RED HOOK INTEGRATED FLOOD PROTECTION SYSTEM FEASIBILITY STUDY (IFPS)

RED HOOK

INTEGRATED FLOOD PROTECTION SYSTEM FEASIBILITY STUDY FINDINGS

The Mayor's Office of Resiliency (MOR), in partnership with the New York City Economic Development Corporation (NYCEDC), is working with local stakeholders to advance resiliency in Red Hook. The Integrated Flood Protection System (IFPS) Project is a federally and City-funded coastal protection initiative aimed at reducing flood risk due to coastal storms and sea level rise in Red Hook, Brooklyn.

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Project Overview

The Red Hook neighborhood saw unprecedented flooding during Hurricane Sandy which left many residents and businesses without basic services for weeks. The Red Hook IFPS was first recommended in 2013 in *A Stronger, More Resilient New York* as a critical step toward ensuring a more resilient Red Hook community in the face of future extreme weather and a changing climate.

The Red Hook IFPS is an important part of *OneNYC,* Mayor de Blasio's multilayered, $20 billion resiliency plan that the City is implementing around the five boroughs. The plan takes a comprehensive approach to resiliency with the vision that our neighborhoods, economy, and public services will be ready to withstand - and emerge stronger - from the impacts of climate change and other 21st century threats.

Integrated Flood Protection System (IFPS) Feasibility Study Goals

- Gain an understanding of flood risk in Red Hook and whether an IFPS is a feasible way to address these flood risks.
- Build a broader understanding of what comprehensive resiliency means in Red Hook.
- Identify a project for the Federal Emergency Management Agency (FEMA) Hazard Mitigation Grant Program (HMGP) application.
- Develop a proposal for a FEMA-eligible project that 1) reduces Red Hook's coastal flood risk with minimal impact on the neighborhood when there isn't a storm; 2) incorporates community and stakeholder priorities; and 3) is tailored to Red Hook and its unique waterfront.

Feasibility Criteria: What We Analyzed

Key Terms

10-YEAR FLOODPLAIN
The area that has a 10% chance of flooding in any given year (not an area that will flood only once in 10 years. Note - Several 10-year floods may follow one another in rapid succession.)

BASE FLOOD ELEVATION (BFE)
The height of flooding that might be expected in a 100-year flood. It is not measured from ground or sea level, but from a benchmark called the North American Vertical Datum of 1988 (NAVD88). It can be found on FEMA's Flood Insurance Rate Maps (FIRMs).

DESIGN FLOOD ELEVATION (DFE)
The Design Flood Elevation (DFE) corresponds to an elevation above sea level which flood protection interventions would have to be built to depending on the strength of the storm and location.

SEA LEVEL RISE
An increase of volume of the ocean's water, resulting in an increase in the mean sea level.

STORM SURGE
An abnormal rise of water generated by a storm, as a result of atmospheric pressure changes and wind. Storm surges are especially damaging if water is already at high astronomical tide.

What is a Feasibility Study?

- A feasibility study analyzes and evaluates a proposed project to see if it 1) is technically able to be built; 2) addresses community needs and goals; and 3) meets federal and other legal requirements.
- A feasibility study is the first step to develop a technically feasible project that meets FEMA HMGP funding requirements.
- The feasibility study for the IFPS builds upon the important resiliency work that has already been done in Red Hook and the City as a whole.

Funding

- This project has $50 Million FEMA Hazard Mitigation Grant Program (HMGP) funds from New York State and $50 Million in New York City Capital funds for a total of $100 Million committed for design, environmental review, and construction.
- FEMA needs to approve the IFPS project proposal in order for the City to access funding for design and construction.

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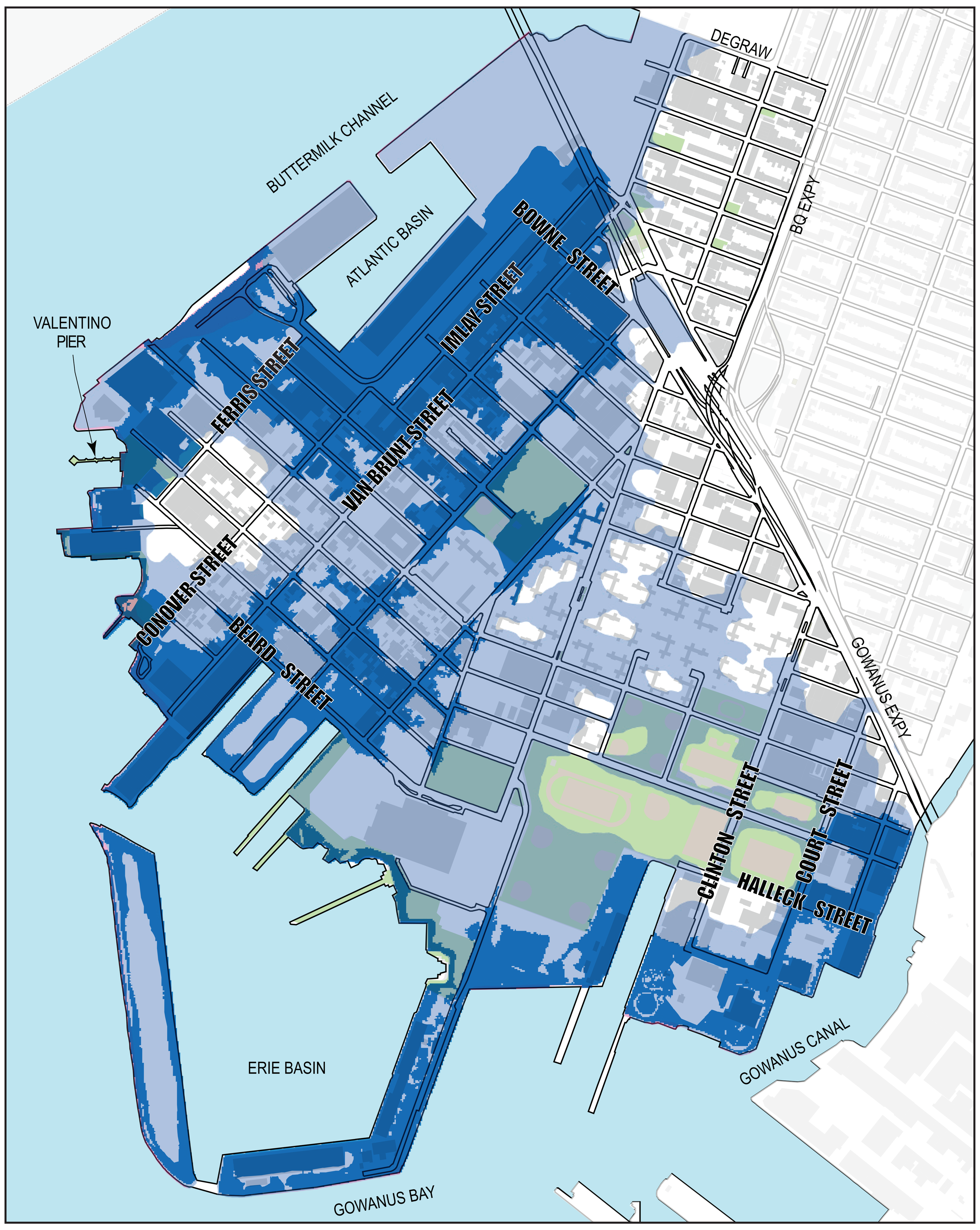
Flood Risk & Vulnerability



Red Hook Flood Risk

LEGEND

- 10-Year + 1 foot of Sea Level Rise (8 feet NAVD88 Floodplain)
- 2015 FEMA Preliminary 100-Year Floodplain
- NYC Parks

Summary of Vulnerability

The proposed project reduces flood risk from a 10-year storm, taking into account coastal storm surge and 1 foot of sea level rise. There are currently approximately 190 acres, 3,150 residents, and 500 buildings at risk of flooding during this level of storm in Red Hook.

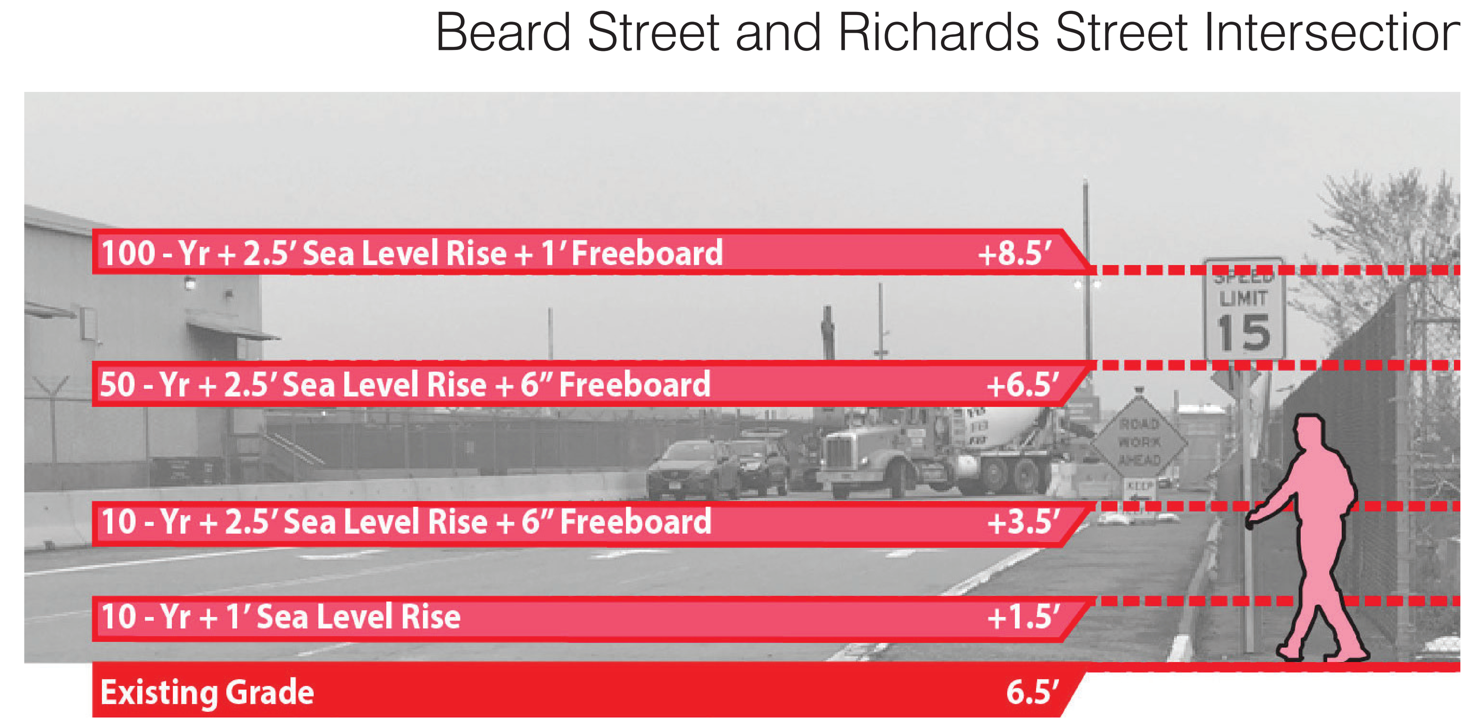
FEMA requires the following for this project:

