Town of Clinton

Coastal Community Resilience Report

April 2022

Clinton Harbor and Marina

Prepared for:

Town of Clinton, Connecticut

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This report was prepared under the direction of the University of Connecticut Climate Corps program alongside the Town of Clinton.

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Introduction and Defining Key Terms and Background

Clinton, Connecticut is a coastal town that has approximately 5,000 households and 13,185 residents. It is about 16 square miles. Clinton is extremely well known for the Clinton Crossing Premium Outlets. There are significant historical and environmental assets within the town.

The Long Island Sound is a valuable asset to the town of Clinton, CT. The coastline provides recreational opportunities, as well as environmental significance, and a source of tourism that boosts the economy. In an effort to preserve both the shoreline and the health of the Long Island Sound, the town of Clinton, CT has committed themselves to creating a coastal resiliency plan.

This report will aid Clinton's efforts to create an initial baseline resiliency plan that can be utilized for future planning purposes and from which a full resiliency plan can be launched. Clinton has been interested in conducting a community coastal resilience plan for many years and this report will highlight important information that should be considered when the full report is launched.

Coastal resiliency includes the ability to withstand, recover from, or adapt to coastal hazards. Coastal hazards include sea level rise, more frequent flooding, and storm surge from more intense storm events. The more resilient an area is the more likely it is to resist and or adapt to change while sustaining the least amount of damage. Coastal resilience refers to both the natural and built structure along the coastline. Including, but not limited to the homes, businesses, the habitats, and tidal wetlands.

The main considerations for adaptation in Clinton, CT take sea level projections, storm surge and recent storm events into account to plan for future hazards and changes in landscape.

Adaptation strategies include accommodation, protection, and retreat which was originally outlined in an Intergovernmental Panel on Climate Change report(IPCC). In essence these three strategies are applied in some capacity when considering coastal adaptation plans.

- Accommodation refers to adapting to the current situation and hazards like flooding with little to no modifications. For example, elevating buildings with elevating structures or transitioning to crops that can withstand flooding and salt water.

Pros:

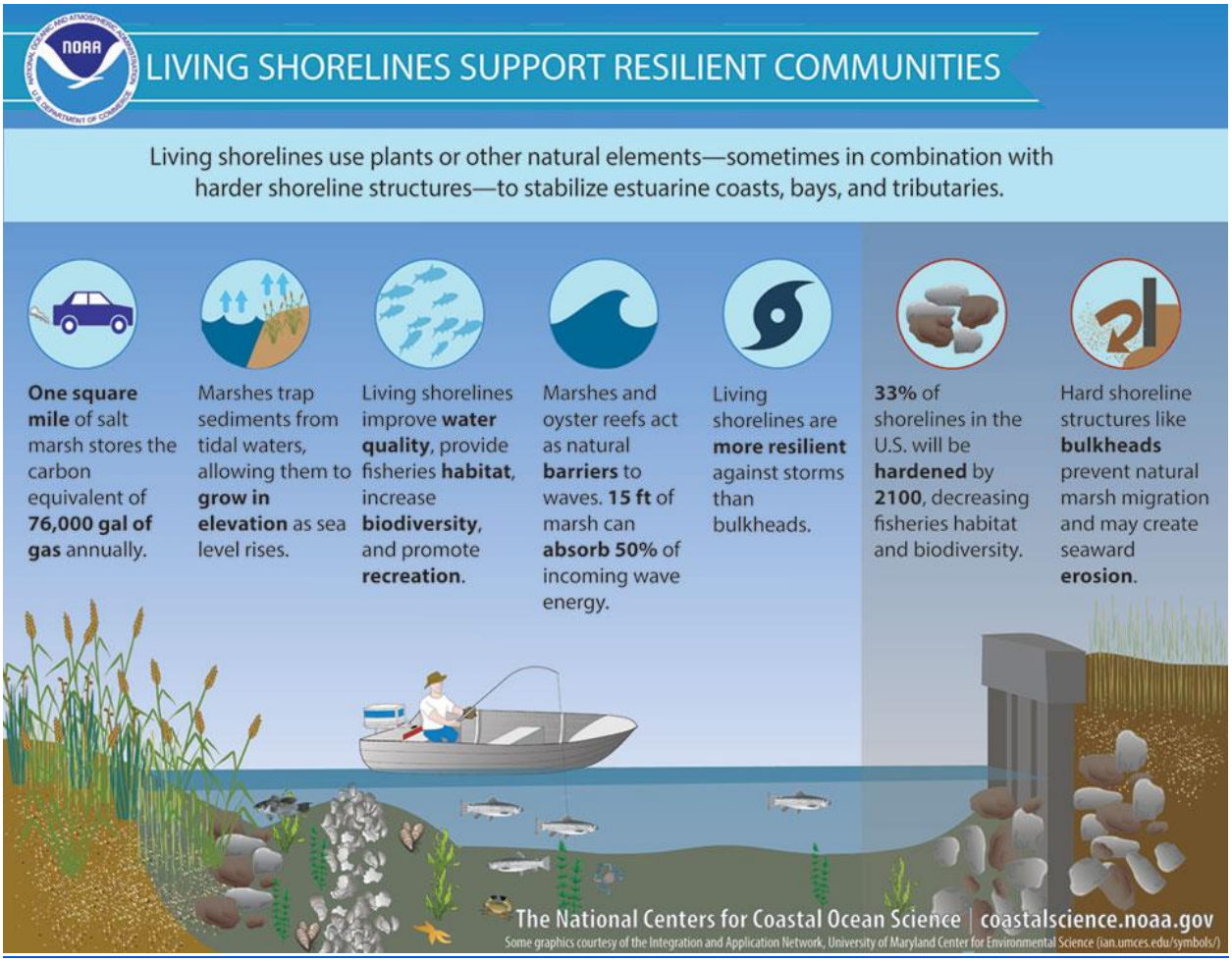
- Little changes to way of life

Cons:

- May not be feasible long term
- Costs can vary
- Challenging to implement

A comprehensive adaptation plan will consider elements of the three adaptation efforts and will combine components of each to create a functional plan to best serve the needs of the area.

- Protection can incorporate both natural and engineered solutions. Some examples of protections are shoreline armoring including seawalls and bulkheads. A more natural solution could be a living shoreline, these include dunes, and other natural features that can absorb storm surge and wave energy.



Pros:

- Can preserve existing ways of life and built structures

- Can include built and natural solutions

- Vary in cost and feasibility

Cons:

- May not function long-term/can fail

- Can be expensive

- Requires upkeep and repairs

- Retreat is often referred to as managed retreat. This process is not as simple as it may sound. It involves the removal or abandonment of built structures from a designated

vulnerable coastal area. There is no further development in the designated region. Development then may occur further inland. This can be accomplished through multiple means including voluntary programs, eminent domain, and creating no-build areas. There then can be habitat restoration within the area where people have retreated, and it will replace a previously developed area with open, green space.

Pros:

- Can move outside of the bounds of storm surge and sea level rise
- Return to more natural shorelines
- Long term protection and reduction of damage
- Voluntary buy-out or buy-back programs for home and business owners
- Can encourage citizens to relocate nearby and within the town boundaries

Cons:

- High upfront costs
- May require purchasing properties using eminent domain
- Communities are already established there
- Require bioremediation of areas or returning them to natural landscapes rather than simply abandonment
- Loss of a residential area or development including the tax base if there are not rebuilding efforts

Mitigation vs. Adaptation

Mitigation refers more to the prevention of rising temperatures and climate change through reducing greenhouse gasses, the major accelerant of climate change. It seeks to eliminate the driving factor behind sea level rise and other negative externalities of climate change.

Adaptation refers to reducing the impact of the effects of climate change. It is adapting to a reality where these changes have already occurred. Both recognize the role in climate change in shaping the future and hazards we face. Both are of equal priority because the impacts of climate change have already been felt. There needs to be adaptation to this current reality, but it is not too late to make significant changes and mitigate more dangerous impacts.

This resiliency report will later focus on adaptation strategies related to specific vulnerabilities that Clinton, CT can adopt to improve their coastal resilience.

Risk is also an important component of planning and creating adaptation and mitigation efforts. Risk is defined as the following by the IPCC report:

Risk = the probability of an event occurring x consequences of the event

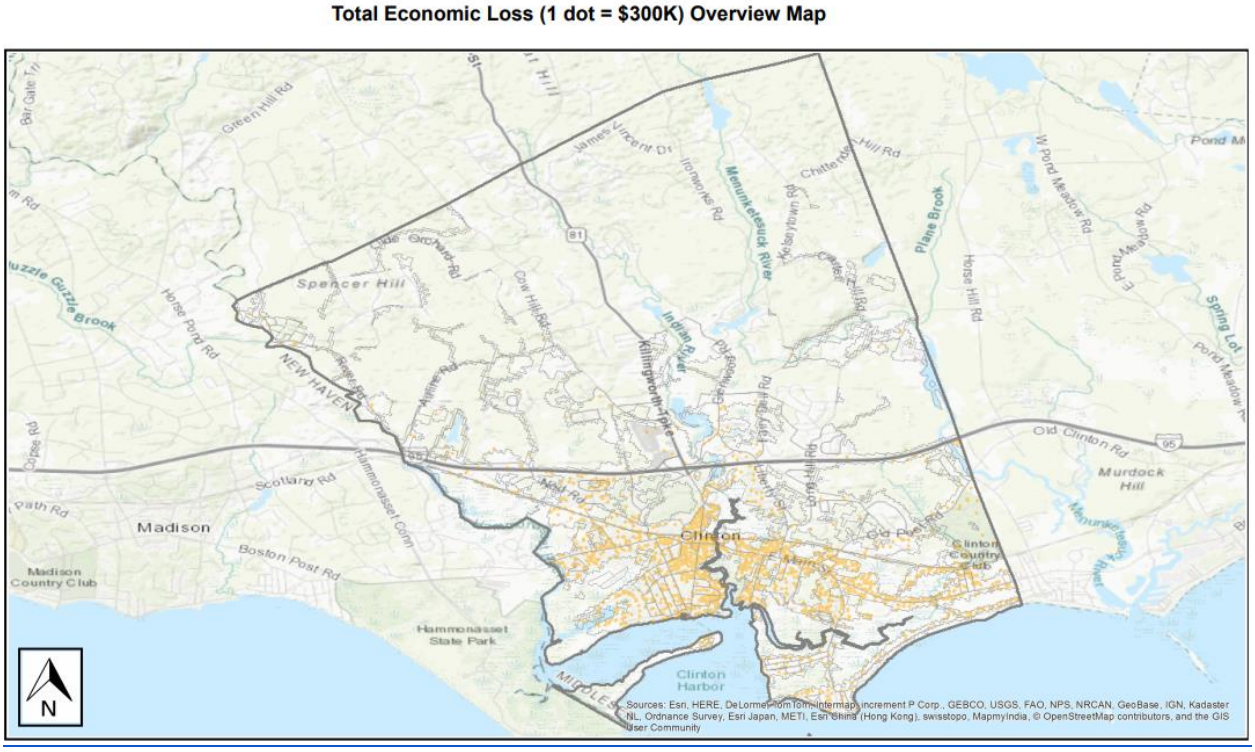
Determining risk allows you to make informed decisions.

