2019 Connecticut Natual Hazards Mitigation Plan Update

Department of Energy and Environmental Protection
Department of Emergency Services and Public Protection
(Division of Emergency Management and Homeland Security)

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Acronym List

Acronym	Definition
ALERT	Connecticut Automated Flood Warning System
BFE	Base Flood Elevation
BOCA	Building Officials and Code Administration
C.G.S.	Connecticut General Statute
CAP	Community Assistance Program
CAV	Community Assistance Visit
CCMA	Connecticut Coastal Management Act
CEO	Council of Elected Officials
CFMA	Connecticut Floodplain Management Act
CFR	Code of Federal Register
CIHMC	Connecticut Interagency Hazard Mitigation Committee
CLEAR	Center for Land Use Education and Research
CMI	Crop Moisture Index
COG	Council of Governments
CRREL	U.S. Army Cold Regions Research & Engineering Laboratory
CRVFCC	Connecticut River Valley Flood Control Compact
CT PHERP	Connecticut Public Health Emergency Response Plan
DEMHS	Connecticut Department of Emergency Management and Homeland Security
DAS	Department of Administrative Services
DCS	Division of Construction Services
DEMHS	Division of Emergency Management and Homeland Security
DEEP	Connecticut Department of Energy and Environmental Protection
DESPP	Department of Emergency Services and Public Protection
DMA 2000	Disaster Mitigation Act of 2000
DOE	Connecticut Department of Education
DOH	Connecticut Department of Housing
DOT	Connecticut Department of Transportation
DPH	Connecticut Department of Public Health
EAS	Emergency Alert System
EOC	State Emergency Operations Center
EWP	Emergency Watershed Protection
FECB	Flood and Erosion Control Board
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FMA	Flood Mitigation Assistance
FMP	Flood Management Program
FPMS	Floodplain Management Studies
GIS	Geographic Information System
GPS	Global Positioning System
HMA	Hazard Mitigation Assistance
HMGP	Hazard Mitigation Grant Program

HMGRC	Hazard Mitigation Grant Review Committee
IA	Individual Assistance
IBC	2003 International Building Code
IPCC	United Nations Intergovernmental Panel on Climate Change
IRC	2003 International Residential Code
IWRD	Inland Water Resources Division
JESTIR	
LISICOS	Long Island Sound Integrated Coastal Observing System
MACOORA	Mid-Atlantic Coastal Ocean Observing Regional Association
MHFMMM	Multi-Hazard Flood Map Modernization Management Program
MIP	Management Information Portal
MOU	Memorandum of Understanding
NAWAS	National Warning System
NCEI	National Centers for Environmental Information
NECIA	Northeast Climate Impacts Assessment group
NFIA	National Flood Insurance Act
NFIP	National Flood Insurance Program
NFIRS	National Fire Incident Reporting System
NGVD	National Geodetic Vertical Datum of 1929
NHMP	Natural Hazard Mitigation Plan
NOAA	National Oceanic & Atmospheric Administration
NRCS	National Resources Conservation Service
NU	Northeast Utilities
NWRAH	NOAA Weather Radio All Hazards
OIM	Connecticut DEEP's Office of Information Management
OLISP	Office of Long Island Sound Program
OPM	Connecticut Office of Policy and Management
OSBI	Connecticut Office of the State Building Inspector
PA	Public Assistance
PDM	Pre-Disaster Mitigation Program
PDSI	Palmer Drought Severity Index
RFC	Repetitive Flood Claims Grant Program
RPA	Regional Planning Agencies
RPO	Regional Planning Organization
SBA	Small Business Administration
SCEL	Stream Channel Encroachment Line
SHMO	State Hazard Mitigation Officer
SHMPT	Connecticut State Hazard Mitigation Planning Team
SHSGP	State Homeland Security Grant Program
SLR	Sea Level Rise
SLOSH	Sea, Lake and Overland Surges from Hurricanes
TRVFCC	Thames River Valley Flood Control Compact
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USDHS	U.S. Department of Homeland Security

USGS	U.S. Geological Survey
WUI	Wildland/Urban Interface

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Executive Summary

The 2019 Connecticut State Hazard Mitigation Plan Update serves as guidance for hazard mitigation for the State of Connecticut. Its vision is supported by three central goals, each with an objective, a set of strategies and associated actions for Connecticut state government, stakeholders, and organizations that will reduce or prevent injury from natural hazards to people, property, infrastructure, and critical state facilities Funding for this Plan was provided through a Federal Emergency Management Agency (FEMA) Pre-Disaster Mitigation (PDM) grant, supplemented with Community Development Block Grant – Disaster Recovery (CDBG-DR) funds. The Department of Emergency Services and Public Protection (DESPP) was grantee for this planning grant. This plan fulfills the standard state mitigation planning requirements (44 CFR §201.4) of the Disaster Mitigation Act of 2000 (DMA2000; Public Law 106-390, signed into law October 10, 2000). This plan was adopted by the State on and approved by FEMA on _____, 2018.

1.1 Planning Process

The development of this plan was led by the hazard mitigation staff at the Department of Emergency Services and Public Protection (DESPP), Division of Emergency Management and Homeland Security, and the Department of Energy and Environmental Protection (DEEP), with the assistance of Dewberry's consulting team. The Connecticut State Hazard Mitigation Planning Team (SHMPT) and a large group of stakeholders that include Connecticut state agencies, Federal government collaborators, non-governmental organizations (NGOs), and local representation attended four plan development meetings and provided comments on the plan draft. Staff from FEMA Region I provided a plan review. Public participation for the update of the Plan was primarily enabled through participation in an internet-based survey and posting of the Draft 2018 Connecticut State Hazard Mitigation Plan Update to DEMHS's website.

1.2 Natural Hazard Identification and Risk Assessment

The SHMPT identified natural hazards that threaten Connecticut and ranked them according to the relative extent of risk they pose to the lives and property of the state's residents and its economy. Vulnerability assessments and loss estimations, which are based on the history of occurrences and exposure, were developed to present an understanding of the potential impacts to the State from natural hazard events. Across all counties, winter weather and thunderstorms are notably higher risk hazards, with tornado, flood, and tropical cyclone having a slightly lower, but still significant risk. Dam failure and wildland fire have particularly low risk across all counties. The impacts of climate change on the frequency and severity of each hazard were considered in each individual hazard section.

1.3 Population

To fully understand the risks and potential impacts of natural hazard events, it is pertinent to understand the assets including facilities and population within the State that may be at risk. Section 2.2.2 presents a summary of Connecticut's demographics. The total state population estimate for 2017 was 3,588,184[1] people. Fairfield, Hartford, and New Haven have the greatest density of people per square mile. Two-thirds of the State's population and housing units are within Fairfield, Hartford, and New Haven Counties.

1.4 Facilities

The Connecticut Office of Policy and Management (OPM) provided available data on critical and state facilities. The assessed values for the buildings were derived from the JESTIR database. There are more than 3,300 state-owned facilities, valued at over $5.6 billion. Hartford contains over 26% of the structures. There are more than 1,940 identified critical facilities listed in data files including law enforcement, fire stations, emergency management services (EMS), health departments, correctional facilities, nuclear power plants, gas stations with generators, petroleum, oil, and lubricant infrastructure, storage facilities, farms, and water pollution control facilities (WPCFs). Fire stations account for 31% of the structures within the critical facilities dataset, followed by EMS (26%), and municipal solid waste (14%). The number and value of state and critical facilities differed from the 2013 plan update due to data constraints, which is further explained in Section 2.2.3 of the Natural Hazard Identification and Risk Assessment.

1.5 Land Use and Development

Existing and planned land use patterns greatly influence a community's hazard vulnerability. Future land use decisions should be informed by a community's potential hazards and vulnerability, directing development toward areas that are least vulnerable, creating a more disaster-resistant environment. Section 2.2.4 summarizes the current land use and development trends within Connecticut. The Center for Land Use Education and Research (CLEAR) at the University of Connecticut provides information, education, and assistance to land use decision makers to support balancing growth and natural resource protection. CLEAR provided a Statewide Land Cover map from 2015, which presents 12 different land cover types across categories, such as developed land, forests, and grass. Over the last 30 years, developed land has increased over 3% throughout the state, and the turf and grass cover type has increased 1.6%, while deciduous and coniferous forests collectively have decreased by 3.9%. Connecticut has also lost almost 60 square miles, or 1.3%, of agricultural fields. A significant amount of the development occurred along the shoreline, which is vulnerable to storm surge and flooding. Development also occurred along Route 91 in the center of the state and within denser municipalities. The pace of development slowed dramatically during years 2007-2011 as a consequence of the economic downturn. Building

[1] Census.gov QuickFacts Connecticut (10/2018)

permits have increased since the recession, but have remained far below the height of development in 2006, and permits took a significant dip in 2016 and 2017.

1.6 Climate Change

Climate change is both a present threat and a slow-onset disaster. It acts as an amplifier of existing hazards. Extreme weather events have become more frequent over the past 40 to 50 years, and this trend is projected to continue. Rising sea levels, coupled with potentially higher hurricane wind speeds, rainfall intensity, and storm surges are expected to have a significant impact on coastal communities. More intense heat waves may mean more heat-related illnesses, droughts, and wildfires. This plan update includes discussions of how climate change is and will continue to impact the frequency, intensity, and distribution of specific hazards. Several state-level committees and task forces have been established to address climate change and sea level rise issues. The progress of these groups is outlined in Chapter 3.

1.7 History of Natural Disasters

Since 2010, Connecticut has experienced eight major disaster declarations, while during the decade prior, the state only experienced two major disaster declarations. There have been 21 State disaster declarations and 11 emergency declarations since 1954. These disasters had significant impacts on Connecticut and its residents, such as loss of residences, property and possessions, loss of life and injury, lost wages and business revenue, in addition to psychological and sociological costs to disaster victims and their families. Historically, flooding has caused the most damage to the State and its citizens, along with wind and winter storm disaster events. Section 2.3.1 presents a summary of disaster declarations in Connecticut.

Section 2.3.2 details the records available within the National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI) database. NOAA has recorded an estimated 5,015 severe weather events for Connecticut in the NCEI storm events database, dating back to 1950. Since the 1950s, $1.8 billion in property losses have been documented in NCEI. The majority of the documented damage is attributed to tornados, specifically in Hartford and New Haven counties. Thunderstorms represent 54% of the events within the database, followed by winter weather (22%) and flood (18%). Litchfield has experienced the most events for the categories of thunderstorms and winter weather. Fairfield has experienced the most flood events, with New Haven closely behind. No losses have been recorded for drought.

1.8 Review of Local Hazard Mitigation Plans

In the preparation of this plan update, 153 local hazard mitigation plans covering 173 communities were reviewed for three components: (1) identified hazards, (2) estimated potential losses, and (3) land use and development trends. Estimations of potential losses were highly variable among the local plans. The majority of plans provided loss estimates based on historical damages from flooding, wind, or earthquake events. Table 0-1 summarizes the results.

Table 0-1 Local Plan Annualized Loss Estimates by Hazard Type

Hazard	Average	Number of Plans with Loss Estimates
Coastal	$470,120	7
Riverine	$118,742	16
Drought	$2,400	1
Dam Fail	$3,550	3
Earthquake	N/A	0
Hailstorm	N/A	0
Hurricane	N/A	0
Thunderstorm	$7,512	42
Wildfire	$8,699	13
Wind	$57,250	10
Winter Storm	$544,707	83
Tornado	$1,612	23

A review of land use from the local hazard mitigation plans presents a closer look at where development is occurring across the state. Although Tolland and Windham Counties have largely remained rural, many of the other counties have experienced development recently, and this trend is expected to continue. Many communities in Fairfield County are projecting that growth will occur near Metro-North stations, including Darien, Greenwich, New Canaan, Norwalk, Stamford, Weston, and Westport. Many towns are limiting development in natural hazard areas (such as coastal areas), but some communities have indicated that growth has been directed to former industrial areas that are located within the coastal flood hazard area.

1.9 Public Input

Public participation and input was gathered though an internet-based survey. Survey questions were related to hazard identification and recent hazards events. In all, 41 people responded to the survey; 14 of those responded as representatives of municipal departments, 1 as a representative of a state agency, and 1 as a representative of a conservation association. The other 20 respondents were members of the public who are residents of the State. Several important messages were provided by the survey responders.

Respondents were asked to rate their concerns regarding different natural hazards as low, moderate, or high. A weighted average of these results revealed that the top four hazards that respondents were the most concerned with were (1) winter storms and blizzards, (2) hurricanes and tropical storms, (3) severe thunderstorms, and (4) climate change. Climate

Change was a top concern, despite the fact that few respondents felt that they had already been impacted by it.
Respondents were asked about the most important things that the state can do to help communities prepare for a disaster. The top two responses were:

- Provide technical assistance to residents, businesses, and organizations to help them reduce losses from hazards and disasters; and
- Help improve warning and response systems to improve disaster management.

Further details and analysis from the public survey are provided in Section 1.10.1 of this plan. The public input was integrated into the development of state mitigation activities as presented in Chapter 5.

1.10 Hazard Analysis and Ranking

A detailed hazard ranking methodology is presented in Section 2.7.1. This process incorporated data on population density, building permits, annualized events, annualized damages, injuries and/or deaths from previous events, level of hazard concern, local plan hazard ranking, geographic extent, and critical infrastructure.

Sections 2.9 through 2.28 contain descriptions of each type of natural hazard that threatens Connecticut. Hazard descriptions include general information, past history, future risk and vulnerability. Supplemental information on past events and analysis is provided in Appendix 2.

The hazards determined to have a significant impact on the population and built environment of Connecticut are:

- Dam Failure
- Drought
- Earthquake
- Flood-Related Hazards
- Sea Level Rise
- Thunderstorm-Related Hazards
- Tornado
- Tropical Cyclone (Hurricane and Tropical Storm)
- Wildland Fire
- Winter Weather

Figure 0-1 depicts the results of the risk analysis. The composite ranking, as shown, provides a tool for the State of Connecticut to prioritize appropriate mitigation actions within each county.

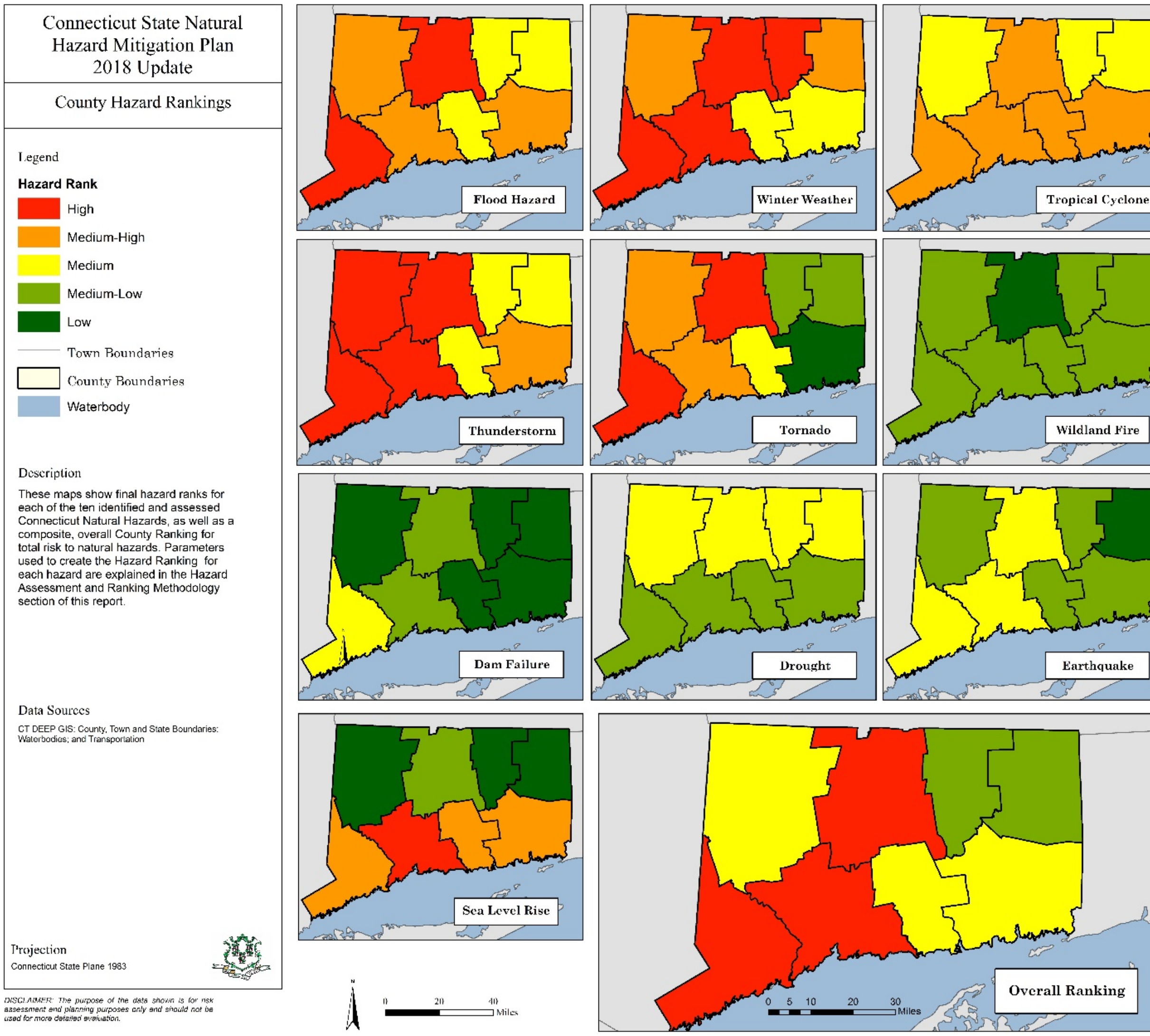

Figure 0-1: Composite County Hazard Ranking

1.11 Potential Losses and Anticipated Impacts

Based on information from the NCEI database, Connecticut has experienced over $1.7 billion in property damages from the hazards profiled in this plan. Tornado events have been responsible for the majority of property damages, with over $1.6 billion in damages. Thunderstorm events were recorded the most frequently in the NCEI database for Connecticut. Litchfield County experienced the highest number of storm events, while Hartford and New Haven Counties experienced the highest property damages.

1.12 Capability Assessment

The State and local governments offer many policies, programs, and capabilities to support the implementation of mitigation actions. Chapter 3 presents in detail the role of federal, state, and local agencies in assisting with mitigation and risk reduction activities across the State. This chapter outlines pertinent executive orders, programs, and policies, at all levels of government, that support the State's mitigation strategy. It also acknowledges capabilities available through utility providers, the University of Connecticut, The Nature Conservancy, Citizen Volunteer Organizations, and other non-governmental organizations such as the American Red Cross and the Salvation Army.

Since 2013, two key groups were established to support resilience initiatives in Connecticut and are discussed in further detail below.

State Agencies Fostering Resilience (SAFR) was formed in 2015 as a permanent working group committed to strengthening the state's resiliency to extreme weather events. The SAFR Council is charged with authoring a Statewide Resilience Roadmap using climate impact research, creating state policies that incorporate forward-looking risk analysis, and assisting municipalities in incorporating climate analysis into their coastal resilience plans.

The Connecticut Institute for Resilience and Climate Adaptation (CIRCA) was established as a multi-disciplinary center of excellence that brings together experts in the natural sciences, engineering, economics, political science, finance, and law to provide practical solutions to problems arising as a result of a changing climate. CIRCA runs a research program as well as an external grants program for Connecticut. Further details are included in Chapter 3.

1.13 Local Planning Coordination

Connecticut continues to encourage and facilitate local planning efforts to ensure that local and multi-jurisdiction hazard mitigation plans are in place. Connecticut began assisting communities drafting local hazard mitigation plans in 1997, utilizing Flood Mitigation Assistance (FMA) planning grant funds. The State of Connecticut's current approach is to work with regional planning organizations (RPOs) as frequently as possible to prepare multi-jurisdiction hazard mitigation plans. Chapter 4 presents a summary of the local hazard mitigation planning process.

1.14 Hazard Mitigation Strategy for 2018

During the 2019 plan update process, the State's planning team met on multiple occasions to discuss the goals, objectives, strategies, and activities required to minimize the identified natural hazard risks. Chapter 5 presents the detailed mitigation strategy which is based on the following goals and objectives. The complete mitigation strategy includes specific strategies for each goal as well as prioritized implementable actions.

Goal 1 – Promote implementation of sound floodplain management and other natural hazard mitigation principals on a State and local level.

Objective for Goal 1: To increase general awareness of Connecticut's natural hazards and encourage State agencies, regional entities, local communities, and the general public to be proactive in taking actions to reduce long-term risk to life and property.

Goal 2 – Implementation of effective natural hazard mitigation projects on a State and local level.

Objective for Goal 2: To enhance the ability of State agencies, regional entities, and local communities to reduce or eliminate risks to life and property from natural hazards through cost-effective hazard mitigation projects, including avoidance.

Goal 3 – Increase research and planning activities for the mitigation of natural hazards on a State and local level.

Objective for Goal 3: To increase general awareness of Connecticut's natural hazards and encourage State agencies, local communities, and the general public to be proactive in taking actions to reduce long-term risk to life and property.

1.15 Plan Monitoring, Maintenance, and Revision

A Mitigation Action Tracker spreadsheet was created for tracking implementation of all new and "carry over" mitigation actions. Primary responsibility for plan monitoring and maintenance resides with the SHMO, within DEMHS. Standing, ad-hoc Mitigation Sub-Committees will be convened, surveyed, or engaged periodically as necessary during the 2019–2024 plan implementation cycle.

1.16 CT NHMP Summary

The 2019 Connecticut Natural Hazard Mitigation Plan provides guidance for hazard mitigation activities within the State and has undergone a full revision using the best available data and subject-matter experts for the required update. This plan fulfills the standard state mitigation planning requirements (44 CFR § 201.4).

The SHMPT is committed to a long-term strategy for reducing risks to natural hazards, as shown in the mitigation strategy set forth in this plan. Mitigation actions will reduce risk from natural hazards to citizens, state facilities, and critical facilities. Connecticut is committed to the implementation of the plan through continued involvement of the steering committee. Capabilities of agencies and programs within the state will allow for collaboration, integration of concurrent planning initiatives, and progress on mitigation actions through to the 2024 plan update.

1 Introduction and Planning Process

1.1 Purpose of the Connecticut State Hazard Mitigation Plan Update

The 2019 Connecticut State Hazard Mitigation Plan Update serves as guidance for hazard mitigation for the State of Connecticut. Its vision is supported by three central goals, each with an objective, a set of strategies and associated actions for Connecticut State government, stakeholders, and organizations that will reduce or prevent injury and damages from natural hazards to people, property, infrastructure, and critical state facilities.

Funding for this Plan was provided through a Federal Emergency Management Agency (FEMA) Pre-Disaster Mitigation (PDM) grant, supplemented with Community Development Block Grant – Disaster Recovery (CDBG-DR) funds. The Department of Emergency Services and Public Protection (DESPP) was grantee for this planning grant.

The areas of focus for the updated 2019 Plan are:

- Expand upon and improve the previous hazard identification and risk assessment section of the Plan, including the addition of analysis using updated state owned and critical facility data;
- Expand the Capabilities Assessment to include state government reorganization and the addition of numerous new initiatives;
- Expand the discussion on potential impacts due to climate change with regards to natural hazard mitigation in applicable hazard risk assessment sections;
- Inclusion of updated information within all chapters of the Plan;
- Reassessment of the goals, objectives, and activities presented in the 2014 Plan; and
- Increase State agency and other stakeholder participation and coordination.

1.1.1 Federal Authorities

This plan fulfills the standard state mitigation planning requirements (44 CFR §201.4) of the Disaster Mitigation Act of 2000 (DMA2000; Public Law 106-390, signed into law October 10, 2000). The DMA2000 amends the 1988 Robert T. Stafford Disaster Relief and Emergency Assistance Act, and reinforces the importance of mitigation planning, emphasizing planning for disasters before they occur. Section 322 of the act specifically addresses mitigation planning at state and local levels. New requirements are identified that allow Hazard Mitigation Grant Program (HMGP) funds to be used for mitigation activities and projects for states and localities with Hazard Mitigation Plans approved by November 1, 2004 and updated on a five year cycle. The 2019 Connecticut State Hazard Mitigation Plan Update is a standard plan meeting the requirements for a Standard State Plan detailed in Interim Rule 44 CRF 201.4, published by FEMA February 28, 2004 and subsequently revised. The Standard Plan was first approved by FEMA Region I during late

2004. Connecticut received approval for subsequent updates in late 2007, early 2011 and early 2014.

Meeting the requirements and criteria of Section 322 regulations and rules enables Connecticut to remain qualified for all disaster-related assistance including categories C through G of the Public Assistance (PA) Program. This is an essential component of disaster recovery. In addition, the State will remain eligible for Hazard Mitigation Assistance (HMA) program funds: Hazard Mitigation Grant Program (HMGP), Flood Mitigation Assistance (FMA), Pre-Disaster Mitigation Program (PDM), and Fire Mitigation Assistance Grants (FMAG). The state also participates in the Community Assistance Program – State Support Services Element (CAP-SSSE).

The State of Connecticut is also in compliance with other related Federal authorities including:

- FEMA regulations - 44 CFR, Part 13, Uniform Administrative Requirements of Grants and Cooperative Agreements to State and Local Governments;
- FEMA regulations - 44 CFR, Part 14;
- Executive Order 12612, Federalism;
- Executive Order 11990, Protection of Wetlands;
- Executive Order 11988, Floodplain Management; and
- 44 CFR, Part 201.4 (c) (7) § 13.11 (c) and § 13.11 (d).

The State of Connecticut will continue to comply with all applicable Federal statutes and regulations during periods for which it receives grant funding, in compliance with 44 CFR 13.11(c), and will amend its plan whenever necessary to reflect changes in the State or Federal laws and statutes as required in 44 CFR 13.11(d).

1.1.2 State Authority

The DESPP was established by PA 11-51—HB 6650 Emergency Certification AN ACT IMPLEMENTING THE PROVISIONS OF THE BUDGET CONCERNING THE JUDICIAL BRANCH, CHILD PROTECTION, CRIMINAL JUSTICE, WEIGH STATIONS AND CERTAIN STATE AGENCY CONSOLIDATIONS and given jurisdiction over emergency management previously held by the Department of Emergency Management and the Department of Public Safety. Other related programs and authorities are addressed in detail in Chapter 3.

1.1.3 Disaster Mitigation Act of 2000 and Implementing Regulations

Section 322 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act or the Act), 42 U.S.C. 5165, was enacted under § 104 of the Disaster Mitigation Act of 2000, (DMA 2000) Public Law 106-390. DMA 2000 was intended to facilitate cooperation between state and local authorities. It encourages and rewards local and state disaster planning in advance of disasters in order to promote sustainability of communities and services as a strategy to improve disaster resistance. This pre-disaster plan is intended to support state and local governments' efforts to articulate accurate and prioritized needs for hazard mitigation that will reduce exposure to natural hazards. This planning effort will result in timely allocation of funding and more effective risk reduction strategies and projects.

FEMA prepared an Interim Final Rule, published in the Federal Register on February 26, 2002 within 44 CFR Parts 201 and 206 that establishes planning and funding criteria for states. The Final Rule was published in October, 2009. The Guidance and Standard Plan Crosswalk was revised November 4, 2006 and was further updated to include requirements for 90%-10% Federal funding for the Severe Repetitive Loss (SRL) and Flood Mitigation Assistance (FMA) grant programs in January, 2009. The most recent revision to the guidance for state plans was in March of 2015. The completed Review Tool for the *2019 Connecticut Hazard Mitigation Plan Update* may be found in Appendix 1-1.

1.1.4 44 Code of Federal Regulations Part 201

44 CFR § 201.1 et seq. was promulgated by the Federal Emergency Management Agency, (FEMA) on February 26, 2002 in order to implement DMA 2000. The interim final rule was amended several times to address standard and enhanced state plans during 2007. Revised guidance for local plans was released July 1, 2008 with additional major revisions in 2013. In addition, guidance for the Severe Repetitive Loss and Flood Mitigation Assistance Programs (44 CFR § 201.4 et seq.) requires amendment of state plans per a new review tool for these programs issued on March 9, 2015. The rule addresses state mitigation planning, and specifically in 44 CFR § 201.3 (c) identifies the states' mitigation planning responsibilities, which include:

1. Prepare a Standard State Mitigation Plan following the criteria in §201.4 as a condition of receiving non-emergency Stafford Act assistance and FEMA mitigation grants. The plan may address severe repetitive loss properties in their plan (§201.4 (c)(3)(v)) to receive the reduced cost share for the FMA and severe repetitive loss programs.
2. Review and update the Standard State Mitigation Plan every five years from the date of the approval of the previous plan to continue program eligibility.
3. Make available the use of up to seven (7) percent of HMGP funding for planning in accordance with §206.434.Prepare and submit to FEMA a Standard Hazard Mitigation Plan following criteria established in 44 CFR § 201.4 as a condition of receiving Stafford Act assistance (except emergency assistance).
4. Provide technical assistance and training to local governments to assist them in applying for HMGP planning grants and in developing local mitigation plans.

44 CFR § 201.4, Standard State Mitigation Plans, lists the required elements of state hazard mitigation plans. Under 44 CFR § 201.4 (a), by November 1, 2004 states must have an approved Standard State Hazard Mitigation Plan that meets the requirements of the regulation to receive Stafford Act assistance. The planning process, detailed by 44 CFR § 201.4 (b), must include coordination with other state agencies, appropriate Federal agencies and interested groups. Guidance for state standard and enhanced plans and local and multi-jurisdictional plans has been updated several times to incorporate changes from the Katrina Reform Act, Unified Hazard Mitigation Assistance Grant Programs, and "lessons learned" through the first cycle of state and local mitigation planning. Current state standard plan guidance and the state plan cross walk were used to inform the *2019 Connecticut State Hazard Mitigation Plan Update.*

44 § 201.4 (c), Plan content, identifies the following elements that must be included in a state hazard mitigation plan:

1. Describe the current process used to update the plan, including how other state and federal agencies and other stakeholders were involved in the process in multiple sectors.
2. Prepare a risk assessment that describes natural hazards and makes a connection between vulnerability and proposed hazard mitigation actions, focusing on areas most at risk by evaluating where populations, infrastructure, and critical facilities are vulnerable to hazards; and identifying to what extent injuries or damage may occur. The risk assessment should also consider the probability of future hazard events associated with climate change.
3. Develop mitigation strategies to guide long-term reduction of the potential losses identified in the risk assessment, describe the process of evaluating and prioritizing actions, and identify funding sources.
4. Describe existing State pre- and post-disaster hazard management policies, programs, and capabilities for mitigating hazards, and how the State supports developing local and Tribal mitigation plans.
5. Identify criteria for prioritizing jurisdictions to receive planning and project grants under federal and non-federal programs.
6. Describe the process to keep the plan current through monitoring, evaluating, and updating the plan, as well as the process to monitor implementation of the mitigation strategies.
7. Document how the plan is formally adopted.
8. Include assurances that the State will comply with all applicable Federal statutes and regulations.
9. Develop a strategy to reduce the number of repetitive loss properties, including severe repetitive loss properties. *44 CFR Part 206*

On February 26, 2002, FEMA also changed *44 CFR Part 206* in order to implement DMA 2000 (See 67 Federal Register 8844 [February 26, 2002]). Changes to *44 CFR Part 206* authorize HMGP funds for planning activities and increase the amount of HMGP funds available to states that develop an Enhanced Mitigation Plan. FEMA amended Part 206 in 2006 following the passage of the Katrina Reform Act which restored HMGP funding to 15 percent of eligible disaster recovery costs for states with approved Standard Mitigation Plans.

44 CFR Part 400

(a) As a condition of the receipt of any disaster assistance under the Stafford Act, the applicant shall carry out any repair or construction to be financed with the disaster assistance in accordance with applicable standards of safety, decency, and sanitation and in conformity with applicable codes, specifications and standards.

(b) Applicable codes, specifications, and standards shall include any disaster resistant building code that meets the minimum requirements of the National Flood Insurance Program (NFIP) as well as being substantially equivalent to the recommended provisions of the National Earthquake Hazards Reduction Program (NEHRP). In addition, the applicant shall comply with any requirements necessary in regard to Executive Order 11988, Floodplain Management, Executive Order 12699, Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction, and any other applicable Executive orders.

(c) In situations where there are no locally applicable standards of safety, decency and sanitation, or where there are no applicable local codes, specifications and standards governing repair or construction activities, or where the Regional Administrator determines that otherwise applicable codes, specifications, and standards are inadequate, then the Regional Administrator may, after consultation with appropriate State and local officials, require the use of nationally applicable codes, specifications, and standards, as well as safe land use and construction practices in the course of repair or construction activities.

(d) The mitigation planning process that is mandated by section 322 of the Stafford Act and 44 CFR part 201 can assist State and local governments in determining where codes, specifications, and standards are inadequate, and may need to be upgraded

1.2 Assurances and Adoption

Placeholder for Assurances and Adoption Letter

1.3 Planning Team

This plan was completed with planning assistance and support by the hazard mitigation staff at the Department of Emergency Services and Public Protection (DESPP), Division of Emergency Management and Homeland Security (DEMHS) and the Department of Energy and Environmental Protection (DEEP). Consulting support was provided by Dewberry Engineers Inc. and its subcontractors. The Connecticut State Hazard Mitigation Planning Team (SHMPT) and a large group of stakeholders that included Connecticut state agencies, Federal government collaborators, non-governmental organizations, and local representation attended plan development meetings and provided comments on the plan draft. Staff from FEMA Region I provided additional technical assistance and plan review.

1.4 Overview of Plan

For the 2019 update, each chapter was reviewed and reinvigorated to highlight progress since the 2014 plan adoption. Some chapters of the plan were restructured for efficiency. All of the chapters had new data integrated and the overall plan was organized to better meet the needs of the state.

Each chapter begins with a brief introduction followed by relevant information, charts, tables, and maps, which fulfill regulation requirements. The main chapters of the plan follow primary requirements of the hazard mitigation planning law:

Chapter 1.0 *Introduction and Planning Process* describes the background and authorities governing the update of the plan, activities and work of the Connecticut DESPP/ DEMHS, DEEP, SHMPT, stakeholders invited to participate in the process, the primary consultant, Dewberry, and two sub-contractors, Tetra Tech and Milone & MacBroom, Inc. The plan participants, planning process, planning products, and relevance to other related plans or state functions are described within this chapter as well.

Chapter 2.0 *Natural Hazard Identification and Risk Assessment* has three primary components. A description of Connecticut is provided that includes: Identification, Risk Assessment, and Vulnerability Analysis, with the impacts of climate change discussed where appropriate. Natural hazards affecting the state are identified, including:

- Descriptions and histories of hazards;
- Assessment of geographic extent and risk of hazards;
- Hazard specific loss estimation for state facilities, where appropriate; and
- Amplifiers, including sea level rise and climate change.

During the early formation of the 2019 plan update process it was decided to continue to focus only on natural hazards. These were condensed into fewer categories to enable use of best available data. Ice jams, removed in the 2014 plan, were added under the flood hazard section based on recent events.

The new vulnerability assessment was initiated in October 2017 with the objective of gathering and incorporating, where usable, data from local and regional plan Hazard Identification and Risk Assessments (HIRAs). The current regional and municipal plans were analyzed and hazard rankings were captured. These were used in the state plan hazard ranking formula. Hazard information from the local plans was archived using an updated tracking spreadsheet. This tracker can be maintained as local plans are updated to facilitate the future update of the 2019 Connecticut State Plan.

The new plan HIRA and associated vulnerability analysis now provides a more comprehensive look at natural hazards challenging Connecticut's people, property, critical facilities, and natural resources. Where data allowed, hazards were ranked comparatively on a county basis using algorithm-based evaluation methods using parameters such as population, population projections, building permit, hazard occurrence, probability, and local hazard mitigation plan scores. Where data was insufficient to provide a formula-based analysis, a detailed hazard description is provided and the hazard is characterized geographically, to the extent practicable. Data gaps are listed, along with strategies to continue to develop analytical data sets for the hazards that require a more analytical analysis.

Chapter 3.0 *Capability Assessment* combines the previous Capability Assessment and Mitigation Programs Chapters into one. This chapter emphasizes the changes in State government agency organization in Connecticut and significantly expands on the capabilities and initiatives that have resulted from government reorganization and increased focus on drought and climate adaptation. There is also emphasis in this chapter on programs available for technical assistance and funding of mitigation actions. It is expanded to include non-state and local programs that also influence mitigation in Connecticut.

Chapter 4.0 *Coordination with Local Mitigation Planning Efforts* describes a comprehensive five-year process to engage all Connecticut communities in hazard mitigation planning. It summarizes the status of plans in Connecticut, projects that have been implemented or funded by FEMA grant programs, and the process by which the State of Connecticut provides financial and technical assistance for local planning, as well as its review and approval process. A summary of vulnerability identified from rolling up the local plans is provided. Details on vulnerability data derived from the local plans is discussed in Chapter 2.

Chapter 5.0 *Hazard Mitigation Strategy* presents the mitigation goals, objectives, strategies, and associated actions identified to reduce the risk from hazards across the state. The section presents the program strategies and projects with complete rankings for importance to reduce exposure to hazards, along with an analysis of their feasibility using the STAPLE/E criteria. The table of identified actions further includes project leads, cost estimates and other information. A complete listing of evaluated 2014 actions is also presented. The evaluation includes the status of the 2014 actions with explanations on progress. Many actions that were determined to be ongoing capabilities or standard operating activities were moved to Chapter 3 – Capability Assessment. Emphasis was placed on diversifying the actions to meet changing vulnerabilities and on expanding the entities involved in "owning" actions to a more diverse range of state agencies and others. A plan to address Repetitive and Severe Repetitive Loss properties is included in Chapter 2.0 with related strategies included in Chapter 5.0.

Chapter 6.0 *Plan Monitoring, Maintenance, and Revision* outlines implementation of the plan and development of the anticipated 2024 plan revision. Processes used to maintain and update data and information contained in the hazard identification and vulnerability assessment are described, as are implementation progress review and reporting techniques. This chapter details progress reviews and provides a detailed schedule for monitoring maintenance, implementation, and revision.

Appendices are found immediately following the plan. These provide detailed listings and agendas from each plan update meeting that was held, new MS Excel tracking tools, results from the surveys and other outreach, and other relevant documents supporting the plan or its production.

1.5 Planning Process

As noted in Section 1.3, the 2019 Connecticut State Hazard Mitigation Plan Update was conducted through a process which involved a review of the Plan by the staff of the Department of Emergency Services and Public Protection (DESPP), Division of Emergency Management and Homeland Security (DEMHS) and the Department of Energy and Environmental Protection (DEEP), and Dewberry, its consultant. Additionally, revisions to the Plan were made based upon the updated 2019 hazard analysis which was created based on new data and processes, as well as the results of the analysis of local mitigation plans. The process was also informed by the 2014 FEMA review crosswalk and with the input of a more inclusive planning team.

1.6 Overview of the Planning Process

The planning process for the 2019 Connecticut State Hazard Mitigation Plan Update was initiated by the Connecticut DESPP/DEMHS and DEEP and supported by Dewberry, and two subcontractors, Tetra Tech and Milone & MacBroom, Inc., who provided capacity and technical support to the State Mitigation staff.

The contractor and DESPP Core Planning Team concurred upon the following strategy to update review of the plan:

1. Three meetings of the SHMPT and additional stakeholders would be conducted at DESPP Headquarters at pre-identified monthly intervals to maximize team time, through completion of the first review draft;
2. Update of the HIRA and Vulnerability Analysis was a priority. All available data sets, including the National Centers for Environmental Information, would be used;
3. All reasonable attempts would be made to incorporate improved state and critical facility data;
4. Stakeholder diversification and involvement would be a priority;
5. The local plan upload would continue to include a MS Excel Tool to enable DESPP/DEMHS staff to maintain status as local plans are updated and mitigation actions are completed beyond this plan update; and
6. After posting the draft plan in mid-November 2018, for team, stakeholder and public comment, a late November Final Plan Review meeting would be hosted with the DESPP Core Team in order to receive and discuss comments, prior to producing a revised draft for delivery to FEMA in mid-November 2018.

Many of the planning activities were completed concurrently throughout the winter and spring of 2018. Datasets from Connecticut and national open sources were gathered and databases to support GIS mapping were developed. Continued development of an inventory of state facilities, analysis of the recorded history of damage impacts due to natural hazards, and synthesis of GIS layers for hazards led to the prediction of probability for incurred damages to state facilities from identified natural hazards. The planning process continued to evolve to ensure comprehensive agency responses as data were developed and analyzed.

1.7 Plan Coordination

Table 1-1 identifies the core group that led data collection, coordination, stakeholder facilitation, analysis, and drafting of the plan.

Table 1-1. Plan Core Team Participants.

DESPP/DEMHS Staff Leads
Rita Stewart – Supervisor, Strategic Planning, Community Preparedness, and Grants Unit Gemma Fabris – Emergency Management Program Specialist Ken Dumais – State Hazard Mitigation Officer Brenda Bergeron – DEMHS Legal Counsel and Planning Manager Kris Wohlgemuth - Emergency Management Program Specialist
DEEP Mitigation Staff
Karen Michaels –Hazard Mitigation Planner Diane Ifkovic – State NFIP Coordinator
Dewberry
Scott Choquette – Consultant Project Manager Jessica Fleck – Resilience Planner Katie Murray – Resilience Planner Rachael Herman - HIRA Quality Lead James Mawby - Hazus Lead Jillian Browning – GIS Lead Deborah Mills – Quality Review
Tetra Tech
Cynthia Bianco – HIRA Support
Milone & MacBroom
David Murphy, PE, and Noah Slovin – Local Plan Role-Up, Capability Assessment, Mitigation Strategy Support

1.8 State Hazard Mitigation Planning Team

The SHMPT is a standing committee that advises the Connecticut Hazard Mitigation Program as participants in mitigation plan updates and other ad hoc program and policy issues. The committee members served as the key technical advisors on mitigation program matters during this update. The SHMPT is made up of representatives of key state agencies whose programs and interests are integral to implementation of the state's hazard mitigation program. The Committee met on several occasions to discuss the plan development process and guide the overall update of the 2019 plan document. Nearly every member of the SHMPT attended the meetings and provided data, specific plan section reviews, and other technical support throughout the planning process. The members of the SHMPT are listed in Table 1-2.

Table 1-2. State Hazard Mitigation Planning Team (additional members)

Team Member	Agency
George Bradner	CT Department of Insurance (Chair of Long Term Recovery Committee)
Brian Thompson	CT DEEP – Inland Water Resources - Director
Bruce Sherman	CT Department of Agriculture
Mark DeCaprio	CT DEEP – Emergency Response and Spill Prevention
Douglas Royalty	CT Department of Economic and Community Development – State Historic Preservation Office
Mike Miszynski	CT Conference of Municipalities
Betsy Gara	CT Council of Small Towns
Gemma Fabris	CT DESPP-DEMHS
Chris Martin	CT DEEP – Forestry
Petty Diaz	CT DEEP - Energy
Chris Brochu	CT DOT
Eugene Livshits	South Central CT Council of Governments
Francesca Provenzano	CT Department of Public Health – Water Bureau
John Field	CT DESPP – Field Coordinator
Douglas Glowacki	CT DESPP-DEMHS
Diane Ifkovic	DEEP - Inland Water Resources –NFIP State Coordinator
Henry Paszczuk	CT DESPP/DEMHS
Rebecca French	CT Department of Housing – Director of NDR and Rebuild by Design (Formerly CIRCA/UCONN)
David Kooris	CT Department of Economic and Community Development – Deputy Commissioner Yale University – Lecturer State Agencies for Resilience - Lead
Jeff Caiola	DEEP – Resilience and Climate Change
Peter Francis	DEEP – Water Protection and Land Reuse
Rebecca Cutler	CT DAS – Construction Services
Eric Lindquist	CT OPM
Jeff Semancik	DEEP – Radiation Control
Margaret Thomas	DEEP – Connecticut State Geologist
Jack Betkoski	Public Utility Regulatory Authority and Water Planning Council
James O'Donnell	UCONN / Connecticut Institute for Resilience and Climate Adaptation (CIRCA)

An extensive list of stakeholders was invited to each of the three working sessions. Those who came to meetings and participated in the process are included in Table 1-3.

Table 1-3. Participating Stakeholders

Participating Stakeholders	Organization
William Kenny	WestCOG
Joanna Wozniak Brown	NortheastCOG
Patrick Carleton	MetroCOG
Eugene Livshits	South Central Region COG
Lynne Pike DeSanto	Capital Region COG
Bill Richards	City of Milford
Laurie Whitten	Town of East Windsor and Region 3 Long Term Recovery
Michael Licata	Town of Windham EMD
Samuel DeBurra Jr.	Town of Madison
Marty Connor	City of Torrington
James McLoughlin	Town of Coventry
Jubenal "Jay" Gonzalez	Town of South Windsor
Neil Brockway	American Red Cross
Phyllis Detwiler	American Red Cross
Mark Fangiullo	Eversource
Brian Balukonis	Silver Jackets – USACE New England Division
Kathleen Knight	CT DEEP – Air
David Kallander	CT DPH
Susan Quincy	CT DEEP – State Parks
Kiernan Wholean	CT DEEP – Air
Roberto Fernando	CT DOT
Michael Hage	CT DPH
Binu Chandy	CT DECD
Michael Barnett	CT DECD
Eric Scoville	DESPP/DEMHS
Connie Mendolia	CT DEEP – Pollution Prevention
Lisa Park Boush	University of Connecticut
Bill Perkins	Capital Region COG
Doug Dalena	Governor's General Council
Bill Hackett	DEMHS
Matt Fulda	Metro COG

1.9 Stakeholder Involvement and Meetings

The involvement of a large array of stakeholders during the planning process was considered a vital element to the success in developing a FEMA-compliant plan. Traditional agency stakeholders were sought from state and federal agencies and local jurisdictions across the state. These stakeholders provided critical input to each step in the plan update process. They shared inventories of state facilities, database layers identifying risk to structures from various hazards, and participated in the refinement of the 2014 mitigation goal and development of 2019 mitigation actions.

Stakeholders participated in all of these meetings at DEEP headquarters, with more than 35 people involved in the kick-off meeting, during this five month planning process. These meetings provided a forum for discussion on hazard identification and assessment methods for a variety of hazards, and the refinement and development of the plan goals and strategies. Please refer to Appendix 1-2 for documentation on all of the Committee Meetings.

The following is a synopsis of the planning process meetings:

1.9.1 Preliminary Project Management Meeting

September 17, 2017

The Core Team held a kick-off meeting at DESPP/DEMHS headquarters. At the meeting time was spent establishing the composition of the Core Team, State Hazard Mitigation Planning Team and Participating Stakeholders. The overall schedule was reviewed and revised and tentative dates were established for the team meetings. A working session was held to discuss anticipated major changes to include in the plan update, including the core hazards, increased emphasis on climate change and adaptation, and changes in and availability of datasets.

1.9.2 SHMPT Project Kick-off Meeting

October 31, 2017

The kick-off meeting of the SHMPT and Stakeholders was hosted by the DEEP. At the kick-off meeting, the requirements of Section 322 of the 2000 Stafford Act were presented along with the project schedule, schedule of meetings, proposed HIRA methodologies and a review of the 2014 plan goals and objectives. Data collection needs were presented and participants were provided with worksheets designed to collect information on available data, capabilities, new initiatives and potential projects and actions. Previously identified hazards were discussed in consideration of disaster activity since the last plan and all natural hazards were reprioritized and grouped into categories.

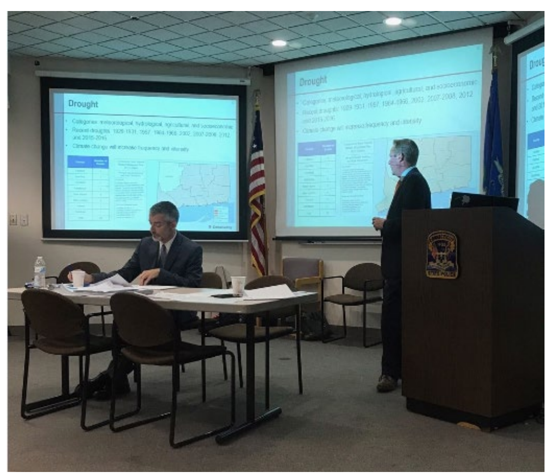

Figure 1-1: Kick-Off Meeting Overview Presentation

Additional tools and templates were also presented and ranking formulas were confirmed so that the weighting algorithm could be finalized to hasten the hazard ranking process. Additional topics covered during the meeting included:

- FEMA state hazard mitigation plan update rule requirements
- HIRA and Vulnerability Analysis update
- Data needs
- Confirmation of hazards to profile
- Ranking protocols
- Map templates
- Climate change and sea level rise
- Organization of HMA grant data, MS Excel workbooks, and tools
- Outreach Methods – website, public survey, regional outreach open houses
- Communication, next steps

1.9.3 HIRA Progress/Capability Assessment/Local Plan Roll-Up Presentation and Goals and Strategies Development Meeting

May 9, 2018

Preliminary progress on the Hazard Identification, Risk Assessment (HIRA) and resultant Vulnerability Analysis was presented along with final data needs. The results of the local plan analysis and roll-up were also presented. Following these presentations, the goals, objectives and strategies were revisited in the context of the results of the local plan analysis. The second half of the meeting focused on the initial definition of mitigation actions in breakout groups arranged by departments.

Figure 1-2: Stakeholder Meeting No. 2

Each breakout group was led by an experienced mitigation planner, either from DEEP, DESPP/DEMHS, or the consulting team. These individuals facilitated and recorded the group as they began to develop mitigation actions to address the natural hazard vulnerabilities presented at the meeting.

1.9.4 Draft Plan Review and Mitigation Action Development Workshop Meeting

October 26, 2018

A two hour working session was conducted on October 26th, 2018. The draft plan was presented to the SHMPT and stakeholders, with an emphasis on significant changes made since the 2014 plan update. Review of the disposition of actions identified in the 2014 plan was conducted, and new actions further developed in light of the HIRA and Capability Assessment results. A ranking of mitigation actions that were identified at the previous meeting and subsequent to the meeting was completed using the STAPLE/E methodology outlined in Chapter 5. The results of the ranking are included in Appendix 5-2. Table 1-4 shows the STAPLE/E criteria used in the ranking.

Table 1-4. STAPLE/E Review and Selection Criteria for Alternatives

Social
• Is the proposed action socially acceptable? • Are there equity issues involved that would mean that one segment of a community is treated unfairly? • Will the action cause social disruption?
Technical
• Will the proposed action work? • Will it create more problems than it solves? • Does it solve a problem or only a symptom? • Is it the most useful action in light of other community(s) goals?
Administrative
• Can the community(ies) implement the action? • Is there someone to coordinate and lead the effort? • Is there sufficient funding, staff, and technical support available? • Are there ongoing administrative requirements that need to be met?
Political
• Is the action politically acceptable? • Is there public support both to implement and to maintain the project?
Legal
• Is the community(ies) authorized to implement the proposed action? Is there a clear legal basis or precedent for this activity? • Are there legal side effects? Could the activity be construed as a taking? • Is the proposed action allowed by a comprehensive plan, or must a comprehensive plan be amended to allow the proposed action? • Will the community(ies) be liable for action or lack of action? • Will the activity be challenged?
Economic
• What are the costs and benefits of this action? • Do the benefits exceed the costs? • Are initial, maintenance, and administrative costs taken into account? • Has funding been secured for the proposed action? If not, what are the potential funding sources (public, non-profit, and private)? • How will this action affect the fiscal capability of the community(ies)? • What burden will this action place on the tax base or local economy? • What are the budget and revenue effects of this activity? • Does the action contribute to other community goals, such as capital improvements or economic development? • What benefits will the action provide?
Environmental
• How will the action affect the environment? • Will the action need environmental regulatory approvals? • Will it meet local and State regulatory requirements? • Are endangered or threatened species likely to be affected?

Comments on the draft plan were received from the following individuals and entities and incorporated into the plan between _______, 2018 and ______, 2018:

- *List names and titles of people who provide comments*

1.9.5 Additional Stakeholder Input Points

Throughout the planning process there were briefings and other input points for stakeholders. They are outlined below:

October 27, 2017 – DESPP/DEMHS Regional Coordination Meeting

Regional Emergency Planning Teams, (REPT) are formal boards that operates under the jurisdiction of the Department of Emergency Services and Public Protection (DESPP) Division of Emergency Management and Homeland Security (DEMHS). The REPT boards are composed of the Chief Elected Official (CEO) of each of the member towns. Each REPT has a lead and regional collaboration meetings are held quarterly. Emergency Managers and Regional Planners typically staff the REPTS. The United States Geologic Survey (USGS), Councils of Government (COGs), and the State Department of Public Health also participate. At this meeting, Brenda Bergeron of the Core Team provided an update on the mitigation plan update, provided an agenda for the kick off meeting scheduled on October 31st, 2018, and encouraged attendance and participation.

January 11, 2018 - DEMHS Statewide Emergency Management and Homeland Security Advisory Council Meeting

The advisory council was founded in 2014 and operates as the DEMHS advisory board, under Connecticut General Statues (CGS) Section 4-8. The advisory Council's authority also derives from CGS, Titles 28 and 29. Its mission is to protect the people and property in the State from all types of natural and human-made disasters, fostering regional collaboration and mutual aid through research, collaborative plan development, resource and information sharing, and coordination. The composition of the Council includes Commissioners of State agencies, representatives of the Connecticut Conference of Municipalities, Connecticut Council of Small Towns, Regional Planning Organizations, and other local representation. In addition to state and local leaders, Federal agency representatives and non-government organizations are represented.

On the January 11, 2018 meeting of the Council, Brenda Bergeron of the Core Team briefed the Council on the status of the plan update, mitigation grant funding and ongoing projects that were eligible for funding as a result of having an approved plan. Ms. Bergeron encouraged the leaders represented to have active participation in the planning process.

January 26, 2018 – DESPP/DEMHS Regional Coordination Meeting

The make-up of the REPTs and the purposes of these collaboration meetings are described above, under the October of 2017 meeting. At this meeting, Rita Stewart gave a briefing on the plan update, and again encouraged participation in the planning process.

August and September 2018 – FEMA Region I Courtesy Review of the Hazard ID and Risk Assessment Draft.

In August of 2018, a draft of the HIRA Chapter was provided to FEMA Region I to conduct a courtesy review. Most comments received are included in this draft.

1.10 Public Outreach

Public participation for the update of the Plan was primarily enabled through participation in an internet-based survey and posting of the Draft 2019 Connecticut State Hazard Mitigation Plan Update to DEMHS's main webpage. Distribution of the online survey is discussed in the subsection below.

1.10.1 Online Public Survey

For the 2018 plan update, a survey was developed to solicit input from the public on local mitigation activities and strategies. The survey was opened and posted online in May 2018 and closed in July 2018. Links to the survey were available on the CT DEEP website, shared at public workshops, and publicized in local news outlets. Paper survey forms were also brought to workshops. Survey answers were reviewed for consideration in updating all sections of the plan, in particular the challenges and strategies sections.

In all, 41 people responded to the survey; 14 of those responded as representatives of municipal departments, 1 as a representative of a state agency, and 1 as a representative of a conservation association (Connecticut Forest & Park Association). The other 20 respondents were members of the public who are residents of the State.

The survey asked about natural hazard and hazard mitigation awareness. About one third (34%) of respondents (11 individuals) were not aware of the statewide Hazard Mitigation Plan prior to taking the survey, while 44% (14 individuals) were not sure whether their own community had a Hazard Mitigation Plan. Regarding natural hazard events 30 respondents noted specific recent events that had made them more aware of the danger of natural hazards. The most frequently cited event was Superstorm Sandy in October 2012 (23 people selecting), followed by the severe storms in May 2018 (20 selecting), Tropical Storm Irene in August 2011 (19 selecting), and Winter Storm Alfred in October 2011 (18 selecting).

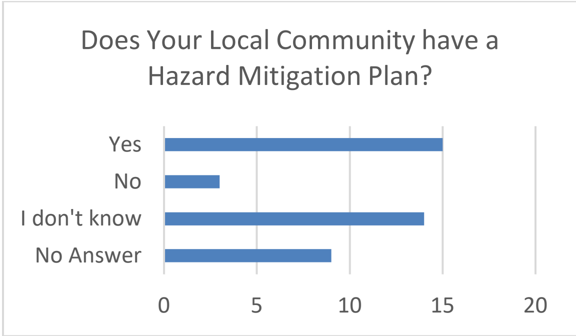

Figure 1-3: Awareness of Local Hazard Mitigation Plans

Respondents were asked to rate their concern about different natural hazards as low, moderate, or high. Taking a "weighted average" of the results yields a prioritized list of hazard concerns in the state.

Table 1-5: Natural Hazards Impacting Homes and Businesses

Natural Hazard	Respondent Level of Concern (Weighted, max is 3.0)	Historically Impacted Respondent
Winter Storms & Blizzards	2.55	22
Hurricanes & Tropical Storms	2.42	21
Severe Thunderstorms (including hail, lightning)	2.26	16
Climate Change	2.03	5
Flooding	1.84	13
Tornadoes / Downbursts	1.81	16
Drought & Severe Heat	1.77	7
Dam Failure (may be caused by other hazards)	1.61	0
Erosion & Shoreline Change	1.61	2
Sea Level Rise	1.55	4
Wildfires	1.33	1
Earthquakes	1.26	0
Wildfires & Brush Fires	1.26	2
Ice Jams	1.26	1
Landslides	1.10	0
Sinkholes or Subsidence	1.07	0

Winter storms, hurricanes and tropical storms, severe thunderstorms, climate change, flooding, and tornadoes/downbursts are the top concerns for survey respondents. Climate change is a top concern despite the fact that few respondents feel they have already been impacted by it.

Respondents were asked to identify specific locations of hazard concern. Responses are summarized Table 1-6, Table 1-7, and Table 1-8, below.

Table 1-6: Specific Locations of Hazard Concern

Community	Total Number of Mentions	Specific Hazard Mentions			
		Coastal Flood	Inland Flood	Dam Failure	Other Storm
Milford	4	4	0	0	0
Westbrook	4	4	0	0	0
Vernon	3	0	0	0	0
Westbrook	2	2	0	0	0
Stratford	2	1	1	0	0
Canton	2	0	2	0	0
East Haddam	2	0	1	1	0
Madison	2	2	0	0	0
Easton CT	2	0	0	1	1
Brookfield	1	0	0	0	0
Meriden	1	0	1	0	0
Seymour	1	0	0	1	0
Granby	1	0	1	0	0
TOTAL*	**27**	**15**	**6**	**4**	**1**

* Total row includes answers that cite a specific hazard but not a specific community, and therefore figures may be larger than the sum of the community-specific mentions.

Table 1-7: Flood Sources for Noted At-Risk Areas

(Note: flood sources were not usually explicitly mentioned but were inferred for this table)

Flood Source	Total Number of Locations
Coastal	15
Housatonic River	3
Connecticut River	3
Farmington River	2
Unspecified	8

Table 1-8: Hazards Mentioned for At-Risk Areas
(Note: hazard type was not always explicitly mentioned but was inferred, when possible, for this table)

Hazard	Total Number of Locations
Coastal Flood	15
Inland Flood	6
Dam Failure	4
Ice Jam Flooding	1
Other Storm	1

Respondents tended to be very aware of coastal and inland flood hazard locations.

The survey asked about different methods for receiving alerts and information about natural hazards, and whether respondents use each method "never," "occasionally," "frequently," or "always." Taking a "weighted average" of the results yields a list of communication methods in the state ranked in order of most used to least used. Respondents were also asked about preferred methods of communication moving forward.

Table 1-9: Methods of Communication, In Order from Most- to Least-Used

Communication Measure	Historic Likelihood of Use (Weighted, max is 3.0)	Preference (number selecting)
Automated Phone Call	2.84	20
Television	2.71	14
Text Message	2.50	24
Radio	2.38	8
Municipal or State Website	2.31	9
Smartphone App	2.07	5
Facebook	1.97	4
Electronic Road Signs	1.76	4
Twitter	1.64	2
Neighbors	1.59	1
Emergency Alert Sirens	1.53	4
Other Social Media	1.46	2
Door-to-door Visits by Officials	1.11	2

These results indicate that the methods of contacting residents with hazard information that were historically most successful were automated phone calls, televised announcements, text messages, and radio broadcasts. Moving forward, the preferred methods of receiving information are text messages, followed by automated phone calls and television.

Respondents were asked about the most important things that the state can do to help communities prepare for a disaster. Answers are summarized below:

Table 1-10: Most important things the State can do to help communities be prepared for a disaster, and become more resilient over time

State Action	Number Selecting
Provide technical assistance to residents, businesses, and organizations to help them reduce losses from hazards and disasters	19
Help improve warning and response systems to improve disaster management	18
Provide outreach and education to residents, businesses, and organizations to help them understand risks and be prepared	16
Make it easier for residents, businesses, and organizations to take their own actions to become more resilient to disasters	15
Make it easier for communities to provide this education and technical assistance	14

Other actions suggested by respondents included:

- Microgrids
- Mandate training for elected officials and department heads
- Bury electrical wires
- Educate consumers
- Assist with tree removal
- Install tornado sirens

The survey asked about actions that local communities can take to help residents prepare for a disaster. Answers are summarized below:

Table 1-11: Most important things each Community can do to help residents be prepared for a disaster, and become more resilient over time

State Action	Number Selecting
Provide outreach and education to residents, businesses, and organizations to help them understand risks and be prepared	20
Make it easier for residents, businesses, and organizations to take their own actions to mitigate for hazards and become more resilient to disasters	13
Conduct projects in the community, such as drainage and flood control projects, to mitigate for hazards and minimize impacts from disasters	12
Improve warning and response systems to improve disaster management	12
Provide technical assistance to residents, businesses, and organizations to help them reduce losses from hazards and disasters	11
Enact and enforce regulations, codes, and ordinances such as zoning regulations and building codes	9

The survey asked about actions individuals have taken to reduce the risk to or vulnerabilities of their families, homes, or businesses. Responses are summarized below.

Table 1-12: Individual Risk Reduction Actions

Action	Number Selecting
Maintain a disaster supply kit for my family, home, or business	14
Developed a disaster plan for my family, home, or business	13
Taken measures to reduce snow build-up on roofs	8
Cut back or removed vegetation from my overhead utility lines or roof	8
I have not taken any of these actions	6
Managed vegetation to reduce risk of wildfire reaching my home or business	5
Installed storm shutters or structural/roof braces to reduce wind damage	2
Elevated my home or business to reduce flood damage	1
Floodproofed my business to reduce flood damage	1
Replaced my overhead utility lines with underground lines	1

The most common activities are maintaining disaster kits, developing disaster plans, reducing snow build-up on roofs, and managing vegetation. One respondents listed purchasing flood and earthquake insurance. In the final two questions of the survey, respondents were asked to describe one action that they would like to see performed by the State to reduce risks from natural hazards, and to provide any other thoughts or comments.

Analysis of the open-ended responses showed that educating both the public and municipal and state staff was the most commonly mentioned action that respondents would like to see. Significant concern over the resilience of the power grid and other utilities was also reflected in the results. Finally, many respondents expressed that the State's goal should be to make residents more self-reliant and resilient following natural disasters, rather than depending on the State and local governments.

1.11 Summary of Other Input

Beginning on ______, 2018, hyperlinks to the draft plan were provided on DEMHS's webpage and an internal post on it intranet page. Figure 1-4 shows a screen shot of the Natural Hazard Mitigation Web Page, inviting public comment on the draft.

Add Figure once posting has been completed

Figure 1-4: DEMHS's Natural Hazard Mitigation Webpage

In addition to comments received from the public as a result of the public survey, and comments received from the SHMPT and larger stakeholder groups, comments were also received and incorporated from:

- *Add additional names and titles once received*

These individuals are also included in the list of Stakeholder providing comments contained in Subsection 1.9.5.

2 Natural Hazard Identification and Risk Assessment

2.1 Introduction

In developing a comprehensive Natural Hazard Mitigation Plan, the first step is to determine what hazards threaten the state and the extent of the risk they pose to the lives and property of the state's residents and its economy. This chapter presents an overview of the hazard identification and risk assessment (HIRA) process. Once identified and analyzed, the hazards were ranked to determine the highest risks to Connecticut. Finally, based on the history of occurrences and exposure, the vulnerability assessment and loss estimates elaborate on potential impacts of the hazards that pose the highest risks.

The hazards impacting Connecticut have been analyzed using geographic information systems (GIS) and available historical information. This allows for comparison between counties of the relative exposures to hazards and sets the groundwork for local hazard mitigation plan updates. It should be noted that hazards in the State Plan are ranked and analyzed in terms of relative risk to local jurisdictions within the state. All the hazards addressed in the plan are only relevant to Connecticut.

2.1.1 HIRA Updates and Changes

As with the previous plan update, the Hazard Mitigation Planning Team (SHMP Team) decided that the results and analysis should be done at a regional scale since 170 current and updated local plans (out of 174 total communities[2]) provide community-specific information. The state plan presents the general findings from the local plan and summarizes them at a county-wide and state-wide level. In addition, the majority of hazard and federal data is only available at the county-level. The 2011 State Plan risk assessment documented that Connecticut is not at risk for landslide, land subsidence, or volcanoes; this observation remains valid so those hazards are not profiled in this update.

To ensure a comprehensive risk assessment, the SHMP Team decided not to disqualify a hazard without at least conducting a preliminary hazard identification and risk assessment. Climate change is addressed in detail in Section 2.4, and in each hazard specific section as a hazard risk amplifier.

In the previous plan, CT DEEP Dam Safety indicated that ice jams had not occurred since 2010 and were subsequently removed as a separate hazard in the HIRA. The project that was completed on the Salmon River aided in the reduction of ice jams on that watercourse. Due to the recent recurrence of Ice jams in both 2015 and 2018, the hazard has been

[2] Connecticut has 169 municipalities; the additional four communities include the two tribal governments and the political subdivisions of Groton and Stonington and Fenwick. Six plans have expired (Shelton, Ansonia, Derby, Seymour, Guilford, and East Haven). Of those, two (Guilford and East Haven) are in the updated SCRCOG HMP which is under review by DEMHS as of May 2018. There is no current plan for the plans to be updated for Shelton, Ansonia, Derby, and Seymour.

included in the Flood portion of the HIRA. Tsunamis have been removed from consideration due to their low probability of occurrence. Appendix 2 includes archived information on tsunamis in Connecticut.

In addition to the HIRA being vital for state and local planning purposes, the Red Cross uses the analysis from the HIRA as the basis for their large scale disaster planning.

Local plans were evaluated to make sure all hazards identified at the local level were included as part of this revision. Chapter 5 describes local plan hazards identification and incorporation of local hazard data into the state mitigation plan hazard analysis.

The Hazard Identification, Risk Assessment and Vulnerability Analysis chapter of the 2019 plan update consolidates, updates, and streamlines content from the previous plan. Sections have been reorganized for ease of review for the reader, including alphabetization of hazards. Chapter content was restructured to address a broad range of emerging hazards, vulnerabilities and risk issues.

In addition, hazard profiles were restructured, and new analyses were performed using updated National Centers for Environmental Information (NCEI) Storm Events data as well as other data sources to capture hazard events that occurred since 2013.

The analysis of state and critical facilities was updated to reflect additional data provided by the State. Estimates and extrapolation of building and content values for numerous counties were replaced with actual values if available.

2.1.2 Data Collection

To update the risk assessment, data was collected from a variety of sources. The assessment began with a thorough review of all the local hazard mitigation plans available in the state. Chapter 5 describes local plan integration into the state plan. While the local plans were a valuable source for qualitative data, additional quantitative data sources were used to determine the jurisdictions most threatened by each hazard. Sources included national databases, published materials, expert interviews, and information from a number of state and federal agencies, as well as university-state partnerships.

To assess the vulnerability of different jurisdictions to each specific hazard, information on damaging hazard events was gathered. This enabled a comparison of the distribution of events between different hazards. In addition, the same data sources were used as appropriate to create hazard profile maps. The primary source of information used to analyze past hazard events and to rank hazards was the NCEI Storm Events database. Hazard data was supplemented with sources such as:

- NOAA National Weather Service weather station data,
- National Oceanic and Atmospheric Administration (NOAA),

- Connecticut Office of Policy and Management (OPM),
- Connecticut Department of Transportation (CTDOT),
- Connecticut Department of Energy & Environmental Data (DEEP), and
- Connecticut Institute for Resilience & Climate Adaptation (CIRCA).

Other hazard-specific sources are described in each hazard section.

Chapter 3 describes programs, policies, and task force/subcommittees which Connecticut can use to support with natural hazard mitigation initiatives and projects.

During 2013, the Connecticut GIS Council was dissolved and the Office of Policy and Management (OPM) became the successor to the GIS Council. OPM is responsible for coordinating, within available appropriations, a GIS capacity for the state, regional planning agencies, municipalities, and others as needed. OPM guides and assists state and local officials involved in transportation, economic development, land use planning, environmental, cultural, and natural resource management, public service delivery, and other areas as necessary. For the 2019 plan update, OPM provided updated critical facilities data and assisted in the building and content value updates to state owned facilities.

2.2 General Description of Connecticut

Connecticut is a "home rule" state where nearly all decisions are made at the municipal level. Planning and implementation of actions to reduce the impacts of hazards must happen locally. As outlined in Chapter 3, the State provides significant guidance and assistance. The SHMP Team made a committee decision during 2012 to complete vulnerability analysis and show results at a county-level for the SHMP. This methodology has been maintained for the 2019 Plan. The Plan is a result of the best available datasets for historical hazards and spatial hazard extents being compiled at the county-level (National datasets).

Connecticut has 169 municipalities, the Mashantucket Pequot and Mohegan tribal governments, and the political subdivisions of Groton and Stonington totaling 173 local political entities. There are 153 regional plans that provide community-specific information related to risk, capabilities, and mitigation strategies. Table 2-1 summarizes the municipalities located within each county, type of local mitigation plan, and expiration date. Connecticut continues to work with local municipalities to update and revise their local mitigation plans and address the gaps in their vulnerability assessments and loss estimates. This state plan presents that general findings from the local plans and summarizes them at a county-wide and state-wide level in each of the hazard specific sub-sections, as well as in Chapter 5. The local mitigation tracking tool is available in Appendix 4. When available, municipality specific data have been provided in this update.

Table 2-1: Status of County and Municipality Local Hazard Mitigation Plans

(MJ= Multi-Jurisdictional, S = Single Jurisdiction)

County	Community or Tribe	Current Regional Planning Organization	2018 HMP Type	FEMA Approval Date	Expiration Date	Status
Fairfield	Bridgeport	MetroCOG	MJ	7/22/2014	7/22/2019	Current
	Easton	MetroCOG	MJ	7/22/2014	7/22/2019	Current
	Fairfield	MetroCOG	MJ	7/22/2014	7/22/2019	Current
	Monroe	MetroCOG	MJ	7/22/2014	7/22/2019	Current
	Stratford	MetroCOG	MJ	7/22/2014	7/22/2019	Current
	Trumbull	MetroCOG	MJ	7/22/2014	7/22/2019	Current
	Bethel	WestCOG	S	1/13/2016	1/13/2021	Current
	Brookfield	WestCOG	S	12/14/2014	12/14/2019	Current
	Danbury	WestCOG	S	3/8/2017	3/8/2022	Current
	New Fairfield	WestCOG	S	1/30/2017	1/30/2022	Current
	Newtown	WestCOG	S	8/7/2015	8/7/2020	Current
	Redding	WestCOG	S	8/6/2015	8/6/2020	Current
	Ridgefield	WestCOG	S	2/2/2016	2/2/2021	Current
	Sherman	WestCOG	S	3/13/2017	3/13/2022	Current
	Darien	WestCOG	MJ	5/12/2016	5/12/2021	Current
	Greenwich	WestCOG	MJ	5/12/2016	5/12/2021	Current
	New Canaan	WestCOG	MJ	5/12/2016	5/12/2021	Current
	Norwalk	WestCOG	MJ	5/12/2016	5/12/2021	Current
	Stamford	WestCOG	MJ	5/12/2016	5/12/2021	Current
	Weston	WestCOG	MJ	5/12/2016	5/12/2021	Current
	Westport	WestCOG	MJ	5/12/2016	5/12/2021	Current
	Wilton	WestCOG	MJ	5/12/2016	5/12/2021	Current
	Shelton	NVCOG	MJ	2/13/2013	2/13/2018	Expired
Hartford	Berlin	CRCOG	MJ	9/13/2016	9/13/2021	Current; Update in progress with CRCOG; anticipated 2018 submittal to DEMHS
	Bristol	NVCOG	MJ	9/13/2016	9/13/2021	Expired
	Burlington	NWHCOG	MJ	9/13/2016	9/13/2021	Current
	New Britain	CRCOG	MJ	9/13/2016	9/13/2021	Current; Update in progress with CRCOG; anticipated 2018 submittal to DEMHS
	Plainville	CRCOG	MJ	9/13/2016	9/13/2021	Current; Update in progress with CRCOG; anticipated 2018 submittal to DEMHS
	Southington	CRCOG	MJ	9/13/2016	9/13/2021	Current; Update in progress with CRCOG; anticipated 2018 submittal to DEMHS
	Avon	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS

	Bloomfield	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	Canton	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	East Granby	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	East Hartford	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	East Windsor	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	Enfield	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	Farmington	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	Glastonbury	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	Granby	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	Hartford	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	Manchester	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	Marlborough	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	Newington	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	Rocky Hill	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	Simsbury	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	South Windsor	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	Suffield	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	West Hartford	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	Wethersfield	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	Windsor	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	Windsor Locks	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	Hartland	NWHCOG	MJ	8/30/2016	8/30/2021	Current
Litchfield	Plymouth	NVCOG	S	9/13/2016	9/13/2021	Current
	Bethlehem	NVCOG	S	11/9/2015	11/9/2020	Current
	Thomaston	NVCOG	S	2/9/2015	2/9/2020	Current
	Watertown	NVCOG	S	6/2/2014	6/2/2019	Current
	Woodbury	NVCOG	S	6/3/2014	6/3/2019	Current
	Bridgewater	WestCOG	S	3/26/2015	3/26/2019	Current
	New Milford	WestCOG	S	1/5/2016	1/5/2021	Current
	Barkhamsted	NWHCOG	MJ	8/30/2016	8/30/2021	Current

	Colebrook	NWHCOG	MJ	8/30/2016	8/30/2021	Current
	Goshen	NWHCOG	MJ	8/30/2016	8/30/2021	Current
	Harwinton	NWHCOG	MJ	8/30/2016	8/30/2021	Current
	Litchfield	NWHCOG	MJ	8/30/2016	8/30/2021	Current
	Morris	NWHCOG	MJ	8/30/2016	8/30/2021	Current
	New Hartford	NWHCOG	MJ	8/30/2016	8/30/2021	Current
	Norfolk	NWHCOG	MJ	8/30/2016	8/30/2021	Current
	Torrington	NWHCOG	MJ	8/30/2016	8/30/2021	Current
	Winchester	NWHCOG	MJ	8/30/2016	8/30/2021	Current
	Canaan	NWHCOG	S	1/30/2015	1/30/2020	Current
	Cornwall	NWHCOG	S	12/2/2014	12/2/2019	Current
	Kent	NWHCOG	S	12/19/2014	12/19/2019	Current
	North Canaan	NWHCOG	S	1/30/2015	1/30/2020	Current
	Roxbury	NWHCOG	S	12/18/2014	12/18/2019	Current
	Salisbury	NWHCOG	S	1/30/2015	1/30/2020	Current
	Sharon	NWHCOG	S	1/14/2015	1/14/2020	Current
	Warren	NWHCOG	S	1/15/2015	1/15/2020	Current
	Washington	NWHCOG	S	2/23/2015	2/23/2020	Current
Middlesex	Chester	RiverCOG	S	9/2/2014	9/2/2019	Current
	Clinton	RiverCOG	S	8/28/2014	8/28/2019	Current
	Cromwell	RiverCOG	MJ	8/20/2014	8/20/2019	Current
	Deep River	RiverCOG	S	9/2/2014	9/2/2019	Current
	Durham	RiverCOG	MJ	8/20/2014	8/20/2019	Current
	East Haddam	RiverCOG	MJ	8/20/2014	8/20/2019	Current
	East Hampton	RiverCOG	MJ	8/20/2014	8/20/2019	Current
	Essex	RiverCOG	S	6/23/2014	6/23/2019	Current
	Fenwick	RiverCOG	S	6/2/2014	6/2/2019	Current
	Haddam	RiverCOG	MJ	8/20/2014	8/20/2019	Current
	Killingworth	RiverCOG	S	6/16/2014	6/16/2019	Current
	Middlefield	RiverCOG	MJ	8/20/2014	8/20/2019	Current
	Middletown	RiverCOG	MJ	8/20/2014	8/20/2019	Current
	Old Saybrook	RiverCOG	S	6/2/2014	6/2/2019	Current
	Portland	RiverCOG	MJ	8/20/2014	8/20/2019	Current
	Westbrook	RiverCOG	S	9/2/2014	9/2/2019	Current
New Haven	Beacon Falls	NVCOG	S	1/5/2016	1/5/2021	Current
	Cheshire	NVCOG	S	12/19/2014	12/19/2019	Current
	Middlebury	NVCOG	S	12/30/2014	12/30/2019	Current
	Naugatuck	NVCOG	S	3/2/2015	3/2/2020	Current
	Oxford	NVCOG	S	8/19/2014	8/19/2019	Current
	Prospect	NVCOG	S	2/26/2015	2/26/2020	Current

	Southbury	NVCOG	S	12/30/2014	12/30/2019	Current
	Waterbury	NVCOG	S	2/27/2015	2/27/2020	Current
	Wolcott	NVCOG	S	2/26/2015	2/26/2020	Current
	Bethany	SCRCOG	MJ	5/14/2018	5/14/2023	Current
	Branford	SCRCOG	MJ	5/14/2018	5/14/2023	Current
	East Haven	SCRCOG	MJ	5/14/2018	5/14/2023	Current
	Guilford	SCRCOG	MJ	5/14/2018	5/14/2023	Current
	Hamden	SCRCOG	MJ	5/14/2018	5/14/2023	Current
	Madison	SCRCOG	MJ	5/14/2018	5/14/2023	Current
	Meriden	SCRCOG	S	5/28/2013	5/28/2018	Current; Single-jurisdiction update under review by DEMHS in 2018
	Milford	SCRCOG	MJ	5/14/2018	5/14/2023	Current
	New Haven	SCRCOG	MJ	5/14/2018	5/14/2023	Current
	North Branford	SCRCOG	MJ	5/14/2018	5/14/2023	Current
	North Haven	SCRCOG	MJ	5/14/2018	5/14/2023	Current
	Orange	SCRCOG	MJ	5/14/2018	5/14/2023	Current
	Wallingford	SCRCOG	MJ	5/14/2018	5/14/2023	Current
	West Haven	SCRCOG	MJ	5/14/2018	5/14/2023	Current
	Woodbridge	SCRCOG	MJ	5/14/2018	5/14/2023	Current
	Ansonia	NVCOG	MJ	2/13/2013	2/13/2018	Expired
	Derby	NVCOG	MJ	2/13/2013	2/13/2018	Expired
	Seymour	NVCOG	MJ	2/13/2013	2/13/2018	Expired
New London	Lyme	RiverCOG	S	8/20/2014	8/20/2019	Current
	Old Lyme	RiverCOG	S	8/22/2014	8/22/2019	Current
	Bozrah	SCCOG	MJ	12/2017	12/2022	Current
	Colchester	SCCOG	MJ	12/2017	12/2022	Current
	East Lyme	SCCOG	MJ	12/2017	12/2022	Current
	Franklin	SCCOG	MJ	12/2017	12/2022	Current
	Griswold	SCCOG	MJ	12/2017	12/2022	Current
	Groton (City)	SCCOG	MJ	12/2017	12/2022	Current
	Groton (Town)	SCCOG	MJ	12/2017	12/2022	Current
	Ledyard	SCCOG	MJ	12/2017	12/2022	Current
	Lisbon	SCCOG	MJ	12/2017	12/2022	Current
	Montville	SCCOG	MJ	12/2017	12/2022	Current
	New London	SCCOG	MJ	12/2017	12/2022	Current
	North Stonington	SCCOG	MJ	12/2017	12/2022	Current
	Norwich	SCCOG	MJ	12/2017	12/2022	Current
	Preston	SCCOG	MJ	12/2017	12/2022	Current
	Salem	SCCOG	MJ	12/2017	12/2022	Current
	Sprague	SCCOG	MJ	12/2017	12/2022	Current

	Stonington (Borough)	SCCOG	MJ	12/2017	12/2022	Current
	Stonington (Town)	SCCOG	MJ	12/2017	12/2022	Current
	Voluntown	NECCOG	MJ	2/1/2016	2/1/2021	Current
	Waterford	SCCOG	MJ	12/2017	12/2022	Current
	Lebanon	SCCOG	MJ	12/2017	12/2022	Current
	Andover	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	Bolton	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	Ellington	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	Hebron	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	Somers	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	Stafford	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
Tolland	Tolland	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	Vernon	CRCOG	MJ	12/5/2014	12/5/2019	Current; Update in progress with anticipated 2018 submittal to DEMHS
	Union	NECCOG	MJ	2/1/2016	2/1/2021	Current
	Columbia	CRCOG	MJ	1/11/2016	1/11/2021	Current; Update in progress with CRCOG; anticipated 2018 submittal to DEMHS
	Coventry	CRCOG	MJ	1/11/2016	1/11/2021	Current; Update in progress with CRCOG; anticipated 2018 submittal to DEMHS
	Mansfield	CRCOG	MJ	1/11/2016	1/11/2021	Current; Update in progress with CRCOG; anticipated 2018 submittal to DEMHS
	Willington	CRCOG	MJ	1/11/2016	1/11/2021	Current; Update in progress with CRCOG; anticipated 2018 submittal to DEMHS
	Ashford	NECCOG	MJ	2/1/2016	2/1/2021	Current
	Brooklyn	NECCOG	MJ	2/1/2016	2/1/2021	Current
	Canterbury	NECCOG	MJ	2/1/2016	2/1/2021	Current
	Eastford	NECCOG	MJ	2/1/2016	2/1/2021	Current
	Killingly	NECCOG	MJ	2/1/2016	2/1/2021	Current
	Plainfield	NECCOG	MJ	2/1/2016	2/1/2021	Current
	Pomfret	NECCOG	MJ	2/1/2016	2/1/2021	Current
Windham	Putnam	NECCOG	MJ	2/1/2016	2/1/2021	Current
	Sterling	NECCOG	MJ	2/1/2016	2/1/2021	Current
	Thompson	NECCOG	MJ	2/1/2016	2/1/2021	Current
	Woodstock	NECCOG	MJ	2/1/2016	2/1/2021	Current
	Chaplin	NECCOG	MJ	2/1/2016	2/1/2021	Current
	Hampton	NECCOG	MJ	2/1/2016	2/1/2021	Current
	Scotland	NECCOG	MJ	2/1/2016	2/1/2021	Current
	Windham	SCCOG	MJ	12/2017	12/2022	Current

Unaffiliated	Mashantucket Pequot Tribal Nation	SCCOG	MJ	12/2017	12/2022	Current
	Mohegan Tribe	SCCOG	MJ	12/2017	12/2022	Current

2.2.1 Geography

Connecticut contains a wide variety of landscapes. From the shores of Long Island Sound in southern Connecticut, the land gently slopes upward to rolling hills across the southern half of the State. More rugged terrain covers the northwestern and northeastern areas of Connecticut with forested hills and mountains climbing to elevations of over 2,000 feet. The Connecticut River Valley cuts through the center of the State, and several deep river valleys cut through the eastern and western sections of the State. All of these rivers generally flow from north to south and empty into Long Island Sound.

Within the State's borders there are approximately 450,000 acres of wetlands, 6,000 miles of streams and rivers, over 2,000 lakes and reservoirs, over 4,000 dams[3] and 600 square miles of estuarine water in Long Island Sound. Connecticut's shoreline and riverine areas were heavily developed for commercial, residential, and industrial uses during the past 200 years, since these areas are relatively flat, highly desirable for construction purposes, and have the ability to provide an ample supply of hydropower, a major power source of early 19th Century industrialization.

The climate of Connecticut is moderate with median annual precipitation ranges from 42 to 52 inches, and snowfall averaging between 30 inches on the coast of Long Island Sound up to 50 inches in the northwest hills. Temperatures range from highs in the 80's and 90's during the summer months, down to lows in the teens and single digits during the winter months.

Transcontinental storms (low pressure systems), and storms that form near the Gulf of Mexico and along the East Coast deliver most of the annual rain and snowfall to the State. Heavy short-duration rains are also caused by thunderstorm activity in all but the winter season. Occasional hurricanes, which typically occur between June 1st and December 1st, deliver heavy rains of longer duration. Less frequent in Connecticut are droughts, forest fires and earthquakes. Large-scale forest fires are rare in Connecticut. Fires are typically small underbrush and ground fires that rarely damage large numbers of buildings.

2.2.2 Demographics

Connecticut's demographics are a major factor in the risk posed by natural hazards. The 2010 U.S. Census Bureau population of Connecticut was 3,574,097, with 2017 estimates at

[3] http://www.ct.gov/deep/cwp/view.asp?a=2720&depNav_GID=1654&q=325632

3,588,184[4]. Connecticut's population is expected to grow a modest 2.2% by 2040.[5] Fairfield, Hartford, and New Haven have the greatest density of people per square mile.

Connecticut has 169 municipalities within 8 counties covering 4,842 square miles of land area. There are four additional communities including two tribal governments, the Mashantucket Pequot and Mohegan, and the political subdivisions of Groton and Stonington. Two-thirds of the State's population and housing units are within Fairfield, Hartford, and New Haven counties. Table 2-2 and Table 2-3 show the 2010-2017 population by municipality and population change from 2010-2017. Bridgeport, Hartford, New Haven, Norwalk, Waterbury, and Stamford, have the largest municipality populations in Connecticut.

Table 2-2: Census Data for the State of Connecticut

County	Population (2010)	Population (2017)	Housing Units (2017)	Land Area In Square Miles (2010)	Population Per Square Mile (2017)
Fairfield	916,829	949,921	372,981	624.9	1,520
Hartford	894,014	895,388	379,719	735.1	1,218
Litchfield	189,927	182,177	88,285	920.6	1,423
Middlesex	165,676	163,410	76,339	369.3	405
New Haven	862,477	860,435	367,195	604.5	198
New London	274,055	269,033	123,398	664.9	442
Tolland	152,691	151,461	59,729	410.2	369
Windham	118,428	116,359	49,742	512.9	227
Total	3,574,097	3,588,184	1,517,388	4,842.4	741

Table 2-3: Population Comparison for 1990 - 2017

County	Population (1990)	Population (2000)	Population (2010)	Population (2017)	Population Change from 2010 to 2017
Fairfield	827,645	882,567	916,829	949,921	3.61%
Hartford	851,783	857,183	894,014	895,388	0.15%
Litchfield	174,092	182,193	189,927	182,177	-4.08%
Middlesex	143,196	155,071	165,676	163,410	-1.37%
New Haven	804,219	824,008	862,477	860,435	-0.24%
New London	254,957	259,088	274,055	269,033	-1.83%
Tolland	128,699	136,364	152,691	151,461	-0.81%

[4] Census.gov QuickFacts Connecticut (10/2017)
[5] https://ctsdc.uconn.edu/2015-to-2040-population-projections-state-level/#data_tables

Windham	102,525	109,091	118,428	116,359	-1.75%
Total	3,287,116	3,405,565	3,574,097	3,588,184	0.39%

Three quarters of Connecticut counties experienced a population decrease between 2010 and 2017, with Fairfield and Hartford Counties the only areas that experienced population growth. Despite modest population growth during the past 17 years, since 2010 the state has had only 0.4% population growth according to US Census Bureau estimates. While low population growth has detrimental impacts on economic prosperity, static growth provides stability in hazard exposure. This aides disaster planning for new development and fewer populations moving into vulnerable areas. Figure 2-1 shows the population density of Connecticut municipalities, and Figure 2-2 displays the total population by town. Notable population centers include Hartford, New Haven, Waterbury, Bridgeport, Norwalk, and Stamford. Connecticut's densest communities are Hartford, New Haven, and Fairfield Counties.

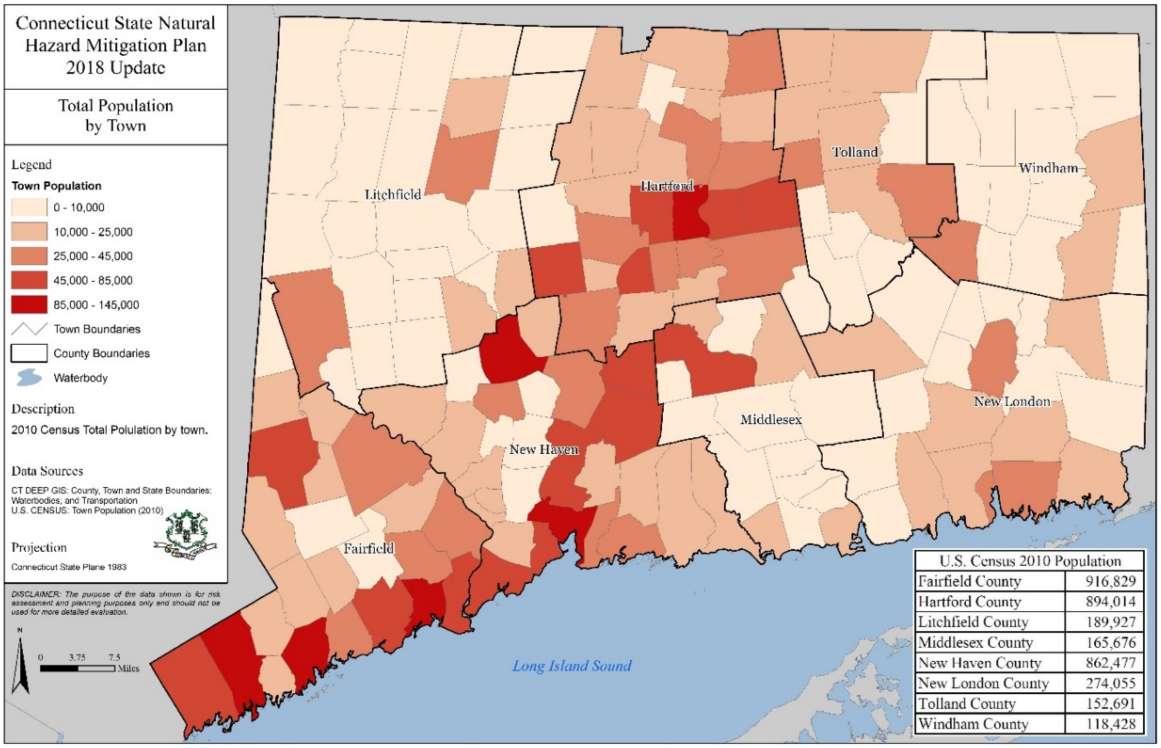

Figure 2-1: Population Density

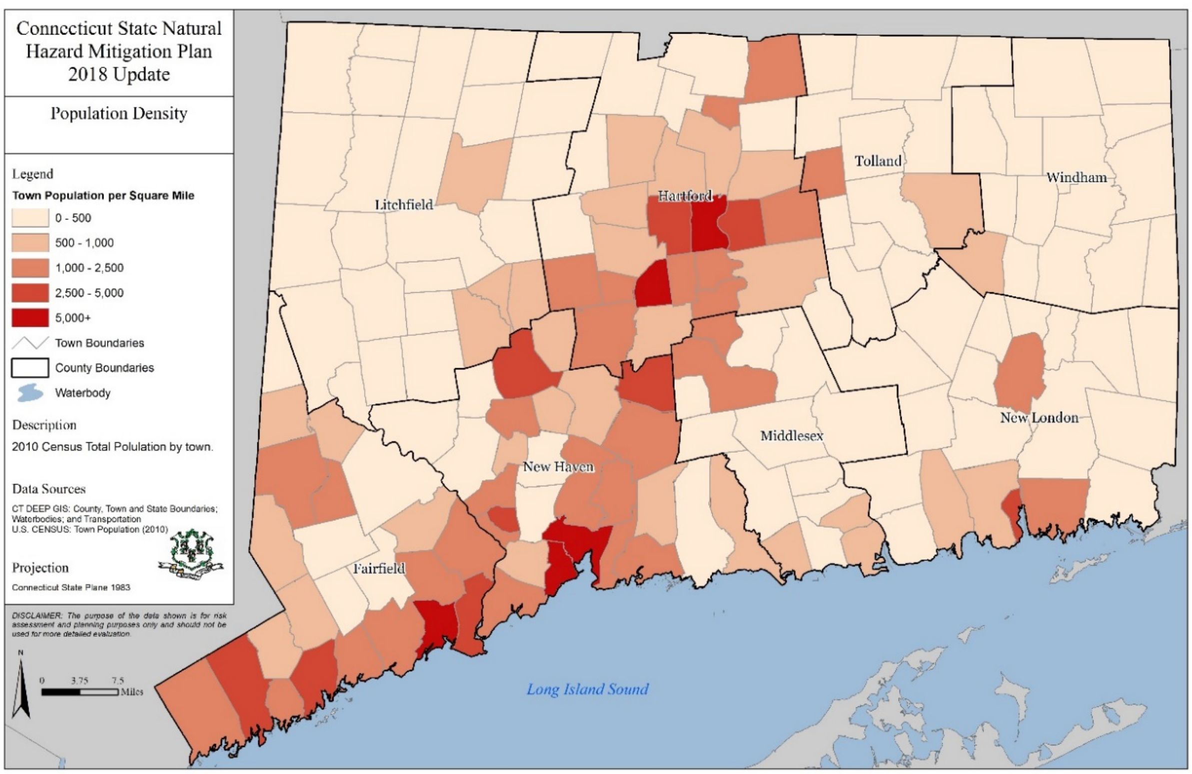

Figure 2-2: Total Population Distribution by Municipality

The State continues to recover from the 2008 recession though some counties have shown more growth than others. Connecticut's economy grew by 1% in 2016, following 2.2% growth in 2015.[6] Table 2-4 displays population projection data for Connecticut from 2017 through 2040. It is anticipated that both population and housing will continue to increase slowly in some communities. A review of projections indicates that many smaller communities may begin to experience increased development pressures, especially when denser communities approach build-out. This will increase the importance of local hazard mitigation planning and natural resource management to help mitigate and reduce potential hazard losses.

Table 2-4: Connecticut Population Projection (2020 – 2040)

2017 Population	Population Projection 2020	Population Projection 2025	Population Projection 2030	Population Projection 2035	Population Projection 2040	% Change (2017 to 2040)
3,588,184	3,604,603	3,618,763	3,633,994	3,645,370	3,654,015	1.83%

2.2.3 Facility and Infrastructure Datasets

The state critical facility data has been updated to reflect best available 2018 information. Facilities data was provided by Connecticut Office of Policy and Management (OPM). Mitigation strategies have been created to support expansion of this dataset and collection of additional attribute information. The current data set has point locations for state and critical facilities throughout the state but has limited attribute information populated for building information. Additional data should be collected (e.g. year built, first floor elevation, construction type, roof type, property value) to be able to provide in-depth analysis and mitigation strategies, including climate adaptation strategies informed by HIRA findings.

Assessed values for critical building infrastructure has been derived from the Joint Effort for State Inventory Reporting (JESTIR) database, and updated with The Office of Policy and Management's assessment of building values during August 2016. This open source data is viewable at Connecticut Open Data located at (https://data.ct.gov/). Since the Connecticut Open Data is hosted on a Socrata platform and is not downloadable in a compatible ESRI geospatial forma, the new information could not be fully mapped and intersected with Connecticut hazard. Updated building and content values were manually applied to the 2013 JESTIR data that offered geospatial locators. Impact analyses were run using this data.

[6] Connecticut Business & Industry Association, State Economy Posts Modest Growth

Water and wastewater treatment plants are critical to society, industry and emergency operation of critical facilities so are included in the facilities analysis. CT DEEP Bureau of Water Protection and Land Reuse provided the information regarding state, municipal, and private Water Pollution Control Facilities (WPCFs) across the state in 2013. The WPCF data was not updated for the 2019 plan, nor did this dataset have geospatial locators. This resulted in an inability to map these facilities for geospatial analysis. The number of WPCFs was obtained from the last plan update, and cross-referenced with lists of WPCFs created by the Connecticut Water Pollution Abatement Association and the Connecticut Department of Energy and Environmental Protection. There are 94 WPCFs in Connecticut. There are 1,940 critical facilities including the 94 unmapped WPCFs, resulting in 1,846 critical facilities mapped and intersected with hazard overlays.

Datasets are constantly changing; mitigation actions have been created to address the gaps in the data and future hazard analysis. State and critical datasets may contain duplicates. The information should be used with caution as the critical facilities also include state run institutions and a handful of federal institutions.

State Infrastructure and Facilities

There are 3,327 mapped state-owned facilities. Using a combination of the 2013 JESTIR database and Connecticut Open Data, the state building portfolio value estimate is $5.6 billion, with more than $866 million in contents value (Table 2-5).

Hartford County houses more than 26% of state-owned structures, followed by Tolland at 18.8%. Building values have been linked to the mapped database for Fairfield, Hartford, Litchfield, Middlesex, and New Haven counties. Though these counties are now mapped, only 43% of these structures had JESTIR ID's that could be linked to a building value to the new 2016 Connecticut Open Data. In addition, the online Open Data states that there are 3,822 state owned buildings with a building value of 8.9 billion dollars and a contents value of $1.1 billion. Unfortunately these data points could not be mapped or intersected with hazards due to inaccurate or unavailable geospatial locators. The state-owned infrastructure and facility data that was used to intersect the State's hazards is the most complete geospatial information available for the 2019 update. Due to the lack of information in the 2013 plan, an average building and content value was assigned and estimated for state facilities in New London, Tolland, and Windham counties. With updated available information from August 2016, average values and estimates for building and contents value were replaced with actual values and were used in the updated analysis. In addition to the facilities provided by Division of Construction Services, UCONN water pollution control facility (WPCF) in Tolland County has been provided by CT DEEP Bureau of Water Protection and Land Reuse and is included as a state-owned facility. A building replacement value or building specific criteria was not available for this structure. The complete infrastructure and facilities datasets can be provided upon request from OPM.

Table 2-5: Number of State Facility / Infrastructure and Building Values

County	Municipality	Total Facilities	2016 Building Values	2016 Content Values
FAIRFIELD	COUNTY	205	$306,766,080	$21,282,935
Fairfield	Bridgeport	26	Not Available	Not Available
Fairfield	Brookfield	2	Not Available	Not Available
Fairfield	Danbury	61	$253,702,928	$16,874,739
Fairfield	New Canaan	9	Not Available	Not Available
Fairfield	New Fairfield	11	Not Available	Not Available
Fairfield	Newtown	25	Not Available	Not Available
Fairfield	Norwalk	19	$19,903,194	$2,982,797
Fairfield	Ridgefield	7	Not Available	Not Available
Fairfield	Shelton	6	Not Available	Not Available
Fairfield	Stamford	11	$33,159,958	$1,425,399
Fairfield	Stratford	12	Not Available	Not Available
Fairfield	Westport	15	Not Available	Not Available
Fairfield	Wilton	1	Not Available	Not Available
HARTFORD	COUNTY	867	$2,193,688,919	$288,756,510
Hartford	Avon	9	$2,726,518	$328,839
Hartford	Berlin	3	$793,133	$82,398
Hartford	Bloomfield	10	$586,090	$364,327
Hartford	Bristol	5	$11,616,520	$1,307,701
Hartford	Burlington	15	$1,888,828	$387,927
Hartford	Canton	1	$5,930	Not Available
Hartford	East Granby	87	$556,118	Not Available
Hartford	East Hartford	7	$2,601,341	$839,579
Hartford	East Windsor	23	$18,539,618	$341,486
Hartford	Enfield	60	$7,243,711	$74,818
Hartford	Farmington	47	$432,659,792	$159,704,615
Hartford	Glastonbury	15	$2,422,153	$285,670
Hartford	Granby	1	$198,267	$1,399
Hartford	Hartford	117	$1,294,293,017	$57,958,711
Hartford	Manchester	20	$96,680,247	$9,398,392
Hartford	New Britain	64	$68,639,469	$6,266,501
Hartford	Newington	57	$95,588,445	$21,950,859
Hartford	Rocky Hill	75	$69,223,833	$18,029,095
Hartford	Simsbury	10	$1,165,845	$69,338
Hartford	South Windsor	1	$198,641	Not Available

Hartford	Southington	10	$8,460,836	$409,279
Hartford	Suffield	33	Not Available	Not Available
Hartford	West Hartford	6	$27,309,960	$3,158,316
Hartford	Wethersfield	20	$37,360,988	$7,044,065
Hartford	Windsor	15	$6,118,731	$719,174
Hartford	Windsor Locks	156	$6,810,888	$34,024
LITCHFIELD	COUNTY	97	$49,393,807	$6,380,386
Litchfield	Barkhamsted	4	Not Available	Not Available
Litchfield	Cornwall	26	Not Available	Not Available
Litchfield	Kent	23	Not Available	Not Available
Litchfield	Litchfield	9	Not Available	Not Available
Litchfield	North Canaan	2	Not Available	Not Available
Litchfield	Torrington	16	$35,701,826	$3,370,208
Litchfield	Warren	1	Not Available	Not Available
Litchfield	Washington	3	Not Available	Not Available
Litchfield	Winchester	13	$13,691,981	$3,010,178
MIDDLESEX	COUNTY	289	$333,187,573	$78,286,749
Middlesex	Chester	2	$35,425	$30,442
Middlesex	Clinton	1	$5,535	Not Available
Middlesex	Cromwell	1	$412,412	$61,759
Middlesex	Deep River	1	$11,046	Not Available
Middlesex	Durham	2	$97,393	Not Available
Middlesex	East Haddam	68	$93,111	Not Available
Middlesex	East Hampton	8	$351,928	$28,875
Middlesex	Essex	4	$860,473	Not Available
Middlesex	Haddam	25	$4,900,739	$470,380
Middlesex	Killingworth	18	$202,749	$2,834
Middlesex	Middlefield	1	Not Available	Not Available
Middlesex	Middletown	121	$307,489,455	$75,818,840
Middlesex	Old Saybrook	6	$12,479,903	$1,222,709
Middlesex	Portland	20	$1,842,358	$316,303
Middlesex	Westbrook	11	$4,405,046	$334,608
NEW HAVEN	COUNTY	561	$729,078,260	$95,519,353
New Haven	Ansonia	2	$11,257,819	$1,819,794
New Haven	Bethany	4	Not Available	Not Available
New Haven	Branford	6	Not Available	Not Available
New Haven	Cheshire	52	$86,420,672	$1,756,683
New Haven	Derby	7	Not Available	Not Available
New Haven	East Haven	17	Not Available	Not Available

New Haven	Guilford	8	$7,789,901	$369,590
New Haven	Hamden	40	$47,576,297	$5,767,670
New Haven	Madison	44	Not Available	Not Available
New Haven	Meriden	46	$78,183,326	$9,961,995
New Haven	Milford	8	Not Available	Not Available
New Haven	New Haven	140	$398,915,751	$72,088,680
New Haven	North Haven	7	Not Available	Not Available
New Haven	Oxford	20	Not Available	Not Available
New Haven	Seymour	1	Not Available	Not Available
New Haven	Southbury	136	$33,238,261	Not Available
New Haven	Wallingford	2	Not Available	Not Available
New Haven	Waterbury	11	$65,696,232	$3,754,941
New Haven	West Haven	2	Not Available	Not Available
New Haven	Wolcott	5	Not Available	Not Available
New Haven	Woodbridge	3	Not Available	Not Available
NEW LONDON	COUNTY	489	$90,561,491	$7,976,135
New London	Bozrah	2	Not Available	Not Available
New London	Colchester	12	$3,679,620	$1,711,211
New London	East Lyme	190	$16,807,120	$49,635
New London	Franklin	13	$760,552	$55,844
New London	Griswold	11	$306,095	$3,347
New London	Groton	57	Not Available	Not Available
New London	Lisbon	6	$605,809	$345,909
New London	Montville	13	Not Available	Not Available
New London	New London	7	Not Available	Not Available
New London	North Stonington	3	$1,538,031	Not Available
New London	Norwich	97	$64,988,671	$5,693,195
New London	Preston	3	Not Available	Not Available
New London	Voluntown	1	$238,129	Not Available
New London	Waterford	74	$1,637,463	$116,995
TOLLAND	COUNTY	628	$1,671,757,487	$344,503,260
Tolland	Andover	1	$8,819	$0
Tolland	Bolton	3	$2,648,766	$184,593
Tolland	Columbia	5	$989,717	Not Available
Tolland	Coventry	7	Not Available	Not Available
Tolland	Ellington	1	$307,559	$8,765
Tolland	Hebron	10	$895,196	Not Available
Tolland	Mansfield	527	$1,564,480,643	$336,740,970
Tolland	Somers	29	$49,440,359	$2,016,981

Tolland	Stafford	10	$528,958	Not Available
Tolland	Tolland	6	$5,045,738	$218,098
Tolland	Union	5	$1,140,231	$115,360
Tolland	Vernon	12	$39,027,477	$6,809,315
Tolland	Willington	12	$7,232,619	$2,715,229
WINDHAM	COUNTY	191	$230,192,255	$2,844,196
Windham	Ashford	5	Not Available	Not Available
Windham	Brooklyn	14	$24,819,537	$374,653
Windham	Canterbury	4	$1,544,332	$1,297,666
Windham	Eastford	9	Not Available	$3,756
Windham	Killingly	36	$24,142,738	Not Available
Windham	Plainfield	29	Not Available	Not Available
Windham	Putnam	10	Not Available	Not Available
Windham	Thompson	12	$729,516	Not Available
Windham	Windham	70	$178,656,579	$1,116,392
Windham	Woodstock	2	$299,554	$51,730

In addition to state infrastructure and facilities, the Department of Transportation (DOT) maintains 4,016 bridges (75.6% of bridges within Connecticut) and 4,103 miles of roads (19.2% of State roads). DOT has noted that damages documented for past events are an underrepresentation of disaster-related transportation infrastructure costs associated with pre-storm response and reconstruction. DOT has provided the following information related to state infrastructure:

- Frequency and impacts of extreme events has increased within the past decade
- Fiscal Impacts:
  - Hurricane Sandy (2012) $6,828,102
  - Winter Storm Alfred (2011) $40,339,301
  - Tropical Storm Irene (2011) $10,548,389
  - Intense Rain (2010) $5,849,308

For the 2019 plan update, DOT provided updated numbers of storm-impacted road miles but no detailed cost estimates.

Loss Estimates for State Facilities

- Loss estimates for Connecticut state facilities were calculated by taking the total building and contents values for each municipality and estimating a percentage of loss for each hazard. The full table of loss estimate data by municipality is available in Appendix 2.

- Building and contents values were derived from two methods of calculation. The first was updating values based on JESTIR ID with information from the Office of Policy and Management's assessment of building values in August 2016.
- The second method was for the facilities without building or contents documented values. The total building and contents values for all 3,823 facilities ($8.9 billion in building values and $1.1 billion in contents values) were divided by the total facility count resulting in average building and contents value. These averages were then assigned to the facilities without building and content values.
- Once values for all mapped facilities were updated or assigned, the building and content values were summarized by both county and municipality. Loss estimates were calculated based on a predicted percent loss, and applied to the total building value for each municipality. The percent of loss was assigned by subject matter experts (SMEs) based on their New England and Connecticut experience with hazard occurrence and magnitude. Estimated losses varied by hazard and by hazard extent. Drought was not included in this analysis, as damage from drought occurs primarily to agricultural areas rather than buildings. The following is a description of the loss percentage for each hazard:
    - Dam Failure: The total loss for all structures in dam inundation areas was assigned by SMEs.
    - Earthquake: SMEs assigned estimated losses of 15 percent to the total building value for each municipality. Higher magnitude earthquakes uncommon in Connecticut would not create uniform damages.
    - Flood: SMEs assigned a loss estimation of 35 percent considering initial losses for buildings within the 100-500 year floodplains.
    - Erosion: Erosion prone areas range from steep slopes to highly erodible soil. A loss estimation of 20 percent was assigned by SMEs to compensate for these variations which can range from topsoil loss to total building destruction.
    - Sea Level Rise: A total loss for all structures in areas prone to sea level rise was assigned by SMEs.
    - Thunderstorm: Thunderstorm risk is universal statewide, so total values for all facilities in all municipalities were used. Since storm intensity varies widely, SMEs assigned a loss estimation of 15 percent. Percentage points were added to include damage from downed trees, debris and fires due to lightning strike along with flooding.
    - Tornado: The density of historic tornado tracks was calculated for Connecticut so that areas with the highest population density were assigned a loss estimation by SMEs of 30 percent. Tornado intensity was considered, as well as how tornadoes damage manifests in communities.
    - Tropical Cyclone: Tropical Cyclones potentially impact all state facilities. However, there is a difference between the effect on a coastal county and an inland county. For inland counties, a loss estimation of 35 percent was assigned by SMEs. Coastal county values were assigned a loss estimation of 50 percent by SMEs due to the effects of storm surge along the coast.
    - Wildland Fire: Two types of Wildland-Urban Interface (WUI) zones were used in loss estimation: intermix and interface. Intermix WUI zones are areas where housing and vegetation intermingle; interface WUI zones are areas

with housing near large tracts of forests. Each zone features a high, medium, and low density monikers. SMEs assigned a 50 percent loss to high and medium density intermix and interface areas. A 25 percent loss was assigned to low density intermix and interface areas. When combined, the community's total loss estimate resulted for Wildland Fire state facilities.

- Winter Weather: Since the threat of winter weather is uniform statewide, total values for all facilities in each municipality were used as initial totals. SMEs assigned a loss estimation of 30 percent for this hazard since annual occurrences has directed increased state capacity to address winter storm hazards.

Critical Infrastructure and Facilities

Classification of what constitutes a "critical" facility/infrastructure can vary from federal, state, and local jurisdictions. Critical infrastructure and facilities include systems and assets, whether physical or virtual, so vital to Connecticut that the incapacitation or destruction of such systems and assets would have a debilitating impact on security, economic property, public health or safety, or any combination of those factors. Facilities and infrastructure presented in this section are not limited to only state facilities and infrastructure. Figure 2-3 displays the location of Connecticut's state and critical facilities.

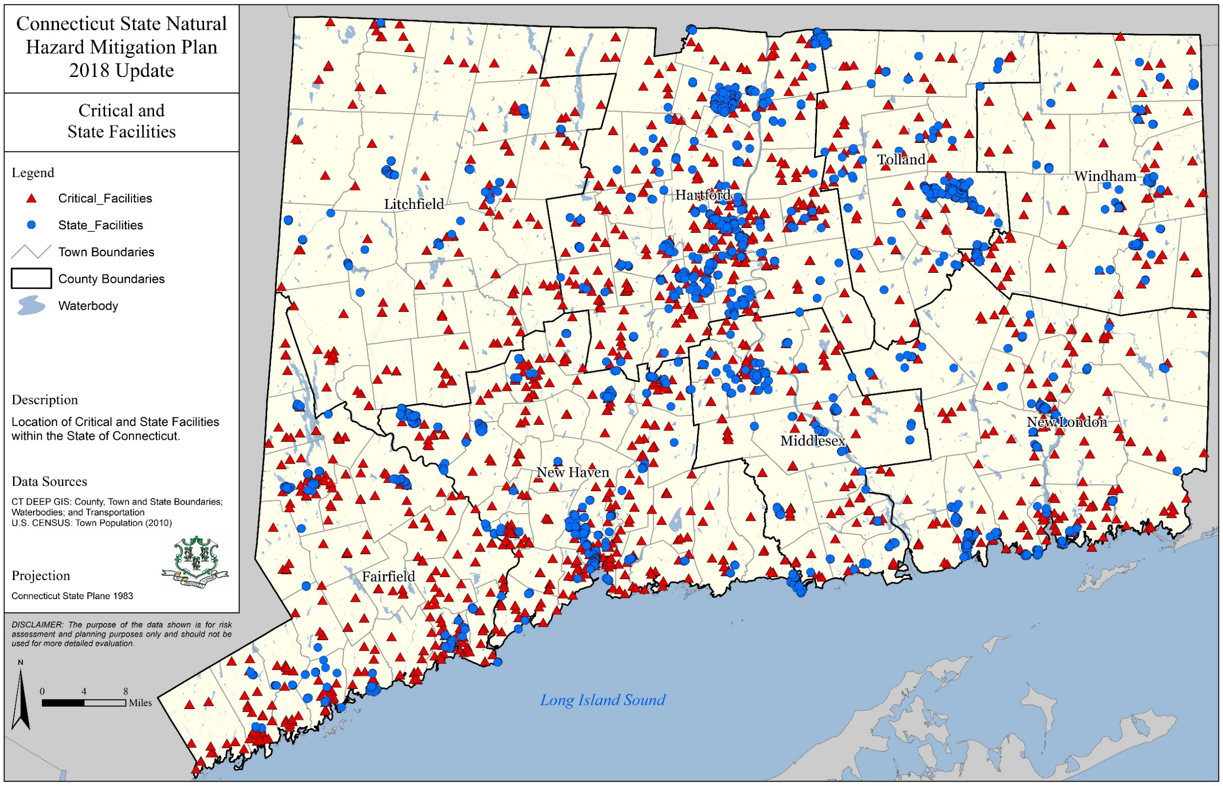

Figure 2-3: Critical and State Facilities

For the plan update, discretion was used to identify specific types of infrastructure and facilities. This does not preclude other types of facilities/structures that may be deemed critical by government entities in the future, nor should it limit the inclusion of other types of facilities that may benefit from assessment of natural or human-caused threat resiliency.

Using this critical facility definition in conjunction with data readily available from OPM, 1,940 facilities/infrastructure were identified in Connecticut. These were listed in several datasets provided by OPM and merged together for spatial analysis.

Infrastructure and facilities include:

- Law Enforcement
- Fire Stations
- EMS
- Health Departments
- Correctional Facilities
- Nuclear Power Plants
- Gas Stations with Generators
- Petroleum, Oil and Lubricant (POL) infrastructure
- Storage Facilities, and Farms
- Water and Waste Water Treatment infrastructure (Public and Private)

Site specific information has been redacted, but is included in the hazard specific analysis. In addition to the 1,846 facilities provided by OPM, 94 WPCFs were provided by CT DEEP Bureau of Water Protection and Land Reuse and are included as critical facilities. The WPCFs, while included in the critical facility count, did not contain geospatial data and therefore were not included in the impact analysis and intersection with hazards.

Table 2-6 provides a breakdown of critical facilities by county and municipality. Fire stations account for 31% of the structures followed by EMS (26%), and municipal solid waste (14%).

Table 2-6: Number and Type of Critical Facility Structures

County	Municipality	Correctional Institutions	EMS	Fire Stations	Gas Station with Generator	Health Departments	Law Enforcement	Municipal Solid Waste	Nuclear Power Plant	Storage Tank Farm	WPCF – Privately Owned	WPCF – Municipality Owned	Critical Facility Totals
FAIRFIELD	COUNTY	4	120	115	22	25	35	43	0	7	6	16	393
Fairfield	Bethel		2	2		1	1	1					7
Fairfield	Bridgeport	2	2	8	4	3	8	3		5		2	37
Fairfield	Brookfield		3	3	1	1	1	1					10
Fairfield	Danbury	1	18	18	1	1	2	4				1	46
Fairfield	Darien		5	3		1	1	2					12
Fairfield	Easton		1	1		1	3	1					7
Fairfield	Fairfield		6	7	2	1	1	2				1	20
Fairfield	Greenwich		8	7	1	2	1	2			4	2	27
Fairfield	Monroe		7	6			1	1					15
Fairfield	New Canaan		2	1	2	1	1	2				1	10
Fairfield	New Fairfield		3	3	1	1	2	1					11
Fairfield	Newtown	1	7	6	3	1	1	1			1	1	22
Fairfield	Norwalk		5	5	1	2	1	2		1		1	18
Fairfield	Redding		7	4		1	1	1				1	15
Fairfield	Ridgefield		2	2		1	1	1				2	9
Fairfield	Shelton		5	4	1		1	3				1	15
Fairfield	Sherman		1	1		1	1	1					5
Fairfield	Stamford		13	14	4	2	2	4		1		1	41
Fairfield	Stratford		6	5		1	1	3				1	17
Fairfield	Trumbull		3	7		1	1	3					15
Fairfield	Weston		3	2			1	1				1	8
Fairfield	Westport		5	4		1	1	2					13
Fairfield	Wilton		6	2	1	1	1	1			1		13
HARTFORD	COUNTY	6	80	141	10	26	44	62	0	8	0	17	394
Hartford	Avon			4		1	1	2					8
Hartford	Berlin		3	4			1	6					14
Hartford	Bloomfield		1	6	1	1	1	1					11
Hartford	Bristol		1	5	3	2	1	5				1	18
Hartford	Burlington		5	5			1						11

Hartford	Canton		3	3			1	1				1	9
Hartford	East Granby		1	3			1			1			6
Hartford	East Hartford		5	6	1	1	1	2		2		1	19
Hartford	East Windsor		3	4			1	1		1		1	11
Hartford	Enfield	3	7	6	1	1	1	2		1		1	23
Hartford	Farmington		6	6		1	2	2				1	18
Hartford	Glastonbury		1	6	2	1	1	3				1	15
Hartford	Granby		1	3			1	1					6
Hartford	Hartford	2	1	13		6	12	7				1	42
Hartford	Hartland		1	2				2					5
Hartford	Manchester		11	10		2	2	4				1	30
Hartford	Marlborough		1	2			1	1					5
Hartford	New Britain		1	6	1	2	2						12
Hartford	Newington		1	5		1	1	3					11
Hartford	Plainville			1		1	1	3				1	7
Hartford	Rocky Hill		1	3			1	1		1		1	8
Hartford	Simsbury		7	6			1	2				1	17
Hartford	South Windsor		5	4	1	1	1	1				1	14
Hartford	Southington			4		2	1	3				1	11
Hartford	Suffield	1	2	4			1	1				1	10
Hartford	West Hartford		6	6		1	1	3					17
Hartford	Wethersfield		1	3		1	1	2		2			10
Hartford	Windsor		1	4		1	1	2				1	10
Hartford	Windsor Locks		4	7			3	1				1	16
LITCHFIELD	COUNTY	0	34	53	8	7	25	29	0	0	3	11	170
Litchfield	Barkhamsted			3			2	1					6
Litchfield	Bethlehem		1	1	1		1	1					5
Litchfield	Bridgewater			1			1	1					3
Litchfield	Canaan		1	1				2					4
Litchfield	Colebrook			2									2
Litchfield	Cornwall		2	2									4
Litchfield	Goshen		1	1							1		3
Litchfield	Harwinton		2	2			1	1					6
Litchfield	Kent		1	1	1		1				1		5
Litchfield	Litchfield		4	4	1		5	1				1	16
Litchfield	Morris		1	1				2					4
Litchfield	New Hartford		1	3			1	1				1	7
Litchfield	New Milford		2	4	1	2	1	1				1	12
Litchfield	Norfolk		2	1	1		1	1				1	7

Litchfield	North Canaan		1	1			2	5				1	10
Litchfield	Plymouth		1	3			1	1				1	7
Litchfield	Roxbury		1	1			1	2					5
Litchfield	Salisbury		2	1			1	1				1	6
Litchfield	Sharon		2	2		1						1	6
Litchfield	Thomaston		1	1			1	2				1	6
Litchfield	Torrington		1	7	2	2	1	1				1	15
Litchfield	Warren		1	1									2
Litchfield	Washington		2	1		1	1	1			1		7
Litchfield	Watertown		2	2			1	1					6
Litchfield	Winchester		1	4		1	1					1	8
Litchfield	Woodbury		1	2	1		1	3					8
MIDDLESEX	COUNTY	1	31	36	8	9	17	21	0	3	0	6	132
Middlesex	Chester		1	1	1		1						4
Middlesex	Clinton		1	2	1		1	2					7
Middlesex	Cromwell		3	3		1	1	1				1	10
Middlesex	Deep River		3	2			1	1				1	8
Middlesex	Durham		2	1	1	1	1						6
Middlesex	East Haddam		4	3			1	3				1	12
Middlesex	East Hampton		1	3		1	1	1				1	8
Middlesex	Essex		1	2		1	2	2					8
Middlesex	Haddam		1	4	1			1					7
Middlesex	Killingworth		3	2	1		1	1					8
Middlesex	Middlefield			1	1	1	1	2					6
Middlesex	Middletown	1	6	6	1	2	2	4				1	23
Middlesex	Old Saybrook		1	1		1	1	1					5
Middlesex	Portland		1	3	1		1	1		3		1	11
Middlesex	Westbrook		3	2		1	2	1					9
NEW HAVEN	COUNTY	5	76	115	23	26	42	45	0	10	3	13	358
New Haven	Ansonia		1	5	1		1	2				1	11
New Haven	Beacon Falls		1	1	1		1	1				1	6
New Haven	Bethany		2	2	1		1						6
New Haven	Branford		5	5		2	1	3				1	17
New Haven	Cheshire	3	1	3	1	1	1	2				1	13
New Haven	Derby		1	4		1	1	2				1	10
New Haven	East Haven		3	4	1		1	1		1			11
New Haven	Guilford		1	5	2	1	1	2					12
New Haven	Hamden		7	7	1		1						16
New Haven	Madison		3	2	1	1	1	2					10

New Haven	Meriden		7	6		3	3					1	20
New Haven	Middlebury		1	2		1	1	1					6
New Haven	Milford		5	5	2	2	1	3			1	2	21
New Haven	Naugatuck		2	2			1					1	6
New Haven	New Haven	2	1	10	3	3	8	4		9		1	41
New Haven	North Branford		4	4	2		1	2					13
New Haven	North Haven		4	4	1	1	1	2					13
New Haven	Orange		2	2	1	1	1	2					9
New Haven	Oxford		1	3	1		1						6
New Haven	Prospect		1	1			1						3
New Haven	Seymour		1	2	1	1	1	2					8
New Haven	Southbury		4	6	1	1	2	2			2		18
New Haven	Wallingford		6	6		2	1	3				1	19
New Haven	Waterbury		1	10	2	3	5	5				1	27
New Haven	West Haven		10	10		2	2	1				1	26
New Haven	Wolcott		1	3			1	2					7
New Haven	Woodbridge			1			1	1					3
NEW LONDON	COUNTY	1	77	68	7	14	33	39	1	2	0	8	250
New London	Bozrah		1	1				1					3
New London	Colchester		2	2		1	2	3					10
New London	East Lyme	1	3	3	1		2	1					11
New London	Franklin		2	2		1		1					6
New London	Griswold		3	2		1	1	1				1	9
New London	Groton		15	14		1	6	5		1		1	43
New London	Lebanon		1	1		1	1	3					7
New London	Ledyard		4	3		1	2	1				1	12
New London	Lisbon		1	1			1	1					4
New London	Lyme		4	3				2					9
New London	Montville		5	5	2	1	4	2				1	20
New London	New London		3	3		1	4	1		1		1	14
New London	North Stonington		2	1	1	1	1	2					8
New London	Norwich		8	7		2	3	1				1	22
New London	Old Lyme		3	3	1	1	1	2					11
New London	Preston		1	1	2		1	2					7
New London	Salem		2	2		1	1	2					8
New London	Sprague		1	1			1	2				1	6
New London	Stonington		7	6		1	1	3				1	19
New London	Voluntown		1	1				1					3

New London	Waterford		8	6			1	2	1				18
TOLLAND	COUNTY	3	35	37	2	4	11	22	0	0	1	4	119
Tolland	Andover		1	1			1	1					4
Tolland	Bolton		1	1				1					3
Tolland	Columbia		1	1				1					3
Tolland	Coventry		3	4			1	2				1	11
Tolland	Ellington		4	4			1	3					12
Tolland	Hebron		3	3			1	1					8
Tolland	Mansfield	1	4	4	1	1	2	3			1		17
Tolland	Somers	2	1	1		1	1	2				1	9
Tolland	Stafford		4	4		1	1	1				1	12
Tolland	Tolland		4	4			2	1					11
Tolland	Union		1	1				2					4
Tolland	Vernon		6	6	1	1	1	1				1	17
Tolland	Willington		2	3				3					8
WINDHAM	COUNTY	1	43	40	2	3	12	17	0	0	0	6	124
Windham	Ashford		2	2				2					6
Windham	Brooklyn	1	3	3		1	1	1					10
Windham	Canterbury		1	1				1					3
Windham	Chaplin		1	1			1	1					4
Windham	Eastford		1	1	1			1					4
Windham	Hampton		2	2				1					5
Windham	Killingly		7	6			2	1				1	17
Windham	Plainfield		5	4			1					2	12
Windham	Pomfret		1	1									2
Windham	Putnam		3	2	1	1	2					1	10
Windham	Scotland		2	2									4
Windham	Sterling		2	2			1						5
Windham	Thompson		6	6				1				1	14
Windham	Windham		4	4		1	4	7				1	21
Windham	Woodstock		3	3				1					7
STATE	TOTAL	21	496	605	82	114	219	278	1	30	13	81	1940

2.2.4 Land Use and Development

Effective land use planning is a central component of any hazard mitigation strategy, as existing and planned land use patterns greatly influence a community's hazard vulnerability. Thus, future land use decisions should consider a community's potential hazards and vulnerability, and direct development towards those areas that are least vulnerable, creating a more disaster-resistant environment. FEMA requires evaluation of land use and development trends in state and multi-jurisdictional mitigation plans so that mitigation options can be considered in future land use decisions.

Most of local hazard mitigation plans include a general overview of land uses and development trends. Connecticut local hazard mitigation plan were reviewed for land use trends. Detailed information from each local plan is available in Appendix 4.

Many communities in Fairfield County are projecting that limited growth will continue to occur near Metro-North rail stations including Darien, Greenwich, New Canaan, Norwalk, Stamford, Weston and Westport. Outside of Fairfield County, most growth over the last three years has been very limited. The Center for Land Use Education and Research (CLEAR) at the University of Connecticut provides information, education and assistance to land use decision makers, in support of balancing growth and natural resource protection. CLEAR is a partnership between the Department of Natural Resources and the

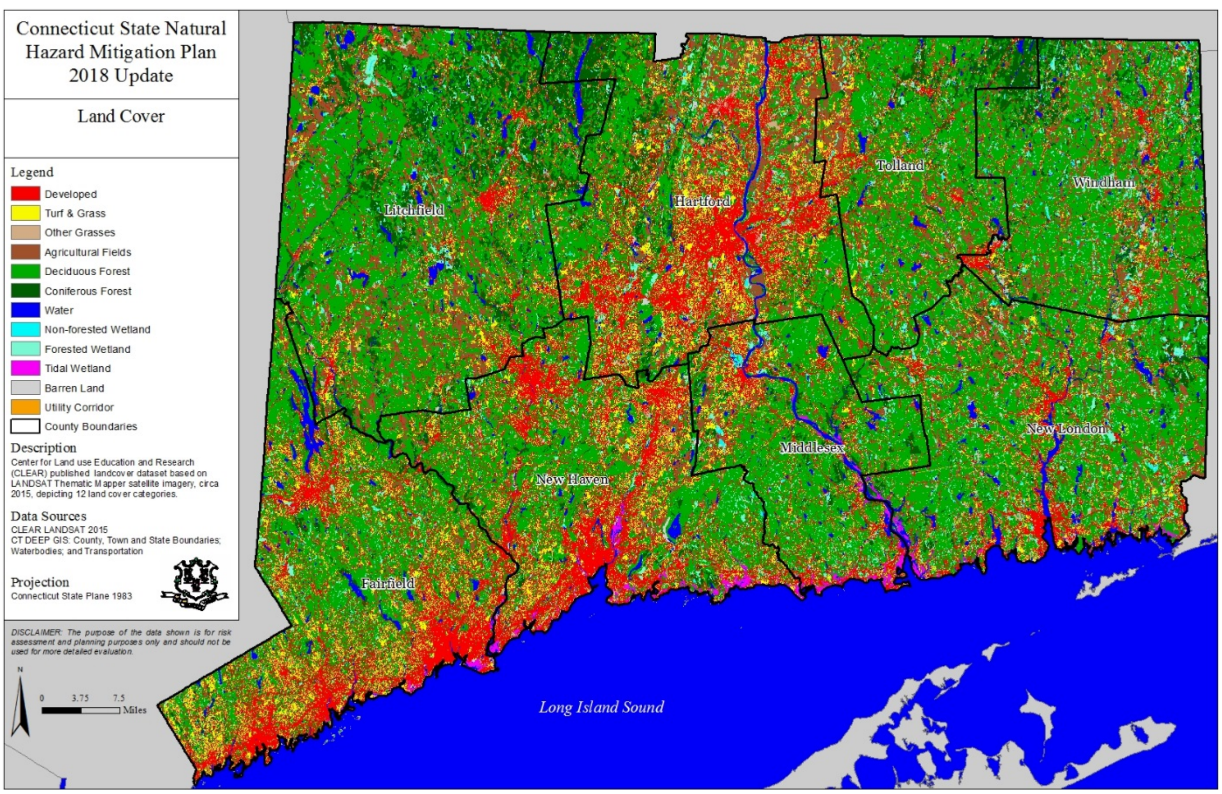

Figure 2-4: Connecticut Land Cover

Environment and the Department of Extension, two units of the College of Agriculture and Natural Resources (CANR), and the Connecticut Sea Grant Program. CLEAR's 2015 Statewide Land Cover map is shown below in Figure 2-4.

There are 12 land cover types:

- Developed land, indicated in red, illustrates high-density developed areas typically associated with commercial, industrial and residential uses and transportation routes. These areas can be expected to contain a significant amount of impervious surfaces, roofs, roads, and other concrete and asphalt surfaces.
- Turf and grass, shown in yellow, represent undifferentiated maintained grasses associated mostly with developed areas. This class contains cultivated lawns typical of residential neighborhoods, parks, cemeteries, golf courses, turf farms, and other maintained grassy areas. Also includes some agricultural fields due to similar spectral reflectance properties.
- Other Grasses, indicated in tan, includes non-maintained grassy areas commonly found along transportation routes and other developed areas, and within and surrounding airport properties.
- Agricultural Field indicated in brown shows areas that are under cultivation, either crop production or active pasture.
- Deciduous forest, shown in bright green, includes southern New England mixed hardwood forests. Also includes scrub areas characterized by patches of dense woody vegetation.
- Coniferous Forest, shown in a dark green, includes southern New England mixed softwood forests, such as pine.
- Water, shown in a bright blue, includes open water bodies and watercourses with relatively deep water.
- Non-forested Wetland in a dark teal includes areas that predominately are wet throughout most of the year and that have a detectable vegetative cover
- Forested wetland in a mint green shows areas depicted as wetland, but with forested cover.
- Tidal wetland, shown in bright teal, shows emergent wetlands, wet throughout most of the year, with distinctive marsh vegetation and located in areas influenced by tidal change.
- Barren areas are shown in gray, and represent mostly non-agricultural areas free from vegetation, such as sand, sand and gravel operations, bare exposed rock, mines, and quarries.
- Utility (Forest), shown in gold, includes utility rights-of-way areas.

Table 2-7 summarizes the statewide land cover and land cover change from 1985 to 2006. Over the last 30-years, developed land has increased over 3% throughout the state and turf & grass has increased 1.6%, while deciduous and coniferous forests have decreased by 3.9%. Connecticut has also lost nearly 60 square miles, or 1.3%, of agricultural areas.

Table 2-7: Statewide Land Cover and Land Cover Change. Source: UCONN Land Use Education and Research.

Land Cover	1985		1990		1995		2002		2006		2015		Change (1985 - 2015)	
	Sq. Miles	% of State	Sq. Miles	% of State	Sq. Miles	% of State	Sq. Miles	% of State	Sq. Miles	% of State	Sq. Miles	% of State	Sq. Miles	% of State
Developed	797.4	16%	862.3	17.40%	885.5	17.80%	922.8	18.60%	942.1	19%	950.6	19.12%	153.2	3.12%
Turf & Grass	308.9	6.20%	325.9	6.60%	341.7	6.90%	362.5	7.30%	381.7	7.70%	389.4	7.83%	80.5	1.63%
Other Grasses	65.3	1.30%	68.7	1.40%	76.1	1.50%	82.4	1.70%	86	1.70%	98.3	1.98%	33.0	0.68%
Agricultural Field	425.2	8.60%	403.9	8.10%	391.8	7.90%	371.8	7.50%	363.4	7.30%	365.4	7.35%	-59.8	-1.25%
Deciduous Forest	2467	49.60%	2410.5	48.50%	2379.7	47.90%	2338.2	47.10%	2307.3	46.40%	2292.0	46.11%	-175.0	-3.49%
Coniferous Forest	455.9	9.20%	452.4	9.10%	449.5	9%	445.2	9%	441.1	8.90%	435.5	8.76%	-20.4	-0.44%
Water	173.1	3.50%	168.8	3.40%	164.1	3.30%	161.1	3.20%	161.2	3.20%	164.8	3.32%	-8.3	-0.18%
Non-forested Wetland	20.2	0.40%	21.2	0.40%	21.2	0.40%	21.7	0.40%	21.1	0.40%	21.2	0.43%	1.0	0.03%
Forested Wetland	183.8	3.70%	177.8	3.60%	174.9	3.50%	173.8	3.50%	173.7	3.50%	181.8	3.66%	-2.0	-0.04%
Tidal Wetland	22.6	0.50%	22.9	0.50%	23	0.50%	23.2	0.50%	22.9	0.50%	22.6	0.45%	0.0	-0.05%
Barren	32.1	0.60%	37.3	0.80%	44.4	0.90%	49.1	1%	51.4	1%	31.6	0.64%	-0.5	0.04%
Utility (Forest)	17.6	0.40%	17.3	0.30%	17.3	0.30%	17	0.30%	17.1	0.30%	17.5	0.35%	-0.1	-0.05%

Although development has continued during the last decade, the pace of development slowed dramatically during 2007-2011 as a consequence of the recession. . Building permits have increased since the recession, hitting a peak in 2015, but have remained below the2006 development peak. New permits decreased from 2016 to 2017. Figure 2-5 shows Connecticut development trends. Data was provided by the Connecticut Department of Economic and Community Development.

