Ossining’s Waterfront on the Rise
We would like to express our deep appreciation for the dedication and input from the Town and Village of Ossining, especially Town Supervisor Dana Levenberg and staff member Victoria Cafarelli, Village Mayor Victoria Gearity, Village Manager Karen D’Attore and Project Manager Jaimie Hoffman. The CaD studio would not have been possible without the insights of the Ossining stakeholders who participated in the process, providing guidance and feedback to the students.

We gratefully acknowledge the expertise and assistance given to the CaD studio by staff at a variety of Hudson Valley organizations including Scenic Hudson, NYS Department of State, NYS Department of Environmental Conservation, the Hudson River National Estuarine Research Reserve, Ossining School District, Riverkeeper, Green Ossining and Hudson Valley Arts & Sciences.

We would also like to thank the students who participated in the Fall 2019 graduate LA7010 CaDStudio, whose work is displayed here, including Gabriel Currant, Jihany Hassun Catherine Kana, Yuyao Liu, Juwan McIntyre, Marco Rangel, Mark Shrader, Akshai Wilkinson, Lingyi Xu, Dean Yeah, Zikun Zhang and Teaching Assistant Kevin Kim. We recognize the contributions of the engineering students who collaborated with us from Professor Todd Walter’s fall 2019 Watershed Engineering course.

This LookBook was made possible through a partnership between Cornell University Department of Landscape Architecture, Resilience Communications & Consulting, LLC and Cornell University Water Resources Institute, with funding from the Environmental Protection Fund through the NYS Department of Environmental Conservation’s Hudson River Estuary Program and Engaged Cornell. This material is based upon the work that is supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under Smith Lever project number 2015-16-210. Any opinions, findings, conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.

Sincerely,

Acknowledgments Contents

4 Getting to Know You
5 The CaD Studio
6 The Town & Village of Ossining
7 Climate Risk in Ossining
8 Project Study Area
9 Key Themes, Challenges and Opportunities
10 Design Strategies
11 CaD Principles
12 Resilient Waterfront Parks
14 Sustainable Shorelines
16 Strategic Relocation & Adaptive Reuse
18 Flood-Adapted Structures
20 Resilient Roadways and Infrastructure
22 Green Infrastructure
24 Looking Ahead
25 Next Steps & Keep In Touch!
26 Protecting The River That Connects Us
28 Design Strategy References & Funding Opportunities
30 Climate Smart Communities Actions
32 More information on Climate Change in the Hudson River Valley

The CaD Team
Joshua F. Cerra
Associate Professor & Director of Graduate Studies
Cornell Department of Landscape Architecture
jf299@cornell.edu
https://trophic.design

Libby Zemaitis
Climate Outreach Specialist
NYS DEC Hudson River Estuary Program
libby.zemaitis@dec.ny.gov
(845) 296-3163

Elizabeth LoGuidice
Principal
Resilience Communications & Consulting, LLC

Tim Dehn
Research Assistant
Cornell University MLA/MRP 2021

Elizabeth Fabis
Research Fellow
Cornell University MLA 2019

Elizabeth LoGuidice
Principal
Resilience Communications & Consulting, LLC

Tim Dehn
Research Assistant
Cornell University MLA/MRP 2021

Elizabeth Fabis
Research Fellow
Cornell University MLA 2019

Sincerely,

Acknowledgments Contents

4 Getting to Know You
5 The CaD Studio
6 The Town & Village of Ossining
7 Climate Risk in Ossining
8 Project Study Area
9 Key Themes, Challenges and Opportunities
10 Design Strategies
11 CaD Principles
12 Resilient Waterfront Parks
14 Sustainable Shorelines
16 Strategic Relocation & Adaptive Reuse
18 Flood-Adapted Structures
20 Resilient Roadways and Infrastructure
22 Green Infrastructure
24 Looking Ahead
25 Next Steps & Keep In Touch!
26 Protecting The River That Connects Us
28 Design Strategy References & Funding Opportunities
30 Climate Smart Communities Actions
32 More information on Climate Change in the Hudson River Valley

The CaD Team
Joshua F. Cerra
Associate Professor & Director of Graduate Studies
Cornell Department of Landscape Architecture
jf299@cornell.edu
https://trophic.design

Libby Zemaitis
Climate Outreach Specialist
NYS DEC Hudson River Estuary Program
libby.zemaitis@dec.ny.gov
(845) 296-3163

Elizabeth LoGuidice
Principal
Resilience Communications & Consulting, LLC

Tim Dehn
Research Assistant
Cornell University MLA/MRP 2021

Elizabeth Fabis
Research Fellow
Cornell University MLA 2019

Elizabeth LoGuidice
Principal
Resilience Communications & Consulting, LLC

Tim Dehn
Research Assistant
Cornell University MLA/MRP 2021

Elizabeth Fabis
Research Fellow
Cornell University MLA 2019

Sincerely,
The Climate-adaptive Design (CaD) studio

Getting to Know You

Who We Are

Inspiring change for waterfront communities

The Climate-adaptive Design (CaD) studio is a course created by Cornell University Associate Professor Joshua F. Cerra that links landscape architecture and engineering students with Hudson riverfront communities to explore design ideas for more climate resilient and connected waterfront areas.

