Section 3
Hazard Identification, Profiling and Prioritization

Contents of this Section

3.1 IFR Requirement for Hazard Identification

IFR §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.*

IFR §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.*

IFR §201.6(c)(2)(ii): *[The risk assessment]* ***must*** *also address National Flood Insurance Program (NFIP insured structures that have been repetitively damaged floods.*

3.2 Hazard History and Identification

Per IFR requirements, and as the first step in the hazard mitigation planning process, Sussex County identified hazards that can impact Sussex County. The following subsections provide an overview of past hazard events in Sussex County and identify the hazards included in the planning process.

Note: The term "planning area" as used in this Plan refers to the geographic limits of Sussex County.

3.2.1 Sussex County's Hazard History

Numerous federal agencies maintain a variety of records regarding losses associated with natural hazards. Unfortunately, no single source offers a definitive accounting of all losses. The Federal Emergency Management Agency (FEMA) maintains records on federal expenditures associated with declared major disasters. The United States Army Corps of Engineers (USACE) and the Natural Resources Conservation Service collect data on losses during the course of some of their ongoing projects and studies. Additionally, the National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center (NCDC) database collects and maintains data about natural hazards in summary format.

The University of South Carolina's Hazards & Vulnerability Research Institute has compiled a county-level hazard data set for the U.S. for 18 different natural hazard events types, called the Spatial Hazard Events and Losses Database for the United States (SHELDUS). The data is derived from several existing national data sources, including the NCDC's monthly Storm Data publications and only contains events that had associated loss of life, injuries, or financial damages. The online NCDC database does not include some of the older events before 1973. However, SHELDUS 7.0 includes events derived from NCDC-provided hardcopies as far back as 1960 that are not included in NCDC's online database. The SHELDUS team also chose to manually determine when losses occurred within the queried county or in another location during the same event. When the location of the loss could not be determined based on the event description, SHELDUS methodology calls for the losses to be evenly distributed across the number of counties that were impacted by the event. NCDC combines all losses for an event and they appear for that county when queried, which causes overestimations within counties and duplicated losses across counties. SHELDUS also provides the option of adjusting for inflation. Adjusting for inflation is important when comparing monetary amounts across multiple years in order to standardize losses and to avoid underestimating older damages. SHELDUS only provides data up to 2008.

For these reasons, the SHELDUS database has been chosen for use in this Plan for events from 1960-2008 and cross-check them with events in the NCDC database, especially for events from 2008-2010. The data includes occurrences, dates, injuries, deaths, and costs.

According to the SHELDUS and NCDC databases, between 1960 and 2010, Sussex County has experienced the following significant, loss-associated hazard events:

- 84 thunderstorm and high wind events
- 38 winter storms/extreme cold temperature events
- 1 drought
- 12 floods/flash floods
- 7 extreme heat events
- 5 hail storms
- 17 lightning events
- 4 hurricanes or tropical storms
- 0 wildfires
- 2 tornadoes

According to the NCDC and SHELDUS, Sussex County has experienced approximately 43 deaths and 33 injuries from natural hazards in the period from 1960 to 2010.[1] In addition to the events recorded in the NCDC database, other sources identified 14 earthquakes, three significant crop loss events, and 5 impactful landslides[2]. These figures are discussed in more detail in the hazard-specific subsections that follow.

Table 3.2.1-1 provides brief descriptions of particularly significant hazard events occurring in Sussex County's recent history per the NCDC. This list is not meant to capture every event that has affected the area; rather it lists some of the more significant events that have occurred.

Sussex County has received seven major Presidential Disaster Declarations and seven Emergency Declarations since 1950. Four of the seven major disaster declarations were the result of significant flooding. All of the major and emergency declarations, and one non-declared event, are included as part of the summary in Table 3.2.1-1 below.

Table 3.2.1-1: Recent Declared Emergency and Major Disasters in Sussex County, 1962-2010

Date and Disaster (DR)	Nature of Event
3/09/1962 (DR-124)	SEVERE STORMS, HIGH WINDS, AND FLOODING–Statewide, the event resulted in damages estimated at $88.4 million (damage estimate adjusted to dollar figures for the year 2003).
8/18/1965 (DR-205)	WATER SHORTAGE–Statewide, the event resulted in damages estimated at $6.4 million (damage estimate adjusted to dollar figures for the year 2003).
9/04/1971 (DR-310)	HEAVY RAINS AND FLOODING–Statewide, the event resulted in damages estimated at $55.8 million (damage estimate adjusted to dollar figures for the year 2003).
2/08/1977 (DR-528)	ICE CONDITIONS–Statewide, the event resulted in damages estimated at approximately $989,000 (damage estimate adjusted to dollar figures for the year 2003).
10/19/1980 (DR-3083)	WATER SHORTAGE (Emergency Declaration)–Statewide, the event resulted in damages estimated at $5 million (damage estimate adjusted to dollar figures for the year 2003).

[1] Hazards & Vulnerability Research Institute (2009). The Spatial Hazard Events and Losses Database for the United States, Version 7.0 [Online Database]. Columbia, SC: University of South Carolina. Retrieved from http://www.shel dus.org NOAA/NCDC database. Retrieved from http://www.ncdc.noaa.gov/oa/climateresearch.html

[2] Crop loss data came from NOAA/NCDC. Earthquake data came from NJDEP - New Jersey Geological Survey - DGS04-1 Earthquakes Epicentered in New Jersey http://www.state.nj.us/dep/njgs/geodata/dgs04-1.htm#image
Landslide data came from NJDEP – New Jersey Geological Survey – DGS06-3 Landslides in New Jersey http://www.state.nj.us/dep/njgs/geodata/dgs06-3.htm

Date and Disaster (DR)	Nature of Event
3/13/1993 (DR-3106)	SEVERE STORMS AND FLOODING (Emergency Declaration)–Event known as the *Storm of the Century* affected as many as 26 states from Florida to Maine, the Gulf Coast, and the Ohio Valley. One of the most intense nor'easters to ever effect the United States. The *Storm of the Century* label was given to the event due to the record low pressure, wind speeds, temperature, and snowfall. All 21 counties in New Jersey were included in the Presidentially Declared Disaster.
1/7/1996 (DR-1088)	BLIZZARD—A State of Emergency was declared for the blizzard that hit the state. Road conditions were dangerous due to the high winds and drifts. Both government and contract snow plowing operations were running at a maximum. Local roads were impassable. This blizzard also brought on coastal flooding with the high tides of Sunday evening and Monday morning, and there were reports of damage to dunes and beaches from the heavy wave activity. More than 400 National Guard personnel were activated for transport assistance, primarily for medic missions.
9/18/1999 (DR-1295)	HURRICANE FLOYD – This downgraded fall hurricane put the entire eastern seaboard on flood watch, including every county in New Jersey. The storm lasted approximately 18 hours resulting in rainfall totals of between 10-14 inches in some parts of the state.
8/12/2000 (DR-1337)	SEVERE STORMS, FLOODING, AND MUDSLIDES – President Clinton declared a major disaster declaration for Sussex and Morris Counties due to the storm. Sparta Township in Sussex County was the hardest hit. Storm damage totals for both counties were estimated at $166.5 million.
11/01/2000 (DR-3156)	WEST NILE VIRUS (Emergency Declaration) – Statewide, the event resulted in damages estimated at approximately $2.9 million (damage estimate adjusted to dollar figures for the year 2003).
9/19/2001 (DR-3169)	FIRES AND EXPLOSIONS (Emergency Declaration) – Statewide, the attacks of September 11, 2001 resulted in damages estimated at approximately $100 million (damage estimate adjusted to dollar figures for the year 2003).
2/16/2003 (DR-3181)	HEAVY SNOW (Emergency Declaration) – The most powerful storm to affect New Jersey since the blizzard of 1996. The combination of the very cold temperatures and the approach of a strong storm system caused widespread snow to break out, starting before sunrise on Sunday, February 16. Snow continued during Sunday day, heavy at times, and continued into Sunday night. Precipitation continued on Monday, before finally coming to an end on Tuesday. Total snowfall in Sussex County ranged from 16″ to 25″. New Jersey requested and was granted a Snow Emergency Declaration for all 21 counties. The President's Day snowstorm tied or set records in all 21 New Jersey counties including Sussex County. Statewide, the event resulted in damages estimated at approximately $30.2 million (damage estimate adjusted to dollar figures for the year 2003).

Date and Disaster (DR)	Nature of Event
10/01/2004 (DR-1563)	SEVERE STORMS AND FLOODING - Hurricane Ivan initially made landfall along the Gulf Coast on September 16, 2004 near the border of Alabama and Florida as a Category 4 Hurricane. As the storm moved inland, it weakened and was eventually downgraded to a tropical depression before reaching New Jersey. As a tropical depression, the storm continued to cause extensive damages from heavy rains that totaled up to six inches in some parts of New Jersey. The heavy rains resulted in significant flood damages particularly along the Delaware River. As a result of the event, a Presidentially-Declared Disaster was declared on October 1st, 2004, for four Counties in northwestern New Jersey (FEMA DR-1563). The majority of the infrastructure damages occurred in neighboring Warren County where FEMA Public Assistance totaled almost three million dollars.
4/19/2005 (DR-1588)	SEVERE STORMS AND FLOODING - For the second time within seven months a greater than 50-year storm affected the Delaware River Basin and its tributaries. The crests along the Delaware River were the highest crests since 1955. In many places, it was the second or third highest crest on record for the Delaware River. In Sussex, Warren, Hunterdon, Mercer, and Morris Counties, about 1,800 homes and businesses were flooded, and 25 homes were destroyed.
7/07/2006 (DR-1653)	SEVERE STORMS AND FLOODING - Beginning on June 23, 2006, portions of northwestern New Jersey were impacted by severe storms and flooding. The severe storms and heavy rains resulted in flooding along the Delaware River. On July 7, 2006 a Presidentially Declared Disaster was declared for four counties in northwestern New Jersey.
4/15/2007 (DR-1694)	SEVERE STORMS AND INLAND AND COASTAL FLOODING–A seven-day nor’easter deluged New Jersey with over 9″ of rain, causing millions of dollars of damage and killing three residents. Statewide damage was estimated at $180 million. The nor'easter also brought strong to high winds as well as some snow to the state. Numerous streams and rivers flooded, but the flooding along the Delaware River was minimal. It was the second worst rain storm (not related to a hurricane) in the state's history. The heavy rain and flooding caused several major roads to be closed in Sussex County. The Wallkill River flooded in Wantage and the Clove Brook flooded in Sussex. The worst flooding occurred along the Raritan and Passaic River Basins.

Sources: NOAA/NCDC; FEMA; New Jersey Office of Emergency Management and the Public Entity Risk Institute.

3.2.2 Hazard Identification

At the outset of the planning process, the Northern Delaware River Region Steering Committee (NDRR SC) and the Sussex County Hazard Mitigation Working Group (HMWG) identified 11 natural and technological hazards and the risks they pose for the county and its material assets, operations, and staff as the focus of the Plan. These hazards were identified per the experience of the NDRR SC and the HMWG and according to other references (e.g., Mitigation 20/20 data entry forms from participating municipalities, county EOPs, the New Jersey State Hazard Mitigation Plan, etc.). The resulting preliminary hazard list is shown in Table 3.2.2-1.

Table 3.2.2-1: Preliminary Hazard List, Sussex County

Hazard	Type (1)	NDRR PDM Application	County EOP	Mitigation 20/20	NJ SHMPU (2)	NDRR RFP (3)	Profiled in HMP?
Dam Failure	T					✓	✓
Drought	N	✓		✓	✓	✓	✓
Earthquake/Geological (4)	N			✓		✓	✓
Flood (5)	N	✓	✓	✓	✓	✓	✓
Hazardous Materials Release	T		✓	✓		✓	✓
High Wind–Straight-Line Winds (6)	N		✓	✓	✓	✓	✓
High Wind–Tornado	N	✓			✓	✓	✓
Landslide (non-seismic)	N			✓	✓	✓	✓
Severe Weather - Summer	N			✓		✓	✓
Severe Weather - Winter	N	✓	✓		✓	✓	✓
Wildfire	N	✓		✓	✓	✓	✓

Notes:

(1) Type Legend: N = Natural; T = Technological/Manmade.
(2) NJSHMPU = State of New Jersey Hazard Mitigation Plan, approved by FEMA in April 2008.
(3) Hazards indicated as likely candidates to include in planning for Sussex County per Northern Delaware River Region Request for Proposals (RFP).
(4) Earthquake/Geological includes effects of surface faulting, ground shaking, earthquake induced landslides, and liquefaction.
(5) Includes tidal, flash, and riverine flooding
(6) High Wind-Straight-Line Winds includes winds due to hurricanes, tropical storms, nor'easters, coastal storms, and other severe storms, excluding tornados.

The following section profiles the 11 hazards listed above, and includes a description of the hazard, location and extent of the hazard, severity of the hazard, documented impacts on life and property, and past occurrences.

3.3 Hazard Profiles

Per IFR requirements, Sussex County profiled hazards that can impact the county. Each hazard section contains the following subsections:

Description of the Hazard

Definition and description of the hazard, including widely accepted indices and classifications.

Occurrence and Future Probability of Hazard

This is an overview of past significant events from national databases, state, and local sources. Our focus will be on events that caused losses in the form of death, injuries, property damages, and/or crop losses. All dollar amounts have been adjusted to 2010 figures for inflation for easier comparison and rounded to the nearest dollar. Probability of future events is based on the number of past events divided by the number of years to obtain a percentage. Any other pertinent information on probability will be considered, including relevant available studies.

Location and Extent of Hazard

Identify geographic area of the county that could potentially be affected by the hazard and its impacts, including maps when possible. Discuss the anticipated degree and severity of potential hazards, such as wind speeds, depth of flooding, peak ground acceleration, etc. Also discuss specific characteristics of the county that may affect the extent of the hazard such as geography, geology, topography, or vegetative cover, and when possible, include maps.

Impact on Life and Property of the Hazard

This is a summary of past event losses of human life, injury, property damages, and crop damages, and the severity of impacts on the county. All dollar amounts have been adjusted to 2010 figures for inflation for easier comparison and rounded to the nearest dollar. Sources include national, state, and local databases and any relevant available studies.

Prioritization and Rationale of the Hazard

In order to summarize the massive amounts of information and provide a level playing field for comparing hazards, each hazard is analysed and the risk to the county is evaluated based on the Calculated Priority Risk Index (CPRI). The purpose of the CPRI is not to replace scientific or local knowledge or to have the final say on a hazard, but to provide the county with a means for looking at the hazards for further vulnerability analysis. Each CPRI is accompanied by a rationale for why that particular hazard will be included or excluded for further exploration in Section 4. In some cases, the county will chose to further review a hazard that has a low CPRI value, and the reasoning for this decision will be provided.

CPRI values are based upon previous event history and hazard definitions, and combine the hazard's probability of future occurrence, magnitude or severity of the hazard's impacts, warning time before an event occurs, and the duration of the event. The categories are shown in Tables 3.3-1 through 3.3-4.

Table 3.3-1: Probability of Future Occurrence Based on Previous Hazard Events

Probability	Index Value	Description
Highly Likely	4	• Frequent significant events with a well documented history of occurrence. • Event has up to 1 in 1 year chance of occurring. (1/1 = 100%) • History of events is 33%-100% likely per year.
Likely	3	• Occasional significant occurrences with at least two or more documented historic significant events. • Event has up to 1 in 3 years chance of occurring. (1/3 = 33%) • History of events is 20%-33% likely per year.
Possibly	2	• Rare significant occurrences with at least one documented or anecdotal historic significant event • Event has up to 1 in 5 years chance of occurring. (1/5=20%) • History of events is 10%-20% likely per year.
Unlikely	1	• Extremely rare with no documented history of significant events occurring. • Event has up to 1 in 10 years chance of occurring. (1/10=10%) • History of events is 0%-10% likely per year.

Table 3.3-2: Magnitude/Severity of Potential Impacts Based on Previous Hazard Events

Magnitude/ Severity	Index Value	Description
Catastrophic	4	• Multiple deaths • More than 50% of property is severely damaged • Complete shutdown of facilities for more than 1 month
Critical	3	• Injuries and/or illnesses result in permanent disability • More than 25% of property is severely damaged • Complete shutdown of critical facilities for at least 14 days
Limited	2	• Injuries and/or illnesses do no result in permanent disability • More than 10% of property is severely damaged • Complete shutdown of critical facilities for at least 1 day
Negligible	1	• Injuries and/or illnesses are treatable with first aid • Less than 25% of property is severely damaged • Shutdown of critical facilities for 24 hours or less

Table 3.3-3: Warning Time of Hazard Event Based on Hazard Definition

Warning Time	Index Value	Description
Less than 6 Hours	4	Less than 6 Hours warning time before event occurs
6-12 Hours	3	6-12 Hours warning time before event occurs
12-24 hours	2	12-24 Hours warning time before event occurs
24+ Hours	1	At least 24 Hours warning time before event occurs

Table 3.3-4: Duration of Hazard Event Based on Hazard Definition

Warning Time	Index Value	Description
More than 1 week	4	Event lasts more than 1 week
Less than 1 week	3	Event lasts less than 1 week
Less than 1 day	2	Event lasts less than 1 day
Less than 6 hours	1	Event lasts less than 6 hours

3.3.1 Dam Failure

Description of the Dam Failure Hazard

According to the New Jersey Department of Environmental Protection (NJDEP), "A dam is any artificial dike, levee or other barrier, together with appurtenant works, which is constructed for the purpose of impounding water on a permanent or temporary basis, that raises the water level five feet or more above the usual, mean, low water height when measured from the downstream toe-of-dam to the emergency spillway crest or, in the absence of an emergency spillway, the top-of-dam."[3]

Dams are manmade structures that serve a variety of uses such as flood protection, power production, agricultural, water supply, and to form recreational areas. They are typically constructed of earth, rock, or concrete, and come in all shapes and sizes. Dam failure is the uncontrolled release of impounded water resulting in downstream flooding, and other impacts that can affect lives and property. Dams can fail because water heights or flows are above the capacity the structure was designed for (including flooding), or because the structure failed in some way. Structures fail for many reasons, including lack of maintenance, erosion, seismic events, insufficient design, development or alteration of the floodplain, or improper construction. Concrete/masonry dams usually fail from loss of a section or undermining, while the primary causes of earthen dam failure are overtopping, followed by piping failure, and then foundation failure. Concrete or masonry dams tend to fail suddenly, while earthen dams usually take longer to fail.

Dam safety inspections and monitoring have become important tools in evaluating dam failure risk, ensuring proper maintenance, and prioritizing actions. The ranking of inspections are often based on a classification system according to the potential impact a dam failure or mis-operation would have on nearby populations and property. FEMA utilizes a Hazard Potential Classification System for Dams that categorizes them as Low, Significant, or High as described in Table 3.3.1-1.

[3] NJDEP's Dam Safety & Flood Control retrieved from http://www.state.nj.us/dep/damsafety/faq.htm

Table 3.3.1-1: Dam Hazard Potential Classification System

Hazard Potential Classification	Loss of Human Life	Economic, Environmental, Lifeline Losses
Low (L)	None Expected	Low and Generally Limited to Owner
Significant (S)	None Expected	Yes
High (H)	Probable; One or More Expected	Yes

Source: FEMA

See Table 3.3.1-2 for the Dam Class categories that New Jersey utilizes to determine the inspection cycle and type of inspection for dams.

Table 3.3.1-2: New Jersey Dam Classification and Inspection Schedule

Dam Class	Description	Regular Inspection	Formal Inspection
Class I Large Dam (High-Hazard Potential)	Failure of dam may result in probable loss of life and/or extensive property damage.	Annually	Once every 3 years
Class I Dam (High-Hazard Potential)	Failure of dam may result in probable loss of life and/or extensive property damage.	Once every 2 years	Once every 6 years
Class II Dam (Significant-Hazard Potential)	Failure of the dam may result in significant property damage, but loss of life not envisioned.	Once every 2 years	Once every 10 years
Class III Dam (Low-Hazard Potential)	Failure of the dam is not expected to result in loss of life and/or significant property damage.	Once every 4 years	Only as required
Class IV Dam (Small-Dam Low-Hazard Potential)	Failure of the dam is not expected to result in loss of life or significant property damage.	Once every 4 years	Only as required

Source: NJDEP's Dam Safety and Flood Control. Retrieved from http://www.state.nj.us/dep/damsafety/faq.htm#q7

Occurrences and Probability of the Dam Failure Hazard

According to the "Flood Mitigation Plan for the Non-tidal, New Jersey Section of the Delaware River Basin" from November 2008, there have not been any catastrophic dam failures in New Jersey. However, there have been an increasing amount of small dam failures. This may be due in part to the age of the dam infrastructure in the state and insufficient maintenance. Stanford University's Department of Civil and Environmental Engineering maintains the National Performance of Dams Program (NPDP) database and website.[4] The database information is based on a library of dam incident files, including a 1975 and 1988 report from the U.S. Committee on Large Dams, and from reports by users. The level of completion for the records is unknown, but when queried, at least thirty-one dam incidents were listed in Sussex County.

[4] Stanford University. Retrieved from http://npdp.stanford.edu/index.html

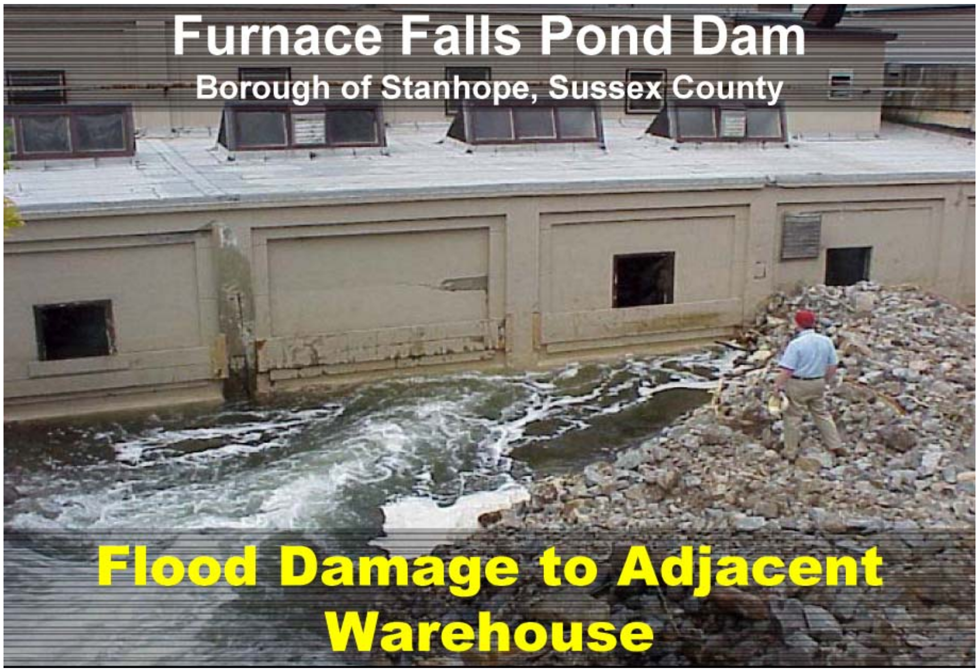
Eighteen of these dam incidents occurred at dams that are part of the National Inventory of Dams (NID), with the eleven foot, significant hazard Seneca Lake Dam failing August 12, 2000 due to inflow flood/hydrologic event and the low hazard Tomahawk Lake Dam failing on the same day due to overtopping as a result of the Seneca Lake Dam failure. There was an unusually heavy rainfall event on that day, with the storm centered over the townships of Sparta, Hopatcong, and Jefferson. Seneca Lake Dam was inspected on two days later and it was found that there was a 50' wide breach and complete failure of the earthen embankment. Four dams completely failed due to the event, all in Sussex. The other thirteen incidents listed in the NPDP occurred on smaller dams that are not tracked and recorded as thoroughly, but two were dam failures from the same event in 2000; Edison Pond Dam and Furnace Falls Pond Dam.

In a presentation at Rowan University in February 2004, the New Jersey Bureau of Dam Safety & Flood Control referenced damages to dams from the August 12, 2000 storm. According to NCDC, Doppler Radar Storm total estimates reached around 15 inches along the Sussex/Morris County Border. Figures 3.3.1-1 through 3.3.1-6 exemplifies some of the dam failures that occurred in a single day.

