Living Above the Street

Stewarding New York City's Historic Built Environment Towards Flood Resilience

DIGITAL REPORT 01

Flood Risk of New York City's Historic Built Environment

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About

This report is part of the independent research project "Living Above the Street: Stewarding New York City's Historic Built Environment Towards Flood Resilience," which is supported by Onera Foundation under 2022 Onera Prize for Historic Preservation.

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Further Readings

To view and download the whole series of policy & design reports, please visit:
https://www.livingabovethestreet.nyc/reports.

This Onera Prize research project is developed upon the author's M.S. Historic Preservation thesis:
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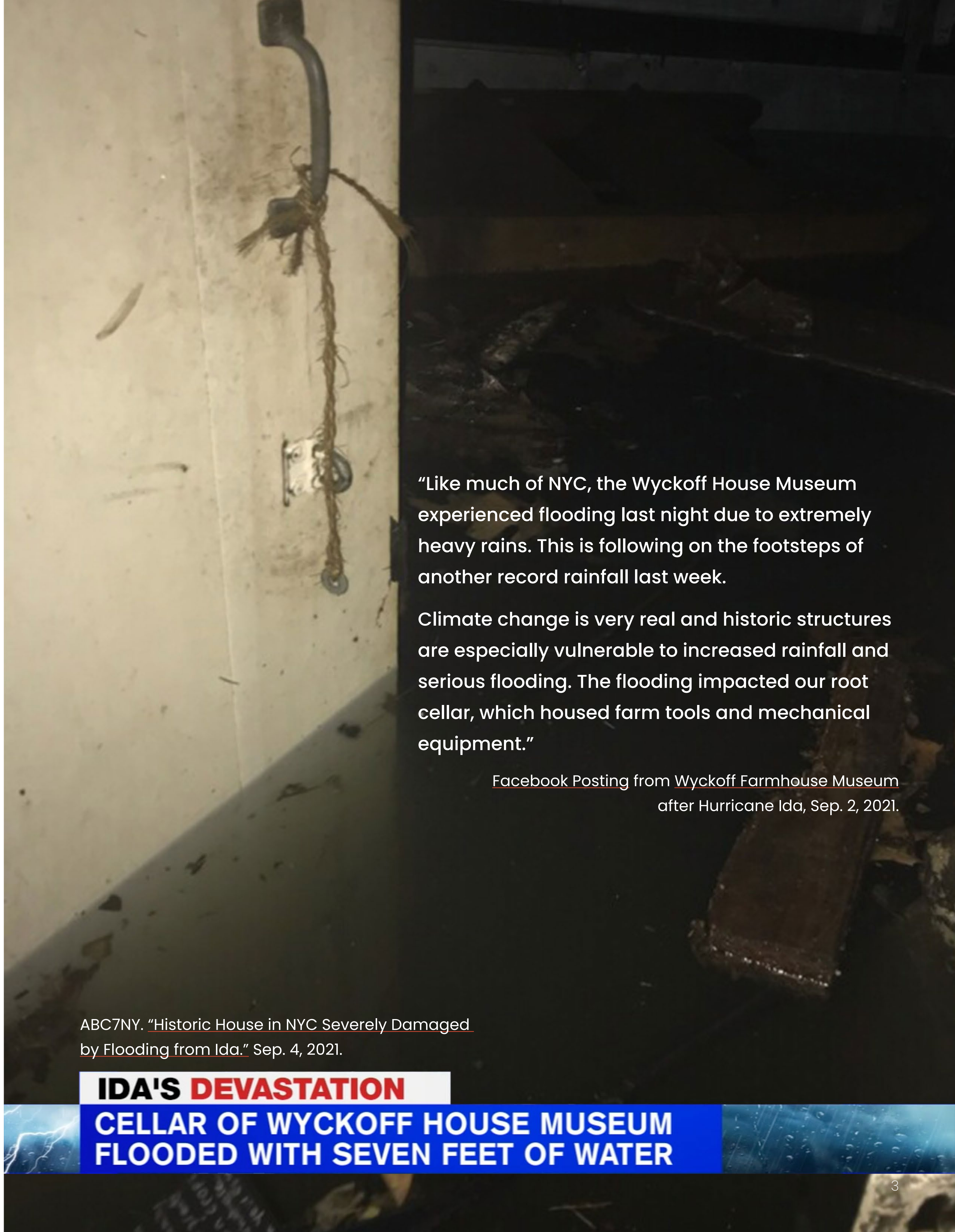
Cover Image:
The Empire Stores in Brooklyn with Jane's Carousel in the background, which were both inundated by Hurricane Sandy in 2012. Photograph taken by the author.



"Like much of NYC, the Wyckoff House Museum experienced flooding last night due to extremely heavy rains. This is following on the footsteps of another record rainfall last week.

Climate change is very real and historic structures are especially vulnerable to increased rainfall and serious flooding. The flooding impacted our root cellar, which housed farm tools and mechanical equipment."

Facebook Posting from Wyckoff Farmhouse Museum after Hurricane Ida, Sep. 2, 2021.

ABC7NY. "Historic House in NYC Severely Damaged by Flooding from Ida." Sep. 4, 2021.

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01

Executive Summary

Executive Summary

Flooding and sea level rise are threatening the integrity of New York City's historic built environment. Currently, 31 locally designated Landmarks Preservation Commission (LPC) historic districts and 33 National Register historic districts intersect with New York City's floodplain, representing respectively **20.0%** and **24.6%** of the whole city's historic district designations. As extreme storms repeat and the floodplain expands, a larger proportion of New York City's historic urban fabric is expected to be under imminent flood risk in the near future.

Although the intersection between historic districts and floodplain might be the most intuitive indicator of the flood risk faced by New York City's historic built environment, it's important to acknowledge **the diverse body of historic assets** that are exposed to flood impact. In the floodplain, we are not only able to find designated historic districts, but also individual landmarks, undesignated historic neighborhoods, and intact historic streetscapes; beyond individual buildings with historic significance, we must take various historic urban forms into consideration, and actively plan for their transformation towards flood resilience.

The physical flood risk faced by New York City's historic built environment is further compounded by the **lack of innovative design strategies as well as systematic construction standards and review procedures** necessary for its flood adaptation. After Hurricane Sandy, New York City's Building and Zoning Codes started to require the eventual elevation of all habitable spaces of structures within the city's 1% floodplain to the Design Flood Elevation (DFE); under this regulation, efforts to lift living spaces above street level have caused uncontrolled streetscape change in New York City's waterfront communities. Meanwhile, historic structures, neighborhoods and districts have been to a considerable extent left out of the city's flood resilience discourse, as there hasn't been any comprehensive city-level retrofitting design guidelines for historic properties, nor neighborhood-scaled flood resilience study featuring historic communities made in recent years. In addition, historic structures are often exempted from both Federal and city-level retrofitting mandates, and their retrofitting is often not financially incentivized. The combined effect of these blank spots in flood adaptation and historic preservation policy-making cause New York City's historic built environment to be **even more vulnerable to both physical flood threat and potential adverse impacts brought by retrofitting interventions.**

In this report, the author discusses how physical flood risk and insufficient adaptation and preservation policy-making leave the future of New York City's historic built environment at high stakes. At the end of this report, several case studies are made to help us better conceptualize real-world impacts of floodwater and sea level rise on urban built heritage.

