

An aerial photograph of a town situated along a wide river. The town features a mix of residential buildings, a church with a steeple, and a large industrial or utility complex in the foreground. The industrial complex includes several large cylindrical storage tanks, some of which are green and white. There are also parking lots, roads, and a building with a green roof. The river is filled with several sailboats. The surrounding area is densely wooded with trees showing autumn foliage in shades of green, yellow, and orange. The overall scene depicts a community with a blend of natural beauty and industrial infrastructure.

RESILIENT CATSKILL

*Report of the Catskill Waterfront
Resilience Task Force*

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RESILIENT CATSKILL: REPORT OF THE CATSKILL WATERFRONT RESILIENCE TASK FORCE

October 23, 2014

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Additional support and technical assistance for this project was provided by Scenic Hudson, the Lincoln Institute of Land Policy, the Consensus Building Institute, and the Dyson Foundation.



A MESSAGE FROM THE PRESIDENT

“Welcome to the Ever Improving Village of Catskill”

That's a tagline we have been promoting for years. Most of our recent improvements are part of an overall strategy, but some improvements have been by accident or by necessity. Our waterfront is home to many of our residents, businesses, schools, parks, and infrastructure. Improving these accidentally is not an option; we needed a strategy for the future of our waterfront.

We are experiencing a shift in the way we view our waterfront and the assets tied to it.

We realize that our waterfront is a tremendous asset but it is also one that comes with a significant risk. We can't ignore the fact that we recently experienced two major weather incidents in a short timeframe. Regardless of the debate over the causes of sea level rise, and the ranging possibilities of its rate, we needed to go through this process of planning for what's become a new normal of larger storms and the flooding they bring.

The Task Force and our journey

As I write this, I'm going back in my mind to the journey this task force made since the first meeting. Each member brought their own experiences, skillsets, and passions to the table but all stayed true to the mission. I can't help but to think that the most important outcome of this is the new relationships, opportunities, and friendships that have been cultivated throughout this process. I can't thank everyone involved on the team enough. Special thanks to the New York State DEC Hudson River Estuary Program and the Consensus Building Institute who kept us on task and on track. And

finally, a huge thank you to our friends at Scenic Hudson for their leadership and overall support.

This is only the beginning.

Too often the research we conduct for the betterment of our community finds itself on a shelf collecting dust. We can't let that happen, this is just too important. The recommendations of this task force are straightforward, smart, and most importantly they are achievable. If you are reading this a year from now and no progress has been made on any of the recommendations, call us out on it.

What's next?

This is not a spectator sport. We need to get to work, it is that simple. Please read on through the recommendations and help where you can. The one true success of a project is seeing it in use. One local business has supported the recommendations and already applied them in a redesign of their facility, and we hope others will follow this example.

Thank you from the “Ever Improving Village of Catskill”.

Vincent J. Seeley

President, Village of Catskill

Greene County Legislator, District 1

December, 2014



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EXECUTIVE SUMMARY

When Tropical Storms Irene and Lee hit in the late summer of 2011, the Village of Catskill experienced unprecedented flooding and damages driven by stormwater flows in Catskill Creek and storm surge from the Hudson River. Just over a year later, Superstorm Sandy hit the northeast, bringing with it a historic coastal storm surge and additional flooding. The three storms led to significant damages to waterfront homes and businesses in the Villages, and prolonged disruptions of services and access in some neighborhoods.

At the same time, the village has been working actively to envision and implement a village-wide revitalization that builds on the central role of the waterfront in the community. In the past several years a range of public and private investments have been made in planning, redeveloping and redesigning the waterfront.

The intersection of the Village's revitalization goals and the community's new appreciation of the risks to the waterfront from flooding and sea level rise highlighted the need for better information about future flood risks as the community works to advance its objectives.

Seeking solutions, the Village, together with its partners Scenic Hudson and the Consensus Building Institute, sought and was awarded support from the New York State Department of Environmental Conservation's Hudson River Estuary Program, for an initiative to address coastal flooding risks related to sea level





rise. The Catskill Waterfront Resilience Task Force initiative was formally launched in November 2013 to begin the work of creating a safer, more vibrant Catskill waterfront.

The Task Force, with its project partners and with input from the public, has synthesized a list of recommendations which, if implemented by the village, can be used as a flood and sea level rise resilience action plan. This report details these recommendations and the studies that support them, which span policy and planning updates, capital investments, municipal operations and infrastructure, and future studies that will better position Catskill to begin taking action and to attract future support for waterfront improvements.

Importantly, through this process task force members and others in the Catskill community have become well-versed in the issues surrounding sea level rise, flooding, adaptation, and resiliency planning. Together they represent an increased capacity in the village as it endeavors towards resilience. The information presented here and in the supplemental materials further enhance the village's ability to visualize and understand its coastal risks and create a foundation for further analysis specific to the village.

Planning for Catskill's resilience will be an ongoing civic conversation in the community for decades to come. With this report, the Task Force makes an opening contribution to that dialog.

Risks and Vulnerability of Catskill’s Waterfront Area

Public health and safety, damage to assets, business downtime, and accessibility are some of the top concerns motivating Catskill to take action to prepare for future flooding events. The Village seeks to become more resilient as those events become more frequent and their severity increase due to increasingly heavy downpours, storm surge events, and sea level rise that exacerbates the impact of both upland and coastal flooding.

The financial impact of recent Tropical Storms Irene and Lee and Hurricane Sandy on the Village of Catskill exceeded \$3 million in damages to structures alone. Losses to business and disruption of the lives of Catskill citizens were significant. Risk and vulnerability assessments conducted during this initiative suggest that, by the end of the century damages to structures from single events like Tropical Storm Irene could more than double as sea level rise exacerbates flood heights. In the absence of steps to adapt to changing conditions along the waterfront, cumulative damages from flood events could exceed \$15 million, with many homes permanently impacted and several key public assets like the sewage treatment facility, Catskill Point public spaces, the Public School, and many roads increasingly at risk.

Sea Level Rise and Planning for the Future

Along the tidal Hudson River, from the Battery in Manhattan to the Federal Dam at Troy, sea level has risen approximately one foot over the past century. There is evidence that annual rates of sea level rise along the Hudson River have accelerated over the past two decades and will continue to outpace the global average.

The Task Force considered sea level rise projections and planning timeframes that it felt were most appropriate for developing Catskill’s adaptation goals. The Task Force ultimately selected 2020s, 2050s, and 2100 as the time horizons for analyzing waterfront risks and elected to consider sea level rise values of 6.5”, 21.5”, and 60” respectively for those time periods. These sea level rise increments represent the middle values of the ranges projected in the three time frames under the Sea Level Rise with Rapid Ice Melt scenario conditions.

year	2020s	2050s	2100
sea level rise projection	6.5”	21.5”	60”

The Task Force chose these projections for planning and analysis because it opted to develop solutions for a relatively severe case and guard against under-preparation, not necessarily because it considered these to be the most likely sea level rise outcomes. Indeed, slower rates of sea level rise are possible, or even likely. In such a case the use of higher projections would mean that the projected levels would be reached at some later date than those used by the Task Force, as sea level continues to rise after 2100.



A Vision of a Resilient Catskill

With input from the public and a range of stakeholders, the Task Force identified several key principles that should guide Catskill's adaptation actions now and into the future. A resilient Catskill...

CONSERVES:

- Natural spaces, ecosystems, and biodiversity
- Historic and cultural assets
- Viewsheds and scenic values
- Existing waterfront investments

PROMOTES:

- Smart economic development and tourism
- Attraction of business investments
- Best uses of waterfront
- Attractive parks and other open spaces
- Community education about flooding resiliency
- Planning for safety, infrastructure, and efficient problem mitigation
- Preparedness for future environmental changes

ENHANCES:

- Community vibrancy
- Residential quality of life
- Waterfront access and public amenities
- Recreational opportunities
- The central role of the waterfront in the community
- Connections of neighborhoods and village centers to waterfront

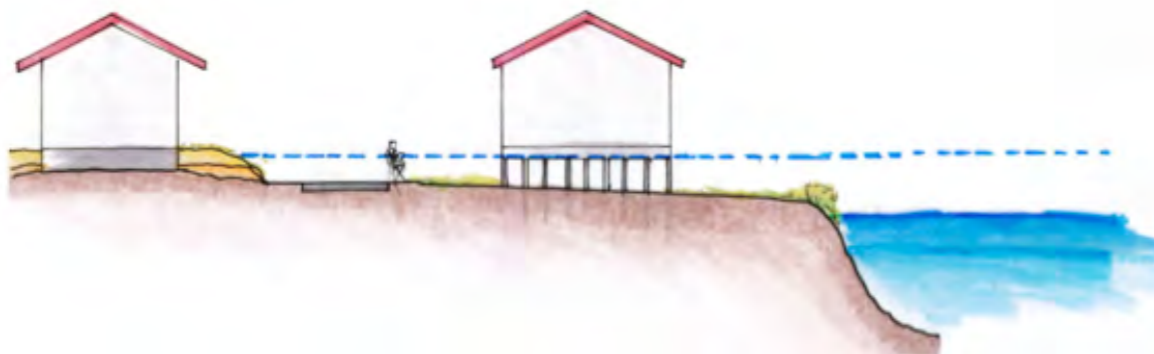
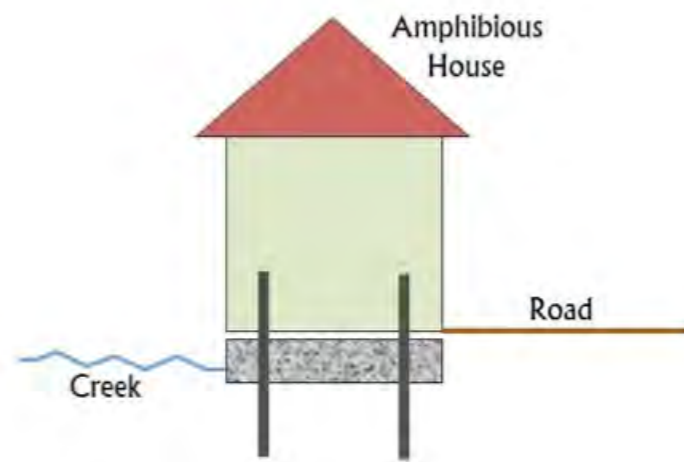
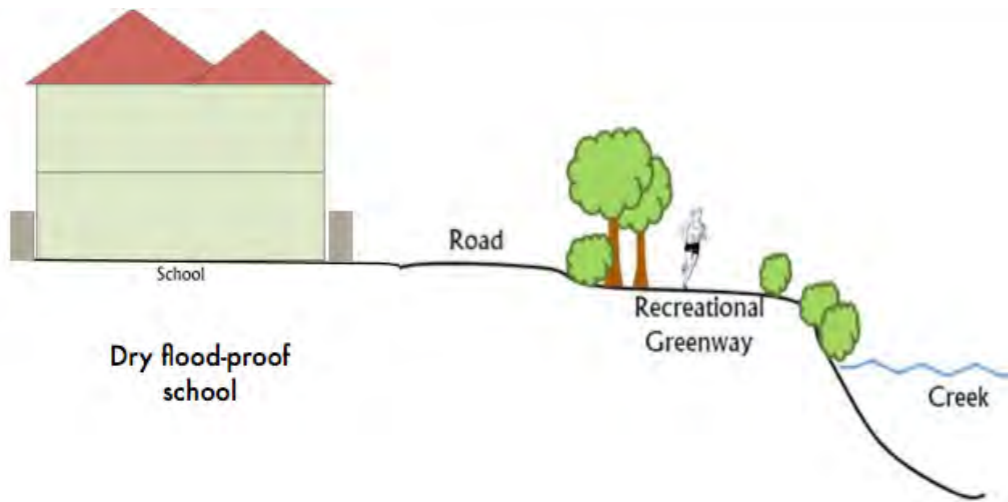
Adaptation Strategies

Examining a wide-range of adaptation types and tools, and evaluating their strengths and weaknesses, was an important part of the Task Force’s process for considering both short-and long-term adaptation alternatives for the Village of Piermont. Many tools exist to implement community-wide adaptation, from land-use planning and regulation, urban design, and coastal engineering to market- and tax-based incentives, grants from state and federal agencies, spending, and public outreach actions.

The Task Force worked to launch the process of planning and designing a more resilient waterfront, not to complete it. Task Force members learned about the range of conceptual, architectural, and regulatory approaches to adaptation currently in practice or development in other coastal areas in the United States and abroad. With this perspective, the Task Force developed and evaluated a portfolio of “Adaptation Alternatives” - alternate scenarios for how specific neighborhoods or the entire Village might reduce risks and achieve the resilience vision principles.

Sketches of some of the Adaptation Alternative strategies explored by the Task Force for specific areas of Catskill’s Waterfront.

A wider range of Adaptation Alternatives and Benefit-Cost Case Studies were considered by the Task Force and are available in this report and in its Supplemental Materials.



TASK FORCE RECOMMENDATIONS

The Task Force recommends the following proactive steps toward a safer, vibrant waterfront and a more resilient Catskill, both for the next storm event and for a future of rising seas.

The recommendations target a broad spectrum of Catskill's physical, natural and social fabric and are focused on actions that tie immediate recovery needs to long-term adaptation goals.

Each recommendation is phased to a specific timeline and implementers have been identified to establish clear lines of responsibility. Also, for most of the recommendation, there are more specific sub-tasks or implementation details described on pages 40-56.

These recommendations comprise an integrated set of actions that will make substantive contributions to the well-being of the community and its residents.

- 1. Review the village comprehensive emergency management plan (CEMP) for any necessary updates.*
- 2. Improve emergency communications.*
- 3. Design and install high-watermark signs in the waterfront area to educate the community about flood risk and sources of flood preparedness informational resources.*
- 4. Establish an Interim Flooding and Storm Resilience committee and create a Permanent Joint Village and Town Conservation Commission.*
- 5. Invite agencies or experts to give public outreach presentations on storm preparedness and flood-mitigation options for families, businesses, institutions, structures and facilities, including funding opportunities when applicable.*
- 6. Create a flooding best practices manual for distribution to village residents and businesses.*
- 7. Post key information on flood risks and emergency plans on the village website.*
- 8. On an annual basis, direct property owners and residents of current and projected future floodplains to the Village's informational resources about flooding and emergency preparedness.*
- 9. Support regular training for the village floodplain manager (Code Enforcement Officer).*
- 10. Work with other communities in the Catskill Creek watershed to better manage stormwater and runoff.*
- 11. Work through the Greene County Multi-Hazard Mitigation Plan to position Catskill for resiliency actions and funding opportunities.*
- 12. Conduct a risk and engineering review of key municipal infrastructure to identify adaptation needs/options/plans.*
- 13. Maintain an inventory and stock all necessary replacement parts for sewage treatment plant and pump stations.*
- 14. Convene a working group including representation from Village boards, committees, officials and municipal planners to review the Task Force Report and identify which/how local codes can be modified to better weather and adapt to future storms and account for sea level rise.*
- 15. Consider applying to participate in the National Flood Insurance Program (NFIP) Community Rating System (CRS), to reduce flood insurance rates and improve flood resilience.*
- 16. Ensure that all proposals and plans address projected sea level rise and are responsive to flood resilience issues.*

17. *Promote the use of Green Infrastructure techniques throughout the village to reduce flooding from runoff and minimize stormwater treatment burdens.*
18. *Consider participating in NYS DEC's Climate Smart Communities and its new certification program, in order to receive free technical assistance and eligibility for future grant applications.*
19. *Promote the long-term persistence of natural storm buffer areas, particularly Ramshorn-Livingston Marsh, Catskill Point, and undeveloped riparian areas along Catskill Creek (e.g. Goat Island, Pelican Island).*
20. *Consult Task Force report for neighborhood/asset specific recommendations and begin developing strategies to address them (e.g. developing an alternate access to the school complex via Bridge Street).*
21. *Take advantage of training opportunities from federal, state and local partners to improve staff and volunteer understanding of tools available to help plan for and respond to flood emergencies.*
22. *Integrate departmental funding requests into a village-wide Capital Improvement Plan that incorporates and prioritizes the needs of all departments, along with phased adaptation of infrastructure to flooding and sea level rise.*
23. *Incorporate cost-benefit analyses and long-term flood risk due to sea level rise and stronger storms into asset design and the prioritization of strategies to manage key municipal assets.*
24. *Create an orientation packet or a presentation on flood hazards and municipal plans for all newly elected/appointed municipal representatives, to ensure that new personnel are well-informed on the issues and procedures in the village.*

Implementation: Top Priorities

The Task Force recognizes that the Village of Catskill, with its small staff and reliance on volunteer leadership, may be unable to simultaneously implement all of the recommended actions in any given time frame. To address this, six recommendations were prioritized as the most urgent or important. Note that while the Task Force recommends these be initiated or implemented in the next five years, some of them also set the Village on a path to addressing its longer-term goals.

Establish a Flooding and Storm Resilience Committee and Joint Village and Town Conservation Commission

Review/update the Village Comprehensive Emergency Management Plan (CEMP)

Improve emergency communications

Create a flooding and best practices manual for residents and businesses

Review the Task Force report and identify how local codes can be modified

Promote the long-term persistence of natural storm buffer areas

OVERVIEW

When Tropical Storms Irene and Lee hit in the late summer of 2011, the Village of Catskill experienced unprecedented flooding and damages driven by stormwater flows in Catskill Creek and storm surge from the Hudson River. Just over a year later, Superstorm Sandy hit the northeast, bringing with it a historic coastal storm surge and additional flooding. The three storms led to significant damages to waterfront homes and businesses in the Villages, and prolonged disruptions of services and access in some neighborhoods.

At the same time, the village has been working actively to envision and implement a village-wide revitalization that builds on the central role of the waterfront in the community. In the past several years a range of public and private investments have been made in planning, redeveloping and redesigning the waterfront.

The intersection of the Village's revitalization goals and the community's new appreciation of the risks to the waterfront from flooding and sea level rise highlighted the need for better information about future flood risks as the community works to advance its objectives. Seeking solutions, the Village, together with its partners Scenic Hudson and the Consensus Building Institute, sought and was awarded support from the New York State Department of Environmental Conservation's Hudson River Estuary Program, for an initiative to address coastal flooding risks related to sea level rise. The Catskill Waterfront Resilience Task Force initiative was formally launched in November 2013 to begin the work of creating a safer, more vibrant Catskill waterfront.



TASK FORCE OBJECTIVES

At the outset of the Task Force initiative, a series of objectives were defined by Village President Seeley, the members of the Task Force, and the partner groups. These included:

- ▶ **Bring the community together to describe a shared vision for the future of their waterfront;**
- ▶ **Create a foundation of analysis, data and communal knowledge about sea level rise and flooding adaptation approaches, and use this information to determine which approaches make sense for Catskill, and why;**
- ▶ **Produce a set of specific, phased recommendations for policy and operational improvements, capital investments, open space/access opportunities and future studies that will move Catskill toward its vision for greater resilience;**
- ▶ **Position the Village of Catskill to begin implementing the Task Force's recommendations and to attract state, federal, and private support for waterfront revitalization;**
- ▶ **Build the community's capacity and experience in planning for waterfront resilience.**

APPOINTED TASK FORCE MEMBERS

Village President Vincent Seeley appointed representatives from the community with a range of interests and expertise to serve on the Task Force. Task force members included village business owners, residents, local government representatives (County, Town, and Village), community leaders, and natural resources professionals. The goal of this wide representation was to integrate a broad view of the village's needs and vision and to draw from different skills and local knowledge, with the intention that the work of the CWRTF would reflect the sensibilities and priorities of the community fairly and effectively.

