TESTIMONY OF THE MAYOR'S OFFICE OF RESILIENCY
BEFORE THE NEW YORK CITY COUNCIL
COMMITTEE ON RESILIENCY AND WATERFRONTS

Tuesday, October 27, 2020

I. INTRODUCTION

Good morning. I am Jainey Bavishi, Director of the Mayor's Office of Resiliency. I would like to thank Chair Brannan and Councilmembers Diaz, Constantinides, Ulrich, and Rose for the opportunity to testify today.

I would also like to acknowledge my colleagues Deputy Commissioner Grimm and Assistant Commissioner Conroy from New York City Emergency Management. Deputy Commissioner Grimm will be providing testimony, and he and Assistant Commissioner Conroy will join me in answering your questions.

II. PROGRESS SINCE HURRICANE SANDY

As you know, Hurricane Sandy was the most catastrophic natural disaster in New York City's history. The storm's strong winds and immense storm surge devastated entire communities, causing $19 billion in damage and tragically taking the lives of 44 New Yorkers. Since Hurricane Sandy, we've made considerable progress toward making New York City safer and more resilient. The importance and urgency of this work has only been further emphasized by how climate change is playing out in our country and around the world. This year has brought devastating and persistent wildfires in the western states and so many Atlantic hurricanes that we've resorted to using the Greek alphabet to name them. These disasters make it clear that amidst the ongoing pandemic we must also continue to prepare for future severe extreme weather events fueled by climate change.

Since Hurricane Sandy, our office has partnered with different city, state, and federal agencies to complete several key coastal resiliency projects. In August of 2019, the City completed a wetlands restoration project in Broad Channel, Queens – one of the lowest-lying areas in all of New York City. Several months later, in October of 2019, we completed another wetlands restoration on the West Shore of Staten Island. These projects took environmentally degraded sites and breathed new life into them. They also created new, nature-based buffers that will reduce wave impacts during storms and provide rich wildlife habitats.

These completed projects build on our many other accomplishments, including the Reconstructed Rockaway Boardwalk, a T-groin project in Sea Gate, Brooklyn, beach renourishments in the Rockaways between Beach 92nd and 103rd Streets, street raisings in Broad Channel, Queens, 26 completed Bluebelt projects across three boroughs, and Emergency Management's Interim Flood Protection Measures program, which now covers more than 50 sites across the city.

As you all know, large capital coastal protection projects take years of planning, contracting, and development, and I'm excited to report we're officially breaking ground on the Rockaways – Atlantic Shorefront project later this week, on the anniversary of Hurricane Sandy. This project will span six miles from Far Rockaway to Jacob Riis beach. Earlier this month, the City also broke ground on a $75 million expansion of the Mid-Island Bluebelt on Staten Island, which uses a series of streams, ponds, and wetlands to capture rainfall and prevent flooding.

And that is not all. We also plan to break ground on the East Side Coastal Resiliency Project next month. This project is one of the most technically complex and ambitious climate adaptation projects anywhere in the world. It's also critically important for advancing climate justice in New York City, seeing as it will protect a highly diverse community that includes more than 28,000 NYCHA residents. This community was devastated by Hurricane Sandy, and this project will deliver the protection they need.

We're also continuing to advance many other resiliency projects all across the city, from Red Hook to Jamaica Bay to Staten Island.

Our office also continues to focus on ensuring that New York City is prepared using a multi-hazard strategy that addresses risks not only related to coastal storms, but also from intense precipitation, extreme heat, and sunny day flooding caused by chronic sea level rise.

One notable example of our multi-hazard approach in action is the GetCool NYC program, created by Mayor de Blasio just as COVID-19 cases were starting to reach their peak in New York City. Recognizing that extreme heat is a "silent killer," this program provided free air conditioners to 74,000 elderly, low-income New Yorkers. With fewer cooling options available to New Yorkers due to the rapidly spreading virus, this program allowed vulnerable seniors to stay safe and cool in the comfort of their own homes.

As we enter a new era of climate catastrophe, we expect that more initiatives like this one will be needed to counter the effects of simultaneous and overlapping disasters. As we advance large-scale, generational infrastructure projects on the coastline, we must remain nimble and adaptable to other emerging threats – including those that impact inland areas.

Additionally, we're glad to announce that this year we published the fourth update to the City's Climate Resiliency Design Guidelines – a critical tool that can be used to increase resiliency for public facilities and infrastructure, supporting a stronger and safer New York City while also saving taxpayers money through averted losses.

All of our work is and must continue to be informed by the best available science and localized data. This year we proudly announced the fourth New York City Panel on Climate Change, which is the most diverse, credentialed, and multidisciplinary panel yet. These twenty members will produce actionable and authoritative scientific information on climate change – research that is critical in grounding our office in a clear understanding of what types of climate risks we face, how they intersect, and what solutions are most appropriate for mitigating these hazards.

Looking forward into the future, we are also focused on seizing the opportunities that come with confronting climate change. In particular, we are excited about a recently announced rezoning that will enable the creation of a climate adaptation center on Governor's Island. This center will create an international hub for climate research, engineering, and design that is focused on the solutions that communities and cities need to navigate climate-related threats. This effort is projected to create 8,000 direct new jobs and $1 billion in economic impact for New York City. We hope to work closely with Council and the Trust for Governor's Island to maximize the impact of this bold and ambitious project.

III. CONCLUSION

While the City has made great strides towards a multi-hazard and multi-layered approach to resiliency, there's still much work to be done, and much of it can only be accomplished through the collaboration and partnership with our federal and state partners. We hope to see increased investment from the Federal government through a stimulus action in the future, long-awaited reforms to the National Flood Insurance Program that improve affordability and flexibility for urban environments, and a reinstated Harbor and Tributaries Study by the Army Corps of Engineers. Additionally, we are hopeful that the Mother Nature Bond Act will move forward in the next legislative session at the State level, providing critical funding for important green infrastructure projects, stormwater management, coastal protections, and heat mitigation strategies.

In conclusion, I would like to thank the Committee on Resiliency and Waterfronts for allowing me to testify here today. I will now yield to Deputy Commissioner Grimm from New York City Emergency Management, and look forward to your questions following my colleague's testimony.

Testimony of John Grimm
Deputy Commissioner for Response
New York City Emergency Management Department
Before the New York City Council Resilience Committee
October 27, 2020

Good morning Speaker Johnson, Chair Brannan, and members of the New York City Council. I am John Grimm, Deputy Commissioner for Response at New York City Emergency Management. I am joined by my colleague Johanna Conroy, Assistant Commissioner for Interagency Operations. We are pleased to be here to discuss hurricane preparedness for the 2020 season, which has been extremely active, and required us to consider cascading impacts from COVID-19.

New York City faces the biggest threat to hurricanes and coastal storms from August through November. This hearing is a poignant reminder that devastating hurricanes, such as Hurricane Sandy, can still wreak havoc late in the season. In one of the most active hurricane seasons in memory, we have tracked 28 tropical cyclones in the Atlantic basin, 27 of which were named storms and ten that were categorized as hurricanes.

Preparation for coastal storms requires coordinated planning to ensure the City is ready to react at any given time. We have a robust training and exercise program to build the capacity to carry out the response and annually host exercises involving City Hall executives, agency commissioners, and interagency partners, with the goal of rehearsing critical decision-making during a coastal storm. An important part of our mission is to support preparedness for all New Yorkers. The Know Your Zone campaign encourages New Yorkers to identify if they live in a hurricane evacuation zone, know the hazards they may face, and take the necessary steps to be prepared. In conjunction with our Ready New York and Ready Kids program, we have educated hundreds of thousands of New Yorkers and work diligently in increase these numbers every day.

We are aware that COVID-19 presents a different set of challenges for coastal storm preparedness. Many months ago we tasked members of our cascading impacts planning team to adapt plans to meet this new challenge. Together with our partners at the federal and state level, and within the private sector, we are finding solutions; for example, by encouraging New Yorkers to add sanitizer and masks to their go-bags, by updating our stockpile for evacuation centers, and by working with DOE to ensure that public schools – used as evacuation centers – can have an expanded footprint to ensure adequate social distancing by using classrooms and other spaces and floor markings for proper flow. Already COVID-19 and this hurricane season has provided us with opportunities to learn.

Additionally, NYCEM leads the City's efforts to provide temporary, deployable flood protection for critical facilities and neighborhoods in low-lying coastal areas through the Interim Flood Protection Program. For the first time outside of an exercise, Emergency Management activated one of 55 operational sites in response to forecasted coastal storm impacts within the South Street

Seaport area which showed the highest potential for coastal flooding from Tropical Storm Isaias. While ultimately, impacts from Isaias did not materialize in this area, the deployment provided useful operational experience and we are applying the lessons learned for future deployments at site across all five boroughs. This is a great example of how we plan, implement, take information gained during an activation, and use it to make our City more resilient in the future.

NYCEM will continue to develop, adapt, and innovate our hurricane preparedness measures to provide the best strategies and resources for the City of New York. Across the boroughs we applaud the efforts of City Council in communicating with your constituents on how to prepare for emergencies. We ask, as always, that you continue to promote Notify NYC, the City’s free service that provides timely, accurate information during emergencies, including coastal storms. Thank you for your time today and I am happy to answer any questions.

Testimony of Daniel Gutman

Before the

Committee on Resiliency and Waterfronts

**Oversight Hearing on the
8th Anniversary of Superstorm Sandy**

October 27, 2020

My name is Daniel Gutman. I am here representing the Metropolitan Storm Surge Working Group composed of scientists, engineers, architects and planners who have come together to advocate for a regional solution to storm surge and sea level rise.

New York City has not been pursuing a regional approach. The current OneNYC plan addresses storm-surge protection by ultimately relying on shoreline barriers, which would provide only piecemeal protection, one neighborhood at a time. The authors of the plan in 2013 recognized that these shoreline barriers would take decades to construct and are only a partial solution.

At the same time, the authors rejected, after little or no investigation, a system of offshore regional storm-surge barriers. But the experiences of many cities around the world have shown that offshore storm-surge barriers with moveable gates are the most efficient and the most cost-effective solution, one that could reliably protect the city for the next hundred years.

Some of the first storm-surge barriers were constructed in the United States in the 1960s and today still protect the harbors of three New England cities — Stamford Connecticut; Providence, Rhode Island; and New Bedford, Massachusetts. New storm-surge barriers were built to protect New Orleans after Hurricane Katrina, and a major new storm-surge barrier is being planned to protect Galveston Bay and Houston.

These storm-surge barriers have gates which stand open in normal weather to allow for unimpeded shipping, daily tidal flows, river discharge and harbor flushing. But the gates can be rapidly closed to protect the region during extreme weather events, such as hurricanes like Sandy.

Largely because of the Army Corps of Engineers' Harbor and Tributaries Study (HATS), of the New York region, today we know much more about offshore storm-surge barriers than the Mayor's Office did in 2013.

We also know much more about the City's shoreline barrier effort. So far it has been concentrated on one project in one neighborhood — the East Side Coastal Resiliency Project (ESCR) for the Lower East Side of Manhattan. That project proved to be much more complicated than its appealing image suggested. Not only have costs for that project more than tripled since it was first proposed, but eight years after Hurricane Sandy, construction has yet to begin. In addition, once constructed the ESCR project would provide full protection only for a short time period — only for 30 years.

Because of the cost and time required to plan and construct each section, protection for many neighborhoods, especially those in the outer boroughs, inevitably will not be constructed for decades. Your proposed bill, Intro 1620-2019, is aimed at overcoming these disparities among neighborhoods.

For this reason, we think that Intro. 1620 should include a provision that requires the City to re-evaluate the choice between onshore and offshore barriers for storm-surge protection.

To further explain the need for re-evaluation, I would like to address a number of misconceptions that came up during the 2018 and 2019 Sandy oversight hearings and some that have come up since then.

Do Shoreline Barriers Also Protect Against Sea Level Rise?

The first issue is whether or not a single solution can address both storm surge and sea level rise. Testimony at your hearings suggested that the answer is “yes.” Offshore storm-surge barriers cannot prevent the effects of gradually increasing sea level, simply because their gates remain open to the sea except when occasional, large storms threaten the region.

Continuous shoreline levees and flood walls could prevent the gradually rising sea from reaching the neighborhoods behind them. But in a city like New York, continuous levees or floodwalls are both impractical and contrary to our 50-year effort to increase access to the waterfront.

Instead shoreline barriers, such as the ESCR project, have gates to provide access to the shoreline for both pedestrians and vehicles. In fact the 50 miles of New York City shoreline barriers analyzed by the Corps in the HATS study have 120 such gates that also must remain open unless a storm threatens. Some gates are even across major highways. Thus shoreline barriers have essentially the same inability to protect against sea level rise as offshore barriers.

On the other hand, because regional offshore barriers are intended to protect only against major storms, the Corps included in those alternatives up 34 miles of shoreline improvements built up to about 3’ above high tide to deal with the “residual risk” of minor storms. That addition to the offshore storm-surge barrier alternatives would also protect against sea level rise. So while neither offshore nor onshore barriers can alone address the long-term problem of sea level rise, offshore barriers allow for a complementary system of shoreline improvements that can address sea level rise.

Are Shoreline Barriers Less Expensive?

Another misleading claim is that shoreline barriers are less expensive than an offshore storm surge barrier system. Not only were you told this in testimony, but the Corps' HATS study has contributed to that misleading impression.

The Corps of Engineers has unfortunately adopted a highly misleading process for estimating costs, with different methods for offshore and shoreline barriers. First the Corps assumed that little water, if any, would be allowed to spill over the top of closed barriers during a major storm. That is an appropriate assumption for shoreline barriers which must keep floods out of city streets and neighborhoods at all times. But it is not an appropriate assumption for offshore barriers, which would be closed at the low tide preceding the arrival of a major storm, thus providing a vast storage reservoir behind them for spillover, as well as storing river water and rain.

When the Corps relaxed that assumption in October, 2019, after its Interim Report had already been issued, the cost of the most expensive offshore barrier system suddenly dropped from $119 billion to $63 billion! Furthermore, based on cost methodology the Corps used in Texas, the actual construction cost of that barrier system would be $42 billion.[1] The corresponding benefit of reduced flood damage would amount to at least $150 billion.

On the other hand, the Corps severely underestimated the cost of shoreline barriers. Shoreline barriers require major additions to the city's drainage system to prevent backup of sewage and rainfall into city streets that could result when storm surges close tide gates on sewer outfalls. Offshore barriers, which close at low tide and allow the sewer system to function normally, would not require such costly drainage upgrades.

As we have learned from the East Side Coastal Resiliency Project, the cost of drainage improvements can equal the cost of local storm surge protection. The Corps intended to add

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[1] Construction costs exclude operations and maintenance and "interest during construction," a fictitious addition for purposes of cost/benefit analysis.

these costs later, but nonetheless published their underestimated shoreline-barrier costs. Thus we were left with overestimates of offshore barrier costs compared with underestimates of shoreline barrier costs. The result was a complete misunderstanding of relative costs.

When all the costs are included, offshore barriers will prove to be much less costly than shoreline barriers providing equivalent protection.[2] This is illustrated by the Corps' study of barriers for Jamaica Bay, where the shoreline barrier alternative was projected to cost 40% more than an offshore barrier.

As a regional system, offshore barriers would protect northern New Jersey as well as the city and thus would qualify for federal and bi-state funding, greatly reducing the cost to New York City.

Do Off-Shore Barriers Bring Dire Environmental Consequences?

Another concern is potential environmental impacts of offshore storm-surge barriers, which have been raised by Riverkeeper, NRDC, and others. One major issue that comes up is the gate closure frequency. Riverkeeper has claimed that closing the gates more and more frequently as sea level rises would "strangle the life out of the river as we know it." However, the Corps was well aware of this argument and its study assumes a closure criterion tied to a fixed storm frequency, e.g. the 2-year storm. As sea level rises, surge heights would also increase, but the storm frequency (once every two years), and hence the closure frequency, would remain the same.[3] Thus any environmental impacts would not increase with time.

Also the Corps of Engineers has been careful to design barriers with a large number of auxiliary gates to allow maximum unimpeded tidal flow. Their calculations show that during

[2] Equivalent protection means protecting as much of the bi-state region as HATS Alternatives 2 and 3A, the regional offshore storm-surge barrier options, would (75% or more). Alternative 5 (shoreline barriers only) doesn't even have the small, proposed storm-surge barriers at Newtown Creek, Gowanus Canal, and Jamaica Bay that are part of New York City's shoreline barrier plan, incorporated into Alternatives 3B and 4. Consequently if it were expanded to provide equivalent protection, it would require even longer stretches of shoreline barriers than Alternatives 3B and 4, and more drainage improvements, *making it the most expensive alternative by far*.

normal conditions, the open gates and supporting structures would reduce tidal flow by only about 7%.