02

Physical Flood Risk of New York City's Historic Built Environment

2.1

Mapping Historic Districts, Landmarks and Neighborhoods in New York City's Floodplain

It's empirically known that various historic resources in New York City are under high risk of flood impact. For example, during Hurricane Sandy of 2012, floodwater inundated the South Street Seaport area, "rising in some areas to eight feet in depth" and causing ground-floor businesses to close for months; during Hurricane Ida of 2021, the Wyckoff House in Brooklyn — the oldest structure in New York City — witnessed up to seven feet of inundation in its root cellar, damaging farm tools and mechanical equipment (The City of New York 2013, 374-375; ABC7NY 2021).

Flood damage on heritage sites may be viewed as part of the broader flood risk faced by New York City's whole waterfront built environment. In 2012, Hurricane Sandy inundated an area of 51 square miles in New York City, containing approximately 88,700 buildings; the area and number of properties at risk of flooding are anticipated to continue to increase through the 2050s, as sea level rises, extreme hurricanes and storms repeat, and the floodplain expands (The City of New York 2013, 13, 85).

Despite the frequent reports of historic neighborhoods and properties being flooded in New York City, there doesn't seem to be a comprehensive survey of historic resources under flood risk. To build a better understanding of the flood risk faced by New York City's historic built environment, this section seeks to locate historic resources at risk by **mapping historic districts, landmarks, and neighborhoods in New York City's floodplain** using GIS-based spatial analysis.

Data Sources

To analyze the flood risk faced by New York City's historic resources, this project uses the following spatial data:

FEMA's PFIRM geodatabase. FIRM (Flood Insurance Rate Maps) and PFIRM (Preliminary Flood Insurance Maps) are FEMA's official nationwide map series showing floodplain boundaries, Base Flood Elevations and floodways. New York City's effective FIRM maps are most recently revised in 2007, incorporating a stock of approximately 35,500 buildings in its 1% floodplain (The City of New York 2013, 23); on the other hand, PFIRMs are FEMA's updated, non-final flood maps issued in December 2013, encompassing a stock of 71,500 buildings in New York City's 1% floodplain (NYCDCP 2014, 16). To keep on track with most recent flood map revisions, this project uses New York City's PFIRM geodatabase acquired from FEMA's Flood Map Service Center in August 2022.[1]

NYC Landmarks Preservation Commission's Historic District and Individual Landmark shapefiles. These shapefiles — available on NYC Open Data — provide geographical information of NYC's locally designated LPC historic districts and individual landmarks. This project uses the Feb. 28, 2023 revision of LPC's historic district database and individual landmark site database (excluding non-building listings such as bridges, lampposts and sidewalk clocks).

New York State Historic Preservation Office's Cultural Resource Information System (CRIS) data. The GIS-based CRIS system lists National Register historic resources across the State. This project uses New York City's CRIS data requested by the author from New York State Historic Preservation Office in April 2023, which the author then processed to separate building assets and historic districts.

Mapping Method

Intersection calculation is executed in ArcMap to find historic resources that overlap New York City's 1% or 0.2% floodplain. In accordance with the data structure of LPC and New York SHPO's shapefiles, **subsequent extensions are mapped and counted as individual historic districts.** Only currently listed National Register Historic Districts are mapped and counted, excluding those with eligible or undetermined status.

Findings: Flood Risk on Neighborhood Level

As maps and diagrams on pages 10-14 have shown, a considerable portion of New York City's neighborhood-level historic fabrics are currently under imminent flood risk. Specifically:

31 locally designated **LPC Historic Districts** intersect with New York City's current floodplain, accounting for **20.0%** of all such designations across the city (see pages 10-11 for details);

33 National Register Historic Districts intersect with New York City's current floodplain, accounting for **24.6%** of all such designations across the city (see pages 12-13 for details).

These results reveal that about **one in every five designated historic districts in New York City will likely be inundated by floods reaching 1-in-100-year magnitude — such as those created by the likes of Hurricane Sandy or Hurricane Ida.**[2]

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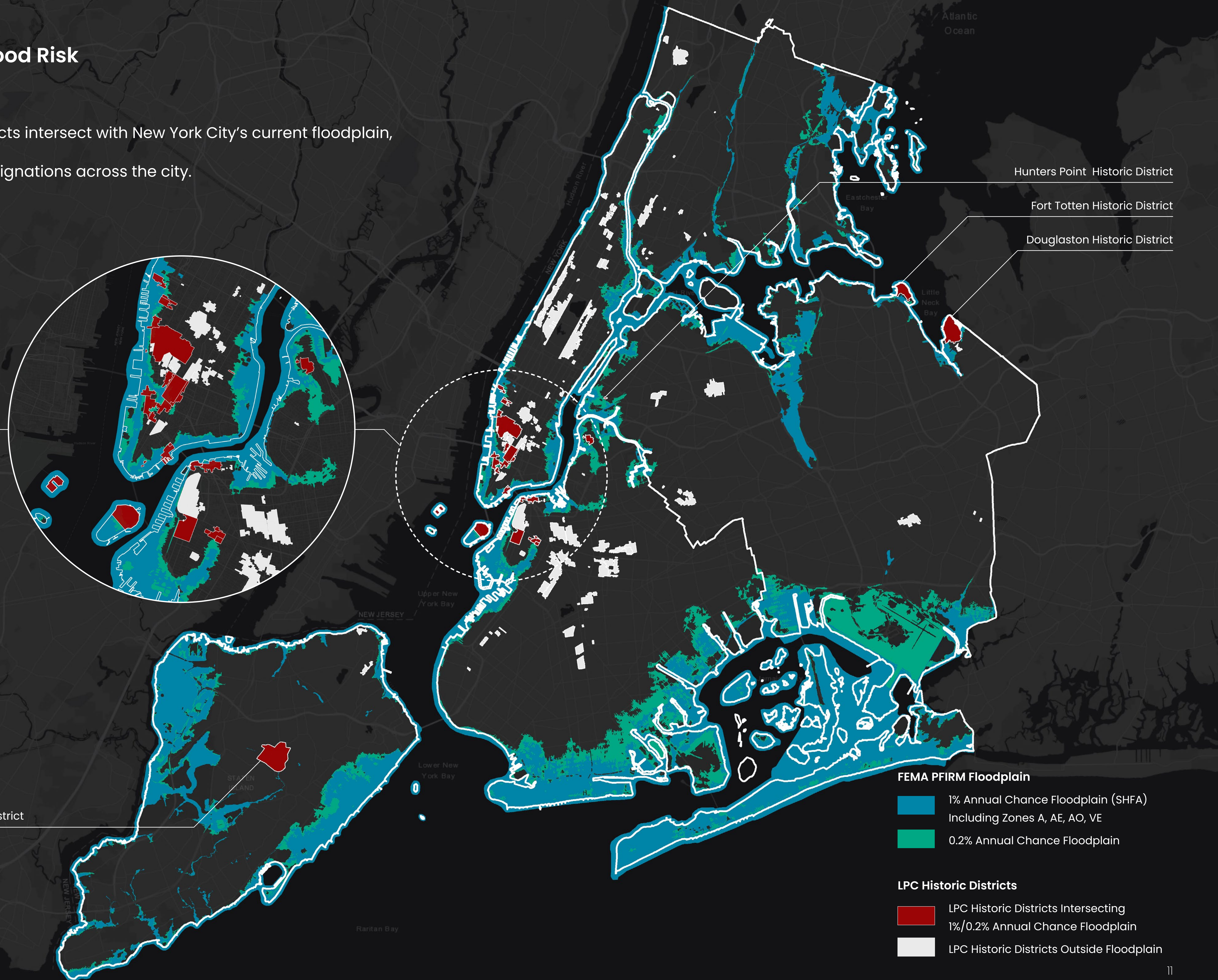
1 For further explanation of terms related FEMA's Flood Maps, please refer to *Digital Report 07: Terms & Full Bibliography*.