The CaD studio is an education and research effort made possible by a partnership between the Department of Landscape Architecture, the NYS DEC Hudson River Estuary Program, the NYS Water Resources Institute and host communities in the Hudson Valley.

What We Do

The CaD team wants to help your community...

• Start the conversation on what change could look like on your waterfront.
• Feel inspired and knowledgeable about adapting to climate change, especially by using natural and nature-based solutions.
• Apply CaD concepts and principles in planning and decision making.
• Access new funding and resources.
• Communicate with regulatory agencies.
• Increase public awareness and support for climate adaptation projects.

What’s Next

• Appoint a committee to advance CaD concepts.
• Host a public event to display CaD materials and inform residents of the CaD design principles.
• Seek to apply CaD design principles to current projects.
• Identify CaD design ideas for future study and seek funding to advance designs toward implementation.
• Seek opportunities to increase local knowledge and capacity for increasing resilience.
• Consider pursuing Climate Smart Community certification or strive for a higher level of certification.
The Town & Village of Ossining
Making strides toward greater sustainability and resilience

Ossining is a Village of approximately 30,000 people, located in the Town of Ossining in Westchester County on the east side of the Hudson River and north of New York City. The Ossining waterfront hosts a wide variety of uses including residential, industrial, recreational and transportation-related activities. Additionally, the county waste water treatment facility and Sing Sing Correctional Facility are located on the waterfront. A Village-owned park adjoins a Town-owned park and boat club, which are all publicly-accessible amenities. All of these uses are at risk of flooding from the tidal Hudson and its tributary the Sing Sing Kill.

The Town and Village jointly hosted the Ossining CaD studio in the fall of 2019. Both municipalities are making great strides toward greater sustainability and resilience by pursuing or completing comprehensive plans and Local Waterfront Revitalization Plans. The Town is pursuing certification through the NYS Climate Smart Communities Program, and both municipalities recently participated in a Nature Conservancy Community Resilience Building workshop to better understand climate risks.

Flooding and Sea-level Rise

- The 1% or “100-year” floodplain is defined as a waterfront area that has a 1% chance of flooding in any given year, based on historical data.
- Added up over time, there is a 25% chance of such a flood happening over the span of a 30-year mortgage, making floodplain properties vulnerable to damage.
- These floods are likely to occur more frequently and impact more of the waterfront by the 2050’s due to projected sea-level rise and intense precipitation.
- NYS has adopted official projections for sea-level rise that are up to 58” higher than current levels by the 2080’s.

Climate Risk in Ossining

Flooding due to extreme precipitation, stormwater runoff, storm surge and sea-level rise.

Temperature extremes impacting seasonal conditions and causing dangerous heat waves.

Disrupted precipitation patterns leading to greater likelihood of short-term drought.

Depths of temporary flooding anticipated in the “100-year” or 1% flood zone on the Ossining waterfront for the present-day baseline condition.

Insulation depths (blue) and temporary flooding depths (green) for the “100-year” or 1% flood condition on the Ossining waterfront with 60” of projected sea-level rise during the 2080’s.

Data source: Columbia University Hudson River Flood Impact Decision Support System Version 2
The CaD studio focused on the Ossining waterfront during the fall semester of 2019. The study area stretched from Shattemuc Yacht Club in the north, to Sing Sing Correctional Facility in the south and included sites on Water Street located east of the waterfront. The study area included the Metro North Rail Station, the Village’s Henry Gourdine Park, the Town’s Louis Engel Park and Ossining Boat & Canoe Club and the future site of the Sing Sing Prison Museum.

Initial meetings with stakeholders helped student teams identify key themes, challenges and opportunities for the study area:

**Key Themes**
- Enhancing waterfront access and circulation, including elevating key infrastructure.
- Improving connections between the waterfront and the Downtown Business District.
- Ossining is a diverse community and the waterfront is used by residents and visitors alike.
- The Metro North commuter rail line is important to Ossining, as many residents work in NYC.
- Adequate, well-located parking, improved pedestrian mobility and way-finding signage are needed.