But the Hudson River estuary has already been extensively altered over the past 150 years by dredging of shipping channels. The effect of that previous alteration has been to increase tidal flow and tidal range. Recent studies indicate that the cumulative increase in tidal range at the Battery due to dredging shipping channels is also about 7%. Thus the net effect of storm-surge barriers reducing tidal flow and dredged shipping channels increasing tidal flow could very well be to return the Hudson River Estuary closer to its "natural state." [4]

Many other environmental concerns such as sediment flow, salinity, water quality, impacts on fish migration and health of other marine organisms have not yet been studied, but must be, and will be, before a decision can be made.

Pending additional studies and completion of comprehensive hydrodynamic, engineering and environmental analyses, such as the Corps of Engineers had almost completed, everyone should keep an open mind. No resiliency plan of the scope required to protect the New York region can ever be entirely good, or entirely bad. All solutions have both positive and negative aspects.

Given the slow pace of providing storm-surge protection on the city's shoreline, and the new information that has become available, the Mayor's Office should re-evaluate the relative merits of offshore vs. shoreline storm-surge barriers. A provision that would require periodic re-evaluation by the Mayor's Office would be a very useful addition to Intro. 1620.

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[3] Since the closure frequency is kept stable, rising sea level would have to be dealt with by measures other than closing the storm-surge gates more frequently.

[4] Philip Orton and David Ralston, "Preliminary Evaluation of the Physical Influences of Storm Surge Barriers on the Hudson River Estuary," Report to Hudson River Foundation, September, 2018, and David Ralston, et. al., "Bigger Tides, Less Flooding: Effects of Dredging on Barotropic Dynamics in a Highly Modified Estuary," Journal of Geophysics Research: Oceans, *124* (2018). .

Riverkeeper Testimony on Intros 1620, 1480, and 382
Tuesday, October 29, 2019; 1:00pm
Paul Gallay, President and Riverkeeper
Jessica Roff, Director of Advocacy and Engagement
Michael Dulong, Senior Attorney

Good afternoon Council Members Constantinides, Brannan, Koo, Levin, Gibson and Grodenchik. Thank you for introducing 1620, an incredibly important piece of legislation to create a comprehensive five borough plan to protect the entire shoreline from climate change, sea level rise, and sunny day flooding. Thank you, Members Constantinides and Ulrich, for introducing 1480, which will help rid our waters of derelict barges and boats and hold those who dump them responsible. And, we thank Member Ulrich for introducing 382 to inform landowners in the floodplain of their potential hazards and insurance requirements. Riverkeeper appreciates the opportunity to provide testimony on these critical laws.

Riverkeeper Supports Passage of Intro 1620 and Hopes The Council Will Consider Adding Provisions to Guarantee Meaningful Public Participation and Comprehensive Resiliency Planning

As we are all aware, there have been, and continue to be, a number of plans throughout New York City and the region to address some combination of climate change, sea level rise, and storm surge flooding. Both the city and state administrations have proposed plans and the federal Army Corps of Engineers is in the midst of a multi-million dollar study to propose multi-billion dollar structures throughout our area. Unfortunately, the processes by which these plans are advancing repeatedly fail to effectively include community voices, and the plans are either ad hoc or fail to address the depth and breadth of issues facing our region.

Boston is taking very positive, comprehensive action to combat climate change and its effects. Not only does Climate Ready Boston follow the trend of moving storm surge and sea level rise responses to shore-based defenses — including restored marshes, deployable floodwalls, elevated waterfront parks, plazas, berms, and wetland terraces. But it also includes adapting infrastructure, energy systems, sustainable development, multi-purpose green spaces, stormwater infrastructure, and engaging communities. And by creating responses with multiple benefits — such as recreational space that absorbs flooding, or transportation service upgrades that go along with resiliency upgrades — we also create a mechanism for greater community buy-in and overall more effective systems. Climate Ready Boston recognizes both that changing climate happens on multiple levels and scales, and that residents, businesses, and communities all have the power to take action and be prepared.

Boston's five guiding resilience principles provide important insight when thinking about how we should frame our five-borough resiliency approach:

1. Generate multiple benefits.
2. Incorporate local involvement in design and decision making.
3. Create layers of protection by working at multiple scales.
4. Design in flexibility and adaptability.
5. Leverage building cycles.

And these five principles led Boston to reject in-water barriers in favor of a balanced plan with: better building codes, shoreline defenses like berms and living shorelines, elevating and hardening public structures and services, creation of salt marshes and other places for the water to go, construction of green infrastructure to store water and, generally, adaptation of an “architecture of accommodation."

It's critical that as we prepare for the future of NYC with all the threats from climate change and sea level rise, that we do it in such a fully comprehensive way. We've learned from the Army Corps' NY/NJ HATS Study that there are many unintended consequences when you're making big plans for big structures. The Corps has finally recognized that deflection or induced flooding from their large in-water barriers could be so problematic — both the actual flooding and the cost of mitigating against it — that they are seriously considering abandoning plans for certain of these structures. Such problems can be avoided by looking at the entire NYC region (and beyond) as a single entity — planning a thoroughly comprehensive strategy that has all boroughs and shorelines and communities represented.

A comprehensive approach to on-shore measures will also continue to support the vibrant eco-systems in the NYC waters as well as the water bodies themselves. Further, such plans will allow the existing sewage system to continue to function without threatening to pollute NYC communities with trapped toxic waters or stopping the continuous flushing of other types of waterborne contaminants. Intro 1620's methodology should also allow for the incorporation of the Long Term Control, MS4, and Green Infrastructure Plans throughout the city.

Community representation and participation must be transparent and an integral part of the process in order to succeed. We have to avoid duplicating situations like the East Side Resiliency Project planning fiasco, which is to say, that communities, community organizations, grassroots, and other issue-based organizations need to be fully incorporated into the process, up through decision-making, not brought along for the ride and then have plans switched at the eleventh hour.

And a comprehensive plan must also include community resilience work and support. In crisis after crisis we see that the best and most immediate responses are always local and community-based, and that the stronger the community social infrastructure is, the better prepared the community is to face a crisis, or worse, to respond to one.

Both our government and communities need to come together to figure out how to live with, and be surrounded by, the ever rising waters in our area. In 1953, Rotterdam began building a series of dams, barriers, and seawalls as part of a national project called Delta Works; five years ago they planned an upgrade, the Rotterdam Climate Proof Program. Arnoud Molenaar, who manages it, said, “Before, we saw the water as a problem. In the Netherlands, we focussed on how to prevent it from coming in. New York City focused on evacuation, how to get people out of the way. The most interesting thing is figuring out what’s between these approaches: what to do with the water once it’s there.” Rotterdam is now experimenting with an architecture of accommodation.

As Mitch Waxman, the historian of the Newtown Creek Alliance said, "Wouldn’t it make more sense to create oceanside topography that breaks up wave action, and that could eat up the energy of a storm surge, than it would be to build giant mechanisms which we are going to have to maintain and replace?” he says. About the Army Corps' approach to addressing storm surge with in-water barriers he said, “Unfortunately, we are taking a very American tack with this, which is building a machine to do something which nature would do better.”

We urge the City Council, as part of the comprehensive five borough plan, to consider incorporating the kinds of creative, adaptive measures along our shorelines that Mr. Waxman references.

Riverkeeper does not support in-water barriers. Accordingly, we appreciate the council members specifically highlighting measures including rip rap, breakwaters, floodwalls, marshes, non-structural living shoreline options, and similar stabilization methods. Following Mr. Waxman’s recommendations of multi-beneficial plans, there is one in-water measure that should be incorporated into a five borough — and beyond — resiliency plan: off-shore wind.

Off-Shore Wind can mitigate storm impacts in addition to moving us from carbon intensive fossil fuel use to large scale, viable, renewable energy. University of Delaware studies have found that turbines - depending on numbers - can provide up to a 30 percent reduction of precipitation, decrease storm surge by up to 79%, and reduce peak wind speeds by up to 92 mph.

Therefore the city, at all levels of government, should be doing whatever it can to support increasing our off-shore wind commitment to increase our renewable energy share, decrease our reliance on dirty and dangerous fossil fuels, and increase storm resilience in all of these ways.

Riverkeeper also appreciates that Intro 1620 begins to tackle the hard questions that living with the water requires. By recognizing that "structural and non-structural risk reduction approaches" also means "strategic relocation programs removing structures from floodplains, wetlands preservation and restoration, densification on high ground, and any similar concepts." It is becoming clearer every day that there are places around this city where maintaining a presence will not be viable moving into a future with increasing sea level rise.

Riverkeeper appreciates the on-going work of the City Council to comprehensively address the growing threats of climate change, sea level rise, and sunny day flooding, while working with communities and community organizations. We fully support Intro 1620 and look forward to working together to implement this important law and to help protect NYC.

Riverkeeper Strongly Supports Passage of Intro 1480

Riverkeeper supports Intro 1480, which would create a program to dispose of, or if appropriate, reuse marine debris left on public beaches. The program would require a plan to recycle the debris where possible. It is common for this type of debris to mar public beaches and other city-owned property, and it is also common for the marine debris, especially derelict barges and boats, to remain in city waterways or on other public lands.

Riverkeeper mounted a campaign in 2015 to have two derelict barges removed from the East River at Flushing Bay. The barges were loose and shifting, jeopardizing maritime traffic. Large and small pieces of expanded polystyrene foam pollution were breaking off the barge. This foam pollution can be found in nearly every tributary, from miniscule particles to large, refrigerator-sized chunks of foam.

It became clear that a complicated legal framework would prevent swift removal of the barges. Working with state and local elected officials, then-Congressperson Joe Crowley, New York City and state agencies, we advocated for Army Corps to remove the navigational threat.

Again in 2017 we coordinated with New York State and City officials on removing an abandoned deck barge from the Upper East River near Whitestone. For years local community members and business owners had tried to get the abandoned barge removed after it had been dumped during the night. It was physically deteriorating, impeding navigation of the waterways and actively discharging copious amounts of polystyrene pollution.

Other smaller debris, such as marine garbage and even yachts have been stranded all over the city, in waters as diverse as the Bronx River and Jamaica Bay where boats have sunk into river beds. In other places, boats are unlawfully moored, and some abandoned, such as near the mouth of Newtown Creek.

It seems the intent of this bill is to remove debris not only left on public beaches, but also the debris that is stranded "in the water or along the shoreline." Intro 1480, Proposed New City Charter Section 20-f(3). It is essential that these areas be included in the bill so the barges, yachts, and other large items that may not land on public beaches could also be cleaned up. Moreover, expressly incorporating these areas would provide city officials authority to address these issues cheaply and efficiently before the debris rots, breaks down smaller, and affects a larger area of city shoreline. The investigation into the individuals responsible for the debris could also begin immediately. The first paragraph of proposed Section 20-f could be modified to add:

> The mayor or such agency as the mayor shall designate shall establish a marine debris disposal office to monitor, recycle or dispose of marine debris left on public beaches <u>and in the water or along the shoreline.</u>

Thank you to Council Members Costa Constantinides and Eric Ulrich for recognizing the importance of removing marine debris and for pushing this bill forward. We fully support your efforts and urge the council to pass Intro 1480.

Riverkeeper Supports Intro 382 and Urges the Council to Modify the Bill to Extend Notice of Flood Hazards to All New York Landowners in the 500-Year Floodplain

Today, seven years after Superstorm Sandy took the lives of at least 43 New Yorkers, most residents remain unaware of the extent of their flood risk. It is crucial to warn New Yorkers of the potential that their homes and businesses will flood so they can take precautions to protect themselves physically and protect their property financially. When the flood hazard area maps are finally set by the Federal Emergency Management Agency (FEMA), Intro 382 will provide notification to all property owners in the special flood hazard areas of their risk and flood insurance requirements. This notification will be crucial to protecting life and property, though it will not go far enough.

Sandy flooded a staggering 51 square miles of New York City, which is 17 percent of the City's total land mass. The previous FEMA flood maps had indicated that only 33 square miles of New York City might be inundated during a so-called 100-yr flood. The flooding affected the homes of 443,000 New Yorkers, not to mention the catastrophic impact it had on businesses and critical infrastructure, all totaling $19 billion in damages. Only about 80% of people affected by Sandy flooding had flood insurance.

FEMA has proposed to update that woefully underestimated map, but its proposal would still cover an area much smaller than the true projected 100-year floodplain. To boot, the new maps would delineate only a fraction of the widely expanded flood plain area that we can expect in 2100 due to the impacts of climate change. If the maps are drawn and published in such a way as to allay the flooding concerns of communities who are "outside the line," those community members will be more likely to shelter in place during major storms, putting their lives at risk. Additionally, developers will be more likely to build in these areas, unnecessarily putting people and real estate in harm's way.

We respectfully request that the City Council modify the bill to inform by mail all of those New Yorkers in the 100- and 500-year floodplains of their potential risk, even though their financial requirements will differ according to the lines that will be drawn by FEMA. It is in the long-term interest of this city to inform all New Yorkers about their risk and insurance options.

* * *

Thank you for your consideration of this testimony, and thank you for all you do to empower our communities, protect clean water, and build resiliency. Riverkeeper looks forward to continuing to work with the Council and other stakeholders to protect and restore our waterfronts and prepare our communities for climate change.

"Oversight: 8th Anniversary of Superstorm Sandy and the 2020 Hurricane Season"
Committee on Resiliency and Waterfronts
October 27, 2020 at 11:00am
Riverkeeper Testimony by Jessica Roff, Director of Advocacy and Engagement

Good afternoon Council Members Brannan, Constantinides, Diaz Sr., Rose, and Ulrich. Thank you for holding this important hearing on the anniversary of Superstorm Sandy to address the critical issues we face in the midst of an historic hurricane season. My name is Jessica Roff, and I am the Director of Advocacy and Engagement for Riverkeeper, a membership organization with nearly 55,000 members and constituents. Riverkeeper protects and restores the Hudson River from source to sea and safeguards drinking water supplies, through advocacy rooted in community partnerships, science, and law.

One year ago, I was here along with two of my colleagues, testifying about Intro 1620, a vital piece of legislation to create a comprehensive five borough plan to protect the entire New York City shoreline from climate change, sea level rise, and sunny day flooding. I will resubmit that testimony for the record today, since one year later we are in nearly the same position we were in on October 29, 2019, without a comprehensive five borough resiliency plan, the East Side or Lower Manhattan Coastal Resiliency Projects, or the Army Corps' New York / New Jersey Harbor and Tributaries Study (NY/NJ HAT Study).

Each of the projects to which I referred would address serious climate change threats in different parts of the city - some in conjunction with others, and some in isolation. As I'm sure you are aware, in February 2020, years into the NY-NJ HAT Study, we found out that it was not funded in the FY 2020 work plan or in the FY 2021 proposed budget. The Corps suspended the HAT Study before releasing any reports or recommendations and the federal government abdicated its responsibility to address the threats of climate change and storm surge in the City and the region. Among the DeBlasio Administration's primary reasons to oppose Intro 1620 was a reliance on the HAT Study, and deferring to its findings and recommendations. The Administration has advanced no plans or proposals since the Corps lost its funding, leaving the city in a very precarious position.

Riverkeeper is extremely concerned that the federal government did not find a resiliency plan for the region important enough to fund in the next fiscal year - making the city's role that much more important - even recognizing that the Corps' feasibility study was deeply flawed: lacking full incorporation of sea level rise and with an incomplete assessment of threats to the environment and ecosystems services. And, the Corps process was severely lacking in community, and especially frontline, engagement.

Because the Corps' failed to fully address sea level rise at all necessary stages of their study, the study's reliance on, and favoritism of, in-water barriers failed to properly account for flood risk and threats to ecological processes and water quality according to Dr. Philip Orton and his colleagues' study, "Storm Surge Barrier Protection in an Era of Accelerating Sea-Level Rise: Quantifying Closure Frequency, Duration and Trapped River Flooding." The study, which I am also attaching to my testimony, shows that as sea level rises it will cause an exponential increase in frequency that gates will have to close, and expand the duration for which they'll have to remain that way because of increased water level exceedances above flood level. The Army Corps' plan to address these increases was to continuously raise the "trigger level" (the water level at which a closure would be triggered), which would require ongoing and costly raising of seawalls. Orton concludes that such an approach should be determined on a neighborhood-by-neighborhood basis, but that managed retreat or non-structural options might be the better option. We support both of these alternatives and, as a member of the steering committee of the Waterfront Alliance convened Rise to Resilience Coalition, we support the coalition recommendations as well.

A good model to follow - Climate Ready Boston - also rejected in-water barriers in favor of a balanced plan with generally, adaptation of an "architecture of accommodation" that includes shoreline defenses like berms and living shorelines, better building codes, creation of salt marshes and other places for the water to go, construction of green infrastructure to store water, and elevating and hardening public structures and services. This approach would support NYC waters and the vibrant eco-systems in them and allow our sewage system to continue to function without threatening to pollute NYC communities with trapped toxic waters or stopping the continuous flushing of other types of waterborne contaminants. Any comprehensive citywide plan should incorporate the Long Term Control, MS4, and Green Infrastructure Plans throughout the city.

