THE BROOKLYN WATERFRONT GREENWAY

An Agent for Green Infrastructure, Climate Change Adaptation, and Resilience

NYS Department of State
Brooklyn Greenway Initiative
WE Design
eDesign Dynamics

CONTENTS

ACKNOWLEDGMENTS

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The study would not have been possible without the exceptional support and contributions of NYC Department of Transportation (DOT), NYC Department of Environmental Protection (DEP) and NYC Department of Design & Construction (DDC). The Brooklyn Waterfront Greenway project cuts across departmental jurisdictions and Brooklyn Greenway Initiative's (BGI) objective of leveraging the construction of the Greenway to achieve unprecedented stormwater management benefits. It has required deep contributions and access to information from each agency. We are most appreciative of the spirit in which DOT, DEP and DDC embraced the potential for new possibilities in cross jurisdictional stormwater management strategies. Throughout the process this work has benefited from the support and guidance of the NYS Department of State Coastal Resources Division, The Brooklyn Borough President's Office and the Mayor's Office for Long-Term Planning and Sustainability.

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S.W.I.M. Coalition

PURPOSE

The Brooklyn Greenway Initiative procured the design and engineering services of WE Design and eDesign Dynamics, through a grant from NYS Department of State Local Waterfront Revitalization Program on a project funded by the NYS Environmental Protection Fund, to develop stormwater infrastructure design guidelines for the 14-mile Brooklyn Greenway. The majority of the Brooklyn Greenway was inundated during Hurricane Sandy and lies within the 1% probability flood risk zone. This project includes looking at ways the Brooklyn Greenway can also provide climate change and flood resilience for adjacent communities.

The New York City Department of Transportation's Brooklyn Waterfront Greenway Implementation Plan details 23 capital projects stretching from Newtown Creek to Bay Ridge. Each of these Greenway "Segments" will run near the lowest contours of Brooklyn's East River sub-watersheds. Brooklyn Greenway Initiative seeks to drive innovation in stormwater management through watershed based green infrastructure networks. Through a combination of green and gray infrastructure, BGI proposes that each Greenway segment serve as the backbone for a sub-watershed stormwater network that can over time divert much of the stormwater in its sub-watershed from the combined sewer system.

Additionally, we propose to investigate the opportunities for the Brooklyn Greenway to function as flood protection infrastructure in order to protect adjacent waterfront communities during future storm events while also providing the benefits of non-motorized transportation, public space and environmental infrastructure.

Implementation of all 23 of the Brooklyn Waterfront Greenway "Segments" will have a cost measured in nine figures. This is a unique opportunity to implement stormwater mitigation improvements that will facilitate the conveyance of upslope stormwater to the East River and New York Harbor.

This scope of work is intended to identify the design requirements, challenges and solutions that will make it possible for the construction of the Brooklyn Waterfront Greenway to transmit upslope stormwater to the natural water bodies while also contributing to storm surge and flood protection.

Local individuals contributing to the vision of the Brooklyn Greenway (Image Source: http://www.brooklyngreenway.org)

INTRODUCTION

The Brooklyn Waterfront Greenway green infrastructure design guidelines and strategies are intended to provide a coherent expression for Greenway development while addressing a range of issues influencing urban coastlines. Fourteen miles of Brooklyn's waterfront perimeter is to be monumentally transformed by the construction of a continuous corridor for bicycles and pedestrians, triggering the opportunity to integrate forward-looking concerns about changing climate, rising sea levels, water quality, and coastal habitat enhancements. Large areas of Brooklyn were flooded by the storm surge generated by Hurricane Sandy in 2012 [Fig.1]. One year earlier, Hurricane Irene brought heavy precipitation and inland flooding caused by inland run-off. Simultaneously protecting against both types of storm risks is technically challenging—balancing the need to protect properties from storm surge and the need to release stormwater from heavy rains. The Brooklyn Waterfront Greenway will precisely delineate those locations where, one day, Irene will meet Sandy. If these low-lying areas are to survive extreme storm events for the indefinite future, comprehensive interventions are required to mitigate risk to property, and maximize resilience of habitat and infrastructure. By including design considerations for green stormwater management and storm surge protection, the Brooklyn Greenway presents an opportunity to address these issues in many locations along the route while creating a valuable public amenity.

New York City's Long Term Control Plan (LTCP), developed to establish compliance with State and Federal environmental regulators enforcing the Clean Water Act, promises dramatic reductions to Combined Sewer Overflows (CSO's) in the coming decades. The LTCP describes massive infrastructure improvements to the City's sewers, along with Green Infrastructure (GI) practices that manage stormwater through source controls and "green" systems that replicate natural hydrological processes. These practices, however, are largely limited by their disconnection from historic drainage ways and connections for release to open water. Because the Brooklyn Waterfront Greenway will lie over precisely those potential points of discharge, the Brooklyn Greenway Initiative (BGI) hopes to demonstrate the benefits of reestablishing the pathways that permit collection, treatment and release of stormwater runoff from developed land to natural waterways. In doing this, BGI proposes using many of the tools established for use by New York City's Department of Environmental Protection (NYCDEP) and the Office of Green Infrastructure. However, some new tools are still needed to reach the full potential of GI systems to capture and treat urban stormwater in these coastal applications.

One such tool planned for use by NYCDEP is the high level storm sewer (HLSS), which redirects runoff collected near shorelines away from the combined sewers toward new points of discharge to the waterways. This form of strategically separating storm and sanitary flows has great potential to reduce CSO, but with minimal use of water quality controls. Once the HLSS becomes common practice in the City, it is expected that State and Federal regulators will impose MS4 obligations to treat stormwater prior to release. The design scenarios in this document illustrate the use of HLSSs and their potential for integration with living filters and wetland treatment systems.

Where coastal flood risks are highest, BGI proposes the construction of the Greenway atop vegetated protective berms using a system of deployable gates where entrances and rights of way crossings are needed. The challenge is to find a sufficient footprint on which to build the elevated Greenway. In only a few locations is there sufficient space within the public right of way to accomplish this. While these structures will require significant cost and integration with private flood protection systems to implement, it is recognized that protective measures are necessary and that over time flood related losses will far outweigh the cost. This will required extensive collaboration and integration with private land owners.

Combined Sewer Overflows (CSO's)

New York City Department of Environmental Protection signed a consent order with New York State to reduce the release of raw sewage in the city's water bodies. Combined Sewer Overflows (CSOs) occur when the volume of stormwater overwhelms the capacity of the sewer interceptors that carry both sanitary waste and stormwater to the city's sewage treatment plants. CSO's can be minimized by reducing the volume of stormwater that enters the interceptors. Green infrastructure is one way to accomplish this. It works by making the landscape more absorbent with underground reservoirs beneath planted infiltration swales. In Greenpoint, Brooklyn Greenway Initiative (BGI) is pursuing a strategy that will intercept 40% of the stormwater falling on streets and sidewalks in the West Street sub-watershed from entering the combined sewer system. This will be accomplished through a combination of green infrastructure and grey infrastructure (high level sewers that deliver stormwater directly to the river). This project is one of the 23 capital projects along the Greenway route. Similar opportunities exist among the other 22 capital projects in the Brooklyn Waterfront Greenway Master Implementation Plan.

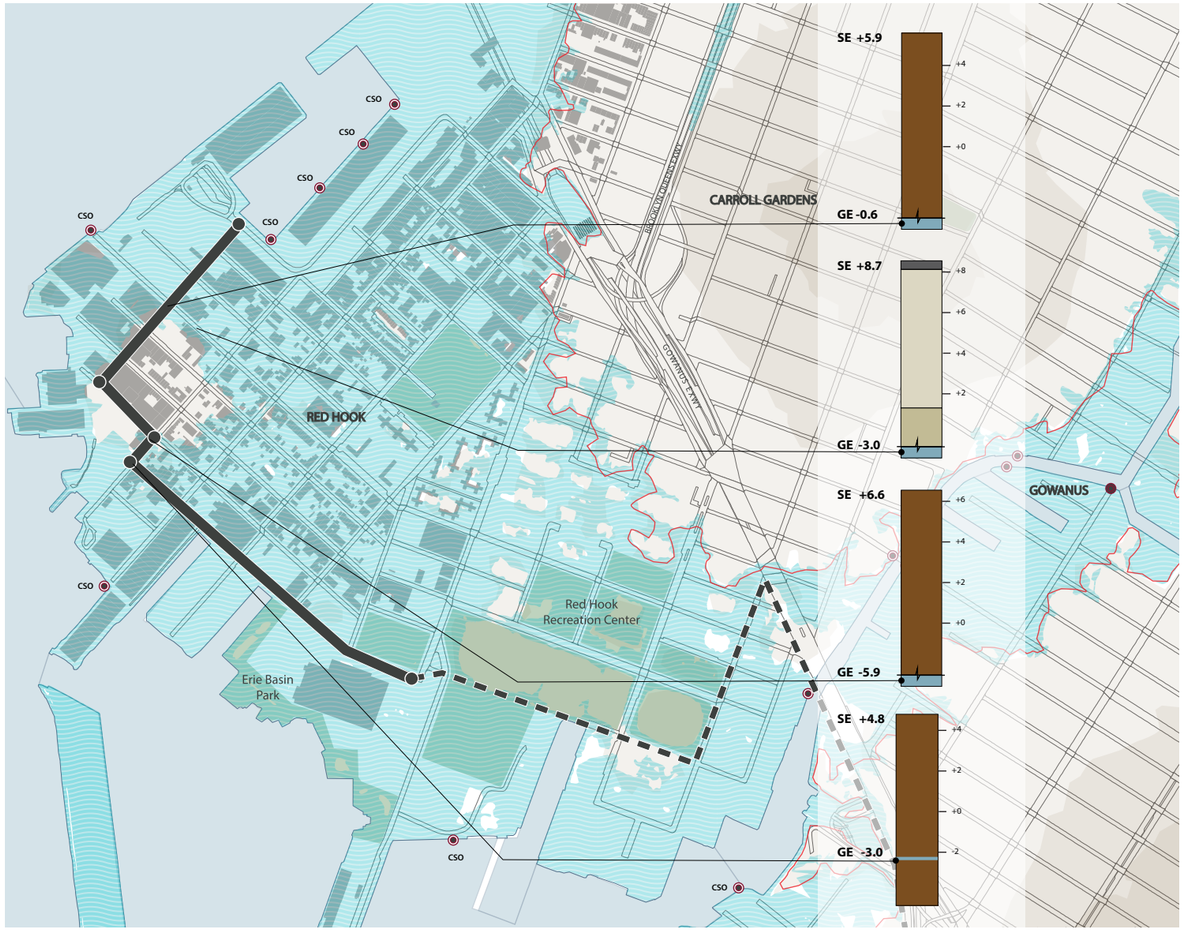


Figure 1: Red Hook (Segment 9) storm surge inundation area

PROJECT CONTEXT

City Context

Greenways are being designed and built throughout all five boroughs of New York City. Hudson River Park is located along Manhattan's West Side on the shore of the Hudson River. The Park includes a continuous five mile promenade and separated bike lanes from Battery Park in Lower Manhattan to 59th Street. Other Greenways in Manhattan include Riverside Park, Harlem River Greenway, and the East River Blueway. The Bronx River Greenway is a 32-mile trail connecting waterfronts in Westchester County and The Bronx, to other boroughs in New York City. Groups like the Jamaica Bay Greenway Coalition are working to create a continuous Jamaica Bay Greenway that would connect with the Brooklyn Waterfront Greenway.

Most recently the New York City Parks Department has identified approximately 45 miles of additional Greenway projects and on-street connections . They have targeted projects that will link under-served communities to their waterfronts and recreational destinations [Fig. 2]. (http://www.nycgovparks.org/facility/bicycling-and-greenways/expansion).

Overall, 41.6 miles of the new Greenway has been funded for design and construction using $133 Million in City, State and Federal funds over the next four years.

The Bronx: 55 miles envisioned
Brooklyn: 35 miles envisioned
Manhattan: 32 miles envisioned
Queens: 63 miles envisioned
Staten Island: 20 miles envisioned

Figure 2: New York City Greenway Plan (Map Source: www.nyc.gov)

Quality of life implications for the proposed Brooklyn Waterfront Greenway are apparent. However, Superstorm Sandy taught us that protection from storm surges, and climate change in general are also needed along NYC's waterfront edges. This project will demonstrate how a network of city Greenways can play an important role in mitigating the effects of climate change, in addressing our imminent stormwater challenges, and contributing to overall community resilience.

Brooklyn Context

The Brooklyn Waterfront Greenway is a 14-mile continuous, separated bike/ped route from Greenpoint through Sunset Park. The Greenway will pass through distinct neighborhoods varying in width and design depending on location.

For the past 10 years, Brooklyn Greenway Initiative (BGI), along with its planning partner Regional Plan Association (RPA) and UPROSE, has been the catalysts for selecting the route, implementing community based planning, securing federal and state funding and building a consensus for the creation of the 14-mile Brooklyn Waterfront Greenway.

From 2004-07, BGI and RPA hosted community workshops to develop a Conceptual Plan for the Greenway. From 2009-11 BGI and RPA worked directly with NYC DOT and UPROSE to host additional community workshops to get input and feedback for the NYC DOT Brooklyn Waterfront Greenway Implementation Plan released on June 21, 2012, comprised of 23 individual segments, or capital projects, each to be designed and built by the City as funding is secured.

Two segments of the Brooklyn Greenway, West Street in Greenpoint and Flushing Avenue along the Brooklyn Navy Yard, are already underway as NYC capital projects. DOT and BGI are actively seeking funding to move additional segments toward implementation

This study is building on the work of BGI , RPA, and the NYCDOT since 2004. This project does recommend specific route alternatives in the NYCDOT Master Plan in order to maximize green infrastructure and storm surge protection goals. The design approaches are the result of input from stakeholders including residents, businesses and public entities.

Segment Context

For the purposes of analyzing the potential of the Greenway to support extensive green infrastructure and storm surge protection, this study investigates 15 segments along the Greenway route. The segments are differentiated by a neighborhood and/or a sub-watershed [Fig. 3].

Each segment is analyzed through various site conditions with emphasis on existing land use, stormwater catchment area, the amount of rain water that is "captured" for a particular storm event, and by its status within the 100-year floodplain [See Part Two - Segment Analysis beginning on page 54 for more detail on each Segment]. The existing land use helps us understand the relationship the Greenway will have to its neighborhood, whether residential, commercial, industrial, governmental or institutional and informs what the Greenway might look like and the programs that are most appropriate. The stormwater volume in the catchment area will determine the amount of green infrastructure necessary to make an impact. The floodplain analysis will help us understand the importance of storm surge and flood protection along the route of the Greenway.

Figure 3: Brooklyn Greenway segment map

METHODOLOGY

Project Format [Fig. 4]

This document has been divided into two parts. *Part 1-Green Infrastructure Design Typologies, Guidelines and Case Studies* consists of green infrastructure design guidelines including: conditions for green infrastructure along the Greenway route, green infrastructure typologies, environmental and social outcomes of green infrastructure systems, "Big Move" strategies for green infrastructure systems placement and storm barrier typologies. *Part 1* suggests how various strategies and typologies could be used as a "Kit of Parts" to be applied where appropriate along the Greenway route. Two case studies, Red Hook (Segments 8, 9, 10) and Sunset Park (segments 11, 12, 13), demonstrate how the 'Kits of Parts" can be applied to specific neighborhoods and sub-watersheds.

Part 2 is an appendix to *Part 1* which consists of detailed site analysis for all 15 of the Brooklyn Greenway segments identified in this project. Analysis includes: topography, storm surge inundation zones, combined sewer overflow locations, existing tree and loading dock locations, private property boundaries, soil boring outcomes including water table depth, stormwater run-off calculations within specific watersheds and a variety of segment specific opportunities and constraints. This analysis led us to specific opportunity areas for green infrastructure and storm surge protection along the Greenway which informed *Part 1-Green Infrastructure Design Typologies, Guidelines and Case Studies*.

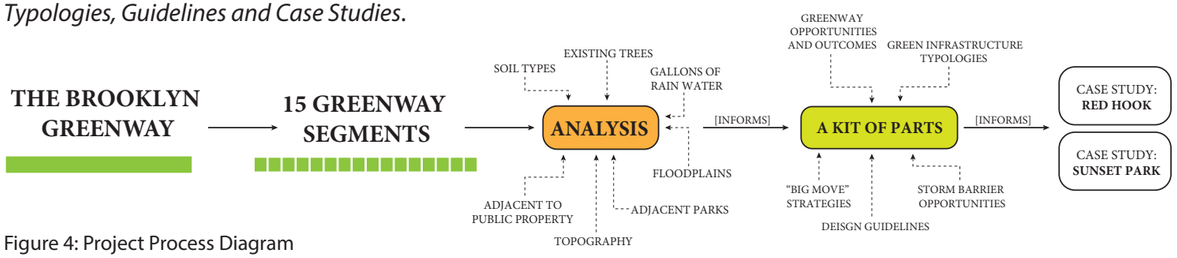


Figure 4: Project Process Diagram

Stormwater Management Calculations Methodology

In order to identify the extent of contributing stormwater run-off within each segment's sub-watershed we have identified four stormwater management "Tiers" as the base criteria to map opportunities for capturing run-off adjacent to the Greenway route [Fig. 5]. While it is not likely that the run-off from these total areas can be entirely managed within the Greenway footprint, the areas provide a target goal and quantified potential for stormwater mitigation. The Tiers are defined as follows:

Tier 1- represents the Greenway footprint itself and the impervious rights-of-way directly adjacent.
Note: This is the current standard extent of GI management in New York City
Tier 2- represents one block upland from the Greenway route and includes right-of-way areas and adjacent impervious areas such as vacant and parking lots
Tier 3- represents building roof areas within one block upland that could be disconnected for future connection with the GI system
Tier 4- includes the remaining area and rooftops of the upland contributing sub-watershed adjacent the Greenway route.

Assuming a total catchment area along all studied segments of the Greenway route, including Tier 1 + 2 + 3 , approximately 2,075,000 cubic feet or 15,527,000 gallons of rain water could be captured within a 1 inch storm event. This amounts to **580,705,000 gallons of rain water** that can potentially be managed annually. A Waterfront Greenway that can mitigate impacts of this magnitude, will become an important and effective element of public utility infrastructure. NOTE: As placement and design parameters become established for GI implementation within the Greenway and priorities for right-of-way land use are decided, the extent of potential runoff capture beyond Tier 1 can be identified and the GI systems sized accordingly.

Figure 5: Example of stormwater management tiers shown on West St. in Greenpoint - (Segment 2 of appendix, page 59)

PART 1
GREEN INFRASTRUCTURE DESIGN TYPOLOGIES, GUIDELINES AND CASE STUDIES

CONTENTS

INTRODUCTION

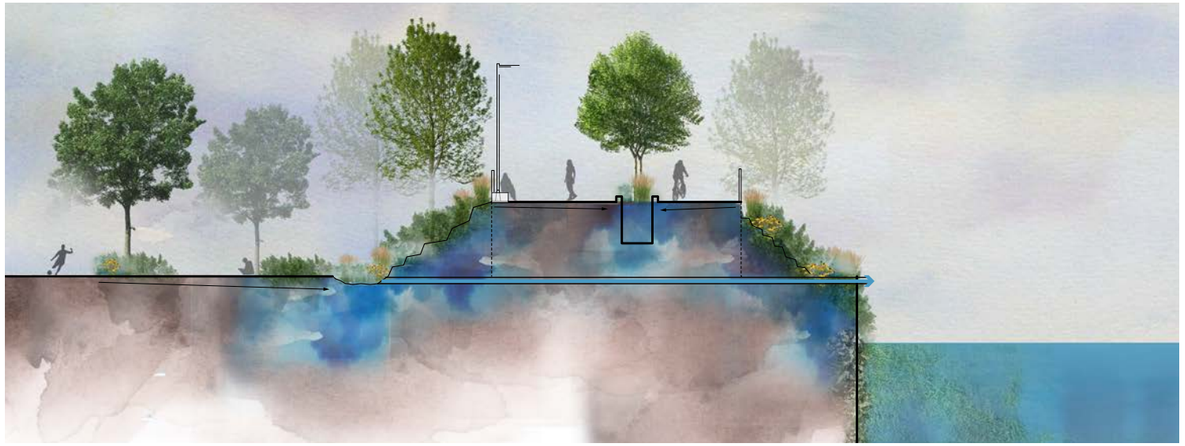
The design guidelines and design typologies have been organized into four different parts. A tool kit of typologies and “Big Moves” are cataloged separately and then expressed as schematic designs for two case studies along the Greenway route.

1. The first part includes a tool kit of stormwater / green infrastructure and storm surge protection typologies that could be applied to a specific set of conditions that exist throughout the 14 miles of Greenway. The combination of site-specific conditions and design typologies that could be applied results in a set of outcomes that meet the goals of this project.

2. The second part showcases the “Big Moves” for the project. These design typologies demonstrate how to connect various green infrastructure systems at transitional junctions in the system. These “Big Moves” include 1. Moving Water Across the Street, 2. Conveying Water to the Receiving Water Body, 3. Moving Water from Private to Public Land or Public to Private, and 4. Conveying Water from an Elevated Structure to the Ground.

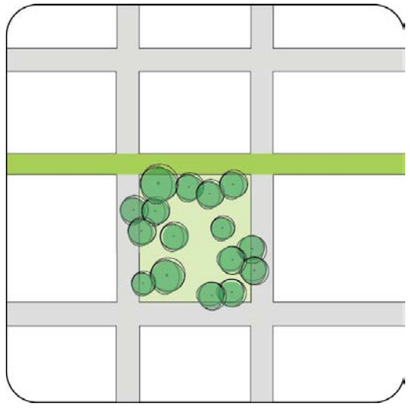
3. The third part includes a variety of elevated Greenway typologies for storm surge protection. The storm “resiliency barrier” typologies have been organized by spatial constraints - narrow, medium and wide.

4. The fourth part consists of two in-depth case studies that demonstrate how and where to apply the above mentioned typologies and “big moves” and the impacts this has on the design configuration of the Greenway and the amount of rain water that can be mitigated within each case study and the storm surge protection that it can provide.

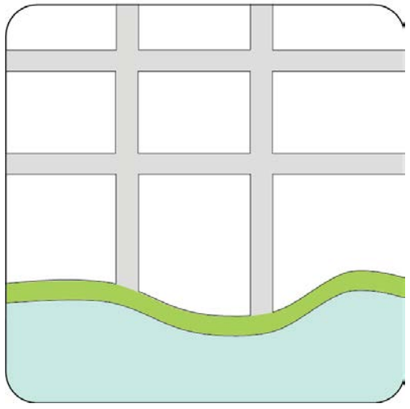


GREENWAY CONDITIONS

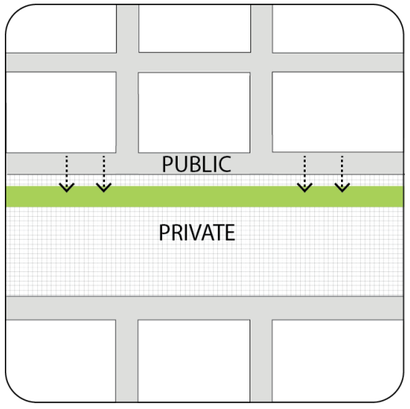
Greenway conditions have been identified along each Greenway segment (see Appendix beginning on p. 54 for Segment Analysis). Identifying conditions along the Greenway route help to inform appropriate stormwater, green infrastructure and/or storm surge protection strategies. The identified conditions include:



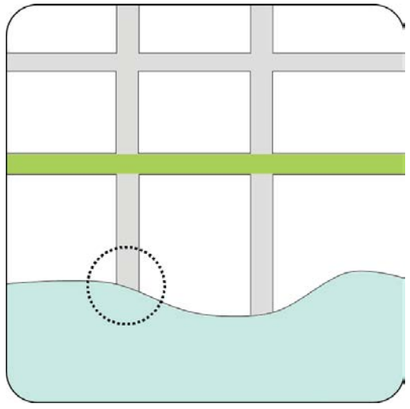
Adjacent to public/open space



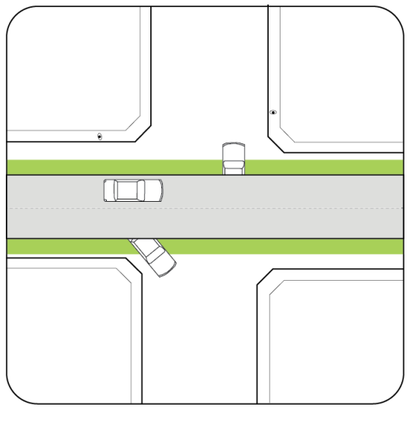
Adjacent to waterfront



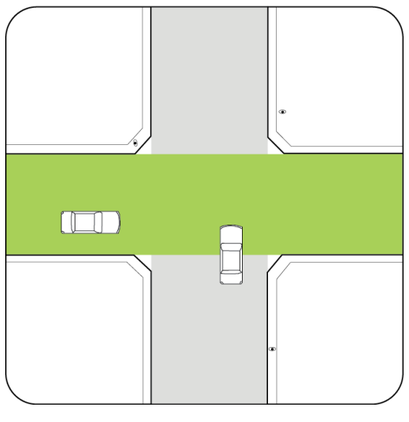
Adjacent to private land



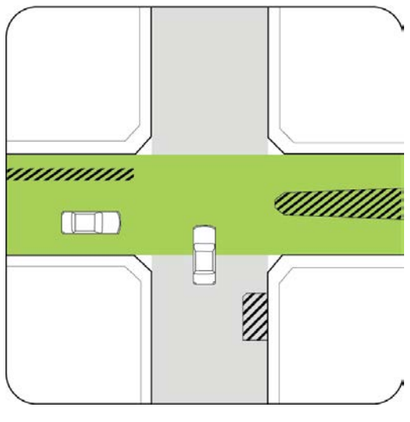
Adjacent to public street end



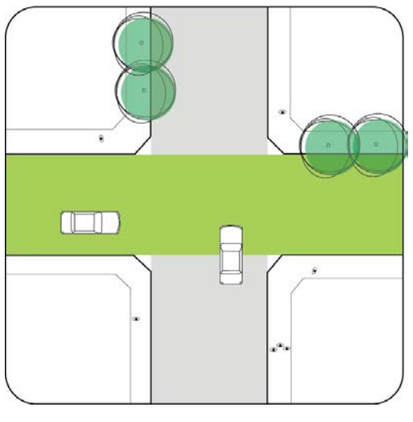
Adjacent to elevated roadway



Narrow right of way

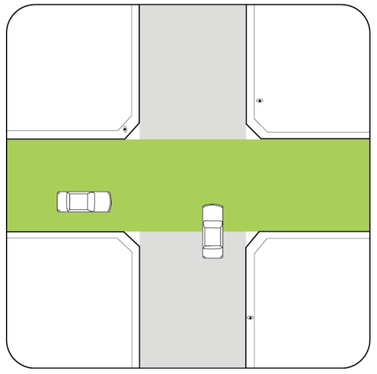


Striping within right of Way



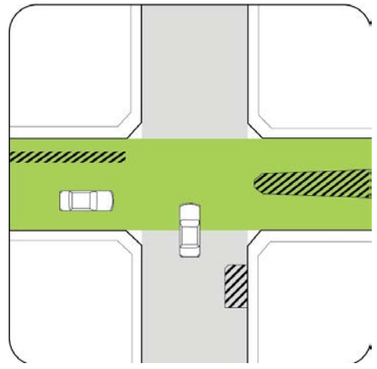
Wide right of way

GREENWAY CONDITIONS (Map and Image Source: Google Maps)



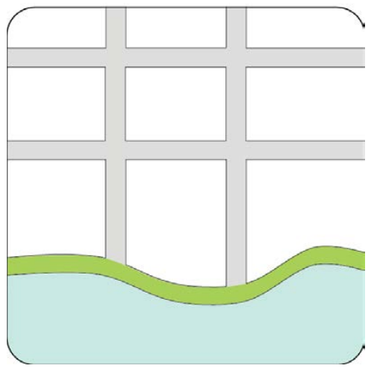
Narrow right of way

Example of Greenway with a narrow right of way on Marginal Street in Sunset Park (Segment 14)



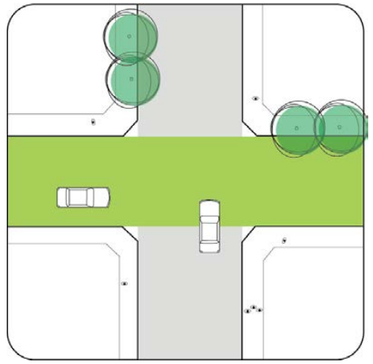
Striping within right of way

Example of roadway striping within Greenway on Kent Ave. in Williamsburg (Segment 4)

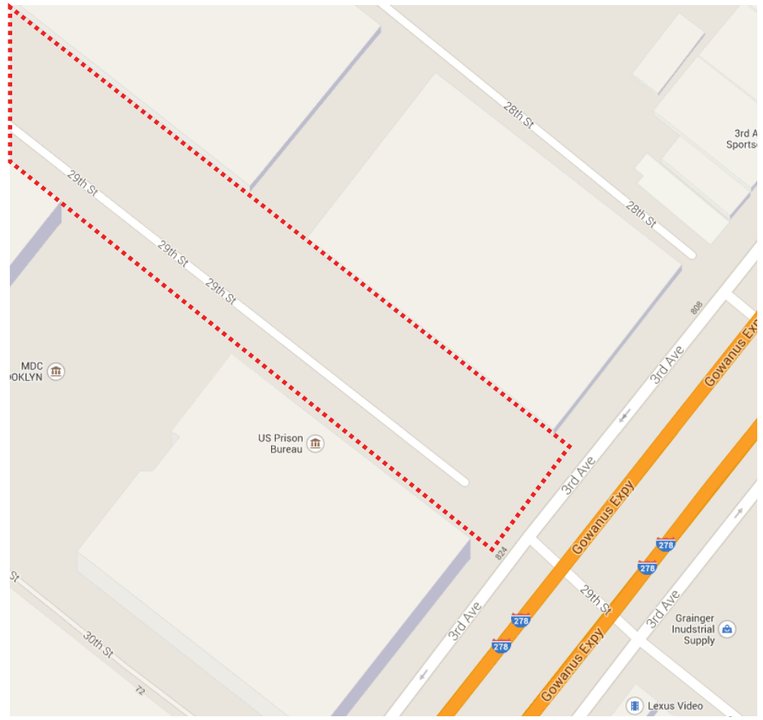


Adjacent to waterfront

Example of Greenway adjacent to waterfront at Halleck Street in Red Hook (Segment 9)

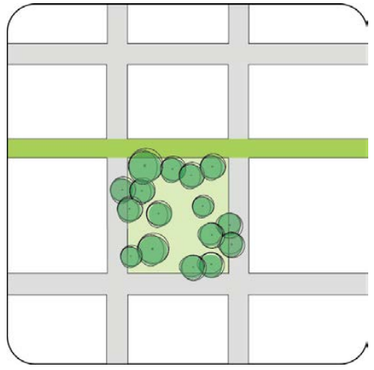


Wide right of way

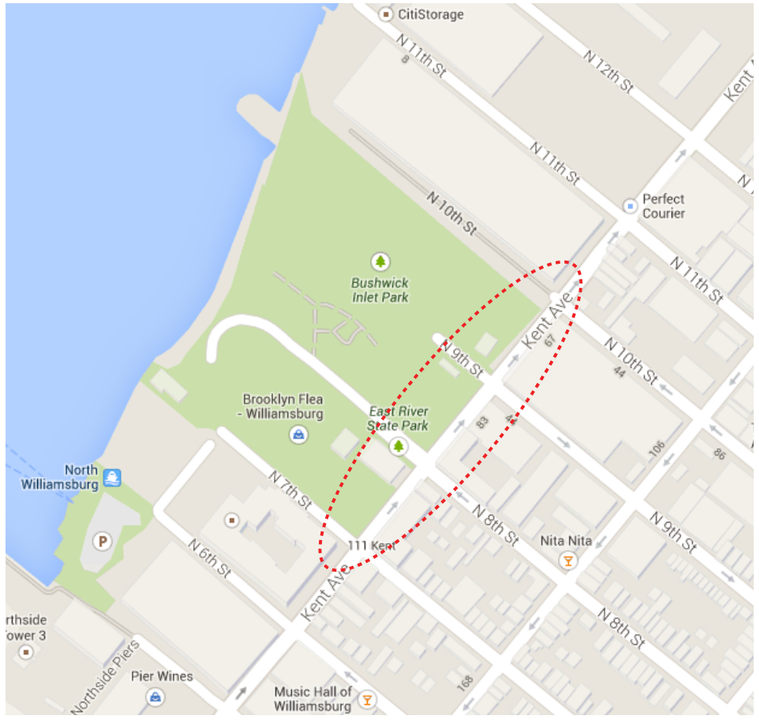


Example of Greenway with a wide right of way on 29th Street in Sunset Park (Segment 12)

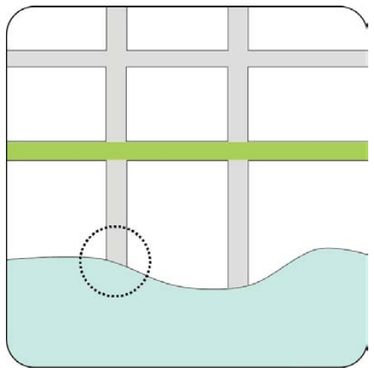
GREENWAY CONDITIONS (Map and Image Source: Google Maps)



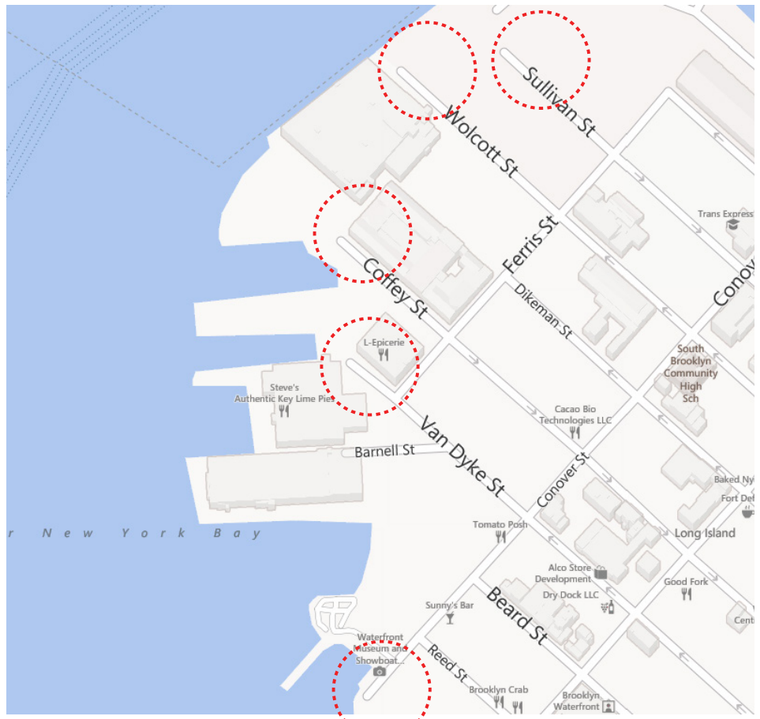
Adjacent to public/open space



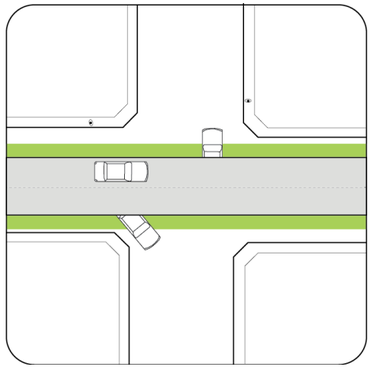
Example of Greenway adjacent to public open space on Kent St. in Williamsburg (Segment 3)



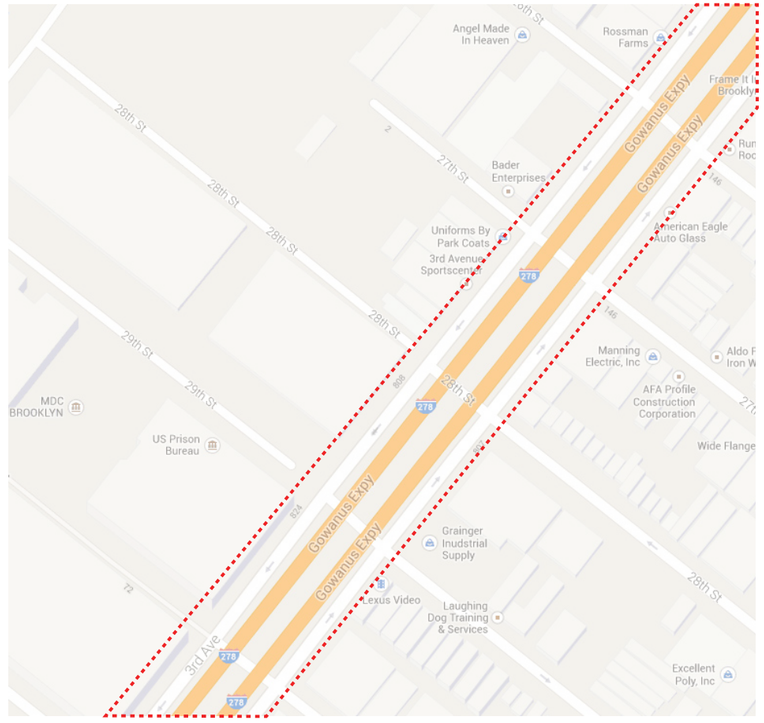
Adjacent to public street end



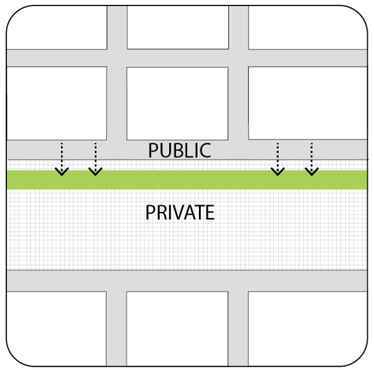
Example of Greenway adjacent to public street ends in Red Hook (Segment 8)



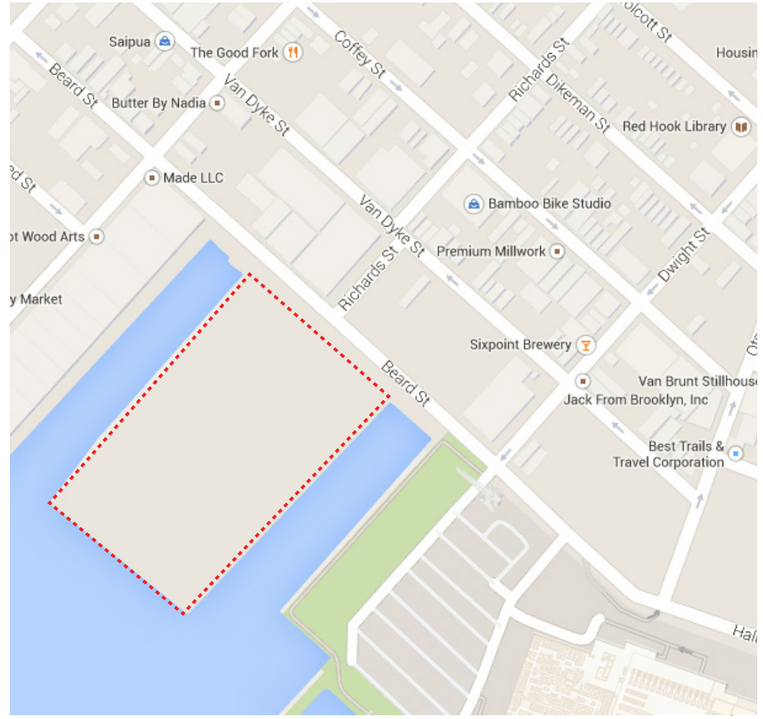
Adjacent to elevated roadway



Example of Greenway below elevated roadway on 3rd Ave. and 29th St. Sunset Park (Segment 12)



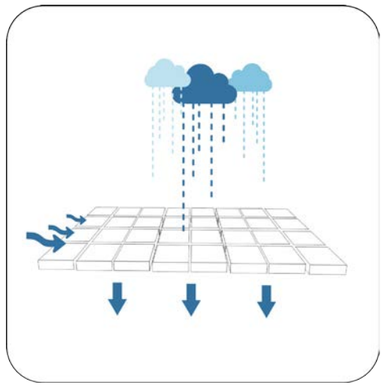
Adjacent to private land



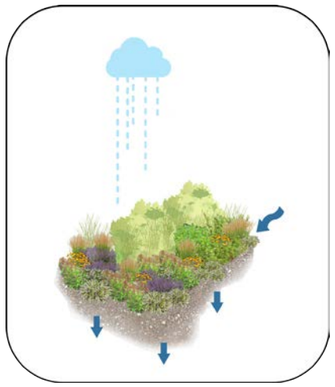
Example of Greenway adjacent to large open private land on Beard Street in red Hook (Segment 8)

GREEN INFRASTRUCTURE TYPOLOGIES

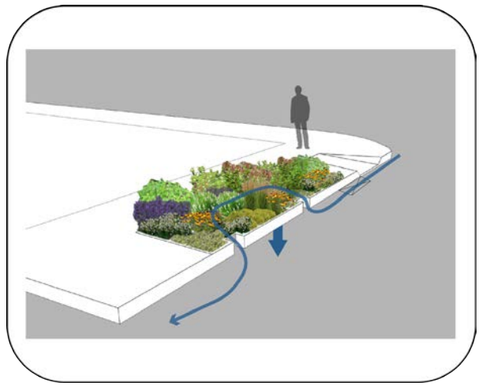
The set of Green Infrastructure typologies presented here are intended to work as a complete "kit of parts" which can be assembled and configured to meet the specific conditions found at each location. Stormwater systems consist of inlets, storage, conveyance, treatment and discharge. While conventional systems rely on street inlets and catch basins to drop run-off below the level of the street. GI systems intended to operate along relatively flat areas must manage water closer to grade. The following icons represent typologies that can be used to meet drainage and storm surge protection needs along the Greenway route and upland adjacent streets.



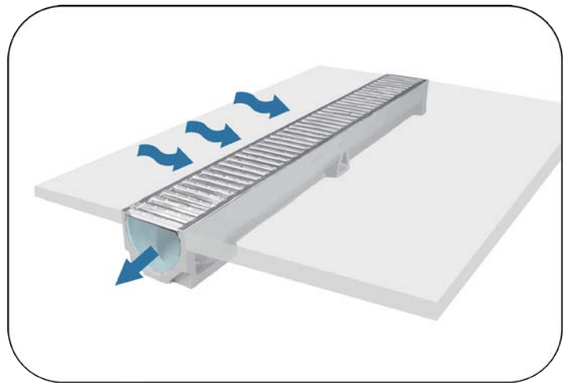
Porous paving



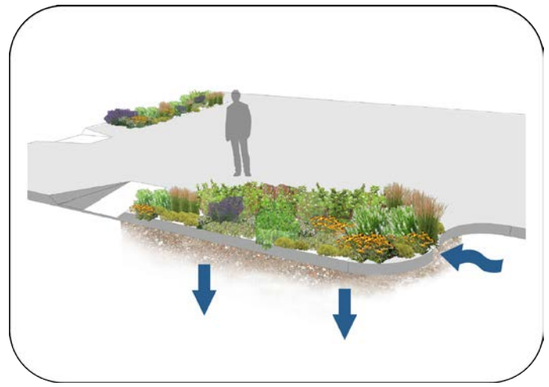
Rain garden



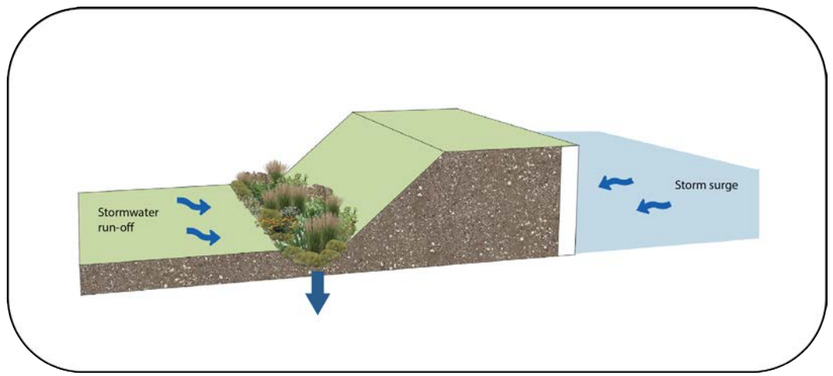
Right of way bio-swale



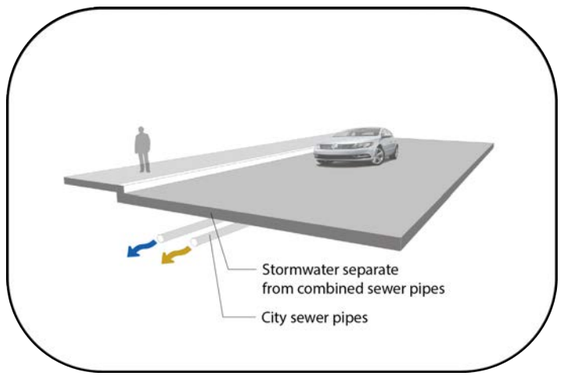
Surface channel



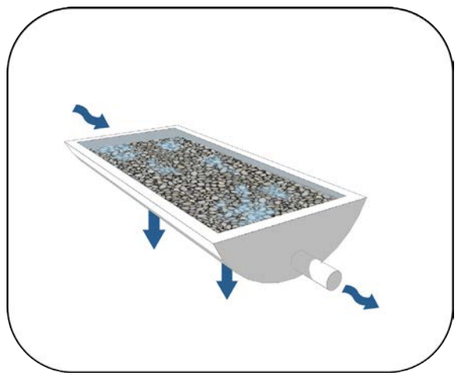
Bulb-out



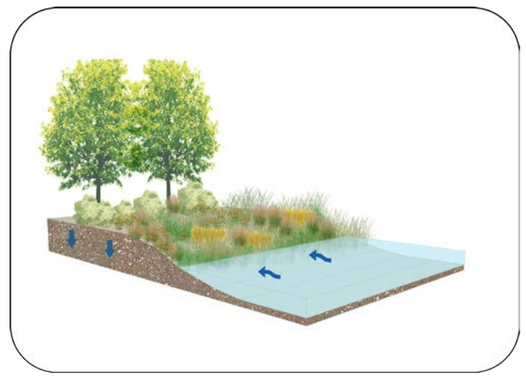
Resiliency barrier



High level storm sewer



Gravel beds



Wetlands/wave-break

“BIG MOVE” CONNECTION STRATEGIES

In addition to the NYCDEP standard GI components proposed for use along the Greenway, BGI is proposing a number of Big Moves that are not currently part of NYC’s GI toolkit. These techniques allow us to expand the role and capacity of GI systems, providing connectivity between sources, BMPs and receiving waters. These measures are not described here in great detail, and their functions can be performed using a variety of means and materials. The GI systems integrated within the Greenway are designed to intercept run-off prior to it reaching the City’s primary storm inlets, and to bypass flows when their capacities are exceeded. For this reason, these proposed conveyance measures need not handle peak flow rates, but instead serve as low-flow pathways for slow release of detention structures, or to equalize water levels between structures when catchment areas or infiltration rates are not equal.

A number of genuine constraints exist to adopting these “Big Moves” within the design vernacular. The GI methods for moving water across streets have no precedence in NYC, and no established system for maintenance.

When using porous conveyance channels, there exists a risk of imposing saturated conditions within roadway foundations, which DOT fears will destabilize the road surface and increase maintenance needs, especially during winter freeze. Moving stormwater between public and private properties introduces questions of liability, ownership and maintenance which are not well resolved. Both of these practices may also change existing catchment boundaries, and alter the conditions behind the NYCDEP’s drainage models. As with the use of High Level Storm Sewers, conveying BMP discharges and overflows to receiving waters creates a need to address the NYSDEC who regulates outfalls. As enforcement of the Clean Water Act advances on several fronts, NYC is in a period of transition with respect to MS4 and stormwater quality discharges, the requirements for which are likely to become more stringent in the coming years. The Greenway design guidelines anticipate these conditions, and offer an opportunity to present an example for resilient design throughout the City and region.

1 Big Move #1: Moving Water Across the Street

Strategies

A) Surface channel with grate at grade
B) Below grade pipe bypassing combined sewer system
C) Porous conveyance channel below grade

2 Big Move 2: Conveying Water to the Receiving Water Body

Strategies

A) High level storm sewer pipe bypassing the combined sewer system
B) Surface channel with grate at grade
C) Porous conveyance channel below grade
D) Vegetated channel

NOTE: Inclusion of surface channels in right-of-way should be approved by the City.

3 Big Move 3: Moving Water from Private to Public Land or from Public to Private

Vertical Connectivity Strategies

A) Conveyance from private or public roof to rain barrels
B) Conveyance from private or public roof to gravel bed
C) Conveyance from private or public roof to rain garden

NOTE: Currently, moving storm water between private and public property and vice versa is not a practice accepted by NYC Department of Environmental Protection.