**Challenges**
- Most of the study area is already at flood risk.
- In particular, Sing Sing Correctional Facility west of the train tracks, the Westchester County Wastewater Treatment Facility and Metro North Railroad are at acute flood risk, posing public health and safety challenges.
- New York State official sea-level rise projections indicate that some areas will be inundated in the future.
- Steep slopes to the east of the waterfront pose constraints to addressing circulation and relocation options.

**Opportunities**
- Tourism and residential development are increasing.
- The Sing Sing Prison Museum, which is under development on the waterfront, is expected to attract thousands of visitors.
- Recent improvements to boating infrastructure have enhanced access for non-motorized boaters and larger vessels.
- The Village is seeking to convert a site on Water Street into a mixed-use/mixed-income development.
- The Town is seeking support to create a Master Plan and upgrade facilities at their waterfront park.
Each strategy comes along with **Actions to Take**—some that you can do today and others that will take more time and planning to implement. Each strategy also features student work to visualize possible ways they could be used in Ossining.

Five icons flag important facts about each strategy. Descriptions about these types of information are detailed here:

- **Important considerations for each strategy** are indicated by this icon.
- **Click here or go to page 29 to find sources of funding.**
- **For more information about a strategy, explore the references in this section, located on page 28.**
- **These numbers correspond to Climate Smart Community Actions that can earn points for your city. Click on the icon or visit page 30 to learn more.**

Ten student teams created comprehensive designs for the study area, which can be viewed in detail at [https://trophic.design/caD/](https://trophic.design/caD/). In their designs, students explored a number of strategies that employ the CaD principles. The following pages provide brief introductions to design strategies that Ossining can explore.

### CaD Principles

The CaD studio focuses on five key principles in its approach to waterfront design. These principles guide student work and inform the concepts they develop.

- **Design a Destination:** Maximize the value of what a waterfront can be.
- **Design for Flooding:** Working with water may be better than working against it.
- **Design with Community:** Waterfronts should be universally accessible and decidedly memorable.
- **Design with Nature:** A healthy Hudson is good for us and the greater ecology.
- **Design for Change:** Build value into waterfronts as they change over time.

These principles can create benefits both for people and the ecosystems in Ossining.
Waterfront parks are an excellent choice for flood-prone areas - they offer recreational opportunities, shoreline access and wildlife habitat, while reducing vulnerability and risk. Waterfront parks should be designed with input from end-users to meet the needs of the community and be universally accessible to people of diverse abilities, needs and resources. The park landscape can accommodate floodwaters and be graded to quickly drain after storm events.

The Ossining waterfront includes the Town’s Lewis Engel Park and Boat & Canoe Club and the Village’s Henry Gourdine Park. The properties experience flooding today and are projected to become more vulnerable in the future. The Town is pursuing funding for an Engel Park master plan and will consider sea-level rise in designs.

Actions To Take
- Consult resources such as the Guidelines for NYC Parks to analyze the resilience and accessibility of current waterfront parks.
- When establishing new parks and promenades in future flood-prone areas, identify flood-adapted uses and features that can recover quickly from storm impacts.
- The design of a floodable park should include recommendations for flood-resistant plants and trees.
- Review policies and procedures of the parks department and revise as needed to require more climate-adaptive and sustainable practices.
- Evaluate the feasibility of installation of green infrastructure to capture stormwater when designing or evaluating waterfront parks.

Waterfront park & promenade at Hunter’s Point South, Long Island City, provides an example of a flood-resilient park that is accessible and provides a memorable destination for visitors. Anticipating that site conditions will change over time, students speculated on the potential for park improvements to have evolving purposes with changing conditions. In this example, land shaping and specialized equipment has recreational uses in the near term. Later, as sites undergo projected inundation due to sea level rise, these same improvements could provide aquatic habitat.

Flexible open space can be periodically inundated by flooding without major infrastructure impacts. Flood-tolerant vegetation provides habitat and aesthetic benefits.

Resilient Waterfront Parks

Naturalized land cover helps to keep urban areas cooler and allows stormwater to infiltrate while providing habitat for wildlife and health benefits for people.

The term “green gentrification” describes inequities caused by environmental improvement projects. Greening of urban areas may increase local property values, which displaces lower-income residents. Municipalities can protect residents by enacting land control laws, increasing affordable housing availability and working with a Community Land Trust to promote home ownership.

Anticipating that site conditions will change over time, students speculated on the potential for park improvements to have evolving purposes with changing conditions. In this example, land shaping and specialized equipment has recreational uses in the near term. Later, as sites undergo projected inundation due to sea level rise, these same improvements could provide aquatic habitat.