The Climate Ready Boston model includes many approaches from deployable floodwalls to wetland terraces, and adapting infrastructure and energy systems to responses with multiple levels of benefits like recreational space that absorbs flooding.

These methods require greater community engagement and foster important community buy-in. It is critical that any plan for our region's resilience not only actively seek out and engage communities and their expertise and experience, but also secures both funding and actual systemic changes to ensure that such participation happens and is incorporated into the city's plans and their implementation. Plans must support and help foster vital community resilience and frontline, shoreline, (BIPOC) Black, indigenous, and communities of color's voices must be prioritized.

It is critical that the Council advances a comprehensive citywide resiliency plan with all the lessons learned from the HAT Study, that fully integrates sea level rise, studies and mitigates against impacts to the environment and ecosystem services, and provides robust community engagement opportunities to allow local communities a chance to meaningfully shape protective measures, focusing on BIPOC and low income communities. Both the city and state administrations must work together with the council to secure the highest probability of successful implementation of these plans.

They say the best time to prepare for an emergency is yesterday, and the second best time is now, so let's move forward in our climate emergency preparation now. There is no time to spare.

Riverkeeper looks forward to continuing to work with the multiple stakeholders and the City Council to restore and protect our shorelines and waterfronts and to help prepare our communities for climate change. Thank you for the opportunity to testify today

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Storm Surge Barrier Protection in an Era of Accelerating Sea-Level Rise: Quantifying Closure Frequency, Duration and Trapped River Flooding

Ziyu Chen [1,*], Philip Orton [1,*] and Thomas Wahl [2]

[1] Davidson Laboratory, Stevens Institute of Technology, Hoboken, NJ 07030, USA
[2] Department of Civil, Environmental and Construction Engineering, University of Central Florida, Orlando, FL 32816, USA; t.wahl@ucf.edu
* Correspondence: zchen44@stevens.edu (Z.C.); porton@stevens.edu (P.O.); Tel.: +1-(973)-393-6846 (Z.C.); +1-(201)-216-8095 (P.O.)

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Abstract: Gated storm surge barriers are being studied by the United States Army Corps of Engineers (USACE) for coastal storm risk management for the New York City metropolitan area. Surge barrier gates are only closed when storm tides exceeding a specific "trigger" water level might occur in a storm. Gate closure frequency and duration both strongly influence the physical and environmental effects on enclosed estuaries. In this paper, we use historical observations to represent future storm tide hazard, and we superimpose local relative sea-level rise (SLR) to study the potential future changes to closure frequency and duration. We account for the effects of forecast uncertainty on closures, using a relationship between past storm surge and forecast uncertainty from an operational ensemble forecast system. A concern during a storm surge is that closed gates will trap river streamflow and could cause a new problem with trapped river water flooding. Similarly, we evaluate this possibility using historical data to represent river flood hazard, complemented by hydrodynamic model simulations to capture how waters rise when a hypothetical barrier is closed. The results show that SLR causes an exponential increase of the gate closure frequency, a lengthening of the closure duration, and a rising probability of trapped river water flooding. The USACE has proposed to prevent these SLR-driven increases by periodically raising the trigger water level (e.g., to match a prescribed storm return period). However, this alternative management approach for dealing with SLR requires waterfront seawalls to be raised at a high, and ongoing, additional future expense. For seawalls, costs and benefits will likely need to be weighed on a neighborhood-by-neighborhood basis, and in some cases retreat or other non-structural options may be preferable.

Keywords: storm surge barrier; sea level rise; hazard assessment; risk reduction; adaptation; flood duration; hydrodynamic model; New York City

1. Introduction

Coastal cities around the world are exploring structural engineering options for defending against extreme storms and the resulting surges of ocean water that can cause massive flooding. Storm surge barriers or tide gates can effectively protect harbors and minimize flooding, property damage, and loss of life during large storms.

Surge barrier systems costing tens of billions of dollars are being evaluated by the United States Army Corps of Engineers (USACE) as one of a number of options for flood risk reduction for the New York City metropolitan area [1]. The USACE estimates that the cost of coastal flood risk is very high in the region, at \$5.1 billion year^{-1} in 2030 and \$13.7 billion year^{-1} at 2100 (under an intermediate sea level rise trajectory; [1] p. 62). The decision of whether or not to build surge barriers to protect one of the nation's main commercial hubs and ports, crossing one of the world's most iconic estuaries, is a major decision worthy of thorough analysis of potential impacts.

These barriers typically span the opening to a harbor or river mouth and include gates that are only closed when storm surges are expected. When gates are open, any fixed infrastructure that reduces the flow cross-sectional area of an inlet or estuary channel leads to some degree of continuous physical changes throughout the estuary [2,3]. Closure of the barrier gates has a more acute effect, reducing water flow and tidal exchange, which in turn could affect water quality and ecological processes [4–6]. Consequently, gate closure frequency and duration are major determinants of surge barrier estuary effects. The present-day and future gate closure frequency and duration are important environmental impact indicators to understand the impacts of the storm surge barriers.

Sea-level rise (SLR) is a major factor that can lead to increased closure requests, raising management challenges because SLR will lead to the increase of water level exceedances above coastal flooding thresholds. For example, Figure 1 shows that the present-day exceedance probability above the "moderate" National Weather Service (NWS) flood threshold at the Battery tide gauge location (National Oceanic and Atmospheric Administration (NOAA) tide gauge station 8518750 at southern Manhattan, NYC) is very small, but it will become much larger with 60 cm SLR (50th percentile, Representative Concentration Pathway (RCP) 4.5) later this century [7]. The barrier closure duration (number of successive tidal cycles where water level exceeds a flood threshold) may also be lengthened with future SLR, as demonstrated in Figure 2. Those changes would intensify any environmental impacts on the estuary.

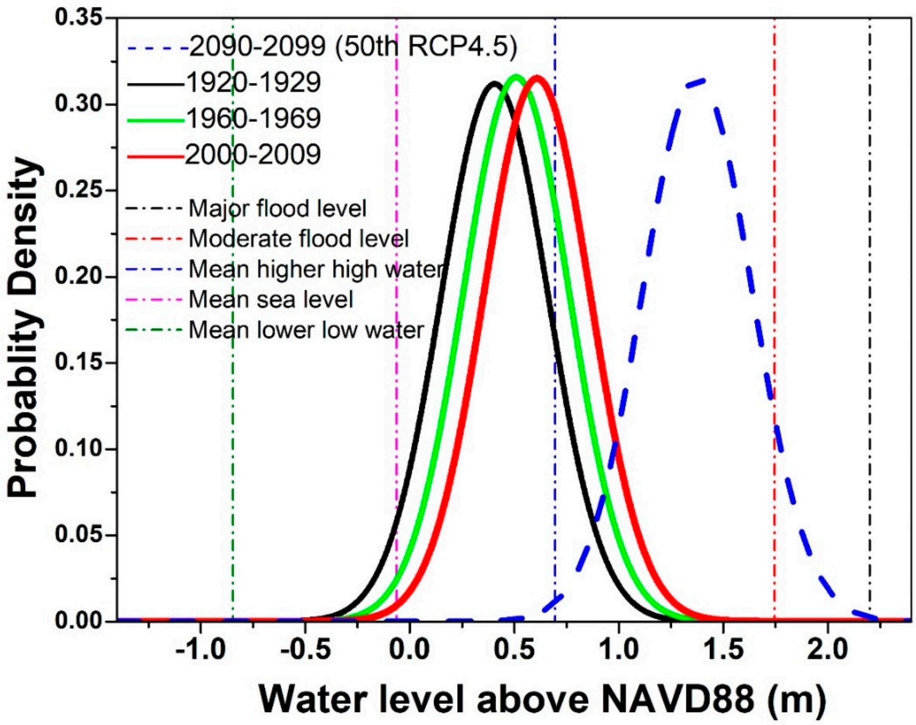

Figure 1. The probability of semidiurnal water level peaks exceeding National Weather Service flood thresholds (moderate, major) increases with sea-level rise (SLR). Probability density functions shown here are based on historical water level data from the Battery, New York City, and with 50th percentile regional SLR projections to 2090–2099 for a moderate emissions pathway (RCP 4.5).

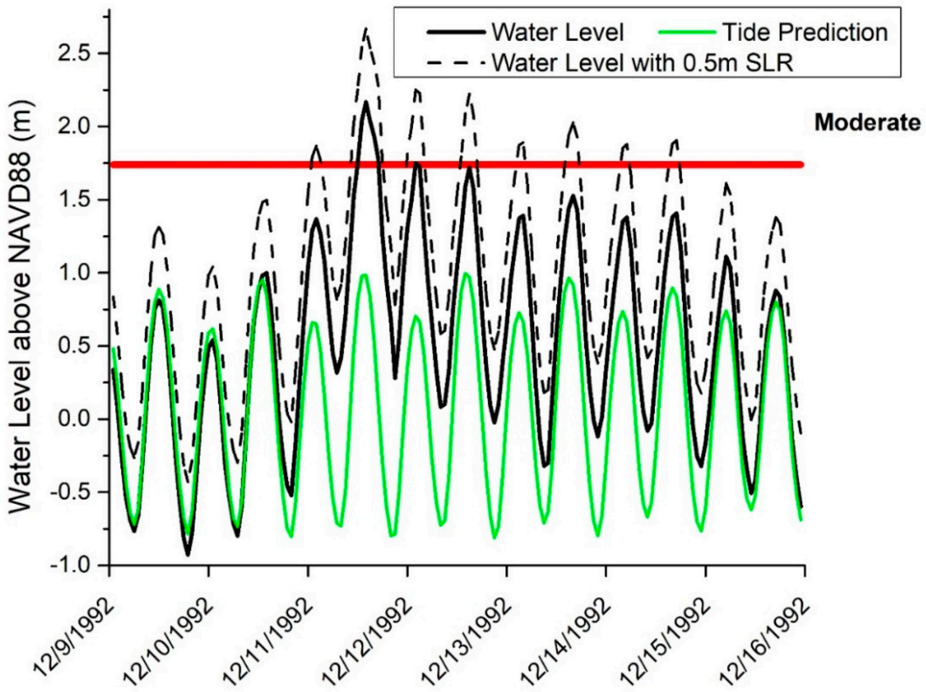

Figure 2. Example of a flood event (1992 Nor'easter) with 3 consecutive semidiurnal peak water levels above the "moderate flood" threshold (red line). Dashed lines show the water level change with 0.5 m SLR, leading to a closure duration change from 3 to 8 tidal cycles. This is an example that requires a long-duration gate closure, over multiple semidiurnal periods.

A lengthened barrier closure duration will also increase the trapped river flood risk behind the barrier. Recent studies have shown that rain (or streamflow) and coastal surge are correlated at many coastal cities around the world, and evidence at some locations that their correlation is increasing, including for New York City (NYC) [8,9]. Climate change could exacerbate future rain intensity and streamflow [10], rendering it even more important to assess flood risk from the co-occurring trapped streamflow due to the closed storm surge barrier.

Prior studies have investigated the continuous effects of open barriers on physical estuary conditions [2,3,11], but there has been a limited number of academic assessments focused on surge barrier closure frequency, duration, and trapped river flooding. These factors also require careful consideration for any proposed surge barrier system. Kirshen et al. [12] evaluated how the gate closure frequency would increase in the future for a hypothetical Boston surge barrier, and performed a preliminary multi-disciplinary assessment of surge barrier effects. However, they did not address how the duration of individual closures will evolve. Also, they did not integrate the forecast effect on the gate closure frequency. To guarantee that the gate closure frequency is less than an acceptable maximum, it is important to introduce a margin of error regarding the effects of inaccuracy of water level forecasting on the calculation of the frequency of exceedance. The forecast uncertainty is not only proposed by the USACE as the required surge barrier design criteria ([1], p. 37 in Engineering Appendix), but also a significant factor that has been considered and addressed in determining surge barrier design from prior Dutch experience [13].

The goals of this paper are:

(1) to demonstrate a simplified, transferable framework for barrier closure analyses that builds upon the work of Kirshen et al. [12];
(2) to estimate the surge barrier gate closure frequency and duration and their future evolution with SLR; and
(3) to assess the probability of trapped river water flooding during periods of gate closure.

Sections below detail the methods, results, discussion and primary conclusions of the research, and Supplementary Materials include additional figures, data and codes for reproducing the primary analyses.

2. Methods

The general methodological approach of this research is to use historical tide gauge data to represent empirically stochastic storm-driven and tide-driven variability in harbor water levels, superimpose SLR on these water levels, and compute the frequency and duration of exceedances (and thus, required gate closures) for each year going forward. We also create a model of 24 h forecast uncertainty for incorporation into the water level data. Then, we quantify the trapped water elevations at the NYC for all the present/future "gate closure triggered" events. Figure 3 shows the flow chart regarding the detailed procedures and steps for the analysis. In this research, we make several simplifications on the dynamic processes of water level change as well as the closure operation of the barrier system; these are further explained and discussed in the following subsections.

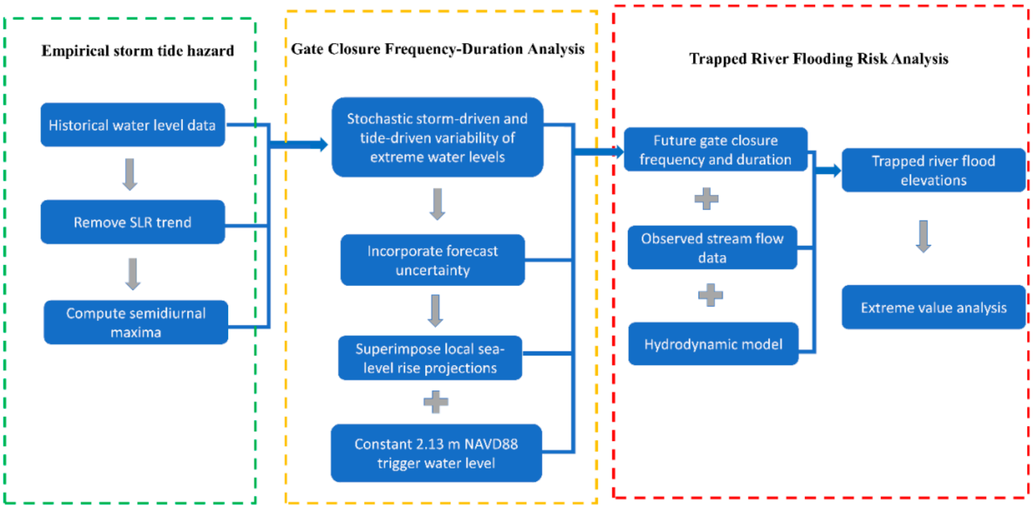

Figure 3. Diagrammatic representation of the processes and analyses in "Methods" section.

2.1. *Gate Closure Trigger Water Level*

Two surge barrier closure management regimes are possible—one is based on a constant water level threshold in forecasts that is a "trigger" for gate closure (e.g., [14]), and the other is a constant annual exceedance probability (AEP) (or inversely, return period), in which case the water level trigger is updated periodically as sea levels rise. Our analyses focus mainly on the first management regime, given that many of the world's existing surge barrier systems are being closed more frequently due to SLR (e.g., the English Thames barrier [15]; the Dutch Rijkswaterstaat and Maeslantkering barriers [16]). However, we will also examine how our analyses inform the second management regime, and discuss the two regimes in Section 4.

We focus mainly on a constant water level trigger of 2.13 m (7 feet) above the North American Vertical Datum of 1988 (NAVD88) in our analyses. This is just below the National Weather Service (NWS) "major flood level" at the Battery, New York City (2.20 m NAVD88), indicating extensive inundation and significant threats to life and property. The value of 2.13 m is the most recent value being used by the USACE in their assessments (B. Wisemiller, USACE New York District, pers. comm, January 2020), balancing protection with environmental concerns by keeping the closure frequency below 0.5 year^{-1} for several decades into the future. The USACE has also proposed that if sea levels rise sufficiently for closure frequencies to exceed 0.5 year^{-1}, they will then use a constant AEP trigger ([1], p. 69).

2.2. Empirical Storm Tide Hazard

The observed water level data is utilized to create the stochastic storm-driven and tide-driven variability in harbor water levels, hereafter referred to as the storm tide hazard. Here, we ignore any changes to tides or storm surge caused by the fixed infrastructure of barriers. Based on past research [3], various hydrodynamic models' results indicate that changes to tidal range conveyance can be kept small, if this location's surge barriers have an open gated flow area that is greater than about 50%, which is the case for all the barrier systems being considered by the USACE ([1], pp. 26–27 in Engineering Appendix). The historical observed hourly water level data from 1920 to 2019 at the Battery tide gauge location is used for this study. We remove a cubic fit to annual mean sea level from 1920 to 2019 to eliminate the effects of long-term SLR but retain intra- and inter-annual variability. Then, we create a semidiurnal maxima dataset from the detrended hourly water level data to represent the stochastic storm-driven and tide-driven signal in harbor water levels. To characterize future flood hazards, we are only considering future SLR and not considering future storm tide climatology changes in this study. Based on recent studies [17,18], projected changes to storm tide climatology in New York City will contribute a relatively minimal (below 10% relative) impact on changing extreme water levels compared with SLR by the end of the 21st century.