The first step in creating a coastal resiliency plan is being aware of the vulnerabilities and risks the area faces. This allows the community to tailor adaptation strategies to best suit public needs and create an action plan that creates the best overall outcome.

Current State of Clinton and the Future

Built Structures

FEMA estimated there are 5844 buildings in the town of Clinton, with an estimated value totaling 2 billion. FEMA estimated that a 10 year flood on the coast would moderately damage 308 buildings, with 25 buildings completely destroyed. Of these 308 buildings, included are essential facilities, such as an emergency operation center, a fire station, a police station, and a school. An estimated 3,677 people would be displaced from flooding and require temporary shelter. FEMA estimated that a 10 year flood on the rivers would moderately damage 2 buildings, with 0 buildings completely destroyed. None of these buildings are essential facilities. An estimated 286 people would be displaced from flooding and require temporary shelter.

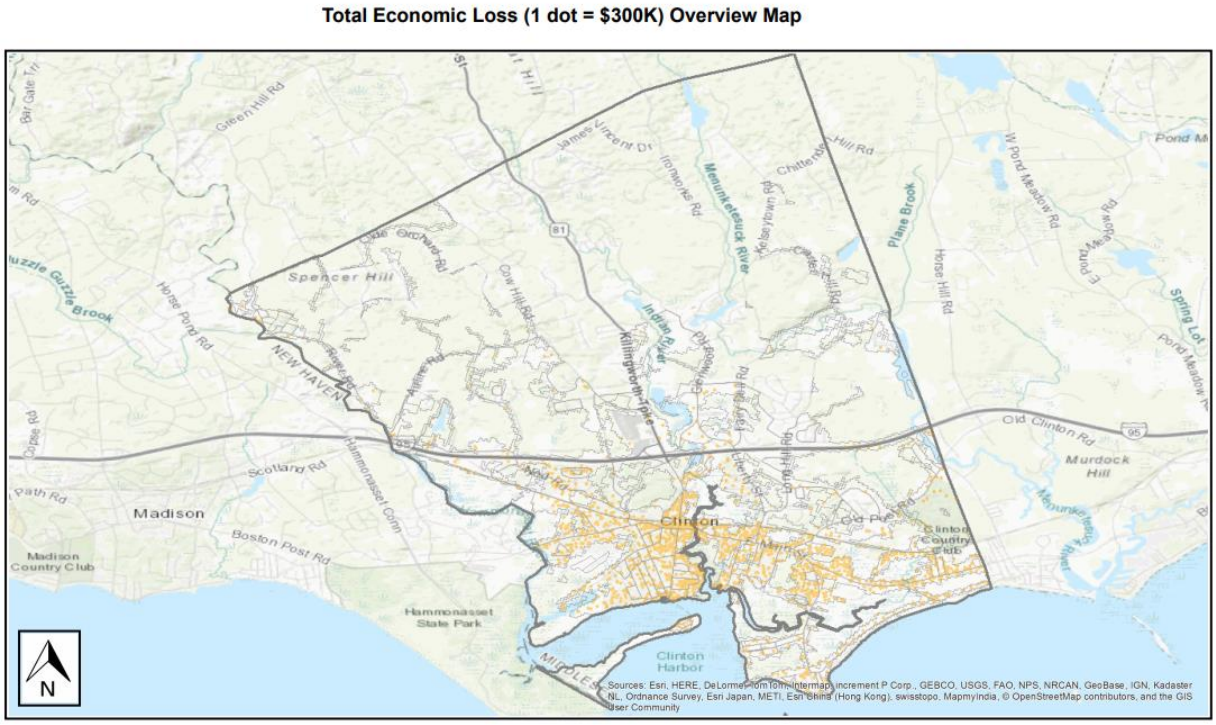


Coastal Flooding from a 10 Year Flood

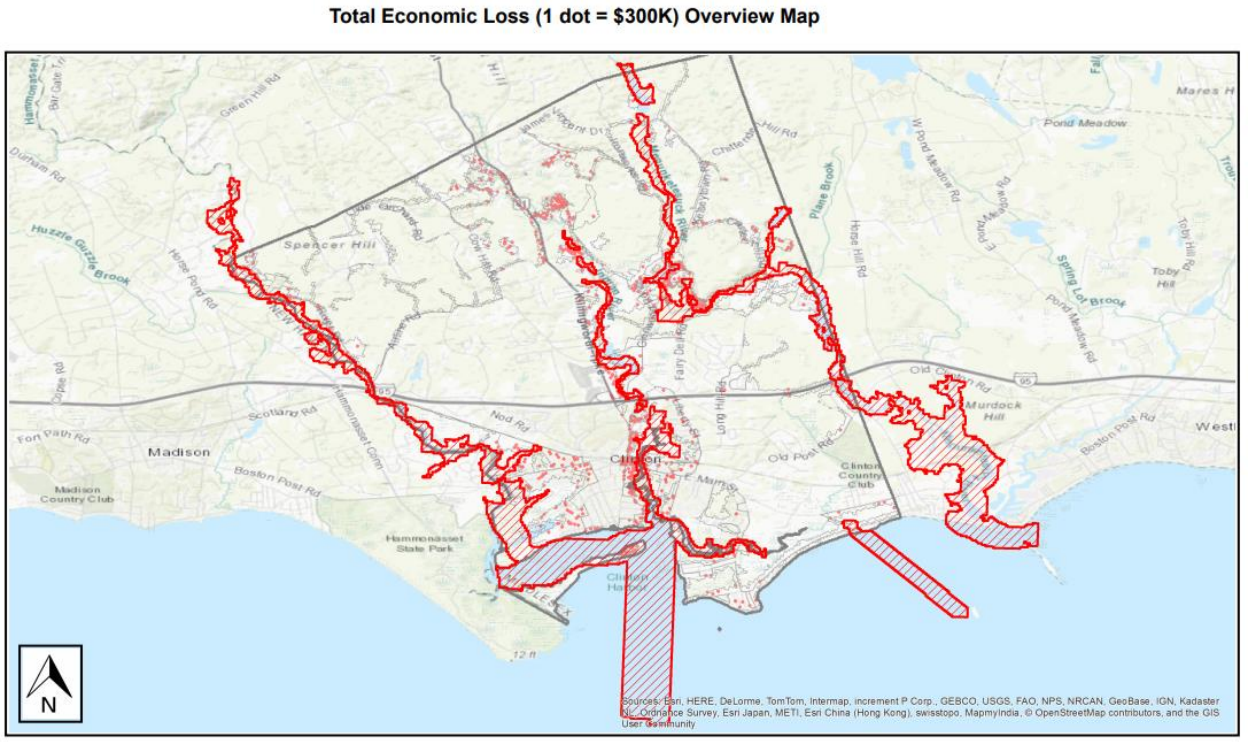
Total Economic Loss (1 dot = $300K) Overview Map

River Flooding from a 10 Year Flood

FEMA estimated that a 25 year flood on the coast would moderately damage 308 buildings, with 25 buildings completely destroyed. Of these 308 buildings, included are essential facilities, such as an emergency operation center, a fire station, a police station, and a school. An estimated 3,677 people would be displaced from flooding and require temporary shelter. FEMA estimated that a 25 year flood on the rivers would moderately damage 4 buildings, with 0 buildings completely destroyed. None of these buildings are essential facilities. An estimated 320 people would be displaced from flooding and require temporary shelter.

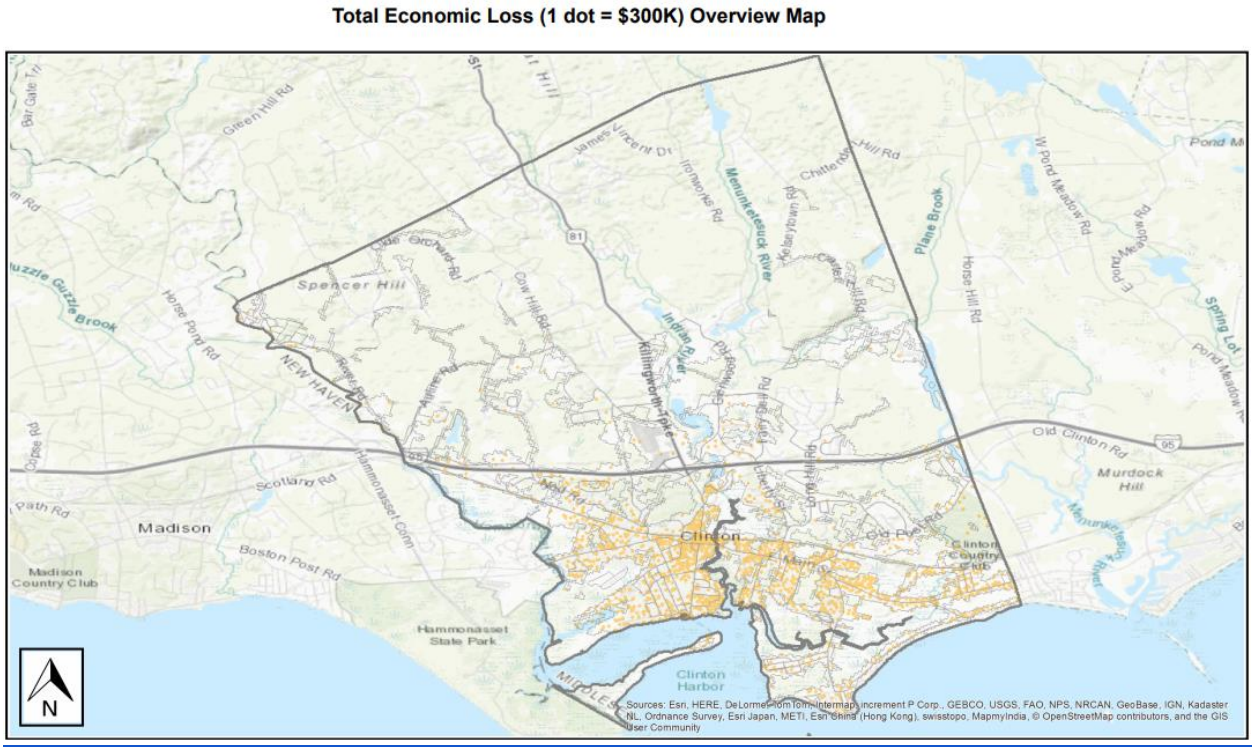


Coastal Flooding from a 25 Year Flood



River Flooding from a 25 Year Flood

FEMA estimated that a 50 year flood on the coast would moderately damage 476 buildings, with 34 buildings completely destroyed. Of these 476 buildings, included are essential facilities, such as an emergency operation center, a fire station, a police station, and 2 schools. An estimated 4,658 people would be displaced from flooding and require temporary shelter. FEMA estimated that a 50 year flood on the rivers would moderately damage 22 buildings, with 0 buildings completely destroyed. None of these buildings are essential facilities. An estimated 465 people would be displaced from flooding and require temporary shelter.