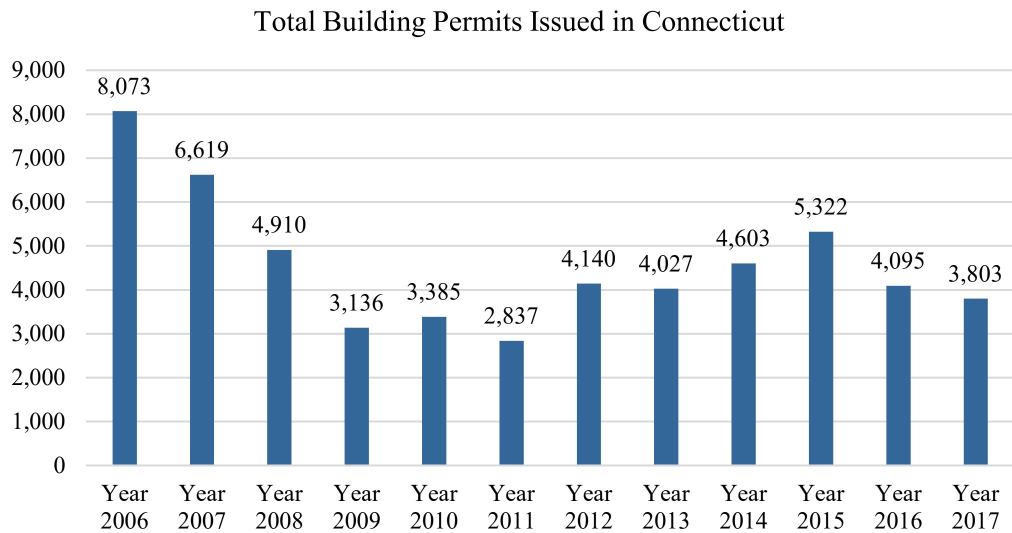

Figure 2-5: Total Building Permits by Year, 2006 - 2017

Table 2-8 provides total building permits issued for 2010-2017 by county. The counties which continue to see the majority of development are Fairfield County and Hartford County. Fairfield County is a popular because of its proximity to New York City for commuters with available transportation options. The City of Hartford is the state capitol and many large companies are located in the City and Hartford County. Thus housing demands in this region of Connecticut have increased due to improved job markets. While building permits had been increasing slowly, there was a significant drop in 2016 and 2017.

Table 2-8: Building Permits by County.

County	2010	2011	2012	2013	2014	2015	2016	2017
Fairfield	790	858	2,007	1,653	1,688	2,582	1,287	1,632
Hartford	614	510	826	892	777	1,002	1,405	964
Litchfield	129	81	92	110	127	5	15	28
Middlesex	262	146	165	215	202	218	217	277
New Haven	902	682	513	582	939	891	575	415
New London	315	197	224	322	591	234	199	155
Tolland	182	260	235	168	182	368	384	313
Windham	191	103	78	85	97	22	13	19
Total	3,385	2,837	4,140	4,027	4,603	5,322	4,095	3,803

Building permit counts are an industry accepted measure of growth. However, tracked building permit information contains data for all building activity requiring a building permit (e.g., new construction, remodeling/additions, demolitions, reconstruction, etc.) so does not accurately represent new construction. So a review of changes in housing inventory was also conducted. Fairfield and Hartford Counties have seen the greatest building permit issuance during the last few years. Table 2-9 shows housing inventory between 2010 and 2017. As of 2017, Hartford County maintained the largest inventory of housing units in the state followed by Fairfield and then New Haven County.

Table 2-9: Total Inventory, Housing Units and Permit Net Gains.

County	2010	2011	2012	2013	2014	2015	2016	2017
Fairfield	361,221	361,760	363,512	365,452	366,779	368,775	370,058	371,239
Hartford	374,249	374,502	375,148	375,733	376,452	377,143	378,508	378,956
Litchfield	87,550	87,643	87,777	87,900	88,015	88,082	88,206	88,316
Middlesex	74,837	74,953	75,165	75,342	75,537	75,788	75,981	76,193
New Haven	362,004	362,507	362,940	363,588	364,494	365,471	366,124	366,672
New London	120,994	121,149	121,401	121,703	122,275	122,717	122,988	123,248
Tolland	57,963	58,258	58,476	58,645	58,813	59,177	59,532	59,809
Windham	49,073	49,144	49,211	49,294	49,381	49,440	49,524	49,632
Total	1,487,891	1,489,916	1,493,630	1,497,657	1,501,746	1,506,593	1,510,921	1,514,065

As the State reviews local mitigation plans in higher growth regions, increased emphasis will be placed on defining the impacts of growth on hazard exposure and risk. Improved data will be collected for incorporation into the next State plan update.

2.3 Connecticut's History of Natural Disasters

Recent disasters have focused the attention of citizens and government officials on hazard impacts to people, humans, the environment, critical facilities and the economy. Since 2010, Connecticut has experienced eight major disaster declarations, during the previous decade only two. There have been 21 State disaster declarations and 11 emergency declarations since 1954.

These disasters have had significant impacts on Connecticut and its residents, such as loss of homes, property and possessions, loss of life and injury, lost wages and business revenue, in addition to psychological and sociological costs to disaster survivors. Following Hurricane Sandy, more than 12,380 Connecticut residents in five counties and two tribal nations registered for federal disaster assistance. More than $11.5 million was approved for housing assistance, including short-term rental assistance and home repair costs. More than $32 million in low-interest disaster loans for homeowners, renters, businesses and private nonprofit organizations was approved by the U.S. Small Business Administration in addition to other aid such as medical and dental assistance. Financial support for lost personal possessions, Disaster Unemployment Assistance, and Public Assistance grants was also provided.[7]

Historically, flooding has caused the most damage to the State and its citizens, along with recent wind and winter storm disaster events. Many figures throughout this plan address the distribution of hazard events and other data by county, as decided by the SHMP Team.

2.3.1 Disaster Declarations and Emergency Declarations in Connecticut

Local and State governments share the responsibility for protecting their citizens from disaster impacts and supporting recovery. When a disaster is beyond the capabilities of the state and local government to respond, federal support may be available. In 1988, the Robert T. Stafford Disaster Relief and Emergency Assistance Act was enacted to support state and local governments and their citizens when disasters overwhelm them and exhaust their resources. This law, as amended, established a process for requesting and obtaining a Presidential disaster declaration, defines the type and scope of assistance available from the Federal government, and sets the conditions for obtaining that assistance.[8] Federal disasters and emergencies are:

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[7] FEMA, February 15, 2013.
[8] A Guide to the Disaster Declaration Process and Federal Disaster Assistance. FEMA March 4, 2008.

A Major Disaster can be declared by the President for any natural event, including any hurricane, tornado, storm, high water, wind-driven water, tidal wave, tsunami, earthquake, volcanic eruption, landslide, mudslide, snowstorm, or drought, or, regardless of cause, fire, flood, or explosion, that the President determines has caused damage of such severity that it is beyond the combined capabilities of state and local governments to respond. A major disaster declaration provides a wide range of federal assistance programs for individuals, families, households, and public infrastructure, including funds for both emergency and permanent work.

An Emergency Declaration is more limited in scope and without the long-term federal recovery programs of a Major Disaster Declaration. The President can declare an emergency for any occasion or instance when the President determines federal assistance is needed. Emergency declarations supplement State and local or Indian tribal government efforts in providing emergency services, such as the protection of lives, property, public health, and safety, or to lessen or avert the threat of a catastrophe in any part of the United States. The total amount of assistance provided for in a single emergency may not exceed $5 million.

Table 2-10 provides details of federally declared disasters from 1954 through 2018. The May 2018 declaration did not yet have funding approved as of October 2018.

Table 2-10: Federally Declared Disasters (1954 – July 2018) and Emergency Declarations (1978 – July 2018).

Disaster	Year	Incident Period	Disaster Types	Counties	IA $	PA $
DR-4385	2018	May 15	Severe Storms, Tornado, and Straight-line Winds	Fairfield, New Haven	TBD	TBD
DR-4213	2015	January 26-January 29	Severe winter storm and snow storm	New London, Tolland, Windham		$9.6M
DR-4106 EM-3361	2013	February 8-February 11	Severe winter storm and snow storm	All		$31.7M
DR-4087 EM-3353	2012	October 27-November 8	Hurricane	Litchfield, Fairfield, New Haven, Middlesex, New London, Windham, Tolland	$15.4M	$64.3M
DR-4046 EM-3342	2011	October 29-October 30	Severe Storm	Litchfield, Fairfield, New Haven, Middlesex,		$87.3M

				Windham, Tolland, Hartford		
DR-4023 EM-3331	2011	August 27-September 1	Tropical Storm/Hurricane	All	$9.5M	$43.0M
DR-1958	2011	January 11-January 12	Snowstorm	Fairfield, Hartford, Litchfield, New Haven, New London, Tolland	$5.3 M	$13.6M
DR-1904	2010	March 12-May 17	Severe Storms and Flooding	Fairfield, Middlesex, New London	$2.6 M	$8M
DR-1700	2007	April 15-April 27	Severe Storms and Flooding	Fairfield, Hartford, Litchfield, Middlesex, New London, New Haven, Windham		$4.9M
EM-3266	2006	February 11-February 12	Snow	Fairfield, Hartford, New Haven, Tolland, Windham		
EM-3200	2005	January 22-January 23	Snow	All		
DR-1619	2005	October 14-October 15	Severe Storms and Flooding	Litchfield, New London, Tolland, Windham		$3.7M
EM-3246	2005	August 29-October 1	Hurricane	All		
EM-3192	2003	December 5-December 7	Snow	Fairfield, Hartford, Litchfield, New Haven, New London, Tolland, Windham		
EM-3176	2003	February 17-February 18	Snow	All	$913K	
DR-1302	1999	September 16-September 21	Tropical Storm	Fairfield, Hartford, Litchfield		$1.9M
DR-1092	1996	January 7-January 13	Blizzard	Not listed		
EM-3098	1993	March 13-March 17	Severe Winds and Blizzard, Snowfall	Not listed		
DR-972	1992	December 10-December 13	Coastal Flooding, Winter Storm	Not listed		
DR-916	1991	19-Aug	Hurricane	Not listed		
DR-837	1989	10-Jul	Severe Storms, Tornadoes	Not listed		
DR-747	1985	27-Sep	Hurricane	Not listed		

DR-711	1984	May 27-June 2	Severe Storms, Flooding	Not listed		
DR-661	1982	14-Jun	Severe Storms, Flooding	Not listed		
DR-608	1979	4-Oct	Tornado, Severe Storms	Not listed		
EM-3060	1978	7-Feb	Blizzards and Snowstorms	Not listed		
DR-42	1955	20-Aug	Hurricane, Torrential Rain, Floods	Not listed		
DR-25	1954	17-Sep	Hurricane	Not listed		

Two major disasters occurred in Connecticut since the previous plan was updated. Additional information on declared disasters prior to 2013 is available in the hazard specific sections as well as in Appendix 2.

DR-4213: Winter Storm Juno, or the January 2015 North American blizzard was an intense storm event which dumped up to three feet of snow in some parts of New England. Connecticut residents were encouraged to leave work and shelter at home by Governor Dannel Malloy. On March 27, 2015, Governor Dannel P. Malloy requested a major disaster declaration due to a severe winter storm and snowstorm during the period of January 26-28, 2015. The Governor requested a declaration for Public Assistance, including snow assistance for four counties and Hazard Mitigation statewide. On April 8, 2015, President Obama declared that a major disaster existed. The declaration made Public Assistance requested by the Governor available to state and eligible local governments and certain private nonprofit organizations on a cost-sharing basis for emergency work and the repair or replacement of facilities damaged by the severe winter storm and snowstorm in New London, Tolland, and Windham Counties.

2.3.2 National Oceanic and Atmospheric Administration (NOAA) National Centers for Environmental Information (NCEI)

NCEI is composed of NOAA's three former data centers: the National Climatic Data Center, the National Geophysical Data Center, and the National Oceanographic Data Center. The NCEI Storm Events Database contains a record of storm occurrence and other significant weather phenomena having sufficient intensity to cause loss of life, injuries, significant property damage, and/or disruption to commerce. Efforts are made to collect the best available information, but because of time and resource constraints, information may be unverified by NOAA's National Weather Service (NWS). The NWS does not guarantee the accuracy or validity of the information. Although the historical records in the database often vary widely in the level of detail, the NWS does have a set of guidelines for use in the preparation of event descriptions that were followed in preparation of this hazard analysis.[9]

To compare NCEI data for the purpose of the updated HIRA, the county in which the event occurred was of primary interest. NCEI catalogues data in formats:

- **County Name** – Event listed as individual record for each county in which it occurred
- **Zone** – Event listed by the zone or multiple zones, which contain multiple counties.

In the absence of better data, it was decided to proceed with the records available in NCEI for these events. In most cases NCEI records for hurricane and wildfire are significant under-representations of past damage occurrences. Additional sources supplemented hazard sections and are referenced therein.

From 1950 through December 31, 2017, The NCEI records 5,015 severe weather events. Table 2-12 provides jurisdictional totals of severe weather events by jurisdiction. To accurately count the number of events occurring by county, the zonal data records were expanded into a set of specific county records, based on NCEI zone definitions. For example, the Northern Fairfield Zone and Southern Fairfield Zone were combined to create Fairfield County. During this process, the number of events and the losses associated with a storm event in zones were combined to represent the entire county.

It is important to note that one storm event often impacts multiple jurisdictions. The same storm event may be entered for each zone, meaning the process of combining zones may artificially increase the number of storm events per county. Individual storm events were also often counted in multiple counties. For this reason, total events by state are not included in data tables, and were instead calculated using Event IDs for a more accurate count. While NCEI has 5,015 event records for Connecticut from 1950 through 2017, there were only 1,962 distinct severe weather events. Table 2-11 provides the number of events per hazard for the state, based on this calculation using Event IDs.

The NCEI Storm Events Database provides information about events from 1950 to December 31st, 2017. Records for most weather events were reported starting in 1996, with the exception of tornado (reports date to 1950), thunderstorm winds (reports date to 1955), and hail (reports date to 1955).

Table 2-13 summarizes the total property losses recorded from all storm events. Damages were not duplicated across jurisdictions, so state totals for damages were included in tables throughout the plan. Since the 1950s, more than $1.8 billion (inflated to 2017 dollars) in property losses has been documented in the NCEI Storm Events Database. The majority of

[9] National Weather Service Instruction 10-1605. Operations and Services Performance: Storm Data Preparation Guide. August 17, 2007. Available at: http://www.nws.noaa.gov/directives/sym/pd01016005curr.pdf

documented damages are attributed to tornado events in Hartford and New Haven counties. Thunderstorms represent 54% of the events within the database, followed by Winter Weather (22%) and Flood (18%). Litchfield has experienced the most events for thunderstorms and winter weather. Fairfield has experienced the most flood events, with New Haven closely behind. No losses have been recorded for drought.

Records on hurricanes and wildfires were not complete in the NCEI, and have not been included in the following tables. Detailed information on the number and the history of hurricanes and wildfires is located in the hurricane and wildfire subsections of this chapter. Chapter 3 includes in-depth information on the NWS capabilities and state severe weather warning system.

Table 2-11 NCEI Total Storm Events by Hazard, 1950 - 2017 (Edited to Eliminate Duplicate Storm Event Records)*

Hazard	Number of Events
Drought	15
Flood	356
Thunderstorm	1,062
Tornado	92
Winter	432
Grand Total	1,962

**Note: NCEI Hurricane and Wildfire Data is incomplete and not used in this analysis. Please refer to the Hurricane and Wildfire Hazard subsections for datasets used in analysis.*

Table 2-12: NCEI Storm Events by County, 1950 - 2017*

County	Drought	Flood	Thunderstorms	Tornado	Winter Weather	County Total
Fairfield	6	128	527	19	183	339
Hartford	9	102	571	20	110	812
Litchfield	2	124	593	32	279	1,031
Middlesex	6	41	186	9	126	368
New Haven	6	123	424	18	168	739
New London	6	99	247	4	124	480
Tolland	9	14	250	11	102	386
Windham	7	13	199	3	96	318

**Note: Many NCEI severe weather events impact multiple counties, and are thus counted in each affected county. NCEI Hurricane and Wildfire Data is incomplete and was not included in this chart. Please refer to the Hurricane and Wildfire Hazard subsections for more details.*

Table 2-13: NCEI Total Property Losses by County, 1950 – 2017, Inflated to 2017 Dollars*

County	Flood	Thunderstorm	Tornado	Winter Weather	County Totals
Fairfield	$17,638,967	$14,535,986	$8,924,729	Not Available	$41,099,682
Hartford	$15,639,328	$7,583,758	$904,150,586	$30,343,304	$957,716,976
Litchfield	$4,072,509	$3,518,514	$106,087,265	$2,070,060	$115,748,348
Middlesex	$643,981	$1,058,327	$2,463,629	Not Available	$4,165,937
New Haven	$4,319,243	$3,346,215	$579,367,790	$4,021,960	$591,055,208
New London	$7,628,644	$3,088,788	Not Available	Not Available	$10,717,431
Tolland	$1,619,491	$2,386,188	$3,093,879	$9,146,488	$16,246,046
Windham	$953,070	$1,765,217	$5,802,369	$2,432,519	$10,953,175
Total	$52,515,233	$37,282,991	$1,609,890,248	$48,014,331	$1,747,702,803

**Note: There were no damages recorded from Drought. Hurricane and Wildfire Data is incomplete and was not included. Please refer to the Hurricane and Wildfire Hazard subsections for more details.*

2.4 Climate Change

Climate change is both a present threat and a slow-onset disaster. It acts as an amplifier of existing hazards. Extreme weather events have become more frequent over the past 40 to 50 years and the trend is projected to continue[10]. Current and projected elevations in sea

[10] Gutowski, W.J., G.C. Hegerl, G.J. Holland, T.R. Knutson, L.O. Mearns, R.J. Stouffer, P.J. Webster, M.F. Wehner, and F.W. Zwiers, 2008: Causes of observed changes in extremes and projections of future changes. In: Weather and Climate Extremes in a Changing Climate: Regions of Focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands [Karl, T.R., G.A. Meehl, C.D. Miller, S.J. Hassol, A.M. Waple, and W.L. Murray (eds.)]. Synthesis and Assessment Product 3.3. U.S. Climate Change Science Program, Washington, DC, pp. 81-116.

level, coupled with potentially higher hurricane wind speeds, rainfall intensity, and storm surges are expected to significantly harm coastal communities. More intense heat waves may mean more heat-related illnesses, droughts and wildfires. The plan update includes a brief discussion of how climate change might impact the frequency, intensity and distribution of specific hazards. New and updated analysis is ongoing and will continue to refine climate change projections which will be incorporated into future plan updates.

2.4.1 Climate Change Impacts

Global Trends

Global predicted future climate change is based on the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5). AR5 replaced the standards employed in previous reports with new scenarios called Representative Concentration Pathways (RCPs). There are four pathways: RCP8.5, RCP6, RCP4.5 and RCP2.6. The numbers refer to forcings for each RCP.[11] Climate scenarios have a common baseline period of 1986–2005, consistent with the 2006 start-point for the RCP scenarios.[12]

- RCP8.5 is characterized by increasing greenhouse gas emissions over time, leading to high greenhouse gas concentration levels.
- RCP6 is a stabilization scenario in which total radiative forcing is stabilized shortly after 2100, without overshoot, by the application of a range of technologies and strategies for reducing greenhouse gas emissions.
- RCP4.5 is a stabilization scenario in which total radiative forcing is stabilized shortly after 2100, without overshooting the long-run radiative forcing target level.
- RCP2.6 is representative of scenarios in the literature that lead to very low greenhouse gas concentration levels. It is a "peak-and-decline" scenario, where greenhouse gas emissions are reduced substantially over time.

Along with the RCP scenarios, the fifth phase of the Coupled Model Intercomparison Project (CMIP5) is used to assess climate models. CMIP5 promotes a standard set of model simulations to evaluate how realistic models are in simulating the recent past projecting future climate change on two time scales, and understanding the factors responsible for differences in model projections.[13] The research based on the phase five of CMIP dataset provided much of the new material underlying the IPCC Fifth Assessment Report (AR5).

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[11] Wayne, G. P. The Beginner's Guide to Representative Concentration Pathways. *Skeptical Science*, Version 1.0, 2013. https://www.skepticalscience.com/rcp.php [Accessed 12.02.2017].
[12] Intergovernmental Panel on Climate Change, Chapter 12: Long-term Climate Change: Projections, Commitments and Irreversibility: Collins, M., R. Knutti, J. Arblaster, J.-L. Dufresne, T. Fichefet, P. Friedlingstein, X. Gao, W.J. Gutowski, T. Johns, G. Krinner, M. Shongwe, C. Tebaldi, A.J. Weaver and M. Wehner, 2013: Long-term Climate Change: Projections, Commitments and Irreversibility. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
[13] Program For Climate Model Diagnosis and Intercomparison, "CMIP5 - Coupled Model Intercomparison Project Phase 5 – Overview" Accessed Feb 26 2018. https://cmip.llnl.gov/cmip5/

Based on these scenarios, AR5 predicts future changes in global temperature and precipitation. Particularly relevant to Connecticut are the following findings:[14]

- The CMIP5 ensemble projects increases in mean annual temperature over North America. The largest changes in mean annual temperature will occur over the high latitudes of the USA and Canada, including greater than 6°C change in the late-21st-century period in RCP8.5.
- There will be increases in the occurrence of extremely hot seasons over North America in early, middle, and late-21st-century periods. This will include greater than 50% of summers exceeding a mid-20th-century baseline throughout much of North America by the mid-21st-century.
- Almost all areas of North America will experience increases of at least 5°C in the warmest daily maximum temperature by the late-21st-century period in RCP8.5.
- The high-latitude areas of North America exhibit changes in mean annual precipitation, with increases occurring in the mid-21st-century period in RCP2.6 and becoming generally more widespread at higher emission scenarios.
- Almost all areas of North America will experience increases of 5 to 20% in the 20-year return value of extreme precipitation by the mid-21st-century period in RCP4.5, while most areas of the USA and Canada exhibit very likely increases of at least 5% in the maximum 5-day precipitation by the late-21st-century period in RCP8.5.

Regional Trends: The Northeastern US

Historical Temperature Data

Across the Northeastern US temperatures have generally remained above the 1901-1960 average, both annually and especially during the winter. Fifteen of the winters from 1992-2011 have been above average. There has been an increasing trend in the length of the freeze-free season since the mid-1980s, with the average season length during 1991-2010 being about 10 days longer than during 1961-1990. Overall warming is further evidenced by later ice-in dates on northeastern lakes, decreases in average snow depth, and an increase in the rate of sea-level rise along the coast.[15]

Historical Precipitation Data

Annual precipitation has varied over time, showing a clear shift towards greater variability and higher totals since 1970. The wettest year since 1895 was 2011, while the 2nd driest

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[14] Romero-Lankao, P., J.B. Smith, D.J. Davidson, N.S. Diffenbaugh, P.L. Kinney, P. Kirshen, P. Kovacs, and L. Villers Ruiz, 2014: North America. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1439-1498.

[15] Kunkel, K.E. Stevens, L.E. Stevens, S.E. Sun, L. Janssen, E. Wuebbles, D. Rennells, J. DeGaetano, and A. Dobson, J.G. (2013). *Regional Climate Trends and Scenarios for the U.S. National Climate Assessment: Part 1. Climate of the Northeast U.S. NOAA Technical Report NESDIS 142-1* (United States, National Oceanic and Atmospheric Administration, National Environmental Satellite, Data, and Information Service). Washington, D.C. https://www.nesdis.noaa.gov/sites/default/files/asset/document/NOAA_NESDIS_Tech_Report_142-1-Climate_of_the_Northeast_US.pdf

year occurred in 1996. The 1960s were characterized by a very severe, long-term drought that was particularly intense in the New England region, where it spanned almost the entire decade. The Northeast's three driest years were 1930, 1941, and 1965. The two wettest summers on record occurred in 2006 and 2009.[16] "The Northeast has experienced a greater recent increase in extreme precipitation than any other regions in the United States; between 1958 and 2010, the Northeast saw more than a 70% increase in the amount of precipitation falling in very heavy events (defined as the heaviest 15 of all daily events)."[17]

Historical Sea Level Rise

Over the past thousand years, regional sea level has risen at a rate of 0.34 to 0.43 inch per decade. More recently, the rate of sea level rise along the Northeast Coast has increased. On average during the 20th century, sea level rose by 1.2 inches per decade. This reflects the increase in ocean water volume as the oceans warm, as well as the melting of glaciers and ice sheets and changes in Atlantic Ocean circulation.[18] This rate of sea level rise exceeds the global average, due primarily to land subsidence, and has caused an increase in coastal flooding in the Northeast.[19]

Temperature Predictions

The northeast will experience an increase in mean temperatures, with little spatial variation. In the near future, changes in temperature vary little between low and high emission scenarios, but later in the 21st century the high emission scenario indicated nearly twice the amount of warming. Throughout the region, the number of days above 95ºF will increase and the number of days below 10ºF will decrease. The mean freeze-free period is expected to increase by 26 days. The largest temperature changes will occur in the north of the region, and the smallest changes will occur in coastal and southern areas. Seasonal changes show more spatial variability, with winter temperature increases ranging from 4.0ºF in the southwestern part of the region to 6.0ºF in the north.[20]

Precipitation Predictions

Models indicate that precipitation will increase across the entire Northeastern US. All areas will experience increases in the number of days with precipitation exceeding 1 inch, with parts of New York experiencing up to 30% increases. The smallest simulated increases of 9 to 12% are mainly in coastal regions. Between 2000 and 2055, the number of consecutive days with precipitation less than 0.1 inches is expected to see small increases or no change. The far northern regions show the largest simulated increases in mean

[16] Kunkel et al. (NOAA Report)
[17] From Climate Change Impacts in the United States, Chapter 16: Northeast
[18] Kunkel et al. (NOAA Report)
[19] From Climate Change Impacts in the United States, Chapter 16: Northeast
[20] Kunkel et al. (NOAA Report)

precipitation while southern and coastal areas show less of an increase. This gradient increases in magnitude as time progresses, particularly for high emission scenarios.[21]

Impacts on the Northeast

The Climate Change Impacts in the United States study on the Northeastern US identifies four main takeaways to be considered in future planning[22]:

1. Heat waves, coastal flooding, and river flooding will pose a growing challenge to the region's environmental, social, and economic systems. This will increase the vulnerability of the region's residents, especially its most disadvantaged populations.
2. Infrastructure will be increasingly compromised by climate-related hazards, including sea level rise, coastal flooding, and intense precipitation events.
3. Agriculture, fisheries, and ecosystems will be increasingly compromised over the next century by climate change impacts. Farmers can explore new crop options, but these adaptations are not cost- or risk-free. Moreover, adaptive capacity, which varies throughout the region, could be overwhelmed by a changing climate.
4. While a majority of states and a rapidly growing number of municipalities have begun to incorporate the risk of climate change into their planning activities, implementation of adaptation measures is still at early stages."

Local Trends: Impacts on Connecticut

The Connecticut State Water Plan provides local climate change predictions. Future climate scenarios for the state were developed using a combination of state-of-the-art climate models and historically available climate observations, centered on a 2080 planning horizon. Future climate projections for the state have been summarized using global climate model (GCM) projection data sets, with projections developed under the World Climate Research Programme Coupled Model Intercomparison Project, Phase 5 (CMIP5). Climate model data were pooled into four different ensembles, each of which is used to develop different future climate scenarios. All 110 GCM projections, downscaled to an area representing Connecticut, are represented in these scenarios:

- Hot/Dry: 50th to 100th percentile Temp, 0 to 50th percentile Precipitation
- Hot/Wet: 50th to 100th percentiles Temp and Precipitation
- Warm/Wet: 0 to 50th percentile Temp, 50th to 100th percentile Precipitation
- Warm/Dry: 0 to 50th percentile Temp and Precipitation

The results of this analysis showed that Connecticut will experience a hotter and wetter future. Both summer and winter temperatures are projected to increase by similar amounts, and a similar shift is observed for both extreme cold and extreme hot months. Precipitation projections are more variable, although consistently projecting a generally wetter future for all four scenarios. The largest precipitation increases are projected for the wetter months, including extreme wet months. Winter and spring precipitation changes are

[21] Kunkel et al. (NOAA Report)
[22] From Climate Change Impacts in the United States, Chapter 16: Northeast

projected to be larger than summer and autumn changes. Drier months are generally projected to remain about the same in terms of both frequency and rainfall level. Small decreases in extreme dry month precipitation are projected for the "hot/dry" scenario.23

Impacts: Water Systems

Implied by these results is the potential for decreased water availability due to significantly higher temperatures and evapotranspiration losses. However, clearly this dynamic would be offset to a certain extent by increased rainfall. The analysis does not explicitly project changes in the distribution of rainfall on an event basis, which could affect flooding potential and also the frequency and intensity of summer droughts. However, typical climate forecasts tend to suggest that increased temperatures coupled with increased annual precipitation generally correspond to higher intensity storms (greater flood risk) and longer dry periods in the summer months (more frequent and/or intense droughts). Because Connecticut has so many small reservoir systems, these systems could be very sensitive to such changes, and case study examples may be advisable in the next phase of work.

Demands could similarly be impacted, with increasing demands due to higher temperatures, but with changes tempered by increased rainfall. The timing of water availability and stream flows will also undoubtedly be impacted, with less snow pack and earlier melt. The combination of potential rapid snow melt and higher extreme precipitation events could translate to an increased flooding risk. Lastly, river water quality could be negatively impacted by the higher temperatures; higher water temperatures can lead to increased growth rates of both algae and bacteria, and lower dissolved oxygen saturation levels.[24]

Impacts: Sea Level Rise and Coastal Flooding

Coastal cities and towns will become more vulnerable to storms in the coming century as sea level rises, shorelines erode, and storm surges become higher. Rising sea level erodes wetlands and beaches, reducing their mitigating effect on coastal storms. Infill and shoreline development further reduce the capacity of natural coastlines to reduce storm surges and impacts of sea level rise. With less natural protection, coastal communities are more vulnerable to the impacts of climate change.

Storms can destroy coastal homes, wash out highways and rail lines, and damage essential communication, energy, and wastewater management infrastructure."[25] The infrastructure planning areas determined to be the most impacted by climate change were coastal flood control and protection, dams and levees, stormwater, transportation and facilities and buildings. Damage to these assets could cause substantial structural and economic

[23] All above text from CT State Water Plan (http://www.ct.gov/water/site/default.asp)
[24] All above text from CT State Water Plan (http://www.ct.gov/water/site/default.asp)
[25] EPA 2016 Report: What Climate Change Means for Connecticut (https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-ct.pdf)

damage.[26] Connecticut is particularly vulnerable to these effects, as a large portion of transportation infrastructure and population centers are located in coastal areas.

Impacts: Ecosystems

Ecological habitats at the highest risk from climate change are Cold Water Streams, Tidal Marsh, Open Water Marine, Beaches and Dunes, Freshwater Wetlands, Offshore Islands, Major Rivers, and Forested Swamps. While the degree of impact will vary, likely changes include conversion of rare habitat types (e.g., cold water to warm water streams, tidal marsh and offshore islands to submerged lands), loss and/or replacement of critical species dependent on select habitats, and the increased susceptibility of habitats to other on-going threats (e.g., fragmentation, degradation and loss due to irresponsible land use management, establishment of invasive species).[27]

Tidal wetlands are particularly vulnerable to sea level rise because of their low elevations, and shoreline development prevents them from migrating inland onto higher ground. Human activities such as filling wetlands have destroyed about one third of New England's coastal wetlands since the early 1800s.[28] Wetlands provide habitat for many bird and fish species, regulate water flows and sediment discharge, and are important environments for nutrient cycling.

Climate change also threatens ecosystems by disrupting relationships between species. Wildflowers and woody perennials are blooming—and migratory birds are arriving— sooner in spring. Not all species adjust in the same way, however, so the food that one species needs may no longer be available when that species arrives on its migration. Warmer temperatures allow deer populations to increase, leading to a loss of forest underbrush, which makes some animals more vulnerable to predators. Rising temperatures also enable invasive species to move into areas that were previously too cold.[29]

Impacts: Agriculture

Most of Connecticut's agricultural features are highly and negatively impacted by climate change. The top five most imperiled agricultural sectors are maple syrup, dairy, warm weather produce, shellfish and apple and pear production.[30] Warmer temperatures cause cows to eat less and produce less milk. This could reduce the output of Connecticut's $70-million dairy industry, which provides 13 percent of the state's farm revenue. Some farms may be harmed if more hot days and droughts reduce crop yields, or if more flooding and

[26] Climate Change Connecticut Report: The Impacts of Climate Change on Connecticut Agriculture, Infrastructure, Natural Resources and Public Health (http://www.ct.gov/deep/lib/deep/climatechange/impactsofclimatechange.pdf)
[27] Climate Change Connecticut Report: The Impacts of Climate Change on Connecticut Agriculture, Infrastructure, Natural Resources and Public Health (http://www.ct.gov/deep/lib/deep/climatechange/impactsofclimatechange.pdf)
[28] EPA 2016 Report: What Climate Change Means for Connecticut (https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-ct.pdf)
[29] EPA 2016 Report: What Climate Change Means for Connecticut (https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-ct.pdf)
[30] Climate Change Connecticut Report: The Impacts of Climate Change on Connecticut Agriculture, Infrastructure, Natural Resources and Public Health (http://www.ct.gov/deep/lib/deep/climatechange/impactsofclimatechange.pdf)

wetter springs delay their planting dates. While most climate change impacts are negative, some farms may benefit from a longer growing season and the fertilizing effect of carbon dioxide.[31] Climate change may also allow for production expansion opportunities, including biofuel crops, witch hazel, and grapes.[32]

Impacts: Human Health

Changes in temperature and precipitation could increase the incidence of acute and chronic respiratory conditions such as asthma. Higher temperatures can increase the formation of ground-level ozone (smog), a pollutant that can contribute to respiratory problems. Extreme heat events will increase heat-induced ailments, especially in those populations who do not have the benefit of air conditioning.[33] Rising temperatures may also increase the length and severity of the pollen season for plants such as ragweed—which has already been observed in other regions. Certain populations are especially vulnerable to these effects, including children, the elderly, the sick, and the poor. [34]

Climate change may increase the risk of some diseases carried by insects, by altering ecosystems in a way that favors increased vector survival, replication, biting frequency, and geographic range.[35] The ticks that transmit Lyme disease are active when temperatures are above 45°F, so warmer winters could lengthen the season during which ticks can become infected or people can be exposed to the ticks. Higher temperatures would also make more of New England warm enough for the Asian tiger mosquito, a common carrier of West Nile virus. The number of cases may or may not increase, depending on what people do to control insect populations and avoid insect bites."[36]

Climate change will impact public health infrastructure including hospitals, health departments, emergency medical services, private practices and shelters. These impacts may be due to extreme weather events or increased use of resources to treat and shelter victims. Specifically, environmental justice communities may be most impacted by the lack access to adequate public health infrastructure, including shelter or evacuation transportation. [37]

2.4.2 Connecticut's Climate Change Initiatives

[31] EPA 2016 Report: What Climate Change Means for Connecticut (https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-ct.pdf)
[32] Climate Change Connecticut Report: The Impacts of Climate Change on Connecticut Agriculture, Infrastructure, Natural Resources and Public Health (http://www.ct.gov/deep/lib/deep/climatechange/impactsofclimatechange.pdf)
[33] Climate Change Connecticut Report: The Impacts of Climate Change on Connecticut Agriculture, Infrastructure, Natural Resources and Public Health (http://www.ct.gov/deep/lib/deep/climatechange/impactsofclimatechange.pdf)
[34] EPA 2016 Report: What Climate Change Means for Connecticut (https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-ct.pdf)
[35] Climate Change Connecticut Report: The Impacts of Climate Change on Connecticut Agriculture, Infrastructure, Natural Resources and Public Health (http://www.ct.gov/deep/lib/deep/climatechange/impactsofclimatechange.pdf)
[36] EPA 2016 Report: What Climate Change Means for Connecticut (https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-ct.pdf)
[37] Climate Change Connecticut Report: The Impacts of Climate Change on Connecticut Agriculture, Infrastructure, Natural Resources and Public Health (http://www.ct.gov/deep/lib/deep/climatechange/impactsofclimatechange.pdf)

Connecticut has a variety of regulations and organizations dedicated to addressing climate change and its impacts. While Chapter 3 outlines in detail the significant progress made by regulations, state committees and tasks forces, and external organizations, Section 2.4.2 provides a brief overview of Connecticut's action on climate change:

The Adaption Subcommittee of the Governor's Steering Committee on Climate Change was formed in 2008 and was charged with the assessment of the impacts of climate change on Connecticut infrastructure, natural resources and ecological habitats, public health, and agriculture; and recommendation of adaptation strategies in accordance with the requirements of Public Act 08-98.

Pursuant to Special Act 13-9, "An Act Concerning Climate Change and Data Collection," the State of Connecticut established the Connecticut Institute for Resilience and Climate Adaptation (CIRCA). CIRCA was established in partnership with DEEP, the former OLISP, and the University of Connecticut. CIRCA is a multi-disciplinary, center of excellence that brings together experts in the natural sciences, engineering, economics, political science, finance, and law to provide practical solutions to problems arising as a result of a changing climate. The Institute helps coastal and inland floodplain communities in Connecticut better adapt to changes in climate and also make their human-built infrastructure more resilient while protecting valuable ecosystems and the services they offer to human society. CIRCA runs a Municipal Resilience Grant Program, which helps municipal governments and councils of government with initiatives that advance resilience.

During 2012 the Connecticut General Assembly passed Public Act 12-101, An Act Concerning the Coastal Management Act and Shoreline Flood and Erosion Control Structures. This legislation combined a number of initiatives to address sea level rise and to revise the regulatory procedures applicable to shoreline protection. Through this Act, the concept of sea level rise was incorporated into the Connecticut Coastal Management Act (CCMA)'s general goals and policies of coastal planning for the very first time

An Act Concerning the Permitting of Certain Coastal Structures by the Department of Energy and Environmental Protection (Public Act 13-179) clarifies several Connecticut statutes by making reference to the NOAA sea level rise discussions in Technical Report OAR CPO-1 (Global Sea Level Rise Scenarios for the United States National Climate Assessment, December 6, 2012). The Act also states that municipalities shall consider sea level rise when developing Plans of Conservation and Development, evacuation plan, or hazard mitigation plan.

An Act Concerning Sea Level Rise and the Funding of Projects by the Clean Water Fund (Public Act 13-15) allows DEEP to maintain a priority list of eligible water quality projects and established a system setting priority for making project grants, grant account loans and project loans. This law essentially incorporates climate change planning into funding of wastewater (sanitary sewer system and sewage treatment) projects.

Executive Order 46 (2015): Established a Governor's Council on Climate Change to monitor the state's greenhouse gas emissions and make recommendations to meet the 2050 GWSA target.

Executive Order 50 (2015): Establishes the State Agencies Fostering Resilience (SAFR) Council, which is responsible for strengthening the state's resiliency from extreme weather events, including tropical storms, hurricanes, storm surges, flooding, ice storms, extreme high winds, extreme heat, and slow onset events such as sea level rise. The "SAFR Council" is responsible for working to create a Statewide Resilience Roadmap based on the best climate impact research and data and assisting OPM in the creation of a State policy on disaster resilience. SAFR interacts with CIRCA and will be involved with the NDRC-funded planning in the coming years.

DEEP's Land and Water Resources Division has taken on the responsibilities of the former Office of Long Island Sound Programs (OLISP), which administered Connecticut's Coastal Management Program. The program is approved by NOAA under the federal Coastal Zone Management Act, and has many responsibilities including the protection of natural shoreline sedimentation and erosion processes, discouraging hard shoreline flood and erosion control structures, creating tools for assorted sea level rise scenarios, and providing guidance in coastal and climate resilience. Formerly, the Office of Long Island Sound Programs ran a number of workshops for climate change adaptation and created the Climate Adaptation Resources Toolkit (CART). The CART is a tool for one stop shopping for climate adaptation tools, resources and strategies for Connecticut communities.

The State Water Plan (2018) includes a climate change analysis that projects an increase in temperature for all calendar months and generally increased precipitation. The largest precipitation increases are projected for the wetter months, and winter and spring precipitation changes are projected to be larger than summer and autumn changes. Drier months are generally projected to remain about the same in terms of both frequency and rainfall level. Based on these results, the State Water Plan recognizes the potential for decreased water availability due to significantly higher temperatures and evapotranspiration losses, as well as the possibility that this dynamic could be offset to a certain extent by increased rainfall. The plan also acknowledges that increased temperatures coupled with increased annual precipitation generally corresponds to higher intensity storms (greater flood risk) and longer dry periods in the summer months (more frequent and/or intense droughts).

The Connecticut Green Bank is the nation's first green bank. Established by the Connecticut General Assembly on July 1, 2011 as a part of Public Act 11-80, Connecticut Green Bank supports the Governor's and Legislature's energy strategy to achieve cleaner, less expensive, and more reliable sources of energy while creating jobs and supporting local economic development. Since its inception, the Connecticut Green Bank and its private investment partners have deployed over a $1 billion in capital for clean energy projects across the state. Projects recorded through fiscal year 2016 show that for every $1 of public funds committed by the Green Bank that an additional $6 in private investment occurred in the economy.

National Disaster Resilience Program Winner: The U.S. Department of Housing and Urban Development (HUD) and the Rockefeller Foundation funded a $1 billion design competition for resilient housing and infrastructure projects. Connecticut was one of 13 winners, receiving $54,277,359 to support a pilot program in Bridgeport that is part of the broader Connecticut Connections Coastal Resilience Plan. The Coastal Resilience Plan is focused on reconnecting and protecting economically-isolated coastal neighborhoods through investments in mixed green and gray infrastructure that protect against flooding while strengthening their connectivity to existing transportation nodes.

The University of Connecticut's Center for Land Use Education and Research (CLEAR) provides information, education, and assistance to land use decision makers in support of balancing growth and natural resource protection. Their Climate Adaptation Academy (CAA) is a partnership between Connecticut Sea Grant and CLEAR to allow researchers, consultants, and others to work with municipalities and relevant professionals on climate adaptation. This program provides specialized training, such as the "Climate Adaptation Training for Coastal Communities."

Sustainable CT is a partnership of municipal leaders, residents, the Connecticut Conference of Municipalities, and people from key agencies, non-profits and businesses. The Institute for Sustainable Energy at Eastern Connecticut State University is coordinating and supporting the initiative. Sustainable CT seeks to help cities and towns across the state become more vibrant, healthy, resilient and thriving places for all of their residents. All of Connecticut's 169 towns and cities have been represented in Sustainable CT's development in some way.

2.4.3 Local and Regional Climate Adaptation Planning

DEEP has a Municipal Climate Change Network of towns and state staff who are moving forward with cutting edge climate efforts, and a Connecticut Climate Education Communication Committee which is a varied group of educators from the private, public, and academic sector who meet virtually or in person every month to keep informed on best available science and educational practices. CHAMP is a Coastal Hazards and Management Planning section of the DEEP website that allows selection of inundation from Sea Level Rise scenarios for all Connecticut towns. The website also provides information on how to take action and can be accessed at:
http://www.ct.gov/dep/cwp/view.asp?a=2705&q=480750&depNav_GID=2022

The Sentinel Monitoring for Climate Change in Long Island Sound Program is a multidisciplinary scientific approach to provide early warning of climate change impacts to Long Island Sound (LIS) ecosystems, species and processes to facilitate appropriate and timely management decisions and adaptation responses. Current program successes include a strategic plan outlining key attributes of a sentinel and identifying 17 priority and 37 candidate sentinels for the LIS ecosystem, a website and a searchable data citation clearinghouse with links to all known LIS sentinel related data sets and local researchers, and funding for two pilot monitoring programs and a data synthesis grant that are currently underway. With a scaled up Sentinel Monitoring program, Connecticut and regional efforts can be leveraged to support key monitoring for discernible climate signals and impacts, as well as inform adaptation strategies to keep our ocean and coastal resources as healthy as possible.

New England has received numerous NOAA Grants to "accelerate the pace of municipal response to coastal climate change," Connecticut was the only state to have more than one town selected for funding of adaptation projects: Guilford for workshops/town plan and Greenwich is mapping for enhanced emergency response.

The Connecticut Adaptation Resource Toolkit (CART) was developed by the Connecticut Department of Energy and Environmental Protection and ICLEI-Local Governments for Sustainability USA (ICLEI USA) with funding from the US Environmental Protection Agency's (US EPA) Climate Ready Estuaries through the Long Island Sound Study, a national estuary program. The CART is a tool for centralized climate adaptation tools, resources and strategies for Connecticut communities It is searchable by profession type, resource type (funding, legal, education, communication tools) as well as where you are in the climate action and planning process.

The Connecticut Geological Survey has prepared digital geologic and soils data for hazards assessments and analyses through cooperative efforts with the Natural Resources Conservation Service and the U.S. Geological Survey. This data supports agency assessments of inland and coastal flooding, shoreline erosion, and sea level rise. Information for these sources have been used in the risk assessment.

2.5 Local Plan Hazard Identification and Integration

Chapter 5 describes Local Planning Coordination in detail. Local plan hazard identification, risk assessment, potential losses, and land use derived from the 173[38] communities that have developed hazard mitigation plans follows. The most current plan document for each community was used, in some cases including drafts or expired plans. Most of the community plans are multi-jurisdictional plans developed by regional planning organizations (RPO), with the remainder being developed by and for individual communities.

2.5.1 Local Hazard Identification

[38] Connecticut has 169 municipalities; the additional four communities include the two tribal governments and the political subdivisions of Groton, Stonington, and Fenwick

Local plans and multi-jurisdiction plan annexes identified 24 distinct hazards, although not all hazards were identified in every plan. Communities used a variety of approaches with a range of complexity to rank their identified hazards. Some plans used a blend of various techniques and discussion to determine final hazard ranking. Ranking/scoring techniques used in the local plans included:

- Quantitative scoring (based on available historical data, i.e. NCEI
- Human judgment/knowledge of locality
- Numerical Scoring Worksheets (based on criteria, i.e. FEMA 386-2 worksheets)
- Interactive activities with Steering Committee Members

FEMA guidance indicates that the jurisdictions at greatest risk to specific hazards should be identified, considering both the characteristics of the hazard and the jurisdictions' degree of vulnerability. A variety of analysis methods may be sufficient to meet these goals; FEMA does not mandate a specific analysis method. As a result, many local and state plans have developed their own ranking system. None of the ranking techniques used in the local plans is incorrect, as there is no standard way to rank hazards that impact specific jurisdictions. Lack of available data for each hazard is often a driving factor in the ranking method's degree of subjectivity. The numerical rankings were frequently performed by different plan preparers, and different data processing methodologies were used. The variability in the ranking systems made it challenging to directly compare local hazard rankings to the state risk assessment.

Instead, the qualitative risk assessment information in local plans was used as a component of the composite ranking maps as discussed in the Hazard Assessment and Ranking Methodology section of this chapter. Some plans provided a direct ranking of hazards by overall risk from low to high, while others only offered general information about hazard risk. In the latter case, a ranking was assumed based on the information provided. Table 2-14 ranks each hazard based on the number of localities that ranked the hazard as High, Moderate-High, Moderate, Low-Moderate, or Low. A score of one to five was assigned to each local plan hazard ranking (one being for low rank and five being for high rank), with a total score determined based on the mean of the individual ranks. Several local plans include hazard discussion but did not qualitatively rank them; as a result these hazards were assigned rankings based on how they were described in detail in the local plans. It is important to note that a score can be high for a particular hazard even when only a handful of communities are at risk. One example is Coastal Flooding and Storm Surge, which is evaluated in only 33 coastal communities. A high score of 3.98 is possible because the total value it is dependent only on the rankings within local plans that include the hazard, rather than the score becoming diluted by averaging across all Connecticut communities. One way to approach the overall risk score is as a measure of the risk that hazard poses to a community if it poses a hazard at all. The "Weighted Score" in Table 2-14 accounts for the number of local plans that address each hazard. This index recalculates the risk score after assigning a score of zero to a hazard in an individual plan ranking if it is not addressed in that plan. Additional details on the local plan review, hazards assessed, loss estimation and tracking information, are available in Appendix 4.

Table 2-14. Local Hazard Mitigation Plan Results of Hazard Identification

Hazard	Overall Ranking	Overall Score	Number of Local Plans	Weighted Score
Dam or Levee Failure	M	3.13	167	3.02
Drought	L-M	1.61	150	1.40
Earthquake	L-M	1.86	172	1.85
Erosion	L-M	1.85	48	0.51
Extreme Cold	M	3.00	29	0.50
Extreme Heat	M	2.82	33	0.54
Flood, Coastal & Storm Surge	M-H	3.98	40	0.92
Flood, Flash	M-H	4.38	26	0.66
Flood, Poor Drainage	M	3.36	78	1.51
Flood, Riverine	M-H	4.12	171	4.07
Hail	M	2.50	98	1.42
Hurricane	M-H	4.44	163	4.18
Ice	M-H	4.23	81	1.98
Ice Jam & Associated Flooding	L-M	1.95	22	0.25
Landslide & Mudflow	L-M	2.08	12	0.14
Land Subsidence & Sinkholes	L-M	2.33	3	0.04
Lightning	M-H	3.62	98	2.05
Sea Level Rise	M	3.03	34	0.60
Thunderstorms (Summer Storms)	M-H	4.38	124	3.14
Tornado	M	2.59	165	2.47
Tsunami	M	2.60	10	0.15
Wildfire	L-M	1.93	147	1.64
Wind	M-H	4.44	99	2.54
Winter Storm / Snow / Blizzard	H	4.90	173	4.90

Winter storms, earthquakes, and riverine floods are directly addressed and evaluated in the greatest number of local plans and multi-jurisdiction plan annexes (173, 172, and 171, respectively – there are 173 available plans and annexes). Dam or Levee Failure, Hurricanes, and Tornadoes are addressed in most plans (167, 163, 165, respectively), as are Wildfires and Thunderstorms (147 and 124, respectively). Interestingly, drought is addressed in 150 plans, despite the fact that it was consistently rated as a low risk hazard. Wildfire is addressed and assigned a low risk ranking in most plans obscuring its high ranking in only a small number of local plans. Lightning, Hail and wind are addressed, either separately or within other hazards like Hurricanes and Thunderstorms in more than half the local plans (98 and 99, respectively).Land subsidence and sinkholes are addressed in only three local plans (Cheshire, New Haven, and Sharon). Tsunami was addressed in ten coastal plans, and landslides were evaluated in twelve plans for communities located primarily the Naugatuck Valley where old mill towns were developed on steep slopes flanking river valleys. The range of the possible "overall score" is one to five. Seven hazards scored greater than 4.0. These include flash floods, riverine floods, hurricanes, ice events, thunderstorms, wind events, and winter storms. Importantly, coastal flooding is addressed in a number of non-coastal community local plans, meaning a falsely low risk score was assigned. Despite this the coastal flooding overall risk score is relatively high (3.98). When considering hazards statewide, accounting for the number of local plans that don't consider a particular hazard, the highest ranked hazards are Winter Storms, Hurricanes, and Riverine Flood ("Weighted Score"). Considered collectively, it is clear that floods of all types, high wind events, and winter storms are of great concern to local communities. Several of the hazard categories that were addressed in the local plans are not subject to detailed analysis in this State plan update. Of the hazards considered in this update, average rankings in local and state analysis are comparable. Future local plan updates present an opportunity to address some of the ambiguity between hazard naming conventions if the State of Connecticut standardizes applicable hazard names or labeling. The State may encourage local plan revisions to approach classifying hazards in a similar fashion as done in the HIRA in this State plan update.

2.5.2 Local Plan Assessment of Potential Losses

Local hazard evaluations are highly variable. As a result, each one has its own set of criteria to develop monetary loss estimates. Many of the first-generation local plans and annexes contained loss estimates only from previous damage events, while plans developed after 2010 included FEMA's Hazus program model runs that predicted flooding, hurricane wind, and earthquake scenario events and damages. By late 2018 most local plans and annexes include Hazus results. Table 2-15 and Table 2-16 summarize loss estimates extracted from each local plan or annex.

Table 2-15 lists annualized loss estimates, which local plans calculated either using Hazus software, through analysis of historic event losses and frequencies, by looking at relevant annual municipal budgets, or through estimation. Average loss value provided is for a single community. Loss estimates have not been adjusted to account for inflation.

Table 2-15. Local Plan Annualized Loss Estimates by Hazard Type.

Hazard	Average	Number of Plans with Loss Estimates
Coastal	$470,120	7
Riverine	$118,742	16
Drought	$2,400	1
Dam Fail	$3,550	3
Earthquake	N/A	0
Hailstorm	N/A	0
Hurricane	N/A	0
Thunderstorm	$7,512	42
Wildfire	$8,699	13
Wind	$57,250	10
Winter Storm	$544,707	83
Tornado	$1,612	23

Table 2-16 lists loss estimates for other hazards. These were calculated using various methods and present losses for hazards of a variety of return periods. The "Methods" column summarizes both the loss calculation methodology and the return period as applicable. Average loss value provided is for a single community. Loss estimates have not been adjusted to account for inflation.

Table 2-16. Local Plan Other Loss Estimates by Hazard Type.

Hazard	Method	Average	Number of Plans with Loss Estimates
Coastal Flood	Hazus: 1% Chance Flood	$238,150,654	26
	Specific Event*	$1,295,000	1
	Total FEMA Reimbursement**	$5,849,822	12
	Average Coastal Flood	$81,765,159	-
Riverine Flood	Hazus 1% Chance Flood	$45,073,650	168
	Specific Event*	$6,460,550	38
	10% of SFHA Property Value	$292,900,000	2
	Total FEMA Reimbursement**	$1,035,458	40
	NFIP Policy Value	$13,064,233	9
	Average Inland Flood	$71,706,778	-
Drought	Specific Event*	$62,000	2
Dam Failure	Hazus***	$50,519,167	12
	Property Value***	$183,092,625	4
	Historic/Reported	$12,397,892	13
	Average Dam Failure	$82,003,228	-
Earthquake	Hazus: Worst-Case****	$401,834,841	138
Hailstorm	Specific Event*	$2,728	12
Hurricane	Hazus: 50 Year	$2,319,091	16
	Hazus: 100 Year	$18,082,460	145
	Hazus: 500 Year	$89,346,372	80
	Hazus: 1938/Cat. 3	$45,512,903	25
	Specific Event*	$9,870,849	11
Thunderstorm	None	-	0
Wildfire	None	-	0
Wind	None	-	0
Winter Storm	Specific Event*	$244,445	16
Tornado	Specific Event*	$1,682,920	30
	Specific Event* (Estimate)	$5,000,000	11
	Average Tornado	$3,341,460	-

** Specific Event: losses from specific historic events were provided. Different communities provided losses from different events, and some plans provided losses from multiple events; in the latter case, losses were averaged.*
*** Total FEMA Reimbursement: includes all PA and NFIP reimbursements provided since community joined the program*
**** Dam failure losses calculated using HAZUS flood modeling or through property value estimation utilized either the 0.2% flood zone, the 1% flood zone, or calculated dam failure inundation areas.*
***** Some plans ran HAZUS for multiple earthquake scenarios; the worst-case scenario for each community was extracted for this summary.*

One continued goal of the State plan update is to standardize the data analysis process so that future state and local plan updates are consistent and comparable, including recommendations for assigning annualized loss estimates for hazards not included in the Hazus software. Chapter 6 includes the relevant actions to reach this goal. Analysis in local plans has improved since the last State plan update, with every local plan providing at least one loss estimate, and many plans using comparable loss estimate methodologies.

2.5.3 Local Land Use

Most of the local hazard mitigation plans include a general overview of land uses and development trends. Each local hazard mitigation plan was reviewed for information on local trends. Detailed information pulled from each local plan is available in Appendix 4. The majority of the plans land use and development included population and the 2006 CLEAR data, similar to what is presented in Section 2.2.4 of this chapter.

A review of land use from the local hazard mitigation plans presents a closer look at where development is occurring across the state. Although Tolland and Windham Counties have largely remained rural, many of the other counties have seen recent development and may continue to see increased development.

Many communities in Fairfield County are projecting continued growth near Metro-North stations, including Darien, Greenwich, New Canaan, Norwalk, Stamford, Weston and Westport. Additionally, there is growth in many towns including Easton and Fairfield. Although towns such as Fairfield are limiting development in natural hazard areas like the coast and the Town of Monroe is considering designation of open space areas. Other communities, like the Town of Stratford, have indicated that growth has been directed to former industrial areas that are located within the coastal flood hazard area.

Local comprehensive plans were also referenced by several local hazard mitigation plans. It is important to combine the comprehensive plan data with hazard mitigation information so that the best information informs land use decisions that encourage resiliency.

2.6 Public Survey Results

2.6.1 2019 Plan Public Survey

For the 2019 plan update, a survey was developed to solicit input from the public on local mitigation activities and strategies. The survey was opened and posted online in May 2018 and closed in July 2018.

The hazards with the highest level of concern were winter storms and blizzards, hurricanes and tropical storms, and severe thunderstorms. Climate change was the fourth highest concern despite few respondents feeling they have already been impacted by it. The top two state actions to help communities prepare for a disaster were

- Provide technical assistance to residents, businesses and organizations to help them reduce losses from hazards and disasters; and
- Help improve warning and response systems to improve disaster management.

The most important action local communities can take according to respondents is to provide outreach and education to residents, businesses, and organizations to help them understand risks and be prepared. Further details and analysis from the public survey are provided in Section 1.10.1 of this plan.

2.6.2 2013 Plan Public Survey

For the 2013 plan update, public participation was also gathered though an internet-based survey. Survey questions related to hazard identification and recent hazards events. Several important messages were provided by the survey responders. With equal emphasis, the top two messages are to:

- Address wind and snow damage to electrical lines that results in power outages, and
- Manage flood risk zones to reduce flood damage.

Responders would like the state, municipalities, and utilities to address wind and snow damage to electrical lines by requiring, facilitating, funding, encouraging, or accomplishing trimming of tree limbs, removal of trees, burying power lines, hardening power lines, and creation of microgrids and other redundancies. Responders would like the State and its municipalities to remove structures from flood zones, prevent new buildings in flood zones, and prevent rebuilding in flood zones after damage occurs. While many of the responders were speaking of inland and coastal flood zones, some of them chose to emphasize retreat from the shoreline.

It is notable that many of the responses to the survey were heavily influenced by the damage to power lines caused by Hurricane Irene and Winter Storm Alfred in 2011, and flooding caused by Hurricanes Irene and Sandy in 2011 and 2012, respectively.

2.7 Hazard Analysis and Ranking Methodology

The hazard identification and risk assessment provides a consistent basis for developing mitigation strategies and for prioritizing those jurisdictions that are most threatened and vulnerable to natural hazards. This section details the risk assessment process and the methods used to rank hazard risk. Results from this process and accompanying methods will be presented in hazard-specific sections that follow.

For the purposes of compliance with the Disaster Mitigation Act, the plan update only fully addresses the hazards identified by the SHMP Team as significant in Connecticut. Additional hazards may be more formally addressed during future plan updates as their significance warrants.

2.7.1 Ranking Methodology

For the plan update, a standardized methodology was developed to compare different hazards' risk on a jurisdiction (County) scale, as decided by the Mitigation Planning Team. This method prioritizes hazard risk based on quantitative factors extracted from NCEI and other available data sources.

In order to compare NCEI data values, events and damages were annualized. This was accomplished by taking the parameter of interest and dividing by the length of record for each hazard. Annualizing the data provides an estimate of how many hazard occurrences can be expected from each hazard annually.

Nine ranking parameters were used to determine jurisdiction risk based hazard rankings. Each parameter was rated on a scale of 1 through 5, with those rated 5 considered high risk and those rated at 1 considered low risk. Population density and building permits were each given a weight of 0.5 relative to all other parameters. While building permit data and housing stock changes showed consistent results when evaluating construction trends, building permit data was used instead of housing stock changes to better capture additional growth activity not captured by new structures alone. Hazard Concern Ranking and Local Plan Hazard Ranking were each given a weight of one relative to all other parameters. Geographic extent was weighted at 1.5. Annualized events, annualized losses, death/injuries count as well as critical infrastructure exposure were each given a weight of 1. Scores were summed by jurisdiction for each hazard separately, allowing for impartial comparison between jurisdictions for each hazard. A summation of all the scores for all stated hazards in each jurisdiction provides a composite risk rank useful in prioritization.

Comparing and prioritizing risk posed by different hazards requires a system for equalizing the units of analysis. Since many of the hazards assessed in this plan do not have quantifiable probability or impact data, some semi-quantitative scoring was used in the ranking algorism used to compare hazards. An overview of the parameters used in ranking follows. Appendix 2 includes the NCEI storm events data and ranking spreadsheet used for this analysis.

2.7.2 Population Vulnerability and Building Permits

Population density is an important factor in the risk assigned to any jurisdiction. A hazard event that occurs in a highly populated jurisdiction generally has a much higher impact compared to an event that takes place in a very rural, sparsely populated jurisdiction. Two population related parameters were used to account for jurisdictions with high populations and jurisdictions with densely populated areas. Each of these parameters was given a weight of 0.5 in an effort to avoid biasing the composite ranking with population data. The 2019 plan update includes revised population values based on DECD was used for the 2012 building permits and UCONN CT state data center for the 2025 population projections.

Population parameters were calculated as the percent of the total population of Connecticut present in each jurisdiction. A value between 1 and 5 was assigned based on a geometric breaks pattern. By ranking jurisdictions in this fashion, those jurisdictions with significantly larger populations or potential future growth have effectively been given extra weight.

2.7.3 Probability of Future Events

NCEI record of historical occurrences of hazards is an important factor in determining where hazards are likely to occur in the future, although it lacks a comprehensive dataset for all hazards. Annualizing this database provides a rough estimate of the number of times a jurisdiction might experience a particular hazard event in any given year. This was accomplished using an approach similar to the other methods described above. For each hazard type in each jurisdiction, the total number of events in the NCEI database was divided by the total years of record for each hazard to calculate an annualized events value. Table 2-5 shows the classifications used for establishing the probability of future events in Connecticut. Events with a 500-year recurrence interval were given a classification of low for probability of future events and hazards with greater than five events annually are classified as a high probability of occurrence.

When applicable, NCEI event totals have been supplemented with additional sources. Hurricane, wildland fire, dam failure, and earthquake were supplemented with information from the SHMP Team, CT Division of Forestry, NPDP, CT DEEP, and the CT State Geologist. The hazard specific sections further detail the probability of future events for the counties and State as a whole.

Table 2-17: Probability of Future Events Classification

Annualized Events	Probability of Future Occurrence
< .002 events/year	Low
0.002 – 1 events/year	Medium-Low
1 – 5 events/year	Medium-High
>5 events/year	High

2.7.4 Property Damage

Property damage was analyzed separately, and each jurisdiction was assigned a score of 1 to 4 for each damage parameter. The data was obtained from the NCEI storm events database, inflated into 2017 dollars, and annualized according to the period of record for each event category.

2.7.5 Deaths and Injuries

Examination of the historical record for events causing deaths and injuries is an important step in determining risk ranking. Hazards having no reported deaths or injuries were assigned a ranking of 1, and hazards resulting in at least one death or injury were assigned a ranking of 4.

2.7.6 Local Mitigation Plan Ranking

Local mitigation plans were reviewed for ranking methodology, loss estimates, and risk to facilities (see Chapter 4). The parameter integrates local planning results into the state plan. Section 1.5 of this chapter provides information on how the plans were reviewed and summarized for incorporation into the ranking formula.

2.7.7 Geographic Extent

Most hazards have defined geography where it is more likely the hazard will occur in the future. To be able to include this in the ranking system, each hazard has been assigned individual scores based on the available hazard data. Geographic extent was given a 1.5 weighting relative to the other parameters, as geographic extent was deemed critically important. Data sources for geographic extent are shown in Table 2-18.

Table 2-18: Sources for Geographic Extent

Hazard	Data Source
Dam Failure	Number of NPDP/NID high or significant dams
Drought	Extent assumed to be uniform across Connecticut
Earthquake	Hazus 500-year Peak Ground Acceleration
Flood	FEMA DFIRMS and Hazus derived floodplains (depth-grids)
Sea Level Rise	NOAA Office for Coastal Management Sea Level Rise Viewer (inland extent and relative depth of inundation)
Thunderstorm Wind	NOAA NCEI Storm Events per square mile
Tornadoes	NOAA NCEI Storm Events per square mile
Tropical Cyclone	Hazus 100-year wind speeds
Wildland Fire	Percent land areas within Wildland Urban Interface (WUI) zones (interface or intermix)
Winter Storm	NWS Weather station data average annual snowfall

2.7.8 Hazard Concern Ranking

In the Public Survey described in detail in Section 1.6, respondents were asked to rank their concern about different natural hazards as low, moderate, or high. A weighted average of the results yields a prioritized list of hazard concerns as identified by the public. This parameter was a new addition to the hazard ranking formula for the 2019 update.

2.7.9 Critical Facilities

The number of critical facilities impacted by each hazard has also been included as a measure of damage. The ratio of number of impacted critical facilities to the total number of critical facilities was used to create a ranking for each hazard by county, and then included in the composite ranking formula. This parameter was a new addition to the hazard ranking formula for the 2019 update.

2.7.10 Composite Hazard Ranking

Composite risk for each jurisdiction was determined by combining the scores for population density, building permits, annualized events, property damage, local plan rankings, geographic extent, public survey hazard concern ranking, critical facilities, and injuries and deaths for each hazard.

The composite or total hazard score for Connecticut was determined by calculating the average hazard risk for each county and using quartiles to assign the ranking. Ranking results and analyses are available in Section 1.29 and in each hazard ranking section for each hazard.

2.7.11 Limitations of Ranking

The NCEI data, described above, is not a complete data source. It was chosen for use in ranking because of its standardized collection of many of the hazards that impact Connecticut. Future plan updates and mitigation actions should assess the availability and creation of other data sources ensure the parameters are still valid for ranking the hazards.

The NWS does not guarantee the accuracy or validity of the information used for weather-related hazards. Although the historical records in the database often vary widely in their level of detail, the NWS does have a set of guidelines for use in the preparation of event descriptions.[39]

2.8 HIRA Hazard Specific Sections

The following subsections present a description of each type of natural hazard Connecticut may expect to experience, as determined by the SHMP team. Each natural hazard sub-category contains general information, past history, future risk, and vulnerability.

Climate change will very likely have an increasingly significant impact on some types of natural disasters in Connecticut (see Section 2.4). The state and municipalities must consider scientists' projections of climate impacts on sea level, precipitation, storm intensity, flooding, drought, and other natural disasters as they plan for the future.

2.9 Dam Failure Hazard Profile

2019 Plan Update Changes

- The hazard profile has been significantly enhanced to include a detailed hazard description, location, extent, previous occurrences, probability of future occurrence, and potential change in climate and its impacts on the drought hazard is discussed
- New and updated figures from federal and state agencies are incorporated
- State and federal agencies responsibilities for oversight of Connecticut dams were incorporated
- Previous occurrences were updated with events

2.9.1 Hazard Description

A dam is an artificial barrier that has the ability to store water, wastewater, or liquid-borne materials for many reasons (flood control, human water supply, irrigation, livestock water supply, energy generation, containment of mine tailings, recreation, or pollution control.

[39] National Weather Service Instruction 10-1605. Operations and Services Performance: Storm Data Preparation Guide. March 23, 2016. Available at: https://www.ncdc.noaa.gov/stormevents/pd01016005curr.pdf

Many dams fulfill a combination of the stated functions. They are an important resource in the United States.[40]

Man-made dams can be classified according to the type of construction material used, the methods used in construction, the slope or cross-section of the dam, the way the dam resists the forces of the water pressure behind it, the means used for controlling seepage, and, occasionally, according to the purpose of the dam. The materials used for construction of dams include earth, rock, tailings from mining or milling, concrete, masonry, steel, timber, miscellaneous materials (plastic or rubber), and any combination of these materials.[40]

More than a third of the country's dams are 50 or more years old. Approximately 14,000 of those dams pose a significant hazard to life and property if failure occurs. There are also about 2,000 unsafe dams in the United States, located in almost every state.

Dam failures can result from natural events, human-induced events, or a combination, Failures due to natural events such as prolonged periods of rainfall and flooding can result in overtopping, which is the most common cause of dam failure. Overtopping occurs when a dam's spillway capacity is exceeded and portions of the dam not designed to convey flow begin to pass water, erode away, and ultimately fail. Other causes of dam failure include design flaws, foundation failure, internal soil erosion, inadequate maintenance, or mis-operation. Complete failure occurs if internal erosion or overtopping results in a complete structural breach, releasing a high-velocity wall of debris-laden water that rushes downstream damaging or destroying everything in its path. An additional hazard concern is the cascading effect of one dam failure causing multiple dam failures downstream due to the sudden release of flow.

While dam failures that occur during flood events compound an already tenuous situation and are certainly problematic, the dam failures that occur on dry days are the most dangerous. These "dry day" dam failures typically occur without warning, and consequently, downstream property owners and others in the vicinity are more vulnerable to being unexpectedly caught in life threatening situations than failures during predicted flood events.

Regulatory Oversight for Dams

The potential for catastrophic flooding caused by dam failures led to the passage of the National Dam Safety Act (Public Law 92-367). The National Dam Safety Program (NDSP) has been used for 30 years to protect Americans from dam failure. The NDSP is a partnership of the states, federal agencies, and other stakeholders that encourages individual and community responsibility for dam safety. Under FEMA's leadership, state assistance funds have allowed all participating states to improve their programs through increased inspections, emergency action planning, and the purchase of needed equipment.

[40] http://www.damsafety.org/news/?p=e4cda171-b510-4a91-aa30-067140346bb2

Connecticut is one of those participating states. FEMA has also expanded existing training programs and initiated new training programs. Grant assistance from FEMA provides support for the improvement of dam safety programs that regulate most of the dams in the U.S.[41]

Connecticut Department of Energy & Environmental Protection (CT DEEP) – Connecticut Dam Safety Program

The Dam Safety Section of the Inland Water Resources Division is charged with the responsibility for administration and enforcement of Connecticut's dam safety laws. The existing statutes require that permits be obtained to construct, repair or alter dams, dikes or similar structures and that existing dams, dikes and similar structures be registered and periodically inspected to assure that their continued operation and use does not constitute a hazard to life, health or property. The dam safety statutes are codified in Section 22a-401 through 22a-411 inclusive of the Connecticut General Statutes. Sections 22a-409-1 and 22a-409-2 of the Regulations of Connecticut State Agencies, have been enacted which govern the registration, classification, and inspection of dams.[42]

Connecticut requires owners of dams of all hazard classes register their dam and provide information to the Commissioner of CT DEEP. To date, the state keeps an inventory of 4,800 dams in Connecticut, 3,088 of which have been registered with the CT DEEP.[42]

Dam Inspection Regulations require that high, significant, and some moderate hazard class dams (over 600 dams) in Connecticut be inspected annually. Dams which pose the greatest potential threat to downstream persons and properties are given priority for inspection. A limited number of lower hazard dams which have not been inspected in the past twenty years are also targeted for inspection. Other structures are inspected as time and funding permit, and upon notification of potentially significant deficiencies or emergency conditions. [42]

Dams found to be unsafe after inspection are required to be repaired by the owner. Depending on the severity of the identified deficiency, an owner is allowed reasonable time to make the required repairs or to remove the dam. If a dam owner fails to make the necessary repairs, the Department may issue an administrative order requiring the owner to restore the structure to a safe condition and may refer noncompliance with such an order to the Attorney General's Office for enforcement. As a means of last resort, the Commissioner is empowered by statute to remove or correct, at the expense of the owner, any unsafe structures which present a clear and present danger to public safety. [42]

U.S. Army Corps of Engineers Dam Safety Program

[41] http://www.fema.gov/about-national-dam-safety-program
[42] http://www.ct.gov/deep/cwp/view.asp?a=2720&q=325632&deepNav_GID=1654

The U.S. Army Corps of Engineers (USACE) is responsible for safety inspections of some federal and non-federal dams in the United States that meet the size and storage limitations specified in the National Dam Safety Act. USACE has inventoried dams and has surveyed each state and federal agency's capabilities, practices, and regulations regarding design, construction, operation, and maintenance of the dams. USACE has also developed guidelines for inspection and evaluation of dam safety.[43]

Federal Energy Regulatory Commission Dam Safety Program

The Federal Energy Regulatory Commission (FERC) has the largest dam safety program in the United States. FERC cooperates with a large number of federal and state agencies to ensure and promote dam safety and, more recently, homeland security. There are 3,036 dams that are part of regulated hydroelectric projects and are included in the FERC program. Two-thirds of these are more than 50 years old. As dams age, concern about their safety and integrity grows, so oversight and regular inspection are important. FERC staff inspects hydroelectric projects on an unscheduled basis to investigate the following:

- Potential dam safety problems
- Complaints about constructing and operating a project
- Safety concerns related to natural disasters
- Issues concerning compliance with the terms and conditions of a license.44

Every five years, an independent consulting engineer, approved by the FERC, must inspect and evaluate projects with dams higher than 32.8 feet (10 meters) or with a total storage capacity of more than 2,000 acre-feet.[44]

FERC monitors and evaluates seismic research in geographic areas where there are concerns about seismic activity. This information is applied in investigating and performing structural analyses of hydroelectric projects in these areas. FERC staff also evaluates the effects of potential and actual large floods on the safety of dams. During and after floods, FERC staff visits dams and licensed projects, determines the extent of damage, and directs any studies or remedial measures the licensee must undertake. FERC's *Engineering Guidelines for the Evaluation of Hydropower Projects* guides the FERC engineering staff and licensees in evaluating dam safety. The publication is frequently revised to reflect current information and methodologies.[44]

FERC requires licensees to prepare emergency action plans and conducts training sessions on how to develop and test these plans. The plans outline an early warning system if there is an actual or potential sudden release of water from a dam failure. The plans include operational procedures that may be used, such as reducing reservoir levels and reducing downstream flows, as well as procedures for notifying affected residents and agencies

[43] http://www.publications.usace.army.mil/Portals/76/Publications/EngineerRegulations/ER_1110-2-1156.pdf
[44] https://www.ferc.gov/industries/hydropower/gen-info/regulation/dam-safety.asp

responsible for emergency management. These plans are frequently updated and tested to ensure that everyone knows what to do in emergency situations. [44]

2.9.2 Location

The National Inventory of Dams (NID) consists of dams meeting at least one of the following criteria;

- High hazard potential classification - loss of human life is likely if the dam fails,
- Significant hazard potential classification - no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or impact other concerns,
- Equal or exceed 25 feet in height and exceed 15 acre-feet in storage,
- Equal or exceed 50 acre-feet storage and exceed 6 feet in height.

According to the NID there are 90,580 dams in the United States that meet NID criteria. Of these 87,359 dams, federal agencies own 3,381; state agencies own 6,622; local agencies own 18,091; public utilities companies own 3,846; and private entities or individuals own 58,148. Ownership to 492 dams is not listed. Figure 2-6 displays the location of these dams throughout the United States. The NID categorizes the dams according to their primary function:

- Recreation – 28% (25,394 dams)
- Flood Control – 17.9% (16,179 dams)
- Fire Protection – 11.9% (10,781 dams)
- Other – 9.3% (8,462 dams)
- Irrigation – 8.5% (7,706 dams)
- Undetermined – 7.2% (6,526 dams)
- Water Supply – 6.2% (5,628 dams)
- Fish and Wildlife – 5.4% (4,930 dams)
- Hydroelectric – 2.3% (2,114 dams)
- Tailings – 1.3% (1,172 dams)
- Grade Stabilization – 1% (906 dams)
- Debris Control – 0.6% (575 dams)
- Navigation – 0.2% (207 dams)[45]

[45] http://nid.usace.army.mil/cm_apex/f?p=838:12

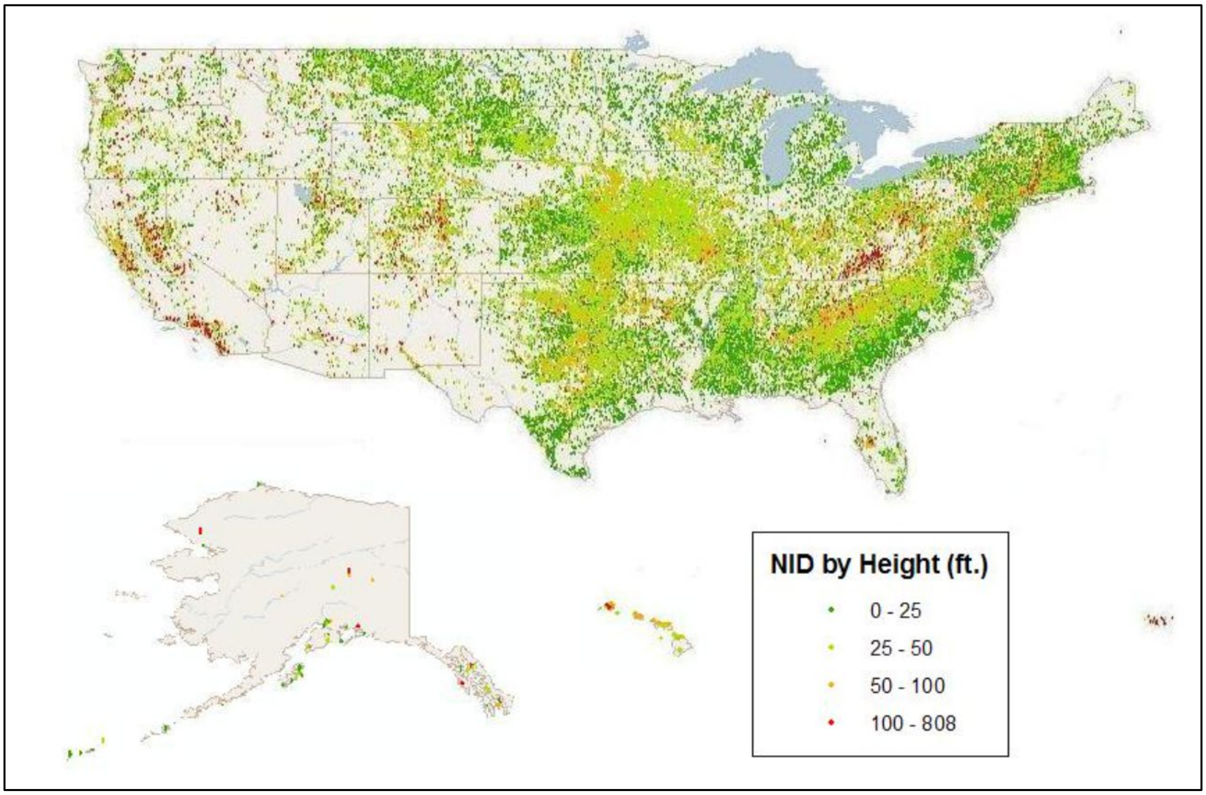


Figure 2-6: Locations of Dams in the United States (National Inventory of Dams)

Figure 2-6 Locations of Dams in the United States (National Inventory of Dams) displays the location of all dams in the US. According to the NID, there are 746 dams in Connecticut that meet NID criteria. This locations of these dams is shows in Figure 2-8. Of these 746 dams, federal agencies own 18; State agencies own 136; local agencies own 181; public utilities companies own 105; and private entities or individuals own 306. Forty percent of the dams in Connecticut are owned by private entities or individuals and the federal government owns the least number (~2%) of all dams in Connecticut.

The NID categorizes the dams according to their primary function (Figure 2-7 Number of Dams in Connecticut, by Primary Function):

- Recreation – 57.4% (428 dams)
- Water Supply – 22% (164 dams)
- Flood Control – 8.4% (63 dams)
- Hydroelectric – 5.5% (41 dams)
- Fish and Wildlife – 2.9% (22 dams)
- Other – 2.1% (16 dams)
- Irrigation – 1% (8 dams)
- Undetermined – 0.4% (3 dams)
- Fire Protection – 0.1% (1 dams)

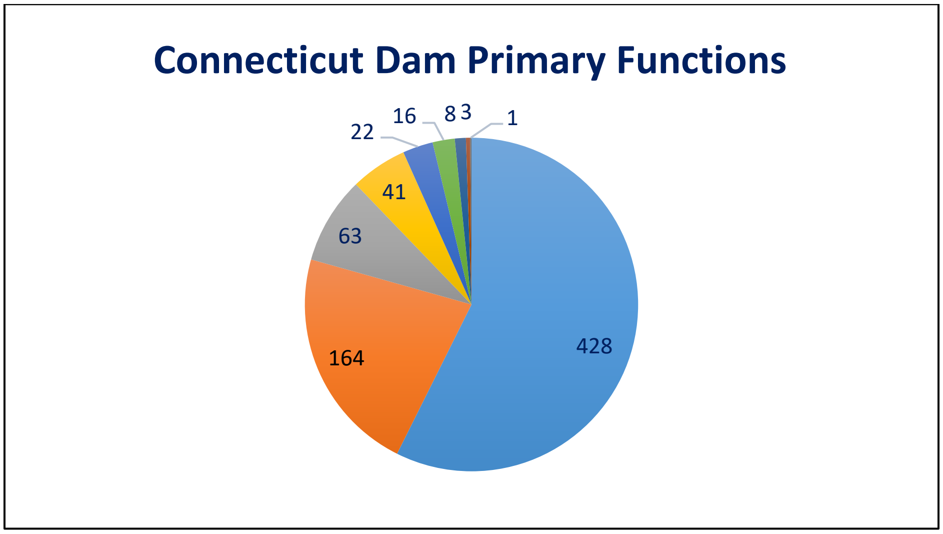


Figure 2-7: Number of Dams in Connecticut, by Primary Function

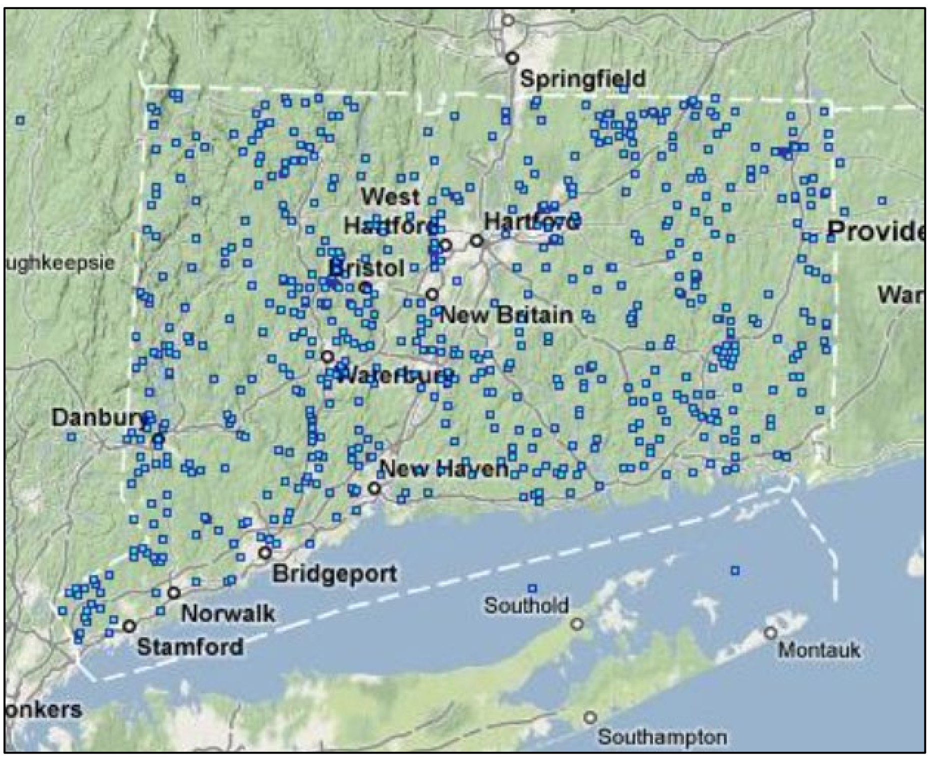


Figure 2-8: Locations of Dams in Connecticut (National Inventory of Dams)

According to the Dam Incident Notification (DIN) system maintained by the National Performance of Dam Program (NPDP), there are 754 dams in the State of Connecticut. Of the 754 dams, there are 48 classified as low hazard (Class A), 444 classified as significant hazard (Class B), 232 classified as high hazard (Class C), and 30 having an unknown classification (NPDP 2018). However, these numbers differ from the CT DEEP, who keeps its own records of state regulated dams. As of January 21, 2016, CT DEEP identifies 1,348 state regulated dams (high, significant, and moderate hazard dams). Of that number, 288 have high hazard potential (Hazard Class C), 296 have significant hazard potential (Hazard Class B), and 764 have moderate hazard potential (Hazard Class BB).[46] CT DEEP data is used for the purpose of this HMP update.

2.9.3 Extent

The extent or magnitude of a dam failure event can be measured in terms of the classification of the dam. FEMA has three classification levels of dams: low, significant, and high. The classification levels build on each other. The hazard potential classification system should be used with the understanding that the failure of any dam or water-retaining structure could represent a danger to downstream life and property.[47]

- Low hazard potential dams are those where failure or mis-operation results in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.
- Significant hazard potential dams are those where failure or mis-operation results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns. Significant hazard potential classification dams are often located in predominately rural or agricultural areas.
- High hazard potential dams are those where failure or mis-operation will probably cause loss of human life.

USACE developed the classification system shown in Table 2-19 for the hazard potential of dam failures. USACE hazard rating systems is based only on the potential consequences of a dam failure; it does not take into account the probability of such failures.

[46] http://www.ct.gov/deep/cwp/view.asp?a=2720&q=325634&deepNav_GID=1625%20
[47] http://www.fema.gov/media-library-data/20130726-1516-20490-7951/fema-333.pdf

Table 2-19. U.S. Army Corps of Engineers Hazard Potential Classification

Hazard Category[a]	Direct Loss of Life[b]	Lifeline Losses[c]	Property Losses[d]	Environmental Losses[e]
Low	None (rural location, no permanent structures for human habitation)	No disruption of services (cosmetic or rapidly repairable damage)	Private agricultural lands, equipment, and isolated buildings	Minimal incremental damage
Significant	Rural location, only transient or day-use facilities	Disruption of essential facilities and access	Major public and private facilities	Major mitigation required
High	Certain (one or more) extensive residential, commercial, or industrial development	Disruption of essential facilities and access	Extensive public and private facilities	Extensive mitigation cost or impossible to mitigate

a. Categories are assigned to overall projects, not individual structures at a project.
b. Loss-of-life potential is based on inundation mapping of area downstream of the project. Analyses of loss-of-life potential should take into account the population at risk, time of flood wave travel, and warning time.
c. Lifeline losses include indirect threats to life caused by the interruption of lifeline services from project failure or operational disruption; for example, loss of critical medical facilities or access to them.
d. Property losses include damage to project facilities and downstream property and indirect impact from loss of project services, such as impact from loss of a dam and navigation pool, or impact from loss of water or power supply.
e. Environmental impact downstream caused by the incremental flood wave produced by the project failure, beyond what would normally be expected for the magnitude flood event under which the failure occurs.

Source: U.S. Army Corps of Engineers 1995

According to the CT DEEP, there are five hazard potential classifications of dams in Connecticut. The classifications relate to the potential for property damage and/or loss of life in the event of a dam failure and dictate inspection frequency requirements:

- **Class AA: Negligible Hazard Potential.** A dam would be considered to have negligible downstream hazard potential if, were it to fail, it would cause no measurable damage to roadways, land and structures, and negligible economic loss. Examples are a dam located just above a large body of water such as a major river which could easily absorb the entire discharge of the released impoundment or a dam and pond so small that the volume of water if released suddenly would cause no damage. Once the Negligible hazard classification is field verified, there is no periodic inspection requirement for dams in this hazard classification.
- **Class A: Low Hazard Potential.** A dam would be considered to have a low downstream hazard potential if, were it to fail, it would cause damage to agricultural land, damage to unimproved roadways, and/or minimal economic loss. The periodic inspection frequency for low hazard dams is 10 years.
- **Class BB: Moderate Hazard Potential.** A dam would be considered to have a moderate downstream hazard potential if were it to fail, it would cause damage to normally unoccupied storage structures, damage to low volume roadways, and/or moderate economic loss. The periodic inspection frequency for moderate hazard dams is 7 years.
- **Class B: Significant Hazard Potential.** A dam would be considered to have a significant downstream hazard potential if were it to fail, it would cause possible

loss of life; minor damage to habitable structures, residences, hospitals, convalescent homes, schools, etc.; damage to or interruption of the use or service of utilities; damage to primary roadways and railroads; or significant economic loss. The periodic inspection frequency for significant hazard dams is 5 years.

- **Class C: High Hazard Potential.** A dam would be considered to have a high downstream hazard potential if were it to fail, it would cause probable loss of life; major damage to habitable structures, residences, hospitals, convalescent homes, schools, etc.; damage to main highways; or great economic loss. The periodic inspection frequency for high hazard dams is 2 years.[48]

Table 2-20 summarizes the number of State-owned dams and their hazard classifications, by County. Figure 2-29 shows the location of all state-regulated dams in Connecticut according to their assigned hazard potential along with the available mapped inundation areas. In addition, the 266 state-owned dams in the state are highlighted in green on the map. Table 2-21 lists the number of dams located in each county, according to their hazard classification. Every county in Connecticut has at least one high hazard dam located within its boundaries. Fairfield County and New Haven County have the highest number of high hazard dams in the State.

Table 2-20. State-owned dams in each county, by hazard potential.

County	C-High Hazard	B-Significant Hazard	BB-Moderate Hazard	A-Low Hazard	AA-Negligible Hazard
Fairfield	3	0	3	8	0
Hartford	12	4	7	15	0
Litchfield	12	5	4	9	1
Middlesex	7	10	10	7	2
New Haven	8	6	3	9	1
New London	3	9	15	24	1
Tolland	6	9	10	11	0
Windham	1	1	16	12	0
Total	52	44	68	95	5

[48] http://www.ct.gov/deep/lib/deep/water_inland/dams/owner_responsible_inspection_information.pdf

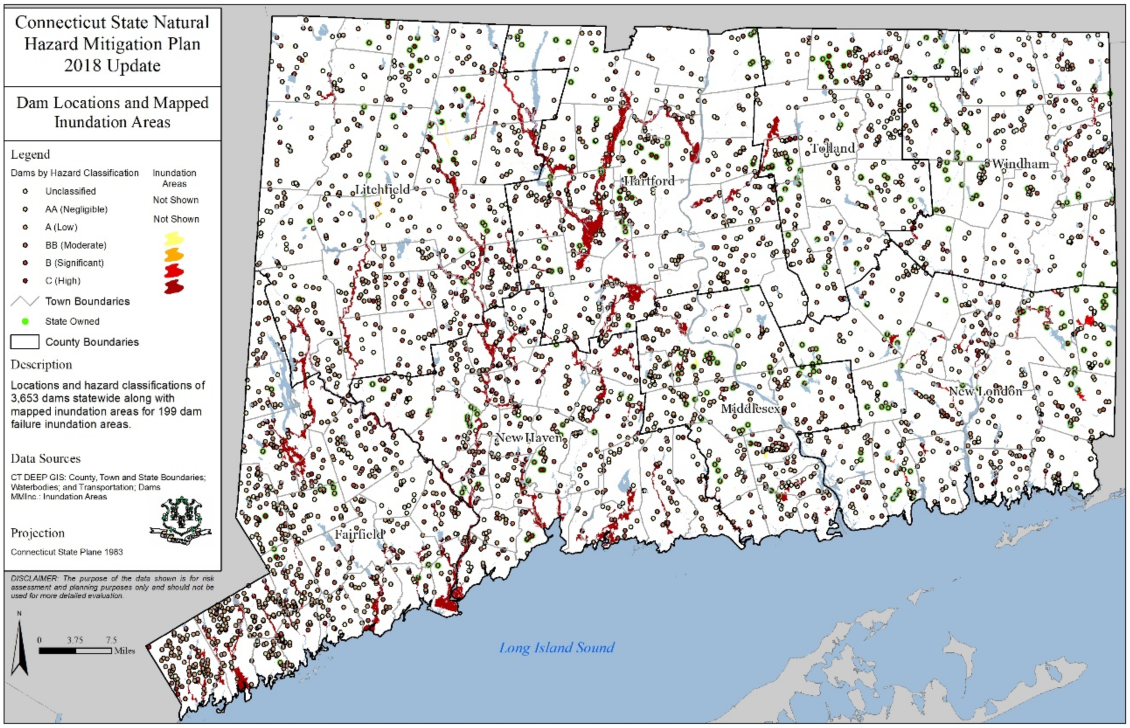


Figure 2-9: Locations of state-regulated dams

Table 2-21. Number of Dams by County in Connecticut, Hazard Potential.

County	High Hazard	Significant Hazard	Moderate Hazard	Low Hazard	Negligible Hazard	Unclassified	Total
Fairfield	44	84	84	460	4	105	781
Hartford	37	49	54	217	1	117	475
Litchfield	43	75	72	225	6	127	548
Middlesex	16	47	56	138	4	71	332
New Haven	55	78	63	178	3	94	471
New London	18	50	49	191	1	136	445
Tolland	14	37	39	121	2	74	287
Windham	10	29	64	120	6	78	307
Total	237	449	481	1,650	27	802	3,646

2.9.4 Primary and Secondary Impacts

Dam failure can primarily cause severe downstream flooding, depending on the magnitude of the failure. Other potential secondary hazards of dam failure are landslides around an impoundment perimeter, bank erosion on the rivers, and destruction of downstream habitat. Dam failures can occur as a result of structural failures, such as progressive erosion of an embankment or overtopping and breaching by a severe flood. Earthquakes may weaken dams. Floods caused by dam failures have caused loss of life and property damage.

2.9.5 Severity

USACE developed a classification system for the hazard potential of dam failures. USACE's hazard rating system is based only on the potential consequences of a dam failure; it does not take into account the probability of such failures. The worst-case scenario would be a failure of one of Connecticut's 278 high-hazard dams. The result could be severe damage to downstream communities and the potential for loss of life.

Flood severity from a dam failure can be measured with a low, medium, or high severity level, which are further defined as follows:

- Low severity - No buildings are washed off their foundations; structures are exposed to floodwater depths of less than 10 feet.
- Medium severity - Homes are destroyed but trees or mangled homes remain for people to seek refuge in or on; structures are exposed to floodwater depths of more than 10 feet.
- High severity - Floodwaters sweep the area and nothing remains. Locations are flooded by the near instantaneous failure of a concrete dam, or an earthfill dam that turns into "jello" and washes out in seconds rather than minutes or hours. In addition, the flooding caused by the dam failure sweeps the area clean and little or no evidence of the prior human habitation remains after the floodwater recedes (Graham 1999).

Two factors that influence the potential severity of a full or partial dam failure are: (1) the amount of water impounded; and (2) the density, type, and value of development and infrastructure located downstream.[49]

2.9.6 Warning Time

Dams can fail with little warning. Intense storms may produce a flood in a few hours or even minutes for upstream locations. Flash floods can occur within six hours of the beginning of heavy rainfall, and dam failure may occur within hours of the first signs of breaching. Other failures and breaches can take much longer to occur, from days to weeks, as a result of debris jams, the accumulation of melting snow, buildup of water pressure on a dam with deficiencies after days of heavy rain, etc. Flooding can occur when a dam operator releases excess water downstream to relieve pressure from the dam.[50]

[49] City of Sacramento. 2005. "Sacramento 2030 General Plan.". On-Line Address: http://www.sacgp.org/
[50] FEMA. 2013b. "Why Dams Fail." October 22. On-Line Address: http://www.fema.gov/why-dams-fail

Warning time for dam failure varies depending on the cause of the failure. In extreme precipitation or rapid snowmelt events, evacuations can be planned with sufficient time. In the event of a structural failure because of earthquake, there may be no warning time. A dam's structural type also affects warning time. Earthen dams do not tend to fail completely or instantaneously. Once a breach is initiated, discharging water erodes the breach until either the reservoir water is depleted or the breach resists further erosion. Concrete gravity dams also tend to have a partial breach as one or more monolith sections are forced apart by escaping water. The time of breach formation ranges from a few minutes to a few hours.

High and significant hazard dam owners are required to prepare and maintain Emergency Action Plans (EAP). The EAP is to be used in the event of a potential dam failure or uncontrolled release of stored water. Owners are also required to have established protocols for flood warning and response to imminent dam failure in the flood warning portion of its adopted emergency operations plan. These protocols are tied to the emergency action plans also created by the dam owners. These documents are customarily maintained as confidential information, although copies are required to be provided to the CT DEEP for response purposes. State and local Offices of Emergency Management also have copies of the approved EAPs.

2.9.7 Previous Occurrences and Losses

Connecticut has experienced many dam failures, mainly resulting from significant rainfall events that led to major flooding. They often occur suddenly and without warning. Dam failures may occur during normal operation conditions, referred to as a "sunny day" failure. Historically, however, the consequences of dam failures have not been well documented. Descriptions of previous dam failure events provided in this section are based on anecdotal data from CT DEEP in combination with data available from the National Performance of Dams Program (NPDP) at Stanford University, the Association of State Dam Safety Officials, and NCEI.

This section provides details about significant dam failure events that occurred in Connecticut. Numerous sources provided historical information regarding previous occurrences and losses associated with dam failure events throughout the State; therefore, loss and impact information could vary depending on the source. The accuracy of monetary figures and event details is based only on the available information identified during research for this HMP.

One of the worst known dam failures in Connecticut occurred in March 1963, when Spaulding Pond Dam in Norwich (New London County) failed, causing six fatalities and more than $6 million in damages (1963 dollars). Two years earlier, in April 1961, Crystal Lake Dam in Middletown (Middlesex County) burst, injuring three people, severely damaging 11 homes, and causing an estimated $600,000 in damages (1961 dollars).

On the weekend of June 5-6, 1982, Connecticut suffered one of its worst floods since 1955. Throughout the state, 17 dams failed and another 31 dams were seriously damaged due to a rainfall event that produced up to 18 inches of rain and resulted in damages totaling $70 million. This event included the failure of the Bushy Mill Pond Dam in Deep River (Middlesex County), which caused an estimated $1 million in damage according to the NPDP database (Figure 2-10).

Figure 2-10: Downstream damage due to the 1982 Bushy Hill Pond Dam Break

In June 2001, torrential rainfall associated with the remnants of Tropical Storm Allison caused a private dam in Hampton (Windham County) to fail, which closed a portion of Route 97, but according to NCEI data resulted in no reported damages.

In October 2005, Connecticut experienced moderate to major flooding statewide. Major flooding occurred in several river basins in Hartford and Tolland counties and widespread moderate flooding was experienced across the rest of the state. Flood flow frequencies exceeded a 100-year event in parts of north-central and northeastern Connecticut. CT DEEP is aware of 14 dams which completely failed or partially failed in Hartford and Tolland counties. Another 30 dams were damaged throughout Connecticut. Several bridges failed and several dozen roads were washed out or undermined. Thousands of homes experienced flooded basements and evacuations were conducted in dozens of towns due to severe flooding. As a result of the flooding that resulted in an estimated $42 million in damages, with more than 5,200 homes and 355 businesses impacted, President Bush declared Litchfield, New London, Tolland, and Windham counties disaster areas.

According to the NPDP database, there are 24 incidents recorded as dam failures in the state since 1877, of which 10 are attributed to the 1982 flood event. The NPDP database does not include any of the reported dam failure events from 2005. Further, exact numbers of dam failures caused by Connecticut's record flood events in 1938 and 1955 are not available, but anecdotal information suggests that many more dams were damaged during those storm events than in the more recent 1982 or 2005 flood events. Table 2-22 provides a history of recorded consequences for dam failure events in Connecticut according to the NPDP database.

Table 2-22. NPDP Total Dam Failure Events

County	Number of Events	Property Damages
Fairfield	3	Undocumented
Hartford	0	Undocumented
Litchfield	4	$150,000.00
Middlesex	7	$1,190,400.00
New Haven	1	Undocumented
New London	3	$3,078,000.00
Tolland	5	$117,430.00
Windham	1	$250,000.00
Total	24	$4,785,830.00

FEMA Disaster Declarations

To date, Connecticut has had no FEMA Disaster Declarations specifically due to dam release.[51]

2.9.8 Probability of Future Events

Dam failure events are infrequent and usually coincide with events that cause them, such as earthquakes, landslides, and excessive rainfall and snowmelt. While considered an unlikely occurrence, the potential for dam failure in Connecticut is a significant concern given the large number of dams across the state and numerous dam failure events in the past. The probability of future dam failure events is not easily measured, but correlates with the probability of future major flood events coupled with preventative measures, including the routine inspection, maintenance, repair, and proper operation of dams by their owners, and as regulated by CT DEEP's Dam Safety Section.

The Dam Safety Section is tasked with monitoring routine inspection and maintenance of those dams that present the greatest risk or are in need of structural repair. State regulations require that over 600 dams in Connecticut must be inspected annually, with priority placed on dams which pose the greatest potential threat to downstream persons and properties. Other structures are inspected as time and funding permit, and upon notification of potentially significant deficiencies or emergency conditions. Dam owners are responsible for complying with maintenance and repair requirements and developing

51 https://www.fema.gov/media-library/assets/documents/28318?id=6292

Emergency Operations Plans (EOPs), which are required for high and significant hazard dams.

Dams which receive construction permits for repair and/or reconstruction are designed to pass at least the 100-year rainfall event with one foot of freeboard (a factor of safety against overtopping). The most critical and hazardous dams are required to meet a spillway design standard much higher than passing the runoff from a 100-year rainfall event. Although not all of the dams under CT DEEP jurisdiction have been shown to be able to withstand the 100-year rainfall event, most of the dams meet this standard due to original design requirements or recent spillway upgrades. For the most part if smaller rainfall events (e.g., 10-year and 25-year events) occur more frequently there will be little impact on the ability of Connecticut dams to operate safely.

As more state-owned and privately-owned dams are repaired, the number of dams that will not meet the State minimum requirements for spillway design diminishes. However, the average age of all dams in Connecticut continues to increase and thus the State must remain vigilant in administering its dam safety regulations and related programs.

There is no season or geographic location that is more susceptible to dam failures than another in Connecticut. However, CT DEEP has started to monitor climate change predictions as they affect the numbers of and severity of heavy rain events in Connecticut. Since dam overtopping caused by excessive rainfall is the leading cause of dam failures in Connecticut, it is appropriate to relate future dam structure vulnerability directly with the potential for increased rainfall in Connecticut.

2.9.9 Climate Change Impacts

Connecticut's climate is changing. Throughout the northeastern United States, spring is arriving earlier and bringing more precipitation, heavy rainstorms are more frequent, and summers are hotter and drier. Severe storms increasingly cause floods that damage property and infrastructure. In the coming decades, the changing climate is likely to increase flooding, harm ecosystems, disrupt farming, and increase some risks to human health.[52]

Dams are designed partly based on assumptions about a river's flow behavior, expressed as hydrographs. Changes in weather patterns can have significant effects on the hydrograph used for the design of a dam. If the hygrograph changes, it is conceivable that the dam can lose some or all of its designed margin of safety, also known as freeboard. Loss of designed margin of safety may cause floodwaters more readily to overtop the dam or create unintended loads. Such situations could lead to a dam failure.

[52] https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-ct.pdf

Climate change may increase the probability of dam failures, as indicated above. Changes in climate may lead to higher intensity rainfall events. As a result, the failure probability of low hazard, significant hazard, and under-designed high hazard dams may increase.

2.10 Dam Failure Vulnerability Assessment

Dams have been an important part of Connecticut's water infrastructure for centuries. In addition to the historic economic benefits provided by dams, they are used for flood control, water supply, power generation, recreation, and for mitigating the impact of increased runoff typically caused by land use changes associated with property development.

Today there are nearly 4,000 dams in the State of Connecticut (3,646[53]), which pose a potential hazard to downstream properties due to their location and size. These dams are regulated by CT DEEP under Connecticut General Statutes which require permitting for construction, repair or alteration of dams, and that existing dams be registered and periodically inspected to assure that their continued operation and use does not constitute a hazard to life, health or property. A failure of most of Connecticut dams would not be catastrophic, but 686 of high and significant hazard dams pose a possible or even a probable threat to human life upon failure. Information on dams is not provided for general public distribution due to security concerns. Requests for this information may be submitted either to the CT DEMHS or CT DEEP

Two factors influence the severity of a dam failure: the amount of water impounded, and the density, type, and value of development and infrastructure downstream of the impoundment. The potential severity of a dam failure may be classified for each dam according to its "hazard potential," meaning the probable impact that would occur if the structure failed in terms of loss of human life and economic loss or environmental damage. Table 1-5 includes the number of infrastructure/facilities, building value and contents value by municipality. There are 3,327 mapped state-owned facilities. Based on a combination of the 2013 JESTIR database and Connecticut Open Data, the estimated total value of state buildings is $5.6 billion, with over $866 million in content value; the building and contents values have not been estimated for all state-owned building. The State's total building and contents value only includes those buildings where value information was available and is intent for use in this plan and should not be used for other applications. The state contains 1,940 identified critical facilities in the categories of correctional institutions, EMS facilities, fire stations, gas stations with generator, health departments, law enforcement facilities, municipal solid waste, nuclear power plants, and storage tank farms. 1,846 of these critical facilities were able to be geospatially mapped for analysis.

Appendix 2 includes the infrastructure and facilities datasets, as well as the loss estimates by municipality for facilities located within the known hazard geographic extents. For the

[53] 2018 CT DEEP

purposes of this 2019 Plan update, all State buildings and local assets located in the dam failure inundation areas will be exposed to a dam failure event. Due to the sensitive nature of the dam/levee failure inundation zones, not all inundation zones were available for use to estimate potential losses to state facilities. As the State of Connecticut continues to become more urbanized, the State facilities will need to be developed in locations that will serve the growing population. For this 2019 Plan, 199 combined dam failure inundation areas were used to define the extent of the dam failure hazard area. Dam failure inundation areas were obtained from Milone & MacBroom (2018). This data provides information which may be used for planning purposes but does not reflect the comprehensive risk posed by dam failure as the data set continues to be under development. While many inundation areas may be coincident with the available data used in the 2013 State HMP, certain inundation areas may differ or be absent from this dataset and result in dissimilar totals for at-risk assets.

2.10.1 Assessment of State Vulnerability and Potential Losses

All State facilities in a dam/levee failure inundation zones may be vulnerable to damage. Buildings and properties located closest to the dam inundation zone have the greatest potential to experience the largest, most destructive surge of water in the event of a failure. All critical facilities and transportation infrastructures in the dam failure inundation zone may be vulnerable to damage. Flood waters may potentially cut off evacuation routes, limit emergency access, and create isolation issues. Utilities such as overhead power, cable, and phone lines in the inundation zone may also be vulnerable. Loss of these utilities could create additional isolation issues for State facilities and populations residing in inundation zones.

Table 2-23 provides a breakdown of the regulated dams in Connecticut by hazard potential. Of the 3,646 dams, 237 are classified as having high hazard potential (major damage and probable loss of life) and 449 are classified as having a significant hazard potential (minor damage and possible loss of life). The remaining dams are not considered to pose a threat to life and safety following a failure, and only minimal to moderate damages or economic loss.

Table 2-23. State-regulated dams in Connecticut, by hazard potential.

Hazard Classification	Number of Dams	Percentage
C – High Hazard	237	7%
B – Significant Hazard	449	12%
BB – Moderate Hazard	481	13%
A – Low Hazard	1,650	45%
AA – Negligible Hazard	27	1%
Unclassified	802	22%
Total Regulated Dams	3,646	100%

Table 2-24 and Table 2-25 provide a breakdown of the numbers and values of state-owned buildings intersecting mapped dam failure inundation areas of high and significant classified hazard dams by county. A total of 94 state-owned buildings (2.80% of the total number of state-owned buildings in the state) are located within a known potential dam failure hazard area; 56 of these are in Fairfield County. It is important to note however that dam failure inundation mapping is for the 199 areas included in the dataset and does not represent all the 3,646 dams in the state.

Table 2-24. Number of state-owned buildings within mapped dam inundation areas.

County	Total State-Owned Buildings	# Buildings High Hazard Dam Inundation	# Buildings Significant Hazard Dam Inundation	Total Buildings At Risk	Total Percent At Risk
Fairfield	205	54	2	56	27.3%
Hartford	867	1	4	5	0.6%
Litchfield	97	17	0	17	17.5%
Middlesex	289	2	0	2	0.7%
New Haven	561	14	0	14	2.5%
New London	489	0	0	0	0.0%
Tolland	628	0	0	0	0.0%
Windham	191	0	0	0	0.0%
Total	3,327	88	6	94	2.8%

Table 2-25. Value of state-owned buildings within mapped dam inundation areas.

County	Total Value of State-Owned Buildings	Value in High Hazard Dam Inundation	Value in Significant Hazard Dam Inundation	Total Value At Risk	Total Percent At Risk
Fairfield	$328,049,014	$191,924,476	$193,629	$192,118,105	58.6%
Hartford	$2,482,445,429	$0	$1,159,160	$1,159,160	0.0%
Litchfield	$55,774,193	$18,838,322	$0	$18,838,322	33.8%
Middlesex	$411,474,322	$4,124,511	$0	$4,124,511	1.0%
New Haven	$824,597,613	$77,871,747	$0	$77,871,747	9.4%
New London	$98,537,626	$0	$0	$0	0.0%
Tolland	$2,016,260,747	$0	$0	$0	0.0%
Windham	$253,657,976	$0	$0	$0	0.0%
Total	$6,470,796,920	$292,759,056	$1,352,789	$294,111,845	4.5%

Table 2-26 provides a breakdown of the numbers of critical facilities intersecting mapped dam failure inundation areas of high and significant hazard dams by county. A total of 139 critical facilities (7.5% of the total number of critical facilities in the state) are located within a known potential dam failure hazard area.

Table 2-26. Number of critical facilities within mapped dam inundation areas.

County/Facility Types	All Critical Facilities	High Hazard Dam Inundation		Significant Hazard Dam Inundation		Total # At Risk	Total % At Risk
		# Critical Facilities	% Critical Facilities	# Critical Facilities	% Critical Facilities		
Fairfield							
Correctional Institutions	4	1	25.0%	0	0.0%	1	25.0%
EMS	120	9	7.5%	2	1.7%	11	9.2%
Fire Stations	115	8	7.0%	2	1.7%	10	8.7%
Gas Station	22	0	0.0%	0	0.0%	0	0.0%
Health Department	25	3	12.0%	0	0.0%	3	12.0%
Law Enforcement	35	3	8.6%	0	0.0%	3	8.6%
Municipal Solid Waste	43	5	11.6%	0	0.0%	5	11.6%
Nuclear Power Plant	0	0	0.0%	0	0.0%	0	0.0%
Storage Tank Farm	7	1	14.3%	0	0.0%	1	14.3%
Fairfield Total	371	30	8.1%	4	1.1%	34	9.2%
Hartford							
Correctional Institutions	6	0	0.0%	0	0.0%	0	0.0%
EMS	80	3	3.8%	2	2.5%	5	6.3%
Fire Stations	141	5	3.5%	1	0.7%	6	4.3%
Gas Station	10	0	0.0%	0	0.0%	0	0.0%
Health Department	26	1	3.8%	0	0.0%	1	3.8%
Law Enforcement	44	1	2.3%	2	4.5%	3	6.8%
Municipal Solid Waste	62	6	9.7%	6	9.7%	12	19.4%
Nuclear Power Plant	0	0	0.0%	0	0.0%	0	0.0%
Storage Tank Farm	8	0	0.0%	0	0.0%	0	0.0%
Hartford Total	377	16	4.2%	11	2.9%	27	7.2%
Litchfield							
Correctional Institutions	0	0	0.0%	0	0.0%	0	0.0%
EMS	34	6	17.6%	0	0.0%	6	17.6%
Fire Stations	53	6	11.3%	2	3.8%	8	15.1%
Gas Station	8	1	12.5%	0	0.0%	1	12.5%
Health Department	7	2	28.6%	0	0.0%	2	28.6%
Law Enforcement	25	3	12.0%	2	8.0%	5	20.0%
Municipal Solid Waste	29	3	10.3%	0	0.0%	3	10.3%
Nuclear Power Plant	0	0	0.0%	0	0.0%	0	0.0%
Storage Tank Farm	0	0	0.0%	0	0.0%	0	0.0%
Litchfield Total	156	21	13.5%	4	2.6%	25	16.0%
Middlesex							
Correctional Institutions	1	0	0.0%	0	0.0%	0	0.0%

County/Facility Types	All Critical Facilities	High Hazard Dam Inundation		Significant Hazard Dam Inundation		Total # At Risk	Total % At Risk
		# Critical Facilities	% Critical Facilities	# Critical Facilities	% Critical Facilities		
EMS	31	0	0.0%	0	0.0%	0	0.0%
Fire Stations	36	0	0.0%	0	0.0%	0	0.0%
Gas Station	8	0	0.0%	0	0.0%	0	0.0%
Health Department	9	0	0.0%	0	0.0%	0	0.0%
Law Enforcement	17	0	0.0%	0	0.0%	0	0.0%
Municipal Solid Waste	21	0	0.0%	0	0.0%	0	0.0%
Nuclear Power Plant	0	0	0.0%	0	0.0%	0	0.0%
Storage Tank Farm	3	0	0.0%	0	0.0%	0	0.0%
Middlesex Total	126	0	0.0%	0	0.0%	0	0.0%
New Haven							
Correctional Institutions	5	0	0.0%	0	0.0%	0	0.0%
EMS	76	10	13.2%	0	0.0%	10	13.2%
Fire Stations	115	10	8.7%	0	0.0%	10	8.7%
Gas Station	23	5	21.7%	0	0.0%	5	21.7%
Health Department	26	1	3.8%	0	0.0%	1	3.8%
Law Enforcement	42	6	14.3%	0	0.0%	6	14.3%
Municipal Solid Waste	45	9	20.0%	0	0.0%	9	20.0%
Nuclear Power Plant	0	0	0.0%	0	0.0%	0	0.0%
Storage Tank Farm	10	2	20.0%	0	0.0%	2	20.0%
New Haven Total	342	43	12.6%	0	0.0%	43	12.6%
New London							
Correctional Institutions	1	0	0.0%	0	0.0%	0	0.0%
EMS	77	1	1.3%	0	0.0%	1	1.3%
Fire Stations	68	1	1.5%	0	0.0%	1	1.5%
Gas Station	7	0	0.0%	0	0.0%	0	0.0%
Health Department	14	0	0.0%	0	0.0%	0	0.0%
Law Enforcement	33	1	3.0%	0	0.0%	1	3.0%
Municipal Solid Waste	39	0	0.0%	0	0.0%	0	0.0%
Nuclear Power Plant	1	0	0.0%	0	0.0%	0	0.0%
Storage Tank Farm	2	0	0.0%	0	0.0%	0	0.0%
New London Total	242	3	1.2%	0	0.0%	3	1.2%
Tolland							
Correctional Institutions	3	0	0.0%	0	0.0%	0	0.0%
EMS	35	1	2.9%	0	0.0%	1	2.9%
Fire Stations	37	3	8.1%	0	0.0%	3	8.1%

County/Facility Types	All Critical Facilities	High Hazard Dam Inundation		Significant Hazard Dam Inundation		Total # At Risk	Total % At Risk
		# Critical Facilities	% Critical Facilities	# Critical Facilities	% Critical Facilities		
Gas Station	2	0	0.0%	0	0.0%	0	0.0%
Health Department	4	0	0.0%	0	0.0%	0	0.0%
Law Enforcement	11	1	9.1%	0	0.0%	1	9.1%
Municipal Solid Waste	22	1	4.5%	0	0.0%	1	4.5%
Nuclear Power Plant	0	0	0.0%	0	0.0%	0	0.0%
Storage Tank Farm	0	0	0.0%	0	0.0%	0	0.0%
Tolland Total	114	6	5.3%	0	0.0%	6	5.3%
Windham							
Correctional Institutions	1	0	0.0%	0	0.0%	0	0.0%
EMS	43	0	0.0%	0	0.0%	0	0.0%
Fire Stations	40	0	0.0%	0	0.0%	0	0.0%
Gas Station	2	0	0.0%	0	0.0%	0	0.0%
Health Department	3	0	0.0%	0	0.0%	0	0.0%
Law Enforcement	12	1	8.3%	0	0.0%	1	8.3%
Municipal Solid Waste	17	0	0.0%	0	0.0%	0	0.0%
Nuclear Power Plant	0	0	0.0%	0	0.0%	0	0.0%
Storage Tank Farm	0	0	0.0%	0	0.0%	0	0.0%
Windham Total	118	1	0.8%	0	0.0%	1	0.8%
Statewide Total	1,846	120	6.5%	19	1.0%	139	7.5%

2.10.2 Assessment of Local Vulnerability and Potential Losses

The potential for loss of life is affected by the capacity and number of evacuation routes available to populations living in areas of potential inundation. Vulnerable populations are all populations downstream from dam failures that are incapable of escaping the area within the needed timeframe. The vulnerable population includes elderly and young who may be unable to evacuate from the inundation zone. Economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make decisions to evacuate based on the cost to their family. Populations over 65 are highly vulnerable because they are often more medically fragile, requiring assistance that may not be available during a flood event.

All populations, buildings, infrastructure, and natural resources located in a dam failure inundation zone may be considered exposed and vulnerable. The environment could be exposed to a number of risks in the event of dam failure. Inundation can introduce foreign elements into local waterways, which can damage downstream habitat harming many animal and aquatic species. In addition, damage to buildings can impact a community's economy and tax base. Buildings and property located closest to the inundation zone have the greatest potential to experience the largest, most destructive surge of water. Because of the sensitive nature of the dam failure inundation zones, mapped inundation zones were not available to use to estimate potential losses.

Connecticut's population according to the 2010 US Census is 3,574,097. Table 2-27 provides a breakdown by county of the population within mapped dam failure inundation areas. This analysis was conducted by a portion of the census block group intersected the hazard area, only that same portion of the population is counted. For example, if 20% of the census block group intersects with a dam inundation area, only 20% of the population number for that census block group is counted). This results in estimated values. While there is potential for error with this methodology, it is considered a more refined approach than assuming 100% of the population is contained within the 20% of the census block group that intersects the hazard area. The total population at risk is estimated at 169,419, which is 4.7% of the state's population. It is important to note that dam failure inundation mapping covers 199 areas included in the dataset and does not fully represent the state's 3,646 dams.

Table 2-27: Population within mapped dam inundation areas.

County	Total Population (2010)	High Hazard Dam Inundation		Significant Hazard Dam Inundation		Total Population At Risk	Total % At Risk
		Population at Risk	% Population at Risk	Population at Risk	% Population at Risk		
Fairfield	916,829	65,567	7.2%	1,638	0.2%	67,205	7.3%
Hartford	894,014	25,080	2.8%	7,305	0.8%	32,385	3.6%
Litchfield	189,927	12,603	6.6%	1,125	0.6%	13,728	7.2%
Middlesex	165,676	2,559	1.5%	0	0.0%	2,559	1.5%
New Haven	862,477	43,195	5.0%	1,015	0.1%	44,210	5.1%
New London	274,055	2,523	0.9%	1,559	0.6%	4,081	1.5%
Tolland	152,691	3,115	2.0%	397	0.3%	3,513	2.3%
Windham	118,428	1,736	1.5%	1	<1%	1,737	1.5%
Total	3,574,097	156,378	4.4%	13,041	0.4%	169,419	4.7%

2.10.3 Changes in Development

An understanding of population and development trends can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The State considered the following factors to examine previous and potential conditions that may affect hazard vulnerability:

- Potential or projected development

- Projected changes in population
- Other identified conditions as relevant and appropriate

Any new development and increases in population located within the identified dam failure inundation areas will be vulnerable to the impacts from a dam failure event. As discussed in Section 1.2.4 (Land Use and Development), Fairfield County and Hartford County continue to experience the greatest development rates. As of 2016, approximately 65.7% of the building permits statewide were in Fairfield and Hartford Counties; both of these counties accounted for nearly half of the housing units in the State. If recent trends in development continue, dam failure vulnerability in these counties will continue to increase, especially in Fairfield County, which currently has the greatest risk to dam failure inundation exposure in the State. Statewide, there is an estimated 2.2% change in population expected between 2020 and 2040; the increases in population will increase the State population's vulnerability to dam failure events.

2.10.4 Hazard Ranking

Quantitative risk assessment has been completed for dam failure using the methodology described in the Hazard Analysis and Ranking methodology Section 2.6 of this chapter. Scores for each jurisdiction were calculated based on population, building permits, geographic extent, average score from local plan rankings, average hazard concern, and measures of historical impact including injuries and deaths, property damage, and the number of reported events. The number of impacted critical facilities was also incorporated, and ranked based on the number of facilities impacted in relation to the number of total critical facilities in Connecticut. As shown in Table 2-28, the composite ranking has Fairfield County as medium risk, Hartford and New Haven as medium-low risk, and all other counties as low risk. Higher risk scores were primarily driven by large populations, numbers of building permits, and geographic extent.

Table 2-28: Hazard Ranking by County for Dam Failure

County	Hazard Concern Rank	Local Plans Hazard Rank	Geographic Extent Rank	Population Density Rank	Building Permits Rank	Facility Intersect Rank	Ann. Events Rank	Ann. Losses Rank	Injury & Death Rank	Composite Ranks
Fairfield	Low	Medium-High	High	High	High	Low	Low	Low	Low	**Medium**
Hartford	Low	Medium-High	Medium-High	High	High	Low	Low	Low	Low	**Medium-Low**
Litchfield	Low	Medium-High	Medium-High	Low	Low	Low	Low	Low	Low	**Low**
Middlesex	Low	Medium-High	Medium	Medium-Low	Medium-Low	Low	Low	Low	Low	**Low**
New Haven	Low	Medium-High	High	High	Medium	Low	Low	Low	Low	**Medium-Low**

County	Hazard Concern Rank	Local Plans Hazard Rank	Geographic Extent Rank	Population Density Rank	Building Permits Rank	Facility Intersect Rank	Ann. Events Rank	Ann. Losses Rank	Injury & Death Rank	Composite Ranks
New London	Low	Medium-High	Medium	Medium-Low	Medium-Low	Low	Low	Low	Low	**Low**
Tolland	Low	Medium-High	Medium-Low	Medium-Low	Medium-Low	Low	Low	Low	Low	**Low**
Windham	Low	Medium-High	Medium-Low	Medium-Low	Low	Low	Low	Low	Low	**Low**

2.11 Winter Weather Hazard Profile

2019 Plan Update Changes

- Previous Occurrences of winter weather
- FEMA disaster declarations
- Extent, Severity, and Primary and Secondary Impacts of Winter Weather
- Climate change impacts
- The definitions of Winter Storm and Blizzard were updated with recent information
- Geospatial analysis of Winter Weather was updated
- Analysis of State and Critical Facilities intersected with average annual total snow-depth

2.11.1 Hazard Description

Winter weather includes snow, sleet, freezing rain, and cold temperatures. Three elements are needed to create any type of winter precipitation:

- Cold Air – below freezing temperatures in the clouds and near the ground;
- Lift – something to raise the moist air to form the clouds and cause precipitation; and
- Moisture – needed to form clouds and precipitation.

According to the Northeast States Emergency Consortium (NESEC), winter weather can occur from late September through late April in Connecticut. The most severe storm and weather conditions usually occur from December through March. Severe winter weather events may include ice storms, Nor'easters with coastal flooding, blizzards, and large accumulation snow storms.

- **Blizzard** - Includes winter storm conditions of sustained winds or frequent gusts of 35 mph or more that cause major blowing and drifting of snow, reducing visibility to less than one-quarter mile for three or more hours. Extremely cold temperatures and low visibility, or white-out conditions are often associated with dangerous blizzard conditions.

- **Cold/Wind Chill** - Period of low temperatures or wind chill temperatures reaching or exceeding locally/regionally defined advisory (typical value is -180F or colder) conditions.
- **Extreme Cold/Wind Chill** - A period of extremely low temperatures or wind chill temperatures reaching or exceeding locally/regionally defined warning criteria (typical value around -350F or colder).**Frost/Freeze** - A surface air temperature of 32 degrees Fahrenheit (F) or lower, or the formation of ice crystals on the ground or other surfaces, for a period of time long enough to cause human or economic impact, during the locally defined growing season.
- **Heavy Snow**- Snow accumulation meeting or exceeding locally/regionally defined 12 and/or 24 hour warning criteria. This could mean values such as 4, 6, or 8 inches or more in 12 hours or less; or 6, 8, or 10 inches in 24 hours or less.
- **Ice Storm** - Ice accretion meeting or exceeding locally/regionally defined warning criteria (typical value is 1/4 or 1/2 inch or more).
- **Winter Storm** - A winter weather event that has more than one significant hazard (i.e., heavy snow and blowing snow; snow and ice; snow and sleet; sleet and ice; or snow, sleet and ice) and meets or exceeds locally/regionally defined 12 and/or 24 hour warning criteria for at least one of the precipitation elements.
    - A winter storm warning is issued by the National Weather Service (NWS) in which there is more than one of the following: snow, sleet, and ice (freezing rain), and one of the warning criteria is met. The warning criteria for snow is 6 inches expected in a 12 hour period, or 8 inches expected in a 24 hour period. The warning criteria for ice is accumulations meeting or exceeding 1/2 inch. A winter storm warning may also be issued for heavy snow combined with strong winds of 25-34 mph that will cause blowing and drifting of the snow. A warning may still be warranted if the event is expected to exceed advisory criteria, but fall just short of warning criteria and will significantly impact mass transit and/or utilities.54
- **Winter Weather** - A winter precipitation event that causes a death, injury, or a significant impact to commerce or transportation, but does not meet locally/regionally defined warning criteria. A winter weather event could result from one or more winter precipitation types (snow, or blowing/drifting snow, or freezing rain/drizzle). The winter weather event can also be used to document out-of-season and other unusual or rare occurrences of snow, or blowing/drifting snow, or freezing rain/drizzle.

2.11.2 Location

Winter weather affects the entire state because of its New England location. Each county has experienced disaster winter storm disaster declarations during e 2011 through 2015 The northwestern upland areas' high elevations result in heavier snow accumulations than the coastal regions, causing more severe storm impacts, but the entire state has experienced January and February blizzards during the past decade.

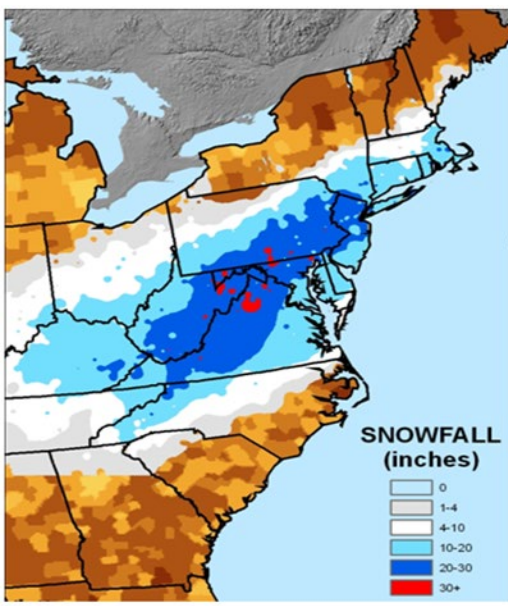
[54] https://www.weather.gov/okx/wwa_definitions#winter2

2.11.3 Extent

The Northeast Snowfall Impact Scale (NESIS), shown in Figure 2-11 is similar to the Enhanced Fujita Scale (for tornadoes) and the Saffir-Simpson Scale (for hurricanes) because it measures the severity of a winter storm based on an algorithm.,

NESIS can indicate a storm's societal impacts. It was developed because of the national impact of northeast snowstorms due to transportation and economic networks. NESIS scores are based on algorithms that evaluate the extent of the storm, snowfall total, and population in the impacted area. Figure 2-11 illustrates how NESIS values are calculated within a geographic information system (GIS). The aerial distribution of snowfall and population information are combined in an equation that calculates a NESIS score which varies from around one for smaller storms to greater than 10 for extreme storms.

Approximately 59 of the most notable winter storms that impacted the Northeast United States have been analyzed and categorized using NESIS; many impacted Connecticut.



n	Area (SqMi)	Population
0	118,837	15,182,500
1	107,526	16,432,000
4	103,951	19,913,500
10	107,786	29,907,800
20	63,532	30,216,900
30	2,364	340,889

$$NESIS = \sum_{n=4}^{n=30}\left[\frac{n}{10}\left(\frac{A_n}{A_{mean}} + \frac{P_n}{P_{mean}}\right)\right]$$

NESIS = 11.78
:
NESIS Category 5
Extreme

Figure 2-11: Algorithm to Determine NESIS Category of Severity and Example of Results

The Regional Snowfall Index (RSI) is an evolution of NESIS, operated through NOAA's National Center for Environmental Information and tracks. This index ranks significant snowstorms that impact the eastern two-thirds of the United States. The RSI ranks snowstorm impacts on a scale from 1-5, as does NESIS, but while NESIS is thought to be a quasi-national index, the RSI is a regional index.[55] Table 2-29 shows the RSI Index scale descriptions and definitions. The index differs from other meteorological indices because it uses population information in addition to meteorological measurements. The largest NESIS values result from storms that produce heavy snowfall over large areas that include major metropolitan centers.

[55] https://www.ncdc.noaa.gov/snow-and-ice/rsi/

Table 2-29: Regional Snowfall Index (RSI)

Category	NESIS Range	Description	Definition
1	1 – 2.499	Notable	These storms are notable for their large areas of 4-inch accumulations and small areas of 10-inch snowfall.
2	2.5 – 3.99	Significant	Includes storms that produce significant areas of greater than 10-inch snows while some include small areas of 20-inch snowfalls. A few cases may even include relatively small areas of very heavy snowfall accumulations (greater than 30 inches).
3	4 – 5.99	Major	This category encompasses the typical major Northeast snowstorm, with large areas of 10-inch snows (generally between 50 and 150 × 103 mi.2— roughly one to three times the size of New York State with significant areas of 20-inch accumulations
4	6 – 9.99	Crippling	These storms consist of some of the most widespread, heavy snows of the sample and can be best described as crippling to the northeast U.S, with the impact to transportation and the economy felt throughout the United States. These storms encompass huge areas of 10-inch snowfalls, and each case is marked by large areas of 20- inch and greater snowfall accumulations.
5	10+	Extreme	The storms represent those with the most extreme snowfall distributions, blanketing large areas and populations with snowfalls greater than 10, 20, and 30 inches. These are the only storms in which the 10-inch accumulations exceed 200 × 103 mi2 and affect more than 60 million people.

The RSI differs from other indices because it includes population. RSI is based on the spatial extent of the storm, the amount of snowfall, and the juxtaposition of these elements with population. Including population information ties the index to societal impacts. Currently, the index uses population based on the 2000 Census.[56]

The extent of winter weather in Connecticut depends on numerous factors but can be evaluated through the use of meteorological measurements and indices such as the RSI Index. The extent of winter weather, for historic events as well as future probability, is

[56] https://www.ncdc.noaa.gov/snow-and-ice/rsi/

highlighted through the historical overview of winter storms and the extent areas of the state.

2.11.4 Primary and Secondary Impacts

Winter weather, including heavy snow, ice, sleet, and freezing rain can slow or halt commerce and daily life through transportation and utility infrastructure disruption. Snow load poses a threat to structures. Roads and bridges may also experience structural damage due to rapid temperature variation during winter weather, chemicals used to treat roads, and ice loads. Winter weather has the potential to disrupt traffic, close offices and schools, and impact productivity and revenue statewide. In addition, the large concentration of Connecticut commuters are greatly impacted if winter weather disrupts train service to New York City. Ice and heavy snow have the potential to disrupt power and utilities, downing powerlines and uprooting trees onto vital infrastructure and components of the electrical grid.

Adverse winter weather necessitates an increase in municipal and state workforces to clear roads and additional emergency management personnel to attend to the community.

2.11.5 Severity

From Nor'easters to blizzards, winter weather in Connecticut ranges in severity. During autumn, light winter weather gradually becomes more severe as the season progresses into winter. Blizzards are not uncommon during the winter months, blizzard occurrence during January or February during 2016-2018.

Winter weather has the capacity to immobilize a region, cut communities off from emergency management personnel, and make travel impossible. When winter weather is paired with freezing rain and ice storms, utilities including water, gas, and electric can be compromised. These issues put vulnerable communities and populations, such as the elderly at an increased risk.

2.11.6 Warning Time

Warning time for winter weather events is typically greater than 24 hours. Winter weather is observed, monitored, and tracked by the National Weather Service (NWS) a U.S. agency and is part of NOAA. The NWS tracks snowfall forecasts, ice accumulation, and winter storm threats and aids communities in planning, preparing, and mitigating against natural events such as winter weather. With 122 Weather Forecast Offices, 13 River Forecast Centers, nine National Centers, and other support offices, the NWS collects and analyzes more than 76 billion observations and releases about 1.5 million forecasts and 50,000 warnings each year.[57] The NWS issues warnings for winter weather events, with frequencies and length that vary by specific conditions.

2.11.7 Previous Occurrences and Losses

Connecticut's geographic location in the Northeastern United States leads to at least 14 winter weather annually. Events include heavy snow storms, blizzards, Nor'easters, and ice storms (especially in the northern portion of the state). NOAA's State Climate Extremes Committee (SCEC) tracks, records, and verifies climate records. The record 24 hour snowfall and snow depth for Connecticut are highlighted in the Table 2-30.

Table 2-30: Record Snowfall and Snow Depth in Connecticut[58]

Measure of Interest	Value	Date	Location	Station ID	Status
Greatest 24-Hour Snowfall	36 in.	February 8 - 9, 2013	ANSONIA 1 NE	060128	NSA
Snow Depth	55 in.	February 5, 1961	NORFOLK 2 SW	065445	E

The snowfall and snow depth data is recorded and monitored by NOAA National Centers for Environmental Information and or by the State Climate Extremes Committee and determined to be valid. The "Status" nomenclature indicates that daily snowfall record is updated from the extremes table last updated by the National Climatologic Data Center (NCDC) from 1998-2006. In addition this information has been reviewed by a State Climate Extremes Committee and additional information is available. The snow depth has not changed from the previous extremes table as updated by NCDC from 1998-2006.[59]

The NCEI Storm Events Database contains records of Blizzards, Cold/Wind Chill, Extreme Cold/Wind Chill, Frost/Freeze, Heavy Snow, Ice Storms, Winter Storms, and Winter Weather. All storm types were included to create comprehensive representation of winter storm events. In previous plan updates, data was provided by the NCDC. In early 2015, NCDC merged with three other NOAA data centers to form NCEI, which can account for data variances between the 2013 and 2019 plan updates.