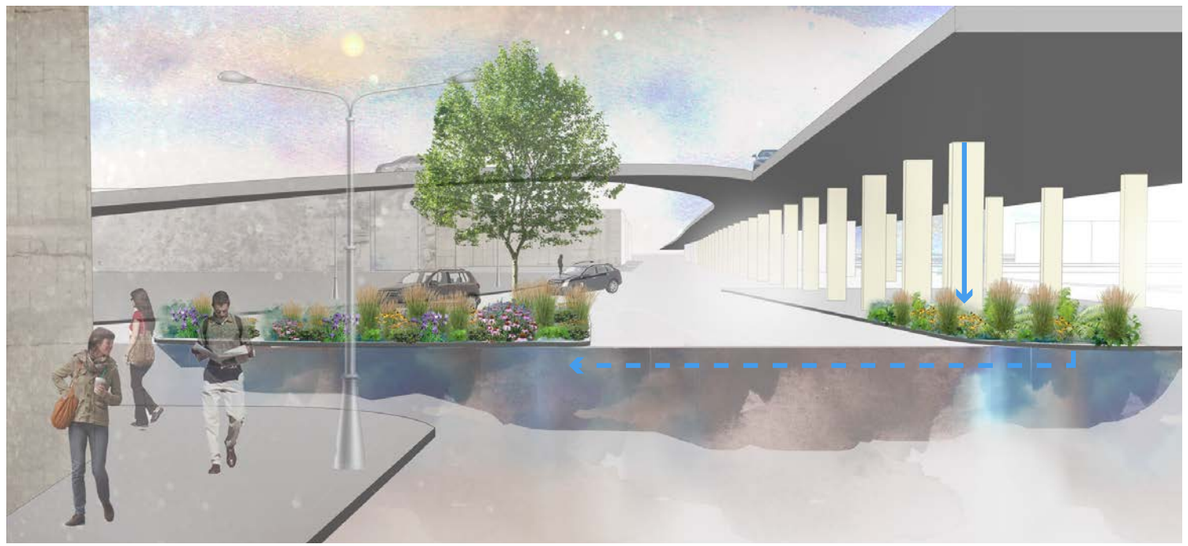
Strategies

A) Conveyance from private or public land to public or private land through surface channel to Bio-swale
B) Conveyance from private or public land to public or private land through below grade pipe to Bio-swale
C) Conveyance from private or public land to public or private land through porous conveyance channel
D) Conveyance from public roadway to private constructed wetland

4 Big Move 4: Conveying Water from an Elevated Structure to the Ground

Vertical Connectivity Strategies

A) Conveyance from elevated roadway to rain garden
B) Conveyance from elevated roadway to false catch basin
C) Conveyance from elevated roadway to gravel bed

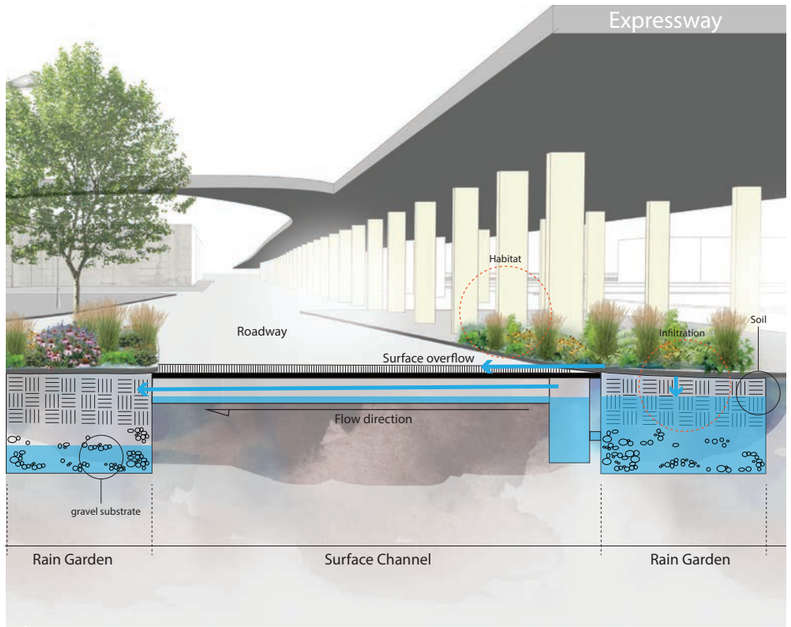


“BIG MOVE” CONNECTION STRATEGIES

1 **Big Move #1: Moving Water Across the Street**

Strategies

A) Surface channel with grate at grade
B) Below grade pipe bypassing combined sewer system
C) Porous conveyance channel below grade



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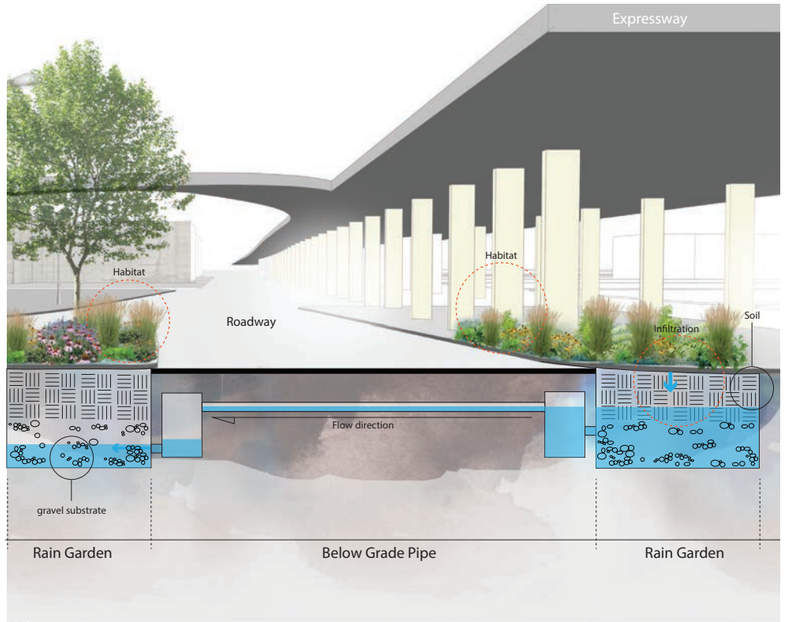

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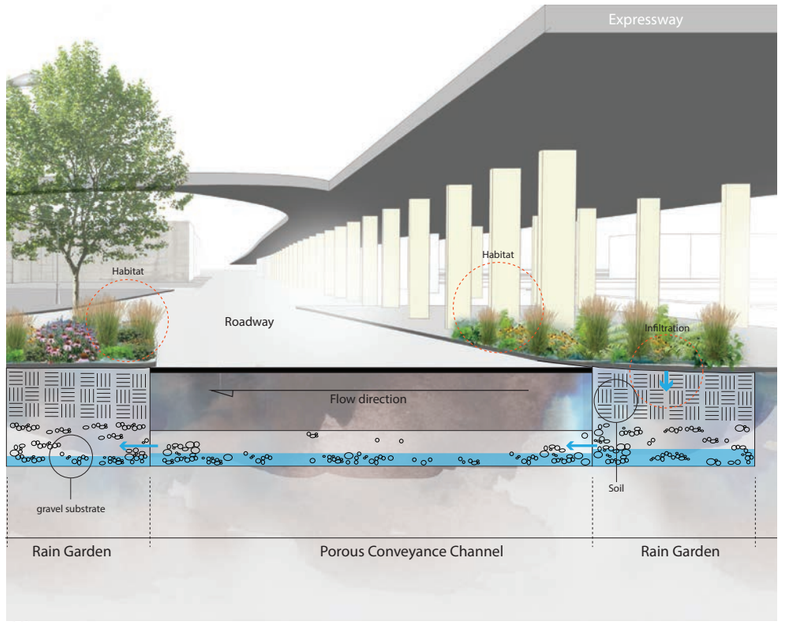


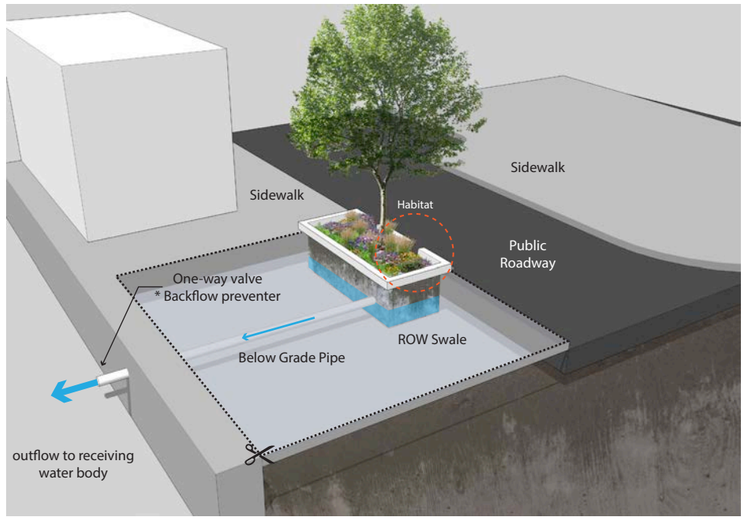
C)

“BIG MOVE” CONNECTION STRATEGIES

2 **Big Move 2: Conveying Water to the Receiving Water Body**

Strategies

A) High level storm sewer pipe bypassing the combined sewer system
B) Surface channel with grate at grade
C) Porous conveyance channel below grade
D) Vegetated channel



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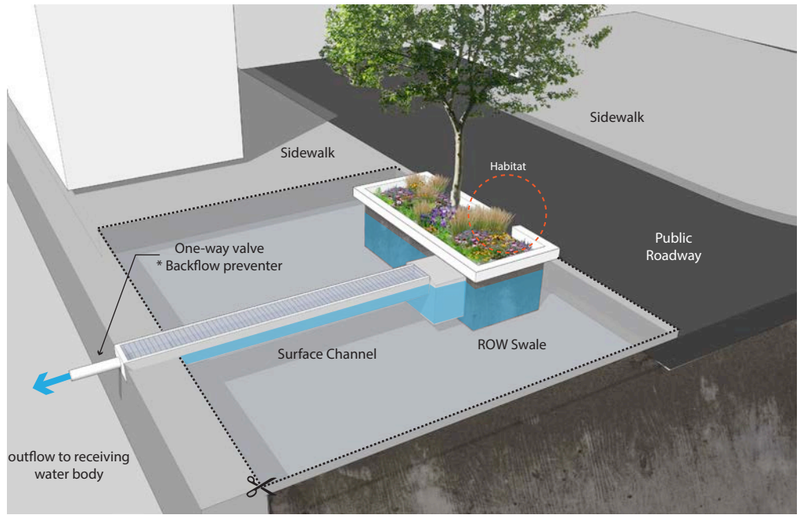

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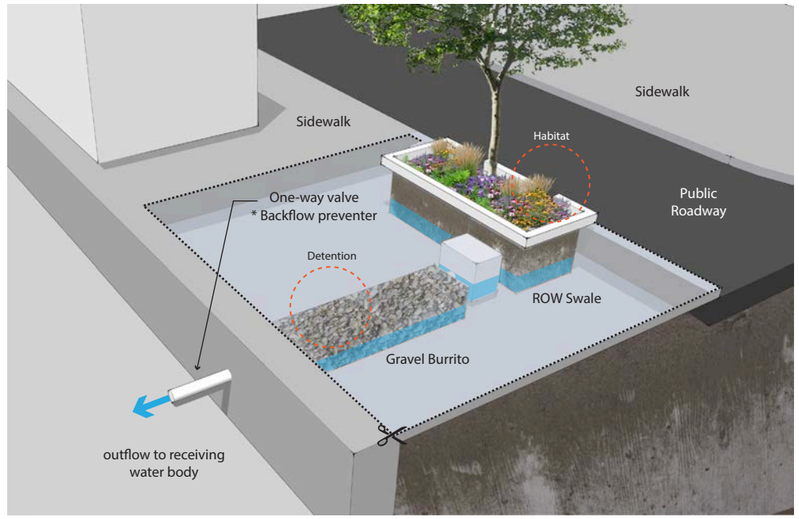

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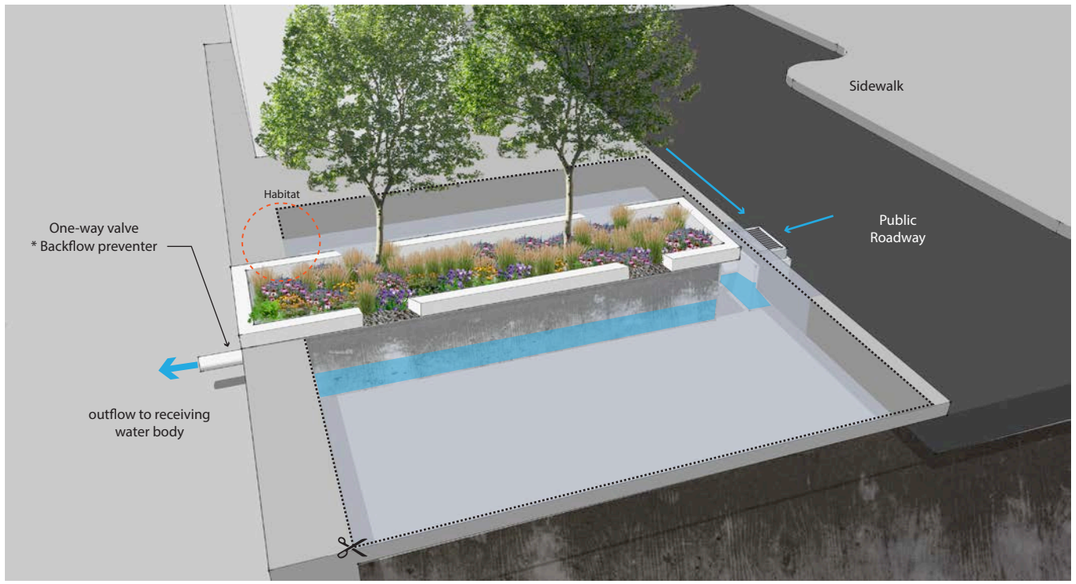


D)

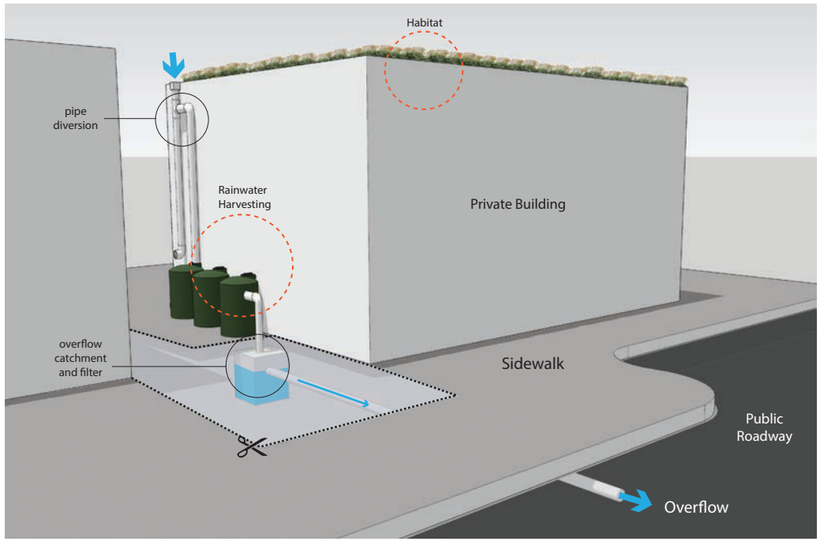
“BIG MOVE” CONNECTION STRATEGIES

3

Big Move 3: Moving Water from Private to Public Land or from Public to Private

Vertical Connectivity Strategies

A) Conveyance from private or public roof to rain barrels
B) Conveyance from private or public roof to gravel bed
C) Conveyance from private or public roof to rain garden
* Note: Retain 10’ setback from green infrastructure intervention to existing building



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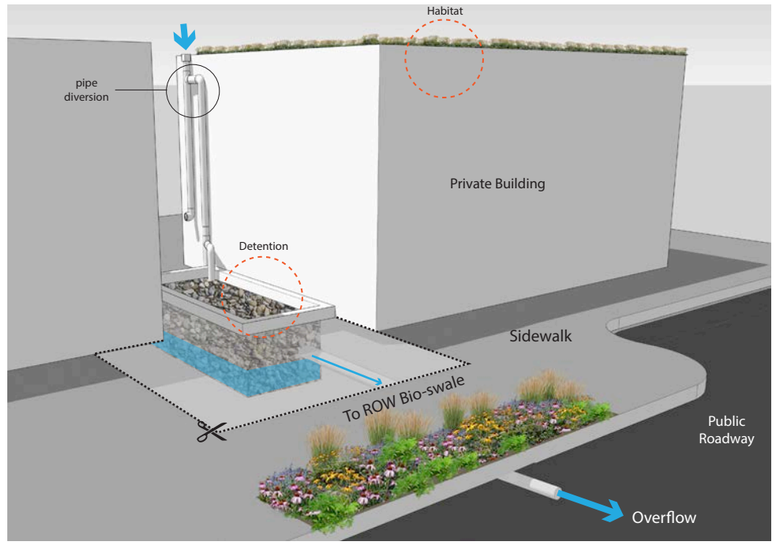

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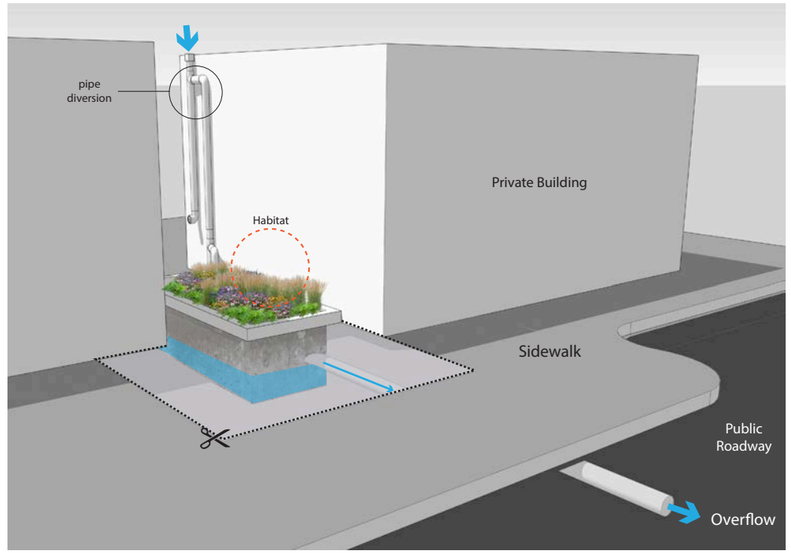

C)

“BIG MOVE” CONNECTION STRATEGIES

3 **Big Move 3: Moving Water from Private to Public Land or from Public to Private**

Strategies

A) Conveyance from private or public land to public or private land through surface channel to Bio-swale
B) Conveyance from private or public land to public or private land through below grade pipe to Bio-swale
C) Conveyance from private or public land to public or private land through porous conveyance channel
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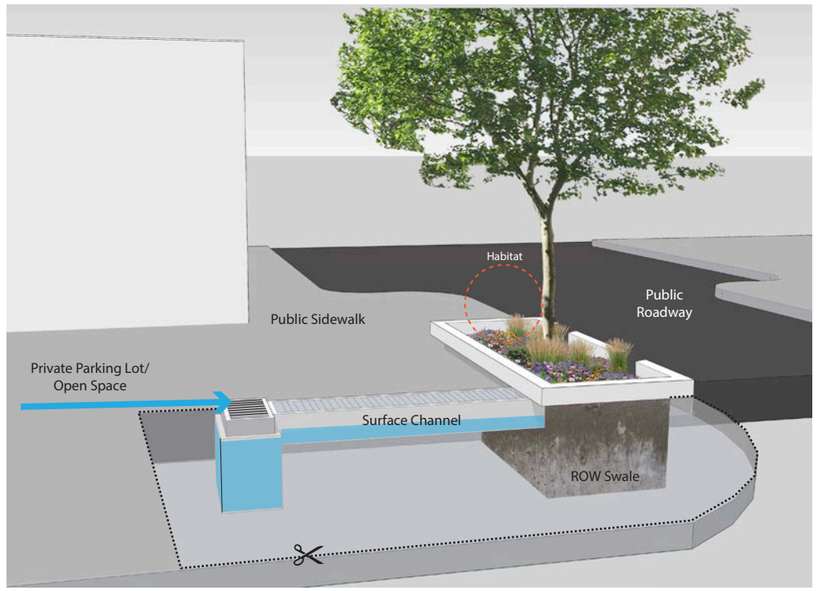

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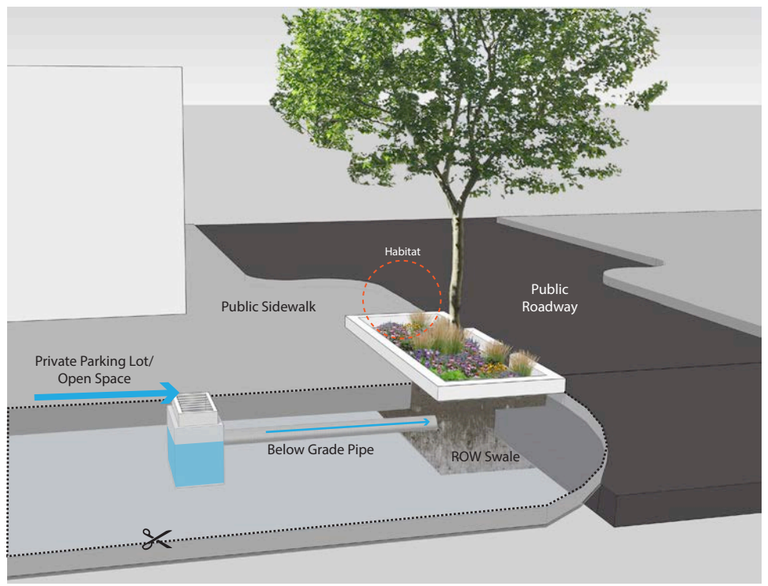

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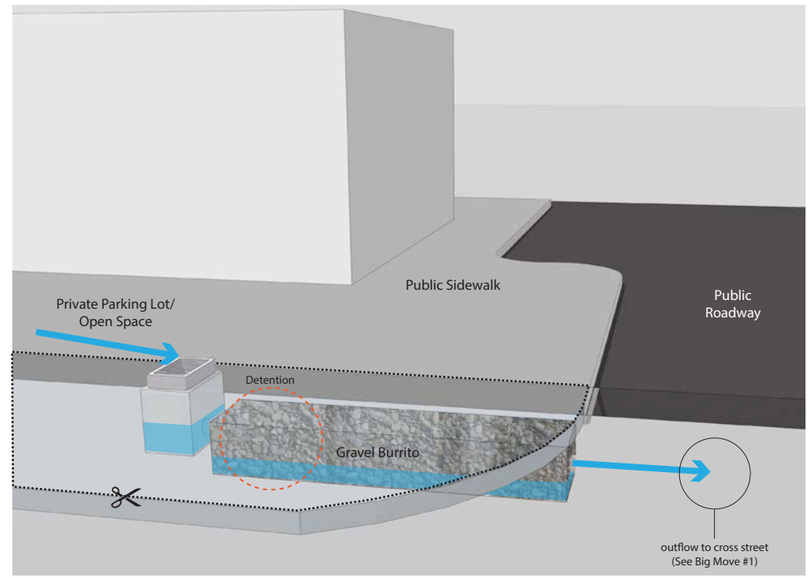

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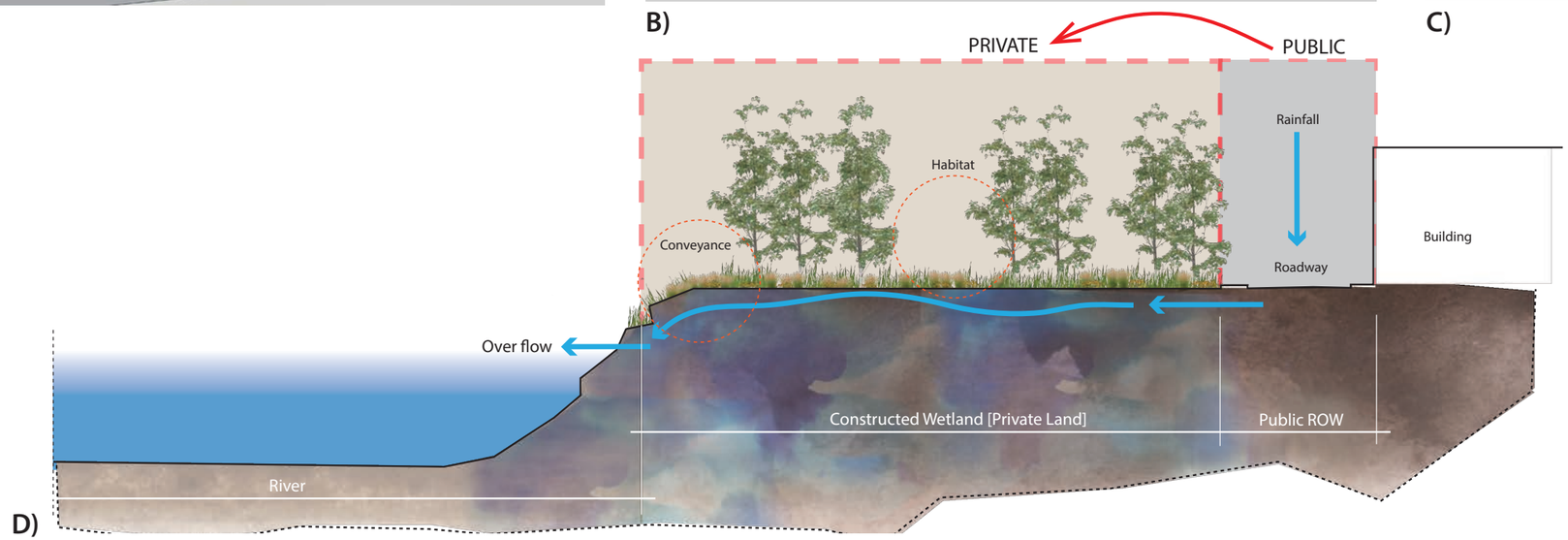


D)

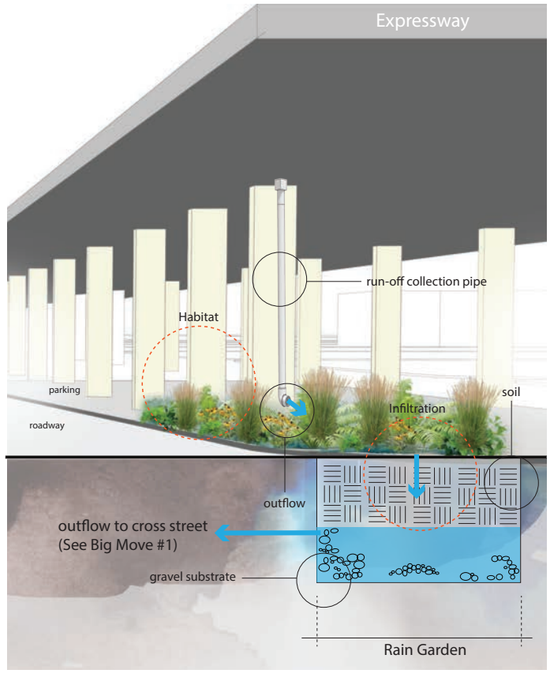
“BIG MOVE” CONNECTION STRATEGIES

4 **Big Move 4: Conveying Water from an Elevated Structure to the Ground**

Vertical Connectivity Strategies

A) Conveyance from elevated roadway to rain garden
B) Conveyance from elevated roadway to false catch basin
C) Conveyance from elevated roadway to gravel bed

* Consideration: Structural integrity of support pilings must be considered in advance of imposing infiltration.



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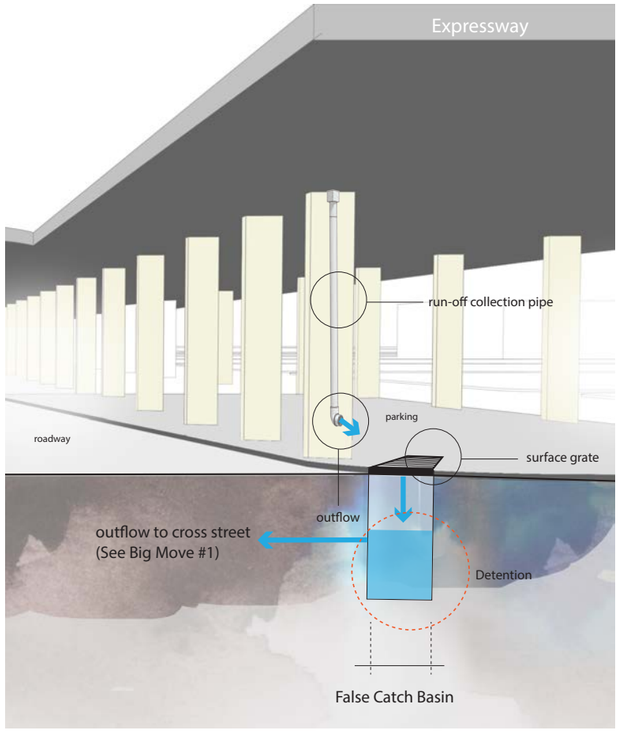

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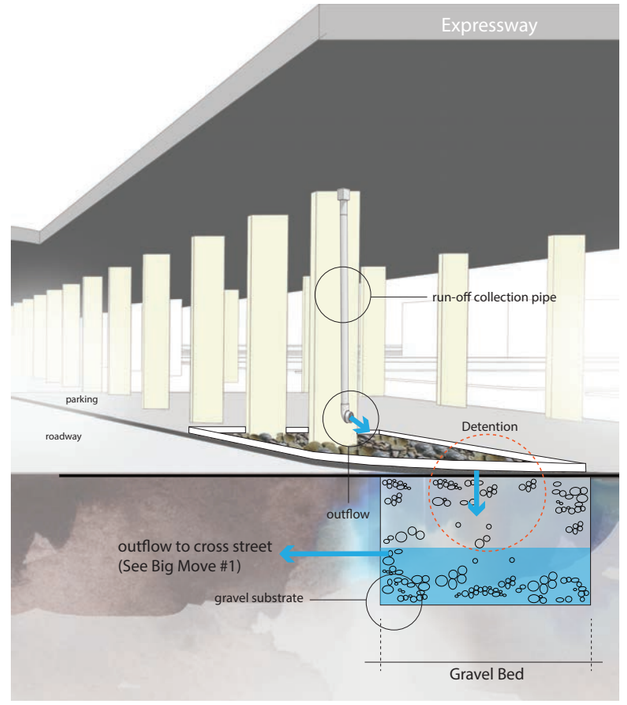


C)

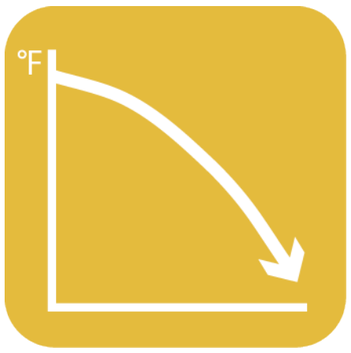
GREEN INFRASTRUCTURE BENEFICIAL OUTCOMES

Benefits from green infrastructure practices go beyond management of stormwater and reductions to CSOs. Integrating green systems within the urban landscape can serve to replace many of the hydrological functions lost through dense urban development. These functions include conveyance, contaminant and nutrient filtration, groundwater recharge, and niche habitat improvements. GI structures also detain and slow the release of stormwater through pipes to waterways and reduce flashy conditions that create flood hazards downstream. Recent studies have been quantifying the contributions of green roofs in reducing the urban heat island effect through evapotranspiration and changes in surface albedo. More recently, coastal area planners have been looking toward beach nourishment, dune creation, salt marsh and offshore reef structures to reduce damage from storm surge and make cities more resilient in the face of rising sea levels. BGI has integrated as many of these benefits within the Greenway network as possible, while simultaneously maximizing the potential to manage stormwater and provide publicly accessible green amenities.

Storm surge protection

Stormwater detention

Stormwater conveyance



Reduced heat island effect

Carbon sequestration

Evapotranspiration

Stormwater filtration

Stormwater infiltration

GREEN INFRASTRUCTURE OUTCOME CONSIDERATIONS

Introduction

While there are benefits to integrating green infrastructure and storm surge protection into the design of the Greenway, there are also important regulatory, maintenance, and technical considerations that need to be weighed when making final design decisions.

Regulatory Considerations

NYC Department of Transportation (DOT)
- Big Move Connection Strategies - Moving Water Across the Street
- Anything on the ROW
- Parking spaces
- Bus stops
- Lanes, traffic, crosswalks, bike paths, pedestrian ways

NYC Department of Environmental Protection (DEP)
- Big Move Connection Strategies - Conveying Water from Private to Public Land or Public to Private
- Change mapped catchment areas
- Storm sewers, combined sewers, catch basins, culverts, or any storm water infrastructure
- Discharge to surface water

NYC Department of Parks and Recreation (DPR)
- Parks or open spaces
- Tree pits
- ROW swales

NYS Department of Environmental Conservation (DEC)
- Big Move Connection Strategies - Conveyaing Water to the Receiving Water Body
- Outfalls to surface waters
- Storm resiliency barrriers
- Wetland wave breaks (shoreline habitat)

NYC Department of Health and Mental Hygiene (DOH)
- Water reuse
- Human contact with stored water (or saturated soils) in public access zones

Private Utilities
- Setbacks from utility lines
- Rules for infrastructure overlay (esp. at street crossings)

Maintenance Considerations

Big Moves Strategies

1) Moving Water Across the Street
- Removing debris and sediment from trench drains

2) Conveying Water to the Receiving Water Body
- Removing debris and sediment from sump portions of pipe connections to surface water

3) Moving Water from Private to Public Land or from Public to Provate
- Removing debris and sediment from private connections to green infrastructure
- Public outreach to reduce improper disposal into storm drains

4) Conveying Water from an Elevated Structure to the Ground
- Removing debris and sediment from elevated drainage structures

Sustain Plant Health

- Regular weeding of planted areas
- Pruning and plant replacement
- Soil replacement
- Pest control

Sediment and Litter Removal

- Inspect erosion and sediment build up
- Catch basin clean-out
- Vacuum / pressure wash porous pavements
- Leaf and trash removal

Technical Considerations

Big Moves Strategies

1) Moving Water Across the Street
- Proper structural support for trench drains
- New roadway designs with porous sub-base
- Creating connections between BMPs along a contour

2) Conveying Water to the Receiving Water Body
- Moving water from inland flooding through a constructed barrier
- Water quality of discharges
- Potential pretreatment required before discharge (DEC Guidelines)
- Preventing backflow

3) Moving Water from Private to Publid Land or Public to Private
- Re-evaluating/overloading existing storm water infrastructure capacities (Change of existing catchments)
- Maintenance/liability/access/ownership issues

4) Conveying Water from an Elevated Structure to the Ground
- Setbacks from structural columns
- Energy attenuation of downspout discharge
- Avoiding clogging at oulets

General Brooklyn Greenway Considerations

- Finding enough areas appropriate for infiltration / subsurface storage
- Utility setbacks and competition for space
- Limited changes in elevation
- Limited space available for elevated and shoreline Greenway sections
- Instability caused by soil saturation, esp adjacent to roadways
- Basement intrusion

General GI Considerations

Bioengineering
- Plant selection
- Soil selection
- Sub-surface structure (esp. at storm resiliency barriers)

Plant Health
- Water
  - Proper catchment area sizing for sufficient watering
  - Prolonged ponding
  - Contaminated runoff to planted zones
  - Salt water intrusion/spray
- Soil
  - Moisture regime
  - Permeability
  - Sediment loading to planted zones
  - Sediment run-off
- Light regime

Construction/Existing Conditions
- Anomalous subsurface conditions: ie. foundations
- High water table
- Low permeability soils/fill
- Contamination of future planted zones, soil disposal

Vandalism/Mis-use
- Illegal dumping
- Plant theft
- Trampling

GREENWAY RESILIENCY BARRIER TYPOLOGIES

Introduction

In many towns and cities across the globe, flood protection systems are being reinforced or raised due to sea level rise and increasingly strong storm surges. Often, flood defense in urban areas consist of sheer walls due to the lack of space. If there is enough space, flood protection lines can consists of dikes or levees that are often earthen embankments; they can constitute dynamic landscape features with powerful ecological design potentials.

Although engineering challenges are recognized in creating preliminary Greenway barrier designs, landscape potentials to improve public amenities, manage stormwater and create habitat have been explored.

The Greenway barrier designs on the following pages have been conceptually grouped by space availability: narrow, moderately wide and wide width conditions. These typologies are intended to offer conceptual design guidelines that address important considerations of waterfront barrier systems. Note: the exact barrier details will depend on specific site conditions and limitations.

The barrier typologies categorized for "narrow conditions" (15-25 ft.) will have include structural erosion control; structural lattice or sheet piling for example. Typologies for "moderately wide conditions" (30-40 ft.) can potentially accommodate gradual vegetated slopes and stairs for seating and access. Lastly, and the most desirable, is barrier typologies for "wide conditions" (50 + ft.) where a variety of ecological, cultural and economic functions could emerge. Barriers for "wide conditions" can furnish a variety of ecological functions such as constructed wetlands and rain gardens. Additionally, Greenway barrier typologies within wide urban conditions have the potential to become important conduits for stormwater collection, ecological restoration, public enjoyment and commercial activity.

Barrier Typology Considerations

(Maximization of green infrastructure opportunity, habitat value and structural feasibility)

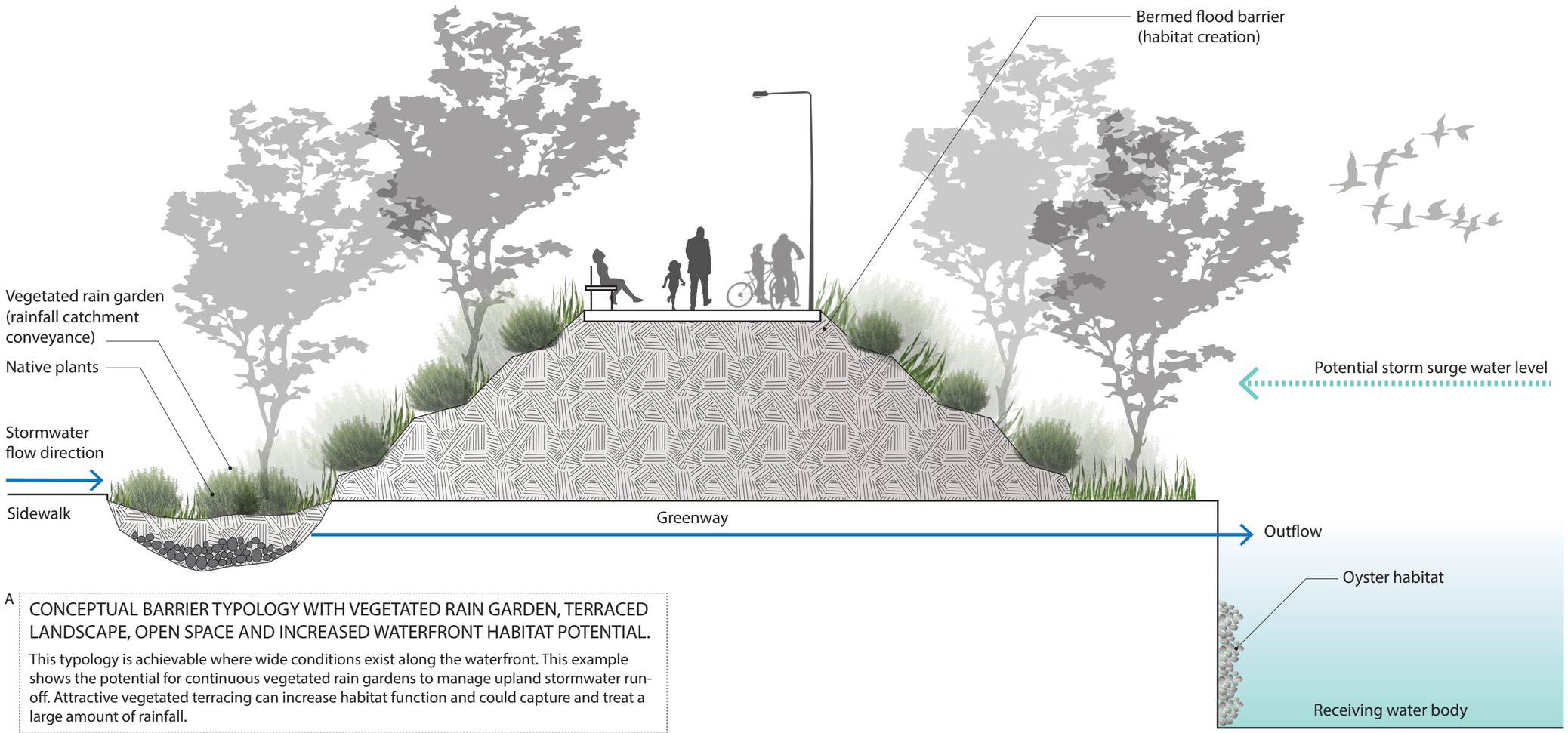
- The shallower the side-slope, the better for planting mediums.
- The plantings on the water side are susceptible to a variety of issues: garbage/debris collection from high tides, salt inundation, lack of maintenance.
- A pipe that goes through the barrier that allows stormwater to flow to the surface water is a good opportunity for stormwater management, releasing stormwater slowly toward the sea-side. This pipe would be controlled with check valves to prevent the higher salinity surface water from reaching the plantings on the land side. The precise spacing and sizing of these pipes will have to be determined based on specific conditions.
- Any stairs or public access points to the barrier will be determined by location of the barrier along the street.
- Rip-rap can serve as erosion control but cannot be used alone as a storm surge barrier. Techniques for integrating habitat niches within rip-rap slopes can be applied.
- Stairs along the water side are a great option for public access. Public amenities and increased habitat value can be combined by using hard risers and intermittent planted runs.
- Flood tolerant plantings, furniture and paving materials such as boardwalks, stairs, paths and plazas should be considered.
- Boulders and stepping stones which rise above the mean water level allow visitors to experience the water at certain times of the year, creating an ephemeral connection with the river's edge.
- All Greenway barrier designs should consider aesthetic qualities that respond to high and low water levels as well as all season use.Artful lighting designs can contribute to a very pleasing environment for cyclist and pedestrians. Consider lighting designs to be sensitive to wildlife functions and resilient to water inundation.

Structural

- In order to determine the best option for structurally supporting the barrier, geo-technical site information is needed. This especially plays a role when considering barriers with steeper slopes. In addition, the level of required erosion control will depend on the degree of site exposure to marine waters.
- The exact structural details of the barrier will be determined by the specialized engineer tasked with the complete barrier design, as well as the available budget for the construction. Before any cost estimating can be done, soil borings must be performed to determine the bearing capacity of the land forms below.
- The range of possible civil engineering interventions include: structural pilings, sheet pilings, excavation and fill, poured concrete retaining walls, etc.
- Wave action to different sites specifically will alter the structural needs of the barrier given its location.
- The use of structural lattice, gabions, or willow stakes depends on many factors such as geo-technical requirements and budget. Gabions have a lifespan of 20-30 years, so they may have to be replaced in the long term. Willow stakes are typically used along freshwater streams, and may not be appropriate as a shoreline barrier. Sheer or vertical walls are also feasible where space is most limited. Typical techniques in this application involve use of sheet pilings, which offer very little or no habitat value. On the land-side, sheer walls could be proposed that receive or support plantings.

Vegetated riparian terracing as storm protection system with overlook platforms and access boardwalks.
Precedent: Shanghai Houtan Park: Landscape as a Living System
Shanghai, China
(Image Source: http://www.asla.org/2010awards/006.html)

GREENWAY RESILIENCY BARRIER TYPOLOGIES: WIDE CONDITIONS



A

CONCEPTUAL BARRIER TYPOLOGY WITH VEGETATED RAIN GARDEN, TERRACED LANDSCAPE, OPEN SPACE AND INCREASED WATERFRONT HABITAT POTENTIAL.

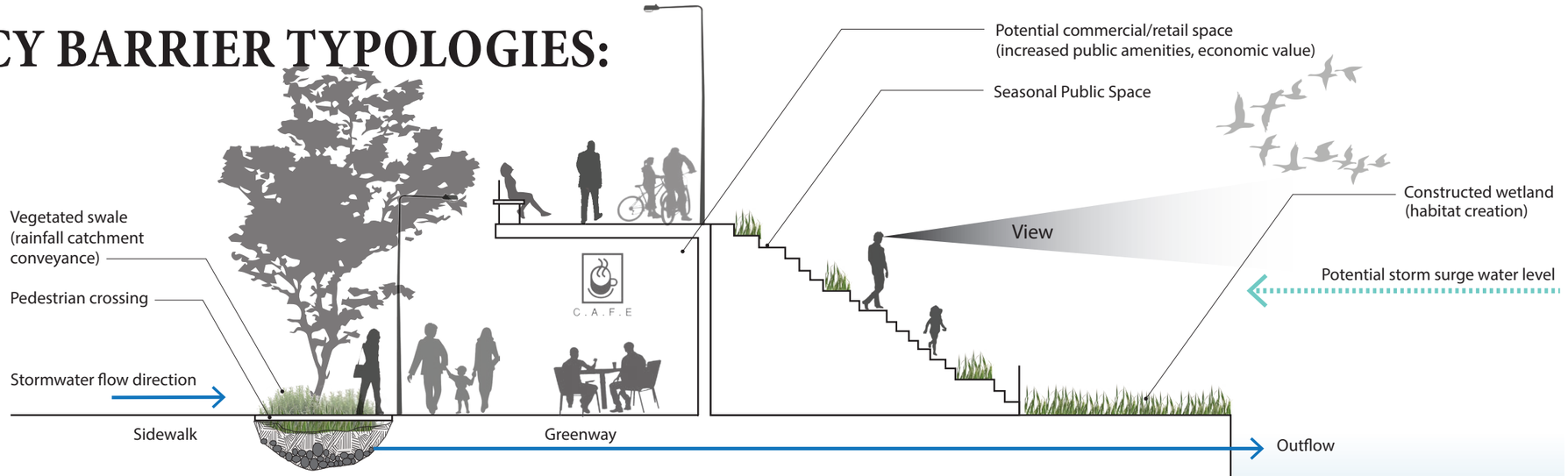
This typology is achievable where wide conditions exist along the waterfront. This example shows the potential for continuous vegetated rain gardens to manage upland stormwater run-off. Attractive vegetated terracing can increase habitat function and could capture and treat a large amount of rainfall.

GREENWAY RESILIENCY BARRIER TYPOLOGIES: WIDE CONDITIONS

Temporary flood defense walls allow year round access to the waterfront and provide protection during storm events.
Precedent: Parque Del Agua
River: Ebro - Zaragoza, Spain
Image Source: Prominki

Vegetated terracing provides storm protection and opportunities to interact with the waterfront. Sculptural art has been integrated into the terraced staircase.
Precedent: Green Ring
River: Neckar - Ladenburg, Germany
Image Source: Prominki

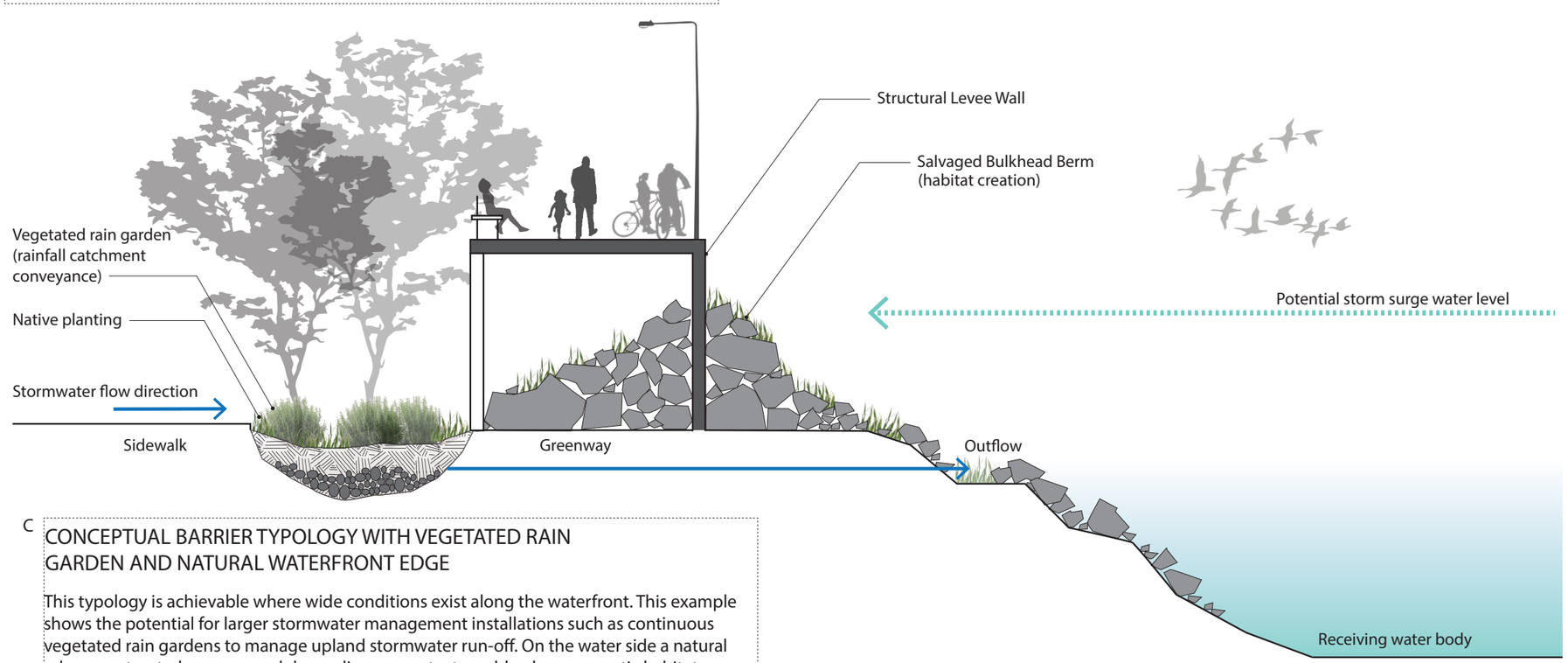
A large stepped storm barrier creates an urban plaza for public gathering while remaining a working waterfront.
Precedent: IJsselkade Residential Area
River: IJssel - Doesburg, Netherlands
Image Source: Prominki



B

CONCEPTUAL BARRIER TYPOLOGY WITH VEGETATED SWALE, COMMERCIAL ACTIVITY, PUBLIC PLAZA SPACE AND CONSTRUCTED WETLANDS

This typology is achievable where wide conditions exist along the waterfront. This example shows the potential for commercial activity to be embedded into the Greenway structure. This condition allows for stormwater management installations and public access to the waterfront.

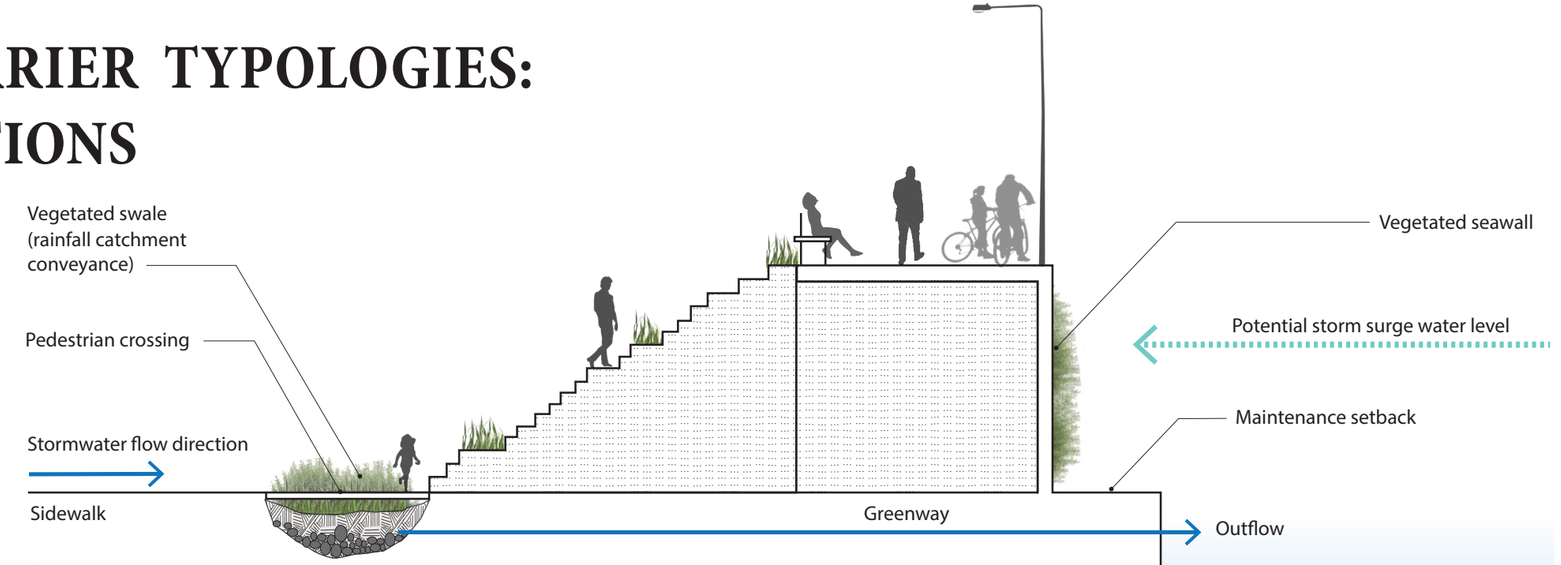


C

CONCEPTUAL BARRIER TYPOLOGY WITH VEGETATED RAIN GARDEN AND NATURAL WATERFRONT EDGE

This typology is achievable where wide conditions exist along the waterfront. This example shows the potential for larger stormwater management installations such as continuous vegetated rain gardens to manage upland stormwater run-off. On the water side a natural edge, constructed or preserved depending on context, could enhance aquatic habitat functions, slow tidal surges and provide an aesthetically beautiful view of the shoreline.

GREENWAY RESILIENCY BARRIER TYPOLOGIES: MODERATELY WIDE CONDITIONS

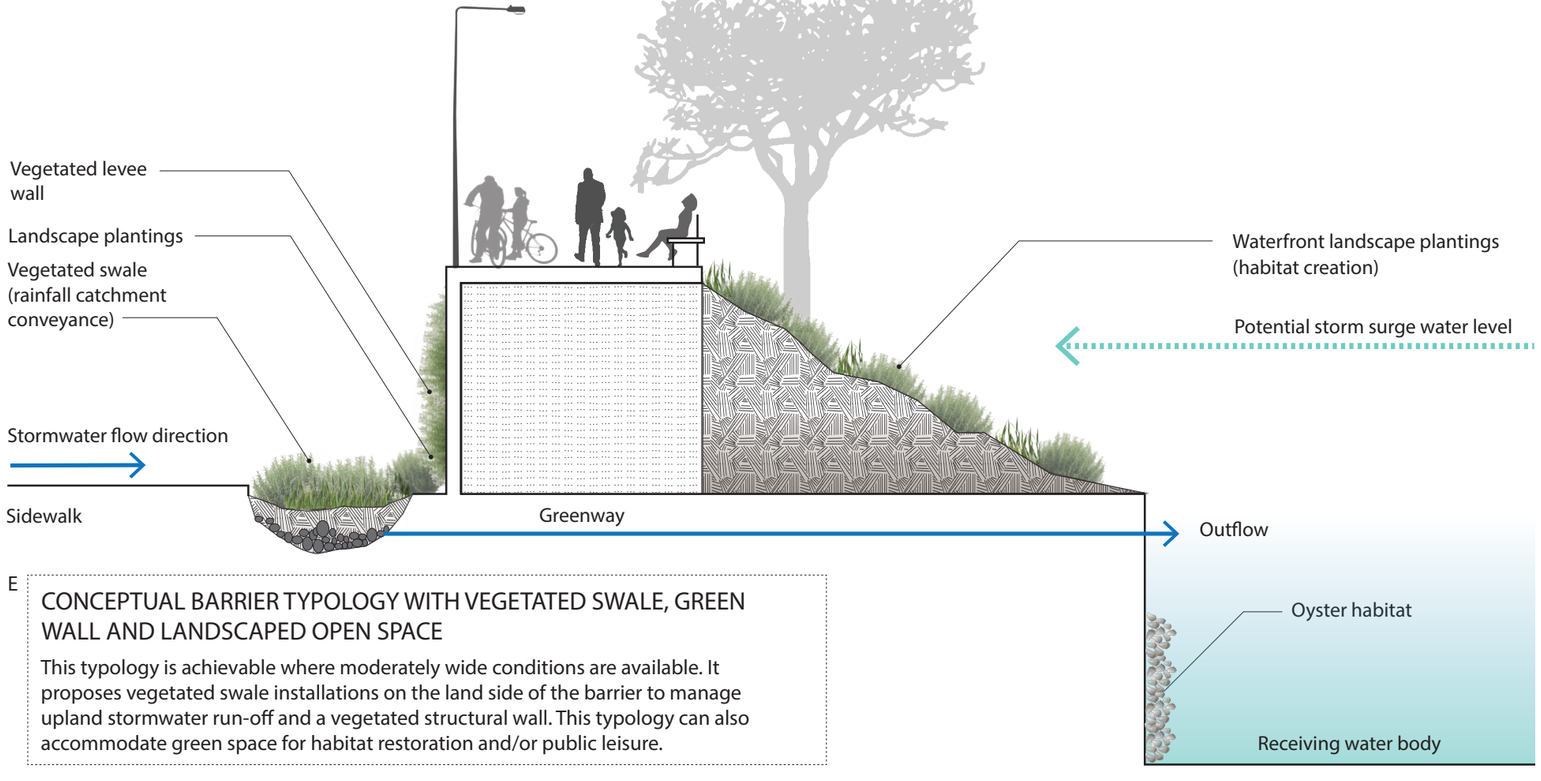


D

CONCEPTUAL BARRIER TYPOLOGY WITH VEGETATED SWALE AND PUBLIC GATHERING SPACE

This typology is achievable where moderately wide conditions are available. It proposes vegetated swale installations on the land side of the barrier to manage upland stormwater run-off. This typology can also accommodate public plaza space, stairs and seating for gathering. On the waterfront side, the structural face of the levee can house a green wall system to encourage habitat functions at the water's edge.

An earthen berm storm barrier serves as a bike and pedestrian route with access ramps to the lower level waterfront edge.
Precedent: Parque Del Agua
River: Ebro - Zaragoza, Spain
Image Source: Prominki

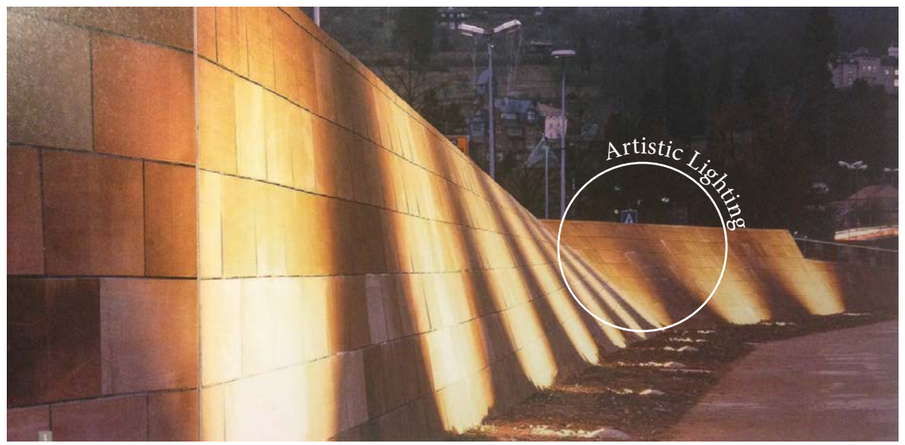


E

CONCEPTUAL BARRIER TYPOLOGY WITH VEGETATED SWALE, GREEN WALL AND LANDSCAPED OPEN SPACE

This typology is achievable where moderately wide conditions are available. It proposes vegetated swale installations on the land side of the barrier to manage upland stormwater run-off and a vegetated structural wall. This typology can also accommodate green space for habitat restoration and/or public leisure.

