Neighborhood Coastal Flood Protection Project Planning Guidance

December 2021

Mayor's Office of Climate Resiliency

Neighborhood Coastal Flood Protection Project Planning Guidance (Version 1.0)

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New York City Department of City Planning, New York City Department of Design and Construction, New York City Department of Environmental Protection, New York City Department of Parks & Recreation, New York City Department of Transportation, New York City Economic Development Corporation, New York City Emergency Management, New York City Housing Authority, Mayor's Office of Environmental Coordination, New York City Office of the Deputy Mayor for Operations, New York City Mayor's Office of Management and Budget, and the Mayor's Office of Climate Resiliency.

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INTRODUCTION

As part of its overall resiliency efforts, the City of New York[1], led by the Mayor's Office of Climate Resiliency (MOCR), is building neighborhood coastal flood protection projects to reduce the impacts of coastal flooding from rising sea levels and more frequent and intense coastal storms due to climate change. MOCR wrote this report to provide guidance for the development of neighborhood coastal flood protection projects that are equitable, resilient, and well-designed.[2] These projects should be equitably planned in close partnership with residents, increase resiliency by reducing coastal flood risk, and strive to enhance the everyday experience and livability of a neighborhood's waterfront. This guidance is provided in this report is intended to support the City's coastal resiliency efforts.

Warming temperatures will continue to cause sea levels to rise and increase coastal flooding. Today, more than 400,000 New Yorkers live within coastal areas that have a one percent chance of flooding in any given year. The floodplain is expected to grow to cover almost one-fourth of NYC's land mass over the next thirty years and encompass more than 800,000 residents (ten percent of NYC's current population) due to climate change impacts from rising sea levels. New York City must adapt and become more resilient to these climate change impacts.

These large-scale projects can be an effective approach to addressing coastal flood risk when cautiously and deliberatively considered. However, it is important to acknowledge that these projects are

Figure 1: East Side Coastal Resiliency Rendering

1 "The City of New York" or "The City" refers to the city government of New York City.

2 New York City Mayor's Office of Climate Resiliency's defines a "neighborhood coastal protection project" as a large-scale capital project that provides a continuous alignment of defensive measures along the waterfront to reduce coastal flood risk for an entire or a significant portion of a neighborhood.

not appropriate for all locations; are not the only solution to coastal flooding; do not remove all current and future risk of coastal flooding; come with immense costs in terms of funding, time, and resources; and can have significant impacts on the built and natural environment. In short, neighborhood flood coastal protection projects are a powerful resiliency tool that must be carefully and appropriately applied.

It is important to acknowledge that these projects are just one resiliency strategy amongst many. A variety of capital projects, programs, and policies that address systemic inequality and create more resilient infrastructure, buildings, and communities are also needed to reduce vulnerability to climate hazards.[3] These projects also do not solve or address the main cause of climate change, the burning of fossil fuels into the Earth's atmosphere[4] and efforts to reduce emissions must also be undertaken. Resiliency measures such as these projects will continue to be needed to adapt our environment to the impacts of human-induced climate change.

Background

In the aftermath of Hurricane Sandy, the City of New York embarked on the design and construction of several large-scale neighborhood coastal flood protection projects to protect against coastal storm surge flooding.[5] At the time, there was no precedent of any city attempting to simultaneously build the number, scale, and complexity of neighborhood coastal flood protection projects in a centuries' old dense urban landscape.

The neighborhood coastal flood protection projects designed to date have varied in location, typology, and level of protection, reflecting the diversity of New York City's coastal neighborhoods. Each project is meticulously designed to the unique characteristics of each neighborhood to ensure they reduce coastal flood risk, maximize community benefits, and integrate and improve the public realm. This approach necessitated close coordination with federal, state, and city agency partners, and a robust engagement process with stakeholders and residents. As of the writing of this report, the City's coastal protection projects are at various stages of planning, design, and construction. *(For a full list of City projects and their status see Appendix 1: New York City Neighborhood Coastal Protection Projects).*

To develop this report, MOCR synthesized the collective knowledge of City agency partners that have played instrumental roles in developing these projects through a series of inter-agency meetings from the second half of 2020 through the first half of 2021.[6]

This report provides guidance for the initial concept planning, feasibility and design stages, which is when many critical decisions are made that will shape the final project and where the City has the most comprehensive experience and knowledge of project implementation. It is not meant to address other waterfront resiliency or planning topics, but rather be a standalone document to guide the development of a particular neighborhood-based coastal protection approach. Other reports and initiatives, however, are valuable resources as well, and can provide additional policies and guidance that are critical to waterfront planning and resiliency.

3 (City of New York Mayor's Office of Climate Resiliency)
4 (City of New York Mayor's Office of Climate and Sustainability)
5 Hurricane Sandy made landfall on October 29, 2012.
6 MOCR consulted with the following City of New York agencies for this report: New York City Department of City Planning (DCP), New York City Department of Design and Construction (DDC), New York City Department of Environmental Protection (DEP), New York City Department of Parks & Recreation (NYC Parks), New York City Department of Transportation (DOT), New York City Economic Development Corporation (NYCEDC), New York City Emergency Management (NYCEM), New York City Housing Authority (NYCHA), Mayor's Office of Environmental Coordination (MOEC), Mayor's Office of Management and Budget (OMB), Office of the Deputy Mayor for Operations (DMO).

(See References and Resources for a list of other relevant resiliency resources.)

A significant amount of time and funding is needed to implement a neighborhood coastal protection project. The planning, design, and construction of these projects can take up to ten years or more due to the many technical challenges, jurisdictional intersections, and robust community engagement that is required. These projects can also cost upwards of hundreds of millions of dollars.

This report provides guidance to maintain transparency and consistency across projects and is intended to be used by a wide variety of practitioners that will be involved in project planning and design. The City's portfolio of neighborhood coastal flood protection projects developed to date were initiated through a variety of city and federal agencies, and are managed by the City or the U.S. Army Corps of Engineers.[7] All agencies bring their own practices and policies to the work. This guidance is a critical step in creating consistency and standardization of managerial practices and analytical processes to ensure the resulting projects meet the City's resiliency goals and help set expectations for the numerous stakeholders involved in developing these projects.

To be transparent and more equitable, all practitioners – whether in City government or not – should have insight as to how projects are developed to engage in the process more effectively. Community engagement specialists, engineers, artists, budget analysts, residents, designers, project managers, policy makers, environmental justice advocates, construction managers and planners (among many others) all have important roles in developing a successful project.

MOCR considers this report to be a first version, and intends to develop additional future versions that go more in-depth into the topics covered in this report; add additional topics (some of which are reviewed in the *Conclusion*); and include guidance for additional phases of project development, namely neighborhood selection, advanced design, construction, and long-term operations and maintenance. The guidance provided in this report reviews many cross-cutting themes, specifically the *Guiding Principles*, which can be applied to all phases of coastal project development; to other resiliency projects; and to other jurisdictions.

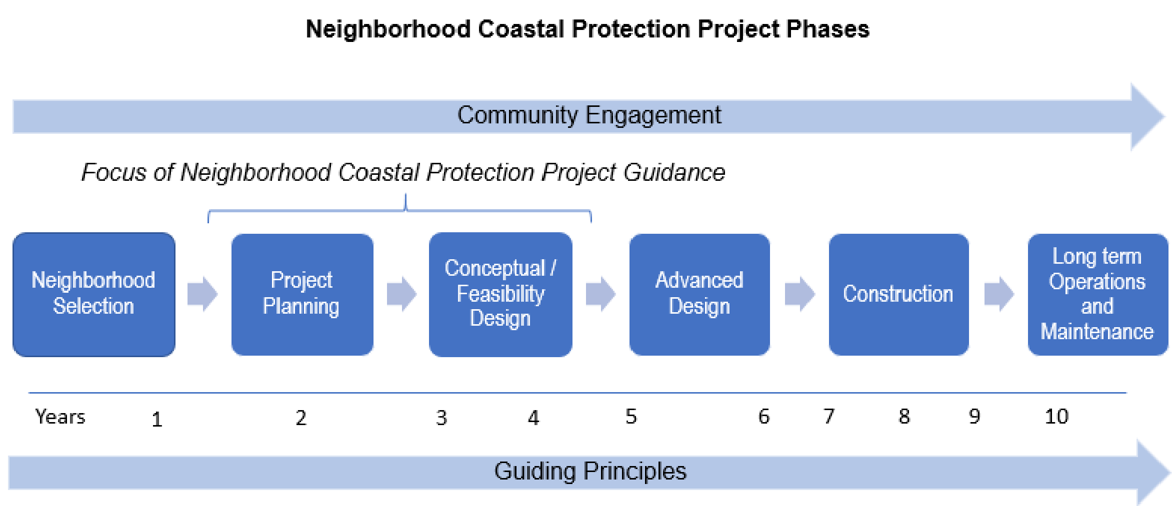

Figure 2: Neighborhood Coastal Protection Project Phases

7 The City of New York's portfolio of Coastal Protection Projects are typically funded by the U.S. Housing and Urban Development Community Block Grant Disaster Recovery Funding (https://www.hud.gov/program_offices/comm_planning/cdbg-dr), U.S. Federal Emergency Management Agency Hazard Mitigation Grant Program (https://www.fema.gov/grants/mitigation/hazard-mitigation), and the U.S. Army Corps of Engineers' Coastal Storm Risk Management Program (https://www.usace.army.mil/Missions/Civil-Works/) and supplemented by City capital funds; and typically managed by the City of New York or the U.S. Army Corps of Engineers (https://www.usace.army.mil/).

There are four sections to this report:

1. *Guiding Principles* provides a values framework to guide the community engagement and technical work throughout project development.
2. *Internal City Project Management and Planning* reviews the internal management structure and support needed to successfully plan and implement a project.
3. *Community Engagement* covers how to develop an equitable and transparent planning process that engages, communicates, shares decision-making power, and builds trust with stakeholders.
4. *Technical Analysis and Feasibility for Design* provides guidance for determining risk and identifying a feasible project that reduces coastal flood risk.

There are many decisions and considerations that are important for the development of neighborhood coastal flood protection projects that are outside the bounds and goals of this report. Specifically, this report will not address:

- Neighborhood Selection - The guidance provided does not identify which neighborhoods could benefit from coastal protection projects. This report assumes that a neighborhood has already been identified for a project through a separate process, informed by an equitable citywide risk and vulnerability analysis.
- Funding – This report assumes that funding has been secured.
- Governance – Guidance on the specific Mayoral Offices and City Agencies that should have oversight and what roles each should play is not provided.
- Advanced Design and Construction – This report does not provide guidance for advanced design or construction. The guidance provided is for early planning, feasibility, and design phases.
- Other Adaptation Strategies – This report only focuses on the planning and design of neighborhood coastal flood protection projects for coastal flooding, not other adaptive flood risk reduction strategies such as building flood-proofing or the elevating of buildings or infrastructure.

SECTION 1. GUIDING PRINCIPLES

SECTION 1: GOALS AND GUIDING PRINCIPLES

The *Guiding Principles* establish a vision for New York City's neighborhood coastal flood protection projects to be equitable, resilient, and well-designed. Projects reflect the great diversity of New York City's waterfront and are tailored to the unique characteristics of each neighborhood. They will vary greatly, so it is necessary to establish a clear values framework that guides all projects from the earliest stages of planning and design. The *Guiding Principles* are informed by the many technical challenges that have arisen in developing a feasible project and emphasize the need to address New York City's history of and inequity that has resulted in many New Yorkers being more vulnerable to coastal flooding.

There are sixteen Guiding Principles that fall under three overarching goals:

I. *Equitably Address Local Neighborhood Needs* by acknowledging existing inequities that make communities more vulnerable to the impacts of climate change, recognizing the need to include community voices into adaptation decision making and planning, and by prioritizing coastal protection resources for vulnerable populations and critical infrastructure.

II. *Increase Resiliency* with neighborhood-scale, community-centered coastal protection projects that protect neighborhoods from coastal flooding.

III. *Apply Good Design Standards* that preserve existing neighborhood character and improve the public realm, while integrating projects into the surrounding neighborhood.

These Guiding Principles are intended to provide a framework for decision-making as the project encounters and navigates constraints, conflicts, and trade-offs to achieve a feasible project.

GOAL I - Equitably Address Local Neighborhood Needs

New York City cannot become more resilient without becoming more equitable. The New York City Panel on Climate Change's (NPCC) 2019 report states, "There is a widespread awareness that the uneven distribution of climate change impacts combined with preexisting social and economic challenges makes some communities more vulnerable than others."[8] Social, economic and health inequities, especially those faced by Black, Indigenous, and People of Color (BIPOC) and low-income or under-resourced communities, makes them more vulnerable to the impacts of climate change. It is critical for project planners in City government to acknowledge historical and existing racial and socioeconomic inequities that have made BIPOC and under-resourced communities in New York City more vulnerable and more exposed to the impacts of climate change.