- Must have independent utility - cannot depend on other separate projects or features to fully function
- Cannot have a negative impact on existing conditions or worsen flooding in other nearby locations
- Must have a Benefit-Cost Ratio (BCR) greater than 1, according to FEMA's Benefit Cost Analysis
- Must be permanent - no temporary measures such as sandbags

Design Flood Elevations & Example Structure Heights

Four DFE scenarios that provide varying levels of flood risk reduction benefits were considered as part of the feasibility analysis. These images demonstrate the intervention heights above ground level that would be required to protect from the four coastal storm event (DFE) scenarios Depending on the DFE scenario, average intervention heights at these locations range from approximately 1.5 feet to more than 10 feet above ground level.

Beard Street and Richards Street Intersection



Atlantic Basin at Clinton Wharf

Commerce Street and Imlay Street

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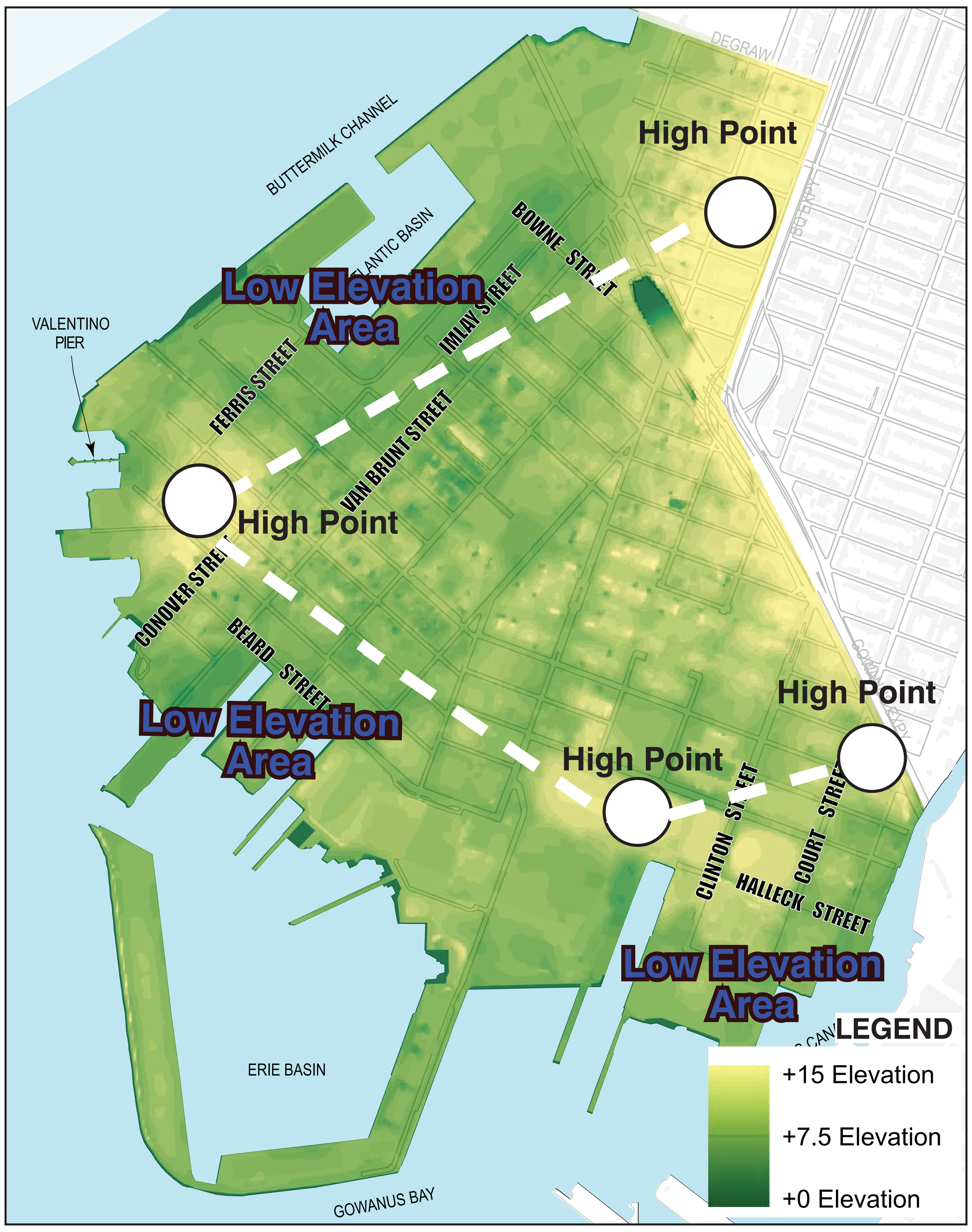
Site Conditions – Ground Elevations



Red Hook Topography:
A coastal flood protection structure is designed to connect high ground locations, reducing the risk of inundation via areas of low ground.

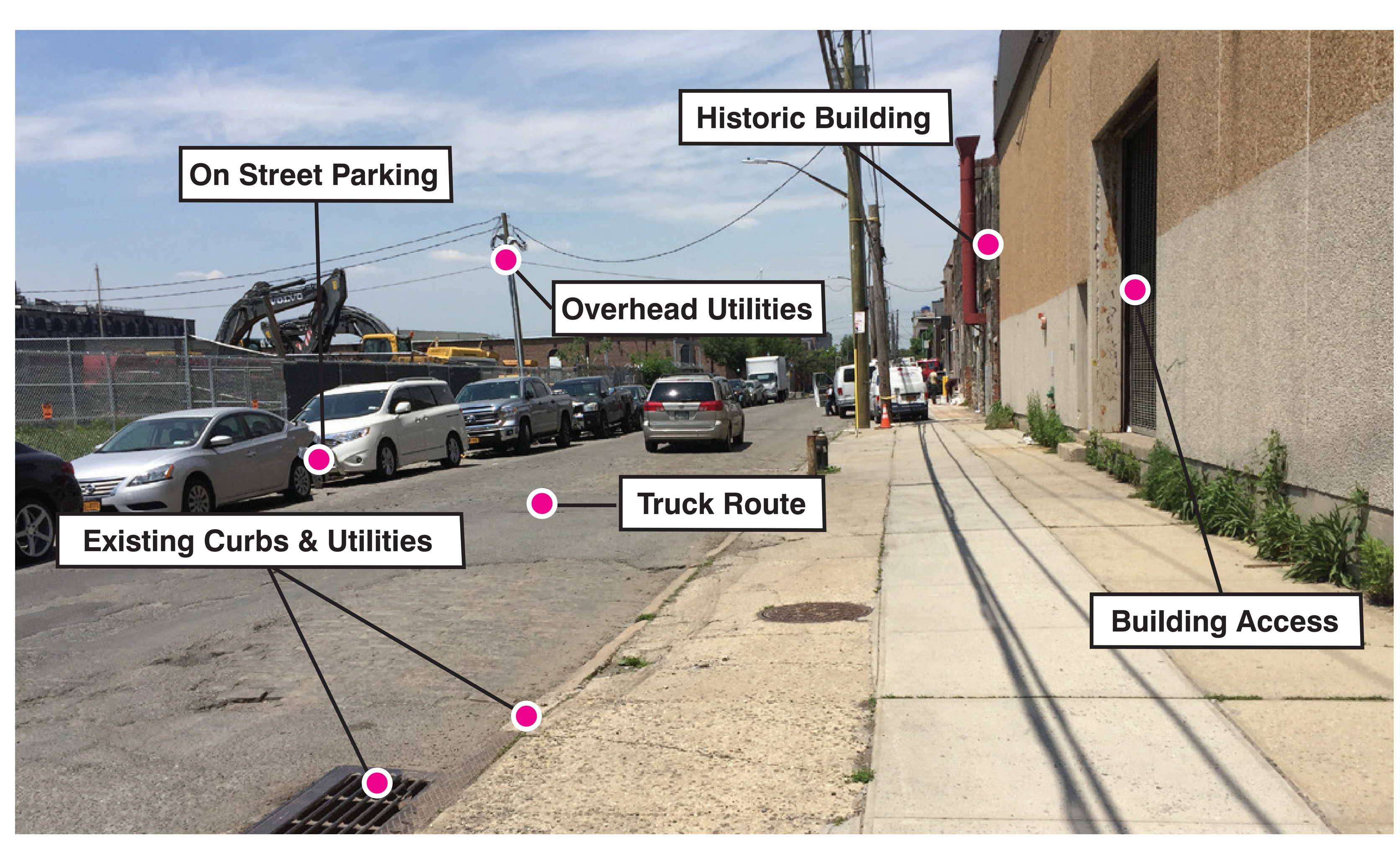
Site Conditions

Site conditions were an important consideration of the IFPS feasibility analysis because of their impact on how it can be designed and where it can be located.