2 According to New York City's Post-Sandy report, "Sandy's storm tide caused flooding that exceeded the 100-year floodplain

LPC Historic Districts Under Flood Risk

31 locally designated LPC Historic Districts intersect with New York City's current floodplain, accounting for **20.0%** of all such designations across the city.

- Boerum Hill Historic District & Extension;
- Chelsea Historic District & Extension;
- Cobble Hill Historic District;
- DUMBO Historic District;
- East 10th Street Historic District;
- Eberhard Faber Pencil Company Historic District;
- Ellis Island Historic District.
- Fraunces Tavern Block Historic District;
- Fulton Ferry Historic District;
- Gansevoort Market Historic District;
- Governors Island Historic District;
- Greenpoint Historic District;
- Greenwich Village Historic District;
- SoHo-Cast Iron Historic District & Extension;
- South Street Seaport Historic District & Extension;
- Stone Street Historic District;
- Sullivan-Thompson Historic District;
- Tribeca East Historic District;
- Tribeca North Historic District;
- Tribeca South Historic District;
- Tribeca West Historic District;
- Weehawken Street Historic District;
- West Chelsea Historic District.

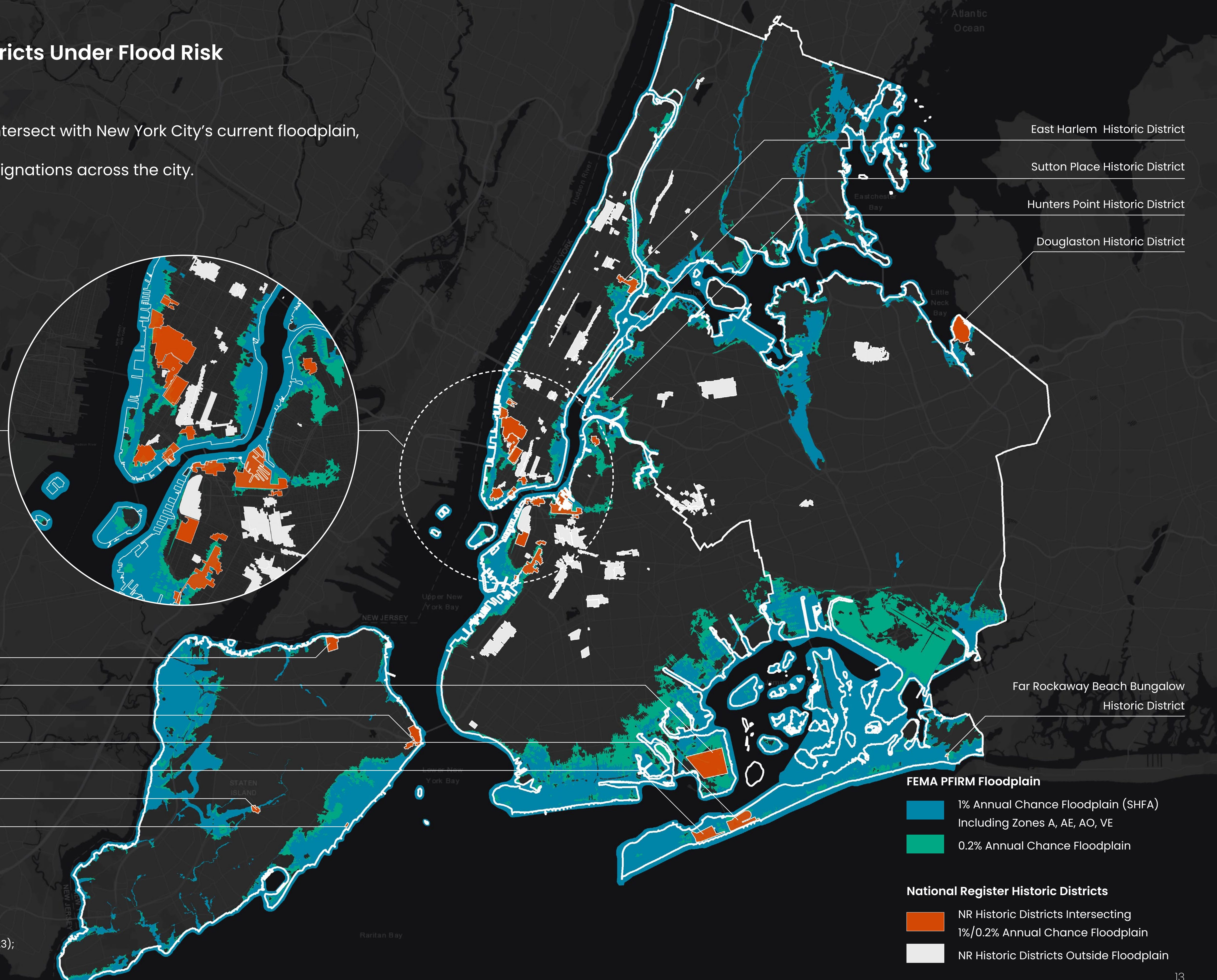


Data Sources: FEMA Map Service Center (2022);
NYC Open Data (2023). Mapped by Ziming Wang, Apr. 2023.