Figure 3.3.1-1: Seneca Lake Dam Failure Following Heavy Rainfall - August 12, 2000

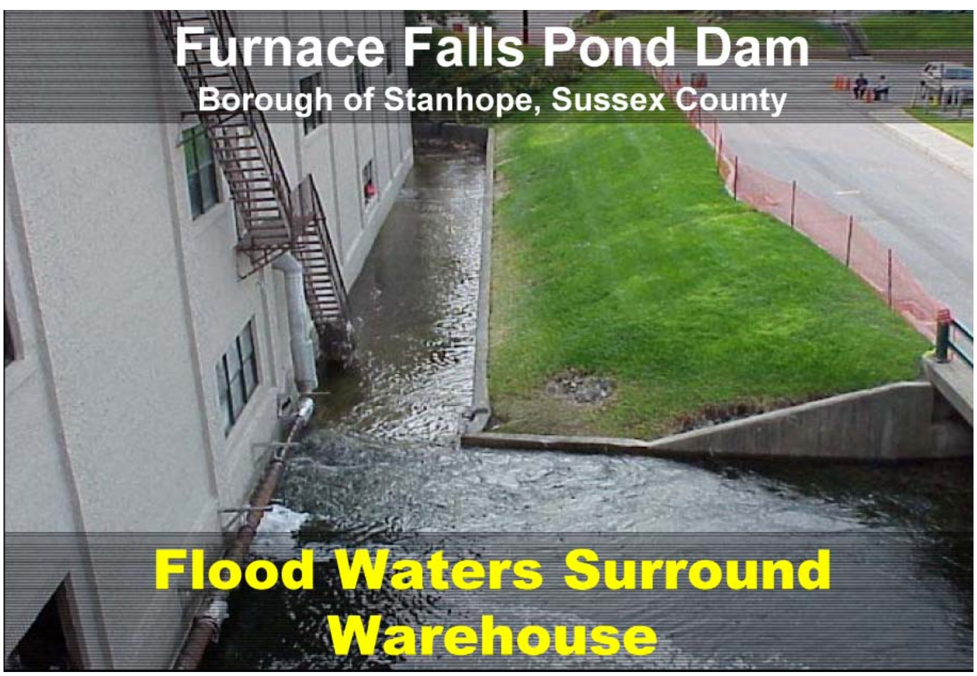
Source: NJDEP's Dam Safety and Flood Control

Figure 3.3.1-2: Furnace Falls Pond Dam Failure Following Heavy Rainfall - August 12, 2000



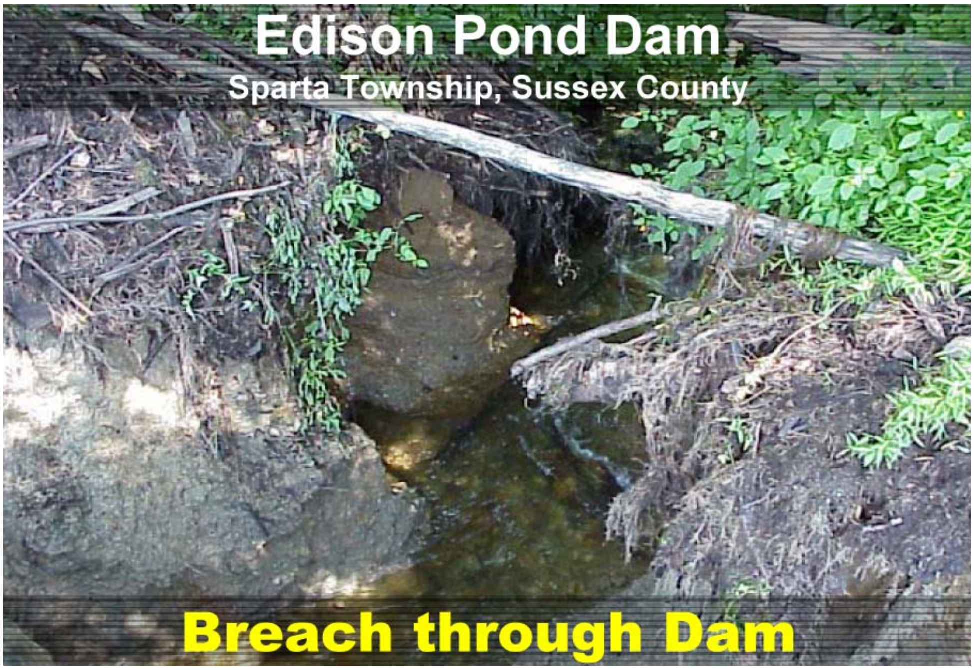
Source: NJDEP's Dam Safety and Flood Control

Figure 3.3.1-3: Furnace Falls Pond Dam Failure Following Heavy Rainfall - August 12, 2000



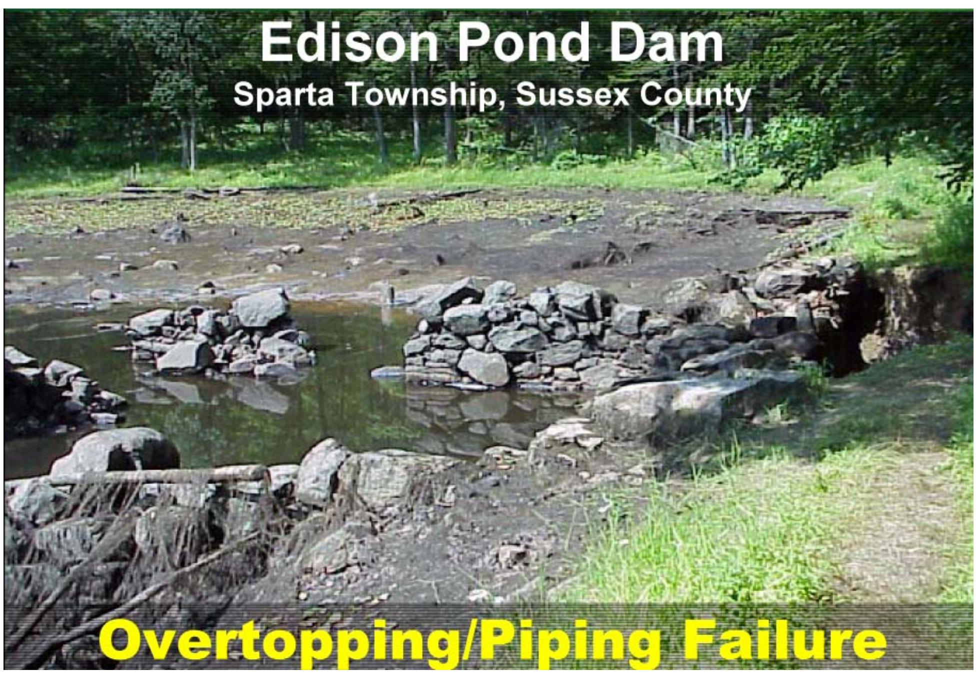
Source: NJDEP's Dam Safety and Flood Control

Figure 3.3.1-4: Edison Pond Dam Failure Following Heavy Rainfall - August 12, 2000



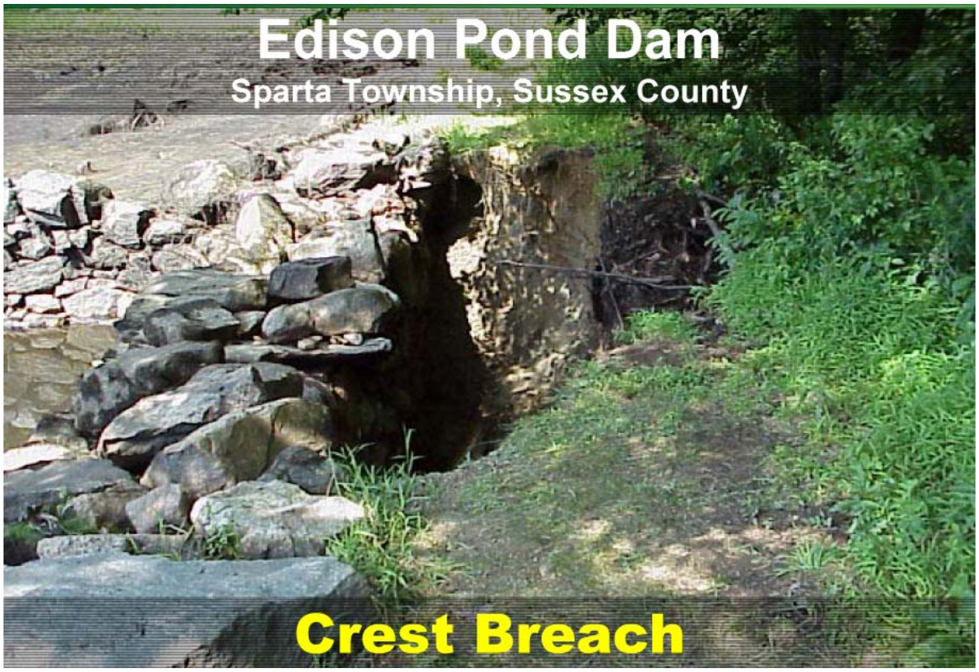
Source: NJDEP's Dam Safety and Flood Control

Figure 3.3.1-5: Edison Pond Dam Failure Following Heavy Rainfall - August 12, 2000



Source: NJDEP's Dam Safety and Flood Control

Figure 3.3.1-6: Edison Pond Dam Failure Following Heavy Rainfall - August 12, 2000



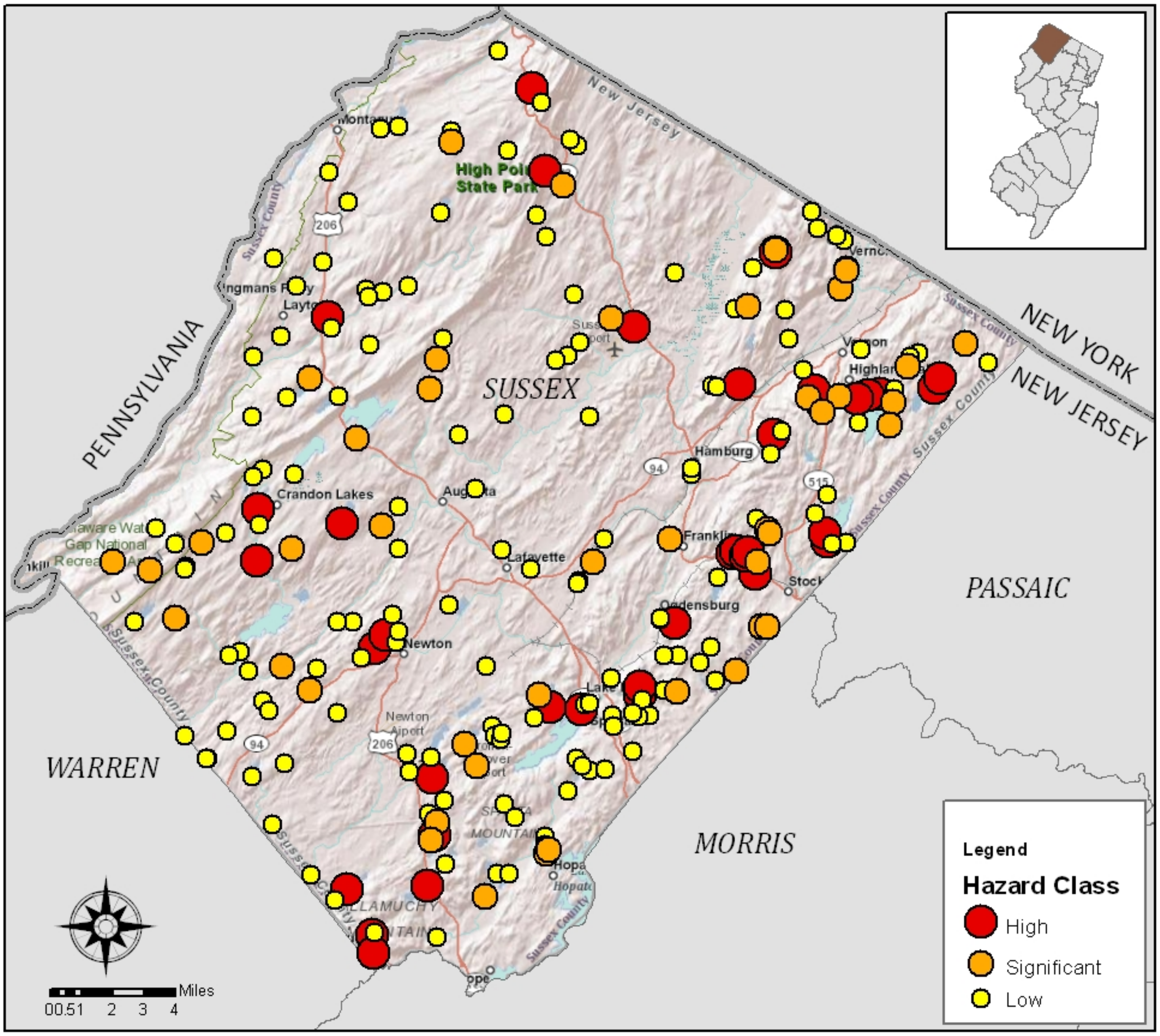
Source: NJDEP's Dam Safety and Flood Control

It is unclear what the losses due to the dam failures were in Sussex County, although there were no reports of deaths or injuries. However, unlike natural events, dam failure probability involves manmade structures that have a specific life expectancy and were designed to meet certain situations that may have changed since the time they were designed and built. Based on the National Inventory of Dams data, the dams in Sussex County are an average of seventy-three years old. This does not account for a number of dams, probably older ones, that the build date is unknown. Predicting the likelihood of a future dam failure is extremely difficult, but the probability is that a dam failure is possible.

Location and Extent of the Dam Failure Hazard

In Sussex County, there are 36 high hazard dams, 45 significant hazard dams, and 153 low hazard dams as shown in Figure 3.3.1-2. The high hazard dams are located in Andover Township, Byram Township, Fredon Township, Green Township, Hampton Township, Hardyston Township, Montague Township, Newton Town, Ogdensburg Borough, Sandyston Township, Sparta Township, Stillwater Township, Sussex Borough, Vernon Township, and Wantage Township. If a dam failure were to occur, the magnitude of the event would depend on many factors including the type, size, condition, design, and construction of the structure, type of failure, the amount of water, water velocity, and the growth within the floodplain.

Figure 3.3.1-7: Sussex County Dam Location and Classification



Source: GIS data obtained from NJDEP

Notes:

(1) Dam inventory may not show some privately owned dams and/or small dams that do not meet certain reporting guidelines.

Impact on Life and Property of the Dam Failure Hazard

Based on a dam's hazard classification, the expected losses can be inferred. If a high (H) hazard dam failed, it is anticipated that lives would be lost. If a significant (S) hazard dam failed, then significant property losses could be expected. If a low (L) hazard dam failed, then the losses would not be wide-spread or catastrophic. All of the high hazard dams in Sussex County have submitted an Emergency Action Plan to Dam Safety, which should reduce the potential impacts of an event. Emergency Action Plans typically include preventative actions based on the situation, contacts, a list of supplies and resources, and evacuation plans.

Within the U.S. Army Corps of Engineers (USACE) is the Risk Management Center under the Institute for Water Resources. They are working to manage and assess risks for USACE dams and levee systems through screening efforts, periodic assessment, and dam safety analysis. They are utilizing HEC-FIA and LifeSim modeling software in conjunction with the Federal Emergency Management Agency's (FEMA) HAZUS inventory data to analyze the life safety, economic, and environmental consequences of dam and levee failures.[5] These assessments are not shared with the public, but are utilized by the USACE and federal agencies to mitigate risks of USACE dams and levees. USACE and FEMA are also working together on efforts to accurately depict risks of flooding behind levees on flood maps. Levee owners must provide documentation to prove the levee meets design, operation, and maintenance standards for protection against the 1% annual chance flood in order to be shown as flood protecting on FEMA flood maps.

Prioritization and Rationale of the Dam Failure Hazard

Based on operation and maintenance requirements and local knowledge of the dams in Sussex County, the probability of dam failure is "likely" for an index value of 3. The county has a number of aging high and significant hazard dams in the area. The severity or magnitude of the damage from a dam failure could range from critical to negligible. In order to balance these two possibilities, an index value of 2 will be used for the magnitude/severity of dam failure in the county. Although there are some predictive conditions that can be observed from an inspection, most dam failures seem to have "less than 6 hours warning time before an event occurs" for an index value of 4. It should be noted that most dam failures occur as a secondary event to a flooding event, which may give some indication of where and when a failure may occur. A dam failure event would have a short duration, for a classification of "the event lasts less than 6 hours" for an index value of 1.

Table 3.3.1-3: CPRI for Degree of Risk for Dam Failure in Sussex County

Probability	+	Magnitude /Severity	+	Warning Time	+	Duration	=	CPRI
3 x .45	+	2 x .30	+	4 x .15	+	1 x .10	=	2.65

Although there have been no previously recorded deaths or injuries from dam failures in Sussex County, there has been significant property damage. The average known age of dams in the county is 73 years old, with 36 high hazard dams and 45 significant hazard dams in the county. There have also been 31 reported 'dam incidents' in the past. For these reasons, dam failure will be reviewed further in this Plan.

[5] "Consequence Assessment for USACE Risk Estimates" presentation by Jason Needham, P.E. Senior Consequence Specialist with USACE Risk Management Center on May 25, 2010.

3.3.2 Drought

Description of the Drought Hazard

A drought is defined as "a period of abnormally dry weather sufficiently prolonged for the lack of water to cause serious hydrologic imbalance in the affected area."[6] Droughts are extended periods of dry weather that cause problems such as crop damage, affects water supplies, and/or increased fire danger. Droughts are often brought on by lack of rainfall or snow over a long period of time, although the amount of time that low precipitation amounts take to impact an area varies in different geographic locations. The Palmer Drought Severity Index (PDSI) is the main classification system used for droughts in the United States and is based on supply and demand. The PDSI assesses total moisture by using temperature and precipitation to compute water supply and demand and soil moisture, and is most effective for long-term predictions. PSDI is also used to describe extended wet conditions using corresponding numbers, with zero representing near normal conditions. NOAA publishes weekly national and regional Palmer Drought maps. There are other indices that can be used for specific situations, ecosystems, or terrain.

Table 3.3.2-1: Palmer Drought Severity Index

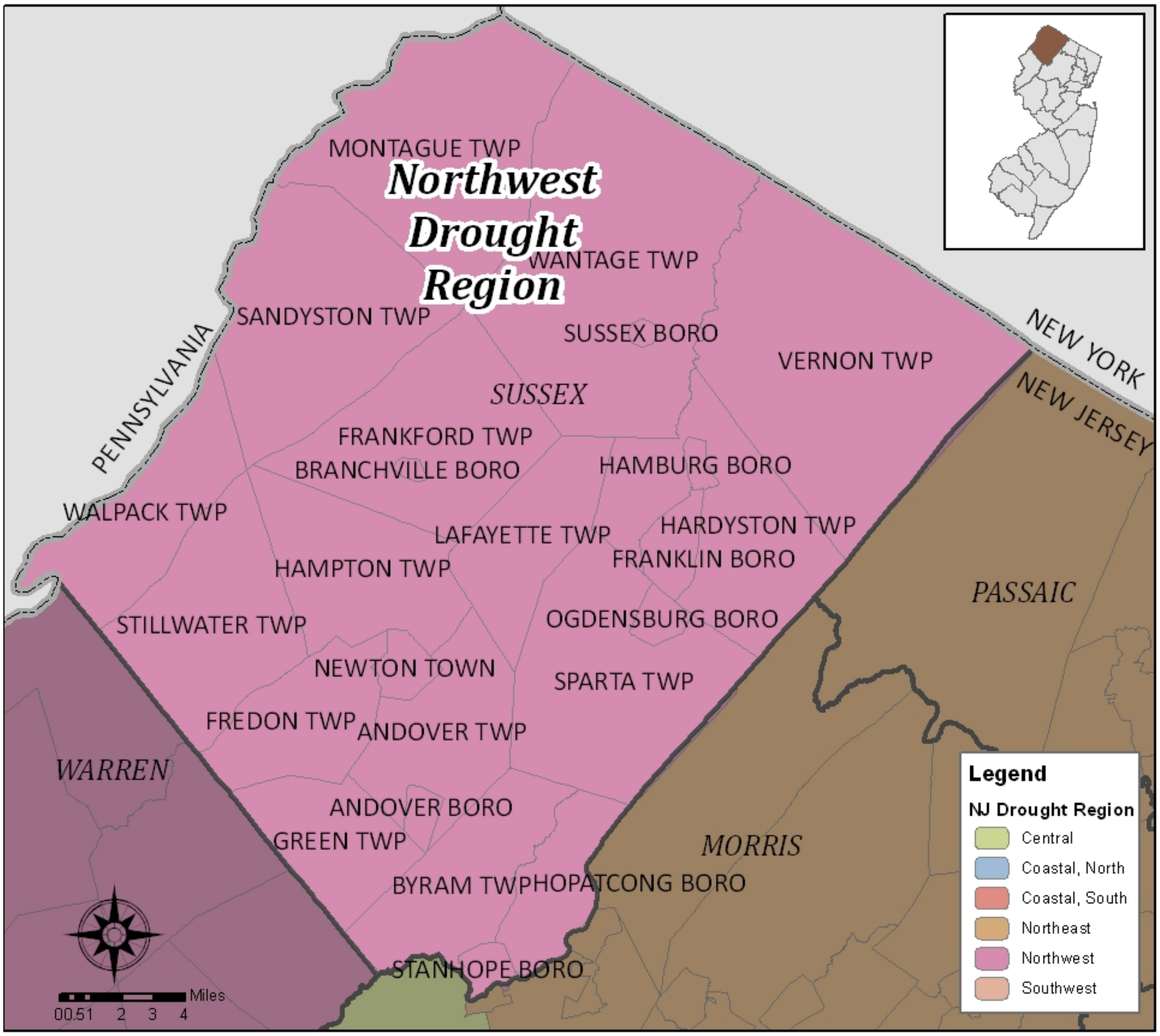
PDSI	Description
4.0 or more	Extremely wet
3.0 to 3.99	Very wet
2.0 to 2.99	Moderately wet
1.0 to 1.99	Slightly wet
0.5 to 0.99	Incipient wet spell
0.49 to -0.49	Near normal
-0.5 to -0.99	Incipient dry spell
-1.0 to -1.99	Mild drought
-2.0 to -2.99	Moderate drought
-3.0 to -3.99	Severe drought
-4.0 or less	Extreme drought

Source: NOAA

The State of New Jersey utilizes auxiliary indices for regional precipitation, stream-flow, reservoir levels, and ground-water levels in addition to the PDSI. The state created six drought regions in order to plan and manage restrictions in separate areas during droughts. The drought regions are grouped based on similar hydrologic characteristics and watershed boundaries and follow municipal boundaries. As seen in Figure 3.3.2-1, Sussex County is in the Northwest Drought Region.

[6] Glossary of Meteorology (1959)

Figure 3.3.2-1: Sussex County Municipalities and Drought Regions



Source: GIS data from NJDEP's NJ Geological Survey's Digital Geodata Series from May 2004. Retrieved from http://www.njgeology.org/geodata/dgs00-1.htm

Occurrence and Future Probability of Drought Hazard

According to a comparison of the SHELDUS and NCDC databases, since 1960 there has been one drought event within Sussex County that resulted in losses. It began on September 1, 1999 and lasted until September 27, 1999 and there was a drought emergency throughout eight New Jersey counties. Agricultural losses throughout the state were estimated at around $80 million in 1999 monetary values.

Table 3.3.2-2: Significant Drought Events, Sussex County, 1960 - 2010

Location	Date	Type	Deaths	Injuries	Property Damage	Crop Damage
Sussex	9/1/1999 – 9/27/1999	Drought	0	0	$0	$6,581,700

Source: SHELDUS 7.0 and NCDC

Notes:

(1) Property Damage and Crop Damage amounts have been adjusted to 2010 inflation amounts using the average Consumer Price Index from the U.S. Department of Labor's Bureau of Labor Statistics.

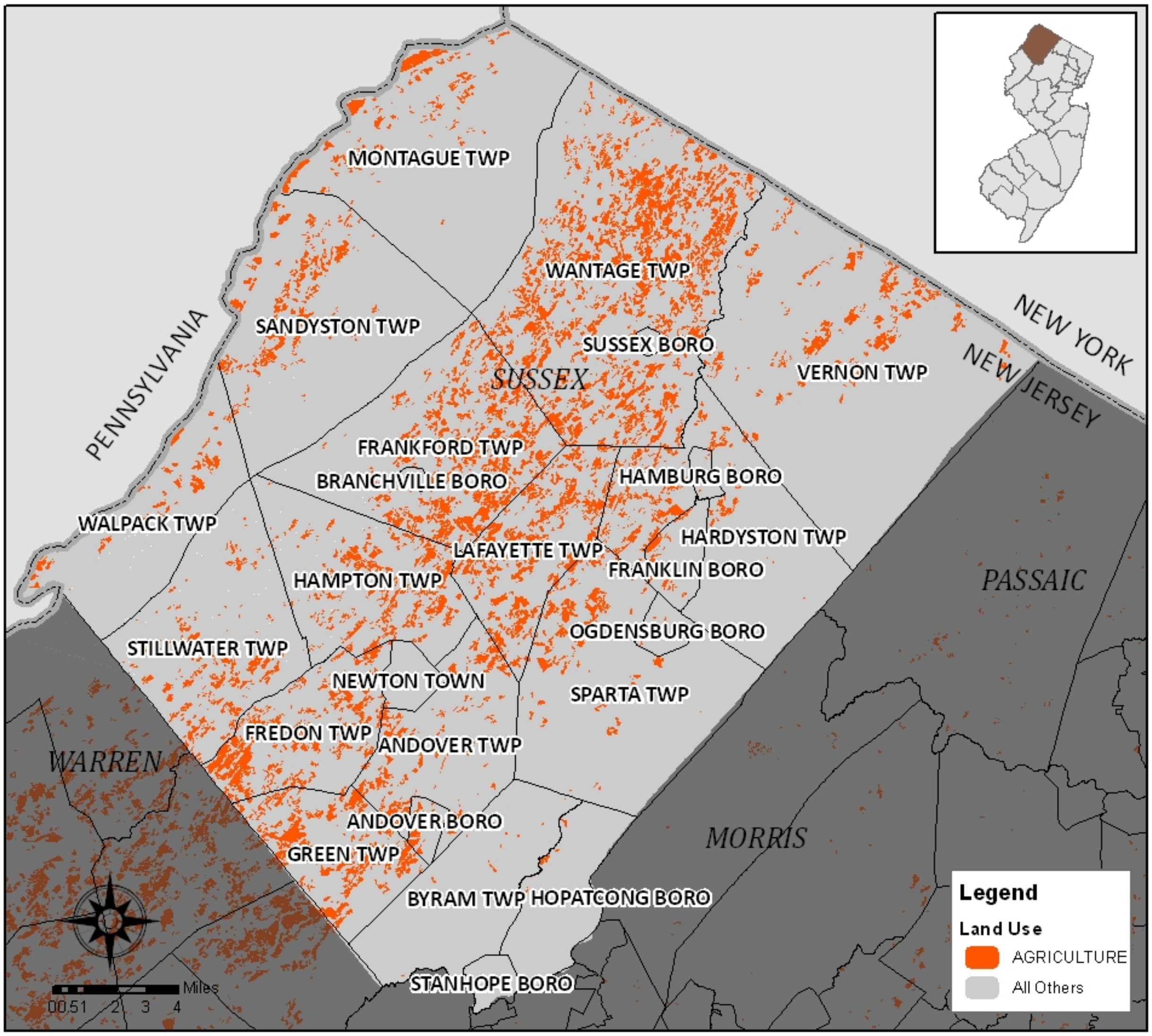
Based on the occurrence of one significant drought event in fifty years, the probability of future loss-causing drought events in Sussex County is 2% likelihood per year.