Disasters like Hurricanes Katrina, Sandy, Maria, and Ida, and the COVID-19 pandemic have repeatedly shown that it is BIPOC and under-resourced communities who are made most vulnerable and have greater exposure to climate change due to existing inequities.[9] The COVID-19 pandemic has prompted governments around the world, including New York City, to examine why and how such inequality persists, leading the City of New York Board of Health to declare that, "racism is a public crisis."[10] City agencies are developing new policies to reduce inequities, and these efforts have informed our thinking when it comes to achieving equitable outcomes in neighborhood coastal protection projects.

Guiding Principle 1: Center Equity throughout the Project

An equity framework should guide every phase of all neighborhood coastal flood protection projects to prioritize those approaches that address the disproportionate impacts of climate change. A coastal

8 (New York City Panel on Climate Change 2019 Report Chapter 6: Community-Based Assessments of Adaptation and Equity, 2019)

9 (New York City Panel on Climate Change 2019 Report Chapter 6: Community-Based Assessments of Adaptation and Equity, 2019)

10 (New York City Panel on Climate Change 2019 Report Chapter 6: Community-Based Assessments of Adaptation and Equity, 2019)

protection project guided by an equity framework acknowledges the disproportionate climate and environmental hazards faced by communities already made vulnerable by existing social, economic, and health inequalities, who are often excluded from adaptation planning and denied the benefits from adaptation resources.

The NPCC cites the "Three Dimensions of Equity in Adaptation" (McDermott, Mahanty, & Schreckenberg, 2013) to serve as a framework for equity informed adaptation planning:[11] The following guidance is not comprehensive, but provides a basic framework to work towards greater climate justice and more equitable outcomes.

1. *Distributive Equity*: emphasizes disparities across social groups, neighborhoods, and communities in vulnerability, adaptive capacity, and the outcomes of adaptation actions."[12] A distributive equitable climate adaptation process will distribute resources and benefits based on need, or to the most vulnerable at risk populations by assessing risks to coastal flood hazards.
2. *Contextual Equity*: emphasizes social, economic, and political processes that have denied power and access to resources that contribute to uneven vulnerability and shape adaptive capacity. The guidance provided in this report emphasizes the need to learn about different the neighborhood, including its assets, culture, and history, and populations so there is a thorough understanding of what historical and existing conditions have made the neighborhood vulnerable to coastal flooding.
3. *Procedural Equity*: Emphasizes the public and community participation in adaptation planning and decision making, specifically of those groups that are made most vulnerable to climate impacts and that have been excluded from the public planning, priority-setting and decision-making. The guidance provided in this report, and specifically in *Section 3: Public Engagement*, emphasizes the need to respect, include, and elevate historically excluded voices.

Guiding Principle 2: Conduct Neighborhood-based Planning and Analysis

New York City has 520 miles of coastline. The coastline encompasses open natural space and recreational parks, historic districts, industrial waterfront, diverse residential areas, and varying geographic conditions. The strategies to protect New York City's waterfront neighborhoods are as diverse as the neighborhoods themselves. Neighborhood coastal flood protection projects should reflect the rich variety of New York City's coastal neighborhoods and be tailored to the unique local characteristics of each project site. There is no archetypical project that should be applied across neighborhoods. Projects require a robust engagement process that facilitates a reciprocal learning process between residents and the City, and a thorough and careful review and assessment of historic and current local existing conditions and risks.

Guiding Principle 3: Consult, Engage, Communicate, and Partner with the Public

Engaging, partnering, and sharing power and decision-making with local communities is critical to good planning and creating an equitable outcome. The engagement process is an opportunity to educate the public about climate risks and adaptation methods, while also learning from residents about the conditions in the neighborhood and their daily experiences with climate change. City government can play a unique role in partnering with residents to understand their vulnerabilities and strengths on climate issues and the vision they have for their neighborhoods. It is also critical to evaluate difficult trade-offs and understand the need to balance limited resources.

Guiding Principle 4: Maximize Community Benefits

A project should aim to provide additional community benefits beyond reducing coastal flood risk. Projects should not become barriers that block residents off from the waterfront, but rather should strive to enhance the public realm by creating a well-designed and universally accessible waterfront, and to maintain and invest in working/industrial, recreational, and commercial waterfronts. In addition, projects should also aim to achieve other City policy priorities to create

11 (New York City Panel on Climate Change 2019 Report Chapter 6: Community-Based Assessments of Adaptation and Equity, 2019)
12 (New York City Panel on Climate Change 2019 Report Chapter 6: Community-Based Assessments of Adaptation and Equity, 2019)

Figure 3: Brooklyn Bridge to Montgomery Coastal Resiliency Rendering

an equitable, more resilient, and healthier waterfront given existing constraints, regulations and budgets.[13]

GOAL II - Increase Resiliency

It is critical that neighborhood coastal flood protection projects increase resiliency to coastal flood hazards by reducing coastal flood risk. Increasing resiliency is the primary purpose and therefore must be central to planning and design process, while creatively working to incorporate or address other priorities. All projects will encounter competing goals, regulations, and technical challenges, but increasing resiliency must be a central focus.

Guiding Principle 5: Apply the Latest Climate Science

Projects must be informed by the latest climate science. New York City is fortunate to have the NPCC, a 20-member independent advisory body of climate experts appointed by the Mayor that synthesizes scientific information on climate change and advises City policymakers on local resiliency and adaptation strategies.[14] Neighborhood coastal flood protection projects must incorporate the most up to date and available climate projections into the planning and design given their long lifespans and critical life/safety functions. This data should then be applied at the neighborhood-scale, to get the most accurate understanding of current and future vulnerabilities to flood risks.

Guiding Principle 6: Reduce Coastal Flood Risk

Reducing flood risk must be a central feature and goal of these projects. Neighborhood risks to flood hazards should be determined by a rigorous risk analysis. Analysis must also determine that a neighborhood coastal flood protection project is the best approach for reducing coastal flood risks as other methods can potentially be more effective, such as providing asset level flood proofing to protect critical infrastructure. Flood risk includes coastal flooding from tidal flooding, in addition to coastal storm surge from hurricanes and nor'easters.

Guiding Principle 7: Mitigate Drainage Impacts

Analyzing drainage impacts to mitigate interior flooding from the project is a critical part of a neighborhood coastal flood protection project. The goal is to manage

13 (City of New York Department of City Planning New York City Comprehensive Waterfront Plan, 2021)
14 (New York City Panel on Climate Change)

interior drainage impacts using standardized models that measure coastal storm surge, rainfall, and sewer system capacity. All coastal flood protection projects have the potential to exacerbate flooding by trapping precipitation and overtopped coastal waters behind the protection system. Analysis is required to provide a comprehensive view of the hydrological impacts of the project and determine necessary mitigation measures.

Guiding Principle 8: Ensure Flood Hazards and Other Environmental Burdens Are Not Shifted to Other Neighborhoods

Coastal flood protection for one neighborhood should not result in increased flood impacts, burdens, and unintended consequences in other neighborhoods. Typically, New York City's projects are not large enough to shift coastal flood waters to another geographic location, but this is still an impact that must be thoroughly analyzed and understood as part of the planning and design process. Additionally, projects should be analyzed for any impacts to the drainage system in adjacent neighborhoods located in the same sewershed. Both issues are of concern to residents located in and adjacent to these projects, so thought should be given to communicating, educating, and engaging with the public about this topic.

Guiding Principle 9: Maximize Resiliency Benefits

Given the level of investment needed, and the multiple other environmental and resiliency challenges facing New York City's flood vulnerable neighborhoods, additional resilience benefits should be maximized whenever feasible. For example, this could be done constructing enhanced drainage infrastructure that also improves water quality or by incorporating more sustainable and resilient landscaping that cools ambient temperatures to reduce the Urban Heat Island effect.

Guiding Principle 10: Maximize Environmental Benefits

Many communities that are most impacted by climate hazards are also environmental justice communities that experience a greater burden of negative environmental impacts. The project should aim to maximized additional environmental benefits and minimize any negative environmental impacts from the project, particularly those identified in the "New York City Environmental Justice for All Report."[15]

Guiding Principle 11: Design a Closed System that Functions Independently

Implementing a project that operates as a closed system and functions entirely on its own without reliance on future projects (also referred to as "independent utility") should be an explicit goal of any neighborhood coastal flood protection project. Given the physical length and expanse of these projects and large amount of funding needed, funding, designing, and implementing the project in sections may appear to be a more manageable approach. However, the overall resiliency benefits of the project can be jeopardized if future additions are never realized - a very real possibility given the complexity and timelines of these projects.

Guiding Principle 12: Align with Broader City Policy and Project Goals

Aligning projects with other stated City and agency goals through all phases of the project can maximize project outcomes and benefits, add momentum, reduce overall costs, save time, and potentially access additional funding. Aligning with other programs or projects can often be difficult because of differences in implementation timelines and funding sources, and potentially increase in regulatory reviews. However, the benefits of finding alignment can outweigh the initial challenges. This approach can also help projects achieve layers of resiliency in a neighborhood.

GOAL III: Apply Good Design Standards

The design processes for neighborhood coastal flood protection projects are complex, time consuming, and costly. Multiple agencies, jurisdictions, and external stakeholders can all have significant roles. There are also many feasibility aspects of a project that need to be meticulously analyzed during design. Keeping broader goals, principles, and standards in sight and centered while the project is in design will help the project stay focused and moving forward.

Guiding Principle 13: Improve Neighborhood Quality of Life and Urban Design

The design process should be guided by DCP's "Urban Design Principles."[16] Neighborhood coastal flood protection projects are large-scale infrastructure

15 (New York City's Environmental Justice For All Report Scope of Work, 2021)
16 (Urban Design Principles, n.d.)

investments that have the potential to completely transform a waterfront neighborhood. Given the significant investment and the impact these projects can have on a neighborhood's waterfront, there should be a focus on addressing broader local needs, making the waterfront more accessible, and improving general quality of life beyond flood protection, where possible. Identifying additional needs should be done in consultation with residents to improve or add community amenities and can build on or incorporate other existing planning and urban design initiatives.

Guiding Principle 14: Prioritize Natural and Nature-Based Features Where Feasible

Neighborhood coastal flood protection projects should enhance or create nature-based features that have added ecological, health, and resiliency benefits, where feasible and appropriate. Waterfronts with nature-based infrastructure enhance New York City's ecological habitat, provide environmental and recreational benefits, and can potentially provide critical green infrastructure for coastal flood protection by attenuating wave action. While the addition of nature-based features may not be practical everywhere, for areas that already have or are comprised of nature-based infrastructure such as beachfronts and wetlands, every attempt should be made to preserve and expand these features.

Guiding Principle 15: Maximize Passive Infrastructure Features and Components

The City prioritizes projects that maximize the use of passive features and components for coastal flood protection components that are fixed in place and do not require human intervention or moveable components to provide flood protection. While achieving a design that maximizes passive features can often be challenging, identifying a range of possible flood protection elements, alignments, and design flood elevations to ultimately

Figure 4: Buried Seawall Rendering on Midland Beach, Staten Island

achieve maximum passivity should be prioritized. A passive system can: decrease the risk of operational failure; minimize strains on operational resources during the City's coastal storm activation procedures; and address the more frequent coastal flood threats from tidal flooding and less intense storms, as it is impractical to deploy moveable features for these more frequent and smaller coastal flood hazards.

Guiding Principle 16: Minimize Operations and Maintenance Needs

Neighborhood coastal protection flood infrastructure is only effective if it can be adequately maintained throughout the lifespan of the system and reliably operated during a coastal flood event. Given the many new technologies and systems that are proposed in the development of these projects, understanding and minimizing operations and maintenance (O&M) needs during design must be a primary focus. Infrastructure elements must be thoroughly analyzed and evaluated for a full understanding of lifecycle costs, maintenance, and testing requirements, and activation.

SECTION 2. INTERNAL MANAGEMENT

SECTION 2: INTERNAL MANAGEMENT

The implementation of neighborhood coastal flood protection projects is inherently complex because they are an entirely new asset class for the City that require holistic, multi-agency engagement and coordination, as well as new approaches to project management. Their physical size and proximity to the coast often means they will overlap with multiple agency assets and jurisdictions. This cross-jurisdictional nature also means that the eventual agency (or collection of agencies) that will permanently operate and maintain the system is not always apparent at the start of the planning and conceptual design process.

Ensuring the establishment of a strong project management structure early on is critical to advancing the project from conception through design, construction, and onto long-term operations and maintenance. Like other complex infrastructure projects, coastal protection projects take a significant amount of time to complete. A ten-year timeline from initial concept planning through the end of construction is not unusual for projects of this scale and should be planned for. This section will provide guidance for the earliest stages of planning and conceptual design: defining project objectives, establishing a management structure, grant/budget management, procurement, and planning for long-term operations and maintenance.