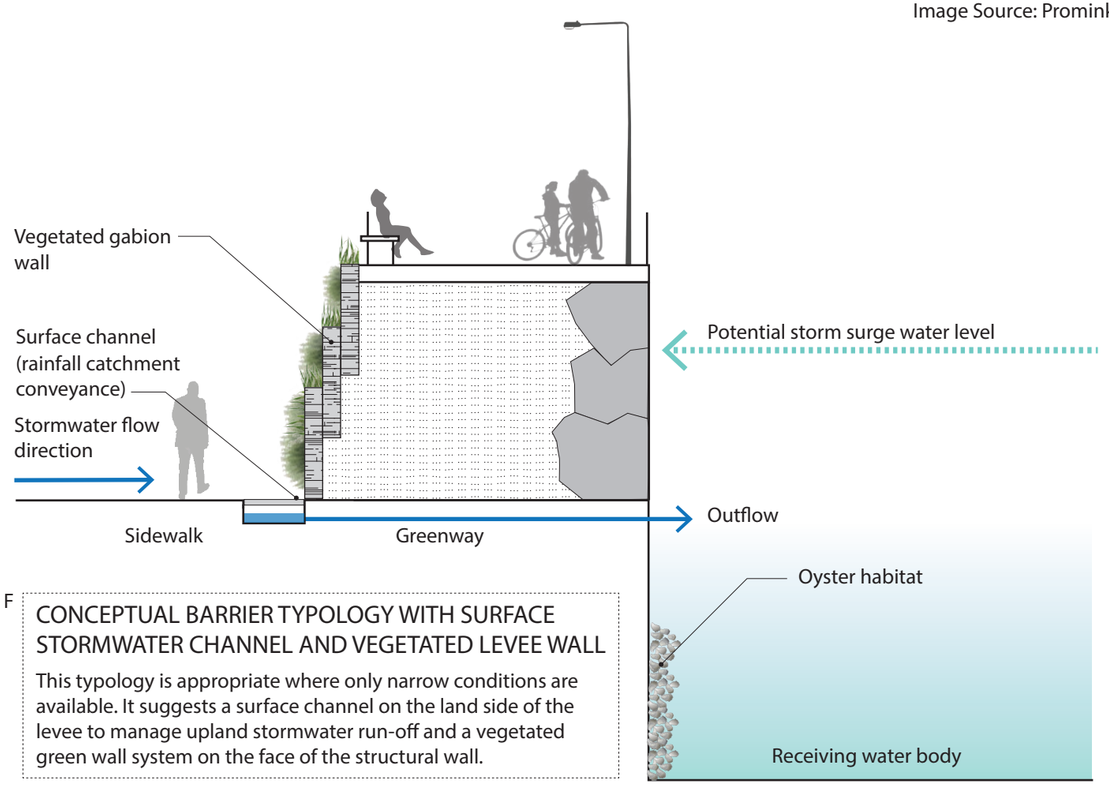
GREENWAY RESILIENCY BARRIER TYPOLOGIES: NARROW CONDITIONS



This protective system divides the waterfront edge into an upper level behind a decorative retaining wall and a lower terrace, which can be flooded.
Precedent: Flood Management Concept
River: Main - Miltonburg, Germany
Image Source: Prominki

A series of large boardwalks and promenades are elevated and constructed on an existing bulkhead to create open spaces with playgrounds, restaurants, and programmed public gathering areas. The lower level promenade, located under the boardwalk shown above, is inundated by seasonal flooding.
Precedent: Berges du Rhone
River: Rhone - Lyon, France
Image Source: Prominki

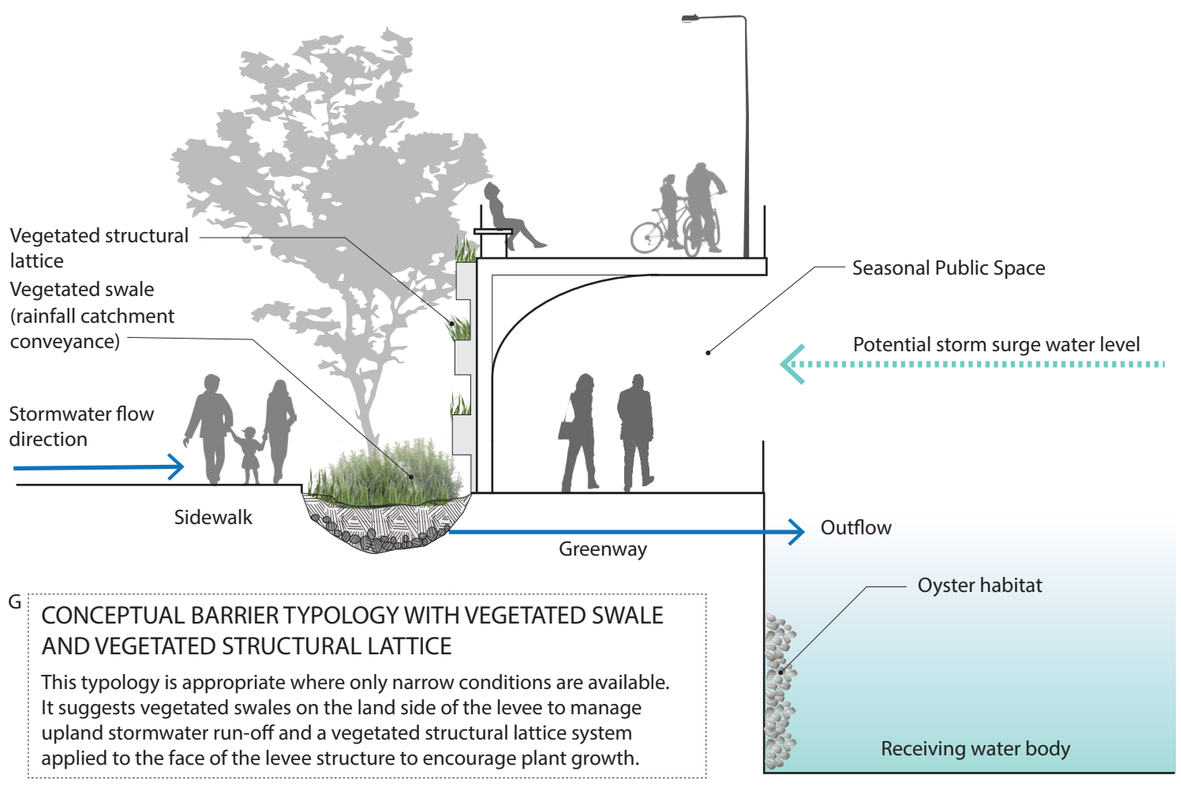
A planted retaining wall using reinforced concrete stacks can be found on the inter-urban Greenway trail in the Pacific Northwest, United States.
Precedent: Bellingham Greenway Trail at Arroyo Park
(Image Source: www.bellinghamgreenroofs.com/case-studies)



F

CONCEPTUAL BARRIER TYPOLOGY WITH SURFACE STORMWATER CHANNEL AND VEGETATED LEVEE WALL

This typology is appropriate where only narrow conditions are available. It suggests a surface channel on the land side of the levee to manage upland stormwater run-off and a vegetated green wall system on the face of the structural wall.

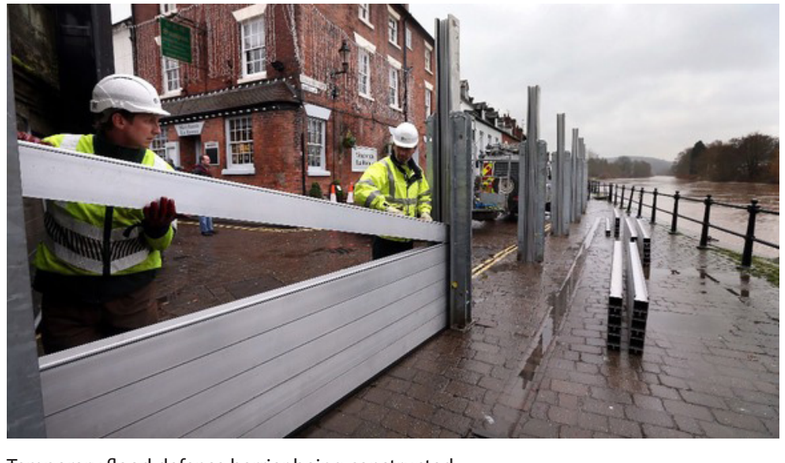


G

CONCEPTUAL BARRIER TYPOLOGY WITH VEGETATED SWALE AND VEGETATED STRUCTURAL LATTICE

This typology is appropriate where only narrow conditions are available. It suggests vegetated swales on the land side of the levee to manage upland stormwater run-off and a vegetated structural lattice system applied to the face of the levee structure to encourage plant growth.

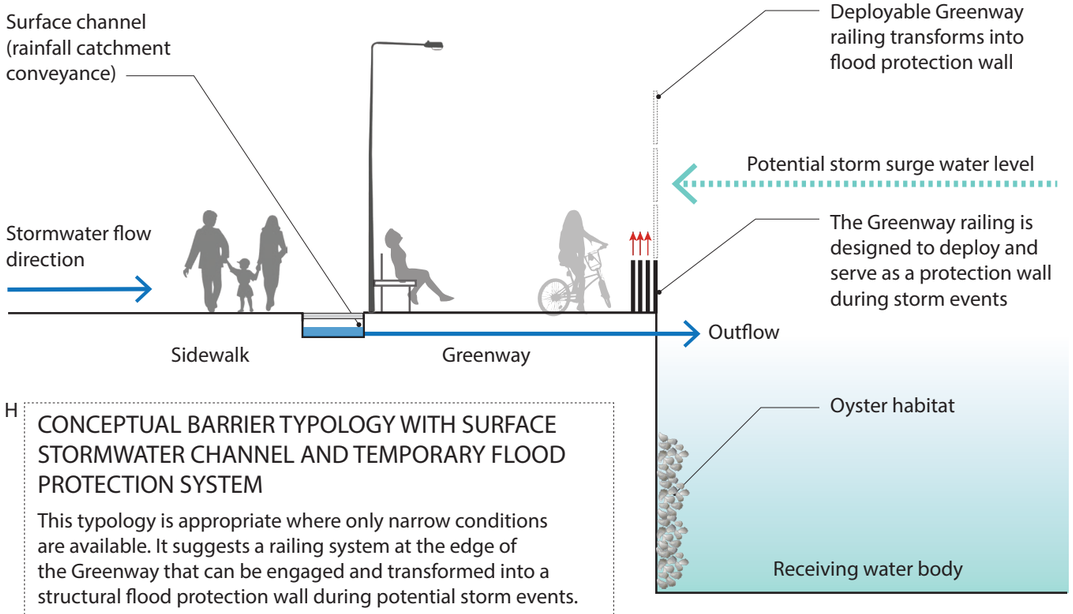
GREENWAY RESILIENCY BARRIER TYPOLOGIES: NARROW CONDITIONS



Temporary flood defense barrier being constructed.
Precedent: Bewdley, Worcestershire
River: Severn - United Kingdom
(Image Source: www.boxbarrier.com)

Temporary flood defense wall during storm surge event.
Precedent: Bewdley, Worcestershire
River: Severn - United Kingdom
(Image Source: www.boxbarrier.com)

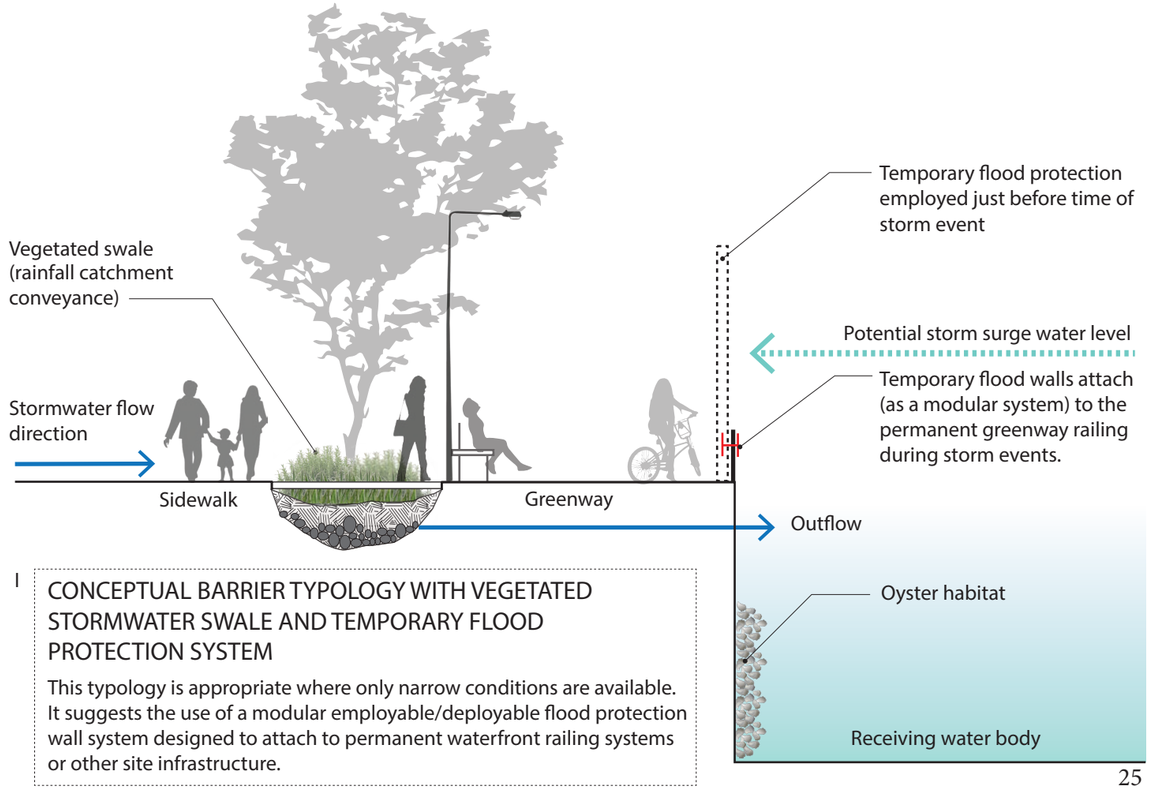
Temporary flood defense wall attached to permanent waterfront railing and pillar system.
Precedent: Modern Woodmen Park
River: Mississippi - Davenport, Iowa
(Image Source: www.ibsengineeredproducts.com)



H

CONCEPTUAL BARRIER TYPOLOGY WITH SURFACE STORMWATER CHANNEL AND TEMPORARY FLOOD PROTECTION SYSTEM

This typology is appropriate where only narrow conditions are available. It suggests a railing system at the edge of the Greenway that can be engaged and transformed into a structural flood protection wall during potential storm events.



I

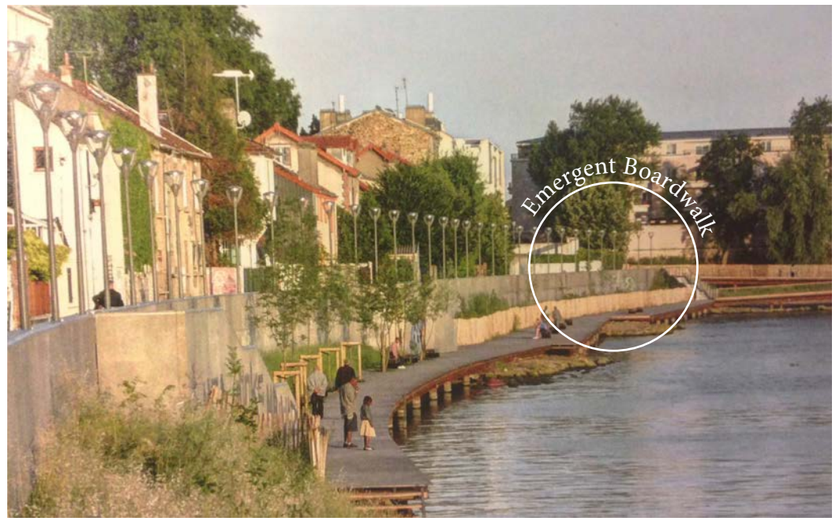
CONCEPTUAL BARRIER TYPOLOGY WITH VEGETATED STORMWATER SWALE AND TEMPORARY FLOOD PROTECTION SYSTEM

This typology is appropriate where only narrow conditions are available. It suggests the use of a modular employable/deployable flood protection wall system designed to attach to permanent waterfront railing systems or other site infrastructure.

GREENWAY RESILIENCY BARRIER TYPOLOGIES: ADDITIONAL CASE STUDIES

The precedents below show examples of how a waterfront barrier can be designed as a multi-faceted and high-performance piece of urban infrastructure. The Brooklyn Greenway, as a bike and pedestrian route, can contribute much more than only access. As a storm surge barrier it can contribute to vital ecological functions and become an important public amenity—allowing city dwellers to access the waterfront while providing nearby residents adequate flood protection during storm events. (Image Sources: Prominki)

A variety of garden-like promenades speckle this waterfront. The upper terrace is accessible year round while lower levels become submerged in storm events.
Precedent: Berges du Rhone
River: Rhone - Lyon, France

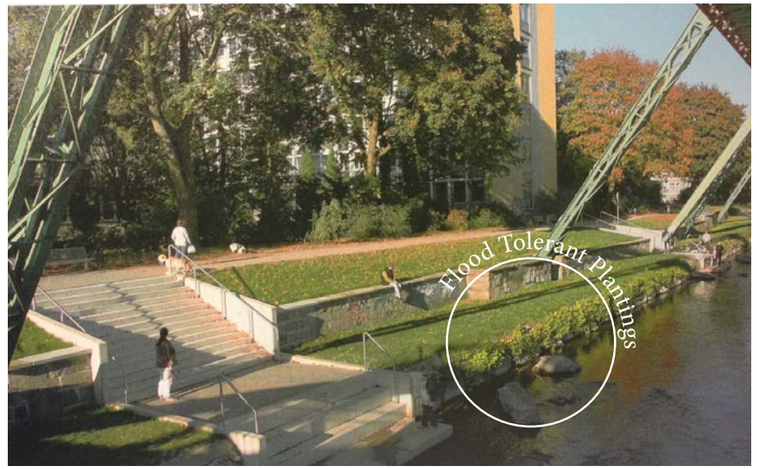


This riverside area has been divided into two levels. The existing promenade has been retrofitted with a 1meter high embankment wall that also serves as a parapet for site lighting. The second (lower level) terrace is built just above the mean water level at the water's edge.
Precedent: Quai des Gondoles
River: Seine - Choisy-le-Roi, France

Along with renewed public waterfront access and double-tiered promenades this design incorporates ecological upgrading of the Seine river. The creation and restoration of riparian shores contributed to increased habitat functions.
Precedent: Quai des Gondoles
River: Seine - Choisy-le-Roi, France

Wide public embankment promenades have been designed at three different levels with the highest being 4.5m above sea level.
Precedent: Hafen City
River: Elbe - Hamburg, Germany

This project utilizes a historic riverfront mill site to mitigate flood inundation. In the sections between former canal walls (once used for the mills production efforts) wave-like terraces have been built into the terrain as a defense mechanism.
Precedent: Factory by the Water
River: Limmat - Zurich, Switzerland



This waterfront protection strategy provides access to the water using a path system parallel to the river. Catwalks, balconies and direct routes have been delineated to serve a variety of functions including: connecting open spaces, providing views, and enabling direct interaction with the water.
Precedent: Wuppertal 90 degrees
River: Wupper - Wuppertal, Germany

GREENWAY RESILIENCY BARRIER TYPOLOGIES

Applicable Brooklyn Locations

Potential locations along Brooklyn's waterfront where a Greenway barrier may be applicable:

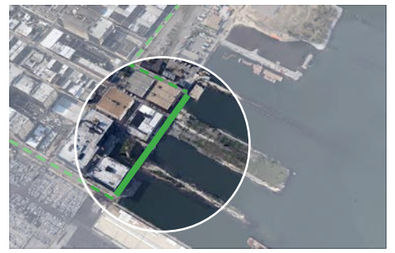
Wide Conditions

Commercial St. at Newtown Barge Playground
GREENPOINT

Kent Ave. at Bushwick Inlet Park
WILLIAMSBURG

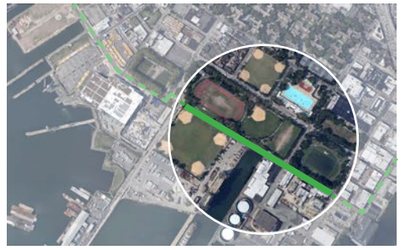
Brooklyn Bridge Park Greenway
BROOKLYN HEIGHTS

2nd Ave. between 29th and 36th at Industry City
SUNSET PARK

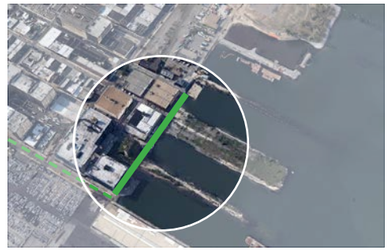


Marginal St. at Marginal St. Piers and Industry City
SUNSET PARK

Moderately Wide Conditions



Halleck St. at Red Hook Park
RED HOOK



Marginal St. at Marginal St. Piers and Industry City
SUNSET PARK

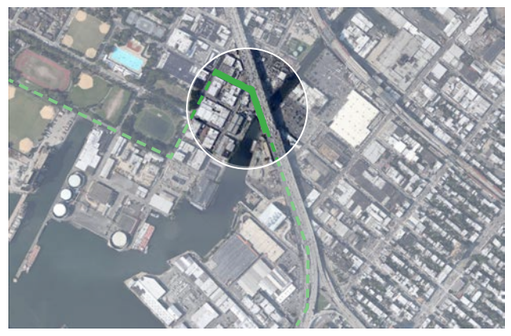
First Ave. between 43rd and 51st St.
SUNSET PARK

Ferris St. at Louis Valentino Jr. Park and Canover St. at Pier 44 Waterfront Garden
RED HOOK

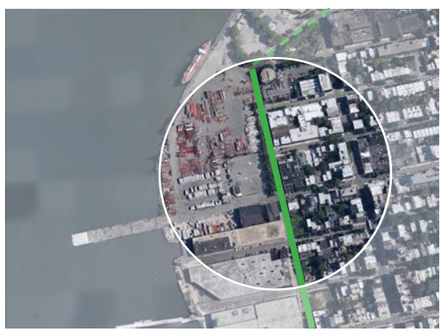
Narrow Conditions

Beard St. Between Van Brunt and Dwight St. - RED HOOK

Ferris St. between Van Dyke and King St. - RED HOOK



Hamilton Ave. at Smith St. - GOWANUS

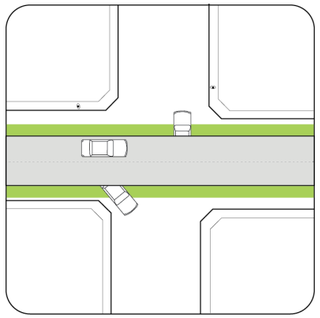


West St. - GREENPOINT

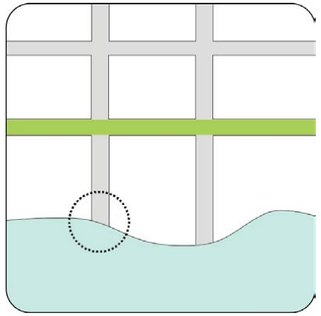
DESIGN CASE STUDY- RED HOOK

Context

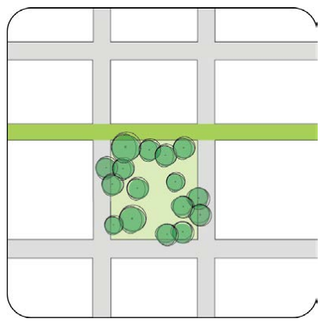
Red Hook experienced extensive damage from Superstorm Sandy and much of the neighborhood is within the 100 year floodplain. Additionally, Red Hook also experiences flooding and frequent combined sewer overflows due to inadequate and aging stormwater management systems. In addition to the data available for Red Hook, our team is following other developments and projects related to post-Sandy recovery and planning efforts. On January 22nd, the design team presented our conceptual proposals to the New York Rising Committee. There is support for our project in Red Hook and the team will continue to follow other developments by The Port Authority of New York and New Jersey, including a stormwater modeling project and by other consultants working as part of the Rebuild By Design Initiatives.



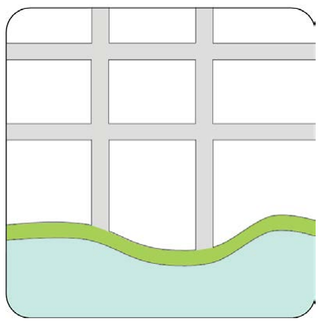
Narrow right of way



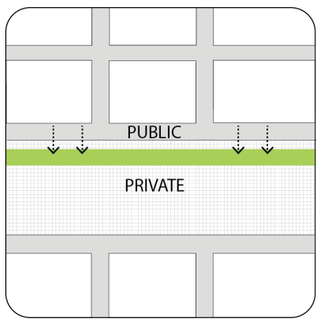
Adjacent to public street end



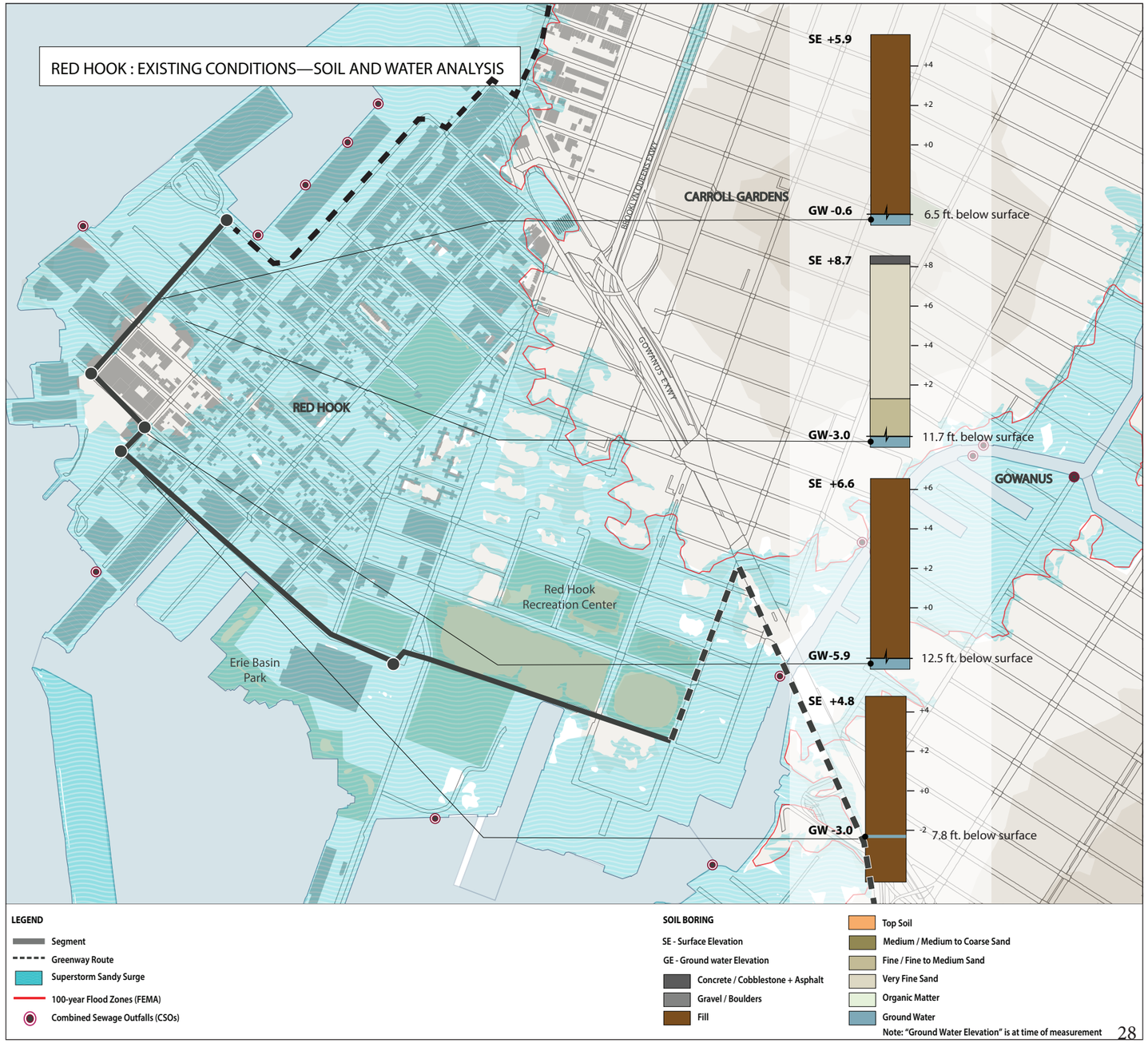
Adjacent to open space



Adjacent to waterfront

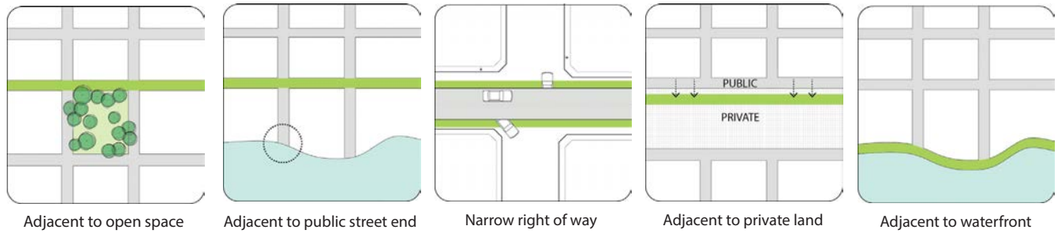


Adjacent to private land

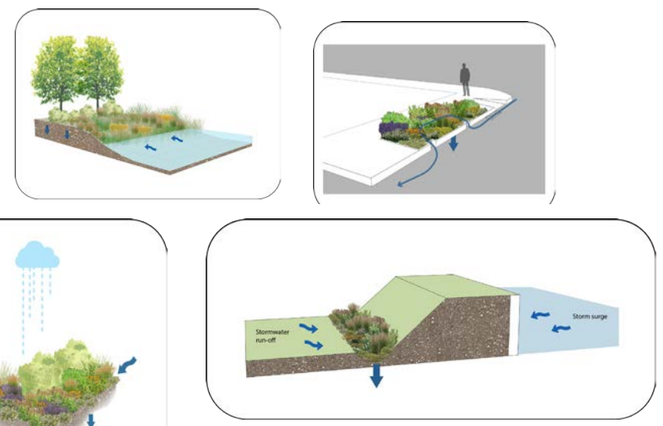


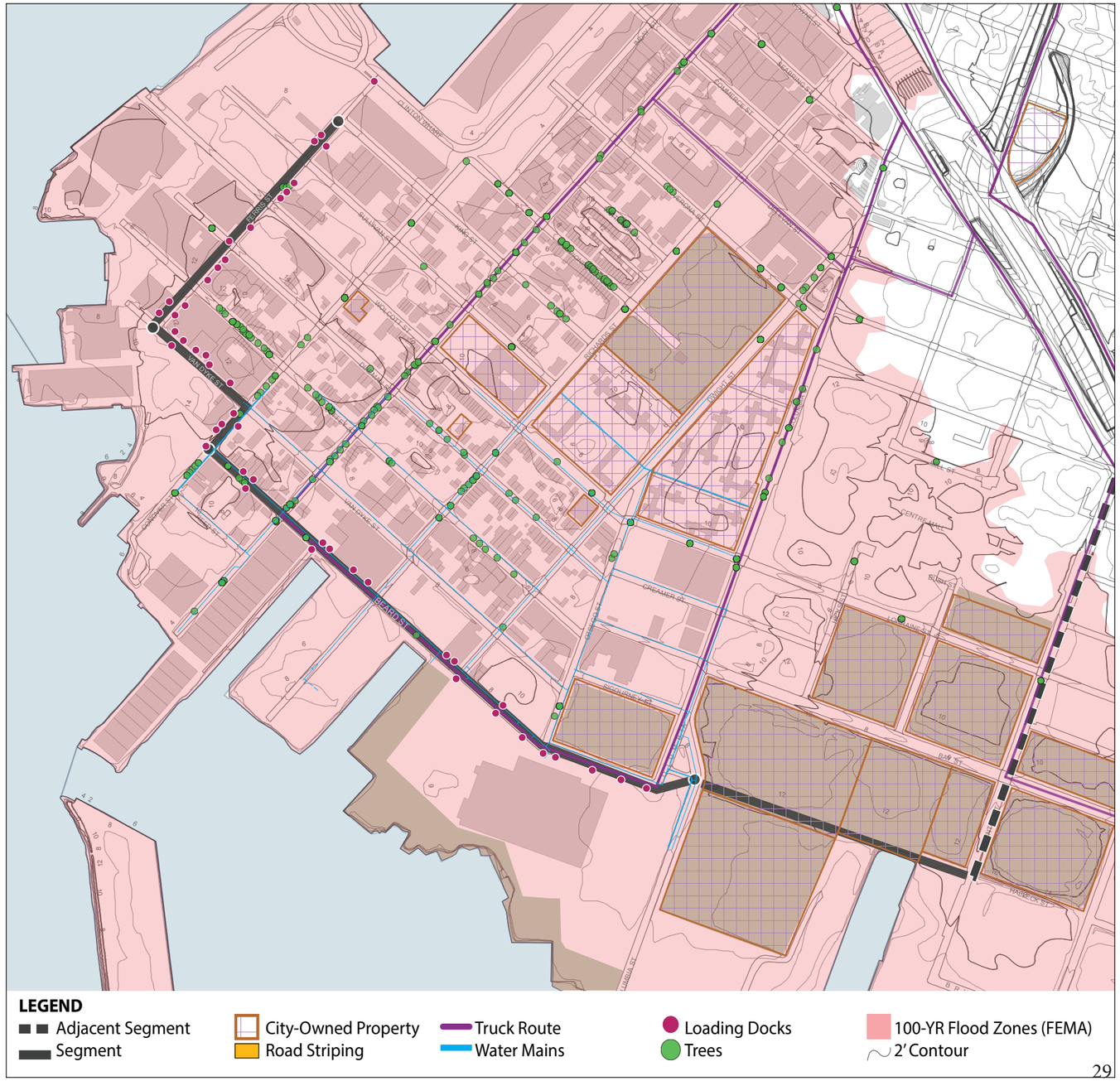
DESIGN CASE STUDY- RED HOOK

Red Hook is characterized by a diversity of land-uses including big box retail mixing with recreational fields, small-scale residential, and active maritime uses. Red Hook also contains the largest public housing development in Brooklyn. We identified five different conditions along the Greenway route in Red Hook. Red Hook is unique in that the Greenway follows along the waterfront at two different stretches. Once along Beard street and second, within the Recreational ball fields. We have proposed two alternative designs. The second proposal explores the idea that the elevated Greenway could run along the waterfront throughout much of Red Hook, providing maximum protection from future storm surges and wave damage. Specific stormwater / green infrastructure strategies that we recommend include ROW bio-swales along sidewalks that are greater than 10 feet in width, rain gardens within stripped and traffic triangles and within public parks, larger vegetated swales within public parks, and wetlands along waterfront parks. Additionally, the Greenway is elevated where possible to connect with other protection strategies to become part of a contiguous protective barrier.

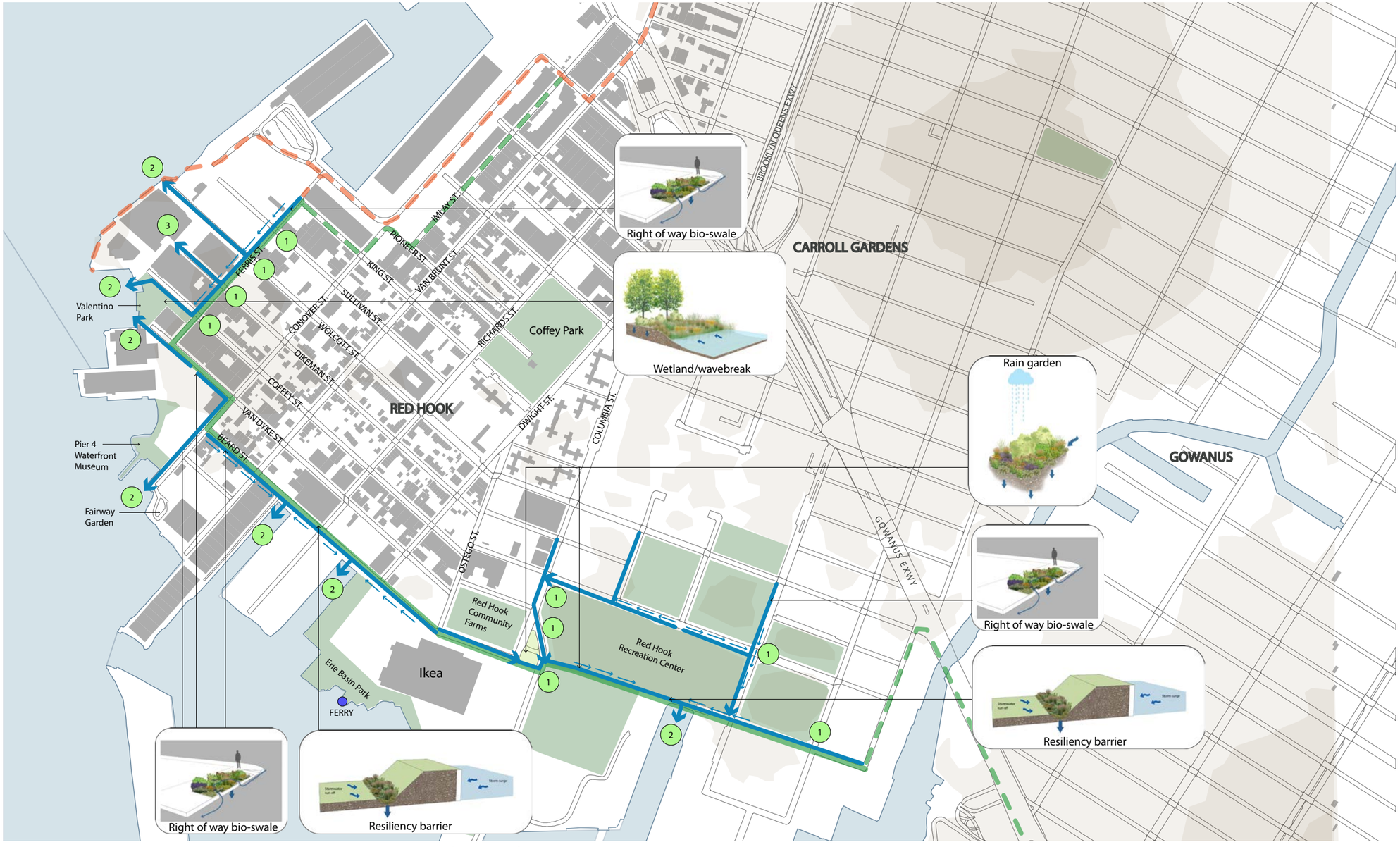


Adjacent to open space | Adjacent to public street end | Narrow right of way | Adjacent to private land | Adjacent to waterfront





RED HOOK MASTER PLAN DESIGN - ALT 1



Brooklyn Greenway
Stormwater conveyance at grade
Stormwater conveyance below grade
Directional flow of surface water

DOT Master Plan preferred route alternative

Stormwater Big Moves

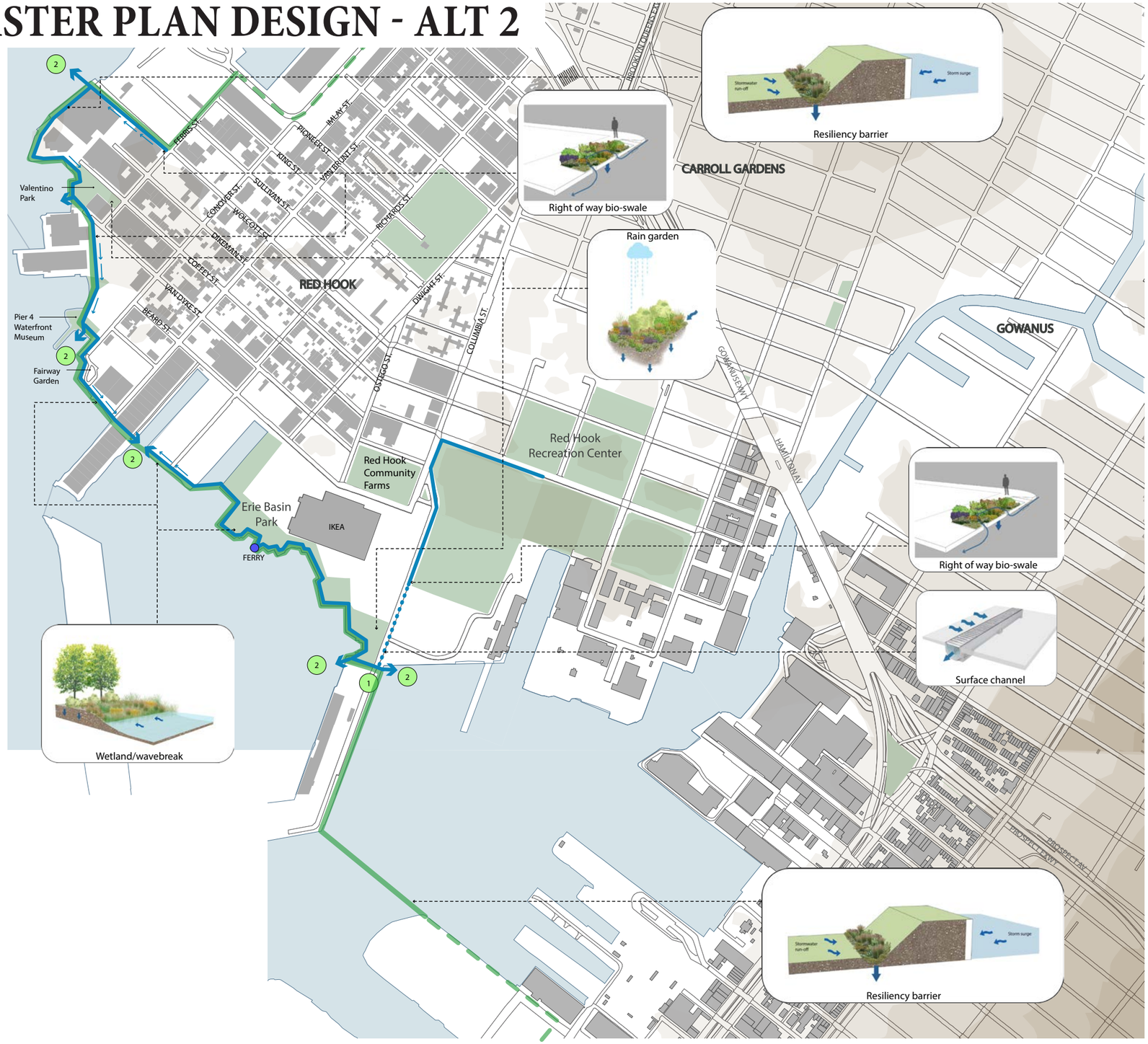
1. Moving Water Across the Street
2. Conveying Water to the Receiving Water Body
3. Moving Water from Private to Public Land or from Public to Private

Green Infrastructure Typologies

Wetland/wavebreak
Rain garden
Resiliency barrier
Surface channel
Right of way bio-swale

1" = 500'

RED HOOK MASTER PLAN DESIGN - ALT 2



Brooklyn Greenway
Stormwater conveyance at grade
Stormwater conveyance below grade
Directional flow of surface water

Stormwater Big Moves

1. Moving Water Accross the Street
2. Conveying Water to the Receiving Water Body

Green Infrastructure Typologies

Wetland/wavebreak
Rain garden
Resiliency barrier
Surface channel
Right of way bio-swale

1" = 500'

RED HOOK WATER MANAGEMENT CALCULATIONS

Proposed green infrastructure interventions for the *Red Hook Master Plan Alt. 1* design has the capacity to **capture 5,069,000 gallons** of stormwater run-off annually with **10,300 sq. ft. of green infrastructure**. This matrix is based on our methodology's "Tier 1" goal to capture and treat 100% of the first one inch of rainfall within the Greenway ROW (adjacent to or containing the Greenway, measured from building to building).

The chart below shows the area of impervious surface of the Greenway footprint along six public streets in Red Hook. This area has then been used to calculate how much area of green infrastructure is needed to manage 100 % of the first 1 inch of rainfall that reaches this watershed in a given storm.

Red Hook Greenway Segments 8,9 & 10	ROW Area (ft^2) (Assume all impervious)	Area of green infrastructure proposed (ft^2) - See Note 1	Managed Volume 1-inch Storm Event (gal)	Managed Volume Annual 85% (gal) - See Note 2
Ferris St. between Sullivan and Van Dyke	40,644	2,000	25,335	990,589
Van Dyke St. between Ferris and Canover	20,017	1,000	12,477	487,861
Conover St. between Van Dyke and Beard	10,652	500	6,640	259,614
Beard St. between Conover and Dwight	54,439	2,700	33,934	1,326,805
Beard St. between Dwight and Columbia (Bike Lane only)	11,991	600	7,474	292,249
Halleck St. between Columbia and Court	70,227	3,500	43,775	1,711,596
Total ROW area (ft^2)	207,970			
Total green infrastructure area proposed (ft^2)		10,300		
Total Managed Volume 1-inch Storm Event (gal)			129,635	
Total Managed Volume Annual 85% (gal)				5,068,714
		Note 1: Assumes 20:1 ratio of impervious area to GI		*Note 2: Assumes 46 inches of annual rainfall.*

Moving water across the street

5' x 20' Bulb-out (typ)

5' x 20' Bio-swale (typ)

Canover Street

Loading dock location

Parking Lot

Outflow to River

Conveying Water to the Receiving Water Body

Wolcott Street

21ST AVE. TRANSPORTATION

LIBERTY TRANSIT

Dikeman Street

Coffey Street

CORNELL PAPER AND BOX CO.

Van Dyke Street

Waterfront Garden and Museum

Liberty Warehouse

Pier 41 Assoc.

FLICKINGER GLASSWORKS

Wave Attenuation/ Habitat Creation

A

Outflow to park

10'

8'

10'

Ferris Street

Greenway

RED HOOK WINERY

STEVE'S KEY LIME PIES

THE LIBERTY WAREHOUSE

TIME SHRED SERVICES

Outflow into park (channel)

Valentino Park

Vegetated channel

Overflow through proposed development

Outflow to River

NORTH

Location

Plan A - Ferris Street to Beard Street Proposed

Scale: 1"=110'

Note: Alternative 1 Design

Improved Public Amenities

Wetland/Wavebreak

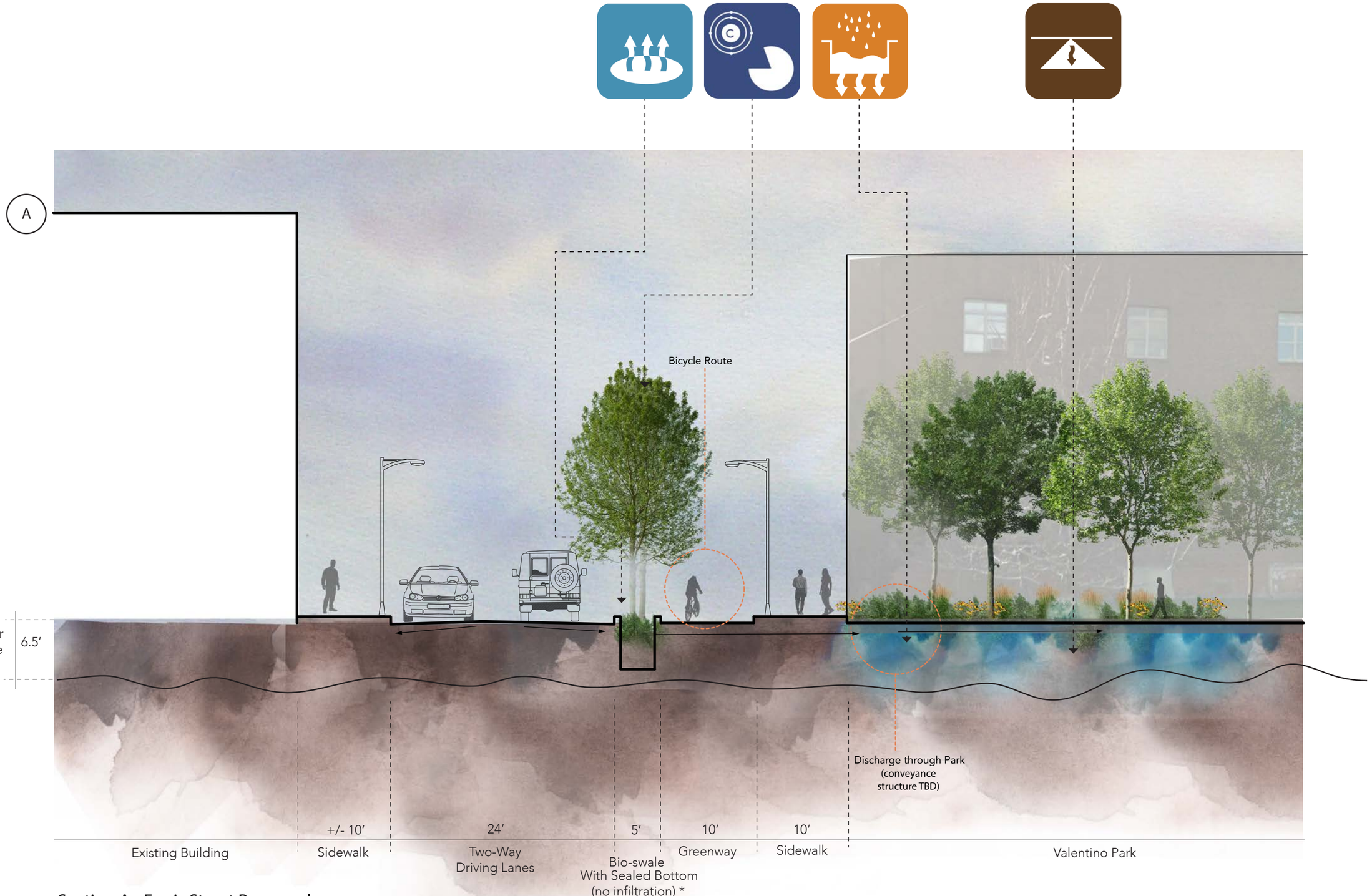
Flow direction of water run-off

Outflow direction of water to receiving waterbody

Flow direction of water through conveyance structure TBD

Vehicular traffic flow direction

Direction of high level storm sewer flow

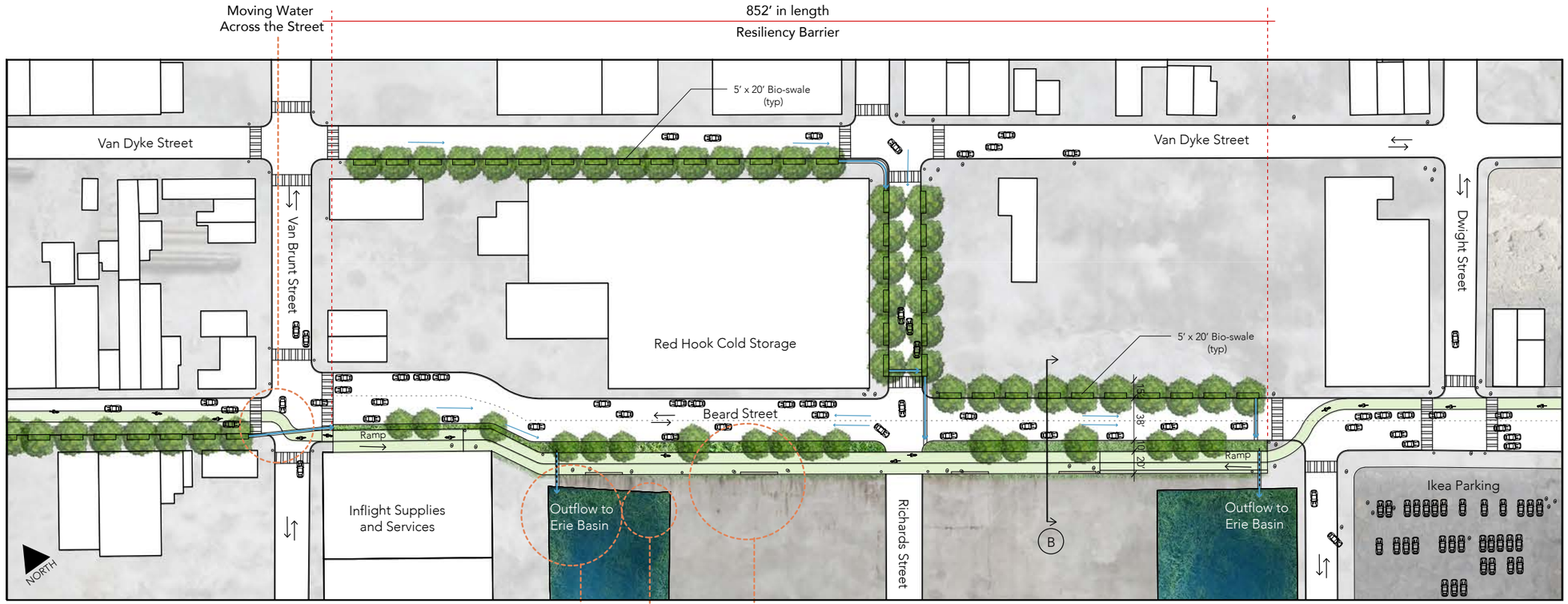


Section A - Ferris Street Proposed

Looking South

Scale: 1″=10′

* High Ground Water Level = Sealed Bio-swale (no infiltration)



Plan B - Beard Street Proposed

Scale: 1"=110'