According to NCEI records, there have been 432 winter storm events statewide from January 1996 to December 31, 2017 resulting in $48,014,331 in estimated property damages (in adjusted dollars) (Table 2-31). One death and 52 injuries occurred during this period. Information of deaths and injuries by county is not available since NCEI reports this information by regional zones.

Table 2-31: NCEI Total Winter Storm Events by County, 1996 – 2017

57 https://www.weather.gov/about/forecastsandservice
58 https://www.ncdc.noaa.gov/extremes/scec/records
59 https://www.ncdc.noaa.gov/extremes/scec/records

County	Number of Winter Storm Events	Property Damage (2017 dollars)
Fairfield	183	N/A
Hartford	110	$30,343,304
Litchfield	279	$2,070,060
Middlesex	126	N/A
New Haven	168	$4,021,960
New London	124	N/A
Tolland	102	$9,146,488
Windham	96	$2,432,519
Total	*	$48,014,331

**Note: event totals were not included because NCEI events may be counted more than once if one storm event affects multiple counties.*

The most significant blizzard to impact Connecticut occurred on March 11-14, 1888 (Figure 2-12), known as the Great White Hurricane. Snowfall in this event was estimated at 45 to 50 inches. Significantly high snow drifts occurred shutting down major cities throughout the Northeast. Fifty inched was verified in one Connecticut town, where a snow drift was reported as 38 feet high. More than 400 died in the East Coast as a result of this blizzard. Total damages were estimated at more than $20 million (1888 dollars).

Figure 2-12: Pictures from the 1888 blizzard

Since the 1888 blizzard, Connecticut has experienced many major winter storms. Some claimed lives and produced damages in the millions of dollars. Notable recent storms include:

Ice Storm Felix – Connecticut's most severe ice storm occurred on December 18, 1973 causing two deaths and widespread extended power outages.

Blizzard of 1978 – Occurred on February 5, 1978; record snowfall amounts were recorded in several areas of Connecticut. Governor Grasso ordered all roads closed except for emergency travel, closing the State.

Nor'easter of 1992 – This storm, December 10 -13, 1992 killed three and destroyed 26 homes. Tides in Long Island Sound were stacked up by the continued strong east/northeast winds reaching 55 mph. The "stacking" of water resulted in the third highest tide (10.16 Feet NGVD measured at Bridgeport, Connecticut) ever recorded in Long Island Sound causing more than $4.3 million (1992 dollars) in damages to more than 6,000 homes. Inland areas received up to four feet of snow in northeastern Connecticut. The heavy wet snow snapped tree limbs and power lines cutting power to 50,000 homes.

Winter Storm Ginger – On January 8-9, 1996 27 inches of snow was recorded in Connecticut. The storm forced the state to shut down all roads for 24 hours except for emergency travel.

February 12-13, 2006 Nor'easter – The major disaster was declared due to damages in some areas from record snowfall (second largest snowfall recorded since 1906). Also known as the North American Blizzard of 2006. Governor M. Jodi Rell ordered closure of state highways to facilitate efficient snow removal.

Figure 2-13 shows the recorded snowfall amounts and the NESIS rating for The North American Blizzard of 2006.

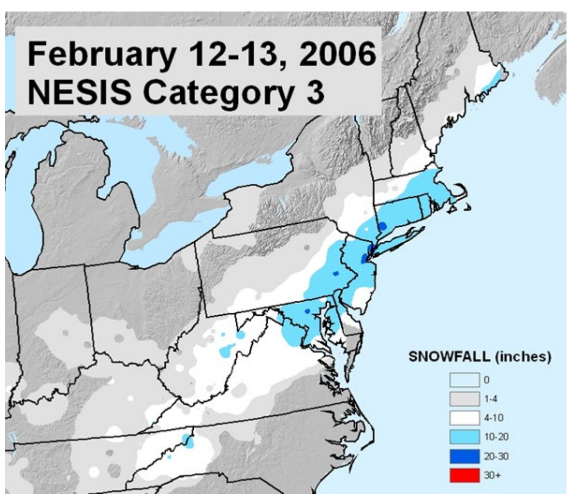


Figure 2-13 NESIS analysis rating of the February 12-13, 2006 winter storm

January 11-12, 2011 (Heavy Snow) – Very heavy snow developed across the region, producing snowfall rates of three to four inches per hour and snow totals ranging from 15 to 30 inches in southern Connecticut. The highest snowfall totals occurred in Fairfield and New Haven counties. At least four roof collapses were documented,

January 26-27, 2011 (Heavy Snowstorm) – A period of moderate to heavy snow moved through the region, producing two to five inches before a second round of heavy snow. This system produced three to four inches of snowfall hourly over during four - to six hours, raising accumulation to 12 to 20 inches causing at least 19 documented roof collapses.

February 1-2, 2011 "Groundhog Day Blizzard" – Three to five inches of snow and sleet fell across interior portions of Southern Connecticut during this two-day storm. With accumulation up to ten inches. Between 1/4 and 3/4 of an inch of ice accreted across Southern Connecticut, with the highest amounts across far Southwestern Connecticut and interior Northeastern Connecticut. This storm caused power outages, tree damage, the collapse or partial collapse of more than 100 roofs, resulting in $5.25 million in property damage across four counties (Hartford, New Haven, Tolland, and Windham) (source: NCDC).

October 29-30, 2011 "Winter Storm Alfred" – A historic and unprecedented early-season winter storm impacted the area with more than one foot of heavy wet snow falling on interior portions of Southern Connecticut, while coastal areas received mainly rainfall. In addition to heavy rain and snow, strong winds impacted the immediate coastline. Hundreds of thousands of people across southern Connecticut lost power during as heavy snow accumulated on trees that still had partial to full foliage during mid-autumn. This caused extensive wind throw of trees and limbs across the region, downing power lines, closing roads, and creating many dangerous situations of isolated residential areas without emergency vehicle access. Communications networks were also significantly disrupted (especially cellular networks). This was the first time a winter storm of this magnitude has occurred during October. A total of $247 million in insurance claims including personal, commercial, and auto claims were processed.

February 7-8, 2013 "Winter Storm Nemo" – By February 7, 2013, this powerful winter storm had prompted winter storm warnings and winter weather advisories from the Upper Midwest to New England. A blizzard warning was in effect for Connecticut; a state of emergency was declared February 8, 2018. The highest amount of snowfall nationally recorded was 40 inches in Hamden, CT. More than 800 National Guard soldiers and airmen were activated in Connecticut, Massachusetts, and New York to support road emergencies.

The Blizzard of January 26-27, 2015 "Winter Storm Juno" - A potent Alberta Clipper low moved from southwestern Canada on January 24 to the Plains states and Ohio Valley the next day. The low then redeveloped off the Mid Atlantic coast January 26, rapidly intensifying into a strong nor'easter, bringing heavy snow and strong winds to the State.

The heaviest snow and strongest winds occurred across eastern Long Island and southeastern Connecticut where up to 2 feet of snow fell, with blizzard conditions observed60

The Blizzard of January 22-24, 2016 "Winter Storm Anna" - Low pressure moving across the deep South January 21 - 22 intensified and moved off the Mid Atlantic coast January 23, bringing heavy snow and strong winds to southern Connecticut, and blizzard conditions to coastal locations. Bridgeport ASOS (KBDR) reported blizzard conditions for three hours.61

The Blizzard of February 9, 2017 - A cold front associated with low pressure across southeast Canada moved across the region February 8, followed by an upper level trough amplified across the Midwest. Energy within this trough acted on the cold front to develop a new low pressure across the Middle Atlantic which rapidly intensified moving to Long Island later that day.

The southeast coast of Long Island including the eastern Hamptons and Montauk were warmer at the onset of the storm. Montauk first experienced rain which turned to heavy snow as temperatures dropped throughout the day.

The day before the blizzard record warmth was observed across the Tri-State area. Record highs included 62 degrees at Central Park, NY. Temperatures dropped 30-40 degrees within 12-15 hours to the mid-upper 20s during the storm. 62 Blizzard conditions occurred across southern Connecticut with heavy snow and strong winds. The blizzard also created delays and cancellations to the region's transportation systems as well as numerous accidents on roadways.63

March 14th, 2017 Nor'Easter - Rapidly deepening low pressure tracked up the eastern seaboard on March, 14 created blizzard conditions in New Haven County. Heavy snow and sleet was observed across the southern Connecticut.

Trees fell onto power lines causing approximately 3,700 power outages due to strong winds and heavy snow. CT DOT reported 10.3 inches of snow and sleet in Milford and 8.8 inches of snow and sleet in New Haven. The Oxford-Waterbury AWOS showed blizzard conditions, with visibility less than one quarter mile in heavy snow and frequent wind gusts over 35 mph March 14.[64]

January 3-4, 2018 (Bomb Cyclone) - The blizzard developed Wednesday, January 3as a low pressure off the coast of Florida. The low underwent rapid intensification as it moved

[60] https://www.weather.gov/okx/Blizzard_01262715
[61] https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=617436
[62] https://www.weather.gov/okx/Blizzard_Feb92017
[63] https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=680087
[64] https://www.ncdc.noaa.gov/stormevents/eventdetails.jsp?id=687573

north-northeast along the eastern seaboard with the central pressure dropping from 1004 millibar to to 950 millibar which is a 54 millibar drop. The rapid intensification of the storm led to heavy snow and blizzard conditions across portions of the region, setting a daily snowfall record for January 4 at Bridgeport, CT (9.0")

FEMA Disaster Declarations

Table 2-32 below outlines the most recent winter weather disaster declarations. A full list of disaster declarations prior to 2013 is included in Appendix 2.

Table 2-32 Major Federal Winter Weather Disaster Declarations

Declared Date	Declaration Number	Counties Affected	Description
April 8, 2015	FEMA-4213-DR	New Haven, New London, Tolland, Windham	Severe winter storm and snowstorm
March 21, 2013	FEMA-4106-DR	All eight counties in the State, including the Tribal lands of the Mashantucket Pequot and the Mohegan Tribal Nations	Severe Winter Storm and Snowstorm

2.11.8 Probability of Future Events

Connecticut will likely experience at least two or more major snow storms each winter. Based on NCEI historical events, it is reasonable to assume that Connecticut has a medium-high probability of future events. Table 2-33 summarizes the probability of future events by county (annualized events). Table 2-37 shows the ranking and risk parameters which includes the annualized events for each county.

Based on historical CTDOT records, an average of up to 14 events per winter season, major or otherwise, could require CTDOT hazardous road response. The 10-year average for winter storm events that prompted a response from CTDOT is 12 events annually, New Englanders expect this weather but climate change, increasing temperatures by mid to late century, could reduce the number of major snow storms. Recent climate change studies have projected winter seasons shortened by as much as two weeks for the state along with reduced duration of ground cover and snow pack. In addition, climate models have indicated that fewer but more intense precipitation events will occur during winter with more rainfall than snow.[65]

[65] Sources: U.S. Global Change Research Program, Global Climate Change Impacts in the United States, 2009; Northeast Climate Impacts Assessment Group, Confronting Climate Change in the U.S. Northeast, 2007; and U.S. Climate Change Science Program, Weather and Climate Extremes in a Changing Climate, 2008.

This change in winter precipitation could result in less frequent but more intense snow storms with heavier (denser) snow. NOAA's Snowfall/Meltwater Table[66] shows that as temperatures increase the amount and weight of snowfall decreases. For example, one inch of meltwater at 34°-28° F equals 10 inches of snow. This same amount of meltwater equals to 40 inches of snow at 9°-0° F.

In addition, the increasing change in the type of winter precipitation may also decrease the number of major snow storms experienced, but increase the number of ice storms occurring. This is an important issue that requires further study as a change in snow density or changeover to more freezing rain/ice could have a large impact on managing future winter storms and the impact of such storms on the residents of Connecticut (including travel and utility services). Figure 2-14 shows average annual snowfall in inches for Connecticut.

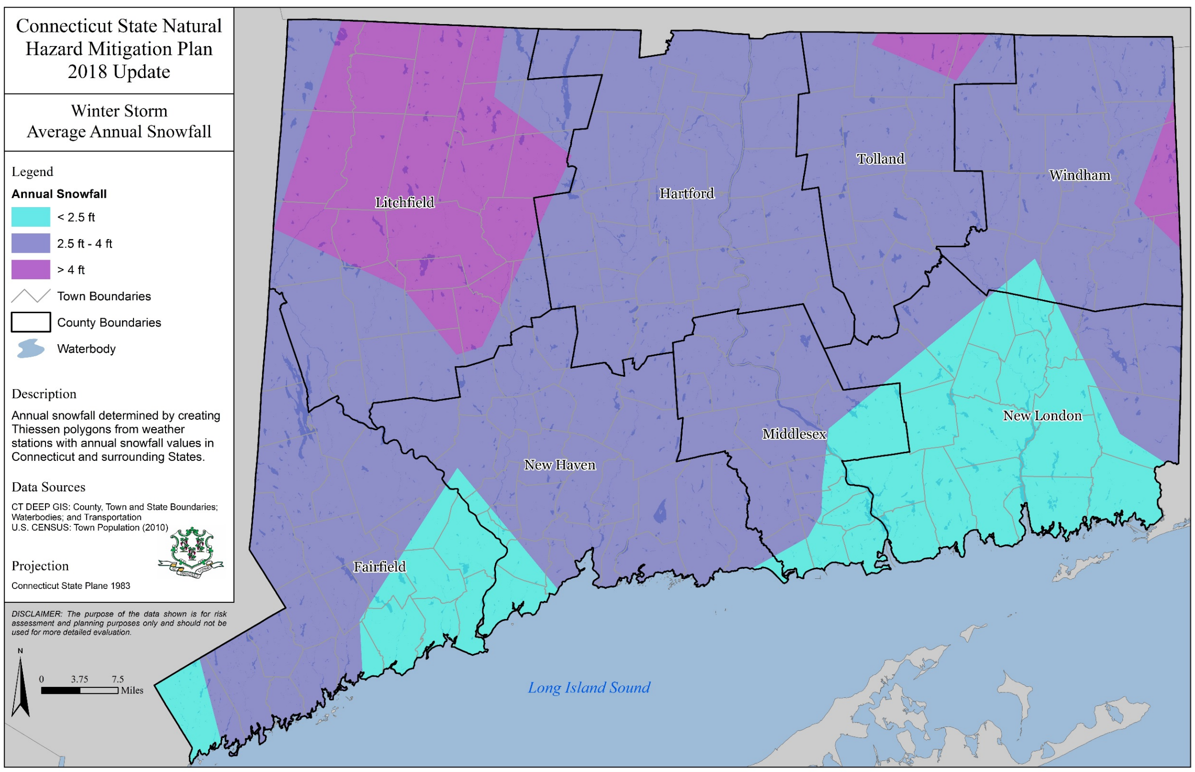


Figure 2-14: Winter Storm Average Annual Snowfall

2.11.9 Climate Change Impacts

Annual mean temperature in Connecticut has increased by about 3°F (1.7°C) since 1895, faster than rising global mean temperatures.[67] Due to rising temperatures, increased rain

[66] NOAA website. The amounts listed in the table are general estimates and are noted to vary greatly between snowstorms, given the specific characteristics per storm event.
[67] https://www.geo.umass.edu/climate/stateClimateReports/CT_ClimateReport_CSRC.pdf

could mean more ice storms.[68] Climate change will have significant impacts on winter weather patterns and precipitation during the winter months. Connecticut continues to analyze possible scenarios of how climate variations will impact weather patterns, but as recent winter storm conditions have shown, winter weather has been, and will continue to be impactful to communities, infrastructure, and public safety.

2.12 Winter Weather Vulnerability Assessment

Winter weather is one of the most impactful hazards to the State and its 174 municipalities, tribes, and boroughs annually. Harsh winter storms ranging from ice storms and blizzard conditions to nor'easters battering coastal communities affect the entire State though snowfall and coastal winter varies geographically,

2.12.1 Assessment of State Vulnerability and Potential Losses

People living in the rural areas are vulnerable to potential power losses and property damages from major winter storms. In addition, Connecticut's elderly population is especially vulnerable to winter storm impacts (heat loss, power loss, safe access to grocery stores, pharmacies and medical care).

It is anticipated that severe transportation gridlock during winter storms will continue to occur. Severe traffic congestion from winter storms happened due to rapid onset of heavy snow over urban areas and icing of roadways as a result of lighter snow events that lead to freezing of water on roadways or freezing rain or ice storms. Traffic congestion and safe commuter travel can be mitigated by the use of staggered timed releases from work, pre-storm closing of schools, and later start times for businesses. Most Connecticut employers and school districts implement such practices. However, the costs associated with transportation disruptions and the loss of work and school time are projected to increase.

Table 2-33 shows annualized loss information for the state by jurisdiction, including the annualized number of events, and total annualized damages due to winter storm.

Table 2-33: NCEI Annualized Winter Weather Events and Property Damages

[68] https://www.geo.umass.edu/climate/stateClimateReports/CT_ClimateReport_CSRC.pdf

County	Annualized Events	Annualized Damages (2017 Dollars)
Fairfield	7.55	N/A
Hartford	4.68	$1,352,323.52
Litchfield	11.68	$92,629.71
Middlesex	5.18	N/A
New Haven	7.05	$179,972.10
New London	5	N/A
Tolland	4.41	$408,386.24
Windham	4.05	$105,940.23

Table 1-5 depicts infrastructure/facilities, building value and contents value by municipality. The estimated total value of Connecticut's 3,327 state buildings is $5.6 billion, with more than $866 million in contents value. Building and contents values have been estimated for the plan update and should not be used elsewhere. Appendix 2 includes the infrastructure and facilities datasets and loss estimates by municipality for facilities located within areas vulnerable to winter storms.

State Facilities Exposure

Table 2-34 and Table 2-35 shows the annual exposure of these assets to annual averaged total snow-depth. Eighty-one percent (2,710) are located in an area of the state with an average annual snow-depth of 2.5 feet or greater, thus $3.5 billion in estimated building value is exposed to severe snow accumulation (62% of the total known value of all state-owned buildings in the state).

Table 2-34: State-owned Building Winter Weather Exposure

County	Total State-Owned Buildings	< 2.5FT Annual	2.5FT to 4FT Annual	> 4FT Annual	Total Buildings At Risk
Fairfield	205	0	205	0	205
Hartford	867	96	771	0	867
Litchfield	97	0	94	3	97
Middlesex	289	1	286	2	289
New Haven	561	134	421	6	561
New London	489	57	424	8	489
Tolland	628	283	303	42	628
Windham	191	46	134	11	191
Total	3,327	617	2,638	72	3,327

Table 2-35: Value of State-owned Buildings Exposed to Winter Weather

County	Total State-Owned Buildings	< 2.5FT Annual Building Value	2.5FT to 4FT Annual Building Value	> 4FT Annual Building Value	Total Building Value at Risk
Fairfield	205	N/A	$306,766,079	N/A	$306,766,079
Hartford	867	N/A	$1,748,115,127	N/A	$2,193,688,919
Litchfield	97	N/A	$49,393,806	N/A	$49,393,806
Middlesex	289	N/A	$333,187,573	N/A	$333,187,573
New Haven	561	$222,600,542	$506,081,106	$396,611	$729,078,259
New London	489	N/A	$88,717,364	$1,844,126	$90,561,490
Tolland	628	$1,339,246,606	$319,693,278	$12,817,601	$1,671,757,487
Windham	191	$105,309,715	$124,882,539	N/A	$230,192,255
Total	3,327	$2,112,730,656	$3,476,836,875	$15,058,340	$5,604,625,871

Critical Facilities Exposure

The state contains 1,940 identified critical facilities ranging from correctional institutions, EMS facilities, fire stations, gas stations with generators, health departments, law enforcement facilities, nuclear power plants, and fuel storage tank farms. 1,846 of the critical facilities were intersected with the winter weather hazard overlays.[69] Table 2-36 provides a breakdown of the numbers of critical facilities exposed to areas of the state averaging annual snow-depth less than 2.5ft, 2.5 – 4ft, and greater than 4ft. Seventy-seven percent (1,415) are located in an area averaging 2.5 feet or greater annual snow-depth.

Table 2-36: Number of critical facilities exposed to winter storm hazards

[69] While there are a total 1,940 critical facilities, the WPCF's lacked spatial data in which to overlay with hazards and assess vulnerability. 1,846 critical facilities were intersected with Connecticut's hazards.

County	< 2.5FT Annual Snow-depth				2.5FT to 4FT Annual Snow-depth								> 4FT Annual Snow-depth		Total Buildings At Risk
	EMS	Fire Station	Law Enforcement	Municipal Solid Waste	Correctional Institution	EMS	Fire Station	Gas Station with Generator	Health Department	Law Enforcement	Municipal Solid Waste	Storage Tank Farm	Fire Station	Municipal Solid Waste	
Fairfield	34	69	28	0	4	86	42	22	25	7	10	7	4	33	371
Hartford	12	31	31	1	6	68	108	10	26	13	51	8	2	10	377
Litchfield	9	20	2	0	0	25	33	8	7	23	27	0	0	2	156
Middlesex	1	11	2	0	1	30	21	8	9	15	18	3	4	3	126
New Haven	13	68	16	0	5	63	47	23	26	26	19	10	0	26	342
New London	17	36	11	0	1	60	32	7	14	22	26	2	0	13	242
Tolland	2	3	2	0	3	33	34	2	4	9	21	0	0	1	114
Windham	4	3	4	0	1	39	37	2	3	8	15	0	0	2	118
Statewide Total	12	31	31	1	6	68	108	10	26	13	51	8	2	10	1,846

2.12.2 Assessment of Local Vulnerability and Potential Losses

While winter weather deeply impacts Connecticut, vulnerability is experienced locally. Winter weather prohibits or delays school and business openings, hinders transportation, reduces local economic revenue, threatens at-risk populations including the elderly, young and poor, and effects critical facility operation. Runoff from plowed snow which contains sand, debris, salt, heavy metals and petroleum has the potential to affect local water sources, streams, rivers, and drinking water. While the State is responsible for clearing main highways and infrastructure, municipalities clear local roads and re-establish and community access.

For more detail regarding the vulnerability of specific municipalities to winter weather, please refer Appendix 2.

2.12.3 Changes in Development

Connecticut's population growth has been minimal recently, with modest to low growth projected in the next few decades. This minimal growth has reduced the vulnerability to winter weather.

2.12.4 Hazard Ranking

Quantitative risk assessment was completed for winter weather using the methodology described in the Hazard Analysis and Ranking methodology Section 2.6 of this chapter. Scores for each jurisdiction were calculated based on population, building permits, geographic extent, average score from local plan rankings, average hazard concern, and measures of historical impact including injuries and deaths, property damage, and the number of reported events. The number of impacted critical facilities was also incorporated, and ranked based on the number of facilities impacted in relation to the number of total critical facilities in Connecticut. As shown in Table 2-37, the composite winter weather rank shows a "high" risk for Fairfield, Hartford, New Haven, and Tolland Counties; Litchfield and Windham Counties as medium-high risk; and Middlesex and New London Counties as medium risk.

Table 2-37: Hazard Ranking by County for Winter Weather

County	Hazard Concern Rank	Local Plans Hazard Rank	Geographic Extent Rank	Population Density Rank	Building Permits Rank	Facility Intersect Rank	Ann. Events Rank	Ann. Losses Rank	Injury & Death Rank	Composite Ranks
Fairfield	Medium-High	High	Medium-High	High	High	Medium	High	Low	High	**High**
Hartford	Medium-High	High	Medium-High	High	High	Medium	High	High	Low	**High**
Litchfield	Medium-High	High	High	Low	Low	Medium	High	Medium	Low	**Medium-High**
Middlesex	Medium-High	High	Medium	Medium-Low	Medium-Low	Medium	High	Low	Low	**Medium**
New Haven	Medium-High	High	Medium	High	Medium	Medium	High	Medium-High	Low	**High**
New London	Medium-High	High	Medium	Medium-Low	Medium-Low	Medium	High	Low	Low	**Medium**
Tolland	Medium-High	High	Medium-High	Medium-Low	Medium-Low	Medium	High	Medium-High	Low	**High**
Windham	Medium-High	High	Medium-High	Medium-Low	Low	Medium	High	Medium-High	Low	**Medium-High**

2.13 Flood-Related Hazard Profile

2019 Plan Update Changes

- Updated the hazard profile to add a discussion about Ice Jams (previously discussed in the 2010 plan exclude from 2014 plan update).
- Updated the National Flood Insurance Program (NFIP) section to include a discussion about Connecticut Community Rating System communities.
- Updated NFIP section to include a discussion about Coastal Barrier Resource Areas.
- Updated the Previous Occurrences and Losses section to include recent storm events.
- Added a section that discusses Flood Impacts (Severity, Warning Time, and Secondary Impacts).
- Removed 2000 AAL Comparison.
- Ran both 100-year and multi-frequency flood scenarios for vulnerability analysis.
- Average Annualized Losses calculated for multi-frequency scenarios.

2.13.1 Hazard Description

This section provides general information on State flood hazards including riverine (inland) flooding, coastal flooding, shallow flooding, and ice jams. Flooding is one of the most common natural hazards in the United States. Other natural hazard events like hurricanes, coastal storms, severe rains, occurrence of ice jams and dam failures often result in flooding including. Flooding can cause extensive damage to property and risk of injury and loss of life. The following are five characteristics of a flood:

- **Hydrodynamic forces** -– Structural damage created by moving waters. There are three ways in which hydrodynamic forces can damage a structure's walls: by frontal impact to the walls (water striking the walls of a structure); drag effect (water running alongside of a structure's walls); and, eddies or negative pressure (water passing the downstream side of a structure).
- **Debris Impact** - includes damage by direct impact of any object that flood waters can pick up and move to another location.
- **Hydrostatic Forces** – the pressure, both downward and sideways which standing water exerts on a structure's floor and walls. Hydrostatic pressure can also cause damage to structures due to buoyancy and flotation which can occur in flood waters.
- **Soaking** – the warping, swelling and changes in a material's form and structure resulting from being submerged in flood waters.
- **Sediments and Contaminants** – the sand, sediments, chemicals, and biological contaminants (such as untreated sewage) that flood waters can move and leave behind after the flood waters subside.

Riverine Flooding

Riverine flooding occurs when streams, rivers, channels and other waterbodies receive more rain or snowmelt from their watershed than their capacity can handle within the normal floodplain or when the waterbody becomes blocked by an ice jam or debris. Excess water overloads the channel and extends into or even beyond the natural floodplain.

Flash flooding can occur during a rapid rise of water throughout a watershed or in poorly drained urban areas composed mostly of impervious surfaces which cannot absorb precipitation. Flash flooding is typically a result of an unusually large amount of rain and/or high velocity of water flow (especially in hilly areas) within a very short period of time (e.g., intense rainfall, dam failure, ice jam).

Coastal Flooding

Coastal flooding can occur along the coastline of oceans, bays, inlets, large lakes, and coastal rivers. Coastal floods feature submersion of land adjacent to oceans and large water bodies as a result of overtopping of seawater above normal tidal action. Coastal flooding occurs from coastal storms that produce storm surges, extreme rainfall or inadequate capacity to drain inland waterbodies. Coastal flooding often exacerbated by severe dune erosion. These conditions are produced in Connecticut by hurricanes or tropical storms during the summer and fall, and Nor'easters and large coastal storms or extra-tropical storms during the autumn, winter, and spring.

Storm surge is an abnormal rise of water generated by a storm that exceeds predicted astronomical tide elevations. Storm surge is produced by water pushed towards the shore by winds associated with a storm. Storm surges may overrun barrier islands and push sea water into coastal rivers and inlets, blocking the downstream flow of inland runoff. Agricultural lands, forests, and wetlands along with developed areas may be inundated by fresh, brackish and salt water. Evacuation routes from coastal communities and barrier islands may be cut off quickly, stranding residents in flooded and inaccessible areas.

Waves are a unique and damaging characteristic of coastal flooding that are addressed in floodplain hazard assessment. FEMA's Flood Insurance Rate maps (FIRMs) delineate areas vulnerable to wave heights greater or equal to three feet as Zone V (including Zones VE, V1-30, and V), also known as the Coastal High Hazard Area. V Zones are an area within the Special Flood Hazard Area (SFHA) extending from offshore to the inland limit of the primary frontal dune along an open coast and any other portion of the SFHA subject to high-velocity wave action from storms or seismic sources (Figure 2-15).

Zone A or AE is the coastal portion of the SFHA that is subject to wave heights of less than three feet. The Limit of Moderate Wave Action divides Zone AE into two sections: a Coastal A-zone where wave heights are between 1.5 and three feet (Moderate Wave Action area) and a Zone AE where wave heights are less than 1.5 feet (Minimal Wave Action area) (FEMA 2011).

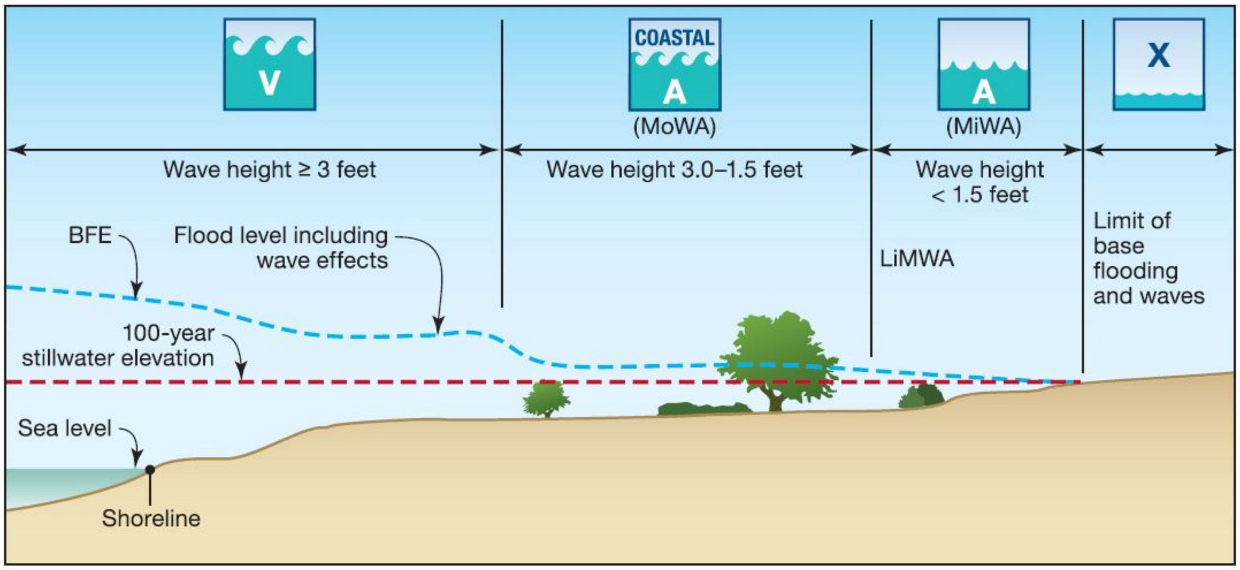


Figure 2-15: Transect schematic showing coastal flood zones

Shallow Flooding

Shallow flooding occurs in flat areas where the lack of a defined channel results in poor drainage. There are three types of shallow flooding:

- Sheet Flow – water spreads out over a large area at a uniform depth;
- Ponding – runoff collects in depressions and cannot drain out; and
- Urban Flooding – when a drainage system, consisting of manmade features, is overloaded by a larger amount of water than the system was designed to accommodate.

Ice Jams

An ice jam is an accumulation of ice in a river that restricts water flow causing backwater that floods low-lying areas upstream from the jam. Ice jams occur when early spring warming temperatures combined with heavy rain cause rapid snow melt. The combination of snow melt and heavy rains can cause frozen rivers to swell, breaking the ice layer on top of the river. The ice layer often breaks into large chunks which float downstream and become jammed at man-made and natural obstructions. (Northeast States Emergency Consortium and FEMA). Areas below the ice jam can be affected by flash flooding when the jam releases, sending water and ice downstream rapidly.

According to the Special Report 94-7 Ice Jam Data Collection, by the US Army Cold Regions Research and Engineering Laboratory (CRREL) (March 1994), ice jams can be grouped into three categories: freeze-up jams, breakup jams, or both. Each ice jam type different characteristics and associated mitigation and control.

The following description of the types of ice jams, and mitigation and control techniques is detailed in *Flooding: Causes and Possible Solutions, US Army Corps of Engineers, November 1994.*

Freeze-up jams are characterized by low air and water temperatures, fairly steady water and ice discharges, and a consolidated top layer. Freeze-up jams are composed primarily of frazil ice (often described as slush ice). The floating frazil may slow or stop due to a change in water slope from steep to mild because it reaches an obstruction to movement such as a sheet ice cover, or because some other hydraulic occurrence slows the movement of the frazil. Jams are formed when floating frazil ice stops moving downstream, forms an "arch" across the river channel, and begins to accumulate.

Breakup jams occur during periods of thaw, generally in late winter and early spring, and are composed primarily of fragmented ice formed by the breakup of an ice cover or freeze-up jam. The ice cover breakup is usually associated with a rapid increase in runoff and corresponding river discharge due to a significant rainfall event or snowmelt. In these cases, the increased river discharge causes the ice to rise and buckle or break apart. These broken pieces of ice are then moved downstream by the rising water. Late season breakup is often accelerated by sudden increases in air temperatures and solar radiation usually accompanying a rainfall/runoff event.

The broken, fragmented ice pieces move downstream until they encounter a strong intact downstream ice cover or other surface obstruction to flow (such as a dam or bridge), or other adverse hydraulic conditions such as a significant reduction in water surface slope, or a sudden rise in the river bed. Once they reach such a jam initiation point, the fragmented ice pieces stop moving, begin to accumulate, and form a jam. The ultimate size of the jam (i.e., its length and thickness) and the severity of the resulting flooding depend on the flow conditions, the available ice supply from upstream reaches of the river, and the strength and size of the ice pieces.

Midwinter thaw periods marked by flow increases may cause a minor breakup jam. The river flow subsides to normal winter level and the jammed ice drops with the water level as cold weather begins. The jam may become grounded as well as consolidated or frozen in place. During normal spring breakup, this location is likely to be the site of a severe jam. Combination jams involve both freeze-up and breakup jams.

2.13.2 Location

Flooding

Flooding is the most prevalent and frequent natural hazard that impacts Connecticut. The state features thousands of miles of rivers, brooks and streams along with lakes, and ponds. Flooding in Connecticut is a direct result of frequent weather events such as coastal storms, Nor'Easters, heavy rains, tropical storms, and hurricanes.

Ice Jams

In Connecticut, ice jams can occur along the many large rivers. Ice Jams are most likely to occur during the early spring months with the first winter thaws. Ice jams are exacerbated by river geometries, weather characteristics, and floodplain land-use practices such as bridge obstructions or dams. Many times if building infrastructure is not located within close proximity to the location of the jam, ice jams are not recorded if flooding or other damages did not occur.

2.13.3 Extent

Connecticut has more than 235,000 acres of FEMA delineated special flood hazard areas (SFHAs) and 88,689 acres of floodplain modeled through the FEMA Hazus model. The SFHA is a delineation of the extent (flood height and area flooded of a one-percent chance or "100-year flood" event which is a flood with a one percent probability of happening or being exceeded annually. Figure 2-16 shows the location of 100-year floodplains. The floodplain area for each jurisdiction has been used for the geographic extent factor for the flood hazard ranking. New Haven County has more than 59,200 acres of floodplain (93 square miles), followed by Hartford County (78 square miles) and Fairfield County (75 square miles). Within New Haven County, communities with greater than 7,000 acres of floodplain include Madison, Milford and Guilford. The Town of Stratford in Fairfield County has 6,256 acres of floodplain.

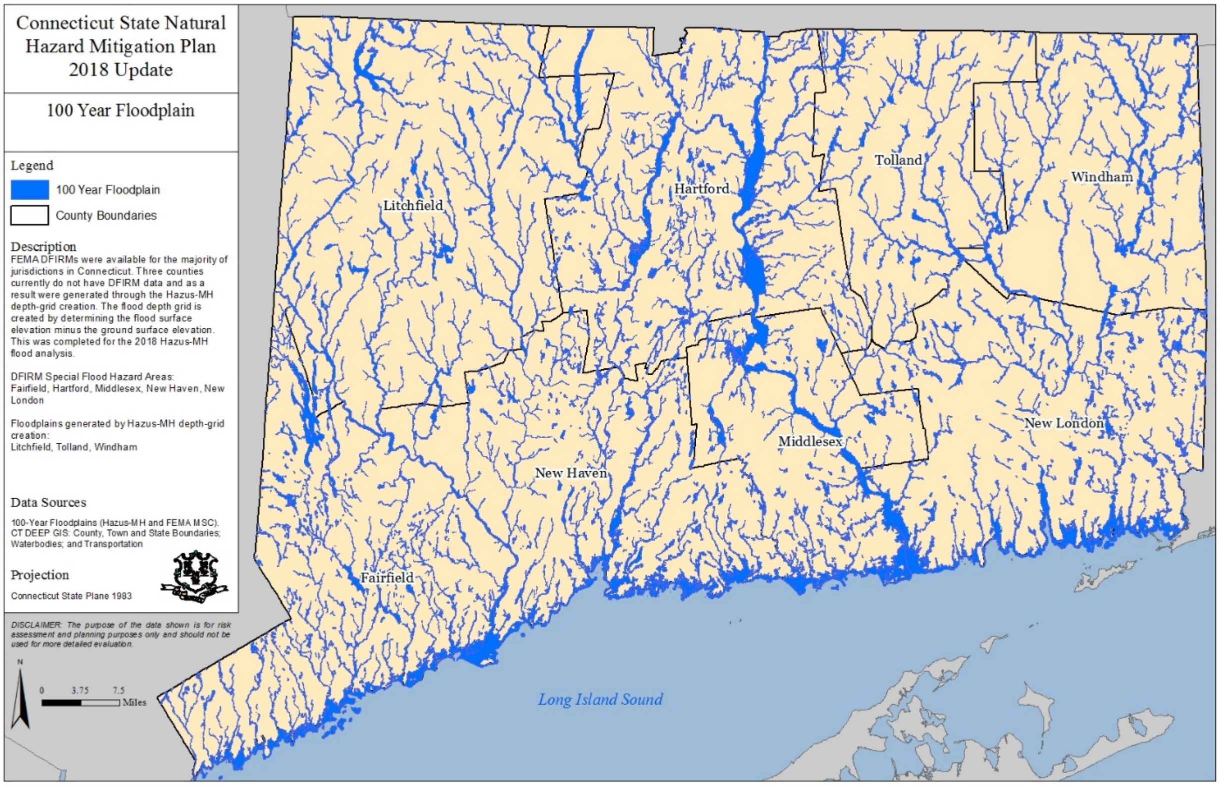


Figure 2-16: 100-year Floodplain

2.13.4 Primary and Secondary Impacts

Flooding

Primary Impacts:

- Transport of small and large objects at high velocity can damage structures in flooded areas or constricted areas of the waterbody.
- Erosion that undermines bridge structures, levees, and buildings causing structural failure and collapse.
- Landslides following intense flooding in areas with steep topography.
- Water damage to property, including primary and secondary residences, accessory structures, contents, businesses, government facilities and critical infrastructure.
- Deposit of suspended sediment resulting in thick layers of mud covering landscapes and interiors of flooded buildings.
- Loss of crops, livestock, pets, and wildlife.
- Injury and loss of human life due to vehicular accidents, drowning or impact from debris.

Secondary Impacts:

- Floodwaters often are contaminated with toxins, garbage, and debris that can impact the heath of exposed humans and animals.
- Disruption of utilities.
- Economic loss due to flood damage to buildings, contents, and agriculture.

People and property are extremely vulnerable to flooding. Homes and businesses may suffer damage and be susceptible to collapse due to heavy flooding. Floodwaters can carry chemicals, sewage, and toxins from roads, factories, and farms; therefore, any property affected by the flood may be contaminated with hazardous materials. Debris from vegetation and man-made structures can be hazardous following a flood. In addition, floods may threaten water supplies and quality, and cause utility interrupting and boil water mandates.

Ice Jams

Primary Impacts:

- Flooding/flash flooding to areas adjacent to rivers.
- Debris accumulation.
- Damage to structures such as bridges, decks, and buildings. ,
- Impacts to powerlines.
- Transportation disruption.

2.13.5 Severity

Flooding

The severity of a flood depends on water accumulation over time and the watershed's capacity absorb and manage flood waters. Infiltration rates and river, stream or channel capacity impact flood severity.

The severity of a flood can be measured based on the depth and probability of flooding. The 100-year flood zone delineates the regulatory boundary of the flooding that has a 1% annual probability of occurrence, also known as the special flood hazard area (SFHA) or base flood. Federal and state agencies, including FEMA's National Flood Insurance Program (NFIP), use the SFHA as a standard for floodplain management. Federally-backed and many private mortgage lenders require flood insurance for buildings in or near the SFHA. Structures located within an SFHA shown on an NFIP map have a 26% chance of suffering flood damage during the term of a 30-year mortgage.

The National Weather Service classifies river flooding as Minor, Moderate, or Major based on water height and impacts along the river that have been coordinated with the NWS and local officials. Minor riverine flooding means that low-lying areas adjacent to the stream or river, mainly rural areas, farmland and secondary roadways near the river flood. Moderate flooding means water levels rise high enough to impact homes and businesses near the river and some evacuations may be needed. Larger roads and highways may also be impacted. Major flooding means that extensive rural and/or urban flooding is expected. Towns may become isolated and major traffic routes may be flooded. Evacuation of homes and business may be required (National Oceanic and Atmospheric Administration).

Ice Jams

The severity of an ice jam is worsened when heavy snowfall and cold temperatures are followed by sudden periods of warm temperatures and heavy rain. The magnitude of an ice jam can depend on how much broken ice has accumulated in the river and if there are other manmade obstructions in a river that are blocking the passage of the ice.

2.13.6 Warning Time

Flooding

It is unusual for a flood to occur without warning due to the pattern of meteorological conditions needed to cause flooding. Coastal flooding due to a tropical cyclone may be predicted two to three days ahead of occurrence, whereas flash floods can develop within six hours of the immediate cause of flooding (heavy rainfall).

Ice Jams

Ice jams often happen with little warning time. The rate of water level rise during an ice jam varies from feet/minute to feet/hour. Rapid rise behind ice jams can lead to temporary ponding and flooding along rivers. A sudden release of a jam can lead to downstream flash flooding especially when compounded by large pieces of ice in the wall of water.

In addition to causing flooding, ice jams can have economic and ecological impacts. Navigation can be delayed or suspended, hydropower operations can be ceased and vessels may sustain damage. Jams can cause riverbank erosion, impede migration of aquatic creatures and adversely impact wildlife habitats. Loss of life has also been attributed to flooding caused by ice and debris jams (National Oceanic and Atmospheric Administration).

Ice jam damages can affect homes, buildings, roads, bridges and the environment (e.g., through erosion, sedimentation, bank scour, tree scarring, etc.) According to the *Special Report 94-7 Ice Jam Data Collection*, by the US Army Cold Regions Research and Engineering Laboratory (CRREL) (March 1994), ice jams cause more than $100 million in damages annually in the United States.

2.13.7 Previous Occurrences and Losses

Flooding

Flooding is the most frequently occurring natural hazard that impacts Connecticut. The Cornell University Extreme Precipitation in New York and New England modeling project (in collaboration with the Northeast Regional Climate Center (NRCC) and the Natural Resources Conservation Service (NRCS)) shows increased flood frequency during the past 60-years.

According to FEMA's disaster declaration database, Connecticut had fourteen major disaster declarations that resulted in severe flooding since 1954. There have been no declarations of major disaster since the 2014 plan update. Eight of the most notable Connecticut flood disasters in the twentieth and beginning of the twenty-first centuries include:

- The Flood of 1936;
- The Flood of 1955 (discussed in subsection 2.7.2 of this chapter)
- The Flood of 1982;
- The Flood of October 2005;
- The Flood of April 2007;
- The Floods of March 2010;
- The Flood of 2011 (Tropical Storm Irene); and
- The Flood of 2012 (Super Storm Sandy).

Table 2-38 provides detailed information on all significant flood events in Connecticut from 1936 to 2017. The most recent major flood disaster events were Tropical Storm Irene in 2011 and Hurricane Sandy in 2012.

Table 2-38: Significant Flood Events in Connecticut, 1936 to 2017

Date(s) of Event	Event Name	Flood Event Type	Areas Affected	Description
March 1936	Great Connecticut River Flood	Riverine Flood	The Connecticut River; the Housatonic River; and the Thames River	Melting snow and moderately heavy rains (six to eight inches) over a 13-day period totaled ten to thirty inches of water entering rivers across the Northeast. The Connecticut, Housatonic, and Thames Rivers reached record flood heights, and the event was estimated to be a 500-year flood. An estimated 14,000 people were left homeless, several people died, and epidemic disease from contaminated waters threatened the population. In Connecticut, the flood resulted in an estimated twenty million dollars (1936 dollars) in property damage.
September 21, 1938	The Great New England Hurricane of 1938	Riverine Flood; Coastal Flood;	Throughout Connecticut	The eye of the storm made landfall in New Haven, CT during high tide, creating an immense storm surge ranging from 14 to 18 feet along the Connecticut coast. Entire coastal communities were washed away by the force and magnitude of the storm surge. In addition, 10 – 17 inches of rain fell on the Connecticut River basin leading to massive river flooding. Across southern New England, a total of 8,900 homes, cottages and buildings were destroyed, and over 15,000 were damaged by the hurricane.
June 4 - 7, 1982	June 1982 Floods	Riverine Flood; Coastal Flood	South-central Connecticut	About 16 inches of rain fell from June 4 to 7, 1982, with the heaviest amounts occurring in south central Connecticut. Smaller rivers, such as the Yantic, Farmington, and Shetucket, experienced the most significant flooding. Damages were estimated at more than $276 million dollars, 11 deaths were recorded, over 15,000 homes were damaged, and over 400 commercial and industrial establishments were damaged. A total of 30 dams throughout the state failed or were partially breached during the storm.
October 8 - 9 and 13 - 15 2005	October 2005 Floods	Riverine Flood	Hartford and Tolland Counties	On October 8 - 9 and 13 - 15, 2005, nine to sixteen inches of rainfall resulted in major flooding in several basins in Hartford and Tolland Counties.[70] A total of 14 dams completely or

[70] CT DEP website publication *Heavy Rains and Flooding of Sub-Regional Drainage Basins: October 7-15, 2005*.

				partially failed, and another 30 dams were damaged throughout Connecticut. Several bridges failed and several dozen roads were washed out or undermined. The total damages to state, municipal, and non-profit properties was estimated at $6.1 million. Damages to businesses were estimated at $6.9 million, and damages to private residences were estimated at $29.6 million.
April 15, 2007	April 2007 Floods	Riverine Flood	Throughout Connecticut	Portions of the state received up to eight inches of rain within a 24-hour period, resulting in major flooding in central and western Connecticut. High tides increased flooding, and winds gusts reached 60 miles per hour. By early morning April 16, floodwaters, as well as downed trees and powerlines, had caused numerous state highway and local road closures. Over 44,000 customers lost electricity. Some damages included: $40,500 to Air National Guard facilities in Orange; $327,591 to state facilities; $313,894 to a firing range in Simsbury; $199,298 to other buildings statewide; $100,000 to non-FEMA eligible bridges in Bristol and Wallingford; and $7,500 related to washouts along the Danbury Branch Line of the Amtrak rail.
March 2010		Riverine Flood; Coastal Flood	Throughout Connecticut, having the highest impact in the southeastern part of the state	During the month of March 2010, three major rain events occurred on March 12, March 23, and March 29-30. On March 12, many areas received between 4 and 5 inches of rainfall in a 24-hour period. Wind gusts from 60 to 75 miles per hour were recorded. In Greenwich, 400 of 700 roads were impassable due to a combination of fallen trees and energized power lines. On March 23, an additional 1.5 to 3.2 inches of rain fell on already swollen rivers and saturated soil, preventing recovery. On March 29 - 30, the state was struck by the third and most severe of the heavy rain episodes. During a 36-hour period, heavy rainfall totaling from 4 to 10 inches occurred across the state. The heaviest rainfall occurred in southeastern Connecticut, where some locations received up to 10 inches of rain in 36-hours. In at least 8 different locations in New London County, the CT DOT records indicate that 500-year water levels were reached.
August 28, 2011	Tropical Storm Irene	Riverine Flood; Coastal Flood	Throughout Connecticut	Tropical Storm Irene swept across the east coast on August 28, 2011 hitting Connecticut harder than any other state. Maximum wind gusts were 66 mph, while average wind gusts

				for the entire state were 52.3 mph. The storm killed two Connecticut residents and left hundreds of thousands of people without power. The storm hit the coast at high tide, which caused a storm surge that flooded roads and homes from Fairfield to New London counties. Many homes were a 'total loss' and residents needed to be rescued as waters rose up to a quarter mile from the shoreline. Following the storm, trees, branches, and power lines remained scattered across roads in every town in the state. About 2,000 residents were in shelters and the number of power outages was highest in recent memory.
October 19, 2012	Hurricane Sandy	Coastal Flood	Coastal counties	Super Storm Sandy began as a tropical wave in the Caribbean on October 19, 2012, quickly developed into a tropical storm in just six hours, and ultimately upgraded to a hurricane on October 24th as maximum winds reached 74 mph. An emergency declaration for Sandy was issued in Connecticut on October 28, followed by a disaster declaration on October 30. As it reached Connecticut, Sandy caused the Long Island Sound to flood basements and roads along the coast. Millions of gallons of raw and partly untreated sewage were discharged into the Long Island Sound.[71] The storm left about 30 percent of customers in the state without power, and three deaths were reported. As of May 2013, more than $367 million in federal assistance had been approved to help Connecticut with disaster expenses. Fairfield County was the hardest hit with over 1,000 trees down, 1,000 homes flood-damaged, 5,000 citizens evacuated, six homes washed out to sea, and more than 24 homes condemned.

[71] The Huffington Post. Hurricane Sandy: Connecticut Shoreline Damage Assessment Begins. 11/13/2012. Dave Collins.

According to NCEI records, there have been 356 flood events from January 1993 to December 31, 2017. These events resulted in $52,515,233 in estimated property damages in adjusted dollars (**Table 2-39**). A total of one death and three injuries are attributed to these floods. Fairfield County has experienced 128 flood events since 1993; accounting for one-third Connecticut's flood and total damages. Deaths and injuries by county is not provided because NCEI reports list damages by regional zones.

Table 2-39: NCEI Total Flood Events by County, 1993 – 2017

County	Number of Events	Property Damages (2017 Dollars)
Fairfield	128	$17,638,967
Hartford	102	$15,639,328
Litchfield	124	$4,072,509
Middlesex	41	$643,981
New Haven	123	$4,319,243
New London	99	$7,628,644
Tolland	14	$1,619,491
Windham	13	$953,070
Total	*	$52,515,233

**Note: totals were not included because NCEI events may be counted more than once if one storm event affects multiple counties.*

Ice Jams

The US Army Corps of Engineers' Cold Regions Research and Engineering Laboratory (CRREL) maintains a database of ice jam history drawing largely from USGS river gauge information. This database includes 199 records of jams from February 28, 1902 to January 21, 2015. Five additional ice jams were recorded during 2018. Events recorded during in the last 20 years have been summarized in Table 2-40. The database indicates that the state experiences both freeze and breakup events. Other sources of information include historical accounts, newspapers, personal interviews and CRREL files. However these data sources often lack quantitative information available in USGS data sources.

Table 2-40: History of Ice Jams in Connecticut

Event Date	River	Location	Description/Losses
1/15/2018	Connecticut River	Middle Haddam	Break-up jam
1/15/2018	Housatonic River	New Milford	Unknown
1/13/2018	Quinebaug River	Quinebaug	Break-up jam
1/13/2018	Housatonic River	Kent	Break-up jam
1/13/2018	Shepaug River	Roxbury	Break-up jam
1/21/2015	Saugautuck River	Westport	The Saugautuck River near the Levitt Pavillion for the Performing Arts was jammed with ice late on January 21, 2015.
1/6/2014	Pomperaug River	Woodbury	An ice jam resulted on the Pomperaug River at Judson Avenue bridge in Woodbury, CT on Monday, January 6 due to warm temperatures and heavy rain.
1/27/2005	Connecticut River	Middletown	An ice jam on the Connecticut River in Middletown, CT was frozen in place for about one week. The ice jam was located immediately upstream of Wilcox Island, which is just upstream of Arrigoni Bridge. The jam slowly began to dissipate starting February 7.
2/7/2004	Yantic River	Norwich	The National Weather Service reported an ice jam developed on the Yantic River at Norwich, CT at noon on 2/7/2004. By 7AM on 2/8/2003, NWS reported the river was rising rapidly behind the jam, with no flooding reported.
1/24/2003	Shetucket River	Baltic	Freeze up ice jams developed on the Shetucket River near the route 97 bridge at Baltic, a site that previously had ice jam problems including the 1994 ice jam.
2/29/2000	Housatonic River	Gaylordsville	The Housatonic River reached a maximum gage height of 7.5 feet after an ice jam formed near Bulls Bridge and water backed up through drains into Veterans Plaza. Six homes in the low-lying residential neighborhood of Oxford were flooded.
1/19/1999	Housatonic River	New Milford	Minor flooding occurred on the Housatonic River at the Rocky River Plan due to an ice jam.
1/24/1999	Housatonic River	Kent	An ice jam was located on the Housatonic River about two mils south of Kent above Bulls Bridge Dam. The jam resulted in some overflow onto Route 7.
1/24/1999	Housatonic River	New Milford	An ice jam was located on the Housatonic River south of New Milford, CT. A flood warning was issued for the Housatonic River in CT.

1/24/1999	Housatonic River	Kent	A second ice jam was located above Kent on the Housatonic River in New York, just upstream of the Falls Village Hydroplant. The river was just over 6 feet at Falls Village, which is bankful.
1/25/1999	Housatonic River	Gaylordsville	The Housatonic River crested in Gaylordsville during the early morning of Monday, January 25th near 9.5' (flood stage is 8'). Flooding occurred on Youngfield Court. The rise in the Housatonic River was caused by an ice jam.

Salmon River, East Haddam (Leesville)

Ice jam-related flooding has historically been a problem along the lower reach of the Salmon River in the Leesville area of East Haddam. A damaging ice jam occurred most recently in 2000 causing localized road closures.

A similar event in 1994 was caused by break-up of thick river ice due to a sudden increase in discharge from snowmelt and heavy rain. The ice jam formed about a half mile downstream of the Route 151 bridge and progressed back to about 500 feet downstream of the dam. The jam caused water levels in the river to rise, flooding several homes and Powerhouse Road. The flood pool created by the ice jam eventually stabilized as the water created a new path around the ice and into a riverbank.

Another ice jam event occurred in February, 1982 when ice flowed over the dam and jammed at the Route 151 bridge. Many residents in the area believe the lowering of the dam and removal of its control gates has resulted in increased ice jam activity below the dam. Historical evidence supports this assumption as similar winter jams occurred in January 1910 and 1940 when structural damage to the dam allowed ice to flow out of the impoundment. In contrast to the years when the dam was in place and the conditions that result in ice jams existed, there were no ice jams noted downstream of the dam.

Based on available records for the Salmon River, severe ice jam events similar to 1982 and 1994 are probable when ice thickness exceeds 9 inches and average daily discharge increases by at least 1,400 cubic feet per second (cfs) during a single day. The USACE CRREL assumes that seasonal breakup events based on discharge occur when the one-day increase in stage flow is in excess of 1.5 times the ice thickness. Also, tides (tidally influenced back water from the Connecticut River) appear to influence the ice jam location and ice jams form above and downstream of the Route 151 bridge.

Shetucket River, Sprague (Baltic)

The Village of Baltic, a section of Sprague located along the Shetucket River about 9 miles upstream from the Thames River confluence. The total drainage area at Baltic is 460 square miles. Two hydroelectric dams that affect river discharge. The Scotland Dam is located about four miles upstream and the Occum Dam is located about 2.2-miles downstream from the Main Street bridge (Route 97).

Since 1956, the town experienced several ice jams during mid to late winter, usually in January and February. Prior to 1956, no ice-related flooding was recorded in the village, probably because the Baltic Dam, which breached in 1955, controlled the ice upstream of the populated area of the village.

Break-up ice jams form when solid ice cover on the Shetucket River breaks up and moves downstream. It appears that ice causing problems in Baltic comes from a two mile river reach between the Scotland Dam upstream on the Shetucket River and the village. The slope of the river through the reach is very flat and the channel meanders, causing ice floes to lose momentum and slow. In addition, the backwater of Occum Dam, located about two miles downstream of the village, causes thick ice and a stable water surface elevation. As a result, ice jams tend to remain intact until sufficient pressure is built up behind the jam to dislodge it and move it downstream.

During the mid-1950's, the town requested assistance from the U.S. Army Corps of Engineers (USACE) for non-ice related flooding. The USACE supported construction of an earthen flood control berm along the low elevation residential area. The berm top elevation is 77.5 feet NGVD, and a top width of eight feet. Although the berm does not tie into high ground, it does provide protection against a 10-year flood event.

On January 29, 1994, an ice jam occurred on the Shetucket River downstream of the Route 97 bridge in Baltic. The ice jam, about three-fourths of a mile in length, was grounded in numerous locations. Although the average ice thickness was 18 to 20 inches, the jam was about eight feet thick in several locations. Floodwaters behind the jam overtopped the flood control berm flooding 31 houses and four commercial businesses. One house was severely damaged when the ice broke through its masonry block foundation wall. Eventually, a channel opened under the ice to allow flood discharge to pass by the jam so the flood area drained, but the jam remained in place.

This severe ice jam flood prompted a post-disaster reconnaissance study by the USACE, who estimated that the 1984 ice jam caused flood damages of $526,000 for 31 residential properties and four commercial properties. In addition, it was estimated that the flood stages experienced during the January 1994 flood could occur as a result of ice affected flow approximately once in 12 years. The principal ice jam flood problem is located adjacent to Route 97. It extends a distance of about 2,200 linear feet from a drainage culvert under Route 97 that drains a low area south of the state highway to an area upstream of the Blanchette Field at River Drive. It is estimated that there are 84 structures in the 500-year flood plain, 77 of which are residential structures, four are commercial structures and three are public buildings.

FEMA Disaster Declarations

There have been no federally declared major disasters related to flooding since the 2014 plan update.

2.13.8 National Flood Insurance Program (NFIP)

Floodplain management begins at the community level with operation of a community program of corrective and preventative measures for reducing flood damage. For inclusion in the NFIP, communities adopt their flood hazards maps and the community Flood Insurance Study (FIS). In addition, a FEMA-compliant floodplain management ordinance that regulates activity in the floodplain is adopted and enforced.

A community's agreement to adopt and enforce floodplain management ordinances, including regulation of new construction in the Special Flood Hazard Area (SFHA) or 100-year floodplain, is a requirement for making flood insurance available to home and business owners. To address the threat of flood damage, many communities and residents participate in the NFIP. Homeowner insurance policies do not cover damage from flood.

As of November 28, 2017, 177 communities in Connecticut participated in the NFIP. Data on active NFIP policies was obtained from FEMA's Community Information System. Table 2-41 shows NFIP flood policy and claim information by county. There are 39,040 policies in-force for Connecticut NFIP communities. Policy holders pay more than $53 million annually in premiums for $9.9 billion in building and contents coverage.

The coastal counties of Fairfield, Middlesex, New Haven and New London, along with Hartford County (due to the location of the Connecticut River within the center of the county), have the highest risk of flooding within the State. Fairfield has 16,468 policies in place, with 11,361 losses and $248 million in payment for those losses. New Haven has 10,208 policies in-force, 9,280 losses, and $164 million in payments for those losses.

Appendix 2 includes the municipality specific information for the NFIP statistics.

Table 2-41: NFIP Policy and Claim Information (As of November 2017)

County	# of Policies In-Force	Insurance In-Force	Written Premium In-Force	# of Total Losses	Total Payments Since 1978
Fairfield	16,468	$4,352,495,800	$22,692,534	11,361	$247,840,546
Hartford	3,152	$747,638,300	$3,897,489	1,707	$13,534,450
Litchfield	997	$229,638,800	$1,399,126	481	$6,002,992
Middlesex	3,522	$900,515,600	$5,146,416	2,204	$36,905,194
New Haven	10,208	$2,448,043,000	$13,110,651	9,280	$164,538,542
New London	4,266	$1,108,482,700	$6,366,313	2,106	$29,412,265
Tolland	253	$59,204,000	$303,089	158	$1,604,997
Windham	174	$42,100,100	$245,310	68	$1,338,495
Total	39,040	$9,888,118,300	$53,160,928	27,365	$501,177,481

Community Rating System (CRS)

The National Flood Insurance Program's (NFIP) Community Rating System (CRS) is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum NFIP requirements. As a result, flood insurance premium rates are discounted to reflect the reduced flood risks. There are ten CRS classes: Class 1 requires the most credit points and gives the largest flood insurance premium reduction; Class 10 receives no premium reduction. These discounts are applied per each CRS community and apply to all flood insurance policyholders. For CRS participating communities, flood insurance premium rates are discounted in increments of 5%; i.e., a Class 1 community receives a 45% premium discount, while a Class 9 community receives a 5% discount. If a community does not apply or fails to receive at least 500 points, it's in Class 10, and property owners get no discount (FEMA 2017). Table 2-42 lists the communities in Connecticut that are currently participating in the CRS.

Table 2-42: Participating CRS Communities in Connecticut

Community #	Community	CRS Entry Date	Current Effective Date	Current Class	% Discount for SFHA	% Discount for Non-SFHA	Status
90007	Town of Fairfield	10/1/2016	10/1/2016	8	10%	5%	C
90011	Town of Newtown	10/1/1991	10/1/1991	9	5%	5%	C
90012	City of Norwalk	10/1/1993	10/1/1998	10	0%	0%	R
90015	City of Stamford	10/1/2002	10/1/2002	7	15%	5%	C
90019	Town of Westport	10/1/1995	10/1/2000	8	10%	5%	C
90070	Town of Westbrook	5/1/2005	5/1/2011	10	0%	0%	R
90074	Town of Cheshire	10/1/1993	10/1/2003	10	0%	0%	R
90076	Town of East Haven	10/1/2003	10/1/2010	10	0%	0%	R
90078	Town of Hamden	10/1/1993	10/1/2006	10	0%	0%	R
90082	City of Milford	5/1/2012	5/1/2012	9	5%	5%	C
90084	City of New Haven	5/1/2017	5/1/2017	7	15%	5%	C
90096	Town of East Lyme	10/1/1991	5/1/2016	8	10%	5%	C
90106	Town of Stonington	10/1/2017	10/1/2017	8	10%	5%	C
90193	Borough of Stonington	10/1/2004	10/1/2014	8	10%	5%	C
95082	Town of West Hartford	10/1/1991	10/1/2007	8	10%	5%	C
Source: FEMA Community Rating System Eligible Communities Effective October 1, 2017.							

Addressing Repetitive Loss (RL) and Severe Repetitive Loss (SRL) Properties

The Bunning-Bereuter-Blumenauer Flood Insurance Reform Act of 2004 was signed into law by President George W. Bush on June 30, 2004. The Act (Public Law 108-264) revised the existing Flood Mitigation Assistance (FMA) Program by creating a Pilot Program at $40 million per year to mitigate Repetitive Loss (RL) properties. The Severe Repetitive Loss (SRL) Program provides funds for local governments to address the most egregious flood prone properties with the most flood insurance claims. The program features a reduced non-Federal match (from 25% to 10%) with an approved mitigation plan that specifies the State's strategy to reduce the number of RL and SRL properties. The amendment authorizes scheduled increases in flood insurance premium rates to actuarial rates for SRL property owners who refuse a formal and complete mitigation grant offer through the SRL grant program to mitigate an SRL structure. The three NFIP-funded flood mitigation programs, SRL, RFC and FMA were combined through the Biggert-Waters National Flood Insurance Reform Act of 2012, signed into law by President Barack Obama on July 6, 2012. The Consolidated Appropriations Act of 2014 (Omnibus), prohibits FEMA through the National Flood Insurance Program (NFIP) from implementing Section 207 of the Biggert-Waters Flood Insurance Reform Act of 2012. Section 207 directed FEMA to ensure that certain properties' flood insurance rates reflects their full risk after a mapping change or update occurs.[72] On March 21, 2014, President Obama signed the Homeowner Flood Insurance Affordability Act of 2014 into law. The law repeals and modifies certain provisions of the Biggert-Waters Flood Insurance Reform Act, which was enacted in 2012, and makes additional program changes to other aspects of the program not covered by that Act. Many provisions of the Biggert-Waters Flood Insurance Reform Act remained and are still being implemented. The new law lowered the recent rate increases on some policies, prevented some future rate increases, and implemented a surcharge on all policyholders. The Act also repealed certain rate increases that had already gone into effect and provided for refunds to those policyholders.[73]

Many flood insured properties have had more than one claim. A property that is currently insured, and which two or more NFIP losses (occurring more than ten days apart) of at least $1,000 each have been paid within any 10-year period since 1978 is defined as a "repetitive loss property" in the NFIP program.

As of February, 2018, Connecticut has a total of 3,368 repetitive loss properties, of which 298 have been mitigated (Table 2-43). Of the 3,070 unmitigated RL properties which includes Special Direct Facility (SDF) properties, 2,039 are insured (66% of the unmitigated properties). These buildings have experienced 5,876 insured losses of $160 million. The City

[72] https://www.fema.gov/media-library-data/1392062928758-80537fe9ad63607837d8a29f04280492/BW12_consolidated_app_2014.pdf
[73] https://www.fema.gov/media-library-data/1396551935597-4048b68f6d695a6eb6e6e7118d3ce464/HFIAA_Overview_FINAL_03282014.pdf

of Milford has 84 mitigated properties, the Town of Hamden 34 mitigated properties and the Town of Westport 30 mitigated properties.

The number of repetitive loss properties in the Town of Guilford increased from 12 listed in 2010 to 60 listed in 2013, and 64 in 2018. While this is attributed in part to coastal storms such as Tropical Storm Irene in 2011 and Super Storm Sandy in 2012, inland communities have also experienced an increase in listed properties. For example, the number of repetitive loss properties in the town of Southbury increased from 10 listed in 2008 to 20 listed in 2013 due to a series of floods along the Pomperaug River. The community has 19 unmitigated RL properties in 2018.

Table 2-43: Summary of Connecticut Repetitive Loss Properties.

County	Total RL Properties	Total Insured RL Properties	Total Mitigated RL Properties	Total Unmitigated RL Properties	Total Insured Unmitigated RL Properties
Fairfield County	1330	914	89	1241	851
Hartford County	168	63	18	150	63
Litchfield County	40	24	1	39	24
Middlesex County	272	192	17	255	185
New Haven County	1390	902	159	1231	815
New London County	154	95	12	142	94
Tolland County	9	4	2	7	4
Windham County	5	3	0	5	3
State Total	3,368	2,197	298	3,070	2,039

Residential Severe Repetitive Loss (SRL) properties consist of any NFIP-insured residential property that has met one of the following paid flood loss criteria since 1978, regardless of ownership:

- 4 or more separate claim payments of more than $5,000 each (including building and contents payments); or
- 2 or more separate claim payments (building payments only) where total payments exceed current value of the property

For either scenario, two of the claim payments must have occurred within 10 years of each other. If multiple losses are at the same location with 10 days of each other, they are counted as one loss, with payment amounts added together.

The state has 163 validated residential properties that are categorized as Severe Repetitive Loss properties. Additional site specific SRL and RL claims histories can be obtained by contacting the State. A complete listing of the number of RL and SRL properties by Jurisdiction is included in Appendix 2.

Connecticut state agencies and communities have taken many actions that are intended to reduce the number of repetitive loss properties and severe repetitive loss properties since 2013. Many of these actions are described in the Capability Assessment.

The fundamental action needed to begin reducing the number is to enable and encourage currency of local mitigation plans to enable continued eligibility for grant funding to mitigate these properties as well as detail strategies to encourage outreach to repetitive property owners for mitigation collaboration and solutions. Thus, the planning process is a key critical first step for reducing the number of repetitive loss properties and severe repetitive loss properties.

The State identifies, evaluates and prioritizes cost-effective, environmentally sound, and technically feasible mitigation actions for repetitive loss properties. Before this can be done, two actions must be accomplished. First, the State and local communities must validate repetitive loss and severe repetitive loss inventories to focus on properties that could benefit from mitigation. This can be accomplished by field-verifying listed RL and SRL properties. FEMA's National Flood Mitigation Data Collection Tool (NFMDCT), known more succinctly as the National Tool can aide this process.

Second, Connecticut DESPP/DEMHS will continue to prioritize targeted RL/SRL properties for local mitigation actions supporting communities in which they are located. Emphasis will be placed on the ten communities with the highest number of listed properties (Milford, Norwalk, Westport, East Haven, Fairfield, Branford, Greenwich, Stamford, Westbrook, Old Saybrook).

Per the State's Repetitive Loss Strategy, when funds are available, the Connecticut will pursue Federal grants to mitigate SRL and RL properties. The State will continue to act as the Applicant for FEMA HMA funds and support eligible Sub-applicants (typically municipalities and Tribal Governments). The State will encourage eligible Sub-Applicants to apply for funds to mitigate RL and SRL properties. The Flood Mitigation Assistance Program (FMA), when funded, provides one of the best mechanisms for mitigating NFIP-insured properties. Through pre-determined cost share percentages, FEMA has established priorities under this program. SRL properties can be funded at 100% of eligible project costs and RL properties can be funded at 90% of eligible project costs. FEMA has also established a Project Useful Life (PUL) for mitigation projects. The State will give priority to Sub-applications for projects with a higher PUL as defined by FEMA. The State will attempt to maximize funding under this program and, in keeping with FEMA's prioritization, place higher priority on mitigating SRL properties under FMA. A Benefit Cost Analysis (BCA) is required to be run for projects submitted under the FMA program. Where projects are evenly ranked, those project sub- applications with higher BCA result will be given a higher priority.

As Federal funding becomes more competitive, the State will make efforts to identify alternative funding for mitigation. As part of the FEMA-approved Repetitive Loss Strategy, the State will continue its attempt to maximize funding under programs other than those managed by FEMA. This includes funding from the Natural Resource Conservation Service (NRCS) and as available under State bonding initiatives. DEMHS will continue to advocate for the allocation of State Bond funds to support mitigation efforts. This includes mitigation of SRL and RL properties by local governments or private property owners.

The Pre-Disaster Mitigation Program (PDM) and the Hazard Mitigation Grant Program (HMGP), under FEMA's Hazard Mitigation Assistance (HMA) grant program portfolio, can fund projects unrelated to flooding and can benefit structures without NFIP coverage. As these programs can fund a diverse range of project types, the repetitive loss strategy will not apply to these funds. This will allow the State to determine priorities for these programs to address all hazards.

Coastal Barrier Resource System

Coastal barriers are unique landforms that provide protection for diverse aquatic habitats and serve as the mainland's first line of defense against coastal storms and erosion. Congress recognized the vulnerability of development on coastal barriers and passed the Coastal Barrier Resources Act of 1982 (COBRA) and the Coastal Barrier Improvement Act of 1990 (CBIA), establishing a system of protected COBRA areas and Otherwise Protected Areas (OPAs) known as the Coastal Barrier Resources System (CBRS).

The Acts protect these areas by prohibiting the expenditure of most Federal funds that encourage development, including "any form of loan, grant, guarantee, insurance, payment, rebate, subsidy or any other form of direct or indirect federal assistance". Federal disaster assistance is limited to emergency relief – there are no loans or grants to repair or rebuild structures in CBRS areas. COBRA also banned the sale of National Flood Insurance Program (NFIP) flood insurance for structures built or substantially improved on or after October 1, 1983 in these areas. By restricting federal expenditures and financial assistance which have the effect of encouraging development of coastal barriers, Congress aimed to minimize the loss of human life and damage to fish, wildlife, and other natural resources associated with coastal barriers.

Table 2-44 summarizes the communities in Connecticut that have a COBRA or OPA unit. Overall, Connecticut has 19 COBRA and nine OPA units, with the most units located in New London County. Figure 2-17 shows the locations of these units.

Table 2-44: Coastal Barrier Resource Areas in Connecticut

Community	County	COBRA	OPA
Town of Branford	New Haven	Y	N
City of Bridgeport	Fairfield	Y	Y
Town of Clinton	Middlesex	Y	Y
Town of East Lyme	New London	Y	N
Borough of Fenwick	Middlesex	Y	N
City of Groton	New London	Y	N
Town of Groton	New London	Y	Y
Groton Long Point Association	New London	Y	N
Town of Madison	New Haven	Y	N
City of Milford	New Haven	Y	Y
City of New Haven	New Haven	N	Y
City of New London	New London	Y	N
City of Norwalk	Fairfield	Y	Y
Town of Old Lyme	New London	Y	N
Town of Old Saybrook	Middlesex	Y	N
Borough of Stonington	New London	Y	N
Town of Stonington	New London	Y	N
Town of Stratford	Fairfield	N	Y
Town of Waterford	New London	Y	N
City of West Haven	New Haven	N	Y
Town of Westbrook	Middlesex	Y	N
Town of Westport	New Haven	Y	Y
Town of Branford	Fairfield	Y	N

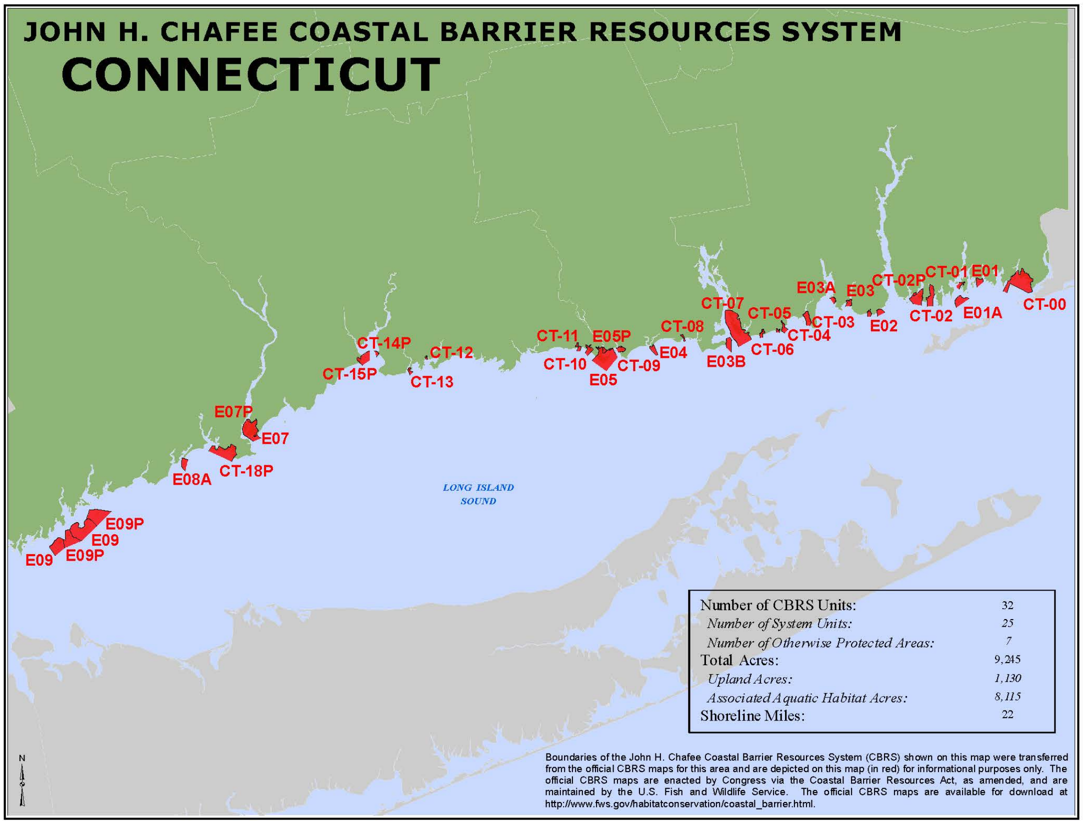


Figure 2-17: Connecticut Coastal Barrier Resources System

2.13.9 Probability of Future Events

Flood

Major riverine flooding can occur in any month of the year, but three seasons have heightened flood vulnerability:

- Late winter/spring melt;
- Late summer/early fall; and
- Early winter.

Floods can be described based on their extent and their recurrence interval. The recurrence interval, or return period, is based on the probability that a given event will be equaled or exceeded in any year. A rainfall recurrence interval, therefore, is based on the magnitude and the duration of a rainfall event.

A Special Flood Hazard Area is subject to inundation by a flood that has a 1-percent or greater chance of being equaled or exceeded in any given year. Commonly referred to as the 100-year flood, 1% chance flood or base flood; 100-year flood is not a flood that occurs every 100 years. The 100-year flood has a 26 percent chance of occurring during a 30 year period, the typical length of many mortgages. It is also important to note that once a flood occurs, its chance of recurring remains the same. The 100-year flood is a regulatory standard used by Federal agencies, states and NFIP-participating communities to administer and enforce floodplain management programs. The 100-year flood is also used by the NFIP as the basis for insurance requirements nationwide[74]. The main recurrence intervals used on FEMA NFIP Flood Insurance Rate Maps (FIRM's) are shown in Table 2-45.

Table 2-45: USGS Recurrence Intervals and Probabilities of Occurrences

Recurrence Interval (years)	Annual Probability of Occurrence	Annual Percent Change of Occurrence
500	1 in 500	0.2
100	1 in 100	1
some	1 in 50	2
25	1 in 25	4
10	1 in 10	10
5	1 in 5	20
2	1 in 2	50

Flooding has had significant impacts on Connecticut in the past and is likely to impact the State in the future. NCEI data suggests that approximately one to six events of some significance occur somewhere in Connecticut annually. Connecticut, based on historical information, has a high probability of future flood occurrence. Fairfield and Litchfield counties have had the highest number of reported flood events, followed by Hartford and New London counties. Table 2-46 shows the annualized number of flood events by county and the annualized property damage based on the NCEI historical record.

Table 2-46: NCEI Annualized Flood Events and Property Damages

County	Number of Events	Property Damage (2017 dollars)
Fairfield County	5.82	$801,771.24
Hartford County	4.64	$710,878.56
Litchfield County	5.64	$185,114.03
Middlesex County	1.86	$29,271.86
New Haven County	5.59	$196,329.24
New London County	4.5	$346,756.53
Tolland County	0.64	$73,613.21
Windham County	0.59	$43,321.36
Total	*	$2,387,056.04

*Note: *annualized event totals were not included because NCEI events may be counted more than once if one storm event affects multiple counties. This duplication renders totals inaccurate.*

[74] National Flood Insurance Program (www.fema.gov)

Ice Jams

Ice jams are a frequent hazard in Connecticut that can affect any community that borders a river. The CRREL database recorded 199 ice jams between 1902 and 2015. Based on this record, Connecticut can expect to experience between one and two ice jams annually.

2.13.10 Climate Change Impacts

More intense rainfall, the result of climate change, is likely to increase peak flooding, particularly in urban environments in the future. The magnitude of this increase is dependent on the level and rate of greenhouse gas emissions through the end of the century. Changes in precipitation patterns in Connecticut are likely to amplify flood and drought impact.[75] Average annual precipitation in the Northeast increased 10 percent from 1895 to 2011, and precipitation from extremely heavy storms has increased 70 percent since 1958.[76] Climate change is increasing water temperatures in the ocean and cause the development of stronger tropical storms that can cause more severe coastal flooding and intensify storm surge, increasing the vulnerability of coastal communities. Additional information regarding the impacts of climate change on Connecticut can be found in Section 2.4 of this chapter.

2.14 Flood-Related Hazards Vulnerability Assessment

Flooding can impact all areas of Connecticut, especially those areas located near the Long Island Sound and along rivers.

2.14.1 Assessment of State Vulnerability and Potential Losses

The entire state continues to be vulnerable to flooding and the impacts associated with this natural hazard. There are many factors which continue to affect future vulnerability to flooding including:

- Connecticut is a water-rich state with many rivers, streams and brooks with some drainage basins extending beyond state borders.
- Connecticut's past land use patterns and building stock and infrastructure within flood-vulnerable areas will continually be vulnerable to flooding. Local land use regulations and ordinances made progress to reduce unregulated development within flood hazard areas. However, Connecticut is one of the oldest states in the nation with limited undeveloped land creating high property values. Limited land availability and high property values encourages redevelopment in high risk areas.
- Increases in flooding have occurred with increased impervious surfaces in watersheds. Some Connecticut watersheds drain from Canada. Increased impervious areas in watershed combined with increased precipitation has resulted

[75] https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-ct.pdf
[76] Average annual precipitation in the Northeast increased 10 percent from 1895 to 2011, and precipitation from extremely heavy storms has increased 70 percent since 1958.

in increased flooding. Low Impact Development (LID) techniques and other onsite hydrology management techniques should be implemented wherever possible. LID is an approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible.

Flooding often results because of other natural hazards such as hurricanes and tropical storm systems, winter and coastal storms, ice jams, dam failures, and severe precipitation events. Sea level rise and the increased intensity of frequency of storm surge due to climate change also contribute to flood severity. All areas of Connecticut continue to be vulnerable to flooding and the impacts associated with this natural hazard. Impacts related to development type and density in the flooded area. Table 2-5 includes the number of infrastructure/facilities, building value and contents value by municipality. There are 3,327 state-owned facilities valued at $5.6 billion, with more than $866 million in contents value. It should be noted that building and contents value data is limited, with roughly 50% of state owned structures lacking building and contents value estimates. Appendix 2 includes the infrastructure and facilities datasets, as well as the loss estimates by municipality for facilities located within the known hazard geographic extents.

Flood loss estimates and risk to critical facilities have been derived using the FEMA Hazus module for riverine and coastal flood hazards. Flood hazard is defined by a relationship between depth of flooding and the annual chance of flooding to that depth. A Hazus Level 2 analysis was performed with user-provided depth grids were generated from provided terrain data, and FEMA Digital Flood Insurance Rate Maps (DFIRMs).

Loss estimation for the Hazus flood module is based on specific input data. The type of data shown in Table 2-47 includes information on the local economy that is used in estimating losses.

Table 2-47: Hazus direct economic loss categories and descriptions.

Category Name	Description of Data Input into Model	Hazus Output
Building	Cost per sq ft to repair damage by structural type and occupancy for each level of damage	Cost of building repair or replacement of damaged and destroyed buildings
Contents	Replacement value by occupancy	Cost of damage to building contents
Inventory	Annual gross sales in $ per sq ft	Loss of building inventory as contents related to business activities
Relocation	Rental costs per month per sq ft by occupancy	Relocation expenses (for businesses and institutions)
Income	Income in $ per sq ft per month by occupancy	Capital-related incomes losses as a measure of the loss of productivity, services, or sales
Rental	Rental costs per month per sq ft by occupancy	Loss of rental income to building owners
Wage	Wages in $ per sq ft per month by occupancy	Employee wage loss as described in income loss
Business Disruption	N/A	Combination of inventory, relocation, income, rental, wage loss, direct output loss*

** Calculated value*

The flood model was used to run a 1-percent (i.e. 100-year) annual chance frequency flood based on the hazard depicted on the FIRMs. DFIRMS were available for Fairfield, Hartford, Middlesex, New Haven, and New London Counties. Floodplains derived using the Hazus software with 10 meter NED (National Elevation Dataset) and a one square mile threshold was used to analyze Litchfield, Tolland, and Windham. An additional multi-frequency scenario was run which included the following return periods; 10- percent (10 year), 4-percent (25 year), 2-percent (50 year), 1-percent (100 year), as well as the 0.2-percent (500 year) using a 30 meter NED and a 10 squares mile threshold. The multi-frequency scenario was performed for all counties using this methodology. The average annualized losses (AAL) for flood were calculated using this multi-frequency scenario. Both are provided for analysis.

Figure 2-18 and Figure 2-19 show the estimated total 100-year economic flood loss by county and census block. It is apparent that the coastal and riverine areas are at higher risk, specifically in Fairfield and New Haven counties. Appendix 2 includes scenario- and jurisdiction-specific results from the Hazus analysis. The Connecticut officials should be contacted for the supporting Hazus data sets.

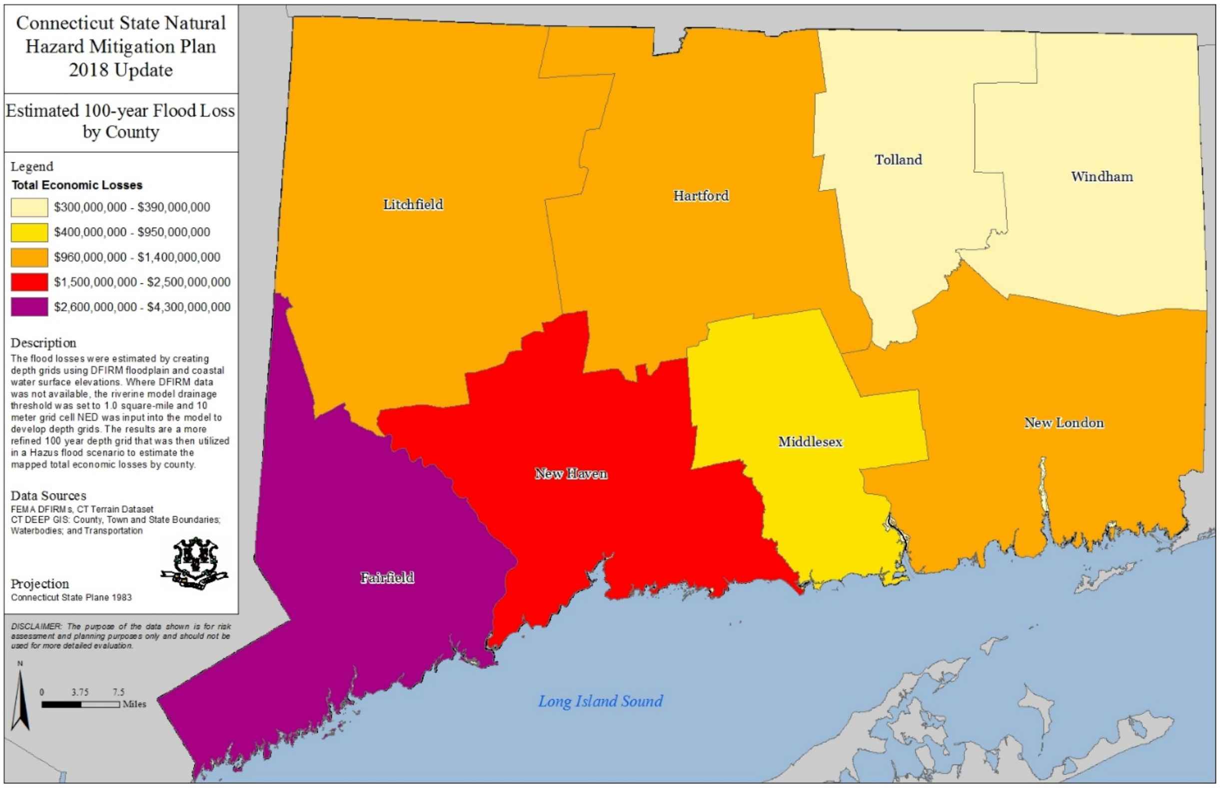


Figure 2-18: 100-year Flood Loss by County

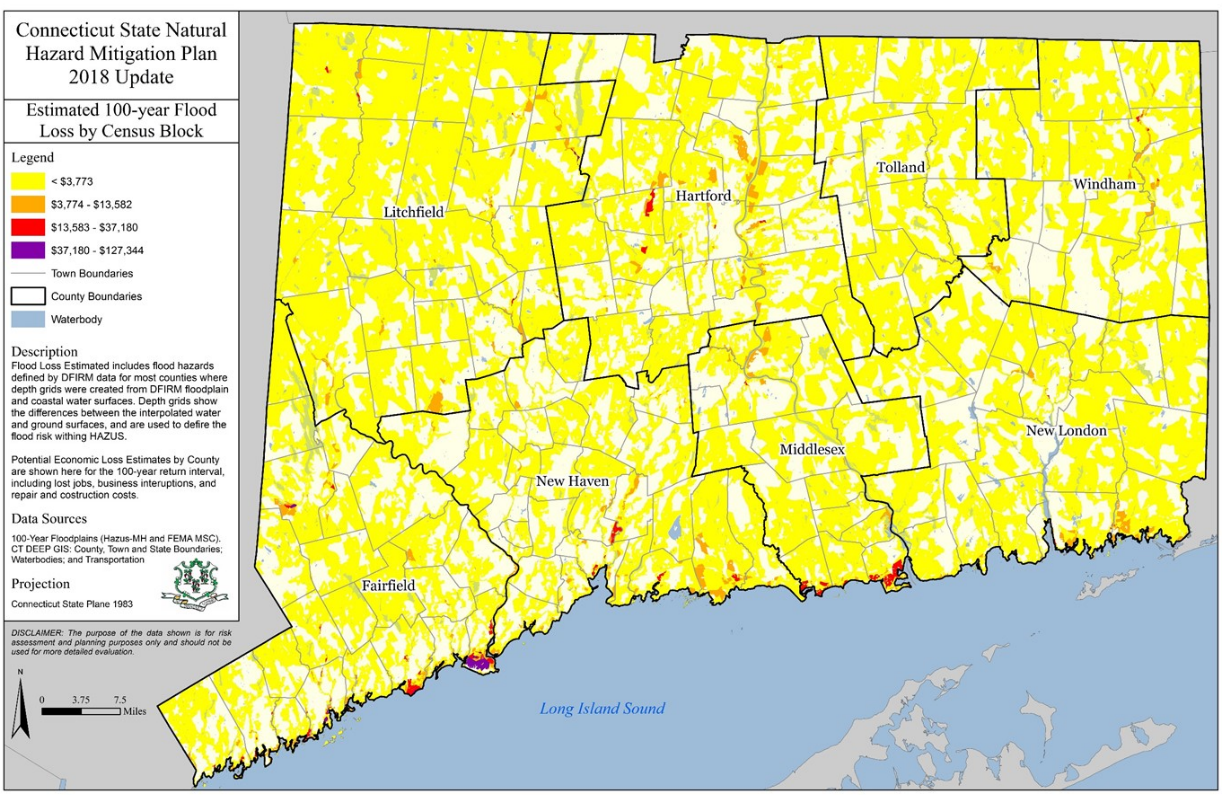


Figure 2-19: Estimated 100-year Flood Loss by Census Block

Table 2-48 shows the flood loss estimation values by county. The contents value is the highest estimated damage, with more than $7 billion with building loss of $5.1 billion. Litchfield County is estimated to experience the largest percent loss at 3.04 percent, while Fairfield will experience the largest total loss at $4,274,167. Fairfield County will also experience the largest amount of business disruption, with estimated losses of $110,802.

Table 2-48. Hazus 100-year flood loss estimation by County ($000's)

County	Actual Replacement Value	Building Loss	Contents Loss	Business Disruption	Total Loss	Percent Loss
Fairfield	$221,118,675	$1,727,377	$2,458,298	$110,802	$4,274,167	1.93%
Hartford	$202,087,968	$635,753	$781,849	$39,849	$1,447,299	0.72%
Litchfield	$46,324,195	$576,982	$792,744	$47,610	$1,408,816	3.04%
Middlesex	$41,974,738	$412,534	$521,510	$17,996	$947,479	2.26%
New Haven	$195,569,109	$1,044,654	$1,369,465	$60,380	$2,461,474	1.26%
New London	$60,119,835	$526,259	$677,933	$21,883	$1,220,849	2.03%
Tolland	$29,719,543	$120,061	$172,928	$12,714	$304,143	1.02%
Windham	$23,324,314	$154,214	$225,732	$14,866	$393,144	1.69%
State Totals	$820,238,377	$5,197,834	$7,000,459	$326,100	$12,457,371	1.52%

Impacts and areas of vulnerability include:

- Out of the total number of essential facilities (fire stations, police stations, schools, and hospitals) located within a county, each county may expect a small number of facilities to receive moderate damage, and in most cases just a couple of facilities are projected to experience substantial damage. No loss of use was projected in any county.
- Building occupancy most affected by a 100-year flood event is residential followed by commercial. In addition, the building material type in all counties that is most vulnerable is wood. Since damage to residential structures was shown through the Hazus model to be most prevalent in all county model scenarios, it is apparent that homeowner outreach programs should emphasize flood prevention, protection and safe recovery and clean up strategies.
- All counties may expect emergency shelter demand during evacuations and after disaster strikes. Though current Hazus simulations did not analyze shelter requirements for Windham and New London Counties, it is expected that shelter needs for Windham County will be similar to those of Tolland County, and that New London County shelter requirements are similar, though possibly slightly higher, than those of

Middlesex County (because New London County has more lower elevation coastal communities).

Complete Hazus scenario generated reports for flooding can be found in Appendix 2.

As evidences in property loss estimations (Table 2-49) obtained from NCEI and Hazus, floods have the potential to be destructive and, although analyses vary, the overall trends are consistent. Total annualized damages range from more than $43,321 in Windham County to more than $801,771 in Fairfield County using NCEI data. Total annualized damages are compared to a total loss of all buildings within the 100-year floodplain, as estimated by Hazus. While Hazus reports much higher loss values than NCEI, it also shows that Fairfield County has the highest losses in the state, New Haven County has the second highest, and Tolland and Windham Counties have the lowest. The differences in the magnitude of the loss values may be a result of inconsistent storm event reporting in the NCEI Storm Events Database.

Table 2-49: Comparison of NCEI annualized events, Hazus 100-yr losses

County	NCEI Annualized Events	NCEI Total Annualized Damages (2017 dollars)	Hazus Total 100-year Losses
Fairfield	5.82	$801,771	$4,274,167,000
Hartford	4.64	$710,879	$1,447,299,000
Litchfield	5.64	$185,114	$1,408,816,000
Middlesex	1.86	$29,272	$947,479,000
New Haven	5.59	$196,329	$2,461,474,000
New London	4.5	$346,757	$1,220,849,000
Tolland	0.64	$73,613	$304,143,000
Windham	0.59	$43,321	$393,144,000

State Facilities Exposure. The state contains 3,327[77] state-owned buildings valued at $5.6 billion in building values.[78] Table 2-50 provides a breakdown of the number of state-owned buildings within the SFHA by county. A total of 192 state-owned buildings (just under 6% of the total number of state-owned buildings) are located within the mapped 100-year floodplain. There are a total of 127 (under 4% of the total number of state-owned buildings) state-owned buildings located within the 500 year floodplain.

[77] 3332 Total State Owned Buildings; 6 are outside of spatial boundaries
[78] Based on state facility data provided by DCS in 2012, supplemented by Connecticut Open Source Building values from August 2016

There are 1,536 (46% of the total number of state-owned buildings) state-owned buildings within areas susceptible to erosion. Geospatial data for erosion susceptibility from the 2014 plan update was overlaid with updated state facility data to provide updated numbers for the 2019 plan update. Table 2-50 summarizes the number of state-owned buildings in erosion susceptible areas by county. Hartford County leads with a total of 583 state-owned buildings in erosion susceptible areas, while New Haven and New London Counties follow with 282 and 244 respectively.

Table 2-50: State Facilities within the 100 and 500-year floodplain and erosion susceptibility areas (count)

County	Total Buildings in 100-year Floodplain	Total Buildings in 500-year Floodplain	Total Buildings in mapped Floodplain	Total Buildings in Erosion Areas
Fairfield	22	28	50	112
Hartford	14	31	45	583
Litchfield	10	5	15	42
Middlesex	10	12	22	108
New Haven	73	28	101	282
New London	42	16	58	244
Tolland	9	2	11	109
Windham	12	5	17	56
Total	192	127	319	1,536

The 192 state owned buildings that fall within the 100-year floodplain have roughly $62 million dollars in building value and $212 million dollars in content value (Table 2-51). The building and content value are significantly underestimated, due to the availability of structure value data and Windham and New London Counties lack of data. By applying a 1.58x multiplier (derived from the additional building value data that was not accessible in a spatial format), the total building value in the 100-year floodplain is nearly $98 million.

Table 2-51: State Facilities within the 100-year Floodplain

County	Total Buildings in 100-year Floodplain	Total Building Value in the 100-year Floodplain	Total Content Value in the 100-year Floodplain
Fairfield	22	$157,240	$17,649,656
Hartford	14	$15,919,748	$89,493,455
Litchfield	10	$3,833,512	$4,110
Middlesex	10	$45,332	$1,018,529
New Haven	73	$40,356,758	$82,694,995
New London	42	N/A	$6,147,318
Tolland	9	$1,728,415	$10,718,593
Windham	12	N/A	$4,615,793
Total	192	$62,041,006	$212,342,448

Critical Facilities Exposure. In order to determine the number of critical facilities within FEMA's SFHA, the critical facility points were intersected with the SFHA layer. This analysis, depicted below in Table 2-52 shows 133 critical facilities throughout the state in the 100-year floodplain. Fairfield County has the most critical facilities within the zone, with a total of 30, while New Haven and Litchfield follow closely behind with 24 and 23 critical facilities respectively.

Specific municipalities have a high number of critical facilities within SFHA. In Fairfield County, Bridgeport has 12 critical facilities intersecting the floodplain. The facilities in Bridgeport at risk include one correctional institution, one fire station, one gas station with a generator, two municipal solid waste facilities, five storage tank farms, two law enforcement agencies. In New Haven County, the City of New Haven has 15 critical facilities in Zone A, including nine storage tank farms, one fire station and two law enforcement facility, two municipal solid waste facilities, and a gas station with a generator.

WPCFs were not intersected with the floodplain boundaries, due to the lack of previous spatial data. Discrepancies between Hazus and State facility data are common due in part to differing definitions of facilities and to which jurisdictions' facilities are counted.

Table 2-52: Critical Facilities in the Special Flood Hazard Area (SFHA).

County	Correctional Institutions	EMS	Fire Stations	Gas Station with Generator	Health Departments	Law Enforcement	Municipal Solid Waste	Storage Tank Farm	Critical Facility Totals
Fairfield	1	5	7	1	1	3	7	5	30
Hartford	0	0	1	0	1	0	10	2	14
Litchfield	0	7	8	1	0	5	3	0	24
Middlesex	0	3	2	0	0	0	1	1	7
New Haven	0	4	5	1	0	2	2	9	23
New London	0	6	6	0	0	3	1	0	16
Tolland	0	2	4	0	0	1	0	0	7
Windham	0	4	3	0	0	2	3	0	12
Totals	1	31	36	3	2	16	27	17	133

Table 2-53 shows the critical facilities within the 500 year floodplain, excluding the 100 year floodplain critical facilities. To determine the number of critical facilities within the 500 year floodplain, the critical facility points were used and intersected with the FEMA 500-year floodplain. There are a total of 127, with Hartford County leading with 31 facilities, and Fairfield and New Haven coming in a close second with 28 facilities a piece.

Table 2-53. Critical Facilities in the 500 year Floodplain by County

County	Correctional Institutions	EMS	Fire Stations	Gas Station with Generator	Health Departments	Law Enforcement	Municipal Solid Waste	Storage Tank Farm	Critical Facility 500-year Floodplain Totals
Fairfield		10	9		2	1	4	2	28
Hartford		5	10			7	9		31
Litchfield		1	2				2		5
Middlesex	1	1	2		2	3	1	2	12
New Haven		5	7	3	1	6	6		28
New London		6	4		1	2	2	1	16
Tolland		1	1						2
Windham		2	2			1			5
Totals	1	31	37	3	6	20	24	5	127

Connecticut has a total of 172 critical facilities within hurricane storm surge zones. In order to determine this number, the buffered critical facilities were intersected with Connecticut's storm surge layer. Table 2-54 provides totals for each hurricane category and jurisdiction. A Category 1 hurricane has maximum sustained wind speeds of 74-95 miles per hour (mph), Category 2 hurricanes have a maximum sustained wind speed of 96-110 mph, Category 3 hurricanes have a maximum sustained wind speed of 111-130 mph, and Category 4 hurricanes have a maximum sustained wind speed of 131-155 mph.

Fairfield County has the highest number of critical facilities within the storm surge zones. With a Category 1 storm, Bridgeport has five critical facilities in the storm surge, Greenwich has two, Stamford has three, and Norwalk, Fairfield, and Stratford each have one. A category 2 storm would put an additional 23 critical facilities within the storm surge zone: six critical facilities in Bridgeport, eight facilities in Fairfield, two facilities in Greenwich, one facility in Norwalk, three facilities in Stamford, one facility in Stratford, and two facilities in Westport. With a category 3 storm 12 more critical facilities would be at risk: one facility in Bridgeport, five facilities in Stamford, and six facilities in Stratford.

New Haven County has 56 critical facilities within hurricane storm surge zones 1 through 4. The majority of these critical facilities are located in the City of New Haven: a total of 22. Of the 22, 13 are located in Category 1, three in Category 2, five in Category 3, and one in Category 4.

Table 2-54. Critical Facilities in Hurricane Storm Surge Zones

County	Category 1	Category 2	Category 3	Category 4	Total (Cat 1-4)
Fairfield	13	23	12	15	63
Hartford	0	0	0	0	0
Litchfield	0	0	0	0	0
Middlesex	2	2	9	1	14
New Haven	17	8	19	12	56
New London	13	7	9	10	39
Total	45	40	49	38	172

In 2013, FEMA Modeling Task Force (MOTF) provided 1,300 surveyed high water marks from Hurricane Sandy storm surge. This data was used to create depth-grids and Hazus analysis. Results of this analysis found 13 critical facilities within hurricane Sandy storm surge, five schools, six fire stations, and two police stations. These results were not rerun for the purposes of the 2019 Plan Update.

Out of the total 1,940 critical facilities in Connecticut, there are 936 that are located on areas susceptible to erosion. The four areas are: 1) Highly erodible soil and coarse grained erodible surficial materials, 2) Highly erodible soil and finer grained erodible surficial materials, 3) Erodible surficial materials, and 4) Highly erodible soil. A breakdown of the types of critical facilities by county located on these areas is shown in Table 2-55. The table shows that EMS facilities and Fire Stations are most at risk, totaling 263 and 326 respectively. The counties with the highest number of critical facilities in areas susceptible to erosion are Hartford, New Haven and Fairfield, with 264, 187, and 147 facilities respectively.

Table 2-55: Critical Facility Types in Erosion Susceptibility Areas

County	Correctional Institutions	EMS	Fire Stations	Gas Station with Generator	Health Departments	Law Enforcement	Municipal Solid Waste	Storage Tank Farm	Critical Facility Totals
Fairfield	2	52	49	6	5	16	15	2	147
Hartford	1	57	103	9	16	30	40	8	264
Litchfield	0	15	23	0	1	11	13	0	63
Middlesex	1	13	15	3	5	5	8	0	50
New Haven	3	47	63	15	17	24	17	1	187
New London	1	39	35	5	7	7	12	0	106
Tolland	0	16	17	1	1	3	14	0	52
Windham	0	24	24	2	1	5	11	0	67
Totals	8	263	329	41	53	101	130	11	936

Danbury and Stamford in Fairfield County have the highest number of critical facilities in areas susceptible to erosion with 46 and 41 respectively. There are a significant amount of EMS and Fire Stations within both municipalities.

2.14.2 Assessment of Local Vulnerability and Potential Losses

Counties and jurisdictions face of variety of challenges in terms of flooding, be that coastal or riverine. Flooding continues to be a jurisdictional level issue throughout the state with communities each making an effort to mitigate that numerous threats from variable flooding sources. The vulnerability of state and critical facilities on a jurisdictional and county level is highlighted in Appendix 2. Coastal communities face a larger amount of potential losses due to their exposure to tropical storms and sea level rise.

2.14.3 Changes in Development

Connecticut's population growth has been minimal over the past few years, with very modest to low growth projected in the next few decades. This minimal growth, paired with the State's focus on the risks and inherent vulnerabilities from both coastal and riverine flooding, has resulted in very flood-conscious planning, zoning, and development.

2.14.4 Hazard Ranking

Quantitative risk assessment, to the degree possible, has been completed for flood using the methodology described in the Hazard Analysis and Ranking methodology Section 2.6 of this chapter. Scores for each jurisdiction were calculated based on population, building permits, geographic extent, average score from local plan rankings, average hazard concern, and measures of historical impact including injuries and deaths, property damage, and the number of reported events. The number of impacted critical facilities was also incorporated, and ranked based on the number of facilities impacted in relation to the number of total critical facilities in Connecticut. As shown in Table 2-56, the composite flood rank has Fairfield and Hartford Counties ranked as high risk; Litchfield, New Haven, and New London Counties as medium-high risk; and Middlesex, Tolland, and Windham Counties as medium risk.

Table 2-56: Hazard Ranking by County for Flood

County	Hazard Concern Rank	Local Plans Hazard Rank	Geographic Extent Rank	Population Density Rank	Building Permits Rank	Facility Intersect Rank	Ann. Events Rank	Ann. Losses Rank	Injury & Death Rank	Composite Ranks
Fairfield	Medium-High	Medium-High	Low	High	High	High	High	High	Low	**High**
Hartford	Medium-High	Medium-High	High	High	High	Medium-Low	High	High	Low	**High**
Litchfield	Medium-High	Medium-High	Medium-Low	Low	Low	High	High	Medium-High	Low	**Medium-High**
Middlesex	Medium-High	Medium-High	Low	Medium-Low	Medium-Low	Medium	High	Medium-Low	Low	**Medium**
New Haven	Medium-High	Medium-High	Low	High	Medium	High	High	Medium-High	Low	**Medium-High**
New London	Medium-High	Medium-High	Low	Medium-Low	Medium-Low	High	High	Medium-High	Low	**Medium-High**
Tolland	Medium-High	Medium-High	Medium-High	Medium-Low	Medium-Low	Low	Medium	Medium	Low	**Medium**
Windham	Medium-High	Medium-High	Medium-High	Medium-Low	Low	Medium-High	Medium	Medium-Low	Low	**Medium**

Connecticut will continue to be at risk for flood events due to the geographic location along the Northeast Atlantic seaboard, abundance of waterways, and future projections by climate change models and studies that project an increase in more intense precipitation events punctuated by periods of drought conditions.[79,80] Published climate change studies discuss an increase in extreme precipitation frequency, and an actual change in precipitation types and intensity throughout the next century. Tools developed by Cornell University, Northeast Regional Climate Center and Natural Resource Conservation Service include interactive data for extreme precipitation and frequency estimates. Using these

[79] M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (eds) Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007

[80] Rosenzweig, C., G. Casassa, D.J. Karoly, A. Imeson, C. Liu, A. Menzel, S. Rawlins, T.L. Root, B. Seguin, P. Tryjanowski, 2007: Assessment of observed changes and responses in natural and managed systems. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 79-131.

tools, Hartford and Fairfield counties are have a slightly higher estimate for precipitation extremes, relative to Connecticut.[81]

The Sentinel Monitoring for Climate Change in Long Island Sound Program is a currently collecting, developing and synthesizing SLR products that will be stored on their data clearinghouse website.[82] In 2017, the Connecticut Institute for Resilience and Climate Adaptation released localized sea level rise scenarios for the state and recommended that Connecticut plan for the upper end of the likely range of 20in/50cm of sea level rise by 2050.

2.15 Sea Level Rise Hazard Profile

2019 Plan Update Changes

- Expectations of sea level rise from the Connecticut Institute for Resilience & Climate Adaptation
- The hazard profile has been updated to included location, extent, severity, warning time and secondary impacts
- Gage readings from The Center for Operational Oceanographic Products and Services water level stations in Bridgeport and New London
- Local planning and adaptation for sea level rise

2.15.1 Hazard Description

Relative Sea Level Rise (RSLR) presents a hazard that must be considered in long-term land use, development, and critical infrastructure planning within Connecticut. Relative sea level rise is defined as the sea level relative to the level of the continental crust. Relative sea level changes can thus be caused by absolute changes of the sea level and/or by absolute movements of the continental crust. Connecticut has large exposure to the potential impacts of RSLR, with over 618 miles of tidal shoreline on Long Island Sound which includes numerous inlets and significant areas of low elevation.

According to the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report (AR5) Report, between 1901 and 2010, global mean sea level rose by 0.19 meters, of which the report states with high confidence that roughly 75% of the rise can be attributed to glacier mass loss and ocean thermal expansion from warming.[83] Climate change, including the continued increase in global temperature, is projected to result in an acceleration of observed rates of RSLR. Projections in global increases in sea level by 2100 due to climate change range from 1-2 feet up to 6.6 feet.

The Center for Operational Oceanographic Products and Services (CO-OPS) and its predecessors have gathered oceanographic data along our nation's coasts for over 200 years

[81] Cornell Extreme Precipitation in New York and New England. Version 1.12 Joint project between Northeast Regional Climate Center (NRCC) and Natural Resource Conservation Service (NRCS) http://precip.eas.cornell.edu/ Assessed 8/26/2013.
[82] Sentinel Monitoring for Climate Change in Long Island Sound Program http://longislandsoundstudy.net/research-monitoring/sentinel-monitoring/
[83] https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_All_Topics.pdf

and have been measuring sea level for over 150 years. Changes in mean sea level (either rise or fall) are computed at 142 long-term water level stations, utilizing a minimum time span of 30 years and averaged by the month to removed outliers, and computes an accurate linear sea level trend. Tide gauge measurements are made with respect to a local fixed reference level on land; therefore, if there is some long-term vertical land motion occurring at that location, the relative MSL trend measured there is a combination of the global sea level rate and the local vertical land motion.[84] CO-OPS calculates the linear trends for two stations in Connecticut, one in Bridgeport and one in New London. These two stations have registered mean sea level trends of 2.83 mm/year and 2.57 mm/year respectively. The changes are highlighted in Figure 2-20 and Figure 2-21.

Connecticut continues to bolster its commitment to studying and analyzing climate change and sea level rise through investments at the state level in collaborative projects with universities, neighboring states, non-profits, and federal agencies.

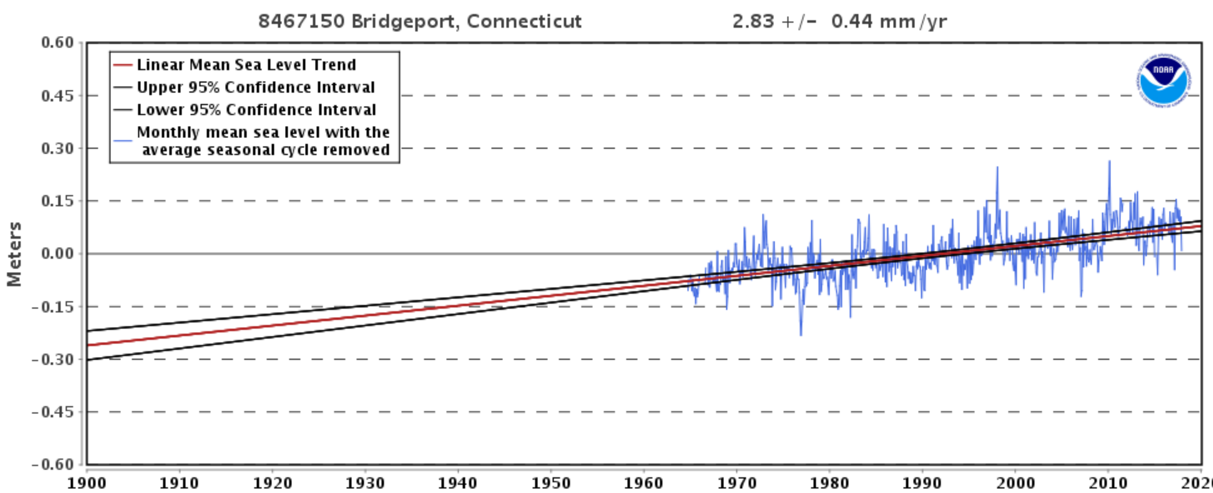


Figure 2-20: The mean sea level trend is 2.83 mm/year with a 95% confidence interval of +/- 0.44 mm/year based on monthly mean sea level data from 1964 to 2016 which is equivalent to a change of 0.93 feet in 100 years

[84] https://tidesandcurrents.noaa.gov/sltrends/sltrends.html

In 2014, Connecticut's Department of Energy & Environmental Protection and the University of Connecticut founded the Connecticut Institute for Resilience & Climate Adaptation (CIRCA). CIRCA's mission is to increase the resilience and sustainability of vulnerable communities along Connecticut's coast an inland waterways to the growing impacts of climate change on the natural, built, and human environment.

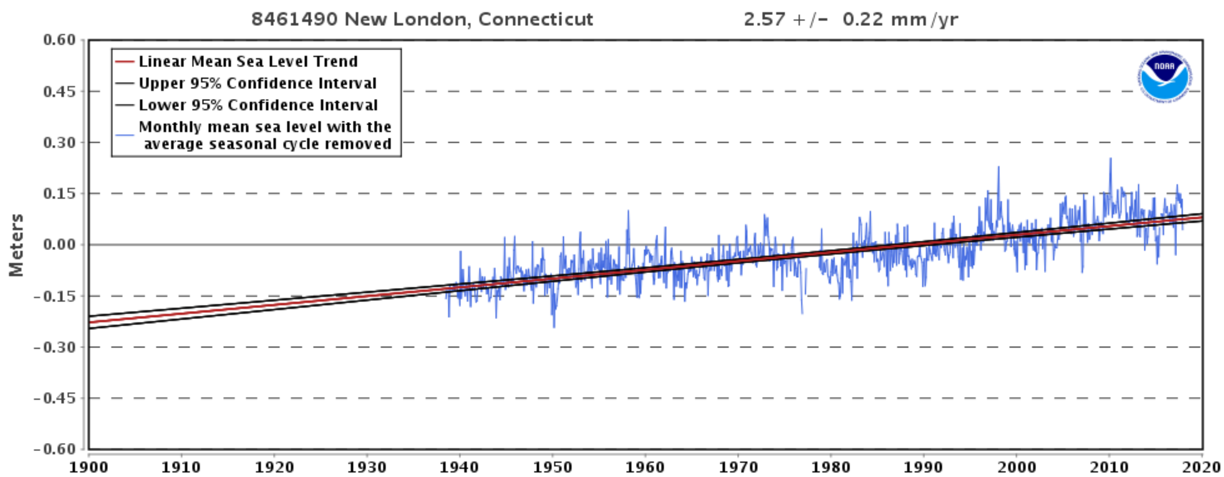


Figure 2-21: The mean sea level trend is 2.57 mm/year with a 95% confidence interval of +/- 0.22 mm/year based on monthly mean sea level data from 1938 to 2016 which is equivalent to a change of 0.84 feet in 100 years

In October 2017, CIRCA released the local sea level rise scenarios for Connecticut in a public meeting, and recommended that the State plan for 50cm (20 inches) of sea level rise by 2050.[85] Furthermore, they noted that the sea level will most likely continue to rise above this level in the future. Figure 2-22 shows Connecticut SLR Projections based on local tide gage observations model simulations near Long Island Sound.

[85] https://circa.uconn.edu/wp-content/uploads/sites/1618/2017/10/Coastal-Flood-Risk-in-CT-ODonnell.pdf

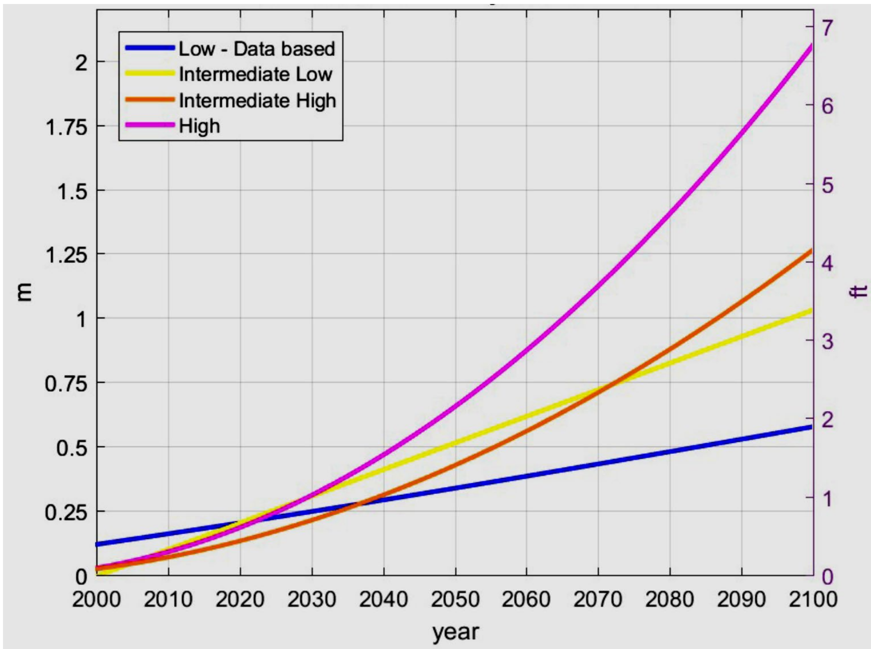


Figure 2-22: Connecticut SLR Projections; Sea Level Rise Projections based on local tide gage observations (blue), the IPCC 2013 RCP 4.5 model simulations near Long Island Sound (yellow line), the semi-empirical model predictions are in orange and the magenta shows the ice mass balance projections

The State is also part of the Climate Change and Sentinel Monitoring Program which utilizes a multidisciplinary scientific approach to provide early warning of climate change impacts to Long Island Sound ecosystems, species, and processes to facilitate appropriate and timely management decisions and adaptation responses. The program proved a deeply successful collaborative project with a number of partners, and has been scaled up for the entire Northeast and Gulf of Maine region through the joint Ecosystem Heath Committee of Northeast Regional Ocean Council (NROC) and Northeast Regional Association of Coastal and Ocean Observing Systems (NERACOOS). The integrated Sentinel Monitoring program allows not only Connecticut, but the entire region to combine efforts to support key monitoring for discernible climate signals and impacts, as well as inform adaptation strategies to keep our ocean and coastal resources as healthy as possible. Data from these efforts are available on their databases, which capture information (metadata) about data sources that could be used to detect changes in the environment due to climate change.

Readers are referred to:

http://www.ct.gov/deep/cwp/view.asp?a=4423&q=521742&ampdeepNav_GID=2121 for reports and detailed information on actions to date.

2.15.2 Location

Sea level rise is mostly contained within the coastal communities along the State's eastern seaboard. According to NOAA, Connecticut has 618 miles of coastline bordering Long Island Sound and the Atlantic Ocean. This coastal area includes four counties and 24 municipalities. Municipalities along waterways that drain into the Sound are also at risk as is shown in the figures below.

2.15.3 Extent

The extent of sea level rise, while mostly contained amongst coastal communities, has potential detrimental impacts to more inland communities as the rising sea levels pushes flooding up waterways and impacts the water sources, water tables, and water related infrastructure. As of now, the extent of sea level rise has yet to be definitively determined, and numerous factors will play a role in inundation. Figure 2-23 below shows what the Connecticut coastline would look like with an additional one foot and an additional six feet of sea level rise. Figure 2-24 and Figure 2-25 provide more detailed maps of these projections. Bridgeport and New London were chosen to illustrate localized sea level rise projections. Based on sea level rise projections, CIRCA recommends that the State of Connecticut prepares for 20 inches of sea level rise by 2050.

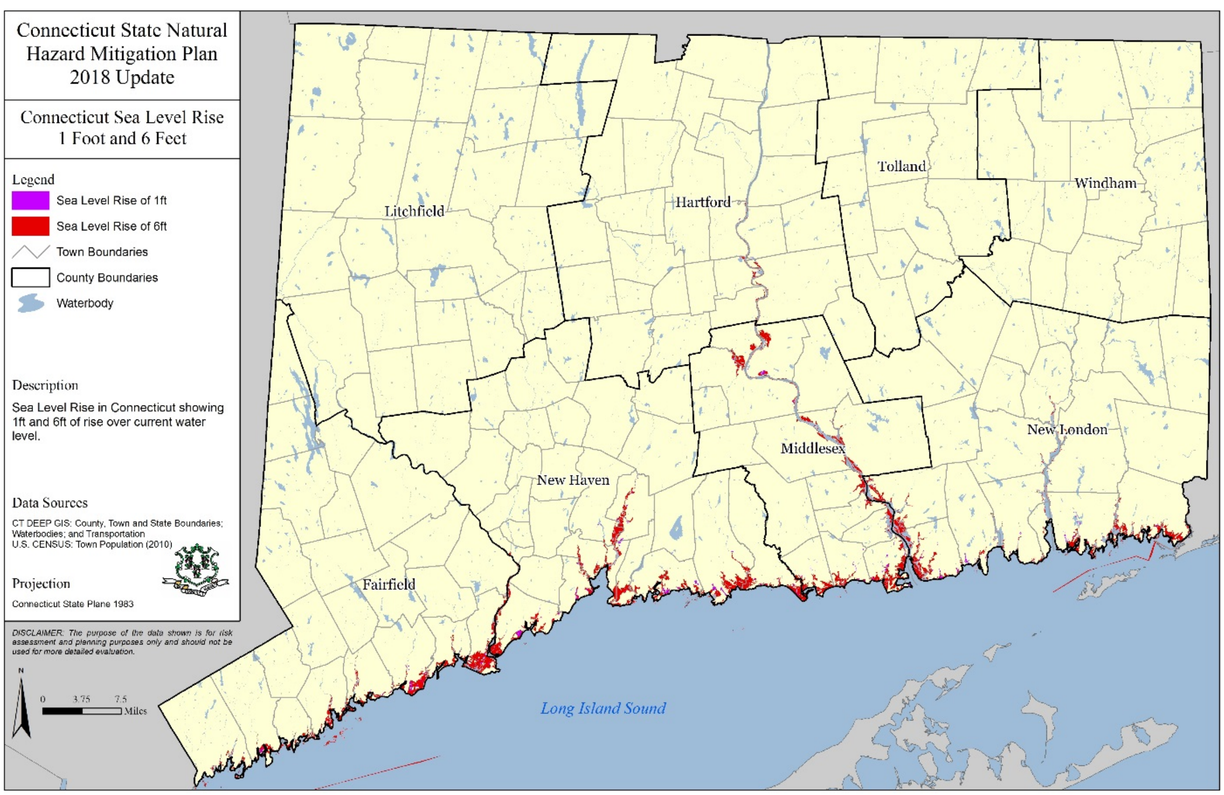


Figure 2-23: Potential Sea Level Rise on Connecticut's Coast (1ft, 6ft)

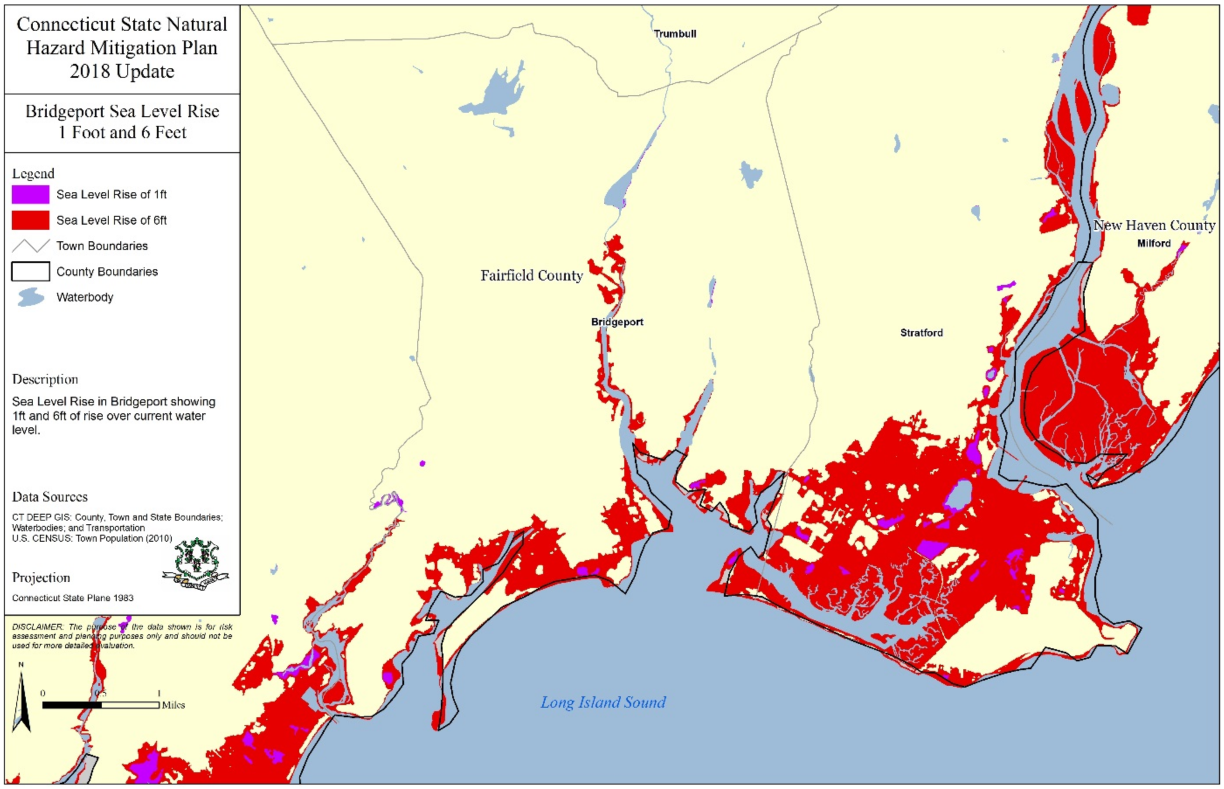


Figure 2-24: Potential Sea Level Rise in Bridgeport (1ft, 6ft)

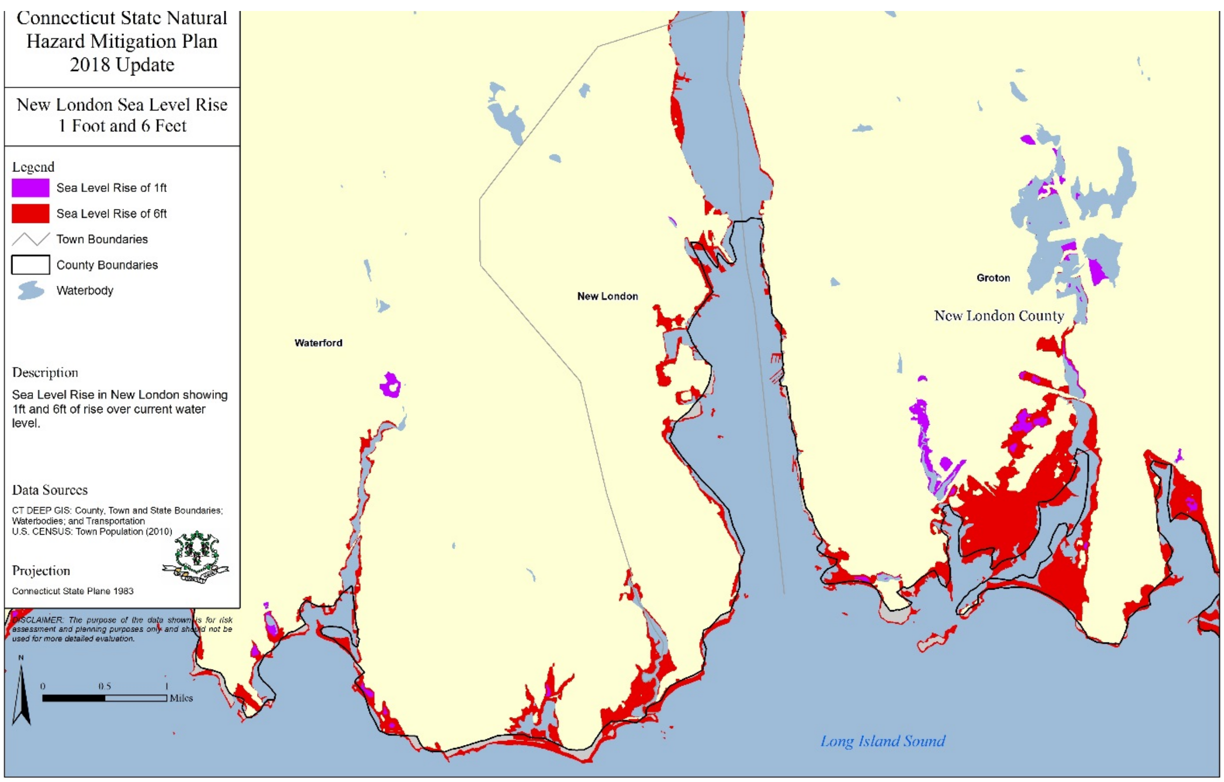


Figure 2-25: Potential Sea Level Rise in New London (1ft, 6ft)

2.15.4 Primary and Secondary Impacts

The severity of sea level rise, and the extensive secondary impacts rising seas could bring to the state of Connecticut, are wide ranging and dependent on a number of interrelated factors including greenhouse gas emissions, varying ocean temperatures, land subsidence along the coast, coastal erosion due to severe storms, as well as resilience and mitigation measures that the State has and continues to implement. Only time will be an indicator of the severity of the threat, but projections show that the impact will be severe if average global temperatures and average ocean temperatures continue to increase.

Two of the largest secondary impacts of SLR include the increased threat of coastal flooding as well as coastal erosion. Rising sea level erodes wetlands and beaches and increases damage from coastal storms. Tidal wetlands are inherently vulnerable, due to their low elevations, and spatial constraints in the form of coastal development prevents them from migrating inland onto higher ground.[86] Shoreline development prevents wetlands, and the vital ecosystems which they contain, from migrating inland to higher ground.

Secondary impacts such as compromised sources of drinking water, threatened wastewater treatment and sewage collection systems, and reduced hydraulic capacities, all have the potential to affect residents and communities along the coast of Connecticut. Most of the agricultural features, which the State analyzed in 2011, will also be extensively impacted. Shellfish production was included among top five most imperiled agricultural planning areas or features in Connecticut.[87]

The infrastructure items most likely to be impacted by SLR are coastal flood control and protection infrastructure such as dams, levees, berms and seawalls. In addition, vital the built environment including roads, bridges, utilities, and critical facilities will also be increasingly vulnerable.

The natural resources at the highest risk include cold water streams, tidal marshes, open water marine, beaches and dunes, freshwater wetlands, offshore islands, major rivers, and forested swamps. The degree of impact will vary, but likely changes include conversion of rare habitat types, loss and/or replacement of critical species dependent on select habitats, and the increased susceptibility of habitats to other on-going threats. Severity

The severity of sea level rise, and the extensive secondary impacts rising seas could bring to the state of Connecticut, are wide ranging dependent on a number of interrelated factors including greenhouse gas emissions, varying ocean temperatures, land subsidence along the coast, coastal erosion due to severe storms, as well as resilience and mitigation measure implemented. Only time will be an indicator of the severity of the threat, but projections show that the impact will be severe if greenhouse gas emissions continue to warm ocean temperatures.

[86] https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-ct.pdf
[87] http://www.ct.gov/deep/cwp/view.asp?a=2705&q=475764&deepNav_GID=2022

2.15.5 Warning Time

The warning time for sea level rise has been, and will continue to be, extensive. Sea level rise is expected to occur gradually over time, though the near-term impacts will vary depending on severity.

2.15.6 Previous Occurrences and Losses

Connecticut has experienced eight inches of sea level rise since the mid-1800's, much of which is fairly unnoticeable due to the changing daily tides.[88] Though this rise is not so visible to the naked eye, combined with the effects of climate change on changing weather patterns, increased coastal flooding has occurred along the states shorelines during storms such as Hurricane Sandy. The gradual rising level of sea, will continue to be visible during hurricanes and storms, as well as through the erosion of beaches and coastal land mass.

2.15.7 Probability of Future Events

It is difficult to assign quantitative probabilities to projections of sea level increases. Climate planning is being completed in an adaptive approach to allow for best available science to be continually updated. No widely accepted method is currently available for probabilistic projections at the regional or local level. Multiple scenarios allows for experts and decision makers to consider multiple future conditions and develop responses based on the information that may reduce future impacts and vulnerabilities.[89] While the science clearly indicates that SLR is occurring, using the probability range applied to the other hazards in this plan, Connecticut has a medium-low probability of future SLR events. Table 2-57 are based on four estimates of global SLR that reflect different degrees of ocean warming and ice sheet loss ranging from 0.2 meters (8 inches) to 2.0 meters (6.6 feet) by 2100.

These scenarios provide a set of plausible trajectories of global mean SLR for use in assessing vulnerability, impacts, and adaptation strategies. None of these scenarios should be used in isolation, and experts and coastal managers should factor in locally and regionally specific information on climatic, physical, ecological, and biological processes and on the culture and economy of coastal communities.[90]

[88] https://circa.uconn.edu/sea-level-rise/
[89] Parris, A., P. Bromirski, V. Burkett, D. Cayan, M. Culver, J. Hall, R. Horton, K. Knuuti, R. Moss, J. Obeysekera, A. Sallenger, and J. Weiss. 2012. Global Sea Level Rise Scenarios for the US National Climate Assessment. NOAA Tech Memo OAR CPO-1. 37 pp.
[90] Parris, A., P. Bromirski, V. Burkett, D. Cayan, M. Culver, J. Hall, R. Horton, K. Knuuti, R. Moss, J. Obeysekera, A. Sallenger, and J. Weiss. 2012. Global Sea Level Rise Scenarios for the US National Climate Assessment. NOAA Tech Memo OAR CPO-1. 37 pp.

Table 2-57: Global SLR Scenarios. *Using mean sea level in 1992 as a starting point

Scenario	SLR by 2100 (m)*	SLR by 2100 (ft)*
Highest	2.0	6.6
Intermediate-High	1.2	3.9
Intermediate-Low	0.5	1.6
Lowest	0.2	0.7

2.15.8 Climate Change Impacts

Sea level has been rising since the end of the last ice age, but the rate of change has been greater in the in the 19th and 20th centuries, much of which has been attributed to anthropogenic influence.[91],[92] Sea level rise is a complex problem, but the future impacts will be influenced by two primary factors: thermal expansion of water in the ocean and the melting of land-based ice, much of which is contained in ice sheets in Greenland and the Antarctic.[93] These two factors are accelerated by the observed increase in global average temperatures since the mid-20th century, which is very likely due to the observed increase in anthropogenic greenhouse gas concentrations.[94] As the oceans warm and expand, and the ice sheets continue to melt, sea level rise will continue to be seen in coastal communities around the world, within the United States, and on the coast of Connecticut.