DEC HREP | DEC CSC | EFC GISDP | DOS LWRRP | ORPHP | Hudson River Valley Greenway

712 Conserve, Re-vegetate & Reconnect Floodplains | 714 Strategic Relocation Of Non-Water Dependent Uses | 716 Green Infrastructure for Stormwater Management | 718 Nature-Based Shoreline Protection
Combining ‘soft’ features, such as tree and shrub plantings, along with ‘hard’ features like riprap can help stabilize shorelines while adding ecological benefits.

Waterfront park & promenade at Hunter’s Point South, Long Island City. Riprap protecting the shoreline is gently sloped and is adjacent to plantings.

A student design team during a prior Kingston studio proposed adding habitat complexity to bulkheads and sheet piling with enhancements that add textured surfaces and shelf and burrow tube retrofits to bulkheads and pilings.
Key assets at high risk for damage or permanent loss under current and projected flooding and sea-level rise should be relocated out of the flood zone. Alternatively, some structures may be repurposed or adapted to reduce flooding and inundation impacts. These kinds of interventions may benefit from enhanced zoning ordinances, policy measures or incentive programs to facilitate the transition of waterfronts to more adaptive and resilient uses and features.

The Village of Ossining can begin exploring options for funding strategic relocation of at-risk infrastructure and properties now to be prepared for future flooding. Options such as FEMA buy-outs and Transfer of Development Rights may provide solutions for repetitive loss properties.

This student project proposed phased plans to move buildings and infrastructure out of areas at greater risk of flooding and inundation due to projected sea-level rise.

### Strategic Relocation & Adaptive Reuse

Actions to Take

- Identify municipally-owned assets that are at high risk from flooding.
- Identify properties that have been repetitively damaged from flooding.
- Explore potential for Transfer of Development Rights (TDR) to steer development toward safe locations.
- Create a plan for the relocation of municipally-owned assets, (see Westchester County Hazard Mitigation Plan) to improve funding options through FEMA.
- Identify partnerships and funding opportunities to relocate municipally-owned assets and assist private property owners with relocation efforts.

### Transitioning residences, businesses, infrastructure and services out of the flood zone reduces risk.

- Returning floodplain functions provides benefits to people, wildlife and waterways.

### DEC HREP || DEC CSC || DOS LWRP || FEMA || HUD CDBG

- A just and equitable approach to strategic relocation is critical to its successful implementation.

### CSC

- 714 Strategic Relocation Of Non-Water Dependent Uses

### OCTREG

- New York Governor’s Office of Storm Recovery Report & Acquisition Program

This drawing visualizes a future waterfront that has transitioned from flood susceptible infrastructure at the mouth of the Sing Sing Kill to a public plaza, wetlands and a naturalized shoreline, along with flood-adapted and strategically-located waterfront uses.

In this vision of the 2080 waterfront the oil transfer facility, county waste water treatment plant and the east section of Sing Sing Correctional Facility have all been relocated to higher ground. The marina has moved to the former site of the correctional facility to maintain water-dependent, recreational opportunities along the waterfront.

This student project proposed phased plans to move buildings and infrastructure out of areas at greater risk of flooding and inundation due to projected sea-level rise.
Flood-Adapted Structures

If a structure is located in a flood-prone area, there are a number of actions that can be taken to reduce risk of damage. Options range from elevating an entire structure above the reach of floodwaters, to raising utilities within a building to keep them dry under flood conditions. Property owners can take steps to seal a building off from water or create conditions that allow the floodwaters to enter and exit with minimal disruption. Flood insurance rates may be reduced by flood-proofing or elevating buildings.

Actions To Take

- Become familiar with the NYS official sea-level rise projections.
- Conduct or update vulnerability assessments to identify key assets located in the current and future flood zones.
- Raise utilities (outlets, HVAC, etc.) to the 2080’s 500-year flood height on municipal properties on the waterfront.
- Evaluate the long-term costs and benefits of flood-adapting vs. strategic relocation in flood-prone areas.
- Consider extending where additional two-foot freeboard restrictions on first-floor uses are required by local zoning code.
- See the NYS Community Risk and Resiliency Act (CRRA) guidance for model local laws.

At-risk buildings in the current and/or future 180-year floodplain can be retrofitted using flood adaptation techniques if strategic relocation is not feasible.

Increasing the resilience of structures located in flood-prone areas has many benefits including reduction of hazards during and after floods, greater ability to return to functionality after a flood event and cost savings from avoided damages.