A. Define Project Objectives

At the earliest stages of project development, project leadership must begin to identify the scope of the project and what level of coastal flood hazard the project should aim to protect against (given available information) to ensure all agencies and partners involved are working towards a common objective. Identifying a common objective will be necessary as feasibility challenges arise during design, necessitating the need to adjust the project. If funding is from a non-City source such as a federal agency, there may be specific requirements for the scope of the project in addition to any City identified objectives.

While the objectives or scope of the project may evolve over time as new information is learned and constraints identified, the initially identified objective should provide a preliminary framework for decision-making. Objectives should be developed and reviewed with internal and external stakeholders and updated through all phases of the project to ensure the project is meeting the overall project goals. To ensure everyone involved has the same understanding, the common objective should be clearly communicated to internal and external stakeholders continuously throughout project development. Tradeoffs between objectives or unforeseen changes to the common objective should also be shared with internal and external stakeholders as well.

B. Establish a Management Structure

A project management structure and definition of agency responsibilities should be developed at the earliest stages of the project planning process (preferably before the development of the first request for proposals or RFP) to manage community engagement, design, construction, and long-term operations and maintenance. It is important that impacted agencies are a part of this early planning process to weigh in on decisions and provide information on project goals, scope, and budget. Agency responsibilities may evolve as the project is developed.

The number of agencies involved in the implementation of a neighborhood coastal flood protection project makes decision-making more complex compared to a more traditional City capital project housed in a single agency. Because of this, a clear structure is necessary for decision-making for these complex projects that cross agency jurisdictions. A Memorandum of Understanding (MOU) or similar type of document should be developed at the start of each development stage of a project (e.g., feasibility, design, construction) to clearly define roles, set expectations, and define the decision-making structure for impacted agencies. The MOU should address agency roles and responsibilities – including identifying lead decision-makers, the agency leads for the environmental review, agency responsibilities for operations and maintenance, and project procurement and management – and the decision-making structure.

The appropriate agency for project management of design and construction should be identified as early in the process as possible. Ideally, the same agency should manage both design and construction. When it is not possible to have the same agency responsible for all phases of project development, the managing agency for each phase should be determined at the outset so a structure can be created for seamless integration and information sharing and transfer.

I. General Agency Roles and Responsibilities:[17]

- Mayor's Office of Climate Resiliency (MOCR) - Provides resilience policy, overall project planning and coordination, and public engagement guidance.
- Mayor's Office of Environmental Coordination (MOEC) – Assists City agencies in carrying out their environmental review responsibilities. At times, manages environmental review of multi-agency capital projects.
- Office of the Deputy Mayor(s) – Provides overall policy guidance and coordination of agencies.
- Office of Management and Budget (OMB) - Manages grant compliance and offer guidance on and approval of budget and finance needs.
- Department of City Planning (DCP) – Provides ULURP, community engagement, inter-governmental affairs, and general planning and policy guidance.
- Department of Buildings (DOB) – Is the official Floodplain Administrator for the City of New York and must approve and sign-off on all applications to FEMA for levee accreditation. Also enforces the City's Building Code, including Appendix G for flood resilient design and construction.
- Department of Design and Construction (DDC) - Procures for and manages the design, and construction phases for cross-jurisdictional projects.
- Department of Environmental Protection (DEP) – Directs interior drainage infrastructure design and construction. Manages the operations and maintenance of the interior drainage infrastructure.
- Department of Parks & Recreation (NYC Parks) – Directs design and construction of infrastructure on property under NYC Parks' jurisdiction. Manages the operations and maintenance of infrastructure on parkland, with some exceptions.
- Department of Transportation (DOT) – Directs design and construction of infrastructure on DOT right-of-way. Manages the operations and maintenance of floodwalls and floodgates for many City-owned systems on DOT right-of-way.
- New York City Economic Development Corporation (NYCEDC) – Directs infrastructure design and construction on NYCEDC assets – many of which are on the waterfront. Manages the operations and maintenance of infrastructure on NYCEDC owned or managed properties, with some exceptions. Procures for and manages study, design, and construction phases for cross-jurisdictional projects.
- New York City Emergency Management (NYCEM) – Provides technical assistance for FEMA Hazard Mitigation funded projects. Provides emergency planning policy and planning guidance.
- New York City Housing Authority (NYCHA) - Directs infrastructure design and construction on NYCHA property. Manages the operations and maintenance of infrastructure on NYCHA property, with some exceptions.

C. Grant Management

Strong grant management by the agency responsible for the project management is critical for projects that are funded by federal sources as they often have complex grant reporting requirements. Coastal protection projects are typically funded by the Federal Emergency Management Agency (FEMA), U.S. Department of Housing and Urban Development (HUD), the United States Army Corps of Engineers (USACE), and supplemented with City capital dollars.[18] Each federal government funder has different reporting requirements. OMB provides overall grant management expertise and assistance. For FEMA funded grants, NYCEM provides technical assistance and an additional layer of expertise in FEMA reporting requirements.[19]

17 *Note* - These are general agency responsibilities. Every project team should be developed to respond to the needs of each specific coastal protection project.
18 U.S. Department of Housing and Urban Development (HUD) funding typically come through their Community Development Block Grant funding for Disaster Recovery (CDBG-DR). US Federal Emergency Management Agency (FEMA) funding typically comes from the Hazard Mitigation Grant Program (HMGP).
19 NYCEM provides coordination for FEMA HMA grants.

The project management agency has the responsibility of meeting requirements and deadlines of grants with assistance and support from OMB (and NYCEM for FEMA funded projects). The project managing agency needs expertise in grant management to ensure the project is meeting all grant requirements. This requires open communication with OMB (and NYCEM for FEMA funded projects) and the City project team, and management of tasks and deadlines with the consultant team and City project team. The project managing agency should ensure the selected consultant team has experience delivering successful projects with the grant funding the project.

D. Procurement Management

Since projects will be managed by different combinations of City agencies it is important for there to be consistency across projects in the procurement language (including performance specifications) to ensure a coordinated citywide approach. Language from the *Guiding Principles* and *Technical and Feasibility Analysis for Design* sections of this report can be used to draft the requests for proposals (RFPs) for planning and design consultants. Strong and clear language that reflects the City's goals of having a project that is equitable, resilient, and well-designed should be included in the RFP. In addition, the procurement manager will need to coordinate agency input and review for writing the RFP and reviewing proposals. Every effort should be made to contract with organizations with connections to the study area, and organizations within the Mayor's Office of Minority and Women-owned Business Enterprises (MWBE) program.[20]

<u>I. Consultant Team Experience</u>

Identifying the right consultant team can be challenging. These projects require a highly skilled and coordinated multi-disciplinary team that can communicate effectively and work closely with multiple City agencies and local stakeholders. The consultant team should be expected to embrace and imbue the project with the *Guiding Principles* provided in this guidance.

The team should possess the following skills and experience: community engagement and communications; benefit cost analysis; environmental review (in particular, demonstrated experience with CEQR and SEQRA reviews in addition to NEPA); hydrologic and hydraulic modeling; hydrodynamic coastal modeling; floodplain management; coastal/structural/civil engineering and design; urban planning and design; landscape architecture; cost estimating; transportation analyses; use of climate change data to inform design; historic preservation; experience with relevant grant reporting, requirements and compliance (FEMA, HUD); personnel resource management; and any other discipline needed for the specific study area (including FEMA accreditation requirements, if applicable).

The consultant team should have a sustainability management policy in place. This policy should define the project team's commitment to sustainable performance and commit the project team to meeting or exceeding all health and safety standards and improving environmental, social, and ethical performance.

Experience with and preparing for public review process such as the City's Uniform Land Use Review Procedure (ULURP) and the Public Design Commission (PDC) is also recommended. Experience with conducting a benefit cost analysis (BCA) particularly, for outside federal funding source such as HUD, FEMA, or USACE, is also recommended as it can be a highly technical and time-consuming process. It is critical that the contracted design team has experience running and achieving positive benefit cost ratios (BCRs). This includes having a thorough understanding of external funding requirements and approaches to including all potential costs and benefits in the BCA.

The planning and design processes for these projects is highly iterative and consultant teams must be able to creatively problem solve, and repeatedly develop and refine options with impacted stakeholders from residents to business and property owners. The consultant team should be able to take direction from relevant City agencies in addition to their managing agency client. The consultant team should be able to work with the project manager to prioritize and align tasks to keep the project on schedule. The selected consultant will also need the skills to manage the large number of sub-

20 (The Mayor's Office of Minority and Women-Owned Business Enterprises) https://www1.nyc.gov/nycbusiness/mwbe

Figure 5: East Side Coastal Resiliency Rendering

consultants these projects often require.

II. Community Engagement Consultant Procurement

The managing agency should: 1) allocate sufficient resources for communications and engagement; 2) ensure that engagement needs and goals are reflected in project RFPs; and 3) accurately judge RFP responses for relevant communications and engagement experience. Having a consultant or sub-consultant that is rooted in the community and has local knowledge and experience is important for community engagement and trust-building. Consultants who demonstrate experience and skills in incorporating environmental and climate justice history and issues in planning is a plus. Consultants should commit to follow MOCR's climate justice values when designing and conducting their engagement. More information on community engagement is provided in *Section 3: Public Engagement.*

E. Planning for Operations & Maintenance

Operations and maintenance (O&M) needs should be planned for from the earliest stages of the project and continually honed through project development. The agencies initially identified to own and operate systems and system components must be fully engaged in the planning and design process from the beginning to ensure that any decisions made are in line with agency standards and resources, and to optimize the effectiveness of the system itself. This is especially important as many of these projects are developed outside of an operating agency's normal capital planning process, where O&M planning and budgeting traditionally occurs.

O&M standards should be shaped by careful consideration of both operational capacities and precedents of other projects. While the project location and project component typologies often determine which operating agency would have jurisdiction, due to the cross-jurisdictional nature of these projects, as well as potential interaction with private property, it may not always be clear what the O&M needs will be at this outset. For some projects, there may need to be a consolidation of agency responsibilities that cross jurisdictions (for example, DOT maintaining a floodwall on parkland) or an agreement with another entity to operate and maintain specific components.

Activation analyses for long-term O&M, including identification of activation triggers and estimates of equipment and the labor needed to perform deployments, should be developed during the early design phase, and then continue to be updated and refined throughout the design process. Cost estimates for O&M can be prepared later in design, with input from operating agencies. All O&M decisions should be reviewed and approved by relevant operating agencies to ensure alignment with their larger agency-wide operations expense budget planning processes. MOUs for design and O&M should clearly delineate and memorialize project-specific roles and responsibilities.

SECTION 3. PUBLIC ENGAGEMENT

SECTION 3: PUBLIC ENGAGEMENT

Public engagement is critical to implementing a successful neighborhood coastal protection project. A high level of engagement and communication with a wide variety of stakeholders will be needed. This requires a robust engagement plan that shares information and resources, and respects residents as partners in increasing resiliency.

This section reviews how to incorporate the City's goals for building equity and resiliency into coastal flood protection projects by incorporating robust engagement, including during the design process as reviewed in the next section: *Section 4 Technical and Feasibility Analysis*.

Much of this guidance is based on the City's direct experiences of working with communities to implement coastal protection projects after Hurricane Sandy. The implementation of those first generation of projects created new opportunities for the City to engage with communities, and often challenged and stretched the City's existing engagement practices and resources. There were instances where new ideas for creating equitable and substantive engagement processes were successfully implemented and can stand as models to inform future communication and engagement planning.

A. Climate Justice Centered Engagement

The goal for all neighborhood coastal flood protection projects is to create an equitable project and that requires an equitable public engagement process. The project team must communicate with and engage the public throughout the life of the project. MOCR's Climate Justice Framework can be used to inform public engagement planning for the project.

MOCR defines climate justice as addressing the structural root causes of vulnerability to climate change. Climate justice in public policy means removing the unequal burdens of climate change on historically marginalized communities and ensuring these communities receive their share of benefits from climate mitigation and adaptation solutions. Climate justice improves quality of life by addressing climate change and removes social, economic, and health barriers that make communities more vulnerable to a changing climate.

To advance equity and climate justice and increase resiliency, MOCR has developed the following Climate Justice Values to guide the City's climate resiliency work:

I. Shift power and resources: Shift power and re-distribute resources, opportunities, and information to communities made vulnerable to increase well-being and agency, build on community strengths, culture, and assets, and uplift community climate work and leadership.

II. Acknowledge and learn from history and trauma: Acknowledge and learn from the City's role in systemic oppression and trauma that make BIPOC and under-resourced communities vulnerable to climate change.