Location and Extent of Drought Hazard

The entire county has approximately the same risk for drought. Generally, droughts are a regional phenomena and dependent on the extent of the heat and range of precipitation in the area. Predicting dry spells and therefore potential droughts is very difficult because there are multiple factors involved that are challenging to anticipate including precipitation, pressure and temperature, soil moisture, surface water, and other water-related variables. Due to the nature of droughts, agricultural areas are most likely to suffer financial losses during a long-term drought event. Figure 3.3.2-2 shows an overview of the agricultural land use in Sussex County. As of 2002, Sussex County had 38,408 acres of agricultural land, a decrease of 4,791 acres since 1995.[7]

[7] NJDEP, http://www.state.nj.us/dep/gis/lulc2002stattablescounty.htm

Figure 3.3.2-2: Sussex County Municipalities and Agricultural Land Use



Source: GIS data from NJDEP's 2002 Landuse/Landcover dataset. Retrieved from http://www.state.nj.us/dep/gis/lulc02shp.html

Impact on Life and Property of the Drought Hazard

According to a comparison of the SHELDUS and NCDC databases, since 1960 there has been one drought event in Sussex County that has resulted in losses. There have been no documented deaths, injuries, or property damages due to droughts during this time in the county. However, the estimated amount of agricultural damage for that single event is more than $6.58 million in 2010 currency.

Prioritization and Rationale of the Drought Hazard

Since the probability of future significant droughts in the county is 2%, this is considered 'unlikely' for an index value of 1. Based on previous occurrences, the magnitude or severity for anticipated drought hazard impacts is considered 'negligible' because although the estimated agricultural losses were extreme, there was no loss of life, injury, or property damage, for an index value of 1. The warning time for a drought is usually "at least 24 hours before an event occurs" for an index value of 1. Droughts can last for extended periods of time, so the classification would be that "the event lasts more than 1 week" for an index value of 4.

Table 3.3.2-3: CPRI for Degree of Risk for Drought Hazard in Sussex County

Probability	+	Magnitude /Severity	+	Warning Time	+	Duration	=	CPRI
1 x .45	+	1 x .30	+	1 x .15	+	4 x .10	=	1.3

Although droughts can occur in Sussex County, there has been no risk to residents' health and non-agricultural property over the past fifty years. Based on past events, the likelihood of a severe drought event occurring is unlikely, though possible. For these reasons, droughts will not be studied in further detail in this Plan.

3.3.3 Earthquake/Geological

Description of the Earthquake Hazard

An earthquake is a sudden, rapid movement of the earth caused by the breaking and shifting of rock beneath the earth's surface. The earth's surface is broken into shifting slabs or tectonic plates, which continents move along with. At the plate boundaries, the plates interact by sliding past one another, running into one another, or moving away from one another. Sometimes these movements are slow and gradual, at other times the plates are locked together unable to release the accumulating energy. Most active faults are located along or near boundaries between shifting plates, although some are located in the interior of plates (intra-plate earthquakes, such as the New Madrid). Earthquakes occur when rock suddenly moves, or slips, along these faults and accumulated energy is released. This energy causes seismic waves that when strong enough, may be experienced by us as ground shaking. The amount of energy released, combined with the physical environment, will impact the amount of damage to buildings and infrastructure. The main earthquake is often followed by smaller magnitude earthquakes, called aftershocks. Earthquakes may also cause additional hazards such as ground rupture, landslides, avalanches, fires, soil liquefaction, tsunamis, floods, and tidal forces.

There are two main types of scales for measuring earthquakes: intensity and magnitude.

Intensity scales measure the amount of shaking at a particular location, so the intensity of an earthquake will vary depending on the location, although people tend to use the maximum intensity level produced when referring to a particular earthquake. Intensity is determined from effects on people, human structures, and the natural environment. Intensity scales include the Modified Mercalli Scale, shown in Table 3.3.3-1, and the Rossi-Forel Scale.

Magnitude scales measure the energy released or size of the earthquake at its source, so it will not vary based on location. Magnitude is determined from measurements on seismographs. Magnitude scales include the Richter Magnitude (Local Magnitude) and Moment Magnitude. Moment Magnitude Scale is newer and more precise, but more complex to calculate.

Table 3.3.3-1: Abbreviated Modified Mercalli Intensity Scale

Mercalli Intensity	Description
I	Not felt except by a very few under especially favorable conditions.
II	Felt only by a few persons at rest, especially on upper floors of buildings.
III	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
XI	Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
XII	Damage total. Lines of sight and level are distorted. Objects thrown into the air.

Source: US Geological Survey (USGS). Retrieved from http://earthquake.usgs.gov/learn/topics/mercalli.php

Table 3.3.3-2 shows the intensities that are typically observed at locations near the epicenter of earthquakes of different magnitudes.

Table 3.3.3-2: Earthquake Magnitude versus Modified Mercalli Intensity Scale

Magnitude	Typical Maximum Modified Mercalli Intensity
1.0 – 3.0 (Very Minor)	I
3.0 – 3.9 (Minor)	II – III
4.0 – 4.9 (Light)	IV – V
5.0 – 5.9 (Moderate)	VI – VII
6.0 – 6.9 (Strong)	VII – IX
7.0 and Higher (Major to Great)	VIII and Higher

Source: USGS. Retrieved from http://earthquake.usgs.gov/learn/topics/mag_vs_int.php

Occurrence and Future Probability of Earthquake Hazard

According to USGS and NJDEP, New Jersey has been affected by a number of earthquakes to a minor degree, as shown in Table 3.3.3-2

Table 3.3.3-3: Earthquake Events That Have Affected New Jersey

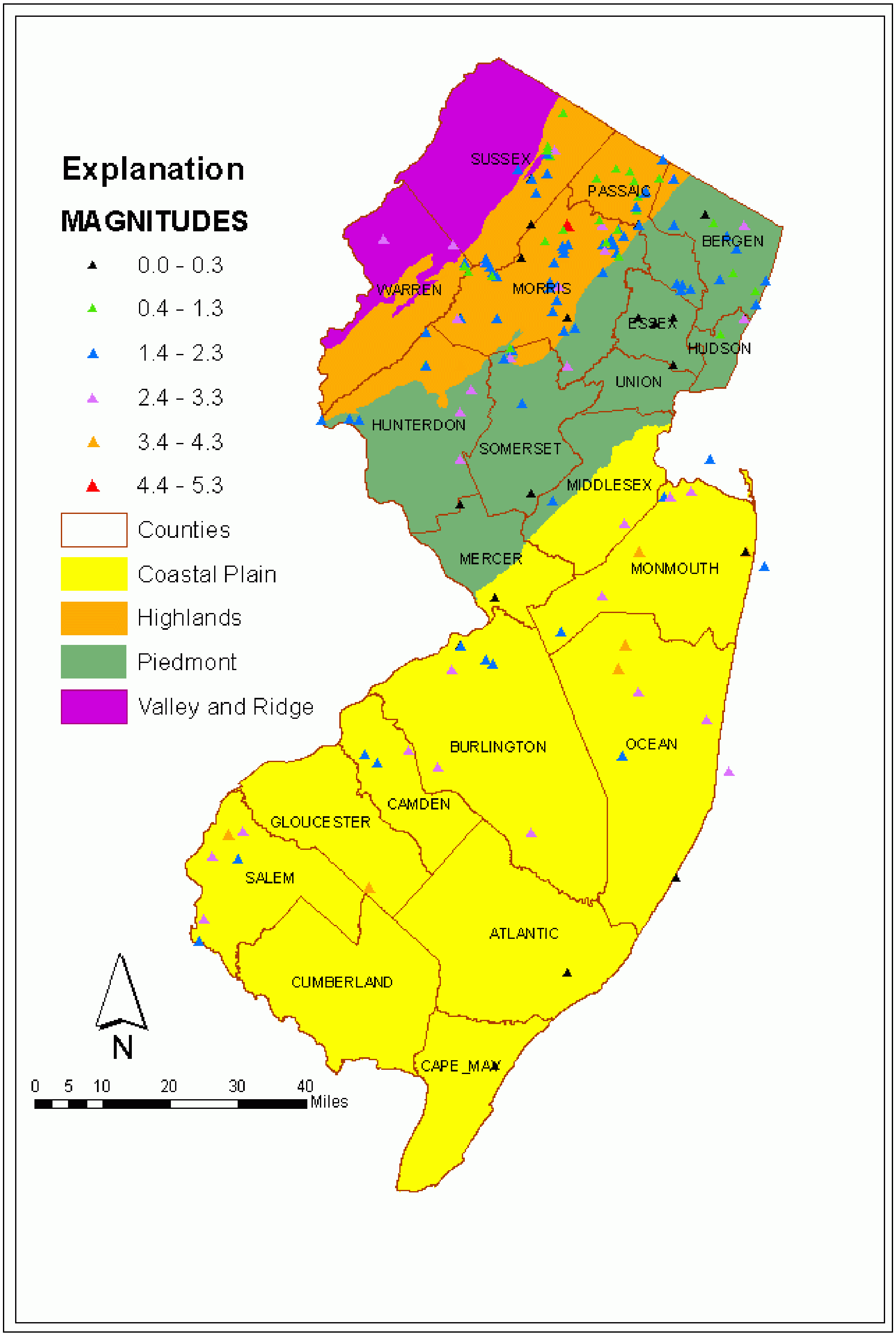
Epicenter Location	Date	Intensity (Max in NJ)	Magnitude	Effects in NJ
Near NYC	12/18/1737	VII	-	Chimneys down in NYC. Felt in Boston, MA and Philadelphia, PA.
Cape Ann, MA	11/18/1755	IV	6.0	Chimneys and brick buildings down in Boston. Caused a tsunami that grounded boats in West Indies.
West of NYC	11/30/1783	VII	5.3	Felt from NH to PA.
New Madrid, Missouri Area	1811 – 1812	IV-V	8.0 to 8.8	Four great earthquakes. Changed course of Mississippi River. Town of New Madrid destroyed. Loss of life low due to sparse settlement. Damage in Chicago.
Riviere-Ouelle, Canada	1860	-	-	Unknown
Wilmington, DE	10/09/1871	VII	-	Chimneys toppled and windows broke in DE. Reported felt in NJ.
NYC	1884	VII	5.5	Toppled chimneys in NYC and NJ. Cracked masonry from Hartford, CT to West Chester, PA. Felt from ME to VA, and eastern OH.
Charleston, SC	1886	IV	7.7	Sixty killed. Over 10,000 chimneys down.
High Bridge, NJ	09/01/1895	VI	-	Felt from ME to VA. In Hunterdon County towns, articles fell from shelves and buildings rocked. Philadelphia reported broken windows.
Moorestown/Riverton, NJ	01/26/1921	V	-	Moderate shaking. Rumbling noise heard.
Asbury Park, NJ	06/01/1927	VII	-	Highest intensity earthquake observed in NJ. Three shocks felt along the coast from Sandy Hook to Toms River. Maximum intensities of VII at Asbury Park and Long Branch, NJ. Several chimneys fell, plaster cracked, and articles thrown from shelves.

Epicenter Location	Date	Intensity (Max in NJ)	Magnitude	Effects in NJ
Lakehurst, NJ	01/24/1933	V	-	Sharp jolt felt over central NJ from Lakehurst to Trenton. Unclear if shock of seismic origin. Lakehurst people rolled out of bed.
Central NJ	08/22/1938	V	-	Caused minor damage at Gloucester City and Hightstown. Glassware broken and furniture moved, some windows broken. Four smaller shocks on August 23 and one on August 27.
Salem County	11/14/1939	-	-	Disturbance felt from Trenton to Baltimore, MD and from Cape May to Philadelphia. Little to no damage noted.
Rockland County, NY	09/03/1951	VI	-	Northeastern NJ experienced minor effects. Chimneys cracked, windows and dishes broke, and pictures fell at Lebanon and other towns.
Northeastern Philadelphia, PA Area	12/27/1961	V	-	Rumbling sounds and tremor felt in Bordentown and Trenton, where houses shook and windows and dishes rattled.
Burlington County, NJ	12/10/1968	V	2.5	Some broken windows with intensity V effects noted at Camden, Moorestown, Darby, and Philadelphia. Toll booths on Benjamin Franklin and Walt Whitman Bridges from NJ to Philadelphia, PA trembled during shock.
Salem County, NJ	02/28/1973	V	3.8	Moderately strong earthquake cracked plaster at Laurel Springs and Penns Grove and cracked cinder blocks at Harrisonville. Minor damage in areas of DE, MD, and PA.

Source: USGS. Retrieved from http://earthquake.usgs.gov/earthquakes/states/new_jersey/history.php and NJDEP's Land Use Management & NJ Geological Survey's study *Earthquake Risk in New Jersey* (1998, Revised 2005). Retrieved from http://www.state.nj.us/dep/njgs/enviroed/freedwn/e-quake.pdf

Figure 3.3.1 shows earthquakes whose epicenter is located in New Jersey from New Jersey Geological Survey Report DGS04-1, *Earthquakes Epicentered in New Jersey* that includes 166 earthquakes. Most were minor events, with magnitudes ranging from 0.4 to 5.3 and depths up to 25 km below sea level. The oldest event in the dataset is from 1783, and there are 21 recorded epicenters within Sussex County, with the highest listed magnitude at 2.8 with a depth of 7.36 km that occurred in 1986 near Tranquility.

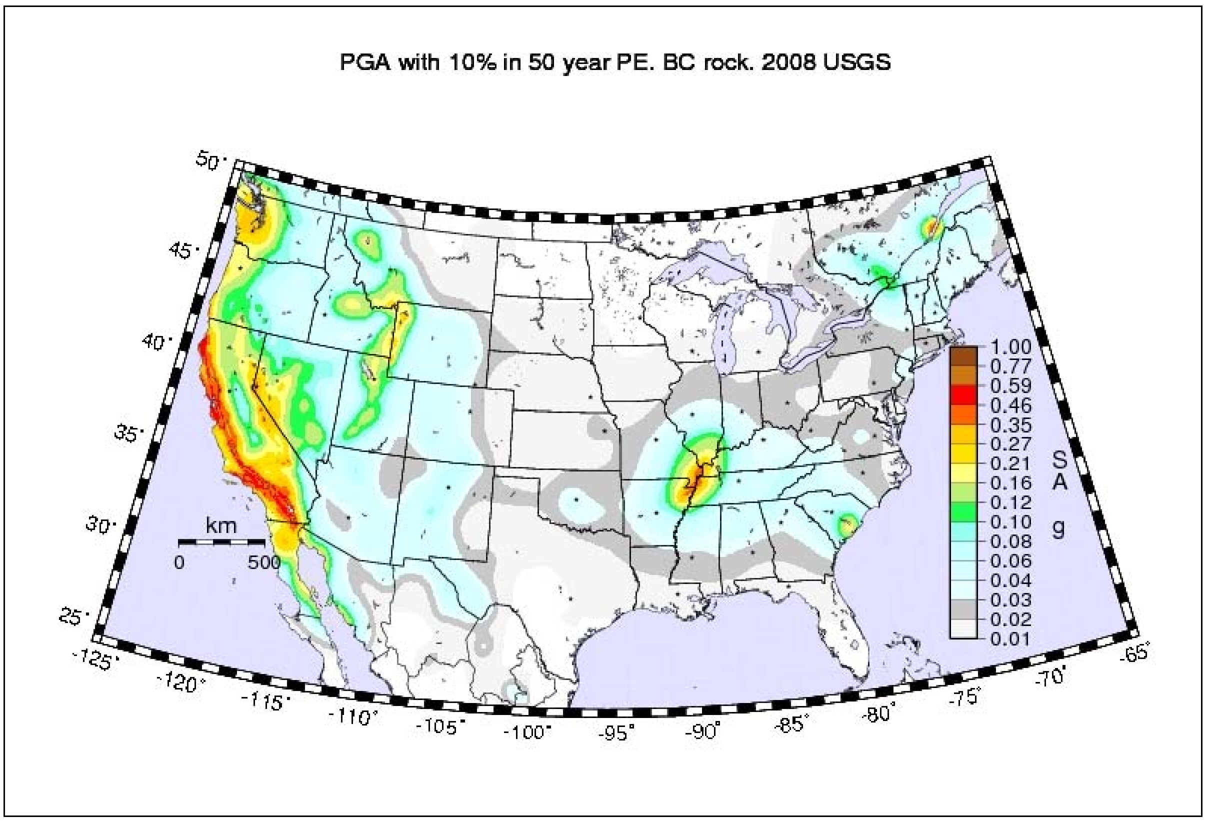
Figure 3.3.3-1: Earthquakes Epicentered in New Jersey



Source: NJDEP. Retrieved from http://www.state.nj.us/dep/njgs/geodata/dgs04-1.htm

Figures 3.3.3-2 and 3.3.3-3 depict future earthquake hazard by using contour lines and different colors to show the earthquake ground motions that have a similar probability of being exceeded in 50 years. On a given map, for a given probability of exceedance (10% in Figure 3.3.3-2 and 2% in Figure 3.3.3-3), locations shaken more frequently will have larger ground motions.[8] The 10% exceedance probability map will show lower ground motions than the 2% exceedance probability map, while the 2% exceedance probability map will be a better depiction of less likely but larger magnitude and/or nearer events. The maps are designed this way so that when building codes are being determined, one can look at the map and see what ground motion level the structures should be able to resist at a specific location. These particular maps are based on peak ground acceleration, which is best used as an index to hazard for short, stiff structures.

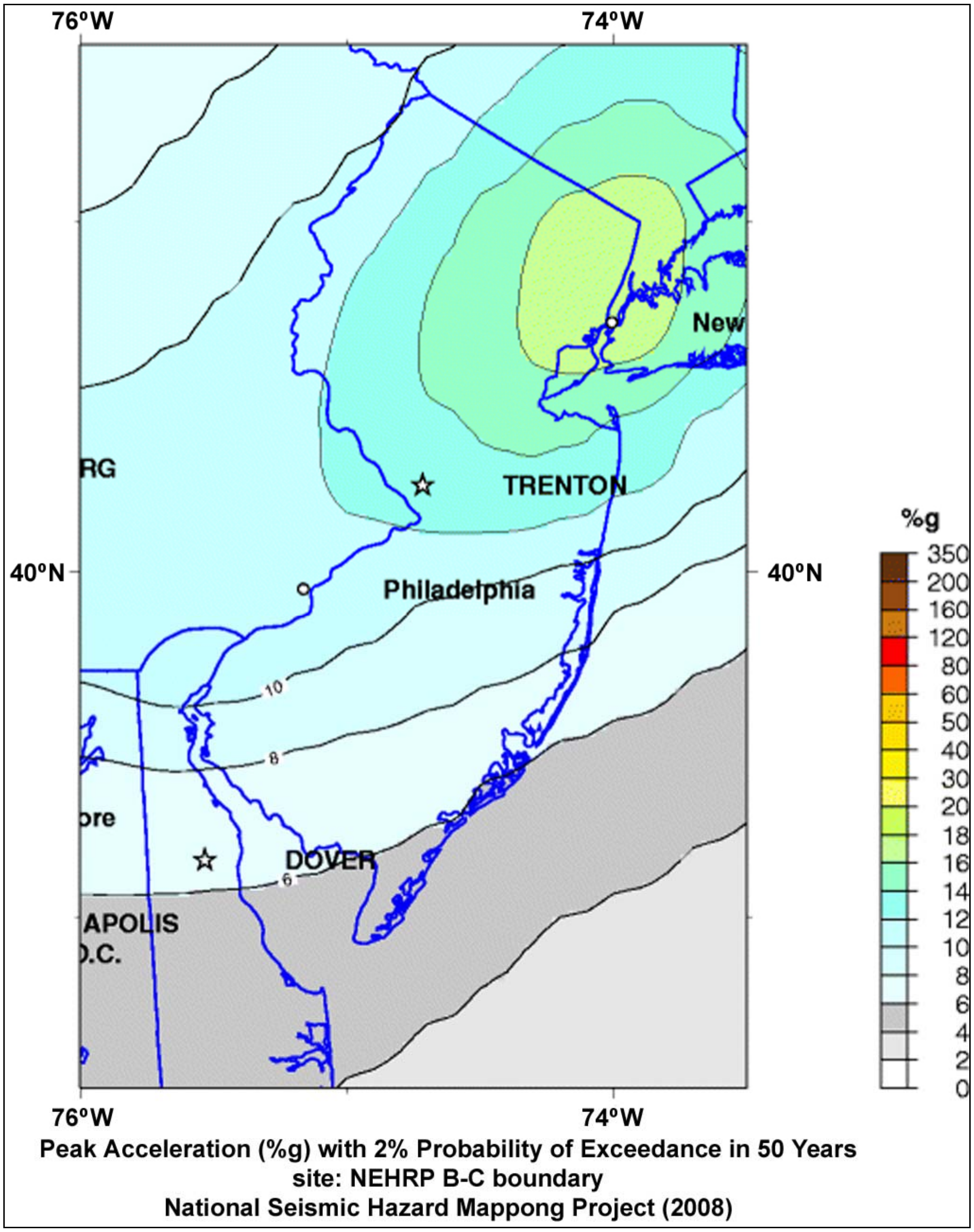
Figure 3.3.3-2: U.S. Seismic Hazard Map (2008) – Return Period 10% in 50 Years



Source: USGS. Retrieved from
http://earthquake.usgs.gov/hazards/products/conterminous/2008/maps/

[8] USGS from http://earthquake.usgs.gov/learn/faq/?faqID=207

Figure 3.3.3-3: New Jersey Seismic Hazard Map (2008) – Return Period 2% in 50 Years



Source: USGS. Retrieved from http://earthquake.usgs.gov/earthquakes/states/new_jersey/hazards.php

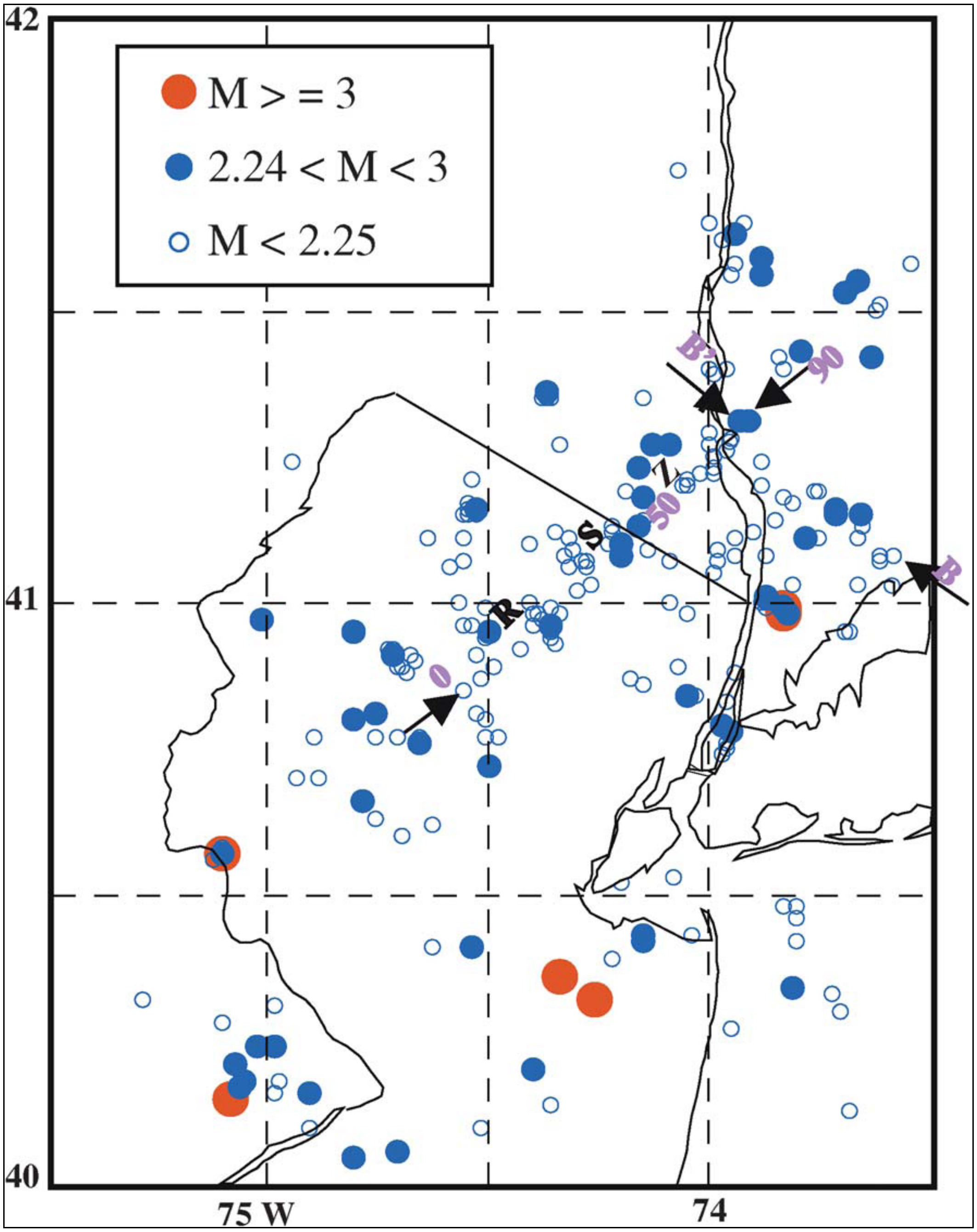
Based on Figures 3.3.3-1 and 3.3.3-2, Sussex County has a great enough peak ground acceleration (%g) that warrants further assessment. According to USGS's 2009 Earthquake Probability Mapping Tool, and utilizing the center of Sussex County as the location, the probability of future 5.0M earthquakes in the county is approximately 5% probability within a 100 year time span and a 4% probability for an 8.0M within a 100 year time span.[9] This makes the probability of an earthquake that could affect Sussex County possible.

[9] USGS. Retrieved from http://geohazards.usgs.gov/eqprob/2009/index.php

Location and Extent of Earthquake Hazard

The entire county is at risk for the impacts of an earthquake. Fault lines are throughout the state, with the Ramapo Seismic Zone of particular concern. Ramapo runs from New York to New Jersey to Pennsylvania and consists of a braid of smaller fractures, including a set of nearly parallel northwest-southeast faults. A June 2007 study from Lamont-Doherty Earth Observatory of Columbia University by Sykes, et al entitled *Observations and Tectonic Settings of Historic and Instrumentally Located Earthquakes in the Greater New York City-Philadelphia Area* casts faults in the greater New York City area in a new, riskier light. Unlike the existing west coast model concerned with one large obvious fault, they voice concerns about a network of more subtle faults, previously thought to be inactive, that could add up to something big.