Note: Alternative 1 Design

Location

B

Infiltration

Bicycle Route

Improved Public Amenities

Living Wall

Waterfront

Coastal Protection

Ground Water
below Surface

8′

Pipe overflow to receiving waterbody

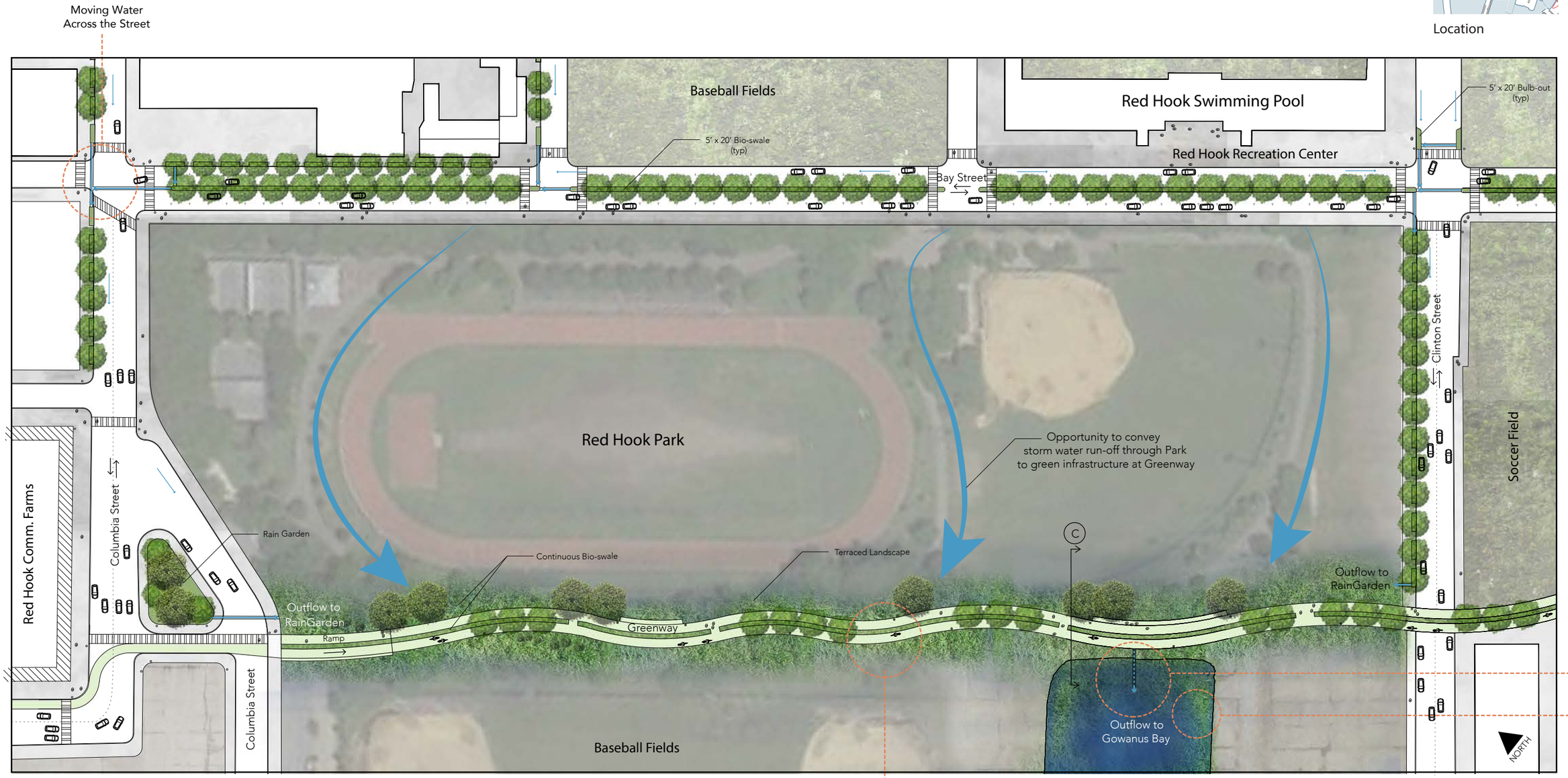
15′	5′	8′	38′	8′	5′	6′	20′
Existing Building	Sidewalk	Bio-swale	Parking	Two-Way Driving Lanes	Parking	Rain Garden	Terraced Landscape	Greenway Resiliency Barrier	Industrial Pier

Section B - Beard Street Proposed

Looking East

Scale: 1″=10′

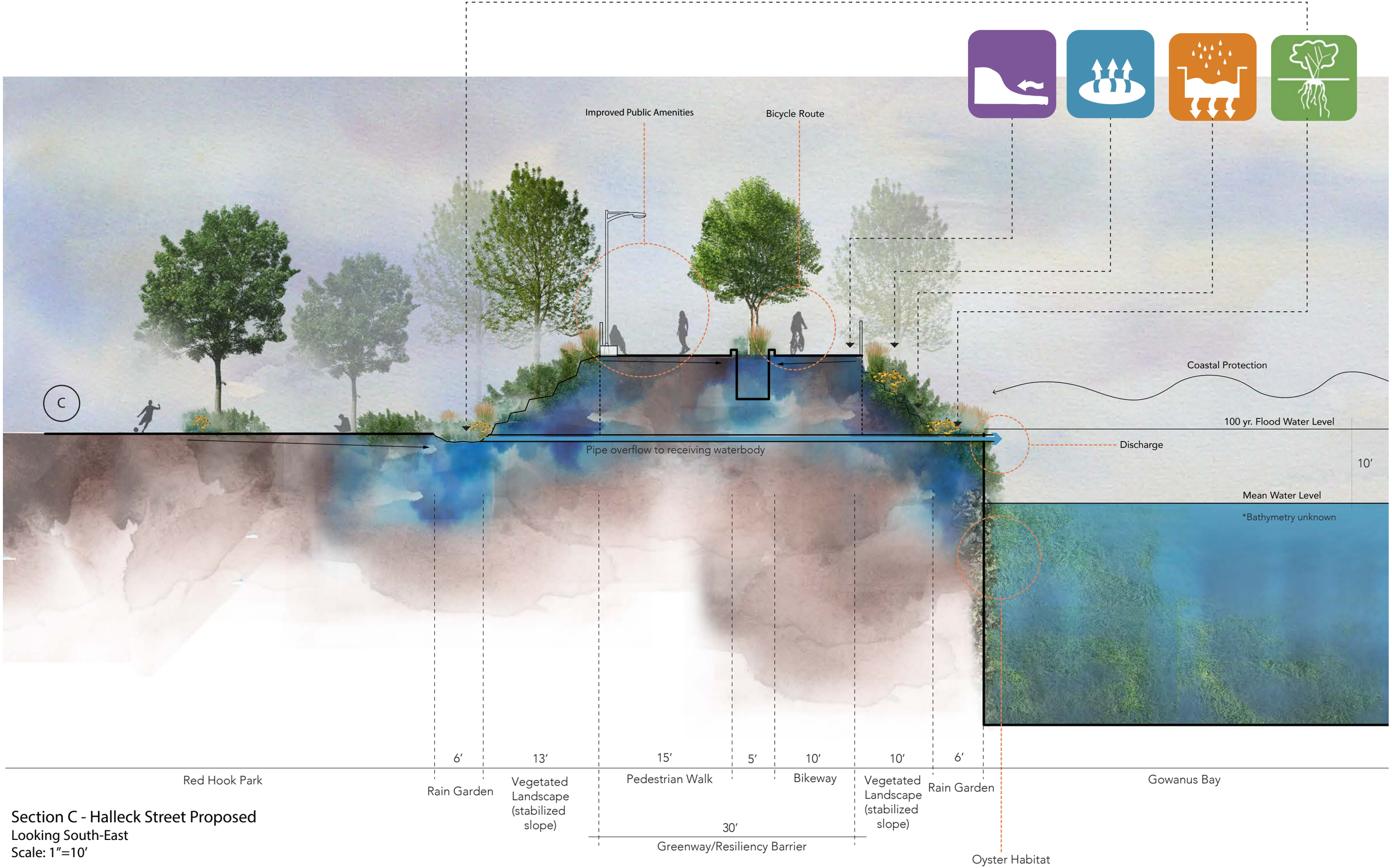
Location



Plan C - Halleck Street Proposed

Scale: 1"=110'

Note: Alternative 1 Design



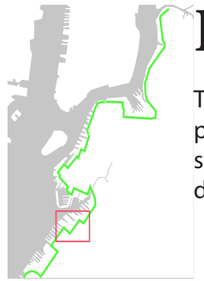
Section C - Halleck Street Proposed

Looking South-East

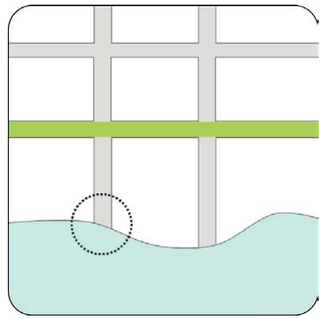
Scale: 1″=10′

DESIGN CASE STUDY- SUNSET PARK

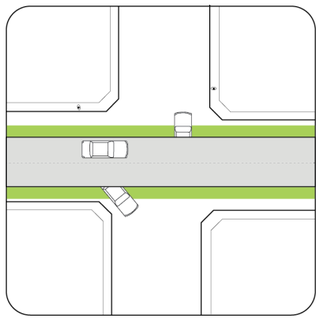
The Greenway travels mostly through industrial land use in Sunset Park. This stretch is particularly unique in that much of the land ownership is by one or two developers and a long stretch of the Greenway passes along the waterfront. Sunset Park has many opportunities to demonstrate how the Greenway can be an elevated barrier and serve as storm surge protection while also improving the quality of life for those working and commuting to and from Sunset Park. Our team will continue to be in touch with the developers of Industry City to collaborate in creating a Greenway that meets all of their needs while providing an infrastructural amenity for the entire district.



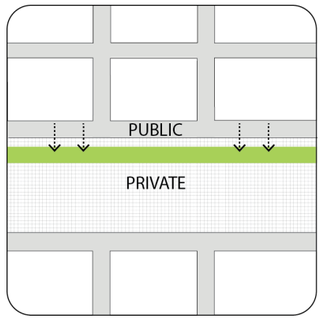
Context



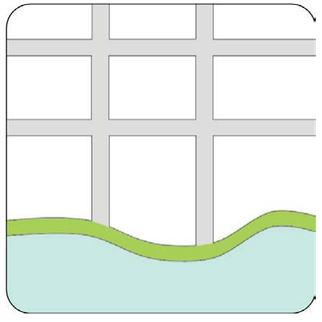
Adjacent to public street end



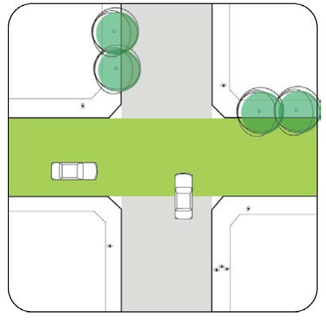
Adjacent to elevated roadway



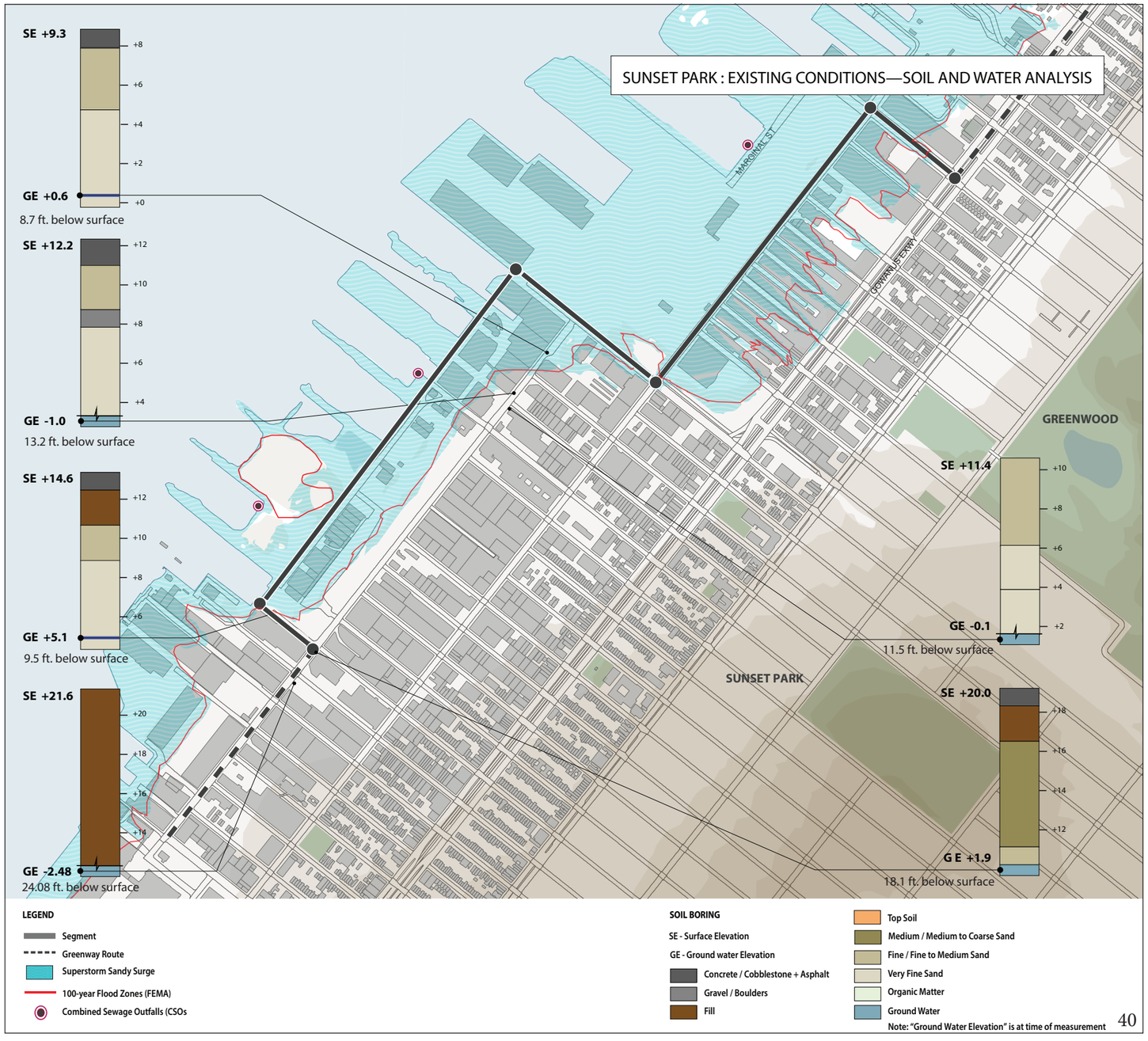
Adjacent to private land



Adjacent to waterfront

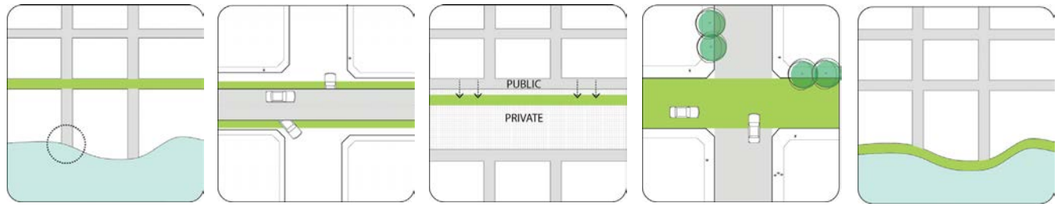


Wide right of way



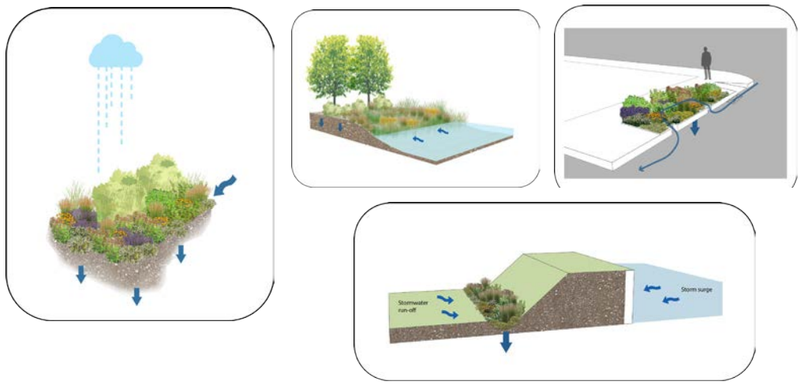
DESIGN CASE STUDY- SUNSET PARK

We identified five different conditions along the Greenway in Sunset Park with the opportunity to integrate four different GI design typologies, including ROW bio-swales along 2nd Avenue, rain gardens down the center of 29th Street, and wetlands along Marginal Street. In addition, we have proposed two different design alternatives for an elevated Greenway along Marginal Street. One alternative shows the elevated barrier hugging the existing bulkhead. The second alternative is a more ambitious proposal where the Greenway is integrated into a large park-like space, with fingers of constructed wetlands, boardwalks and kayak launches for visitors.



Adjacent to public street end | Adjacent to elevated roadway | Adjacent to private land | Wide right of way | Adjacent to waterfront

+



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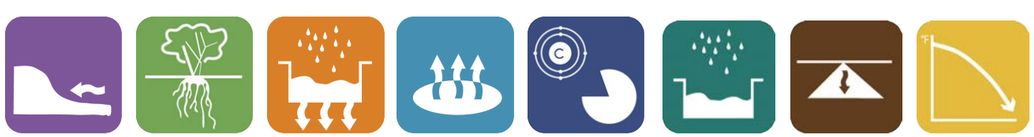
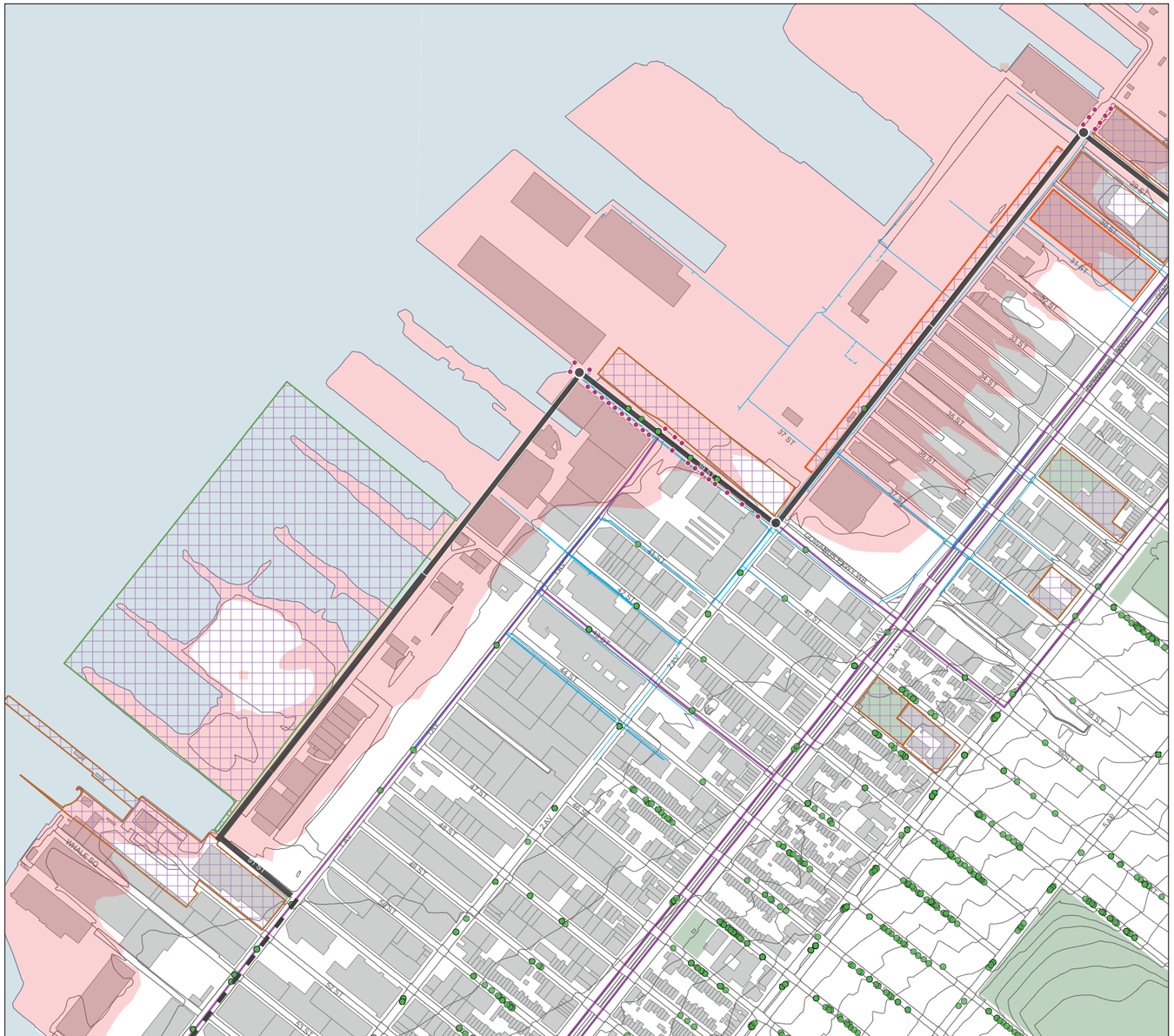




SUNSET PARK MASTER PLAN DESIGN

Brooklyn Greenway
Stormwater Conveyance At-Grade
Stormwater Conveyance Below-Grade

Stormwater Big Moves

1. Moving Water Across the Street
2. Conveying Water to the Receiving Water Body
3. Moving Water from Private to Public Land or from Public to Private
3. Conveying Water from an Elevated Structure to the Ground

Green Infrastructure Typologies

Wetland/wavebreak
Rain garden
Resiliency barrier
Surface channel
Right of way bio-swale

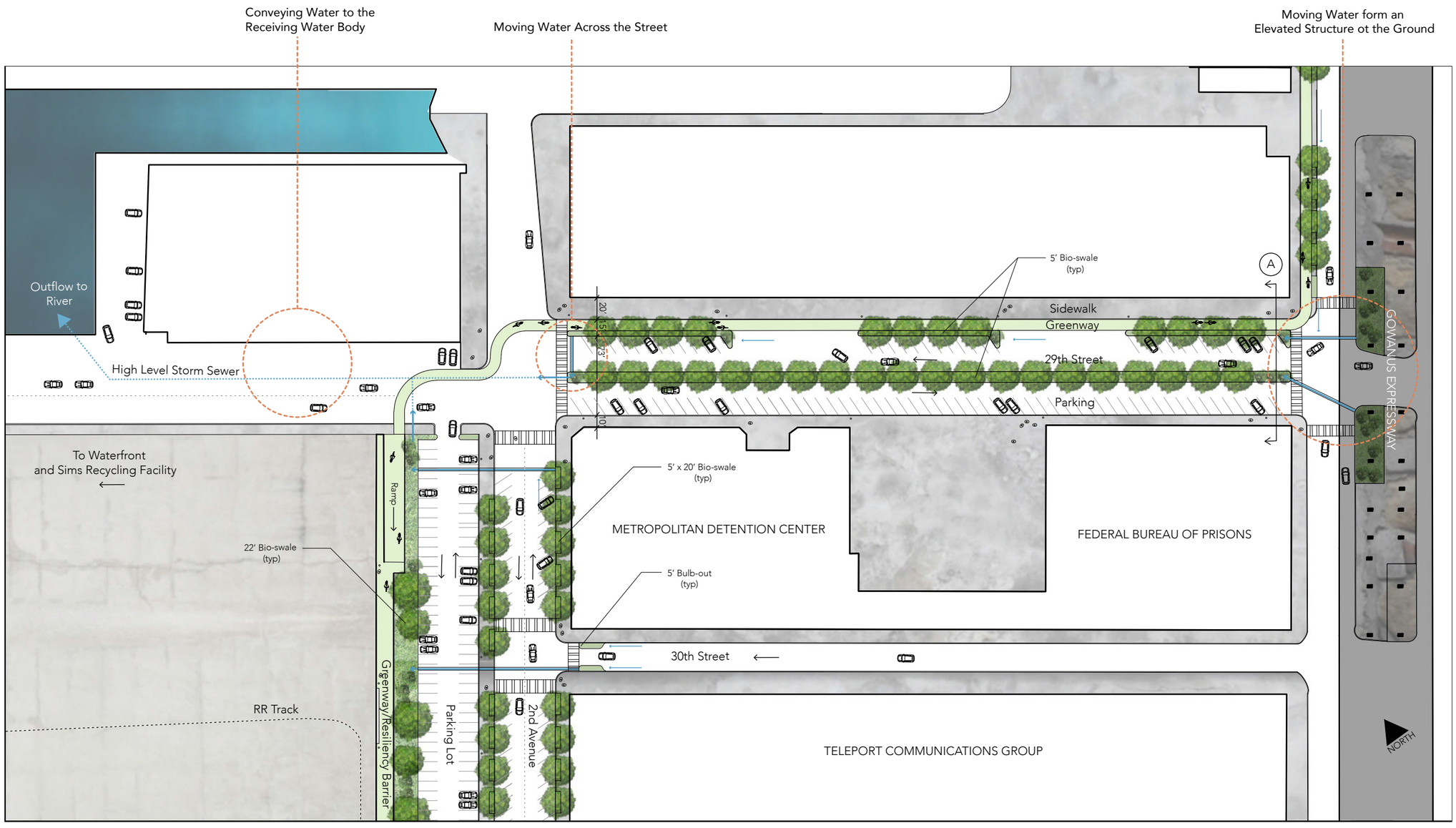
1" = 500'

SUNSET PARK WATER MANAGEMENT CALCULATIONS

Proposed green infrastructure interventions for the *Sunset Park Master Plan Alt. 1* design has the capacity to **capture 11,738,000 gallons** of stormwater run-off annually with **24,100sq. ft. of green infrastructure**. This matrix is based on our methodology's "Tier 1" goal to capture and treat 100% of the first one inch of rainfall within the Greenway ROW (adjacent to or containing the Greenway, measured from building to building).

The chart below shows the area of impervious surface of the Greenway footprint along four public streets in Sunset Park. This area has then been used to calculate how much area of green infrastructure is needed to manage 100% of the first 1 inch of rainfall that reaches this watershed in a given storm.

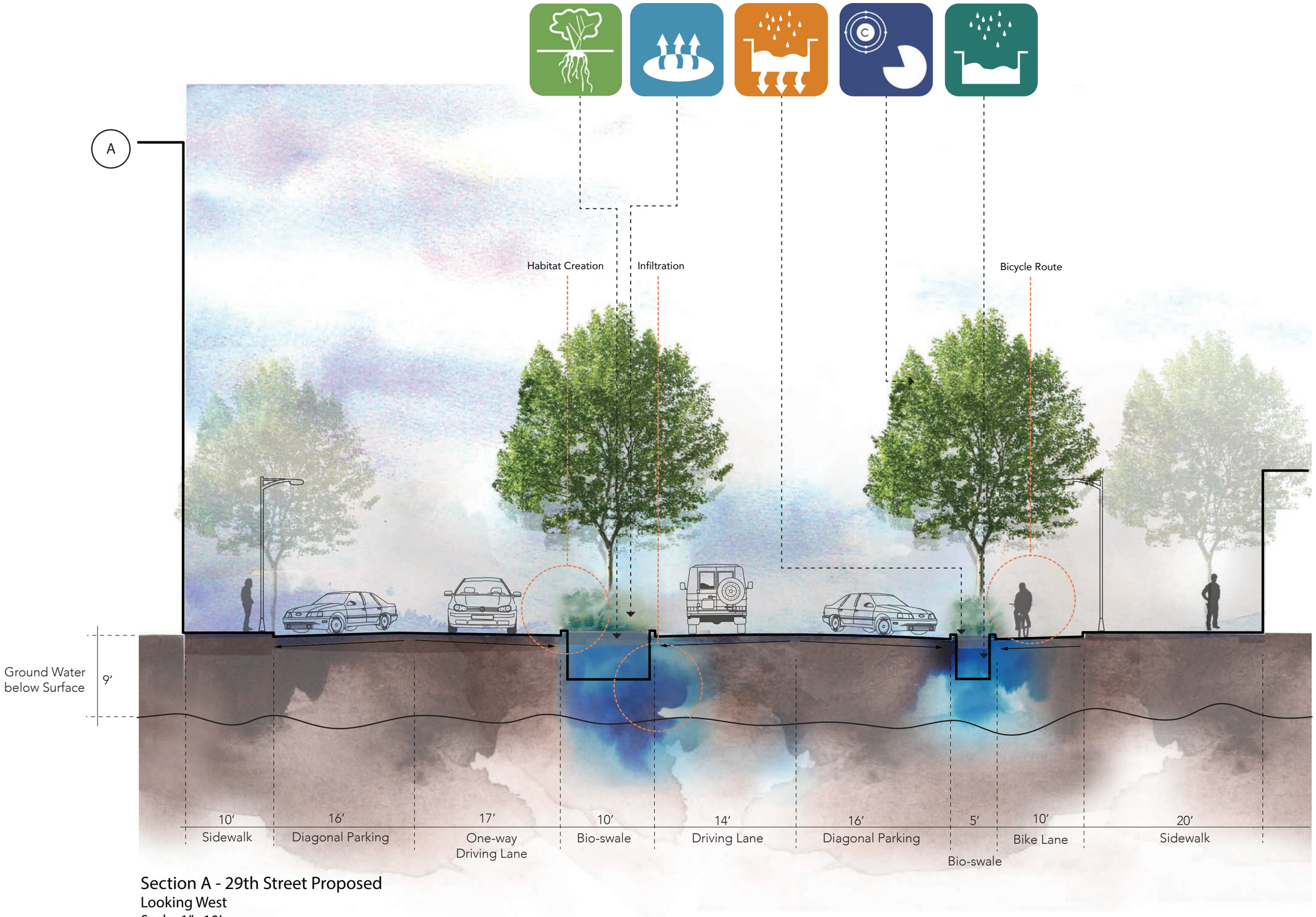
Sunset Park Greenway Segments 12,13 & 14	ROW Area (ft^2) (Assume all impervious)	Area of green infrastructure proposed (ft^2) - See Note 1	Managed Volume 1-inch Storm Event (gal)	Managed Volume Annual 85% (gal) - See Note 2
3rd Avenue between 28th and 29th Streets (A)	16,598	800	10,346	404,532
29th Street between 3rd Avenue and 2nd Avenue	83,830	4,200	52,254	2,043,133
2nd Avenue from 29th Street and 36th Street	301,107	15,100	187,690	7,338,680
Marginal Avenue Alt 1 from 39th Street to 44th Street	80,093	4,000	49,925	1,952,053
Total ROW area (ft^2)	481628			
Total green infrastructure area proposed (ft^2)		24,100		
Total management volume of GI proposed (gal)			300,215	
Total annual volume managed (gal/yr)				11,738,398
		Note 1: Assumes 20:1 ratio of impervious area to GI		*Note 2: Assumes 46 inches of annual rainfall.*



Plan A - 29th Street Proposed
Scale: 1"=100'

Outflow direction of water to receiving waterbody
Flow direction of water through conveyance structure TBD
Vehicular traffic flow direction
Direction of high level storm sewer flow

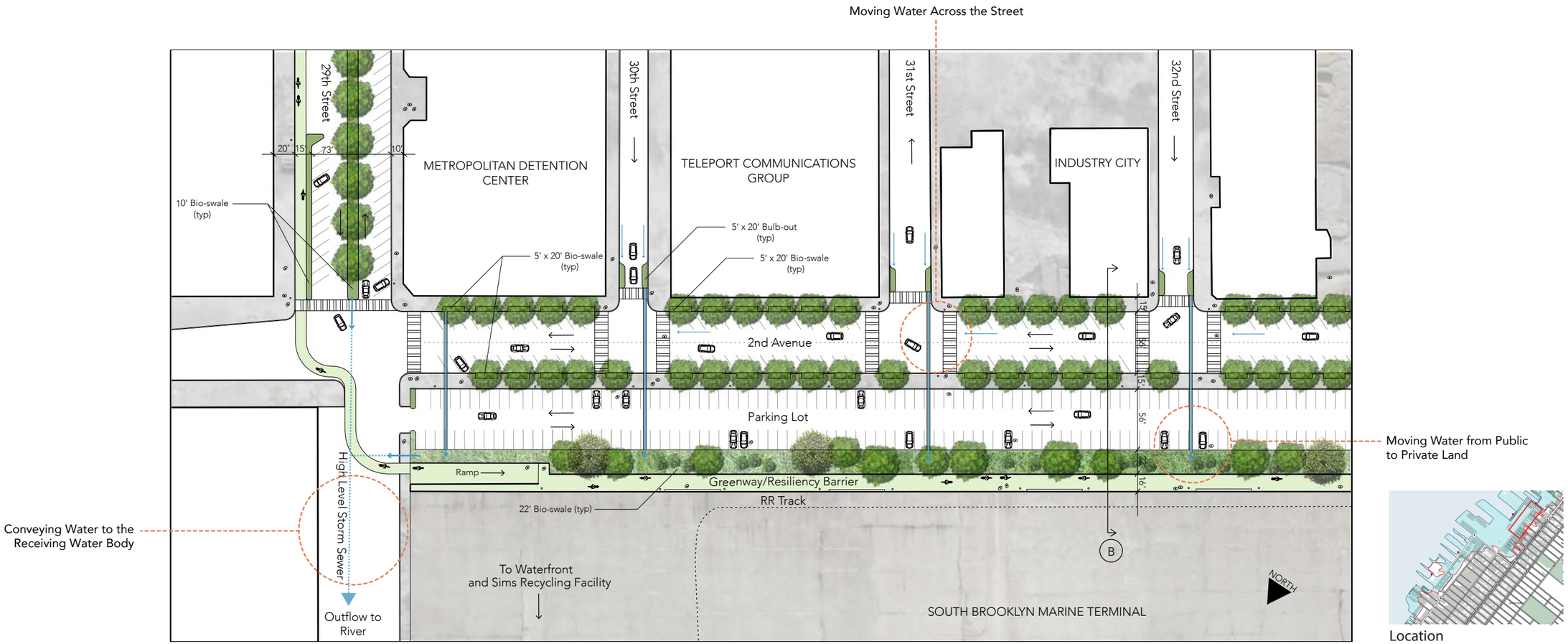
Location



Section A - 29th Street Proposed

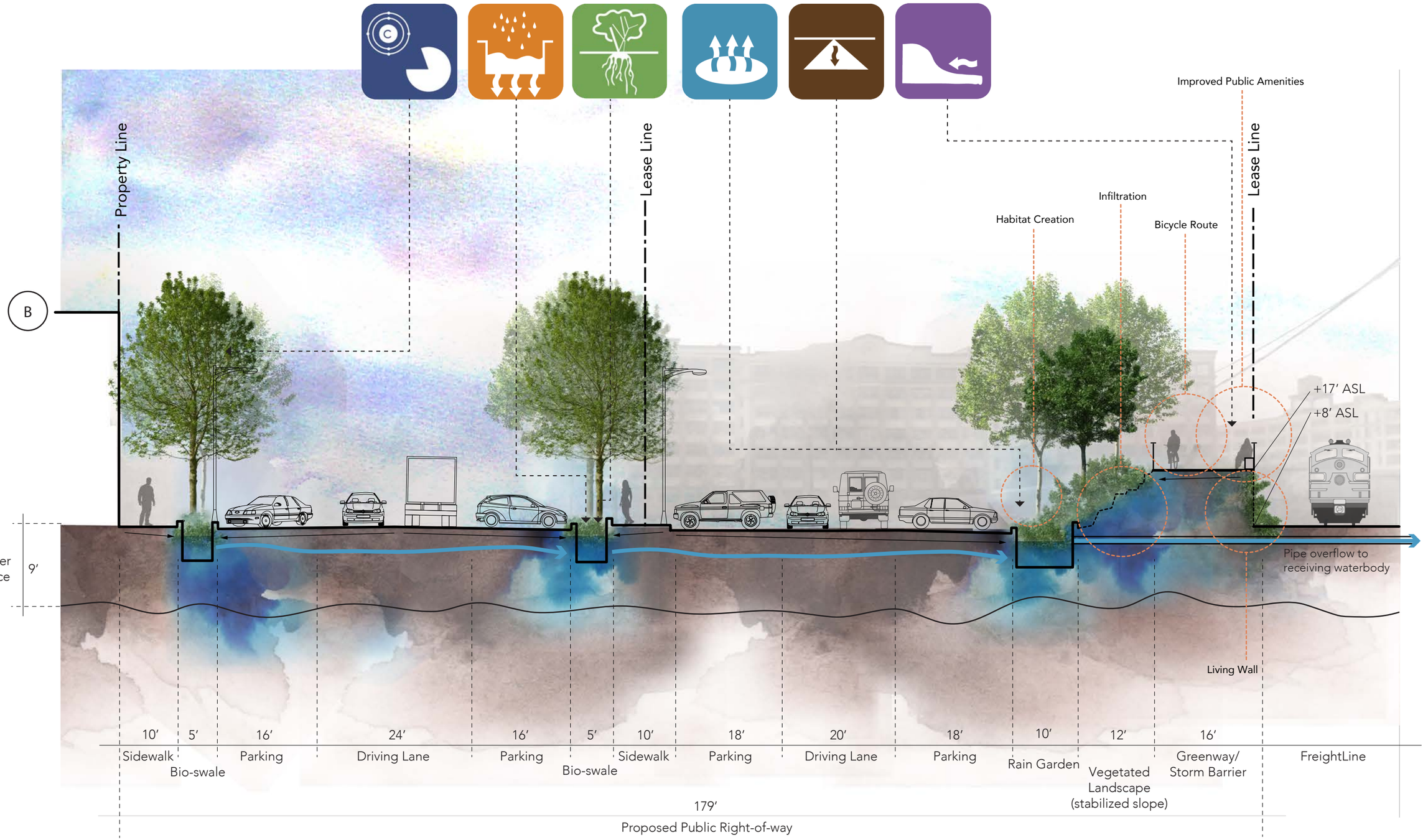
Looking West

Scale: 1″=10′



Plan B - 2nd Avenue Proposed
Scale: 1"=100'

Photos of deployable flood barriers for entrances and other gaps in a flood barrier.
(Image Sources: ekofloodusa.com)

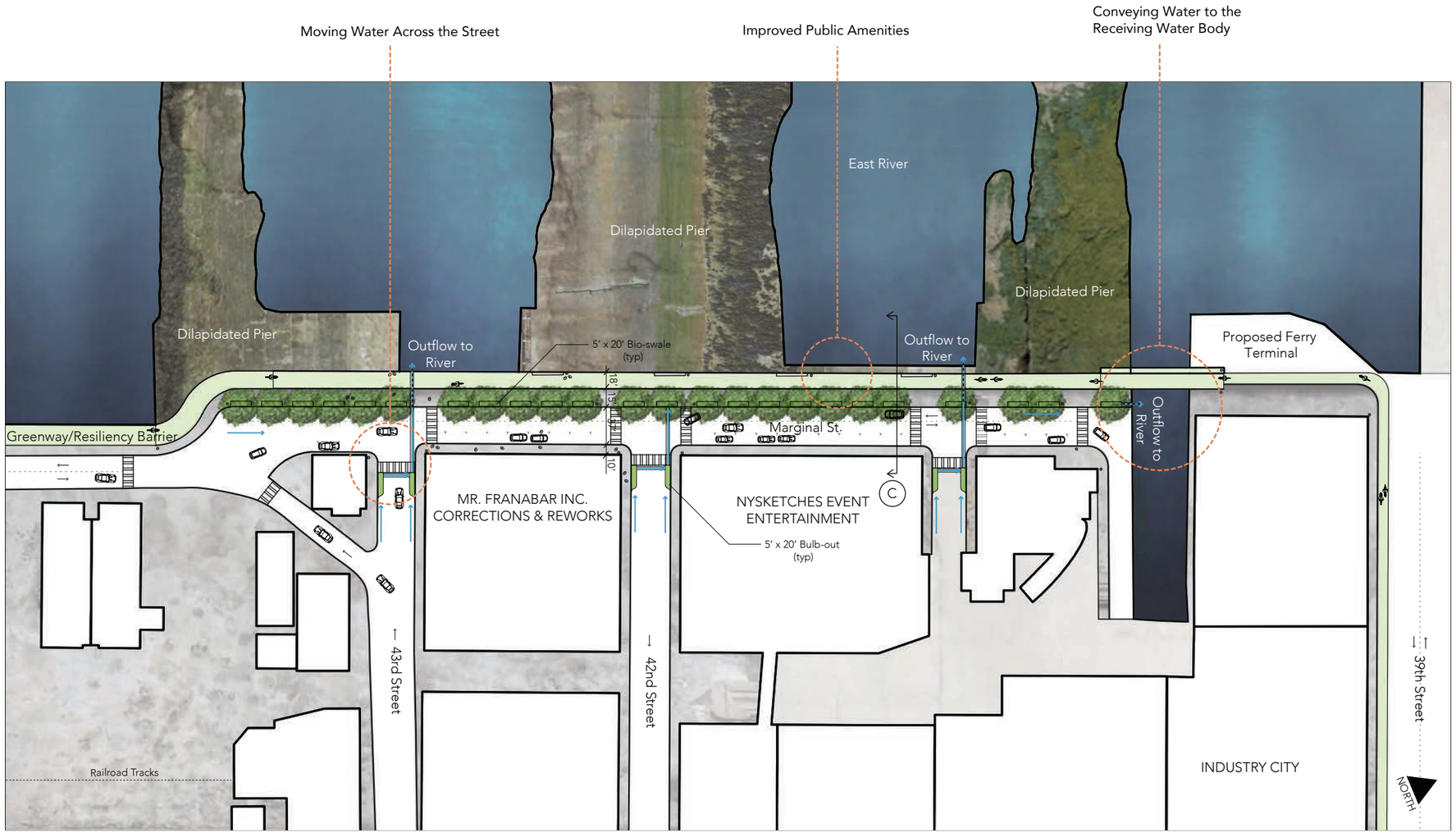


Section B - 2nd Avenue Proposed

Looking South

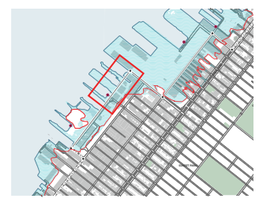
Scale: 1″=16′

Birds Eye View - Green Infrastructure and Climate Change Resiliency
The Greenway at 29th Street and 2nd Avenue - Sunset Park

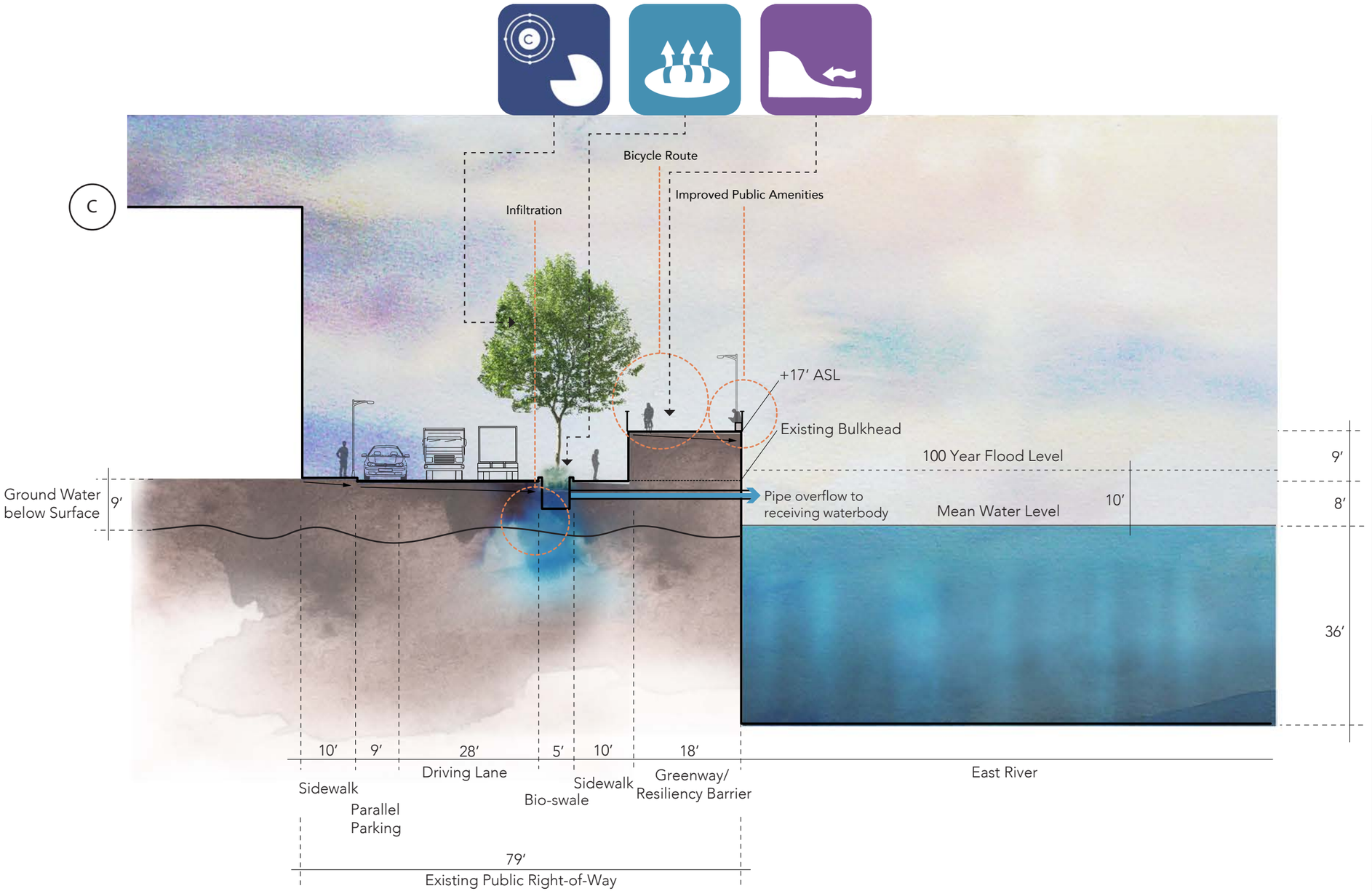


Plan C - Marginal Street Alt.1 Proposed
Scale: 1"=110'

Outflow direction of water to receiving waterbody
Flow direction of water through conveyance structure TBD
Vehicular traffic flow direction
Direction of high level storm sewer flow



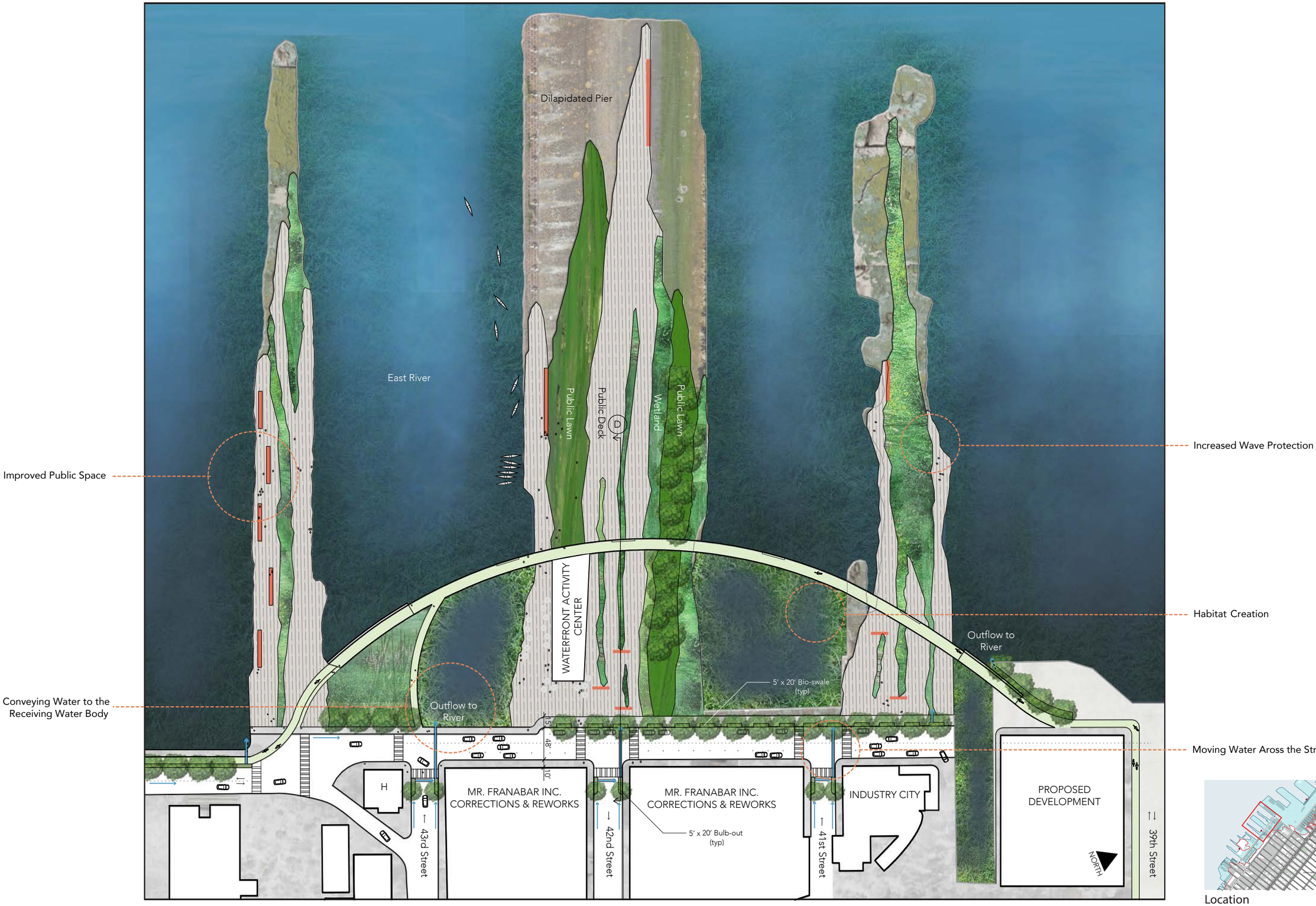
Location



Section C - Marginal Street Alt. 1 Proposed

Looking South

Scale: 1″=20′



Location

Plan D - Marginal Street Alt. 2 (Restored Piers) Proposed

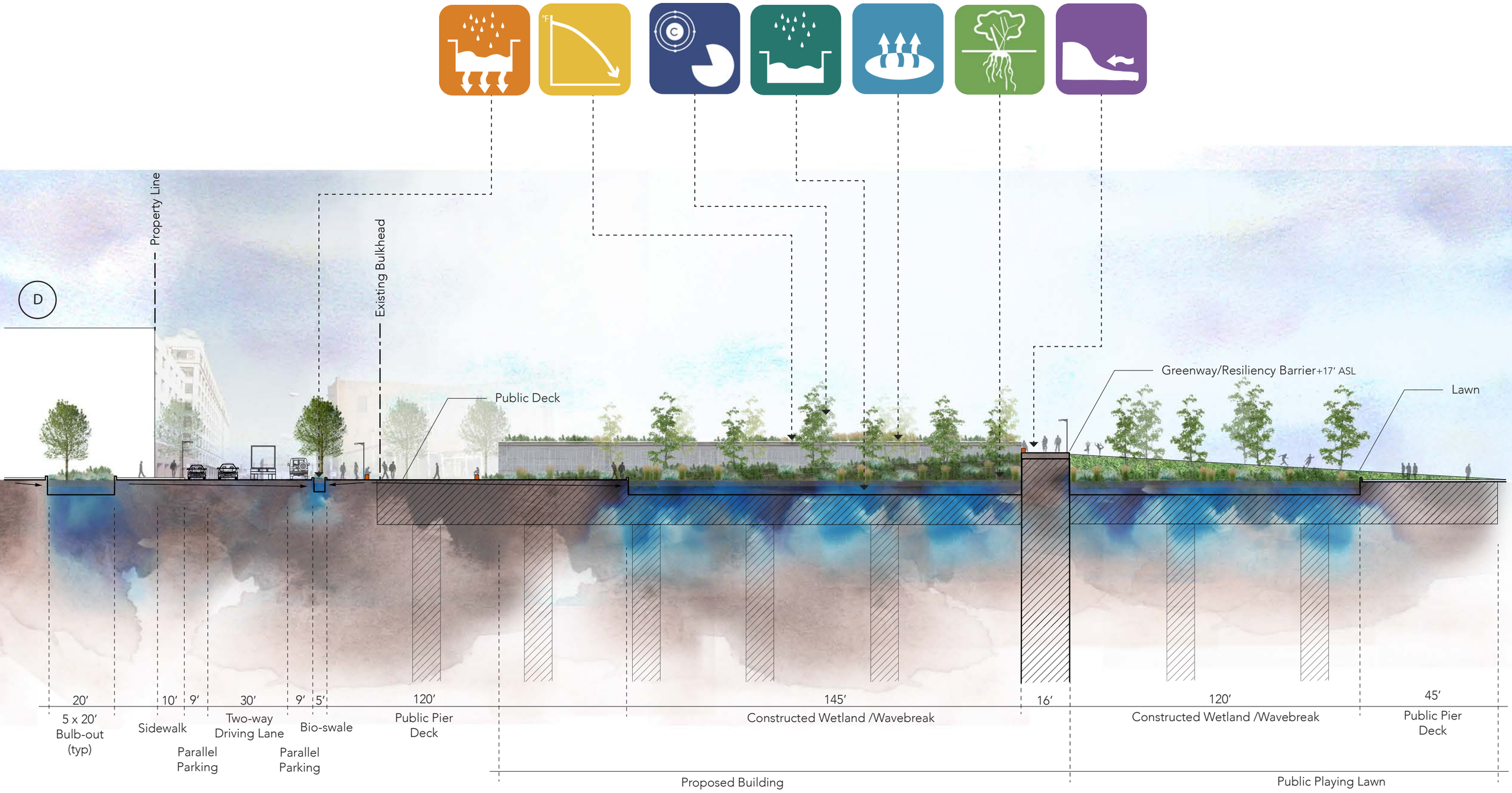
Scale: 1"=120'

Outflow direction of water to receiving waterbody

Flow direction of water through conveyance structure TBD

Vehicular traffic flow direction

Direction of high level storm sewer flow



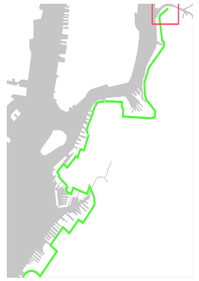
Section D - Marginal Street Alt. 2 (Restored Piers) Proposed

Looking South

Scale: 1"=30'

PART 2
APPENDIX - SEGMENT ANALYSIS

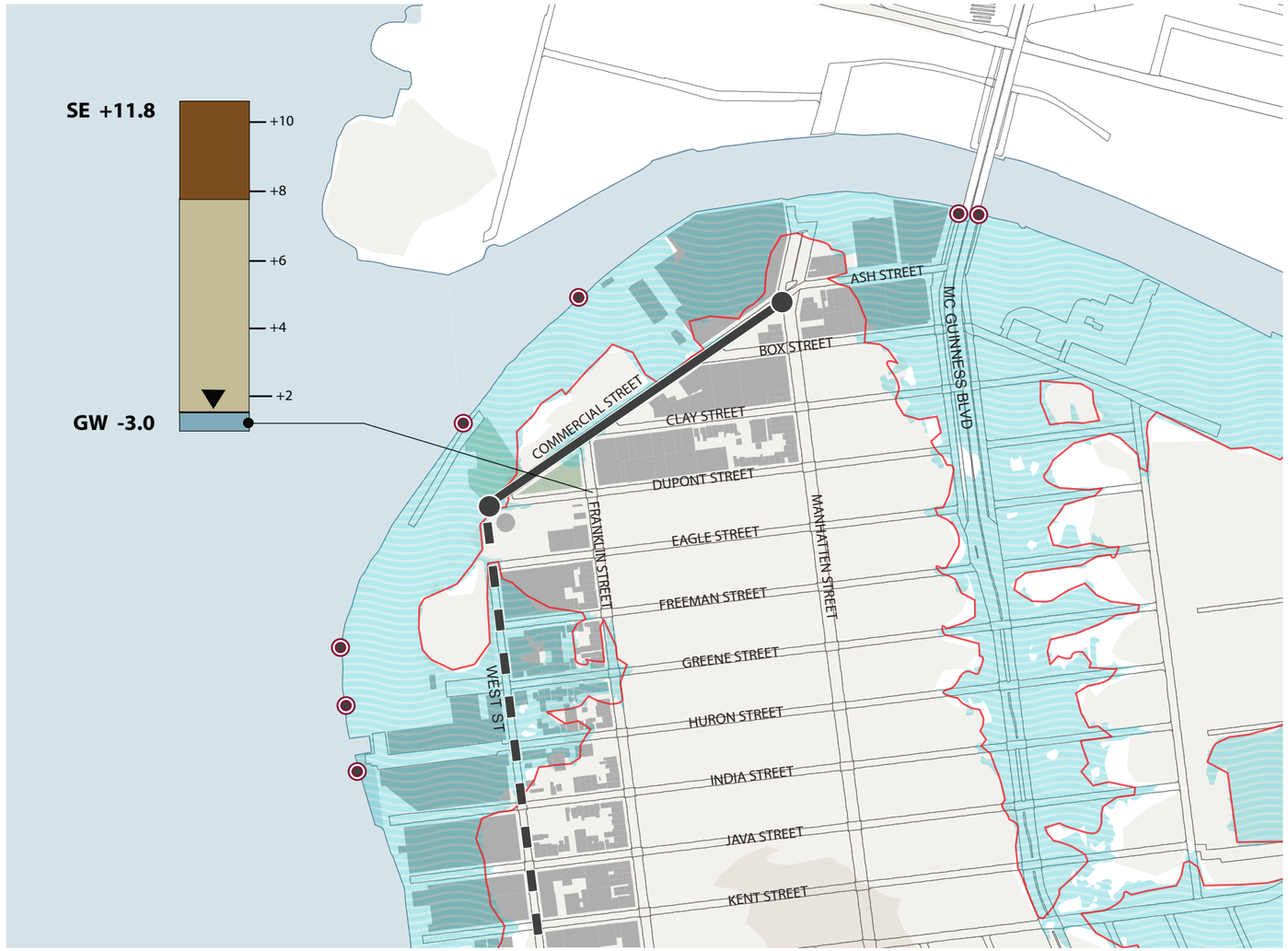
CONTENTS



SEGMENT 1- COMMERCIAL ST.

