





Lower Connecticut River Valley Council of Governments

RiverCOG 2026 NHMP

NATURAL HAZARD MITIGATION PLAN

CHESTER •
CLINTON •
CROMWELL •
DEEP RIVER •
DURHAM •
EAST HADDAM •
EAST HAMPTON •
ESSEX •
HADDAM •
KILLINGWORTH •
LYME •
OLD LYME •
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1. Introduction and Planning Process

1.1. Purpose and Authority

Hazard mitigation is defined as the use of long- and short-term strategies to reduce or alleviate the loss of life, personal injury, and property damage that can result from a disaster. It involves strategies such as planning, policy changes, programs, projects, and other activities that can mitigate the long-term impacts of hazards. The responsibility for hazard mitigation lies with many, including private property owners; business and industry; and local, state and federal government.

The federal Disaster Mitigation Act (DMA) of 2000 (Public Law 106-390) and implementing regulations (Title 44 CFR, Part 206, Subpart N) required state and local governments to develop and update hazard mitigation plans as a condition for federal disaster grant assistance. Prior to 2000, federal disaster funding focused on disaster relief and recovery, with limited funding for hazard mitigation planning. The DMA increased the emphasis on planning for disasters before they occur.

The DMA encourages state and local authorities to work together on pre-disaster planning, and it promotes sustainability for disaster resilience. Sustainable hazard mitigation includes the sound management of natural resources and the recognition that hazards, and mitigation, must be understood in the largest possible social and economic context. The enhanced planning network called for by the DMA helps local governments articulate accurate needs for mitigation, resulting in faster allocation of funding and more cost-effective risk reduction projects.

This hazard mitigation plan identifies resources, information, and strategies for reducing risk from natural hazards. Elements and strategies in the plan were selected because they meet a program requirement and because they best meet the needs of the planning partners and their citizens. One of the benefits of multi-jurisdictional planning is the ability to pool resources and eliminate redundant activities within a planning area that shares some uniform risk exposure and vulnerabilities. The Federal Emergency Management Agency (FEMA) encourages multi-jurisdictional planning under its guidance for the DMA. The plan will help guide and coordinate mitigation activities throughout the RiverCOG region. It was developed to meet the following objectives:

- Meet or exceed requirements of the DMA.
- Enable all planning partners to continue using federal grant funding to reduce risk through mitigation.
- Meet the needs of each planning partner as well as state and federal requirements.
- Create a risk assessment that focuses on RiverCOG' s hazards of concern.
- Create a single planning document that integrates all planning partners into a framework that supports partnerships within the region and puts all partners on the same planning cycle for future updates.

- Coordinate existing plans and programs so that high-priority initiatives and projects to mitigate possible disaster impacts are funded and implemented.

1.2. Planning Background and Summary of Changes

The 2021 Hazard Mitigation Plan for the RiverCOG communities was the first multi-jurisdictional plan, for 15 of the 17 communities that formerly were members of the Midstate Regional Planning Agency (MRPA) and the Connecticut River Estuary Regional Planning Agency (CRERPA). Those two entities voluntarily dissolved in 2012 to form the Lower Connecticut River Valley Council of Governments (RiverCOG). Prior to the 2021 plan update. Prior to that time, there was one hazard mitigation plan for the eight northern communities and free-standing plans for the nine southern communities.

All of these communities joined the 2021 regional hazard mitigation plan update, with the exception of Old Saybrook and Westbrook, who maintain stand-alone plans. This 2026 update mirrors the participation and format of the 2021 update. Regional and community level information is contained in this volume, including potential losses from the identified hazards. More anecdotal data is included in the Volume II annexes. Additionally, at the request of the communities, an "Other Hazards" section was added to address extreme temperatures, and invasive species (i.e., aquatic, terrestrial, and tree infestations). Analysis for those hazards are largely qualitative, but the associated impacts to the region are significant enough to warrant inclusion.

Additional changes to the 2021 plan are noted throughout this document.

1.3. Planning Process

To update this multi-jurisdictional Natural Hazards Mitigation Plan, the region followed a process that included the following primary objectives:

- Secure Funding and Technical Assistance
- Form a Steering Committee and Regional and Local Teams
- Establish municipal planning teams
- Coordinate with Stakeholders
- Review existing programs
- Engage the public

These objectives are discussed in the following sections.

1.3.1. Grant Funding

This plan update effort was funded by a Building Resilient Infrastructure and Communities (BRIC) grant from the Federal Emergency Management Agency (FEMA) Region I, implemented by the Connecticut Department of Emergency Services and Public Protection (DESPP), Division of

Emergency Management and Homeland Security (DEMHS). RiverCOG was the applicant for the grant, on behalf of the 15 participating municipal jurisdictions. The grant covered 75 percent of the cost for development of this plan; the municipal jurisdictions covered the remaining 25 percent of the cost through cash contributions.

1.3.2. Formation of the Planning Teams

A small group of project management staff was formed as a Steering Committee. The Steering Committee met in May of 2025 to discuss final workplan and schedule and to begin the planning process. At this meeting, a Regional Planning Committee of RiverCOG and municipal leadership was formed. At the formal project kickoff meeting on May 28, 2025, the Regional Planning Committee formed Local Planning Teams. Each is discussed further below.

Steering Committee

The RiverCOG region hired Dewberry Engineers Inc. (Dewberry) and its teaming partners Resilient Land and Water, LLC (RLW) and Gradient Planning LLC (GP) in May of 2025 as planning consultants to assist with and guide the development of the plan. The Steering Committee formed to lead the planning effort, made up of the following members:

- Sam Gold, AICP, Executive Director, River COG
- Margot Burns, Senior Environmental Planner (Mitigation Plan Update Project Manager)
- Kevin Armstrong, GIS Manager, RiverCOG
- Scott Choquette, Dewberry, Project Manager
- David Murphy, Resilient Land and Water, Deputy Project Manager (subconsultant)

The Steering Committee coordinated as needed throughout the update process to ensure consistent communication among all partners and organizations.

Regional Planning Committee

A Regional Planning Committee was established, including representatives of RiverCOG, its consultant, and the 15 participating municipal jurisdictions. The purpose of the committee was to provide leadership to ensure collection of best available data, participation of municipal staff, input on risk and vulnerability, review of draft sections of the plan and development of mitigation goals, objectives and actions based on the results of the risk and vulnerability assessment. Table 1.3.1. Regional Planning Committee includes the names, titles and affiliations of the Planning Committee members. Municipal membership was comprised of elected officials and their designees. Due to elections and attrition, there were some changes to the committee over the course of the planning process. The table indicates membership at the end of the planning process. Sign in sheets and meeting documentation included in Appendix A show attendance at committee meetings.

Table 1.3.1. Regional Planning Committee

Name	Title	Jurisdiction Representing
Cindy Lignar	First Selectwoman	Chester
Michelle Benivegna	Town Manager	Clinton
Abby Piersall	Town Planner	Clinton
Anthony Salvatore	Town Manager	Cromwell
Carol Doak-Jones	First Selectwoman	Deep River
Brendan Rea	First Selectman	Durham
Todd Gelston	First Selectman	East Haddam
Dave Cox	Town Manager	East Hampton
Norman Needleman	First Selectman	Essex
Carey Duques	Land Use Official	Essex
Sean Donlan	First Selectman	Haddam
Eric Couture	First Selectman	Killingworth
Christine Erica Zelek	First Selectwoman	Lyme
Bab Yamartino	First Selectman	Middlefield
Gene Nocera	Mayor	Middletown
Marek Kozikowski	Director of Land Use	Middletown
Michael Pelton	First Selectman	Portland
Martha Shoemaker	First Selectwoman	Old Lyme
Sam Gold	Executive Director	River COG
Margot Burns	Sr. Environmental Planner	RiverCOG
Kevin Armstrong	GIS Manager	RiverCOG
Scott Choquette	Vice President	Dewberry
David Murphy	Managing Principal	Resilient Land & Water
Julia Bontempo	Sr. Resilience Planner	Dewberry

Local Planning Teams

Local Planning Teams were formed for each of the participating jurisdictions. The purpose of the teams was to support Regional Planning Committee representatives from their jurisdiction by providing required input into the planning process. Each core team met multiple times to assist with data collection, review plan sections, and development and ranking of mitigation actions. Meetings are described in more detail later in this section. Table 1.3.2 lists the participants of each of the Local Planning Teams.

Table 1.3.2. Local Planning Teams

Name	Title	Municipality
Andrew Armstrong*	Director of Planning & Development	Town of Cromwell
Bruce Drisks	Development Compliance Officer	
Jennifer Tranquillo	Admin. Assistant, P&D	
Daniel Parisi	Sewer Administrator	
Harold Holmes	Fire Marshal	
Richard Driscol	Assistant Fire Chier, Safety and Training	
Jason Brade	Fire Chief	
Joe Palmieri	Water Operations Manager	
Lou Spina	Director of Public Works	
Jon Harriman	Town Engineer	
Fred Sifodaskalskis	Chief of Police (retired)	
Steven Penn	Chief of Police	
John Carlson	Captain	
Abby Piersall*	Town Planner	Town of Clinton
Todd Hajek	Director of Public Works	
Michael Neff	Emergency Management Director	
Richard Pleines	Building Official	
Ken Cain	Police Department	
Vince DeMaio	Police Department	
Brian Manware	Fire Department	
Kathleen Savona	Zoning Enforcement Officer and Floodplain Manager	
Michelle Benivegna	Town Manager	
Cindy Lingar*	First Selectwoman	Town of Chester
Cameron Evangelisti	Director of Public Works / Tree Warden	
Patricia Bandzes	Selectwoman	
James Grzybowski	Emergency Management Director	
Henry Krempel	Planning and Zoning Chair	

Name	Title	Municipality
Richard Leighton	Fire Marshall	
Zoe Chatfield	Zoning Official	
Carol Doak-Jones*	First Selectwoman	Town of Deep River
Adam Kerop	Fire Marshall/Asst. Chief	
Eric Waltke	Public Works Supervisor	
Matt Herman	Emergency Management Director	
Sara Connor	Sustainable Deep River	
Brendan Rea	First Selectman	Town of Durham
Jack Trifilo	Emergency Management Director	
John Jenkins	Public Works Foreman	
Frank DeFelice	Chairman, Planning and Zoning	
Robin Newton*	Town Planner	
Todd Gelston	First Selectman	Town of East Haddam
Donald Angersola	Acting Director of Public Works / Director of Operations	
Richard French	Building Department	
Craig Mansfield	Emergency Management Director	
Jim Ventres*	Land Use Administrator	
TBD	Public Works Foreman	
Matt Walsh*	Director of Public Works	Town of East Hampton
Russel Melmed	Director of Health	
Juliet Hodge	Planning & Zoning Official, Floodplain Administrator	
James Prue	Building Official	
Dennis Woessner	Chief of Police	
David Cox	Town Manager	
Carey Duques*	Land Use Administrator	Town of Essex
John Grzybowski	Town Planner (contracted)	
John Planas	Fire Marshal	
Lisa Fasulo	Deputy Emergency Management Director	

Name	Title	Municipality
Ryan Welch	Public Works Director	
Stacey Abbott	Sustainable Essex	
Sean E. Donlan*	First Selectman	Town of Haddam
Bill Warner	Town Planner	
Chris Corsa	Assistant Director, Public Works	
Anthony Gentile*	Emergency Management Director	Town of Killingworth
Eric Couture	First Selectman	
Christopher Mello	Public Works Director	
Christy Zelek*	First Selectwoman	Town of Lyme
Josh Adams	Emergency Management Director	
John Evans	Public Safety / Fire Chief	
Don Gerber	Town Engineer	
K. George Mooney	President, Lyme EMS	
Steve Olstein	Chief of Services, Lyme EMS	
Tom St. Louis	Third Selectman	
Lars Anderson	Public Works	
Chris Hatt	Public Works	
Bob Collins	Public Works	
Kyle Turner	Public Works	
Peter John Signore	Public Works	
Robert Yamartino*	First Selectman	Town of Middlefield
Robert Poturnicki	Emergency Management Director	
Robin Newton	Town Planner	
Gene Nocera	Mayor	City of Middletown
Steven Kovach	Chief of Staff	
Robert Russo	Acting Director of Public Works	
Dean Lisitano	Building Official	
Christine Marques	Director or Economic & Community Development	
Marek Kozikowski*	Director of Land Use	
Rob Kronenberger	Director of Emergency Management	

Name	Title	Municipality
David Albert	Fire Chief	
Erik Costa	Police Chief	
James Trzaski	South Fire Chief	
Phil coco	Fire Chief Westfield	
Martha Shoemaker*	First Selectwoman	Town of Old Lyme
Greg Futoma	Chair of Open Space Commission	
Eric Knapp	Land Use Coordinator	
Dave Roberge	Fire Marshal and Emergency Management Director	
Juliann Michell	Land Use Technician	
Mike Pelton	First Selectman	Town of Portland
Don Gouin	Emergency Management Director	
Robbert Shea	Board of Education	
Robert Puida	Fire Chief	
Jason Morrocco*	Director of Public Works	
Dan Bourret	Town Planner	

**Jurisdictional lead point of contact*

1.3.3. Defining the Planning Area

The RiverCOG planning area consists of all of Middlesex County and two New London County communities, Lyme and Old Lyme. For this plan, Old Saybrook and Westbrook were not included, though when appropriate, information pertaining to these jurisdictions is incorporated into the narrative. All partners to this plan have jurisdictional authority over specific locations within this planning area.

1.3.4. Stakeholder Involvement

In addition to the Steering Committee, Regional Planning Committee and Local Planning Teams, various stakeholders from the region were invited to participate in the process. Stakeholder participation was sought primarily through an online survey and requests to review and comment on the draft plan. The survey is discussed in detail in Section 1.3.6, below. Not all stakeholders identified their organizations while completing the survey. Data gathered from the survey results indicated that members of the organizations shown here provided responses:

- Connecticut Institute for Resilience and Climate Adaptation
- Tetra Tech

- The Incarnation Center
- Heritage Cove Condo Association
- Essex Housing Management LLC
- SLR Consulting
- Connecticut General Assembly, State Rep. Renee LaMark Muir

Several stakeholder organizations were invited to participate in meetings and review the draft plan and/or provide input during the planning process. They are included in Table 1.3.3 along with their participation type.

Table 1.3.3. Stakeholder Participation

Organization	Participation Type
Connecticut Institute for Resilience and Climate Adaptation (CIRCA – UCONN)	• Two members took the survey • Provided data related to social vulnerability and heat index
CT Dept. of Energy and Environmental Protection (DEEP)	• Dam Safety Section provided EAPs for select high hazard dams • Floodplain Management Section provided aggregate RL and SRL property information
Connecticut General Assembly	• State Senator and Deputy President Norm Needleman is a member of the Regional Planning Committee as part of his role as First Selectman of Essex. • State Congresswoman Renee LaMark Muir completed the survey.
U.S. House of Representatives	• Julia McGrath, Grants Coordinator for Rep. Courtney's office attended the kickoff meeting
Town of Old Saybrook	• This neighboring community was invited to review the regional mitigation strategy and disposition of past actions for consistency. Although in the RiverCOG region, Old Saybrook maintains its own mitigation plan
Town of Westbrook	• This neighboring community was invited to review the regional mitigation strategy and disposition of past actions for consistency. Although in the RiverCOG region, Old Saybrook maintains its own mitigation plan

Organization	Participation Type
South Central Region Council of Governments	• This neighboring COG was invited to participate in meeting and to review the regional mitigation strategies developed for this plan, and the disposition of previous strategies for consistency
Capitol Region Council of Governments	• This neighboring COG was invited to participate in meeting and to review the regional mitigation strategies developed for this plan, and the disposition of previous strategies for consistency
Southeastern Connecticut Council of Governments	• This neighboring COG was invited to participate in meeting and to review the regional mitigation strategies developed for this plan, and the disposition of previous strategies for consistency
Federal Highway Administration (FHWA)	• Jennifer Brady, FHWA, CT Division, attended RPC kickoff meeting.
Connecticut Dept. of Transportation (CTDOT)	• Grayson Wright, Transportation Planner, CT DOT attended RPC kickoff meeting.
Connecticut Department of Emergency Management and Homeland Security	• Nicole Velardi, Regional Emergency Manager, attended the RPC kickoff meeting representing DEMHS.
Westbrook Economic Development Commission	• Darleene Briggs, Commission Member, attended the RPC kickoff meeting. Westbrook is a RiverCOG community not participating in this plan.
Town of Old Saybrook	• Carl Fortuna, First Selectman, participated in the RPC kickoff meeting. Old Saybrook is a RiverCOG community not participating in this plan.
River Valley Transit	• Joe Comerford, Executive Director, and Laurie McElwee, Regional Manager attended the RPC kickoff meeting.

1.3.5. Committee and Team Meetings

Steering Committee Kickoff Meeting

The Steering Committee met In May of 2025 to officially kick off the planning process. During this meeting, expectations and roles for Regional Planning Committee members and Local Planning

Teams were established. The Dewberry Team gave an overview of the workplan and timeline. A hazard identification discussion was started in order to reconcile the hazards from the previous plan. Potential data sources and methodologies to be used in Hazard Identification and Risk Assessment were discussed. Finally, members of the Regional Planning Committee were identified. Meeting documentation can be found in Appendix A.

Regional Planning Committee Kickoff Meeting

The Planning Committee met on May 28, 2025, to officially kick off the planning process. During this meeting, expectations and roles for Planning Committee members were established. The Dewberry team gave an overview presentation of the planning process and timeline. A hazard identification exercise was completed. The hazards were then ranked by factors including, probability, primary and secondary impacts, and area impacted. Potential data sources to be used in the Hazard Identification and Risk Assessment were discussed, as well as the region's current capabilities in mitigation. Information was collected on hazards of concern, current capabilities, and specific areas of concern in their communities. Finally, a review of goals and objectives was performed, and regional goals and objectives were established and confirmed. At the kickoff meeting, Municipal Planning Teams were identified for each of the 15 participating Jurisdictions and meeting dates were established each to convene. Meeting documentation can be found in Appendix A.

Local Planning Team Working Session Series I

Between June 2nd and June 25th, 2025, each Municipal Planning Team held a facilitated working session in its community. The RiverCOG project manager and a member of the consulting team attended each session and helped to facilitate. Municipal team members who were not at the Regional Planning Committee meeting were given a brief overview of the planning process. The format of each meeting was similar, and the following items were addressed:

- Goals and Objectives were reviewed for appropriateness at the jurisdictional level and modified if necessary.
- Critical Facilities were reviewed for completeness and currency.
- Development trends were discussed.
- Changes in capabilities were discussed.
- Changes in critical infrastructure were discussed.
- Storm data since 2021 were reviewed.
- Repetitive Loss and Severe Repetitive Loss numbers were evaluated.
- Risk assessment data was collected.
- 2021 mitigation actions and strategies were reviewed for disposition.
- 2020-2025 mitigation actions were discussed preliminarily.

Table 1.3.4 provides the dates, time and number of attendees at each Municipal Team working session. Attendees include one representative from Dewberry and one from RiverCOG.

Table 1.3.4. Local Planning Team Meeting Series 1

Community	Date	Time	Attendees
Chester	June 18, 2025	1:00 PM	James Grzybowski, Emergency Management Director Margot Burns, RiverCOG David Murphy, RLW
Clinton	June 4, 2025	1:00 PM	Abby Piersall, Town Planner Michael Neff, Emergency Management Director Todd Hajek, Public Works Richard Pleines, Building Official Ken Cain, Police Department Vince DeMaio, Police Department Brian Manware, Fire Department
Cromwell	June 25, 2025	1:00 PM	Bruce Driska, Planning & Development Jennifer Tranquilllo, Planning & Zoning Daniel Parisi, Sewer Harold Holmes, Fire Marshall Rich Driscoll, Asst. Fire Chief Jason Brade, Fire Chief Joe Palmieri, Water Operations Manager Lou Spina, Public Works Jon Harriman, Town Engineer Fred Sifodaskalakis, Police Chief Steven Penn, Police Dept. (now Chief) Margot Burns, RiverCOG David Murphy, RLW
Durham	June 16, 2025	1:00 PM	John Jenkins – Road Forman Terry Wall, Fire Chief Frank DeFelice, P&Z Chairman Brendan Rea, First Selectman Jaclyn Lehet, Exec. Assistant Robin Newton, Planner (via phone) Margot Burns, RiverCOG Scott Choquette, Dewberry

Community	Date	Time	Attendees
Deep River	June 16, 2025	10:00 AM	Cailey Anderson, Director of Parks and Recreation Crol Jones, First Selectwoman Tanner Steeves, Chair, Conservation & Inland Wetlands Stacie Dinello, Chair, Economic Development Sara Conner, Chair, Sustainable Deep River Cynthia Torres, Director of Emergency Management Zoe Chatfield, Zoning Officer Eliza LoPresti, RiverCOG Margot Burns, RiverCOG Scott Bighinatti, RLW
East Haddam	June 16, 2025	10:00 AM	Irene Haines, First Selectman Jim Ventres, Land Use Administrator Margot Burns, RiverCOG Scott Choquette, Dewberry
East Hampton	June 2, 2025	10:00 AM	Russel Melmed, Director of Health Matt Walsh, Director of Public Works Juliet Hodge, Planning & Zoning Official James Prue, Building Official Dennis Woessner, Chief of Police Margot Burns, RiverCOG Scott Choquette, Dewberry
Essex	June 4, 2025	10:00 AM	Ryan Welch, Public Works Lisa Fasulo, Emergency Management and Health Dept. Frank Hall, Sustainable Essex Stacy Abbott, Sustainable Essex John Planas, Fire Marshall Lynn Ral, Fuss & O'Neill (Engineering) Margot Burns, RiverCOG David Murphy, RLW
Haddam	June 2, 2025	1:00 PM	Bob McGarry, First Selectman

Community	Date	Time	Attendees
			Christopher, Corsa, Asst. Dir. PW Margot Burns, RiverCOG Scott Choquette, Dewberry
Killingworth	June 5, 2025	10:00 AM	Eric Couture, First Selectman Dan O'Sullivan, President, Ambulance Association Rick Darin, Fire Chief Linda Kieft-Robitaille, Zoning Enforcement Officer Margot Burns, RiverCOG Scott Choquette, Dewberry
Lyme	June 3, 2025	10:00 AM	David Lahm, First Selectman Margot Burns, RiverCOG Victoria Vetre, RLW
Middlefield	June 3, 2025	1:00 PM	Jason Wickham, Public Works Supervisor Caleb Stevens, Resident State Trooper Robert Yamartino, First Selectman Robin Newton, Town Planner Rob Poturnicki, Emergency Management Director Margot Burns, RiverCOG David Murphy, RLW
Middletown	June 18, 2025	10:00 AM	Marek Kozikowski, Dir. Of Land Use Rohan Manning, Mayor's Office Robert Kronenberger, Director of Emergency Management Christine Marques, Dir. Comm and Economic Development Bobbye Knoll Peterson, Acting Director of Public Works Jerrid Christoff, GIS Technician Margot Burns, RiverCOG Scott Choquette, Dewberry
Old Lyme	June 17, 2025	10:00 AM	Martha Shoemaker, First Selectwoman Greg Futoma, Chair, Open Space Eric Knapp, Land Use Coordinator

Community	Date	Time	Attendees
			Dave Roberge, Fire Marshall and Emergency Management Director Margot Burns, RiverCOG Victoria Vetre, RLW
Portland	June 5, 2025	1:00 PM	Dan Bourret, Town Planner Michael Pelton, First Selectman Don Gouin, Emergency Management Director Margot Burns, RiverCOG Eliza LoPresti, RiverCOG Scott Choquette, Dewberry

Meeting documentation can be found in Appendix A.

Local Planning Team Working Session Series II

Between January 12th and January 26th, 2026, each Local Planning Team held a facilitated working session in its community. The RiverCOG project manager and a member of the consulting team attended each session and helped to facilitate. Municipal team members who were not at the Regional Planning Committee meeting were given a brief overview of the planning process. The format of each meeting was similar, and the following items were addressed:

- Review of municipal annex edits completed to update the 2021 annexes.
- Review of annex tables, including Hazard Ranking, Critical Facilities, Development Trends. Dam inventories, and 2021 plan project disposition, from the first meeting.
- Brainstorming of mitigation actions for the 2026 plan update based on capability assessment and preliminary risk assessment results.

Table 1.3.5 provides the dates, time and number of attendees at each Municipal Team working session. Attendees include one representative from Dewberry and one from RiverCOG.

Table 1.3.5. Local Planning Team Meeting Series 1

Community	Date	Time	Attendees
Chester	January 26, 2026	1:00 PM	Cindy Lignar, First Selectwoman James Grzybowski, Emergency Management Director Howard Pfrommer, Consulting Eng. Carolyn Kane, Harbor Management Charles Greeney, Jr., Deputy Fire Chief

Community	Date	Time	Attendees
			Henry Krempel, Chair, Planning & Zoning Lisa Wahl, Chair, Conservation Commission Cameron Evangelisti, Public Works Margot Burns, RiverCOG Kevin Armstrong, RiverCOG David Murphy, RLW
Clinton	January 21, 2026	10:00 AM	Abby Piersall, Town Planner Michael Neff, Emergency Management Director Todd Hajek, Public Works Richard Pleines, Building Official Michelle Benivegna, Town Manager Kathy Savona, Zoning Enforcement Officer and Floodplain Manager Vince DeMaio, Police Department Brian Manware, Fire Department Margot Burns, RiverCOG Victoria Vetre, RLW
Cromwell	January 13, 2026	1:00 PM	Bruce Driska, Planning & Development Andrew Armstrong, Director of Planning & Development Daniel Parisi, Sewer Rich Driscoll, Asst. Fire Chief Joe Palmieri, Water Operations Manager Lou Spina, Public Works Jon Harriman, Town Engineer Fred Sifodaskalakis, Police Chief Steven Penn, Police Dept. (now Chief) Margot Burns, RiverCOG David Murphy, RLW
Durham	January 12, 2026	3:00 PM	John Jenkins – Road Forman Frank DeFelice, P&Z Chairman Brendan Rea, First Selectman

Community	Date	Time	Attendees
			Margot Burns, RiverCOG Scott Choquette, Dewberry
Deep River	January 23, 2026	1:00 PM	Crol Jones, First Selectwoman Sara Conner, Chair, Sustainable Deep River Margot Burns, RiverCOG Scott Bighinatti, RLW
East Haddam	January 20, 2026	1:00 PM	Todd Gelston, First Selectman Jim Ventres, Land Use Administrator Craig Mansfield, EM Director Don Angersola, Operations, Public Works Margot Burns, RiverCOG Scott Choquette, Dewberry
East Hampton	January 23, 2026	10:00 AM	Russel Melmed, Director of Health Matt Walsh, Director of Public Works Juliet Hodge, Planning & Zoning Official James Prue, Building Official Dennis Woessner, Chief of Police David Cox, Town Manager Margot Burns, RiverCOG Scott Choquette, Dewberry
Essex	January 21, 2026	1:00 PM	Ryan Welch, Public Works Director Carey Duques, Land Use Official Lisa Fasulo, Emergency Management and Health Director Stacy Abbott, Sustainable Essex Margot Burns, RiverCOG Victoria Vetre, RLW
Haddam	January 14, 2026	10:00 AM	Sean Donlan, First Selectman Christopher, Corsa, Asst. Dir. PW Scott Larson, President, Haddam Fire Margot Burns, RiverCOG Scott Choquette, Dewberry
Killingworth	January 22, 2026	1:00 PM	Eric Couture, First Selectman

Community	Date	Time	Attendees
			Dan O'Sullivan, President, Ambulance Association Linda Kieft-Robitaille, Zoning Enforcement Officer Margot Burns, RiverCOG Scott Choquette, Dewberry
Lyme	January 12, 2026	10:00 AM	Christy Zelek, First Selectwoman John Evans, Fire Chief Don Gerber, Town Engineer K George Mooney, President Lyme EMS Steve Olstein, Chief of Svc, EMS Tom St. Louis, Third Selectman Lars Anderson, Public Works Chris Hall, Public works Bob Collins, Public Works Kyle Turner, Public Works Peter J. Signore, Public Works Margot Burns, RiverCOG Victoria Vetre, RLW
Middlefield	January 13, 2026	1:00 PM	Robert Yamartino, First Selectman Robin Newton, Town Planner Rob Poturnicki, Emergency Management Director Margot Burns, RiverCOG Kevin Armstrong, RiverCOG David Murphy, RLW
Middletown	January15, 2026	10:00 AM	Marek Kozikowski, Dir. Of Land Use Steven Kovach, Mayor's Chief of Staff Joseph Fazzino, Director W&S Erik Costa, Chief of Police Brian Gartner, Jr., Acting Deputy Director of Public Works Brian Robillard, Chief Engineer, W&S Robert Kronenberger, Director of Emergency Management Jerrid Christoff, GIS Technician Margot Burns, RiverCOG

Community	Date	Time	Attendees
			Scott Choquette, Dewberry
Old Lyme	January 20, 2026	10:00 AM	Martha Shoemaker, First Selectwoman Juliann Carlos, Land Use Technician Eric Knapp, Land Use Coordinator Dave Roberge, Fire Marshall and Emergency Management Director Margot Burns, RiverCOG Scott Bighinatti, RLW
Portland	January 22, 2026	10:00 AM	Dan Bourret, Town Planner Michael Pelton, First Selectman Don Gouin, Emergency Management Director Robert Shea, Board of Education Robert Puida, Fire Chief Margot Burns, RiverCOG Scott Choquette, Dewberry

Regional Mitigation Planning Committee Hazard Identification and Risk Assessment Meeting

On February 2, 2026, the Regional Planning Committee was reconvened to review progress-to-date. At that meeting, a refresher of the overall planning process was presented. Plan integration and synchronization with other planning efforts was discussed. The results of the public survey (see 1.3.6, below) were presented and discussed.

At this meeting a draft of the Hazard Identification and Risk Assessment (HIRA), including hazard profiles, vulnerability analysis and loss estimation, was presented. Goals and objectives were revisited and confirmed, based on the results of the HIRA regional hazard mitigation actions were reviewed by the municipal participants for buy in.

After the main presentation and discussion, municipal participants held virtual break-out sessions to review the disposition of their 2021 mitigation actions and review the regional actions for 2026-2031 that were developed.

Regional Mitigation Planning Committee Draft Review Meeting

On May 27, 2026, there was a virtual meeting of the Committee, hosted via MS Teams to review the final draft elements of the plan, fill data gaps and address comments. Plans for additional stakeholder engagement were discussed, and the regional mitigation strategies were finalized. Plans to post the final draft to various websites and social media platforms prior to submission to

DEMHS and FEMA for review were also discussed, as was the eventual adoption process. Meeting documentation can be found in Appendix A.

1.3.6. Public Engagement

Strategy

The strategy for involving the public in the planning process emphasized the following elements:

- Use an online public survey to determine if the public's perception of risk and support of hazard mitigation has changed since the last plan update.
- Attempt to reach as many planning area citizens as possible using multiple media.
- Identify and involve planning area stakeholders.

Public Meeting 1

On July 23, 2025, stakeholders and members of the public were invited to an overview of the plan's purpose and review the plan's progress-to-date and to provide input on hazards and mitigation strategies. The public meeting was announced in a notice in July 11, 2025 on Zip06 Events page of the Shoreline Times, H-K News Press Release (Haddam and Killingworth) and on July 21, 2025 to the Middletown Press (See Appendix A). It was also noticed on the RiverCOG website and Facebook, LinkedIn, and Instagram on July 10-11, 2025. (Figure 1.3.1). A notice was sent to all participating jurisdictions asking them to share the notice on their social media and/or web pages. Video recordings of this and other public meetings were posted to the RiverCOG webpage.

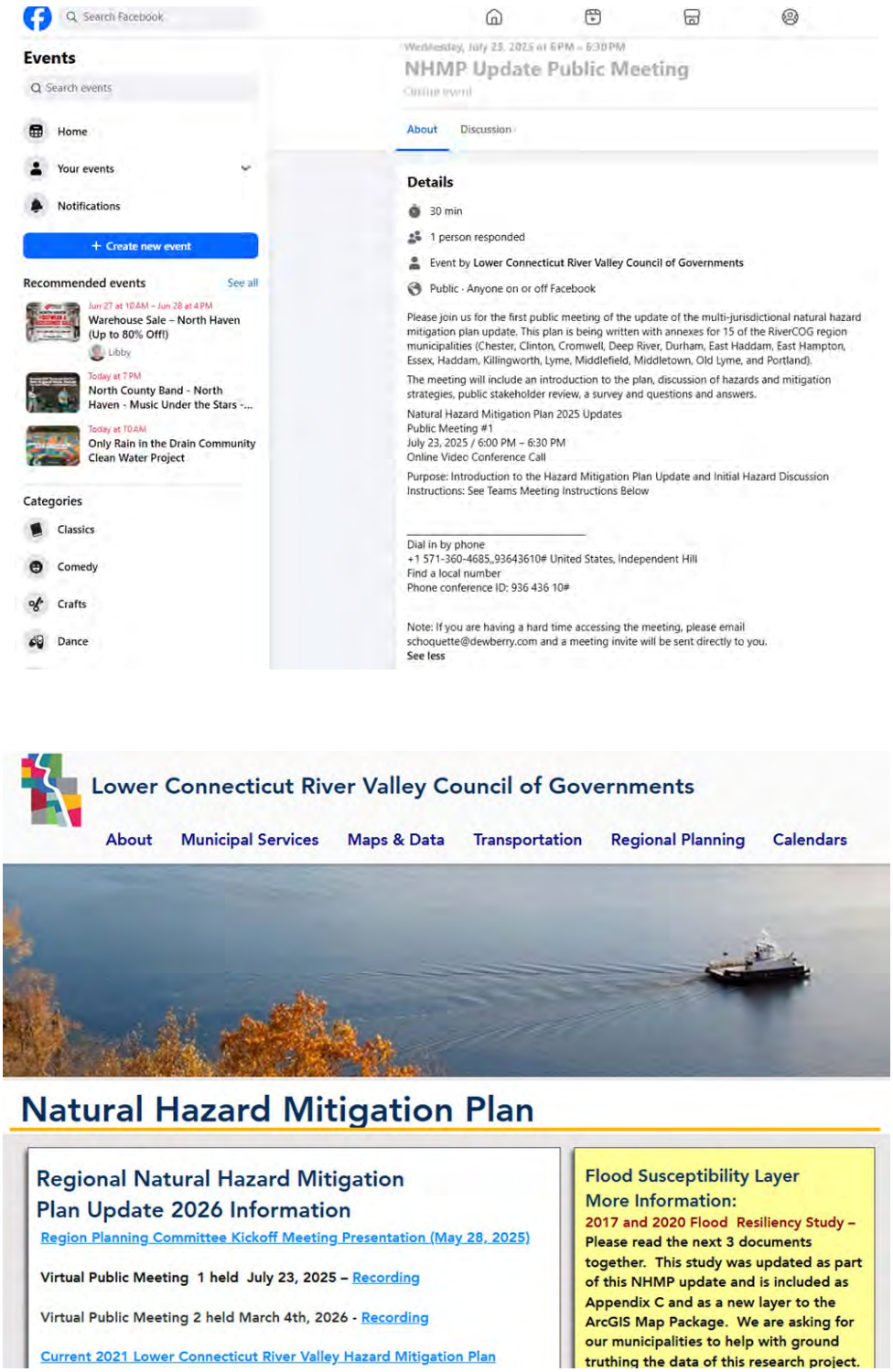


Figure 1.3.1 Online Posting of Meeting Notice

Attendance at the first public meeting was disappointing. In addition to RiverCOG staff and the consultants, representatives of three of the participating communities (Deep River, Durham, and

Middlefield) were in attendance. No additional members of the public were in attendance. Meeting documentation can be found in Appendix A.

Public Meeting 2

A second public meeting was held on March 4, 2026, at 7:00 PM. It was announced on February 27, 2026, for consecutive days, in five editions of the Patch (Clinton, East Hampton-Portland, Durham-Middlefield, Haddams-Killingworth, and Essex-Chester-Deep River). (Figure 1.3.2). At this meeting, the results of the previous survey and public input were discussed, and a draft of the plan's risk assessment and capabilities assessment were reviewed on-screen. The audience was then invited to offer additional comments and review the plan once posted on the RiverCOG website.

There was a total of nine participants at the meeting. Two were members of the public or business community. Meeting documentation can be found in Appendix A.



Figure 1.3.2. Sample Advertisement in Middletown Patch

Public Survey

A hazard mitigation plan public survey was developed by the Regional Planning Committee. The survey was used to gauge preparedness for natural hazards and the level of knowledge of tools and techniques that assist in reducing risk and loss from natural hazards. This survey was designed to help identify areas vulnerable to one or more natural hazards, based on the experiences of

RiverCOG region residents, business owners and stakeholders. The survey was available online and advertised between August 19, 2025, and December 30, 2025. The answers to its 15 questions helped guide the committee in evaluating goals, objectives and mitigation strategies. The survey was web-based and was posted on the RiverCOG Hazard Mitigation Planning webpage. The survey link was also posted on RiverCOG's social media pages and shared with the communities for posting on theirs. It was also emailed to various lists of local planners and other stakeholder interest groups. Two hundred and four (204) questionnaires were completed during this planning process. The complete questionnaire and a summary of its findings can be found in Appendix A of this volume. Survey input was used to inform the risk assessment and mitigation strategy development. Figure 1.3.3 shows the general composition of respondents.

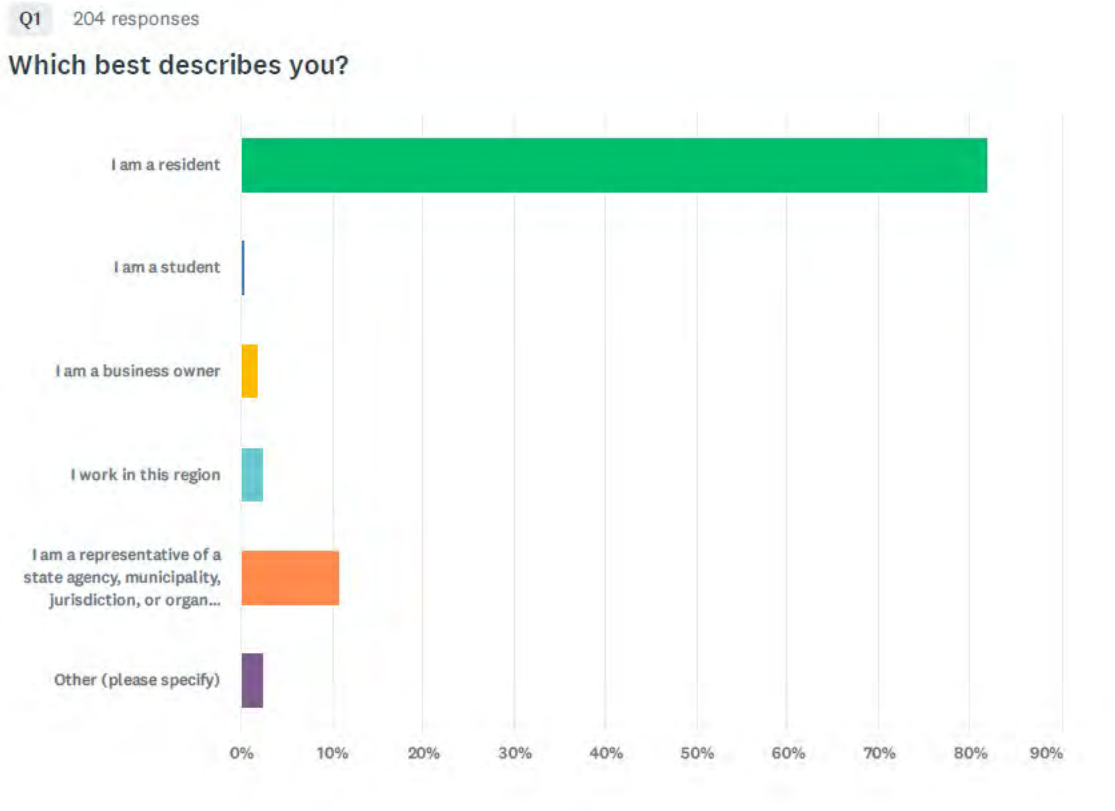


Figure 1.3.3 Public Survey Respondents Composition

When asked if they were aware that the Lower Connecticut River Valley communities maintain hazard mitigation plans, 60% reported yes, 38% reported no and three did not answer (Figure 1.3.4).

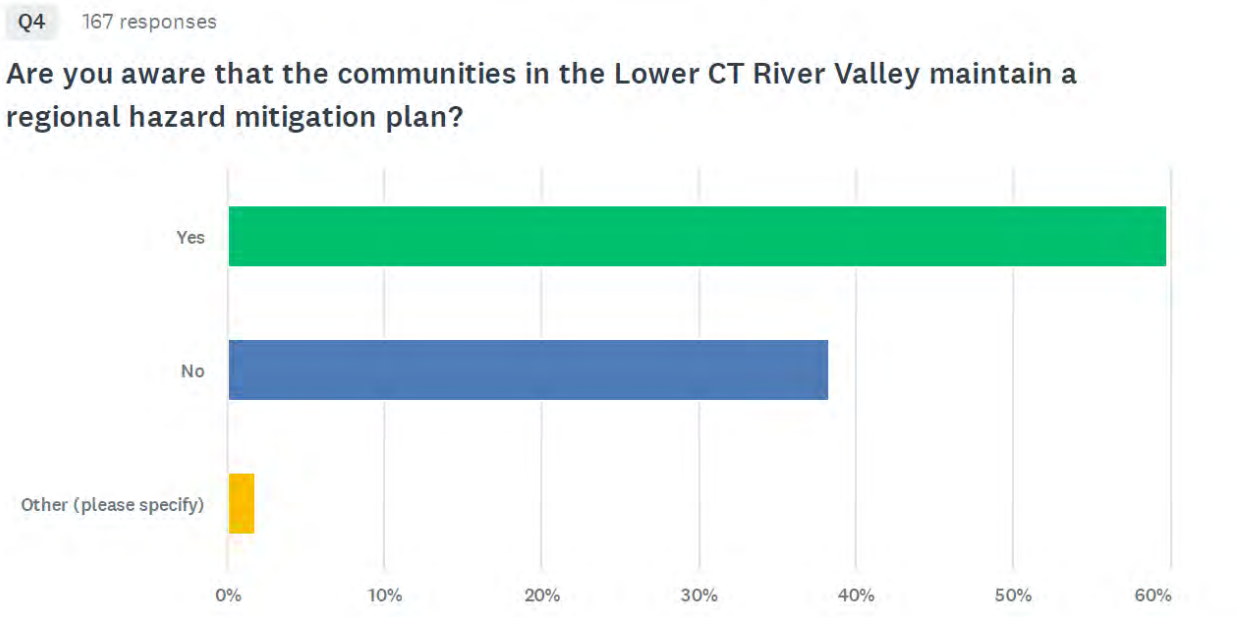


Figure 1.3.4 Respondent Awareness of Hazard Mitigation Planning

When asked how concerned respondents were asked which hazards they were concerned about impacting their homes, business or community, the highest ranked hazards of high concern were:

- Climate Change (63% of Respondents)
- Aquatic Invasive Species (49% of Respondents)
- Wind (38% of Respondents)
- Terrestrial Invasive Species (38% of Respondents)
- Flooding (Coastal, Seal Level Rise, River, Drainage) (38% of Respondents)

The highest ranked hazards of moderate concern were:

- Severe Thunderstorms (including Hail and Lightning) (60% of Respondents)
- Wind (52% of Respondents)
- Winter Storms/Blizzards (50% of Respondents)

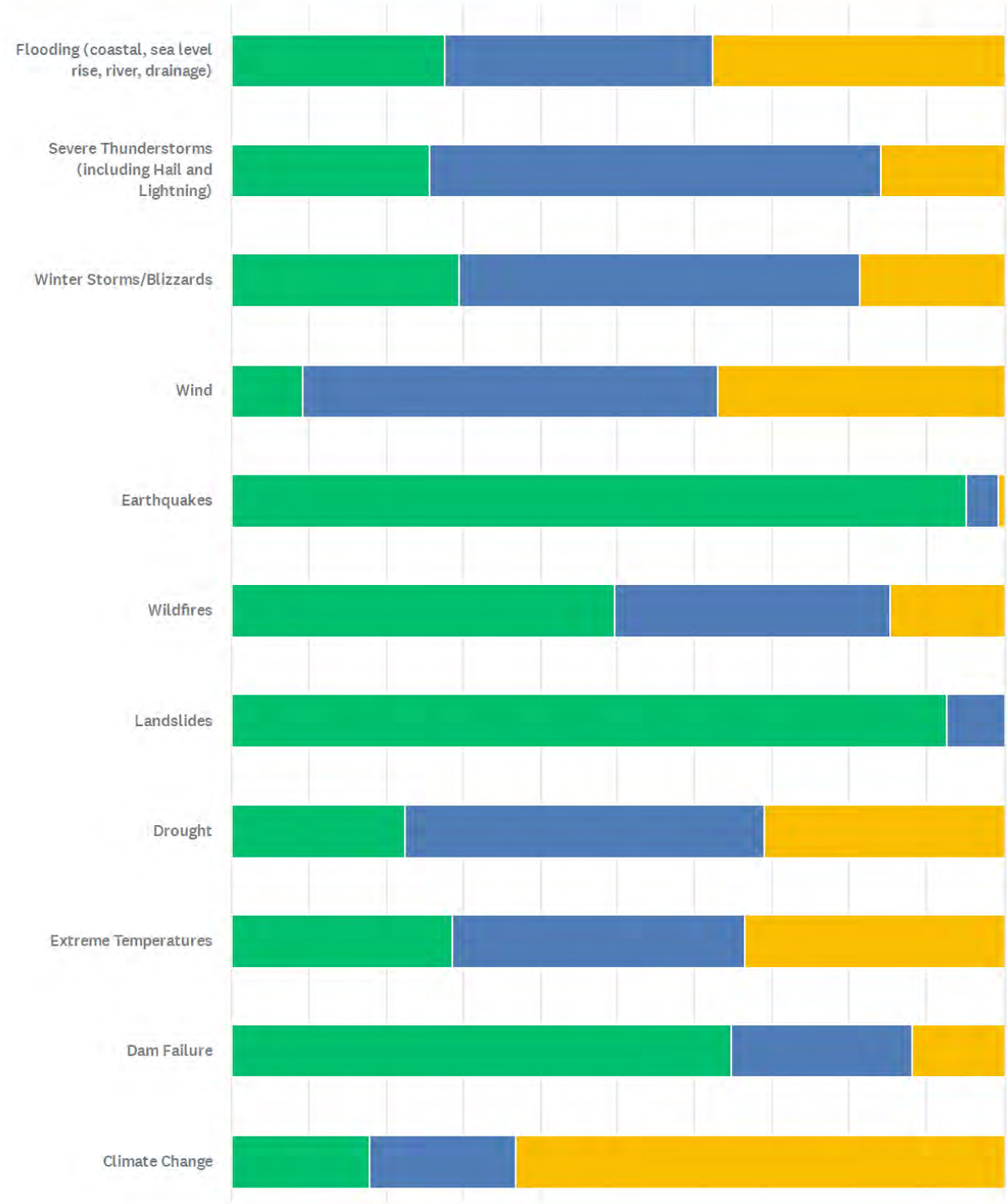
The highest ranked hazards of low concern were:

- Earthquakes (95% of Respondents)
- Landslides (92% of Respondents)
- Dam Failure (64% of Respondents)

Figure 1.3.5 shows the results of the ranking.

Q6 168 responses

How concerned are you about each of the following hazards impacting your home, business, community, or organization?



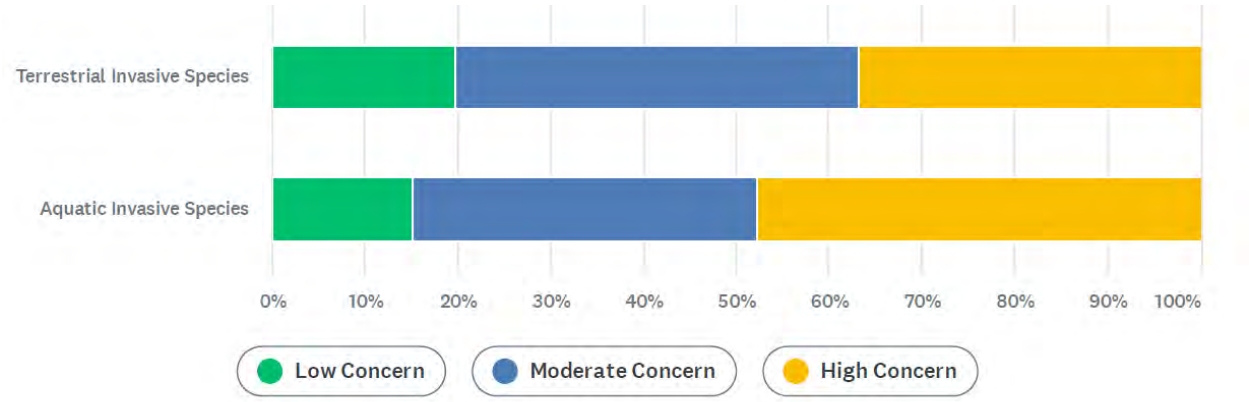


Figure 1.3.5 Respondent Concern about Hazards

When asked to note specific areas of concern for vulnerability to natural hazards, respondents mentioned the below locations, by topic in Table 1.3.6.

Table 1.3.6 Vulnerable Areas and other Concerns in RiverCOG Jurisdictions by Hazard Type

Hazard	Key Findings	Details
Flooding	• Riverine flooding along the Connecticut River is a major concern, particularly in Essex, Chester, Old Saybrook, and East Haddam • Coastal flooding during high tides and storm events affects shoreline communities • Localized flooding from heavy rainfall impacts roads, downtowns, and low-lying areas • Critical infrastructure vulnerability includes evacuation routes and access roads	• Shore Road, Clinton (emergency access concern during construction detour) • Route 154, south of Harvey's Beach (floods during high tides) • Downtown Essex, Main Street • Chester Creek and downtown Chester, Water Street • East Hampton Village Center • Commerce Street and Grove Street intersection, Clinton
Coastal and Shoreline Vulnerability	• Sea level rise and storm surge are primary concerns for coastal communities • Shoreline erosion threatens residential and recreational areas • Marsh and estuarine areas are experiencing climate impacts • Municipal infrastructure along the coastline is at risk	• Long Island Sound shoreline (areas within 1/4 mile) • Old Saybrook at sea level • Fenwick, Fenwood, Saybrook Point • Black Point and Mago Point • Clinton town dock, bulkhead, and waterfront infrastructure • Old Lyme shoreline communities

Hazard	Key Findings	Details
Infrastructure Vulnerability	• Road washouts and drainage failures create safety hazards and property damage • Tree-lined roads and overhead power lines are vulnerable to storms • Vegetation management along utility corridors requires improvement • Dam infrastructure shows signs of aging and failure	• Long Island Sound shoreline (areas within 1/4 mile) • Old Saybrook at sea level • Fenwick, Fenwood, Saybrook Point • Black Point and Mago Point • Clinton town dock, bulkhead, and waterfront infrastructure • Old Lyme shoreline communities
Invasive Species	• Both terrestrial and aquatic invasive species are widespread concerns • Invasive plants increase wildfire risk and threaten biodiversity • Lakes and waterways face threats from aquatic invasives • Spotted Lanternfly is emerging as a new threat	• **Terrestrial Invasive Species of concern:** • Japanese knotweed (multiple locations, widespread) • Barberry • Phragmites (Duck River estuary and other wetlands) • Russian olive • Japanese stilt grass • Tree of Heaven (East Main Street and Liberty Place - fire risk) • Invasive bamboo (community-wide) • Spotted Lanternfly • **Aquatic Invasive Species Concerns:** • Hydrilla (threat to Cedar Lake and Connecticut River) • Cedar Lake - multiple reports of aquatic invasives • Rogers Lake - aquatic invasive species • Lake Beseck - invasive plant species • Beseck Lake and Middlefield Coe Hill open space
Wildfire Risk	• Extensive forests create wildfire vulnerability, especially during drought • Tree of Heaven and other invasive species increase fire risk • Regional air quality impacts from distant wildfires noted	
Drought	• Concerns about well water levels for private homes	

Hazard	Key Findings	Details
	• Increased wildfire risk during prolonged drought • Impact on vegetation and forest health	
Climate Change	• Cedar Lake and Pattaconk Cove/Creek identified as climate-vulnerable • Clinton coastline facing climate impacts including tides and storm surge • Trees showing stress from changing weather patterns	
Winter Weather	• Hilly terrain in Chester vulnerable to icy, snowy conditions • Road maintenance costs during severe winter conditions	

Other findings of the survey include:

- Wind and flooding have reportedly caused the most damage to homes, businesses and communities.
- Respondents identified Text Message (80%), Automated calls (39%), CT Alert (36%), and Email (35%) as being the preferred way of receiving emergency information about natural hazards.
- The top three were listed as the options that respondents used the most currently.
- Providing outreach; Enacting and enforcing regulations, codes, and ordinances; and technical assistance were ranked highest among things communities can do to help residents prepare for disasters and become more resilient.
- The top three mitigation actions residents have taken on their own were, cutting back vegetation from roofs and power lines, managing vegetation to reduce risk of wildfire, and maintaining a disaster supply kit.

When given the opportunity to choose one thing communities could do to reduce damage from natural hazards, survey respondents had many recommendations. Table 1.3.6 summarizes the top 5 priority actions identified by residents when asked: *"If you could choose one action that could be taken in the region to reduce its vulnerability to hazards and the disasters associated with these hazards, what would it be?"* These 5 themes represent 71 of 94 responses (75.5%), indicating strong consensus on priority areas for mitigation investment.

Table 1.3.7 Survey Respondents' Recommended Actions to Reduce Damages from Natural Hazards

Recommendation Theme	Responses	Key Actions Requested	Representative Quote
Flood Mitigation	20 (21.3%)	Replace culverts and bridges Improve drainage systems Maintain storm drains Address low-lying areas	*"Reexamine existing storm drain system to ensure that it is a) maintained and b) does not increase risk of flooding."*

Recommendation Theme	Responses	Key Actions Requested	Representative Quote
		Implement permeable surfaces	
Tree Management / Vegetation Control	17 (18.1%)	Trim trees near power lines Remove dead/hazardous trees Target vulnerable species Improve utility coordination	*"Take down the tall trees and branches near utility poles!!"*
Public Education and Outreach	15 (16.0%)	Webinars and presentations Disaster planning education Climate action guidance Resource awareness	*"Educating the public on how to develop a disaster plan and supply kit. They need presentations - not handouts."*
Underground Power Lines	10 (10.6%)	Bury lines during road work Install conduit for future use Phase in underground systems	*"Every time a road is worked on, the lines should be buried, or AT A MINIMUM bury conduit to prepare to bury lines."*
Coastal Protection	9 (9.6%)	Restore marshes and wetlands Allow defensive structures Streamline permitting Address beach erosion	*"Restore the marshes and other wetlands to reduce flooding and storm surge damage."*

Full survey results including all responses are provided in Appendix A.

1.3.7. Incorporation of Existing Plans and Studies

At the beginning of the planning process, all relevant existing plans and studies were reviewed for incorporation into the hazard mitigation plan. The planning committee relied heavily on data provided at the COG and municipal levels as well as on data from the Connecticut State Natural Hazards Mitigation Plan (2023). A detailed discussion of policies, plans, and studies included in this plan is included in Chapter 3, Section 3.1 Capabilities Assessment and in each of the municipal annexes in Volume 2 of this plan.

1.4. Lower Connecticut River Valley Profile

Much of the information in this section is comprised of descriptions, facts and figures gleaned from other planning resources in the region. Each municipal annex in Volume II of this plan includes a profile at the community level.

1.4.1. Setting

The Lower Connecticut River Valley region is comprised of seventeen unique municipalities linked and centered on one of Connecticut's greatest natural features': the Connecticut River. Figure 1.4.1 provides the location of the region in context to the rest of the state.

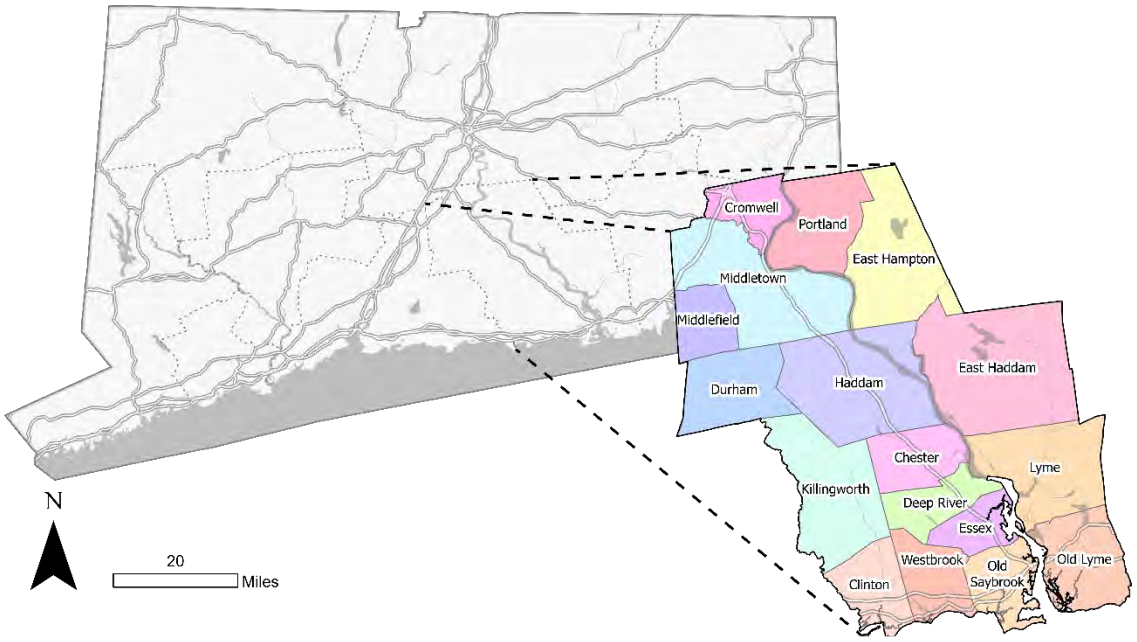


Figure 1.4.1. RiverCOG Location Map (Source: CIRCA)

Despite geographic proximity, the seventeen municipalities offer a great variety of natural, cultural, and physical amenities to residents, workers, and visitors. The region's natural amenities – such as beaches, forests, agriculture, protected open spaces, trails system, and the Connecticut River – are cherished assets and help establish the unique character in the region. These natural amenities are complemented by diverse towns, anchored by the City of Middletown and its vibrant Main Street, the region's only city. The regional economy is supported by activity centers that range from historic town centers to modern shopping centers and established industrial parks. These assets make the region attractive to visit, as do its several tourist destinations, including the Essex Steam Train, Gillette Castle, and the Goodspeed Opera House, among many others.

Middletown is a vibrant and diverse community and the region's urban center. It is home to an increasingly vibrant downtown serving as a popular retail, dining, and bar district as well as a diverse set of neighborhoods, parks, and open spaces. As the region's sole urban center, it is home to the regional hospital, court system, and two of the region's higher education institutions

(Wesleyan University and Middlesex Community College). Although the city's access to the Connecticut River is limited by the path of the CT Route 9 expressway, there is great opportunity for a revitalization, with the establishment of better river access.

The shoreline towns of Clinton, Westbrook, Old Saybrook, and Old Lyme have the dual attractions of Long Island Sound and the maintenance of small-town character by the lack of dense beach development. These towns are home to numerous beach communities that were predominantly developed as seasonal dwellings. Similar land use patterns have occurred near lakes in East Hampton, East Haddam, Chester, Old Lyme, and Middlefield. While these seaside and lakeside communities are experiencing an increase in the conversion of dwelling units from seasonal to year-round habitation, absence of water and sewer utilities limit the amount of conversion in some areas. As more and more seasonal dwellings are converted to year-round use, associated construction will aggravate daily traffic flows, emergency response and recovery during storm events, and generally will put more pressure on town-delivered services.

Continuing development along regional arterials is transforming rural landscapes and increasing traffic volumes. Current zoning regulations and development patterns trend toward isolated commercial strip development. As a result, lack of shared access to driveways and poor traffic flow creates challenges for safety and mobility along these corridors. In addition, the town boundaries and individuality of towns become less distinct as subdivision and chain-store commercial development erode the character of the village centers and venues for civic interactions. In recent POCD updates the region is pointing to the development of walkable town centers and mixed use development in commercial zones as a way to address this challenge.

Durham and Middlefield are rural agricultural communities with easy access to the larger town centers of Middletown, Meriden, North Haven and Wallingford. These larger towns are characterized by large lot development and rural town centers.

Cromwell is the most suburban municipality with higher density residential and strip mall development near Route 9 and Route 372. The other areas of town are primarily lower density residential units with a town government center that is rural in character. Cromwell also has a significant number of houses along the Connecticut River.

Chester, Deep River, East Haddam, Haddam, Killingworth, Lyme, Old Lyme, Portland, and Essex are characterized by their small village centers. All except Killingworth are located on the Connecticut River and contain recreational boating facilities. The large tracts of state-owned forested open land between each town define distinct village centers.

In the 19th century, East Hampton was a center for the manufacturing of bells, with residential, commercial, and industrial development historically located in the town center adjacent to Lake Pocotopaug. East Hampton is connected to Hartford and Norwich via the Route 2 expressway.

In general, the rural character of the region north of I-95 results from predominantly large unbroken tracts of privately-owned forestland, state forest and park lands, and public water supply land

holdings. State parks and forests and wildlife management areas account for approximately 12.5% of the region's existing land use.

1.4.2. Physiography & Hydrology

The region contains a wide variety of natural resources such as the Connecticut River, other rivers, streams and wetlands, coastal dunes and beaches, as well as abundant forests and farm properties. These natural areas constitute primary habitats for the region's vast flora and fauna and support the migration routes for animals, particularly migrating birds, across the region. This plethora of resources is distinct to the Region and has been a driving force in support of conservation efforts, development, and tourism related to outdoor recreation. Although the region's natural systems are generally healthy, they have been diminished somewhat over time from both past and present land use practices. The future of some resources is threatened by the ever-present changing climate.

The Connecticut River is the longest River in New England, flowing 410 miles between Canada and the Long Island Sound, where it discharges after flowing through the Region. Tributaries in the region, from north to south, include the Mattabesset, Salmon, Deep, Eightmile, Falls, and Black Hall Rivers. Due to the presence of large, shifting sandbars at its mouth, the Connecticut River is the only major river in the Northeastern United States without an industrial port at its mouth. While lacking a port, the scenic and bucolic character of the river and its estuary makes it a destination for recreational fishing and boating.

There are many state parks, forests and trails within the Region. The Region's state parks and forests provide local as well as regional environments for activities such as hiking, fishing, camping and other recreational uses. Remarkably, all the Region's seventeen municipalities contain part of a state park or forest. A density of natural resources contributes to the Region's reputation as a location with high scenic beauty and quality of life. These resources also add to the identity of the region.

1.4.3. Climate

Connecticut has a generally temperate climate. The lower Connecticut River valley is like the rest of the state. Summers are hot and humid, while winters range from mild on the coast to cold and snowy in the interior. The January mean temperature is 27°F (-3°C) and the July mean is 70°F (21°C). Coastal areas have warmer winters and cooler summers than the interior. The annual rainfall (1971–2000) was 46.2 in (117 cm) and evenly distributed throughout the year. The state receives some 25 to 60 in (64 to 150 cm) of snow each year with heavier snowfall in higher elevations. While annual precipitation has remained fairly steady in the region in the past few decades, the intensity of rainfall events is increasing as are wind and other severe weather events.

1.4.4. Land Use and Development Trends

The RiverCOG region is predominately rural, covered by forest and woodlands, with large lot single family housing. The exception to this is the area around Middletown, which is the region's urban center. More densely populated historic town centers are common near the Connecticut River, while town centers toward the western area of the region are more rural in character. The shoreline supports higher residential densities, with beach communities, retail, and commercial developments oriented towards I-95 exits and along Route 1.

An analysis of the historic patterns of development from 1985 – 2025 shows that land consumption has generally kept pace with the growth in population. This suggests that over those four decades, the pattern of development of the region has not substantially changed. Had there been increases in residential lot sizes or amount of commercial development necessary to support a household, one would expect that the consumption of land for development purposes would have increased. Much of this new development of land has occurred in areas proximate to development that existed in 1985. This development mostly occurred in the northern municipalities of Portland, Cromwell, Middlefield, and Durham.

Residential housing accounts for over 37% (106,988 acres) of RiverCOG's land as measured by parcels, making it by far the Region's largest land use. Residential uses also make up the majority, if not vast majority of the grand list of every municipality in the region.

Town & village centers serve as the heart of the municipalities of the RiverCOG. These traditional New England city, town, and village centers are often the primary areas in municipalities where there is a mix of uses: residential dwellings alongside commercial establishments (restaurants, shops, and other businesses), and, often, civic and institutional uses including schools, municipal buildings, and museums. Such a mix of uses is often not allowed under traditional zoning laws, which generally separate different uses from each other to a greater degree than is found in these historic centers of municipal life.

Commercial land uses in the region are historically comprised of small village centers that provided goods and daily staples to the communities in which they were located. Small villages and downtown centers such as those in Chester, Portland, and Old Lyme are examples of the small-scale commercial uses that historically made up most of RiverCOG's commercial developments. Goods and services such as grocery stores, hardware stores, banks, and local restaurants are common today in many of the region's towns and are scattered throughout the region.

Larger commercial centers in communities such as Middletown, Cromwell, and Old Saybrook have grown and expanded to include a mix of small "mom and pop" businesses such as cafes, diners, and specialty shops, as well as larger chain retailers such as Walmart, Home Depot, and West Marine. These large-scale commercial businesses typically draw patrons from across the region

and are often located in large shopping plazas with multiple stores, creating a commercial destination.

Historically, most of the industrial plants in the region were in Middletown, which is still home to more factories than any other town. However, the highway system has facilitated the dispersal of industry beyond its historic seats and now many of the region's municipalities have a significant manufacturing base.

Currently, approximately 1.4 percent (or roughly 4,000 acres) of the land area in the region is zoned for industrial use. Industrial development in the region is limited due to the lack of water, and sewer and natural gas infrastructure in many of the Region's municipalities. For this reason, and because of Euclidean zoning's separation of land uses, industries tend to be clustered in designated industrial parks and other smaller areas of high concentration.

Since the 2021 NHMP update, development has been slow in the region. The municipal annexes in Volume 2 of this plan provide more details on a community-by-community basis.

1.4.5. Population

The following discussion of population in the region is from the 2023 Regional Metropolitan Transportation Plan (MTP) and original sources of data are noted. [1]

The total population of the RiverCOG region was 174,983 based on the 2023 5-year American Community Survey (ACS) conducted by the U.S. Census Bureau, an increase of 1.2% from the population estimate in the 2019 ACS. According to the 2023 ACS estimates, the State of Connecticut's population increased slightly (0.7%) from 2019 to 2023.

Six out of the fifteen municipalities in the RiverCOG region recorded a decline in population during this same time period (Table 1.4.1). The estimated decline ranged from 10.6% in Chester to 0.8% in East Haddam. The other nine municipalities in the region had an increase in population. The populations of Haddam and Old Lyme had the largest increase, with increases of 4.1% and 3.4% respectively from 2019 to 2023. The Connecticut State Data Center (SDC) at the University of Connecticut produced population projections for all municipalities in the state in 2015, forecasting until 2040. The projections used vital statistics, net migration, and other variables to project the statewide populations. Physical factors such as land use limitations, changes in the transportation system, and economic conditions were not factored into municipal projections. For these reasons, there is no exact standard of comparison between projection statistics and those recorded by the Census Bureau. Connecticut Department of Transportation's (CTDOT) Travel Demand and Air Quality Modeling Unit used the SDC projections and forecasted out to 2050, the horizon year of the MTP. According to the SDC, the RiverCOG region's population will increase 6% to 184,920 by 2035.

[1] https://www.rivercog.org/_files/ugd/3b20a9_a2a39e99eb7e4272acdeb9238bfae764.pdf

By 2045, the population will increase by an additional 4% to 192,761, and by 2050, the RiverCOG region's population will increase by an additional 2% to 196,620.

Table 1.4.1. Municipal Population Projections

Geography	TP 2019*	TP 2023 (PC 2019-2023)**	TP 2035 (PC 2023-2035)***	TP 2045 (PC 2035-2045)***	TP 2050 (PC 2045-2050)***
Connecticut	3,575,074	3,598,348 (0.7%)	3,746,581 (4%)	3,856,272 (3%)	3,910,067 (1%)
RiverCOG	172,948	174,983 (1.2%)	184,920 (6%)	192,761 (4%)	196,620 (2%)
Chester	4,234	3,786 (-10.6%)	4,633 (22%)	4,889 (6%)	5,014 (3%)
Clinton	12,944	13,317 (2.9%)	13,558 (2%)	13,946 (3%)	14,137 (1%)
Cromwell	13,910	14,301 (2.8%)	15,159 (6%)	15,949 (5%)	16,342 (2%)
Deep River	4,480	4,432 (-1.1%)	4,608 (4%)	4,708 (2%)	4,757 (1%)
Durham	7,221	7,182 (0.5%)	7,908 (10%)	8,360 (6%)	8,583 (3%)
East Haddam	9,007	8,934 (-0.8%)	10,235 (15%)	10,990 (7%)	11,364 (3%)
East Hampton	12,827	12,834 (0.1%)	14,349 (12%)	15,295 (7%)	15,763 (3%)
Essex	6,604	6,766 (2.5%)	7,251 (7%)	7,607 (5%)	7,782 (2%)
Haddam	8,227	8,562 (4.1%)	8,857 (3%)	9,261 (5%)	9,461 (2%)
Killingworth	6,392	6,219 (-2.7%)	7,240 (16%)	7,774 (7%)	8,038 (3%)
Lyme	2,499	2,356 (-5.7%)	2,497 (6%)	2,607 (4%)	2,662 (2%)
Middlefield	4,381	4,236 (-3.3%)	4,587 (8%)	4,715 (3%)	4,777 (1%)
Middletown	46,511	47,646 (2.4%)	48,905 (3%)	50,523 (3%)	51,315 (2%)
Old Lyme	7,396	7,644 (3.4%)	7,729 (1%)	7,983 (3%)	8,109 (2%)
Portland	9,322	9,421 (1.1%)	9,591 (2%)	9,788 (2%)	9,885 (1%)

TP = Total Population

PC= Percent Change

** 2019 ACS 5-year Estimates*

*** 2023 ACS 5-year Estimates*

**** RiverCOG 2023 MTP utilizing SDC and CTDOT population projections*

Based on the population projections in Table 1.4.1, Chester will experience the largest population increase, at 32% growth from 2023 to 2050. Killingworth, East Haddam, East Hampton, and Durham also have high growth rates by 2050, all of which are projected to increase by over 20%. Portland, Old Lyme, Clinton, Deep River, and Middletown have the lowest rate of increase from 2023 to 2050, all of which are below a 10% percent change.

As population density increases, so does the level of economic activity, resulting in a greater demand for public amenities (i.e., water & sewer, schools, etc.). Table 1.4.2 shows that the RiverCOG's population density has increased each decade from 1970 to 2010 but then decreases from 2010 to 2020. The population of the RiverCOG region declined from 2010 to 2020 resulting in a slight decrease in population density for most municipalities. In 2020, there were an estimated 393 residents living in each square mile of the region. The regional population density is significantly less than the state average of 745 residents per square mile. The areas with the highest population densities are Middletown, Cromwell, and Clinton. The areas with the lowest population densities are Lyme, East Haddam, Killingworth and Haddam, all with less than 200 individuals per square mile.

Table 1.4.2. Population Density by Jurisdiction

Geography	Land Area (SQMI)	Population Density per Square Mile in 1980	Population Density per Square Mile in 1990	Population Density per Square Mile in 2000	Population Density per Square Mile in 2010	Population Density per Square Mile in 2020
Connecticut	4,844.1	642	679	703	738	745
RiverCOG	424.2	323	358	388	417	393
Chester	16	192	214	234	250	234
Clinton	16.3	687	783	803	813	809
Cromwell	12.4	828	991	1,038	1,129	1,147
Deep River	13.6	294	319	339	340	326
Durham	23.6	218	243	281	313	303
East Haddam	54.3	104	123	153	168	163
East Hampton	35.6	241	293	375	364	357
Essex	10.4	488	568	625	643	651
Haddam	44	145	158	163	190	192
Killingworth	35.3	113	136	170	185	175

Geography	Land Area (SQMI)	Population Density per Square Mile in 1980	Population Density per Square Mile in 1990	Population Density per Square Mile in 2000	Population Density per Square Mile in 2010	Population Density per Square Mile in 2020
Lyme	31.9	57	61	63	75	74
Middlefield	12.7	299	309	331	348	332
Middletown	40.9	955	1,046	1,055	1,189	1,163
Old Lyme	23.1	267	283	321	329	330
Portland	23.4	358	360	373	406	401

Sources: 1980, 1990, 2000, 2010, 2020 Decennial Census of Population and Housing

1.4.6. Housing

The region has seen steady growth with two major boom periods: from 1920 to 1930 when the population grew by 31% and from 1950 to 1970 when the population grew by 55%. The first major period is the pre-WWII period which corresponds to the Early Industrialization period discussed in the History section. Across the region, housing that is approaching a century in age accounts for about one-quarter of all housing.

Following World War II and the opening of I-95, there was a major influx of residents to the region. During that time, there was a 73% increase in population and gains of approximately 51,000 residents. Housing from this era accounts for 38% of the region's housing stock.

In the proceeding five decades, population growth stabilized around 10% per decade, resulting in an increase of approximately 52,000 residents over that same time period. However, housing from this era represents half of all the housing stock in the region. This may be the result of several factors including smaller household sizes, demolition of older homes, urban revitalization efforts, and increased demand for suburban and semi-rural housing, among many other factors.

With more homes coming on the market due to out-migration and the passing of older residents, the demand for new housing has decreased substantially. If this trend continues, many of the region's municipalities will see only single-digit net housing gains or even a decrease in total housing units in coming years.

Table 1.4.3 shows the American Communities Survey of households and per household occupancy estimated for the five-year period between including 2020-2024 by community.

Table 1.4.3. Households by Community

Geography	Households	Persons per Household
RiverCOG	74,068	2.28

Geography	Households	Persons per Household
Chester	1,561	2.42
Clinton	5,509	2.41
Cromwell	5,763	2.41
Deep River	1,922	2.35
Durham	2,986	2.40
East Haddam	3,663	2.41
East Hampton	5,248	2.45
Essex	2,987	2.22
Haddam	3,389	2.52
Killingworth	2,516	2.48
Lyme	1,093	2.21
Middlefield	1,711	2.56
Middletown	20,390	2.09
Old Lyme	3,185	2.40
Portland	3,762	2.48

Source: 2020—2024 American Community Survey 5-year Estimates

1.4.7. Business and Labor

The information in this subsection comes from the 2023 Regional Metropolitan Transportation Plan and the sources cited within the narrative.

The economic base in the RiverCOG region includes a diverse set of industries and employment centers. As of 2018, the region was home to 4,305 firms, the majority categorized as “retail trade”. Based on data from the Census Bureau’s Longitudinal Employer-Household Dynamics database, 68,493 individuals were employed in the RiverCOG region in 2019. Of those employed in the region, 18.0% were employed in the health care and social assistance sector, followed by 13.9% in the manufacturing sector (Table 1.4.4). Table 1.4.5 lists the five largest employers by town. Of the 85 firms listed, 14 are in the manufacturing sector, and 10 are in the health care sector. Many of the largest employers in the region are located in Middletown, including Middlesex Hospital, Connecticut Valley Hospital (now closed but not reflected in the data), Wesleyan University, and FedEx Ground, which employs 722 people in a new facility built in 2018. The region’s largest employer outside of Middletown is the Lee Company, which manufactures hydraulic equipment in their facility on Pettipaug Road in Westbrook. In many of the RiverCOG region’s municipalities, the public schools and supermarket chains are the largest employers. Significant clusters of retail jobs

can be found in the region's two outlet malls, Clinton Crossing in Clinton and Tanger Outlets in Westbrook, both located near I-95.

In 2019, the region's workforce totaled 86,150 individuals, a larger number than those individuals employed within the RiverCOG region. The majority of RiverCOG region residents (67.7%) commuted outside of the region for work. The majority of the region's workers travel north-bound for work, with 10.4% employed in Middletown and 7.1% in Hartford. Meriden, East Hartford, New Britain, and Newington are also large employment hubs for the region's residents. Table 1.4.4 shows employment by sector and Table 1.4.5 shows the top employers by community as of 2022. There is no indication that this has changed in the last three years.

Table 1.4.4. Industries and Workers in the RiverCOG Region by Sector, 2019

Sector	Count of Jobs in the Region	Percent Total of Jobs in the Region	Count of Workers Residing in the Region	Percent Total of Workers Residing in the Region
Agriculture, Forestry, Fishing and Hunting	380	0.6%	286	0.3%
Mining, Quarrying, and Oil and Gas Extraction	7	0.0%	17	0.0%
Utilities	391	0.6%	571	0.7%
Construction	4,038	5.9%	3,935	4.6%
Manufacturing	9,505	13.9%	9,689	11.2%
Wholesale Trade	2,839	4.1%	3,455	4.0%
Retail Trade	8,332	12.2%	8,759	10.2%
Transportation and Warehousing	1,721	2.5%	2,305	2.7%
Information	894	1.3%	1,716	2.0%
Finance and Insurance	1,701	2.5%	5,183	6.0%
Real Estate and Rental and Leasing	538	0.8%	904	1.1%
Professional, Scientific, and Technical Services	3,420	5.0%	5,215	6.0%
Management of Companies and Enterprises	980	1.4%	1,541	1.8%
Administration & Support, Waste Management and Remediation	3,039	4.4%	3,667	4.3%
Educational Services	6,147	9.0%	9,761	11.3%

Sector	Count of Jobs in the Region	Percent Total of Jobs in the Region	Count of Workers Residing in the Region	Percent Total of Workers Residing in the Region
Health Care and Social Assistance	12,295	18.0%	14,213	16.5%
Arts, Entertainment, and Recreation	1,367	2.0%	1,706	2.0%
Accommodation and Food Services	6,177	9.0%	6,558	7.6%
Other Services (excluding Public Administration)	2,872	4.2%	3,130	3.6%
Public Administration	1,866	2.7%	3.700	4.3%
Total	**68,449**	**100.0%**	**86,331**	**100.0%**

Table 1.4.5. Top Five Employers by Town, 2022

Jurisdiction	Top Employers #1	Top Employers #2	Top Employers #3	Top Employers #4	Top Employers #5
Chester	Whelen Engineering	Greenwald Industries	Roto Frank	Camp Hazen	Norma Terris Theatre
Clinton	Stop and Shop	Shop Rite	Joel School	Big Y	National Sintered Alloys
Cromwell	Stop and Shop	Walmart	Pilgrim Manor	Shop Rite	Apria Healthcare
Deep River	Adam's	Hale-Ray Middle School (in East Haddam)	Silgan Plastics	Incarceration Center	Deep River Elementary School
Durham	Hobson Motzer	Durham Manufacturing	Morgan AM&T	Coginchaug High School	Brewster School
East Haddam	Chestelm Health and Rehab	Goodspeed Theater	Hale-Ray High School	Hale-Ray Middle School	Shagbark True Value
East Hampton	Stop and Shop	Dickinson Brands Inc.	Cobalt Healthcare &	East Hampton High School	East Hampton

Jurisdiction	Top Employers #1	Top Employers #2	Top Employers #3	Top Employers #4	Top Employers #5
			Rehab Center		Middle School
Essex	Essex Meadows	Underwater Construction	Griswold inn	Valley Railroad	Tower Labs
Haddam	Saybrook at Haddam	Haddam-Killingworth High School	Burr District Elementary School	AAA Plumbing, Heating, and Cooling	Higganum Heating
Killingworth	Regional School District 17	Killingworth Elementary School	Budget Dry Waterproofing	Simpson Healthcare	AAA Plumbing
Lyme	H.P. Broom Housewright Inc.	Reynold's Marine	Hadlyme Public Hall	Becket Hill State Park	Lyme Fire Company
Middlefield	Ametek Zygo	Marquee Events	Cooper-Atkins	Lyman Orchards	Rogers Manufacturing
Middletown	Connecticut Valley Hospital (now closed)	Middlesex Hospital	Wesleyan University	FedEx	Whiting Forensic Institute
Old Lyme	Neumann USA	Kellogg Marine Supply	Big Y	Mile Creek School	Lyme-Old Lyme High School
Portland	Town of Portland	Standard-Knapp	Valley Oil	Promold Plastics	Saint Clements Castle

1.4.8. Transportation

The transportation network of the RiverCOG region has been shaped and shaped by the region's history, technology, topography, and settlement patterns. The Connecticut River was the basis of transportation, industry, and commerce for centuries. In the 18th century, rail lines became the primary means of transportation for people and goods. In the 20th Century, cars and highways reshaped the region, better connecting it to surrounding urban areas, while also making it possible to live further away from those city centers in a suburban style throughout the region. These

changes helped make the 1940s, 50s, and 60s the highest growth decades in the region's history, doubling the population from 56,085 in 1940 to 116,502 by 1970.

The region is serviced by a variety of rail, bus, highway, bike, pedestrian, and trail networks. Car ownership is currently a necessity in much of the region. The shoreline portion of the region is connected to New London and New Haven by I-95, as well as to the larger northeast region. Route 9 is the third most traveled expressway in the region and is the major north-south connection within the region. Interstate 91 crosses the far western portion of the region and connects to New Haven, Hartford, and Springfield, MA.

East-west highway infrastructure is less robust, owing to the area's historic development along the Connecticut River. Major river crossings are limited but include the I-95 crossing in the south, the Haddam Swing Bridge in the center of the region, and the Arrigoni Bridge to the north. The Chester-Hadlyme Ferry provides additional crossings during the summer months as does the Plum Island ferry in Old Saybrook. Other major east-west highways include Route 66, which connects Middletown to I-691 to Meriden and Waterbury in the west and to Portland, East Hampton, and Route 2 in Colchester in the east. U.S. Route 1, the Boston Post Road, also serves as the main street of most of the shoreline towns, going through the centers of Clinton, Westbrook, Old Saybrook, and Old Lyme.

The region encompassed two transit districts in the timeframe of the last edition of this plan (adopted in 2021): Middletown Area Transit (MAT) and Estuary Transit District (ETD). These two districts provided public bus service in the region. In 2022, MAT and ETD were merged and subsumed by the Estuary Transit District (ETD). ETD is a transit district doing business as "River Valley Transit" (RVT). RVT's mission is to support the mobility of residents, offer alternatives to privately owned vehicles, provide seamless connectivity to other transit services in Connecticut, and to promote environmentally and financially sustainable transportation choices. RVT provides a variety of public transportation resources and serves 16 municipalities. Transportation options include traditional buses, trolleys, shuttles, taxis, and paratransit services. Most services are open to the general public with no age or disability restrictions.

Of particular interest in recent years, XtraMile has greatly increased mobility in the region. XtraMile is a ride sharing service that anyone can use to get to and from anywhere in the service area. A shuttle bus picks up passengers based on requests using a mobile app or telephone number. XtraMile operates in two service areas as of spring 2026: the Shoreline XtraMile area and the new Middletown XtraMile area.

1.4.9. Infrastructure

Infrastructure is one of the key factors that affects the ability of property owners to develop their land and the scale and character of such development. For example, the ability of business and residents to have access to forms of infrastructure such as broadband internet and water is critical.

Areas of the region that are presently served by sanitary sewer systems (parts of Cromwell, Middletown, Portland, East Hampton, Chester, Deep River, East Haddam, and Old Lyme) will continue to be served by sanitary sewers in the future. Very few sewer system expansions are likely in the five-year timeframe of this plan, although nomimal expansions could occur at the fringes of the existing systems. Statewide efforts related to affordable housing development (and other types of housing) from 2027 onward, to be described in new "Housing Growth Plans," may spur additional sewer system expansions from existing systems. However, expansion of sewer service into municipalities not currently served by sewers is very unlikely. In fact, RiverCOG towns that are typically considered sewer avoidance areas (e.g., Clinton) will continue to address wastewater challenges on a case-by-case basis in accordance with wastewater facility plans (where developed) or in accordance with approvals from local health districts and departments. One potential exception is the Town of Old Lyme, where the potential for significant expansion of sewer service is under consideration by the local water pollution control authority and Town management.

Likewise, areas of the region that are presently served by major community public water systems (parts of Cromwell, Middletown, Portland, East Hampton, Chester, Deep River, Essex, Clinton, and Old Lyme) will continue to be served by these systems in the future. The last major extension of a water system was from the Connecticut Water Company's Chester system into the Tylerville part of Haddam. Meanwhile, small community water systems are present in areas of need, such as East Haddam center, and will be developed over the next decade where needed to address water supply needs.

Cellular coverage is reflective of population density with higher density regions enjoying more comprehensive coverage. Of the seventeen municipalities in the region, only Lyme has significant areas where coverage is poor. However, within the Region there are smaller areas of poor coverage which result from the often-hilly topography of the landscape and limited number of cell towers. In particular, the Route 154 corridor in Haddam has spotty coverage which has prevented residents and police from communicating during emergency situations that occur in that area.

Wireless broadband service is a fast-growing and integral part of modern life that provides opportunity and supports economic development, education, and health care. Based on data published by the FCC, there are 3 or more providers which offer at least 25 Mbps download and 3 Mbps upload speeds, which meets the FCC's definition of broadband service. There is also a single provider that offers 100 Mbps download and 10 Mbps uploads.

The electricity generated and used in the region comes primarily from power plants which burn natural gas as well as the Millstone Nuclear Power Plant. Single-family homes predominate in the region, and the cost of heating detached structures exceeds that of heating multi-family buildings. Most homes in the region are heated by fuel oil, with a small percentage coming from propane and other bottled gases. Only 12 percent of homes in the region are heated with natural gas, a considerably lower proportion than found in more urbanized areas of the state.

Sustainable energy is leveraged in the RiverCOG region, though there are challenges. Solar technology has progressed greatly in the past two decades, and the efficiency of those systems has gone up while costs have come down. As a result of significant investments from the State in deployment of offshore wind and renewables such as solar technology, communities in the region may experience continued shifts to provision of electricity through other means over the next decade.

1.4.10. Conclusion

In summary, the Lower Connecticut River Valley is a unique and diverse region of the state, comprised of a small urban area, rural and coastal communities. Each of the 17 communities that comprise the area is unique. The area is centered around the Connecticut River (New England's largest), its estuary and Long Island Sound. Its natural beauty and diversity place it among the most desirable areas in the state to live and work. In addition to the Connecticut River, the region contains a wide variety of natural resources, including other rivers, streams and wetlands, coastal dunes and beaches and abundant forests and farm properties. Such resources are distinct to the region and have been a driving force in support of conservation efforts, development, and tourism related to outdoor recreation.

Protecting the unique character of the region is a common goal of all its member municipalities and its residents and businesses. Resiliency of natural resources, the economic base, housing and transportation are major focuses of the remaining sections of this plan.

2. Hazard Identification and Risk Assessment

2.1. Introduction

The risk assessment analyzes the potential natural hazards that may occur within the RiverCOG region and its participating municipalities as well as the relationship between those hazards and current land uses, potential future development, and critical infrastructure. This section also includes a vulnerability assessment that estimates the potential damage that could result from certain large-scale natural hazard events.

Identifying the risk and vulnerability for a community is critical when determining how to allocate finite resources to carry out feasible and appropriate mitigation actions. The hazard analysis involves identifying all the hazards that potentially threaten the region, then analyzing them individually to determine the degree of threat posed by each hazard. Addressing risk and vulnerability through hazard mitigation measures will reduce societal, economic, and environmental exposure to natural hazard impacts.

2.2. Summary of Changes

Every five years, the RiverCOG Natural Hazard Mitigation Plan (NHMP) Planning Committee, in consultation with the 15 Local Mitigation Planning Teams, updates the Hazard Identification and Risk Assessment (HIRA) section of the document to incorporate newly available data and techniques for evaluating risk, as well as the data gathered through the participation of stakeholder and community members. Significant changes to the 2021 plan that are incorporated into this 2026 RiverCOG NHMP update include:

Utilized FEMA's National Risk Index (NRI) to assess vulnerability, impacts and estimated losses by providing risk ratings and expected annualized losses for severe winter weather, riverine and coastal flooding, thunderstorms and severe weather, hurricanes and tropical storms, tornadoes, earthquakes, drought, wildland fires, and extreme temperatures. This dataset provided annualized loss values and a metric for risk measurement when not previously available for a hazard, and supplemented loss data from Hazus, Public Assistance (PA) claims and from the National Oceanic and Atmospheric Administration's (NOAA) National Center for Environmental Information (NCEI).

Updated the Risk Assessment Rating System methodology to increase understanding and transparency for plan users, and to ensure that the rating process was commensurate across hazards and replicable in the future. See Section 2.8.1 for a more detailed description of the methodology.

Fortified the Extreme Heat section by aligning it with the State of Connecticut's NHMP. In its most recent NHMP, the State of Connecticut identified Extreme Heat as a hazard with significant primary

impacts to the state as well as a hazard that can amplify the negative harms of other hazards. The State NHMP conducted a robust analysis of Extreme Heat's impact, vulnerability, and the state's overall risk using best available data from the Connecticut Institute of Resilience and Climate Adaptation (CIRCA) that was produced prior to the last state plan and the 2021 RiverCOG NHMP. RiverCOG has modeled its own analysis of Extreme Heat on the state's methodology, and in doing so, has made the analysis of the COG's risk more robust.

Expanded the invasive species sections from a brief statewide overview into a data-driven, region-specific analysis incorporating current Connecticut Agricultural Experiment Station (CAES) and Department of Energy & Environmental Protection (DEEP) 2024 data, economic and ecological impacts, targeted management measures for key terrestrial and aquatic invasive plants and forest pests, and references to related climate and wildfire risks.

2.3. Hazard Identification and Ranking

The RiverCOG region is exposed to a range of hazards that threaten both human life and property. The natural hazards profiled in the Connecticut State NHMP of 2023 are compared in Table 2.3.1 to the hazards selected by the RiverCOG communities for inclusion in this plan update. Table 2.3.2 details the hazards that were not included in the Connecticut NHMP 2023 Plan but were included in this plan update.

Table 2.3.1. Hazards identified in the Connecticut NHMP 2023 that are of concern to RiverCOG

Hazards Identified in Connecticut NHMP 2023	Hazard of Concern to RiverCOG?	Included in Plan?
Dam Failure	YES	Included
Drought	YES	Included
Earthquake	YES	Included
Extreme Cold	YES	Included
Extreme Heat	YES	Included
Flooding	YES	Included
Flooding Related to Dam Failure or Overtopping	YES	Included
Sea Level Rise	YES	Included
Thunderstorm	YES	Included
Tornado	YES	Included
Tropical Cyclone	YES	Included
Wildland Fire	YES	Included
Winter Weather	YES	Included

Table 2.3.2. Hazards not identified in the Connecticut NHMP 2023 that are of concern to RiverCOG

Hazards Not Identified in Connecticut NHMP 2023 Included in the 2026 RiverCOG NHMP	Hazard of Concern to RiverCOG	Included in Plan?
Aquatic Invasive Species	YES	Included
Terrestrial Invasive Species	YES	Included
Tree Infestation	YES	Included

Some of these hazards are interrelated or cascading (i.e., hurricanes can cause flooding, high wind, and tornadoes). For preliminary hazard identification purposes these distinct hazards are broken out separately.

The hazards listed below were not included in the State's plan as they are not considered significant threats in Connecticut. For the same reason, they are not included in this plan.

- Avalanche
- Expansive Soils
- Land Subsidence
- Tsunami
- Volcano

2.4. Federal Disaster Declarations

Historic disaster data is a leading indicator of hazards that will likely affect the region in the future. Presidential Disaster Declarations and other historic storm data were used for this purpose. According to FEMA, since 1954 there have been 32 major disaster declarations (including the COVID- 19 pandemic) for Middlesex and New London Counties. Federal disaster declarations, and most recordings of damages, by national sources, from disasters are at the county level. In subsequent sections of the plan, specific disasters are linked to the municipalities they impacted, to the extent the data allows.

Of the 32 federal disaster or emergency declarations, eight were related to severe storms (likely to include flooding as well). Nine were related to snow. Twelve were related to hurricanes. One was related to flooding only and one was related to a tornado. These events are detailed in Table 2.4.1.

Table 2.4.1. Presidential Declared Disasters and Emergency Declarations for the RiverCOG Region, 1954 - 2025

Disaster Number	Disaster Type	Incident Type	Incident Begin Date	Individual Assistance Programs Declared	Public Assistance Programs Declared
4629	DR	Hurricane	9/1/2021	X	X
4580	DR	Hurricane	8/4/2020		X
4500	DR	Pandemic	1/20/2020	X	X
4410	DR	Severe Storm(s)	9/25/2018		X
4106	DR	Snow	2/8/2013		X
3361	EM	Snow	2/8/2013	X	X
4087	DR	Hurricane	10/27/2012	X	X
3353	EM	Hurricane	10/27/2012		X
4046	DR	Severe Storm(s)	10/29/2011		X
3342	EM	Severe Storm(s)	10/29/2011	X	X
4023	DR	Hurricane	8/27/2011	X	X
3331	EM	Hurricane	8/26/2011	X	X
1904	DR	Severe Storm(s)	3/10/2010	X	X
1700	DR	Severe Storm(s)	4/15/2007	X	
3266	EM	Snow	2/11/2006	X	X
3246	EM	Hurricane	8/29/2005	X	X
3200	EM	Snow	1/22/2005	X	X
3192	EM	Snow	12/5/2003	X	X
3176	EM	Snow	2/17/2003	X	X
1302	DR	Hurricane	9/16/1999	X	X
1092	DR	Snow	1/7/1996	X	X
3098	EM	Snow	3/13/1993	X	X
972	DR	Flooding	12/10/1992	X	X
916	DR	Hurricane	8/19/1991	X	X
837	DR	Severe Storm(s)	7/10/1989	X	X
747	DR	Hurricane	9/27/1985	X	X
711	DR	Severe Storm(s)	5/27/1984	X	X
661	DR	Severe Storm(s)	6/14/1982	X	X
608	DR	Tornado	10/4/1979	X	X
3060	EM	Snow	2/7/1978	X	X

Disaster Number	Disaster Type	Incident Type	Incident Begin Date	Individual Assistance Programs Declared	Public Assistance Programs Declared
42	DR	Hurricane	8/20/1955	X	X
25	DR	Hurricane	9/17/1954	X	X

2.5. USDA Disaster Declarations

The United States Department of Agriculture (USDA) Farm Service Agency (FSA) declares agriculture-related disasters to mitigate losses by producers and to trigger eligibility for emergency assistance and disaster assistance programs. The FSA administers Secretarial disaster declarations, presidential major disaster declarations (see Section 1.4) as well as Presidential emergency declarations, physical loss notifications, and quarantine designations.