National Register Historic Districts Under Flood Risk

33 National Register Historic Districts intersect with New York City's current floodplain, accounting for **24.6%** of all such designations across the city.

- Boerum Hill Historic District;
- Brooklyn Navy Yard Historic District;
- Chelsea Historic District & Extension;
- Cobble Hill Historic District;
- DUMBO Industrial Historic District;
- Fulton Ferry Historic District;
- Gansevoort Market Historic District;
- Gowanis Canal Historic District;
- Greenpoint Historic District;
- Greenwich Village Historic District;
- Rockwood Chocolate Factory Historic District;
- SoHo Historic District (NR+NHL);
- South Street Seaport Historic District & Extension;
- South Village Historic District;
- Stone Street Historic District;
- Two Bridges Historic District;
- Wall Street Historic District;
- Wallabout Industrial Historic District.



Data Sources: FEMA Map Service Center (2022); NYSHPO (2023); NYC Open Data (2022). Mapped by Ziming Wang, Apr. 2023.

Selected Undesignated Historic Neighborhoods Under Flood Risk

Stuyvesant Town

A National Register Eligible neighborhood featuring 35 Post-WWII highrise apartment buildings incorporated into a superblock layout. These buildings, cladded in red brick, represent the "towers in the park" paradigm of design.

Red Hook

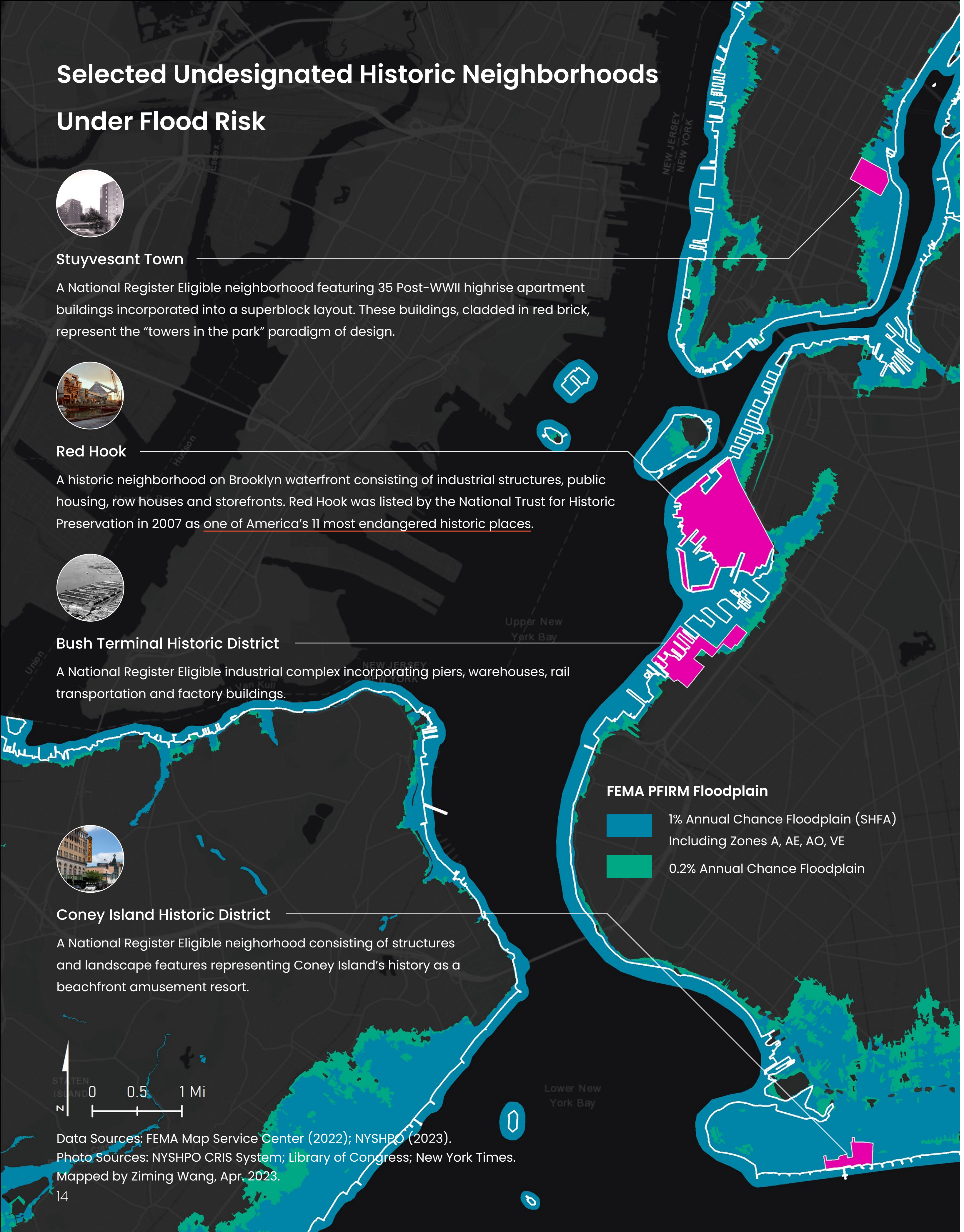
A historic neighborhood on Brooklyn waterfront consisting of industrial structures, public housing, row houses and storefronts. Red Hook was listed by the National Trust for Historic Preservation in 2007 as one of America's 11 most endangered historic places.

Bush Terminal Historic District

A National Register Eligible industrial complex incorporating piers, warehouses, rail transportation and factory buildings.

Coney Island Historic District

A National Register Eligible neighborhood consisting of structures and landscape features representing Coney Island's history as a beachfront amusement resort.



Data Sources: FEMA Map Service Center (2022); NYSHPO (2023).
Photo Sources: NYSHPO CRIS System; Library of Congress; New York Times.
Mapped by Ziming Wang, Apr. 2023.

Most of these flood-threatened historic districts cluster around Downtown Manhattan and Downtown Brooklyn, which corresponds to the overall distribution of all LPC and National Register historic districts in New York City.

Additionally, multiple historic neighborhoods not yet recognized by Federal or local designation are also sitting in the floodplain — such as Stuyvesant Town, Red Hook, Bush Terminal, or Coney Island (see page 14). Lacking the protection of local Landmark Law and Federal historic preservation regulation, these neighborhoods are likely to be more susceptible to redevelopment or adverse impacts brought by flood retrofitting interventions.[3]

Findings: Flood Risk on Building Level

As maps on pages 16-19 have shown, **182 LPC Individual Landmark Buildings** are located partially or fully within New York City's current floodplain, accounting for **13.2%** of all such designations across the city; **99 National Register historic buildings** are located partially or fully in the floodplain, accounting for **12.8%** of all such designations across the city.

