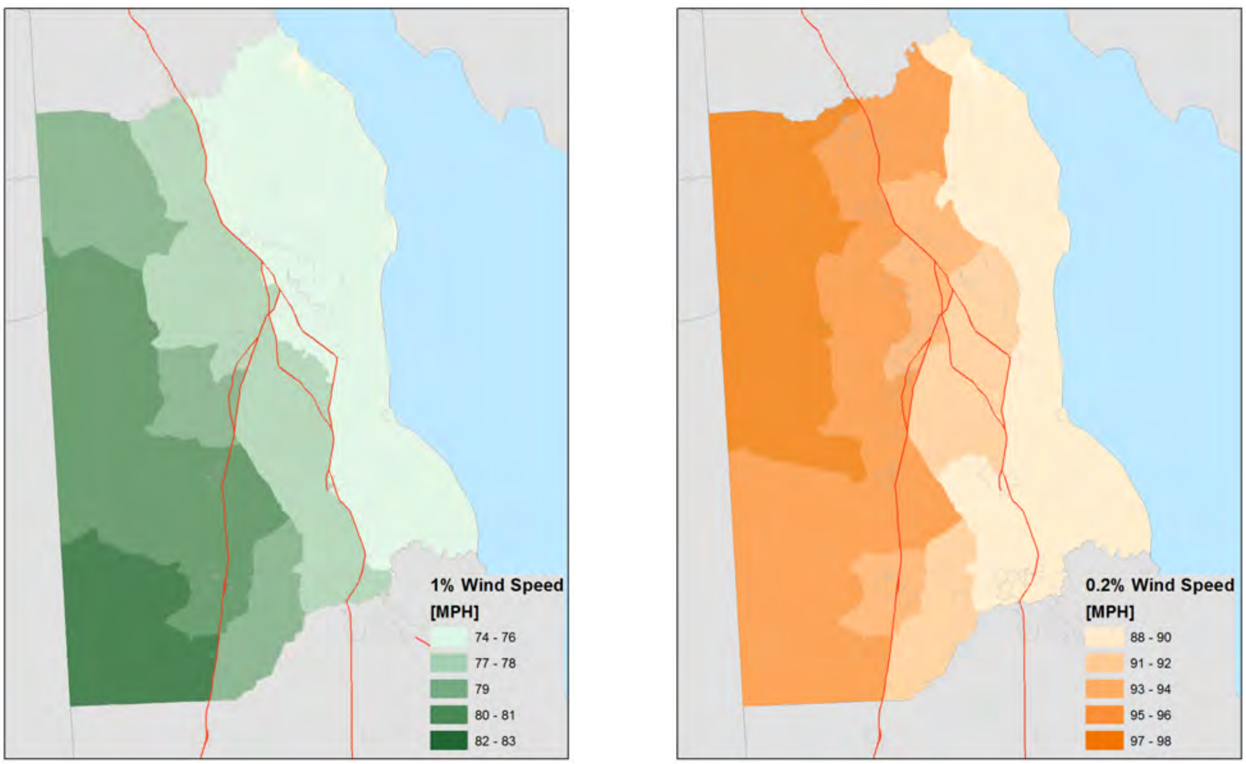
Figure 4.3-7
Location of Repetitive Loss Properties



4.3.6 Coastal Winds

Historical evidence shows that the State of Delaware is vulnerable to severe, hurricane and tropical storm-force winds. The approach for determining vulnerability to coastal winds included a number of factors. HAZUS-MH was used for wind speed data as well as an inventory and in-house damage functions, which were used in estimating losses. The potential hurricane wind gusts that could affect the area range from 74 to 83 mph for a 1% chance per year event to 88 to 98 mph for a 0.2% chance per year event, with the stronger winds being on the western side of the county (**Figure 4.3-8**).

Figure 4.3-8
Potential Hurricane Wind Gusts for 1% and 0.2% per year Wind Events



Modeled from HAZUS-MH, the total built property exposure to coastal winds (both building and contents) in the county is $29,312,397,000 (**Table 4.3-5**). Comparing this to the total building assessed value from the County's property data (around $3 billion), it seems that HAZUS-MH's estimates of exposure are quite a bit higher than one would expect. Thus, the total estimated annualized losses of $$2,730,424 need to be understood in context as also being extraordinarily elevated. The standardized loss ratio of 0.000093 (or 47x less potential annual damage from wind as flooding) makes more sense given historical loss records. Loss ratios in the county's municipalities range from 0.000056 in Clayton to 0.000165 in Houston. Among the CCDs, Felton and Harrington are most vulnerable to coastal wind (0.000137).

Table 4.3-5
Potential Annualized Losses from Coastal Winds by Jurisdiction

Jurisdiction	Total Exposure	Estimated Losses	Loss Ratio
Bowers Beach	$1,959,060	$296	0.000151
Camden	$690,147,652	$65,887	0.000095
CCD Central Kent	$3,724,126,139	$501,094	0.000135
CCD Dover	$6,942,615,339	$625,933	0.000090
CCD Felton	$839,347,820	$115,294	0.000137
CCD Harrington	$1,977,116,154	$270,947	0.000137
CCD Kenton	$1,013,716,423	$79,347	0.000078
CCD Milford North	$1,468,837,441	$186,014	0.000127
CCD Smyrna	$3,347,087,475	$242,770	0.000073
Cheswold	$108,001,640	$8,418	0.000078
Clayton	$417,190,844	$23,309	0.000056
Dover	$6,627,391,313	$431,697	0.000065
Farmington	$456,140	$63	0.000138
Felton	$11,117,125	$1,527	0.000137
Frederica	$49,009,710	$6,498	0.000133
Harrington	$166,140,453	$18,097	0.000109
Hartly	$1,126,738	$91	0.000081
Houston	$11,372,236	$1,876	0.000165
Kenton	$3,537,283	$277	0.000078
Leipsic	$2,083,950	$305	0.000146
Little Creek	$6,219,291	$585	0.000094
Magnolia	$19,179,584	$2,807	0.000146
Milford	$650,899,383	$63,420	0.000097
Smyrna	$931,797,557	$55,980	0.000060
Viola	$5,581,948	$689	0.000123
Woodside	$5,446,047	$672	0.000123
Wyoming	$290,569,541	$26,490	0.000091
TOTAL	**$29,312,397,000**	**$2,730,424**	**0.000093**

Another means of gauging the vulnerability within Kent County to coastal wind was the vulnerability of critical facilities to the 1% chance per year and 0.2% chance per year wind return periods. During a 1% chance per year wind event, only 1 critical facility has more than a 50% chance of sustaining minor, moderate, or severe damage, namely Kent General Hospital in Dover. In a 0.2% chance per year wind event, just 1 facility has a better than 50% chance of sustaining severe (10 to 50%) damage, namely Kent General Hospital in Dover (**Table 4.3-6**).

Table 4.3-6
Potential Damage to Critical Facilities from Coastal Winds by Jurisdiction[3]

Jurisdiction	Total Number of Critical Facilities	1% chance per year Wind			0.2% chance per year Wind		
		> 50 % Chance of Minor Damage	> 50 % Chance of Moderate Damage	> 50 % Chance of Severe Damage	> 50 % Chance of Minor Damage	> 50 % Chance of Moderate Damage	> 50 % Chance of Severe Damage
Bowers Beach	1	0	0	0	0	0	0
Camden	9	0	0	0	0	0	0
CCD Central Kent	5	0	0	0	0	0	0
CCD Dover	17	0	0	0	0	0	0
CCD Felton	2	0	0	0	0	0	0
CCD Harrington	1	0	0	0	0	0	0
CCD Kenton	2	0	0	0	0	0	0
CCD Milford North	1	0	0	0	0	0	0
CCD Smyrna	1	0	0	0	0	0	0
Cheswold	1	0	0	0	0	0	0
Clayton	3	0	0	0	0	0	0
Dover	24	0	0	1	0	0	1
Farmington	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Felton	3	0	0	0	0	0	0
Frederica	2	0	0	0	0	0	0
Harrington	5	0	0	0	0	0	0
Hartly	1	0	0	0	0	0	0
Houston	1	0	0	0	0	0	0
Kenton	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Leipsic	1	0	0	0	0	0	0
Little Creek	1	0	0	0	0	0	0
Magnolia	2	0	0	0	0	0	0
Milford	5	0	0	0	0	0	0
Smyrna	8	0	0	0	0	0	0
Viola	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Woodside	1	0	0	0	0	0	0
Wyoming	3	0	0	0	0	0	0
TOTAL	**100**	**0**	**0**	**1**	**0**	**0**	**1**

[3] The definitions used are as follows. Negligible: less than 1 percent damage. Slight: 1 to 5 percent damage. Moderate: 5 to 30 percent damage. Extensive (where applicable): 30 to 60 percent damage.

4.3.7 Severe Thunderstorm/Wind

Kent County, according to historical records, is affected by severe thunderstorms several times a year. The strong winds and lightning generated from severe thunderstorms pose a threat to the residents, the built environment, and particularly the trees within the County. However, because severe thunderstorms are not spatially-constrained, one must consider the entire County at risk. In addition, the extent of damage from severe thunderstorm wind may be either localized or widespread but it is rarely consistent across space. Therefore, it is impossible to predict if certain areas of the county may be more vulnerable than others and even to estimate the number of buildings that may suffer loss from a severe thunderstorm wind.