USDA secretarial disaster declarations must be requested of the Secretary of Agriculture by a governor (or their designee) with an expedited process for drought. In general, the Secretarial Disaster Declaration process for drought may be triggered as soon as any portion of a county meets the D2 (Severe Drought) drought intensity value for eight consecutive weeks or a higher drought intensity value for any length of time as reported in the U.S. Drought Monitor at http://droughtmonitor.unl.edu. For all other natural disaster occurrences, including drought conditions that do not trigger a Fast Track designation, the county must have a 30% production loss of at least one crop, among other potential triggers. Eligible natural disasters include, but are not necessarily limited to, drought, flooding, excessive rain and humidity, severe storms, lightning, hail, mudslides, landslides, snow, ice, blizzards, frost, freeze, below-normal temperatures, wind, tornadoes, hurricanes, typhoons, tropical storms, fire, excessive heat, volcanoes, pests, and disease.

Of the 37 Secretarial or Presidential emergency declarations since 2014, 16 were related to drought; six were related to hurricanes or tropical storms; four were related to severe storms and flooding; three were related to frosts and/or freezing conditions; three were related to excessive rainfall (and subsequent flooding); three were related to severe winter storms; one was related to severe storms and flooding that resulted in mud slides and landslides; and one was related to severe storms that resulted in tornadoes and/or severe straight-line winds. These events are detailed in Table 2.5.1.

Table 2.5.1. USDA Secretarial Disasters and Presidential Emergency Declarations for the RiverCOG Region, 2012-2025

Disaster Designation	Designation Type	Incident Type	Incident Begin Date	Total Disbursement to RiverCOG Region by Accounting Year
4839	P	Severe Storms and Flooding	8/18/2024	$0

Disaster Designation	Designation Type	Incident Type	Incident Begin Date	Total Disbursement to RiverCOG Region by Accounting Year
4820	P	Severe Storms, Flooding, Landslides, and Mudslides	8/18/2024	$0
4766	P	Severe Storm and Flooding	1/9/2024	$0
4694	P	Severe Winter Storm and Snowstorm	12/23/2023	$0
4765	P	Severe Storms and Flooding	12/17/2023	$0
S5483	S	Excessive Rain and Flooding	7/2/2023	$0
S5482	S	Excessive Rain	7/2/2023	$0
S5450	S	Frost	5/18/2023	$15,955.00
S4814	S	Drought – Fast Track	9/22/2022	$28,571.92
S4808	S	Drought – Fast Track	9/15/2022	“
S4803	S	Drought – Fast Track	9/15/2022	“
S5280	S	Drought – Fast Track	8/30/2022	“
S5308	S	Drought – Fast Track	8/16/2022	“
S5271	S	Drought – Fast Track	8/16/2022	“
S5267	S	Drought – Fast Track	8/16/2022	“
S5257	S	Drought – Fast Track	8/9/2022	“
S5292	S	Drought – Fast Track	8/2/2022	“
S5287	S	Drought – Fast Track	7/26/2022	“
4653	P	Severe Winter Storm and Snowstorm	1/28/2022	$0
S5121	S	Remnants of Hurricane Ida	9/1/2021	$14,535.46
4615	P	Remnants of Hurricane Ida	9/1/2021	“
S5069	S	Tropical Storm Elsa	7/9/2021	“
S4832	S	Drought – Fast Track	9/29/2020	$1,860.00
S4873	S	Tropical Storm Isaias & high winds	8/4/2020	$160,368.66
4580	P	Tropical Storm Isaias	8/4/2020	“
4567	P	Tropical Storm Isaias	8/4/2020	“
4410	P	Severe Storms and Flooding	9/25/2018	$4.00

Disaster Designation	Designation Type	Incident Type	Incident Begin Date	Total Disbursement to RiverCOG Region by Accounting Year
S4478	S	Excessive rainfall	8/1/2018	"
4385	P	Severe Storms, Tornadoes, and straight-line winds	5/15/2018	"
4322	P	Severe Winter Storm and Snowstorm	3/14/2017	$561.00
S4076	S	Drought	8/2/2016	$0
S4055	S	Drought – Fast Track	8/2/2016	$0
S4045	S	Drought – Fast Track	7/26/2016	$0
S4075	S	Freeze and unseasonably warm temperatures	2/14/2016	$0
S4048	S	Frost and freeze	2/12/2016	$0
S3928	S	Drought	4/1/2015	$71.00
S3775	S	Drought	7/1/2014	$750.00

S = Secretarial; P = Presidential

2.6. NCEI Storm Event Data

The NCEI Storm Events Database is published by the NOAA's National Weather Service (NWS). The storm events database contains information on storms and weather phenomena that have caused loss of life, injuries, significant property damage, and/or disruption to commerce. The NCEI data currently provides information about events from January 1950 to February 2025. Records for most weather events (48 types) were reported starting in 1996, as defined in NWS Directive 10-1605. The exception is tornado events that were recorded from 1950 through 1954 and tornado, thunderstorm, and hail events that were recorded starting in 1955.

The NCEI Storm Events Database publishes data by county, therefore the storm event summary tables in each section of the HIRA will report totals for Middlesex and New London Counties. The NCEI database is organized by episode ID and event ID. The episode ID is the overall storm system (ex. Thunderstorm) that affects an area and can include several associated events ID's, such as hail, lightning, and high wind.

There have been 438 total hazard episodes reported in Middlesex County and 568 in New London County from January 1950 to February 2025 as summarized in Table 2.6.1 and Table 2.6.2, along with reported property damage, deaths, and injuries. There was no reported crop damage for any of the noted hazards. The hazards specific sections in this plan profile the historic events and include, when applicable, narratives from this dataset. It is important to understand the limitations of this dataset. It is based on reported damage. Not all events are reported. It is also likely that

many of the events noted for one county, likely impacted the other, resulting in double counting in some instances.

Table 2.6.1. Hazard episodes reported in Middlesex County, Connecticut, (1950-2025)

Hazard	Episodes	Property Damage (2025)	Deaths	Injuries
Drought	6	$0	0	0
Extreme Temperature	7	$0	0	0
Flood	49	$695,251	0	0
Hurricane	5	$1,309,278	0	0
Severe Weather	212	$1,489,327	0	7
Tornadoes	7	$2,721,409	0	8
Winter Storm	152	$0	0	0
Total	**438**	**$6,215,265**	**0**	**15**

Table 2.6.2. Hazard episodes reported in New London County, Connecticut (1950-2025)

Hazard	Episodes	Property Damage (2025)	Deaths	Injuries
Drought	6	$0	0	0
Extreme Temperature	4	$0	0	0
Flood	116	$8,333,884	1	0
Hurricane	6	$1,509,278	0	0
Severe Weather	282	$3,508,488	0	26
Tornadoes	6	$63,500	0	0
Winter Storm	148	$0	0	0
Total	**568**	**$13,415,150**	**1**	**26**

These estimates are believed to be an underrepresentation of the actual losses experienced, as some hazard losses go unreported or are difficult to quantify accurately. The tables only summarize the NCEI database hazards and do not include other hazards that will be discussed in this risk assessment, such as earthquake and wildfire. Other best available national and local datasets are used in these hazard sections to quantify losses. Although these losses are for all communities in the two counties, they give a sense of which hazards have historically posed the most significant threat.

2.7. Hazard Specific Datasets

The level and type of analysis that can be completed depends on the type and quality of data available. Most of the hazards impacting the RiverCOG region (e.g. thunderstorms, winter weather) do not have definitive impact boundaries, and, as a result, past occurrences were used to try to identify probable locations where these events may happen in the future. Table 2.7.1 provides a breakdown, by hazard, of the datasets used for analysis and mapping in the hazard-specific sections that follow. The available datasets illustrate the difficult nature of quantitatively assessing vulnerability and risk within the region. Datasets in Table 2.7.1 are not all inclusive. More details are provided in the individual hazard sections of this plan. This assessment has been compiled using the best available data.

Table 2.7.1. Hazard Specific Data Utilized for Analysis and Mapping

Hazard	Dataset	Source
All Hazards	Computer Aided Mass Appraisal (CAMA) Data	Connecticut Open Data
All Hazards	NCEI Storm Events Database	NOAA NCEI
All Hazards	Buildings	Connecticut Open Data
All Hazards	Declared Disasters	FEMA
All Hazards	Critical Assets Layer	CIRCA, RiverCOG
Flood	Flood Insurance Rate Maps (DFIRMs)	FEMA
Flood	National Flood Insurance Program (NFIP) Policy & Claims	FEMA
Flood	Repetitive and Severe Repetitive Loss (RL and SRL) Parcels	FEMA
Flood	NFIP Claims	FEMA
Flood	FEMA National Flood Hazard Layer (NFHL)	FEMA
Flood	Sea Level Rise planning thresholds combined with mean high-water levels and storm events	University of Connecticut CIRCA
HHPD	State Dam Inventory	Connecticut Open Data
Heat and Flood	Climate Change Vulnerability Index (CCVI)	University of Connecticut CIRCA
Hurricane	The Sea, Lake, and Overland Surges from Hurricanes (SLOSH) Hurricane Storm Surge Data	NOAA National Hurricane Center (NHC)
Wildfire	Wildland Urban Interface (WUI) geospatial dataset	SILVIS Lab, University of Wisconsin - Madison
Drought	USDA Drought Data	USDA

Hazard	Dataset	Source
Thunderstorms and Severe Weather	Significant Storm Events for thunderstorms, high wind, hail, and lightning	The Tornado Project, Wikipedia, State NHMP
Aquatic Invasive Species	Qualitative assessment plus Office of Aquatic Invasive Species (OAIS) database by water body	DEEP; CT Agricultural Experiment Station - OAIS
Terrestrial Invasive Species	Qualitative assessment plus October 2025 Connecticut Invasive Plant List; and University of Georgia's EDDMapS geographical database	DEEP; CAES - Connecticut Invasive Plant Working Group (CIPWG); University of Georgia Center for Invasive Species and Economic Health
Tree Infestations	Qualitative assessment per Cooperative Agricultural Pest Survey (CAPS) of Connecticut	DEEP; CAES

2.8. Risk Assessment

2.8.1. Hazard Ranking

The purpose of the HIRA is to provide a factual basis for developing mitigation strategies by prioritizing areas most threatened and vulnerable to natural hazards. During the kickoff meeting for the plan held on May 28, 2025, the natural hazards applicable to the region were discussed in terms of frequency and historical damages.

A standardized methodology, which allows for greater flexibility and room for subject matter expertise, was developed to compare each hazard's risks for the 2026 update. This method prioritizes hazard risk based on a blend of quantitative factors extracted from NCEI and other available data sources. Many of the hazards assessed in this HIRA did not have quantifiable probability or impact data, thus a semi-quantitative ranking system was used to compare all the hazards of interest instead. These include:

- **Probability:** Probability of each hazard is determined by assigning a level based on the likelihood of occurrence from historical data.
- **Impact:** The range of the impact of a hazard is broken down into three sub-criteria:
    - **Affected Area:** Affected area for each hazard is determined by assessing what percentage of the total RiverCOG Area is affected.
    - **Primary Impact:** Primary impact for each hazard measures how many people might be killed or injured and how much property might be damaged or destroyed if the expected event does occur.
    - **Secondary Impact:** Secondary impact for each hazard assesses loss of function of critical facilities, downtime of critical facilities, and whether an evacuation was called for.

Additionally, input received from the Community Survey was used as parameter in the ranking.

- **Level of Community Concern:** this criterion reflects the perceived risk of each hazard as indicated by respondents to question 6 of the community survey. This question asks "How concerned are you about each of the following hazards impacting your home, business, community, or organization?" and received 204 responses.

Each of these five criteria are assigned weights, as well as point values for each of their responses.

Table 2.8.1 provides a summary of the categories used to rank the hazards and their weighted values for the Composite Hazard Risk Index.

Table 2.8.1. Hazard Risk Ranking Parameters

Criteria	Weight	1 Point	2 Points	3 Points	4 Points
Hazard Probability	2.0	Unlikely Less than 1% probability in next 100 years or has a recurrence interval of greater than every 100 years.	Somewhat Likely Between 1 and 10% probability in next year or has a recurrence interval of 11 to 100 years.	Likely Between 10 and 100% probability in next year or has a recurrence interval of 10 years or less	Highly Likely Near 100% probability in next year or happens every year.
Impact – Affected Area	0.8	Isolated Less than 1% of area affected	Small Between 1 and 10% of area affected	Medium Between 10 and 50% of area affected	Large Between 50 and 100% of area affected
Impact – Primary Impact	0.7	Negligible 1 to 10% of people or property	Limited 10% to 25% of people or property	Critical 25 to 50% of people or property	Catastrophic > 50% of people or property
Impact – Secondary Impact	0.5	Negligible No loss of function, downtime, and/or evacuations	Limited Minimal loss of function, downtime, and/or evacuations	Moderate Some loss of function, downtime, and/or evacuations	High Major loss of function, downtime, and/or evacuations
Level of Community Concern	1.0	Low Concern	Moderate Concern	High Concern	-

The total score is the sum of each criteria point score multiplied by the criteria weight.

This total score is then used to assign each hazard its overall Risk Ranking category: Limited, Moderate, and Significant. Table 2.8.2 provides details on how these categories are determined based on total score values.

Table 2.8.2. Overall Risk Ranking Category Details

Overall Risk Ranking Category	Total Score Range
Limited	> 12.45
Moderate	12.46 - 14.05
Significant	14.06 <

The hazard risk ranking generated from this exercise, along with consideration of available data, was used to prioritize the level of effort assigned to further analysis of each hazard in the vulnerability analysis and lost estimation sections. All the participating communities agreed on the results of the hazard ranking for the overall region. Based on the results of the exercise, the hazards were ranked as follows in Table 2.8.3.

In the Annexes in Volume II, small adjustments are made by some towns to reflect uniqueness (e.g. coastal v. inland with higher agricultural concerns).

Table 2.8.3. Summary of Hazard Risk Ranking by Hazard

Hazard	Data Sources	Probability (2)	Impact: Affected Area (0.8)	Impact: Primary Impact (0.7)	Impact: Secondary Impacts (0.5)	Level of Community Concern (1)	Total Score	Hazard Planning Consideration
Aquatic Invasive Species	Semi-quantitative, supplemented by state and municipal figures, recommend survey	**Highly Likely - 4**	**Large - 4**	Critical - 3	Moderate - 3	High Concern - 3	17.8	Significant
Terrestrial Invasive Species	Semi-quantitative, supplemented by state and municipal figures, recommend survey	**Highly Likely - 4**	**Large - 4**	Critical - 3	Moderate - 3	High Concern - 3	17.8	Significant
Tree Infestation	Semi-quantitative, supplemented by state and municipal figures, recommend survey	**Highly Likely - 4**	**Large - 4**	Critical - 3	Moderate - 3	High Concern - 3	17.8	Significant
Hurricanes	Hazus for wind	Likely - 3	**Large - 4**	Critical - 3	Moderate - 3	High Concern - 3	15.8	Significant

Hazard	Data Sources	Probability (2)	Impact: Affected Area (0.8)	Impact: Primary Impact (0.7)	Impact: Secondary Impacts (0.5)	Level of Community Concern (1)	Total Score	Hazard Planning Consideration
Winter Storms (Snow, Ice, Wind, including Noreasters)	Historic analysis for probability and annualized damages	Highly Likely - 4	Large - 4	Negligible - 1	Moderate - 3	Moderate Concern - 2	15.4	Significant
Flood – Riverine and Inland Flooding (Riverine, Drainage, Coastal Surge, Sea Level Rise - includes flooding from Noreasters)	Hazus, SLR Overlay, FS Model Overlay, Historic data and damages for additional probability	Likely - 3	Medium - 3	Limited - 2	Moderate - 3	High Concern - 3	14.3	Significant
Flood – Coastal Flood (Riverine, Drainage, Coastal Surge, Sea Level Rise - includes flooding from Noreasters)	Hazus, SLR Overlay, FS Model Overlay, Historic data and damages for additional probability	Likely - 3	Medium - 3	Limited - 2	Moderate - 3	High Concern - 3	14.3	Significant
Extreme Heat and Cold	Qualitative based on historic	Likely - 3	Large - 4	Negligible - 1	Limited - 2	High Concern - 3	13.9	Moderate
Severe Weather (thunderstorms, downbursts, hail, lightning)	Historic analysis for probability and annualized damages	Highly Likely - 4	Small - 2	Negligible - 1	Limited - 2	Moderate Concern - 2	13.3	Moderate

Hazard	Data Sources	Probability (2)	Impact: Affected Area (0.8)	Impact: Primary Impact (0.7)	Impact: Secondary Impacts (0.5)	Level of Community Concern (1)	Total Score	Hazard Planning Consideration
Wildfire	Historic analysis for probability and annualized damages	Likely - 3	Small - 2	Critical - 3	Moderate - 3	Moderate Concern - 2	13.2	Moderate
Drought	Historic analysis for probability and annualized damages - some qualitative	Likely - 3	Medium - 3	Negligible - 1	Limited - 2	High Concern - 3	13.1	Moderate
Tornadoes	Historic analysis for probability and annualized damages - pulling in surrounding counties	Likely - 3	Isolated - 1	**Catastrophic - 4**	Limited - 2	Moderate Concern - 2	12.6	Moderate
Earthquakes	Hazus, 3 scenarios	Somewhat Likely - 2	Small - 2	**Catastrophic - 4**	**High - 4**	Low Concern - 1	11.4	Limited
Flooding from Dam Failure	Dam Inundation areas, Historic analysis for probability and annualized damages	Unlikely - 1	Small - 2	Limited - 2	Moderate - 3	Moderate Concern - 2	8.5	Limited

2.8.2. Regional Development Trends

Development trends are discussed in each hazard specific analysis, in subsequent sections, and supplemented with community unique information in each annex in Volume II. The potential impacts of changes in development, as they relate to each hazard, are discussed in those sections. Overall, development, since the last plan update has been very light in the region and is not expected to change levels of risk and vulnerability.

2.9. Vulnerability Analysis

The purpose of the vulnerability assessment is to estimate the extent of potential damage from natural hazards of varying types and intensities. The vulnerability and risk assessment builds upon the information by identifying and characterizing an inventory of assets in the region and its communities and then assessing the potential impact and amount of damage that can be expected to be caused by each identified hazard event. The primary objective of the vulnerability assessment is to quantify exposure, and potential loss estimates for each hazard. In so doing, the communities and partners may better understand their unique risks to selected hazards and be better prepared to evaluate and prioritize specific hazard mitigation actions.

2.9.1. Critical Facility Analysis

For regional level analysis, a critical facility GIS dataset was created using a RiverCOG (2017) layer supplemented and updated with data provided by CIRCA. The CIRCA state critical facility data was updated to reflect best available information as of 2022. Critical facility data was reviewed with each of the 15 jurisdictions during LPT meetings in June of 2025 and January of 2026 and lists and maps were supplemented with data provided. Mitigation strategies have been identified in the 2023 State NHMP to support expansion of this dataset and collection of additional attribute information in the future. The current state 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 by the State (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.

The types of facilities included are discussed in the individual hazard subsections below. During the development of the community annexes in Volume II of this plan, each participating community addressed critical facilities unique to their town and not always addressed in the regional analysis.

2.9.2. Hazus-MH and the National Risk Index (NRI)

Hazus-MH (multiple-hazards) is a computer model developed by FEMA to estimate losses due to a variety of natural hazards. The following overview of Hazus-MH is taken from the FEMA website. For more information on the Hazus-MH software, go to:

https://www.fema.gov/flood-maps/products-tools/hazus

"Hazus-MH is a nationally applicable standardized methodology and software program that contains models for estimating potential losses from earthquakes, floods, and hurricane winds. Hazus-MH was developed by the Federal Emergency Management Agency (FEMA) under contract with the National Institute of Building Sciences (NIBS). Loss estimates produced by Hazus-MH are based on current scientific and engineering knowledge of the effects of hurricane winds, floods and earthquakes. Estimating losses is essential to decision-making at all levels of government, providing a basis for developing and evaluating mitigation plans and policies as well as emergency preparedness, response and recovery planning.

Hazus-MH uses state-of-the-art geographic information system (GIS) software to map and display hazard data and the results of damage and economic loss estimates for buildings and infrastructure. It also allows users to estimate the impacts of hurricane winds, floods and earthquakes on populations."

There are three modules included with the Hazus-MH software: hurricane wind, earthquake, and flooding. For the previous plan update (2021), Hazus-MH Version 4.2 was run for hurricane wind earthquake and flooding. The program was used to develop various types of loss estimates for the region regarding different sized earthquakes, hurricanes, riverine, and coastal flooding events. Hazus calculated hydrology and hydraulics data at a drainage area threshold of 1.0 square mile. While a more advanced analysis can be conducted in Hazus, this level is appropriate for hazard mitigation planning purposes. Across the RiverCOG region, changes in population, infrastructure and building stock have been minimal since 2021. This plan uses the Hazus model runs from the previous plan and inflates damages to 2025 dollars. This data is supplemented with average annualized loss data from FEMA's NRI, which was not available for either the 2021 RiverCOG NHMP update or the 2023 CT State NHMP update. Many of the NRI loss calculation formulas are shared between the two methodologies.

Annual loss values vary significantly between Hazus and NRI. According to FEMA, the primary reason for differing Average Annualized Loss (AAL) estimates—referred to as Expected Annual Loss (EAL) in the National Risk Index—is that they use different mathematical methodologies and data sources to define risk.

While Hazus typically uses a probabilistic approach to model damage to specific building inventories, the National Risk Index (NRI) uses a multiplicative approach based on broader historic loss ratios. Key methodological differences are noted below:

Calculation Formula:

- **NRI (EAL):** Uses a simplified equation: EAL = Exposure X Annualized Frequency X Historic Loss Ratio
- **Hazus (AAL):** Calculates the mean value of a Loss Exceedance Probability distribution, integrating losses across multiple return periods (e.g., 10-year, 50-year, 100-year events) to approximate a continuous damage function

Data Specificity:

- **Hazus** models impacts at a high resolution, often using building-specific Depth-Damage Functions and detailed asset inventories (General Building Stock) to estimate physical damage.
- **NRI** is designed as a nationwide baseline. It aggregates risk at the Census tract or county level, relying on authoritative national datasets and historical records rather than site-specific engineering simulations for all hazards.

Asset Valuation:

- Studies have shown that **Hazus** default General Building Stock data may underestimate square footage while overestimating replacement costs on a dollar-per-square-foot basis compared to local inventories.
- The **NRI** leverages **Hazus** version 4.2 data for its initial building value and population estimates but then applies its own frequency and loss ratio factors.

Hazard Scope:

- **Hazus** focuses deeply on a few specific hazards (Flood, Earthquake, Hurricane, Tsunami) with detailed physics-based modeling.
- **NRI** covers **18 natural hazards**, many of which do not have a dedicated Hazus model and thus rely on different statistical data sources.

For more technical details on how these calculations are performed, you can review the FEMA National Risk Index Methodology or the Hazus Technical Manuals.

2.9.3. CAMA Exposure Analysis

An exposure analysis was conducted using ESRI ArcGIS to estimate maximum potential exposure-related losses for multiple hazards. The data used included updated Computer Aided Mass Appraisal (CAMA) tax data on the parcel level. By identifying the parcels in certain hazard areas, a financial exposure was calculated based on the most recent assessed property value. The resulting exposure figure reveals how much potential damage and property is at risk for a certain hazard. In addition to the hazards used in Hazus and the NRI, this CAMA data was used to identify exposure for other events such as dam failure, storm surge, severe storms, and drought.

Multiple challenges arose with the use of the CAMA data. Some parcels were assessed as both residential and commercial, potentially being captured in the analysis twice. Data storage, such as addresses and building and property values, was inconsistent between municipalities making parcel joining challenging. Also, not all properties had an assessed value within the data, which could have led to an underestimation if these properties are in a hazard area. However, overall, CAMA data is believed to be much more accurate than the data available in 2020 that was used for the previous edition of this plan.

2.9.4. Hazard Specific Analysis

The hazard identification highlights the types of hazards the region is most vulnerable to and ranks them based on specific parameters. A vulnerability and risk assessment are then completed for each of the hazards to measure the potential losses resulting from each hazard. Each of the hazards are presented as sub-sections of this plan with the following primary components:

- Name of Hazard
- Description and Background
- Location and Extent
- History of Past Events
- Probability of Future Events
- Climate Change Impacts
- Impacts and Estimated Losses to Region
- Development Trends

The level of analysis for vulnerability and risk assessment varies based on the designated hazard ranking. The hazard assessment also examines the impact of hazards on existing and future land uses and development trends, within the identified hazard areas. Current conditions were evaluated in terms of what is already developed, and in terms of people and property types. The communities have plans of conservation and development, zoning ordinances, capital improvement plans, and other documents, which were used as indicators of potential future risks to undeveloped properties, services, and infrastructure. New development and areas targeted for re-development often present the best opportunities for incorporating new methods of development or retrofitting development so that it will be able to withstand the effects of hazards.

2.10. Severe Winter Weather

2.10.1. Description and Background

Winter storms, which consist of snow, ice, wind, and other cold-weather precipitation, are a regular occurrence in Connecticut. Temperatures during the winter months typically drop below freezing at night and occasionally fall below zero degrees Fahrenheit. Some winter storms are mild and have little consequence. However, others, including blizzards, ice storms, and nor'easters

cause large-scale and regular disruptions by restricting transportation, causing the loss of electricity, and through direct physical damages due to wind, snow, sleet, ice, and bitter cold.

All communities within the RiverCOG region have Winter Weather listed in their top 3 hazards. Communities note that snow and ice removal have a tremendous impact on municipal budgets and in some cases if a large enough event occurs it can exceed the ability of crews to keep roads open for safe travel. Damage from heavy wind, ice and snow events are exacerbated by sick or dying trees, common in the region, causing increased power outages, property damage, clean-up costs and road closures.

2.10.2. Location and Extent

All areas of the RiverCOG communities are susceptible to winter storms. Some areas, particularly those in the northern section of the region, experience more frequent winter storms than those at lower elevations. Although in recent years, nor'easters and other coastal winter storms have resulted in significant winter weather events along the shoreline. In addition, low-lying areas (such as floodplains) can experience additional impacts of winter storms such as flooding.

According to NOAA, there are several types of winter storms and associated precipitation conditions.

- **Blizzards** include winter storm conditions of sustained winds or frequent gusts of 35 mph or greater that cause major blowing and drifting of snow, reducing visibility to less than one-quarter mile for 3 or more hours. Extremely cold temperatures and/or wind chills are often associated with dangerous blizzard conditions.
- **Freezing Rain** consists of rain that freezes on objects, such as trees, cars, or roads, and forms a coating or glaze of ice. Temperatures in the mid to upper atmosphere are warm enough for rain to form, but surface temperatures are below the freezing point, causing the rain to freeze on impact.
- **Ice Storms** are forecast when freezing rain is expected to create ice buildups of one-quarter inch or more that can cause severe damage.
- **Nor'easters** are the classic winter storm in New England caused by a warm, moist, low pressure system moving up from the south colliding with a cold, dry, high-pressure system moving down from the north. The nor'easter derives its name from the northeast winds typically accompanying such storms, and such storms tend to produce a large amount of rain or snow. They usually occur between November 1 and April 1 of any given year, with such storms occurring outside of this period typically bringing rain instead of snow.
- **Sleet** occurs when raindrops freeze into ice pellets before reaching the ground. Sleet usually bounces when hitting hard surfaces and does not stick to objects. It can accumulate like snow and cause a hazard to motorists.
- **Snow** is frozen precipitation composed of ice particles that forms in cold clouds by the direct transfer of water vapor to ice.

- **Winter Storms** are defined as heavy snow events that have a snow accumulation of more than 6 inches in 12 hours or more than 12 inches in a 24-hour period.

To characterize and rank high-impact northeast snowstorms, NOAA uses the Regional Snowfall Index (RSI), and until recently, the Northeast Snowfall Impact Scale (NESIS) was used by NOAA to characterize and rank high-impact northeast snowstorms. This ranking system has evolved into the currently used RSI. The RSI ranks snowstorms that impact the eastern two thirds of the United States, placing them in one of five categories: Extreme, Crippling, Major, Significant, and Notable. The RSI is based on the spatial extent of the storm, the amount of snowfall, and the juxtaposition of these elements with population still based on the 2000 census. RSI differs from NESIS in that it uses more refined geographic areas to define the population impact, resulting in a more region-specific analysis of a storm's impact. The use of population in evaluating impacts provides a measure of societal impact from the event. Table 2.10.1 below presents the RSI categories, their corresponding RSI values, and a descriptive adjective.[2]

Table 2.10.1. RSI Categories.

Category	RSI Value	Event Description
1	1 to 3	Notable
2	3 to 6	Significant
3	6 to 10	Major
4	10 to 18	Crippling
5	18+	Extreme

RSI values are calculated within a Geographic Information System (GIS). The aerial distribution of snowfall and population information are combined in an equation that calculates the RSI score, which varies from around one for smaller storms to over 18 for extreme storms. The raw score is then converted into one of the five RSI categories. The largest RSI values result from storms producing heavy snowfall over large areas that include major metropolitan centers. Approximately 230 of the most notable historic winter storms to impact the Northeast have been analyzed and categorized by RSI since 1900 through March 2023. Events discussed below can be assumed to be in the Category 3-5 range.

According to some resources, the Sperry-Piltz Ice Accumulation Index (SPIA® Index) is becoming a resource for addressing ice events. The index is a copyright product with controlled distribution, according to its developers (refer to https://spia-index.com/). The SPIA® Index is “a forward-looking, ice accumulation and ice damage prediction index that uses an algorithm of researched

[2] Source: NOAA

parameters that, when combined with NWS forecast data, predicts the projected footprint, total ice accumulation, and resulting potential damage from approaching ice storms. It is a tool to be used for risk management and/or winter weather preparedness. The index ranges from 0 ("minimal risk of damage to exposure utility systems") to 5 ("catastrophic damage to entire exposure utility systems"). To date, this type of system has not been needed in the RiverCOG region.

The RSI classification system, coupled with the SPIA and the NWS warning systems, is appropriate for the region, as they have been used for many of the severe winter storms that have occurred in the region and its communities. Storms have not been characterized outside of these systems of classification.

2.10.3. History of Past Events

Using the Killingworth weather station as a reference point, the RiverCOG region receives an average annual snowfall of about 40 inches per year although snowfall amounts vary widely from year to year and can vary dramatically across the region in any given storm. The region saw an average annual snowfall of approximately 20 inches per year over the past five years (2020-2024). The amounts vary widely from year to year, for example in 2023 there was only 5 inches of snowfall while there was around 34 inches of snowfall the year prior in 2022.[3] In January and February of 2026 there were two large snowfall events that when combined exceeded 24 inches of snow in most of the region. Severe winter storms can result in damage to buildings and infrastructure, loss of life, and disruptions to regional transportation and communication systems.

Since 1954, Connecticut has received eleven major federal disaster declarations following major winter or snowstorms. Federal assistance is frequently used to offset the snow/ice removal costs the state and municipalities incur. For example, federal disaster declarations were declared for winter storm Nemo in February 2013 and again in January of 2015, in several counties in Connecticut (including communities in the RiverCOG) to help share the costs of snow removal. FEMA obligated over $8 million in Public Assistance funds to RiverCOG municipalities to reimburse costs associated with the January 11-12, 2011, snowstorm and Storm Alfred in October. The frequency, intensity, and timing of winter storms dramatically impact snow removal budgets. Storm Alfred was particularly costly for municipalities because of the heavy debris loads resulting from the high number of fully leafed trees downed in this storm. Municipalities also incur higher labor costs for snow removal on weekends and holidays. Between 2021 and 2025 there were no winter storm events significant enough to warrant federal assistance. In January and February of 2026 there were two major winter storms. As of the update of this plan, it is unknown whether they will result in disaster declarations.

NOAA's NCEI database is the most comprehensive source of historic data dating back to 1950. Table 2.10.2 lists the number of winter weather events in Middlesex and New London Counties,

[3] https://www.ncei.noaa.gov/cdo-web/

along with injuries, deaths, and damages. There have been 300 total episodes reported in the two counties, with no reported property damage, deaths, or injuries.

Table 2.10.2. Winter Weather episodes reported in Middlesex and New London County, Connecticut, (1950-2025)

County	Episodes	Property Damage (2025)	Deaths	Injuries
Middlesex	152	$0	0	0
New London	148	$0	0	0
Total	**300**	**$0**	**0**	**0**

Notable winter storms such as the blizzards of 1888, 1978, and 2013 delivered nearly an entire season's worth of snow in single events to the region. The blizzard of 1888, called the Great White Hurricane, occurred on March 11 through 14. This blizzard produced over 50 inches of snow in some parts of the state and caused over 400 deaths along the East Coast. The blizzard of 1978, which occurred on February 6, paralyzed the state for 3 days and resulted in four Connecticut deaths. The blizzard caused widespread damage throughout New England, resulting in 99 deaths and $520 million in damage. This storm is rated 4th overall in the RSI as an "Extreme" storm. Ice storm Felix which occurred on December 18, 1973, was Connecticut's most severe ice storm and resulted in two deaths and widespread power outages.

Following are descriptions of some of the winter storms that have hit the region in the last 32 years and their impacts from the NOAA's NCEI Storm Events Database (unless otherwise noted). [4] As is evident from these descriptions, individual winter storm events need not be unusually intense to cause damages and even loss of life. Although property damages and deaths/injuries may be reported below, they may not have occurred in either Middlesex or New London county, but in the state of Connecticut as a whole, which accounts for the discrepancy between the below descriptions and Table 2.10.2 above.

List of Historical Snowstorms

March 13-14, 1993: A massive, powerful storm dubbed the "Storm of the Century" caused "whiteout" blizzard conditions stretching from Jacksonville, Florida, into eastern Canada and affected 26 states, producing 24 inches of snow in Hartford and up to 21 inches of snow in New Haven County. A total of 40,000 power outages and $550,000 in property damage were reported throughout Connecticut, and the state received a federal emergency declaration. The storm had an RSI rating of "Extreme" and is the 2nd highest ranking storm recorded by RSI.

[4] https://www.ncei.noaa.gov/stormevents/

January 7, 1996: This storm was one of the most significant winter storms to hit southern New England in the past 25 years and was named the "Blizzard of '96" from the middle Atlantic states to southern New England. However, by NWS definition, Winter Storm Ginger did not bring actual blizzard conditions to the state. Snowfall across the north and northeast portions of the state ranged from 15 to 23 inches This storm disrupted transportation systems and closed schools and businesses. The storm had an RSI rating of "Extreme" and is the 3rd highest ranking storm recorded by RSI.

December 6-7, 1996: This storm brought heavy, wet snow and resulted in widespread power outages. There had been another heavy, wet snow event the day before, too. A total of 225,000 electric customers lost power statewide, including 100,000 in central Connecticut and 95,000 in the eastern part of the state. Power remained out for several days despite the efforts of dozens of electric company repair crews, many from out of state. Many roads remained unplowed until the utility companies could clear away fallen wires. Up to 22 shelters were opened across the region, and many residents left their unheated and darkened homes. Many vehicles and homes were damaged by falling tree limbs, and damage was estimated in millions of dollars.

December 20, 1999: Light freezing rain fell in the deeper valleys of northern Connecticut as rain fell into a shallow layer of below-freezing air at the surface. The resultant light coating of ice formed "black ice" on many roadways, which caused many accidents.

November 26, 2000: Low pressure moving north up the mid-Atlantic coast brought a period of light freezing rain to much of northern Connecticut. Ice accretion was under one quarter inch, but the freezing rain left black ice on roads, causing dozens of accidents at the end of the Thanksgiving weekend, usually a busy travel day. Temperatures warmed into the 40s by late morning, ending the danger of icing.

February 5, 2001: A major winter storm brought heavy snow and strong winds to northern Connecticut. Several minor accidents were attributed to the storm. Several thousand electric customers were left without power.

November 16, 2002: A major ice storm caused significant damage in north central Connecticut. There were numerous reports of downed trees, limbs, and power lines as a result of one-half to three-quarters of an inch of icing. The damage from the ice storm was compounded by high winds 1 day later. Gusts as high as 50 mph hampered the cleanup effort and downed more trees and branches that were weighted down by ice.

February 17, 2003: A heavy snowstorm caused near-blizzard conditions and produced 24 inches of snow in areas of the state. The storm had an RSI rating of "Crippling" and is the 8th ranked winter storm by RSI. Connecticut received a federal emergency declaration.

January 8, 2005: Low pressure quickly strengthened as it passed south of New England and brought a mix of snow, sleet, and freezing rain to much of interior southern New England. North central Connecticut was especially hard hit by freezing rain where as much as one half inch of

glaze brought down trees, tree limbs, and power lines. There was no estimate of how many customers lost power, but dozens of accidents were reported as a result of icy roads.

March 8, 2005: Low pressure strengthened rapidly off the Delaware coast and tracked southeast of New England, bringing heavy snow and high winds to parts of northern Connecticut. Several highways, including Interstate 84, were described by state police as "barely passable" during the height of the storm. In Hartford, downtown streets were jammed with cars as many businesses and state offices closed early. Commuting times were doubled or tripled in many locations.

February 11, 2006: The "Blizzard of 2006" was a nor'easter that began on the evening of February 11, 2006. It dumped heavy snow across the northeast United States from Virginia to Maine through the early evening of February 12 and ended in Canada on February 13. Hartford received a total of 21.9 inches of snow — the second largest snowfall since 1906 — and West Hartford received 27 inches of snow. Despite the large amounts of snow, there were only isolated individual power outages. Bradley International Airport was closed for several hours. While Connecticut was one of the hardest hit areas, the state was well prepared for the storm and managed to avoid major problems. At the storm's onset, Governor M. Jodi Rell ordered all tractor-trailer trucks off the state's highways to facilitate the efforts of highway crews with snow removal. Connecticut mobilized 2,500 state-owned and privately contracted snowplows to keep state highways open during the storm. The state's 169 cities and towns employed hundreds of additional plows to keep local roads passable.

December 2, 2007: A strong low-pressure system moved across southern New England producing wintry precipitation across much of northern Connecticut. Ice accretion downed tree limbs and wires, causing power outages across much of Hartford County.

Winter 2010/2011: Significant snowfalls from December 2010 through February 2011 with only brief thaws in between allowed snow to pile up across southern New England, resulting in numerous roof collapses, towns seeking permission to dump excess snow in area rivers and bays, and numerous disruptions to transportation. The first major snowstorm occurred December 26 and 27, 2010, with several other snowfalls following in January. On January 11 and 12, 2011, a developing nor'easter and coastal storm dumped up to 2.5 feet of snow across Connecticut in a 24-hour period. Twenty-two and a half inches fell at Bradley International Airport, setting a 1-day snowfall record for that location. This was the second major storm of an above-average winter of snowfall. Then on January 26, 2011, a strong low-pressure system moved up the coast and southeast of Nantucket producing up to a foot and a half of snow across Connecticut. Another major storm hit February 1 and 2. Because there was no appreciable melting between storms, roof collapses continued. Federal assistance was sought by Governor Malloy for costs associated with the January 12 winter storm and its cleanup. It was granted by President Obama for Hartford and Tolland Counties. According to the Connecticut Division of Emergency Management and Homeland Security, municipalities and other local and private nonprofit agencies incurred expenses of over $3.15 million due to the heavy snowfalls associated with the federally declared

disaster. The municipalities and agencies are eligible for reimbursement of 75% of these costs under FEMA's PA program. Snow for the winter season totaled 86.4 inches.

Storm Alfred, October 29, 2011: A rare and historic October nor'easter brought very heavy snow to portions of southern New England on Saturday October 29. The accumulation of the heavy wet snow on trees and power lines resulted in widespread tree damage and power outages. Heavy, wet snow fell on foliated trees, breaking branches and downing trees and wires, resulting in widespread power outages that lasted for up to 11 days. At the peak, 830,000 customers in Connecticut were without power. Throughout Connecticut, 164 AT&T cell phone towers were damaged, resulting in degraded cell phone service until towers could be repaired and power restored. According to the Connecticut Division of Emergency Management and Homeland Security, municipalities and other local and private nonprofit agencies incurred expenses of over $68 million due to Alfred. Most of this expense was due to cleanup efforts associated with the enormous amount of debris generated by the storm.

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 observed. [5]

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.

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 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. Blizzard conditions occurred across southern Connecticut

[5] https://www.weather.gov/okx/blizzard_01262715

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.

March 14, 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 were observed across 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.

January 3-4, 2018 (Bomb Cyclone) - The blizzard developed Wednesday, January 3 as a low pressure off the coast of Florida. The low underwent rapid intensification as it moved north-northeast along the eastern seaboard with the central pressure dropping from 1004 millibar 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").

January 29, 2022 - Blizzard– A blizzard hit the Northeastern United States on January 29, 2022. Forming from the energy of a mid- to upper-level trough, the system developed into a low-pressure area off the Southeast United States, intensifying as it traveled northeasterly, bringing heavy snowfall blow by high winds to the Northeast and to Connecticut. In Connecticut, the highest snowfalls were in the southeast of the state in areas such as New London and Norwich seeing up to 21 and 22 inches respectively. Bridgeport to the west saw 10.5 inches of snow and Hartford to the north saw 8.5 inches of snow.

January 25, 2026 - Winter Storm – (Not yet in NCEI). This storm was characterized as a major nor'easter and dropped up to 2 feet of snow in some areas, causing widespread travel bans, significant flight cancellations, and several deaths, with the hardest-hit areas in the southeastern part of the state. The storm, accompanied by 40-50 mph wind gusts, caused dangerous, near-blizzard conditions.

February 22-2024, 2026 – Blizzard – (Not yet in NCEI.) This event, classified as a "bomb cyclone," dropped 10–30 inches of snow across Connecticut, crippling travel and causing significant power outages. Stonington was hardest hit with 30 inches, while shoreline and inland areas saw over 2 feet, creating dangerous, "sideways" snow, stranded drivers, and 90% flight cancellations at both of Connecticut's airports. Local media outlets compared the storm to the Blizzard of 1978. Clean-up and damage assessments are still underway as of the writing of this plan.

Federal Disaster Declarations

Understanding the natural hazards that may affect a community is essential to strengthening preparedness and improving the ability to respond effectively during disasters. To evaluate natural hazard risks in the RiverCOG region, past major disaster events can be examined to understand their impacts on lives, property, and community infrastructure. Reviewing historical losses experienced by municipalities, the state, residents, and businesses provides important insight into the types and severity of hazards the region is most likely to face.

The sections below describe major winter storm events and their impact on the RiverCOG Region. Table 2.10.3 presents winter-related Emergency and Disaster Declarations issued for Connecticut since 1978. Although not all events listed resulted in declarations for the two counties within the RiverCOG region, they still provide a meaningful representation of historical winter storm risk. There have been no new federally declared winter-related disasters in Connecticut since the 2015 severe winter storm and snowstorm.

Table 2.10.3. Connecticut Federally Declared Disasters for Winter Events Since 1978

Disaster Number	Year	Incident Period	Disaster Type	Counties
DR-4213	2015	January 26-29	Severe Winter Storm and Snowstorm	New London, Tolland, Windham
DR-4106 **EM-3361**	2013	February 8-11	Severe Winter Storm and Snowstorm - Nemo	All
DR-4046 **EM-3342**	2011	October 29-30	Severe Storm - Alfred	Litchfield, Fairfield, New Haven, Middlesex, Windham, Tolland, Hartford
DR-1958	2011	January 11-12	Snowstorm	Fairfield, Hartford, Litchfield, New Haven, New London, Tolland
EM-3266	2006	February 11-12	Snow	Fairfield, Hartford, New Haven, Tolland, Windham
EM-3200	2005	January 22-23	Snow	All
EM-3192	2003	December 5-7	Snow	Fairfield, Hartford, Litchfield, New Haven, New London, Tolland, Windham
EM-3176	2003	February 17-18	Snow	All
DR-1092	1996	January 7-13	Blizzard	Not listed
EM-3098	1993	March 13-17	Severe Winds and Blizzard, Snowfall	Not listed
EM-3060	1978	February 7	Blizzards and Snowstorms	Not listed

A federal disaster or emergency declaration for the availability of funding reimbursements from the federal government. Such reimbursements may take the form of Public Assistance payments to municipal governments, nonprofit organizations, and state agencies to clean up communities affected by disaster debris and fund the repair, restoration, reconstruction, or replacement of a public facility or infrastructure damaged or destroyed by a disaster. In cases where private property damage is widespread, FEMA may also offer Individual Assistance payments to individuals and families who have sustained losses from disasters.

Natural disasters can be costly for local communities. By way of example, Table 2.10.4 outlines the costs incurred by RiverCOG Region municipalities and other local and private nonprofit agencies in each community from two federally declared disasters in 2011 and one in 2013.[6] The costs incurred due to Storm Alfred in fall 2011 and Nemo in winter 2013 were particularly high due to the enormous amounts of debris generated in the aftermath of those storms.

Table 2.10.4. Costs Incurred by Municipalities and Local Agencies Due to Federally Declared Disasters in 2011-2013. Amount Eligible for 75% Reimbursements from FEMA per Disaster and Total Damages Eligible for FEMA Public Assistance Due to these 2011-2013 Disasters.

Applicant	DR-1958-CT 2011 Snow	DR-4046-CT Severe Weather Oct. 2011 (Alfred)	DR-4106-CT EM-3361-CT Severe Weather Feb. 2013 (Nemo)	Total Damages Eligible for Assistance Due to 2011-2013 Disasters
Town of Chester	$0	$0	$26,513.86	$26,513.86
Town of Clinton	$0	$0	$124,977.09	$124,977.09
Town of Cromwell	$0	$321,781.74	$83,881.27	$405,663.01
Town of Deep River	$0	$0	$37,692.62	$37,692.62
Town of Durham	$0	$273,358.50	$49,581.47	$322,939.97
Town of East Haddam	$0	$0	$60,661.32	$60,661.32
Town of East Hampton	$0	$82,699.47	$135,263.53	$217,963.00
Town of Essex	$0	$0	$33,628.71	$33,628.71

[6] https://www.fema.gov/openfema-data-page/disaster-declarations-summaries-v2

Applicant	DR-1958-CT 2011 Snow	DR-4046-CT Severe Weather Oct. 2011 (Alfred)	DR-4106-CT EM-3361-CT Severe Weather Feb. 2013 (Nemo)	Total Damages Eligible for Assistance Due to 2011-2013 Disasters
Town of Haddam	$0	$174,677.19	$71,919.14	$246,596.33
Town of Killingworth	$0	$105,049.87	$89,095.30	$194,145.17
Town of Lyme	$16,544.40	$0	$23,412.45	$39,956.85
Town of Middlefield	$0	$99,720.31	$25,817.90	$125,538.21
City of Middletown	$0	$1,084,598.07	$276,006.42	$1,360,604.49
Town of Old Lyme	$51,885.44	$0	$103,493.39	$155,378.83
Town of Portland	$0	$269,003.45	$43,699.20	$312,702.65
RiverCOG Region	**$68,430**	**$3,768,845**	**$1,185,643.67**	**$5,022,918.67**

A Public Assistance reimbursement database is maintained by FEMA and is available through the FEMA website. The database contains federal reimbursement data shown in Table 2.10.5. The total damage column assumes that the federal reimbursement reported by FEMA represented 75% of the actual damage. Since the last update, there have been no federal declarations, stemming from winter storms, leading to public assistance payments. All Public Assistance reimbursement damages have been inflated to 2025 dollars.

Table 2.10.5. Public Assistance Reimbursements as of July 1, 2025.

Community	Total Damage Reported	Annualized Loss for Winter Storms
Chester	$110,944	$4,109
Clinton	$300,340	$11,124
Cromwell	$630,886	$23,366
Deep River	$95,360	$3,532
Durham	$521,776	$19,325
East Haddam	$203,937	$7,553
East Hampton	$436,460	$16,165
Essex	$105,024	$3,890

Community	Total Damage Reported	Annualized Loss for Winter Storms
Haddam	$423,686	$15,692
Killingworth	$379,590	$14,059
Lyme	$115,018	$4,260
Middlefield	$262,765	$9,732
Middletown	$2,377,518	$88,056
Old Lyme	$373,072	$13,817
Portland	$487,746	$18,065
RiverCOG Region	**$7,136,192**	**$264,303**

The damages above include significant reimbursements to State of Connecticut agencies such as the DOT and the Judicial Branch. State-level reimbursements were allocated to individual communities by estimating the breakdown per county (e.g., by locating the facilities of the agencies reporting damages) and then distributing the county-wide agency loss based on each community's population relative to each county's population.

Annualized loss estimates were also prepared based on the Public Assistance data. The annualized loss from winter storm damage in the region, based on these data, is $264,303. Note that this is based on reimbursements from the federal government alone and is believed to significantly underreport actual annualized losses.

2.10.4. Probability of Future Events

Winter storms of varying levels of severity are common in the region. Data from weather stations in the RiverCOG Region reveal that in an average year there are approximately 85 days when it snows at least 0.1 inches and approximately 2 days where snow totals at least 1 inch.[7] This data indicates that communities within the RiverCOG region should anticipate multiple heavy snowfall events each year and plan accordingly to ensure they are adequately prepared for these conditions.

A review of Emergency and Disaster Declarations for winter weather shows that the RiverCOG region experienced 11 such events over the 47-year period from 1978 to 2025. These numbers equate to an approximate 23% likelihood that a winter storm severe enough to warrant an Emergency or Presidential Disaster Declaration will occur in any given year. The NCEI Storm Events Database captures a broader range of winter weather incidents, including all events with reported damage, which reflects a much lower threshold for inclusion. Analysis conducted for the 2023 Connecticut State NHMP update, using NCEI data, found that Middlesex County experiences an

[7] https://www.ncdc.noaa.gov/

average of 5.62 significant snow events per year, while New London County experiences an average of 5.54 such events annually.

Shifts in the type of winter precipitation may reduce the frequency of major snowstorms while increasing the likelihood of ice storms. This trend warrants further study, as changes in snow density or a transition toward more freezing rain and ice could significantly affect how future winter storms are managed and how they impact Connecticut residents, including implications for travel, utilities, and overall public safety. Figure 2.10.1 (from the 2023 CT State NHMP) shows average annual snowfall in feet for Connecticut.

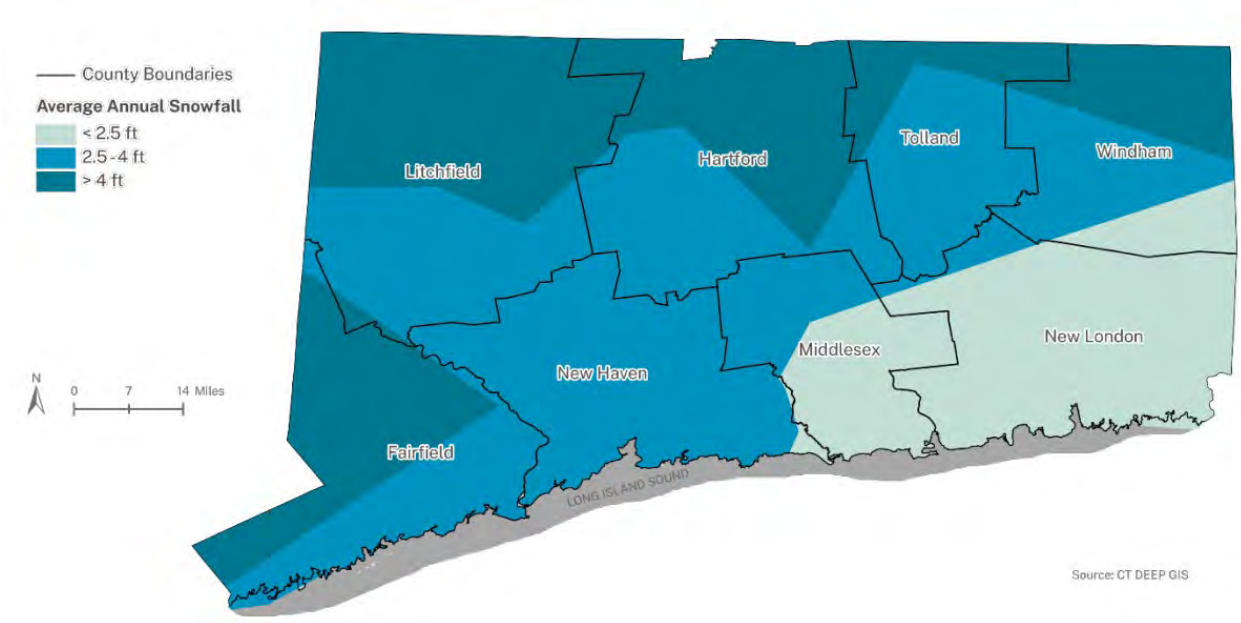


Figure 2.10.1. Winter Storm Average Annual Snowfall

2.10.5. Climate Change Impacts

Connecticut's annual mean temperature has risen by approximately 3°F (1.7°C) since 1895, a rate of increase that exceeds the global average. The most pronounced warming has occurred during the winter months (December through February), with temperatures increasing at roughly 0.4°F per decade.[8] Climate change will significantly impact winter weather patterns and precipitation.

According to the 2023 Connecticut NHMP Update, recent climate change studies predict a shorter winter season for Connecticut (by as much as 2 weeks) and fewer snow-covered days with a

[8] https://circa.media.uconn.edu/wp-content/uploads/sites/1618/2019/11/CTPCSAR-Aug2019.pdf

decreased overall snowpack.[9] These models also predict that fewer, more intense precipitation events will occur with more precipitation falling as rain rather than snow. This trend suggests that future snowfall events will consist of heavier (denser) snow, and the potential for ice storms will increase. Such changes will have a significant impact on how the state and its communities manage future winter storms and will affect the impact such storms have on the residents, roads, and utilities in the State.

2.10.6. Impacts and Estimated Losses to the Region

Impacts

Impacts from severe winter weather can become dangerous and threaten people and property. Most deaths from winter storms are indirectly related to the storm, such as traffic accidents on icy roads and hypothermia from prolonged exposure to cold. Damage to trees and tree limbs, and the resulting downing of utility cables, are common effects of these types of events. Secondary effects include power outages, heat loss, and flooding due to rapid snowmelt.

Although the probability of a winter storm occurring is generally consistent across the region, the level of risk varies based on factors such as infrastructure conditions and population density. Communities with more vulnerable infrastructure or higher population density are likely to experience greater impacts from the same type of storm. Areas with higher levels of development and more extensive road networks tend to face greater potential for damage, in part because the volume of infrastructure increases the burden of snow and ice removal. Heavy snow and even light icing can also lead to a high likelihood of traffic accidents and congestion. Conversely, travelers moving through less-developed areas may face elevated risks due to fewer available alternate routes and, in some locations, relatively steep terrain that can become hazardous during winter weather.

After a storm, snow piled along roadways can obstruct sight lines and reflect a blinding amount of sunlight. When coupled with slippery road conditions, poor sight lines, and heavy glare create dangerous driving conditions. Stranded motorists, especially senior and/or handicapped citizens, are at particularly high risk of injury or death from exposure during a blizzard.

Areas with greater levels of development are also at greater risk of business disruptions, loss of life, and structural damage. Middletown has the greatest level of development and the greatest potential risk. For example, with more roofs comes more potential for roof collapse. There are also more sidewalks to clear, more homes to heat, and more people to protect.

[9] https://portal.ct.gov/demhs/-/media/demhs/_docs/plans-and-publications/ehsp0024---2023-natural-hazard-mitigation-plan---final.pdf?rev=01aae6d47e8e4bf8a0e24f4ca71581ee&hash=D7467FC0C0E730B61AD407EC3487AD9B

Section 2.9.3 describes the exposure analysis method used to characterize the upper boundaries of exposure in the region. The following Table 2.10.6 presents the exposure to winter hazards.

Table 2.10.6. Winter Weather Exposure Analysis for RiverCOG Communities

Community	Number of Parcels	Value of At-Risk Parcels	Number of Critical Facilities	Value of At-Risk Critical Facilities	Number of Historic Assets	Value of At-Risk Historic Assets
Chester	1,822	$558	11	$30	44	$17
Clinton	6,989	$1,586	9	$74	654	$230
Cromwell	6,069	$1,707	14	$138	226	$113
Deep River	2,216	$577	13	$78	380	$99
Durham	3,066	$583	8	$18	94	$22
East Haddam	5,743	$1,124	14	$35	201	$64
East Hampton	6,203	$1,151	14	$39	399	$100
Essex	3,442	$1,378	12	$40	544	$271
Haddam	4,271	$816	14	$45	209	$69
Killingworth	2,775	$771	8	$25	47	$22
Lyme	1,709	$711	5	$9	280	$136
Middlefield	2,247	$464	8	$14	21	$9
Middletown	13,549	$5,581	36	$608	804	$1,474
Old Lyme	5,624	$1,544	12	$50	502	$217
Portland	4,725	$847	21	$24	161	$46

**All dollar figures are in millions*

With an even distribution of winter storm exposure across the region, data from the NRI was used to analyze severe winter weather at the census tract level within the RiverCOG region. Displayed in Figure 2.10.2, winter weather risk across RiverCOG ranges from Relatively Low to Relatively Moderate.

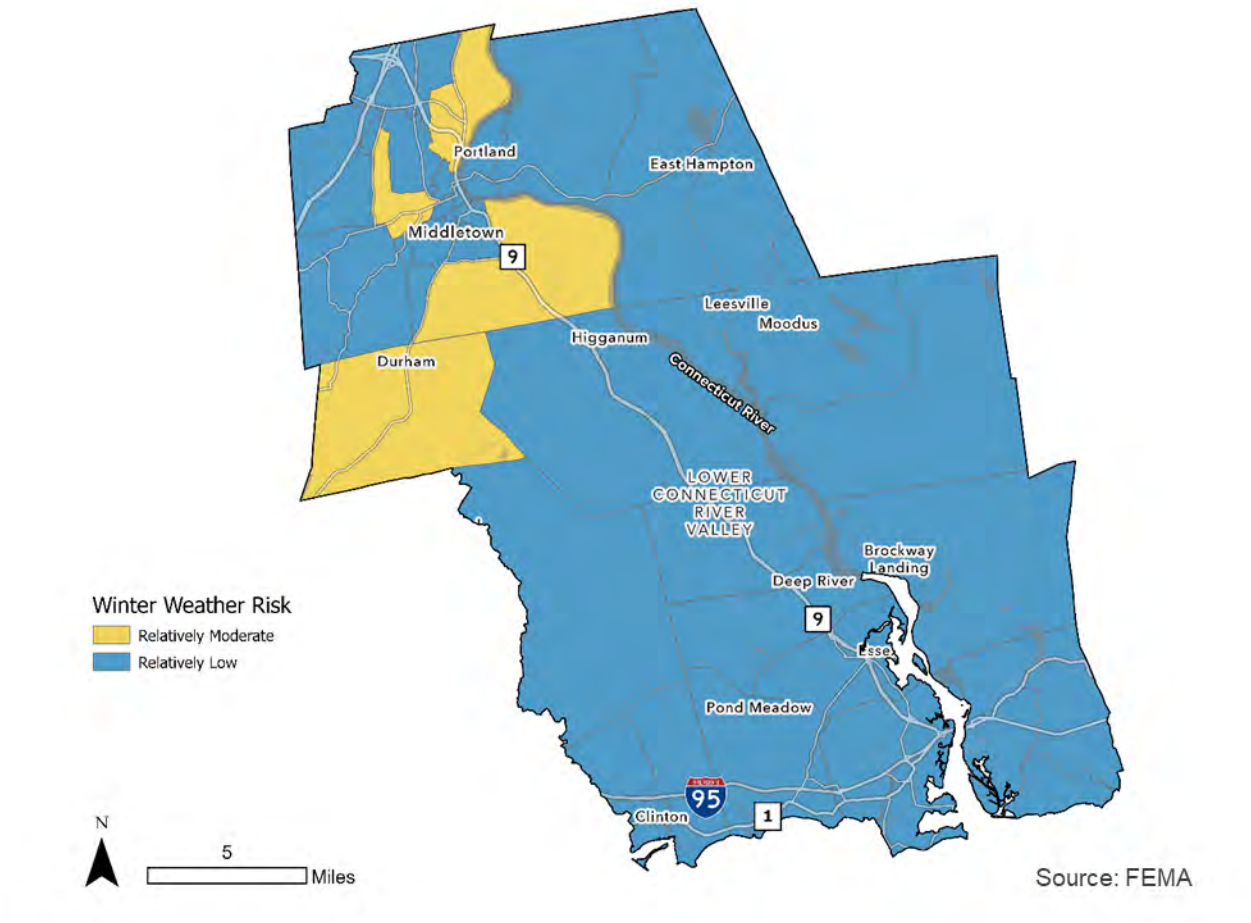


Figure 2.10.2. NRI Risk Rating for Winter Weather, shown at the census tract level (2025)

Middletown has the highest number of census tracts at relatively moderate risk from winter weather, with two of its thirteen tracts falling into this category.

Additionally, all of Durham and one of the three census tracts in Cromwell have relatively moderate risk to winter weather. The remaining communities in RiverCOG have relatively low risk to winter weather. Table 2.10.7 displays communities in RiverCOG and the number of census tracts for each winter weather risk rating.

Table 2.10.7. Breakdown of Community Risk to Winter Weather

Community	Number of Census Tracts with Relatively Low Risk	Number of Census Tracts with Relatively Moderate Risk
Chester	1	-
Clinton	4	-
Cromwell	2	1

Community	Number of Census Tracts with Relatively Low Risk	Number of Census Tracts with Relatively Moderate Risk
Deep River	1	-
Durham	-	1
East Haddam	2	-
East Hampton	3	-
Essex	2	-
Haddam	2	-
Killingworth	1	-
Lyme	1	-
Middlefield	1	-
Middletown	11	2
Old Lyme	3	-
Portland	2	-
Total for RiverCOG Region	**36**	**4**

The following discussions examine the economic impact of snowstorms on the region.

Municipal Budgets

Snow and ice removal have a tremendous impact on municipal budgets. The impact varies by community; some communities use their own staff to clear roads, which may represent savings but also be inefficient. Other towns hire contractors to remove 100% of the snow and ice. The remainder of towns use a combination of municipal staff and contractors. Regardless of staffing, every community is faced with spending between $100,000 and $1 million per year on snow and ice management. In recent years, towns have budgeted and spent widely varying amounts on their snow removal budgets depending on severity.

Roof Collapse

Heavy snow and ice accumulation bring with them the threat of roof collapse and catastrophic damage to the building's occupants

As reported by the Insurance Institute for Business and Home Safety, two feet of old snow and 2 feet of new snow could weigh as much as 60 pounds per square foot of roof space, which is beyond

the typical snow load capacity of most roofs.[10] One inch of ice is equivalent to 1 foot of fresh snow. A house should be able to support 20 to 25 pounds of snow per square foot.

As seen in Table 2.10.8, snow alone can put a large burden on roofs; however, when coupled with rain and sleet, this load per square foot increases.[11]

Table 2.10.8. The Burden of Snow on a Roof

Type	Equivalent to 1 inch of water	Load per Square Foot	Maximum
Fresh Snow	10-12 inches	5 lbs.	4 ft.
Packed Snow	3-5 inches	5 lbs.	2 ft.

The winter of 2011 saw many buildings condemned due to snow accumulation, leading to roof collapses. The community annexes in Volume 2 of this plan discuss roof collapses, where applicable.

Road Closures

Like many other types of disasters, winter weather and heavy snowfall can cause localized and widespread road closures. Closures can result from a variety of causes, including poor driving conditions, heavy snow and drifts, and detritus such as fallen trees and power lines. When a blizzard struck on February 8, 2013, Governor Malloy called for a traffic ban on all vehicles the following day, except for emergency response and recovery vehicles capable of maneuvering in heavy snow. For the winter storm events in 2026, Governor Lamont similarly banned commercial vehicle travel on interstates. Events with large impacts on transit also have major economic impacts, such as preventing employees from reaching work and halting or delaying shipments and deliveries.

Burst Pipes

Cold and winter weather can pose substantial hazards not only outdoors but also indoors. Frozen pipes pose a particular risk, as pipe bursts can lead to severe interior damage and costly repairs. A complete ice blockage within a pipe causes the trapped water to freeze and expand, increasing pressure along the line and ultimately forcing the pipe to fail. Although formal records of burst-pipe incidents in the region are limited, such failures occur frequently and can cause substantial damage to homes, businesses, and institutional facilities.

[10] Insurance Institute for Business & Home Safety; https://ibhs.org/.

[11] Source: Insurance Institute for Business & Home Safety; https://ibhs.org/.

Power Outages

Heavy snow and ice can cause tree limbs to snap and fall onto power lines, often leading to widespread outages. These impacts are typically more severe in rural areas, where overhead electrical infrastructure is more common. In contrast, urban areas, where a larger share of power lines is installed underground, tend to experience fewer and less severe outages during winter storms. Not only are power outages inconvenient, but they can also cause property damage, disrupt business, and threaten lives if heating systems or medical devices and equipment are affected.

During the October 2011 snowstorm, more than 80% of the region's population was without power during peak outages, and outages often lasted for 5 days or more. Figure 2.10.3 shows a summary of the number of customers who were without power. In general, the northern communities (i.e., Middletown) within the RiverCOG region were more impacted by power outages. In the municipal annexes, more detail is provided about how many days customers in those towns were without power (if the local planning teams were able to provide this information).

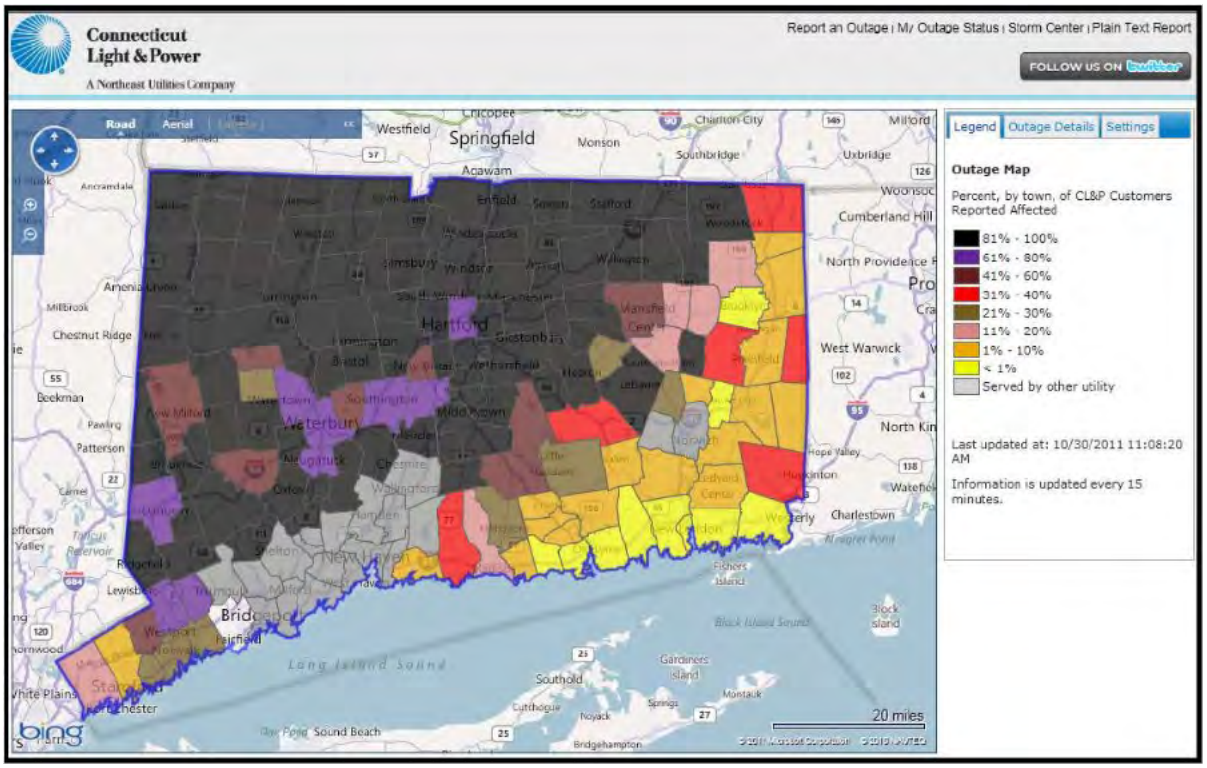


Figure 2.10.3. Outage Map from October 2011 Winter Storm Alfred. Source CL&P

Threats

Although the region and the State are well prepared for the clean-up efforts needed after most winter storms, the public may not be prepared for large winter storms, which can have a dangerous effect. Ice storms pose danger as the weight of the ice can knock down power lines and telephone

poles. Power outages during the winter months can be dangerous as residents may not have a heat source. Excessive snowfall can lead to roof collapses if roofs are not cleared of snow. Some of the threats facing the public include:

- Exposure to cold
- Hypothermia
- Frostbite
- Vehicle accidents
- Fires in the home
- High winds
- Icing conditions
- Loss of utilities due to power outages
- Loss of food and perishables due to power outages

Sheltering

Because of heavy icing, power outages are likely. Shelters will be opened, with Public Health supervision. Extended power outages mean spoiled perishable foodstuffs. Shelters can provide meals as necessary.

Cold Injuries

About half of all cold-related injuries occur in individuals over 60, and approximately 75 percent involve men. Roughly 20 percent of these injuries occur at home.

Estimated Losses

Winter weather is one of the most impactful hazards to the RiverCOG region and its municipalities. 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 conditions vary geographically.

FEMA Public Assistance - Based on the public assistance reimbursements shown on Table 2.10.5, the RiverCOG region has incurred approximately $7,136,192 in winter-storm-related losses over the 27-year period since 1998. This equates to an annualized loss of about $264,303. Annualized losses for each community are presented in Table 2.10.9. These annualized loss estimates should be used with caution as they report only federal reimbursement and do not reflect total damage. Public assistance expenditures are only a small part of the overall losses the region and its municipalities incur. Nevertheless, these figures provide useful planning metrics for assessing the overall vulnerability of the RiverCOG Region to winter storms.

Table 2.10.9. Annualized Loss Estimates due to Winter Storms Based on Public Assistance Reimbursements between 1998-2025.

Community	Loss Estimate
Chester	$4,109

Community	Loss Estimate
Clinton	$11,124
Cromwell	$23,366
Deep River	$3,532
Durham	$19,325
East Haddam	$7,553
East Hampton	$16,165
Essex	$3,890
Haddam	$15,692
Killingworth	$14,059
Lyme	$4,260
Middlefield	$9,732
Middletown	$88,056
Old Lyme	$13,817
Portland	$18,065
RiverCOG Region	**$264,303**

Reported damages from the NCEI database are another common way of determining annualized losses. NCEI primarily aggregates damages at the county level. In the 2023 Connecticut NHMP Update, the ratio of each town's population to the county population was used to attribute a portion of the county-wide annualized loss to each town. In general, the annualized loss estimates prepared by this method were lower than those developed through the Public Assistance reimbursements. There are no damages included in NCEI for Middlesex and New London Counties, so this approach could not be used for RiverCOG towns.

To supplement the lack of county-level damage data in the NCEI database for Middlesex and New London Counties, annualized loss estimates from NRI data were incorporated. Figure 2.10.4 below shows the expected annual loss ratings throughout the COG and Table 2.10.10 describes the projected annualized losses from winter weather by community. The highest expected annual losses are in Middletown, with a projected $17,781 in winter weather-related losses. Additionally, Cromwell, East Hampton, and Clinton are all projected to lose over $4,000 annually due to winter weather. The total expected annual loss for the COG is estimated to be $47,558.

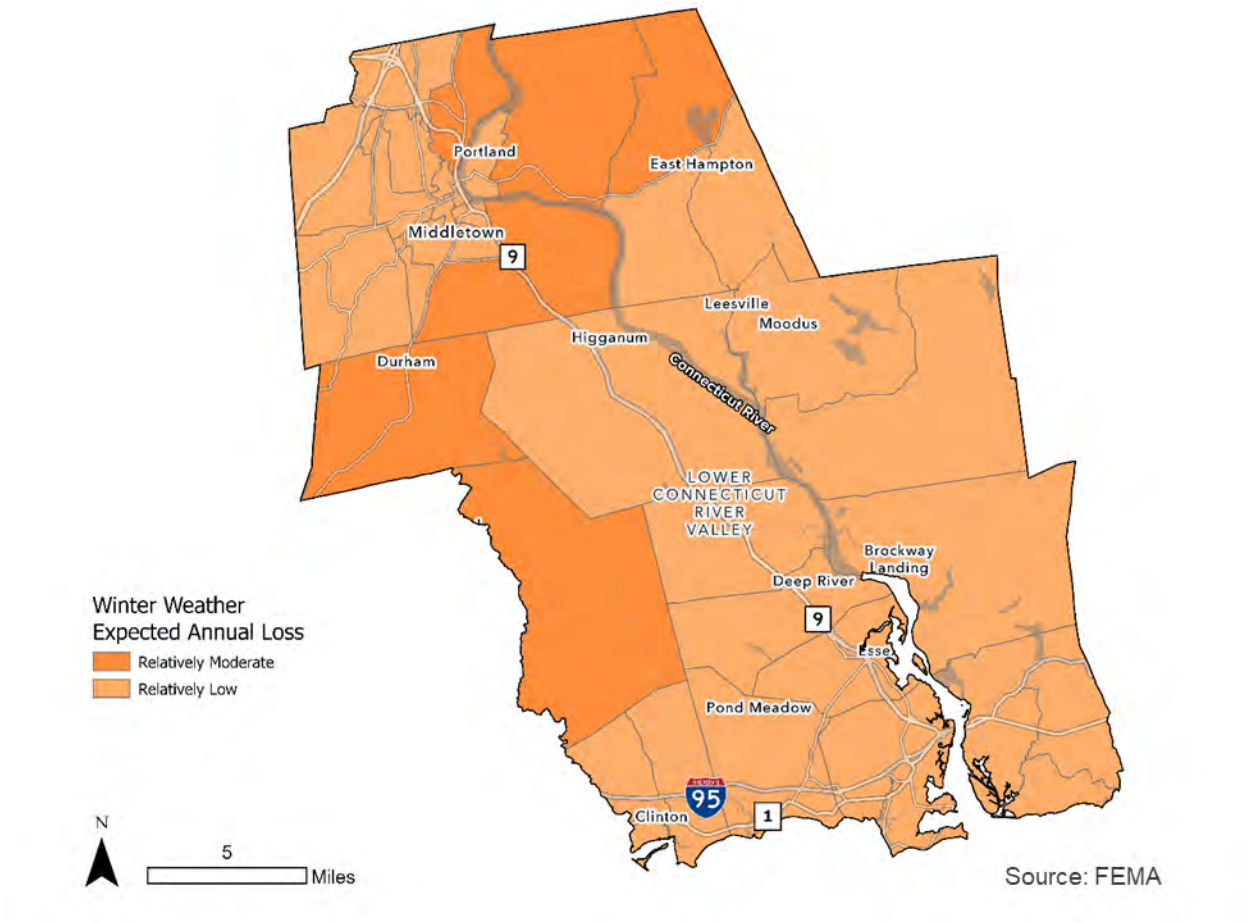


Figure 2.10.4. NRI Winter Weather Expected Annual Loss Rating (2025)

Table 2.10.10. Breakdown of Expected Annual Losses from the NRI by Community for Winter Weather

Community	Expected Annual Loss
Chester	$1,498
Clinton	$4,440
Cromwell	$5,539
Deep River	$1,500
Durham	$2,840
East Haddam	$3,514
East Hampton	$4,794
Essex	$2,364
Haddam	$3,303
Killingworth	$2,389

Community	Expected Annual Loss
Lyme	$582
Middlefield	$1,635
Middletown	$17,781
Old Lyme	$1,680
Portland	$3,699
Total for RiverCOG Region	**$47,558**

2.10.7. Development Trends

Since the 2021 plan update, development within the RiverCOG region has remained limited. Over the five-year period from 2019 to 2023, the region's population increased by approximately 1.7%,[12] a modest rise that is about 0.5% lower than Connecticut's statewide growth rate of roughly 2.2% during the same timeframe. Haddam, Old Lyme, Clinton, Cromwell, Middletown, and Essex experienced the largest population increases during this period, though the highest rate of growth was a modest 4.1% in Haddam. Chester saw the most significant decline, with its population decreasing by 10.6% over the same five-year span. Several factors contribute to these shifting growth patterns, with the COVID-19 pandemic playing a major role.

Similarly, there has been only a 0.37% increase in housing stock in the region during the 2019-2023 five-year period, with only 195 building permits issued in 2023 across RiverCOG.[13] The majority of these building permits issues in 2023 are in East Hampton (37) and East Haddam (25), both of which have seen decreases in housing stock during these five years. Killingworth, Durham, Haddam, Deep River, and Clinton have seen the largest increase in housing stock during this period. Additionally, commercial and industrial growth has been relatively stagnant during this time frame.

Housing development and population growth in these areas will increase the number of residents exposed and at risk to severe winter weather. One benefit of new development, however, is that newer construction is generally built to stronger building codes. Therefore, newer buildings that replace older-code buildings should generally reduce overall risk from winter storms. More specific changes in development are addressed at the community level in the municipal annexes in Volume II of this plan.

[12] https://www.rivercog.org/data-population

[13] https://www.rivercog.org/data-housingcharacteristics

2.10.8. Overall Risk Rating

Using the parameters described in Table 2.8.1, the following hazard risk ratings were developed for severe winter weather (Table 2.10.11).

Table 2.10.11. Overall Risk Rating of Severe Winter Weather

Criteria	Hazard Risk Rating
Probability	4 (Highly Likely)
Impact: Affected Area	4 (Large)
Impact: Primary Impact	1 (Negligible)
Impact: Secondary Impacts	3 (Moderate)
Survey Rating	2 (Moderate Concern)
Total Score	15.4
Overall Risk Ranking	**Significant**

2.11. Flooding - Riverine and Inland Flooding

2.11.1. Description and Background

Riverine and inland flooding is a well-documented natural hazard that threatens many areas and neighborhoods throughout the Region. It is one of the most common natural hazards and can damage property and disrupt the quality of life for many residents.

Triggered by a variety of events, flooding can result from other natural hazards such as heavy precipitation, hurricanes, winter storms, snowmelt, ice jams, or dam failures. The RiverCOG Region's numerous rivers and streams, along with its few urbanized areas, make flooding and flash flooding a regular risk. Historical development patterns encouraged dense construction of town centers near water bodies; consequently, many areas with chronic flooding problems are in population centers. Individuals and local governments face significant economic loss, risks to public safety, and degraded waterways from flooding

2.11.2. Location and Extent

According to FEMA, most municipalities in the United States have at least one clearly recognizable area at risk of flooding around a river, stream, or large body of water. Many communities also have localized flooding areas outside the FEMA-defined regulatory floodplain. These floods tend to be shallower and chronically recur in the same area due to a combination of factors, including ponding, poor drainage, inadequate storm sewers, clogged culverts or catch basins, sheet flow, obstructed drainageways, sewer backup, or overbank flooding from minor streams.

FEMA classifies inland flooding into several types, reflecting the various ways flood conditions can develop and affect communities.

- Riverine Flooding: Also known as overbank flooding, it occurs when channels receive more rain or snowmelt from their watershed than normal, or the channel becomes blocked by an ice jam or debris. Excess water spills out of the channel and into its floodplain.
- Flash Flooding: A rapid rise of water along a water channel or low-lying urban area, usually a result of an unusually large amount of rain and/or high velocity of water flow (particularly in hilly areas) within a very short period of time. Flash floods can occur with limited warning.
- Shallow Flooding: Occurs in flat areas where a lack of a water channel results in water being unable to drain away easily. The three types of shallow flooding include:
    - Sheet Flow: Water spreads over a large area at uniform depth.
    - Ponding: Runoff collects in depressions with no drainage ability.
    - Urban Flooding: Occurs when man-made drainage systems are overloaded by a larger amount of water than the system was designed to accommodate.

Flood events are commonly described in terms of their annual probability of occurrence. FEMA delineates floodplains based on the 1% and 0.2% annual-chance flood events, also referred to as the 100-year and 500-year floods. Table 2.11.1. provides a comparison of recurrence intervals, annual probabilities, and FEMA's preferred terminology.

The area with a 1% annual chance of flooding is delineated as a Special Flood Hazard Area (SFHA) for the purposes of the National Flood Insurance Program (NFIP). The 0.2% annual chance floodplain indicates areas of moderate flood hazard.

Table 2.11.1. Flood probabilities for the Region

Recurrence interval, in years	Probability of occurrence in any given year	Percent chance of occurrence in any given year
500	1 in 500	0.2
100	1 in 100	1
50	1 in 50	2
1	1 in 25	4
10	1 in 10	10
5	1 in 5	20
2	1 in 20	50

However, because the 1% floodplain (or any percent floodplain) reflects the percentage chance that the area will be inundated in any given year, it is possible to observe a 1% flood more than once every 100 years. For example, FEMA notes that a structure located within a 1% annual chance

flood zone has a 26% chance of suffering flood damage during the term of a 30-year mortgage. Furthermore, the 1% floodplain is based on empirical evidence. If more or fewer floods of a certain magnitude are observed, FEMA may restudy the floodplains and update corresponding insurance maps. This means that there can be a lag between the official risk and the empirical risk presented on the Flood Insurance Rate Maps (FIRM).

SFHAs in RiverCOG communities are delineated on a FIRM produced as part of a Flood Insurance Study (FIS). Major watercourses in the RiverCOG communities typically have SFHAs mapped as Zone AE, while smaller tributary streams are mapped as Zone A. Other small streams have shading as Zone X, and other classifications are also possible. Table 2.11.2 presents the various flood hazard zones (including coastal zones, which will be discussed in the subsequent section) mapped on FIRM panels in the RiverCOG Region.

Table 2.11.2. Description of FEMA Flood Zones.

Zone	Description
A	An area with a 1% chance of flooding in any given year for which no base flood elevations (BFEs) have been determined
AE	An area with a 1% chance of flooding in any given year for which base flood elevations have been determined. This area may include a mapped floodway
X (Levee)	An area where the flood risk has been reduced below the 1% annual chance by a levee
X (Shaded)	An area with a 0.2% chance of flooding in any given year for which no base flood elevations have been determined
X (Unshaded)	An area that is determined to be outside of the 1% and 0.2% annual chance floodplains
V (Coastal)	A coastal flood zone area that is subject to a 1% annual chance event, however, there are no base flood elevations identified for these areas.
VE (Coastal)	Also known as the coastal high hazard area, this flood zone is also subject to high velocity wave action and is defined by the 1% base flood limits. This area may also experience wave impacts 3 feet or greater.

During large storms, the recurrence interval level of a flood discharge on a tributary tends to be greater than the recurrence interval level of the flood discharge on the main channel downstream. In other words, a 1% annual chance flood event on a tributary may only contribute to a 2% annual chance flood event downstream. This is due to the distribution of rainfall throughout large watersheds during storms and the greater hydraulic capacity of the downstream channel to convey floodwater. Dams and other flood control structures can also reduce the magnitude of peak flood flows if pre-storm storage is available. Similarly, the recurrence interval level of a precipitation event also generally differs from the recurrence interval level of the associated flood. Flood events can also be mitigated or exacerbated by in-channel and soil conditions such as low or high flows, frozen ground, or a deep or shallow water table.

The FEMA flood risk mapping systems, coupled with the NWS warning systems, are appropriate for the region, as they have been used for all floods that have occurred in the RiverCOG region and its communities. Flood events have not been characterized outside of these systems of classification.

Flood Susceptibility Model and Mapping

In 2017 a flood mapping study was performed for the Lower Connecticut River Valley Region (LCRVR). The study was funded by CIRCA and a Housing and Urban Development (HUD) grant through the Department of Housing. Several methods were considered to estimate flood susceptibility. The final selected method involved logistic regression, which is a statistical method that uses several variables (flood risk factors) that allows the development of an equation to estimate the chance that a location will be inundated by a particular flood. The flood risk factors represent site characteristics that could potentially affect the region and for which sufficient data are available. Flood risk factors considered include elevation, slope, land curvature (concave, convex, or flat), distance to water body, land cover, vegetative density, surficial materials, soil drainage class, and percent impervious surface. The objective was to link each of the flood risk factors to the extent of a flood event with a 1% chance of occurring annually using GIS modeling capabilities. Since the overall quality of recent satellite images, after flooding events, over the region was not sufficient for this analysis, it was decided to use the 100-year FEMA floodplain to estimate the extent of a typical 100-year flood.

The FEMA 100-year flood maps are limited to the sub-watersheds of greater than one square mile that FEMA chose to study with limited resources. Other limiting factors are the age of the underlying studies illustrated by the FEMA maps (often more than two decades old) and their focus on only areas where development existed or was imminently anticipated. FEMA's flood mapping is developed using physical models to perform hydrologic and hydraulic analysis of a statistical rainfall event with a one percent chance of being equaled or exceeded in any given year (referred to as the 100-year flood). In general terms, hydrologic analysis is the study of transforming rainfall amounts into quantity of runoff. Hydraulic analysis takes that quantity of water and uses a physical model to route it through existing terrain, while considering such factors as topography and vegetative density. This modeling is referred to as "detailed analysis." Some areas are studied by "approximate methods." In general, areas studied by approximate methods use a simplified hydrologic analysis methodology and route runoff quantity along best available topography alone.

In 2020, in parallel with the development of the previous plan update, the 2017 CIRCA and HUD study was expanded to include higher resolution land cover and elevation data. The expanded analysis also included testing of the significance of all flood risk factors and comparing the results of the analysis initially conducted at a sub-regional (i.e. urban, rural and coastal) level, versus, at the overall regional level. The 2017 susceptibility mapping was updated to incorporate the refined results. The susceptibility maps from this study provided a less expensive method of covering all land area within the region. By using the statistical modeling methodology described in the associated report it was possible to identify the contribution of flood risk factors within the

physically modeled FEMA 100-year floodplain and apply them to the entire study region to identify areas thought to be susceptible to flooding. An ArcGIS mapping product was generated for future planning analysis containing the flood susceptibility, land use, and critical infrastructure datasets.

An important disclaimer about the flood susceptibility map is that it was created for present-day conditions and is only to be used for planning and analysis purposes. It was not intended to replace the FEMA mapping for regulatory or flood insurance decisions. This mapping product was created as part of a research project. The purpose of its inclusion in this plan is to encourage planning partners to field verify the mapping's accuracy and to use it to conduct additional risk analysis, as appropriate.

The original study report, expanded analysis report, GIS mapping, and a link to a technical article describing the study, published in the *Water Resources Research* journal, entitled "A Statistical Approach to Mapping Flood Susceptibility in the Lower Connecticut River Region", are included in Appendix C.

2.11.3. History of Past Events

The most notable floods in the RiverCOG region occurred in 1936, 1938, 1955, 1982, and 1984. The 1936 and 1984 flooding were higher-than-usual Spring Floods, while the 1938 flooding was caused by the Great Hurricane of 1938, and the 1982 flood was caused by a stalled rainstorm over the region that dropped as much as 16 inches of rain in three days in some areas. In recent years, several notable events have produced flooding across the region, including an early spring event in 2010, Hurricane Irene in 2011, Superstorm Sandy in 2012, and a heavy rainfall event in September 2018. Within the past five years, the most significant flooding occurred in 2021 during Tropical Storms Elsa and Ida, which generated flash flooding across the region but caused only relatively minor damage.

The flood of March 1936 was the result of a stalled system over New England which included increased temperatures and heavy rain (Figure 2.11.1). This combination rapidly washed away the extensive snowpack, resulting in flooding throughout New England. The entire Connecticut River was impacted, with record flows in Hartford. Between 150 and 200 lives were lost, and losses are estimated to have exceeded $100 million (in 1936 dollars).



Figure 2.11.1. Aerial photograph of the 1936 flood in Middletown, Connecticut.

The flood of 1955 was one of the worst in Connecticut's history. It resulted from heavy rains caused by back-to-back hurricanes in August. According to NOAA, Hurricane Connie produced 4 to 6 inches of rainfall over southern New England on August 11 and 12, saturating the ground and raising river and reservoir levels to above-normal levels. Then Hurricane Diane came a week later and "dealt a massive punch" to New England. Rainfall totals from Diane ranged up to nearly 20 inches over a 2-day period.

The following are descriptions of recent flood events drawn from the NCEI Storm Events Database.

January 12, 1996: A low-pressure system from Virginia moved up the coast across Southern New England, where precipitation ultimately shifted rapidly from snow to heavy rain. This precipitation quickly melted the snowpack that had fallen a few days earlier during a blizzard, causing extensive flooding across both Middlesex and lower New London counties.

April 16, 1996: A low-pressure system from the Midwest, with abundant moisture, brought heavy rain and strong wind gusts up to 39 mph. This heavy rain causes widespread flooding in rivers and small streams, as well as urban flooding in streets and low-lying areas. Middlesex County received between 3 and 6 inches of rain from the southeast to the northwest, respectively. New London County received slightly less rainfall, with records of 2.32 to 3.31 inches.

March 9, 1998: Two low-pressure systems moved north-northeast toward New England, intensifying as they did so. The culmination results in strong thunderstorms and heavy rainfall that cause river, stream, and urban flooding. Home evacuations were necessary in Clinton, Portland, Middletown, Haddam, Durham, and Middlefield. It is estimated that rainfall totals ranged between 3 and 5 inches across Middlesex County

June 17, 2001: Remnants of Tropical Storm Allison, in conjunction with a western cold front, resulted in heavy rainfall across southern Connecticut with rates of up to 2 inches per hour. Some rivers approached capacity rapidly, with some exceeding flood stage.

October 8, 2005: Heavy rain moved north across Connecticut due to the remnants of tropical storm Tammy. The storm began late afternoon, October 7, and ended on October 9 as the system continued north. The heaviest rain fell across the state's interior, with urban and low-lying areas heavily impacted.

June 23, 2011: A slow-moving system bringing heavy precipitation resulted in flash flooding throughout southern Connecticut, including Old Lyme. North Bride Brook Road was closed as a result of four feet of standing water on the roadway.

July 8, 2011: A heavy summer rainstorm resulted in flash flooding in the Town of Portland where several basements, government buildings were flooded. The flood caused extensive damage to town and school records, along with other materials stored in basements. Water rescues were also performed as a result of this event.

September 25, 2018: Heavy rain traveled east from New York City across southern Connecticut during the afternoon and into the evening. The storm resulted in widespread heavy rainfall of 4 or more inches in a relatively short period, with a station near Durham reporting 7.24 inches. There were numerous reports of flash flooding across the state, damage such as bridge and road washouts, and reported water rescues.

July 9, 2021: Tropical Storm Elsa brought heavy rainfall to the region, resulting in widespread flash flooding across southern Connecticut. Rainfall totals ranged from three to five inches. Reports of roads closed due to flooding in Portland.

September 2, 2021: Remnants of Hurricane Ida caused extremely heavy rainfall across southern portions of Connecticut, with totals averaging between five and eight inches in some areas. This rainfall resulted in extensive flash flooding and riverine flooding, with upwards of eight inches reported in some towns along the shoreline. Damages across Middlesex County were reported upwards of $50,000.

July 4, 2023: Some localized flash flooding occurred as a result of a stalled storm system, which produced torrential rains.

July 10, 2023: A stalled storm system resulted in torrential rains, which produced three to five inches of rain within a several-hour timeframe. There were reports of flooding and submerged cars in New London.

July 16, 2023: A stationary tropical airmass produced heavy rain, causing widespread flash flooding throughout Connecticut. The storm produced a rate of up to 3 inches per hour. There were reports of flooding in New London.

January 10. 2024: A large low-pressure system brought long-duration, persistent moderate to heavy rainfall, which caused widespread river flooding and some localized flash flooding. The Yantic River reached major flood stage, resulting in a reported partial dam break in Fitchville and prompting downstream evacuations.

2.11.4. Probability of Future Events

All municipalities in the region are vulnerable, to some degree, to flooding. The inland towns of Durham, Middlefield, and Killingworth are not vulnerable to seasonal flooding along the Connecticut River. There is, however, still a risk for flash floods, poor drainage, and low-lying floods, along with other riverine and stream flooding. Those communities along the Connecticut River are vulnerable to seasonal flooding in addition to other inland flooding hazards.

While climate change is expected to affect precipitation patterns, the probability of future floods can be discussed in relation to the base flood, or the "1% annual chance" flood. Trends in climate change suggest that rainfall intensity will increase over time, resulting in greater flooding damage at each of these recurrence intervals. Several recent studies have shown that rainfall in Connecticut is increasing over time. Although annual precipitation in Connecticut is approximately 47 inches, the average annual precipitation has been increasing by 0.17 inches per decade since the end of the 19th century, according to UConn CIRCA.[14] Figure 2.11.2 demonstrates this information graphically.

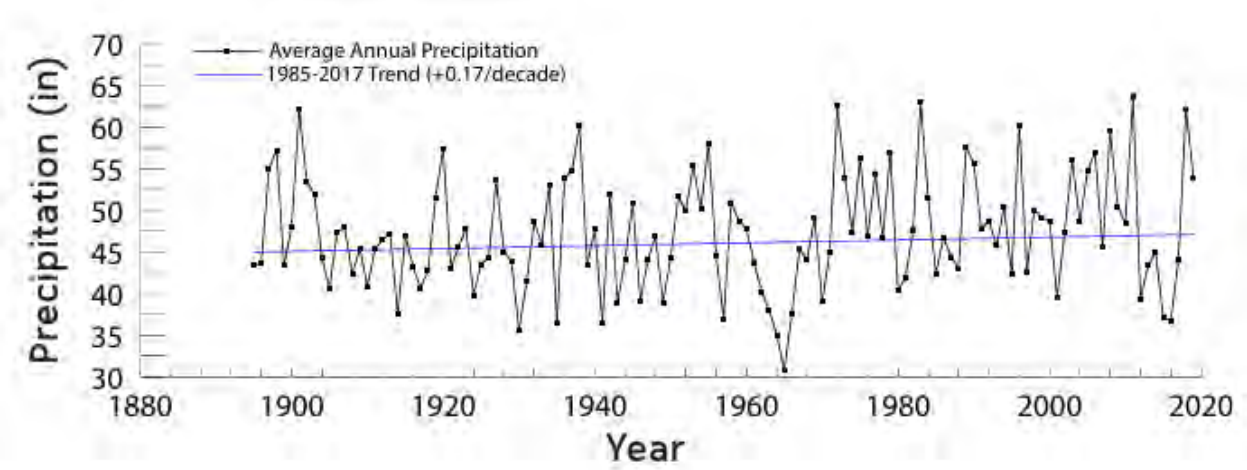


Figure 2.11.2. Precipitation Record for Connecticut Since 1895.