2.16 Sea Level Rise Vulnerability Assessment

2.16.1 Assessment of State Vulnerability and Potential Losses

RSLR hazard layers that represent inundation extents for generalized RSLR scenarios of 0.0, 1.0, 2.0, 3.0, 4.0, 5.0, and 6.0 feet, relative to mean sea level and intersected with the critical and state-owned facility geospatial database. Reported values represent exposed assets in the inundation range of the hazard layer. Occurrence of a higher range scenario would accumulate risk in a step-wise fashion on top of a lower range scenario.

Exposed state-owned and critical facilities and exposed asset value were tabulated by county. Counties with no exposure were excluded from reporting. Counts of State Owned and Critical facilities are reported in Table 2-58 and Table 2-59 below:

[91] http://www.ct.gov/deep/cwp/view.asp?a=2705&q=475764&deepNav_GID=2022
[92] https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf
[93] https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf
[94] https://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_full_report.pdf

Table 2-58: State Facilities intersection with RSLR Scenarios

County	6' SLR	5' SLR	4' SLR	3' SLR	2' SLR	1' SLR
Fairfield	5	3	0	0	0	0
Middlesex	5	4	0	0	0	0
New Haven	38	15	4	3	3	1
New London	12	5	1	1	1	1

Table 2-59: Critical Facilities intersection with RSLR Scenarios

County	Facility Type	6' SLR	5' SLR	4' SLR	3' SLR	2' SLR	1' SLR
Fairfield	Law Enforcement	2	1	0	0	0	0
	EMS	2	2	0	0	0	0
	Fire Station	2	2	0	0	0	0
	Municipal Solid Waste	6	4	0	0	0	0
	Storage Tank Farm	5	3	0	0	0	0
New Haven	EMS	1	0	0	0	0	0
	Fire Station	2	1	0	0	0	0
	Storage Tank Farm	7	6	2	0	0	0
New London	Law Enforcement	1	1	0	0	0	0
	EMS	2	2	0	0	0	0
	Fire Station	2	2	0	0	0	0
	Storage Tank Farm	1	1	0	0	0	0

2.16.2 Assessment of Local Vulnerability and Potential Losses

Vulnerability from sea level rise is very much a local issue, as sea level rise affects only those communities that border the coast. The impacts of sea level rise are variable and dependent on a number of factors such as planning, development, mitigation, and resilience initiatives – in tandem with climate variation and greenhouse gas emissions. Potential losses will come from economic impacts, devalued real-estate, the displacement of communities and residents, with socio-economically disadvantaged groups being impacted the greatest. The State and communities that border the coast will be forced to continue to devote funds to study, research, and implement interventions in Connecticut's ocean front communities. Only time will tell the full impacts that sea level rise will have on the coastal communities in Connecticut in both the near-term, and long-term future, but current research indicates significant vulnerability at the municipal level with very little chance of abatement or relief from the encroaching oceanfront. A detailed breakdown of sea level rise vulnerability analysis by municipality can be found Appendix 2.

2.16.3 Changes in Development

Coastal management in Connecticut is a comprehensive, cooperative program that functions at all levels of government. Connecticut's Coastal Management Program is administered by DEEP and is approved by NOAA under the federal Coastal Zone Management Act. The Coastal Management Program has worked with many of our state's urban communities on redevelopment projects to reclaim their once-active waterfronts. Central too many of these efforts is the revitalization of developed shorefronts to accommodate active water-dependent uses such as waterborne commerce, commercial and recreational fishing, boating and public access.[95] While many of these coastal areas are being redeveloped for greater utilization, Connecticut's overall low population growth and limited expansion of building permits, indicates that very little new construction is taking place in vulnerable areas along the coast line. Despite this, there is a continuing trend of tear-down and rebuilding of coastal homes after severe storms. These rebuilt home will be increasingly vulnerable to sea level rise.

2.16.4 Hazard Ranking

Quantitative risk assessment, to the degree possible, has been completed for sea level rise using the methodology described in the Hazard Analysis and Ranking methodology Section 2.6 of this chapter. Scores for each jurisdiction were calculated based on population, building permits, geographic extent, average score from local plan rankings, average hazard concern, and measures of historical impact including injuries and deaths, property damage, and the number of reported events. The number of impacted critical facilities was also incorporated, and ranked based on the number of facilities impacted in relation to the number of total critical facilities in Connecticut. As shown in Table 2-60, the composite sea level rise rank has New Haven ranked as high risk; Fairfield, Middlesex, and New London Counties as medium-high risk; Hartford County as medium-low risk; and Litchfield, Tolland, and Windham Counties as low risk.

[95] http://www.ct.gov/deep/cwp/view.asp?a=2705&q=323536&depNav_GID=1622

Table 2-60: Hazard Ranking by County for Sea Level Rise

County	Hazard Concern Rank	Local Plans Hazard Rank	Geographic Extent Rank	Population Density Rank	Building Permits Rank	Facility Intersect Rank	Ann. Events Rank	Ann. Losses Rank	Injury & Death Rank	Composite Ranks
Fairfield	Medium	High	Medium	High	High	Medium-High	High	Low	Low	**Medium-High**
Hartford	Medium	High	Medium-Low	High	High	Low	Low	Low	Low	**Medium-Low**
Litchfield	Medium	High	Low	Low	Low	Low	Low	Low	Low	**Low**
Middlesex	Medium	High	High	Medium-Low	Medium-Low	Medium-Low	High	Low	Low	**Medium-High**
New Haven	Medium	High	Medium-High	High	Medium	High	High	Low	Low	**High**
New London	Medium	High	Medium-High	Medium-Low	Medium-Low	Medium	High	Low	Low	**Medium-High**
Tolland	Medium	High	Low	Medium-Low	Medium-Low	Low	Low	Low	Low	**Low**
Windham	Medium	High	Low	Medium-Low	Low	Low	Low	Low	Low	**Low**

2.17 Earthquake Hazard Profile

2019 Plan Update Changes

- Updated the Connecticut seismic hazard map
- Updated the Northeast Seismicity graph
- Updated the Earthquake epicenters near Connecticut (1976– 2016) map
- Added Climate Change Impacts, Primary and Secondary Impacts, Extent, and Severity
- Updated loss estimates for earthquake scenarios
- Updated hazard rankings and risk assessments

2.17.1 Hazard Description

An earthquake, also known as a seismic event, is a shaking of the ground caused by the sudden movement of large sections (tectonic plates) of the earth's lithosphere. The lithosphere is made up of the Earth's crust, which ranges in size from about 22 miles thick for continents to about five miles thick for the oceans, and a portion of the upper mantle which is composed of solidified magma. The edges of the tectonic plates are marked by faults. Most earthquakes occur along the fault lines when the plates slide past or collide against each other. This movement sends out seismic waves that may be powerful enough to alter the surface of the Earth, thrusting up mountains and opening great cracks in the ground, and cause great damage, collapse of buildings and other man-made structures, broken power and gas lines (and the consequent fires), landslides, snow avalanches, tsunamis (giant sea waves) and volcanic eruptions.

The magnitude of an earthquake is a measure of the energy released as seismic waves from the focus of an earthquake.[96] Each earthquake has a magnitude assigned to it. The magnitudes of earthquakes which occur east of the Rocky Mountains and into Canada are often determined by the use of local or regional magnitude scales. Many earthquakes in Northeast earthquake catalogs calculate magnitude for such events based on the Coda-length magnitude scale or the Nuttli magnitude scale and use the Richter Scale as a default magnitude scale.[97] The Richter Scale is used to express the magnitude of an earthquake in terms of energy released, not in terms of its impact. An earthquake in a densely populated area which results in many deaths and considerable damage may have the same magnitude as a shock in a remote area that has no direct impact. Large-magnitude earthquakes that occur beneath the oceans may not even be felt by humans.

The effect of an earthquake on the Earth's surface is called the intensity. Once a magnitude for an earthquake event has been calculated using one of several scientifically accepted formulas, it can then be connected to an intensity measurement. Intensity scales consist of a series of certain key responses such as people awakening, movement of furniture, damage to chimneys, and, finally, total destruction. Although numerous intensity scales have been developed over the last several hundred years to evaluate the effects of earthquakes, the one currently used in the United States is the Modified Mercalli Intensity (MMI) Scale. Further information on the MMI Scale is detailed in Section 1.17.3 below.

Surficial earth materials behave differently in response to seismic activity. Unconsolidated materials such as sand and artificial fill can amplify the shaking associated with an earthquake. In addition, artificial fill material has the potential for liquefaction. Liquefaction is a phenomenon in which the strength and stiffness of a soil are reduced by earthquake shaking or other rapid loading. It occurs in soils at or near saturation, especially the finer textured soils. When liquefaction occurs, the strength of the soil decreases and the ability of soil to support building foundations and bridges is reduced. Increased shaking and liquefaction can lead to greater damage to buildings and other structures, and a greater loss of life.

Areas of fine sand and clay (glacial lake bottom deposits) are also vulnerable, and have been classified as having the highest risk for seismic wave amplification (NEHRP). The distribution of these glacial materials has been mapped on the Surficial Materials Map of

[96] Source of information is USGS's web page entitled *Magnitudes* located at http://neic.usgs.gov/neis/epic/code_magnitude.html
[97] LCSN and Weston Observatory earthquake logs, being the most comprehensive for the Northeast utilize Nuttli or Coda-length magnitudes scale as the primary scale and Richter as the default scale.

Connecticut[98] and The Quaternary Geologic Map of Connecticut and The Long Island Sound Basin[99]. New England State Geologists have promoted the use of surficial geology in Hazus loss estimations. Based on the distribution of surficial materials, a pilot NEHRP seismic risk classification has been prepared for Hartford County. "Although the areas of highest seismic event frequency are to the southwest and southeast, the Hartford County area is largely underlain by glacial lake clays and fine sands that have a high liquefaction potential." [100] Targeted geophysical surveys of these areas and similar areas statewide have the potential to better define the seismic risk and potential for ground failure. Figure 2-26 depicts Connecticut's surficial materials on the landscape. Figure 2-27 below depicts the Quaternary Geology of Connecticut.

Areas of steep slopes can collapse during an earthquake, creating landslides. Seismic activity can also break utility lines, such as water mains, electric and telephone lines, and storm water management systems. Dam failures also pose a significant threat to developed areas during an earthquake. Structures in these areas are at increased risk from earthquakes due to amplification of seismic energy and/or collapse.

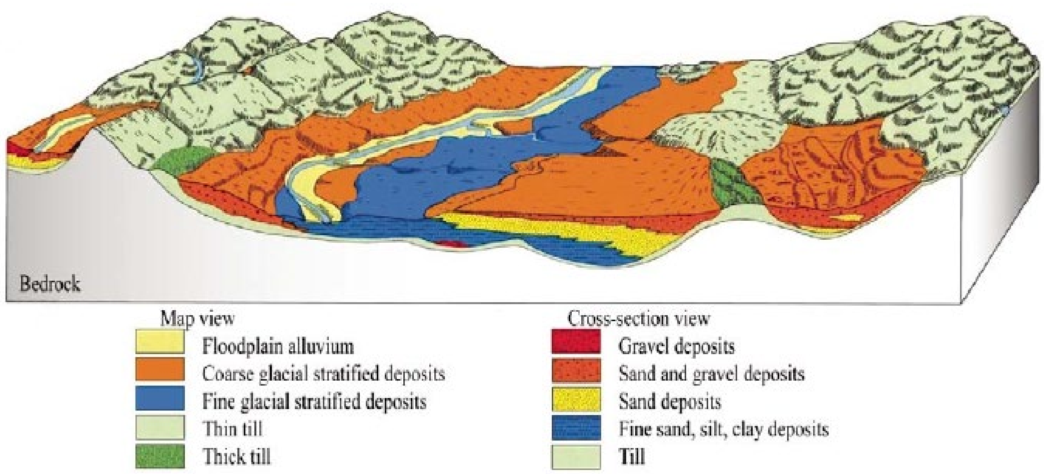


Figure 2-26: Block Diagram Depicting Connecticut Surficial Materials on the Landscape

The best mitigation for future development in areas of sandy or filled material may be application of the most stringent building codes, or possibly the prohibition of certain types of new construction.

[98] Stone, J.R., Schafer, J.P., London, E.H. and Thompson, W.B., 1992. Surficial Materials Map of Connecticut. U.S. Geological Survey Special Map, 2 sheets, scale 1:125,000

[99] Stone, Janet Radway; Schafer, John P.; London, Elizabeth Haley; DiGiacomo-Cohen, Mary L.; Lewis, Ralph S.; Thompson, Woodrow B., 2005. Quaternary Geologic Map of Connecticut and Long Island Sound Basin. Geological Survey (U.S.) Scientific Investigations Map 2784, 5 maps on 2 sheets : col. ; 106 x 136 cm. and 34 x 42 cm., sheets 117 x 168 cm. and 99 x 139 cm., folded in envelope 30 x 23 cm. + 1 pamphlet (iv, 72 p. : ill., map ; 28 cm.); Includes text, 2 colored cross sections, 3 diagrams, and 8 colored photos [Link]

[100] Laurence R. Becker, Steven P. Patriarco, Robert G. Marvinney, Margaret A. Thomas, Stephen B. Mabee, and Edward S. Fratto, Improving seismic hazard assessment in New England through the use of surficial geologic maps and expert analysis *Geological Society of America Special Papers, 2013, 493, p. 221-242, doi:10.1130/2012.2493(11)*

2.17.2 Location

Although California is widely known for its seismic activity, earthquakes, mostly with a magnitude of < 3.0, occur at a high frequency within the Northeast United States.[101] In fact, the Northeast States Emergency Consortium notes that from 1538 to 1989 1,215 earthquakes occurred in New England.[102]

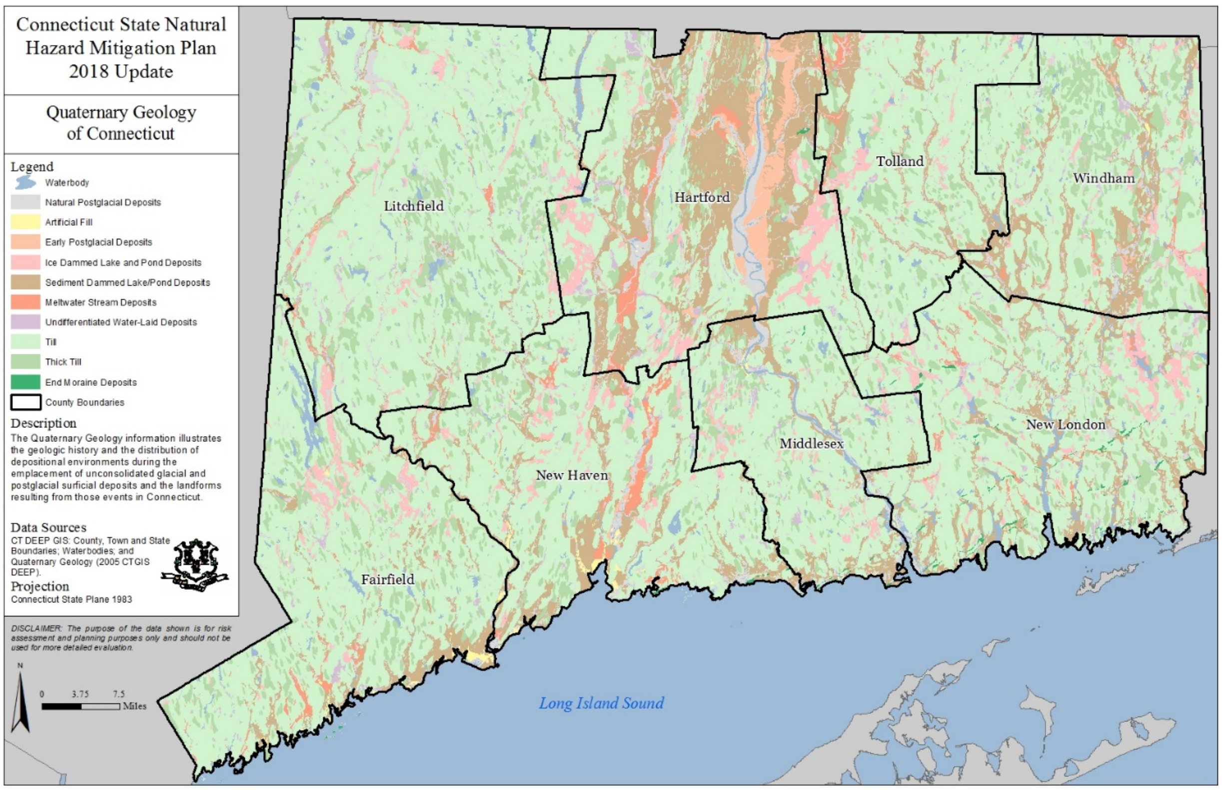


Figure 2-27: Map of Quaternary Geology in Connecticut

Earthquakes that occur within the northeastern United States are intraplate earthquakes, meaning that the earthquake occurs not along the faults between plates, but within plate boundaries.[103] The earthquake process itself is complex in plate interiors. The quaternary geology of Connecticut is shown in Figure 2-27. There are two important points that can affect earthquake prediction in these areas (i.e., the where and when an earthquake will occur):

- There is no obvious relationship between earthquakes and geologically mapped faults in most intraplate areas; and

[101] Source of information is a paper entitled, *Why Does the Earth Quake in New England*, written by Alan L. Kafka and located on Boston College's Weston Observatory website
[102] Source: NESEC website: www.nesec.org/hazards/earthquakes.cfm
[103] Source: see Kafka's paper *Why Does the Earth Quake in New England?*, located at Weston Observatory's website. Intraplate means within plates, in contrast to along plate boundaries.

- It is not at all clear whether faults mapped at the earth's surface in the Northeast are the same faults along which the earthquakes are occurring.

The current accepted theory to explain the occurrence of earthquakes in the Northeast is that ancient zones of weakness are being reactivated due to present day stress. The last

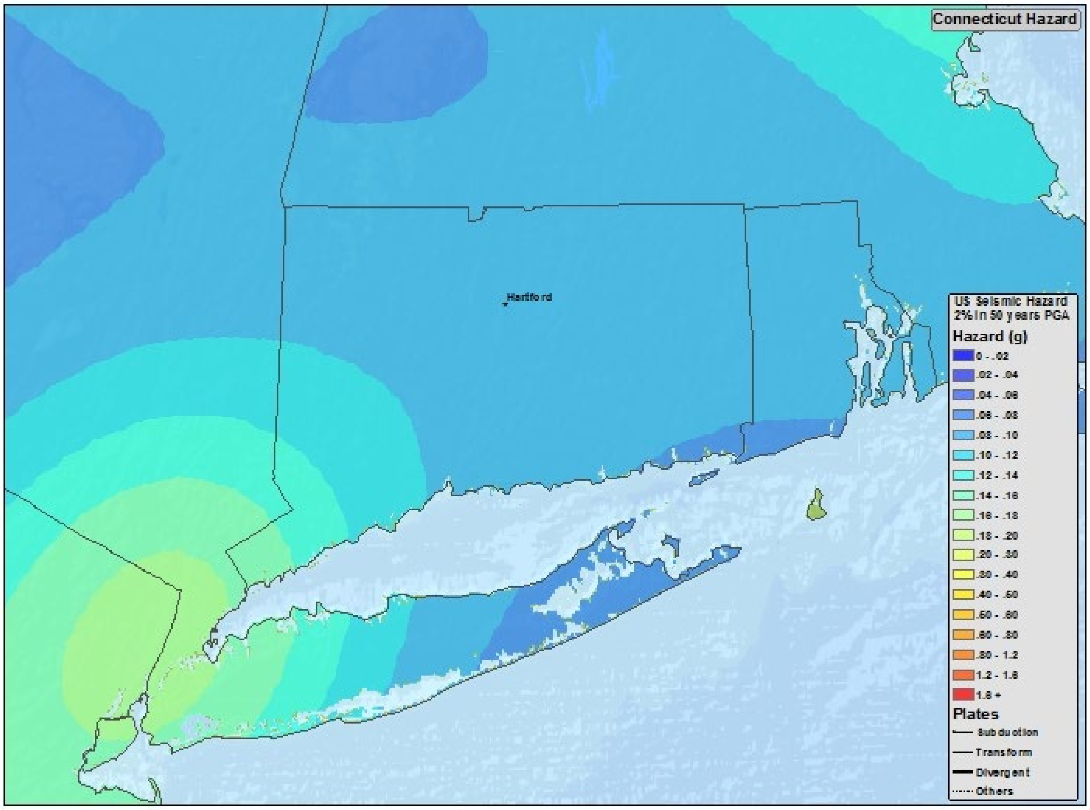


Figure 2-28: Connecticut Seismic Hazard Map. Source USGS

major episode of geologic activity to affect New England bedrock occurred during the Mesozoic Era, approximately 100 million years ago.[104] The remains of Mesozoic rifting can be found in a series of ancient continental rift zones in the Northeast, including the Hartford rift basin (located in central Connecticut and central Massachusetts), and the Newark rift basin (located in the greater New York area).[105] Figure 2-28 is the Connecticut seismic hazard map for 2% in 50-years PGA.

Figure 2-29 shows recent seismic activity of the Northeast between 1975 and 2016.[106] Most earthquakes have a calculated magnitude of less than 3.0. This map also shows clusters of earthquakes occurring around the Portland-Haddam-East Haddam area, as well as the New Haven –Greenwich area of Connecticut.

[104] Source: see Kafka's paper *Why Does the Earth Quake in New England?*, located at Weston Observatory's website.
[105] Source: see Kafka's paper *Why Does the Earth Quake in New England?*, located at Weston Observatory's website.
[106] Map downloaded from the Weston Observatory website: www.bc.edu/research/westonobservatory/.

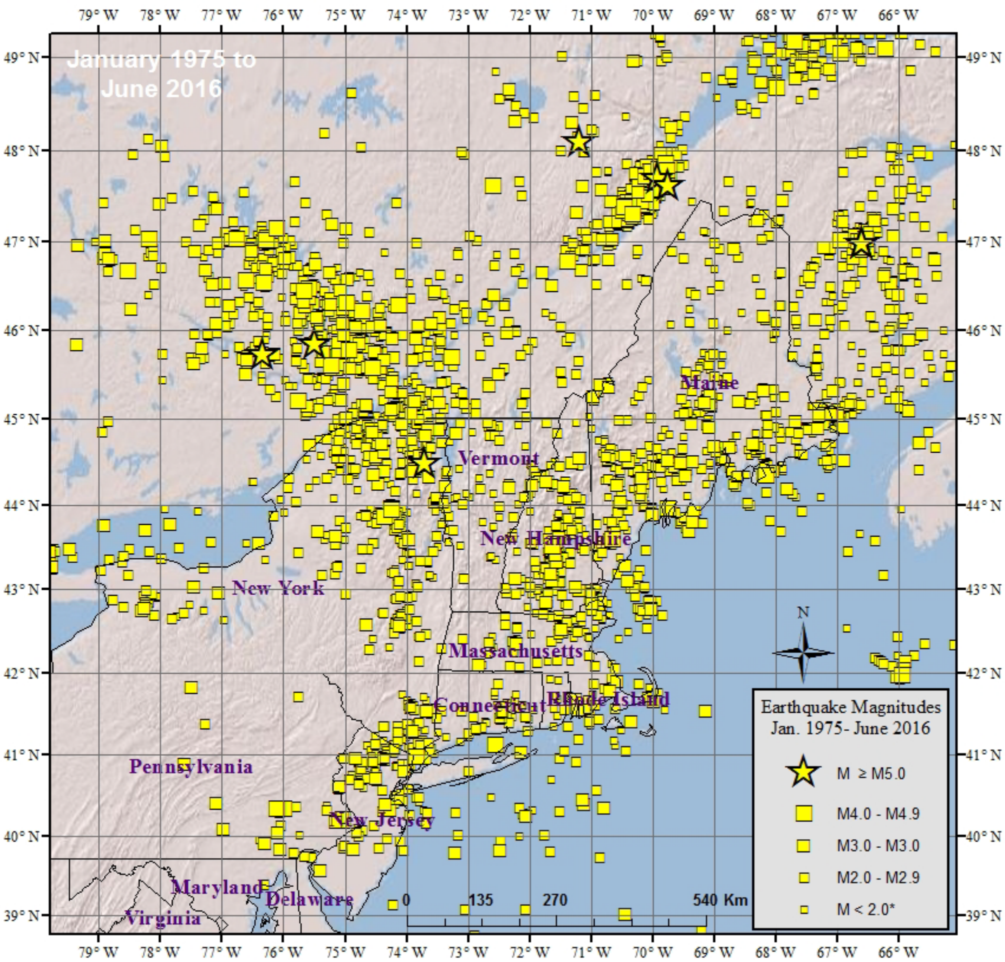


Figure 2-29: Northeast Seismicity 1975-2016, Weston Observatory

A number of seismic stations have been established within New England and Canada. There are four seismic stations currently operating in Connecticut. Two stations are operated and maintained by the Weston Observatory, and are part of the observatory's New England seismic network. Two stations are operated and maintained by the Lamont-Doherty Cooperative Seismographic Network.[107]

2.17.3 Extent

The potential effects of an earthquake are dependent on the magnitude of the event, the intensity (distance from the epicenter), and the type of geologic material in the area:

- Magnitude is a measure of the strength of an earthquake or energy released by it. Magnitude is measured by a device known as a seismograph. The scale used to

[107] More information for both network can be found at the following websites: Lamont –Doherty Cooperative Seismographic Network – http://www.1deo.columbia.edu/LCSN/intro.html; and the Weston Observatory – http://www.bc.edu/research/westonobservatory/about/aboutwo.html.

measure earthquake magnitude was originally defined by Charles Richter in the 1930s, and is commonly referred to as the Richter scale, which assigns a magnitude number to quantify the strength of an earthquake. Many earthquakes in Northeast earthquake catalogs calculate magnitude for such events based on the Coda-length magnitude scale or the Nuttli magnitude scale and use the Richter Scale as a default magnitude scale.[108] Nuttli is the most commonly used magnitude scale in the Northeast. It is computed from the vertical component 1-second Lg seismic-waves (short period surface waves).[109] The Richter Scale is used to express the magnitude of an earthquake in terms of energy released, not in terms of its impact.

- Intensity is a measure of the effects of an earthquake at a particular place on people, structures, or the land itself. Earthquake intensity is most commonly measured in the United States using the Modified Mercalli (MMI) scale. The intensity at a point depends not only upon the strength of the earthquake, but also upon the distance from the earthquake to the point and the local geology at that point. Further information on the MMI scale is below.

- Peak Ground Acceleration (PGA) is another common measure of earthquake shaking along the earth's surface. PGA expresses acceleration along the earth's surface as a percentage of g, the acceleration due to gravity (32.2 ft. /s2). PGA varies significantly depending on the ground type and the geology of an area.

The Modified Mercalli Intensity (MMI) Scale was developed in 1931 by the American seismologists Harry Wood and Frank Neumann. This scale, composed of 12 increasing levels of intensity that range from imperceptible shaking to catastrophic destruction, is designated by Roman numerals. It does not have a mathematical basis; instead, it is an arbitrary ranking based on observed effects. The MMI value assigned to a specific site after an earthquake has a more meaningful measure of severity to the nonscientist than the magnitude because intensity refers to the effects actually experienced at a particular place.

The lower numbers of the intensity scale deal with the manner in which people feel the earthquake. The higher numbers of the scale are based on observed structural damage. Structural engineers contribute information for assigning intensity values of VIII or above. Table 2-61 shows the connection between computed magnitudes and related intensities of earthquake events. Table 2-62 provides an abbreviated description of each intensity level of the Modified Mercalli Intensity Scale.

Table 2-61: Earthquake Magnitude / Mercalli Intensity Comparison

[108] LCSN and Weston Observatory earthquake logs, being the most comprehensive for the Northeast utilize Nuttli or Coda-length magnitudes scale as the primary scale and Richter as the default scale.
[109] USGS's web page entitled *Magnitudes*

Richter Magnitude Scale	Typical Maximum Modified Mercalli Intensity
1.0 – 3.0	I
3.0 – 3.9	II - III
4.0 – 4.9	IV - V
5.0 – 5.9	VI - VII
6.0 – 6.9	VII - IX
7.0 or higher	VIII or higher

Table 2-62: Modified Mercalli Intensity Scale

Intensity Level	Description of Effects on People, Structures, or Natural Environment
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.

2.17.4 Primary and Secondary Impacts

Earthquakes can cause damage directly to buildings, infrastructure, and the landscape. Infrastructure systems that can be particularly affected are communication, water, and electricity. In addition, there is significant threat of injury and loss of life as a result of collapsing structures and falling debris.

Strong earthquakes in particular, often trigger secondary effects which have a high loss potential as well and are usually the prime factor for determining whether an earthquake is categorized as a catastrophe. Secondary effects can include landslides (in hilly or mountainous areas), amplification, seismic sea waves (tsunamis), surface rupture, subsidence, fires (from ruptured gas lines and downed utility lines), and liquefaction of soil.

2.17.5 Severity

Although other natural hazards account for greater annual loss in the United States, earthquakes pose the largest risk in terms of sudden loss of life and property. Risk factors that impact the severity and extent of damage include:

- Amount of seismic energy released: The greater the vibrational energy, the greater the chance for destruction.
- Duration of ground movement: This is one of the most important parameters of ground motion for causing damage.
- Depth of the focus, or hypocenter: The shallower the focus (the point of an earthquake's origin within the earth), usually the greater the potential for destructive seismic waves reaching the earth's surface. Even stronger magnitude events with a much greater focus depth typically produce only moderate movement at ground level.
- Distance from epicenter: The potential for damage tends to be greatest near the epicenter (the point on the ground directly above the focus), and decreases away from it.
- Geologic setting: A wide range of foundation materials exhibits a similarly wide range of responses to seismic vibrations. For example, in soft unconsolidated material, earthquake vibrations last longer and develop greater amplitudes, which produce more ground movement, than in areas underlain by hard bedrock. Likewise, areas having active faults are at greater risk.
- Population and building density: In general, risk increases as population and building density increase.
- Types of buildings: Wooden frame structures tend to respond to earthquakes better than do more rigid brick or masonry buildings. Taller buildings are more vulnerable than one- or two-story buildings when located on soft, unconsolidated sediments, but taller buildings tend to be the more stable when on a hard bedrock foundation.
- Time of day: Experience shows there are fewer casualties if an earthquake occurs in late evening or early morning because most people are at home and awake and thus in a good position to respond properly.

All these factors affect each other and add up to the severity of the earthquake.

2.17.6 Warning Time

The further the distance from an earthquake epicenter, the smaller the impact and the more warning time available. Unfortunately, it is unlikely that adequate warning time will be given. For very large, distant earthquakes there may be 60 seconds of warning time possible. This small warning time is particularly impactful in urban areas, where it takes more than 60 seconds to descend from a many-storied building. For a warning to be effective, it must arrive before the serious shock waves occur, which is rarely possible with current technology.

2.17.7 Previous Occurrences

The USGS National Earthquake Information Center maintains a national database of significant earthquake epicenters. USGS defines significant earthquakes as those that caused deaths, property damage, or geological effects, or that were experienced by populations in the epicentral area.[110] The Weston Observatory maintains the history of earthquakes in Northeast. Past earthquakes which occurred in and near Connecticut are presented in Figure 2-30. The list was compiled from several northeast earthquake catalog files. Several events include:

- The largest earthquake in Connecticut occurred in East Haddam on May 16, 1791. It was estimated to be a VII in intensity.[111] A description of the earthquake and the events that followed states: "It began at 8 o'clock p.m., with two very heavy shocks in quick succession. The first was the most powerful; the earth appeared to undergo very violent convulsions. The stone walls were thrown down, chimneys were untopped, doors, which were latched were thrown open, and a fissure in the ground of several rods in extent was afterwards discovered. Thirty lighter ones followed in a short time, and upwards of one hundred were counted in the course of the night."[112]
- The next moderate earthquake occurred in Hartford in April 1837. This was followed by three subsequent earthquake events in 1840 (a few miles southeast of Hartford), June 1858 (occurred at New Haven), and the June 1875 (which have an estimated intensity level of a V and was felt within a general 2,000 square mile area of Connecticut and Massachusetts).
- A noticeable earthquake occurred in Connecticut on March 11, 2008. It was a 2.0 magnitude with its epicenter three miles northwest of the center of Chester.
- A magnitude 5.0 earthquake struck at the Ontario-Quebec border region of Canada on June 23, 2010. This earthquake did not cause damage in Connecticut but was felt by residents in Hartford and New Haven Counties.

[110] United States Geological Survey, http://www.nationalatlas.gov/mld/quksigx.html (June 2013).
[111] Note: Seismic recorders were not in use until the early 1900's and routine reporting of earthquake activity was not implemented until the 1930's for the Northeast region, hence intensity levels for early earthquakes (prior to 1900's) were based on expert determinations based on damage and activity reports..
[112] Source: USGS, 2009, http://earthquake.usgs.gov/regional/states/connecticut/history.php.

- A magnitude 3.9 earthquake occurred 117 miles southeast of Bridgeport, Connecticut on the morning of November 30, 2010. The quake did not cause damage in Connecticut but was felt by residents along Long Island Sound.
- On June 3, 2011, a 1.7 magnitude earthquake occurred near East Hartford about 3 miles below ground. It was minimal, as many residents believed the shaking to be from nearby road construction.[113]
- A magnitude 5.8 earthquake occurred 38 miles from Richmond, Virginia on August 23, 2011. The quake was felt from Georgia to Maine and reportedly as far west as Chicago. Many residents of Connecticut experienced the swaying and shaking of buildings and furniture during the earthquake although widespread damage was constrained to an area from central Virginia to southern Maryland. According to Cornell University, the August 23 quake was the largest event to occur in the east central United States since instrumental recordings have been available to seismologists.
- On September 8, 2012, a 2.1 magnitude, 4 km deep earthquake occurred near Stamford. Dozens of residents reported feeling the ground move, but no injuries were reported.
- A magnitude 3.3 earthquake occurred about three miles away from Plainfield, 6.5 km below ground on January 12, 2015. Reports differ on the intensity of the earthquake, with MMI values ranging from II to V.

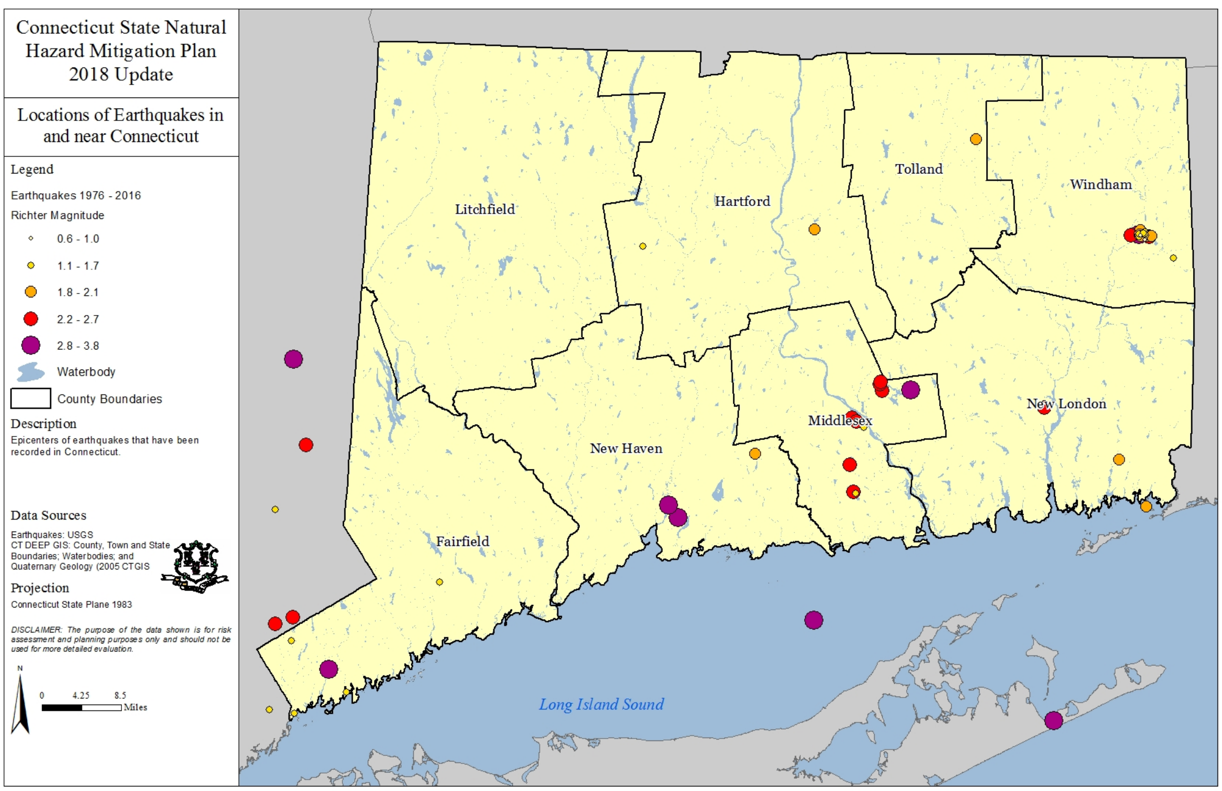


Figure 2-30: Earthquake epicenters near Connecticut (1976– 2016).

113 http://articles.courant.com/2011-06-03/community/hc-east-hartford-earthquake-0604-20110603_1_water-heater-gas-line-road-construction

FEMA Disaster Declarations

There are no new federally declared disasters related to earthquakes since the 2014 plan update.

2.17.8 Probability of Future Events

Earthquake events do occur in the state, though of much less intensity than elsewhere in the region or on the west coast. Additionally earthquake events are more likely to be felt as a result of an earthquake that occurs in the surrounding region rather than originating within Connecticut. Based on historical information, it is reasonable to assume that Connecticut has a medium-low probability of future earthquake events.

Probabilistic ground motion maps are typically used to assess the magnitude and frequency of seismic events. These maps measure the probability of exceeding a certain ground motion, expressed as percent peak ground acceleration (%PGA), over a specified period of years. The severity of earthquakes is site specific, and is influenced by proximity to the earthquake epicenter and soil type, among other factors. Average PGA, for the 100-year return period, has been used in the hazard ranking as the geographic extent parameter. The average PGA values for the state would result in no felt shaking or potential damage.

Connecticut may be categorized as having a low or moderate risk for an earthquake $\geq$ 3.5 occurring in the future and a moderate risk of an earthquake $\leq$ 3.0 occurring in the future. USGS currently ranks Connecticut as 43 out of 50 states for earthquake activity (based on geologic and historical data) and notes that no earthquake with a magnitude of $\geq$ 3.5 has occurred in Connecticut within at least the last 30 years.[114] As Kafka notes, it is impossible to predict when, where, and what magnitude would be for a future earthquake, especially in New England, due to this geographic area being located in an intraplate area of the United States.[115] However, future probabilities of potential events can be developed given geologic information and historical information on past events for a particular area.

The USGS earthquake hazard map in Figure 2-31 indicates a low probability of an earthquake occurring within Connecticut that would cause substantial damage within a fifty-year time period. The hazard map shows, "the distribution of earthquake shaking levels that have a certain probability of occurring in the United States."[116] For the northeastern area of the United States, USGS suggests the use of either a 2% or 5%/50 year hazard map to provide higher, more realistic probabilities for planning purposes. Depending upon the specific geographic area of Connecticut in question, the earthquake PGA (certain amount of mapped shaking distribution) that has a 2% chance of being exceeded in 50 years has a value between 7 – 15 % of %g (percent of gravity). Kafka notes

[114] Source: USGS
[115] Source: Kafka, Alan, L. Why Does the Earth Quake in New England.
[116] Sources: USGS and Weston Observatory

that it requires more than 100% of the force of gravity to throw objects into the air. This is a relatively low probability since a 2% percent chance of exceedance means there is a 98% chance that the shaking will not exceed the indicated value of %g.

In addition, a series of probability maps were created using the USGS's interactive web-based mapping tools for East Haddam, Portland, and Haddam, and the New Haven to Greenwich area of the state. The maps were created to help analyze the probability of a magnitude ≥ 5.0 (shown as a magnitude ≥ 4.75), and a magnitude ≥ 6.0 earthquake occurring within 50, 100, 250 and 350 year time period. Since the probabilities were the same for Portland, Haddam and East Haddam, only one of these communities' map series (Haddam) along with the map series for Stamford are located in Appendix 2. Due to the relative historic infrequency of an earthquake of the selected magnitudes occurring within the state, USGS encourages the use of a longer time period to provide a truer projection of probabilities.

Table 2-63 and Table 2-64 present the projected percentages of such earthquake magnitudes occurring within Connecticut. The chance (percent) of a minimum 5.0 earthquake occurring within a 350-year time period (maximum mapped for this plan) is relatively moderate for the New Haven-Greenwich area of Connecticut. This may be a result of the geographic proximity of this area to a Mesozoic rift basin.

Table 2-63: Probability of an earthquake of specific magnitude occurring in the Haddam-East Haddam-Portland area of Connecticut

Timeframe (years)	Equal or Greater Than a 5.0 Quake	Equal or Greater Than a 6.0
50	3.00%	0.30%
100	8.00%	0.50%
250	20.00%	1.50%
350	20.00%	2.00%

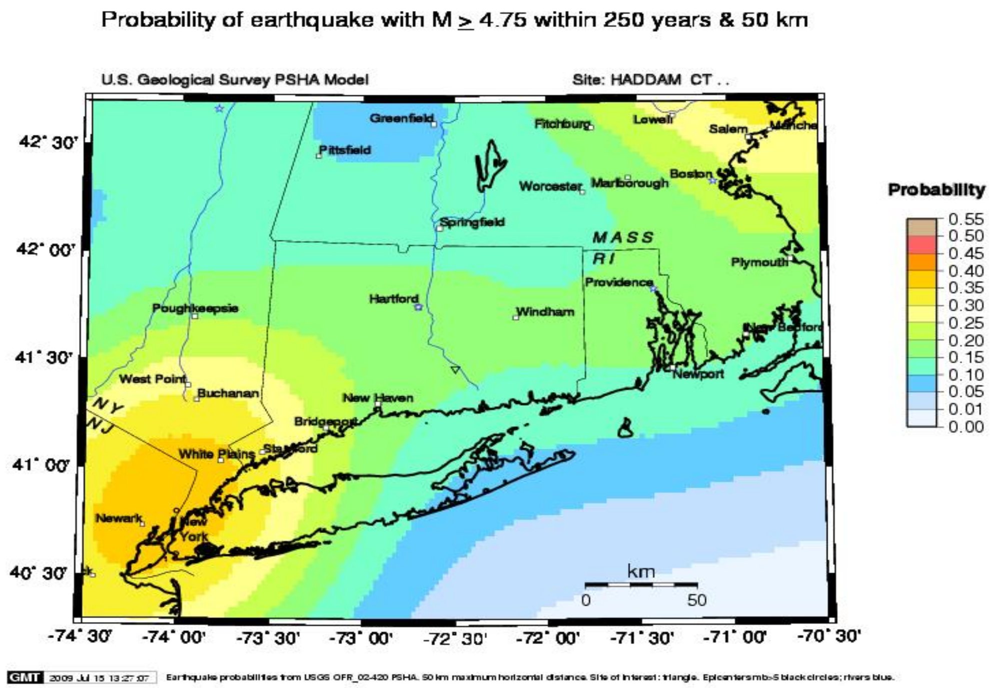


Figure 2-31: Example of Probability Maps Developed for Haddam-East Haddam-Portland and New Haven-Greenwich Areas of Connecticut

Table 2-64: Probability of an Earthquake of Specific Magnitude Occurring in the New Haven-Greenwich Area of Connecticut

Timeframe (years)	Greenwich		Stamford		Bridgeport		New Haven	
	≥ 5.0	≥ 6.0	≥ 5.0	≥ 6.0	≥ 5.0	≥ 6.0	≥ 5.0	≥ 6.0
50	7.50%	0.70%	8.00%	0.70%	5.00%	0.50%	4.00%	0.30%
100	18.00%	1.50%	12.00%	1.00%	10.00%	1.00%	8.00%	0.50%
250	30.00%	3.50%	30.00%	3.50%	20.00%	2.50%	15.00%	1.50%
350	40.00%	5.00%	40.00%	4.50%	30.00%	3.00%	20.00%	2.50%

Based on the historic record of earthquakes and the information collected for this plan, one can make the following conclusion with regards to risk of a future earthquake event occurring in Connecticut:

1. There are geographic areas within the state that have had seismic activity in the past;

2. Although the risk is relatively very low, the long-term probability does exist of an earthquake with a magnitude ≥ 5.0 to occur within the state; and

3. Although the probability of an earthquake with a magnitude ≥ 5.0 is extremely small (under 1%), based on Connecticut's historical record of earthquake events, it is

likely that one or more earthquake(s) with a magnitude $\leq$ 3.0 will occur within the next hundred years.

2.17.9 Climate Change Impacts

Evidence that climate change has an impact on the occurrence or magnitude of earthquakes is currently inconclusive. Some recent research indicates that geologic events such as earthquakes are sensitive to changes on the earth's surface, such as shifts in water or atmospheric pressure. Other scientists have expressed doubts that earthquakes are significantly impacted by climate change.[117]

2.18 Earthquake Vulnerability Assessment

Earthquakes are low probability, high-consequence events. Although earthquakes may occur infrequently they can have devastating impacts. Ground shaking can lead to the collapse of buildings and bridges; disrupt gas, life lines, electric, and phone service. Deaths, injuries, and extensive property damage are possible vulnerabilities from this hazard. Some secondary hazards caused by earthquakes may include fire, hazardous material release, landslides, flash flooding, avalanches, tsunamis, and dam failure. Moderate and even very large earthquakes are inevitable, although very infrequent, in areas of normally low seismic activity. Consequently, buildings in these regions are seldom designed to deal with an earthquake threat; therefore, they are extremely vulnerable.

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

An earthquake risk assessment is difficult because it is challenging to monetize the potential damages accurately. FEMA has developed a software suite, Hazards US (Hazus), for estimating potential losses to natural disasters. The Hazus® earthquake model was utilized to estimate damages and losses to buildings, lifelines, and essential facilities from deterministic (scenario-based) and probabilistic earthquakes. The model which was first developed and released as HAZUS®99 and has continually been updated by FEMA since its release, leverages many of the methodologies for estimating damage and loss from the

[117] Pearce, Fred. 2012. Yale Environment 360. *Could a Changing Climate Set Off Volcanoes and Quakes?* https://e360.yale.edu/features/could_a_changing_climate_set_off_volcanoes_and_quakes

devastating effects of earthquakes. The update to this section uses 2010 census-based inventory data that comes standard and packaged with the software by state.

Hazus was utilized to perform a variety of earthquake scenarios for the current Plan Update; to include probabilistic scenarios for East Haddam, Haddam, Portland, and Stamford. Noting the unpredictability of earthquakes, these scenarios are in accordance with the recommended scenarios of the State of CT Geologic Survey and offer perspective of earthquake scenarios that the state could potentially experience. The probabilistic scenario is a multi-frequency annual chance scenario that takes into account a range of magnitudes across the entire state and no single epicenter is defined. In contrast, the various scenarios named by specific cities, demonstrate a specific shaking-scenario at a specific epicenter.

The two geographic areas most vulnerable to potential earthquakes in Connecticut are New Haven-Greenwich and Hartford-East Haddam-Haddam-Portland. Most at risk are people who work or live in unreinforced masonry buildings built on filled land or unstable soil.[118] Other population groups who may be more vulnerable to the impacts from a potential earthquake with a magnitude > 5.0 in both geographic areas include the elderly, the very young (under 18 years of age), people with various special needs.

For this plan update, Hazus simulations were re-run with 2010 inventory updates for the following earthquake scenarios:

- Magnitude 5.7, epicenter located in Portland (largest historic event, information within Hazus database);
- Magnitude 5.7, epicenter located in Haddam (largest historic event, information within Hazus database);
- Magnitude 6.4, epicenter located in East Haddam (largest historic event, information within Hazus database); and
- Magnitude 5.7, epicenter located in Stamford (magnitude scenario based on probabilities calculated by USGS in their probability maps).

The magnitudes chosen for these simulations and this plan are the maximum plausible magnitude for a potential earthquake in the scenario areas. The following should be noted for the review and use of these scenarios:

No historic earthquake of a magnitude 5.0 or greater has been recorded for Fairfield County, however USGS potential probabilities for such an event are possible when calculated for a long time period (250 to 350 years); and the last large earthquake with a magnitude of 6.0 occurred around the Portland-Haddam-East Haddam area over 200 years ago. Seismographs were not in use at that time however, an expert determination was made based on damage reports and geographic extent to which the quaking was felt.

[118] Source: The Northeast States Emergency Consortium website, www.nesc.org/hazards/earthquakes.cfm.

The results for each Hazus earthquake simulation are located in Appendix 2. Each Hazus simulation that was run included the entire state of Connecticut for its analysis region. Therefore, it should be noted that the damage and injury estimations are based on state-wide building and infrastructure inventories and Census 2010 population per census tract. These Hazus scenarios were run for planning purposes of this plan to highlight potential areas that may warrant further analysis either at the state, regional or local level. It is very difficult to predict what the actual impacts would be to the State of Connecticut from these earthquake scenarios. The range of potential impacts for these scenarios is wide and extends from minor impact to the maximum potential impacts as presented as a result of the Hazus analyses.

Table 2-65 presents the total estimated losses that may result from the earthquake scenarios created for this plan, as estimated by FEMA's Hazus software. Though the projected economic impacts resulting from these simulations may appear low, the results do indicate that attention does need to be given to potential economic impacts from a magnitude ≥ 5.7, since the earthquake epicenters would be located near highly urbanized areas of the state. Thus economic losses should be anticipated from the physical impacts of an earthquake ≥ 5.7.

2.18.1 Assessment of State Vulnerability and Potential Losses

Table 2-65 shows the estimated total losses by census tract for all four earthquake scenarios: East Haddam, Haddam, Portland, and Stamford. The East Haddam scenario, below shows the highest estimated losses (between $370 million and $900 million) occurring in the towns of East Haddam, East Hampton, Middletown, and Colchester. The Haddam scenario, shows Haddam, East Haddam, Middlesex, East Hampton and Middletown with the highest estimated losses (between $180 million and $590 million). Figure 2-35 depicting the Portland scenario, shows the towns of Middletown and Glastonbury with the highest estimated losses (between $360 million and $603 million). Figure 2-34 depicting the Stamford scenario, shows the highest estimated losses (between $270 million and $710 million) occurring in the towns of Greenwich, Stamford, New Canaan, and Fairfield.

Table 2-65: Hazus Estimated Direct Losses of Earthquake Scenario Events (shown in thousands of dollars and 2010 Census)

Epicenter Location	Estimated Total Capital Losses	Estimated Total Income Losses	Estimated Total Losses
Stamford	$26,034,390,000	$4,635,220,000	$374,382,622,244
Haddam	$13,714,610,000	$2,667,110,000	$175,758,678,251
Portland	$21,796,420,000	$5,034,860,000	$610,757,561,304
East Haddam	$31,551,170,000	$7,875,450,000	$479,293,444,345

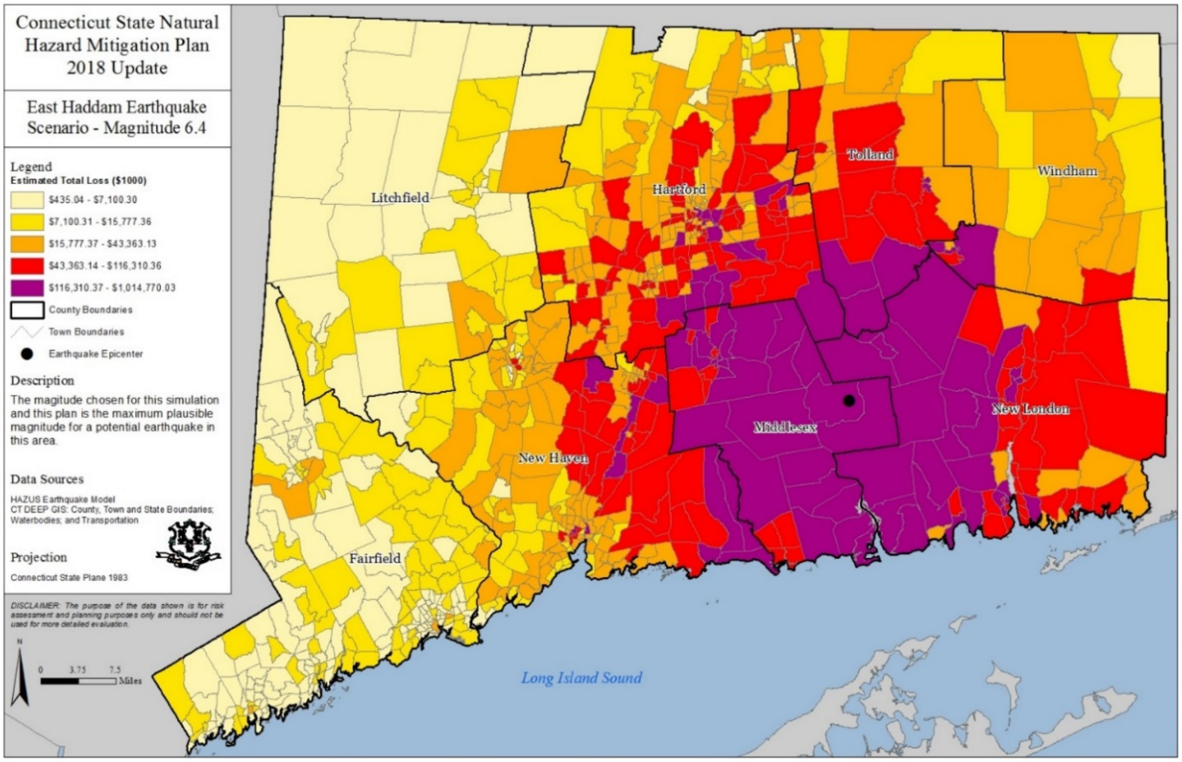


Figure 2-32: East Haddam Earthquake Scenario Estimated Total Losses

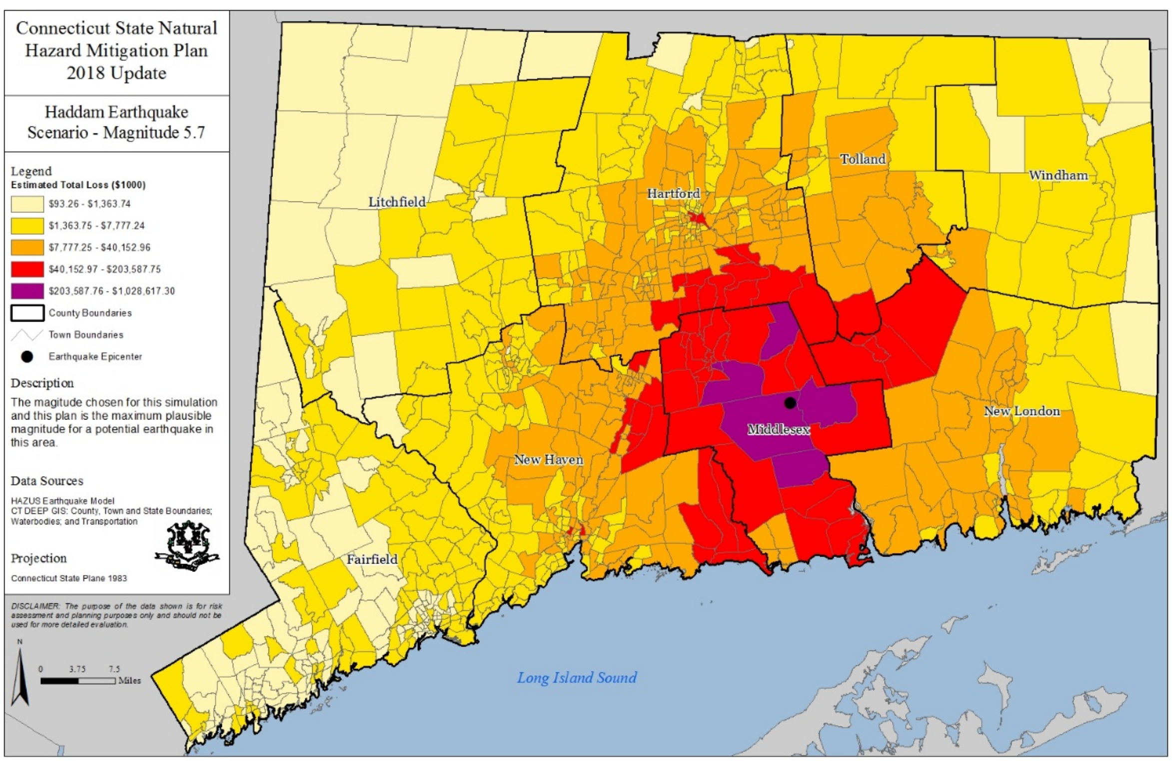


Figure 2-33: Haddam Earthquake Scenario Estimated Total Losses

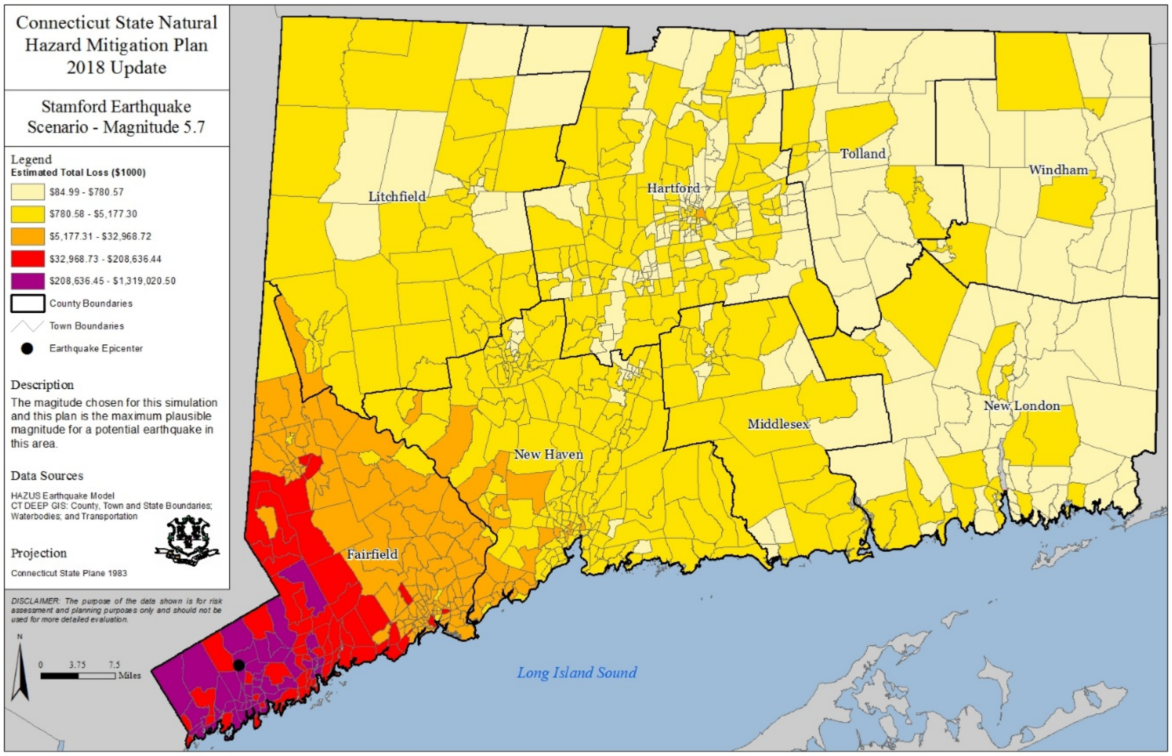


Figure 2-34: Stamford Earthquake Scenario Estimated Total Losses

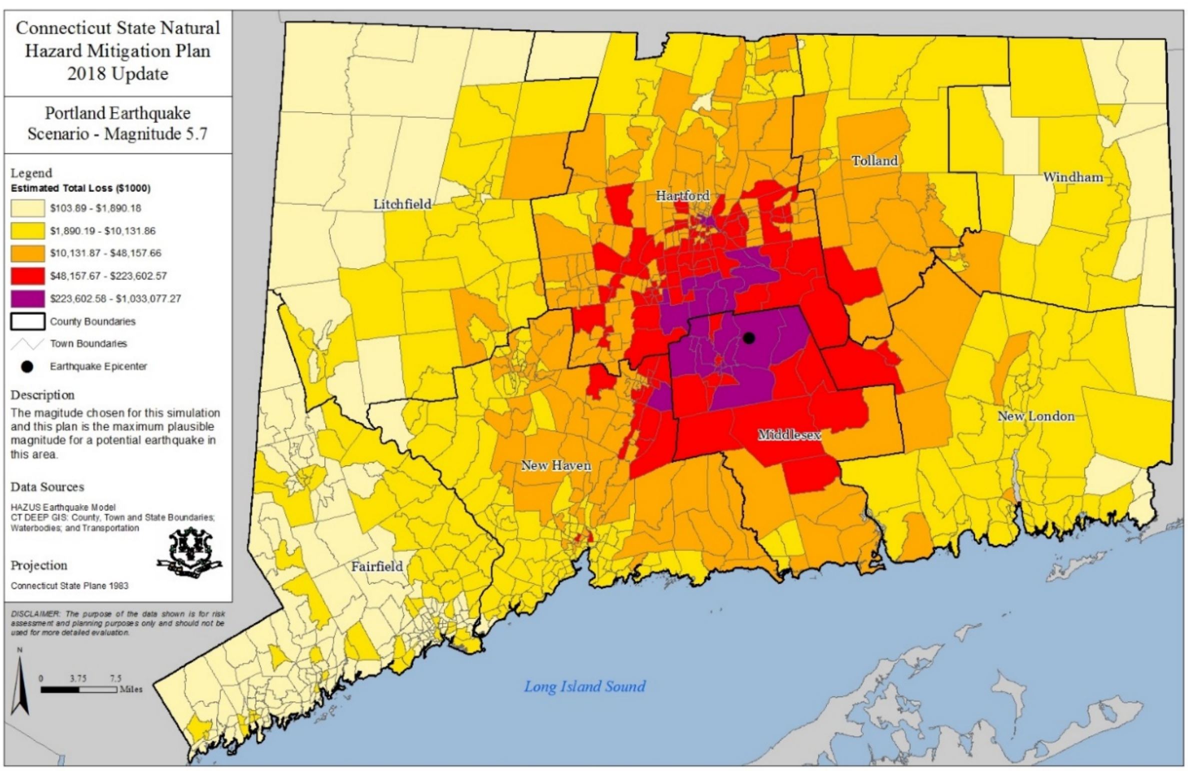


Figure 2-35: Portland Earthquake Scenario Estimated Total Losses

Table 2-66 shows the projected estimated building damage from the four earthquake scenarios. The estimated numbers in this table are based on the total building inventory for the state. A significant percentage of buildings damaged (88-96%) to any degree are estimated to be either one-family homes or other residential buildings (e.g., apartment buildings, 2- or 3-family homes, etc.). Though residential structures comprise the majority of building damages in the simulations, other building occupancy types will also experience damage. Other building occupancy types include agriculture, commercial, education, government, industrial, and religion. Though smaller in total number of buildings, these other occupancy types are vital to communities and impacts to these structures will be felt by a wide group of people within the immediate location and beyond.

Table 2-66. Total number of buildings damaged by expected degree of damage.

Expected Damage	East Haddam (magnitude 6.40)	Haddam (magnitude 5.70)	Portland (magnitude 5.70)	Stamford (magnitude 5.7)
None	870,681	1,044,983	989,944	1,070,951
Slight	206,112	115,797	139,903	83,723
Moderate	96,265	44,136	62,530	41,029
Extensive	31,080	10,465	18,371	13,628
Complete	14,831	3,588	8,222	9,638

People requiring short-term shelter is estimated to be between 2,000+ to over 11,000 people, depending on the specific scenario. In addition, the estimated the number of displaced households ranged from almost 4,000 to a little over 11,000 in total. The estimates by Hazus may be on the maximum end of an impact range, but do indicate that the potential does exist for individual assistance needs such as sufficient temporary shelter accommodations, and household relocation assistance (temporary or possibly permanent relocation).

For the simulations, Hazus also calculated physical injuries to people by number per injury level. The injury levels are as follows:

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

Injury estimates were developed for three times of day (i.e., 2:00 a.m., 2:00 p.m., and 5:00 p.m.) representing various times of the day during which different community sectors are at their peak occupancy loads. The community sectors considered for the analysis were: commuting; educational; hotels; industrial; other residential; and single family. The vast majority of injuries projected for all scenarios (92-96%) fall within the Severity Level 1 or 2 categories. An analysis of potential fire ignitions resulting from each scenario is shown in Table 2-67. The data from this analysis was not updated in the 2019 plan update, due to the disabling of Fire Following Earthquake in Hazus Version 4.0.

Table 2-67: Potential Fire Impact from Each Earthquake Scenario*

Epicenter Scenario	Number of Ignitions	Population Exposed	Value of Exposed Structures (thousands)
East Haddam	43	552	$58,693
Haddam	71	619	$62,797
Portland	25	351	$38,240
Stamford	15	435	$50,482

*Fire Following Earthquake was disabled in Hazus Version 4.0 (GETTING STARTED WITH HAZUS V4.0, Page 16)

For the Stamford scenario, all projected fire ignitions were located in Fairfield County. For the other three scenarios, the majority, were estimated to be within communities in Hartford, Middlesex, New Haven, and New London counties. The projected estimates for both injuries and fire starts directly related to a magnitude $\geq$ 5.7 earthquake indicate an increased demand on state and local medical and emergency services (including police and fire) for injuries ranging from non-life-threatening to loss of life.

2.18.2 Assessment of Local Vulnerability and Potential Losses

Connecticut's geology, combined with the fact that earthquake events are more likely to be felt as a result of an earthquake that occurs in the surrounding region rather than originating within Connecticut, results in a relatively small difference in local impacts across the state. The New Haven-Greenwich and Hartford-East Haddam-Haddam-Portland areas are the most vulnerable to potential earthquakes in Connecticut. Additionally, Hartford and New Haven are large population centers, with a higher concentration of low income and underserved communities, making these areas particularly vulnerable to the impacts of an earthquake.

While Connecticut is predicted to experience a low population growth rate between 2016 and 2040, many smaller communities may begin to experience increased development pressures, especially when larger communities reach their build-out limits. This will increase the importance of hazard mitigation planning and natural resource management on a local level to help mitigate and/or reduce potential losses such development activities can create. In particular, strengthening local building codes will help mitigation damage from earthquakes.

2.18.3 Changes in Development

Connecticut is expected to have a 2.2% population growth rate between 2016 and 2040. This low rate reflects the state's relatively stable development projections. As of 2016, approximately 65.7% of the building permits statewide were in Fairfield and Hartford Counties, and both of these counties accounted for nearly half of all the housing units in the State. If recent trends in development continue, these two Counties will continually increase their vulnerability to earthquakes. According to the Connecticut State Data Center, New Haven County is expected to see the most growth, exceeding 900,000 residents by 2025. As the baby boomer generation ages, a generational shift is projected to occur in Connecticut as the Millennials (individuals born 1981-2000) remain a nearly stable population in Connecticut while the population born after 2000 is projected to continue to rise from 637,464 in 2015 to a projected 1,817,658 by 2040. While Connecticut as a whole is projected to see stable growth in the near future, areas where higher population growth is expected should prepare to develop in ways that mitigate the earthquake vulnerability of its residents.

2.18.4 Hazard Ranking

Quantitative risk assessment, to the degree possible, has been completed for earthquake using the methodology described in the Hazard Analysis and Ranking methodology Section 2.6 of this chapter. Scores for each jurisdiction were calculated based on population, building permits, average score from local plan rankings, average hazard concern, and measures of historical impact including injuries and deaths, property damage, and the number of reported events. The number of impacted critical facilities was also incorporated, and ranked based on the number of facilities impacted in relation to the number of total critical facilities in Connecticut. As shown in Table 2-68, the composite earthquake rank shows Fairfield, Hartford, and New Haven Counties as medium risk; Litchfield, Middlesex, New London, and Tolland Counties as medium-low risk; and Windham County as low risk.

Table 2-68 Hazard Ranking by County for Earthquake

County	Hazard Concern Rank	Local Plans Hazard Rank	Geographic Extent Rank	Population Density Rank	Building Permits Rank	Facility Intersect Rank	Ann. Events Rank	Ann. Losses Rank	Injury & Death Rank	Composite Ranks
Fairfield	Medium-Low	Medium-Low	Medium-Low	High	High	High	Medium-High	Low	Low	**Medium**
Hartford	Low	Medium-Low	Medium-Low	High	High	High	Medium-High	Low	Low	**Medium**
Litchfield	Medium-Low	Medium-Low	Medium-Low	Low	Low	High	Medium-High	Low	Low	**Medium-Low**
Middlesex	Low	Medium-Low	Low	Medium-Low	Medium-Low	High	Medium-High	Low	Low	**Medium-Low**
New Haven	Medium-Low	Medium-Low	Medium-Low	High	Medium	High	Medium-High	Low	Low	**Medium**
New London	Low	Medium-Low	Low	Medium-Low	Medium-Low	High	Medium-High	Low	Low	**Medium-Low**
Tolland	Medium-Low	Medium-Low	Low	Medium-Low	Medium-Low	High	Medium-High	Low	Low	**Medium-Low**

County	Hazard Concern Rank	Local Plans Hazard Rank	Geographic Extent Rank	Population Density Rank	Building Permits Rank	Facility Intersect Rank	Ann. Events Rank	Ann. Losses Rank	Injury & Death Rank	Composite Ranks
Windham	Low	Medium-Low	Low	Medium-Low	Low	High	Medium-High	Low	Low	**Low**

2.19 Drought Hazard Profile

2019 Plan Update Changes

- The hazard profile has been significantly enhanced to include a detailed hazard description, location, extent, previous occurrences, probability of future occurrence, and potential change in climate and its impacts on the drought hazard is discussed
- New and updated figures from federal and state agencies are incorporated
- U.S. 2010 Census data was incorporated, where appropriate
- Previous occurrences were updated with events that occurred between 2013 and 2017
- Incorporation of information from the 2017 Connecticut State Water Plan

2.19.1 Hazard Description

Droughts can vary widely in duration, severity, and local impact. They may have widespread social and economic significance that require the response of numerous parties. Although associated with deficient precipitation, droughts are measured in a number of ways.

The 2003 Connecticut Drought Preparedness and Response Plan identifies seven criteria for assessing drought:

- Precipitation
- Groundwater
- Streamflow
- Reservoir levels
- Palmer Drought Severity Index (PDSI)
- Crop Moisture
- Fire Danger

Other entities, such as water utilities, may measure drought conditions by these or other criteria, such as the duration in which their well pumps must operate in a day.

Four categories of drought are listed in the drought literature. The first three types of drought are physical in nature, while the fourth type of drought is measured by societal impact[119]:

1. Meteorological Drought – Is a measure of departure of precipitation from the normal. It is relatively regional in nature and affects a specific geographic area due to large variability of precipitation and climatic differences between geographic locations.
2. Hydrological Drought – Occurs when surface and subsurface water supplies are below normal.
3. Agricultural Drought – Refers to a situation where the amount of moisture in the soil no longer meets the needs of a particular crop grown in an area. The key to vulnerability to this type of drought is two-fold—severity and timing. This type of drought tends to be more serious if it occurs when plants are forming or filling their seed (mid-summer in Connecticut).[120]
4. Socioeconomic Drought – The situation that occurs when physical water shortages begin to affect people.

Although all droughts originate with a deficiency of precipitation, hydrologists are more concerned with how this deficiency plays out through the hydrologic system. Hydrological droughts are usually out of phase with the occurrence of meteorological and agricultural droughts. It takes longer for precipitation deficiencies to show up in components of the hydrological system such as soil moisture, streamflow, and ground water and reservoir levels. As a result, these impacts are out of phase with impacts in other economic sectors. For example, a precipitation deficiency may result in a rapid depletion of soil moisture that is almost immediately discernible to agriculturalists, but the impact of this deficiency on reservoir levels may not affect hydroelectric power production, drinking water supply availability, or recreational uses for many months.

Human actions can increase the risk of water shortage without any change in meteorological conditions. For instance, as the degree of imperviousness and water run-off is increased during land development, recharge of groundwater is reduced. This not only reduces the availability of groundwater to wells, it also reduces dry weather flows in streams.[121] Although weather condition is a primary contributor to hydrological drought, other factors such as changes in land use, land degradation, and the construction of dams all affect the hydrological characteristics of a water basin.

[119] Sources of information on the four drought categories include the National Weather Service Forecast Office, National Drought Mitigation Center, and the Connecticut State Climate Center.
[120] Miller, Dr. David. Drought, Forests, and Agriculture in Connecticut, 2002. The University of Connecticut.
[121] The National Drought Mitigation Center website, *Understanding and Defining Drought*.

2.19.2 Location

Connecticut's general climate has four main characteristics relevant to drought:[122]

- Equitable distribution of precipitation among the four seasons;
- Large ranges of temperature both daily and annually;
- Great differences in the same season or month of different years, and
- Considerable diversity of the weather over short periods of time.

From north to south of the state, the mean annual temperature difference is approximately 6 degrees Fahrenheit. The greatest temperature contrast occurs during the winter season. Precipitation is generally evenly distributed throughout all parts of the state, with Connecticut averaging 120 days of rainfall annually.

Three types of air affect the state, with the first two types influencing the state's climate the most:

- Cold, dry air coming down from sub-arctic North America;
- Warm, moist air flowing up overland from the Gulf of Mexico and sub-tropical waters of the Atlantic; and
- Cool damp air moving in from the Atlantic.

Climate divisions are regions within a state that are climatically homogenous. The National Oceanic and Atmospheric Administration (NOAA) has divided the United States into 359 climate divisions. The boundaries of these divisions typically coincide with the county boundaries, except in the western United States, where they are based largely on drainage basins. According to NOAA, Connecticut is made up of three climate divisions: Northwest (01), Central (02), and Coastal (03).[123] Figure 2-36[124] shows the climate divisions throughout the United States and Figure 2-37 shows the climate divisions of Connecticut.

As seen in Figure 2-37, the State is divided into three climate divisions for purposes of computing the Palmer Drought Severity Index:

- Northwest Climate Division – Consisting of Litchfield County;
- Central Climate Division – Consisting of parts of Tolland, Windham, Hartford counties and portions of Fairfield, New Haven Middlesex, and New London counties; and
- Coastal Climate Division – Consisting of the coastal portions of Fairfield, New Haven, Middlesex, and New London counties.

[122] Narration from Weather America 2001, and presented on Connecticut's State Climate Center website.
[123] http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/regional_monitoring/CLIM_DIVS/states_counties_climate-divisions.shtml
[124] https://www.ncdc.noaa.gov/monitoring-references/maps/us-climate-divisions.php

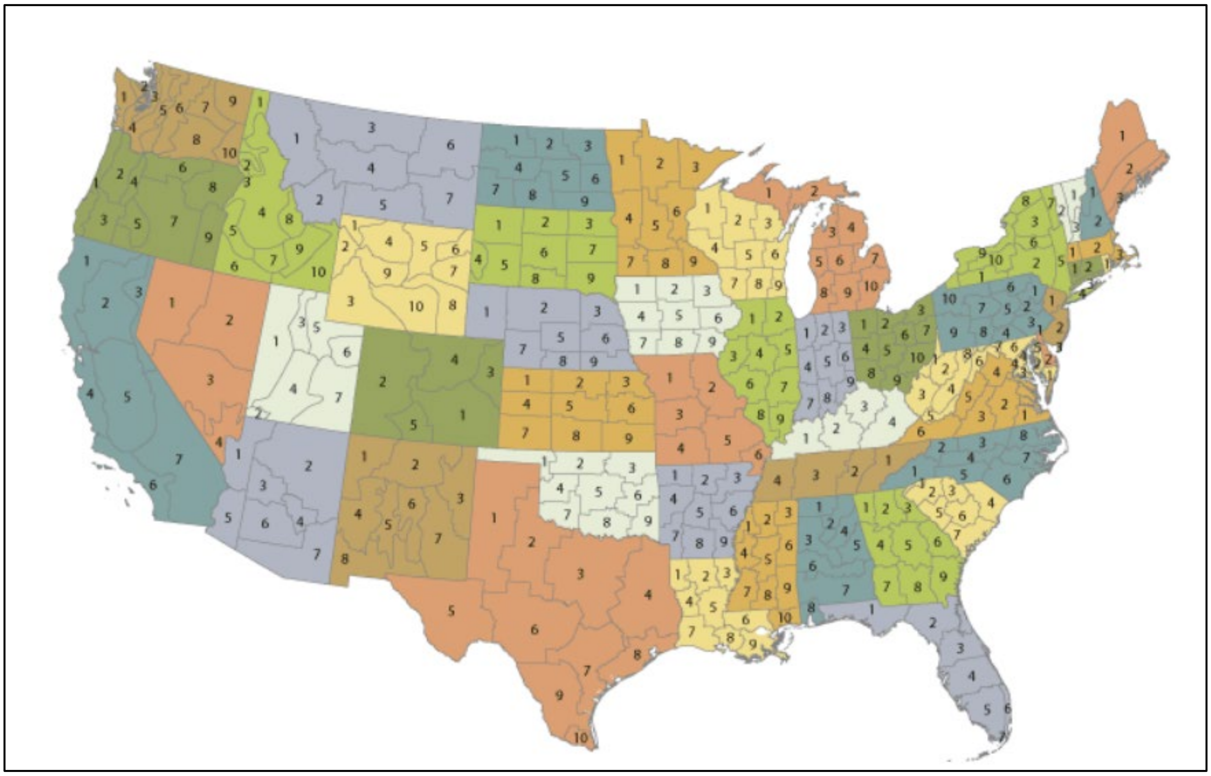


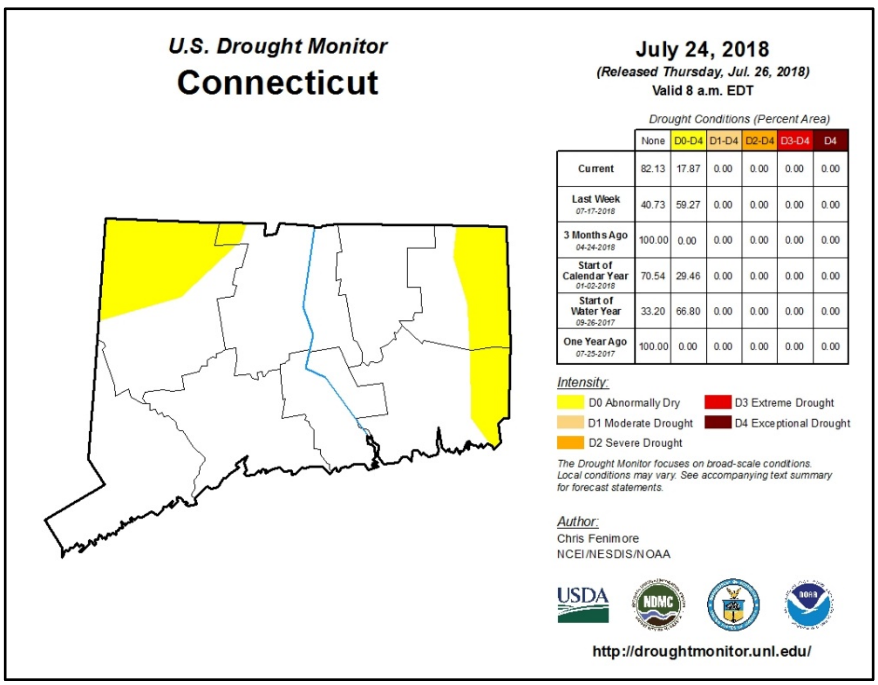
Figure 2-37 Climate Divisions of the United States

Figure 2-36: Climate Divisions of Connecticut

2.19.3 Extent

The extent (i.e., magnitude or severity) of drought can depend on the duration, intensity, geographic extent, and the regional water supply demands made by human activities and vegetation. The intensity of the impact from drought could be minor to total damage in a localized area or regional damage affecting human health and the economy. Generally, impacts of drought evolve gradually, and regions of maximum intensity change with time. The severity of a drought is determined by areal extent as well as intensity and duration. The frequency of a drought is determined by analyzing the intensity for a given duration, which allows determination of the probability or percent chance of a more severe event occurring in a given mean return period.

The U.S. Drought Monitor is a related product produced in partnership between the National Drought Mitigation Center, the United States Department of Agriculture, and the National Oceanic and Atmospheric Administration. As shown in Figure 2-38, as of July 2018 the northwestern and eastern portions of the state were designated abnormally dry by the US Drought Monitor.



	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	82.13	17.87	0.00	0.00	0.00	0.00
Last Week 07-17-2018	40.73	59.27	0.00	0.00	0.00	0.00
3 Months Ago 04-24-2018	100.00	0.00	0.00	0.00	0.00	0.00
Start of Calendar Year 01-02-2018	70.54	29.46	0.00	0.00	0.00	0.00
Start of Water Year 09-26-2017	33.20	66.80	0.00	0.00	0.00	0.00
One Year Ago 07-25-2017	100.00	0.00	0.00	0.00	0.00	0.00

Figure 2-38 U.S. Drought Monitor for Connecticut as of July 24th, 2018 obtained from the National Drought Mitigation Center

2.19.4 Primary and Secondary Impacts

On July 1, 2014, Public Act 14-163, "An Act Concerning the Responsibilities of the Water Planning Council," directed the state's Water Planning Council (WPC) to develop a State Water Plan. The WPC is comprised of representatives of the four state entities with oversight or regulatory responsibility for water management: The Department of Energy and Environmental Protection (DEEP), the Department of Public Health (DPH), the Office of Policy and Management (OPM), and the Public Utilities Regulatory Authority (PURA). While Connecticut has historically enjoyed plentiful, clean water, unique factors in the state have combined to emphasize the importance of the Public Act and its recommended evaluation of water management strategies in the future:

- The recent drought in 2016 raised awareness that even in Connecticut, river basins can be depleted.
- Connecticut is the only state in the U.S. that prohibits wastewater discharges to drinking water sources, preserving the highest quality water for drinking (Class A). This protects human health and helps keep treatment costs low, but the policy could, however, limit future drinking water sources.
- New state streamflow requirements downstream of water supply reservoirs are highlighting the ecological need for water, which must be balanced with other water needs.
- Future climate trends in the northeast are uncertain, and planning for adaptation is essential.[125]

Droughts may have devastating effects on communities and the surrounding environment. The amount of devastation depends on the strength and duration of a drought event. One impact of drought is its impact on water supply. When drought conditions persist with little to no relief, water restrictions may be put into place by local or state governments. These restrictions can include watering of lawns, washing cars, etc. In exceptional drought conditions, watering of lawns and crops may not be an option. If crops are not able to receive water, farmland will dry out and crops will die. This can lead to crop shortages, which, in turn, increases the price of food (North Carolina State University 2013).

Droughts also have the potential to lead to water pollution due to the lack of rain water to dilute any chemicals in water sources. Contaminated water supplies may be harmful to plans and animals. If water is not getting into the soils, the ground will dry up and become unstable. Unstable soils increase the risk of erosion and loss of top soil (North Carolina State University 2013).

The impacts on public health from drought can be severe which includes increase in heat-related illnesses, waterborne illnesses, recreational risks, limited food availability, and reduced living conditions. Those individuals who rely on water, such as farmers, may experience financial-related stress. Decreased amounts and quality of water during drought

[125] http://www.ct.gov/water/cwp/view.asp?a=4801&Q=586878&PM=1

events have the potential to reduce the availability of electricity (hydropower, coal-burning and nuclear) (North Carolina State University 2013).

2.19.5 Severity

In 2010 the WPC tasked the WPC Advisor Group to update the Drought Plan. Significant changes in the updated draft Plan include a provision that drought declarations can apply to any geographic area; drought stage names were revised to clarify their severity and to avoid confusion with similarly-named stages in the Individual Water Supply Plans; and encouragement for the use of professional judgment concerning recommendations for drought declarations and related response activities. Enforceable actions are not identified. The draft Drought Plan identifies the following five stages of increasingly dry conditions:

- Heightened Awareness
- Below Normal Conditions
- Moderate Drought
- Severe Drought
- Extreme Drought[126]
- These proposed classifications are intended to align more closely with U.S. Drought Monitor terminology and limit confusion with any individual utility drought statuses.

However, some water utilities still utilize the older five-stage method that pre-dates the 2003 *Connecticut Drought Preparedness and Response Plan:*

- "Alert" which did not include a reduction goal
- "Advisory" with a voluntary 10% reduction goal
- "Emergency Phase I" with a voluntary 15% reduction goal
- "Emergency Phase II" with a voluntary 20% reduction goal
- "Emergency Phase III" with water rationing

2.19.6 Warning Time

As per the National Drought Mitigation Center (NDMC), droughts are climatic patterns that occur over long periods of time. Only generalized warning can take place due to the numerous variables that scientists have not pieced together well enough to make accurate and precise predictions.

The NDMC states that empirical studies conducted over the past century have shown that meteorological drought is never the result of a single cause. It is the result of many causes, often synergistic in nature; these include global weather patterns that produce persistent,

[126] Connecticut State Water Plan

upper-level high-pressure systems along the West Coast with warm, dry air resulting in less precipitation.

The National Weather Service Climate Prediction Center can provide seasonal outlooks for droughts that last for 3 month increments. To view the current seasonal outlook, visit http://www.cpc.ncep.noaa.gov/products/expert_assessment/sdo_summary.php. Predicting drought depends on the ability to forecast precipitation and temperature. Anomalies of precipitation and temperature may last from several months to several decades. How long they last depends on interactions between the atmosphere and the oceans, soil moisture and land surface processes, topography, internal dynamics, and the accumulated influence of weather systems on the global scale.

The Interagency Drought Advisory Workgroup, comprised of the Commissioners of DPH and the Department of Energy and Environmental Protection (DEEP), and the Chairman of the Public Utility Regulatory Authority (PURA), monitors and analyzes water-related data to ensure that Connecticut's water supplies remain stable.[127] The Workgroup has drought benchmarks that include: precipitation, ground water, streamflow, reservoirs, Palmer Drought Severity Index, Crop Moisture Index, and fire danger.[128]

2.19.7 Previous Occurrences and Losses

Considering just the Palmer Drought Severity Index (PDSI), severe droughts have occurred periodically in Connecticut, most recently during 1929-1931, 1957, 1964-1966, 2002, 2007-2008, 2012, 2013, and 2015-2017.129 While the agricultural drought of 1957 was especially disastrous to the State's agricultural interests it was also a severe meteorological drought for small reservoirs in the State. Other meteorological droughts of June 1929 through March 1931 and the mid-1960s were also very serious. Connecticut experienced its drought of record during the 1960s with rainfall deficits reaching their highest levels in the spring of 1965. This drought severely limited water resources throughout the state.

A meteorological drought was declared in 2012 as the result of precipitation that had been approximately one half of normal from January 2012 through April 2012. The main impact of the drought was periods of very high fire danger. In addition, small pond levels were reduced. While soil moisture was well below normal, this drought occurred prior to the beginning of the growing season. Thus, no agricultural impacts were realized.

The region became free of severe drought for the first time since late June 2016. Moderate drought eased in Maine, Massachusetts, New York, most of New Hampshire and Vermont, and portions of Connecticut, Pennsylvania, and Maryland. According to an April 21 press release, all of Connecticut Water's reservoirs throughout the state were at 100 percent of capacity, so the water supply advisory was lifted. Aquarion's Bridgeport and Greenwich

[127] Drought Advisory Press Release 6_24_16
[128] Drought Preparedness Response Plan 2003

[129] http://www.nrcc.cornell.edu/regional/drought/drought.html

(Connecticut) reservoirs were at near to above-average capacity as of April 24th but its Stamford reservoir was still below-average capacity at 88.4 percent as of April 25th. Effective April 1st, the Connecticut River Valley and southeast Massachusetts improved to a Drought Advisory from a Drought Watch, while western Massachusetts improved to normal status from a Drought Advisory.[130]

A total of four distinct drought events have been recorded in NCEI from 1996 to 2017, with at least one event impacting each of the state's eight counties during this time (Table 2-69). These events did not have any deaths, injuries, or damages associated with them. However, the USDA reported a total of over $57.4 million in crop insurance claims between 1996 and 2016 in the State of Connecticut.[131]

Table 2-69: NCEI Total Drought Events 1996 – 2017, and USDA Annualized Crop Losses 1996 - 2016

County	Number of Events	USDA Annualized Insured Crop Losses
Fairfield	6	$26,002
Hartford	9	$31,826,077
Litchfield	2	$3,055,123
Middlesex	6	$1,069
New Haven	6	$360,109
New London	6	$340,087
Tolland	9	$11,850,855
Windham	7	$9,988,829

FEMA Disaster Declarations

Between 1954 and 2017, the State of Connecticut was not included in any FEMA drought-related major disaster (DR) or emergency (EM) declarations.

USDA Disaster Declarations

Agriculture-related drought disasters are quite common. One-half to two-thirds of the counties in the United States have been designated as disaster areas in each of the past several years. The USDA Secretary of Agriculture is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. USDA Secretarial disaster designations must be requested of the Secretary of Agriculture by a governor or the governor's authorized representative, by an Indian Tribal Council leader or by an FSA State Executive Director (SED). The Secretarial disaster designation is the most widely used and its process is the most complicated of the four. An expedited process for drought

[130] http://www.nrcc.cornell.edu/regional/narrative/narrative.html
[131] https://www.rma.usda.gov/data/cause.html

was introduced in 2012.[132] Table 2-70 presents USDA declared drought and excessive heat events impacting the State.[133]

Table 2-70: Drought-Related USDA Declarations (2013-2017)

Year	Approval Date	Designation Number	Description of Disaster	Counties Affected
2012	10/24/2012	S3427	Drought, Excessive Heat	Fairfield, Litchfield
2014	12/10/2014	S3775	Drought	Hartford, Litchfield, Middlesex, New Haven, New London, Tolland, Windham
2015	11/4/2015	S3928	Drought	Fairfield, Hartford, Litchfield, Middlesex, New Haven, New London, Tolland, Windham
2016	9/7/2016	S4032	Drought – Fast Track	Windham
2016	9/21/2016	S4045	Drought – Fast Track	New London
2016	9/21/2016	S4047	Drought – Fast Track	Hartford, Litchfield, Tolland, Windham
2016	9/21/2016	S4050	Drought	Litchfield
2016	9/28/2016	S4055	Drought – Fast Track	Fairfield, Hartford, Litchfield, Middlesex, New Haven, New London, Tolland, Windham
2016	10/19/2016	S4076	Drought	New London, Windham
2017	3/3/2017	S4160	Drought – Fast Track	Hartford, Litchfield, Tolland

Note: *Fast track designations for severe droughts provide a nearly automatic designation when, during the growing season, any portion of the county meets the severe drought intensity value for eight consecutive weeks or a higher drought intensity value for any length of time as reported by the U.S. Drought Monitor.*

2.19.8 Probability of Future Events

As noted by the National Drought Mitigation Center, drought risk is based on four elements:

- Frequency;
- Severity;
- Physical nature of the drought; and
- The affected area's vulnerability to the effects of the drought.

Predicting the future occurrence of a drought within a given time period is difficult. Other factors may also contribute to the degree of droughts and their impacts on Connecticut. These include projections of humidity levels (decrease), hotter temperatures and increased

[132] https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/FactSheets/2017/emergency_disaster_designation_and_declaration_process_oct2017.pdf
[133] https://www.fsa.usda.gov/programs-and-services/disaster-assistance-program/disaster-designation-information/index

heat wave occurrences, transpiration rates, increased water demands by the general population, and industry sectors.

However there are indicators and tools available that can help indicate to scientists when a drought may occur and to monitor the duration of said drought. Connecticut, as with most states within the United States, use both the PDSI and the Crop Moisture Index (CMI) as indices for a drought occurrence. The PDSI indicates prolonged and abnormal moisture deficiency or excess and helps climatologists evaluate the scope severity and frequency of prolonged periods of dryness, while the CMI (a derivative of the PDSI) provide information on the short-term or current status of purely agricultural drought or moisture surplus. The PDSI is most effective for determining long-term drought conditions, while the CMI is effective at helping determine short-term droughts.

Based on historical data, it is reasonable to assume that Connecticut has a medium probability of future drought events. Table 2-71 summarizes the probability of future events by county (annualized events) highlighting the probability of a drought every two to three years.

Table 2-71: NCEI Annualized Events for Drought Hazards

County	Annualized Events	Total Annualized Damages
Fairfield	0.27	$1,182
Hartford	0.41	$1,446,640
Litchfield	0.09	$138,869
Middlesex	0.27	$49
New Haven	0.27	$16,369
New London	0.27	$15,459
Tolland	0.41	$538,675
Windham	0.32	$454,038

Note: Reporting Period from January 1993 to December 2017

2.19.9 Climate Change Impacts

As a result of the analysis done in the Connecticut State Water Plan, there is general consensus in the climate models for a hotter and wetter future. Mean annual temperature changes for the 2080 planning horizon, compared to historical baseline, range from approximately +0.5 ˚C to + 6.5 ˚C. Mean annual precipitation changes range from approximately -5% to +30%, with the vast majority of the projections predicting an increase in mean annual precipitation.

Both summer and winter temperatures are projected to increase by similar amounts; and a similar shift is observed for both extreme cold and extreme hot months. Precipitation projections are more variable, although consistently projecting a generally wetter future. The largest precipitation increases are projected for the wetter months (higher percentiles), including extreme wet months. The seasonality plots show that winter and spring precipitation changes are projected to be larger than summer and autumn changes. Drier months are generally projected to remain about the same in terms of both frequency and rainfall level. Small decreases in extreme dry month precipitation are projected for the "hot/dry" scenario.

Typical climate forecasts tend to suggest that increased temperatures coupled with increased annual precipitation generally correspond to higher intensity storms (greater flood risk) and longer dry periods in the summer months (more frequent and/or intense droughts). Because Connecticut has so many small reservoir systems, these systems could be very sensitive to such changes.

Demands could similarly be impacted, with increasing demands due to higher temperatures, but with changes tempered by increased rainfall. The timing of water availability and stream flows will also undoubtedly be impacted, with less snow pack and earlier melt. The combination of potential rapid snow melt and higher extreme precipitation events could translate to an increased flooding risk. Lastly, river water quality could be negatively impacted by the higher temperatures; higher water temperatures can lead to increased growth rates of both algae and bacteria, and lower dissolved oxygen saturation levels. The results presented above generally agree with other studies that have been done on potential future climate trends in Connecticut. In 2010, a report was issued by Climate Change Connecticut that suggested the following summary conclusions:

1. Connecticut could see a temperature increase of 4 – 7.5°F by end of the 21st century.
2. Precipitation in Connecticut could increase by 5-10% by end of the century, and redistribute itself so that more of this increase occurs during winter months.
3. Sea-level rise may increase 12-23 inches by the end of the century.
4. Drought frequency may increase as well as duration and intensity.
5.

2.20 Drought Vulnerability Assessment

To understand risk, the assets exposed and vulnerable to the hazard areas are identified. For the drought hazard the entire State of Connecticut is exposed. This section addresses assessing vulnerability and estimating potential losses by jurisdiction within Connecticut and to State facilities.

Table 2-5 includes the number of state infrastructure/facilities, building value and contents value by municipality. There are 3,327 mapped state-owned facilities. Based on a combination of the 2013 JESTIR database and Connecticut Open Data, the estimated total value of state buildings is $5.6 billion, with over $866 million in content value; the building and contents values have not been estimated for all state-owned building. The State's total building and contents value only includes those buildings where value information was available and is intent for use in this plan and should not be used for other applications. The state contains 1,940 identified critical facilities in the categories of correctional institutions, EMS facilities, fire stations, gas stations with generator, health departments, law enforcement facilities, municipal solid waste, nuclear power plants, and storage tank farms. 1,846 of these critical facilities were able to be geospatially mapped for analysis.

For the purposes of this 2019 Plan update, all State buildings and local assets are exposed to droughts. As the State of Connecticut continues to become more urbanized, the State facilities will need to be developed in locations that will serve the growing population.

2.20.1 Assessment of State Vulnerability and Potential Losses

Drought events generally do not impact buildings, however they have the potential to impact agriculture-related facilities and critical facilities that are associated with potable water supplies. No structures are anticipated to be directly affected by a drought, and all are expected to be operational during a drought event. However, droughts contribute to conditions conducive to wildfires. Risk to life and property is greatest in areas where forested areas adjoin urbanized areas (high-density residential, commercial, and industrial), known as the wildland-urban interface (WUI). Therefore, all state buildings, critical facilities and infrastructure within the WUI zone are considered vulnerable to wildfire. Section 2.27 describes the wildland fire hazard in the State.

2.20.2 Assessment of Local Vulnerability and Potential Losses

Drought impacts cross jurisdictional boundaries and primarily impact the population's water supply and the agricultural industry. Buildings are not anticipated to be directly affected by a drought, and all are expected to be operational during a drought event.

To estimate land exposure to drought, agricultural land acreage was used. Table 2-72 lists the agricultural statistics, by county, for the State of Connecticut. The counties with the greatest acreage of farmland include: Litchfield and New London.

Table 2-72: USDA Agricultural Statistics for Connecticut

County	Number of Farms	% of Total Farms in State	Land in Farms (acres)	Market Value of Products Sold	% of State Total
Fairfield	439	7.34%	53,948	$34,820,000	6.32%
Hartford	899	15.04%	54,062	$113,896,000	20.69%
Litchfield	1,207	20.19%	90,963	$46,281,000	8.41%
Middlesex	518	8.67%	24,070	$53,487,000	9.71%
New Haven	695	11.63%	42,309	$84,620,000	15.37%
New London	949	15.88%	65,159	$118,331,000	21.49%
Tolland	578	9.67%	47,764	$54,972,000	9.98%
Windham	692	11.58%	58,264	$44,212,000	8.03%

The agricultural industry is most at risk. Damaged and dead crops are also vulnerable to wildland fires which can spread easily during periods of drought. A prolonged drought event could have significant impacts to the State's economy, particularly in counties that have large amounts of agricultural lands. While agriculture is not the primary commodity for Connecticut, it is significant enough to impact the State should a prolonged drought occur.

According to the 2012 USDA Agricultural Census, the top three counties for agricultural production, in terms of percent of state total market value of products sold, are: New London (21.5-percent), Hartford (20.7-percent), and New Haven (15.4-percent).

According to the 2012 USDA Agricultural Census, approximately 2,766 farm operators reported farming as their primary occupation. The market value of agricultural products sold from all farms in the State total over $550 million, with total sales averaging $92,123 per farm. Crop sales, including nursery and greenhouse, accounted for over $389 million (71-percent) of total sales. Livestock sales accounted for over $161 million (29-percent) of total sales. The lead agricultural products sold were nursery, greenhouse, floriculture, and sod ($252.9 million); milk from cows ($69.8 million); and poultry and eggs ($48.8 million) (USDA National Agricultural Statistics Service 2012). It is evident that damage or complete loss of a crop will have direct economic impacts on the agricultural industry.

There are approximately 322,578 private residential wells in Connecticut that serve approximately 23% of the state's population of 3,574,097 persons (2010 census). About 822,575 people are served by their own private residential well. Residents who rely on well water may experience a decrease in water supply during times of drought. As development continues in Connecticut, the demand for water will increase as well. While the State is not particularly prone to extreme instances of drought, increased demand has the potential to exacerbate moderate or severe droughts.

Drought events impact the economy, including loss of business function and damage and loss of inventory. Industries that rely on water for business may be impacted the hardest (e.g., landscaping businesses). Even though most businesses will still be operational, they may be impacted aesthetically. These aesthetic impacts are most significant to the recreation and tourism industry.

2.20.3 Changes in Development

An understanding of population and development trends can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The State considered the following factors to examine previous and potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate

Since the entire State is exposed to drought, any new development and increases in population will be vulnerable to the impacts from these events. As discussed in Section 1.2.4 (Land Use and Development), Fairfield County and Hartford County continue to see the majority of development. As of 2016, approximately 65.7% of the building permits statewide were in Fairfield and Hartford Counties, and both of these counties accounted for nearly half of all the housing units in the State. Statewide, there is an estimated 2.2% change in population expected between 2020 and 2040. In regard to drought, a major concern with increased development is the added stress on the water supply. Increases in development and population will result in a greater water requirement for the region, and in times drought, will put more of the population at risk unless the water supply is properly managed.

2.20.4 Hazard Ranking

Quantitative risk assessment, to the degree possible, has been completed for drought using the methodology described in the Hazard Analysis and Ranking methodology Section 2.6 of this chapter. Scores for each jurisdiction were calculated based on population, building permits, geographic extent, average score from local plan rankings, average hazard concern, and measures of historical impact including injuries and deaths, property damage, and the number of reported events. The number of impacted critical facilities was also incorporated, and ranked based on the number of facilities impacted in relation to the number of total critical facilities in Connecticut. For drought, critical facilities was given a weight of 0.5, compared to the weight of 1 given for all other hazards. This reduced weight reflects the low impact drought has on structures, and the high impact it has on agricultural areas. As shown in Table 2-73, the composite drought rank shows Hartford County as medium-high risk; Fairfield and New Haven Counties as medium risk; and Litchfield, Middlesex, New London, Tolland, and Windham as medium-low risk.

Table 2-73: Hazard Ranking by County for Drought

County	Hazard Concern Rank	Local Plans Hazard Rank	Geographic Extent Rank	Population Density Rank	Building Permits Rank	Facility Intersect Rank	Ann. Events Rank	Ann. Losses Rank	Injury & Death Rank	Composite Ranks
Fairfield	Medium-High	Medium	Low	High	High	Medium	Medium	Low	Low	**Medium-Low**
Hartford	Medium-High	Medium	Low	High	High	High	Medium-High	Low	Low	**Medium**
Litchfield	Medium-High	Medium	High	Low	Low	Medium-High	Medium-High	Low	Low	**Medium**
Middlesex	Medium-High	Medium	Low	Medium-Low	Medium-Low	Medium	Medium	Low	Low	**Medium-Low**
New Haven	Medium-High	Medium	Low	High	Medium	Medium-High	Medium	Low	Low	**Medium-Low**
New London	Medium-High	Medium	Low	Medium-Low	Medium-Low	Medium	Medium	Low	Low	**Medium-Low**
Tolland	Medium-High	Medium	High	Medium-Low	Medium-Low	Medium-High	Medium-Low	Low	Low	**Medium**
Windham	Medium-High	Medium	High	Medium-Low	Low	Medium-High	Medium-Low	Low	Low	**Medium**

2.21 Thunderstorm Related Hazards Profile

2019 Plan Update Changes

- The hazard profile has been significantly enhanced to include a detailed hazard description, location, extent, impact (severity, warning time, and secondary impacts), previous occurrences, probability of future occurrence, and potential change in climate and its impacts on the thunderstorm hazard is discussed
- Previous occurrences were updated with events that occurred between 2013 and 2017
- Events reported in this update include Hail, High wind, Lightning, Strong Wind, and Thunderstorm Wind. Hail events were not reported in the 2014 update

2.21.1 Hazard Description

Thunderstorms are formed when the right atmospheric conditions combine to provide moisture, lift, and warm unstable air that can rise rapidly. Thunderstorms occur any time of the day and in all months of the year, but are most common during summer afternoons and evenings and in conjunction with frontal boundaries. The National Weather Service classifies a thunderstorm as severe if it produces hail at least one inch in diameter, winds of 58 mph or greater, or a tornado. About 10 percent of the estimated 100,000 annual thunderstorms that occur nationwide are considered severe. [134] Thunderstorms affect a smaller area compared with winter storms or hurricanes, but they can be dangerous and destructive for a number of reasons. Storms can form in less than 30 minutes, giving very little warning; they have the potential to produce lightning, hail, tornadoes, powerful straight-line winds, and heavy rains that produce flash flooding. Thunderstorms can contribute to other hazard events, such as flooding (Section 1.13), strong straight-line winds, tornadoes (Section 1.25), hail, and lightning, as well as the possibility of lightning-initiated fires. For the purpose of this plan update, this section will include thunderstorms, hail, lightning, and straight-line winds.

Thunderstorms and Lightning

All thunderstorms produce lightning, and therefore all thunderstorms are dangerous. Lightning often strikes outside of areas where it is raining, and may occur as far as 10 miles away from rainfall. It can strike from any part of the storm, and may even strike after the storm has seemed to pass. Hundreds of people across the nation are injured annually by lightning, most commonly when they are moving to a safe place but have waited too long to seek shelter. Lightning strike victims often suffer long-term effects such as memory loss, sleep disorders, weakness and fatigue, chronic pain, depression and muscle spasms.[135]

Hail

Hail forms inside a thunderstorm where there are strong updrafts of warm air and downdrafts of cold water. If a water droplet is picked up by the updrafts, it can be carried well above the freezing level. Water droplets freeze when temperatures reach 32°F or colder. As the frozen droplet begins to fall, it may thaw as it moves into warmer air toward the bottom of the thunderstorm. However, the droplet may be picked up again by another updraft and carried back into the cold air and re-freeze. With each trip above and below the freezing level, the frozen droplet adds another layer of ice. The frozen droplet, with many layers of ice, falls to the ground as hail. Most hail is small and typically less than two inches in diameter.[136]

Straight-Line Winds

High winds, other than tornadoes, are experienced in all parts of the United States. Areas that experience the highest wind speeds are coastal regions from Texas to Maine, and the Alaskan coast; however, exposed mountain areas experience winds at least as high as those along the coast.[137] Wind begins with differences in air pressures. It is rough horizontal movement of air caused by uneven heating of the earth's surface. Wind occurs at all scales, from local breezes lasting a few minutes to global winds resulting from solar heating of the

[134] National Oceanic and Atmospheric Administration, http://www.nws.noaa.gov/om/severeweather/resources/ttl6-10.pdf.
[135] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3737249/
[136] NWS. 2010. "Hail Awareness." On-Line Address: http://www.weather.gov/cae/hail.html
[137] FEMA. 1997. "Atmospheric Hazard." On-Line Address: http://www.fema.gov/media-library-data/20130726-1545-20490-1407/mhira_n1.txt

earth. Effects from high winds can include downed trees and power lines, and damages to roofs, windows, etc.[138] Table 2-74 provides the descriptions of winds used by the NWS.

Table 2-74: NWS Wind Descriptions

Descriptive Term	Sustained Wind Speed (miles per hour)
Strong, dangerous, or damaging	≥40
Very Windy	30-40
Windy	20-30
Breezy, brisk, or blustery	15-25
None	5-15 or 10-20
Light or light and variable wind	0-5

Two basic types of damaging wind events other than tropical systems affect Connecticut: synoptic-scale winds and thunderstorm winds. Synoptic-scale winds are high winds that occur typically with cold frontal passages or Nor'easters. When thunderstorm winds exceed 58 mph, the thunderstorm is considered severe and a warning is issued. "Downbursts" cause the high winds in a thunderstorm. Downburst winds result from the sudden descent of cool or cold air toward the ground. As the air hits the ground, it spreads outward, creating high winds. Unlike tornadoes, downburst winds move in a straight line, without rotation. The term "microburst" refers to a small downburst with damaging winds up to 168 mph and less than 2.5 miles in length. The term "macroburst" refers to a large downburst that can extend greater than 2.5 miles with winds up to 134 mph and can last 5 to 30 minutes.

Another widespread thunderstorm wind event is known as a derecho. Derechos are associated with lines (squall lines) of fast-moving thunderstorms that might vary in length and have the potential to travel hundreds of miles. Winds in these types of events can rival those of "weaker" tornadoes with gusts of 80 to 100 mph covering a wide area.

In the United States, an average of 300 people are injured and 80 people are killed by lightning each year. Typical thunderstorms are 15 miles in diameter and last an average of 30 minutes. An estimated 100,000 thunderstorms occur each year in the United States, with approximately 10% of them classified as severe. During the warm season, thunderstorms are responsible for most of the rainfall.[139]

2.21.2 Location

[138] Rosenstiel School of Marine & Atmospheric Science. 2005. "Katabatic Winds." University of Miami. December 1. On-Line Address: http://www.rsmas.miami.edu/personal/milicak/katabatic/node3.html
[139] https://www.nssl.noaa.gov/education/svrwx101/thunderstorms/

Thunderstorms and Lightning

Thunderstorms affect relatively small localized areas, rather than large regions like winter storms and hurricane events. Thunderstorms can strike in all regions of the United States; however, they are most common in the central and southern states. The atmospheric conditions in these regions of the country are ideal for generating these powerful storms. It is estimated that there are as many as 40,000 thunderstorms each day worldwide.

Figure 2-39 shows the average number of thunderstorm days throughout the United States. The most thunderstorms are seen in the southeast states, with Florida having the highest incidences (80 to over 100 thunderstorm days each year). This illustrates that locations in Connecticut experience between 20 and 30 thunderstorm days each year.[140] The black circle indicates the approximate location of Connecticut. According to this figure, the State experiences an average between 20 and 30 thunderstorms annually.

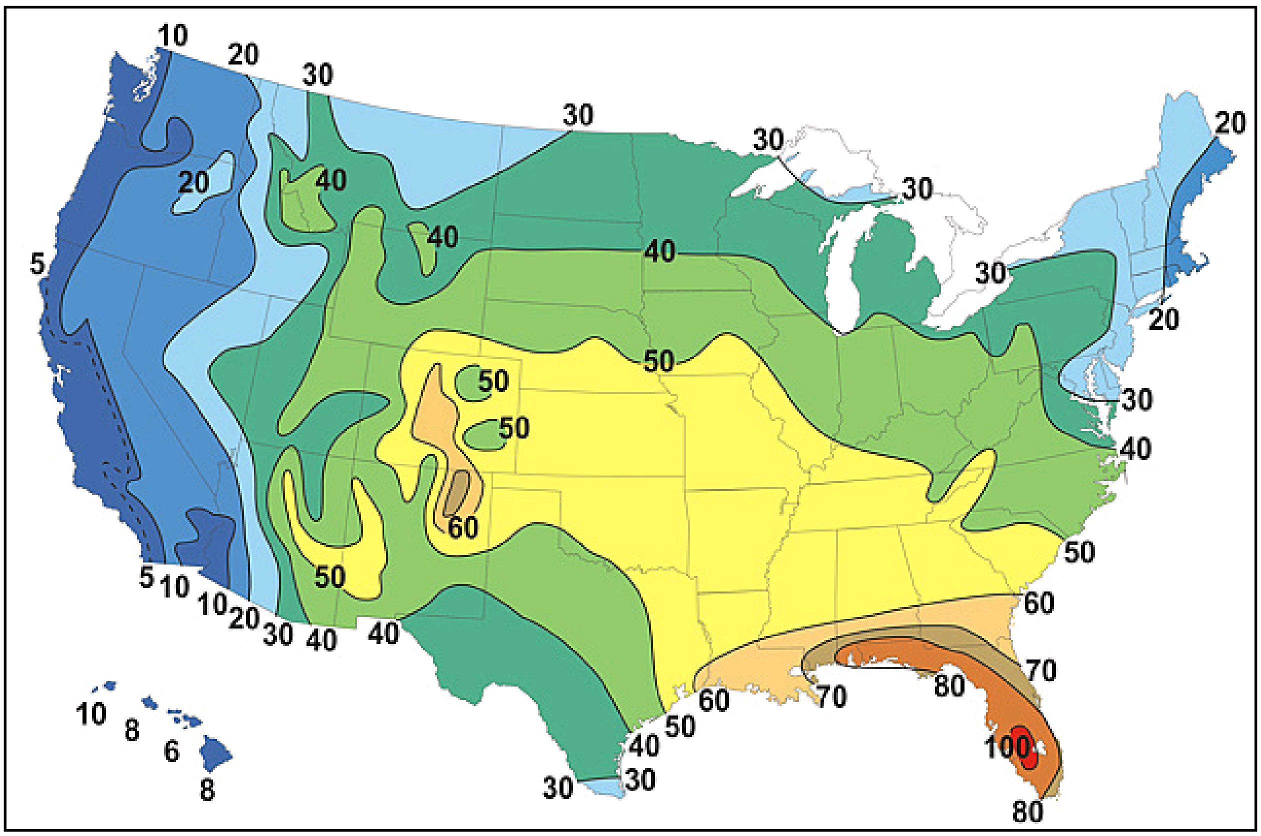


Figure 2-39: Annual Average Number of Thunderstorm Days in the United States

Hail

Hail causes nearly $2 billion in crop and property damages, on average, each year in the United States. Hail occurs most frequently in the southern and central plain states;

140 https://www.weather.gov/jetstream/tstorms_intro

however, since hail occurs with thunderstorms, the possibility of hail damage exists throughout the entire United States.[141] Figure 2-40 indicates that Connecticut experiences between three and four severe hail days a year, on average.

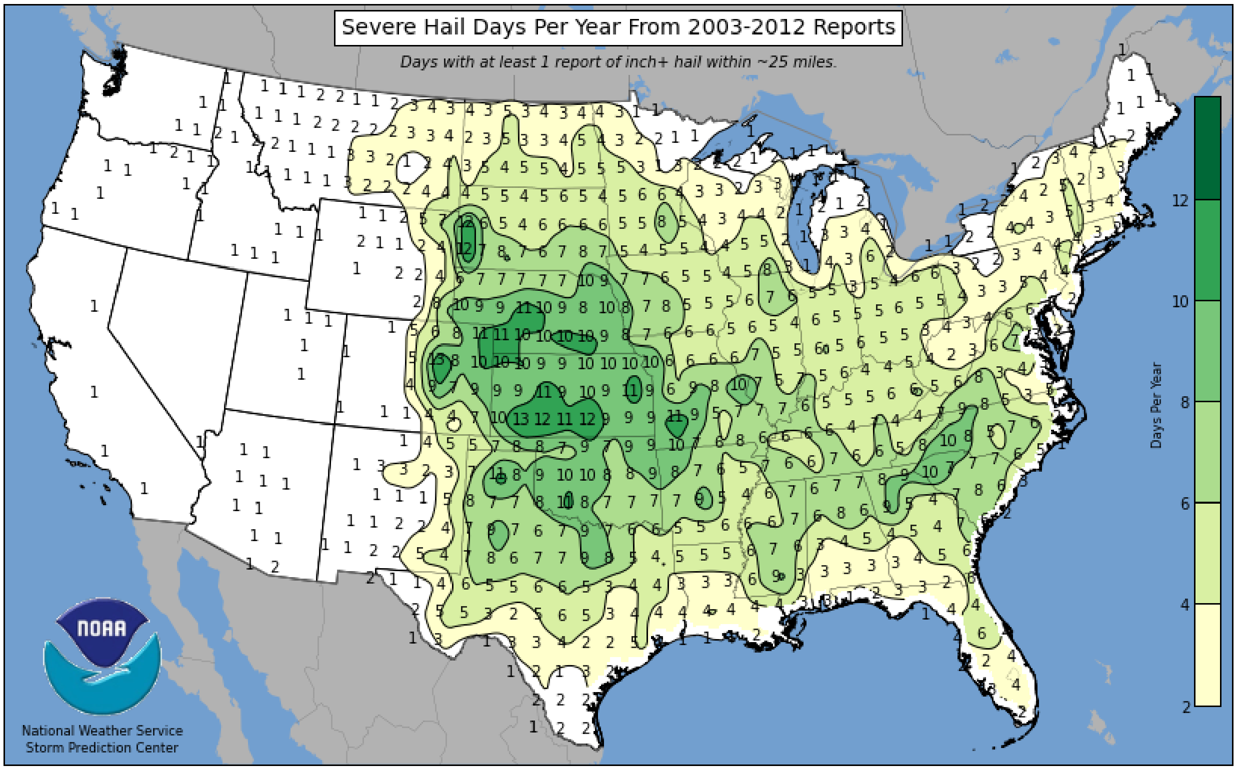


Figure 2-40: Annual Frequency of Hailstorms in the United States, NOAA

Straight-Line Winds

Figure 2-41 indicates how the frequency and strength of windstorms impacts the United States and the general location of the most wind activity. This is based on 40 years of tornado data and 100 years of hurricane data, collected by FEMA. States located in Wind Zone IV have experienced the greatest number of tornadoes and the strongest tornadoes. Connecticut is located within Wind Zone II, which may experience wind speeds up to 160 mph. The entire State is also located within the hurricane-susceptible region.

[141] http://www.flash.org/peril_hail.php

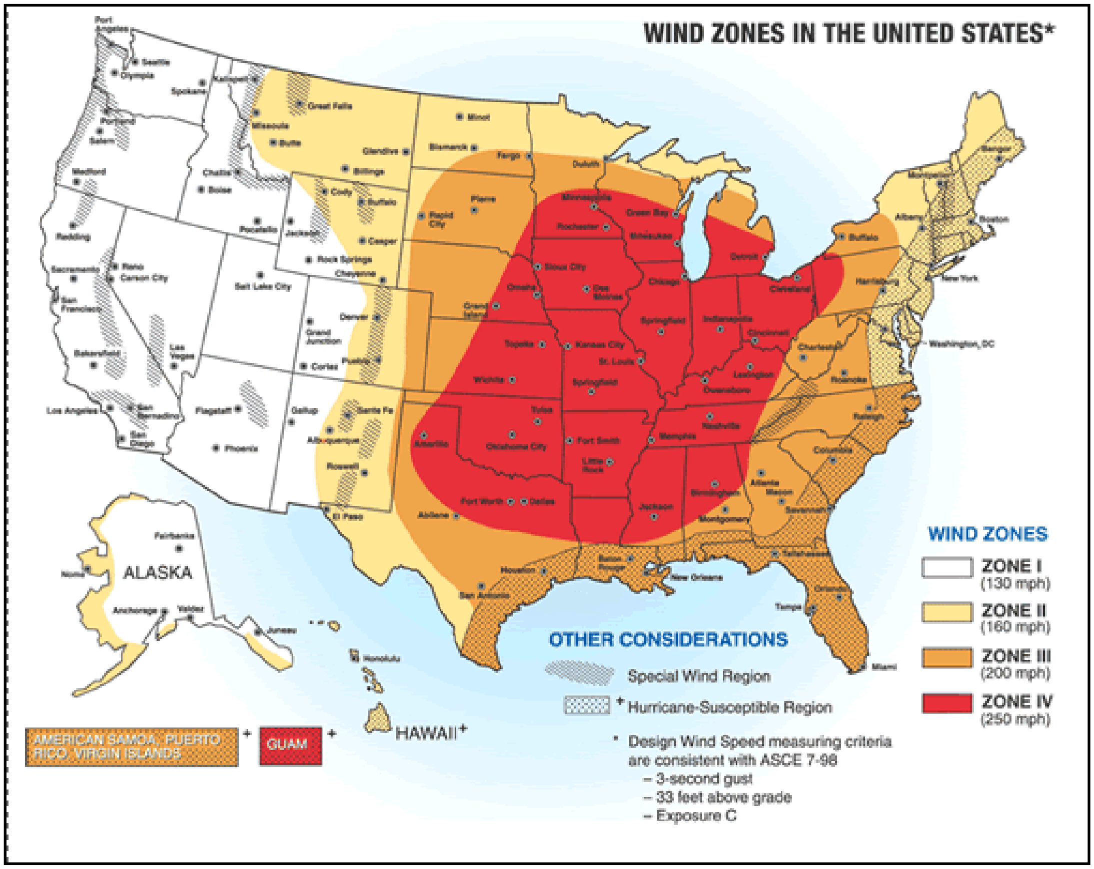


Figure 2-41: Wind Zones in the United States, FEMA, 2012

2.21.3 Extent

Thunderstorms and Lightning

Worldwide, there are an estimated 16 million thunderstorms each year, and at any given moment, there are roughly 2,000 thunderstorms in progress. There are about 100,000 thunderstorms each year in the U.S. alone. About 10% of these reach severe levels.[142] A Severe Thunderstorm is defined by the National Weather Service as a thunderstorm that produces a tornado, winds of at least 58 mph (50knots), and/or hail at least 1" in diameter. Structural wind damage may imply the occurrence of a severe thunderstorm. A thunderstorm wind equal to or greater than 40 mph (35 knots) and/or hail of at least 1" is defined as approaching severe.[143]

Hail

Hail can be produced from many different types of storms. Typically, hail occurs with thunderstorm events. The size of hail is estimated by comparing it to a known object. Most hailstorms are made up of a variety of sizes, and only the very largest hail stones pose

[142] https://www.nssl.noaa.gov/education/svrwx101/thunderstorms/
[143] http://w1.weather.gov/glossary/index.php?letter=s

serious risk to people, when exposed. Table 2-75 shows the different sizes of hail and the comparison to real-world objects.

Table 2-75: Hail Size, NOAA 2012

Size	Inches in Diameter
Pea	0.25 inch
Marble/mothball	0.50 inch
Dime/Penny	0.75 inch
Nickel	0.875 inch
Quarter	1.0 inch
Ping-Pong Ball	1.5 inches
Golf Ball	1.75 inches
Tennis Ball	2.5 inches
Baseball	2.75 inches
Tea Cup	3.0 inches
Grapefruit	4.0 inches
Softball	4.5 inches

Straight-Line Winds

Straight-line winds, winds that come out of a thunderstorm, in extreme cases, can cause wind gusts exceeding 100 mph. These winds are most responsible for hailstorm and thunderstorm wind damage. Windstorms have been known to cause damage to utilities. The predicted wind speed given in wind warnings issued by the NWS is for a one-minute average; gusts may be 25% to 30% higher.

The NWS issues advisories, watches, and warnings for winds. A wind advisory is defined as sustained winds 25 to 39 mph and/or gusts of 46 to 57 mph. Issuance is normally site-specific. High wind advisories, watches, and warnings are products issued by the NWS when wind speeds may pose a hazard or are life threatening. The criterion for each of these varies from state to state (NWS 2010).

2.21.4 Primary and Secondary Impacts

Severe thunderstorms, like tornadoes, are often accompanied by strong winds and hail. Both of these hazards have the potential to damage critical infrastructure. Additionally, flash flooding, particularly in low lying areas, is a secondary effect of thunderstorms as intense rain often accompanies thunderstorms.

The most significant secondary hazard of high wind storms is utility failure resulting from downed power lines and tree branches. As noted, high wind storms can cause localized or regional power outages, thus leading to exposure extreme temperatures for vulnerable populations. An example was the widespread power outages following Superstorm Sandy and the exceptionally cold temperatures which led counties to open additional shelter place for displaced residents. An additional secondary hazard is traffic accidents that may occur when power to traffic control devices is disrupted.

Hailstorms, like many of the other hazards discussed, are often accompanied by other severe weather. One secondary effect of hailstorms is the damage to critical infrastructure which in turn may lead to utility failure. Additionally, extreme hailstorms impact traffic route and may lead to transportation accidents.

2.21.5 Severity

The most common problems associated with severe storms (thunderstorms) are immobility and loss of utilities. Fatalities are uncommon, but can occur due to lightning strikes. Roads may become impassable due to flooding, downed trees, or a landslide. Power lines may be downed due to high winds, and services such as water or phone may be disrupted. Lightning can cause severe damage and injury. Wind storms can be a frequent problem and have caused damage to utilities. Wind storms, as mentioned previously, may occur as part of thunderstorms or independently. The predicted wind speed given in wind warnings issued by the NWS is for a one-minute average; gusts may be 25 to 30% higher.

The severity of hail is measured by duration, hail size, and geographic extent. All of these factors are directly related to thunderstorms, which creates hail. There is wide potential variation in these severity components. The most significant impact of hail is damage to crops. Hail also has the potential to damage structures and vehicles during hailstorms. The State has a relatively low potential for significant hail events, based on previous records.

2.21.6 Warning Time

Meteorologists can often predict the likelihood of a severe thunderstorm and hailstorms. This can give several days warning. However, meteorologists cannot predict the exact time of onset, specific location, or the severity of the storm. Some storms may come on more quickly and have only a few hours of warning time. Like a Tornado Warning, the Severe Thunderstorm Warning is issued by your National Weather Service Forecast Office (NWFO). Severe Thunderstorm Warnings will include where the storm was located, what towns will be affected by the severe thunderstorm, and the primary threat associated with the severe thunderstorm warning. If the severe thunderstorm will affect the nearshore or coastal waters, it will be issued as the combined product--Severe Thunderstorm Warning and Special Marine Warning. If the severe thunderstorm is also causing torrential rains, this warning may also be combined with a Flash Flood Warning. If there is an ampersand (&) symbol at the bottom of the warning, it indicates that the warning was issued as a result of a severe weather report.

After it has been issued, the affected NWFO will follow it up periodically with Severe Weather Statements. These statements will contain updated information on the severe thunderstorm and they will also let the public know when the warning is no longer in effect.

A Severe Thunderstorm Watch is issued by the National Weather Service when conditions are favorable for the development of severe thunderstorms in and close to the watch area. A severe thunderstorm by definition is a thunderstorm that produces one inch hail or larger in diameter and/or winds equal or exceed 58 miles an hour. The size of the watch can vary depending on the weather situation. They are usually issued for a duration of 4 to 8 hours. They are normally issued well in advance of the actual occurrence of severe weather. During the watch, people should review severe thunderstorm safety rules and be prepared to move a place of safety if threatening weather approaches.

A Severe Thunderstorm Watch is issued by the Storm Prediction Center in Norman, Oklahoma. Prior to the issuance of a Severe Thunderstorm Watch, SPC will usually contact the affected local National Weather Service Forecast Office (NWFO) and they will discuss what their current thinking is on the weather situation. Afterwards, SPC will issue a preliminary Severe Thunderstorm Watch and then the affected NWFO will then adjust the watch (adding or eliminating counties/parishes) and then issue it to the public by way of a Watch Redefining Statement. During the watch, the NWFO will keep the public informed on what is happening in the watch area and also let the public know when the watch has expired or been cancelled.

A Severe Thunderstorm Warning is issued when either a severe thunderstorm is indicated by the WSR-88D radar or a spotter reports a thunderstorm producing hail one inch or larger in diameter and/or winds equal or exceed 58 miles an hour; therefore, people in the affected area should seek safe shelter immediately. Severe thunderstorms can produce tornadoes with little or no advance warning. Lightning frequency is not a criteria for issuing a severe thunderstorm warning. They are usually issued for a duration of one hour. They can be issued without a Severe Thunderstorm Watch being already in effect.

2.21.7 Previous Occurrences and Losses

The entire State of Connecticut is vulnerable to thunderstorms and their impacts. The NCEI database was used to identify thunderstorms that occurred in the State between January 1955 and December 2017. It should be noted that the database does not categorize thunderstorms as storm events, but it does categorize thunderstorm characteristics. To create Table 2-76, the following thunderstorm characteristics were searched: hail, high wind, lightning, strong wind, and thunderstorm wind. According to NCEI storm events records, there were at least 4 fatalities and 160 injuries reported within the state between January 1955 and December 2017. The thunderstorm related hazards used in this analysis are defined as:

- Hail - Frozen precipitation in the form of balls or irregular lumps of ice.

- High wind - Sustained non-convective winds of 35 knots (40 mph) or greater lasting for 1 hour or longer, or gusts of 50 knots (58 mph) or greater for any duration (or otherwise locally/regionally defined).
- Lightning - A sudden electrical discharge from a thunderstorm, resulting in a fatality, injury, and/or damage.
- Strong wind - Non-convective winds gusting less than 50 knots (58 mph), or sustained winds less than 35 knots (40 mph), resulting in a fatality, injury, or damage.
- Thunderstorm Winds - Winds, arising from convection (occurring within 30 minutes of lightning being observed or detected), with speeds of at least 50 knots (58 mph), or winds of any speed (non-severe thunderstorm winds below 50 knots) producing a fatality, injury, or damage.

Table 2-76 provides a summary of historic thunderstorm events, by county, that occurred in the State. It should be noted that many sources provided historical information regarding previous occurrences and losses associated with tornadoes that impacted the State of Connecticut. With many sources reviewed for the purpose of this HMP update, loss and impact information could vary depending on the source. Therefore, accuracy of monetary figures discussed is based only on the available information identified during research for this HMP update. Figure 2-42 shows the locations and tracks of historic wind events in Connecticut from 1955 to 2016.

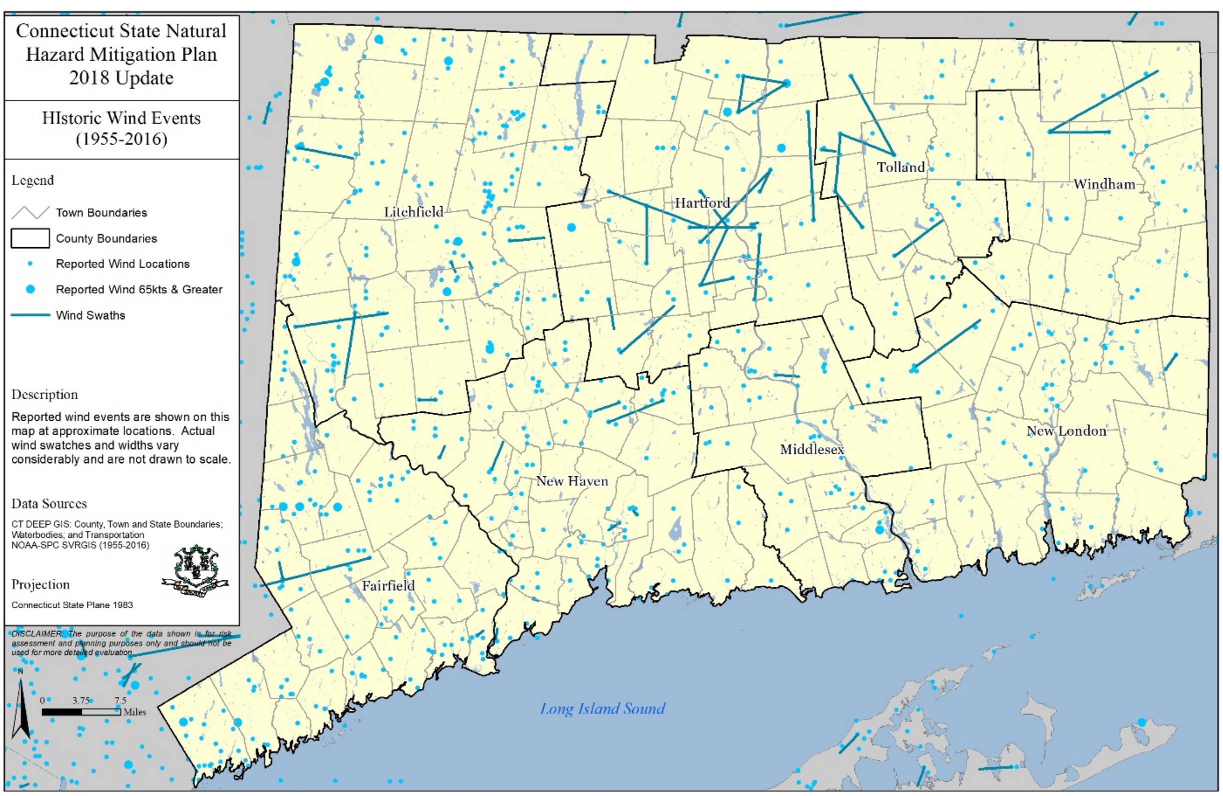


Figure 2-42: Historic Wind Events, Connecticut and Adjacent States

Table 2-76: NCEI Total Thunderstorm Events, 1950 – 2017, Adjusted to 2017 Dollars

County	Number of Events	Number of Injuries	Number of Deaths	Property Damages	Crop Damages
Fairfield	525	58	2	$14,535,986	$0.00
Hartford	571	33	0	$7,583,758	$0.00
Litchfield	593	17	1	$3,518,514	$45,705
Middlesex	186	4	0	$1,058,327	$0.00
New Haven	424	19	1	$3,346,215	$0.00
New London	247	21	0	$3,088,788	$0.00
Tolland	250	5	0	$2,386,188	$0.00
Windham	199	3	0	$1,765,217	$0.00
Total	**	160	4	$37,282,991	$45,705

*Note: *Number of Injuries and Deaths are reported by NWS as zonal events and as a result the individual jurisdiction totals are not cumulative for the state.*
***Event totals were not included because NCEI events may be counted more than once if one storm event affects multiple counties. This duplication renders totaling by county inaccurate.*

Some of the most notable thunderstorm events in recent history in the state of Connecticut in terms of deaths, injuries, and/or property damages include the following (dollar values listed in the descriptions below are not adjusted for inflation):

1. October 19, 1996: a strong low-pressure system developed on a cold front over the DelMarVa Peninsula resulting in strong winds. With a high pressure system in place across Northern New England, the low intensified and moved slowly off the Southern New Jersey Coast. As the difference in pressures increased, strong and gusty east winds developed across the region. Strong gusty winds and torrential rain combined to down trees and power lines. In New Canaan (Southern Fairfield County), a 40 year old man died when a tree fell on the pick-up truck he was driving on Route 23. His 13 year old daughter was treated for injury. High winds downed numerous trees and power lines from Greenwich east to Norwalk, including New Canaan. At Bridgeport Airport, the peak wind gust was 56 mph. High winds combined with high tides wrecked at least $1 million worth of sail and power boats torn from the moorings off Wilson Cove. More than a dozen luxury yachts and assorted smaller boats were smashed against private sea walls and the Bell Island Bridge in Bell Island. In Southern New Haven County, the peak wind gust measured at Outer Island was 58 mph. In New Haven, a woman was taken to St. Raphael's hospital with minor injuries after being struck by a falling tree limb.

2. June 24, 2010: A cold front and strong upper level trough moved across the Tri-State, triggering severe thunderstorms across Southwest Connecticut. Including both supercells and squall lines, producing an EF-1 tornado with 100 mph winds in Bridgeport area just north of Interstate 95. In Bridgeport, straight line winds and the EF1 tornado, caused the collapse of 5 complete buildings, and damage to 9 other

buildings. The winds also blew a billboard off an apartment building, blew out windows and off bricks from buildings, flipped over a tractor trailer on I-95 between exits 27 and 28, flipped over cars on Route 25 between exits 3 and 4. Around two dozen people were displaced by the storm. Significant tree damage was reported throughout the Southwest, with some falling on houses.