Figure 3.3.3-4: Quakes Located By Instruments 1974-2007 with Ramapo Seismic Zone



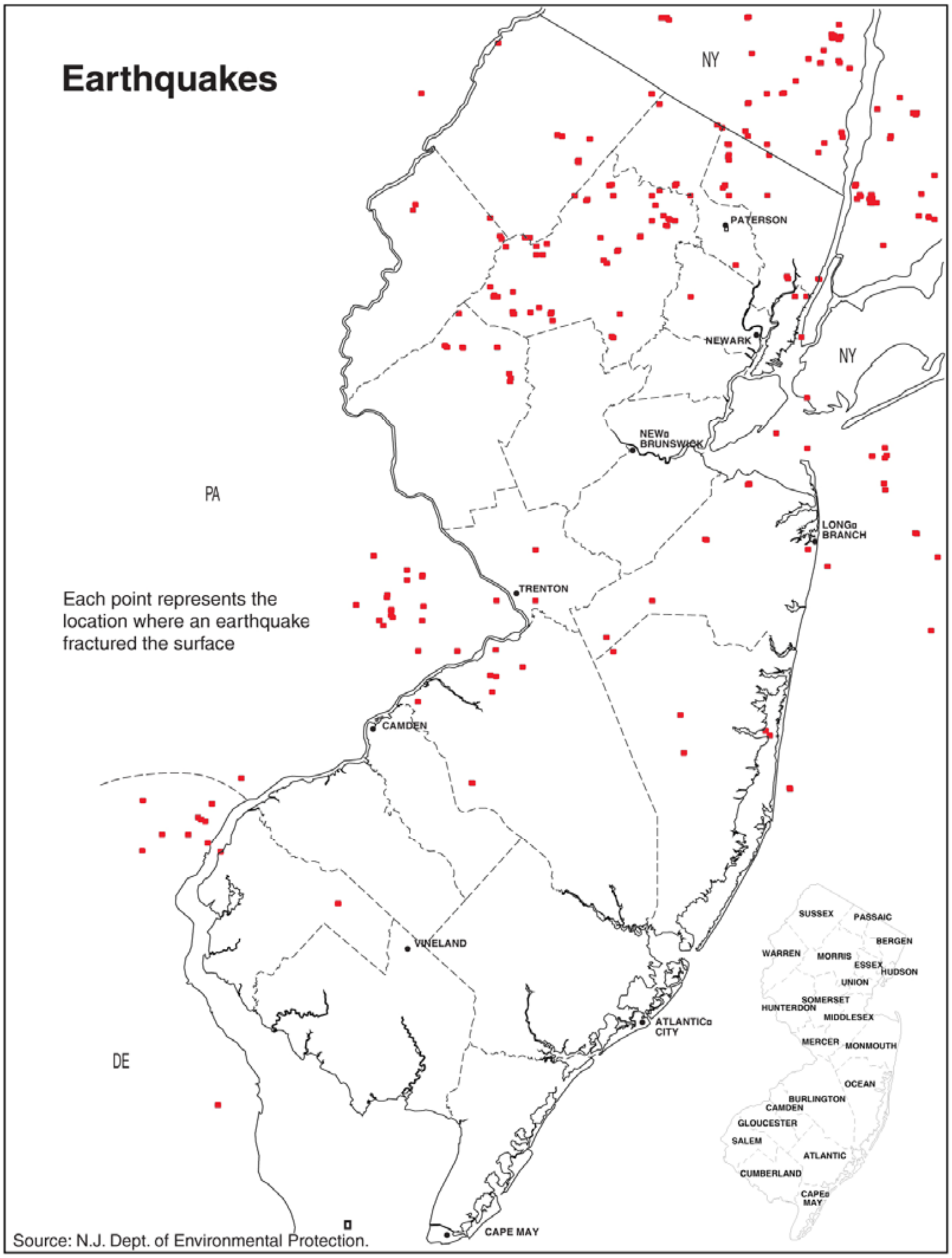
Source: Sykes et al., Lamont-Doherty Earth Observatory of Columbia University, Palisades, New York 10964 (June 29, 2007) *Observations and Tectonic Settings of Historic and Instrumentally Located Earthquakes in the Greater New York City-Philadelphia Area.* Retrieved from http://www.ldeo.columbia.edu/files/sykespdf.pdf

Notes:

(1) Arrows denote approximate southeastern boundary of the Ramapo Seismic Zone and northwest-striking seismic boundary of the Peekskill-Stamford seismic line.

Figure 3.3.3-5 shows points where earthquakes have fractured the surface of the earth over the years. Sussex County has experienced multiple surface fractures in the past.

Figure 3.3.3-5: Map of Surface Fractures from New Jersey Earthquakes



Source: NJDEP.

Impact on Life and Property of the Earthquake Hazard

There are no known deaths or injuries from earthquakes in Sussex County, although there have been reports on multiple occasions of people feeling the effects of earthquakes. If a strong earthquake event were to occur in the region, ground shaking could cause the collapse of buildings and bridges, disrupt utility lines, and/or trigger landslides, avalanches, flash floods, and fires. When earthquakes occur in a populated area, they can cause deaths, injuries, and extensive property damage.

According to NJDEP's study *Earthquake Risk in New Jersey*, an earthquake occurring in the eastern part of the United States could inflict ten times more damage than one occurring west of the Rocky Mountains, due to higher population and density in the east. In New Jersey, structures built before 1977 may have been designed and constructed without seismic considerations. Under the NJ Rehabilitation Sub-code there are limited requirements for retrofitting existing buildings for seismic safety, such as when a conversion to a public facility occurs.[10]

According to *FEMA 366: Estimated Annualized Earthquake Losses for the United States* [11], it is estimated that New Jersey is ranked 14th in the nation for annualized earthquake losses (AEL) of $39.7 million, with Sussex County's building inventory around $10 to $50 billion, and AEL approximately $0.5 to $1 million. This study is based on HAZUS-MH MR2 probabilistic analyses utilizing a thick alluvium soil type throughout the nation. See Section 3.4 for a more localized earthquake loss analysis utilizing HAZUS-MH MR4.

Prioritization and Rationale of the Earthquake Hazard

The probability of future significant earthquake in the county is 'possibly' for an index value of 2. The magnitude of a future earthquake is very difficult to predict, however recent studies support that an event could be severe or "catastrophic" for an index value of 4. Earthquakes can occur unexpectedly and therefore the warning time is "less than 6 hours warning time" for an index value of 4. Earthquake duration can vary, but generally "lasts less than 1 day" for an index value of 2.

Table 3.3.3-4: CPRI for Degree of Risk for Earthquake in Sussex County

Probability	+	Magnitude /Severity	+	Warning Time	+	Duration	=	CPRI
2 x .45	+	4 x .30	+	4 x .15	+	2 x .10	=	2.9

Based on USGS, NJDEP, and Lamont-Doherty Earth Observatory of Columbia University studies, there is a possibility that an earthquake event could occur with a high magnitude that impacts Sussex County severely. For these reasons, earthquakes will be studied in further detail in this Plan.

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[10] NJDEP's Land Use Management & NJ Geological Survey's study *Earthquake Risk in New Jersey* (1998, Revised 2005). Retrieved from http://www.state.nj.us/dep/njgs/enviroed/freedwn/e-quake.pdf

[11] FEMA, *FEMA 366: Estimated Annualized Earthquake Losses for the United States* (April 2008). Retrieved from http://www.fema.gov/library/viewRecord.do?id=3265

3.3.4 Flood

Description of the Flood Hazard

In simple terms, a flood is an excess of water on land that is normally dry. Floods are usually caused by weather events that deliver more precipitation to a drainage basin then can be easily absorbed or stored within the basin. Flooding is a significant natural hazard through the United States. Causes include heavy precipitation, snowmelt, ice jams, dam failures, hurricanes, reservoir overflows, and local thunderstorms. Flood waters can bring down structures, topple trees, destroy infrastructure, sweep people and vehicles away, and alter landscapes. Floods can occur quickly and without warning, such as flash floods or floods caused by dam breaks, or can build slowly, becoming more significant over time. There may be a lag time between precipitation and the time when the flood peaks, which in some situations may allow for warning and evacuating populations.

FEMA is responsible for the National Flood Insurance Program (NFIP) which was created in 1968 by Congress to provide a means for property owners to purchase flood insurance if their community participates in the NFIP. Participating communities agree to adopt and enforce ordinances that meet or exceed FEMA requirements to reduce the risk of flooding. As part of the NFIP, FEMA produces Flood Insurance Rate Maps (FIRMs) and Digital FIRM (DFIRM) databases for communities that describe the risk of flooding in different locations. The risk areas are shown using Special Flood Hazard Areas (SFHAs) to show high risk, also referred to as regulatory floodplains. The 1% annual chance flooding areas (often shown on FIRMs as a Zone A or Zone AE) are areas that have a 1 in 100 chance of flooding each year, and are commonly referred to as "100-year recurrence interval floods" or "100-year return period events", or "base floods". A recurrence interval is the average time within which the magnitude of a given flood event will be equaled or exceeded one time. But, this does not mean that a flood will only occur once every 100 years, actually they can occur much closer together than 100 years or much further apart; two 100-year flood events can occur in the same week. A home located within a SFHA has a 26% chance of suffering flood damage during the term of a 30-year mortgage.[12]

Areas outside the SFHA are considered to have moderate to low risk of flooding and are not in immediate danger, however they still have a risk of flooding. Another common quantity to describe a flood risk area is .2% annual chance of flooding each year, which is the equivalent as a 500-year recurrence interval flood area and often shown as a Shaded Zone X or 0.2% Annual Chance Flood Hazard Zone on FIRMs. These areas are expected to flood less often than those in the 1% annual chance areas, but this may not always be the case.

SFHAs boundaries are based on a number of factors, including flood history, hydrologic and hydraulic factors, topography, and flood control measures. Engineering studies have been completed and are summarized in the accompanying Flood Insurance Study (FIS). The FIS and FIRMs also contain useful information regarding discharges and cross-sections with Base Flood Elevations (BFEs) that can be used by communities for planning purposes and considered when designing building code standards.

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[12] FEMA. Retrieved from http://www.floodsmart.gov/floodsmart/pages/faqs/what-is-a-special-flood-hazard-area.jsp

In 1972, New Jersey legislature adopted a statute which authorized the Division of Water Policy and Supply (now the NJDEP) to delineate and mark flood hazard areas and to adopt regulations for these areas.[13] The State developed flood hazard area maps that delineated the New Jersey Flood Hazard Area (NJFHA), based on discharge 25% larger than the 100-year flood discharge. These maps predated the FIRMs. The NJFHA is important because it is the State's regulatory standard. On November 5, 2007, NJDRP adopted new Flood Hazard Area Control Act rules which incorporate more stringent standards for development in flood hazard areas, including a 0% net-fill requirement for all non-tidal flood hazard areas of the State.[14]

Occurrence and Future Probability of the Flood Hazard

According to the 2008 *Multi-Jurisdictional Flood Mitigation Plan for Municipalities in the Non-tidal, New Jersey Section of the Delaware River Basin,* there were severe floods on the Delaware River in the County in October 1903, August 1955, and May 1972. The 1955 flood was the worst event recorded on the Delaware River, with an approximate 150-year recurrence interval and between 25 and 99 deaths. This event followed three heavy rain storms and Hurricane Diane. Impacts were minimal, due to limited development in the area.[15]

According to a comparison of the SHELDUS and NCDC databases, since 1960 there have been twelve flood events within Sussex County that resulted in losses, shown in Table 3.3.4-1.

Table 3.3.4-1: Significant Flood Events, Sussex County, 1960 - 2010

Location	Date	Type	Deaths	Injuries	Property Damage	Crop Damage
Sussex	7/27/1969	Heavy Rain, Flood	0	0	$139,293	$0
Sussex	11/13/1970	Local Flood	0	0	$1,848	$0
Sussex	8/2/1973	Rain, Flood	0	0.5	$2,089,459	$0
Sussex	11/6/1977	Rain, Flood	0	0	$8,645,784	$0
Sussex	1/19/1996	Flood after Blizzard of 1996	0.14	0	$2,118,017	$0
Sussex	9/16/1999	Flood	0	0	$3,290,850	$0
Sussex	8/12/2000	Flood	0	0	$211,247,778	$0
Sussex	9/18/2004	Flash Flood	0	0	$462,888	$0
Sussex	9/19/2004	Flood	0	0	$578,610	$0
Sussex	4/2/2005	Flood	0	0	$1,232,312	$0
Sussex	6/28/2006	Flood	0	0	$651,386	$0
Sussex	4/15/2007	Flood	0	0	$1,053,069	$0

Source: SHELDUS 7.0 and NCDC

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[13] NJDEP, Flood Control Section, Bureau of Dam Safety and Flood Control. Retrieved from http://nj.gov/dep/floodcontrol/about.htm#mapping

[14] NJ Flood Mitigation Task Force. Retrieved from http://www.njflood.org/current.html

[15] Delaware River Basin Commission's *Multi-Jurisdictional Flood Mitigation Plan for Municipalities in the Non-tidal, New Jersey Section of the Delaware River Basin,* November 2008, p57. Retrieved from *http://www.state.nj.us/drbc/Flood_Website/NJmitigation/index.htm*

Notes:

(1) Property Damage and Crop Damage amounts have been adjusted to 2010 inflation amounts using the average Consumer Price Index from the U.S. Department of Labor's Bureau of Labor Statistics.

The following descriptions of major floods are taken from excerpts from NCDC database, except as stated:

- The Blizzard of 1996 paralyzed the east coast with heavy snow and winds from January 6 to 8, with another storm on January 12, then the weather warmed up and heavy rainfall followed, melting the snowpack quickly. According to NCDC, flash flooding began on January 19 which led to larger river flooding through January 21, 1996. Delaware River crested at its highest since 1955 and caused the worst damage. Damage estimates exceeded $10 million. Hunterdon, Morris, Sussex, and Warren Counties were declared disaster areas. In Sussex County, the worst damage was in Montague, Sandyston, Vernon, and Walpack Townships. Many roads were washed out and bridges damaged. At Montague, the Delaware River crested at 26.6 feet, flood stage is 25 feet.

- In September 1999, Hurricane Floyd brought heavy rainfall and winds to the area and caused extensive flooding and damage. According to NCDC, the hurricane is the greatest natural disaster to date to affect the State of New Jersey. Raritan River Basin experienced record breaking flooding with approximately ten inches. Some water treatment plants were also inundated and many municipalities did not have water or had to boil it, while raw sewage was released and contaminated water in other areas. Structures and property were damaged by floodwaters, roads were flooded, and some areas were cut-off. On a relative basis, the effects of Floyd diminished across Warren and Sussex Counties. Approximately 38,000 homes and businesses lost power. Hardest hit in Sussex County were Byram Township, Frankford Township, Hopatcong Borough, and the Town of Newton.

- According to the Sussex Preliminary FIS (which can change at any time before going Effective), between August 11 and 14, 2000, heavy thunderstorms produced record rainfall amounts in areas of southeastern Sussex County. Total rainfall was more than 14 inches in four hours. On the Musconetcong River at the outlet of Lake Hopatcong, peak flows far exceeded the previous record set during the August 1955 flood. Throughout the State, approximately 2,600 people were evacuated. The flood completely destroyed the dams on Seneca Lake, Tomahawk Lake, Furnace Pond, and Edison Pond, and caused damage to many other dams. Several bridges in Sparta Township and Ogdensburg collapsed. A Federal Disaster was declared on August 16.[16]

- In mid-September, 2004, the remnants of Hurricane Ivan created heavy rainfall in the upper and middle sections of the Delaware River Valley. Storm total estimates averaged between 2 and 5 inches in Sussex County. The torrential rain caused widespread poor drainage, creek, and river flooding. It was the worst flooding along the Delaware River since 1955. The county was declared a disaster area. Damage was estimated at just over $1.041 million in 2010 currency in Sussex County alone.

[16] FEMA's *Preliminary Flood Insurance Study for Sussex County, New Jersey*, August 31, 2009, p8.

- Many of the same areas that flooded in September 2004 were in a similar or worse flood situation in April 2005 when heavy rains were caused by a low pressure system from the Gulf. The flooding was exacerbated by the already wet soil conditions due to heavy rain during the end of March, snowmelt in the Delaware River's upper basin, and full capacity reservoirs in New York. In Sussex, Warren, Hunterdon, Mercer, and Morris Counties about 1,800 homes and businesses were flooded, twenty-five homes were destroyed, and about 4,000 people were evacuated. Many major roads were closed and about a dozen low-lying bridges were damaged, partially due to debris in the floodwaters. In Sussex County, storm totals averaged three to four inches, with Montague and Sandyston Townships the hardest hit. Flooding problems also occurred in Byram, Hardyston, and Stillwater Townships. Summit Lake Dam leaked but did not fail. Some basements in Newton and Byram Township flooded. Numerous roads were closed. There were no deaths or major injuries. On April 19th, a Major Disaster Declaration was announced for Gloucester, Hunterdon, Mercer, Morris, Sussex, and Warren Counties.

- On June 28, 2006 flooding occurred throughout the Delaware River Basin following several days of heavy rain. It was the second or third highest crest on record for the Delaware River along Sussex County. The county was declared a disaster area. Event totals in Sussex County averaged four to six inches, but storm totals exceeded ten inches in parts of the Upper Delaware Basin in New York State. Approximately 1250 homes and businesses in the State were damaged and four were destroyed. Many basements had flooding, and there were cases of oil in basements from ruptured tanks. Between Mercer and Sussex Counties ten Delaware River bridges were closed.

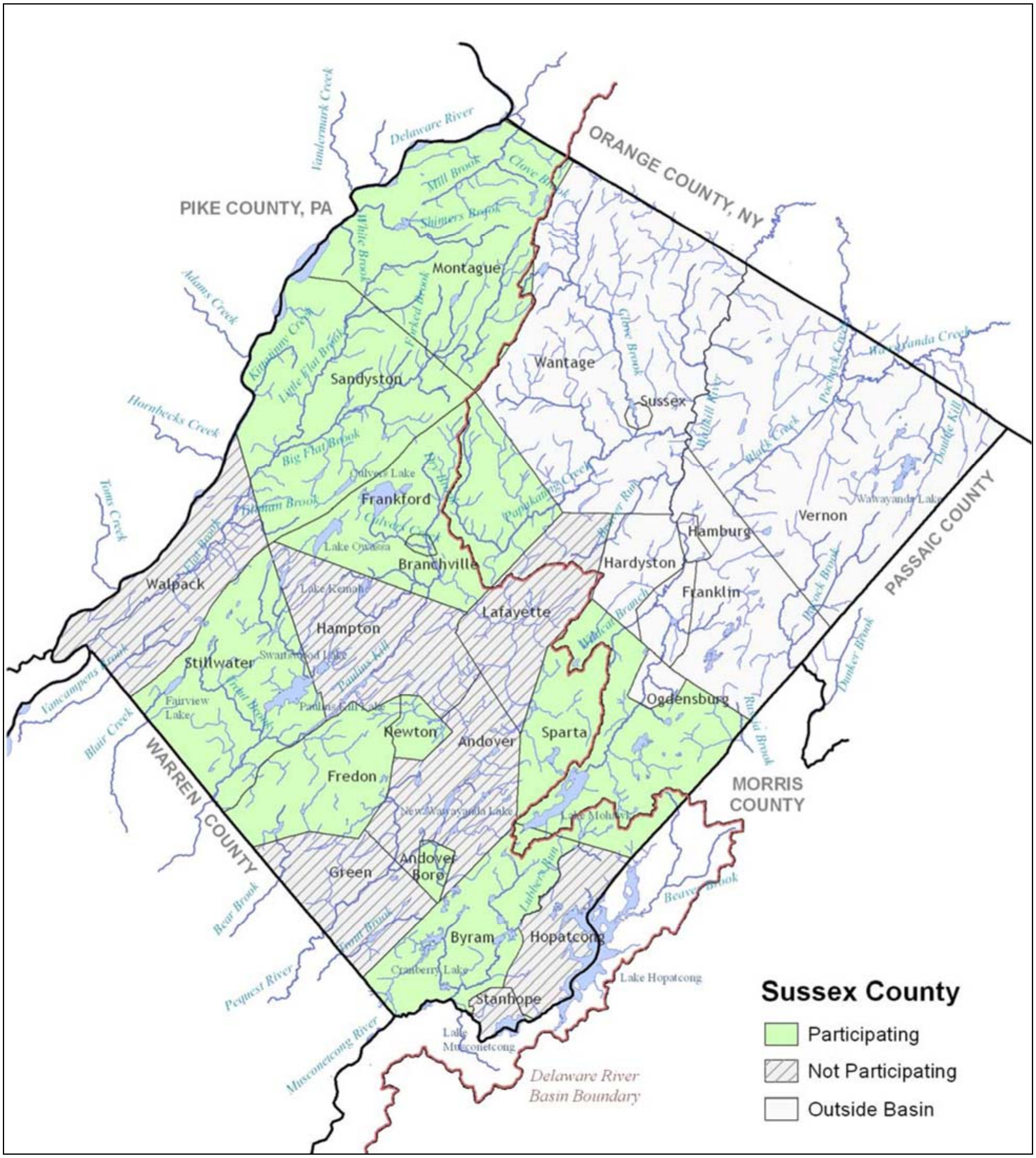
- An intense nor'easter brought heavy rain and flooding to New Jersey that started on the 15th of April, 2007. The worst flooding occurred along the Raritan and Passaic Basins. It was the worst flooding in the Raritan Basin since Hurricane Floyd in 1999. Bound Brook and Manville were once again hit hard. The nor'easter also brought strong to high winds as well as some snow to the state on the 16th. Numerous streams and rivers flooded, but the flooding along the Delaware River was minimal. Statewide damage was estimated at $180 million dollars. Event precipitation totals averaged 3 to 6 inches. The combination of the heavy rain, even some snow and the winds helped knock down numerous trees and power lines. The heavy rain and flooding caused several major roads to be closed in Sussex County. The Wallkill River flooded in Wantage and the Clove Brook flooded in Sussex. Twelve counties in the state were declared federal disaster areas (DR 1694) and included Burlington, Camden, Gloucester, Mercer, Middlesex, Morris, and Somerset Counties.

Following the three events in 2004, 2005, and 2006, a multi-agency and local partnership formed to produce the *Multi-Jurisdictional Flood Mitigation Plan for Municipalities in the Non-tidal, New Jersey Section of the Delaware River Basin,* which was finalized in November 2008. The goal of the plan is "to make the Delaware River Basin more disaster resilient by reducing long-term risks to loss of life and property damage from flooding. The aim is to empower local communities to mitigate and support a sustainable community plan so that, when confronted by a natural disaster, they will sustain fewer losses and recover more quickly."[17]

[17] Delaware River Basin Commission's *Multi-Jurisdictional Flood Mitigation Plan for Municipalities in the Non-tidal, New Jersey Section of the Delaware River Basin,* November 2008, p9. Retrieved from *http://www.state.nj.us/drbc/Flood_Website/NJmitigation/index.htm*

Ten Sussex County municipalities, out of the seventeen that were eligible, chose to participate including: Andover Township, Branchville, Byram Township, Frankford Township, Fredon Township, Montague Township, Newton, Sandyston Township, Sparta Township, and Stillwater Township, shown in green in Figure 3.3.4-1. Only the municipalities within the designated Delaware River Basin were eligible to participate. The Flood Mitigation Plan also contains recommended mitigation actions specific to the local communities that participated in the plan.

Figure 3.3.4-1: Sussex County Municipalities Participating in the 2008 Multi-Jurisdictional Flood Mitigation Plan for the Non-tidal Section of the Delaware River Basin



Delaware River Basin Commission's *Multi-Jurisdictional Flood Mitigation Plan for Municipalities in the Non-tidal, New Jersey Section of the Delaware River Basin,* November 2008, p243. Retrieved from *http://www.state.nj.us/drbc/Flood_Website/NJmitigation/index.htm*

Based on the occurrence of 12 significant drought events in fifty years, the probability of future loss-causing flood events in Sussex County is 24% likelihood per year.

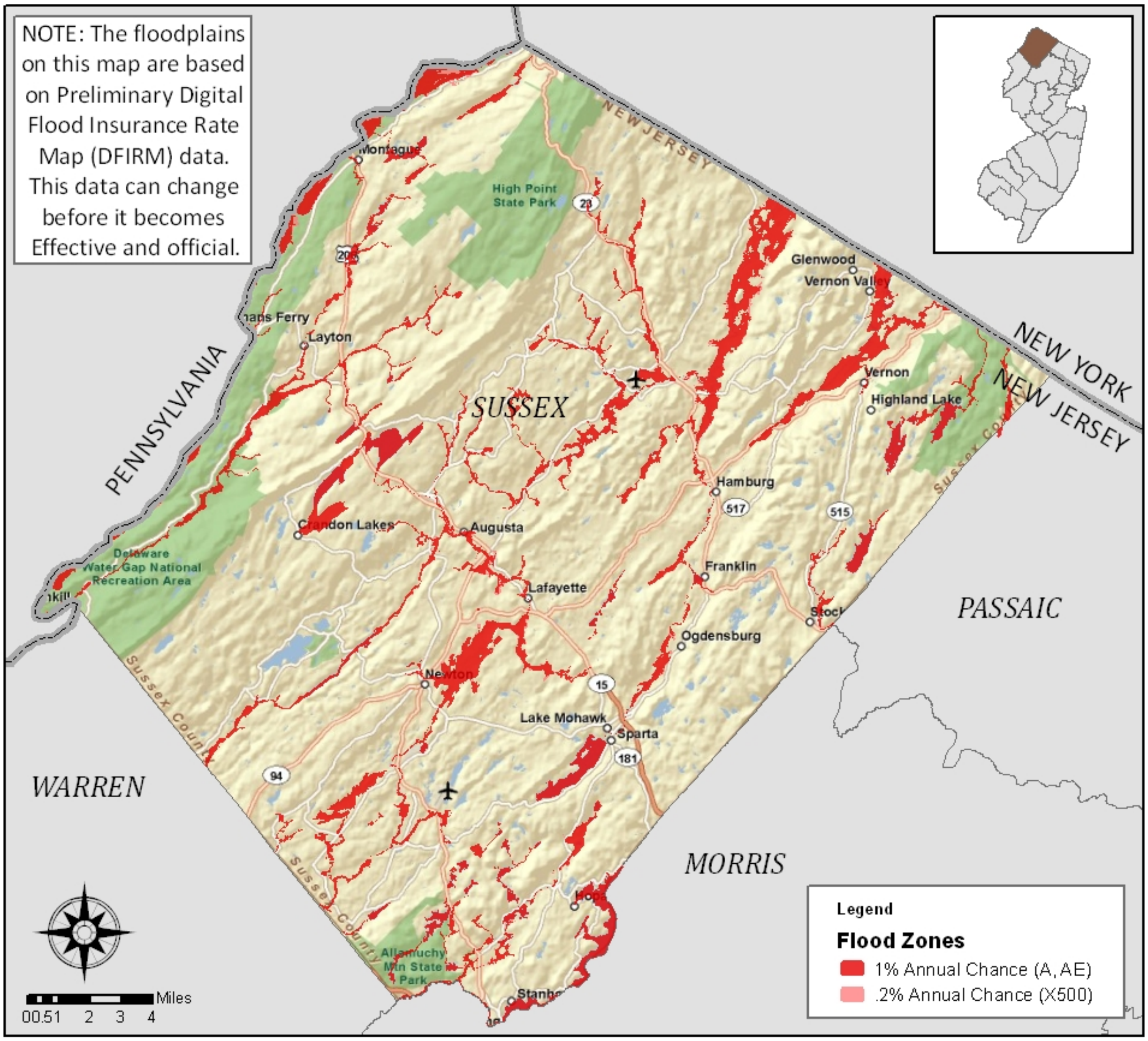
Location and Extent of the Flood Hazard

The area's characteristics can also impact the severity of a flood, such as topography, current soil moisture, vegetation, reservoir levels, and manmade alterations to the landscape. Densely populated areas are also at a high risk for flash floods because the construction of buildings, highways, driveways, and parking lots increases runoff by reducing the amount of rain absorbed by the ground.[18]

Certain areas of the county are at higher risk for flooding than others. As previously mentioned, the Delaware River has been the source of many damaging previous events. Flooding in this area is commonly due to snow melt combined with a rain event, heavy rains, or cyclonic events (including hurricanes, tropical storms, or nor'easters). Areas depicted on FIRMs as being in both the 1% and .2% annual chance of flood have a higher risk of flooding than areas outside of the floodplain, as shown in Figure 3.3.4-1. According to Sussex County's Preliminary DFIRM data (which is subject to change at any time before going Effective), of Sussex County's 342,698.02 acres, 28,000.22 acres are in the SFHA and at higher risk for flooding, or 8.17% of the County's land.