It is important to note that although a recurrence interval is given for a storm of a certain magnitude, that does not mean this size storm only occurs once in a certain number of years. For example, a 1% annual chance flood, or 100-year flood, has a 1% chance of occurring each year. There is always a chance that a storm of the same magnitude can occur more than once in the same year.

In addition to this statistical probability, there is also an increased chance of flooding in communities that are not maintaining natural floodplains and infrastructure. Urban flooding can

[14] https://crcogct.gov/wp-content/uploads/2024/07/CRCOG-HMCAP-Appendix-K-CIRCA-Climate-Change-Fact-Sheets.pdf

often be minimized or avoided with consistent drainage system maintenance. In addition, by maintaining clean floodways, natural floodplains will be allowed to flood naturally, minimizing damage to adjacent property.

Like many areas in the United States, the RiverCOG region experienced population growth following World War II. This population increase led to concurrent increases in impervious surfaces and the amount of drainage infrastructure. Many post-war storm drainage systems and culverts were likely designed using rainfall data published in Technical Paper No. 40 by the U.S. Weather Bureau (now the National Weather Service) (Hershfield, 1961). The rainfall data in this document date from 1938 to 1958. These figures are the standard used in the Connecticut Department of Transportation (CTDOT) Drainage Manual (2000) and were the engineering standard in Connecticut for many years. This engineering standard was based on the now-disproven premise that extreme rainfall series in Connecticut do not change over time, and therefore older analyses reflect current conditions.

Numerous regional analyses of rainfall data have found that increasing precipitation over time is changing rainfall magnitudes, resulting in the need for updated design standards. On November 3, 2015, the CTDOT Office of Engineering issued bulletin EB-2015-2, directing that updated precipitation frequency estimates from NOAA Atlas 14 be used for planning and design in Connecticut. These estimates were released on September 30, 2015. Estimated rainfall amounts for Haddam are presented on Table 2.11.3. Note that NOAA Atlas 15 is expected to be published in 2026 and will update these figures. The Connecticut Stormwater Manual (effective in 2024) reportedly uses recommendations consistent with the draft materials for NOAA Atlas 15 but did not report the draft figures. The 24-hour design storm figures in the Manual are shown in the table below, in the last row.

Table 2.11.3. Increase in Rainfall Recurrence Intervals for the 24-Hour Storm

Rainfall Data Source	2-Year (50% Annual Chance)	10-Year (10% Annual Chance)	25-Year (4% Annual Chance)	50-Year (2% Annual Chance)	100-Year (1% Annual Chance)	500-Year (0.2% Annual Chance)
TP-40 (1961)	3.2	4.9	5.6	6.3	7.1	N/A
NOAA Atlas 14 (2015)	3.44	5.23	6.35	7.18	8.08	10.8
Connecticut Stormwater Manual (from Atlas 14)	3.35	5.23	6.41	7.28	8.23	11.3

The continued increase in precipitation only heightens the need for hazard mitigation planning as the occurrence of floods may change in accordance with the greater precipitation.

2.11.5. Climate Change Impacts

Climate change models predict shifts in precipitation patterns for the New England region. As warming progresses, precipitation events are expected to increase in intensity with seasonal variations. This means fewer spring and summer rainstorms, but when they do occur, they are likely to bring more rain than typically experienced. In addition, precipitation is expected to increase during the winter months; however, due to warmer air temperatures, it is expected to fall more frequently as rain or freezing rain rather than snow.

These changing precipitation patterns could increase the number of riverine or stream flooding events in the RiverCOG region if precipitation totals are higher. In addition, flash floods may become an increasing concern with heavy rainfall over a short period. Changes in winter precipitation could lead to more ice jams or more winter storm flooding events.

The National Climate Assessment estimates 5% to 20% more precipitation will occur during winter and spring months for the northeast by the turn of the next century. The assessment also predicts an increase in severe weather events in the region, which may increase the likelihood of flooding. Additional intense precipitation, combined with increased impervious surfaces and thus increased surface runoff, suggests that the potential for flooding will likely increase in the future. Municipalities can improve their resiliency to flooding by considering the impacts of locally observed severe weather and, where necessary, exceeding federal, state, and local requirements to meet local needs.

2.11.6. Impacts and Estimated Losses to the Region

Impacts

Flooding presents several safety hazards to people and property and can cause extensive damage and potential injury or loss of life. Floodwaters cause massive damage to the lower levels of buildings, destroying business records, furniture, and other sentimental papers and artifacts. In addition, floodwaters can prevent emergency and commercial egress by blocking streets, deteriorating municipal drainage systems, and diverting municipal staff and resources.

Furthermore, damp conditions trigger the growth of mold and mildew in flooded buildings, contributing to allergies, asthma, and respiratory infections. Snakes and rodents are forced out of their natural habitat and into closer contact with people, and ponded water following a flood presents a breeding ground for mosquitoes. Gasoline, pesticides, poorly treated sewage, and other aqueous pollutants can be carried into areas and buildings by floodwaters and soak into soil, building components, and furniture.

RiverCOG communities are typically impacted most by riverine or flash floods, though many communities also experience challenges related to pluvial or poor drainage flooding. The topography of the RiverCOG region can be characterized as having significant elevation differences, as well as many streams. Flash flooding has the potential to significantly impact all

municipalities within the region due to the high presence of streams and unique topography. These flash floods can cause high velocity flows that can damage properties, create debris, injure those in their path, and have serious erosive effects as it moves toward the Connecticut River or other waterbodies. Flash floods can be localized events, as seen with historic occurrences, and can be extremely dangerous. The many small streams throughout the region are vulnerable to flash flooding, ultimately putting the adjacent properties at risk.

Seasonal floods can also impact the RiverCOG communities. A typical cause of seasonal flooding is when a heavy rainstorm occurs in late winter or early spring and melts the snowpack within the watershed. This can occur on a local level, or higher up in the Connecticut River watershed up to the Canadian border. Those communities most vulnerable to these events are those along the Connecticut River, however, small occurrences are possible within the inland communities. Many historic events were considered seasonal floods, and some have had severe impacts on the region.

National Flood Insurance Program Statistics

Flood damage is predictable in its location. As seen in Table 2.11.4 below, properties in Clinton and Old Lyme have experienced substantial losses due to floods. Essex and Middletown have also experienced large numbers of losses. In some cases, the properties have been mitigated, but in many cases these properties continue to be at risk of flooding.

Table 2.11.4. NFIP Loss Statistics as of December 2025

Community Name	Total NFIP Policy Count	Total Net Dollars Paid
Chester	46	$644,994
Clinton	535	$8,392,646
Cromwell	57	$ 403,210
Deep River	17	$140,877
Durham	9	$24,125
East Haddam	27	$577,034
East Hampton	13	$82,207
Essex	51	$1,390,011
Haddam	38	$391,932
Killingworth	16	$34,173
Lyme	28	$ 695,985
Middlefield	5	$1,217
Middletown	178	$1,427,934
Old Lyme	417	$8,134,631
Portland	51	$1,300,942

Note that the NFIP Insurance Program statistics presented above also include properties impacted by coastal flooding, as a specific breakdown is not available in the summaries available from the NFIP.

Repetitive and Severe Repetitive Loss Properties

Many towns in the region have one or more specific properties that are regularly damaged by flooding. These properties are defined by the NFIP as Repetitive Loss (RL) properties or Severe Repetitive loss (SRL) properties. An RL property is any insurable building for which two or more claims of more than $1,000 were paid by the NFIP within any rolling 10-year period since 1978. At least two of the claims must be more than 10 days apart but within 10 years of each other.

In the 15 participating RiverCOG communities, 125 properties are defined by FEMA as NFIP Loss Properties. These properties have received 351 flood insurance claim payments totaling $10.6 million. There are 6 SRL properties in the region (excluding Old Saybrook), with 29 claims paid totaling $974,189.00.

Since RiverCOG as an entity is not an eligible NFIP participant, more detail is provided regarding these properties in the municipal annexes in Volume II of this plan. Mitigating or eliminating RL and SRL properties is a shared priority of the communities in the region.

Estimated Losses

Exposure Analysis

Using CAMA data, the 1% annual chance and 0.2% annual chance flood scenarios were overlain on attributed parcel data. Attributes included total assessed property values. Table 2.11.5 through Table 2.11.6 show total exposure to properties in the various inundation zones. Note that all values are in millions. Dam inundation areas, erosion, and sea level rise are included where appropriate. Coastal flooding is included in a subsequent section. Exposure is an inventory of assets at risk, rather than an estimation of losses.

Table 2.11.5. FEMA 1% Annual Chance Flood Exposure of At-Risk Parcels, Critical Facilities, and Historic Assets for the RiverCOG Region

Community	Number of Parcels	Value of At-Risk Parcels	Number of Critical Facilities	Value of At-Risk Critical Facilities	Number of Historic Assets	Value of At-Risk Historic Assets
Chester	403	$131	3	$6	22	$7
Clinton	2504	$669	5	$53	246	$110
Cromwell	610	$330	5	$39	99	$54
Deep River	392	$178	4	$41	77	$26
Durham	241	$51	3	$13	9	$3
East Haddam	938	$196	2	$2	59	$25

Community	Number of Parcels	Value of At-Risk Parcels	Number of Critical Facilities	Value of At-Risk Critical Facilities	Number of Historic Assets	Value of At-Risk Historic Assets
East Hampton	580	$156	2	$2	59	$24
Essex	598	$377	2	$25	137	$88
Haddam	647	$146	3	$27	37	$35
Killingworth	320	$92	0	$0	16	$13
Lyme	540	$293	0	$0	82	$52
Middlefield	88	$17	0	0	8	$4
Middletown	1011	$1,633	4	$449	55	$379
Old Lyme	2102	$676	4	$29	219	$120
Portland	743	$109	6	$3	24	$4

**All Values are in Millions*

Table 2.11.6. FEMA 0.2% Annual Chance Flood Exposure of At-Risk Parcels, Critical Facilities, and Historic Assets for the RiverCOG Region

Community	Number of Parcels	Value of At-Risk Parcels	Number of Critical Facilities	Value of At-Risk Critical Facilities	Number of Historic Assets	Value of At-Risk Historic Assets
Chester	260	$91	2	$3	11	$4
Clinton	1320	$391	6	$54	221	$88
Cromwell	396	$246	5	$28	62	$46
Deep River	189	$83	2	$13	69	$24
Durham	62	$25	2	$13	4	$2
East Haddam	513	$145	4	$25	26	$8
East Hampton	149	$35	0	$0	33	$15
Essex	439	$288	2	$7	128	$89
Haddam	627	$178	6	$39	47	$38
Killingworth	26	$7	0	0	1	$1
Lyme	152	$103	0	0	32	$24
Middlefield	47	$13	0	0	3	$3
Middletown	674	$1,426	4	$462	45	$415
Old Lyme	1701	$561	4	$29	34	$108
Portland	349	$69	6	$3	19	$3

All Values are in Millions

Economic Loss

With varying levels of flood vulnerability throughout the region, the estimated economic losses also vary greatly. Hazus-MH generates economic loss estimates based on building damage and business interruption. The average loss for the region for a 100-year flood event is $68.6 million, with the highest loss being Middletown with an estimate of $316 million. Table 2.11.7. (a – e) presents building and content losses percentages by building type for each return frequency scenario across the region. Table 2.11.8 presents the aggregate data for each municipality in the region for all scenarios generated and includes building loss, content loss, inventory loss, business loss of income, relocation, rental income and wage losses. In all towns, these losses are related to riverine flooding only. These losses can help towns get a better estimate of what to expect annually from riverine flooding and how to focus mitigation efforts accordingly. Average Annualized Loss (AAL) was calculated based on these aggregated numbers using the following formula found in Figure 2.11.3.

$$AAL = \sum_{i=1}^{n-1} \left((F_i - F_{i+1}) * \frac{(L_i + L_{i+1})}{2} \right) + (F_n * L_n)$$

Figure 2.11.3. AAL Calculation Formula.

F = Frequency, L = Loss , i = return period, n = final return period

Table 2.11.7. a-e Flood-Related Building and Contents Losses for the Standard Suite of Return Periods by Building Occupancy

Table 2.11.7.a 10-Year Return Period

Building Occupancy	Percent Loss 1-10%	Percent Loss 11-20%	Percent Loss 21-30%	Percent Loss 31-40%	Percent Loss 41-50%	Percent Loss >50%
Agriculture	0	0	0	0	0	0
Commercial	6	0	0	0	0	0
Education	0	0	0	0	0	0
Government	0	0	0	0	0	0
Industrial	0	0	0	0	0	0
Religion	0	0	0	0	0	0
Residential	601	90	6	4	5	29

Table 2.11.7.b 25-Year Return Period

Building Occupancy	Percent Loss 1-10%	Percent Loss 11-20%	Percent Loss 21-30%	Percent Loss 31-40%	Percent Loss 41-50%	Percent Loss >50%
Agriculture	0	0	0	0	0	0
Commercial	10	1	0	0	0	0
Education	0	0	0	0	0	0
Government	1	0	0	0	0	0
Industrial	0	0	0	0	0	0
Religion	0	0	0	0	0	0
Residential	677	149	12	4	5	33

Table 2.11.7.c 50-Year Return Period

Building Occupancy	Percent Loss 1-10%	Percent Loss 11-20%	Percent Loss 21-30%	Percent Loss 31-40%	Percent Loss 41-50%	Percent Loss >50%
Agriculture	0	0	0	0	0	0
Commercial	9	2	0	0	0	0
Education	0	0	0	0	0	0
Government	1	0	0	0	0	0
Industrial	0	0	0	0	0	0
Religion	0	0	0	0	0	0
Residential	731	246	28	4	5	40

Table 2.11.7.d 100-Year Return Period

Building Occupancy	Percent Loss 1-10%	Percent Loss 11-20%	Percent Loss 21-30%	Percent Loss 31-40%	Percent Loss 41-50%	Percent Loss >50%
Agriculture	0	0	0	0	0	0
Commercial	17	12	0	0	0	0
Education	1	0	0	0	0	0
Government	1	1	0	0	0	0
Industrial	0	0	0	0	0	0
Religion	0	0	0	0	0	0
Residential	376	702	257	87	36	33

Table 2.11.7.e 500-Year Return Period

Building Occupancy	Percent Loss 1-10%	Percent Loss 11-20%	Percent Loss 21-30%	Percent Loss 31-40%	Percent Loss 41-50%	Percent Loss >50%
Agriculture	0	0	0	0	0	0
Commercial	14	44	0	0	0	2
Education	2	0	0	0	0	1
Government	3	1	0	0	0	0
Industrial	0	1	0	0	0	0
Religion	0	1	0	0	0	0
Residential	451	1,303	570	228	56	50

Table 2.11.8. RiverCOG Region Aggregate Cumulative Economic Losses for Riverine Flood Scenarios.

Municipality	10-year	25-year	50-year	100-year	500-year	AAL
Chester	$25,712,500	$31,629,400	$35,017,400	$39,143,500	$52,489,800	$3,229,042
Clinton	$9,510,600	$11,047,300	$16,456,000	$20,049,700	$29,015,800	$1,328,592
Cromwell	$140,347,900	$166,278,200	$206,631,700	$232,441,000	$330,003,300	$18,033,029
Deep River	$27,817,900	$31,460,000	$36,021,700	$42,386,300	$65,158,500	$3,405,690
Durham	$33,662,200	$38,308,600	$41,127,900	$48,968,700	$57,644,400	$3,945,713
East Haddam	$3,249,728	$3,854,016	$4,619,448	$5,546,024	$8,312,321	$420,732
East Hampton	$13,334,200	$15,391,200	$2,032,800	$24,926,000	$41,527,200	$1,519,663
Essex	$66,102,300	$76,786,600	$87,700,800	$99,074,800	$141,073,900	$8,108,162
Haddam	$23,135,200	$27,467,000	$32,924,100	$39,506,500	$59,193,200	$2,997,315
Killingworth	$6,558,200	$9,220,200	$10,817,400	$13,951,300	$20,352,200	$975,490
Lyme	$4,924,700	$6,025,800	$7,562,500	$8,651,500	$22,034,100	$712,279
Middlefield	$6,534,000	$8,421,600	$13,624,600	$17,835,400	$21,828,400	$1,028,742
Middletown	$164,523,700	$202,675,000	$237,462,500	$315,870,500	$687,328,400	$23,571,453
Old Lyme	$20,037,600	$25,724,600	$29,342,500	$32,972,500	$56,240,800	$2,704,447
Portland	$11,144,100	$15,403,300	$24,272,600	$86,962,700	$112,312,200	$2,771,082
RiverCOG Region	**$556,594,828**	**$669,692,816**	**$785,613,948**	**$1,028,286,424**	**$1,704,514,521**	**$74,751,432**

To supplement the Hazus information, FEMA's NRI was utilized to obtain information for a risk analysis on riverine flooding at the census tract level across RiverCOG. Figure 2.11.4 displays the risk rating by census tract in the RiverCOG region for riverine flooding. Risk in the RiverCOG region

ranges from very low to relatively high. The relatively high portion of Figure 2.11.4 below is Old Saybrook which is not a municipal participant in this plan.

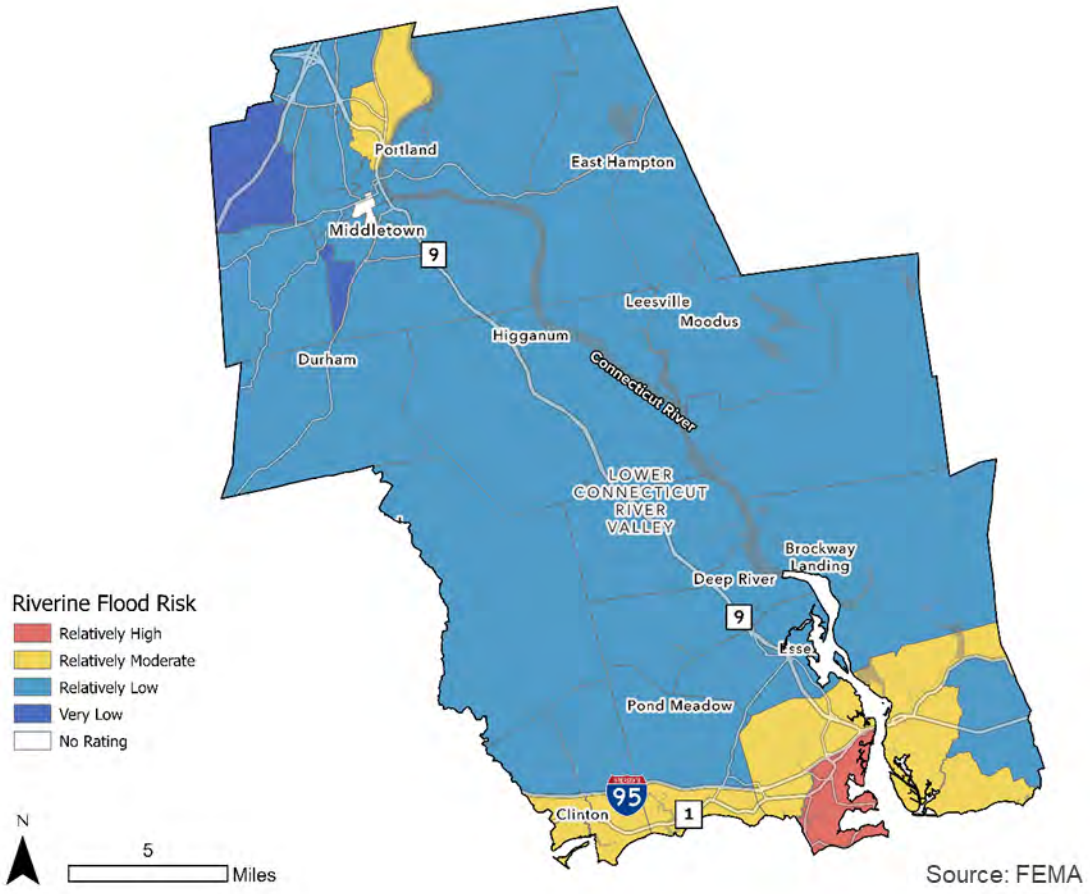


Figure 2.11.4. NRI Risk Rating for Riverine Flood, shown at the census tract level (2025)

According to the NRI, the majority of the RiverCOG region is at a relatively low risk to riverine flooding. Clinton, Old Lyme, and Cromwell have the highest risk rating, with some census tracts at a relatively moderate risk to riverine flooding. Table 2.11.9 displays communities in RiverCOG and the number of census tracts at each risk rating to riverine flood.

Table 2.11.9. Breakdown of community risk to Riverine Flood

Community	Number of Census Tracts with No Rating	Number of Census Tracts with Very Low Risk	Number of Census Tracts with Relatively Low Risk	Number of Census Tracts with Relatively Moderate Risk
Chester	-	-	1	-
Clinton	-	-	2	2
Cromwell	-	-	2	1
Deep River	-	-	1	-
Durham	-	-	1	-
East Haddam	-	-	2	-
East Hampton	-	-	3	-
Essex	-	-	2	-
Haddam	-	-	2	-
Killingworth	-	-	1	-
Lyme	-	-	1	-
Middlefield	-	-	1	-
Middletown	1	2	10	-
Old Lyme	-	-	1	2
Portland	-	-	2	-
Total for RiverCOG Region	**1**	**2**	**32**	**5**

Figure 2.11.5 below shows the expected annual loss ratings throughout the COG according to the NRI and Table 2.11.10 describes the projected annualized losses from riverine flooding by community. The highest expected annual losses are found in Old Lyme, Clinton, and Middletown with a projected $212,956, $155,652, and $120,337 in expected annual losses due to riverine floods respectively. The RiverCOG region has a total expected annual loss of $732,638.

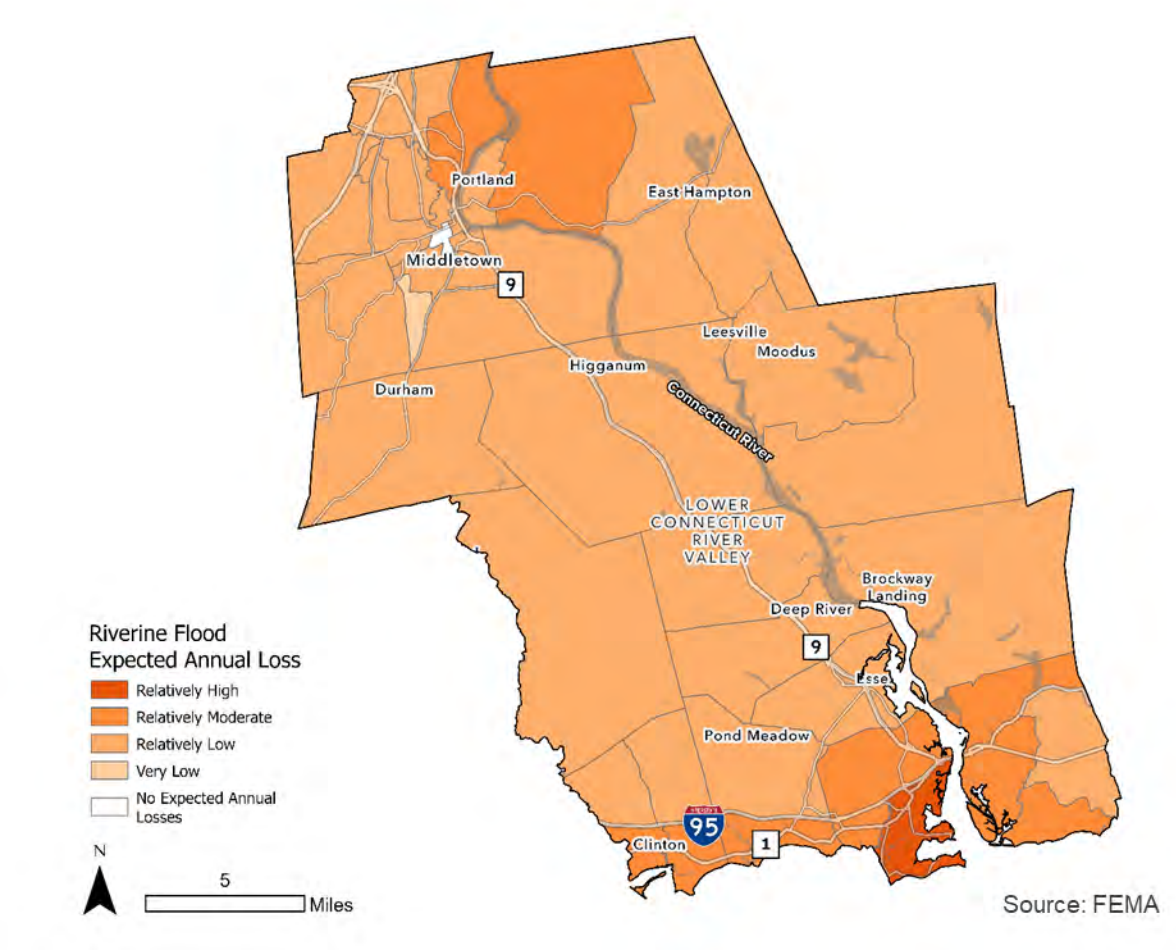


Figure 2.11.5 NRI Riverine Flood Expected Annual Loss Rating (2025)

Table 2.11.10. Breakdown of NRI expected annual losses from riverine flooding by community

Community	Expected Annual Loss
Chester	$17,425
Clinton	$155,652
Cromwell	$54,362
Deep River	$15,669
Durham	$15,174
East Haddam	$12,973
East Hampton	$13,554
Essex	$30,361
Haddam	$14,069
Killingworth	$6,010

Community	Expected Annual Loss
Lyme	$15,140
Middlefield	$4,474
Middletown	$120,337
Old Lyme	$212,956
Portland	$44,482
Total for RiverCOG Region	**$732,638**

Annual loss values vary significantly between Hazus and NRI as noted and explained in Section 2.9.2, above. Both provide value for comparing relative risk of losses among jurisdictions.

2.11.7. Development Trends

Since the 2021 plan update, development within the RiverCOG region has remained limited. Over the five-year period from 2019 to 2023, the region's population increased by approximately 1.7%,[15] a modest rise that is about 0.5% lower than Connecticut's statewide growth rate of roughly 2.2% during the same timeframe. Haddam, Old Lyme, Clinton, Cromwell, Middletown, and Essex experienced the largest population increases during this period, though the highest rate of growth was a modest 4.1% in Haddam. Chester saw the most significant decline, with its population decreasing by 10.6% over the same five-year span. Several factors contribute to these shifting growth patterns, with the COVID-19 pandemic playing a major role.

Similarly, there has been only a 0.37% increase in housing stock in the region during the 2019-2023 five-year period, with only 195 building permits issued in 2023 across RiverCOG.[16] The majority of these building permits issued in 2023 are in East Hampton (37) and East Haddam (25), both of which have seen decreases in housing stock during these five years. Killingworth, Durham, Haddam, Deep River, and Clinton have seen the largest increase in housing stock during this period. Additionally, commercial and industrial growth has been relatively stagnant during this time frame.

Housing development and population growth in these areas will increase the number of residents exposed to and at risk to riverine and inland flooding. One benefit of new development, however, is that newer construction is generally built to stronger building codes and floodplain regulations. Therefore, newer buildings that replace older-code buildings should generally reduce overall risk from riverine and inland flooding with lower exposure within the floodplain. More specific changes

[15] https://www.rivercog.org/data-population

[16] https://www.rivercog.org/data-housingcharacteristics

in development are addressed at the community level in the municipal annexes in Volume II of this plan.

2.11.8. Overall Risk Rating

Using the parameters described in Table 2.8.1, the following hazard risk ratings were developed for riverine and inland flooding (Table 2.11.12).

Table 2.11.11. Overall Risk Rating of Riverine and Inland Flooding

Criteria	Hazard Risk Rating
Probability	3 (Likely)
Impact: Affected Area	3 (Medium)
Impact: Primary Impact	2 (Limited)
Impact: Secondary Impacts	3 (Moderate)
Survey Rating	3 (High Concern)
Total Score	14.3
Overall Risk Ranking	**Significant**

2.12. Flooding - Coastal Flood

2.12.1. Description and Background

Coastal flooding is a natural hazard that threatens the RiverCOG Region. Much like inland flooding, coastal flooding represents a common naturally occurring event that causes damage to property and residents' quality of life. Coastal flooding can occur as a result of a hurricane or tropical storm which produces storm surge, or nuisance flooding, which occurs at low elevations during astronomical high tides. Although RiverCOG has four member communities that are directly impacted by coastal flooding, the two communities that are participating in this regional plan are the Towns of Clinton and Old Lyme.

The Town of Clinton is vulnerable to coastal flooding, along with nuisance flooding in the low-lying areas, especially along the Indian and Hammonasset Rivers. The coastal boundary of the town is comprised of approximately 1,700 acres; much of which is within the FEMA mapped floodplain.

The Town of Old Lyme is located at the mouth of the Connecticut River. Similar to Clinton, Old Lyme is vulnerable to both coastal and nuisance flooding. Because of the extensive shoreline in this town, a majority of the 1% annual chance flood zone is also vulnerable to coastal flooding.

2.12.2. Location and Extent

Coastal flooding is when land that is typically dry is inundated with seawater, whether it is during a storm event or during extremely high tides. Areas inundated are typically low-lying and can be impacted by storm surge and high wave velocity.

Similar to inland flooding, FEMA uses established probabilities to identify areas with coastal flood risk. These include Zone A and Zone AE, as well as Zone X (shaded), which are considered to have minimal wave action; and others, including Zone V or VE, which are subject to wave action. The definitions of coastal flood zones are presented in Table 2.12.1.

Table 2.12.1. Description of FEMA Flood Zones for Coastal Flooding.

Zone	Description
A	An area with a 1% chance of flooding in any given year for which no base flood elevations (BFEs) have been determined. This area may include wave heights of less than three feet.
AE	An area with a 1% chance of flooding in any given year for which base flood elevations have been determined. This area may include wave heights of less than three feet.
X (Levee)	An area where the flood risk has been reduced below the 1% annual chance by a levee.
X (Shaded)	An area with a 0.2% chance of flooding in any given year for which no base flood elevations have been determined
X (Unshaded)	An area that is determined to be outside of the 1% and 0.2% annual chance floodplains
V (Coastal)	A coastal flood zone area that is subject to a 1% annual chance event, however, there are no base flood elevations identified for these areas. This flood zone is also subject to high velocity wave action and is defined by the 1% base flood limits. This area may also experience wave impacts 3 feet or greater.
VE (Coastal)	Also known as the coastal high hazard area, this flood zone is also subject to high velocity wave action and is defined by the 1% base flood limits. This area may also experience wave impacts 3 feet or greater.

The Limit of Moderate Wave Action (LiMWA) is a FEMA designation on FIRMs showing the boundary in a coastal A or AE zone where wave heights during a base flood are between 1.5 and 3 feet. This level has been determined by FEMA to be capable of causing significant structural damage such that VE-level construction standards are highly recommended by FEMA to reduce risk and insurance costs.

Most coastal areas in Clinton vulnerable to coastal flooding are located south of Route 1. This region is about half marsh and wildlife area, with the remaining primarily residential development. There are several water dependent businesses located along Clinton Harbor. Old Lyme's

vulnerable areas are largely residential, in addition to vast open space areas such as the Great Island Wildlife Area.

The NOAA uses a variety of tidal datums to evaluate sea level and coastal flooding. These are typically set relative to the National Tidal Datum Epoch (NTDE)[17], a 19-year time period established by NOAA's National Ocean Service for collecting observations of water levels at tidal stations. NOAA currently utilizes the 1983-2001 NTDE, but new tidal datums based on the next iteration of the NTDE are anticipated after 2027.

While coastal flood elevations defined by FEMA are typically set relative to mean sea level, other tidal datums are sometimes used when reporting flood events. A description of common tidal datums is presented in Figure 2.12.2.[18]

Table 2.12.2. Description of Common Tidal Datums

Tidal Datum	Description
Mean High High Water (MHHW)	The average of the higher high water height of each tidal day observed over the NTDE.
Mean High Water (MHW)	The average of all the high water heights observed over the NTDE.
Mean Sea Level (MSL)	The arithmetic mean of hourly heights observed over the NTDE. Shorter series may be specified by name; e.g. monthly mean sea level and yearly mean sea level.
Mean Low Water (MLW)	The average of all the low water heights observed over the NTDE.
Mean Low Low Water (MLLW)	The average of the lower low water height of each tidal day observed over the NTDE.
Station Datum	A fixed base elevation at a tide station to which all water level measurements are referred. The datum is unique to each station and is established at a lower elevation than the water is ever expected to reach. It is referenced to the primary benchmark at the station and is held constant regardless of changes to the water level gauge or tide staff. The datum of tabulation is most often at the zero of the first tide staff installed.

To avoid under- or over-estimation of flooding impacts in public weather communications, particularly in locations without physical tide gages in close proximity, and to quantify changes in flood risk, a more consistent definition of minor, moderate, and major coastal flooding impacts was determined to be needed. The NWS has therefore established coastal flooding severity thresholds (minor, moderate, and major) for tide gages along Long Island Sound to help inform

[17] https://tidesandcurrents.noaa.gov/datum-updates/ntde/

[18] https://tidesandcurrents.noaa.gov/datum_options.html

coastal planning and to assist local emergency managers in identifying potential impact levels based on flood heights.[19]

Hurricane storm surge areas along Long Island Sound were previously developed by the National Hurricane Center (NHC) using the Sea Lake and Overland Surge from Hurricanes (SLOSH) Model. In 2021, CIRCA simulated storm surge levels using a coupled coastal circulation and wave model for various coastal storm events including the potential for sea level rise and developed data viewers to assist coastal communities in planning for coastal storm surge events.[20]

The FEMA flood risk mapping systems, SLOSH mapping, and CIRCA-developed risk mapping coupled with the NWS warning systems are appropriate for the region, as they have been used for the coastal floods that have occurred in the RiverCOG region and the coastal communities. Flood events have not been characterized outside of these systems of classification.

2.12.3. History of Past Events

The shoreline of Connecticut, including Clinton and Old Lyme, is often subject to coastal flood watches and warning throughout the year. These warnings are a result of weather systems moving in that have the potential to push water on land due to high winds, and sometimes in conjunction with already high tides. While both communities may experience coastal or nuisance flooding regularly on small scales, the following are some notable past events which resulted in coastal flooding. These examples are drawn from the NCEI Storm Events Database, from 1996 to the present.

December 6, 1996: A strong low-pressure system developed off the Delmarva coast and moved slowly northeast. The storm produced heavy rain and gusty winds and resulted in minor coastal flooding.

April 16, 2007: A strong late season nor'easter, in conjunction with an unusually high spring tide, resulted in moderate coastal flood along the Connecticut shoreline. Tidal levels were between 2.5 and 3.5 feet higher than normal. While models projected surges as high as 4.5 feet, the storm did not result in that high a departure but did result in considerable property damage.

August 28, 2011: Hurricane Irene, which made landfall as a tropical storm, brought along high, gusty winds which ultimately pushed between 3 to 5 feet of surge into Long Island Sound. This increase resulted in moderate coastal flooding, wave damage and erosion. There was damage along the coastline, with certain Connecticut municipalities taking a considerable hit.

October 29, 2012: Superstorm Sandy produced a storm surge of 8-to-9 feet along much of western Long Island Sound, with its effects further exacerbated by its coincidence with the high tide.

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[19] https://coastalscience.noaa.gov/project/defining-nationally-consistent-coastal-flood-severity-thresholds/

[20] https://resilientconnecticut.uconn.edu/datasets/connecticut-sea-level-rise-viewer/#:~:text=The%20modeled%20storm%20surge%20water,20%20inches%20of%20sea%20level

Coastal RiverCOG communities experienced two successive tidal cycles with at least moderate coastal flooding during this event. This large storm surge resulted in 2 to 3 feet of inundation several blocks inland along the sound, with records showing 1 to 2 feet of inundation north of I-95 in several spots, including along the Hammonasset River in Clinton, and almost 15 miles inland along the Connecticut River.

October 16, 2019: In advance of an intensifying low pressure system, strong southerly winds produced moderate coastal flooding statewide. The NWS moderate coastal flood threshold was exceeded at the New Haven and New London tidal gauges.

January 10, 2024: A large low pressure system brought long duration persistent moderate to heavy rainfall which cause widespread river flooding, and some localized flash flooding, In addition the system produced high winds which combined with high astronomical tides producing moderate coastal flooding along the shoreline. The NWS moderate coastal flood threshold was exceeded at the New Haven and New London tidal gauges.

January 13, 2024: Strong winds combined with high astronomical tides produced widespread coastal flooding along the southern Connecticut shoreline. The NWS moderate coastal flood threshold was exceeded at the New London tidal gauges.

2.12.4. Probability of Future Events

Coastal flooding is a likely event as it can occur on sunny days and during strong storms, not just larger events. An intense localized storm can cause flooding along the coast and along upland watercourses, larger rainfall events can cause flooding at a larger watershed scale and impact areas where streams and shorelines conjoin, and larger storms such as hurricanes and tropical storms can cause significant flooding.

The probability of a moderate or severe coastal flood can potentially be tied to a larger storm event such as a hurricane or tropical storm. To determine the probability of this event, hurricane probabilities can be evaluated for frequency and magnitude. Since, in general, the probabilities for tropical storms and hurricanes striking coastal Connecticut are predicted to increase in the future, it is anticipated that coastal flooding will become more frequent in the future.

It is important to note that although a recurrence interval is given for a storm of a certain magnitude, that does not mean this size storm only occurs once in a certain number of years. For example, a 1% annual chance flood, or 100-year flood, has a 1% chance of occurring each year. There is always a chance that a storm of the same magnitude can occur more than once in the same year.

Looking at the significant flooding events listed in the NCEI database, there were four events in a 29-year period between 1996-2025. That would indicate about a 14% chance of coastal flooding in the region in any given year. Note that the storms listed in the NCEI database present notable storm events tied to flooding, but unlisted storms as well as king tides (the highest tides of the year) also

have a significant impact on the region. These storms may not rise to the level of being reported to the NCEI but nonetheless result in damages in the RiverCOG region.

2.12.5. Climate Change Impacts

As climate change changes precipitation patterns and increases the intensity and locational frequency of hurricanes, coastal flooding event frequency and intensity may also increase. As mentioned, coastal flooding may occur during heavy rainstorms; with precipitation events expected to become heavier and more intense, coastal flooding may be more frequent during these storms. Also, as hurricanes and tropical storms also intensify, and potentially become a more frequent occurrence in the Atlantic, coastal flooding attributed to storm surge may also occur more often than seen in the past.

In addition to these storm event changes, this is all in conjunction with rising sea levels. As levels rise, nuisance flooding is occurring more frequently during high tides and is expected to worsen. A future high tide, in combination with a storm surge, can result in coastal flooding reaching areas not seen during past events.

According to the CIRCA,

> *"Sea level rise is caused by a number of factors, but in recent decades ocean warming and ice sheet loss due to global warming have contributed significantly to global sea level rise. Along the east coast, including Connecticut, sea level rise rates are more rapid than the global average rate because of subsidence or sinking of the coastline. Sea level rise has multiple impacts on the Connecticut shoreline, including increased erosion rates, increased frequency of flooding, and coastal inundation. With sea level rise, the shoreline is impacted - beaches get eroded, salt marshes move landward, and property can be damaged. With a higher sea level, a storm surge or high tide that would not have been a problem in the past, now results in more frequent flooding and extreme hurricane events cause even greater damage."*

CIRCA research and state mandated local sea level rise projections, which were first developed in 2019, recommend that coastal planning efforts anticipate that sea level will be 20 inches (50 cm) higher than the national tidal datum in Long Island Sound by 2050.[21] Per Public Act 18-82, this projection was adopted for planning purposes. The projection was reevaluated in 2025 which reaffirmed the planning threshold of 20 inches by 2050. Additional work by CIRCA has mapped the potential area to be affected by these 20 inches of sea level rise relative to existing MHHW levels and coastal base flood elevations identified by FEMA. Figure 2.12.1 below shows Sea Level Rise Projections for Connecticut based on local tide gage observations.

[21] https://circa.media.uconn.edu/wp-content/uploads/sites/1618/2019/10/Sea-Level-Rise-Connecticut-Final-Report-Feb-2019.pdf

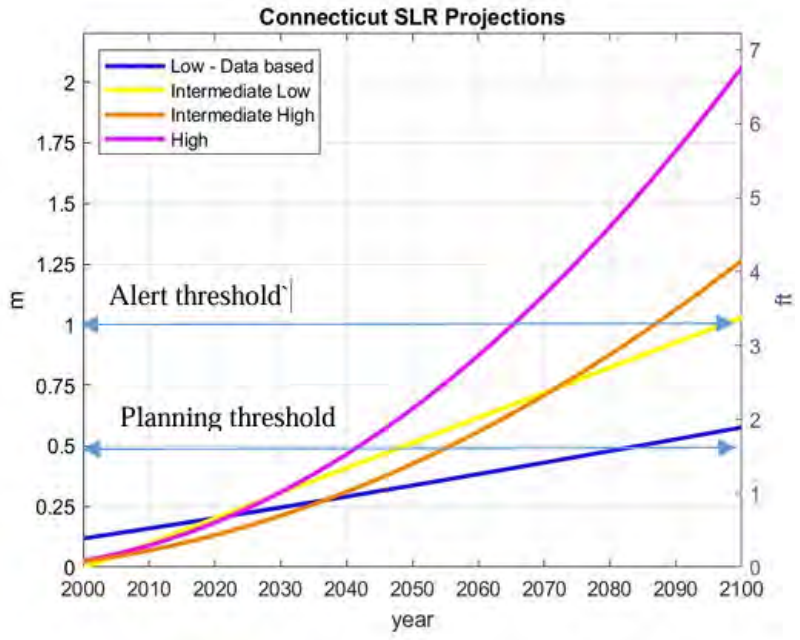


Figure 2.12.1 Sea Level Rise Projections for Connecticut based on local tide gage observations (CIRCA, 2019)

2.12.6. Impacts and Estimated Losses to the Region

Impacts

The impacts of coastal flooding are not as widespread as other hazards in the RiverCOG region, as there are only two municipalities in this planning effort with shoreline directly along Long Island Sound, and tidal influence dissipates going upstream along the Connecticut River. In addition to coastal flooding, storm surge from hurricanes, tropical storms, and nor'easters can result in inundation, movement of debris, scour, and erosion which can cause foundation failure to buildings. Larger past coastal storm events have had impacts of up to 15 miles inland along the Connecticut River; this indicates that riverine communities as far north as Haddam have been, and could again, be impacted by coastal flooding.

Estimated Losses

NFIP statistics for flood losses do not provide a breakdown of damages between inland and coastal flood events. While it may be possible to estimate potential coastal flood losses under the NFIP, that level of data analysis was beyond the scope of this plan update. Instead, NFIP statistics and RL property statistics for both inland and coastal flooding are presented under the Inland Flooding section above.

Exposure Analysis

Using CAMA data, various coastal flood scenarios were overlain on attributed assessed property value data. Table 2.12.3 to Table 2.12.6 show total exposure to properties in coastal storm surge and sea level rise projection areas. The municipalities of Chester, Clinton, Deep River, East

Haddam, Essex, Killingworth, Lyme and Old Lyme are impacted by coastal surge and sea level rise. All values are in millions. This exposure analysis lists all parcels that are in the mapped inundation areas. Values do not represent actual loss scenarios.

Table 2.12.3. FEMA VE Zone Exposure of At-Risk Parcels, Critical Facilities, and Historic Assets for the RiverCOG Region

Community	Number of Parcels	Value of At-Risk Parcels	Number of Critical Facilities	Value of At-Risk Critical Facilities	Number of Historic Assets	Value of At-Risk Historic Assets
Clinton	376	$193	0	$0	49	$33
Lyme	5	$0.03	0	$0	0	$0
Old Lyme	631	$253	0	$0	69	$36

**All dollar values are in millions*

Table 2.12.4. CIRCA 100-year Plus 20-Inch Sea Leve Rise Scenario Exposure of At-Risk Parcels, Critical Facilities, and Historic Assets for the RiverCOG Region

Community	Number of Parcels	Value of At-Risk Parcels	Number of Critical Facilities	Value of At-Risk Critical Facilities	Number of Historic Assets	Value of At-Risk Historic Assets
Clinton	1,600	$450	2	$6	220	$85
Essex	27	$26	0	0	2	$0.4
Killingworth	11	$2	0	0	1	$0.1
Lyme	25	$5	0	0	0	$0
Old Lyme	1,600	$554	2	$27	198	$108

**All dollar values are in millions*

Table 2.12.5. CIRCA Mean-High-High-Water Plus 20-Inch Sea Level Rise Scenario Exposure of At-Risk Parcels, Critical Facilities, and Historic Assets for the RiverCOG Region

Community	Number of Parcels	Value of At-Risk Parcels	Number of Critical Facilities	Value of At-Risk Critical Facilities	Number of Historic Assets	Value of At-Risk Historic Assets
Clinton	942	$299	2	$6	112	$54
Essex	27	$26	0	0	2	$0.4
Killingworth	0	$0	0	$0	0	$0
Lyme	25	$5	0	$0	0	$0
Old Lyme	724	$301	1	$2	92	$59

**All dollar values are in millions*

Table 2.12.6. Storm Surge Scenario Exposure of At-Risk Parcels, Critical Facilities, and Historic Assets for the RiverCOG Region

Category	Community	Number of Parcels	Value of At-Risk Parcels	Number of Critical Facilities	Value of At-Risk Critical Facilities	Number of Historic Assets	Value of At-Risk Historic Assets
1	Chester	123	$47	1	$0.3	3	$2.2
1	Clinton	1,090	$328	2	$6.5	138	$55.6
1	Deep River	84	$61	1	$12.1	12	$6.9
1	East Haddam	3	$1	0	$0.0	1	$0.5
1	Essex	207	$202	0	$0.0	50	$58.0
1	Killingworth	0	$0	0	$0.0	0	$0.0
1	Lyme	274	$190	0	$0.0	38	$31.6
1	Old Lyme	1,029	$391	2	$27.0	131	$89.4
2	Chester	154	$57	1	$0.3	3	$2.2
2	Clinton	1,492	$425	2	$6.5	200	$73.0
2	Deep River	99	$66	1	$12.1	13	$7.2
2	East Haddam	4	$2	0	$0.0	1	$0.5
2	Essex	221	$210	0	$0.0	53	$59.7
2	Killingworth	4	$0.4	0	$0.0	0	$0.0
2	Lyme	311	$209	0	$0.0	53	$40.3
2	Old Lyme	1,521	$524	2	$27.0	192	$103.5
3	Chester	185	$67	1	$0.3	3	$2.2
3	Clinton	2,227	$574	3	$13.4	300	$115.6
3	Deep River	127	$73	1	$12.1	24	$11.1
3	East Haddam	5	$2	0	$0.0	1	$0.5
3	Essex	253	$234	0	$0.0	63	$68.0
3	Killingworth	18	$3	0	$0.0	1	$0.1
3	Lyme	342	$226	0	$0.0	57	$41.6
3	Old Lyme	1,929	$645	2	$27.0	234	$127.2
4	Chester	225	$81	2	$1.6	6	$3.9
4	Clinton	2,648	$672	3	$13.4	406	$150.1
4	Deep River	150	$78	1	$12.1	33	$13.0

Category	Community	Number of Parcels	Value of At-Risk Parcels	Number of Critical Facilities	Value of At-Risk Critical Facilities	Number of Historic Assets	Value of At-Risk Historic Assets
4	East Haddam	5	$2	0	$0.0	1	$0.5
4	Essex	378	$293	0	$0.0	86	$83.0
4	Killingworth	20	$4	0	$0.0	1	$0.1
4	Lyme	364	$235	1	$1.1	60	$44.0
4	Old Lyme	2,255	$734	2	$27.0	278	$141.3

**All dollar values are in millions*

Building Damage

Hazus-MH was used to develop loss estimates for coastal flooding events. Although communities along the Connecticut River are vulnerable to tidally influenced events, the extent of the program only identifies Clinton and Old Lyme as coastal communities. The exposure analysis tables in Section 2.11.6 identify the property values of the riverine parcels at-risk of storm surge and sea level rise inundation. Estimated percentage of losses to buildings, in a 100-year flood scenario, based on occupancy type can be found in Table 2.12.7. It is important to note that the Town of Clinton has significantly higher development in the coastal area in comparison to Old Lyme. For example, during a 100-year event, 63 buildings are expected to be destroyed, or damaged more than 50%.

Table 2.12.7. Percent of Building Damaged Based on Occupancy Type for a 100-Year Event.

Occupancy Type	1-10 % of building damaged	11-20 % of building damaged	21-30 % of building damaged	31-40 % of building damaged	41-50 % of building damaged	>50 % of building damaged
Agriculture	0	0	0	0	0	0
Commercial	0	3	0	0	0	0
Education	0	0	0	0	0	0
Government	0	1	0	0	0	0
Industrial	0	1	0	0	0	0
Religion	0	0	0	0	0	0
Residential	96	385	269	108	5	63

Economic Losses

Hazus-MH was also used to develop financial loss estimates for coastal floods. Table 2.12.8 presents the aggregate data for Clinton and Old Lyme for all scenarios generated and includes building loss, content loss, inventory loss, business loss of income, relocation, rental income and

wage losses. In all towns, these losses are related to coastal flooding only. The Town of Clinton has significantly higher estimates than Old Lyme, indicating a higher risk for developed areas. The total loss estimates for five flood scenarios can be found in Table 2.12.8, Complete Hazus results are in Appendix B.

Table 2.12.8. Hazus-MH economic loss estimates for coastal flood scenarios.

Community	10-year	25-year	50-year	100-year	500-year	AAL
Clinton	$362,358,700	$362,358,700	$548,529,300	$696,814,800	$870,921,700	$45,089,912
Old Lyme	$70,651,900	$70,651,900	$101,228,600	$108,186,100	$196,249,900	$8,615,236

To supplement the above information, FEMA's NRI was utilized to obtain information for a risk analysis on coastal flooding at the census tract level across RiverCOG. Figure 2.12.2 displays the risk rating by census tract in the RiverCOG region for coastal flooding. Risk in the RiverCOG region ranges from very low to relatively high with some portions of the region having no risk rating to coastal flooding due to the communities being inland and without impacts from storm surge.

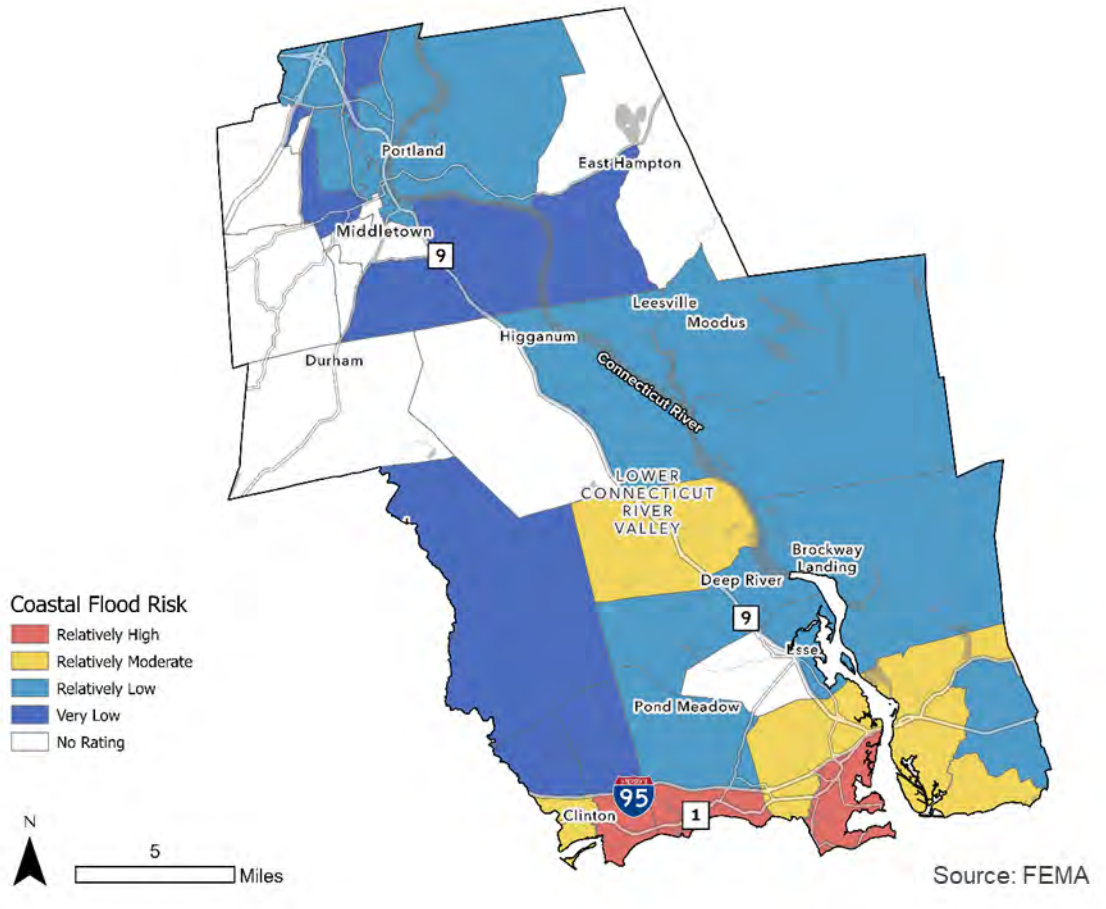


Figure 2.12.2. NRI Risk Rating for Coastal Flood, shown at the census tract level (2025)

Clinton has the most at risk to coastal flooding according to the NRI, with one census tract (out of four) at a relatively high risk to coastal flooding. Old Lyme and Chester also have census tracts at relatively moderate risk to coastal flooding. Table 2.12.9 displays communities in RiverCOG and the number of census tracts at each risk rating to coastal flood.

Table 2.12.9. Breakdown of community risk to Coastal Flood

Community	Number of Census Tracts with No Rating	Number of Census Tracts with Very Low Risk	Number of Census Tracts with Relatively Low Risk	Number of Census Tracts with Relatively Moderate Risk	Number of Census Tracts with Relatively High Risk
Chester	-	-	-	1	-
Clinton	-	2	-	1	1
Cromwell	-	1	2	-	-
Deep River	-	-	1	-	-
Durham	1	-	-	-	-
East Haddam	-	-	2	-	-
East Hampton	2	1	-	-	-
Essex	1	-	1	-	-
Haddam	1	-	1	-	-
Killingworth	-	1	-	-	-
Lyme	-	-	1	-	-
Middlefield	1	-	-	-	-
Middletown	6	3	4	-	-
Old Lyme	-	-	1	2	-
Portland	-	-	2	-	-
Total for RiverCOG Region	**12**	**8**	**15**	**4**	**1**

Figure 2.12.3 below shows the expected annual loss ratings throughout the COG according to the NRI and Table 2.12.8 describes the projected annualized losses from coastal flooding by community. The highest expected annual losses are found in Clinton and Old Lyme, the two coastal communities in the region, with a projected $475,187 and $153,666 in expected annual losses due to coastal floods respectively. The RiverCOG region has a total expected annual loss of $776,745.

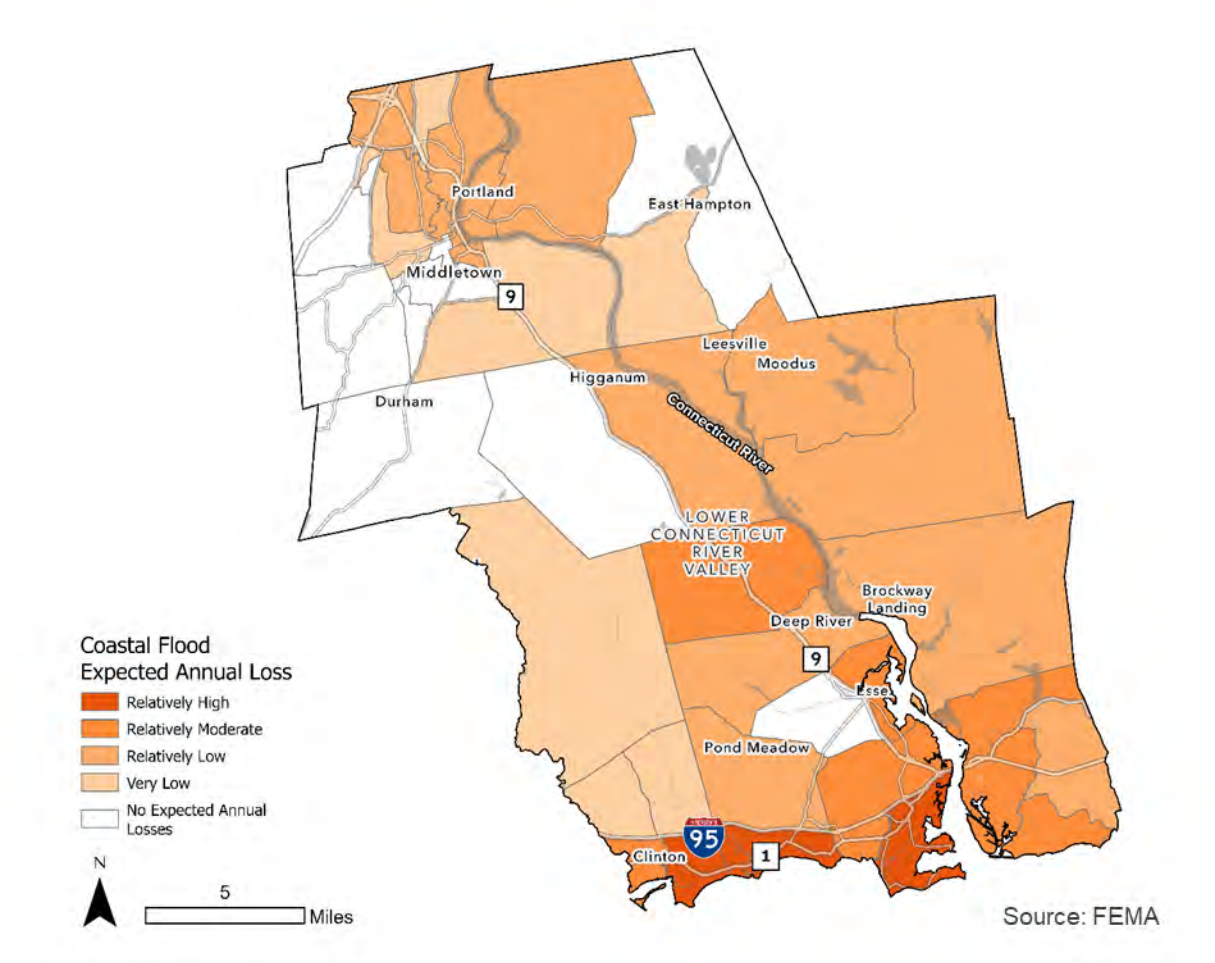


Figure 2.12.3. NRI Coastal Flood Expected Annual Loss Rating (2025)

Table 2.12.10. Breakdown of NRI expected annual losses from coastal flooding by community

Community	Expected Annual Loss
Chester	$35,122
Clinton	$475,187
Cromwell	$4,147
Deep River	$17,607
Durham	$0
East Haddam	$5,412
East Hampton	$56
Essex	$42,214
Haddam	$8,777
Killingworth	$6

Community	Expected Annual Loss
Lyme	$17,674
Middlefield	$0
Middletown	$11,101
Old Lyme	$153,666
Portland	$5,776
Total for RiverCOG Region	**$776,745**

As noted in the inland flooding section, there are very significant differences between average annualized losses modeled by Hazus and expected annual losses modeled by NRI. The reasons for these differences are explained in Section 2.9.2. Both datasets are valuable for comparing relative risk among jurisdictions.

2.12.7. Development Trends

Since the 2021 plan update, development within the RiverCOG region has remained limited. Over the five-year period from 2019 to 2023, the region's population increased by approximately 1.7%,[22] a modest rise that is about 0.5% lower than Connecticut's statewide growth rate of roughly 2.2% during the same timeframe. Haddam, Old Lyme, Clinton, Cromwell, Middletown, and Essex experienced the largest population increases during this period, though the highest rate of growth was a modest 4.1% in Haddam. Chester saw the most significant decline, with its population decreasing by 10.6% over the same five-year span. Several factors contribute to these shifting growth patterns, with the COVID-19 pandemic playing a major role.

Similarly, there has been only a 0.37% increase in housing stock in the region during the 2019-2023 five-year period, with only 195 building permits issued in 2023 across RiverCOG.[23] The majority of these building permits issues in 2023 are in East Hampton (37) and East Haddam (25), both of which have seen decreases in housing stock during these five years. Killingworth, Durham, Haddam, Deep River, and Clinton have seen the largest increase in housing stock during this period. Additionally, commercial and industrial growth has been relatively stagnant during this time frame.

Housing development and population growth in these areas will increase the number of residents exposed to and at risk to coastal flooding. One benefit of new development, however, is that newer construction is generally built to stronger building codes and floodplain regulations. Therefore, newer buildings that replace older-code buildings should generally reduce overall risk from coastal

[22] https://www.rivercog.org/data-population

[23] https://www.rivercog.org/data-housingcharacteristics

flooding with lower exposure within the floodplain. More specific changes in development are addressed at the community level in the municipal annexes in Volume II of this plan.

2.12.8. Overall Risk Rating

Using the parameters described in Table 2.8.1, the following hazard risk ratings were developed for coastal flooding (Table 2.12.11).

Table 2.12.11 Overall Risk Rating of Coastal Flooding

Criteria	Hazard Risk Rating
Probability	3 (Likely)
Impact: Affected Area	3 (Medium)
Impact: Primary Impact	2 (Limited)
Impact: Secondary Impacts	3 (Moderate)
Survey Rating	3 (High Concern)
Total Score	14.3
Overall Risk Ranking	**Significant**

2.13. Flooding from Dam Failure

2.13.1. Description and Background

Dams provide vital benefits to the RiverCOG region such as water supply, power generation, flood control, and recreation, but in the event of failure, they can pose a threat to lives and property. Dam failure can happen for a number of reasons including as a result of natural disasters, such as structural failure due to earthquakes or overtopping due to heavy precipitation. Failure due to material fatigue is also possible, but regular maintenance and dam inspections can detect leaks and other signs of material fatigue before the problem escalates.

The two primary types of dam failure are catastrophic failure (characterized by the sudden, rapid, and uncontrolled release of impounded water) and design failure (which occurs as a result of minor overflow events). When flows are greater than expected, spillway overflow events (often referred to as “design failures”) can occur. These overflows result in increased discharges downstream and increased flooding potential.

2.13.2. Location and Extent

Dam failure can only occur at and along the watercourses and low-lying areas downstream of dams. Although the effects of dam failure can impact any of the RiverCOG communities, the actual level of impact can differ based on the number and hazard classification of the dams within, and upstream of, the community. In the case of a lower hazard dam, the effect of the failure would

likely be constrained within the 1% annual chance floodplain or the 0.2% annual chance floodplain. The failure of a higher hazard dam could produce effects far greater than the 0.2% annual chance flood and could also cause a chain reaction where downstream dams also overtop and fail.

Dams in Connecticut are regulated by the Connecticut DEEP. Dams are rated by their hazard potential as outlined in the table below (Table 2.13.1). According to CT DEEP's "Guidelines for Inspection and Maintenance of Dams"[24], owners of Class B and C dams are required to prepare and implement an emergency action plan (EAP), which would include an identification of the area inundated by a dam failure, establishment of a procedure for monitoring the dam during heavy rainfall and runoff, and formalizing a warning system to alert local emergency management officials. Dams are required to be inspected by a professional engineer on a regular basis based on the hazard classification as noted in the table below. The exception is for dams subject to the jurisdiction of the Federal Energy Regulatory Commission which are exempt from state regulation but must comply with federal regulation.

Table 2.13.1. CT DEEP Dam Hazard Classifications

Hazard Classification	Hazard Potential	Formal Inspection Schedule
Class C	High hazard potential dam which, if it were to fail, would result in the probable loss of life; major damage to habitable structures, residences, hospitals, convalescent homes, schools, etc.; damage to main highways; or great economic loss	**Every 2 Years**
Class B	Significant hazard potential dam which, if it were to fail, would result in 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	**Every 5 Years**
Class BB	Moderate hazard potential dam which, if it were to fail, would result in damage to normally unoccupied storage structures, damage to low-volume roadways, or moderate economic loss	**Every 7 Years**
Class A	Low hazard potential dam which, if it were to fail, would result in damage to agricultural land, damage to unimproved roadways, or minimal economic loss	**Every 10 Years**
Class AA	Negligible hazard potential dam which, if it were to fail, would result in no measurable damage to roadways, land and structures, and negligible economic loss	**N/A**

[24] https://portal.ct.gov/deep/water/dams/dam-inspections

Not all dams pose a serious threat; the vast majority of dams in the region impound water bodies that, either because of their size or location, would not cause major destruction in the event of a dam failure. DEEP's list of dams currently has 74% of all dams in the state classified as AA, A, or BB such that only a small percentage are classified as significant or high hazard dams. Note that dam classification can change as a result of downstream development. In the RiverCOG region, there are 28 dams rated Class B (significant hazard) and 16 dams rated Class C (high hazard). High hazard potential dams would have the greatest impact to the region if a failure were to occur.

The following table (Table 2.13.2) presents a list of the high hazard potential dams within the RiverCOG region, their owners, and information on the current condition. Not all RiverCOG communities have a high hazard dam present. Note that there are certain dams located outside of the RiverCOG region whose failure could also impact the region; these dams are not listed in the table below but will be described as applicable in the vulnerability assessment.

Table 2.13.2. High Hazard Dam Location Information for RiverCOG Region

CT Dam #	Dam Name	Town	Downstream Channel(s)	Owner	Data to Analize Inundation Risk*
2605	Jennings Pond Dam	Chester	Pattaconk Brook	Municipal	✓
2614	Pattaconk Reservoir Dam	Chester	Pattaconk Brook	State	✓
3601	Bushy Hill Pond Dam	Deep River	Unnamed tributary to Falls River	Private	✓
4103	Leesville Dam	East Haddam	Salmon River	State	✓
5002	Mill Pond Dam	Essex	Falls River	Private	✓
6101	Higganum Reservoir Dam	Haddam	Ponset Brook (Higganum Creek)	State	✓
6102	Scovill Reservoir Dam	Haddam	Unnamed tributary to Candlewood Hill Brook	Private	✓
7001	Hammonasset Dam	Killingworth	Hammonasset River	Water Utility	NA
7002	Killingworth Reservoir Dam	Killingworth	Blueberry Brook	Water Utility	NA
8205	Laurel Brook Reservoir Dam	Middlefield	Laurel Brook	Municipal	✓
8301	Crystal Lake Dam	Middletown	Prout Brook	State	✓
8302	Adder Reservoir	Middletown	Roaring Brook	Municipal	✓
8303	Mount Higby Reservoir Dam	Middletown	Fall Brook	Municipal	✓
8304	Upper Mill Pond Dam	Middletown	Sumner Brook	Private	✓

CT Dam #	Dam Name	Town	Downstream Channel(s)	Owner	Data to Analize Inundation Risk*
8307	Dooley Pond Dam	Middletown	Long Hill Brook	State	✓
11301	Portland Reservoir Dam	Portland	Reservoir Brook	Municipal	✓

**RiverCOG was able to obtain EAPs for seven of the high hazard dams. Other plans, EOPs, topographic data and other sources were used to determine exposure in the inundation areas for all but two dams. Analysis of vulnerability in the exposure areas is included in the municipal annexes in Volume II of this plan.*

The National Inventory of Dams maintains information on dams across the United States, including information on dam conditions.[25] This information is not always up to date but often provides a good indicator of the recent condition of a dam within the past decade. The inventory was accessed to determine information regarding the condition of high hazard dams within the RiverCOG region and dams whose failure may affect the RiverCOG region. These are presented in Table 2.13.3. All high hazard dams are in fair or satisfactory condition. The only dam cited as in "poor" condition is the Crystal Lake Dam owned by the CT DEEP.

Table 2.13.3. High Hazard Dam Condition Information for RiverCOG Region

CT Dam #	Dam Name	Town	EAP Available for Review	Reported Dam Condition	Dam Condition Date
2605	Jennings Pond Dam	Chester	Yes	Satisfactory	10/22/2024
2614	Pattaconk Reservoir Dam	Chester	Yes	Fair	5/1/2024
3601	Bushy Hill Pond Dam	Deep River	No	Satisfactory	3/1/2022
4103	Leesville Dam	East Haddam	Yes	Satisfactory	5/1/2024
5002	Mill Pond Dam	Essex	Yes	Fair	8/31/2023
6101	Higganum Reservoir Dam	Haddam	Yes	Fair	5/1/2024
6102	Scovill Reservoir Dam	Haddam	No	Satisfactory	10/11/2023
7001	Hammonasset Dam	Killingworth	No	Satisfactory	10/16/2024
7002	Killingworth Reservoir Dam	Killingworth	No	Satisfactory	10/20/2022
8205	Laurel Brook Reservoir Dam	Middlefield	No	Satisfactory	4/18/2024
8301	Crystal Lake Dam	Middletown	Yes	Poor	10/18/2016
8302	Adder Reservoir	Middletown	No	Fair	4/18/2024
8303	Mount Higby Reservoir Dam	Middletown	No	Satisfactory	4/18/2024
8304	Upper Mill Pond Dam	Middletown	No	Fair	8/30/2023

[25] https://nid.sec.usace.army.mil/nid/#/

CT Dam #	Dam Name	Town	EAP Available for Review	Reported Dam Condition	Dam Condition Date
8307	Dooley Pond Dam	Middletown	Yes	Fair	9/29/2020
11301	Portland Reservoir Dam	Portland	Yes	Satisfactory	10/10/2024

Note that many dams in Connecticut were originally constructed in the 19th century without the benefit of modern engineering design and construction oversight. Dams can fail because of structural problems due to age and/or lack of proper maintenance.

According to FEMA, the common dam failure modes include those in the following table (Table 2.13.4). [26] Any of these failure modes could result in an uncontrolled downstream release of water with potential downstream consequences.

Table 2.13.4. Dam Failure Modes

Failure Type	Description
Seepage and Piping	Seepage and piping can cause internal erosion within the dam that can erode embankment or foundation materials and lead to dam failure. Evidence of piping is generally detected at the location of seepage discharge.
Overtopping (hydrologic failure)	Overtopping can cause erosion and head-cutting of embankment materials and can lead to dam failure.
Deformation	Deformation is caused by differential settlement; transverse or longitudinal cracking; or slope instability, slumps, or other slope failures. Deformation can provide a path for seepage through the dam and lead to failure. Low areas in the crest of the dam can make the dam more vulnerable to overtopping.
Liquefaction	Liquefaction can occur when the strength and stiffness of a saturated soil is reduced by earthquake shaking or other rapid loading. The weakened soil can cause the collapse of the dam.
Concrete failure	Concrete failure, structural cracking, broken masonry, and offsets at joints can lead to sudden failures.
Neglected maintenance and deterioration	Neglected maintenance and deterioration can leave a dam vulnerable to several failure modes: • Missing riprap can leave areas of an embankment unprotected and vulnerable to erosion from wave action or head-cutting during overtopping events. • Woody vegetation growing on a dam can interfere with effective dam safety monitoring. Uprooted trees can create large voids in the

[26] https://www.fema.gov/sites/default/files/2020-08/fact-sheet_dam-awareness.pdf

Failure Type	Description
	embankment, and roots can create preferred seepage paths, causing internal erosion problems. Vegetation can also block spillways. • Animal burrows in the embankment can cause preferred seepage paths. Livestock activity can damage embankment slopes and increase erosion potential. • Malfunctioning gates, conduits, or valves can reduce discharge capacity and cause the dam to overtop, which could lead to failure.
Other	Other problems that can leave a dam vulnerable to failure include outdated designs; hydraulically inadequate spillways; and damage from vandalism, cyber-attacks, or terrorism.

Due to the pattern of meteorological conditions needed to cause serious flooding, it is unusual for a major storm to occur without warning. Flash flooding, which occurs when excessive water fills either normally dry creeks or riverbeds or dramatically increases the water surface elevation on currently flowing creeks and rivers, can be less predictable. However, potential hazard areas can be warned in advance of potential flash-flooding danger. Flooding is more likely to occur due to a rainstorm when the soil is already wet and/or streams are already running high from recent previous rains.

The EAPs prepared by the owners of high hazard dams in the region are required to follow the template provided by the CT DEEP.[27] Although not all EAPs may look exactly alike, the same information must be within each EAP. The template requires:

- A physical description of the dam and its components, its history, and its drainage areas and downstream water courses.
- The modeling assumption used to estimate the downstream inundation area to be flooded by a dam breach.
- A detailed description of the affected area including mapping and address ranges of the streets potentially affected, potential evacuation routes and road closures, and emergency shelter locations.
- An abridged “rip and run” document for field implementation.
- Directions to the dam.
- Location of the Emergency Operations Center that would manage a dam failure incident.
- Roles and responsibilities of the dam owner, operators, and responders.
- Determination of dam monitoring, early warning, and final warning levels.
- Notification and communication call trees.
- Expected actions and procedures for termination of emergency.

[27] https://portal.ct.gov/deep/water/dams/emergency-action-plans

The dam classifications, modes of failure, and warning procedures outlined in this section are appropriate for the dams in the RiverCOG region and for upstream dams in Connecticut that could affect the RiverCOG region; and these classifications, failure modes, and warning procedures are believed appropriate for future conditions. Dam failures or overtopping events have not been characterized outside of these systems of classification. Response procedures in the EAPs can be revised during any of the routine updates to the EAPs.

2.13.3. History of Past Events

The most damaging dam failure in the RiverCOG region occurred on June 6, 1982.[28] At least nine inches of rain (and reportedly up to 15 inches of rain in some locations) fell over Middlesex County in a 24-hour period. The Bushy Hill Pond in Deep River near Ivoryton breached at 12:30 am, sending water downstream to Clark's Pond. The dam at Clark's Pond failed, sending a wall of water through a residential neighborhood and the Pratt, Read and Co. piano factory complex. Outflow from the ponds merged into the Falls River in Ivoryton, Centerbrook, and Essex, damaging three additional dams, several bridges, and dozens of homes until the floodwaters dissipated in the Connecticut River. More than $50 million in damage was reported (1982 dollars) but fortunately there were no deaths from this event. Throughout the State, 17 dams failed and another 31 were damaged resulting in total losses of approximately $70 million (1982 dollars). [29]

The Crystal Lake Dam in Middletown failed in 1961.[30] Significant flooding occurred downstream, along Prout Brook, destroying some homes and flooding others. No deaths were reported. The dam was rebuilt in 1966 and is now owned by the State.

Other major dam failures in Connecticut occurred in 1938 and 1955 due to hurricanes and in 1963 (Spaulding Pond Dam in Norwich). The October 7-15, 2005, heavy rainfall caused 10 complete or partial dam failures and damage to another 30 dams across the state, demonstrating the region's vulnerability to localized storm impacts on dams. Several low and moderate hazard potential dams suffered some impact from localized major flooding, including the Mile Creek Dam (Class B) in Old Lyme. Most recently, outside the region, in January 2024 a partial dam breach occurred at the Fitchville Dam on the Yantic River in Bozrah, resulting in evacuations downstream in Bozrah and Norwich.

2.13.4. Probability of Future Events

According to the 2023 *Connecticut NHMP Update*:

[28] https://www.courant.com/2002/06/06/a-look-back-at-the-flood-of-82/

[29] https://portal.ct.gov/deep/water/dams/introduction-to-dams

[30] https://www.middletownpress.com/middletown/article/The-day-the-Crystal-Lake-dam-breached-14821377.php

> *"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 the dams under CT DEEP jurisdiction have been measured to withstand the 100-year rainfall event, most of the dams meet this standard due to original design requirements or recent spillway upgrades. Therefore, when smaller rainfall events, such as 10-year and 25-year, occur more frequently there will be little impact on the ability of Connecticut dams to operate safely."*

Dam failures are most likely triggered by the occurrence of another natural disaster or hazard and are not likely to occur when regular maintenance and inspections are performed. Therefore, dam failures are less likely to occur than the natural disasters that may trigger them. For example, a 1% annual chance flood will not always cause a dam failure, particularly when the spillway is designed to pass a larger flood event. However, dams throughout Connecticut are aging, and as dams age, they are generally considered to be at higher risk of failure without continual maintenance. For that reason, it is generally expected that the risk of dam failure will increase in the future as existing dams continue to age.

2.13.5. Climate Change Impacts

According to the 2023 *Connecticut NHMP Update*, climate change may lead to higher intensity rainfall events and increase the potential for stress on dams to lead to dam failure. It is expected that precipitation patterns will become more variable over time, with fewer days with precipitation, but heavier and more intense events when it does rain. As a result, the failure probability of high hazard dams may increase.

However, a lack of historical data and interaction between dam infrastructure and environmental characteristics makes it difficult to determine long-term changes in frequency or intensity of future events. Dam failure events often occur over a smaller time frame and smaller geographic areas, which also makes the future changes of events unclear. As such, climate science has been unable to determine conclusively at this time that the risk to dams will increase.

2.13.6. Impacts and Estimated Losses to the Region

Impacts

Although dams and their associated impoundments provide many benefits to a community, such as water supply, recreation, hydroelectric power generation, and flood control, they also pose a potential risk to lives and property. Dam failure is not a common occurrence, but dams do represent a potentially disastrous hazard. When a dam fails, the potential energy of the stored water behind the dam is instantly released, oftentimes with catastrophic consequences as the water rushes in a torrent downstream flooding an area known as an "inundation area." The number of casualties and the amount of property damage will depend upon the timing of the warning provided to downstream residents, the number of people living or working in the inundation area, and the number of structures in the inundation area.

Estimated Losses

Exposure Analysis

The 2023 *Connecticut NHMP Update* estimates there are nearly 6,240 people in the RiverCOG region within the mapped dam inundation areas of high hazard dams. This is equivalent to approximately 3.7% of the population in the RiverCOG region. However, it is noted that the analysis did not include all dam failure inundation areas such that it is likely that this represents a lower bound of potential risk.

Properties, people, historic resources, and critical facilities in the RiverCOG region are exposed to the risk of dam failure. As an initial screening of exposure to dam failure, dam inundation areas (provided by the CT DEEP or generated through review of EAPs) have been overlaid onto parcel and point data in a GIS to understand the maximum potential exposure to hazards. The results of this analysis are found in Table 2.13.5.

Table 2.13.5 Dam Failure Inundation Exposure of At-Risk Parcels, Critical Facilities, and Historic Assets for the RiverCOG Region

Community	Number of Parcels	Value of At-Risk Parcels	Number of Critical Facilities	Value of At-Risk Critical Facilities	Number of Historic Assets	Value of At-Risk Historic Assets
Chester	1,822	$558	11	$30	44	$17
Clinton	6,989	$1,586	9	$74	654	$230
Cromwell	6,069	$1,707	14	$138	226	$113
Deep River	2,216	$577	13	$78	380	$99
Durham	3,066	$583	8	$18	94	$22
East Haddam	5,743	$1,124	14	$35	201	$64
East Hampton	6,203	$1,151	14	$39	399	$100
Essex	3,442	$1,378	12	$40	544	$271
Haddam	4,271	$816	14	$45	209	$69
Killingworth	2,775	$771	8	$25	47	$22
Lyme	1,709	$711	5	$9	280	$136
Middlefield	2,247	$464	8	$14	21	$9
Middletown	13,521	$7,466	39	$1,136	804	$1,593
Old Lyme	5,624	$1,544	12	$50	502	$217
Portland	4,725	$847	21	$24	161	$46

**All dollars are in millions*

Specific areas at risk for dam failure are presented in each municipal annex, including a description of the potential built environment, population, and environment in the downstream inundation area that could potentially be impacted.

Economic Losses

Although only one failure event in the RiverCOG region had a recorded monetary damage, that figure is sufficient to estimate the potential risk of dam failure in the RiverCOG region. The $50 million damage estimate is equivalent to $167,863,212 today.[31] This figure, divided by 43 years of record, represents an estimated AAL of $3,903,795 for dam failure. Note that this should be considered a lower bound, as other events may have caused relatively minor damage to dams in the region that have not been widely reported. Nevertheless, this provides a useful planning number suggesting that the downstream risk is relatively high for the region although the likelihood of dam failure is believed to be very low.

2.13.7. Development Trends

Since the 2021 plan update, development within the RiverCOG region has remained limited. Over the five-year period from 2019 to 2023, the region's population increased by approximately 1.7%,[32] a modest rise that is about 0.5% lower than Connecticut's statewide growth rate of roughly 2.2% during the same timeframe. Haddam, Old Lyme, Clinton, Cromwell, Middletown, and Essex experienced the largest population increases during this period, though the highest rate of growth was a modest 4.1% in Haddam. Chester saw the most significant decline, with its population decreasing by 10.6% over the same five-year span. Several factors contribute to these shifting growth patterns, with the COVID-19 pandemic playing a major role.

Similarly, there has been only a 0.37% increase in housing stock in the region during the 2019-2023 five-year period, with only 195 building permits issued in 2023 across RiverCOG.[33] The majority of these building permits issues in 2023 are in East Hampton (37) and East Haddam (25), both of which have seen decreases in housing stock during these five years. Killingworth, Durham, Haddam, Deep River, and Clinton have seen the largest increase in housing stock during this period. Additionally, commercial and industrial growth has been relatively stagnant during this time frame.

According to the 2023 *NHMP Update*, downstream development increases the potential consequences of a dam failure due to an increased number of structures and population in the inundation zone. This is of particular concern because in many cases there is no easy way for developers, the public, or municipal officials to access information about potential dam failure

[31] https://www.in2013dollars.com/us/inflation/1982?amount=50000000

[32] https://www.rivercog.org/data-population

[33] https://www.rivercog.org/data-housingcharacteristics

inundation areas, which may lie proximally to, but extend laterally beyond, flood risk zones mapped by FEMA. Thus, development is proposed, approved, and constructed in areas of risk, resulting in increased economic, social, and environmental impacts as development increases downstream from dams. Additionally, more dams will be re-classified as significant hazard potential and high hazard potential, which will increase the need for EAPs and planning to avoid disruption to essential facilities as well as prevent loss of life.

2.13.8. Overall Risk Rating

Using the parameters described in Table 2.8.1, the following hazard risk ratings were developed for flooding from dam failure (Table 2.13.6).

Table 2.13.6 Overall Risk Rating of Flooding from Dam Failure

Criteria	Hazard Risk Rating
Probability	1 (Unlikely)
Impact: Affected Area	2 (Small)
Impact: Primary Impact	2 (Limited)
Impact: Secondary Impacts	3 (Moderate)
Survey Rating	2 (Moderate Concern)
Total Score	8.5
Overall Risk Ranking	**Limited**

2.14. Thunderstorms and Severe Weather

2.14.1. Description and Background

Within the context of this NHMP update, severe weather includes thunderstorms, severe wind, lightning, and hail events.

Thunderstorms

Thunderstorms are a common occurrence in Connecticut and occur on approximately 20 to 40 days each year.[34] The NWS defines a thunderstorm as a localized storm produced by a cumulonimbus cloud, accompanied by lightning and thunder.[35] Thunderstorms are typically the result of warm, moist air that is pushed upwards into the atmosphere where it cools and forms into cumulonimbus clouds. As the air continues to cool, it starts to form water droplets or ice. As these

[34] https://www.ctinsider.com/weather/article/ct-weather-thunderstorms-19454914.php

[35]https://forecast.weather.gov/glossary.php?word=thunderstorm#:~:text=Severe%20supercell%20development%20is%20most,accompanied%20by%20lightning%20and%20thunder

droplets or ice start to fall, they may collide and combine many times into larger forms before reaching the Earth's surface. Thunderstorms can also occur without precipitation – these storms can cause wildfires. 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 the majority of rainfall.[36]

Thunderstorms can form in any geographic region and are sometimes the cause of other natural phenomena such as downburst winds, heavy rain, flash floods, large hailstones, tornadoes, and waterspouts. While many thunderstorms produce relatively little damage, stronger "supercell" thunderstorms can produce heavy winds, hail, damaging lightning strikes, and even tornadoes. Such storms have historically caused significant damage, injury, and even death through the destruction of trees; damage to buildings, vehicles, and power lines; and direct lightning strikes.

Wind

Severe winds have been broken down into three categories by the NCEI Storm Events database:

- **High Wind**: Sustained non-convective winds of 35 knots (40 mph) or greater lasting for one hour or longer or winds (sustained or gusts) of 50 knots (58 mph) for any duration (or otherwise locally/regionally defined), on a widespread or localized basis. In some mountainous areas, the above numerical values are 43 knots (50 mph) and 65 knots (75 mph), respectively.
- **Strong Wind**: Non-convective winds gusting less than 50 knots (58 mph), or sustained winds less than 35 knots (40 mph) resulting in fatality, injury, or damage.
- **Thunderstorm Wind**: 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. Events with maximum sustained winds or wind gusts less than 50 knots (58 mph) should be entered as a Storm Data event only if they result in fatalities, injuries, or serious property damage.

High wind events can occur for a variety of reasons: low- and high-pressure systems, isolated thunderstorms, tropical cyclones, and Nor'easters. Using the NCEI severe wind categories listed above, sustained non-convective winds of 40 mph or greater lasting for one hour or longer or winds (sustained or gusts) of 58 mph for any duration, on a widespread or localized basis are considered a minimum severity event. A major severe event would be wind events of greater than 58 mph or a wind event resulting in death, injury or significant damage. Wind associated with hurricanes is evaluated in *Section 2.15 Hurricanes and Tropical Storms*, tornadoes in *Section 2.16 Tornado*, and flooding in *Section 2.12 Flooding - Coastal Flood*.

[36] https://www.nssl.noaa.gov/education/svrwx101/thunderstorms/

Thunderstorm Winds

The strength of thunderstorms is typically measured in terms of their effects, namely the speed of the wind, the presence of significant lightning, and the size of hail. In general, thunderstorm winds are less than tropical cyclone speeds, but strong winds associated with downbursts can be extremely hazardous and reach speeds up to 168 mph. [37]

A severe thunderstorm includes damaging winds greater than 58 mph (50 knots) or greater and hail one inch or larger in diameter.

Derecho

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.

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.[38] 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 earth. Effects from high winds can include downed trees and power lines, and damage to roofs, windows, and other physical infrastructure.[39]

Table 2.14.1 provides the descriptions of winds used by the NWS.

Table 2.14.1. 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

[37] https://www.noaa.gov/jetstream/wind_damage

[38] FEMA 1997; Kosiba et al. 2013

[39] https://www.weather.gov/lix/htiwind

Descriptive Term	Sustained Wind Speed (miles per hour)
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, or downbursts:

- **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** are powerful winds that descend from a thunderstorm and spread out quickly once they hit the ground. Downburst activity is sometimes mistaken for tornado activity, as downburst wind speeds can exceed 165 mph.[40]

Both of these storms are more common than tornadoes in Connecticut, and these "straight line" winds are distinguishable from tornadic activity by the pattern of destruction and debris, such that the best way to determine the damage source is to fly over the area.

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. Depending on the size and location of downburst events, the destruction of property may be significant. Downbursts fall into two categories:

1. Microbursts affect an area less than 2.5 miles in diameter, last 5 to 15 minutes, and can cause damaging winds up to 168 mph.
2. Macrobursts affect an area at least 2.5 miles in diameter, last 5 to 30 minutes, and can cause damaging winds up to 134 mph.

Lightning

Lightning is defined by the NWS as a visible electrical discharge (i.e. lightning bolt) produced by a thunderstorm. The discharge may occur within or between clouds, between the cloud and air, between a cloud and the ground or between the ground and a cloud. According to NOAA, the creation of lightning during a storm is a complicated process that is not fully understood. In the initial stages of development, air acts as an insulator between the positive and negative charges. However, when the potential between the positive and negative charges becomes too great, a discharge of electricity (lightning) occurs. A bolt of lightning can reach temperatures approaching 50,000 degrees Fahrenheit. Lightning rapidly heats the sky as it flashes, but the surrounding air cools following the bolt. This rapid heating and cooling of the surrounding air causes thunder.

[40] https://www.weather.gov/lmk/downburst

In-cloud lightning occurs between the positive charges near the top of the cloud and the negative charges near the bottom. Cloud-to-cloud lightning occurs between the positive charges near the top of the cloud and the negative charges near the bottom of a second cloud. Cloud-to-ground lightning (CG) is the most dangerous. In summertime, most CG lightning occurs between the negative charges near the bottom of the cloud and positive charges on the ground.

While there is no established index for lightning, a lightning strike is of minimum severity when it has limited impacts on the natural and built environment (ex. tree limbs and buildings) and major severity when it causes extensive damage (ex. loss of life, fire, structural damage). The potential damage resulting from lightning strikes are primarily injury, loss of life, power outages, business interruption, fire and minor structural damage. A false sense of security often leads people to believe that they are safe from a lightning strike because it may not appear to be near their location. However, lightning can strike 10 miles away from a rain column, which puts people who are still in clear weather at risk. In the United States, an average of 243 people are injured and 27 people are killed by lightning each year.[41]

Hail

Hail is precipitation in the form of ice pellets larger than five mm that forms in thunderstorms between currents of rising air (updrafts) and currents of descending air (downdrafts) as shown in Figure 2.14.1.[42] Most hailstones are smaller in diameter than a dime, but stones weighing more than 1.5 pounds have been recorded. NOAA has estimates of the velocity of falling hail ranging from 9 meters per second (m/s) (20 mph) for a 1-centimeter (cm) diameter hailstone to 48 m/s (107 mph) for an 8 cm, 0.7 kilogram stone. These events typically occur in late spring and early summer. One criterion for severe thunderstorms, as defined by the NWS, is hail that is one inch in diameter (quarter-size) or larger.

[41] https://www.weather.gov/safety/lightning-odds

[42] (Source: NOAA).

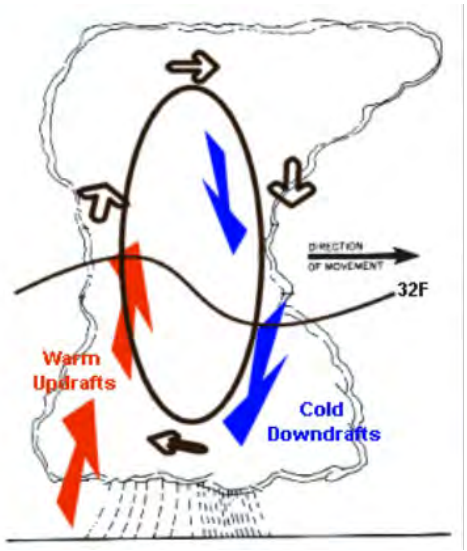


Figure 2.14.1. Formation of Hail

Using the NWS definition for a severe thunderstorm, dime-sized hail is considered a minimum hazard and quarter-sized hail is considered a major hazard. Quarter-sized hail can cause significant damage to agricultural crops and livestock, as well as property such as automobiles, aircraft, and roofs. Although rare, large hailstones may even cause injury or death. The amount of cover obtained during a hailstorm can greatly reduce the risk to human health during these events. 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; however, since hail occurs with thunderstorms, the possibility of hail damage exists throughout the entire United States. Figure 2.14.2 indicates that Connecticut experiences an average of three to four severe hail days per year.

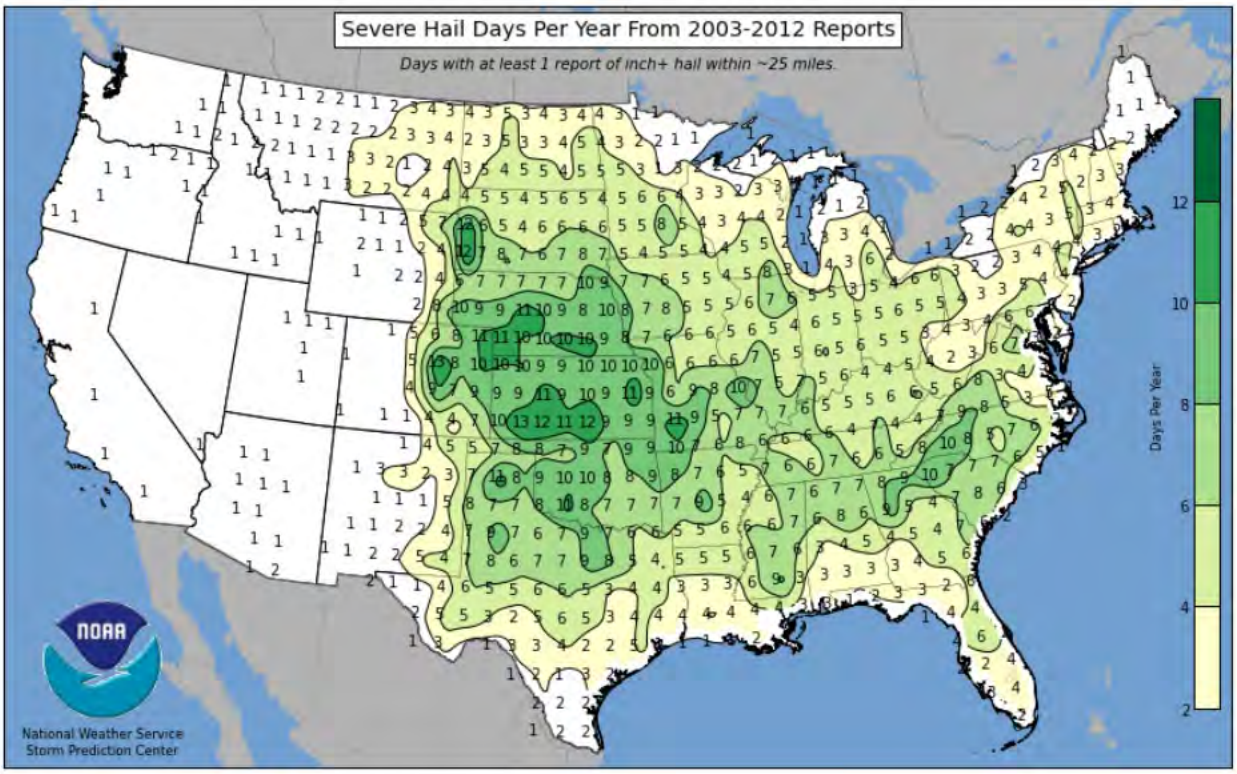


Figure 2.14.2. Annual Frequency of Hailstorms in the United States, NOAA.

2.14.2. Location and Extent

All areas of the RiverCOG communities are susceptible to thunderstorms and severe weather events. The likelihood of damage, injury, and death increases dramatically when a supercell thunderstorm occurs in a more populated area. For that reason, Middletown, Portland, Cromwell and the more suburban northern RiverCOG municipalities are at higher risk. While the heavy winds and tornadoes associated with strong thunderstorms are more likely to cause measurable damage near populated areas, hail can cause damage to crops in rural areas and can damage vehicles and buildings in populated areas. Lightning can cause injuries or fires in any area.

Thunderstorms affect relatively small, localized areas, rather than large regions like winter storms and hurricane events.