3. October 29, 2012: Sandy, a hybrid storm with both tropical and extra-tropical characteristics, brought high winds and coastal flooding to southern New England. Record breaking high tides and wave action was combined with sustained winds of 40 to 60 mph and wind gusts of 80 to 90 mph. Emergency managers recommended mandatory evacuations of 362,000 people that lived in low lying areas. Widespread significant statewide power outages of 667,598 lasted up to 8 days. Subsection 2.72 and 2.75 include additional details on Superstorm Sandy.

4. May 27, 2014: An isolated thunderstorm moved southeast through Litchfield County during the late afternoon and early evening hours. The thunderstorm strengthened as it reached the southern portion of the county and produced a period of gusty winds, heavy rainfall and frequent cloud to ground lightning. The storm produced wind damage to trees and homes in the town of New Milford. Several roads were closed as a result of downed trees and power lines. In addition, schools in New Milford were closed the following day due to ongoing cleanup from the storm damage. A NWS Storm Survey determined that straight line winds produced winds up to 100 MPH. Unfortunately, one person in New Milford died due to electrocution as a result of downed wires falling on a vehicle. Up to 13,000 people through the area lost power as a result of the thunderstorms.

FEMA Disaster Declarations

Between 1954 and 2017, the State of Connecticut was included in 9 severe storm-related major disasters (DR) or emergency (EM) declarations classified as one or a combination of the following disaster types: severe storm, flooding, and tornadoes. Generally, these disasters cover a wide region of the State; therefore, they can impact many counties. However, not all counties were included in the disaster declarations as determined by FEMA.[144] Since the 2013 State HMP, Connecticut has not been included in any additional declarations.

2.21.8 Probability of Future Events

Due to the somewhat unpredictable nature (especially into the longer term) of damaging wind and thunderstorms in particular, it is difficult to quantitatively determine future probability of the hazard. Modeling of future occurrence is difficult and not practical for purposes of this plan. Instead, an examination of past events was performed using NCEI data that dates to 1950. Historically, thunderstorm events have occurred throughout the state, with more than 16 events expected in any given year, with western (Hartford, New Haven, Fairfield, and Litchfield) Connecticut experiencing the greatest number of events.

[144] https://www.fema.gov/disasters

Litchfield typically will experience over nine events annually while Middlesex and Windham may experience three events per year. Table 2-77 provides the annualized number of the combined thunderstorm categories by jurisdiction based on the NCEI historical record. The categories summarized include hail, high wind, lightning, strong wind, and thunderstorms.

Table 2-77: Annualized Events and Losses for Thunderstorms

County	Annualized Events	Annualized Damages
Fairfield	8.37	$230,730
Hartford	9.06	$120,377
Litchfield	9.41	$56,575
Middlesex	2.95	$16,799
New Haven	6.73	$53,115
New London	3.92	$49,028
Tolland	3.97	$37,876
Windham	3.16	$28,019
Total	*	$592,519

*Note: *annualized event totals were not included because NCEI events may be counted more than once if one storm event affects multiple counties. This duplication renders totals inaccurate.*

It is reasonable to assume that Connecticut will continue to experience thunderstorms and is considered to have a high probability of future events. Table 2-77 summarizes the probability of future events by county (annualized events). It is worth noting that the differences in the number of reported events may be significantly related to population and population density. Regardless, based on this analysis, it is clear that thunderstorms are a significant hazard to Connecticut.

In general, the pattern of occurrence and potential locations for tornadoes to occur in Connecticut is expected to remain relatively unchanged in the 21st Century. Based on NOAA's historical data, the northwest area of the state, namely Litchfield and Hartford counties, have the highest historical incidences of tornadoes and therefore may be considered to have a higher risk for the occurrence of future tornadoes. The second area of moderate to high risk based on historical occurrences is in Fairfield and New Haven counties. The counties of Middlesex, Tolland, and Windham have a moderate risk, while the counties of Windham and New London may be considered to have a low risk since tornadoes have historically occurred less frequently than in other counties in the state. More information on Tornado Hazards can be found in Section 1.25.

2.21.9 Climate Change Impacts

Connecticut's climate is changing. The state has warmed two to three degrees (F) in the last century. Throughout the northeastern United States, spring is arriving earlier and bringing more precipitation, heavy rainstorms are more frequent, and summers are hotter and drier. Sea level is rising, and severe storms increasingly cause floods that damage property and infrastructure. In the coming decades, changing the climate is likely to increase flooding, harm ecosystems, disrupt farming, and increase some risks to human health.[145]

Major clusters of summertime thunderstorms in North America will grow larger, more intense, and more frequent later this century in a changing climate, unleashing far more rain and posing a greater threat of flooding across wide areas.[146] At century's end, the number of summertime storms that produce extreme downpours could increase by more than 400 percent across parts of the United States, including sections of the Gulf Coast, Atlantic Coast, and the Southwest. In addition, the intensity of individual extreme rainfall events could increase by as much as 70 percent in some areas.[147]

Thunderstorms and other heavy rainfall events are estimated to cause more than $20 billion of economic losses annually in the United States. Particularly damaging, and often deadly, are mesoscale convective systems (MSCs): clusters of thunderstorms that can extend for many dozens of miles and last for hours, producing flash floods, debris flows, landslides, high winds, and/or hail. The persistent storms over Houston in the wake of Hurricane Harvey were an example of an unusually powerful and long-lived MCS.[148]

Storms have become more intense in recent decades, and a number of scientific studies have shown that this trend is likely to continue as temperatures continue to warm. The reason, in large part, is that the atmosphere can hold more water as it gets warmer, thereby generating heavier rain.[148]

Modeling has found that the number of severe MCSs in North America more than tripled by the end of the (21st) century. Moreover, maximum rainfall rates became 15 to 40 percent heavier, and intense rainfall reached farther from the storm's center. As a result, severe MCSs increased throughout North America, particularly in the northeastern and mid-Atlantic states, as well as parts of Canada, where they are currently uncommon.[148]

The study also looked at the potential effect of particularly powerful MCSs on the densely populated Eastern Seaboard. It found, for example, that at the end of the century, intense MCSs over an area the size of New York City could drop 60 percent more rain than a severe present-day system. That amount is equivalent to adding six times the annual discharge of the Hudson River on top of a current extreme MCS in that area.[148]

Additionally, National Aeronautics and Space Administration (NASA) scientists suggest that the United States will face more severe thunderstorms in the future, with deadly

[145] https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-ct.pdf
[146] https://www2.ucar.edu/atmosnews/news/130085/north-american-storm-clusters-could-produce-80-percent-more-rain
[147] https://www2.ucar.edu/atmosnews/news/124334/extreme-downpours-could-increase-fivefold-across-parts-us
[148] https://www2.ucar.edu/atmosnews/news/130085/north-american-storm-clusters-could-produce-80-percent-more-rain

lightning, damaging hail, and the potential for tornadoes in the event of climate change. A recent study conducted by NASA predicts that smaller storm events like thunderstorms will also be more dangerous due to climate change.[149]

2.22 Thunderstorm Vulnerability Assessment

To understand risk, the assets exposed to hazards must be identified. Certain areas are more vulnerable to specific thunderstorm-related events than others due to geographic location and local weather patterns. For thunderstorm hazard, the entire State of Connecticut is exposed. Therefore, all State assets are potentially vulnerable.

Wind poses a threat to Connecticut in many forms, including that produced by severe thunderstorms and tropical weather systems. The effects can include blowing debris, interruptions in elevated power and communications utilities and intensified effects of winter weather. Harm to people and animals as well as damage to property and infrastructure may be the result.

Building construction, location, and nearby trees or other tall structures will have a large impact on how vulnerable an individual facility is to a lightning strike. A rough estimate of a structure's likelihood of being struck by lightning can be calculated using the structure's ground surface area, height, and striking distance between the downward-moving tip of the stepped leader (negatively charged channel jumping from cloud to earth) and the object.[150] In general, buildings are more likely to be struck by lightning if they are located on high ground or if they have tall protrusions such as steeples or poles which the stepped leader can jump to. Electrical and communications utilities are also vulnerable to direct lightning strikes. Damage to these lines has the potential to cause power and communications outages for businesses, residencies, and critical facilities.

[149] https://climate.nasa.gov/news/897/severe-thunderstorms-and-climate-change/
[150] Hasbrouck, P.E. *Determining the Probability of Lightning Striking a Facility*, National Lightning Safety Institute, http://lightningsafety.com/nlsi_lhm/prbshort.html (April 2004).

Structure vulnerability to hail is determined mainly by construction and exposure. Metal siding and roofing is better able to stand up to the damages of a hailstorm than many other materials, although it may also be damaged by denting. Exposed windows and vehicles are also susceptible to damage. Crops are extremely susceptible to hailstorm damage, as even the smallest hail stones can rip apart unsheltered vegetation.

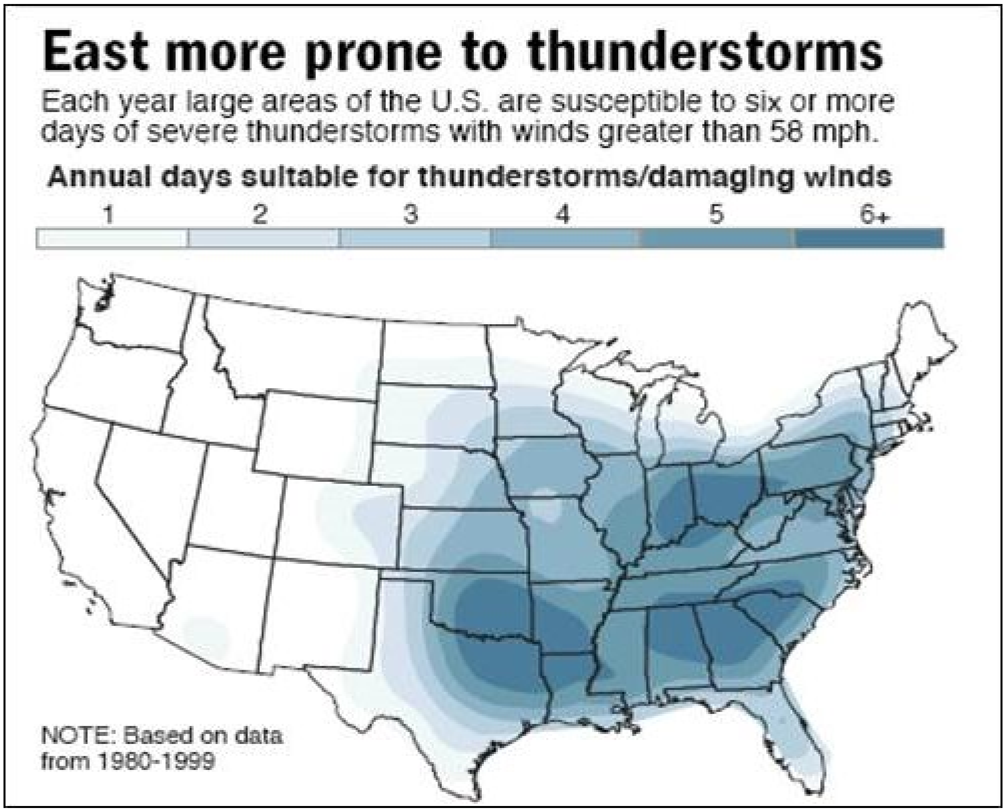


Figure 2-43: Annual Days Suitable for Thunderstorms / Damaging Winds

Human vulnerability is largely determined by the availability and reception of early warnings for the approach of severe storms, and by the availability of nearby shelter. Individuals who immediately seek shelter in a sturdy building or metal-roofed vehicle are much safer than those who remain outdoors. Early warnings of severe storms are also vital for aircraft flying through the area. Table 2-76 gave a breakdown of injuries and deaths attributed to thunderstorms in Connecticut between 1955 and 2017. Fairfield County tops the list with 72 injuries.

As discussed above, risk, as defined as probability multiplied by impact, cannot be fully estimated for damaging winds due to the lack of intensity-damage models for this hazard. Instead, financial impacts of damaging winds can be analyzed based on NCEI Storm Events data. Using this data, which was displayed above in Table 2-77, total damage related to thunderstorm wind, hail, lightning, high wind, and strong wind events totaled nearly $143,898,000 or $2,320,935 annually. Fairfield County has the highest annualized losses at $344,097, with Hartford County following with an average of $320,274 in annual damages.

These estimates are believed to be an underrepresentation of the actual losses experienced due to hazards as losses from events that go unreported or that are difficult to quantify are not likely to appear in the NCEI database.

Table 2-5 includes the number of state infrastructure/facilities, building value and contents value by municipality. There are 3,327 mapped state-owned facilities. Based on a combination of the 2013 JESTIR database and Connecticut Open Data, the estimated total value of state buildings is $5.6 billion, with over $866 million in content value. The State's total building and contents value only includes those buildings where value information was available and is intent for use in this plan and should not be used for other applications. The state contains 1,940 identified critical facilities in the categories of correctional institutions, EMS facilities, fire stations, gas stations with generator, health departments, law enforcement facilities, municipal solid waste, nuclear power plants, and storage tank farms. 1,846 of these critical facilities were able to be geospatially mapped for analysis.

For the purposes of this 2019 Plan update, all State buildings and local assets are exposed to thunderstorm-related events. As the State of Connecticut continues to become more urbanized, the State facilities will need to be developed in locations that will serve the growing population.

2.22.1 Assessment of State Vulnerability and Potential Losses

Thunderstorms and Lightning

All of the State-owned and -leased buildings may be exposed to the effects of thunderstorms. Thunderstorms will often be accompanied by high winds and sometimes hail. Losses related to thunderstorms primarily will be structural when falling or projectile debris impacts state-owned buildings.

According to NOAA's Technical Paper on *Lightning Fatalities, Injuries, and Damage Reports in the United States from 1959 - 1994*, monetary losses for lightning events range from less than $50 to greater than $5 million. The larger losses are associated with forest fires with homes destroyed and crop loss (NOAA 1997). Lightning can be responsible for damages to buildings; cause electrical, forest and/or wildfires; and damage infrastructure such as power transmission lines and communication towers.

Hail

Similar to thunderstorms, hail may affect all state-owned and –leased buildings across Connecticut. Damages will result from the hail stones themselves and will have a specific impact on roofs of state facilities. The extent of damage will depend on the size and extent of the hailstorm. The primary impact of hailstorms is to the agricultural industry (crops and livestock).

As for hailstorms, they cause considerable damage to United States crops and property, occasionally causes death to farm animals, but seldom causes loss of human life. All counties are considered vulnerable to the effects of hailstorms, but those with farmland and high agricultural yields are more likely to be impacted. According to the 2012 United States Department of Agriculture's Agricultural Census, the State of Connecticut has 5,977 farms equaling 436,539 acres. Of this Fairfield County has 439 farms at 53,948 acres, Harford County has 899 farms at 54,062 acres, Litchfield County has 1,207 farms at 90,963 acres, Middlesex County has 518 farms at 24,070, New Haven County has 695 farms at 42,309 acres, New London County has 949 farms at 65,159 acres, Tolland County has 578 farms at 47,764 acres, and Windham County has 692 farms at 58,264 acres.[151]

Straight-Line Winds

Damage to buildings is dependent upon several factors including wind speed and duration, and building construction. Refer to the Tropical Cyclone Vulnerability Assessment (Section 1.27) for the vulnerability to wind-related damages.

Critical facilities, legacy structures and infrastructure throughout the state may be vulnerable to strong winds. In particular, structures that were built before building codes and use of construction design wind speeds and corresponding zones (Figure 3) may be vulnerable to wind damage. Critical and state facilities in western Connecticut can be assumed to be at a slightly greater risk due to thunderstorm related events.

Impacts to transportation lifelines affect both short-term (e.g., evacuation activities) and long-term (e.g., day-to-day commuting and goods transport) transportation needs. Utility infrastructure (power lines, gas lines, electrical systems) could suffer damage and impacts can result in the loss of power, which can impact business operations and can impact heating or cooling provision to the population. The impacted population can include the young and elderly, who are particularly vulnerable to temperature-related health impacts. Post-event, there is a risk of fire, electrocution or explosion.

Generally speaking, structures should be designed to withstand the total wind load of the zone in which they are located. Refer to the State Building Code for appropriate reference wind pressures, wind forces on roofs, and other relevant codes.

2.22.2 Assessment of Local Vulnerability and Potential Losses

This section discusses the vulnerability of jurisdictions to areas susceptible to thunderstorms. As stated above in the State Vulnerability and Potential Losses, the entire State is exposed to thunderstorm-related events. This includes the entire State population (3,574,097 people according to the 2010 U.S. Census).

[151] https://www.agcensus.usda.gov/Publications/2012/Online_Resources/County_Profiles/Connecticut/

Thunderstorms and Lighting

Agricultural losses can be devastating due to lightning and resulting fires. Table 2-78 summarizes the potential monetary loss of crops in each county. The counties with the amount of high value crop types have the highest potential loss due to storms. Windham and New London Counties have the highest amount of potential monetary crop loss.

Table 2-78: USDA Agricultural Statistics for Connecticut

County	Number of Farms	% of Total Farms in State	Land in Farms (acres)	Market Value of Products Sold
Fairfield	439	7.3	53,948	$34,820,000
New Haven	695	15.0	42,309	$84,620,000
Hartford	899	20.2	54,062	$113,896,000
New London	949	8.7	65,159	$118,331,000
Litchfield	1,207	11.6	90,963	$46,281,000
Tolland	578	15.9	47,764	$54,972,000
Middlesex	518	9.7	24,070	$53,487,000
Windham	692	11.6	58,264	444,212,000
Total	**5,977**	**100%**	**436,539**	**$550,620,000**

Hail

As discussed above, all Counties are considered vulnerable to the effects of hailstorms, but those with farmland and high agricultural yields are more likely to be impacts. According to the 2012 USDA's Agricultural Census, Windham and New London Counties have the highest amount of potential monetary crop loss.

Straight-Line Winds

Straight-line wind events may threaten life safety, damage buildings and impact the economy, including: loss of business function, damage to inventory, relocation costs, wage loss, and rental loss due to the repair/replacement of buildings. Recovery and clean-up costs can also be costly and impact the economy as well.

Because of differences in building construction, residential structures are generally more susceptible to wind damage than commercial and industrial structures. Wood and masonry buildings in general, regardless of their occupancy class, tend to experience more damage than concrete or steel buildings. High-rise buildings are also vulnerable structures. Mobile homes are the most vulnerable to damage, even if tied down, and offer little protection to people inside.

2.22.3 Changes in Development

An understanding of population and development trends can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The State considered the following factors to examine previous and potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate

Since the entire State is exposed to thunder-storm related events, any new development and increases in population will be vulnerable to the impacts from these events. As discussed in Section 1.2.4 (Land Use and Development), Fairfield County and Hartford County continue to see the majority of development. As of 2016, approximately 65.7% of the building permits statewide were in Fairfield and Hartford Counties, and both of these counties accounted for nearly half of all the housing units in the State. If recent trends in development continue, these two Counties will continually increase their vulnerability to thunderstorm-related events. Statewide, there is an estimated 2.2% change in population expected between 2020 and 2040; the increases in population will increase the State population's vulnerability to thunderstorm-related events.

2.22.4 Hazard Ranking

Quantitative risk assessment, to the degree possible, has been completed for thunderstorms using the methodology described in the Hazard Analysis and Ranking methodology Section 2.6 of this chapter. Scores for each jurisdiction were calculated based on population, building permits, geographic extent, average score from local plan rankings, average hazard concern, and measures of historical impact including injuries and deaths, property damage, and the number of reported events. The number of impacted critical facilities was also incorporated, and ranked based on the number of facilities impacted in relation to the number of total critical facilities in Connecticut. As shown in Table 2-79, the composite thunderstorm rank shows Fairfield, Hartford, Litchfield, and New Haven Counties as high risk; New London County as medium-high risk; and Middlesex, Tolland, and Windham Counties as medium risk.

Table 2-79: Hazard Ranking by County for Thunderstorms

County	Hazard Concern Rank	Local Plans Hazard Rank	Geographic Extent Rank	Population Density Rank	Building Permits Rank	Facility Intersect Rank	Ann. Events Rank	Ann. Losses Rank	Injury & Death Rank	Composite Ranks
Fairfield	Medium-High	Medium	Low	High	High	Medium	Medium	Low	Low	**Medium-Low**
Hartford	Medium-High	Medium	Low	High	High	High	Medium-High	Low	Low	**Medium**
Litchfield	Medium-High	Medium	High	Low	Low	Medium-High	Medium-High	Low	Low	**Medium**
Middlesex	Medium-High	Medium	Low	Medium-Low	Medium-Low	Medium	Medium	Low	Low	**Medium-Low**
New Haven	Medium-High	Medium	Low	High	Medium	Medium-High	Medium	Low	Low	**Medium-Low**
New London	Medium-High	Medium	Low	Medium-Low	Medium-Low	Medium	Medium	Low	Low	**Medium-Low**
Tolland	Medium-High	Medium	High	Medium-Low	Medium-Low	Medium-High	Medium-Low	Low	Low	**Medium**
Windham	Medium-High	Medium	High	Medium-Low	Low	Medium-High	Medium-Low	Low	Low	**Medium**

2.23 Tornado Hazard Profile

2019 Plan Update Changes

- The hazard profile has been significantly enhanced to include a detailed hazard description, location, extent, impact (severity, warning time and secondary impacts), previous occurrences, probability of future occurrence, and potential change in climate and its impacts on the tornado hazard is discussed
- New and updated figures from federal and state agencies are incorporated. U.S. 2010 Census data was incorporated, where appropriate
- Previous occurrences were updated with events that occurred between 2013 and 2018

2.23.1 Hazard Description

Tornadoes are nature's most violent storms and can cause fatalities and devastate neighborhoods in seconds. A tornado appears as a rotating, funnel-shaped cloud that extends from a thunderstorm to the ground with whirling winds that can reach 250 mph. Damage paths can be greater than one mile in width and 50 miles in length. Tornadoes typically develop from either a severe thunderstorm or hurricane as cool air rapidly overrides a layer of warm air. Tornadoes typically move at speeds between 30 and 125 mph and can generate internal winds exceeding 300 mph. The lifespan of a tornado rarely is longer than 30 minutes.[152]

Tornadoes develop from mainly two types of thunderstorms: supercell and non-supercell. The most common, and often most dangerous, are tornadoes produced by supercell thunderstorms. NOAA defines this type of tornado as, "a long lived (greater than 1 hour) and highly organized storm feeding off an updraft that is tilted and rotating." Non-supercell tornadoes are circulations that do not form from organized storm-scale rotation. There are two types of non-supercell thunderstorm tornadoes:

- Gustnado – a whirl of dust or debris at or near the ground with no condensation tunnel; and
- Landspout – a narrow rope-like condensation funnel that forms when the thunderstorm cloud is still growing and there is no rotating updraft (the spinning motion originates near the ground). Waterspouts are similar to landspouts but occur over water rather than land.[153]

2.23.2 Location

Tornadoes have been documented in every state in the United States, and on every continent with the exception of Antarctica. Approximately 1,200 tornadoes occur in the United States each year, with the central portion of the country experiencing the most. Tornadoes can occur at any time of the year, with peak seasons at different times for different states.[154]

Because a tornado is part of a severe convective storm, and these storms occur all over the Earth, tornadoes are not limited to any specific geographic location. In fact, tornadoes have been documented in every state of the United States, and on every continent, with the exception of Antarctica (even there, a tornado occurrence is not impossible). In fact, wherever the atmospheric conditions are exactly right, the occurrence of a tornadic storm is possible.

However, some parts of the world are much more prone to tornadoes than others. Globally, the middle latitudes, between about 30° and 50° North or South, provide the most favorable environment for tornadogenesis. This is the region where cold, polar air meets against warmer, subtropical air, often generating convective precipitation along the collision boundaries. In addition, air in the midlatitudes often flows at different speeds and directions at different levels of the troposphere, facilitating the development of rotation within a storm cell. Interestingly, the places that receive the most frequent tornadoes are also considered the most fertile agricultural zones of the world. This is due in part to the

[152] FEMA. 1997. "Atmospheric Hazard." On-Line Address: http://www.fema.gov/media-library-data/20130726-1545-20490-1407/mhira_n1.txt
[153] https://www.nssl.noaa.gov/education/svrwx101/tornadoes/types/
[154] National Severe Storms Laboratory. 2013. "Severe Thunderstorm Climatology." National Oceanic & Atmospheric Administration. March 29. On-Line Address: http://www.nssl.noaa.gov/projects/hazard/index.html

high number of convective storms delivering needed precipitation to these areas. Simply because of the large number of convective storms and the favorable environment, the odds are increased that some of these storms will produce tornadoes. In terms of absolute tornado counts, the United States leads the list, with an average of over 1,000 tornadoes recorded each year.[155] As seen in Figure 2-44, the average annual number of tornadoes for Connecticut is two.

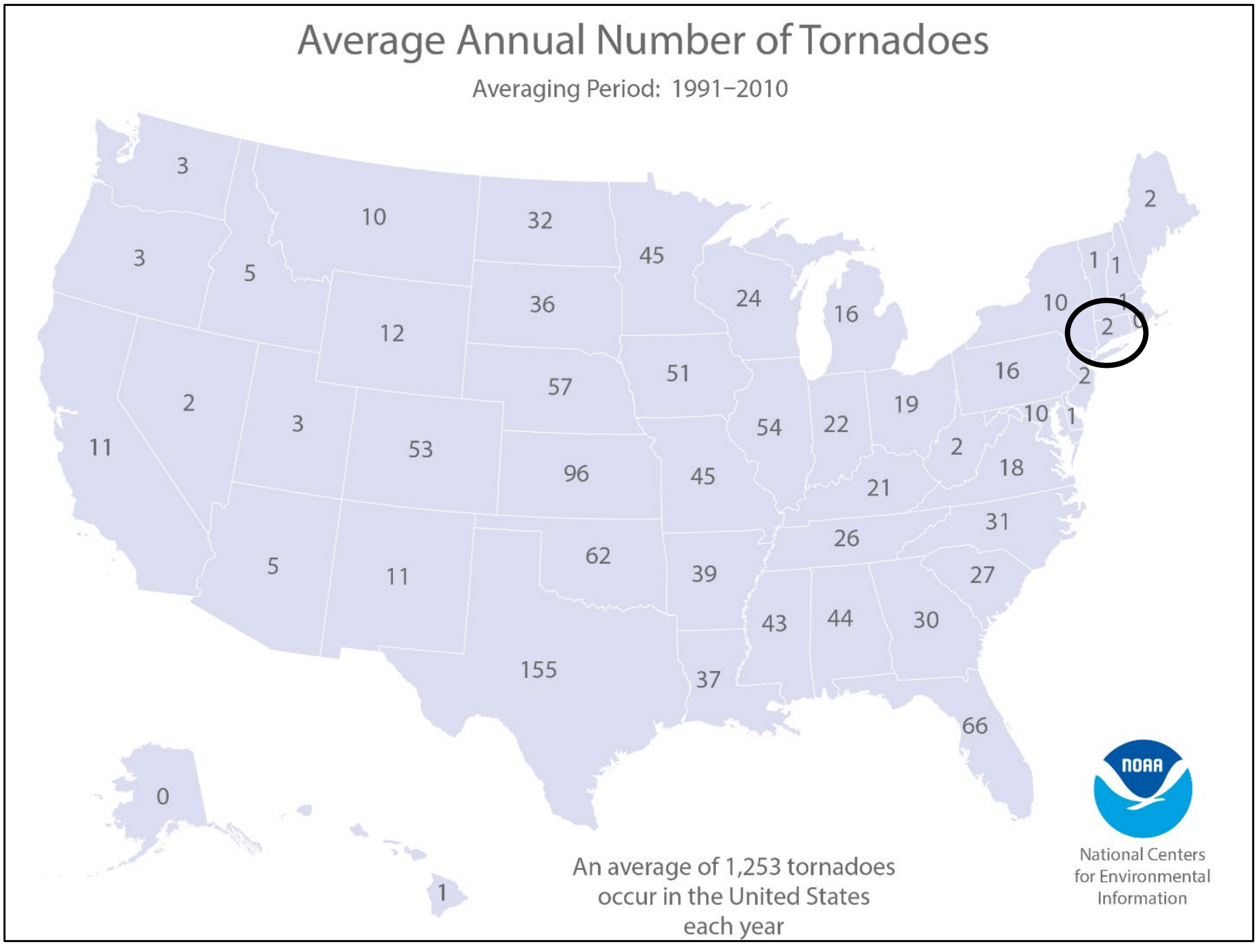


Figure 2-44: Average Annual Number of Tornados

Note: The black circle indicates the approximate location of Connecticut.

2.23.3 Extent

The magnitude or severity of a tornado was originally categorized using the Fujita Scale (F-Scale) or Pearson Fujita Scale introduced in 1971. This used to be the standard measurement for rating the strength of a tornado. The F-Scale categorized tornadoes by intensity and area and was divided into six categories, F0 (gale) to F5 (incredible). Table 2-80 explains each of the six F-Scale categories.

155 https://www.ncdc.noaa.gov/climate-information/extreme-events/us-tornado-climatology

Table 2-80: Fujita Damage Scale, Storm Prediction Center, NOAA

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

The Enhanced Fujita Scale (EF-Scale) is now the standard used to measure the strength of a tornado. It is used to assign tornadoes a 'rating' based on estimated wind speeds and related damage. When tornado-related damage is surveyed, it is compared to a list of Damage Indicators (DI) and Degree of Damage (DOD), which help better estimate the range of wind speeds produced by the tornado. From that, a rating is assigned, similar to that of the F-Scale, with six categories from EF0 to EF5, representing increasing degrees of damage. The EF-Scale was revised from the original F-Scale to reflect better examinations of tornado damage surveys. This new scale considers how most structures are designed.[156] Table 2-81 displays the EF-Scale and each of its six categories.

[156] http://www.crh.noaa.gov/arx/efscale.php

Table 2-81: Enhanced Fujita Damage Scale, NOAA

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

The EF-Scale is a set of wind estimates, not measurements, based on damage. It uses three-second gusts estimated at the point of damage based on a judgement of eight levels of degrees of damage (DOD) to 28 damage indicators. As indicated in Table 2-82, each indicator has a description of the typical construction for that category indicator and the eight DODs. Each DOD in each category is given an expected estimate of wind speed, a lower bound of wind speed, and an upper bound of wind speed. NOAA provides detailed information for each damage indicator on its website (http://www.spc.noaa.gov/efscale/ef-scale.html) such as average structure size, building construction and material characteristics, and damage descriptions per DOD.[157]

[157] http://www.spc.noaa.gov/efscale/ef-scale.html

Table 2-82: Damage Indicators for the EF Scale

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

2.23.4 Primary and Secondary Impacts

Like hurricanes, earthquakes, and floods, tornadoes can lead to massive destruction to homes, property, and infrastructure, and may lead to deaths and injuries. The following provides information regarding the severity, warning time, and secondary impacts a tornado may have.

Tornadoes have the potential to lead to widespread utility outages, downed trees, closed roadways, and damages to critical and essential infrastructure. Tornado events may also be accompanied by strong thunderstorms, straight-line winds, and hail which can lead to traffic accidents and flash flooding.

2.23.5 Severity

The high winds and air speeds of a tornado often result in power outages, disruptions to transportation corridors and equipment, significant property damage, injuries and loss of life, and the need to shelter and care for individuals impacted by the event. A large amount of damage can be inflicted by trees, branches and other objects that fall onto power lines, buildings, roads, and vehicles.

2.23.6 Warning Time

There are still many unknowns regarding tornadoes and their development such as (1) exactly when will a storm event trigger a tornado; (2) How do tornadoes dissipate; and (3) How does cloud-seeding affect tornado development. The National Weather Service (NWS) is the official agency that forecasts tornadoes nationwide. Tornado watches and warning are issued by the local NWS office. A tornado watch is released when tornadoes are possible in an area. A tornado warning means a tornado has been sighted or indicated by weather radar. The current average lead time for tornado warnings is 13 minutes. Occasionally, tornadoes develop so rapidly, that little, if any, advance warning is possible.[158]

Because most tornadoes are related to the strength of a thunderstorm, and thunderstorms normally gain most of their energy from solar heating and latent heat released by the condensation of water vapor, it is not surprising that most tornadoes occur in the afternoon and evening hours, with a minimum frequency around dawn (when temperatures are lowest and radiation deficits are highest). However, tornadoes have occurred at all hours of the day, and nighttime occurrences may give sleeping residents of a community little or no

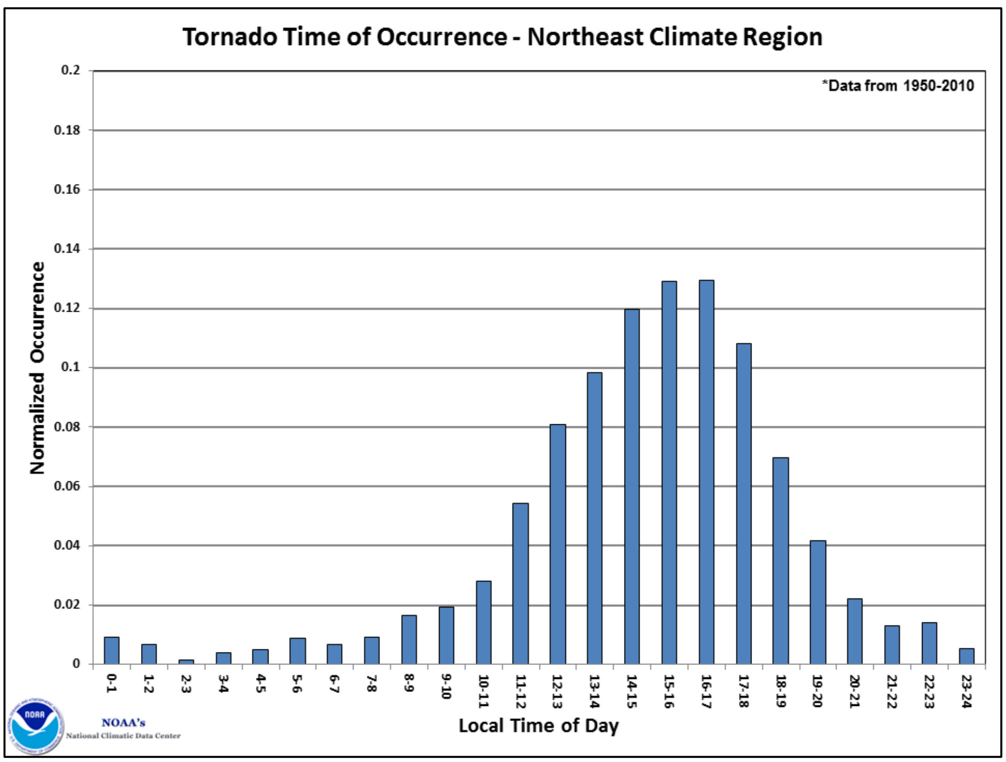


Figure 2-45: Tornado Time of Occurrence, Midwestern Regional Climate Center

warning.[159] Figure 2-45 indicates the time of occurrence in the northeast climate region.

[158] http://w1.weather.gov/glossary/
[159] https://www.ncdc.noaa.gov/climate-information/extreme-events/us-tornado-climatology/trends

2.23.7 Previous Occurrences and Losses

The entire State of Connecticut is vulnerable to tornadoes and their impacts. Between 1950 and 2018, the State has experienced 97 tornadoes that injured over 700 people, resulted in six deaths, and caused over $600 million in damages. The most tornado activity has been during the summer months (June through August). Figure 2-46 shows historic tornado tracks and magnitude from 1950 to 2016. Please refer to Table 2-83 for a summary of tornado events, by county, that occurred in the State.

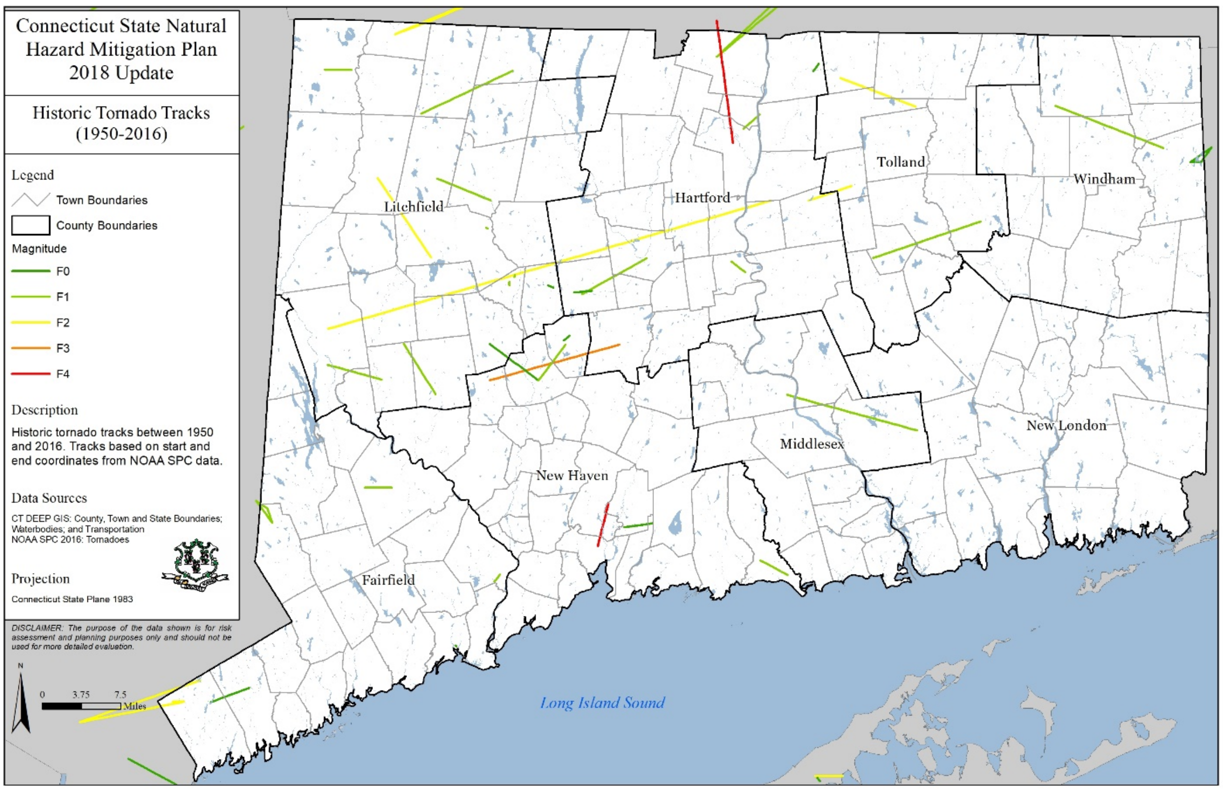


Figure 2-46 Historic Tornado Events in Connecticut, 1950 – 2016

Table 2-83: NCEI Total Tornado Events, 1950-2017

County	Number of Events	Number of Injuries	Number of Deaths	Property Damages (2017 Dollars)
Fairfield	13	13	0	$8,924,729
Hartford	19	502	3	$904,150,586
Litchfield	27	84	0	$106,087,265
Middlesex	8	8	0	$2,463,629
New Haven	14	92	3	$579,367,790
New London	1	0	0	$0.00
Tolland	11	4	0	$3,093,879
Windham	4	0	0	$5,802,369
Total	*	703	6	$1,609,890,248

*Note: event totals were not included because NCEI events may be counted more than once if one storm event affects multiple counties. This duplication renders totals inaccurate.

It should be noted that many sources provided historical information regarding previous occurrences and losses associated with tornadoes that impacted the State of Connecticut. With many sources reviewed for the purpose of this HMP update, loss and impact information could vary depending on the source. Therefore, accuracy of monetary figures discussed is based only on the available information identified during research for this HMP update.

Some of the most notable tornado occurrences in recent history in the state of Connecticut in terms of deaths, injuries, and/or property damages include the following (dollar values listed in the descriptions below are not adjusted for inflation):

- July 14, 1950 – This F2 tornado in Fairfield County injured several people and resulted in an estimated $250,000 in property damages.
- August 21, 1951 – This F2 tornado in Litchfield County injured nine people and resulted in an estimated $250,000 in property damages.
- May 10, 1954 – This F3 tornado in Tolland County resulted in at least two injuries and $25,000 in property damages.
- September 7, 1958 – This F2 tornado resulted in at least two injuries and $250,000 in property damages.
- May 24, 1962 – This F3 tornado in New Haven County killed one person and injured 50 people. The tornado had an estimated path length of 11.6 miles and was estimated to be 120 feet in width. Damage estimates for this event range from $500,000 to $5 million.
- October 3, 1970 – This F1 tornado in Hartford County resulted in one injury.

- July 29, 1971 – This F3 tornado in New Haven County caused at least two injuries and at least $250,000 in property damages.
- June 28, 1973 – This F1 tornado in Hartford County resulted in one injury.
- October 3, 1979 (FEMA-DR-608) – This F4 tornado in Hartford County is the deadliest tornado on record to strike Connecticut according to NOAA. It had an estimated path length of 11.3 miles and an estimated width of 1,400 feet. Damages were estimated between $50 million and $500 million. Five hundred people were injured and three people died from this event. As a result of this tornado, two towns were declared Federal disaster areas.
- July 10, 1989 (FEMA-DR-837) – This F4 tornado cut a path through western Connecticut, from Salisbury to New Haven, in less than one hour. One person was reported as being killed, 110 people were injured, and 67 homes were destroyed. Damages totaled $125 million and a Presidential Disaster Declaration was issued.
- August 29, 1990 – This F0 tornado caused seven injuries in Fairfield County and caused several thousand dollars in damages.
- June 23, 2001 – This F1 tornado in Litchfield County caused at least one injury and at least $150,000 in property damages.
- June 26, 2009 – This EF1 tornado affected Wethersfield in Hartford County. On June 29, Governor M. Jodi Rell requested a FEMA preliminary damage assessment (PDA) as a result of the tornado, heavy winds, rain, and hail which were associated with severe thunderstorms on June 26. An estimated $750,000 in reported property damages were recorded by NCEI.
- July 31, 2009 – This EF1 tornado touched down in Madison in New Haven County and in Shelton in Fairfield County. An estimated $20,000 in property damages were reported between the two counties.
- June 24, 2010 – This EF1 tornado impacted Bridgeport in Fairfield County injuring three people and causing at least $3,200,000 in reported property damages, according to NCEI records.
- July 21, 2010 – This EF1 tornado impacted Hartford and Litchfield counties causing at least $584,000 in reported property damage, according to NCEI records. The tornado made brief touchdowns in Bristol in Hartford County and in East Litchfield, Thomaston, and Terryville in Litchfield County with damage mainly to hardwood and softwood trees.

- July 9, 2011 – A National Weather Service Storm Survey Team confirmed that a brief tornado touched down in Litchfield County. No damages were recorded as being associated with this EF1 tornado.

- July 1, 2013 - Three tornadoes touched down across the state; one in Fairfield County and two in Hartford County. Majority of impact limited to downed trees, though the EF1 caused notable structural damage near East Windsor

- July 10, 2013 - An EF1 tornado caused tree damage along an 11.2-mile (18.0 km) long intermittent path in Tolland County

- July 27, 2014 – A weak EF-0 tornado touched down in Wolcott in New Haven County causing $25,000 in property damage. Damage was done to trees, large fixed sports equipment at the local high school, a trailer and a home.

- August 10, 2016 – This EF-0 tornado caused $15,000 in property damage in Southern New Haven County. The property damage was mainly caused by trees that fell onto power lines and cars.

- May 15, 2018 - Two EF1 tornadoes led to widespread wind damage across southern Connecticut, resulting in power outages, blocked roadways, and school and business closures. The first of the tornados touched down in Southbury and continued southeast into Oxford, leaving a path of 4.2 miles and had wind gusts of 100 mph. The second tornado touched down in Beacon Falls and continued to move west to Hamden. It had maximum wind gusts of 110 mph while traveling a length of 9.5 miles.

FEMA Disaster Declarations

Between 1954 and 2017, Connecticut was included in two FEMA declared tornado-related disasters (DR) or emergencies (EM). Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. Since the 2013 State HMP, Connecticut has not been included in any additional declarations (EM or DR).[160]

2.23.8 Probability of Future Events

Since tornadoes occur on such small spatial scales and are a product of current weather patterns (they can occur with very little warning), it is difficult to provide a detailed and highly specific predictive analysis for this type of hazard event. Table 2-84 summarizes the probability of future events by county (NCEI annualized events), which was used to analyze future probability and losses.

Table 2-84: NCEI Annualized Events and Losses for Tornado, 1950-2017

[160] https://www.fema.gov/disasters

County	Annualized Events	Annualized Damages (2017 Dollars)
Fairfield	0.28	$131,246
Hartford	0.29	$13,296,332
Litchfield	0.47	$1,560,107
Middlesex	0.13	$36,230
New Haven	0.26	$8,520,115
New London	0.06	$0
Tolland	0.16	$45,498
Windham	0.04	$85,329
Total	*	$23,674,857

*Note: event totals were not included because NCEI events may be counted more than once if one storm event affects multiple counties. This duplication renders totals inaccurate.

In general, the pattern of occurrence and potential locations for tornadoes to occur in Connecticut is expected to remain relatively unchanged in the 21st Century. Based on NOAA's historical data, the northwest area of the state, namely Litchfield and Hartford counties, have the highest historical incidences of tornadoes and therefore may be considered to have a higher risk for the occurrence of future tornadoes. The second area of moderate to high risk based on historical occurrences is in Fairfield and New Haven counties. The counties of Middlesex, Tolland, and Windham have a moderate risk, while the counties of Windham and New London may be considered to have a low risk since tornadoes have historically occurred less frequently than in other counties in the state.

2.23.9 Climate Change Impacts

In the United States, more than one-third of the $1 billion weather disasters over the last 25 years were due to tornado and severe thunderstorm events. Additionally, damages from these events have undergone the largest increase since 1980. While historic reporting of these events has been determined by visual sightings or post-storm damage assessments and that reporting has been susceptible to changes in population density, modifications to reporting procedures and training, the introduction of video and social media, and so on, judicious use of the report database has revealed important information about tornado trends. Since the 1970s, the United States has experienced a decrease in the number of days per year on which tornadoes occur, but an increase in the number of tornadoes that form on such days. One important implication is that the frequency of days with large numbers of tornadoes—tornado outbreaks—appears to be increasing. The extent of the season over which such tornado activity occurs is increasing as well: although tornadoes in the United States are observed in all months of the year, an earlier calendar-day start to the season of high activity is emerging. In general, there is more interannual variability, or volatility, in tornado occurrence.

Figure 2-47 shows the annual tornado activity in the United States over the period 1955-2013. The black squares indicate the number of days per year with at least one tornado rated (E)F1 or greater, and the black circles and line show the decadal mean line of such tornado days. The red triangles indicate the number of days per year with more than 30 tornadoes rated (E)F1 or greater, and the red circles and line show the decadal mean of these tornado outbreaks.[161]

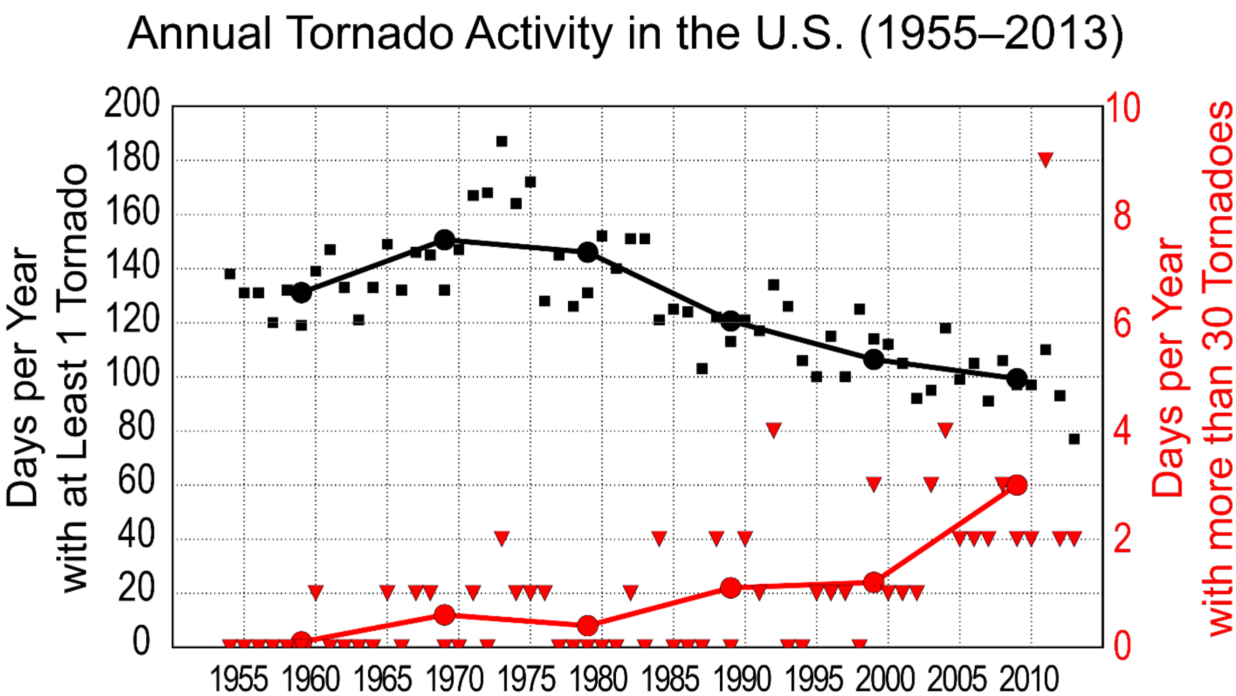


Figure 2-47: Annual Tornado Activity in the U.S., 1955 – 2013

2.24 Tornado Vulnerability Assessment

Tornadoes in Connecticut are expected to continue to occur more frequently in western and northwestern Connecticut, and less frequently in southeastern Connecticut. Although the frequency of tornadoes may be greater in western Connecticut, vulnerability may not be greatest in that part of the state due to relatively low population density. When the frequency and population density are combined, the highest vulnerability to damage exists in Hartford and New Haven counties. Even though tornadoes pose a real threat to public safety, their occurrence is not considered frequent enough in Connecticut to justify construction of tornado shelters at this time.

In lieu of a tornado shelter program, the State of Connecticut, through CT DEMHS, has chosen to provide NOAA weather radios to all public schools and many municipalities for

[161] Climate Science Special Report, Fourth National Climate Assessment (NCA4), Volume 1, Chapter 9: Extreme Storms

use in local government buildings. These radios are tuned into the NWS radio frequencies. When weather warnings are given by the NWS, the schools and local communities receive immediate notification of a storm event. Based on the type of warning provided, residents are advised to seek shelter or take appropriate precautions as directed by the NWS. NOAA radios have proven to be very popular with communities in Connecticut, as they serve to warn local populations of many types of weather events, not just tornado activity.

Advances in weather forecasting, use of Doppler radar and computer modeling have reduced the time for issuing tornado warnings and implementing tornado event preparations by local communities and the general public. However, warning times are still very short due to the nature of these types of events, and the impacts from tornado activity are still considered a significant threat to life and property.

The tornado risk for the 2019 update is based on probability of occurrence of past events. The density per 25-square miles indicates the probable number of tornado touchdowns for each 25-square mile cell within the contoured zone that can be expected over a similar period of record (nearly 70 years). It should be noted that the density number does not indicate the number of events that can be expected across the entire zone, but the percent probability of occurrence in the given area. The analysis indicated that the area at greatest risk for a tornado touchdown runs from southwestern to northern central Connecticut, with the greatest historical touch-down density located in predominately in Hartford County, Litchfield County, New Haven County, and Tolland County. Figure 2-48 illustrates the reported tornado occurrences, based on initial touch-down locations across the State. The number of historical tornado touch-downs per 25-square miles was generated using the NOAA Storm Prediction Center's dataset through 2016 (2017 data were not available at the time of the 2019 Plan update). To calculate density, the ArcGIS kernel density tool was used.

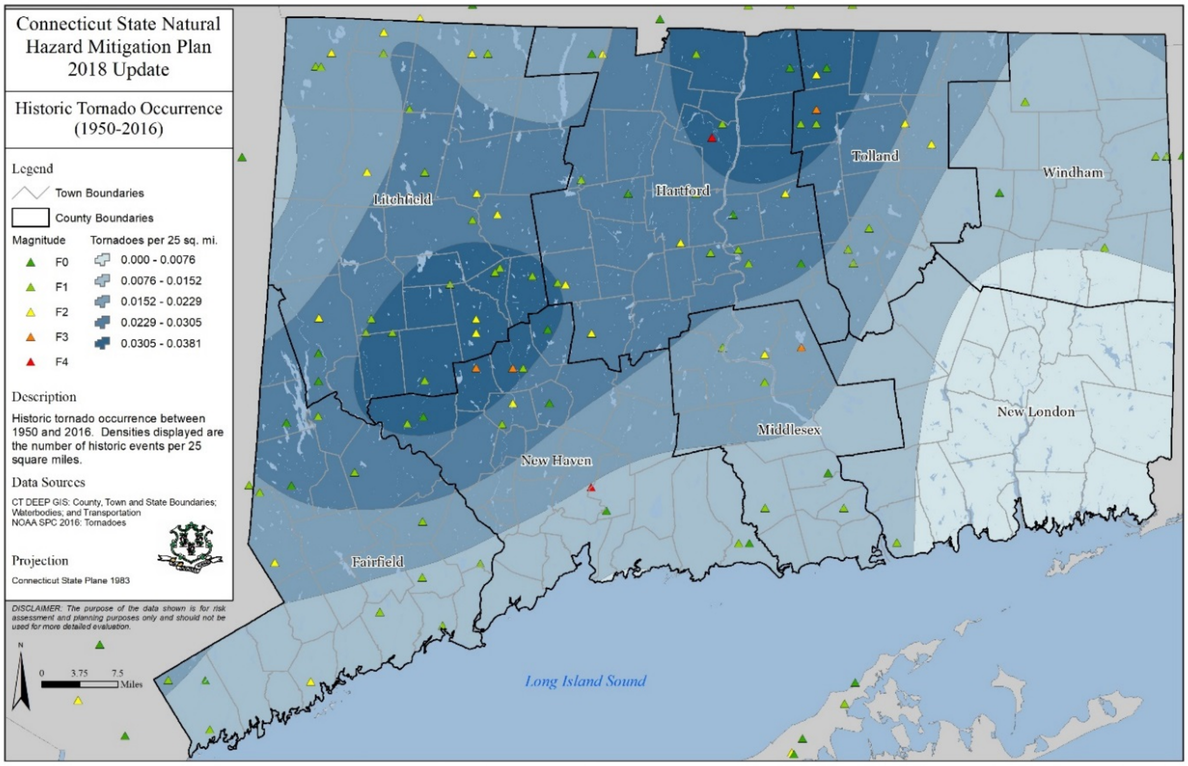


Figure 2-48 Historic Tornado Frequency Analysis per Square Mile (1950-2016)

Table 2-5 includes the number of infrastructure/facilities, building value and contents value by municipality. There are 3,327 mapped state-owned facilities. Based on a combination of the 2013 JESTIR database and Connecticut Open Data, the estimated total value of state buildings is $5.6 billion, with over $866 million in content value. The State's total building and contents value only includes those buildings where value information was available and is intent for use in this plan and should not be used for other applications. The state contains 1,940 identified critical facilities in the categories of correctional institutions, EMS facilities, fire stations, gas stations with generator, health departments, law enforcement facilities, municipal solid waste, nuclear power plants, and storage tank farms. 1,846 of these critical facilities were able to be geospatially mapped for analysis.

Appendix 2 includes the infrastructure and facilities datasets, as well as the loss estimates by municipality for facilities located within the known hazard geographic extents. Tornadoes can occur anywhere in the State, and therefore all State buildings and local assets are exposed to tornadoes; however, for the purposes of this 2019 Plan Update, the calculated high-density tornado areas were used to estimate potential impacts. As the State of Connecticut continues to become more urbanized, the State facilities will need to be developed in locations that will serve the growing population.

2.24.1 Assessment of State Vulnerability and Potential Losses

All State-owned facilities and critical facilities are exposed to the tornado events. To assess the vulnerability of state-owned facilities provided by Connecticut DCS, an analysis was conducted using historic tornado touch-down densities. Using ArcGIS, the area of greatest historical tornado density (0.030 to 0.038) was overlaid on the State-owned facilities and critical facilities for Connecticut. Facilities located within the high tornado probability area are more likely vulnerable to the tornado hazard than other facilities in the State.

Table 2-85 and Table 2-86 provide a breakdown of the numbers and values of state-owned buildings intersecting the high tornado probability area by county. A total of 578 state-owned buildings (17.4-percent of the total number of state-owned buildings in the state) are located within the high-density zone. This amounts to a total of $231 million in building values vulnerable to the tornado hazard (3.6-percent of the total value of all state-owned buildings in the state). The remaining 2,749 state facilities are in low tornado probability areas (<0.030).

Table 2-85: Number of State-Owned Facilities in the High Tornado Probability Area, by County

County	Total State-Owned Buildings	High Tornado Probability Area (0.030-0.038)	Low Tornado Probability Area (<0.030)
Fairfield	205	0	205
Hartford	867	372	495
Litchfield	97	0	97
Middlesex	289	0	289
New Haven	561	165	396
New London	489	0	489
Tolland	628	40	588
Windham	191	0	191
Total	3,327	578	2,749

Table 2-86: Value of State-Owned Facilities in the High Tornado Probability Area, by County

County	Total State-Owned Buildings	High Tornado Probability Area (0.030-0.038)	Low Tornado Probability Area (<0.030)
Fairfield	$328,049,014	$0	$328,049,014
Hartford	$2,482,445,429	$48,837,342	$2,433,608,087
Litchfield	$55,774,193	$0	$55,774,193
Middlesex	$411,474,322	$0	$411,474,322
New Haven	$824,597,613	$102,689,434	$721,908,179
New London	$98,537,626	$0	$98,537,626
Tolland	$2,016,260,747	$79,202,954	$1,937,057,793
Windham	$253,657,976	$0	$253,657,976
Total	$6,470,796,920	$230,729,729	$6,240,067,191

Table 2-87 provides a breakdown of the numbers of critical facilities intersecting the high tornado probability area by county. A total of 192 critical facilities (10.4-percent of the total number of critical facilities in the state) are located within the high tornado probability area.

Table 2-87: Number of Critical Facilities in the High Tornado Probability Area by County and Agency

County/Facility Types	All Critical Facilities	# within High Tornado Probability Area	Percent within High Tornado Probability Area	# within Low Tornado Probability Area	Percent within Low Tornado Probability Area
Fairfield					
Correctional Institutions	4	0	0.0-percent	4	100.0-percent
EMS	120	0	0.0-percent	120	100.0-percent
Fire Stations	115	0	0.0-percent	115	100.0-percent
Gas Station with Generator	22	0	0.0-percent	22	100.0-percent
Health Departments	25	0	0.0-percent	25	100.0-percent
Law Enforcement	35	0	0.0-percent	35	100.0-percent
Municipal Solid Waste	43	0	0.0-percent	43	100.0-percent
Nuclear Power Plant	0	0	0.0-percent	0	100.0-percent
Storage Tank Farm	7	0	0.0-percent	7	100.0-percent
Total for Fairfield	**371**	**0**	**0.0-percent**	**371**	**100.0-percent**
Hartford					
Correctional Institutions	6	4	66.7-percent	2	33.3-percent
EMS	80	23	28.8-percent	57	71.3-percent
Fire Stations	141	30	21.3-percent	111	78.7-percent
Gas Station with Generator	10	2	20.0-percent	8	80.0-percent
Health Departments	26	3	11.5-percent	23	88.5-percent
Law Enforcement	44	9	20.5-percent	35	79.5-percent
Municipal Solid Waste	62	8	12.9-percent	54	87.1-percent
Nuclear Power Plant	0	0	0.0-percent	0	0.0-percent
Storage Tank Farm	8	3	37.5-percent	5	62.5-percent
Total for Hartford	**377**	**82**	**21.8-percent**	**295**	**78.2-percent**
Litchfield					
Correctional Institutions	0	0	0.0-percent	0	0.0-percent
EMS	34	9	26.5-percent	25	73.5-percent

Fire Stations	53	12	22.6-percent	41	77.4-percent
Gas Station with Generator	8	2	25.0-percent	6	75.0-percent
Health Departments	7		0.0-percent	7	100.0-percent
Law Enforcement	25	6	24.0-percent	19	76.0-percent
Municipal Solid Waste	29	14	48.3-percent	15	51.7-percent
Nuclear Power Plant	0	0	0.0-percent	0	0.0-percent
Storage Tank Farm	0	0	0.0-percent	0	0.0-percent
Total for Litchfield	**156**	**43**	**27.6-percent**	**113**	**72.4-percent**
Middlesex					
Correctional Institutions	1	0	0.0-percent	1	100.0-percent
EMS	31	0	0.0-percent	31	100.0-percent
Fire Stations	36	0	0.0-percent	36	100.0-percent
Gas Station with Generator	8	0	0.0-percent	8	100.0-percent
Health Departments	9	0	0.0-percent	9	100.0-percent
Law Enforcement	17	0	0.0-percent	17	100.0-percent
Municipal Solid Waste	21	0	0.0-percent	21	100.0-percent
Nuclear Power Plant	0	0	0.0-percent	0	100.0-percent
Storage Tank Farm	3	0	0.0-percent	3	100.0-percent
Total for Middlesex	**126**	**0**	**0.0-percent**	**126**	**100.0-percent**
New Haven					
Correctional Institutions	5	0	0.0-percent	5	1
EMS	76	6	7.9-percent	70	92.1-percent
Fire Stations	115	19	16.5-percent	96	83.5-percent
Gas Station with Generator	23	2	8.7-percent	21	91.3-percent
Health Departments	26	5	19.2-percent	21	80.8-percent
Law Enforcement	42	8	19.0-percent	34	81.0-percent
Municipal Solid Waste	45	6	13.3-percent	39	86.7-percent
Nuclear Power Plant	0	0	0.0-percent	0	0.0-percent
Storage Tank Farm	10	0	0.0-percent	10	100.0-percent

Total for New Haven	**342**	**0**	**0.0-percent**	**296**	**100.0-percent**
New London					
Correctional Institutions	1	0	0.0-percent	1	100.0-percent
EMS	77	0	0.0-percent	77	100.0-percent
Fire Stations	68	0	0.0-percent	68	100.0-percent
Gas Station with Generator	7	0	0.0-percent	7	100.0-percent
Health Departments	14	0	0.0-percent	14	100.0-percent
Law Enforcement	33	0	0.0-percent	33	100.0-percent
Municipal Solid Waste	39	0	0.0-percent	39	100.0-percent
Nuclear Power Plant	1	0	0.0-percent	1	100.0-percent
Storage Tank Farm	2	0	0.0-percent	2	100.0-percent
Total for New London	**242**	**0**	**0.0-percent**	**242**	**100.0-percent**
Tolland					
Correctional Institutions	3	2	66.7-percent	1	33.3-percent
EMS	35	4	11.4-percent	31	88.6-percent
Fire Stations	37	4	10.8-percent	33	89.2-percent
Gas Station with Generator	2	1	50.0-percent	1	50.0-percent
Health Departments	4	3	75.0-percent	1	25.0-percent
Law Enforcement	11	2	18.2-percent	9	81.8-percent
Municipal Solid Waste	22	5	22.7-percent	17	77.3-percent
Nuclear Power Plant	0	0	0.0-percent	0	0.0-percent
Storage Tank Farm	0	0	0.0-percent	0	0.0-percent
Total for Tolland	**114**	**21**	**18.4-percent**	**93**	**81.6-percent**
Windham					
Correctional Institutions	1	0	0.0-percent	1	100.0-percent
EMS	43	0	0.0-percent	43	100.0-percent
Fire Stations	40	0	0.0-percent	40	100.0-percent
Gas Station with Generator	2	0	0.0-percent	2	100.0-percent
Health Departments	3	0	0.0-percent	3	100.0-percent

Law Enforcement	12	0	0.0-percent	12	100.0-percent
Municipal Solid Waste	17	0	0.0-percent	17	100.0-percent
Nuclear Power Plant	0	0	0.0-percent	0	100.0-percent
Storage Tank Farm	0	0	0.0-percent	0	100.0-percent
Total for Windham	**118**	**0**	**0.0-percent**	**118**	**100.0-percent**
Total for Connecticut	**1,846**	**192**	**10.4-percent**	**1,654**	**89.6-percent**

2.24.2 Assessment of Local Vulnerability and Potential Losses

The impact of tornado events on life, health and safety is dependent upon several factors including the severity of the event and if adequate warning time was provided to residents. The entire population of Connecticut (3,574,097 people) is exposed to the tornado hazard (U.S. Census Bureau, 2010).

Unfortunately, some tornadoes strike with little or no warning and residents must act quickly. The following populations are more vulnerable to a tornado or other type of wind or severe storm event: 1) population located in communities without, or having ineffective, early warning systems; 2) population with functional needs and/or over the age of 65 because they may have more difficulty evacuating or seeking shelter; 3) economically disadvantaged populations because they are likely to evaluate their risk and make decisions based on the major economic impact to their family and may not have funds to evacuate; 4) population with a language barrier unable to follow warning messages; 5) population in mobile homes; and 5) population in automobiles at the time of a tornado. The elderly and functional needs populations are considered most vulnerable because they require extra time or outside assistance to seek shelter and are more likely to seek or need medical attention, which may not be available due to isolation during and/or after an event.

Residents may be displaced or require temporary to long-term sheltering. In addition, downed trees, damaged buildings and debris carried by high winds can lead to injury or loss of life. Socially vulnerable populations are most susceptible, based on a number of factors including their physical and financial ability to react or respond during a hazard and the location and construction quality of their housing.

Tornadoes in Connecticut are expected to continue to occur more frequently in western and northwestern Connecticut. When the frequency and population density are combined, the highest vulnerability to damage exists in Hartford and New Haven counties. The lowest vulnerability to tornado damage will likely continue to be along the southeast coast. Although this area is very densely populated, the frequency of tornado activity is low with only one confirmed tornado during the past 30 years in New London County.

To estimate potential losses by jurisdiction, the exposure analysis methodology was used. Similar to the analysis conducted for State-owned facilities and critical facilities, the 2010 U.S. census blocks intersecting the area of greatest historical tornado density (0.030 to 0.038) are listed in Table 2-88. This analysis was conducted by intersecting the 2010 U.S. census blocks with the high-density tornado area using GIS. In instances where only a portion of the census block intersected the hazard area, only that same portion of the population is counted. For example, if 20-percent of the census block intersects with an intermix area, only 20-percent of the population number for that census block group is counted). This results in estimated values and there is potential for error with this methodology, but this is considered a more refined approach than assuming 100-percent of the population is contained within the 20-percent of the census block that intersects the hazard area. The total population at risk is estimated at 417,866, which is 11.7 percent of the total population of the state.

Table 2-88. Population Intersecting the Tornado Probability Area.

County	Total Population	Population Intersecting the High Tornado Probability Area (0.030-0.038)	Population Intersecting the Low Tornado Probability Area (<0.030)
Fairfield	916,829	8	916,821
Hartford	894,014	129,405	764,609
Litchfield	189,927	63,580	126,347
Middlesex	165,676	70,408	95,268
New Haven	862,477	114,787	747,690
New London	274,055	0	274,055
Tolland	152,691	39,677	113,014
Windham	118,428	0	118,428
Total	3,574,097	417,866	996,614

2.24.3 Changes in Development

An understanding of population and development trends can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The State considered the following factors to examine previous and potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population

- Other identified conditions as relevant and appropriate

Since tornadoes can occur anywhere in the State, any new development and increases in population will be vulnerable to the impacts from these events. As discussed in Section 1.2.4 (Land Use and Development), Fairfield County and Hartford County continue to see the majority of development. As of 2016, approximately 65.7% of the building permits statewide were in Fairfield and Hartford Counties, and both of these counties accounted for nearly half of all the housing units in the State. If recent trends in development continue, these two Counties will continually increase their vulnerability to tornadoes. As discussed in the Hazard Profile, Litchfield and Hartford County have the highest historical incidences of tornadoes and may be considered to have a higher risk for tornadoes, and Fairfield County and New Haven County have the second highest risk based on historical events. Statewide, there is an estimated 2.2% change in population expected between 2020 and 2040; the increases in population will increase the State population's vulnerability to tornadoes.

2.24.4 Hazard Ranking

Quantitative risk assessment, to the degree possible, has been completed for tornados using the methodology described in the Hazard Analysis and Ranking methodology Section 2.6 of this chapter. Scores for each jurisdiction were calculated based on population, building permits, geographic extent, average score from local plan rankings, average hazard concern, and measures of historical impact including injuries and deaths, property damage, and the number of reported events. The number of impacted critical facilities was also incorporated, and ranked based on the number of facilities impacted in relation to the number of total critical facilities in Connecticut. As shown in Table 2-89, the composite tornado rank shows Fairfield and Hartford Counties as high risk; Litchfield and New Haven Counties as medium-high risk; Middlesex County as medium risk; Tolland and Windham Counties as medium-low risk; and New London County as low risk.

Table 2-89: Hazard Ranking by County for Tornado

County	Hazard Concern Rank	Local Plans Hazard Rank	Geographic Extent Rank	Population Density Rank	Building Permits Rank	Facility Intersect Rank	Ann. Events Rank	Ann. Losses Rank	Injury & Death Rank	Composite Ranks
Fairfield	High	Medium-High	High	High	High	Low	High	Medium-High	High	**High**
Hartford	High	Medium-High	High	High	High	Low	High	Medium-High	High	**High**
Litchfield	High	Medium-High	Medium-High	Low	Low	Low	High	Medium	High	**High**
Middlesex	High	Medium-High	Medium	Medium-Low	Medium-Low	Low	High	Medium-Low	Low	**Medium**
New Haven	High	Medium-High	Medium-High	High	Medium	Low	High	Medium-Low	High	**High**

County	Hazard Concern Rank	Local Plans Hazard Rank	Geographic Extent Rank	Population Density Rank	Building Permits Rank	Facility Intersect Rank	Ann. Events Rank	Ann. Losses Rank	Injury & Death Rank	Composite Ranks
New London	High	Medium-High	Medium-Low	Medium-Low	Medium-Low	Low	High	Medium-Low	High	**Medium-High**
Tolland	High	Medium-High	Medium	Medium-Low	Medium-Low	Low	High	Medium-Low	Medium-Low	**Medium**
Windham	High	Medium-High	Medium-Low	Medium-Low	Low	Low	High	Medium-Low	Low	**Medium**

2.25 Tropical Cyclone Hazard Profile

2019 Plan Update Changes

- The hazard profile has been significantly enhanced to include a detailed hazard description, location, extent, impact (severity, warning time, and secondary impacts), previous occurrences, probability of future occurrence, and potential change in climate and its impacts on the tropical cyclone hazard is discussed.
- Previous occurrences were updated with events that occurred between 2013 and 2017.
- Included increase in surge information including difference between storm surge and storm tide
- Included reference to similar impacts from sub-tropical, extra-tropical, and post-tropical cyclones
- Included updated historic hurricane track map for the State of Connecticut

2.25.1 Hazard Description

A tropical cyclone is a rotating, organized system of clouds and thunderstorms that originates over tropical or sub-tropical waters and has a closed low-level circulation. Tropical depressions, tropical storms, and hurricanes are all considered tropical cyclones. These storms rotate counterclockwise in the northern hemisphere around the center and are accompanied by heavy rain and strong winds.[162] Almost all tropical storms and hurricanes in the Atlantic basin (which includes the Gulf of Mexico and Caribbean Sea) form between June 1 and November 30 (hurricane season). August and September are peak months for hurricane development. September is typically the most active month for tropical cyclones in Connecticut. The average wind speeds for tropical storms and hurricanes are listed below:

- A tropical depression has a maximum sustained wind speeds of 38 miles per hour (mph) or less
- A tropical storm has maximum sustained wind speeds of 39 to 73 mph
- A hurricane has maximum sustained wind speeds of 74 mph or higher. In the western North Pacific, hurricanes are called typhoons; similar storms in the Indian Ocean and South Pacific Ocean are called cyclones.
- A major hurricane has maximum sustained wind speeds of 111 mph or higher.[162]

[162] Nation Weather Service (NWS). 2013. "Tropical Cyclones: A Preparedness Guide." April. On-Line Address: http://www.nws.noaa.gov/os/hurricane/resources/TropicalCyclones11.pdf

Figure 2-49 shows a diagram of the anatomy of a tropical cyclone (hurricane) which consists of:

1. An eye – the center of a hurricane which is the calmest part of the storm, and is typically 20-40 miles across;

2. An eye wall – surrounds the eye and consists of a ring of tall thunderstorms that produce heavy rains and usually the strongest winds; and

3. Rain bands – curved bands of clouds and thunderstorms that rail away from the eye wall in a spiral fashion. Rain bands are capable of producing high winds, heavy outburst of rain and tornadoes.

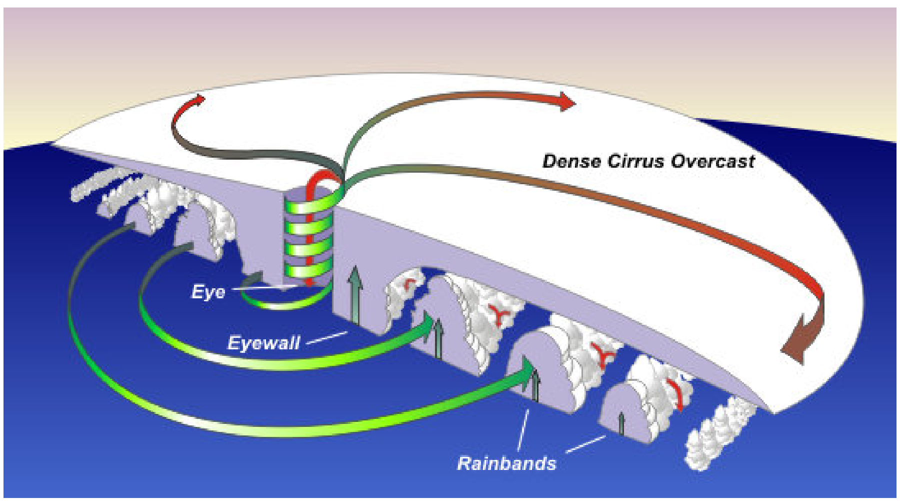


Figure 2-49. Diagram of a Tropical Cyclone (Hurricane), Weather.gov

There are several environmental conditions which must be present for a tropical cyclone to form:[163]

1. Warm ocean waters (at least 80^{o}F) throughout a depth of about 150 feet;

2. An atmosphere which cools fast enough with height such that it is potentially unstable to moist convection;

3. Relatively moist air near the mid-level of the troposphere;

4. A minimum 300 mile distance from the equator;

5. A pre-existing near surface disturbance; and

6. Low values of vertical wind shear (change in wind speed with height) between the surface and the upper troposphere.

[163] Source: NOAA website.

Storm Surge

Tropical storms and hurricanes are typically accompanied by a storm surge, an abnormal local rise in sea level. The storm surge is caused by several factors including:

1. Storm intensity (wind speed)
2. Storm size (radius of the wind field)
3. Storm speed (forward motion)
4. Storm direction (at what angle a storm makes landfall)
5. Bathymetry (shelves and channels in the coastal sea floor)
6. Coastal features (shape of the coastline)
7. Barometric pressure (interaction between low pressure at the core of a storm and higher pressure in surrounding area)

Barometric pressure has often been identified as the primary cause of storm surge. However, it is only responsible for around 5% of the storm surge value.[164] Because of the variety of factors that can influence storm surge, stronger hurricanes do not always correlate with larger storm surges and even weaker systems can result in dramatic storm surge events.

No matter the precise cause and factors of storm surge, the end result is that water is pushed onto a coastline. The height of the surge is measured as the deviation from predicted astronomical tides and can reach over 25 feet in extreme circumstances. Storm tide is the combination of storm surge and astronomical tide. Astronomical tides can amplify or dampen the impact of a storm surge. A storm surge arriving at low astronomical tide will have less impact than a storm surge arriving at high astronomical tide. A diagram of storm surge and storm tide is shown below in Figure 2-50.

[164] https://www.nhc.noaa.gov/surge/surge_intro.pdf

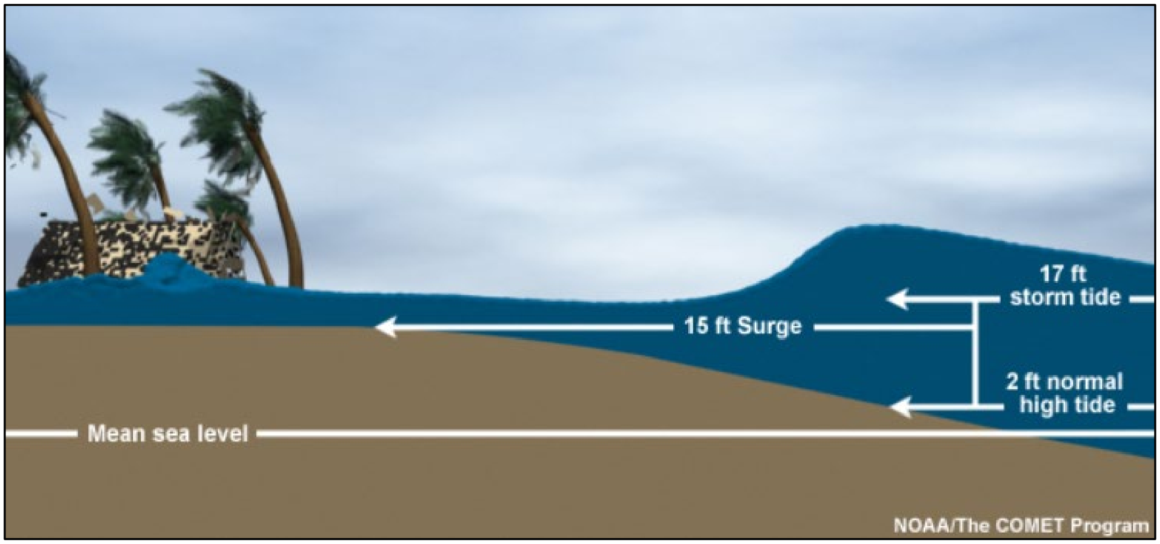


Figure 2-50: Storm Surge vs Storm Tide

2.25.2 Location

Hurricanes are a very real and costly hazard to Connecticut. Based on historic events and storm scenario simulations generated with Hazus, the information shows that the entire state of Connecticut is vulnerable to the impacts of such an event. Connecticut is located along the Atlantic coastline and has experienced all three types of tropical cyclone systems including some of the worst hurricanes to make landfall within the United States

The location of the damage varies greatly depending on the track, intensity and duration of the tropical cyclone. While storm surge and wave impacts are limited to low elevations near the coast, damaging winds and heavy rain associated with tropical cyclones can impact the entire state. Riverine flooding caused by heavy rain can impact the state's rivers with amplification near the coast by storm surge.

NOAA's Historical Hurricane Tracks tool is a public interactive mapping application that displays Atlantic Basin and East-Central Pacific Basin tropical cyclone data. This interactive tool catalogs tropical cyclones that have occurred from 1842 to 2016 (latest date available from data source). Between 1842 and 2016, Connecticut has experienced 34 tropical cyclone events. These events tracked within 50 nautical miles of the State. Figure 2-51 shows historic tracks for significant tropical storms and hurricanes within 50 nautical miles that have impacted Connecticut.[165]

[165] Source: NOAA website, interactive mapping tool. https://coast.noaa.gov/digitalcoast/tools/hurricanes

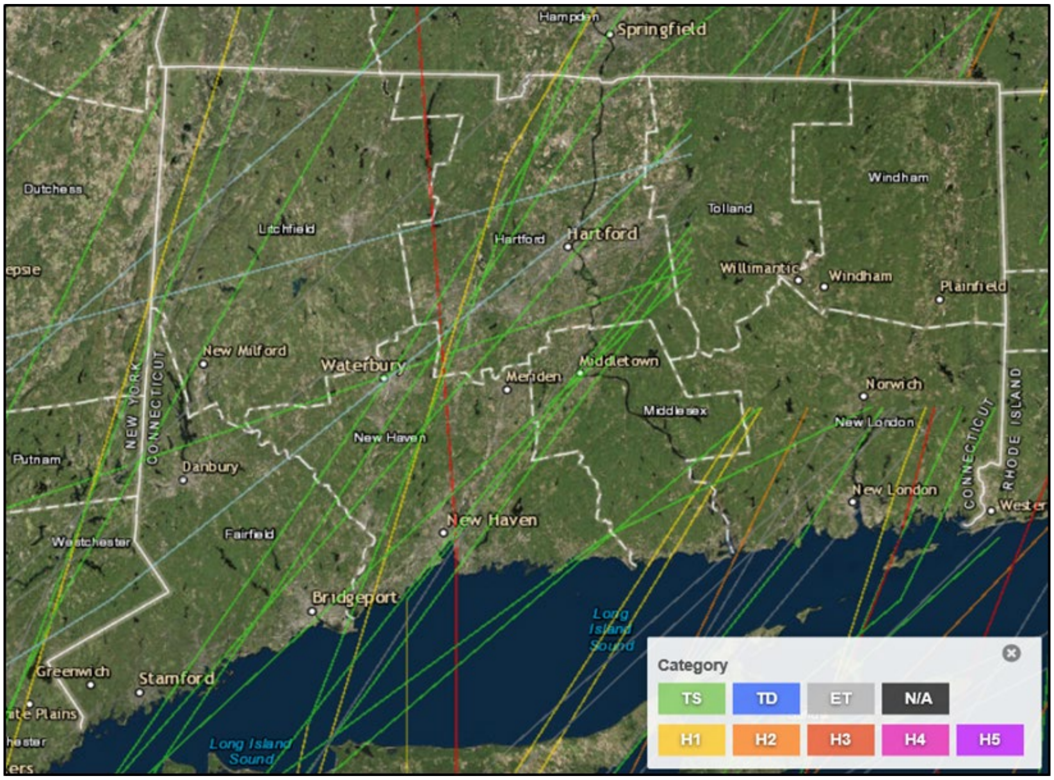


Figure 2-51 Tropical Cyclone Tracks 1856 - 2016

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

U.S. Army Corp of Engineers' (USACE) Sea, Lake, and Overland Surges from Hurricanes (SLOSH) study is especially useful for flood risk analysis on a regional and local level. The SLOSH computer program is a numerical computer model, developed by the NWS, for the USACE, and designed to forecast the rise in water level caused by the wind and pressure forces of a hurricane. This rise in the water surface, which accompanies a hurricane, is referred to as the storm surge. The SLOSH model computes the storm surge over water and along the coastline and extends the computations inland over the coastal flood plain. The results of the model can be utilized along with topographic information to determine hurricane flood inundation zones. The SLOSH model calculates four inundation zones. The four zones correspond to Hurricane Categories I & II, III, and IV respectively on the Saffir/Simpson scale.

The SLOSH model is used to evaluate the potential impact of storm surge. Emergency managers use data from SLOSH to identify at-risk populations and determine evacuation areas. Storm surges also affect tidal rivers and creeks, potentially increasing evacuation areas. Figure 2-52 indicates the potential inland extent of storm surge as a function of hurricane category. It is readily apparent from this figure that Connecticut has significant vulnerability to storm surge. Figure 2-53 and Figure 2-54 show the hurricane storm surge zones for Bridgeport and New London, as examples of a localized view of the storm surge maps.

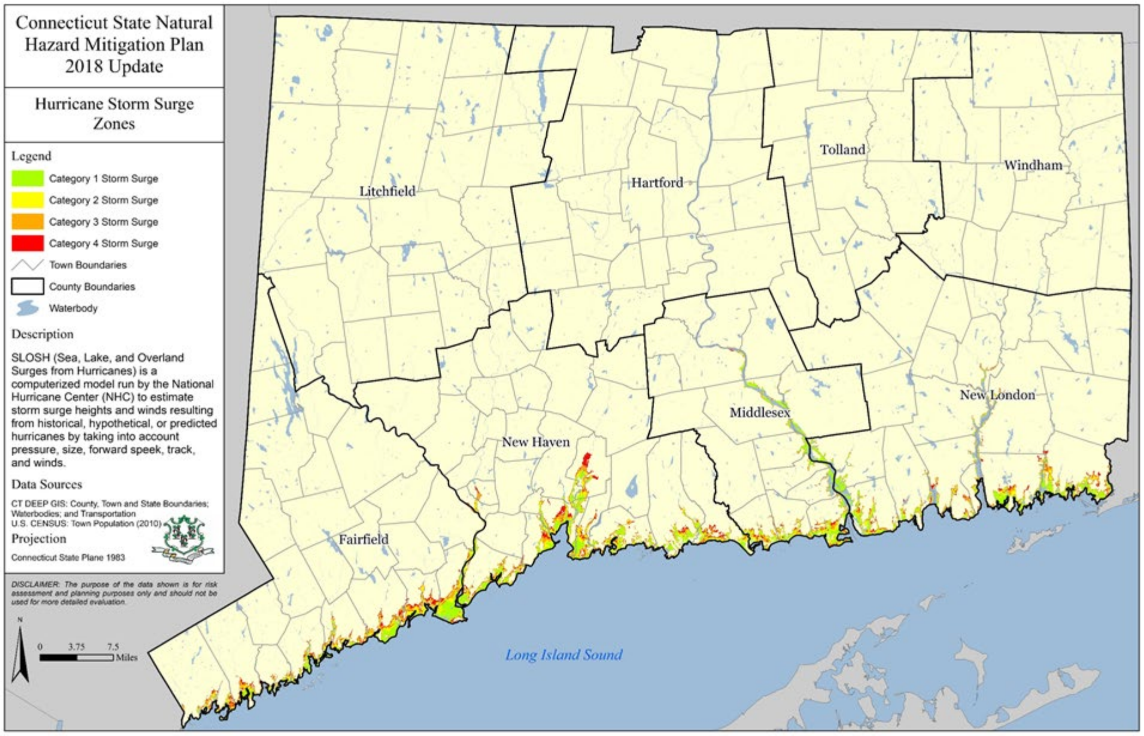


Figure 2-52 Potential Storm Surge Inundation by Hurricane Category

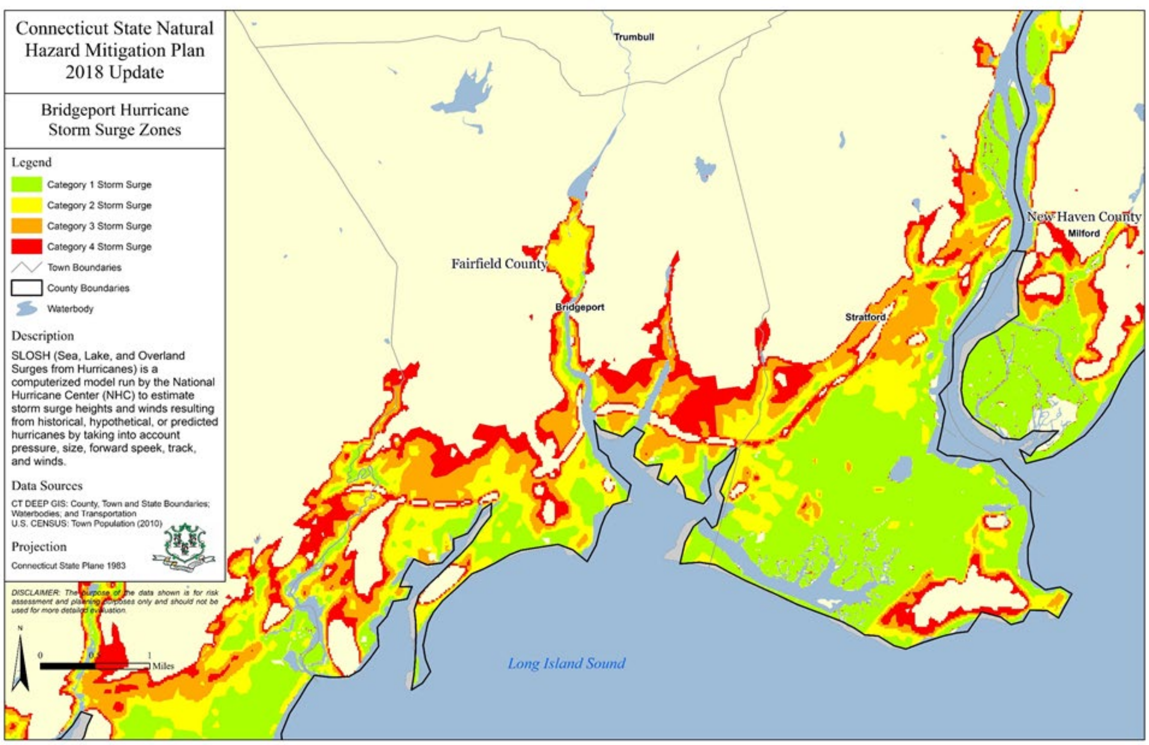


Figure 2-53 Bridgeport Hurricane Storm Surge Zones

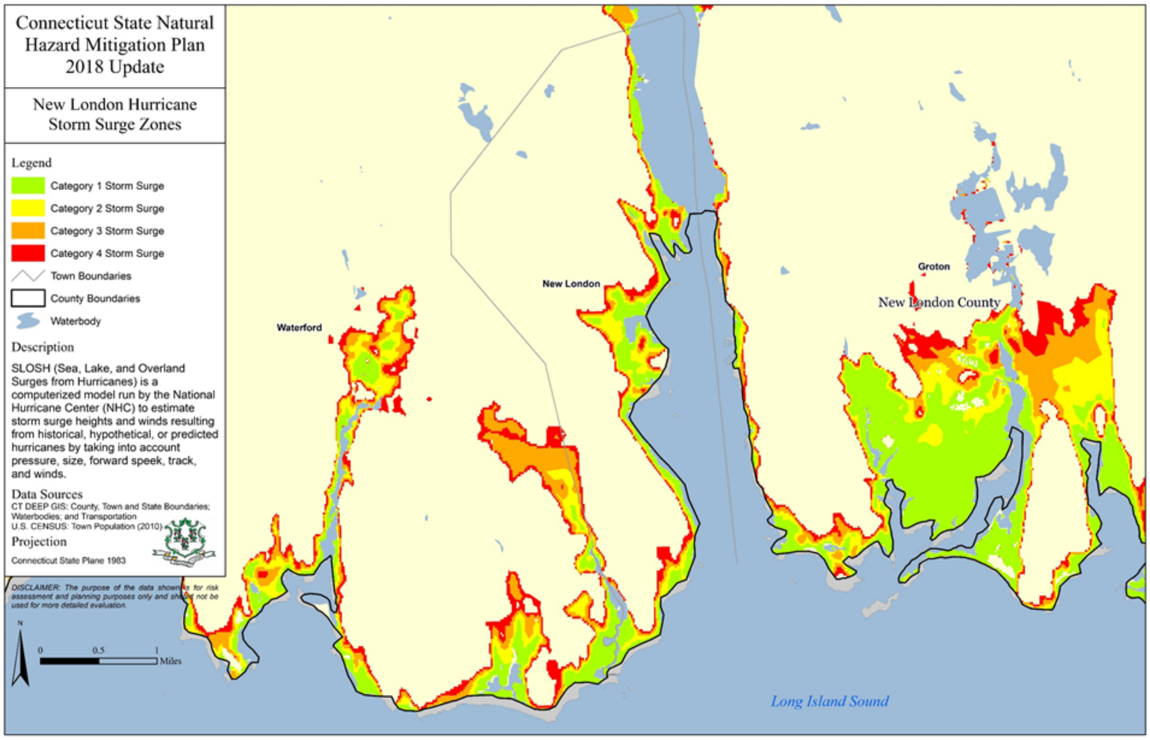


Figure 2-54 New London Hurricane Storm Surge Zones

In March 2016 FEMA and USACE completed the Connecticut Hurricane Evacuation Study Technical Data Report with an Evacuation Map Atlas and an Inundation Map Atlas (utilizing the NWS' SLOSH model). This study served as a decision-making tool which provided information on the extent and severity of potential flooding from hurricanes, the associated vulnerable population, capacity of shelters, estimated sheltering requirements, and evacuation time. This information has been provided to municipalities for local hazard mitigation plans.

DEMHS has updated information on public shelters, medical and institutional facilities, and mobile home parks in the 25 coastal municipalities and produced updated Evacuation and Inundation Maps located at http://www.ct.gov/demhs/cwp/view.asp?a=4490&q=596222. The State and its municipalities use the study and maps to plan for a possible evacuation.

Inundation from storm surge can have devastating impacts on the State's coastal communities. The United States Army Corps of Engineers (USACE), in cooperation with FEMA, initially prepared Sea, Lake and Overland Surge from Hurricanes (SLOSH) inundation maps. The SLOSH model is used to evaluate the potential impact of storm surge. Emergency managers use data from SLOSH to identify at-risk populations and determine evacuation areas. Storm surges also affect tidal rivers and creeks, potentially increasing evacuation areas. Figure 2-55 provides an example of a SLOSH map for Bridgeport.

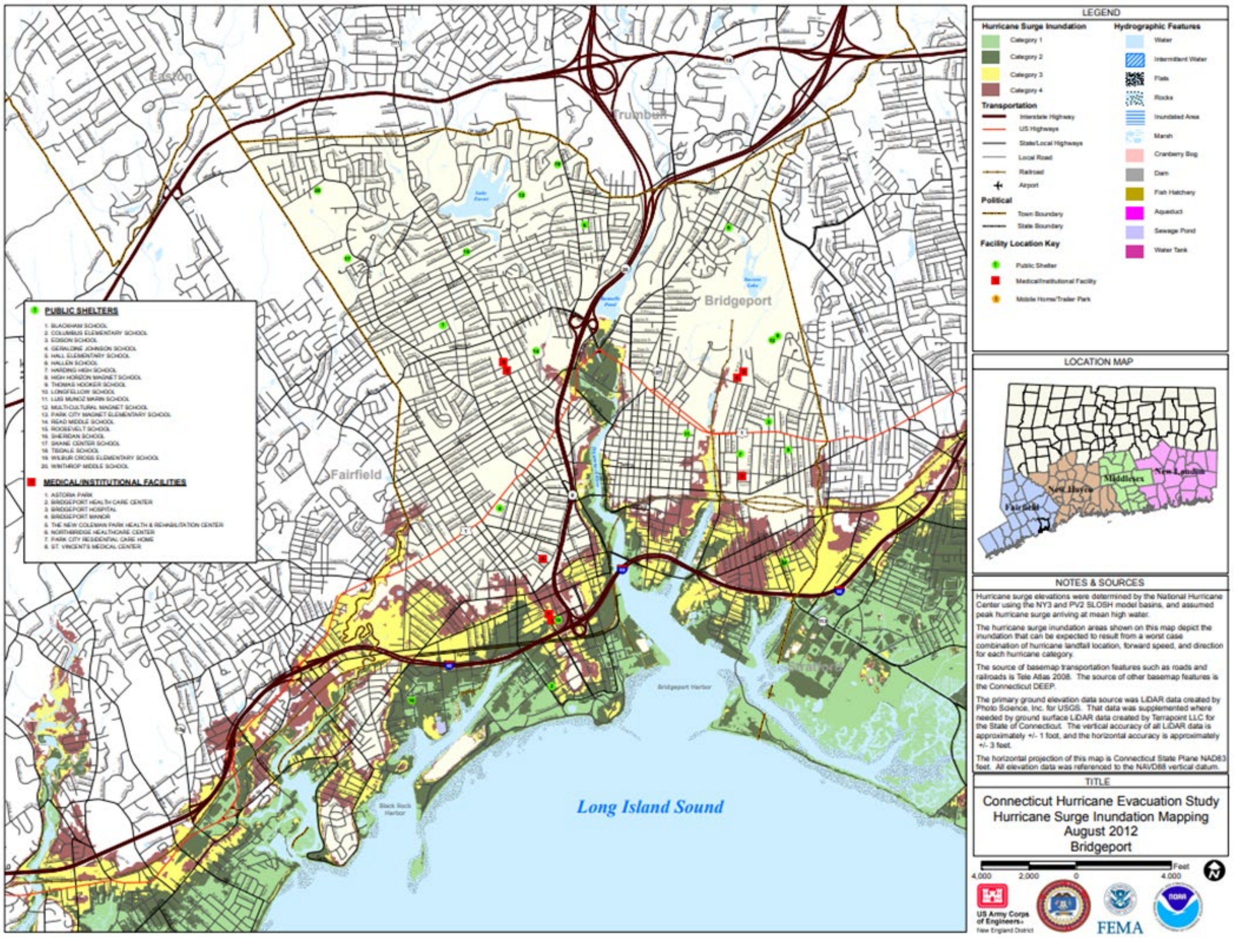


Figure 2-55 Example of the State of Connecticut SLOSH Map: Bridgeport

2.25.3 Extent

The extent of a hurricane is categorized in accordance with the Saffir-Simpson Hurricane Scale. The Saffir/Simpson scale (Table 2-90) was developed in 1971 by Herbert Saffir and Dr. Robert Simpson as a way to classify hurricanes. The scale rates the intensity of hurricanes based on wind speed and barometric pressure measurements. The scale gives an indication of the potential flooding and wind damages associated with each hurricane category. Prior to 2009 hurricane season, hurricanes were categorized by the Saffir-Simpson Hurricane Scale that incorporated central pressure and storm surge as components of the categories. Due to criticisms and confusion regarding this practice, in 2009, the scale was revised and is now called the Saffir-Simpson Hurricane Wind Scale.[166] This modified scale, which is more scientifically defensible, is predicated on maximum sustained wind speeds and removed both storm surge and central pressure as factors.

Table 2-90: Saffir/Simpson Scale

[166] http://www.nhc.noaa.gov/aboutsshws.php

Category	Wind Speed (mph)	Expected Damage
1 (weak)	74-95 mph (64-82kt)	Minimal Damage: Damage is primarily to shrubbery, trees, foliage, and unanchored mobile homes. No real damage occurs in building structures. Some damage is done to poorly constructed signs.
2 (moderate)	96-110 mph (83-95kt)	Moderate Damage: Considerable damage is done to shrubbery and tree foliage, some trees are blown down. Major structural damage occurs to exposed mobile homes. Extensive damage occurs to poorly constructed signs. Some damage is done to roofing materials, windows, and doors; no major damage occurs to the building integrity of structures.
3 (strong)	111-130 mph (96-113kt)	Extensive damage: Foliage torn from trees and shrubbery; large trees blown down. Practically all poorly constructed signs are blown down. Some damage to roofing materials of buildings occurs, with some window and door damage. Some structural damage occurs to small buildings, residences and utility buildings. Mobile homes are destroyed. There is a minor amount of failure of curtain walls (in framed buildings).
4 (very strong)	131-155 mph (114-135kt)	Extreme Damage: Shrubs and trees are blown down; all signs are down. Extensive roofing material and window and door damage occurs. Complete failure of roofs on many small residences occurs, and there is complete destruction of mobile homes. Some curtain walls experience failure.
5 (devastating)	Greater than 155 mph (>135kt)	Catastrophic Damage: Shrubs and trees are blown down; all signs are down. Considerable damage to roofs of buildings. Very severe and extensive window and door damage occurs. Complete failure of roof structures occurs on many residences and industrial buildings, and extensive shattering of glass in windows and doors occurs. Some complete buildings fail. Small buildings are overturned or blown away. Complete destruction of mobile homes occurs.

Mean Return Period

In evaluating the potential for hazard events of a given magnitude, a mean return period (MRP) is often used. The MRP provides an estimate of the magnitude of an event that may occur within any given year based on past recorded events. MRP is the average period of time, in years, between occurrences of a particular hazard event, equal to the inverse of the annual frequency of exceedance[167].

Figure 2-56 and Figure 2-57 show the estimated maximum three-second gust wind speeds that can be anticipated in the study area associated with the 100- and 1,000-year MRP events. These peak wind speed projections were generated using Hazards U.S. Multi-Hazard (HAZUS) model runs. The estimated hurricane track used for the 100- and 1,000-year event was not generated as an output for the HAZUS model. The maximum three-second gust wind speeds for the State equate to Category 1 hurricane speeds for the 100-year MRP event. The maximum three-second gust wind speeds for the State range from Category 1 to Category 3 hurricane speeds for the 1,000-year MRP event. The associated

[167] Dinicola 2009 MRPFederal Emergency Management Agency (FEMA). 2013. "Disaster Declarations." On-Line Address: http://www.fema.gov/disasters

impacts and losses from these 100-year and 1,000-year MRP hurricane event model runs are reported in the Vulnerability Assessment presented later in this section.

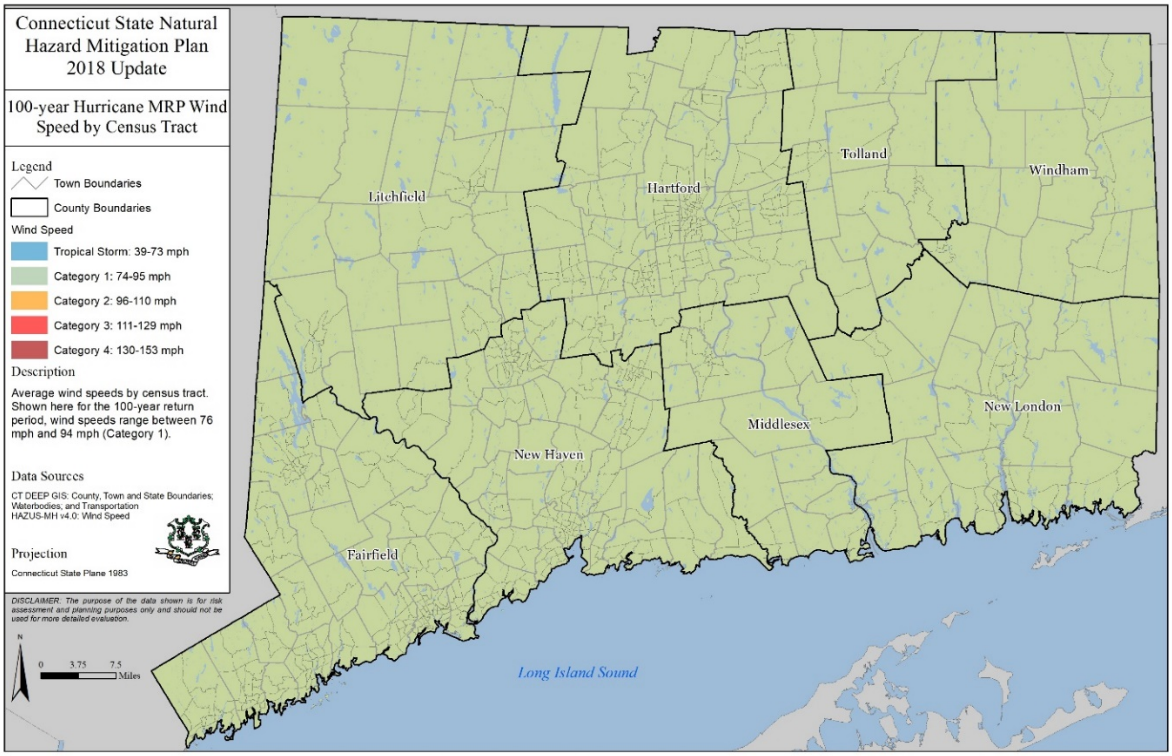


Figure 2-56: Wind Speeds for 100-Year Mean Return Period Event

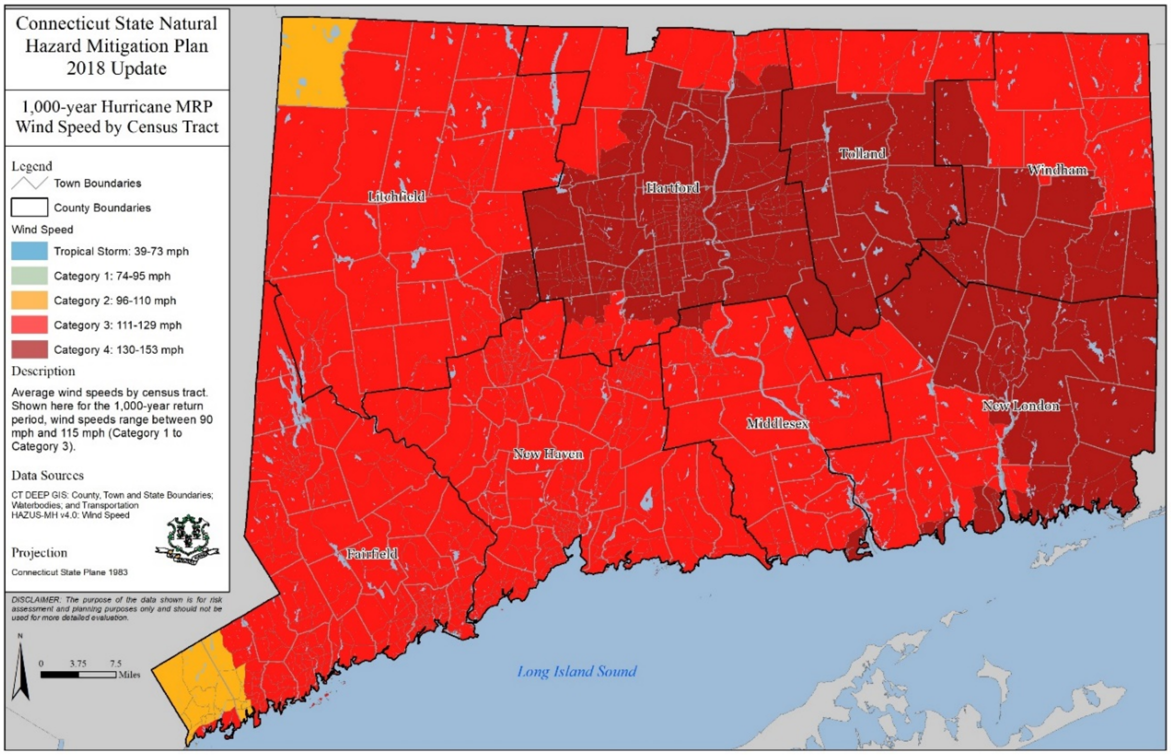


Figure 2-57: Wind Speeds for 1,000-Year Mean Return Period Event

2.25.4 Primary and Secondary Impacts

Tropical cyclone secondary impacts include increased risk of fire hazards, hazardous materials, coastal erosion, compromise of dams or levees, increased risk of landslides, and other environmental impacts. Cascading events following a tropical cyclone may also include health issues related to mold and mildew, disruption to transportation, relocation costs, capital related losses, wage losses, and rental income losses. Lingering stress from disasters such as hurricanes have been acknowledged by many, including FEMA.[168]

2.25.5 Severity

Hurricanes can disrupt the individual lives of Connecticut residents and create costly interruptions to businesses and commerce within the state. The impacts from tropical cyclones can be physical (injury/death), emotional (stress), and/or economic in nature. Economic impacts can include building damages, contents damages, and inventory losses. Flooding from heavy rain and storm surge can severely damage roadways, rail lines, and other infrastructure. High winds often result in extensive power outages threatening critical infrastructure services.

A hurricane strike to Connecticut has the potential to cause moderate to extensive damage within the State. The severity of the damage varies greatly depending on the track,

[168] https://www.fema.gov/coping-disaster

intensity, and duration of the tropical cyclone. Hazards associated with tropical cyclones include:

- Storm Surge: Storm surge is the abnormal rise of water generated by a storms winds. It is the leading cause of deaths from hurricanes in the United States[169] (NWS 2018). Storm tides (combined astronomical tide and storm surge) neared 20 feet in Connecticut with the landfall of an intense tropical cyclone on September 21, 1938.

- Wind: Connecticut has been impacted by Category 3 hurricanes in the past which can have sustained winds as high as 130 mph and higher gusts. Hurricanes often spawn weak tornados in outer rain bands, creating additional high wind threats. Tornados are discussed in Section 1.25.

- Rain: Intense and heavy rainfall from tropical cyclones leads to flash flooding and riverine flooding.

- Waves: Large and dangerous waves caused by tropical cyclone winds can batter coastlines even when a storm is 1,000 miles offshore.[169] These waves can cause erosion, rip currents, and damage to structures.

2.25.6 Warning Time

Past history has shown, and current evidence implies, that it is vital for state and local officials to plan and prepare for such events, and to implement effective mitigation procedures and post-event procedures to reduce, to the extent possible, loss of life and property.

The National Hurricane Center is responsible for forecasting and tracking tropical cyclones. While forecasting accuracy has increased in recent years, the ability of meteorologists to reliably predict tropical cyclone formation, tracks, and impacts beyond one week remains extremely limited. The National Hurricane Center and National Weather Service will issue alerts leading up to possible and expected impacts from a tropical cyclone:

- Tropical Storm Watch: An announcement that tropical-storm conditions are possible within the specified area.

- Hurricane Watch: An announcement that hurricane conditions are possible within the specified area.

- Tropical Storm Warning: An announcement that tropical-storm conditions are expected within the specified area.

[169] http://www.nws.noaa.gov/om/hurricane/index.shtml

- Hurricane Warning: An announcement that hurricane conditions are expected within the specified area.
- Extreme Wind Warning: Extreme sustained winds of a major hurricane (115 mph or greater), usually associated with the eyewall, are expected to begin within an hour. [170]

The National Hurricane Center also provides forecasting information on areas where tropical cyclone development is likely, a forecast cone for the probable path of the center of the cyclone, various storm surge products, and other mapping and discussion products that describe the anticipated evolution of systems and their associated hazards.

2.25.7 Previous Occurrences and Losses

Connecticut and New England are no strangers to tropical cyclone systems. To date, a Category 3 hurricane was the most severe tropical cyclone that impacted Connecticut. However, many Category 3 hurricanes which have come up the Atlantic coast into the cooler waters off New England were downgraded to a Category 2 hurricane or lower when they made landfall in/near Connecticut.

The National Weather Service reports that: Since 1900, 49 tropical systems have impacted Southern New England. Twenty-five were hurricanes, while 18 were of tropical storm strength. Any tropical storm or hurricane is capable of bringing a combination of high winds, large storm surges, and severe inland flooding along Area Rivers and streams.

Of the 25 hurricanes, nine made landfall along the Southern New England coast. Of those nine hurricanes, seven were either of a Category 2 or 3 intensity based on the Saffir-Simpson Hurricane Scale. Through the primary threat to New England is during August and September, the region has been affected as early as June and as late as mid-October." [171]

Historic tracks and peak wind gusts, from Hazus, for the 1938 Hurricane, 1944 Hurricane, Hurricane Carol (1954), Hurricane Donna (1960), and Hurricane Gloria (1985) are shown in Figure 2-58.

[170] https://www.nhc.noaa.gov/prepare/wwa.php
[171] Source: National Weather Service Forecast Office, Boston, MA.

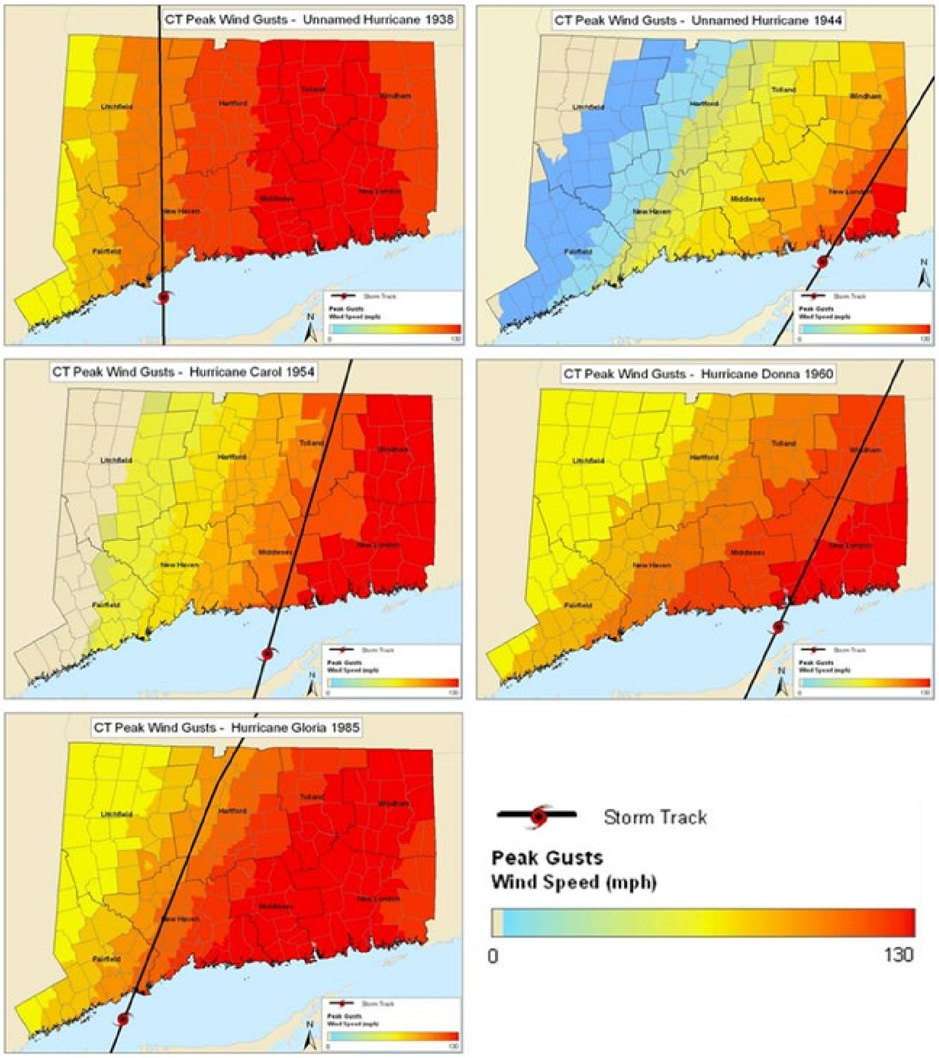


Figure 2-58 Historical Hurricane Tracks and Peak Wind Gusts (Hazus Derived)

It should be noted that many sources provided historical information regarding previous occurrences and losses associated with hurricanes and tropical storms that impacted the State of Connecticut. With many sources reviewed for the purpose of this HMP update, loss and impact information could vary depending on the source. Therefore, accuracy of monetary figures discussed is based only on the available information identified during research for this HMP update.

Some of the most notable hurricane and tropical storm occurrences in recent history in the state of Connecticut in terms of deaths, injuries, and/or property damages include the following (dollar values listed in the descriptions below are not adjusted for inflation):

The most intense hurricane to strike Connecticut occurred on September 21, 1938 (unofficially known as the Great New England Hurricane of 1938, or the Long Island

Express).[172] This Category 3 Hurricane made landfall in Connecticut in Milford, with the eye of the hurricane observed in New Haven Connecticut. Sustained winds of 91 mph with gusts of 121 mph were reported on Block Island, Rhode Island. The storm downed power lines in many areas of Connecticut and resulted in catastrophic fires in New London and Mystic, CT. Low pressures of 28.00 inches and 28.04 inches were reported in Middletown and Hartford, respectfully. Storm tides of 14 to 18 feet were reported along the Connecticut coast with 18 to 25 foot tides reported from New London, Connecticut to Cape Cod, Massachusetts.

Inland flooding was another result of the hurricane and a substantial amount of rain which occurred several days prior to the hurricane. Three to six inches of rain fell throughout most of Connecticut with 14 to 17 inches reported in Central Connecticut, resulting in severe flooding of rivers and streams and roadways and rail lines being washed out. In Hartford the Connecticut River reached 35.4 feet, which was 19.4 feet above flood stage.

Impacts on Southern New England from this storm were:

- 8,900 homes/cottages and buildings were destroyed, and 15,000 structures were damaged;
- An estimated $38,000,000 (in 1938 dollars) in damages to property in Connecticut;
- 564 deaths and 1,700 injuries; and
- 2,605 vessels destroyed and 3,369 vessels damaged.

In recent years, there have been two significant hurricanes. Hurricane Irene occurred on August 28, 2011 and weakened to a tropical storm as it made landfall. The storm hit the coast at high tide, which caused a storm surge that flooded roads and homes from Fairfield to New London. The storm produced high winds (maximum wind gusts were 66 mph, while the average wind gust for the entire state was 52.3 mph), heavy rains and flash flooding, and left ten people dead in Connecticut. At times, winds reached hurricane force from Westport to Woods Hole Massachusetts.[173] The storm also destroyed many houses, particularly in East Haven, Milford and Fairfield.[174] Hundreds of thousands of people were without power due to Irene; Connecticut had the largest population without power, about 16% of customers.[175] Following the, trees, branches and power lines remained scattered across roads in every town in the state. About 2,000 residents were in shelters across the state[176] Additional details on this event are available in Section 2.3 on Connecticut's History of Natural Disasters and in the flood history section.

[172] Source: NWS, Boston Office; information describing this event was taken from the NWS Boston website. Pictures are from the Connecticut State Library online archives.
[173] http://en.wikipedia.org/wiki/List_of_New_England_hurricanes
[174] Connecticut Post. Connecticut's worst hurricanes. 10/30/2012.
[175] World Socialist website. Power outages, flooding continues in wake of Hurricane Irene. 9/2/2011.
[176] The Hartford Courant. Home Destroyed, People Missing and 767,000 without power after Irene. 8/28/2011.

Super Storm Sandy occurred October 29-30, 2012, causing storm surges, wind and rain and devastating the Jersey Shore, Southern NYC, parts of Long Island and the Connecticut and Rhode Island coastlines. Coastal residents and business owners suffered from storm surge and its damage, and more than 360,000 people were evacuated from low-lying areas along the coast from Old Saybrook to Fairfield. Inland cities and towns saw widespread power failures. A travel ban was issued on state highways, and commuter rail and Amtrak service was canceled.[177]

Although one of the most damaging storms in Connecticut history, Super Storm Sandy was not a Hurricane by definition when it made landfall in Connecticut. It had both extratropical cyclone and nor'easter characteristics combined, illustrating the possibility of dangerous changes in storm dynamics. In Connecticut, all eight counties saw damages, with more than $360 million in total damage. At its peak, Sandy cut power to 640,000 homes and businesses, and it was reported to be at least 5 storm-related deaths. As of May 2013, more than $367 million in federal assistance had been approved to help Connecticut with disaster expenses. Figure 2-59 shows an example of the damage from flooding that was seen in many coastal towns.

Figure 2-59: Milford, Connecticut after Hurricane Sandy (10/2012), Daily News

FEMA Disaster Declarations

There are no new federally declared disasters related to flooding since the 2014 plan update.

[177] The New York Times. State-by-State Guide to Hurricane Sandy. 10/29/2010

2.25.8 Probability of Future Events

The Atlantic hurricane season begins on June 1 and runs through November 30 of each year. This is the time period when the environmental conditions are most favorable for a tropical cyclone to develop. The greatest risk of a hurricane impacting New England within this six-month period is from late August to mid-October.

In general it is impossible to predict when and where a hurricane will occur. Some researchers such as Klotzbach and Gray[178] develop forecasts and probabilities of landfall strikes for the annual Atlantic hurricane season. However, this forecast is revised throughout the season. Other researchers and Federal agencies like NOAA do not make such landfall predictions. NOAA states that, "Hurricane landfalls are largely determined by the weather patterns in places the hurricane approaches, which are only predictable when the storm is within several days of making landfall." NOAA does issue a seasonal hurricane outlook that provides a general guide to the expected overall nature of the upcoming hurricane season. The outlook combines the impacts of three climate factors to analyze an expected level of activity for the season:

- The tropical multi-decadal signal;
- The El Niño/La Niña (ENSO – El Niño Southern Oscillation) cycle; and
- The tropical Atlantic sea surface temperatures.

Hurricanes have the greatest destructive potential of all natural disasters in Connecticut, due to the potential combination of high winds, storm surge and coastal erosion, heavy rain, and flooding which can accompany this hazard. Figure 2-60 provides an example of a probability map, showing the likelihood of a named hurricane impacting a given area during hurricane season.

[178] Philip J. Klotzbach and William M. Gray run the Tropical Meteorology Project at Colorado State University. Information about and the actual hurricane season forecasts can be downloaded from website..

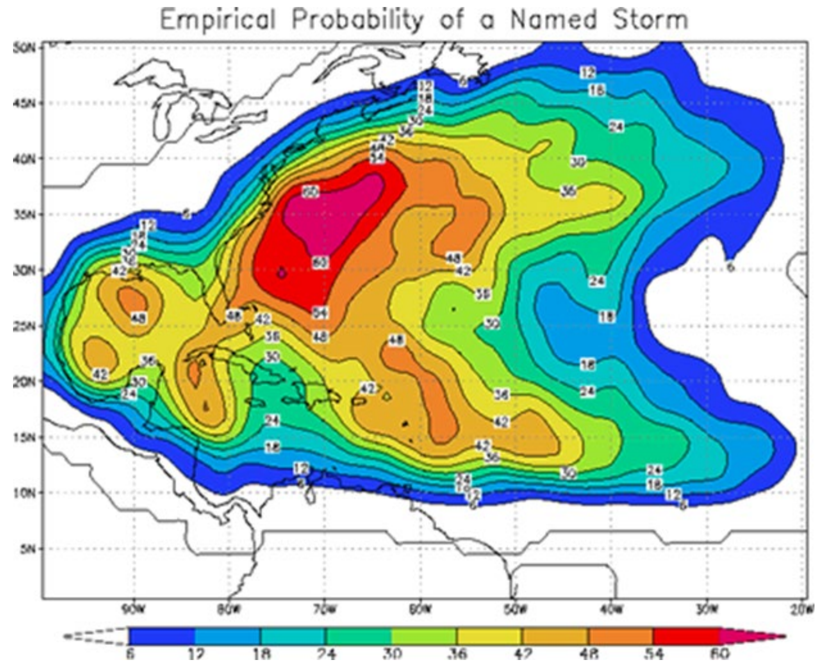


Figure 2-60: Probabilities of a Named Storm Impacting an Area during Hurricane Season (June to November)

Researchers have recently analyzed data that has indicated that the intensity of tropical cyclones (hurricanes and typhoons) has increased over the last thirty-five years. With changing weather patterns resulting from climate change, increases in frequency and intensity are also expected to continue. NOAA developed a series of hurricane return periods for the northeast based on historical data of events within 65 nautical miles of the storm tracks Figure 2-61. NOAA methodology for this is as follows:

Hurricane return periods are the frequency at which a certain intensity or category of hurricane can be expected within 75 nautical miles(nm) or 86 statute miles of a given location. In simpler terms a return period of 20 years for a Category 3 or greater hurricane means that on average during the previous 100 years, Category 3 or greater hurricane passed within 75 nm (86 miles) of that location about five times. We would then expect, on average, an additional five Category 3 or greater hurricanes within that radius over the next 100 years. The basic idea is that a population of tropical cyclones falling within the 65 nm (75 miles) circle is obtained from the best-track file. For that set of storms, the maximum wind within the circle is found. Then, a count is conducted to find how many systems had winds of 30-34 knot (kt), 35-39 kt etc. Once the count is known, a function is used to "fit" the distribution. Since there are only a few intense tropical cyclones typically in the 100-year record for a particular site, the mathematical function helps to smooth this out and "fill in the holes". The smooth function is then used to estimate the number of systems that would occur over a longer time period.

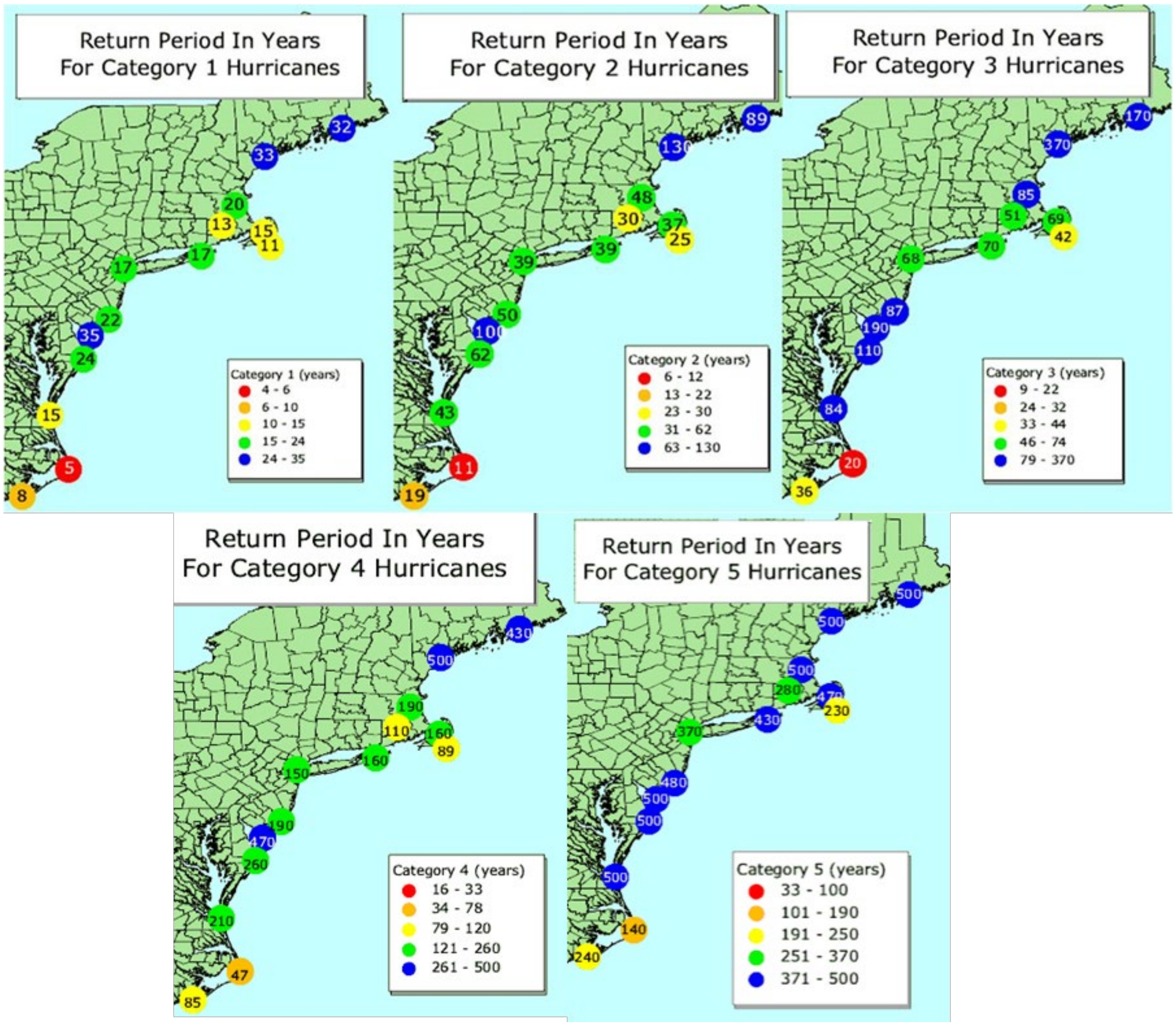


Figure 2-61: Return Periods for Hurricane Categories 1-3 in the Northeast

According to Figure 2-61, a Category 1 hurricane can be expected to make landfall in/near Connecticut once every ten to fifteen years. A Category 2 hurricane could be expected to make landfall in/near Connecticut once every twenty-three to thirty years, and a Category 3 hurricane has a calculated return period of forty-six to seventy-four years. With the last hurricane (Hurricane Bob, Category 2,) to impact Connecticut occurring in 1991, we can expect the occurrence of another hurricane to impact the state within the foreseeable future.

Given the past history of major storms and a reasonable estimate of likely future scenarios, it would be prudent for Connecticut to expect that there will be forthcoming hurricanes which make landfall in or near Connecticut and they will be of a greater intensity and longer duration than in the past. This may mean a potential increase in all categories of hurricanes normally experienced in New England. Based on historical data for hurricane tracks within 50 miles of Connecticut, it is reasonable to assume that the state has a medium-low probability of future events (less than 1 event per year). It should be noted that this probability is based on the historical hurricane tracks since 1900 and is medium-low on an annual basis but high based on recent events and perception.

2.25.9 Climate Change Impacts

Tropical cyclones rely on warm surface waters to develop and thrive. With increasing global temperatures, an increase to the frequency and severity of tropical cyclones would appear likely. However, climactic changes beyond surface water temperatures make predicting the likely impacts of climate change on tropical cyclones difficult. Researchers have recently analyzed data that has indicated that the intensity of tropical cyclones (hurricanes and typhoons) has increased over the last thirty-five years.[179]

Given the past history of major storms and a reasonable estimate of likely future scenarios, it would be prudent for Connecticut to expect that there will be forthcoming hurricanes which make landfall in or near Connecticut and they will be of a greater intensity and longer duration than in the past. This may mean a potential increase in all categories of hurricanes normally experienced in New England.

Storm surge impacts are likely to worsen in the future as a result of sea level rise. For example a storm surge of 3 feet today will have the impact of a surge of 5 feet if sea levels rise 2 feet (3 feet of storm surge + 2 feet of sea level rise = 5 feet of flooding). For more information on sea level rise refer to Section 1.15.

2.26 Tropical Cyclone Vulnerability Assessment

Hurricanes are a very real and costly hazard to Connecticut. Based on historic event and storm scenario simulations generated with Hazus in 2011, 2013, and 2018, the information shows that the entire state of Connecticut is vulnerable to the impacts of such an event. These impacts can be physical, emotional, and/or economic in nature. Hurricanes can disrupt the individual lives of Connecticut residents and create costly interruptions to businesses and commerce within the state. Past history has shown, and current evidence implies, that it is vital for state and local officials to plan and prepare for such events, and to implement effective mitigation procedures and post-event procedures to reduce, to the extent possible, loss of life and property.

Factors that may lead to increased vulnerability of tropical cyclones include:

1. Increasing in population within coastal communities;
2. Local zoning and development patterns in highly vulnerable areas of the community;

[179] http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf

3. Locating state and local facilities (i.e. schools) within highly vulnerable areas; and

4. Building codes currently in place and the age/number of structures located within highly vulnerable areas of a community.

Most of the existing housing stock in Connecticut was built before 1990 and is unaffected by the code changes. Since much of the existing housing stock predates recent building code updates,[180] many structures are highly susceptible to roof and window damage from high winds. In addition, homes located within FEMA designated significant flood hazard areas (SFHAs) are at risk from flooding as a result of heavy rain and storm surges from these types of major storms.

Table 2-5 includes the number of infrastructure/facilities, building value and contents value by municipality. The state contains 3,327 state-owned buildings totaling $6.5 billion in building values; the building and contents values have not been estimated for all state-owned building. The State's total building and contents value only includes those buildings where value information was available and is intent for use in this plan and should not be used for other applications. The state contains 1,940 identified critical facilities in the categories of correctional institutions, EMS facilities, fire stations, gas stations with generator, health departments, law enforcement facilities, municipal solid waste, nuclear power plants, and storage tank farms. 1,846 of these critical facilities were able to be geospatially mapped for analysis.

Appendix 2 includes the infrastructure and facilities datasets, as well as the loss estimates by municipality for facilities located within the known hazard geographic extents. For the purposes of this 2019 Plan update, all State buildings and local assets are exposed to tropical cyclones. As the State of Connecticut continues to become more urbanized, the State facilities will need to be developed in locations that will serve the growing population.

2.26.1 Assessment of State Vulnerability and Potential Losses

All State buildings are exposed to the wind and/or rain from tropical cyclones. Table 2-5 summarizes the number of state-owned and –leased buildings in the state. For an assessment of vulnerability and potential losses as a result of storm surge from a tropical cyclone, refer to Section 2.14 (Flood-Related Vulnerability Assessment).

As the State of Connecticut continues to grow from a development standpoint, State facilities need to be located where they will serve the population base. Populations continue to grow in existing urban areas within hurricane and tropical storm hazard areas. These areas will continue to be prone to the impacts of these hazards and as the population grows; however, as discussed above, improved mapping, elevation data, and regulatory changes

[180] More information regarding Connecticut's building codes can be found at the following websites: http://portal.ct.gov/DAS/Office-of-State-Building-Inspector/Connecticut-State-Building-Code/Regulations.

will mitigate future damages to new development and areas being rebuilt after a hazard event.

2.26.2 Assessment of Local Vulnerability and Potential Losses

Historically, hurricanes and tropical storms have impacted all eight Connecticut counties. All local hazard mitigation plans identified hurricanes and tropical storms as a hazard of concern.

The impact of a hurricane or tropical storm on life, health, and safety depends on several factors, including the severity of the event and whether or not adequate warning time was provided to residents. It is assumed that the entire State's population is exposed to the wind hazard associated with a hurricane or tropical storm event.

Analysis for the plan update included probabilistic runs for the all return periods with the 2010 inventory in Hazus v4.0. Figure 2-62 below shows the estimated 100-year hurricane return period by census tract (analysis with 2010 population per census tract). Fairfield County, Hartford County, and New Haven County show the highest estimated losses, with census tracts estimating a total of $494 to $583 million in losses. Figure 2-63 shows the estimated 1,000-year hurricane return period by census tract. In this scenario, Fairfield County, Hartford County, and New Haven County also show the highest estimated losses, between $2 and $7 billion, the majority of which are in Hartford and New Haven counties.

It is noted that maps displaying the 100- and 1,000 year storm tracks were not developed for this plan due to an issue within Hazus v4.0 export function which precluded the creation of the spatial layer for these events.

The estimated total losses for all hurricane return periods are shown in Table 2-91. This shows that Fairfield, New Haven and Hartford counties have the highest estimated total losses for all hurricane return periods combined, $6.8 billion, $9.1 billion, and $10.3 billion respectively.