III. Repair mistrust and build relationships: Repair mistrust between communities and the City due to repeated patterns of exclusion, racism and social injustices, and lack of transparency in climate change planning, policymaking, and decision-making.

These climate justice values should be applied to inform all aspects of project development, but specifically for engagement. These values are informed by the "Three Dimensions of Equity in Adaptation"[21] to serve as a framework for equity informed adaptation planning.[22] The following guidance is not comprehensive, but provides a basic framework to work towards greater climate justice and more equitable outcomes.

Climate Justice Value I. Shift power and re-distribute resources, opportunities, and information to communities made vulnerable to climate change to increase well-being and agency, build on community strengths, culture, and assets, and uplift community climate work and leadership.

To create more equitable outcomes and advance climate justice, the City needs to shift power and resources to residents that have been made more vulnerable to climate change impacts, to those that have been historically excluded from the City planning processes, and to those with the least resources. For the project, this means finding strategies to ensure residents have

21 (McDermott, Mahanty, & Schreckenberg, 2013)
22 (Foster, et al., 2019)

multiple opportunities and avenues to work with the team to inform and shape the project. Residents should be informed of the opportunities to engage with the team, to provide feedback, and to understand how their information will be used. The City has the responsibility to provide full information to residents so they can substantively engage with the project and make informed decisions about their neighborhoods in partnership with the City.

Any opportunity to contract, sub-contract or support local organizations and businesses should be pursued to strengthen ties to the neighborhood. Contracting with local neighborhood community groups and organizations to assist with developing a community engagement plan is an effective way to shift resources to the neighborhood, widen outreach and engage more residents, and acknowledge the knowledge and resources that residents bring to the table.

Climate Justice Value II. Acknowledge and learn from the City's role in systemic oppression and trauma that make under-resourced and BIPOC communities vulnerable to climate change.

All New Yorkers deserve to be protected from the impacts of climate change. However, we know that inequity makes people less resilient and climate change will impact people unequally. BIPOC and under-resourced communities are often made more vulnerable to climate change threats. The City's "Where We Live" report details how "people in different neighborhoods experience the most fundamental aspects of life, and how those experiences are often connected to race and a history of unjust decisions and policies."[23] The report describes how New York City's history of racism and segregation has impacted "New Yorkers' current residential patterns; the persistent disparities between groups and neighborhoods in housing quality, income, education, and health."

Historic and existing inequities contribute to a neighborhood's vulnerability to coastal flood hazards by shaping the conditions of the neighborhood that affect how at risk a neighborhood is. Neighborhoods with older infrastructure, with residents that have less access to resources to prepare, respond, and recover from coastal flood events, and with residents who experience greater exposure to more environmental health hazards and daily stressors directly are more vulnerable and less resilient to climate impacts.

As a result of these inequities, many of these communities have a strong history of climate and environmental justice community organizing and activism to advocate for more equitable policies, resources, and access to decision-making. These groups should especially be engaged because of the wealth of knowledge they will bring to the planning and design process. Local organizations that are trusted and have a breadth of knowledge about a neighborhood can help a project reach out to disenfranchised voices and thoughtfully engage them.

Conversations with neighborhood residents, particularly those neighborhoods with under-resourced and BIPOC communities, must be a space where residents can communicate their experiences, expertise, needs and the risk factors that they have identified as contributing to making them less resilient to coastal flood hazards. It is important to acknowledge the daily stressors and hazards people and neighborhoods face that are created by inequitable high-risk conditions that also make neighborhoods more vulnerable to the impacts of climate change.

Many of these issues may be well beyond the scope of the project, and the project team may not have ready answers. However, the City must acknowledge and learn from existing and historical trauma to better assess the conditions that are making the neighborhood more vulnerable and therefore less resilient. By listening first to resident concerns and respecting their knowledge the City can begin to rebuild trust and proceed to have open and honest dialogues as the project progresses.

Climate Justice Value III. Repair mistrust between communities and the City due to repeated patterns of exclusion, racism and social injustices, and lack of transparency in climate change planning, policymaking,

23 (Where We Live NYC Fair Housing Together - Confronting segregation and taking action to advance opportunity for all., 2021, p. 10)

and decision-making.

To begin to repair mistrust and rebuild relationships, the project team should create a transparent, two-way, and inclusive process that substantively communicates and engages with residents from the very beginning of project planning and development through design. This requires making engagement a central part of the project through the allotment of sufficient funds, resources, and time. It also requires being transparent and up front about difficult funding constraints, decision-making and project trade-offs.

Engagement must also be adapted to the unique characteristics of the neighborhood, such as culture and language, and should be thoughtful about meeting formats and times, communication mediums, accessibility needs, and engagement strategies. It is important to understand how residents want to be communicated with and in what settings to facilitate a robust engagement process.

The project should fully integrate and uplift resident voices, especially those voices that have been historically excluded from City planning process and those that have been made most vulnerable to climate change impacts, such as BIPOC communities, under-resourced communities, undocumented immigrants, young people, elderly people, people with disabilities, and non-English speakers, among other groups.

B. Opportunities for Engagement in Planning and Design

The design phase provides an opportunity to engage and communicate with residents. Residents should be substantively engaged in a design process that is equitable, transparent, informative, accessible, and with plenty of opportunities to provide feedback. The design process will need to ground engagement in conversations around equity and the feasibility realities of the project and these conversations require consistency, active listening, and transparency to maintain trust.

Because communications and engagement are a critical part of the design process, they should be adequately planned and budgeted for. The design process will need a holistic and sophisticated plan for engagement, including language access, for each phase of design. The engagement plan should align with project goals and milestones to ensure the City is allotting sufficient time to communicate at important junctures to provide updates or obtain information from stakeholders. Appropriate technical and complex information needs to be shared between the project team and residents, and there should be sufficient time and resources to facilitate a robust engagement with residents.

The engagement plan should articulate goals and identify target groups and populations, top spoken languages, methods and opportunities, expectations for outcomes, as well as how the plan meets MOCR's climate justice framework, especially the values. Opportunities for community input, information gathering, and decision-making to inform project design should be identified and incorporated into the project schedule and aligned with other project management tasks and schedules. Project planning should clearly identify and communicate and provide opportunities for engagement and public input around key decision points. This should include

EQUITY FRAMING LANGUAGE

The use of language that acknowledges historic and existing conditions of inequity should be used. Policy language often uses terms to identify or define populations that describe a consequence of a condition and not the root cause. For example, language such as, "high-risk", "vulnerable", "low-income" is often used to describe vulnerable populations. However, these words are describing consequences and outcomes, not causes of vulnerability.

Consequence	*Cause*
High Risk Populations	High-Risk Conditions
Vulnerable Communities	Communities Made Vulnerable
Under-represented	Historically Excluded
Low-Income	Under Resourced

When a group is referred to as a "high-risk population", the language infers that "high-risk" is a characteristic that is innate or a fixed circumstance. However, when a group is referred to as "living in high-risk conditions" this reframes the conversation to focus on those conditions that are causing a population to be at risk. The project team should focus on those factors that are causing vulnerability.

what information is needed from residents, how the information will be used for decision-making, as well as defining clear roles, responsibilities, and expectations of all involved parties.

MOCR has found that communities are often very eager to discuss and learn more about climate change. The project team should provide information on how climate science is used to inform project planning and design, clearly translate the data and science, and supplement that information with the everyday lived experiences of the residents. MOCR's *State of Climate Knowledge* (2021) report found that, "Participants expressed interest in the development of communication and outreach strategies which motivate action, connect with various audiences, and improve trust and transparency. In addition to more inclusive and sustained engagement processes, addressing these priorities requires developing a greater understanding of how different communities connect with various forms of information; how individuals perceive their climate risk; and improved understanding of how communication strategies contribute to individual and collective action."[24]

The conceptual phase before the formation of design alternatives is a time for project leadership to learn from and listen to residents before proposing specific coastal protection solutions. It is critical that the project team have a preliminary but holistic comprehension of a neighborhood, including neighborhood history, community relationships, challenges, and strengths. This knowledge will inform every aspect of the project including project goals, solutions, scope, communication and engagement planning, RFPs, and design.

Project objectives or defining the risk the project is intended to reduce should be informed by resident input and recommendations during the conceptual phase and continuously shared as the project progresses. This ensures that everyone engaging with the project has the same outcomes in mind and it creates a level of accountability. It also gives the project an opportunity to realign or adjust if a project is not meeting resident expectations. Ideally, project objectives should be developed in a collaborative process with project

Figure 6: Battery Coastal Resiliency Rendering

24 (State of Climate Knowledge, 2021, p. 15)

partners and stakeholders before design begins.

To substantively engage with the project, conversations with stakeholders should be grounded in the constraints facing the project. Stakeholders should understand all projects will have constraints and what these are for a specific project, including available technologies, budgets, timelines, regulations, grant requirements, existing conditions, and any other known constraints that impact project scope. This information should be shared at the very beginning and communicated throughout the project's implementation development.

Coastal protection projects can generate controversy because of these trade-offs, and a strong communications plan is necessary to address the concerns. Neighborhood residents should have the information to understand and inform decision-making on any trade-offs that need to be made due to project constraints.

Finally, there may be stretches of time when the team does not have any new information to share. During these periods, some level of engagement or contact with stakeholders should be conducted to maintain relationships. This can include providing or connecting to other City services and initiatives such as emergency preparedness planning or informational sessions on sustainability and resiliency topics like the Climate Knowledge Exchange.

I. Engagement Opportunities During Planning and Design

Communication and engagement with residents during design should aim to provide residents a clear overview of what the design process is comprised of, what aspects of analysis are needed to achieve project feasibility, and when and where they can expect to be engaged during the design process to provide feedback and/or receive information. The following sub-sections mirror the design tasks and phases reviewed in *Section 4: Technical and Feasibility Analysis* and how engagement can be used to inform design.

a. Existing Conditions

Engaging with residents on existing conditions can provide insight into the factors that make the neighborhood more vulnerable to coastal flood hazards. For example, exposure to coastal flood hazards is determined by a neighborhood's geographic location, and racial segregation has often determined where communities live, specifically BIPOC communities.[25] The communication and engagement process can be used to better understand a neighborhood's history, including the connection between history and present-day vulnerability and how high-risk conditions to coastal flooding have evolved. Residents can provide valuable information about their visions for their neighborhoods, current and future coastal flood hazards, impacts to quality of life, health, and well-being, neighborhood history and characteristics, demographics, land use and zoning, property inventory and ownership, and existing utilities and infrastructure.

b. Vulnerability and Risk Assessments

The project team should inform residents of their risks to coastal hazards and the feasible options to reduce those risks, while also listening and learning from residents about their visions for their neighborhoods in the future and their perceived vulnerabilities to coastal flood hazards. Obtaining information directly from residents can provide more insight into the issues at hand and can be used to further understand current and future coastal storm surge hazards and risks. Residents, particularly long-time residents, will often have a wealth of knowledge about how, when and where flooding occurs, and how flood patterns have changed over time. Information should be gathered on what areas, buildings, homes, facilities, recreation areas, and streets were flooded and how residents were impacted, including impacts to their quality of life, health, and well-being. Information should be gathered about any utility service disruptions caused by the flooding and the cascading impacts that may have had on residents. Special attention should be paid to any impacts to populations made more vulnerable climate change and to critical facilities.

The NPCC reports provide a wealth of knowledge and this information should be actively shared with residents.[26] The City should engage with residents to understand what impact a coastal storm surge would have on the neighborhood, especially unanticipated

25 (The End of Segregation? Hardly., 2012)
26 (New York City Panel on Climate Change, 2021)

impacts that residents are more attuned to, with a specific focus on identifying which populations would be the most severely impacted. Resident engagement should also be solicited and used to learn which housing, buildings, infrastructure, and critical facilities are the most at risk to future coastal flooding from the residents' perspective.

c. Level of Protection

The project team should engage residents on the factors that determine the level of protection and work with residents to ensure that the project is reducing risk and prioritizing the protection of the most vulnerable populations and infrastructure in the neighborhood. Clear and accessible communication materials should be developed to explain current and future risks, the level of protection, and storm definitions.

It should also be made clear to residents and stakeholders that neighborhood coastal flood protection projects (or any other risk mitigation strategy) will not completely eliminate all flood risk. Residual risk will always remain. Residents should be informed about any residual risk that may not be able to be addressed by the coastal protection project, and what that means for potentially impacted populations, infrastructure and buildings. This can help residents and stakeholders understand other mitigation measures or operational and behavioral changes that might be needed to further reduce their risk to flooding.

