

Municipal Resilience Planning Assistance Final Report

Prepared for the Department of Housing: Community Development Block Grant

Connecticut Institute for Resilience and Climate Adaptation
November, 2019

Project Summary

The “Municipal Resilience Planning Assistance Project” combined science, policy, and planning at the state and local levels to address the resilience of vulnerable communities along Connecticut’s coast and inland waterways to the growing impacts of climate change. The purpose of this project was to develop tools that help municipalities assess vulnerable infrastructure to inundation by river flow, sea level rise, and storm surge in the next 25-50 years. This work was made possible through a Municipal Resilience Planning Assistance grant from the State of Connecticut Department of Housing CDBG-Disaster Recovery Program and the US Department of Housing and Urban Development.

To complete the ten tasks summarized below, the Connecticut Institute for Resilience and Climate Adaptation ([CIRCA](#)) partnered with the Connecticut Department of Energy and Environmental Protection ([CT DEEP](#)), University of Connecticut faculty, the UConn Center for Land Use Education and Research ([CLEAR](#)), and [Connecticut Sea Grant](#) to develop information and tools organized under the following topics: 1) sea level rise and coastal flooding, 2) inland flooding, 3) critical infrastructure, and 4) policy and planning.

Throughout the project, a variety of workshops, webinars, and email announcements were sent to engage the public about progress and products. Results include the technical reports, policy guidance documents, case studies, and interactive map viewers described below to help the state of Connecticut with adaptation and resilience planning. All products are also available and described on the [Municipal Resilience Planning Assistance](#) website (<https://circa.uconn.edu/projects/municipal-resilience-planning/>). A brief description of the ten tasks and related products are as follows. More detailed summaries and full reports can be found in the Appendices indicated with each task.

Task 1 Summary: Tracking the Coast Using Aerial Infrared Photography (Appendix A)

Documenting the features of Connecticut’s shoreline and how those features change as a result of past and future storms helps make informed planning and investment decisions about coastal resilience and hazard mitigation. Inland aerial photography is a useful tool to monitor and assess the natural and infrastructure features of the CT shoreline. This technique results in images that make it easy to distinguish between different types of land uses and water features. Aerial photos are already used in regulatory, land use planning and resource management activities by the state’s Land and Water Resources Division (LWRD) at CT DEEP. LWRD has conducted coastal aerial photo flights at roughly five year intervals from 1974 to the most recent iteration in 2010.

Continuation of the time series in 2016 through the Municipal Resilience Planning Assistance grant is a valuable tool for continued assessment of storm impacts, planning, and land use hazard mitigation activities.

Task 1 included interpretation of 2016 coastal aerial photos to examine areas of tidal wetlands for internal water features and, through comparison with U.S. Fish & Wildlife Service National Wetlands Inventory data, digitize them within a new Geographic Information System (GIS) layer. By digitizing these internal tidal marsh features, CT DEEP derived more accurate values for the overall area of functioning tidal wetlands across the state. Quantifying areas of functioning tidal wetlands and areas of wetland loss using aerial photography and GIS supports development of resilience measures in response to coastal flooding and sea level rise.

Products from Task 1 (Appendix A) include:

- Summary Report: Tracking Connecticut’s Coast Using Aerial Infrared Photography
- [Online Enhanced Tidal Wetland Layer](#) (search for "CT Wetlands") – an inventory of data for estuarine and marine and freshwater emergent tidal wetlands compared with 2016 aerial photography, captures areas included in the NWI data that are more accurately described as a water feature, saturated, non-vegetated wetland, or stands of upland trees surrounded by wetlands.
- [2016 Aerial Infrared Photography](#) – the most recent aerial infrared photography can be found online through [UConn CTECO](#) and is an effective tool for monitoring and assessing the natural and man-made features of the Connecticut shoreline.

Task 1 Research Team:

DeAva Lambert, Peter Francis, and Kevin O’Brien - Connecticut Department of Energy and Environmental Protection

**Task 2 - Sea Level Rise Projections
(Appendix B1)**

Accurate projections of future sea level rise are critical for storm preparedness and climate change vulnerability assessment and adaptation planning in Connecticut coastal communities. The National Oceanic and Atmospheric Administration (NOAA) 2012 CPO-1 report provided guidance on the magnitude of potential changes in the global mean sea level based on analyses of both models and data. Four projections were shared so that managers could select what they judged to be appropriate. To provide more local guidance for Connecticut, CIRCA reviewed and modified the projections to include the effects of local oceanographic conditions, more recent data and models, and local land motion.