[18] NOAA. Retrieved from http://www.nssl.noaa.gov/primer/flood/fld_basics.html

Figure 3.3.4-2: Sussex County Floodplains from Preliminary DFIRM Data



Source: FEMA DFIRM Preliminary data, which is subject to change at any time before becoming Effective.

Another way to look at where flooding has caused damages in the past is to review information and general locations of Repetitive Loss and Severe Repetitive Loss Properties. A Repetitive Loss (RL) property is a structure covered under an NFIP flood insurance policy that has submitted at least two insurance claims of more than $1,000 in a ten-year period. According to the National Flood Insurance Act, a Severe Repetitive Loss (SRL) property is residential property covered under an NFIP flood insurance policy and 1) that has at least four NFIP claim payments (including building and contents) over $5,000 each, and the cumulative amount of such claims payments exceeds $20,000, or 2) for which at least two separate claims payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building. In either case, two of the referenced claims must have occurred within a ten-year period and are greater than 10 days apart.

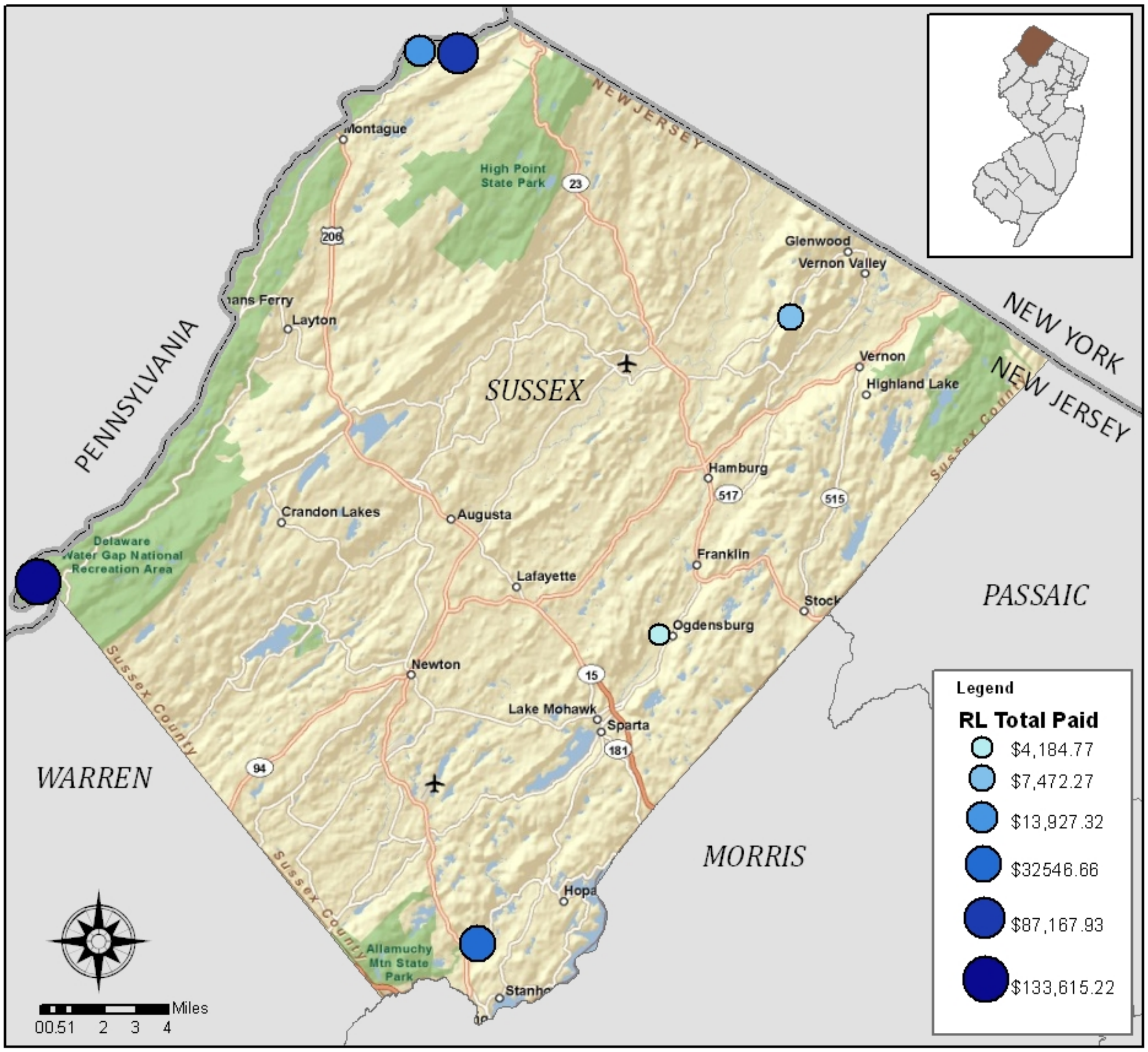
Table 3.3.4-2 and Figure 3.3.4-3 show the county's RL properties. The five municipalities with paid RL claims are: Walpack Township, Montague Township, Byram Township, an unknown municipality, and Ogdensburg. Walpack and Montague Townships share a boundary with the Delaware River, whose overflow was the cause of many of the RL flood events in the county. In Byram Township, Lubbers Run, and the Musconetcong River have been known to cause flooding. In Ogdensburg, the Wallkill River is a source of flooding. Many lakes in Sussex County also cause flooding. Sussex County has no reported SRL claims.

Table 3.3.4-2: Sussex County Municipality Repetitive Loss Properties by Total Paid

Municipality	# Residential Properties	# Non-Residential Properties	Building Claims Paid	Contents Claims Paid	# Claims	Total Paid
Walpack Township	1	0	$133,492	$124	2	$133,615
Montague Township	2	0	$100,539	$557	5	$101,095
Byram Township	1	0	$23,739	$8,807	2	$32,547
Miscellaneous Sussex County	1	0	$7,472	$0	2	$7,472
Ogdensburg	1	0	$1,809	$2,376	2	$4,185
Sussex County RL Totals	6	0	$267,051	$11,864	13	$233,914

Source: FEMA Repetitive Losses Queried May 10, 2010.

Figure 3.3.4-3: Sussex County Repetitive Loss Properties



Source: FEMA Repetitive Losses Queried May 10, 2010.

Impact on Life and Property of the Flood Hazard

According to the USGS, "Floods are the most chronic and costly natural hazard in the United States, causing an average of 140 fatalities and $5 billion damage each year (Schildgen, 1999)."[19] More than half of all fatalities during floods are auto related, and usually the result of drivers misjudging the depth of water on a road and the force of moving water – a car can float in just a few inches of water. In the U.S. in the past 50 years, loss of life to floods has declined, mostly due to improved warning systems, however economic losses have continued to rise due to increased urbanization and coastal development.[20]

[19] USGS *Large Floods in the United States: Where They Happen and Why Circular 1245,* 2003, p1. Retrieved from http://pubs.usgs.gov/circ/2003/circ1245/pdf/circ1245.pdf

[20] USGS *Flood Hazards – A National Threat Circular*. Retrieved from http://pubs.usgs.gov/fs/2006/3026/2006-3026.pdf

Flood events have severely impacted the county in the past, including deaths, injuries, significant property damage, sewage and storm water drainage issues, road damage, dam damage, and utility damage. According to a comparison of the SHELDUS and NCDC databases, since 1960 there have been twelve flood events within Sussex County that resulted in losses, summarized in Table 3.3.4-1. These twelve flood events are estimated to have caused 1 possible death, 1 possible injury, and $231,511,294 in property damages in 2010 currency. The NFIP has paid out a total of $233,914 in 6 Repetitive Loss claims.

According to the 2008 *Multi-Jurisdictional Flood Mitigation Plan for Municipalities in the Non-tidal, New Jersey Section of the Delaware River Basin*, all of the Sussex County jurisdictions that participated in the Flood Mitigation Plan are classified as having a low to medium flood vulnerability.

The USACE Philadelphia District, in partnership with NJDEP, is currently working on an Interim Feasibility Study for New Jersey which is expected to be submitted around 2013. The purpose is to evaluate possible flood mitigation options, including flood-proofing and removing or relocating structures within the floodplain of the Delaware River Basin which aim to reduce flood losses.

The Green Acres, Farmland, Blue Acres, and Historic Preservation Bond Act of 2007 authorized $12 million for acquisition of lands in the floodways of the Delaware River, Passaic River or Raritan River, and their tributaries, for recreation and conservation purposes.[21] Properties that have been damaged by flooding, or are prone to incurring flood damage, are eligible for acquisition. There have also been recent approved funding and efforts for improving flood warning and education in the Delaware River Basin area.

Prioritization and Rationale of the Flood Hazard

The probability of future significant flood events in the county is 24%, or 'likely' for an index value of 3. Based on previous impacts from flood events, the magnitude of a future event could be "critical" for an index value of 3. Floods can occur unexpectedly, but are usually followed by some type of predicted weather event, so the warning time for a flood event will be "6-12 hours" for an index value of 3. Flood duration can vary, but generally "lasts less than 1 week" for an index value of 3.

Table 3.3.4-3: CPRI for Degree of Risk for Flood in Sussex County

Probability	+	Magnitude /Severity	+	Warning Time	+	Duration	=	CPRI
3 x .45	+	3 x .30	+	3 x .15	+	3 x .10	=	3

Based on previous flood history and that more than 8% of the county's land is in the SFHA, floods will continue to impact the county. For these reasons, floods will be studied in further detail in this Plan.

[21] NJDEP. Retrieved from http://www.nj.gov/dep/greenacres/

3.3.5 Hazardous Materials Release

Description of the Hazardous Materials Release Hazard

In general terms, 'hazardous materials' refers to hazardous substances, petroleum, natural gas, synthetic gas, and acutely toxic chemicals. They can come in many forms. The term Extremely Hazardous Substance is used in Title III of the Superfund Amendments and Reauthorization Act of 1986 to refer to those chemicals that could cause serious health effects following short-term exposure from accidental releases. Hazardous material releases can occur as a result of transportation accidents or a release from a fixed site due to flooding, earth movement, an accident, or an attack. Nuclear power generating facilities have the greatest concentration of radioactive materials of any private source. Usually the most immediate threat to public safety is caused when a hazardous material release causes an explosion.

Starting in 1986, the Emergency Planning and Community Right-to-know Act (EPCRA) required certain industries to report the locations and quantities of chemicals stored on-site to government officials. EPCRA Section 313 requires the EPA and the States to collect this data annually and make it publicly available. The Toxic Release Inventory (TRI) database is the vehicle to make public the information about releases and transfers of toxic chemicals from facilities in certain industrial sectors, including manufacturing, waste handling, mining, and electricity generation. Reporting is mandatory for facilities that use specific Standard Industrial Classification Codes, have at least 10 full-time workers, manufacture/process/use more than minimum amounts of the chemical, and have a chemical on the TRI list. Therefore, not all toxic on-site occurrences are recorded in TRI.

Occurrences and Probability of the Hazardous Materials Release Hazard

According the Right-To-Know Network's Toxics Release Inventory (TRI), Sussex County facilities had a total of 2,235,480 pounds of releases and 7,264,831 pounds of waste from 1987 to 2008. The types of chemicals that are reported through the TRI were originally established by Congress (based on lists that Maryland and New Jersey were using at the time), with the intent that the list would be improved through a process for listing and de-listing hazardous chemicals and categories.[22] Table 3.3.5-1 lists the county's top 5 types of chemicals for onsite releases from 1987 to 2008. 1,1,1-Trichloroethane was the top chemical released in the County for this time period, which is a type of solvent. It is a colorless, sweet-smelling liquid that was previously used in correction fluid, and can cause poisoning and illness from inhalation and skin irritation from skin contact with the liquid. It has been found to be an ozone depleting substance and is being regulated by the Montreal Protocol, and phased out in most cases.

[22] RTK TRI. Retrieved from http://www.rtknet.org/node/630

Table 3.3.5-1: Sussex County's Top 5 Chemicals for On-Site Releases from 1987 - 2008

Chemical Name	Quantity Releases (in Pounds)
1,1,1-Trichloroethane	968,322
Trichloroethylene	489,790
Methyl Ethyl Ketone	339,494
Methyl Isobutyl Ketone	337,662
Toluene	76,786

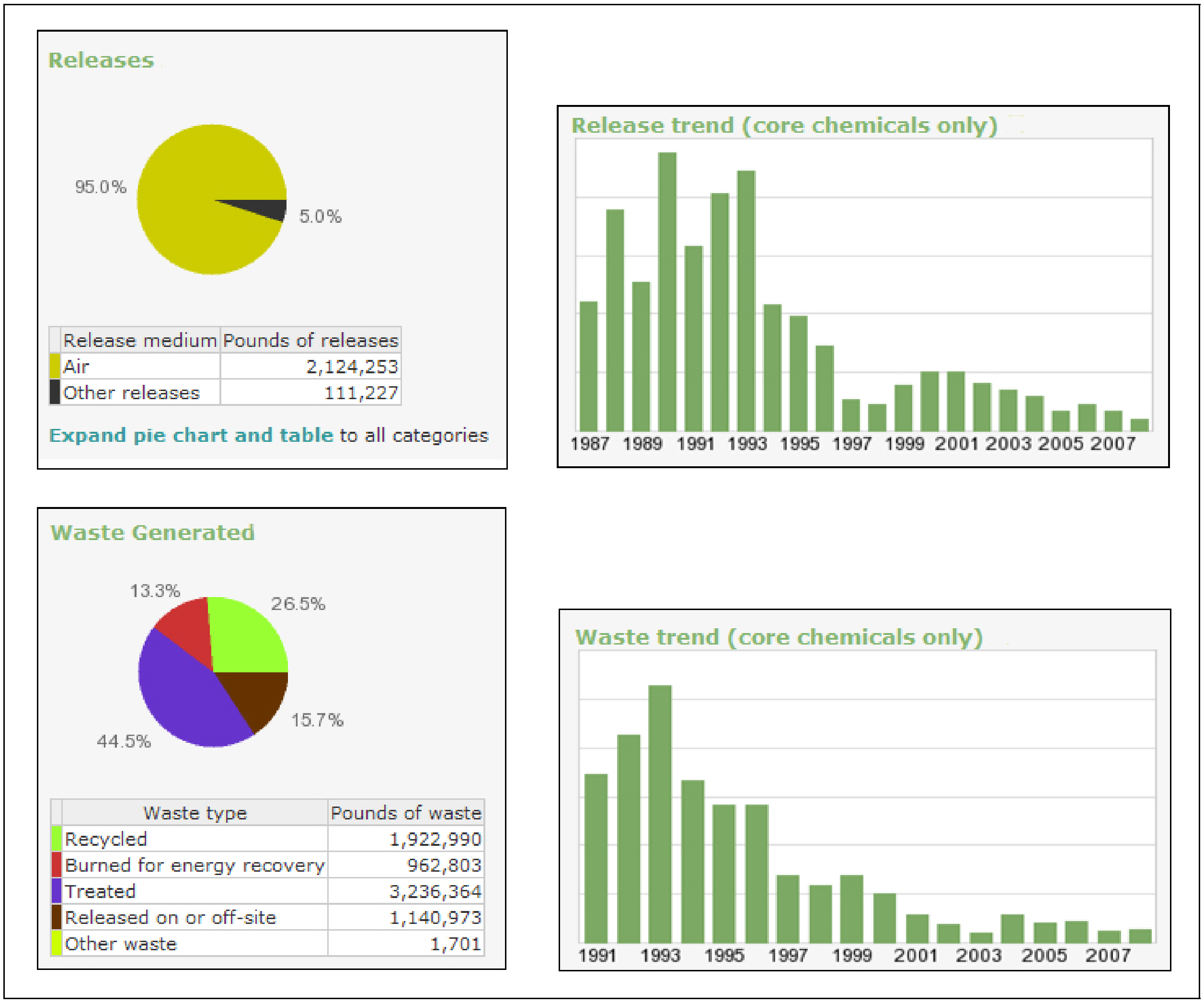
Source: RTK TRI. Retrieved from www.rtknet.org

Table 3.3.5-2: Sussex County's Top 5 Industries for On-Site Releases from 1987 - 2008

Top Industries for On-Site Releases	Quantity Releases (in Pounds)
Plastics and Rubber	1,209,886
Fabricated Metals	495,746
Printing and Publishing	364,807
Miscellaneous or No Industry Code	158,818
Chemicals	3,000

Source: RTK TRI. Retrieved from www.rtknet.org

Figure 3.3.5-1: Sussex County's Waste Released and Generated - Totals and Trends from 1987 - 2008



Source: RTK TRI. Retrieved from www.rtknet.org

According to the New York Times, on March 14, 2003, a propane truck exploded at Able Energy Products fuel depot just after 5 p.m. The explosion forced the evacuation of about 700 people living within a half-mile radius and caused eight minor injuries. Firefighters from 19 towns and a foam-spraying truck were used to fight the fire. The explosion was deemed an accident that occurred as a result of human error and mechanical malfunction.

Another component to hazardous material events is the possibility of a release of chemicals during transport. The U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA) maintain the Hazmat Incident Database which records events that occurred during transport. The database contains data from the past ten years, and indicates if an incident was a "serious incident" or not.

A "serious incident" is defined as a hazardous material release incident that caused a fatality or major injury, the evacuation of 25 or more persons, closure of a major transportation artery, alteration of aircraft flight plan or operation, the release of radioactive materials from Type B packaging, the release of more than 11.9 gallons or 88.2 pounds of a severe marine pollutant, or the release of a bulk quantity of a hazardous material.[23] Sussex County had two "serious incidents" during transport listed in Figure 3.3.5-3.

Table 3.3.5-3: Sussex County Hazardous Material Serious Incidents During Transport

Location	Date	Carrier/ Reporter Name	Shipper Name	Packaging Type	Commodity	Quantity Released	Deaths	Injuries	Total Amount of Damages
Fredon	2/9/2004	Ferrell Gas Inc	Ferrell Gas Inc	Portable Tank	Liquefied Petroleum Gases	1	0	0	$2
Hamburg	12/11/2003	Ferrell Gas Inc	Ferrell Gas Inc	Portable Tank	Liquefied Petroleum Gases	50	0	0	$1,232

Source: PHSA. Retrieved from https://hazmatonline.phmsa.dot.gov/IncidentReportsSearch/

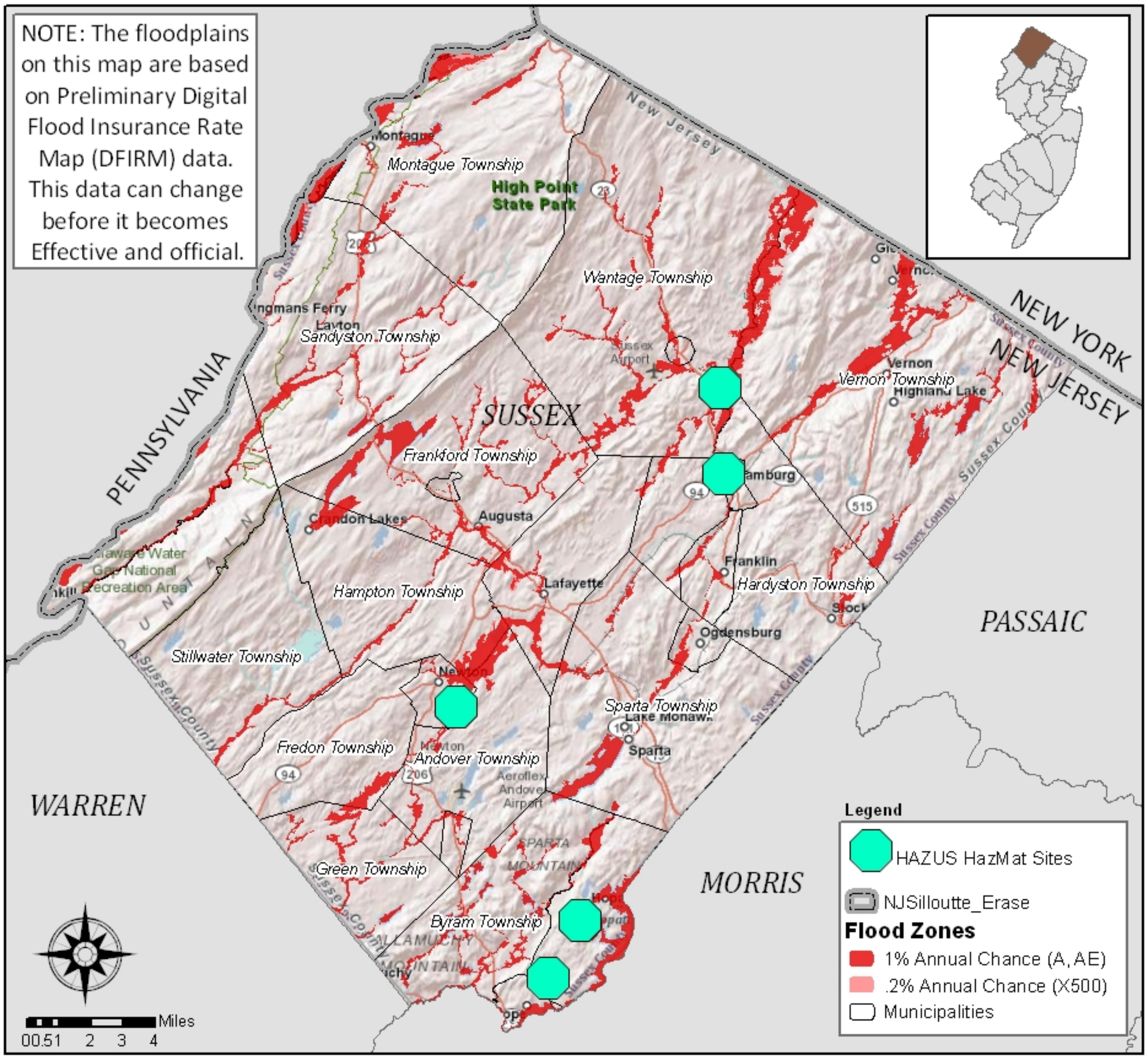
It is highly likely that smaller hazardous material releases and transportation incidents will continue to occur. However, Sussex County has not experienced a severe large-scale hazardous material incident at a fixed site or during transport resulting in deaths or serious injuries. The probability of a severe event occurring in Sussex County is unlikely.

Location and Extent of the Hazardous Materials Release Hazard

Hazardous material releases are more likely to occur in areas surrounding fixed site facilities and along major transport routes in Sussex County. Figure 3.3.5-2 shows hazardous material sites according to the HAZUS-MR4 inventory data. There are only five facilities listed in Sussex County, and none are in the floodplain. Nuclear sites are not included in the HAZUS data, but the only New Jersey nuclear sites are located in Salem and Ocean Counties.

[23] PHSA. Retrieved from https://hazmatonline.phmsa.dot.gov/IncidentReportsSearch/

Figure 3.3.5-2: Sussex County Hazardous Materials Facilities



Source: GIS Hazardous Material site data from HAZUS MR4. Floodplain GIS data from FEMA's Preliminary Digital Flood Insurance Rate Map database which is subject to change at any time before becoming Effective in the future.

Table 3.3.5-4: Sussex County's Top 5 Municipalities for On-Site Releases from 1987 - 2008

Municipality	Quantity Releases (in Pounds)
Hamburg	796,787
Sussex	668,602
Newton	343,636
Franklin	179,141
Vernon	134,702

Source: RTK TRI. Retrieved from www.rtknet.org

Impact on Life and Property of the Hazardous Materials Release Hazard

Public health impacts of a hazardous material release can be varied, ranging from temporary minor skin irritation to death. Mechanisms are in place to prevent catastrophic hazardous materials releases from occurring, but they are still possible. In Sussex County, it is more likely that smaller scale controlled and accidental chemical releases will occur. Sussex County has an active Hazardous Materials Response Unit that works in concert with the New Jersey State Police Hazardous Materials Response Unit, and offers training for first responders on how to deal with hazardous materials and related emergency response.

Prioritization and Rationale of the Hazardous Materials Release Hazard

Since the probability of future catastrophic hazardous materials release events are unlikely, this is considered an index value of 1. Based on previous occurrences, the magnitude or severity for anticipated hazardous materials release event impacts is considered 'negligible' because "less than 25% of property that is severely damaged" for an index value of 1. The warning time for a hazardous materials release event is "less than 6 hours warning time before an event occurs" for an index value of 4. Hazardous material release events, can end very quickly or last an entire day, therefore they would be classified as "the event lasts less than one day" for an index value of 2.