Therefore, the approach to determining the County's vulnerability to severe thunderstorm wind is to examine not just severe thunderstorm events in the County boundary, but to look at all of the events of the neighboring counties within 25 miles of the boundary of the County as well. A severe thunderstorm that impacts Caroline County, MD (to the west of Kent County) could have just as easily impacted Kent County instead. The actual location of the severe thunderstorm at this scale of analysis is simply a matter of luck rather than any of the County's unique geographical factors. Because the neighboring jurisdictions are of differing sizes and densities, the results for must be scaled appropriately. For example, Kent County had 5.68 severe thunderstorm events per year, compared to New Castle County's 7.09 events per year. But, Kent County is bigger than New Castle – one would expect the larger county to have more thunderstorm events. In fact, Kent County is 137.5% the size of New Castle County. Therefore, a county the size of New Castle should have been impacted by 9.75 events per year if the county had been the same size as Kent. The annualized losses are scaled similarly, but use numbers of housing units as a proxy for differences in building exposure.

Table 4.3-7 shows the number of events in Kent County and those counties within 25 miles of Kent County. **Table 4.3-8** shows the number of annual events and the amount of annual loss in Kent County and those counties within 25 miles of the County after the appropriate scale factor has been applied. **Table 4.3-9** shows annualized expected losses from severe thunderstorm wind events by jurisdiction within Kent County. The total estimated annualized losses for the county equal $88,589 or a loss ratio of 0.000027.

Table 4.3-7
Losses from Severe Thunderstorm Wind Events (NOAA)

County	Total Events	Total Loss	Years	Annual Events	Annual Loss	Deaths	Injuries
Kent County, DE	318	$3,473,000	56	5.68	$62,018	0	2
New Castle County, DE	383	$14,942,000	54	7.09	$276,704	1	6
Sussex County, DE	600	$8,185,000	57	10.53	$143,596	1	7
Kent County, MD	231	$710,480	46	5.02	$15,445	0	10
Queen Anne's County, MD	221	$1,253,000	40	5.53	$31,325	0	4
Caroline County, MD	188	$769,800	58	3.24	$13,373	0	1
Average	**323.5**	**$4,888,880**	**51.8**	**6.18**	**$90,410**	**0.3**	**5.0**

Table 4.3-8
Normalized Occurrences and Losses from Severe Thunderstorm Wind Events

County	Annual Events	Area Scale Factor	Scaled Events	Annual Loss	HU Scale Factor	Scaled Annual Loss
Kent County, DE	5.68	1.000	5.68	$62,018	1.000	$62,018
New Castle County, DE	7.09	1.375	9.75	$276,704	0.306	$84,608
Sussex County, DE	10.53	0.626	6.59	$143,596	0.528	$75,825
Kent County, MD	5.02	2.116	10.62	$15,445	6.298	$97,279
Queen Anne's County, MD	5.53	1.576	8.72	$31,325	3.301	$103,389
Caroline County, MD	3.24	1.835	5.95	$13,373	4.966	$66,412
Normalized Average			**7.88**			**$88,589**

Table 4.3-9
Potential Losses from Thunderstorm Wind by Jurisdiction

Jurisdiction	Total Exposure	% of Total Exposure	Estimated Losses
Bowers Beach	$7,182,154	0.219	$194
Camden	$73,141,732	2.227	$1,972
CCD Central Kent	$444,420,828	13.530	$11,981
CCD Dover	$628,957,377	19.149	$16,956
CCD Felton	$109,659,741	3.339	$2,957
CCD Harrington	$179,225,267	5.183	$4,589
CCD Kenton	$115,083,828	3.504	$3,103
CCD Milford North	$124,164,839	3.780	$3,347
CCD Smyrna	$231,377,241	7.044	$6,237
Cheswold	$16,991,783	0.518	$459
Clayton	$52,294,064	1.592	$1,410
Dover	$844,922,049	25.724	$22,778
Farmington	$1,300,648	0.040	$35
Felton	$21,167,271	0.644	$570
Frederica	$10,837,285	0.330	$292
Harrington	$59,117,411	1.800	$1,594
Hartly	$983,149	0.030	$27
Houston	$5,452,527	0.166	$147
Kenton	$3,322,168	0.101	$89
Leipsic	$2,459,068	0.075	$66
Little Creek	$2,361,793	0.072	$64
Magnolia	$3,135,862	0.095	$84
Milford	$111,284,044	3.388	$3,000
Smyrna	$215,816,547	6.571	$5,819
Viola	$2,160,536	0.066	$58
Woodside	$2,997,870	0.091	$81
Wyoming	$23,586,371	0.718	$636
TOTAL	**$3,284,595,900**	**100.0**	**$88,589**

4.3.8 Tornado

Historical evidence shows that Kent County is vulnerable to tornadic activity. This particular hazard may result from severe thunderstorm activity or may occur during a tropical storm or hurricane. Because it cannot be predicted where a tornado may touch down, all buildings and facilities are considered to be exposed to this hazard and could potentially be impacted. It is also not possible to estimate the number of residential, commercial, and other buildings or facilities that may experience losses.

The approach to determining vulnerability to tornadoes is similar to that used for severe thunderstorm wind. Historical tornado loss data from the National Oceanic and Atmospheric Administration (NOAA) was gathered for Kent County and the neighboring counties within 25 miles of the boundary of the County. All historical losses were scaled to account for inflation, and average historic tornado losses were calculated (**Table 4.3-10**). As with severe thunderstorms (above), because the neighboring jurisdictions are of differing sizes and densities, the results must be normalized appropriately using the method described previously (**Table 4.3-11**). **Table 4.3-12** shows annualized expected losses from tornado events by jurisdiction within Kent County. The total estimated annualized losses for the county equal $45,532 or a loss ratio of 0.000013. The location and magnitude of past tornado events within the county, in relation to population density, is presented in **Figure 4.3-9**.

Table 4.3-10
Losses from Tornado Events (NOAA)

County	Total Events	Total Loss	Years	Annual Events	Annual Loss	Deaths	Injuries
Kent County, DE	20	$5,158,000	50	0.40	$103,160	2	56
New Castle County, DE	23	$7,413,000	60	0.38	$123,550	0	8
Sussex County, DE	19	$593,500	59	0.32	$10,059	0	11
Kent County, MD	4	$502,500	64	0.06	$7,852	0	0
Queen Anne's County, MD	10	$526,000	49	0.20	$10,735	0	0
Caroline County, MD	5	$375,250	62	0.08	$6,052	0	0
Average	**13.5**	**$2,428,042**	**57.3**	**0.240**	**$43,568**	**0.3**	**12.5**

Table 4.3-11
Normalized Occurrences and Losses from Tornado Events

County	Annual Events	Area Scale Factor	Scaled Events	Annual Loss	HU Scale Factor	Scaled Annual Loss
Kent County, DE	0.40	1.000	0.40	$103,160	1.000	$103,160
New Castle County, DE	0.38	1.375	0.52	$123,550	0.306	$37,778
Sussex County, DE	0.32	0.626	0.20	$10,059	0.528	$5,312
Kent County, MD	0.06	2.116	0.13	$7,852	6.298	$49,455
Queen Anne's County, MD	0.20	1.576	0.32	$10,735	3.301	$35,431
Caroline County, MD	0.08	1.835	0.15	$6,052	4.966	$30,055
Normalized Average			**0.285**			**$45,532**