Overall speaking, **one in every ten designated historic buildings in New York City is subject to imminent flood risk.** Furthermore, extreme floods and storm surges can also impact historic properties located outside the floodplain. For example, the Wyckoff House Museum inundated by Ida is only adjacent to FEMA's PFIRM floodplain, but not located within it.

The designated historic buildings in New York City's floodplain represent a great diversity in scale and characteristics. They range from detached houses in Staten Island and Bronx, to attached row houses in South Street Seaport and Chelsea, to large-scale civic structures such as the U.S. Custom House and Marine Air Terminal, and to various commercial buildings including the Hanover Bank and the Barclay-Vesey Building. There are also religious structures (e.g. St. Cecilia Church and Convent) and industrial structures (e.g. Sohmer Piano Factory) identified in the floodplain. These buildings have together constituted a diverse flood risk portfolio, and thus call for flexible and customized strategies in flood adaptation.

Based on observations made from the mapping of historic resources in New York City's floodplain, in the next section, the author will further discuss the diversities that lie within the city's flood-threatened historic resources. In addition, non-building assets such as bridges, subway stations, memorials, forts and cemeteries are also found in or near the city's floodplain, which may be worthy of further research in the future.

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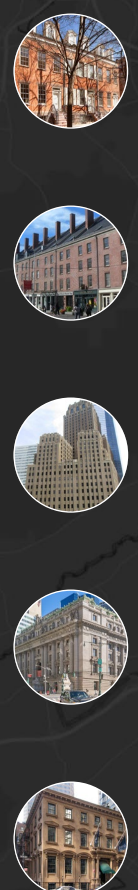
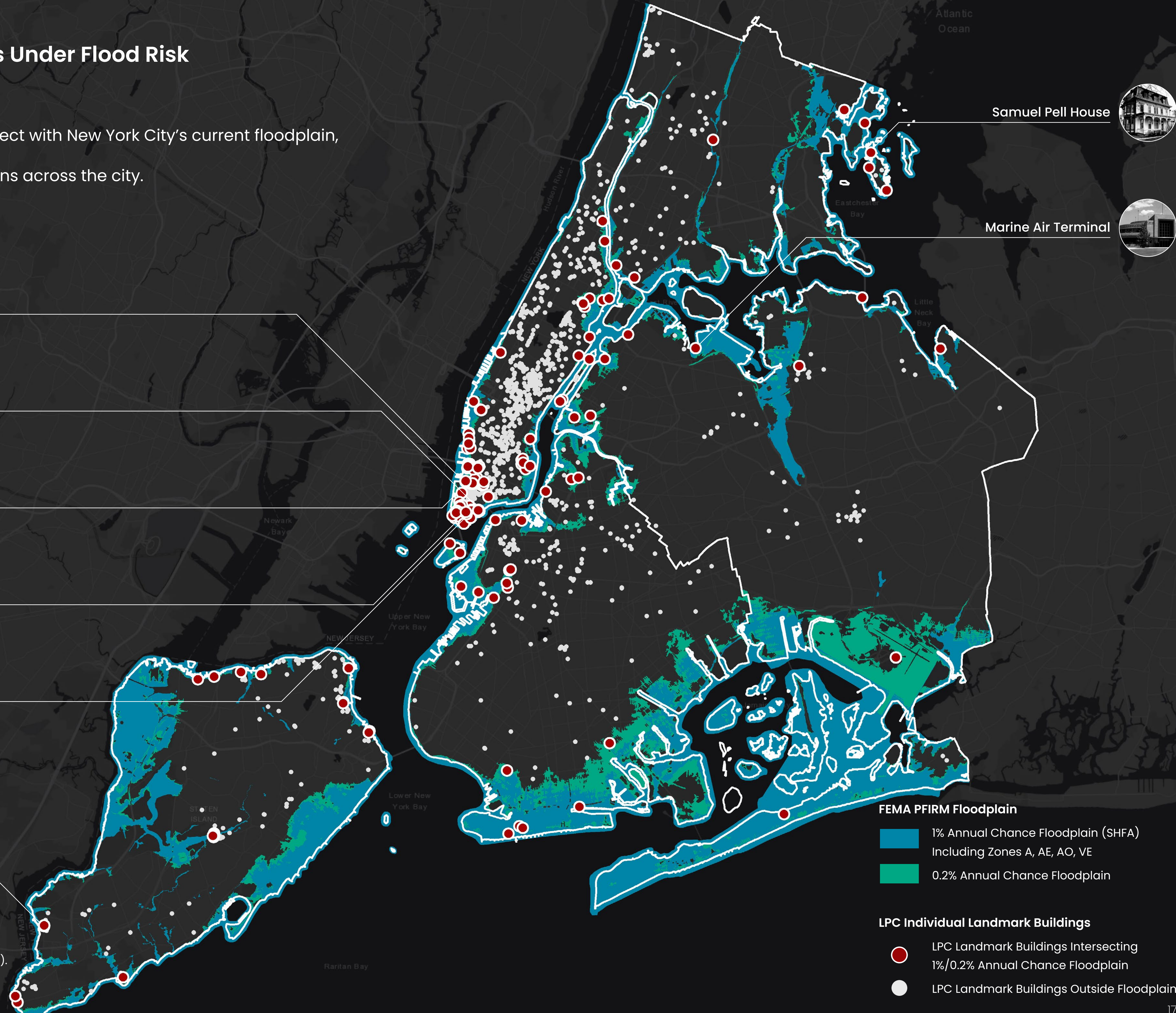
boundaries by 53 percent citywide" (The City of New York 2013, 13). Similarly, NOAA's forecast predicted that Hurricane Ida could potentially cause 1-in-100-year rainfall for some areas.

3 Further discussions will be made in Section 3.2 and *Digital Report 02 - Adaptive Streetscape: Concept & Framework* regarding the adverse streetscape impacts brought by flood retrofitting interventions.

LPC Individual Landmark Buildings Under Flood Risk

182 LPC Individual Landmark Buildings intersect with New York City's current floodplain, accounting for **13.2%** of all such designations across the city.



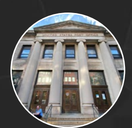


Data Sources: FEMA Map Service Center (2022); NYC Open Data (2023).
Photo Sources: NYCLPC; NYC-Landmarks.com; Wikimedia Commons.
Mapped by Ziming Wang, Apr. 2023.