Appointed Task Force members

Mike Aguiar* - *Business Owner*

Trevor Babb* - *Business Owner*

Fred Calvo* - *Village Planning Board*

John Farrell - *Greene County Emergency Management*

Larry Federman* - *Audubon New York*

Arielle Herman* - *Business Owner*

Joseph Kozloski* - *Greene County Legislature*

Liz LoGiudice* - *Cornell Cooperative Extension*

Sean Meagher - *Business Owner*

Lew O'Connor* - *Village Public Works Department*

Nancy Richards* - *Village Community Development Coordinator*

Vincent Seeley* - *Village President*

Joe Stefko* - *Business Owner, Village Planning Board*

Hudson Talbott* - *Catskill Community Center*

Pat Walsh* - *Town Council*

John Willabay - *Catskill Schools*

* indicates attendance at 3 or more Task Force meetings.

PROJECT TEAM

Project leadership and technical assistance was provided by Scenic Hudson, the Consensus Building Institute, NYS DEC Hudson River Estuary Program, Catalysis Adaptation Partners and Hone Strategic, with additional support from the Lincoln Institute for Land Policy and the Dyson Foundation.

Scenic Hudson - Science, Planning, and Project Management

Jeffrey Anzevino - *Director of Land Use Advocacy*
Amy Kacala - *Senior Planner*
Steve Rosenberg - *Executive Vice President*
Sacha Spector - *Director of Conservation Science*
Nava Tabak - *Conservation Scientist*
Mark Wildonger - *Senior Planner*

Consensus Building Institute and Lincoln Institute for Land Policy - Facilitation and Project Management

Carri Hulet - *Senior Associate*

Hudson River Estuary Program, NYS DEC - Science and Planning

Kristin Marcell - *Climate Program Coordinator*
Libby Murphy - *Climate Outreach Specialist*

Catalysis Adaptation Partners - Benefit-Cost Economic Analysis

Jonathan Lockman - *Partner*

Hone Strategic, LLC - Planning

Jennifer Schwartz Berky - *Principal*



Some of the members of the Task Force and Project Team. From left to right: Liz Loguidice, Sacha Spector, Nava Tabak, Hudson Talbot, Arielle Herman, Joe Stefko, Libby Murphy, Vincent Seeley, Nancy Richards, and Carri Hulet.



PROJECT SEQUENCE AND ACTIVITIES

The Task Force was formally launched in November 2013 and, met 10 times, in addition to holding a public workshop and a presentation to municipal and county officials.

Over the course of the initiative, the CWRTF worked through several phases to identify challenges, learn about a wide range of potential adaptation options, and develop solutions that are suited to Catskill. These phases were roughly sequential, though there was considerable overlap at times.

Phase 1: Data Gathering, Analysis and Risk Assessment

Phase 2: Community Visioning

Phase 3: Adaptation Strategy and Alternatives Analysis

Phase 4: Adaptation Strategy Selection

Phase 5: Presentation of Results (public engagement and final report)

ACTIVITIES

1. **Inventoried, mapped, classified, and evaluated current and future flood risks of waterfront assets (Phase 1).**

Through exercises with the public and task force members, and complemented by a meeting of a small working group, Scenic Hudson used the Department of State's Inventory and Coastal Risk Assessment tool to examine risk, exposure, and vulnerability in the village. Modeled risk areas allowed for analysis of both current and future conditions, providing an overall picture of risks to private and public waterfront assets, and a focus on critical village facilities, access routes, and natural resources that will require flood resiliency planning.

2. **Selected a sea level rise projection for use in future planning (Phase 1).** Scenic Hudson presented the task force with the latest available projections of sea level rise for the upper tidal Hudson River in the coming century, based on recent scientific studies endorsed by New York State. The task force elected to use increases in sea level of 6.5 inches for the 2020s, 21.5 inches for the 2050s, and 60 inches for 2100. These represent the middle values of the projected range of sea level rise under rapid ice-melt conditions. While those projected sea level increases are near the upper ends of potential ranges for the chosen time frames, the Task Force used them in planning exercises and analyses as a way to illustrate severe scenarios and/or to prepare for a longer timeframe if sea level rises more slowly. (See section on Flooding Risks for a more complete discussion of this issue.)
3. **Compiled a shared vision of waterfront resiliency for the village of Catskill (Phase 2).** In early task force meetings, participants were invited to share their ideas and priorities for a resilient Catskill waterfront. The project team combined this information with ideas expressed by the public as part of the Downtown & Waterfront Revitalization Strategy (Elan Planning & Design, Inc., 2009), to use as a reference and to guide them in subsequent long-term planning exercises.
4. **Detailed past flood experiences from village residents and Task Force members (Phase 1).** Task force members described the experiences of village residents, business owners, and staff during recent storm and flooding events and used them to identify emergency response and post-storm recovery issues.
5. **Developed multiple long-term adaptation scenarios for the village waterfront (Phase 3).** Following informational sessions on a wide range of possible flood adaptations and adaptation planning concepts, task force members collectively participated in a “design workshop” to develop ideas for the village’s long-term adaptation. The group further developed these scenarios through a subsequent iterative process, which included the evaluation of pros and cons for each scenario and additional visualization of potential adaptations.
6. **Compared the benefit-cost ratios of three long-term adaptation scenarios and a no-action scenario (Phase 3).** Catalysis Adaptation Partners used the Coastal Adaptation to Sea level rise Tool (COAST) to analyze future projected costs to village real property from one time storms and cumulative storm events at different time frames. The tool enables comparison of no-action scenarios (i.e., no adaptations are undertaken for assets) with those scenarios in which real property assets are partially or wholly protected from flood damages. This analysis provided insight on the economic factors that will contribute to long-term plans for the village waterfront.
7. **Inventoried existing village, town, and county plans to identify strengths and planning opportunities (Phase 3).** Hone Strategic, LLC, a planning consulting contractor, researched and gathered information from municipal representatives in completing the Climate Smart Resiliency Planning tool. The work catalogs existing plans and identifies additional policies that can be used to address flooding issues in the village, and new opportunities for more resilient planning.

8. **Compiled a set of recommendations for actions the Village of Catskill and partners can take for improved flood and storm resilience (Phase 4).** The 24 recommendations draw on the various exercises and analyses outlined above. They are categorized by recommended time frames for action (e.g. immediate, short/medium-term) and by sector (e.g. emergency management, flood preparedness, planning). This final report of the CWRTF presents these recommendations to the Village Board to consider for endorsement and implementation.

Task Force members examining flood and sea level rise scenario maps during a meeting.





FLOODING RISKS: TODAY AND INTO THE FUTURE

The same confluence of waterways that attracted commerce and amenities to Catskill's waterfront presents the risks of serious waterfront flooding and other coastal hazards. The Village's waterfront is subject to flooding from both the Catskill Creek, due to heavy rainfall events, and the Hudson River, with high tides and coastal storm surges (associated with hurricanes, tropical storms, and nor'easters) that travel up the river from the Atlantic Ocean.

Over the last 100 years the waterfront has experienced flooding from at least 12 hurricanes and tropical storms and many nor'easters. In recent years, the Village's entire waterfront - including residential neighborhoods, commercial areas, and Catskill Point - was seriously impacted by flooding from both the Hudson and Catskill Creek during Tropical Storms Irene and Lee in 2011 and by a record-breaking storm surge during Hurricane Sandy in 2012.

Public health and safety, damage to assets, business downtime, and accessibility are some of the top concerns motivating the Village of Catskill to prepare for future flooding events, whose frequency and intensity are likely to increase due to more frequent heavy downpours, storm surge events, and rising sea level that exacerbates the impact of both upland and tidal flooding.

Assessing the risks facing Catskill and their shifting nature within a changing climate provides the community with critical information for taking proactive measures to stay a safe and welcoming place.

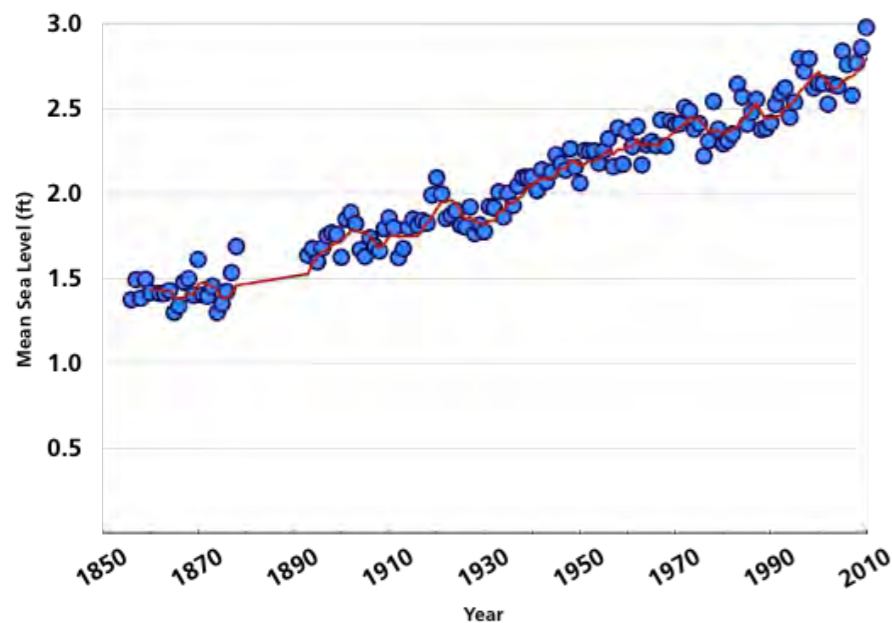
Task Force member Mike Aguiar indicates the high water levels reached by Hurricanes Sandy and Irene on his marina building.

Facing page: Catskill Wastewater Treatment Facility on the morning after Hurricane Sandy. (John Carl D'Annibale / Times Union)



SEA LEVEL RISE

Around the world ocean sea levels are rising at an accelerating pace. Along the Hudson River, from the Battery in Manhattan to the Federal Dam at Troy, sea level has risen approximately one foot over the past century. There is evidence that annual rates of sea level rise along the Hudson River have accelerated over the past two decades and will continue to outpace the global average. While the exact pace of future sea level rise is not yet certain, there is every reason to believe that sea level will continue to accelerate throughout this century and beyond. Much depends on how much more greenhouse gas pollution we add to the atmosphere and how quickly the global climate system warms in response. It also depends on how quickly the Greenland and Antarctic ice sheets melt and add their water to the oceans.



Mean sea level measured by tidal gauge at The Battery, Manhattan from 1856-2012. Blue dots denote annual mean sea level, the red line is a 5-year running average. Source: NOAA

Projections for future sea level rise on the Hudson River and elsewhere in New York State have been provided in recent reports from NYS CLIMAID, the New York State Sea Level Rise Task Force and the NYS2100 Commission. These projections are based on a combination of empirical data about the historical relationships between climate and sea level, predictions of future climate conditions generated by a suite of global circulation/climate models, and estimates of ice sheet melt behavior from current observation and models. For the upper Hudson River estuary, they are as follows:

	2020s	2050s	2080s	2100
Sea Level Rise	1 to 4	5 to 9	8 to 18	11 to 26
Sea Level Rise with Rapid Ice Melt	4 to 9	17 to 26	37 to 50	52 to 68

Sea Level rise projections for the upper Hudson River, from NYS 2100 Commission report (in inches, relative to a baseline year of 2000).

The Sea Level Rise scenario in the upper row is based on the central range (middle 67%) of values from model-based probabilities rounded to the nearest inch. The Sea Level Rise with Rapid Ice Melt scenario is based on acceleration of recent rates of ice melt in the Greenland and West Antarctic Ice sheets and paleoclimate studies.

LOCAL SEA LEVEL RISE PROJECTIONS

The Task Force considered sea level rise projections and planning timeframes that it felt were most appropriate for developing Catskill’s adaptation goals. Broad discussion focused on balancing the scientific consensus and uncertainties surrounding sea level rise, as well as whether planning proactively for “worst case scenarios” or “best case scenarios” are desirable in preparing for long-range flooding challenges.

The task force ultimately selected 2020s, 2050s, and 2100 as the time horizons for analyzing waterfront risks and elected to consider sea level rise values of 6.5”, 21.5”, and 60” respectively for those time periods. These sea level rise increments represent the middle values of the ranges projected in the three time frames under the Sea Level Rise with Rapid Ice Melt scenario conditions.

The Task Force chose these projections for planning and analysis because it opted to develop solutions for a relatively severe case and guard against under-preparation, not necessarily because it considered these to be the most likely sea level rise outcomes. Indeed, slower rates of sea level rise are possible, or even likely. In such a case the use of higher projections would mean that the projected levels would be reached at some later date than those used by the Task Force, as sea level continues to rise after 2100.

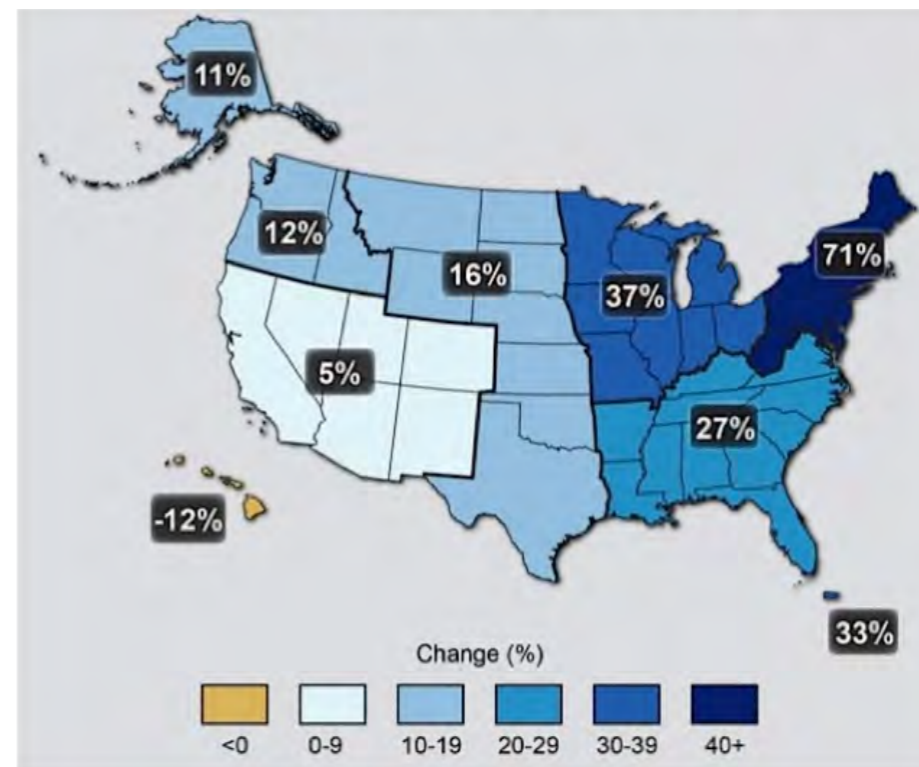
year	2020s	2050s	2100
sea level rise projection	6.5”	21.5”	60”

Sea Level rise projections and planning timeframes selected by the Task Force.

LOCAL PRECIPITATION AND FLOODING PROJECTIONS

Substantial evidence indicates that extreme precipitation events in the Northeast are becoming more frequent and larger (see figure below). This can be expected to lead to higher stream flows and expanding riparian flood zones along Hudson River tributaries such as the Catskill Creek.

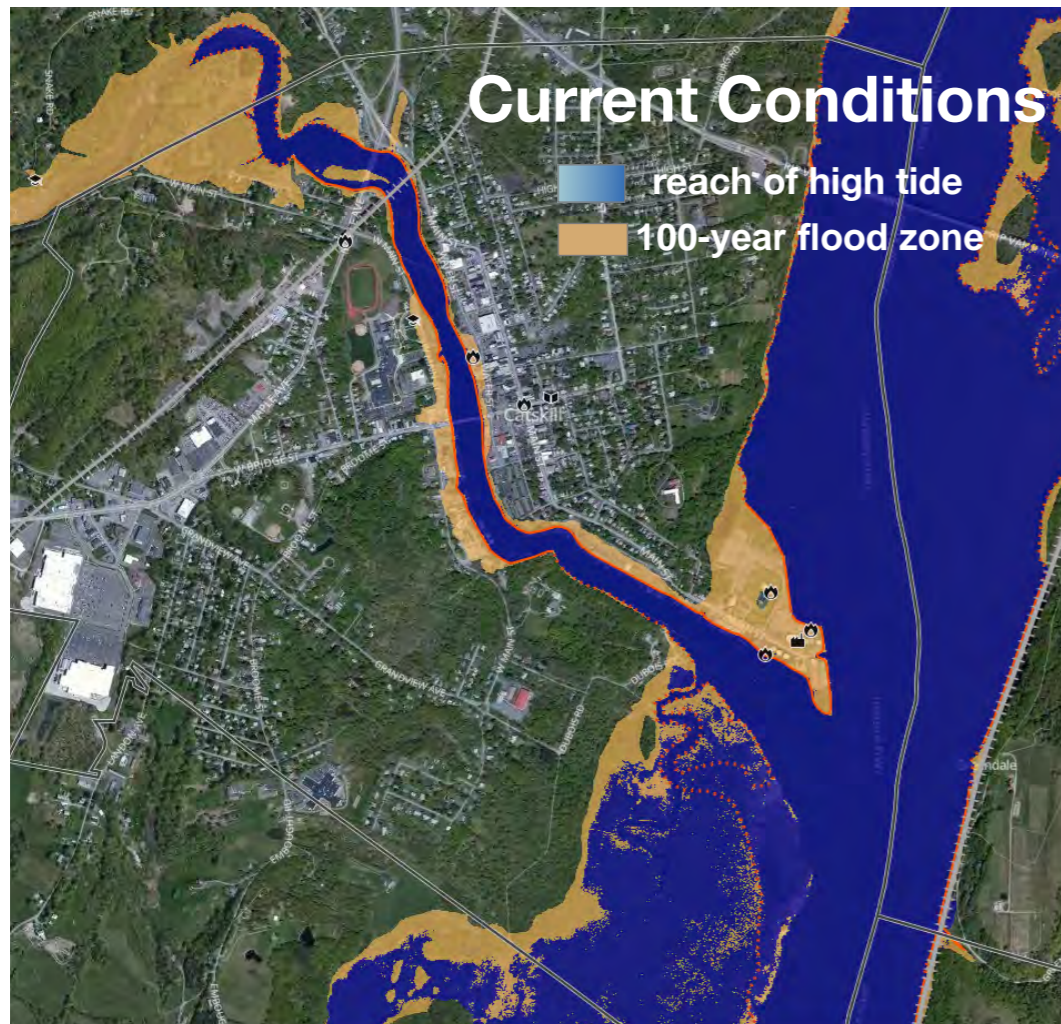
However, because there was not enough information at this time to project future rainfall amounts and upland flooding dynamics into this analysis, base flood depths along the waterfront were assumed to remain constant. Future flood elevations were increased by the amount of sea level rise, however.