Figure 2.14.3 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). The figure illustrates that communities in the RiverCOG study area experience approximately 20 thunderstorm days each year.[43]

[43] https://www.weather.gov/jetstream/tstorms_intro

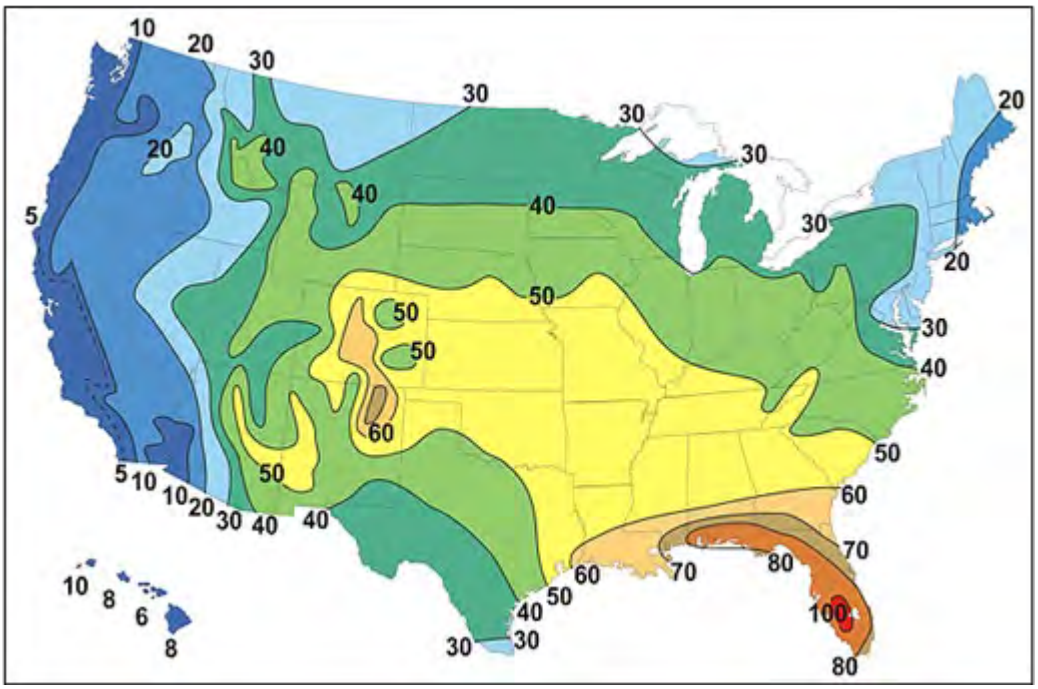


Figure 2.14.3. Annual Average Number of Thunderstorm Days in the United States

In addition to wind and lightning strike damages, 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 windstorms is utility failure resulting from downed power lines and tree branches. Power outages due to high windstorms can lead to greater exposure to extreme temperatures (discussed in *Section 2.20 Extreme Temperature*) for vulnerable populations particularly during peak hot and cold months. The widespread power outages following Superstorm Sandy mixed with the exceptionally cold temperatures led counties to open additional shelters for displaced residents. Power outages in the RiverCOG region are amplified by the number of diseased and dying trees (see *Section 2.20 Extreme Temperature*) falling on power lines. While more urbanized areas like Middletown have more assets at risk, heavily forested more rural towns like Durham or Essex may experience more power outages due to fallen trees. Traffic accidents may also occur when power to traffic control devices are disrupted by these high windstorm events.

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. Extreme hailstorms impact traffic routes and may lead to transportation accidents. Hail may cause more damage in the rural communities but is considered equally probable across the region.

Warning Time

Meteorologists can often predict the likelihood of a severe thunderstorm and hailstorms. This can provide several days' warning. However, meteorologists cannot predict the exact time of onset, specific location, or the severity of the storm.

The NWS issues Severe Thunderstorm Watch and Warning messages to warn residents of potential tornadoes.

- A Severe Thunderstorm Watch is issued when severe thunderstorms are possible in and near the watch area. Residents are told to stay informed and be ready to act if a severe thunderstorm warning is issued. The watch area is typically large, covering numerous counties or even states.
- A Severe Thunderstorm Warning is issued when severe weather has been reported by spotters or indicated by radar. Warnings indicate imminent danger to life and property. Residents are told to take shelter in a substantial building and to get out of mobile homes that can blow over in high winds. Warnings typically encompass a much smaller area (around the size of a city or small county) that may be impacted by a large hail or damaging wind identified by an NWS forecaster on radar or by a trained spotter/law enforcement who is watching the storm.

A Severe Thunderstorm Watch is issued by the Storm Prediction Center (SPC). Prior to the issuance of a Severe Thunderstorm Watch, SPC will usually contact the affected local NWS 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, the affected NWFO will 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 let the public know when the watch has expired or been cancelled.

Like a Tornado Warning, the Severe Thunderstorm Warning is issued by the SPC and 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 NWFO will follow it up periodically with Severe Weather Statements. These statements will contain updated information on severe thunderstorms, and they will also let the public know when the warning is no longer in effect.

Scales to characterize thunderstorms and severe weather are primarily focused on the watch and warning systems described above. To characterize individual hazards within a thunderstorm such as hail and lightning the threat to life and property is communicated.

Past efforts to develop scales for classifying lightning risk have been focused on components of larger risk communication projects. For example, the Lightning Activity Level (LAL) was a tool that was developed in the 1960s in Montana to characterize lightning risk for use as an input into the National Fire Danger Rating System (NFDRS). The LAL had a range of values from 1 through 6: a value of 1 represented no lightning, values from 2 through 5 represented an increasing coverage of wet thunderstorms and corresponding increases in the frequency of lightning strikes, while 6 represented rare dry lightning events with a lightning frequency similar to a LAL of 3. The NWS currently supports public use of mapping lightning threats ranging from "non-threatening" to "extreme." The scale is based on the likelihood that CG lightning from thunderstorms will occur combined with the anticipated flash rate.

The NWS currently supports public use of mapping hail threats ranging from "non-threatening" to "extreme." The scale is based on the likelihood that severe hail will occur combined with the anticipated size (diameter) of the biggest stones.

Table 2.14.2 summarizes the criteria for the different threat levels for both lightning and hail.

Table 2.14.2. Threat Level Description for Lightning and Hail

Threat Level	Lightning Description	Hail Description
Extreme	• Within 12 miles of a location, a moderate likelihood of CG lightning (or 50% thunderstorm probability), with storms capable of excessive CG lightning. • And/or a high likelihood of CG lightning (or 60% to 70% thunderstorm probability), with storms capable of frequent CG lightning. • And/or a very high likelihood of CG lightning (or 80% to 90% thunderstorm probability), with storms capable of occasional CG lightning.	• Within 12 miles of a location, a moderate likelihood or greater (16% probability or greater) of severe hail, with storms capable of baseball to softball sized stones. See diameter description below. • *And/or* a high likelihood or greater (26% probability or greater) of severe hail, with storms capable of golf ball to baseball sized hail stones. See diameter description below. • *And/or* a very high likelihood (36% or greater) of severe hail, with storms capable of quarter to golf ball sized hail stones. See diameter description below.
High	• Within 12 miles of a location, a low likelihood of CG lightning (or	• Within 12 miles of a location, a low likelihood (6% to 15% probability) of severe hail, with

Threat Level	Lightning Description	Hail Description
	30% to 40% thunderstorm probability), with storms capable of excessive CG lightning. • *And/or* a moderate likelihood of CG lightning (or 50% thunderstorm probability), with storms capable of frequent CG lightning. • *And/or* a high likelihood of CG lightning (or 60% to 70% thunderstorm probability), with storms capable of occasional CG lightning.	storms capable of baseball to softball sized stones. See diameter description below. • *And/or* a moderate likelihood (16% to 25% probability) of very large hail (golf ball to baseball sized hail stones). See diameter description below. • *And/or* a high likelihood (26% to 35% probability) of large hail (quarter to golf ball sized hail stones). See diameter description below.
Moderate	• Within 12 miles of a location, a very low likelihood of CG lightning (or 10% to 20% thunderstorm probability), with storms capable of excessive CG lightning. • *And/or* a low likelihood of CG lightning (or 30% to 40% thunderstorm probability), with storms capable of frequent CG lightning. • *And/or* a moderate likelihood of CG lightning (or 50% thunderstorm probability), with storms capable of occasional CG lightning.	• Within 12 miles of a location, a very low likelihood (2% to 5% probability) of severe hail, with storms capable of baseball to softball sized stones. See description below. • *And/or* a low likelihood (6% to 15% probability) of severe hail, with storms capable of golf ball to baseball sized hail stones. See description below. • *And/or* a moderate likelihood (16% to 25% probability) of severe hail, with storms capable of quarter to golf ball sized hail stones.
Low	• Within 12 miles of a location, a very low likelihood of CG lightning (or 10% to 20% thunderstorm probability), with storms capable of frequent CG lightning. • *And/or* a low likelihood of CG lightning (or 30% to 40% thunderstorm probability), with storms capable of occasional CG lightning.	• Within 12 miles of a location, a very low likelihood (2% to 5% probability) of severe hail, with storms capable of golf ball to baseball sized hail stones. See diameter description below. • *And/or* a low likelihood (6% to 15% probability) of severe hail, with storms capable of quarter to golf ball sized hail stones.
Very Low	• Within 12 miles of a location, a very low likelihood of CG lightning (or 10% to 20% thunderstorm	• Within 12 miles of a location, a very low likelihood (2% to 5% probability) of severe hail, with storms capable of nickel to golf

Threat Level	Lightning Description	Hail Description
	probability), with storms capable of occasional CG lightning.	ball sized hail stones. See diameter description below. • *And/or* a low likelihood or greater (6% or greater) of small hail (less than 1 inch).
Non-Threatening	• Within 12 miles of a location, environmental conditions do not support CG lightning.	• Within 12 miles of a location, environmental conditions do not support the occurrence of severe hail.
Definitions	• The flash rate definitions are: • Occasional - CG lightning at the rate of 1 to 3 flashes per minute (about 5 to 15 flashes per 5 minutes) associated with a given lightning storm. • Frequent - CG lightning at the rate of 4 to 11 flashes per minute (about 20 to 55 flashes per 5 minutes) associated with a given lightning storm. • Excessive - CG lightning rate of 12 flashes or more per minute (about 60 flashes or more per 5 minutes); and is nearly continuous and associated with a given lightning storm.	• The size definitions are: • Small Hail - Hail less than 1 inch in diameter (from the size of peas to nickels). • Large Hail - Hail from 1 inch to 1 3/4 inch in diameter (from the size of quarters to golf balls) causing minor damage. • Very Large Hail - Hail from 1 3/4 inch to 2 3/4 inch in diameter (from the size of golf balls to baseballs) causing moderate damage. • Giant Hail - Hail larger than 2 3/4 inch (larger than baseballs, such as the size of grapefruit or softballs) causing major damage.

Furthermore, for hail, NOAA provides a range from “bb” (<0.25 inch) to “softball” (4.5 inches) with common sizes reported in Massachusetts ranging from pea to nickel-sized (0.25 inch to 0.875 inch).

The NOAA/NWS classification systems coupled with the NWS warning systems are appropriate for severe storms in the RiverCOG region, inclusive of high winds, lightning, and hail. These classification systems have been used for many of the severe storms that have occurred in the region and its communities. Severe storms have not been characterized outside of these systems of classification.

2.14.3. History of Past Events

NOAA’s NCEI database is the most comprehensive source of historic data, based on reported past events that have caused damages. According to records in the database, since 1960, there have been just over $1 Million worth of reported property damage to RiverCOG communities, relating to

severe weather events. It is quite likely that there have been far more damaging events that are not captured in the database. The database also often records more events that affect more populated communities, where there are more people making reports and a higher likelihood of damages. Table 2.14.3 lists the number of severe weather events by RiverCOG community, along with injuries, deaths, and damages. Middletown has the greatest number of events while Old Lyme and Middlefield have the least. There were 57 events in total that could not be narrowed down to a specific town within Middlesex and New London Counties and therefore have been given their own record within the table. Table 2.14.4 lists the severe weather events by event type. Thunderstorm Wind is the most numerously reported event, with 107 reported cases in RiverCOG over the 70 years the NCEI has been keeping records for such events. [44] Crop damages are not included in the table due to lack of reporting. This should not be construed as a minimal risk of crop damage.

Table 2.14.3. NCEI Total Severe Weather Events, 1960 – 2025.

County	Number of Events	Number of Injuries	Number of Deaths	Property Damages	Crop Damages
Chester	9	0	0	$11,500	$0
Clinton	4	2	1	$0	$0
Cromwell	7	4	0	$23,500	$0
Deep River	7	0	0	$9,500	$0
Durham	12	0	0	$42,000	$0
East Haddam	7	0	0	$13,000	$0
East Hampton	23	0	0	$82,500	$0
Essex	8	0	0	$22,000	$0
Haddam	13	0	0	$58,500	$0
Killingworth	8	0	0	$5,000	$0
Lyme	7	0	0	$5,000	$0
Middlefield	3	0	0	$1,500	$0
Middlesex County	57	1	1	$785,000	$0
Middletown	34	0	1	$49,000	$0
Old Lyme	3	0	0	$7,500	$0
Portland	11	0	0	$84,500	$0

[44] https://www.ncei.noaa.gov/stormevents/

County	Number of Events	Number of Injuries	Number of Deaths	Property Damages	Crop Damages
Total	**	**7**	**3**	**$1,200,000**	**$0**

***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.*

Table 2.14.4. NCEI Severe Weather Events, 1960 – 2025.

Event Type	Number of Events	Year First Recorded	Year Latest Recorded	Number of Years	Annualized Events
Hail	41	1960	2024	64	0.64
Heavy Rain	18	1996	2005	9	2.00
High Wind	33	1996	2024	28	1.18
Lightning	17	1998	2024	26	0.65
Strong Wind	7	1996	2019	23	0.30
Thunderstorm Wind	107	1963	2025	62	1.73
Total	**	**1960**	**2025**	**65**	*

***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.*

Federal Disaster Declarations

Understanding the natural hazards RiverCOG is likely to face is crucial to its communities' ability to prepare for and respond to disasters. Researching historic data on major storms and other natural disasters can be helpful in this analysis. Knowing where and when natural disasters have occurred in the past is important to understand risks. To assess the risks, the RiverCOG region faces from natural disasters, past occurrences of major disasters were evaluated, looking at the losses to life and property incurred by communities, state, residents, and businesses. The following section contains descriptions of major severe weather events and their impact on RiverCOG. Table 2.14.5 below lists the federal Emergency ("EM") and Disaster declarations ("DR") for the RiverCOG region related to severe weather events.

Table 2.14.5. Public Assistance Reimbursements as of 2025.

Disaster Number	Year	Incident Period	Disaster Type	Counties
DR-4629	2021	September 1-2	Remnants of Hurricane Ida	Litchfield, Fairfield, New Haven. Middlesex, New London
DR-4580	2020	August 4	Tropical Storm Isaias	Statewide

Disaster Number	Year	Incident Period	Disaster Type	Counties
DR-4410	2018	September 25-26	Severe Storms and Flooding	Middlesex, New London
DR-4046	2011	October 29-30	Severe Storm - Alfred	Litchfield, Fairfield, New Haven, Middlesex, Windham, Tolland, Hartford
DR-1904	2010	March 12 - May 17	Severe Storms and Flooding	Fairfield, New Haven, Middlesex, New London, Windham

A federal disaster or emergency declaration for a county opens the availability of funding reimbursements from the federal government. Such reimbursements may take the form of Public Assistance payments to municipal governments, nonprofit organizations, and state agencies to clean up communities affected by disaster debris and fund the repair, restoration, reconstruction, or replacement of a public facility or infrastructure damaged or destroyed by a disaster. In some cases where private property damage is widespread, FEMA may also offer Individual Assistance payments to individuals and families who have sustained losses due to disasters.

A Public Assistance reimbursement database is maintained by FEMA and is available through the FEMA website. The database contains records of damage reimbursements dating back to August 26, 1998, for municipalities, nonprofit organizations, schools, and state agencies. For Connecticut, the majority of losses are related to flooding, wind, or winter storm damage. Total damages from the Public Assistance database are summarized for each community in Table 2.14.6.[45] The total damage column assumes that the federal reimbursement reported by FEMA represented 75% of the actual damages. These numbers increased significantly from the 2021 NHMP update as reimbursements from more damaging severe storms came in since that update.

Table 2.14.6. Public Assistance Reimbursements for severe storm events as of October, 2025.

Community	Total Damages	Annualized Loss for Severe Weather
Town of Chester	$191,798	$7,377
Town of Clinton	$802,107	$30,850
Town of Cromwell	$224,583	$8,638
Town of Deep River	$149,425	$5,747

[45] https://www.fema.gov/openfema-data-page/public-assistance-applicants-program-deliveries-v1

Community	Total Damages	Annualized Loss for Severe Weather
Town of Durham	$148,263	$5,702
Town of East Haddam	$2,594,149	$99,775
Town of East Hampton	$0	$0
Town of Essex	$259,952	$9,998
Town of Haddam	$0	$0
Town of Killingworth	$881,518	$33,905
Town of Lyme	$0	$0
Town of Middlefield	$94,323	$3,628
City of Middletown	$511,823	$19,686
Town of Old Lyme	$139,258	$5,356
Town of Portland	$261,441	$10,055
RiverCOG Region	**$6,258,640**	**$240,717**

The damages in the table above include reimbursements to State of Connecticut agencies such as the DOT and the Judicial Branch. State-level reimbursements were allocated to individual communities by estimating the breakdown per county (such as by locating the facilities of the agencies reporting damages) and then distributing the county-wide agency loss based on the ratio of the population of each community to the population of each county.

Annualized loss estimates were also prepared based on the Public Assistance data as shown in Table 2.14.7. The annualized loss due to severe storm damage in the region from this data is $240,717 per year. Since Public Assistance Damages are limited to reimbursed expenditures, for only certain items, as requested by communities, annualized loss estimates from this data should be considered considerably lower than actual, all inclusive, damages.

2.14.4. Probability of Future Events

According to NOAA's NWS, there is an average of 100,000 thunderstorms per year in the United States. An average of 27 people per year died from lightning strikes in the United States from 2009 to 2018.[46] Most lightning deaths and injuries occur outdoors, with 45% of lightning casualties occurring in open fields and ballparks, 23% under trees, and 14% involving water activities. Thunderstorms typically occur on 20 to 40 days each year in Connecticut.[47] NOAA reports that

[46] https://www.weather.gov/safety/lightning-odds

[47] https://www.ctinsider.com/weather/article/ct-weather-thunderstorms-19454914.php

there are 10 downburst reports for every tornado report in the United States.[48] This implies that there are approximately 10,000 downbursts reported in the United States each year and further implies that downbursts occur in approximately 10% of all thunderstorms in the United States annually. This figure suggests that downbursts are a relatively uncommon yet persistent hazard. Of the individual RiverCOG communities, Middletown is the most likely to have a damaging severe weather event, predicted to have one every other year. Table 2.14.7 lists the RiverCOG communities and their annualized events. Annualized events were determined by dividing the period of record by the number of events.[49] There were 57 events in total that could not be narrowed down to a specific town within Middlesex County and therefore have been given their own record in the table.

Table 2.14.7. Annualized Events for Severe Weather Hazard

Community	Annualized Events
Chester	0.14
Clinton	0.06
Cromwell	0.11
Deep River	0.11
Durham	0.18
East Haddam	0.11
East Hampton	0.35
Essex	0.12
Haddam	0.20
Killingworth	0.12
Lyme	0.11
Middlefield	0.05
Middlesex County	0.88
Middletown	0.52
Old Lyme	0.05
Portland	0.17
Total	*

[48] https://www.spc.noaa.gov/climo/online/

[49] Note: *Annualized event totals were not included because NCEI events may be counted more than once if one storm event affects multiple communities. This duplication renders totals inaccurate.

2.14.5. 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, the changing climate is likely to increase flooding, harm ecosystems, disrupt farming, and increase some risks to human health.[50]

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.[51] 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 Atlantic Coast. In addition, the intensity of individual extreme rainfall events could increase by as much as 70 percent in some areas.[52]

Storms have become more intense in recent decades, and several 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.[53]

Additionally, National Aeronautics and Space Administration (NASA) scientists suggest that the United States will face more severe thunderstorms in the future, with deadly 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.[54]

2.14.6. Impacts and Estimated Losses to the Region

All areas of the RiverCOG are susceptible to thunderstorms and severe weather events. Fortunately, in Connecticut, injury and death due to these events are relatively uncommon. Although thunderstorm damage is expected each year, most events do not cause significantly reported or measured damage. Most thunderstorm damage is associated with downbursts, which typically have a greater effect on elevated areas such as hilltops, ridges, and "wind corridors"

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

[51]https://www2.ucar.edu/atmosnews/news/124334/extreme-downpours-could-increase-fivefold-across-parts-us

[52] https://www2.ucar.edu/atmosnews/news/124334/extreme-downpours-could-increase-fivefold-across-parts-us

[53] https://climate.nasa.gov/news/897/severe-thunderstorms-and-climate-change/

[54] https://climate.nasa.gov/news/897/severe-thunderstorms-and-climate-change/

within communities. Areas with more trees in proximity to power lines and structures are more vulnerable to the effects of thunderstorm damage than more urban areas.

Section 2.9.3 describes the exposure analysis method used to characterize the upper boundaries of exposure to risks in the region. The following table (Table 2.14.8) presents the exposure to thunderstorms and severe weather hazards.

Table 2.14.8 Thunderstorm and Severe Weather Exposure Analysis for RiverCOG Communities

Hazard	Number of Parcels	Value of At-Risk Parcels	Number of Critical Facilities	Value of At-Risk Critical Facilities	Number of Historic Assets	Value of At-Risk Historic Assets
Chester	1,822	$558	11	$30	44	$17
Clinton	6,989	$1,586	9	$74	654	$230
Cromwell	6,069	$1,707	14	$138	226	$113
Deep River	2,216	$577	13	$78	380	$99
Durham	3,066	$583	8	$18	94	$22
East Haddam	5,743	$1,124	14	$35	201	$64
East Hampton	6,203	$1,151	14	$39	399	$100
Essex	3,442	$1,378	12	$40	544	$271
Haddam	4,271	$816	14	$45	209	$69
Killingworth	2,775	$771	8	$25	47	$22
Lyme	1,709	$711	5	$9	280	$136
Middlefield	2,247	$464	8	$14	21	$9
Middletown	13,549	$5,581	36	$608	804	$1,474
Old Lyme	5,624	$1,544	12	$50	502	$217
Portland	4,725	$847	21	$24	161	$46

**All dollar figures are in millions*

To supplement the exposure analysis, the NRI was utilized to obtain information for a risk analysis on thunderstorms and severe weather at the census tract level across RiverCOG. Figure 2.14.4 through Figure 2.14.6, display the risk rating by census tract in the RiverCOG region for lightning, strong wind, and hail.

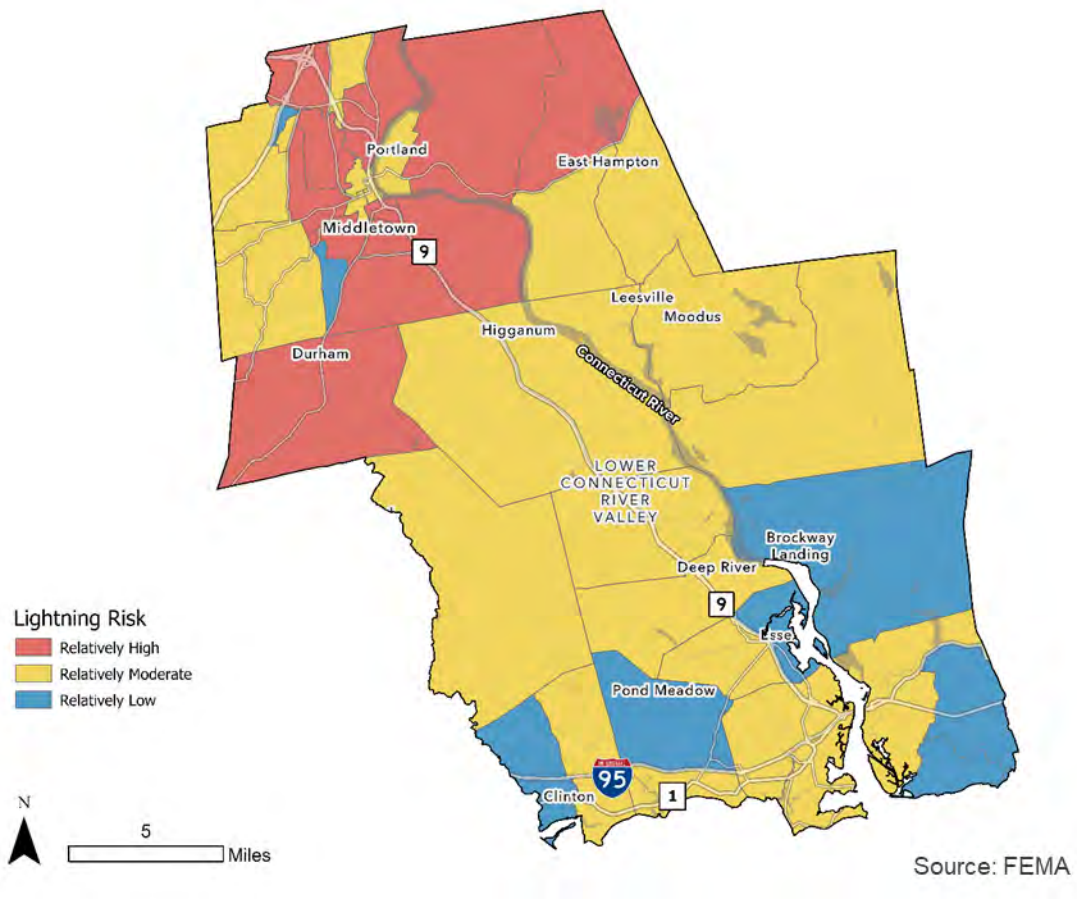


Figure 2.14.4. NRI Risk Rating for Lightning, shown at the census tract level (2025)

Middletown has the most census tracts at a relatively high risk to lightning with six census tracts (out of thirteen). All of Durham and portions of Cromwell, East Hampton, and Portland additionally have a relatively high risk to lightning. Table 2.14.9 displays communities in RiverCOG and the number of census tracts at each risk rating to lightning.

Table 2.14.9. Breakdown of community risk to lightning

Community	Number of Census Tracts with Relatively Low Risk	Number of Census Tracts with Relatively Moderate Risk	Number of Census Tracts with Relatively High Risk
Chester	-	1	-
Clinton	2	2	-
Cromwell	-	1	2
Deep River	-	1	-

Community	Number of Census Tracts with Relatively Low Risk	Number of Census Tracts with Relatively Moderate Risk	Number of Census Tracts with Relatively High Risk
Durham	-	-	1
East Haddam	-	2	-
East Hampton	-	2	1
Essex	1	1	-
Haddam	-	2	-
Killingworth	-	1	-
Lyme	1	-	-
Middlefield	-	1	-
Middletown	2	5	6
Old Lyme	2	1	-
Portland	-	1	1
Total for RiverCOG Region	**8**	**21**	**11**

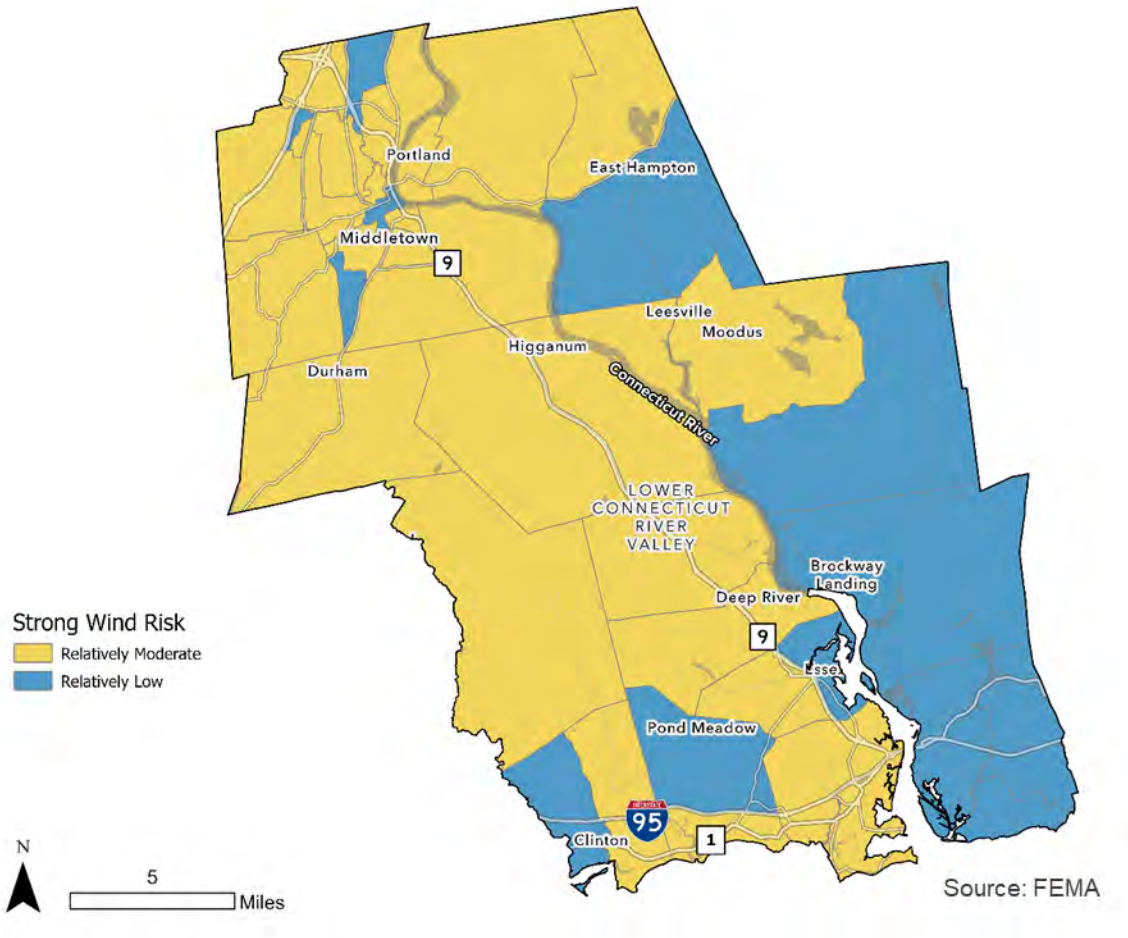


Figure 2.14.5. NRI Risk Rating for Strong Wind, shown at the census tract level (2025)

Chester, Deep River, Durham, East Haddam, Killingworth, Middlefield, and Portland are all at a relatively moderate risk to strong wind. Additionally, Middletown has the most census tracts at relatively moderate risk to strong wind with nine census tracts (out of thirteen) at this risk level. Table 2.14.10 displays communities in RiverCOG and the number of census tracts at each risk rating to strong wind.

Table 2.14.10. Breakdown of community risk to strong wind

Community	Number of Census Tracts with Relatively Low Risk	Number of Census Tracts with Relatively Moderate Risk
Chester	-	1
Clinton	2	2
Cromwell	1	2

Community	Number of Census Tracts with Relatively Low Risk	Number of Census Tracts with Relatively Moderate Risk
Deep River	-	1
Durham	-	1
East Haddam	-	2
East Hampton	2	1
Essex	1	1
Haddam	2	-
Killingworth	-	1
Lyme	1	-
Middlefield	-	1
Middletown	4	9
Old Lyme	3	-
Portland	-	2
Total for RiverCOG Region	**16**	**24**

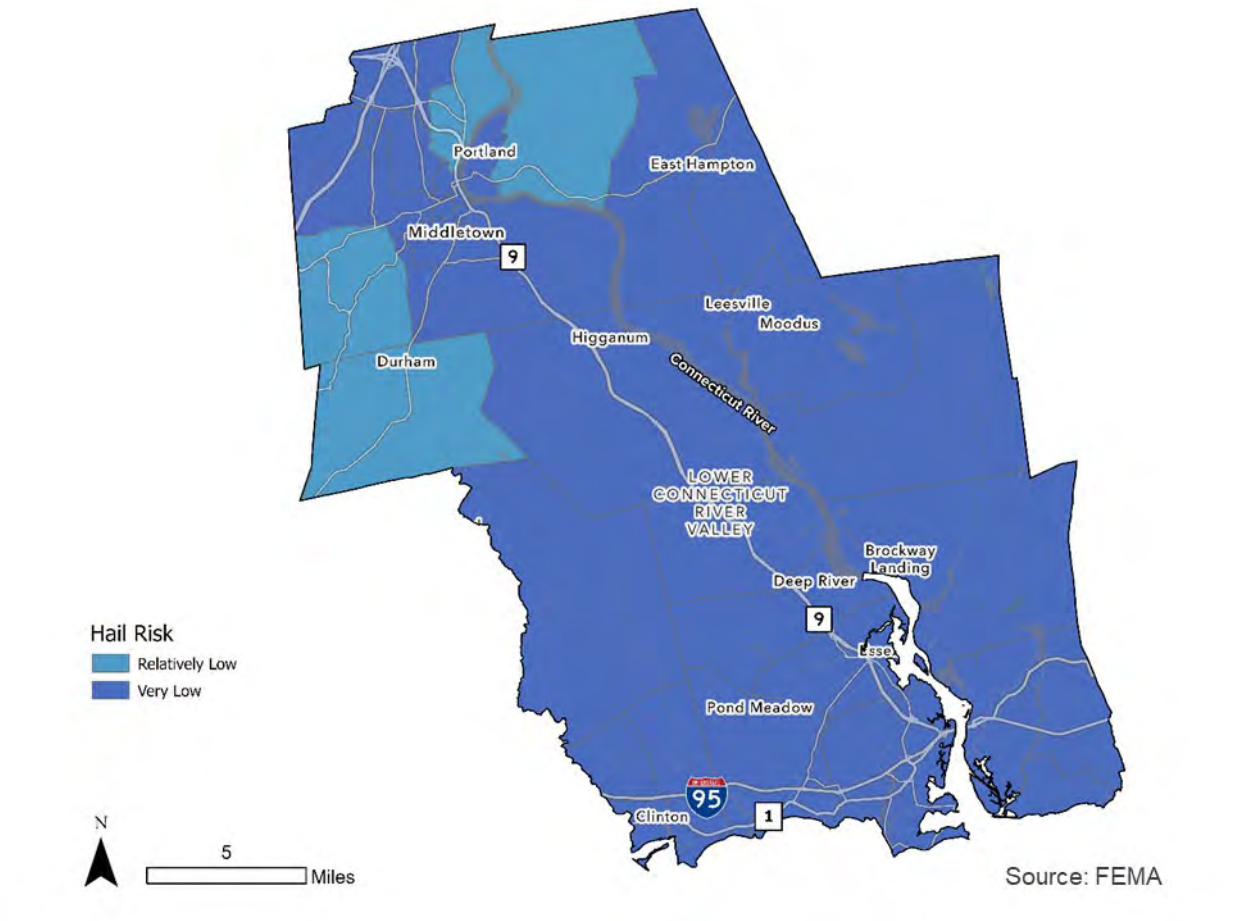


Figure 2.14.6. NRI Risk Rating for Hail, shown at the census tract level (2025)

Cromwell, Durham, Middlefield, and Portland are the only communities with a relatively low risk to hail. The remaining communities in RiverCOG have very low risk. Table 2.14.11 displays communities in RiverCOG and the number of census tracts at each risk rating to hail.

Table 2.14.11. Breakdown of community risk to hail

Community	Number of Census Tracts with Very Low Risk	Number of Census Tracts with Relatively Low Risk
Chester	1	-
Clinton	4	-
Cromwell	2	1
Deep River	1	-
Durham	-	1

Community	Number of Census Tracts with Very Low Risk	Number of Census Tracts with Relatively Low Risk
East Haddam	2	-
East Hampton	3	-
Essex	2	-
Haddam	2	-
Killingworth	1	-
Lyme	1	-
Middlefield	-	1
Middletown	13	-
Old Lyme	3	-
Portland	1	1
Total for RiverCOG Region	**36**	**4**

Estimated Losses

While crops are the major victims of hail, larger hail is also a hazard to people, vehicles, and property. Lightning strikes are relatively infrequent in Connecticut but can cause permanent damage to property or injury and death to a person along with starting fires. Lightning can also occur on any day even if a thunderstorm is not occurring. In general, the economic impact of thunderstorms is much lower than that of tropical cyclones winds but still significant because the damage is expected to occur each year.

Economic data was obtained from the NRI to determine expected annual loss from severe weather events. Figure 2.14.7 through Figure 2.14.9 below shows the expected annual loss ratings throughout the COG for lightning, strong wind, and hail. Table 2.14.12 through Table 2.14.14 describe the projected annualized losses from each of these hazards by community. The highest expected annual losses to all three hazards combined are found in Middletown with a projected $405,412 in annual losses due to severe weather. Additionally, Cromwell is another community with over $100,000 in expected annual loss due to severe weather with a combined $122,193 expected annual loss.

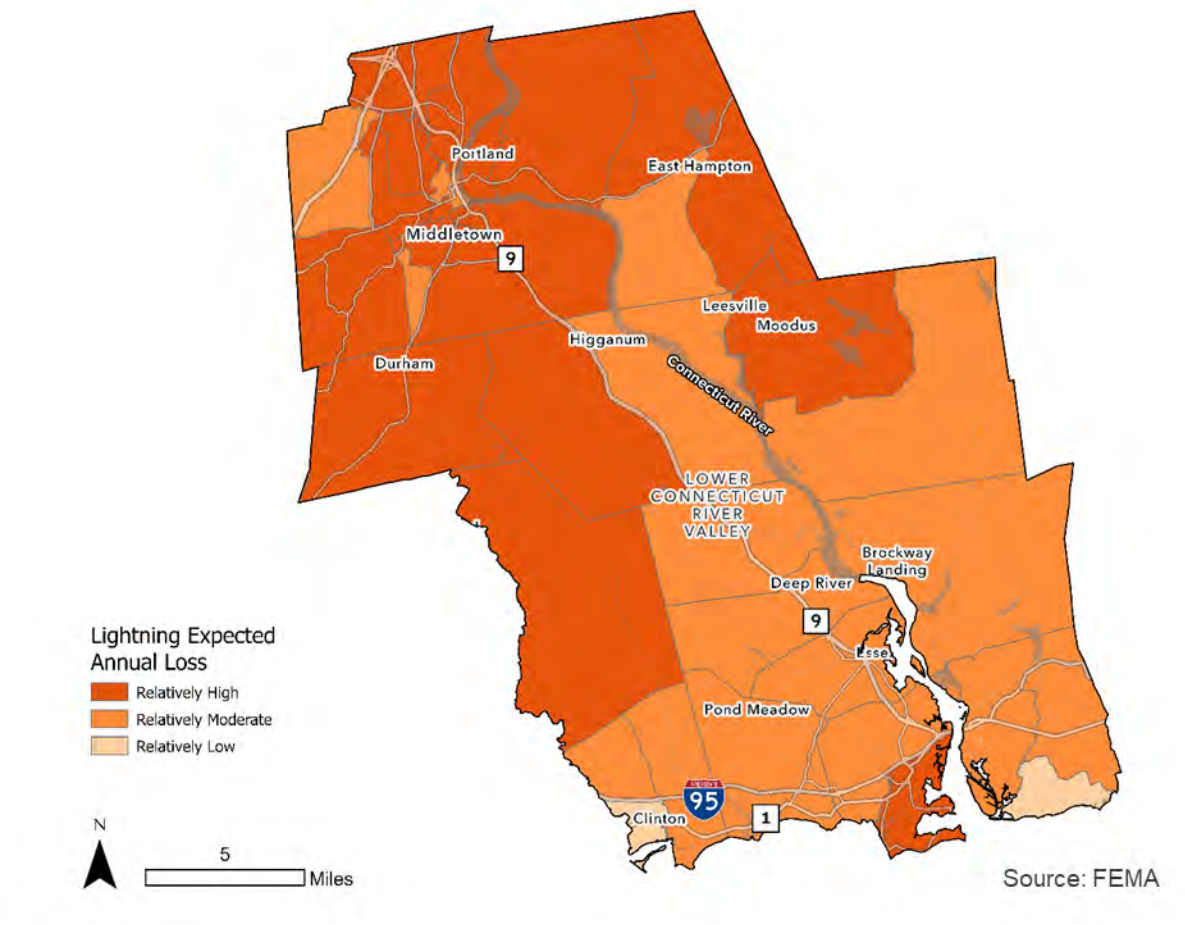


Figure 2.14.7. NRI Lightning Expected Annual Loss Rating (2025)

Table 2.14.12. Breakdown of Expected Annual Losses from the NRI by Community for Lightning

Community	Expected Annual Loss
Chester	$9,216
Clinton	$23,309
Cromwell	$52,473
Deep River	$11,299
Durham	$26,947
East Haddam	$24,553
East Hampton	$42,108
Essex	$17,186
Haddam	$24,299
Killingworth	$16,741

Community	Expected Annual Loss
Lyme	$7,640
Middlefield	$15,516
Middletown	$175,120
Old Lyme	$22,849
Portland	$32,113
Total for RiverCOG Region	**$501,369**

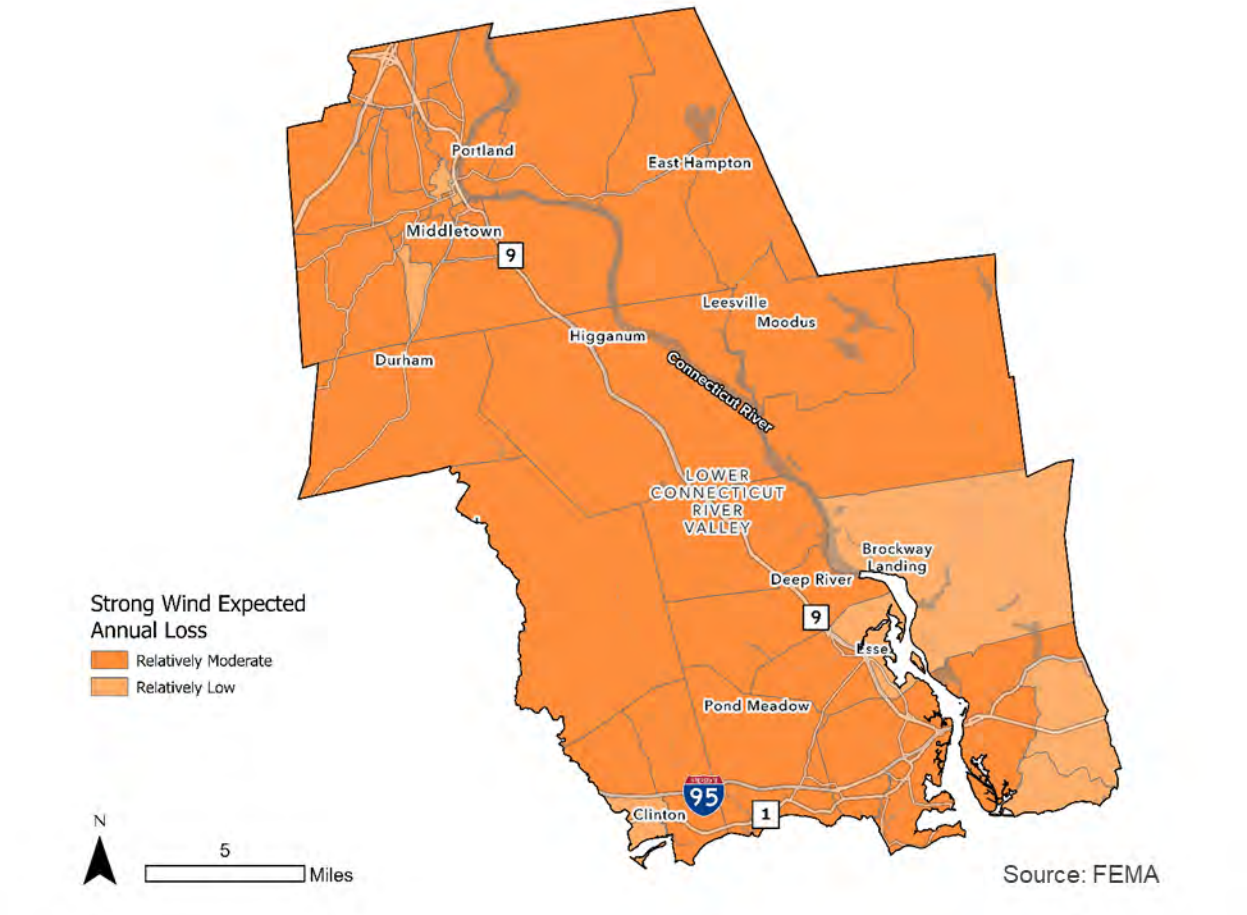


Figure 2.14.8. NRI Strong Wind Expected Annual Loss Rating (2025)

Table 2.14.13. Breakdown of Expected Annual Losses from the NRI by Community for Strong Wind

Community	Expected Annual Loss
Chester	$15,265

Community	Expected Annual Loss
Clinton	$52,148
Cromwell	$66,515
Deep River	$17,526
Durham	$32,100
East Haddam	$35,968
East Hampton	$45,828
Essex	$27,477
Haddam	$33,813
Killingworth	$24,484
Lyme	$9,058
Middlefield	$27,038
Middletown	$226,246
Old Lyme	$30,349
Portland	$36,569
Total for RiverCOG Region	**$680,384**

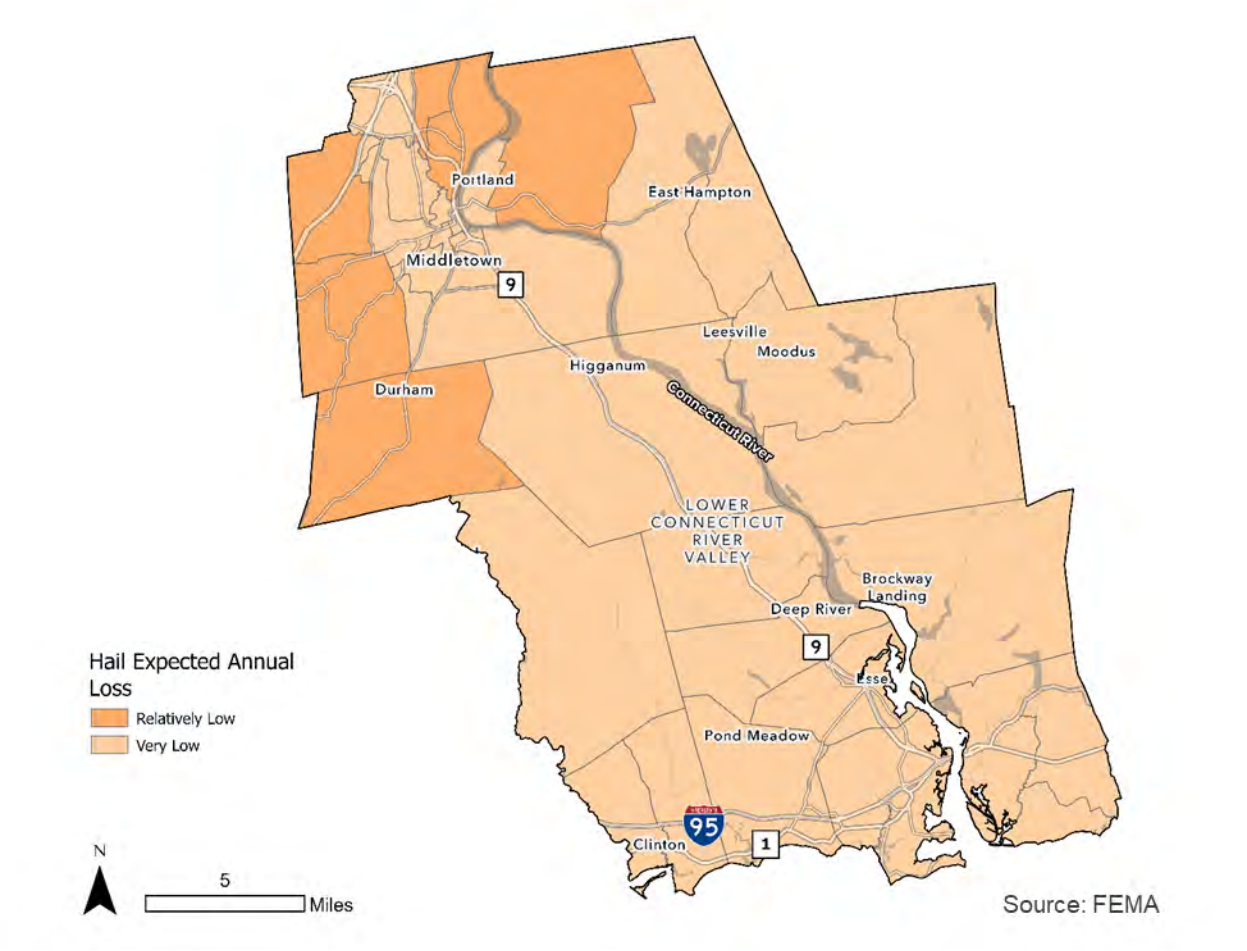


Figure 2.14.9. NRI Hail Expected Annual Loss Rating (2025)

Table 2.14.14. Breakdown of Expected Annual Losses from the NRI by Community for Hail

Community	Expected Annual Loss
Chester	$306
Clinton	$923
Cromwell	$3,205
Deep River	$314
Durham	$2,184
East Haddam	$1,348
East Hampton	$1,094
Essex	$566
Haddam	$812
Killingworth	$491

Community	Expected Annual Loss
Lyme	$358
Middlefield	$3,069
Middletown	$4,406
Old Lyme	$301
Portland	$1,756
Total for RiverCOG Region	$21,133

Additional estimates of community impacts have been determined based on data taken from the NCEI, shown in Table 2.14.15.[55] Please note that there were 64 events that could not be pin attributed to a specific town and are therefore included in a record called Middlesex County.

Table 2.14.15. Comparative Loss Estimates due to Thunderstorms

Community	Total Number of Events	Annualized Events	Total Damages	Annualized Damages
Chester	10	0.15	$13,500	$208
Clinton	4	0.06	$0	$0
Cromwell	7	0.11	$23,500	$362
Deep River	7	0.11	$25,500	$392
Durham	14	0.22	$32,000	$492
East Haddam	8	0.12	$18,000	$277
East Hampton	23	0.35	$82,500	$1,269
Essex	8	0.12	$22,000	$338
Haddam	13	0.20	$58,500	$900
Killingworth	8	0.12	$5,000	$77
Lyme	7	0.11	$5,000	$77
Middlefield	3	0.05	$1,500	$23
Middlesex County	64	0.98	$990,000	$15,231
Middletown	33	0.51	$46,000	$708
Old Lyme	3	0.05	$7,500	$115
Portland	11	0.17	$84,500	$1,300

Community	Total Number of Events	Annualized Events	Total Damages	Annualized Damages
Total	**	*	**$1,415,000**	**$21,769**

**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.*

FEMA Public Assistance

Based on the public assistance reimbursements in Table 2.14.5, the RiverCOG Region has incurred losses of approximately $6,258,640 since 1998 (26 years) from impacts due to severe weather. Based on this information, the annualized loss due to severe weather in the RiverCOG region is therefore $240,717. Annualized losses for each community are presented back in Table 2.14.6. These annualized loss estimates should be used with caution and as a minimum loss estimate. Public assistance expenditures are only a small part of the overall losses the region and its municipalities incur. Nevertheless, these figures provide useful planning numbers when considering the overall vulnerability of the RiverCOG Region to severe weather.

2.14.7. Development Trends

Since the 2021 plan update, development in the RiverCOG region has been light. Over the five year span (2019-2023) available on the RiverCOG Data Dashboard, population in the region has grown by approximately 1.7%.[56] A relatively small increase in population size, 0.5% below the growth rate of the state of Connecticut, which has had approximately a 2.2% population growth rate during the same time span.[57] Haddam, Old Lyme, Clinton, Cromwell, Middletown, and Essex have seen the greatest increases in population growth during this time span. That being said, the highest percent growth is only a 4.1% increase in Haddam. Chester has seen the largest population decrease with a decrease of 10.6% during this five-year time span. There are multiple reasons for this declining growth rate, but the COVID-19 pandemic is a large contributor.

Similarly, there has been only a 0.37% increase in housing stock in the region during the 2019-2023 five-year time frame with only 195 building permits issued in 2023 throughout RiverCOG.[58] The majority of these building permits issues in 2023 are in East Hampton (37) and East Haddam (25), both of which have seen decreases in housing stock during these five years. Killingworth, Durham, Haddam, Deep River, and Clinton have seen the largest increase in housing stock during this period. Additionally, commercial and industrial growth has been relatively stagnant during this time frame.

[56] https://www.rivercog.org/data-population

[57] https://www.census.gov/programs-surveys/popest.html

[58] https://www.rivercog.org/data-housingcharacteristics

Housing development and population growth in these areas will increase the number of residents exposed to and at risk to thunderstorms and severe weather. One benefit of new development, however, is that newer construction is generally built to stronger building codes. Therefore, newer buildings that replace older-code buildings should generally decrease overall risk due to thunderstorms and severe weather. For example, newer commercial and industrial buildings will be equipped with sprinklers and built to higher wind loading standards. When aging power infrastructure is replaced or retrofitted, typically it is more resilient to wind damages than older infrastructure. More specific changes in development are addressed at the community level in the municipal annexes in Volume II of this plan.

2.14.8. Overall Risk Rating

Using the parameters described in Table 2.8.1, the following hazard risk ratings were developed for thunderstorms and severe weather (Table 2.14.16).

Table 2.14.16. Overall Risk Rating of Thunderstorms and Severe Weather

Criteria	Hazard Risk Rating
Probability	4 (Highly Likely)
Impact: Affected Area	2 (Small)
Impact: Primary Impact	1 (Negligible)
Impact: Secondary Impacts	2 (Limited)
Survey Rating	2 (Moderate Concern)
Total Score	13.3
Overall Risk Ranking	**Moderate**

2.15. Hurricanes and Tropical Storms

2.15.1. Description and Background

Hurricanes and tropical storm systems threaten Connecticut residents with the possibility of storm surges, powerful winds, and heavy rains. These elements can lead to devastating inland and coastal flooding, as well as the loss of power and structural damage to homes and businesses. The coastal communities of the region (Clinton and Old Lyme) are the municipalities most at risk to inundation from a tropical event, with increased risk to those municipalities closer to the mouth of the Connecticut River. Further repercussions from tropical systems include substantial and widespread property damage, and loss of utility services, including electricity, water, telephone, cell service, sewage, and internet.

2.15.2. Location and Extent

A tropical cyclone is defined by the NWS as a "rotating, organized system of clouds and thunderstorms that originates over tropical or subtropical waters and has a closed low-level circulation." A tropical cyclone is further classified as a tropical depression, tropical storm, hurricane, or major hurricane and is most likely to form from June 1 through November 30 each year in the northern Atlantic Ocean.[59]

The Saffir-Simpson Hurricane Wind Scale is a 1 to 5 rating based on a hurricane's sustained wind speed. This scale estimates potential property damage. Hurricanes reaching Category 3 and higher are considered major hurricanes because of their potential for significant loss of life and damage. Category 1 and 2 storms are still dangerous, however, and require preventative measures.[60]

All areas of the RiverCOG communities are susceptible to tropical storms. Wind can impact all communities of the region. Coastal municipalities can experience storm surge and some of the highest winds, while low-lying areas can experience inland or riverine flooding. Typical damages from the Saffir-Simpson Hurricane wind scale are shown in Table 2.15.1.[61]

Table 2.15.1. Saffir-Simpson Hurricane Wind Scale and Typical Damages.

Category	Sustained Wind Speeds (mph)	Surge (ft)	Pressure (mb)	Typical Damage
Tropical Depression	<39	--	--	
Tropical Storm	39-73	--	--	
Hurricane 1	74-95	4-5	> 980	*Minimal* – Damage primarily to shrubbery and trees, unanchored manufactured homes damaged, some signs damaged, no real damage to structures on permanent foundations.
Hurricane 2	96-110	6-8	965-980	*Moderate* – Some trees toppled, some roof coverings damaged, major damage to manufactured homes.
Hurricane 3	111-130	9-12	945-965	*Extensive Damage* – Large trees toppled, some structural damage to roofs, manufactured

[59] https://www.nhc.noaa.gov/climo/

[60] https://www.weather.gov/mfl/saffirsimpson

[61] https://www.weather.gov/mfl/saffirsimpson

Category	Sustained Wind Speeds (mph)	Surge (ft)	Pressure (mb)	Typical Damage
				homes destroyed, structural damage to small homes and utility buildings.
Hurricane 4	131-155	13-18	920-945	*Extreme Damage* – Extensive damage to roofs, windows, and doors; roof systems on small buildings completely fail; some curtain walls fail.
Hurricane 5	> 155	> 18	< 920	*Catastrophic Damage* – Roof damage considerable and widespread, window and door damage severe, extensive glass failures, some buildings fail completely.

The Saffir-Simpson scale coupled with the NWS warning systems are appropriate for tropical storms and hurricanes in the RiverCOG region. These classification systems have been used for the tropical storms and hurricanes that have occurred in the region and its communities. Furthermore, the previously described flood risk mapping and warning systems are appropriate for flood associated with tropical systems. Tropical storms and hurricanes have not occurred outside of these systems of classification.

2.15.3. History of Past Events

Through research efforts by NOAA's National Climate Center in cooperation with the NHC, records of tropical cyclone occurrences within the Atlantic Cyclone Basin have been compiled from 1851 to present. Thirty-six hurricanes and tropical systems have passed within a 20-mile buffer of RiverCOG between 1851 and 2025, and 189 hurricanes and tropical storms passed within a 200-mile buffer.[62] Based on this data, the RiverCOG area is impacted by a close tropical event or hurricane once every 4.8 years and could be impacted by a tropical event or hurricane tracking farther afield every 0.9 years. While it is difficult to predict when a tropical storm or hurricane will strike the area, there is some consistency in the frequency of these storms.

Of the 36 tropical storms and hurricanes that have passed within 65 miles, the majority (27 storms) have been classified as either a tropical storm or a tropical depression at landfall. However, six of the hurricanes made impact as either Category 2 or 3.

The storm tracks of each hurricane event are displayed in Figure 2.15.1.[63]

[62] https://coast.noaa.gov/hurricanes/#map=4/32/-80

[63] https://coast.noaa.gov/hurricanes/#map=4/32/-80

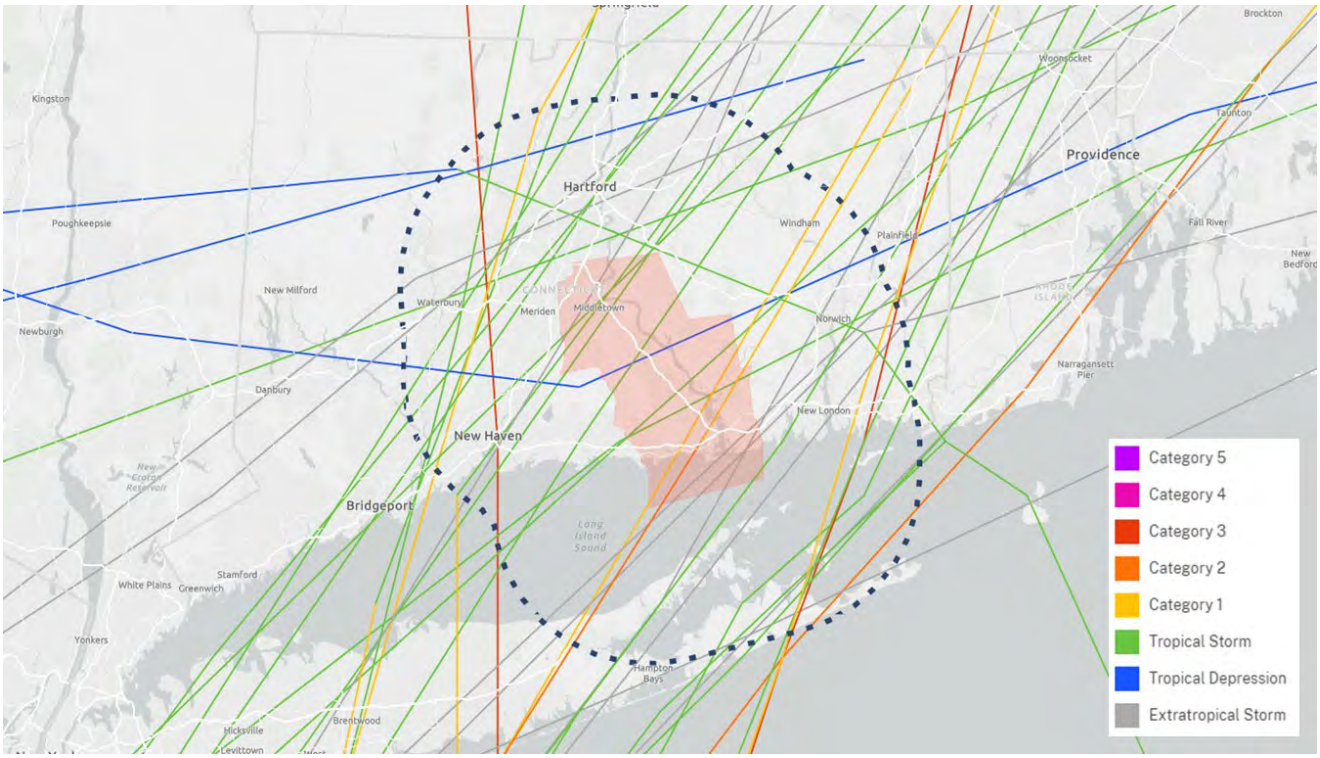


Figure 2.15.1. Hurricane tracks of the past events with a 20-mile buffer around the RiverCOG boundary

The following are detailed historical accounts of the major tropical storm systems that have affected the state of Connecticut. The accounts are compiled from NOAA. The records cover events from 1900 until present.

September 21, 1938: While this storm has no official name, it is often referred to as the Great New England Hurricane. It was classified as a Category 3 hurricane when it made landfall in Milford, Connecticut and is regarded as the most intense hurricane to ever strike Connecticut during the twentieth century. Sustained winds of 91 mph and gusts to 121 mph were reported on Block Island in Rhode Island. In Connecticut, high winds caused downed power lines in many areas and resulted in two catastrophic fires in New London and Mystic. While three-to-six inches of rain fell across most portions of the state, isolated amounts of 14-to-17 inches were reported in central Connecticut. The Connecticut River rose close to 20 feet above flood stage in Hartford as a result of the heavy rains. Further damage was caused from storm tides that reached up to 25 feet in portions of eastern Connecticut, while western sections saw storm tides of 14-to-18 feet. Many of the shorelines homes and cottages were destroyed, with far more experiencing varying degrees of damage.

September 14 and 15, 1944: Due to the system's large size and immense strength, the Miami Hurricane Warning Office named this storm the "Great Atlantic Hurricane". While there was no direct landfall made over Connecticut many places across the state saw hurricane force winds,

with a gust of 109 mph being reported in Hartford, Connecticut. However, it was the heavy rain, not strong winds that produced the greatest storm impact for the state. More than ten inches of rain fell in the City of Bridgeport, which was the highest total in the State.

August 31, 1954: Hurricane Carol arrived as a Category 3 system and was the most destructive tropical system to strike southern New England since the Great New England Hurricane of 1938. The storm made land fall near the mouth of the Connecticut River in Old Saybrook. The system brought sustained winds of 80-to-100 mph across much of the shoreline and through Rhode Island, and Cape Cod in Massachusetts. Heavy devastation occurred from large numbers of uprooted and snapped trees, and miles of downed power lines. Along Connecticut's coast, storm surge values varied greatly from five-to-eight feet in the west, to ten-to-fifteen in eastern portions of the state. There was also heavy crop damage, with 40 percent of apple, corn, peach, and tomato crops being destroyed along portions of eastern Connecticut to Cape Cod. It is reported that 48 people lost their lives and damages to possessions and property exceeded one billion dollars (in 1954 dollars) for the Northeast.

August 11 and 12, and 18 through 20, 1955: In an unusual occurrence, two named hurricanes, Connie and Diane, passed within proximity of the state within nine days. While neither storm directly struck Connecticut, their combined impact was immense.

Hurricane Connie was the first system, passing to the west. The system produced four-to-six inches of rain across southern New England. The rain saturated the ground and caused river and reservoir water levels to be well above normal.

When Hurricane Diane impacted Connecticut, the State's watercourses were already inundated from Connie and the ground was unable to absorb the additional rainfall. Over the two day period, up to 20 inches of rain fell in parts of the State. At the headwaters of the Farmington River, 18 inches of rain within a 24-hour period was recorded. This resulted in arguably the most devastating inland floods to ever hit the state. Roads and bridges were washed out across the state, residents lost drinking water and public utilities were inoperable. More than 90 people were confirmed dead from the storm and another dozen were missing and presumed dead. The damage was estimated to have exceeded 1.5 billion dollars (1955 dollars).

September 27, 1985: Hurricane Gloria formed off Cape Verde on September 15, 1985. It reached tropical storm status on September 17th but was downgraded to a tropical depression as optimal conditions deteriorated. The storm continued its west-northwest movement and strengthened to a major hurricane by September 24th. As the storm tracked further northward along the Atlantic coast it weakened significantly. Gloria was downgraded from a Category 4 hurricane near the Bahamas, to a Category 2 storm by the time it made landfall on the Outer Banks of North Carolina. Gloria maintained its strength through landfalls on Long Island, New York, and Bridgeport, Connecticut. It was only downgraded to Category 1 after passing to the west of Hartford, Connecticut. Gloria brought devastation to the state primarily in the form of heavy wind damage. The storm toppled thousands of trees and caused major structural damage statewide. Relatively

light rain from the storm meant that there was little flooding accompanying the wind damages and the power outages.

September 16, 1999: Torrential and record rainfall brought from Tropical Storm Floyd caused widespread urban, small stream, and river flooding. Fairfield, Hartford and Litchfield Counties were declared disaster areas. Serious widespread inland flooding throughout low elevation and poor drainage areas was prevalent and resulted in the closure of numerous roads and the flooding of many basements.

Connecticut and the RiverCOG region were impacted by two recent events that occurred in back-to-back years: Tropical Storm Irene and Superstorm Sandy.

August 28, 2011: Irene began as a tropical wave, moving off the coast of western Africa on August 15, 2011. After passing over Puerto Rico on August 22nd, Irene gained hurricane status and reached to Category 3 on August 24th with peak wind intensities of 120 mph.

As the storm proceeded north it passed offshore of Florida and Georgia, weakening along the way. Irene made landfall as a Category 1 near Cape Lookout, North Carolina on August 27th. After moving offshore, Irene tracked further north-northeastward along the Delmarva Peninsula making its second US landfall near Atlantic City, New Jersey as a tropical storm with maximum sustained winds of 69 mph. The system tracked up the Hudson River Valley before turning east across the northern Litchfield Hills of Connecticut on August 28th.

In Connecticut, Irene had been predicted to make landfall as a strong Category 1 or weak Category 2 hurricane, but it had been downgraded to a tropical storm by the time it reached the state. Irene produced average maximum wind gusts of 52 mph and downed approximately one-to-two percent of the trees in Connecticut. The extensive number of downed trees resulted in over 800,000 power outages. Restoration of power took up to twelve days. Heavy rains, up to six inches, caused widespread coastal flooding. Damage and inundation of seawater along the coast was worsened by a large wind envelop that pushed water into western Long Island Sound. Although Irene was a tropical storm by the time it reached Connecticut, it created a storm surge of about four feet, which is consistent with a Category 1 or 2 hurricane.

On September 2, 2011, President Obama issued a presidential disaster declaration for the entire state as a result of the damage caused by Tropical Storm Irene.

October 29, 2012: Sandy was a classic late-season Caribbean hurricane, originating from the remnants of a tropical wave that moved westward from the west coast of Africa. It made landfall in Jamaica as a Category 1 and increased in strength to a Category 3 east of Cuba. Despite weakening to a Tropical Storm as it moved out of the Caribbean Sea, it continued to grow. As it continued north-northwest and parallel to the US coast, Sandy re-strengthened into a Category 1 hurricane.

As Hurricane Sandy moved northward, several other atmospheric conditions affected it size, direction and damage potential. Typically, a high-pressure system is established over Bermuda

that causes tropical storms to veer to the northeast away from land. This high was not present to deflect the storm away from the Northeast. Secondly, a low-pressure frontal system was forming in the central US. This pattern typically creates conditions for a nor'easter to form. Instead, this trough combined with Sandy to increase its size and intensity. Finally, a large high-pressure system built-up over northeastern North America and blocked Sandy from moving out to sea turning it westerly toward the Mid-Atlantic coast. It accelerated at an average forward speed of 23 mph, but, at the same time, the colder waters weakened the system and caused Sandy to lose its tropical characteristics. It made landfall in New Jersey as a post-tropical (extratropical) storm with maximum sustained winds of about 65 mph. However, because of its size, Sandy created a catastrophic storm surge into the New York and New Jersey coastlines.

In Connecticut, the highest storm tide and greatest inundation occurred along western sections of the Connecticut coast. The National Oceanic Service tide gauge in New London measured 6.46 feet above normal tide levels, and 9.1 feet above normal tide levels in New Haven. The Connecticut River gauge height was recorded at 7.99 feet, when the mean daily height is typically between 1.0 and 1.5 feet. Inundation along the eastern coast of Connecticut were estimated to be between 3 to 5 feet above ground level. Various estimated values of flood water inundation based on United States Geological Survey (USGS) high-water marks and storm tide pressure sensors are listed below (Tropical Cyclone Report Hurricane Sandy, NHC, February 2013):

- Clinton: Estimated Inundation = 3.8 feet
- Old Lyme: Estimated Inundation = 3.2 feet

In Connecticut, Superstorm Sandy was responsible for the deaths of five people and caused damage to approximately 3,000 homes. The preliminary estimated value of the damage was about $360 million state-wide.

August 4, 2020: Category 1 Hurricane Isaias with maximum sustained winds of 85 mph, made landfall near Ocean Isle Beach, NC on August 3rd. Isaias' intensity weakened back to Tropical Storm strength as its forward speed increased to near 30 mph during the early morning of August 4th. Tropical Storm Isaias brought sustained tropical storm winds with gusts to near hurricane force across Southern Connecticut, resulting in widespread wind damage and power outages. There was also a confirmed EF-1 tornado in Westport, CT around 1:40 pm. Coastal impacts were minimal, and mainly from high surf along the coast. Rainfall amounts of 1/2 to 1 1/2 inches were observed across southwestern portions of CT.

July 9, 2021: Tropical Storm Elsa with maximum sustained winds of 65 mph, made landfall as a strong tropical storm on the panhandle of Florida on the morning of July 7th. The highest sustained winds generally measured 30 to 40 mph with peak gusts to 45 mph along the immediate central and southeastern Connecticut coast. A maximum sustained wind of 40 mph with peak gust of 47 mph was recorded at the US Coast Guard Academy in New London Connecticut. Across coastal southwestern Connecticut and interior of the coast, maximum sustained winds were generally ranged from 20 to 30 mph with gusts to 35 mph. Wind damage and coastal impacts were minimal

from Elsa. Heavy rainfall and flash flooding were the main impacts from Elsa. As Tropical Storm Elsa tracked across the eastern portion of the area during the morning hours of July 9, heavy rainfall north and west of the storm's center resulted in flash flooding across much of southern Connecticut. Rainfall totals ranged from 3-5 inches across much of the area.

September 1, 2021: The wide band of extremely heavy rain from the remnants of Hurricane Ida moved across southern Connecticut from the Greenwich area to the Norwich area in the southeastern part of the state. Rainfall rates within this band were measured at approximately 3 inches per hour. Major to catastrophic urban flooding of roads, buildings, and vehicles was reported across the southern swath of the state by dozens of cities and towns.

2.15.4. Probability of Future Events

Based on historical records, the RiverCOG region may be impacted by a tropical storm or hurricane at least once every 4.8 years and may be increasingly affected by more distant events once every 0.9 years. According to the Connecticut 2023 NHMP, a Category 1 hurricane can be expected to hit Connecticut every 17 years, a Category 2 every 39 years and Category 3 every 58-70 years. Despite these rates, it remains a possibility that a destructive storm will hit the area anytime during the hurricane season and the frequency of these storms is independent of when the last storm occurred.

According to the Geophysical Fluid Dynamics Laboratory at NOAA, tropical cyclone intensities are expected (greater than 66% chance) to increase 1% to 10% globally due to climate change and to also bring higher rainfall rates. More intensive tropical cyclones are likely to have higher wind speeds and storm surges. In addition to more intense storms, recent studies have indicated that while the number of hurricane and tropical storm events is not increasing on a global scale at this time, the regional distribution of these events is apparently shifting as a result of climate change.[64] It has been noted that since 1980 the number of tropical cyclones has been increasing in the Northern Atlantic and Central Pacific and declining in the Western Pacific and the South Indian Ocean.[65]

2.15.5. Climate Change Impacts

Climate change has begun to influence both the location and intensity of tropical storm events. Many climate simulations indicate that greenhouse gas warming can be attributed to the increasing frequency and intensity of these storms. Storm events are anticipated to bring heavier precipitation and stronger winds, which may increase damage, debris, and inland and coastal flooding events.

[64] (Murakami, et al. 2020)

[65] https://www.pnas.org/content/117/20/10706

Tropical Storm Isaias in August 2020, which caused massive power outages across Connecticut, and the remnants of Hurricane Ida in September 2021, which brought record-breaking rainfall and subsequent flooding, are two recent examples of the kind of supercharged extreme events expected under climate change. While floods, hurricanes, droughts, and other extreme events are not new to the state, the increased intensity and frequency pose magnified dangers to residents' health and wellbeing. Atlantic hurricanes are already becoming more intense with higher sustained wind speeds and greater amounts of precipitation, and this is expected to amplify as climate change progresses. Additionally, higher sea levels lead to more severe storm surges associated with coastal storms.

Given the history of storm events, as well as the climate change model projections, it is prudent to expect that there will be hurricanes impacting Connecticut in the near future that may be of greater frequency and intensity than in the past.

2.15.6. Impacts and Estimated Losses to the Region

Impacts

Tropical storms and hurricanes impact Connecticut with heavy rains, storm surge, and strong winds. Storm surge and devastating winds, while not unique to hurricanes and tropical storms, have the largest impact when associated with tropical events. Therefore, this plan discusses impacts from these conditions in this section.

Severe Winds

Section 2.9.3 describes the exposure analysis method used to characterize the upper boundaries of exposure to risks in the region. The following table (Table 2.15.2) presents the exposure to severe winds hazards associated with tropical storms and hurricanes.

Table 2.15.2. Tropical Storm and Hurricane Wind Exposure Analysis for RiverCOG Communities

Hazard	Number of Parcels	Value of At-Risk Parcels	Number of Critical Facilities	Value of At-Risk Critical Facilities	Number of Historic Assets	Value of At-Risk Historic Assets
Chester	1,822	$558	11	$30	44	$17
Clinton	6,989	$1,586	9	$74	654	$230
Cromwell	6,069	$1,707	14	$138	226	$113
Deep River	2,216	$577	13	$78	380	$99
Durham	3,066	$583	8	$18	94	$22
East Haddam	5,743	$1,124	14	$35	201	$64
East Hampton	6,203	$1,151	14	$39	399	$100

Hazard	Number of Parcels	Value of At-Risk Parcels	Number of Critical Facilities	Value of At-Risk Critical Facilities	Number of Historic Assets	Value of At-Risk Historic Assets
Essex	3,442	$1,378	12	$40	544	$271
Haddam	4,271	$816	14	$45	209	$69
Killingworth	2,775	$771	8	$25	47	$22
Lyme	1,709	$711	5	$9	280	$136
Middlefield	2,247	$464	8	$14	21	$9
Middletown	13,549	$5,581	36	$608	804	$1,474
Old Lyme	5,624	$1,544	12	$50	502	$217
Portland	4,725	$847	21	$24	161	$46

**All dollar figures are in millions*

Storm Surge

When a tropical storm or hurricane passes through the Region, it will impact the entire area. However, because these storms have the capability of producing an excessive surge of water, inundation of coastal areas is more likely, and, as a result, these areas are more vulnerable and at a greater risk. Hurricane storm surge maps depict the inundation of flood waters that would be expected from a worst-case scenario of different categories of hurricane (such as Figure 2.15.2).

Based on the storm surge mapping and other GIS data developed by RiverCOG, the exposure of parcels, buildings, historic resources, and critical facilities has been developed for each storm surge zone. Table 2.15.3 presents the exposure for the towns Chester, Clinton, Deep River, Essex, Lyme, and Old Lyme, respectively. Exposure is not an estimation of losses; it is a complete inventory of the number and value of property at risk in the surge zones. Note that the remaining communities in the region do not have any areas that lie within storm surge zones.

Table 2.15.3. Hurricane Storm Surge Exposure of At-Risk Parcels, Critical Facilities, and Historic Assets for the RiverCOG Region (values are cumulative)

Hazard	Category	Number of Parcels	Value of At-Risk Parcels	Number of Critical Facilities	Value of At-Risk Critical Facilities	Number of Historic Assets	Value of At-Risk Historic Assets
Chester	Category 1	123	$47	1	$0.3	3	$2.2
Clinton	Category 1	1,090	$328	2	$6.5	138	$55.6
Deep River	Category 1	84	$61	1	$12.1	12	$6.9

Hazard	Category	Number of Parcels	Value of At-Risk Parcels	Number of Critical Facilities	Value of At-Risk Critical Facilities	Number of Historic Assets	Value of At-Risk Historic Assets
East Haddam	Category 1	3	$1	0	$0	1	$0.5
Essex	Category 1	207	$202	0	$0	50	$58.0
Killingworth	Category 1	0	$0	0	$0	0	$0.0
Lyme	Category 1	274	$190	0	$0	38	$31.6
Old Lyme	Category 1	1,029	$391	2	$27	131	$89.4
Chester	Category 2	154	$57	1	$0.3	3	$2.2
Clinton	Category 2	1,492	$425	2	$6.5	200	$73.0
Deep River	Category 2	99	$66	1	$12.1	13	$7.2
East Haddam	Category 2	4	$2	0	$0	1	$0.5
Essex	Category 2	221	$210	0	$0	53	$59.7
Killingworth	Category 2	4	$0	0	$0	0	$0.0
Lyme	Category 2	311	$209	0	$0	53	$40.3
Old Lyme	Category 2	1,521	$524	2	$27	192	$103.5
Chester	Category 3	185	$67	1	$0.3	3	$2.2
Clinton	Category 3	2,227	$574	3	$13.4	300	$115.6
Deep River	Category 3	127	$73	1	$12.1	24	$11.1
East Haddam	Category 3	5	$2	0	$0	1	$0.5
Essex	Category 3	253	$234	0	$0	63	$68.0
Killingworth	Category 3	18	$3	0	$0	1	$0.1
Lyme	Category 3	342	$226	0	$0	57	$41.6
Old Lyme	Category 3	1,929	$645	2	$27	234	$127.2
Chester	Category 4	225	$81	2	$1.6	6	$3.9
Clinton	Category 4	2,648	$672	3	$13.4	406	$150.1
Deep River	Category 4	150	$78	1	$12.1	33	$13.0
East Haddam	Category 4	5	$2	0	$0	1	$0.5

Hazard	Category	Number of Parcels	Value of At-Risk Parcels	Number of Critical Facilities	Value of At-Risk Critical Facilities	Number of Historic Assets	Value of At-Risk Historic Assets
Essex	Category 4	378	$293	0	$0	86	$83.0
Killingworth	Category 4	20	$4	0	$0	1	$0.1
Lyme	Category 4	364	$235	1	$1.1	60	$44.0
Old Lyme	Category 4	2,255	$734	2	$27	278	$141.3

**All dollar values are in millions*

In Clinton, a Category 1 or 2 hurricane is likely to cause widespread flooding along the coastline, however, the flooding will likely be confined to the marshes throughout the area. Some roadways in the Hammock Point neighborhood, such as W Road, Uncas Road, Kelsey Road, and Hammock Parkway, may become inundated. A category 3 or 4 event may result in increased flooding of properties south of Route 1, including residential neighborhoods to the west of the Indian River, along with commercial properties on Route 1 that are located south of the Hammock River, and north of the Hammock River Marsh Wildlife area.

In Old Lyme a Category 1 hurricane is likely to cause flooding throughout the marshes of the Great Island Wildlife Area, and those along the Black Hall River. A small number of residential properties west of Shore Road and east of Boxwood Manor may also be impacted. In addition, properties adjacent to the Swan Brook would be inundated during a Category 1 event. A Category 2 event would be widespread flooding to the developed areas north of Soundview Beach, in addition to those areas inundated during Category 1. A Category 3 or 4 would inundate about half of the Soundview Beach developed area south of Shore Road, as well as result in inundation of the properties off of Shore Road located northeast of the Black Hall River and Connecticut River confluence.

In Lyme, a majority of inundation from all Category storms is confined to the marsh areas along the Connecticut River, Eight Mile River, and within Whalebone Cove. Some sections of roadways near these and other marsh areas will be inundated, most often as a result of a Category 2 or 3 hurricane.

In Chester, there is marginal difference between the inundation areas of a Category 1 and 4 hurricanes; this is due to the steep topography of the river shoreline. Most properties inundated appear to be marina or yacht clubs along the river. There is one waterway, Chester Creek, that allows for the most inland inundation. Both Chester Point Marina and Hays Haven Marina are along this water way, which allows storm surge inland where properties near the Main Street and Water Street intersection are vulnerable to inundation of a Category 2 hurricane. Several properties along the Pattaconk Brook would be inundated as a result of a Category 4 event.

Similar to the previous riverine communities, storm surge inundation for Deep River is relatively confined along the shoreline, and within the marsh areas. The largest area of inundation would occur within the marsh area southwest of Eustasia Island in Post Cove. Multiple sections of Essex Street will be inaccessible in this area as a result of a Category 1, or larger, hurricane. There are also several properties along the river, from Brockway Ferry Road south to the Essex town boundary, that will become inundated during a Category 1 hurricane.

In Essex during a Category 1 hurricane, the northern half of the town is fairly protected by a large marsh that acts as a barrier island, however, the Pettipaug Yacht Club located on this island would become inundated. Otherwise, a Category 1 event would result in minimal inundation impacting shoreline dependent properties such as marinas. A Category 2 event would not result in much more inundation in comparison, this event would however inundate a cluster of sites located off Main Street including the Essex Yacht Club, the Town Dock and the Connecticut River Museum. A Category 3 or 4 event would result in increased inundation of this Main Street area, in addition to some properties along the shore in South Cove, and the condominiums of Heritage Cove. Figure 2.15.2 presents hurricane surge inundation areas for the region including the two coastal municipalities, and those along the Connecticut River that may be impacted.

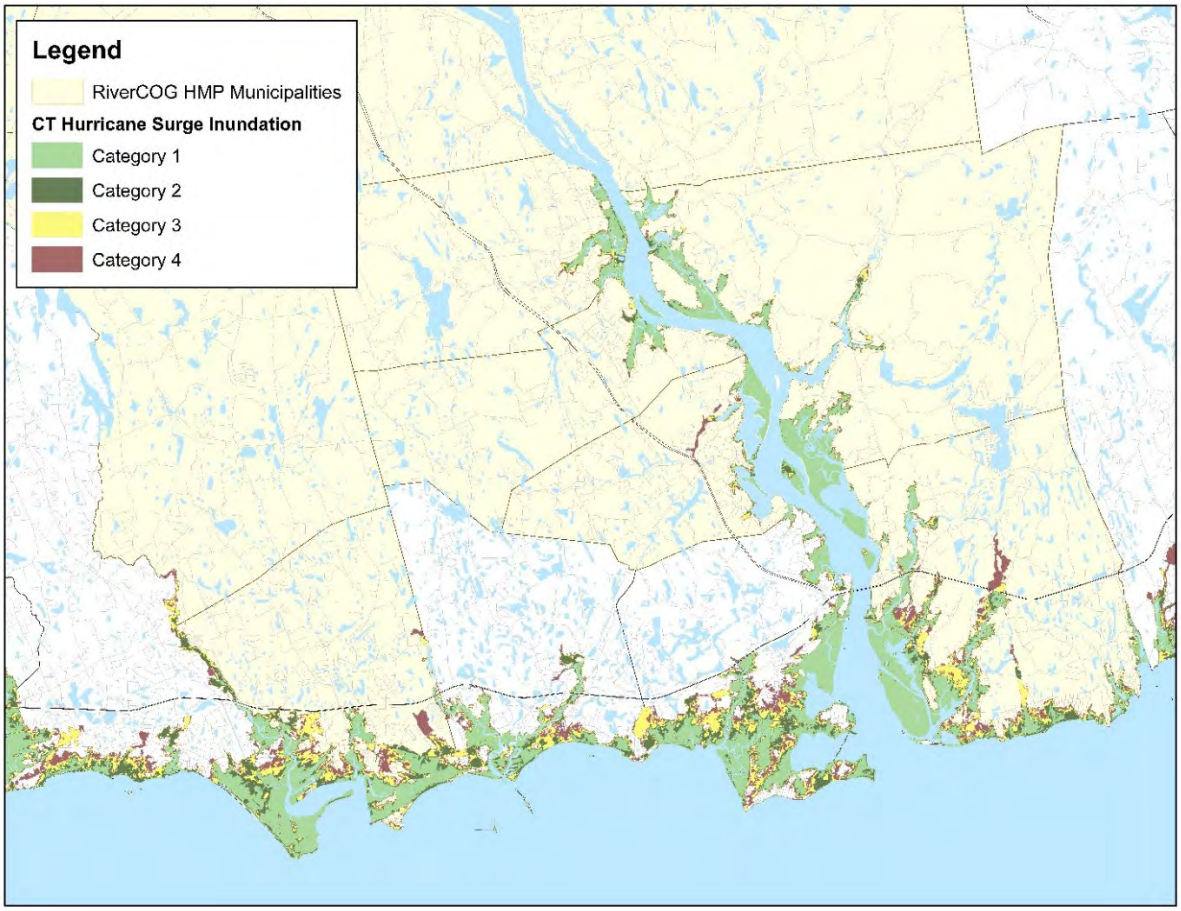


Figure 2.15.2. Hurricane storm surge inundation areas for the RiverCOG Region.

Other factors that influence vulnerability to tropical cyclones in the Region include building codes currently in place, local zoning and development patterns, and the age and number of structures located in highly vulnerable areas of the communities. In general, as the residents and businesses of Connecticut become more dependent on the internet and mobile communications, the impact of hurricanes on commerce will continue to increase. A major hurricane has the potential of causing complete disruption of power and communications for up to several weeks, rendering electronic devices and those that rely on utility towers and lines inoperative.

Debris such as signs, roofing material, and small items left outside become flying missiles in hurricanes. Extensive damage to trees, towers, aboveground and underground utility lines (from uprooted trees or failed infrastructure), and fallen poles cause considerable disruption for residents. Streets may be flooded or blocked by fallen branches, poles, or trees, preventing egress. Downed power lines from heavy winds can also start fires during hurricanes with limited rainfall. While moving all utilities underground would prevent wind damage to this infrastructure, this activity is generally too cost-prohibitive for communities.

Estimated Losses

Wind

Wind damage from tropical cyclones affects the entire Region. To quantify the impact of these storms the Hazus-MH 4.2 Hurricane Model was utilized. Hazus-MH does not estimate damage based on hurricane category but rather runs a probabilistic analysis similar to terminology associated with flooding. For hurricanes, probabilistic scenarios of 10, 20, 50, 100, 500, and 1000-year wind events were separately modeled for each municipality.

Building Damage

The default building stock from Hazus-MH was used for all the Hazus-MH analyses in this report. According to this database there are 64,206 buildings in the Region. Middletown has the most buildings with 14,449.

Hazus-MH uses a hazard-load-resistance-damage-loss methodology to produce loss estimations. Using wind models along with damage probabilities, expected building losses were estimated. The descriptions of damage by be found Table 2.15.4.

Table 2.15.4. Damage description from **Hazus-MH Hurricane Model Technical Manual.**

Damage State	Qualitative Damage Description	Roof Cover Failure	Window Door Failures	Roof Deck	Missile Impacts on Walls	Roof Structure Failure	Wall Structure Failure
0	**No Damage or Very Minor Damage** Little or no visible damage from the outside. No broken	≤2%	No	No	No	No	No

Damage State	Qualitative Damage Description	Roof Cover Failure	Window Door Failures	Roof Deck	Missile Impacts on Walls	Roof Structure Failure	Wall Structure Failure
	windows, or failed roof deck. Minimal loss of roof over, with no or very limited water penetration.						
1	**Minor Damage** Maximum of one broken window, door, or garage door. Moderate roof cover loss that can be covered to prevent additional water entering the building. Marks or dents on walls requiring painting or patching for repair.	>2% and ≤15%	One window, door, or garage door failure	No	<5 impacts	No	No
2	**Moderate Damage** Major room cover damage, moderate window breakage. Minor roof sheathing failure. Some resulting damage to interior of building from water.	>15% and ≤50%	> one and ≤ the larger of 20% & 3	1 to 3 panels	Typically 5 to 10 impacts	No	No
3	**Severe Damage** Major window damage or roof sheathing loss. Major roof cover loss. Extensive damage to interior from water.	>50%	> the larger of 20% & 3 and ≤50%	>3 and ≤25%	Typically 10 to 20 impacts	No	No
4	**Destruction** Complete roof failure and/or, failure of wall frame. Loss of more than 50% of roof sheathing.	Typically >50%	>50%	>25%	Typically >20 impacts	Yes	Yes

In the Region, no buildings were damaged in a 10-year event and severely damaged buildings were first estimated in a 100-year event.

Table 2.15.5 aggregates the data for a regional projection. Town specific projections can be found in Appendix B. In the region, 210 buildings are at least moderately damaged in a 100-year event, but that number increases to over 5,200 buildings at least moderately damaged in a 1000-year event with 403 buildings being completely destroyed.

Table 2.15.5. Aggregate data for regional building damages based on occupancy type.

Building Occupancy	Return Period	None	Minor	Moderate	Severe	Destruction
Agriculture	10-Year	290	0	0	0	0
Commercial	10-Year	3,718	0	0	0	0
Education	10-Year	178	0	0	0	0
Government	10-Year	93	0	0	0	0
Industrial	10-Year	1,383	0	0	0	0
Religion	10-Year	303	0	0	0	0
Residential	10-Year	58,242	0	0	0	0
Agriculture	20-Year	290	0	0	0	0
Commercial	20-Year	3,709	9	0	0	0
Education	20-Year	178	0	0	0	0
Government	20-Year	93	0	0	0	0
Industrial	20-Year	1,382	1	0	0	0
Religion	20-Year	303	0	0	0	0
Residential	20-Year	58,216	24	1	0	0
Agriculture	50-Year	289	0	0	0	0
Commercial	50-Year	3,681	35	0	0	0
Education	50-Year	178	0	0	0	0
Government	50-Year	93	0	0	0	0
Industrial	50-Year	1370	12	0	0	0
Religion	50-Year	302	1	0	0	0
Residential	50-Year	57,828	486	23	0	0
Agriculture	100-Year	278	11	0	0	0
Commercial	100-Year	3,596	107	10	0	0

Building Occupancy	Return Period	None	Minor	Moderate	Severe	Destruction
Education	100-Year	176	1	0	0	0
Government	100-Year	91	2	0	0	0
Industrial	100-Year	1340	41	1	0	0
Religion	100-Year	293	7	0	0	0
Residential	100-Year	55,632	2,416	199	3	2
Agriculture	200-Year	258	29	3	0	0
Commercial	200-Year	3,388	272	53	4	0
Education	200-Year	195	13	0	0	0
Government	200-Year	87	4	0	0	0
Industrial	200-Year	1,268	93	18	1	0
Religion	200-Year	274	24	2	0	0
Residential	200-Year	51,177	6,232	786	27	18
Agriculture	500-Year	215	54	14	4	0
Commercial	500-Year	2,996	586	204	34	0
Education	500-Year	140	27	6	0	0
Government	500-Year	72	16	3	0	0
Industrial	500-Year	1093	203	71	17	0
Religion	500-Year	237	50	11	0	0
Residential	500-Year	42,794	12,534	2,575	200	144
Agriculture	1,000-Year	177	71	39	14	0
Commercial	1,000-Year	2432	801	395	86	0
Education	1,000-Year	118	39	17	2	0
Government	1,000-Year	62	20	7	1	0
Industrial	1,000-Year	924	278	144	38	1
Religion	1,000-Year	199	74	30	4	0
Residential	1,000-Year	35,910	16,733	4581	565	402

Economic Loss

Economic loss was calculated from both direct property damage and business interruption. Direct property damage includes the estimated costs to repair or replace the damage caused to the buildings and its contents. The business interruption costs are those associated with the inability of a business to function due to the hurricane. The breakdown of economic loss in these categories can be found in Appendix B. Again, these estimates are for wind damage only.

Table 2.15.6 summarizes the combined economic loss for each town. These values were inflated to 2026 dollar amounts. The combined economic loss for the region from the 100-year wind event was estimated at $174.5 million, while the combined economic loss from the 1000-year wind event was estimated at $1.74 billion.

Table 2.15.6. Combined economic loss for each RiverCOG municipality for each hurricane scenario.

Municipality	10-Year	20-Year	50-Year	100-Year	200-Year	500-Year	1,000-Year
Chester	$0	$79,921	$1,919,387	$5,428,508	$11,676,657	$26,803,061	$47,178,711
Clinton	$0	$716,102	$7,806,823	$20,913,495	$50,585,575	$130,522,325	$237,873,138
Cromwell	$0	$16,759	$3,890,997	$12,161,758	$26,493,773	$63,480,012	$118,257,946
Deep River	$0	$42,084	$1,526,185	$4,611,709	$10,504,119	$25,685,444	$48,465,969
Durham	$0	$43,028	$1,790,812	$5,693,425	$12,151,304	$30,624,035	$58,427,706
East Haddam	$0	$178,209	$4,104,562	$11,577,268	$24,038,925	$59,273,471	$110,449,732
East Hampton	$0	$74,826	$3,217,862	$9,921,189	$21,318,506	$52,428,380	$92,216,230
Essex	$0	$299,427	$4,423,675	$12,280,145	$26,315,020	$66,174,041	$125,840,339
Haddam	$0	$57,402	$2,241,997	$6,749,029	$14,394,172	$34,812,051	$66,302,591
Killingworth	$0	$49,211	$1,937,029	$5,458,407	$11,190,358	$28,074,323	$48,685,790
Lyme	$0	$129,180	$1,455,110	$3,719,250	$7,211,346	$18,265,132	$33,145,869
Middlefield	$0	$10,430	$1,045,537	$3,208,702	$6,950,809	$17,458,763	$37,493,774
Middletown	$0	$260,646	$12,596,294	$41,336,831	$95,466,616	$234,589,331	$421,033,016
Old Lyme	$0	$1,098,426	$9,657,288	$22,990,387	$48,304,204	$129,658,034	$220,201,281

Municipality	10-Year	20-Year	50-Year	100-Year	200-Year	500-Year	1,000-Year
Portland	$0	$67,385	$3,072,856	$8,489,275	$17,960,575	$44,437,129	$78,734,264
RiverCOG Region	**$0**	**$3,123,034**	**$60,686,413**	**$174,539,378**	**$384,561,958**	**$962,285,533**	**$1,744,306,355**

To supplement the above information, FEMA's NRI was utilized to obtain information for a risk analysis on hurricanes at the census tract level across RiverCOG. Figure 2.15.3 displays the risk rating by census tract in the RiverCOG region for hurricanes. The relatively high portion of Figure 2.15.3 below is Old Saybrook which is not covered in this plan.