NYC DOT Capital Project Number 1

* Refer to The Brooklyn Waterfront Greenway Implementation Plan, page 60-71



LEGEND

- Segment
- Adjacent Segment
- Superstorm Sandy Surge
- 100-year Flood Zones (FEMA)
- Combined Sewage Outfalls (CSOs)

SOIL BORING

SE - Surface Elevation

GW - Ground Water Elevation

- Concrete / Cobblestone + Asphalt
- Gravel / Boulders
- Fill
- Top Soil
- Medium / Medium to Coarse Sand
- Fine / Fine to Medium Sand
- Very Fine Sand
- Organic Matter
- Ground Water

OVERVIEW

Segment 1 is the northern-most segment of the Brooklyn Greenway. It runs along Commercial Street from Manhattan Avenue to Dupont Street. Commercial Street is primarily light industrial, however, there is considerable open space with one playground and one park currently in design for renovation and another proposed new park. Commercial Street runs parallel to Newtown Creek and provides the sole access for the buildings and sites along the Newtown Creek waterfront. Commercial Street is a priority NYCDOT Greenway capital project in preliminary design. This is an important opportunity to incorporate green infrastructure and design the Greenway to stop flood waters from crossing Commercial Street.

Greenpoint Manufacturing Center and Design Center is a neighborhood anchor that provides office and work space for small manufacturing enterprises, artisans and artists.

At the west end of Commercial Street is land owned by developer Park Tower Group which plans to build a 10-tower luxury development called Greenpoint Landing.

The Greenpoint and Williamsburg waterfront was re-zoned from industrial to residential in 2005. The area is transforming from a low density waterfront to a high density residential area of 30-story towers along the water's edge. These developments are being built above the flood risk elevation.

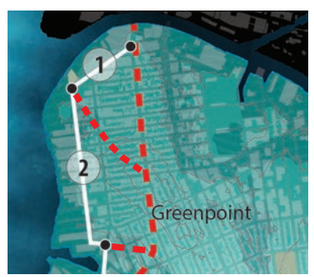
There are seven combined sewer outfalls emptying into Newtown Creek and the East River. Environmental remediation and sustainability are important goals for the Greenpoint community. Flooding from Superstorm Sandy (2012) submerged parts of Segment 1 and the surrounding area.

SUMMARY OF OPPORTUNITIES

- Various of islands and striping as cross streets intersect with Commercial Street offer opportunities for rain gardens.

- Proposed Box Street Park and Barge Park can provide open space and green infrastructure connectivity

- Wide sidewalks provide opportunity for public ROW bio-swales



Segment 1 sub-watershed map

NYC DOT Implementation Plan cross section

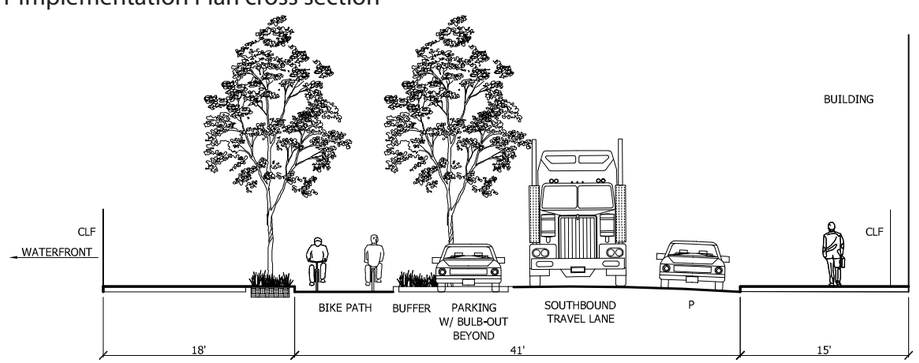


Fig. 2: Possible Reconfiguration for Commercial Street

EXISTING CONDITIONS

Segment 1 runs the full length of Commercial Street from Manhattan Avenue to Dupont Street. The area is zoned industrial with large lots and large warehouse structures on both the north and south sides of the street. There are few street trees along Commercial Street but there are large sidewalks on both sides of the street. Because of the industrial land-uses there are also many curb cuts and driveways along commercial street. Striping in the road, public parks and wider than average sidewalks could provide opportunities for green infrastructure.

Geotechnical Analysis

Segment 1 slopes down along Commercial Street from Manhattan Avenue (+10.6) to Dupont Street (+8.5). Geotechnical boring records (1962) identify the groundwater level 13 feet below the surface (+11.8) at the intersection of Franklin and Dupont.

SEGMENT 1	
SIDEWALK WIDTHS	15-18 FEET
ROADWAY WIDTH	~ 41 FEET
ROADWAY CONFIGURATION	2-WAY, 2-LANE TRAVEL
PARKING	PARALLEL, BOTH SIDES

SEGMENT 1	Tier 1	Tier 2	Tier 3	Tier 1+2+3
RUN-OFF VOLUME (ft3)	7,597	14,527	19,319	41,443

NOTE: Calculations are based on the total run-off from the 1 inch storm event (DEP standard)

(Images Source: Google Earth)

1. NYCDEP water tower

2. View of Barge Park

3. Proposed location for Box Street

4. Ash Street west to Manhattan

OPPORTUNITIES

Large Street Islands

- *Greenway Condition:* NYCDOT Greenway capital project in preliminary design - Large Street Islands
- Stormwater / *Green Infrastructure Techniques:* Porous Paving, ROW Bio-swales, Rain Gardens
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Heat Island Mitigation, Carbon Sequestration

Newtown Barge Playground

- *Greenway Condition:* Adjacent Parks
- *Stormwater / Green Infrastructure Techniques:* Porous Paving, Constructed Wetlands, Rain Gardens
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Heat Island Mitigation, Carbon Sequestration, Habitat Creation

Future Box Street Park

- *Greenway Condition:* Adjacent Parks
- *Stormwater / Green Infrastructure Techniques:* Porous Paving, Constructed Wetlands, Rain Gardens
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Heat Island Mitigation, Carbon Sequestration

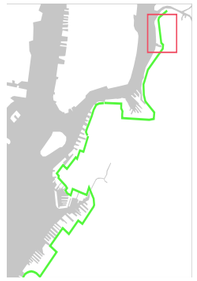
Striping and continuous wide sidewalks

- *Greenway Condition:* Striping and Wide Sidewalks
- Stormwater / *Green Infrastructure Techniques:* Porous Paving, ROW Bio-swales, Rain Gardens
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Heat Island Mitigation, Carbon Sequestration

LEGEND

- Adjacent Segment
- Segment
- City-Owned Property
- Road Striping
- Truck Route
- Water Mains
- Loading Docks
- Trees
- 100-YR Flood Zones (FEMA)
- 2' Contour

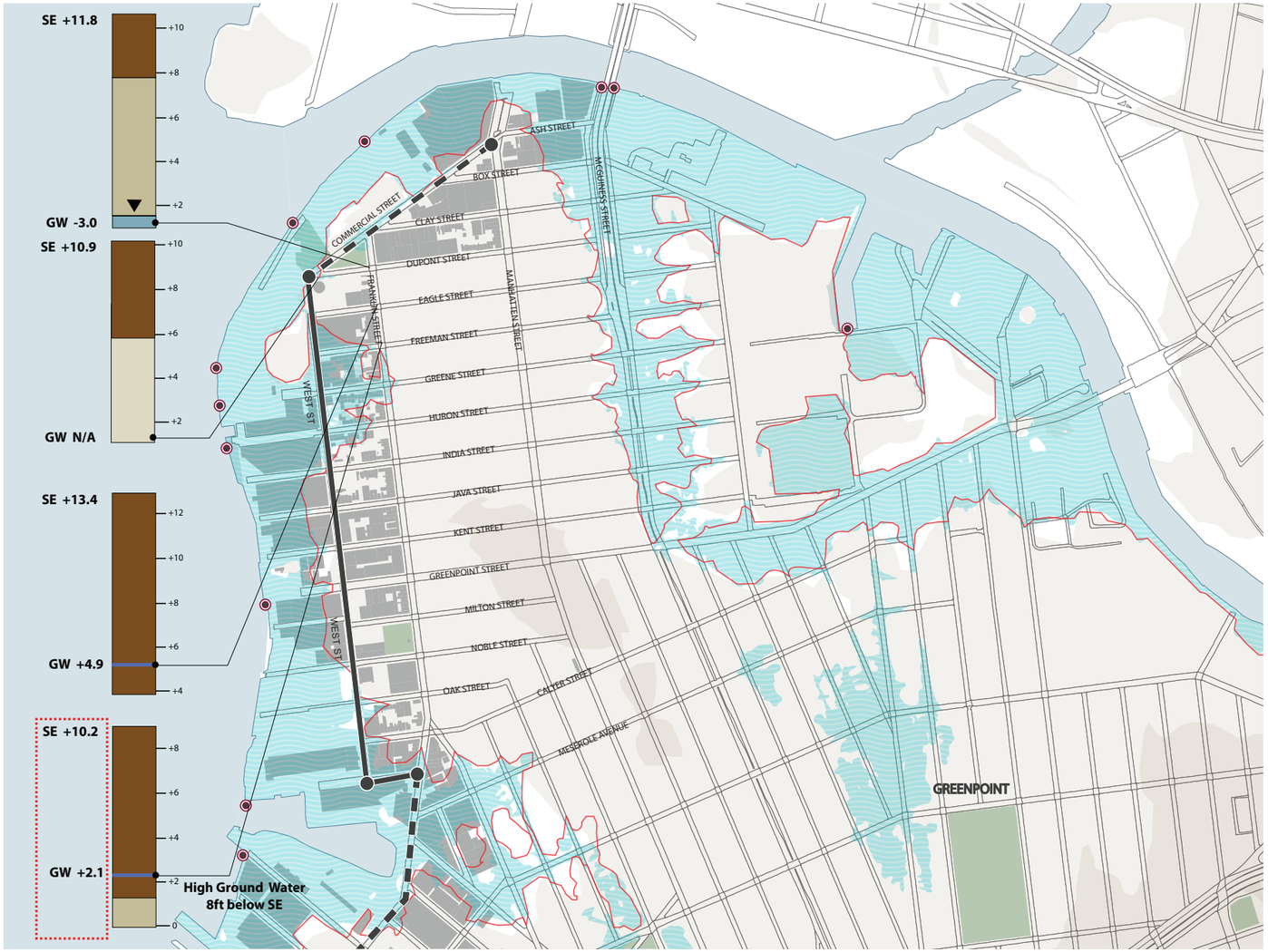
(Images Source: Google Earth)



SEGMENT 2- WEST ST.

NYC DOT Capital Projects Numbers 2 & 3

* Refer to The Brooklyn Waterfront Greenway Implementation Plan, page 60-71



LEGEND

- Segment
- Adjacent Segment
- Superstorm Sandy Surge
- 100-year Flood Zones (FEMA)
- Combined Sewage Outfalls (CSOs)

SOIL BORING

SE - Surface Elevation

GW - Ground Water Elevation

- Concrete / Cobblestone + Asphalt
- Gravel / Boulders
- Fill
- Top Soil
- Medium / Medium to Coarse Sand
- Fine / Fine to Medium Sand
- Very Fine Sand
- Organic Matter
- Ground Water

OVERVIEW

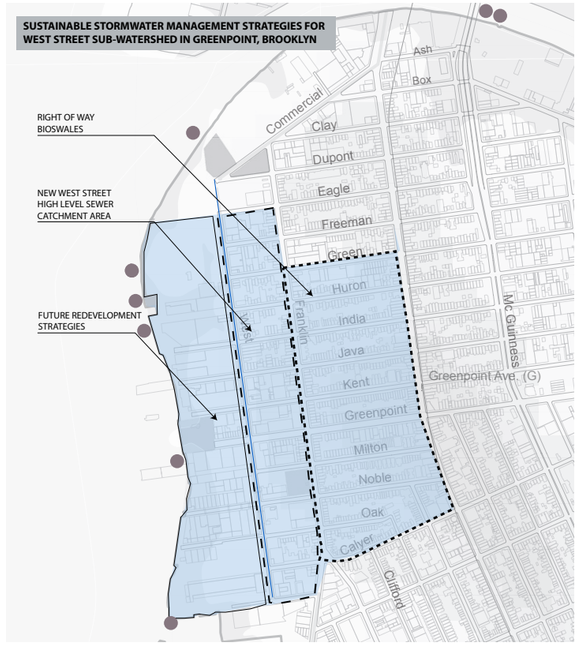
Segment 2 runs along West Street, parallel to the East River in Greenpoint, Brooklyn. The land use is currently light industrial along the West side of West Street and residential along the East side of West Street. The Greenway will run from Dupont Street to Quay Street along West Street. This segment is a fully funded NYC capital project that includes a high level storm sewer for the northern half of the segment. High level sewer is planned for the southern half in the future, subject to achieving adequate right of way for the outfall. The high level storm sewer will capture the stormwater from the side streets for one block east of West Street where it is implemented. The West Street sub-watershed reaches two blocks east to Manhattan Avenue.

There are currently three major proposed developments underway along the waterfront including: Greenpoint Landing and 77 Commercial Street.

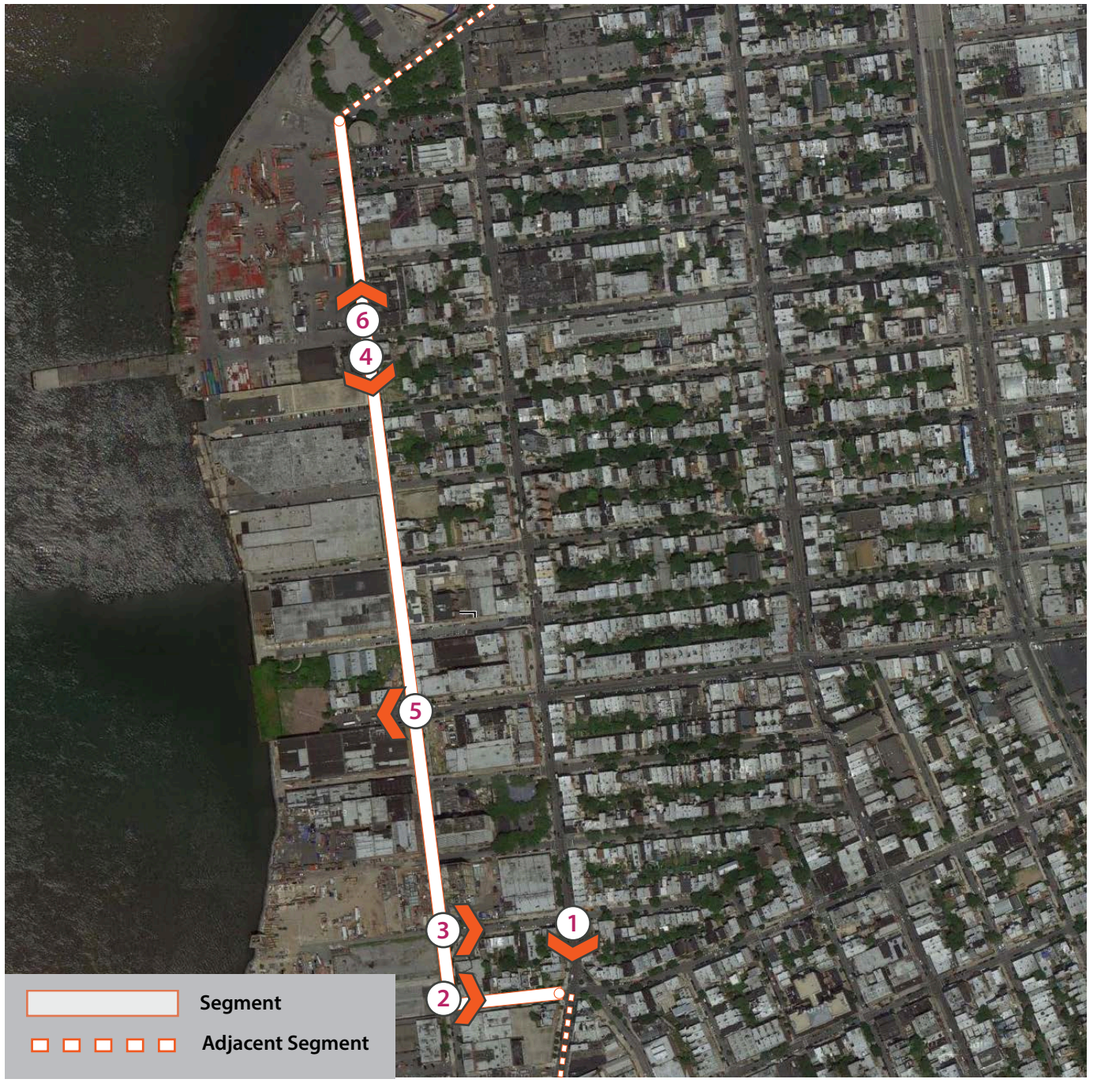
Flooding from Superstorm Sandy (2012) covered parts of Segment 2 from Eagle Street to India Street and from Oak Street to Quay Street.

SUMMARY OF OPPORTUNITIES

- Existing and proposed street-end parks can be connected to green infrastructure interventions along the Greenway
- Proposed adjacent developments can connect into the Greenway's green infrastructure system.
- Wide sidewalks can accommodate public ROW bio-swales.



Segment 2 sub-watershed map



NYC DOT Implementation Plan cross section

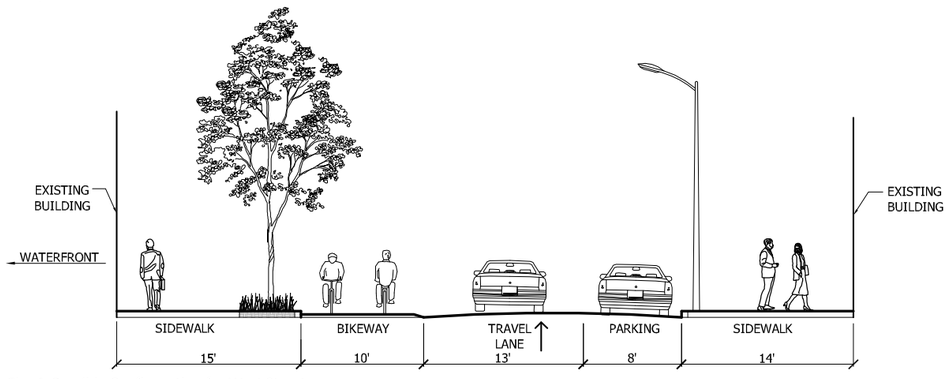


Fig. 4: Possible Configuration for West Street

EXISTING CONDITIONS

Approximately 0.65 miles in length

Geotechnical Analysis

The water table is 8' or more below the ground surface. Fill is predominate soil medium for at least the first 5' and in some areas there is up to 10' of fill.

SEGMENT 2	
SIDEWALK WIDTHS	~15 FEET
ROADWAY WIDTH	~ 31 FEET
ROADWAY CONFIGURATION	2-WAY, 2-LANE TRAVEL
PARKING	PARALLEL, BOTH SIDES

SEGMENT 2	Tier 1	Tier 2	Tier 3	Tier 1+2+3
RUN-OFF VOLUME (ft3)	14,415	31,672	45,350	91,438

NOTE: Calculations are based on the total run-off from the 1 inch storm event (DEP standard)

(Images Source: Google Earth)

1. Franklin St. south from Calyer

2. Quay St. east from West St.

3. Calyer St. east from West St.

4. West St. south from Green St.

5. West towards Transmitter Park at West St. and Greenpoint Ave.

6. West St. north from Green St.

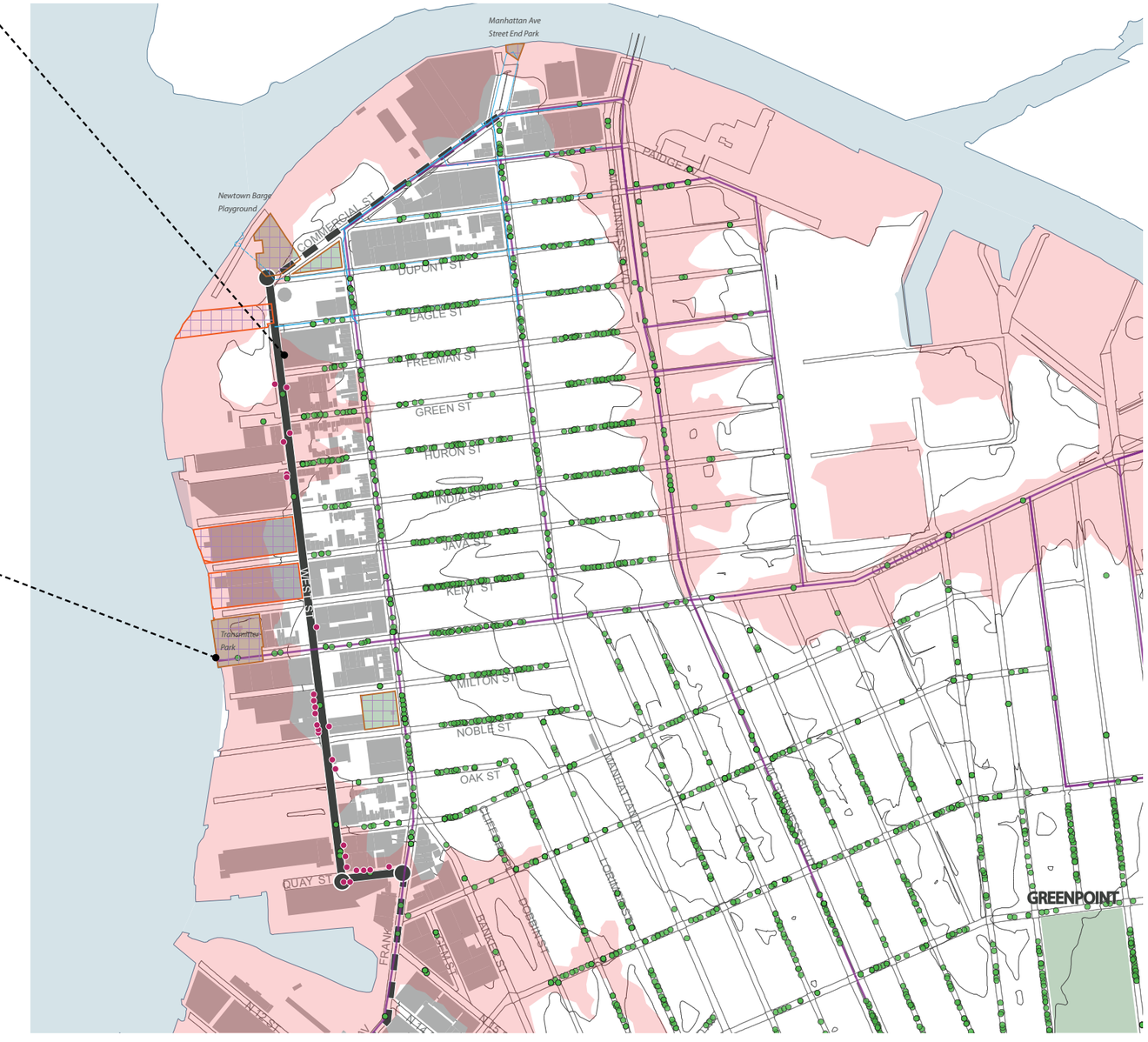
OPPORTUNITIES

Wide continuous sidewalks on west side of West St.

- *Greenway Condition:* Wide sidewalks
- *Stormwater / Green Infrastructure Techniques:* ROW Bio-swales, Porous Paving
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance

Transmitter Park: Street End Park

- *Greenway Condition:*, Street-end Park
- *Stormwater / Green Infrastructure Techniques:* Rain Gardens, Porous Paving, Constructed Wetlands
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance, Flood Prevention



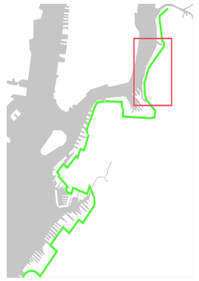
LEGEND

- Adjacent Segment
- Segment
- City-Owned Property
- Road Striping
- Truck Route
- Water Mains
- Loading Docks
- Trees
- 100-YR Flood Zones (FEMA)
- 2' Contour

Adjacent Proposed Development - various locations

- *Greenway Condition:* Adjacent Proposed Development
- *Stormwater / Green Infrastructure Techniques:* Bioremediation Gardens, Porous Paving, ROW Bio-swales, Constructed Wetlands, Storm Barrier
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance, Wave Break, Flood Prevention

(Images Source: Google Earth)



SEGMENT 3- KENT AVE., FRANKLIN TO CLYMER STS.

NYC DOT Capital Project Number 4

* Refer to The Brooklyn Waterfront Greenway Implementation Plan, page 60-71

LEGEND

- Segment
- Adjacent Segment
- Superstorm Sandy Surge
- 100-year Flood Zones (FEMA)
- Combined Sewage Outfalls (CSOs)

SOIL BORING

SE - Surface Elevation

GW - Ground Water Elevation

- Concrete / Cobblestone + Asphalt
- Gravel / Boulders
- Fill
- Top Soil
- Medium / Medium to Coarse Sand
- Fine / Fine to Medium Sand
- Very Fine Sand
- Organic Matter
- Ground Water

OVERVIEW

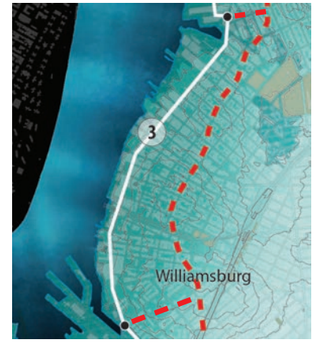
Segment 3 is the longest continuous segment and runs along Kent Street, parallel to the East River in Williamsburg and South Williamsburg. NYCDOT has implemented the Greenway on Kent Avenue separated from traffic by a floating parking lane and continuous striped buffer. It is a priority segment for which NYCDOT is pursuing preliminary design of Greenway capital improvements. This is an important opportunity to incorporate green infrastructure in the design of this segment.

Flooding from Superstorm Sandy (2012) inundated waterfront properties along the East River but Kent Avenue did not experience flooding.

NOTE: Soil boring documents for boring sites at Division Street end and Kent Avenue, “Ground water will be tidally influenced”.

SUMMARY OF OPPORTUNITIES

- Public parks exist on both the west and east sides of Kent Avenue that can provide important green infrastructure connectivity.
- Opportunities to incorporate green infrastructure in the Kent Avenue Greenway capital project.
- Opportunities to collect rain water off the elevated Williamsburg Bridge
- Opportunities to convey water along side streets towards street end parks before final discharge into the East River.



Segment 3 sub-watershed map

NYC DOT Implementation Plan cross section

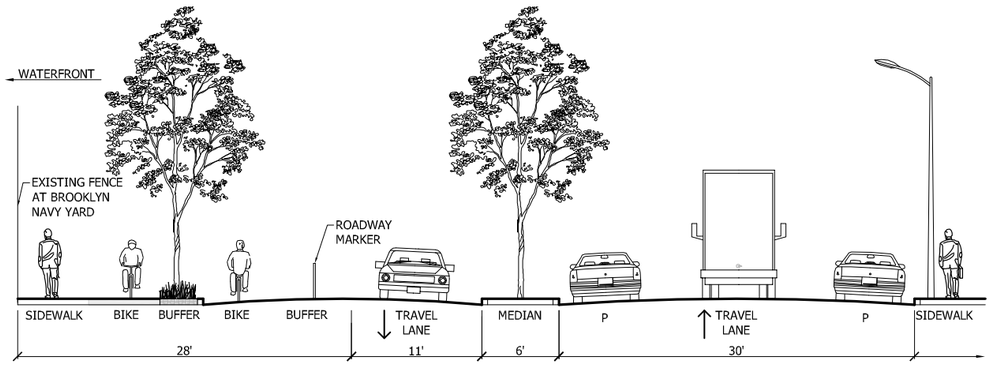


Fig. 8: Possible Configuration for Kent Avenue South at Navy Yard - Reprogram Parking Space as Bike Lane

EXISTING CONDITIONS
Approximately 1.7 miles in length

Geotechnical Analysis
Two soil borings from the southern section of the segment show a significant layer of fill and a low water table.

SEGMENT 3	
SIDEWALK WIDTHS	~12-15 FEET
ROADWAY WIDTH	~ 40-62 FEET
ROADWAY CONFIGURATION	CALYER 1-WAY OTHERWISE 2-WAY, 2-LANE TRAVEL
PARKING	PARALLEL, BOTH SIDES

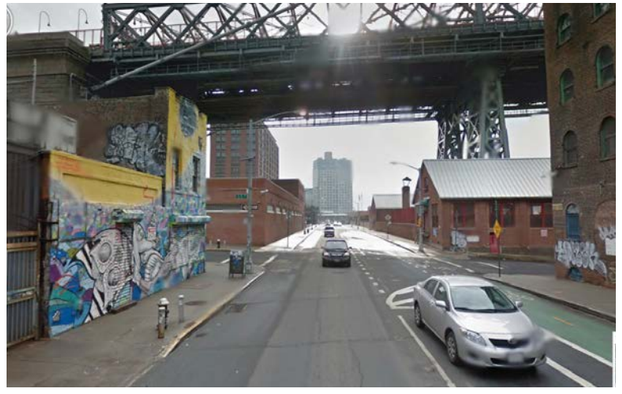
SEGMENT 3	Tier 1	Tier 2	Tier 3	Tier 1+2+3
RUN-OFF VOLUME (ft3)	3,255	44,662	134,268	246,985

NOTE: Calculations are based on the total run-off from the 1 inch storm event (DEP standard)

(Images Source: Google Earth)

1. Kent Avenue north from N 6th

2. Kent Avenue south from N 9th



3. Kent Avenue south to S 5th

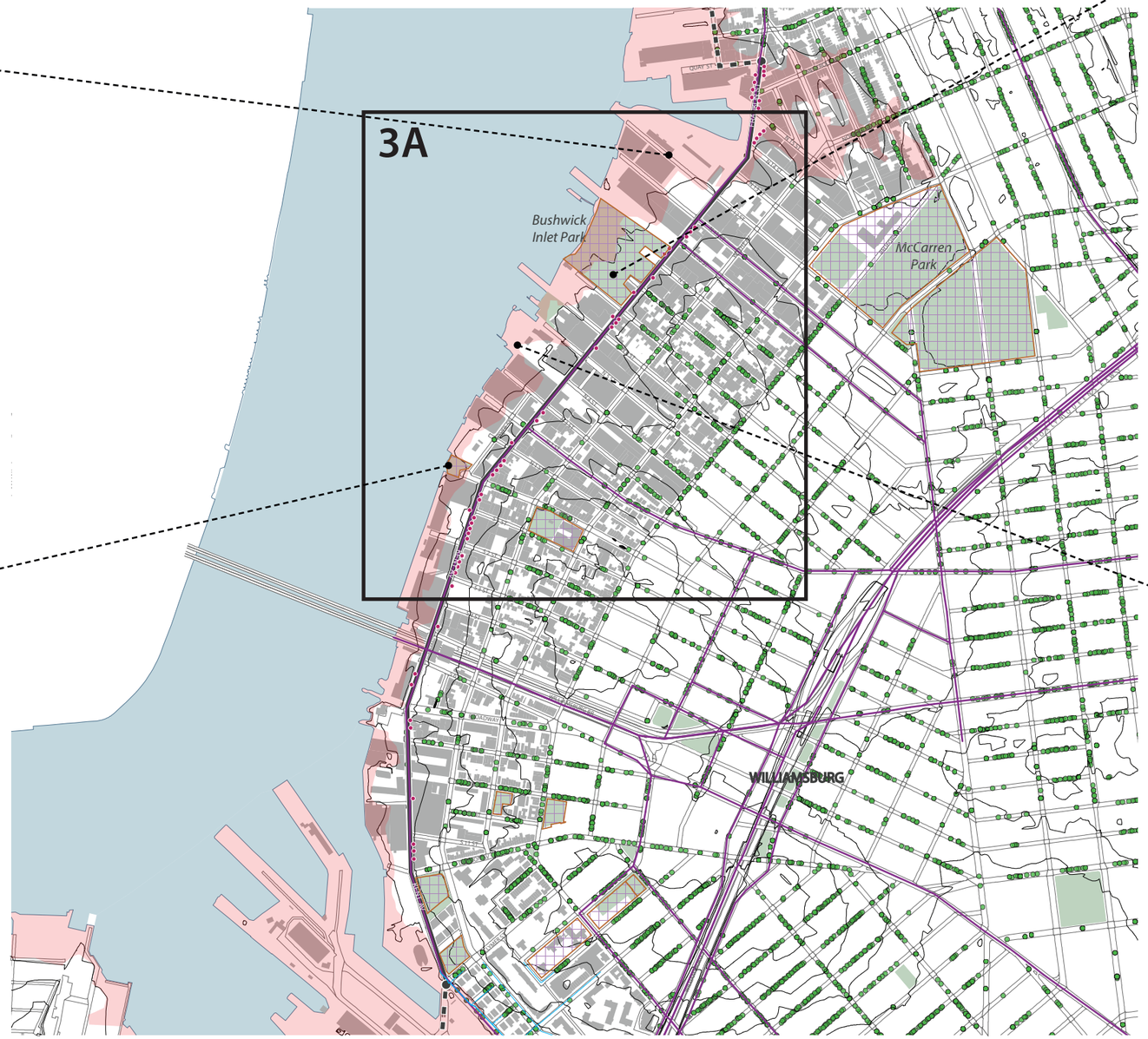
4. Kent Avenue south at Division St.

Bush Inlet Park

- *Greenway Condition:* Adjacent to park
- *Stormwater Management / Green Infrastructure Techniques:* Bioremediation Gardens, Porous Paving, ROW Bio-swales, Constructed Wetlands
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Heat Island Mitigation, Carbon Sequestration, Flood Protection

Grand Ferry Park at the corner of Grand Ave, and Ferry St.

- *Greenway Condition:* Waterfront Edge Condition
- *Stormwater Management / Green Infrastructure Techniques:* Bioremediation Gardens, Porous Paving, ROW Bio-swales, Constructed Wetlands, Barrier
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance, Wave Break, Flood Protection

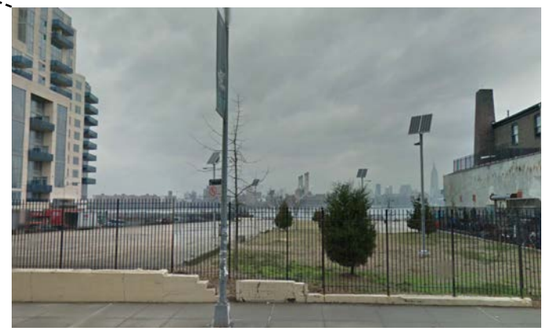


LEGEND

- Adjacent Segment
- Segment
- City-Owned Property
- Road Striping
- Truck Route
- Water Mains
- Loading Docks
- Trees
- 100-YR Flood Zones (FEMA)
- 2' Contour

Continuous Greenway street striping on the west side of Kent Ave.

- *Greenway Condition:* Capital project in preliminary design phase
- *Stormwater Management / Green Infrastructure Techniques:* Rain Gardens, Porous Paving, ROW Bio-swales
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Heat Island Mitigation, Carbon Sequestration



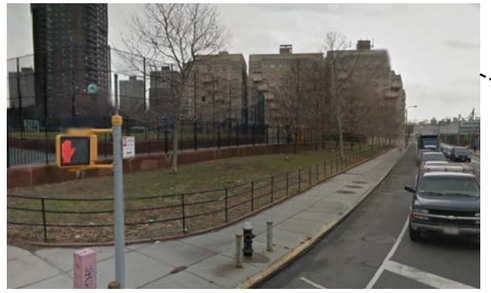
East River State Park

- *Greenway Condition:* Adjacent to park
- *Stormwater Management / Green Infrastructure Techniques:* Bioremediation Gardens, Porous Paving, Constructed Wetlands
- *Environmental Outcomes*: Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Heat Island Mitigation, Carbon Sequestration, Flood Protection

(Images Source: Google Earth)

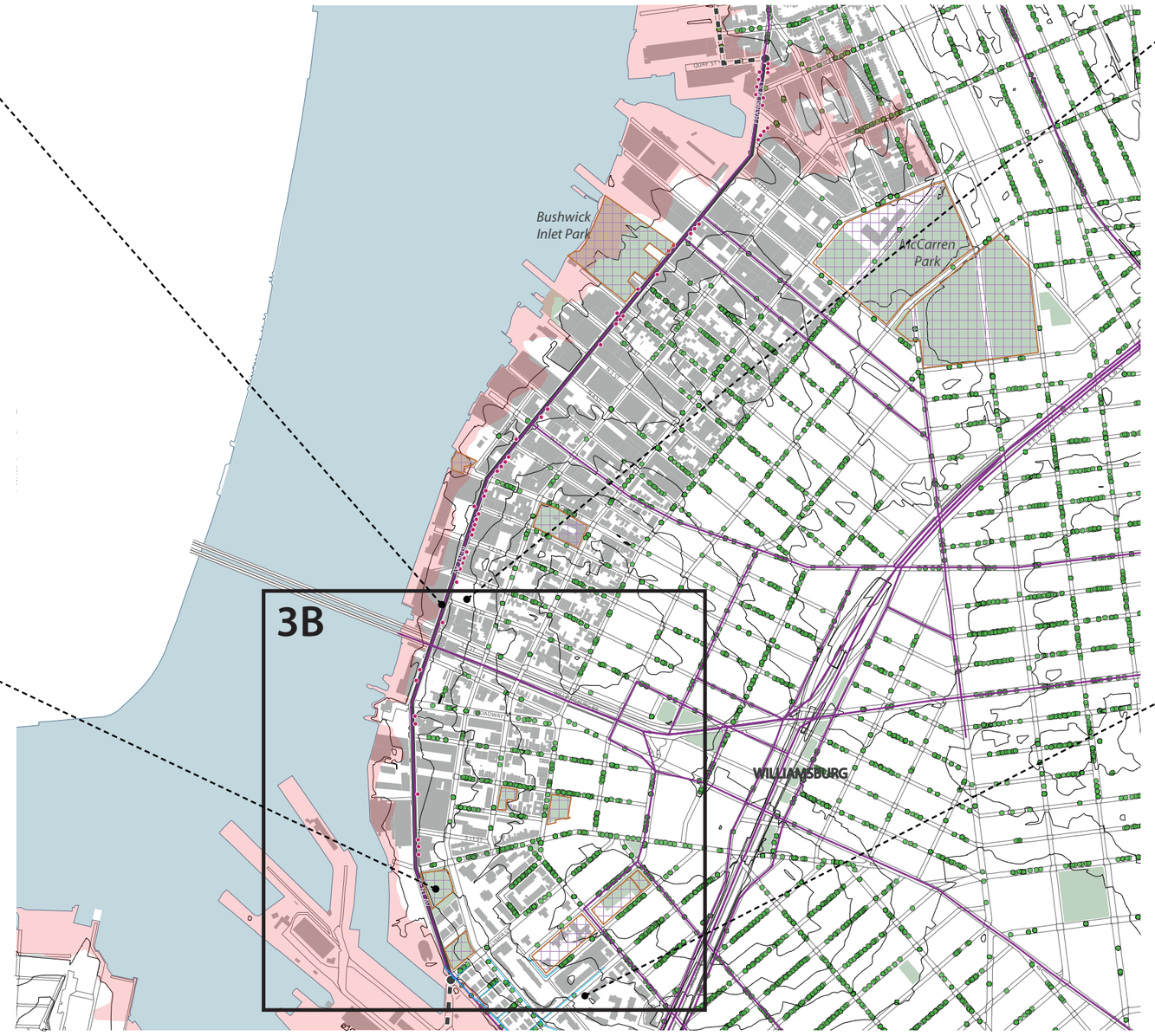
Greenway implemented with striping and floating parking lane.

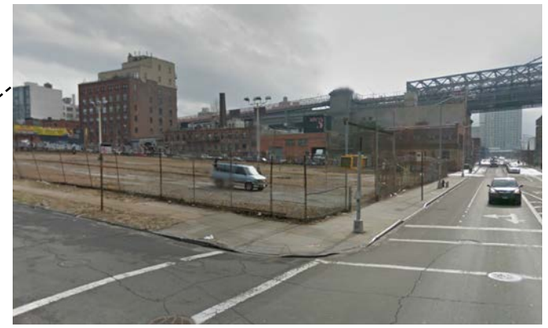
- *Greenway Condition:* Wide Sidewalk / Public ROW
- *Stormwater Management / Green Infrastructure Techniques:* Rain Gardens, Porous Paving, ROW Bio-swales
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Filtration, Stormwater Detention, Heat Island Mitigation, Carbon Sequestration



Roberto Clemente Ball field at Kent Ave. and Division St.

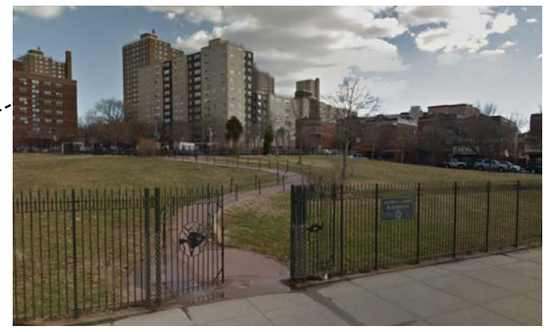
- *Greenway Condition:* Across the street from park
- *Stormwater Management / Green Infrastructure Techniques:* Porous Paving, Constructed Wetlands
- *Environmental Outcomes*: Infiltration, Evapotranspiration, Stormwater Filtration, Stormwater Detention, Heat Island Mitigation, Carbon Sequestration, Flood Protection





Havemeyer Park between S 3rd and S 4th on Kent Ave.

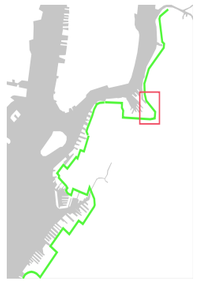
- *Greenway Condition:* Adjacent to park
- *Stormwater Management / Green Infrastructure Techniques:* Bioremediation Gardens, Porous Paving, Constructed Wetlands
- *Environmental Outcomes*: Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Heat Island Mitigation, Carbon Sequestration, Flood Protection



Jacob's Ladder Playground on Kent Ave. and Clymer St.

- *Greenway Condition:* Across Kent Ave. (upslope) from park
- *Stormwater Management / Green Infrastructure Techniques:* Porous Paving, Wetlands
- *Environmental Outcomes*: Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Heat Island Mitigation, Carbon Sequestration, Flood Protection

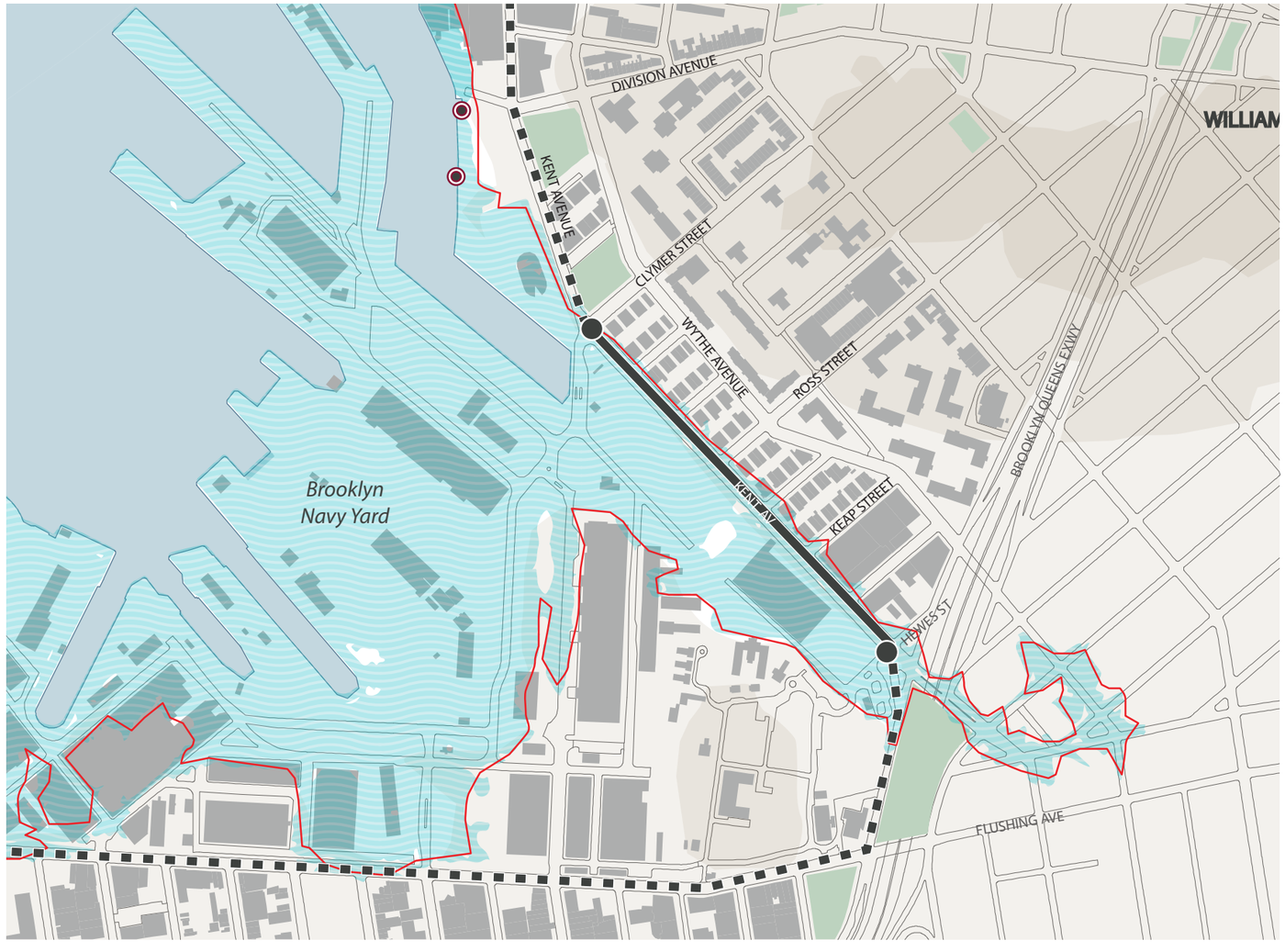
(Images Source: Google Earth)



SEGMENT 4- KENT AVE., CLYMER TO HEWES STS.

NYC DOT Capital Project Number 5

* Refer to The Brooklyn Waterfront Greenway Implementation Plan, page 60-71



LEGEND NOTE: Soil Borings N/A

- Segment
- Adjacent Segment
- Superstorm Sandy Surge
- 100-year Flood Zones (FEMA)
- Combined Sewage Outfalls (CSOs

OVERVIEW

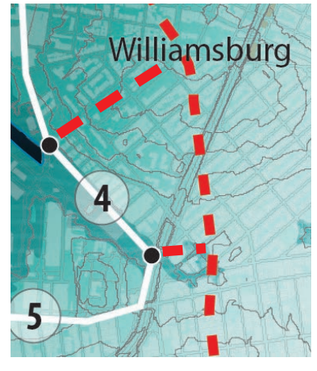
Segment 4 runs along Kent Avenue from Clymer Street to Hewes Street. This area is characterized by the Brooklyn Navy Yard to the south and residential housing to the north. This segment is a priority NYCDOT Greenway capital project in preliminary design. This is an important opportunity to incorporate green infrastructure.

Flooding from Superstorm Sandy (2012) covered most of Segment 4.

SUMMARY OF OPPORTUNITIES

- Long, continuous stretch of wide sidewalks provide opportunities for well connected ROW Bio-swales

- Large open spaces within the Navy Yard provide opportunities for public to private stormwater management / green infrastructure interventions.



Segment 4 sub-watershed map

NYC DOT Implementation Plan cross section

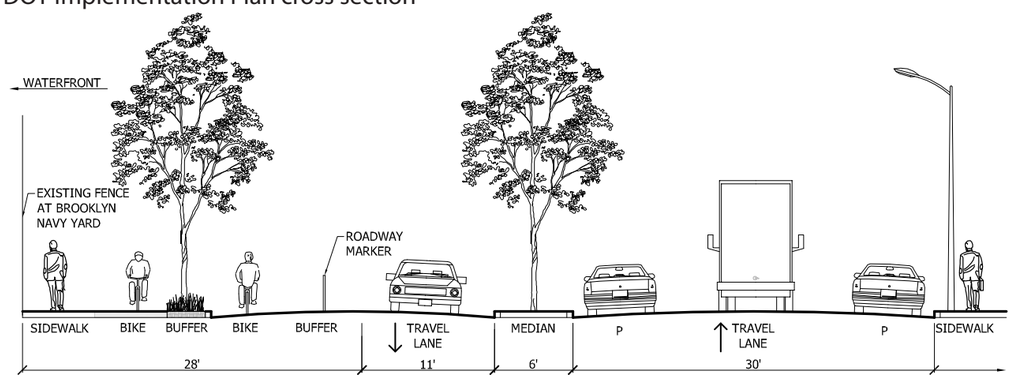


Fig. 8: Possible Configuration for Kent Avenue South at Navy Yard - Reprogram Parking Space as Bike Lane

EXISTING CONDITIONS
Approximately 0.35 miles in length

Geotechnical Analysis
We do not have any geotechnical data for Segment 4

SEGMENT 4	
SIDEWALK WIDTHS	~10-16 FEET
ROADWAY WIDTH	~ 62 FEET
ROADWAY CONFIGURATION	2-WAY, 3-LANE TRAVEL
PARKING	PARALLEL, BOTH SIDES

SEGMENT 4	Tier 1	Tier 2	Tier 3	Tier 1+2+3
RUN-OFF VOLUME (ft3)	13,702	11,962	20,369	46,034

NOTE: Calculations are based on the total run-off from the 1 inch storm event (DEP standard)

(Images Source: Google Earth)

1. Triangular Sidewalk Island at Kent Ave. and Williamsburg St.

2. Williamsburg St. southwest from Kent Ave.

3. Kent Ave. at Washington St. looking southwest to East River

4. Clymer St. and Kent Ave. south

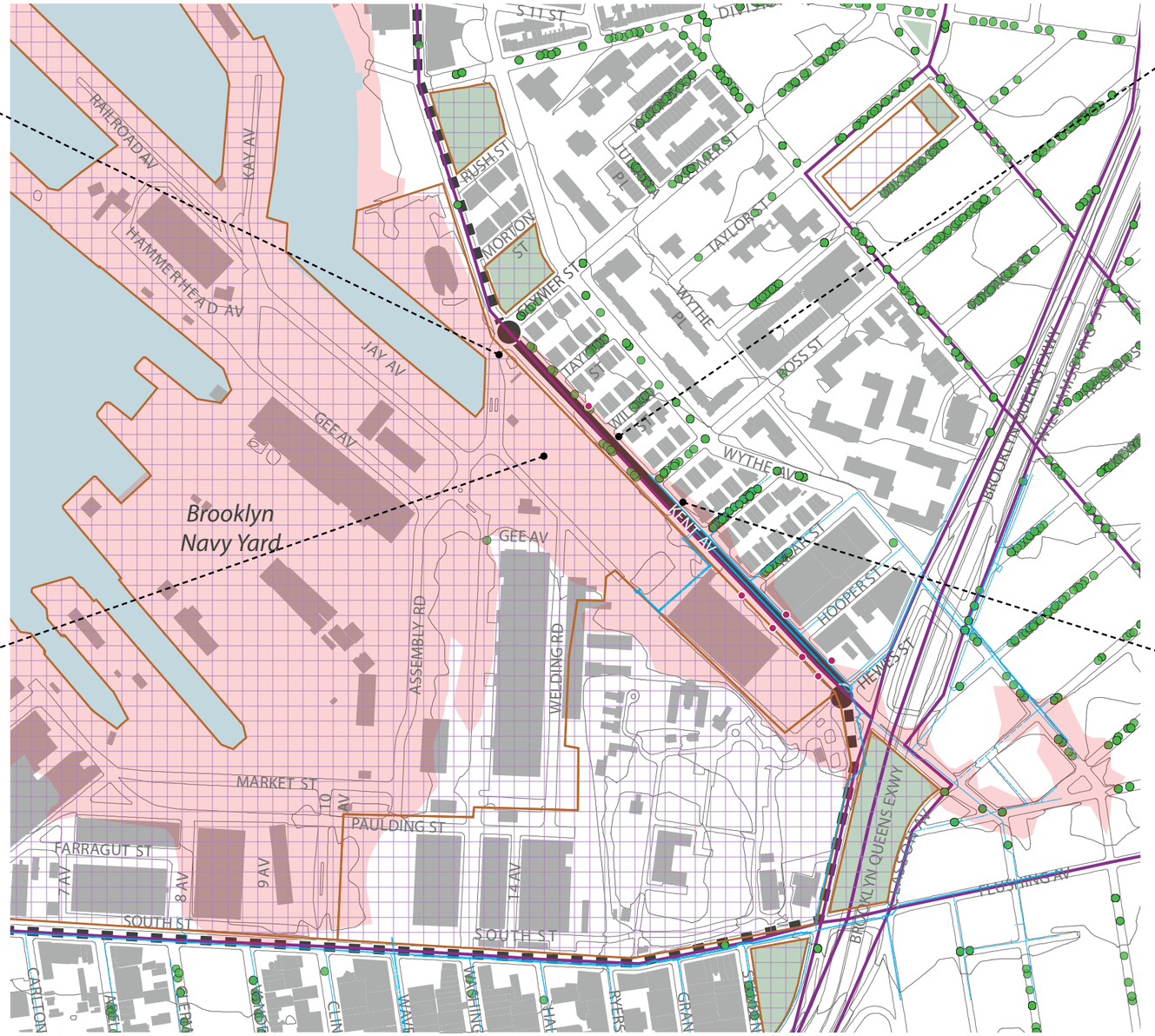
Clymer St. and Kent Ave. intersection adjacent to Buttermilk Basin

- *Greenway Condition:* Waterfront Edge Condition, tier 1 CSO outfall
- *Green Infrastructure Techniques:* Bioremediation Gardens, Porous Paving, ROW Bio-swales, Constructed Wetlands,
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance, Flood Protection

Industrial development site on west side of Kent Ave.