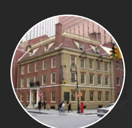
National Register Historic Buildings Under Flood Risk

99 National Register historic buildings intersect with New York City's current floodplain, accounting for **12.8%** of all such designations across the city.

Sohmer Piano Factory



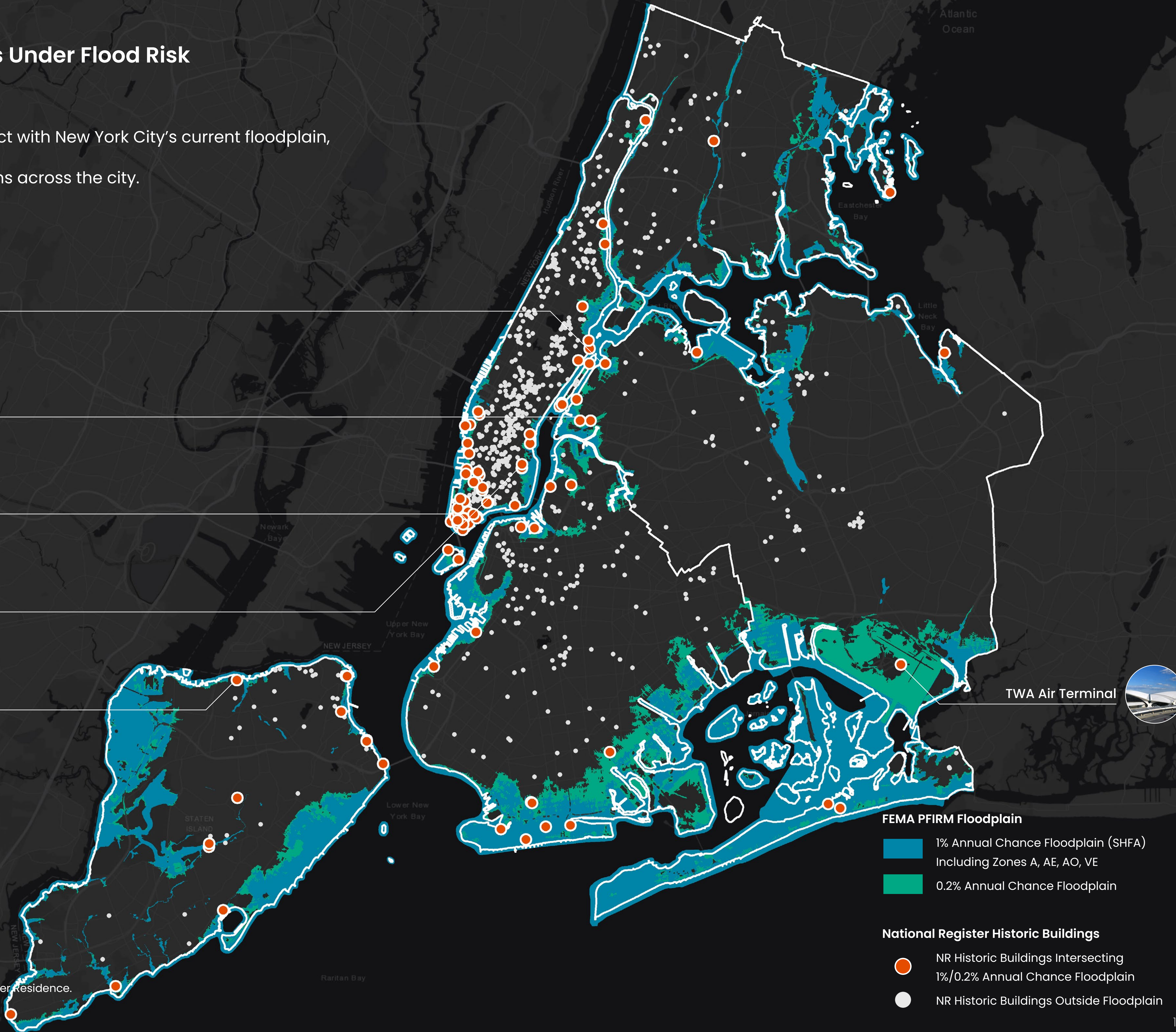
Long Island City Post Office



Fraunces Tavern

Charlie Parker House

Reformed Church on Staten Island



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Data Sources: FEMA Map Service Center (2022); NYSHPO (2023).
Photo Sources: Wikimedia Commons; Untapped New York; Charlie Parker Residence.
Mapped by Ziming Wang, Apr. 2023.

2.2

Characterizing New York City's Flood-Threatened Historic Built Environment

The historic resources in New York City's floodplain represent a wide range of historic periods, structural types, construction methods, styles and characters. To better understand how diversities within New York City's flood-threatened historic built environment would influence its flood adaptation, this section summarizes key factors on neighborhood and building level that create varieties in historic characters and affect adaptation planning decisions.

Neighborhood-Level Varieties

Designation Status. Designated historic districts are generally better researched and protected than undesignated historic neighborhoods. According to the *Rules of New York City Landmark Preservation Commission* ("Title 63"), all alterations of historic district buildings and new constructions in selected historic districts are subject to an application—review process; preservation master plans have also been made by LPC for several local historic districts. On the Federal level, the designation of a National Register historic district requires an owner consent process, and may thus represent local property owners' collective acknowledgment of its historic significance (see NPS n.d.). For both LPC and National Register historic districts, designation reports tend to provide a comprehensive understanding of a historic district's history, significance, formal features, and current condition.