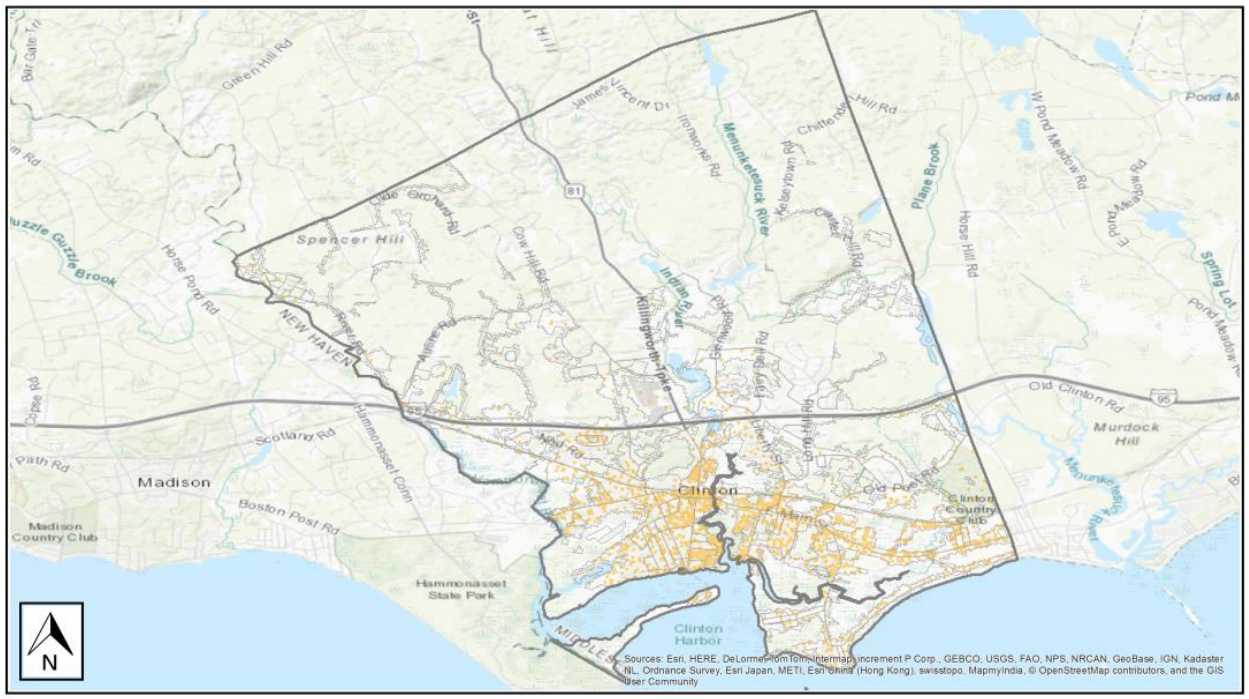
Coastal Flooding from a 50 Year Flood

Total Economic Loss (1 dot = $300K) Overview Map

River Flooding from a 50 Year Flood

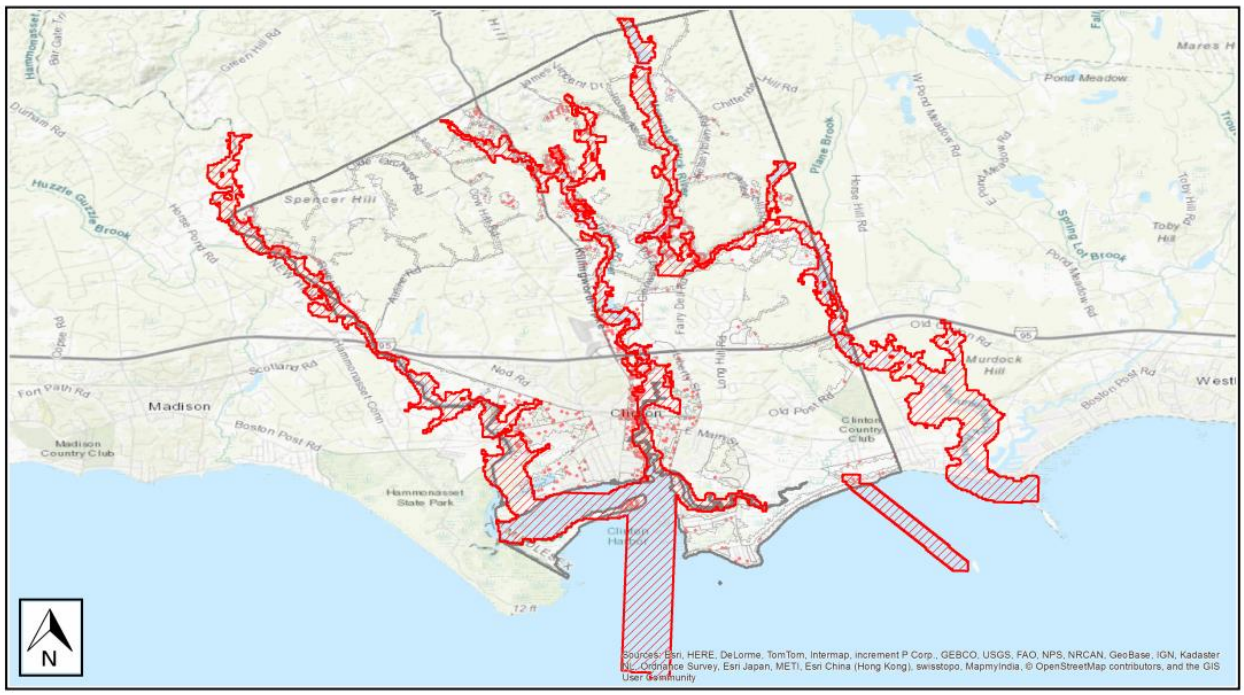
FEMA estimated that a 100 year flood on the coast would moderately damage 779 buildings, with 63 buildings completely destroyed. Of these 779 buildings, included are essential facilities, such as an emergency operation center, a fire station, a police station, and 2 schools. An estimated 4,996 people would be displaced from flooding and require temporary shelter. It is estimated that a 100 year flood on the rivers would moderately damage 29 buildings, with 0 buildings completely destroyed. None of these buildings are essential facilities. An estimated 555 people would be displaced from flooding and require temporary shelter.

Total Economic Loss (1 dot = $300K) Overview Map



Coastal Flooding from a 100 Year Flood

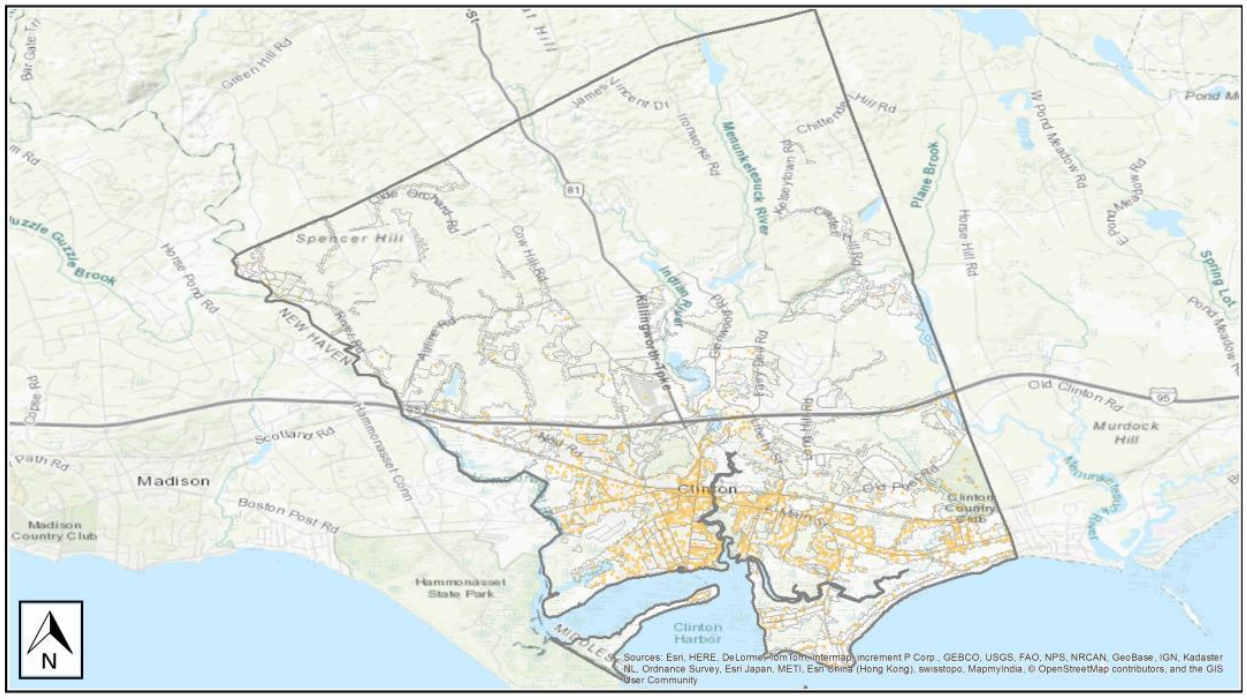
Total Economic Loss (1 dot = $300K) Overview Map