Communities should consider sea-level rise projections when planning for future flood risk. FEMA recommends considering raising new residential structures to the 500-year flood elevation in high-risk flood zones.

NYS DEC Community Risk & Resiliency Act Model Local Laws

FEMA: Floodproofing Non-Residential Buildings
FEMA: Designing For Flood Levels Above Base Flood Elevation (BFE)

The Clearwater Home Port in Kingston is an example of a flood-adapted structure. Note the large doors that can be opened to allow floodwaters to enter in and out of the building. Concrete floors and other water-resistant materials aid in rapid recovery after a flood.

This schematic drawing depicts a proposed sunken garden that captures stormwater from buildings and paved areas. New construction is elevated, allowing for potential floodable uses below such as parking and gathering spaces.

7.1 || 7.14 || 7.19

DEC OCC || WQIP (for waste water treatment plants) || FEMA || HUD CDBG

DEC DEC Community Risk & Resiliency Act Model Local Laws

The Clearwater Home Port in Kingston is an example of a flood-adapted structure. Note the large doors that can be opened to allow floodwaters to enter in and out of the building. Concrete floors and other water-resistant materials aid in rapid recovery after a flood.

This schematic drawing depicts a proposed sunken garden that captures stormwater from buildings and paved areas. New construction is elevated, allowing for potential floodable uses below such as parking and gathering spaces.
Resilient Roadways and Infrastructure

Roadways and rail lines can be vulnerable to flooding if they are located in close proximity to waterways. Bridges and culverts may contribute to flooding by restricting water flow during heavy precipitation. Infrastructure that is frequently flooded may need to be elevated or relocated to improve safe access under all conditions. A ‘complete street’ approach to new roadway design considers pedestrians, bicyclists and other users in addition to motor vehicles. Nature-based features, like rain gardens and bioswales, can be strategically placed to absorb stormwater from paved roadways and parking lots.

Students considered the resilience of infrastructure, such as the rail line and Metro North Train Station, the Westchester County Wastewater Treatment Plant and roads connecting the waterfront to downtown.

Actions To Take

- Identify vulnerable roadways and infrastructure.
- Develop an inventory and prioritization plan for infrastructure upgrades.
- Include upgrades in your municipality’s capital improvement plan.
- Make sure that infrastructure upgrades are included in your municipality’s FEMA Hazard Mitigation Plan.
- Consider use of pervious surfaces when designing roadways, paths and parking lots.
- Learn more about the Hudson Estuary Culvert Prioritization Project, which may provide assistance in identifying culverts that are contributing to flooding and/or pose barriers to aquatic migration.

Green street design tools, which integrate stormwater control and management within the right-of-way, are a critical component of complete street design, ensuring the street remains usable and safe for all people during storm events, regardless of mode.

DEC HREP, DEC CSC, WQIP (aquatic connectivity restoration), EFC GIGP, FEMA

Communities that identify flood-prone roads and infrastructure in their Hazard Mitigation Plans may be eligible for FEMA funding to mitigate these problems after a declared disaster.

7.21 Hudson Estuary Culvert Prioritization Project, NYC DEP Stream Crossing Best Management Practices

These images envision elevating tracks to allow water to flow freely beneath them during flooding while community uses can take place beneath the rail during dry periods.

A "complete streets" approach offers non-motorized transportation options and includes trees and other plantings help absorb storm water while increasing shade.
Green Infrastructure

Green infrastructure (GI) enhances or mimics characteristics and processes of the natural landscape. These practices employ naturalized land cover to maintain or restore the pre-development flow patterns of stormwater at a site by allowing runoff to soak into the soil. On a regional scale, green infrastructure includes preserving and restoring natural landscape features, along with reducing impervious cover. At the site scale, green infrastructure includes practices that capture stormwater runoff such as vegetated swales, infiltration planters, green roofs, pervious pavement and rain barrels. These practices allow water to soak into the soil to be used by plants or to recharge groundwater. Nature-based features typically provide additional co-benefits like improving water quality or providing habitat.

Actions To Take

□ Become familiar with GI techniques by reviewing chapter 5 of the NYS Stormwater Management Design Manual.

□ Visit GI in the Hudson Valley using the NYS DEC’s Green Infrastructure Examples website to identify locations.

□ Read Newburg’s GI Feasibility Report for an example of planning for GI.

□ Complete an analysis to prioritize locations that would benefit the most from GI.

□ Require new development to conserve existing natural features and use GI before traditional pipe-and-gutter solutions.

□ Add GI to municipal properties.

Green infrastructure can improve water and air quality, store carbon, enhance habitat diversity and cool urban areas during hot times of the year.