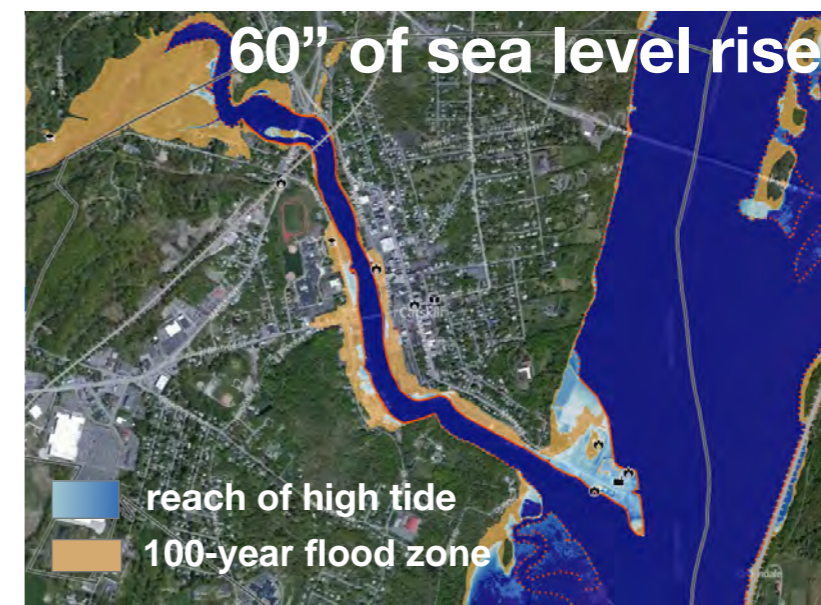
Observed Change in Magnitude of Very Heavy Precipitation Events (top 1% of all events) 1958 - 2012
Source: National Climate Assessment 2014

MAPPING SEA LEVEL RISE AND FLOODING

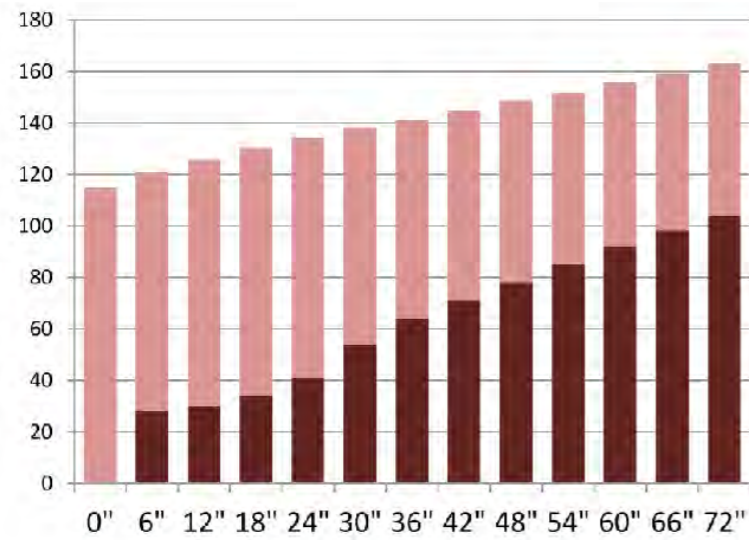
Using information from Scenic Hudson's Sea Level Rise Mapper and additional modeling by Scenic Hudson, the Task Force examined the current extent of flood prone areas, and areas that will be exposed to daily tides (inundated) or become increasingly flood prone under various sea level rise scenarios. For mapping the future extent of floodplains above the high tide line, the base flood elevation was simply added to projected future Mean Higher High Water (MHHW) following sea level rise.



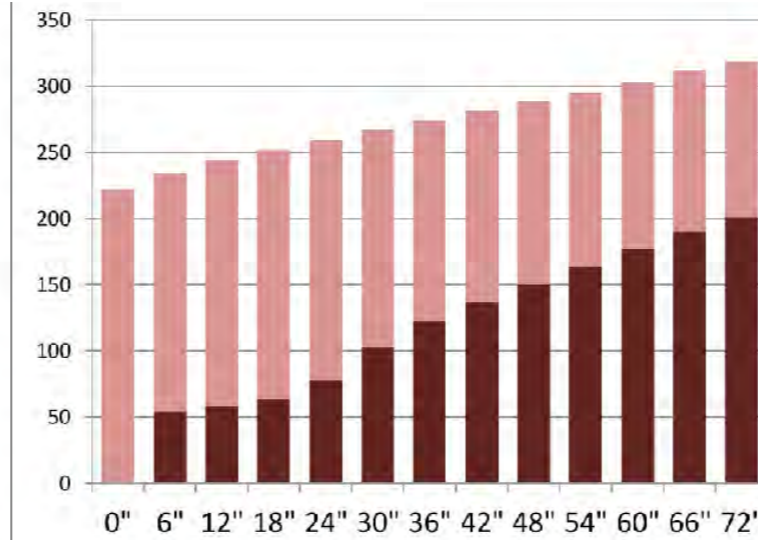
These and other maps of the extent of tidal reach and flood zones under various sea level rise values are available through the Scenic Hudson Sea Level Rise Mapper. Note: The Sea Level Rise Mapper shows projected changes for 6" increments; those values closest to the Task Force's planning sea levels are shown at right. (www.scenichudson.org/slr)



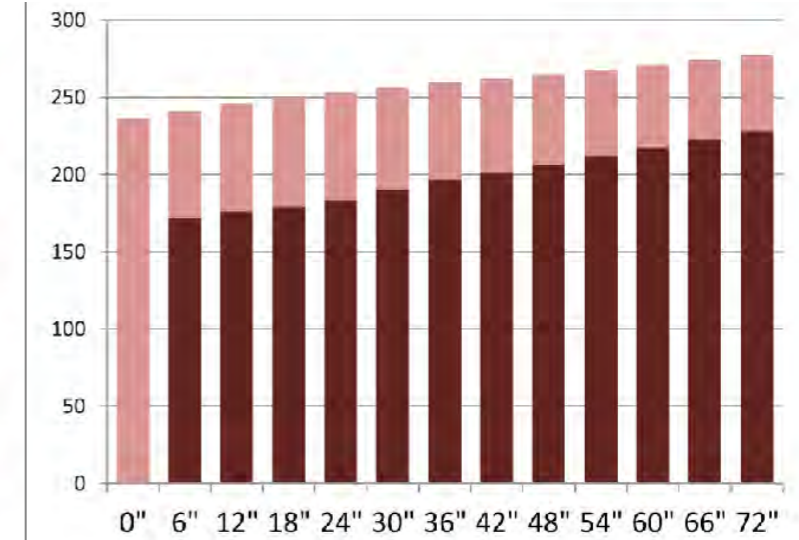
HOUSEHOLDS



PEOPLE



LAND (acres)



Amount of Sea Level Rise

- at risk from daily tidal inundation
- at risk from flooding

Above: Estimates of the number of Households, People and Land potentially exposed to flooding and/or daily high tide inundation given increasing increments of sea level rise. Derived from US Census data and Scenic Hudson sea level rise data. Available through the Scenic Hudson Sea Level Rise Mapper (www.scenichudson.org/slr)

EXPANDING HAZARDS

Over the course of the century, as sea level rise changes the reach of daily high tides and flood elevations, risks to people and property will shift. If sea level rises by 60 inches—the sea level rise projections adopted by the Task Force for the 2100 planing timeframe—the areas along Catskill’s waterfront and it’s low-lying neighborhoods will be increasingly subject to flooding from precipitation events or inundation by daily tides.

Modeling by Scenic Hudson estimates that the area waterfront subject to tides or flooding could expand from approximately 240 acres to 265 acres. Within areas already at risk of flooding, flood events will reach higher elevations and potentially cause more damage. In the expanding risk zone lie additional community assets, households and citizens that will experience flooding or daily inundation.

ASSESSING RISK

Using a risk assessment tool developed by the NYS Department of State as part of the New York Rising Community Reconstruction Program (NYR-CR Program), the Task Force evaluated Catskill's risk from flooding and storm surge events.

In this tool, overall risk scores are calculated based on multiple factors having to do with a particular structure, household, or item of infrastructure's position on the land, its ability to resist damage from

a flood event, and the likelihood and magnitude of anticipated flood events.

(See Supplemental Materials for the full results of the NYR-CR Program Risk Assessment Tool analysis)

HOW DO WE MEASURE RISK?

In this project, the Task Force assessed risks to people and property along Catskill's waterfront. Overall risk was calculated based on multiple factors according to the formula:

RISK SCORE = HAZARD x EXPOSURE x VULNERABILITY

Hazard: the likelihood and magnitude of future storm events (in this analysis a constant for a 100 year storm was used).

Exposure is a combination of Risk Area and Landscape Attributes

Risk Areas: a flood-prone zone modeled based on current and projected sea levels, elevation, and FEMA's Base Flood Elevations

Landscape Attributes: the presence/absence of protective shoreline features or characteristics

Vulnerability: an assigned score of the level of impairment or consequences that assets may experience from a storm event, or its resiliency or ability to recover from an event

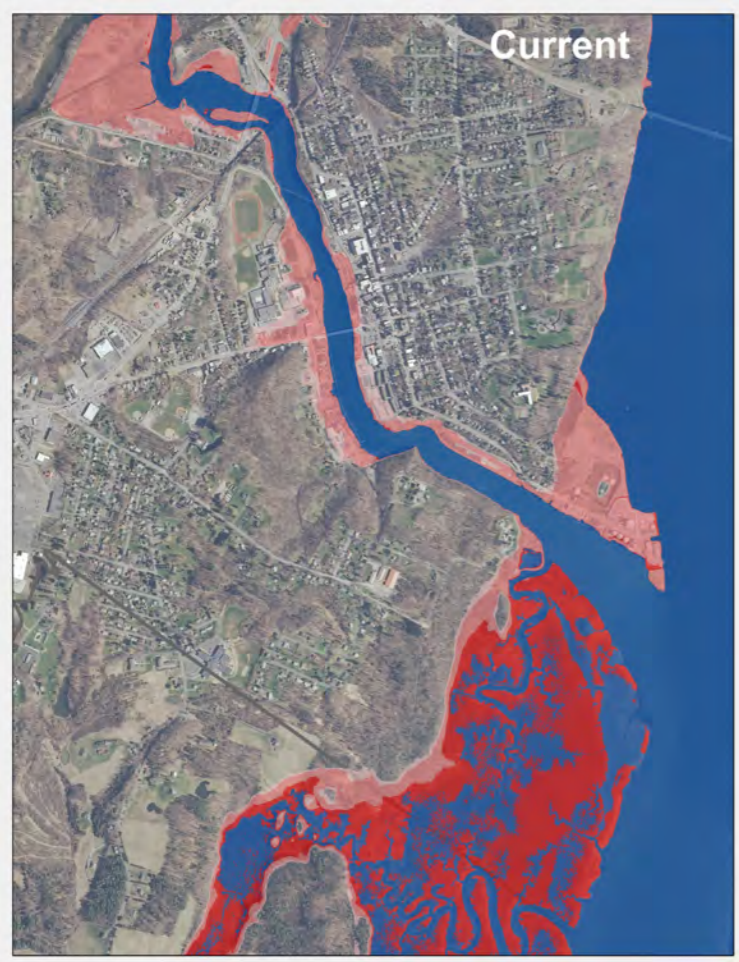
The risk assessment tool illustrated that current risks and predicted future changes in risk vary considerably along the Catskill Creek and the Hudson waterfronts. This range in variation is due to both Catskill's varied waterfront topography and Base Flood Elevations, and the different impacts that stormwater and coastal storm surge flooding events have on the waterfront.

Catskill Point and smaller, low-lying floodplain areas along the creek are expected to experience a dramatic increase in risk and regular

inundation by the end of the century. In contrast, the currently high risk Bushnell Avenue residential area is predicted to remain in the same risk category in the coming decades without experiencing daily inundation. In the West Bridge Street area, the businesses fronting the creek are in the highest risk area, but it is the portion of West Main Street that provides access to the public schools that is expected to experience regular inundation by 2100.

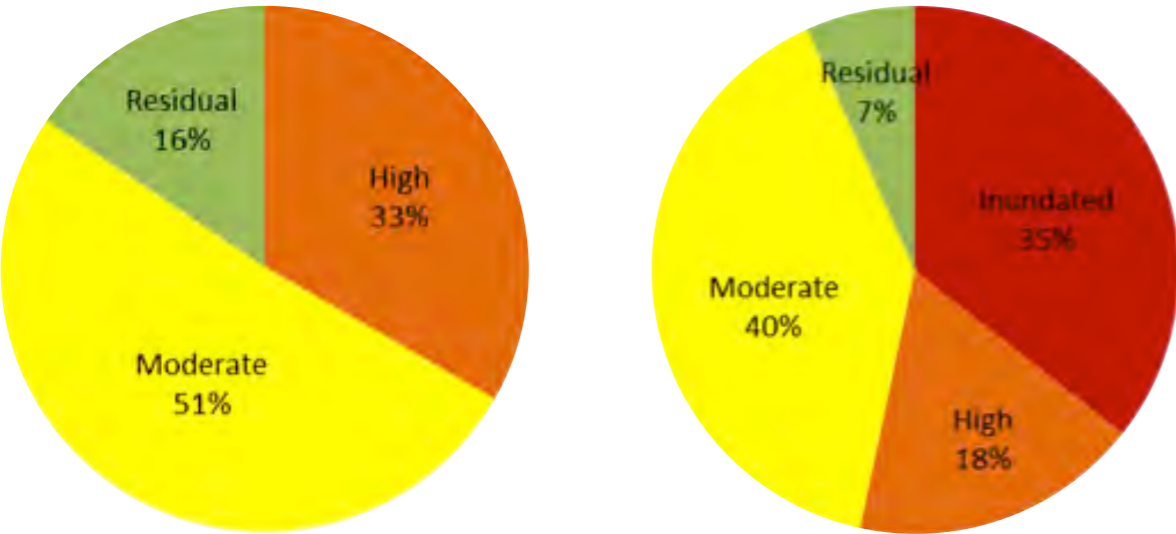
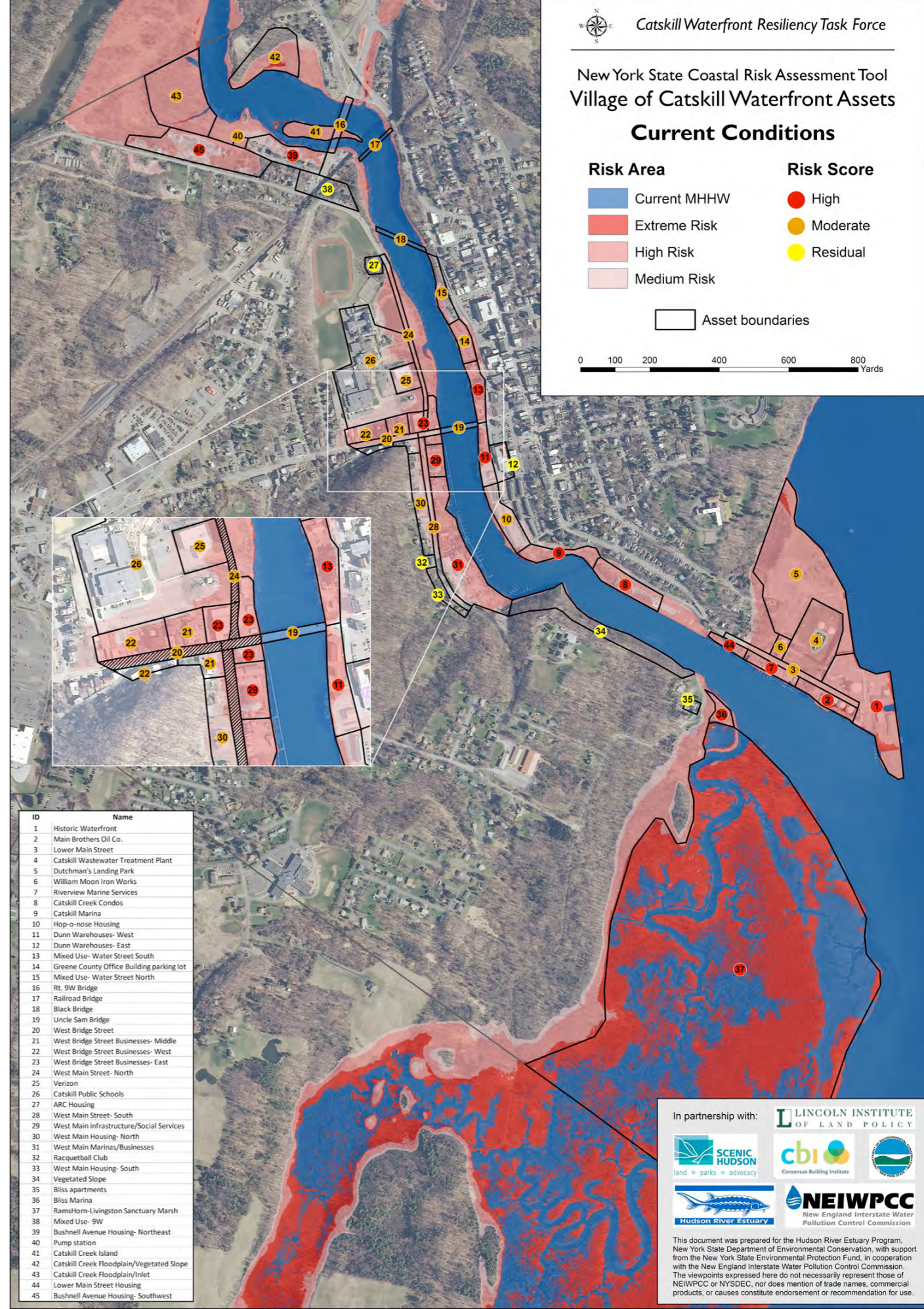
Risk Areas

Modeled risk areas for current conditions, 2050s, and 2100. Inundated zones represent areas that would be expected to be underwater during daily high tides.



Forty five individual structures, neighborhood areas, and infrastructure (collectively called “assets”) were identified, assessed, and given *risk scores*. In contrast with risk areas, risk scores incorporate landscape attributes and vulnerability, thus accounting for additional ground and situational conditions that are relevant to the overall risk of assets in the village.

Risk scores were categorized into High, Moderate, and Residual levels. The overall pattern of risk scores is similar to that of the modeled risk areas in Catskill. Over time a small number of new assets are projected to become at-risk, while currently at-risk assets generally became more so.