Based on research described in a full report published in 2018, [Sea Level Rise Projections for the State of Connecticut](#) (Appendix B), CIRCA recommends that Connecticut plan for the upper end of the range of values projected of SLR or up to 20 inches (50cm) of SLR higher than the national tidal datum in Long Island Sound by 2050 and that it is likely that sea level will continue to rise after that date. The Institute also recommended that the scenarios be updated at least every 10 years to incorporate the best available science and new observations.

CIRCA's report provided the basis for sea level rise projections included in Governor's Bill S.B. 7, which was introduced into the 2018 legislative session and was enacted into law as Public Act 18-82 An Act Concerning Climate Change Planning and Resiliency.

The product from Task 2/Appendix B1 includes:

- [Sea Level Rise in Connecticut Final Report](#) – this final report explains the results of four different approaches for forecasting future annual mean sea level in Long Island Sound and describes why Connecticut should plan for up to 20 inches of sea level rise higher than the national tidal datum in Long Island Sound by 2050.

Task 2 Researcher:

James O'Donnell – CIRCA Executive Director and UConn Marine Sciences Professor

Task 3 and 4 – Simulations and Validation of Riverine/Coastal Interaction during Storms (Appendix B2-B6)

The University of Connecticut has developed a simulation system for sea level variations induced by storms and has conducted tests in areas where NOAA tides gage data is available. This project has developed a coupled model that allows the combined effects of river flow and coastal surge induced flooding. The model is nested within a regional model (northwest Atlantic) of at high resolution to provide predictions in long Island Sound and its many inlets where there is complex coastal geometry. The model now has the capacity to predict the combined effects of flooding due to rivers and coastal storm surges in two different ways. We resolve the rivers and prescribe the river flow using either data from gages or results from the CREST Model (see Task 5) and can predict the joint effects. This development effort is summarized in Appendix B2. We can also use the results of the model to force simpler, volume conserving models of marsh systems that are too small to be efficiently resolved in the LIS model. An example of the approach is included in Appendix B3. We find that the model of the water level in the Sound during storms is excellent. We showed that the variation of mean sea level along the Sound is weak but that the effects of storms varies substantially. An increase in the mean sea level will increase the frequency of flooding throughout the Sound in a highly predictable way in areas near the Sound. However, in areas with tide gates and narrow channels, the change in flooding is more complex. In Appendix B3 we show how the volume of a marsh and the presence of a tide gate combine to provide effective flood protection. In such areas detailed analyses of flow pathways and rates are essential.

The effects of waves on coastal flooding has also been included in both the large domain and high resolution models. The development and testing of the Long Island Sound Wave model is summarized in Appendix B4 and B5, though the evaluation at a coastal site (Branford) is included in Appendix B3. We demonstrate that these models are useful planning tools.

The interaction of coastal surges and precipitation induced flooding is an important concern. To evaluate the probability of the combined effects of these mechanisms we report in Appendix B6 an analysis of long records of sea level and precipitation at Bridgeport, CT. We show that the mechanisms are uncorrelated, and the probability of both high rainfall and high water on the same day is very low. However, sea level rise and increased precipitation will drastically increase this likelihood and additional attention to the problem is warranted.

The products from Task 3 and 4 (Appendix B) include:

- **Appendix B2.** McCardell, G; O'Donnell, J. White Paper 2019. An Assessment of the Long Island Sound Circulation and Storm Surge Model.
- **Appendix B3.** O'Donnell, J. White Paper 2019. Wave and Storm Surge Flooding in a Small Marsh System.
- **Appendix B4.** Cifuentes-Lorenzen, A; O'Donnell, J; Howard-Strobel, K; Fake, T. White Paper 2019. Simulation and Observation of Wind Driven Waves in a Fetch-Limited Urban Estuary: Long Island Sound.
- **Appendix B5.** Ilia, A; O'Donnell, J. An Assessment of Two Models of Wave Propagation in an Estuary Protected by Breakwaters. *Journal of Marine Science and Engineering*.2018, 4, 145.
- **Appendix B6.** O'Donnell, J. White Paper 2019. Coastal Storm Surge and Precipitation in Coastal Connecticut: A Preliminary Assessment.

Task 3/4 Research Team:

James O'Donnell – CIRCA Executive Director, and UConn Marine Sciences Professor
Grant McCardell and Alejandro Cifuentes – UConn Marine Sciences Postdoc
Amin Ilia – UConn Marine Sciences PhD
Kay Howard Strobel and Todd Fake – UConn Marine Sciences Research Associates

Task 5 - Statewide Mapping Tool for Projections of Sea Level Rise and Storm Surge Inundation Impacts on Municipal Infrastructure (Appendix C)

Based on SLR projections described in Task 2, a statewide mapping tool illustrating projections of sea level rise and storm surge inundation combined with overlaid data layers indicating the location of municipal infrastructure, including municipal wastewater treatment plants and pump stations was developed. This mapping tool provides scenarios of flooding that infrastructure will experience under current and future storm and sea level rise conditions. This information will characterize the risk that Connecticut's infrastructure will experience. The mapping tool will be used to assess risk and inform vulnerability assessments (Task 7).