- Elevations for 10-year to 100-year coastal storm surge events vary between 7 feet and 16 feet North American Vertical Datum (NAVD88)
- Low topographic ("low ground") areas are by the Gowanus Canal, the intersection at Beard Street and Richards Street, and Atlantic Basin by Clinton Wharf
- Transportation routes include bus, truck, bicycle, and NYC Ferry
- Older, often attached buildings with multiple pedestrian and garage openings make placement of a curb/sidewalk-area intervention and maintenance of access difficult.
- Active working waterfront structures would require retrofitting to provide flood protection which would add complexity to the current on-going operations and cost.
- Waterfront property is mostly privately owned

Site Conditions Examples

Residential Street: These conditions constrain the space available within the public Right-of-Way, the intervention type, and create public safety and access concerns with higher DFE and structure heights.



Commercial Street: These conditions constrain the height and location of proposed intervention types as well as the number of deployables needed to maintain access.

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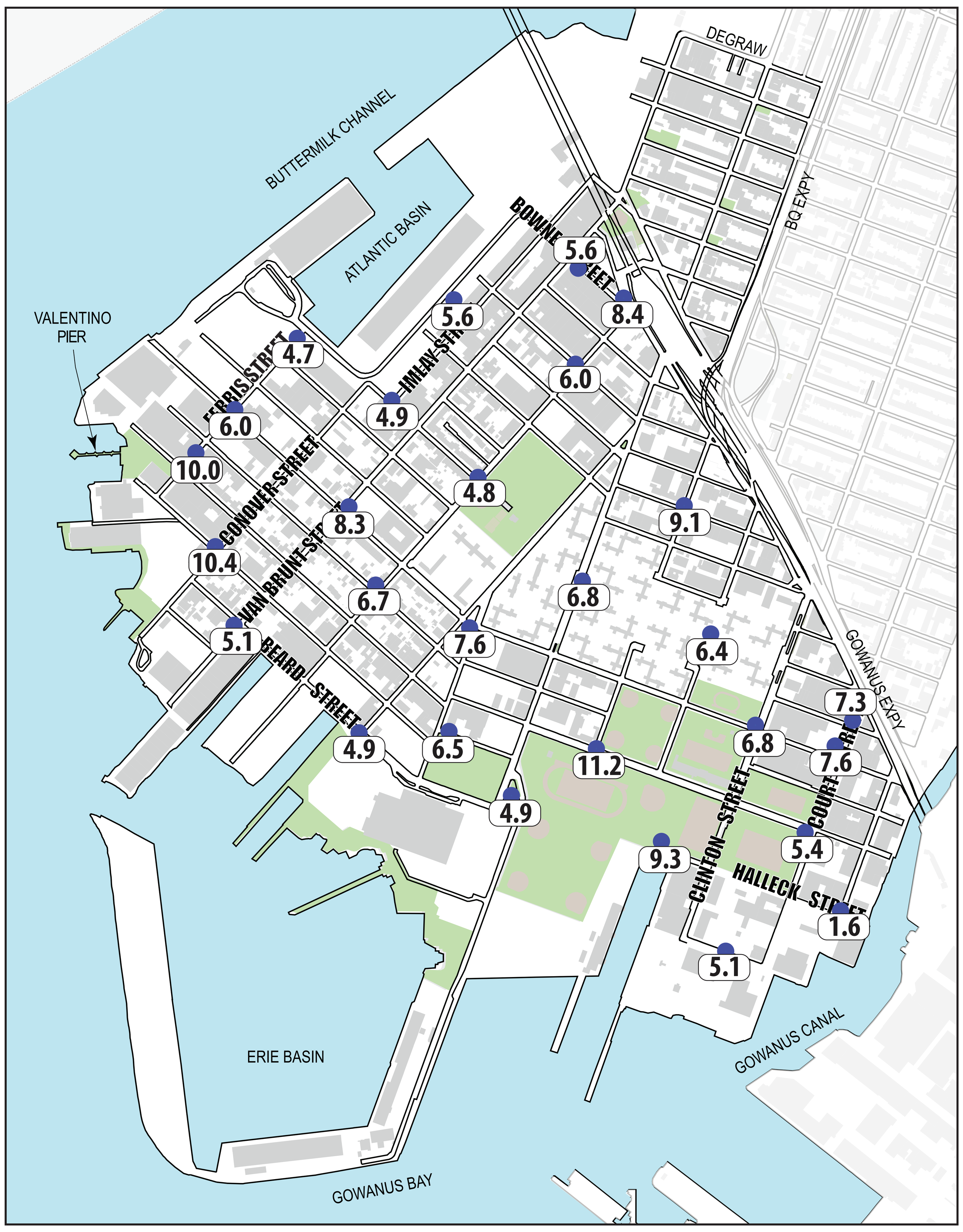
Site Conditions – Field Investigation Results

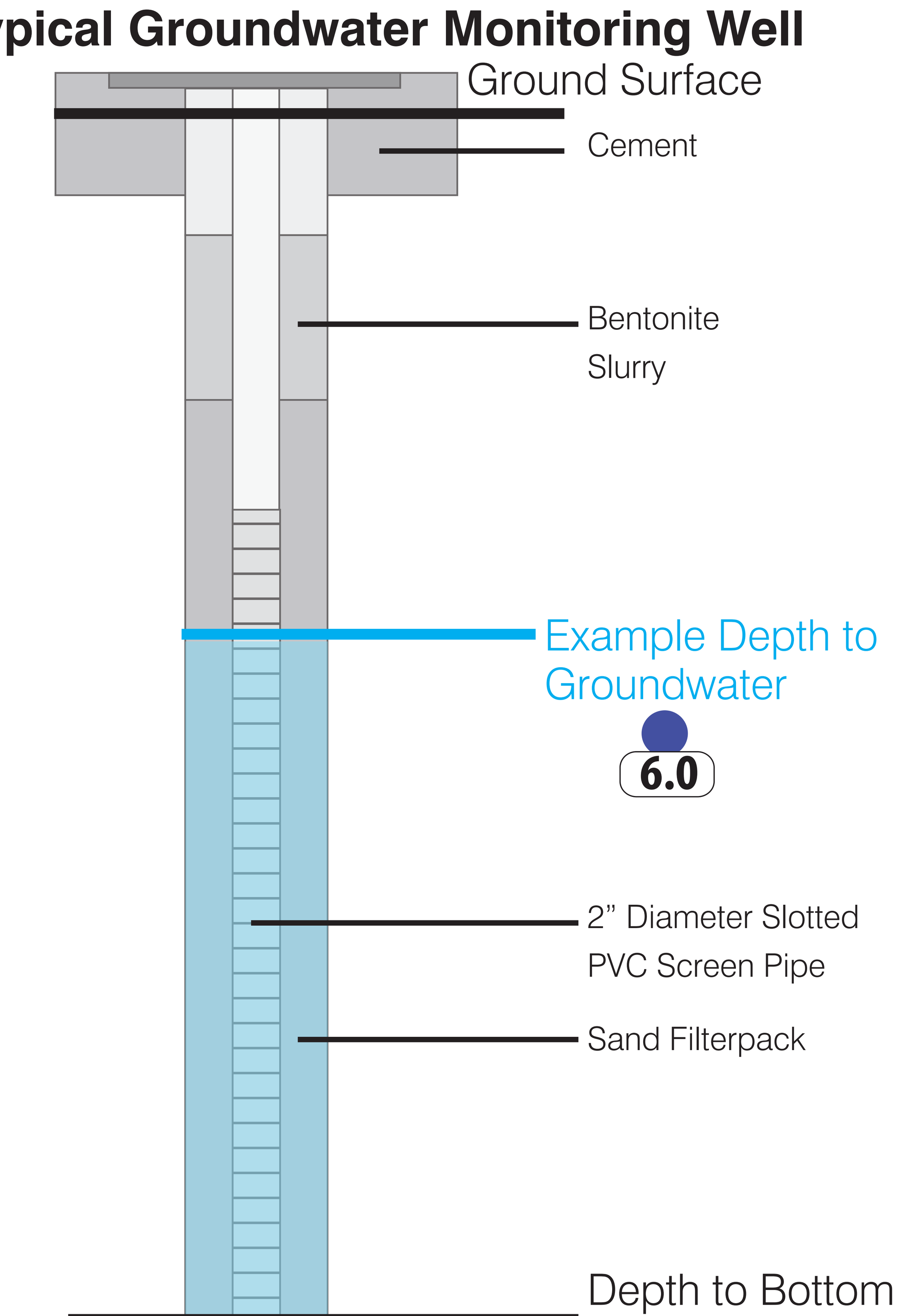


Red Hook Groundwater Depth

LEGEND ● Temporary Groundwater Monitoring Well Location (6.0) Groundwater Depth

NYC Parks

Typical Groundwater Monitoring Well



LiDAR/Topographic Survey

Groundwater Monitoring

Soil Borings

Soil and Groundwater Investigation Findings:

- Shallow groundwater depth (<10-feet below ground level)
- Potential seepage problems may allow coastal storm surge to enter through the soil

Impacts:

- Shallow groundwater depth makes green infrastructure ineffective in managing storm water
- Seepage barrier is needed and included in conceptual design
- Temporary or solely above-ground interventions may not effectively address seepage

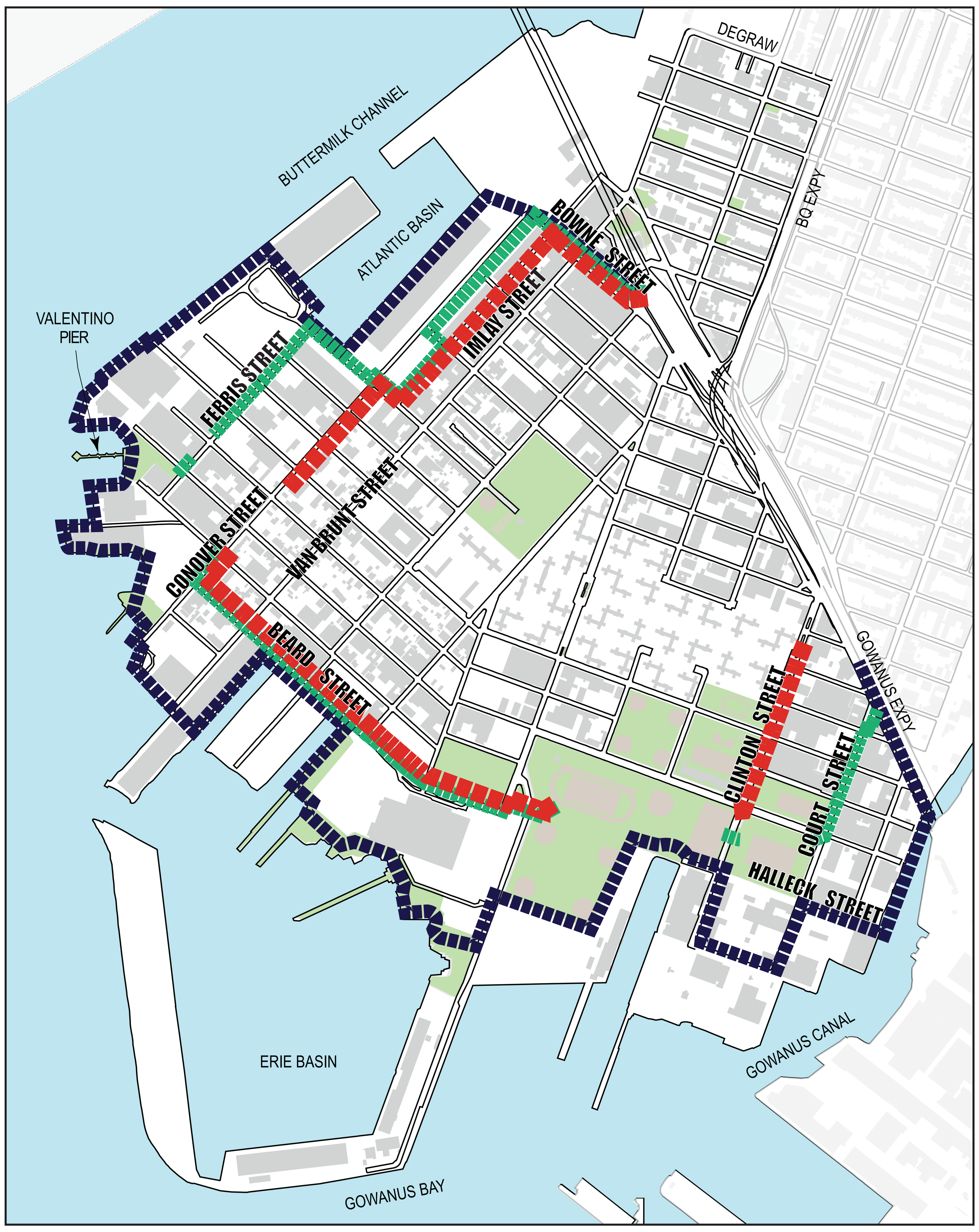
Topographic, Utility, and Boundary Survey:

The light detection and ranging (LiDAR)/topographic and utility survey identifies, in detail, potential conflicts with utilities, Right-of-Way, road width, sidewalk width, building entrances, and driveways.

RED HOOK INTEGRATED FLOOD PROTECTION SYSTEM FEASIBILITY STUDY (IFPS)

How the Proposed Conceptual Project was Developed

Coastal Protection Alignment Scenarios Analysis



LEGEND

Outermost Alignment | In-Between Alignment | Innermost Alignment | NYC Parks

Based on our analysis of existing conditions in Red Hook and flood risk from coastal storm surge and sea level rise, three alignment scenarios were developed and analyzed. Alignments are potential locations for the IFPS, and the scenarios can be mixed and matched. Generally, an alignment closer to the waterfront requires higher structure heights, and alignments further inland require lower structure heights for the same level of protection. Each alignment presented various benefits and significant challenges.

The Outermost Alignment follows mostly privately-owned land along the waterfront, and has no public land to construct an IFPS in the public right-of-way. It is approximately 19,000 feet (3.6 miles) long and requires higher and stronger walls to account for wave action and potential physical impacts from water-born objects. It has the greatest negative impacts to waterfront access and views.

The In-Between Alignment is approximately 11,850 feet (2.25 miles) long, takes advantage of natural high points, and is inland from the waterfront. It follows along public streets, and as such requires 43 deployable barriers when crossing intersections and building openings for pedestrians and vehicle access.

The Innermost Alignment is approximately 10,000 feet (1.9 miles) long and takes advantage of natural high points. It is the furthest inland from the waterfront, providing flood risk reduction benefit for the least land area compared to the other two alignment scenarios. Because it follows along public streets, it requires 38 deployable barriers when crossing intersections and building openings for pedestrians and vehicle access.

Given the goals of the project, the City wanted to identify an alignment that has the greatest potential to integrate into and enhance the unique urban fabric of Red Hook while also providing flood risk reduction benefits. The City decided to focus on analyzing the In-Between alignment at different DFEs.

Analysis of Four Design Flood Elevations

The study analyzed four DFE Alternatives, outlined in the chart below, for the In-Between alignment.

1: 10 year + 1' SLR (DFE 8 feet NAVD88)	Requires approx. 1.5 - 3 feet maximum intervention height above grade
2: 10 year + 2.5' SLR + 0.5' FB (DFE 10 feet NAVD88)	Requires approx. 3 feet of average intervention height above grade
3: 50 year + 2.5' SLR + 0.5' FB (DFE 13 feet NAVD88)	Requires approx. 6 feet of average intervention height above grade
4: 100 year + 2.5'SLR + 1' FB (DFE 16 feet + NAVD88)	Requires approx. 9 feet of average intervention height above grade
SLR = Sea Level Rise FB = Freeboard, an additional amount of height above the BFE to provide a factor of safety.	

- DFE 1 focuses the IFPS on the two lowest points in the neighborhood at Atlantic Basin and Beard Street.
- DFE 1 can be integrated into the neighborhood, avoiding the need for deployable structures, which impact the reliability of the whole system. DFEs 2, 3, and 4 would require 25 or more deployable structures
- DFE 1 has negligible impacts on views and pedestrian/ vehicle flow compared to other alternatives
- DFE 1 allows for future adaptability of the flood protection structure along Beard Street
- All DFEs, except DFE. 1, have drainage impacts

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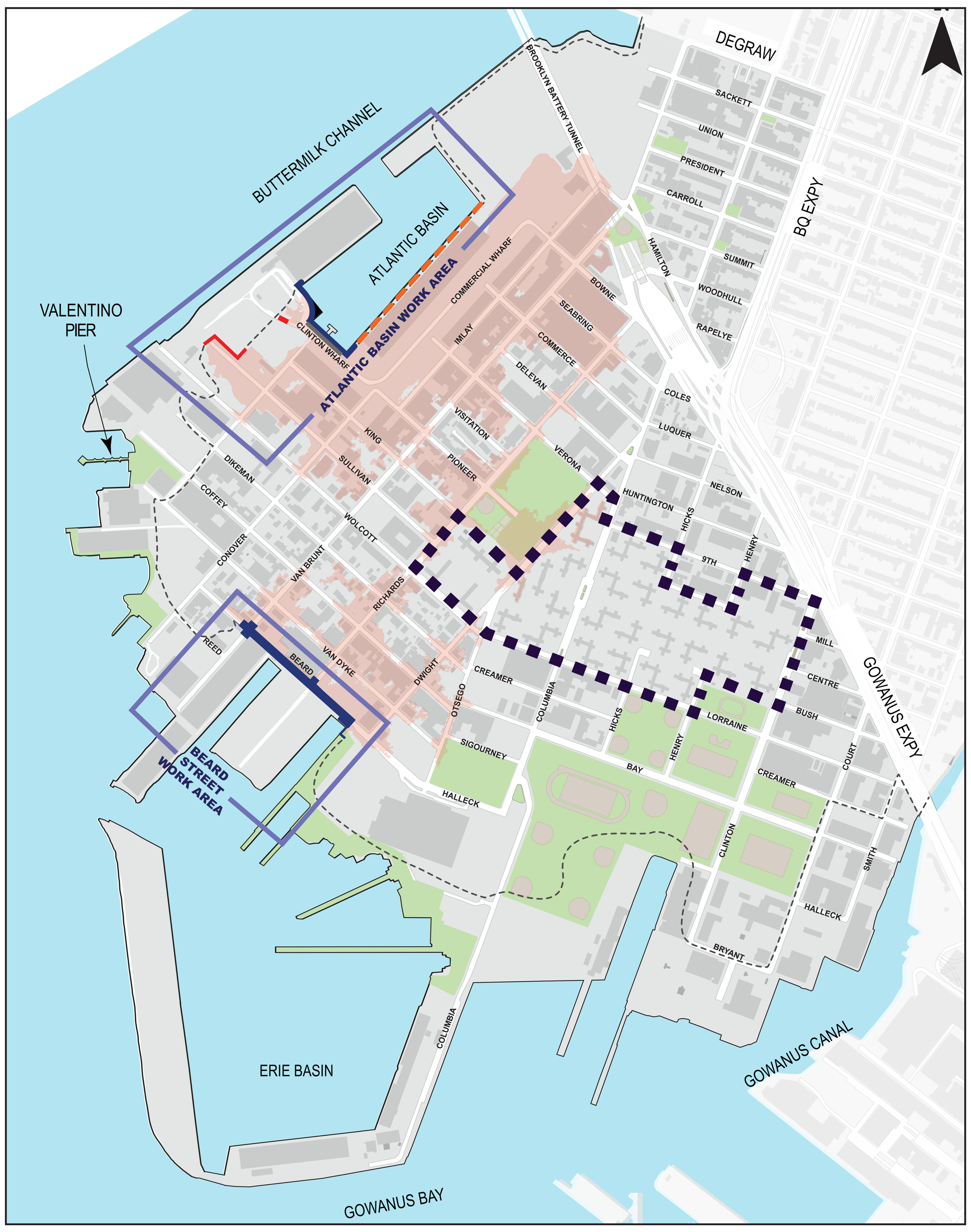
Proposed Conceptual Project for Review and Approval by FEMA