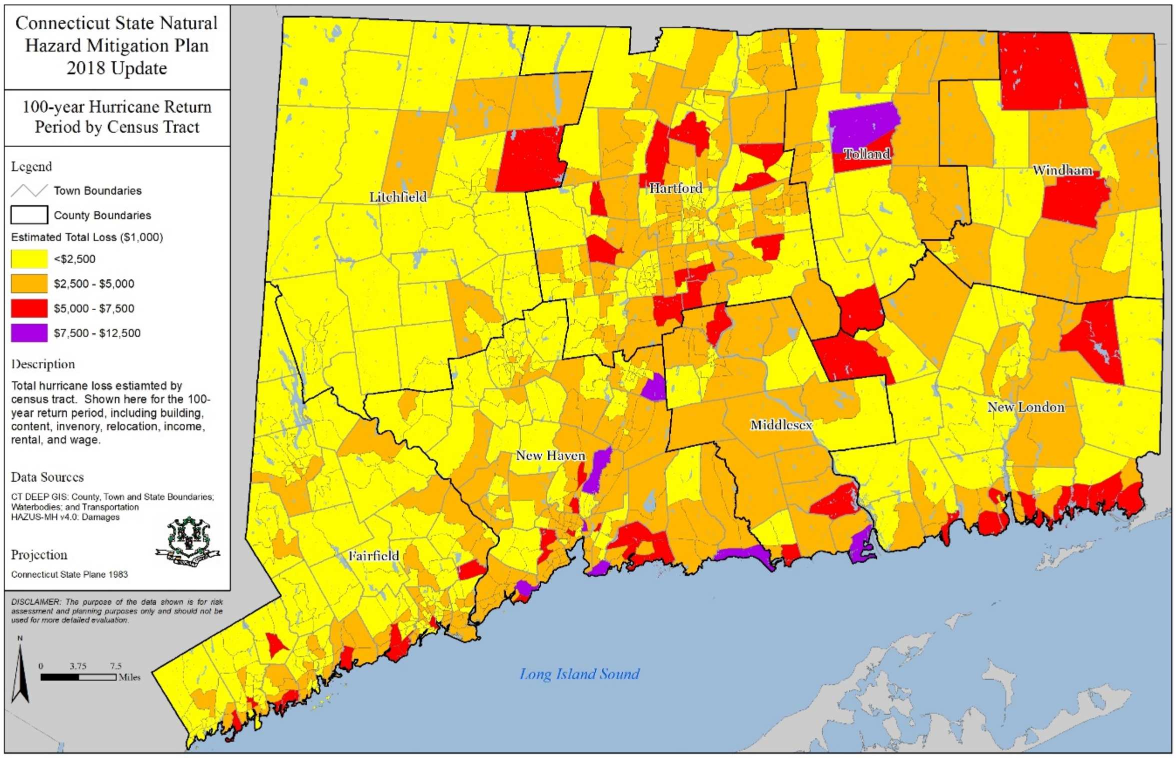


Figure 2-62: Estimated 100-year Hurricane Return Period by Census Tract

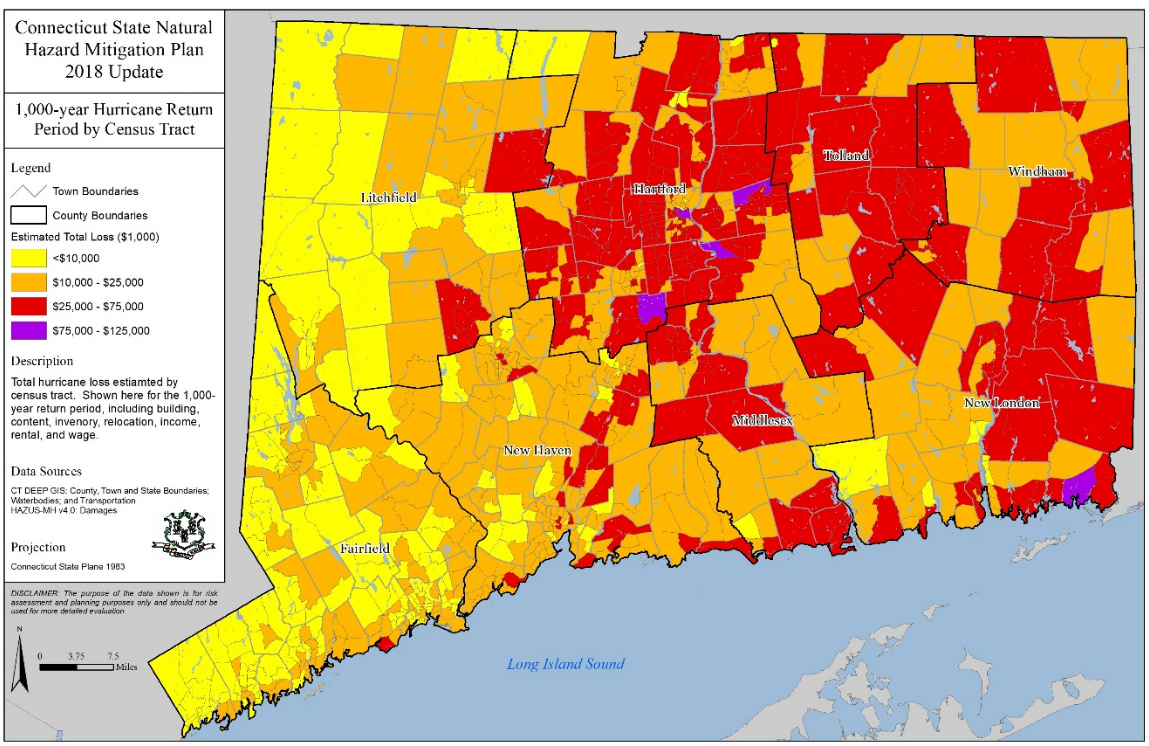


Figure 2-63: Estimated 1,000-year Hurricane Return Period by Census Tract

Table 2-91: Estimated Total Losses for Hurricane Return Periods. Shown in thousands of dollars.

Jurisdiction	10-yr	20-yr	50-yr	100-yr	200-yr	500-yr	1,000-yr	Total
Fairfield	$0	$5,381	$0	$494,016	$795,624	$3,511,912	$1,998,134	$6,805,067
Hartford	$0	$14,055	$11,685	$558,773	$950,393	$1,497,097	$7,287,319	$10,319,322
Litchfield	$0	$862	$0	$70,962	$56,906	$168,713	$678,390	$975,833
Middlesex	$0	$5,410	$36,480	$123,165	$460,938	$685,278	$891,644	$2,202,915
New Haven	$0	$9,844	$12,063	$583,958	$1,269,932	$3,983,949	$3,312,166	$9,171,912
New London	$610	$24,504	$593,660	$208,674	$627,831	$745,343	$1,835,120	$4,035,742
Tolland	$0	$4,491	$26,316	$83,832	$258,066	$180,860	$976,405	$1,529,970
Windham	$148	$8,159	$150,565	$67,445	$246,538	$137,241	$667,791	$1,277,887
Totals	$758	$72,707	$830,769	$2,190,825	$4,666,228	$10,910,393	$17,646,969	$36,318,649

The Hazus simulations for several historical storms and their associated storm tracks that were used in the past plans were run in the updated version of Hazus (v4.0). The results of these simulations help to estimate potential maximum damages that would occur in the present day given the same track and characteristics of an individual event. It should be noted that Hazus only considers wind damage for its hurricane simulation and does not account for rain and flooding effects. This is important to note because much of the historic impacts of hurricanes experienced by the state have come in the form of severe rain and flooding. Thus the damage estimations and shelter/displacement estimates have the potential of being higher for each scenario when one considers the potential threat of flooding that is associated with hurricanes.

Table 2-92 shows the estimated tonnage of debris that would be generated by wind damage for each storm scenario, based on Census 2010 structure data and other sources of data in Hazus. Table 2-93 shows storm debris for the three counties that were projected to generate the most wind damage debris for a given storm scenario. If one compares the figures showing peak wind gusts and hurricane track with these tables, one will see a correlation between the track and the counties which would be hardest hit by a potential storm scenario. According to the HAZUS Hurricane User Manual: 'The Eligible Tree Debris columns provide estimates of the weight and volume of downed trees that would likely be collected and disposed at public expense. As discussed in Chapter 12 of the Hazus Hurricane Model Technical Manual, the eligible tree debris estimates produced by the Hurricane Model tend to underestimate reported volumes of debris brought to landfills for a number of events that have occurred over the past several years. This indicates that that there may be other sources of vegetative and non-vegetative debris that are not currently being modeled in Hazus. For landfill estimation purposes, it is recommended that the Hazus debris volume estimate be treated as an approximate lower bound. Based on actual reported debris volumes, it is recommended that the HAZUS results be multiplied by three to obtain an approximate upper bound estimate. It is also important to note that the Hurricane Model assumes a bulking factor of 10 cubic yards per ton of tree debris. If the debris is chipped prior to transport or disposal, a bulking factor of 4 is recommended. Thus, for chipped debris, the eligible tree debris volume should be multiplied by 0.4'. The probabilistic analysis for the 100-year event indicate over 180 thousand tons of brick and wood debris, 3 tons of concrete and steel debris, and nearly 270 thousand tons in tree debris, and for the 1,000-year event, nearly 1.4 million tons of brick and wood debris, 5,000 tons of concrete and steel debris, and more than 11 million tons in tree debris are estimated.

Table 2-92: Estimated Debris from Wind Damage by Material Type per Hazus Storm Scenario.

Storm Scenario	Brick, Wood and Other (in tons)	Reinforced Concrete and Steel (in tons)	Eligible Tree Debris (in tons)	Total (in tons)
1938 Unnamed	982,081	2,987	884,811	1,869,879
1944 Unnamed	2,367	0	6,229	8,596
Carol	6,627	0	16,047	22,674
Donna	31,039	4	63,234	94,277
Gloria	116,105	1	170,345	286,451
Totals	1,138,219	2,992	1,140,666	2,281,877

Table 2-93: Counties Estimated to Generate the Greatest Amount of Debris for Hurricane Scenarios

Storm Scenario	3 Counties with Greatest Amount of Debris	Total Amount (in tons) for 3 Counties for Wood, Brick, and Other	Percentage of Total Tonnage for Wood, Brick and Other	Total Amount (in tons) for 3 Counties for Tree Debris	Percentage of Total Tonnage for Tree Debris
1938 Unnamed	Hartford, New Haven, New London	718,012	73%	539,385	61%
1944 Unnamed	New London, Windham, Middlesex	2,364	99.9%	5,877	94%
Carol	New London, Windham, Middlesex	6,570	99%	15,114	94$
Donna	New London, Hartford, Windham	25,321	82%	52,437	83%

Gloria	Hartford, New Haven, Middlesex	90,134	78%	108,768	64%

It is interesting to note that for certain storm scenarios, Hazus has shown that often times one county will generate the majority of all estimated damage. This most likely is a result of the potential tracks that were used in the simulations for historic storms when they made landfall in Connecticut. The state as a whole is vulnerable to the property and economic losses resulting from hurricane strikes.

Table 2-94, Table 2-95, and Table 2-96 show various estimates statewide for property damages, economic losses, and sheltering needs of state residents as a result of a similar hurricane making landfall in Connecticut, as in the past. Again, the counties with the greatest need for sheltering, hospital needs, emergency food and water requirements, and property damage (both in estimated values and total number of structures damaged) coincide with the figures showing the peak wind gusts and hurricane storm tracks. As stated previously, the damage estimates from Hazus are based on wind damage by a hurricane and do not include damages and shelter needs from damages and property losses by flooding. This is important because depending on the characteristics of a potential hurricane (i.e., does it make landfall at low or high tide, does if pick up strength at the last moments before landfall, is there a stalled weather pattern and the storm produces more rain than anticipated, etc.), state and local officials will need to be aware and anticipate potential flooding that may accompany such a storm event.

Capital Stock Losses include the subcategories of building damages, contents damages, and inventory losses. Income losses include the subcategories of relocation costs, capital related losses, wage losses, and rental income losses. Loss estimates only consider costs and damages due to wind and due to the limitations of the Hazus hurricane model, do not calculate estimates for damages and losses for flooding, which can be a major impact from a hurricane.

Table 2-94: Total Estimated Building Damages per Storm Scenario Statewide (number of structures).

Storm Scenario	None	Minor	Moderate	Severe	Destruction
1938 Unnamed	961,438	201,970	48,961	4,502	2,091
1944 Unnamed	1,218,434	507	27	1	0
Carol	1,217,357	1,503	104	4	1
Donna	1,211,128	7,142	668	26	5
Gloria	1,002,924	17,521	800	38	5

Table 2-95. Estimated Sheltering Needs for Historic Storm Simulations

Storm Scenario	Total number of Displaced Households	Total Number of People Requiring Short Term Shelter	County with the Greatest Number Displace Households and People Requiring Shelter
1938 Unnamed	14,538	3,587	Hartford (4,533 households, 1,178 people needing temp. shelter)
1944 Unnamed	1	0	New London (1 households, 0 people needing temp. shelter)
Carol	18	2	New London (18 households, 2 people needing temp. shelter)
Donna	172	38	New London (154 households, 38 people needing temp. shelter)
Gloria	729	178	Hartford (313 households, 80 people needing temp. shelter)

Table 2-96: Estimated Direct Economic Losses for Buildings Statewide.

Storm Scenario	Capital Stock Losses	Income Losses	Total Estimated Losses
1938 Unnamed	$11,091,797	$1,147,106	$12,238,903
1944 Unnamed	$45,223	$615	$45,837
Carol	$110,614	$2,891	$113,506
Donna	$436,479	$18,042	$454,521
Gloria	$1,391,568	$71,201	$1,462,769

Storm surge inundation is a significant threat to the population along the coast. To estimate the population exposed to the surge inundation areas, an exposure analysis methodology was used. Table 2-97 provides a breakdown by county of the numbers of people intersecting the surge inundation areas. This analysis was conducted by intersecting census block groups with SLOSH data using GIS. In instances where only a portion of the census block group intersected the hazard area, only that same portion of the population is counted. For example, if 20-percent of the census block group intersects with an intermix area, only 20-percent of the population number for that census block group is counted). This results in estimated values and there is potential for error with this methodology, but this is considered a more refined approach than assuming 100-percent of the population is contained within the 20-percent of the census block group that intersects the hazard area. Statewide, approximately 1.6% (Category 1) to 6.8% (Category 4) of the population is exposed to hurricane storm surge inundation areas. Fairfield County, Middlesex County, New Haven County, and New London County are the only four counties in the State that exposure to storm surges from a tropical cyclone.

Of the total State population, economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make decisions based on the major economic impact to their family and may not have funds to evacuate. The population over the age of 65 is also more vulnerable, and they may physically have more difficulty evacuating. The elderly are considered most vulnerable because they require extra time or outside assistance during evacuations. Also, they are more likely to seek or need medical attention, which may not be available because of isolation during a storm event.

Table 2-97: Estimated Population in Category 1 through 4 SLOSH Zones

Jurisdiction	Total Population	Population Intersecting Category 1	Population Intersecting Category 2	Population Intersecting Category 3	Population Intersecting Category 4
Fairfield	916,829	23,963	47,685	77,028	105,999
Hartford	894,014	0	0	0	0
Litchfield	189,927	0	0	0	0
Middlesex	165,676	5,203	8,363	11,515	13,544
New Haven	862,477	21,921	42,436	69,736	98,346
New London	274,055	7,346	12,484	18,686	24,144
Tolland	152,691	0	0	0	0
Windham	118,428	0	0	0	0
Totals	3,574,097	58,433	110,968	176,965	242,034

As Connecticut continues to develop, the State will remain vulnerable to the impacts of wind and storm surge from tropical storms and hurricanes. Improved mapping and higher regulatory standards will mitigate future impacts to new and redeveloped areas in defined hazard zones.

Residents may be displaced or require temporary to long-term sheltering as a result of a hurricane or tropical storm. In addition, downed trees, damaged buildings and debris carried by high winds can lead to injury or loss of life. Socially vulnerable populations are most susceptible, based on a number of factors including their physical and financial ability to react during a hazard and the location and construction quality of their housing.

2.26.3 Changes in Development

An understanding of population and development trends can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The State considered the following factors to examine previous and potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population

- Other identified conditions as relevant and appropriate

Since the entire State is exposed to tropical cyclones, any new development and increases in population will be vulnerable to the impacts from these events. As discussed in Section 1.2.4 (Land Use and Development), Fairfield County and Hartford County continue to see the majority of development. As of 2017, approximately 68.3% of the building permits statewide were in Fairfield and Hartford Counties, and both of these counties accounted for nearly half of all the housing units in the State. If recent trends in development continue, these two Counties will continually increase their vulnerability to tropical cyclones; especially coastal communities in Fairfield County where communities may be vulnerability to the combined effects of wind and storm surge. Statewide, there is an estimated 2.2% change in population expected between 2020 and 2040; the increases in population will increase the State population's vulnerability to tropical cyclone.

2.26.4 Hazard Ranking

Quantitative risk assessment, to the degree possible, has been completed for tropical cyclone using the methodology described in the Hazard Analysis and Ranking methodology Section 2.6 of this chapter. Scores for each jurisdiction were calculated based on population, building permits, geographic extent, average score from local plan rankings, average hazard concern, and measures of historical impact including injuries and deaths, property damage, and the number of reported events. The number of impacted critical facilities was also incorporated, and ranked based on the number of facilities impacted in relation to the number of total critical facilities in Connecticut. As shown in Table 2-98, the composite tropical cyclone rank shows Fairfield, Hartford, Middlesex, New Haven, and New London counties as medium-high risk; and Litchfield, Tolland, and Windham counties as medium risk.

Table 2-98: Hazard Ranking by County for Tropical Cyclone

County	Hazard Concern Rank	Local Plans Hazard Rank	Geographic Extent Rank	Population Density Rank	Building Permits Rank	Facility Intersect Rank	Ann. Events Rank	Ann. Losses Rank	Injury & Death Rank	Composite Ranks
Fairfield	High	High	Medium	High	High	Medium-High	Low	Medium-High	Low	**Medium-High**
Hartford	High	High	Medium	High	High	Medium-Low	Low	Medium	Low	**Medium-High**
Litchfield	High	High	Medium	Low	Low	Medium-Low	Low	Medium-Low	Low	**Medium**
Middlesex	High	High	Medium-High	Medium-Low	Medium-Low	Medium-High	Low	Medium-High	Low	**Medium-High**
New Haven	High	High	Medium	High	Medium	Medium-High	Low	Medium-High	Low	**Medium-High**
New London	High	High	High	Medium-Low	Medium-Low	Medium-High	Low	Medium-High	Low	**Medium-High**
Tolland	High	High	Medium-High	Medium-Low	Medium-Low	Medium-Low	Low	Medium-Low	Low	**Medium**

Windham	High	High	Medium-High	Medium-Low	Low	Medium-Low	Low	Medium-Low	Low	**Medium**

2.27 Wildland Fire Hazard Profile

2019 Plan Update Changes

- The wildland fire hazard profile has been significantly enhanced to include a detailed hazard description, location, extent, impact (severity, warning time and secondary impacts), previous occurrences, probability of future occurrence, and potential impacts of climate change
- New and updated figures from state agencies are incorporated
- Potential change in climate and its impacts on the wildland fire hazard is discussed.
- Previous occurrences were updated with events that occurred between 2013 and 2017

2.27.1 Hazard Description

A wildland fire can be defined as any non-structural fire that occurs in the wildland. Three distinct types of wildland fires have been defined and include naturally occurring wildland fire, human-caused wildland fire, and prescribed fire. Many of these are highly destructive and can be very uncontrollable. They occur in forested, semi-forested, or less developed area. Wildland fires can be caused by lightning, human carelessness, and arson Wildland fires can be naturally occurring—such as those ignited when lightning or wind-falling trees collide with power lines—or caused by humans, which is the primary cause of all types of fires. Wildland fires result in the uncontrolled destruction of forests, brush, field crops, grasslands, real estate, and personal property, and have secondary impacts on other hazards such as flooding, by removing vegetation and destroying watersheds.[181]

Connecticut's high population density has created land use pressures in which more people are moving from urban areas to build homes in rural wildland areas.[182] With more people living in the State's forested areas, the number of fires started could increase. A potentially explosive combination is created when hazardous wildland fuels interface home development, and an increased risk of human-caused ignition come together under extreme fire weather conditions.

Wildfires occur when all the necessary elements of a fire come together in a wooded or grassy area. According to the U.S. Bureau of Land Management, in order to have any type of fire, wildland or otherwise, three elements must be present:

[181] http://ready.nj.gov/mitigation/2014-mitigation-plan.shtml
[182] https://www.fs.fed.us/ne/newtown_square/publications/resource_bulletins/pdfs/2004/ne_rb160.pdf

1. Fuel – something which will burn (e.g., vegetation, houses, paper, etc.);
2. Heat – enough to make the fuel burn (e.g., match, spark from a machine, or lightning); and
3. Oxygen – air around (Figure 2-64).[183]

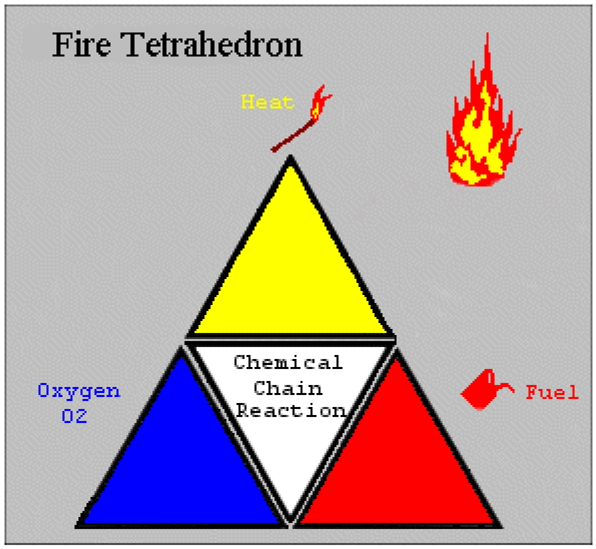


Figure 2-64: Fire Tetrahedron, Fire Safety Advice Centre

The cause of a wildland fire can be natural (e.g., lightning strike) or human induced (e.g., intentional acts of arson, negligently discarded cigarettes, unattended open burning of debris, unattended campfires, etc.). When not quickly detected and contained, wildland fires have the potential to cause extensive damage to property and threaten human life. Other impacts may include:

- Increase in the potential for flooding, debris flows, or landslides;
- Increase in pollutants in the air that can cause significant health problems;
- Destruction of timber, forage, wildlife habitats, scenic vistas, and watershed, on a temporary basis;
- Development of long-term impacts such as reduced access to recreational areas, destruction of community infrastructure, and cultural and economic resources.

Firefighters are trained to fight either structural (building) fires or wildland fires, and they typically maintain a primary focus on one and a secondary focus on the other. Structural firefighting focuses on reducing the heat or the oxygen side of the fire tetrahedron. With wildland fires, firefighters focus their main efforts on reducing the fuel side of the triangle. There are four types of fuels which are a concern for wildland fires:

[183] http://www.ct.gov/deep/cwp/view.asp?a=2720&q=325652

- Ground Fuels – organic soils, forest floor duff, stumps, dead roots, and buried fuels;
- Surface Fuels – litter layer, downed woody materials, dead and live plants to two meters in height;
- Ladder Fuels – vine and draped foliage fuels; and
- Canopy Fuels – tree crowns.

The abundance of a specific fuel type will help to determine which wildland areas may be at higher risk for a specific class of wildland fire: surface fire (surface and ladder fuels); ground fire (ground fuels); or crown fire (ladder and canopy fuels).

An important aspect to any fire is how it behaves. The USDA Forest Service defines fire behavior as, "the manner in which fuel ignites, flame develops, and fire spreads as determined by the interaction of fuel, weather, and topography". There are three important weather factors that affect fire start, fire spread, and fire weather danger:

- Wind – most important factor since it dries out fuel and drives a fire;
- Relative humidity – affects fuel moisture; and
- Precipitation.

CT DEEP Division of Forestry Forest Fire Prevention and Control

The Connecticut Department of Energy and Environmental Protection (DEEP) is tasked with conserving, improving, and protecting the natural resources and environment of the state of Connecticut. Within DEEP, the Division of Forestry maintains an active forest fire prevention program and a specially trained force of firefighting personnel to combat fires that burn an average of 500 acres of woodland per year. The Division also has crews that are able to assist the US Forest Service in controlling large fires that take place outside of Connecticut.[184]

Fire Seasons

The forest fire season in Connecticut can be broken down into spring, summer, and fall. Each portion of the forest fire season is attributed to different conditions which can result in different fire behavior.

Spring Fire Season: Normally mid-March to mid-May

In the spring, deciduous trees are still bare and the warm spring sun heats up the forest fuels; typically grasses, leaves, twigs, branches and decaying material in the soil. As the days grow longer and hotter, the fuels that are most exposed dry out very fast. Grasses, twigs, and very small branches are called '1-hour fuels' as they can take on atmospheric conditions within an hour. Larger fuels take longer to dry out. Typically fires that start in

[184] http://www.ct.gov/deep/site/default.asp

the spring burn just the surface leaves and can spread very fast. Generally they cause little, long term damage to the forest.[185]

Summer Fire Season: Normally mid-May through September

Entering the summer, trees are fully leafed out and past precipitation (drought) becomes the most critical condition. Due to shade from trees and shrubs and higher humidity, forest fuels dry slowly. As vegetation grows, it draws moisture from the soil. As a result, summer fires tend to grow more slowly than a spring fire but tend to burn deeper into the ground. Fires that burn deeper into the ground burn organic matter in the soil (including tree roots), are more difficult to suppress, and cause extensive mortality to vegetation.[185]

Fall Fire Season: Normally October through snow fall

The fall fire season takes on some of the characteristics of both the spring and the summer. Falling leaves are dry but not quite cured. Although the sun is lower and drying capacity is diminished, fires can still spread rapidly. [185]

Fire Suppression

Fire suppression is the primary activity utilized at all levels of fire management (Federal, state, and local) to deal with wildland fires. Although fire suppression activities can reduce or eliminate the threat of small wildland fires, they result in continued growth of vegetation that would have otherwise been naturally reduced by fire. This vegetation provides a larger fuel load, increasing fire susceptibility.

In addition to fire suppression activities, State and local fire departments engage in many prevention activities, including public awareness activities and limitations on open burning, especially during increased fire danger levels. Some communities also proactively engage in local wildland fire mitigation programs, such as the National Fire Protection Association's Firewise Program, that encourage fire safety and prevention activities at a neighborhood or property-owner level, including but not limited to fuel reduction, defensible space creation, fire resistant construction, and emergency planning.

2.27.2 Location

According to the U.S. Department of Agriculture, about 60-percent of Connecticut is forested, nearly 1.9 million acres. Private homeowners own 73-percent of the forested areas of the state.[186] The Connecticut River Valley is comprised of oak- and hickory-dominated woodlands. The northwestern corner of the State, home to the foothills of the Berkshires and New England Highlands, begins to be dominated by northern hardwoods. Litchfield County, in the northwest corner of Connecticut, is the most heavily forested with more than 75-percent of its land area is covered by forests. The majority of the state's other counties

[185] http://www.ct.gov/deep/cwp/view.asp?a=2697&q=322782
[186] http://www.ct.gov/deep/cwp/view.asp?a=2697&q=322788&depNav_GID=1631

are also dominated by forests. Only in the more heavily urbanized counties of Fairfield and New Haven does forested area dip below 50-percent (USDA 2004).

Connecticut's forests are biologically diverse with a wide variety of shrubs, trees, herbaceous plants, lichens, and mosses. The diversity in flora provides habitat and food for a wide range of fauna. In terms of dominance, blueberry is the most common shrub species and white pine is the most common softwood tree species. The variety of hardwood tree species are dominated by red maple, black cherry, and sweet birch. Connecticut's forests have changed in composition during the state's history as the result of various pressures including farming, logging, disease (Dutch elm disease), powerful storm events, invasive species, and urban sprawl.[187]

In addition to being one of the most heavily forested states in the nation, Connecticut also ranks among the most densely populated, and in turn, among the highest in terms of-percentage of land considered in WUI areas. According to 2010 U.S. Census data, Connecticut ranks as the fourth most densely populated state in the United States with more than 700 persons per square mile. In a 2005 study, Connecticut ranked number one in the nation with 72-percent of its land mass considered in WUI areas (ranking number 2 with 60-percent of its land mass considered located in intermix areas, and ranking number 3 with 12-percent of its land mass considered interface areas). These high-percentages of WUI areas is a result of people's desire to move from the traditional highly urbanized geographic areas of the state to more suburban and rural wildland areas of the state. Figure 2-65 illustrates wildland fire hazard areas based on 2010 WUI map products developed by the SILVIS Lab at the University of Wisconsin-Madison. The northeast and northwest corners of Connecticut are predominantly rural and forested, with other large sections of rural landscape in the southeast corner and south central parts of the state. Fuels are primarily hardwood leaf litter, as over 80-percent of the woodlands are hardwood species. Volatile fuels of concern include mountain laurel, huckleberry, greenbrier, and

[187] https://www.fs.fed.us/ne/newtown_square/publications/resource_bulletins/pdfs/2004/ne_rb160.pdf

phragmites which are found along coastal and wetland areas. The northwestern corner has the steepest terrain.

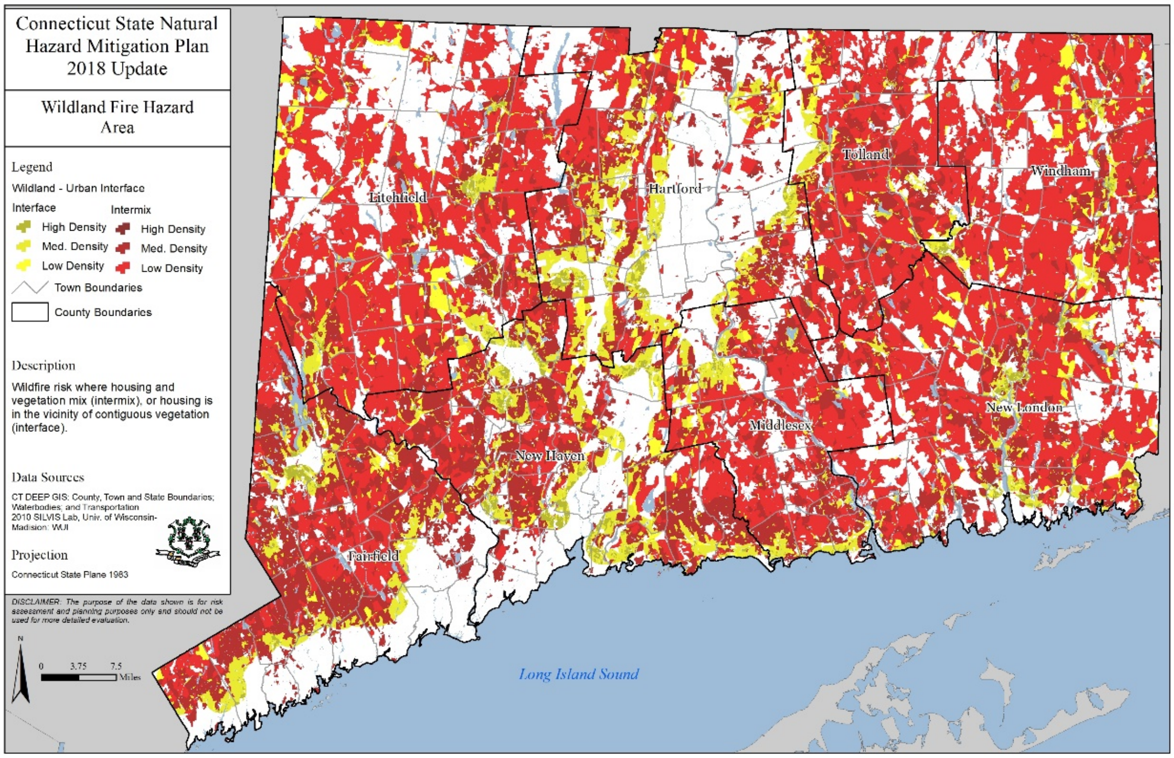


Figure 2-65: Wildfire Hazard Areas

The areas considered most vulnerable to wildland fire risks and losses are those classified as WUI areas. These areas and the people and structures located within these areas will continue to be vulnerable to the risk of fires. However, the risk of wildland fires in Connecticut is currently managed through a variety of State and local activities, such as declining requests for open burning, and less uncontrolled or unsupervised interaction with forests and the natural environment as a whole. Wildland fire risk is also routinely addressed by the State through fire danger monitoring and fire suppression activities, as described in Chapter 3 and Appendix 3.

2.27.3 Extent

The extent (that is, magnitude or severity) of wildland fires depends on weather and human activity. The magnitude of wildland fire events is often characterized by their speed of propagation, total number of acres burned, and potential destructive impacts to people and property. The severity and impact of a wildland fire is greatly dependent on how it behaves (as described above), in combination with fire detection, control, and suppression capabilities.

The DEEP Division of Forestry issues Forest Fire Danger Ratings for Connecticut starting in the spring of each year. A National Fire Danger Rating system that utilizes two indexes is used in Connecticut: spread index and build up index, as shown in the table below.[188]

The "spread" of a fire is predicted with the Spread Index, which is a numeric rating that corresponds with how fast a fire travels in 'Chains per Hour' (a chain is 66'). For example, if a prediction is made that the Spread Index will be 19, it means the fire is predicted to spread 1,254 feet (19 x 66') in an hour.[189]

Connecticut also uses a build-up index (BUI) that measures drought (shown in Table 2-99). The BUI is a relative scale that is based upon past precipitation.[190] It is a number that reflects the combined cumulative effects of daily drying and precipitation in fuels with a 10-day time lag constant. The BUI can represent three to four inches of compacted litter or can represent up to six inches or more of loose litter.[191]

Table 2-99: Build-Up Index

Rating or Class Days	Spread Index	Build Up Index
Low	0-10	0-22
Moderate	11-15	23-44
High	16-29	45-59
Very High	30-39	60-74
Extreme	> 40	> 75

Additionally, the State of Connecticut looks at Red Flag Warnings that are issued by the National Weather Service (NWS). Connecticut is divided between three different National Weather Service stations. Predictions for Hartford, Tolland and Windham counties are made in Taunton, MA; predictions for Litchfield County are made in Albany, NY and predictions for Fairfield, New Haven, Middlesex and New London counties are made in Brookhaven, NY.

A Red Flag warning is a warning to the firefighting community that extreme burning conditions are expected. Red Flag warnings are not a fire danger rating and they are not synonymous with High, Very High or Extreme fire danger. Red Flag warnings are issued when winds will be sustained or there will be frequent gusts above a certain threshold (normally 25 mph). In addition, relative humidity needs to be below 30-percent and precipitation for the previous 5 days has to have been less than 1/4-inch.[192]

[188] http://www.ct.gov/deep/cwp/view.asp?a=2697&q=322782
[189] http://www.ct.gov/deep/cwp/view.asp?a=2697&q=322782
[190] http://www.ct.gov/deep/cwp/view.asp?a=2697&q=322782
[191] http://www.ncforestservice.gov/fire_control/pdf/technotes/FDTN03.pdf
[192] http://www.ct.gov/deep/cwp/view.asp?a=2697&q=322782&deepNav_GID=1631

In addition to the tools used by DEEP, there are several tools are available to estimate fire potential, extent, danger and growth, including (but not limited to) the following:

- **Wildland/Urban Interface (WUI)** is the area where houses and wildland vegetation coincide. Interface neighborhoods are found all across the United States, and include many of the sprawling areas that grew during the 1990s. Housing developments alter the structure and function of forests and other wildland areas. The outcomes of the fire in the WUI are negative for residents; some may only experience smoke or evacuation, while others may lose their homes to a wildland fire. All states have at least a small amount of land classified as WUI. To determine the WUI, structures per acre and population per square mile are used. Across the United States, 9.3-percent of all land is classified as WUI. The WUI in the area is divided into two categories: intermix and interface. Intermix areas have more than one house per 40 acres and have more than 50-percent vegetation. Interface areas have more than one house per 40 acres, have less than 50-percent vegetation, and are within 1.5 miles of an area over 1,235 acres that is more than 75-percent vegetated.[193]
- Concentrations of WUI can be seen along the east coast of the United States, where housing density rarely falls below the threshold of one housing unit per 40 acres and forest cover is abundant. In the mid-Atlantic and north central regions of the United States, the areas not dominated by agriculture have interspersed WUI and low density vegetated areas. Areas where recreation and tourism dominate are also places where WUI is common, especially in the northern Great Lakes and Missouri Ozarks.
- **Wildland Fire Assessment System (WFAS)** is an Internet-based information system that provides a national view of weather and fire potential, including national fires danger, weather maps and satellite-derived "greenness" maps. As per the USFS, the WFAS was developed by the Fire Behavior unit at the Fire Sciences Laboratory in Missoula, Montana, and is currently supported and maintained at the National Interagency Fire Center (NIFC) in Boise, Idaho.
- As per the NWS, each day during the fire season, national maps of selected fire weather and fire danger components of the National Fire Danger Rating System (NFDRS) are produced by the WFAS. The USFS indicates that the Fire Danger Rating level takes into account current and antecedent weather, fuel types, and both live and dead fuel moisture. This information is provided by local station managers. **Table 2-100** describes the fire danger ratings and color codes.

Table 2-100: Fire Danger Rating and Color Code, Wildland Fire Assessment System

[193] Stewart et al. 2006. "The wildand-urban interface in the United States." U.S. Department of Agriculture. Newtown Square, PA.

Fire Danger Rating and Color Code	Description
Low (L) (Dark Green)	Fuels do not ignite readily from small firebrands although a more intense heat source, such as lightning, may start fires in duff or punky wood. Fires in open cured grasslands may burn freely a few hours after rain, but woods fires spread slowly by creeping or smoldering, and burn in irregular fingers. There is little danger of spotting.
Moderate (M) (Light Green or Blue)	Fires can start from most accidental causes, but with the exception of lightning fires in some areas, the number of starts is generally low. Fires in open cured grasslands will burn briskly and spread rapidly on windy days. Timber fires spread slowly to moderately fast. The average fire is of moderate intensity, although heavy concentrations of fuel, especially draped fuel, may burn hot. Short-distance spotting may occur, but is not persistent. Fires are not likely to become serious and control is relatively easy.
High (H) (Yellow)	All fine dead fuels ignite readily and fires start easily from most causes. Unattended brush and campfires are likely to escape. Fires spread rapidly and short-distance spotting is common. High-intensity burning may develop on slopes or in concentrations of fine fuels. Fires may become serious and their control difficult unless they are attacked successfully while small.
Very High (VH) (Orange)	Fires start easily from all causes and, immediately after ignition, spread rapidly and increase quickly in intensity. Spot fires are a constant danger. Fires burning in light fuels may quickly develop high-intensity characteristics such as long-distance spotting and fire whirlwinds when they burn into heavier fuels.
Extreme (E) (Red)	Fires start quickly, spread furiously, and burn intensely. All fires are potentially serious. Development into high-intensity burning will usually be faster and occur from smaller fires than in the very high fire danger class. Direct attack is rarely possible and may be dangerous except immediately after ignition. Fires that develop headway in heavy slash (trunks, branches, and tree tops) or in conifer stands may be unmanageable while the extreme burning condition lasts. Under these conditions the only effective and safe control action is on the flanks until the weather changes or the fuel supply lessens.

- The Fire Potential Index (FPI) is derived by combining daily weather and vegetation condition information and can identify the areas most susceptible to fire ignition. The combination of relative greenness and weather information identifies the moisture condition of the live and dead vegetation. The weather information also identifies areas of low humidity, high temperature, and no precipitation to determine which areas are most susceptible to fire ignition. The FPI enables local and regional fire planners to quantitatively measure fire ignition risk (USGS 2005). The United States Forest Service provides FPI maps on a daily basis. The scale ranges from 0 (low) to 100 (high). The calculations used in the NFDRS are not part of the FPI, except for a 10-hour moisture content.[194]

- Fuel Moisture (FM) content is the quantity of water in a fuel particle expressed as a percent of the oven-dry weight of the fuel particle. The NWS indicates that the FM content is an expression of the cumulative effects of past and present weather events and must be considered in evaluating the effects of current or future weather on fire potential. FM is computed by dividing the weight of the "water" in the fuel by the

[194] Burgan et al. 2000. "Fuel Models and Fire Potential from Satellite and Surface Observations."

oven-dry weight of the fuel and then multiplying by 100 to get the-percent of moisture in a fuel.

- NOAA states that there are two kinds of FM: live and dead. Live FM is much slower to respond to environmental changes and is most influenced by things such as a long drought period, natural disease and insect infestation, annuals curing out early in the season, timber harvesting, and changes in the fuel models caused by being blown down from windstorms and ice storms. Dead FM is the moisture in any cured or dead plant part, whether attached to a still-living plant or not. Dead fuels absorb moisture through physical contact with water (such as rain and dew) and absorb water vapor from the atmosphere. The drying of dead fuels is accomplished by evaporation. These drying and wetting processes of dead fuels are such that the moisture content of these fuels is strongly affected by fuel sizes, weather, topography, decay classes, fuel composition, surface coatings, fuel compactness, and arrangement.[195]

- Fuels are classified into four categories that respond to changes in moisture. This response time is referred to as a time lag. A fuel's time lag is proportional to its diameter and is loosely defined as the time it takes a fuel particle to reach two-thirds of its way to equilibrium with its local environment. The four categories include:

  - 1-hour fuels: up to 0.25-inch diameter – fine, flashy fuels that respond quickly to weather changes. Computed from observation time, temperature, humidity, and cloudiness.

  - 10-hour fuels: 0.25-inch to 1-inch diameter - computed from observation time, temperature, humidity, and cloudiness or can be an observed value.

  - 100-hour fuels: 1-inch to 3-inch diameter - computed from 24-hour average boundary condition composed of day length (daylight hours), hours of rain, and daily temperature/humidity ranges

  - 1,000-hour fuels: 3-inch to 8-inch diameter - computed from a seven-day average boundary condition composed of day length, hours of rain, and daily temperature/humidity ranges.[196]

- The **Haines Index**, also known as the Lower Atmosphere Stability Index, is a fire-weather index based on stability and moisture content of the lower atmosphere that measures the potential for existing fires to become large fires. It is named after its

[195] Schroeder, M. and Buck, J. 1970. "Fire Weather." U.S. Department of Agriculture.
[196] https://www.nps.gov/articles/understanding-fire-danger.htm

developer, Donald Haines, a Forest Service research meteorologist, who did the initial work and published the scale in 1988.[197]

- The Haines Index can range between two and six. The drier and more unstable the lower atmosphere is, the higher the index. It is calculated by combining the stability and moisture content to the lower atmosphere into a number that correlates well with large fire growth. The stability term is determined by the temperature difference between two atmospheric layers; the moisture term is determined by the temperature and dew point difference. The index has shown to correlate with large fire growth on initiating and existing fires where surface winds do not dominate fire behavior.[198] The Haines Index levels are described below:
  - Very Low Potential (2) – moist, stable lower atmosphere
  - Very Low Potential (3)
  - Low Potential (4)
  - Moderate Potential (5)
  - High Potential (6) – dry, unstable lower atmosphere
- The SPC states that the Haines Index is intended to be used all over the United States. It is adaptable for three elevation regimes: low elevation, middle elevation, and high elevation. Low elevation is for fires at or very near sea level. Middle elevation is for fires burning in the 1,000 to 3,000 feet in elevation range. High elevation is intended for fires burning above 3,000 feet in elevation.

2.27.4 Primary and Secondary Impacts

Wildfires can increase the probability of other natural disasters, specifically floods and mudflows. Wildfires, particular large-scale fires, can dramatically alter the terrain and ground conditions, making land already devastated by fire susceptible to floods. Lands impacted by wildfire increase the risk of flooding and mudflow in those areas impacted by wildfire. Normally, vegetation absorbs rainfall, reducing runoff. However, wildfires leave the ground charred, barren, and unable to absorb water; thus, creating conditions perfect for flash flooding and mudflows. Flood risk in these impacted areas remain significantly higher until vegetation is restored, which can take up to five years after a wildfire.[199]

Flooding after a wildfire is often more severe, as debris and ash left from the fire can form mudflows. During and after a rain event, as water moves across charred and denuded ground, it can also pick up soil and sediment and carry it in a stream of floodwaters. These mudflows have the potential to cause significant damage to impacted areas. Areas directly

[197] Storm Prediction Center. n.d. "Haines Index." National Oceanic and Atmospheric Administration. On-Line Address: http://www.spc.noaa.gov/exper/firecomp/INFO/hainesinfo.html
[198] http://www.fs.fed.us/
[199] https://www.fema.gov/news-release/2017/11/14/4344/flood-after-fire-increased-risk

affected by fires and those located below or downstream of burn areas are most at risk for flooding.Error! Bookmark not defined.

2.27.5 Severity

Potential losses from wildland fire include human life, structures and other improvements, and natural resources. Given the immediate response times to reported wildland fires, the likelihood of injuries and casualties is minimal. Smoke and air pollution from wildland fires can be a health hazard, especially for sensitive populations including children, the elderly, and those with respiratory and cardiovascular diseases. Wildland fire may also threaten the health and safety of those fighting the fires. First responders are exposed to the dangers from the initial incident and after-effects from smoke inhalation and heat stroke. In addition, wildland fire can lead to ancillary impacts such as landslides in steep ravine areas and flooding caused by the impacts of silt in local watersheds.[181]

The magnitude of wildland fire events is often characterized by their speed of propagation, total number of acres burned, and potential destructive impacts to people and property. The severity and impact of a wildland fire is greatly dependent on how it behaves, in combination with fire detection, control, and suppression capabilities.

2.27.6 Warning Time

Wildfires are often caused by humans, intentionally or accidentally. There is no way to predict when one might break out. However, there are tools used to identify the possibility of fire weather in an area. Fire weather watches and red flag warnings are used to convey the possibility of severe fire weather to wildland fire agencies. Because fireworks often cause brush fires, extra diligence is warranted around the Fourth of July holiday when the use of fireworks is highest. Dry seasons and droughts are factors that greatly increase fire likelihood. Dry lightning may trigger wildland fires. Severe weather can be predicted; therefore, special attention can be paid during weather events that might include lightning. Reliable NWS lightning warnings are available on average 24 to 48 hours prior to a significant electrical storm.

The National Weather Service (NWS) issues Fire Weather Watches and Red Flag Warnings to alert fire departments and residents of the onset, or possible onset, of critical weather and dry conditions that could lead to rapid or dramatic increases in wildfire activity. The watches, warnings, and evacuation notices are science-based predictions that are intended to provide adequate time for evacuation.

A fire weather watch is issued by the NWS when the potential for severe fire weather exists in the near future. A watch is used when there is a relatively low probability of occurrence and less chance of verifying. The fire danger rating is usually in the high to extreme category. It is normally issued 12 to 24 hours in advance of the expected onset of severe fire weather conditions and typically in conjunction with the routine narrative forecasts. The area affected, onset time, and a statement describing the conditions will be included in the forecast. A Red Flag Warning is issued by the NWS to indicate the imminent danger of severe fire weather and a relatively high probability of occurring. The fire danger is usually in the high to extreme category. A Red Flag Warning may or may not be preceded by a Fire Weather Watch. A Red Flag Warning will normally be issued for severe fire weather events less than 12 hours away from occurring. They are typically issued in conjunction with the routine narrative forecasts. The area affected, onset time, and a statement describing the conditions will be included in the forecast.[200]

If a fire does break out and spread rapidly, residents may need to evacuate within days or hours. A fire's peak burning period generally is between 1:00 p.m. and 6:00 p.m. Once a fire has started, fire alerting is reasonably rapid in most cases. The rapid spread of cellular and two-way radio communications in recent years has further contributed to a significant improvement in warning time.

2.27.7 Previous Occurrences and Losses

The State of Connecticut is one of the most heavily forested states in the United States. It is estimated that 1.8 million acres of forest and wildland cover the State.[201] While wildland fires have historically, and continue to be, a very frequent occurrence, the Division of Forestry estimates that these incidents burn only approximately 1,300 acres per year—less than a fraction of one-percent of the total forested acreage in the state. This is due to the fact that most wildland fires are quickly detected, contained, and suppressed before they are able to spread. See Figure 2-66 for a detailed map of the land cover of the State of Connecticut.

[200] https://www.nps.gov/fire/wildland-fire/learning-center/fire-in-depth/watches-warnings.cfm
[201] https://www.fs.fed.us/nrs/pubs/ru/ru_fs19.pdf

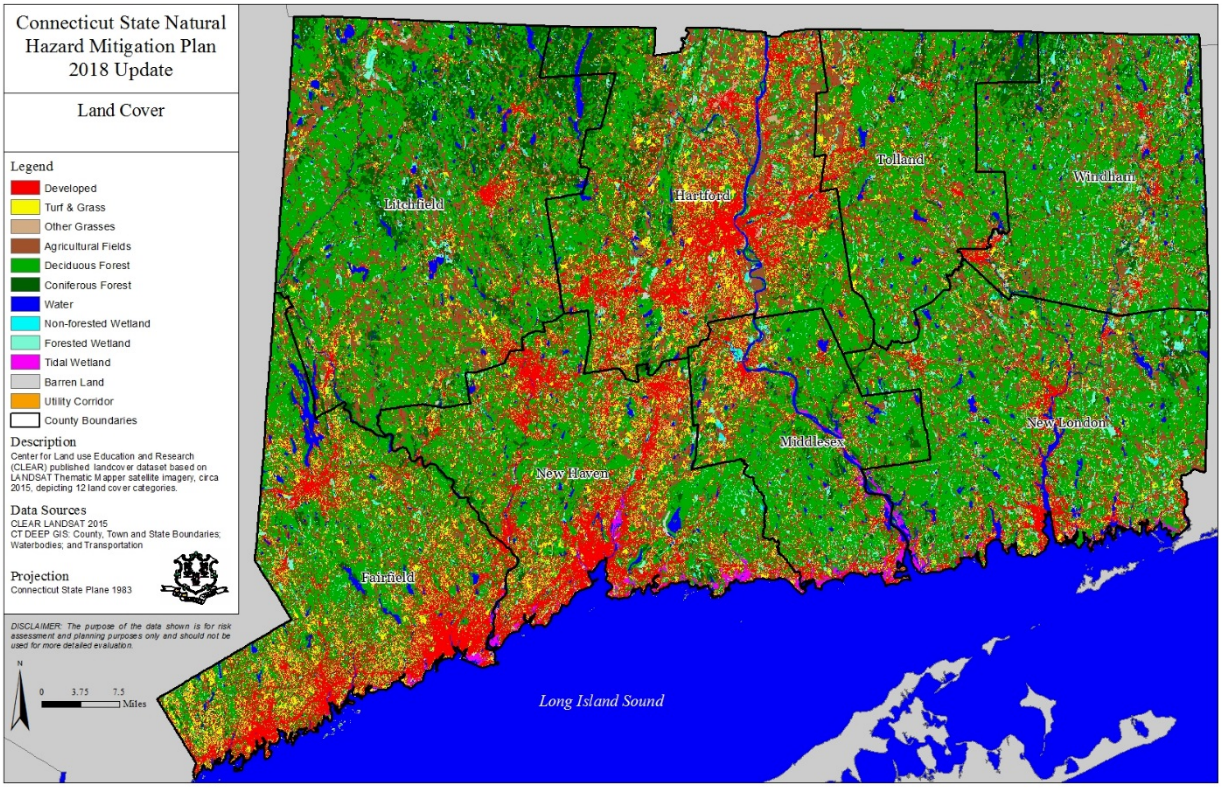


Figure 2-66: Forest and Other Land Cover, Connecticut 2015

Reporting of wildland fires is based on the National Fire Incident Reporting System (NFIRS). This system has greatly improved the accuracy of reported data concerning wildland fires (cause, size, etc.). However, it is believed that many additional small fires have occurred but gone unreported (Connecticut State HMP 2013). In 2016, 97 wildfires were reported to the National Interagency Fire Center (NIFC) and burned 243 acres in the State of Connecticut.[202] Table 2-101 summarizes the NFIRS data on reported wildland fire events from 2013-2017. According to these records, there have been 545 events reported between 2013 and 2017. The average fire size (total acres burned) per incident is very small at only 2.7 acres. Only one wildland fire incident in the past 5 years burned greater than 300 acres. This occurred in September 2016 and burned 381 acres.[203] During the past 5 years, the worst wildland fire year in terms of number of fires was 2016 with 778 separate wildland fire events. 2016 was also the worst year in terms of acres burned with 778 acres burned.

Many sources provided information regarding previous occurrences and losses associated with wildfire events throughout the State of Connecticut. The 2013 Plan discussed specific

[202] https://www.predictiveservices.nifc.gov/intelligence/2017_statssumm/fires_acres17.pdf
[203] https://www.geomac.gov/viewer/viewer.shtml

wildfire events that occurred in the State through 2013. For this 2019 Plan update, wildfire events were summarized between January 1, 2013 and December 31, 2017. Table 2-101 summarizes events that occurred between 2013 and 2017. Please note that not all sources have been identified or researched. Additionally, loss and impact information for many events could vary depending on the source. Therefore, Table 2-101 may not include all events that have occurred in the state and the accuracy of monetary figures discussed is based only on the available information identified during research for this HMP update. Lastly, it should be noted that both the NFIC and NCEI databases rely on reporting from similar sources, however the NFIC database includes far more wildfire events than the NCEI database. Therefore, the NFIC was considered to provide more comprehensive data and, as such, was used for this analysis.

Table 2-101: NFIC Wildland Fire Events in Connecticut, 2013-2017

Year	# of Events	# of Acres Burned
2013	76	238
2014	28	69
2015	76	159
2016	268	778
2017	97	243

FEMA Disaster Declarations

Between 1954 and 2017, the State of Connecticut has not been included in any wildfire-related major disaster (DR) or fire management assistance (FM) declarations.[204]

2.27.8 Probability of Future Events

Based on available data, wildland fires will continue to be a highly probable occurrence (>5 events per year) in Connecticut, though the size and severity of these events are deemed minimal due to the rapid detection, containment, and suppression of fire incidents. Estimating the approximate number of a catastrophic wildland fires to occur in Connecticut every year is next to impossible. This is because a number of variable factors impact the potential for a fire to occur and because some conditions (for example, ongoing land use development patterns, location, fuel sources) exert increasing pressure on the WUI zone.

Given the numerous factors that can impact urban fire and wildland fire potential, the likelihood of a fire event starting and sustaining itself should be gauged by professional fire managers on a daily basis.

Although the total land mass of Connecticut is much smaller in comparison to larger mid-western and western states, and recent history suggests that wildland fires are not currently a major hazard threat for the state overall, wildland fires may pose a greater

[204] https://www.fema.gov/disasters

threat in the future. This is due to a combination of factors, including but not limited to increasing population densities in WUI areas, increasing fuel loads due to disease, pests, and storm events that result in dieback of mature trees, and potentially drier, longer, and more severe fire seasons as a result of climate change. Each of these factors is described in more detail below.

Extreme weather events, including Tropical Storm Irene, Superstorm Sandy, Winter Storm Alfred, Winter Storm Nemo, and other snow/ice/wind events caused heavy damage and dieback to forested areas throughout the state. These impacts have resulted in a significantly increased amount of woody debris and fuel loads, increasing the probability of future wildland fire occurrences.

Due to the composition of the flora species that exist today in Connecticut's wildland areas and the unknown rate of transference of species from the current forest and wildland species to more southern and invasive species, it is difficult to project the exact risk or potential increased number of fire outbreaks which may occur in the future. However, what is known from past research on the topic of WUI areas is that education of private property owners and the mitigation efforts implemented by homeowners will be significantly important as the risk of wildland fires increases in the future. These educational and mitigation efforts will require a collaboration between government agencies (Federal, state, and local) and private property owners.[205]

The problem of vast WUI areas does exist within the state, although not to the degree that it exists in western states. Factors which lessen the risk for WUI areas in Connecticut include fuel-loading levels which are significantly less than other parts of the country; weather patterns producing median annual precipitation of greater than 42 inches which is well distributed throughout the year; and a landscaping preference which emphasizes large expanses of lawn around buildings. However, a change in these factors may increase the risk and potential number of wildland fire outbreaks experienced within WUI areas.

2.27.9 Climate Change Impacts

Fire is determined by climate variability, local topography, and human intervention. Hot, dry spells create the highest fire risk. Increased temperatures may intensify wildland fire danger by warming and drying out vegetation. A warmer climate would result in a longer wildland fire season. When climate alters fuel loads and fuel moisture, this changes the forest susceptibility to wildland fires. Climate changes also may increase winds that spread fires. Faster fires are harder to contain, and thus are more likely to expand into residential neighborhoods.

Providing projections of future climate change for a specific region is challenging. Shorter term projections are more closely tied to existing trends making longer term projections

[205] Cohen, Jack, *The Wildland-Urban Interface Fire Problem*, Forest History Today, Fall 2008.

even more challenging. The further out a prediction reaches the more subject to changing dynamics it becomes.[181]

The USDA Forest Service states that wildland and forest ecosystems are very complex and it is difficult to project what the exact impacts of climate change may be on such systems. Climate change studies for the Northeast indicate that over the next century, the existing forest habitat range may move 300 to 500 miles northward. Thus trees and vegetation currently found in the forests and wildland areas of Connecticut today would be replaced over the next century with tree species and vegetation more adapted to a warmer climate. This change in the flora composition will have an effect on the existing risk of wildland fires due to changes in the fuel load wildland areas will develop. In addition it has been projected that climate change will have an effect on the state's wildland areas by creating a warmer climate more conducive to invasive plant species and destructive vectors that will change the fire regime.

Currently Connecticut is experiencing climate conditions to support invading insects such as the Asian Longhorned Beetle and the Emerald Ash Borer. These insects are already a concern for today's wildland areas in Connecticut. Though not a direct threat to humans, these invasive pests are a threat to the existing ecosystem. These species have the ability to survive through Connecticut's current winter climate and threaten Connecticut's very mature forested areas across the state. The introduction of disease, pests, and invasive plants promotes the dieback of mature tree species thus creating increased available vegetative fuel loads in wildland areas. The direct threat to humans comes in the form of increased fire outbreaks in WUI areas which have the potential to burn hotter and greater amounts of acreage, thus putting people and their properties at increased risk.

Due to the composition of the flora species that exist today in Connecticut's wildland areas and the unknown rate of transference of species from the current forest and wildland species to more southern and invasive species, it is difficult to project the exact risk or potential increased number of fire outbreaks which may occur in the future. As the existing forests continue to change in age, structure, and species composition, wildland fire danger will continue to be an issue.

2.28 Wildland Fire Vulnerability Assessment

In addition to being one of the most heavily forested states in the nation, Connecticut also ranks among the most densely populated, and in turn, among the highest in terms of-percentage of land considered in WUI areas. According to 2010 U.S. Census data, Connecticut ranks as the fourth most densely populated state in the United States with more than 700 persons per square mile. In a 2005 study, Connecticut ranked number one in the nation with 72-percent of its land mass considered in WUI areas (ranking number 2 with 60-percent of its land mass considered located in intermix areas, and ranking number

3 with 12-percent of its land mass considered interface areas).[206] These high-percentages of WUI areas is a result of people's desire to move from the traditional highly urbanized geographic areas of the state to more suburban and rural wildland areas of the state.

Table 2-5 includes the number of infrastructure/facilities, building value and contents value by municipality. The state contains 3,327 state-owned buildings totaling $6.5 billion in building values; the building and contents values have not been estimated for all state-owned building. The State's total building and contents value only includes those buildings where value information was available and is intent for use in this plan and should not be used for other applications. The state contains 1,940 identified critical facilities in the categories of correctional institutions, EMS facilities, fire stations, gas stations with generator, health departments, law enforcement facilities, municipal solid waste, nuclear power plants, and storage tank farms. 1,846 of these critical facilities were able to be geospatially mapped for analysis.

For the purposes of this 2019 Plan update, all State buildings and local assets located in the wildland-urban interface hazard areas are exposed to wildfires. As the State of Connecticut continues to become more urbanized, the State facilities will need to be developed in locations that will serve the growing population.

2.28.1 Assessment of State Vulnerability and Potential Losses

To assess the vulnerability of state-owned facilities provided by Connecticut DCS, an analysis was conducted with the wildfire hazard areas (WUI). Using ArcGIS, the wildland-urban interface hazard areas were overlaid on the State-owned facilities and critical facilities for Connecticut. Facilities located within the interface and intermix areas are exposed to the wildfire hazard.

Table 2-102 and Table 2-103 provide a breakdown of the numbers and values of state-owned buildings intersecting wildland intermix and wildland interface areas by county. A total of 1,078 state-owned buildings (32.4-percent of the total number of state-owned buildings in the state) are located within a wildland fire hazard area. This amounts to a total of $1.8 billion in building values exposed to the wildland fire hazard (28.1-percent of the total value of all state-owned buildings in the state).

Table 2-102: Number of State-Owned Facilities in the WUI, by County

[206] *Wildland-Urban Interface in the United States*, by Susan Stewart, Volker Radeloff, and Roger B. Hammer. Ranking was based on 2000 Census data and WUI mapping.

County	Total State-Owned Buildings	Buildings Intersecting Intermix	Buildings Intersecting Interface	Total Buildings At Risk
Fairfield	205	42	15	57
Hartford	867	48	64	112
Litchfield	97	9	29	38
Middlesex	289	88	69	157
New Haven	561	121	73	194
New London	489	79	28	107
Tolland	628	104	169	273
Windham	191	51	89	140
Total	3,327	542	536	1,078

Table 2-103: Value of State-Owned Facilities in the WUI, by County

County	Total State-Owned Buildings	Buildings Intersecting Intermix	Buildings Intersecting Interface	Total Buildings At Risk
Fairfield	$328,049,014	$112,446,653	$56,736,569	$169,183,222
Hartford	$2,482,445,429	$15,198,887	$179,792,697	$194,991,584
Litchfield	$55,774,193	$4,416,798	$51,357,395	$55,774,193
Middlesex	$411,474,322	$24,701,724	$132,327,077	$157,028,801
New Haven	$824,597,613	$14,252,473	$139,502,299	$153,754,772
New London	$98,537,626	$14,353,447	$36,144,739	$50,498,186
Tolland	$2,016,260,747	$31,101,262	$773,628,416	$804,729,678
Windham	$253,657,976	$30,911,919	$204,036,538	$234,948,457
Total	$6,470,796,920	$247,383,163	$1,573,525,729	$1,820,908,892

The state contains 1,940 identified critical facilities in the categories of correctional institutions, EMS facilities, fire stations, gas stations with generator, health departments, law enforcement facilities, municipal solid waste, nuclear power plants, and storage tank farms. 1,846 of these critical facilities were able to be geospatially mapped for analysis.

Table 2-104 provides a breakdown of the numbers of critical facilities intersecting wildland intermix and wildland interface areas by county. A total of 986 critical facilities (53.4-percent of the total number of critical facilities in the state) are located within a wildland fire hazard area.

Table 2-104: Number of Critical Facilities in the WUI by County and Agency

County/Facility Types	All Critical Facilities	# within Intermix	Percent within Intermix	# within Interface	Percent within Interface	Total Facilities At Risk	Total Percent At Risk
Fairfield							
Correctional Institutions	4	1	25.0-percent	0	0.0-percent	1	25.0-percent
EMS	120	32	26.7-percent	31	25.8-percent	63	52.5-percent
Fire Stations	115	24	20.9-percent	28	24.3-percent	52	45.2-percent
Gas Station with Generator	22	6	27.3-percent	4	18.2-percent	10	45.5-percent
Health Departments	25	5	20.0-percent	5	20.0-percent	10	40.0-percent
Law Enforcement	35	8	22.9-percent	4	11.4-percent	12	34.3-percent
Municipal Solid Waste	43	8	18.6-percent	4	9.3-percent	12	27.9-percent
Nuclear Power Plant	0	0	0.0-percent	0	0.0-percent	0	0.0-percent
Storage Tank Farm	7	0	0.0-percent	0	0.0-percent	0	0.0-percent
Total for Fairfield	**371**	**84**	**22.6-percent**	**76**	**20.5-percent**	**160**	**43.1-percent**
Hartford							
Correctional Institutions	6	1	16.7-percent	0	0.0-percent	1	16.7-percent
EMS	80	13	16.3-percent	18	22.5-percent	31	38.8-percent
Fire Stations	141	19	13.5-percent	31	22.0-percent	50	35.5-percent
Gas Station with Generator	10	2	20.0-percent	0	0.0-percent	2	20.0-percent
Health Departments	26	0	0.0-percent	3	11.5-percent	3	11.5-percent
Law Enforcement	44	2	4.5-percent	8	18.2-percent	10	22.7-percent
Municipal Solid Waste	62	10	16.1-percent	8	12.9-percent	18	29.0-percent
Nuclear Power Plant	0	0	0.0-percent	0	0.0-percent	0	0.0-percent
Storage Tank Farm	8	0	0.0-percent	2	25.0-percent	2	25.0-percent

Total for Hartford	**377**	**47**	**12.5-percent**	**70**	**18.6-percent**	**117**	**31.0-percent**
Litchfield							
Correctional Institutions	0	0	0.0-percent	0	0.0-percent	0	0.0-percent
EMS	34	12	35.3-percent	14	41.2-percent	26	76.5-percent
Fire Stations	53	22	41.5-percent	21	39.6-percent	43	81.1-percent
Gas Station with Generator	8	3	37.5-percent	5	62.5-percent	8	100.0-percent
Health Departments	7	1	14.3-percent	5	71.4-percent	6	85.7-percent
Law Enforcement	25	10	40.0-percent	11	44.0-percent	21	84.0-percent
Municipal Solid Waste	29	17	58.6-percent	4	13.8-percent	21	72.4-percent
Nuclear Power Plant	0	0	0.0-percent	0	0.0-percent	0	0.0-percent
Storage Tank Farm	0	0	0.0-percent	0	0.0-percent	0	0.0-percent
Total for Litchfield	**156**	**65**	**41.7-percent**	**60**	**38.5-percent**	**125**	**80.1-percent**
Middlesex							
Correctional Institutions	1	0	0.0-percent	0	0.0-percent	0	0.0-percent
EMS	31	14	45.2-percent	11	35.5-percent	25	80.6-percent
Fire Stations	36	15	41.7-percent	15	41.7-percent	30	83.3-percent
Gas Station with Generator	8	5	62.5-percent	2	25.0-percent	7	87.5-percent
Health Departments	9	3	33.3-percent	5	55.6-percent	8	88.9-percent
Law Enforcement	17	4	23.5-percent	8	47.1-percent	12	70.6-percent
Municipal Solid Waste	21	13	61.9-percent	3	14.3-percent	16	76.2-percent
Nuclear Power Plant	0	0	0.0-percent	0	0.0-percent	0	0.0-percent
Storage Tank Farm	3	0	0.0-percent	0	0.0-percent	0	0.0-percent
Total for Middlesex	**126**	**54**	**42.9-percent**	**44**	**34.9-percent**	**98**	**77.8-percent**
New Haven							

Correctional Institutions	5	0	0.0-percent	0	0.0-percent	0	0.0-percent
EMS	76	13	17.1-percent	18	23.7-percent	31	40.8-percent
Fire Stations	115	17	14.8-percent	37	32.2-percent	54	47.0-percent
Gas Station with Generator	23	4	17.4-percent	10	43.5-percent	14	60.9-percent
Health Departments	26	3	11.5-percent	4	15.4-percent	7	26.9-percent
Law Enforcement	42	5	11.9-percent	10	23.8-percent	15	35.7-percent
Municipal Solid Waste	45	16	35.6-percent	7	15.6-percent	23	51.1-percent
Nuclear Power Plant	0	0	0.0-percent	0	0.0-percent	0	0.0-percent
Storage Tank Farm	10	0	0.0-percent	0	0.0-percent	0	0.0-percent
Total for New Haven	**342**	**58**	**17.0-percent**	**86**	**25.1-percent**	**144**	**42.1-percent**
New London							
Correctional Institutions	1	0	0.0-percent	0	0.0-percent	0	0.0-percent
EMS	77	24	31.2-percent	24	31.2-percent	48	62.3-percent
Fire Stations	68	20	29.4-percent	19	27.9-percent	39	57.4-percent
Gas Station with Generator	7	4	57.1-percent	3	42.9-percent	7	100.0-percent
Health Departments	14	3	21.4-percent	5	35.7-percent	8	57.1-percent
Law Enforcement	33	12	36.4-percent	6	18.2-percent	18	54.5-percent
Municipal Solid Waste	39	26	66.7-percent	5	12.8-percent	31	79.5-percent
Nuclear Power Plant	1	0	0.0-percent	0	0.0-percent	0	0.0-percent
Storage Tank Farm	2	0	0.0-percent	0	0.0-percent	0	0.0-percent
Total for New London	**242**	**89**	**36.8-percent**	**62**	**25.6-percent**	**151**	**62.4-percent**
Tolland							
Correctional Institutions	3	1	33.3-percent	0	0.0-percent	1	33.3-percent

EMS	35	22	62.9-percent	8	22.9-percent	30	85.7-percent
Fire Stations	37	24	64.9-percent	7	18.9-percent	31	83.8-percent
Gas Station with Generator	2	1	50.0-percent	0	0.0-percent	1	50.0-percent
Health Departments	4	1	25.0-percent	1	25.0-percent	2	50.0-percent
Law Enforcement	11	4	36.4-percent	3	27.3-percent	7	63.6-percent
Municipal Solid Waste	22	10	45.5-percent	4	18.2-percent	14	63.6-percent
Nuclear Power Plant	0	0	0.0-percent	0	0.0-percent	0	0.0-percent
Storage Tank Farm	0	0	0.0-percent	0	0.0-percent	0	0.0-percent
Total for Tolland	**114**	**63**	**55.3-percent**	**23**	**20.2-percent**	**86**	**75.4-percent**
Windham							
Correctional Institutions	1	0	0.0-percent	1	100.0-percent	1	100.0-percent
EMS	43	29	67.4-percent	12	27.9-percent	41	95.3-percent
Fire Stations	40	28	70.0-percent	10	25.0-percent	38	95.0-percent
Gas Station with Generator	2	0	0.0-percent	2	100.0-percent	2	100.0-percent
Health Departments	3	0	0.0-percent	2	66.7-percent	2	66.7-percent
Law Enforcement	12	3	25.0-percent	8	66.7-percent	11	91.7-percent
Municipal Solid Waste	17	7	41.2-percent	3	17.6-percent	10	58.8-percent
Nuclear Power Plant	0	0	0.0-percent	0	0.0-percent	0	0.0-percent
Storage Tank Farm	0	0	0.0-percent	0	0.0-percent	0	0.0-percent
Total for Windham	**118**	**67**	**56.8-percent**	**38**	**32.2-percent**	**105**	**89.0-percent**
Total for State	**1846**	**527**	**28.5-percent**	**459**	**24.9-percent**	**986**	**53.4-percent**

Most roads and railroads would not be damaged except in the worst-case wildfire scenarios. Fires can create conditions that block or prevent access and can isolate residents and emergency service providers. Power lines are the most at risk to wildfire because most poles are made of wood and susceptible to burning. In the event of a wildfire, pipelines that provide a source of fuel could be ignited, leading to a catastrophic explosion. The wildfire hazard typically does not have a major direct impact on bridges, but it can create conditions in which bridges are obstructed or weakened.

2.28.2 Assessment of Local Vulnerability and Potential Losses

In addition to threatening life and safety and destroying buildings and critical facilities, wildfire events can have major economic impacts on a community from the initial loss of structures and the subsequent loss of revenue from destroyed business and decrease in tourism. Wildfires can cost thousands of taxpayer dollars to suppress and control and involve hundreds of operating hours on fire apparatus and thousands of volunteer man hours from the volunteer firefighters. There are also many direct and indirect costs to local businesses that excuse volunteers from working to fight these fires.

To estimate potential losses by jurisdiction, the exposure analysis methodology was used. Table 2-105 provides a breakdown by county of the numbers of people intersecting wildland fire hazard areas. This analysis was conducted by intersecting the 2010 U.S. census blocks with wildland fire hazard data using GIS. In instances where only a portion of the census block intersected the hazard area, only that same portion of the population is counted. For example, if 20-percent of the census block intersects with an intermix area, only 20-percent of the population number for that census block group is counted). This results in estimated values and there is potential for error with this methodology, but this is considered a more refined approach than assuming 100-percent of the population is contained within the 20-percent of the census block that intersects the hazard area. The total population at risk is estimated at 1,863,092, which is 52.1-percent of the total population of the state.

Table 2-105: Population Intersecting Wildland Fire Hazard Areas.

County	Total Population	Population Intersecting Intermix	Population Intersecting Interface	Total Population At Risk
Fairfield	916,829	183,134	142,857	325,991
Hartford	894,014	115,711	223,247	338,958
Litchfield	189,927	94,072	83,097	177,169
Middlesex	165,676	70,408	56,757	127,165
New Haven	862,477	150,753	298,970	449,723
New London	274,055	112,737	97,903	210,640
Tolland	152,691	78,472	42,034	120,506
Windham	118,428	61,190	51,750	112,940
Total	3,574,097	866,478	996,614	1,863,092

2.28.3 Changes in Development

An understanding of population and development trends can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The State considered the following factors to examine previous and potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate

Ass discussed above in Section 1.28.2, Connecticut is one of the most heavily forested states in the nation and ranks among the most densely populated, and in turn, among the highest in terms of-percentage of land considered in WUI areas. Most of the wildland-urban interface areas in the State are categorized as intermix areas. If not adequately planned, any new development and increases in population may be vulnerable to these events. As discussed in Section 1.2.4 (Land Use and Development), Fairfield County and Hartford County continue to see the majority of development. As of 2016, approximately 65.7% of the building permits statewide were in Fairfield and Hartford Counties, and both of these counties accounted for nearly half of all the housing units in the State. If recent trends in development continue, these two Counties can increase their vulnerability to wildfire. While the data displayed in Figure 2-65 shows Litchfield County has the greatest intermix area in the State, Fairfield County has the greatest area of high and medium density intermix; it is possible that many new developments and increases in population within Fairfield County will be located in these areas. Statewide, there is an estimated 2.2% change in population expected between 2020 and 2040; the increases in population will increase the State population's vulnerability to wildfire if populations move into the wildland-urban interface hazard areas.

2.28.4 Hazard Ranking

Quantitative risk assessment, to the degree possible, has been completed for wildland fire using the methodology described in the Hazard Analysis and Ranking methodology Section 2.6 of this chapter. Scores for each jurisdiction were calculated based on population, building permits, geographic extent, average score from local plan rankings, average hazard concern, and measures of historical impact including injuries and deaths, property damage, and the number of reported events. The number of critical facilities in the WUI was also incorporated, and ranked based on the number of facilities impacted in relation to the number of total critical facilities in Connecticut. As shown in Table 2-106, the composite wildland hazard rank shows Hartford County as low risk, and all other counties as medium-low risk.

Table 2-106: Hazard Ranking by County for Wildland Fire

County	Hazard Concern Rank	Local Plans Hazard Rank	Geographic Extent Rank	Population Density Rank	Building Permits Rank	Facility Intersect Rank	Ann. Events Rank	Ann. Losses Rank	Injury & Death Rank	Composite Ranks
Fairfield	Medium-Low	Low	Medium-High	High	High	Medium	Low	Low	Low	**Medium-Low**
Hartford	Medium-Low	Low	Medium	High	High	Low	Low	Low	Low	**Low**
Litchfield	Medium-Low	Low	Medium-High	Low	Low	High	Low	Low	Low	**Medium-Low**
Middlesex	Medium-Low	Low	High	Medium-Low	Medium-Low	High	Low	Low	Low	**Medium-Low**
New Haven	Medium-Low	Low	Medium-High	High	Medium	Medium	Low	Low	Low	**Medium-Low**
New London	Medium-Low	Low	Medium-High	Medium-Low	Medium-Low	Medium-High	Low	Low	Low	**Medium-Low**
Tolland	Medium-Low	Low	High	Medium-Low	Medium-Low	Medium-High	Low	Low	Low	**Medium-Low**
Windham	Medium-Low	Low	High	Medium-Low	Low	High	Low	Low	Low	**Medium-Low**

2.29 Hazard Rankings Summary

For the State of Connecticut, the hazards discussed in this chapter were ranked on a scale from High (5), Medium-High (4), Medium (3), Medium-Low (2), and Low (1) based on a number of factors. To summarize the overall risk from natural hazards for each county, the individual hazard-specific rankings were combined. For each individual hazard, the rank score for each parameter (described in detail in Section 2.7) was multiplied by its weight. These rankings were then averaged across counties and hazard to provide the composite data presented below. As a note, the high to low comparison only ranks these hazards comparatively for Connecticut. That does not mean that a low or medium-low hazard will not occur or does not have some impact on the community. It does provide an overview of what hazards may pose the greatest risk to Connecticut. This document should serve as a guide to help planners and officials in managing risk and prioritize mitigation actions.

Figure 2-67 shows the overall hazard ranking for each county in Connecticut. Fairfield, New Haven, and Hartford Counties have a high hazard risk. Litchfield County has a medium-high risk; Middlesex, New London, and Tolland Counties have a medium risk, and Windham County has a medium-low risk. Table 2-107 provides more detail on the individual hazard rankings for each county. Across all counties, winter weather and thunderstorms are notably higher risk hazards, with tornado, flood, and tropical cyclone having a slightly lower, but still significant risk. Dam failure and wildland fire have particularly low risk across all counties.

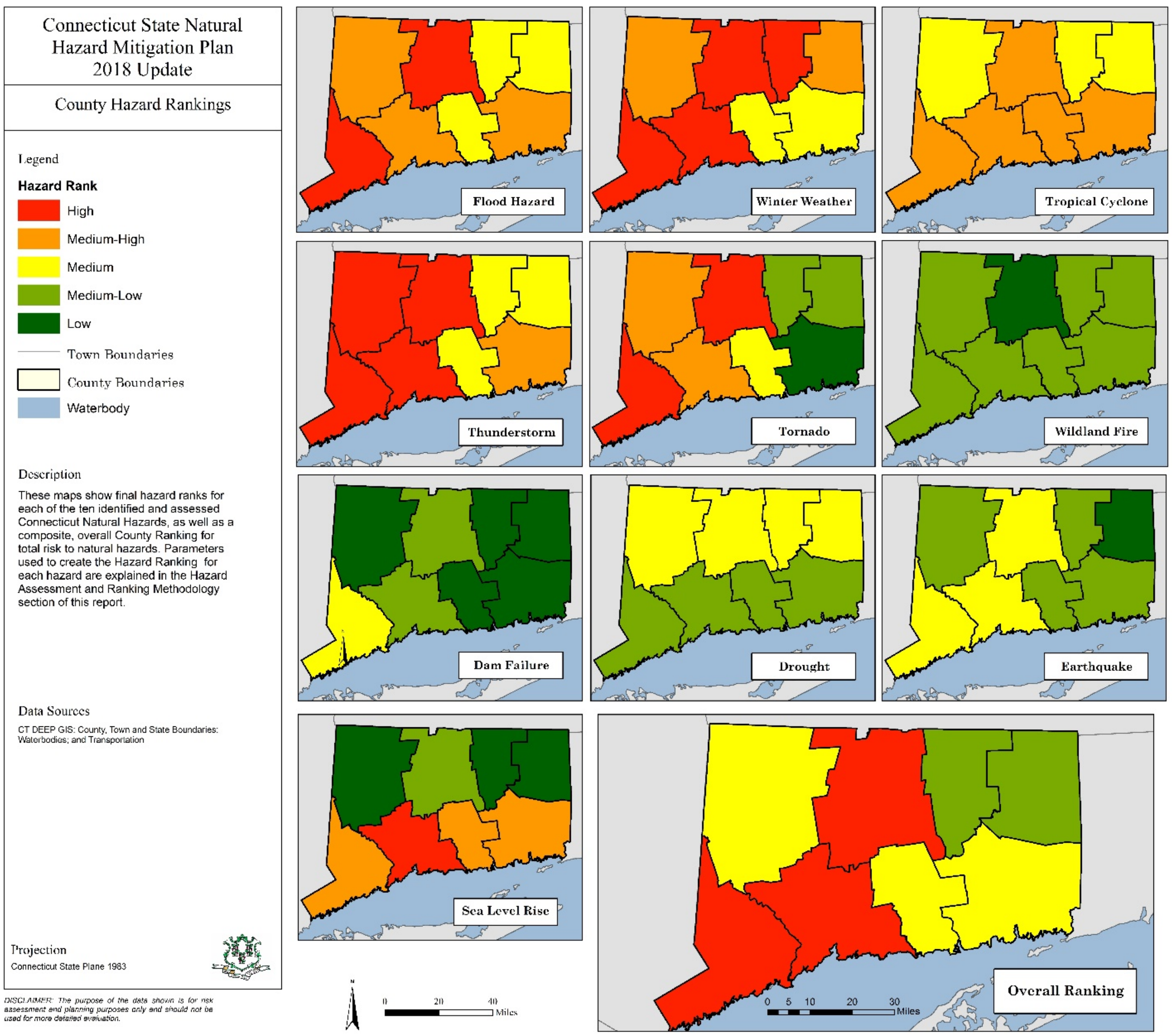


Figure 2-67: Composite County Hazard Ranking

Table 2-107: Hazard Ranking by County for all Hazards

County	Dam Failure Hazard Ranking	Drought Hazard Ranking	Earthquake Hazard Ranking	Flood Hazard Ranking	Sea Level Rise Hazard Ranking	Thunderstorm Hazard Ranking	Tornado Hazard Ranking	Tropical Cyclone Hazard Ranking	Wildland Fire Hazard Ranking	Winter Weather Hazard Ranking
Fairfield	Medium	Medium-Low	Medium	High	Medium-High	High	High	Medium-High	Medium-Low	High
Hartford	Medium-Low	Medium	Medium	High	Medium-Low	High	High	Medium-High	Low	High
Litchfield	Low	Medium	Medium-Low	Medium-High	Low	High	Medium-High	Medium	Medium-Low	Medium-High
Middlesex	Low	Medium-Low	Medium-Low	Medium	Medium-High	Medium	Medium	Medium-High	Medium-Low	Medium
New Haven	Medium-Low	Medium-Low	Medium	Medium-High	High	High	Medium-High	Medium-High	Medium-Low	High
New London	Low	Medium-Low	Medium-Low	Medium-High	Medium-High	Medium-High	Low	Medium-High	Medium-Low	Medium
Tolland	Low	Medium	Medium-Low	Medium	Low	Medium	Medium-Low	Medium	Medium-Low	High
Windham	Low	Medium	Low	Medium	Low	Medium	Medium-Low	Medium	Medium-Low	Medium-High

3 Capability Assessment

This chapter outlines State and local natural hazard mitigation policies, programs, and capabilities. In particular, the roles and responsibilities are described for the various agencies, departments, and offices that participated in the NHMP planning process.

Several significant changes occurred over the three years prior to development of the 2014 edition of this plan with regard to the State's capabilities analysis. Many of these changes were related to the re-organization of state agencies that either directly or indirectly addressed natural hazards, such as the formation of the Department of Energy and Environmental Protection (DEEP) and the merging of DEMHS into DESPP. In contrast, State Agency changes have not occurred since 2014. Rather, the focus of State Agencies has been to further develop their programs as related to hazard mitigation, which has included some internal changes in divisions. Furthermore, the Connecticut Institute for Resilience and Climate Adaptation (CIRCA) was formed as a partnership between DEEP and UConn. CIRCA is described in more detail below in Section 3.2.

Other changes to State capabilities that were described in the 2014 edition of this plan included the following state-level committees and task forces (described in Section 3.2.3), some of which are either inactive at the present time or have ceded their interests to other agencies:

- The Adaptation Subcommittee of the Governor's Steering Committee on Climate Change (formed in 2008);
- The Governor's Two Storm Panel (formed in 2011);
- The Connecticut GIS Council's Storm Response and Recovery Assessment Group (formed in 2011);
- The Shoreline Preservation Task Force (formed in 2012);
- The State's Long-Term Recovery Committee (formed in 2012); and
- The State Vegetation Management Task Force (formed in 2012).

Aside from internal state agency changes and the formation of CIRCA, a number of other changes in capabilities have been underway such as Risk MAP progress, updates to the State Building Code, updates to the State Conservation and Development Policies Plan, and development of the State Water Plan. Although they do not represent new capabilities, this section of the plan describes the planning and technical assistance services provided by DCS Technical Services, the University of Connecticut, The Nature Conservancy, and other organizations that work with Connecticut's community leaders and officials.

Local capabilities are largely the same as they were in 2014. However, with the recognition that local communities have a significant role in disaster preparedness and implementation of hazard mitigation measures, this update to the plan provides more detail about these local capabilities.

The following sub-sections describe federal, state, intra-state regional, local (municipal), and non-governmental capabilities, in that sequence.

3.1 Federal Agencies and Programs for Disaster Response and Recovery, and Related Executive Orders

This section describes the roles, executive orders and programs of the primary federal agencies that assist the State of Connecticut by providing funding for natural hazard mitigation and disaster response. This chapter does not serve as a grant administrative plan[207], however the general grant administrative procedures for some grants (e.g., FEMA) are included in this chapter. The following descriptions of the grant programs and general administrative practices are not intended to dictate state policy or decision-making procedures or outcomes.

In general the potential financial support sources listed in this chapter have not changed from the 2014 Plan. Hazard mitigation assistance grant programs remain under one umbrella grant program and process, called the Hazard Mitigation Assistance Program (HMA).

3.1.1 Federal Executive Orders

The following Federal Executive Orders apply to DEEP projects that relate to natural hazard mitigation:

- Executive Order 11988 – Floodplain Management – This Executive Order requires Federal agencies to evaluate the potential effects of any Federal action that may affect floodplains and to eliminate or reduce any negative effects of that action.
- PL-566, Section 205 – This Public Law authorizes the USDA, NRCS and the USACE to undertake flood and erosion control projects in cooperation with the DEEP.
- Executive Order 11990 – Protection of Wetlands.
- Executive Order 13632 - Establishing the Hurricane Sandy Rebuilding Task Force
- Executive Order 13653 - Preparing the United States for the Impacts of Climate Change
- Executive Order 13690 - Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Stakeholder Input. On August 15, 2017, President Trump repealed Executive Order 13690, the Federal Flood Risk Management Standard (FFRMS). The repeal is part of Trump's efforts to eliminate and streamline permitting regulations for infrastructure projects.
- Executive Order 13717 - Establishing a Federal Earthquake Risk Management Standard – Requires proactive steps to enhance the resilience of buildings to earthquakes that are owned, leased, financed, or regulated by the Federal Government.
- Executive Order 13728 - Wildland-Urban Interface Federal Risk Mitigation - Section 2 (f) requires agencies assisting in the financing of any buildings above 5,000 gross square feet within the wildland-urban interface at moderate or greater wildfire risk

[207] DEMHS revised the former State Grant Administration Plan and developed it as a stand-alone state procedures plan for the HMGP, entitled *2008 HMGP Administration Plan.* A copy of the HMGP Administration Plan is located in Appendix 3-1 of this Plan.

to consider updating its procedures for providing the assistance to ensure appropriate consideration of wildfire-resistant design and construction.
- Executive Order 13744 - Coordinating Efforts To Prepare the Nation for Space Weather Events – Requires a Federal plan to predict, protect against, and recover from extreme space weather events to minimize the extent of economic loss and human hardship.

3.1.2 Federal Emergency Management Agency (FEMA)

In March 2003, FEMA became a part of the newly established U.S. Department of Homeland Security under the Emergency Preparedness and Response Directorate.

FEMA sponsors the major flood related programs through the Federal Insurance Administration, the National Preparedness Programs Directorate, and the State and Local Programs Directorate. FEMA also provides disaster assistance under Section 404 of the Robert T. Stafford Disaster Assistance and Recovery Act and the Flood Mitigation Assistance Act, Part 78.

FEMA Enabling Legislation

FEMA regulations are mandated under the Code of Federal Regulations (CFR), Title 44 Part 14. CFR Title 44, Part 13 entitled Uniform Administrative Requirements of Grants and Cooperative Agreements to State and Local Governments authorized the original FMA Regulations and the eventual HMA umbrella program. Executive Orders 12612 (Federalism), 11990 (Protection of Wetlands), and 11988 (Floodplain Management) have further requirements to be followed by FEMA.

The NFIP is mandated under the CFR Title 44 Sections 59 - 80 inclusive. FEMA Law - Title V, the National Flood Insurance Reform Act of 1994, Subtitles D, E, and F also apply.

Robert T. Stafford Disaster Relief and Emergency Assistance Act

On November 23, 1988, President Reagan signed the Robert T. Stafford Disaster Relief and Emergency Assistance Act (42 USC 5121 et seq.) into law. The Stafford Act provides disaster assistance to states and municipalities after major disasters through the Hazard Mitigation Grant Program (HMGP) and through individual assistance and public assistance aid programs. A major disaster is defined as a natural disaster that causes damage equal to or greater than $1.00 per capita in a state. Based on current population information, this Act would normally be initiated for Connecticut after a disaster that caused greater than $3.2 million in damages statewide. If several states are affected by the same disaster, the $1.00 per capita standard may be waived.

FEMA Disaster Preparedness Programs
The National Flood Insurance Program (NFIP)

The U.S. Congress established the NFIP on August 1, 1968, with the passage of the National Flood Insurance Act of 1968. The NFIP is a Federal program administered by

FEMA enabling property owners in participating communities to purchase insurance protection against losses from flooding. This insurance is designed to provide an alternative to disaster assistance to meet the escalating costs of repairing damage to buildings and their contents caused by floods.

The State of Connecticut and all of its communities participate in the NFIP. Connecticut's NFIP coordinator is located within DEEP's IWRD. FEMA prepares Flood Insurance Rate Maps (FIRM) which identify Special Flood Hazard Areas (SFHA), high risk areas defined as any land that would be inundated by a flood having a 1-percent chance of occurring in any given year. Participation in the NFIP is based on an agreement between local communities and the Federal government that states if a community adopts and enforces a floodplain management ordinance to reduce future flood risks to new construction in SFHAs, the Federal Government will make flood insurance available within the community as a financial protection against flood losses.

A major effort of FEMA is the continued implementation of the NFIP. This is accomplished by:

- Requiring the first floor of buildings to be elevated above the base flood elevation;
- Discouraging development in Coastal Barriers Resource Act (COBRA) areas;
- Conducting detailed engineering studies of most watercourses;
- Delineating floodways and floodway fringes showing flood conveyance and storage areas;
- Requiring communities to adopt floodplain management regulations;
- Subsidizing insurance for structures already in flood risk areas;
- Requiring insurance at actuarial rates for new structures proposed for flood risk areas;
- Joining the availability of disaster relief programs, federal grants and loans and federally backed mortgages to a community's willingness to participate in the program; and
- Requiring lending institutions to notify the purchaser or lessee of special flood hazard in advance of the signing of purchase or lease agreements.

The NFIP Community Rating System (CRS) was implemented in 1990 as a voluntary program for recognizing and encouraging community floodplain management activities exceeding the minimum NFIP standards. Above-and-beyond management is rewarded with discounted insurance premium rates within that community. In 2013, the CRS Coordinator's Manual was updated to reflect changing demographics and other built conditions, as well as current understanding of the effects of climate change.

The Biggert-Waters Flood Insurance Reform Act of 2012 was meant to gradually phasing out subsidized and grandfathered rates for Pre-FIRM properties and properties mapped in the floodplain with the goal of making the NFIP more self-sufficient through the use of actuarial insurance rates for all properties. When the 2014 edition of this plan was approved, the Act was still in effect as passed.

The Consolidated Appropriations Act of 2014 prohibited the implementation of Section 207 of the Biggert-Waters Act, which ensured properties' flood insurance rates reflect their full risk after a mapping change or update occurs. The 2014 Act stopped rate increases while new law was being developed to address rate concerns. This did not affect any other provision of Biggert-Waters, meaning FEMA is still prohibited from offering subsidized rates to Pre-FIRM properties purchased after Biggert-Waters was enacted, properties not insured when Biggert-Waters was enacted, and properties that experienced a lapse in coverage. Additionally, FEMA will continue to phase-out subsidized rates for Pre-FIRM non-primary residences, businesses, and properties with severe or repeated flooding.[208]

The Homeowner Flood Insurance Affordability Act of 2014 repealed certain parts of the Biggert-Waters Act, restoring grandfathering, putting limits of certain rate increases and updating the approach to ensuring the fiscal soundness of the fun by applying an annual surcharge to all policyholders.[209]

On November 17, 2017, the House passed HR 2874, the 21st Century Flood Reform Act, to revamp the NFIP and authorize the program for five more years.

Civil Preparedness Activities

These activities are funded in part by FEMA, and are described elsewhere in this chapter under the description for the Division of Emergency Management and Homeland Security (DEMHS).

FEMA Natural Hazard Mitigation Programs

FEMA administers the following major natural hazard mitigation programs:

- Hazard Mitigation Grant Program (HMGP);
- Pre-Disaster Mitigation (PDM);
- Flood Mitigation Assistance (FMA); and
- Emergency Management Performance Grant (EMPG).

The Biggert Waters Flood Insurance Reform Act of 2012 eliminated the RFC program, and the former SRL grant is covered under FMA.

The first three programs are administered under the Hazard Mitigation Assistance (HMA) umbrella program, while EMPG is administered separately. Each program is similar in its funding formula (75% federal / 25% State or Local) except FMA, which may have a 90%

[208] https://www.fema.gov/media-library-data/1392062928758-80537fe9ad63607837d8a29f04280492/BW12_consolidated_app_2014.pdf
[209] https://www.fema.gov/media-library-data/1396551935597-4048b68f6d695a6eb6e6e7118d3ce464/HFIAA_Overview_FINAL_03282014.pdf

federal and 10% state or local cost share for SRL properties. However, each program has different eligibility criteria and timelines for project completion. Each program also requires that all projects be cost-effective (i.e., at least one dollar of benefit must result from each dollar of cost). This is accomplished through the utilization of FEMA's Benefit-Cost Analysis (BCA) software.

The Hazard Mitigation Assistance Program

HMA was created by FEMA to unify the application process of three of its current and two of its former hazard mitigation grant programs (HMGP, PDM, FMA, RFC, and SRL). As stated in the HMA Unified Guidance document, "these programs provide significant opportunities to reduce or eliminate potential losses to State, Tribal, and local assets through hazard mitigation planning and project grant funding. Each HMA program was authorized by separate legislative action, and as such, each program differs slightly in scope and intent". Table 3-1 summarizes the five hazard mitigation grant programs.

Potential projects under each program are shown in Table 3-2 as published in the 2010 HMA Unified Guidance Document.

Table 3-1: FEMA Grant Programs Available Under the Unified HMA Program.

FEATURE / PROGRAM	HAZARD MITAGATION GRANT PROGRAM	FLOOD MITIGATION ASSISTANCE	PRE-DISASTER MITIGATION
AUTHORIZATION	Section 404 of the Stafford Act Only available after a Presidentially Declared Disaster	44 Code of Federal Regulations Part 78	Disaster Mitigation Act of 2000
QUALIFYING CRITERIA	Must be a project that mitigates damages from a current disaster or past disaster within Connecticut.	Must be a project that mitigates damages from flooding to insurable repetitive loss structures,	Full range of Natural Disaster Hazard in Connecticut, however, flood mitigation is preferred.
APPROVALS	State approval based on recommendations from the CIHMC. Federal approval from FEMA	State approval based on recommendations from the CIHMC. Federal approval from FEMA	State approval based on recommendations from the CIHMC. Federal approval from FEMA
FUNDING LIMITS	Tiered percentages based on estimated aggregate amounts of disaster assistance	\$20,000 for plans \$20,000 for technical assistance \$300,000 for projects	\$4 million for mitigation projects \$400,000 for new plans \$300,000 for plan updates
TIME LIMITS	2 Years for construction 3 Years for plans	2 Years for construction 3 Years for plans	2 Years for construction 3 Years for plans

Table 3-2: Eligible Activities by Program

Eligible Activities	HMGP	PDM	FMA
Property Acquisition and Structure Demolition or Relocation	X	X	X
Structure Elevation	X	X	X
Mitigation Reconstruction			X
Dry Floodproofing of Historic Residential Structures	X	X	X
Dry Floodproofing of Nonresidential Structures	X	X	X
Generators	X	X	
Localized Flood Reduction Projects	X	X	X
Non-localized Flood Reduction Projects	X	X	
Structural Retrofitting of Existing Buildings	X	X	
Nonstructural Retrofitting of Existing Buildings and Facilities	X	X	X
Safe Room Construction	X	X	
Wind Retrofit for One- and Two-Family Residences	X	X	
Infrastructure Retrofit	X	X	X
Soil Stabilization	X	X	X
Wildfire Mitigation	X	X	
Postdisaster Code Enforcement	X		
Advance Assistance	X		
5% Initiative Projects	X		
Miscellaneous/Other	X	X	X

Source: Table 3 – HMA Unified Guidance document, 2015

The following subsections will provide a more detailed description of each of the grant programs which have been placed under this umbrella grant program for application process efficiency. In Connecticut, DEMHS administers these grants.

The Hazard Mitigation Grant Program (HMGP)

Section 404 of the Stafford Act created the HMGP, which provides federal grants to states and municipalities for post-disaster natural hazard mitigation. HMGP funding is allocated to a state by the use of a sliding scale calculation. The total grant funding from HMGP cannot exceed 15% (for a state with a FEMA approved Standard Natural Hazard Mitigation Plan) or 20% (for a state with a FEMA approved Enhanced Natural Hazard Mitigation Plan) of the total disaster damages for the first $2 billion. After the total aggregate amount of $2 billion in damages the amount of funding for subsequent aggregate damages is decreased according to FEMA's formula. This FEMA formula calculates the next portion of aggregate damages between $2 billion and $10 billion by 10%, and for the next portion of aggregate damages between $10 billion and $35.333 billion, funding is calculated at 7.5%.

The monies from this federal grant are given to Connecticut to support local mitigation projects, with a cost share ratio of 75% federal and 25% local match. [210]

The HMGP is active only after a presidentially declared disaster. The HMGP grant provides communities with up to 75% of the total cost of projects that reduce or prevent further damage from natural disasters. Projects may include, but are not limited to: acquisition, relocation, elevation or demolition of flood prone structures, construction of small scale flood control projects such as levees and small dams, retrofitting of structures to withstand wind and seismic forces and the drafting of plans that lead directly to the implementation of mitigation measures. Municipalities are not able to receive funding under the HMGP without an approved local hazard mitigation plan.

Pre-Disaster Mitigation Program (PDM)

The disaster experiences of the 1990s demanded that federal, state and local emergency managers reassess their approach to disaster response and recovery. It became apparent that the nation needed to shift its approach from a disaster-response driven system to a system based on pre-disaster or ongoing risk analysis so that the nation as a whole could become proactive rather than reactive to hazard events. This acknowledgement caused FEMA to re-evaluate its national strategy, resources and priorities. As a result of this evaluation, a unit for Natural Hazard Mitigation Planning was established in 1998 within FEMA to provide guidance and resources to states and local communities to promote and support the mitigation planning process. FEMA and the State of Connecticut place great value on the planning process as an approach to mitigation that must be promoted and supported in order to build sustainable, disaster resilient communities.

On October 20, 2000, Congress passed the Disaster Mitigation Act of 2000 (DMA 2000) (Public Law 106-390). This was the first major amendment to the Robert T. Stafford Disaster Relief and Emergency Assistance Act since that law was initially passed in 1988. Through DMA 2000, Congress approved the creation of a new mitigation grant program, PDM, to provide a mitigation funding mechanism that is not dependent on a presidential disaster declaration and could fund both natural hazard mitigation construction projects and natural hazard mitigation planning initiatives. PDM funding has changed since its inception. In the program's initial years, a base allocation of funding was granted to each state and additional funds were provided using a population formula. Recently, FEMA has changed the program to a nationally competitive grant program where projects from all states compete against each other with FEMA choosing the winning projects that will receive funding. Eligible PDM projects include: state and local natural hazard mitigation planning, mitigation projects, and community outreach and education. The PDM grant is a 75% federal 25% local cost-share grant (e.g., cash, in-kind services, etc.).

[210] Information derived from FEMA Hazard Mitigation Grant Program website: www.fema.gov/hazard-mitigation-grant-program

For fiscal years 2002-2007, a main focus of the PDM program was on the development of local or regional natural hazard mitigation plans to help meet the new local natural hazard mitigation planning requirements of DMA 2000. Communities applying for any FEMA mitigation grant to conduct mitigation projects (e.g. home elevations, acquisitions) must have an adopted local natural hazard mitigation plan in place prior to receiving funds.

The PDM program is undergoing significant changes, and has not been supported in the last two years. FEMA anticipates that PDM will be available in the near future, although national funding levels may be reduced. In 2017, FEMA added an emphasis on public-private partnerships.

Flood Mitigation Assistance (FMA)

In 1994 the United States Congress established FMA to assist state and local governments in funding cost-effective actions that reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other insurable structures. The long-term goal of FMA is to reduce or eliminate claims under the NFIP through the use of mitigation activities with a specific focus on repetitive loss properties. Repetitive loss properties are those properties that suffer at least 2 claims of more than $1,000 each for flood damage in a 10-year period.

The FMA program provides cost-share grants for three purposes: 1) planning grants to states and communities to assess the flood risk and identify actions to reduce that risk; 2) project grants to execute measures to reduce flood losses; and 3) technical assistance grants that states may use to fund staff salary and program expenses in order to administer the FMA program.

The Biggert-Waters Flood Insurance Reform Act of 2012 eliminated the RFC and SRL programs and made the following changes to the FMA program:

- The definitions of repetitive loss and severe repetitive loss properties have been modified.
- Cost-share requirements have changed to allow more federal funds for properties with repetitive flood claims and SRL properties.
- There is no longer a limit on in-kind contributions for the nonfederal cost share.

The Emergency Management Performance Grant Program (EMPG)

The purpose of the EMPG Program is to make grants to States to assist State, local, territorial, and tribal governments in preparing for all hazards, as authorized by the *Robert T. Stafford Disaster Relief and Emergency Assistance Act* (42 U.S.C. 5121 et seq.). Title VI of the *Stafford Act* authorizes FEMA to make grants for the purpose of providing a system of emergency preparedness for the protection of life and property in the United States from hazards and to vest responsibility for emergency preparedness jointly in the Federal Government, States, and their political subdivisions. The Federal Government, through the EMPG Program, provides necessary direction, coordination, and guidance, and provides necessary assistance, as authorized in this title so that a comprehensive emergency preparedness system exists at all levels for all hazards.

The EMPG supports core capabilities across the five mission areas of Prevention, Protection, Mitigation, Response, and Recovery based on allowable costs. Either the State Administering Agency (SAA) or the State's EMA are eligible to apply directly to FEMA for EMPG Program funds on behalf of State and local emergency management agencies, however only one application will be accepted from each State or territory. In Connecticut, the EMPG is administered by DEMHS.

3.1.3 Natural Resources Conservation Service

The United States Department of Agriculture's (USDA) NRCS provides significant technical and engineering assistance to the DEEP, DEMHS, and other state agencies in the planning and implementation of activities. Most projects are conducted under Public Law (PL)-566, the Small Watershed Program Authorization and are related with soil erosion and flooding. A member of the NRCS is also appointed to the CIHMC (as discussed later).

NRCS projects are conducted under federal PL-566 and CGS Sections 22a-318 through 324 and provide the framework for state cooperation with the NRCS when utilizing the Watershed Protection and Flood Prevention Act, PL 83-566 Section 6, Statute 666 for planning and implementation of flood damage reduction projects on a watershed basis.

NRCS Water Resources Programs

The Watershed Protection and Flood Prevention Act, P.A. 83-566, CGS 22a-318 through 22a-323, authorizes the Secretary of Agriculture to "cooperate with states and local agencies in the planning and carrying out of works of improvement for soil conservation and other purposes." It provides for technical and financial assistance by the department through the NRCS to local organizations representing persons living in small watersheds (less than 250,000 acres). The Act provides for a project-type approach to solving land, water, and related resource problems. Flood prevention is an eligible purpose for which NRCS can pay 100% of the costs for planning studies, design and construction of structural solutions. The local sponsoring organization is solely responsible for land rights, operation and maintenance. Often these costs are equal to 1/2 the total costs of the project. For on-site measures such as flood proofing, the costs for implementation are divided 75% federal and 25% non-federal.

Federal Level Recommendation 3 of "A Unified National Program for Floodplain Management" and Section 6 of PL 83-566 provide the authorization to NRCS for Floodplain Management and Cooperative USDA River Basin studies.

Floodplain Management Studies (FPMS) authorized in Section 6 of PL-566 are a means of NRCS assisting state agencies and communities in the development, revision, and implementation of their floodplain management programs.

A FPMS can identify site-specific flood problem areas (or potential problem areas), inventories natural values, incorporates public participation, studies the community's management alternatives, and provides for study follow-up assistance. A FPMS may serve as the source of technical data for the community to implement local floodplain management programs.

Emergency Watershed Protection (EWP)

The Emergency Watershed Protection Program (EWP) is administered by the NRCS under Section 216, PL 81-516 and Section 403 of Title IV of the Agricultural Credit Act of 1978, PL 95-334. The EWP program provides the State and local units of government with technical and financial assistance to plan, design and implement measures that repair watershed impairments resulting from natural disasters. This program's objective is to assist in relieving imminent hazards to life and property from floods and the products of erosion created by natural disasters. Any corrective measure must prevent flooding or soil erosion, and reduce threats to life or property.

Authorized EWP technical and financial assistance may be made available when an emergency exists. Federal funds may bear a percentage of the construction costs of emergency measures in an exigency situation as well as in a non-exigency situation. Sponsors are responsible for obtaining any needed land rights and federal, state, and local permits. The numbers of EWP projects initiated after the most recent natural hazard events in Connecticut include:

- 37 EWP projects after the June 1982 floods;
- 1 EWP project after a thunderstorm in June 1989 in Franklin, Connecticut;
- 1 EWP project after the July 1989 tornadoes in western Connecticut;
- EWP projects after Tropical Storm Floyd;
- 1 EWP project after the April 2005 storm in Danbury;
- 7 EWP projects after the October 2005 storm;
- 4 EWP projects after the April 2007 storm and floods;
- 10 EPW projects after Tropical Storm Irene in 2011; and
- 4 EWP projects after Storm Sandy in 2012.

Watershed and Flood Prevention Operations (WFPO)

The Watershed Protection and Flood Prevention Program helps units of federal, state, local and tribal of government (project sponsors) protect and restore watersheds up to 250,000 acres. This program provides for cooperation between the Federal government and the states and their political subdivisions to work together to prevent erosion, floodwater, and sediment damage; to further the conservation, use, and disposal of water; and to further the proper use of land in authorized watersheds. In October 2017, NRCS announced they will be investing $150 million in 48 new projects.[211]

[211] https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/landscape/wfpo/?cid=nrcs143_008271

3.1.4 United States Army Corps of Engineers (USACE)

The USACE has undertaken several large flood control projects all across New England to reduce flood levels by retaining storm water runoff in upstream impoundments. These projects located in the Connecticut, Housatonic, Naugatuck, and Thames river basins. These structural measures have saved the State millions of dollars in flood damages.

The USACE has provided significant flood assistance to Connecticut and continues to do so. In its role as an assisting federal agency, the USACE has undertaken several flood and erosion control projects within the State since the 1950s.

The USACE has worked in Connecticut to develop several floodplain management studies. These studies include ice jam protection on the Salmon River in Haddam and East Haddam, and a feasibility study of flood protection on the West River in West Haven, Connecticut and New Haven, Connecticut.

Connecticut is able to undertake projects with the USACE as authorized under CGS Section 25-76 entitled "Small Flood Control, Tidal and Hurricane Protection and Navigation Projects; and State Cooperation with Federal and Municipal Governments," and through CGS Section 25-95 entitled "Agreements Concerning Navigation and Flood and Erosion Control."

The USACE, in cooperation with the DEEP and the city of Milford, elevated 36 residential structures under the authority of Section 205 of PL-858 in 2002 and 2003. The total cost of the project was estimated at $3.4 million. The city and State contributed 35% of the cost and the USACE covered the remaining 65% of the construction costs. The project was completed in 2003.

Finally, the USACE works in cooperation with the DEEP by providing technical assistance on flood control and prevention projects, and assistance to the State's flood warning system.

The USACE Building Resilience website contains information on how to improve building conditions to be more resilience to natural disasters.212

3.1.5 United States Department of Agriculture (USDA)

Funding for state and local governments with regard to wildfire mitigation is available from the USDA Forest Service. Grant programs under this federal agency include the following:[213]

Volunteer Fire Assistance - The Volunteer Fire Assistance program provides critical funding and technical assistance directly to local and volunteer fire departments that protect communities with populations under 10,000. Funds improve the ability of rural fire

[212] http://www.usace.army.mil/Missions/Sustainability/Building-Resilience/
[213] Source: grant program descriptions excerpted from the USDA Forest Service website: http://www.fs.fed.us/r1/pgr/afterfire/keypoint4/contacts.shtml. This site provides a description of many of the USDA Forest Service grants available and links to other webpages that describe additional grant programs.

departments to respond to wildfires, especially in the wildland/urban interface. Funding can be used for training and equipment to complement federal firefighting commitments, so protection capabilities can be enhanced across ownerships. Delivery is through consolidated grants to the State Forester, and funds are cost-shared on a 50/50 basis.

State Fire Assistance - The State Fire Assistance program provides technical training, financial assistance, and equipment to states to ensure that state and local firefighting crews can deliver a safe, effective, and coordinated response to wildland fire. Funding is available for preparedness, high priority prevention, and mitigation education programs including FIREWISE. These funds complement readiness levels at the federal level and are available through consolidated grants to State Foresters. Funds are cost-shared on a 50/50 basis.

Community Planning - Funding is available for development and revision of communities' strategic, action, and fire risk management plans. The goal for these funds is to increase community resiliency and capacity while creating an environment for development and growth. Funding will be targeted to communities most impacted by fires. Delivery is through grants awarded directly to communities and to a variety of other partners including state, county, and tribal governments, and not-for-profit corporations identified by the National Forestry Service in conjunction with the State Department of Commerce. Funds are cost shared 80/20.

For a more complete listing of USDA Forest Service grant programs that have been administered in Connecticut since 2010, please see Appendix 3-2. When additional information becomes available, these resources will be added to this section.

USDA Climate Hubs

In an effort to mitigate climate-related risks, USDA has established seven regional hubs for risk adaptation and mitigation to climate change. These Hubs will deliver science-based knowledge and practical information to farmers, ranchers and forest landowners on a regional basis to support decision-making related to changing climate. The Hubs provide technical support for land managers to respond to drought, heat stress, floods, pests, and changes in the growing season, and assessments and regional forecasts for hazard and adaptation planning to provide more time to prepare. They also facilitate outreach and education for farmers, ranchers and forest landowners on ways to mitigate risks and thrive despite change. The Northeast Climate Hub encompasses 12 states, including Connecticut. There is also a Northern Forests Climate Hub, which prepares regional land managers for climate change risks, supporting them to make climate-informed management decisions.[214]

USDA Disaster Resource Center

The USDA Disaster Resource Center provides information about specific disasters and emergencies, how to prepare, recover, and help build long-term resilience, as well as

[214] https://www.climatehubs.oce.usda.gov/

information about USDA assistance during disaster events. Categories of disasters include climate, drought, storms, hurricanes, tornadoes, flooding, and wildland fire.[215]

Extension Disaster Education Network

The Extension Disaster Education Network (EDEN) is made possible by USDA Cooperative Extension and NOAA Sea Grant Extension programs. The program reaches over 300 delegates in 50 states and 3 US territories. Their Resource Catalog combines research-based publications, websites, webinars, courses and exercises developed by the Network's member institutions, helping increase knowledge-sharing between states. [216]

3.1.6 U.S. Environmental Protection Agency Resilience and Adaptation in New England

Resilience and Adaptation in New England (RAINE) is a database that catalogs actions being taken by New England communities to adapt to climate change. The goal of the site is to share lessons being learned, discover how to better assist municipalities, and promote collaboration. RAINE provides information about actions at the state, regional or local level. It not only includes links to web pages, reports and plans but also examples of presentations that communities use to engage their citizens, what tools they used to identify their vulnerabilities and who funded their projects.[217]

Climate Change Adaptation Resource Center

EPA's Adaptation Resource Center (ARC-X) is an interactive resource to help local governments effectively deliver services to their communities even as the climate changes. Decision makers can create an integrated package of information tailored specifically to their needs. Once users select areas of interest, they will find information about: the risks posed by climate change to the issues of concern; relevant adaptation strategies; case studies illustrating how other communities have successfully adapted to those risks and tools to replicate their successes; and EPA funding opportunities.[218]

Climate Ready Estuaries Program

The Climate Ready Estuaries program works to help the National Estuary Programs (NEPs) and all environmental mangers to address climate change in watersheds and coastal areas. This effort, initiated in 2008, brings together EPA's Oceans and Coastal Protection Programs and Climate Change Programs to build additional capacity in the NEPs and coastal communities as they prepare to adapt to the effects of climate change. The program coordinates and communicates with other federal agencies and external

[215] https://www.usda.gov/topics/disaster
[216] https://eden.lsu.edu/
[217] https://www.epa.gov/raine
[218] https://www.epa.gov/arc-x

partners that work on coastal adaptation efforts to share information, identify opportunities for collaboration, and minimize duplication of effort.[219]

Drinking Water and Wastewater Resilience

The U.S. EPA provides resources for assessing, planning, and training communities on improving the resilience of their water and wastewater systems. Resources include instructions for conducting risk assessments, assessing financial impacts of a water disruption, developing emergency response plans, building hazard resilience, sharing resources during emergencies, and finding federal funding for utilities. They also provide tools such as the Response On-The-Go Tool, and the Route to Resilience Tool, which guides users through the process of building their own unique Roadmap to Resilience.[220]

Water Infrastructure and Resiliency Finance Center

The Water Infrastructure and Resiliency Finance Center is an information and assistance center, helping communities make informed decisions for drinking water, wastewater, and stormwater infrastructure to protect human health and the environment. The Center's goals focus on research, advising stakeholders, innovation, and building large networks.[221]

Governor's Institute on Community Design

The Governors' Institute on Community Design helps governors and their staff make informed decisions about investments and policy decisions that influence the economic health and physical development of their states. Working with a governor's staff and cabinet, the institute provides tailored technical assistance, typically through one- to two-day workshops that bring together the governor and his or her staff with nationally renowned experts to address issues the governor has identified. This assistance is designed to provide state leaders with practical strategies for creating vibrant, economically competitive communities. Assistance often includes exploring the connections among economic development, transportation, land use, housing, energy, and the environment. The Governors' Institute has helped the governors of Iowa, Vermont, and New Hampshire recover from disaster events and prepare for a more resilient future.[222]

Smart Growth Strategies for Disaster Resilience and Recovery

In 2016, EPA and the Federal Emergency Management Agency (FEMA) updated a Memorandum of Agreement that makes it easier for the two agencies to work together to help communities become safer, healthier, and more resilient. The agencies collaborate to help communities hit by disasters rebuild in ways that protect the environment, create long-term economic prosperity, and enhance neighborhoods. FEMA and EPA also help communities incorporate strategies that improve quality of life and direct development

[219] https://www.epa.gov/cre/about-climate-ready-estuaries-program
[220] https://www.epa.gov/waterresilience
[221] https://www.epa.gov/waterfinancecenter
[222] https://www.epa.gov/smartgrowth/governors-institute-community-design

away from vulnerable areas into their hazard mitigation plans. EPA and FEMA are using the lessons they learn from working together under this agreement and with other federal agencies to better coordinate assistance to communities on hazard mitigation planning and post-disaster recovery. The Memorandum of Agreement also helps the agencies work together on climate change adaptation.[223]

Other Resilience and Adaptation Resources

EPA provides a variety of resources for preparing communities for the effects of climate change. These include the Coastal Adaptation Toolkit, Adaptation Planning Workbook, Risk Identification Checklists, Online Tool for Vulnerability Assessments, Sea Level Rise Resources, Adaptation Options for Coastal Areas, King Tides Fact Sheet, and archives of Climate Change Adaptation Projects.[224]

3.1.7 U.S. Department of Housing and Urban Development

The U.S. Department of Housing and Urban Development (HUD)'s Office of Economic Development leads multiple programs that aim to prepare for the impacts of climate change.[225] In the HUD Strategic Plan for 2014 – 2018, Strategic Objective 4C for Disaster Resilience is to "support the recovery of communities from disasters by promoting community resilience, developing state and local capacity, and ensuring a coordinated federal response that reduces risk and produces a more resilient built environment."[226] In support of this objective, the following programs provide support for greater capacity in and utilization of resilient approaches to community development at the local, regional, and state levels.

- Rebuild by Design: Launched in 2013 in response to Hurricane Sandy, Rebuild by Design was a design competition for implementable resilience solutions for impacted areas. Bridgeport, CT was chosen as a winner, and received $10 million for a comprehensive project in the South End of the city.[227]
- National Disaster Resilience Competition: Based on the success of Rebuild by Design, the National Disaster Resilience Competition (NDRC) was a collaboration between HUD and the Rockefeller Foundation that competitively awarded nearly $1 billion in HUD Disaster Recovery funds to eligible communities. Connecticut was one of 13 winners, receiving $54,277,359 to support a pilot program in Bridgeport that is part of the broader Connecticut Connections Coastal Resilience Plan.
- Climate Change Adaptation Plan: HUD created a department-wide Climate Change Adaptation Plan as part of the Obama Administration's objective to ensure preparedness in the face of more extreme weather events and climate-related risks.
- Community Resilience Portal: HUD created the Community Resilience Portal to provide a catalogue of resources that local planners could use to help plan and prepare for changing natural hazards when undertaking HUD-funded activities. HUD's annual programs fund the construction and maintenance of infrastructure

[223] https://www.epa.gov/smartgrowth/smart-growth-strategies-disaster-resilience-and-recovery
[224] https://www.epa.gov/cre
[225] https://www.hud.gov/program_offices/economic_development/resilience/about
[226] https://www.huduser.gov/portal/publications/pdf/HUD-564.pdf
[227] http://www.rebuildbydesign.org/our-work/all-proposals/winning-projects/ct-resilient-bridgeport

and housing in communities across the country. In addition, Congress has appropriated over $45 billion to HUD since 2000 to fund disaster recovery activities.

In addition to these programs, HUD prioritizes environmental justice (EJ) in all its initiatives. In 2012, HUD published its first Departmental Environmental Justice Strategy to address EJ concerns and increase access to environmental benefits through HUD programs. In particular, programs related to climate resilience, energy efficiency, and place-based work address environmental justice.

3.1.8 U.S. Climate Resilience Toolkit

The U.S. Climate Resilience Toolkit is a partnership of federal agencies and organizations led by NOAA and initially launched on November 17, 2014. This inter-agency initiative operates under the auspices of the United States Global Change Research Program. The site is managed by NOAA's Climate Program Office and is hosted by NOAA's National Centers for Environmental Information. The Toolkit improves people's ability to understand and manage their climate-related risks and opportunities, and to help them make their communities and businesses more resilient to extreme events. The Toolkit offers information from all across the U.S. federal government in one easy-to-use online location.[228]

3.2 State Hazard Mitigation Programs and Related Laws

Connecticut has many state statutes, regulations, policies and practices that achieve the goal of natural hazard mitigation in areas prone to natural hazards. During the past 100 years, flooding has caused more damage and loss of life than any other natural disaster in the State. Most of the State's programs and policies deal either directly (structural mitigation) or indirectly (non-structural methods through enforcement, education and monitoring) with flooding. These state programs and policies focus on damage prevention within special flood hazard areas (SFHAs) and in some cases the 500-year flood zones (0.2% annual chance flood zones). Since all municipalities within Connecticut contain mapped SFHAs areas within their political boundaries, these programs are implemented on a statewide basis and affect every municipality.

Structural flood mitigation projects in Connecticut have either dealt with the initial causes of flooding (e.g., construction of flood control projects to reduce the frequency of flooding) or the effects of the flooding (e.g., elevating or moving structures out of the floodplain). The DEEP has historically been the lead agency for the pursuance of flood hazard mitigation activities and administration of federal mitigation grants in Connecticut, although this responsibility was transferred to DEMHS in 2013. The two agencies work together to address flooding and flood mitigation.

The distribution of state or federal funding requires full compliance with all regulations. Federal funding for the programs are provided through the smart-link system maintained

[228] https://toolkit.climate.gov/content/about

between FEMA and DEMHS. Transfer invoices are utilized to channel approved funding to the eligible projects. A formal contract is entered into between the applicant and the State to ensure compliance with all applicable regulations.

3.2.1 State of Connecticut Enabling Legislation

State participation in the NFIP, Stafford Act, and related actions are authorized under the Connecticut General Statutes Section 25-68b through 25-68h and associated regulations. Other provisions of FEMA grant programs are authorized under Connecticut General Statutes Title 28, Chapter 517, Section 28-9, 28-15a, and 28-15b, Civil Preparedness and Emergency Services. Additional authorization is found in the Federal Aid Connecticut General Statutes, Title 4, Chapter 24, Section 4-28a, Management of State Agencies, State Properties and Funds, Advisory Commission, and Section 25-68b et seq. flood control projects.

State Floodplain Management Act

The Flood Management Act as referenced in the Connecticut General Statutes (CGS) Section 25-68b through Section 25-68h outlines the flood management responsibilities of DEEP and lays out the rules and regulations to be used by all state agencies when undertaking or funding activities within or affecting floodplain areas, which are normally coincident with SFHAs in this context.

CGS Section 25-68b defines the terms (e.g., Floodplain, Base Flood, etc.) used in the Flood Management Act. Section 25-68c goes beyond the regulations contained within the National Flood Insurance Program (NFIP) in many aspects and references the NFIP standards as a minimum standard.

The Commissioner of DEEP has the following powers and duties under Section 25-68c:

- To coordinate, monitor and analyze the floodplain management activities of state and local agencies;
- To coordinate flood control projects within Connecticut and be the sole initiator of a flood control project with a federal agency;
- To act as the primary contact for federal funds for floodplain management activities sponsored by the State;
- To regulate actions by state agencies affecting floodplains except conversion by the University of Connecticut of commercial or office structures to an educational structure;
- To regulate proposed state actions that impact natural or man-made storm drainage facilities located on property that the commissioner determines to be controlled by the state, including, but not limited to, programs that regulate flood flows within a floodplain and site development that increases peak runoff rates;
- To designate a repository for all flood data within the State;
- To assist municipalities and state agencies in the development of comprehensive floodplain management programs;

- To determine the number and location of State-owned structures and uses by the State in the floodplain and to identify measures to make such structures and uses less susceptible to flooding including flood-proofing or relocation;
- To mark or post the floodplains within lands owned, leased or regulated by state agencies in order to delineate past and probable flood heights and to enhance public awareness of flooding;
- To designate the base flood elevation for a critical activity where no such base flood elevation is designated by the NFIP. The Commissioner may add a freeboard factor to any such designation; and
- To require that any flood control project be designated to provide protection equal to or greater than the base flood.

Section 25-68f mandates that if more than one floodplain designation exists for the same area, the most stringent designation shall be used to fulfill the provisions of sections 25-68b to 25-68h, inclusive.

An Act Concerning Floodplain Management and Hazard Mitigation

During the 2004 session, the State legislature passed the Floodplain Management and Hazard Mitigation Act. This legislation covers many aspects of floodplain management. It requires municipalities to revise their current floodplain zoning regulations or ordinances to include new standards for compensatory storage and equal conveyance of floodwater. Municipalities were not required to make such revisions until they revise their regulations for another purpose. The DEEP has developed model regulation language which incorporates these new State requirements and has issued this model floodplain ordinance to communities for their use since 2007.

Other enabling State Legislation related to flood plain management includes:

- Sections 22a-28 through 22a-45, inclusive – Inland Wetlands and Watercourses Act;
- Section 22a-401 through 22a-410, inclusive – Dam Safety;
- Section 13a-94 – Construction Over and Adjacent to Streams;
- Section 25-84 through 25-98 – Flood & Erosion Control Board Statutes;
- Section 22a-318, 22a-321 – NRCS Statutes;
- Section 25-74 through 25-76 – Authorization to perform flood and erosion projects under Federal authority;
- Section 22a-342 through 22a-350 – Stream Channel Encroachment Line Program Statutes; and
- Section 22a-365 through 22a-378 – The Connecticut Water Diversion Policy Act.

Table 3-3 shows each state funded program related to floodplain management and whether it is associated with pre-disaster mitigation or post-disaster mitigation efforts.

Table 3-3: State Funded Programs Related to Floodplain Management

State Funded or Staffed Program in Hazard Prone Area.	Pre or Post Disaster
Flood Management Section 25-68	Pre and Post Disaster
Dam Safety Section 22a-401 – 22a-410	Pre and Post Disaster

State Funded or Staffed Program in Hazard Prone Area.	Pre or Post Disaster
Flood and Erosion Control Boards Section 25-84	Pre and Post Disaster
National Flood Insurance Program	Pre-Disaster
Stream Channel Encroachment Line Program Section 22a-342 through 22a-350	Pre-Disaster
Section 22a-318, 22a-321 – NRCS Statutes	Pre and Post Disaster
Section 25-74 through 25-76 – Authorization to perform flood and erosion projects under Federal authority.	Pre and Post Disaster
Floodplain Management and Mitigation Act	Pre-Disaster
PDM Planning	Pre-Disaster

An Act Concerning the Coastal Management Act and Shoreline Flood and Erosion Control Structures

In 2012 the Connecticut General Assembly passed Public Act 12-101, An Act Concerning the Coastal Management Act and Shoreline Flood and Erosion Control Structures. This legislation combined a number of initiatives to address sea level rise and to revise the regulatory procedures applicable to shoreline protection. Through this Act, the concept of sea level rise was incorporated into the Connecticut Coastal Management Act (CCMA)'s general goals and policies of coastal planning for the very first time. The following goal was added to the CCMA:

> *"To consider in the planning process the potential impact of a rise in sea level, coastal flooding and erosion patterns on coastal development so as to minimize damage to and destruction of life and property and minimize the necessity of public expenditure and shoreline armoring to protect future new development from such hazards" [CGS section 22a-92(a)(5), as amended]*

The Act also allows the Commissioner of the Department of Energy and Environmental Protection to establish a pilot program to encourage "innovative and low-impact approaches to shoreline protection and adaptation to a rise in sea level. Such approaches may include living shorelines techniques utilizing a variety of structural and organic materials, including, but not limited to, tidal wetland plants, submerged aquatic vegetation, coir fiber logs, sand fill and stone to provide shoreline protection and maintain or restore coastal resources and habitat." It is possible that some of these methods will be evaluated in the coming years, helping to build capabilities at the state and municipal levels to increase hazard mitigation.

PA 12-101 also contains a requirement for communities to consider Sea Level Rise in their plans of Conservation and Development. This was detailed more in the 2013 legislative session, and a bill to require Clean Water Act funded projects to consider climate was also passed.

An Act Concerning Climate Change and Data Collection

Pursuant to Special Act 13-9, "An Act Concerning Climate Change and Data Collection," the State of Connecticut must establish a "Center for Coasts" that will conduct research, analysis, design, outreach and education projects to guide the development and implementation of technologies, methods and policies that increase the protection of ecosystems, coastal properties and other lands and attributes of the state that are subject to the effects of rising sea levels and natural hazards. Specifically, the Connecticut Center for Coasts was charged with undertaking the following activities:

- Mapping exercises to assess and visualize key characteristics of shoreline resiliency, such as shoreline changes,
- Pilot-scale engineering and impact assessment studies,
- Consensus building efforts to determine state-wide uniform guidelines for planning and development purposes, including the expected rate of sea level rise for the next 100 years,
- Ways to develop state-wide, science-based planning and management alternatives,
- Development in science and information-based outreach and technology transfer programs for state and local agencies and officials involved in planning and development,
- An assessment of soft shore protection strategies in Long Island Sound and the development of instructional guides for the use of such soft shore protection strategies,
- A comprehensive coastal infrastructure inventory and risk assessment,
- An analysis of the impact of seawalls in urban and rural communities,
- The development of uniform, state-wide models that predict inundation flood scenarios under slow, constant sea level rise and under storm surges,
- Projects that lead to the development of rapid storm damage assessment technology,
- Developing design guidelines for the construction and repair of structural and non-structural shore protection, and
- Developing tools for determining appropriate shore protection strategies and providing coastal protection information to a diverse range of end users.

Subsequently, the DEEP Office of Planning and Program Development and the former OLISP teamed with the University of Connecticut to establish the Connecticut Institute for Resilience and Climate Adaptation (CIRCA). CIRCA has been actively engaged in outreach, education, local partnerships, and dispensing of funds since 2014. More information about CIRCA is provided below.

An Act Concerning the Permitting of Certain Coastal Structures by the Department of Energy and Environmental Protection

Public Act 13-179 clarifies several Connecticut statutes by making reference to the National Oceanic and Atmospheric Administration (NOAA) sea level rise discussions in Technical Report OAR CPO-1 (Global Sea Level Rise Scenarios for the United States National Climate Assessment, December 6, 2012).

Pursuant to Public Act 13-179, the definition of sea level rise was changed as follows: "Rise in sea level" means the arithmetic mean of the most recent equivalent per decade rise in the surface level of the tidal and coastal waters of the state, as documented in National Oceanic and Atmospheric Administration online or printed publications for said agency's Bridgeport and New London tide gauges.

The Act states that municipalities shall consider sea level rise when developing Plans of Conservation and Development, and also states that in the preparation of any municipal evacuation plan or hazard mitigation plan, a municipality shall consider sea level change scenarios published by NOAA in Technical Report OAR CPO-1.

An Act Concerning Sea Level Rise and the Funding of Project by the Clean Water Fund

Public Act 13-15 allows DEEP to maintain a priority list of eligible water quality projects and established a system setting priority for making project grants, grant account loans and project loans. This law essentially incorporates climate change planning into funding of wastewater (sanitary sewer system and sewage treatment) projects.

In establishing such priority list and ranking systems, DEEP shall consider factors deemed relevant including but not limited to the following: (1) public health and safety; (2) protection of environmental resources; (3) population affected; (4) attainment of state water quality goals and standards; (5) consistency with the state plan of conservation and development; (6) state and federal regulations; (7) the formation in municipalities of local housing partnerships; and (8) the necessity and feasibility of implementing measures designed to mitigate the impact of a rise in sea level over the projected life span of such project.

The following Executive Orders related to climate change and resilience were issued subsequent to the 2014 edition of this plan:

- Executive Order 46 (2015): Established a Governor's Council on Climate Change to monitor the state's greenhouse gas emissions and make recommendations to meet the 2050 GWSA target.[229]
- Executive Order 50 (2015): Establishes the State Agencies Fostering Resilience (SAFR) Council, which is responsible for strengthening the state's resiliency from extreme weather events, including tropical storms, hurricanes, storm surges, flooding, ice storms, extreme high winds, extreme heat, and slow onset events such as sea level rise. The "SAFR Council" is responsible for working to create a Statewide Resilience Roadmap based on the best climate impact research and data and assisting OPM in the creation of a State policy on disaster resilience. SAFR interacts with CIRCA and will be involved with the NDRC-funded planning in the coming years.

[229] http://www.ct.gov/deep/lib/deep/climatechange/eo_46_climate_change.pdf

An Act Concerning Climate Change Planning and Resiliency

This bill (SB 7 (PZ 18-82)) establishes a new greenhouse gas (GHG) emissions reduction requirement and integrates GHG reductions into various state planning documents and efforts, such as the state's Integrated Resources Plan and its plan of conservation and development. It also incorporates the new reduction into the law's existing energy source solicitation requirements.

The bill integrates sea level change projections, determined by UConn's Marine Sciences Division as an update of existing federal projections, into various municipal and state planning documents, such as state and municipal plans of conservation and development and municipal evacuation or hazard mitigation plans. It also applies these projections to the state's coastal management and flood management laws.

The bill renames the state's Comprehensive Energy Strategy as the Comprehensive Climate and Energy Strategy, and requires it to be updated to account for the state's GHG reduction requirements.

The bill establishes the Connecticut Council on Climate Change as a statutory council, which must facilitate and coordinate efforts with various parties to reduce GHG emissions and increase the state's resiliency to climate change.

The bill also makes many minor, technical, and conforming changes, including those to account for the council's renaming and incorporate the revised content, eliminate obsolete provisions such as a law on the Governor's Steering Committee subcommittee on climate change, replace a reference in the flood management statutes to "one-hundred-year flood" with "base flood," and eliminate an incorrect statutory reference.

The Act incorporates the State's official sea level rise projections into various statutes, and amends the definitions in Chapter 476A, Floodplain Management (CGS 25-68(b) through 25-68(o)) to incorporate freeboard directly into the definition of floodproofing:

(6) "Flood-proofing" means any combination of structural or nonstructural additions, changes or adjustments which reduce or eliminate flood damage to real estate or improved real property, to water and sanitary facilities, and to structures and their contents, including, but not limited to, for properties within the coastal boundary, as established pursuant to subsection (b) of section 22a-94, not less than an additional two feet of freeboard above base flood and any additional freeboard necessary to account for the most recent sea level change scenario updated pursuant to subsection (b) of section 25-68o, as amended by this act.

3.2.2 Connecticut State Agencies Associated with Natural Hazard Mitigation

There are a number of state agencies that are associated with natural hazard mitigation within Connecticut. Some divisions and agencies such as DEMHS and DEEP share the roles and responsibilities for hazard mitigation. These are the two primary entities associated with natural hazard planning and mitigation efforts.

Other agencies are associated with natural hazard mitigation through their policies or plans in which they are charged with developing and implementing. The following is a presentation of the state agencies and their relative divisions associated with natural hazard mitigation in Connecticut.

Department of Emergency Services and Public Protection, Division of Emergency Management and Homeland Security (DEMHS)

Title 28 of the Connecticut General Statutes outlines the roles and responsibilities of the DEMHS. DEMHS is responsible for:

- Providing a coordinated, integrated program for state-wide emergency management and homeland security;
- Directing the preparation of a comprehensive plan and program for the civil preparedness of the State;
- Coordinating with state and local government personnel, agencies, authorities, and the private sector to ensure adequate planning, equipment, training, and exercise activities;
- Coordinating emergency communications and communication systems of the state and local government personnel, agencies, authorities, the general public, and the private sector; and
- Distributing and coordinating the distribution of information and security warnings to state and local government personnel, agencies, authorities, and the general public.

The division assumes many roles for the State including:

- Maintains the local branch of the National Warning System (NAWAS);
- Serves as the Alternate State Warning Point (AWSP). DESPP serves as the Primary State Warning Point (PSWP).
- Develops and maintains various types of emergency operations plans for state government;
- Provides technical planning assistance to communities as requested or as needed;
- Provides emergency management and homeland security training programs for state and local governments;
- Conducts emergency operations drills and exercises;
- Administration of the Hazard Mitigation Programs of the state.

In times of disaster or emergency, alerts key state, federal and local response organizations and acts as a central coordination point for all state agencies at the State Emergency Operations Center (EOC) in Hartford, CT.