Current (left) and projected in 2100 (right) distribution of Catskill waterfront assets into risk categories

Right: Map of assets identified and assessed using the NYR-CR Program Risk Assessment Tool. (A larger image of this map and a full list of assets is available in Supplemental Materials.)

The village's wastewater treatment plant, located on Catskill Point, is considered to be at moderate current risk, and has shown resilience in past flooding events. However, by the end of the century portions of this critical asset's property and the surrounding Point (including the access route via lower Main Street) will inundate regularly, necessitating long-range planning for major retrofits or relocation. Most stretches of roads and bridges that were included in the

assessment are currently at relatively low risk, and most are expected to remain so through the remainder of the century. The aforementioned stretch of lower Main Street is an exception, and along with a portion of West Main Street north of West Bridge Street is predicted to experience some inundation in the second half of the century.

Risk Scores

Risk scores for waterfront assets under current, 2050s, and 2100 conditions. Inundated zones represent areas expected to be underwater during daily high tides.



Inundated



Moderate Risk

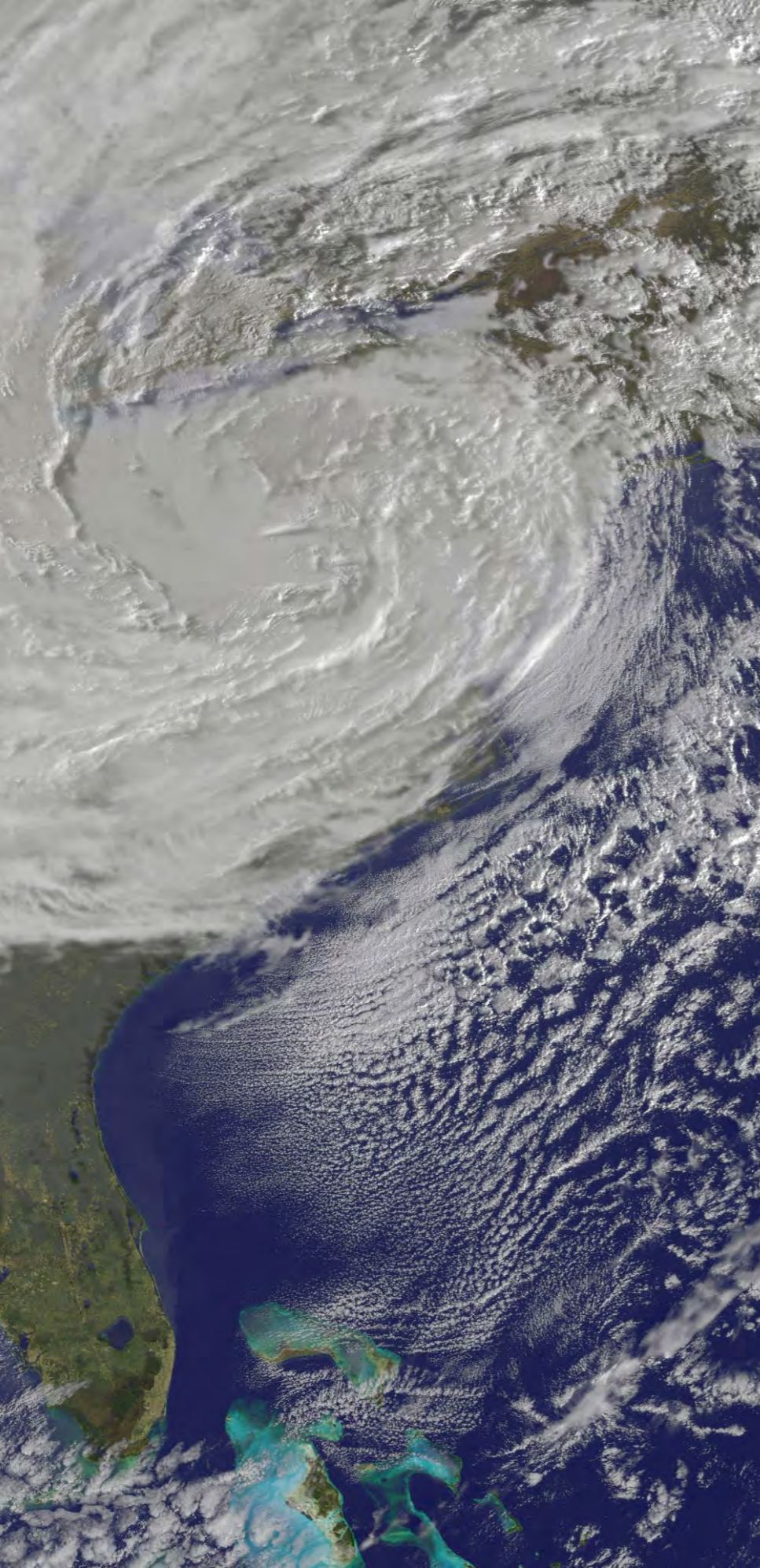


High Risk



Residual Risk





ESTIMATING FINANCIAL IMPACTS

The risk of damages from storm surges and upland flooding is a real and present concern for the people and economy of Catskill.

In 2011 Hurricane Irene and Tropical Storm Lee caused significant physical, economic, and social disruption in the Village. Losses to over 50 residences were estimated at \$1 million dollars, and approached \$1.5 million for the many affected waterfront businesses. Services such as sewage treatment, schooling, and key transportation routes were disrupted. Severe erosion in some reaches of Catskill Creek poses an ongoing threat for some landowners in the Village and the watershed beyond. Hurricane Sandy's storm surge significantly impacted some of the same people and assets in the Village barely a year later.

The Task Force worked to develop a preliminary understanding of the potential financial impacts of future flooding events and sea level rise *if no actions are taken by the Village or its residents to reduce risks*. This provides both a clear economic motivation for undertaking adaptation initiatives and an initial economic baseline against which to

consider the relative benefits of potential alternatives.

The Task Force worked with Catalysis Adaptation Partners of Freeport, Maine, to use its COastal Adaptation to Sea Level Rise Tool (COAST) to conduct an economic vulnerability assessment for the Village from the threat of future storm surges, made worse by sea level rise over time.

The COAST modeling approach is designed to help communities evaluate their vulnerabilities and investigate the merits of various adaptation options, and to show which ideas might merit further study. The results of this initial study are not considered definitive or precise, but instead are meant to offer general insights into the economic implications of changing coastal risk in Catskill. More rigorous evaluation of potential costs by engineering, architecture and planning experts will be needed before any designs are prepared or actions can be taken.

The economic projections created by COAST suggest a need to pursue funding to begin designing adaptation strategies to protect the community and make it more resilient.



**COAST Model for Catskill
Modeled Water Levels and Vulnerability Assessment Results For the 100 Year Storm with Sea Level Rise
in the Years 2025, 2055 and 2100**

Year	Projected sea level rise	Number of Tax Parcels Affected by Sea Level Rise	Expected Damage Values to Buildings and Improvements (in \$ Millions)		
			From a Single Storm In This Year	Permanently Inundated by SLR	Cumulative from SLR and All Storms Up To This Year
2025	6.5"	6	2.3	0.09	1.6
2055	21.5"	7	3.0	1.4	6.3
2100	60"	30	6.1	2.8	17.2

Results of the COAST Model Vulnerability assessment, **assuming no adaptation actions are undertaken.** Results in \$Million, non-constant dollars (undiscounted).

See Chapter 6 and Supplemental Materials for full report from the COAST model work, including Benefit-Cost ratios for multiple adaptation alternatives.

The COAST Vulnerability Assessment predicts that with no adaptation action:

- ▶ By the year 2100, if sea level increases by 5 feet over today’s, cumulative damages to buildings over time in Catskill, from all storms, would total \$17.2 million (in constant dollars).
- ▶ By the year 2100, if sea level increases by 5 feet over today’s, 30 parcels will be permanently inundated by the Hudson River, with a total taxable assessed value of \$3.8 million (*based on current assessed values*).

- ▶ A 100-year storm in the year 2055, arriving on top of a sea level increased by 1.79 feet over today’s level, would inflict one-time damages of up to \$3 million— significantly higher than from Storms Irene and Lee.

NOTE: More rigorous evaluation of potential costs conducted by engineering, architecture and planning firms will be needed before any designs are prepared or actions can be taken.



RESILIENCE

The ability to plan for, withstand, and recover from severe events – without suffering permanent loss of functions, devastating damage, diminished productivity or quality of life.

VISIONS AND PRINCIPLES FOR A RESILIENT CATSKILL

Adaptation to new stresses such as sea level rise require communities to change, reinvent, or even transform themselves. At the outset of its work, the initiative sought to describe its vision and priorities for a resilient waterfront, then use it to inform its deliberations and establish something of a guiding concept to ensure that its ultimate recommendations would be consistent with the community's desired outcomes for the Village. Members of the Task Force provided their input on priorities and visions at early meetings. Additionally, the group drew on the community vision described in the Village's 2009 Downtown and Waterfront Revitalization Strategy (by Elan Planning & Design, Inc), which solicited public input on a broader vision of village revitalization.

Based on this input and existing plans, the Task Force compiled the following adaptation principles that support the economic, social, and natural vitality of the Village.

The Village of Catskill community envisions a waterfront that...

CONSERVES:

- Natural spaces, ecosystems, and biodiversity
- Historic and cultural assets
- Viewsheds and scenic values
- Existing waterfront investments

PROMOTES:

- Smart economic development and tourism
- Attraction of business investments
- Best uses of waterfront
- Attractive parks and other open spaces
- Community education about flooding resiliency
- Planning for safety, infrastructure, and efficient problem mitigation
- Preparedness for future environmental changes

ENHANCES

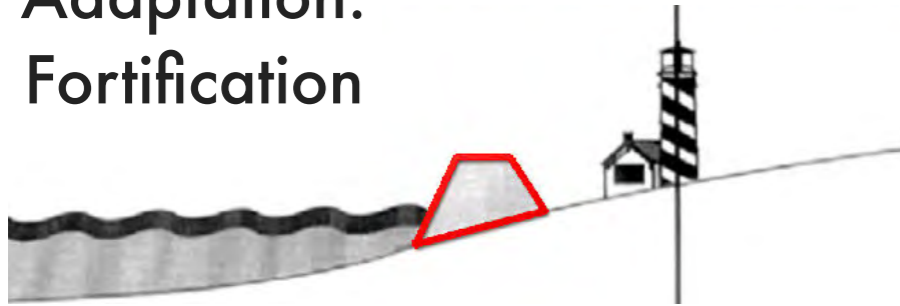
- Community vibrancy
- Residential quality of life
- Waterfront access and public amenities
- Recreational opportunities
- The central role of the waterfront in the community
- Connections of neighborhoods and village centers to waterfront



ADAPTATION

Actions or steps taken to minimize impacts from stresses, extreme events, or changing conditions.

Adaptation: Fortification



Adaptation: Accommodation



Adaptation: Relocation



ADAPTATION STRATEGIES

Adaptation, in its most basic sense, is the process of changing to better fit or adjust to a place or situation. Climate change adaptation, in particular, includes actions to adjust to changing conditions, to minimize potential impacts, and to better cope with the consequences. Adaptation can also include taking advantages of opportunities as they present themselves to reduce risk and increase resilience.

There are many types of adaptation and various frameworks which individuals or communities can use to categorize approaches to sea level rise and other flood hazard adaptation. One framework that the Task Force referenced, particularly in considering the built assets in the village's waterfront, divides flood adaptations into three categories: **Fortification**, **Accommodation**, and **Relocation**.

Fortification, sometimes referred to as structural or shoreline defenses, aims to reduce the impact of the hazard by keeping floodwaters out of contact with structures. Examples include sea walls,

levees, and dry-floodproofing of buildings.

Accommodation approaches can be described as those that allow for exposure to floodwater, but reduce its impact or the extent of recovery effort needed. Structural accommodation examples include various types of building elevations (e.g. on piles or floating bases), wet-floodproofing, and enhancement/restoration of natural protective features such as shorelines and wetlands.

In a **Relocation** approach, individuals or communities seek to avoid exposure to flooding altogether by moving structures or uses out of the hazard areas. While this approach is conceptually straightforward, it can be socially and economically complex. There are many planning tools and incentives that can be used to reduce the economic and social impact of such relocations.



Examining a wide-range of adaptation types and tools, and evaluating their strengths and weaknesses, was an important part of the Task Force’s process for considering both short- and long-term adaptation alternatives for the Village of Catskill. Many tools exist to implement community-wide adaptation, including land use planning, regulatory, market-based (e.g. incentives/taxes), spending, and outreach.

The Task Force considered how a range of fortification, accommodation, and relocation actions could be applied, and coordinated community-wide. Some adaptations were found to depend on others, while some fit particularly well with others (were considered interoperable) or provided benefits beyond flood adaptations (i.e. co-benefits).

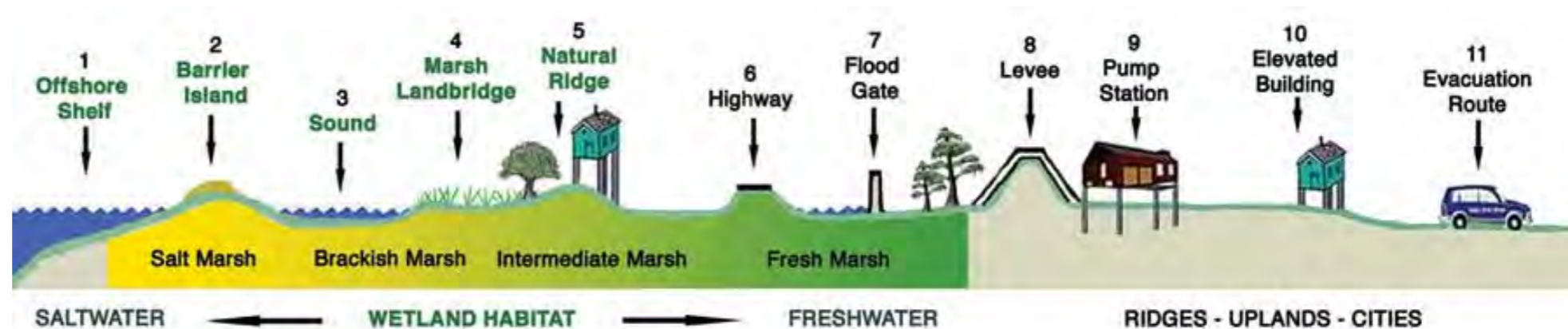


top: Relocation - a conceptual plan for a new resilient waterfront park, Toronto, Canada

bottom left: Fortification - hard bulkhead along the Hudson River.

bottom right: Housing built to accommodate floodwaters in lowest floor, Waterrijk, Netherlands.

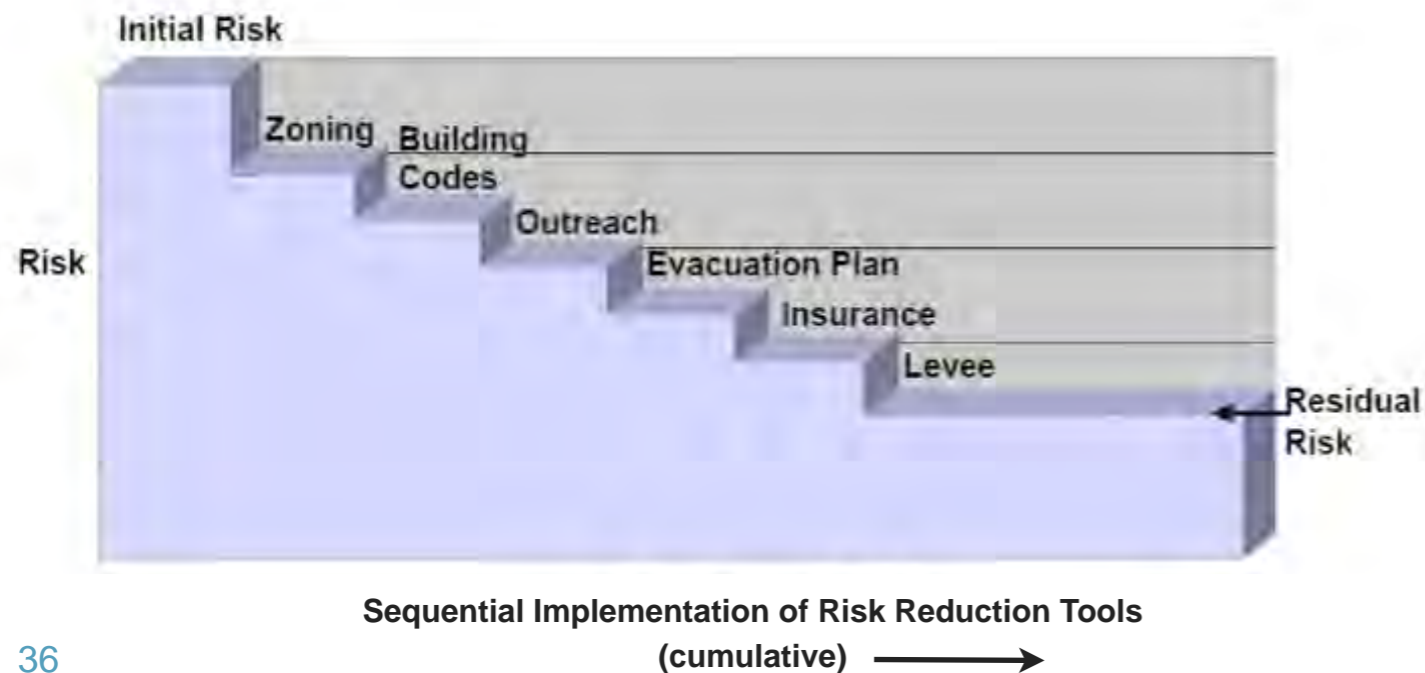
The Multiple Lines of Defense Strategy to Sustain Coastal Louisiana. Lopez, John A., Lake Pontchartrain Basin Foundation, Metairie, LA January 2006



Indeed, it was apparent that a high degree of coordination between strategies would be needed to enhance resilience of the entire Village. This is consistent with the Multiple Lines of Defense Strategy developed in Louisiana and elsewhere that emphasizes the need to employ complementary, sequential strategies that help create a more “fail-safe” system (see figure above).

The Waterfront Resilience Task Force recognized that no single adaptation is perfect for all situations, and in examining different adaptation types sought to evaluate their applicability.