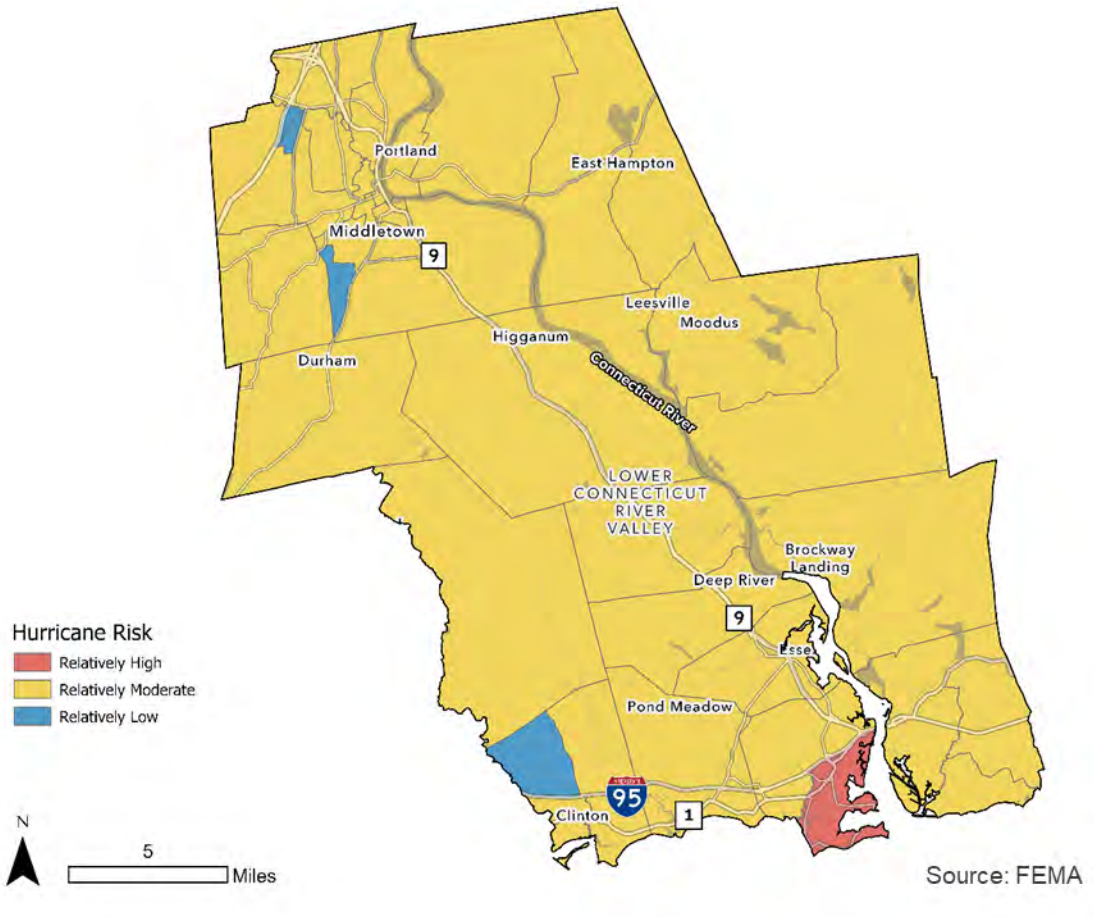


Figure 2.15.3. NRI Risk Rating for Hurricane, shown at the census tract level (2025)

The majority of the RiverCOG region is at a relatively moderate risk to hurricanes, with the exception of parts of Clinton and Middletown, which have some census tracts at a relatively low risk to hurricanes. Table 2.15.7 displays communities in RiverCOG and the number of census tracts at each risk rating to hurricane.

Table 2.15.7. Breakdown of community risk to tornado

Community	Number of Census Tracts with Relatively Low Risk	Number of Census Tracts with Relatively Moderate Risk
Chester	-	1
Clinton	1	3
Cromwell	-	3
Deep River	-	1
Durham	-	1
East Haddam	-	2
East Hampton	-	3
Essex	-	2
Haddam	-	2
Killingworth	-	1
Lyme	-	1
Middlefield	-	1
Middletown	3	10
Old Lyme	-	3
Portland	-	2
Total for RiverCOG Region	**4**	**36**

Figure 2.15.4 below shows the expected annual loss ratings throughout the COG based on the NRI and Table 2.15.8 describes the projected annualized losses from hurricanes by community. The highest expected annual losses are found in Middletown, Old Lyme, and Clinton with a projected $2.84 million, $1.10 million, and $1.07 million in expected annual losses due to hurricanes respectively. The RiverCOG region has a total expected annual loss of $12.48 million.

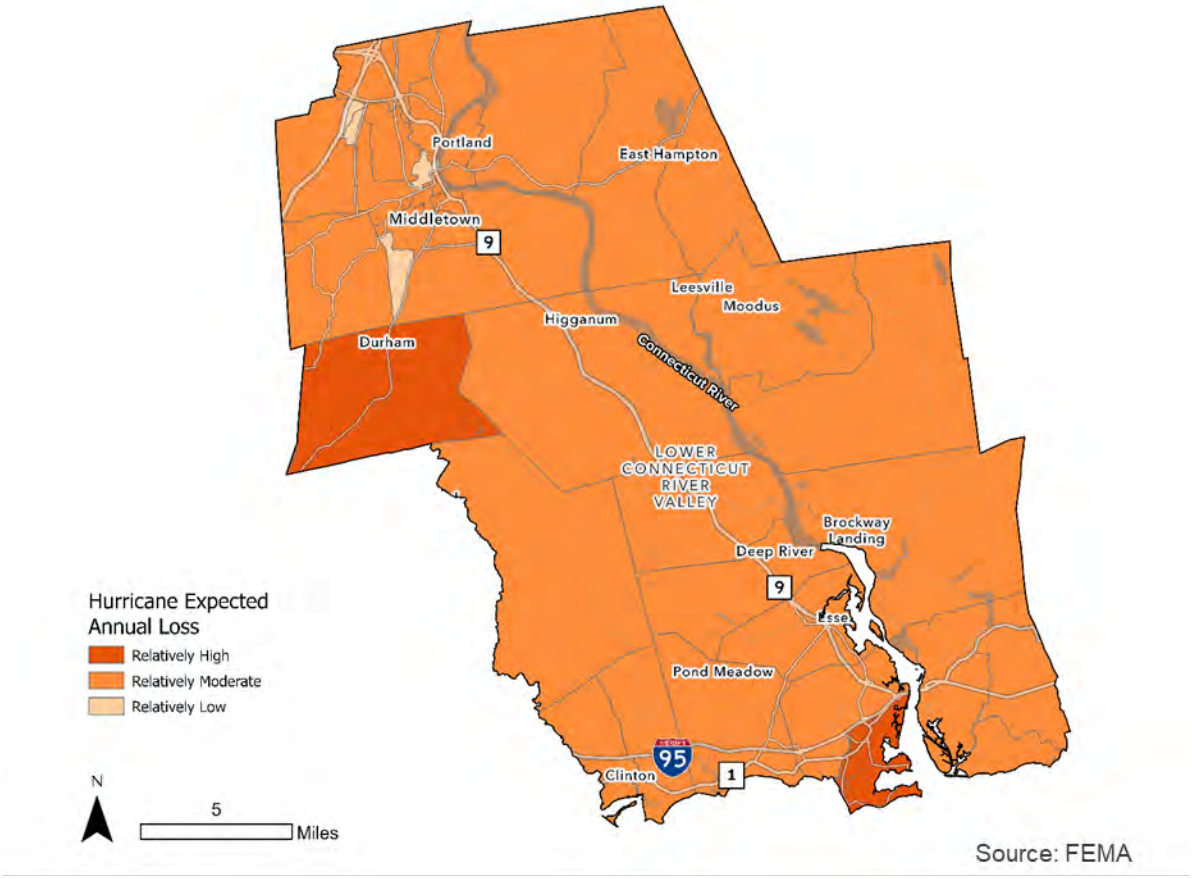


Figure 2.15.4. NRI Hurricane Expected Annual Loss Rating (2025)

Table 2.15.8. Breakdown of NRI expected annual losses from hurricanes by community

Community	Expected Annual Loss
Chester	$368,635
Clinton	$1,067,915
Cromwell	$973,747
Deep River	$367,076
Durham	$689,154
East Haddam	$850,918
East Hampton	$807,499
Essex	$671,266
Haddam	$742,683
Killingworth	$510,044
Lyme	$310,739

Community	Expected Annual Loss
Middlefield	$330,686
Middletown	$2,838,718
Old Lyme	$1,096,063
Portland	$850,720
Total for RiverCOG Region	**$12,475,863**

As noted in Section 2.9.2, Hazus AAL and NRI EAL are modeled using two different methodologies and therefore yield quite different results. Both are worth analyzing in the plan to lend insight to the relative risks from hurricane wind across jurisdictions.

2.15.7. Development Trends

Since the 2021 plan update, development in the RiverCOG region has been light. Over the five year span (2019-2023) available on the RiverCOG Data Dashboard, population in the region has grown by approximately 1.7%.[66] A relatively small increase in population size, 0.5% below the growth rate of the state of Connecticut, which is has had approximately a 2.2% population growth rate during the same time span.[67] Haddam, Old Lyme, Clinton, Cromwell, Middletown, and Essex have seen the greatest increases in population growth during this time span. That being said, the highest percent growth is only a 4.1% increase in Haddam. Chester has seen the largest population decrease with a decrease of 10.6% during this five-year time span. There are multiple reasons for this declining growth rate, but the COVID-19 pandemic is a large contributor.

Similarly, there has been only a 0.37% increase in housing stock in the region during the 2019-2023 five-year time frame with only 195 building permits issued in 2023 throughout RiverCOG.[68] The majority of these building permits issues in 2023 are in East Hampton (37) and East Haddam (25), both of which have seen decreases in housing stock during these five years. Killingworth, Durham, Haddam, Deep River, and Clinton have seen the largest increase in housing stock during this period. Additionally, commercial and industrial growth has been relatively stagnant during this time frame.

Housing development and population growth in these areas will increase the number of residents exposed and at risk to hurricanes. One benefit of new development, however, is that newer construction is generally built to stronger building codes. Therefore, newer buildings that replace older-code buildings should generally decrease overall risk due to hurricanes. For example, newer

[66] https://www.rivercog.org/data-population

[67] https://www.census.gov/programs-surveys/popest.html

[68] https://www.rivercog.org/data-housingcharacteristics

commercial and industrial buildings will be constructed to higher wind loading standards. When aging power infrastructure is replaced or retrofitted, typically it is more resilient to wind damages than older infrastructure. Additionally, new development in Old Lyme and Clinton, the two coastal communities in RiverCOG, are more at risk to coastal storm surge from hurricanes and must be built to higher standards. More specific changes in development are addressed at the community level in the municipal annexes in Volume II of this plan.

2.15.8. Overall Risk Rating

Using the parameters described in Table 2.8.1, the following hazard risk ratings were developed for hurricanes and tropical storms (Table 2.15.9).

Table 2.15.9: Overall Risk Rating of Hurricanes and Tropical Storms

Criteria	Hazard Risk Rating
Probability	3 (Likely)
Impact: Affected Area	4 (Large)
Impact: Primary Impact	3 (Critical)
Impact: Secondary Impacts	3 (Moderate)
Survey Rating	3 (High Concern)
Total Score	15.8
Overall Risk Ranking	**Significant**

2.16. Tornado

2.16.1. Description and Background

A tornado is a violent, destructive whirling windstorm accompanied by a funnel-shape cloud that progresses in a narrow path over land. Tornadoes are a relatively infrequent occurrence in Connecticut but can be very destructive when they do occur. While small tornadoes in outlying areas cause little to no damage, larger tornadoes in populated sections of Connecticut have historically caused significant damage, injury, and death through the destruction of trees, buildings, vehicles, and power lines.

Between 1950 and 2024, Connecticut has experienced 130 tornadoes that injured over 700 people, resulted in four deaths, and caused over $600 million in damages.[69] The state averages almost two tornadoes every year, with the majority of past tornado occurrences occurring in the western

[69] https://data.norwichbulletin.com/tornado-archive/

counties in the state.[70][71] Within the RiverCOG region, 13 recorded tornadoes touched down since 1799, the most damaging was in 1951 in East Hampton which caused 8 injuries and $250,000 of property damage.[72] Typically, tornadoes occur between April and October. High winds and microbursts (strong straight-line downburst winds) can also inflict damage to property and result in injuries.

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."[73] 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 like landspouts but occur over water rather than land.[74]

2.16.2. Location and Extent

All areas of the RiverCOG Region communities are susceptible to tornadoes. The likelihood of damage, injury, and death increases dramatically when a tornado occurs in a populated area. Tornadoes typically cause damage in a straight line although "skipping" tornadoes are also possible where a tornado can pass over portions of its route without causing damage.

The Fujita Damage Scale (F-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 2.16.1, 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

[70] https://data.norwichbulletin.com/tornado-archive/

[71] Connecticut NHMP https://portal.ct.gov/demhs/-/media/demhs/_docs/plans-and-publications/ehsp0024---2023-natural-hazard-mitigation-plan---final.pdf?rev=01aae6d47e8e4bf8a0e24f4ca71581ee&hash=D7467FC0C0E730B61AD407EC3487AD9B

[72] https://data.norwichbulletin.com/tornado-archive/connecticut/1951/

[73] https://www.nssl.noaa.gov/education/svrwx101/thunderstorms/types/

[74] https://www.nssl.noaa.gov/education/svrwx101/tornadoes/types/

structure size, building construction and material characteristics, and damage descriptions per DOD.[75] Figure 2.16.1 shows the anatomy of a typical tornado.[76]

Table 2.16.1. 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.

[75] http://www.spc.noaa.gov/efscale/ef-scale.html

[76] https://wu-next-prod.wunderground.com/article/science/weather-explainers/news/2025-04-29-supercell-thunderstorm-explainer

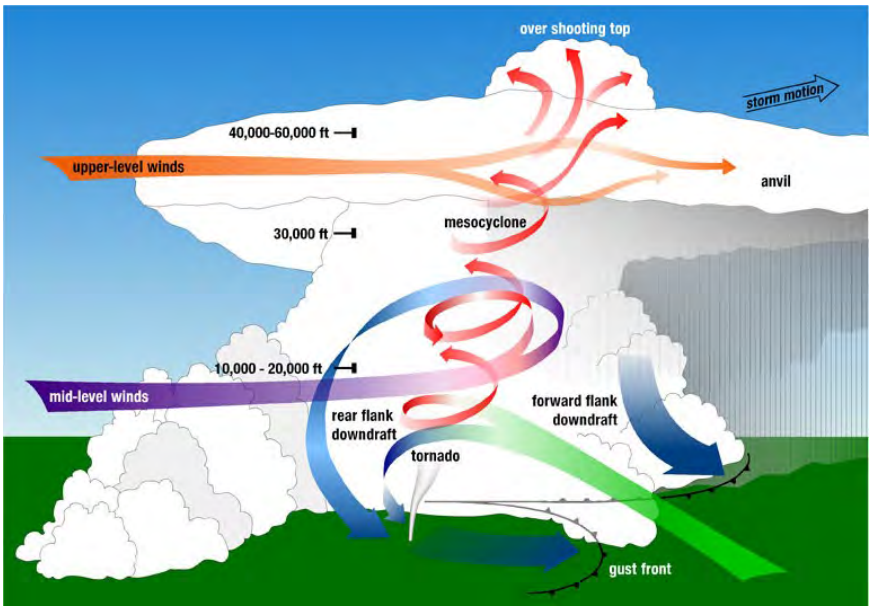


Figure 2.16.1. A schematic of the basic morphology of a tornadic supercell

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 DODs which help better estimate the range of wind speeds produced by the tornado. From that, a rating is assigned, like 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. Table 2.16.2 shows the different measurements of wind by scale.[77]

Table 2.16.2. Enhanced F-Scale for Tornado Damage

Fujita Scale - F Number	Fujita Scale - Fastest ¼-mile (mph)	Fujita Scale - 3 Second Gust (mph)	Derived EF Scale - EF Number	Derived EF Scale - 3 Second Gust (mph)	Operational EF Scale – EF Number	Operational EF Scale - 3 Second Gust (mph)
0	40-72	45-78	**0**	65-85	**0**	65-85
1	73-112	79-117	**1**	86-109	**1**	86-110
2	113-157	118-161	**2**	110-137	**2**	111-135
3	158-207	162-209	**3**	138-167	**3**	136-165
4	208-260	210-261	**4**	168-199	**4**	166-200
5	261-318	262-317	**5**	200-234	**5**	Over 200

[77] IMPORTANT NOTE ABOUT ENHANCED F-SCALE WINDS: The Enhanced F-scale still is a set of wind estimates (not measurements) based on damage judgments. Source: https://www.weather.gov/oun/efscale

Like hurricanes, earthquakes, and floods, tornadoes can lead to massive destruction to homes, property, and infrastructure, and may lead to deaths and injuries.

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.

The EF scale coupled with the NWS warning systems are appropriate for tornadoes in the RiverCOG region. Furthermore, the scales and classification systems previously described are appropriate for high winds, lightning, and hail that may occur with tornado activity. These classification systems have been used for many of the severe storms that have occurred in the region and its communities, whether or not tornadoes occurred. Severe storms and tornadoes have not been characterized outside of these systems of classification.

2.16.3. History of Past Events

As previously noted, the entire State of Connecticut is vulnerable to tornadoes and their impacts. Between 1950 and 2024, the State experienced 130 tornadoes that injured over 700 people, resulted in four deaths, and caused over $600 million in damages.[78] The most tornado activity has been during the summer months (June through August). Figure 2.16.2 shows approximate historic tracks of all 130 tornadoes that affected Connecticut between July 1950 and July 2024, shown with Fujita scale rankings.[79] [80]For tornado touch downs without a recorded track, coordinates are also mapped.

[78] https://data.norwichbulletin.com/tornado-archive/

[79] https://data.norwichbulletin.com/tornado-archive/ and NOAA

[80] *** Enhanced Fujita Scale describes the strength of the tornado based on the amount and type of damage caused by the tornado. The F-scale of damage will vary in the destruction area; therefore, the highest value of the F-scale is recorded for each event. EF0 – Light Damage (40 – 72 mph), EF1 – Moderate Damage (73 – 112 mph), EF2 – Significant damage (113 – 157 mph), EF3 – Severe Damage (158 – 206 mph), EF4 – Devastating Damage (207 – 260 mph), EF5 – Incredible Damage (261 – 318 mph)

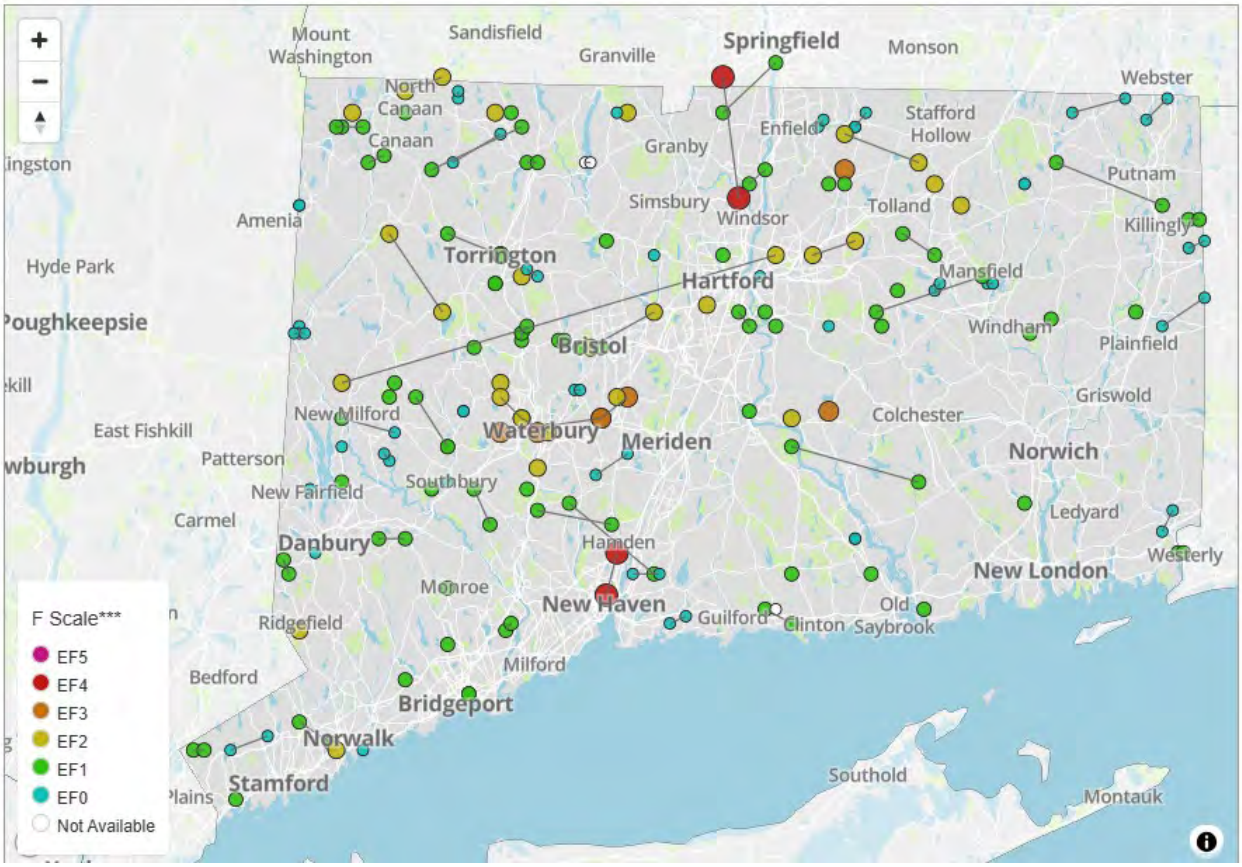


Figure 2.16.2: 1950 to 2024 Tornado Tracks across Connecticut

Statewide, Connecticut averages approximately two tornadoes every year; however, since 2020, 20 tornadoes have hit the state, causing $950,000 of reported property damage.[81] Although these were not located in the RiverCOG Region, they were a reminder of the very severe impacts that can occur from these powerful storms. Hartford and Litchfield Counties are at the highest risk for tornadoes within the state based on historical patterns and locations of their occurrence.

Within the RiverCOG region 13 tornadoes touched down since 1799.[82] However, since records were unreliable prior to 1950 the discussion below focuses on tornado events that occurred within the RiverCOG Region between 1950-2024. Since 1950 there have been 10 recorded tornado events, the most damaging was an F3 tornado in 1951 in East Hampton which caused 8 injuries.

An extensively researched list of tornado activity in Connecticut is available on Wikipedia. Dewberry routinely compares this list to NOAA reports and has found that the list remains reliable and current with frequent updates. This list extends back to 1648 although it is noted that the historical data prior to 1950 is incomplete due to lack of official records and gaps in populated

[81] https://data.norwichbulletin.com/tornado-archive/

[82] https://www.tornadoproject.com/

areas. Tornadoes that have impacted the RiverCOG Region communities found both on Wikipedia and The Tornado Project (sourced primarily by NOAA) are noted.

August 2, 1799: A tornado destroyed two houses in New London County, affecting the towns of Franklin, Lebanon, and Bozrah.

August 9, 1878: At least three tornadoes affected the state from a single storm system. The first touched down in South Kent, causing major damage but no injuries. The second, the Wallingford Tornado of 1878, touched down just outside Wallingford. A severe tornado, likely an F4, it smashed through the north side of town, destroying dozens of houses. At least 29 people were killed in that town (likely 34), the most by any tornado event in Connecticut history. A third tornado moved through Durham and Killingsworth, unroofing houses but again causing no injuries.

August 7, 1918: A possible tornado touched down in Westbrook, causing roof damage and downing trees. A house was moved off its foundation in Fenwick

July 12, 1950: An F2 tracked 10 miles (16 km) through Middlesex County.

August 21, 1951: A long-tracked F2 touched down in southwestern Litchfield County, passing more than 40 miles (64 km) well into Hartford County. Another tornado, an F3 (some sources say F2), touched down in northern Middlesex County, unroofing a factory and causing $100,000 in damage. Nine people were injured in the first tornado, with another eight injured in the second.

July 19, 1963: an F1 touched down in Middlesex county. The Tornado originated in Middletown and tracked southeast through northeast Haddam and East Haddam.

July 21, 1972: an F1 touched down in Middlesex County. The Tornado touched down in southeast Cromwell.

June 27, 1974: An F1 touched down in Middlesex County. The Tornado touched down in Essex.

August 1, 1983: An F0 struck Middlesex County. The Tornado touched down in Chester.

June 30, 1998: Two F1 tornadoes briefly touched down in Killingworth and Lyme, and an F0 briefly touched down in Chester. Note that NCEI data records this event 3 separate times within Chester, Killingworth, and Old Lyme (See Table 2.16.3below).

https://en.wikipedia.org/wiki/List_of_Connecticut_tornadoes - cite_note-69

July 31, 2009: Significant wind damage was reported across the state, including two EF1 tornadoes. The first tornado caused tree and minor property damage along a 0.5-mile (0.80 km) path through eastern Shelton. The second downed trees along a sporadic 2.75-mile (4.4 km) path in Madison. Many trees were also snapped and uprooted in Fairfield, Milford, Guilford, Chester, Old Lyme and Naugatuck.

There have been 10 recorded tornadoes in the RiverCOG region since 1950, the most recent having been in 2009 (originated just west of Clinton outside of the RiverCOG Region). Tornadoes that have

impacted the River COG Region communities are noted in Figure 2.16.3. Please refer to Table 2.16.3 for a summary of tornado events, that occurred in the RiverCOG Region.[83] [84] [85]

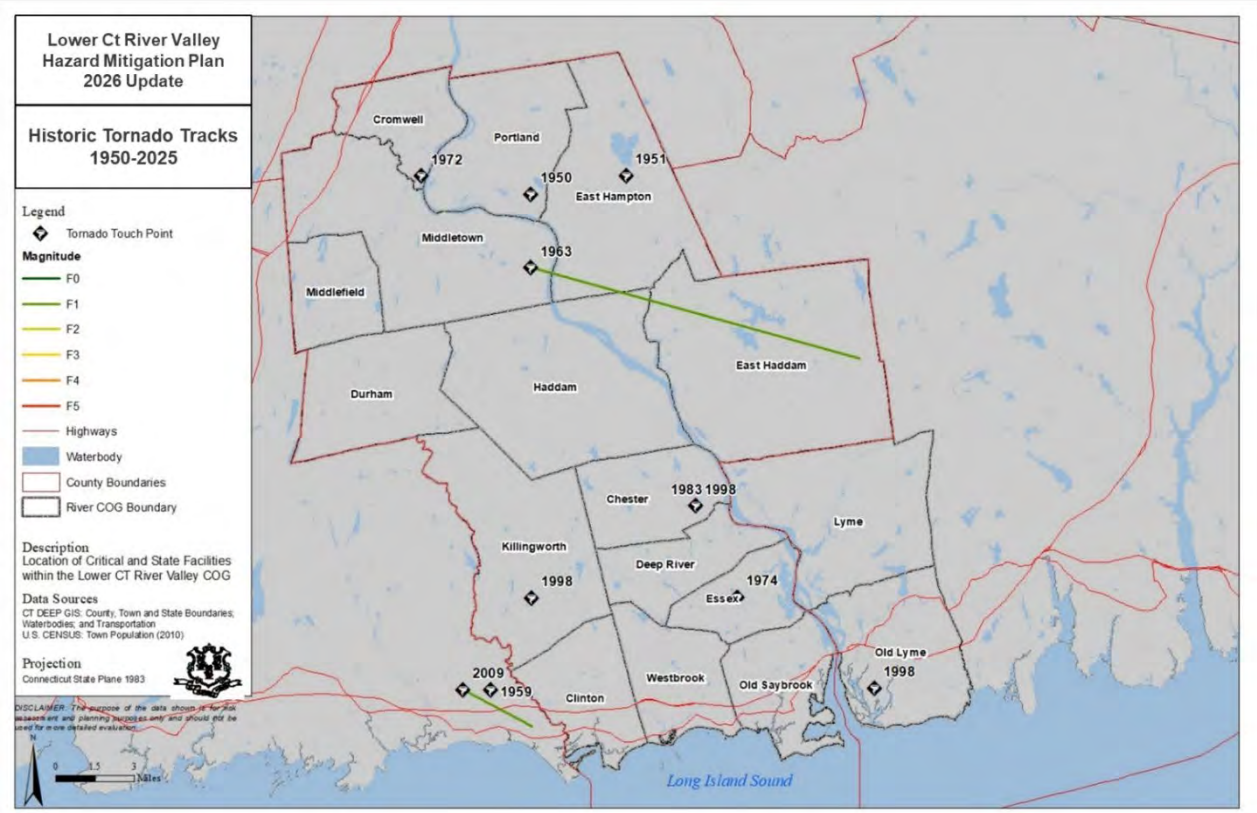


Figure 2.16.3. Tornado Tracks and Touchpoints in the River COG Region 1950-2025

Table 2.16.3: Recorded Tornadoes in RiverCOG Region 1950-2025

Town	Enhanced Fujita Scale	Date	Injuries	Fatalities
Portland	EF 2	July 12, 1950	0	0
East Hampton	EF 3	August 21, 1951	8	0
Middletown	EF 1	July 19, 1963	0	0
Middletown	EF 1	July 21, 1972	0	0
Essex	EF 1	June 27 1974	0	0

[83] The Tornado Project, www.tornadoproject.com

[84] "List of Connecticut Tornadoes," https://en.wikipedia.org/wiki/List_of_Connecticut_tornadoes

[85] *Note: The 2009 event originated outside of the RiverCOG Region in Madison, CT. There were damages from the event in Chester and Old Lyme and is therefore included in Middlesex County numbers.

Town	Enhanced Fujita Scale	Date	Injuries	Fatalities
Chester	F0	August 1, 1983	0	0
Killingworth	EF 0	June 30, 1998	0	0
Chester	EF 1	June 30,1998	0	0
Old Lyme	EF 1	June 30, 1998	0	0
Chester and Old Lyme	EF1	July 31, 2009	0	0

2.16.4. Probability of Future Events

According to the 2023 *Connecticut NHMP Update*, "The pattern of occurrence and potential locations for tornadoes to occur in Connecticut is expected to remain relatively unchanged in the upcoming years. Based on NOAA and NCEI historical data, Litchfield County has the highest count of past tornado events, indicating a higher risk for the occurrence of future tornadoes. The western portion of the state, including Fairfield, Hartford, and New Haven counties, each have moderately high risk for future tornadoes, followed by Tolland county with a moderate risk based on previous occurrences. Middlesex, Windham and New London counties may be considered to have a low risk since tornadoes have historically occurred less frequently than in other counties in the state."

It is possible that the pattern of occurrence in Connecticut could change in the future – NOAA states that climate change has the potential to increase the frequency and intensity of tornadoes – however, because 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.

While Connecticut is an unlikely area for dangerous tornadoes, there have been instances where tornadoes have developed in conjunction with high wind events and storms. Tornadoes are produced inside powerful thunderstorms, which, in turn, are created near the junction between warm, moist air and cold, dry air. The conditions that produce a "tornadic thunderstorm" exist when warm, moist air gets trapped beneath a stable layer of cold, dry air. A primary future difficulty with tornadoes in Connecticut is the relative density of population and structures to the potential for damage. According to NOAA's NCEI database there have been 10 tornado events over the past 75 years within the RiverCOG Region (period of historic data used for this analysis is 1950-2025) which equates to a 13% chance of a tornado in any given year impacting the RiverCOG region (Table 2.16.4).

Table 2.16.4: NCEI Annualized Events and Losses for Tornado, 1950-2025.

Area	Annualized Events
RiverCOG Region	**0.13**

2.16.5. 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.[86] 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 with 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.[87]

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.[88] With that increased threat of thunderstorms comes the greater risk of a tornado impacting the RiverCOG region. 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 Atlantic Coast. In addition, the intensity of individual extreme rainfall events could increase by as much as 70 percent in some areas.[89]

[86] https://www.ncei.noaa.gov/access/billions/state-summary/US

[87] 2019 Connecticut NHMP Update, DEEP and DEMHS, January 2019

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

[89] https://www2.ucar.edu/atmosnews/news/130085/north-american-storm-clusters-could-produce-80-percent-more-rain

Storms have become more intense in recent decades, and several 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.[90]

Additionally, NASA scientists suggest that the United States will face more severe thunderstorms in the future, with deadly 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.[91]

2.16.6. Impacts and Estimated Losses to the Region

While Connecticut clearly faces some risk from tornadoes, the nature of the storms makes them unpredictable. Tornadoes can strike with very little warning; cause significant to catastrophic damage to homes, vehicles, and businesses; and result in significant injury and death. All towns in the region share equal vulnerability to these events, and although property destruction may be unavoidable, loss of life can be minimized through efficient, coordinated warning and response. The more populated areas in the River COG Region are more likely to experience damage and casualties than the less densely populated communities.

Section 2.9.3 describes the exposure analysis method used to characterize the upper boundaries of exposure to risks in the region. The following table (Table 2.16.5) presents the exposure to severe winds hazards associated with tornadoes.

Table 2.16.5. Tornado Exposure Analysis for RiverCOG Communities

Hazard	Number of Parcels	Value of At-Risk Parcels	Number of Critical Facilities	Value of At-Risk Critical Facilities	Number of Historic Assets	Value of At-Risk Historic Assets
Chester	1,822	$558	11	$30	44	$17
Clinton	6,989	$1,586	9	$74	654	$230
Cromwell	6,069	$1,707	14	$138	226	$113
Deep River	2,216	$577	13	$78	380	$99
Durham	3,066	$583	8	$18	94	$22
East Haddam	5,743	$1,124	14	$35	201	$64
East Hampton	6,203	$1,151	14	$39	399	$100
Essex	3,442	$1,378	12	$40	544	$271

[90] https://www2.ucar.edu/atmosnews/news/124334/extreme-downpours-could-increase-fivefold-across-parts-us

[91] https://climate.nasa.gov/news/897/severe-thunderstorms-and-climate-change/

Hazard	Number of Parcels	Value of At-Risk Parcels	Number of Critical Facilities	Value of At-Risk Critical Facilities	Number of Historic Assets	Value of At-Risk Historic Assets
Haddam	4,271	$816	14	$45	209	$69
Killingworth	2,775	$771	8	$25	47	$22
Lyme	1,709	$711	5	$9	280	$136
Middlefield	2,247	$464	8	$14	21	$9
Middletown	13,549	$5,581	36	$608	804	$1,474
Old Lyme	5,624	$1,544	12	$50	502	$217
Portland	4,725	$847	21	$24	161	$46

**All dollar figures are in millions*

Although impacts to Connecticut and the RiverCOG region from tornadoes are infrequent (Table 2.16.6), tornadoes that have struck the area have had devastating impacts (Table 2.16.7).[92]

Table 2.16.6: NCEI Total Tornado Events by county, 1950-2025.

County	Number of Events	Number of Injuries	Number of Deaths
Middlesex	*9	8	0
New London	1	0	0
Total	10	8	0

Table 2.16.7: Property Damages due to Tornado

County	Town Impacted	Date of Event	Property Damage*
Middlesex	Portland	July 12, 1950	$25,903
Middlesex	East Hampton	August 21, 1951	$2,401,401
Middlesex	Middletown, Haddam, East Haddam	July 19, 1963	$20,400
Middlesex	Cromwell	July 21, 1972	$14,935
Middlesex	Essex	June 27, 1974	$1,266
Middlesex	Chester	August 1, 1983	$772

[92] *Note: The 2009 event originated outside of the RiverCOG Region in Madison, CT. There were damages from the event in Chester and Old Lyme and is therefore included in Middlesex County numbers.

County	Town Impacted	Date of Event	Property Damage*
Middlesex	Killingworth	June 30, 1998	$0
Middlesex	Chester	June 30, 1998	$0
New London	Lyme	June 30, 1998	$0
Middlesex	Chester and Old Lyme	July 31, 2009	$11,951
		TOTAL DAMAGES:	**$2,476,628**

Based on this limited available data, the RiverCOG region experienced approximately $2.5 million dollars of reported damage in a 75-year period. That equates to an annualized loss of $33,022 per year. These numbers are not inclusive of all damages but are a good indicator of potential losses for planning purposes. Anticipated losses could occur anywhere throughout the geographic area of the RiverCOG region.

Supplementing NCEI historical loss data, the risk and expected annual loss from tornadoes was taken from FEMA's NRI. Displayed in Figure 2.16.4 tornado risk across RiverCOG ranges from Very Low to Relatively Low.

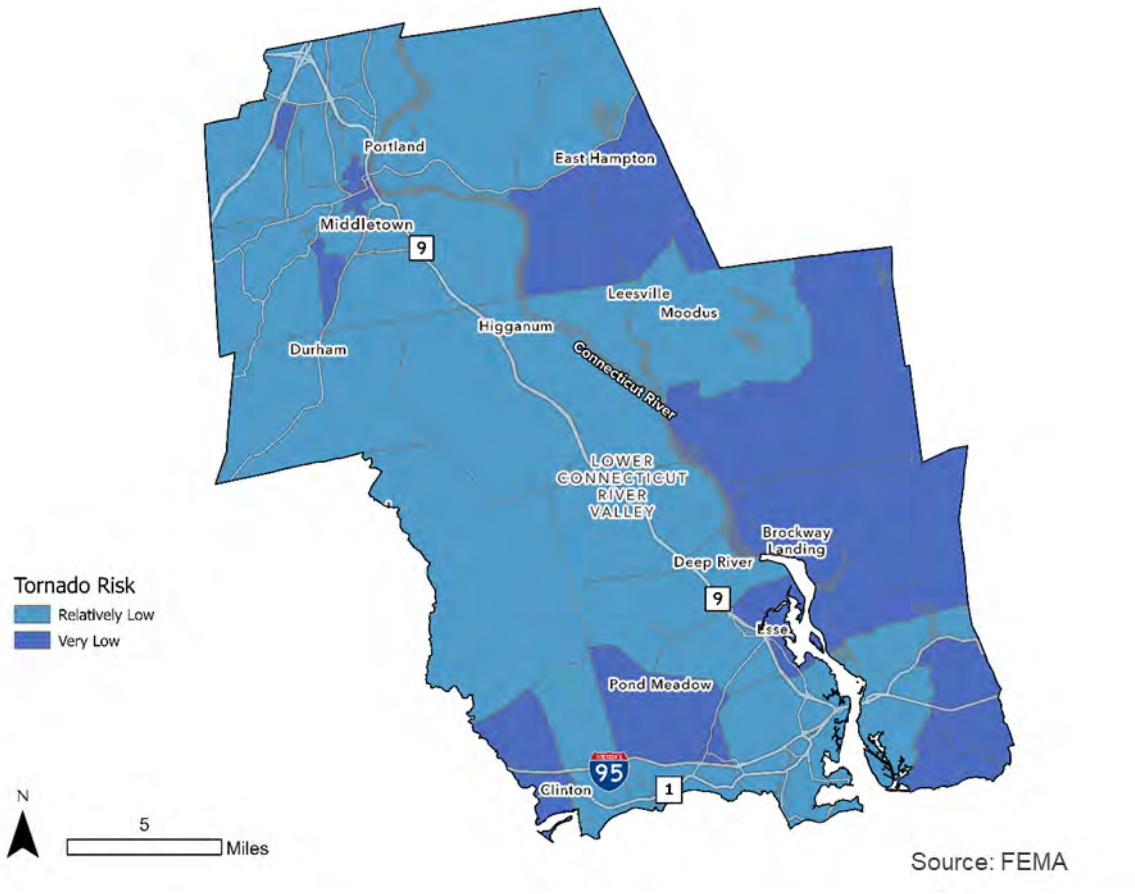


Figure 2.16.4. NRI Risk Rating for Tornado, shown at the census tract level (2025)

All communities in the region are at a relatively low risk to tornado, with the exception of parts of Middletown, with five census tracts (out of thirteen) at very low risk to tornado. Table 2.16.8 displays communities in RiverCOG and the number of census tracts at each risk rating to tornado.

Table 2.16.8. Breakdown of community risk to tornado

Community	Number of Census Tracts with Very Low Risk	Number of Census Tracts with Relatively Low Risk
Chester	-	1
Clinton	-	4
Cromwell	-	3
Deep River	-	1
Durham	-	1
East Haddam	-	2
East Hampton	-	3

Community	Number of Census Tracts with Very Low Risk	Number of Census Tracts with Relatively Low Risk
Essex	-	2
Haddam	-	2
Killingworth	-	1
Lyme	-	1
Middlefield	-	1
Middletown	5	8
Old Lyme	-	3
Portland	-	2
Total for RiverCOG Region	**5**	**35**

Figure 2.16.5 shows the expected annual loss ratings throughout the COG and Table 2.16.9 describes the projected annualized losses from tornadoes by community. The highest expected annual losses are found in Middletown and Cromwell with a projected $237,752 and $105,427 in expected annual losses due to tornadoes respectively. Additionally, Clinton and East Hampton have the next highest expected annual loss totals, both with over $70,000 in expected annual loss due to tornadoes. The RiverCOG region has a total expected annual loss of $939,686

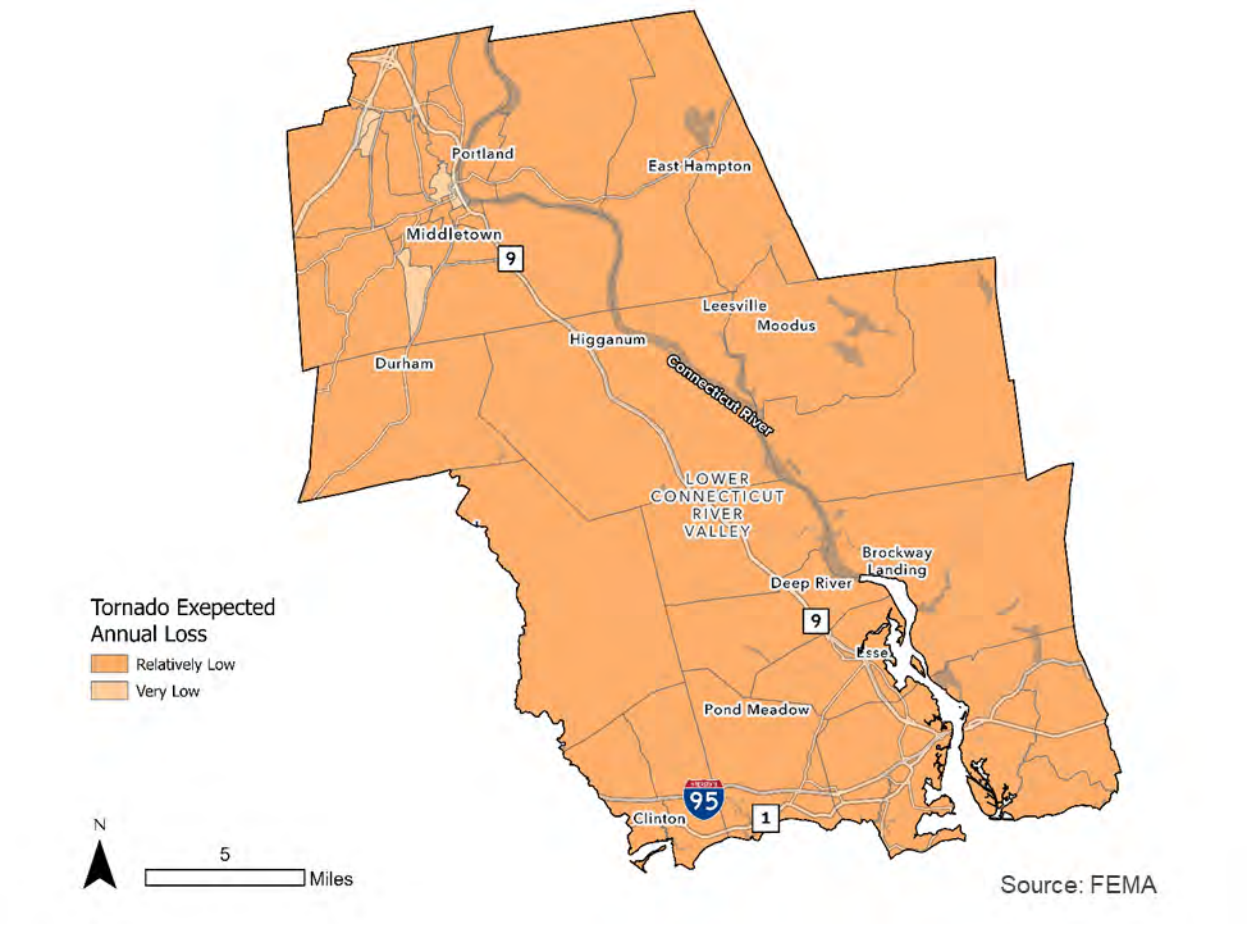


Figure 2.16.5. NRI Tornado Expected Annual Loss Rating (2025)

Table 2.16.9. Breakdown of Expected Annual Losses from the NRI by Community for Tornado

Community	Expected Annual Loss
Chester	$24,899
Clinton	$74,306
Cromwell	$105,427
Deep River	$25,464
Durham	$47,801
East Haddam	$56,593
East Hampton	$72,234
Essex	$45,269
Haddam	$50,715
Killingworth	$35,300

Community	Expected Annual Loss
Lyme	$15,434
Middlefield	$28,373
Middletown	$237,752
Old Lyme	$57,390
Portland	$62,729
Total for RiverCOG Region	**$939,686**

2.16.7. Development Trends

Since the 2021 plan update, development in the RiverCOG region has been light. Over the five year span (2019-2023) available on the RiverCOG Data Dashboard, population in the region has grown by approximately 1.7%.[93] A relatively small increase in population size, 0.5% below the growth rate of the state of Connecticut, which is has had approximately a 2.2% population growth rate during the same time span.[94] Haddam, Old Lyme, Clinton, Cromwell, Middletown, and Essex have seen the greatest increases in population growth during this time span. That being said, the highest percent growth is only a 4.1% increase in Haddam. Chester has seen the largest population decrease with a decrease of 10.6% during this five year time span. There are multiple reasons for this declining growth rate, but the COVID-19 pandemic is a large contributor.

Similarly, there has been only a 0.37% increase in housing stock in the region during the 2019-2023 five-year time frame with only 195 building permits issued in 2023 throughout RiverCOG.[95] The majority of these building permits issues in 2023 are in East Hampton (37) and East Haddam (25), both of which have seen decreases in housing stock during these five years. Killingworth, Durham, Haddam, Deep River, and Clinton have seen the largest increase in housing stock during this period. Additionally, commercial and industrial growth has been relatively stagnant during this time frame.

Housing development and population growth in these areas will increase the number of residents exposed and at risk to tornadoes. One benefit of new development, however, is that newer construction is generally built to stronger building codes. Therefore, newer buildings that replace older-code buildings should generally decrease overall risk due to tornadoes. For example, newer commercial and industrial buildings will be equipped with sprinklers and built to higher wind loading standards. When aging power infrastructure is replaced or retrofitted, it is typically more

[93] https://www.rivercog.org/data-population

[94] https://www.census.gov/programs-surveys/popest.html

[95] https://www.rivercog.org/data-housingcharacteristics

resilient to wind damage than older infrastructure. More specific changes in development are addressed at the community level in the municipal annexes in Volume II of this plan.

2.16.8. Overall Risk Rating

Using the parameters described in Table 2.8.1, the following hazard risk ratings were developed for tornado (Table 2.16.10).

Table 2.16.10: Overall Risk Rating of Tornado

Criteria	Hazard Risk Rating
Probability	3 (Likely)
Impact: Affected Area	1 (Isolated)
Impact: Primary Impact	4 (Catastrophic)
Impact: Secondary Impacts	2 (Limited)
Survey Rating	2 (Moderate Concern)
Total Score	12.6
Overall Risk Ranking	**Moderate**

2.17. Earthquakes

2.17.1. Description and Background

Although damaging earthquakes are rare in Connecticut, low-magnitude earthquakes occur regularly in the state. In addition, very strong, damaging earthquakes have occurred in Connecticut, and the state can also feel the effects of earthquakes that occur several hundred miles away.

2.17.2. Location and Extent

All areas of the RiverCOG region are susceptible to earthquakes although the likelihood of an earthquake occurring directly below the region is relatively small. In general, RiverCOG communities are likely to be part of a larger regional area affected by an earthquake as opposed to being individually affected.

An earthquake is a sudden rapid shaking of the earth caused by the breaking and shifting of rock beneath the earth's surface. Earthquakes can cause buildings and bridges to collapse; disrupt gas, electric, and telephone lines; and often cause landslides, flash floods, fires, avalanches, and tsunamis. Earthquakes can occur at any time without warning.

The underground point of origin of an earthquake is called its focus; the point on the surface directly above the focus is the epicenter. Earthquakes are described based on their magnitude and intensity.

Magnitude is an estimate of the relative size or strength of an earthquake and is related to the amount of seismic energy released at the hypocenter of the earthquake. It is based on the amplitude of earthquake waves recorded on instruments that have a common calibration. The magnitude of an earthquake is thus represented by a single instrumentally determined value recorded by a seismograph, which records the varying amplitude of ground oscillations.

The Richter scale was developed in 1935 and was used exclusively until the 1970s. It set the magnitude of an earthquake based on the logarithm of the amplitude of recorded waves. Being logarithmic, each whole number increase in magnitude represents a tenfold increase in measured strength. Earthquakes with a magnitude of about 2.0 or less are usually called "microearthquakes" and are generally only recorded locally. Earthquakes with magnitudes of 4.5 or greater are strong enough to be recorded by seismographs all over the world.

As more seismograph stations were installed around the world following the 1930s, it became apparent that the method developed by Richter was valid only for certain frequency and distance ranges, particularly in the southwestern United States. New magnitude scales that are an extension of Richter's original idea were developed for other areas. In particular, the Moment magnitude scale (Mw) was developed in the 1970s to replace the Richter scale and has been in official use by the USGS since 2002.

According to the USGS, these multiple methods are used to estimate the magnitude of an earthquake because no single method is capable of accurately estimating the size of all earthquakes. Some magnitude types are calculated to provide a consistent comparison to past earthquakes, and these scales are calibrated to the original Richter scale. However, differences in magnitude of up to 0.5 can be calculated for the same earthquake through different techniques. In general, Moment magnitude provides an estimate of earthquake size that is valid over the complete range of magnitudes and so is commonly used today.

Although Moment magnitude is the most common measure of earthquake size for medium and larger earthquakes, the USGS does not calculate Mw for earthquakes with a magnitude of less than 3.5. Localized Richter scales or other scales are used to calculate magnitudes for smaller earthquakes. This is often the case in Connecticut.

Regionally, the Weston Observatory utilizes two scales to track the magnitude of earthquakes. These include the Nuttli magnitude (Mn) for North America east of the Rocky Mountains and is more appropriate for the relatively harder continental crust in Connecticut compared to California. Weston Observatory also utilizes the Coda Duration magnitude (Mc), which is based on the duration of shaking at a particular station. The advantages of the Coda Duration magnitude is that

this method can quickly estimate the magnitude before the exact location of the earthquake is known.

Earthquakes in Connecticut are intraplate or intratectonic as opposed to occurring at fault lines. In these types of earthquakes, soil composition determines the magnitude of the impact. Soft soils and filled wetlands conduct energy better than bedrock. A magnitude 5.1 earthquake near Plattsburgh, New York, in April 2002 was felt in Hartford and lower-lying areas in western Connecticut because of ground-motion amplification resulting from the soft soils located in these areas. Many of the strongest earthquakes felt in Connecticut had epicenters in upstate New York, New Hampshire, and Massachusetts.

The effect of an earthquake on the earth's surface is called the intensity. The Modified Mercalli Intensity Scale consists of a series of key responses such as people awakening, movement of furniture, damage to chimneys, and total destruction. This scale, composed of 12 increasing levels of intensity that range from imperceptible shaking to catastrophic destruction, is designated by Roman numerals. It is an arbitrary ranking based on observed effects. A comparison of Richter magnitude to typical Modified Mercalli intensity is presented in Table 2.17.1 while a description of each intensity level is presented as Table 2.17.2.

Table 2.17.1. Comparison of earthquake magnitude and intensity (Source: USGS).

Moment Magnitude	Typical Maximum Modified Mercalli Intensity
1.0 to 3.0	I
3.0 to 3.9	II to III
4.0 to 4.9	IV to V
5.0 to 5.9	VI to VII
6.0 to 6.9	VII to IX
7.0 and above	VIII or higher

Table 2.17.2. Modified Mercalli Intensity.

Modified Mercalli Intensity	Description
I	Not felt except by a very few under especially favorable conditions
II	Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.
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. Vibration 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.

Modified Mercalli Intensity	Description
V	Felt by nearly everyone; many awakened. Some dishes and 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 in the air.

Magnitude 3.0 to 3.9 earthquakes are often felt by people up to a hundred miles away from the epicenter but rarely cause damage. Magnitude 4.0 to 4.9 earthquakes cause shaking of objects indoors but generally cause none to slight damage. Magnitude 5.0 to 5.9 earthquakes can cause moderate to major damage to poorly constructed buildings but none to slight damage to other buildings.

The existing magnitude scales are appropriate for earthquakes in the RiverCOG region. These classification systems have been used for earthquakes that have occurred in the region and those occurring in neighboring States that were felt in the RiverCOG region. Earthquakes have not been characterized outside of these systems of classification.

2.17.3. History of Past Events

Connecticut has a moderate risk of earthquakes based on the frequency of their occurrence, regardless of the intensity of individual earthquakes. Of those where the magnitude was known, all were under magnitude 4.0.

Instances of seismic activity occurring in and around the region are noted below based on information in USGS documents and from the Weston Observatory, the 2023 *Connecticut NHMP Update*, other municipal hazard mitigation plans, and newspaper articles.

February 5, 1663: A devastating earthquake near Three Rivers, Quebec, on February 5, 1663, caused moderate damage in parts of Connecticut.

November 1727 and November 1755: Strong earthquakes in Massachusetts were felt strongly in Connecticut.

May 16, 1791: The strongest earthquake in Connecticut history occurred in East Haddam in 1791 and is recorded with intensity VII. See the text box to the right. Weston Observatory estimates that this quake had a 4.4 magnitude.

August 1840: A moderate tremor with its epicenter 10 to 20 miles north of New Haven shook Hartford buildings but caused little damage. This quake is estimated as having a 3.8 magnitude.

The strongest earthquake in Connecticut history occurred in the RiverCOG region. This earthquake struck East Haddam in 1791 and was recorded with intensity VII. According to USGS, the earthquake, which was felt in Boston and New York City, caused stone walls and chimney tops to fall and latched doors to open. Weston Observatory estimates that this quake had a 4.4

October 1845: An intensity V earthquake occurred in Bridgeport and approximated at 4.3 on the Richter scale.

July 28, 1875: An early morning tremor caused intensity V damage throughout Connecticut and Massachusetts.

November 1935: The Timiskarning, Ontario earthquake caused minor damage as far south as Cornwall, Connecticut. This earthquake affected 1 million square miles of Canada and the United States.

September 1944: An earthquake near Massena, New York, produced mild effects in Hartford, Marion (Southington), and New Haven, Connecticut.

June 23, 2010: A magnitude 5.0 earthquake struck at the Ontario-Quebec border region of Canada. This earthquake did not cause damage in Connecticut but was felt by residents in Hartford and New Haven Counties.

August 21, 2011: A magnitude 5.8 earthquake struck 38 miles from Richmond, Virginia. 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. According to Cornell University, the quake was the largest event to occur in the east-central United States since instrumental recordings have been available to seismologists.

October 16, 2012: A magnitude 4.6 earthquake that struck near Portland, Maine, was felt in Connecticut, including the Capitol Region. However, no damage was reported.

January 8-12, 2015: A series of quakes hit Plainfield, Connecticut. These events registered magnitudes of 2.0, 0.4, and 3.1. Residents in the Moosup section of Plainfield reported minor damage such as the tipping of shelves and fallen light fixtures.

December 17, 2017: A small quake struck 5 km east-southeast of Kensington registering Mn 1.0 and Mc 1.6.

February 2, 2017: A small quake occurred 8 km east northeast of Terramuggus, registering Mn 1.4 and Mc 1.8.

July 27, 2019: A small quake occurred 6 km south of Middletown, registering Mn 2.0 and Mc 2.2.

March 5, 2021: A small quake occurred 5 km northwest of Newington, registering Mn 1.7 and Mc 2.5.

March 6, 2024: A small quake occurred 5 km east-northeast of East Hampton, registering Mn 1.2 and Mc 2.2.

March 28, 2024: A series of quakes occurred 3 to 5 km north northwest of Old Mystic. These events registered magnitudes of 2.0, 1.6, and 1.8.

March 16, 2025: A small quake occurred 11 km south of Higganum, registering 0.6 Mn and 1.8 Mc.

2.17.4. Probability of Future Events

According to the USGS, Connecticut is in an area of moderate to low risk for earthquakes. Central Connecticut has a 10 to 20% chance of seeing an earthquake with a magnitude greater than 4.75 within 250 years (Figure 2.17.1). An earthquake of this magnitude is generally considered one that would damage older dwellings and those not resistant to earthquakes.

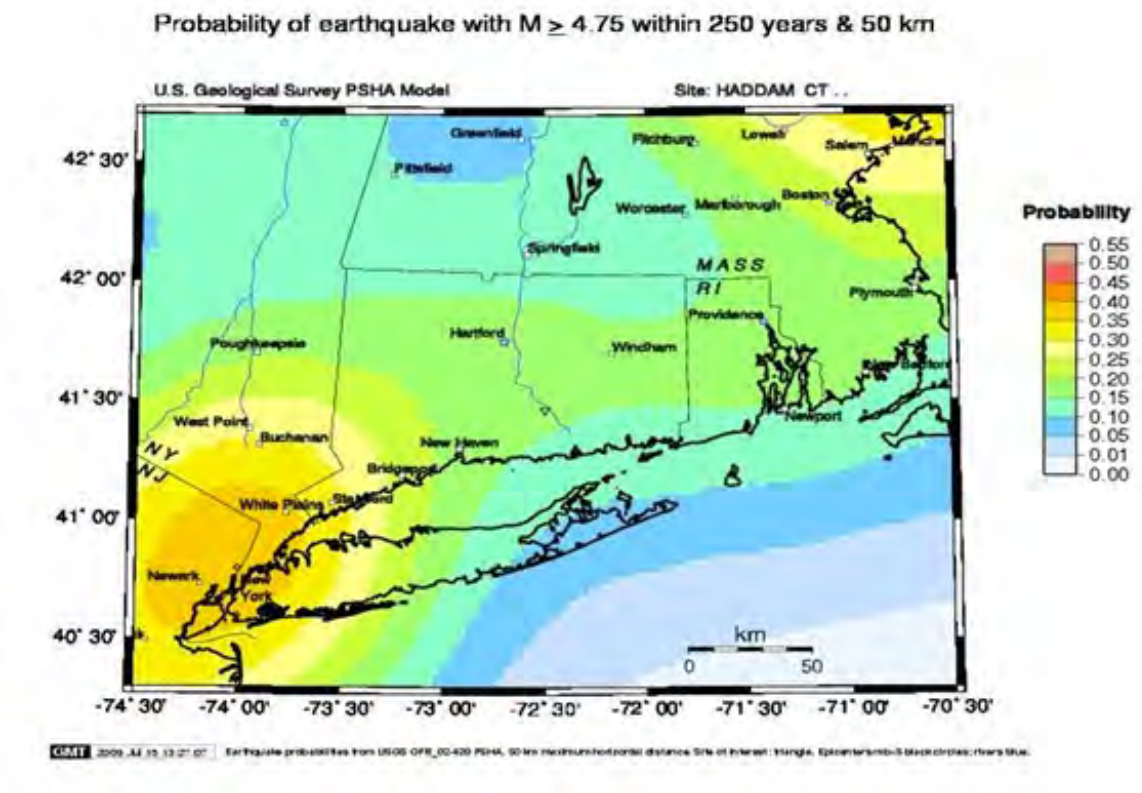


Figure 2.17.1. Earthquake probability map from the 2023 Connecticut State NHMP.

According to the 2023 *Connecticut NHMP Update*, Connecticut "has a low or moderate risk for an earthquake >3.5 occurring in the future, and a moderate risk of an earthquake < 3.0 occurring in the future ." The State plan also identified the probability of an earthquake of a specific magnitude for the Haddam-East Haddam-Portland area. When earthquakes are reported in Connecticut, they have most frequently occurred in the southern and eastern portions of the state. These probabilities are presented in Table 2.17.3.

Table 2.17.3 Probability of an earthquake of specific magnitude occurring in the Haddam-East Haddam-Portland area of Connecticut (CT NHMP, 2023)

Timeframe (years)	Equal or Greater than a 5.0 Quake	Equal or Greater than a 6.0 Quake
50	3%	0.3%
100	8%	0.5%
250	20%	1.5%
350	20%	2%

2.17.5. Climate Change Impacts

Currently, evidence to support climate change impacts on earthquake frequency or magnitude is inconclusive. Some scientists have found that some geologic events can be affected by subtle changes on the earth's surface such as temperature changes and shifts in water or atmospheric pressure. However, others have concluded that earthquakes are in fact not affected by climate change.[96] Overall, earthquakes will be minimally impacted by climate change compared to other hazards addressed in this plan.

2.17.6. Impacts and Estimated Losses to the Region

Impacts

Unlike seismic activity in California, earthquakes in Connecticut are not associated with specific known faults. Instead, earthquakes with epicenters in Connecticut are referred to as intraplate activity. Bedrock in Connecticut and New England in general is highly capable of transmitting seismic energy; thus, the area impacted by an earthquake in Connecticut can be four to 40 times greater than that of California. For example, the relatively strong earthquake that occurred in Virginia in 2011 was felt in Connecticut because the energy was transmitted over a great distance through hard bedrock. In addition, population density is up to 3.5 times greater in Connecticut than in California, potentially putting a greater number of people at risk.

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 and especially in finer textured soils as well as artificial fill. When liquefaction occurs, the ability of soil to support building foundations and bridges is reduced. Increased shaking and liquefaction can cause greater damage to buildings and structures and a greater loss of life.

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 stormwater management systems. Damage to utility lines can lead to fires, especially in electric and gas mains. Dam failure can also pose a significant threat to developed areas during an earthquake.

The built environment in Connecticut includes old nonreinforced masonry that is not seismically designed. Connecticut incorporated building codes for seismic activity into the state building code in 1992. There were no requirements prior to that. So, while the risk for a very damaging earthquake is relatively low in the region, some structures may be impacted by less intense earthquakes

[96] 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

depending on the soil and integrity of the structure. Those who live or work in nonreinforced masonry buildings, especially those built on filled land or unstable soils, are at the highest risk for injury due to the occurrence of an earthquake.

According to the 2023 *Connecticut NHMP Update*, the Hartford-East Haddam-Haddam-Portland area is one of the most vulnerable areas of the state to earthquakes. While the geographic region is the most vulnerable, it is important to note that because of the relatively low developed areas throughout many parts of the RiverCOG region, potential losses or impacts may not be as high as urbanized, or highly developed areas that are vulnerable to earthquakes, such as Middletown, where buildings and infrastructure are tightly packed and many buildings were erected before seismic impacts were incorporated into the State building code in 1992.

Section 2.9.3 describes the exposure analysis method used to characterize the upper boundaries of exposure to risks in the region. The following table (Table 2.17.4) presents the exposure to earthquakes.

Table 2.17.4. Earthquake Exposure Analysis for RiverCOG Communities

Hazard	Number of Parcels	Value of At-Risk Parcels	Number of Critical Facilities	Value of At-Risk Critical Facilities	Number of Historic Assets	Value of At-Risk Historic Assets
Chester	1,822	$558	11	$30	44	$17
Clinton	6,989	$1,586	9	$74	654	$230
Cromwell	6,069	$1,707	14	$138	226	$113
Deep River	2,216	$577	13	$78	380	$99
Durham	3,066	$583	8	$18	94	$22
East Haddam	5,743	$1,124	14	$35	201	$64
East Hampton	6,203	$1,151	14	$39	399	$100
Essex	3,442	$1,378	12	$40	544	$271
Haddam	4,271	$816	14	$45	209	$69
Killingworth	2,775	$771	8	$25	47	$22
Lyme	1,709	$711	5	$9	280	$136
Middlefield	2,247	$464	8	$14	21	$9
Middletown	13,549	$5,581	36	$608	804	$1,474
Old Lyme	5,624	$1,544	12	$50	502	$217
Portland	4,725	$847	21	$24	161	$46

**All dollar figures are in millions*

Estimated Losses

Economic Losses

To determine potential loss estimates, Hazus-MH was used to simulate four event scenarios that were originally developed in previous editions of the State NHMP:

- Magnitude 5.7, epicenter in Portland, based on historic event
- Magnitude 5.7, epicenter in Haddam, based on historic event
- Magnitude 6.4, epicenter in East Haddam, based on historic event
- Magnitude 5.7, epicenter in Stamford, magnitude based on USGS probability mapping

The Hazus estimates identify four different states of structural damage when estimating building losses. These states and their respective descriptions can be found in Table 2.17.5. The resulting building damage estimates by occupancy type for each of the four epicenter scenarios is in Table 2.17.6

Table 2.17.5. States of Structural Damage due to Earthquake Events.
(Source: FEMA Hazus Earthquake Manual)

Damage State	Description
Slight	Small plaster or gypsum-board cracks at corners of door and window opening and wall-ceiling intersections; small cracks in masonry chimneys and masonry veneer.
Moderate	Large plaster or gypsum-board cracks at corners of door and window openings; small diagonal cracks across shear wall panels exhibited by small cracks in stucco and gypsum wall panels; large cracks in brick chimneys; toppling of tall masonry chimneys.
Extensive	Large diagonal cracks across shear wall panels or large cracks at plywood joints; permanent lateral movement of floors and roof; toppling of most brick chimneys' cracks in foundations' splitting of wood sill plates and/or slippage of structure over foundation; partial collapse of "room-over-garage" or other "soft-story" configurations; small foundation cracks.
Complete	Structure may have large permanent lateral displacement, may collapse, or be in imminent danger of collapse due to cripple wall failure or the failure of the lateral load resisting system; some structures may slip and fall off the foundations; large foundation cracks.

Table 2.17.6. Hazus-MH Regional Estimates of Structural Damages.

Scenario Epicenter	Building Type by Occupancy	None	Slight	Moderate	Extensive	Complete
Portland	Agriculture	91	45	63	49	48
Portland	Commercial	924	415	683	717	930
Portland	Education	38	18	29	36	49
Portland	Government	21	8	17	17	25

Scenario Epicenter	Building Type by Occupancy	None	Slight	Moderate	Extensive	Complete
Portland	Industrial	335	144	252	273	358
Portland	Other Residential	1,399	925	950	618	646
Portland	Religion	99	50	47	41	53
Portland	Single Family	28,461	13,713	8,189	1,976	661
Stamford	Agriculture	268	14	6	4	4
Stamford	Commercial	3,364	159	80	35	27
Stamford	Education	156	6	3	2	2
Stamford	Government	83	1	1	2	1
Stamford	Industrial	1,242	55	35	24	21
Stamford	Other Residential	4,255	193	76	10	4
Stamford	Religion	271	13	3	2	1
Stamford	Single Family	50,966	1,478	456	82	17
Haddam	Agriculture	45	48	93	65	48
Haddam	Commercial	538	501	994	895	746
Haddam	Education	21	18	46	44	37
Haddam	Government	14	11	26	24	18
Haddam	Industrial	170	155	346	364	333
Haddam	Other Residential	1,422	940	928	731	518
Haddam	Religion	89	60	63	47	36
Haddam	Single Family	26,694	15,673	8,133	1,721	481
East Haddam	Agriculture	10	25	78	82	105
East Haddam	Commercial	171	268	767	996	1,453
East Haddam	Education	8	10	33	46	70
East Haddam	Government	3	5	18	28	39
East Haddam	Industrial	47	73	236	381	626
East Haddam	Other Residential	1,083	904	868	778	908
East Haddam	Religion	60	53	61	49	71
East Haddam	Single Family	20,512	17,121	11,292	3,031	1,047

In addition to building damages, Hazus-MH was used to develop economic loss estimates for each municipality for the four earthquake scenarios. Table 2.17.7 presents the estimated economic

losses for each community in the RiverCOG region, as well as estimated total losses for all municipalities. This economic loss is based on building damages and business interruption because of an earthquake event and are expressed in 2026 dollars.

Table 2.17.7. Hazus-MH Estimated Economic Losses to the Region as a Result of an Earthquake. Earthquake Scenarios used include Haddam, East Haddam, Portland, and Stamford.

Municipality	Haddam	East Haddam	Portland	Stamford
Chester	$397,037,300	$546,315,000	$70,409,900	$1,621,400
Clinton	$145,212,100	$420,499,200	$45,738,000	$4,077,700
Cromwell	$388,845,600	$642,764,100	$1,285,516,100	$5,178,800
Deep River	$240,790,000	$450,446,700	$43,221,200	$1,706,100
Durham	$216,081,800	$270,265,600	$205,821,000	$2,407,900
East Haddam	$583,691,900	$1,091,843,500	$162,902,300	$2,383,700
East Hampton	$682,016,500	$950,128,300	$692,555,600	$2,964,500
Essex	$234,885,200	$704,643,500	$47,202,100	$2,891,900
Haddam	$178,704,900	$228,980,400	$52,235,700	$1,633,500
Killingworth	$178,704,900	$228,980,400	$52,235,700	$1,633,500
Lyme	$40,401,900	$167,028,400	$9,462,200	$508,200
Middlefield	$97,405,000	$140,323,700	$190,466,100	$190,466,100
Middletown	$2,930,922,500	$3,285,815,500	$4,714,147,900	$19,178,500
Old Lyme	$87,470,900	$426,258,800	$27,817,900	$2,674,100
Portland	$433,869,700	$499,342,800	$764,163,400	$2,867,700
RiverCOG Region	$6,836,040,200	$10,053,635,900	$8,363,895,100	$242,193,600

To supplement the above information, the risk rating and expected annual loss from earthquakes was pulled from FEMA's NRI. Displayed in Figure 2.17.2 earthquake risk across RiverCOG ranges from Very Low to Relatively Low.

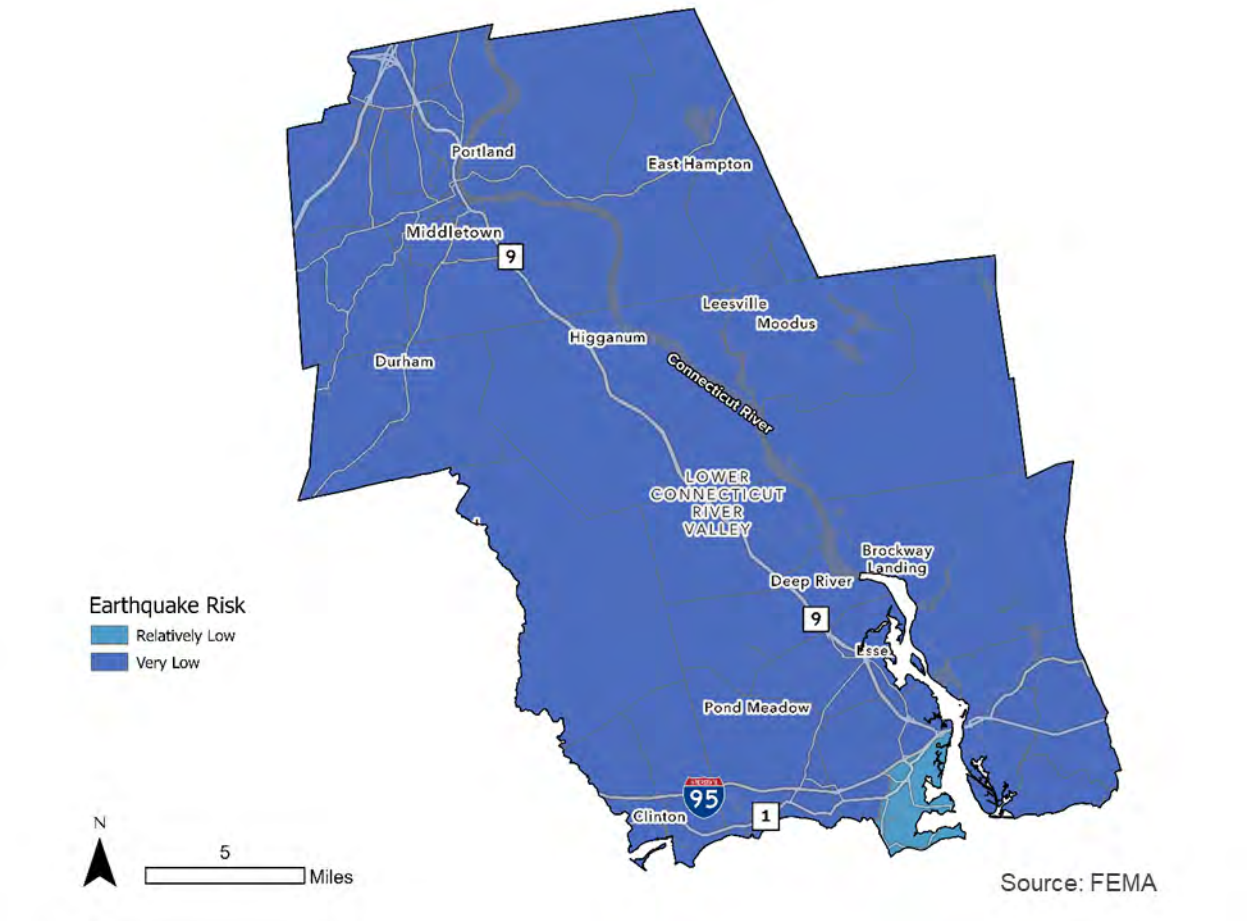


Figure 2.17.2. NRI Risk Rating for Earthquake, shown at the census tract level (2025)

All communities in the region are at a very low risk to earthquake. Only parts of Old Saybrook are at relatively low risk to earthquake as shown in Figure 2.17.2. Table 2.17.8 displays communities in RiverCOG and the number of census tracts at each risk rating to earthquake. For earthquakes, all census tracts are at a very low risk.

Table 2.17.8. Breakdown of community risk to Earthquake

Community	Number of Census Tracts with Very Low Risk
Chester	1
Clinton	4
Cromwell	3
Deep River	1
Durham	1
East Haddam	2

Community	Number of Census Tracts with Very Low Risk
East Hampton	3
Essex	2
Haddam	2
Killingworth	1
Lyme	1
Middlefield	1
Middletown	13
Old Lyme	3
Portland	2
Total for RiverCOG Region	**40**

Figure 2.17.3 below shows the expected annual loss ratings throughout the COG and Table 2.17.9 describes the projected annualized losses from earthquake by community. The highest expected annual losses are found in Middletown, Cromwell, and Clinton, with a projected $63,437, $26,515, and $25,936 in expected annual losses due to earthquakes respectively. The RiverCOG region has a total expected annual loss of $255,086.



Figure 2.17.3. NRI Earthquake Expected Annual Loss Rating (2025)

Table 2.17.9. Breakdown of NRI expected annual losses from Earthquakes by community

Community	Expected Annual Loss
Chester	$11,539
Clinton	$25,936
Cromwell	$26,515
Deep River	$7,499
Durham	$10,198
East Haddam	$13,167
East Hampton	$16,749
Essex	$19,550
Haddam	$9,874
Killingworth	$10,032

Community	Expected Annual Loss
Lyme	$2,807
Middlefield	$5,015
Middletown	$63,437
Old Lyme	$19,908
Portland	$12,860
Total for RiverCOG Region	**$255,086**

As noted in Section 2.9.2, Hazus and NRI loss estimation are modeled using two different methodologies and therefore yield quite different results. Both are worth analyzing in the plan to lend insight into the relative risks from earthquakes across jurisdictions.

2.17.7. Development Trends

Since the 2021 plan update, development within the RiverCOG region has remained limited. Over the five-year period from 2019 to 2023, the region's population increased by approximately 1.7%,[97] a modest rise that is about 0.5% lower than Connecticut's statewide growth rate of roughly 2.2% during the same timeframe. Haddam, Old Lyme, Clinton, Cromwell, Middletown, and Essex experienced the largest population increases during this period, though the highest rate of growth was a modest 4.1% in Haddam. Chester saw the most significant decline, with its population decreasing by 10.6% over the same five-year span. Several factors contribute to these shifting growth patterns, with the COVID-19 pandemic playing a major role.

Similarly, there has been only a 0.37% increase in housing stock in the region during the 2019-2023 five-year period, with only 195 building permits issued in 2023 across RiverCOG.[98] The majority of these building permits issues in 2023 are in East Hampton (37) and East Haddam (25), both of which have seen decreases in housing stock during these five years. Killingworth, Durham, Haddam, Deep River, and Clinton have seen the largest increase in housing stock during this period. Additionally, commercial and industrial growth has been relatively stagnant during this time frame.

Housing development and population growth in these areas will increase the number of residents exposed to and at risk to earthquakes. One benefit of new development, however, is that newer construction is generally built to stronger building codes. Therefore, newer buildings that replace older-code buildings should generally reduce overall risk from earthquake. Additional seismic building codes, designed for new construction to withstand greater impacts from earthquakes,

[97] https://www.rivercog.org/data-population

[98] https://www.rivercog.org/data-housingcharacteristics

have been added to the international building code (IBC) and adopted by the state of Connecticut. [99]More specific changes in development are addressed at the community level in the municipal annexes in Volume II of this plan.

2.17.8. Overall Risk Rating

Using the parameters described in Table 2.8.1, the following hazard risk ratings were developed for earthquake (Table 2.17.10).

Table 2.17.10: Overall Risk Rating of Earthquakes

Criteria	Hazard Risk Rating
Probability	2 (Somewhat Likely)
Impact: Affected Area	2 (Small)
Impact: Primary Impact	4 (Catastrophic)
Impact: Secondary Impacts	4 (High)
Survey Rating	1 (Low Concern)
Total Score	11.4
Overall Risk Ranking	Limited

2.18. Drought

2.18.1. Description and Background

Although Connecticut has a relatively even distribution of precipitation throughout the year, droughts periodically occur. Lack of precipitation in combination with the typical summer temperatures in the high 80s and low 90s can quickly dry out the soil and streams, leading to drought conditions.

2.18.2. Location and Extent

All areas of the RiverCOG communities are susceptible to drought although the likelihood of crop damage and economic loss is generally greater in rural communities. More developed communities are also susceptible to drought, particularly when the drought impacts the availability of water supply. In general, RiverCOG communities are likely to be part of a larger regional area affected by drought as opposed to being individually affected.

[99]https://portal.ct.gov/-/media/das/office-of-state-building-inspector/2022-state-codes/2022-csbc-final.pdf

According to the climatological community (including NOAA, NCEI, and the USDA Drought Monitor), there are four types of droughts (meteorological, hydrological, agricultural, and socioeconomic). Multiple types of droughts can and often do occur simultaneously.

- **Meteorological Droughts** are periods of time where precipitation is lower than "normal" for a time that is longer than "normal." Because it is defined according to typical conditions, it is region specific. In the New England region, both hydrological droughts and agricultural droughts are directly tied to meteorological droughts.
- **Hydrological Droughts** are characterized by low streamflow, groundwater, and reservoir levels resulting from a lack of precipitation over the course of months. When the presence of rainfall becomes scarce, streams, rivers, and groundwater can suffer, and water utilities can be forced to set restrictions on usage. It can take months to recover from such droughts. Land use also influences the severity and timing of droughts. Areas with vast impervious surface coverage inhibit groundwater recharge and can therefore hasten the onset of a hydrological drought or increase its intensity. Wildfires can also be more prevalent during such droughts.
- **Agricultural Droughts** occur during the growing season due to a lack of adequate precipitation and soil moisture to sustain crops. It is determined when the hydration needs of crops are not being sustained by the soil. The region can recover from an agricultural drought more quickly than from a hydrological drought; however, an agricultural drought can result in significant economic losses for the agricultural community.
- **Socioeconomic Droughts** occur when physical water shortages begin to affect people, and are typically experienced when the demand for goods exceeds the supply due to a decline in water supply.

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, 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. Figure 2-13 and Figure 2-14 summarize the status of drought conditions for the entire United States and the Northeast Region, including Connecticut and the RiverCOG Region.

Based on NOAA's NCEI precipitation data, in November 2025 Connecticut was ranked 20th nationwide and had a "Below Average" precipitation status compared to the period between 1895-2020 (Figure 2.18.1).

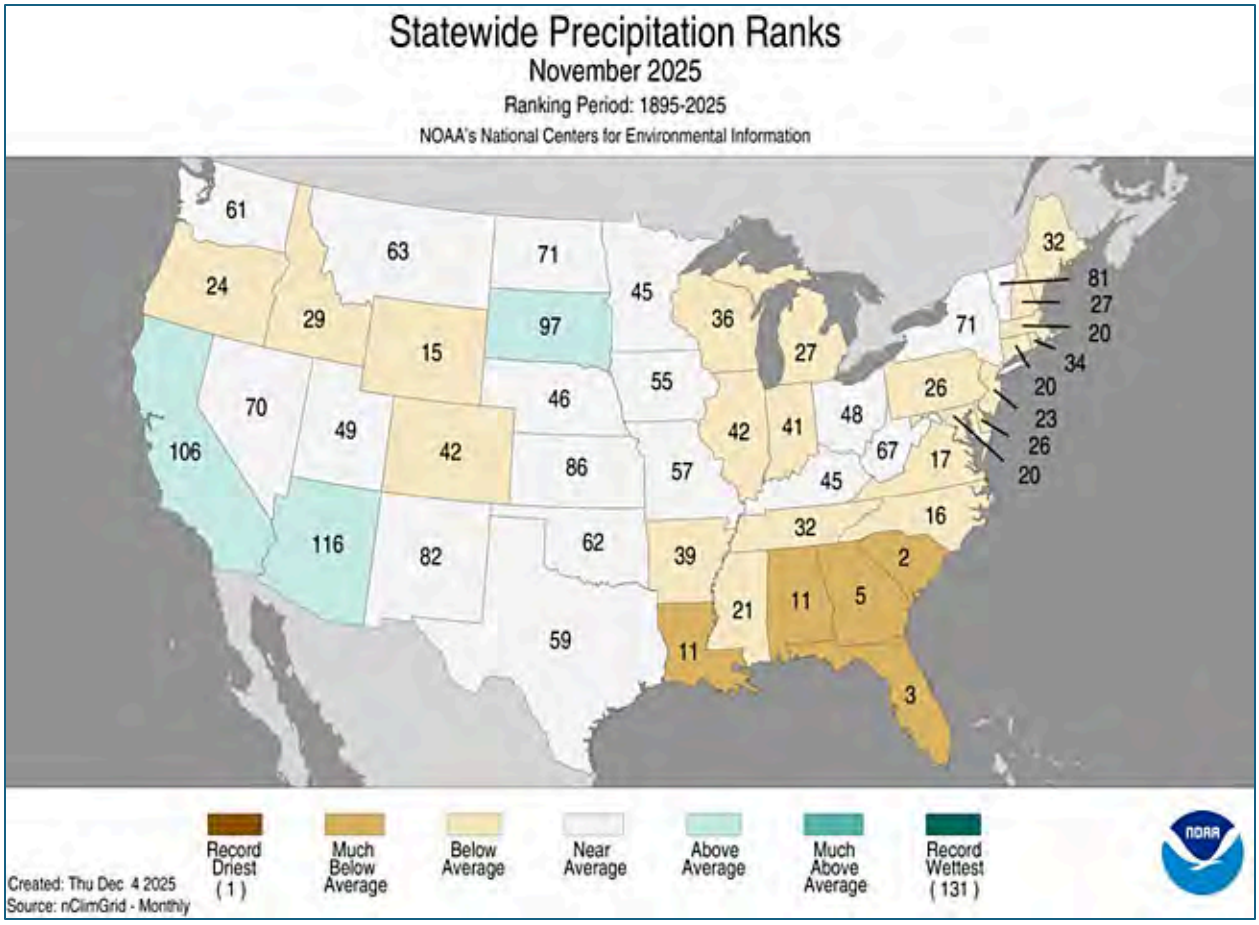


Figure 2.18.1. Current Statewide Precipitation Ranking as of November 2025.
(NOAA National Centers for Environmental information, Climate at a Glance: County Mapping, published December 2025, retrieved on December 15, 2025 from https://www.ncei.noaa.gov/access/monitoring/us-maps/)

Parts of Connecticut, including the southern reaches of the RiverCOG region is currently in an "Abnormally Dry" period as of December 9, 2025. According to U.S. Drought Monitor current conditions, as of December 9, 2025, Connecticut has 15.98% of the state in within "Abnormally Dry" conditions.(Figure 2.18.2). The U.S. Drought Monitor is a product produced in partnership between the National Drought Mitigation Center, the USDA, and NOAA

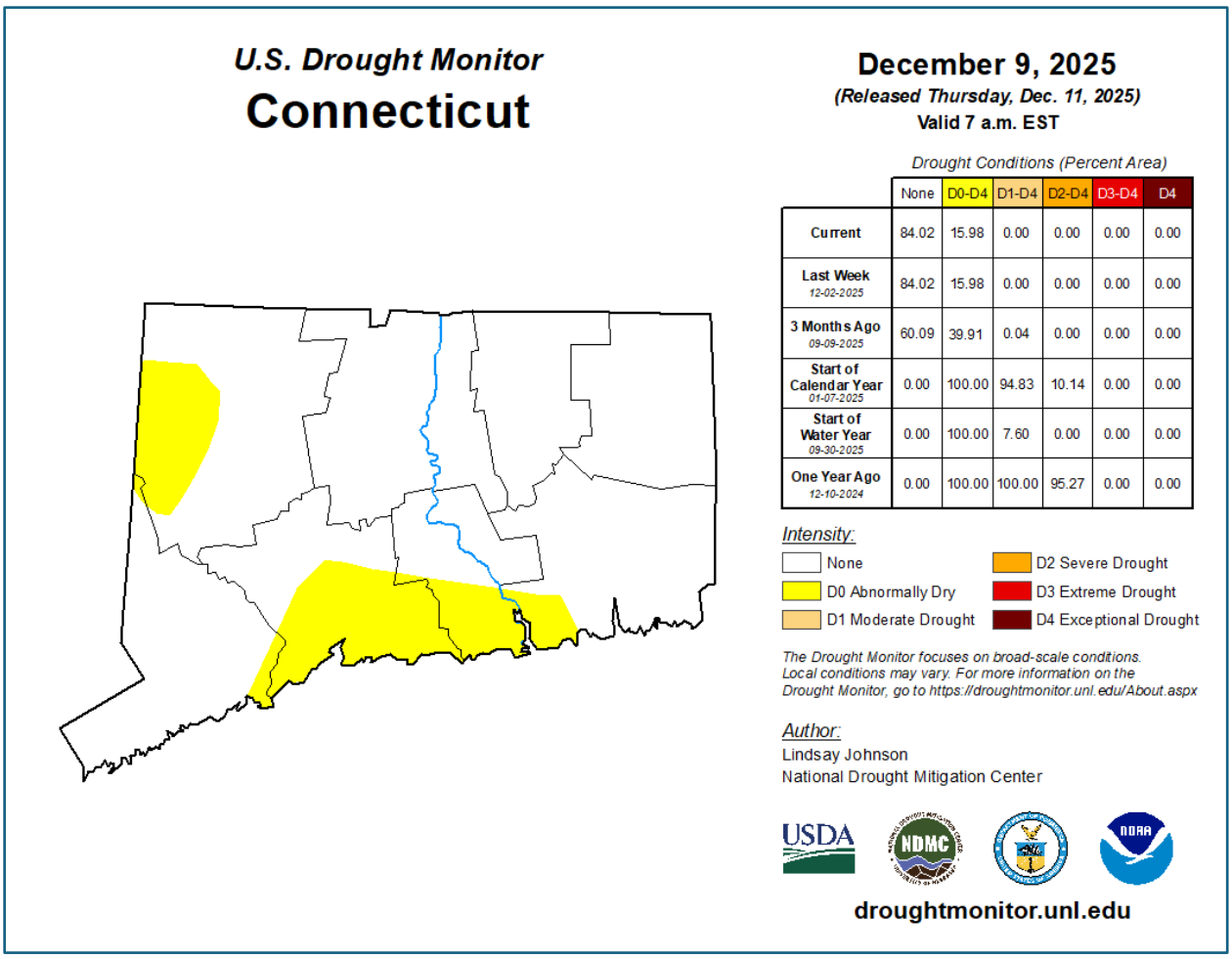


Figure 2.18.2. Current Drought Conditions for Connecticut as of December 9, 2025.

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. Although weather conditions are 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.

According to the 2023 *Connecticut NHMP Update*, Connecticut's general climate has four main characteristics relevant to drought:[100]

- Equitable distribution of precipitation among the four seasons;

[100] https://portal.ct.gov/demhs/-/media/demhs/_docs/plans-and-publications/ehsp0024---2023-natural-hazard-mitigation-plan---final.pdf?rev=01aae6d47e8e4bf8a0e24f4ca71581ee&hash=D7467FC0C0E730B61AD407EC3487AD9B

- 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. 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).[101] The RiverCOG Region is split between the Coastal Climate Division and the Central Climate Division (Figure 2.18.3).

- 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.

[101] http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/regional_monitoring/CLIM_DIVS/states_counties_climate-divisions.shtml



Figure 2.18.3. Climate Divisions of Connecticut (NOAA).

The Palmer Drought Severity Index was devised in 1965. It uses temperature and precipitation data to calculate water supply and demand, incorporates soil moisture, and is considered most effective for determining the severity of drought on unirrigated cropland. It primarily reflects long-term drought and has been used extensively to initiate drought relief. The index ranges from -4.0 (or less) to +4.0 (or more), with an index of 0.0 representing normal conditions. Indexes from -2.0 to -.9 indicate moderate drought, indexes from -3.0 to -3.9 represent severe drought, and indexes of -4.0 or less indicate extreme drought. Positive indices represent increasing moisture in the soil.

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.

In addition to those resources discussed above, the State of Connecticut has defined five stages of drought as part of the 2022 *Connecticut Drought Preparedness and Response Plan*, or more commonly referred to as the State Drought Plan. The stages have been identified and designated using a broad range of indicators which are to be used when considering the intensity and geographic scope of a drought. The Interagency Drought Workgroup (IDW) at the State level meets regularly during droughts to discuss indicators and declare stages. It is important to note that the stages and indicators in the State Drought Plan may differ in comparison to those used by public drinking water suppliers.

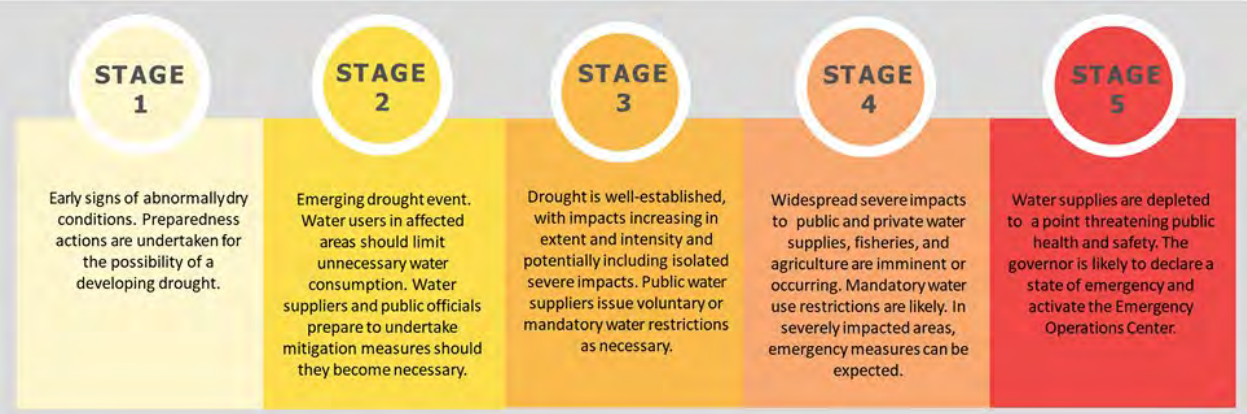


Figure 2.18.4 Five Stages of Drought as Identified in the 2022 Connecticut Drought Preparedness and Response Plan

The existing national and State systems for classifying and declaring droughts are appropriate for the RiverCOG region. Droughts have not been characterized outside of these systems of classification. In fact, recent revisions to the Connecticut Drought Preparedness and Response Plan have only strengthened preparation and response actions in Connecticut.

2.18.3. History of Past Events

According to the 2022 *Connecticut Drought Preparedness and Response Plan*, droughts have occurred periodically in the state. Serious hydrological droughts were recorded from June 1929 through July 1932. The 1957 drought was both hydrological and agricultural, with the largest impact being on crops. The most recent droughts occurred in 1964-1968, 1981, 1987, 2002, 2005, 2007-2008, 2012, and 2015-2017, 2020, and 2022.

During the 2002 drought, several water utilities imposed mandatory water conservation and restriction measures on their customers while most other companies imposed voluntary restrictions. Such restrictions can impact businesses as well as residences. The state responded to the 2002 drought by developing a drought management plan, which established monitoring and assessment protocols. During the height of this drought, some municipalities conducted public outreach and education regarding water conservation.

A meteorological drought was declared for Hartford, Tolland, and Windham Counties from April 12 through April 24, 2012, due to precipitation levels that were approximately half of normal levels. According to the NOAA Storm Events Database, rivers and streams were most affected as most ran at record low levels during the spring runoff season. The state did not issue a drought declaration; however, as reservoirs were at normal levels thanks largely to above-normal precipitation falling between August 2011 and November 2011. The main impact of this meteorological 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 2016 drought was one of the most severe for Connecticut in recent memory, with precipitation in Windsor Locks measured at nearly 13 inches below normal for the year. Numerous water utilities imposed mandatory water use restrictions on their customers, and several areas reported private wells running dry. The state responded to this drought by updating the 2003 State Drought Preparedness and Response Plan in 2018, which was again updated in 2022.

A severe drought warning for Connecticut was issued in 2022, affecting 87% of the state and causing significant agricultural losses. Shortages in reservoirs, streams, and wells were experienced throughout the State.