Table 3.3.5-5: CPRI for Degree of Risk for Hazardous Materials Release Hazard in Sussex County

Probability	+	Magnitude /Severity	+	Warning Time	+	Duration	=	CPRI
1 x .45	+	1 x .30	+	4 x .15	+	2 x .10	=	1.55

Although hazardous material releases can occur in Sussex County, as documented by historical reports, there have been no previously reported deaths or injuries, and the financial impacts have been extremely low in the past. Based on past events, the likelihood of a severe hazardous material release event occurring is very unlikely, though possible. For these reasons, hazardous materials release events will not be studied in further detail in this Plan.

3.3.6 High Wind – Straight Line Winds

Description of the High Wind – Straight Line Winds Hazard

Straight line high wind hazards include tropical cyclone winds (hurricanes, tropical storms, and tropical depressions), nor'easter storm winds, and winds created by any other type of severe storm such as thunderstorms. Many of these storms have the potential to create both wind and water damages. This section addresses only the wind hazard impacts, although in some cases it is difficult to separate the consequences of the two hazards. Tornado wind events are addressed separately in Section 3.3.7.

Tropical cyclones are formed as a developing center moves over warm water, the pressure drops in the center of the storm and as the pressure drops, the system becomes better organized and the winds begin to rotate around the low pressure, pulling the warm and moist ocean air. Tropical cyclones can evolve from a tropical depression to a tropical storm to a hurricane as they intensify as shown in Table 3.3.6-1. In the Northern Hemisphere, hurricane winds rotate in a counter-clockwise direction with different wind speeds and characteristics in each quadrant, with the most severe effects in the right-front quadrant.

Table 3.3.6-1: Types of Tropical Cyclones

Name	Maximum Sustained Surface Wind Speed (Using the U.S. 1-minute average)		
Tropical Depression	33 kt or less	38 mph or less	62 km/hr or less
Tropical Storm	34kt to 63 kt	39 mph to 73 mph	63 km/hr to 118 km/hr
Hurricane	64 kt or more	74 mph or more	119 km/hr or more

Source: NOAA, National Hurricane Center (NHC). Retrieved from http://www.nhc.noaa.gov/aboutgloss.shtml#h

The Saffir-Simpson Hurricane Scale defines hurricane strength by categories, with a Category 1 storm being the weakest and Category 5 being the strongest as shown in Table 3.3.6-2. Depending on where and how hurricanes strike, it is possible for a lower category storm to inflict greater damage than a higher category storm.

Table 3.3.6-2: Saffir-Simpson Hurricane Scale

Category	Wind Speeds	Likely Effects
1	74 to 95 mph	No real damage to building structures. Damage primarily to unanchored mobile homes, shrubbery, and trees. Also some coastal road flooding and minor pier damage.
2	96 to 110 mph	Some roofing material, door, and window damage to buildings. Considerable damage to vegetation, mobile homes, and piers. Small craft in unprotected anchorages break moorings.
3	111 to 130 mph	Some structural damage to small residences and utility buildings with a minor amount of curtainwall failures, mobile homes are destroyed. Flooding near the coast destroys smaller structures with larger structures damaged by floating debris. Terrain may be flooded well inland.
4	131 to 155 mph	More extensive curtainwall failures with some complete roof structure failure on small residences. Major erosion of beach areas. Major damage to lower floors of structures near the shore. Terrain may be flooded well inland.
5	155 mph or more	Complete roof failure on many residences and industrial buildings. Some complete building failures with small utility buildings blown over or away. Major damage to lower floors of all structures located near the shoreline. Massive evacuation of residential areas may be required.

Source: NOAA, NHC. Retrieved from http://www.nhc.noaa.gov/

Notes:

(1) The scale corresponds to the 1-minute average sustained wind speed as opposed to gusts which could be 20 percent higher or more.
(2) Effects depend on a number of factors and may differ from the examples here.

A nor'easter is a cyclonic storm that moves along the east coast of North America with winds that blow from a northeasterly direction. They may occur at any time of the year, but are most common and strongest in the winter months. These storms are usually most intense near New England and Canada. Nor'easters can produce heavy snow and rain, and may bring gale force winds greater than 58 miles per hour and can cause rough seas, coastal flooding, and beach erosion.[24]

Thunderstorms often bring strong winds in addition to hail and lightening. A thunderstorm is considered severe when the hail is .75" or larger, frequent and dangerous lightening is present, or has wind speeds 58 miles per hour or greater.

Occurrences and Probability of the High Wind – Straight Line Winds Hazard

According to a comparison of the SHELDUS and NCDC databases, since 1960 there have been four hurricane/tropical storm events within Sussex County that have resulted in losses. It is difficult to determine the losses due to wind damage versus the losses due to flooding damage. Table 3.3.6-3 shows the events with total losses from both types of damage. In addition to these four hurricane/tropical storm events, NCDC and SHELDUS also list Hurricane Floyd as separate 'Wind' and 'Flooding' events in the database, stating in the description that Hurricane Floyd will go down in history as the greatest natural disaster to ever effect the state of New Jersey to date. Hurricane Floyd hit New Jersey on September 16, 1999 and caused $1.1 billion dollars of damage and six deaths in the State. Estimates for wind damage only in Sussex County are $329.085 in 2010 adjusted dollars, with no deaths, injuries, or crop damages.

Table 3.3.6-3: Significant Hurricane/Tropical Storm Events with Wind and Flooding Losses, Sussex County, 1960 - 2010

Location	Date	Name	Deaths	Injuries	Property Damage	Crop Damage
Sussex	7/30/1960	Tropical Storm Brenda	0	0	$17,909	$0
Sussex	9/12/1960	Hurricane Donna	0.14	0.43	$179,088	$179,088
Sussex	8/28/1971	Tropical Storm Doria	0	0.14	$12,536,410	$12,536
Sussex	6/22/1972	Tropical Storm Agnes	0	0	$125,364	$1,253,641
Sussex	9/16/1999	Hurricane Floyd	0.13	0	$329,085	$0

Source: SHELDUS 7.0, NCDC, and NOAA's NWS Storm Prediction Center GIS data

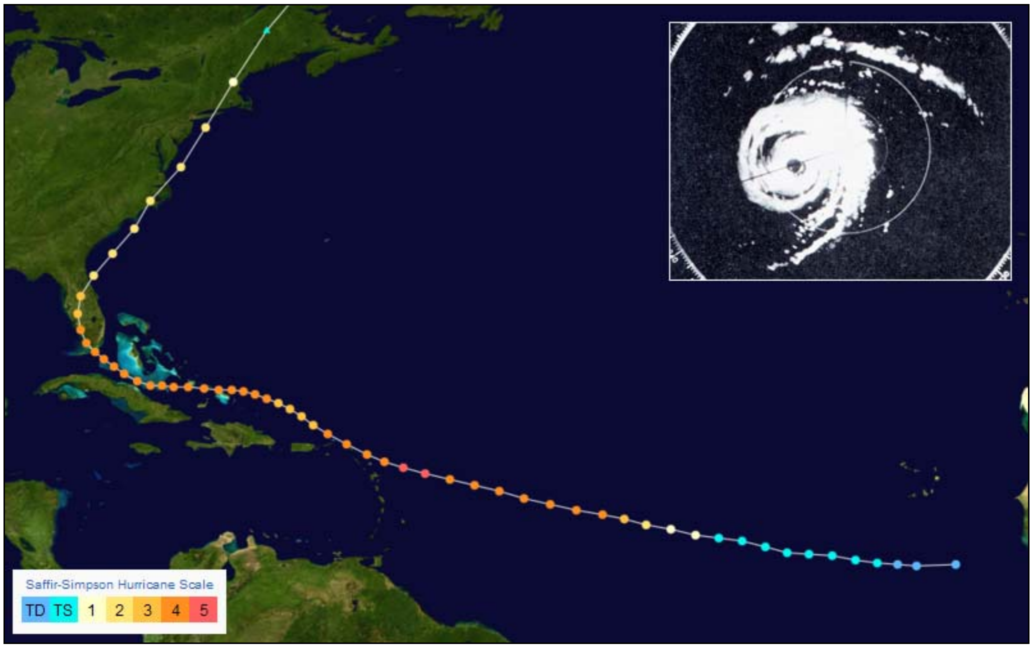
Notes:

(1) All efforts were made to research the actual location of deaths and injuries associated with a specific event, however when a specific county could not be determined then the number of deaths or injuries were divided by the number of counties associated with that event according to NCDC. This is the methodology utilized by SHELDUS 7.0. This can cause fractions of deaths or injuries associated with a specific county for an event.

(2) Property Damage and Crop Damage amounts have been adjusted to 2010 inflation amounts using the average Consumer Price Index from the U.S. Department of Labor's Bureau of Labor Statistics.

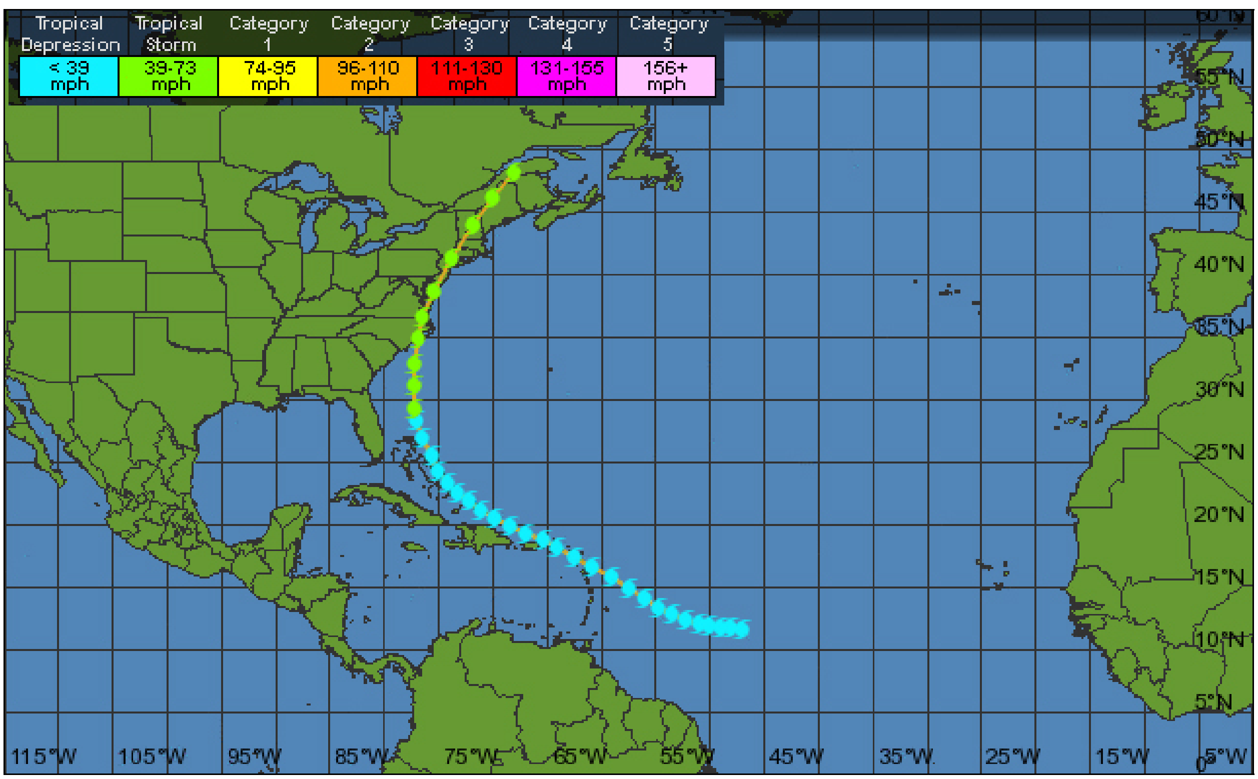
[24] NOAA, from http://www.noaa.gov/features/03_protecting/noreasters.html

Figure 3.3.6-1: Hurricane Donna Track and Radar Image, September 1960



Source: NOAA.

Figure 3.3.6-2: Tropical Storm Doria Track, August 1971



Source: NOAA.

Nor'easters are not a separate category in the NCDC or SHELDUS databases, but upon cross-referencing a list of known significant nor'easters against the significant winter weather events and wind events in the database, it was determined that the blizzard of 1996 was a nor'easter with significant impacts. See Section 3.3 and Figure 3.3.10-2 for further information regarding this event. On February 14-19, 2003, another nor'easter known as the "Presidents' Day Storm II", hit Sussex County and had significant impacts. It is unclear if any of the damages reported for Sussex County were due to wind damage.

According to the SHELDUS and NCDC databases, an additional 67 straight line wind events that caused damages in Sussex County occurred between 1960 and 2010. These were caused by straight line high wind damage associated with thunderstorms and other severe storms.

Based on the occurrence of four significant hurricane/tropical storm wind events, two nor'easter wind events, and sixty-seven other wind-related events in fifty years, the probability of future loss-causing straight line high wind events in Sussex County is above 100% likelihood per year.

Location and Extent of the High Wind – Straight Line Winds Hazard

The entire county has approximately the same risk for occurrence of straight line high wind events. They can occur at any location within Sussex County, although weather patterns will affect where the severity is the greatest. As cyclonic storms come inland, they begin to lose some of their intensity; however this does not lessen the effects for one part of the county as opposed to another.

Impact on Life and Property of the High Wind – Straight Line Winds Hazard

Wind events can create windblown debris that become damage-causing missiles, cause failure of structures, and cause destruction of infrastructure including utility lines and bridges. Trees are often uprooted in severe winds and after acting as missiles, become debris that must be dealt with before access to some areas and repair work can commence.

According to a comparison of the SHELDUS and NCDC databases, since 1960 there have been four hurricane/tropical storm events as summarized in Table 3.3.6-3. These four events may have caused 1 death and 1 injury, and totaled $12,858,770 in property damages and $1,445,265 in crop damages in 2010 currency. Again, it is important to note that these damages may be due more to flooding than to winds. In Sussex County, the two previously mentioned nor'easters caused 1 death and 1 potential injury, and approximately $3.187 million in property damages in adjusted for 2010 values. However, these losses are mostly attributed to the high snowfall during these two nor'easters, and the true amount of wind damage is unknown.

The additional sixty-seven other wind-related storms (including Hurricane Floyd) that caused losses in Sussex County caused an estimated 2 deaths, 12 injuries, $1,044,858 in property damages, and $167 in crop damage, based on 2010 inflation values. These losses may be most reflective of true wind losses in Sussex County as opposed to the cyclone event losses that are a combination of wind and precipitation losses.

Prioritization and Rationale of the High Wind – Straight Line Winds Hazard

Since the probability of future significant straight line high wind events in the county is greater than 100%, this is considered 'highly likely' for an index value of 4. Based on previous occurrences, the magnitude or severity for anticipated tornado hazard impacts is considered 'critical' due to the potential one or two previous deaths, multiple injuries, and property damages for an index value of 3. The warning time for a straight line high wind event can vary depending on the type of event, with cyclonic events prompting a warning from NOAA's National Hurricane Center in advance, but thunderstorms may have less lead time. The issued warnings often change as a storm approaches, therefore the category of "12 to 24 hours warning time before an event occurs" for an index value of 2 will be used. The duration of the event can also vary, but generally the "event lasts less than 1 day" for an index value of 2.

Table 3.3.6-4: CPRI for Degree of Risk for High Wind – Straight Line Hazard in Sussex County

Probability	+	Magnitude /Severity	+	Warning Time	+	Duration	=	CPRI
4 x .45	+	3 x .30	+	2 x .15	+	2 x .10	=	3.2

As documented by previous reports, many straight line high winds have occurred in Sussex County over the past fifty years. Based on past events, straight line high wind events will continue to occur in Sussex County and cause significant losses. For these reasons, straight line high winds will be analyzed in further detail in Section 3.4 of this Plan.

3.3.7 High Wind – Tornado

Description of the High Wind – Tornado Hazard

Tornadoes are defined as violently rotating columns of air extending from thunderstorms down to the ground. Tornadoes are unpredictable and can occur at any time of day or night, and at any season throughout the year. The Fujita Tornado Scale (F-Scale) was introduced in 1971, and is a damage scale (not a wind speed scale) that categorizes each tornado by intensity and area.[25] The F-Scale categories range from low intensity F0 with estimated wind speeds of 40 to 72 miles per hour up to F5 with estimated wind speeds of over 260 miles per hour. In 2007, the Enhanced Fujita Scale (EF-Scale) was introduced, and although it relates to the original Fujita Scale, it is more complex and has different wind speed ranges associated with the classifications. To determine an EF rating, begin with the 28 Damage Indicators, then determine the Degree of Damage (DOD), and based on the DOD, each category is given an expected estimate of wind speed.[26]

[25] "Proposed Characterization of Tornadoes and Hurricanes by Area and Intensity" (Feb, 1971). Dr. T. Fujita
[26] NOAA from http://www.spc.noaa.gov/efscale/

Table 3.3.7-1: F-Scale and EF-Scale Wind Speed Range Comparison

F-Scale			EF-Scale	
F-Scale	Fastest ¼-mile Wind Speeds (mph)	3-Second Gust Speed (mph)	EF-Scale	3-Second Gust Speed (mph)
F0	40 - 72	45 - 78	EF0	65 - 85
F1	73 - 112	79 - 117	EF1	86 - 109
F2	113 – 157	118 – 161	EF2	110 – 137
F3	158 207	162 – 209	EF3	138 – 167
F4	208 – 260	210 – 261	EF4	168 – 199
F5	261 – 318	262 – 317	EF5	200 - 234

Source: Wind Science and Engineering Center at Texas Tech University and NOAA/National Weather Service.

Occurrences and Probability of the High Wind – Tornado Hazard

According to a comparison of the SHELDUS and NCDC databases, since 1960 there has been one F2 tornado that resulted in losses, and another possible tornado in Sussex County. Sources are conflicting as to whether this was a tornado, and it is not included in NOAA's tornado GIS datasets, so in our analysis, it will not carry as much weight as the other event.

Table 3.3.7-2: Significant Tornado Events, Sussex County, 1960 - 2010

Location	Date	Type	Magnitude	Deaths	Injuries	Property Damage	Crop Damage
Byram	8/3/1974	Possible Tornado*		1	0	$219,389	$0
Wantage	7/29/2009	Tornado	F2	0	0	$812,947	$203,237

Source: SHELDUS 7.0, NCDC, and NOAA's NWS Storm Prediction Center GIS data

Notes:

(1) Property Damage and Crop Damage amounts have been adjusted to 2010 inflation amounts using the average Consumer Price Index from the U.S. Department of Labor's Bureau of Labor Statistics.

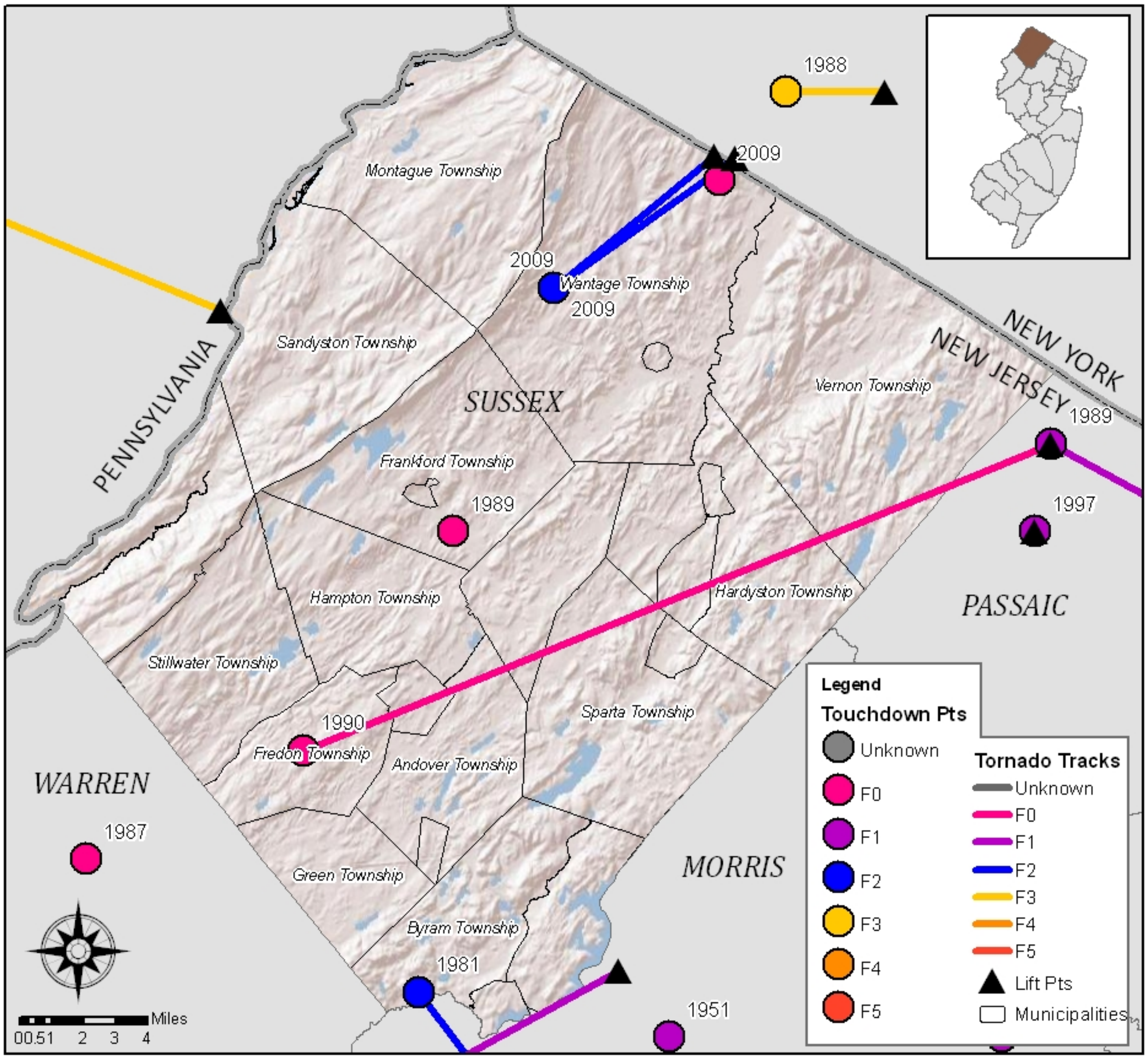
(2) 1974 event is listed as a "possible tornado" in SHELDUS, and is not included in the NOAA GIS data which goes back to 1950, so it is very questionable if it should be considered in these analyses.

According to NCDC, an EF2 tornado touched down in Wantage Township at about 2:48 p.m. on July 29, 2009. It was the first confirmed tornado in Sussex County since August of 1990, the first tornado of F2 or EF2 strength in New Jersey since the Manalapan tornado of May 27, 2001. The tornado remained on the ground for 6.6 miles before it crossed the border into New York State. Its maximum width was about 100 yards and its highest estimated wind speed was 120 mph. The tornado damaged thousands of trees, decimated acres of farmland and some rural property.

The worst damage of the entire tornado occurred along Beemer Road and on the north side of New Jersey State Route 23. Substantial damage occurred to the Ricker Farm, as two barns and one silo were destroyed. The tornado weakened after it crossed Wolfpit Road and Black Dirt Road on its way into New York State.

Figure 3.3.7-1 is based on USGS data, and shows where previous tornadoes have occurred in Sussex County from 1950 to 2009. Not all events have known tracks, so touchdown points are used for an approximation of where the tornado occurred.

Figure 3.3.7-1: Tornado Events, Sussex County, 1950 - 2010



Source: NOAA. GIS data retrieved from http://www.spc.ncep.noaa.gov/gis/svrgis/

According to NOAA's National Severe Storms Laboratory (NSSL), Sussex County had between 0.6 and 0.8 tornado days per year for any tornado, regardless of strength, and approximately five days per century for significant tornadoes (F2 or greater).[27] Based on the occurrence of one or two significant events in fifty years, the probability of future loss-causing tornado events in Sussex County is 2% to 4% likelihood per year.

[27] NOAA NSSL. Retrieved from http://www.nssl.noaa.gov/primer/tornado/tor_hazardgraph.html

Location and Extent of the High Wind – Tornado Hazard

The entire county has approximately the same risk for occurrence of tornadoes. They can occur at any location within Sussex County, although tornado events tend to occur more frequently in flatter terrain. See Figure 3.3.7-1 for an overview of the county's terrain. Tornado paths can range from 100 yards to a mile wide and are usually less than 15 miles long. The most severe recorded tornado event to occur in the county was an F2 in 1973, which is associated with 'considerable damage' and estimated wind speeds of 113 to 157 miles per hour.

Impact on Life and Property of the High Wind – Tornado Hazard

According to a comparison of the SHELDUS and NCDC databases, since 1960 there have been one or two tornado events within Sussex County that have resulted in losses. There has been one documented death associated with the event that may or may not have been a tornado. There have been no documented injuries due to tornadoes during this time in the county, and the estimated amount of total property damages is nearly $812,947 to $1,032,336 and $203,237 of crop damages in 2010 currency. A wind velocity of 200 miles per hour will result in a wind pressure of 102.4 pounds per square foot of surface area; a load that exceeds the tolerance limits of most buildings and cause high amounts of property damage. According to reports, Sussex County has not experienced a F3 or higher tornado.

The National Weather Service tries to provide accurate and timely warnings for tornadoes to reduce the loss of life and property. However, it is difficult to ensure the public knows how to react and find shelter to a tornado, particularly when tornadoes are such rare events in the county that can occur at any time of year. According to a recent study by National Severe Storms Laboratory Research Meteorologist Dr. Harold Brooks, violent tornadoes rated F4 or higher are responsible for 67% of the total deaths from 1921 to 1995.[28] The most severe recorded tornado in Sussex County was only an F2. The most vulnerable population in the path of tornadoes are residents of manufactured or mobile homes. According to the 2000 Census, Sussex County has 780 manufactured housing units, with an average household size of 2.8 for an estimated 2,184 people at higher risk.[29]

Prioritization and Rationale of the High Wind – Tornado Hazard

Since the probability of future significant tornadoes in the county is 2% to 4%, this is considered 'unlikely' for an index value of 1. Based on previous occurrences, the magnitude or severity for anticipated tornado hazard impacts is considered 'critical' because potentially one death occurred due to a tornado, and the losses are over $1 million 2010 dollars for an index value of 3. The warning time for a tornado is "less than 6 hours warning time before an event occurs" for an index value of 4. Tornadoes begin and end relatively quickly, therefore they would fall into "the event lasts less than 6 hours" classification for an index value of 1.