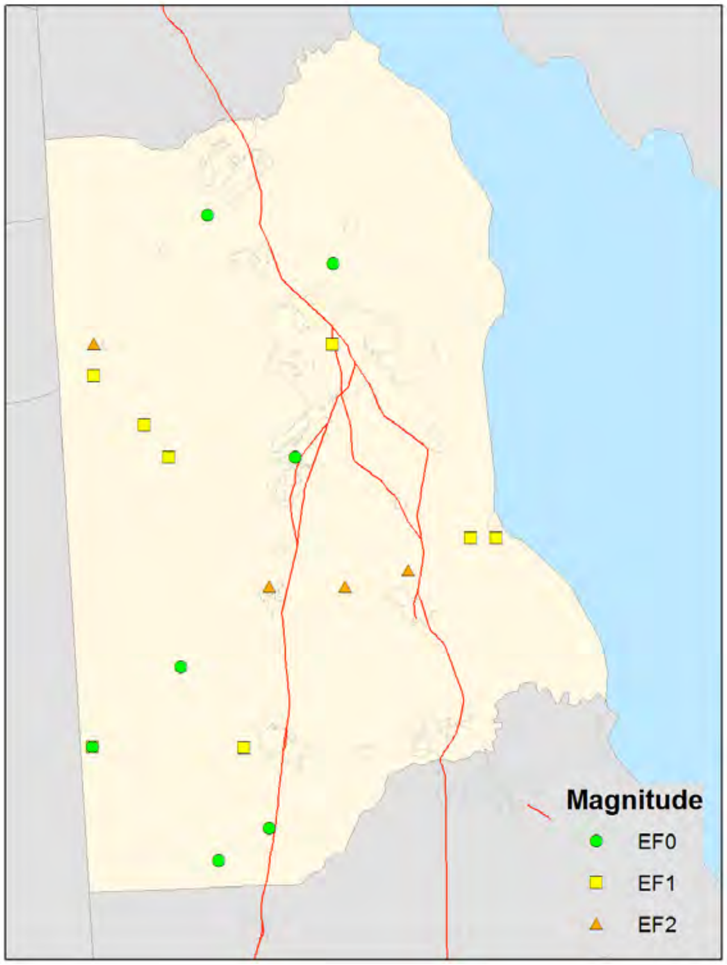
Table 4.3-12

Potential Annualized Losses from Tornado by Jurisdiction

Jurisdiction	Total Exposure	% of Total Exposure	Estimated Losses
Bowers Beach	$7,182,154	0.219	$100
Camden	$73,141,732	2.227	$1,014
CCD Central Kent	$444,420,828	13.530	$6,160
CCD Dover	$628,957,377	19.149	$8,719
CCD Felton	$109,659,741	3.339	$1,520
CCD Harrington	$179,225,267	5.183	$2,360
CCD Kenton	$115,083,828	3.504	$1,595
CCD Milford North	$124,164,839	3.780	$1,721
CCD Smyrna	$231,377,241	7.044	$3,207
Cheswold	$16,991,783	0.518	$236
Clayton	$52,294,064	1.592	$725
Dover	$844,922,049	25.724	$11,713
Farmington	$1,300,648	0.040	$18
Felton	$21,167,271	0.644	$293
Frederica	$10,837,285	0.330	$150
Harrington	$59,117,411	1.800	$820
Hartly	$983,149	0.030	$14
Houston	$5,452,527	0.166	$76
Kenton	$3,322,168	0.101	$46
Leipsic	$2,459,068	0.075	$34
Little Creek	$2,361,793	0.072	$33
Magnolia	$3,135,862	0.095	$43
Milford	$111,284,044	3.388	$1,543
Smyrna	$215,816,547	6.571	$2,992
Viola	$2,160,536	0.066	$30
Woodside	$2,997,870	0.091	$41
Wyoming	$23,586,371	0.718	$327
TOTAL	**$3,284,595,900**	**100.0**	**$45,532**

Figure 4.3-9

Location and Magnitude of Past Tornado Events



4.3.9 Drought

Although the State of Delaware as a whole is vulnerable to drought, estimated potential losses are somewhat difficult to calculate because drought causes little damage to the built environment, mostly affecting crops and farmland. Therefore, it is assumed that all buildings and facilities are exposed to drought but would experience negligible damage in the occurrence of a drought event.

The approach used to determine vulnerability within Kent County consisted of a number of factors. Statistical data for the past 100 years from the University of Nebraska, developed based on Palmer Drought and Crop Severity Indices, was analyzed. Drought event frequency/impact was then determined for Kent County. Also used was USDA agriculture data from 2012. Drought impact on the non-irrigated agriculture products profile was then determined. **Table 4.3-13** shows annualized expected losses from drought events by rural jurisdiction within Kent County. The total estimated annualized losses for the county equal $470,588. Given the total value of land in farms in Kent County is $1,377,914,128, which yields an annualized loss ratio of 0.00034.

Figure 4.3-10 shows the hazard profile for drought in the geographic area surrounding Kent County[4].

4.3.10 Hail

The State of Delaware is minimally vulnerable to hail storms. Hail does occur in the Mid-Atlantic but is usually not large enough nor widespread enough to cause any significant damage to the built environment. It does, however, have the potential of harming crops in the agricultural areas of Kent County.

The approach to determining vulnerability to hail is similar to that used for severe thunderstorm wind. Historical hail loss data from the National Oceanic and Atmospheric Administration (NOAA) was gathered for Kent County and the neighboring counties within 25 miles of the boundary of the County. All historical losses were scaled to account for inflation, and average historic losses were calculated (**Table 4.3-14**). As with severe thunderstorms (above), because the neighboring jurisdictions are of differing sizes and densities, the results must be normalized appropriately using the method described previously (**Table 4.3-15**). Because the total estimated annualized losses for the county is negligible ($2,779), annualized expected losses from hail events by jurisdiction were not calculated.

[4] This information was obtained from the National Drought Mitigation Center (www.drought.unl.edu), which helps people and institutions develop and implement measures to reduce societal vulnerability to drought, stressing preparedness and risk management rather than crisis management.

Table 4.3-13
Potential Losses from Drought by Jurisdiction

Jurisdiction	Total Exposure	% of Total Exposure	Estimated Losses
CCD Central Kent	$110,973,070	8.054	$37,900
CCD Dover	$168,612,596	12.237	$57,585
CCD Felton	$179,812,282	13.050	$61,410
CCD Harrington	$235,572,333	17.096	$80,453
CCD Kenton	$132,051,022	9.583	$45,098
CCD Milford North	$360,440,289	26.158	$123,098
CCD Smyrna	$190,452,535	13.822	$65,044
TOTAL	**$1,377,914,128**	**100.0**	**$470,588**

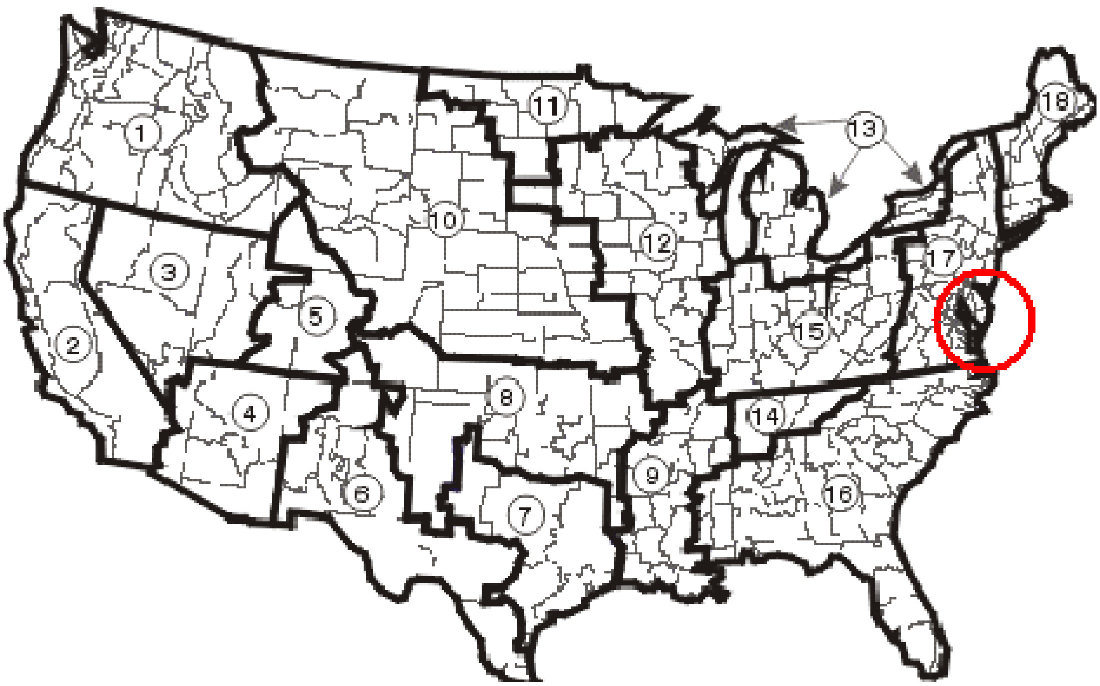
Table 4.3-14
Losses from Hail Events (NOAA)

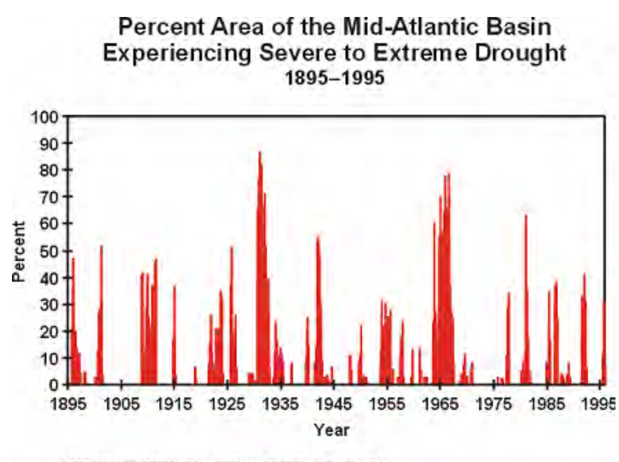
County	Total Events	Total Loss	Years	Annual Events	Annual Loss	Deaths	Injuries
Kent County, DE	24	$105,000	46	0.52	$2,283	0	0
New Castle County, DE	53	$5,000	44	1.20	$114	0	0
Sussex County, DE	31	$310,000	46	0.67	$6,739	0	0
Kent County, MD	15	$0	39	0.38	$0.00	0	0
Queen Anne's County, MD	10	$0	30	0.33	$0.00	0	0
Caroline County, MD	13	$50,000	23	0.57	$2,174	0	0
Average	**24.3**	**$78,333.33**	**38.0**	**0.533**	**$1,885**	**0**	**0**