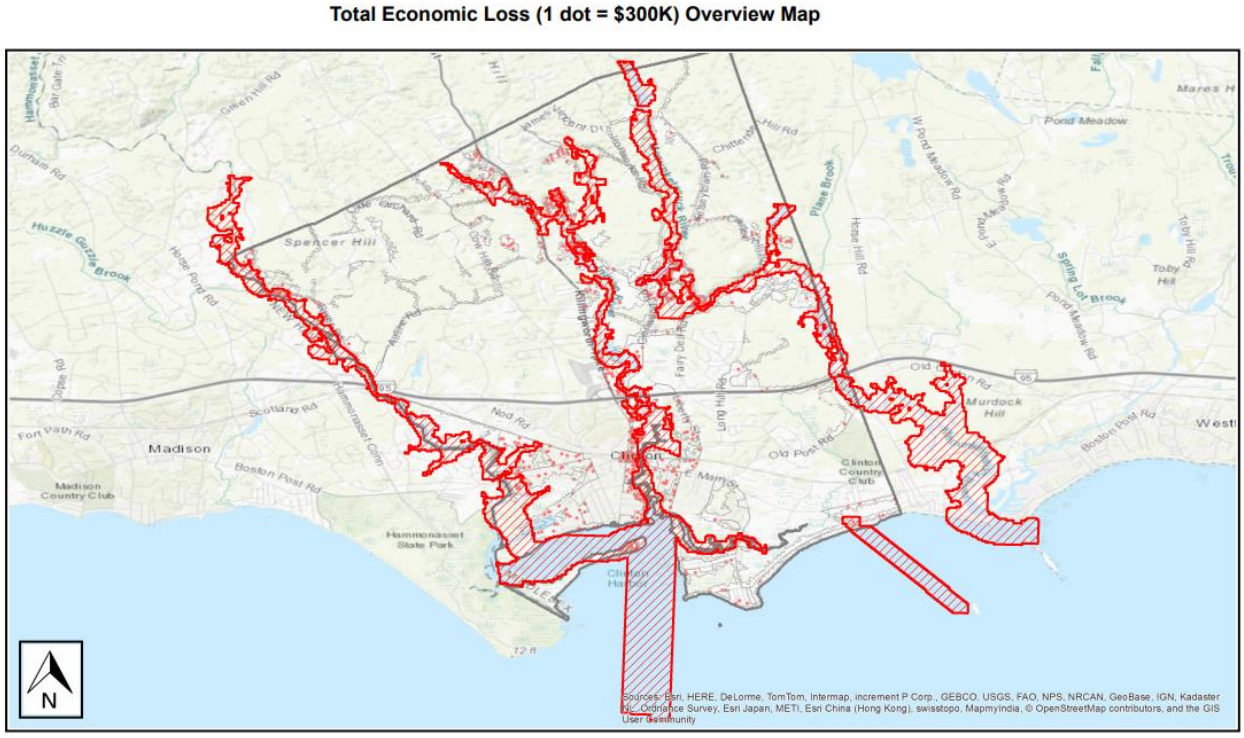
River Flooding from a 100 Year Flood

FEMA estimated that a 500 year flood on the coast would moderately damage 993 buildings, with 63 buildings completely destroyed. Of these 993 buildings, included are essential facilities, such as an emergency operation center, a fire station, a police station, and 2 schools. An estimated 5,460 people would be displaced from flooding and require temporary shelter. FEMA estimated that a 500 year flood on the rivers would moderately damage 51 buildings, with 0 buildings completely destroyed. None of these buildings are essential facilities. An estimated 732 people would be displaced from flooding and require temporary shelter.

Total Economic Loss (1 dot = $300K) Overview Map



Coastal Flooding from a 500 Year Flood



River Flooding from a 500 Year Flood

Past Storms

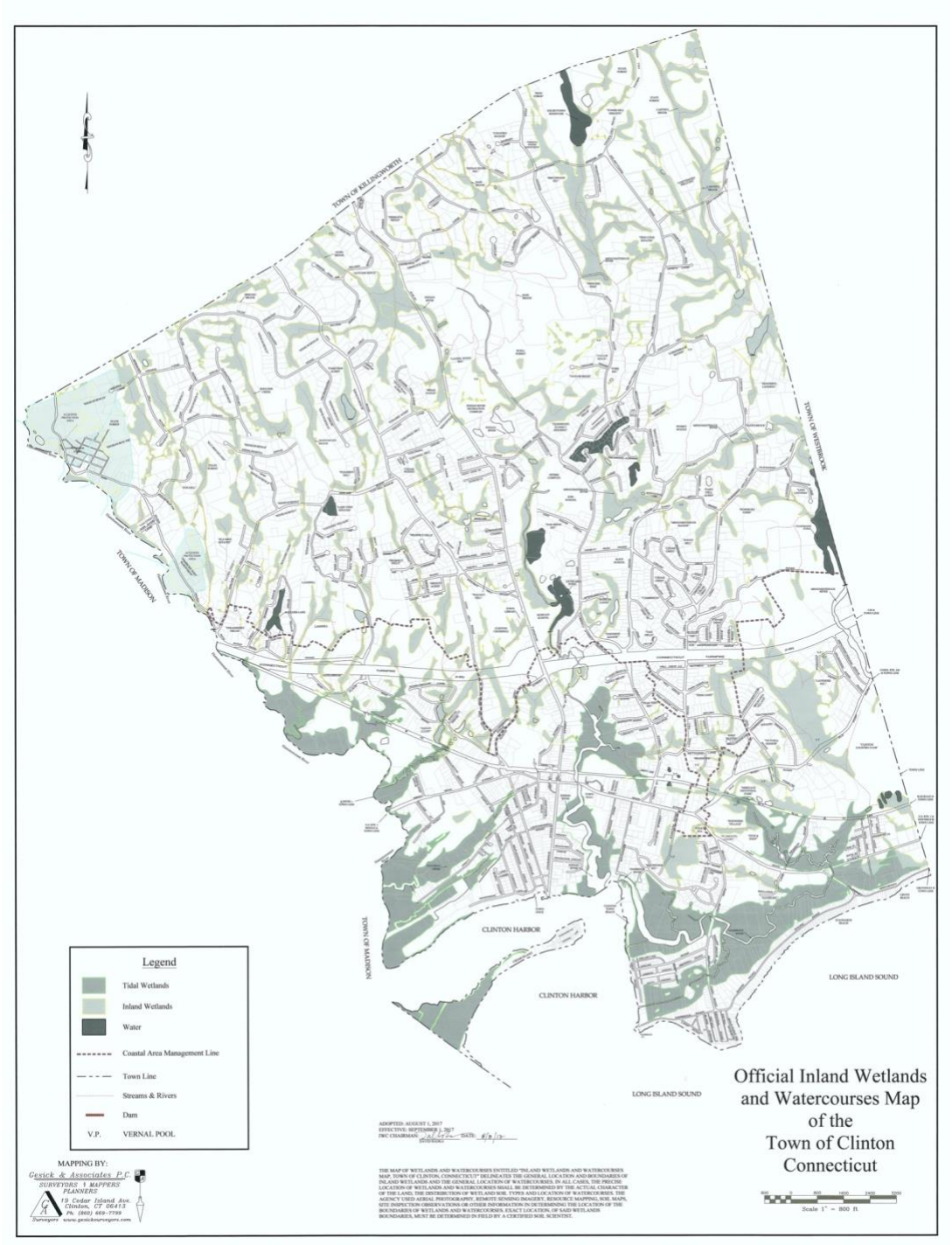
Hurricane Sandy impacted 54 properties in Clinton CT due to storm surge. All of these properties were either on the Long Island Sound or rivers. Most properties experienced a foot of flooding, while the most experienced was over four feet. Hurricane Irene impacted 38 properties in Clinton CT. All of these properties were on the Long Island Sound or rivers. Most properties experienced a foot of flooding, while the most experienced was 3.8 feet.

Flooding after Storm Sandy in Clinton, CT from photos taken by the Connecticut National Guard on Tuesday, October 30, 2012

Conservation

The areas of focus for the coastline in terms of conservation include the tidal wetlands and salt marshes. There are 23 miles of shoreline along Clinton, CT. Among the coast there are open spaces. These open spaces include coastal wetlands and are mainly publicly owned by the Clinton Land Conservation Trust and the Connecticut Department of Energy and Environmental Protection otherwise known as CT DEEP. “A recent analysis by The Nature Conservancy estimated the rising sea levels and storm surge by 2080 will create substantial new areas of

inundation along Clinton's shoreline and will expand the areas of saltmarsh and tidal wetlands."



Town of Clinton Recognized Wetlands

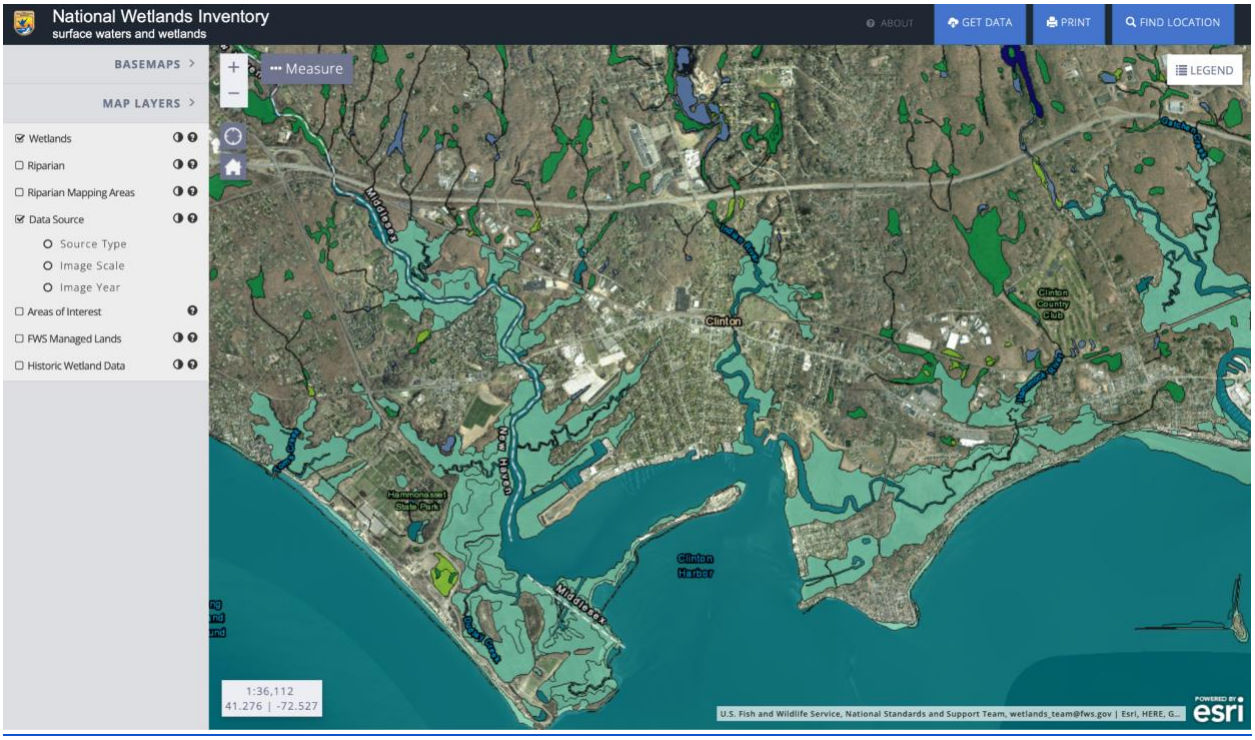
Coastal wetlands provide habitat for important bird species and other ecologically organisms. They also absorb storm surge and wave energy lessening the impacts of sea level rise. They provide crucial ecosystem services such as water filtration and overall protection from sea level rise.