DEMHS and DESPP currently operate the state's "Alert" Emergency Notification System (ENS) which is powered by Everbridge. The Alert ENS utilizes the state's Enhanced 911 database for location-based notifications to the public for potentially life-threatening emergencies. The Enhanced 911 database includes traditional wire-line telephone numbers in the state (the "land line" phones). However, residents may register on-line at www.ct.gov/despp for other means of communication to the Alert ENS, in addition to the land line. Residents can receive emergency alerts on communication methods such as a mobile phone, e-mail, text message, or certain hearing impaired receiving devices.

At the present time, most of the state's municipalities subscribe to the Everbridge-powered Alert system. However, a handful of towns opted out of the system and utilize the CodeRED notification system (or other), citing reasons such as cost and control of their abilities to distribute messages.

DEMHS Disaster Preparedness Programs

DEMHS is responsible for administering the State's disaster preparedness programs and for developing and implementing Connecticut's Natural Disaster Plan, which outlines the steps to be taken prior to, during and after the occurrence of a disaster event (a copy of this plan is provided within Appendix 3-3). In addition, DEMHS administers the following disaster preparedness programs:

- **State Homeland Security Grant Program** – DEMHS is the State Administering Agency (SAA) for Emergency Management and Homeland Security grants provided by the U.S. Department of Homeland Security (DHS) and FEMA. These grants include the State Homeland Security Grant Program (SHSGP) Emergency Management Performance Grant Program (EMPG). The Buffer Zone Protection Program and Urban Area Security Initiative are now contained under the SHSGP cadre of grants. Funds from these programs are used for providing planning and equipment grants to state, regional, and local government agencies. The purchase of interoperable communication systems has been a major activity in ensuring disaster preparedness.
- **Radiological Emergency Preparedness (REP) Program** – This program is responsible for off-site planning and preparedness in the event of an accident at either the Millstone Nuclear Power Stations in Waterford or the station at Indian Point, New York. The REP program develops and maintains radiological plans and procedures, which are regularly evaluated by FEMA. The REP network includes ten emergency planning zone communities including Fishers Island, five host communities, numerous key state agencies, and local emergency responders. In addition, the REP program conducts other related activities such as annual conferences for public officials, media briefings, and training of state and local emergency workers.

Department of Energy and Environmental Protection

Public Act 11-80, "An Act Concerning the Establishment of the Department of Energy and Environmental Protection and Planning for Connecticut's Energy Future" (Act), combined the former Department of Public Utility Control (DPUC) and an energy group from the Office of Policy Management (OPM) with the Department of Environmental Protection (DEP) to form the Department of Energy and Environmental Protection (DEEP) to better address the challenges of the modern environmental world and energy market. The former

Department of Public Utility Control is now called the Public Utility Regulatory Authority (PURA) and continues to perform the regulatory functions of the former DPUC. The Act also required DEEP establish a Bureau of Energy and Technology Policy – the first energy policy office in decades for the state.

The DEP was established in 1971 at the dawn of the environmental movement, while the public utilities regulatory authority traces its roots back more than 150 years to the state's Railroad Commission.

DEEP is charged with conserving, improving and protecting the natural resources and the environment of the state of Connecticut as well as making less expensive, cleaner and more reliable energy available for the people and businesses of the state. The DEEP is organized into three main branches and the Office of the Commissioner:

The Environmental Quality Branch is comprised of the Bureaus of Air Management, Materials Management and Compliance Assurance, and Water Protection and Land Reuse. These bureaus protect the air, land and water resources of the state by regulating air emissions, wastewater discharges and solid and hazardous wastes. Tools used include the development of regulations, policies and standards; permitting and enforcement; air and water quality monitoring; and public outreach and education.

The Environmental Conservation Branch consists of two bureaus. The Bureau of Natural Resources is charged with managing the state's natural resources (particularly fish, wildlife, and forests) through a program of regulation, management, research, and public education. The Bureau of Outdoor Recreation is charged with the conservation and management of statewide recreation lands and resources through the acquisition of open space and the management of resources, including state parks, to meet the outdoor recreation needs of the public.

The Energy Branch includes the Public Utilities Regulatory Authority (PURA) – formerly the Department of Public Utility Control – which reviews rates for electricity, water, cable television and other utilities as well as a Bureau of Energy and Technology Policy, which develops forward-looking energy efficiency, infrastructure and alternative power programs.

The Office of the Commissioner, including the Offices of Chief of Staff, Planning and Program Development, Information Management, Adjudications, Environmental Justice, and Legal Counsel, provides administrative management, staff assistance, and ancillary service to aid the Commissioner and Bureau Chiefs in their efforts to carry out the mission of the agency. In addition, the centralized Bureau of Central Services provides a wide array of services including financial management, human resource management and purchasing.

DEMHS is the principal flood management agency in the State, with DEEP assisting. Within DEEP, the Inland Water Resources Division (IWRD) formerly housed the Flood Management Program. The IWRD was merged with the Office of Long Island Sound Programs (OLISP) in 2016 and their functions are now part of the Land and Water

Resources Division within the Bureau of Water Protection and Land Reuse. The Land and Water Resources Division is therefore the lead division for planning and coordinating flood management and post natural disaster mitigation responses. Other assisting DEEP divisions are the Water Planning and Management Division (also within the Bureau of Water Protection and Land Reuse) and the Forestry Division (within Natural Resources).

Water Planning and Management Division

The Water Planning and Management Division includes the Dam Safety and State Dam Programs (both from the former IWRD) and the Flood Alert Center.

The following actions were undertaken by DEEP's IWRD and other state agencies in the 1980s and 1990s to improve the State's capability to respond to flood emergencies. These measures were taken as a result of recommendations formulated in the 1983 and 1989 Flood Hazard Mitigation Reports:

- State Sandbag Policy and Procedures (OCP, currently DEMHS 1984)
- Guidance for municipal flood emergency planning issued (1983)
- Operational Guide for the Connecticut Automated Flood Warning System (updated in 2000) prepared, Emergency Operations Guidelines prepared for the Flood Warning System (1987)
- Installations of Advanced Technology NOAA Weather Radios (A.K.A WRSAME) in schools, state parks, and command centers (1992-93)
- Expansion and upgrading of equipment and technology within the Automated Flood Warning System (1992, 2002)
- Installation of telemetry equipment to receive satellite and radar information (1993)
- Establishment of a fax/email weather warning system (1994).

Dam Safety Program

The Connecticut DEEP Dam Safety Program has jurisdiction over all non-federally owned or licensed dams in the State which would by failing or otherwise endanger life or property. The five program staff maintain an inventory for nearly 4800 dams in Connecticut. Smaller dams determined to be of Negligible Hazard and other small dams of undetermined hazard classification while inventoried, are not presently being closely monitored. CT DEEP does not monitor or have jurisdiction over dams that are federally owned including US Army Corps of Engineers (USACE) flood control dams and hydropower dams licensed by Federal Energy Regulatory Commission (FERC). As of March 2018 this includes:

- 281 total and 258 DEEP jurisdictional **High Hazard** (Class C) dams,
- 275 total and 262 DEEP jurisdictional **Significant Hazard** (Class B) dams,
- 722 total and 714 DEEP jurisdictional **Moderate Hazard** (Class BB) dams, and
- Approximately 1900 Low Hazard (Class A) dams.

The Program's ultimate responsibility is to ensure all jurisdictional dams in the state are being operated and maintained in a safe condition. The owners of high and significant hazard dams are required by statue to regularly inspect, maintain, and repair their dams and have current Emergency Action Plans (EAPs) ready for implementation should hazardous conditions arise.

The programs major responsibilities include:

1. **Inspections**. The responsibility to undertake regulatory inspections was transferred from the State DEEP, to Dam owners through legislation in 2013. Program staff still perform inspections of all types, but all regulatory inspections are required to be performed by engineers hired by the dam owner. (In rare cases, DEEP has the authority to perform these inspections and charge the property owner. Regulatory Inspections must meet the requirements of section 22a-409 of the regulation.
    a) Since 2014, Program staff have issued or re-issued over 1200 Notices of Required Inspections (NORI) for state-owned and privately owned dams in CT.
    b) Non-compliance has required program staff to issue notices of violation or reminder letters. Around 150 dams remain in a state of non-compliance with assigned inspections since the 2014 program inception needing staff to issue notices of violations or the appropriate response.
2. **Emergency Action Plans** (EAP) for B and C dams. Program staff review all EAPs for conformance with section 22a-411a of the regulation. Staff attend EAP Tabletops and Drills. The owners of the larger Flood Control Levee's in the state (which are DEEP jurisdictional), have more recently been accredited by FEMA and certified by the USACE are not presently being required to submit an EAP pursuant to 22a-411a of the regulations, as an appropriate guideline for writing an EAP for these levee structures does not exist at this time. The need to have updated EAPs for this small subset of dams was put on hold until guidelines could be written and because the existing levee operations plans written by the USACE are the presiding documents for these structures.
    a) **A total of 245 Class C High hazard dams are expected to have DEEP reviewed EAPs that** conform to section 22a-411a of the regulation. As of March 2018, about 173 Dam owners have EAP's that have been updated and are in various stages of review and approval. EAP's for another 37 dams are being prepared and another 35 dam owners recently were sent notices of violation for failing to submit an updated EAP.
    b) A total of 259 **Class B Significant hazard** dams are expected to have DEEP reviewed EAPs that conform to section 22a-411 of the regulation. As of March 2018, about 94 Dam owners have EAP's that have been updated and are in various stages of review and approval. EAP's for another 30 dams are being prepared and another 135 dam owners recently were sent notices of noncompliance for failing to submit an updated EAP.

3. **Permitting**. Program staff attend pre-application technical meetings, review general and individual permit applications, issue permits and approvals, follow up on repair projects.
   a) Since the October 2015 issue date, program staff have processed 50 general permit filings.
   b) There were 20 individual permit applications in 2017 for repairs or removals.
   c) There were 11 individual permit applications in 2016 for repairs or removals.
   d) There were 14 individual permit applications in 2015 for repairs or removals.

   There is a correlation between the number of request letters to dam owners and the number of permit applications received. As program staff begin to resolve the backlog of inspection reports needing review and issue more request letters, the number of permit applications will increase significantly. General permits are anticipated to become the dominant authorization mechanism for minor repairs that are identified during the inspections while individual permits will be used for major rehabilitation or removal projects.
4. **Enforcement**. When a dam is found to be in need of repairs and the dam owner not responsive, program staff initiate enforcement as needed. Informal enforcement such as Notices of Violation or Non-Compliance and formal enforcement such as unilateral and consent orders are available to ensure that critical issues such as regulatory inspections requirements, EAP preparation requirements, and critical needed repairs are undertaken by the dam owners.
   a) If an **emergency condition** exists which represents a clear and present danger to the public, Dam Safety can order the repair or removal of the structure. Should the dam owner fail to repair or remove the structure in the time specified by the order, the Department may do so and bill the owner for the costs.
5. **Technical Support**. Program staff provide technical support to the staff of the DEEP State-owned dams program and other state agencies. There are over 250 DEEP-owned dams and approximately 50 additional dams owned by other CT State agencies or institutions. Program staff also respond to calls and emails and FOIA requests submitted to the program from dam owners, consultants, elected officials, other state officials, and the general public.
6. **Inventory**. Program staff maintain an Inventory of dams in CT in an Access database which is regularly updated with dam owner information, inspection report data, EAP's and status, dam physical size and shape data, and communications data. Program staff also maintain an electronic document archive of word and Adobe Acrobat PDF documents, and an email archive for each dam along with the original paper files.
7. **GIS Data**. Program staff maintain a GIS data layer which has an old dam failure inundation shapefile which was obtained by digitizing the dam failure inundations maps prepared for the 1980-1982 era Phase I and II dam inspection reports. While outdated, they remain a useful resource in a flood event. Unfortunately section 22a-

411 of the regulation does not require dam owners to submit their EAPs and the inundation area mapping electronically or in a GIS shapefile.

8. **Critical Facilities**. DEEP State-owned Dams program staff maintain Critical Facilities mapping.
9. **DamWatch**. The DEEP subscribes to the US Engineering DamWatch program for DEEP owned dams. DamWatch is an online real-time Nexrad radar precipitation based monitoring application for dams. All 250 DEEP owned dams are monitored by DamWatch. DamWatch will notify DEEP staff whenever a pre-set precipitation threshold has been surpassed within the drainage area to one of the monitored dams. The notice allows staff to know as early as possible when precipitation intensity and duration may create flood conditions at a monitored dam. The DamWatch also makes archived data for each monitored dam such as reports, the EAP and construction drawings available online and includes an assignment ticketing system that allows managers to assign designated field staff to inspect dams in their area.

Automated Flood Warning Systems

The original automated flood warning system was installed in Connecticut by the NRCS in cooperation with DEP in 1985 as a direct result of the June flooding of 1982. The flood warning system aided the NWS in issuing faster flood watches and warnings, and aided communities in responding more rapidly to impending flooding situations. In several communities flood audits were prepared by the NRCS. These flood audits identified which structures were in danger at specific water levels as measured by the water level gages in the warning system.

At its peak, the DEEP owned and maintained 45 ALERT gages. However, due to funding issues, staffing cuts, and obsolescence of the system, the ALERT program has been discontinued. DEEP and other flood response agencies rely on data from USGS and NOAA for information.

Land and Water Resources Division

The Land and Water Resources Division includes the Flood Management Program (formerly in the IWRD) which coordinates directly with FEMA on RiskMap and NFIP as noted below; the Coastal Planning Program (formerly in OLISP) which is charged with coordination on Coastal Zone Management matters including coastal hazard mitigation; and the Coastal Resources Program (formerly in OLISP) which oversees permitting related to coastal resources.

Flood Management Section

The Flood Management Section is the state coordinating entity for the National Flood Insurance Program (NFIP). This section reviews and approves state agency activities within or affecting floodplains and conducts municipal NFIP compliance audits, training workshops, and provides assistance for the development of local floodplain ordinances. The Flood Management Section provides general technical assistance to municipalities on flood mapping and floodplain management inquiries. Furthermore, this section is responsible for the implementation of FEMA's Map Modernization Program at the state-level.

Map Modernization

In the past, FEMA's NFIP re-mapping efforts have been limited by both technology and funding. In recognition of these limitations, Congress has committed to a Multi-Hazard Flood Map Modernization Management Program (MHFMMM); herein referred to as Map Modernization. Starting in fiscal year 2003 the goal of Map Modernization was to upgrade flood hazard data and mapping to create a more accurate digital product by 2010. Upgrading the maps was planned to improve floodplain management throughout the nation by providing more accurate flood data for use in planning and regulatory decision-making and by providing a product in a digital format that will be easily accessible to multiple users. The Map Modernization Program has been phased in over the course of several years with priority given to areas of greatest flood risk as determined by the State and approved by FEMA.

The purpose of this Map Modernization Plan; herein referred to as Business Plan, is to outline the DEEP's strategic approach for partnering with FEMA to participate in Map Modernization through DEEP's existing Floodplain Management Program (FMP). The Plan describes the FMP's current roles and responsibilities related to floodplain management, outlines its future role, organizational design, and execution strategy to meet the data and mapping needs of communities within the State of Connecticut.

The FMP currently includes a proactive approach that combines two key elements under one organization: (1) NFIP community compliance, and (2) technical assistance and outreach to communities and agencies. It is envisioned that the compliance element will expand significantly based on map modernization activities due to municipal floodplain management ordinance changes. This linkage of NFIP community status assurance from the existing NFIP Compliance efforts, within the DEEP Community Assistance Program (CAP), will complement and enhance the effectiveness of the expanded FMP. If fully funded by FEMA, program management of the FMMP will be achieved through the expertise of a diverse, skilled project team complemented by external support from an independent state mapping contractor, and other state and federal partners. Program management will be centered on the identification of program goals and clear implementation and tracking of these goals during the program execution. Program management will be further enhanced by a data management system such as the Management Information Portal (MIP) provided by FEMA's National Service Provider.

The Business Plan addresses how Map Modernization will integrate with existing program needs over time, such as coastal erosion mapping, stream flow modeling for varying flow conditions, comprehensive land use planning, and others.

Education and outreach play a vital role in Map Modernization by promoting and building floodplain management capacity throughout the State, which includes training, workshops and presentations for local officials, lenders, insurance agents, land surveyors, engineers, regional planning commissions, and various state agencies and programs.

The success of the FMP and related programs within the DEEP is contingent on the receipt of adequate funding over multiple years from our Federal partners. Approximately $1.45 million per year (on average) is required to implement this plan. Of that amount, the FMP anticipates that approximately $480,000 per year may be available from state and partner contributions, which are mostly in-kind, and data matches. Total implementation costs over the five-year period are estimated to be $8 million. In order to adequately pursue efforts to manage mapping activities and contractors a multiple year commitment from FEMA for funding for staff is essential.

Risk MAP

Risk Mapping, Assessment, and Planning (Risk MAP) is the FEMA program that provides communities with flood information and tools they can use to enhance their mitigation plans and take action to better protect their citizens. Risk MAP focuses on products and services beyond the traditional FIRM and works with officials to help put flood risk data and assessment tools to use, effectively communicating risk to citizens and enabling communities to enhance their mitigation plans and actions.

The initial Risk MAP products in Connecticut were associated with the new coastal flood mapping prepared by the STARR team for FEMA. These coastal maps were distributed to the communities of Fairfield, New London, New Haven, and Middlesex counties in 2011 as drafts and will be adopted by the communities in 2013. Along with the new FIRMs, the Risk MAP product "Changes Since Last FIRM" (CSLF) were distributed to the coastal communities. These maps were created as communication tools and were presented to the communities at meetings with the intent that communities will better understand the changes due to the updated coastal analysis.

Flood Management Certification

The Flood Management Certification Program regulates all state actions in or affecting floodplains including regulating state sponsored changes to storm water drainage. Any state activity or grant funds supporting an activity located in a FEMA-mapped SFHA or 0.2% annual chance flood zone must certify to the DEEP that certain statutory and regulatory requirements have been met. These requirements always are equal to or exceed NFIP minimum standards (e.g., critical facilities and activities must be mitigated up to or elevated above the 500-year floodplain elevation, no increase in "intensity of use" in the floodplain without going through an exemption request demonstrating that the project is "in the public interest" and that the project "will not injure persons or damage property in the area of the project", etc.).

Stream Channel Encroachment Lines

The SCEL Program predated the NFIP and was a state program that regulated the placement of encroachments and obstructions in the floodplains of certain watercourses by regulating these obstructions and encroachments riverward of legally established lines. A permit from the DEEP was required for any activity riverward of established encroachment lines.

Encroachment lines were generally based on a 100-year flood or the flood of record, whichever is greater. The lines encompassed significant floodwater conveyance areas, areas of high velocity flows, and areas subject to significant depths of flooding. The majority of the lines were established following the devastating floods of 1955. However, in 1982 an additional 12 miles were established on the Yantic River in southeastern Connecticut. More recently, the Norwalk River Basin was re-studied, and revised SCEL maps were established in 1997.

While the program was successful in discouraging inappropriate development within the 273 river miles that have been delineated, the high cost of establishing new lines (between $12,000 - $14,000 per mile in 1997 dollars) ultimately reduced the ability of the State to extend lines along other rivers. Furthermore, the strong home rule ethos of municipalities in Connecticut led many communities to regulate development in local floodplains through local zoning regulations which is required for participation in the NFIP program.

Public Act 13-205 was passed in June 2013 to streamline the program. The bill allows, rather than requires, the DEEP commissioner to establish lines to restrict activity along certain tidal or inland waterways or flood-prone areas without authorization, and revokes any order establishing such lines. By eliminating the commissioner's authority to establish these lines, the bill eliminated the related permitting program, and the program is defunct.

Former Office of Long Island Sound Programs

The former Office of Long Island Sound Programs (OLISP) administered Connecticut's Coastal Management Program, which is approved by NOAA (National Oceanic and Atmospheric Administration) under the federal Coastal Zone Management Act. The Land and Water Resources Division is currently charged with these duties.

Under the statutory umbrella of the Connecticut Coastal Management Act (CCMA) enacted in 1980, the Coastal Management Program ensures balanced growth along the coast, restores coastal habitat, improves public access, promotes water-dependent uses, public trust waters and submerged lands, promotes harbor management, and facilitates research. The Coastal Management Program also regulates work in tidal, coastal, and navigable waters and tidal wetlands under the CCMA (Section 22a-90 through 22a-112 of the Connecticut General Statutes), the Structures Dredging and Fill statutes (Section 22a-359 through 22a-363f), and the Tidal Wetlands Act (Section 22a-28 through 22a-35). Development of the shoreline is regulated at the local level through municipal planning and the zoning boards and commissions under the policies of the CCMA, with technical assistance and oversight provided by Program staff via the Coastal Management Manual.

The CCMA contains a number of strong policies encouraging the protection of natural shoreline sedimentation and erosion processes, and discouraging shoreline flood and erosion control structures (also known as "hard" structures or shoreline armoring, such as seawalls, bulkheads and revetments) except in certain specified conditions. In general, DEEP can authorize the repair of existing erosion control structures and, in limited circumstances, the construction of new erosion control measures in areas waterward of the coastal jurisdiction line through the Structures, Dredging and Fill statutes and Coastal Management Act standards. Currently, a hierarchy or checklist of considerations must be satisfied before a flood and erosion control structure can be authorized. The goal for new development, however, is one of prevention: designing and building with appropriate setbacks to prevent the need for such structures. Additionally recent activities by DEEP have advanced coastal hazard planning, notably:

- The acquisition of historic shoreline data for use in identifying and quantifying areas of erosion and accretion;
- The use of high-accuracy coastal elevation data to develop a series of visualization tools for assorted sea level rise scenarios;
- The development of a web site that centralizes various data relative to Connecticut's coastal hazard; and
- Establishing partnerships with various regional organizations such as the Northeast
- Regional Ocean Council (NROC) and the Northeast Regional Association Ocean
- Observing System (NERACOOS) all of whom have an active interest and role to play in regional hazard planning and mitigation.

The Program also provided key administration and guidance in the following areas:

- Coastal and Climate Resilience
- Urban Waterfront Revitalization
- Watershed Management/Nonpoint Source Control
- Protecting Water-Dependent Uses
- Improving Public Access
- Restoring Coastal Habitat
- Promoting Harbor Management
- Facilitating Research
- Managing and Protecting Coastal Resources
- Protecting the Public Trust
- Flood and Erosion Control/Coastal Hazards

Former OLISP Regulatory Programs

Relative to flood and erosion control, OLISP authorized the repair of existing erosion control structures and, in limited circumstances, the construction of new erosion control measures in areas waterward of the coastal jurisdiction line through the Structures, Dredging and Fill statutes and Coastal Management Act standards. The Land and Water

Resources Division is currently charged with these duties. The goal for new development, however, is one of prevention: designing and building with appropriate setbacks to prevent the need for such structures. Additionally, recent activities by DEEP have advanced coastal hazard planning, notably:

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Former OLISP Technical Services and Grant Programs

The Technical Services and Grant Programs section of OLISP initially spearheaded coastal and climate adaptation planning in Connecticut. Subsequent to the adoption of the 2010 Connecticut Hazard Mitigation Plan, OLISP administered a climate change planning process in 2010 and 2011 that was funded by EPA's Climate Ready Estuaries (CRE) program and Long Island Sound Study (LISS). The process included personnel from OLISP and focused on the town of Groton, Connecticut. OLISP partnered with the International Council for Local Environmental Initiatives (ICLEI) to host three workshops with the Town of Groton in 2010 focusing on (1) the climate adaptation planning process and projected global, regional and local climate changes; (2) identification of vulnerabilities from projected changes in global and regional climate; and (3) identification of potential actions that could be used to increase resilience towards existing and projected changes in global and regional climate.

The ICLEI/OLISP/Town planning process resulted in the report "Preparing for Climate Change in Groton, Connecticut: A Model Process for Communities in the Northeast" (April 2011). This report contains lessons learned that can be applied in all communities in Connecticut and beyond. After the workshops and report release, EPA recognized the success of this project as a model for other communities, and funded the development by OLISP and ICLEI of the CT Adaptation Resource Toolkit, or CART. This website, which has recently been migrated to the DEEP website, is one stop shopping for communities who are ready to reduce risk.

As a tangential benefit of this planning effort, the Town of Groton incorporated some of the findings and strategies into its part of the Southeastern Connecticut Multi-Jurisdiction Hazard Mitigation Plan update, its Municipal Coastal Program update, and its Plan of Conservation and Development update.

There are several other communities OLISP supported for adaptation programs and actions including Greenwich. The town of Greenwich evaluated coastal risks by cataloguing and analyzing elevation certificates for buildings in the coastal AE flood zones.

OLISP partnered with UCONN/SeaGrant/CLEAR to offer multiple coastal resilience trainings and workshop in 2012-2013, as well as partnered with NOAA to bring a three-day training to ten communities to provide tools and strategies for land use and infrastructure decision makers.

Former OLISP of DEEP continue to provide technical assistance, outreach, and education with regard to sea level rise, flooding, coastal hazards, and coastal adaptation planning. However, these actions are typically coordinated with CIRCA's similar actions.

DEEP Energy Branch

The Public Utilities Regulatory Authority (PURA) replaced the former Department of Public Utility Control (DPUC) and, along with the Bureau of Energy and Technology Policy, is part of the Energy Branch of DEEP.

PURA is statutorily charged with regulating the rates and services of Connecticut's investor owned electricity, natural gas, water and telecommunication companies and is the franchising authority for the state's cable television companies. In the industries that are still wholly regulated, PURA balances the public's right to safe, adequate and reliable utility service at reasonable rates with the provider's right to a reasonable return on its investment. PURA also keeps watch over competitive utility services to promote equity among the competitors while customers reap the price and quality benefits of competition and are protected from unfair business practices.

The Bureau of Energy and Technology Policy is charged with developing forward-looking energy efficiency, infrastructure and alternative power programs. Together, PURA and the Bureau of Energy and Technology Policy have overseen several key efforts in the last few years:

DEEP developed the first-ever Comprehensive Energy Strategy (CES) for the State of Connecticut. This is an assessment and strategy for all residential, commercial, and industrial energy issues, including energy efficiency, industry, electricity, natural gas, and transportation. The strategy was developed as called for in the milestone energy legislation, Public Act 11-80, passed in June of 2011 prior to the storms of 2011 (Tropical Storm Irene and Winter Storm Alfred) and 2012 (Sandy) , and as amended by PA 13-303, that impacted energy utilities. Section 51 of this Act requires that DEEP, in consultation with the Connecticut Energy Advisory Board (CEAB), prepare a Comprehensive Energy Strategy for Connecticut every three years. In 2017, DEEP prepared an update to the CES to advance the State's goal to create a cheaper, cleaner, more reliable energy future for Connecticut's residents and businesses.[230]

Connecticut's Energy Assurance Plan (EAP) was developed in 2009-2012 using ARRA funds. This effort commenced at OPM and migrated to DEEP with the agency consolidations. The utility-damaging storms of 2011 and 2012 provided impetus to expand the EAP report. The EAP's structure is influenced by four phases of emergency management – preparedness, response, recovery, and mitigation. Mitigation encompasses all activities throughout the preparedness, response, and recovery phases of emergency management that attempt to prevent energy supply disruptions from occurring or to reduce the impact of an energy supply disruption event. Mitigation activities include, for example, enforcing tree trimming standards (preparedness), administering the Lead By Example program (preparedness), building Microgrids in town centers (response), and incentivizing the inclusion of renewable technology during a rebuild of property (recovery).

Natural gas utilities are an important aspect of energy. Although gas lines are mainly underground, shoreline flooding impacted a few hundred customers in 2012. Public Act 12-148 changed the way that PURA viewed recovery, requiring funding from gas companies. Docket 12-06-09 created performance standards.

Docket 11-09-09 required many changes to the operations of the State's two major electric utilities, Eversource and UI. The NSTAR/CL&P merger that created Eversource resulted in a commitment of $300 million from ratepayers to make hardening improvements. Docket 12-01-07 reviews the merger and lists the conditions of the merger. Status reports are also required. Docket 12-07-06 reflects the storm hardening program. The DEEP's vegetation management task force has also resulted from these dockets and acts.

Docket 12-11-07 concerns Superstorm Sandy. As a result of this docket, PURA must investigate any storm that causes an outage that exceeds 48 hours.

Another ongoing focus of PURA and ISO is the review of gas dependency for generating electricity. This effort is being undertaken by DEEP, PURA, ISO-New England and other regional entities as well as FERC to consider compelling issues with the electric and gas markets and potential shortages of gas during emergency outage situations.

Microgrids are discussed in Docket 12-01-07 and Public Act 12-148. PURA is actively planning for redundant and hardened energy infrastructure such as microgrids and harden transmission lines. DEEP is conducting the Microgrid Grant and Loan Pilot Program which seeks projects that support local distributed energy generation for critical facilities during times of electric grid outages. To date, DEEP has issued three rounds of requests for proposals, and a fourth round of funding is expected as a result of PA 13-239 which

[230] http://www.ct.gov/deep/cwp/view.asp?a=4405&q=500752&deepNav_GID=2121

committed the State to $30 million in bonding revenue to support microgrids after the pilot round in 2013.[231]

The Energy Efficiency Board (EEB) is a group of advisors who utilize their experience and expertise with energy issues to evaluate, advise, and assist the state's utility companies in developing and implementing comprehensive, cost-effective energy conservation and market transformation plans to help Connecticut consumers reduce energy use in their homes and businesses and to help Connecticut meet its changing and growing energy needs. The Board was created in 1998 by the Connecticut State Legislature, and now operates under a mandate in Public Act 11-80. The EEB has nine voting members and five non-voting representatives of Connecticut's electric and gas utility companies. By statute the Chairman of the EEB is Commissioner of the DEEP. Other members represent the Office of the Attorney General, the Office of Consumer Council, statewide business, the environmental field, the manufacturing sector, and retail organizations, a chamber of commerce, and retail customers

Forestry Division

There are 32 state forests (totaling nearly 170,000 acres) in the Connecticut state forest system managed by the Division of Forestry. These forests provide a variety of recreational experiences, natural diversity (including threatened, endangered and special concern species), and the preservation of unique sites (both geologic and archeological), the provision of raw materials as forest products, and the maintenance of wildlife and fisheries habitats. The Division's professional foresters work to insure that these forests remain healthy and vigorous while meeting the wide range of demands that the public places on these lands.

The Division of Forestry maintains an active forest fire prevention program and a specially trained force of firefighting personnel to combat forest fires. The division also has crews ready to assist the USDA Forest Service in controlling large fires across the nation. The Division prepares a daily Forest Fire Danger Report. Division of Forestry programs and activities related to forest fire prevention include:

- Maintaining a fully trained and equipped crew of fire fighters "on call" for assistance both in-state and to the federal government in fighting fires in the other parts of the U.S.;
- Conducting a forest fire prevention program utilizing Smokey Bear as a focus;
- Coordinating the timely suppression of all forest fires in the state using trained DEEP personnel, the Connecticut Interstate Fire Crew, local fire departments, and the Connecticut National Guard;
- Administering the federally-funded Volunteer Fire Assistance Program, which provides federal funds for equipment and training to fire departments which serve small communities; and

[231] http://www.ct.gov/deep/cwp/view.asp?a=4405&Q=508780&deepNav_GID=2121

- Participating in the Northeastern Forest Fire Protection Commission to coordinate mutual aid in fire prevention and suppression efforts among compact members.

Since prevention is still the primary means of reducing wildfire risks, the DEEP regularly posts updates about wildfire risk and circulates warnings to the press. For example, on March 27, 2012 the following DEEP press release was issued and picked up by several news agencies:

> *"DEEP Reminds State Residents of Spring Fire Danger – Forest Fire Danger Level is Very High*
>
> *As firefighters battle a large brush fire that is threatening two homes near Devils Hopyard State Park, East Haddam, the Connecticut Department of Energy and Environmental Protection (DEEP) today reminded residents that the Forest Fire Danger Level is currently VERY HIGH and that weather conditions will cause any brush fires to spread rapidly.*
>
> *With this fire danger, open burning of brush is NOT allowed – even if a resident has a permit from the local open burning official.*
>
> *In addition, the National Weather Service has issued a Red Flag Warning for Connecticut because of weather conditions conducive to the rapid spread of fire. Red Flag warnings are issued when high winds will be sustained or there will be frequent gusts above a certain threshold (normally 25 mph), as is expected to be the case today. Red Flag conditions are also defined by humidity levels, below 30%, and precipitation for the previous five days of less than ¼-inch.*
>
> *Residents need to know that any permit to burn brush is not valid when the Forest Fire Danger is rated high, very high, or extreme," said DEEP Deputy Commissioner Susan Frechette. "Anyone spotting a forest fire should remain calm and dial 911 to report the fire as quickly as possible to the local fire Department.*
>
> *DEEP's Division of Forestry constantly monitors the danger of forest fire to help protect Connecticut's 1.8 million acres of forested land. Forest fire danger levels are classified as low, moderate, high, very high or extreme.*
>
> *DEEP firefighters are currently assisting local fire departments in fighting a fire in East Haddam in the vicinity of Devils Hopyard State Park. The first efforts to battle this blaze began Monday evening and continue today."*

Solid Waste Division – Debris Management Plan

The DEEP prepared the State of Connecticut Disaster Debris Management Plan in 2007 (the Plan) as a component in the State's overall comprehensive efforts to support and implement improved planning for disaster debris management. This Debris Plan was made an Annex to the State's Natural Disaster Plan (2009). An update was prepared in June 2013, remaining an annex to the State Natural Disaster Plan. The Plan establishes the framework for State agencies and municipalities to facilitate proper management of debris generated by a natural disaster. In addition to the Plan, the State has established pre-need and pre-event contracts to assist the State in disaster debris management preparedness. These contracts will be activated only by the Governor as the result of an emergency declaration and will cover debris removal operations and the monitoring of these operations.

The Plan is based on guidance provided by FEMA, EPA, USACE and lessons learned from the destructive hurricanes in the gulf coast states in 2004 and 2005. The Plan outlines the DEEP's processes to consider, approve or disapprove requests for authorizations, variances, and waivers as needed for rapid and environmentally sound waste management, specifically with regard to managing the natural-disaster debris waste stream. In addition, this Plan outlines debris removal and monitoring roles and responsibilities and presents an overview of eligible federal reimbursable costs resulting from debris clean up and monitoring. State government agencies and municipalities will be the primary users of this Plan. Municipalities in particular, will make use of the information for planning pre-positioned contracts with waste haulers, as well as identifying disaster Temporary Debris Storage and Reduction Sites (TDSRS) that may be called into use during disaster recovery operations. Much of the information will also be useful to the waste management industry as they develop their own in-house plans for participating in a potential disaster recovery scenario.

The Disaster Debris Management Plan implemented by Connecticut state agencies and municipalities is based on recycling and material separation at the point of generation to the extent possible with additional segregation occurring at TDSRS in order to minimize disposal and reduce potential threats to human health and safety. TDSRS will be those sites that have been identified by local and state government, and which have been evaluated and approved by DEEP for the purposes of collection, volume reduction, and transfer to final permitted disposal and recycling facilities. The DEEP is responsible for the permitting of these sites. The goal will be to maximize potential processing and recycling options consistent with the State Solid Waste Management Plan. This strategy will be of highest priority and public education together with municipal, State, and federal cooperation will be imperative to effectively carry out this mission.

DEMHS has established pre-need and pre-event contracts to assist the State in disaster debris management preparedness. These contracts have been active on three occasions (Tropical Storm Irene, Winter Storm Alfred and Super Storm Sandy) in the past two years by the Governor, as the result of emergency declarations. These contracts cover debris removal operations and the monitoring of these operations.

State Parks Outdoor Recreation and Public Outreach

The Bureau of Outdoor Recreation oversees programs and environmental education workshops for the general public, informal education centers and formal education districts throughout Connecticut. This division is the licensed provider for national curriculum materials such as Project WET- Water Education for Teachers. The focus of Project WET is to provide curriculum materials to teachers in the K-12 educational system, integrating current educational standards and objectives while advancing knowledge of natural resources and conservation activities. As such the Project WET workshops target understanding of water science through watersheds, human impacts and environmental changes that include climate change. A series of workshops currently provided to educators includes emergency preparedness materials for natural disaster planning, as well as using natural disasters as a teaching tool to highlight concepts of sea level rise, flooding, public health and safety, cost analysis and land use planning.

The application of educator workshops that combine DEEP materials and policy with Project WET activities helps illustrate the road to management decisions. The inclusion of such materials in school programs helps support the goals of DEEP and Connecticut's Environmental Literacy Plan – to provide for an environmentally literate citizen. The public outreach office also serves to connect DEEP's actions and policy with non-government organizations and educational centers through professional development workshops that support their educational outreach, in order to provide for current information and consistent messaging about resource policy and management decisions.

Connecticut Geological Survey

It is a role of the State Geologist and the Connecticut Geological Survey to reduce risks from geologic and seismic hazards through assessment and mapping of areas vulnerable to natural hazard events. Geologic research and field investigations support hazard assessments and assist policy makers to minimize damages of future events. These investigations are accomplished through cooperative efforts between the State Geological Survey of DEEP, Connecticut State Universities, private colleges and Universities, and other State and Federal agencies.

The following CT Geological Survey cooperative efforts are related to hazards:

- Surficial Geologic Mapping for NEHRP (National Earthquake Hazards Reduction Program) site effect classification in HAZUS-MH (NE SGs/NESEC) (2010)
- Geochemical Landscapes Soil Analyses and Mapping (DEEP/USGS) (2008-2010) – natural vs. anthropogenic geochemical information
- Subsurface Geologic Mapping from Well Completion Reports (DEEP/USGS) (2008/09) – ground water resource mapping
- Surficial Aquifer Potential Mapping (DEEP/EPA) (2006-2008) – water resource protection
- Characterization of Bedrock Aquifers (DEEP/USGS) (2002) – source water protection; surface/groundwater interactions
- State Geological Map of Connecticut digitized (DEEP/CT DEM) (1998-99) – seismic hazards mapping
- Indoor Radon Potential Mapping (DEEP/DPH/EPA) (1990-1997) – well water & indoor air radon distribution mapping

The Connecticut Geological Survey provided support for DEEP efforts involving erosion susceptibility (1:24,000 scale) as a planning tool for predicting terrace escarpment erosion. This mapping was derived from a synthesis of Quaternary geology and soil mapping characteristics. Field testing at 60 key locations enabled mapping methodology to be applied statewide. Erosion susceptibility mapping is available to environmental planners within DEEP through GIS and to the public through free data download.

The Connecticut Geological Survey has prepared digital geologic and soils data for hazards assessments and analyses through cooperative efforts with the NRCS and the U.S. Geological Survey. These data support agency assessments of seismic risk, inland and coastal flooding, shoreline erosion, and sea level rise.

The catalog of digital GIS data available from DEEP, including geologic and soils data is available through www.ct.gov/deep/gisdata/.

Department of Transportation (DOT)

In addition to its overall responsibility to provide a safe, efficient and cost-effective transportation system that meets the mobility needs of its users, the Connecticut Department of Transportation (DOT) is responsible for several short- and long-term natural hazard mitigation objectives in Connecticut. The short-term objectives include plowing of roads during winter storms and repairing the public transportation network after natural disasters. DOT's long-term goals include the design of flood and earthquake resistant roads and bridges.

Four of DOT's major short-term mitigation efforts are their Storm Control Center, State Tracking Automated Request System (STARS), Advanced Traffic Management System (ATMS), and Bridge Inspection Program:

The DOT Storm Control Center is operational during severe weather events ranging from winter storms to hurricanes. The Storm Control Center coordinates the plowing operations of over 600 crews during winter storms, as well as tree and debris removal crews when deemed necessary during all other severe weather events winter or summer.

The DOT has implemented STARS, a program to post road closures to the DOT's internet site for the public during major storms.

The ATMS system is a network of cameras and road sensors that monitor road conditions and traffic flow on Connecticut's Interstate Highways. Using automated road signs, the ATMS system also warns drivers of traffic congestion, accidents or hazardous driving conditions.

The Bridge Inspection program uses an automated computer based monitoring system that alerts DOT personnel when a scour critical bridge is experiencing a high rainfall or stream flow event. The system uses rain intensity and river gage information to trigger alerts so that bridge inspectors can be dispatched to the identified bridge(s). A plan of action has been developed for each scour critical bridge to aid the inspector in monitoring and possible closure of the structure.

Some of DOT's long-term mitigation efforts include:

- Improving the design of roads and bridges above the 100-year floodplain;
- Seismic resistant bridge retrofit projects and designing new bridges to resist earthquakes;
- Storm evacuation route planning; and
- Increasing the clear zone on all roadways where needed to prevent road closures and damage due to downed trees and limbs.

DOT commenced a "Climate Change and Extreme Weather Pilot Project" in 2013 using a grant from the Federal Highway Administration. The project will include vulnerability assessments of culverts and bridges in Litchfield County that are between six and 20 feet in length, with regard to flooding caused by increasing precipitation and extreme rainfall events. The assessment will evaluate the existing storm event design standards, the recent (ten year) historic actual rainfall intensity and frequency, and evaluate the hydraulic capacity of these structures using the projected increases in rainfall based on best available data and studies. Litchfield County was selected due to the inland flood damages observed in the northwest corner of the state over the last few years. The scope of this project was identified in the Connecticut Climate Change Preparedness Plan which was a product of a statewide effort that took place from 2005 through 2011.

In addition to the vulnerability assessment, the project will include a process that assigns a criticality value to the risk of failure. This will assist the Department in prioritizing replacement and reconstruction efforts to these structures where they pose the greatest risk to human health and safety, public and private property loss, and the economic risk of replacement after failure versus proactive replacement. This project will add to the existing framework by providing a model process for assessing the hydraulic capacity of smaller structures in the rural urban fringe and the criticality of those assets in similar geographies.

DOT provides technical assistance to DEEP and DEMHS in reviewing projects concerned with implementing roadway construction projects and other related transportation issues. A member of the DOT is appointed to the CIHMC.

Department of Public Health (DPH)

In the course of a day, more than 2.86 million Connecticut residents, as well as many others who visit the state, come into contact with drinking water provided by a public water system, whether community, non-community or non-transient, non-community. The CT Department of Public Health (DPH) Drinking Water Section (DWS) is responsible for ensuring that all public water supply systems provide a water supply of adequate quantity and quality to their consumers.

The DPH maintains the following two plans that relate to emergency response and mitigation: 1) Connecticut Public Health Emergency Response Plan and 2) DWS Emergency Contingency Plan.

DPH provides technical assistance to DEEP and DEMHS in reviewing projects with respect to drinking water issues including sources, adequacy, and infrastructure. A member of the DHCD may be appointed to the CIHMC.

Connecticut Public Health Emergency Response Plan

The DPH is the lead administrative and planning agency in Connecticut for public health initiatives including public health emergency preparedness. DPH works with federal, state, regional, and local partners to improve the State's ability to respond to public health emergencies. The Connecticut Public Health Emergency Response Plan (PHERP) identifies the appropriate DPH response activities during a public health emergency. This plan supports the public health and medical care component in existing state disaster and emergency plans.

The purpose of the PHERP is to support the following four functions of the Connecticut emergency response effort:

- Maximize the protection of lives and properties;
- Identify the DPH procedures to implement when responding to a natural, biological, chemical, radiological, nuclear, or explosive emergency that threatens the public health of Connecticut;
- Contribute to emergency support functions, as appropriate, particularly emergency support function #8 of the PHERP (Health and Medical Services) at the state level to define policies and procedures for DPH and other public health partners in preparation for and in response to a public health emergency; and
- Enable the State of Connecticut to continue to operate and provide services as normally and effectively as possible in the event of a public health emergency.

Connecticut Drinking Water Section Emergency Contingency Plan

Acting on behalf of the DPH, the DWS protects public health through regulatory oversight of public water systems throughout the state. Implicit in this mission statement is providing immediate "emergency" support to water supplies and the public. It is part of the DPH's mission to influence, through regulation and communication, the operation of public water systems so that all necessary precautions to protect and preserve sources and systems of supplies are taken.

The DPH DWS requires all public water systems serving 250 or more customers or 1,000 or more people to develop an Emergency Contingency Plan. The plan aims to avoid or address emergencies by evaluating vulnerabilities and how to mitigate potentially harmful events. The public water systems are encouraged to address risk prone items and areas where a system may fail and take steps to correct them. The DPH DWS addresses emergencies by communication with and responding to water quality issues at public drinking water systems Emergency Contingency Plans are developed to address emergencies including contamination of water, power emergencies, drought, flooding, and/or failure of any or all critical water system components.

Connecticut Department of Public Health Drinking Water Section Incident Report Forms: Standard Operating Procedure

There is a formal standard operating procedure (SOP) for the DWS Public Water System Security Incident Report Form and the DWS Public Water System Emergency Incident Report Form. The form describes the scope of public water system's distribution and storage. The procedure provides a consistent means for internal notification of staff on emergency and security situations at Public Water Systems. The Incident Report Forms also provide the DWS a means to notify key personnel within the Department of Public Health as well as other partners outside the Department of Public Health. Emergency and security situations at Public Water Systems can be divided into two categories, routine operating emergencies such as pipe breaks, pump malfunctions, acute risk water quality issues and power outages; and non-routine emergencies such as intentional acts of sabotage, chemical spills, floods, hurricanes, windstorms or droughts. The DWS Public Water System Security Incident Report Form and the DWS Public Water System Emergency Incident Report Form have been provided to capture all emergency scenarios. As of 2018, DPH is in the process of updating the report forms and SOP to include key stakeholders and response actions like putting a system on interim measures.

Connecticut Water Supply Planning

All public water systems serving 1,000 or more persons, or 250 or more consumers are required by the DPH to prepare water supply plans in accordance with CGS 25-32d Sections 1a – 5 in order to maximize efficient and effective development of the state's public water supply systems and to promote public health, safety and welfare. The water supply planning process provides for a coordinated approach to long-range water supply planning by addressing water quality and quantity issues from an area-wide perspective. In CT, there are approximately 90 water utilities that fall under this category. These 90 systems must provide updates on the water supply plan every five years and plan their system viability over a five, 20, and 50-year period. The water supply plan also includes an emergency contingency plan section (described above).

Per Public Act 85-535, the State also has a program for Public Water Supply Coordination to maximize efficient and effective development of the state's public water supply systems and to promote public health, safety and welfare. This Act provides for a coordinated approach to long-range water supply planning by addressing water quality and quantity issues from an area-wide perspective. The process is designed to bring together public water system representatives and regional planning organizations to discuss long-range water supply issues and to develop a plan for dealing with those issues. The state has been divided into three management areas based upon a number of factors, including similarity of water supply problems, proliferation of small water systems, groundwater contamination problems, and over-allocated water resources. The three regions have completed coordinated planning and have water utility coordinating committees (WUCCs) in place to continue region-wide planning.

Connecticut Water Planning Council

The Connecticut Water Planning Council was created by the Energy and Technology Committee of the Connecticut General Assembly in 2001 with representation from four state agencies (DPH, OPM, and the predecessors of DEEP and PURA [DEP and DPUC]). The charge of the WPC is to "identify issues and strategies which bridge the gap between the water supply planning process and water resources management in order that water can be appropriately allocated to balance competing needs while protecting the health, safety and welfare of the people of Connecticut and minimizing adverse economic and environmental effects."

The WPC initially established three Committees to investigate specific issues identified in PA 01-177 and submitted an Issues Work Plan to the Legislature on January 28, 2002. The three committees were the Water Resource Management Committee, the Water Utility Committee, and the Technical Management Committee. Each committee supervised the work of two subcommittees that, together, evaluated 11 issues. The WPC established the Water Planning Council Advisory Group (WPCAG) pursuant to PA 07-4, Section 2(c) in 2007 to assist in researching and analyzing water resources issues. The WPCAG has formed a number of work groups over the years. To date, the WPC and WPCAG have not undertaken any initiatives directly related to water-related natural hazards. However, they have addressed climate change, floods, and droughts through the development of the State Water Plan described below.

State Water Plan

On July 1, 2014, Public Act 14-163, "An Act Concerning the Responsibilities of the Water Planning Council," became effective in the State of Connecticut. The Act directs the Water Planning Council to develop a State Water Plan. In 2015, the WPC formed a Steering Committee with representatives from the WPC and the WPCAG to work with any parties providing services during the development of a State Water Plan. The plan was developed in 2016-2017 with delivery of a draft in June 2017 and submittal to the State Legislature in January 2018.

The State Water Plan includes a climate change analysis completed by the consultant. Results of a "hybrid delta ensemble" (HDe) analysis were presented in the plan. Four scenarios were the focus of the analysis: "warm/dry," "warm/wet," "hot/dry," and "hot/wet." Summary output included a.) monthly time series plots of average temperature and total precipitation, b.) mean monthly temperature and precipitation bar charts, and c.) monthly temperature and precipitation percentile plots. The first summarized the raw output and illustrates month to month variability, the second provided insight into the seasonality of the projected changes, and the third showed the full range of projected changes including extreme months. Differences across sets of ensemble plots highlighted the variability and uncertainty associated with the climate model projections and potential differences associated with greenhouse gas emissions pathways. For example, the "hot/dry" ensemble projects a mean monthly temperature change of 4.5 ˚C and a mean monthly precipitation change of 10 mm/month, while the "warm/wet" ensemble projects a temperature change of 2.6 ˚C and a precipitation change of 17 mm/month.

The *State Water Plan* notes that there is general consensus in the climate models for a hotter and wetter future. Mean annual temperature changes for the 2080 planning horizon, compared to historical baseline, range from approximately +0.5 ˚C to + 6.5 ˚C. Mean annual precipitation changes range from approximately -5% to +30%, with most of the projections predicting an increase in mean annual precipitation.

All model ensembles project an increase in temperature for all calendar months. Projected temperature changes appear relatively consistent across calendar months and percentile levels for each of the ensemble scenarios. In other words, both summer and winter temperatures are projected to increase by similar amounts; and a similar shift is observed for both extreme cold and extreme hot months. Precipitation projections are more variable, although consistently projecting a generally wetter future for all four scenarios. The largest precipitation increases are projected for the wetter months (higher percentiles), including extreme wet months. The seasonality plots in the plan show that winter and spring precipitation changes are projected to be larger than summer and autumn changes. Drier months are generally projected to remain about the same in terms of both frequency and rainfall level. Small decreases in extreme dry month precipitation were projected for the "hot/dry" scenario.

Implied by the results presented in the State Water Plan is the potential for decreased water availability due to significantly higher temperatures and evapotranspiration losses. However, this dynamic would be offset to a certain extent by increased rainfall. Typical climate forecasts tend to suggest that increased temperatures coupled with increased annual precipitation generally correspond to higher intensity storms (greater flood risk) and longer dry periods in the summer months (more frequent and/or intense droughts).

State Drought Planning

Public water systems that conduct water supply planning have developed drought planning and response plans as part of their emergency contingency plans. Currently, the drought planning and response plans developed by public water systems are either based on the Water Supply Plan Regulations (25-32d-3) or the parameters identified in the 2003 Connecticut Drought Preparedness and Response Plan prepared by the Interagency Drought Work Group. Public Act 17-211 requires that drought planning and response procedures developed by public water systems now be available to the public. As a result, drought planning and response plans will need to be decoupled from emergency contingency plans as they are updated.

For public water systems primarily reliant on reservoir sources, the amount of storage in the reservoir is typically used to define the criteria for each drought stage. Public water systems primarily reliant on groundwater sources typically use the amount of storage in a primary storage tank over a period of days, or a combination of precipitation and groundwater levels, to define the criteria for each drought stage. The four drought stages in the water supply planning regulations with water conservation goals from the 2003 Connecticut Drought Preparedness and Response Plan include:

- "Advisory" with a voluntary 10% reduction goal for residents and organizations;
- "Watch" with a voluntary 15% reduction goal for residents and organizations;
- "Warning" with a voluntary 20% reduction goal for residents, organizations, and state agencies; and
- "Emergency" with a Governor-mandated 25% reduction in water use by residents, businesses, and state agencies.

Utilities have strengthened these goals where appropriate. For example, many utilities identify the 20% reduction goal under Drought Warning to be mandatory, as utilities have found that a better reduction in demand is realized when mandatory conservation measures are enacted. In addition, some utilities also define and utilize an "Alert" cautionary stage to prepare internally for implementation of voluntary and mandatory water conservation measures.

The Interagency Drought Work Group has been working on an update to the 2003 Plan. The current draft of the update is dated 2017, and includes the following drought stages (in increasing severity):

- "Heightened Awareness";
- "Below Normal Conditions";
- "Moderate Drought";
- "Severe Drought"; and
- "Extreme Drought".

These proposed classifications are intended to align more closely with U.S. Drought Monitor terminology and limit confusion with any individual utility drought statuses.

However, some water utilities still utilize the older five-stage method that pre-dates the 2003 Connecticut Drought Preparedness and Response Plan:

- "Alert" which did not include a reduction goal
- "Advisory" with a voluntary 10% reduction goal
- "Emergency Phase I" with a voluntary 15% reduction goal
- "Emergency Phase II" with a voluntary 20% reduction goal
- "Emergency Phase III" with water rationing

Over time, the State expects that these water utilities will shift to the four stages described in the Water Supply Plan Regulations (25-32d-3).

The drought of 2015-2016 raised public awareness of voluntary and mandatory water conservation measures, which are enacted by many utilities to reduce demands during a drought. Typically, such reductions are requested on a percentage basis for each customer. Utilities typically request reductions from all users concurrently. Many utilities have Emergency Contingency Plans that focus water conservation enforcement on high-volume users by recommending more frequent (weekly) meter readings of high-volume customers when conservation measures are requested or mandated, and recommending requiring large customers to file a water conservation "plan of action" with the utility to demonstrate how that customer will reduce its water usage to the requested percentage.

It has long been recognized that water utilities, particularly non-municipal utilities, have limited methods to enforce voluntary and mandatory conservation measures. As noted in the 2003 Connecticut Drought Preparedness and Response Plan, municipal authority may be necessary to locally enforce any measures, but many municipalities do not have local ordinances in place to ensure proper implementation of water conservation measures during droughts and other emergencies. To that end, a model ordinance was developed to encourage adoption of these policies at the local level, but few municipalities have adopted the model ordinance. The model ordinance includes examples of banned uses, the procedures for announcing the need for conservation measures, and procedures for issuing fines or even curtailment of service. Municipal drought ordinances have been successful in southwest Connecticut. This occurred through municipal interest prior to the drought of 2015-2016 (for example, in Greenwich), as well as during reaction to the drought of 2015-2016 (in Stamford, Darien, and New Canaan).

For reservoir systems, the number of days of supply remaining has been suggested by some water utilities as a method that could potentially be used for determining drought stage criteria in conjunction with the percentage of storage remaining. The number of days of supply remaining should be tied to a relatively predictable number for a water system, such as maximum month average day demand (MMADD) or MMADD from a year with a similar drought. There are several reasons for this suggestion:

- For some storage-rich systems, a Drought Emergency could be issued under the current plans despite the system having more than 300 days of supply remaining, and there is concern that this could result in increased political pressure to not request or mandate emergency water conservation measures.
- The use of MMADD provides a condition where water would be withdrawn faster than would be expected given implementation of conservation measures. As such, it provides a baseline against which users in a system could be encouraged for their conservation efforts. Projecting that a system has 90 days of supply remaining, but then still having 80 days of supply remaining a month later despite minimal rainfall, can provide quantitative reinforcement to a community of the positive effects being developed.
- Furthermore, such a procedure would standardize the triggers between utilities. The volume of reservoir storage between utilities vastly differs, but a method based on the days of supply remaining would provide consistency for state agencies attempting to understand the status of multiple public water systems across the

state. For example, CT DPH would immediately understand that a utility entering a Drought Warning was projecting a certain amount of days of supply remaining, regardless of the size of the system or storage available.

Alternatively, a risk-based approach could be used based on historical drought data and the projected frequency of hitting drought triggers. A variety of approaches along this vein are presently under consideration by utilities. Regardless of approach, a delicate balance must be achieved where activating drought triggers can ensure that water is properly conserved, but where activation does not result trigger "fatigue" among end users who become immune to constant announcements of rapidly changing levels of requested and mandatory conservation.

In summary, drought-related capabilities are changing rapidly in Connecticut. The next edition of this Natural Hazard Mitigation Plan will revisit drought capabilities and report on the final changes to the Drought Preparedness and Response Plan.

Department of Administrative Services
Division of Construction Services

Within the Department of Administrative Services is the Division of Construction Services (DCS). Just prior to the adoption of the 2014 edition of this plan, DCS consolidated services provided by the Bureau of Design and Construction from the former Department of Public Works, the Bureau of School Facilities from the State Department of Education and the Division of Fire and Building Services from the former Department of Public Safety, which includes the Office of the State Building Inspector, the Office of Education and Data Management and the Office of State Fire Marshal.

DAS is the state's primary agency for executive and judicial branches for facility planning, design, and construction-related services; administration of the state school construction grant program; and development, administration and training of state building and fire safety codes.

Office of Design and Construction

The Office of Design and Construction (ODC) implements and administers state capital projects planning and management for the majority of state agencies by working with them in the areas of facilities planning, design, construction, and technical expertise. ODC administers and promotes the following:

- High Performance Building or Sustainable Design guidelines for capital projects;
- Design and implement energy retrofit projects to existing state buildings;
- Review and approve Life Cycle Cost Analysis submissions for all state-funded new buildings, additions or renovations;
- Provides technical expertise in regulatory compliance in the areas of permits, mitigation, hazardous materials (lead, asbestos, PCBs, mold), and soil contamination;
- Administers the State Asbestos Program; and

- Provides geographical information system (GIS) support for state agencies, including State real estate inventories.

DCS – Environmental Planning and GIS Services

The Technical Services Unit within DCS provides important technical reviews and analysis of DCS administered State projects. This unit works closely with other state agencies when they are in the initial planning phases and in particular, siting a new facility. Part of this review involves assessing potential impacts relating to natural hazards, recommendations of alternatives to avoid, minimize or mitigate potential natural hazard impacts, and regulatory approvals (e.g., Flood Management Certification).

DCS offers GIS services to the majority of state agencies, which include custom maps/figures, geographic analysis for relocation of state facilities, assisting in overall statewide facility planning efforts, project pre-planning, and identification of potential environmental impacts for proposed projects. This Unit also maintains a GIS inventory of state land and buildings. In conjunction with DESPP and OPM staff, this unit is also involved with mapping of critical infrastructure and key resources data and conducting assessments of such resources as they relate to natural or man-made hazards.

Office of School Facilities

The Office of School Facilities (0SF) is responsible for overseeing the local school construction grant program. In addition to design and construction oversight, OSF Code Reviewers and DCS Technical Services Unit evaluate building code and environmental requirements and determine adequacy and appropriateness of proposed new school facility sites. In addition, DDC Technical Services reviews and approves these local school construction projects for consistency with the State's Flood Management Act.

Fire and Building Services: Office of the State Building Inspector, Office of State Fire Marshal, and Office of Education and Data Management

These offices provide the following functions: works with the State Codes and Standards Committee to develop, adopt and administer state building and fire safety codes and the fire prevention code, provide interpretations and clarifications of code language; act upon requests for code modifications and waivers; review construction drawings, issue building permits and inspect large state buildings; train and credential building and fire code officials; inspect and issue operating certificates for boilers and elevators; issue demolition and crane licenses; maintain burn injury and fire incident reporting systems; and provide technical assistance to state agencies, municipal code officials, design and construction professionals, and building owners.

Office of the State Building Inspector (OSBI)

The lead authority for the adoption and administration of building code provisions for wind, flood, and seismic matters is OSBI. The 2014 edition of this plan noted that the 2005 State Building Code was adopted effective December 31, 2005. It also noted that the 2009 amendments to the 2005 State Building Code and the 2005 Connecticut State Fire Safety Code were effective on August 1, 2009; and that additional code amendments were underway. The proposed 2013 amendments adopting the 2009 IRC and the 2011 National Electrical Code were subject to a public hearing held on April 10, 2013. Included in the amendments were passages regarding substantial improvement/damage determinations for structures in floodplains, wind speed design criteria, snow load design criteria, and seismic design criteria. A new appendix (R) specifies the wind and seismic criteria categories for each town in Connecticut. The 2014 edition of this plan reflected the expectation of adoption of the amendments, and the amended code was effective February 28, 2014.

The 2014 edition of this plan also noted that the technical review process for adoption of the 2012 ICC code family was underway. It was anticipated that a new State Building Code based on this model would be adopted sometime in 2015. These codes contained the latest weather data and mitigation techniques. The current State Building Code is indeed based on the International Code Council's (ICC) widely-adopted 2012 International Codes. The 2016 State Building Code is effective for projects where permit applications are made on or after October 1, 2016.

However, the State Building Code is again in flux. The State Building Inspector, State Fire Marshal, and the Codes and Standards Committee announced on December 29, 2016 the intent to adopt the 2018 State Building and Fire Safety Codes based on the 2015 editions of the ICC and National Fire Protection Association (NFPA) documents. Technical review of these codes was conducted by the Committee's Codes Amendment Subcommittee (CAS) along with DAS staff. This review began January 2017 and was completed with the Codes and Standards Committee's approval for DAS to move both codes to the legislative approval process at its November 8, 2017 meeting. The proposed codes are:

- 2015 International Building Code
- 2015 International Existing Building Code
- 2015 International Energy Conservation Code
- 2015 International Mechanical Code
- 2015 International Plumbing Code
- 2015 International Residential Code
- 2015 International Fire Code
- 2015 NFPA 101 Life Safety Code
- 2017 NFPA 70 National Electrical Code
- 2009 ANSI A117.1 Accessible and Usable Buildings and Facilities

The new code is reportedly significant relative to flood mitigation. It will require one foot of freeboard in all A, AE, and VE zones; coastal A zones will be regulated like VE zones where the LimWa is delineated; flood openings will be required in breakaway walls; and essentially facilities must be elevated two feet above the BFE or to the 0.2% annual chance flood elevation.

Office of Policy and Management

Given its role as the Governor's staff agency, OPM plays a central role in providing the information and analysis used in formulating state policy. OPM provides the Governor with an objective view of the issues and with an assessment of available policy alternatives. OPM also assists state agencies and municipalities in implementing policy decisions on behalf of the Governor. Integrating natural hazard mitigation considerations with development, resource management and public investment policies helps minimize the loss of life and property due to natural disasters.

Beyond its broader role in the development and implementation of state policy, OPM is responsible for coordinating drought management activities of state agencies. OPM is a member of the Interagency Drought Working Group and of the Water Planning Council described above. OPM also provides technical support to DEMHS and DEEP in reviewing project applications. A member of OPM is appointed to the CIHMC.

OPM is responsible for the Connecticut Conservation and Development Policies Plan (informally known as the State Plan of Conservation and Development [POCD]) which identifies the state's development, resource management and public investment policies. The POCD identifies the policies that guide the state in (1) addressing human resource needs and development; (2) balancing economic growth with environmental protection and resource conservation concerns; and (3) coordinating the functional planning activities of state agencies to accomplish long-term effectiveness and economies in the expenditure of public funds.[232]

Conservation & Development Policies, the Plan for Connecticut

OPM is required to continuously incorporate consideration of natural hazards into the revision of the Conservation & Development Policies Plan as part of the compliance with the Floodplain Management and Hazard Mitigation Act. The Conservation & Development Policies Plan 2013-2018 incorporates this requirement and was adopted in June 2013. The new natural hazards policy in the revised POCD entitled is *"Minimize the potential risks and impacts from natural hazards, such as flooding, high winds and wildfires, when siting infrastructure and developing property. Consider potential impacts of climate change on existing and future development."*

Other relevant policies include:

- Minimize the siting of new infrastructure and development in coastal areas prone to erosion and inundation from sea level rise or storms, encourage the preservation of undeveloped areas into which coastal wetlands can migrate, and undertake any development activities within coastal areas in an environmentally sensitive manner consistent with statutory goals and policies set forth in the Connecticut Coastal Management Act.

[232] For a copy of the CT Plan of Conservation and Development and more information please see the following web page: http://www.ct.gov/opm/cwp/view.asp?a=2990&q=383182.

- Allow redevelopment and rebuilding of coastal areas consistent with coastal area management principles and regulations and prevailing federal rules and requirements.
- Discourage new development activities within floodway and floodplain areas, manage any unavoidable activities in such areas in an environmentally sensitive manner and in compliance with applicable laws, and seek to prevent the loss of life and property by maintaining existing dikes, channels, dams, and other barriers, or removing such structures where removal would be a more cost-effective option for reducing threats to downstream property.
- Proactively address climate change adaptation strategies to manage the public health and safety risks associated with the potential increased frequency and/or severity of flooding and drought conditions, including impacts to public water supplies, air quality and agriculture/aquaculture production.

The Connecticut Conservation and Development Policies Plan 2018-2023 was issued in 2017 and will be adopted in 2018. Revised policies include:

- Minimize the siting of new infrastructure and development in coastal areas prone to erosion and inundation from sea level rise or storms, as anticipated in sea level change scenarios published by the National Oceanic and Atmospheric Administration, ensure that coastal hazards are accounted for when considering options for the replacement, expansion, or reduction of existing infrastructure under Policy 1.1, and otherwise limit development activities within coastal areas to those consistent with statutory goals and policies set forth in the Connecticut Coastal Management Act.
- Discourage new development activities within areas prone to flooding and coastal erosion, manage any unavoidable activities in such areas in an environmentally sensitive manner and in compliance with applicable laws, and seek to prevent the loss of life and property by maintaining existing dikes, channels, dams, and other barriers, or removing such structures where removal would be a more cost- effective option for reducing threats to downstream property.

Department of Economic and Community Development
State Historic Preservation Office

The State Historic Preservation Office (SHPO) is responsible for overseeing the governmental program of historic preservation for Connecticut's citizens. Originally established as the Connecticut Historical Commission in 1955, the agency was merged into the Commission on Culture & Tourism in 2003 and was renamed the Historic Preservation and Museum Division. The State Historic Preservation Office was again moved in 2011 into the Department of Economic and Community Development providing new opportunities for collaboration on restoration and community revitalization.

SHPO administers a range of federal and state programs that identify, register and protect the buildings, sites, structures, districts and objects that comprise Connecticut's cultural heritage. This includes the creation of a State Historic Preservation Plan, administration of four historic sites open to the public, and administration of grants supporting historic resources.[233]

State Agency Capabilities Status from Prior State Hazard Mitigation Plan

This update of the State's Natural Hazard Mitigation Plan recognizes that some strategies and actions from prior editions of the plan may have been continued several times. Specifically, the timeframes assigned to these State Agency (DEEP and DESPP/DEMHS) action items have typically been "ongoing" or "to be continued." Because these actions are truly ongoing or meant to continue in perpetuity, they have become capabilities. The following ongoing and continued actions are considered DEEP and DESPP/DEMHS capabilities.

Table 3-4. Continued Strategies and Actions from Prior State Hazard Mitigation Plans

Activity #	Activity	Status	Description/Explanation
1.1.2	Provide local ordinance reviews for communities to provide them with an indication as to where existing ordinances require updates or enhancements to current standards.	To Be Continued	In conjunction with the Map Modernization Program, ordinance reviews were completed for communities in Middlesex, Hartford, New London, New Haven and Fairfield Counties. DEEP will continue as needed.
1.1.3	Perform community assistance visits (CAVs) each year to maximize efforts to provide technical guidance and educational materials to communities. This activity is important to promote compliance with NFIP minimum standards and any additional requirements as stated in local ordinances.	To Be Continued	Typically the program completes five CAVs per year. CAVs are normally performed with a community on the following intervals: at least once every five years for a coastal community and at least one visit every ten years for an inland community.
1.1.5	Investigate the feasibility of participating at local events such as home shows, fairs, etc. to provide information to the public regarding the NFIP and impacts from flooding and other natural hazards and ways individuals can help mitigate effects from these hazards. Investigate the feasibility of developing and packaging educational materials for such events.	To Be Continued	Implementation of activity is dependent on available resources and funding. However, such actions were performed post-Irene and post-Sandy by DEEP and DESPP personnel along with FEMA Joint Filed Office staff. Activity will be evaluated annually for possible incorporation into DESPP and DEEP program workplans.

233 http://www.ct.gov/cct/cwp/view.asp?q=293806

1.1.6	Providing technical assistance to other state agencies, local communities and the public regarding natural hazard mitigation.	To Be Continued	Implementation of activity is dependent on available resources and funding. However, three mitigation courses were presented through the Sandy Joint Field Office which were available to various state agency personnel with respect to floodplain management which included: BCA training, project identification and development, hazard mitigation planning. In addition, CT DESPP and DEEP staff have participated on panels for various climate resiliency and hazard mitigation workshops held within the state.
1.2.1	Develop a series of workshops to take place over the next 3-year period that will include floodplain management 101 (presentation of FEMA floodplain management requirements and the NFIP), overview of elevation certificates, coastal construction standards, effective flood and other natural hazards mitigation measures, floodplain resource protection, and the use of DFIRMs.	Ongoing / Continuous	Typically 1-2 workshops per year focused on floodplain management activities. In addition, DEEP's training program for municipal inland wetlands commissioners and staff includes floodplain management activities as all floodplain soils are wetlands in CT. This program includes approximately 15 seminars per year. Educational workshops are developed and presented on an on-going basis for several natural hazard mitigation topics, especially with regards to floodplain management issues. Also, three mitigation courses were presented through the Sandy Joint Field Office which were available to various state agency personnel with respect to floodplain management which included: BCA training, project identification and development, hazard mitigation planning.
1.2.2 and 2.1.2	Act as a clearinghouse for FEMA-produced educational materials in the area of natural hazards mitigation including flood management and planning; as well as climate change and adaptation approaches.	Ongoing / Continuous	This activity is performed on a continuous basis by DEEP flood management staff. Approximately 40 information requests were received and processed per month. Currently, between DEEP Flood Management staff and OLISP Climate Change staff, it is estimated that the State now receives and processes 80+ inquiries per month.
1.2.3	Investigate the modification and update of the CT DEEP's flood management web pages to expand information and educational materials available to the general public.	Ongoing / Continuous	Modifications are dependent on available resources and funding. However, the web pages are intact and available to the public in the current format.
1.3.3	Utilize meetings with other state agencies, including pre-permitting conferences, as opportunities to encourage responsible floodplain management and floodplain	Ongoing / Continuous	Approximately two meetings are attended per month by DEEP staff. Strong working relationships have been developed between the flood management program and other IWRD sections and programs. OLISP is now

	development activities, and natural hazards mitigation potential in proposed projects.		linking efforts with climate change initiatives. There has also been a concerted effort by DEEP's Flood Management Section and OLISP to coordinate education and outreach efforts where possible for climate change and community resilience and hazard mitigation. Positive working relationships will continue to be pursued with other internal agency divisions and between DEEP and other State agencies.
2.1.1	Utilize meetings with other state agencies, including pre-permitting conferences, as opportunities to encourage responsible floodplain management and floodplain development activities, and natural hazards mitigation potential in proposed projects.	Ongoing / Continuous	This is an on-going activity performed by DEEP flood management staff. Approximately two meetings are attended per month.
2.2.4	Encourage use of EMI's independent study courses which people can access at their computer free-of-charge from EMI.	To Be Continued	This is an activity which is normally done by promoting available courses through DEEP's Flood Management newsletter.
3.1.3	Process technical assistance requests from communities and state agencies to FEMA for technical assistance in the area of project development.	Ongoing / Continuous	When DEEP receives requests from local communities for technical assistance in the area of hazard mitigation project development, it typically refers the request to Region 1 of FEMA for response and possible assistance to the community.
3.2.2	Provide planning workshops through FEMA assistance to promote planning and enhanced planning activities that communities can utilize to develop comprehensive hazard mitigation plans.	To Be Continued	Three mitigation courses were presented through the Sandy Joint Field Office which were available to various state agency personnel with respect to floodplain management which included: BCA training, project identification and development, hazard mitigation planning. This will continue when funding is available.
3.2.3	Encourage state agencies to perform research and planning activities in the area of natural hazards mitigation for their facilities and operations.	Ongoing / Continuous	An effort continues on the state level to continually improve communication between state agencies with regards to hazard mitigation. See comments regarding IWRD partnerships with OLISP, DESPP/DEMHS, and others.
3.2.6	Develop a communication process including webpage development and reminder notifications of potential grant opportunities to encourage continued project planning tasks by state agencies and	To Be Continued	Done on an annual basis (PDM, FMA) or when grant funding becomes available (HMGP).

	communities to develop highly competitive and effective mitigation projects.		

3.2.3 Connecticut Legislative and Executive Programs and State-Level Committees and Task Forces

There are a number of high-level programs and inter-agency planning groups that are associated with natural hazard mitigation within Connecticut. While some groups have a direct role, other inter-agency planning groups are associated with natural hazard mitigation through their policies or plans in which they are charged with developing and implementing. The following is a presentation of the inter-agency planning groups associated with natural hazard mitigation in Connecticut.

Connecticut Interagency Hazard Mitigation Committee (CIHMC)

As a result of a Federal disaster declaration in July 1989, the State of Connecticut formed the Hazard Mitigation Grant Review Committee (HMGRC). The purpose and goal of the HMGRC was to oversee the new post-disaster Hazard Mitigation Grant Program (HMGP) that became law with the passage of the Stafford Act in 1988.

The HMGRC consisted of representatives of the DEP (now DEEP), NWS, Connecticut Department of Education (DOE), Connecticut Office of Emergency Management (OEM, currently DEMHS), Connecticut OPM, Natural Resources and Conservation Service (NRCS), Small Business Administration (SBA), and FEMA. The Department of Transportation (DOT) and the Connecticut Department of the Military joined the HMGRC in the late 1990s. A private group, the Hartford Financial Services Group (Hartford Group) also joined the HMGRC to give private companies representation on the Committee.

During the 1990s the HMGRC met quarterly after each disaster and met annually in non-disaster years to review hazard mitigation project applications. The HMGRC began reviewing and approving applications for the newly developed Flood Mitigation Assistance (FMA) grant program in 1998.

The HMGRC was renamed to the Connecticut Interagency Hazard Mitigation Committee (CIHMC) in 1998. The Connecticut Interagency Hazard Mitigation Committee continued the duties of discussing and overseeing mitigation-related activities and issues within the State. Due to the group's name change, the CIHMC developed a revised MOU that was signed by the top agency official of each participating state and federal agency in 2001. The five participating state agencies and divisions at this time are DEEP, DEMHS, OPM, Department of Transportation (DOT), and the Office of the State Building Inspector (OSBI). The one participating federal agency is the NRCS. In addition, one private sector representative from the Hartford Life Insurance Company sits on the Committee.

The State of Connecticut's CIHMC reviews and approves projects submitted by eligible applicants for formal submission to FEMA under the State's grant application for FEMA grants programs FMA, PDM, and HMGP. The CIHMC meets annually, but may meet more frequently if necessary, to review and approve potential FEMA grant funded projects. Although the final responsibility for selection of projects remains with the SHMO, the CIHMC advises the SHMO. It is the responsibility of the SHMO to reconvene or re-staff the committee as necessary for future grant awards.

The CIHMC ranks potential projects for submission to FEMA. Projects must have a benefit to cost ratio of one-to-one (1:1) or greater for each project application. Projects must solve the problem being addressed. HMGP, FMA, RFC, PDM and SRL funding may not be used as a substitute or a cost share for any other federally funded projects. In addition, sub-grantees may secure funding from other state and local programs to provide their required cost share for a particular project.

Proposed sub-applicant and state projects are evaluated and selected for funding based on the degree to which they address the following stated criteria put forth in the State's annual PDM and FMA grant guidance documents, such as how a project will:

- Utilize the best strategy to ensure the success of the project goal;
- Allocate sufficient staff and resources for the successful implementation of the proposed mitigation project;
- Demonstrate that the proposed mitigation activity reduces the overall risks to the general population and structures;
- Result in a long-term solution to a flooding problem with minimal maintenance required;
- Provide a benefit to the general population of an area (ex. culvert upgrade, storm damage system upgrade, public education);
- Protect critical facilities;
- Leverage Federal/State/tribal/local/private partnerships to enhance the outcome of the proposed activity;
- Promote measures that prevent future construction or development in hazard-prone areas;
- Promote stormwater management practices according to CGS Section 25-68h;
- Are located in a community listed on the Public Investment Community Index with a PIC rank of 1-42 (OPM website);
- Have a multi-objective mitigation purpose;
- Are consistent with the State Natural Hazard Mitigation Plan; and
- Are consistent with Local or Regional Hazard Mitigation Plans.

Proposed projects are given a score base on several factors such as the ones stated above. Specific evaluation criteria may be modified for a particular grant year in response to FEMA stated requirements as set forth in FEMA grant guidance document for a particular grant and fiscal year, or based upon state mitigation grant priorities for any given year.

Connecticut GIS State Coordination (OPM)

OPM is the lead agency for GIS coordination within the state and with other states; it is the successor to the CT GIS Council. OPM is responsible for coordinating, within available appropriations, a GIS capacity for the state, regional planning agencies, municipalities, and others as needed. OPM guides and assists state and local officials involved in transportation, economic development, land use planning, environmental, cultural, and natural resource management, public service delivery, and other areas as necessary.

Since natural hazard mitigation is intrinsically linked to location and geography, the following are highlights of the past GIS Council efforts and are anticipated to continue under the direction of OPM:

Critical Infrastructure and Key Resources (CI/KR) Subcommittee

The purpose of this subcommittee is to be knowledgeable of all available CI/KR GIS data that exists at the federal, state, and local level within the state; and to develop data inventories and data development and maintenance protocols and procedures. Beginning in 2012 and through 2013, the CI/KR Subcommittee is working on a draft CI/KR Data Standards and Guidelines.

Critical infrastructure includes those assets, systems, networks, and functions – physical or virtual – that are vital to Connecticut, the region, and the country so that their incapacitation or destruction would have a debilitating impact on security, economic security, public health or safety, or any combination. Key resources are publicly or privately controlled resources essential to minimal operation of the government and economy.

The federal government has organized CI/KR into 16 sectors that together provide essential functions and services that support various aspects of State and local government, private entities, and the general public. For purposes of identifying and organizing Connecticut's CI/KR GIS data, the subcommittee has adopted the U.S. DHS data classification and taxonomy. The following are the 16 sectors which GIS data will be collected and organized:

- Food and Agriculture
- Financial Services
- Chemical
- Commercial Facilities
- Communications
- Critical Manufacturing
- Dams
- Defense Industrial Base
- Emergency Services
- Energy
- Government Facilities
- Healthcare and Public Health
- Information Technology
- Nuclear Reactors, Materials and Waste
- Transportation Systems

- Water Systems and Wastewater Pollution Control Facility (WPCF) Systems

It should be noted that within DEMHS is a Critical Infrastructure Unit that assesses, evaluates, and inventories CI/KR information, but not in a GIS-based database. This Unit acknowledges DHS's definitions and criteria for what constitutes CI/KR.

Recently, for purposes of establishing a "mircogrid" grant and loan pilot program, Public Act 12-148 defined "critical facility" as, "any hospital, police station, fire station, water treatment plant, water pollution control facilities (WPCFs), public shelter or correctional facility, any commercial area of a municipality, a municipal center, as identified by the chief elected official of any municipality, or any other facility or area identified by the Department of Energy and Environmental Protection as critical…." For purposes of this plan, for developing mitigation strategies and other statewide programs/projects going forward, the more inclusive definitions and understandings of what constitutes CI/KR will take precedence over the above definition.

Storm Response and Recovery Assessment Group

The GIS Council on November 17, 2011, established a Storm Response and Recovery Assessment Group ("Assessment Group"). The Assessment Group's purpose was to focus on various aspects of how GIS was used for during both Tropical Storm Irene and the October 2011 Winter Storm Alfred (pre-storm, storm, and post-storm) response and recovery efforts at the local, regional, utility, state, and federal levels. The Assessment Group's effort ran parallel to and in some cases went deeper into the findings of what the Governor's Two Storm Panel had identified.

During both storms' response and recovery efforts, the use of GIS served as an important decision making tool for those who used it. While there was and is general understanding of GIS and its benefit to emergency management, in the aftermath of both major natural events, anecdotal evidence began to surface about missed opportunities to utilize GIS in an effective and efficient way. In particular, issues surrounding data sharing and coordination between municipalities and utility companies, as well as other GIS issues, became topics on the CT GIS List Serv. The Assessment Group created and sent out a questionnaire to the Connecticut GIS community to solicit more detailed information about what are barriers to success and recommendations for improvement.

In March 2012, the Assessment Group presented and the GIS Council approved the Findings Report.[234] Within the Findings Report are specific recommendations that relate to natural hazard mitigation planning and response.

The Adaptation Subcommittee of the Governor's Steering Committee on Climate Change (GSC)

[234] http://ct.gov/gis/cwp/view.asp?a=2858&q=501796

Since natural hazards such as extreme storm events and flooding are expected to increase in frequency and magnitude with climate change, adaptation planning will be important to mitigate the effects of these hazards. The Adaptation Subcommittee of the Governor's Steering Committee on Climate Change (GSC) is charged with the assessment of the impacts of climate change on Connecticut infrastructure, natural resources and ecological habitats, public health, and agriculture; and recommendation of adaptation strategies in accordance with the requirements of Public Act 08-98.

The Adaptation Subcommittee prepared the report "The Impacts of Climate Change on Connecticut Agriculture, Infrastructure, Natural Resources and Public Health" in 2010 as required by the Act. The report was organized into the four categories defined by the Act: Agriculture, Infrastructure, Natural Resources, and Ecological Habitats and Public Health

Most of the agricultural features were found to be highly impacted by climate change, and most of these impacts were negative. The top five most imperiled agricultural planning areas or features in Connecticut were maple syrup, dairy, warm weather produce, shellfish and apple and pear production. There were opportunities for production expansion, including biofuel crops and witch hazel and grapes, with the future climate, as well as benefits identified for all agricultural planning areas.

The infrastructure planning areas to be the most impacted by climate change were coastal flood control and protection, dams and levees, stormwater, transportation and facilities and buildings. Infrastructure planning areas were most affected by changes in precipitation and sea level rise, which could cause substantial structural and economic damage.

The ecological habitats at the highest risk from climate change may be Cold Water Streams, Tidal Marsh, Open Water Marine, Beaches and Dunes, Freshwater Wetlands, Offshore Islands, Major Rivers, and Forested Swamps. These habitat types are broadly distributed from Long Island Sound and the coast to the upland watersheds and forests across Connecticut. The degree of impact will vary but, likely changes include conversion of rare habitat types (e.g., cold water to warm water streams, tidal marsh and offshore islands to submerged lands), loss and/or replacement of critical species dependent on select habitats, and the increased susceptibility of habitats to other on-going threats (e.g., fragmentation, degradation and loss due to irresponsible land use management, establishment of invasive species).

Relative to public health, climate change will have the most impact on public health infrastructure, environmental justice communities, air quality and extreme heat ailments and vector-borne diseases. Climate change will impact public health infrastructure including hospitals, health departments, emergency medical services, private practices and shelters, due to direct impacts from extreme weather events, and increased use of resources to treat and shelter victims.

With the conclusion of the climate change impacts assessment phase, the Adaptation Subcommittee next developed recommended adaptation strategies for the most impacted features of Connecticut agriculture, infrastructure, natural resources and public health. The subcommittee's second report, "Connecticut Climate Change Preparedness Plan" (2011) is a response to the legislative requirement that the Adaptation Subcommittee identify strategies for adapting to the impacts of a changing climate in Connecticut. In this report there are a number of strategies for addressing impacts to agriculture, infrastructure, natural resources, and public health.

More information on the Adaptation Subcommittee, including copies of the above reports is posted DEEP website.[235]

Two Storm Panel

Governor Daniel P. Malloy announced the formation of The State Team Organized for the Review of Management ("STORM") of Tropical Storm Irene on September 13, 2011. The eight member Panel was charged with the following mission, "a broad, objective evaluation reviewing how Irene was handled in the state both in preparation and recovery, identify areas that can be improved upon and, most importantly, make recommendations for future disaster preparedness and response." Following the October snow storm Alfred, the Governor expanded the work of the Panel, renamed it "The Two Storm Panel," and directed it to report its findings to him by the first week of January, 2012.

The Two Storm Panel first reviewed the State Emergency Framework as well as several representative municipal emergency plans in order to benchmark state and local emergency planning. In addition, the Panel conducted eight days of hearings with over 100 witnesses providing written and/or oral testimony to the Panel. Panel hearings were also carried on CT-N so that they could be viewed by the public. In addition to the public hearings, many members of the public provided written comments to the Panel that were also considered in the preparation of the panel's report.

PURA docket 11-09-09 is the Report of the Two Storm Panel. The report acknowledged that "Tropical Storm Irene and the 'October Nor'easter' (Winter Storm Alfred) had tested Connecticut's emergency resources in ways that they had not been tested in more than 25 years. In that intervening 25 years, Connecticut's infrastructure had increased significantly, while the manpower associated with the maintenance and repair of that infrastructure had decreased significantly."

The Report of the Two Storm Panel included 82 individual recommendations that have been shaping legislative initiatives and inter-agency policies since 2012, helping to increase capabilities in Connecticut. Some of these policies have already helped, as noted during Hurricane Sandy in October 2012. Although not all of the 82 recommendations can be listed here, those listed in the Executive Summary include:

- The need to develop reasonable performance standards for utility recovery and restoration after storms, and link recoverable costs to these standards;

[235] www.ct.gov/deep/climatechange

- Revisions to State engineering standards to accommodate predicted increases in storm surge along coastal areas;
- The need for improved worst-case planning and staffing by the State's utilities;
- Connecticut's infrastructure needs to be better hardened to withstand natural disasters, and such work should begin as quickly as possible;
- The use of microgrids and other emerging technologies should be considered as potential methods for mitigation of impacts to infrastructure;
- Increased collaboration between municipalities, State resources, and electric utilities and telecommunications service providers with respect to tree trimming;
- Increased communication and planning between municipalities and utilities before a storm or disaster is imminent;
- Increased communication between labor and management in all utilities is strongly recommended;
- Additional emergency response training and exercises for municipalities, utilities and the State;
- A review of sheltering needs to ensure that at-risk populations can be served if sheltering is required for a significant length of time;
- The use of geographical information systems (GIS) should be better leveraged for both emergency planning and response purposes;
- The Public Utilities Regulatory Authority and the Connecticut Siting Council should be provided with additional enforcement resources;
- A Center for Research should be developed to study and make recommendations on storm hazard mitigation and power system resiliency; and
- Standards should be more clearly developed for backup power requirements and communication infrastructure hardening for wireless telecommunications.

Shoreline Preservation Task Force

In February 2012, a bipartisan task force was formed to study and make legislative recommendations on storm impacts on shoreline homeowners and businesses. The task force was charged with looking at the impact of climate change on efforts to preserve shoreline communities. The task force was asked to make recommendations for legislation to:

- Assist those rebuilding and recovering from the 2011 storms (primarily Tropical Storm Irene, but including October storm Alfred);
- Develop new policies to address the needs of shoreline and waterfront residents and businesses regarding shoreline erosion, rising sea levels, and future storm planning; and
- Ensure that these policies complement existing laws regarding emergency communications between towns and the state, utility company preparedness, response and accountability, and insurance issues.

The task force held public hearings on July 9, 2012 in Branford; July 23, 2012 in Fairfield; and August 6, 2012 in Groton. The task force issued a wide range of recommendations regarding the DEEP regulatory programs, coastal structures, municipalities and land use, insurance and real estate, climate change and sea level rise, and education, among other things. It is expected that some of these recommendations will be addressed in the coming years, helping to build capabilities at the state and municipal levels to increase hazard mitigation. Public Act 12-101 in 2012 (described in Section 3.2.1.3) was influenced by the Shoreline Preservation Task Force findings.

It is important to note that the Shoreline Preservation Task Force completed the majority of its work prior to Hurricane Sandy. The occurrence of storm Sandy only underscored the importance of the work, but recovery efforts (described below in Section 3.2.3.7) have largely attracted more attention in the last year.

The State Vegetation Management Task Force

On April 24, 2012, the State Vegetation Management Task Force held its inaugural meeting. The Mission of the Task Force is to develop standards for road side tree care in Connecticut, vegetation management practices and schedules for utility rights of way, tree/right place standards, and standards for tree wardens, municipal tree inventories and pruning schedules. This Task Force has been formed by the Commissioner of DEEP, as called for in the report of the Governor's Two Storm Panel. The goal is to develop consensus recommendations to DEEP within the stated mission.

State-Wide Long-Term Recovery Committee

Established as part of Governor Malloy's Emergency Planning and Preparedness Initiative from 2012, the State of Connecticut identified the Department of Economic and Community Development (DECD) and Department of Insurance (DOI) to serve as co-chairs of the State's Long-term Recovery Committee. The purpose of the committee is to provide support for local and tribal governments, non-governmental organizations and the private sector, which will enable them to recover from significant incidents. This is accomplished by facilitating problem solving, improving access to resources and fostering coordination among State and Federal agencies and other stakeholders.

As part of this effort, the Long Term Recovery Committee is establishing working groups or Recovery Support Functions (RSFs) to address specific needs, which is consistent with those established at the federal level under the National Disaster Recovery Framework (NDRF). The NDRF is a guide that defines roles and responsibilities; promotes establishment of post-disaster organizations to manage recovery; promotes a deliberate, transparent process that provides well-coordinated support to the Community; and offers strong, focused recovery leadership at the State and Tribal level, supported by strong Federal recovery leadership.

Members of the RSF's consist of public, private, and non-profit organizations that work together to address the unmet needs of a community. The RSF's that have currently been established include:

- Individual Assistance, which includes a housing taskforce and volunteer organizations active in disasters;

- Natural and Cultural Resources (discussed above in Section 3.2.2.2 under the discussion related to OLISP capabilities);
- Economics; and
- Community Planning and Capacity Building.

The RSFs are designed to take advantage of private and public agencies' existing resources and fully integrate community planning, public works, economic development, housing, health and social services expertise and resources of other organizations. Through the RSFs, relevant stakeholders and experts are brought together during the pre-disaster planning stage and when activated post-disaster, and are used to identify and resolve recovery challenges that are not being met at the local level. Together, these RSFs help facilitate local stakeholder participation and promote intergovernmental and public-private partnerships, which ultimately support recovery and resiliency.

It is notable that the NDRF is being launched on a state level in Connecticut through the RSFs for the first time ever in the United States. Connecticut is the first state to ever partake in this type of effort.

Connecticut Interagency Debris Management Task Force

In the event of a declared state of Civil Preparedness Emergency, the Governor will authorize the Interagency Debris Management Task Force (IDMTF). Members of the task force will participate in all preparedness activities, serve as operational representatives when debris management and monitoring activities are undertaken, and assign work for the State Debris Management and Monitoring Contractors by developing task orders. The core membership of the IDMTF includes: Department of Emergency Services and Public Protection (Division of Emergency Management and Homeland Security), Department of Energy and Environmental Protection, Department of Administrative Services, Department of Transportation, and the state debris contractors. Connecticut National Guard, Northeast Utilities, and United Illuminating will provide continuing participation throughout the event. Other agencies and organizations that may be requested to participate on the task force as needed.[236]

Connecticut Green Bank

The Connecticut Green Bank is the nation's first green bank. Established by the Connecticut General Assembly on July 1, 2011 as a part of Public Act 11-80, Connecticut Green Bank supports the Governor's and Legislature's energy strategy to achieve cleaner, less expensive, and more reliable sources of energy while creating jobs and supporting local economic development. The Connecticut Green Bank evolved from the Connecticut Clean Energy Fund (CCEF) and the Clean Energy Finance and Investment Authority (CEFIA), which was given a broader mandate in 2011 to become the Connecticut Green Bank. The powers of the Connecticut Green Bank are vested in and exercised by the Board of

[236]http://www.ct.gov/deep/lib/deep/waste_management_and_disposal/debris_management/conceptofoperationsplanfordisasterdebrismanagement.pdf

Directors, which is governed through Section 16-245(n) of the Connecticut General Statutes.[237]

The Connecticut Green Bank works with private-sector investors to create low-cost, long-term sustainable financing in the residential (single and multifamily), commercial, industrial, institutional and infrastructure sectors. Since its inception, the Connecticut Green Bank and its private investment partners have deployed over a $1 billion in capital for clean energy projects across the state. Projects recorded through fiscal year 2016 show that for every $1 of public funds committed by the Green Bank that an additional $6 in private investment occurred in the economy.

State Agencies Fostering Resilience

State Agencies Fostering Resilience (SAFR) was created by Executive Order No. 50, signed by Governor Dannel P. Malloy on October 26, 2015. SAFR is a permanent working group committed to strengthening the state's resiliency to extreme weather events including hurricanes, flooding, extreme heat, and slow onset events such as sea-level rise. The SAFR Council is comprised of 12 members, appointed by the Governor, including agency heads and experts. The SAFR Council is charged with authoring a Statewide Resilience Roadmap using climate impact research and assisting Connecticut's Office of Policy and Management in creating state policies that incorporate forward looking risk analysis. They also assist municipalities in incorporating climate analysis into their coastal resilience plans.[238]

3.2.4 Interstate Programs

There are a number of interstate groups and compacts that are associated with natural hazard mitigation within Connecticut.

National Disaster Resilience Program

The U.S. Department of Housing and Urban Development (HUD) and the Rockefeller Foundation funded a $1 billion design competition, the National Disaster Resilience Competition (NDRC). Through NDRC, HUD provided funding for resilient housing and infrastructure projects to states and communities that were impacted by major disasters between 2011 and 2013. Connecticut was one of 13 winners, receiving $54,277,359 to support a pilot program in Bridgeport that is part of the broader Connecticut Connections Coastal Resilience Plan. The Coastal Resilience Plan is focused on reconnecting and protecting economically-isolated coastal neighborhoods through investments in mixed green and gray infrastructure that protect against flooding while strengthening their connectivity to existing transportation nodes.

United States Climate Alliance

[237] http://www.ctgreenbank.com/

[238] http://portal.ct.gov/office-of-the-governor/press-room/press-releases/2015/10-2015/gov-malloy-permanently-establishes-state-council-on-storm-resiliency

In response to the U.S. federal government's decision to withdraw the United States from the Paris Agreement on climate change, the United States Climate Alliance was created on June 1st, 2017, with Connecticut joining on June 2nd. This bi-partisan coalition of states is committed to the goal of reducing greenhouse gas emissions consistent with the goals of the Paris Agreement: a 26-28% reduction in greenhouse gas emissions below 2005 levels by 2025. They published the first U.S. Climate Alliance Annual Report in 2017, which takes stock of the progress being making towards achieving this objective and discusses future initiatives that will help meet or exceed their goals.[239]

Land Use Law Center at Pace University

The Center provides research, training, technical assistance, support, and strategic planning services to communities and individuals. Working with trained law students, the Center quickly, affordably, and effectively develops techniques to remedy nearly all types of land use problems that afflict urban, suburban, and rural communities. Some topics they cover include smart growth, urban revitalization, climate change mitigation, local wind and solar energy, and community resiliency. For example, in 2015 the Land Use Law Center worked with the Town of Derby, CT to improve public engagement during the creation of a plan for conservation and development.[240]

New England Resilience and Transition Network

The New England Resilience & Transition (NERT) Network is a network connecting grassroots groups working on community resilience, Transition, new economy, economic and environmental justice initiatives, permaculture, renewable local energy, local food, time banking, and sustainability projects to foster an equitable, inclusive, and thriving world for all.[241]

Thames River and Connecticut River Flood Control Compacts

There are two active interstate flood control commissions; the Thames River Valley Flood Control Compact (1957 TRVFCC), and the Connecticut River Valley Flood Control Compact (CRVFCC 1953) (http://crvfcc.org/). These compacts were enacted to provide the authority to create detention reservoirs. The creation of each of the compacts required an act of Congress and legislative authorization from each of the signatory states. The CRVFCC is composed of three representatives each, from Connecticut, Massachusetts, New Hampshire, and Vermont, while the TRVFCC has three representatives from Connecticut and three from Massachusetts.

Representatives of the CRVFCC are chosen by their respective governors, and in Connecticut, are appointed for six-year terms. The CRVFCC requires all states to share in the cost of the office located in Massachusetts, and to share in reimbursements of property

[239] https://www.usclimatealliance.org/
[240] http://www.law.pace.edu/our-programs
[241] https://nertnetwork.org/

tax losses to the 21 communities in which the reservoirs are located. The office fees and tax reimbursements are fixed in the Compact according to proportional benefits. Because Connecticut and Massachusetts benefit most from the upstream dams, they pay more relative to the other states. Although tax reimbursement proportions are fixed, while property assessments change, correspondingly yearly payments change.

The costs of building the 16 dams and 16 local protection projects works along the Connecticut River and its tributaries have been principally borne by the Federal government.

Similar to the CRVFCC, the TRVFCC assesses each state for the tax losses associated with the flood control benefits provided by upstream communities. DEEP pays for the two flood control commission assessments on behalf of the state through a dedicated budget line item.

Figure 3-1 and Figure 3-2 show the land areas associated with both of these flood control compacts.

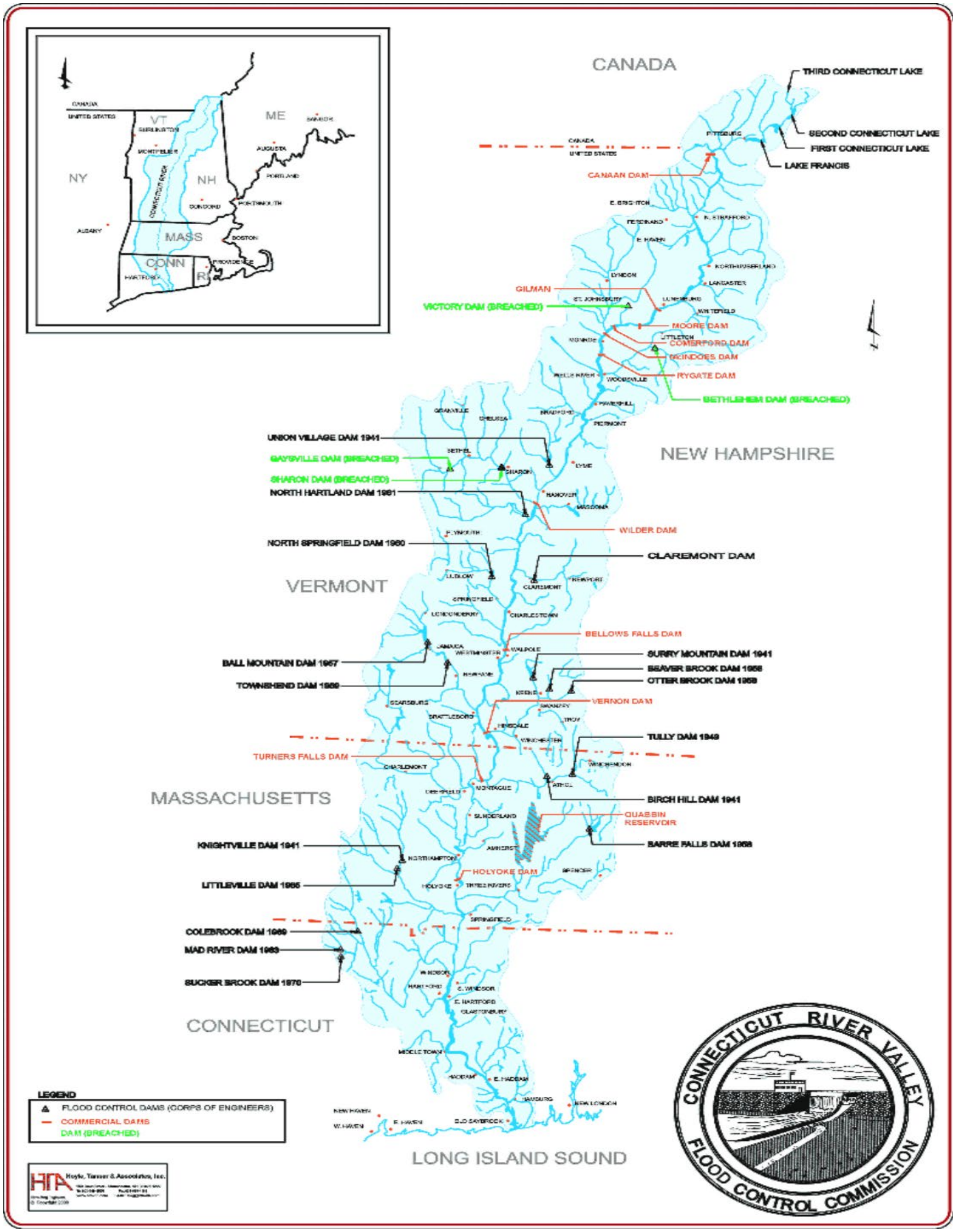


Figure 3-1: Map of Connecticut River Flood Control Facilities

Source CRVFCC website: www.crvfcc.org/damprojects.htm

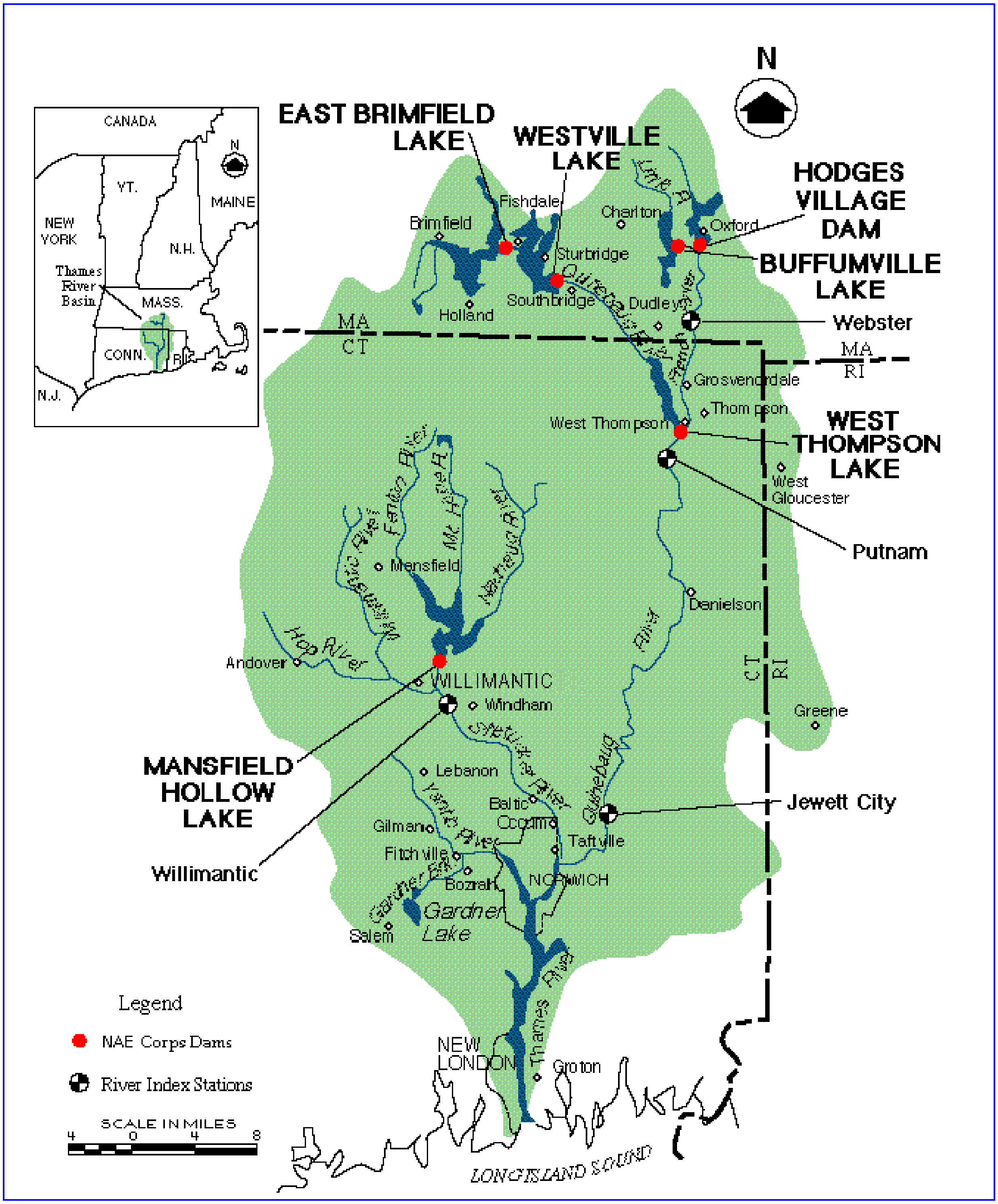


Figure 3-2: Map of Thames River Basin[242]

[242] Source: CT DEMHS.

The National Weather Service and the State Severe Weather Warning System

NWS offices in Albany, NY, Upton, NY (on Long Island), and Taunton, MA share Forecast and warning operations for Connecticut (see Figure 3-3 for NWS Connecticut county responsibility). Connecticut's eight counties are sub-divided into 13 weather forecast zones to account for topography and climate variation across the State. See Figure 3-4 for a depiction of Connecticut forecast zones.

Each NWS office maintains sophisticated computer forecasting technology and Doppler radar for continuous weather and radar surveillance of Connecticut. NWS offices collaborate on forecast and warning services for Connecticut. Furthermore, each NWS office enlists the aid of volunteer severe weather observers through Skywarn training across the State.

Four NOAA Weather Radio All Hazards (NWRAH) transmitters are located in Connecticut. These transmitters are located in Cornwall, Meriden, Hartford, and New London. The Cornwall transmitter serves Litchfield County and is controlled by the NWS office in Albany, New York. In addition, NWRAH transmitters in neighboring states provide forecast and warning information for adjacent Connecticut municipalities. Computer-generated depictions of NWRAH coverage in Connecticut are provided in Figure 3-5. NWRAH is the official voice of the NWS and delivers weather forecasts, watches and warnings 24 hours per day, and as requested by emergency management officials other hazardous awareness information such as Civil Emergency Messages. Advisories, watches and warnings are defined in Table 3-5.

As a direct result of the 1989 western Connecticut tornado outbreak, the State purchased 300 advanced technology Specific Area Message Encoder (SAME) radios in 1992 and 1994. These SAME radios allow the NWS to issue watches and warnings to specific counties in Connecticut when severe weather threatens the State. In 2006 the U.S. Department of Homeland Security purchased 92,000 NWRAHs and provided one to every public school in the United States. In 2007-2008 the U.S. Department of Homeland Security purchased additional NWRAH's for all private schools in the United States.

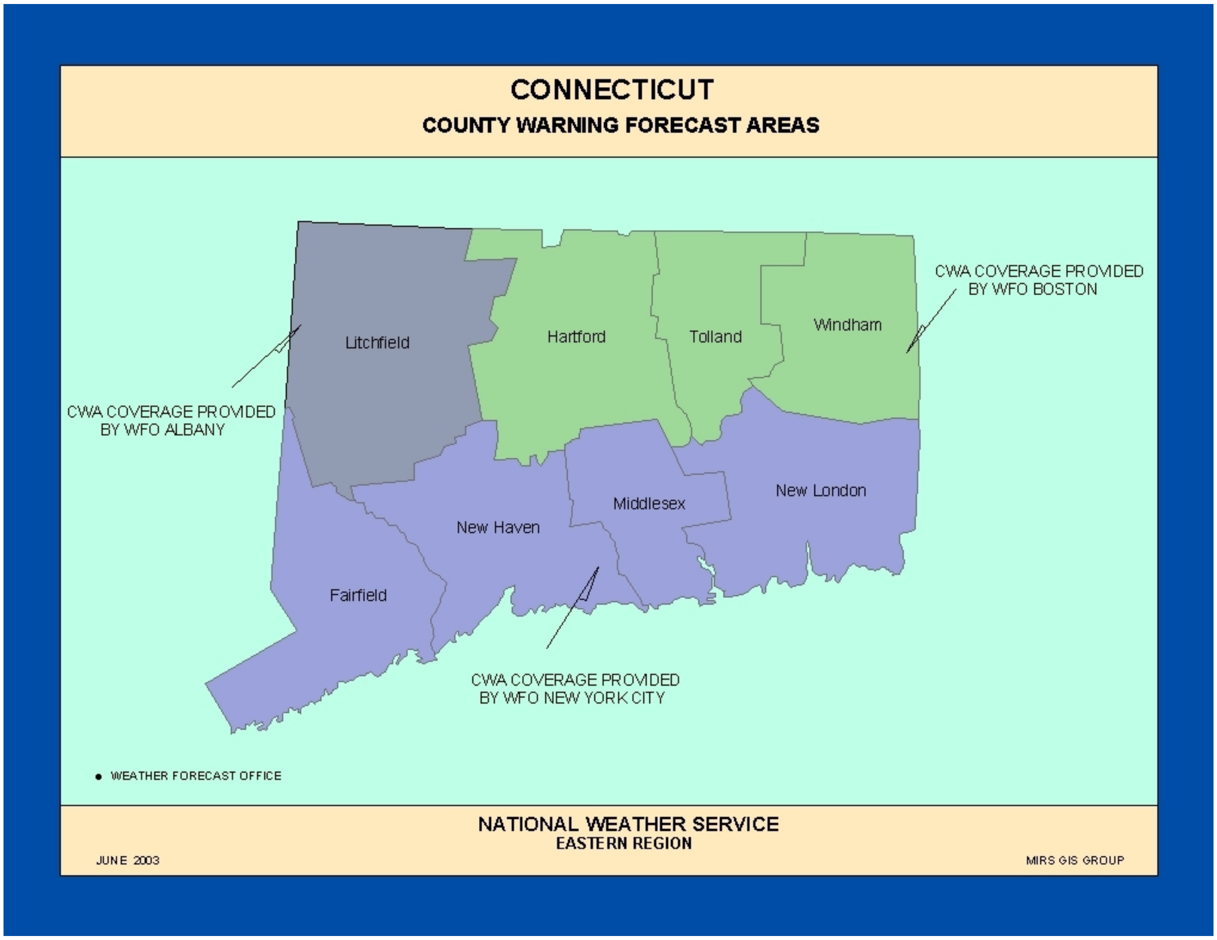


Figure 3-3: Map of NWS County Warning Forecast Areas in Connecticut.

(Note: "WFO Boston" is actually "WFO Taunton, and "WFO New York City" is actually "WFO Upton".)

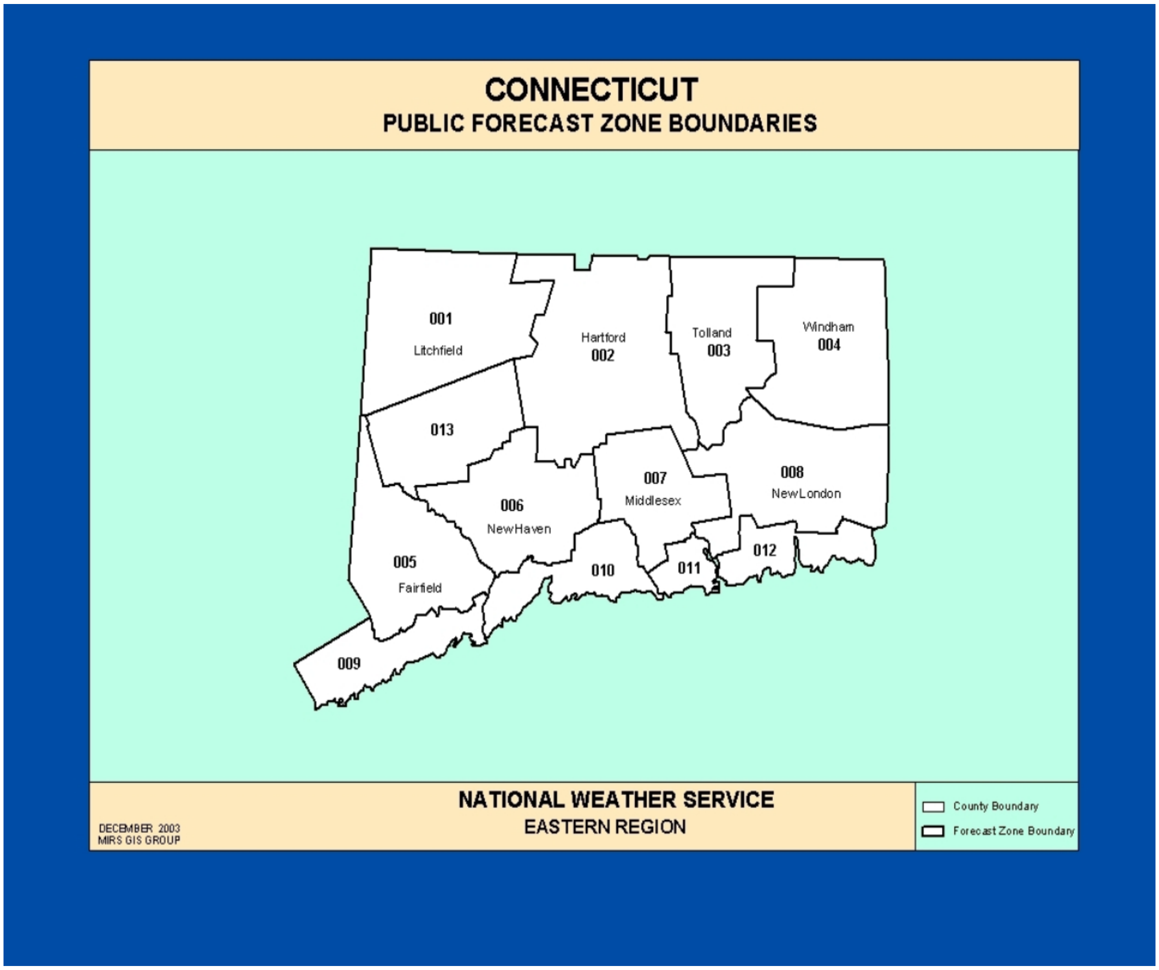


Figure 3-4: Depiction of Connecticut Forecast Zones

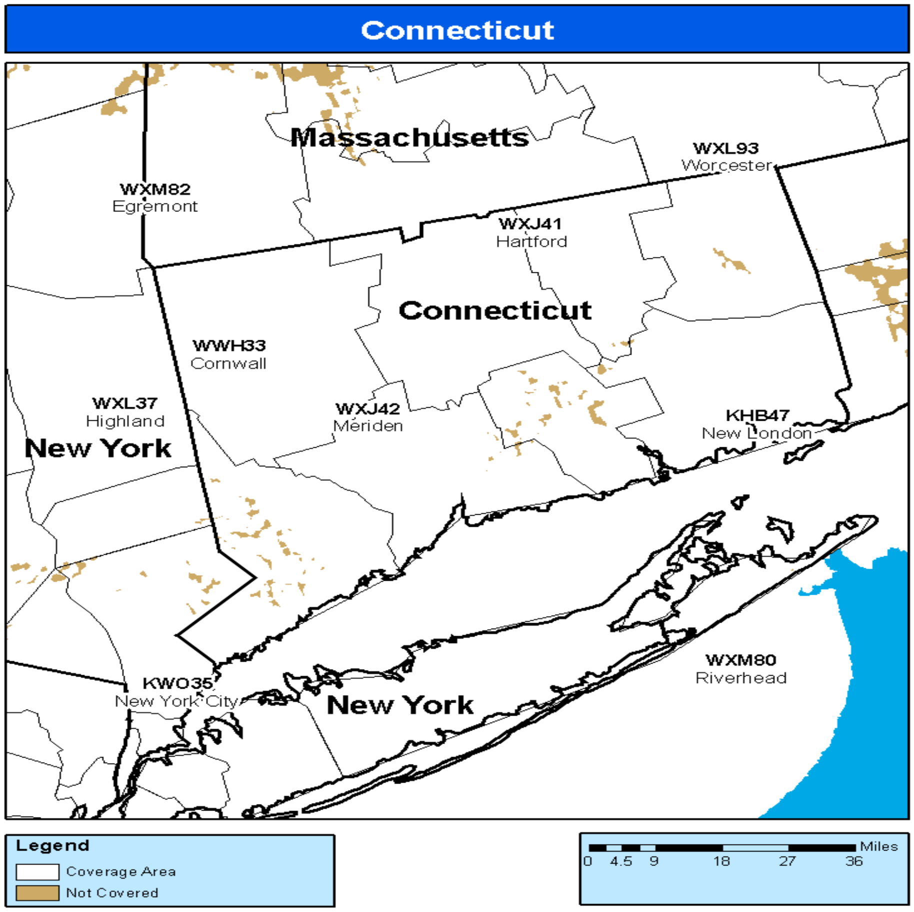


Figure 3-5: Depiction of NWRAH Coverage in Connecticut

Table 3-5: Reference Sheet for Warning/Advisory Thresholds (Last Updated March 7, 2017)

TYPE OF ISSUANCE	WHEN ISSUED FOR CONNECTICUT
WINTER WEATHER ADVISORY	When any of the following is expected within the next 12 to 24 hours: More than one predominant hazard Winter weather event having more than one predominant hazard (ie., snow and ice, snow and sleet, or snow, ice & sleet) meeting or exceeding advisory criteria for at least one of the precipitation elements, but remaining below warning criteria. Snow, Ocean Effect Snow, or Sleet •3 inches averaged over a CT, MA, RI forecast zone in 12 hours Snow and Blowing Snow · Sustained or frequent gusts of 25 to 34 mph accompanied by falling and blowing snow occasionally reducing visibility to < 1/4 mi for > 3 hours Blowing Snow · Widespread or localized blowing snow reducing visibility to < ¼ mi with winds < 35 mph Black Ice · A Special Weather Statement will usually be issued when sufficient moisture is expected to cause a thin layer of ice on road surfaces, typically on cloudless nights ("black ice"). At forecaster discretion a formal Winter Weather Advisory may be issued instead.
FREEZING RAIN ADVISORY	Any accretion of freezing rain or freezing drizzle on road surfaces
WIND CHILL ADVISORY	Wind chill index between -15°F and -24°F for at least 3 hours using only the sustained wind.
WINTER STORM WARNING	When any of the following is expected within the next 12 to 36 hours: More than one predominant hazard · Winter weather event having more than one predominant hazard, i.e. heavy snow and blowing snow (below blizzard conditions), snow and ice, snow and sleet, sleet and ice, or snow, sleet and ice} meeting or exceeding warning criteria for at least one of the precipitation elements. Snow, Ocean Effect Snow, or Sleet 6 inches averaged over a forecast zone in a 12 hour period 8 inches averaged over a CT, MA, RI forecast zone in a 24 hour period
BLIZZARD WARNING	Sustained winds or frequent gusts > 35 mph AND considerable falling and/or blowing snow frequently reducing visibility < ¼ for > 3 hours Blizzard conditions need to be the predominant condition over a 3 hour period
ICE STORM WARNING	½ inch or greater accretion of freezing rain in any zone
WIND CHILL WARNING	Wind chill index < -25°F for at least 3 hours using only sustained wind
WIND ADVISORY	Sustained winds 31-39 mph (27-34 kts) for at least 1 hour; OR any gusts to 46-57 mph (40-49 kts)
HIGH WIND WARNING	Sustained winds 40-73 mph (≥35 kts) for at least 1 hour; OR any gusts ≥ 58 mph (≥50 kts)

SMALL CRAFT ADVISORY	Over the coastal waters…sustained winds 25-33 kts AND/OR Seas ≥ 5 feet within 24 hours
GALE WARNING	Over the coastal waters…sustained winds 34-47 kts within 24 hrs from a non-tropical system
STORM WARNING	Over the coastal waters…sustained winds 48-63 kts within 24 hours from a non-tropical system
HURRICANE FORCE WIND WARNING	Sustained winds or frequent gusts ≥ 64 kts (> 2 hrs) within 24 hours from a non-tropical system
TROPICAL STORM WARNING	Sustained winds 39-73 mph (34-63 kts) (no gust criteria) associated with a tropical storm expected to affect a specified coastal zone within 24 hours
TROPICAL STORM WIND WARNING (INLAND)	Sustained winds 39-73 mph (34-63 kts) (no gust criteria) associated with a tropical storm affecting areas beyond coastal zone (inland) within 24 hours
HURRICANE WARNING	Sustained winds ≥ 74 mph (64 kts) (no gust criteria) associated with a hurricane expected to affect a specified coastal area within 24 hours
HURRICANE WIND WARNING (INLAND)	Sustained winds ≥ 74 mph (no gust criteria) associated with a hurricane affecting areas beyond coastal zone (inland) within 24 hours
SPECIAL MARINE WARNING	Brief/sudden occurrence of sustained wind or frequent gusts ≥ 34 knots, usually associated with thunderstorms; AND/OR hail ≥3/4" in diameter; also issued for waterspouts
SEVERE THUNDERSTORM WARNING	Thunderstorms with wind gusts ≥ 58 mph (50 kts) AND/OR hail ≥1" in diameter
TORNADO WARNING	Likelihood of a tornado within the given area based on radar or actual sighting; usually accompanied by conditions indicated above for "Severe Thunderstorm Warning"
FLOOD ADVISORY	Expected inundation of some low lying and poor drainage areas, resulting in a nuisance to the public but not a threat to life and property.
FLASH FLOOD WARNING	Rapid and extreme flow of high water into a normally dry area, or a rapid water level rise in a stream or creek above a predetermined flood level, beginning within a short timeframe from the onset of heavy rain. A dam or levee failure, or water released from an ice jam is also considered
FLOOD WARNING	Expected overflow or inundation by water which causes or will cause damage and/or a threat to life
RIVER FLOOD WARNING	Water level at a River Forecast point along a main stem or larger tributary river (such as the Connecticut, Shetucket or Yantic) is expected to reach or exceed flood stage
COASTAL FLOOD ADVISORY	Minor coastal flooding expected within 12 hours. Examples include: splash over causing a few roads briefly impassable, standing water in parking lots, etc.
COASTAL FLOOD WARNING	Coastal flooding expected within 12 hours; widespread serious coastal flooding which damages property AND/OR is a threat to life
EXCESSIVE HEAT WARNING	Daytime heat indices of ≥ 105°F for 2 or more hours
HEAT ADVISORY	Daytime heat indices of 100ºF-104ºF for 2 or more hours

HEAT WAVE	Issued for non-criteria warning/advisory heat. A heat wave is defined as 3 or more days of > 90ºF temperatures.
DENSE FOG ADVISORY	Widespread visibility ≤1/4 mile for at least 3 hours
FREEZING FOG ADVISORY	Very light ice accumulation from predominantly freezing fog
FROST ADVISORY	Issued under clear, light wind conditions with forecast minimum shelter temperature 33-36ºF during growing season
FREEZE WARNING	When minimum shelter temperature drops to < 32ºF during growing season
HIGH SURF ADVISORY	When high surf poses a danger to life in the form RIP currents or breaking seas
RED FLAG WARNING	High degree of confidence that dry fuels and weather conditions support extreme fire danger within 24 hours using the following criteria as a guide: · Winds sustained or with frequent gusts > 25 mph · Relative Humidity at or below 30% anytime during the day · Rainfall amounts for the previous 5 days less than 0.25 inches (except 3 days in pre-greenup) · Lightning after an extended dry period · Significant dry frontal passage · Dry thunderstorms · Keetch-Byram Drought Index values of 300 or greater (summer only)

This table contains National Weather Service criteria for issuing Advisories and Warnings for various weather events. Watches generally are issued with longer lead times in expectation of meeting Warning criteria.

3.3 Regional Planning Organizations

Regional planning organizations (RPOs) in Connecticut include the Councils of Governments (COGs). RPOs have traditionally conducted or overseen transportation planning, emergency planning, and some types of land use and environmental planning for their member communities. The RPOs may provide land use guidance to municipalities and assist with drafting of ordinances or zoning regulations in the more rural communities of the state.

Several of the RPOs in Connecticut have been responsible for development of multi-jurisdiction hazard mitigation plans or single-jurisdiction hazard mitigation plans for member communities. The RPOs have administered the planning grants to develop these plans, then either developed the plans using in-house planning staff or contracted a consultant to develop the plans.

Legislation passed in June 2013 made a number of changes to RPOs, including eliminating regional planning agencies and regional councils of elected officials after January 1, 2015, leaving regional COGs as the only type of RPO. The number and configuration of RPOs in Connecticut changed as funding sources were altered. As of 2019, there are nine RPOs.

The Regional Performance Incentive (RPI) Program, administered by the Connecticut Office of Policy and Management, was established under the provisions of Section 8 of

Public Act 07-239, "An Act Concerning Responsible Growth". The goal of the RPI Program is to encourage municipalities to participate in voluntary inter-municipal or regional shared services projects that have the potential to produce measurable "economies of scale", provide desired or required public services, and lower the costs and tax burdens associated with the provision of such services. Eligible applicants include any regional council of governments (COG), any two or more municipalities acting through a COG, any Economic Development District, or any combination thereof.[243]

CT Council of Small Towns (COST) is a member-driven organization committed to giving Connecticut's 139 smaller communities a strong voice in the legislative process. Founded in 1975, COST is the state's only organization dedicated exclusively to the interests of Connecticut's smaller towns. COST marshals the collective talent, experience and vision of municipal leaders to help shape public policies in ways that help Connecticut's smaller communities provide critical services to residents.[244]

CT Conference of Municipalities (CCM) was founded in 1966, and is the state's largest nonpartisan organization of municipal leaders, representing 165 member municipalities. Their mission is to improve everyday life for every resident of Connecticut through sharing best practices and objective research, and advocating at the state level for issues affecting local taxpayers. CCM is governed by a board of directors that is elected by the member municipalities.[245]

3.4 Municipal Programs

All municipalities within Connecticut have developed and implemented, locally or on a regional level, several sets of plans and regulations that are used to effectively manage natural resources on a community level. These plans and regulations are updated on a regular basis either due to a statutory requirement or through normal practices at the local level. Since all these mechanisms exist and are available to all municipalities, largely through the State's enabling legislation, the State understands that local communities maintain adequate capability for pursuing and implementing hazard mitigation activities.

Table 3-6 lists many of the plans, regulations, and ordinances that communities have developed and continue to maintain, and the connection of these plans and regulations to hazard mitigation. Additional details are provided after the table.

Table 3-6. Local Plans and Regulations Used by Communities

[243] http://www.ct.gov/opm/lib/opm/igp/grants/rpi/2017_annual_report_on_the_regional_performance_incentive_program.pdf
[244] http://www.ctcost.org/Pages/index
[245] http://www.ccm-ct.org/

Plan or Regulations	Significance to Hazard Mitigation
Emergency Operations Plans	Assist local communities in the preparation and implementation of resources prior to and during an emergency, including natural hazard events. The plans are updated as needed and help local communities assess the locations of vulnerable areas within their communities and how to handle these areas during an emergency. This plan may be a good source of information for local risk assessment activities. A new template was issued by DEMHS in 2016, and most communities are working toward a revision toward the new template.
Floodplain Management Regulations/ Ordinance or Flood Damage Prevention Regulations/Ordinance	These regulations assist a community in effectively manage its floodplain areas and are typically organized similar to the NFIP regulations. These regulations are usually part of a community's land use regulations (described below). However, depending on the community, they may be a part of the municipal code of ordinances. These regulations may require specific minimum design/construction/or development elements which must be complied with for health and safety reasons.
Zoning Regulations	Primary tool for community for shaping the character and development of a community. Zoning regulations may restrict particular uses or structures from being located in vulnerable areas in a community. These regulations may also require specific minimum design/construction/or development elements which must be complied with for health and safety reasons. If the flood damage prevention regulations are not in the municipal code of ordinances, they are typically in the Zoning Regulations.
Subdivision Regulations	Important tool for community for shaping the character and development of a community through subdivisions. These regulations often describe how floodprone areas must be addressed, specify minimum and maximum roadway dimensions, specify where utilities may be placed (underground vs. above-ground), and specify how fire protection will be provided. Some elements of the flood damage prevention regulations are often repeated in the Subdivision Regulations.
Stormwater Regulations	Some communities have developed stormwater regulations or ordinances that are separate than the Zoning and Subdivision Regulations. Stormwater regulations provide requirements for addressing stormwater in connection with development, redevelopment, and road projects.
Wetland Regulations	In Connecticut, all wetland regulations describe wetlands as necessary for a number of functions including flood management. These regulations help a community maintain and protection the integrity of its wetland resources. Wetland areas often coincide with FEMA delineated floodplain areas in a community.
Local Adoption of CT State Building Code	Critical to maintain adequate safety and building integrity factors in construction. In addition, these codes may limit structure size, type or place additional requirements in the construction of structures located in a identified hazard area (i.e., high wind, coastal, floodplain, wildland/urban interface area, etc.).
Local Plan of Conservation and Development	Primary plan that helps guide a community in its land use and management decisions with regard to development and conservation and/or preservation of open space.

Plan or Regulations	Significance to Hazard Mitigation
Local Municipal Coastal Programs	Assists local coastal communities with development and management of coastal resources and preventing adverse impacts on coastal resources. As the municipal coastal programs are updated, communities typically increase the emphasis on coastal hazard mitigation and management.

3.4.1 Local Boards, Commissions, and Departments

Most Connecticut communities are governed by a Board of Selectmen, Board of Aldermen, Town Council system, or City Council system. The chief elected official (for example, mayor or First Selectman) or his town/city manager oversees many of the municipal departments, commissions, and boards and are directly responsible for appointing members of many commissions and boards that are involved with hazard mitigation.

Within each municipality, appropriate municipal departments, commissions, and boards are involved with natural hazard mitigation. The following subsections describe general departmental responsibilities and duties related to natural hazard mitigation within communities.

Emergency Management Department, Office, or Agency

The typical mission of the local Emergency Management Department or Office (under an Emergency Management Director, or EMD) is to maximize survival of people, prevent and/or minimize injuries, and preserve property and resources in its jurisdiction by making use of all available manpower, equipment, and other resources in the event of natural or technological disasters or national security threats. In addition to coordinating activities during disasters, the Emergency Management Office typically coordinates all early warning activities and is involved in educating the public on how to react during emergency situations. The EMD is typically charged with developing and updating the community's Emergency Operations Plan (EOP). The Emergency Management Department is one of the primary agencies involved with hazard mitigation through the mitigation categories of "emergency services" and "public education."

In some communities, the Fire Chief or Police Chief is the director of the Emergency Management Department, although this is not always the case. DEMHS recommends that the EMD not be a Fire Chief or Police Chief or other major public official because, during an emergency, a Fire Chief or Police Chief that is also the EMD may become overwhelmed. Some communities have an Emergency Management Agency that includes the EMD and members of other departments, and the agency meets as needed prior to hurricanes, tropical storms, snowstorms, etc.

Department of Fire/Rescue/EMS

Local communities may have either full-time or volunteer fire companies. Larger cities or towns generally have several fire houses in different areas of the city or town to assure rapid emergency response. The Fire Department is one of the primary agencies involved with hazard mitigation through the mitigation categories of "emergency services" and "public education." As noted above, the Fire Chief is the EMD in some communities, although this is not required.

Police Department

Police departments are found in most of the suburban and urban municipalities and tribes but not in all rural towns in Connecticut. Day-to-day duties of a Police Department include crime prevention, criminal investigations, traffic enforcement, motor vehicle accident investigations, and patrols. Duties related to natural hazard mitigation include planning and coordination of personnel, equipment, shelters, and other resources necessary during an emergency. Communication and coordination with the Fire Department is critical before, during, and after natural hazard emergencies. Many of the less-populated towns have resident state troopers in lieu of a municipal police department. As noted above, the Police Chief is the EMD in some communities, although this is less frequent than the Fire Chief serving as the EMD.

Public Works and Highway Departments

Most Connecticut communities have a Public Works Department or Highway Department whose responsibilities include construction and maintenance of roadways, sidewalks, and drainage systems; maintenance of all parks and school properties; street sweeping, sanding, and snow removal; the preservation, care and removal of trees within the community's rights-of-way and/or public places; and maintenance of community vehicles and equipment. Larger communities will have a public works department while smaller communities will typically have a Highway department.

As is common throughout Connecticut, the public works departments are often charged with implementing numerous structural projects that are related to hazard mitigation. Specifically, roadway/infrastructure maintenance and complaint logging/tracking are the two primary duties of the Public Works departments. For example, a public works department may track, plan, prepare for, and respond to flooding, inundation, and/or erosion of roads and infrastructure. The public works departments also conduct snow removal and deicing on roads; tree and tree limb maintenance; and the appropriate maintenance and upgrades of storm drainage systems to prevent flooding caused by rainfall.

Because of the duties described above, the public works departments are often the "de facto" first responders during emergencies. The public works departments must maintain access for the Police and Fire Departments to respond to emergencies. In some communities, a Public Works Commission manages the department and will develop budgets, make recommendations to other boards, and establish regulations.

Building Departments

Local Building Departments administer a building inspection program adhering to and enforcing all code requirements of the State of Connecticut relating to building construction. Tribal governments have building departments that utilize the international building code. Additional responsibilities include administering and enforcing all related codes for the safety, health, and welfare of persons and properties in the jurisdiction, supervising departmental policies and procedures, and providing technical assistance to local officials.

The Building Official has a unique responsibility when it comes to hazard mitigation as he or she is responsible for overseeing a number of codes such as those related to wind damage prevention as well as those related to inland and coastal flood damage prevention. Although other departments and commissions may review development plans and develop or revise regulations, many important types of pre-disaster mitigation are funneled through and enforced by the Building Department. For example, the Building Department enforces A- and V-zone standards for flood proof construction and building elevations, maintains elevation certificates, and enforces building codes that protect against wind and fire damage. Thus, the types of mitigation that are administered by the Building Department include "prevention" and "property protection."

Typically, the building department provides hazard mitigation assistance at the time of the building permit application. The primary role of the Building Department during disaster situations is to provide damage assessment, inspect damaged buildings and issue permits for temporary structures and actions necessary to maintain safety standards.

In some communities, the Building Official is the administrator of the local flood regulations under the NFIP. This person also has access to map information showing the location and extent of SFHAs in the community. This mapping is important in raising the public's awareness of natural hazards in the community.

Fire Marshal

The local Fire Marshal administers a building inspection program adhering to and enforcing all code requirements of the State of Connecticut relating to Life Safety and Fire prevention. Tribal governments have fire marshal offices that utilize the international fire code. Additional responsibilities include administering and enforcing all related codes for the safety, health, and welfare of persons and properties in the jurisdiction, supervising departmental policies and procedures, and providing technical assistance to citizens and property owners.

Typically, the fire marshal's office provides hazard mitigation assistance at the time of the building permit application and during the construction of a structure. The primary role of the fire marshal's office during disaster situations is to provide assistance with damage assessments and actions necessary to maintain safety standards.