Understanding residual risk should be used to engage in conversations around the continued need for emergency planning and evacuation ahead of a storm. Systems are meant to protect infrastructure and housing, but residual risk means evacuation will still be necessary when ordered by officials. Coordination with NYCEM will be needed to communicate with residents what to expect ahead of a coastal storm event, where to find information (e.g., Know Your Zone), and how residents should prepare and plan for evacuation orders.

d. System Typology

Large-scale neighborhood-wide coastal flood protection projects are a newer form of capital asset in the city and many New Yorkers are unfamiliar with the various physical designs these projects can have and the various levels of protection they can provide. Providing information to and educating residents about the various types of coastal protection systems, their components, and operations and maintenance needs will be necessary. Residents should also understand and see the analysis that the City uses to find the best design for protection.

The City needs to communicate how the coastal protection project will look and function during typical "blue sky" days. These conversations should involve identifying features of the project where added benefits can be provided such as additional landscaping or recreational space. The City also needs to provide information on how the system will look and function during a storm event. For systems that rely on deployable elements, residents should also be informed of when and for what duration deployable features will be in place, and what if any impacts deployable components will have on pedestrian and vehicular traffic.

e. Interior Drainage

Engaging with residents on the state of existing interior drainage is an opportunity to inform and enhance the interior drainage analysis and learn about existing conditions from residents. The project should plan to communicate to residents why a drainage analysis is necessary, what the analysis would encompass, and the potential solutions to mitigate any impacts.

It is very likely that residents will have concerns and issues with interior drainage that often go beyond the scope of the coastal protection project. These neighborhoods often deal with flooding caused by a variety of sources, including coastal storm surge, tidal flooding, precipitation flooding, and a high groundwater table. Listening to and understanding those concerns should be a part of engagement planning, even if the concerns are outside of the scope of the project.

f. Benefit Cost Analysis

The project team needs to communicate the requirements of a benefit cost analysis – this is especially important for federally funded projects which have specific requirements. Residents should understand why a positive benefit-cost ratio is necessary to justify funding and that some funders require the cost of the project cannot exceed the cost of avoided damages. Discussing the benefit cost analysis can also be used to frame conversations on "trade-offs" or prioritizing features in order of benefit and need.

SECTION 4. TECHNICAL AND FEASIBILITY GUIDANCE

SECTION 4: TECHNICAL AND FEASIBILITY GUIDANCE FOR DESIGN

This section will review the key challenges associated with a feasibility analysis for a coastal protection project. Many technical challenges arise during the design phase and this section aims to fill gaps in the current documentation and provide guidance. This section is divided into six sub-sections that are part of a typical feasibility analysis for design and highlights tasks that are unique to coastal protection projects:

A. Existing Conditions
B. Neighborhood Risk Assessment
C. Level of Protection
D. Coastal Protection System Typology
E. Interior Drainage
F. Benefit Cost Analysis

Note, these steps can be iterative and are not presented in any particular order. This section does not provide guidance on the project schedule or specific task activities of the design phase. The project schedule and tasks should be planned according to the managing agency's planning and design schedule. This guidance provided in this section is intended for any stakeholder (not just the project manager or design team) involved in the planning and design of a neighborhood coastal protection project to highlight the various aspects of analysis needed to develop a feasible project.

Achieving technical feasibility for the design of a neighborhood coastal protection project depends on many factors. It is important to note that feasibility is not just defined as technically implementable from an engineering standpoint, but that it also considers important factors such as the benefit cost ratio, property ownership and jurisdiction, regulatory compliance, reduction of impacts to the natural and built environment, constructability, operations and maintenance needs, and integration into the existing urban fabric. All of these different factors have a significant impact on project feasibility and design.

The work of developing a coastal protection project is very technical, but the project team must also consider the project's social impacts because these projects can reshape a neighborhood's waterfront – where people live, work, and recreate. Neighborhood coastal flood protection projects are fundamentally about good and responsible urban planning and design. The technical aspects of the project must be closely coordinated with the broader goals of neighborhood equity, resiliency, and livability.

A. Existing Conditions

A review and analysis of the existing conditions in a neighborhood or study area is a standard task for any capital project, but there are some parts or aspects of this analysis that are more uniquely relevant for neighborhood coastal protection flood projects. Understanding the existing conditions should consist of (but not be limited to) the following data gathering topics:

I. Study Area
II. Current and Future Coastal Flood Hazards
III. Additional Current and Future Climate Hazards
IV. Neighborhood History of Social, Built, and Natural Characteristics
V. Demographics
VI. Land Use and Zoning
VII. Property Inventory and Ownership
VIII. Utilities, Infrastructure, and Facilities
IX. Geotechnical and Topographical Data

<u>I. Study Area</u>

Defining the study area for a proposed project should be carefully considered as it provides the basis for all future analysis and communications.[27] "Neighborhood" is the first word in the title of this report and is purposely used to designate that these coastal protection projects are meant to reduce flood risk for the residents of a distinct geographic area that go beyond a single property or block. New York City is a city of neighborhoods and it is the residents and their interactions that turn a geographic area into these distinct places.[28] However, neighborhoods have no official designation. They have often developed organically over many decades, if not centuries. Locally recognized neighborhood

27 (City of New York, Department of City Planning Population FactFinder, n.d.)
28 (New York City A City of Neighborhoods, n.d.)

boundaries, current and future, floodplain extents, sewershed boundaries, community board districts, city council districts, census tracts, and/or topography can all be used to help define the study area.

II. Current and Future Coastal Flood Hazards

Current and future coastal flood hazards, including overland flooding due to coastal storm surge and tidal flooding, should be identified in the early stages of project planning. The coastal flood hazard information will inform the study area, risk assessment, level of protection, and typology selection. Flood extents from the coastal flood hazard information should be mapped onto the neighborhood.

a. Storm Surge

Storm surge is the primary risk for which these projects are developed and as such, the most comprehensive information of current and future flood risks should be identified. To cover a realistic but broad variety of likely coastal flood events for New York City, and to understand the degree of flooding expected for the neighborhood, the flood extents of the standard 10-year, 50-year, and 100-year recurrence intervals should be mapped on the study area. The data from the most recent FEMA Flood Insurance Study (FIS) should be used to produce this information.[29] Depth grids for each extent should also be developed. The depth grids provide an additional layer of information that can illuminate where in the neighborhood the flooding is expected to be the deepest as it indicates depth of flooding above ground, rather than the elevation data indicated in the FIS and Flood Insurance Rate Maps (FIRMs).

To account for future conditions, an assessment of future storm surge extents due to sea level rise should also be completed using the most recent 90th percentile projections from the most recent New York City Panel on Climate Change (NPCC) climate data and projects. This information should account for future sea level rise impacts on the 100-year recurrence interval in the 2050s, 2080s, and 2100, and should also be mapped onto the study area. Future sea level rise must be accounted for to ensure the system is designed to protect against coastal storm surge depths and loads now and in the future.[30] The City currently has basic future flood maps available, based on simplified bathtub models that combine the data from the FIRMs and the NPCC projections to depict future flood extents. At the time of the writing of this report, the City is also developing dynamically-modeled future flood risk maps that will be based on forthcoming updated FEMA storm surge models and the NPCC projections.

In addition to flood extents, elevations, and depths, an initial assessment of the area's exposure to wave action is necessary, as wave forces can have an increased destructive impact on neighborhoods, and their presence will also inform the type and size of coastal protection intervention that may be needed. On the FEMA FIRMs, the areas subject to waves are indicated by the VE and Coastal A Zones[31]. While these zones are not indicated in the future flood maps produced by the NPCC, every attempt should be made through hydrodynamic flood modeling of the study area to understand how wave impacts may grow in the future with sea level rise. As the project moves further into design, this will be accomplished through more sophisticated coastal models.

b. Tidal Flooding

Tidal flooding is increasingly occurring in New York City's coastal areas and will increase as sea levels continue to rise. Current and future high tide levels should be identified and mapped on the study area, specifically the current high tide as indicated by the Mean Higher High Water (MHHW) datum developed by NOAA, as well as future MHHW in the 2050s, 2080s, and 2100 using the most recent 90th percentile projections from the NPCC. It may also be useful to identify and map the future Mean Monthly High Water (MMHW) levels and extents, as developed by the NPCC, to understand what parts of the study area will be at risk first.[32]

c. Previous Coastal Flood Events

Investigate how the neighborhood has been previously

29 While FEMA maps the 100-year flood in the Flood Insurance Rate Maps (FIRMS), the FIS provides the data for other recurrence intervals as well.

30 Currently, modeling climate change impacts on sea level rise projects after 2100 becomes less reliable given current data.

31 (City of New York Department of City Planning Climate Resiliency Initiatives - Frequently Asked Questions, n.d.)

32 (New York City Panel on Climate Change 2019 Report Chapter 4: Coastal Flooding, 2019)

affected by coastal flooding events and note any risk mitigation actions that were taken in response, including getting information directly from residents, tide gauge data, or the Hurricane Sandy inundation map.

d. Evacuation Zones

While evacuation zones will not be a direct input into the design or alignment of the flood protection system, it is helpful to understand what portions of the study area are in what zone. This information will be useful context when emergency operations planning begins, as it is one way to understand where the movement of people may occur in advance of a major flood event.[33]

III. Additional Current and Future Climate Hazards

Data on climate hazards beyond coastal flooding should also be collected to get a more comprehensive risk profile of the neighborhood and identify additional climate benefits the project can implement. For New York City, the three main climate hazards are sea level rise (exacerbating both coastal storm surge and tidal flooding), rising temperatures, and increased precipitation.[34] According to the NPCC 2019 Report, Advancing Tools and Methods for Flexible Adaptation Pathways and Science Policy Integration," many New York City neighborhoods are increasingly vulnerable to stormwater flooding due to extreme rainfall events and heat due to an increase of days per year above 90 degrees.[35]

The City's "New York City Stormwater Resiliency Plan" (2021)[36], and "The New Normal: Combating Storm-Related Extreme Weather in New York City" (2021)[37] outline the City's plans to manage flood risks from increasing high rain events or "cloudbursts" as climate change continues to put additional pressure on the City's drainage infrastructure due to increased rain events and sea level rise. While coastal protection projects are not designed with the goal of resolving these issues, it is important that project planners understand the impacts of stormwater risk in the study area, especially as interior drainage approaches are being explored. Broader, more integrated and coordinated responses will be needed as the City continues to adapt neighborhoods to the impact of climate change.

New York City's Heat Vulnerability Index identifies neighborhoods vulnerable to high heat impacts.[38] Heat waves are New York City's most deadly climate hazard.[39] All New York City neighborhoods have residents that are at risk for heat impacts, but these risks are not distributed equally, and under-resourced and BIPOC communities are disproportionately impacted. The City's 2017, "Cool Neighborhoods NYC" report outlines the City's comprehensive approach for addressing extreme heat. While a coastal protection project may not have any direct impact on this, the project can have indirect added benefits for example, by incorporating more nature-based features to lower ambient temperatures or by providing shading and cooling features.

NYCEM's Hazard Mitigation Dashboard provides a comprehensive overview of the most common hazards including coastal flood risks; risk assessments for nine hazards discussing probability, location, and historic events; and best practices and specific City-led strategies for managing risks associated with each of these hazards.[40] It can be referenced to help identify key features of the city's environment that makes it vulnerable to hazards.

IV. Neighborhood History of Social, Built, and Natural Characteristics

History will largely predict present day vulnerability

33 (Know Your Zone, 2021)
34 The City has developed several tools for understanding climate hazard risks: (NYC Flood Hazard Mapper, 2021); (City of New York Mayor's Office of Climate Resiliency New York City Stormwater Resiliency Plan, 2021); (City of New York Department of Mental Health and Hygience Heat Vulnerability Explorer, n.d.)
35 (New York City Panel on Climate Change 2019 Report Executive Summary, 2019)
36 (City of New York Mayor's Office of Climate Resiliency New York City Stormwater Resiliency Plan, 2021)
37 (City of New York Mayor's Office of Climate Resiliency The New Normal: Combating Storm-Related Extreme Weather in New York City, 2021)
38 (City of New York Department of Mental Health and Hygience Heat Vulnerability Explorer, n.d.)
39 (City of New York Mayor's Office of Climate Resiliency Cool Neighborhoods NYC A Comprehensive Approach to Kepp Communities Safe in Extreme Heat, p. 7)
40 (City of New York Emergency Management NYC Hazard Mitigation, 2021)

and resiliency. For coastal protection projects, it is important to consider the neighborhood's social history and population settlement, and historical land uses and development to develop a comprehensive view of the neighborhood's coastal flood risks. To do so requires an in-depth understanding of what populations settled in the study area and how the land was developed and used. The project team should engage and talk to residents about neighborhood history, as well as doing additional research to include in their understanding of risk and history in a neighborhood.

a. Social History

The neighborhood's social history will be used to inform the risk assessment and resident engagement and should encompass understanding which populations have historically lived in the study area and how/when/and why that settlement occurred. This historical understanding is especially necessary in New York City, where there is a long history of class and racial segregation. Exposure to coastal flood hazards is determined by a neighborhood's geographic location, and population and racial segregation often determined where different populations live. BIPOC communities have historically been segregated by racist housing policies to geographic locations that can make them more vulnerable to numerous environmental and climate hazards, including coastal flooding.

b. Built and Natural History

A neighborhood's history can also provide information related to the development of its natural and built environment. The historic development of the neighborhood's coastline can provide insight into existing conditions and would typically be analyzed in detail for any required environmental assessment as part of the design process.