There are tidal wetlands all along the coast of Clinton, CT. The East End of Clinton includes commercial development that is surrounded by tidal wetlands. This could pose a risk because there will be nowhere for tidal wetlands to expand to. This will lead to increased flooding and damage within the commercial areas. Additionally, there are significant wetland areas within the harbor and marina area. This is geographically represented in the U.S Fish and Wildlife Service national wetland's inventory below.

An area of potential focus for adaptation is improving the quality of these salt marshes and coastal wetlands. This includes removal of invasive species including phragmites, which are a reed like plant that have become increasingly invasive in wetland ecosystems. When phragmites grow in clumps then they do not provide ecosystem benefits and overall reduce biodiversity because they limit habitat options for plant and wildlife species. Preserving wetland quality ensures that they are environmentally important areas that fulfill their role in ecosystems.

Additionally, an area of concern is the ability of the marshes' ecosystem's ability to migrate in response to rising sea levels and changing conditions. Due to the higher level of infrastructure and homes along the coastline of Clinton there are limited areas for the marshes to migrate to. Therefore, when there are higher sea levels the marshes will be inundated with water, they will degrade and disappear. Versus if they had areas that they could migrate to the ecosystems shift and there would be less loss of biodiversity and ecosystem services. This should

be an area of focus and efforts should be taken to preserve salt marshes where that is in their existing forms or in new migrated habitats.



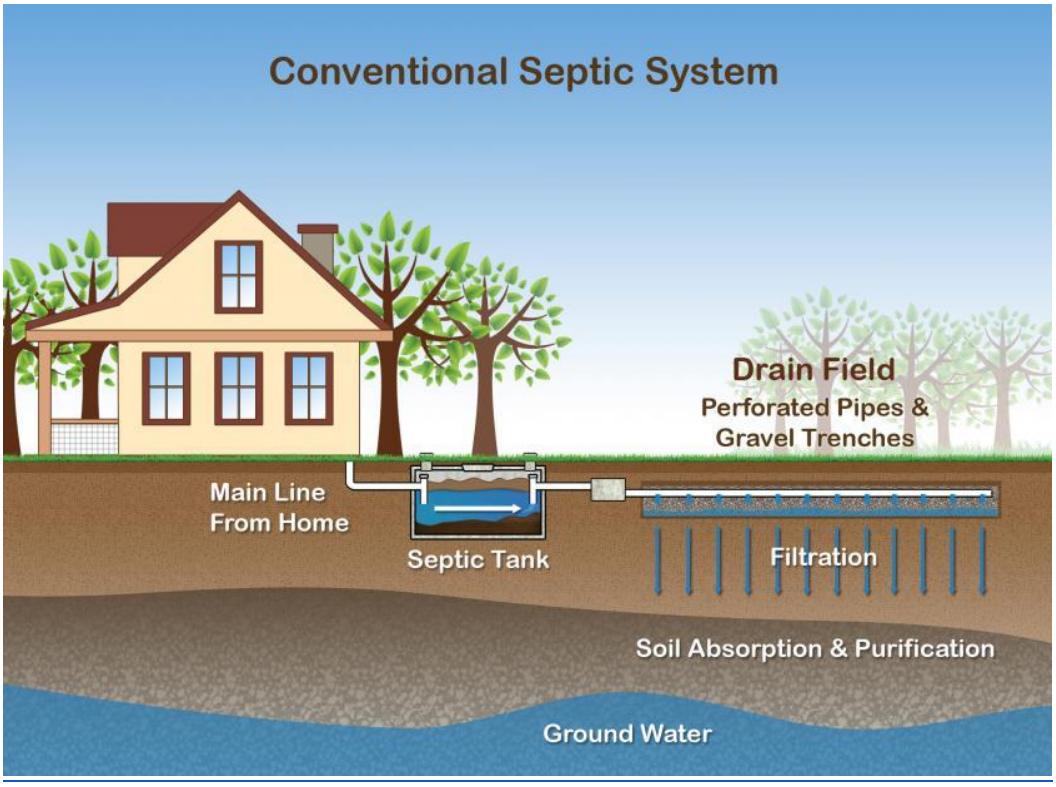
U.S. Fish and Wildlife National Wetlands Inventory- Wetlands within Clinton, CT are designated by the blue shading on the map

Vulnerability: Septic Systems

Septic systems are a way to treat waste on-site and are often found in coastal towns where there is not an established comprehensive sewage system. While this is typically an effective way to treat wastewater locally, they are vulnerable when there is sea level rise.

Septic systems rely on unsaturated soil below the drain field to store and treat wastewater. This serves a primary safeguard against pathogens and the prevention of raw sewage from being released into the ground. If more of the soil near the septic system is saturated it

makes it more likely for the septic system to fail- this could lead to waste water that is not being properly treated being released in the surrounding soil that can contaminate the surrounding groundwater and surface water. Since there is little intermediate soil that serves as a filtrate this can have severe impacts on public health in the form of disease causing pathogens ending up in ground and surface water. When there is sea level rise not only is there surface flooding, but it also raises the level of the ground water. Which is of primary concern for septic systems. When the ground water level is higher septic systems no longer function properly and are unable to filter the wastewater. When systems fail there can be nutrient pollution because there are higher levels of nitrogen and ammonia in the wastewater- this will impact the environmental health of coastal regions.



Conventional Septic System with a normal ground water level (Minnesota Pollution Control Agency)

These failed septic systems can pose an immediate threat to public health and can have significant impacts on the ecological quality of the surrounding groundwater and water ways. It can significantly alter the coastlines because of the impacts of nutrient pollution- which include eutrophication. Eutrophication refers to the harmful algal bloom created because of an abundance of nitrogen and phosphorus fertilizers. Algae has a high respiration rate and can consume oxygenated water faster than it can be replaced, ultimately creating dead zones with limited to no oxygen when the algae die and decomposes. Without oxygenated water, aquatic life cannot respirate and die, which leads to an overall decrease in biodiversity. Nutrient pollution can have devastating consequences for the Long Island Sound because it has limited wave action and water movement. If a significant number of septic systems fail it can render areas of Long Island Sound unusable from a recreational standpoint.

There are certain vulnerable populations who would be more at risk if they were to ingest the water or swim in it. These people include children, the elderly, immunocompromised individuals, and those with open wounds. These widespread hazards could be a reality for Clinton, CT if efforts are not taken to limit the risks of septic systems in vulnerable areas.

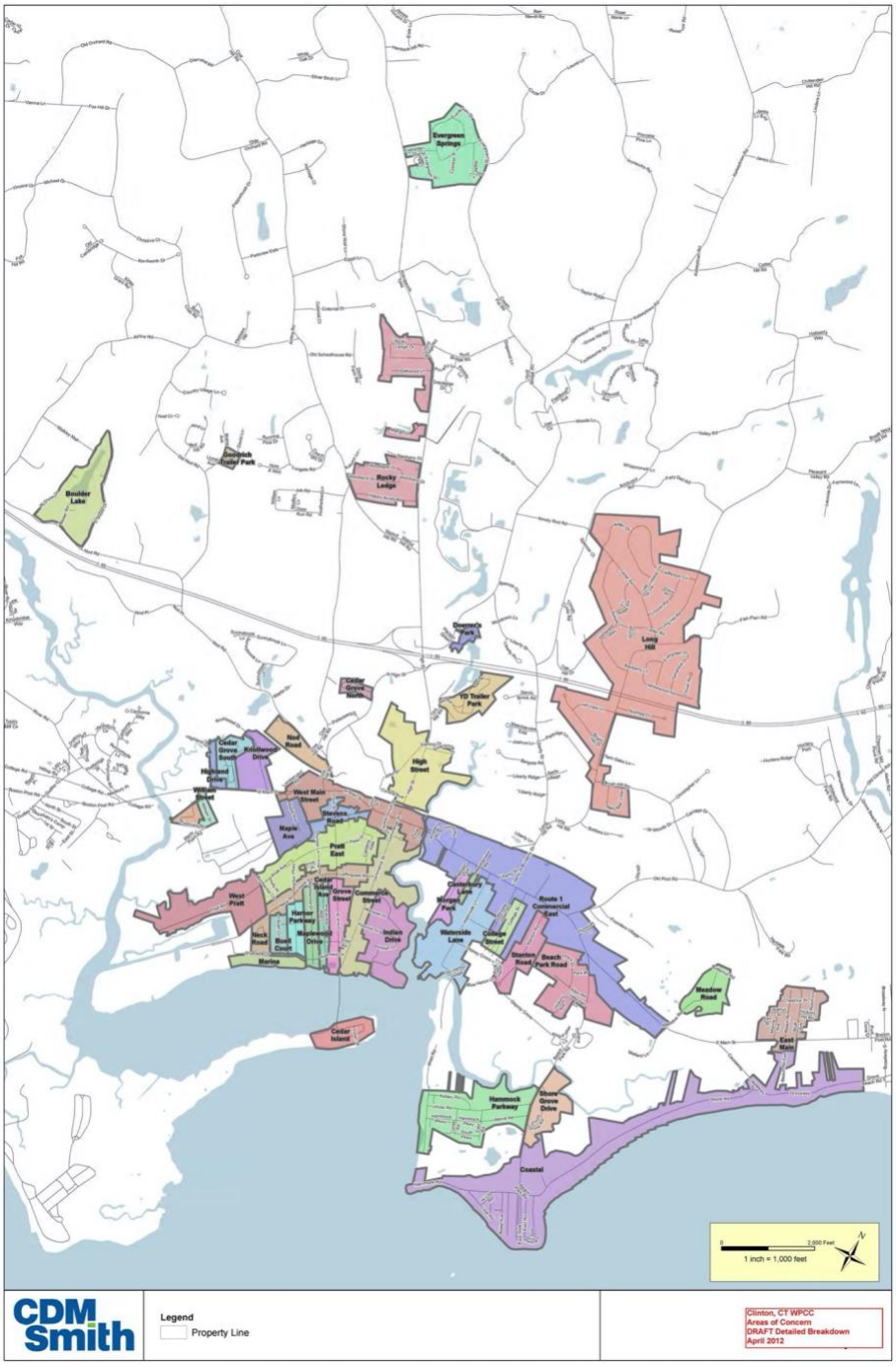
This is a particular area of concern within Clinton, CT because all residents are reliant on septic systems throughout the town, including along the coastline. In the entirety of Clinton there are 5,654 homes with septic systems. When zooming in and looking at Beach Park Road there are 44 septic systems. This street is of particular concern because of its proximity to not only the Long Island Sound, but also to the Hammock River. All of the areas of concern related to septic system systems are outlined in the map below.