Table 4.3-15
Normalized Occurrences and Losses from Hail Events

County	Annual Events	Area Scale Factor	Scaled Events	Annual Loss	HU Scale Factor	Scaled Annual Loss
Kent County, DE	0.52	1.000	0.52	$2,283	1.000	$2,283
New Castle County, DE	1.20	1.375	1.65	$114	0.306	$35
Sussex County, DE	0.67	0.626	0.42	$6,739	0.528	$3,559
Kent County, MD	0.38	2.116	0.80	$0.00	6.298	$0
Queen Anne's County, MD	0.33	1.576	0.52	$0.00	3.301	$0
Caroline County, MD	0.57	1.835	1.05	$2,174	4.966	$10,796
Normalized Average			**0.83**			**$2,779**

Figure 4.3-10
Hazard Profile for Drought In and Around Kent County





4.3.11 Winterstorms

Historical evidence shows that Kent County is quite vulnerable to winter storms, with several occurring each year. Because winter storms generally impact large areas, all buildings and facilities are considered to be exposed to this hazard and could potentially be impacted. It is also not possible to estimate the number of residential, commercial, and other buildings or facilities that may experience losses.

The approach to determining vulnerability to winter storms is similar to that used for severe thunderstorm wind. Historical winter storm loss data from the National Oceanic and Atmospheric Administration (NOAA) was gathered for Kent County and the neighboring counties within 25 miles of the boundary of the County. All historical losses were scaled to account for inflation, and average historic losses were calculated (**Table 4.3-16**). As with severe thunderstorms (above), because the neighboring jurisdictions are of differing sizes and densities, the results must be normalized appropriately using the method described previously (**Table 4.3-17**). **Table 4.3-18** shows annualized expected losses from winter storm events by jurisdiction within Kent County. The total estimated annualized losses for the county equal $90,867[5] and an annualized loss ratio of 0.000028.

Table 4.3-16
Losses from Winter Storm Events (NOAA)

County	Total Events	Total Loss	Years	Annual Events	Annual Loss	Deaths	Injuries
Kent County, DE	110	$3,650,000	21	5.24	$173,810	0	5
New Castle County, DE	141	$5,350,000	21	6.71	$254,762	4	76
Sussex County, DE	185	$6,300,000	21	8.81	$300,000	1	15
Kent County, MD	102	$125,000	21	4.86	$5,952	0	0
Queen Anne's County, MD	101	$320,000	21	4.81	$15,238	1	1
Caroline County, MD	95	$200,000	21	4.52	$9,524	0	0
Average	**122.3**	**$2,657,500**	**21**	**5.83**	**$126,548**	**1.0**	**16.2**

Table 4.3-17
Normalized Occurrences and Losses from Winter Storm Events

County	Annual Events	Area Scale Factor	Scaled Events	Annual Loss	HU Scale Factor	Scaled Annual Loss
Kent County, DE	5.24	1.000	5.24	$173,810	1.000	$173,810
Kent County, DE	6.71	1.375	9.23	$254,762	0.306	$77,899
Cecil County, MD	8.81	0.626	5.52	$300,000	0.528	$158,413
Kent County, MD	4.86	2.116	10.28	$5,952	6.298	$37,488
Chester County, PA	4.81	1.576	7.58	$15,238	3.301	$50,293
Delaware County, PA	4.52	1.835	8.29	$9,524	4.966	$47,297
Normalized Average			**7.69**			**$90,867**

[5] It is important to note that for winter storm, some factors that contribute to a community's actual and perceived losses are not reflected in this analysis, such as removal of snow from roadways, debris clean-up, some indirect losses from power outages, etc.

Table 4.3-18
Potential Annualized Losses from Winter Storms by Jurisdiction

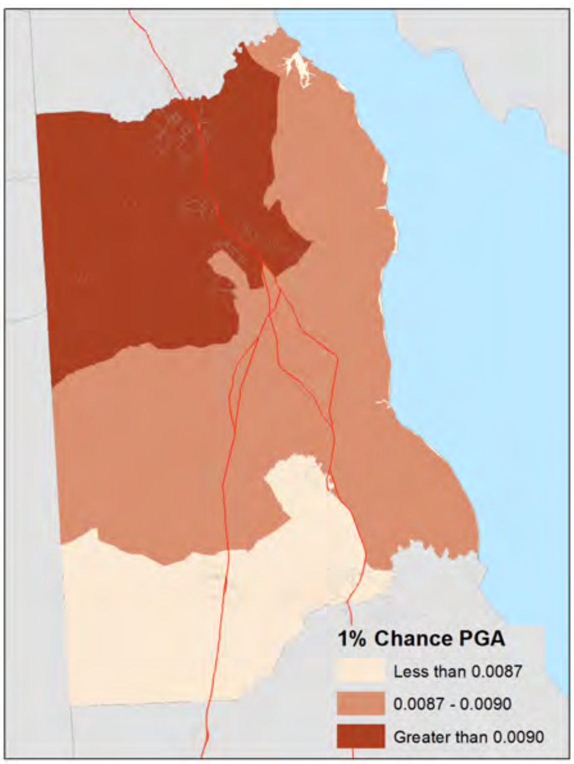
Jurisdiction	Total Exposure	% of Total Exposure	Estimated Losses
Bowers Beach	$7,182,154	0.219	$199
Camden	$73,141,732	2.227	$2,024
CCD Central Kent	$444,420,828	13.530	$12,294
CCD Dover	$628,957,377	19.149	$17,400
CCD Felton	$109,659,741	3.339	$3,034
CCD Harrington	$179,225,267	5.183	$4,710
CCD Kenton	$115,083,828	3.504	$3,184
CCD Milford North	$124,164,839	3.780	$3,435
CCD Smyrna	$231,377,241	7.044	$6.401
Cheswold	$16,991,783	0.518	$471
Clayton	$52,294,064	1.592	$1,447
Dover	$844,922,049	25.724	$23,375
Farmington	$1,300,648	0.040	$36
Felton	$21,167,271	0.644	$585
Frederica	$10,837,285	0.330	$300
Harrington	$59,117,411	1.800	$1,636
Hartly	$983,149	0.030	$27
Houston	$5,452,527	0.166	$151
Kenton	$3,322,168	0.101	$92
Leipsic	$2,459,068	0.075	$68
Little Creek	$2,361,793	0.072	$65
Magnolia	$3,135,862	0.095	$86
Milford	$111,284,044	3.388	$3,079
Smyrna	$215,816,547	6.571	$5,971
Viola	$2,160,536	0.066	$60
Woodside	$2,997,870	0.091	$83
Wyoming	$23,586,371	0.718	$652
TOTAL	**$3,284,595,900**	**100.0**	**$90,867**

4.3.12 Earthquake

Figure 4.3-11 shows the potential ground motion for a 100-year and 500-year earthquake. While Kent County has felt earthquakes every so often, none have been significant enough to cause any damage for well over 100 years. The coastal plain of the Mid-Atlantic is notorious for being a seismically quiet zone. However, if a serious earthquake were to occur, the losses would likely be significant. This explains the amount of potential annualized losses for the county of $43,454 (**Table 4.3-19**). **Table 4.3-20** shows potential damage to critical facilities from earthquake events by jurisdiction within Kent County.

Figure 4.3-11
Peak Ground Acceleration (Ground Motion) for 1% and 0.2% Chance per Year Events