- *Greenway Condition:* Adjacent Development - Brooklyn Navy Yard
- *Green Infrastructure Techniques:* Bioremediation Gardens, Porous Paving, ROW Bio-swales, Constructed Wetlands,
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance, Flood Protection

(Images Source: Google Earth)

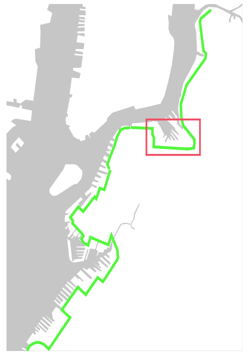


Street striping separating bike lane from traffic and at ends of on-street parking

- *Greenway Condition:* Striping
- *Green Infrastructure Techniques:* Bioremediation Gardens, Porous Paving, ROW Bio-swales
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance, Flood Prevention

Long continuous center road median and wide continuous sidewalks on the West side

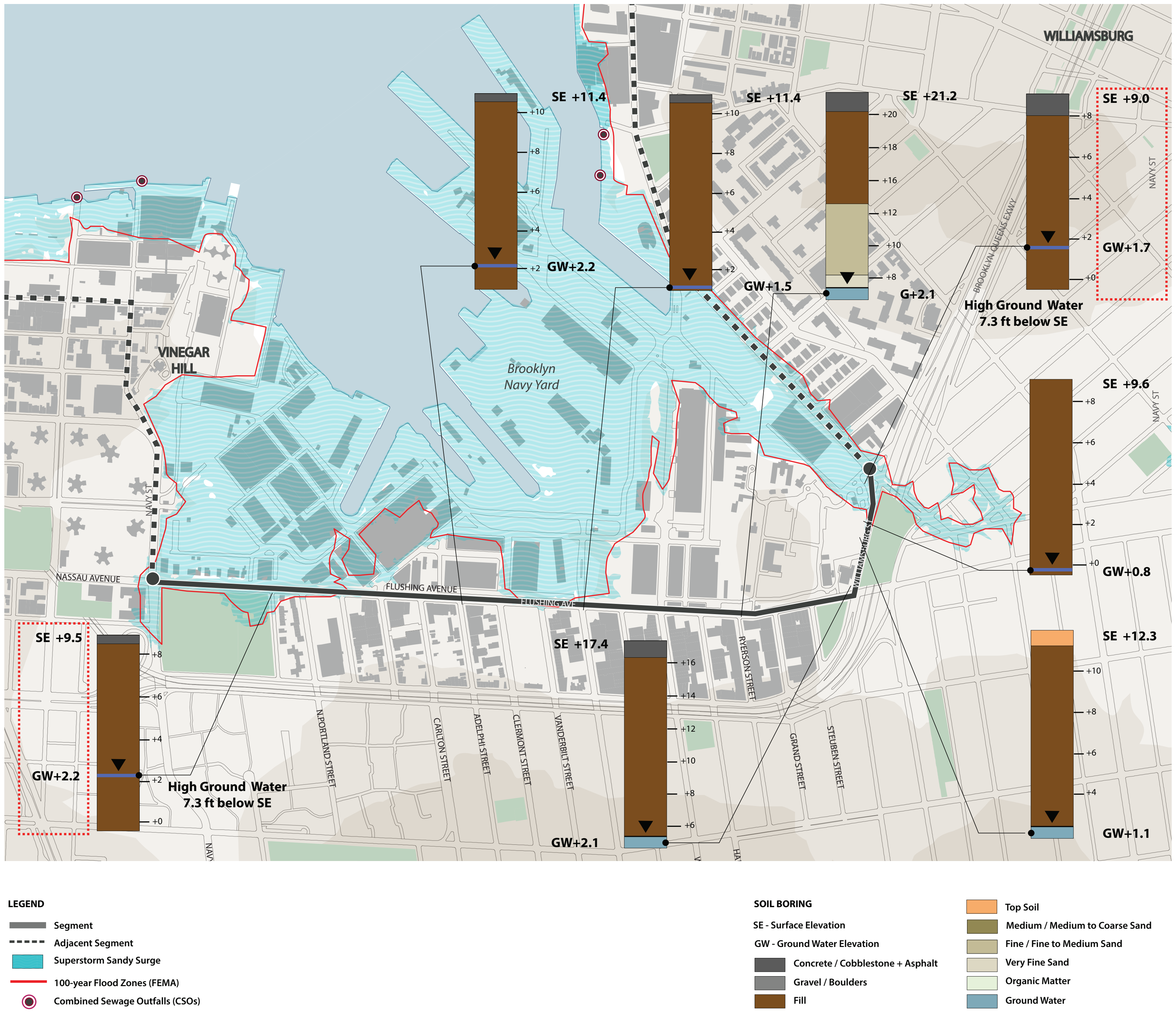
- *Greenway Condition:* Wide Sidewalk
- *Green Infrastructure Techniques:* Bioremediation Gardens, Porous Paving, ROW Bio-swales
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Convey Water, Flood Prevention



SEGMENT 5- FLUSHING AVE.

NYC DOT Capital Projects Numbers 6 & 7

* Refer to The Brooklyn Waterfront Greenway Implementation Plan, page 60-71

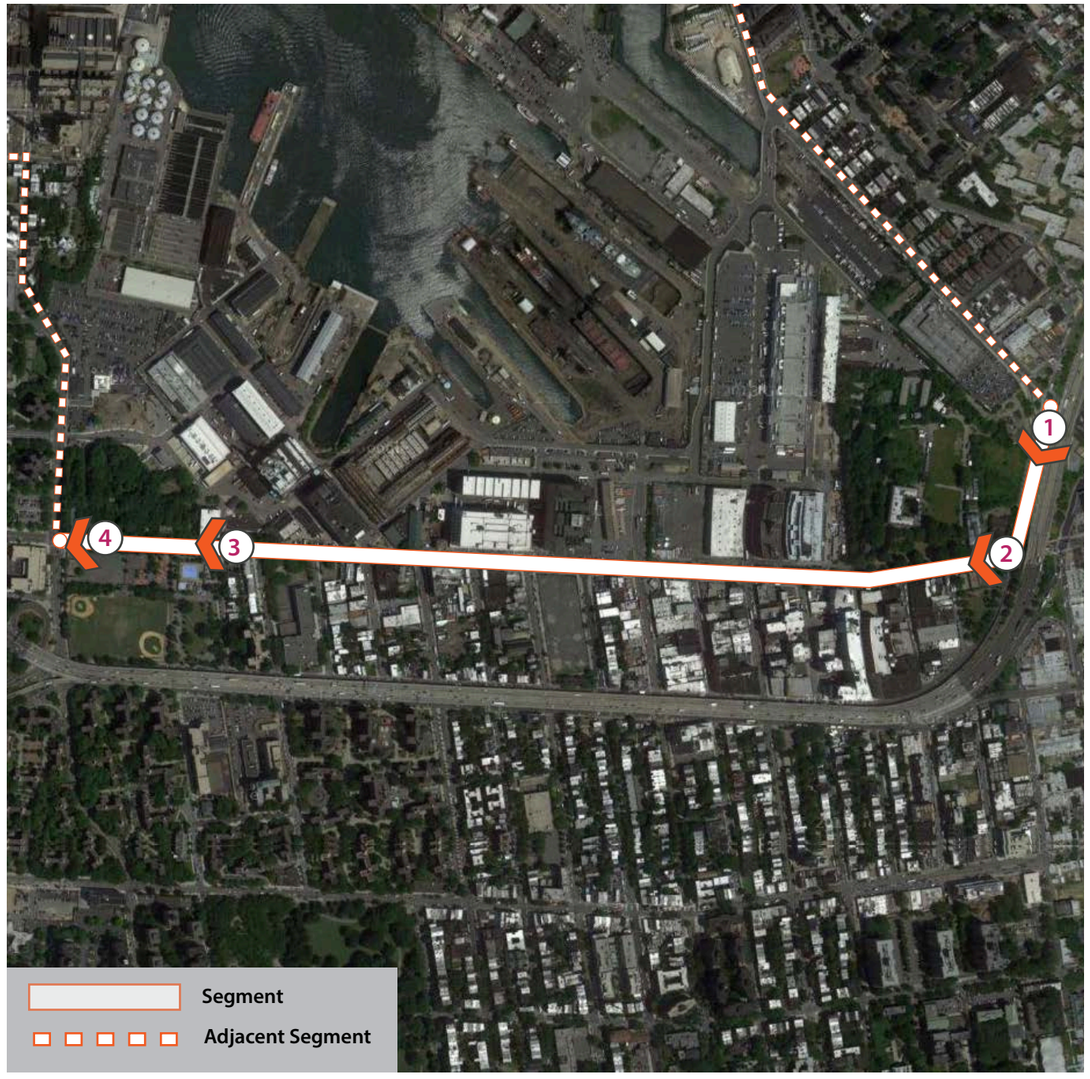


OVERVIEW

Segment 5 runs along Flushing Avenue from WIlliamsburg Street to Navy Street. It is characterized by larger warehouse buildings, the Brooklyn Navy Yard, public housing projects and Commodore Barry Park where Flushing Street meetings Navy Street. The Williamsburg Street stretch of this segment will not support right of way swales due to its high water table and water lines running under the sidewalk along the curb. The Flushing Avenue segment of the Greenway is a funded capital project that was in final design at the time of this report's publication. There is no longer an opportunity to include green infrastructure in this capital project.

Flooding from Superstorm Sandy (2012) submerged parts of Segment 5 including the blocks between Clinton Avenue and Claremont Avenues and between Oxford and N. Elliot Street

Segment 5 sub-watershed map



NYC DOT Implementation Plan cross section

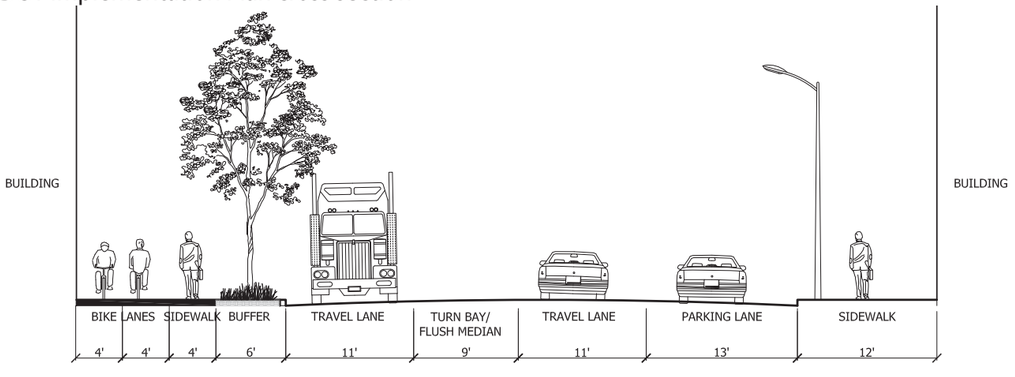


Fig. 9: Possible Configuration for Flushing Avenue

EXISTING CONDITIONS
Approximately 1.10 miles in length

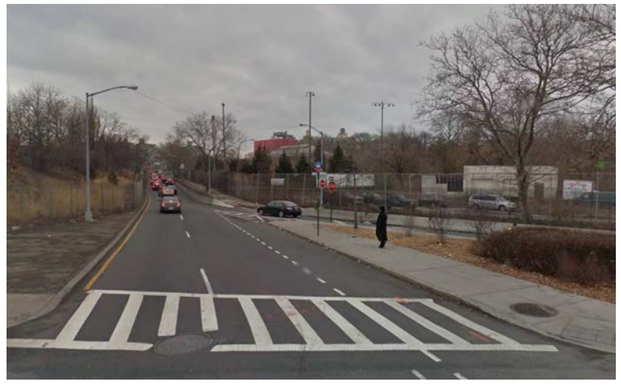
Geotechnical Analysis
Although there are thin layers of concrete or rubble at some of the soil boring locations the predominant soil medium is fill. The water table is high in a couple of locations with a 7' depth to water table at Commodore Barry Park. There is nearly 20' to the water table at Washington Avenue.

SEGMENT 5	
SIDEWALK WIDTHS	~10 FEET
ROADWAY WIDTH	~ 50 FEET
ROADWAY CONFIGURATION	2-WAY, 2-LANE TRAVEL
PARKING	PARALLEL, BOTH SIDES

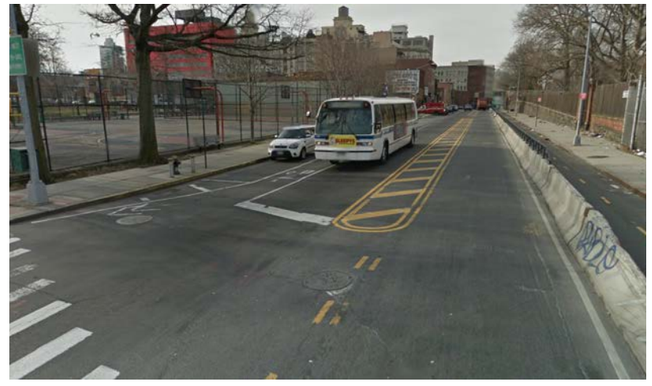
SEGMENT 5	Tier 1	Tier 2	Tier 3	Tier 1+2+3
RUN-OFF VOLUME (ft3)	30,526	70,140	95,610	196,277

NOTE: Calculations are based on the total run-off from the 1 inch storm event (DEP standard)

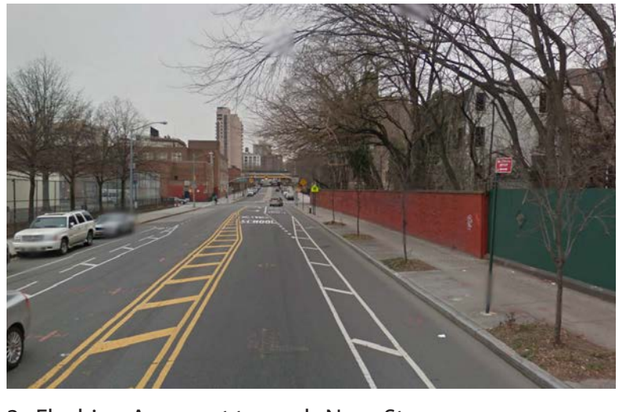
(Images Source: Google Earth)



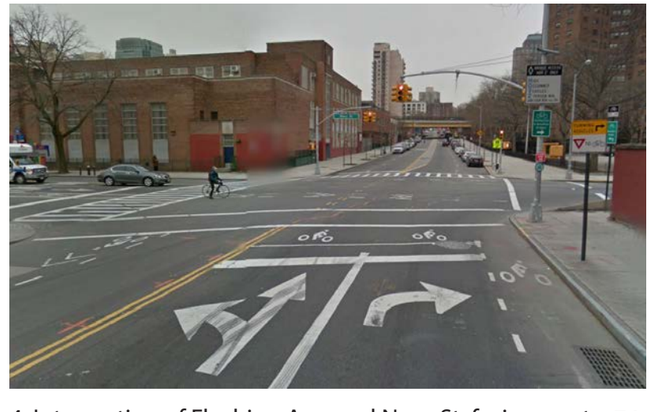
1. Williamsburg St. south at Kent Ave.



2. Flushing Ave. east at Williamsburg St.



3. Flushing Ave. west towards Navy St.

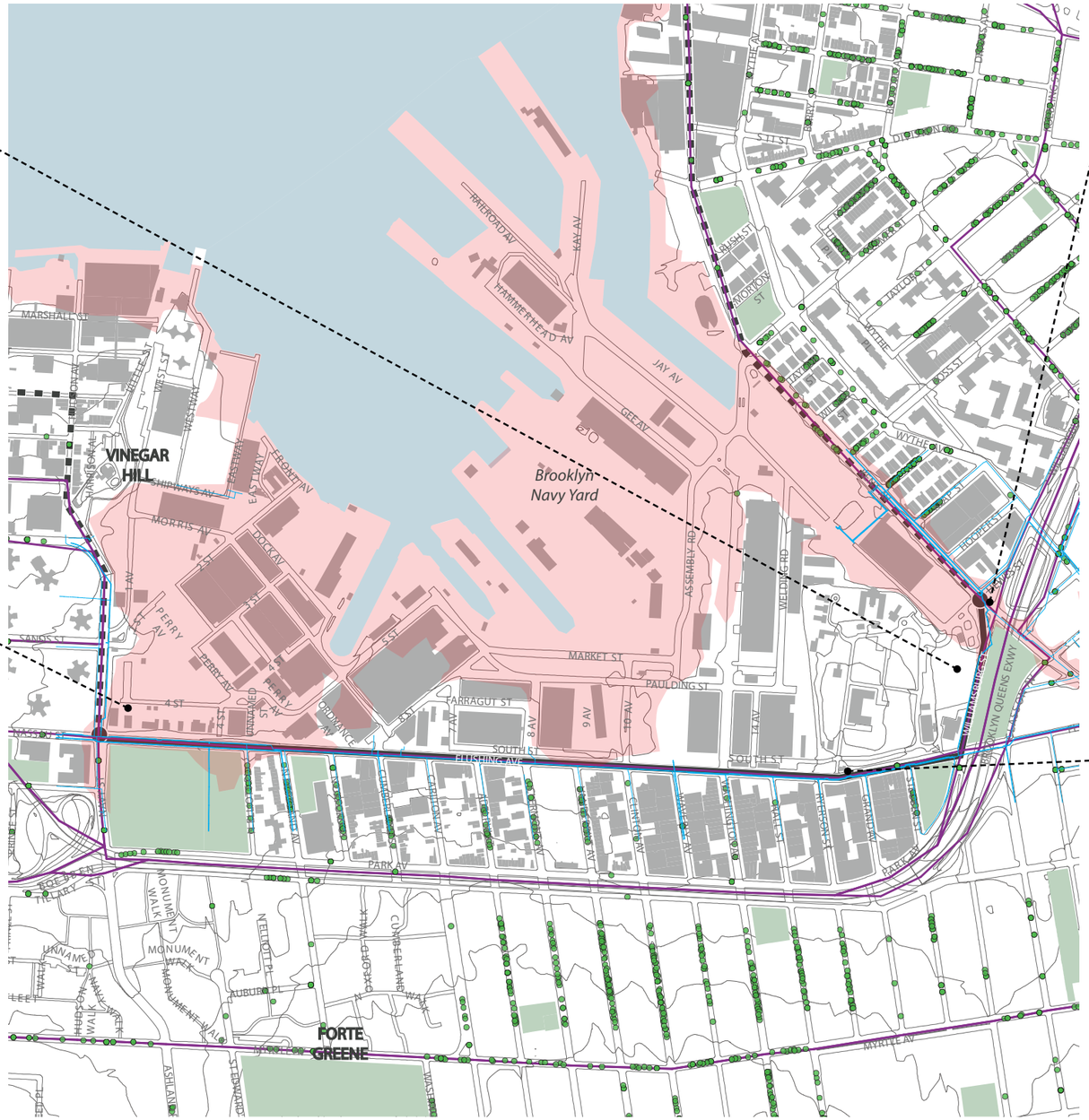


4. Intersection of Flushing Ave. and Navy St. facing west.

OPPORTUNITIES

The Naval Cemetery Landscape - Williamsburg Street

- *Greenway Condition:* Adjacent Natural open space
- *Stormwater / Green Infrastructure Techniques:* Limited opportunity due to high water table, inappropriate soils and water lines under the sidewalk.



Williamsburg St. W south from Kent Ave.

- *Greenway Condition:* Protected by jersey barrier
- *Stormwater / Green Infrastructure Techniques:* Porous Paving, ROW Bio-swales
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance

Admiral Row - Proposed Development

- *Greenway Condition:* Pending Greenway capital project, Adjacent Proposed Development
- *Stormwater / Green Infrastructure Techniques:* Rain Gardens, Constructed Wetlands
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance, Flood Prevention

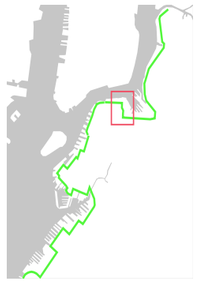
Street Striping as center median and Jersey Barrier as separation for bike and vehicular lanes. May be an opportunity to replace with green infrastructure.

- *Greenway Condition:* Striping and jersey barrier, pending Greenway capital project
- *Stormwater / Green Infrastructure Techniques:* Bioremediation Gardens, Porous Paving, ROW Bio-swales, Constructed Wetlands, Levee
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance, Wave Break, Flood Prevention

LEGEND

Adjacent Segment
Segment
City-Owned Property
Road Striping
Truck Route
Water Mains
Loading Docks
Trees
100-YR Flood Zones (FEMA)
2' Contour

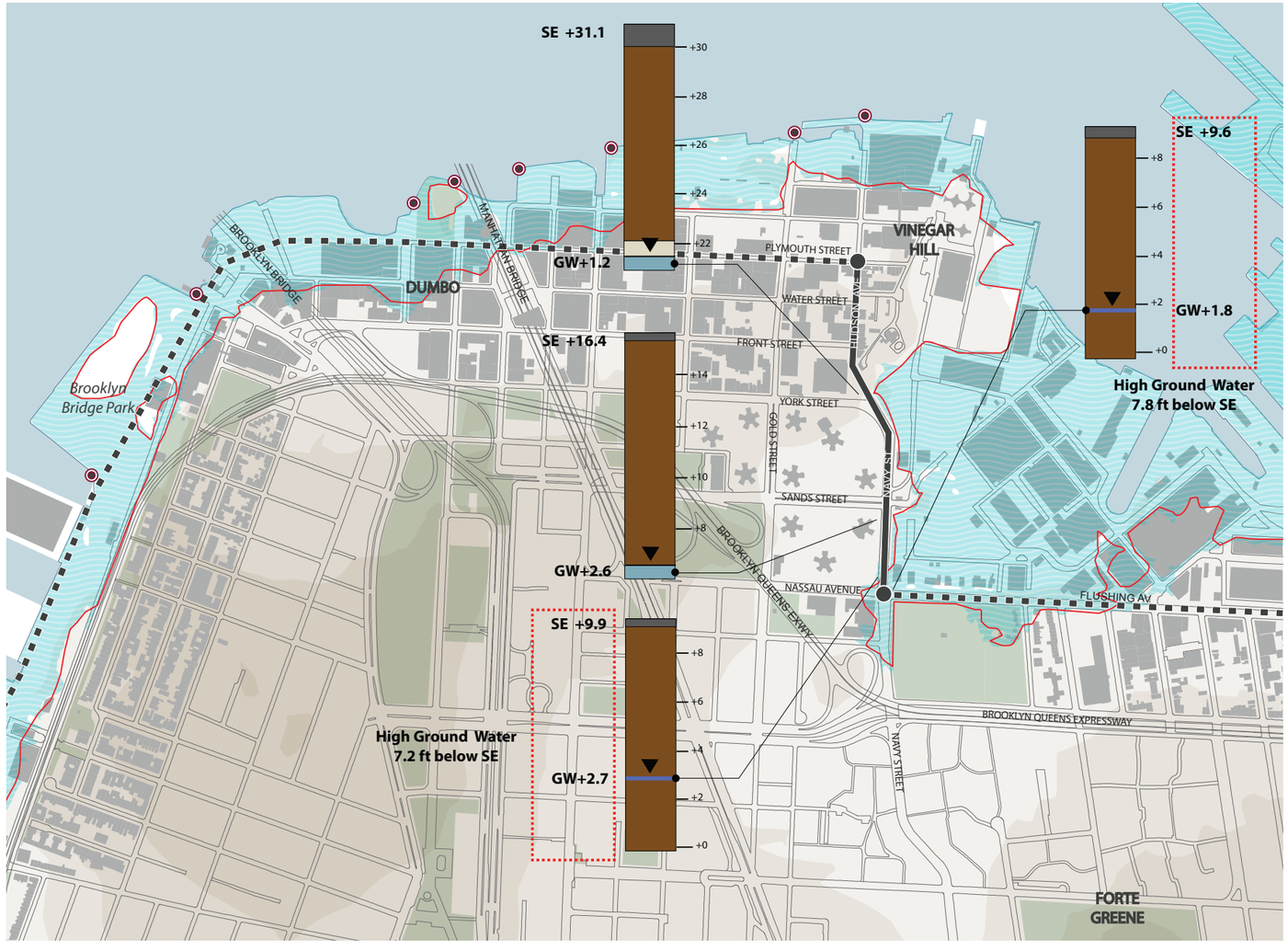
(Images Source: Google Earth)



SEGMENT 6- NAVY ST.

NYC DOT Capital Project Number 8

* Refer to The Brooklyn Waterfront Greenway Implementation Plan, page 60-71



LEGEND

- Segment
- Adjacent Segment
- Superstorm Sandy Surge
- 100-year Flood Zones (FEMA)
- Combined Sewage Outfalls (CSOs)

SOIL BORING

SE - Surface Elevation

GW - Ground Water Elevation

- Concrete / Cobblestone + Asphalt
- Gravel / Boulders
- Fill
- Top Soil
- Medium / Medium to Coarse Sand
- Fine / Fine to Medium Sand
- Very Fine Sand
- Organic Matter
- Ground Water

OVERVIEW

Segment 6 runs along Navy Street from Flushing Avenue to Plymouth Street. This short stretch passes through public housing, the Brooklyn Navy Yard, and the historic neighborhood of Vinegar Hill.

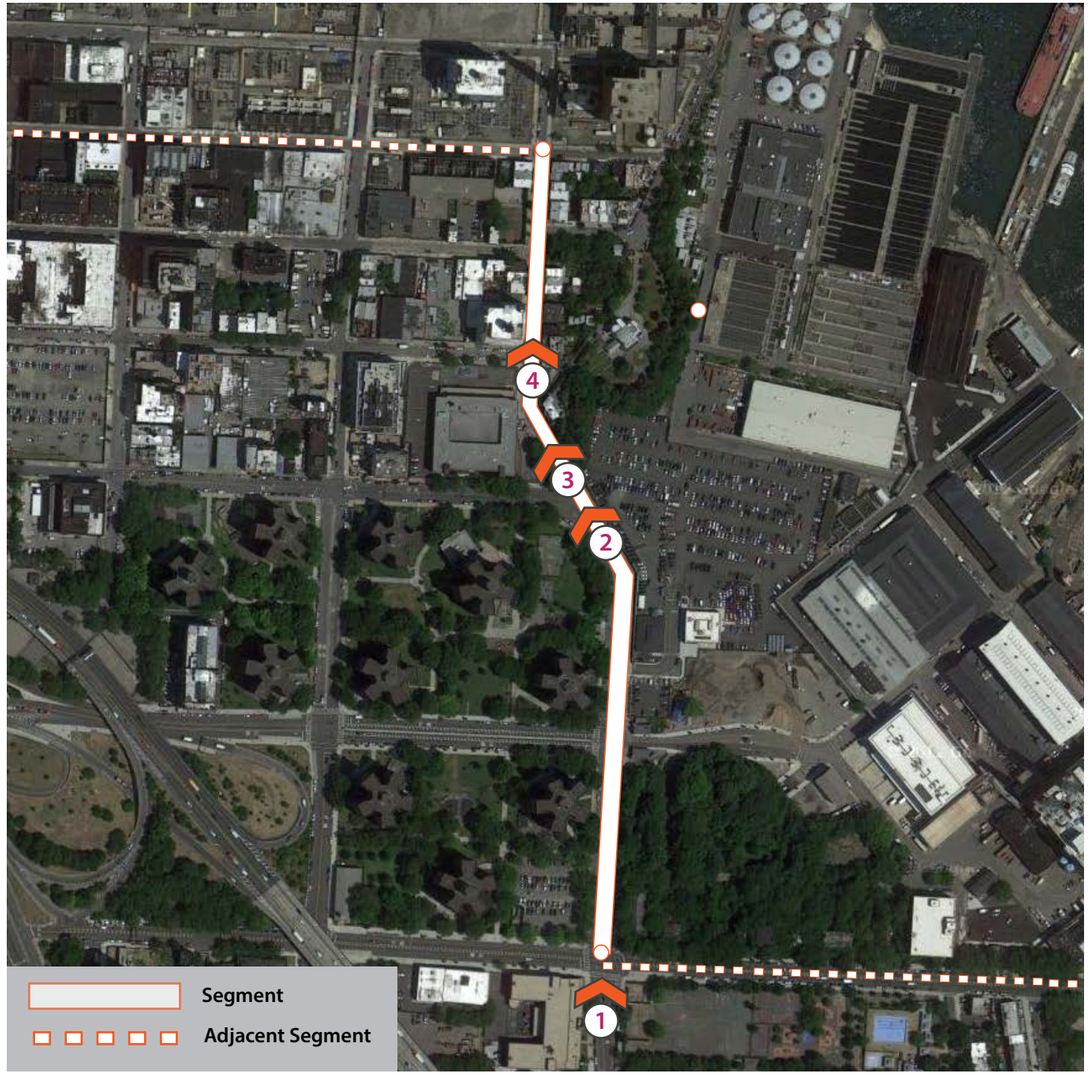
Flooding from Superstorm Sandy (2012) covered the intersection of Navy Street and Flushing Avenue.

SUMMARY OF OPPORTUNITIES

- 13-foot sidewalk along Navy Street provide opportunities for ROW Bio-swales.

- The Navy Yard to the north of Navy Street may provide opportunities for green infrastructure connectivity.

Segment 6 sub-watershed map



NYC DOT Implementation Plan cross section

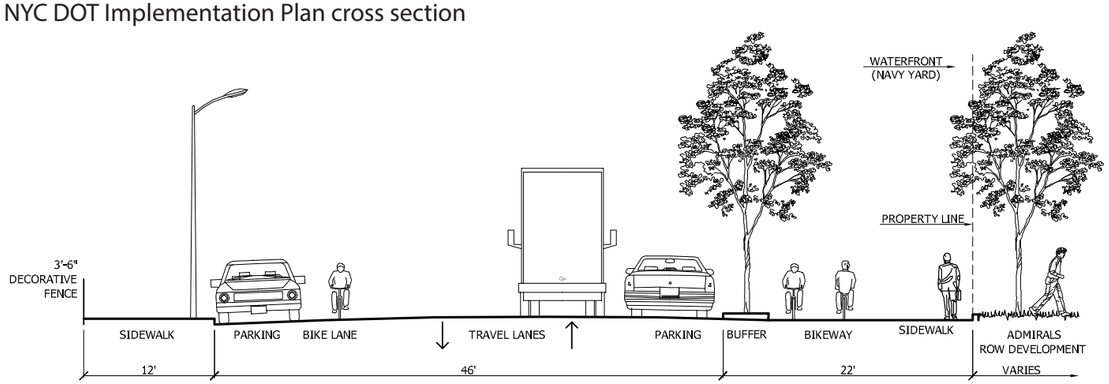


Fig. 11: Possible Configuration for Navy Street

EXISTING CONDITIONS
Approximately 0.42 miles in length

Geotechnical Analysis
There is a high water table at the intersection of Navy Street and Flushing Avenue.
Fill is the dominant soil medium along Navy Street.

SEGMENT 6	
SIDEWALK WIDTHS	~12 FEET
ROADWAY WIDTH	~ 57 FEET
ROADWAY CONFIGURATION	2-WAY, 2-LANE TRAVEL
PARKING	PARALLEL, BOTH SIDES

SEGMENT 6	Tier 1	Tier 2	Tier 3	Tier 1+2+3
RUN-OFF VOLUME (ft3)	10,390	28,245	21,418	60,054

NOTE: Calculations are based on the total run-off from the 1 inch storm event (DEP standard)

(Images Source: Google Earth)

1. Looking north on Navy St. from Sand St.

2. Northwest on Navy St. toward Hudson St. at York St.

3. Northwest on Hudson St. toward Front St.

4. North toward the East River on Hudson St. at Front St.

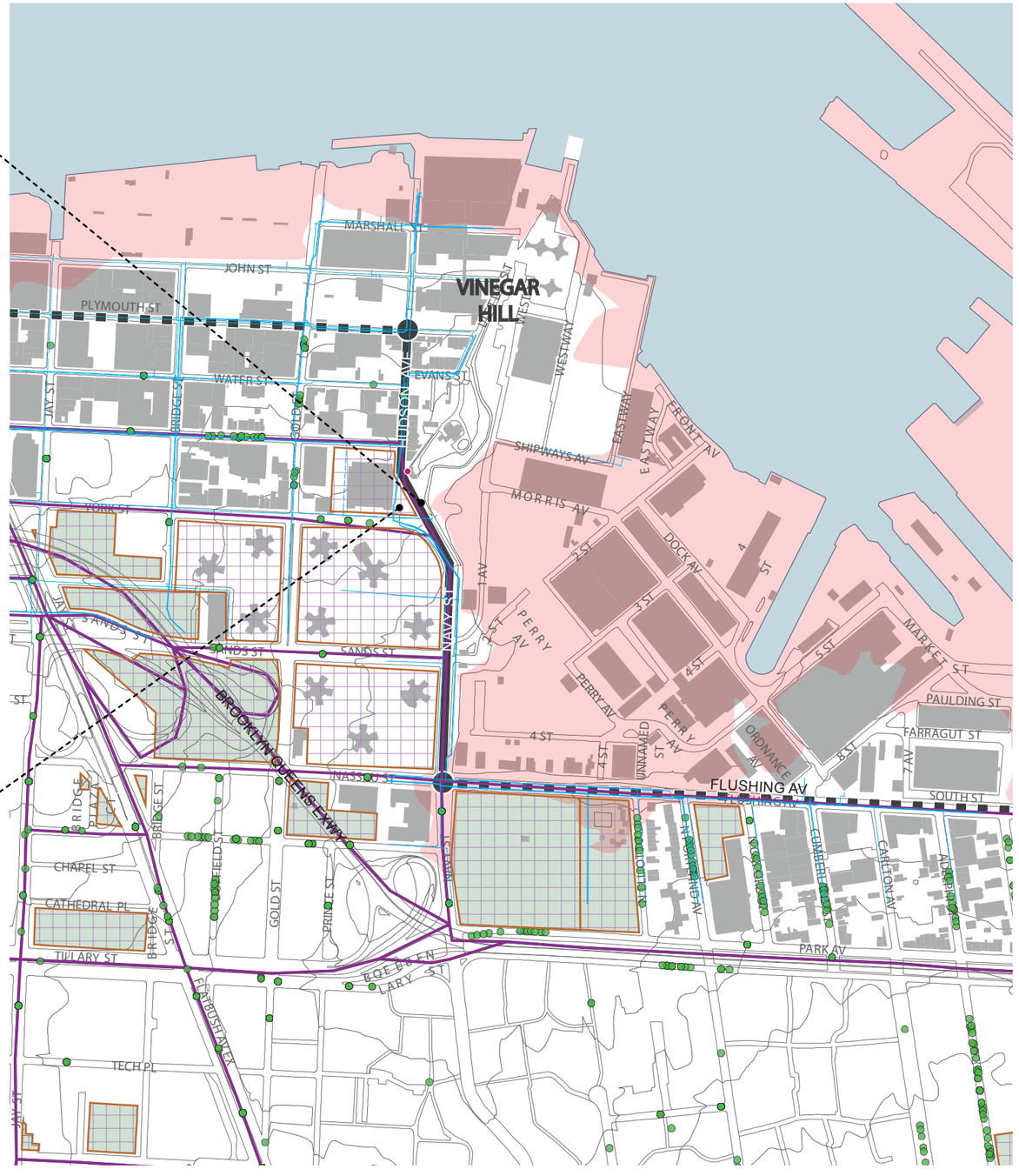
OPPORTUNITIES

Street Striping on Navy St. at York St.

- *Greenway Condition:* Street Striping
- Stormwater Management / *Green Infrastructure Techniques:* Porous Paving, ROW Bio-swales, Rain Gardens
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Heat Island Mitigation, Carbon Sequestration

Playground at the intersection of Navy St., York St. and Hudson Ave.

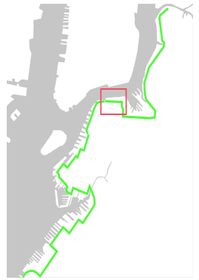
- *Greenway Condition:* Adjacent Park
- *Stormwater Management / Green Infrastructure Techniques:* Bioremediation gardens, Porous Paving, ROW Bio-swales
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Heat Island Mitigation, Carbon Sequestration



LEGEND

- Adjacent Segment
- Segment
- City-Owned Property
- Road Striping
- Truck Route
- Water Mains
- Loading Docks
- Trees
- 100-YR Flood Zones (FEMA)
- 2' Contour

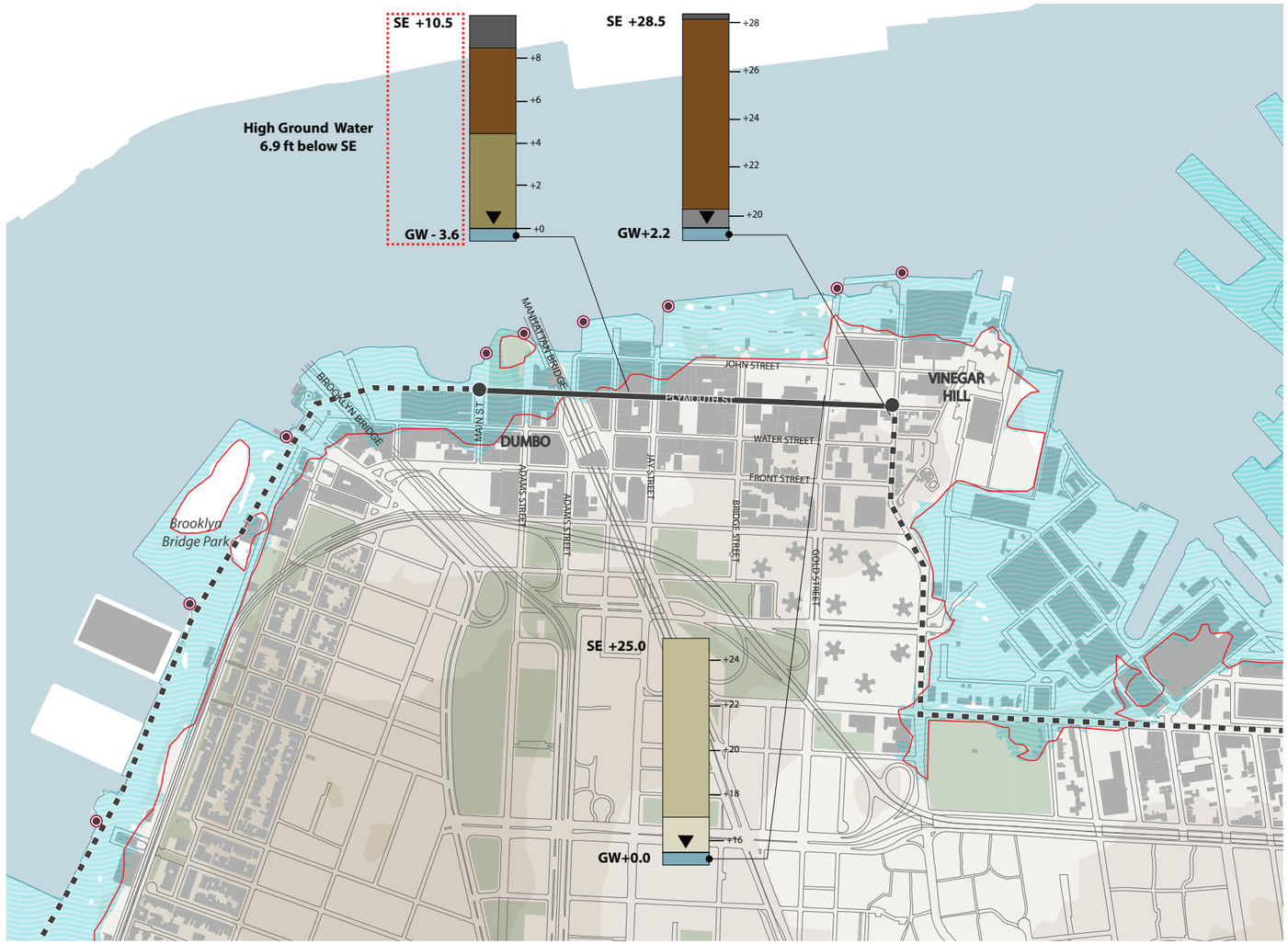
(Images Source: Google Earth)



SEGMENT 7- PLYMOUTH ST.

NYC DOT Capital Project number 9

* Refer to The Brooklyn Waterfront Greenway Implementation Plan, page 60-71



LEGEND

- Segment
- Adjacent Segment
- Superstorm Sandy Surge
- 100-year Flood Zones (FEMA)
- Combined Sewage Outfalls (CSOs)

SOIL BORING

SE - Surface Elevation

GW - Ground Water Elevation

- Concrete / Cobblestone + Asphalt
- Gravel / Boulders
- Fill
- Top Soil
- Medium / Medium to Coarse Sand
- Fine / Fine to Medium Sand
- Very Fine Sand
- Organic Matter
- Ground Water

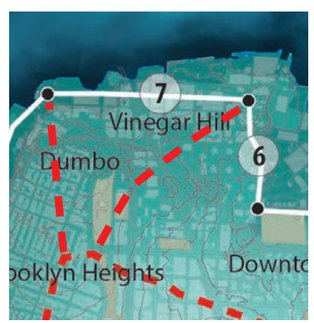
OVERVIEW

Segment 7 runs along Plymouth Street through the historic neighborhoods of Vinegar Hill and DUMBO.

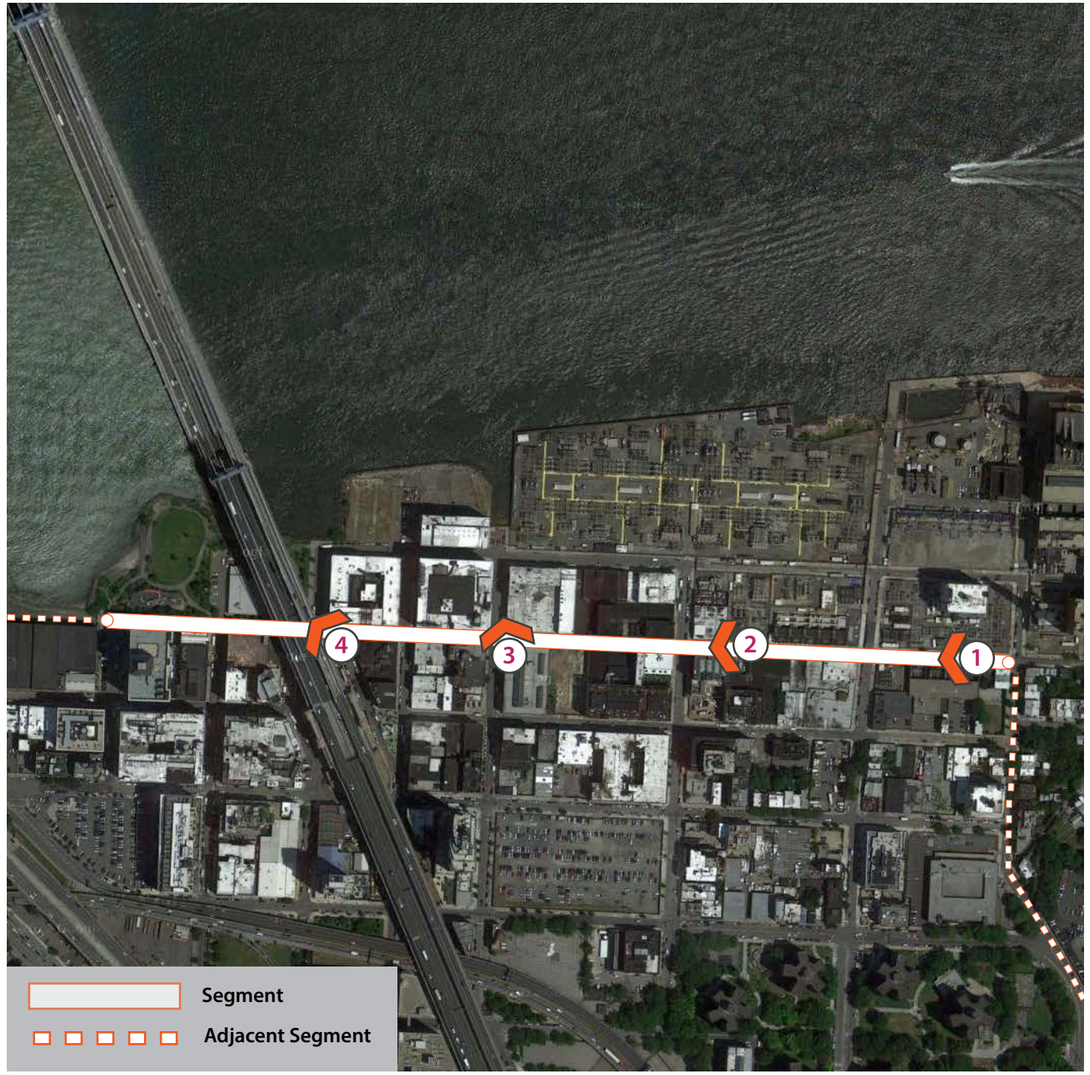
Flooding from Superstorm Sandy (2012) covered the western end of Plymouth Street along Main Street Park.

SUMMARY OF OPPORTUNITIES

- Opportunities to convey run-off from the streets into adjacent open spaces and parks
- Opportunities to collect rain water from the elevated bridge structures into Brooklyn Bridge Park
- Opportunities to pave Plymouth Street with porous pavers in order to capture maximum stormwater.



Segment 7 sub-watershed map



NYC DOT Implementation Plan cross section

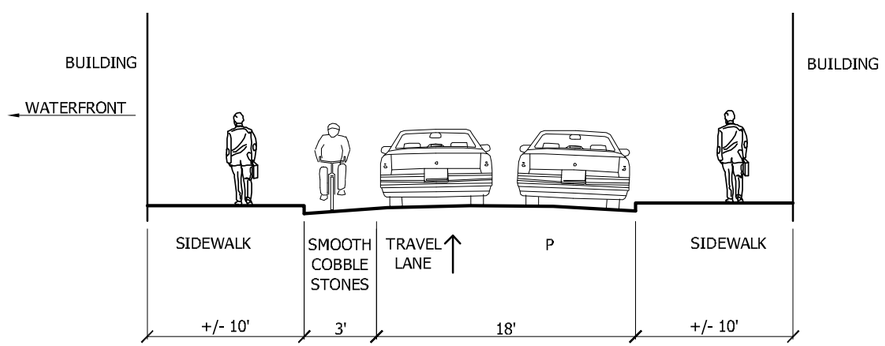


Fig. 18: Possible Configuration for Plymouth Street looking west from Jay Street

EXISTING CONDITIONS
Approximately 0.50 miles in length

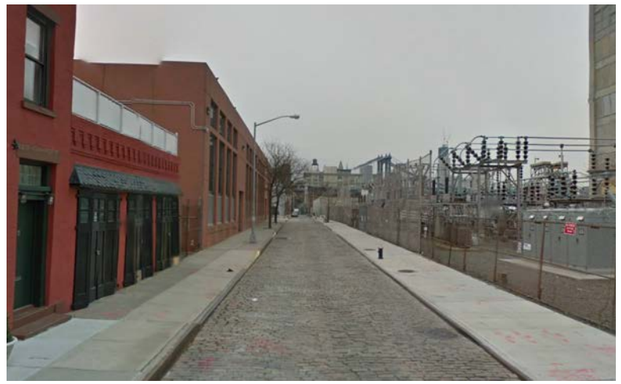
Geotechnical Analysis
The water table ranges from over 20' below the surface at the higher elevations towards Navy Street and less than 8' at the lower elevations in DUMBO. The soil is predominantly fill.

SEGMENT 7	
SIDEWALK WIDTHS	~10 FEET
ROADWAY WIDTH	~ 21 FEET
ROADWAY CONFIGURATION	1-WAY, 1-LANE
PARKING	PARALLEL

SEGMENT 7	Tier 1	Tier 2	Tier 3	Tier 1+2+3
RUN-OFF VOLUME (ft3)	8,130	8,392	25,720	42,243

NOTE: Calculations are based on the total run-off from the 1 inch storm event (DEP standard)

(Images Source: Google Earth)



1. Plymouth west at Hudson Ave.

2. Jay St. north at Plymouth St.

3. Jay St. north at Plymouth St.

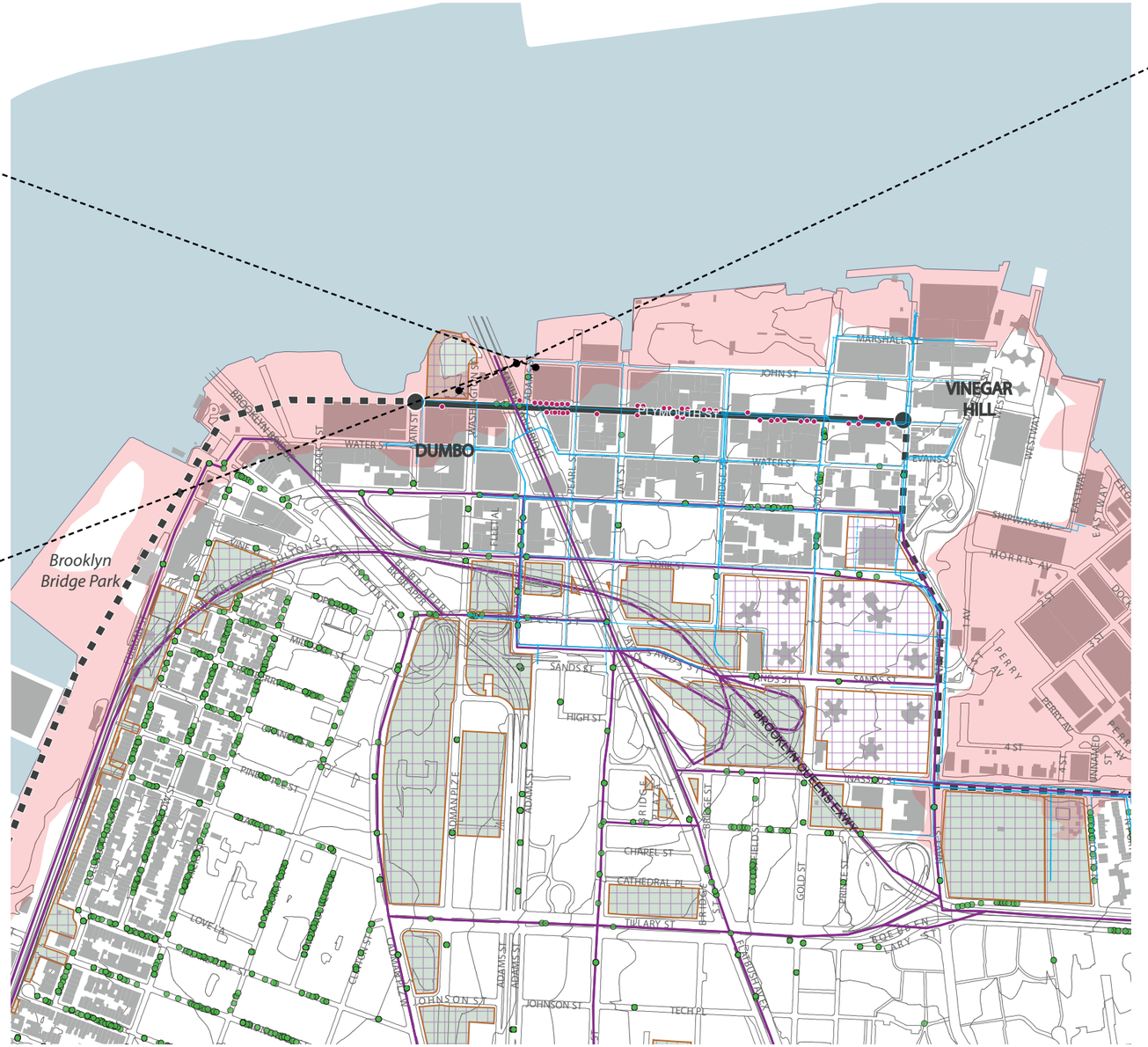
4. Plymouth and Adams intersection northwest

Brooklyn Bridge Park development site on John St. at Adams St.

- *Greenway Condition:* Adjacent Park
- *Stormwater Management / Green Infrastructure Techniques:* Rain Gardens, ROW Bio-swales
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Heat Island Mitigation, Carbon Sequestration

Adams Street-end north from Plymouth St. adjacent to Main Street Park

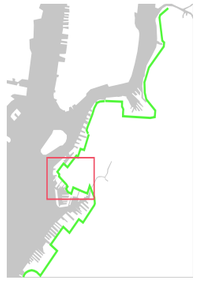
- *Greenway Condition:* Street End, Adjacent Park
- *Stormwater Management / Green Infrastructure Techniques:* Rain Gardens, Constructed Wetlands
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Heat Island Mitigation, Carbon Sequestration, Habitat Creation



Brooklyn Bridge Park at Washington St. end at Plymouth St.