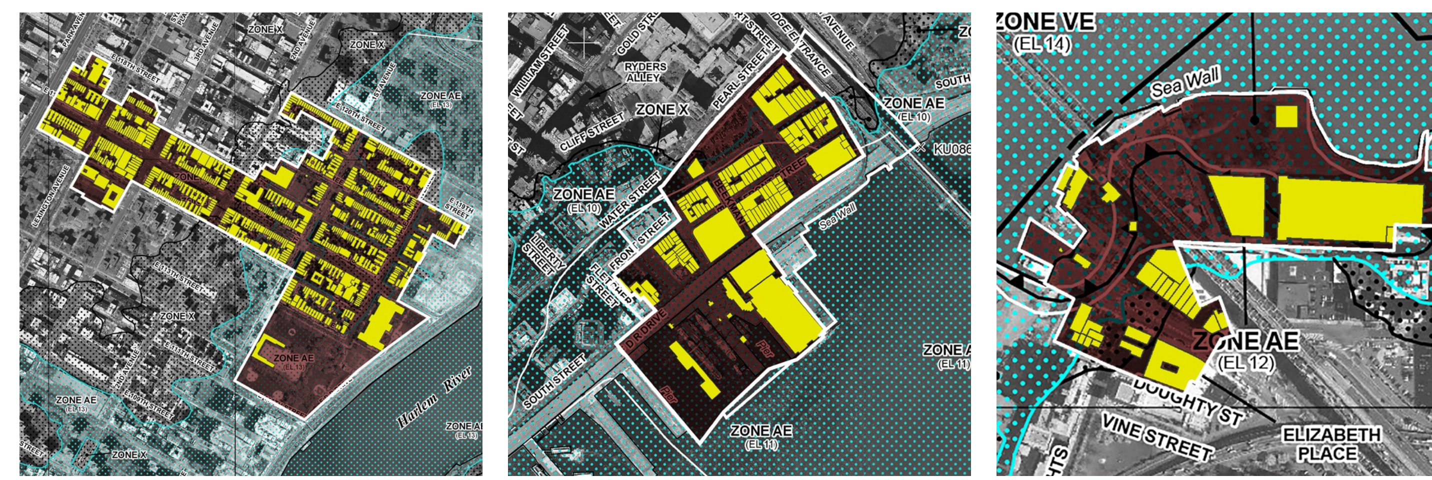
Street Corridor Function. Street corridor function is a deciding factor for both the character of a historic neighborhood characteristics and its flood adaptation options. Different street-level uses (Residential, Commercial or Mixed-Use) not only create different formal qualities and spatial compositions, but also define pedestrians' behavioral patterns as they interact with the streetscape. For example, as compared to a residential corridor, a commercial corridor tends to have greater street-level transparency, more street furniture, awnings and signage, and better accessibility to streetfront structures; it may attract a more diverse body of visitors, who will likely perform a variety of activities along the street. **More importantly, commercial and residential first-floors are subject to separate flood-resistant construction standards in New York City's Building Code, and thus involve different available options of retrofitting strategies.**[4]

4 More detailed discussion on New York City's regulation framework on floodplain buildings will be made in Chapter 3 and *Digital Report 02 - Adaptive Streetscape: Concept and Framework*.

Lot Size. Lot size plays a significant role as it defines the scale and influences the human experience of historic urban environment; moreover, lot size may also be able to reflect a historic neighborhood's predominant building type(s). A historic neighborhood may primarily consist of **small lots**, which are typically around 25 ft in frontage, accommodating row houses or similar low-to-mid-rise structures; **mid-sized lots**, where lot mergers have occurred to accommodate mid-rise apartment/mixed-use buildings with a larger footprint than row houses; or **large lots**, which often incorporate a frontage larger than 50 ft and house large-scale industrial and commercial buildings.

Predominant Building Type(s). Many historic districts and neighborhoods are known for the stylistic features and spatial layouts of buildings commonly found within them — for example, cast-iron commercial structures are associated with SoHo; mixed-use, mid-rise apartments and storefronts are associated with South Street Seaport; and brownstone row houses may be associated with Central & East Harlem. Building typology not only defines a historic neighborhood's character, but is also connected to decisions on what flood-resistant standards are applicable and what flood retrofitting interventions are appropriate.

Based on the key factors identified above, the illustration below examines three historic districts with distinct characters through a comparison of their site plans.



East Harlem / 116th St Corridor	South Street Seaport / Front St Corridor	Fulton Ferry / Water St Corridor
National Register	LPC + National Register	LPC + National Register
Small Lot	Mid-Sized Lot	Large Lot
Residential Use	Mixed Use	Commercial Use
Low-Rise Row Houses	Mid-Rise Apartments & Storefronts	Former Industrial Structures

Various physical characters of New York City's flood-threatened historic neighborhoods.
Data Sources: FEMA (2015); NYCLPC (2023); NYSHPO (2023); NYCDCP (2022). Mapped by Ziming Wang.

Building-Level Varieties

As revealed in the mapping process, great diversities lie within the flood-threatened historic building stock of New York City. These historic buildings incorporate various structural, formal and historic features that define their significance, and call for more customized retrofitting solutions and more detailed classifications as compared to those targeted at the general existing building stock. While New York City Department of City Planning's *Retrofitting Buildings for Flood Risk* report (2014) characterizes New York City's residential-related floodplain building stock into 6 major categories (Bungalow, Detached, Semi-Detached, Mid-Rise Walk-up, and Mid-Rise Elevator) and identifies key issues and retrofitting design strategies based on each category (NYCDCP 2014, 20; 32-36), a more case-by-case approach may be necessary to form strategies for historic buildings in New York City's floodplain. Below are several key factors that should be considered when plans to mitigate the flood hazard of historic structures are made.

Structural Type, Construction and Scale. New York City's waterfront historic buildings incorporate a wide range of structural types, from wood-framed houses to masonry, concrete and steel-framed structures. Many of them also have specific, character-defining materials and constructions (for example, the shared party walls between speculative row houses, and the cast-iron facades used in SoHo's commercial storefronts). Furthermore, the structural type of a building may to a considerable extent define its scale: for example, wood frames are generally used for small, low-rise structures, while concrete and steel frame may support large commercial and civil structures. **The question of structural type is important, because it defines what retrofitting strategies are feasible** — for example, it would be possible to structurally elevate a detached single-family house onto a new foundation, but such intervention would be impractical for mid-rise masonry apartments and row houses with shared party walls.

Function & Use. Whether a building is residential, commercial or mixed-use (which typically means first-floor commercial use and upper-floor residential use) is a key factor that shapes historic characters, because **it defines what flood-resistant construction standard a building is subject to, and which retrofitting strategies are recognized by the Building Code.** New York City's Post-Sandy Building Code requires residential structures in floodplain to have their habitable use relocated above the Design Flood Elevation (DFE); while commercial storefronts on street level may just be dry-floodproofed (see New York City's 2014 Building Code, Appendix G, Section G304.1).

Character-Defining Features and Spatial Layouts with Historic Significance. Historic properties often incorporate architectural, spatial and decorative features that demonstrate their historic significance and reflect historic social-spatial relationships. **Understanding these character-defining features and layouts may help us choose appropriate retrofitting strategies that best preserve a building's historic significance.** For example, it would be inappropriate to elevate detached single homes by a great height over exposed concrete piles, as it significantly damages the building's historic form, proportion, entrance context and streetscape relationship; it would also be unfavorable to directly relocate retail storefronts in a historic main street to above street level without sufficient streetscape mitigation design, since this intervention alters the historic social-spatial relationship where pedestrians and residents interact with transparent, human-scaled retail spaces as they walk along the street. Important interior spaces (e.g. lobbies or entrance halls) and decorative features (such as historic signage and wall finishing materials) should also be preserved during retrofitting intervention. Since character-defining features vary from one building to another, a **case-by-case evaluation** may be needed to select the retrofitting strategy that best preserves a building's historic characters.