LEGEND
- Flood Risk Reduction Area
- Work Area
- High Ground Elevation (>8ft NAVD88)
- NYC Parks
- NYCHA*

Proposed Project Features

Based on the feasibility assessment analysis, the City is proposing to focus on two low points that are most vulnerable to coastal storm surge and sea level rise along Beard Street and on Atlantic Basin. This approach maximizes coastal flood risk reduction benefits while minimizing negative impacts on the neighborhood.

The project will consist of flood walls covered by raised and re-graded streets to fully integrate the flood protection system into the community:

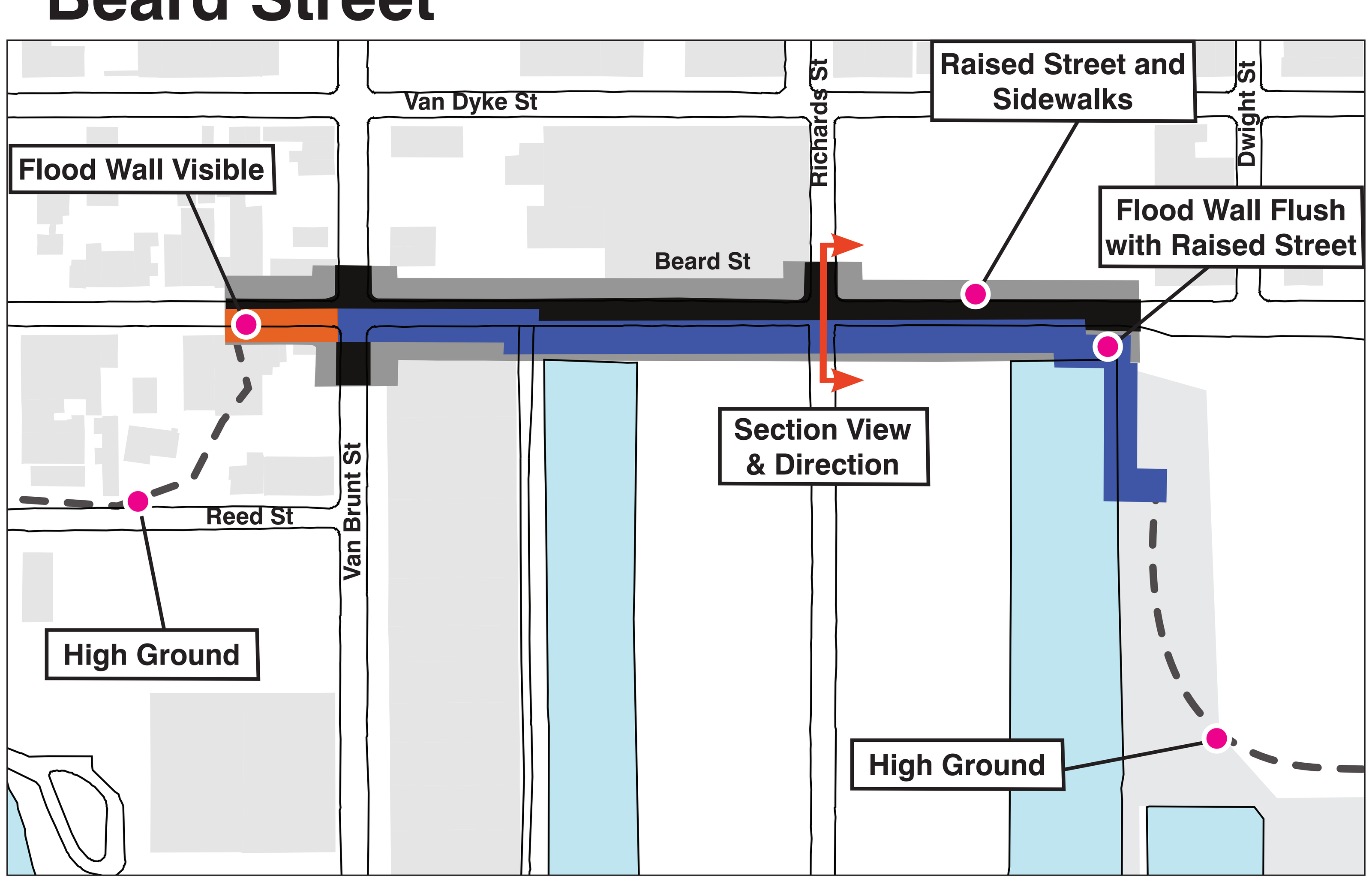
- A floodwall underneath a portion of Beard Street to be covered by raising and regrading the street
- A floodwall under regraded streets and an upgraded bulkhead at Atlantic Basin

Proposed Project Benefits

- Reduces flood risks from a 10-year coastal storm surge accounting for 1-foot of future sea level rise
- Provides flood risk reduction benefits for approximately 3,000 residents and 400 buildings
- The foundation of the coastal flood structure along Beard Street will allow for future adaptability
- Does not require use of deployable structures
- Does not have negative impacts on drainage

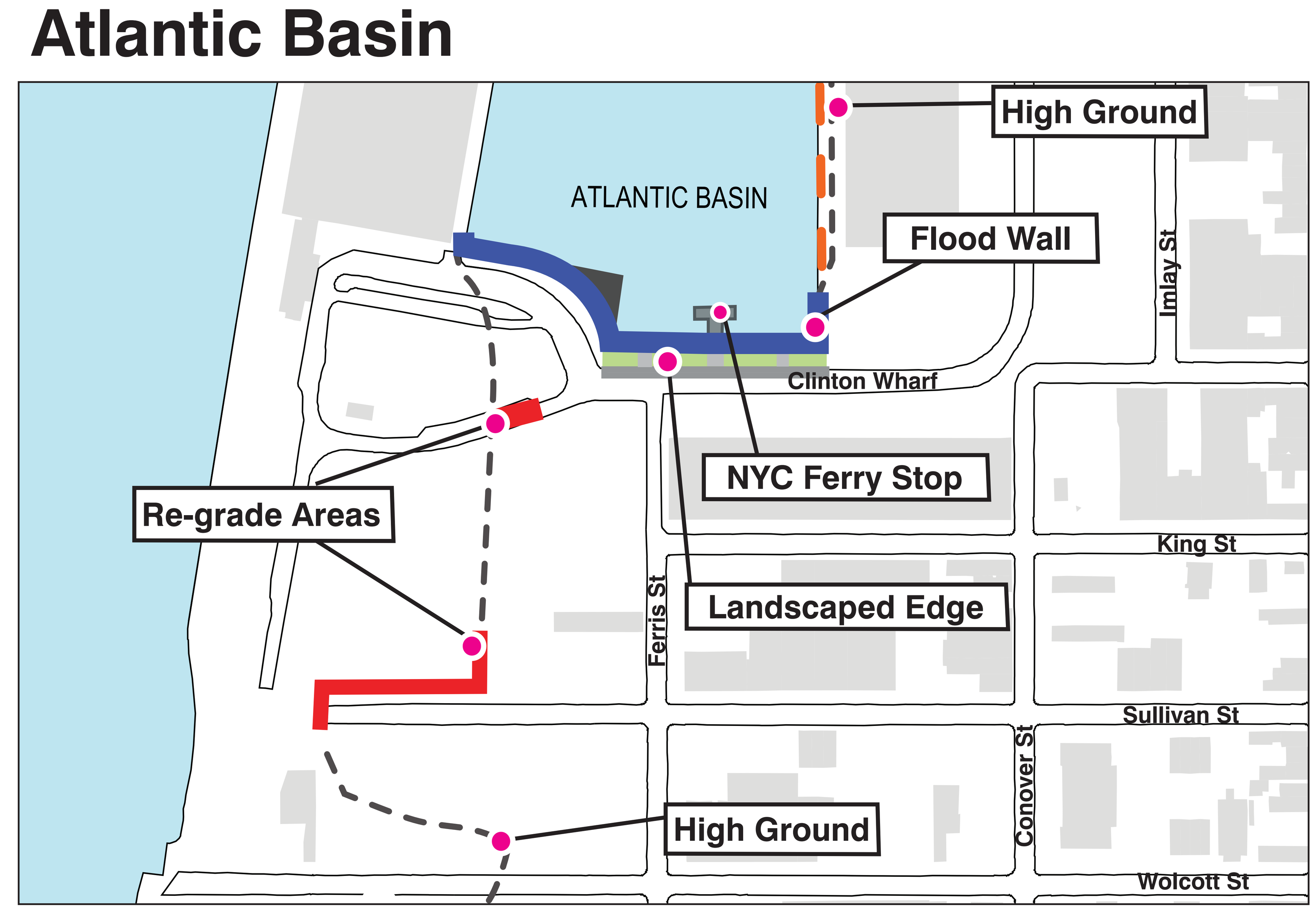
*Separate NYCHA FEMA-funded Recovery and Resiliency Project. For more information visit: on.nyc.gov/nycha-sandy.