- *Greenway Condition:* Elevated Structure and Adjacent Park
- *Green Infrastructure Techniques:* Rain gardens, Porous Paving, ROW Bio-swales, Constructed Wetlands
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance, Flood Prevention

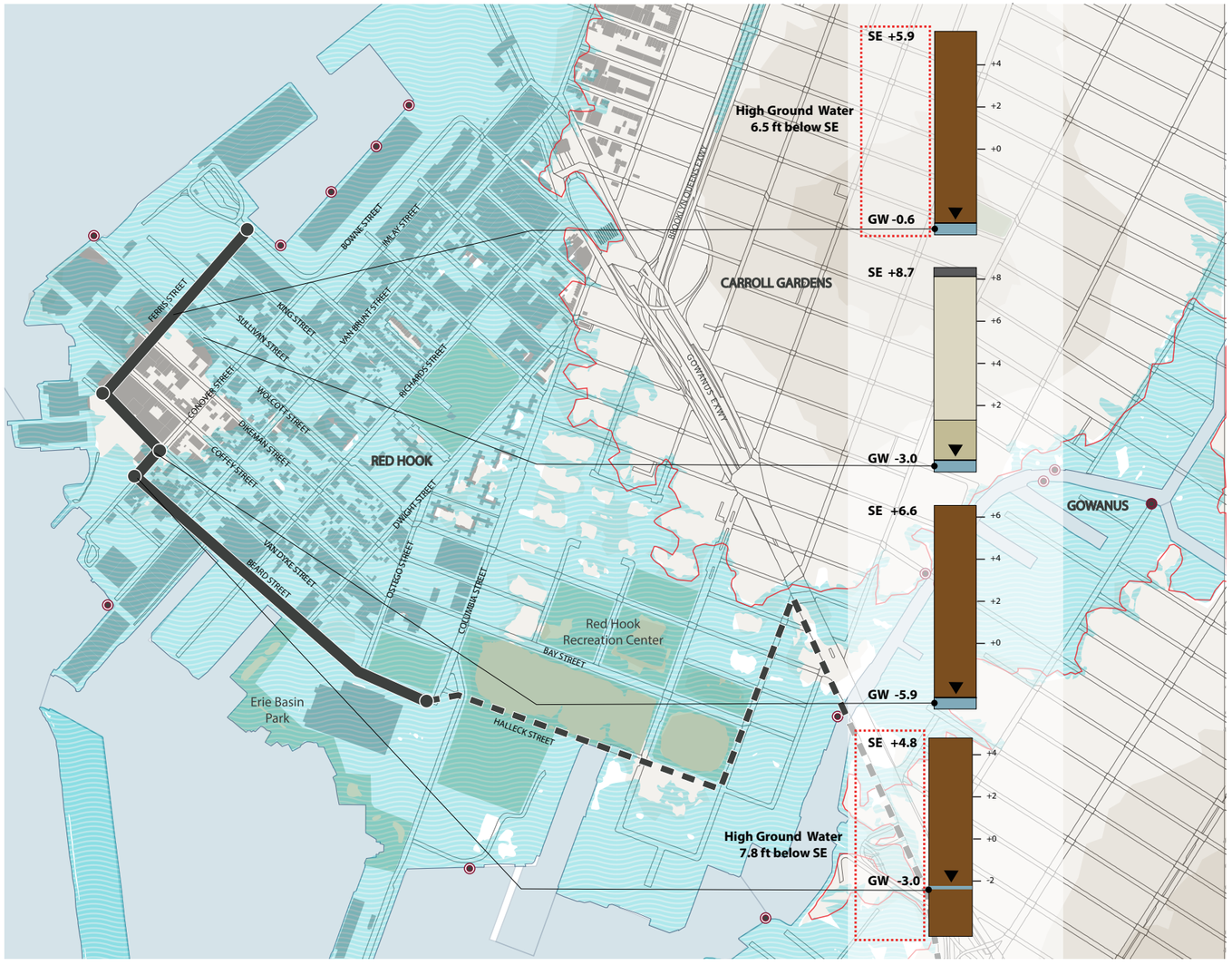
(Images Source: Google Earth)



SEGMENT 8- FERRIS ST. TO BEARD ST .

NYC DOT Capital Projects numbers 13, 14, 15 & 16

* Refer to The Brooklyn Waterfront Greenway Implementation Plan, page 60-71



LEGEND

- Segment
- Adjacent Segment
- Superstorm Sandy Surge
- 100-year Flood Zones (FEMA)
- Combined Sewage Outfalls (CSOs)

SOIL BORING

SE - Surface Elevation

GW - Ground Water Elevation

- Concrete / Cobblestone + Asphalt
- Gravel / Boulders
- Fill
- Top Soil
- Medium / Medium to Coarse Sand
- Fine / Fine to Medium Sand
- Very Fine Sand
- Organic Matter
- Ground Water

OVERVIEW

Segment 8 wraps around the eastern, industrial edge of Red Hook and then parallel to Erie Basin along Beard Street. Ferris Street and Beard Street are high priority Greenway segments for which NYCDOT has begun preliminary design. This represents an opportunity to incorporate green infrastructure in these capital projects and to investigate the potential for the Greenway to play a role in a flood barrier system for Red Hook.

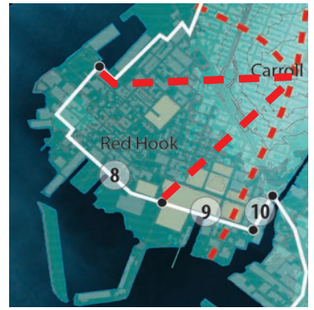
The segment begins on Ferris Street providing an opportunity for the Greenway to connect with Louis Valentino Park. The Beard Street stretch is primarily industrial with some pockets of residential use. The street is cobblestone from Conover to Richards street.

Waterfront properties along this segment include: Port Authority Piers 10, 11 and 12, Estate 4's sites including the former Snapple and ATF buildings, The O'Connell Organization's civil war era warehouse properties and Thor Equities' Revere Sugar Refinery development site. Two important big box destinations are adjacent to Segment 8 - Fairway Market and Ikea. Both locations also have water taxi stops providing important boat / bike transportation connections in an area under-served by public transportation. The former Revere sugar refinery on the south side of Beard Street between Van Brunt and Dwight Streets is a major waterfront development site immediately adjacent to the Greenway route.

Flooding from Superstorm Sandy (2012) covered most of segment 8 and the surrounding area. There is one high point in this area that did not get flooded as you can see from the map on the left. The soil is mostly fill along segment 8 with one exception off Ferris Street where the a thin layer of concrete and cobblestone rubble covers a deep layer of very find sand and organic matter.

SUMMARY OF OPPORTUNITIES

- Ferris Street has 14-foot sidewalks that might support ROW Bio-swales
- Filtered water can be conveyed via Ferris Street toward Wolcott and Sullivan Streets for conveyance to Buttermilk Channel. Stormwater on Beard Street can be released to Erie Basin.
- Wide streets and sidewalks where we could integrate ROW swales and other infiltration strategies.
- Connecting the green infrastructure with Erie Basin Park and possibly the Added Value Farm. Working with waterfront property owners to create an integral barrier system to protect Red Hook from future storm surge related flooding.



Segment 8 sub-watershed map

NYC DOT Implementation Plan cross section

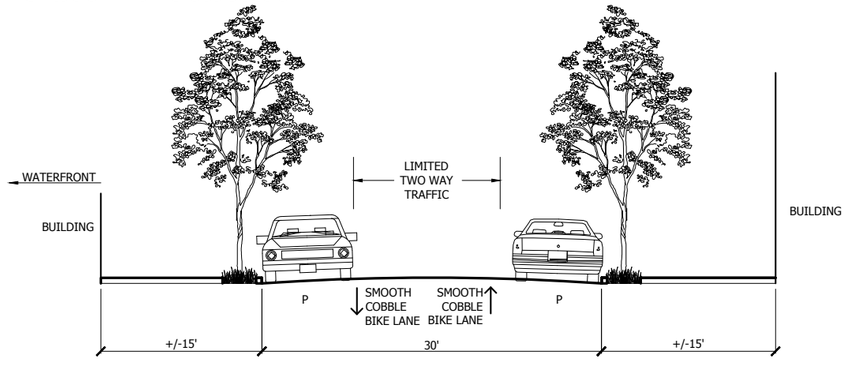


Fig. 28: Possible Configuration for Beard Street between Conover Street and Erie Basin Park

EXISTING CONDITIONS

Approximately 0.9 miles in length

Segment 8 runs the full length of Ferris Street from King to Van Dyke Streets, where it travels East-West for one block on Van Dyke Street to Conover Street, and North-South one block to Beard Street. Louis Valentine Park is at the southern end of Ferris Street through Coffey Street and is the only green open space along this segment. Most of Ferris consists of industrial and manufacturing buildings with wide sidewalks. There are no trees or plantings. There are street trees along the south side of Van Dike Street and numerous loading docks on the north side of Van Dike and east side of Ferris, opposite the NYCDOT Greenway route alternate on Ferris.

Geotechnical Analysis

Segment 8 has a relatively high water table with the highest at 6.5' below the surface elevation along Ferris Street and the lowest water table at the corner of Van Brunt and Conover. Infiltration may be a challenge in this area that experiences flooding even without a storm.

SEGMENT 8	
SIDEWALK WIDTHS	~10-15 FEET
ROADWAY WIDTH	~ 30 FEET
ROADWAY CONFIGURATION	2-WAY, 2-LANE
PARKING	PARALLEL, BOTH SIDES

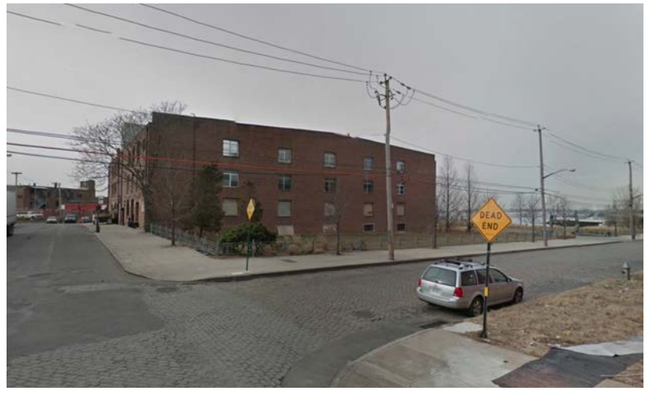
SEGMENT 8	Tier 1	Tier 2	Tier 3	Tier 1+2+3
RUN-OFF VOLUME (ft3)	22,111	53,316	42,721	118,149

NOTE: Calculations are based on the total run-off from the 1 inch storm event (DEP standard)

(Images Source: Google Earth)

1. Ferris St. north at Dikeman St.

2. North end of Ferris St. looking into Piers 11 and 12



3. Ferris Street south toward Valentino Park-Coffey St. on the right

4. Continuous wide sidewalks throughout the area

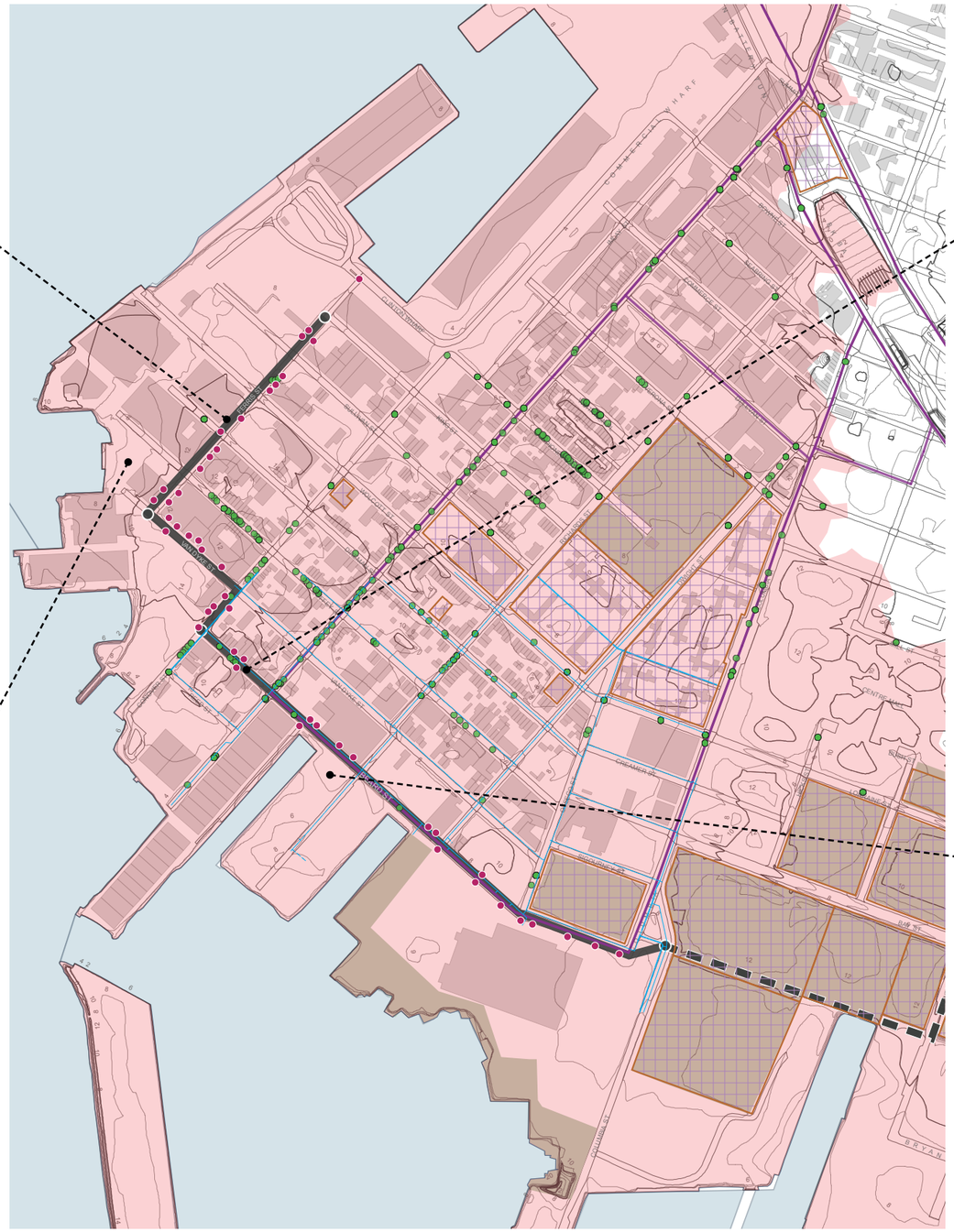
OPPORTUNITIES

Wide sidewalks along Ferris Street

- *Greenway Condition:* Wide Sidewalk
- *Green Infrastructure Techniques:* ROW Bio-swales, High Level Storm Sewer
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance, Heat Island Mitigation

Connect to Louis Valentino Park

- *Greenway Condition:* Wide Sidewalk / Public ROW, Public Street End, Adjacent Park / Waterfront
- *Green Infrastructure Techniques:* ROW Bio-swales, High Level Storm Sewer, Constructed Wetlands
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Heat Island Mitigation, Water Conveyance, Wave Breaks, Habitat Creation



Beard Street is a cobble street with some street trees.

- *Greenway Condition:* 14-foot Sidewalk / Public ROW
- *Green Infrastructure Techniques:* Bioremediation Gardens, Porous Paving, ROW Bio-swales, High Level Sewer
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance, Heat Island Mitigation

New waterfront developments and large, parking lots may provide opportunities for larger green infrastructure installations.

- *Greenway Condition:* Wide Sidewalk / Public ROW
- *Green Infrastructure Techniques:* ROW Bio-swales, High Level Storm Sewer
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance, Heat Island Mitigation

LEGEND

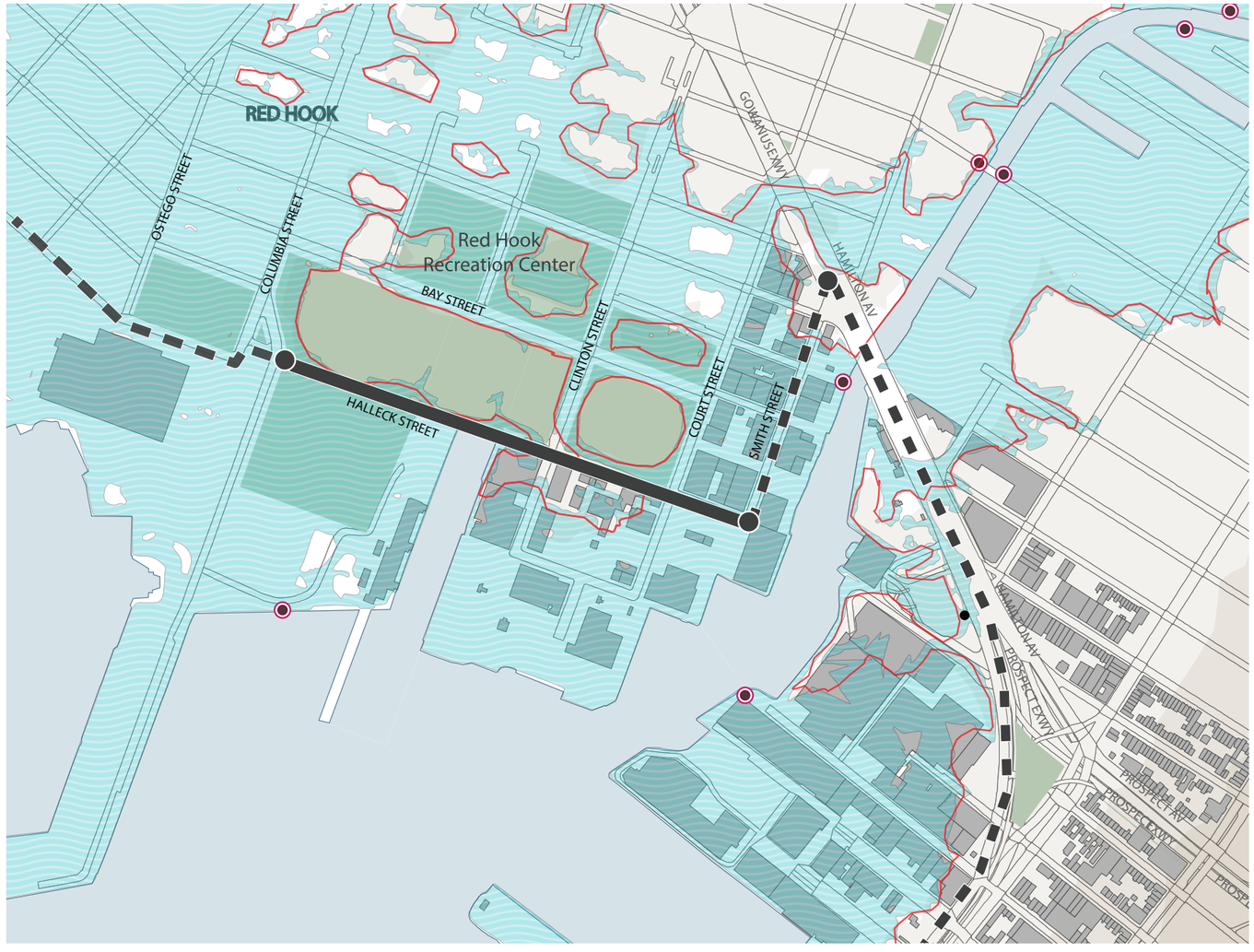
- Adjacent Segment
- Segment
- City-Owned Property
- Road Striping
- Truck Route
- Water Mains
- Loading Docks
- Trees
- 100-YR Flood Zones (FEMA)
- 2' Contour

(Images Source: Google Earth)

SEGMENT 9- COLUMBIA ST. TO SMITH ST. ON HALLECK ST.

NYC DOT Capital Project Number 17

* Refer to The Brooklyn Waterfront Greenway Implementation Plan, page 60-71



LEGEND

- Segment
- Adjacent Segment
- Superstorm Sandy Surge
- 100-year Flood Zones (FEMA)
- Combined Sewage Outfalls (CSOs)

SOIL BORING

SE - Surface Elevation

GW - Ground Water Elevation

- Concrete / Cobblestone + Asphalt
- Gravel / Boulders
- Fill
- Top Soil
- Medium / Medium to Coarse Sand
- Fine / Fine to Medium Sand
- Very Fine Sand
- Organic Matter
- Ground Water

OVERVIEW

Segments 9 runs along mapped Halleck Street through Red Hook Park.

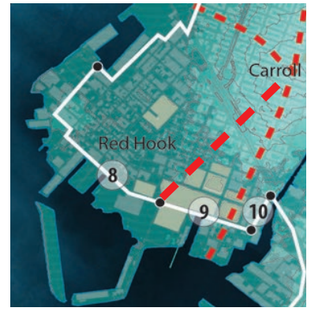
The Red Hook Recreation Facilities adjacent to Segment 9 provide more pervious surface area than the typical Greenway segment.

Flooding from Superstorm Sandy (2012) submerged all of Segment 9

SUMMARY OF OPPORTUNITIES

- Available public land for an expanded Greenway integrated into existing Red Hook Park

- The integration of resilience and adaptation mechanisms into the design of an elevated Greenway for storm surge protection.



Segment 9 sub-watershed map

NYC DOT Implementation Plan cross section

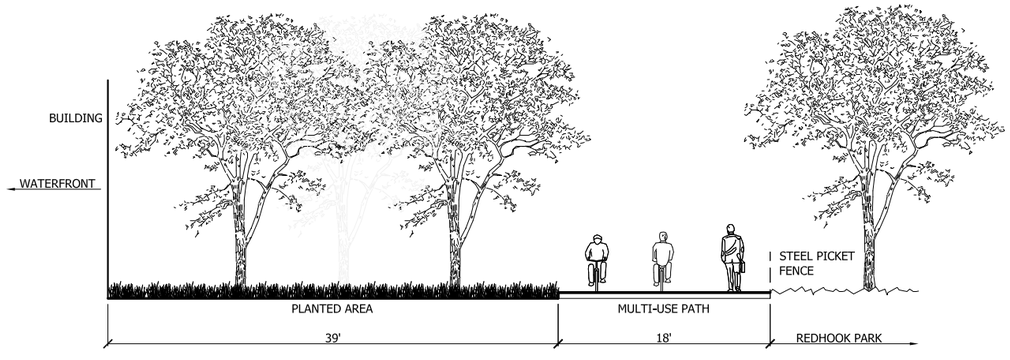


Fig. 32: Possible Configuration for Halleck Street between Court Street and Clinton Street

EXISTING CONDITIONS
Approximately 0.45 miles in length

Segment 9 runs along Halleck Street, an abandoned legally "mapped" street. From Columbia Street to Court Street it runs through Red Hook Park. It is currently populated by naturalized trees and other undergrowth plant material. However, this narrow band of public land is not accessible to the public due to toxic dumping from adjacent industrial land uses. Between Court Street and Smith street the park is currently used mostly as a truck route and for loading for the adjacent manufacturing and industrial uses.

This is one of several stretches of the Greenway that will be able to cut through a large open space, completely separated from vehicular traffic. Given its close location to the water's edge and a large area of public space, opportunities exist to integrate resilience and adaptation mechanisms into the design of the Greenway to protect the community beyond that was heavily flooded during Superstorm Sandy.

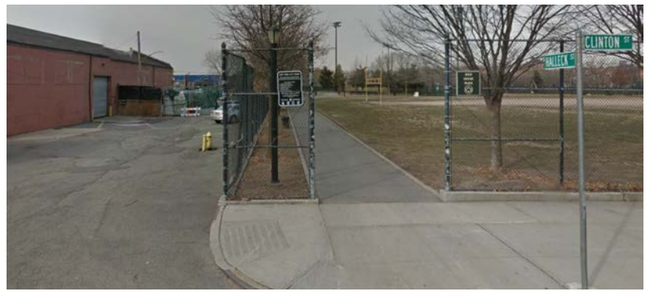
Geotechnical Analysis
Geotechnical information was not available for Segment 9.

SEGMENT 9	
SIDEWALK WIDTHS	~10-15 FEET
ROADWAY WIDTH	~ 27 FEET
ROADWAY CONFIGURATION	1-WAY, 1-LANE
PARKING	PARALLEL

SEGMENT 9	Tier 1	Tier 2	Tier 3	Tier 1+2+3
RUN-OFF VOLUME (ft3)	5,993	7,082	5,514	18,590

NOTE: Calculations are based on the total run-off from the 1 inch storm event (DEP standard)

(Images Source: Google Earth)

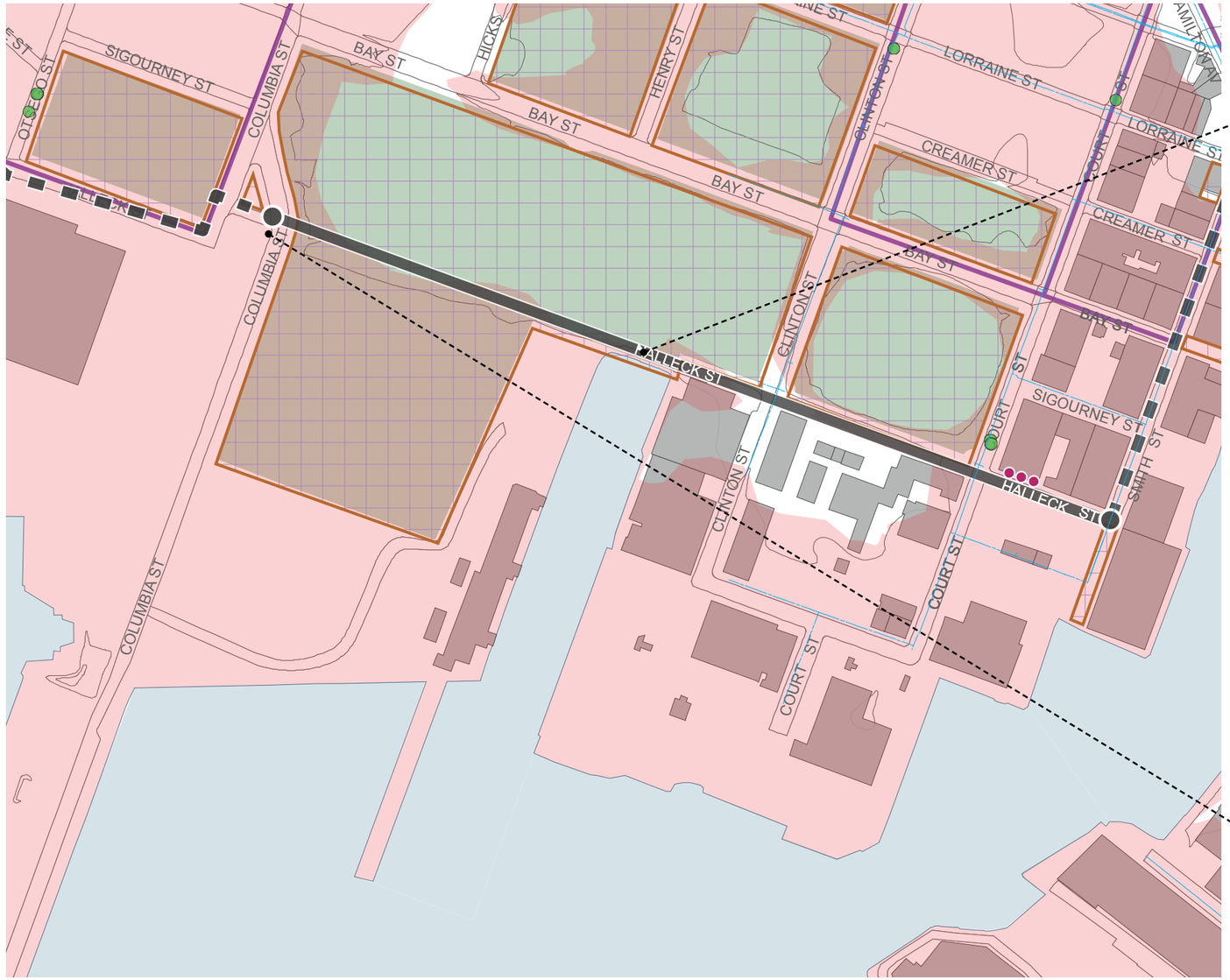


2. Halleck Street continues through Red Hook Park , west from Clinton Street

4. Halleck Street as truck route and loading zone between Court St. and Smith St.

1. Halleck St. continues through Red Hook Park, east from Columbia St.

3. Halleck St. shown as overgrown right of way running along Red Hook Park and existing manufacturing , west from Court St.

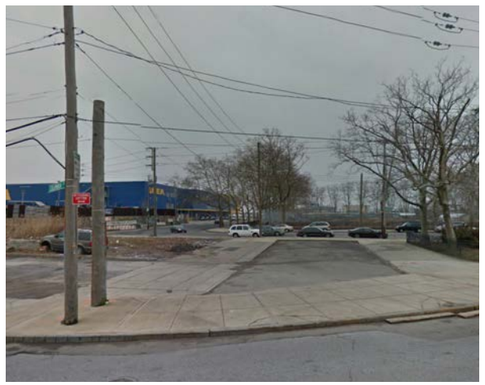


LEGEND

- Adjacent Segment
- Segment
- City-Owned Property
- Road Striping
- Truck Route
- Water Mains
- Loading Docks
- Trees
- 100-YR Flood Zones (FEMA)
- 2' Contour

Privately-owned basin off Gowanus Bay immediately south of the Greenway route:

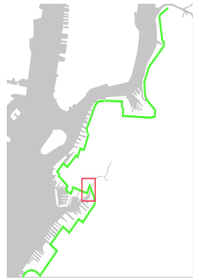
- *Greenway Condition:* Adjacent to Water, Adjacent to Park
- *Stormwater / Green Infrastructure Techniques:* Porous Paving, Constructed Wetlands, Storm Barrier, Elevated Greenway
- *Environmental Outcomes*: Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Heat Island Mitigation, Carbon Sequestration, Flood Prevention, Wave Break



Todd Triangle at Columbia and Halleck Streets: Surface area for green infrastructure

- *Greenway Condition:* Wide Sidewalk / Public ROW
- *Green Infrastructure Techniques:* Porous Paving, ROW Bio-swales
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Heat Island Mitigation

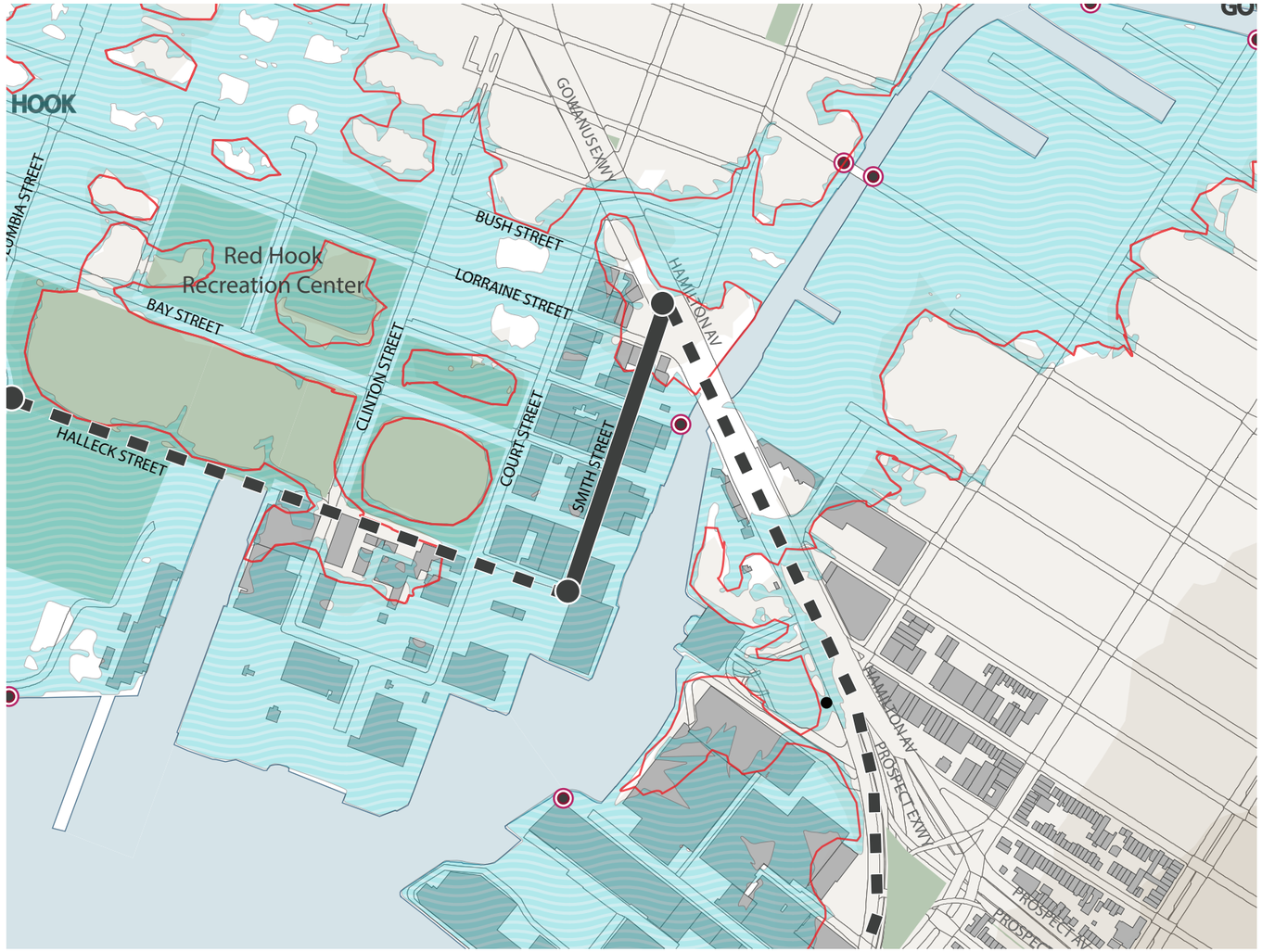
(Images Source: Google Earth)



SEGMENT 10- SMITH ST.- HALLECK TO HAMILTON STS.

NYC DOT Capital Project Number 18

* Refer to The Brooklyn Waterfront Greenway Implementation Plan, page 60-71



LEGEND

- Segment
- Adjacent Segment
- Superstorm Sandy Surge
- 100-year Flood Zones (FEMA)
- Combined Sewage Outfalls (CSOs)

SOIL BORING

SE - Surface Elevation

GW - Ground Water Elevation

- Concrete / Cobblestone + Asphalt
- Gravel / Boulders
- Fill
- Top Soil
- Medium / Medium to Coarse Sand
- Fine / Fine to Medium Sand
- Very Fine Sand
- Organic Matter
- Ground Water

OVERVIEW

Segment 10 runs through the industrial southern stretch of Smith Street.

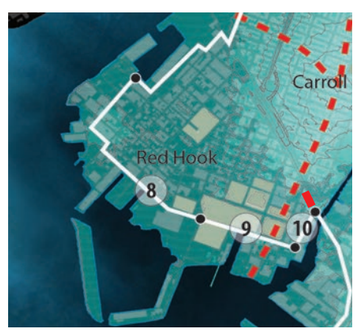
Segment 10 falls within the Gowanus Canal watershed, one of nearly a dozen high priority areas the NYC DEP have prioritized for the implementation of stormwater best management practice and low impact development.

Flooding from Superstorm Sandy (2012) covered Segments 10.

SUMMARY OF OPPORTUNITIES

• Street end mechanisms can be connected to the Greenway along Smith Street in order to filter run-off from this industrial area with low pervious surface area.

• Opportunities for the collection of run ruff from the elevated Gowanus Expressway at Hamilton Avenue.



Segment 10 sub-watershed map

NYC DOT Implementation Plan cross section

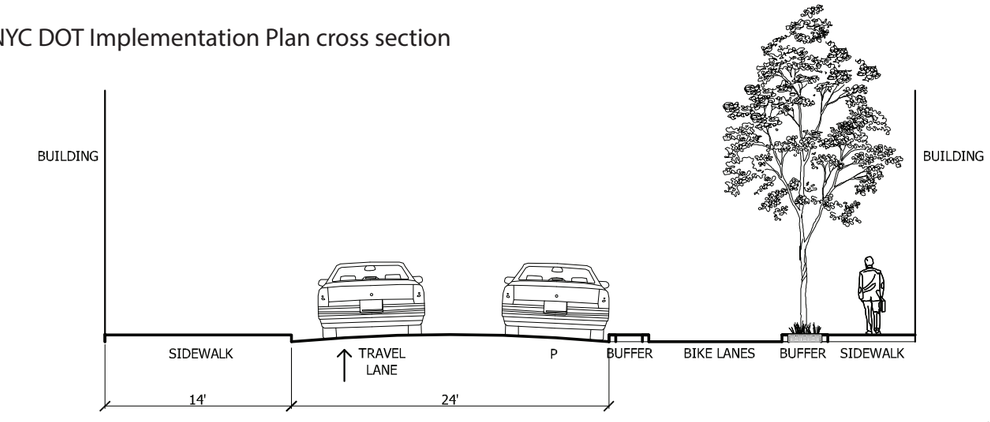


Fig. 36: Possible Configuration for Smith Street between Sigourney Street and Bay Street

EXISTING CONDITIONS
Approximately 0.20 miles in length

Segment 10 starts at the southern end of Smith Street, where it intersects with the eastern end of Halleck Street, and travels north up Smith Street to the intersection of Smith and Lorraine Streets and Hamilton Avenue.

Smith Street is an industrial route, characterized by truck loading and traffic. It is a low lying segment that frequently experiences flooding. Along this route, three streets terminate at the Gowanus Canal (Bay, Creamer and Smith Streets), and there is currently a vacant lot on the waterfront, eastern side of Smith Street. Overhead electrical wires run above the east side of the street.

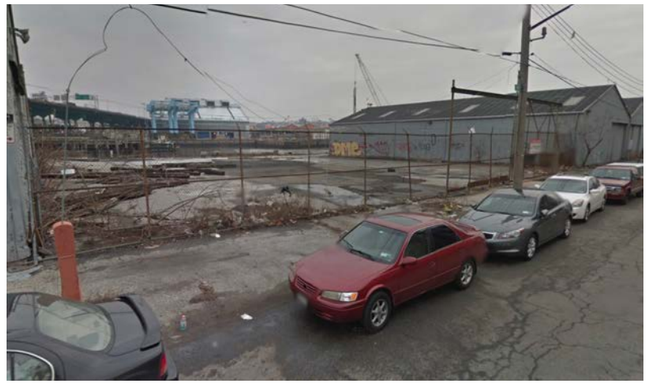
Geotechnical Analysis
Geotechnical information was not available for Segment 10.

SEGMENT 10	
SIDEWALK WIDTHS	~14 FEET
ROADWAY WIDTH	~ 33 FEET
ROADWAY CONFIGURATION	1-WAY, 1-LANE
PARKING	PARALLEL, BOTH SIDES

SEGMENT 10	Tier 1	Tier 2	Tier 3	Tier 1+2+3
RUN-OFF VOLUME (ft3)	5,352	12,362	14,541	32,256

NOTE: Calculations are based on the total run-off from the 1 inch storm event (DEP standard)

(Images Source: Google Earth)

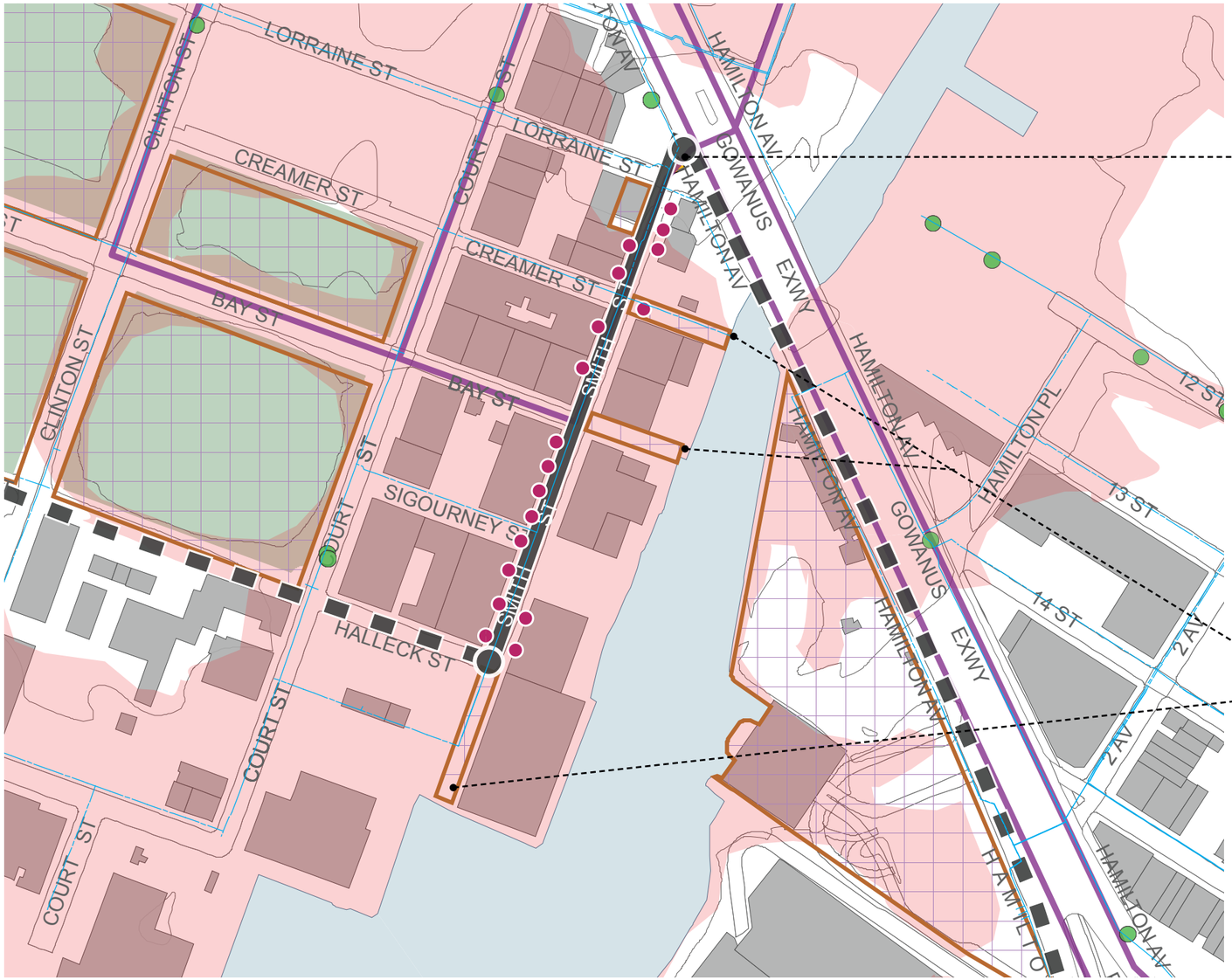


1. Vacant Lot on East side of Smith St., south of Bay St., adjacent to the Gowanus Canal

2. Loading docks at the South end of Smith St., view north

3. Smith St. north from Bay St.

4. Smith St. south from Creamer St.

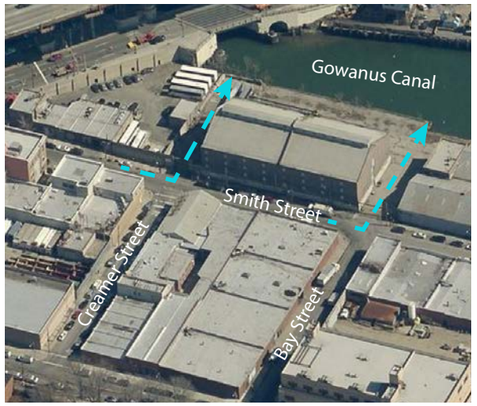


LEGEND

- Adjacent Segment
- Segment
- City-Owned Property
- Road Striping
- Truck Route
- Water Mains
- Loading Docks
- Trees
- 100-YR Flood Zones (FEMA)
- 2' Contour

Striped road surfaces at Smith Street and Hamilton Avenue

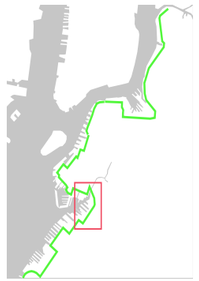
- *Greenway Condition:* Street Striping
- *Stormwater / Green Infrastructure Techniques:* ROW Swales
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Heat Island Mitigation



Public street ends at Creamery and Bay Street

- *Greenway Condition:* Public Street-end
- *Stormwater / Green Infrastructure Techniques:* Bioremediation Gardens, Porous Paving, Constructed Wetlands
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Heat Island Mitigation, Flood Prevention

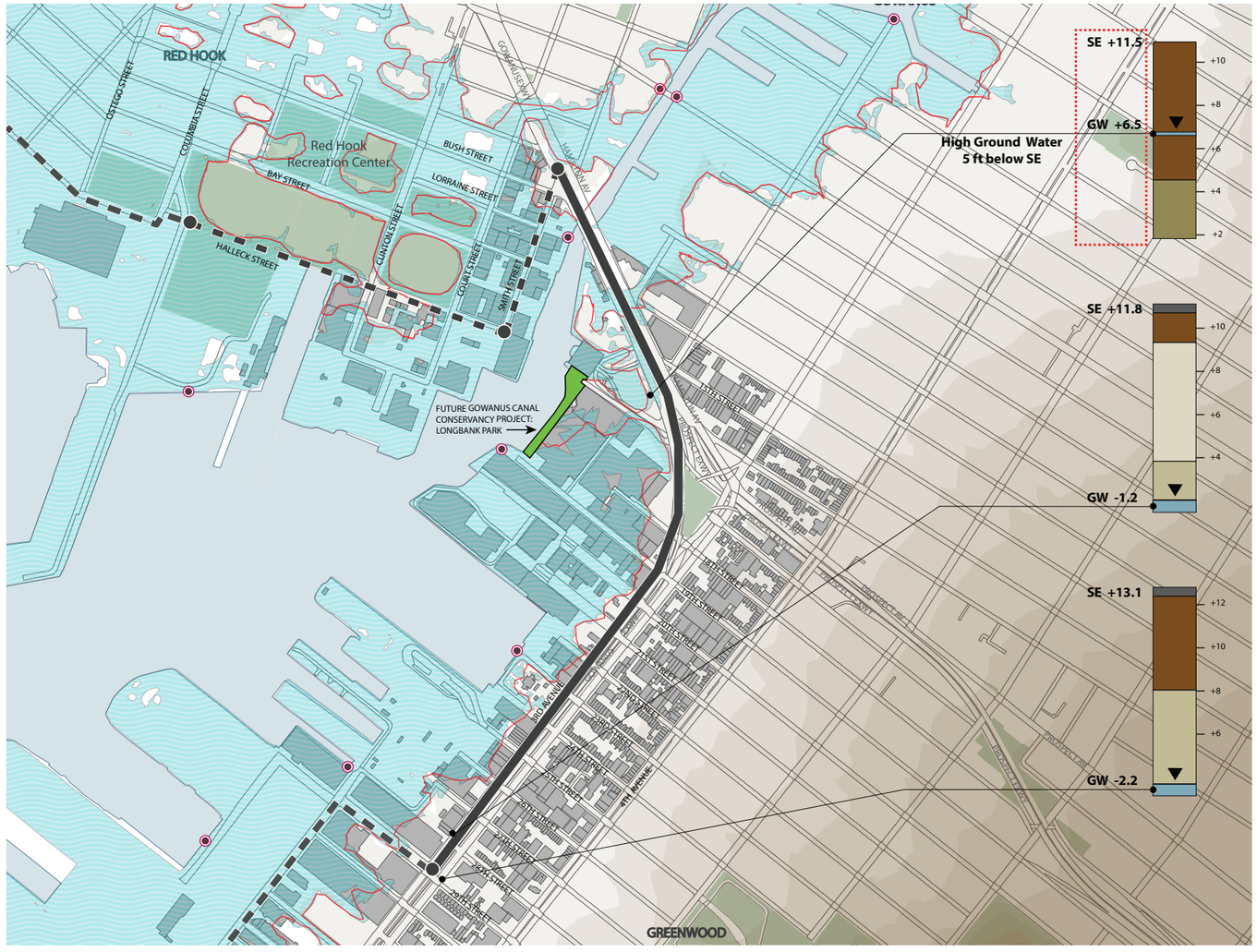
(Images Source: Google Earth)



SEGMENT 11- SMITH ST. TO 29TH ST. AND 3RD AVE.

NYC DOT Capital Project Number 19

* Refer to The Brooklyn Waterfront Greenway Implementation Plan, page 60-71



LEGEND

- Segment
- Adjacent Segment
- Superstorm Sandy Surge
- 100-year Flood Zones (FEMA)
- Combined Sewage Outfalls (CSOs)

SOIL BORING

SE - Surface Elevation

GW - Ground Water Elevation

- Concrete / Cobblestone + Asphalt
- Gravel / Boulders
- Fill
- Top Soil
- Medium / Medium to Coarse Sand
- Fine / Fine to Medium Sand
- Very Fine Sand
- Organic Matter
- Ground Water

OVERVIEW

Segment 11 wraps around the mouth of the Gowanus Canal, connecting Red Hook and Sunset Park.

The northern portion of Segment 11 falls within the Gowanus Canal watershed, one of NYC DEP's priority areas for investing DEP capital funds in stormwater infrastructure. NYC DEP should be engaged in the development of this NYCDOT Greenway capital project referred to as the Gowanus Connector. The Gowanus Connector is a high priority Greenway capital project on which DOT has begun design and capital funding as of the publication of this report.

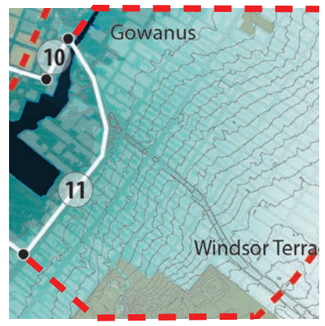
Flooding from Superstorm Sandy (2012) covered much of the waterfront property along Segment 11.

SUMMARY OF OPPORTUNITIES

- There is an opportunity to secure DEP investment in green infrastructure and possibly in high level storm sewers along this segment. The combination of the two could divert a substantial portion of the first tier of this sub watershed from the combined sewer system.

- Opportunities exist to capture and filter water runoff from the elevated Gowanus Expressway and to connect these mechanisms with street-end green infrastructure installations at the water's edge.

- Opportunities to connect right of way bio-swales along 3rd Avenue with street-end green infrastructure installations at the water's edge.



Segment 11 sub-watershed map

NYC DOT Implementation Plan cross section

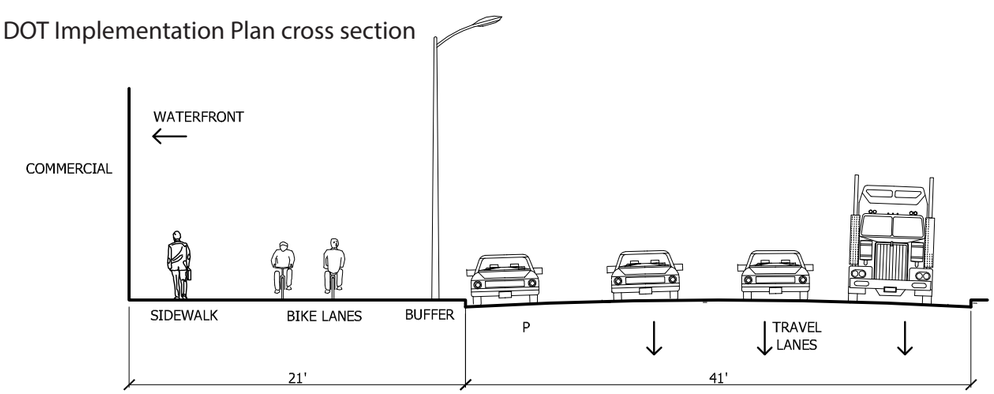


Fig. 41: Possible Configuration for Third Avenue between 21st Street and 27th Street

EXISTING CONDITIONS

Approximately 1.10 miles in length

Segment 11 begins along the northern edge of Gowanus Canal at the intersection of Smith Street and Hamilton Avenue. It travels southeast on Hamilton Ave, crossing the Canal, bearing right onto 3rd Ave after crossing the bridge. The Greenway rout follows along the west side of 3rd Ave to 29th Street. Segment 11 is lined with industrial and commercial land uses including big box retail, a DSNY barge loading facility, large warehouse and manufacturing buildings, heavy traffic, and an overhead highway structure.

Geotechnical Analysis

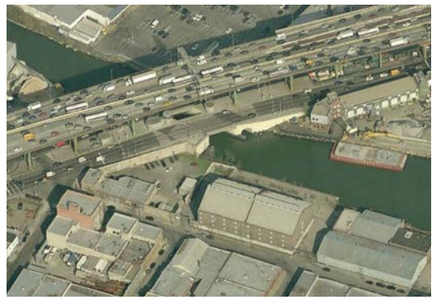
Segment 11 has a relatively high water table at 5' below the surface elevation near the Gowanus bridge. The other two borings show an adequate water table level for infiltration purposes at 13 to 15 feet below the surface. Fill is the dominant soil type for the first 5-10 feet below surface. The soils should have good permeability as the layers below the fill layers are very fine sand to medium fine sand.

SEGMENT 11	
SIDEWALK WIDTHS	~12 FEET
ROADWAY WIDTH	~ 50 FEET
ROADWAY CONFIGURATION	1-WAY, 3-LANE
PARKING	PARALLEL, ONE SIDES

SEGMENT 11	Tier 1	Tier 2	Tier 3	Tier 1+2+3
RUN-OFF VOLUME (ft3)	108,034	434,323	84,177	626,535

NOTE: Calculations are based on the total run-off from the 1 inch storm event (DEP standard)

(Images Source: Google Earth)



1. Gowanus Expressway and Hamilton Avenue Bridge over the Gowanus Canal

2. Wide Roadway along 3rd Ave., south from 20th St.

There are catch basins on the east side of 3rd Ave., but the majority of the road surface drains to the west curb.

Heavy storm water runoff from the Gowanus Expressway can be effectively diverted through a conveyor system at street level to be cleaned before flowing into the bay.

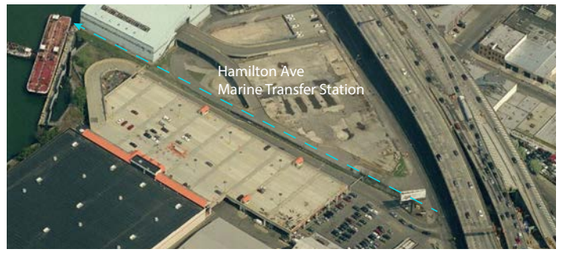
Interstitial space beneath the Gowanus Expressway may support stormwater infiltration.

OPPORTUNITIES

LEGEND

- Adjacent Segment
- Segment
- City-Owned Property
- Road Striping
- Truck Route
- Water Mains
- Loading Docks
- Trees
- 100-YR Flood Zones (FEMA)
- 2' Contour

(Image Sources: Google Earth)



Home Depot driveway south of Hamilton Transfer Station could convey runoff from 3rd Ave.