2.3. Impacts of Forecast Uncertainty

In the practical operation of the surge barrier system, decisions on gate closure will be based on forecasts of future water levels, which will always have uncertainty. Notably, the forecast water level uncertainty is usually larger for more extreme events, such as deep extratropical low-pressure systems or hurricanes (e.g., [19,20]). The forecast water level needs to come 24 h or even earlier in advance of the projected flooding event giving time for the cumbersome gate closure operation before the event hits. Typically, the surge barrier manager will refer to the spread of an ensemble of forecast water levels and close the barrier even if there is a small chance of the trigger threshold being exceeded. This will inevitably cause more closures, but minimize the risk (monetary and political) of not closing the barrier and having a surprise, damaging flood (a false negative).

We quantify typical uncertainty in water-level forecasts and its dependence on storm surge by utilizing the past 4 years of forecast results from an operational forecast system [19,21]. The 95th percentile forecast is chosen as a hypothetical value for barrier closure decisions, which leads to a probability of 5% of false negatives. A "high-end uncertainty" (95th percentile—minus the 50th percentile at the time of the forecast peak) is defined as an additional increment to add to historical observations to represent the average effect of forecast uncertainty.

The storm surge component is the key factor that influences the forecast uncertainty, due to uncertainty in the meteorological forecasts. We investigate the relationship between storm surge height and forecast uncertainty by using water-level observations and past ensemble forecasts. First, we perform a harmonic analysis (considering 37 harmonic constituents) to extract the tide and remove it from the observed water level to obtain the surge values. Then, we match the surge values for each water-level peak with the corresponding ensemble forecast. We capture the semidiurnal maxima from the observed water levels, and find the historical ensemble forecast that was delivered 24 h prior to arrival of that peak and compute the "high-end uncertainty". We selected only the top 20 high water-level events (a threshold being exceeded with a 5 year^{-1} frequency) from the dataset and use these as samples to fit the regression model. In this way, we obtained a relationship between high-end uncertainty and surge (Figure S1 in Supplementary Materials; uncertainty = 0.214 × surge + 0.100; Coefficient of determination r^2 = 0.523) and add it to observed maxima. While the formula was derived during a period with no extreme events, we also find it to give a reasonable result for a retrospective forecast of Hurricane Sandy (2012). When we use this relationship to compute the "high-end uncertainty" for Hurricane Sandy, the result is 0.66 m. This is close to the corresponding 0.5 m high-end uncertainty published before using the same ensemble forecast model [21].

2.4. Local Sea-Level Rise (SLR) Projections

Probabilistic sea level rise scenarios are considered to quantify gate closure frequency and uncertainty in the future. We utilized relative SLR projections [22,23] for the Battery under two emissions scenarios (RCP4.5 Intergovernmental Panel on Climate Change (IPCC) moderate emissions pathway; RCP8.5 IPCC high emissions pathway). These SLR projection studies provided 20,000 Monte Carlo samples at decadal time steps. After unifying the water-level data and SLR data to the same datum, we compute the 10th, 50th and 90th percentile of SLR and linearly superimpose them on the synthesized peak water level maxima (those with uncertainty added, as described above) to represent their future evolution with future SLR and calculate the surge barrier closure frequency and duration. Here, we do not consider the non-linear interaction between storm tides and SLR, we simply superimpose the SLR data to the water level to represent the future water level under SLR. This static assumption has been tested and verified at this area through past research using hydrodynamic modeling [24,25]; model results are very close to the superposition of water level and SLR. We also utilize the USACE intermediate/high SLR data [26] for analysis to compare with our results.

2.5. Gate Closure Frequency and Duration Analysis

In quantifying the future gate closure frequency and duration, we are considering the actual closure operations; if there are temporally-consecutive water level peaks (i.e., high tides) above the threshold, it will be counted as one gate closure. This assumes the gate will not be closed and opened within one tidal cycle. Thus, the "duration" is defined as the number of semidiurnal tidal cycles during which the threshold is exceeded (see example in Figure 2). This is reasonable because the processes of opening and closing gates of surge barriers both typically take several hours [12]. The gate will stay closed in a long-duration flood event (e.g., extra-tropical storm), as has been assumed in other surge barrier closure modeling studies (e.g., [27]).

We ignore spatial variations in water level, using only water levels from the Battery in our analysis. This is a reasonable way of creating a simplified analysis and avoiding a large quantity of hydrodynamic model simulations, because spatial variations in water levels around New York and New Jersey Harbor are typically small (on the order of 10% of the storm tide; e.g., [28]).

2.6. Trapped River Flooding Analysis

A combination of hydrodynamic modeling of water levels during six past storms (Table 1) with three barriers closed (Verrazano Narrows barrier; Throgs Neck barrier; Arthur Kill barrier) and 25 years of historical observed streamflow data are used to quantify the annual frequency of trapped river water flooding during gate closures. Here, we are only looking at the trapped water rise at the Battery location in the model run, as NYC is the most populated location behind the barrier. Considering that there are small spatial variations along the Hudson River normally (averaging only a ~40 cm rise over the 225 km tidal reach; [3]) and these will be reduced due to the gate closure at the ocean end, we do not examine the spatial variations. The streamflow observations are used to obtain accumulated water volume during closure events and modelling is used to turn this into the water elevation increment at the Battery and infer a relationship between the two based on the historical storm scenarios. First, we use the historical hourly streamflow data from 16 available the United States Geological Survey (USGS) gauges in the study area to construct the total streamflow volume input time series from 1990–2014. Figure S4 (in Supplementary Materials) shows the study area with all the USGS gauge locations, the three barriers' closure system and the Battery location. There are gaps of several gauges that do not have the streamflow records for some periods of time. These gaps are closed by using nearby available gauge data and scaling by relative watershed drainage area. Then, we utilize the gate closure duration results (assuming constant 2.13 m trigger water level) to calculate the simultaneous total trapped water volume for each gate closure triggering event.

Table 1. Six historical storms modeled with surge barriers closed, for trapped water analysis.

Simulation Dates	Storm Name	Storm Type	Peak Storm Tide (m, NAVD88)	Peak Streamflow Total (m^3/s)
17 January 1996–23 January 1996-	None	Extratropical cyclone	1.14	6458.3
6 January 1998–12 January 1998	1998 Ice Storm	Extratropical cyclone	0.99	4713.9
13 September 1999–19 September 1999	Floyd	Tropical cyclone	1.11	2994.4
31 March 2005–5 April 2005	None	Wet extratropical cyclone	1.23	6566.6
9 April 2007–19 April 2007	Tax Day storm	Extratropical cyclone	1.53	6250.0
22 August 2011–1 September 2011	Irene	Tropical cyclone	1.97	7897.2

To illustrate how trapped water flooding changes with SLR, we superimpose three SLR scenarios (0.3 m, 0.6 m and 1 m SLR) to the storm tide maxima over the same period, to evaluate cases where the surge barrier closure would be triggered. We then calculate the trapped water volume based on two possible gate operation methods: (1) the gates close at the slack tide at the Battery and reopen at the slack tide, and we assume streamflow starts to accumulate from mean sea level at the Battery for each triggering event; and (2) the gates close at low tide and reopen at low tide, in which case we assume streamflow starts to accumulate from mean low water level at the Battery. This mean low water value is raised with superposition for the sea level rise scenarios.

The New York Harbor Observing and Prediction System (NYHOPS) hydrodynamic model is used to model six historical storms [29] in order to obtain an empirical relationship between trapped water volume from the observed tributaries and water level rise elevation at the Battery. The model accounts for freshwater inputs from all sources in this area [28,30] and includes the three barriers' closure system. We used the relationship obtained from the hydrodynamic model to transfer the trapped water volume to water level increase for all gate closure events. Figure S5 (in Supplementary Materials) shows the empirical relationship between observed trapped water volume coming from different tributaries and modeled rise in water level elevation at the Battery. Multiple types of historical storm (Table 1) are used as the model inputs for constructing the relationship.

Lastly, we perform extreme value analysis on the trapped water elevation data for the different future SLR scenarios to estimate the probability of surpassing the 2.13 m flood threshold. We fit the generalized Pareto distribution to the trapped river flood elevation data and calculate the exceedance probability for the 2.13 m NAVD88 flood threshold for each case. To best model the distribution's tail, we choose the top 25 trapped river flood elevations (a 1 year^{-1} closure frequency based on the 1990-2014 data) as samples in each SLR scenario. For sea-level rise scenarios where the number of gate closures is smaller than 25 times (e.g., 8 closures in 25 years, for the 0.3 m scenario), we do not fit a distribution for two reasons: (1) there are too few points to robustly fit a distribution and (2) the probability is effectively zero, because none of the trapped water levels is within 1 m of 2.13 m.

3. Results

3.1. Gate Closure Frequency Analysis

Analysis of barrier gate closures contrasted two potential approaches for managing barrier gate closure: (1) the case of a constant water-level trigger and (2) the case of a constant AEP such that the trigger water level is raised periodically as sea levels rise. Figures 4–6 demonstrate how SLR could affect barrier closures based on a constant water level trigger. Figure 4 contrasts the influence of the trigger water level (moderate flood vs. 2.13 m flood level) on the number of closures, which shows that the trigger water level has a strong influence on the number of closures. A 0.39 m rise of trigger water level (1.74 m NAVD88 to 2.13 m NAVD88) makes about a factor of 10 difference of the closure frequency.

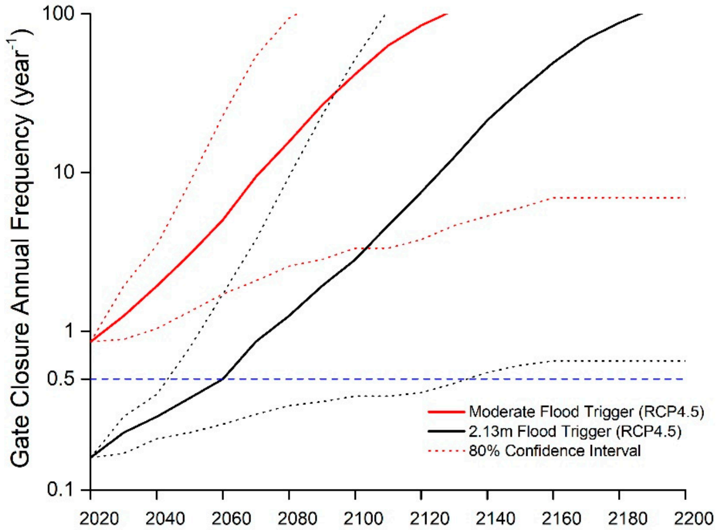

Figure 4. Gate closure frequency analysis results based on constant water level triggers and RCP 4.5 sea level rise; red lines are using moderate flood trigger (1.74 m NAVD88), black lines are using 2.13 m flood trigger. The horizontal dashed line is the given maximum closure frequency (0.5 year^{-1}). The y-axis is cut off at 100 year^{-1} since the closure frequency above 100 year^{-1} is far beyond our research interest.

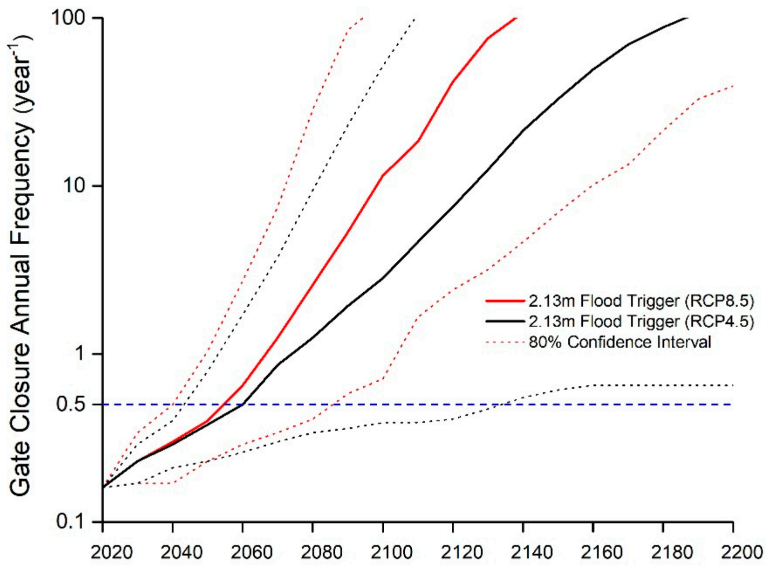

Figure 5. Gate closure frequency analysis results based on constant 2.13 m flood trigger; red lines are using the RCP 8.5 sea level rise; black lines use the RCP 4.5 sea level rise. Dashed line is as Figure 4.

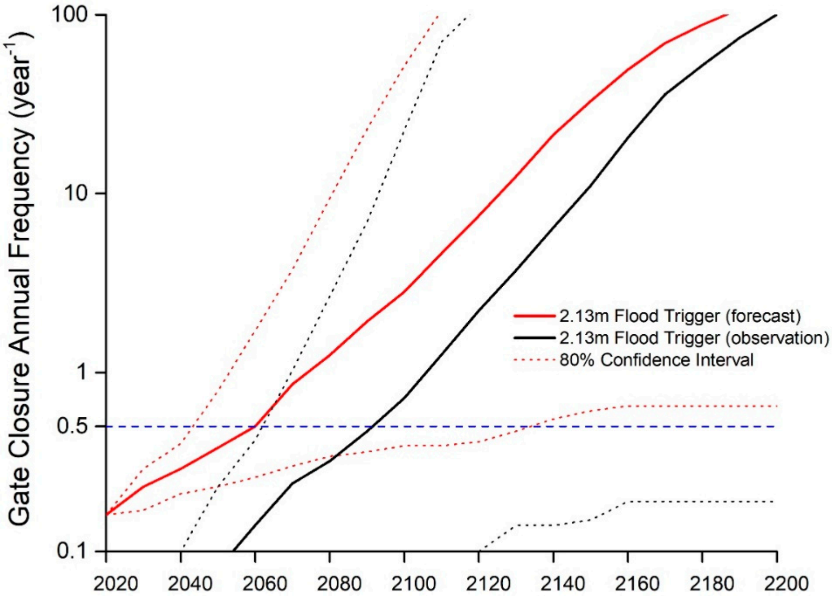

Figure 6. Gate closure frequency analysis results based on a constant 2.13 m flood trigger and RCP 4.5 sea level rise; red lines are based on an estimated storm tide hazard with forecast uncertainty (the 95th percentile); black lines are based on the storm tide hazard with zero forecast uncertainty. Horizontal dashed line is as Figure 4.

Figure 5 compares different SLR scenarios (RCP 4.5 vs RCP 8.5) effects on the gate closure frequency; The sensitivity of the number of closures to these two greenhouse gas emissions trajectories becomes larger with time, However, the difference of arrival time of the 0.5 year^{-1} maximum closure frequency between these two is small (2054 versus 2060).

The forecast uncertainty has a large effect on gate closure frequency, particularly at or below the 0.5 year^{-1} frequency threshold). Figure 6 shows the effect of incorporating the forecast uncertainty on the number of annual gate closures (comparing red and black lines). For example, in 2060 the central estimate of the closure frequency by using synthesized forecast water level is reaching the 0.5 year^{-1} frequency threshold, while the corresponding closure frequency calculated without forecast uncertainty ("observation") is only about 0.15 year^{-1}. After considering the forecast uncertainty, the threshold of 0.5 year^{-1} is reached 30 years earlier, in 2060 instead of 2090.

The alternative gate closure management regime of a constant gate closure AEP requires a rise in the trigger water level in future decades (Figure 7). As the gates would not be closed for lower water levels, this would require a higher elevation for shoreline protection. The closure AEP was assumed to be constant at 0.5 year $^{-1}$. The results indicate the useful time horizon of the barrier/seawall combined system based on RCP 4.5/ RCP 8.5 future greenhouse gas emissions trajectories (2020–2200) and USACE SLR projection (2020–2100, [26]). For a risk-averse planning perspective, we show high-end 90th percentile scenarios (dash lines) with the 50th percentiles (solid lines), but we omit the 10th percentiles. The 90th percentile results show that using the 2.13 m flood level as the trigger can make this system functional at least until 2040; raising the trigger water level to 2.6 m extends functionality at least until 2070.