Products from Task 5 (Appendix C) include:

- Task 5-6 Summary and Overview
- Shen, X; Wang, D; Mao, K; Anagnostou, E. Inundation Extent Mapping by Synthetic Aperture Radar: A Review. *Remote Sensing*, 2019, 11, 879.

- Shen, X; Anagnostou, E; Allen, G.; Brakenridge, R; Kettner; A. Near-real-time non-obstructed flood inundation mapping using synthetic aperture radar. *Remote Sensing of Environment*, 2019, 221, 302-315.
- [Connecticut Sea Level Rise and Storm Surge Viewer](#) - To illustrate projected sea level rise in a public map viewer, tide gauge data from Long Island Sound was analyzed to determine the return period of various flood events and to calculate the sea level for the 100-year storm. GIS layers were then created and referenced to NAVD88 for mean higher high Water (MHHW) and the 100 Year Flood Event plus 1 foot and 20 inches of SLR to reflect Public Act 18-82. CIRCA worked with CT DEEP staff to ensure the data displayed in this new map viewer best serves the needs of municipalities. Based on consultation with DEEP staff, FEMA's Limit of Moderate Wave Action (LiMWA) line was added to the SLR viewer to enhance the map viewer's effectiveness.

Task 5 Research Team:

Emmanouil Anagnostou – UConn Department of Civil and Environmental Engineering Professor
Xinyi Shen – UConn Department of Civil and Environmental Engineering Postdoc

Task 6 - Floodplain Mapping Based for Projections of Future Precipitation Events and High Resolution Topographic Data (Appendix D)

The 2014 National Climate Assessment shows a 70% increase in heavy precipitation events over the period of 1958-2012 for the Northeast. Additionally, a 2019 report entitled, [Connecticut Physical Climate Science Assessment Report](#) projects an increase in annual precipitation with the largest increase expected in winter and spring (results in fall and summer are inconclusive) and an increase in the number of heavy rain days, increasing flood risk. Given these projections, the goal of Task 6 was to better understand the return interval of flow rates for points along CT river networks.

To produce flood frequency analysis maps for Task 6, the research team developed models for selected locations (Milford and New London) to produce synthetic flows for events in the period 1979-2016. For these locations, researchers integrated the different model simulations for selected storm events to compute the total impact from coastal and river flooding. They then provided updates on combined flood inundation simulations based on the coastal and riverine models including results of flood frequency (5 to 200 year return period daily peak flows) for the entire CT river network and created an online map viewer (described in Task 6 products below).

To convert return intervals to actual flood inundation areas, researchers need to work on a case-by-case basis to apply 2d hydraulic modeling driven by the volumetric flow rates. Using the flood frequency analysis from this study and a static culvert model, the Task 5 research team estimated overtopping risks of large number of road crossings during different flood scenarios for the Housatonic Valley Association (HVA) in Salmon Kill, Hollenbeck, Kent, Macedonia, Mill, Sandy brooks, as well as Tenmile, Seymour and Oxford. Researchers extracted the 100 year flood peaks at selected culvert sites (~500 culverts) and for each site, solved the steady state road overtopping risk based on culvert and river crossing/road characteristics provided by HVA. Products can be found on the [Planning for Flood Resilient and Fish-Friendly Road-Stream Crossings in the Southern Naugatuck Valley](#) project website. This type of analysis can be expanded to any region within CT if details of the hydraulic structures and river cross sections are

provided (e.g. Task 6 results and the hydraulic models are now being used to estimate potential risk under different storm scenarios for the Mystic River for more accurate information about flooding conditions).