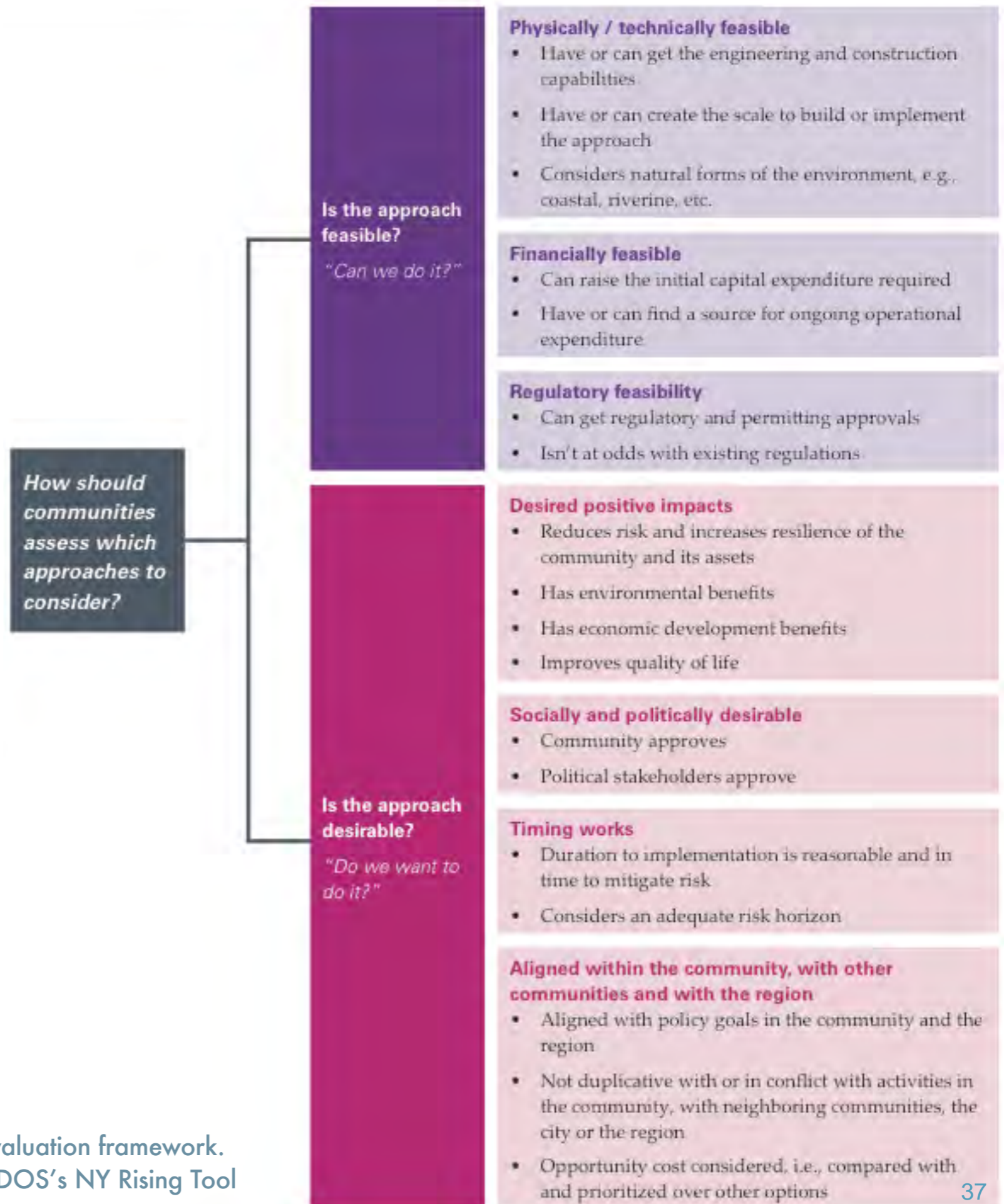
Considerations included cost, technical or regulatory feasibility, social/political desirability, fairness, environmental impact, and implementation timeframe. Another important consideration for any adaptation type is its residual risk- the risk incurred if the adaptation fails to mitigate the hazard. Some of the adaptation strategies considered during this project, such as bulkheads and other structural shore defenses, had high protective value but also high residual risk, as they could be overtopped or breached with potentially catastrophic consequences. (See figure below for an illustration of residual risk.)



Graphic of risk level following sequential implementation of risk reduction tools (zoning, outreach, etc.), with residual risk remaining after all the tools have been deployed.

How should communities assess which adaptation strategies make sense for them?

The resilience visions and principles compiled by the Task Force are an essential set of guideposts for Catskill's current and future discussions about which kinds of adaptation strategies are best for the Village's unique character and circumstances. Also useful to consider are questions about technical, financial and legal feasibility, and whether strategies achieve the desired outcomes of reductions of risk and increases in resilience. During its deliberations, the Task Force referred to a framework created by NY Department of State that helps evaluate whether strategies are feasible and desirable.



RECOMMENDATIONS

The Task Force presents the Village with the following recommendations for proactive steps toward a safer, vibrant waterfront and a more resilient Catskill. The recommendations are grouped into the following categories:

1. Communications & Emergency Management
2. Increase Flood Preparedness
3. Reduce Infrastructure Risks
4. Update Zoning & Codes
5. Update Planning
6. Municipal Operations
7. Site-based recommendations

Some recommended actions would be implemented immediately, (in the next 12 months) and others in the short- to medium-term (1-5 years). Additionally, the Task Force recognized that for the Village to remain flexible and responsive to climate change over this century, long-range planning and adaptation considerations will be an ongoing dialog within the community.

For each recommendations, lead implementers have been identified so that lines of responsibility are as clear a possible.

IMMEDIATE ACTIONS



Communications and Emergency Management

The Village of Catskill should ensure the efficiency and effectiveness of emergency management and communication strategies to promote the safety of residents, limit damage to infrastructure and properties, and enable rapid recovery from significant emergency events.

1. Review the village comprehensive emergency management plan (CEMP) for any necessary updates, including:

- ▶ Evacuation plan (including routes, defined mandatory evacuation conditions)
- ▶ Emergency communications procedures before, during, and after storms (building in redundancy where possible)
- ▶ Emergency shelters - designate, supply (including alternate power source) and staff; one shelter on each side of the creek to accommodate people and pets
- ▶ Designated loose asset (e.g. boats, cars) storage locations
- ▶ Recovery plan (including debris removal, short-term housing options)

LEAD IMPLEMENTER: **FIRE COMMISSIONER (HEAD OF EMERGENCY MANAGEMENT)**

IMPLEMENTATION TIMEFRAME GOAL: **NEXT 6 MONTHS**

2. Improve emergency communications:

- ▶ Inform residents of CODE RED (Greene County's rapid emergency notification system) and NY-ALERT (NY state's All-Hazards Alert and Notification system), and use these tools to communicate emergencies
- ▶ Organize emergency preparedness and communications networks by neighborhood.
- ▶ Develop a village communication system to inform the public of emergency conditions such as road closures and alternate routes (can be part of CEMP above); include options for communication during power outage and/or phone system failure
- ▶ Provide a web-based system for the public to share updates on emergency conditions

LEAD IMPLEMENTER: **FIRE COMMISSIONER AND POLICE LIEUTENANT, IN COOPERATION WITH GREENE COUNTY EMERGENCY SERVICES**

IMPLEMENTATION TIMEFRAME GOAL: **NEXT 12 MONTHS**

3. **Design and install high-watermark signs in the waterfront area to educate the community about flood risk and sources of flood preparedness informational resources.**

LEAD IMPLEMENTER: **DEPARTMENT OF PUBLIC WORKS**

IMPLEMENTATION TIMEFRAME GOAL: **NEXT 12 MONTHS**



Residents watching Catskill Creek flooding during Hurricane Irene on Uncle Sam Bridge (Philip Kamrass / Times Union)

Increase Flood Preparedness

The Village of Catskill should ensure that all residents, businesses, and municipal staff are prepared for flood events, armed with the tools and information they need to reduce their vulnerability.

IMMEDIATE ACTIONS

- 4. Establish an Interim Flooding and Storm Resilience committee and create a Permanent Joint Village and Town Conservation Commission.** This interim committee will begin implementing the immediate Task Force recommendations and help define the scope of the new Joint Village and Town Conservation Commission. At the time that the Joint Conservation Commission is established, the responsibilities of the committee should transfer to the Conservation Commission. The Commission will advance and track progress in implementing the Task Force recommendations and continue the long-term process of planning for a resilient waterfront.

LEAD IMPLEMENTER: **VILLAGE AND TOWN BOARDS**

IMPLEMENTATION TIMEFRAME GOAL: **NEXT 6 MONTHS**

- 5. Invite agencies or experts to give public outreach presentations on storm preparedness and flood-mitigation options for families, businesses, institutions, structures and facilities, including funding opportunities when applicable. Examples include:**

- ▶ FEMA: flood mitigation strategies, the Community Rating System, Base Flood Elevations, and resilient construction techniques in the Coastal Construction Manual
- ▶ Scenic Hudson: sea level rise inundation maps, cumulative risk assessments, NYHOPS

LEAD IMPLEMENTER: **FLOODING AND STORM RESILIENCE COMMITTEE/JOINT CONSERVATION COMMISSION**

- 6. Create a flooding best practices manual for distribution to village residents and businesses, which can include:**

- ▶ Flood hazard and safety education information
- ▶ Village communications and shelter information
- ▶ Home preparation procedures (including securing fuel tanks and other buoyant items)

- ▶ Car/boat preparation and storage procedures and locations
- ▶ Maps of flood prone roads and alternate routes
- ▶ Procedures/planning for pets
- ▶ Post storm debris removal options
- ▶ Versions in alternate languages

(Note - Consider distribution and outreach strategies to ensure adequate preparedness of all populations.)

LEAD IMPLEMENTER: **VILLAGE COMMUNITY DEVELOPMENT COORDINATOR AND CORNELL COOPERATIVE EXTENSION**

IMPLEMENTATION TIMEFRAME GOAL: **NEXT 12 MONTHS**

7. Post key information on flood risks and emergency plans on the village website:

- ▶ Base Flood Elevation (BFE) map, including guidance on their interpretation (e.g. they do not account for current rates of SLR or future acceleration)
- ▶ Comprehensive Emergency Management Plan
- ▶ Links to FEMA resources including the Coastal Construction Manual, National Flood Insurance Program, and the Community Rating System

LEAD IMPLEMENTER: **VILLAGE WEBSITE UPDATE PERSONNEL**

IMPLEMENTATION TIMEFRAME GOAL: **NEXT 6 MONTHS**

8. On an annual basis, direct property owners and residents of current and projected future floodplains to the Village's informational resources about flooding and emergency preparedness.

LEAD IMPLEMENTER: **FLOODING AND STORM RESILIENCE COMMITTEE/JOINT CONSERVATION COMMISSION, WITH VILLAGE CLERK AND FLOODPLAIN MANAGER**

IMPLEMENTATION TIMEFRAME GOAL: **NEXT 6 MONTHS**

SHORT/MEDIUM TERM ACTIONS & STRATEGIES

9. Support regular training for the village floodplain manager (Code Enforcement Officer).

LEAD IMPLEMENTER: **VILLAGE BOARD**

10. Work with other communities in the Catskill Creek watershed to better manage stormwater and runoff. This can include:

- ▶ Host a meeting of creek corridor municipalities to explore inter-municipal coordination on watershed management, including maintaining/improving rainwater infiltration (to moderate creek flooding extent)
- ▶ Investigate the feasibility of a hydrology study of Catskill Creek to determine baseline conditions and model future conditions

LEAD IMPLEMENTER: **CORNELL COOPERATIVE EXTENSION AND NYS DEPARTMENT OF ENVIRONMENTAL CONSERVATION HUDSON RIVER ESTUARY PROGRAM**

IMPLEMENTATION TIMEFRAME GOAL: **NEXT 12-18 MONTHS**

Reduce Infrastructure Risks

The Village of Catskill should ensure that critical infrastructure and services are robust and resilient - able to function during and after major events with minimal damage or downtime.

IMMEDIATE ACTIONS

11. Work through the Greene County Multi-Hazard Mitigation Plan to position Catskill for resiliency actions and funding opportunities:

- ▶ Update the plan to identify coastal hazards specific to the Village of Catskill, including shoreline erosion, sea level rise, and hurricanes
- ▶ Use the plan to propose retrofits for flood vulnerable infrastructure in the village

(NOTE - these updates will make the community eligible for hazard mitigation funds.)

LEAD IMPLEMENTER: **FLOODING AND STORM RESILIENCE COMMITTEE/JOINT CONSERVATION COMMISSION AND VILLAGE BOARD**

IMPLEMENTATION TIMEFRAME GOAL: **NEXT 6 MONTHS**

12. Conduct a risk and engineering review of key municipal infrastructure to identify adaptation needs/options/plans for:

- ▶ Wastewater treatment plant
- ▶ Pump stations
- ▶ Primary roadways
- ▶ Water supply
- ▶ MainCare (oil terminal)
- ▶ Greene County Highway Department
- ▶ Other municipal facilities

LEAD IMPLEMENTER: **VILLAGE BOARD (WITH CONSULTANT)**

13. Maintain an inventory and stock all necessary replacement parts for sewage treatment plant and pump stations.

LEAD IMPLEMENTER: **DEPARTMENT OF PUBLIC WORKS**

IMPLEMENTATION TIMEFRAME GOAL: **NEXT 3 MONTHS**



Update Zoning and Codes

The Village of Catskill should plan for resilient land use patterns and encourage safe, resilient structures in the waterfront area through planning, zoning, permitting and building codes in existing and new development.

SHORT/MEDIUM TERM ACTIONS & STRATEGIES

14. Convene a working group including representation from Village boards, committees, officials and municipal planners to review the Task Force Report and identify which/how local codes can be modified to better weather and adapt to future storms and account for sea level rise (possibly with a consultant). Considerations may include:

- ▶ Revisions to zoning and codes to more specifically address flood risk areas and extend those areas to reflect projected sea level rise and future conditions; this could include:
 - Special floodzone or waterfront overlay district that corresponds to floodway, 10-year and 100-year flood areas, and future SLR areas, with a corresponding building permit process
 - Preferred shoreline treatments for sea level rise and flood resilience
 - Resilient building standards
 - Steep slopes ordinance
 - Stormwater management techniques
 - Code for securing fuel tanks and other potentially bouyant tanks/structures
- ▶ Consider requiring property owners in flood-prone areas to include additional flood-proofing and adaptive measures for new, substantially damaged or substantially improved buildings above the FEMA standard (for example, by exceeding the 2-foot freeboard requirement in local code); *NOTE - upon consultation with the state and the floodplain manager.*

LEAD IMPLEMENTER: **VILLAGE BOARD (INITIATE AND APPOINT)**

15. Consider applying to participate in the National Flood Insurance Program (NFIP) Community Rating System (CRS), to reduce flood insurance rates and improve flood resilience.

LEAD IMPLEMENTER: **FLOODING AND STORM RESILIENCE COMMITTEE/JOINT CONSERVATION COMMISSION (INITIATE WITH FEMA) AND VILLAGE BOARD**

Update Planning

The Village of Catskill should plan for resilient land use patterns through updates to existing plans and implementation of new planning tools.

SHORT/MEDIUM TERM ACTIONS & STRATEGIES

16. Ensure that all proposals and plans address projected sea level rise and are responsive to flood resilient issues. Possibilities include:

- ▶ Adopt a policy that requires all new proposals and plans to demonstrate how they incorporate projected sea level rise and flood resilience issues
- ▶ Update and adopt the LWRP (NYS DOS funding is available for updates AND this will make the community eligible for waterfront improvement funds)
- ▶ Update and adopt village and town Joint Comprehensive Plan
- ▶ Revise Downtown and Waterfront Revitalization Strategy

LEAD IMPLEMENTER: **VILLAGE AND PLANNING BOARDS**

IMPLEMENTATION TIMEFRAME GOAL: **NEXT 9 MONTHS**

17. Promote the use of Green Infrastructure techniques throughout the village to reduce flooding from runoff and minimize stormwater treatment burdens.

LEAD IMPLEMENTER: **FLOODING AND STORM RESILIENCE COMMITTEE/JOINT CONSERVATION COMMISSION**

18. Consider participating in NYS DEC's Climate Smart Communities and its new certification program, in order to receive free technical assistance and eligibility for future grant applications.

LEAD IMPLEMENTER: **FLOODING AND STORM RESILIENCE COMMITTEE/JOINT CONSERVATION COMMISSION**

19. Promote the long-term persistence of natural storm buffer areas, particularly Ramshorn-Livingston Marsh, Catskill Point, and undeveloped riparian areas along Catskill Creek (e.g. Goat Island, Pelican Island).

LEAD IMPLEMENTER: **FLOODING AND STORM RESILIENCE COMMITTEE/JOINT CONSERVATION COMMISSION**

20. Consult the Task Force report for neighborhood/asset specific recommendations and begin developing strategies to address them (e.g. developing an alternate access to the school complex via Bridge Street).

LEAD IMPLEMENTER: **VILLAGE BOARD AND FLOODING AND STORM RESILIENCE COMMITTEE/JOINT CONSERVATION COMMISSION**



left: Map of revitalization zones identified in the Downtown and Waterfront Revitalization Strategy

right: Map of revitalization zones identified in the Downtown and Waterfront Revitalization Strategy with future flood/inundation zones displayed in shades of red.

Municipal Operations

Village operations, funding and decision making should strive to reduce vulnerability to flooding and increase resilience.

Village boards, committees, and staff responsible for the management and regulation of resources, infrastructure and vulnerable populations should consider the impacts of flooding, sea level rise and climate change in all relevant decision making. This should include long-term planning, programming, permitting, regulation, emergency response, and funding and capital-expenditure decisions.

IMMEDIATE ACTIONS

- 21. Take advantage of training opportunities from federal, state and local partners to improve staff and volunteer understanding of tools available to help plan for and respond to flood emergencies.**

LEAD IMPLEMENTER: **CORNELL COOPERATIVE EXTENSION AND GREENE COUNTY EMERGENCY SERVICES**

IMPLEMENTATION TIMEFRAME GOAL: **NEXT 6 MONTHS**

SHORT/MEDIUM TERM ACTIONS & STRATEGIES

- 22. Integrate departmental funding requests into a village-wide Capital Improvement Plan that incorporates and prioritizes the needs of all departments, along with phased adaptation of infrastructure to flooding and sea level rise.**

LEAD IMPLEMENTER: **VILLAGE BOARD, VILLAGE CLERK, AND ALL VILLAGE DEPARTMENTS**

- 23. Incorporate cost-benefit analyses and long-term flood risk due to sea level rise and stronger storms into asset design and the prioritization of strategies to manage key municipal assets.**

LEAD IMPLEMENTER: **VILLAGE BOARD**

- 24. Create an orientation packet or a presentation on flood hazards and municipal plans for all newly elected/appointed municipal representatives, to ensure that new personnel are well-informed on the issues and procedures in the village.**

LEAD IMPLEMENTER: **FLOODING AND STORM RESILIENCE COMMITTEE/JOINT CONSERVATION COMMISSION**



Site-Based Recommendations

The Village should consider the uniqueness of each stretch of its waterfront, as well as its connections to other stretches, in determining the best options for flood adaptation.

As a means to understand the Catskill waterfront more deeply and plan at a more granular level, the Task Force delineated 8 Adaptation Neighborhoods - segments of the waterfront united by their physical conditions, uses, assets and populations. Each of these neighborhoods present challenges and opportunities for positive transformation toward resiliency.

Below are recommendations, considerations, or concepts for adapting each waterfront neighborhood. Some of these actions are near-term and some might be appropriate several decades from now.