An "After Action Report" published by the IDW documented the conditions of the 2024-2025 "flash drought" which is a drought that occurs due to a significant lack of precipitation in a short period of time. September and October 2024 marked the driest two-month period for Connecticut ever recorded. A Stage 2 drought was declared November 2024 and remained in effect until April 2025. It is important to note that this flash drought event was preceded by two months of significant rainfall, including the record-setting 16-inch rainfall event on August 18, 2024 which resulted in extensive damage throughout parts of the state.

Drought data specific to the RiverCOG region is not widely available. The NOAA NCEI database lists six drought events impacting the region between 1996 and 2025, while USDA declared agricultural drought disasters occurred in five years from 2014 to 2024.

Agriculture related drought disasters are declared much more frequently and for smaller incidents. The USDA is authorized to designate counties as disaster areas to make emergency loans available to producers who are suffering losses. Table 2.18.1 presents USDA declared droughts and excessive heat events in the region since the last updates of the RiverCOG municipalities hazard mitigation plans.

Table 2.18.1. Drought-Related USDA Declarations Including RiverCOG Counties (2013-2024).

Year	Approval Date	Designation Number	Description of Disaster	Counties Affected
2014	12/10/2014	S3775	Drought	Middlesex, New London,
2015	11/4/2015	S3928	Drought	Middlesex, New London
2016	9/21/2016	S4045	Drought – Fast Track	New London
2016	9/28/2016	S4055	Drought – Fast Track	Middlesex, New London
2016	10/19/2016	S4076	Drought	New London
2020	10/15/2020	S4832	Drought – Fast Track	New London
2022	9/21/2022	S5287	Drought – Fast Track	Middlesex, New London
2022	9/26/2022	S5292	Drought – Fast Track	Middlesex, New London
2022	8/15/2022	S5257	Drought – Fast Track	New London

Year	Approval Date	Designation Number	Description of Disaster	Counties Affected
2022	10/11/2022	S5308	Drought – Fast Track	Middlesex
2022	8/22/2022	S5271	Drought – Fast Track	New London
2022	8/22/2022	S5267	Drought – Fast Track	Middlesex, New London
2022	9/7/2022	S5280	Drought – Fast Track	New London
2022	10/14/2022	S4808	Drought – Fast Track	New London
2022	10/14/2022	S4803	Drought – Fast Track	Middlesex, New London
2022	10/14/2022	S4814	Drought – Fast Track	Middlesex, New London

2.18.4. Probability of Future Events

The 2023 *Connecticut NHMP Update* indicates that Connecticut is likely to experience a drought every two to three years, though it also important to note that predicting a future occurrence of drought is difficult. In the Northeast, short seasonal droughts lasting 1 to 3 months usually occur every 2 or 3 years. Longer droughts, with durations exceeding 3 months, are less frequent and occur every 20 to 30 years.

The future frequency of droughts in the region may depend upon the changes in climate and resource use. Climate change can bring more intense heat waves and fewer days with precipitation (though potentially more precipitation on wet days) which may result in more droughts. Drought remains a potential natural hazard for the RiverCOG Region. Also noted in the State's plan, because human actions can increase the risk of water shortages without any change in meteorological conditions, efforts to conserve water and reduce runoff can protect water resources even in no drought periods.

2.18.5. Climate Change Impacts

Climate change will very likely have an increasingly significant impact on droughts in Connecticut. The state and municipalities must consider scientists' projections of climate impacts on drought as they plan for the future.

Based on analysis in the *Connecticut State Water Plan* dated June 5, 2019, there is 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.

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.

The FEMA Climate Mapping for Resilience and Adaptation (referenced in the 2023 *Connecticut NHMP Update*) suggests that for early century (2015 to 2044) Middlesex and New London Counties will experience 1.3 to 1.6 less days with precipitation, a 0.3 to 0.5 day increase in consecutive dry days, and between 6.0 to 7.6 more days with a maximum temperature over 90 degrees Fahrenheit. It is also important to note that these projections anticipate an increase of 2.1 to 2.5 inches in average annual total precipitation. Mid-century projections (2035 to 2064) suggest the county will experience 2.7 to 4.2 less days with precipitation, a 0.4 to 0.7 day increase in consecutive dry days, and between 9.9 to 17.5 more days with a maximum temperature over 90 degrees Fahrenheit. Average annual total precipitation is expected to increase by 2.4 to 3.5 inches, though days per year with precipitation is expected to decrease by 3.0 to 4.1 days.

In summation, the projections anticipate a wetter future, though these wet days will likely become more infrequent, couple with slightly longer dry periods and significantly more warmer days. Typical climate forecasts tend to suggest that these 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.

Water 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 snowpack and earlier melt. The combination of potential rapid snow melt and higher extreme precipitation events could translate to an increased flooding risk.

2.18.6. Impacts and Estimated Losses to the Region

While a drought does not pose immediate threats to life and property, it can have severe economic, environmental, and social consequences. A lack of precipitation can affect not only agricultural production but also tourism, water utilities, residential wells, businesses, and more. Droughts may also lead to losses or destruction of fish and wildlife habitat, loss of wetlands, and lower water levels in reservoirs, lakes, and ponds. The reduction in water levels can also cause private wells to go dry or pumps to fail and can cause dry hydrants to be unusable for fire protection purposes.

In addition, droughts can increase the severity of flooding as land that has been dry for extended periods of time does not allow water to infiltrate as quickly, which may lead to flash flooding. Droughts also exacerbate the possibility of wildfires due to the very dry conditions.

The impacts on public health from drought can be severe which includes increases 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.

According to the American Planning Association, since 1980 drought has been the fourth most common type of disaster in the United States but is the second most costly overall and per incident. Even when the RiverCOG region is not in a drought, the impacts of drought elsewhere can be felt in the region due to price increases for food, as was seen during the 2012 drought that affected 40% of the United States' agricultural land and nearly a third of all farms but was not a severe drought in the RiverCOG region.

Drought impacts cross jurisdictional boundaries and primarily affect 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. Droughts do, however, 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, buildings, critical facilities and infrastructure within the WUI zone are considered vulnerable to wildfire. Section 2.19 describes the wildland fire hazard in the region.

Exposure Analysis

To estimate land exposure to drought, agricultural land acreage was used. Table 2.18.2 lists the agricultural statistics, by county.

Table 2.18.2. USDA Agricultural Statistics for Connecticut from the 2023 Connecticut NHMP.

County	Number of Farms	% of Total Farms in State	Land in Farms (acres)	Market Value of Products Sold	% of State Total
Middlesex	441	7.99%	16,417	$57,077,777	9.84%
New London	823	14.91%	60,122	$135,786,000	23.41%

The following table (Table 2.18.3) summarizes those parcels, critical facility parcels, and historic resource parcels that have an increased exposure to drought due to the assumed use of a private well. Connecticut Department of Public Health (DPH) has created a data resource which identifies those parcels throughout the state which are not served by a public drinking water utility and are assumed to be occupied and/or developed, and therefore likely utilize a private well as their primary drinking water source. These parcels may have an increased risk of impact during a drought due to the lack of redundancy often available from a public drinking water system.

Table 2.18.3. Drought Exposure Analysis for RiverCOG Communities

Community	No. of Parcels with Private Wells	Value with Private Wells	No. of Critical Facility Parcels	Value of Critical Facility Parcels	No. of Historic Resource Parcels	Value of Historic Resource Parcels
Chester	948	$315	3	$6.2	10	$4
Clinton	1,759	$378	0	$0.0	9	$2
Cromwell	381	$54	0	$0.0	0	$0
Deep River	1,163	$298	3	$0.7	73	$21
Durham	2,577	$518	2	$0.3	81	$17
East Haddam	3,778	$947	10	$26.7	154	$52
East Hampton	4,665	$899	6	$3.0	341	$77
Essex	1,571	$620	1	$0.2	29	$14
Haddam	3,321	$689	8	$3.0	175	$37
Killingworth	2,317	$703	7	$21.9	35	$11
Lyme	1,193	$619	4	$4.0	243	$125
Middlefield	1,732	$390	5	$4.9	12	$6
Middletown	565	$740	2	$3.5	23	$51
Old Lyme	2,875	$943	6	$30.4	268	$150
Portland	1,194	$258	1	$0.3	8	$1
RiverCOG Region	**30,039**	**$8,372**	**58**	**$105.1**	**1,461**	**$569**

**All dollar figures are in millions*

Although New London County has the second highest percentage of farms in Connecticut the towns within the RiverCOG (Old Lyme and Lyme) have a low percentage of agricultural land acreage compared to other communities within the RiverCOG (i.e. Middlefield and Durham). This is shown in Figure 2.18.5. Note that most of the agricultural land within the RiverCOG is categorized as Pasture/Hay rather than Cultivated Crops, although there has been an increase in small specialty farms in recent years.

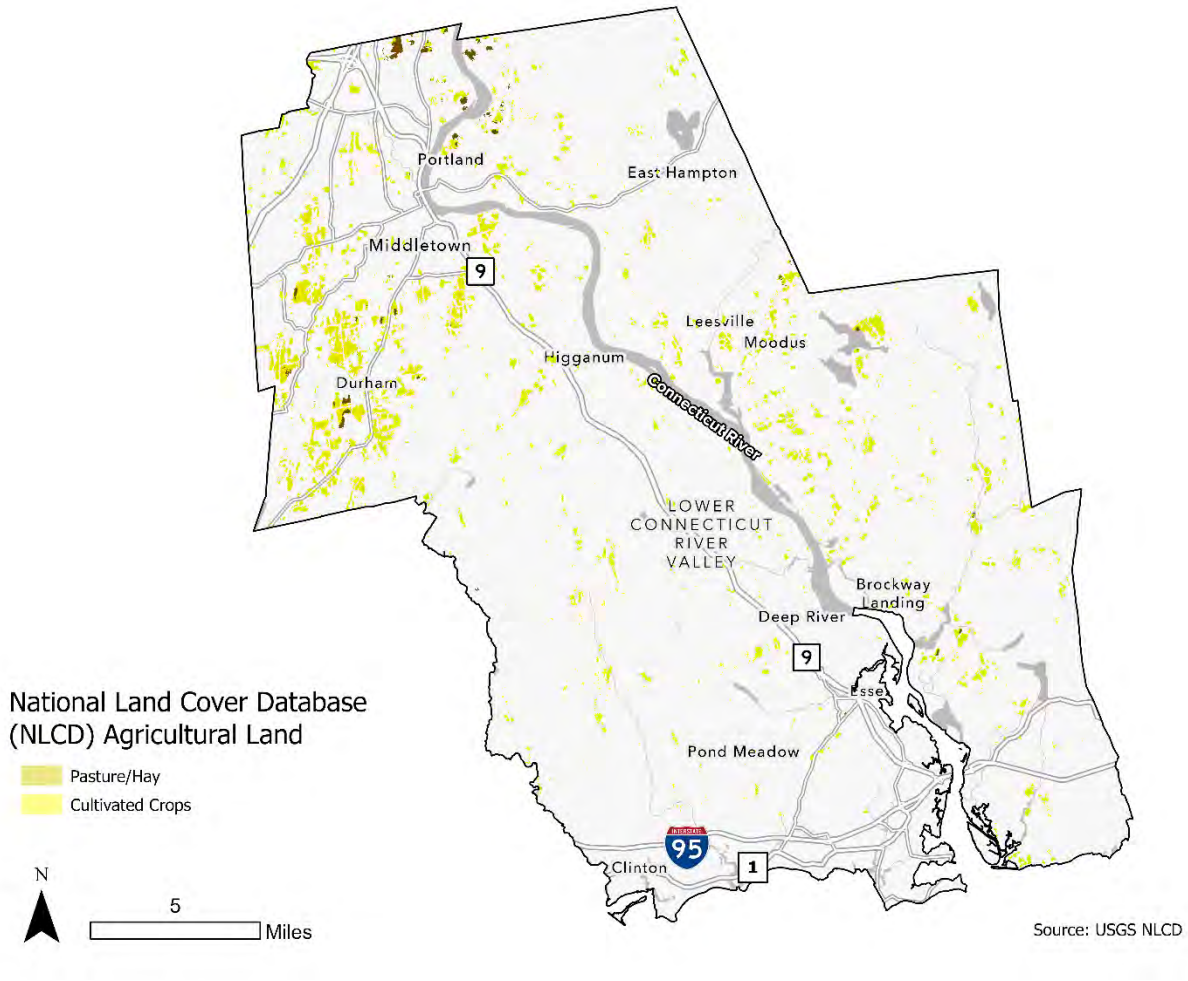


Figure 2.18.5. Agricultural land susceptible to drought damages within the RiverCOG Region.

Economic Losses

As noted above, a total of six distinct drought events have been recorded in NCEI from 1996 to 2025 for Middlesex and New London Counties. NCEI did not report any deaths, injuries, or damages records; as discussed elsewhere, USDA data provides drought losses.

Agriculture-related drought disasters are quite common. 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. Table 2.18.4 includes the number USDA-declared droughts between 2011 and 2025 along with USDA annualized insured crop losses for the same period. It is important to note that the values for New London County only include Old Lyme and Lyme. While the data in the table is a partial indicator of losses associated with drought, there are many more that are not quantified or available.

Table 2.18.4. USDA Annualized Crop Losses 2011-2025.

County	Number of Events (USDA)	USDA Insured Crop Losses	AAL
Middlesex	4	$33,204	$2,371
New London	5	$6,663	$476
Total for RiverCOG	**5**	**$39,867**	**$2,848**

Additionally, FEMA's NRI was utilized to gain another perspective on drought risk and expected annual loss due to drought in the RiverCOG region. That being said, the majority of the region has no risk to drought and does not have a rating. Displayed in Figure 2.18.6, drought risk, when available, across RiverCOG ranges from Very Low to Relatively Moderate.

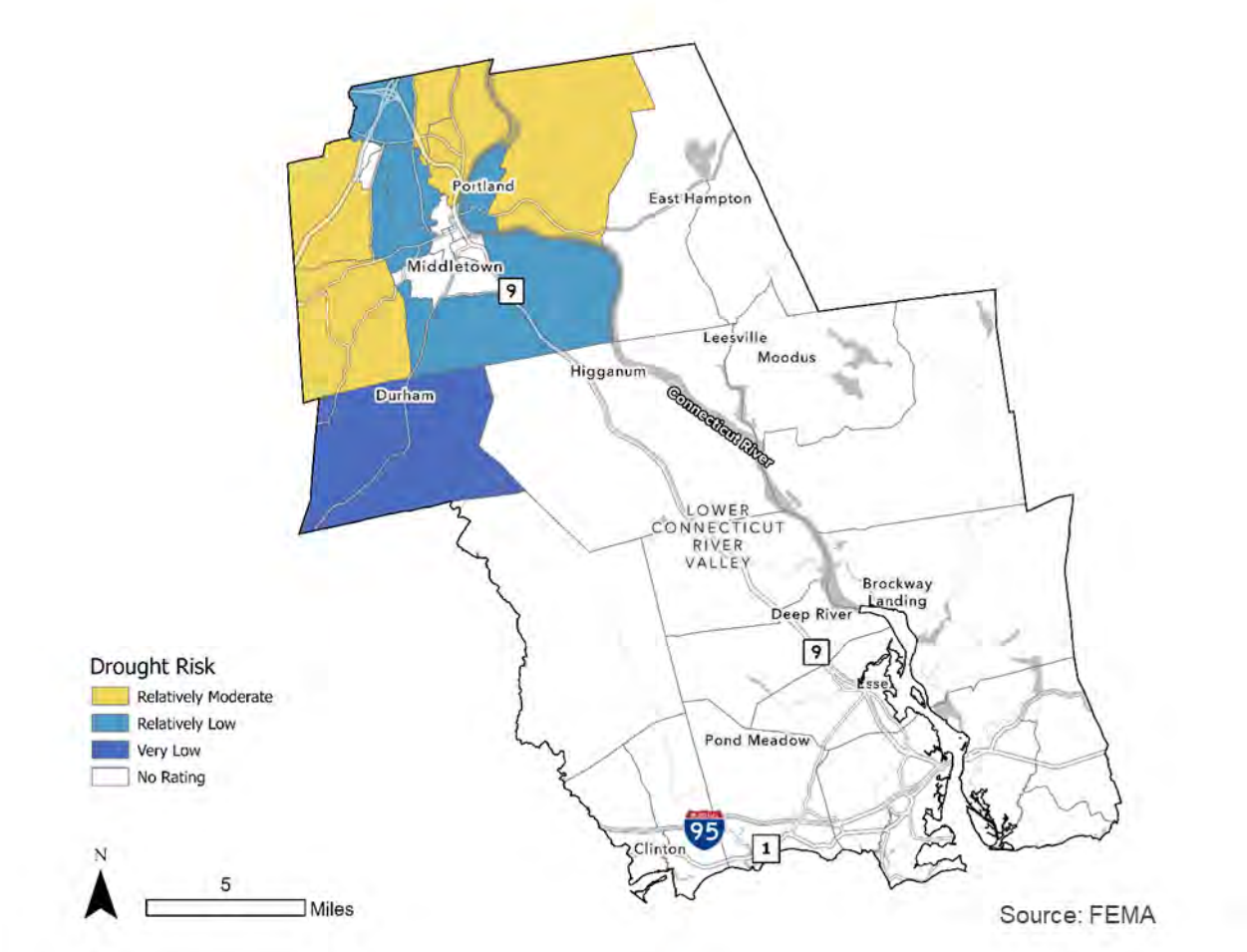


Figure 2.18.6. NRI Risk Rating for Drought, shown at the census tract level (2025)

Most communities in the region do not have a rating for drought. Cromwell has the most census tracts (2 out of 3) with a relatively moderate risk to drought, and Middlefield is fully at a relatively moderate risk to drought. Table 2.18.5 displays communities in RiverCOG and the number of census tracts at each risk rating to drought.

Table 2.18.5. Breakdown of community risk to drought

Community	Number of Census Tracts with No Rating	Number of Census Tracts with Very Low Risk	Number of Census Tracts with Relatively Low Risk	Number of Census Tracts with Relatively Moderate Risk
Chester	1	-	-	-
Clinton	4	-	-	-
Cromwell	-	-	1	2
Deep River	1	-	-	-
Durham	-	1	-	-
East Haddam	2	-	-	-
East Hampton	3	-	-	-
Essex	2	-	-	-
Haddam	2	-	-	-
Killingworth	1	-	-	-
Lyme	1	-	-	-
Middlefield	-	-	-	1
Middletown	8	-	4	1
Old Lyme	3	-	-	-
Portland	-	-	1	1
Total for RiverCOG Region	**28**	**1**	**6**	**5**

Figure 2.18.7 below shows the expected annual loss ratings throughout the COG and Table 2.18.6 describes the projected annualized losses from drought by community. The highest expected annual losses are found in Middlefield and Cromwell with a projected $200,435 and $194,285 in expected annual losses due to drought respectively. The RiverCOG region has a total expected annual loss of $532,772.

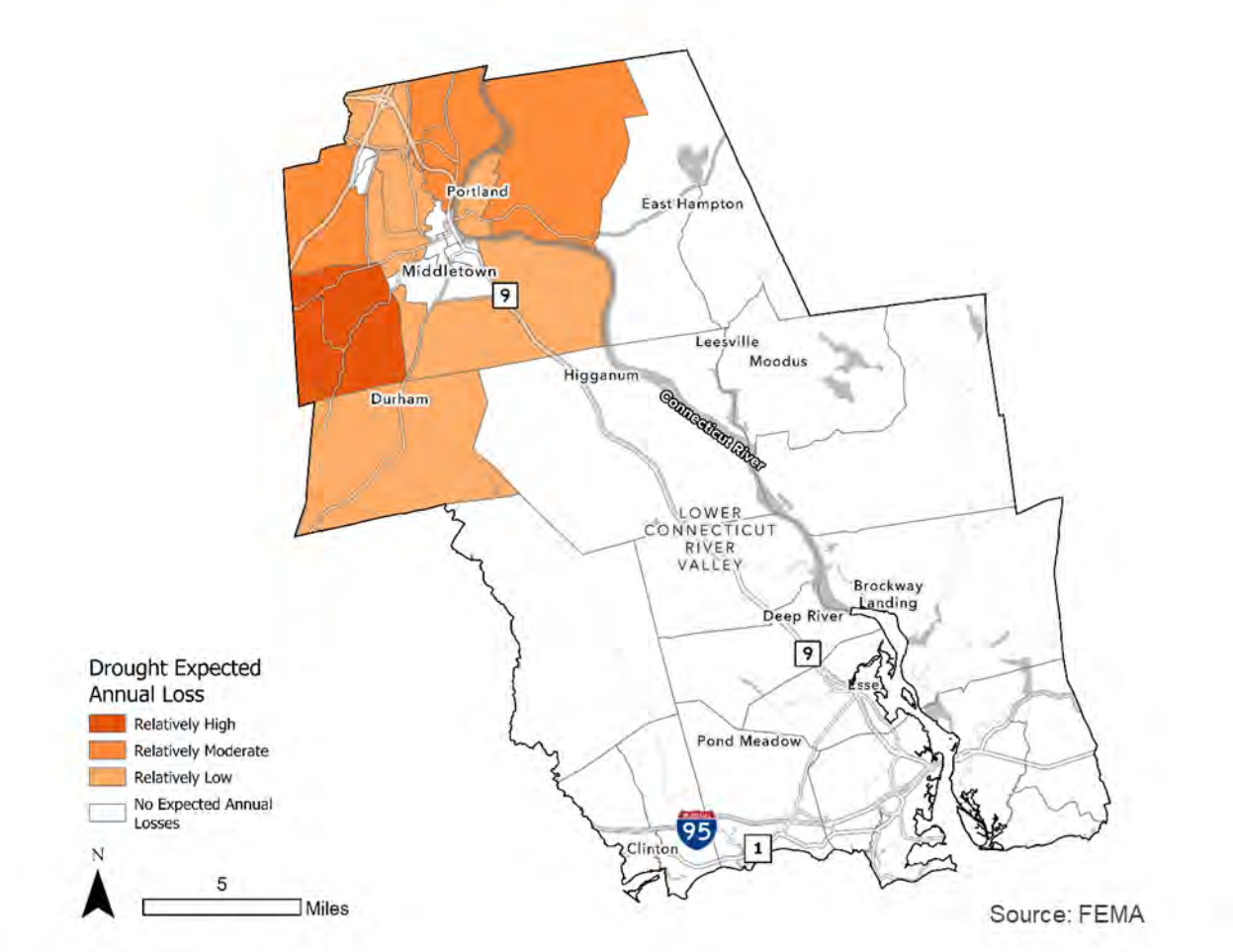


Figure 2.18.7. NRI Drought Expected Annual Loss Rating (2025)

Table 2.18.6. Breakdown of Expected Annual Losses from the NRI by Community for Drought

Community	Expected Annual Loss
Chester	$0
Clinton	$0
Cromwell	$194,285
Deep River	$0
Durham	$507
East Haddam	$0
East Hampton	$0
Essex	$0
Haddam	$0
Killingworth	$0

Community	Expected Annual Loss
Lyme	$0
Middlefield	$200,435
Middletown	$98,299
Old Lyme	$0
Portland	$39,246
Total for RiverCOG Region	**$532,772**

2.18.7. Development Trends

Since the 2021 plan update, development within the RiverCOG region has remained limited. Over the five-year period from 2019 to 2023, the region's population increased by approximately 1.7%,[102] a modest rise that is about 0.5% lower than Connecticut's statewide growth rate of roughly 2.2% during the same timeframe. Haddam, Old Lyme, Clinton, Cromwell, Middletown, and Essex experienced the largest population increases during this period, though the highest rate of growth was a modest 4.1% in Haddam. Chester saw the most significant decline, with its population decreasing by 10.6% over the same five-year span. Several factors contribute to these shifting growth patterns, with the COVID-19 pandemic playing a major role.

Similarly, there has been only a 0.37% increase in housing stock in the region during the 2019-2023 five-year period, with only 195 building permits issued in 2023 across RiverCOG.[103] The majority of these building permits issues in 2023 are in East Hampton (37) and East Haddam (25), both of which have seen decreases in housing stock during these five years. Killingworth, Durham, Haddam, Deep River, and Clinton have seen the largest increase in housing stock during this period. Additionally, commercial and industrial growth has been relatively stagnant during this time frame.

An understanding of development trends can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. Since the entire region is exposed to drought, any new development and increases in population will be vulnerable to the impacts from these events.

Regarding drought, a concern with increased development is the added stress on the water supply. Increases in development and population would result in a greater water requirement for the region, and in times of drought, would put more of the population at risk unless the water supply is properly managed. There is also an increase in small specialty farms in the region. If that trend continues, droughts may become a greater economic concern. More specific changes in

[102] https://www.rivercog.org/data-population

[103] https://www.rivercog.org/data-housingcharacteristics

development are addressed at the community level in the municipal annexes in Volume II of this plan.

2.18.8. Overall Risk Rating

Using the parameters described in Table 2.8.1, the following hazard risk ratings were developed for drought (Table 2.18.7).

Table 2.18.7: Overall Risk Rating of Drought

Criteria	Hazard Risk Rating
Probability	3 (Likely)
Impact: Affected Area	3 (Medium)
Impact: Primary Impact	1 (Negligible)
Impact: Secondary Impacts	2 (Limited)
Survey Rating	3 (High Concern)
Total Score	13.1
Overall Risk Ranking	**Moderate**

2.19. Wildland Fires

2.19.1. Description and Background

Wildland fires are a relatively common occurrence in Connecticut but are typically small and cause little to no damage to populated areas. Structural fires in higher-density areas of the region are not considered in this Plan.

Wildfire damage is typically greatest at the wildland-urban interface where low-density suburban/rural developed areas border undeveloped wooded and shrubby areas. All RiverCOG communities are susceptible to wildfires. Unlike the other hazards described in this Plan, the likelihood of damage due to wildfires in Connecticut typically decreases with increasing population density, meaning that less developed communities such as Killingworth have a greater risk than heavily developed communities such as Middletown.

2.19.2. Location and Extent

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 which include naturally occurring wildland fire, human-caused wildland fire, and prescribed fire. In the RiverCOG area, humans are the primary cause of wildland fires. Some of these are highly destructive and can be very uncontrollable. 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.[104]

According to the National Fire Protection Association (NFPA), several elements (known as the fire tetrahedron) must be present in order to have any type of fire:

- **Fuel**: Without fuel, a fire will stop. Fuel can be removed naturally (when the fire has consumed all burnable fuel) or manually by mechanically or chemically removing fuel from the fire. In structure fires, removal of fuel is not typically a viable method of fire suppression. Fuel separation is important in wildfire suppression and is the basis for controlling prescribed burns and suppressing other wildfires. The type of fuel present in an area can help determine overall susceptibility to wildfires. According to the Forest Encyclopedia Network, four types of fuel are present in wildfires:
    - Ground Fuels: organic soils, forest floor duff, stumps, dead roots, buried fuels
    - Surface Fuels: the litter layer, downed woody materials, dead and live plants to 2 meters tall
    - Ladder Fuels: vine and draped foliage fuels
    - Canopy Fuels: tree crowns
- **Heat**: Without sufficient heat, a fire cannot begin or continue. Heat can be removed through the application of a substance, such as water, powder, or certain gases, that reduces the amount of heat available to the fire. Scraping embers from a burning structure also removes the heat source.
- **Oxygen**: Without oxygen, a fire cannot begin or continue. In most wildland fires, this is commonly the most abundant element of the fire triangle and is therefore not a major factor in suppressing wildfires.
- **Uninhibited Chain Reaction**: The chain reaction is the feedback of heat to the fuel to produce the gaseous fuel used in the flame. In other words, the chain reaction provides the sustained heat necessary to maintain the fire. Fire suppression techniques, such as dry chemical extinguishers, break up the uninhibited chain reaction of combustion to stop a fire.

Wildland fires occur in forested, semi-forested, or less developed areas, although smaller fires can also occur along highway medians. Fires within forested areas that are ignited by natural causes such as lightning or as part of a controlled burn process are part of the natural fire cycle and an important contributor to forest health. It is estimated that approximately 75% of Connecticut is under some type of tree canopy. Of the 1.8 million forested acres across the state, 73% is privately

[104] http://ready.nj.gov/mitigation/2014-mitigation-plan.shtml

owned, with municipalities owning an additional 9%.[105] The Connecticut River Valley is comprised of oak- and hickory-dominated woodlands.

The forests of the RiverCOG region are biologically diverse, with a wide variety of shrubs, trees, herbaceous plants, lichens, and mosses. This rich flora supports an equally diverse array of wildlife by providing essential habitat and food resources. Among shrubs, highbush blueberry and mountain laurel are especially common and widespread across the region's mixed hardwood forests. A common softwood tree in RiverCOG forests is eastern white pine, a dominant conifer in southeastern Connecticut's native plant collections. The hardwood canopy is typical of southern New England and is dominated by red maple, black oak, and American beech, all documented as common native species in Connecticut and the broader New England flora. 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.

The extent (e.g., 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, in combination with fire detection, control, and suppression capabilities.

Three fire seasons are recognized in Connecticut. The spring season runs from mid-March to mid-May. Prior to leaf-out, fuels such as grasses, dead leaves, branches, and twigs on the forest floor are heated and dried out by the sun. These fuels cause spring fires that tend to spread quickly although they tend to cause little long-term damage to the forest. The summer fire season lasts from mid-May through September and is largely dependent on precipitation, or lack thereof. Summer fires tend to spread less quickly than spring fires because they burn deeper into the ground. However, the burning of organic material in the soil makes summer fires more difficult to suppress. Summer fires are the most destructive to vegetation. Consequently, erosion usually follows summer forest fires. The fall fire season runs from October through the first snowfall. Fall fires can spread rapidly because of dry leaves that have fallen.

According to 2020 U.S. Census data, Connecticut ranks as the fourth most densely populated state in the United States with almost 750 persons per square mile. Since wildfire damage is typically greatest at the wildland interface where low-density suburban/rural developed areas border undeveloped wooded and shrubby areas, and because Connecticut is one of the most heavily forested states in the nation and ranks among the most densely populated, Connecticut is among the highest ranked states in terms of percentage of land considered to be within Wildland Urban Interface (WUI) areas, which are the areas considered most vulnerable to wildland fire risks.

[105] https://portal.ct.gov/DEEP/Forestry/Landowner-Assistance/Technical-Assistance-and-Service-Forestry-Support-for-CT-Landowners

These high percentages of WUI areas are 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. Wildland fires are of concern for areas with limited firefighting access such as outlying areas without public water service and large contiguous forest parcels with limited access.

A WUI is a zone of transition between unoccupied land (wildland) and human development. Communities with WUI zones are at higher risk of catastrophic wildfires, and their presence disrupts the ecology of the area. The WUI is typically split into two categories:

1. Intermix Zones, which are lands that contain at least one housing unit per 40 acres in which vegetation occupies more than 50% of terrestrial area; a heavily vegetated intermix WUI is an area in which vegetation occupies over 75% of terrestrial area (at least 5 km^2).
2. Interface Zones, which are lands that contain at least one housing unit per 40 acres in which vegetation occupies less than 50% of terrestrial area (at least 2.4 km^2).

Structures in intermix WUI are interspersed with vegetation, whereas homes in interface WUI are adjacent to heavy vegetation. Human development has increasingly encroached into the WUI in parallel with a climate change driven increase in large wildland fires which has caused an increase in fire protection costs.

Figure 2.19.1 illustrates wildland fire hazard areas for the RiverCOG based on 2020 WUI map products developed by the SILVIS Lab at the University of Wisconsin-Madison.

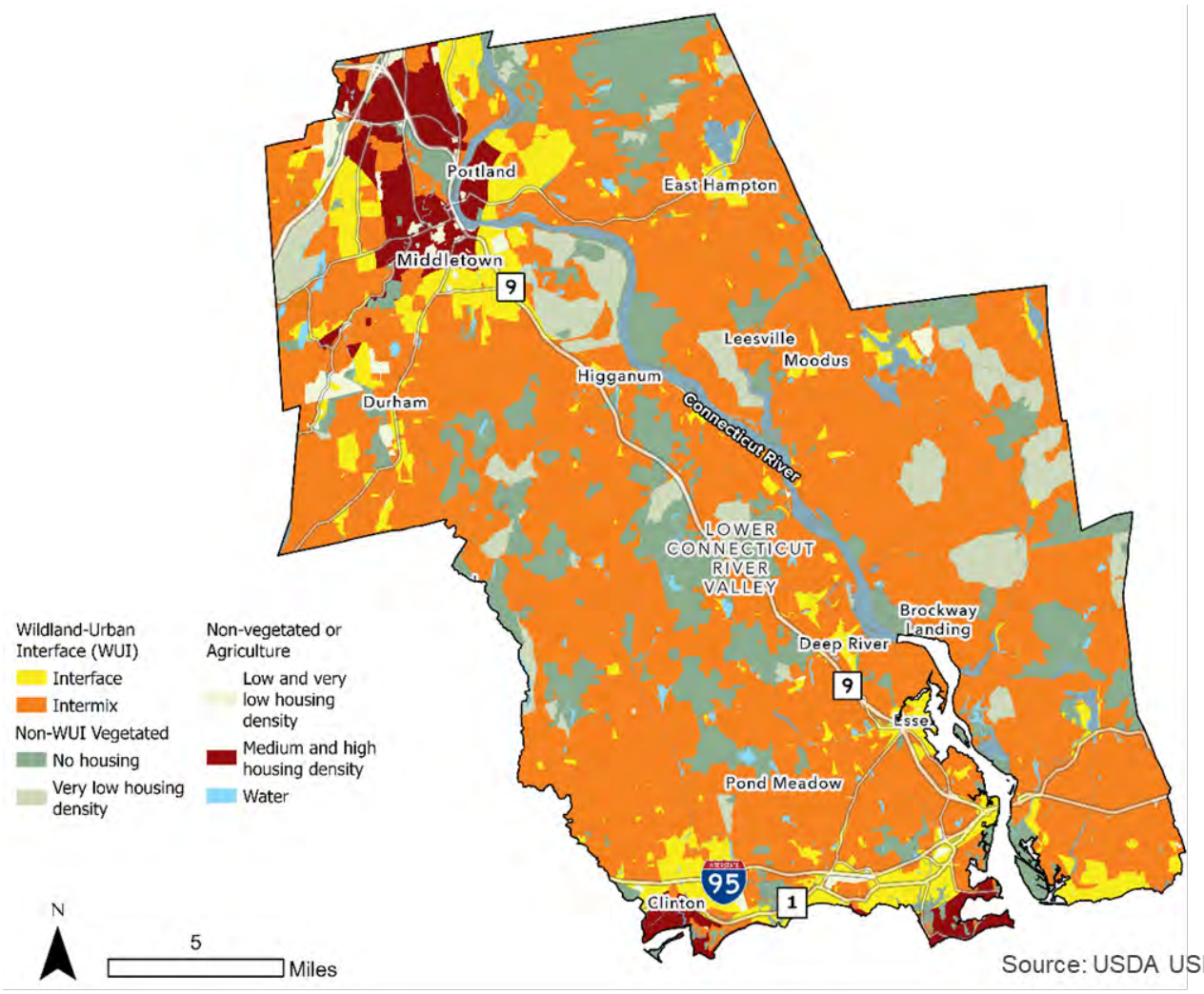


Figure 2.19.1. Wildfire Hazard Areas.

The CT DEEP states that while the primary cause of wildland fires throughout Connecticut is typically undeterminable, the secondary causes of wildfires tend to be arson or debris burning. 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. The Connecticut DEEP Division of Forestry issues forest fire danger ratings. The ratings are low, moderate, high, very high, and extreme. These are based on an index of how quickly a fire is likely to spread and measures of drought. In addition, NWS issues "Red Flag" warnings. A Red Flag warning means that if a fire occurs, firefighters can expect it to behave erratically due to weather conditions.

The NWS and State systems for classifying and declaring wildfire risks are appropriate for the RiverCOG region. Wildfires have not been characterized outside of these systems of classification. The notable wildfires of fall 2024 occurred within these classification systems.

2.19.3. History of Past Events

According to the Connecticut DEEP Forestry Division, much of Connecticut was deforested by settlers and converted to farmland during the colonial period. A variety of factors in the 19th century caused the decline of farming in the state, and forests reclaimed abandoned farm fields. In the early 20th century, deforestation again occurred in Connecticut, this time for raw materials needed to ship goods throughout the world. Following this deforestation, shipping industries in Connecticut began to look to other states for raw materials, and the deciduous forests of today began to grow in the state.

During the early 20th century, wildfires regularly burned throughout Connecticut. Many of these fires began accidentally by sparks from railroads and industry while others were deliberately set to clear underbrush in the forest and provide pasture for livestock. A total of 15,000 to 100,000 acres of land was burned annually during this period. This destruction of resources led to the creation of the position of the State Forest Fire Warden and led to a variety of improved coordination measures described in Section 3.

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.

Table 2.19.1 provides a summary of wildland fires occurring across Connecticut as reported to the US Forest Service (USFS) Fire Program Analysis (FPA) and the National Interagency Fire Center (NIFC) from 2013 to 2022. The table was extracted from the 2023 *Connecticut NHMP Update*. Data could not be identified for the individual communities.

Table 2.19.1. Fire Events in Connecticut. (Source: 2023 Connecticut NHMP Update)

Year	Number of Events	Total Acres Burned
2013	76	238
2014	28	69
2015	372	418
2016	636	945
2017	332	389
2018	67	45
2019	106	68
2020	603	366
2021	60	127
2022	150	347

Year	Number of Events	Total Acres Burned
Total	**2,430**	**3,012**

Table 2.19.2 and Table 2.19.3 summarize the NFIRS data on reported wildland fire events from 2012 to 2024 by year and town. According to these records, there have been 808 events reported for the RiverCOG region, including Old Saybrook and Westbrook, or 62 wildland fire events per year. Most have been brush, grass, or other vegetation fires, with the rest mostly being forest based fires. These brush fires are over 5 times more numerous than the forest fires.

Table 2.19.2. NFIRS Wildland Fire Events in the RiverCOG Region by Year, 2012-2024

Year	Total Wildland Fires	Year	Total Wildland Fires
2012	115	**2019**	6
2013	130	**2020**	17
2014	94	**2021**	29
2015	127	**2022**	59
2016	143	**2023**	46
2017	12	**2024**	22
2018	8	**Total**	808

Table 2.19.3. NFIRS Wildland Fire Events in the RiverCOG Region by Town, 2012-2024

Community	Community Wildland Fire Totals 2012-2016	Community Totals Wildland Fire Totals 2017-2024	Total
Town of Chester	4	0	4
Town of Clinton	43	11	54
Town of Cromwell	58	2	60
Town of Deep River	16	2	18
Town of Durham	28	0	28
Town of East Haddam	30	11	41
Town of East Hampton	36	0	36
Town of Essex	9	3	12
Town of Haddam	42	27	69
Town of Killingworth	11	9	20
Town of Lyme	21	21	42
Town of Middlefield	25	0	25

Community	Community Wildland Fire Totals 2012-2016	Community Totals Wildland Fire Totals 2017-2024	Total
City of Middletown	193	79	272
Town of Old Lyme	6	11	17
Town of Old Saybrook	37	0	37
Town of Portland	32	22	54
Town of Westbrook	18	1	19
RiverCOG Totals	**609**	**199**	**808**

Over the last 5 years, three notable wildfires have occurred in the RiverCOG region. These fires have been captured in a visual database by the *Norwich Bulletin*[106] and are described below.

May 10, 2022: A wildfire occurred east of Aircraft Road, west of River Road, and north of Freeman Road in Middletown that burned nearly 300 acres and cost over $10,000 to control. The fire was sparked by a tree that fell on a power line and ignited nearby brush. The fire required more than 100 firefighters and high winds reportedly made the response challenging.[107]

November 2, 2024: During a severe drought period in Connecticut, more than 100 wildfires occurred throughout the state. Although no major wildfires were reported in the RiverCOG region, 13 minor wildfires were reported to the Connecticut Department of Emergency Management and Homeland Security (DEMHS)[108] including one wildfire was reported in Chester, two in Clinton, one in Cromwell, two in Durham, two in East Hampton, three in Haddam, and two in Lyme.

April 18, 2025: A car fire in Haddam spread to a nearby structure and then to a nearby wooded area on Tinker Road and Old Cart Road, consuming 200 acres of forest. CT DEEP assisted the Town of Haddam and other mutual aid partners in fighting the blaze. A back burn fire was used to prevent the fire from spreading further.[109] Firefighting costs were estimated at over $50,000.

FEMA Disaster Declarations

Between 1954 and 2025, the State of Connecticut has not been included in any wildfire-related major disaster (DR) declaration by the federal government. One fire management assistance (FM)

[106] https://data.norwichbulletin.com/wildfire-history/?query=Connecticut

[107] https://www.middletownpress.com/middletown/article/Middletown-brush-fire-reached-nearly-300-acres-17165030.php

[108] https://www.wfsb.com/2024/11/04/fire-crews-battling-numerous-brush-fires-across-state/

[109] https://dailydispatch.com/fire-news/connecticut/200-acres-of-forest-land-burned-due-to-fire-in-haddam/

declaration was recently issued.[110] Disaster 5542, the Connecticut Hawthorne Fire, was declared on October 24, 2024 for an incident near Lamentation Mountain in Berlin which began on October 21, 2024. The fire burned over 100 acres and took weeks to fully contain. The emergency declaration designated Hartford and New Haven Counties as eligible areas for FEMA PA.

2.19.4. Probability of Future Events

The 2023 *Connecticut NHMP Update* notes that wildland fires burn less than a fraction of one percent of the total forested acreage in the state each year. In general, the wildland fires in Connecticut are small and detected quickly. While the overall incidence of forest fires is relatively low (an average of 301 fires per year, or less than two fires per Connecticut municipality per year), wildfires are a hazard communities must be prepared for each year.

Based on the numbers of occurrences identified above there have been an average of 62 wildland fire events per year in the RiverCOG region over the last 13 years. In the 2023 *Connecticut State NHMP Update*, there were 3,012 reported wildland fire incidents statewide between 2013 and 2022, for an annual occurrence of 301 events. Since RiverCOG is only approximately 9.1% of Connecticut's land area but has been experiencing approximately 20% of the wildfires occurring in Connecticut, this suggests that wildland fires occur in the RiverCOG region with more frequency than in other parts of Connecticut.

Based on the historic record, the average wildfire in Connecticut in a very dry year (1999) burned an average of 5 acres per fire while the average acres burned per fire is 1.2 acres according to the 2023 *Connecticut NHMP Update*. These averages are also reasonable for the RiverCOG communities although it is expected that larger wildfires can and may occur, particularly in relatively undeveloped areas of the region. The potential frequency of wildfires caused by humans is expected to increase as population in the region increases, while the potential frequency of wildfires caused by natural conditions may change as noted below.

2.19.5. 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 change 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 even more

[110] https://www.fema.gov/disasters

challenging. The further out a prediction reaches, the more subject to changing dynamics it becomes.

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 influence 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 influence 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.

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. This is already being seen in the region. The direct threat to humans comes in the form of increased fire outbreaks in WUI areas which have the potential to burn hotter and burn 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.

2.19.6. Impacts and Potential Losses to Region

Forest fires can cause not only long-term damage to vegetation and ecosystems but also damage to developments, especially as residential development has increased in woodland areas. 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.

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. 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.

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.

Exposure Analysis

Table 2.19.4 lists the property values of the CAMA parcels that intersect intermix or interface WUI Areas for the communities in the RiverCOG, indicating total value of property exposed to risk.

Table 2.19.4. Property Value Intersecting Wildland Fire Hazard Areas

Community	Value Intersecting Intermix	Value Intersecting Interface	Total Value at Risk
Chester	$509	$75	$583
Clinton	$703	$663	$1,366
Cromwell	$115	$336	$451
Deep River	$469	$117	$586
Durham	$422	$191	$613
East Haddam	$921	$175	$1,097
East Hampton	$865	$296	$1,161
Essex	$880	$528	$1,408
Haddam	$761	$67	$828
Killingworth	$761	$31	$792
Lyme	$617	$61	$678
Middlefield	$241	$207	$448
Middletown	$254	$166	$421
Old Lyme	$867	$741	$1,608
Portland	$396	$448	$844
Total	**$8,781**	**$4,102**	**$12,883**

**All dollar values in Millions*

The following tables provide breakdowns for Intermix and Interface including critical facilities and historic resources.

Table 2.19.5. Parcels, Critical Facility Parcels, and Historic Resource Parcels Intersecting Wildland Fire Hazard Areas - Intermix

Community	No. of Parcels in an Intermix Zone	Value in an Intermix Zone	No. of Critical Facility Parcels in an Intermix Zone	Value of Critical Facility Parcels in an Intermix Zone	No. of Historic Resource Parcels in an Intermix Zone	Value of Historic Resource Parcels in an Intermix Zone
Chester	1,638	$509	11	$30	39	$15
Clinton	3,243	$703	9	$74	79	$34
Cromwell	416	$115	14	$138	37	$9
Deep River	1,764	$469	13	$78	201	$48
Durham	2,181	$422	8	$18	42	$12
East Haddam	4,388	$921	14	$35	143	$40
East Hampton	4,669	$865	14	$39	243	$61
Essex	2,416	$880	12	$40	205	$68
Haddam	3,921	$761	14	$45	171	$63
Killingworth	2,730	$761	8	$25	44	$22
Lyme	1,385	$617	5	$9	243	$119
Middlefield	1,193	$241	8	$14	11	$5
Middletown	1,008	$254	0	$0	63	$17
Old Lyme	2,837	$867	12	$50	204	$127
Portland	2,216	$396	21	$24	18	$3
RiverCOG Region	**36,005**	**$8,781**	**163**	**$618**	**$1,743**	**$642**

Note: All dollar values in millions.

Table 2.19.6. Parcels, Critical Facility Parcels, and Historic Resource Parcels Intersecting Wildland Fire Hazard Areas - Interface

Community	No. of Parcels in an Interface Zone	Value in an Interface Zone	No. of Critical Facility Parcels in an Interface Zone	Value of Critical Facility Parcels in an Interface Zone	No. of Historic Resource Parcels in an Interface Zone	Value of Historic Resource Parcels in an Interface Zone
Chester	243	$75	3	$5	12	$4
Clinton	2,918	$663	6	$66	319	$120
Cromwell	1,079	$336	2	$18	18	$24

Community	No. of Parcels in an Interface Zone	Value in an Interface Zone	No. of Critical Facility Parcels in an Interface Zone	Value of Critical Facility Parcels in an Interface Zone	No. of Historic Resource Parcels in an Interface Zone	Value of Historic Resource Parcels in an Interface Zone
Deep River	478	$117	4	$15	194	$52
Durham	994	$191	6	$16	57	$12
East Haddam	1,188	$175	3	$5	59	$25
East Hampton	1,566	$296	6	$7	162	$40
Essex	1,088	$528	6	$8	343	$204
Haddam	370	$67	2	$9	41	$9
Killingworth	97	$31	0	$0	5	$1
Lyme	182	$61	1	$1	27	$13
Middlefield	952	$207	5	$3	11	$5
Middletown	576	$166	1	$2	21	$9
Old Lyme	2,867	$741	5	$17	316	$118
Portland	2,526	$448	11	$13	145	$42
RiverCOG Region	**17,124**	**$4,102**	**61**	**$184**	**1,730**	**$680**

Note: All dollar values in millions.

Table 2.19.7 provides a breakdown of the numbers of critical facilities intersecting wildland intermix and wildland interface areas by facility type. A total of 64 critical facilities (80-percent of the total number of critical facilities in the RiverCOG) are located within a WUI Area. Municipal level critical facilities are discussed in the municipal annexes in Volume II of this plan.

Table 2.19.7. Number of Critical Facilities in the WUI for RiverCOG

Facility Type	All Critical Facilities	# within Intermix	# within Interface
Care Facility/Assisted Living/Senior Living	24	7	12
EMS	15	6	5
Fire Stations	32	15	17
Law Enforcement	14	3	7
Municipal	83	40	36
Municipal Solid Waste	17	12	2
Private	9	5	3

Facility Type	All Critical Facilities	# within Intermix	# within Interface
Storage Tank Farm or Utility	7	0	2
Total	**201**	**88**	**84**

Regional parcels were further assessed for wildland fire exposure by cross-referencing those that intersect the intermix or interface and are also assumed to be reliant on a private drinking water well. The identification of these parcels may highlight an increased exposure, and vulnerability, given that water sources for firefighting purposes may be more limited in these areas due to lack of community water infrastructure. This analysis does not consider the presence of water sources such as dry hydrants, underground water storage tanks, or firefighting water truck capacity; it is meant to further identify wildland exposed locations throughout the region.

Table 2.19.8 through Table 2.19.10 present property values for exposed and well-reliant parcels, critical facilities, and historic resources.

Table 2.19.8. Property Value for Parcels Intersecting Wildland Fire Hazard Areas and Reliant on Private Wells.

Community	Value Intersecting Intermix with Well	Value Intersecting Interface with Well	Total Value at Risk
Chester	$295	$38	$334
Clinton	$320	$58	$378
Cromwell	$2	$4	$6
Deep River	$291	$8	$299
Durham	$372	$159	$530
East Haddam	$820	$111	$931
East Hampton	$663	$243	$906
Essex	$578	$63	$640
Haddam	$647	$48	$696
Killingworth	$694	$24	$718
Lyme	$543	$58	$601
Middlefield	$190	$181	$371
Middletown	$296	$167	$462
Old Lyme	$694	$285	$979
Portland	$221	$36	$257
Total	**$6,625**	**$1,482**	**$8,108**

**All dollar values in Millions*

Table 2.19.9. Parcels, Critical Facility Parcels, and Historic Resource Parcels Intersecting Wildland Fire Hazard Areas and Reliant on Private Wells.

Community	No. of Parcels with wells in an Intermix Zone	Value of Parcels with wells in an Intermix Zone	No. of Critical Facility Parcels with wells in an Intermix Zone	Value of Critical Facility Parcels with wells in an Intermix Zone	No. of Historic Resource Parcels with wells in an Intermix Zone	Value of Historic Resource Parcels with wells in an Intermix Zone
Chester	860	$295	3	$6.2	10	$4.2
Clinton	1,417	$320	0	$0.0	6	$1.8
Cromwell	5	$2	0	$0.0	0	$0.0
Deep River	1,124	$291	3	$0.7	68	$19.8
Durham	1,809	$372	0	$0.0	38	$9.2
East Haddam	3,241	$820	8	$25.2	115	$34.7
East Hampton	3,469	$663	4	$2.3	216	$46.3
Essex	1,444	$578	1	$0.2	28	$13.4
Haddam	3,065	$647	7	$2.7	142	$31.3
Killingworth	2,297	$694	6	$21.7	35	$11.3
Lyme	1,007	$543	1	$0.3	210	$107.7
Middlefield	853	$190	1	$3.4	5	$2.7
Middletown	1,012	$296	0	$0.0	63	$17.1
Old Lyme	2,012	$694	4	$27.4	185	$107.5
Portland	995	$221	0	$0.0	5	$0.7
RiverCOG Region	**24,610**	**$6,625**	**38**	**$90.2**	**1,126**	**$407.6**

**All dollar values in Millions*

Table 2.19.10. Parcels, Critical Facility Parcels, and Historic Resource Parcels Intersecting Wildland Fire Hazard Areas and Reliant on Private Wells

Community	No. of Parcels with wells in an Interface Zone	Value of Parcels with wells in an Interface Zone	No. of Critical Facility Parcels with wells in an Interface Zone	Value of Critical Facility Parcels with wells in an Interface Zone	No. of Historic Resource Parcels with wells in an Interface Zone	Value of Historic Resource Parcels with wells in an Interface Zone
Chester	132	$38	1	$2.2	3	$2
Clinton	343	$58	0	$0.0	3	$1
Cromwell	17	$4	0	$0.0	0	$0
Deep River	44	$8	0	$0.0	4	$1
Durham	854	$159	2	$0.3	47	$9
East Haddam	513	$111	2	$1.4	44	$20
East Hampton	1,227	$243	3	$1.5	130	$31
Essex	167	$63	0	$0.0	1	$0
Haddam	294	$48	1	$0.2	36	$6
Killingworth	78	$24	0	$0.0	4	$1
Lyme	129	$58	1	$1.1	24	$13
Middlefield	772	$181	4	$1.5	6	$3
Middletown	577	$167	1	$1.8	21	$9
Old Lyme	935	$285	3	$3.6	96	$54
Portland	208	$36	0	$0.0	3	$1
RiverCOG Region	**5,713**	**$1,482**	**18**	**$13.7**	**422**	**$150**

**All dollar values in Millions*

Economic Losses

To supplement the exposure analysis performed above, FEMA's NRI gives another representation of wildfire risk throughout RiverCOG. Displayed in Figure 2.19.2, wildfire risk across RiverCOG ranges from Very Low to Relatively Low.

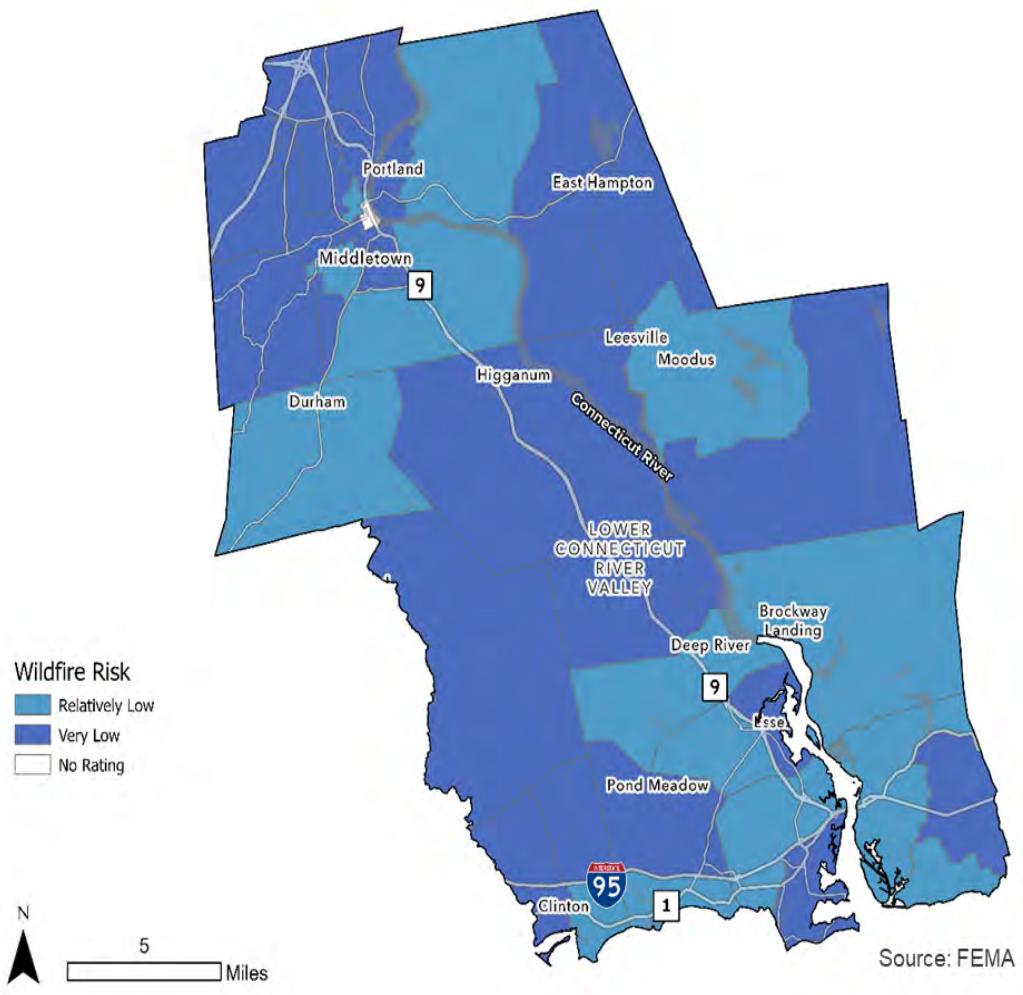


Figure 2.19.2. NRI Risk Rating for Wildfire, shown at the census tract level (2025)

Middletown has the most census tracts (3 out of 13) with a relatively low risk to wildfire. Old Lyme also has 2 out of 3 census tracts at relatively low risk to wildfire. Table 2.19.11 displays communities in RiverCOG and the number of census tracts at each risk rating to wildfire.

Table 2.19.11. Breakdown of community risk to wildfire

Community	Number of Census Tracts with No Rating	Number of Census Tracts with Very Low Risk	Number of Census Tracts with Relatively Low Risk
Chester	-	1	-
Clinton	-	3	1
Cromwell	-	3	-

Community	Number of Census Tracts with No Rating	Number of Census Tracts with Very Low Risk	Number of Census Tracts with Relatively Low Risk
Deep River	-	-	1
Durham	-	1	-
East Haddam	-	1	1
East Hampton	-	3	-
Essex	-	1	1
Haddam	-	2	-
Killingworth	-	1	-
Lyme	-	-	1
Middlefield	-	1	-
Middletown	1	9	3
Old Lyme	-	1	2
Portland	-	1	1
Total for RiverCOG Region	**1**	**28**	**11**

Figure 2.19.3 below shows the expected annual loss ratings throughout the COG and Table 2.19.12 describes the projected annualized losses from wildfire by community. The highest expected annual losses are found in Old Lyme and Middletown with a projected $4,026 and $1,903 in expected annual losses due to wildfire respectively. The RiverCOG region has a total expected annual loss of $15,641.

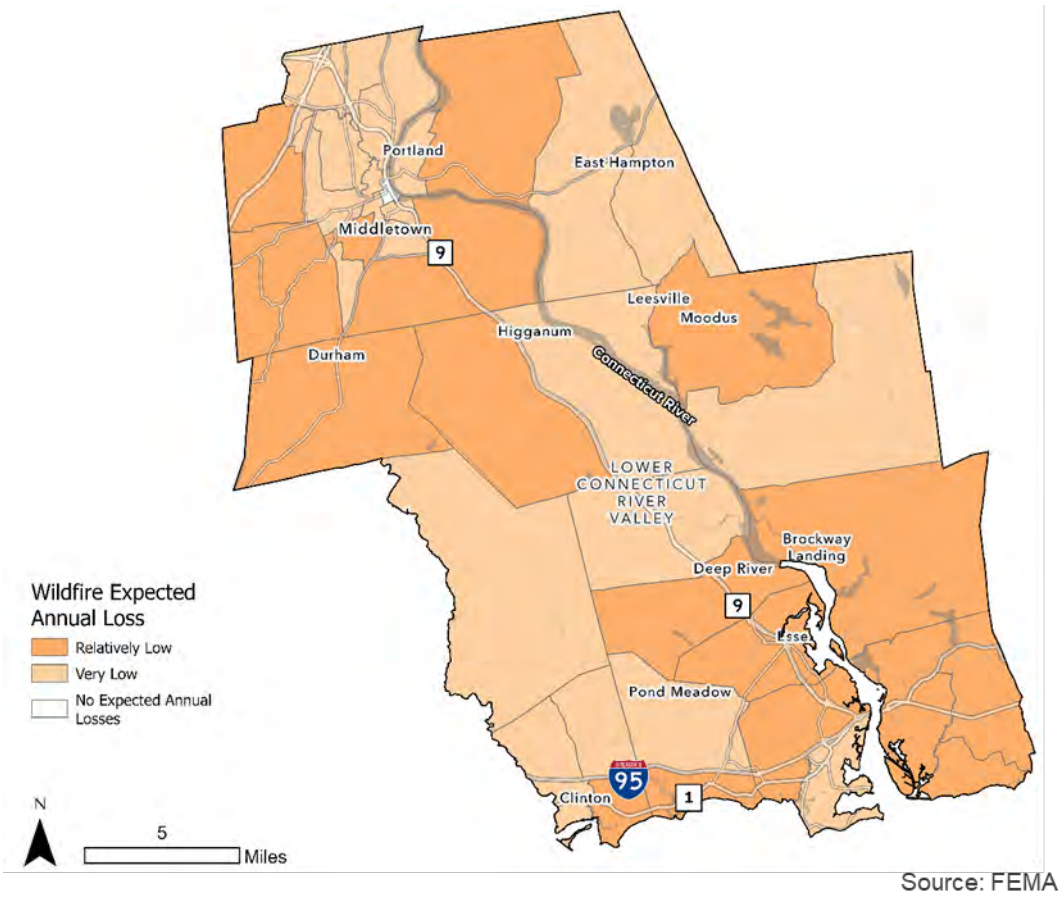


Figure 2.19.3. NRI Wildfire Expected Annual Loss Rating (2025)

Table 2.19.12. Breakdown of Expected Annual Losses from the NRI by Community for Wildfire

Community	Expected Annual Loss
Chester	$189
Clinton	$1,241
Cromwell	$381
Deep River	$597
Durham	$1,292
East Haddam	$1,293
East Hampton	$537
Essex	$1,604
Haddam	$726
Killingworth	$164
Lyme	$568

Community	Expected Annual Loss
Middlefield	$357
Middletown	$1,903
Old Lyme	$4,026
Portland	$763
Total for RiverCOG Region	**$15,641**

2.19.7. Development Trends

Since the 2021 plan update, development in the RiverCOG region has been light. Over the five year span (2019-2023) available on the RiverCOG Data Dashboard, population in the region has grown by approximately 1.7%.[111] A relatively small increase in population size, 0.5% below the growth rate of the state of Connecticut, which is has had approximately a 2.2% population growth rate during the same time span.[112] Haddam, Old Lyme, Clinton, Cromwell, Middletown, and Essex have seen the greatest increases in population growth during this time span. That being said, the highest percent growth is only a 4.1% increase in Haddam. Chester has seen the largest population decrease with a decrease of 10.6% during this five year time span. There are multiple reasons for this declining growth rate, but the COVID-19 pandemic is a large contributor.

Similarly, there has been only a 0.37% increase in housing stock in the region during the 2019-2023 five-year time frame with only 195 building permits issued in 2023 throughout RiverCOG.[113] The majority of these building permits issues in 2023 are in East Hampton (37) and East Haddam (25), both of which have seen decreases in housing stock during these five years. Killingworth, Durham, Haddam, Deep River, and Clinton have seen the largest increase in housing stock during this period. Additionally, commercial and industrial growth has been relatively stagnant during this time frame.

Housing development and population growth in these areas will increase the number of residents exposed and at risk to wildfire. New development, particularly of wood framed residential construction in the WUI will increase the overall vulnerability to wildland fires. One benefit of new development, however, is that newer construction is generally built to stronger building codes. More specific changes in development are addressed at the community level in the municipal annexes in Volume II of this plan.

[111] https://www.rivercog.org/data-population

[112] https://www.census.gov/programs-surveys/popest.html

[113] https://www.rivercog.org/data-housingcharacteristics

2.19.8. Overall Risk Rating

Using the parameters described in Table 2.8.1, the following hazard risk ratings were developed for wildland fires (Table 2.19.13).

Table 2.19.13: Overall Risk Rating of Wildland Fires

Criteria	Hazard Risk Rating
Probability	3 (Likely)
Impact: Affected Area	2 (Small)
Impact: Primary Impact	3 (Critical)
Impact: Secondary Impacts	3 (Moderate)
Survey Rating	2 (Moderate Concern)
Total Score	13.2
Overall Risk Ranking	**Moderate**

2.20. Extreme Temperature

2.20.1. Description and Background

Extreme Heat

Extreme heat is typically a summer phenomenon that involves substantially hotter temperatures and/or more humid than average weather for a location at that time of year. The NWS can issue heat-related messages to inform citizens of forecasted extreme heat conditions.

These messages are based on projected or observed heat index values and include:

- Excessive Heat Outlook: When there is a potential for an excessive heat event within three to seven days;
- Excessive Heat Watch: When conditions are favorable for an excessive heat event within 12 to 48 hours, but some uncertainty exists regarding occurrence and timing; and
- Excessive Heat Warning / Advisory: When an excessive heat event is expected within 36 hours. These messages are usually issued when confidence is high that the event will occur. A warning implies that conditions could pose a threat to life or property, while an advisory is issued for less serious conditions that may cause discomfort or inconvenience but could still lead to threat to life and property if caution is not taken.

Extreme Cold

Extreme cold events occur when temperatures drop well below normal in an area for a period of time. Extremely cold air comes every winter and affect millions of people across the United States.

This arctic air, together with brisk winds, can lead to dangerously cold wind chill values. People exposed to extreme cold are susceptible to frostbite in a matter of minutes. Areas of the body most prone to frostbite are uncovered skin and the extremities, such as hands and feet. Hypothermia is another threat during extreme cold. Hypothermia occurs when the body loses heat faster than it can produce.

Cold weather can also affect crops. In late spring or early fall, cold air outbreaks can damage or kill produce for farmers, as well as residential plants and flowers. A freeze occurs when the temperature drops below 32°F. Freezes and their effects are significant during the growing season. Frost develops on clear, calm nights and can occur when the air temperature is in the mid-30s. Each plant species has a different tolerance to cold temperatures.[114]

2.20.2. Location and Extent

The entire RiverCOG region has the potential to be impacted by extreme temperatures. The "heat index" or "apparent temperature" is often used to measure how hot the air "feels" based on temperature and humidity. The index can be used as an indicator of potential health effects (Figure 2.20.1).

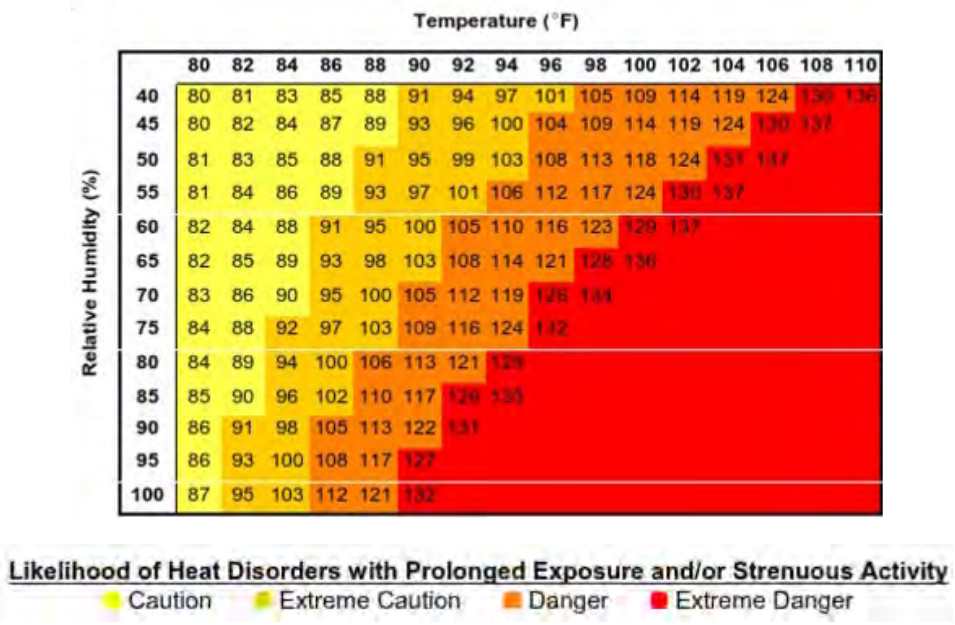


Figure 2.20.1. NWS Heat Index Chart

The NWS Wind Chill Temperature chart uses advances in science, technology, and computer modeling to provide an accurate, understandable, and useful formula for calculating the dangers from winter winds and freezing temperatures. The chart (Figure 2.20.2) does the following:

[114] https://www.weather.gov/safety/cold

- Calculates wind speed at an average height of 5 feet, the typical height of an adult human face, based on readings from the national standard height of 33 feet, typical height of an anemometer
- Is based on a human face model
- Incorporates heat transfer theory based on heat loss from the body to its surroundings, during cold and breezy/windy days
- Lowers the calm wind threshold to 3 mph
- Uses a consistent standard for skin tissue resistance
- Assumes no impact from the sun, i.e., clear night sky.

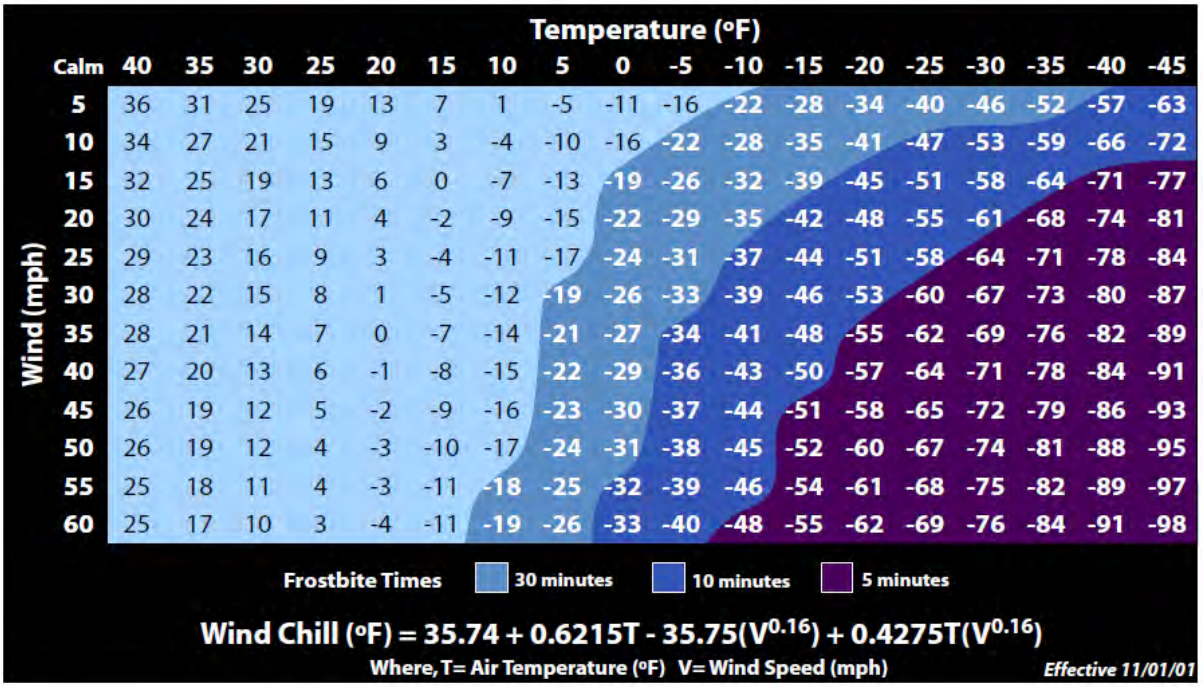


Figure 2.20.2. NWS Wind Chill Chart

The existing systems for classifying and declaring extreme temperature risks are appropriate for the RiverCOG region. Extreme temperatures have not been characterized outside of these systems of classification. Furthermore, the communities of the region are using these risk products and warnings to determine when warming and cooling centers should be opened.

2.20.3. History of Past Events

In Connecticut, extreme heat events typically occur in summer. The impact of these events can affect the local population, tourism industry, and agricultural industry. NOAA indicates that there

are between seven and 10 days above 90 degrees in summer in Connecticut. The hottest temperature on record in Connecticut is 106 degrees Fahrenheit, occurring in Danbury, on July 15, 1995. That same record temperature was reached again in August of 1916 in Torrington. The NOAA NCEI Storm Events Database has recorded only four occurrences of high excessive heat in the RiverCOG Region since 1998, all of which occurred in July. This list is not intended to be a full accounting of previous events. Rather provides examples of historic heat events that will very likely repeat in the future.

July 22, 2011: Excessive heat between 95 and 105 degrees, along with heat indices in excess of 105 degrees occurred. The heat index was as high as 108 degrees at 3 PM at New Haven Airport (KHVN), and 107 degrees at 2 PM at Groton Airport in New London on July 22nd. An oppressive hot and humid air mass produced excessive heat that resulted in daytime temperatures 95 to 105 degrees with night time lows in the 70s and 80s.

July 1, 2018: The Automated Weather Observing System (AWOS) at Chester reported heat indices of 105 to 109 during the afternoon hours. A Bermuda high pumped in heat and high humidity across the area.

July 20, 2019: The AWOS at Chester reported heat indices of 105 to 109 during the afternoon hours. A Bermuda high pumped in heat and high humidity across the area.

July 21, 2019: The KSNC AWOS recorded a heat index between 105 and 110 from 1400 and 1900 hours. A Bermuda High pumped in a hot and humid air mass northward into the area.

Even fewer extreme cold temperatures were listed in the NOAA NCEI database, for the same period of record, with only three events listed; two of which were in January of 2000 and one in February of 2023. The coldest recorded days in Connecticut were in 1943 and 1961, with the record setting temperature of negative 32 degrees Fahrenheit. Temperatures with below zero wind chill values were recorded as recently as February 2023.

2.20.4. Probability of Future Events

Extreme heat and heat waves are *very likely* during the summer months in the communities within the RiverCOG region. As global temperatures continue to climb, it seems likely that heat waves will occur more frequently in the future.

Extreme temperatures are often unpredictable and may be localized, which makes it difficult to assess the probability. Using historical records, it can be estimated that the RiverCOG Region will experience an extreme temperature event once every five years.

Extreme temperature events can occur simultaneously with drought and winter storms, but one can occur without the other. While extreme temperature events can cause death to any person of any age, the elderly, very young, and mobility restricted are considered the most at risk.

2.20.5. Climate Change Impacts

The Connecticut State Water Plan (2018) provides local climate change predictions. Future climate scenarios for the state were developed utilizing a combination of state-of-the-art climate models and historically available climate observations and were 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 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.[115]

Annual mean temperature in Connecticut has increased by about 3°F (1.7°C) since 1895, faster than rising global mean temperatures.[116]

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).

[115] All above text from CT State Water Plan (https://portal.ct.gov/water/water-planning-council/state-water-plan)

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

2.20.6. Impacts and Estimated Losses to the Region

Impacts

Heat - According to climatecentra.org, heat kills more humans in the U.S. than any other natural hazard. It estimates that 12,000 Americans die of heat related illness annually. More than 80% of people who die from heat are over the age of 60. 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.[117] 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.

Cold – The top dangers of extreme cold temperatures include:

- Frostbite: damages the body, especially extremities such as ears, nose, cheeks, chin, fingers and toes.
- Hypothermia: if body temperatures drop below 95 degrees Fahrenheit the body can lose more heat than it is capable of making. The results may range from shivering clumsiness and confusion, fatigue to death.
- Heart problems: Cold weather increases the risk of heart attacks in vulnerable populations, since the heart must work harder to keep the body warm, resulting in increased heart rate and blood pressure.

Certain populations are especially vulnerable to these effects, including children, the elderly, the sick, and the poor.[118] Table 2.20.1 shows the population of RiverCOG communities under the age of five and over the age of 65 who are at higher risk to temperature extremes.[119]

Table 2.20.1. Vulnerable Population by Age

County	Total Population	Under 5 Years Old	65 Years and Older	At Risk Population	Percent At Risk of Population
Chester	3,786	141	1,010	1,151	30%
Clinton	13,317	313	2,921	3,234	24%

[117] Climate Change Connecticut Report: The Impacts of Climate Change on Connecticut Agriculture, Infrastructure, Natural Resources and Public Health (https://portal.ct.gov/-/media/DEEP/climatechange/ImpactsofClimateChangepdf.pdf)

[118] EPA 2016 Report: What Climate Change Means for Connecticut (https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-ct.pdf)

[119] Source: CERC 2025 Town Profiles produced by Connecticut Data Collaborative.

County	Total Population	Under 5 Years Old	65 Years and Older	At Risk Population	Percent At Risk of Population
Cromwell	14,301	774	2,945	3,719	26%
Deep River	4,432	142	910	1,052	24%
Durham	7,182	405	1,368	1,773	25%
East Haddam	8,934	375	2,099	2,474	28%
East Hampton	12,834	785	2,340	3,125	24%
Essex	6,766	152	1,843	1,995	29%
Haddam	8,562	215	1,623	1,838	21%
Killingworth	6,219	300	1,402	1,702	27%
Lyme	2,356	80	620	700	30%
Middlefield	4,236	177	937	1,114	26%
Middletown	47,646	1,848	7,659	9,507	20%
Old Lyme	7,644	330	1,825	2,155	28%
Portland	9,421	552	1,610	2,162	23%
RiverCOG	**157,636**	**6,589**	**31,112**	**37,701**	**24%**

Community Impacts

In addition to health impacts noted above, severe winter weather has the ability to knock out heat, power and communications services to a home or office, sometimes for days at a time. The extreme cold temperatures often associated with these kinds of events can put entire regions at risk. Frozen pipes in homes and business, although not often reported, are major expenses during extreme cold events. Similarly, car problems are common, as are disruptions to commerce and education during prolonged periods of extreme cold.

Extreme heat can similarly impact large regions and populations in a variety of ways. The most common result of prolonged periods of extreme heat is a drought that can damage local vegetation and agriculture. A drought is a meteorological event that usually occurs for an extended period of time (six or more months) in which an area experiences less than 75% of its normal precipitation. Extreme heat events coupled with droughts can increase the chance of a wildfire occurring. Wildfires can be particularly problematic during a drought as there may not be enough water available for firefighters to use to fight them. Extreme heat is also hazardous to livestock, agriculture, and structures such as roads and bridges, and may diminish water and energy supplies, which may increase the risk to human health. Severe thunderstorms associated with the heat caused lengthy power outages, forcing people to cope with the heat as they lost the ability to have air conditioning.

With its dense forest coverage and abundant water features, the communities of the RiverCOG region are slightly more protected from extreme heat than some of their neighbors, but heat waves do occur. A heat wave in Connecticut is defined as any period in which daytime high temperatures reach more than 90ºF three consecutive days or longer.[120]

All areas of communities within the RiverCOG region are, for the most part, equally susceptible to extreme heat. Depending on wind direction, areas directly along the Connecticut River shoreline may stay slightly cooler because of cooler water temperatures having a cooling effect on the surrounding air.

In an effort to determine extreme heat exposure, CIRCA extreme heat Climate Change Vulnerability Index (CCVI) was used as an overlay dataset. However, because the dataset is comprehensive and calculated extreme heat vulnerability across the entire region only those CCVI cells which scored 0.27 or greater (>60th percentile) were used. It is important to note that the CCVI characterizes extreme heat vulnerability based on a number of factors including social, infrastructure and environmental, therefore the actual exposure and vulnerability may vary greatly from parcel to parcel depending on a number of on-the-ground characteristics such as who is occupying the property, structure age and type, or surrounding tree canopy.

Table 2.20.2. Heat CCVI Exposure Analysis for RiverCOG Communities

Community	No. of Parcels Intersecting Extreme Heat CCVI	Value of Parcels Intersecting Extreme Heat CCVI	No. of Critical Facility Parcels Intersecting Extreme Heat CCVI	Value of Critical Facility Parcels Intersecting Extreme Heat CCVI	No. of Historic Resource Parcels Intersecting Extreme Heat CCVI	Value of Historic Resource Parcels Intersecting Extreme Heat CCVI
Chester	232	$109	5	$12	4	$2
Clinton	2,352	$677	6	$59	461	$179
Cromwell	2,983	$1,004	12	$135	145	$94
Deep River	575	$245	10	$77	192	$57
Durham	74	$26	2	$8	4	$1
East Haddam	359	$114	7	$30	42	$19
East Hampton	770	$194	7	$27	138	$37
Essex	1,015	$520	11	$39	282	$183
Haddam	349	$142	8	$43	58	$39

[120] https://www.ctinsider.com/weather/article/ct-weather-tuesday-heat-wave-heat-index-20391002.php

Community	No. of Parcels Intersecting Extreme Heat CCVI	Value of Parcels Intersecting Extreme Heat CCVI	No. of Critical Facility Parcels Intersecting Extreme Heat CCVI	Value of Critical Facility Parcels Intersecting Extreme Heat CCVI	No. of Historic Resource Parcels Intersecting Extreme Heat CCVI	Value of Historic Resource Parcels Intersecting Extreme Heat CCVI
Killingworth	59	$47	5	$23	1	$1
Lyme	72	$36	3	$9	25	$14
Middlefield	691	$165	7	$10	13	$7
Middletown	8,407	$5,604	30	$576	640	$1,546
Old Lyme	2,573	$768	10	$47	328	$146
Portland	1,927	$377	18	$24	134	$42
RiverCOG Region	**22,438**	**$10,029**	**141**	**$1,118**	**2,467**	**2,366**

**All dollar figures are in millions*

To supplement the above information, FEMA's NRI data was pulled for heat wave and cold wave to give broader context on areas at risk to extreme temperatures. Displayed in Figure 2.20.3, heat wave risk across RiverCOG ranges from Very Low to Relatively Low.

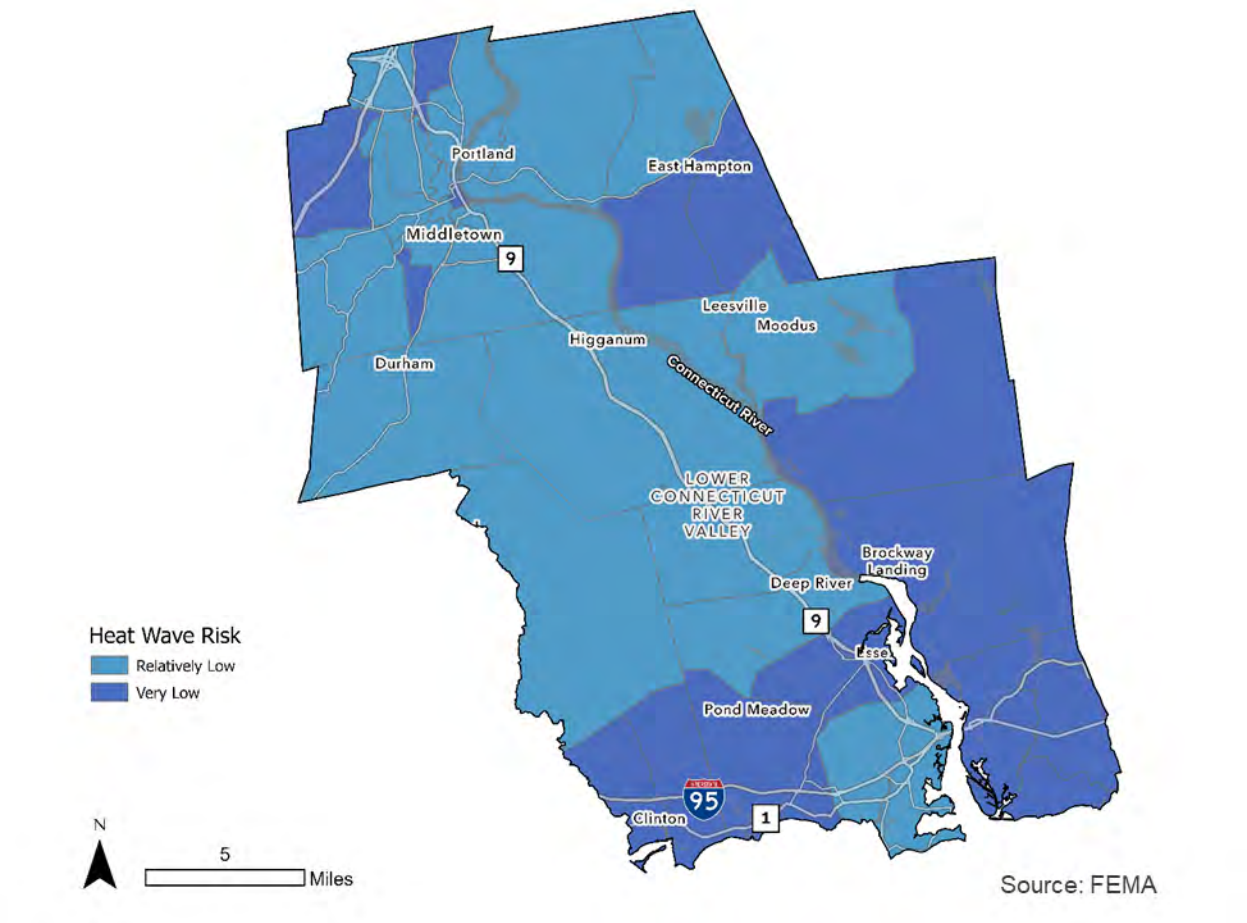


Figure 2.20.3. NRI Risk Rating for Heat Wave, shown at the census tract level (2025)

Middletown has the most census tracts at a relatively low risk to heat wave with 9 (out of 13). Additionally, Haddam, Chester, Deep River, Durham, Killingworth, Middlefield, and Portland are all completely at a relatively low risk to heat wave. Table 2.20.3 displays the communities in RiverCOG and the number of census tracts at each risk rating to heat wave.

Table 2.20.3. Breakdown of community risk to heat wave

Community	Number of Census Tracts with Very Low Risk	Number of Census Tracts with Relatively Low Risk
Chester	-	1
Clinton	4	-
Cromwell	1	2
Deep River	-	1
Durham	-	1

Community	Number of Census Tracts with Very Low Risk	Number of Census Tracts with Relatively Low Risk
East Haddam	1	1
East Hampton	2	1
Essex	2	-
Haddam	-	2
Killingworth	-	1
Lyme	1	-
Middlefield	-	1
Middletown	4	9
Old Lyme	3	-
Portland	-	2
Total for RiverCOG Region	**18**	**22**

Displayed in Figure 2.20.4, cold wave risk across RiverCOG ranges from Very Low to Relatively Low.

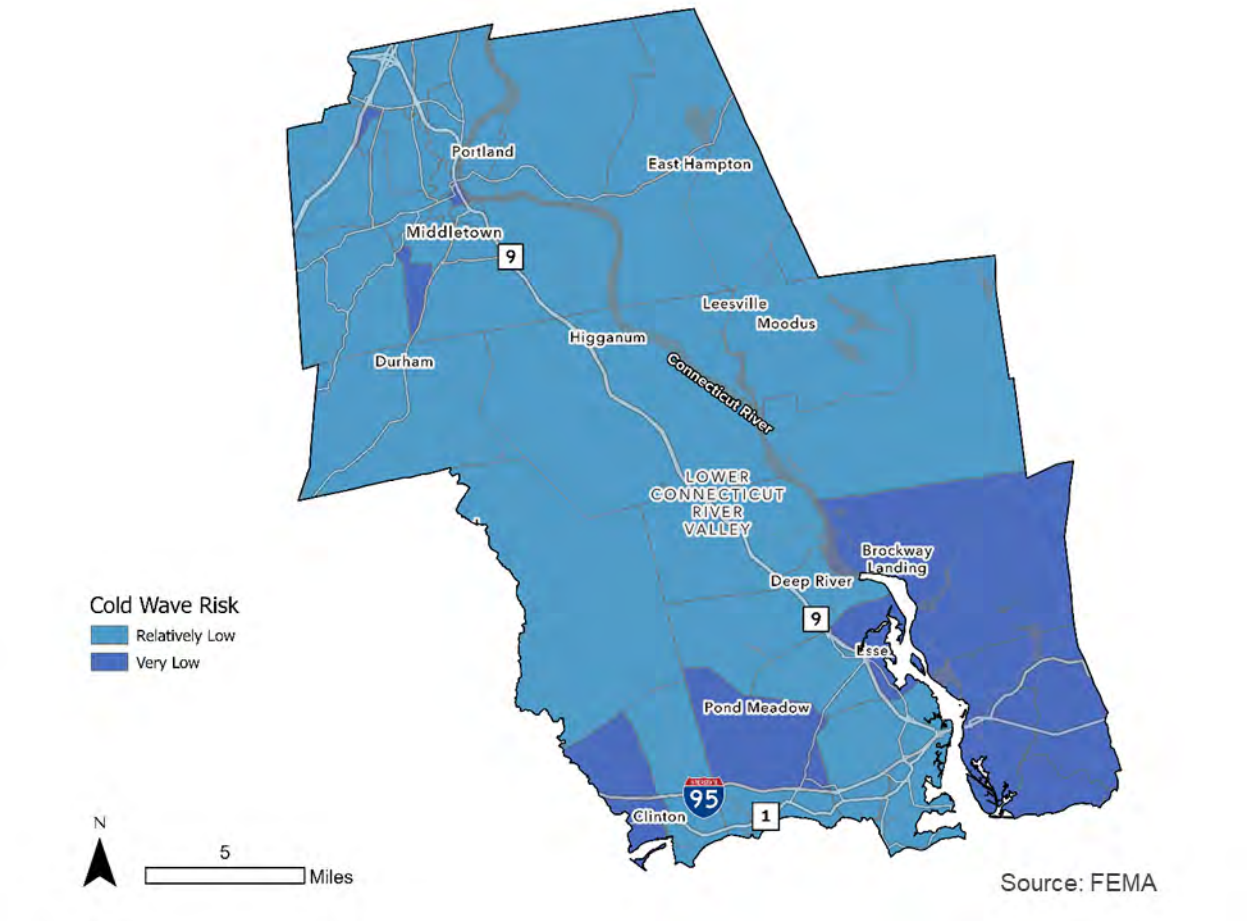


Figure 2.20.4. NRI Risk Rating for Cold Wave, shown at the census tract level (2025)

Middletown has the most census tracts (10 out of 13) with a relatively low risk to cold wave. Overall, the majority of RiverCOG is at a relatively low risk to cold wave. Table 2.20.5 displays communities in RiverCOG and the number of census tracts at each risk rating to cold wave.

Table 2.20.4. Breakdown of community risk to cold wave

Community	Number of Census Tracts with Very Low Risk	Number of Census Tracts with Relatively Low Risk
Chester	-	1
Clinton	2	2
Cromwell	-	3
Deep River	-	1
Durham	-	1
East Haddam	-	2

Community	Number of Census Tracts with Very Low Risk	Number of Census Tracts with Relatively Low Risk
East Hampton	-	3
Essex	1	1
Haddam	-	2
Killingworth	-	1
Lyme	1	-
Middlefield	-	1
Middletown	3	10
Old Lyme	3	-
Portland	-	2
Total for RiverCOG Region	**10**	**30**

Another impact metric the NRI provides is expected annual loss. Figure 2.20.5 below shows the expected annual loss ratings throughout the COG and Table 2.20.6 describes the projected annualized losses from heat wave by community. The highest expected annual losses are found in Middletown and Cromwell with a projected $7,284 and $2,426 in expected annual losses due to heat wave respectively. The RiverCOG region has a total expected annual loss of $23,667.

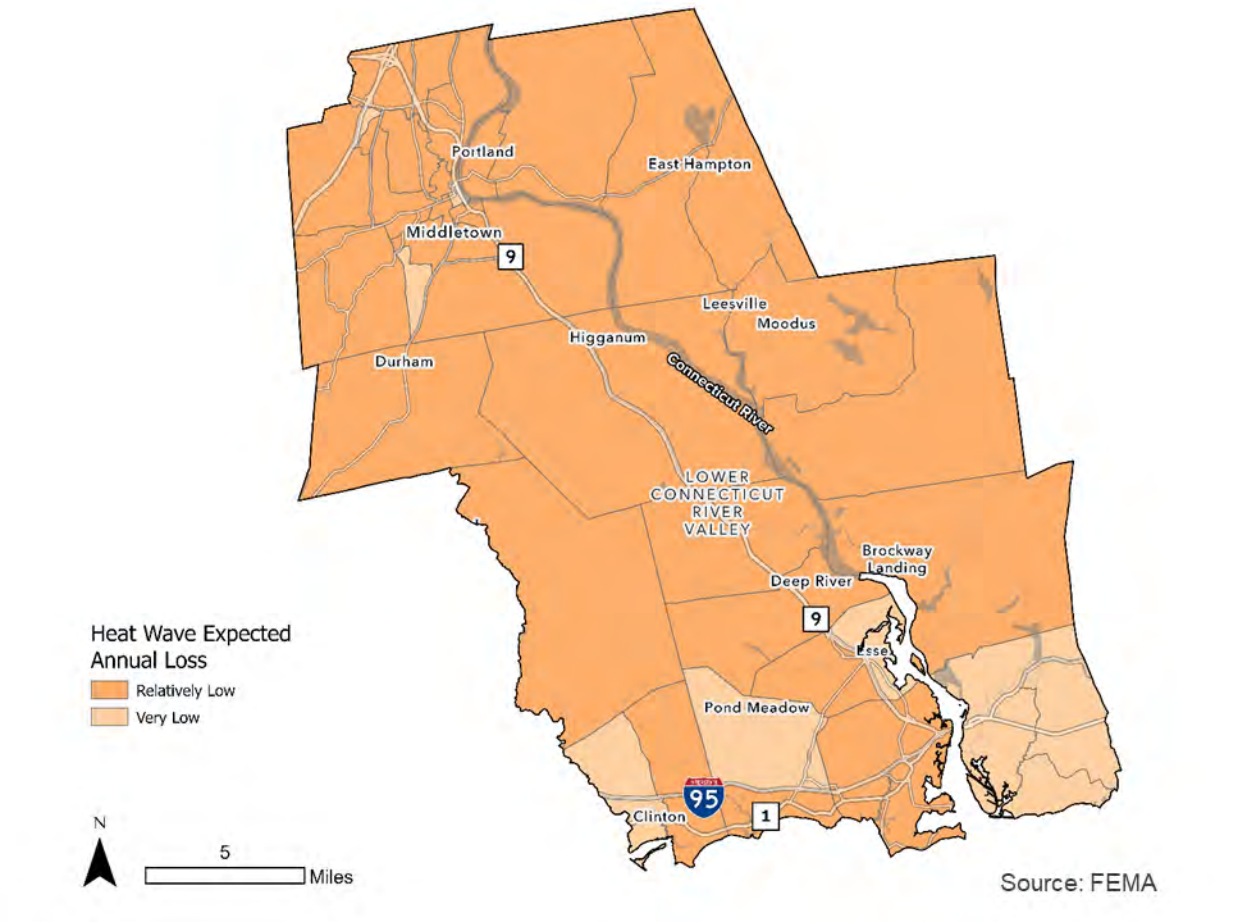


Figure 2.20.5. NRI Heat Wave Expected Annual Loss Rating (2025)

Table 2.20.5. Breakdown of Expected Annual Losses from the NRI by Community for Heat Wave

Community	Expected Annual Loss
Chester	$550
Clinton	$1,402
Cromwell	$2,426
Deep River	$471
Durham	$1,477
East Haddam	$1,491
East Hampton	$1,908
Essex	$720
Haddam	$1,294
Killingworth	$921

Community	Expected Annual Loss
Lyme	$390
Middlefield	$1,200
Middletown	$7,284
Old Lyme	$518
Portland	$1,615
Total for RiverCOG Region	**$23,667**

Figure 2.20.6 below shows the expected annual loss ratings throughout the COG from cold waves and Table 2.20.6 describes the projected annualized losses from cold wave by community. The highest expected annual losses are found in Middletown and Cromwell with a projected $6,431 and $2,168 in expected annual losses due to cold wave respectively. The RiverCOG region has a total expected annual loss of $21,118.