Products from Task 6 (Appendix D) include:

- Hardesty, S.; Shen, X.; Nikolopoulos, E; Anagnostou, E. A Numerical Framework for Evaluating Flood Inundation Hazard under Different Dam Operation Scenarios – A Case Study in Naugatuck River. *Water*, 208, 10, 1798.
- Shen, X; Anagnostou, E. A Framework to Improve Hyper-resolution Hydrological Simulation in Snow-Affected Regions. *Journal of Hydrology*, 2017, 552, 1-12.
- [Connecticut River Flow Viewer](#) illustrates the return interval of flow rates for points along CT river networks. A google map interface is used to display locations where flow rate data exists. Users can zoom to a location of interest and click on a specific point to view a graph displaying flow rates over different return intervals. These graphs show the upper and lower boundary for return intervals of 5, 10, 50, 100, and 200 years at specific river locations. To view the data, users click on a point of interest to activate a graph of river flow rates for different storm events.
- Models used to create the Connecticut River Flow Viewer include: 1) CREST-SVAS, a distributed hydrological model to compute long-term and fine spatiotemporal resolution stream flows; and 2) hydrological-hydrodynamic (based on HEC-RAS) framework to construct synthetic hydrograph from estimated flood frequency (magnitude) and historical flood events (timing structure). HEC-RAS is a hydrodynamic software that is open source and maintained by Army Corps. More information can be found at: here <http://www.hec.usace.army.mil/software/hec-ras/>.
- A culvert model to compute overtopping risk at small road crossings.
- [Planning for Climate Resilient and Fish-Friendly Road-Stream Crossings in Connecticut's Northwest Hills, May 2018.](#)

Task 6 Research Team:

Emmanouil Anagnostou – UConn Department of Civil and Environmental Engineering Professor
Xinyi Shen – UConn Department of Civil and Environmental Engineering Postdoc

Task 7 - Municipal Infrastructure Vulnerability Assessment and Decision-Making Using a Risk-Based Approach (Appendix E)

Wastewater (WW) systems provide invaluable societal services and are critical to public and environmental health, economic vitality, and national security. Yet, they are sensitive to extreme winds, precipitation, and flooding. Past storms including Alfred, Sandy, and Irene exposed these sensitivities inflicting billions of dollars in damage to WW infrastructure in the Connecticut and across the Northeastern United States (U.S.). Changes in the economy, aging infrastructure, and an uncertain regulatory environment exacerbate these vulnerabilities as does accelerated sea level rise and more

frequent extreme precipitation expected with climate change. To lessen the impacts of current extreme events and to withstand future climate changes requires WW managers to institute adaptation actions that lessen vulnerabilities and build resilience—the capacity to prepare for, cope with, recover, and learn. While WW managers must adapt and build resilience, very little is known about what WW managers are doing, what informs, motivates, supports, or impedes those actions, and if those actions are building resilience.

The purpose of Task 7 was to understand the vulnerabilities WW systems in Connecticut face, the adaptation actions WW systems are taking, and what makes WW systems more (or less) resilient. Results from this research, including surveys and interviews, have helped inform state agency resilience building efforts in Connecticut and Rhode Island. This information has also been incorporated into the New England Interstate Water Pollution Control Commission (NEIWPC) WW Resilience Trainings and were designed to supplement the NEIWPC *Preparing for Extreme Weather at Wastewater Utilities: Strategies and Tips* guide.

A GIS analysis was also conducted by the Task 7 research team to assess the potential impact of a 100-year flood event under varying sea level rise scenarios for all wastewater treatment plants in Connecticut. The analysis considered both the extent and depth of flooding within the wastewater treatment plant site and the impact of flood waters on plant accessibility, measured using a transportation network. The percentage of the site impacted by flooding, the mean water level observed within the site, and the maximum water level observed within the site were determined for each plant. The accessibility of each wastewater treatment plant was also assessed. For all roadway segments within 0.5 mile of a wastewater treatment plant, the percentage of the road network impacted by flooding, the mean water level observed over all impacted roadway segments, and the maximum water level observed over all impacted roadway segments was determined. Table 1 in Appendix E illustrates the potential impact of a 100-year flood event under varying sea level rise scenarios with respect to the extent and depth of flooding within the site footprint.

- Without the addition of SLR, 9 of the 18 WWTP had greater than 90% of their site footprint impacted by flooding, with average water depths at each site ranging from 2.7-5.4 feet.
- With the addition of 3 feet of SLR, 13 WWTPs experienced flooding across greater than 90% of their site footprint, with average water depths increasing to a range of 2.8-8.3 feet.
- A more conservative projection of 1 foot of SLR results in 13 WWTP experiencing flooding across greater than half the site footprint with average water depths of 2.7-6.3 feet.

Tables 2 and 3 in Appendix E illustrate the potential impact of a 100-year flood event under varying sea level rise scenarios on the accessibility of a WWTP.