Catskill Point & Lower Main Street

- ▶ Consider ways to maintain the viability and accessibility of the mainly commercial (with a small component of residential) uses of the point. These may include using fill to elevate Main Street along with commercial and residential uses, converting Main Street to an elevated Pier, using docks and boat piers to maintain and encourage additional water-based commercial uses, and adapting residences through wet-floodproofing or other structure adaptations.
- ▶ Begin planning for long-term relocation of the village's wastewater treatment plant.
- ▶ Allow low-lying open spaces (including Dutchmans Landing Park and wastewater treatment plant site, once relocated) to revert to tidal wetland habitat.
- ▶ Seek alternate locations for waterfront parkland, to maintain public access opportunities for residents and visitors.
- ▶ Reconcile proposed redevelopment alternatives proposed in the Downtown and Waterfront Revitalization Strategy with sea level rise and risk area projections, to generate a more resilient redevelopment vision.

Central Waterfront (East Shore of Catskill Creek)

- ▶ Explore near- and long-term flood adaptations for waterfront buildings, and encourage/incentivize their implementation. Wet-floodproofing of buildings may be feasible in the short-term, while elevation of individual buildings or raising sections of the waterfront with fill may be investigated as long-term options.
- ▶ Research upgrades to erosion-controlling shoreline treatments, including nature-based and ecologically-enhanced options, as well as the hydrological impacts such upgrades may have on other stretches of the Catskill Creek waterfront within the village.
- ▶ Reconcile proposed redevelopment alternatives proposed in the Downtown and Waterfront Revitalization Strategy with sea level rise and risk area projections, to generate a more resilient redevelopment vision.

West Main Street Waterfront (West Main Street- South)

- ▶ Consider various long-term adaptation pathways for the area, including floodproofing or elevating existing structures, raising or otherwise upgrading West Main Street, incentivizing a shift of water-based businesses to the landward (west) side of the road, or using fill or nature-based erosion protection solutions to create areas that extend the longevity of water-based businesses on the water (east) side of the road.
- ▶ Continue supporting Greene County with planning for relocation of its Highway Department facility out of the flood hazard zone.
- ▶ Reconcile proposed redevelopment alternatives proposed in the Downtown and Waterfront Revitalization Strategy with sea level rise and risk area projections, to generate a more resilient redevelopment vision.

West Bridge Street

- ▶ Work with present and potential new business/property owners to encourage building adaptations such as wet floodproofing.
- ▶ Assess interest in developing a master plan to coordinate the adaptation activities of individual property owners, in order to minimize expenses and create an appealing commercial area.
- ▶ Reconcile proposed redevelopment alternatives proposed in the Downtown and Waterfront Revitalization Strategy with sea level rise and risk area projections, to generate a more resilient redevelopment vision.

Schools (West Main Street- North)

- ▶ Research erosion-controlling shoreline treatments, including nature-based and ecologically-enhanced techniques, as well as the hydrological impacts such upgrades may have on other stretches of the Catskill Creek waterfront within the village. Such shoreline treatments may be incorporated into the Bridge-to-Bridge greenway design.
- ▶ Seek an alternate route to the school complex, possibly via Dumond Street, in order to maintain access and continued operation of the facilities during and immediately after flood events.
- ▶ Monitor flood risk to school buildings, and plan ahead for dry-floodproofing when necessary.
- ▶ Consider moderately raising West Main Street to reduce flood impacts to road infrastructure.

Bushnell - Route 9W

- ▶ Ensure that re-developments or substantial improvements are adapted to current and future projected flood risks.
- ▶ Research the possibility of partial or full neighborhood buyouts in order to reduce the continued impacts on property and human safety. Areas of research may include sources of funding that allow for adaptive redevelopment, assessing property owner and resident opinion/interest, identifying potential places for whole-neighborhood relocation within the village, exploring the possibility of extending the planned recreational Bridge-to-Bridge walkway along this shore, and understanding the benefits and costs of restoring the creek floodplain to a more natural state.
- ▶ Consider developing a master plan to either coordinate the adaptation activities of individual property owners or find collective alternatives.

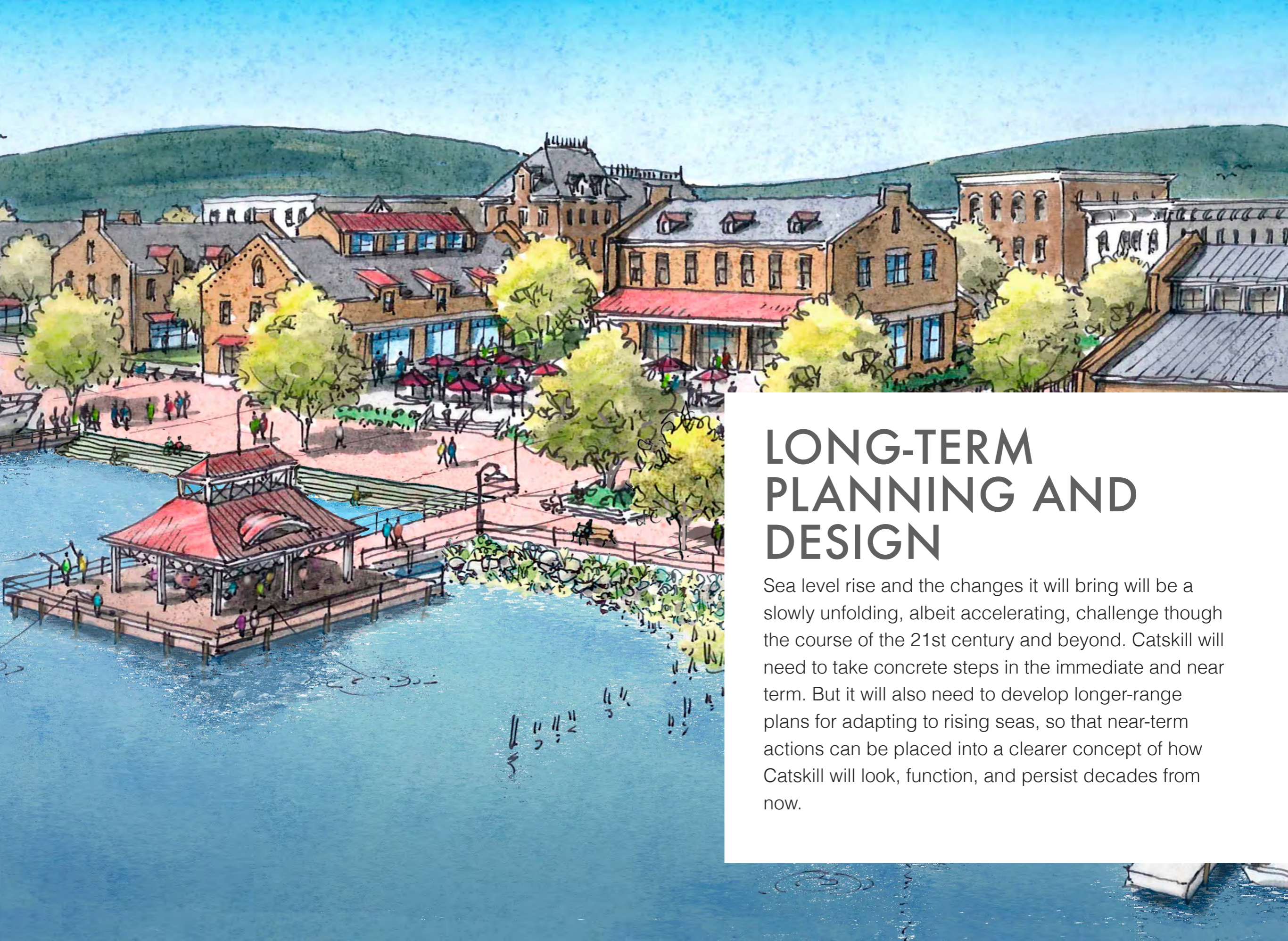
Natural Buffer

- ▶ Consider permanent protection and/or restoration efforts to enhance the protective services of this floodplain area upstream of the Village waterfront.

Ramshorn Livingston Marsh

- ▶ Evaluate ways to enhance the flood-buffering characteristics of the marsh, to protect the existing marsh area from degradation, and to secure open space for inland marsh migration.
- ▶ Research the need for and feasibility of assisted marsh adaptation (e.g. assisted accretion).





LONG-TERM PLANNING AND DESIGN

Sea level rise and the changes it will bring will be a slowly unfolding, albeit accelerating, challenge though the course of the 21st century and beyond. Catskill will need to take concrete steps in the immediate and near term. But it will also need to develop longer-range plans for adapting to rising seas, so that near-term actions can be placed into a clearer concept of how Catskill will look, function, and persist decades from now.

Developing consensus around Catskill's adaptation to the challenges of flooding and sea level rise will be a topic of a civic dialog in the Village for the foreseeable future. It will require sustained public engagement, detailed study and considerable creativity.

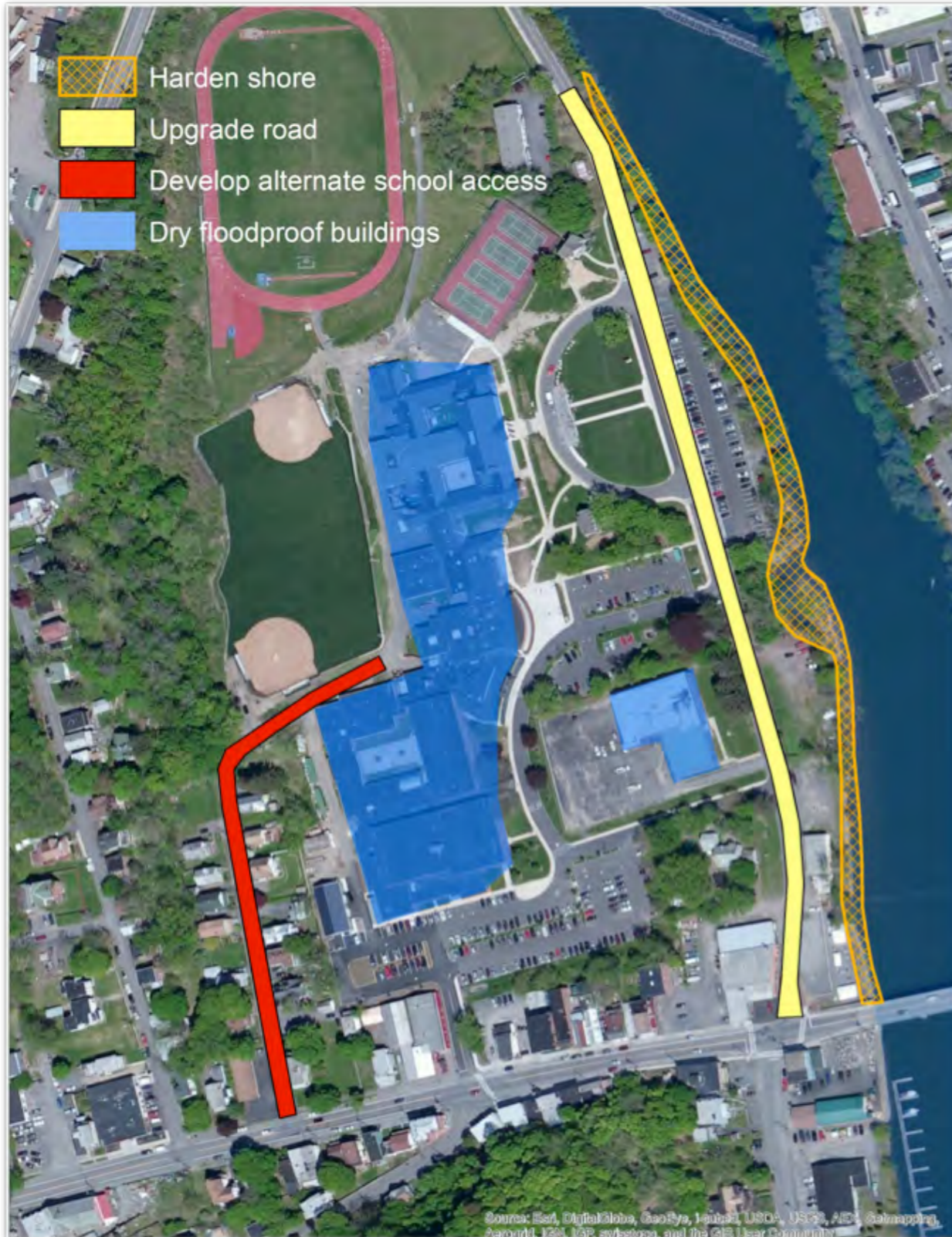
The Task Force undertook a variety of studies to begin the Village's process of planning and designing a more resilient waterfront, but the results of this effort and this report should not be seen as the completion of this process. Task Force members learned about the range of conceptual, physical, and regulatory approaches to adaptation currently in practice or development in other coastal areas in the United States and elsewhere.

Armed with this broader perspective, the Task Force developed a portfolio of "Adaptation Alternatives" - competing scenarios for how a specific neighborhood might be redesigned to reduce risks and

achieve the vision statements and principles. A few examples of these Adaptation Alternatives are provided here to show the types of options and tradeoffs that could be examined in the future to ensure a resilient Catskill.. (The full set of Adaptation Alternatives are available in Supplemental Materials.)

What follows are three case studies with differing levels of upfront investment and long-term costs and benefits in order to demonstrate some of the different types of planning options the community might consider. These alternatives are "sketches" of potential approaches, illustrative of strategies the Task Force sought to learn from - they are *not* recommendations or endorsements of desirability, feasibility, etc. Indeed, there are myriad other possible alternatives, many of which might be worthy of consideration or adoption.





Overhead view of School neighborhood with adaptation actions indicated.

Example Adaptation Alternative: School Zone

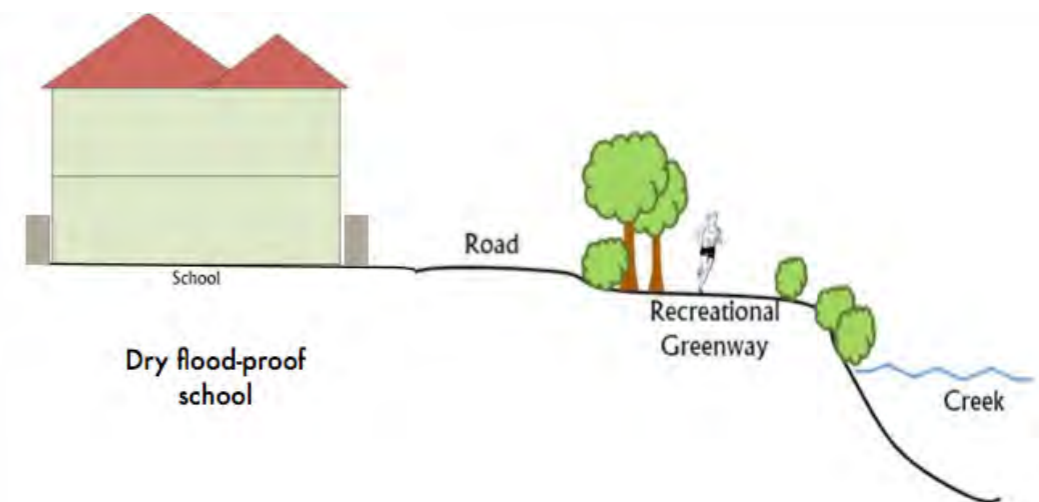
This Alternative sought to minimize flood risks to the schools, ensure access to the area and avoid shoreline erosion while enhancing recreational and environmental benefits. It combines ecologically-enhanced shoreline treatments, upgrades to the road network and flood-proofing all or parts of the complex of school buildings.

Pros:

- Creates redundant access to the schools
- Potentially financially and technically feasible
- Provides recreation and tourism opportunities.

Cons:

- This approach becomes less effective over time, with the school at greater risk as sea level rises.
- There is residual risk of significant loss if flood-proofing level is overtopped during a storm event.



Example Adaptation Alternative:

Catskill Point - Piers, Wharfs, and Amphibious or Flow-Through Structures

Overhead view of Catskill Point showing the location of the new pier, docks, and adapted structures.



This Alternative, one of several considered for Catskill Point, sought to accomplish multiple goals simultaneously. Foremost, it seeks to preserve access and current waterfront uses along Main Street and at Catskill Point as well as preserve the Village's connection to the Hudson River through its marquis parkland. This alternative also works to reduce risks to private and municipal infrastructure while also making way for development of new marsh habitat in the former parkland.

The scenario integrates amphibious homes (which rest on the ground but are capable of floating during flood events) or permanently floating structures, elevated roadway, and breakwaters (to provide wave attenuation needed by the homes). The scenario also contemplates the relocation of the wastewater treatment plant and the creation of a new boat pier.

The Task Force made the following observations about this Adaptation Alternative:

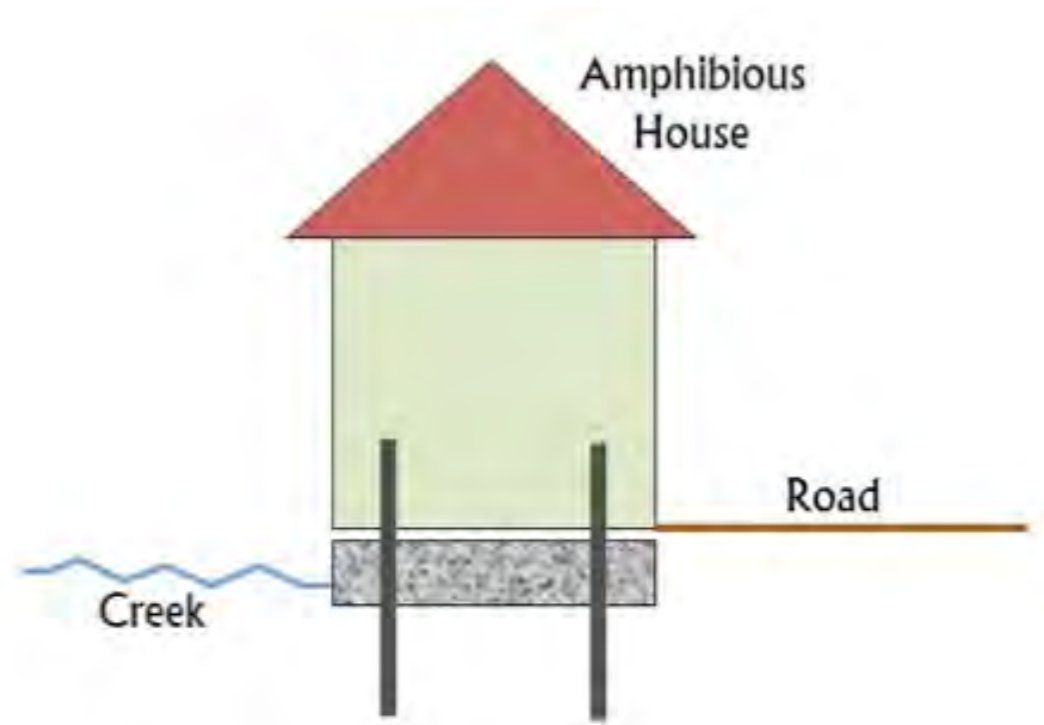
Pros:

- This approach maintains some current uses, preserves a historic/cultural asset and public access
- Supports the waterfront economy and tourism
- Environmental and flood mitigation benefits in creating new marsh
- This approach is effective in making the structures more resilient, potentially for an unlimited time horizon because the adapted structures cannot be overtopped or flooded regardless of sea level rise

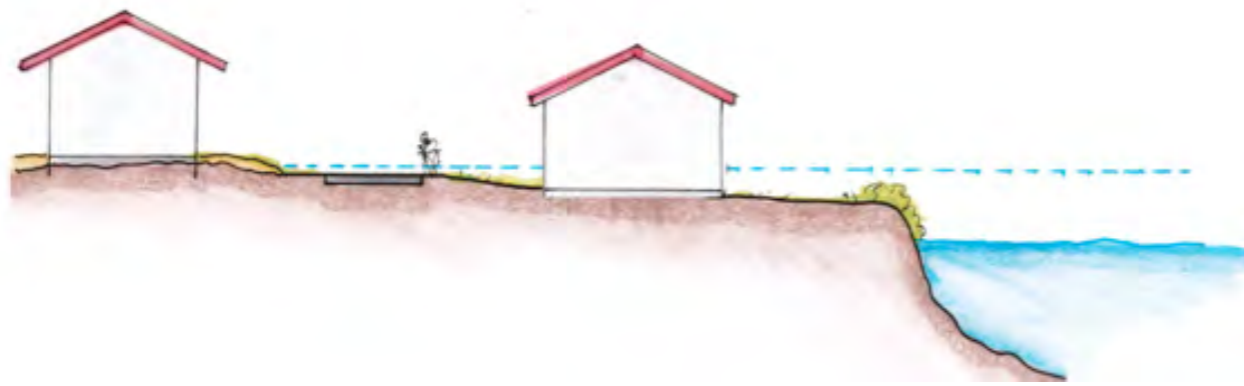
Cons:

- This approach is likely to have a high cost, mostly shouldered by the public
- This approach faces potential regulatory hurdles, is technically complex, and would require coordination with State regulators
- This approach may entail some loss of some existing businesses

Notes: This approach would likely have significant impact on the village's waterfront character, with unknown positive or negative consequences.