Clinton has a storied history of challenges with septic systems within their neighborhoods, specifically within the Rocky Ledge neighborhood. While this area may not be

considered directly coastal it is in close proximity to a nearby Indian River that flows into Long Island Sound. So full septic failure would have far reached negative impacts. In these areas septic systems were and continue to be undersized, not properly up to code due to age, and had high ground water, ledge and/or poor soil. This limits the effectiveness of the septic systems and can contaminate sources of water, including surface and groundwater. This poses a risk to public health especially due to its proximity to the shoreline. These homes in the Rocky Ledge neighborhood are also dependent on wells for their sources of drinking water. The groundwater in the neighborhood, especially on the smaller lots, have been tested for high levels of pollutants including ammonia, nitrogen, and bacteria/viruses. This is likely due to proximity of the septic systems and wells. The land, composition of the soil, and the zoning (density of the homes) make it not well suited to have this type of infrastructure and there have been consent orders since the 1990s. There have been proposals to install a water main to service this neighborhood and the latest update was in 2017- funding is/was a challenge so there has been limited progress.

The goal of the water main project would connect individuals to a public water source and the water main extension project has the approval of the Department of Energy and Environmental Protection (DEEP) and the Connecticut Department of Public Health (DPH) and is supported by CRAHD as "the most desirable to solve environmental issues in the Rocky Ledge Area." Rather than creating a full sewer system or additional wastewater treatment it would simply expand upon an existing water main that provides a public water supply. Unfortunately, that seems like where efforts have stalled due to economic challenges. This establishes Clinton's relationship with septic issues and how there need to be action taken

regarding wastewater treatment.



Areas of concern for either existing or potential pollution issues related to on-site sewage treatment.

Economic consequences

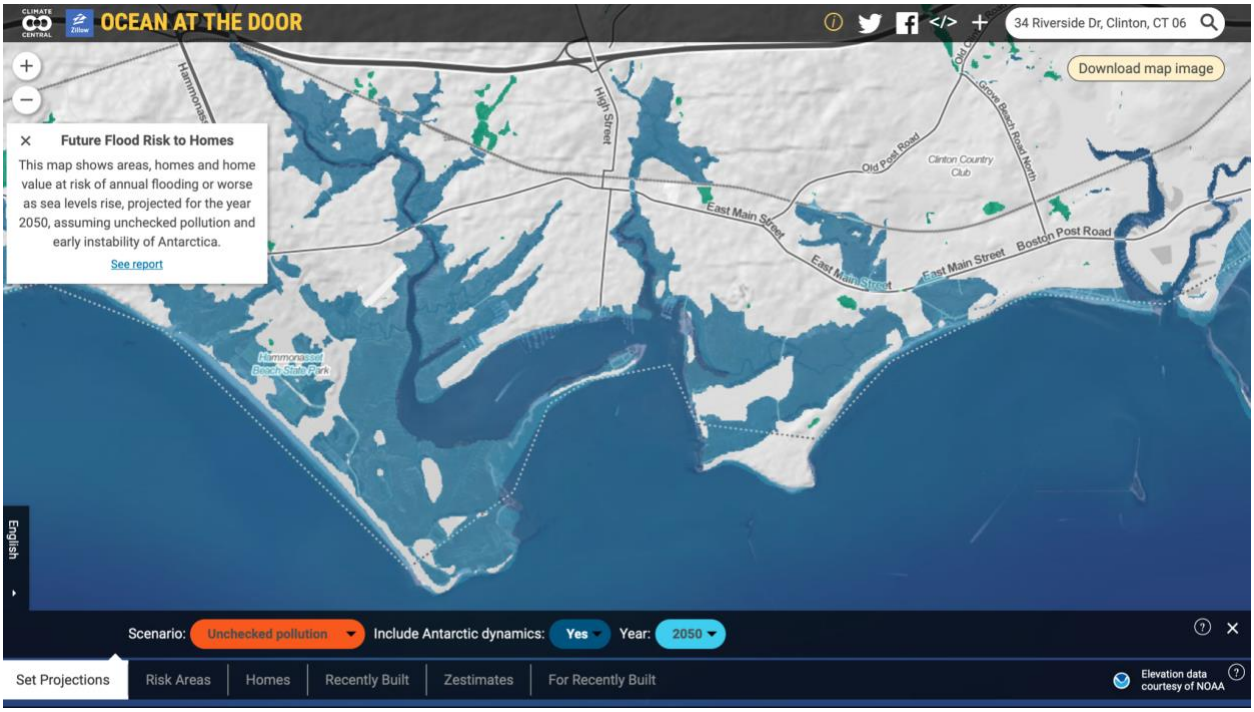
The most expensive homes in Clinton are located on the coastline. These homes are also the most vulnerable to sea level rise. They are right on the coast with little to no intermediary land or space between the water and the built structures. These homes make up a significant portion of the tax base that is included in Clinton's grand list. Therefore, it would be devastating not only from a personal standpoint if these homes were damaged from sea level rise, but it would also harm the economic health of Clinton, CT.

Zillow estimates and sea level rise

The red zones include areas that have homes that are appraised at over a million dollars. The shaded areas that are darker in color and have a blue tint are areas that are predicted to be inundated with sea water by 2050 if pollution continues to be unchecked. Clearly many of these expensive homes are predicted to be impacted by sea level rise.

The Cedar Island Marina is also an area of economic activity within Clinton. There are nearby homes as well. With even limited sea level rise this area could be subjected to nuisance flooding. There are openings within the seawalls and moorings where water can go over the edge. The area is largely constructed of impermeable surfaces so flooding could be significant depending on the nature of the event, whether it was simply high tide versus a storm surge event.

The train station is also located in close proximity to the Indian River that feeds directly into the Long Island Sound. It could be subject to storm surge, and this would have serious economic consequences if it was damaged because it serves as a connection to the entire Connecticut rail system. The Amtrak system throughout the entire northeastern corridor, including Clinton, CT, is vulnerable to sea level rise and climate change.

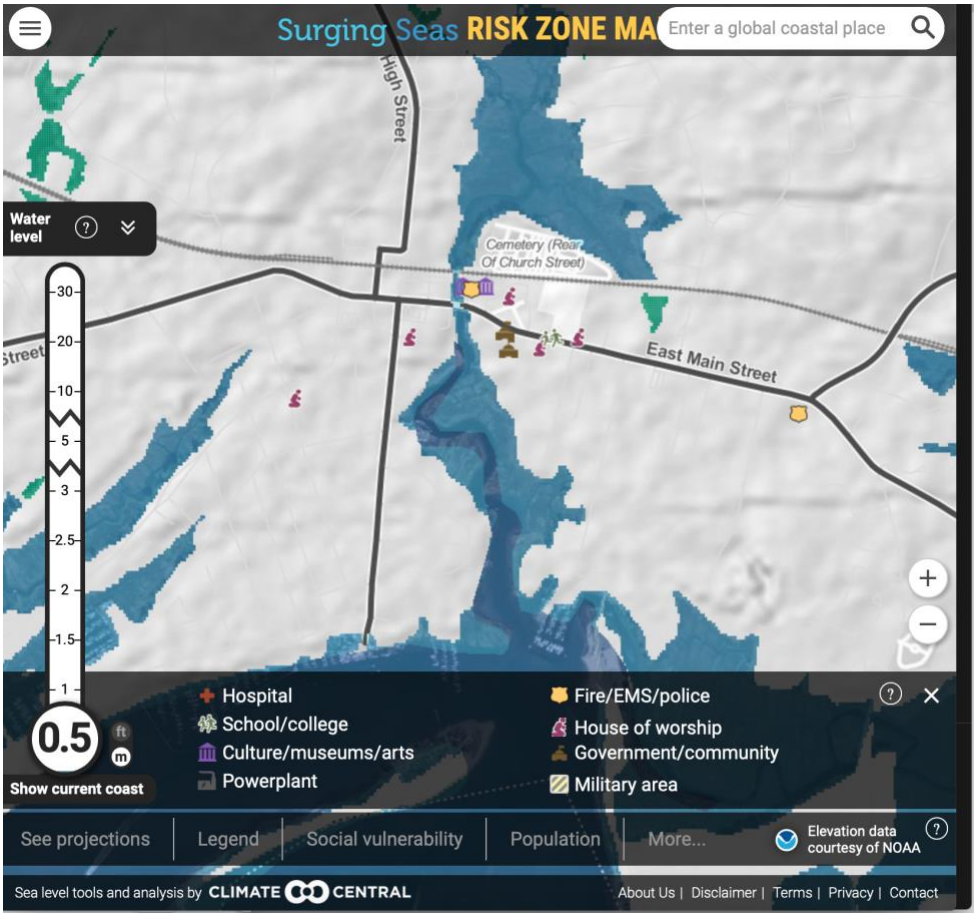


The dotted gray line is the railroad and with 0.5 ft of sea level rise it would be at risk from periodic flooding- this is a major hazard that could prevent the connectivity of the train station to the overall rail system.

Areas of Cultural Significance

Clinton is an incredibly historic town that has colonial roots. The coast is deeply ingrained in the history of Clinton and serves as the location for coastal trade as well as disputes between Americans and the British. Due to the nature of development, a significant portion of the historical areas are located near the shoreline.

Clinton expanded linearly along Main Street. Then expanded outwards towards the harbor in the agricultural and early industrial period. Many people who lived near the harbor at that time were in some way employed on the water ways. Oystering began in 1853. After 1850 Clinton became known as a summer beach town where people would rent rooms and cottages. Commerce street has historical homes and is an area where a lot of growth occurred in the 19th century. It is close to the water line along Clinton. Additionally, Liberty Street is a designated local historic district within the town of Clinton. Due to Clinton's economic history being related to the waterways there is a significant portion of historical homes along the coastlines that will be impacted by the predicted 0.5 meter or 1 foot 8 inches sea level rise by 2050, that was predicted/adopted by Connecticut Legislature. There are also 2 historically related museums along Church Road and a cemetery that is also located there. That would be vulnerable as well, under the same sea level rise scenario.