Green infrastructure projects should be sited in locations that will maximize stormwater benefits and minimize the potential for gentrification of nearby neighborhoods.

6.8 Green Parking Lots || 6.9 Complete Streets || 7.8 Shade Structures in Public Places || 7.16 Green Infrastructure for Stormwater Management

NYSDEC's GI in the Hudson River Valley
NYS’s Stormwater Management Design Manual
A GI Guide for Small Cities, Towns and Rural Communities
City of Newburgh’s Green Infrastructure Feasibility Report

DEC HREP || DEC CSC || DEC WQIP || EFC GIGP

A "green corridors" concept that includes installation of green infrastructure along roadways within new development projects to connect the Downtown Business District to the waterfront.

This image from a prior studio in Kingston, NY depicts urban trees and other types of green infrastructure that contribute to the aesthetic and vitality of a neighborhood.

This image depicts a wetland area that can enhance habitat value and add aesthetic interest on waterfronts.

This image depicts sections of the railroad tracks are protected by a combination of berms and nature-based features including trees and stormwater planters.
Looking Ahead

Next Steps

☐ Learn more about protecting and restoring the Hudson River estuary on pages 26 & 27.

☐ Explore the design strategy references on page 28.

☐ Research funding opportunities listed on page 29.

☐ Share this Look Book with municipal staff, elected officials, planning boards, waterfront stakeholders and other interested people.

☐ Consider joining the Hudson River Flood Resilience Network of municipalities.

☐ Stay in touch and contact us with ideas, questions or if you are in need of assistance.

Keep in Touch!

Joshua F. Cerra
Associate Professor
Cornell University Department of Landscape Architecture
jfc299@cornell.edu
https://trophic.design

Libby Zemaitis
Climate Outreach Specialist
NYS DEC Hudson River Estuary Program
libby.zemaitis@dec.ny.gov
(845) 256-3153

Stay in touch and contact us with ideas, questions or if you are in need of assistance.
A History of Human Development

The Hudson's natural shorelines have been altered by human development over the past 200 years. An inventory of shoreline types by NYSDEC found that nearly half of the shoreline from the Mario M. Cuomo Bridge to the Troy dam has been altered by bulkheads and riprap, dikes and other hard structures intended to protect property from erosion or to facilitate industry, transportation or cultural use. Comparisons between modern and historic maps have estimated that 71 miles of shoreline in the upper estuary were eliminated when shallows and backwaters were filled during construction of the federal navigation channel. The loss of natural shorelines and shallow water habitats have impacted ecosystem function and fish populations.

Comparisons between modern and historic maps have estimated that 71 miles of shoreline in the upper estuary were eliminated when shallows and backwaters were filled during construction of the federal navigation channel. The loss of natural shorelines and shallow water habitats have impacted ecosystem function and fish populations.

Looking Into the Future

How communities respond to sea level rise will affect the health of the Hudson. Protecting against flooding by building hard structures like sea walls and levees can lead to unintended consequences. When barriers are overtopped by floodwaters serious damage can occur. Hard structures may increase erosion and flooding of adjacent areas and do not commonly provide habitat value. If your community has critical infrastructure that may require the protection of hard structures, a good reference to start with is the "20 Questions to Ask When Building Defenses to Protect Hudson River Shorelines." It is important to meet with the NYSDEC Regional Permits Program early in the planning stage of any waterfront project to understand shoreline protection regulations.

Restoring Hudson's Habitats

Initiatives to protect natural landscapes and to restore critical habitats are ongoing. Land use ordinances, dam removals, re-vegetating stream banks and wetland restoration efforts are important to the future of the estuary. The Hudson River Comprehensive Restoration Plan, was produced in 2018 by a consortium of NGOs, public agencies, municipalities and academic institutions. The plan includes an assessment of current conditions and sets goals for ecosystem restoration and conservation. Learn more at http://thehudsonweshare.org/.
Design Strategy References

Resilient Waterfront Parks
Design and Planning for Flood Resiliency: Guidelines for NYC Parks
High Performing Landscape Guidelines: 21st Century Parks for NYC
Naturally Resilient Communities

Hudson River Sustainable Shorelines
http://medium.com/hudsonriver/sustainable-shorelines

Sustainable Shorelines
NYS DOCS Geographic Information Gateway Living Shorelines
http://nys.dostrm.gov/index.html
Hudson Valley Natural Resource Mapper
http://hvdgis.hudsonvalleymap.org/hvnrjm/hvnrjmap.html
RAPID Assessment Protocol Manual
https://nysmap.com/rapid-assessment-protocol
Waterfront Edge Design Guidelines (WEDG)