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[28] NOAA. Retrieved from http://www.oar.noaa.gov/spotlite/archive/spot_climatology.html

[29] Bureau of the Census. Retrieved from http://factfinder.census.gov

Table 3.3.7-3: CPRI for Degree of Risk for Tornado Hazard in Sussex County

Probability	+	Magnitude /Severity	+	Warning Time	+	Duration	=	CPRI
1 x .45	+	3 x .30	+	4 x .15	+	1 x .10	=	2.05

Although tornadoes can occur in Sussex County, as documented by historical reports, there may or may not have been one previously recorded death due to a tornado with no reported injuries over the past fifty years. Based on past events, the likelihood of a severe tornado event occurring is relatively unlikely. For these reasons, tornadoes will not be studied in further detail in this Plan.

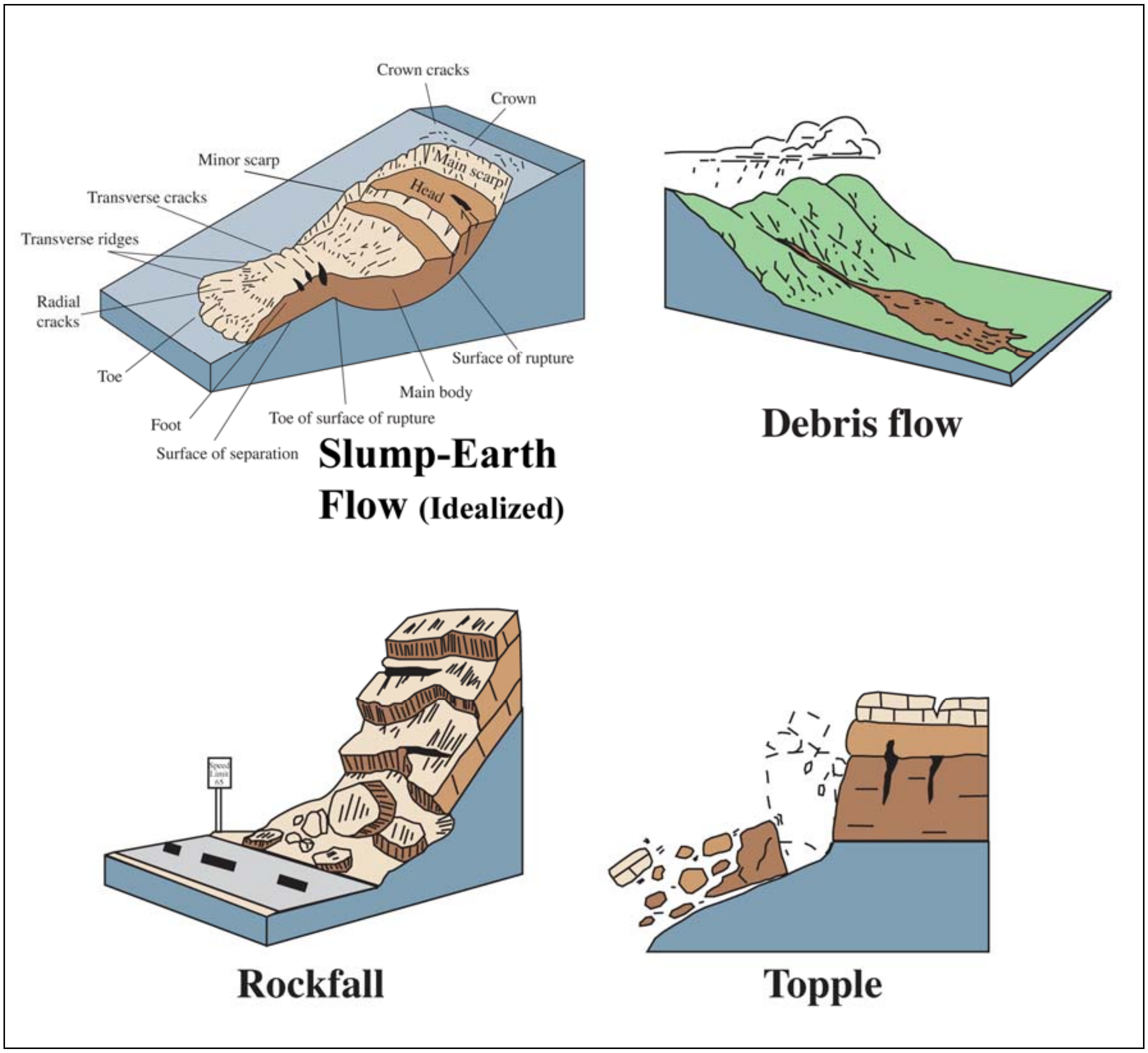
3.3.8 Landslide (Non-Seismic)

Description of the Landslide Hazard

A landslide is defined as "the movement of a mass of rock, debris, or earth down a slope"[30]. The term 'landslide' includes events such as rock falls, slides, topples, spreads, and flows. A debris flow is a form of rapid mass movement in which a combination of loose soil, rock, organic matter, air, and water mobilize as slurry that flows down slope.[31] Landslides are more likely on certain combinations of soil, moisture, angle of slope, and following wildfires. They may occur suddenly or in slow gradual slides. They can be triggered by rains, floods, earthquakes, and other natural causes as well as man-made causes such as grading, terrain cutting and filling, reservoir draw-downs and excessive development. This section does not include earthquake caused landslides; see Sections 3.3.3 and 4.3.2 for a further discussion on earthquake-related landslides. The U.S. Geological Survey National Landslide Hazards Program (NLHP) conducts research and provides public products to try to reduce long-term losses from landslides.

[30] Cruden, D.M., 1991. A Simple Definition of a Landslide. Bulletin of the International Association of Engineering Geology, No. 43, pp. 27-29
[31] USGS Fact Sheet 2004-3072 Landslide Types and Processes retrieved from http://pubs.usgs.gov/fs/2004/3072/

Figure 3.3.8-1: Examples of Common Types of Landslides



Source: USGS Fact Sheet 2004-3072 *Landslide Types and Processes* Retrieved from http://pubs.usgs.gov/fs/2004/3072/

Occurrence and Future Probability of Landslide Hazard

NJDEP's NJ Geological Survey maintains a dataset for landslides in the State, with 171 locations to date. Table 3.3.8-1 and Figure 3.3.8-2 provide a summary of events in Sussex County that caused damages or had unknown impacts.

Table 3.3.8-1: Landslide Events with Damages or Unknown Severity, Sussex County, 1782 - 2009

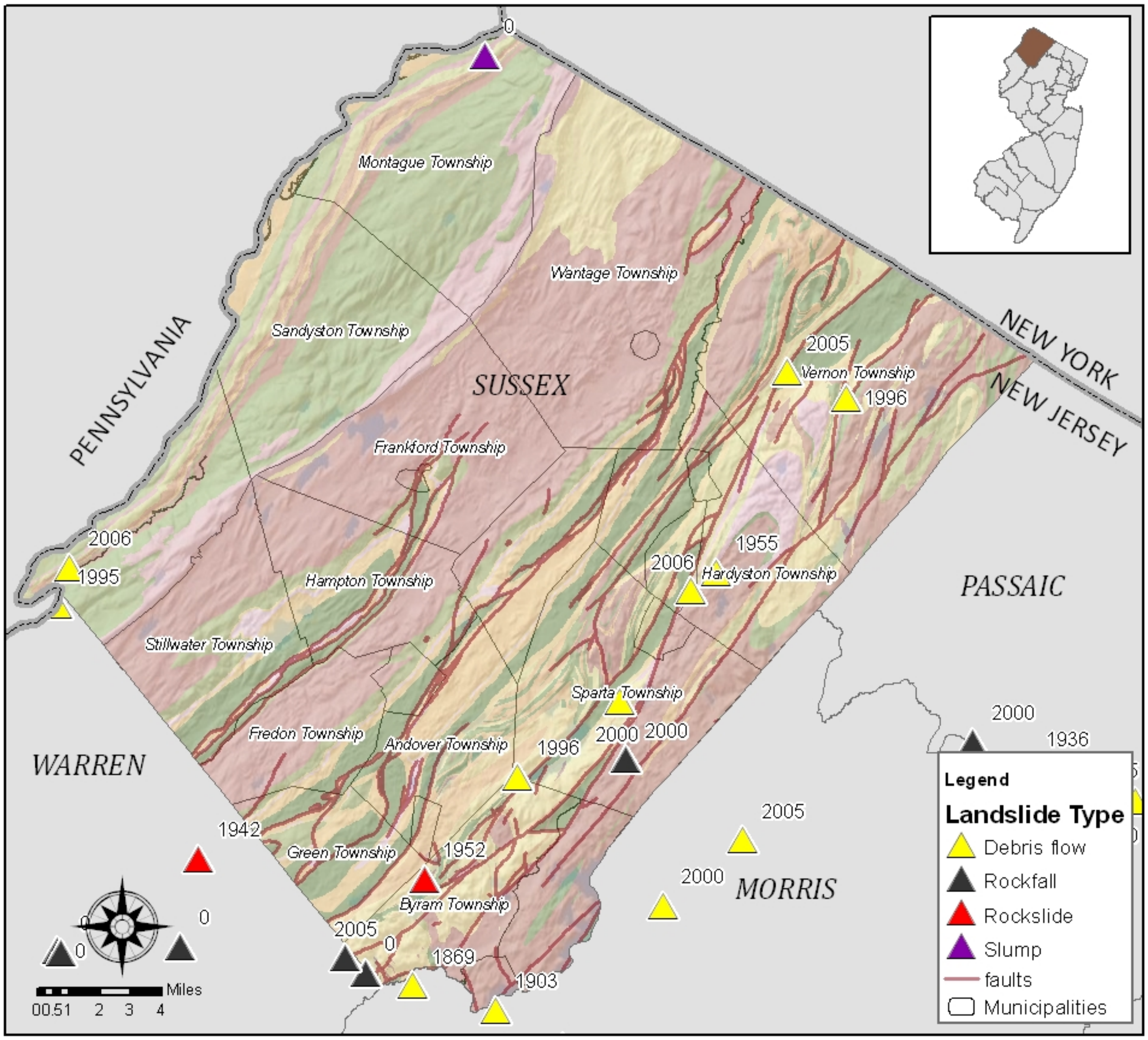
Location	Date	Type	Trigger	Description	Deaths	Injuries	Property Damage
Byram Township	12/1952	Rockslide	Weathering	A rockslide killed a 10 year old boy, another 10 year old boy suffered a broken ankle while playing on Panther Mountain.	1	1	No
Hardyston Township	08/1955	Debris Flow	Heavy Rain	Rte 23 closed at Beaver Lake as a result of landslide due to heavy rain from Hurricane Diane.	0	0	Yes
Sparta Township	01/1996	Debris Flow	Heavy Rain/ Snowmelt	Two landslides after heavy rain and melting snow, house destroyed in Lake Mohawk section.	0	0	Yes
Sparta Township	08/2000	Debris Flow	Heavy Rain	Massive landslide after heavy rain, property damage, railroad and Glen Road temporarily closed.	0	0	Yes
Franklin Borough	05/2006	Debris Flow	Heavy Rain	Heavy rains caused a retaining wall to collapse triggering a debris flow, damaging a deck.	0	0	Yes

Source: NJDEP Landslide GIS Data retrieved from http://www.nj.gov/dep/njgs/geodata/dgs06-3.htm

Notes:

(1) There were five other Sussex County events in the database, but these reportedly caused no damage.

Figure 3.3.8-2: Reported Sussex County Landslides



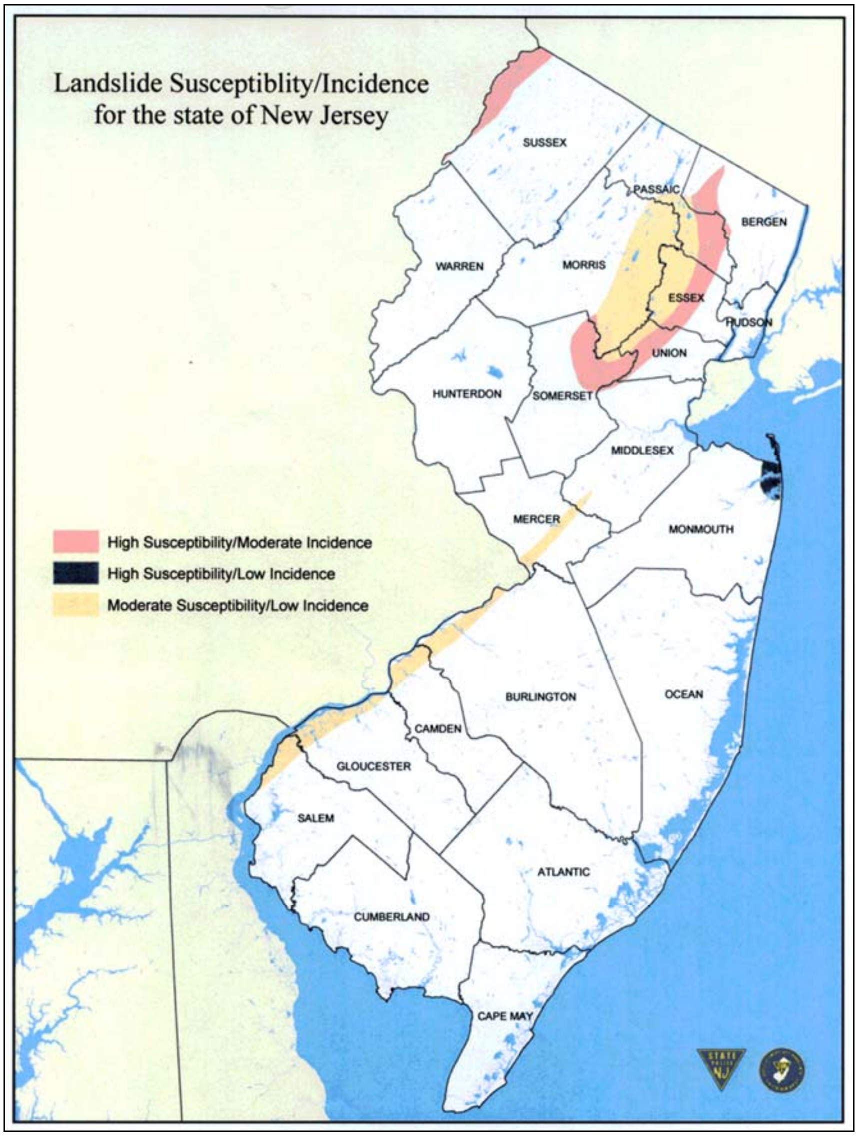
Source: NJDEP Landslide GIS Data retrieved from http://www.nj.gov/dep/njgs/geodata/dgs06-3.htm

Based on the occurrence of five landslide events that potentially caused damage in one-hundred twenty-three years, the probability of future landslide events Sussex County is 4% likelihood per year.

Location and Extent of Landslide Hazard

According to USGS and NJGS, Sussex County overall has a low susceptibility of landslide incidence, with the northern part of the county in a swath of high susceptibility/moderate incidence, as shown in Figure 3.3.8-3. However, some areas may be more or less prone to landslides based on geology, man-made alterations of the area, and soil moisture. Detailed landslide susceptibility maps were created for northern New Jersey Counties as part of a NJDEP NJGS study, but Sussex was not part of the study.

Figure 3.3.8-3: New Jersey Landslide Susceptibility/Incidence



Source: NJDEP NJGS

Impact on Life and Property of the Landslide Hazard

Landslides can pose a danger to public health, can damage infrastructure including roads and utilities, and can cause property damage. According to the NJGS data, there has been one documented death, and one injury caused by previous landslide events in Sussex County. There have been instances of financial impacts and road damages due to landslides in the county. Some New Jersey communities have made attempts to mitigate landslide hazards through building codes.

Prioritization and Rationale of the Landslide Hazard

Since the probability of future significant landslides in the County is 4%, this is considered 'unlikely'; however, given the USGS's determination that a swath in the northern part of the County has a high susceptibility/moderate incidence, an index value of 2 will be used. Based on previous occurrences, the magnitude or severity for anticipated landslide hazard impacts is considered 'critical' because there has been one previous death, one previous injury, and some previous road and property damages, for an index value of 3. The warning time for a landslide is usually "less than 6 hours" for an index value of 1; although USGS does have a list of landslide warning signs on their website, such as soil moving away from foundations, sunken or down-dropped road beds, sudden decrease in creek water levels, a faint rumbling sound that increases, and more at http://landslides.usgs.gov/learning/prepare/index.php Landslides generally last for "less than 6 hours", so the index value would be 1.

Table 3.3.8-2: CPRI for Degree of Risk for Landslide Hazard in Sussex County

Probability	+	Magnitude /Severity	+	Warning Time	+	Duration	=	CPRI
2 x .45	+	3 x .30	+	4 x .15	+	1 x .10	=	2.5

Landslides can occur in Sussex County and cause losses. There was one death and one injury that occurred in 1952 when two 10 year old boys were playing on Panther Mountain. There have been no other deaths reported in 123 years, and the probability of a future event is low. The majority of the county, where most of the population centers are, is considered to be in a Low susceptibility area. For these reasons, non-seismic landslides will not be studied in further detail in this Plan.

3.3.9 Severe Weather – Summer

Description of the Severe Weather – Summer Hazard

In the northeastern United States, periods of hotter than normal temperatures, often with high levels of humidity, can occur in the summer. These extreme temperature events can last a day to a week or longer. It is usually considered a heat wave in this area when the temperature rises above 100 degrees Fahrenheit, accompanied by high humidity. NOAA's National Weather Service (NWS) has created the Heat Index (HI) that combines relative humidity and actual air temperature to try to accurately measure how hot the air feels to the human body, and then demonstrate the potential health effects.

Figure 3.3.9-1: NOAA's National Weather Heat Index

Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity
Caution   Extreme Caution   Danger   Extreme Danger

Source: NOAA. Retrieved from http://www.weather.gov/om/heat/heatindex.shtml

Occurrence and Future Probability of Severe Weather – Summer Hazard

According to a comparison of the SHELDUS and NCDC databases, since 1960 there have been six extreme heat events within Sussex County that resulted in losses.

Table 3.3.9-1: Significant Severe Summer Weather Events, Sussex County, 1960 - 2010

Location	Date	Type	Deaths	Injuries	Property Damage	Crop Damage
Sussex	7/31/1993	Heat Wave	0	0.08	$0	$0
Sussex	7/01/1995	Unseasonably Warm	0	0.63	$0	$0
Sussex	7/14/1995	Excessive Heat	0	1	$0	$0
Sussex	8/1/1995	Unseasonably Warm	0	0.71	$0	$0
Sussex	7/12/1997	Excessive Heat	1.56*	0	$0	$0
Sussex	6/7/2008	Excessive Heat	0	0.625	$0	$0

Source: SHELDUS 7.0 and NCDC

Notes:

(1) All efforts were made to research the actual location of deaths and injuries associated with a specific event, however when a specific county could not be determined then the number of deaths or injuries were divided by the number of counties associated with that event according to NCDC. This is the methodology utilized by SHELDUS 7.0. This can cause fractions of deaths or injuries associated with a specific county for an event.

(2) The 1997 excessive heat wave was listed as 1.56 deaths for Sussex County in SHELDUS, however this same event had zero deaths in NCDC (with 25 injuries), so the source of this number is unclear.

Based on the occurrence of six significant events in fifty years, the probability of future loss-causing heat events in Sussex County is 12% likelihood per year.

Location and Extent of Severe Weather – Summer Hazard

The entire county has approximately the same risk for severe summer weather. Generally, heat waves are regional phenomena, but pockets of extreme heat can exist based on elevation and pressure system patterns. Climate change may or may not influence the severity of heat waves in the area in the future.

Impact on Life and Property of the Severe Weather – Summer Hazard

Heat waves can cause deaths, injuries, wide-spread power outages, and damage such as road buckling. According to a comparison of the SHELDUS and NCDC databases, since 1960 there have been six extreme heat temperature events in Sussex County that have resulted in losses. There have been possibly 0 to 2 deaths and 3 injuries in the county. From July 4, 1999 to July 6, 1999 there was a serious heat wave in New Jersey that caused 17 deaths and 160 injuries in neighboring counties. According to NOAA's NWS, on average, heat kills more Americans than any other natural hazard except extreme cold temperatures.[32] NWS has increased its efforts to alert the public and authorities to the hazards of heat waves, and communities have implemented cooling centers during some events to reduce the loss of life.

Prioritization and Rationale of the Severe Weather – Summer Hazard

Since the probability of future significant heat waves in the county is 12%, this is considered 'possibly' for an index value of 2. The magnitude or severity for anticipated heat wave hazard impacts could be 'critical' since one or two deaths may have occurred in the past for an index value of 3. The warning time for severe summer weather is usually "at least 24 hours before an event occurs" for an index value of 1. Heat waves can usually last more than a day but less than a week, so the index value would be 3.

Table 3.3.9-2: CPRI for Degree of Risk for Severe Weather – Summer Hazard in Sussex County

Probability	+	Magnitude /Severity	+	Warning Time	+	Duration	=	CPRI
2 x .45	+	3 x .30	+	1 x .15	+	3 x .10	=	2.35

[32] NOAA NWS. Retrieved from http://www.weather.gov/os/brochures/heat_wave.shtml

Summer severe weather events can cause serious harm to people. However, it is unclear if the previous deaths and injuries occurred in Sussex County or elsewhere in the state. Based on past events, the likelihood of a significant heat wave event occurring is possible but not likely in Sussex County. For these reasons, the severe summer weather hazard will not be examined in further detail in this Plan.

3.3.10 Severe Weather – Winter

Description of the Severe Weather – Winter Hazard

Severe winter weather may include one or more of the following: snowstorms, blizzards, sleet, freezing rain, ice storms, and extreme cold temperatures. Extreme cold temperatures are characterized by the ambient air temperature dropping to approximately 0 degrees Fahrenheit or below. Significant snowstorms are characterized by a rapid accumulation of snow, while a blizzard is categorized as a snowstorm with winds of 35 miles per hour or greater and/or visibility of less than ¼ mile for three or more hours. Many of these types of storms can immobilize a region, cause treacherous roadways, power outages, and property damage or collapse. Although there is no widely used scale to classify snowstorms, the National Weather Service (NWS) developed the Northeast Snowfall Impact Scale (NESIS). NESIS classifies high impact Northeast snowstorms that have large areas of 10 inch snowfall accumulations or more. The index utilizes population information in addition to meteorological measurements for an indication of the storm's impacts on society. The five categories are: Extreme (5), Crippling (4), Major (3), Significant (2), and Notable (1). NOAA's National Weather Service (NWS) in cooperation with a team of universities and other agencies developed the current wind chill temperature index (WCT) formula in 2001.[33] WCT uses wind speed at 5 feet (the average height of a human's face), incorporates heat loss from the body, is based on a human face model, utilizes 3 miles per hour as the calm wind threshold, uses a consistent standard for skin tissue resistance and assumes a clear night sky for solar radiation.

[33] NOAA. Retrieved from http://www.crh.noaa.gov/lsx/?n=winterday

Figure 3.3.10-1: Wind Chill Temperature Index

Temperature (°F)

Wind (mph)	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
Calm																		
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times
- 30 minutes
- 10 minutes
- 5 minutes

Source: NOAA. Retrieved from http://www.crh.noaa.gov/lsx/?n=winterday

Occurrence and Future Probability of Severe Weather – Winter Hazard

According to a comparison of the SHELDUS and NCDC databases, since 1960 there have been thirty-eight severe winter weather events within Sussex County that resulted in losses. Table 3.3.10-1 lists the twenty winter weather events with reported bodily harm in Sussex County.

Table 3.3.10-1: Severe Winter Weather Events with Reported Deaths and/or Injuries, Sussex County, 1960 - 2010

Location	Date	Type	NESIS Category	Deaths	Injuries	Property Damage	Crop Damage
Sussex	2/13/1960	Glaze, Sleet, Snow	-	2.38	0.33	$1,791	$0
Sussex	2/19/1960	Snow, High Winds	-	0	0.1	$17,909	$0
Sussex	3/3/1960	Snow, High Winds	5	2.86	0.43	$17,909	$0
Sussex	12/11/1960	Snow, Strong Winds	-	0	2.48	$17,909	$0
Sussex	1/19/1961	Heavy Snow, Strong Winds	3	0	0.05	$17,909	$0
Sussex	1/12/1964	Heavy Snowstorms	4	0	0.1	$16,715	$0
Sussex	12/16/1973	Snow, Sleet, Freezing Rain	-	0.38	0.14	$119,398	$0
Sussex	1/3/1974	Snow and Ice	-	0.1	0	$10	$0
Sussex	1/9/1974	Snow and Ice	-	1.48	0	$10	$0
Sussex	3/29/1974	Snow, Wind	-	1.5	0	$0	$0
Sussex	4/10/1974	Snow and Ice	-	0.13	0.13	$0	$0
Sussex	12/28/1976	Snow	-	0	0.05	$0	$0

Location	Date	Type	NESIS Category	Deaths	Injuries	Property Damage	Crop Damage
Sussex	1/19/1978	Snow	4	0	0.1	$0	$0
Sussex	1/7/1996	Blizzard (DR-1088)*	5	0	0.23	$2,003,817	$0
Sussex	1/13/1999	Winter Storm	-	3.13	0	$0	$0
Sussex	4/9/2000	Heavy Snow	-	4	0	$0	$0
Sussex	1/14/2003	Winter Weather	-	0.44	0	$0	$0
Sussex	2/16/2003	Winter Weather (DR-3181)*	4	1	0.13	$1,183,225	$0
Sussex	1/28/2005	Extreme Cold/Wind Chill	-	0	2	$0	$0
Sussex	12/24/2008	Winter Weather	-	0.08	0	$0	$0

Source: SHELDUS 7.0, NCDC, and NWS's NESIS from http://www.ncdc.noaa.gov/snow-and-ice/nesis.php?sort=nesis_asc#rankings

Notes:

(1) All efforts were made to research the actual location of deaths and injuries associated with a specific event, however when a specific county could not be determined then the number of deaths or injuries were divided by the number of counties associated with that event according to NCDC. This is the methodology utilized by SHELDUS 7.0. This can cause fractions of deaths or injuries associated with a specific county for an event.

(2) Events with an asterisk (DR)* denote Declared Emergencies. See Table 3.2.1-1.