There are two historically related museums that are likely to be impacted by 0.5 m sea level rise that is predicted in Connecticut, the blue shading represents area that will be inundated by sea level rise

Adaptation strategies

Beach nourishment

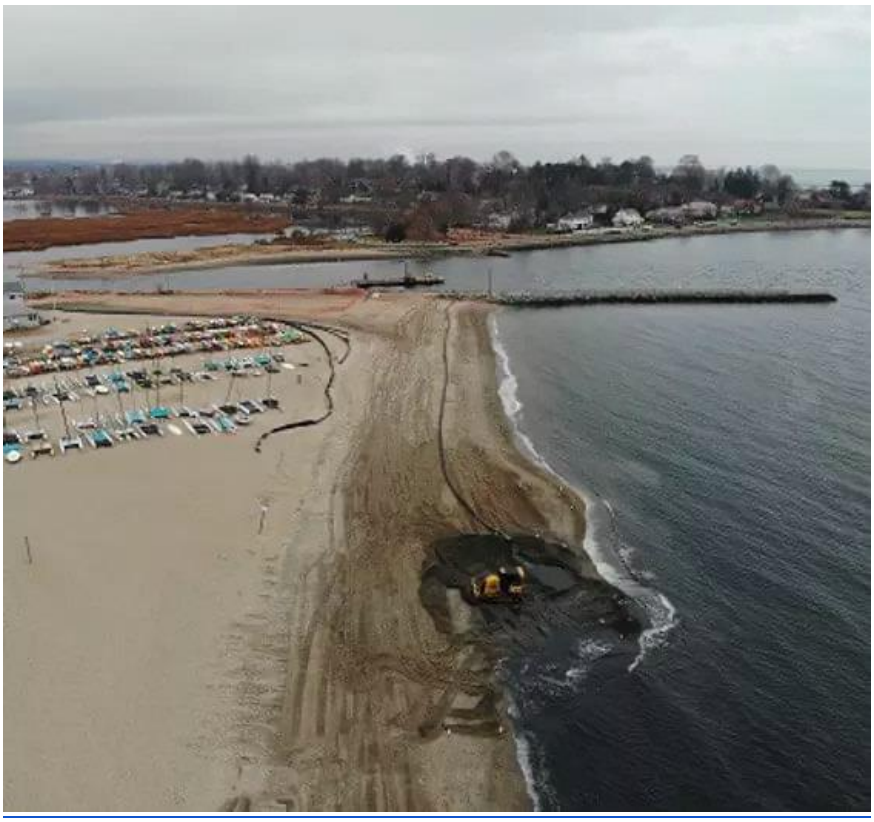
Beach nourishment is the process of adding sediment to a beach or in the nearshore. This is done to provide storm protection for coastal structures, strengthen the beach for recreational

use, and provide new habitat. Sand and other sediment is commonly dredged offshore and pumped directly onto the beach. Dredging is a process of removing built up sediment from waterways where the sediment is accumulating. This is done to replenish sediment displaced by erosion. This means that beach nourishment projects require a continuous supply of sediment due to the continued erosion.

The main benefit of beach nourishment is that it maintains the environment and requires the least behavioral change from the people who access it. To most people, it would look like nothing changed, just an occasional closing for the renourishment to occur.

The main disadvantage of beach nourishment is that it is a temporary solution to a permanent problem. The process of erosion cannot be stopped, any nourishment project will have to be continuously renourished. While all projects require maintenance, beach nourishment requires the most intensive maintenance.

Milford, CT recently underwent a beach nourishment project. The project began in 2016 when the Walnut and Wildmere Beach area was identified as a vulnerable area. This evaluation was done after Hurricane Sandy when the Long Island Sound area in general was hit fairly hard by the storm impacts. The intention of this project is to protect the shoreline and the residential neighborhood that is located right behind it from a 100 year storm event. It involved adding sand that matched the grain size of the beach to create a dune area. They then seeded the dunes with America beach grass to reinforce the structural integrity of the dune, to preserve the sediment depositions, and provide an opportunity for increased biodiversity. This project and beach nourishment in general provides a multitude of benefits because it enhances the landscape, creates habitats, and serves as a protective barrier from erosion and storm events.



This image shows beach nourishment in Fairfield, CT that was conducted in 2020 and 27,000 cubic yards of sand was hydraulically pumped onto the beach from a local Marina dredging project

Sea walls

Sea walls are an adaptation strategy where a wall is constructed along the coast. This protects the land behind the wall from flooding by creating a barrier between the coast and the inland. Sea walls are typically constructed from concrete, steel, or boulders. A benefit of sea walls is that they offer the best protection against storm surge and sea level rise, but they may interfere with natural erosion patterns and shoreline habitats. While sea walls do require maintenance, if maintained properly, they will last longer than soft engineering options, like beach nourishment as seen by numerous sea walls that are hundreds of years old. A disadvantage

to sea walls is the change in wildlife and erosion patterns. By constructing sea walls, wildlife and erosion patterns are disrupted and can have unpredictable consequences in neighboring areas. Another factor of sea walls that should be considered is the cost. The cost of a sea wall can vary greatly, as it depends on numerous factors, such as height, design, wave strength, and construction material.

Sea walls have the potential to be used as a renewable energy source, by capturing the energy of the waves. This has the benefits of being a green and renewable energy source but has the disadvantage of further increasing the price of the sea wall and requiring more intensive maintenance.

A significant number of Connecticut beaches include sea walls in their design of their shorelines and town beaches. There is a distinctive New England style that complements the shoreline rather than detracting. They can be set right on the beach or shoreline or may be a way back. A few towns in Connecticut that utilize sea walls along their town beaches are Stratford, Stamford, and Greenwich (this is not an exhaustive list).

While seawalls are prominent along the Connecticut shoreline, they have harmful environmental consequences and are not a true protection against sea level rise. Sea walls and other engineered structures are regulated by the CT DEEP coastal permit program and are discouraged by the policies of the Connecticut Coastal Management Act. Bulkheads, seawalls, revetments, jetties, and groins are often only permitted to protect existing structures and water dependent uses, such as a marina, and even so they are highly discouraged. There are environmental consequences associated with built shoreline protections that impact biodiversity, shoreline habitats, and overall changing of the shoreline when engineered solutions are put into place. Therefore, in the state of Connecticut, there will be limited construction of new sea walls

because of the immense difficulty in getting a permit from CT DEEP, so it is not a viable adaptation strategy.

Above is an example of a sea wall in Stamford, CT. (Photo: Chris Burke)

Living sea walls

Living sea walls are similar to regular sea walls but are built to mimic habitat surfaces to provide an ecosystem for aquatic organisms. Regular sea walls are usually too smooth for organisms to live on but living sea walls have surfaces that aquatic organisms can easily attach to. Living sea walls have the same benefits of regular sea walls, but with less of the drawback of ecosystem interruption and decreased biodiversity. This is not to say that there is no interruption to wildlife patterns and biodiversity, just less than regular sea walls. While they offer these benefits, they are more expensive and require more maintenance than regular sea walls.

A living sea wall project in Australia

Living shoreline projects

There are numerous living shoreline projects that are being completed along the coast of the Connecticut shoreline. A significant project occurred in Stratford Point in Stratford, CT that has been a massive success. The project began in May of 2014 under a DEEP pilot program. The goal was to restore an area of degraded tidal marshes along the northern shoreline. There were remediation efforts to remove lead contaminants from lead shot from the gun club that was previously there. Then 64 marine compatible concrete reef balls were installed in effort to limit coastal erosion, provide opportunities for sedimentation, and create a biodiverse habitat. The initial installation was an immense success and increased sedimentation to up to 60 cm in some locations. The sedimentation increased marsh development and then acted as a feedback loop to increase sedimentation even more. In 2016 the project was expanded, and 273 additional reef balls were installed. There were further efforts to plant native marsh grasses which has improved

the marsh ecosystem. This project speaks to the success of mimicking ecosystems and installing nature-based infrastructure solutions to protect shorelines.

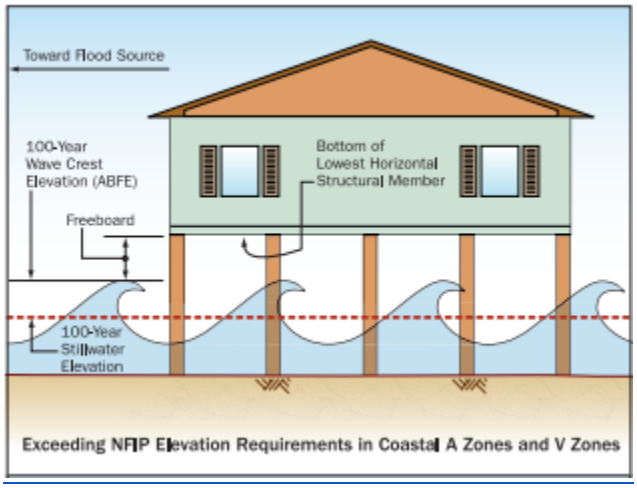
Reef balls along the coastline of Stratford, CT

Elevating structures

Elevating structures are an option for built structures in the wake of flooding. By raising built structures on elevating structures, they are out of the way of flooding. Houses on elevating structures are constructed by and for the homeowner so most of the expenses are covered by the homeowner, usually with a discounted flood insurance.

Elevating structures offer a similar benefit to beach nourishment in that aside from the house being a few feet in the air, there is very little behavioral change required of residents. They also offer the unique benefit of keeping unwanted vermin out of houses. A disadvantage of

elevating structures is that they can be visually unappealing and may upset neighbors if an elevated house blocks their oceanfront view. Although there are benefits associated with elevating structures, the infrastructure that must be on the ground is still being flooded. This means that emergency services still would not be able to access places they could be needed in an emergency because of flooding. Also typically, cars are kept underneath the house to save horizontal space, so when homes are elevated, there is nothing to protect the cars from floods. Rather residents would have to park their cars at a higher elevation, farther away from their homes during a flood event. However, if elevating structures is combined with other adaptation strategies, they become far more effective and meaningful than just on their own.