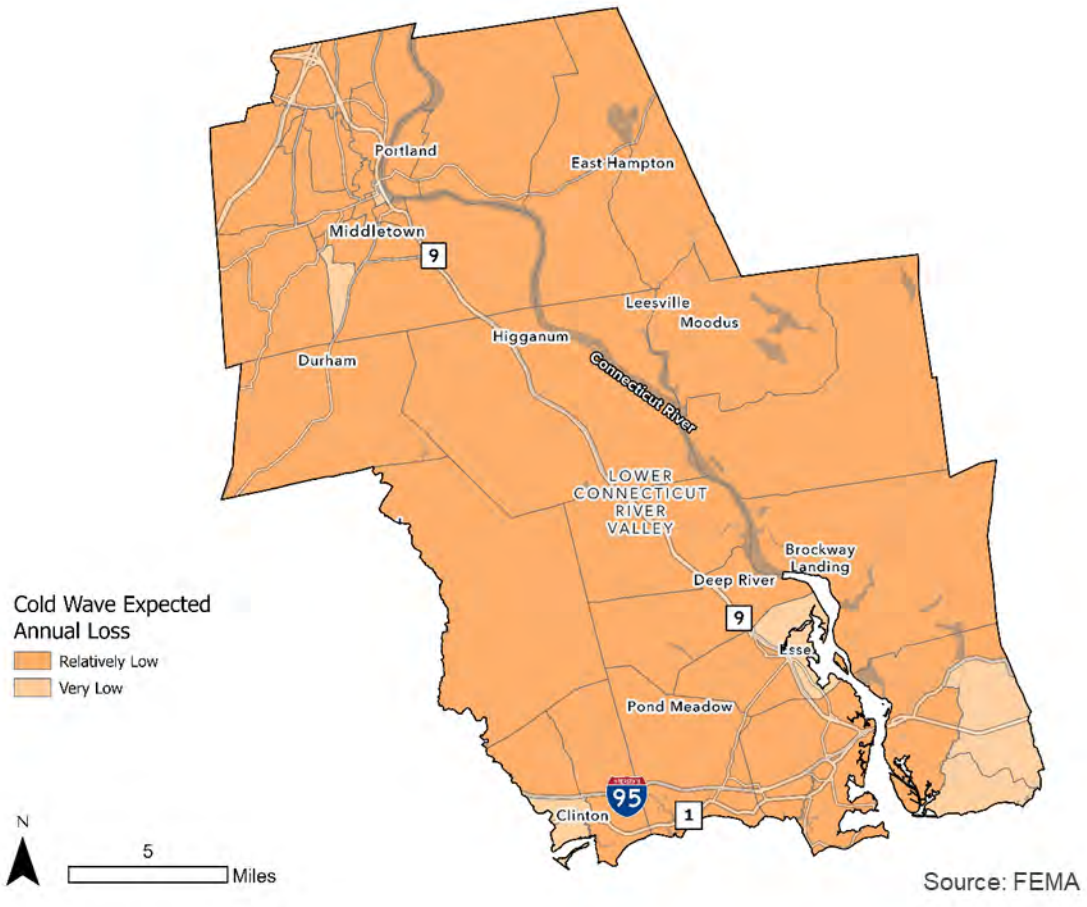


Figure 2.20.6. NRI Cold Wave Expected Annual Loss Rating (2025)

Table 2.20.6. Breakdown of Expected Annual Losses from the NRI by Community for Cold Wave

Community	Expected Annual Loss
Chester	$489
Clinton	$1,137
Cromwell	$2,168
Deep River	$382
Durham	$1,334
East Haddam	$1,334
East Hampton	$1,686
Essex	$587
Haddam	$1,150
Killingworth	$816
Lyme	$385
Middlefield	$1,094
Middletown	$6,431
Old Lyme	$679
Portland	$1,446
Total for RiverCOG Region	**$21,118**

2.20.7. Development Trends

Since the 2021 plan update, development in the RiverCOG region has been light. Over the five year span (2019-2023) available on the RiverCOG Data Dashboard, population in the region has grown by approximately 1.7%.[121] A relatively small increase in population size, 0.5% below the growth rate of the state of Connecticut, which has had approximately a 2.2% population growth rate during the same time span.[122] Haddam, Old Lyme, Clinton, Cromwell, Middletown, and Essex have seen the greatest increases in population growth during this time span. That being said, the highest percent growth is only a 4.1% increase in Haddam. Chester has seen the largest population decrease with a decrease of 10.6% during this five year time span. There are multiple reasons for this declining growth rate, but the COVID-19 pandemic is a large contributor.

[121] https://www.rivercog.org/data-population

[122] https://www.census.gov/programs-surveys/popest.html

Similarly, there has been only a 0.37% increase in housing stock in the region during the 2019-2023 five-year time frame with only 195 building permits issued in 2023 throughout RiverCOG.[123] The majority of these building permits issues in 2023 are in East Hampton (37) and East Haddam (25), both of which have seen decreases in housing stock during these five years. Killingworth, Durham, Haddam, Deep River, and Clinton have seen the largest increase in housing stock during this period. Additionally, commercial and industrial growth has been relatively stagnant during this time frame.

Housing development and population growth in these areas will increase the number of residents exposed and at risk to extreme temperatures. One benefit of new development, however, is that newer construction is generally built to stronger building codes. Therefore, newer buildings that replace older-code buildings should generally decrease overall risk due to extreme temperature. For example, newer buildings are built to higher standards for insulation and with building envelopes equipped to handle extreme heat and cold. That being said, an increase in the development of built infrastructure will increase the heat island effect and increase the likelihood of residents to be negatively impacted by extreme heat. More specific changes in development are addressed at the community level in the municipal annexes in Volume II of this plan.

2.20.8. Overall Risk Rating

Using the parameters described in Table 2.8.1, the following hazard risk ratings were developed for extreme temperature (Table 2.20.7).

Table 2.20.7: Overall Risk Rating of Extreme Temperature

Criteria	Hazard Risk Rating
Probability	3 (Likely)
Impact: Affected Area	4 (Large)
Impact: Primary Impact	1 (Negligible)
Impact: Secondary Impacts	2 (Limited)
Survey Rating	3 (High Concern)
Total Score	13.9
Overall Risk Ranking	**Moderate**

[123] https://www.rivercog.org/data-housingcharacteristics

2.21. Terrestrial Invasive Species

2.21.1. Description and Background

An *invasive plant* is defined by the Connecticut Invasive Plants Council (IPC), established under Connecticut General Statutes §22a-381a through §22a-381d, as a non-native species whose introduction causes, or is likely to cause, environmental harm, economic loss, or harm to human health. Connecticut's official list of invasive and potentially invasive plants is maintained and periodically updated by the IPC in collaboration with CT DEEP, CAES, and UConn's Department of Plant Science and Landscape Architecture (CAES, 2024; DEEP, 2025).

The State of Connecticut compiled a list of plant species that have been determined by floristic analysis to be invasive or potentially invasive in the state of Connecticut, a two-tier designation for invasive plants, in accordance with Public Act 03-136. The IPC restricts some of the plants on that list to recognize the need to balance the detrimental effects of invasive plants with the agricultural and horticultural value of some of these plants, while still protecting the state's habitats. In May 2004, Public Act 04-203 banned a subset of the January 2004 list making it illegal to move, sell, purchase, transplant, cultivate or distribute invasive plants. Since 2004, new legislation emerged from additional IPC recommendations.

In 2024, Public Act 24-11 made it illegal in Connecticut to import, move, sell, purchase, transplant, cultivate, or distribute 67 specific invasive plant species, regardless of any municipal ordinance. In addition, new invasive plants were added to the list.

In 2025, Public Act 25-126, new potentially invasive and invasive species were added to the list. It also applied a phase-out prohibition to others already on the list.

Invasive terrestrial plants are introduced through the nursery trade, soil and equipment movement, and storm-related dispersal. Once established, many species form dense monocultures. CAES and CT DEEP note that some species, such as Japanese barberry and knotweed, also have public health or infrastructure implications—barberry thickets are associated with higher tick densities, while knotweed can destabilize streambanks and damage pavement.

Invasive terrestrial plants fall broadly into three growth forms:

- **Woody Trees and Shrubs** – long-lived species that dominate forest understories or edges (e.g., Norway maple (*Acer platanoides)*, Japanese barberry (*Berberis thunbergii)*, autumn olive (*Elaeagnus umbellata*)).
- **Vines and Creepers** – species that climb or smother trees and vegetation (e.g., Oriental bittersweet (*Celastrus orbiculatus)*, Chinese wisteria (*Wisteria sinensis*)).
- **Herbaceous and Grasses** – species that invade open areas, meadows, and roadsides (e.g., mugwort (*Artemisia vulgaris)*, garlic mustard (*Alliaria petiolata*)).

While the RiverCOG region boasts a diverse array of native plant life, a variety of non-native invasive plants, bushes, grasses, and wildflowers are found in all regions of Connecticut, including the RiverCOG region.

The RiverCOG region's upland forests, riparian buffers, meadows, and disturbed landscapes are increasingly impacted by terrestrial invasive plants. These species spread aggressively; outcompete native vegetation; reduce biodiversity; alter soil and hydrological processes; degrade wildlife habitat; and can increase maintenance and restoration costs for towns.[124]

Table 2.21.1 lists invasive terrestrial plants in the RiverCOG Region. The sources include the Connecticut IPC per Connecticut General Statutes §22a-381a through §22a-381d (2025), and CAES (2024).[125]

Table 2.21.1. Connecticut's 2025 Invasive Plants Found in RiverCOG Region

Species (Scientific Name)	Species (Common Name)	Growth Form	Key Impacts	Regulatory Status (CT IPC, 2025)
Acer platanoides	Norway maple	Tree	Outcompetes native maples; dense shade inhibits regeneration	Designated invasive by 2030
Ailanthus altissima	Tree-of-heaven	Tree	Rapid colonizer of disturbed soils; allelopathic compounds suppress native growth	Invasive
Alliaria petiolata	Garlic mustard	Herbaceous	Alters soil fungi essential to native tree seedlings	Invasive
Ampelopsis brevipedunculata (Maxim.) Trautv.	Porcelainberry	Vine	Not documented in RiverCOG region, but found elsewhere in CT; aggressively forms dense mats that block sunlight and smother native vegetation.	Invasive
Artemisia vulgaris	Mugwort	Herbaceous	Forms dense mats in disturbed soils; allelopathic	Invasive

[124] Picone, Peter, Wildlife Biologist with CTDEEP. Presentation, *NVCOG Environmental Sustainability Forum: Invasive Species Management,* April 27, 2023.

[125] Sources: CT IPC, Connecticut Invasive and Potentially Invasive Plant List (2025); CAES Office of Aquatic and Invasive Species; UConn CIPWG (2024); CT DEEP, Invasive Species Program and Plant Factsheets (2025).

Species (Scientific Name)	Species (Common Name)	Growth Form	Key Impacts	Regulatory Status (CT IPC, 2025)
Berberis vulgaris L.	Common barberry	Shrub	Dense thickets reduce native understory; alters soil pH; associated with increased tick density	Invasive
Berberis thunbergii	Japanese barberry	Shrub	Dense thickets reduce native understory; alters soil pH; associated with increased tick density	Designated invasive by 2028
Celastrus orbiculatus	Oriental bittersweet	Vine	Strangles trees, topples canopies, alters forest dynamics	Invasive
Elaeagnus umbellata	Autumn Olive	Tree	Displaces native plants; spreads rapidly; poor-nutritional replacement for wildlife	Invasive
Elymus repens	Quackgrass	Grass	Displaces native grasses; spreads via rhizomes	Invasive
Fallopia japonica (Reynoutria japonica)	Japanese knotweed	Herbaceous	Spreads along rivers and disturbed sites; damages pavement and structures	Invasive
Lonicera maackii / L. morrowii / L. tatarica	Bush honeysuckles (i.e., Amur honeysuckle, Tatarian honeysuckle, Belle honeysuckle)	Shrub	Outcompete natives, reduce wildlife habitat diversity	Invasive
Polygonum perfoliatum L.	Mile-a-minute vine	Vine	Dense mats outcompete native plants; hinders forest regeneration; destroys young trees	Invasive
Rosa multiflora	Multiflora rose	Shrub	Forms dense, thorny thickets; displaces natives	Not listed as invasive, but aggressive in coastal areas
Wisteria sinensis / W. floribunda	Chinese & Japanese wisteria	Vine	Smothers trees and shrubs; spreads vegetatively	Potentially Invasive

Species Summaries

- **Norway maple**: A fast-growing shade tree introduced from Europe, Norway maple forms dense canopies that outcompete native sugar and red maples. Its prolific seedlings and deep shade inhibit native forest regeneration. Designated invasive by 2030.
- **Tree-of-heaven**: It thrives in disturbed urban and roadside habitats and produces allelopathic chemicals that suppress nearby plant growth. It spreads aggressively through root suckers and winged seeds. Invasive.
- **Garlic Mustard**: This biennial herb invades forest understories, releasing compounds that disrupt beneficial soil fungi essential for native tree seedlings. It can dominate shaded habitats and reduce spring wildflower diversity. Invasive.
- **Porcelainberry**: Currently not found in RiverCOG towns but found in other parts of Connecticut. Porcelainberry is a fast-growing woody vine that blankets shrubs and trees, blocking light and suppressing native vegetation. Its bird-dispersed fruits enable rapid spread along forest edges and riparian corridors, where it alters habitat structure, reduces biodiversity, and increases erosion risk. Invasive.
- **Mugwort:** A resilient perennial herb that spreads rapidly by rhizomes, forming dense mats in disturbed areas. Its allelopathic properties prevent native species from establishing. Invasive.
- **Common and Japanese barberries:** Thorny shrubs common in forests and edges, barberry alters soil chemistry and creates humid microhabitats favorable for ticks. Its dense thickets exclude native understory species. Common barberry is invasive. Japanese barberry designated invasive by 2028.
- **Oriental bittersweet:** A woody vine that climbs and girdles trees, bittersweet causes canopy collapse and alters forest succession. Its prolific seed dispersal by birds accelerates spread. Invasive.
- **Autumn olive:** A nitrogen-fixing shrub that invades open fields and forest edges, displacing native vegetation. Its fruits favor wildlife dispersal but provide lower nutritional value than native species. Invasive.
- **Quackgrass:** A perennial grass that spreads by extensive rhizomes, forming monocultures in meadows and disturbed soils. It competes strongly with native grasses and wildflowers. Invasive.
- **Japanese knotweed:** This robust herb grows along rivers and roadsides, forming dense stands that outcompete natives and damage infrastructure. It regenerates from small root or stem fragments. Invasive.
- **Bush honeysuckles:** These non-native shrubs leaf out early, shading native plants and altering habitat structure. They reduce wildlife diversity and hinder forest regeneration. Invasive.

- **Mile-a-minute vine:** An annual vine with triangular leaves and sharp barbs, it grows up to six inches per day, smothering seedlings and young trees. It thrives in open, disturbed areas. Invasive.
- **Multiflora rose:** Once planted for erosion control, this thorny shrub forms impenetrable thickets that displace native vegetation. It spreads readily by seed and root sprouts. Not listed as invasive, but aggressive in coastal areas.
- **Chinese and Japanese wisteria:** Highly ornamental vines that escape cultivation, wisterias climb and smother trees and shrubs. They spread vegetatively through root fragments and runners. Potentially invasive.

2.21.2. Location and Extent

The instances of invasive plants in the RiverCOG region are consistent with the two-tier designation for invasive plants in Connecticut: invasive or potentially invasive. Invasive and potentially invasive species of concern in the RiverCOG region are listed in Table 2.19.1 and are consistent with this designation.

Invasive terrestrial plants are widespread across all RiverCOG municipalities—including Chester, Clinton, Cromwell, Deep River, Durham, East Haddam, East Hampton, Essex, Haddam, Killingworth, Lyme, Middlefield, Middletown, Old Lyme, Portland, and Westbrook. These species are especially prevalent along:

- Roadside rights-of-way (Route 9, Route 17, Route 82);
- Streambanks and riparian zones of the Connecticut River and tributaries;
- Abandoned fields and forest edges; and
- Disturbed development sites and utility corridors.

CAES field surveys and EDDMapS Connecticut records confirm widespread occurrences of Japanese knotweed, multiflora rose, and bittersweet along the lower Connecticut River corridor and its tributary floodplains. More impacted sites are being identified every year, and more land surveys to understand the extent of the problem are needed.

The existing CAES IPC systems for classifying and declaring invasive species occurrences and risks are appropriate for the RiverCOG region. Invasive species have not been characterized outside of these systems of classification. However, as an evolving threat, the State of Connecticut may revise classification systems over the next decade.

2.21.3. History of Past Events

The introduction of terrestrial invasive plants to the United States predates modern environmental regulation and often paralleled the nation's agricultural and cultural development. Many invasive species arrived intentionally as ornamentals, medicinal herbs, or crops brought by European settlers and immigrants seeking to recreate familiar landscapes and food systems. Others arrived accidentally through contaminated seed shipments, ship ballast soil, and global trade. Before the

first federal plant protection laws—such as the Plant Quarantine Act of 1912 and Connecticut's early noxious weed regulations—there were few mechanisms to prevent or track the introduction of non-native species. Consequently, numerous plants that were initially valued for their aesthetic, agricultural, or erosion control benefits—such as Japanese barberry, multiflora rose, honeysuckle, and Japanese knotweed—spread aggressively beyond cultivation and became established throughout New England's forests, roadsides, and riparian areas.

Connecticut's experience with invasive plants reflects both the state's long agricultural history and its leadership in plant science and regulation. Many invasive species were first introduced here through colonial agriculture and 19th-century horticulture. By the early 1900s, CAES had already identified Japanese barberry as an agricultural and ecological threat, leading one of the nation's earliest invasive plant eradication programs. The post-war expansion of suburban landscaping further accelerated the spread of non-native species such as honeysuckle, Norway maple, and multiflora rose. In 2003, Connecticut established the IPC to coordinate research, policy, and public education, a model now used by other states. Continued updates to Connecticut's invasive plant list, guided by CAES research and DEEP oversight, demonstrate the state's ongoing role in managing this complex environmental challenge. Despite the research work of CAES and permitting and guidance of DEEP the removal and mitigation of invasive species falls to individual municipalities. These efforts are costly and not supported by state resources. Rapid response protocols and long-term management need to be implemented by both state and local resource managers but most municipalities do not have resources and knowledgeable staff to manage the programs required for management and mitigation efforts. The forested landscape of the region and Connecticut exacerbates the emergency management aspect of this hazard.

Over time, certain landscape practices and natural processes have played a particularly significant role in the spread and establishment of terrestrial invasive plants in Connecticut and the RiverCOG region, including the following:

- Mid-20th century introductions: Many invasive plants (e.g., barberry, honeysuckle, multiflora rose, Norway maple) were promoted as ornamentals or erosion control species before their ecological impacts were recognized.
- Transportation corridors: Highway mowing and fill movement have accelerated dispersal along roads and rights-of-way.
- Riparian flooding: Floodwaters redistribute seeds and root fragments, spreading knotweed and mugwort downstream.

2.21.4. Probability of Future Events

The probability of continued spread is high due to the plants' vegetative reproduction, resilience to disturbance, and adaptability to Connecticut's climate. New additions to the CT IPC list (e.g., mugwort, quackgrass, wisteria) indicate that invasive plant introductions continue despite current regulations. Without sustained management, existing spread is expected to continue within the next planning cycle.

2.21.5. Climate Change Impacts

Climate change is expected to significantly influence the spread, establishment, and persistence of terrestrial invasive plants across Connecticut, including the RiverCOG region. Warmer average temperatures, longer growing seasons, and more frequent extreme weather events are already creating favorable conditions for many invasive plant species that previously had climatic limits in New England.

According to CAES and CT DEEP, milder winters enhance seed survival and extend the growing window for species such as Japanese knotweed, mugwort, and garlic mustard. More intense precipitation and flooding events also facilitate the downstream movement of seeds and root fragments, while drought stress on native vegetation reduces competition and opens new areas for colonization. These combined effects plus delayed management are likely to accelerate invasive plant establishment in both upland and riparian habitats, particularly where disturbance or development has altered natural vegetation patterns as summarized below:

- **Warmer winters** improve seed germination and survival rates of invasive plants previously limited by cold;
- **Increased storm intensity and flooding** facilitate the dispersal of root fragments and seed pods along waterways;
- **Drought and disturbance** reduce native vegetation vigor, creating openings for invasive colonization; and
- **Elevated atmospheric CO_2** can enhance growth rates and biomass production in many invasive plant species.

2.21.6. Impacts and Estimated Losses to the Region

The proliferation of terrestrial invasive plants in the RiverCOG region poses a wide range of ecological, economic, and public health challenges. These species disrupt native plant communities, alter soil chemistry, and reduce wildlife habitat quality. Forest understories invaded by honeysuckle and barberry exhibit decreased native seedling regeneration, while riverbanks dominated by knotweed and multiflora rose experience reduced stability and increased erosion risk. At the municipal level, infestations increase maintenance costs along roadways, parks, and conservation lands. CAES has also documented elevated tick populations in dense barberry thickets, highlighting a secondary public health concern.

In addition to ecological degradation, terrestrial invasive plants impose hidden economic losses—ranging from reduced property values and tourism appeal to added costs for vegetation management and restoration. Left unchecked, these impacts can compound over time, affecting the resilience of both natural and built environments in the lower Connecticut River Valley as summarized below:

- **Ecological:** Reduction in native forest and wetland plant diversity; disruption of pollinator and wildlife habitat; decreased regeneration of native canopy species.
- **Infrastructure and Economic:** Increased municipal maintenance costs for roadside and park vegetation management; Japanese knotweed damage to sidewalks, retaining walls, and foundations; reduced aesthetic and recreational value of public lands.
- **Public Health:** Dense Japanese barberry thickets create favorable microhabitats for blacklegged ticks, increasing potential Lyme disease exposure (CAES, 2019–2024).

There is no known consistent source of data available to quantify the economic losses from terrestrial invasive species in the RiverCOG Region.

2.21.7. Development Trends

Since the 2021 plan update, development in the RiverCOG region has been light. Over the five year span (2019-2023) available on the RiverCOG Data Dashboard, population in the region has grown by approximately 1.7%.[126] A relatively small increase in population size, 0.5% below the growth rate of the state of Connecticut, which is has had approximately a 2.2% population growth rate during the same time span.[127] Haddam, Old Lyme, Clinton, Cromwell, Middletown, and Essex have seen the greatest increases in population growth during this time span. That being said, the highest percent growth is only a 4.1% increase in Haddam. Chester has seen the largest population decrease with a decrease of 10.6% during this five-year time span. There are multiple reasons for this declining growth rate, but the COVID-19 pandemic is a large contributor.

Similarly, there has been only a 0.37% increase in housing stock in the region during the 2019-2023 five-year time frame with only 195 building permits issued in 2023 throughout RiverCOG.[128] The majority of these building permits issues in 2023 are in East Hampton (37) and East Haddam (25), both of which have seen decreases in housing stock during these five years. Killingworth, Durham, Haddam, Deep River, and Clinton have seen the largest increase in housing stock during this period. Additionally, commercial and industrial growth has been relatively stagnant during this time frame.

New development, soil disturbance, and landscaping practices can unintentionally introduce or spread invasives, such as the Tree of Heaven, Japanese Barberry, and Oriental Bittersweet among others.[129] Some RiverCOG towns have adopted conservation subdivision and open space management practices. More specific changes in development are addressed at the community level in the municipal annexes in Volume II of this plan.

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[126] https://www.rivercog.org/data-population

[127] https://www.census.gov/programs-surveys/popest.html

[128] https://www.rivercog.org/data-housingcharacteristics

[129] https://cipwg.uconn.edu/bmps-for-movement-of-topsoil-mulch-and-equipment/

2.21.8. Preventing Further Damage

CT DEEP and CAES recommend the following strategies for municipalities and landowners to prevent further damage from terrestrial invasive plants:

Clean, Contain, Restore

- **Clean:** Inspect and clean mowing, excavation, and transport equipment before moving between sites. Verify that topsoil, mulch, and fill materials are free of invasive propagules.
- **Contain:** Control infestations before seed set through hand-pulling, cutting, or herbicide treatment where appropriate. Properly dispose of biomass (burning, deep burial, or solarization); do not compost invasive material.
- **Restore:** Replant treated areas with native or non-invasive vegetation to stabilize soils and reduce re-invasion risk.

Additional and Recommended Best Management Practices

- Integrate the CT Invasive Plant List (IPC 2025) into all municipal landscaping, procurement, and subdivision regulations.
- Require “invasive-free” certification from vendors providing plant stock, mulch, or fill.
- Use Early Detection and Rapid Response (EDRR) programs to identify and control new invasions.
- Partner with UConn’s CIPWG and CAES to train municipal staff and volunteers in plant identification and control.
- Include invasive species management in open space stewardship and capital improvement planning.

Town-Level Next Steps for RiverCOG Municipalities

- **Inventory and Mapping:** Compile existing data from CAES, CT DEEP, and local conservation commissions; fill gaps with new survey data; and develop GIS maps of priority infestations.
- **Regional Coordination**: Share data and control resources across towns to ensure consistent management along transportation and riparian corridors. Ensure the use of best practices combined with horticultural expertise to plan invasive species management and removal practices. Maintain efforts annually.
- **Public Education:** Develop outreach materials on invasive plant identification, disposal, and native alternatives.
- **Policy Integration:** Update municipal Plans of Conservation and Development, inland wetlands regulations, and zoning ordinances to reference the CT Invasive Plant List and best management practices. Also, require invasive-free materials for landscaping and construction.

- **Funding:** Apply for CT DEEP Invasive Species Grants, Natural Resources Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP) funds, and other federal and local cost-share programs to support management. Also, The Rockfall Foundation of the Lower Connecticut River Valley has an environmental restoration grant and the application is due annually by November.

2.21.9. Overall Risk Rating

Using the parameters described in Table 2.8.1, the following hazard risk ratings were developed for terrestrial invasive species (Table 2.21.2).

Table 2.21.2: Overall Risk Rating of Terrestrial Invasive Species

Criteria	Hazard Risk Rating
Probability	4 (Highly Likely)
Impact: Affected Area	4 (Large)
Impact: Primary Impact	3 (Critical)
Impact: Secondary Impacts	3 (Moderate)
Level of Community Concern	3 (High Concern)
Total Score	17.8
Overall Risk Ranking	**Significant**

2.22. Aquatic Invasive Species

2.22.1. Description and Background

The definition of aquatic invasive species in Connecticut is the same as terrestrial invasive species. An *invasive plant* is defined by the Connecticut IPC—established under Connecticut General Statutes §22a-381a through §22a-381d—as a non-native species whose introduction causes, or is likely to cause, environmental harm, economic loss, or harm to human health. Aquatic invasive species for the RiverCOG region come from the same list as the terrestrial invasive species list and have the two-tier designation of invasive and potentially invasive.

Aquatic invasive plants occur in several growth forms that determine how they spread, the habitats they occupy, and the problems they cause. Understanding these categories helps in selecting

effective management techniques. The majority of ponds and lakes in the region have at least one aquatic invasive plant.[130]

- **Submerged plants**: Grow beneath the water surface, sometimes forming dense mats at the water surface that block sunlight and deplete oxygen. These species, such as h*ydrilla verticillata* and *Eurasian watermilfoil*, can interfere with boating, fishing, and aquatic life.
- **Emergent plants:** Rooted in shallow water with stems and leaves rising above the surface. They often dominate wetlands, marshes, and shorelines. *Yellow iris* and *purple loosestrife* are examples that crowd out native cattails and sedges.
- **Floating plants:** Either free-floating or rooted, with most leaf tissue resting on or above the water surface. They spread quickly over ponds and lakes, shading native species and reducing dissolved oxygen. Examples include *water chestnut* and *water hyacinth*.
- **Wetland and shoreline plants:** Occupy saturated soils at the edges of lakes, rivers, and estuaries. Although sometimes considered "semi-aquatic," species like *purple loosestrife, phragmites,* and *yellow iris* play a significant role in altering wetland hydrology and habitat diversity.

The RiverCOG region's defining natural features, especially the Connecticut River, its estuary, and the Long Island Sound shoreline, are vulnerable to invasion by non-native aquatic species. These species can degrade water quality; alter habitat; reduce biodiversity; clog waterways; and interfere with recreation (i.e., boating, fishing, swimming). They also pose risks to drinking water infrastructure and local economies.

Aquatic invasive plants are particularly problematic because they can grow submerged, emergent, or floating, forming dense mats that exclude native vegetation, reduce open water, impede navigation, and alter ecosystem functions (e.g. oxygen dynamics, shading, substrate). Wetlands are among the most biodiverse ecosystems and are especially vulnerable as invasives replace beneficial native species and reduce ecological resilience.

It is important to note the methods of prevention and removal of aquatic invasive species include the following: early season hand-pulling can prevent new establishment, as well as mechanical and chemical control. And lastly, "Clean, Drain, Dry" and Aquatic Invasive Species Stamp program (CT DEEP, 2025) target boater education.

[130] CAES, Office of Aquatic Species, Water Body Map, website: https://experience.arcgis.com/experience/39f2d565ea304c0aa97335ad2d3c7f0d?org=CAES&views=Instructions-1.

Table 2.22.1 lists the invasive and potentially invasive aquatic plants as determined by the Connecticut IPC in accordance with Connecticut General Statutes §22a-381a through §22a-381d.[131]

Table 2.22.1 Aquatic and Wetland Invasive Plants in the RiverCOG Region

Species (Scientific Name)	Species (Common Name)	Growth Form	Key Impacts in Region	Invasive Status / Regulation
Nelumbo lutea	American water lotus	Floating	Can form dense stands in shallow coves; impacts habitat diversity and recreational access.	Potentially Invasive
Egeria densa	Brazilian waterweed	Submerged	Competes with native species; clogs canals and lakes; easily spread by aquarium release.	Potentially Invasive
Najas minor	Brittle water nymph	Submerged	Competes with natives in ponds and reservoirs; detaches easily; spreads via boat traffic.	Potentially Invasive
Potamogeton crispus	Crispy-leaved pondweed	Submerged	Early-season growth shades natives; die-off causes oxygen depletion; regenerates from turions.	Invasive
Common Reed	Phragmites australis	Wetland	Ubiquitous across all RiverCOG towns; displaces entire wetland ecosystems and alters hydrology.	Invasive
Myriophyllum spicatum	Eurasian watermilfoil	Submerged	Rapid spread via fragments; reduces native habitat; impedes boating and swimming; widespread in CT lakes.	Invasive
Marsilea quadrifolia	European waterclover	Submerged / Floating	Forms mats in shallow wetlands; displaces native aquatic vegetation.	Potentially Invasive –
Cabomba caroliniana	Fanwort	Submerged	Forms dense submerged mats; obstructs recreation; spreads through fragmentation and trade.	Invasive
Butomus umbellatus	Flowering rush	Emergent	Forms thick stands along shorelines and rivers; interferes with boating and native vegetation.	Potentially Invasive

[131] Sources: CT IPC, *Connecticut Invasive and Potentially Invasive Plant List* (2025); CAES Office of Aquatic and Invasive Species; UConn CIPWG (2024); CT DEEP, *Invasive Species Program and Plant Factsheets* (2025).

Species (Scientific Name)	Species (Common Name)	Growth Form	Key Impacts in Region	Invasive Status / Regulation
Salvinia molesta	Giant salvinia	Floating	Rapidly covers pond surfaces; causes hypoxia; impedes flood flow.	Potentially Invasive
Hydrilla verticillata	Hydrilla	Submerged	Forms dense mats that block sunlight, impede navigation, outcompete native vegetation; threatens drinking water and recreation; spreads via fragments and tubers.	Invasive
Nasturtium microphyllum	Onerow yellowcress	Submerged / Wetland	Crowds out native aquatic vegetation; hybridizes with watercress.	Potentially Invasive
Myriophyllum aquaticum	Parrotfeather	Submerged / Emergent	Hybrid aquatic plant forming dense mats; can block drainage canals and flood infrastructure.	Potentially Invasive
Callitriche stagnalis	Pond water-starwort	Submerged	Forms mats in shallow ponds; reduces biodiversity and oxygen levels.	Potentially Invasive
Lythrum salicaria	Purple loosestrife	Emergent / Wetland	Replaces native wetland species; reduces wildlife habitat and biodiversity; alters hydrology.	Invasive
Myosotis scorpioides	Forget-me-not	Emergent	Invades stream margins and ditches; outcompetes native wildflowers; contributes to monocultures.	Invasive
Myriophyllum heterophyllum	Variable-leaf watermilfoil	Submerged	Dense canopy mats reduce oxygen; restricts fish movement; spreads by fragments.	Invasive
Trapa natans	Water chestnut	Floating	Dense floating rosettes deplete oxygen, shade out natives, and hinder boating; sharp fruits are a safety hazard.	Invasive
Eichhornia crassipes	Water hyacinth	Floating	Rapid reproduction; blocks waterways; can double coverage within weeks in warm weather.	Potentially Invasive (Climate-limited in CT)
Pistia stratiotes	Water lettuce	Floating	Spreads rapidly in calm waters; forms thick floating layers; can block oxygen exchange.	Potentially Invasive
Nasturtium officinale	Watercress	Submerged / Wetland	Common in disturbed waterways; can hybridize with native species and spread vegetatively.	Potentially Invasive

Species (Scientific Name)	Species (Common Name)	Growth Form	Key Impacts in Region	Invasive Status / Regulation
Nymphoides peltata	Yellow floating heart	Floating	Rapid spread; thick surface mats restrict sunlight and oxygen; aesthetic and recreational nuisance.	Potentially Invasive
Iris pseudacorus	Yellow iris	Emergent	Crowds out cattails and sedges; forms dense rhizome mats that trap sediment; toxic to livestock.	Invasive

Key Species Summaries

Below are refreshed summaries of several of the highest-priority aquatic invasive species in the RiverCOG area. They focus on identity, behavior, spread, and management relevance

Common reed (Phragmites australis)

Phragmites australis, commonly known as common reed, is a tall perennial grass that forms dense stands along riverbanks, tidal marshes, ponds, and roadside ditches. It can reach heights exceeding 15 feet, with thick, hollow stems and large, feathery plumes that persist through winter. Phragmites spreads aggressively through wind-dispersed seeds and an extensive rhizome network that can extend more than 30 feet laterally, allowing rapid colonization of disturbed or nutrient-rich wetlands.

In the RiverCOG region, Phragmites are among the most ecologically dominant and visually apparent invasive plants, occurring extensively in tidal and freshwater wetlands along the Connecticut River and its tributaries. Mapping by CAES and Connecticut DEEP has documented widespread infestations in towns such as Old Saybrook, Old Lyme, Chester, Haddam, and Cromwell, often replacing entire native marsh communities once dominated by cattail (Typha), sedges (Carex), and wild rice (Zizania).

The ecological and infrastructure impacts of Phragmites include the following:

- Displacement of native wetland species, resulting in severe loss of plant and animal biodiversity.
- Alteration of wetland hydrology by increasing sedimentation and evapotranspiration, raising the ground surface and reducing open-water habitat.
- Reduction in habitat quality for waterfowl, amphibians, and marsh-nesting birds, including state-listed species.
- Increased fire hazard due to accumulation of dry stems and litter.
- Obstruction of views and access along shorelines, impacting recreation, aesthetics, and property management.

Phragmites australis is considered a severe, landscape-scale threat that is far more widespread and persistent than most aquatic invasives. Its ecological footprint extends across hundreds of acres of wetland complexes, where it fundamentally transforms hydrology, soil chemistry, and wildlife use. Control requires multi-year integrated management combining herbicide treatment, mechanical cutting, and hydrologic restoration. Even after initial suppression, regrowth from rhizome fragments is common, demanding long-term monitoring and repeated intervention.

In response, DEEP's Habitat Restoration Program, The Nature Conservancy, and several RiverCOG municipalities in the lower Connecticut River estuary have undertaken coordinated Phragmites management in tidal marshes and conservation lands. Efforts focus on selective herbicide application followed by mechanical cutting and re-establishment of native vegetation to prevent recolonization.

Because Phragmites thrives in disturbed or nutrient-enriched areas, prevention and habitat restoration are as important as control. Reducing stormwater nutrient inputs, restoring tidal flow, and limiting soil disturbance are critical to slowing its spread.

Hydrilla (Hydrilla verticillata)

Hydrilla is a submerged perennial aquatic plant often described as "the world's worst aquatic weed." It has slender stems that can grow more than 20 feet long and are covered in whorls of 4–8 serrated leaves. The plant reproduces from fragments, turions (buds), and underground tubers.

Hydrilla was first identified in the Connecticut River near Glastonbury in 2016. Subsequent mapping by CAES revealed spread throughout the lower Connecticut River, including Portland, East Haddam, Lyme, and Haddam, with dense infestations observed in 2023–2024. Genetic testing confirmed a unique U.S. genotype, making control especially challenging.

The ecological and infrastructure impacts include the following:

- Forms dense mats that block sunlight and deplete dissolved oxygen, suffocating fish and invertebrates.
- Impedes boat navigation, water intakes, and hydropower facilities.
- Reduces recreational value and can lower property values.
- Alters nutrient cycles and may increase sedimentation.

The U.S. Army Corps of Engineers (USACE) launched a Hydrilla Control Research and Demonstration Project in 2022 partnering with RiverCOG and CAES to test site-specific herbicide treatments and long-term mitigation methods.

The CAES Invasive Aquatic Plant Program (IAPP) is continuously mapping hydrilla.

Water Chestnut (Trapa natans)

Water chestnut is a floating-leaved annual plant native to Eurasia. It produces glossy triangular leaves that form dense rosettes on the water surface, supported by spongy stems. Beneath the

rosette, a single seed develops a four-spined woody fruit capable of puncturing tires and injuring swimmers.

Brought to the United States in the late 1800's It is now found throughout the Northeast and Mid-Atlantic. It has been controlled in the lower Connecticut River from Cromwell south to Essex by a partnership of volunteers, non-profit organizations, and all levels of government. Similar efforts have taken place throughout the Connecticut River watershed and the Northeast. Several established infestations of the lower Connecticut River region, including Mattabesset/Floating Meadows area and Post Cove, and those to the north of the region remain a concern because water chestnut spreads by seed and can be transported downstream, by wildlife, and by boats or recreation gear.[132]

The ecological and infrastructure impacts include the following:

- Surface mats block sunlight and reduce oxygen, leading to fish kills.
- Chokes coves and ponds, restricting boating, swimming, and fishing.
- Sharp spines create recreational hazards.
- Large die-offs can cause foul odors and decreased water clarity.

It is important to note that early-season hand-pulling (June–August) before seed set is highly effective. There is annual monitoring of all RiverCOG lower Connecticut River coves such as Selden Cove in the Town of Lyme and the Mattabesset River in the City of Middletown where annual mitigation efforts take place.

Eurasian Watermilfoil (Myriophyllum spicatum)

Eurasian watermilfoil is a submerged perennial identifiable by its feather-like leaves arranged in whorls of four around the stem, each leaf divided into 12–21 fine leaflets.

Widespread across the state in both natural and impounded water bodies. Notable infestations occur in Bashan Lake (East Haddam). Spread primarily occurs through boat and trailer fragments.

The ecological and infrastructure impacts include the following:

- Dense underwater growth forms surface mats that impede navigation and swimming.
- Outcompetes native vegetation, reducing aquatic biodiversity.
- Alters water flow and light penetration, impacting fish habitat.

Variable-Leaf Watermilfoil (Myriophyllum heterophyllum)

A native-hybrid species complex with dense feathery underwater leaves and a distinctive emergent flowering spike. It was first documented in Connecticut in the late 20th century; and is currently

[132] Burns, M. (2018). *Lower Connecticut River water chestnut, Trapa natans 2018*. Lower Connecticut River Valley Council of Governments. Report prepared for the Silvio O. Conte National Fish and Wildlife Refuge, U.S. Fish and Wildlife Service.

widespread in lakes and backwaters of Middlesex County. It occurs in Moodus Reservoir and Bashan Lake in the RiverCOG region.

The ecological and infrastructure impacts include the following:

- Forms dense mats that smother native vegetation and degrade habitat for fish and macroinvertebrates.
- Easily spread through fragmentation and waterfowl.

It is important to note the methods of prevention and removal are similar to Eurasian Watermilfoil. Ongoing CT DEEP monitoring in Moodus Reservoir (East Haddam) and Pine Brook Pond (Middletown).

Crispy-leaved Pondweed (Potamogeton crispus)

An early-growing submerged plant with wavy, “lasagna-like” leaves. It dies back in midsummer after releasing turions (reproductive buds) that overwinter in sediment. It is common across the state in lakes, ponds, and slow-moving streams. It is found in Great Hill Pond (Portland) and Lake Pocotopaug (East Hampton).

The ecological and infrastructure impacts include the following:

- Early growth shades native spring vegetation.
- Mid-summer die-offs create oxygen depletion and algae blooms.
- Turions (i.e., dormant buds that do not bloom due to unfavorable growing conditions) allow rapid recolonization after control efforts.

It is important to note the methods of prevention and removal include herbicides in the spring before turions are released. Other control measures include raking and bottom barriers to prevent new growth. Continual monitoring of shallow coves and boat launches is a helpful prevention strategy.

Fanwort (Cabomba caroliniana)

A submerged aquatic plant with finely divided fan-shaped leaves arranged opposite each other. Small white flowers emerge among floating leaves in summer. Native to South America, fanwort was introduced through the aquarium trade. Found in Portland Reservoir, Moodus Reservoir, and several small ponds in Haddam and East Hampton.

The ecological and infrastructure impacts include the following:

- Rapid stem growth creates thick mats in shallow water, reducing biodiversity.
- Spreads by stem fragmentation and water movement.
- Clogs outflows, storm drains, and small culverts.

It is important to note the methods of prevention and removal include suction harvesting or diver-assisted removal. Chemical treatments have limited efficacy, and CAES discourages broad application. Other control measures include public education against aquarium release.

Purple Loosestrife (Lythrum salicaria)

A tall perennial emergent plant with square stems and spikes of magenta flowers. Each plant produces up to 2.5 million seeds annually. Widespread in wetlands, riverbanks, and ditches throughout the RiverCOG towns, especially in the Connecticut River floodplain.

The ecological and infrastructure impacts include the following:

- Outcompetes native wetland flora (sedges, rushes, cattails).
- Degrades habitat for muskrats, amphibians, and birds.
- Reduces wetland water storage and filtration capacity.

It is important to note the methods of prevention and removal include the statewide release of Galerucella beetles since the 1990s and this is showing localized success. It is also effective to remove isolated plants before seed set. Other control measures include prohibition of ornamental use.

Yellow Iris (Iris pseudacorus)

Yellow iris is a tall, showy perennial that thrives in shallow water and wet soils along the edges of rivers, lakes, ponds, and ditches. It has bright yellow flowers and sword-like leaves that can grow up to 3 feet tall. It reproduces both by seed and by thick, creeping rhizomes that interlock to form dense mats.

It aggressively colonizes shorelines, floodplains, and wetlands; forms dense monotypic stands that crowd out native vegetation (e.g., cattails and sedges) and trap sediment, narrowing waterways. Rhizomes interlock to form thick mats that impede flow and clog culverts. All plant parts are toxic to livestock and wildlife, and dense stands can reduce fish and amphibian habitat.

Originally imported as an ornamental in the 1700s, yellow iris is now documented by CAES and CT DEEP in numerous RiverCOG municipalities, including Lyme, Old Lyme, Haddam, East Haddam, and Deep River. It is expanding in tidal marshes, stormwater ponds, and floodplain wetlands along the lower Connecticut River. Seeds disperse readily through floodwaters and can remain viable for a year or longer, while rhizomes persist for over a decade in wet soils.

CAES and CT DEEP have prioritized yellow iris for control along tidal and freshwater marshes of the Connecticut River corridor, given its role in wetland habitat loss and flood-flow obstruction. Volunteer removal efforts are supported by Connecticut River Conservancy and local land trusts.

Other Species Summaries

The 2025 Connecticut Invasive Plant List and CAES Aquatic and Wetland Invasive Plant Identification Guide provide information about other invasive and potentially invasive species in Connecticut as summarized below. These summaries are further supported by information in the U.S. Geological Survey's Nonindigenous Aquatic Species Database.

- **American water lotus:** A native species in parts of North America but expanding beyond its range in Connecticut, American water lotus can form dense colonies in shallow coves. These mats reduce open-water habitat diversity and limit boating or fishing access. Potentially Invasive.
- **Brazilian waterweed:** An aquarium escapee that establishes in lakes and slow-moving rivers, Brazilian waterweed forms thick underwater stands that block light and deplete oxygen. It can rapidly spread by fragments or intentional release. Potentially Invasive.
- **Brittle waternymph:** A delicate submerged annual that fragments easily, allowing it to spread through water movement and boats. It competes with native pondweeds and water stargrasses, altering habitat structure. Potentially Invasive.
- **European waterclover:** A fern-like aquatic plant that forms floating mats in shallow wetlands and backwaters. It displaces native aquatic vegetation and reduces biodiversity in calm-water habitats. Potentially Invasive.
- **Flowering rush:** An ornamental escapee that establishes dense stands along lakeshores and river margins. It outcompetes native emergent plants and interferes with boating and fish habitat. Potentially Invasive.
- **Giant salvinia:** A fast-growing floating fern capable of doubling in size within days under warm conditions. It forms dense surface mats that block sunlight, reduce oxygen, and impede drainage and navigation. Potentially Invasive.
- **Onerow yellowcress:** This aquatic mustard spreads along cool, clear streams, and can form hybrids with watercress. It can alter streambank composition and native plant diversity. Potentially Invasive.
- **Parrot feather:** An aquatic plant with emergent feathery stems that create thick floating mats. It obstructs drainage canals and culverts, reducing flood conveyance and increasing maintenance costs. Potentially Invasive.
- **Pond water-starwort:** Forms dense, surface-level mats in ponds and backwaters that limit light penetration and oxygen exchange. Its rapid growth displaces native submerged vegetation. Potentially Invasive.
- **True forget-me-not:** A wetland and stream-margin invader that forms striking blue-flowered carpets. It displaces native riparian plants and contributes to monocultures in shallow wetlands. Invasive.
- **Water hyacinth:** A highly buoyant tropical plant with glossy leaves and purple flowers that can rapidly expand its surface coverage in warm conditions. While limited by Connecticut's

climate, it poses risks in warmer years or artificial ponds. Potentially Invasive (Climate-limited in CT).

- **Water lettuce:** An ornamental floating plant that forms dense rosettes on still waters, blocking sunlight and oxygen exchange. It can survive brief cold spells and may expand under warmer climate conditions. Potentially Invasive.
- **Watercress:** A common aquatic herb found in disturbed waterways and ditches. It spreads rapidly by stem fragments. Potentially Invasive.
- **Yellow floating heart:** Produces circular floating leaves and bright yellow flowers that blanket ponds and coves. It restricts light and oxygen, impedes recreation, and is difficult to eradicate once established. Potentially Invasive.

2.22.2. Location and Extent

The instances of invasive plants in the RiverCOG region are consistent with the two-tier designation for invasive plants in Connecticut: invasive or potentially invasive. Invasive and potentially invasive aquatic species of concern in the RiverCOG region are listed in Table 2.20.1 and are consistent with this designation.

Aquatic invasive species are found throughout the RiverCOG region, particularly within the Connecticut River and its tributaries, the estuaries of Long Island Sound, and numerous inland ponds, reservoirs, and wetlands. The regional hydrology—characterized by interconnected waterways, extensive floodplains, and tidal influence—creates ideal conditions for the establishment and spread of both submerged and emergent invasive plants.

The CAES IAPP and CT DEEP's 2023–2025 mapping surveys have documented the presence of more than 20 invasive and potentially invasive aquatic plant species within or adjacent to RiverCOG municipalities. Key areas of concern include:

Connecticut River Mainstem:

- Infested with hydrilla with especially dense populations observed in all fresh water tidal wetlands from Cromwell south and on mud flats of the main stem.
- Water chestnut controlled by volunteer and municipal efforts is found in all fresh water and slightly brackish tidal wetlands and can be found in tributaries and other water bodies of the region. Variable-leaf watermilfoil occur in coves and oxbows such as Selden Cove (Lyme), Whalebone Cove (Hadlyme), and Chapman Pond (East Haddam).
- Purple loosestrife and yellow iris are found in floodplain wetlands and riparian margins.

Inland Lakes and Ponds:

- Curly-leaf pondweed, Eurasian watermilfoil, and fanwort are established in Bashan Lake, Moodus Reservoir, and Lake Hayward (East Haddam), and in Great Hill Pond (Portland).
- Yellow floating heart has been confirmed in small impoundments in Haddam and Lyme.

Coastal and Estuarine Waters:

- Invasive emergents such as yellow iris and purple loosestrife are present in tidal marshes and coastal fringe wetlands along the Old Lyme and Old Saybrook shorelines.
- Salt-tolerant invasives, though less dominant, threaten restoration areas along Long Island Sound.

Aquatic invasive plants vary in both distribution and ecological impact:

- **Widespread / Severe:** Hydrilla, phragmites, water chestnut, purple loosestrife, and yellow iris—these species occur region-wide and directly affect navigation, flood management, and wetland habitat function.
- **Moderate / Localized:** Eurasian watermilfoil, variable-leaf watermilfoil, curly-leaf pondweed, and fanwort—present in numerous inland lakes and ponds, impacting recreation and biodiversity.
- **Emerging / Climate-Limited:** Water hyacinth and water lettuce—currently limited by winter temperatures but potentially expanding due to milder winters and warming water temperatures linked to climate change.

The hydrilla infestation represents the most significant and regionally unprecedented aquatic invasive plant event in Connecticut's history. Since its first detection in 2016, CAES and CT DEEP mapping (2024) estimate that the species now occupies over 1,000 acres of the Connecticut River and connected coves, extending through multiple RiverCOG towns. Research to control the hydrilla's unique genotype and rapid vegetative reproduction is currently being done by the U.S. Army Corps Aquatic Plant Control Program to inform management of the species in the future.

RiverCOG towns participate in regional aquatic plant monitoring through:

- CAES IAPP annual surveys and mapping program (public database).
- CT DEEP Hydrilla Monitoring Dashboard (interactive map, 2024–2025).
- RiverCOG's Aquatic Invasive Plant Program.
- Jonah Center for Earth and Art and the Connecticut River Conservancy Water Chestnut volunteer efforts.

Mapping data are used to identify infestation "hotspots," prioritize rapid-response treatment, and coordinate inter-municipal management strategies.

2.22.3. History of Past Events

The spread of aquatic invasive species in the RiverCOG region reflects more than a century of introductions and management efforts. Many species now considered invasive were introduced intentionally to the United States during the late 1800s and early 1900s as ornamental or aquarium plants—well before the establishment of modern invasive species laws.

The earliest documented invasives include purple loosestrife (Lythrum salicaria), first recorded in Connecticut wetlands in the 1800s. By the mid-1900s, curly-leaf pondweed and Eurasian watermilfoil had become widespread in inland lakes and ponds, prompting early control programs by lake associations and CT DEEP.

Beginning in the mid-20th century, common reed (Phragmites australis) expanded dramatically throughout the lower Connecticut River and coastal marshes. Multi-year control and monitoring projects led by CT DEEP's Wetlands Habitat and Mosquito Management Program, The Nature Conservancy, and local conservation commissions have focused on selective herbicide treatment, mowing, and tidal restoration to suppress regrowth and restore native marsh vegetation and hydrology. Despite these efforts, Phragmites remains one of the most persistent and ecologically transformative invasives in the RiverCOG region.[133]

The CT DEEP website states that water chestnut was first discovered in Connecticut in 1999 and is now found at scattered sites along the Connecticut River from Hartford to Lyme, including the mainstem river, coves such as White Oaks Cove, Keeney Cove, and Hamburg Cove, connected ponds, and other waters such as the Mattabesset, Hockanum, and Podunk Rivers.

In the last decade, northern hydrilla (Hydrilla verticillata ssp. Lithuanica), a new strain of hydrilla never seen before in the U.S. has emerged as the most significant aquatic invasion in Connecticut's history. It was first detected in the Connecticut River in 2016 near Glastonbury and by CAES surveys of the Connecticut River in 2019, 2020, and 2021 to be found from Agawam, Massachusetts near the Connecticut border south to Essex, Connecticut near the mouth of the Connecticut River where water salinity levels increase due to its proximity to where the River enters Long Island Sound Hydrilla forms dense mats of vegetation which fill the water column and spread across the surface. In 2023, USACE initiated the Connecticut River Hydrilla Control Research & Demonstration Project to study management strategies. This program is ongoing and dependent on annual federal appropriations.

2.22.4. Probability of Future Events

The probability of future aquatic invasive species spread in the RiverCOG region is high. Given the region's extensive hydrologic connectivity, recreational boating use, and proximity to major marine and fresh water corridors, new infestations are likely to occur without continued efforts to prevent introductions through boating decontamination stations, rapid response measures, and public education and awareness programs.

- High Likelihood (Annual–Ongoing): Continued spread of hydrilla, water chestnut, purple loosestrife, and yellow iris through fragments, seeds, and waterfowl transport.

[133] *Controlling Invasive Phragmites in Connecticut's Wetlands,* State of Connecticut Department of Energy and Environmental Protection Bureau of Natural Resources, Wildlife Division, Wetland Habitat and Mosquito Management Program, June 2018.

- Moderate Likelihood (2–5 years): Expansion of yellow floating heart, curly-leaf pondweed, and fanwort into additional ponds and reservoirs.
- Emerging Threat (5–10 years): Possible establishment of southern or aquarium-trade species such as water hyacinth (Eichhornia crassipes) and water lettuce (Pistia stratiotes) under warming conditions.

2.22.5. Climate Change Impacts

Climate change will likely amplify the spread, establishment, and persistence of aquatic invasive plants across the RiverCOG region. According to CT DEEP and CAES monitoring and surveillance reports, warmer water temperatures, longer growing seasons, and increased storm frequency enhance conditions for invasive plants that thrive in disturbed, nutrient-rich environments.[134]

Key projected impacts include:

- **Longer growing season:** Warmer springs and later frosts extend the reproductive window for hydrilla, water chestnut, and yellow iris.
- **Higher storm intensity:** Flooding facilitates the transport of seeds and fragments downstream, accelerating colonization of coves and backwaters.
- **Drought stress on natives:** Reduced native plant vigor after drought events allows invasives to dominate shorelines and shallow wetlands.
- **Elevated CO_2 concentrations:** Boosts biomass production in fast-growing aquatic plants, worsening mat formation and oxygen depletion.

USACE notes that hydrilla verticillata can tolerate lower light and higher nutrient loads, allowing it to outcompete natives under altered climate conditions.[135][136] As climate change increases the frequency of warm, low-flow summers, infestations are expected to become more severe and longer-lasting. (USACE 2024)

2.22.6. Impacts and Estimated Losses to the Region

Aquatic invasive plants cause a wide range of ecological, economic, and infrastructure impacts in the RiverCOG region:

Ecological Impacts

- Loss of native aquatic vegetation diversity and degradation of fish and invertebrate habitat.

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[134] CT DEEP Biodiversity & Habitat Adapting to Connecticut's Changing Climate, March 13, 2009, https://portal.ct.gov/-/media/deep/air/climatechange/adaptation/090313biodiversitypdf.pdf.

[135] U.S. Army Corps of Engineers, New England District. 2024. *History of Hydrilla in Connecticut*. May 2024 fact sheet.

[136] U.S. Army Corps of Engineers, New England District. 2024. *Connecticut River Hydrilla Control Research and Demonstration Project: Final Environmental Assessment*. July 2024.

- Reduced oxygen levels in coves and backwaters due to dense vegetation mats and decomposition.
- Displacement of wetland species critical to migratory birds and pollinators.

Economic and Infrastructure Impacts

- **Property Value Reductions:** Waterfront and lakeshore parcels might lose value when aquatic invasives block views, restrict access, or reduce water clarity. For example, Eurasian watermilfoil has been observed to reduce lakefront property values by up to 16% in Vermont and 13% in Wisconsin.[137]
- **Recreational Losses:** Dense plant mats impede boating, fishing, and swimming in the region's high-value waterbodies. CAES notes that invasive aquatic plants reduce aesthetic and recreational value of water bodies, thereby affecting tourism (e.g., boating, fishing, swimming) and real estate values.
- **Flooding and Drainage:** Aquatic invasive plants trap sediment and narrow flood channels and increase maintenance costs for culverts and stormwater infrastructure.
- **Water Supply and Treatment:** Hydrilla and other aquatic invasive species threatens the public water supply reservoirs for the RiverCOG region.
- **Infrastructure Maintenance:** Maintenance costs increase for dredging, mechanical removal, herbicide application, aquatic vegetation management, disposal of biomass, municipal water intakes, pump stations, irrigation systems, dams, canals, and bridges (e.g., clogging, damage).

CT DEEP's annual aquatic invasive species grant program currently provides approximately $500,000 statewide for control, research, and monitoring efforts for inland waters. While this does not account for all mechanical removal, herbicide, or other mitigation costs that are currently proposed or completed, it indicates the scale of state support for regional aquatic invasive management where one annual treatment for hydrilla may cost $100,000.00 or more.[138] There is no consistent source of data available in the RiverCOG region to quantify all economic losses associated with aquatic invasives.

2.22.7. Development Trends

Since the 2021 plan update, development in the RiverCOG region has been light. Over the five year span (2019-2023) available on the RiverCOG Data Dashboard, population in the region has grown by approximately 1.7%.[139] A relatively small increase in population size, 0.5% below the growth rate of the state of Connecticut, which has had approximately a 2.2% population growth rate during the

[137] U.S. Fish and Wildlife, The Cost of Invasive Species, January 2012, https://www.perc.org/wp-content/uploads/2016/09/costofinvasivesfactsheet.pdf

[138] https://www.coventry-ct.gov/CivicSend/ViewMessage/message/233271

[139] https://www.rivercog.org/data-population

same time span.[140] Haddam, Old Lyme, Clinton, Cromwell, Middletown, and Essex have seen the greatest increases in population growth during this time span. That being said, the highest percent growth is only a 4.1% increase in Haddam. Chester has seen the largest population decrease with a decrease of 10.6% during this five-year time span. There are multiple reasons for this declining growth rate, but the COVID-19 pandemic is a large contributor.

Similarly, there has been only a 0.37% increase in housing stock in the region during the 2019-2023 five-year time frame with only 195 building permits issued in 2023 throughout RiverCOG.[141] The majority of these building permits issues in 2023 are in East Hampton (37) and East Haddam (25), both of which have seen decreases in housing stock during these five years. Killingworth, Durham, Haddam, Deep River, and Clinton have seen the largest increase in housing stock during this period. Additionally, commercial and industrial growth has been relatively stagnant during this time frame.

Development patterns in the RiverCOG region continue to influence the spread of aquatic invasive species.

- **Increased Shoreline Development:** Expansion of docks, boat launches, and stormwater infrastructure creates new vectors for plant fragments and nutrient runoff.
- **Recreational Boating Growth:** According to CT DEEP's Boating Division (2023) and the Statewide Comprehensive Outdoor Recreation Plan (2023–2028), demand for river access and marina slips has risen, particularly along the lower Connecticut River corridor encompassing the RiverCOG towns. Rising recreational traffic along the Connecticut River and coastal marinas increases the probability of fragment transfer between infested and uninfested waters.[142]
- **Restoration and Green Infrastructure Projects:** While beneficial, new detention basins, ponds, and floodplain restoration areas can be unintentionally colonized if not monitored.

As development continues near aquatic resources, preventive design—such as vegetated buffers, sediment controls, boater education (e.g., Clean, Drain, Dry Technique) and resident education, and routine monitoring—will be essential to reducing long-term management costs and ecological damage.

More specific changes in development are addressed at the community level in the municipal annexes in Volume II of this plan.

[140] https://www.census.gov/programs-surveys/popest.html

[141] https://www.rivercog.org/data-housingcharacteristics

[142] CT DEEP, *2023 Boating Statistical Report* notes that the number of registered vessels in Connecticut increased by approximately 6% between 2018 and 2023.

2.22.8. Preventing Further Damage

Protecting the RiverCOG region's rivers, lakes, ponds, and wetlands from aquatic invasive species requires consistent prevention practices, early detection, and coordinated local response. Because aquatic invasives spread rapidly through connected waterways and recreational use, prevention is far more effective—and far less costly—than long-term control.

Municipal staff, lake associations, marinas, and recreational users should follow the strategies below, based on CTDEEP and CAES guidance including the *Connecticut Aquatic and Wetland Invasive Plant Identification Guide, 2nd Edition*.

Clean, Drain, Dry

- **Clean:** Remove all plants, mud, and aquatic organisms from boats, trailers, docks, fishing gear, and work equipment before leaving a launch site.
- **Drain:** Drain all water from boats, bait wells, motors, and ballast tanks prior to transport.
- **Dry:** Allow boats and equipment to fully dry (minimum 5 days when possible) or disinfect using CT DEEP-approved decontamination methods before entering a new waterbody.

Contain

- Respond quickly to new detections using CT DEEP-approved methods such as hand-pulling, suction harvesting, benthic barriers, or licensed herbicide treatment.
- Avoid mechanical cutting or raking during peak growth of hydrilla, Eurasian watermilfoil, and fanwort, which increases fragmentation.
- Ensure removed plant material is contained and dried upland, never returned to the water or composted near shorelines.

Restore:

- Replant disturbed shorelines with native riparian vegetation to reduce erosion and nutrient runoff.
- Protect and improve buffers around waterbodies to limit pollution that fuels invasive plant growth.

Best Management Practices for Towns

- Incorporate the aquatic invasive plant list into inland wetlands permitting, harbor management, and stormwater work. Include aquatic invasive animals, like zebra mussels, Asian clams, and rusty crayfish into this program, too.
- Require contractors to follow aquatic invasive species prevention practices when conducting dredging, drainage repairs, culvert work, or shoreline stabilization.
- Coordinate with lake associations and marinas to implement EDRR procedures for hydrilla, water chestnut, and other priority species.

- Ensure all public launches display Clean, Drain, Dry signage and distribute DEEP-approved outreach materials.

Town-Level Next Steps

Inventory and Mapping:

- Use CAES IAPP data and local knowledge to update town-level maps of aquatic invasive species.
- Conduct simple annual surveys at launches and priority ponds to detect early infestations.

Regional Coordination:

- Work with RiverCOG, neighboring towns, and lake or river associations to share monitoring data, equipment, and contracted control services.
- Coordinate containment actions in connected waterbodies to prevent downstream spread.

Public Education:

- Provide short, consistent messaging on town websites and signage: “Remove all plants from boats, trailers, and gear. Clean, Drain, Dry before launching anywhere.”
- Partner with lake associations, conservation groups, and harbormasters to distribute identification guides for hydrilla, water chestnut, milfoils, and fanwort.

Policy Integration:

- Include aquatic invasive species prevention requirements in municipal POCDs, inland wetlands regulations, and public works contracts.
- Require that nursery and landscaping suppliers certify aquatic plant stock as aquatic invasive species-free.

Funding:

- Pursue CT DEEP Aquatic Invasive Species Grants, Long Island Sound Futures Fund grants, and multi-town funding applications for monitoring and control.

Realistic Expectations

Aquatic invasive species are extremely difficult to eradicate once they are established. Effective management in the RiverCOG region must focus on:

- Preventing spread between waterbodies,
- Rapidly addressing small new infestations, and
- Reducing impacts on recreation, navigation, and habitat.

A consistent regional approach at boat launches, marinas, and connected tributaries is the most effective way to reduce long-term ecological and economic impacts.

2.22.9. Overall Risk Rating

Using the parameters described in Table 2.8.1, the following hazard risk ratings were developed for aquatic invasive species (Table 2.22.2).

Table 2.22.2: Overall Risk Rating of Aquatic Invasive Species

Criteria	Hazard Risk Rating
Probability	4 (Highly Likely)
Impact: Affected Area	4 (Large)
Impact: Primary Impact	3 (Critical)
Impact: Secondary Impacts	3 (Moderate)
Level of Community Concern	3 (High Concern)
Total Score	17.8
Overall Risk Ranking	**Significant**

2.23. Tree Diseases and Pests

2.23.1. Description and Background

A tree pest or disease is defined by CT DEEP and CAES as any non-native insect, pathogen, or other biological agent whose introduction causes, or is likely to cause significant damage to forest health, ecosystem stability, or the state's economy. Connecticut's surveillance and management of forest pests are coordinated under federal and state partnerships—principally among CAES, CT DEEP's Division of Forestry, the USDA, and the USFS—with periodic updates provided through the *Connecticut Forest Health Highlights (2024),* the *Connecticut State Forest Action Plan (2020), and the Forest Sub-Group Final Report (2020)*.

The State of Connecticut monitors both established and emerging tree pests and pathogens through detection surveys, trapping programs, and citizen-science reporting initiatives such as CT Grown Forest Pest Alerts and the USDA Cooperative Agricultural Pest Survey (CAPS). Federal quarantine authority under the Plant Protection Act (7 U.S.C. §7701 et seq.) restricts the interstate transport of infested materials—including firewood, nursery stock, and wooden packaging—to slow pest spread, while Connecticut General Statutes §22-84 and corresponding Regulations §§22-84-5d through 5g govern the intrastate movement of regulated materials. Connecticut currently maintains quarantines for species such as the Spotted Lanternfly, administered jointly by CAES and DEEP.

Tree pests and diseases are introduced primarily through the movement of infested nursery stock, untreated firewood, and wood-packing materials, or through wind-borne adult dispersal. Once established, infestations can spread rapidly, leading to canopy loss, habitat alteration, increased

fire risk, and costly tree removal. In some cases—such as Dutch Elm Disease and Chestnut Blight—these agents have caused near-eradication of American chestnut and widespread mortality of elms across the landscape.

Tree pests and diseases in the RiverCOG region fall broadly into three categories:

- **Invasive Insects:** Defoliators, borers, or sap-feeders that directly damage trees (e.g., Emerald Ash Borer, Spotted Lanternfly, Spongy Moth).
- **Pathogenic Fungi and Bacteria:** Non-native pathogens that cause widespread mortality or decline (e.g., Dutch Elm Disease, Chestnut Blight, Beech Leaf Disease).
- **Native Pests with Expanding Impact:** Species native or long-established but increasing in range or severity due to climate stress or invasive-plant interactions (e.g., Southern Pine Beetle).

While the RiverCOG region remains home to extensive hardwood forests and diverse native canopy species, the spread of invasive tree pests and diseases continues to threaten ecological stability, public safety, and the region's cultural landscapes.

The RiverCOG region's forests provide canopy cover, slope stability, habitat, and community character. Tree diseases and insect pests convert living canopy into hazardous trees, increasing wind and ice failures, blocking roads, blocking streams and diverting flood water, damaging buildings and utilities, and driving debris volumes and costs. These consequences can lead to a host of undesirable outcomes beyond debris cleanup. They can affect public safety, infrastructure, utilities, local economy, and environmental resilience. Affected roadside trees especially due to invasive insects, pathogens and disease have proven to be a costly and formidable threat to property and infrastructure.

Public Safety Risks

- Falling limbs or trunks can injure or kill motorists, pedestrians, and residents, particularly during high-wind or ice events.
- Blocked evacuation routes and obstructed access for police, fire, EMS, and public works delay emergency response.
- Downed lines create electrocution and fire hazards; entangled trees increase response time for line crews.
- Post-storm response poses secondary safety risks for municipal crews, contractors, and volunteers operating around unstable trees and powerlines.

Infrastructure and Utility Damage

- Prolonged power and communications outages occur when diseased trees fall onto transmission and distribution lines; and in heavily forested towns outages can last days.
- Structural damage to homes, schools, and municipal buildings results from tree or limb impact.

- Blocked roads, culverts, and bridges delay emergency and recovery operations and increase public assistance costs.
- Drainage and flooding impacts arise when downed trees clog storm drains, culverts, and small tributaries, creating localized flooding.
- Critical infrastructure impacted by falling trees can damage pump stations, elevated tanks, well houses, and control buildings, interrupting water and wastewater service.

Economic and Fiscal Impacts

- Municipalities can incur high emergency-response and cleanup costs for debris removal, traffic control, and contractor mobilization after each storm.
- Ongoing hazard-tree removal and maintenance programs represent a growing share of public works budgets.
- Property owners face private cleanup expenses and insurance claims for structural damage.
- Businesses experience interruptions and lost revenue due to extended power outages or blocked access.
- Reduced property values and aesthetic losses occur where mature canopy is removed along scenic roads or village centers.

Community and Long-Term Effects

- School and facility closures occur when access routes or power are compromised.
- Parks, trails, and campgrounds require temporary closure and cleanup, disrupting recreation and tourism.
- Loss of historic or scenic character diminishes community identity and visual appeal, particularly in towns with heritage street trees.
- The widespread death of shade and wind-buffer trees leads to increased heating and cooling costs for residents and businesses.
- Rapid canopy loss can have psychological and community impacts, as residents experience grief and stress over sudden landscape changes.

Priority Tree Disease and Pest Threats

Priority threats to Connecticut trees and forests[108] are included in Table 2.23.1. Also included are several diseases and pests that are not listed by CT DEEP as primary threats to Connecticut trees and forests but are mentioned as concerns in other state literature.

These threats are multiplied by the added stress posted by terrestrial invasives (e.g., oriental bittersweet, knotweed, Norway maple) that increase failure likelihood by overloading crowns, girdling stems, or destabilizing banks. See Section 2.21of this plan for more information about terrestrial invasive plants.

Table 2.23.1. Tree Diseases and Pests that are Priority Threats per CTDEEP in the RiverCOG Region

Species (Scientific Name)	Species (Common Name)	Type	Key Impacts in Region	Status / Regulation
Adelges tsugae	Hemlock Woolly Adelgid (HWA)	Invasive insect (sap feeder)	Progressive decline of eastern hemlock; loss of shade and riparian habitat; slope instability.	Established statewide; biological control agents in use.
Agrilus planipennis	Emerald Ash Borer (EAB)	Invasive insect (borer)	Causes near-total mortality of ash; hazards from dead roadside trees; costly removals for towns and utilities.	Detected statewide since 2012.
Amynthas spp. (A. agrestis, A. tokioensis, M. hilgendorfi)	Jumping Worms	Invasive soil invertebrate	Depletes forest floor organic matter; reduces soil fertility; inhibits seedling growth and increases erosion risk.	Established statewide.
Anoplophora glabripennis	Asian Longhorn Beetle (ALB)	Invasive insect (borer)	Attacks maple, birch, and poplar; potential for catastrophic hardwood loss if introduced.	Not detected in CT currently, high alert species for CAES.
Bretziella fagacearum	Oak Wilt	Invasive fungal pathogen	Causes wilting and mortality of red and white oak groups; rapid spread via root grafts and insect vectors.	Not yet detected in CT (2025); high-risk watch list under CAES surveillance.
Cryphonectria parasitica	Chestnut Blight	Non-native fungal pathogen	Nearly eliminated mature American chestnut; sprouts continue to die back before reaching maturity; persists in forest understories across Connecticut.	Legacy invasive, statewide presence.
Dendroctonus frontalis	Southern Pine Beetle (SPB)	Native beetle with expanding range	Increasing pine mortality along CT shoreline and interior valleys due to warming winters.	Monitored by CAES and USFS.
Discula destructiva, Apiognomonia quercina, Colletotrichum spp.	Anthracnose Diseases (Maple, Oak, Sycamore)	Fungal pathogens (native / opportunistic)	Cause early-season browning and leaf drop in hardwoods; repeated infections reduce vigor of shade and street trees, especially maples and sycamores.	Monitored statewide by CAES.
Litylenchus crenatae mccannii	Beech Leaf Disease (BLD)	Invasive nematode/ pathogen	Rapid canopy decline of American and European beech;	Under CAES active research

Species (Scientific Name)	Species (Common Name)	Type	Key Impacts in Region	Status / Regulation
			altering forest composition and wildlife food sources.	and regional monitoring.
Lycorma delicatula	Spotted Lanternfly (SLF)	Invasive insect (sap feeder/ nuisance)	Feeds on maple, walnut, grape; causes honeydew soot mold and economic losses to vineyards and nurseries.	Detected statewide; public reporting encouraged.
Lymantria dispar dispar	Spongy Moth	Invasive insect (defoliator)	Severe oak defoliation during periodic outbreaks; canopy stress and tree mortality following drought years.	Established; monitored by CAES.
Neonectria faginata / N. ditissima with Cryptococcus fagisuga	Beech Bark Disease (BBD)	Invasive scale–fungus complex	Scale insect wounds allow fungal infection causing extensive bark cankers and eventual mortality of mature beech; often co-occurs with BLD.	Established statewide; Monitored by CAES and USFS.
Operophtera brumata	Winter Moth	Invasive insect (defoliator)	Early-spring defoliation of oaks, maples, and ornamentals; currently suppressed by biocontrol (*Cyzenis albicans*).	Populations low; monitored by CAES.
Ophiostoma ulmi / O. novo-ulmi	Dutch Elm Disease (DED)	Non-native fungal pathogen	Widespread mortality of mature elms; loss of street tree canopy and heritage shade trees.	Managed through resistant cultivars and sanitation practices.
Verticillium dahliae / V. albo-atrum	Verticillium Wilt	Soil-borne fungal pathogen	Causes branch dieback and vascular wilting in maples, catalpas, and other hardwoods; symptoms mimic drought stress; persists in soils for years.	-

Management techniques are included in the pest descriptions below. Note that they are guidelines based on public information and educational materials from CTDEEP, CAES, and U.S. Forest Research and Development. A subject matter expert should be consulted for specific treatments to ensure successful pest control.

Hemlock Woolly Adelgid (HWA)

An aphid-like insect introduced from Asia in the 1950s, the HWA infests eastern hemlocks, feeding at the base of needles and depleting stored nutrients. Infested trees exhibit needle loss, grayish foliage, and gradual decline, often dying within four to ten years.

HWA is widespread throughout Middlesex and New London Counties, especially in East Haddam, Lyme, Old Lyme, Deep River, and Haddam, where it has reshaped forest structure. Hemlock loss destabilizes steep slopes and streambanks, increases erosion, and raises summer stream temperatures critical to trout and aquatic habitat.

Management techniques include monitor and treat high-value trees with systemic insecticides or horticultural oils; maintain shade and soil moisture; and use biological controls (e.g., *Sasajiscymnus tsugae* beetle releases) where feasible.

Emerald Ash Borer (EAB)

First detected in Connecticut in 2012, EAB is a metallic-green beetle native to Asia that attacks all species of North American ash. The larvae feed on the inner bark, disrupting water and nutrient transport and killing trees within three to five years of infestation.

Ash trees once comprised 2–5% of Connecticut's forests and were common along streets and riparian corridors. Nearly all untreated ash trees in the RiverCOG region have now died or are in advanced decline, resulting in thousands of brittle hazardous trees along roads, trails, and powerlines. The removal burden on towns and utilities remains substantial.

EAB has caused significant ash mortality throughout the state although efforts to manage EAB through biological control are promising. As of 2024, parasitoid wasps that target EAB have spread beyond their initial release sites, and EAB populations have crashed in the vicinity of the first detection site in New Haven County

In addition to parasitoid wasps, management techniques include removal of dead and high-risk ash, and replanting with non-host species. CT DEEP encourages firewood movement restrictions ("Don't Move Firewood").

Jumping Worms

Jumping worms, comprising several Asian species including *Amynthas agrestis*, *A. tokioensis*, and *Metaphire hilgendorfi,* are invasive soil-dwelling earthworms introduced to North America through potted plants, compost, and soil movement. Unlike the slow-moving European earthworms common in gardens, jumping worms thrash vigorously when disturbed and live near the soil surface, rapidly consuming leaf litter and organic matter.

Their activity transforms forest soils, leaving a loose, granular layer that erodes easily and holds less moisture. This loss of organic material reduces soil fertility, disrupts fungal networks essential to tree root health, and inhibits regeneration of native seedlings. In forests across the RiverCOG region, jumping worms are altering the structure and nutrient balance of forest floors, amplifying the impacts of canopy loss from other stressors such as Emerald Ash Borer and Beech Leaf Disease.

CT DEEP identifies jumping worms as an emerging threat to Connecticut's forest health. While no chemical or biological control currently exists, management recommendations focus on prevention—cleaning soil and equipment, avoiding compost or mulch containing live worms or cocoons, and educating the public about soil hygiene. CAES and UConn Extension continue to research the worms' spread, reproductive biology, and ecological effects.

Asian Longhorned Beetle (ALB)

The ALB is a destructive wood-boring pest native to China and Korea that attacks maples, elms, willows, and other hardwoods. It was detected in Massachusetts in the 1990s but has not yet been found in Connecticut. Adults tunnel deep into trunks and branches, weakening structural integrity and eventually killing host trees.

Though not currently present, the ALB represents a high-consequence emerging threat. The species' preferred hosts—maples and other hardwoods—are abundant in the RiverCOG region, meaning a single introduction could cause large-scale losses affecting tourism, fall foliage, property values, and municipal budgets. Continued surveillance and public awareness are critical.

ALB may become a pest in Connecticut in the future, therefore CTDEEP advises towns to look out for this pest and report any sightings to CAES. Spotting potentially harmful insects early helps limit the amount of damage that can be caused. Practices such as using only locally grown firewood reduce vulnerability.

Oak Wilt

Oak Wilt is a lethal vascular disease that affects red, black, and pin oaks, causing leaves to bronze, wilt, and fall within weeks. It spreads via root grafts or beetles carrying fungal spores from infected trees.

Monitoring and preparation efforts on behalf of the CAES continue for oak wilt through 2024 and 2025 although it is not currently known to be present in the RiverCOG or the state. However, Oak Wilt has reached western Massachusetts and New York's Hudson Valley, putting RiverCOG's oak-rich forests at high risk. A local outbreak could result in extensive canopy loss and significant hazard-tree generation.

Management techniques include early detection and containment. CAES and CT DEEP maintain surveillance. Movement of oak firewood across state lines is discouraged and often illegal unless the wood is heat-treated, certified, or permitted.

Chestnut Blight

Introduced from Asia around 1904, chestnut blight is a fungal disease that nearly eradicated the once-dominant American chestnut (*Castanea dentata*) from eastern forests. The fungus enters through bark wounds, forming orange cankers that girdle stems and kill trees above the infection point.

In the RiverCOG region, chestnut persists only as small root sprouts within mixed hardwood forests and along slopes and old field margins. These sprouts rarely reach maturity before being reinfected and dying back, leaving chestnut as an understory relic rather than a canopy species.

While there are no management actions for wild populations, restoration and breeding efforts led by CAES, The American Chestnut Foundation, and the USFS aim to develop blight-resistant hybrids. CT DEEP continues to list chestnut blight as a legacy but ongoing forest health threat due to its lasting ecological impact on forest composition and wildlife.

Southern Pine Beetle (SPB)

A native bark beetle expanding northward with warmer winters, the Southern Pine Beetle (SPB) could target pitch pine in Connecticut. It is known to bore S-shaped galleries that disrupt water flow and kill trees rapidly. No sightings were recorded in surveys conducted by CAES between 2021 and 2023. In 2024, beetles in traps were detected in Connecticut, however no SPB-attacked trees were reported and to date. SPB remains at endemic levels in Connecticut, potentially due to the small remaining pitch pine population in the state including the RiverCOG region.

SPB has been observed in endemic levels in pitch-pine stands in East Haddam, Haddam Neck, and Cromwell State Forest. Outbreaks, which have not yet occurred, could cause concentrated pine mortality and increase wildfire risk during drought years.

CT DEEP and CAES monitor SPB through pheromone trapping. Prompt salvage and thinning reduce stand vulnerability.

Anthracnose Diseases (Maple, Oak, Sycamore)

Anthracnose diseases are a group of fungal infections that cause early-season browning, curling, and leaf drop in hardwood trees, especially maples, oaks, and sycamores. Infected leaves develop irregular brown patches along veins, and repeated infections can reduce vigor, leading to branch dieback.

In the RiverCOG region, anthracnose is most noticeable after cool, wet springs, particularly in riparian forests and street-tree canopies in towns such as Middletown, Essex, and Old Saybrook. The disease does not usually kill mature trees but contributes to stress and aesthetic decline, often predisposing trees to secondary pests such as scale insects and canker fungi.

Management recommendations include raking and removing infected leaf litter, improving air circulation, and pruning to promote canopy drying. Fungicide treatments may be warranted in nurseries or for high-value specimen trees. CT DEEP lists anthracnose as a statewide forest health threat, with CAES monitoring periodic outbreaks.

Beech Leaf Disease (BLD)

First confirmed in Connecticut in 2019, BLD is caused by a microscopic nematode that invades leaf tissue, producing dark banding, curling, and premature leaf drop. Affected trees exhibit canopy thinning and branch dieback within several years.

BLD threatens the dominance of American beech (Fagus grandifolia) in lowland and mesic forests (i.e., lower slopes, stream terraces, and upland flats with well-draining yet moisture-retaining soils) of the RiverCOG towns. The resulting canopy gaps create safety risks along trails and property lines and accelerate invasion by opportunistic plants such as barberry and bittersweet.

Management techniques include early detection and pruning of infected saplings; avoid stress and soil compaction; ongoing CAES and USDA research on nematode control; diversify regeneration away from single species stands.

Spotted Lanternfly (SLF)

An invasive species that is not a direct forest or tree threat, however it doesn't usually kill trees outright but is considered a stressor. It feeds on sap and causes decline rather than mortality contributing to long-term weakening of established trees. It was first detected in Connecticut in 2020 and is now established in several RiverCOG municipalities including Cromwell, Portland, Middlefield, East Haddam, Essex, Old Saybrook, and Lyme. Tree-of-Heaven, listed in Terrestrial Invasive Species, Section 2.19 of this plan, is highly favored by the Spotted Lanternfly and outbreaks in natural areas, especially those without tree-of-heaven, are rare per CAES.

CAES and CT DEEP monitor infestations and encourage egg mass scraping, host-tree removal, and public reporting. Municipalities can help by managing tree-of-heaven stands and educating residents about detection and disposal.

Spongy Moth

Formerly known as the European Gypsy Moth, this invasive defoliator has a long history in New England. Caterpillars feed on more than 500 species of trees and shrubs, with oaks most affected. Often defoliation of entire stands occur during outbreak years. Connecticut's 2016–2018 outbreak, compounded by drought, caused widespread oak mortality, particularly in Middlesex County. Outbreaks occur when dry springs suppress the naturally occurring fungus (i.e., Entomophaga maimaiga) that normally keeps populations in check.

Many oaks weakened or killed during the most recent outbreak still stand dead or decayed, posing ongoing hazard-tree risks.

Management techniques include monitoring egg masses; conserving natural fungal and viral pathogens; avoiding large-scale insecticide use unless outbreaks recur; and promoting oak regeneration diversity.

Beech Bark Disease (BBD)

Beech Bark Disease results from a two-part interaction between the non-native beech scale insect and fungal pathogens. The insects puncture the bark, allowing fungal entry that causes cankers, callusing, and eventual bark deformation and tree mortality. Infestations spread slowly but persist for decades once established.

Throughout the RiverCOG region, BBD commonly affects mature American beech in upland and mid-slope forests, especially where Beech Leaf Disease is already present. The combined effects of these two diseases have accelerated canopy decline and mortality, creating hazardous conditions along trails and steep forested slopes.

Management includes removing heavily infested trees to reduce hazards, encouraging mixed-species regeneration, and protecting saplings that show resistance. DEEP and CAES list BBD as a priority forest health threat and continue long-term monitoring and resistance studies with the USFS.

Winter Moth

The Winter Moth is a small, pale-gray moth native to Europe that was first detected in New England in the early 2000s and in Connecticut shortly thereafter. Adults emerge and mate in late fall, and larvae hatch in early spring, feeding on the buds and newly flushed leaves of maples, oaks, apples, and other deciduous trees. Repeated spring defoliation can severely weaken trees, predisposing them to secondary pests and decline.

Winter Moth outbreaks were common in southeastern and coastal Connecticut during the 2000s and early 2010s, including portions of the lower Connecticut River Valley and shoreline towns within the RiverCOG region. However, populations have since declined sharply due to the successful establishment of a biological control agent—the tachinid fly Cyzenis albicans—which parasitizes Winter Moth caterpillars.

Although defoliation events are now infrequent, CT DEEP continues to list Winter Moth as a forest health threat because residual populations persist and could resurge under favorable climatic conditions. Ongoing CAES monitoring focuses on early detection of population rebounds, with management emphasizing biological control, proper tree care, and minimizing unnecessary pesticide applications.

Dutch Elm Disease (DED)

A vascular wilt disease introduced from Europe in the early 1900s, DED spread rapidly through Connecticut's urban and rural landscapes, killing mature American elms that once lined village streets. Transmitted by bark beetles and root grafts, the fungus blocks water transport and causes rapid crown wilt and death.

DED continues to affect surviving street and park elms in Middletown, Cromwell, Portland, Essex, and Chester, requiring ongoing monitoring and selective removal. The loss of mature elms has permanently altered the aesthetic character of many town centers.

Management techniques include remove diseased trees; plant resistant elm cultivars (e.g., Princeton, Valley Forge); and pruning during dormant season to avoid attracting bark beetle vectors (i.e., November through March).

Verticillium Wilt

Verticillium Wilt, caused by soil-borne fungi, infects tree roots and disrupts the vascular system, leading to wilting, dieback, and leaf scorch that mimic drought stress. The pathogen can persist for years in soils and infect a wide range of hosts including maple, elm, catalpa, and redbud.

Within the RiverCOG region, verticillium wilt is commonly observed in urban and landscaped settings, park trees, and riparian maples where soil disturbance, compaction, or drought have weakened trees. Repeated infections reduce growth and longevity, requiring increased removal and replacement by town tree crews.

Management focuses on maintaining soil health and watering during droughts, pruning affected limbs, and avoiding replanting with susceptible species in contaminated soils. CT DEEP lists verticillium wilt as a priority forest health threat, and CAES provides diagnostic support and educational outreach to local tree wardens.

Tree Disease and Pest Threats Not Listed as a Priority per CT DEEP (2025)

There are several diseases and pests that are not listed by CT DEEP as primary threats to Connecticut trees and forests, but are mentioned as concerns in other CAES and CT DEEP literature (e.g., 2024 Forest Health Highlights) and they are presented in Table 2.23.2. While these diseases and pests are not considered to be priority threats, they are monitored and pose emerging risks to trees and forests in the RiverCOG region.

Table 2.23.2. Tree Diseases and Pests that are not Priority Threats per CTDEEP in the RiverCOG Region

Species (Scientific Name)	Species (Common Name)	Type	Key Impacts in Region	Note
Complex of Mycosphaerella, Lecanosticta, and other fungi	White Pine Needle Disease (WPND)	Native/ fungal needle cast complex	Premature needle drop and reduced growth of eastern white pine; landscape decline after wet springs.	Monitored by CAES.
Aproceros leucopoda	Elm Zigzag Sawfly (EZS)	Invasive insect (defoliator)	Defoliates native and ornamental elms; first found in CT in 2023, potential to compound DED stress.	Monitored by CAES.

Species (Scientific Name)	Species (Common Name)	Type	Key Impacts in Region	Note
Various species (e.g., *Armillaria* spp., *Ganoderma* spp.)	Root and wood decay fungi	Native/ opportunistic fungi	Cause structural weakness and hazard tree failures after storm events or stress; elevate removal needs near infrastructure.	Naturally occurring.

White Pine Needle Disease (WPND)

A complex of fungal pathogens (i.e., Lecanosticta acicola, Septorioides strobi, and Davisomycella medusa) collectively cause White Pine Needle Disease, resulting in browning and premature shedding of older needles.

WPND is now widespread in Haddam, East Haddam, Killingworth, and Lyme, where repeated defoliation weakens trees, increases susceptibility to storm damage, and reduces timber quality. Stressed pines are also more prone to secondary pests such as bark beetles and root rot fungi.

Management techniques include reducing stand density to improve airflow; maintain species diversity; remove severely infected individuals; and CT DEEP recommends mixed replanting on affected slopes. WPND is not listed as a priority threat to CT trees and forests by CT DEEP as of 2025.

Elm Zigzag Sawfly (EZS)

An invasive sawfly native to Asia, the EZS was first confirmed in Connecticut in 2023 and has caused local defoliation of elm trees. The larvae feed on elm leaves in a distinctive zigzag pattern, often causing heavy defoliation through multiple generations each year.

EZS has been documented in Middlesex County, including Middletown and Portland, where it threatens elm street trees and young restoration plantings already stressed by DED. Repeated defoliation can hasten canopy decline and increase maintenance needs.

Management techniques include monitor foliage for characteristic zigzag feeding; prune and destroy infested branches (e.g., burn, bag, or deep burial); and protect new elm plantings with targeted treatments if outbreaks intensify. EZS is not listed as a priority threat to CT trees and forests by CT DEEP as of 2025.

Root and Wood Decay Fungi

Native and non-native decay organisms such as Armillaria, Ganoderma, and Inonotus species exploit stressed or wounded trees, degrading structural wood and leading to unpredictable limb or whole-tree failure.

These decay fungi are increasingly common in older parks, roadside trees, and post-storm damaged stands, particularly where drought, construction, or invasive insects have weakened host defenses.

Management techniques include conducting regular risk assessments; removing trees with advanced decay; avoiding root disturbance and soil compaction; and replacing them with structurally sound, pest-resistant native species. Root and wood decay fungi is not listed as a priority threat to CT trees and forests by CT DEEP.

2.23.2. Location and Extent

The instances of tree diseases and pests in the RiverCOG region are consistent with the two-tier designation in Connecticut: listed as priority threats to Connecticut state trees and forests, or not listed.[109] Tree diseases and pests of concern in the RiverCOG region, listed in Table 2.21.1 and Table 2.21.2, are consistent with this designation.

Tree diseases and pests are widespread across the RiverCOG region, with impacts varying by forest type and species composition. They are listed in priority order below:

- **Emerald Ash Borer (EAB) and Oak Decline:** Present across all 15 towns; ash and oak mortality visible along major roads, power corridors, and parklands.
- **Beech Leaf Disease (BLD):** Increasingly documented throughout Middlesex County for American beech in lowland, lower slopes, stream terraces, and upland flats with well-draining yet moisture-retaining soils.
- **Hemlock Woolly Adelgid (HWA):** Concentrated along shaded valleys and river corridors in East Haddam, Lyme, Old Lyme, Deep River, and Haddam.
- **Beech Bark Disease (BBD):** Established throughout the RiverCOG region, especially in mature upland forests of Haddam, Killingworth, and East Haddam. The scale–fungus complex causes extensive mortality of mature beech and often co-occurs with Beech Leaf Disease, accelerating canopy gaps and slope instability.
- **Spongy Moth:** Once a major defoliator of oak forests, the population collapsed after the 2018 infestation, but CT DEEP monitoring indicates periodic defoliation persists in oak-dominated uplands in Haddam, East Haddam, and Durham.
- **Anthracnose Diseases (Maple, Oak, Sycamore):** Common across all RiverCOG towns during cool, wet springs; most pronounced in urban and riparian corridors such as Middletown, Portland, and Essex. Repeated infections cause leaf browning, early defoliation, and reduced vigor in shade and street trees, especially mature maples and sycamores.
- **Verticillium Wilt:** Occurs sporadically across the region, particularly in landscaped and riparian maples in Middletown, Cromwell, and Deep River. The disease is favored by compacted or drought-stressed soils and contributes to chronic branch dieback in shade and park trees.

- **White Pine Needle Disease (WPND):** Impacts white pine trees and widespread outbreaks have been documented in Haddam, East Haddam, Killingworth, and Lyme.
- **Dutch Elm Disease (DED):** Persistent in town centers and older street-tree populations.
- **Chestnut Blight:** Present as a long-established infection across all RiverCOG towns, affecting stump sprouts and saplings in mixed hardwood forests and along field margins. While no longer an active canopy disease, its historic impact permanently altered forest composition.
- **Winter Moth:** Detected primarily in coastal and near-coastal portions of Middlesex County, including Old Saybrook, Old Lyme, and Clinton with reduced outbreak frequency due to the establishment of the establishment of the parasitoid fly *Cyzenis albicans* has reduced outbreak frequency.
- **Southern Pine Beetle (SPB):** No outbreaks to date but endemic levels impacts pitch pine known to be in East Haddam, Haddam Neck, and Cromwell State Forest.
- **Elm Zigzag Sawfly (EZS):** Detected in low populations in central Connecticut; potential for establishment along riparian elm populations within the lower Connecticut River corridor.
- **Jumping Worms:** Established throughout the RiverCOG region in both urban and forested settings. Highest densities occur in disturbed soils, compost piles, and shaded hardwood stands.

The location and extent information sources are primarily from CAES including their *Forest Health Monitoring Reports* (2023-2025); and *Beech Leaf Disease Mapping* (2023-2024) as well as the CT DEEP Division of Forestry State Forest Inventory (GIS Portal); and *Connecticut Forest Health Update* (2024). Another source includes the USFS's *Forest Health Highlights in Connecticut* (2023).

The associated systems for classifying and declaring tree diseases and pest occurrences and risks are appropriate for the RiverCOG region. Tree diseases and pests have not been characterized outside of these systems of classification. However, as tree diseases and pests are evolving threats, the USDA and State of Connecticut may revise classification systems over the next decade.

2.23.3. History of Past Events

Connecticut's forests have experienced successive waves of insect and disease outbreaks that have reshaped the River COG region's canopy and increased hazardous tree conditions. Since the 1930s, impacts from DED eliminated the most mature elms from town centers and riparian corridors, though resistant cultivars are now replacing lost trees.

Chestnut blight arrived in the early 1900s and by the 1950s had already destroyed nearly all mature American chestnut trees in Connecticut. Because the pathogen is now ubiquitous and functionally permanent in eastern forests, contemporary "forest pest" lists limit discussion to active or emerging threats (e.g., beech leaf disease, emerald ash borer, spotted lanternfly). For the purposes of this NHMP, chestnut blight is no longer a spread-risk issue—it's a legacy impact issue.

The arrival of HWA in the mid-20th century led to widespread hemlock decline across shaded valleys and slopes in Middlesex and New London Counties, reducing streambank stability and altering cold-water habitats. By the late 2010s, EAB was detected in 2012 and established region-wide and has caused near-total ash mortality along roads and rivers, creating large volumes of hazardous debris and removal costs for towns.

Between 2016 and 2018, a major Spongy Moth outbreak caused severe oak defoliation and mortality, especially in the uplands of Haddam, East Haddam, Durham, and Killingworth. Although naturally suppressed by the Entomophaga maimaiga fungus, low-level defoliation still occurs.

Since 2019, BLD has expanded rapidly across Connecticut, now confirmed in all RiverCOG towns, while WPND has increased following several wet springs. SPB, first detected in 2015, remains at endemic levels statewide, limited by the small remaining pitch-pine population. EZS was found at low densities in central Connecticut in 2023–2024.

Collectively, these events have altered forest composition, increased the number of standing hazard trees, and elevated risks to power lines, roads, and buildings during storms.