Strategic Relocation & Adaptive Re-use
Climigration Network
www.climigration.org

Flood Adapted Structures
NYS Community Risk and Resilience Act Model Local Laws
https://climigration.org/NYS-CRRA
FEMA: Flooding Non-Residential Buildings
https://www.fema.gov/flooding
FEMA: Designing for Flood Levels Above the BFE
https://www.fema.gov/flooding

Resilient Roadways & Infrastructure
U.S. Climate Resilience Toolkit: Rebuilding Roadways to Maximize Resilience
https://toolkit.climate.gov/case-studies/rebuilding-roadways-maximize-resilience
NYS DEC Stream Crossings: Best Management Practices
http://www.dec.ny.gov/pubs/44044.html

Green Infrastructure
GI Examples for Stormwater Management in the Hudson Valley
https://www.dec.ny.gov/lands/58930.html
NYC’s Stormwater Management Design Manual
http://www.dec.ny.gov/lands/20721.html
A GI Guide for Small Cities, Towns and Rural Communities
https://medium.com/go-green
"City of Newburgh GI Feasibility Report"
https://medium.com/go-green

Funding Opportunities
State and federal agencies offer financial assistance to municipalities and non-profit organizations for activities building resilience to waterfront flooding, sea-level rise and other climate risks.

Agency | Assistance Program | Grant amounts, required match | Department of Environmental Conservation (DEC) | Hudson River Estuary Program (HREP) | $10,500-$50,000, 15% match |
| | | | Climate Smart Communities (CSC) | Climate Smart Communities (CSC) | $10,000-$2M, 50% match |
| | | | Water Quality Improvements Program (WQIP) | Water Quality Improvements Program (WQIP) | 25-60% match |
| | | | Trees for Tribes | Trees for Tribes | N/A |
| | | | Environmental Facilities Corporation (EFC) | Wastewater Infrastructure Engineering Planning | $100,000-$200,000, 20% match |
| | | | Clean Water Revolving Loan Fund | Clean Water Revolving Loan Fund | N/A |
| | | | Green Innovation Grant Program (GIGP) | Green Innovation Grant Program (GIGP) | 10-60% match |
| | | | Hazard Mitigation Assistance (HMAA) | Hazard Mitigation Assistance (HMAA) | Over $3M, 25% match |
| | | | Public Assistance | Public Assistance | N/A |
| | | | Community Rating System (CRS) | Community Rating System (CRS) | N/A |
| | | | Local Waterfront Revitalization Program (LWRP) | Local Waterfront Revitalization Program (LWRP) | 15-25% match |
| | | | New York State Energy Research and Development Authority (NYSERDA) | NYSERDA | ≤$250,000, no match |
| | | | NYS Office of Parks, Recreation and Historic Preservation (OPRHP) | OPRHP | ≤$300,000, 25-50% match |
| | | | US Housing and Urban Development (HUD) | HUD | ≤$10,000-$900,000, 0-5% match |
| | | | Empire State Development | Empire State Development | 80% match for soft costs |
| | | | Hudson River Jewish Community Funding Options | Hudson River Jewish Community Funding Options | N/A |
| | | | NYS Office of Parks, Recreation and Historic Preservation (OPRHP) | NYS Office of Parks, Recreation and Historic Preservation (OPRHP) | ≤$300,000, 25-50% match |
| | | | Open Space Funding Options | Open Space Funding Options | N/A |
Relevant Climate Smart Community Actions

Get points and funding projects related to CaD concepts through the state’s Climate Smart Communities certification program. See related actions below and learn more at: https://climatesmart.ny.gov/

Pledge Element 6: Reduce greenhouse gas emissions through use of climate-smart land-use tools

6.1 Develop and adopt a comprehensive plan with sustainability elements
6.2 Incorporate smart growth principles into land-use policies and regulations
6.3 Adopt a renewable energy ordinance
6.4 Establish green building codes
6.5 Create resource-efficient site design guidelines
6.6 Incentivize renewable energy and energy efficiency projects
6.7 Adopt land use policies that support or incentivize farmers’ markets, community gardens and urban and rural agriculture
6.8 Adopt green parking lot standards
6.9 Adopt a complete streets policy
6.10 Implement strategies that support bicycling and walking
6.11 Install electric-vehicle infrastructure
6.12 Implement strategies that increase public transit ridership and alternative transport modes
6.13 Implement a Safe Routes to School program
6.14 Implement traffic calming measures
6.15 Adopt and enforce an anti-idling ordinance
6.16 Implement transportation technology solutions
6.17 Develop a natural resource inventory
6.18 Develop a local forestry or tree planting project or program
6.19 Preserve natural areas through zoning or other regulations