- Without the addition of SLR, 9 of the 18 WWTP experienced flooding at more than 50% of the *intersections* within 0.5 mile of their plant, with average water depths at nearby intersections ranging from 2.7-8.1 feet.
- or this same set of plants, 8 of the 9 WWTPs had greater than 50% of the *total roadway length* within 0.5 mile of the plant under flood waters, with average depths ranging from 2.2-7.2 feet.
- When 3 feet of SLR is factored into the analysis, 11 WWTPs experience flooding over more than 50% of the *intersections* within 0.5 mile of their plant and 12 WWTPs experience flooding over more than 50% of the *total roadway length* within 0.5 mile of the plant.

The Task 7 research team also worked with local officials in Milford, Connecticut to develop site specific sea level rise information for the Beaver Brook Wastewater Treatment Plant and produced more usable flood recurrence projections for Milford (return periods of 1, 5, 10, 25, 50, and 100 year were developed). Maps were produced for Milford showing the water depth at the plant at the Mean Higher-High Water level (MHHW), Superstorm Sandy inundation levels, 100 year flood levels, and 100 year flood plus 1 to 7 feet of sea level rise.

Results suggests that WW systems are not adapting to climate change unless there is a mandate to do so and that adaptive management together with generic and specific adaptive capacities can help systems be more resilient to a changing climate. Task 7 products identify actions that state agencies can use to encourage and support WW systems in their adaptation efforts. Moreover, the publications, guide, and GIS maps and tables provide specific strategies and data that wastewater systems and local communities can use to make their systems more resilient.

Products from Task 7 (Appendix E) include:

- Task 7 Summary: Vulnerability and Resilience of Municipal Wastewater Infrastructure
 - GIS analysis of Connecticut wastewater systems vulnerability to flooding and sea level rise (included in Task 7 Summary)
- Kirchhoff, C.J. and P.L. Watson. 2019. [Are Wastewater Systems Adapting to Climate Change?](#) Journal of the American Water Resources Association 1-12.
- Mullin, C.A. and C.J. Kirchhoff. 2018. [Marshaling Adaptive Capacities within an Adaptive Management Framework to Enhance the Resiliency of Wastewater Systems.](#) Journal of the American Water Resources Association 1-14.
- Kirchhoff, C.J., Mullin, C.A., Utemuratov, B., and Tashev, A. 2019. [White paper: Wastewater System Resilience: Learning from Connecticut Wastewater Systems.](#)
- Cifuentes, A. 2019. White Paper: Flood Recurrence Analysis for Milford, CT.

Task 7 Research Team:

Christine Kirchhoff – UConn Department of Civil and Environmental Engineering Professor
Amy Burnicki – UConn Dept of Geography Assistant Professor
Christina Mullin – UConn Department of Civil and Environmental Engineering PhD student

Task 8 Summary: Municipal Resilience Plan in CDBG-DR Eligible County Communities (Appendix F)

Task 8 was focused on a pilot study using the sea level rise map viewer developed in Task 5 and serves as a model for other towns using new mapping and resilience tools. When choosing the pilot community, consideration was given to a municipality that demonstrates significant vulnerability of their infrastructure to coastal or inland flooding, willingness to commit to integrating the maps and tools into their institutional operations and demonstrated commitment to taking a regional approach to resilience planning and decision-making. Task 8 researchers chose the city of New London to develop a community-based resiliency plan focused on sea level rise for the year 2100. Situated on the Thames

River and Long Island Sound, the city of New London has been historically vulnerable to flooding, and sea level rise projections depict even worse scenarios. The research team worked with the city's Mayor's Office and the Business Owners Association to develop a science-based design to mitigate negative impacts of sea level rise while spurring economic growth along South Water Street.

The Task 8 research team used sea level rise projections developed by CIRCA and referenced by the recently introduced state-wide legislation on Climate Change Planning and Resiliency (Public Act 18-82), to communicate the potential impacts of rising waters to the local community. This science guided approach began with the creation of three different design strategies. These were then presented to local officials and property owners to discuss potential solutions that would ensure a sustainable future for their community. Designs were revised based on public input, and a new meeting was held to ensure that multiple options were explored.

The research team sought to develop a plan that would address flood vulnerability due to sea level rise while capturing the needs and desires of the New London community for the future of Bank Street and South Water Street. To do so, the project focused on five strategies:

1. **Science-Informed Design:** The project used Connecticut Institute for Resilience & Climate Adaptation (CIRCA) data to analyze projected sea level rise scenarios to determine the mitigation strategies proposed and communicate impacts to the public.
2. **Graphically Translate Impacts:** The team focused on ways to strategically communicate the impacts of sea level rise on the city to the public and support the design approaches proposed.
3. **Collaborative and Multidisciplinary Approach to Design:** The design team was composed of experts from a variety of disciplinary backgrounds, focused on green infrastructure, surface water, urban horticulture, architectural design, communication and public outreach. Together the team collaborated to compose design options that focused on both social and environmental impacts of the proposals.
4. **Design for Socio-Environmental Resilience:** In this project resiliency is addressed from both a social and an environmental aspect. It seeks to ensure that the community and its landscape will be able to bounce back and recover in the face of rising waters. Moreover, it is an opportunity to connect the city to the Thames River.
5. **Public Engagement:** The entire design process was founded on public involvement. To do so an expert in public engagement and communication participated in the meetings as a moderator. After designs were presented the moderator made sure that property and business owners, and city officials, were heard. The process also included an anonymous voting system, so that those less vocal could express their preferences. Participants were asked to comment on the pros and cons of all the design options, and revisions to the design were made based on the input gathered. Engagement results are described in more detail in Appendix F.

CIRCA's sea level rise projections indicate that 1%, or 100-year storm events will likely be 2' higher than indicated by the current data utilized for flood insurance by FEMA. Moreover, the projections also show that FEMA's baseline data for 100-year storm events may represent the 20% likelihood, or 20-year storm event. Trends based on preliminary CIRCA data estimate that approximately 87 buildings along the Thames River will be vulnerable to flooding. This is a significant increase when compared to current FEMA projections, which estimate only 12 buildings in danger.

Proposed Designs

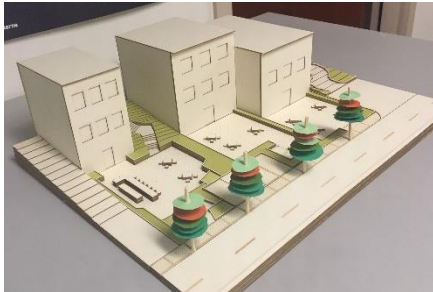
Based on the sea level rise data analyzed, the design team proposed three design approaches to mitigate potential effects of flooding from rising waters up to 12 feet above the shoreline.

Design Option 1: proposed a series of berms/landforms running between the train tracks and river. It included deployable gates to close the ends of the berm system. This alternative would protect Amtrak, South Water Street and buildings on the eastside of Bank street from flood waters.

Design Option 2: proposed that South Water Street be elevated 3' with a 3' glass wall added to the elevated plane, to protect both the street and buildings on the eastside of Bank Street from flood waters. This design was later revised, by changing the material of the 3' wall from glass to masonry, and focused interventions on the right of way, with only suggested changes to private properties.

Design Option 3: in this design proposal, the back of the buildings, facing South Water Street, are filled by 6'. This is intended to protect buildings on the eastside of Bank Street from flood waters. In some cases, the first floor would have to be converted to basement space.

Final Design



The final design further revises Design Option 2, based on requests gathered from the public engagement process during the second meeting. The community requested the incorporation of aspects of Design Option 1, so that a park is created on the edge between Amtrak and the Thames River, connecting the area to the river and creating a leisure space that would draw the community to South Water Street.

Next Steps and Future Recommendations

In order to elevate South Water Street, the project should expand to include the area to the east of the site, where Union Station is located. Grading will need to be done on the connections between State Street and Water Street so that the elevation of the road effectively addresses potential water rise. With that said, Union Station, a historic building siting just outside of the studied site, has come to our attention as particularly vulnerable structure that should be addressed in order to ensure the success of the plan. Additional studies on stormwater management and green infrastructure should also be produced to compliment the project. Finally, the community will need to support to secure funds for the construction of the final design.

The Task 8 Product (Appendix F) includes:

- [Bank Street – South Water Street Project, New London CT.](#) December 2018. Community Research & Design Collaborative, UConn Landscape Architecture Program.

Task 8 Research Team:

Professor Peter Miniutti – UConn Department of Landscape Architecture Professor and Community Research & Design Collaborative
Natalie Miniutti – UConn Department of Landscape Architecture Adjunct Faculty
Mariana A. Fragomeni – UConn Department of Landscape Architecture Adjunct Faculty
Tao Wu – UConn Department of Landscape Architecture PhD Student
Miriah Kelly – UConn Cooperative Extension

Task 9 Summary: Legal and Policy Analyses that Support State and Municipal Efforts to Implement Resiliency Measures (Appendix G)

Connecticut faces unique challenges in climate resilience planning and implementation. Statewide resilience planning may be challenged by the legal relationship between state and municipal governments, undergirded by home rule principles that ensure municipal autonomy. While Tasks 2-8 consider the maps, data, and tools to identify and make decisions on infrastructure, there also needs to be more information available for Connecticut communities to implement resilience measures through law and public policy, which take Connecticut's unique challenges into account. To address this need, the UConn School of Law's Center for Energy and Environmental Law conducted legal and policy analysis on critical topics in climate resilience and a targeted educational campaign for key decision-makers.