Schematic of an amphibious house, which could be located along the road to Catskill Point. Amphibious structures are capable of floating on anchored platforms during flood events but are designed to rest on the ground most of the time.



BENEFIT-COST ANALYSIS CASE STUDIES: COAST MODELING OF ADAPTATION ALTERNATIVES

To further advance the information available to the Village for long-range resilience planning, the Task Force developed three highly-detailed Adaptation Alternatives and worked with Catalysis Adaptation Partners to investigate their potential economic costs and benefits relative to avoiding damages from flooding events.

These case studies were intended to explore a range of hypothetical approaches to increasing resiliency in specific areas using specific strategies and to begin understanding their physical, social, environmental and economic implications.

The Task Force considers these case studies to be illustrative of the adaptation planning process and believes that they may be informative to the Village as it considers the future of the waterfront. These case studies are not intended as recommendations, nor does the Task Force endorse any of these specific strategies for implementation without further study and public input.

COAST (COastal Adaptation to Sea level rise Tool) can be used to calculate a Benefit-Cost ratio for various adaptation types, using projected dollar figures for economic vulnerability over time (see pages 29-30), projected avoided damages, and estimated costs of adaptation. The larger the Benefit-Cost ratio, the more damage is avoided relative to adaptation costs. Ratios smaller than 1 result when the costs are higher than the avoided damages. The generalized methodology of COAST produces estimates only, and the resulting Benefit-Cost ratios are intended to be used in conjunction with non-economic considerations to guide communities in evaluating which adaptation options they may wish to study further. All estimates in the COAST analysis for Catskill were based on the three sea level rise projections chosen by the Task Force for all their planning exercises (see page 22).

CASE STUDY 1: BUSHNELL GREENWAY

GOAL: TO HELP REDUCE THE NUMBER OF
PEOPLE & PROPERTIES IN RISK-PRONE AREAS
AND CREATE NEW GREEN INFRASTRUCTURE
IN VILLAGE



Parcels for relocation now



Parcels for relocation in 2055



Catskill Greenway trail

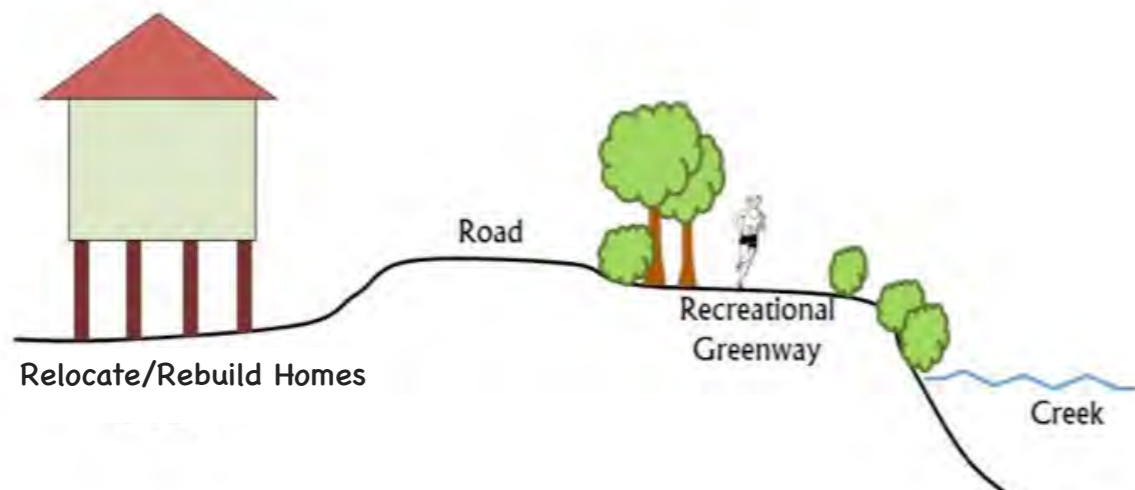
ADAPTATION OVERVIEW

The neighborhood along Bushnell Avenue was one of the hardest hit by Hurricane Irene, Tropical Storm Lee and Hurricane Sandy. Many homes in this area are within the current 100-year flood zone, are constructed at elevations that make them vulnerable to flooding events, and were damaged during the recent storms. Several property owners in the area have rebuilt, but some are still recovering or have abandoned or sold their properties.

This case study scenario explores ways to reduce risks to private infrastructure in the neighborhood by proposing a relocation strategy, with potential later redevelopment of the land using flood-resilient building standards. This scenario also proposes creating a new Catskill Creek Greenway trail way along the shoreline that would simultaneously provide floodway buffering and increase recreational opportunities along the creek.

ADAPTATION ELEMENTS

- Parcels in red are bought out between now and 2055.
- Parcels in yellow are bought out between 2055 and 2100.
- Create an extension of the Catskill Creek Greenway trail along the dotted green line, to provide floodway buffering and increase recreational opportunities along the Creek.



BENEFIT-COST ANALYSIS

- The cost of purchasing the parcels would be approximately \$2.15 million over the two phases of the relocation program.
- Avoided costs (damages) from flood events with this adaptation in place is estimated to total approximately \$1.03 million over the course of the 21st century.
- The Greenway trail would be an additional, unknown cost.

INTERPRETATIONS AND LEARNINGS

The Task Force recognized that this scenario, while simple in terms of the steps required for implementation, was more complex in terms of its social and economic implications. There are significant questions regarding property owner interest in this approach, whether public funding will be available, whether tax base loss can be offset by redevelopment or new development elsewhere, and how the neighborhood's sense of community can be maintained.

The Task Force also recognized that this scenario has a substantial potential upside - it eliminates risks to life and property in one of the most flood-vulnerable neighborhoods in Catskill and creates a new, environmentally sensitive amenity that is consistent with the Downtown and Waterfront Redevelopment Plan.

The Benefit-Cost ratio of this scenario is less than 1, meaning the expected costs are higher than the expected value of avoided damages over the course of the 21st century. However, given the relatively low overall cost of the scenario (\$2M), the shortfall in benefits might be outweighed by other considerations such as improving public safety, helping residents avoid dislocation during floods, or the attractiveness of a new municipal greenway.

CASE STUDY 2: FLOODPROOF WEST MAIN

GOAL: TO
MAINTAIN
WATERFRONT USES
AND ROAD ACCESS
WHILE MINIMIZING
DAMAGES FROM
FLOODING

ADAPTATION OVERVIEW

The stretch of West Main Street extending south of West Bridge Street includes a mix of uses, primarily waterfront-dependent (e.g. marinas) and residences. Many built assets in this neighborhood, including sections of the road, currently experience high flood risk that is expected to increase through the century and even include some regular inundation due to sea level rise.

This accommodation-oriented scenario aims to maintain current uses and access to them by adapting existing buildings and infrastructure to withstand floodwaters, using either wet- or dry-floodproofing, and elevation above flood hazard heights. *Wet-floodproofing* retrofits and limits the uses in the lower portions of buildings, so that floodwaters can enter and recede with minimal damage. *Dry-floodproofing* entails sealing all the openings in the lower portions of structures with water-tight doors, windows, and vents, or by other mechanism. The Greene County Highway Department building was excluded from the analysis, as plans are already underway to find a suitable place for its relocation. All parcels predicted by COAST to be affected by future flooding are included in the adaptation scenario (for more detail on COAST methods see the supplemental materials).

Adaptation Elements

- All properties in red are wet/dry flood-proofed now (first floor) and elevated to 17.5ft (Base Flood Elevation 10.5ft + 2 ft freeboard + 60 inches sea level rise) between 2055 and 2100.
- All properties in yellow wet/dry flood-proofed (first floor) after 2055.
- Roadway in purple elevated to 9.76 ft (Mean Higher High Water of 2.76ft + 2ft freeboard + 60 inches sea level rise) after 2055.

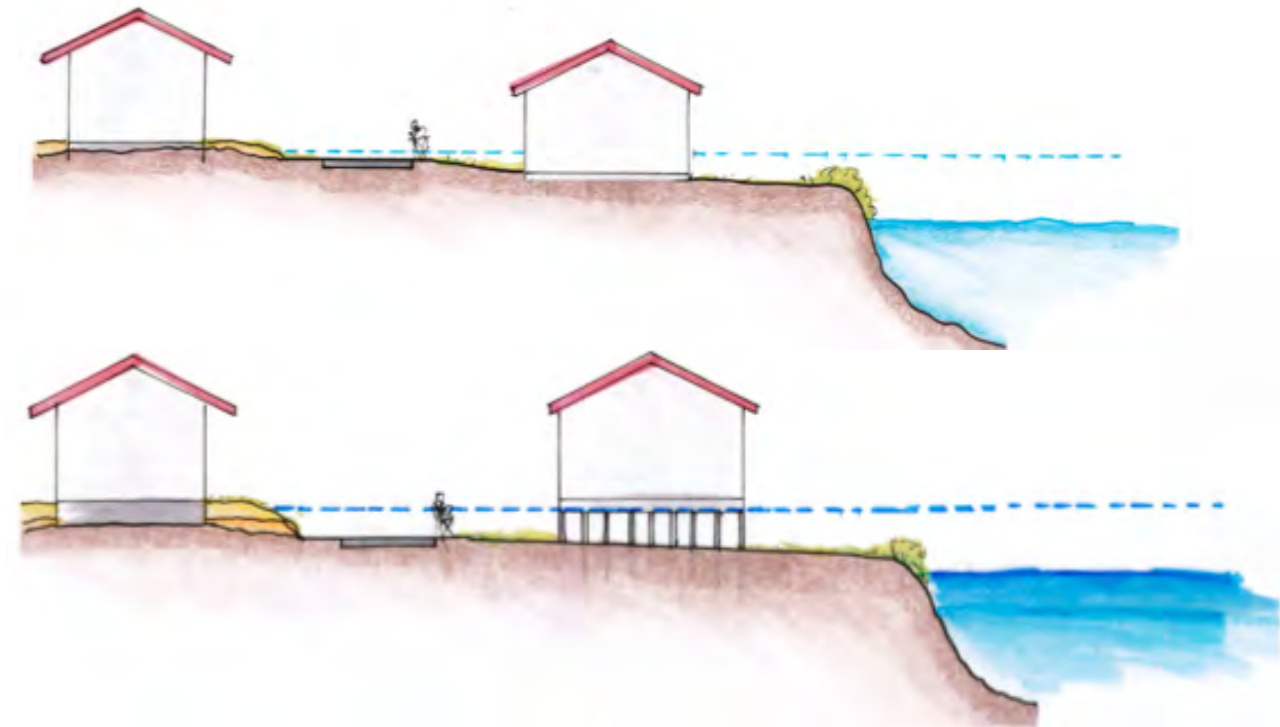
BENEFIT-COST ANALYSIS

- The cost of flood-proofing or elevating the structures, and eventually elevating the roadway would be approximately \$1.6 million over the two phases of the adaptation process.
- Avoided costs (damages) from flood events with this adaptation in place is estimated to total approximately \$1.31 million over the course of the 21st century.

INTERPRETATIONS AND LEARNINGS

This accommodation-based scenario resulted in a positive Benefit-Cost ratio by 2055 but a negative one by 2100. The relatively low-cost floodproofing approach would more than pay for itself in avoided damages in the next few decades. However, projected sea level rise and the related increased flood hazards in the second half of the century would necessitate more aggressive adaptations. In this scenario such adaptations included elevating West Main Street and elevating buildings. These expensive actions may not be economically feasible or desirable relative to the number and assessed value of the structures that the road serves.

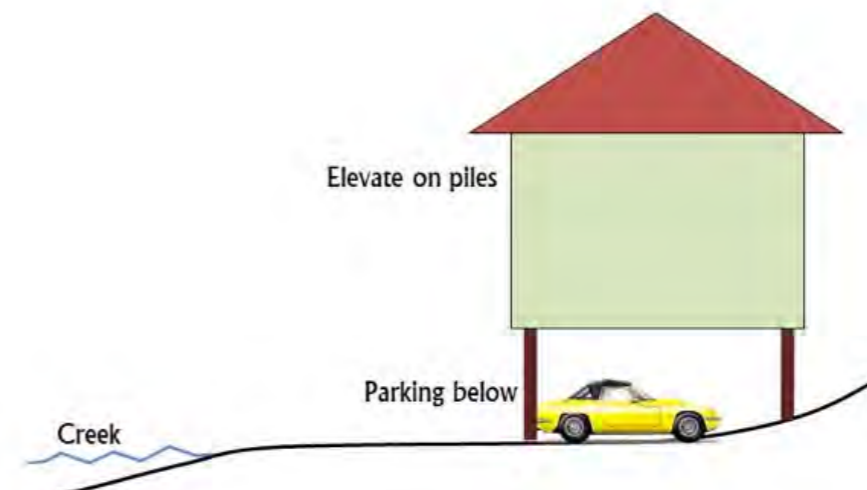
This adaptation scenario includes a mix of building adaptation methods, in an attempt to allow for current uses to continue unchanged. Still, in reality some structures may not be well-suited to any of the options, or individual owners may not be able to bear the fiscal burden. This could mean that threats to property and safety may not be adequately addressed, and that properties may ultimately be abandoned due to repeated damages. The analysis did not include the adaptations or relocation that would be necessary for the village wastewater pump station that is also located on this shore. Planning for the long-term viability of the marinas will also entail consideration of means to secure boats or store them off-site during flood events.



top: Sketch of current conditions with Base Flood Elevation indicated by blue dotted line

above: Sketch of future adaptation condition, with elevated structure on right side of road, dry flood-proofed structure on the left side of road, and higher Base Flood Elevation indicated by blue dotted line.

below: Illustration of an elevated structure with space for parking underneath.



CASE STUDY 3: WEST MAIN REDESIGN

GOAL: ENHANCE
WATERFRONT USES, AND
MAINTAIN RESIDENTIAL USES
ALONG WITH ROAD ACCESS
WHILE MINIMIZING
DAMAGES FROM FLOODING

ADAPTATION OVERVIEW

As an alternative to Case Study #2, this scenario combines a portfolio of relocation and accommodation adaptations to achieve similar goals but with a stronger focus on maintaining or enhancing water-dependent uses along Catskill Creek, while allowing water and habitats to advance upslope where possible. In this scenario, the adaptation of uses immediately adjacent to the waterfront (primarily water-dependent ones) would be relocated onto constructed and phase-elevated fill areas. This concentrates the water-dependent uses and allows water to advance into other areas between the road and the current creek limits. Residential and other uses on the other side of the road would be adapted by elevation in a manner similar to Case Study #2, as would the roadway itself.

ADAPTATION ELEMENTS

- Create new waterfront access in areas outlined in black: bulkhead and fill to 14.29 ft by 2055 (Base Flood Elevation of 10.5 ft + 2 ft freeboard + 21 inches sea level rise) and 17.5 feet (Base Flood Elevation 10.5 ft + 2 ft freeboard + 60 inches sea level rise) after 2055.
- Move all/most waterfront structures east of road to waterfront access areas outlined and crosshatched in black.
- Elevate all properties in yellow to 17.5 feet (Base Flood Elevation 10.5 ft + 2 ft freeboard + 60 inches sea level rise) after 2055.
- Elevate roadway in red to 9.76 feet (Mean Higher High Water 2.76 ft + 2 ft freeboard + 60 inches sea level rise) after 2055.

BENEFIT-COST ANALYSIS

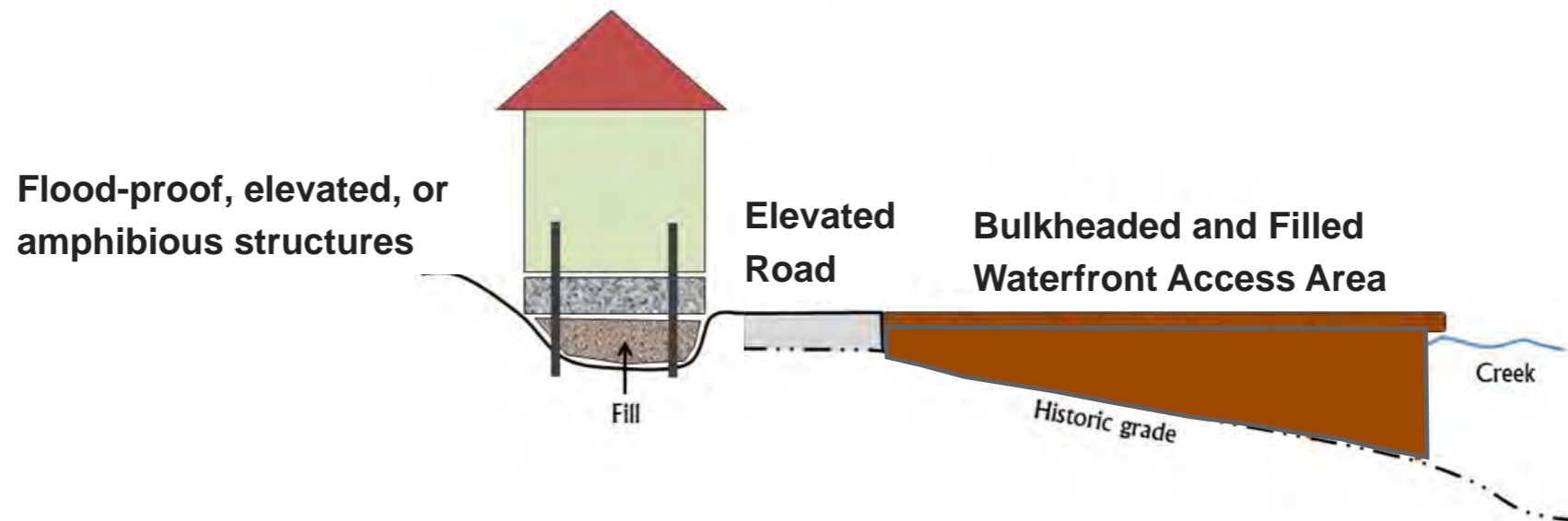
- The cost of bulkheading and filling the new wharf areas, and elevating structures and the roadway would be approximately \$2.76 million over the two phases of the adaptation process.
- Avoided costs (damages) from flood events with this adaptation in place are estimated to total approximately \$5.48 million over the course of the 21st century.