Pledge Element 7: Plan for adaptation to unavoidable climate change

7.1 Conduct a vulnerability assessment
7.2 Develop a climate resiliency vision and associated goals
7.3 Review existing community plans, policies and projects to identify climate adaptation strategies and policies or projects that may decrease vulnerability
7.4 Develop climate adaptation strategies
7.5 Incorporate climate resilience vision, goals, and strategies into local plans and projects
7.6 Update the multi-hazard mitigation plan to address changing conditions and identify specific actions to reduce vulnerability to natural hazards
7.7 Develop and implement a heat emergency plan
7.8 Require shade structures and features in public spaces
7.9 Open new or expand existing cooling centers
7.10 Create or update a watershed assessment to identify flooding and water quality priorities
7.11 Adopt a floodplain management and protection ordinance to reduce vulnerability to flooding and erosion
7.12 Conserve, revegetate and reconnect floodplains and buffers in riparian areas
7.13 Conserve natural areas for species migration and ecosystem resilience
7.14 Facilitate a strategic relocation of uses that are not water dependent from flood prone areas
7.15 Promote community flood prevention strategies through the National Flood Insurance Program Community Rating System
7.16 Use green infrastructure to manage stormwater in developed areas
7.17 Conserve wetlands and forests to manage stormwater, recharge groundwater and mitigate flooding
7.18 Use natural, nature-based or ecologically enhanced shoreline protection
7.19 Expand areas in which the two foot freeboard requirement applies
7.20 Require consideration of sea level rise in planning coastal development
7.21 Right size bridges and culverts and remove unnecessary and hazardous dams
7.22 Develop or enhance early warning systems and community evacuation plans
7.23 Implement a water conservation and reuse program
7.24 Encourage xeriscaping
7.25 Implement a source water protection program
**More Information on Climate Change in the Hudson River Valley**

<table>
<thead>
<tr>
<th>Websites</th>
<th>URL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resources for resilience</td>
<td>tinyurl.com/resilienceres</td>
</tr>
<tr>
<td>Hudson River Sustainable Shorelines</td>
<td>hrnerr.org/hudson-river-sustainable-shorelines</td>
</tr>
<tr>
<td>NY Climate Smart Communities</td>
<td>climatesmart.ny.gov</td>
</tr>
<tr>
<td>Hudson River Estuary Program grants</td>
<td><a href="http://www.dec.ny.gov/lands/5001.html">www.dec.ny.gov/lands/5001.html</a></td>
</tr>
<tr>
<td>Adaptation Clearinghouse</td>
<td><a href="http://adaptationclearinghouse.org/">http://adaptationclearinghouse.org/</a></td>
</tr>
<tr>
<td>NY Community Risk and Resiliency Act (CRRA)</td>
<td><a href="http://www.dec.ny.gov/energy/102559.html">www.dec.ny.gov/energy/102559.html</a></td>
</tr>
<tr>
<td>Estuary Program’s Climate Resilience webpage</td>
<td><a href="http://www.dec.ny.gov/lands/37386.html">www.dec.ny.gov/lands/37386.html</a></td>
</tr>
<tr>
<td>CAD studio designs from host communities</td>
<td><a href="https://caRAIN-designs.com/">https://caRAIN-designs.com/</a></td>
</tr>
</tbody>
</table>

**Interactive Maps**

| Hudson River Flood Mapper | www.ciesin.columbia.edu/hudson-river-flood-map/ |
| Protecting the Pathways, Scenic Hudson | https://caya.icr.org/ |
| Sea level Rise Mapper, Scenic Hudson | seahudson.org/ab/mapsec |
| NYS Department of State Geographic Information Gateway | http://cemap.dec.ny.gov/index.html#/map/resilience |

**Publications**

| Financing waterfront resilience fact sheet | tinyurl.com/finres |
| Rentailing Hudson Riverfronts, Scenic Hudson | tinyurl.com/CSCvideoSLR |
| Flood Adaptation Strategies for Hudson Riverfront Communities | www.nysersa.ny.gov/flood-strategies |
| NYSERDA’s Responding to Climate Change in New York ClimAID | www.nysersa.ny.gov/poecistleague |
| Hudson River Comprehensive Restoration Plan | http://thehudsonestuary.org/about-the-plan/ |

**Videos**

| Sustainable Shorelines | tinyurl.com/CSCvideoSS |
| Planning for Sea-level Rise | tinyurl.com/CSCvideoSLR |
| Climate-adaptive Design | tinyurl.com/CSCvideoCAD |