Beard Street



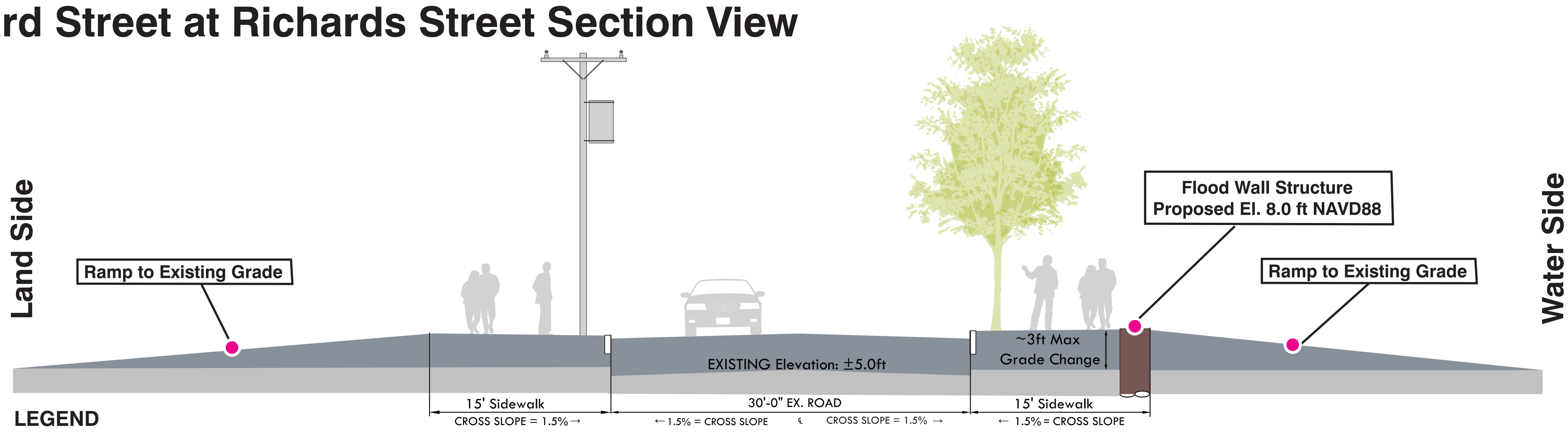
LEGEND
- Raised Street
- Raised Sidewalk
- Flood Wall Flush with Raised Street/Sidewalks
- Flood Wall Structure Visible (Max 1ft Above Ground)
- High Ground Elevation (>8ft NAVD88)

Atlantic Basin



LEGEND
- Flood Wall Structure
- Re-grade Area
- Landscaped Edge
- Reinforce Existing Bulkhead
- High Ground Elevation (>8ft NAVD88)

Beard Street at Richards Street Section View



LEGEND
- Existing Grade (~5ft NAVD88)
- Proposed Grade (8' NAVD88 at Flood Wall Structure; Maximum 3 feet increase)

CLIMATE RISK / HAZARD MITIGATION

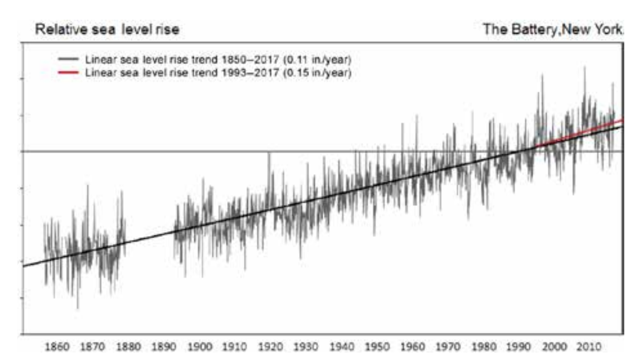
CLIMATE HAZARDS

In the coming years New York City (NYC) will face new challenges from a rapidly changing climate. Understanding the historical climate data and developing projections based on scientific evidence of climate change, provides the basis for decision making and planning to determine the appropriate resilient design strategies.

DID YOU KNOW ?

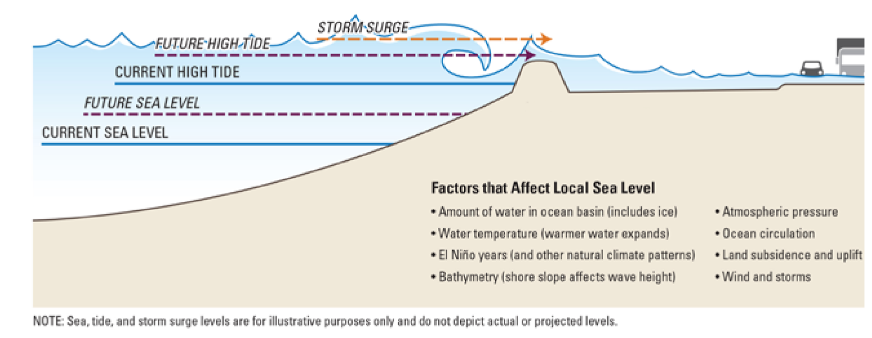
SEA LEVEL IS RISING IN NYC

Sea level rise in New York has averaged 1-2 inches over the last decade. Sea level is rising faster in the northeast US and is expected to rise 0.7 – 2.5 feet by the 2050s.



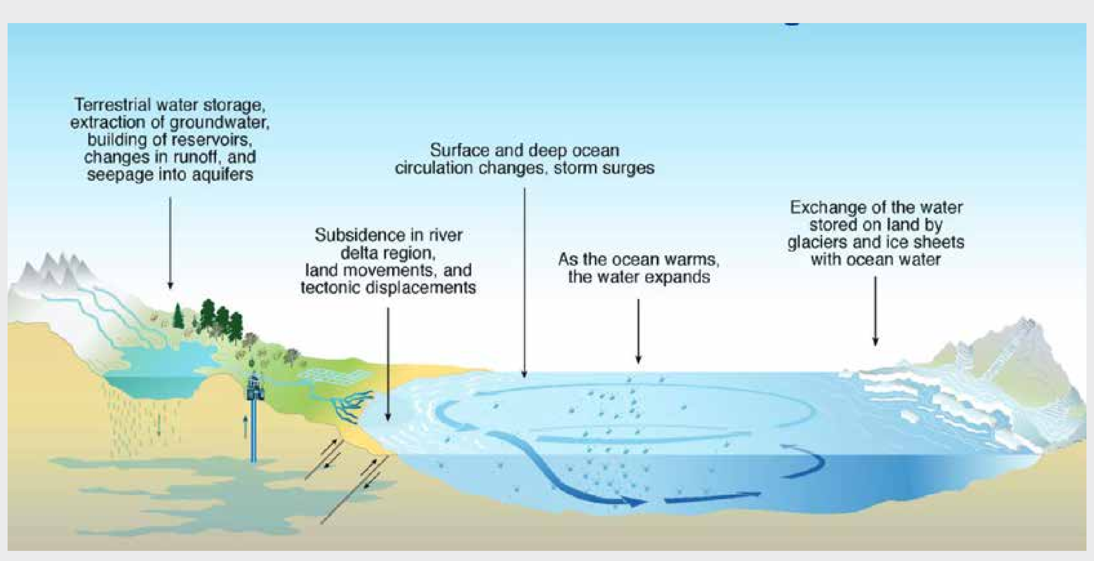
FLOODING IS GETTING WORSE

Storm surge represents short-term high water levels superimposed on to mean sea level. The current 100 year flood can produce approximately an 8.6 feet surge.