- *Greenway Condition:* Gowanus Connector segment in design
- *Stormwater Management / Green Infrastructure Techniques:* Porous Paving, ROW Swales
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance, Heat Island Mitigation

Striped road surface on 3rd Ave. (North of 18th St. on East and West sides)

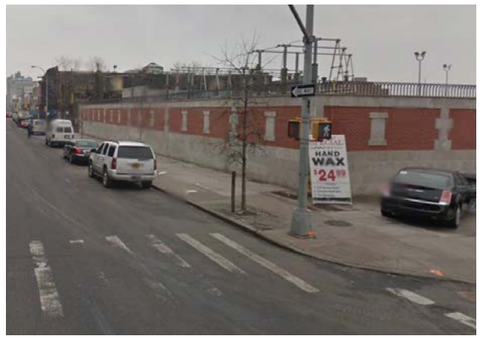
- *Greenway Condition:* Gowanus Connector Greenway segment is in design phase
- *Green Infrastructure Techniques:* Porous Paving. ROW Swales
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance, Heat Island Mitigation

19th St. access to the Gowanus Canal, possible HLSS outfall. Opportunity to utilize future park development for green infrastructure installations.

- *Greenway Condition:* Public Street End
- *Stormwater Management / Green Infrastructure Techniques:* Porous Paving, ROW Bio-swales, Constructed Wetlands
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance

LEGEND

- Adjacent Segment
- Segment
- City-Owned Property
- Road Striping
- Truck Route
- Water Mains
- Loading Docks
- Trees
- 100-YR Flood Zones (FEMA)
- 2' Contour



3rd Ave. sidewalk is 15 feet wide between 20th to 29th Streets with frequent curb cuts

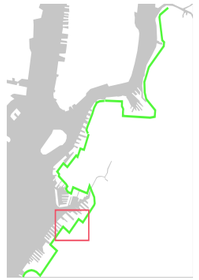
- *Greenway Condition:* Gowanus Connector Greenway segment is in design.
- *Stormwater Management / Green Infrastructure Techniques:* Bioremediation Gardens, Porous Paving, ROW Bio-swales,

Environmental Outcomes: Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance

Area below Gowanus Expressway receives runoff from elevated highway and from upslope side streets, east of 3rd Avenue. Shady conditions beneath the highway are separated from the Greenway route by the southbound lanes of 3rd Avenue

- *Greenway Condition:* Elevated Roadway
- *Stormwater Management / Green Infrastructure Techniques:* Porous Paving, Gravel Beds
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance

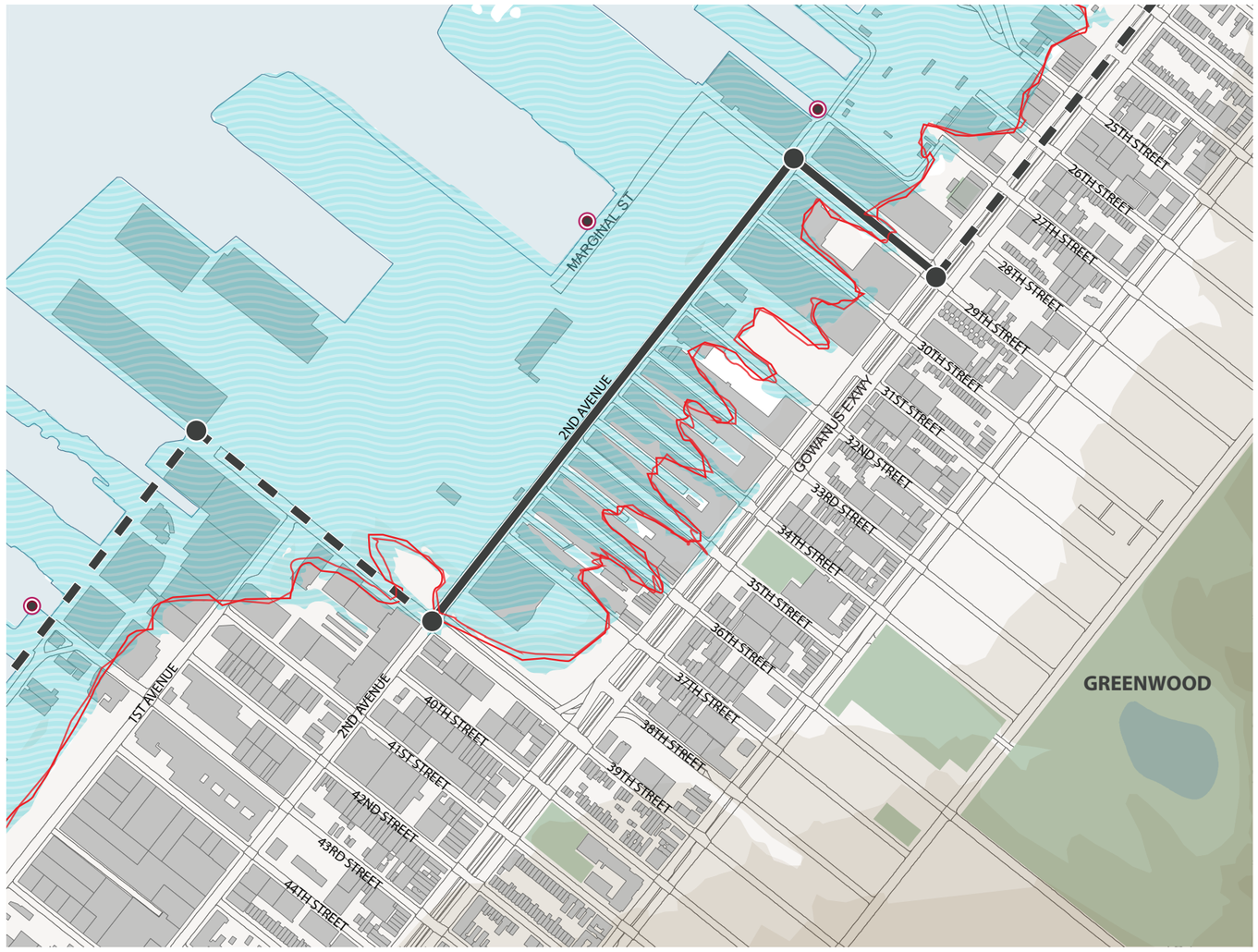
(Images Source: Google Earth)



SEGMENT 12- 2ND AVE. - 29TH ST. - 39TH ST.

NYC DOT Capital Project Number 20

* Refer to The Brooklyn Waterfront Greenway Implementation Plan, page 60-71



LEGEND

- Segment
- Adjacent Segment
- Superstorm Sandy Surge
- 100-year Flood Zones (FEMA)
- Combined Sewage Outfalls (CSOs)

SOIL BORING

SE - Surface Elevation

GW - Ground Water Elevation

- Concrete / Cobblestone + Asphalt
- Gravel / Boulders
- Fill
- Top Soil
- Medium / Medium to Coarse Sand
- Fine / Fine to Medium Sand
- Very Fine Sand
- Organic Matter
- Ground Water

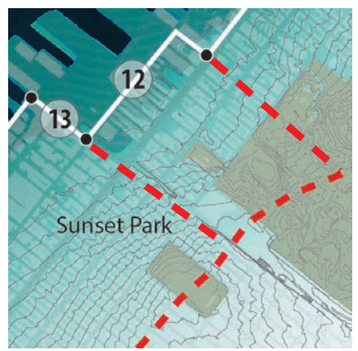
OVERVIEW

Segment 12 runs along the east side of Upper New York Harbor, west of the Gowanus Expressway and downhill from the Sunset Park residential neighborhood. In most cases, the Greenway is separated from the waterfront by the publicly owned South Brooklyn Marine Terminal.

Flooding from Superstorm Sandy (2012) covered Segments 12

SUMMARY OF OPPORTUNITIES

- 29th Street has wide sidewalks for moving water from 3rd Ave to 2nd Ave.
- Public street-end at 28th street for filtering water before it enters the harbor
- Alternate placement of the Greenway on Industry City leasehold located on South Brooklyn Marine Terminal along the west side of 2nd Ave. Opportunity for elevating the Greenway to create a flood barrier.



Segment 12 sub-watershed map

NYC DOT Implementation Plan cross section

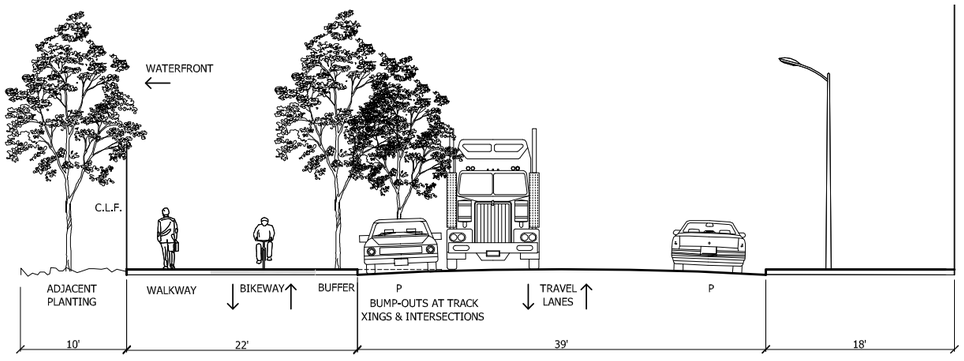


Fig. 44: Possible Configuration for Second Avenue 27th Street to 39th Street

EXISTING CONDITIONS
Approximately 0.60 miles in length

Segment 12 runs along 29th Street between 3rd and 2nd Avenues and down 2nd Avenue between 29th and 39th Streets. 29th Street carries two-way traffic and has extensive impervious parking areas. Three groups of loading docks exist along the north side of the street, where the furthest west is a built out structure that fills the sidewalk.

2nd Avenue is also wide (79 ft. right of way) with truck traffic that extends north to 28th Street, where access is restricted to a Con-Edison sub-station. The road surface is asphalt over Belgian block; railroad tracks run down the middle of the avenue. The South Brooklyn Marine Terminal and Sims recycling facility lie to the west of 2nd Ave. Industry City has a 100-foot deep leasehold on the SBMY property immediately west of the 2nd Ave right of way.

Geotechnical Analysis
We do not have any geotechnical data for Segment 12. See Segments 13-14 for geotechnical data within a few hundred feet of Segment 12.

SEGMENT 12	
SIDEWALK WIDTHS	~10-18 FEET
ROADWAY WIDTH	~ 51 FEET
ROADWAY CONFIGURATION	2-WAY, 2-LANE
PARKING	PARALLEL, BOTH SIDES

SEGMENT 12	Tier 1	Tier 2	Tier 3	Tier 1+2+3
RUN-OFF VOLUME (ft3)	22,791	61,885	66,657	151,312

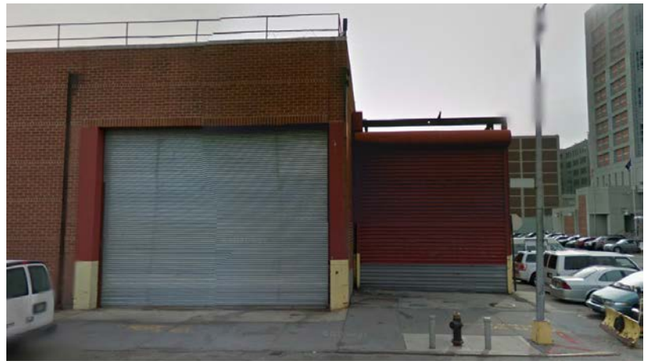
NOTE: Calculations are based on the total run-off from the 1 inch storm event (DEP standard)

(Images Source: Google Earth)

1. 29th Street West from 3rd Avenue: Wide right of way and wide sidewalks

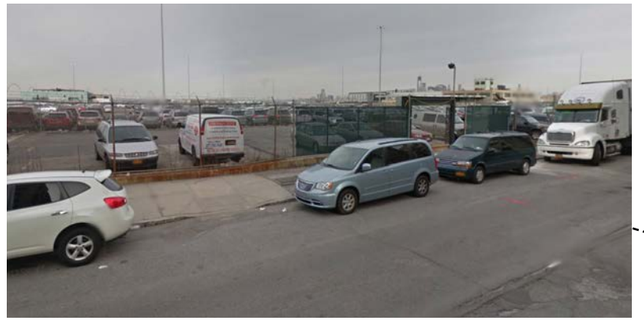
2. 2nd Avenue south of 29th Street

3. Built out structure on the north west end of 29th Street at the corner of 2nd Avenue



4. Built out structure at 29th St. and 2nd Ave looking east along 29th.

OPPORTUNITIES

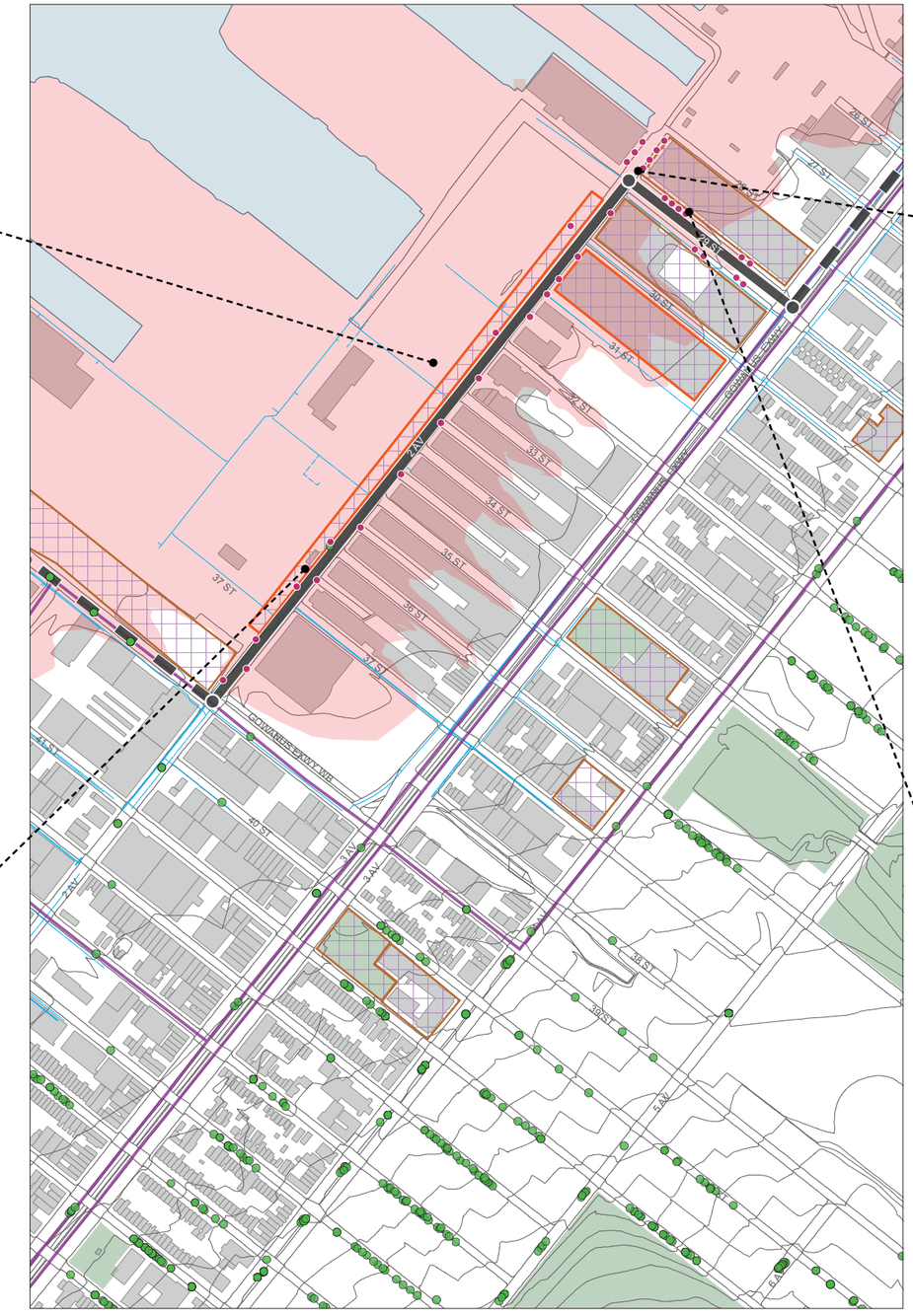


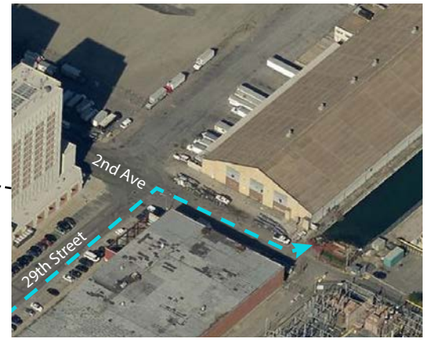
Leasehold west of 2nd Ave. offers an alternative routing for the Greenway where an elevated Greenway as flood barrier is possible.

- *Greenway Condition:* On SBMT or Public ROW, *Stormwater Management / Green Infrastructure Techniques:* Porous Paving, ROW Bio-swales, High Level Storm Sewer
- *Storm Surge Protection*: Elevated Greenway
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Convey Water, Flood Protection, Storm Barrier

Wide right-of-way along 2nd Ave., looking North from Costco at 39th St.

- *Greenway Condition:* On SMBT or Public ROW
- *Stormwater Management / Green Infrastructure Techniques:* Porous Paving, ROW Bio-swales, High Level Storm Sewer, Constructed Wetlands
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance

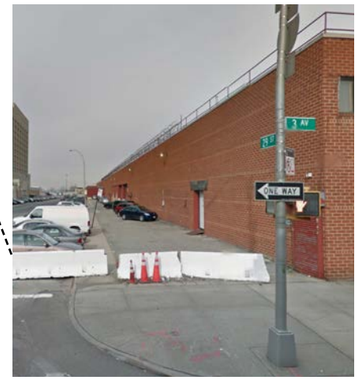




Opportunity to connect runoff from 29th Street and 2nd Ave. to the waterfront at 28th and 2nd Ave.

- *Greenway Condition:* Wide Public ROW, Public Street End
- *Stormwater Management / Green Infrastructure Techniques:* Porous Paving, ROW Bio-swales, High Level Storm Sewer, Constructed Wetlands
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance, Flood Protection, Storm Barrier

Waterfront access at the west end of 28th Street at 2nd Avenue



Wide sidewalk on north side of 29th St.

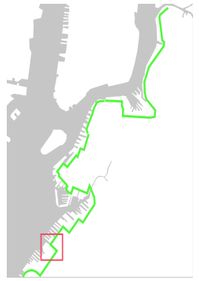
Wide right-of-way along 29th St., view east toward 3rd Ave.

- *Greenway Condition:* Wide Public ROW
- *Stormwater Management / Green Infrastructure Techniques:* Porous Paving, ROW Bio-swales, High Level Storm Sewer
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance

LEGEND

Adjacent Segment
Segment
City-Owned Property
Road Striping
Truck Route
Water Mains
Loading Docks
Trees
100-YR Flood Zones (FEMA)
2' Contour

(Images Source: Google Earth)



SEGMENT 13- 39TH ST.- 2ND AVE. - WATER

NYC DOT Capital Project Number 20

* Refer to The Brooklyn Waterfront Greenway Implementation Plan, page 60-71

LEGEND

- Segment
- Adjacent Segment
- Superstorm Sandy Surge
- 100-year Flood Zones (FEMA)
- Combined Sewage Outfalls (CSOs)

SOIL BORING

SE - Surface Elevation

GW - Ground Water Elevation

- Concrete / Cobblestone + Asphalt
- Gravel / Boulders
- Fill
- Top Soil
- Medium / Medium to Coarse Sand
- Fine / Fine to Medium Sand
- Very Fine Sand
- Organic Matter
- Ground Water

OVERVIEW

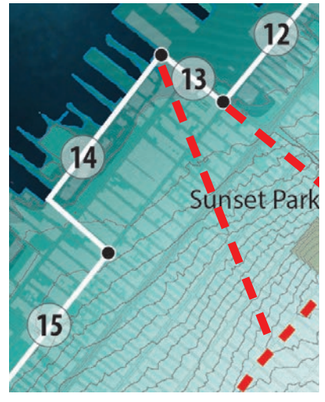
Segment 13 runs along 39th Street from 2nd Ave. to the waterfront. Property of Industry City lines the south side of the street and South Brooklyn Marine Terminal (SBMT) lines the north side of the street.

Flooding from Superstorm Sandy (2012) covered Segment 13

SUMMARY OF OPPORTUNITIES

- Possible connections to take water along 39th Street to the Harbor

- Wide sidewalks provide opportunity for right of way bio-swales. Opportunity for continuation of elevated Greenway as flood barrier.



Segment 13 sub-watershed map

EXISTING CONDITIONS

Approximately 0.20 miles in length

Segment 13 is the stretch of 39th Street between 2nd Avenue and to the waterfront. This two-block portion of 39th Street is a wide, Belgian block paved road with heavy truck access along the south side and an MTA bus turn-around in the middle on the northern side. Water main pipes are along the south side of the street. The west end of 39th is a dead end with South Brooklyn Marine Terminal entrance at the end and north side, and currently unoccupied Industry City buildings at the south.

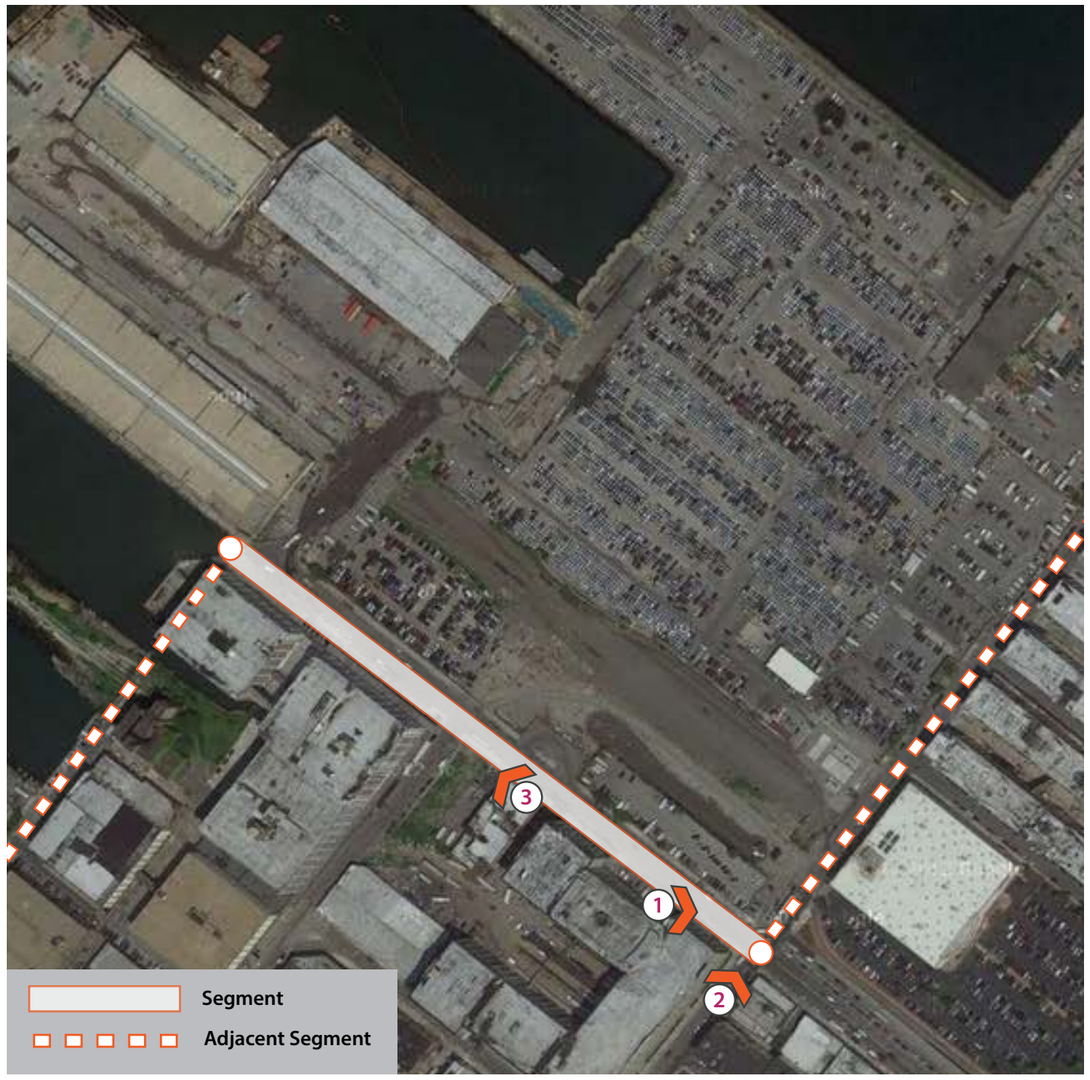
Geotechnical Analysis

Segment 13 has medium to low groundwater elevations. The highest elevation is at 9.9' below the surface elevation. After a shallow layer of concrete or gravel the soil medium is fine/ medium fine sand.

SEGMENT 13	
SIDEWALK WIDTHS	~12-18 FEET
ROADWAY WIDTH	~ 60 FEET
ROADWAY CONFIGURATION	2-WAY, 4-LANE
PARKING	PARALLEL, BOTH SIDES

SEGMENT 13	Tier 1	Tier 2	Tier 3	Tier 1+2+3
RUN-OFF VOLUME (ft3)	10,243	15,113	35,897	61,255

NOTE: Calculations are based on the total run-off from the 1 inch storm event (DEP standard)



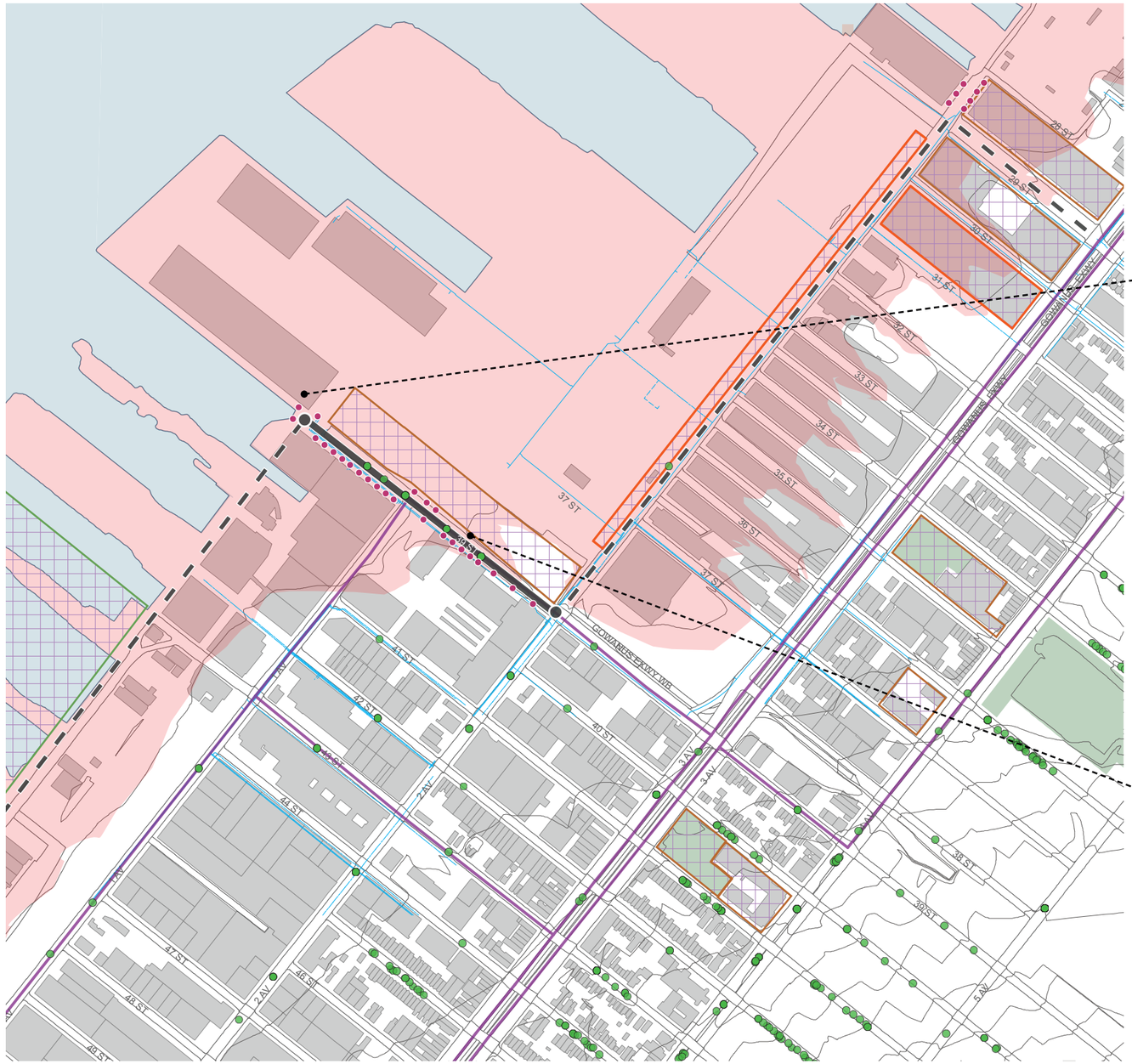
(Images Source: Google Earth)

1. Intersection of 39th Street and 2nd Avenue, view east toward Costco

2. Intersection of 39th Street and 2nd Avenue, view north toward South Brooklyn Marine Terminal (SBMT)

3. Active loading docks on the south side of 39th Street

4. Wide right of way with Belgian block paving

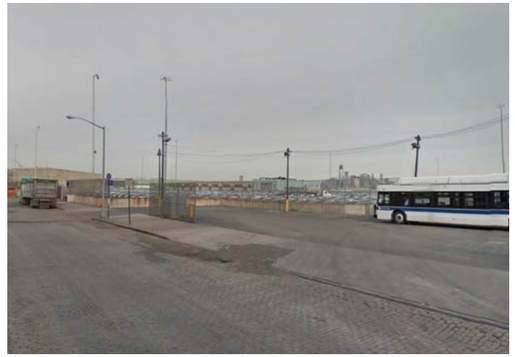


West end of 39th Street, SBMT on the right

39th Street and waterfront

- *Greenway Condition:* Potential for elevated Greenway.
- *Stormwater Management / Green Infrastructure Techniques:* Porous Paving, ROW Bio-swales, High Level Storm Sewer, Constructed Wetlands
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance, Elevated Greenway, Storm Barrier

Wide sidewalk on North side of 39th St., view East



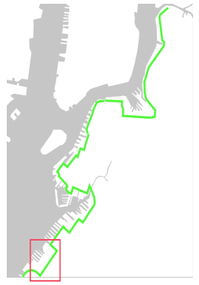
Bus turnaround on North side of 39th St., view west

- *Greenway Condition:* Wide Sidewalk / Public ROW
- *Stormwater Management / Green Infrastructure Techniques:* Porous Paving, ROW Bio-swales, High Level Storm Sewer
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance

(Images Source: Google Earth)

LEGEND

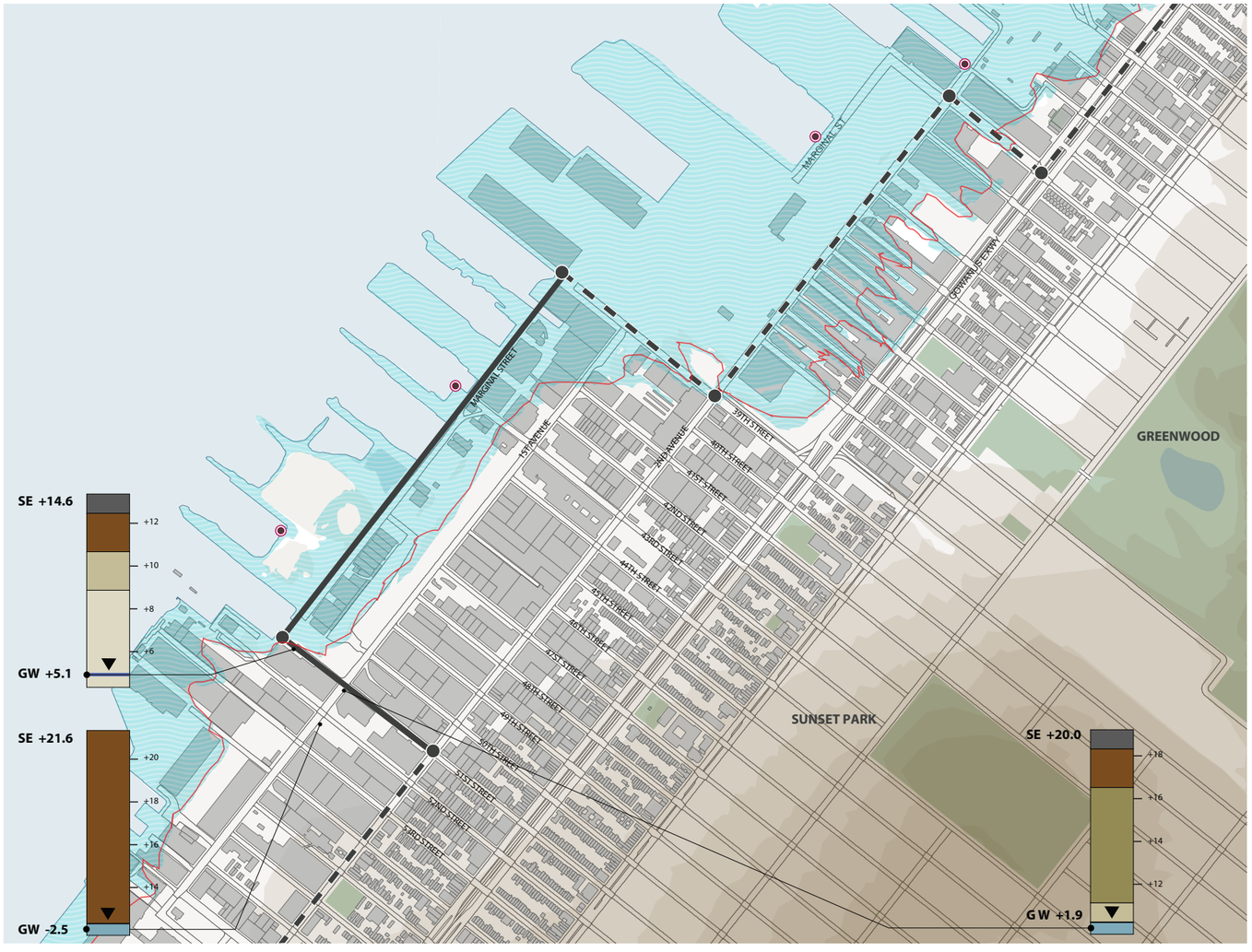
- Adjacent Segment
- Segment
- City-Owned Property
- Road Striping
- Truck Route
- Water Mains
- Loading Docks
- Trees
- 100-YR Flood Zones (FEMA)
- 2' Contour



SEGMENT 14- MARGINAL ST.- 39TH ST. TO 51ST ST.

NYC DOT Capital Project Numbers 21 & 22

* Refer to The Brooklyn Waterfront Greenway Implementation Plan, page 60-71



LEGEND

- Segment
- Adjacent Segment
- Superstorm Sandy Surge
- 100-year Flood Zones (FEMA)
- Combined Sewage Outfalls (CSOs)

SOIL BORING

SE - Surface Elevation

GW - Ground Water Elevation

- Concrete / Cobblestone + Asphalt
- Gravel / Boulders
- Fill
- Top Soil
- Medium / Medium to Coarse Sand
- Fine / Fine to Medium Sand
- Very Fine Sand
- Organic Matter
- Ground Water

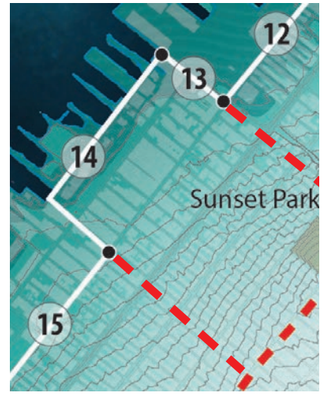
OVERVIEW

Bush Terminal Piers Park at the south end of Marginal Street is nearing completion with ball fields and natural areas. Waterfront infrastructure along the north end is dilapidated including the bulkhead, relieving platform and piers 6 and 7.

Flooding from Superstorm Sandy (2012) nearly covered all of Segment 14.

SUMMARY OF OPPORTUNITIES

- Opportunities for direct stormwater discharge
- Opportunity for continuous elevated Greenway as flood barrier
- Terminal Piers



Segment 14 sub-watershed map

EXISTING CONDITIONS

Approximately 0.80 miles in length

Segment 14 is comprised of Marginal Street between 39th and 51st Streets, and the east-west connector of 50th or 51st Streets between Marginal Street and 1st Avenue. This alignment of the Greenway will allow it to function as part of a flood barrier that would remove 8 million square feet of industrial space from the 1% risk flood zone.

Manufacturing and industrial uses dominate Segment 14. The Bush Terminal Industrial Park Complex between 41st and 51st Street is a heavily used facility with truck traffic and active freight. A Port Authority rail float barge loading facility operates between Marginal and 1st Ave. between 50th and 51streets.

Moving north to south, a slip at 40th Street will have to be bridged and the bulkhead will have to be rebuilt up to 43rd Street. An elevated Greenway will require a significant portion of the Marginal Street roadway. At the south end, the Greenway should turn east in line with 50th Street to avoid crossing the rail line at the float bridge and should return to grade at 1st Ave with a deployable flood gate across the rail line crossed.

Geotechnical Analysis

Segment 14 has medium to low water tables. The highest elevation is at 9.9' below the surface elevation. Borings taken along 1st Ave. show lower water tables than along Marginal Street.

Fill was the dominant soil layer along 51st stree. The soil along Marginal Streets was mostly rubble with layers of fine to medium sand.

SEGMENT 14	
SIDEWALK WIDTHS	N/A
ROADWAY WIDTH	~ 40 FEET
ROADWAY CONFIGURATION	N/A
PARKING	N/A

SEGMENT 14	Tier 1	Tier 2	Tier 3	Tier 1+2+3
RUN-OFF VOLUME (ft3)	15,618	69,166	25,664	110,448

NOTE: Calculations are based on the total run-off from the 1 inch storm event (DEP standard)

(Images Source: Google Earth)

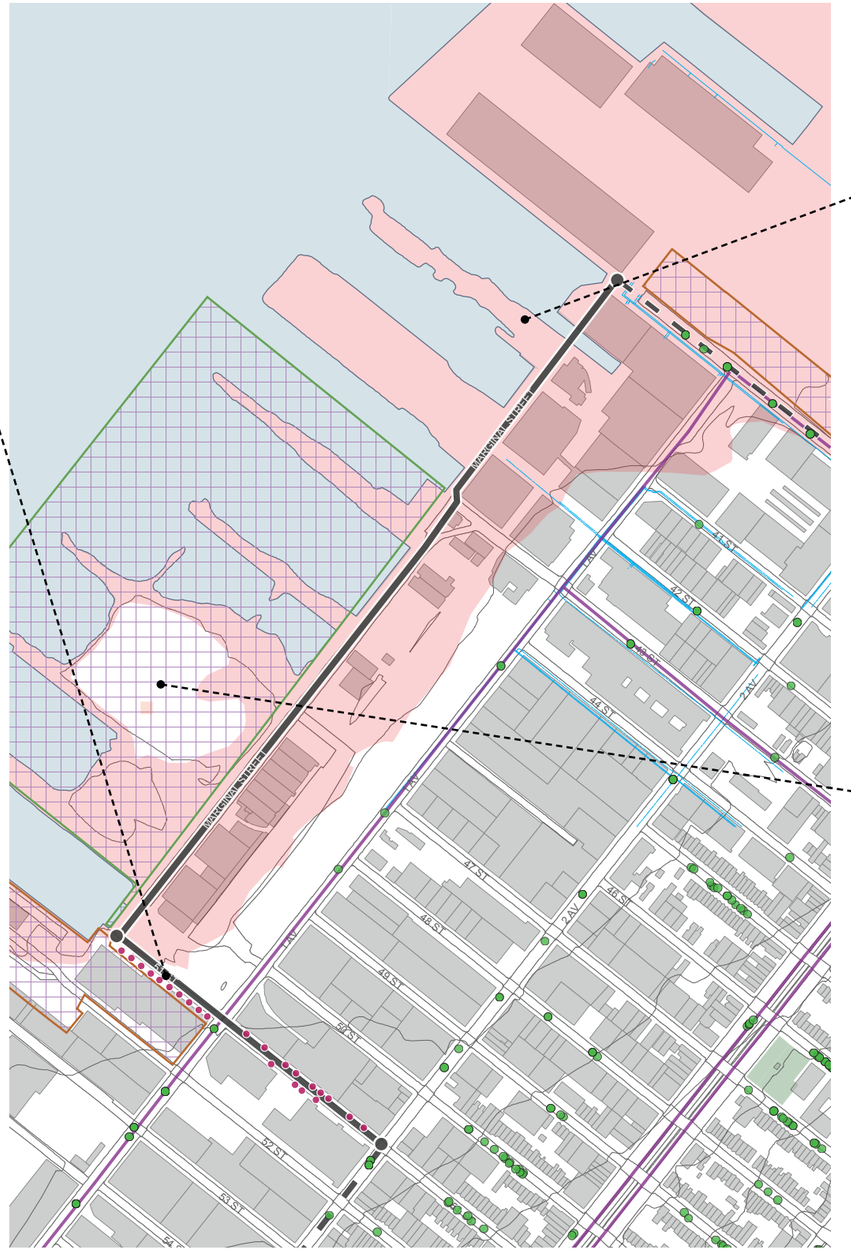
1. Bush Terminal Piers Park currently under construction between 45th and 50th Streets

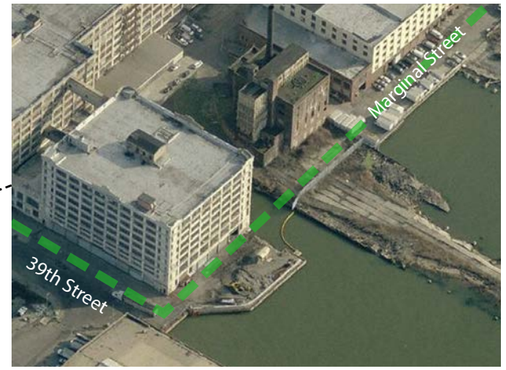
Master plan of Bush Terminal Park.
(Image Source: www.NY.curbed.com)

OPPORTUNITIES

Wide sidewalks along 51st Street; water main pipes along the north (right) side of the road

- *Greenway Condition:* Wide Sidewalk, Public ROW
- *Stormwater / Green Infrastructure Techniques:* Porous Paving, ROW Bio-swales, High Level Storm Sewer
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance

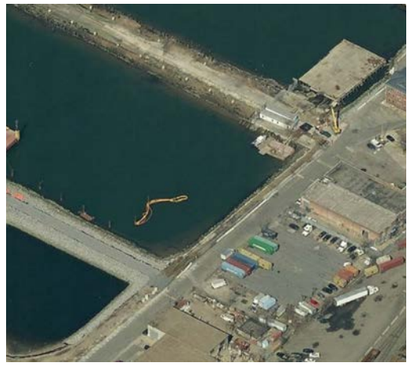




Connection needed to link the West end of 39th St. to the unmapped Marginal St.

- *Greenway Condition:* Waterfront Edge Condition
- *Green Infrastructure Techniques:* Bioremediation Gardens, Porous Paving, ROW Bio-swales, Wetland
- *Storm Surge Protection:* Elevated Greenway
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance, Wave Break, Flood Prevention

Bush Terminal Piers Park site between 45th and 50th Streets



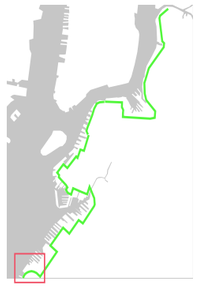
Marginal St. right of way along the bulk-head.

- *Greenway Condition:* Waterfront Edge Condition
- *Green Infrastructure Techniques:* Porous Paving, ROW Bio-swales, Constructed Wetlands, Levee, Storm Barrier
- Storm Surge Protection: Elevated Greenway
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance, Wave Break, Flood Prevention

LEGEND

- Adjacent Segment
- Segment
- City-Owned Property
- Road Striping
- Truck Route
- Water Mains
- Loading Docks
- Trees
- 100-YR Flood Zones (FEMA)
- 2' Contour

(Images Source: Google Earth)



SEGMENT 15- 2ND AVE. - 58TH ST. TO SHORE PARKWAY

NYC DOT Capital Project Number 23

* Refer to The Brooklyn Waterfront Greenway Implementation Plan, page 60-71

LEGEND NOTE: Soil Borings N/A

- Segment
- Adjacent Segment
- Superstorm Sandy Surge
- 100-year Flood Zones (FEMA)
- Combined Sewage Outfalls (CSOs

OVERVIEW

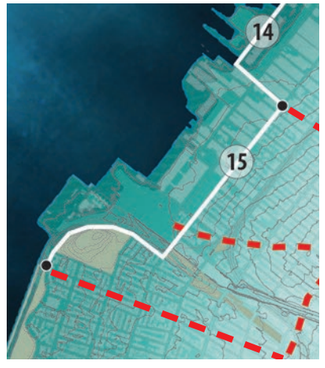
Segment 15 connects the Brooklyn Greenway to the remaining 13 miles of Brooklyn's Waterfront Greenway - the Shore Road Greenway. This segment runs on 2nd Ave. along the Brooklyn Army Terminal from 58th Street to Wakeman Pl. and around Owl's Head Park to connect to the Shore Road Greenway.

There is one combined sewer overflow and this segment also runs along the Owl's Head Wastewater Treatment Plant and the Brooklyn Navy Terminal.

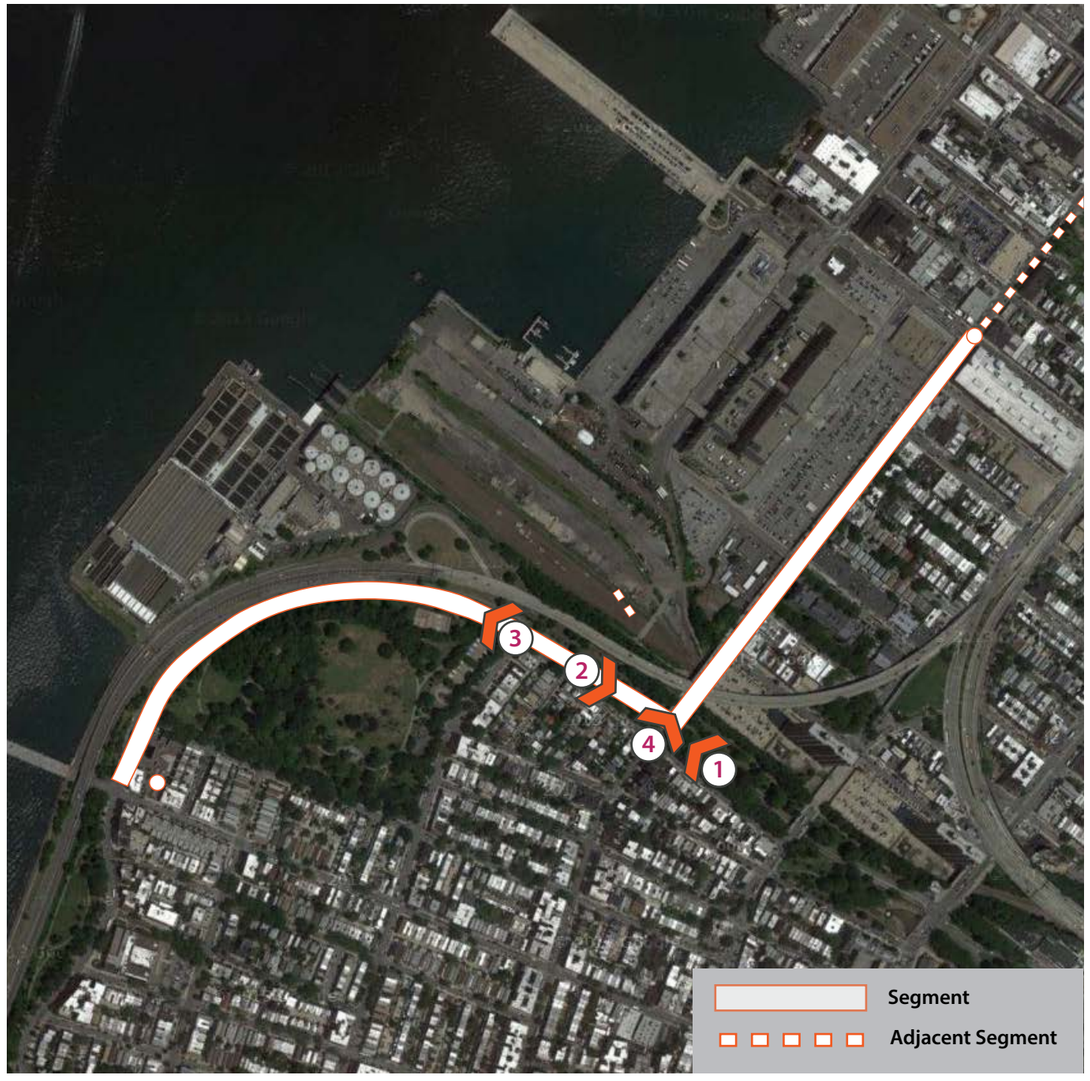
Most of Segment 15 was not affected by flooding during Superstorm Sandy (2012) except for some of low lying edge of Owl's Head Park along the Shore Parkway.

SUMMARY OF OPPORTUNITIES

- Stormwater capture on 2nd Avenue



Segment 15 sub-watershed map



NYC DOT Implementation Plan cross section

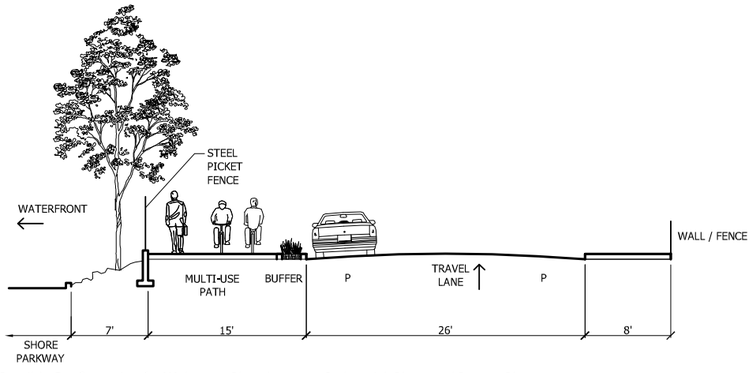


Fig. 56: Possible Configuration for Wakeman Place between Sedgewick Place and Bergen Place

EXISTING CONDITIONS

Approximately 1.05 miles in length

The Greenway along 2nd Ave is a priority project in design at NYC DOT. The Greenway will run along the west side of the street where there is one entrance to the Brooklyn Army Terminal, but no loading docks. There are not many street trees and those that do exist are not very healthy.

Geotechnical Analysis

We do not have geotechnical analysis for this segment but the elevation on 2nd Ave and Wakeman Place are high.

SEGMENT 15	
SIDEWALK WIDTHS	~8 FEET
ROADWAY WIDTH	~ 31 FEET
ROADWAY CONFIGURATION	1-WAY, 1-LANE
PARKING	PARALLEL, BOTH SIDES

SEGMENT 15	Tier 1	Tier 2	Tier 3	Tier 1+2+3
RUN-OFF VOLUME (ft3)	30,716	81,761	114,041	232,594

NOTE: Calculations are based on the total run-off from the 1 inch storm event (DEP standard)

(Images Source: Google Earth)

1. Wakeman Pl. west from 2nd Ave.

2. Wakeman Pl. east to 2nd Ave.

3. Wakeman Pl. west at Colonial Rd.

4. 2nd Ave. north from Wakeman Pl., view of Belt Pkwy.

Northwest end of Owl's Head Park on Shore Road

- *Greenway Condition:* Adjacent Park
- *Stormwater / Green Infrastructure Techniques:* Rain Gardens, ROW Bio-swales, Constructed Wetlands
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance, Flood Prevention

View from West corner of park facing Owl's Head Park to Shore Roads Parks Conservancy

- *Greenway Condition:* Waterfront Edge Condition
Stormwater / Green Infrastructure Techniques: Rain Gardens, Porous Paving, ROW Bio-swales, Wetland
- *Surge Protection Techniques:* Elevated Greenway
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration, Water Conveyance, Wave Break, Flood Prevention

LEGEND

- Adjacent Segment
- Segment
- City-Owned Property
- Road Striping
- Truck Route
- Water Mains
- Loading Docks
- Trees
- 100-YR Flood Zones (FEMA)
- 2' Contour

Striping on the West corner of Owl's Head Park at Shore Rd. and 86th St.

- *Greenway Condition:* Striping
- *Stormwater / Green Infrastructure Techniques:* Rain Gardens, ROW Bio-swales
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration

Belt Pkwy. overpass from 2nd Ave. facing South.

- *Greenway Condition:* Striping
- *Stormwater / Green Infrastructure Techniques:* Rain Gardens, ROW Bio-swales
- *Environmental Outcomes:* Infiltration, Evapotranspiration, Stormwater Detention, Stormwater Filtration

(Images Source: Google Earth)

BIBLIOGRAPHY

WEBSITES:

www.bellinghamgreenroofs.com/case-studies
www.NY.curbed.com
www.ekofloodusa.com
www.boxbarrier.com
www.ibsengineeredproducts.com
www.google.com/maps

DESIGN STUDIES:

Brooklyn Greenway Initiative and WE Design. *Brooklyn Waterfront Greenway: West Street Stormwater Study.* 2009-2010.

NYC Department of Environmental Protection. *Guidelines for the Design and Construction of Stormwater Management Systems*, NYC Department of Environmental Protection, 2012.

PlaNYC and NYC Department of Environmental Protection. *New York City Green Infrastructure Plan: A Sustainable Strategy for Clean Waterways*. NYC Department of Environmental Protection, 2010.

PlaNYC. *A Stronger, More Resilient New York*. The City of New York, 2013.

RBA and NYC Department of Transportation. *Brooklyn Waterfront Greenway Implementation Plan,* NYC Department of Transportation, 2013

PUBLICATIONS:

Hellmund, Paul Cawood and Smith, Daniel Somers, *Designing Greenways: Sustainable Landscapes For Nature and People*. Island Press, Washington DC, 2006.

Benedict, Mark and McMahon, Edward. *Green Infrastructure: Linking Landscapes and Communities*. Washington DC: Island Press, 2006.

Prominki, Marin, Stokman, Antje, Zeller, Susanne, Stimberg, Daniel, Voermanek, Hinnerk. *River. Space. Design.: Planning Strategies, Methods and Projects for Urban Rivers.* Basel, Switzerland: Birkhauser, 2012.

Gruzen Sampton LLC and Matthews Nielson Landscape Architects. *Sustainable Urban Site Design Manual*. Prepared for NYC Department of Design and Construction, June 2008.

NYC Department of Environmental Protection. *New York City Green Infrastructure Annual Report*. NYC Department of Environmental Protection, 2011-2013.