1% Chance per Year Ground Motion



0.2% Chance per Year Ground Motion

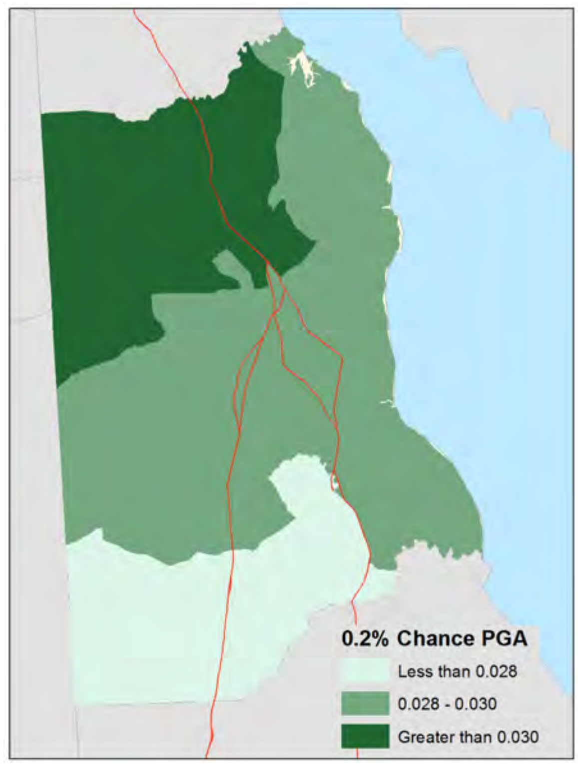


Table 4.3-19
Potential Annualized Losses from Earthquake per Jurisdiction

Jurisdiction	Total Exposure	Estimated Losses	Loss Ratio
Bowers Beach	$1,959,060	$6	0.0000031
Camden	$690,147,652	$1,964	0.0000028
CCD Central Kent	$3,724,126,139	$10,133	0.0000027
CCD Dover	$6,942,615,339	$21,737	0.0000031
CCD Felton	$839,347,820	$2,340	0.0000028
CCD Harrington	$1,977,116,154	$4,885	0.0000025
CCD Kenton	$1,013,716,423	$3,430	0.0000034
CCD Milford North	$1,468,837,441	$3,878	0.0000026
CCD Smyrna	$3,347,087,475	$11,560	0.0000035
Cheswold	$108,001,641	$361	.0.0000033
Clayton	$417,190,844	$1,464	0.0000035
Dover	$6,627,391,313	$22,238	0.0000034
Farmington	$456,140	$1	0.0000022
Felton	$11,117,125	$31	0.0000028
Frederica	$49,009,710	$129	0.0000026
Harrington	$166,140,453	$434	0.0000026
Hartly	$1,126,738	$4	0.0000036
Houston	$11,372,236	$27	0.0000024
Kenton	$3,537,283	$12	0.0000034
Leipsic	$2,083,950	$7	0.0000034
Little Creek	$6,219,291	$19	0.0000031
Magnolia	$19,179,584	$50	0.0000026
Milford	$650,899,383	$1,536	0.0000024
Smyrna	$931,797,557	$3,226	0.0000035
Viola	$5,581,948	$16	0.0000029
Woodside	$5,446,047	$15	0.0000028
Wyoming	$290,569,541	$838	0.0000029
TOTAL	**$29,312,397,000**	**$90,342**	**0.0000031**

Table 4.3-20
Potential Damage to Critical Facilities from Earthquakes per Jurisdiction[6]

Jurisdiction	Total Number of Critical Facilities	1% chance per year			0.2% chance per year		
		Moderate Damage	Slight Damage	Negligible Damage	Moderate Damage	Slight Damage	Negligible Damage
Bowers Beach	1	0	0	1	0	0	1
Camden	9	0	0	9	0	0	9
CCD Central Kent	5	0	0	5	0	0	5
CCD Dover	17	0	0	17	0	0	17
CCD Felton	2	0	0	2	0	0	2
CCD Harrington	1	0	0	1	0	0	1
CCD Kenton	2	0	0	2	0	0	2
CCD Milford North	1	0	0	1	0	0	1
CCD Smyrna	1	0	0	1	0	0	1
Cheswold	1	0	0	1	0	0	1
Clayton	3	0	0	3	0	0	3
Dover	24	0	0	24	0	0	24
Farmington	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Felton	3	0	0	3	0	0	3
Frederica	2	0	0	2	0	0	2
Harrington	5	0	0	5	0	0	5
Hartly	1	0	0	1	0	0	1
Houston	1	0	0	1	0	0	1
Kenton	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Leipsic	1	0	0	1	0	0	1
Little Creek	1	0	0	1	0	0	1
Magnolia	2	0	0	2	0	0	2
Milford	5	0	0	5	0	0	5
Smyrna	8	0	0	8	0	0	8
Viola	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Woodside	1	0	0	1	0	0	1
Wyoming	3	0	0	3	0	0	3
TOTAL	**100**	**0**	**0**	**100**	**0**	**0**	**100**

[6] The definitions used are as follows. Negligible: less than 1 percent damage. Slight: 1 to 5 percent damage. Moderate: 5 to 30 percent damage. Extensive (where applicable): 30 to 60 percent damage.

4.3.13 Dam/Levee Failure

The approach for determining vulnerability to dam and/or levee failure consists of a number of factors. Data from the USACE National Inventory of Dams (NID)[7] in addition to the HAZUS-MH demographic inventory was used, with an assumption that dam breaks most likely will occur at the time of maximum capacity.[8] The affected population was then calculated.

Table 4.3-21 shows estimated exposure of people to dam failure.

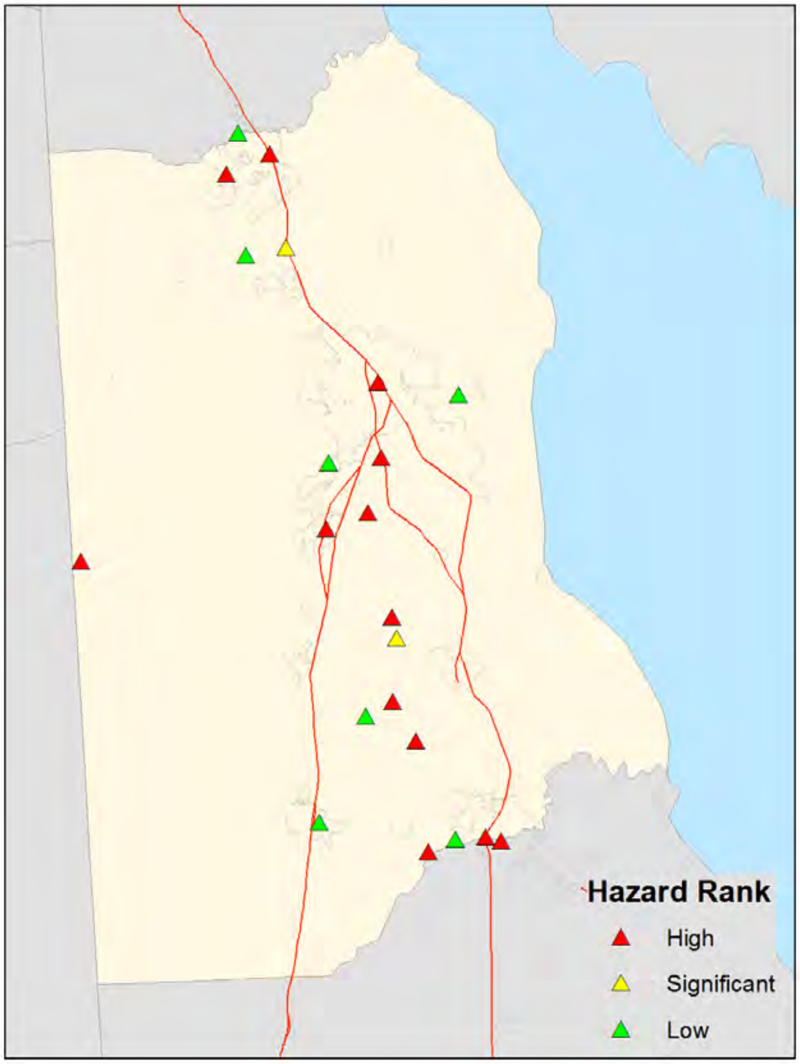
Table 4.3-21
Estimated Exposure of People to Dam Failure

Dam Name	Nearest City/Town	Potential People at Risk
Silver Lake Dam	Dover	2,329
Moores Lake Dam	Dover	1,308
Silver Lake Dam	Milford	1,003
Wyoming Lake Dam	Camden	979
Voshell Pond Dam	Rising Sun	810
Haven Lake Dam	Milford	659
Garrisons Lake Dam	Leipsic	313
Derby Pond Dam	Woodside	177
Tub Mill Pond Dam	Milford S	140
Coursey Pond Dam	Frederica	115

Figure 4.3-12 shows the location of dams within Kent County, along with their hazard ranking (high, significant or low), in relation to population density.

[7] With the National Dam Inspection Act of 1972, the U.S. Congress authorized the U.S. Army Corps of Engineers (USACE) to inventory dams located in the United States. The Water Resources Development Act of 1986 authorized USACE to maintain and periodically publish an updated National Inventory of Dams (NID).
[8] Downstream quarter-circle buffer proportional to the maximum capacity of dams are assumed to represent the maximum impact area.

Figure 4.3-12
Location of Dams



4.3.14 Weapons of Mass Destruction

Using FEMA Publication 426—Reference Manual to Mitigate Potential Terrorist Attacks in High Occupancy Buildings—as a basis, a vulnerability assessment was conducted for Weapons of Mass Destruction (WMDs) in order to expand the scope of the hazard mitigation planning process in the State of Delaware to include vulnerability to acts of terrorism. The methodology used employs a vulnerability ranking of 1 to 5 for certain transportation, water/hydrology, emergency and public safety, and utility elements. The sum total for each element is then multiplied against a value for that asset (also on a 1 to 5 scale) and multiplied against a factor representing the Department of Homeland Security Threat Level. For the purposes of this Plan, the Threat Level is assumed to be Orange (High). This part of the assessment is the same for all three counties in Delaware. In the final analysis, the total risk for each county is multiplied by a unique weighted factor to arrive at county-specific scores. For Kent County, a weighted factor of 1.15 was used. Abbreviated findings of this methodology are presented in **Table 4.3-22**. Complete information is stored in a Microsoft® Excel® file separate from this Plan.