FEMA designing a home to be elevated a foot above the above the Base Flood elevation

Low Impact Development

Low impact development otherwise known as green infrastructure mainly addresses storm water. It aims to mimic or use natural processes to ensure storm water is infiltrated into ground water or returned to hydrologic cycle. Low impact development enhances water quality

by reducing runoff and therefore pollution in nearby bodies of water. Some examples of low impact development include bioretention facilities, rain gardens, vegetated rooftops, rain barrels and permeable pavements. LID also aims to reduce impervious ground cover that typically prevent water from infiltrating the ground.

Low impact development options

Retreat

One final option is retreat. Retreat can be either a voluntary process or through the state. Homeowners may not want to be subjected to sea level rise and storm surge therefore they may voluntarily choose to move. If individuals have no desire to move the state can purchase private property through eminent domain. This may occur on the coast when it costs more to maintain these properties than to outright purchase. This is an option when attempting to maintain the current coastline becomes impossible due to extreme erosion and sea level rise. The new coastline would be moved inland. The property that currently exists on the coast can either be torn down or abandoned, and the land can either be used to construct other coastal defenses or left as an intertidal habitat.

Managed retreat is not a new concept and has historically been utilized throughout Connecticut. One of the earlier examples of retreat is in Ocean Beach Park, New London, CT after the Hurricane of 1938. Because of the intense damages suffered by homes along the coastline rather than rebuilding in the same place the area was surrendered and turned into a town beach. This along the area serves as a protective intermediary when there are large storm events and New London has and will continue to suffer less damages to homes as a result. A more recent example is in West Haven, Connecticut after Hurricane Sandy in 2012. Similar to New London, after Hurricane Sandy destroyed many homes, homeowners were given the option to sell their houses to the town of West Haven for their value before the storm. When the town of West Haven bought these houses, they were demolished, and the area is being turned into a protected wetlands that resembles its natural state 100 years ago.

Kristin Walker, project engineer for the USDA's Natural Resource Conservation Service, showing new plant growth in former home sites.

Recommendations

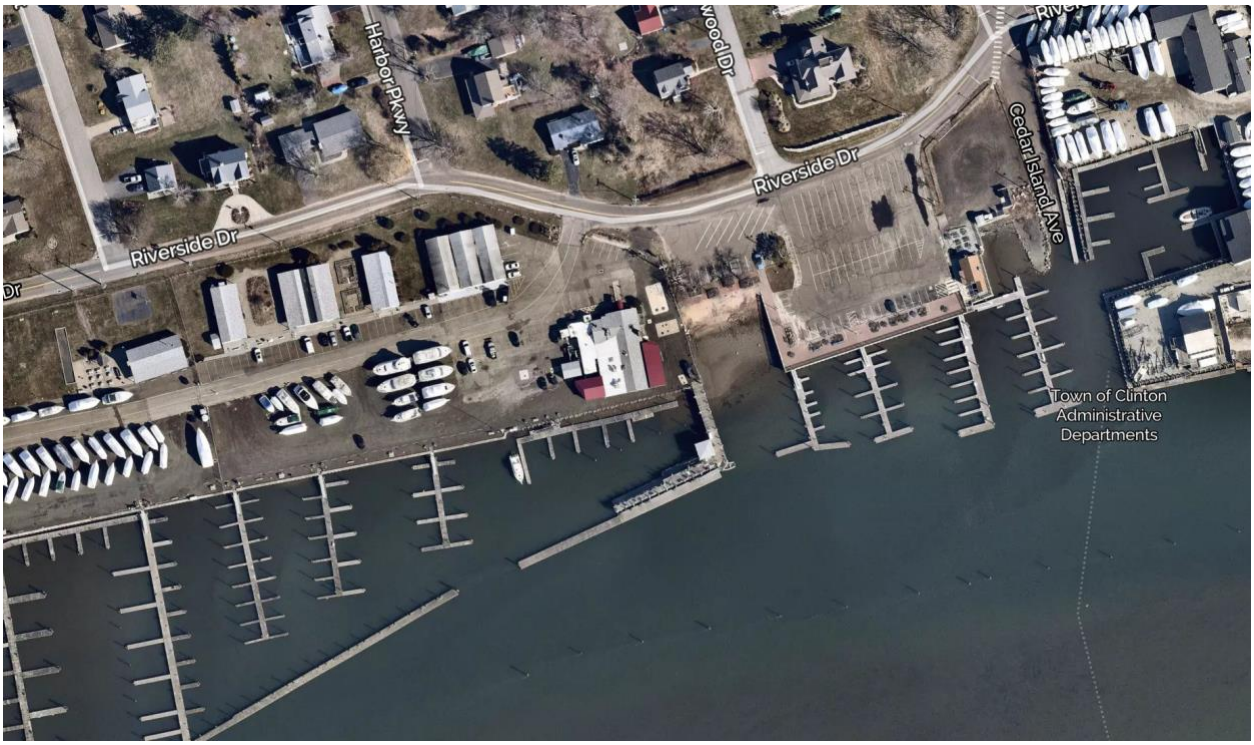
Low Impact Development (LID)

Low impact development and green infrastructure is strongly encouraged to be utilized in all new development throughout Clinton, CT. This is being implemented across the state of Connecticut and Clinton has the opportunity to be a leader in its implementation. When implementing these forms of development it minimizes stress on the stormwater system, recharges groundwater, and reduces erosion and pollution. It is recommended for all infrastructure, not only along the coastline. The stormwater system is often outdated and based on TP-40 standards. It would be challenging to resize the entire stormwater system, so it can be more beneficial to minimize the water that initially enters the stormwater system. Implementing pervious pavement in new developments, especially throughout parking lots, will reduce impervious cover. This will have numerous benefits including recharging ground water, reducing strain on the storm water system. Low impact development is best for addressing precipitation events, but it could aid in managing smaller instances of coastal flooding, even if it included salt water.

A particular area that could benefit from low impact development would be the implementation of bioswales or previous pavement along the sidewalk on Riverside Drive. This will provide a small last line of defense against smaller scale impacts of storm surge and flooding events. While also enhancing aesthetic values and creating more pervious ground cover. This could and should be applied throughout Clinton, even in non-coastal areas.

Another significant area within the marina includes a small beach. This can pose a risk with flooding because when the water level rises it can spill over onto the impervious surfaces

and it can flood the nearby homes that are off of Riverside Drive. This is an area that could benefit from native plantings. Adding sea grass along the edge of the beach will protect from storm surge. It would act as a line of defense. It is important that the plantings are salt tolerant because they will likely be periodically inundated with sea water when there is increase in sea level. This would also act as a guard against nuisance flooding.



Riverside Drive and the small beach that is included along the privately owned Harbor

Managed Retreat

Managed retreat is a multifaceted option because of its tremendous environmental benefits, but significant economic considerations and costs. Within the context of Clinton, Connecticut activity seems to be intensifying along the shoreline instead of decreasing. There has been significant investment in properties and business along the shoreline. These homes are a large contributor to the town's taxable grand list. Losing this high value tax base would have

negative consequences on the town's budget. There also is historical and cultural significance associated with living on the coastline. This emotional connection to the area makes it challenging to relocate this established community. That being said, from a strictly environmental standpoint, managed retreat is a valuable, forward thinking adaptation strategy. A component of managed retreat that can be utilized within Clinton, CT could be restricting further development and investment in areas that will be subject to frequent flooding, storm surge, and damage in the next few years. Additionally, the town of Clinton should focus on open space acquisition whenever possible as well as repetitive loss property acquisition, for homes that are frequently subjected to damage from flooding, in an effort to increase resilience.

It is crucial that future development is curtailed along the coastline to minimize the future vulnerability of residents and structures. These areas are already vulnerable to sea level rise and other coastal hazards. If there is further economic investment into these areas, there will be more extensive losses in the future. Clinton has recognized the importance of minimizing future financial investment of the coastline because it is not reliable long term in the Plan of Conservation and Development. Since this report was published in 2015 climate change has worsened and expanded making it even more critical that action is taken. This is an opportunity to plan for future resilience that will benefit the town overall that Clinton should not pass up.

Improving Coastal Resilience

The Town Beach can act as a stronger barrier and protect nearby homes because of its geographic location. One adaptation option that could be implemented within Clinton is replacing commercial turf grass to native coastal plantings. Rather than reseeding every year with commercial grass or turf, native plants and vegetation can be planted. This will provide

increased protection from storm surge as natural vegetation has better absorptive capacity. This is due to the deeper and more extensive root systems. It holds soil in place and ensures that there is minimized erosion. This also will enhance biodiversity. Native plantings will attract native organisms. Sea grass and small shrubbery also ensures that sand does not erode. There will be a savings associated with native plants rather than reseeding the grass every season. Traditional grass needs to be maintained with weekly mowing, which would not be needed with native plantings. There will be enhanced aesthetic values in comparison to regular grass. The Town Beach is an area that the town can explore as an alternative to traditional landscaping to improve coastal resilience. This a relatively low cost change that can provide environmental and aesthetic benefits to the town.

Beach nourishment is also a beneficial adaptation strategy that can be utilized. It would involve adding dredged materials to the surface of the beach. Previously Clinton had dredged the Harbor in 2019 to ensure it remained functional and gave the materials to Hammonasset Beach State Park which is a part of Madison, CT. This was ultimately beneficial because this area is geographically linked to Clinton. But another possibility that could be explored is utilizing dredging material in the future to revitalize and nourish the Clinton beach as well.

Wetland Enhancement

Clinton, CT features extensive coastal wetlands and salt marshes that provide valuable ecosystem services including coastal reliance. Enhancing wetlands offers further natural protection from sea level rise and storm surge. One way to enhance wetlands is to remove invasive plants and ensure that there is a healthy functioning ecosystem to provide a larger

absorptive capacity and water filtration. Another relatively new advancement in wetland advancement is Thin Layer Placement that is being tested on a smaller scale in nearby towns such as Guilford, CT. It involves adding thin layers of dredged sediment on top of the wetlands to enhance carbon sequestration and the resilience of the wetland itself. It enables there to be more native vegetation, a slightly higher elevation, and an overall healthier wetland ecosystem. While it has not yet been applied on a larger scale it is a promising approach that could be investigated to enhance the extensive wetlands within Clinton, CT.

Thin layer placement of sediment on a coastal wetland

Conclusion

Investing in adaptation strategies will improve quality of life for the citizens of Clinton and can help to boost the tourism industry and the overall economy. Additionally, adaptation strategies are evolving as the situation progresses and there will be advancements and innovations that address the changing climate future. There are several state and federal

opportunities for funding that Clinton can pursue in order to finance these adaptation strategies among others. It is crucial that Clinton commits itself to implementing adaptation strategies and continuing to research adaptation options that can best address Clinton's specific resilience needs.