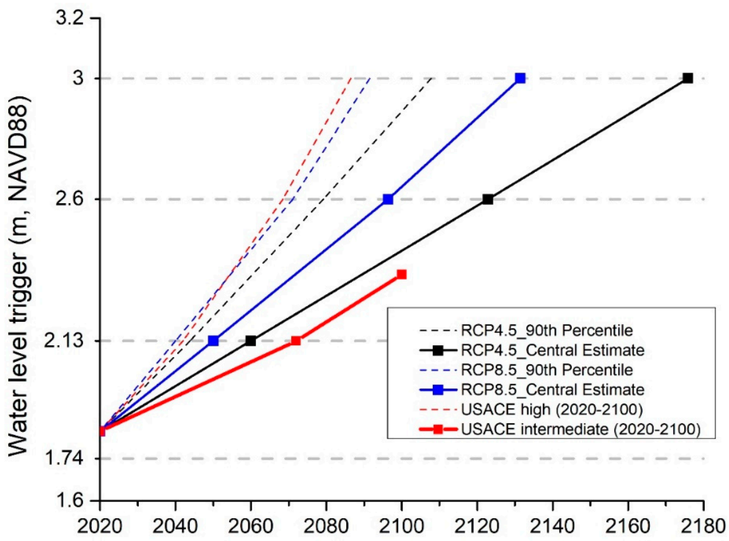

Figure 7. Future evolution of the water-level trigger based on a constant AEP (0.5 $year^{-1}$) and three sea level projections: RCP 4.5 (black), RCP 8.5 (blue) and the USACE intermediate projection (red). These results use observed data incorporated with forecast uncertainty (the 95th percentile).

3.2. Gate Closure Frequency-Duration Analysis

While gate closure frequency rises exponentially with SLR, the gate closure duration rises more slowly. For each flood event, we calculated the corresponding gate closure duration based on its flood duration time (See example from Figure 2). Here, we obtain the result of the closure frequency for different closure duration events. Figure 8 shows the exceedance frequency (frequency for the flood events equal or greater than N semidiurnal tide cycles) for flood events with various durations (ranging from 1 semidiurnal tide cycle to 10 semidiurnal tide cycles). We assume a constant 2.13 m flood water level trigger and RCP 4.5 future greenhouse gas emissions trajectories for the analysis. The median (50th percentile) scenarios are shown for 2050 and 2100 (solid lines). For a risk-averse planning perspective, we also show high-end 90th percentile scenarios (dash lines), but we omit the 10th percentiles.

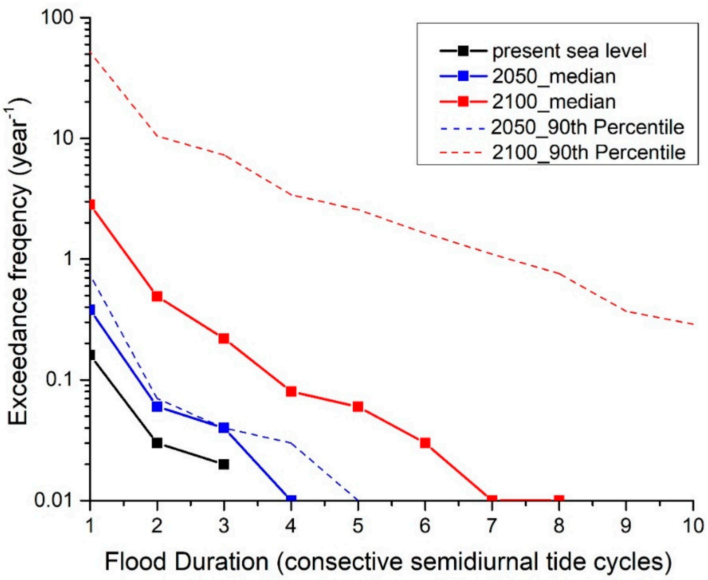

Figure 8. Gate closure frequency-duration analysis results based on constant 2.13 m flood trigger and RCP 4.5 sea level rise; red lines are using the SLR projection at 2100; blue lines are using the SLR projection at 2050; black line is using present day sea level.

3.3. Trapped River Water and Flooding

Figure 9 demonstrates the potential risk of the trapped river water flood due to closures of the surge barrier system. As sea level rises, the combination of a higher water level starting point, and increased closure frequency and duration leads to increased trapped river water and a higher probability of trapped river water flooding. With the constant closure trigger of 2.13 m, the frequency for the present day is 0.20 year^{-1} and it will trap 7.2 million m^3 year^{-1} river water (assuming gates close/open at slack tide). With 0.3/0.6/1 m SLR, the frequency increases to 0.36/3.2/42.7 year^{-1} and the annual trapped river water volume increases to 11/76/1240 million m^3 respectively. This exponential increase of the annual trapped river water volume by SLR would cause problems with poor circulation/flushing of the estuary, and such a high closure frequency would likely not be permissible.

If the gates close at low tide instead of slack tide (Figure S6 in Supplementary Materials), the river water behind the barrier will begin to be trapped from a relatively lower water level compared with gates closing at slack tide, and this will reduce the probability of trapped river water flooding. However, the gate closure operation at low tide when the water velocity is high is more challenging. This would also increase the gate closure duration, which would increase the volume of water trapped by gate closures. Both strategies are tested in the trapped river water flood risk analysis and results indicate that there is only a very small probability (below 0.005 year^{-1}) of trapped river flood for both strategies under 0.6 m SLR based on the extreme value analysis with a generalized Pareto distribution.

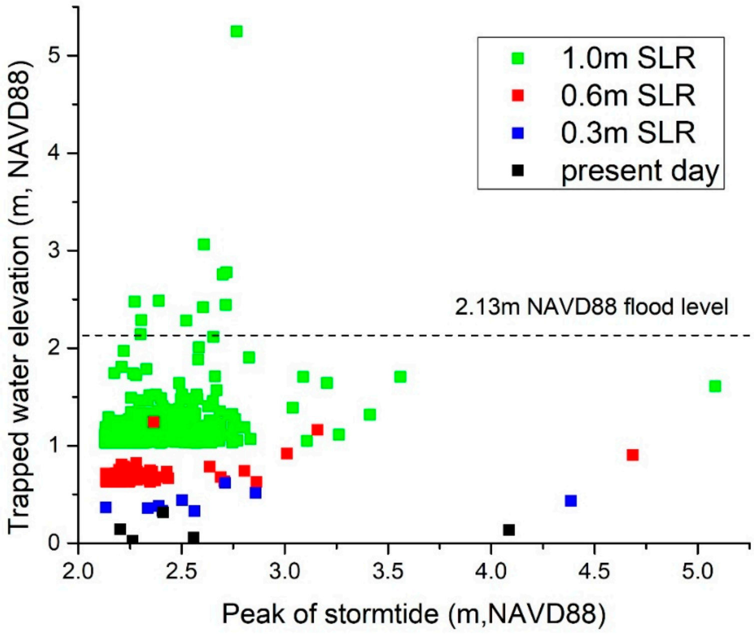

Figure 9. Trapped river flooding analysis results based on constant 2.13 m flood trigger assuming gates close/open at slack tide (almost mid tide at the three barrier locations). The scatter points are the historical gate closure events (black) or future gate closure events with 0.3 m, 0.6 m and 1 m SLR (blue, red, green). The horizontal axis shows the peak water level of the storm tide events; the vertical axis is the corresponding trapped water elevation at the Battery location. The horizontal line is the 2.13 m flood threshold at the Battery gauge station.

4. Discussion

Our results illustrate that SLR will cause an exponential increase in the gate closure frequency and also an increased duration, if a constant water-level trigger is used to manage gate closures (Figures 4–6 and 8). This will cause the arrival of the USACE's maximum allowable gate closure frequency in the near future. Based on our constant gate closure AEP results (Figure 7), if using the 2.13 m flood trigger, the annual closure frequency will exceed 0.5 year^{-1} around 2060 based on RCP central estimate of sea level rise results. Therefore, for a 100-year planning horizon, the constant-trigger AEP management regime is needed, and seawalls would need to be raised higher for protection against more frequent floods.

Some of the lower waterfronts in the region have no seawalls and already experience monthly flooding (e.g., Hamilton Beach, bordering Jamaica Bay) or have areas with seawalls as low as 1.7–1.8 m NAVD88 elevation (e.g., Coney Island and Belle Harbor, [31]; and Hoboken). Obviously, a surge barrier with a trigger water level of 2.13 m will not help these neighborhoods avoid frequent flooding, also known as "residual risk". To prevent flooding for these locations, seawalls will immediately be needed to be built or raised. At a typical cost of $20 million per kilometer of length and meter of elevation for seawalls/levees [32], and on the order of 100 km of waterfront likely requiring new construction to reach the 2.13 m protection level, this will add billions of dollars to any comprehensive plan that seeks to address both surge and SLR. Most likely, costs and benefits will need to be weighed on a neighborhood-by-neighborhood basis, and in some cases retreat may be a better option.

If seawalls heights are raised uniformly to 2.13 m, the combined surge barrier/seawall system's useful time horizon (UTH) could be as short as 2040, if accounting for high-end sea level rise and forecast uncertainty (Figure 7). Alternatively, the UTH could be 2090 if using a central estimate of sea level rise and no forecast uncertainty (Figure S2 in Supplementary Materials). Lastly, the UTH could extend into the 22nd century if sea-level rise trends lower than the central estimate.

Wave-driven overtopping of seawalls makes the problem of sea-level rise even more challenging, and was not quantified in this study. New York Harbor significant wave heights during a typical 0.5 year^{-1} AEP storm tide are approximately 1 m in height, with crests 0.5 m above the still water-level. At downwind locations with a large enough wind fetch, frequent overtopping will occur if the waterfront height is only high enough to stop the still-water level. To comprehensively assess seawall heights and costs, a study would need to include wave modeling and consider the allowable overtopping volumes.

4.1. Sensitivity to Uncertainty in SLR

There is a large uncertainty for the gate closure frequency (Figures 4–6) and the barrier/seawall useful time horizon (Figure 7) in the future due to the high uncertainty of SLR. If using the central estimate of SLR to plan for the gate closure trigger and required shoreline elevation, the sea level could rise more rapidly, in which case the shoreline elevation would need to be further raised to adapt to a higher SLR. Planning for the 90th percentile SLR trajectory up front will substantially increase the construction cost of the barrier/seawall system, but this can avoid the risk of requiring future seawall reconstruction. Even if SLR does not occur at such a high rate, the high waterfront elevation can extend the useful lifetime of the barrier/seawall system.

Applying USACE SLR projections (2020–2100) for the constant frequency analysis and comparing it with other SLR projections shows that USACE's intermediate SLR is below the central estimate and well below the 90% percentile of either RCP4.5 or RCP8.5 (Figure 7). The USACE intermediate SLR projection is used by USACE for its cost-benefit analysis ([1], p. 18 in Economics Appendix). Therefore, the Harbor and Tributaries Focus Area Feasibility Study (HATS) may underestimate the cost of seawalls and the benefit of reduced flood damage in their cost-benefit analysis.

4.2. Sensitivity to Forecast Uncertainty

In the practical operation of the surge barrier system, gates must be closed if there is a reasonable likelihood (e.g., 5%) of exceeding the trigger water level, for risk-averse purposes. The incorporation of forecast uncertainty based on data from an existing operational ensemble flood model shows that it leads to an increase in closure frequency. This requires a higher trigger water level, in order to keep closures at the acceptable frequency of 0.5 year^{-1} (Figure 7 v.v. Figure S2 in Supplementary Materials). This impact should be taken into consideration for the gate closure frequency prediction and benefit-cost analysis.

In the future, forecast precision could be improved as weather and ocean modeling techniques improve. However, there will always remain aleatoric uncertainty due to natural processes, even if models were to become perfect. As forecast uncertainties will shrink, uncertainty will always exist, and the actual closure frequency is likely to be between the two cases shown in Figure 6.

4.3. Sensitivity to Interannual Variability in Storm Surge and Mean Sea Level (MSL)

The gate closure frequency is only sensitive to storm surge and MSL interannual variability in the first 3–4 decades when SLR uncertainty is low (Figure S3 in Supplementary Materials). This analysis requires a more complex analysis approach for synthesizing future water level exceedance data. We use a Monte Carlo approach to merge these sources of interannual variability with SLR uncertainty by superimposing 20,000 samples of SLR on random past years of storm tide data. In this way, we can convolve the empirical annual flood frequency distribution together with the probabilistic SLR distributions, from which we obtain the distribution of single-year closure frequency at each at decadal time step, instead of an annual-average closure frequency. We use the 90th percentile from the distributions to represent the "single-year max annual closure frequency". With the large uncertainty of SLR beyond 30 years into the future, results become insensitive to interannual variability.

4.4. Low Near-Term Risk of Trapped River Water Floods

If a constant trigger water level is used, SLR will increase the gate closure duration and frequency (Figure 8) which will increase the risk of trapped river water flooding. This is shown using historical events in Figure 9. However, the probability of trapped river water flooding for cases of SLR of 0.6 m and below is still below 0.005 year^{-1} for either the gates closed at the low tide or slack tide. Our trapped water analysis results are conservative (i.e., if anything, biased high). First, some types of smaller auxiliary flow gates (not the large navigational gates) may have the capability to be partially opened to release some water when the offshore water level is periodically near low tide (cases shown in Figure 2). If gates have this capability, then this could be done anytime the offshore water level dips below the inshore water level. In addition, the hydrodynamic model we use does not have floodplains, and hence the trapped water level could have a high-bias due to not being able to spread into a floodplain. Nevertheless, the results still show a low risk of trapped river water flooding for up to 0.6 m SLR.

Looking further into the future, a higher SLR scenario of 1 m results in more risk of trapped water floods exceeding the 2.13 m flood threshold (Figure 9). Here, the future barrier management regime becomes important, because the annual number of closures for sea-level rise of 0.6 m is more than 3 year^{-1}, and for 1.0 m is above 42 year^{-1}, far exceeding the rate which the USACE has said would be acceptable. Thus, the frequency of closure would likely be unacceptable well in advance of the arrival of this quantity of SLR. If the management is based on a constant AEP trigger, then trapped water flooding will always remain a very low-probability event.

Considering that future rain intensity could be higher than the present-day rain intensity, due to climate change, there could be an increase in streamflow. Based on climate change research for the New York area, the runoff volume increase is less than 30% for the 2-year/50-year extreme events [33]. Similarly, another study found that the rain intensity increase is less than 22% for extreme events [34]. However, the worst of our historically-based trapped river flood events, even with 0.6 m SLR (Figure 9), would need to increase by about 80% to reach the 2.13 m flood level at the Battery. While we neglect the effect of future rainfall increases in our analysis, these studies suggest this effect would not significantly alter our conclusions above.

A closer look at the trapped water modeling results with no floodplain (Figure S5 in Supplementary Materials) reveal a fairly linear relationship between trapped water level and volume, where the slope is related to the tidal waterway area. This suggests a simplified method of quantifying trapped river water levels without hydrodynamic modeling, which is to assume there is no floodplain and compute water level as time-integrated water volume divided by the area of tidal waterways behind the barrier. The assumption of no floodplain is reasonable if there is high topography, as is the case in most of the

Hudson River valley, or if seawalls are blocking the flooding, which is correct up until the point where flood stage exceedances occur (which is the point we are interested in capturing). One must provide a gate closure duration and estimate the total freshwater input to the system, which can often be different from the total that is measured at river gauges. This can be done by scaling up the measured volume by the ratio of total (ungauged plus gauged) watershed area divided by the gauged watershed area [35].

5. Conclusions

This study quantifies how SLR would influence the closure frequency, duration, and trapped river flood risk for a storm surge barrier system being considered for the New York City metropolitan area. The research demonstrates a transferable framework that includes a combination of historical observations, superposition of sea-level rise, and optional computational hydrodynamic modeling. The results indicate the trigger water level and the forecast uncertainty both strongly influence the annual number of gate closures. With gate closure management based on a constant trigger water level, SLR causes an exponential increase of the gate closure frequency and a lengthening of the closure duration. With gate closure management based on a constant AEP, a useful time horizon is defined for the barrier/seawalls system, which help inform the required seawall heights and the HATS benefit–cost analyses. If seawalls heights are raised uniformly to 2.13 m, the system's useful time horizon could be as soon as 2040, accounting for high-end sea-level rise and forecast uncertainty, or 2090 with a central estimate of sea-level rise and no forecast uncertainty, or longer if sea-level rise trends are lower than the central estimate. The probability of trapped river water flooding is presently very low, but increasing sea levels lead to an increase in this probability. However, closure frequency rises well above 0.5 year^{-1} before this becomes a problem and hence closure frequency is a more immediate problem that could be addressed by raising the trigger water level.