Much of New York's waterfront was developed by infilling wetlands, streams, and open water.[41] This development occurred over centuries beginning when New York City was a colony and when there was little to no regulation for coastal management. Industrial uses were historically sited along New York's waterfront, sometimes leaving environmental contamination. This historic development can impact current day coastal elevations, groundwater tables, and soil contamination conditions. These conditions can ultimately impact the project's design flood elevation, alignments, constructability, and even feasibility.

V. Demographics

The demographic information collected is a foundational part of learning about the community and informing the project, specifically when developing the *Risk Assessment* and *Engagement* plans.[42] Demographic information collected will begin to help understand the make-up of a neighborhood and identify populations that are made vulnerable to coastal flooding in the study area. The characteristics that should be understood are, but are not limited to race, ethnicity, age, disability, primary language, poverty level, education level, and employment. All these characteristics should also be broken down by race if that data is available. Beyond the stated characteristics, the project team should also analyze and assess other data relevant to quality of life, well-being, health, and equity to better understand not only the composition of a neighborhood, but the existing conditions and disparities they experience.

VI. Land Use and Zoning

The coastal protection project should integrate with and enhance the urban fabric of the neighborhood. Industrial, residential, commercial, or mixed-use neighborhoods can require very different typologies of protection. Waterfront uses also vary greatly across New York City or even in one neighborhood. These uses will shape the typology of the project depending on whether for example, the waterfront is a working, residential, commercial, recreational, or inaccessible waterfront. Current and future uses should be analyzed with residents to identify priorities and potential additional benefits from the project. DCP's 2021 "Comprehensive Waterfront Plan" should be consulted to guide planning and policy for the city's waterfront.[43]

VII. Property Inventory and Ownership

Property types (e.g., residential, commercial, industrial,

41 (The Wildlife Conservation Society Beyond Manahatta The Welikia Project, n.d.)
42 (City of New York, Department of City Planning Population FactFinder, n.d.)
43 (City of New York Department of City Planning New York City Comprehensive Waterfront Plan, 2021)

open space) and land ownership (e.g., City owned, non-City owned[44]) will impact feasibility and design and should be catalogued and mapped. Property ownership will directly impact the availability of land to build and access the coastal protection system for on-going operations and maintenance, and inspections. When analyzing potential alignments, effort should be made to keep the system on City-owned land. This is preferred to ensure continuity of access for construction and ongoing operations and maintenance, and avoidance of complex, costly, and timely access and easement agreements with other property owners.

Understanding the types and conditions of properties in the study areas will help inform the risk profile of a neighborhood. Where possible, collecting the year built (or known major renovations) of buildings that provide a critical service will help identify those that were constructed with stronger flood-resilient building standards (after 1983) and those constructed under DOB's strengthened 2014 "Appendix G" flood-resistant building code.[45]

Public serving facilities, including schools, public housing developments, libraries, and community centers, as well as public parks, open space, street trees and vegetation, and natural habitat should also be mapped and assessed as part of the City's infrastructure assets. These spaces have critical roles in the daily health, emergency response operations, and the long-term resiliency of neighborhoods. The community should also be consulted on what facilities they deem important.

VIII. Utilities, Infrastructure, and Facilities

Design will require the assessment and survey of the existing conditions of infrastructure assets. Every attempt should be made to identify any infrastructure assets that will be impacted or have the potential to impact the project. This is needed to understand coastal flood risk, feasibility, and potential impacts on the design flood elevation and alignment of the coastal protection system. Utilities include sewer, water main, natural gas, steam, electric, water, telephone, cable/broadband, and public Wi-Fi. Infrastructure includes public transportation (bus and subway), road networks, bridges, and public parkland. All tunnels, regardless of ownership or purpose, should be identified. An assessment should: 1) survey the exact location (including vertical datum for underground infrastructure); 2) summarize current conditions; 3) determine criticality as defined by FEMA, the City, or residents;[46] 4) catalogue any resiliency features that have been implemented; and 5) assess any vulnerabilities to coastal flooding.

UNIFORM LAND USE REVIEW PROCEDURE (ULURP)

While the need to go through ULURP is not unique to coastal protection projects, it is critical to understand whether or not the project will require it and to factor this into project costs and schedules as the process can be quite time consuming. Common actions that can trigger the need for ULURP on coastal protection projects are (but are not limited to):

- Acquisitions of private property, including for easements
- Road raisings that go higher than the official legal grade
- Zoning text amendments

It is important to also consider any cascading impacts to infrastructure and facilities in the study area that can be triggered by a coastal flooding event. This includes an assessment of potential interruption of services by local utilities, for example, a wastewater treatment plant ceasing portions of operations due to a power outage. This may inform the climate change risk assessment report or provide insights into site specific conditions and design options.[47]

IX. Geotechnical, Topographical, and Subsurface Conditions

Several below-ground physical conditions – both natural and built – can influence the feasibility and design of a coastal flood protection project. Factors to be examined and considered include:

Geotechnical Conditions

44 Non-City owned property includes private property and property owned by quasi-governmental authorities such as NYCHA or the MTA, or other jurisdiction such as the State or Federal government.
45 (Appendix G Flood Resistant Construction)
46 (Climate Resiliency Design Guidelines, 2020, p. 15) and FEMA Glossary "Critical Facility" (FEMA Critical Facility, n.d.)
47 (City of New York Department of City Planning, 2021)

The physical characteristics of the underground rock, soils, and groundwater in an area can greatly influence the complexity, or even feasibility, of constructing flood control structures. For example, some areas may feature sound rock to support the foundations of a floodwall while blocking water flow underneath the structures, whereas other areas may feature loose soils such as fill, which present greater challenges for supporting a flood structure while also increasing the need for deep seepage barriers beneath it. The presence of potentially contaminated soils could also present challenges.

Topographical Conditions

The elevations and contours of the land itself in an area will have a strong influence on the potential for coastal flood protection. Areas of low elevation along and near the shoreline can create potential entry points for storm surge to find its way inland. The rate at which the topography of the land slopes upwards as it moves inland from the waterfront can influence the difficulty of designing the "tie backs" to high ground that allow the creation of a flood-protected "compartment" with independent utility. For example, broad flat land at a low elevation will require long tie backs to reach high ground, whereas steeply sloped land may allow for much shorter and less complex tie backs.

The Underground, Built Environment

Any construction project in a dense older city such as New York involves accounting for underground infrastructure such a utilities and vaults. The need to consider utilities has been discussed in another section, but the construction of coastal protection systems along or close to the waterfront, may involve the consideration of additional underground complexities. These can include:

- Infrastructure that crosses the shoreline. A coastal protection system built parallel to the shoreline may need to cross over underwater infrastructure as it crosses the shoreline to become underground infrastructure. Examples of infrastructure that crosses water bodies (and therefore the shoreline) include subway tunnels, LIRR tunnels, PATH tunnels, Amtrak/NJ Transit tunnels, MTA vehicular tunnels, Port Authority vehicular tunnels, Con Edison tunnels, electrical transmission lines, petroleum and natural gate pipelines, DEP outfalls, non-DEP outfalls, water tunnels, and power plant intake and/or discharge tunnels. Any such structure must be considered. In addition, there are numerous locations where bridges (rail, vehicular, and pedestrian) cross above the waterfront, potentially creating issues of vertical clearance, construction access, and jurisdiction.
- Waterfront structures. In much of the New York City, the water's edge often takes the form of built structures, and these can influence the design and construction of a coastal protection project. Common features include various combinations and types of bulkheads, seawalls, relieving platforms, and piers.

B. Neighborhood Risk and Vulnerability Assessments

The goal of this section is to provide guidance to equitably assess a neighborhood's vulnerability and risk to coastal flood hazards and inform the design of a coastal protection system that ensures the most vulnerable populations and critical physical assets are protected. A coastal neighborhood with vulnerable critical assets and populations is more vulnerable compared to a coastal neighborhood that has more resilient critical assets and a more resourced population, even if the exposure to the same coastal flood hazard is equal.

Assessing overall neighborhood risks for a coastal flood hazard is a combination of assessing: 1) the vulnerability of the built environment (including utilities, buildings, and transportation networks); and 2) the vulnerability of the population within the neighborhood. Together, an equitable risk assessment of the neighborhood's built environment and population will produce a comprehensive and equitable Neighborhood Coastal Risk Profile to guide the design of a coastal protection system that prioritizes the protection of the vulnerable populations and critical physical assets.

A neighborhood's overall level of coastal flood risk is determined by evaluating the likelihood that a coastal flood event will occur and assessing the consequence of that impact. Evaluating risks for both a neighborhood's built environment, and residents will be necessary to determine the overall risk for a neighborhood. The Neighborhood Coastal Risk Profile should produce quantifiable and geospatial profiles of a neighborhood's coastal flood risk that prioritizes protection for the most vulnerable populations and critical assets, and should inform the appropriate alignment and level of protection needed to reduce coastal flood risk.

Note – This current version of this report provides a framework to begin comprehensively assessing a neighborhood's risk for coastal flooding, however more work and research will need to be done to develop and refine the assessment framework in future versions of this report.

I. Built Environment Risk Assessment

The following guidance describes an approach to determine risk to the built environment from coastal flooding, not a full step-by-step methodology. A risk assessment of the built environment should:

1. Identify critical assets as defined by the funder, FEMA, the City, or the community.[48]
2. Determine exposure to current and future coastal flooding for each critical asset.
3. Estimate the impact from coastal flood events without a neighborhood coastal protection project.

The City's 2020 Climate Resiliency Design Guidelines (CRDG) provides specific guidance for assessing a public asset's vulnerability to a climate hazards.[49]

II. Population Vulnerability Assessment

The guidance in the current version of the report is limited in that it does not provide a methodology to assess a population's vulnerability to a coastal flood hazard. More research is needed to determine what indicators should be used to identify populations made vulnerable to coastal flooding, and what factors increase the risks of suffering a severe consequence from a coastal flood. While this methodology has yet to be fully developed, a vast body of research currently exists that acknowledges the "widespread awareness that the uneven distribution of climate change impacts combined with preexisting social and economic challenges makes some communities more vulnerable than others."[50]

The goal of the population risk assessment should be to measure what impacts a coastal flood event will have on various populations within a neighborhood by estimating the sensitivity to the consequences from the event and the severity of impacts caused by varying flood events. Vulnerable populations need to be identified, assessed for risks, and prioritized for protection. A population that is more vulnerable will be more sensitive to a coastal flood event and suffer greater consequences than a population that is less sensitive. A population that is vulnerable will have a lower threshold for being severely impacted by a flood event compared to a population that is less vulnerable. More research needs to be done to index how varying flood events can create serious to severe risks for vulnerable populations.

The categories of BIPOC and low-income can serve as proxies for vulnerability because these populations are often made more vulnerable to climate change threats by:

- being in neighborhoods with older, more at-risk infrastructure;
- having less access to resources to prepare, respond, and recover from coastal flood events;
- being exposed to more environmental health hazards, such as air pollution;
- experiencing daily stressors like poverty resulting in higher rates of negative health and other life outcomes; and
- having less access to political power.

Additional demographic categories can also be used as indicators of vulnerability. Various scientific studies track a variety of specific indicators for vulnerabilities. The NPCC has developed an initial proposed list of indicators for coastal flood vulnerability, acknowledging that there are additional indicators that are viewed as relevant by the City or by residents:[51]

- Access and functional needs populations
- Educational attainment
- English fluency
- Female-headed household
- Foreign-born population

48 (U.S. Federal Emergency Management Agency, n.d.) (Climate Resiliency Design Guidelines, 2020, p. 15)
49 (Climate Resiliency Design Guidelines, 2020, p. 5)
50 (New York City Panel on Climate Change 2019 Report Chapter 6: Community-Based Assessments of Adaptation and Equity, 2019)
51 (New York City Panel on Climate Change 2019 Report Chapter 6: Community-Based Assessments of Adaptation and Equity, 2019, p. Table 6.6)

- Income
- Older adults over 65
- Poverty
- Race/ethnicity
- Rent burden

Public housing residents should also be identified due to the higher proportion of residents that are elderly, children, disabled, or low-income and the vulnerability of public housing infrastructure to coastal flood impacts. This list should not be considered comprehensive, but a rather starting point to begin to identify populations that should be prioritized for protection by the project. Conversations with residents can provide additional information for identifying additional populations that are made vulnerable to coastal flood hazards and understanding the potential impacts.