2.23.4. Probability of Future Events

The probability of future tree disease and insect pest impacts in the RiverCOG region is high. Connecticut's forest composition, aging canopy, and trees stressed by drought, storms, and development create conditions favorable to pest establishment and disease spread. Warmer winters extend the range of southern insects such as the Southern Pine Beetle, while wetter springs and prolonged growing seasons favor fungal and foliar pathogens such as Anthracnose and White Pine Needle Disease. Without coordinated management, these factors are expected to cause continued canopy decline, increased debris volumes, and higher municipal maintenance and hazard-tree removal costs.

High Likelihood (Annual–Ongoing):

- **Emerald Ash Borer (EAB):** Mortality has peaked but remains widespread, leaving thousands of standing hazard trees along roads, rights-of-way, and parklands.
- **Beech Leaf Disease (BLD)** and **Beech Bark Disease (BBD):** These co-occurring pathogens are causing accelerating canopy loss and slope instability throughout beech-dominated stands in the region.
- **Hemlock Woolly Adelgid (HWA):** Continues to cause decline in riparian and valley forests, reducing shade cover and habitat complexity.
- **White Pine Needle Disease (WPND):** Expected to persist during cool, wet spring seasons, reducing vigor and increasing dieback of eastern white pine across upland and mixed forests.

- **Anthracnose Diseases:** Recurrent leaf infections will continue during wet years, especially in riparian and urban forests, contributing to chronic stress in maples, sycamores, and oaks.
- **Verticillium Wilt:** Chronic in stressed urban and park trees; will continue to cause branch dieback and premature decline in maples and catalpas under compacted or drought-prone soil conditions.

Moderate Likelihood (2–5 years):

- **Spongy Moth:** Populations remain suppressed by natural fungal controls but may resurge periodically during dry springs.
- **Southern Pine Beetle (SPB):** Range expansion northward is expected as winters continue to warm, with potential outbreaks in pitch pine stands near East Haddam and Haddam Neck.
- **Elm Zigzag Sawfly (EZS):** Early detections in central Connecticut suggest potential establishment along riparian elm stands in the lower Connecticut River corridor.
- **Jumping Worms:** Populations are expanding through soil movement and compost exchange; ongoing soil degradation and loss of forest litter are expected to exacerbate seedling mortality and erosion.

Emerging Threat (5–10 years):

- **Oak Wilt:** Not yet detected in Connecticut but remains a high-risk watch-list species. Introduction could cause rapid mortality of red and white oaks, with major canopy and habitat impacts.
- **Asian Longhorn Beetle (ALB):** Although not currently found in Connecticut, infestations in neighboring Massachusetts and New York maintain a persistent introduction risk through movement of firewood or infested nursery stock.

Legacy Threats:

- **Chestnut Blight:** While long established, it continues to suppress natural regeneration of American chestnut; restoration efforts may determine future forest composition resilience.
- **Dutch Elm Disease (DED)** also qualifies as a legacy pathogen—once catastrophic, now endemic but managed through resistant cultivars and sanitation in municipal forests.

2.23.5. Climate Change Impacts

Continued climate change is expected to significantly influence the spread, severity, and persistence of tree diseases and insect pests across the RiverCOG region. According to the CT DEEP and the CAES Forest Health Program in 2024, warmer average temperatures, milder winters, and longer growing seasons are already accelerating pest lifecycles and reducing natural winter mortality.

Extended growing seasons allow multiple generations of insects such as the EZS and SPB to develop each year, increasing cumulative stress on trees. Warmer winters enable survival of previously range-limited species like HWA and Spongy Moth, allowing populations to persist through seasons that once suppressed them.

Increased precipitation and humidity promote foliar and needle diseases such as WPND and Anthracnose, while prolonged wet springs favor BLD outbreaks and expand habitat for the associated BBD complex. Conversely, more frequent summer droughts weaken trees, increasing vulnerability to Verticillium Wilt, decay fungi, and opportunistic borers such as the EAB.

Climate-driven stress also intensifies species interactions. Drought-stressed oaks are more susceptible to Spongy Moth and Oak Wilt, while storm damage opens new infection sites for DED, BLD, and BBD. Decomposition changes linked to invasive Jumping Worms further degrade soil structure and nutrient cycling, compounding recovery challenges after pest outbreaks.

Longer frost-free seasons favor secondary insects and pathogens like bark beetles, root and wood decay fungi, and Verticillium species that accelerate mortality in already weakened stands. Warmer winters may also allow isolated populations of Winter Moth and SPB to rebound under favorable conditions.

Combined, these climate-linked trends are expected to increase canopy gaps, woody debris accumulation, and the number of hazardous trees near infrastructure—raising management costs and complicating storm recovery throughout the RiverCOG towns.

2.23.6. Impacts and Estimated Losses to the Region

Tree diseases and insect pests cause widespread ecological degradation, economic losses, and public safety risks across the RiverCOG region. As infestations progress and affected trees decline, communities face compounding impacts to forest health, infrastructure, and municipal budgets.

Ecological Impacts

A 2024 aerial survey by the CAES indicated that BLD was the most damaging forest health agent in Connecticut, with all beech trees statewide showing defoliation symptoms.[110] The survey also documented extensive oak defoliation and mortality caused by the Spongy Moth and noted that WPND affected nearly all white pine stands across the state. These overlapping stressors have contributed to rapid canopy decline in both upland and riparian forests, altering ecosystem structure and reducing biodiversity.

Loss of dominant canopy species including ash, hemlock, beech, and white pine is transforming the region's forest composition and habitat quality. Canopy gaps left by declining trees allow invasive plants such as Japanese barberry and multiflora rose to spread, reducing regeneration of native species. Loss of hemlock along stream corridors contributes to warmer stream temperatures (i.e., due to loss of shade and microclimate) and higher sedimentation, while beech

decline disrupts mast production critical to wildlife such as black bear, turkey, and small mammals.

Infrastructure and Economic Impacts

Hazardous trees resulting from EAB, BLD, and other pests have significantly increased costs for municipalities, utilities, and landowners. According to previous Regional Hazard Mitigation Plans, RiverCOG towns collectively spend hundreds of thousands of dollars each year removing dead or failing trees along public roads, parks, and rights-of-way, and this amount of money is not adequate to address the hazardous tree issues that most communities face.

Eversource has an aggressive program that spends hundreds of thousands of dollars in the region annually to protect its assets and to protect supply to its customers. With the heavy winter snow falls and tropical storms that were frequent in the past decade, prolonged power outages and storm clean-up costs from fallen tree debris were significant. All RiverCOG municipalities have secondary power capabilities at critical municipal facilities, however, when hazardous trees block routes to those facilities, municipal and other staff response times are delayed.

Street and shade-tree losses from DED, Spongy Moth, and WPND also reduce aesthetic and property values in town centers and residential areas. Timber and nursery sectors experience reduced market value for species such as ash, beech, and hemlock, as well as regulatory limitations on transport and sales due to pest quarantines.

There is no known consistent source of data available to quantify all losses related to this hazard. Based on meetings with all of the RiverCOG communities participating, more than $1 million is spent annually from municipal budgets to remove dead or failing trees. Electric utility Eversource likely spends in excess of $1 million annually in the RiverCOG region for the same purpose.

Public Safety and Community Resilience

Dead and structurally compromised trees pose serious hazards to homes, vehicles, pedestrians, and critical facilities (e.g., water and wastewater utilities, communication and lower lines, transportation routes), particularly during high-wind or ice events. Accumulated woody debris from declining forests increases wildfire potential during drought periods, especially in pine and oak stands. Loss of canopy cover reduces shade and stormwater interception, intensifying heat-island effects from reduced shade and micro-climate cooling; and localized flooding. These factors link declining forest health directly to community safety, infrastructure resilience, and long-term climate adaptation goals across the RiverCOG towns.

Overall, the combined effects of these tree diseases and insect pests are expected to continue generating significant aesthetic, ecological, and fiscal costs, underscoring the importance of coordinated monitoring, proactive management, and replanting with climate-resilient native species.

2.23.7. Development Trends

Since the 2021 plan update, development in the RiverCOG region has been light. Over the five year span (2019-2023) available on the RiverCOG Data Dashboard, population in the region has grown by approximately 1.7%.[143] A relatively small increase in population size, 0.5% below the growth rate of the state of Connecticut, which has had approximately a 2.2% population growth rate during the same time span.[144] Haddam, Old Lyme, Clinton, Cromwell, Middletown, and Essex have seen the greatest increases in population growth during this time span. That being said, the highest percent growth is only a 4.1% increase in Haddam. Chester has seen the largest population decrease with a decrease of 10.6% during this five-year time span. There are multiple reasons for this declining growth rate, but the COVID-19 pandemic is a large contributor.

Similarly, there has been only a 0.37% increase in housing stock in the region during the 2019-2023 five-year time frame with only 195 building permits issued in 2023 throughout RiverCOG.[145] The majority of these building permits issues in 2023 are in East Hampton (37) and East Haddam (25), both of which have seen decreases in housing stock during these five years. Killingworth, Durham, Haddam, Deep River, and Clinton have seen the largest increase in housing stock during this period. Additionally, commercial and industrial growth has been relatively stagnant during this time frame.

Development and land management practices in the RiverCOG region continue to influence forest health and the spread of tree diseases and insect pests. Fragmented forests, expanding residential areas, and intensive utility and transportation corridor maintenance all contribute to increased tree stress and pest vulnerability. Construction and clearing activities often damage roots, alter drainage patterns, and compact soils—creating entry points for decay fungi and reducing tree resilience to insects and pathogens.

- **Urban and Suburban Canopy Stress:** Many towns, including Middletown, Cromwell, and Old Saybrook, have large aging street and park tree populations with constrained root zones and compacted soils. These conditions increase susceptibility to **Dutch Elm Disease (DED)**, **White Pine Needle Disease (WPND)**, **Anthracnose**, **Verticillium Wilt**, and **root and wood decay fungi**. Stress from constrained growing conditions accelerates decline and increases the number of hazard trees near sidewalks, utilities, and municipal facilities.
- **Forest Fragmentation and Edge Effects:** Subdivision and road development increase forest edges, exposing trees to wind, sun, and temperature fluctuations that favor pests such as HWA and BLD, which thrive along warm, disturbed boundaries. Edge conditions

[143] https://www.rivercog.org/data-population

[144] https://www.census.gov/programs-surveys/popest.html

[145] https://www.rivercog.org/data-housingcharacteristics

also favor aggressive invasive plants (e.g., barberry, knotweed), which reduce native regeneration and compound the impacts of canopy loss from pests and pathogens.

- **Utility Corridor and Transportation Maintenance:** Ongoing vegetation management by utilities and municipalities reduces short-term hazard risks but can unintentionally facilitate pest spread when infested debris or soils are moved or stockpiled. Movement of firewood, wood chips, logs, and fill remains a major vector for EAB, SPB, and EZS. Soil movement associated with corridor maintenance also enables the spread of Jumping Worms, which degrade forest soils and hinder natural regeneration.
- **Landscaping and Nursery Trade:** Continued demand for non-native ornamental trees and shrubs increases the likelihood of new pest introductions. Imported nursery stock has historically been the source of several significant pests, including HWA, EZS, and potentially Oak Wilt if introduced to the region.
- **Adaptation and Planning Opportunities:** RiverCOG municipalities are beginning to integrate tree health and species diversity into public works and open space planning. Replanting with pest-resistant and climate-tolerant native species, enforcing firewood transport restrictions, and incorporating forest health monitoring into land-use and capital improvement programs can help reduce long-term costs and hazard risks. Examples are as follows:
- **Middletown:** Adopted a Tree Ordinance (2022) and Urban Forestry Management Plan with species diversity targets and street tree replacement cycles.
- **Old Saybrook:** Old Saybrook Sustainability & Resilience Plan (2023) recommends “tree canopy restoration using climate-resilient and pest-tolerant native species.”
- **Haddam:** The Open Space and Conservation Commission (2025) minutes note the development of a native tree ordinance and invasive plant removal initiatives.
- **East Haddam:** The document, East Haddam Community Resilience Building - Summary of Findings, dated April 2023 identifies local invasive species threats and priority actions to control the threats.
- **Six RiverCOG towns (i.e., Cromwell, East Hampton, Killingworth, Middlefield, Old Lyme, and Westbrook)** are registered and certified under Sustainable CT, with actions completed in the “Environment & Natural Resources” category focused on tree canopy and native species planning. Other RiverCOG towns are in process to become registered.
- Lower Connecticut River Valley Plan of Conservation and Development identifies these mitigation activities for 2021 to 2031:
- **High Urgency:** Protect the region’s biodiversity and control invasive species by investing in invasive species removal, public education, and outreach, particularly along rivers, trails, and recreation corridors where new introductions are most likely.

Collectively, these development and maintenance trends underscore the need for coordinated forest management strategies that balance growth, safety, and ecological resilience across the RiverCOG towns.

More specific changes in development are addressed at the community level in the municipal annexes in Volume II of this plan.

Preventing Further Damage

Protecting trees and forests in the RiverCOG region requires both public vigilance and coordinated municipal action. Because the region's landscape is heavily forested and interconnected, early detection and containment are challenging—but early action can still reduce spread, protect critical canopy, and limit infrastructure damage.

Residents, landowners, and municipal staff must remain alert for the presence of harmful insects and tree diseases in all life stages. Prompt identification and reporting to the CAES or local tree wardens help limit damage. Using only locally sourced firewood and mulch reduces the risk of introducing new infestations. Public outreach and volunteer monitoring (through EDDMapS or Sustainable CT initiatives) strengthen early warning capacity.

When an invasive pest is confirmed, the first step is to map the extent of the infestation and establish a quarantine zone to prevent movement of infested materials. This includes lumber, nursery stock, trunk wood, branches, stumps, roots, and all types of firewood. These restrictions are essential to keep pests such as the EAB or SLF from spreading across town and state boundaries. Municipalities should coordinate with CT DEEP, CAES, and the USDA Animal and Plant Health Inspection Service (APHIS) to ensure compliance with state and federal quarantines.

The following regional and local town risk mitigation action list for tree diseases and pests combines the relevant information in the Lower Connecticut River Valley Plan of Conservation and Development for 2021 to 2031, Forest Sub-Group Final Plan (2020), and this plan:

- Strengthen Monitoring and Reporting
- Expand mapping of hazard trees and infestations to prioritize early warning and rapid response.
- Train municipal staff, utilities, road crews, and tree wardens to identify priority pests and diseases.
- Encourage reporting to CAES Forest Health, CT DEEP, and through community science apps (e.g., iMapInvasives, EDDMaps).
- Coordinate Hazard-Tree Management
- Develop regional contracts or shared services for tree removal and debris management.
- Standardize infested wood disposal through chipping, burning, or secure transport.
- Adopt and promote biocontrol methods, where possible, and work with partners at the state level to test and apply these methods.
- Integrate tree-risk assessments into storm-response and capital improvement planning.
- Restore and Diversify Canopy
- Replant with mixed-species, climate-resilient, and non-host trees; avoid heavy reliance on ash, beech, oak, and hemlock in high-risk areas.

- Track replanting progress and canopy change through RiverCOG's regional GIS.
- Prioritize riparian buffers, parks, streetscapes, and heat-vulnerable areas for canopy restoration.
- Reduce Spread Pathways
- Enforce firewood transport restrictions ("Don't Move Firewood") under C.G.S. Sec. 22-84.
- Require pest-free certification for mulch, fill, and nursery stock in municipal projects.
- Incorporate pest-prevention language in public works and contractor specifications.
- Integrate Forest Health into Local Policy
- Reference CT DEEP and CAES pest lists in zoning and subdivision regulations.
- Include canopy and forest-resilience goals in Plans of Conservation and Development and Open Space Plans.
- Seek funding through Sustainable CT, Urban Forestry Climate Resilience Grants, and NRCS EQIP for tree inventories, pruning, removals, and planting.
- Public Education and Outreach
- Educate residents on identifying BLD, BBD, EAB, HWA, SLF, EZS, SPB, WPND, Anthracnose, Verticillium Wilt, and Jumping Worms.
- Encourage reporting through CAES and CTDEEP.
- Promote workshops on proper pruning, disposal, and replanting practices.

Realistic Expectations and Hazard Implications

Although early detection is vital, the dense and forested nature of the RiverCOG region makes full containment of invasive insects or pathogens impractical once established. Swift, widespread, and often irreversible canopy loss is a recurring natural hazard. Recognizing tree disease and pest outbreaks as part of the region's hazard profile enables towns to plan coordinated debris management, prioritize tree-risk reduction, and restore lost canopy with more resilient species.

2.23.8. Overall Risk Rating

Using the parameters described in Table 2.8.1, the following hazard risk ratings were developed for tree diseases and pests (Table 2.23.3).

Table 2.23.3. Overall Risk Rating of Tree Diseases and Pests

Criteria	Hazard Risk Rating
Probability	4 (Highly Likely)
Impact: Affected Area	4 (Large)
Impact: Primary Impact	3 (Critical)
Impact: Secondary Impacts	3 (Moderate)
Level of Community Concern	3 (High Concern)
Total Score	17.8
Overall Risk Ranking	**Significant**

3. Multiple-Hazard Regional Mitigation Strategy

In many cases, a natural hazard event will impact several municipalities in the region at once, although variations with highly localized damage can occur. In addition to the inevitable regional effect of natural hazards, RiverCOG staff recognized common existing strategies, concerns, and mitigation needs while working with individual member municipalities on this plan. This section reviews mitigation strategies common to most if not all municipalities and the region and discusses the challenges that are common throughout the region. Because of the regional nature of natural hazards and common concerns, some mitigation activities are better addressed at the regional level.

For the 2021 update RiverCOG chose to develop goals, objectives and actions of its own, at the regional level and actions to be shared between regional and local entities. The disposition of those actions is included in this section, as are actions and strategies identified for the 2026-2031 planning cycle. Regional strategies proposed are evaluated for costs and benefits. Mitigation actions and strategies specific to the municipalities are contained in the municipal annexes in Volume II of this plan.

This section also discusses the capabilities and effectiveness of the existing authorities, policies, programs, and resources available to accomplish hazard mitigation at the federal, state and regional level. Capabilities at the local level are contained in the annexes.

3.1. Capability Assessment

Capabilities are viewed here as policies, programs and actions that occur regularly or are underway that contribute to or can contribute to natural hazard loss reduction. It should be noted that RiverCOG primarily provides support functions and is not a regulatory agency, or a standalone participant in the National Flood Insurance Program.

3.1.1. Federal Capabilities

National Flood Insurance Program, FEMA Flood Maps, and Floodplain Regulations

All seventeen RiverCOG communities, including the fifteen participating in this plan update, have participated in FEMA's National Flood Insurance Program (NFIP) for at least thirty years and all are in good standing in the program. All municipalities in the region intend to continue participation in the NFIP, including continued compliance and enforcement on the local level with all NFIP requirements. (See Table 3.1.1 below for the latest information on current flood insurance rate maps). All seventeen municipalities have adopted floodplain management regulations that have helped to prevent increased flood risks from new developments. Most municipalities in the region incorporate floodplain management regulations in their zoning. Others use separate ordinances for floodplain management. Many municipalities go above and beyond the FEMA minimum

requirements for participation (for example in Chester they include dedicated open space requirements in floodplains of at least 50%). Table 3.1.2 provides a summary of local floodplain management regulations. The Connecticut Department of Energy and Environmental Protection (DEEP) periodically reviews these municipal regulations for conformance to the latest Flood Insurance Studies, FEMA flood maps and model flood hazard regulations. Chapter 124, Section 8-2 of the Connecticut General Statutes governs the municipal regulation of development within floodplains as defined by the National Flood Insurance Program.

Table 3.1.1 Community Participation in the National Flood Insurance Program

Community ID	Municipality	County	Initial FHBM Identified	Initial FIRM Identified	Current Effective Map Date
090060#	Chester	Middlesex	**09/07/73**	**07/16/80**	**02/06/13**
090061#	Clinton	Middlesex	**02/01/74**	**09/30/80**	**02/06/13**
090123#	Cromwell	Middlesex	**03/22/74**	**06/15/78**	**02/06/13**
090062#	Deep River	Middlesex	**12/28/73**	**01/16/81**	**02/06/13**
090185#	Durham	Middlesex	**11/29/74**	**04/01/82**	**02/06/13**
090063#	East Haddam	Middlesex	**08/23/74**	**11/01/79**	**02/06/13**
090064#	East Hampton	Middlesex	**05/10/74**	**10/16/79**	**02/06/13**
090065#	Essex	Middlesex	**10/26/73**	**07/16/80**	**02/06/13**
090066#	Haddam	Middlesex	**05/31/74**	**01/16/80**	**02/06/13**
090174#	Killingworth	Middlesex	**04/04/75**	**03/15/82**	**02/06/13**
090067#	Middlefield	Middlesex	**05/31/74**	**03/28/80**	**02/06/13**
090068#	Middletown	Middlesex	**08/16/74**	**12/16/80**	**02/06/13**
090103#	Old Lyme	New London	**02/04/77**	**07/16/80**	**08/05/13**
090130#	Portland	Middlesex	**03/15/74**	**07/03/78**	**02/06/13**

Source: FEMA National Flood Insurance Program Community Status Book Information (https://www.fema.gov/cis/CT.html), June, 25, 2026.

The National Flood Insurance Program offers an additional voluntary program, the Community Rating System (CRS), which provides discounts on flood insurance premiums to property owners. The CRS recognizes a community's efforts which go beyond the minimum standards for floodplain management by reducing flood insurance premiums from 5% to 45% depending on the number and type of activities undertaken in the community. These activities may include issuing elevation certificates for new construction in floodplains; outreach to property owners; maintaining flood and property data digitally; stormwater management regulations; open space preservation; and a host of other activities, many of which may be currently undertaken in a community. In the

RiverCOG Region, there are no communities that currently participate in the CRS program. A few municipalities have, however, identified participation in the CRS as a mitigation action they will be considering this plan update, as identified in the annexes. Assistance is available, from CT DEEP for communities wishing to join the program. The Connecticut Institute for Resilience and Climate Adaptation (CIRCA). has developed open space mapping for the region to determine points eligibility under the CRS. Table 3.1.2 identifies the location of floodplain management regulations in the participating communities.

Table 3.1.2. Summary of Floodplain Regulations

Municipality	Regulation/Ordinance	Reference
Chester	Zoning Regulations	Chapter 11
Clinton	Zoning Regulations	Section 17
Cromwell	Zoning Regulations	Chapter 4.2
Deep River	Zoning Regulations	Section 14.3
Durham	Zoning Regulations	Section 12.06
East Haddam	Zoning Regulations	Section 9.1
East Hampton	Zoning Regulations	Section 3.5
Essex	Zoning Regulations	Section 30A.3
Haddam	Zoning Regulations/Special Flood Hazard Zone Regulations	Article XIV, 270-56-270-73
Killingworth	Zoning Regulations/Floodplain District	Article XV, 500-82-500-93.13
Middlefield	Zoning Regulations	Article III, Section 09.04
Middletown	Zoning Code	Article 4, Section 46
Old Lyme	Zoning Regulations	Chapter 4, Section 4.4
Portland	Planning and Zoning Regulations	Section 7.6

FEMA and Other Federal Agency Grants Supporting Hazard Mitigation

The following sources of funding and technical assistance may be available for the mitigation projects identified by each community.

FEMA Hazard Mitigation Assistance (HMA)

- FEMA Hazard Mitigation Grant Program (HMGP) – funding for hazard mitigation projects following a presidentially declared disaster. More information on the HMGP program can be found at: Hazard Mitigation Grant Program (HMGP) | FEMA.gov

- FEMA Building Resilient Infrastructure and Communities (BRIC) – funding for hazard mitigation projects on a nationally competitive basis. More information on the PDM program can be found at: Building Resilient Infrastructure and Communities | FEMA.gov
- FEMA Flood Mitigation Assistance (FMA) Program – Provides grants for flood hazard mitigation planning and projects such as property acquisition, relocation of residents, and flood retrofitting with the goal of mitigating risk to buildings insured under the NFIP. More information can be found online at: https://www.fema.gov/grants/mitigation/learn/flood-mitigation-assistance.
    - The FMA Swift Current effort provides funding to mitigate buildings insured through the NFIP after a major disaster declaration following a flood-related disaster event in order to reduce risk against future flood damage. More information can be found at: https://www.fema.gov/grants/mitigation/learn/flood-mitigation-assistance/swift-current.

Other Federal Mitigation Assistance Programs

- U. S. Small Business Administration – Disaster Loan Program – provides funding to individuals, businesses and non-profits including relocation loans. More information can be found at: *http://www.sba.gov/content/disaster-loan-program*
- U. S. Economic Development Administration-Disaster Recovery – EDA assists local governments affected by disasters. More information can be found at: *http://www.eda.gov/disasterrecovery.htm*
- U.S. Department of Housing and Urban Development - CDBG Disaster Recovery Assistance-HUD provides flexible grants to help cities, counties and States recover from presidentially declared disasters, especially in low-income areas, subject to availability of supplemental appropriations. More information can be found at: *http://portal.hud.gov/hudportal/HUD?src=/program_offices/comm_planning/communitydevelopment/programs/drsi*
- U.S. Department of Housing and Urban Development – CDBG Program – generally CDBG funds to municipalities can be used as local match for other federal assistance granted for disaster mitigation provided the activity meets all applicable CDBG requirements. More information can be found at: *http://portal.hud.gov/hudportal/HUD?src=/program_offices/comm_planning/communitydevelopment/programs*
- U.S. Army Corps of Engineers Flood Risk Management Program – Provides 50/50 match funding for flood proofing and flood preparedness projects. More information can be found online at: https://usace.contentdm.oclc.org/utils/getfile/collection/p16021coll11/id/7234 and https://www.usace.army.mil/Missions/Civil-Works/Flood-and-Coastal-Storm-Risk-Management/.
- U.S. Department of Agriculture Natural Resources Conservation Service Emergency Watershed Protection and Watershed and Flood Prevention Operations Programs –

Provides technical and financial assistance to reduce or prevent flood damage, reduce soil erosion and improve water quality. More information can be found at: http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/wfpo/ and at http://www.nrcs.usda.gov/wps/portal/nrcs/main/ct/programs/financial/ewp/

Hurricane Mitigation

- FEMA Building Science Disaster Support Program – Provides technical assistance to state and local governments provided through reports and technical manuals based on assessments of building performance in response to disasters. More information can be found online at: https://www.fema.gov/emergency-managers/risk-management/building-science/disaster-support.

Wildfire Mitigation

- Assistance to Firefighters Grant Program – Grants are provided to fire departments to enhance their ability to protect the public and fire service personnel from fire and related hazards. The applicable grant programs under this umbrella include Assistance to Firefighters Grants (AFG), Staffing for Adequate Fire and Emergency response (SAFER), and Fire Prevention & Safety Grants. More information can be found at: https://www.fema.gov/grants/preparedness/firefighters.

USDA Natural Resources Conservation Service (NRCS) Emergency Watershed Protection Program

Several towns within the region have used the technical and financial assistance of the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) to minimize damages from natural disasters. The Emergency Watershed Program provides financial and technical assistance to the state and towns to address dangerous problems that result from natural hazards. The Watershed Protection and Flood Prevention program provides technical assistance in designing and planning for structural measures to reduce flooding damage. The Connecticut Department of Energy and Environmental Protection then assists in the actual installation of planned measures.

EPA Climate Pollution Reduction Grant Coordination

The State of Connecticut, as well as CRCOG and RiverCOG received grants from EPA under the Climate Pollution Reduction Grant Program in summer 2023 to develop Climate Action Plans. The process develops Climate Action Plans for the state and the Hartford – East Hartford – Middletown Metropolitan Statistical Areas, respectively.

CRCOG and RiverCOG kicked off the planning process for development of the Priority Climate Action Plan (PCAP) in November 2023. The PCAP was developed from December 2023 through January 2024, with a draft available in January 2024. The EPA's Climate Pollution Reduction Grant Program specifically excludes the funding of climate adaptation projects, but the PCAP planning

process does not discourage the appropriate planning for strategies that provide co-benefits in climate mitigation and adaptation. During some of the planning meetings for the PCAP (for example, the meeting for municipal committees and commissions on November 27, 2023), some of the municipal contacts asked about coordination between the NHMP and the PCAP. Many of the strategies related to urban forestry may provide benefits related to climate mitigation and extreme heat adaptation. The planning process for the Comprehensive Climate Action Plan was completed in August 2025 and can be found (along with the PCAP) on the CRCOG website: https://crcogct.gov/regional-planning-and-development/regional-climate-action-plan/.

3.1.2. Statewide Capabilities

Connecticut Natural Hazards Mitigation Plan (2023)

The 2023 Connecticut Natural Hazards Mitigation Plan provides guidance for hazard mitigation activities within the State and has undergone 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 state 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. The complete mitigation strategy includes specific strategies for each goal as well as prioritized implementable actions.

- Goal 1 – Protect safety, public infrastructure, private property, and the environment by implementing physical hazard mitigation and climate adaptation projects that effectively and equitably reduce risk.
- Goal 2 – High Hazard Dams: Reduce vulnerabilities to and from high hazard potential dams.
- Goal 3 – Forward-Looking Policy and Planning: Adapt to climate change and natural hazards through forward-looking policies, plans, regulations, and programs that reduce risk and support long-term resilience.
- Goal 4 – Awareness and Education: Increase general awareness of Connecticut's natural and climate-related hazards and promote measures available to reduce risks through educational outreach.
- Goal 5 – Capability- and Capacity-Building: Enhance the capability and capacity of State agencies, regional entities, and local governments to identify vulnerabilities and risks, integrate risk reduction strategies, and implement resilience projects.

The plan provides hazard ranking, vulnerability analysis and loss estimation that supports development of regional mitigation plans. Each state plan update "rolls up" local and regional plan data. State and local plans are intended to complement one another and to provide for a two-way exchange of information.

Connecticut State Building Code

Connecticut municipalities currently use the 2026 Connecticut State Building Code. This statewide code is based on the 2021 International Code Council (ICC) codes, with specific state amendments. The Code incorporates the standards in high-wind design and seismic activity appropriate for the state. The code is significant relative to flood mitigation. It requires 1 foot of freeboard in all A, AE, and VE zones (VE zones have a risk of significant wave action and tend to be found along coastlines; coastal A zones (A or AE zones occurring in coastal areas are regulated like VE zones in certain cases; flood openings are required in breakaway walls; and essential facilities must be elevated 2 feet above the BFE or to the 0.2% annual chance flood elevation. Local building officials are bound by the state code.

Through local implementation of the State Building Code, RiverCOG municipalities help reduce the risks associated with natural hazards in new developments. According to the Connecticut Department of Administrative Services, the 2026 State Building Code includes the 2021 International Building Code. Pursuant to sections 29-252a and 29-253 of the Connecticut General Statutes, respectively, this code shall be the building code for all towns, cities and boroughs and all state agencies. The provisions of this code apply to the construction, alteration, movement, enlargement, replacement, repair, equipment, use and occupancy, location, maintenance, removal and demolition of every building or structure or any appurtenances connected or attached to such buildings or structures.

Connecticut State Historic Preservation Office (SHPO)

The State Historic Preservation Office (SHPO) administers a range of federal and state programs that identify, register, and protect buildings and areas that represent Connecticut's cultural heritage. Recognizing that historic and cultural resources are increasingly at risk to natural hazards and climate change, SHPO embarked on a resiliency planning study for historic and cultural resources beginning in 2016. Working with the state's Councils of Government and municipalities throughout the planning process, numerous examples were identified where historic and cultural resources were specifically at risk now, could be at risk in the future, and could help generate consensus for resiliency actions.

Historic resources are difficult to floodproof, elevate, or relocate without potential loss of their historicity. Therefore, a thorough understanding of the site-specific options for each set of historic resources is necessary prior to disasters that could damage these resources in order to avoid damage during recovery. The five coastal COGs in Connecticut hosted historic resources resiliency planning meetings in June 2016. During winter 2016-2017, individual meetings were held with the shoreline communities. Reports were issued to these communities in late 2017 based on the COG meetings and the local meetings. These reports outline eight strategies that can be employed to make historic and cultural resources more resilient. They are:

- Strategy: Identify Historic Resources

- Strategy: Revisit Historic District Zoning Regulations
- Strategy: Strengthen Recovery Planning
- Strategy: Incorporate Historic Preservation into Planning Documents
- Strategy: Revisit Floodplain Regulations and Ordinances
- Strategy: Coordinate Regionally and with the State
- Strategy: Structural Adaptation Measures
- Strategy: Educate

A best practice guide for planning techniques to make historic resources more resilient was distributed in 2018. This guide can be used by all jurisdictions in Connecticut, including those in the RiverCOG, when undertaking development of hazard mitigation plans. Resiliency concepts were added to the update of the Statewide Historic Preservation Plan in 2017-2018, with the goal of helping all of the state's communities making historic resources more resilient. In 2022, SHPO released an up-to-date GIS inventory of historic resource sites within Connecticut, which municipalities can use to evaluate potential vulnerability to historic resources.

Connecticut Institute for Resilience and Climate Adaptation (CIRCA)

CIRCA is a multidisciplinary 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, as well as make their human-built infrastructure more resilient while protecting valuable ecosystems and the services they offer to human society. Initiatives 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 23 projects through its Municipal Resilience Grants Program to 19 municipalities and the state's regional planning organizations (councils of governments). The 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, policy analysis and planning. This program funded the Hepburn Dune and Marsh Preservation Project in Fenwick and the Back River Living Shoreline design project in Old Saybrook. A matching funds program previously managed by CIRCA was used to support the RiverCOG Regional Long-Term Recovery-Land Use Resiliency Plan completed in 2018.

Through its initial 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 20 inches/50 centimeters of sea level rise by 2050. That analysis is used in Section 2 of this plan.

The Resilient Connecticut program was originally deployed by the CIRCA in 2020. Funded by a Housing and Urban Development National Disaster Resilience Competition, it focuses on regional resilience and adaptation planning through engagement and risk assessments that inform municipal to regional scale initiatives and pilot projects. It was deployed to the RiverCOG planning area in 2022. As part of this effort, a Climate Change Vulnerability Index (CCVI) was developed statewide. Under "Phase III", studies and concept designs were developed and executed in Portland ("Resilient Portland") and East Haddam ("Resilient East Haddam") as well as in other areas. The final reports for these two areas are available at the Resilient Connecticut Website at: https://resilientconnecticut.uconn.edu/. Thus, CIRCA's Resilient Connecticut program is listed as a potential funding source for potential actions.

Farmland Preservation - Public Act 490

Public Act 490 (Connecticut General Statutes Sections 12-107a through 107-f) allows farm, forest, or open space land to be assessed at its use value rather than its fair market or highest and best use value (as determined by the property's most recent "fair market value" revaluation) for purposes of local property taxation. Without the lower use value assessment, most landowners would have to sell the land because they would not be able to afford the property taxes on farms, forest, or open space land. (https://portal.ct.gov/DOAG/Commissioner/Commissioner/Public-Act-490---The-Basics)

PA 490 enables landowners to pay tax on PA 490 land at its current value rather than its highest value (i.e. as farmland rather than as potential housing development). This helps reduce the municipal property tax burden on farms and helps to prevent the forced conversion of farm, forest, and open space lands to more lucrative uses. Unlike many tax statutes, PA 490 includes a Declaration of Policy, which is public policy making it within the public interest to encourage the preservation of these lands to maintain a readily available source of food and farm products in the state.

Emergency Alerting and Notification Systems

All the RiverCOG communities currently have a reverse notification system. This may be part of or an addition to the CT Alert Emergency Alerting and Notification System powered by Everbridge offered by the State of Connecticut. This emergency notification system, which relies on GIS technologies, allows communities in the Region to alert residents to impending natural hazards, thereby reducing risks to life and property. According to the CTALERT.gov website, all RiverCOG municipalities currently subscribe to the CTAlert system. All citizens in Connecticut, however, can register with CTAlert to receive emergency notifications that are sent statewide.

Many communities rely upon alerts from the State of Connecticut to open heating and cooling centers within their communities. The identification and discussion of heating and cooling centers is a major change from previous editions of this NHMP, with new actions considered regarding the

placement of such centers as well as their accessibility connection to nearby transit options that will allow people to reach the centers.

Stormwater and Erosion Control

By statute (Section 22a-325 – 22a-329 of the CGS), all municipalities in Connecticut are required to adopt regulations pertaining to soil erosion and sediment control and all applications for proposed development which will disturb more than a half-acre must include a soil erosion and sediment control plan. The DEEP has guidelines which serve as the technical standard for compliance with the statute. The Connecticut Stormwater Quality Manual provides guidance on site planning, source control and stormwater practices, including the design, construction and maintenance of stormwater systems, to protect the quality of Connecticut waters. The practices detailed in the Manual aim to reduce the volume of urban runoff and pollutant discharges, recharge groundwater and control peak flows. These types of stormwater best practices not only protect water quality but also minimize flooding risks.

The Connecticut Guidelines for Erosion and Sedimentation Control also detail specific measures that can reduce the damages and pollution associated with erosion and sedimentation, while simultaneously reducing flooding risks. In 2012, CT DEEP updated the Manual and Guidelines to incorporate appendices on Low Impact Development (LID). Low Impact Development manages stormwater by designing with nature in mind. LID techniques seek to retain stormwater close to where it falls thus keeping runoff out of pipes that drain to waterways. The most recent update occurred in 2024.

RiverCOG encourages its member municipalities to adopt and enforce regulations that would require new development to implement these types of best practices in as far as is possible.

The State of Connecticut passed legislation in 2021 that makes it easier for municipalities to form stormwater authorities and implement stormwater utilities. Specifically, the Connecticut legislature passed Substitute House Bill 6441, authorizing the creation of municipal stormwater authorities pursuant to Section 22a-498 of the Connecticut General Statutes. This bill allows any Connecticut municipality to establish a stormwater authority, which assesses and collects scaled user fees from property owners, for the purpose of maintaining. To date, no RiverCOG communities have developed stormwater authorities.

Regulation of Wetlands and Watercourses

Activities in wetlands areas and watercourses are regulated under Chapter 440 (Sec. 22a-28 – Sec. 22a-45d) of the Connecticut General Statutes. Under this statute, each municipality is required to establish an inland wetlands agency, identify boundaries of inland wetlands and watercourse areas, promulgate regulations to protect the inland wetlands and watercourses within its boundaries, and require that no regulated activities shall be conducted without a permit. All municipalities in the region have established inland wetlands agencies and have enacted inland wetlands and watercourses regulations.

According to the Connecticut Council on Environmental Quality (CEQ), between 60 and 90 acres of inland wetlands were altered statewide by development from 2004 until 2011 when the rate spiked to more than 200 acres. (Detailed data are not available to the public or CEQ.) Also, according to CEQ, municipal agencies, which issue 95 percent of all inland wetland permits, have become more conserving of wetlands in recent years. CEQ attributes this increased protectiveness to the completion of wetlands training programs by municipal agency members and staff.

Dam Safety

The Dam Safety Section of the Connecticut Department of Energy and Environmental Protection's (DEEP) Inland Water Resources Division enforces the state's dam safety laws. The Dam Safety Office administers the inspection of existing dams, dikes or similar structures, and the permitting process for the construction, repair or alteration of dams. The Office inspects hundreds of dams annually based on their classification and potential risk to life and property and then targets a limited number of lower hazard dams for inspection on a rolling basis. Any dams deemed unsafe upon inspection must be repaired by the owner.

The Office of Dam Safety works to minimize the potential damage of dam breaches. Dams which receive Dam 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 the dams under 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, i.e., the 10-year and 25-year events occur more frequently there will be little impact on the ability of Connecticut dams to operate safely. The Dam Safety 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 statute to regularly inspect, maintain, and repair their dams and have current Emergency Action Plans (EAPs) ready for implementation should hazardous conditions arise. The program's major responsibilities include:

- 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.
- 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 levees in the state, which are DEEP jurisdictional and have more recently been accredited by FEMA and certified by the USACE, are not presently

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.

As more and more state- and privately-owned dams get 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 increases and we should remain vigilant.

Additional dam safety resources can be found here:

- Association of State Dam Safety Officials- Website with advice and information on dam safety. More information can be found at: http://www.damsafety.org/
- Connecticut Department of Energy and Environmental Protection (DEEP) Dam Safety Program - More information can be found at: https://portal.ct.gov/deep/water/dams/dams-safety.
- U.S. Army Corps of Engineers Levee Program – Information on levee safety, risk assessment and risk reduction. More information can be found on the Army Corps website at: https://www.usace.army.mil/Missions/Civil-Works/Levee-Safety-Program/.

Power Outages

The following program is available for municipalities to apply for funding for the creation of micro-grids.

- State of Connecticut, Microgrid Program – An initial award of $18 million was announced in 2013 for nine microgrid projects in Connecticut. An additional $15 million in funding to continue microgrid work was authorized as part of the State's FY14-FY15 Biennial Budget. More information can be found at: https://portal.ct.gov/deep/energy/microgrid-grant-and-loan/microgrid-grant-and-loan-program. While the program is currently not available, it is still valid and may be funded in the future.
- Solar and battery storage (e.g. Tesla Powerwall) technologies are available to provide backup to residential and certain commercial buildings, increasing resilience.
- FEMA's HMGP and PDM programs will fund backup power generators for municipal critical facilities.

Forest Fire Aid

There are procedures in place for requesting assistance or other resources to aid in responding to all hazards, including forest and wildland fires. In the State of Connecticut, the first responding authority would be the local jurisdiction. If there is a need for additional aid or resources beyond the local capabilities, the Intrastate Mutual Aid Compact (CGS Sec. 28-22a) outlines the process for requesting assistance. If regional resources are depleted, the Connecticut Department of

Energy and Environmental Protection's Division of Forestry may be requested to assist local fire departments in suppressing wildland fires. The Forestry Division maintains an active forest fire prevention program and a specially trained force of firefighting personnel to combat fires that ravage an average of 1,300 acres of forestland per year.

During the spring fire season and at other times of high or above fire danger, the Division broadcasts daily predictions of fire danger and issues advisories to state park staff, municipalities, fire departments and the media. The Division also has crews ready to assist the US Forest Service in controlling large fires across the nation.

Additional State Resources

Additional information on state resources and funding sources include:

- Connecticut Department of Energy and Environmental Protection (DEEP) Climate Resilience Fund – This state- and federally-funded program began accepting applications in 2022 in order to fund innovative resilience plans and projects to help municipalities and other entities develop project pipelines to protect their communities from extreme weather. Projects are supported at the planning, advancement, and deployment stages. In 2025, DEEP announced that the 2025 priorities for awards through this fund include projects that use innovative approaches to increase community resilience by addressing multiple natural hazards, support reliable energy and reduce electrical outages, as well as promote nature-based solutions and community engagement. More information can be found at https://portal.ct.gov/connecticutclimateaction/executive-order/deep-climate-resilience-fund.
- Connecticut Department of Housing CDBG Small Cities Program - This federally funded program provides funding to municipalities with populations of less than 50,000 for a variety of activities including acquisition of property, relocation, public facilities and improvements, code enforcement, planning and capacity building, among other uses. More information can be found at: https://portal.ct.gov/doh/doh/programs/small-cities-program.
- Connecticut Department of Energy and Environmental Protection (DEEP) Open Space and Watershed Land Acquisition Grant Program – provides financial assistance to municipalities and nonprofit land conservation organizations to acquire open space. More information can be found at: https://portal.ct.gov/deep/open-space/open-space-and-watershed-land-acquisition-grant-program.
- Connecticut Department of Energy and Environmental Protection (DEEP) Nonpoint Source Management Grant Program – provides grants for the prevention, control and/or abatement of nonpoint source pollution. Funded under Section 319(h) of the Federal Clean Water Act. More information can be found at: https://portal.ct.gov/deep/water/nps/request-for-proposals-for-nonpoint-source-management-grant-program.
- Connecticut Department of Emergency Services and Public Protection, Division of Emergency Management and Homeland Security – provides strategic planning and grant

assistance. More information can be found at: https://portal.ct.gov/demhs/emergency-management/resources-for-officials/community-preparedness-and-grants?language=en_US.

- Connecticut Sea Grant and New York Sea Grant Sustainable and Resilient Communities (SRC) Program – The SRC Program was deployed in response to a needs assessment for communities in the Long Island Sound watershed in Connecticut and New York. The program administers grant writing assistance (applicants can use Sea Grant funds to develop applications for various resilience-related grants) and planning support. Funds are not provided to a municipality; instead, the Sea Grant program retains a consultant to assist the awarded municipality. Round 1 projects were completed near the end of 2025, and Round 2 were completed in early 2026. More information can be found online at: https://seagrant.uconn.edu/focus-areas/resilient-communities/programs/.

3.1.3. Regional Capabilities

Lower Connecticut River Valley Council of Governments (RiverCOG)

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 the state's nine Councils of Governments (COGs) as frequently as possible to prepare multi-jurisdiction hazard mitigation plans.

The Lower Connecticut River Valley Council of Governments, or RiverCOG, is one of Connecticut's nine regional Councils of Governments. In 2012, RiverCOG was created from the merger of two regional planning agencies, Connecticut River Estuary Regional Planning Agency (CRERPA) and Midstate Regional Planning Agency (MRPA) and was designated as the Metropolitan Planning Organization (MPO) for the new region.

A metropolitan planning organization (MPO) is a federally mandated and federally funded transportation policy-making organization. They were created to ensure regional cooperation in transportation planning and federal funding for transportation projects and programs are channeled through these entities. Resiliency of transportation networks from storms is an eligible use of MPO funds and should be a focus of transportation planning.

RiverCOG serves its region by:

- Allocating federal transportation funding.
- Coordinating land use decisions among member municipalities.
- Providing planning assistance to the region's municipalities.
- Acting as a forum for furthering regional cooperation and collaboration.
- Representing the region and its municipalities' interests in Hartford and Washington, D.C.

- Performing a variety of advisory review functions.

Regional Emergency Planning Team (REPT) – Regions 2, 3, and 4

The Regional Emergency Planning Team (REPT) for DEMHS Region 2, 3, and 4 operates under their established bylaws, which address their mission, membership, and procedures. The multi-jurisdictional REPTs are supported by Regional Emergency Support Functions (RESFs). These RESFs are discipline-oriented workgroups that provide collaborative planning and resource support within each discipline and act as subcommittees to whichever Region REPT the community is in. The REPT Region 2 is comprised of 30 municipalities located in the south-central portion of the State. The following are included from the Lower Connecticut River Valley (LCRV): Chester, Clinton, Deep River, Durham, Essex, Haddam, Killingworth, Middlefield, Old Saybrook, and Westbrook (Old Saybrook and Westbrook are not included in this HMP update). Region 3 is comprised of 41 municipalities located in the north central portion of the State, including the following from the LCRV: Middletown, East Haddam, East Hampton, Portland, and Cromwell. Region 4 is comprised of 42 municipalities located in the eastern portion of the State including the municipality of Old Lyme from the LCRV.

The REPT's authority derives from Connecticut General Statutes Title 28, including Conn. Gen. Stat. §§28- 1b(a)(4) and (5) and other provisions dealing with the Department of Emergency Management and Homeland Security (DEMHS). They provide guidelines that:

- Maximize the preservation of life and property,
- Correct or alleviate, as expeditiously as possible, serious disaster or emergency-related conditions which present continued threats to the health or welfare of the residents of Region 3, and
- Facilitate a return to normalcy by all practical means.

Its mission is to protect people and property in from all types of natural and man-made disasters, fostering regional collaboration and mutual aid through research, collaborative plan development, resource sharing and coordination.

Open Space Acquisition – Lower Connecticut River Land Trust

The permanent preservation of undeveloped land can help support natural hazard mitigation efforts by preventing development in areas prone to natural hazards such as floodplains and wildland/urban interfaces. The State of Connecticut has established a goal that, "State parks, forests, wildlife management areas and other state-owned conservation lands shall constitute 10 percent of Connecticut's land area." "In 2019, DEEP acquired 788 acres of land under the Recreation and Natural Heritage Trust Program, the primary vehicle for adding land to the State's system of parks, forests, wildlife areas, water access areas, and other open spaces." (Source: Council on Environmental Quality (CEQ), 2019). Over the past 10 years, the state has preserved an average of approximately 640 acres per year. The statute governing open space preservation, CGS section 23-8, divides responsibility for meeting this goal between the State (10% or 320,576 acres)

and municipalities, non-profit land conservation organizations and water utilities (11% or 352,634 acres).

The State's second goal (CEQ, 2019), regarding all conservation land states, "land conserved by towns and cities, the state, land trusts, and others shall constitute 21 percent of Connecticut's land area." The State grants helped municipalities and land trusts acquire or protect 435 acres through the Open Space and Watershed Land Acquisition Gran Program in 2019. An additional 1,070 acres were protected through DEEP's involvement in "other" conservation efforts in the state (CEQ, 2019).

RiverCOG staffs the Lower CT River Valley Land Trust, which supports the activities of the land trusts in the region. The prior Lower Connecticut River Land Trust Exchange (LTE) first met in 2009 with the intent of bringing together the land trusts of the lower Connecticut River Valley. Today, the LTE only exists as a prior informational organization and program of RiverCOG. It was replaced by the 501 c(3) Lower Connecticut River Land Trust in 2019.

As stated on the RiverCOG website,

"…[t]he Lower CT River and Coastal Region Land Trust Exchange (LTE) is an informal collaboration of 14 land trusts representing the 17 communities of its coordinating organization the Lower CT River Valley Council of Governments (LCRVCOG), formerly the CT River Estuary Regional Planning Agency and Mid State Regional Planning Agency, consecutive CT River centered regional planning organizations just merged in large part to conserve and protect the unique character and environment of the communities of the lower CT River and Coastal Region."

The Lower Connecticut River Land Trust is managed and staffed by RiverCOG. It was established in 1986 and has helped in the conservation of over 1,000 acres. It serves 18 communities, including the RiverCOG member communities.

In 2025, The Lower Connecticut River Land Trust updated its 2015 plan and completed a conservation planning tool to bring together GIS resources to assist planners with land conservation decision making.

The Connecticut Land Conservation Council can also provide advice on additional sources of funding to local land trusts for open space acquisition.

Plans of Conservation and Development

Regional planning agencies and municipalities are required by state law (Chapter 127, Section 8-35a and Chapter 126, Sec. 8-23, respectively) to update plans of conservation and development every ten years. These plans outline the policies and goals for physical and economic development of the region or municipality. Table 3-3 provides a list of the status of plans in the region. The Regional Plan of Conservation and Development (POCD) was published in 2023.

RiverCOG has assigned regional planning responsibilities to a Regional Planning Committee (RPC). The duties of the RPC include oversight and review of plans and studies, the review of municipal zoning amendments and subdivisions for intermunicipal impacts, and the development of a Regional Plan of Conservation and Development. The goal is to produce a Regional Plan that is relevant, useful, and facilitates towns working together on common issues and goals. Table 3.1.3 shows the status of the POCDs of the participating jurisdictions.

Table 3.1.3 Status of POCDs

Municipality	Date of Plan of Conservation & Development	Planning Horizon
Chester	03/14/2019	2019-2029
Clinton	12/15/2025	2025-2035
Cromwell	03/19/2024	2024-2034
Deep River	10/15/2015	2015-2025*
Durham	07/20/2016	2016-2026
East Haddam	08/27/2019	2019-2029
East Hampton	06/01/2016	2016-2026
Essex	11/12/2015	2015-2025*
Haddam	12/07/2017	2018-2028
Killingworth	08/07/2018	2018-2028
Lyme	11/12/2025	2025-2035
Middlefield	05/31/2017	2017-2027
Middletown	01/13/2021	2020-2030
Old Lyme	02/11/2021	2021-2031
Portland	03/03/2016	2016-2026*

**Update underway in 2026*

POCDs, by state law, must include climate change, sea level rise (where applicable) and reference floodplain management and hazard mitigation. Public Act 25-33 was passed into law in 2025. It specifically requires all updates of POCDs after October of 2027 to include climate resilience, including a vulnerability assessment for multi-hazards and resilience goals policies and projects.

Additionally, communities within the RiverCOG have incorporated land use, public health and safety, and infrastructure requirements (i.e. water and sewer) as part of their POCD's. For example, the Town of East Hampton has a future land use plan and associated maps, improved emergency services capacity (review of NFPA standards and guidelines), and buildable land regulations to address building in environmentally sensitive areas. The Town of Portland maintains areas of sewer

and water services to Neighborhood Conservation Areas, to promote infill development and maintains open space areas within the Town. The Town of Cromwell maintains development within sewer treatment and/or water service areas as Growth and Neighborhood Conservation Areas, maintains open space for conservation and preservation mainly along the Connecticut and Mattabassett Rivers, and updated town zoning regulations for flood plain district use restrictions (farming, recreation, public utility wire and pipe lines, storage of materials and equipment, flood protective uses and recreational or cultural events. The Town of Clinton, Old Lyme, and Essex (and all the RiverCOG communities) encourage prioritization of purchasing land in flood hazard zones to allow for more open space in these areas, and prioritizing road construction projects in order to lower the risk of flooding by raising roads and replacing inadequate bridges and culverts.

Metropolitan Planning Organization

The RiverCOG Metropolitan Planning Organization (MPO) policy board is made up of municipal, transit, and business representatives and was created and federally designated to carry out the metropolitan transportation planning process in the Lower Connecticut River Valley. Serving as the MPO, RiverCOG is responsible for ensuring that existing and future expenditures of governmental funds for transportation projects and programs are based on a continuing, cooperative, and comprehensive ("3-C") planning process. This includes the creation of regional transportation plans, such as the Metropolitan Transportation Plan (MTP). This plan includes evaluation of the transportation network on a variety of measures. It identifies current and long-term needs and identifies priority transportation projects and improvements in a fiscally constrained manner. The (MTP) defines the region's future transportation vision and outlines regional transportation funding priorities. The plan identifies how the metropolitan area will manage and operate a multi-modal transportation system, including transit, highway, bicycle, pedestrian, and accessible transportation to meet the region's economic, transportation, development, and sustainability goals. The plan includes long-range and short-range strategies based on a minimum twenty-year planning horizon and is updated every four years. The last MTP was adopted in March 2023.

Comprehensive Economic Development Strategy (CEDS)

The regional CEDS is a federally recognized economic development Plan. It is based on local engagement and regional perspective. The process of creating a CEDS is designed to build capacity for economic growth, resiliency, and prosperity in a region. It links individuals, organizations, local governments, institutions of learning, and private industry in conversation and creates consensus around regional economic goals and strategies. The plan focusses on regional business and economic resiliency and is informed by the Regional Plan of Conservation and Development and this Natural Hazards Mitigation Plan and the former GrowSMART regional economic development plan That plan notes that choosing not to build or extend new sewer service has been a major way that municipalities have been able to limit growth in the region. Its purpose is to help define a desirable and feasible pathway to economic prosperity for each town as well as the collective region.

Regional Agriculture Council (RAC)

The region has the only Regional Agriculture Council (RAC) in the state, consisting of one representative from each of the region's 17 municipalities. The RAC is an advisory body that provides guidance to municipal boards and commissions on agricultural issues.

Municipalities Emergency Notification System/Plan(s)

Many of the RiverCOG municipalities have their own emergency notification system and emergency operations plans in addition to the CT Alert system powered by Everbridge mentioned previously. Municipalities emergency operations plans may include posting emergency warnings on community website and social media, emergency generators and shelters, pro-active natural hazard emergency drills and training, posted evacuation routes, posted emergency updates on lighted sign boards, distributing proactive informational pamphlets to community describing emergency procedures, active monitoring of NOAA broadcasts and other local emergency broadcasts, and emergency funds in case of severe hazard events.

For example:

- The Town of East Haddam uses the Town website as well as social media and a lighted sign board to notify residents of approaching severe weather and provide updates to residents during storms.
- The Town of Middlefield has implemented the reverse-911 system and updates the Town website to notify residents of approaching sever weather and update residents during storm events. In addition, the Town of Middlefield follows their Emergency Operations Plan in case of any emergencies within the Town.
- The City of Middletown monitors NOAA broadcasts and other emergency broadcasts during severe storm events and will activate their emergency plan when necessary. Also, Middletown is pushing all residents to register with CT Alert and will continue to do so.
- Old Lyme follows their Emergency Operations Plan in case of any emergencies within the Town. In addition, Old Lyme has publicized the emergency hotline phone number or website for public information and support to the Town website.
- The Town of Clinton provides proactive pamphlets to families outlining emergency procedures.
- The Town of Cromwell has (as part of their Emergency Management Program) access to WEBEOC for current information and assets available for the emergency response recovery modes. The Town of Cromwell's emergency management team maintains multimedia communications and monitors NOAA broadcasts and other emergency broadcasts when conditions are right for severe weather.
- The Town of Durham and East Haddam regularly use the Town notification system and Town website to notify residents of approaching severe weather and update residents during storm events and have added a new lighted sign board as well as social media accounts for notification of events.

Regional Debris Management Planning

As this plan is being finalized, RiverCOG is undergoing a Vegetative Debris Management Planning initiative. Upon completion in 2026, the plan will include an existing conditions assessment, hazard and debris generation analysis and a regional debris management strategy. The modeling completed as part of the plan will provide useful scenario-based data for use by the region and its municipalities to complete more localized strategies and undergo siting of more formal disposal facilities.

3.1.4. Local Capabilities

Local capabilities that contribute to hazard loss reduction are addressed in the municipal annexes in Volume II of this plan.

3.2. Effectiveness of Existing Strategies, Authorities, Policies, Programs, and Resources

The communities of the RiverCOG Region have a variety of tools and resources to draw upon to prepare for and mitigate the impacts of natural hazards. Connecticut municipalities are enabled with a broad scope of government authorities and powers, including the ability to tax, establish laws, ordinances, and regulations, exercise eminent domain, provide police protection, and establish, construct, and maintain public facilities and infrastructure. The municipalities have established commissions and boards to undertake their planning, zoning, inland wetlands, development, and conservation responsibilities. These commissions and boards are supported by professional staff and/or consultants. Local communities also have either full-time or volunteer fire departments. Police services are provided by a local department in most communities; however, in smaller communities, a resident state trooper may provide police services. Most municipalities also have public works or highway departments and building inspection departments. These are addressed in the municipal annexes in Volume II of this plan.

While much has been accomplished to implement natural hazard mitigation throughout the region, because of local governments' broad range of responsibilities and financial limitations, resources may not be applied to natural hazard mitigation at a level that allows the communities to accomplish all their proposed mitigation actions within the timeframes proposed. Networks for collaboration among government agencies at the local, state and federal level, as well as with regional agencies and various organizations also have been established and are effective in supporting and supplementing the capabilities of individual communities. The ability of communities and the RiverCOG to receive state and federal grants and other assistance also improves the effectiveness of local and regional hazard mitigation efforts.

The 2021 - 2026 hazard mitigation strategy disposition tables in the 15 municipal annexes in Volume II highlight the accomplishments of the participating communities. Overall, many identified

activities in that plan have been successfully implemented with the resources outlined in this capability assessment.

3.3. Regional Mitigation Strategy Disposition

This section presents the progress made on the 2021 goals objectives and actions and establishes new goals, objectives and actions identified for the 2026-2031 planning horizon.

The strategies for which RiverCOG is responsible and their disposition are included in Table 3.3.1, along with their disposition. Its role was primarily to support and assist with various identified municipal actions. Municipal actions and their respective dispositions are included in the 15 municipal annexes in Volume II.

Table 3.3.1 Status of Mitigation Strategies and Actions from the 2021 Plan

Activity #	Activity Description	Status of Activity
1	**NFIP Community Rating System Support** Encourage member municipalities to participate in the National Flood Insurance Program's Community Rating System by hosting an information workshop.	None of the RiverCOG municipalities pursued CRS entry over the last five years. However, this activity will be carried forward in case interest emerges.
2	**Hazard Mitigation Plan Updates** Support member municipalities with subsequent updates to the regional natural hazard mitigation plan by tracking activities, cataloguing updated hazard information, and seeking additional grant funding as needed.	This activity will be carried forward to ensure that the plan and its annexes are updated if new activities emerge in response to Statewide and regional initiatives.
3	**Implementation Support** Facilitate multi-jurisdictional collaboration by hosting annual mitigation meetings and bi-annual COG updates	RiverCOG and CIRCA collaborated in summer 2022 to review each municipality's mitigation actions during local meetings. This experience was valuable and will continue.

Activity #	Activity Description	Status of Activity
4	**Stormwater Management Support** Encourage all municipalities in the region to adopt regulations that incorporate or refer to recommended practices from the most current Connecticut Stormwater Quality Manual, Connecticut Guidelines for Erosion and Sedimentation Control and, in particular, those that promote low impact development and green infrastructure techniques. This will encourage development that is in harmony with natural drainage systems	The Connecticut Stormwater Quality Manual was updated in 2024, and CT DEEP is commencing development of guidance for nature-based solutions. This activity will be carried forward to ensure that municipalities receive appropriate guidance. Activity #6 below will be merged into this activity.
5	**Educational Support** Continue to maintain and update the Regional Hazard Mitigation webpage at least annually	The web page has been continuously supported, and was updated periodically (for example, in 2022 to reflect the outcomes of activity #3 above). This activity will continue.
6	**Green Infrastructure Support** Foster improved understanding of the importance of stream management, maintenance of natural drainage channels, and use of green infrastructure practices among municipal staff, inland wetlands commissions, and planning and zoning commissions through education.	This activity will be merged into activity #4 above.
7	**Mitigation Implementation Support** Annually notify communities of the opportunities to apply for mitigation funds under the PDM and FMA programs and notify communities of HMGP opportunities as applicable. Provide letters of support when appropriate.	Notifications have been provided when grant programs have been made available by DEMHS. This activity will continue.

Activity #	Activity Description	Status of Activity
8	**Critical Facility Support** Encourage the installation of generators at critical facilities and in developments serving the elderly or special need populations, or development of microgrids to serve the same purpose, through outreach and associated work with local officials to determine which facilities still do not possess standby power but require it.	RiverCOG municipalities have made progress with standby power installations, and individual annexes include actions for remaining needs. This activity will be merged into a new activity related to the Public Act 25-33 (the Climate Bill).
9	**Professional Development Support** Investigate the possibility of holding the CFM exam and CFM courses on an annual basis for interested persons.	The CFM exam process has changed significantly since 2021. The resources and the exam are available as online/virtual experiences. Furthermore, CAFM offers events, webinars, and an annual conference. This activity can be retired.
10	**Water Conservation Support** Assist municipalities that do not currently have drought ordinances in enacting such ordinances to enable the enforcement of water conservation and assist with messaging and notifications regarding droughts. These actions should be consistent with guidance resulting from implementation of the State Water Plan (2018) and the Coordinated Water System Plan (2018) as well as the updated Connecticut Drought Preparedness and Response Plan.	The State's Interagency Drought Workgroup has advanced considerably in its capabilities over the last five years, and these resources are available from the Water Planning Council with the Workgroup's assistance. This activity can be retired.

Activity #	Activity Description	Status of Activity
11	**Tree Hazard and Invasive Aquatic Plant Support** Reduce and prevent the potential damage caused by extremely invasive pests and plants and disease whose invasive nature results in potential damage from trees and water features to public utility, transportation, and natural or manmade flood storage capacity by coordinating with CT DEEP, the Connecticut Agricultural Experiment Station, University of CT, and federal agencies such as US Fish and Wildlife, the Army Corp of Engineers, Natural Resource Conservation Service, and the Environmental Protection Agency among others. Promote, assist, and carry out educational and outreach initiatives to slow the spread of these insects and plants. RiverCOG will support regional collaboration on such initiatives by disseminating information provided by CT DEEP, CAES, and federal agencies and NGOs to local municipalities or other regional partners and participate in monitoring and surveying programs especially for the hyper invasive aquatic plants Trapa natans (water chestnut), Hydrilla, Emerald Ash Borer, Gypsy Moth, and the Asian Longhorned Beetle among other potential future invasive threats.	Tree hazards, terrestrial invasive species, aquatic invasive species, and tree pests have been given enhanced attention in the 2026 edition of the hazard mitigation plan. The hazards have been included in the municipal annexes, and each municipality has elected to include specific actions related to terrestrial invasive species, aquatic invasive species, and/or tree pests. Therefore, this regional action can be retired.
12	**Plan Integration** Incorporate additional natural hazard mitigation concerns into the Regional Plan of Conservation and Development if it is updated in 2020-2025 and provide specific instructions to municipalities to address natural hazard mitigation in local Plans of Conservation and Development as they are updated.	Public Act 25-233 (the Climate Bill) includes numerous provisions for RPOCDs and POCDs adopted in (or later than) 2027. This activity will be merged into a new activity related to the Climate Bill.

Activity #	Activity Description	Status of Activity
13	**Protect Historic and Cultural Resources** RiverCOG and its member municipalities will endeavor to coordinate efforts with the Connecticut State Historic Preservation Office (CT SHPO) to increase the resilience of historic and cultural resources to natural hazards and climate change. These efforts will leverage and build upon the SHPO's ongoing initiatives to support the identification of vulnerable historic resources and preparation of resiliency plans for municipalities across the state. Specifically, this action will focus on incorporating the SHPO provided historic and cultural resource resilience analysis into planning documents and updated historic preservation ordinances	Individual RiverCOG municipalities have utilized the SHPO resources for planning. For example, the SHPO GIS mapping was used for the Clinton POCD (adopted December 2025); and the Towns of Chester, Deep River, and Essex utilized the SHPO GIS data to characterize flood risks to historic and cultural resources while developing a climate vulnerability assessment (completed in June 2026). This activity will be carried forward with a focus on POCD updates and resilience planning.

Activity #	Activity Description	Status of Activity
14	**Education and Awareness of Small Businesses** Coordinate with CT DEEP and local chambers of commerce to promote natural hazard risk awareness and risk reduction practices. This specifically includes but is not limited to implementing an educational program for small businesses with recommendations to eliminate/reduce toxic chemicals on-site when possible and/or use best management practices (BMPs) to prevent pollution from chemicals getting out into the environment. In coordination with CT DEEP, RiverCOG and participating jurisdictions will help disseminate information (as developed by DEEP) to increase the awareness of small businesses of any chemical/toxic products they use, store, and/or sell; and to use BMPs to decrease the risks associated with chemical releases into the environment during natural hazard events. For example, municipalities may provide such information on their website, through social media, with a brochure/poster, or workshop.	Some progress has been made relative to the specifics of this activity. This will be merged into a new activity about business recovery and resiliency.
15	**Apply CT "Official" Sea Level Rise Projections or Better Available Data** For future hazard mitigation plan updates, resiliency planning efforts, and plans of conservation and development, use the sea level rise projections created by DEEP and CIRCA, under PA 18-82, as best available data	The Connecticut planning threshold ("projection") was used in POCDs developed over the last five years (e.g., Clinton). The threshold was renewed in 2025 and will continue to be used. This activity will be merged into a new activity related to the Climate Bill.
16	**Support Municipalities to Become Sustainable CT Certified** Provide outreach materials and one annual training and technical assistance to municipalities wishing to join this initiative	The Sustainable CT program has reached saturation in Connecticut, and municipalities are individually managing their certifications. This activity can be retired.

Activity #	Activity Description	Status of Activity
17	**State Building Code Update (10/1/18)** RiverCOG provide support to communities to update floodplain management ordinances/regulations, using DEEP's Model Regulations, to incorporate language from the new state building code addressing floodplain management.	State Building Code updates are anticipated in the next few years. This activity will be carried forward.
18	**RiverCOG Flood Susceptibility Model** For future hazard mitigation plan updates, resiliency planning efforts, and plans of conservation and development, use the susceptibility model flood layer to supplement other flood layers for hazard analysis. Field check the validity of the layer.	The Towns of Chester, Deep River, and Essex utilized the Flood Susceptibility Model outcomes (i.e., the mapping) to characterize flood risks to critical facilities, regional assets, and historic and cultural resources for the climate vulnerability assessment referenced above. This activity will be merged into a new activity related to the Climate Bill.
19	**Debris Management Planning** Assist local municipalities in debris management planning	Municipalities have made significant progress in this effort. RiverCOG is continuing to provide support in this area, and the activity will be carried forward.

3.4. Setting Mitigation Goals and Objectives

At the May 28, 2025 Regional Planning Committee kickoff meeting, the goals from the 2021 plan were discussed and trends identified. Back in 2021, the Committee agreed to develop one simplified set of regional Goals and associated Objectives. Three goals, each with their own respective objectives, were developed and centered around 1) future development through policy, planning, regulation emergency services and the environment, 2) physical mitigation projects, and 3) the people component (e.g. outreach education integration and research). At this meeting, a consensus was reached to carry forward the 2021 goals and objectives as still relevant and addressing the region's priorities.

At the first series of 15 Local Planning Team meetings held in June of 2025, each Team was afforded the opportunity to review the goals and objectives and modify them to differentiate any unique needs in its community that may have been missed. Most communities kept the goals and objectives identified at the regional level. Each municipal annex in Volume II includes discussion of

these goals and objectives at the community level. The three regional goals and objectives are as follows:

- Goal 1: Promote implementation of sound flood management and other natural hazard mitigation principles on a regional and local level. Note: Covers future development through policy, planning, regulation, emergency services, and environmental strategies.
    - Objective for Goal 1: To promote the development, improvement and implementation of programs, policies, regulations and emergency services that result in the reduction of long-term risks to life and property.
- Goal 2: Implementation of effective natural hazard mitigation projects at the regional and local level. Note: Covers infrastructure and building related projects – the existing built environment.
    - Objective for Goal 2: To enhance the ability of RiverCOG, other 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, planning and outreach activities for the mitigation of natural hazards on a regional and local level. Note: Covers the people component of mitigation via outreach and education, and integration with other planning and continuous improvement through increased research.
    - Objective for Goal 3: To increase general awareness of the region's natural hazards and encourage State agencies, local communities, and the public to be proactive in taking actions to reduce long-term risk to life and property

3.5. Prioritization of Mitigation Actions

As a non-regulatory organization designed to provide planning assistance to its municipal members, RiverCOG focused on projects and initiatives that would benefit from a regional approach. Support actions were developed specifically for RiverCOG on its own, and actions that the communities would "buy-in" to and complete in coordination with RiverCOG. In considering which projects, processes, and other measures to undertake in the upcoming plan period, municipal and regional officials evaluated the need to address problems and vulnerabilities in their communities against the communities' resources and capabilities.

To prioritize mitigation strategies, a set of criteria commonly used by public administration officials and planners was applied to each proposed strategy. The method, called STAPLEE, is outlined in FEMA planning documents such as Developing the Mitigation Plan (FEMA 386-3) and Using Benefit-Cost Review in Mitigation Planning (FEMA 386-5). STAPLEE stands for the "Social, Technical, Administrative, Political, Legal, Economic, and Environmental" criteria for making planning decisions. Benefit-cost review was emphasized in the prioritization process. Criteria were divided into potential benefits (pros) and potential costs (cons) for each mitigation strategy. The following questions were asked about the proposed mitigation strategies:

- **Social:**
  - Benefits: Is the proposed strategy socially acceptable to the community?
  - Costs: Are there any equity issues involved that would mean that one segment of the community could be treated unfairly? Will the action disrupt established neighborhoods, break up voting districts, or cause the relocation of lower-income people? Is the action compatible with present and future community values?
- **Technical:**
  - Benefits: Will the proposed strategy work? Will it reduce losses in the long term with minimal secondary impacts?
  - Costs: Is the action technically feasible? Will it create more problems than it will solve? Does it solve the problem or only a symptom?
- **Administrative:**
  - Benefits: Does the project make it easier for the community to administrate future mitigation or emergency response actions?
  - Costs: Does the community have the capability (staff, technical experts, and/or funding) to implement the action, or can it be readily obtained? Can the community perform the necessary maintenance? Can the project be accomplished in a timely manner?
- **Political:**
  - Benefits: Is the strategy politically beneficial? Is there public support both to implement and maintain the project? Is there a local champion willing to see the project to completion? Can the mitigation objectives be accomplished at the lowest cost to the community (grants, etc.)?
  - Costs: Have political leaders participated in the planning process? Do project stakeholders support the project enough to ensure success? Have the stakeholders been offered the opportunity to participate in the planning process?
- **Legal:**
  - Benefits: Is there a technical, scientific, or legal basis for the mitigation action? Are the proper laws, ordinances, and resolutions in place to implement the action?
  - Costs: Does the community have the authority to implement the proposed action? Are there any potential legal consequences? Will the community be liable for the actions or support of actions or for lack of action? Is the action likely to be challenged by stakeholders who may be negatively affected?
- **Economics:**
  - Benefits: Are there currently sources of funds that can be used to implement the action? What benefits will the action provide? Does the action contribute to community goals such as capital improvements or economic development?
  - Costs: Does the cost seem reasonable for the size of the problem and the likely benefits? What burden will be placed on the tax base or local economy to implement

this action? What proposed actions should be considered but be tabled for implementation until outside sources of funding are available?

- **Environmental:**
  - Benefits: Does the proposed action protect, restore, or enhance natural resources such as wetlands, forests, floodplains, or habitats? Will it reduce erosion, sedimentation, invasive species, or pollution of air and water? Does the project support long-term environmental resilience, climate adaptation, and carbon reduction goals? Could it improve ecosystem services that benefit the community, such as water filtration, stormwater absorption, or biodiversity?
  - Costs: Could the action negatively impact sensitive environments, threatened or endangered species, or designated conservation areas? Will construction or maintenance cause habitat fragmentation, noise, or air quality degradation or facilitate the introduction or spread of non-native invasive species (e.g., through soil disturbance, contaminated equipment, imported fill, or landscaping materials)? Does the project require permits or mitigation for potential environmental impacts under state or federal law (e.g., CT DEEP, USACE, or EPA)? Are there opportunities to offset or minimize environmental harm through design changes, green infrastructure, or sustainable materials?

Each proposed mitigation strategy presented in this plan was evaluated and quantitatively assigned a "benefit" score and a "cost" score for each of the seven STAPLEE criteria as outlined below:

- For potential benefits, a score of "1" was assigned if the project will have a beneficial effect for that criterion or a "0" if the project would have a negligible effect or if the questions were not applicable to the strategy.
- For potential costs, a score of "-1" was assigned if the project would have an unfavorable impact for that criterion or a "0" if the project would have a negligible impact or if the questions were not applicable to the strategy.
- Technical and Economic criteria were double-weighted (multiplied by two) in the final sum of scores.
- The total benefit score and cost score for each mitigation strategy was summed to determine each strategy's final STAPLEE score.

Although a community may implement recommendations as prioritized by the STAPLEE method, additional consideration is important for those recommendations that may be funded under the FEMA mitigation grant programs. To receive federal funding, the mitigation action must have a benefit-cost ratio (BCR) that exceeds a value of 1.0. Calculation of the BCR is conducted using FEMA's Benefit Cost Analysis (BCA) toolkit. The calculation method may be complex and vary with the mitigation action of interest. Calculations are dependent on detailed information such as property value appraisals, design and construction costs for structural projects, and tabulations of previous damages or NFIP claims. The BCR scoring system used is outlined in Table 3.5.1.

Table 3.5.1 BCR Scoring System

Scoring	Benefits	Costs
Low: 0-1 points	Few would benefit; the impacts being addressed are not severe; benefits may be short-term.	Likely to be done by existing personnel with little impact on budget; not complicated to accomplish. Costs to implement are likely to be under $10,000.
Medium: 2-3 points	Benefits may be felt by many in the community; the action may solve a problem or otherwise benefit the community for several years.	May need additional funding or studies; may require changes in practices; costs to implement may be between $10,000 and $100,000.
High: 4-5 points	Benefits would accrue to many in the community; benefits may accrue to the most vulnerable or those not able to recover on their own; benefits would be long term and may permanently protect from damages.	Likely to cost over $100,000 and require obtaining funding outside of operating budget; complicated, lengthy process to implement.

The STAPLEE method accounts for cost-benefit considerations both directly (through the "Economic" category) and indirectly (through general consideration of costs and benefits of actions). Additionally, the range of estimated costs of each strategy are included in the STAPLEE table. The assumed costs of projects and generalized presentation of the benefits accruing from them are not based on specific detailed cost estimates as that level of analysis is not appropriate for this type of planning effort. For some projects, such as routine or recurring operations that are established practices and conducted with municipal general operating funds and existing staff, the STAPLEE results can be the only explicit comparison of costs and benefits. For projects for which bonding and/or grant funding will be sought, more in-depth evaluations of costs and benefits will be required. As project scopes are detailed, benefits and costs can be identified with more precision, and the benefit-cost ratio which results from a full benefit-cost analysis may differ from the planning-level STAPLEE results presented here.

Higher BCRs do not necessarily correspond to high priorities, nor do low BCRs or BCRs under 1.0 correspond to low-priority projects. An important project with a high priority to the community may have a lower BCR because of its complexity, assumed high expense, and other costs. Communities should not be discouraged or deterred from further consideration of projects that have low BCRs or BCRs less than 1.0 until additional, more specific evaluations of the costs and benefits have been undertaken.

Many of these review criteria are simplified for the regional portion of the mitigation strategy since projects are primarily support functions.

3.6. 2026 - 2031 Prioritized Regional Hazard Mitigation Actions

RiverCOG and the Regional Planning Committee identified or carried over from the last update, ranked and evaluated the actions in Table 3.6.1. For each identified action, the goal and objective it addresses is noted. Additionally, a description, lead agency, indication of costs and potential funding sources and estimated timeline for completion is included. Also included are the hazards addressed by a specific action.

Table 3.6.1 RiverCOG and the Regional Planning Committee Activities Identified

Activity #	Goal/Objective	Activity Description	Lead Agency	Est. Cost*	Potential Funding Sources	Timeframe for Completion	Hazard(s) Addressed	Weighted STAPLEE Criteria														Total STAPLEE Score/ Priority
								Social Benefit	Social Cost	Technical Benefit	Technical Cost	Administrative Benefit	Administrative Cost	Political Benefit	Political Cost	Legal Benefit	Legal Cost	Economic Benefit	Economic Cost	Environmental Benefit	Environmental Cost	
1	1-1, 3-1	**NFIP Community Rating System Support** Encourage member municipalities to participate in the National Flood Insurance Program's Community Rating System by hosting an information workshop.	RiverCOG	$0-$1,000	Staff Time	10/27, 10/28, 10/29, and 10/30	F	1	0	0	0	1	1	1	0	0	0	1	1	1	0	3/Low
2	1-1	**Hazard Mitigation Plan Updates** Support municipalities with updates or amendments (which are allowed per resolutions) to the hazard mitigation plan annexes by tracking activities, cataloguing updated hazard information, and seeking additional grant funding as needed.	RiverCOG	$2,000-$5,000	Staff Time	10/27, 10/28, 10/29, and 10/30	All	1	0	1	0	1	0	0	0	0	0	1	0	1	0	7/High
3	1-1	**Hazard Mitigation Plan Implementation Support** Facilitate multi-jurisdictional collaboration by hosting annual mitigation meetings and bi-annual COG-level updates.	RiverCOG	$2,000-$5,000	Staff Time	10/27, 10/28, 10/29, and 10/30	All	1	0	1	0	1	0	1	0	0	0	1	0	1	0	8/High
4	1-1,2-1	**Hazard Mitigation Action Implementation Support** Notify communities of the opportunities to apply for mitigation funds under all applicable Hazard Mitigation Assistance (HMA) programs.	RiverCOG and DEMHS	$0-$1000	Staff Time	2027-2030, per DEMHS schedule	All	1	0	1	0	1	0	1	0	0	0	1	0	1	0	8/High

Activity #	Goal/Objective	Activity Description	Lead Agency	Est. Cost*	Potential Funding Sources	Timeframe for Completion	Hazard (s) Addressed	Weighted STAPLEE Criteria														Total STAPLEE Score/ Priority
								Social Benefit	Social Cost	Technical Benefit	Technical Cost	Administrative Benefit	Administrative Cost	Political Benefit	Political Cost	Legal Benefit	Legal Cost	Economic Benefit	Economic Cost	Environmental Benefit	Environmental Cost	
		Provide letters of support when appropriate.																				
5	3-1	**Hazard Mitigation Educational Support** Continue to maintain and update the Regional Hazard Mitigation webpage at least annually; upload items of interest related to hazard mitigation.	RiverCOG	$0-$1000	Staff Time	2026-2031	All	1	0	1	0	1	0	0	0	0	0	0	0	1	0	5/Med
6	1-1, 2-1	**Stormwater Management Support, Low Impact Development, and Green Infrastructure** Encourage municipalities in the region to adopt regulations that incorporate or refer to recommended practices from the Connecticut Stormwater Quality Manual (2024), Connecticut Guidelines for Erosion and Sedimentation Control and, in particular, those that promote low impact development and green infrastructure techniques. Foster improved understanding of the importance of stream management, maintenance of natural drainage channels, and use of green infrastructure practices among municipal staff, inland wetlands commissions, and planning and	RiverCOG and DEEP	$2,000-$5,000	Staff Time	2027-2031	F	1	0	1	0	1	0	0	0	1	0	0	0	1	0	6/High

Activity #	Goal/Objective	Activity Description	Lead Agency	Est. Cost*	Potential Funding Sources	Timeframe for Completion	Hazard (s) Addressed	Weighted STAPLEE Criteria														Total STAPLEE Score/ Priority
								Social Benefit	Social Cost	Technical Benefit	Technical Cost	Administrative Benefit	Administrative Cost	Political Benefit	Political Cost	Legal Benefit	Legal Cost	Economic Benefit	Economic Cost	Environmental Benefit	Environmental Cost	
		zoning commissions through education.																				
7	1-1, 2-1, 3-1	**Protect Historic and Cultural Resources** RiverCOG will routinely provide guidance to municipalities to incorporate SHPO GIS data (visible historic and cultural resources) into POCDs, resilience plans, and other planning documents.	RiverCOG and SHPO	$2,000-$5,000	Staff Time	2027-2031	All	0	0	1	0	0	0	1	0	0	0	1	0	0	0	5/Med
8	1-1, 3-1	**Businesses Recovery and Resiliency Plan** The Comprehensive Economic Development Strategy (2023) helps advance business resiliency and recovery. RiverCOG will assist with aspects of the Strategy implementation to advance business resiliency.	RiverCOG	$2,000-$5,000	Staff Time	2027-2028	All	1	0	1	0	1	1	1	0	0	0	1	0	1	0	7/High
9	2-1	**State Building Code Update** Provide support to communities to update floodplain management ordinances and regulations using DEEP's Model Regulations, which routinely incorporate language from updates to the State Building Code's flood damage prevention section.	RiverCOG and DEEP	$2,000-$5,000	Staff Time	2027-2031	F	1	0	1	0	1	0	0	0	1	0	1	0	1	0	8/High
10	1-1, 3-1	**Debris Management Planning**	RiverCOG	$50,000-$100,000	Staff Time,	2026-2027	All	1	0	1	0	1	0	1	0	0	0	0	1	1	0	4/Med

Activity #	Goal/Objective	Activity Description	Lead Agency	Est. Cost*	Potential Funding Sources	Timeframe for Completion	Hazard (s) Addressed	Weighted STAPLEE Criteria														Total STAPLEE Score/ Priority
								Social Benefit	Social Cost	Technical Benefit	Technical Cost	Administrative Benefit	Administrative Cost	Political Benefit	Political Cost	Legal Benefit	Legal Cost	Economic Benefit	Economic Cost	Environmental Benefit	Environmental Cost	
		Use the results of the currently ongoing Debris Management Planning initiative to educate and provide technical assistance to local municipalities in debris management planning and potential facility siting.			OPM, DEMHS																	
11	1-1	**Climate Bill Support** The Climate Bill (Public Act 25-33) requires robust utilization of climate-related hazard information in the RPOCD and municipal POCDs; data collection and GIS data management related to stream crossings (culverts and bridges); and other activities. COGs are given specific duties in the Bill. RiverCOG will assist over the next five years to convey information between the municipalities and the State, review POCDs for consistency with Public Act 25-33, and provide general support. Additionally, RiverCOG will help evaluate where Resiliency Improvement Districts (RIDs) may be feasible or effective in its municipalities. As a subset of RID-related planning, microgrid and standby power deployment will be supported by RiverCOG in municipal planning (POCDs, LEOPs, and resilience plans).	RiverCOG, DEEP, and OPM	$200,000 - $500,000	Staff Time, OPM, DEEP	2026-2031	All	1	0	1	0	1	1	1	0	1	0	1	1	1	0	6/High

Activity #	Goal/Objective	Activity Description	Lead Agency	Est. Cost*	Potential Funding Sources	Timeframe for Completion	Hazard(s) Addressed	Weighted STAPLEE Criteria														Total STAPLEE Score/ Priority
								Social Benefit	Social Cost	Technical Benefit	Technical Cost	Administrative Benefit	Administrative Cost	Political Benefit	Political Cost	Legal Benefit	Legal Cost	Economic Benefit	Economic Cost	Environmental Benefit	Environmental Cost	
12	3-1	**Pluvial Flood Hazard Modeling** Pluvial flood analysis can demonstrate where stormwater-related flood risks are present, whether inside or outside of FEMA-delineated areas of flood risk. RiverCOG may be able to assist in advancing funding to conduct such analysis for the region.	RiverCOG	$200,000 - $500,000	Staff Time, OPM	2029-2030	F	1	0	1	0	1	1	1	0	0	0	0	1	1	0	3/Low
13	1-1, 3-1	**Transportation Resilience Planning** PROTECT funds from USDOT are contingent on developing a transportation resilience improvement plan. RiverCOG may be able to assist in developing a transportation resilience improvement plan for the region.	RiverCOG and USDOT	$200,000 - $500,000	Staff Time, PROTECT	2027-2029	F	1	0	1	0	1	1	1	0	1	0	1	1	1	0	6/High
14	2-1, 3-1	**DEEP Climate Resilience Fund (DCRF)** The DCRF is expected to continue in future cycles. RiverCOG may assist with grant writing support or by serving as an applicant for groups of member municipalities.	RiverCOG and DEEP	$50,000-$100,000	CT Sea Grant SRC, DCRF	2027-2031	All	1	0	1	0	1	1	1	0	0	0	1	0	1	0	7/High

4. Plan Maintenance, Evaluation, and Update Process

4.1. Overview

A hazard mitigation plan must present a plan maintenance process that includes the following (44 CFR Section 201.6.c.4):

- A section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan over a 5-year cycle
- A process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms, such as comprehensive or capital improvement plans, when appropriate
- A discussion on how the community will continue public participation in the plan maintenance process.

This section details the formal process that will ensure that the RiverCOG Multi-Jurisdictional Hazard Mitigation Plan remains an active and relevant document and that the planning partners maintain their eligibility for applicable funding sources.

The plan maintenance process includes a schedule for monitoring and evaluating the plan annually and producing an updated plan every five years. This section also describes how public participation will be integrated throughout the plan maintenance and implementation process. It also explains how the mitigation strategies outlined in this Plan will be incorporated into existing planning mechanisms and programs, such as Plans of Conservation and Development planning processes, capital improvement planning, and building code enforcement and implementation. The Plan's format allows sections to be reviewed and updated when new data becomes available, resulting in a plan that will remain current and relevant.

4.2. Plan Implementation

The effectiveness of the hazard mitigation plan depends on its implementation and incorporation of its action items into partner jurisdictions' existing plans, policies, and programs. Together, the action items in the Plan provide a framework for activities that the Partnership can implement over the next five years. The planning team and the steering committee have established and recommitted to the goals and objectives and have prioritized mitigation actions that will be implemented through existing plans, policies, and programs.

RiverCOG, through the Regional Planning Committee, will have the lead responsibility of overseeing the plan implementation and maintenance strategy. Plan implementation and evaluation will be a shared responsibility among this group and the Local Planning Teams, each of which has an identified lead. (see municipal annexes in Volume II of this plan).

4.3. Regional Hazard Mitigation Planning Committee

The Regional Planning Committee is the body that oversaw the development of the Plan update and made recommendations on key elements of the plan, including the maintenance strategy. It was comprised primarily by representatives of RiverCOG and all participating jurisdictions. As determined in the previous NHMP Update cycle, the committees will stay in place and have an active role in the plan maintenance strategy. Therefore, it is recommended that the committee remain a viable body involved in key elements of the Plan maintenance strategy. With this planning cycle, the committee will strive to include full representation from all jurisdictions, as well as other stakeholders in the planning area.

The principal role of the committee in the plan maintenance strategy will be to review the annual progress report and provide input to RiverCOG and the Local Planning Teams on possible enhancements to be considered at the next update. Future plan updates will be overseen by a committee similar to the one that participated in this plan update process, so keeping a Regional Planning Committee intact will provide a head start on future updates. Completion of the progress report is the responsibility of each planning partner, not the responsibility of the committee. It will simply be the committee's role to review the progress report to identify issues needing to be addressed by future plan updates.

4.4. Annual Progress Report

The minimum task of each LPT will be the evaluation of the progress of its individual action plan during a 12-month performance period. These updates were not completed consistently through the planning cycle beginning in 2021, although good progress with mitigation actions was made by each community. The LPTs have renewed their commitment to the reports during this plan update process. This review will include the following:

- Summary of any hazard events that occurred during the performance period and the impact these events had on the planning area
- Review of mitigation success stories
- Review of continuing public involvement
- Brief discussion about why targeted strategies were not completed
- Re-evaluation of the action plan to determine if the timeline for identified projects needs to be amended (such as changing a long-term project to a short-term one because of new funding)
- Recommendations for new projects
- Changes in or potential for new funding options (grant opportunities)
- Impact of any other planning programs or initiatives that involve hazard mitigation

RiverCOG will assume the responsibility of initiating the annual progress reporting process. A template to guide the planning partners in preparing a progress report will be created and will be

used for this cycle. RiverCOG will then prepare a formal annual report on the progress of the plan. This report should be used as follows:

- Posted on the RiverCOG Mitigation Planning web page
- Presented to LPT governing bodies to inform them of the progress of actions implemented during the reporting period

Uses of the progress report will be at the discretion of each LPT. Annual progress reporting is not a requirement specified under 44 CFR. However, it may enhance the planning partnership's opportunities for funding. While failure to implement this component of the plan maintenance strategy will not jeopardize a planning partner's compliance under the DMA, it may jeopardize its opportunity to partner and leverage funding opportunities with the other partners. Each planning partner was informed of these protocols at the beginning of this plan update.

4.5. Plan Update

44 CFR requires that local hazard mitigation plans be reviewed, revised if appropriate, and resubmitted for approval in order to remain eligible for benefits under the DMA (Section 201.6.d.3). This is the third five-year plan update, and the second multi-jurisdictional plan for the entire region. The RiverCOG partnership intends to continue to update the hazard mitigation plan on a 5-year cycle from the date of adoption of this plan update. This cycle may be accelerated to fewer than 5 years based on the following triggers:

- A Presidential Disaster Declaration that impacts the planning area
- A hazard event that causes loss of life
- A comprehensive update of the region or participating jurisdiction's Plan of Conservation and Development
- Newly identified priorities and projects need to be added

It will not be the intent of future updates to develop a completely new hazard mitigation plan for the planning area. The update will, at a minimum, include the following elements:

- The update process will be convened through the Regional NHMP Planning Committee consisting of the municipal CEOs.
- The hazard risk assessment will be reviewed and, if necessary, updated using the best available information and methodologies.
- The action plans will be reviewed and revised to account for any initiatives completed, dropped, or changed and to account for changes in the risk assessment or new partnership policies identified under other planning mechanisms (such as the comprehensive plan).
- The draft update will be sent to appropriate agencies and organizations for comment.
- The public will be given an opportunity to comment on the update prior to adoption.
- The partnership governing bodies will adopt their respective portions of the updated plan.

4.6. Continuing Public Involvement

The public will continue to be apprised of the plan's progress through the RiverCOG website and social media and by providing copies of annual progress reports to the media, as appropriate. Each community will provide links to the plan on their individual jurisdictional websites to increase avenues of public access to the plan. RiverCOG has agreed to maintain the natural hazard mitigation plan website. This site will not only house the final updated plan, but it will also become the one-stop shop for information regarding the plan, the partnership, and plan implementation. Upon initiation of future update processes, a new public involvement strategy will be initiated based on guidance from the committee. This strategy will be based on the needs and capabilities of the planning partnership at the time of the update. At a minimum, this strategy will include the use of local media outlets within the planning area, as was done for this update.

4.7. Incorporation Into Other Planning Mechanisms

The information on hazard, risk, vulnerability, and mitigation contained in this plan update is based on the best data and methodologies available at the time this plan was prepared, within the limits of scope and budget constraints. The RiverCOG Plan of Conservation and Development (POCD) was updated in 2023. The POCDs of the participating jurisdictions are in various stages of the required 10-year update cycle. The regional POCD will have an emphasis on climate resilience and will incorporate portions of this plan. Public Act 25-33 has strengthened required inclusion of a multi-hazard vulnerability assessment and associated resilience actions. The act specifically sites integration and synchronization with local hazard mitigation plans, ensuring, by statute, plan integration. The Act takes effect during this planning cycle. The RiverCOG and participating jurisdictions, through adoption of POCDs and zoning regulations, have planned for the impact of natural hazards. The plan development process provided the region and the communities with the opportunity to review and expand on policies contained within these planning mechanisms. Mitigation actions at the regional level and in each of the municipal annexes include plan integration. Some of the documents identified for integration with hazard mitigation planning include:

- Plans of Conservation and Development
- Floodplain Zoning
- Stormwater Management Plans and Regulations
- Historic Preservation Ordinances
- Capital Improvement Plans

Continued integration with the regional Comprehensive Climate Action Plan (CCAP) is also anticipated. Some action items do not need to be implemented through plans and regulation. Instead, these items can be implemented through the creation of new educational programs, continued interagency coordination, or improved public participation. As information becomes

available from other planning mechanisms that can enhance this plan, that information will be incorporated via the update process.

5. Plan Adoption and Approval

Section 201.6.c.5 of 44 CFR requires documentation that a hazard mitigation plan has been formally adopted by the governing body of the jurisdiction requesting federal approval of the plan. For multi-jurisdictional plans, each jurisdiction requesting approval must document that it has been formally adopted. This plan update will be submitted for a pre-adoption review to the CT DESPP/DEMHS and FEMA prior to adoption. Once pre-adoption approval has been provided, all planning partners will formally adopt the plan. All partners understand that DMA compliance and its benefits cannot be achieved until the plan is adopted. Copies of the resolutions adopting this updated plan for all planning partners can be found in Appendix D.

RiverCOG and 15 of its 17 member jurisdictions participated actively in the planning process and will formally adopt this plan by resolution of their governing boards.

The full adoption process will take several months, as significant coordination by the LPTs with their governing bodies is required to:

1. Place the plan review and adoption on the appropriate meeting agendas in each jurisdiction;
2. Advertise the meetings and provide copies or summaries in the Boards'/Councils' adoption meeting packets;
3. Facilitate the actual adoption;
4. Collect the adoption resolutions; and
5. Incorporate the adopted resolutions into the final hazard mitigation plan

5.1. Documentation of Adoption

Signed adoption resolutions for the fifteen participating communities and the RiverCOG are included in Appendix D.

5.2. Plan Approval Letter

FEMA final approval documentation is included in Appendix D.