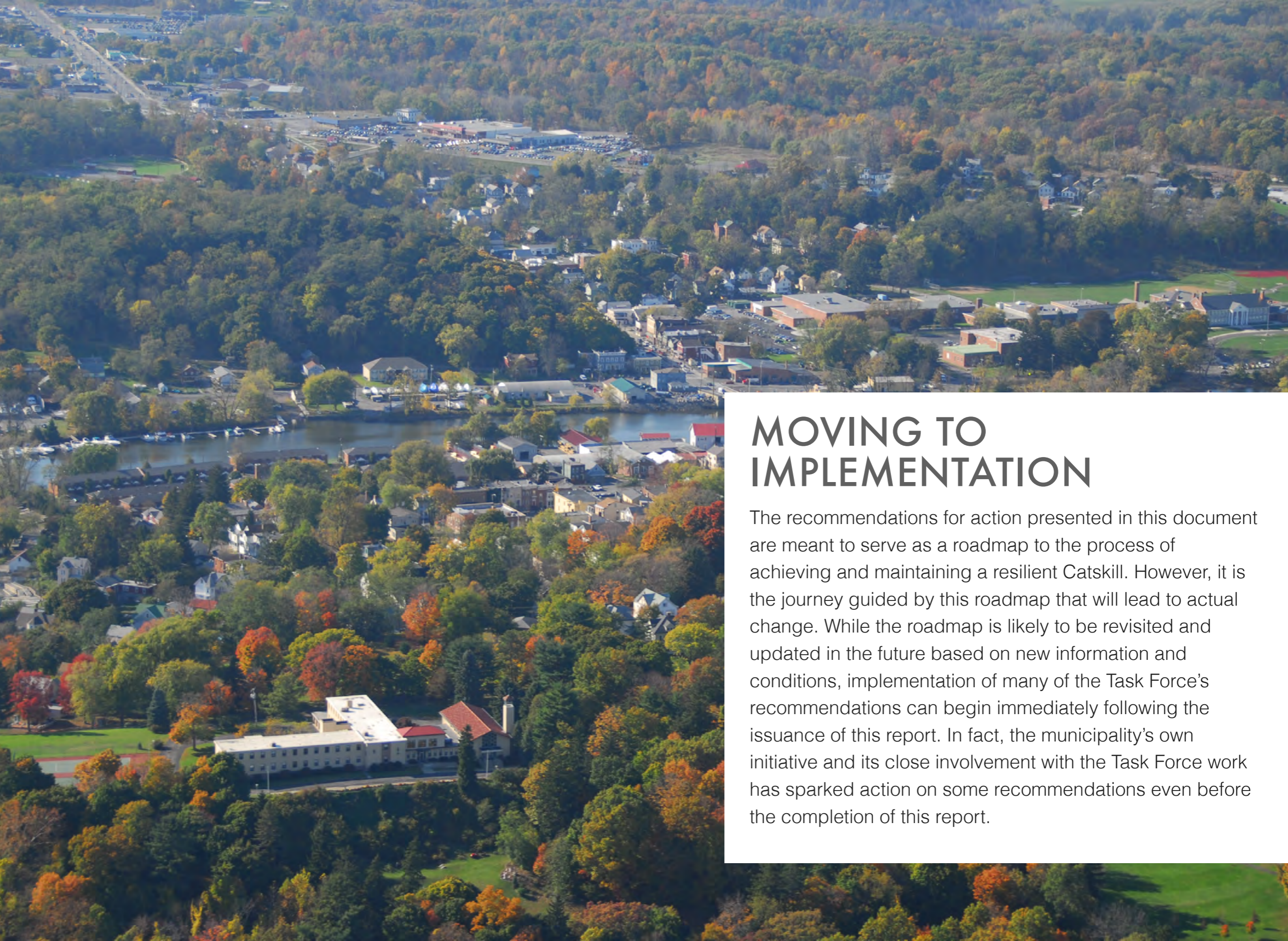
INTERPRETATIONS AND LEARNINGS

The COAST analysis of this version of adaptation indicates that it may be a more economically viable approach in the long-term, as indicated by a Benefit-Cost ratio of nearly 2 by the year 2100. However, without the early and lower-cost floodproofing adaptation element included in Case Study #2, the ratio remains unfavorable until after 2055.

This scenario has a strong focus on enhancing the water-dependent businesses in this neighborhood, and ensuring that they remain viable in the long-term. By concentrating the waterfront uses on fill areas, it has the advantage of reducing the flood risks to people and property along other waterfront sections, and allowing more room for the creek to flow.

While the large investments in filled and bulk-headed areas would likely support a strong commercial economy, they may not be suitable for the few other uses that currently exist between West Main Street and Catskill Creek (e.g. wastewater pump station, businesses other than marinas and their associated amenities). As in Case Study #2, it is unclear whether property owners would be able to shoulder the burden of these adaptation costs. The regulatory feasibility of filling areas in the creek is also unknown. A related scenario discussed by the Task Force, but not modeled in COAST, was to orchestrate a buy-out option for properties on the west side of the road and relocate water-based uses there. This would achieve the goal of sustaining water-based uses in this neighborhood without the need for fill areas or flood-proofed, elevated, or amphibious structures.





MOVING TO IMPLEMENTATION

The recommendations for action presented in this document are meant to serve as a roadmap to the process of achieving and maintaining a resilient Catskill. However, it is the journey guided by this roadmap that will lead to actual change. While the roadmap is likely to be revisited and updated in the future based on new information and conditions, implementation of many of the Task Force's recommendations can begin immediately following the issuance of this report. In fact, the municipality's own initiative and its close involvement with the Task Force work has sparked action on some recommendations even before the completion of this report.

The Task Force has taken several steps to encourage implementation of its recommended actions. One has been to identify the most likely and effective lead implementer and the implementation timeframe (immediate and short to medium-term) for many recommendations. This should facilitate timely action with defined leadership for each item.

The Task Force recognizes that the Village of Catskill, with its small staff and reliance on volunteer leadership, may be unable to simultaneously implement all of the recommended actions in any given time frame. To address this, six recommendations were prioritized as the most urgent or important, either because a particular action is critical for making other recommended actions possible or because of the urgency of preparing for future flood events.

Establish a Flooding and Storm Resilience Committee and Joint Village and Town Conservation Commission

Review/update the Village Comprehensive Emergency Management Plan (CEMP)

Improve emergency communications

Create a flooding and best practices manual for residents and businesses

Review the Task Force report and identify how local codes can be modified

Promote the long-term persistence of natural storm buffer areas

Note that while the Task Force recommends these be initiated or implemented in the next five years, some of them also set the Village on a path to addressing its longer-term goals. Please refer to the recommendations section of this report (page 38) for full descriptions of these items.

The establishment of a village committee (and later a joint Village and Town Conservation Commission) tasked with addressing issues of flooding and storm resilience may be crucial for implementing the other 23 recommendations of the CWRTF. Not only will these committees be the lead implementers for several of the recommendations, but they will also serve to track progress on all recommendations and to foster continued planning for Catskill's long-term resilience.

The vision of a prosperous, safe, and resilient Catskill is one that is shared by the community, and we hope that the Village Board of Trustees will soon formally adopt this report as a guiding document to achieve this vision. The Task Force also hopes that village residents and business owners will become active participants in following this roadmap to achieve our collective goals. Once endorsed by the Village Board, this report should be made available through various village outlets (e.g. website, library, village hall). All stakeholders in the future of the Village of Catskill are encouraged to consider getting involved in steering the community towards resilience.



APPENDICES

RECOMMENDATIONS BY SECTOR

		Sector							
		Communications & Emergency Management	Increase Flood Preparedness	Reduce Risk to Critical Infrastructure		Increase Flood Preparedness	Update Zoning & Codes	Update Planning	Municipal Operations
Time frame	Immediate (next 12 months)	1. Review/update the Village Comprehensive Emergency Management Plan (CEMP)	4. Establish a Flooding and Storm Resilience Committee/Joint Village and Town Conservation Commission	13. Work through the Greene County Multi-Hazard Mitigation Plan	Short-Term/ Medium-Term (1-5 years)	10. Consider applying to participate in the NFIS Community Rating System (CRS)	16. Review the Task Force report and identify how local codes can be modified	17. Ensure that all proposals and plans address projected sea level rise and flood resiliency	22. Integrate departmental funding requests into a Capital Improvement Plan
		2. Improve emergency communications	5. Invite expert presentations on storm preparedness and flood mitigation	14. Conduct a risk and engineering review of ke municipal infrastrucutre		11. Support regular training for the village floodplain manager		18. Promote the use of Green Infrastructure	23. Incorporate cost-benefit analysis and long-term flood risk projections into municipal asset design and management
		3. Design and install high-water-mark signs in the waterfront area	6. Take advantage of training opportunities to improve staff and volunteer response to flood emergencies	15. Maintain an inventory and stock all replacement parts for sewage treatment plant and pump stations		12. Work with other communities in the Catskill Creek Watershed		19. Consider participating in the Climate Smart Communities program	24. Create an orientation on flood hazards and municipal plans for all new municipal representatives
			7. Create a flooding and best practices manual for residents and businesses					20. Promote the long-term persistence of natural storm buffer areas	
			8. Post key information on flood risks and emergency plans on the Village website					21. Begin developing strategies to address neighborhood/asset-specific Task Force recommendations	
			9. Regularly notify owners/residents of properites in current and projected floodplain/flood hazard areas						



GLOSSARY

Accommodation, the use of strategies that allow the continued use of vulnerable lands, but that do not attempt to prevent flooding or inundation with shoreline flooding protection.

Adaptation, adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

Base flood, the flood that has a one percent chance of being equaled or exceeded in any given year, also known as the "*one-percent*" or "*100-year flood*".

Base flood elevation, the computed elevation to which floodwater is anticipated to rise during the base flood, shown on flood insurance rate maps.

CEMP, comprehensive emergency management plan.

Climate Smart Resilience Planning, a planning evaluation tool for New York State communities.

Community Rating System (CRP), a voluntary incentive program of the National Flood Insurance Program (NFIP) that encourages communities to adopt floodplain management activities that exceed the NFIP requirements.

Conservation Easement, a power invested in a qualified private land conservation organization (often called a "land trust") or

government (municipal, county, state or federal) to constrain, as to a specified land area, the exercise of rights otherwise held by a landowner so as to achieve certain conservation purposes.

CWRTF, Catskill Waterfront Resilience Task Force

DEM, digital elevation model, a digital or 3-dimensional representation of a terrain's surface.

FEMA, Federal Emergency Management Agency.

Fortification, traditional coastal hardening techniques such as seawalls, and beach nourishment that attempt to maintain a static shoreline position.

FIRM, flood insurance rate maps, official map of a community on which FEMA has delineated both the special hazard areas and the risk premium zones applicable to the community.

FIS, flood insurance study (survey), A flood insurance survey is a compilation and presentation of flood risk data within a community. When a flood study is completed, the information and maps are assembled into a flood insurance study report, which contains detailed flood elevation data in flood profiles and data tables.

Freeboard, a factor of safety usually expressed in feet above a flood level for purposes of floodplain management. Often used to

describe the height of a structure's first floor over the base flood elevation.

GIS, Geographic Information System, a system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data.

Hazard, a dangerous phenomenon or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

LiDAR, light detecting and ranging radar, a remote sensing technology used to make high-resolution maps.

MHHW, mean higher high water, the average of the higher high water height of each tidal day.

NFIP, National Flood Insurance Program.

NYHOPS, New York Harbor Observing and Prediction System, a model operated by the Stevens Institute to provide ocean and weather information for the Port of New York and New Jersey.

NYSDEC, New York State Department of Environmental Conservation.

NYSDOS, New York State Department of State.

Relocation, moving development out of harm's way in a planned and controlled manner using techniques such as abandonment, relocation, avoidance.

Resilience (also Resiliency), the capacity of an individual, community, or institution to dynamically and effectively respond to

shifting climate impact circumstances while continuing to function and prosper.

Risk Assessment, a process to analyze both the probability of an event and the consequences.

Rolling Easement, a special type of easement placed along the shoreline to prevent property owners from holding back the sea but allowing any other type of use and activity on the land. As the sea advances, the easement automatically moves or "rolls" landward, and tidal lands become public.

SLR, sea level rise, an increase in the mean level of the ocean.

Special Flood Hazard Area, the land area covered by the floodwaters of the base flood, as designated on NFIP maps.

USGS, United State Geological Survey.

Vulnerability, the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes, or susceptible attribute or resource.

RESOURCES LIST

The following resources were either used or referred to during the Catskill Waterfront Resilience Task Force's work.

Village of Catskill Studies and Plans

Village of Catskill, NY, Downtown and Waterfront Revitalization Strategy, published by Elan Planning & Design, Inc. (2009).

<http://greengovernment.com/wp-content/uploads/2013/10/Downtown-and-Waterfront-Revitalization-Strategy-Village-of-Catskill.pdf>

Resilient and Adaptive Waterfront Strategies

Coastal Climate Resilience, Urban Waterfront Adaptive Strategies, prepared by New York City Department of City Planning (June 2013).

http://www.nyc.gov/html/dcp/pdf/sustainable_communities/urban_waterfront_print.pdf

Coastal No Adverse Impact Handbook, Chapter 5: Mitigation. (May 2007). http://www.floods.org/NoAdverseImpact/CNAI_Handbook/CNAI_Handbook_Chapter5.pdf

Georgetown Climate Center Adaptation Tool Kit: Sea Level Rise and Coastal Land Use, How Governments Can Use Land-Use Practices to Adapt to Sea Level Rise, by Jessica Grannis (October 2011). <http://www.georgetownclimate.org/resources/adaptation-tool-kit-sea-level-rise-and-coastal-land-use>

Incorporating Sea Level Change Scenarios at the Local Level published by NOAA (2012). http://www.csc.noaa.gov/digitalcoast/_pdf/slcsenarios.pdf

Revitalizing Hudson Riverfronts: Illustrated Conservation & Development Strategies for Creating Healthy, Prosperous Communities. Eisenman, R. J. Anzevino, S. Rosenberg, and S. Spector (eds.), published by Scenic Hudson, Inc. (2010). <http://www.scenichudson.org/ourwork/riverfrontcommunities/publications>

Coastal Construction Manual: Principles and Practices of Planning, Siting, Designing, Constructing, and Maintaining Residential Buildings in Coastal Areas. FEMA P-55 (2011).

<http://www.fema.gov/media-library/assets/documents/3293>

Flooding and Stormwater Management, Flood Maps, and Flood Insurance

FEMA Brochure on Flood Insurance Changes: Build Back Stronger- What you need to know. <http://www.fema.gov/library/viewRecord.do?id=6712>

FEMA Map Services Center <https://msc.fema.gov/webapp/wcs/stores/servlet/FemaWelcomeView?storeId=10001&catalogId=10001&langId=-1&userType=G>

Scenic Hudson Sea Level Rise Mapper. <http://www.scenichudson.org/slr/mapper>

New York Climate Change Reports and Resources

New York State 2100 Commission (2013) Recommendations to Improve the Strength and Resilience of the Empire State's Infrastructure. <http://www.rockefellerfoundation.org/blog/nys-2100-commission-report-building>

ClimAID-Response to Climate Change in New York State (2011). <http://www.nyserda.ny.gov/climaid>

New York State Sea Level Rise Task Force Report (2010). http://www.dec.ny.gov/docs/administration_pdf/slrffinalrep.pdf

New York State Climate Action Plan Interim Report(2011). <http://www.dec.ny.gov/energy/80930.html>

NYSDEC Climate Change, New Yorkers are Working on Many Fronts. <http://www.dec.ny.gov/energy/44992.html>

NYSDEC Hudson River Estuary Program & Climate Change. <http://www.dec.ny.gov/lands/39786.html>

Hudson River Sustainable Shorelines Project. <http://www.hrnerr.org/hudson-river-sustainable-shorelines>

Assessing Risks and Costs

Guidance for New York Rising Community Reconstruction Plans: A Planning Toolkit for CR Planning Committees. NY Rising Community Reconstruction Program.

[http://stormrecovery.ny.gov/sites/default/files/documents/Guidance for Community Reconstruction Plans.pdf](http://stormrecovery.ny.gov/sites/default/files/documents/Guidance%20for%20Community%20Reconstruction%20Plans.pdf)

COAST: COastal Adaptation to Sea level rise Tool

Summary of COAST. http://catalysisadaptationpartners.com/uploads/3/1/4/8/3148042/coast_summary_111012.pdf

Examples of previous COAST applications.

Merrill, S., P. Kirshen, D. Yakovleff, S. Lloyd, C. Keeley, and B. Hill. 2012. COAST in Action: 2012 Projects from New Hampshire and Maine. New England Environmental Finance Center. Series Report #12-05. Portland, Maine. http://catalysisadaptationpartners.com/uploads/3/1/4/8/3148042/cre_coast_final_report.pdf

Merrill, S., D. Yakovleff, S., Holman, D. Cooper, J., and P. Kirshen (2010) Valuing Mitigation Strategies: A GIS-based approach for climate adaptation analysis, Arc Users. <http://www.esri.com/news/arcuser/1010/files/coast.pdf>



SUPPLEMENTAL MATERIALS AND ANALYSIS

Over the course of the Task Force project, a wide range of analysis, mapping and additional materials were developed. The results of this work, listed below, separately and *in toto* represent a foundation of quality information that may be used in current and future efforts by the Village to increase community resilience. The materials are available for download at the Village of Catskill website, www.villageofcatskill.net, and at Scenic Hudson website, www.scenichudson.org.

1. Sea Level Rise and Flood Zone Project Maps
2. Department of State Coastal Risk Assessment: Results and Maps
3. Climate Smart Resilience Planning: results and recommendations
4. COAST Analysis: Results and Maps
5. Adaptation Alternatives - Full Set Developed by the CWRTF



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