Laws and public policies are often cited as barriers to the adoption of resiliency measures. In Connecticut, key decision-makers often lack information about the scope of their legal authority. The Task 9 research team identified laws and policies that are the biggest barriers and offered strategies to ensure that decision-makers have tools they need to make sound planning decisions.

The goal of Task 9 was to identify climate resilience opportunities for the Connecticut shoreline that could be implemented within the complex and unique legal structures that define the relationships between the state government, municipal governments, property owners and the general public. Limiting the scope of work to issues that had not been adequately addressed by others, the following subtasks were undertaken to meet this overall goal:

- The evaluation of coastal management programs in other oceanfront states to identify coastal management policies, legal structures, practices, and procedures that could be useful in Connecticut.
- The examination of Connecticut legal structures to identify opportunities for, and obstacles to, climate resilience planning and implementation.
- The identification of legal structures to support coastal and floodplain management based upon forward-looking sea level rise projections instead of the traditional backward-looking "100 year flood" events.
- The communication of the results of this work to state and municipal leaders, regulators, officials, and other interested parties through white papers and outreach events.

The Task 9 research team generated a series of deliverables aimed at educating both policymakers and the general public on resilience best practices in law and policy. These deliverables include legal research white papers and drafts of model rules for adoption, with the overall goal of removing barriers to climate resilience efforts at the state and municipal levels. Topics suitable for analysis include zoning regulations, building codes, coastal protection and armoring, takings jurisprudence, and the public trust doctrine. In coordination with the community engagement described in Task 10, CIRCA staff, and teams from the nine other tasks, the Task 10 research team partnered to hold a conference, series of workshops, and meetings for municipal and state leaders to communicate the legal and policy recommendations coming from this project.

Several municipalities contacted CIRCA for help in implementing the recommendations from this Task. Many of these towns and cities used the white papers created for this task to inform the adoption of their regulations. To assist in the implementation, a professional architect was hired to work with CIRCA staff to develop individual, street scale, and neighborhood scale layered computer documents that depict illustrations of common resilience problems. These publicly available tools make reference to planning concepts developed throughout the project. The files contain computerized “layers” whose display can be toggled on and off. The documents are designed to assist town planners, engineers, and educators to communicate common resilience problems and solutions in a neutral setting that does not represent any single location but were developed by analyzing several Connecticut coastal communities and creating an amalgamation of their common challenges. A CIRCA webinar entitled, “[New Planning and Visualization Tools for Sea Level Rise](#)” described these schematics in more detail to a public audience.

Task 9 Products (Appendix G) include:

1. Appendix G1: Task 9 Summary Report: Legal and Policy Analysis that Support State and Municipal Efforts to Implement Resiliency Measures
2. Appendix G2:
 - The publication of four white papers on climate resilience issues:
 - [Floodplain Building Elevation Standards](#)
 - [Height Restrictions on Elevated Buildings](#)
 - [Oceanfront State Coastal Management Programs](#)
 - [Statutory Adoption of Updated SLR Scenarios](#)
 - The presentation of sixteen community outreach events that engaged 517 interested and influential parties.
 - Co-hosting of an all-day conference ([Creating a Resilient Connecticut: A CIRCA Forum on Science, Policy, and Law](#)) that attracted 128 registrants and served as a capstone outreach event for all of the tasks within the Municipal Resilience Planning Assistance Project.
 - The enactment of climate resilience legislation that was informed by the recommendations developed during this task.
3. Planning and visualization tools for sea level rise:
 - [Barrier Beach Resilience Diagram](#)
 - [Marsh Resilience Diagram](#)
 - [Resilience Corridor Diagram](#)

Task 9 Research Team:

Joe MacDougald - UConn Professor in Residence and the Executive Director of Center for Energy & Environmental Law

William Rath - UConn Center for Energy & Environmental Law Legal Fellow

Alex Felson – CIRCA Director of Resilience Design

Task 10 Summary: Determination of Municipal Policy, Research, and Issue Needs (Appendix H)

Coastal municipalities are facing a significant number of challenges in planning for, and adapting to, changing weather patterns and climate change. Lack of resources and staff expertise make it more important than ever that research and support designed to assist municipalities with resiliency planning and implementation be something that they can truly use. The purpose of Task 10 was to understand the most pressing needs facing Connecticut's municipalities with respect to climate change and to develop a list of research needs that municipal officials need answered by researchers. In addition, interviews sought to determine what standard of authority and data uncertainty municipal officials are willing to accept, in terms of research results for sea level rise and floodplain mapping for inclusion in their planning and regulatory documents. This information will guide researchers and state agencies so that they can provide results that municipalities find applicable and defensible when they are used. This project also included coordination with a Legal Research Fellow from UConn's law School Center for Energy and Environmental Law (Task 9) and appropriate CIRCA staff on the questions asked and information gathered. This task was implemented by faculty from the Connecticut Sea Grant College Program and the UConn Center for Land Use Education and Research.