Supplementary Materials: The following are available online at http://www.mdpi.com/2077-1312/8/9/725/s1. Figure S1: Scatterplot is the top 20 high-water level events showing the storm surge and its corresponding "high-end uncertainty" 24 hours before the event (from an ensemble forecast) in the past 4 years. The red line is the "forecast uncertainty" regression model with the 95% prediction interval (black dash line). Figure S2. Water level trigger future evolution by allowing constant AEP (0.5 year-1) based on RCP 4.5 (black) and RCP 8.5 (blue) future greenhouse gas emissions trajectories and the USACE intermediate SLR projection (red); these results are using observed data only (no forecast uncertainty has been incorporated), in contrast to Figure 7. Figure S3. Gate closure frequency analysis results based on constant 2.13 m flood trigger and RCP 4.5 future greenhouse gas emissions trajectory; Black dashed line is the 90th percentile single-year closure frequency. Dashed line is as Figure 4. Figure S4. The study area with the USGS gauge locations (Purple dots), the three barriers' closure system (red dots) and the Battery tide gauge location (Green square). Figure S5. The relationship between water elevation rise at Battery and total accumulated water volume. Different colors are corresponding to different historical flood events with multiple points for different time of the event; the points recorded the modeled water rise at Battery and the corresponding total freshwater input; the dash lines are the linear fit of each flood event; the black solid line is the final relationship fitted by using all the points. Figure S6. Trapped river flooding analysis results based on constant 2.13 m flood trigger assuming gates close/open at low tide, in contrast to Figure 9.

Author Contributions: Conceptualization, P.O., Z.C.; methodology, P.O., Z.C., T.W.; software, Z.C.; validation, Z.C., P.O.; formal analysis, Z.C., P.O.; investigation, P.O., Z.C.; resources, P.O.; data curation, Z.C., P.O.; writing—original draft preparation, Z.C., P.O.; writing—review and editing, P.O., Z.C., T.W.; visualization, Z.C., P.O.; supervision, P.O., T.W.; project administration, P.O.; funding acquisition, P.O. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest: The authors declare no conflict of interest.

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Testimony of Carlos Castell Croke
Associate for NYC Programs
New York League of Conservation Voters

City Council Committee on Resiliency and Waterfronts
Oversight Hearing
October 27, 2020

Good afternoon, my name is Carlos Castell Croke and I am the Associate for New York City Programs at the New York League of Conservation Voters (NYLCV). NYLCV represents over 30,000 members in New York City and we are committed to advancing a sustainability agenda that will make our people, our neighborhoods, and our economy healthier and more resilient. I would like to thank Chair Brannan for holding this important hearing and for the opportunity to testify today.

When Superstorm Sandy hit our city in 2012 it was dubbed a “one in a hundred year” storm, a misleading label that undervalues the growing threat climate change continues to impose on our world. We believe that in order to better protect our city from this threat we must establish a resiliency plan that preemptively protects us from another superstorm like Sandy.

To date, much of our resiliency work has been reactive and fragmented, relying on federal disaster response funds mobilized by devastation to help certain vulnerable neighborhoods recover and build back stronger. But in a city of islands, with 520 miles of coastline, this approach is inadequate. We need a comprehensive and anticipative citywide approach to resilience.

NYLCV supports the passage of legislation, such as Intro 1620, that would establish and implement a resiliency plan to protect us before another superstorm hits. This plan should build off of and work in tandem with existing community based plans such as the Special Initiative for Rebuilding and Resiliency, and the Local Waterfront Revitalization Plans to reduce redundancies in our resilience work. The plan should also accurately evaluate and report on the specific risks to waterfront properties, neighborhoods and developments and be updated regularly to reflect current storm and flood data so that we may develop clear, accessible, and equitable targets for risk reduction. This is critical for the low income communities and communities of color who too often bear the brunt of the effects of climate change. Lastly, since our waterfront is home to so much critical infrastructure, from public housing to airports to power facilities to wastewater treatment plants, it is also important that the plan brings those relevant stakeholders into the planning process.

Our other priorities for a plan should include but are not limited to:

- Informed by the New York City Panel on Climate Change and regularly updated as new projections and plans are developed;
- Clarifies the agencies responsible for key functions of resiliency governance (communication, planning, implementation, maintenance);
- Dedicated funding;
- Upfront about the limitations and possibilities for resiliency in all areas at risk of flooding;
- Establishes flood districts and targets for flood risk reduction and long-term planning, based on logical hydrologic/topographic boundaries, including mechanisms for planning across state and municipal jurisdictional lines;
- Considers a more comprehensive approach to rezoning, based on the multiple challenges and opportunities facing the city;
- Better positions the City to prepare for and respond quickly to state and federal funding opportunities as they arise;
- Identifies opportunities to incorporate resiliency into “dig once” policies for maintenance and capital projects;
- Prioritizes low-income communities and communities of color, including siting of green infrastructure with an equitable planning process and investment strategy; and
- Develops clear, accessible, and equitable targets for risk reduction.

As climate change continues to intensify the magnitude and frequency of natural disasters, it has become clear that New York does not have the luxury of choosing whether or not to improve its resiliency - it is a requirement. Taking a proactive approach would get out in front of the problem before more lives and infrastructure are threatened. We will continue to work with the council and our partners in the Rise to Resilience Coalition for a more resilient future for our city.

Thank you for the opportunity to testify today.

NSWC
The North Shore Waterfront Conservancy of Staten Island, Inc.
54 Port Richmond Avenue
Staten Island, New York 10302

October 27, 2020

To: Justin Brannan, Chair and to Council members Ruben Diaz., Sr., Costa Constantinides, Eric A. Ulrich, Deborah Rose of the NYC Resiliency & Waterfronts Committee

Reference: 8 Year Anniversary of Hurricane Sandy and the City's Resilience

On behalf of the North Shore Waterfront Conservancy of Staten Island, Inc., we would like to thank you for the invitation to submit our testimony on where we are in the City's efforts to make our shorelines resilient to the effects of Climate Change's sea level rise, storm surges and flooding.

Over the course of the 8 years since Hurricane Sandy as well as the 9 years passed since Hurricane Irene, we have reviewed all of the City's documents mentioned in your Oversight: 8th Anniversary of Superstorm Sand and the 2020 Hurricane Season. As well as the various City websites and maps that talk about the City's resiliency efforts. And whereas they all mention that the North Shore of Staten Island waterfront is prone to flooding. And in one instance we were told by NYC Department of City Planning that their approach to dealing with flood waters were to elevate existing structures onto stilts and have the street level of the building have break out walls allowing the water to flow through the structure.

We determined that due to the North Shore consisting of communities and structures that are over 150 years old that the elevated stilt idea would not work for many of the buildings including homes and churches at the waterfront. In addition, the expense for property owners to attempt such a project would not be financially viable. And that most property owners would be hesitant to place themselves further in debt by taking out loans that would require them to have to pay off that debt along with their mortgage and other financial responsibilities, the same thing would apply for flood insurance costs. We ask that you keep in mind that these were the communities that were hit hard by predatory lenders. In terms of renters the above measures if possible, would cause their landlords to pass off additional financial burdens onto their tenants. The measures would literally price low income residents in our Environmental Justice communities out of their homes and Mom and Pop businesses. Thereby sanctioning in gentrification.

Most of the City's resiliency documents that we have reviewed are talking about resiliency for residents in the future. None of these documents speak to existing communities and how the City Plans to protect them now while they are experiencing flooding from extreme storm activities. Especially about Staten Island's North Shore with its lowline industrial waterfront that is adjacent to Environmental Justice communities from Rosebank to Graniteville. Many of these industrial properties still have contaminants on them that can migrate off the property and back to the Environmental Justice residential communities. It is perplexing how even with the information that the 8th Anniversary of Superstorm Sandy and the 2020 Hurricane Season talks about in terms of areas of the waterfront that will be permanently under water over the course of several decades. The City is still encouraging building high density housing on the waterfront in areas that are flooding now. Basically, implying that these flood prone areas are safe for people to live in during extreme storm activities. By the City allowing residential buildings in these areas it is the equivalent of giving the Gold Medal Stamp of Approval that residents have nothing to fear. That the City has done its research thoroughly vetted the situation and decided that these areas are safe.

There is flooding taking place in these areas during high tide and under regular storm activities. The City is talking about providing Affordable Housing to low income residents, but they are talking about building it in areas that already flood. To continue to build in areas that flood in this manner without providing protective measures to hold back flood waters - is irresponsible and dangerous.

The North Shore has an industrial waterfront that sits across the river from the State of New Jersey's industrial waterfront. In talking about high winds, during a hurricane there is extreme strong wind activity taking place which causes anything that is not securely strapped down to become a flying projectiles that can easily break through a double pane window or lodge itself in the walls of a building. https://edc.nyc/project/new-stapleton-waterfront
Who can forget the John B. Caddell Tanker that Hurricane Sandy pushed on Front Street like it was a baby carriage?
https://www.youtube.com/watch?v=l9lNdMkJo0k

Furthermore, the City is not acknowledging human nature which causes people to stay put even when told to evacuate.
https://www.vox.com/science-and-health/2017/8/25/16202296/hurricane-florence-2018-evacuation-psychology

There is no doubt that as the effects of Climate Change increase retreating from the waterfront will become necessary as private property owners and the City will not be able to afford to try and maintain flood proofing the waterfronts. Common sense should kick in and the City should be saying now that nothing should be at the waterfront that cannot withstand being underwater for various durations of time. Or to which the owners of these properties are not willing or able to repair, renovate and or replace as frequently as it becomes necessary.

Furthermore, the City still allows for building in unmapped freshwater wetlands that are under 12.4 acres that are privately owned. Many of these freshwater wetlands are adjacent to tidal wetlands and act as a secondary buffer in retaining flood waters. The City is following regulations established by NYS Department of Environmental Conservation for Freshwater Wetland Protection. The laws and regulations for Freshwater Wetland protection are over 40 years old and predate Hurricanes Irene and Sandy. They predate the discussions about Climate Change, based on today's storm activities these regulations/laws are obsolete. They make no

sense with the Climate Change activities that we are experiencing. At this point all wetlands are relevant and need to be looked at as being beneficial in protecting existing communities from flooding. And a moratorium preventing building on them needs to be applied to all freshwater wetlands that are privately owned and/or are under 12.4 acres until such time as their beneficial uses have been decided upon. The City of New York is surrounded by water every wetland counts.
https://www.dec.ny.gov/lands/4937.html
https://ny.curbed.com/2019/9/6/20851432/staten-island-graniteville-swamp-development-photo-essay

The City's viewpoint about these smaller wetlands run contradictory to their actual uses as these properties have been used by residents as Green Park Spaces for decades within Urban areas that lack Public Green Spaces. And because they have been used for decades by the residents, it has given residents the impression that these properties belong to the City of New York and are indeed Public Park properties for the communities' benefit and use. Public properties that are beneficial in helping to combat some of the effects of Climate Change such as torrential down pours that cause street flooding and forests that provide canopies that help to reduce the heat levels from nearby hard surfaces.

We have not seen anything from the City of New York for the North Shore of Staten Island in terms of fortification from Climate Change activities. Perhaps this is because the City cannot figure out how to fortify the North Shore Waterfront from sea level rise, storm surges and flooding and not impact the Maritime Businesses or whatever else is at the waterfront. Presenting the dilemma to the adjacent Environmental Justice communities that they be damned.

We recognize that walls and levees cannot be permanently built from East to West on North Shore as what is being done for the most Eastern and Southern Shores of Staten Island which are predominantly white and middle income. We recognize this! However, an emergency, temporary removable barriers can be placed along the North Shore waterfront that can deflect the storm surges and reduce the amount of flood waters coming in during a Hurricane or severe storm. With this, it is at least giving residents on the waterfront a fighting chance of getting upland to safety. https://www.floodpanel.com/

As far as the loss of electrical power due to downed power lines. Where it is feasible in communities all power lines need to be placed under ground. Con Edison has made a fortune from its' consumers, they can afford to do this without passing the cost onto its customers. They can write it off as the cost of doing business in New York City.

The City or Con Edison needs to invest in electric backup generators that can be brought out and placed in communities temporarily so that residents that have lost power during storms can remain in their homes. The City should see if HUD is willing to provide it with a grant for electrical backup generators.

In reference to evacuation shelters, during Sandy we inquired about evacuation shelters and as you stated most shelters are in schools. But perhaps you should be looking for other facilities that are inland to help provide temporary shelters in addition to the schools. Such as the National

Guard Armory on Manor Road. We do not know what the condition of the Armory is, but these times require looking at sites that can be used in multiple functions based on the needs of the communities.
http://readme.readmedia.com/New-York-National-Guard-Reoccupying-Manor-Road-Armory/2508474

If you will recall the U.S. Army Corp of Engineers opened their facility in Manhattan the old Jacob Javits Center into a hospital during the Covid -19 epidemic.
https://www.defense.gov/Explore/News/Article/Article/2133514/corps-of-engineers-converts-nycs-javits-center-into-hospital/

Another possible location for emergency temporary shelter is the Corporate Park
http://officespacestatenisland.com/

We must look at things differently, we cannot continue to keep doing the same old things that are not working because it is what was done in the past. Once again thank you for your time and consideration.

Sincerely,

Beryl A. Thurman

Beryl A. Thurman, Executive Director/President
NSWC
Creating Livable Communities
www.sinorthshoreresilience.org

Testimony of Summer Sandoval

Energy Democracy Coordinator

New York City Council Committee on Resiliency and Waterfronts

Oversight: 8th Anniversary of Superstorm Sandy and the 2020 Hurricane Season

October 27th, 2020

Thank you for the opportunity to submit testimony today on the 8th Anniversary of Superstorm Sandy. My name is Summer Sandoval and I am the Energy Democracy Coordinator at UPROSE. I am here today on behalf of UPROSE, to share the importance of supporting community-led comprehensive waterfront planning in the era of COVID-19 and climate change. Founded in 1966 and located in Sunset Park, UPROSE is an intergenerational and BIPOC community-based organization working at the intersection of racial justice and climate change.

Today, we are faced with multiple crises- all hitting communities of color and low-income communities the hardest. As we anticipate more "unprecedented" disasters, NYC must change its culture of practice when it comes to working with communities and building for climate mitigation, adaptation, and recovery.

A Just Transition rooted in equity requires us to rethink how we utilize and plan our waterfronts for the future. Economic recovery means that we cannot afford for climate adaptation and economic growth to be addressed in silos. Decisions on land use, zoning, policies, funding, and partnerships will determine how infrastructure can either support our communities or continue to perpetuate cross sector inequities in environmental justice communities.

Sunset Park is New York City's largest Significant Maritime and Industrial Area (SMIA), and we need the political will, investment, and support to use this waterfront to host thousands of climate jobs from NY's Climate leadership and Community Protection Act and NYC's Climate Mobilization Act.

In 2019, UPROSE partnered with the Collective for Community, Culture and Environment to develop a community-led proposal for Sunset Park, called the Green Resilient Industrial District (GRID). The GRID is a scalable and replicable framework to realize thousands of climate jobs, and address coastal resiliency in Sunset Park and the region by training local residents in renewable energy, energy efficiency, retrofit, construction, and sustainable manufacturing jobs.

The GRID is a model of a 21st Century green re-industrialization of an industrial waterfront that can be utilized for regional economic resilience and COVID-19 recovery. It is also an example of a frontline community-led solution to meet local and regional needs. We need the City to support not only goal setting, but creating real processes of how to achieve a Just Transition.