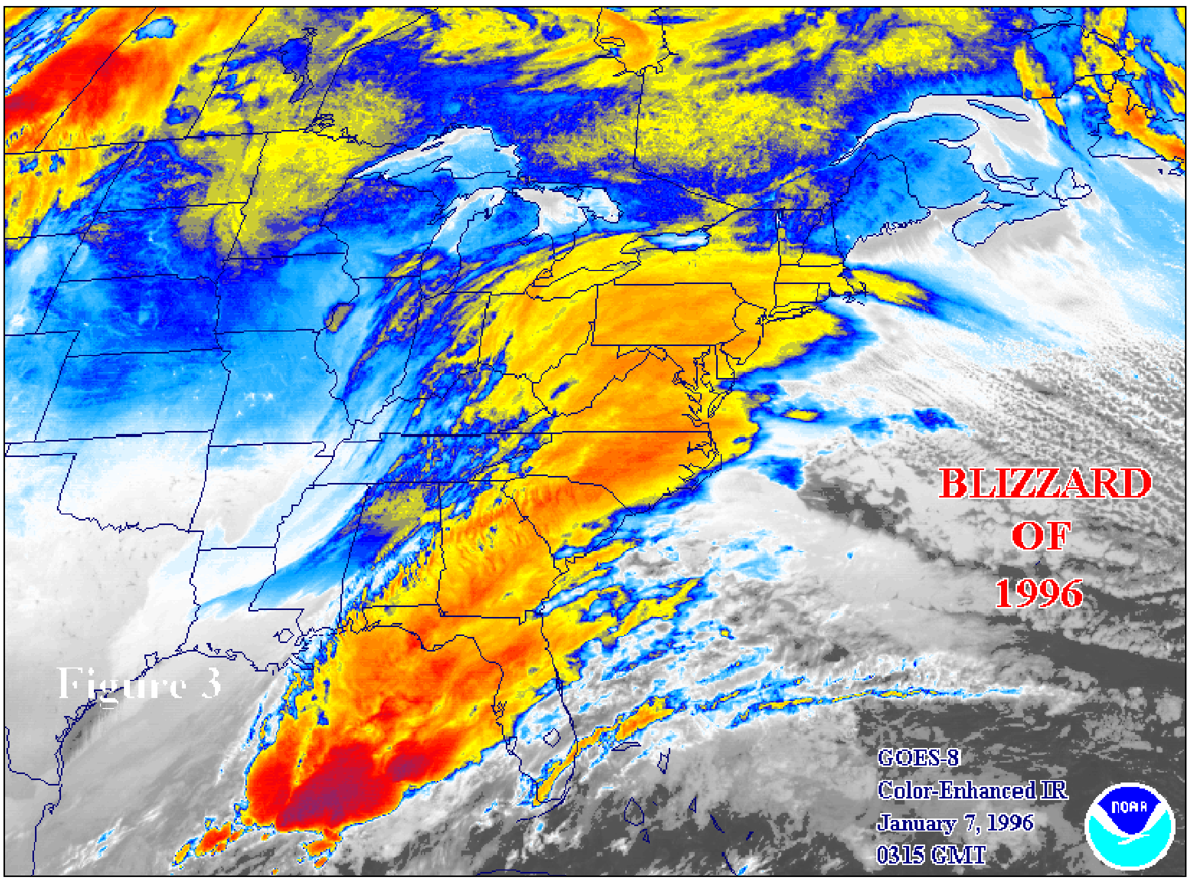
The "Blizzard of 1996" was a severe nor'easter that paralyzed the eastern coast with up to 4 feet of snow. In many locations, the storm did not meet the technical definition of a blizzard, however on January 7; the Trenton-Mercer Airport recorded conditions to meet the true classification of a blizzard. A State of Emergency was declared for New Jersey and then a Presidential Disaster Declaration was issued.

The "April Fool's Day Blizzard" was a major winter storm that hit the northeastern U.S. on March 31 to April 1, 1996, with Sussex County being one of the hardest hit counties in the State. The low pressure system responsible for this storm looked rather innocuous on March 30th as it moved with its associated cold front through the Midwest, as temperatures warmed into the 50s and 60s in New Jersey. The rain changed to snow close to dawn in areas across Northwest New Jersey. Impacts were very elevation dependent, and a limited state of emergency was declared in Sussex County, with shelters opened in 12 municipalities. Vernon Township declared a state of emergency that banned all driving. The combination of heavy wet snow, up to around two feet in some areas, and strong winds produced numerous power outages. GPU reported 75,000 homes lost power in Morris, Sussex, and Warren Counties with the majority in Sussex County. Trees were described as being "down all over the place". Downed trees also closed most of the major roadways in Sussex County. Accumulation in Sussex County reached 26 inches at High Point. [34]

[34] Retrieved from http://www.ncdc.noaa.gov/oa/climateresearch.html

According to Sussex County Office of Emergency Management, a late season hurricane-like storm occurred on December 11 to 16, 2008 which resulted in severe damages in the County. The storm resulted in several inches of rainfall statewide, but in Highland and Barry Lakes, Vernon Township, and parts of Hardyston and Sparta Townships, extreme icing conditions occurred. The higher elevations were hardest hit. Ice accumulated on trees, wires, and utility poles; causing hundreds of utility poles to snap and block roadways and interrupt power and telephone to Highland Lakes and Barry Lakes. Many trees fell onto homes and roadways. After four days, the roads were cautiously passable, and after another couple of days the utilities were restored. On the sixth day, chipper crews from nearly two dozen municipalities assisted in the Highland and Barry Lakes recovery efforts. This event did not meet any criteria for public assistance and Vernon Township had to fund the recovery themselves. The cost of power, telephone, and cable restoration was over a million dollars.[35]

Figure 3.3.10-2: Color Enhanced Infrared Satellite Image of the Blizzard on January 7, 1996



Source: NOAA. Retrieved from www.crh.noaa.gov

The winter storm that occurred from February 14-19, 2003 caused significant impacts in Sussex County and received a Disaster Declaration because of the effects of heavy snow. Total snowfall in Sussex County ranged from 17' to 25'.

[35] Sussex County Office of Emergency Management (OEM), provided August 2010.

Based on the occurrence of thirty-eight significant events in fifty years, the probability of future loss-causing severe winter weather events in Sussex County is 76% likelihood per year.

Location and Extent of Severe Weather – Winter Hazard

The entire county has approximately the same risk for severe winter weather. However, different areas of the county may be more or less severely affected during a particular event due to elevation, terrain, precipitation levels, and weather and pressure system patterns. According to the Office of the New Jersey State Climatologist, Sussex County is part of the North Climate Zone which averages 40 to 50 inches of annual snowfall.[36] These amounts can vary widely from year to year, with some winters consisting of multiple severe winter weather events, while others are very mild with little or no severe weather. The extent of winter storms varies in terms of storm location, temperature, and ice or snowfall. Extreme temperatures can also occur during the winter in Sussex County, and it is difficult to predict long term patterns. Climate change may or may not influence the severity of severe winter weather in the area in the future.

Impact on Life and Property of the Severe Weather – Winter Hazard

As seen in Table 3.3.10-1, severe winter weather events have potentially caused 17 or 18 deaths and 6 to 7 injuries in Sussex County. The cause of death and injuries due to winter storms can be attributed to car accidents, hypothermia, exhaustion and heart attacks, frostbite, wind chill, fires, carbon monoxide poisoning, structure collapse, and electrocution. According to NOAA's NWS, on average, extreme cold temperatures kills more Americans than any other natural hazard.

During a winter storm, infrastructure can be severely impacted, including damaged roadways, utility lines and pipes, railroads, and bridges. The twenty severe weather events that caused bodily harm also account for property damages totaling $3,396,602 in 2010 currency. According to SHELDUS and NCDC databases, in addition to these twenty events, there have been eighteen additional severe winter weather events that caused property damages since 1960. The most severe of the events in which no deaths or injuries occurred, was a heavy snow event on January 22, 2005 that caused the 2010 monetary equivalent of $1,760,446 in property damages. The remaining seventeen storms with reported property damages total $1,198,879 in adjusted dollar figures for the year 2010. This puts property damage estimates at approximately $6.356 million for all severe winter weather events since 1960 in Sussex County.

Prioritization and Rationale of the Severe Weather – Winter Hazard

The probability of future significant winter weather in the county is 76%, or 'Highly Likely' for an index value of 4. The magnitude or severity for anticipated severe winter weather hazard impacts could be 'catastrophic' since multiple deaths, injuries, and hefty financial impacts have occurred in the past, for an index value of 4. The warning time for severe winter weather is usually "at least 24 hours before an event occurs" for an index value of 1. Severe winter weather usually lasts more than a day but less than a week, so the index value would be 3.

[36] Office of New Jersey State Climatologist. Retrieved from http://climate.rutgers.edu/

Table 3.3.10-2: CPRI for Degree of Risk for Severe Weather – Winter Hazard in Sussex County

Probability	+	Magnitude /Severity	+	Warning Time	+	Duration	=	CPRI
4 x .45	+	4 x .30	+	1 x .15	+	3 x .10	=	3.45

Severe winter weather events can cause serious harm to people and property, as demonstrated by past events and impacts in Sussex County. Based on past events, the likelihood of a significant winter weather event occurring is very likely. For these reasons, this hazard will be examined in further detail in Section 4 in this Plan.

3.3.11 Wildfire

Description of the Wildfire Hazard

A wildfire is any fire that burns out of control and typically occurs in grasslands, forest, brush land, etc. Wildfire is a natural process that is important to ecosystems, and fire suppression can lead to more severe fires due to the buildup of vegetation, which creates more fuel. However, wildfires can also endanger the lives of people and destroy property when out of control. Wildfires can also cause secondary effects including erosion, landslides, introduction of invasive species, and changes in water quality. Wildfires can be caused by lightning strikes, but are most often the intentional or unintentional result of humans.

Occurrences and Probability of the Wildfire Hazard

According to the 2007 State Hazard Mitigation Plan for the State of New Jersey, Sussex County had a total of 1,135 fire incidents that burned a total of 802 acres from 1996 to 2006, for an average of 103.2 fire incidents per year and an annual average of 73 acres.[37]

According to a comparison of the SHELDUS and NCDC databases, since 1960 there have been no wildfire events within Sussex County that have resulted in losses.

Based on the occurrence of zero significant events in fifty years, the probability of future loss-causing wildfire events in Sussex County is below 1% likelihood per year.

Location and Extent of the Wildfire Hazard

When hot and dry conditions develop, forests and vegetation may become vulnerable to wildfires. Commercial and residential development near forested areas are at the highest risk of wildfire. The Wildland-Urban Interface (WUI) is where houses meet or intermingle with wildland vegetation. The WUI is where wildfires pose the greatest risk to human lives and structures. Figure 3.3.11-1 shows the extent of the WUI by census block, where the risk is the greatest in the yellow intermix and gold interface areas. Both areas must have a density of at least one structure per 40 acres. Intermix communities are places where housing and vegetation intermingle and wildland vegetation is continuous, with more than 50% vegetation. Interface communities are areas with housing in the vicinity of contiguous vegetation, within 1.5 miles of an area over 1,325 acres that is more than 75% vegetated.[38]

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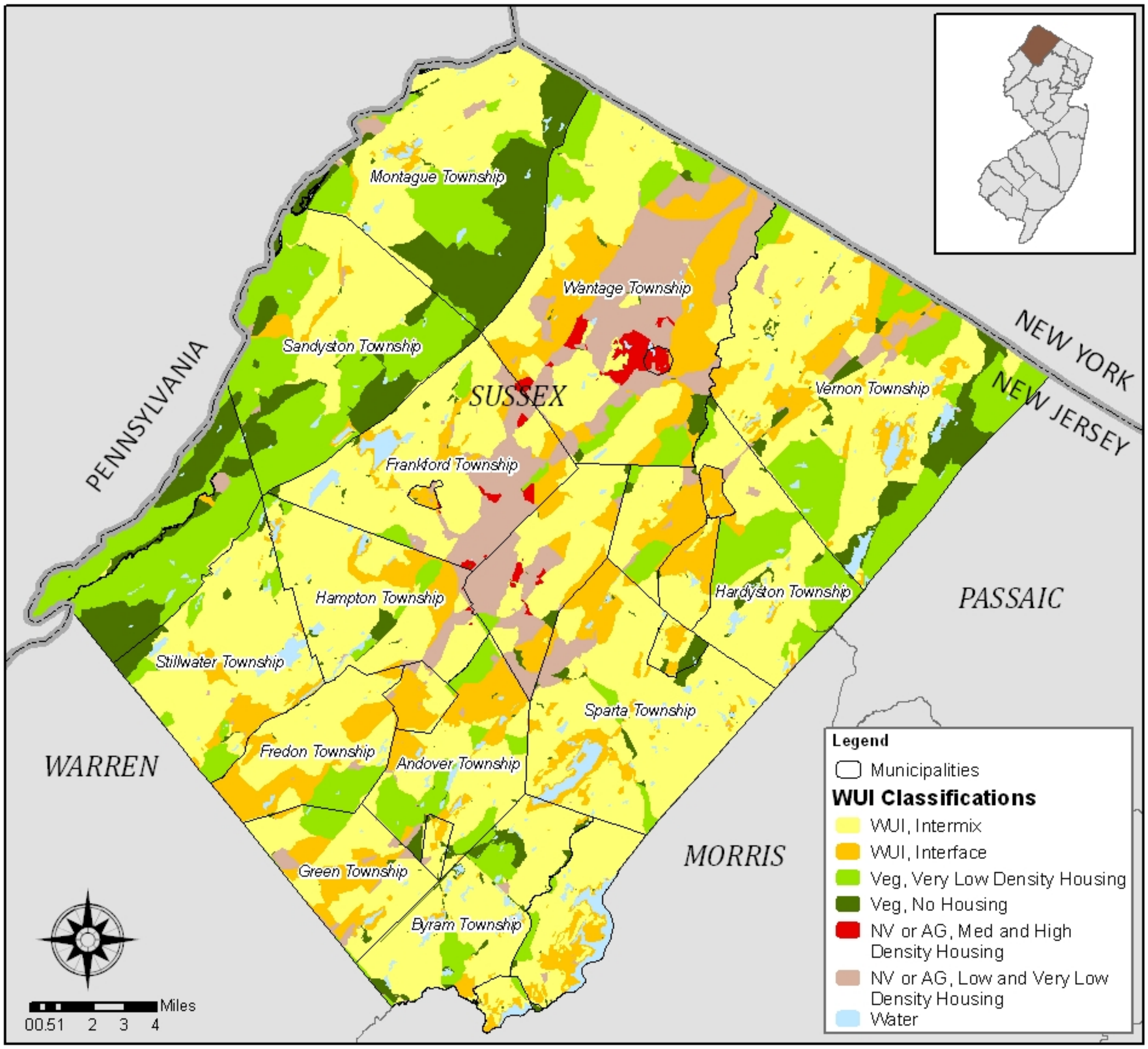
[37] 2007 NJ State Hazard Mitigation Plan pg 66-67.

[38] Radeloff, V. C., R. B. Hammer, S. I Stewart, J. S. Fried, S. S. Holcomb, and J. F. McKeefry. 2005. The Wildland Urban Interface in the United States. Ecological Applications 15:799-805. Retrieved from http://silvis.forest.wisc.edu/projects/WUI_Main.asp

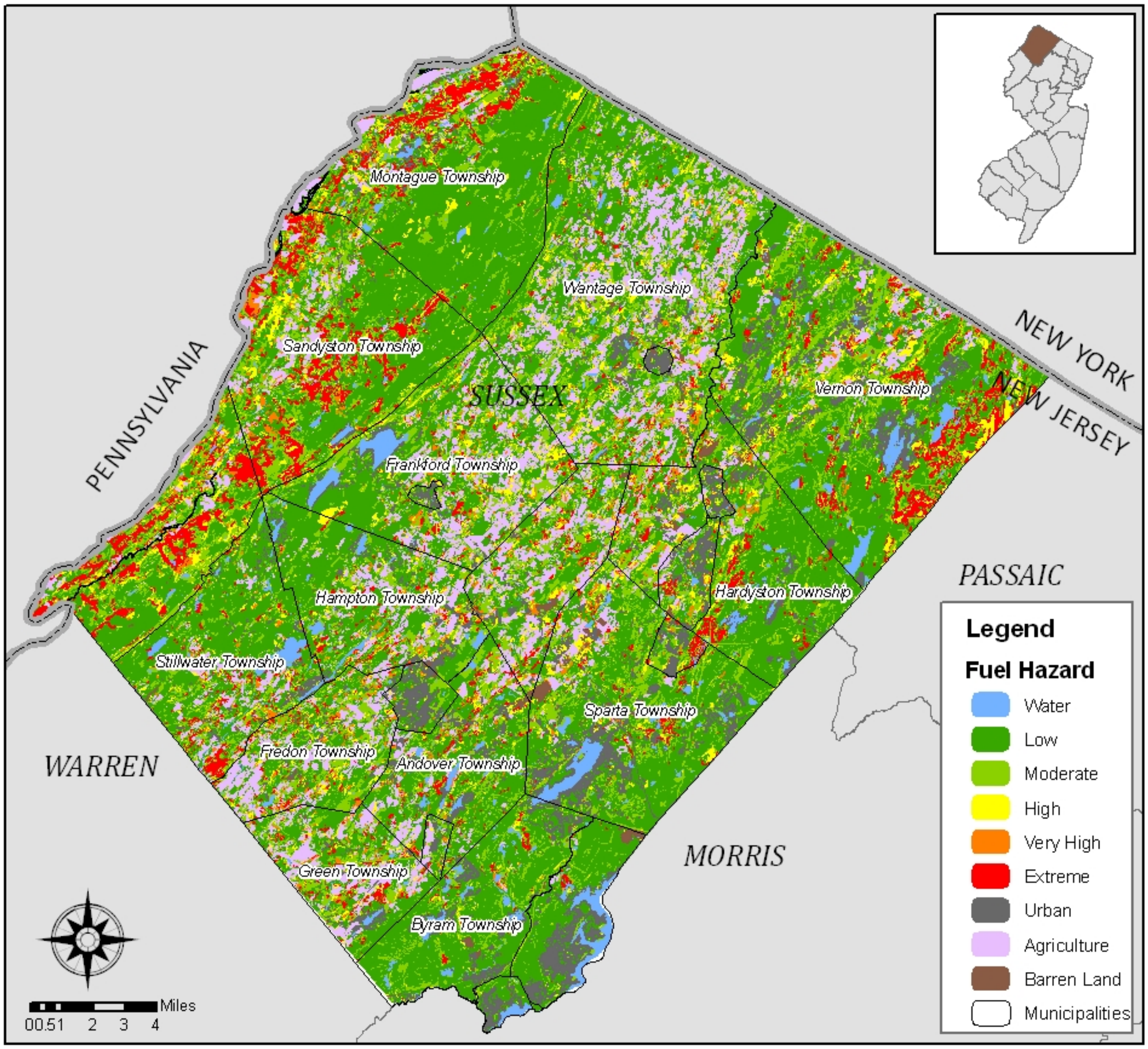
Figure 3.3.11-1: Sussex County Wildland-Urban Interface 2000 Extent



Source: Radeloff, V. C., R. B. Hammer, S. I Stewart, J. S. Fried, S. S. Holcomb, and J. F. McKeefry. 2005. The Wildland Urban Interface in the United States. Ecological Applications 15:799-805. WUI 2000 GIS data retrieved from http://silvis.forest.wisc.edu/Library/WUIDefinitions.asp

Temperature, humidity, and wind affect the severity and duration of wildfires. The type and amount of fuel, in addition to its burning qualities and level of moisture, affect wildfire potential and behavior. Topography is also important because it affects the movement of air and fire over the ground. The slope and shape of terrain can change the rate of speed at which the fire travels. In May 2009, NJDEP's New Jersey Forest Fire Service released wildfire fuel hazard GIS data, shown in Figure 3.3.11-2. They incorporated land type and slope into the hazard ranking. The areas of highest wildfire fuel risk are shown in red (extreme risk), orange (very high risk), and yellow (high risk).

Figure 3.3.11-2: Sussex County Wildfire Fuel Hazard Risk



Source: NJDEP's New Jersey Forest Fire Service. GIS Data retrieved from
http://www.state.nj.us/dep/gis/njfh.html#HUN

Impact on Life and Property of the Wildfire Hazard

According to a comparison of the SHELDUS and NCDC databases, since 1960 there have been no wildfire events within Sussex County that have resulted in losses. According to New Jersey's 2007 State Hazard Mitigation Plan, there have been wildfire incidents in Sussex County that caused 2 injuries, but no property damages.

Prioritization and Rationale of the Wildfire Hazard

Since the probability of future significant wildfires in the county is less than 1%, this is considered ‘unlikely’ for an index value of 1. Based on previous occurrences, the magnitude or severity for anticipated wildfire hazard impacts is considered ‘negligible’ because two injuries that are treatable are considered an index value of 1. The warning time for a wildfire is “less than 6 hours warning time before an event occurs” for an index value of 4. Wildfires can last multiple days, but usually the “event lasts less than 1 week” for an index value of 3.

Table 3.3.11-1: CPRI for Degree of Risk for Wildfire Hazard in Sussex County

Probability	+	Magnitude /Severity	+	Warning Time	+	Duration	=	CPRI
1 x .45	+	1 x .30	+	4 x .15	+	3 x .10	=	1.65

Although past wildfires have not previously caused any deaths or financial damages in Sussex County, the New Jersey Forest Fire Service believes that 80% of the County is susceptible to wildfire. Approximately thirty years ago, the State and the Forest Fire Service enacted and began enforcing strict open burning laws. At the same time, the Forest Fire Service was upgraded from an “on call” system of section fire wardens to career, full time field personnel with a cadre of “on call” district wardens and crews. The number of fire engines and other fire suppression equipment was increased statewide. These changes sharply decreased the number and severity of wildland fires throughout the State. However, wildland fires continue to occur and many Sussex County wildland fires are stopped just short of the loss of improved property. Sussex County consists of steep slope terrain that can contribute to rapidly-building, up-slope drafting of wildland fires. The potential for a wildfire that severely impacts entire neighborhoods and communities still exists. For these reasons, wildfires will be studied in further detail in this Plan.

3.4 Hazard Priorities

Section 3.3 provided an overview and profiles for all of the hazards that have potential to impact Sussex County in the future. However, in Section 4 the hazards of highest concern to the county will be further reviewed through detailed risk assessments.

A summary of all of the profiled hazards for Sussex County is shown in Table 3.4-1. It includes the CPRI value that was compiled in the profiles, the probability of future loss-causing/significant events occurring in the county annually, overview of relevant background information, reasoning for why to include or exclude the hazard from further risk assessment in Section 4, and if it will or will not be reviewed further in this Plan. This is meant to be a brief overview of information from Section 3.3, and any further details regarding the hazards and associated information can be found there.

Table 3.4-1: Prioritization and Rationale for Further Risk Assessment for Sussex County Hazards

Hazard	CPRI	Future Probability of Loss-Causing Events in County	Background	Rationale	Further Risk Assessment?
Severe Weather - Winter	3.45	64%	• 38 severe events with 17-18 deaths and 6-7 injuries • @$3.397 million in property damages	• Previous multiple deaths and injuries and severe financial impacts • Highly likely loss-causing events will continue to occur	Yes
High Wind – Straight Line	3.2	100%	• 2-3 previous deaths and 12-13 injuries • At least $1.045 million in property damages	• Highly likely for loss-causing events to occur often in county • Past history of severe losses	Yes
Flood	3	24%	• Possibly 1 previous death and 1 injury • @$231.511 million in previous property damages • Multiple severe events, three recent in 2004,2005, & 2006	• Significant event that is highly likely • Previous events have been very severe • Will continue to severely impact county in the future	Yes
Earthquake /Geological	2.9	Possible	• 19 previous events, none significant • Studies that risk in area is higher than previously thought due to active network of faults	• Concerns raised based on Sykes 2007 study that lower frequency but high severity events possible in area • USGS and NJDEP possible risk with high magnitude • Event could be catastrophic with many older structures not seismically sound	Yes

Hazard	CPRI	Future Probability of Loss-Causing Events in County	Background	Rationale	Further Risk Assessment?
Dam Failure	2.65	Possible	• 36 high, 45 significant, 153 low hazard dams • 31 dam incidents, 4 dam failures • Previous property damage of unknown amounts • County average dam age = 73 years old (many unknown age)	• No previously recorded deaths or injuries, but financial impacts from complete failures • All high hazard dams have EAPs, but very large number of high and significant hazard dams • 4 past failures and 31 'dam incidents' in the county	Yes
Landslide (non-seismic)	2.5	4%	• 5 previous events • 1 death, 1 injury in 1952 • Property damage amount unknown but house destroyed, railroad repairs, and road repairs	• Previous death and injury of children on a mountainside in 1952 are only reported in 123 years • Most of county in Low Susceptibility/Incidence area • Probability based on previous occurrences low	No
Severe Weather - Summer	2.35	12%	• 6 events with possibly 0-2 deaths and 3 injuries • No property damages	• Unclear if 2 deaths occurred in county or elsewhere in state • Probability of future events is possible but not likely	No
High Wind - Tornado	2.05	2%-4%	• 1-2 previous events • Death occurred from unconfirmed tornado event – sources are conflicting • @$812,947-$1.032 million in property damages	• One reported death occurred from questionable event • Most severe previous tornado was F2 • Probability low of future events	No
Wildfire	1.65	<1%	• No previous events with deaths, injuries, property, or crop damages	• No previous deaths, injuries, or damages • Very unlikely loss-causing event will occur	Yes
Hazardous Material Release	1.55	Unlikely	• Both transportation and on-site have occurred in past • All have been minor	• No previously reported deaths or injuries • Low previous financial impacts • Unlikely to occur	No

Hazard	CPRI	Future Probability of Loss-Causing Events in County	Background	Rationale	Further Risk Assessment?
Drought	1.3	2%	• 1 previous significant event with @$6.58 million in crop damages	• No previously recorded deaths, injuries, or property damages • Unlikely for event with impacts to occur, and impacts have previously been only crop damages	No

Notes:

(1) Property Damage and Crop Damage amounts have been adjusted to 2010 inflation amounts using the average Consumer Price Index from the U.S. Department of Labor's Bureau of Labor Statistics.
(2) Sources for losses and basis for probabilities explained in Section 3.3.

As shown in Table 3.4-1, winter severe weather, high wind – straight line, floods, earthquake/geological hazards, and dam failure have been selected for further in-depth risk assessment in Section 4.