The research team developed a list of questions pertaining to current climate related issues and needs, future climate change issues, climate adaptation planning and policy, and questions pertaining to acceptable standards of authority for planning and regulatory municipal purposes. Topics included flooding, coastal erosion, policy and regulatory issues, health issues and economic impacts. The questions were submitted to UConn's Institutional Review Board (IRB) to ensure that proper protocols were followed in interviewing municipal officials. The project questionnaire was determined to be Exempt from further IRB protocols as the municipal officials were answering questions in the official capacity and not as private citizens.

Outcomes

From June 2016 to February 2017, officials from twenty municipalities in counties impacted by Superstorm Sandy were interviewed. Interviewees were a mix of municipal officials including elected officials and officials from town departments including public works, planning, conservation, emergency management and health. All interviews were conducted in person. The first round of interviews was with officials from thirteen towns. Results from these interviews were compiled and a second round of interviews was conducted with an additional seven towns to determine agreement or disagreement with the results. All responses were kept confidential to ensure an uninhibited flow of information.

The following issues were of highest priority by those interviewed:

- ***Flooding: Impacts on Infrastructure*** (particularly roads, wastewater treatment plants and pump stations) both from storm events and "sunny day" flooding.
- ***Flooding: Predicting inundation levels during storm events.*** This information is critical in determining when and where to issue evacuation orders, deploy emergency operations equipment and protect vulnerable infrastructure. Also, communities that border both Long Island Sound and major rivers need maps that combine storm surge along Long Island Sound with potential riverine flooding.
- ***Stormwater Management and Extreme Precipitation Events:*** Intense precipitation events and increased amounts of impervious surfaces are leading to flooding in both coastal and inland

communities. Stormwater system analyses, best practices and retrofit information are needed.

- ***Coastal Erosion***: Numerous concerns were raised with regard to lose of tax base due to coastal erosion, restoration and management of breached dunes and exposure of septic systems.

The Final Report for this task (found in Appendix H) also provides information on medium and lower priority issues for municipalities. This report provides guidance to university faculty, state leaders and NGO's with regard to municipal priorities for climate adaptation research and guidance. As municipal budgets continue to tighten, the need for these priorities only increases. Priorities should be used to determine how limited funds are spent so as to best provide resources and information that municipalities find most relevant and applicable to their needs and defensible when used.

The Task 10 Product includes:

- Hyde, B. and Barrett, J. White Paper: [Municipal Issues & Needs for Addressing Climate Adaptation in Connecticut](#). 2017. UConn Center for Land Use Education and Research, UConn Extension, and Connecticut Sea Grant College Program.

Task 10 Research Team:

Bruce Hyde - UConn Center for Land Use Education and Research and UConn Extension
Juliana Barrett - Connect Sea Grant and UConn Extension

Conclusion

CIRCA coordinated with multiple partners in the state to create valuable products through generous funding from a Municipal Resilience Planning Assistance grant from the State of Connecticut Department of Housing CDBG-Disaster Recovery Program and the US Department of Housing and Urban Development. The following products from ten tasks assess vulnerabilities and strategies to mitigate potential damage from climate change and storm impacts:

- Applications for new coastal aerial photography,
- State sea level rise projections and associated map viewer
- Inland and coastal flood vulnerability data, map viewer, and case studies
- A vulnerability assessment of Connecticut wastewater systems
- A municipal needs assessment, and
- Legal and policy recommendations to support resiliency in the state.

Importantly, CIRCA's report *Sea Level Rise and Coastal Flood Risk in Connecticut*, provided the basis for sea level rise projections in Governor's Bill S.B. 7, which was introduced in the 2018 legislative session and enacted into law as Public Act 18-82, [An Act Concerning Climate Change and Resiliency](#).

This work combined science, policy, and planning at the state and local levels to address the resilience of vulnerable communities along Connecticut's coast and inland waterways to the growing impacts of climate change. Findings and products have been and will continue playing a vital role in building resiliency throughout Connecticut and preparing communities for future storm impacts, especially coastal areas affected by projected sea level rise.