Table 4.3-22
Assessment of Vulnerability to Weapons of Mass Destruction

	Based on FEMA 426: Reference Manual to Mitigate Potential Terrorist Attacks in High Occupancy Buildings																
	Asset Visibility	Target Value to Pot. Threat Element	Asset Accessability	Asset Mobility	Target Threat of CBR Hazard	Collateral Damage Potential	Site Population/Capacity	Pot. for Collateral Mass Casualties	SUM		Asset Value of Target Site		Homeland Security Threat Condition		Risk	X	Kent 0.85
Transportation																	
Major bridges	5	4	5	5	0	2	1	0	**22**	**X**	**4**	**X**	**6**	**=**	**528**	**:**	**449**
Airports	4	4	3	5	0	1	2	0	**19**	**X**	**4**	**X**	**6**	**=**	**456**	**:**	**388**
Water / Hydrology																	
Reservoirs	3	5	3	5	1	3	1	0	**21**	**X**	**5**	**X**	**6**	**=**	**630**	**:**	**536**
Dams	4	5	2	5	1	4	1	0	**22**	**X**	**5**	**X**	**6**	**=**	**660**	**:**	**561**
Emergency and Public Safety																	
Hospitals	4	3	4	5	4	2	2	2	**26**	**X**	**5**	**X**	**6**	**=**	**780**	**:**	**663**
Military Facilities	2	4	1	5	4	3	3	2	**24**	**X**	**5**	**X**	**6**	**=**	**720**	**:**	**612**
Schools	4	4	4	5	1	1	2	1	**22**	**X**	**3**	**X**	**6**	**=**	**396**	**:**	**337**
Utilities																	
Gas LNG plant	3	3	3	5	2	3	1	2	**22**	**X**	**3**	**X**	**6**	**=**	**396**	**:**	**337**
Electric substations	3	2	3	5	1	2	1	0	**17**	**X**	**2**	**X**	**6**	**=**	**204**	**:**	**173**

In order to give some perspective to these findings, the final scores for each element in Table 4.3-15 were compared to the maximum score defined in FEMA Publication 426 (**Table 4.3-23**). This comparison shows hospitals, military facilities and day care centers to have the three highest rankings compared to all other elements. These three elements are the focal point of the chemical and radiological agents sections.

Table 4.3-23
Comparison of Kent County and FEMA 426 Model

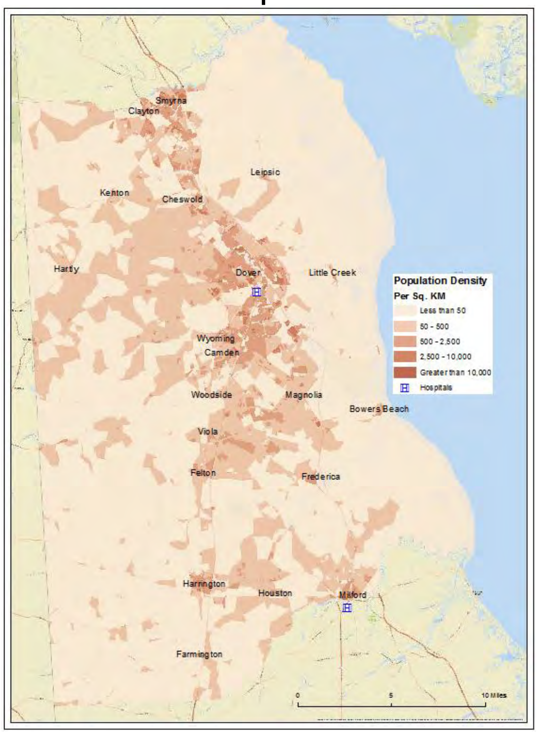
Facility	Threat	Percent Comparison
Maximum Score in FEMA 426 Model	**14.400**	**100%**
Hospitals	6.630	46%
Military Facilities	6.120	43%
Day Care Centers	5.865	41%
Hazardous Material Sites	5.610	39%
Dams	5.610	39%
Reservoirs	5.355	37%
Major Bridges	4.488	31%
All Gas Pipelines	0.867	6%
U.S. Roads	0.816	6%
State Roads	0.816	6%

Chemical Agents

In planning for the possible release of a chemical agent as an act of terrorism, Kent County identified one (1) hospital and 45 day care facilities throughout the county as potential targets. (**Figure 4.3-13** graphically illustrates the locations of these facilities.) In order to create a more complete assessment of the damage that would be inflicted should such an attack occur, Kent County also determined the surrounding population and building stock within both an 8-mile radius of the target (the “Immediate Response Zone”) and a 20-mile radius (the “Protective Action Zone”). This approach is believed to more accurately represent the overall exposure of the county and its communities to the threat of a chemical agent. **Tables 4.3-24** and **4.3-25** offer the results of this analysis. In order to keep this planning document brief, only the top four day care facilities in terms of affected population are included in Table 16. Complete information for all 45 facilities is stored in a Microsoft® Excel® file separate from this Plan.

Figure 4.3-13
Location of Day Care Facilities and Hospitals in Kent County

Hospitals



Day Care Facilities

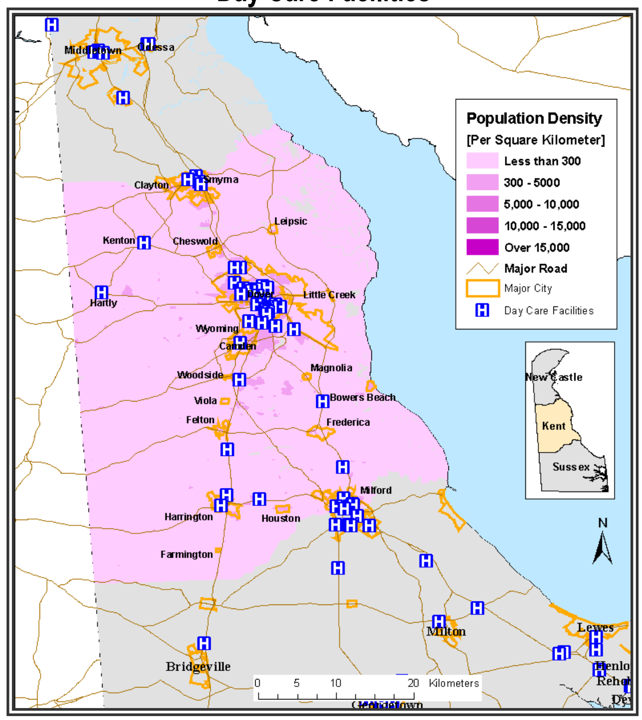


Table 4.3-24
Hospitals and Surrounding Exposure

Name of Hospital	City	Immediate Response Zone (IRZ) 8 miles from each hospital		Protective Action Zone (PAZ) 20 miles from each hospital	
		Population	Buildings	Population	Buildings
Bayhealth Medical Center	Dover	102,568	40,334	184,516	71,834

Table 4.3-25
Day Care Facilities and Surrounding Exposure[9]

Name of Day Care Facility	City	Immediate Response Zone (IRZ) 8 miles from each hospital		Protective Action Zone (PAZ) 20 miles from each hospital	
		Population	Buildings	Population	Buildings
Tot's Turf Child Care (DAPI)	Camden/Wyoming	110,639	43,403	188,812	73,529
Dover Early Learning Center	Dover	108,034	42,385	186,346	72,554
Brighter Beginnings	Dover	106,064	41,657	186,498	72,657
DTCC, Terry Campus (ECAP)	Dover	105,784	41,592	179,524	69,306

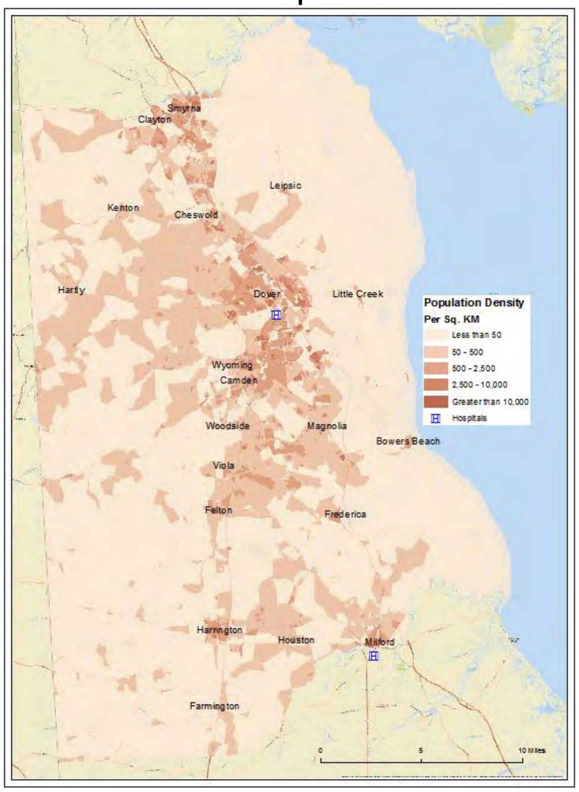
Radiological Agents

In planning for the possible release of a radiological agent as an act of terrorism, Kent County identified one (1) hospital and five (5) military facilities throughout the county as potential targets. (**Figure 4.3-14** graphically illustrates the locations of these facilities.) In order to create a more complete assessment of the damage that would be inflicted should such an attack occur, Kent County also determined the surrounding population and building stock within both an 8-mile radius of the target (the "Immediate Response Zone") and a 20-mile radius (the "Protective Action Zone"). This approach is believed to more accurately represent the overall exposure of the county and its communities to the threat of a radiological agent. **Tables 4.3-26** and **4.3-27** offer the results of this analysis.