I would like to thank the New York City Council for holding this hearing and for the opportunity to testify. For more information, please visit the GRID report: http://bit.ly/GRIDReport

Sea Level Rise and Flooding Along the NYC Coastline

Testimony to NYC Council
Committee on Resiliency and Waterfronts
October 27, 2020

William Sweet
NOAA

NOAA Tidal-to-Storm Surge Flood Severity and Impacts

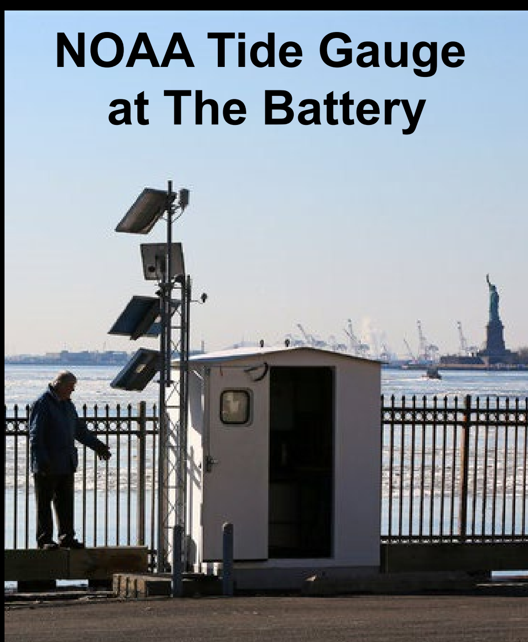
Coastal Flooding Thresholds

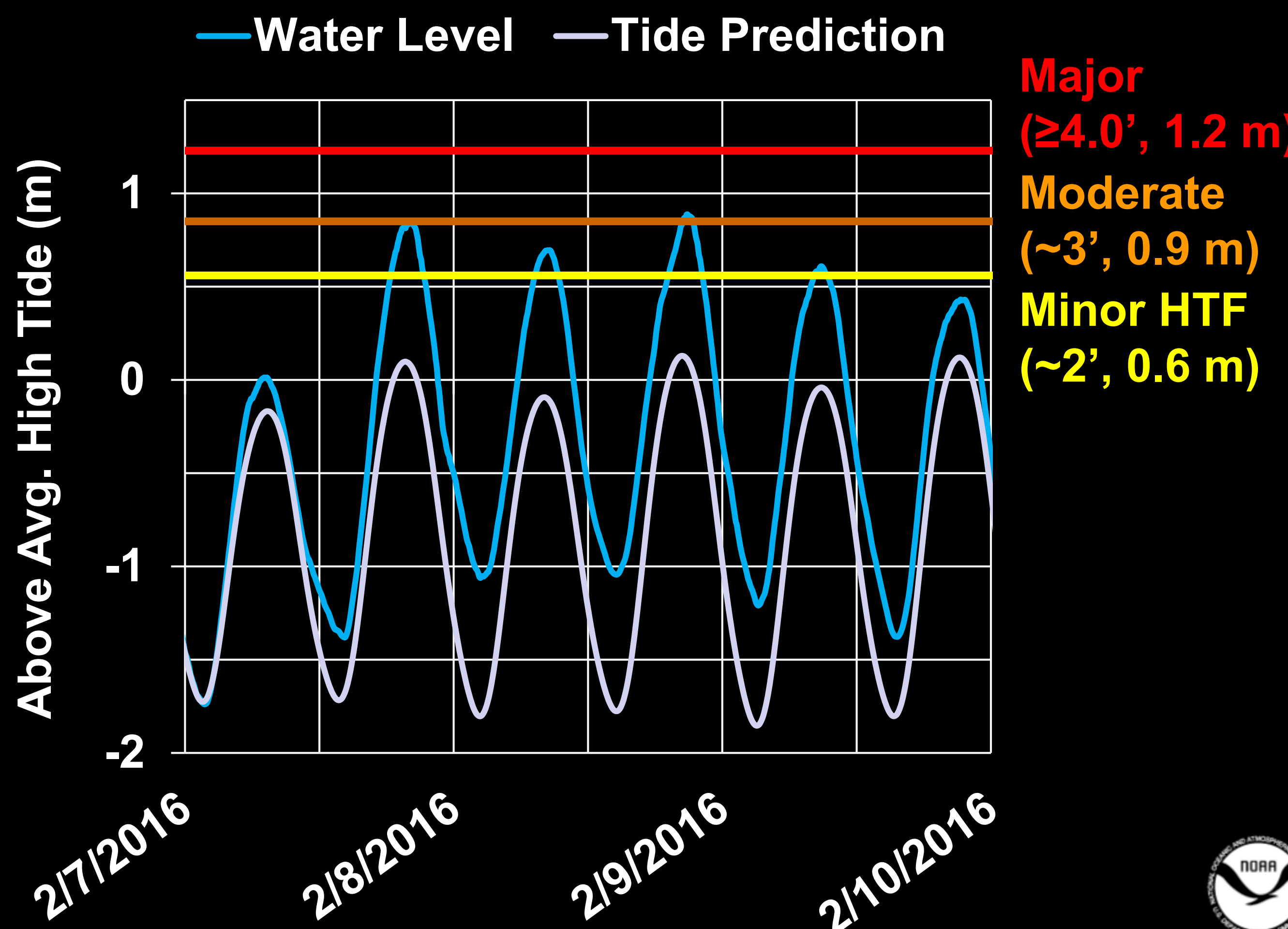
	Minor (CF Advisory)	Moderate (CF Warning)	Major (Warning)
Picture	**High Tide Flood (HTF)** 		
Hazard	• **Low threat of property damage**…and no direct threat to life. • **1 to 2 ft of inundation** in shoreline and vulnerable areas.	• **Elevated threat of property damage**…with a risk to life if one places themselves in unneccesary danger. • **2 to 3 ft of inundation** in shoreline and vulnerable areas. • Minor to no inundation of surrounding coastal communities.	• **Significant threat to life and property.** • **3-5+ ft of inundation** in shoreline and other vulnerable areas. • Minor to moderate inundation (1 to 3 ft) of surrounding coastal communities that rarely experience coastal flooding.
Impact	• A few shoreline and vulnerable roadways and adjacent properties will experience shallow flooding.	• Several shoreline and vulnerable area home and businesses will experience water inside. • Several low-lying coastal and shoreline roads will be closed. • A few cars may take on water or even be destroyed.	• Evacuations will be necessary for the most vulnerable shoreline and coastal areas. • Many coastal communities will experience damage…with some shoreline and flood prone homes and businesses being destroyed. • Many cars will likely be submerged or washed away. • Several sections of nearshore roads and escape routes will be impassable and a few could be washed out. • Flood waters may extend well inland in low lying areas.

New York Coastal Weather Forecast Office of NOAA National Weather Service

NOAA Tide Gauges and Coastal Flooding

Minor, moderate and major flooding occur occurs at about 2’, 3’ and 4’ above MHHW measured by NYC tide gauges.





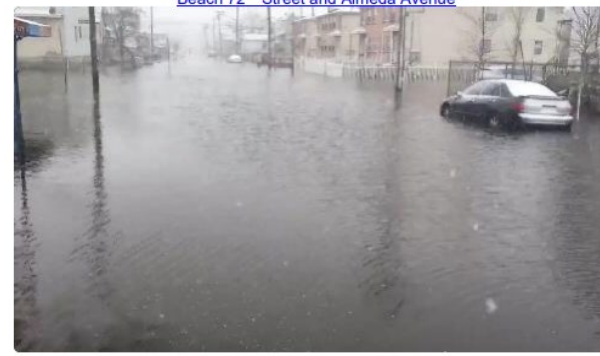
Flooding in Jamaica Bay Region Feb 8-9, 2016

2 to 3 Ft of inundation in the most vulnerable sections of Brookville/Rosedale, Arverne/Edgewater, Howard Beach, Old Howard Beach, Far Rockaway, Hamilton Beach Broad Channel. (Morning high tides of 2/8/2016)

In Brookville/Rosedale: Moderate flooding on Rockaway Blvd and Brookville Blvd
In Rosedale: Moderate Flooding on Hungry Harbor Road and Hook Creek Boulevard
In Bayswaters: Norton Drive from Westbourne Ave to Healy Ave.
In Far Rockaway: Flooding on Beach 26th and Seagirt Blvd
In Edgemere/Arverne:
  Minor Flooding on Beach 38th-60th and 67-72nd streets
  Moderate Flooding on Beach 58th Street and Rockaway Beach Boulevard
  Moderate Flooding on Beach 59th Street and Rockaway Beach Boulevard
In Broad Channel: Flooding on Crossbay Blvd and East 9th Street
In Howard Beach: Flooding on 102nd St and 160th Avenue

Arverne/Edgemere in Rockaways

Beach 72nd Street and Almeda Avenue



Broad Channel
Water 2 ft deep on sidewalk on 14th Road in Broad Channel

Beach 36th Street

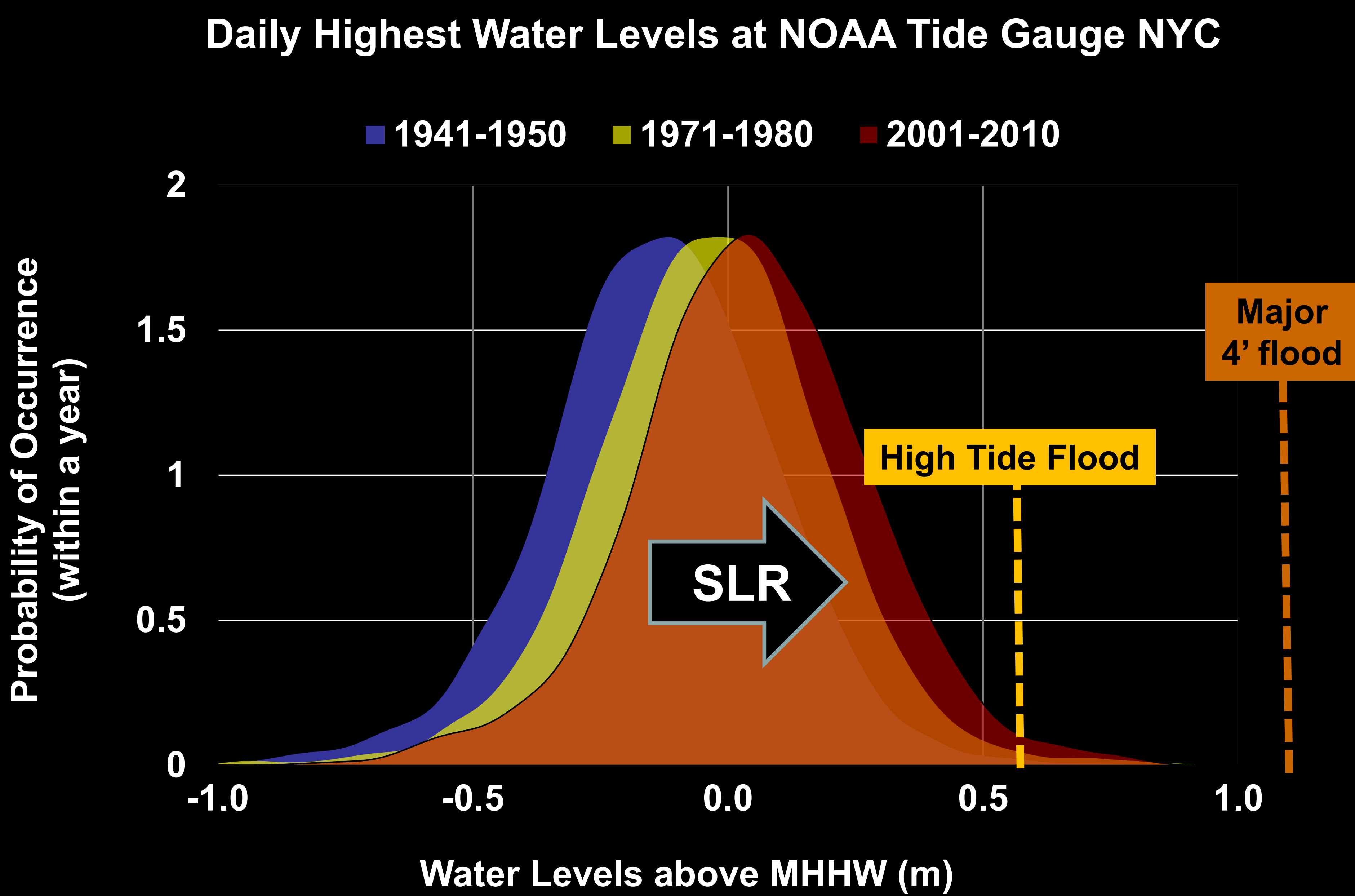
Old Howard Beach

Far Rockaway

https://www.weather.gov/media/okx/coastalflood/Jamaica

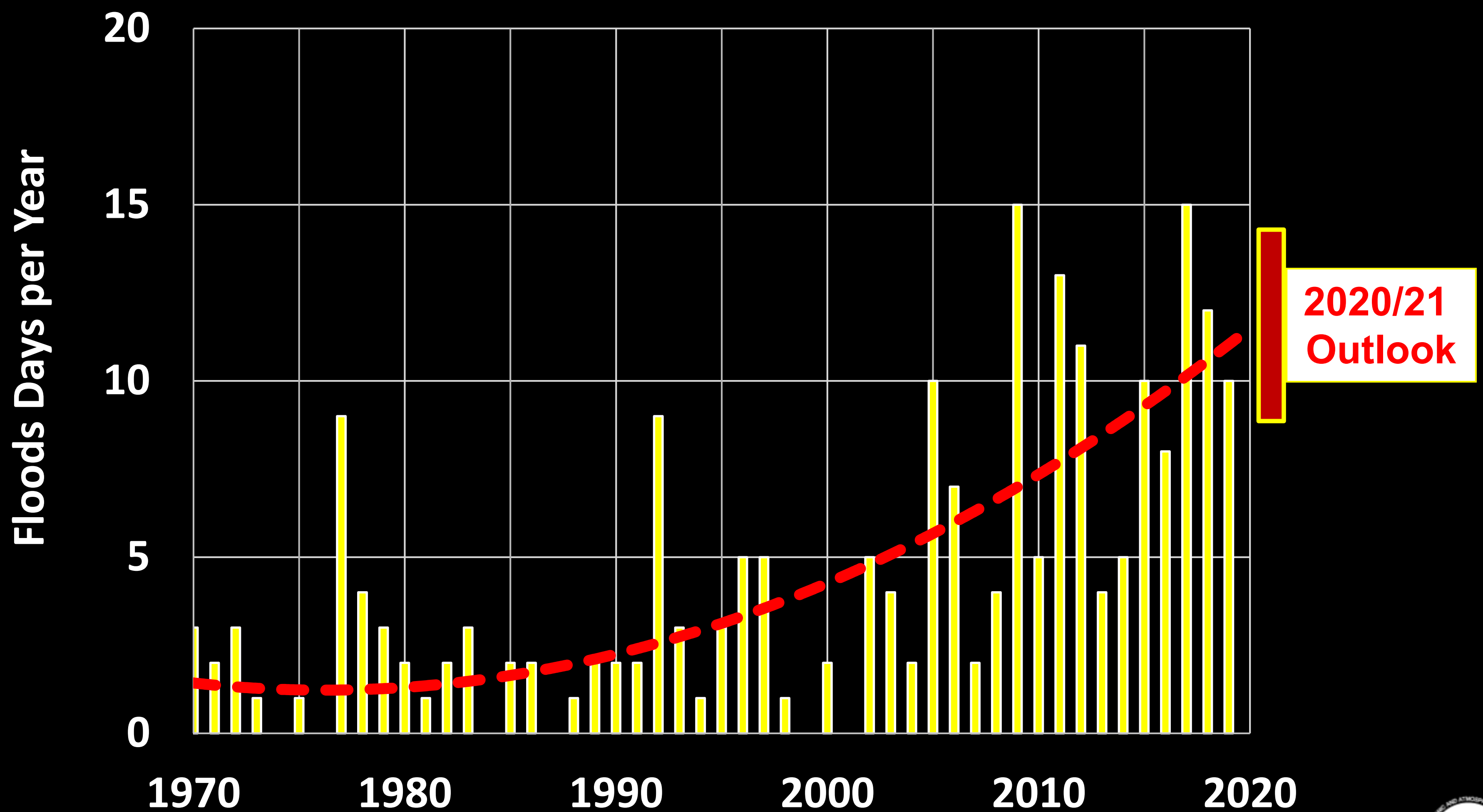
https://www.weather.gov/media/okx/coastalflood/Jamaica%20Bay%20at%20Inwood%20impacts.pdf

General Nature of the Problem: Shifting Geometry



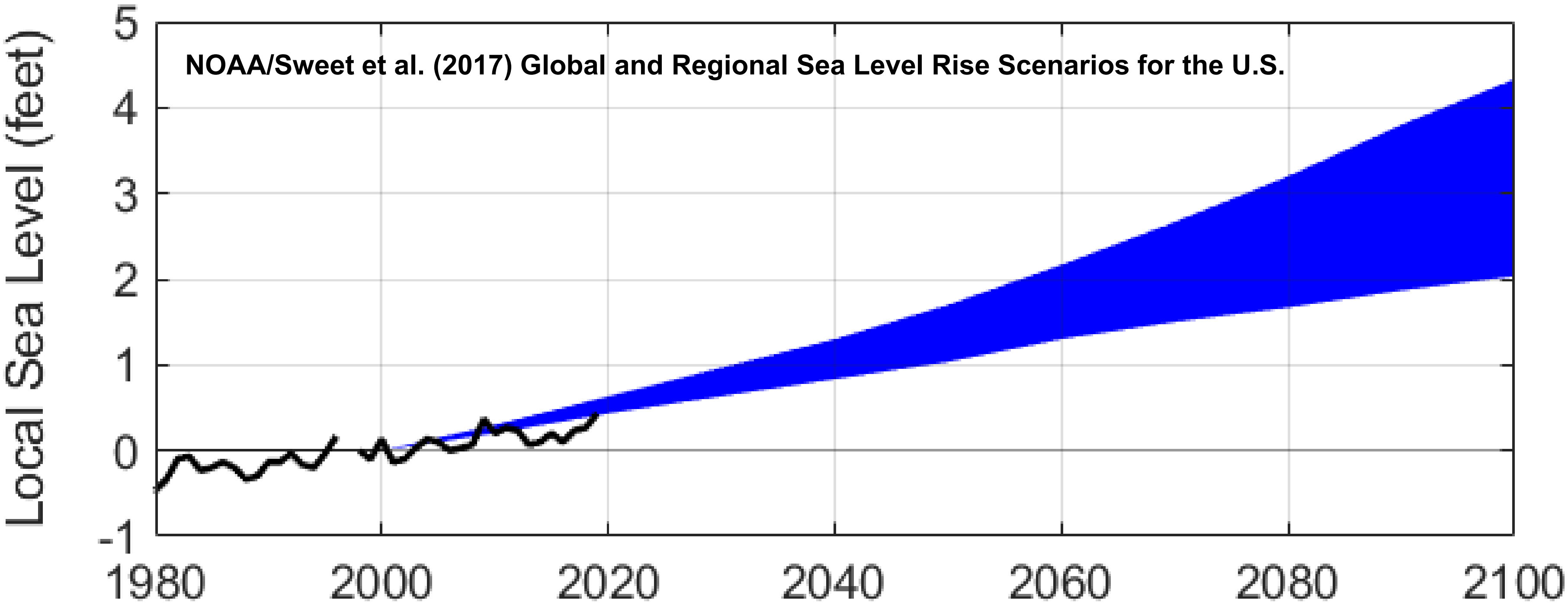
The Accelerating Nature of SLR-Tidal Flooding

Due to SLR, the number of days/year with high tide flooding is now accelerating on an annual basis.