III. Create a Neighborhood Coastal Risk Profile

A Neighborhood Coastal Risk Profile should include quantifiable and geospatial data and summarize the consequence sensitivity and impact thresholds for critical physical assets and the population. The Neighborhood Coastal Risk Profile should help guide what level of protection is needed and where the alignment should be located, focusing on protecting the most vulnerable populations and the most vulnerable critical infrastructure.

As noted at the start of this section, this version of the report will not provide complete guide to developing a full neighborhood equitable Neighborhood Coastal Risk Profile that assesses infrastructure and social vulnerability due to current resource limitations. Further research will be needed to develop a tool that can be used to guide policymakers.

No project will mitigate all risks or address all vulnerabilities. Any residual risks that a coastal protection project cannot protect against should be identified throughout the project for other potential mitigation measures. Existing inequities that are making the population more vulnerable to coastal flooding and that require a more programmatic approach or separate capital investments should also be documented. Throughout the design process, the level of risk reduction achieved should be reassessed and documented using the updated proposed design alternatives and at major project milestones.

C. Level of Protection

Determining the level protection is a balance of maximizing benefits, while minimizing negative impacts from the coastal protection project. The level of protection should be determined by finding the optimal height needed for the unique conditions of each neighborhood while considering current and future sea levels. Coastal protection projects must withstand the impacts of climate change and given that climate change projections are continually updated, planning must be based on the best available data at the time, which is provided by FEMA (for current flood risk) and NOAA (for current tidal elevations), and the NPCC (for climate projections).

New York City neighborhood coastal flood protection projects vary in their final Design Flood Elevations (DFE) (or elevation of the flood protection system) due to local existing conditions that shape the project. Waterfront uses, property ownership, underground infrastructure, urban design goals, interior drainage needs, and risk profiles all impact the DFE. Each project should be designed to fit the unique characteristics of a neighborhood. Equally as important to tailoring projects to each neighborhood, is having a process that is transparent, accessible, and communicated to stakeholders. The project team should also consult with stakeholders on how they define acceptable levels of protection.

I. Design Flood Elevation Methodology

Finding the optimal DFE is determined by identifying the level of protection that is needed to reduce risk given technical constraints. Design must allow for an iterative and flexible process that can adjust to the risk profile and technical constraints that are identified, but the methodology of analysis should be similarly applied to maintain consistency across all projects. This approach will allow for a DFE that is tailored to each neighborhood with the goal of maximizing the DFE given existing conditions and constraints.

Determining which DFE the project should protect to can be influenced by several different factors:

The Neighborhood Risk Assessment should identify the flood level(s) that would cause moderate to severe consequences for critical infrastructure and residents of the neighborhood, especially the most socially vulnerable.

- The anticipated useful life of the project (typically 50 – 100 years, but to be verified by the project team) should be used to adjust target climate projections for the design flood. For example, a project that is designed to protect against a current 100-year flood but has an anticipated lifespan of 100 years, will need to add additional height to protect against future sea level rise.
- The final DFE will also need to account for localized wave impacts and prevent overtopping with additional height if the alignment is adjacent to the coastline.
- At a minimum the project must also be designed with a fully passive system to withstand future tidal flooding due to sea level rise, regardless of the DFE determined to protect against coastal storm surge.[52] This may mean that the system will be designed with two elevations in mind – one, a fully passive lower elevation for tidal flooding, and two, a higher DFE for flooding due to storm surge.
- For projects designed to the current or future 100-year flood, the potential for catastrophic failure due to a higher elevation of flooding must be analyzed (for example, the 500-year flood). Since there is always risk of a larger flood event, it is important that the impacts of potential substantial overtopping or system failure be analyzed. Overtopping by waves can be less consequential than extreme overtopping of the surge itself. Make DFE adjustments if warranted and evaluate in a residual risk analysis.
- Physical constraints (e.g., land availability for project alignment, property ownership, utility locations, soil conditions, costs etc.) will impact how and if a proposed DFE can be met throughout the project area.
- Other stated project needs and benefits such as waterfront access may cause the DFE to be adjusted after weighing project trade-offs.

Determining the optimal DFE for the project will be an iterative process as the design progresses. The DFE should be reevaluated to identify which populations, building infrastructure, critical facilities etc., are being protected and to what level to determine if the DFE is providing protection to reduce risks for vulnerable populations and critical infrastructure. The DFE should also be established to evaluate its effect on the neighborhood fabric and its infrastructure, including ADA access, emergency access, impact to sight lines, and sunny-day uses of the site.

D. Coastal Protection Typology

This section provides guidance for the planning, design, and selection of the coastal protection typology that will meet the City's goals for implementing projects that are equitable, resilient, and well-designed and that reflect the *Guiding Principles* provided in this document. Typology refers to the type of coastal protection features used to reduce coastal flood risk. A coastal protection system refers to the entirety of the coastal protection project including the coastal protection features and drainage infrastructure.

There is no one recommended typology. Instead, this section highlights factors to consider for typology selection, specifically: land availability, operations and maintenance needs, appropriateness of nature-based or green features, desire for future adaptability, and the potential for additional community and environmental benefits. Overall, these systems should be resistant to saltwater corrosion, as they may be in locations where they will be partially or wholly submerged continuously by ocean coastal waters.

There are many typologies and combinations of typologies that can be used for a coastal protection project. NYC DCP's "Urban Waterfront Adaptation Strategies" reviews adaptive strategies and typologies that can be used to increase the resilience of urban coastal areas to coastal hazards associated with sea level rise.[53]

I. Preference for Passive Systems

As covered in the *Guiding Principles*, the City's priority and preference is for passive systems that do not require any moving or deployable elements, including automated moving parts. Passive systems are preferred for their increased reliability, and lower operations and maintenance needs. Passive or fixed typologies include aboveground floodwalls, buried floodwalls,

52 Future tidal flooding at 2100 MHHW is the de facto standard.
53 (Urban Waterfront Adaptive Strategies, 2013)

levees, and road raisings. Deployable typologies include components with automated or self-deployed and human activated moving parts, such as flood gates (e.g., roller, swing, flip-up), and deployable pumps. Some flood gates have self-deployment mechanisms that automatically deploy the gates as water levels rise. These types of self-deploying gates are sometimes referred to as "passive" by gate manufacturers but are still considered to be a deployable typology by the City.

If a deployable system or component must be used due to requirements such as maintaining continuous physical access, the following guidance is provided to reduce their impact. Design should prioritize deployable features that minimize operations and maintenance needs but still maintain reliability. If automated parts are to be used, they must have a manual back-up to ensure the system can still be deployed if the automated feature is not functioning. Deployment systems that require loose components (e.g., stop logs) to be stored when the system is not activated should not be considered due to the additional operational and storage needs that can further complicate deployment. Deployable systems must also be evaluated for performance in storm conditions, including potential wave impacts.

As provided in earlier guidance, coastal protection systems should protect against current and future tidal flooding. Meeting the minimum flood elevation that protects against future tidal flooding and smaller, more frequent storms will require a completely passive system. It is not practical to deploy a system with every high tide, nor is it possible to deploy for every winter flood event (i.e., nor'easters) given the limited notification times associated with these storms.

II. Operations and Maintenance

Coastal protection projects can take on vastly different forms from natural berms and dunes to buried floodwalls under city streets. Regardless of the form, all projects must be operated and maintained or they will not serve their primary function of coastal protection. Minimizing the anticipated operations and maintenance (O&M) requirements (inspections, maintenance, activation) must be a primary focus throughout the entire project development, but also in the early stages

Figure 7: East Side Coastal Resiliency Section of Floodwall Under Construction

of planning and design. O&M needs will need to be planned for with the same level of detail and preparation for grey, hybrid, and nature-based infrastructure.

The operating agency that will ultimately manage the operations and maintenance of the system should be engaged as soon as possible in the development of design to consider operational risks, impacts, needs, and staffing capacities. Agencies also have their own internal guidelines and practices for operations and maintenance, inspections, and testing that should be consulted. To support the associated tasks, agencies may need to expand existing capacity with additional resources (staffing, equipment, contracting, etc.). Having that awareness from the outset helps inform project planning. All O&M decisions should be reviewed and approved by relevant operating agencies to ensure alignment with their larger agency-wide operations and expense budget planning processes. If a contractor will be procured for operations, procurement and training of the contractor should be completed prior to finalizing the system's construction so there are no gaps in operations.

Requirements for inspections and testing are another consideration for O&M and typology selection. FEMA-accredited projects have specific inspections requirements that should also be referred to as a best practice for non-FEMA accredited projects. This involves a certain frequency and level of inspections to ensure that the system can function properly during emergency activation.

Many projects will use new technologies that the City may not have experience operating and maintaining. To facilitate O&M, standardized infrastructure types should be considered whenever possible. This standardization should not preclude innovation but should help reduce differing technologies to create consistency across projects. Analyses for long-term O&M needs, including identification of activation triggers and estimates of equipment and labor needed to perform deployments, should be developed during early design phases (ideally at 30-50% design) and then continue to be refined throughout the design process. The ability of a coastal protection project to be activated in advance of a coastal storm must be closely coordinated with NYCEM's Coastal Storm Activation Playbook (CSAP) and in limited scenarios, the NYC Winter Weather Emergency Plan (WWEP). Here, the feedback loop between O&M planning and design is important for optimizing the effectiveness of the system itself. The time it takes for a system to be deployed must be in sync with the anticipated timeline for activation and must consider availability of equipment and personnel. Alternate routes must also be considered for traffic on city streets ahead of a storm for when gates are deployed. There are hours to days to mobilize and deploy these systems when activated and therefore efficiency is key.

Deployables have significant limitations during nor'easters due to the forecast timelines, which often only allow 24 to 36 hours' notice. This time constraint,

FEMA INSPECTION REQUIREMENTS

Requirements for inspections and testing are another consideration for O&M and typology selection. FEMA-accredited projects have specific inspections requirements that should also be referred to as a best practice for non-FEMA accredited projects. This involves a certain frequency and level of inspections to ensure that the system can function properly during emergency activation. The following inspections approach should be followed:

- *Quarterly Inspections* – routine visual inspections for preventative maintenance.
- *Annual Inspections and Operations* - performed in advance of hurricane season, annual inspections involve a more comprehensive inspection of gates, floodwalls, levees, drainage structures, etc. In addition, all closure mechanisms must be operated to demonstrate full functionality.
- *Periodic Inspections* – an engineering inspection conducted every 5 years to evaluate operational adequacy, assess the structural conditions of components, and structural stability of the overall system.
- *Periodic Assessments* – conducted every 10 years, this is an expansion of the Periodic Inspection to identify changes in storm threat which could result in higher design flood elevations, higher intensity rainfalls, or both; assess the magnitude of sea level rise experienced; and review updated projections of future sea level rise to assist the City in identifying a timeline for future modifications to the flood protection system.
- *Special Inspections* – to be performed after storm events that could damage the flood protection system.

often with low/moderate confidence, creates challenges to have enough time to mobilize teams, install the measures, address towing/no parking needs, and to work in inclement weather such as snow or ice. It is important that the project designers understand these limitations and design a passive system for the elevation of expected flooding from a nor'easter event.

In all cases, additional risk management actions are recommended. This includes developing an Operations and Maintenance Plan, regular training for deployment crews, exercises, education for the community, crews, agencies, and decision-makers, and contingency planning if deployable measures have mechanical failures time-of deployment.

a. Timing of Coastal Flood Events

For nor'easters, the City activates the WWEP. This plan addresses response for all winter hazards, which can include snow, extreme cold, icy conditions, and coastal flooding. Historically, this plan is activated approximately 1-2+ days in advance of the approaching weather. An evacuation order is not expected to occur during a nor'easter, due to the narrow window of time between a confident forecast and the arrival of the storm. The absence of an evacuation can make it even more critical for flood protection measures to be effective. Deployables are not recommended for nor'easter events because the current science does not allow sufficient time due to forecasting limitations.

For hurricanes, the City activates the CSAP and aims to convene the Coastal Storm Steering Committee at -120 hours from Zero Hour or the onset of sustained tropical storm force winds (39 MPH). Key operations and decisions are made when there is still low confidence in the forecast, including activating deployables. A hurricane could include the issuance of a general population evacuation order at approximately -48 hours before Zero Hour.

b. Activation of Deployable Components for Tropical Storms

Deployable flood protection system must factor in the forecast and operational constraints of coastal flood events. Deployable flood protection planning must factor the time needed for crews to mobilize, install, and get to high ground prior to the arrival of hazardous weather. This timeline needs to also factor in messaging and impacts to the community, including closing streets so crews can mobilize, and managing traffic and pedestrians.