[9] Complete information is stored in a Microsoft® Excel® file separate from this Plan.

Figure 4.3-14
Location of Hospitals and Military Facilities in Kent County

Hospitals



Military Facilities

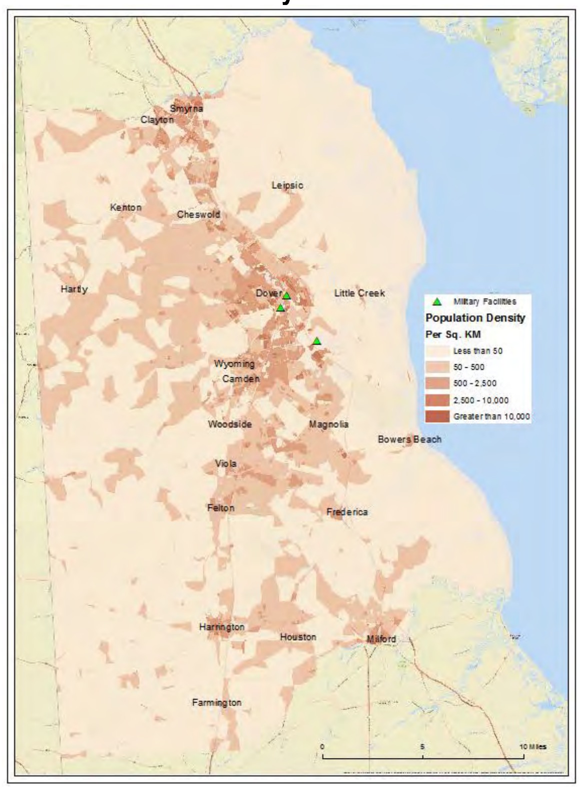


Table 4.3-26
Hospitals

Name of Hospital	City	Immediate Response Zone (IRZ) 8 miles from each hospital		Protective Action Zone (PAZ) 20 miles from each hospital	
		Population	Buildings	Population	Buildings
Bayhealth Medical Center	Dover	116,148	45,739	995,738	426,643

Table 4.3-27
Military Facilities

Name of Military Facility	Immediate Response Zone (IRZ) 8 miles from each hospital		Protective Action Zone (PAZ) 20 miles from each hospital	
	Population	Buildings	Population	Buildings
Army National Guard	121,134	47,457	992,541	420,905
Dover Armory	115,947	45,532	995,546	426,555
Dover Air Force Base	108,394	42,883	1,003,124	432,993
Delaware National Guard	60,313	23,767	499,266	230,181
Milford Armory	55,362	22,497	445,030	208,958

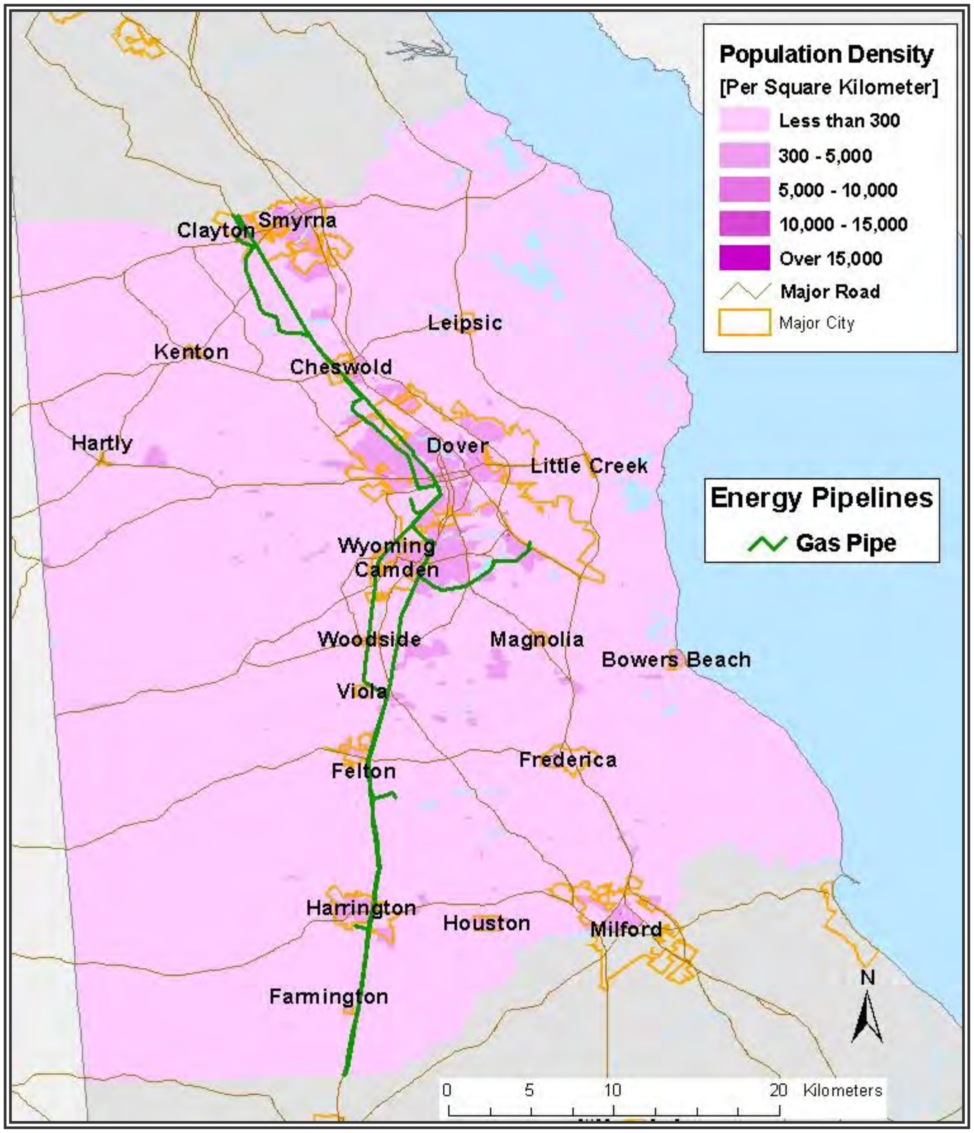
Biological Agents

The relative risk of Kent County to Delaware in terms of the release of a biological agent is 3.41 percent. This is based on a risk formula of "VULNERABILITY x HAZARD x EXPOSURE." Vulnerability in this case is a measure of the speed at which infection will spread among the population. Population was studied based on general occupancy class: residential, commercial, industrial, education, government, agricultural and religious. The hazard component was considered to be a measure of the introduction of the disease among the population. This also was broken down by occupancy class, in this case residential, commercial, industrial, education, government and religious. The exposure was determined using HAZUS-MH data.

4.3.15 Energy Pipelines

Energy pipelines cross most of the state of Delaware, and parts of Kent County. If any of these energy pipelines, oil or gas, were to rupture, such an event could endanger property and lives in the immediate area (within less than half a mile radius).

Figure 4.3-15
Energy Pipelines



4.3.16 Hazardous Materials

Assessing vulnerability to a hazardous materials (HazMat) release on a countywide scale can consist of a number of factors, such as the type(s) of hazardous materials present, the potential for mass casualties, potential consequences for the surrounding area, accessibility, public awareness, and the likelihood of being a terrorist target. The assessment conducted for Kent County focuses on the first three of these factors, and a comprehensive study was undertaken to document information for 15 identified hazardous material sites from State of Delaware exposure data[10]. High consequence events were then selected (high material toxicity and population density), and ALOHA[11] was used to calculate the potential area of impact. Affected population (based on Census 2010) and exposure value (HAZUS-MH) was then reported across selected events.