NOAA/Sweet et al. (2020) 2019 State of U.S. High Tide Flooding with a 2020 Outlook

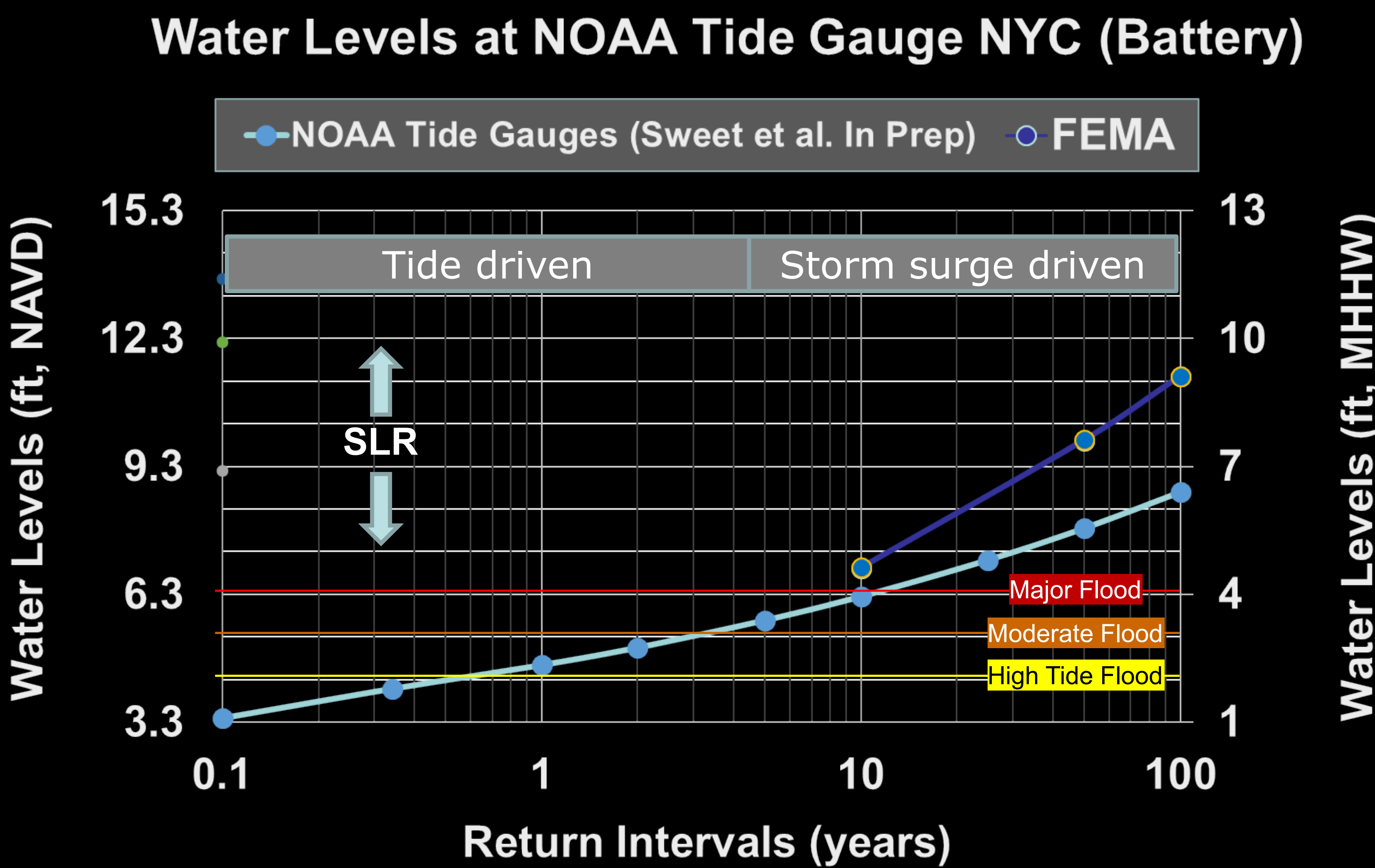
Projections of 'likely' SLR (blue shade) for NYC Region



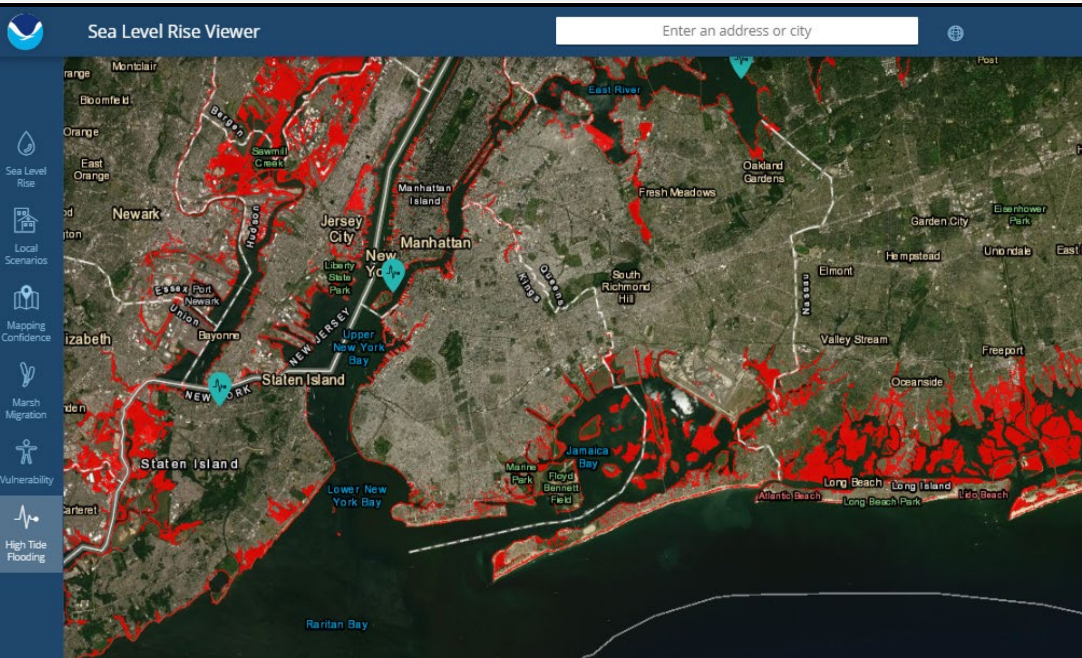
Projections of global rise that also incorporate regional changes due to:

1) land elevation
2) gravitation/rotational effects from melting land-based ice
3) circulation changes (e.g., the Gulf Stream)

Current and Future (?) Flood Risk

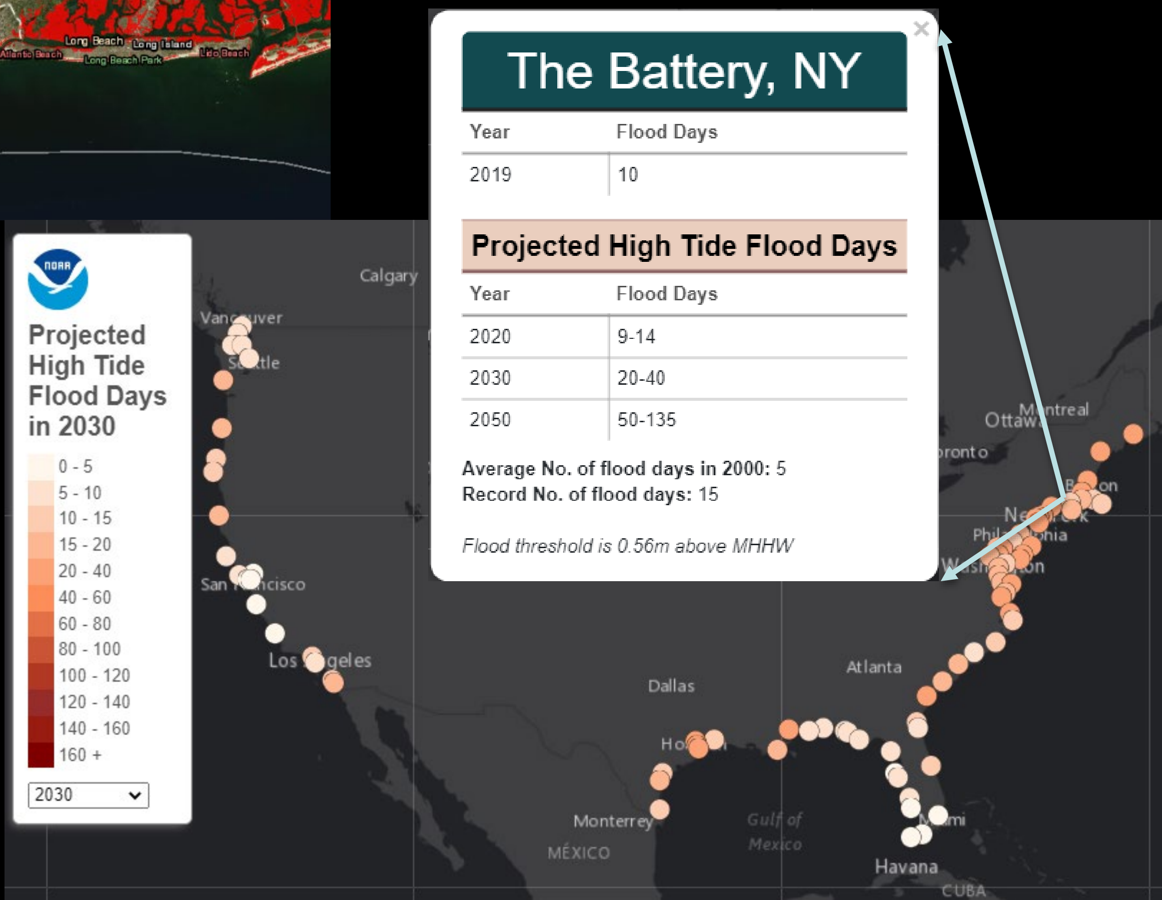


Some Useful NOAA Products and Tools



NOAA SLR Viewer and Flood Mapper
https://coast.noaa.gov/slr/

NOAA High Tide Flood Outlook Next Year, 2030 and 2050
https://tidesandcurrents.noaa.gov/HighTideFlooding_AnnualOutlook



The Breezy Point Cooperative is located on roughly 500 acres on the Rockaway Peninsula in New York City's borough of Queens. We are bordered on the south by the Atlantic Ocean, on the north by Jamaica Bay, and on both the east and west by Gateway National Park. Breezy Point/Roxbury started out as a simple summer tent community nearly 100 years ago. As time went on small bungalows began to replace the tents. In 1960, families came together to purchase the land and their homes and formed what is today known as the Breezy Point Cooperative. Breezy Point slowly evolved over the years with more and more families passing homes down from one generation to the next and many transitioning from summer bungalows to vibrant year-round family homes. What had begun as a simple summer tent community, now boasted 2,836 homes, several churches, and 40 commercial properties and a school.

The Cooperative and its homeowners, while NYC and NYS taxpayers, are a mostly self-sufficient community. We have our own Field Department which handles garbage and refuse collection, maintenance of the common property and water system and beach cleaning and protection. Our Public Safety Department is responsible for safety of the members of our community and our property and handles parking, beach safety operations and interfacing with the 100th precinct when necessary. The Administrative Department is made up of Shareholder and Employee Services, Engineering and Accounting and is tasked with the management of the overall operation.

We are a primarily middle-class community with a large population of civil servants including New York City firefighters, police officers, teachers, sanitation workers and nurses. The largest demographic is our senior citizens. Our year-round population is approximately 6,000 people with that number swelling to more than 11,000 during the summer months. We are a unique multi-generational community. What you may not know is we are a civic minded community who give to others and who support many causes. We annually conduct multiple blood drives, host Veteran's events, welcome the wounded warriors to our beaches, donate to many charities, and support our local philanthropic organizations.

On the evening of October 29, 2012 Superstorm Sandy made landfall in New York. With its unyielding winds and swelling tides, the storm left in its path catastrophic destruction. Eyes all over the world watched their television news broadcasts as the elements of water, fire and wind combined into a horrific picture of annihilation. A massive storm surge, reaching heights of 9 feet, propelled throughout our property from both the Atlantic Ocean and Jamaica Bay and submerged the entire community. Homes, churches, and commercial buildings were ravaged and ripped from their foundations. Windows smashed and walls collapsed. Fire swept through an entire area burning down 127 homes. The storm surge destroyed 221 homes and left more than 2,000 damaged. In all, over 85% of our homes sustained significant damage and every home felt some impact. Many of our people were forced to live elsewhere, many for a year or more. Miraculously, no one died. Our quiet little community became the face of the storm locally and around the world.

For months, the community was without running water, gas, electric and cellular service. Nearly every family returned once essential services were restored and the water system was cleared to operate. The task of rebuilding then began. This would entail a combination of private and public efforts.

Build It Back completed 5-1/2 years of rebuilding and restoring over 395 houses in 2019. 78 homes were complete rebuilds, 182 were elevated, 126 were rehabilitated and 4 were part of the acquisition program. Approximately 500 homes were rebuilt or elevated privately. The community's commercial facilities, school and churches were also rebuilt.

Beyond homes and businesses, the surrounding area lost natural and manufactured structures which had helped to mitigate storm damage in the past, leaving the community more vulnerable than ever to future storms. The Breezy Point Cooperative has worked tirelessly to rebuild the community with a critical focus on resiliency and mitigation. These efforts, like building dunes on the ocean and temporary measures on the bay fronts where feasible, have helped to make the area safer in the face of high tides, tropical storms, and nor'easters. However, severe erosion continues to take its toll. Sand that once filled the beaches slips even more easily out to sea. Homes on our bayfront stand just feet from the water and with each storm the water looms even closer. Due to these circumstances, the single road in and out of the community lies only 50 feet away from the water, creating a potentially tragic situation with each impending storm.

The Cooperative continues to do what it can to protect its land and residents of Breezy Point, Rockaway Point, and Roxbury, however, its resources are limited. In 2014, we were approached by NYC regarding a resiliency program which partnered NYC, NY State, and FEMA. The Breezy Point Coastal Resiliency Project proposed from the Hazard Mitigation Grant Program (HMGP) became the plan to mitigate issues and help ensure the community members, residents and business owners will be exponentially safer. Adaptable, risk reducing measures will make all the difference during future storm events while saving lives and further immeasurable costs.

We have been told the BPC Coastal Resiliency Project is a priority for the administration. But it has been a long 8 years. This project has gone through several starts and stops. We continue to encounter issues that have previously been resolved. And we are moving closer to failing to meet milestone deadlines that could put funding in jeopardy.

We urge the Mayor, all relevant NYC agencies, and City Council to do everything in their power to find ways to make this and other resiliency projects move forward expeditiously. This project, like many others, involve multi-level work with agencies, not only within the city but at the state and federal level. We have found that these groups often focus their efforts on achieving their individual goals and agency objectives rather than the goal of resiliency, safety, and project completion. We must change the mindset from using guidelines and policies to inhibit projects from moving forward to identifying ways to move them in a more expeditious manner.

We must look at waterfront protection projects not as infrastructure and development but as housing and property protection, storm mitigation and public safety.

We must utilize the funding for the projects that have been approved and identified and not look to reallocate or worse give back due to the inability to deliver the goals and objectives.

We must cease the "business as usual approach" that are bureaucratic and archaic and create systems and process that are nimble and meet the extraordinary response for the extraordinary situation.

Completing the project is a good business decision. But it is so much more. Government is charged with the responsibility of protecting the lives and wellbeing of its citizens. This is really about the safety of families, lives, and homes. And this project not only provides protection for the Breezy Point community, but the peninsula and the mainland.

On behalf of the Breezy Point community, we thank you for the opportunity to provide our written testimony to the committee and for your efforts to ensure waterfront communities, especially in the outer boroughs are safe and resilient for years to come. We are particularly poignant at this time of year as we reflect on where we were 8 years ago. Where we stand on October 29, 2020 is at nearly the same level of risk we had on October 29, 2012.

We must renew our efforts to focus on completing what we have started. We must do better!

Denise Lopresti
Assis*tant General Manager*
Breezy Point Cooperative, Inc.
202-30 Rockaway Point Blvd.
Rockaway Point, NY 11697
718.945.2300
dneibel@breezypointcoop.org