Although activating deployables during a tropical storm (e.g., a hurricane) requires very complex, citywide operations when the forecast has high variability and low/moderate confidence, the long forecasting lead time is what makes it possible. As part of the operations and response plan, a traffic management plan must be created. Alternate egress or bypass routes must be considered for traffic on city streets ahead of a storm when deployable systems are activated, and the time needed to open gates should also be considered for street traffic diversions after a flood event if the system is in the public right-of-way. Project planning must also prioritize the health and safety of workers charged with deployment ahead of a coastal storm. Workers will need time to complete all deployment task within the City's coastal storm activation planning timeline, and before conditions become unsafe for personnel to be in the field.

III. Use of Natural and Nature-Based Typologies

Waterfronts with natural and nature-based infrastructure enhance New York City's ecological resources, provide environmental, health and recreational benefits, and provide critical benefits for coastal flood protection by attenuating wave action and reducing erosion. Natural and nature-based infrastructure should be considered in the typology selection and conceptual design approach. While incorporating natural or nature-based components can be challenging along New York City's more developed urban waterfronts, they should remain a priority if adequate protection can be provided. The use of natural and nature-based features should be particularly prioritized in neighborhoods with a high concentration of BIPOC communities that often have less access to nature-based amenities. As with gray infrastructure, the unique maintenance needs of natural and nature-based components must be considered as part of project planning to ensure long-term efficacy and success.

IV. Addressing Future Risks with Adaptability

The protection system may also have to adapt over time; therefore, the typology selection should consider future conditions and allow for future adaptability of the system. At minimum, the typology selection should not preclude future adaptation strategies. Projections for sea level rise may change over time as scientists learn more about the impacts of carbon emissions on the climate. The City should prepare the project for different future conditions and future adaptation of the system. When possible, a stronger foundation should be constructed that can accommodate structures with a higher design flood elevation in the future.

V. Added Benefits

The incorporation of a typology that allows design to include added benefits should be considered.
Added benefits can incorporate community identified goals, enhance the urban realm, and/or protect against additional heat and precipitation climate change hazards. They can include design features such as bike paths, recreation space, natural landscaping, or increased and improved waterfront access.

E. Interior Drainage

Understanding and mitigating drainage impacts is critical to project feasibility. Coastal protection projects can have unintended but significant negative consequences to interior drainage from heavy rain events by trapping water behind the system, and those consequences should be thoroughly understood during design. The mitigation of interior drainage impacts should be considered an essential component of the coastal protection project, not an add-on or after thought.

Analyzing drainage impacts should start in the early stages of analysis, and before recommending a specific coastal flood protection solution. Much of the detailed technical analysis will occur later in the design phase, but laying the groundwork by collecting information on existing conditions should start early in the design phase.

The drainage analysis should provide a comprehensive view of the hydrological and hydraulic conditions of the study area, including from coastal storm surge, tidal flooding, precipitation, and groundwater. Along with a thorough drainage analysis, there needs to be a comprehensive consideration of the sewershed, and evaluation of the cumulative impacts of adjacent projects. Compartmentalizing flood protection can have significant impacts to the drainage system capacity that often covers a larger watershed area, resulting in potential adverse effects to areas that are both within and outside of the protected project area.

The project design will need to consider current and future drainage needs. An assessment and inventory of drainage infrastructure can include any existing pump stations, should be conducted as part of the existing condition task to determine current performance and to evaluate the impacts of the coastal protection system on existing drainage infrastructure. The operational and structural integrity of the infrastructure should also be assessed for deterioration (which can contribute to interior flooding). This assessment should include a survey of soil conditions and the groundwater table. Existing conditions should also be used to inform current and future operations and maintenance needs to the drainage infrastructure to mitigate impacts, such as cleaning outfalls and pipes and removing obstructions from tide gates.

New York City's drainage network can experience flooding above what it was originally designed for during heavy precipitation events or by localized, intense storms (also called "cloudbursts"), causing flooding and backups. Climate change projections indicate that urban flooding is expected to increase in frequency in the city. The project should also consider the impacts of the coastal protection system in these extreme scenarios, especially for emergency operations planning.

I. Modeling Rain and Coastal Storm Events

Modeling will need to factor in the existing conditions in the neighborhood that impact the stormwater drainage such as the amount of impervious surface coverage and sewer size. Different storm surge/rainfall frequency scenarios should be modeled to determine the appropriate drainage needs for each project. Projects will have different parameters for surge, rainfall, and hydraulic grade line (HGL) in the sewer system depending on the unique characteristics and constraints of the study area.
Modeling should also be conducted for adjacent neighborhoods to the proposed project area to determine if the project and any associated drainage mitigation strategies will worsen conditions during a storm event.

Note – future versions of this report will have more detailed guidance on the parameters and modeling approach that are mentioned in this section.

II. Drainage Mitigation Solutions

There are three primary approaches to mitigating the interior drainage impacts of a coastal protection system. These mitigation solutions are not intended to absorb flooding from coastal waters, but rather to alleviate precipitation flooding on the sewer system during a concurrent coastal flood event. All approaches have significant constraints and challenges.

a. Pumps

Pumps can be used to pump out water from the interior side of flood walls during or after a storm event – or when exterior flood levels have lowered to an acceptable level. Pumps can be permanent or temporary equipment that is deployed before or after a storm event. Because a passive system is prioritized, the use of temporary pumps should be minimized. If temporary pumps will be deployed, the design should accommodate sufficient room to stage the equipment needed for operations including for the pumps, vehicles, and piping.

b. Storage

Grey or green storage can be used to alleviate additional stormwater volume on the interior drainage system. Grey storage such as large holding tanks systems can temporarily hold stormwater during a concurrent coastal flood and precipitation event. Green infrastructure incorporates nature-based features like large ponds or smaller rain gardens that can divert stormwater off city streets and out of the storm sewer system depending on volumes. Green infrastructure has its limitations as it has a much lower capacity to store stormwater compared to grey infrastructure and it may not be possible in areas that have high groundwater tables or dense underground infrastructure.

c. Additional Infrastructure Upgrades

Modifying regulators, installing tide gates, adding parallel conveyance systems, isolation gates, and sealed manhole covers can all be used to divert, transport, isolate, or block storm water during a storm event.

F. Benefit Cost Analysis

The benefit cost analysis (BCA) provides the monetary justification for a project by quantifying avoided losses and benefits. Federally funded projects require a positive benefit cost ratio (BCR) greater than 1, meaning quantified benefits must be greater than quantified costs over the project's useful life. HUD and FEMA, the most typical funders of these types of projects, each have their own BCA formulas with different categories and values and the project will need to meet these requirements.

Federal BCAs largely quantify damage and loss based on property values. HUD's BCA is more comprehensive by allowing social benefits, such as improved air quality or more recreational space, to be quantified and included as a benefit. As such, greater benefits can be captured by including design elements that provide environmental, open space, recreational, social, and health benefits. This is particularly important for lower resourced communities that often lack these benefits. Coastal protection projects are an opportunity to incorporate amenities into design.

The project team should also analyze the relationship between the BCA and DFE to help determine the optimal DFE that captures the most benefits. A higher DFE that captures more benefits, avoids more losses, and provides additional benefits can justify greater costs. Avoided losses for more frequent tidal flooding and smaller storms should be included as they often generate greater benefits over the project's useful life

I. Achieving a Feasible Benefit Cost Ratio

The BCA should be calculated and reassessed throughout design to ensure the project can reach a BCR greater than 1 by quantifying all potential costs and benefits. A high-level BCA should be conducted early in the design phase to determine feasibility, and refined as new information is gathered or as major factors change, such as project area, level of protection, or cost. All costs should be comprehensively accounted for as soon as possible, including scoping, design, construction and operations/maintenance. The most accurate value for properties should be included to ensure the BCA is capturing the most possible benefits. Costs can often go overlooked until the end of design (e.g., interior drainage mitigation) which can lead to a negative BCR, putting project feasibility at risk. Involved City agencies should be partners in this exercise.

SECTION 5.
CONCLUSION

SECTION 5: CONCLUSION

The design of neighborhood coastal flood protection projects is an immense undertaking due to their scale, complexity, and impact on the natural and built environment. They should be thoughtfully and cautiously approached. The purpose of this report is to provide guidance and a framework for decision-making for stakeholders to plan and design neighborhood coastal flood protection projects that are equitable, resilient, and well-designed. These projects are fundamentally about the allocation of resources to protect life, infrastructure, and property from coastal flood hazards with good and responsible urban planning and design. These projects should be built to prioritize the protection of the most vulnerable populations and critical infrastructure, using the best science to adapt the City's coastlines to sea level rise, and improve the daily experience of a neighborhood's waterfront for its residents.

Coastal protection projects can bring many benefits, but they are not a long-term solution for sea level rise. Human induced climate change will continue to raise sea levels and increase the intensity of coastal storms due to the burning of fossil fuels and loss of natural habitat. Growing inequality will continue to make BIPOC and under-resourced communities vulnerable to climate change hazards. We cannot design our way out of these problems. In the end, coastal protection projects buy time for our communities to learn to live more sustainably and equitably.

A. Areas in Need of Further Research

This report is a first version that was not able to provide guidance to all the topics involved with the implementation of neighborhood coastal flood protection projects. The following subjects below have been identified for further research with additional resources for future versions of this report:

<u>I. Neighborhood Selection</u>
A Coastal Flood Vulnerability Index that can be applied citywide for identifying and prioritizing which coastal neighborhoods are most vulnerable to coastal flooding and in need of coastal flood adaptation resources.

<u>II. Measurable Outcomes</u>
To ensure projects are implemented and managed in an equitable and transparent manner that holds government accountable, measurable outcomes will need to be developed to determine if the design and operation of these projects are meeting the city's goals.

<u>III. Neighborhood Coastal Risk Profile</u>
This report provides a framework to begin comprehensively assessing a neighborhood's risks from coastal flooding based on the vulnerability of its population and the built environment. However, more work is needed to develop an assessment tool to guide the alignment and height of coastal protection projects to optimize risk reduction.

<u>IV. Modeling Rain and Coastal Storm Events</u>
To ensure a consistent understanding of interior drainage mitigation needs across projects, a set of standardized storm surge/rainfall frequency scenarios will need to be developed to guide the appropriate approach. This standardized set could be supplemented with additional scenarios based on the unique characteristics of the study area.

<u>V. Benefit Cost Analysis</u>
The City does not have its own internal benefit cost analysis (BCA) that reflects the City's resiliency values and goals. A benefit cost analysis (BCA) that comprehensively quantifies social benefits and severity of consequences from coastal flood to life and livelihood, (not just quantified monetary value), should be developed to equitably analyze the cost effectiveness of projects.

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APPENDICES

APPENDIX 1: New York City Neighborhood Coastal Protection Projects

PROJECT NAME	PROJECT WEBSITE	NEIGHBORHOOD	BOROUGH	STATUS
Red Hook Coastal Resiliency	https://www1.nyc.gov/site/rhcr/index.page	Red Hook	Brooklyn	Design
Brooklyn Bridge to Montgomery Coastal Resilience	https://www1.nyc.gov/site/lmcr/progress/brooklyn-bridge-montgomery-coastal-resilience.page	Two Bridges	Manhattan	Design
Battery Coastal Resilience	https://www1.nyc.gov/site/lmcr/progress/battery-coastal-resilience.page	Financial District	Manhattan	Design
Seaport Coastal Resilience	https://www1.nyc.gov/site/lmcr/progress/seaport-coastal-resilience-project.page	Seaport	Manhattan	Planning
Battery Park City Projects	https://www1.nyc.gov/site/lmcr/progress/battery-park-city-resilience-projects.page	Battery Park City	Manhattan	Design
East Side Coastal Resiliency	https://www1.nyc.gov/site/escr/index.page	Lower East Side	Manhattan	Construction
USACE Rockaways Atlantic Shorefront Project	https://www.nan.usace.army.mil/Missions/Civil-Works/Projects-in-New-York/East-Rockaway-Inlet-to-Rockaway-inlet/	Far Rockaway	Queens	Construction
USACE Rockaways High Frequency Flood Risk Reduction Features (HFFRRFs)	https://www.nan.usace.army.mil/Missions/Civil-Works/Projects-in-New-York/East-Rockaway-Inlet-to-Rockaway-inlet/	Far Rockaway	Queens	Design
USACE South Shore of Staten Island Coastal Storm Risk Management Project (SSSI)	https://www.nan.usace.army.mil/Missions/Civil-Works/Projects-in-New-York/South-Shore-of-Staten-Island/	South Shore	Staten Island	Design

nyc.gov/resiliency