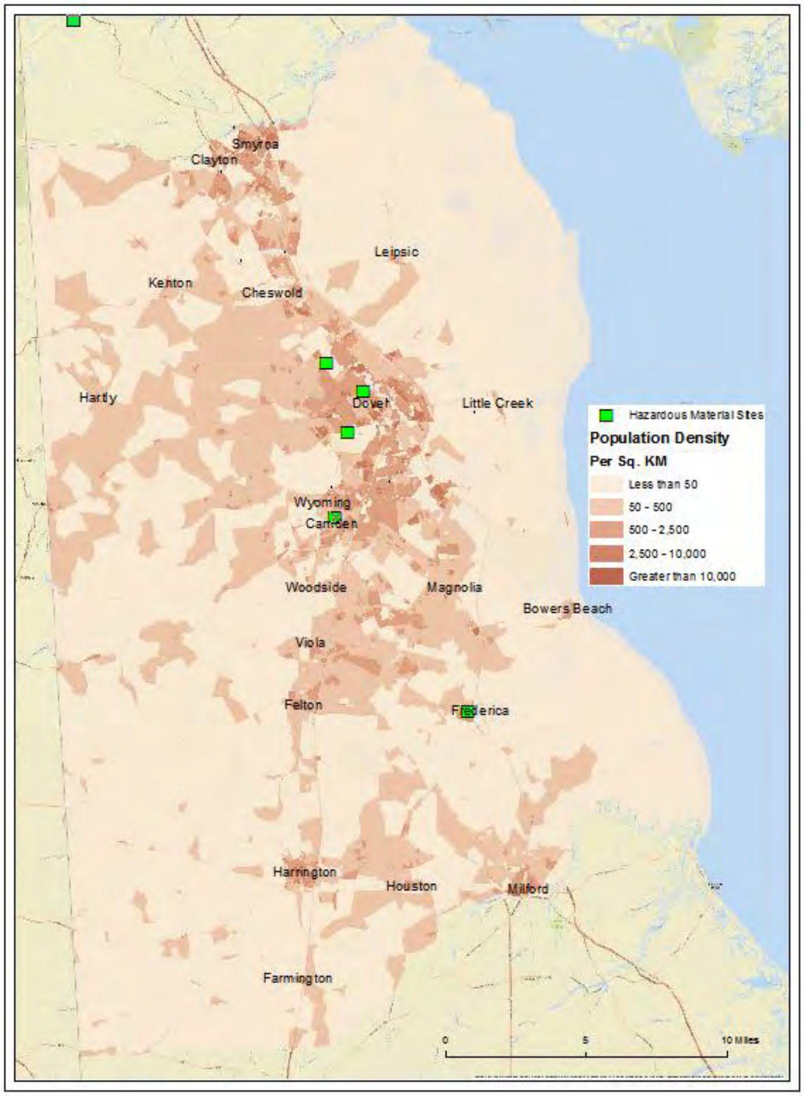
Table 4.3-28 offers the results of this analysis for all 15 HazMat facilities.

Table 4.3-28
Hazardous Materials Facilities (Abbreviated List)

Facility Name	City	Chemical Name	Potential Residential Population at Risk	Clean-up Area (square kms)
Hirsh Industries	Dover	Certain Glycol Ethers	4,095	29.431
Reichhold, Inc.	Cheswold	1,3-Butadiene	2,808	64.687
Reichhold, Inc.	Cheswold	Butyl Acrylate	2,069	51.094
Reichhold, Inc.	Cheswold	Vinyl Acetate	2,046	27.273
Reichhold, Inc.	Cheswold	Acrylonitrile	1,106	8.174
Playtex Products, Inc.	Dover	Chlorine	17	0.038
Hirsh Industries	Dover	N-Butyl Alcohol	5	0.008
Reichhold, Inc.	Cheswold	Acrylic Acid **Solid	3	0.019
General Clothing Co., Inc.	Smyrna	Toluene	8	0.021
Camdel Metals Corporation	Camden	Trichloroethylene	1	0.011
NRG Energy Center	Dover	Hydrochloric Acid	0	0.027
NRG Energy Center	Dover	Sulfuric Acid	0	0.012
NRG Energy Center	Dover	Mercury Compounds	0	0.011
Reichhold, Inc.	Cheswold	N-Methylolacrylamide	0	0.000
Reichhold, Inc.	Cheswold	Formaldehyde	0	0.000

[10] If a facility houses more than one hazardous material, it is treated as a separate entry in this table, partially due to the fact that potential population at risk and projected clean-up area could vary depending on the chemical.
[11] ALOHA (Areal Locations of Hazardous Atmospheres) is a computer program that uses information provided by its operator and physical property data from its extensive chemical library to predict how a hazardous gas cloud might disperse in the atmosphere after an accidental chemical release.

Figure 4.3-16
Location of Hazardous Materials Facilities in Relation to Population Density



4.3.17 Other Hazards

Though communities in the State of Delaware recognize that the state is vulnerable to other hazards such as wildfire, erosion, sinkholes, landslides and tsunamis, a high-level detailed risk assessment was not completed for Kent County due to the low level of risk and/or vulnerability for these hazards within the area as a whole as compared with other hazards.

4.3.18 Conclusions on Hazard Risk

Table 4.3-29 summarizes the annualized expected losses presented for each natural hazard in this section. Based upon the methodologies described in the beginning of this section, the risk from natural hazards in Kent County can be rated on a scale of Low, Moderate or High for each identified natural hazard based upon these annualized losses and an annualized loss ratio (**Table 4.3-30**). Because of the nature of human-caused hazards and the nature in which risk and vulnerability is presented for human-caused hazards, it is not possible to rank them fairly in direct comparison with natural hazards. In summary, all human-caused hazards addressed in this section—terrorism (chemical, radiological and biological agents), hazardous materials incidents (HazMat), and energy pipeline failures—warrant an overall rating of low risk for Kent County.

Table 4.3-29
Potential Annualized Losses Ratios per Jurisdiction

Jurisdiction	Flood	Coastal Wind	Thunder-storm	Tornado	Drought	Hail	Winter Storm	Earth-quake
Bowers Beach	0.0067	0.000151	0.000027	0.000013	---	---	0.000028	0.0000031
Camden	0.0036	0.000095	0.000027	0.000013	---	---	0.000028	0.0000028
CCD Central Kent	0.0042	0.000135	0.000027	0.000013	0.00034	---	0.000028	0.0000027
CCD Dover	0.0048	0.000090	0.000027	0.000013	0.00034	---	0.000028	0.0000031
CCD Felton	0.0029	0.000137	0.000027	0.000013	0.00034	---	0.000028	0.0000028
CCD Harrington	0.0025	0.000137	0.000027	0.000013	0.00034	---	0.000028	0.0000025
CCD Kenton	0.0051	0.000078	0.000027	0.000013	0.00034	---	0.000028	0.0000034
CCD Milford North	0.0049	0.000127	0.000027	0.000013	0.00034	---	0.000028	0.0000026
CCD Smyrna	0.0048	0.000073	0.000027	0.000013	0.00034	---	0.000028	0.0000035
Cheswold	---	0.000078	0.000027	0.000013	---	---	0.000028	.0.0000033
Clayton	0.0034	0.000056	0.000027	0.000013	---	---	0.000028	0.0000035
Dover	0.0045	0.000065	0.000027	0.000013	---	---	0.000028	0.0000034
Farmington	---	0.000138	0.000027	0.000013	---	---	0.000028	0.0000022
Felton	---	0.000137	0.000027	0.000013	---	---	0.000028	0.0000028
Frederica	0.0059	0.000133	0.000027	0.000013	---	---	0.000028	0.0000026
Harrington	---	0.000109	0.000027	0.000013	---	---	0.000028	0.0000026
Hartly	---	0.000081	0.000027	0.000013	---	---	0.000028	0.0000036
Houston	0.0000	0.000165	0.000027	0.000013	---	---	0.000028	0.0000024
Kenton	0.0000	0.000078	0.000027	0.000013	---	---	0.000028	0.0000034
Leipsic	0.0042	0.000146	0.000027	0.000013	---	---	0.000028	0.0000034
Little Creek	0.0050	0.000094	0.000027	0.000013	---	---	0.000028	0.0000031
Magnolia	---	0.000146	0.000027	0.000013	---	---	0.000028	0.0000026
Milford	0.0022	0.000097	0.000027	0.000013	---	---	0.000028	0.0000024
Smyrna	0.0027	0.000060	0.000027	0.000013	---	---	0.000028	0.0000035
Viola	---	0.000123	0.000027	0.000013	---	---	0.000028	0.0000029
Woodside	---	0.000123	0.000027	0.000013	---	---	0.000028	0.0000028
Wyoming	0.0041	0.000091	0.000027	0.000013	---	---	0.000028	0.0000029
TOTAL	**0.0044**	**0.000093**	**0.000027**	**0.000013**	**0.00034**	**---**	**0.000028**	**0.0000031**

Table 4.3-30
Estimated Level of Risk by Hazard (High, Moderate, Low)

Flood	Coastal Wind	Thunder storm	Tornado	Drought	Hail	Winter Storm	Earthquake
High	Moderate	Moderate	Low	High	Low	Moderate	Moderate

It should be noted that although some hazards may show Medium or Low risk, hazard occurrence is still possible. Also, any hazard occurrence could potentially cause a great impact and losses could be extremely high (e.g. an F5 tornado or a Category 5 hurricane).

Table 4.3-31
Overall Risk Ranking for Kent County

Hazard	Rank
Flood	1
Drought	2
Coastal Wind	3
Earthquake	4
Winter Storm	5
Thunderstorm	6
Tornado	7
Hail	8
Extreme Heat/Cold	Unranked
Wildfire	Unranked
Coastal Erosion	Unranked
Dam/Levee Failure	Unranked
Tsunami	Unranked
Volcano	Unranked
Terrorism	Unranked
HazMat Incident	Unranked
Pipeline Failure	Unranked