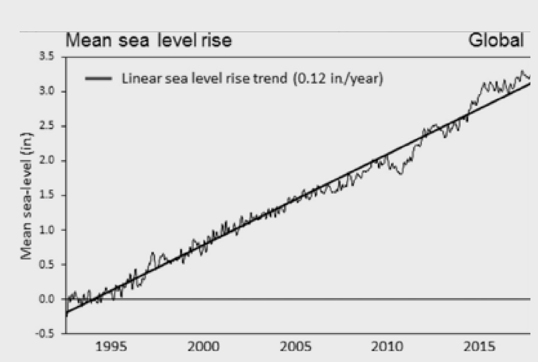


TERMS TO UNDERSTAND

FLOOD RISK



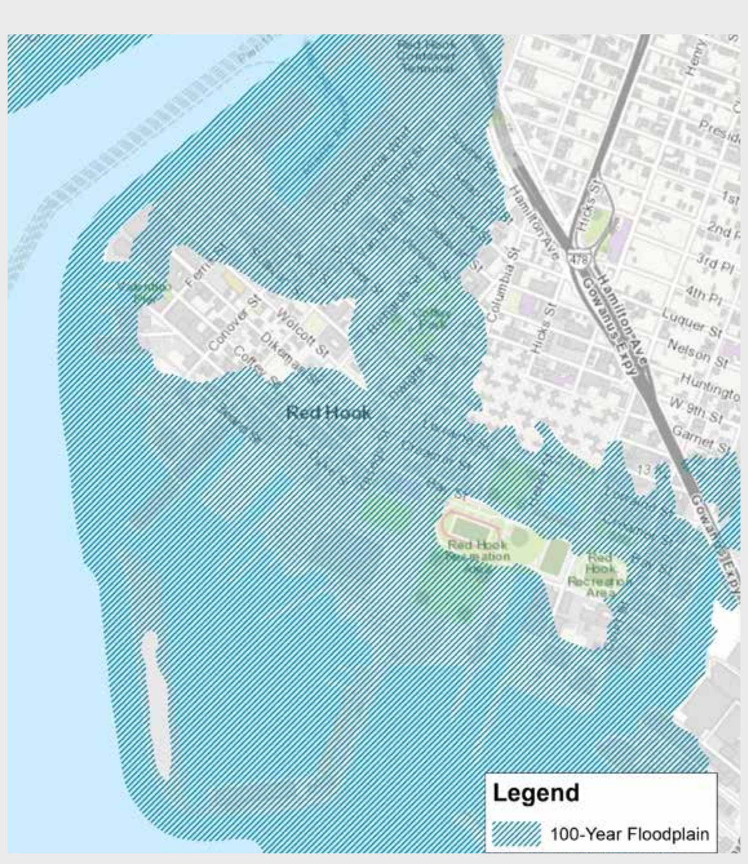
Causes of sea level change



Global mean sea level rise during the satellite era, 1993–2018 (AVISO, France).

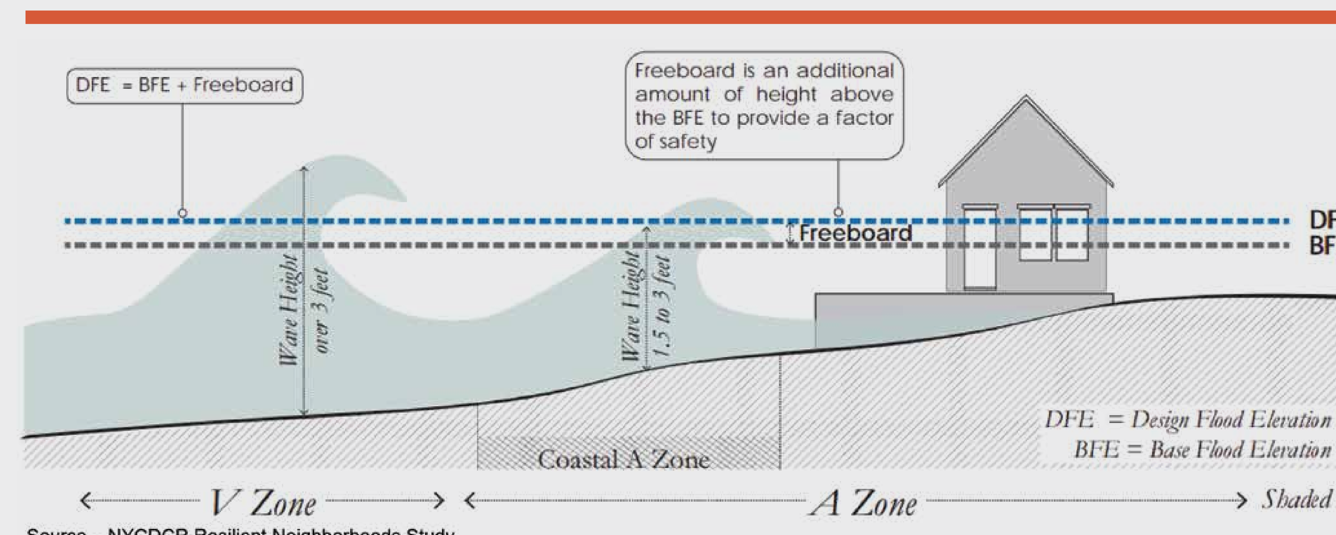
Sea Level Rise (SLR): The increase in the level of the world's oceans due to the effects of climate change.

Return Period: The estimated average time between a flood or storm event. Example: The return period or recurrence interval for the 100-year flood is 100 years.



Annual Exceedance Probability: The probability (or percent chance) of a flood or storm event occurring in any year at a given severity or higher.

FLOOD ELEVATIONS



100-Year Flood: A flood that has a 1% chance of occurring in a given year.

Base Flood Elevation (BFE): The elevation of water that occurs during the 100-year flood

Design Flood Elevation (DFE): The highest level of flood protection provided by a flood resiliency project.

JOINT PROBABILITY

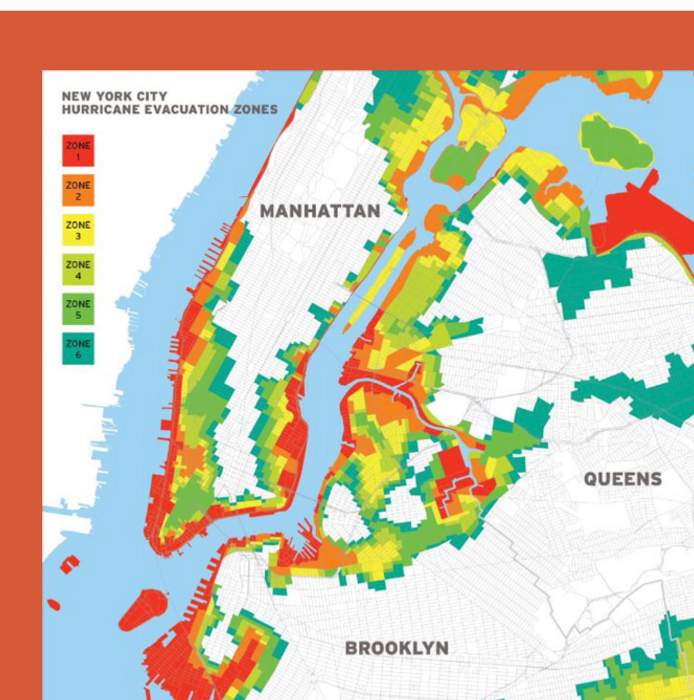
Joint Probability: The likelihood of two or more events occuring at the same time. In the context of flooding, the two events of interest are storm surges and high-intensity rainfall.

Joint probability analyses can be used to determine the probability of a storm surge coincident with rainfall, which allows a better assessment of flood risk.

? WHAT MAKES A FLOOD RESILIENT NEIGHBORHOOD

- Community stakeholders understand potential future conditions due to Climate Change and are engaged in planning for the future.
- Residents know their flood risk and how to prepare in the event of a storm
- Its infrastructure systems can withstand significant flood events.

Note: In the event of a coastal storm event, residents should listen to the media or call 311 to determine which evacuation zone(s) are under an evacuation order. The goals of the RHCR project are to protect property and ensure that the community can return quicker after a storm. The community will need to heed evacuation orders, when issued, even after this system is built.