Engineering Department

Many communities have Engineering Departments and/or a Town or City Engineer who plans, directs, and coordinates engineering contracts and construction projects, including roadway, bridge, sanitary, and marine development. The Engineer provides technical consultation to municipal boards and commissions and serves as the municipal liaison with various state agencies. As such, the Engineer will often need to review issues related to drainage, flood conveyance, and flood mitigation and related elements of structural hazard mitigation. The Engineer usually works closely with Public Works and Highway personnel. Typically, the Engineer or the Public Works / Highway Superintendent will have a list of flood prone areas in the community.

Planning and Zoning / Land Use Department

The Planning and Zoning or Land Use Department of a jurisdiction enforces the local zoning and subdivision regulations, provides staff assistance to the Planning and Zoning Commission (or separate Planning Commission and Zoning Commission), and performs long term planning activities related to land use and community development. This department typically drafts, updates and implements the goals and objectives of the local Plan of Conservation and Development. The planning office provides assistance to local Health Departments and Building and Engineering Departments.

In many communities, the local planning department includes the administrator of the local flood regulations under the NFIP, if it is not the Building Official as discussed above. This person also has access to map information showing the location and extent of SFHAs in the community. This mapping is important in raising the public's awareness of natural hazards in the community.

Because the Planning Department typically directly assists the applicable commissions with administration of the Zoning Regulations, Subdivision Regulations, and Inland Wetland Regulations, the department is responsible for elements of almost all six facets of mitigation ("prevention," "property protection," "natural resource protection," "structural projects," "emergency services," and "public education"). For example, wetlands preservation is one of the purest forms of hazard mitigation due to the natural functions and values of wetlands including stream bank and shoreline stabilization and flood water storage.

In coastal communities, the Planning and Zoning / Land Use Department typically assists the local Harbor Management Commission in administering any Waterway Protection Line Ordinances, as well as reviewing coastal site plan applications for certain development types within the coastal management area defined by the State.

Tree Wardens

Most Connecticut communities have designated an individual as Tree Warden and administer a tree-trimming program. The tree warden is typically the public works director or a staff member from the planning or engineering departments. Tree-trimming on municipally-owned property is typically conducted on an as-needed basis or following complaints by residents. Most tree-trimming is conducted with clean-up activities following storms. In general, local governments maintain small trees and downed branches and contract with tree companies to deal with larger trees.

Flood and Erosion Control Boards

CGS Sections 25-85 through 25-98, inclusive, enable municipalities to form a municipal Flood and Erosion Control Board (FECB) with the power to plan, layout, acquire, construct, reconstruct, repair, maintain, supervise and manage flood and erosion control systems, flood control projects, and dam repair projects. These boards may also enter upon, take and hold by purchase, condemnation or otherwise, property which it determines necessary for use in connection with flood or erosion control systems; defray the cost of such systems by issuing bonds or other evidence debt, or from general taxation, special assessment or any combination thereof; and assess those properties benefiting from such project according to such rules as the FECB may adopt. The FECB is further empowered to negotiate, cooperate, and enter into agreement with: 1) The United States, 2) the United States and the State of Connecticut or 3) the State of Connecticut in order to satisfy the conditions imposed by the United States or the State of Connecticut in authorizing any system for the improvement of navigation of any harbor or river and for protection of property against damage by floods or by erosion, provided such system shall have been approved by DEEP Commissioner.

These statutes listed above enable a municipality, which has recognized a particular flood or erosion hazards potential and is dedicated to reducing or eliminating the hazards, to work with, and receive assistance from, federal and state agencies. The municipality must make a financial commitment based on federal cost-sharing requirements for a federal project. For a state/local project, the cost-sharing ratio is based on the ownership of the benefited property. The State will provide two-thirds of the project cost if the property protected is municipally owned. When the project benefits private properties, the State will provide one-third and the municipality will provide two-thirds of the project costs.

Although most of the municipalities in Connecticut possess the appropriate municipal code to enable the formation of FECBs, few FECBs are actively operating in Connecticut. In some communities, the existing Inland Wetland and Watercourse Commission or Agency or Board of Selectmen may act as the FECB.

Parks and Recreation Department

The Parks and Recreation Department typically oversees community open space and parks. This responsibility includes the properties acquired by the community for hazard mitigation purposes and converted to open space.

Attorney

A community's Attorney's office plays a critical role in hazard mitigation. The office typically reviews and helps to administer grant applications and projects under the HMA programs such as HMGP and PDM.

Commissions Related to Hazard Mitigation

Many commissions are involved with hazard mitigation. These may include:

- Conservation Commissions – Charged with the development, conservation, supervision, and regulation of natural resources and water resources (hazard mitigation through the category of "natural resource protection")
- Inland Wetlands and Watercourses Commissions – Charged with implementing and enforcing all provisions of the Connecticut General Statutes as regards the Inland Wetlands and Watercourses Act (hazard mitigation through "prevention," "natural resource protection," and "structural projects")
- Planning and Zoning Commissions – Charged with establishing, implementing, and overseeing planning and zoning regulations as provided by the Connecticut General Statutes (hazard mitigation through "prevention," "property protection," "natural resource protection," "structural projects," "emergency services," and "public education")
- Public Works Commission – Charged with managing the department and developing budgets (hazard mitigation through "prevention" and "structural projects").
- Land Acquisition Commission – Charged with determining and recommending to the Board of Selectmen or Council the feasibility of acquiring land, development rights, and conservation easements and prioritizing properties for acquisition by the Community (hazard mitigation through "natural resource protection")
- Harbor Management Commission – For coastal communities, charged with the duty and purpose of developing a Harbor and Waterways Management Plan (hazard mitigation through "prevention," "property protection," "structural projects," "emergency services," and "public education")
- Marina Commission – For coastal communities, charged with the control, development, management, operation, and maintenance of the municipal marina facilities (hazard mitigation through "property protection" and "emergency services")

Local Implementation of the National Flood Insurance Program (NFIP)

The State of Connecticut reviews local flood management programs, local NFIP procedures, mitigation actions and local capabilities through the Community Assistance – State Support Services Element (CAP-SSSE) of the NFIP. Each year DEEP IWRD staff perform a number of Community Assistance Visits (CAVs). During the CAV, the community's ordinances are reviewed along with any variances, which have been granted in the floodplain. DEEP staff meet with the local floodplain coordinators and travel around local floodplain areas looking for compliance issues and checking on possible violations. DEEP staff prepare a written report on the CAV and submit it to FEMA. The report is placed in the community's NFIP file and becomes part of the participating community's compliance history.

CAVs are targeted for coastal communities once every five years due to their increased vulnerability to flooding. Inland communities normally receive a CAV once every ten years. Plans for potential future projects are also reviewed back at the DEEP to determine if they are in compliance with NFIP and State floodplain management regulations. The CAV program has uncovered violations and continues to allow the DEEP to more effectively monitor local municipal flood management regulations. Every municipality in Connecticut is a member of the NFIP and is required to submit to a CAV upon request. This has made the program very effective in assisting municipalities to monitor and prevent floodplain violations.

Summary of Land Use Controls

Every municipality within Connecticut has some form of flood zone protection authority authorized by one of several Connecticut General Statutes (C.G.S.). Section 7-148 of the CGS gives municipalities authority to pass ordinances, and many communities have done so under this authority. CGS. Section 8-2 (et. seq.) provides authority for municipal zoning including provisions to use zoning to "secure from flood." A zoning commission administers zoning and its actions in most municipalities, and is independent of a municipality's legislative body. Some communities may have both a flood ordinance and flood zoning. Municipalities also have authorities, which allow them to purchase open space (7-13lb), to conduct comprehensive planning (8-18 et. seq.), to regulate inland wetlands (22a-36 et. seq.), to establish and maintain civil preparedness plans (28-7), and to regulate construction of buildings (29-260 et. seq.). As discussed above, coastal municipalities have additional authority and responsibility under the Connecticut Coastal Management Act including ensuring that development within coastal flood hazard areas are managed to minimize risks to life and property.

Although the State has a 100% participation rate of its municipalities in the NFIP, the real measure of success cannot be determined merely by participation in the program. The minimum regulations required for admission into the NFIP must be adequately understood and enforced at the local level. The Flood Management Section's CAP has enabled DEEP to greatly expand its technical and general assistance capabilities to local officials, residents, banks, insurance agents and engineers.

Available qualitative information and ongoing communications between IWRD programs and local governments indicate that local governments' land use policies and the enforcement of these policies and local regulatory controls have been and continue to be effective with regards to the mitigation of natural hazards at the local level. Many communities have been proactive with regards to managing their local natural resources and in developing local strategies to mitigate and/or plan for post-disaster recovery. The majority of communities located within the state actively work with DEEP and DEMHS to develop and implement local hazard mitigation activities, and enhance and exercise evacuation and post-disaster plans of action

The Effectiveness of Local Hazard Mitigation Plans

Connecticut's local planning effort began in 2000. Once initially approved by FEMA, local hazard mitigation plans are required to be updated every five years. Through the year 2013, DEEP reviewed local plans and submitted them to FEMA for final review and comment. Through this review process, DEEP observed an evolution of the plans in that they are becoming more specific in nature as to the proposed hazard mitigation activities recommended for implementation on a local level.

Beginning in 2013, local plan review was transferred from DEEP to DEMHS. DEMHS evaluates effectiveness of the plans by the quality of the activities that result from the implementation of the adopted plans. Upon the submission of regular plan updates, the regulatory elements of the plan will continue to be analyzed as part of all future planning grants in those communities.

3.5 Activities of Other Entities Located in Connecticut

3.5.1 Electricity Providers

As a result of Tropical Storm Irene in August 2011 and Winter Storm Alfred in October 2011, the state understands that communities now place a higher priority level on tree trimming and maintenance to protect utilities, roads, persons in transit, and structures as compared to its priority level several years ago. Planning has been vigorous, from the publication of James Lee Witt's report "Connecticut October 2011 Snowstorm Power Restoration" (December 2011) to meetings between utility companies and Connecticut municipalities that took place in 2011 and 2012 that resulted in the "Report of the Two Storm Panel" (January 2012). The Report of the Two Storm Panel included 82 individual recommendations that have been shaping legislative initiatives and inter-agency policies since 2012, helping to increase capabilities in Connecticut. Some of these policies have already helped, as noted during Hurricane Sandy in October 2012.

Eversource

Eversource is the largest power utility company within Connecticut. Eversource has several short and long-term programs to reduce the impact of natural disasters on the general public. Eversource short-term programs include using power restoration crews to restore power after small-scale storms. Eversource also has agreements with other states and Canada to bring in additional crews of linesmen after major disasters to restore power.

Eversource maintains an annual proactive program of tree trimming across the State. Trees are identified and property owners are notified that their trees that overhang or threaten power lines will be trimmed. Tree trimming reportedly saves millions of dollars in yearly damage to the power grid.

Aside from tree trimming, Eversource maintains other policies that build capabilities statewide. During the peak summer usage months, Eversource maintains agreements with large companies to curtail power usage during peak periods to prevent the need for brownouts or rolling blackouts. Eversource also issues power watches and warnings when necessary to conserve energy. When a "power warning" is issued, Eversource asks customers to turn off all unnecessary electrical appliances, air conditioning, and lights during the peak hours of 11 a.m. to 4 p.m. This helps assure that sufficient power will be available for all.

United Illuminating

United Illuminating (UI) is the second-largest electricity provider in Connecticut. Like Eversource, UI maintains a tree trimming program to protect its electricity transmission and distribution system. UI is also currently in the process of reinforcing its substations to withstand flooding in areas where the utility has infrastructure at risk.

3.5.2 CtWARN

CtWARN is a Water/Wastewater Agency Response Network (WARN) comprised of utilities providing voluntarily assistance to one other in the form of personnel and resources during emergencies by means of pre-arranged mutual aid agreements. The mission of CtWARN is to support and promote statewide emergency preparedness, disaster response, and mutual assistance matters for public and private water and wastewater utilities. CtWARN accomplishes this mission by providing increased planning, coordination and enhanced access to specialized resources to enable rapid, short-term deployment of emergency services to restore critical operations of the affected water or wastewater utility. A total of 22 water and wastewater utilities and departments are members of CtWARN, covering more than half of Connecticut's geographic area.[246]

3.5.3 University of Connecticut

Center for Land Use Education and Research

The mission of the Center for Land Use Education and Research (CLEAR) is to provide information, education and assistance to land use decision makers, in support of balancing growth and natural resource protection. To achieve this goal, CLEAR conducts remote sensing research, develops landscape analysis tools and training, and conducts outreach education programs. CLEAR houses the following programs:

- NEMO (Nonpoint Education for Municipal Officials) provides information, education and assistance to local land use officials and other community groups on how they can accommodate growth while protecting their natural resources and community character.
- The Land Use Academy provides land use decision-makers the knowledge and skills needed to serve effectively on a land use board through a series of workshops.
- The Climate Adaptation Academy (CAA) is a partnership between Connecticut Sea Grant and UConn Center for Land Use Education and Research (CLEAR) to allow researchers, consultants, and others to work with municipalities and relevant professionals on climate adaptation.[247]
- Geospatial Training program provides hands-on training courses for land use decision-makers to introduce new users to geographic information systems (GIS), global positioning systems (GPS) and remote sensing technologies.
- Forestry program provides information and assistance to private land owners and local communities on how to better manage their forest lands.
- LERIS (Laboratory for Earth Resources Information Systems) is the main research program of CLEAR, and the principal place at the University of Connecticut for conducting remote sensing and GIS research focused on natural resources, landscape characterization and change, and the interaction of the two.

The Land Use Academy and the Climate Adaptation Academy are the primary vehicles for CLEAR's role in building capabilities in Connecticut for hazard mitigation. Most of the training sessions are geared toward local land use commissions and provide instructions on how to review land use proposals according to the regulations administered by the

[246] http://ctwarn.org/Members-List
[247] http://climate.uconn.edu/caa/

commission. Natural hazards such as flooding are routinely addressed by commissions, and the training helps commission members better understand these hazards.

These programs also provide specialized training. For example, a 2013 training session entitled "Climate Adaptation Training for Coastal Communities" provided local officials and other interested individuals in coastal communities with the latest information and skills necessary to proactively adapt to the impacts of changing climate such as coastal flooding and coastal storms. In 2017, workshops have focused on legal issues related to climate adaptation and creating living shorelines.

Connecticut Sea Grant

The Sea Grant College Program is a partnership between the nation's universities and its primary ocean agency, the National Oceanic and Atmospheric Administration (NOAA). The University of Connecticut is Connecticut's Sea Grant College. Connecticut Sea Grant (CTSG) collaborates with maritime industries and coastal communities to identify needs, and fund research, outreach, and educational activities that have special relevance to Connecticut and Long Island Sound. The mission is to work towards achieving healthy coastal and marine ecosystems and consequent public benefits by supporting integrated locally and nationally relevant research, outreach and education programs in partnership with stakeholders. Program activities are focused into the areas of marine aquaculture and biotechnology; use and conservation of marine resources, ecosystems, and habitats; coastal land use and community planning; habitat restoration and enhancement; aquatic invasive species; use and conservation of marine resources; and marine and aquatic science literacy.

The Sea Grant program helps build capabilities in Connecticut through several programs related to its area of coastal land use and community planning. For example, no-cost technical assistance was available in 2012 for communities impacted by Hurricane Sandy. In 2013, they released a report on Cost-efficient Climate Adaptation in the North Atlantic. The Sentinel Monitoring for Climate Change Program in Long Island Sound is a multi-disciplinary scientific approach to provide early warning of climate change impacts to Long Island Sound ecosystems and species to facilitate appropriate and timely management decisions and adaptation responses.[248] The Sea Grant program also coordinates with the CLEAR training described above.

Connecticut Institute for Resilience and Climate Adaptation

The Connecticut Institute for Resilience and Climate Adaptation (CIRCA) is a multi-disciplinary center of excellence that brings together experts in the natural sciences, engineering, economics, political science, finance, and law to provide practical solutions to problems arising as a result of a changing climate. The Institute helps coastal and inland floodplain communities in Connecticut and throughout the Northeast better adapt to changes in climate and also make their human-built infrastructure more resilient while protecting valuable ecosystems and the services they offer to human society. Initiatives

[248] http://seagrant.uconn.edu/focus-areas/resilient-communities/

focus on living shorelines, critical infrastructure, inland flooding, coastal flooding, sea level rise, and policy and planning.

CIRCA runs a Research program as well as an external grants program for Connecticut municipalities and partners in resilience. To date, CIRCA has awarded 18 projects through its Municipal Resilience Grants Program to 14 municipalities and the state's regional planning organizations, Councils of Governments. An additional nine grants were awarded to municipalities, non-profits, academic researchers, a land trust and a conservation district to assist them with meeting the match requirement for federal or foundation grants programs. CIRCA research program has received funding from CT DEEP, CT DOT, the Connecticut Department of Housing, and NOAA. Research projects cover sea level rise and storm flooding statistics, green infrastructure and living shorelines evaluation, economic modeling, and policy analysis and planning.

The CIRCA Municipal and Matching Funds Grant Program project areas include:

- Darien - Low Impact Development for Resilience Against Flooding, Storm Water, and Climate Change
- East Lyme - Coastal Resilience, Climate Adaptation, and Sustainability Project
- Fenwick - Hepburn Dune and Marsh Preservation Project
- Hartford - Green Infrastructure Specialist for a More Resilient and Sustainable Future
- MetroCOG - Beardsley Zoo Green Infrastructure Project
- MetroCOG – Designing Resilience: Living Shorelines for Bridgeport
- Milford – Developing and Implementing a Restoration and Management Plan to Combat Threats and Challenges to Coastal Dune Resiliency in Urban Landscapes
- New Haven - Assessing Impacts of Tides and Precipitation on Downtown Storm Sewer System Through Use of Real-Time Depth and Flow Monitoring
- New Haven – New Haven Industrial Toolbox
- NHCOG– Building Municipal Resilience and Climate Adaptation through Low Impact Development
- NHCOG - Enhancing Rural Resiliency: A Vision and Toolkit for Adaptation in the Northwest Hills
- Oxford - Planning for Flood Resilient and Fish-Friendly Road-Stream Crossings in the Southern Naugatuck Valley
- SCCOG - Southeastern Connecticut Critical Facilities Assessment
- SCRCOG - Climate Adaptation and Resiliency Planning for Protection of Public Drinking Water
- SCRCOG - Design and Technical Guide for Implementing Innovative Municipal Scale Coastal Resilience in Southern Connecticut
- Stamford - Resilience Opportunity Assessment
- Waterford – Waterford Municipal Infrastructure Resilience Project
- WestCOG – Regional CRS Program

Through its first three years as an Institute, CIRCA projects and products provided significant support to municipalities and the state for resilience planning. In October 2017, CIRCA released localized sea level rise scenarios for the state and recommended that Connecticut plan for the upper end of the likely range of 20in/50cm of sea level rise by 2050.

CIRCA also led the research, outreach, and collaborative efforts of several state agencies to develop a regional vulnerability assessment and conceptual framing of coastal resilience for the NDRC, a billion-dollar competition sponsored by the U.S. Department of Housing and Urban Development. In January 2016, Connecticut was announced as the winner of $54.3 million to implement a pilot project in Bridgeport based on the concept and funds to develop a regional Connecticut Connections Coastal Resilience Plan for New Haven and Fairfield Counties. Going forward, CIRCA will lead the development of the Resilience Plan in partnership with the state and municipalities through the year 2022, including localized flood risk modeling and measurements for adaptation option evaluation, site planning and design, and a robust engagement and education program.

Sustainable Connecticut

Sustainable CT seeks to help cities and towns across the state become more vibrant, healthy, resilient and thriving places for all of their residents. Sustainability actions, policies, and investments deliver multiple benefits and help towns make efficient use of scarce resources and engage a wide cross section of residents and businesses. Sustainable CT is being developed by towns, for towns. Municipal leaders and residents from across the state, the Connecticut Conference of Municipalities and people from key agencies, non-profits and businesses all partnered to help create the program. The Institute for Sustainable Energy at Eastern Connecticut State University is coordinating and supporting the initiative. Support is provided by a funding collaborative composed of the Emily Hall Tremaine Foundation (EHTF), Hampshire Foundation and Common Sense Fund. All of Connecticut's 169 towns and cities have been represented in Sustainable CT's development in some way, either by directly by a municipal official or staff person, by a highly engaged local volunteer, or by a regional entity charged with representing member municipalities.[249]

3.5.4 Connecticut Association of Flood Managers

The mission of the Connecticut Association of Flood Managers (CAFM) is to promote education, policies, and activities that mitigate current and future flood losses, costs, and human suffering caused by flooding and to protect the natural and beneficial functions of floodplains – all without causing unreasonable adverse impacts.

CAFM strives to serve as a unifying force for its membership and their related disciplines within the state of Connecticut, providing both a forum and supportive framework. They solicit thoughts, ideas, concerns, and issues related to floodplain management from members in order to affect and integrate better management practices within public policy. Such pursuits are based on the collective experience of a diverse statewide membership and result in both environmental stewardship and better collaboration locally, statewide, and

[249] http://www.easternct.edu/sustainenergy/sustainable-communities/

regionally among all partners and stakeholders who have are interested in minimizing future flood risk and damages in the state of Connecticut.

Specifically, CAFM focuses on the following:

- Providing educational opportunities and dissemination of general and technical information to individuals concerned with sound floodplain management as well as to the general public;
- Promoting public awareness of sound floodplain management principles including mitigation, resiliency, preparedness, response, and recovery and the linkages between them;
- Encouraging the exchange of information, ideas, experiences, etc. among the practitioners of floodplain management at local, state, and regional scales;
- Promoting the professional status of floodplain managers and related disciplines;
- Informing and providing technical information relative to legislation pertinent and necessary to the effective implementation of sound floodplain management practices; and
- Promoting environmentally-sound solutions to floodplain management problems.[250]

3.5.5 The Nature Conservancy

The Nature Conservancy (TNC) is actively engaged with several Connecticut communities in the area of coastal resilience planning. Their Connecticut Coastal Resilience Program provides a decision support platform to better inform a process for decision-making and the implementation of socio-economic and natural infrastructure based solutions. Through this program, TNC has helped the communities of Old Saybrook and Waterford conduct willingness to pay surveys for climate adaptation, collaborated to develop a coastal resilience plan for Guilford, and conducted resilience workshops in Stamford, Madison, Stratford, Fairfield, Bridgeport, and Eastern Connecticut. They have led a comprehensive assessment in 24 coastal communities for future salt marsh advancement, making it the first state in the nation to have this assessment for their entire coastline. Other projects have included the Connecticut Coastal Design Project, which defined the most environmentally-friendly shoreline protection approaches for Connecticut, and the Adapting to the Rise report, which provides resources for a basic understanding of solutions for adapting to sea level rise.[251]

Early in 2012, The Nature Conservancy and Clean Air–Cool Planet, with local partners such as the Greater Bridgeport Regional Council and Regional Plan Association, held climate preparedness workshops in Bridgeport using NOAA's Roadmap for Adapting to Coastal Risk and The Nature Conservancy's Coastal Resilience Decision Support Tool. The goal was to advance a conversation on risk, choices, and actions the community could take to reduce risks and increase resilience. The workshops integrated maps showing potential flooding from extreme events and sea level rise into a community-driven process and dialogue through which the community identified top hazards and priorities for action.

[250] https://ctfloods.org/
[251] http://coastalresilience.org/project/connecticut/

Through this process, Bridgeport was selected as a national case study for addressing climate impacts and reducing risk to infrastructure, with representatives presenting at a White House GreenGov 2012 conference in Washington, D.C.[252]

3.5.6 Citizen Volunteer Organizations

Some communities have a Citizens Emergency Response Team (CERT). The members of these teams have received training in many areas involving disaster situations such as first aid, sheltering management, and traffic control and commodities distribution along with other related tasks. These groups fill voids that exist especially during large scale incidents where standard public safety staffing cannot fulfill all the necessary operations.

3.5.7 Additional Groups

In addition to municipal offices, the American Red Cross (ARC), the Salvation Army and the local health districts provide services related to mitigation and emergency management. The ARC and the Salvation Army help provide shelter and vital services during disasters and participates in public education activities. The local Health Districts become involved with water supply and sanitation issues that may arise during and after emergencies and natural disasters.

3.6 Activities for Future Updates

DEMHS may enhance this section of the NHMP in future updates by performing the following:

- Continue reviews of any future agency/division organizational changes and their effect on the agency/divisions efforts relating to hazard mitigation;
- Continue evaluating state policies and programs associated with natural hazard mitigation; and
- Continue overviews of local hazard mitigation policy initiatives, where available.

This work, as stated above, will be performed through planning efforts supported by FEMA grants and possible other grant/funding sources that may become available to the State.

[252] https://coast.noaa.gov/digitalcoast/stories/bridgeport

4 Local Planning Coordination

In response to the planning requirements of the Disaster Mitigation Act of 2000 (DMA 2000), the State of Connecticut has encouraged and facilitated local planning efforts to ensure that local and multi-jurisdiction hazard mitigation plans are in place. Unlike many states in the country, Connecticut does not have county governments, and local governments are the primary decision makers for land use. In Connecticut, as well as the remainder of FEMA Region I, the unit of local government is the town. Some towns are also incorporated as cities, but all local municipalities are towns.

Connecticut began assisting communities in the drafting of local hazard mitigation plans in 1997, utilizing Flood Mitigation Assistance (FMA) planning grant funds. The town of Westport was the first community to complete a local hazard mitigation plan in 1998. Due to limited FMA funding for planning activities, only one community each year was targeted to develop a plan under this grant program.

DEEP realized that the development of one community plan per year would not be an effective approach if the continued goal is to have a plan for every Connecticut community. The State of Connecticut's current approach is to work with regional planning organizations known as Council of Governments (COGs) as frequently as possible to prepare multi-jurisdiction hazard mitigation plans. Since the last plan update, the Office of Policy and Management (OPM) completed a comprehensive analysis of the boundaries of logical planning regions in Connecticut under Section 16a-4c of the *Connecticut General Statutes (2014 Supplement)*. This analysis resulted in the number of planning regions being reduced from the original fifteen to nine, as a result of four voluntary consolidations and the elimination of two COGs. Connecticut COGs currently include:

1. Capital Region Council of Governments (CRCOG)
2. Connecticut Metropolitan Council of Governments (MetroCOG)
3. Lower Connecticut River Valley Council of Governments (RiverCOG)
4. Naugatuck Valley Council of Governments (NVCOG)
5. Northeastern Connecticut Council of Governments (NECOG)
6. Northwest Hills Council of Governments (NHCOG)
7. South Central Regional Council of Governments (SCRCOG)
8. Southeastern Connecticut Council of Governments (SECCOG)
9. Western Connecticut Council of Governments (WestCOG)

Figure 4-1 below shows the status of the multi-jurisdictional hazard mitigation plans of each of Connecticut's COGs.

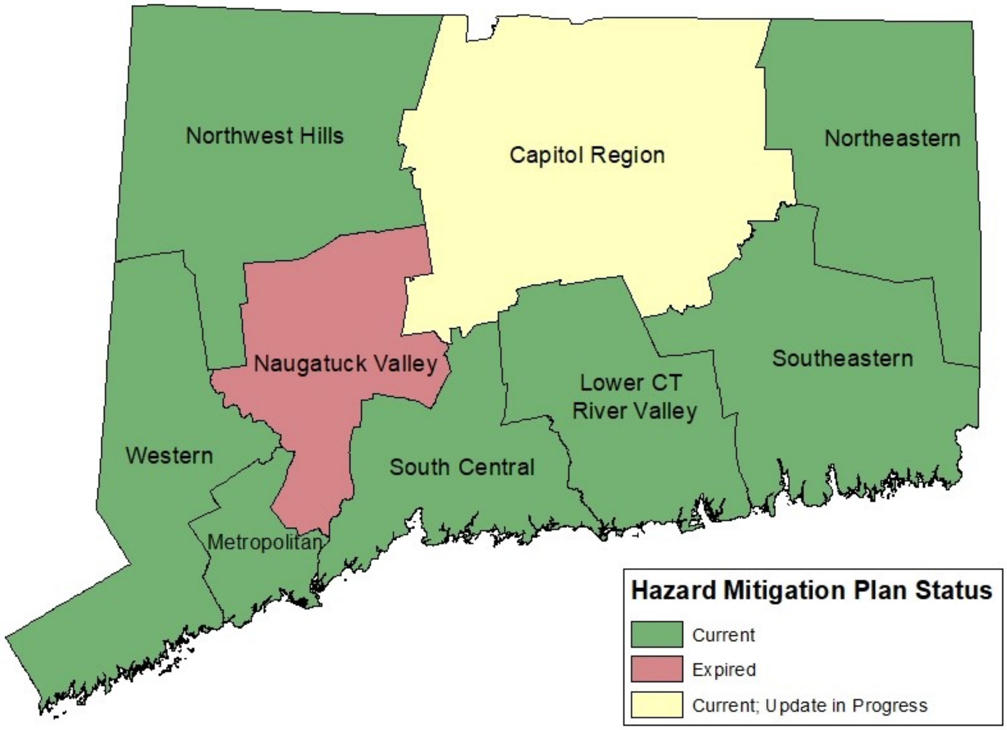


Figure 4-1: Status of Multi-Jurisdictional Hazard Mitigation Plans for Connecticut Council of Governments

When FEMA Pre-Disaster Mitigation (PDM) or Hazard Mitigation Grant Program (HMGP) planning grant funds are made available, the State solicits grant sub-applications from eligible sub-applicants such as municipalities or COGs. The sub-applications are reviewed for eligibility and completeness by the Connecticut Division of Emergency Management and Homeland Security (DEMHS), and are then evaluated and ranked by the Connecticut Interagency Hazard Mitigation Committee (CIHMC). All municipalities and COGs can apply for local assistance to update their hazard mitigation plans. HMGP funding is generally 15% of the total amount of Federal assistance provided to a State, Territory, or federally-recognized tribe following a major disaster declaration. PDM and Flood Mitigation Assistance (FMA) funding depends on the amount congress appropriates each year for those programs. Further details on these programs are available in Section 3.1.2 of the Capability Assessment for this plan.

Table 4-1 provides a list of planning projects funded in part by FEMA grants from Federal Fiscal Years 2012 - 2017. A full table of Connecticut's hazard mitigation activities is available in Appendix 5 of this plan.

Table 4-1: List of Past and Current Planning Activities Funded by FEMA

FEDERAL FISCAL YEAR	PROGRAM	DESCRIPTION	STATUS	FEDERAL FUNDING	LOCAL FUNDING
FFY12	PDM	Prepare a multi-jurisdiction hazard mitigation plan update by LHCEO	Underway	$30,075.00	$10,025.00
FFY12	PDM	Prepare a local hazard mitigation plan by the Town of Bethel	Underway	$30,750.00	$10,250.00
FFY12	PDM	Prepare a multi-jurisdiction hazard mitigation plan update by GBRPC	Underway	$90,000.00	$30,000.00
FFY12	PDM	Prepare three local hazard mitigation plan updates - grant to the Town of Watertown	Underway	$18,000.00	$6,000.00
FFY12	HMGP	Prepare four local hazard mitigation plan updates - grant to the City of Waterbury	Underway	$24,000.00	$8,000.00
FFY12	HMGP	Prepare six local hazard mitigation plan updates - grant to the Town of Southbury	Underway	$43,853.00	$14,618.00
		Totals for FFY 12		$236,678.00	$78,893.00
FFY13	HMGP	Prepare nine local hazard mitigation plan updates by the Northwest Connecticut Council of Governments (NWCCOG)	Underway	$48,750.00	$16,250.00
FFY13	HMGP	Prepare a multi-jurisdiction hazard mitigation plan update by SWRPA	Awarded	$41,700.00	$13,900.00
		Totals for FFY 13		$90,450.00	$30,150
--	HMGP	Prepare a multi-jurisdiction hazard mitigation plan update by CCRPA	FEMA review of grant application pending	$84,502.00	$28,167.00
--	HMGP	Prepare a multi-jurisdiction hazard mitigation plan by HVCEO; and incorporate updates for Danbury, New Fairfield, and Sherman	FEMA review of grant application pending	$123,750.00	$41,250.00
		Total Pending		$208,252	$69,417

Table 4-1 needs to be updated based on the mitigation strategies appendices – update in progress.

4.1 Summary of Planning Efforts

As noted above, hazard mitigation planning is typically performed at the community level; this is true even when COGs coordinate the planning efforts. Connecticut has 169 municipalities, the Mashantucket Pequot and Mohegan tribal governments, and the political subdivisions of Groton and Stonington for a total of 173 local political entities.

Most of the individual community plans are multi-jurisdictional plans developed by COGs, with the remainder being developed by and for individual communities. Table 2-1 in Section 2.2 of the Hazard Identification and Risk Assessment of this plan contains details on the local plans for each jurisdiction, including the FEMA approval date, the expiration date, and the current status of the plan. At the time of the plan update, all multi- and single-jurisdictional plans were current or in the process of being updated, except the Naugatuck Valley Council of Governments, which was expired. All established local plans and draft plans submitted to the State were used as a source to inform the 2019 Connecticut State Hazard Mitigation Plan Update.

4.2 Local Planning Process

Development of a natural hazard mitigation plan at the community level is vital if the community seeks to comprehensively address natural hazards. Communities cannot prevent disasters from occurring, however, they can lessen the impacts and associated damages from these disasters. An effective plan will improve a community's ability to deal with natural disasters and will document valuable local knowledge on the most efficient and effective ways to reduce losses. Preparing a plan to lessen the impact of a disaster before it happens will provide the following benefits to a community:

- Reduce public and private damage costs;
- Reduce social, emotional, and economic disruption;
- Provide better access to funding sources for natural hazard mitigation projects; and
- Improve implementation of post-disaster recovery projects.

DEMHS provides technical assistance to sub-applicants for planning efforts and projects. Technical assistance includes meeting with local officials and COGs to facilitate the planning process, providing available planning guides and tools to support plan development, and reviewing and providing feedback on draft plans submitted for FEMA approval. While DEEP has historically performed much of the local plan review work at the state level, DEMHS assumed these responsibilities in 2013.

DEMHS reviews and analyzes all single-jurisdictional and multi-jurisdictional plans when they are submitted to the agency prior to being forwarded to FEMA. DEMHS plays an active role in the coordination of these reviews. DEMHS is knowledgeable in the contents of each plan and through its review verifies that all plans are consistent with the CT NHMP and DEMHS's mission. DEMHS also provides comments to the community or RPO to ensure the single- or multi-jurisdictional plan is complete and consistent with all State and FEMA requirements. The FEMA crosswalk form was formerly used to provide comments to local officials. It was supplanted by the Local Mitigation Plan Review Tool during 2013.

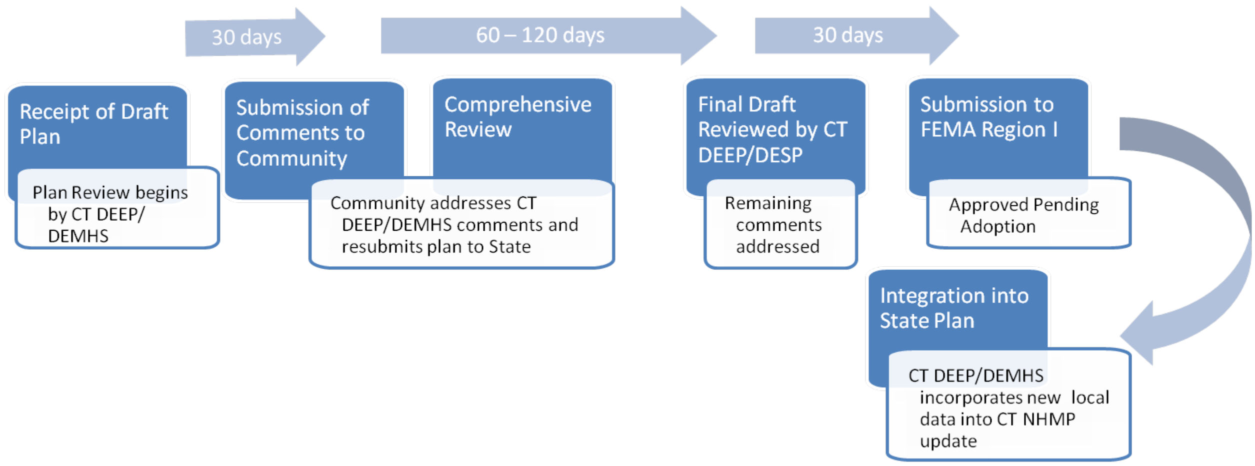


Figure 4-2: Local Plan Submittal Process and Integration Into State NHMP.

The goals established for this process are shown in Figure 4-2 and are as follows:

- Receipt of draft plan – Day 1;
- Initial plan review and submission of draft comments to community – within 30 days of receipt of draft plan;
- Comprehensive review, including time for community to revise plan based on initial comments – 60 to 120 days from submission of draft comments to community;
- DEEP submits plan and its comments to FEMA – within 30 days of receipt of final draft from community for the comprehensive review;
- Incorporate new data from FEMA approved local plan into the state's NHMP by the next update of the Plan.

Once the initial state review is completed, DEMHS will forward the plan to FEMA for its initial review. If the plan meets all of the requirements to receive conditional approval, FEMA will send the COG or the community an Approval Pending Adoption (APA). If the plan requires revisions, FEMA will forward comments to DEMHS. DEMHS will then send the COG or community a letter with comments from both FEMA and the State, and will provide additional technical assistance to the community as it revises the plan. Once the revisions are made to the plan, the COG or community will submit a final draft plan to DEMHS. DEMHS then will forward the final draft plan to FEMA for Conditional Approval. FEMA will then send a letter of APA to the COG or the community when it is approvable.

At this point, the community will hold a public hearing and formally adopt the mitigation plan. A signed resolution of adoption will then be sent to DEMHS. DEMHS will then forward the adoption documentation to FEMA who will review and then issue a letter of approval to the community with a copy to the COG and DEMHS.

Additional State Technical Assistance

In addition to the assistance provided as outlined above, DEMHS provides technical assistance in the form of training, individual meetings with RPOs, and ad-hoc technical assistance via telephone or meetings as requested. It is the responsibility of the local community to update its local natural hazard mitigation plan at least once before expiration in five years, although the community may choose to update the plan more frequently. Risk assessments from the local plans will be used periodically to enhance Connecticut's hazard identification and risk assessment where applicable. Furthermore, DEEP considers actions common to all plans to target resources for mitigation outreach, technical assistance and grant offerings.

4.3 Local Hazard Identification and Risk Assessment

Local plans and multi-jurisdiction plan annexes identified 24 distinct hazards, although not all hazards were identified in every plan. Communities used a variety of approaches with a range of complexity to rank their identified hazards. Some plans used a blend of various techniques and discussion to determine their final hazard ranking. Several of the ranking/scoring techniques used in the local plans included:

- Quantitative scoring (based on available historical data, i.e. NCEI);
- Human judgment/knowledge of locality;
- Numerical Scoring Worksheets (based on criteria, i.e. FEMA 386-2 worksheets); and
- Interactive activities with Steering Committee members.

FEMA guidance indicates that the jurisdictions at greatest risk to specific hazards should be identified, considering both the characteristics of the hazard and the jurisdictions' degree of vulnerability. A variety of analysis methods may be sufficient to meet these goals; FEMA does not mandate a specific analysis method. As a result, many local and state plans have developed their own ranking system.

None of the ranking techniques used in the local plans is incorrect, as there is no standard for ranking hazards that impact specific jurisdictions. Lack of available data for each hazard is often a driving factor in the ranking method's degree of subjectivity. The numerical rankings were frequently performed by different plan preparers, and different data processing methodologies were used. The variability in the ranking systems made it challenging to directly compare local hazard rankings to the state risk assessment. Instead, the qualitative risk assessment information in the local plans was utilized as a component of the composite ranking maps as discussed in the Hazard Assessment and Ranking Methodology section of this chapter. Some plans provided a direct ranking of hazards in terms of overall risk from low to high, while others only offered general information about hazard risk. In the latter case, a ranking was assigned based on the data provided.

Table 4-2 below ranks each hazard based on the percentage of localities that ranked the hazard as High, Moderate-High, Moderate, Low-Moderate, and Low. A score of one to five was assigned to each individual plan ranking (one being for low rank and five being for high rank), with an overall score being determined based on the mean of the individual ranks. Several of the local plans discussed the hazards but did not qualitatively rank them; as a result these hazards were assigned rankings based on how they were described in detail in the local plans.

It is important to note that an overall score can be relatively high for a particular hazard even when only a handful of communities are at risk. One example is coastal flooding and storm surge, which is evaluated in only 33 coastal or estuarine communities. The relatively high score of 3.98 is possible because it is dependent only on the rankings within the local plans and annexes that include the hazard, rather than the score becoming diluted by averaging across all Connecticut communities. One way to approach the overall risk score is as a measure of the risk that hazard poses to a community if it poses a hazard at all.

The "Weighted Score" in Table 4-2 accounts for the number of local plans that address each hazard. This index recalculates the risk score after assigning a score of zero to a hazard in an individual plan ranking if it is not addressed in that plan.

Additional details on the local plan review, hazards assessed, loss estimation, and tracking information are available in Appendix 4.

Table 4-2: Local Hazard Mitigation Plan Results of Hazard Identification

Hazard	Overall Ranking	Overall Score	Number of Local Plans	Weighted Score
Dam or Levee Failure	M	3.13	167	3.02
Drought	L-M	1.61	150	1.40
Earthquake	L-M	1.86	172	1.85
Erosion	L-M	1.85	48	0.51
Extreme Cold	M	3.00	29	0.50
Extreme Heat	M	2.82	33	0.54
Flood, Coastal & Storm Surge	M-H	3.98	40	0.92
Flood, Flash	M-H	4.38	26	0.66
Flood, Poor Drainage	M	3.36	78	1.51
Flood, Riverine	M-H	4.12	171	4.07
Hail	M	2.50	98	1.42
Hurricane	M-H	4.44	163	4.18
Ice	M-H	4.23	81	1.98
Ice Jam & Associated Flooding	L-M	1.95	22	0.25
Landslide & Mudflow	L-M	2.08	12	0.14
Land Subsidence & Sinkholes	L-M	2.33	3	0.04
Lightning	M-H	3.62	98	2.05
Sea Level Rise	M	3.03	34	0.60
Thunderstorms (Summer Storms)	M-H	4.38	124	3.14
Tornado	M	2.59	165	2.47
Tsunami	M	2.60	10	0.15
Wildfire	L-M	1.93	147	1.64
Wind	M-H	4.44	99	2.54
Winter Storm / Snow / Blizzard	H	4.90	173	4.90

Winter storms, earthquakes, and riverine floods are directly addressed and evaluated in the greatest number of local plans and multi-jurisdiction plan annexes (173, 172, and 171, respectively – there are 173 available plans and annexes). Dam or levee failure, hurricanes, and tornadoes are addressed in the vast majority of plans (167, 163, 165, respectively), as are wildfires and thunderstorms (147 and 124, respectively). Interestingly, drought is addressed in 150 plans, despite the fact that it was consistently rated as a low risk hazard. On the other hand, the fact that wildfire is addressed and assigned a low risk ranking in most plans obscures its high ranking in a small number of local plans.

Lightning, hail, and wind are addressed, either separately from or specifically within the context of other hazards like hurricanes and thunderstorms, in more than half the local plans (98 and 99, respectively).

At the other end of the range, land subsidence and sinkholes are addressed in only three local plans (Cheshire, New Haven, and Sharon). Tsunamis were each addressed in ten coastal plans, and landslides were evaluated in twelve plans for communities located primarily the Naugatuck Valley where old mill towns were developed on steep slopes flanking river valleys.

The range of possible "overall score" is one to five. Seven hazards scored greater than 4.0. These are flash floods, riverine floods, hurricanes, ice events, thunderstorms, wind events, and winter storms. Importantly, coastal flooding is addressed in a number of local plans for non-coastal communities, meaning a falsely low risk score was assigned; despite this the coastal flooding overall risk score is relatively high (3.98). When considering hazards statewide, accounting for the number of local plans that don't consider a particular hazard, the highest ranked hazards in terms of risk are winter storms, hurricanes, and riverine flood ("Weighted Score"). Considered collectively, it is clear that floods of all types, high wind events, and winter storms are of great concern to local communities.

Several of the hazard categories that were addressed in the local plans are not subject to detailed analysis in the State plan update. Of the hazards addressed in the update, average rankings in both the local and state analysis are comparable.

Future local plan updates may present an opportunity to address some of the ambiguity between hazard naming conventions if the State of Connecticut standardizes applicable hazard names or labeling. The State may encourage local plan revisions to approach classifying hazards in a similar fashion as done in the HIRA in the State plan update.

4.4 Assessment of Potential Losses

Local hazard evaluations are highly variable. As a result, each one has its own set of criteria to develop monetary loss estimates. Many of the first-generation local plans and annexes contained loss estimates only from previous damage events, while plans developed after 2010 have begun to utilize FEMA's Hazus program to model flooding, hurricane wind, and earthquake events and damages. At this point, the majority of local plans and annexes include Hazus results.

Table 4-3 and Table 4-4 summarize loss estimates extracted from each local plan or annex. Table 4-3 lists annualized loss estimates, which were calculated either using Hazus software, through analysis of historic event losses and frequencies, by looking at relevant annual municipal budgets, or through estimation. Average loss value provided is for a single community. Loss estimates have not been adjusted to account for inflation.

Table 4-3: Local Plan Annualized Loss Estimates by Hazard Type

Hazard	Average	Number of Plans with Loss Estimates
Coastal	$470,120	7
Riverine	$118,742	16
Drought	$2,400	1
Dam Fail	$3,550	3
Earthquake	N/A	0
Hailstorm	N/A	0
Hurricane	N/A	0
Thunderstorm	$7,512	42
Wildfire	$8,699	13
Wind	$57,250	10
Winter Storm	$544,707	83
Tornado	$1,612	23

Table 4-4 lists other loss estimates. These estimates were calculated using a number of methodologies and they present losses for hazards with a variety of return periods. The "Methods" column summarizes both the loss calculation methodology and the return period as applicable. Average loss value provided is for a single community. Loss estimates have not been adjusted to account for inflation.

Table 4-4: Local Plan Other Loss Estimates by Hazard Type

Hazard	Method	Average	Number of Plans with Loss Estimates
Coastal Flood	Hazus: 1% Chance Flood	$238,150,654	26
	Specific Event*	$1,295,000	1
	Total FEMA Reimbursement**	$5,849,822	12
	Average Coastal Flood	$81,765,159	-
Riverine Flood	Hazus 1% Chance Flood	$45,073,650	168
	Specific Event*	$6,460,550	38
	10% of SFHA Property Value	$292,900,000	2
	Total FEMA Reimbursement**	$1,035,458	40
	NFIP Policy Value	$13,064,233	9
	Average Inland Flood	$71,706,778	-
Drought	Specific Event*	$62,000	2
Dam Failure	Hazus***	$50,519,167	12
	Property Value***	$183,092,625	4
	Historic/Reported	$12,397,892	13
	Average Dam Failure	$82,003,228	-
Earthquake	Hazus: Worst-Case****	$401,834,841	138
Hailstorm	Specific Event*	$2,728	12
Hurricane	Hazus: 50 Year	$2,319,091	16
	Hazus: 100 Year	$18,082,460	145
	Hazus: 500 Year	$89,346,372	80
	Hazus: 1938/Cat. 3	$45,512,903	25
	Specific Event*	$9,870,849	11
Thunderstorm	None	-	0
Wildfire	None	-	0
Wind	None	-	0
Winter Storm	Specific Event*	$244,445	16
Tornado	Specific Event*	$1,682,920	30
	Specific Event* (Estimate)	$5,000,000	11
	Average Tornado	$3,341,460	-

** Specific Event: losses from specific historic events were provided. Different communities provided losses from different events, and some plans provided losses from multiple events; in the latter case, losses were averaged.*
*** Total FEMA Reimbursement: includes all PA and NFIP reimbursements provided since community joined the program*
**** Dam failure losses calculated using HAZUS flood modeling or through property value estimation utilized either the 0.2% flood zone, the 1% flood zone, or calculated dam failure inundation areas.*
***** Some plans ran HAZUS for multiple earthquake scenarios; the worst-case scenario for each community was extracted for this summary.*

One continued goal of the State plan update is to standardize the data analysis process so that future state and local plan updates are consistent and comparable, including recommendations for assigning annualized loss estimates for hazards not included in the

Hazus software. Chapter 5 of this plan includes the relevant actions to reach this goal. Analysis in local plans has improved since the last State plan update, with every local plan providing at least one loss estimate, and many plans using comparable loss estimate methodologies.

5 Hazard Mitigation Strategy for 2019 –2024

5.1 Hazard Mitigation Goals, Objectives, and Strategies

The State of Connecticut is committed to reducing future damage from natural disasters through mitigation. The mission of Connecticut's Hazard Mitigation Program and this plan is to mitigate the impacts of natural hazards by minimizing loss of life and property damage. In 2007, the State identified three primary goals to focus its hazard mitigation efforts to assist in accomplishing its mission. These three goals were reaffirmed in 2010, and again in 2014, with slight modification, and included the following:

1. Promote implementation of sound floodplain management and other natural hazard mitigation principles on a state and local level.
2. Implementation of effective natural hazard mitigation projects on a state and local level.
3. Increase research and planning activities for the mitigation of natural hazards on a state and local level.

During the 2014 plan update process, the goals were again reaffirmed, with minor changes to the associated Objectives and Strategies. For the 2019 update, the SHMPT met on multiple occasions to discuss current natural hazard risks as well as the goals, objectives, strategies, and activities required to minimize those risks. The planning team agreed to again reaffirm the goal statements from 2014, but decided to again make some revisions and additions to the objectives and strategies for each goal. These changes were made to better consolidate and eliminate some overlap among strategies, and to help clarify their specific meaning. In some instances they were also expanded to cover possible new mitigation activities under consideration by the planning team.

Figure 5-1. Connecticut's planning team used interactive brainstorming exercises and breakout sessions to identify and evaluate mitigation activities in both 2014 and for this 2019 plan update.

The following goals, objectives, and strategies will serve as the road map for Connecticut to focus its hazard mitigation activities through 2024. The statements are based on (1) the review and consideration of previous mitigation goals, strategies and activities for 2014-2019; (2) the review of updated information for the hazard identification and risk assessment; (3) input and recommendations shared by the planning team during stakeholder meetings for the 2019 plan update; and (4) results of the internet-based survey used for public participation.

It is anticipated that by working towards the goals set out in this plan, effective natural hazard mitigation measures will be implemented to protect residents of Connecticut where appropriate, and will promote responsible natural hazards mitigation throughout the state on both a regional and local level.

5.2 GOAL 1

PROMOTE IMPLEMENTATION OF SOUND FLOODPLAIN MANAGEMENT AND OTHER NATURAL HAZARD MITIGATION PRINCIPLES ON A STATE AND LOCAL LEVEL

Objective for Goal 1: To increase general awareness of Connecticut's natural hazards and encourage State agencies, regional entities, local communities, and the general public to be proactive in taking actions to reduce long-term risk to life and property.

Strategies for Goal 1:

Strategy 1.1 – Provide technical guidance to communities on existing hazard mitigation opportunities with an emphasis on new or improved development or redevelopment, including local floodplain ordinance enhancement and enforcement.

Strategy 1.2 – Conduct public outreach and provide educational opportunities to State agencies, local communities, and other stakeholders on existing natural hazards and the mitigation measures available to reduce hazard risks, including the use of RiskMAP products and new mapping data.

Strategy 1.3 – Strengthen, support, and enhance State policy, legislative efforts, and state-wide coordination and collaboration with other state agencies, COGs, academic institutions, research centers/think-tanks, and nonprofits to mitigate the effects of natural hazards and adapt to climate change. Initiate new policy, legislative, and collaboration / coordination efforts as needed.

Strategy 1.4 – Use State Agencies for Resilience (SAFR) to continue coordination and leverage resources across State agencies by integrating hazard mitigation, climate adaptation and resilience principles into other relevant plans, policies, or program activities.

Strategy 1.5 – Increase emphasis on Long Term Recovery Planning statewide in advance of future disasters.

Strategy 1.6 – Encourage less development in risk zones, statewide, by promoting the NFIP Community Rating System (CRS) and by encouraging open space planning.

5.3 GOAL 2

IMPLEMENTATION OF EFFECTIVE NATURAL HAZARD MITIGATION PROJECTS ON A STATE AND LOCAL LEVEL

Objective for Goal 2: To enhance the ability of State agencies, regional entities, and local communities to reduce or eliminate risks to life and property from natural hazards through cost-effective hazard mitigation projects, including avoidance.

Strategies for Goal 2:

Strategy 2.1 – Refine State-level priorities and evaluation criteria for hazard mitigation project funding (with emphasis on Repetitive Loss and Severe Repetitive Loss properties) that is provided or administered by the State, including FEMA grant funds.

Strategy 2.2 – Identify, develop, and prioritize hazard mitigation projects including climate change adaptation strategies and relocation for State-owned facilities considered at risk to natural hazards.

Strategy 2.3 – Develop, maintain and provide the best available data, training, and technical assistance to State agencies and local communities to assist in the identification, development, and implementation of cost-effective hazard mitigation projects, including relocation or siting of new facilities to avoid hazards, particularly when applying for Federal and State funds.

Strategy 2.4 – Increase and promote the availability of various funding mechanisms to support hazard mitigation project implementation, including Federal, State, and non-governmental sources, by increasing the use of Regional Emergency Planning Teams (REPTs) and subject matter experts to educate and involve elected officials.

Strategy 2.5 – Routinely monitor the implementation of hazard mitigation projects, tracking progress through project closeout and beyond to capture success stories (losses avoided) and lessons learned.

Strategy 2.6 – Increase coordination among state agencies, including state data officers, to more centrally disseminate data that is developed and maintained, in order to promote mitigation action.

5.4 GOAL 3

INCREASE RESEARCH AND PLANNING ACTIVITIES FOR THE MITIGATION OF NATURAL HAZARDS ON A STATE AND LOCAL LEVEL

Objective for Goal 3: To increase general awareness of Connecticut's natural hazards and encourage State agencies, local communities, and the general public to be proactive in taking actions to reduce long-term risk to life and property.

Strategies for Goal 3:

Strategy 3.1 – Promote natural hazard mitigation research, technical analysis (such as mapping), and planning activities that will improve hazard mitigation, resilience and climate adaptation planning and implementation on a State, regional and local level.

Strategy 3.2 – Conduct outreach and provide educational opportunities to state agencies, local communities, regional entities and other stakeholders to assist in translating research and planning activities into practice, using the Councils of Governments (COGs), State Agencies for Resilience (SAFR) and REPTs to help disseminate information.

Strategy 3.3 – Investigate climate change adaptation strategies as they affect natural hazard mitigation and State investment policies, and link hazard mitigation activities with climate adaptation strategies when appropriate and possible.

Strategy 3.4 – Research methods and take action to better engage the private sector and non-profit organizations in hazard mitigation planning activities on a State, regional and local level, including coordination with utility companies to better prepare for, mitigate against, and respond to natural hazard events.

Strategy 3.5 – Create a clearinghouse/database that contains data, research, and information from UCONN/CIRCA, OPM GIS, local resilience plans, local resilience initiatives, as well as any evidence based best practices to increase transparency, promote best practices, and enable easy access for Connecticut communities.

5.5 Hazard Mitigation Activities for 2014–2017

Table 5-1 provides a summary of the recommended hazard mitigation activities developed by the planning team to achieve the above goals, objectives, and strategies, and to assist in reducing impacts from natural hazards which may impact the State. These include those activities which the State, including offices cutting across multiple departments and agencies, may implement as part of their ongoing work programs and contingent on available resources and/or funding, if applicable.

Table 5-1 includes the following information for each recommended activity:

1. **Activity #:** Identifies the unique number for the activity, with the first two digits correlating to the specific Goal and Strategy the activity is intended to help achieve. This helps to demonstrate how *each activity contributes to the overall State mitigation strategy*.
2. **Activity Description:** Provides a narrative description of the recommended mitigation activity. For activities that were carried over from the 2014 plan, the narrative also includes an update on the activity's current status in terms of implementation progress.
3. **Lead Agency:** Identifies the lead department and specific division/office assigned with primary responsibility for implementation of the activity.

4. **Estimated Cost (if applicable):** Provides a general estimate of the anticipated total costs required to complete the activity. In addition to dollar estimates, this may include "staff time" or "in-kind resources."
5. **Potential Funding Sources (if applicable):** Identifies potential funding sources to support implementation of the activity, including any known Federal, State or non-governmental sources.
6. **Timeframe for Completion:** Identifies the target timeline (duration) or specific completion date (month/year) for the activity. In some cases this may include the statement of "ongoing/continuous" for those actions already underway and/or to be continued as a *sustained* mitigation practice with no end date.
7. **Hazard(s) to be Addressed:** Identifies the specific natural hazard the recommended activity is designed to mitigate against. This may include a single, multiple, or all natural hazards identified in the plan.
8. **Priority Level:** Identifies the priority level (i.e., high, medium, low) assigned to the activity, based on the STAPLE-E evaluation and prioritization process described below.

5.6 Assessment of Recommended Mitigation Activities

As done in 2014, each mitigation activity listed in Table 5-1 was evaluated and prioritized according to the "STAPLE-E" evaluation method (Social, Technical, Administrative, Political, Legal, Economic, and Environmental). The specific criteria used in the application of the STAPLE-E method are provided in Appendix 5-1. In addition, the planning team considered the following factors in its general assessment of recommended mitigation activities:

1. Feasibility of implementation (both on a state and local level);
2. Potential mitigation gains that could be achieved by the activity; and
3. If the proposed activity would assist the State in achieving improved resource effectiveness and data collection, two current areas of constraint (in both the 2014 and this 2019 plan update) that have been noted within the current plan.

5.7 Implementation and Integration of Recommended Mitigation Activities

All of the mitigation activities listed in Table 5-1 have been deemed feasible with respect to their implementation or performance on a state or local level. Appendix 5-2 includes a mitigation ranking and action tracker for each of the strategies identified in Table 5-1. Each of the potential activities can be implemented independently of other proposed activities. In addition, each activity will support the improvement of an increasingly effective and comprehensive plan. However, the implementation of any of the proposed activities listed in Table 5-1 is completely dependent up availability of resources both monetary and other (e.g., staff, technical, supplies, etc.). This dependence on available resources will be a significant factor regarding their implementation and performance over the next five years. More information on funding sources for mitigation projects is available in Section 3.1.2 of this plan. Further feasibility analysis of individual activities will be performed prior to the implementation and performance of any activity. Similarly, the implementation of any proposed activity is contingent on confirmation that it satisfies the aforementioned STAPLE-E evaluation criteria at the time of the proposed performance or implementation. This ensures the activity still has the necessary social, technical, administrative, political, legal, economic, and environmental support required even if conditions have changed since plan adoption.

The implementation of effective natural hazards mitigation requires ongoing planning and dedicated persistence both on a state and local level to maintain what has been done in the past, and to improve upon past efforts to strive for implementing the most protection possible from natural hazards. Planning and implementation require the use of historical data. At all times the State of Connecticut will strive to ensure that historical data at both the state and local level is protected and maintained.

The related strategies and activities outlined in this plan provide a guide to assist the State of Connecticut in working towards achieving its three identified hazard mitigation goals, and they will be implemented or initiated during the time period encompassing this plan update. The goals themselves are achievable, yet they require adequate resources such as financial and staff resources to achieve significant results. They also require planning, policy, and program integration across multiple state agencies.

The State also believes that continued and increased focus on climate change and adaptation techniques are an area of continued concern to which hazard mitigation strategies and activities must be linked. This will be accomplished through continued and increased coordination and plan integration across multiple state agencies, as deemed appropriate, and as identified and included in this plan as recommended hazard mitigation activities in support of Strategies 1.3 and 3.3.

Table 5-1: Recommended Hazard Mitigation Activities, 2019–2024

Activity #	Goal/Strategy	Activity Description	Lead Agency	Support Agencies	Estimated Cost*	Potential Funding Sources	Timeframe for Completion	Hazard(s) to be Addressed										Priority Level
								Tropical Cyclone	Tornado	Thunderstorm	Winter Storm	Flood	Dam Failure	Wildland Fire	Drought	Earthquake	Climate Change	
1	1.1	Review model ordinances and samples of higher standards language that communities can adopt into existing floodplain ordinances and building codes.	DEEP - Land and Water Resources Division / DCS	COGs	Staff time	Agency Operating Budgets	Evaluate annually					X					X	Medium
2	1.1	Conduct technical transfer and training associated with current extreme rainfall data.	USDA / Natural Resources Conservation Service		Staff time	Agency Operating Budgets	1-2 years					X	X				X	Low
3	1.1	Conduct technical transfer and training associated with available LiDAR data.	USDA / Natural Resources Conservation Service	DEEP / LWRD	Staff time	Agency Operating Budgets	1-2 years					X						Low
4	1.1	Encourage municipalities to adopt local water use restriction ordinances to ensure that proper water conservation measures are implemented during periods of severe to extreme drought and other water emergencies, in line with the Connecticut Drought Preparedness and Response Plan. Expand the local focus on drinking water vulnerability, with a particular emphasis on private wells.	DPH / Drinking Water Section	Water Planning Council / COGs	Staff time; minimal expense for outreach materials	Agency Operating Budgets	During onset of drought conditions								X			High
5	1.1	Launch an outreach campaign to promote FEMA's Community Rating System (CRS) as a means for local communities to soften the likely increase in many flood insurance policy rates resulting from new reforms to the National Flood Insurance Program (NFIP) enacted by Federal Legislation.	DEEP - Land and Water Resources Division	USACE / Silver Jackets	Staff time; minimal expense for outreach materials	Agency Operating Budgets	1 Year					X						High

6	1.1	Encourage local hazard mitigation plans to consider continuity of agricultural operations during and following hazard events.	DESPP / Emergency Management and Homeland Security		Staff time; minimal expense for outreach materials	Agency Operating Budgets	1-5 years, initiated at each updated plan review				X				X		X	Low
7	1.2	Communicate the importance of natural hazard mitigation to agricultural producers through the Department of Agriculture's weekly newsletter. This would consist of articles with links to useful websites such as DEEP and "ReadyAg" (available from PSU website).	DAG / Bureau of Agricultural Development & Resource Preservation / COGs / Working Lands Alliance		Staff time; minimal expense for outreach materials	Agency Operating Budgets	6 months, then annually thereafter	X	X	X	X	X	X	X	X	X	X	Low
8	1.2	Develop a body of customizable presentations, social media templates, Flood Insurance factsheets and short workshop educational materials that could be utilized on a scheduled basis. While these could be developed for multiple hazards, the emphasis of this activity is on flood mitigation and climate change adaptation.	Connecticut Association of Flood Managers DEEP - Land and Water Resources Division	DEEP / Office of Long Island Sound Programs / USACE / Silver Jackets / CT Insurance Department	Staff time; minimal expense for outreach materials	Agency Operating Budgets	1 year, then 1 presentation annually					X					X	High
9	1.2	Investigate the possibility of holding the CFM exam and CFM courses on an annual basis for interested persons.	Connecticut Association of Flood Managers	DEEP/LWRD	Staff time	Agency Operating Budgets	Annually					X						Low
10	1.2 1.3 3.2	Develop educational tools to inform decision makers on the value of acquiring, maintaining, and increasing climatological data collection, including hydrologic (e.g. stream gage) data, and the continuation of OLISP's sentinel monitoring program to help provide early warning of climate change impacts. Communicate with USGS to maintain monitoring systems. This activity is linked to Activity #28.	CHMC and Water Planning Council / CIRCA	DEEP / LWRD and Office of Long Island Sound Programs / SAFR	Staff time; minimal expense for outreach materials	Agency Operating Budgets	1-2 years	X	X	X	X	X			X		X	Medium

11	1.3	Continue to mitigate and reduce the number of repetitive loss properties. As noted in this plan, CT will do the following: − Seek Federal funds to mitigate through elevation and acquisition, RL and SRL properties − Encourage sub applicants to prioritize RL and SRL properties − As grantee, give priority to RL and SRL properties − When BCAs of RL and SRL property applications are even, priority ranking will be given to RL and SRL properties − Identify outside funding for mitigating RL and SRL properties − Continue to advocate for NRCS and State Bond Funding for mitigating RL and SRL properties − Communicate acquisition process to municipalities − Assist municipalities with Benefit Cost Analysis for RL and SRL properties	DESPP / Emergency Management & Homeland Security	DEEP / Inland Water Resources / Flood Management Section	$20-40k	FEMA (FMA, PDM, or HMGP); in-kind staff resources	1-2 years					X						High
12	2.1	Develop implementation strategy for Public Act 13-15, which requires consideration of the ways in which a water pollution control project mitigates the effects of sea level rise. The Act also requires that the list of priority water quality projects include the necessity and feasibility of implementing measures designed to mitigate the impact of a rise in sea level over the projected life span of such project.	DEEP Municipal Water Pollution Control Section	DEEP / Office of Long Island Sound Programs / OPM / DAS	Staff Time	CT Clean Water Fund	1-2 years	X				X					X	Medium
13	2.1	Develop project category priorities for hazard mitigation funding administered by the State regardless of funding source, and then design consistent evaluation criteria to be used during application reviews for various programs as required (i.e., HMGP Administrative Plan), recognizing there will be differences in program eligibility, etc.	DESPP / Emergency Management & Homeland Security / CT Interagency Hazard Mitigation Committee	DAS / Division of Construction Services / DEEP / DOH	Staff time	Agency Operating Budgets	Annually and post-disaster, whichever is more frequent	X	X	X	X	X	X	X	X	X	X	Medium

14	2.1	Through communications with other state agencies and communities with FEMA-approved Natural Hazard Mitigation Plans, develop a list of potential mitigation projects that can be maintained and assessed for further development upon availability of funding sources. This will also help assist in future NHMP planning by identifying when areas and facilities of concern exist, and developing metrics ahead of time.	DESPP / Emergency Management & Homeland Security	DAS / Division of Construction Services / DOH / COGs	Staff time	Agency Operating Budgets	Annually and post-disaster, whichever is more frequent, and routinely during plan reviews	X	X	X	X	X	X	X	X	X	X	High
15	2.2	Acquire and install emergency backup generators and/or renewables and alternate energy sources at state-owned critical facilities and gas stations.	DAS / Division of Construction Services	DEEP / OPM / Department of Consumer Protection / DOT	<$75k/ generator	FEMA (HMGP)	5 years	X	X	X	X	X	X	X	X	X	X	Medium
16	2.2	Conduct phragmites control/invasive plant control (herbicide and mowing) on state-owned land tidal and freshwater marshes to reduce fuel load and wildfire risk in tidal areas for three year period to control this invasive species. Reduce phragmites by 50% in year one; 40% in year two; 10% in year three with 100% reduction after three years.	DEEP / Bureau of Natural Resources	DAS / Division of Construction Services / DOT	$600/acre Total estimated cost is $2.7 million over three years	Annual Operating Budgets	3 years							X				Low
17	2.3	Continue to direct communities to tools to support improved local vulnerability and risk assessments to support hazard mitigation planning and the development of fundable hazard mitigation projects including RL and SRL acquisitions. Build on successful delivery of online Adaptation Resource Toolkit (ART) and maintain related training workshops.	DESPP / Emergency Management & Homeland Security	DEEP / Inland Water Resources / Flood Management Section and Office of Long Island Sound Programs	Staff time	Agency Operating Budgets, Federal Grants	1-3 years	X	X	X	X	X	X	X	X	X	X	Medium
18	2.3	Convene a forum of state agencies to coordinate and evaluate gaps in policies and in climatalogical data, to establish priorities, and to identify strategies to secure funding for necessary enhancements. This activity is linked to Activity #10.	SAFR	DEEP / Inland Water Resources, Water Planning Council / CIRCA	Staff time	Agency Operating Budgets	1 year	X	X	X	X	X	X	X	X		X	Medium

19	2.3	Promote the capture and use of hydrologic monitoring data for improved Benefit-Cost Analysis (BCA) model population at the state and local level (e.g. high water marks, gauge data, historical damages from all events, recurrence intervals, etc.). Also, expand efforts to include similar data for other hazards, and include the quantification of environmental benefits (according to FEMA Mitigation Policy #FP-108-024-01) to increase Benefit to Cost Ratios for eligible projects.	DESPP / Emergency Management & Homeland Security	USGS / DEEP	Staff Time	Agency Operating Budgets	Annually, or, as data becomes available and in conjunction with BCA reviews					X						Medium
20	2.3	Assist owners/operators of critical facilities, such as municipal water pollution control facilities (WPCFs), and emergency facilities, to pursue grant funds to relocate, flood proof, or otherwise protect electrical and mechanical systems to minimize or eliminate service disruption during and after potential hazard events.	DEEP- Land and Water Resources Division	Municipalities / COGs	Staff time	Agency Operating Budgets	Conduct outreach on an annual basis, and incorporate into all notifications of funding availability	X			X	X					X	High
21	2.4	Create a central repository and web-based portal dedicated to identifying and procuring funding from all available sources. This activity is linked to Activity #17 and Activity #22.	Governor's Office / OPM	LTR Committee	Staff time	Agency Operating Budgets	1 year	X	X	X	X	X	X	X	X	X	X	Low
22	2.4	Through working with the CT IHMP Planning Team, develop a list of potential funding sources available on a state and federal level for natural hazards mitigation planning activities and projects with emphasis on RL and SRL properties. This activity is linked to Activity #21.	DESPP / Emergency Management & Homeland Security	DEEP / Inland Water Resources / Flood Management Section / OLISP / DOT	Staff time	Agency Operating Budgets	1 year	X	X	X	X	X	X	X	X	X	X	Low

23	2.4	Assist communities and state agencies to pursue funding opportunities to develop advanced research and plans in the area of natural hazards mitigation. Planning activities included under this section would be: standalone plans which can assist in enhancing existing Natural Hazards Mitigation Plans (e.g., debris management plans, evacuation and sheltering plans, hazards studies and evaluations (including recommendations) which are not part of existing approved plans).	DESPP / DEMHS	DEEP / Office of Long Island Sound Programs	Staff time	Agency Operating Budgets	1-3 years, in sync with review or EM and MT plans, and during CAVs, workshops and other outreach activities	X	X	X	X	X	X	X	X	X	X	Low
24	2.4	Encourage communities to pursue funding opportunities to develop FEMA approved Natural Hazards Mitigation Plans which promote addressing RL and SRL properties as well as the integration of climate adaptation strategies with conventional hazard mitigation techniques.	DEEP	DESPP / Emergency Management & Homeland Security; DEEP / Office of Long Island Sound Programs	Staff time	Agency Operating Budgets	1-5 years as plan updates are completed and reviewed	X	X	X	X	X	X	X	X	X	X	High
25	2.5	Maintain a tracking system of submitted FEMA grant project/planning applications, to help analyze the types of projects and the mitigation needs that continue to exist within the State.	DESPP / Emergency Management & Homeland Security		$60-80k	FEMA (HMGP)	1-2 years	X	X	X	X	X	X	X	X	X	X	Low
26	2.5	Develop an evaluation process and implement said process to measure the results from the implementation of various activities as listed in the State NHMP.	DEEP / SAFR / CIRCA	DESPP / DEMHS	Staff time	Agency Operating Budgets	1 year	X	X	X	X	X	X	X	X	X	X	Low
27	3.1	Continue planning and development of a database to assist with the storage and maintenance of risk and hazard information from local and multi-jurisdictional hazard mitigation plans.	DEEP / OPM	CIRCA / COGs	Staff time	Agency Operating Budgets	1-5 years, with annual assessment during plan monitoring	X	X	X	X	X	X	X	X	X	X	Low

28	3.1	Encourage municipalities and COGs to conduct watershed-based hydrologic and hydraulic studies to evaluate potential flood mitigation alternatives along river and stream corridors.	DEEP- Land and Water Resources Division	University pf Connecticut / COGs	Staff time	State Bond Funds or other sources – although funding for implementation will have to be sought	1-5 years					X						Low
29	3.1	Develop a system to facilitate the rapid capture, delivery, and documentation of post-storm impacts to coastal areas by local teams and citizens in the field and develop an interactive webpage or other medium for collecting flood information from the general public or other entities. This would include photos and other types of information which would be a valuable asset in documenting impacts from natural hazards, collected through various means such as social networking. Use the latest technology, such as iPads and community GIS, to support these initiatives.	DEMHS	DEEP / Inland Water Resources / Flood Management Section; DESPP / Emergency Management & Homeland Security	Staff time	Agency Operating Budgets	2 years	X			X	X					X	Medium
30	3.1	Upon completion of DOT's systems-level vulnerability assessment in support of the Climate Change and Extreme Weather pilot project in Litchfield County, repeat the process in the remainder of the state. This activity is linked to Activity #32.	DOT	HUA / Uconn	High	FHWA	5 years			X		X					X	Low
31	3.1	Increase hydrologic monitoring in the state relative to precipitation, surface groundwater, and tidal gauges to enhance the statewide data collection effort and improve long term trend analysis for climate change assessments, predictive modeling and hazard mitigation. Communicate with USGS to maintain monitoring stations. This activity is linked with Activity #35.	CIRCA	U.S.G.S	High	Legislative Appropriation	5 years					X			X		X	Low

32	3.1	Develop updated/improved storm surge hazard modeling to supplement sea level rise inundation scenarios. Share this modeling with state agencies and municipalities.	CIRCA	DESPP / Emergency Management & Homeland Security; DEEP – Land and Water Resources Division	Staff time	Agency Operating Budgets $1 Million for Study $300K?	3 years	X			X							Medium
33	3.1	Use shoreline transect data to map coastal erosion zones and develop applicable outreach products.	DEEP		Staff time	Agency Operating Budgets	3 years					X					X	Low
34	3.1	Continue to identify head-of-tide habitat within Connecticut and monitor the change in this habitat due to climate change through sentinel monitoring in order to determine those communities that may endure increased risk from coastal storms and associated flooding. LWRD is currently funding multiple monitoring and data synthesis projects in support of this activity.	DEEP - Land and Water Resources Division – Coastal Resources Section		Staff time	Agency Operating Budgets	1-2 years					X					X	Low
35	3.1	Identify and map the locations of headwater, main stem and coastal dams, culverts, bridges, and other structures or land modifications that contribute to flood damage and act as barriers to habitat connectivity, and assess the feasibility of removal or modification of these structures. This activity is linked to Activity #55.	DEEP - Land and Water Resources Division		Staff time	Agency Operating Budgets	3 years					X						Medium
36	3.1	Create a database of survey elevation points in coastal areas.	DOT		Medium	Agency Operating Budgets	3 years	X				X					X	Medium
37	3.2	Create a literature review of various FEMA publications to be placed on CT DEEP's flood management webpage. Include a short description of the publication and a direct link for convenient downloading of the document, or a note to contact CT DEEP's Flood Management Section to obtain a copy.	DEEP - Land and Water Resources Division	DEMHS	Staff time	Agency Operating Budgets	3-5 years					X					X	Low

38	3.2	Finalize StormSmart Coasts CT site and perform outreach to encourage use by local communities and others to reduce risk.	DEEP - Land and Water Resources Division		Staff time	Agency Operating Budgets	2 years	X			X	X					X	Low
39	3.3	In coordination with local communities, recommend categorical (e.g., wastewater, energy) and site-specific options for adaptation from the projected impacts of climate change and occurrence of natural hazards for public infrastructure (including flood protection structures). Adaptation and hazard mitigation alternatives should include the estimated costs associated with the options evaluated to be the most viable for implementation purposes.	DEEP - Land and Water Resources Division	OPM	Staff time	Agency Operating Budgets	2-5 years					X			X		X	Low
40	3.3	Encourage education and community participation in adaptation, low impact development, and flood management through existing networks and partnerships including the CT Climate Education Communication Committee. This includes coordinating LWRD's coastal community adaptation and risk mitigation work with educational place based student experiences through CT Green Leaf in K-12 to increase participation and maximize local solutions.	DEEP - Land and Water Resources Division	CT Green LEAF	Staff time	Agency Operating Budgets	1-3 years	X			X	X					X	Low
41	3.4	Develop and deliver Micro-grid Pilot Program Trainings.	DEEP / Bureau of Energy and Technology	Utilities	$25,000	Microgrid Grant and Loan Pilot Program; participating electric utilities	2 years	X	X	X	X							Medium
42	3.4	Coordinate with water utilities to more actively promote water conservation measures with their customers, especially now that new legislation allows them to recover revenue while encouraging conservation.	DPH / Drinking Water Section	Water Planning Council	Staff time	Agency Operating Budgets	Annually, but particularly during drought conditions or other water emergencies								X			Medium

43	1.1 1.4 2.1 2.2 2.3 3.3	Local School Construction Grant Program and School Safety Infrastructure Council: • Identify and assess existing public school facilities that could be impacted by natural hazards (including climate change). Correlate identified schools with the School Building Project Priority Lists; identify mitigation strategies for these projects early on in the grant process. • For new grants involving siting a new school, provide and encourage the use of an interactive web based mapping portal for local school districts to use during site selection. Encourage early coordination with DAS Environmental Planning and GIS Services Unit. • Should facilities be located within natural hazard areas, request an assessment of "no feasible or prudent alternative;" encourage higher design standards above minimum criteria for new schools or "renovated as new." • Identify long-term climate change adaptation strategies for each structure/facility.	DAS / Office of School Facilities	DEEP / LWRD/ Flood Management Section	Staff time	Agency Operating Budgets	1-5 years		X		X	X	X				X	Medium

44	1.1 1.4 2.1 2.2 2.3 3.3	Sustainable State Facilities Initiative: • Identify, develop, and prioritize a plan for state facilities' potentially impacted by natural hazards (including climate change) • Assess the risks in relation to the physical structures, the agency's long-term capital planning plans, building life span, etc. • Develop specific mitigation strategies for each structure/facility as part of the plan utilizing existing hazard data, identify timeframe for implementing the strategies, and include estimated mitigation costs. • Identify long-term climate change adaptation strategies for each structure/facility.	DAS / Environmental Planning & GIS Services Unit		Staff time	Agency Operating Budgets	1-5 years		X		X	X	X				X	High
45	1.1 1.3 1.4 2.2 2.3 3.1 3.3	Conduct geophysical research to investigate, classify, and map soil stability and susceptibility to liquefaction during seismic events to assist with future hazard mitigation planning efforts.	DEEP / Geological Survey	USGS	$~50K/yr for 3 years	FEMA (NEHRP)	3 years from support received, with annual progress reporting					X			X	X		Medium
46	1.3 1.4 2.2 2.3 3.1 3.2 3.3	Improve identification of escarpments susceptible to landslide and fluvial erosion risk, utilizing geologic, soils, and elevation data. This activity will provide improved landslide and mass wasting risk estimates, to produce a more comprehensive view of landscape stability during extreme weather events and subsequent impacts.	DEEP / Geological Survey	USDA / Natural Resources Conservation Service	$40-50K	USDA, FEMA	2 years from support received, with annual progress reporting					X			X	X	X	Medium

47	1.1 3.1	Identify and map extent of historic underground mining operations in the State; assess reclamation and current land use relative to risk of land subsidence and mine collapse for the estimated 23 historic underground mining operations in Connecticut. Project deliverables will include georeferenced site maps and assessment reports, as well as a summary of current conditions and potential ground collapse hazards in these areas.	DEEP / Geological Survey	Office of the State Archeologist; State Historic Preservation	$40k	Agency Operating Budgets	12-18 months, contingent on funding and resource availability					X			X	X	X	Low
48	1.1 1.2	Promote consumer awareness of the NFIP and private flood insurance in order to mitigate against the economic impact of natural hazards.	Insurance Department		Staff Time	Agency Operating Budgets	1 year					X						Low
49	2.3 3.2 3.5	Compile recent plans that include independent climate change assessments (State Water Plan [Water Planning Council] and Drinking Water Vulnerability Assessment and Resiliency Plan [CIRCA/UConn/CT DPH]) and then use the combined resources to support the action items within those plans.	SAFR	DPH / Water	Staff Time	Agency Operating Budgets	Ongoing	X	X	X	X	X	X	X	X		X	Low
50	1.1 3.1	Evaluate slope failure, soil erosion potential, and escarpment identification hazards in Connecticut through integrated mapping.	DEEP / State Geological Society		$40k	Agency Operating Budgets	1 year					X					X	Medium
51	2.6	Support New England Seismic Network with a new technical assistance and maintenance agreement with Weston Observatory of Boston College. This will provide local expertise and rapid response to seismic events in CT.	DEEP / State Geological Society		$45k for five years	NESEC	5 years									X		Low
52	1.4 2.6 3.1	Integrate mitigation plan requirements and actions into other appropriate planning mechanisms such as comprehensive plans and capital improvement plans.	OPM	DESPP / DEMHS	Staff Time	Agency Operating Budgets	Annually	X	X	X	X	X	X	X	X	X	X	High

53	1.1 3.1	Support mitigation projects that will result in protection of public or private property from natural hazards. Eligible projects include but are not limited to: 1. Acquisition of flood prone property 2. Elevation of flood prone structures 3. Minor structural flood control projects 4. Relocation of structures from hazard prone areas 5. Retrofitting of existing buildings, facilities, and infrastructure 6. Retrofitting of existing building and facilities for shelter 7. Critical infrastructure protection measures 8. Stormwater management improvements 9. Advanced warning systems and hazard gauging systems (weather radios, reverse-911, stream gauges, I-flows) 10. Targeted hazard education 11. Wastewater and water supply system hardening and mitigation.	CT Interagency Hazard Mitigation Committee / DESPP/DEMHS / DEEP	DCS	Staff Time	Agency Operating Budgets	Annually	X	X	X	X	X	X	X	X	X	X	High
54	1.2 2.4 3.1	Seek funding in order to conduct a survey of historic and cultural resources, to better understand their vulnerability to natural hazards.	DECD-SHPO		Staff Time	Agency Operating Budgets	3-years					X					X	Medium
55	1.2 2.2 3.2	Undertake a targeted outreach of owners of historic resources and properties, to reduce the vulnerability of these assets to natural hazards.	DECD-SHPO		Staff Time	Agency Operating Budgets	3-years					X					X	Low
56	1.2 1.3 3.4	Conduct outreach to business owners in order to increase resilience and reduce the threat of contamination and pollution release during flooding events, as well as increase continuity of business operations after a hazard event.	DEEP - Pollution Prevention	DESPP/ DEMHS / REPTS	Staff Time	Agency Operating Budgets	1 year	X		X		X	X				X	Medium
57	1.2 1.3 3.4	Encourage COGs and Municipalities to identify and businesses at risk from natural hazards, and include consideration of business resilience in all initiatives. This will reduce the threat of contamination and pollution release during flooding events, as well as increase continuity of business operations after a hazard event.	DEEP - Pollution Prevention	DESPP/ DEMHS / COGs	Staff Time	Agency Operating Budgets	Annually	X		X		X	X				X	Medium

58	1.3 2.2 2.4	Through the recently institutionalized Silver Jackets initiative, identify at least one to two projects for funding annually in coordination with all members.	DESPP/ DEMHS / USACE	DEEP	Staff Time	Agency Operating Budgets/ USACE	Annually	X	X	X	X	X	X	X	X	X	X	Medium
59	1.3	Increase support of the State-level Cultural and Natural Resources Initiative to increase resiliency of cultural and natural resources from disasters. - expand SHPO resilience project completed in 2018 to Northern 4 Counties.	DECD-SHPO	DEEP	Staff Time	Agency Operating Budgets/ Disaster Supplemental s / CIRCA	3-years	X	X	X	X	X	X	X	X	X	X	Medium
60	1.3	Develop standards for building nature-based solutions. This activity is linked to Activity #26.	DAS / DEEP		Staff Time	Agency Operating Budgets	5-years	X	X	X	X	X	X	X	X	X	X	Low
61	1.3	Integrate considerations of Public Health into all resilience planning and emergency response. Examples of considerations include drinking water access, widespread contamination and pollution post-natural hazard event, and debris management by municipalities.	DPH / DESPP/ DEMHS	DOT / DPW	Staff Time	Agency Operating Budgets	Annually	X	X	X	X	X	X	X	X	X	X	Medium
62	1.2 1.3 1.4	Evaluate and improve CT emergency response planning. Considerations should include improvement of rapid communication regarding extreme events (with coordination with organizations such as NWS), quickly reopening blocked roads and evacuation routes, efficient and safe transportation to shelters, use of resilient corridors. Ensure effective winter storm management, including snow removal and salt use. Focus on vulnerable populations in all emergency response planning.	DESPP/ DEMHS / DPW / DOT	NWS	Staff Time	Agency Operating Budgets	Annually	X	X	X	X	X	X	X	X	X	X	Medium

63	1.4 3.1	Update all state and local plans relating to hazard mitigation planning and resilience. Incorporate the latest data on hazards, climate change, land use, build environment, etc. Includes plans such as the CT Climate Preparedness Plan and the State Data Plan.	DESPP/ DEMHS / DEEP / Connecticut Data Analysis Technology Advisory Board	DPW / DOT	Staff Time	Agency Operating Budgets, HMA	Annually	X	X	X	X	X	X	X	X	X	X	High
64	3.1	Bedrock fracture mapping in the Plainfield and Danielson area to better characterize the subsurface nature of the geology in the area of recent Eastern CT seismic swarm.	DEEP / State Geological Society		$40K	USGS National Cooperative Geologic Mapping Program, NEHRP	1 year, from onset of funding									X		Low
65	3.1	Depth of unconsolidated materials mapping from LIDAR digital elevation models (depth to bedrock)	DEEP / State Geological Society		$45k per year, for 3 years	FEMA, USGS, NESEC	3 years, from onset of funding									X		Low

5.8 Progress in Hazard Mitigation Activities from 2014–2019

Table 5-2 provides a summary of the progress and current status of those hazard mitigation activities included in the previous (2014) plan. This includes activities which have been carried over for implementation in 2019-2024, as noted in the table under "Current Status." A list of other past activities pursued for natural hazard mitigation by the State and local communities can be found in Appendix 5-3.

Table 5-2 includes the following information for each hazard mitigation activity:

1. **Activity #:** Identifies the unique number for the activity, with the first two digits correlating to the specific Goal and Strategy the activity was intended to help achieve from the 2014 plan.
1. **Activity Description:** Provides a narrative description of the mitigation activity from the 2014 plan.
2. **Lead Agency:** Identifies the lead department assigned with primary responsibility for implementation of the activity.
3. **Current Status:** Describes the current implementation status of the activity, including whether the action was completed, completed/to be continued, partially completed/in progress, deferred, deleted, or deemed an ongoing/continuous activity.
4. **Current Status Description:** Provides a narrative description of the implementation status in 2018.
5. **Priority Level:** Identifies the priority level (i.e., high, medium, low) assigned to the activity, based on the STAPLE-E evaluation and prioritization process completed for the 2014 plan.
6. **Carry Over?**: Identifies whether the activity is to be carried over from the 2014 plan to the 2019 plan.
7. **2014 Activity #:** For those activities to be carried over and/or integrated with an activity for implementation in 2019-2024, identifies the Activity # as listed within Table 5-1.
8. It is important to note that some previous activities, while they may be continued, have been moved to Chapter 3 (Capabilities Assessment) because they are more appropriately considered ongoing program activities. These activities have been highlighted with light gray shading. Any previous activities which have been deleted since the 2014 plan are highlighted in dark gray shading.

Table 5-2: Progress in Hazard Mitigation Activities, 2014–2019

2014 Activity #	Activity Description	Lead Agency	Current Status	Current Status Description	2014 Priority Level	Carry Over	2019 Activity Number
1	Review model ordinances and samples of higher standards language that communities can adopt into existing floodplain ordinances.	DEEP - Land and Water Resources Division	Partially Completed, Continue	Done – SB-9 – passed both chambers SB-7, new climate and sea level rise standards Keep in as a review annually New legislation should not affect this annual activity	High	Yes	1
2	Conduct technical transfer and training associated with current extreme rainfall data.	USDA / Natural Resources Conservation Service	Partially Completed, Continue	Transfer and Training will continues as better data becomes available/evolves	Medium	Yes	2
3	Conduct technical transfer and training associated with available LiDAR data.	USDA / Natural Resources Conservation Service	Partially Completed, Continue	Transfer and Training will continues as better data becomes available/evolves	Medium	Yes	3
4	Encourage municipalities to adopt local water use restriction ordinances to ensure that proper water conservation measures are implemented during periods of severe to extreme drought and other water emergencies, in line with the Connecticut Drought Preparedness and Response Plan.	DPH / Drinking Water Section	Partially Completed, Continue	This has been partially completed with respect to encouraging municipalities to do this. However, only some have been receptive. Greenwich, Stamford, Darien, and New Canaan were required by DPH to adopt ordinances during the 2015-2016 drought. Other towns such as Simsbury have attempted to adopt ordinances voluntarily. Note that the Connecticut Drought Preparedness and Response Plan has been under revision for several years. It is now in final review and will be adopted in early 2019.	High	Yes	4

5	Launch an outreach campaign to promote FEMA's Community Rating System (CRS) as a means for local communities to soften the likely increase in many flood insurance policy rates resulting from new reforms to the National Flood Insurance Program (NFIP) enacted by the Biggert-Waters Flood Insurance Reform Act of 2012 (BW-12).	DEEP - Land and Water Resources Division	Partially Completed, Continue	Underway. WestCOG and SCCOG have received grants to assist their communities. CIRCA is looking at providing funding for other communities to assist with joining CRS. There was a training June 4-7, 2018. This was initiated in 2018 with the support of DEEP of efforts by SCCOG, WestCOG; CAFM with the presentation of EMI's CRS course for community officials; and working with RiverCOG on a CRS initiative that focuses on affiliated communities and open space. DEEP and CAFM have also sponsored trainings on topics associated with CRS including elevation certificate workshop (July 2019); and DEEP has been promoting CRS when performing CAVs and CACs.	Medium	Yes	5
6	Encourage local hazard mitigation plans to consider continuity of agricultural operations during and following hazard events.	DESPP / Emergency Management and Homeland Security	Deferred	No action has been completed.	Medium	Yes	6
7	Communicate the importance of natural hazard mitigation to agricultural producers through the Department of Agriculture's weekly newsletter. This would consist of articles with links to useful websites such as DEEP and "ReadyAg" (available from PSU website).	DAG / Bureau of Agricultural Development & Resource Preservation	Deferred	No action has been completed.	High	Yes	7
8	Develop a body of customizable presentations, social media templates, Flood Insurance factsheets and short workshop educational materials that could be utilized on a scheduled basis. While these could be developed for multiple hazards, the emphasis of this activity is on flood mitigation and climate change adaptation.	Connecticut Association of Flood Managers DEEP - Land and Water Resources Division	Partially Completed, Continue	There has been a lot of training activity but no "canned" presentations. Refresh as a new strategy, adding social media, DOI, docs about flood insurance moon shot and other areas, keep in as deferred. Add in coordination with CAFM DEEP has a set of presentations which are available for presentations. However, additional work needs to be done to ensure all information in said presentations are current and all presentations are located in one main presentation folder on LWRD's shared drive (internal computer drive).	High	Yes	8
9	Investigate the possibility of holding the CFM exam on an annual basis for interested persons.	Connecticut Association of Flood Managers	Partially Completed, Continue	CFM Exams have been offered multiple times since 2014. Changed to do annually, and changed responsible party to CAFM with support from DEEP LWRD	High	Yes	9

10	Investigate the possibility of holding an annual short CFM refresher course for interested persons who desire to take the CFM exam.	Connecticut Association of Flood Managers	Partially Completed, Continue	CFM refreshers have been offered since 2014. Changed to do annually, and changed responsible party to CAFM with support from DEEP LWRD. This activity will be combined with Activity #9 in the 2019 Activities for efficiency.	Medium to High	No	N/A
11	Develop educational materials on successful hazard mitigation projects, and integrate these with other readily available online resources such as StormSmart Coasts, etc.	DESPP / Emergency Management & Homeland Security	Cancelled	During the May 9, 2018 meeting, the committee determined that this should be dropped. However, the CRCOG HMP Update (underway) is including eight fact sheets on successful mitigation projects. These can be used by DEMHS and DEEP.	Medium to High	No	N/A
12	Investigate the development of a series of training media products that introduce, explain, and train interested persons on natural hazards, mitigation, NFIP program, reading flood maps, federal-state grant programs and other related issues	DEEP - Land and Water Resources Division	Cancelled	Deleted and replaced with a new strategy in the 2019 update, to be led by the Insurance Dept. New strategy designed to promote consumer awareness of flood and other insurance.	High	No	N/A
13	Develop educational tools to inform decision makers on the value of acquiring, maintaining, and increasing climatological data collection, including hydrologic (e.g. stream gage) data, and the continuation of OLISP's sentinel monitoring program to help provide early warning of climate change impacts. This activity is linked to Activity #28.	CHMC and Water Planning Council	Partially Completed, Continue	While not completed formally as described, action toward this activity is underway and it will be carried forward.	High	Yes	10
14	Develop regulations and implementation guidance, and public outreach materials, for new legislation requiring inundation maps and Emergency Action Plans (EAPs) for high and significant hazard dams.	DEEP Water Planning and Management Division - Dam Safety Section	Completed	Completed – Regulations and webinar trainings.	High	No	N/A

15	Continue to improve on Statewide Repetitive Loss and Severe Repetitive Loss Strategy to mitigate and reduce the number of repetitive loss properties. As noted on pages 155-156 of this plan, CT will do the following: − Seek Federal funds to mitigate through elevation and acquisition, RL and SRL properties − Encourage sub applicants to prioritize RL and SRL properties − As grantee, give priority to RL and SRL properties − When BCAs of RL and SRL property applications are even, priority ranking will be given to RL and SRL properties − Identify outside funding for mitigating RL and SRL properties − Continue to advocate for NRCS and State Bond Funding for mitigating RL and SRL properties	DESPP / Emergency Management & Homeland Security	Partially Completed, Continue	All of the bulleted items are advanced each year.	High	Yes	11
16	Based on future forecast modeling for increased precipitation, storminess, and sea level rise, develop and propose policies to reduce risks for new development, including consideration towards relocating structures or reducing existing hazards within inundation areas with increasing risk. Policies should also address appropriate use of federal and state mitigation monies.	CIRCA	Completed	CIRCA and DOH provided grants to RiverGOG for completion of a statistical flood susceptibility model. Refinements are being considered. SHPO completed a project with Disaster Supplemental funding to look at the impact of SLR (among other things on Historic and Cultural Resources. Also, SB-9 outlines new climate and sea level rise standards and new requirements for State and federally-funded (State pass-through) projects in CT	Medium	No	N/A
17	Identify partners to help complete acquisition of LiDAR (processed to 1' contours or better) for 100% state coverage.	CLEAR	Completed	There is now 100% state coverage.	Medium	No	N/A
18	Support the State-level Cultural and Natural Resources Recovery Function to increase resiliency of cultural and natural resources from disasters.	DECD-SHPO	Completed	DECD-SHPO completed a project to identify at risk historic and cultural resources to flooding, SLR, winter weather, and wind for the four coastal counties. It included a digital inventory of resources, best practices and incorporation of natural hazards resilience into the State Historic Preservation Plan. A new strategy has been added to build upon this project.	High	No	N/A

19	Implement and institutionalize a coordination program similar to the USACE's "Silver Jackets" between all federal and state agencies, including: NRCS, FEMA, USACE, Long Term Recovery Committee, Natural and Cultural Resources task force, etc.	DESPP	Completed	Completed. New activity added to identify a new project annually with DESPP as lead. The DESPP/DEMHS FY 2019 Silver Jackets application for ICE JAM workshops along the Connecticut and Housatonic Rivers was awarded. The NHMPT will serve as the CT Ice Jam committee and we plan to pursue future (annual) SJ applications.	Medium	No	N/A
20	Support and implement State-level Hurricane Sandy Supplemental Funding "Implementation Strategy" to facilitate interagency coordination between state and federal agencies.	LTR Committee	Completed	Strategy completed and implemented.	High	No	N/A
21	Develop implementation strategy for Public Act 13-15, which requires consideration of the ways in which a water pollution control project mitigates the effects of sea level rise. The Act also requires that the list of priority water quality projects include the necessity and feasibility of implementing measures designed to mitigate the impact of a rise in sea level over the projected life span of such project.	DEEP Municipal Water Pollution Control Section	Deferred	Unknown, follow-up with Denise R..	High	Yes	12
22	Develop project category priorities for hazard mitigation funding administered by the State regardless of funding source, and then design consistent evaluation criteria to be used during application reviews for various programs as required (i.e., HMGP Administrative Plan), recognizing there will be differences in program eligibility, etc.	DESPP / Emergency Management & Homeland Security	Partially Completed, Continue	This is a continuous refinement process and is re-evaluated annually	High	Yes	13
23	Through communications with other state agencies and communities with FEMA-approved Natural Hazard Mitigation Plans, develop a list of potential mitigation projects that can be maintained and assessed for further development upon availability of funding sources. This will also help assist in future NHMP planning by identifying when areas and facilities of concern exist.	DESPP / Emergency Management & Homeland Security	Partially Completed, Continue	This is a continuous refinement process and is re-evaluated annually	Medium	Yes	14
24	Investigate the opportunity for FEMA to re-calculate the Cost/Benefit Analysis used in grant applications such that relocation of homes outside of floodplains is more frequently feasible in the context of hazard mitigation projects.	DESPP	Cancelled	Removed as unrealistic. Consider changing to a strategy to provide more BCA training to subapplicants statewide, and replace lead agency since DEEP no longer administers UHMA grants.	Medium	No	N/A

25	Acquire and install emergency backup generators and/or renewables and alternate energy sources at state-owned critical facilities.	DAS / Division of Construction Services	Partially Completed, Continue	This is a continuous process, additional language has been added to the strategy to focus on micro-grids and other alternative energy sources.	High	Yes	15
26	Conduct phragmites control/invasive plant control (herbicide and mowing) on state-owned land tidal and freshwater marshes to reduce fuel load and wildfire risk in tidal areas for three year period to control this invasive species. Reduce phragmites by 50% in year one; 40% in year two; 10% in year three with 100% reduction after three years.	DEEP / Bureau of Natural Resources	Partially Completed, in progress	Ongoing, but haven't met goals. Carried this activity over to the 2019 activities, and reworded to "reducing", rather than "eliminating".	High	Yes	16
27	Continue to provide communities with tools to support improved local vulnerability and risk assessments to support hazard mitigation planning and the development of fundable hazard mitigation projects including RL and SRL acquisitions. Build on successful delivery of online Adaptation Resource Toolkit (ART) and related training workshops.	DESPP / Emergency Management & Homeland Security	Partially Completed, in progress	In progress and continued annually.	High	Yes	17
28	Convene a forum of state agencies to coordinate assess and evaluate gaps in climatalogical data, to establish priorities, and to identify strategies to secure funding for necessary enhancements. This activity is linked to Activities #13 and #39.	DPH	Partially Completed, in progress	There is coordination between CIRCA, DEEP and DESPP, but the action is not complete	High	Yes	18
29	Promote the capture and use of hydrologic monitoring data for improved Benefit-Cost Analysis (BCA) model population at the state and local level (e.g. high water marks, gage data, historical damages from all events, recurrence intervals, etc.). Also, expand efforts to include similar data for other hazards, and include the quantification of environmental benefits (according to FEMA Mitigation Policy #FP-108-024-01) to increase Benefit to Cost Ratios for eligible projects.	DESPP / Emergency Management & Homeland Security	Deferred	No action has been completed.	High	Yes	19
30	Encourage owners/operators of critical facilities, such as municipal water pollution control facilities (WPCFs), to pursue grant funds to elevate, relocate, flood proof, or otherwise protect electrical and mechanical systems to minimize or eliminate service disruption during and after potential hazard events.	DEEP- Land and Water Resources Division	Partially Completed, Continue	In process, needs to continue. Performed on an annual basis and during the performance of CAVs and CACs.	Medium	Yes	20
31	Create a central repository and web-based portal dedicated to identifying and procuring funding from all available sources. This activity is linked to Activity #33.	Governor's Office	Partially Completed, Continue	Continuous improvements ongoing. Re-assigned to OPM as lead.	High	Yes	21

32	Upon completion of DOT's systems-level vulnerability assessment in support of the Climate Change and Extreme Weather pilot project, allocate funds for increasing capacities of selected culverts in state roads. This activity is linked to Activity #44.	DOT	Completed	Completed.	Medium to High	No	N/A
33	Through working with the State NHMP Planning Team, develop a list of potential funding sources available on a state and federal level for natural hazards mitigation planning activities and projects with emphasis on RL and SRL properties. This activity is linked to Activity #31.	DESPP / Emergency Management & Homeland Security	Partially Completed, Continue	Partially complete (for example, in West Haven) but needs to continue.	Medium	Yes	22
34	Encourage communities and state agencies to pursue funding opportunities to develop advanced research and plans in the area of natural hazards mitigation. Planning activities included under this section would be: standalone plans which can assist in enhancing existing Natural Hazards Mitigation Plans (e.g., debris management plans, evacuation and sheltering plans, hazards studies and evaluations (including recommendations) which are not part of existing approved plans).	DEMHS	Partially Completed, Continue	Done on an annual basis and needs to continue.	Medium to High	Yes	23
35	Develop a State Climate Change Science plan to measure the rate of climate change including sea level rise, evapotranspiration increase, etc. as being tracked through OLISP's sentinel monitoring program, to support climate change adaptation planning and transportation Natural Hazards Mitigation Planning activities and research. Specific tasks include (1) consolidating climatological and ecological data which could be done by OLISP/WPC/USGS/UCONN; and 2) secure and leverage funding for enhanced Sentinel Monitoring for Climate Change program and development of a State Climate Science Plan which should be DEEP and UCONN. This activity is linked with Activity #45.	CIRCA	Completed	CIRCA Grants Annually – Completed. Not likely to continue in the future. A replacement action was added to the plan update (Table 5-1). Compile recent plans that include independent climate change assessments (State Water Plan [Water Planning Council] and Drinking Water Vulnerability Assessment and Resiliency Plan [CIRCA/UConn/CT DPH]) and then use the combined resources to support the individual activities listed in this action. Also, this could be advanced through the NDRC-funded Connecticut Coastal Communities Resilience Plan (2018-2022)	High	No	N/A
36	Encourage communities to pursue funding opportunities to develop FEMA approved Natural Hazards Mitigation Plans which promote addressing RL and SRL properties as well as the integration of climate adaptation strategies with conventional hazard mitigation techniques.	DESP	Partially Completed/ Continue	This is completed on an annual basis. Climate change is now required in NHMP updates and reviews assure the Rep. Loss strategies are always addressed.	High	Yes	24

37	Maintain a tracking system of submitted FEMA grant project/planning applications, to help analyze the types of projects and the mitigation needs that continue to exist within the State.	DESPP / Emergency Management & Homeland Security	Partially Completed, Continue	Ongoing activity.	Medium	Yes	25
38	Develop an evaluation process and implement said process to measure the results from the implementation of various activities as listed in the State NHMP.	DESPP/DEMHS	Deferred	No action has been completed.	Medium	Yes	26
39	Pursue Federal funding to establish additional stream gauges for flood and drought planning purposes. This activity is linked to Activity #28.	DEEP	Cancelled	Deleted – due to significant resource and staff reductions this activity is extremely unlikely to be pursued over the next planning period.	Medium to High	No	N/A
40	Continue planning and development of a database to assist with the storage and maintenance of risk and hazard information from local and multi-jurisdictional hazard mitigation plans.	DEMHS	Deferred	No action has been completed.	Medium	Yes	27
41	Encourage municipalities to conduct watershed-based hydrologic and hydraulic studies to evaluate potential flood mitigation alternatives along river and stream corridors.	DEEP- Land and Water Resources Division	Partially Completed, Continue	Some progress completed under Risk MAP. Meriden HUB and RiverCOG Flood Susceptibility Model are examples of non RiskMAP projects of this nature completed since 2014. Pursued through RiskMAP projects. There is also a USGS model that performs such studies for communities.	Medium	Yes	28
42	Investigate actions of other states with regards to the develop of an interactive webpage or other medium for collecting flood information from the general public or other entities which would include photos and other types of information which would be a valuable asset in documenting impacts from natural hazards. This information can be utilized to support reporting damages to FEMA in a more efficient time frame, in combination with other available sources including but not limited to the StormSmart CHAMP and Connecticut StormReporter websites.	DEEP- Land and Water Resources Division	Cancelled	Duplicative with Activity #43	Medium to High	No	N/A

43	Develop a system to facilitate the rapid capture, delivery, and documentation of post-storm impacts to coastal areas by local teams and citizens in the field and develop an interactive webpage or other medium for collecting flood information from the general public or other entities. This would include photos and other types of information which would be a valuable asset in documenting impacts from natural hazards.	DEMHS	Partially Completed, in progress	Various entities are studying systems like WebEOC. Further action is needed.	Medium	Yes	29
44	Upon completion of DOT's systems-level vulnerability assessment in support of the Climate Change and Extreme Weather pilot project in Litchfield County, repeat the process in the remainder of the state. This activity is linked to Activity #32.	DOT	Deferred	Deferred. Need to check with DOT about status	Medium to High	Yes	30
45	Increase hydrologic monitoring in the state relative to precipitation, surface groundwater, and tidal gauges to enhance the statewide data collection effort and improve long term trend analysis for climate change assessments, predictive modeling and hazard mitigation. This activity is linked with Activity #35.	CIRCA	Partially Completed, in progress	CIRCA is working toward completing this task and making progress. In the updated activities, the LHMPC will be added in a support role.	Medium	Yes	31
46	Develop updated/improved storm surge hazard modeling to supplement sea level rise inundation scenarios.	CIRCA	Partially Completed, in progress	Some portions of this work are complete, via several initiatives. North Atlantic Comprehensive Coastal Study by USACE is complete. DEEP with USACE looking in NH and FFD Co. Flood Risk Management Feasibility Study - $1 Million CIRCA is currently working on storm surge modeling for coastal communities. The USACE/DEEP Flood Risk Management Feasibility Study for New Haven and Fairfield Counties focuses on a review of one or more study reaches within the two counties for the development of potential flood mitigation projects and pursuance of funding by USACE to perform said potential flood mitigation projects in the future.	Medium	Yes	32
47	Use shoreline transect data to map coastal erosion zones and develop applicable outreach products.	DEEP	Deferred	No action has been completed. (check with Pete F. to confirm)	Medium	Yes	33

48	Continue to identify head-of-tide habitat within Connecticut and monitor the change in this habitat due to climate change through sentinel monitoring in order to determine those communities that may endure increased risk from coastal storms and associated flooding. LWRD is currently funding multiple monitoring and data synthesis projects in support of this activity.	DEEP - Land and Water Resources Division – Coastal Resources Section	Deferred	No action has been completed. (check with CRM)	Medium	Yes	34
49	Identify and map the locations of headwater, main stem and coastal dams, culverts, bridges, and other structures or land modifications that contribute to flood damage and act as barriers to habitat connectivity, and assess the feasibility of removal or modification of these structures.	DEEP - Land and Water Resources Division	Deferred	No action has been completed.	Medium	Yes	35
50	Evaluate the hazard potential in Connecticut of land subsidence or slope failures.	DEEP / Geological Survey	Cancelled	Deferred due to lack of funding. Edit activity description with info provided and Keep. This has been replaced with a newly worded strategy.	Medium	No	N/A
51	Create a database of survey elevation points in coastal areas.	DOT	Partially Completed, in progress	In addition to DOT, individual towns are collecting benchmarks in binders and in their GIS systems on a sporadic basis.	Medium to High	Yes	36
52	Create a literature review of various FEMA publications to be placed on CT DEEP's flood management webpage. Include a short description of the publication and a direct link for convenient downloading of the document, or a note to contact CT DEEP's Flood Management Section to obtain a copy.	DEEP - Land and Water Resources Division	Deferred	Kept but reduced to low priority value for this activity due to significant resource and staffing reductions at DEEP.	Medium to High	Yes	37
53	Encourage dissemination and outreach of updated regional IPCC model scenarios, coupled with Northeast Regional Climate Center data and best emerging science, to communities and educators, and to inform all planning processes and statewide education.	CIRCA	Completed	Complete/CIRCA has done this for SLR and NEMO has done this for precipitation.	High	No	N/A
54	Finalize StormSmart Coasts CT site and perform outreach to encourage use by local communities and others to reduce risk.	DEEP - Land and Water Resources Division	Deferred	Not completed.	High	Yes	38

55	Perform a feasibility analysis of the development and expansion of an inventory of infrastructure (including, but not limited to, key transportation, energy, water supply, wastewater and storm water conveyance and treatment structures, dams and levees) at risk from the effects of climate change and prioritize them based on a formalized list of criteria (TBD). In addition, investigate the feasibility of mapping the exact location and elevation of all coastal sewer outflows and coastal flood control structures and including this information in the inventory. Useful data that may be collected for this inventory project includes the exact location of the structure; elevation; structure condition and year built; and value of infrastructure vulnerable to coastal and riverine flooding hazards exacerbated by climate change. This effort should be coordinated with ongoing efforts by CT DOT and the EPA's Climate Ready Water Utilities (CRWU) programs being implemented by the water infrastructure sector. This activity is linked to Activity #49.	DEEP - Land and Water Resources Division	Cancelled	Delete. Due to significant resource and staff reductions in the Agency, this project is very unlikely to be performed during the next planning period.	Medium to High	No	N/A
56	Perform an assessment of increased natural hazard vulnerability and risk from climate change (e.g., effects from increased flooding, sea level rise, and severe weather (e.g., wind, temperature, and drought)). Assessment should be based on local risk and vulnerability assessments already prepared by local communities in coordination with DEEP.	DESPP	Cancelled	Duplicative with other efforts. Agencies perform this already. Activity deleted this since this is done through the state NHMP planning process.	Medium	No	N/A
57	In coordination with local communities, recommend categorical (e.g., wastewater, energy) and site-specific options for adaptation from the projected impacts of climate change and occurrence of natural hazards for public infrastructure (including flood protection structures). Adaptation and hazard mitigation alternatives should include the estimated costs associated with the options evaluated to be the most viable for implementation purposes.	DEEP - Land and Water Resources Division	Deferred	This is a close description to what the USACE/DEEP flood risk management feasibility study intends to achieve at a reduced level due to state funding limitations for this project.	Medium	Yes	39

58	Research and identify the legal authorities applicable to regulation and planning for climate change adaptation activities, especially at the local level. Identify opportunities to build on the success of Public Act 12-101, which combined a number of initiatives to address sea level rise and to revise the regulatory procedures applicable to shoreline protection (more fully described in Section 3.2.1.3).	DEEP	Completed	CIRCA completed this. See the William Rath papers distributed in 2018.	Medium	No	N/A
59	Encourage education and community participation in adaptation, low impact development, and flood management through existing networks and partnerships including the CT Climate Education Communication Committee. This includes coordinating LWRD's coastal community adaptation and risk mitigation work with educational place based student experiences through CT Green Leaf in K-12 to increase participation and maximize local solutions.	DEEP - Land and Water Resources Division	Deferred	No action has been completed. (check with Pete F. to confirm)	Medium	Yes	40
60	Develop and deliver Micro-grid Pilot Program Trainings.	DEEP / Bureau of Energy and Technology	Partially Completed, Continue	This is done on an annual basis.	High	Yes	41
61	Coordinate with water utilities to more actively promote water conservation measures with their customers, especially now that new legislation allows them to recover revenue while encouraging conservation.	DPH / Drinking Water Section	Partially Completed, Continue	Partially complete with the completion of the State Water Plan and the Coordinated Water System Plan (two separate statewide plans published in 2018). Will continue with the implementation of both plans.	Medium	Yes	42

62	**Local School Construction Grant Program and School Safety Infrastructure Council:** • Identify and assess existing public school facilities that could be impacted by natural hazards (including climate change). Correlate identified schools with the School Building Project Priority Lists; identify mitigation strategies for these projects early on in the grant process. • For new grants involving siting a new school, provide and encourage the use of an interactive web based mapping portal for local school districts to use during site selection. Encourage early coordination with DAS Environmental Planning and GIS Services Unit. • Should facilities be located within natural hazard areas, request an assessment of "no feasible or prudent alternative;" encourage higher design standards above minimum criteria for new schools or "renovated as new." • Identify long-term climate change adaptation strategies for each structure/facility.	DAS / Office of School Facilities	Partially Completed / In Progress	This activity is underway and will continue over multiple years.	High	Yes	43
63	**Sustainable State Facilities Initiative:** • Identify, develop, and prioritize a plan for state facilities' potentially impacted by natural hazards (including climate change) • Assess the risks in relation to the physical structures, the agency's long-term capital planning plans, building life span, etc. • Develop specific mitigation strategies for each structure/facility as part of the plan utilizing existing hazard data, identify timeframe for implementing the strategies, and include estimated mitigation costs. • Identify long-term climate change adaptation strategies for each structure/facility.	DAS / Environmental Planning & GIS Services Unit	Partially Completed / In Progress	This activity is underway and will continue over multiple years.	High	Yes	44

64	Establish a Connecticut "Center for Coasts" that will conduct research, analysis, design, outreach and education projects to guide the development and implementation of technologies, methods and policies that increase the protection of ecosystems, coastal properties and other lands and attributes of the state that are subject to the effects of rising sea levels and natural hazards. More information on the specific activities proposed for the Center to undertake is provided in Chapter 3.	CIRCA	Completed	Completed. This effort evolved into the creation of CIRCA.	High	No	N/A
65	Adopt a seismic station currently being installed in CT as part of EarthScope, a nationally funded research program, in order to continue seismic monitoring operations in the Moodus area of East Haddam, beyond the initial two year period. This will enable continuous seismic monitoring with special emphasis on these frequent events. Once adopted, the station will become part of the New England Seismic Network, under a maintenance and technical assistance agreement with Weston Observatory of Boston College.	DEEP / Geological Survey	Cancelled	This activity was defunded and the opportunity was lost. It has been deleted and replaced with a new strategy.	High	No	N/A
66	Conduct geophysical research to investigate, classify, and map soil stability and susceptibility to liquefaction during seismic events to assist with future hazard mitigation planning efforts.	DEEP / Geological Survey	Deferred	Geophysical research to assess seismic stability of soils: unchanged – deferred due to lack of funding- keep this activity as it is written.	High	Yes	45
67	Improve identification of escarpments susceptible to landslide and fluvial erosion risk, utilizing geologic, soils, and elevation data. This activity will provide improved landslide and mass wasting risk estimates, to produce a more comprehensive view of landscape stability during extreme weather events and subsequent impacts.	DEEP / Geological Survey	Deferred		Medium	Yes	46
68	Identify and map extent of historic underground mining operations in the State; assess reclamation and current land use relative to risk of land subsidence and mine collapse for the estimated 23 historic underground mining operations in Connecticut. Project deliverables will include georeferenced site maps and assessment reports, as well as a summary of current conditions and potential ground collapse hazards in these areas.	DEEP / Geological Survey	Deferred	Refer to the Cheshire Hazard Mitigation Plan for an entire chapter dedicated to this. Could be a good example to use.	Medium	Yes	47

6 Plan Monitoring, Maintenance, Evaluation & Revision

6.1 Plan Monitoring Procedures

Connecticut's first formal Natural Hazard Mitigation Plan (Section 406 Plan) was adopted on August 17, 1983 as a result of a major flooding event and disaster declaration (FEMA-661-DP) that occurred on June 6, 1982. Several municipalities participated in the planning process.

Several major recommendations included in this first plan included updating local and state emergency operations plans, establishing an automated flood warning system, expanding the Dam Safety Section of the DEP (now DEEP), setting new standards for road and bridge culvert design, and pursuing several legislative initiatives that enhanced Connecticut's ability to regulate its floodplains.

The Natural Hazard Mitigation Plan was updated regularly following major natural disasters, including during:

- 1985 - in response to a flooding event that also resulted in a Federal disaster declaration;
- 1989 – in response to a powerful tornado that caused extensive damage and two deaths in western Connecticut;
- 1990 – regularly scheduled update;
- 1992 - as a result of Hurricane Bob (FEMA-916-DR-CT) that struck Connecticut and New England on August 19, 1991;
- 1993 - as a result of Winter Storm Beth (FEMA-972-DR-CT), which occurred on December 10 – 13, 1992;
- 1999 – in response to impacts from Tropical Storm Floyd, which caused severe riverine flooding within the state;
- 2004 – a regular scheduled update in response to FEMA's new planning requirements under the Disaster Mitigation Act of 2000, Section 322 requirements issued in 2001;
- 2007 – a regularly scheduled update;
- 2010 – a regularly scheduled update; and
- 2014 – a regularly scheduled update.

Chapter 1 details the planning process employed for the 2018 update. The 2018 plan is consistent with the latest FEMA Hazard Mitigation Plan guidance and Review Tool, including Flood Mitigation Assistance planning requirements that qualify Connecticut to pursue federal funding for severe repetitive loss structure mitigation funded through the Flood Mitigation Assistance, Pre-Disaster Mitigation, and Hazard Mitigation grant programs. Following the precedent set by the 2014 plan update, the 2018 update continued to use state-owned and critical facility data in the risk and vulnerability analysis.

When considering continuity of critical operations in the context of state services and facilities, the impacts of natural hazards can be similar or identical to the impact of a human-caused event. For example, in the aftermath of severe floods or winter storms, tens of thousands of residents can be without power, some for as long as two weeks. A human-caused event that causes failure of a power plant due to operation error or terrorism would have similar impacts to Connecticut's utility customers and operation of critical facilities. While the plan does not specifically consider human-caused hazards, many of the strategies and projects included in the plan that harden critical facilities reduce human-caused hazard exposure.

The 2014 plan contained 68 mitigation actions. In some cases they were indeed actions or projects, while others represented objectives. Many were ongoing activities that represent existing programs or capabilities. For a full description of the changes to and status of 2014 mitigation strategies, see Table 5-2 in Section 5.8 of this plan.

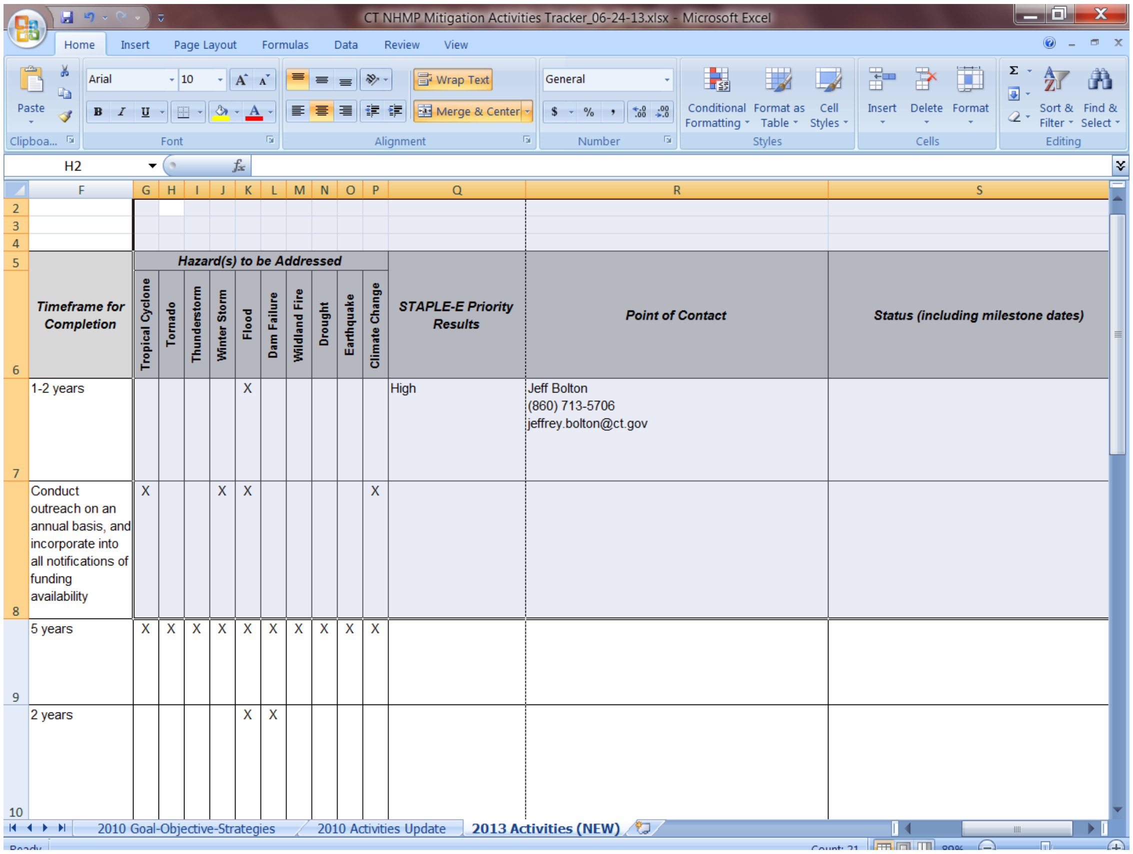
The 2018 Connecticut State Natural Hazard Mitigation Plan Update provides guidance for hazard mitigation within Connecticut. Its vision is supported by three goals, each with a supporting objective, multiple strategies, and associated actions. The actions and projects that support the objectives and strategies were submitted by Connecticut state agencies and stakeholders along with federal agency partners and non-governmental organizations. As described in Chapter 5 and its associated appendices, projects were prioritized at the October 26, 2018 meeting using STAPLE/E criteria where appropriate.

The 2018 mitigation strategies were wholly informed by the improved Vulnerability Analysis and renewed priorities of the State. The updated Hazard Identification & Risk Assessment (HIRA) and Vulnerability Analysis include state and critical facility data, as well as consideration of the risk and vulnerability data evaluation from all local hazard mitigation plans. The continued relevance of current goals, objectives, and strategies and projects will again be evaluated during the development of the next plan revision. Departments and stakeholders will continue to integrate mitigation activities with their planning efforts.

6.1.1 Tracking Actions and Projects

A Mitigation Action Tracker spreadsheet was created for tracking implementation of all new and "carry over" mitigation actions. This tool provides all participants involved in implementation a simple and easy-to-use tracking and reporting mechanism. The tool also assists with maintaining organization as staff changes inevitably occur. Specific annual reporting and update targets have been established with firm due dates in the maintenance schedule which follows in Section 6.2.3.

The mitigation staff, or action leads, will maintain the Mitigation Actions Tracker spreadsheet (see Figure 6-1) that has been developed in accordance with this plan. Primary responsibility for this task will reside with the State Hazard Mitigation Officer, within DEMHS. Actions will be tracked and updated twice per year as outlined in Table 6-1.



Timeframe for Completion	Tropical Cyclone	Tornado	Thunderstorm	Winter Storm	Flood	Dam Failure	Wildland Fire	Drought	Earthquake	Climate Change	STAPLE-E Priority Results	Point of Contact	Status (including milestone dates)
1-2 years					X						High	Jeff Bolton (860) 713-5706 jeffrey.bolton@ct.gov	
Conduct outreach on an annual basis, and incorporate into all notifications of funding availability	X			X	X					X			
5 years	X	X	X	X	X	X	X	X	X	X			
2 years					X	X							

Figure 6-1: Screenshot of Mitigation Actions Tracker Spreadsheet

In addition to tracking progress on mitigation actions, other major aspects of tracking during the five-year plan implementation cycle following plan approval will include:

- Continued development of protocol for local data input;
- Inclusion of local mitigation plan databases from local HIRAs, capability assessments, and local priority mitigation strategies;
- Expansion of state hazard historical data; and
- Refinement of state agency facility inventories and critical facilities data.

These items will be addressed annually and data stored for easy access and use during subsequent updates.

6.2 Plan Maintenance

The State Hazard Mitigation Planning Team (SHMPT) was expanded and enhanced since the 2014 plan update to support development of the plan due to changes in disaster-related activity throughout the state and capabilities as outlined in Chapter 3. While planning committees are generally limited to twenty participants or less, the State broadened the number of stakeholders to include all who participated by attending SHMPT meetings, sponsoring projects, providing information, and reviewing the plan draft. State staff emphasized participation in the manner that was appropriate for each agency and organization.

To develop the 2018 plan mitigation strategies, a sub-group structure was used to encourage departments and other entities not traditionally as engaged in implementation to develop actions for their specific organizations.

Standing, ad-hoc Mitigation Sub-Committees will be convened, surveyed, or engaged periodically as necessary during the 2019–2023 plan implementation cycle. These sub-committees will be responsible for:

- Mitigation of structures;
- Planning, policy, legislation and funding;
- Education and outreach; and
- Risk assessment and data.

The Connecticut DESPP, DEMHS mitigation program staff, in consultation with key state agencies, federal partners, and organizations will direct implementation of the plan. DEMHS serves as the lead coordinating agency for emergency management in Connecticut, and thus will lead the mitigation planning effort, including plan maintenance. DEMHS will track projects identified in both the State Hazard Mitigation plan (using the Mitigation Tracker spreadsheet) and in local plans.

The planning process timeline will be revised continually during the next five years to ensure that the next plan revision will be prepared and submitted to FEMA within the required five-year time period. Special emphasis will be given to increased participation by businesses and special interest groups. State or federal legislative, regulatory, or rule changes or additions that occur during the period following approval of the 2018 plan will be integrated into the 2023 plan update.

Should a specific plan element or section require revision or amendment prior to the subsequent plan revision due to state or federal legislation, policy change, or a declaration of major disaster, DEMHS staff will meet with all appropriate stakeholders and propose the change or addendum to FEMA as quickly as practicable.

6.2.1 Reporting

The sponsors of projects and actions funded through the FEMA Hazard Mitigation Assistance Program provide quarterly progress reporting to DEMHS throughout the duration of the project. DEMHS consolidates these reports into a quarterly summary that is provided to FEMA. Projects that support specific aspects of the Mitigation Plan will be tracked on the Mitigation Action Tracker spreadsheet so that specific FEMA-funded initiatives are tracked to achievement of Mitigation Plan Strategies. A copy of the Mitigation Action Tracker and brief narrative summary of progress will be provided annually to FEMA Region I.

6.2.2 Coordination of Mitigation Operations and related Initiatives

The Connecticut Interagency Hazard Mitigation Committee (CIHMC) was formed in the 1990s with a primary focus on reviewing mitigation grant applications and providing feedback to the State Hazard Mitigation Officer and staff on policy and planning issues. Throughout the first decade of the 2000s, the CIHMC's role evolved. Many of its members were involved in the most recent plan updates as reviewers or stakeholders. Since 2010, many new groups have been formed in Connecticut with varying missions (See Chapter 3). Notably, the following groups are currently active:

- The Adaptation Subcommittee of the Governor's Steering Committee on Climate Change (formed in 2008);
- The Shoreline Preservation Task Force (formed in 2012);
- The State's Long-Term Recovery Committee (formed in 2012);
- The State Vegetation Management Task Force (formed in 2012); and
- State Agencies Fostering Resilience (formed in 2015).

Coordination and information sharing between these groups will be integrated into plan maintenance and implementation during the planning cycle. The CIHMC will meet quarterly to share information and to review implementation of the mitigation actions identified in this plan.

6.2.3 Schedule for Plan Maintenance, Implementation and Revision

The monitoring, maintenance and implementation approach outlined above will be conducted in accordance with the schedule in Table 6-1. The 60-month timeline serves as the framework to ensure that the 2023 plan revision can be prepared and submitted to FEMA within the required five-year time period. Funding sources for the update process will be investigated and secured six months prior to the scheduled start of the process to allow for ample data collection and interagency coordination. As highlighted in the table, the SHMPT will meet semi-annually to discuss plan implementation, changes in the plan, and progress on strategies and projects. The SHMPT meeting will also be used as a forum to discuss changes to the update process, committee members, what works well, what should be changed, and to assess the system (FEMA state plan review tool) used to evaluate the plan for FEMA compliance. At the start of the update, and throughout the implementation, ample time will be needed and allowed for the continued data collection for the vulnerability assessment, relying on information from local plans and new ongoing research (such as climate changes and sea level rise analysis).

Table 6-1: Schedule for Plan Monitoring, Maintenance, Implementation and Revision

Task	Responsibility	Time Frame
Refine Planning Process and timeline for 2023 plan development	DESPP/DEMHS Mitigation Staff	Ongoing
Collect and store expanded facilities, local plan risk data, and historical disaster data	Risk Assessment Sub-Committee	Ongoing with Quarterly Summaries beginning March 2019
Update Mitigation Action Tracker	Project Leads	Quarterly beginning March 2019
Review Action Tracker as a Team	SHMPT	June 2019 December 2019 June 2020 December 2020 June 2021 December 2021 June 2022 December 2022 June 2023
Report Progress to FEMA Region I using Action Tracker	SHMO	December 2019 December 2020 December 2021 December 2022
Consolidate list of known local plan implementation actions with tool similar to Mitigation Action Tracker	DESPP/DEMHS Mitigation Staff	Annually beginning June 2019
Convene the SHMPT or CIHMC to discuss plan implementation, the submittal of additional mitigation activities, and to lay the groundwork for future HIRA, Vulnerability Assessment and strategy changes to the State Plan	DESPP/DEMHS Mitigation Staff Mitigation Staff - ongoing Risk Assessment Sub-Committee Members	June 2019 December 2019 June 2020 December 2020 June 2021 December 2021 June 2022 December 2022 June 2023
Evaluate progress on strategies and projects	DESPP/DEMHS Mitigation Staff Strategy & Project Sponsors	June 2019 December 2019 June 2020 December 2020 June 2021 December 2021

		June 2022 December 2022 June 2023
Upload Local Plan Updates	DESPP/DEMHS Mitigation Staff	June 2019 June 2020 June 2021 June 2022 June 2023
Provide brief implementation progress report to FEMA Region I	DESPP/DEMHS Mitigation Staff	June 2019 June 2020 June 2021 June 2022 June 2023
Initiate Revision Process for 2018 Plan	DESPP/DEMHS Mitigation Staff	September 1, 2019
Review current regulatory requirements for plan revision	DESPP/DEMHS Mitigation Staff	September 1, 2019
Submit new Revised All-Hazard Mitigation Plan to FEMA	DESPP Commissioner	August 1, 2023

6.2.4 Process and Schedule for Plan Evaluation

Table 6-1 identifies meetings every 6 months to evaluate progress on mitigation strategies and projects, as shown in the excerpt below.

Evaluate progress on strategies and projects	DESPP/DEMHS Mitigation Staff Strategy & Project Sponsors	June 2019 December 2019 June 2020 December 2020 June 2021 December 2021 June 2022 December 2022 June 2023

The Connecticut State Hazard Mitigation Officer (SHMO), or responsible designee, will be responsible for evaluating implementation of projects and activities, and plan effectiveness. The evaluation will occur at SHMPT meetings. Each member of the SHMPT responsible for actions in the plan will report out at the meetings. In addition to monitoring projects, as described in the previous section, the following five measures of plan success will be reviewed at each of the meetings:

1. Number or activities underway
2. Number of activities complete
3. Does recent disaster activity reflect accuracy of HIRA?

4. Have there been losses avoided as a result of implementation measures?
5. Have other state level plans or programs used, reference, or integrated the state mitigation plan?

The SHMO will prepare a summary report, in addition to the updated action tracker addressing each of the five measures following each meeting. The reports will be "rolled up" into the annual progress reports to FEMA, also outlined in Table 6-1.

6.3 Project Closeout

Project Closeout is the process that finalizes a completed mitigation project that FEMA has funded. Project Closeouts will continue to be conducted based on FEMA Region I closeout procedures in accordance with national and regional FEMA guidance along with Connecticut financial management procedures. Projects and activities funded through other federal or state grant programs, state general funds or that can be achieved without targeted funding will be completed as dictated by the funding source or state program with administrative oversight for the activity of the project. The following description provides an overview of the closeout process. Details are included in the CT 2008 State Hazard Mitigation Grants Administrative Plan, included in Appendix 3-1.

6.3.1 Project Closeout Process

The subgrantee will notify the State Hazard Mitigation Officer (SHMO) when a project is ready to be closed. It is recognized that, based upon performance period deadlines, the State Hazard Mitigation Officer (SHMO) may suggest project closure to FEMA. The seven steps to closure of a project are:

1. Agreement between the subgrantee and the State that the project is ready to be closed. Should either not agree, the project manager or the State Hazard Mitigation Officer (SHMO) would request an extension, in writing, outlining the justification for the request.
2. The sub-grantee, the State, and FEMA will coordinate to make sure that funds advanced through the program balance with funds expended by the State and sub-grantee. If there is disagreement between the expended funds and the grant amount, FEMA and the State take steps to reconcile and adjust final project expenditures and Grantee Management Costs.
3. The State will submit a final project report that includes:
    - Final Financial and Progress Report to FEMA (if applicable);
    - Final Letter of Credit Payment Request;
    - FEMA Form 20-18, Report of Government Property; and
    - Photos, Property Survey Inventory spreadsheet, etc. to validate expenditures.
4. The State will conduct site visits for all projects to ensure the approved scope of work was completed. The State will provide FEMA with a letter confirming final inspection and that all final payments have been made to project.

5. Subgrantee shall have 30 days to appeal if it does not agree with the State and FEMA's findings. The appeal process previously mentioned will be employed to appeal matters relating to closeout.
6. FEMA and the State will coordinate their financial systems to record the amount and date of the final payment(s). Financial files will be closed and excess funds will be de-obligated.
7. The State will provide FEMA with a letter requesting closure of the project. The information and enclosures:
   - Project name, federal project number, state identification number
   - Financial summary of the project
   - Certifications:
     - All eligible funds paid to subgrantee
     - All work completed according to FEMA and State requirements
     - All costs incurred as the result of eligible work
     - All work completed in accordance with provisions of the FEMA/State and State/Local agreements
     - All payments made according to Federal and State legal and regulatory requirements
     - No bills are outstanding
     - No further requests for funding will be made for the project

6.3.2 Program Closeout

When all projects under a single disaster are closed, the entire program is ready for closure. The steps that comprise program closeout are as follows:

1. Any mission assignments and technical assistance contracts will be closed out.
2. There will be agreement between FEMA and the State on the Final Claim Amount and concurrence date. The State will submit a concurrence letter and sign FEMA Form 425.
3. The HMGP will be closed in program and financial systems. FEMA and the State Hazard Mitigation Officer (SHMO) are responsible for ensuring that Federal and State records are available in the event of an audit.

State-specific responsibilities for the HMA closeout process may be found in the *2010 HMA Unified Guidance* Part VI, D.1, D.2 and D.2.1. All records will be maintained for a minimum three years from the date the program is closed.