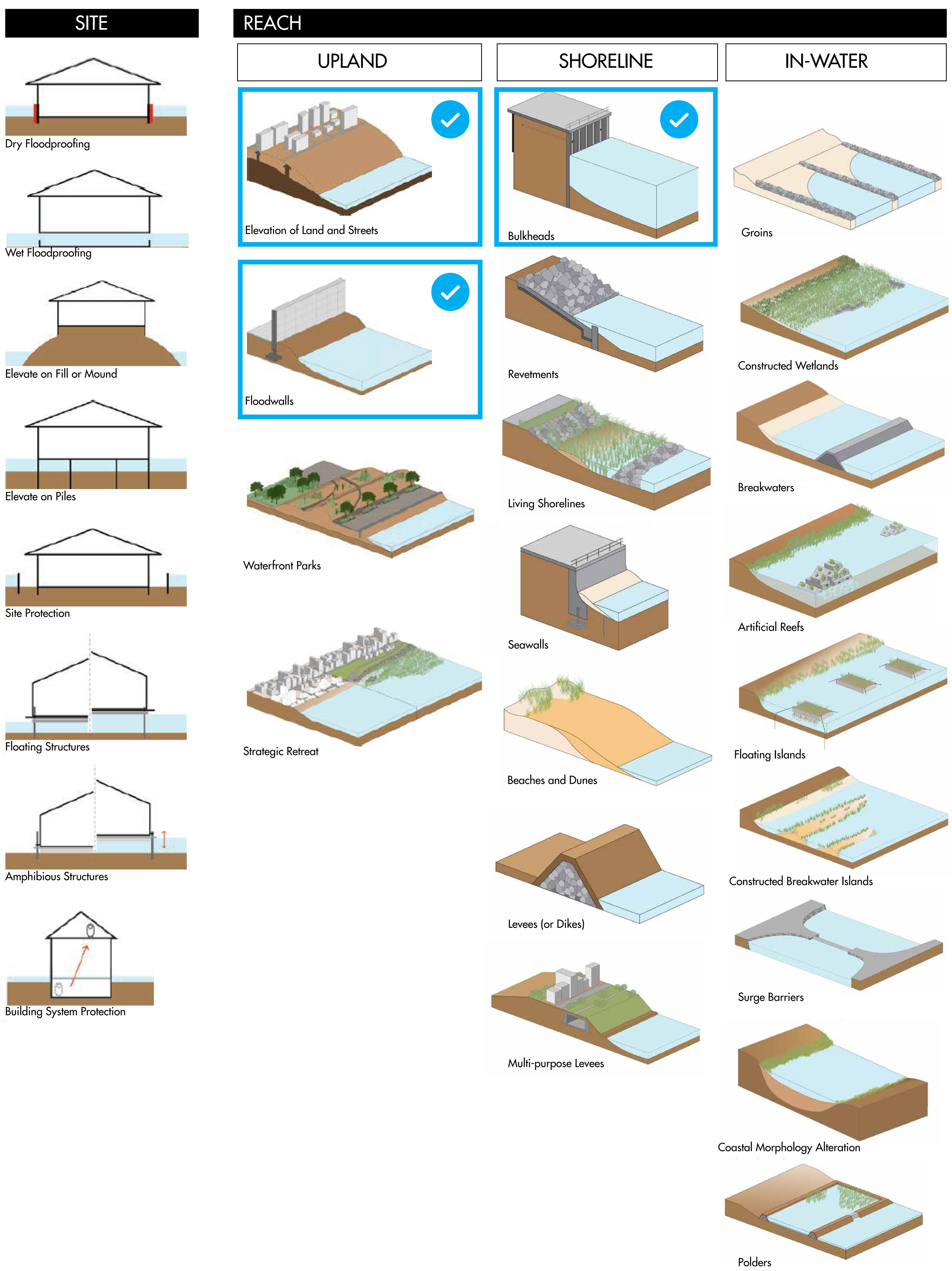
CLIMATE RISK / HAZARD MITIGATION

WHAT IS HAZARD MITIGATION?

Mitigation is the effort to reduce loss of life and property by lessening the impact of disasters. In order for mitigation to be effective we need to take action now—before the next disaster—to reduce human and financial consequences later (analyzing risk, reducing risk, and insuring against risk). It is important to know that disasters can happen at any time and any place and if we are not prepared, consequences can be fatal. To effectively mitigate hazards, it is critical to better understand climate risks.

ADAPTIVE STRATEGIES TOOLKIT

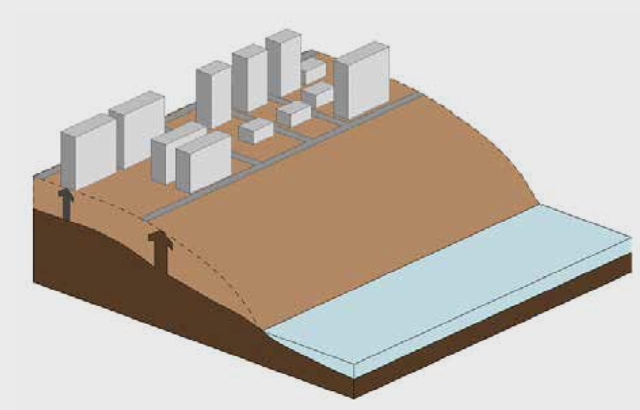
SOURCE: URBAN WATERFRONT ADAPTIVE STRATEGIES, DEPARTMENT OF CITY PLANNING



The Adaptive Strategies Toolkit is intended to serve as a roadmap for municipal leaders working to make their communities more resilient to the impacts of a flood disaster. The Toolkit outlines options that need to be further explored on an individual basis and together as part of a flood protection system, in context of a specific project like the Red Hook Coastal Resiliency. Creating a more resilient neighborhood is a long-term, on-going process of assessing risks, developing and evaluating alternatives, and implementing flexible and adaptive strategies. The evaluation process should be based on a risk-management approach that takes into account a wide range of potential costs and benefits, and is informed by stakeholder input.

STRATEGIES FOR RHCR

ELEVATION OF LAND AND STREETS



Elevating land and streets is a strategy that works best at a neighborhood scale, where both lots and streets can be raised in a coordinated manner. Elevating land and streets reduces risk from frequent inundation and surge events by elevating land to above expected flood levels. This strategy is most suitable for low-lying areas that are vulnerable surge. It is best for protection against low storm surges and frequent flooding due to sea level rise.

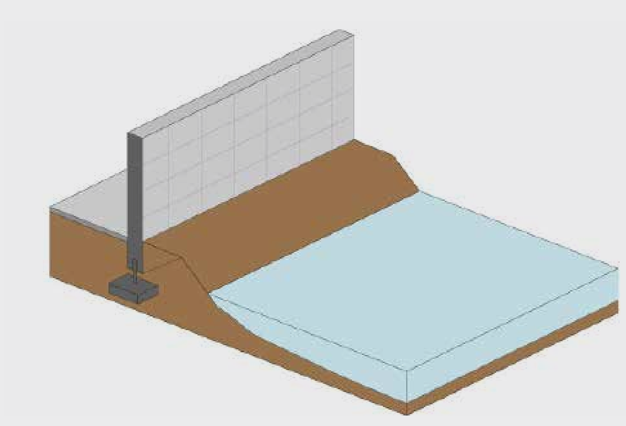
ADVANTAGES

- low maintenance cost
- opportunity to improve subsurface utilities and infrastructure
- brownfield remediation can be done in conjunction

DISADVANTAGES

- high initial cost from construction
- significant disruption to existing land uses during construction
- potential impacts to existing natural and historical resources

FLOODWALLS



Floodwalls are vertical structures anchored into the ground that are designed to withstand flooding from storm surge. They prevent areas behind the wall from flooding and can protect from frequent flooding due to sea level rise.

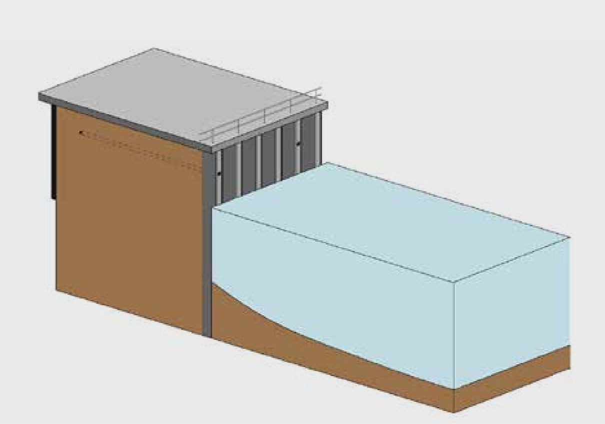
ADVANTAGES

- Can be incorporated into the design of open space to create a flood protection system that is integrated into the urban fabric

DISADVANTAGES

- Potentially separates areas from the waterfront, both visually and physically, which may reduce space for water-dependent uses

BULKHEADS



Bulkheads are vertical retaining walls intended to hold soil in place and allow for a stable shoreline. They protect sites from erosion and moderate wave action. They are not designed to protect from major flood events but do manage daily and monthly fluctuations in tide levels. Bulkheads are most suitable for locations where space is in high demand or where water-dependent uses, such as barge loading and unloading, require a steep vertical shoreline.

ADVANTAGES

- Facilitates maritime vessel access
- Space efficient

DISADVANTAGES

- Can reduce the intertidal zone, which is ecologically productive and provides other ecosystem services such as water quality improvement and wave and wake attenuation
- Incremental raising of new bulkheads to account for sea level rise can be difficult

Mayor's Office of Resiliency
Department of Design and Construction

COMMUNITY INPUT: WHAT WE'VE HEARD SO FAR

OVERVIEW

The success of the Red Hook Coastal Resiliency Project relies on community involvement. Your feedback will help determine the best solutions for reducing flood risk in Red Hook while enhancing places, spaces, and access along the waterfront.

COMMUNITY PRIORITIES

Do you agree with what's listed below? Place a dot in the white rectangle under your top three priorities. Use a post-it to add anything that we may have missed.

WATERFRONT ACCESS AND NEIGHBORHOOD CHARACTER

- Preserve and enhance access to the waterfront
- Preserve Red Hook's identity as a waterfront community and enhance water-based experiences
- Maintain maritime capacity

FLOOD PROTECTION

- Maximize protection of building stock
- Multi-use protective infrastructure (things that serve as amenities not just flood protection)
- Address flood protection needs outside the line of protection and in the interim while protection is in progress

PREPAREDNESS

- Importance of having a better informed community with respect to natural disasters
- Emergency response and readiness training for residents and businesses

COMMUNITY INVOLVEMENT

Provide opportunities throughout project for community input

COORDINATION WITH OTHER PROJECTS

Ensure proper coordination between city agencies and projects to share resources efficiently

JOBS AND JOB TRAINING

Tie in the implementation and construction to local jobs and job training

DRAINAGE

Importance of addressing the CSOs (Combined Sewer Overflow)

Note: A combined sewer is a sewage collection system of pipes and tunnels designed to simultaneously collect surface runoff and sewage water in a shared system.

COMMUNITY INPUT: WHAT WE'VE HEARD SO FAR

OVERVIEW

The success of the Red Hook Coastal Resiliency Project relies on community involvement. Your feedback will help determine the best solutions for reducing flood risk in Red Hook while enhancing places, spaces, and access along the waterfront.

WHAT WE'VE HEARD FROM DIFFERENT GROUPS

Did we capture everything? Use a post-it to add anything that we may have missed.

LOCAL RESIDENTS

- Minimize impact to residential streets
- Maintain parking
- Provide additional trees

LOCAL BUSINESSES

- Van Brunt should be pedestrian and bike-friendly
- Provide streetscape amenities
- Minimize impact to commercial function and transit

LOCAL INDUSTRIES

- Protect and enhance maritime uses
- Consider the pollution in the area
- Create a pedestrian-friendly environment

WATERFRONT AND PARKS USERS

- Integrate the protection elements with the recreation and streetscape elements
- Provide the community with tools to make decisions with respect to flood protection versus recreation
- Preserve the views of the neighborhood and the waterfront
- Coordinate with the Parks Department to improve the parks