Streetscape Expression, Basement & Access. As was just discussed, street-level entrances of detached houses, stoops and yards in front of row houses, transparent storefronts on commercial corridors, commercial spaces in cellars, signage, awnings and other forms street-level expression often serve as a defining feature for the characters of New York City's historic neighborhoods. Many retrofitting interventions — such as structural elevation, implementation of new exterior stairs, and filling basements or cellars — will inevitably damage a historic building's human-scaled and vigorous streetscape expressions by changing how building uses are located or accessed. **Therefore, streetscape change is the key area of tension in the flood retrofitting of historic structures, and has become the focusing point of multiple flood retrofitting design guidelines on local and state level.** The streetscape issues brought by flood retrofitting interventions will continue to be further explored in the upcoming reports.

Critical Systems. Building systems — including Mechanical, Electrical, Plumbing (MEP) and Elevators — are essential for a building's daily functioning, and can be easily inundated by flood (NYCDCP 2014, 33). Historic buildings may have critical systems built or installed in different historic periods and located at different heights. To ensure the normal operation of a building under flood impact, the floodproofing, relocation or replacement of critical systems should also be considered in flood retrofitting design.

03

Flood Risk Compounded by Adaptation & Preservation Policies

New York City's historic built environment is not only threatened by physical flood risk represented by floodplain designation, but also by flood retrofitting interventions under the current regulation framework that may bring adverse impact to the characters of historic urban fabric, as well as historic preservation policies that don't sufficiently support the flood adaptation of historic districts, neighborhoods and buildings. Specifically, the following policy-related issues have been observed:

- **New York City's Post-Sandy Building Code and Flood Zoning require the gradual elevation of all habitable spaces of structures within the 1% floodplain to above Design Flood Elevation (DFE), which has in turn caused various uncontrolled streetscape changes in the city's waterfront neighborhoods;**
- **Historic districts, neighborhoods and buildings have been to a considerable extent left out of New York City's discourse on flood adaptation. As the policy-making process lags behind, there has been a lack of innovative retrofitting design strategies and design-review mechanism targeted at the flood retrofitting of historic structures;**
- **As designated historic buildings are largely exempted from New York City's flood-resistant construction standards and NFIP's floodplain management regulations, they are more likely to be left flood-prone due to the lack of retrofitting mandate and incentives.**

These conditions have together posed compound policy challenges and further complexified the flood adaptation of New York City's historic built environment. By analyzing key flood adaptation policies and regulations relevant to New York City's context — namely **New York City's Building Code, New York City's Flood Zoning, National Flood Insurance Program (NFIP)'s floodplain management regulations, and LPC's design review standards** — this section examines the limitations within New York City's flood adaptation and historic preservation standards, and discusses how they impact the stewardship of New York City's historic built environment towards flood resilience.

3.1 New York City's Flood-Resistant Construction Standard & Flood Zoning

New York City's Post-Sandy Building and Zoning policy-making started as early as in 2013. Currently, New York City's Building Code (2014) implements a mandate for 1% floodplain buildings to eventually elevate habitable spaces; meanwhile, the City's two Flood Zoning Amendments provide zoning-level support to the Post-Sandy Building Code, and lay out exemptions and incentives to expedite flood-resistant construction and reconstruction in the floodplain.

NYC Building Code Appendix G: Flood-Resistant Construction Standard

In January 2013, shortly after Hurricane Sandy stroke United States' Northeast coast, an emergency executive order was adopted by New York City's Office of the Mayor, requesting flood reconstruction projects to raise their first floors and incorporate floodproofing treatments (NYCDCP 2013a). This policy is refined and solidified in the current (2014) version of New York City's *Building Code* (NYCDOB 2014), which explicitly requires in its Appendix G – "Flood-resistant Construction" – that **"all habitable spaces of new construction, and existing buildings that were substantially damaged or are undertaking substantial improvements" within the 1% floodplain "to be raised above the Design Flood Elevation (DFE)," with additional floodproofing requirements** (NYCDOB 2014; NYCDCP 2019b, 2).

Specific provisions on how floodplain buildings shall be elevated and floodproofed are then provided for flood zones subdivided within the floodplain, such as A Zone, V Zone and Coastal A Zone.[5] Since 97% of New York City's 1% floodplain building stock is located in the A Zone (NYCDCP 2014, 16), A Zone provisions are applicable to most structures regulated by Appendix G. In this project's design studies, **A Zone provisions** are always used to evaluate Building Code compliance. Details of the A Zone provisions are listed as follows:

· **Flood-Resistant Standards for Residential Structures (for flood zone purpose).** All new buildings and substantial improvements shall: 1) Raise the lowest floor, including the basement, to at or above the Design Floor Elevation (DFE); 2) restrict uses in enclosed spaces below DFE solely to parking, access, storage, or crawlspace; 3) wet-floodproof enclosed spaces under DFE (see *Appendix G*, Section 304.1.1).

· **Flood-Resistant Standards for Non-Residential Structures (for flood zone purpose).** New buildings and substantial improvements have two options: **A) Elevation Option**, as is applicable to residential structures; **B) Dry Floodproofing option.** Requirements for the Dry Floodproofing option are as follows: 1) The structure should be dry floodproofed to at or above DFE; 2) All dwelling units and sleeping areas should be located at or above DFE (see *Appendix G*, Section 304.1.2).

It can be clearly seen from New York City's current Building Code that a building's use — especially **first-floor function** — is of key importance in the discussion regarding its flood retrofitting, as residential first-floors must be elevated above DFE, while commercial first-floors are granted more flexibility and can stay on street level as long as dry floodproofed.

Although Appendix G explicitly requires residential spaces to be elevated, it doesn't necessarily mean that whole structures have to be raised upon new foundations. Compliance with Appendix G can be either achieved by **Structural Elevation**, where buildings are physically lifted on a new or extended foundation; or **Non-Structural Elevation**, where active uses are relocated and the interior program is altered, while a building's structure largely remains in the same place (see FEMA 2014, 5-1; NYCDCP 2016b, 34).[6]

New York City's Building Code Appendix G is made in accordance with NFIP's floodplain management regulations, which took effect in New York City after the City joined NFIP in 1983 (NYCDCP 2019b, 2). Therefore, streetscape impacts caused by building elevation is not merely a New York-specific issue, but faced by multiple local communities across the country.

Instances of Structural Elevation and Non-Structural Elevation.
Source: NYCDCP 2014, 43; 73.

In New York City, Base Flood Elevation (BFE) — the elevation of surface water created by a 1% annual chance flood — may reach 12-13 ft above sea level in Manhattan's waterfront area, which could roughly mean 6-7 feet above street level. In Appendix G, Design Flood Elevation (DFE) is defined by local BFE plus an additional freeboard height — typically 1 or 2 ft — based on building use (see *Appendix G*, Table 2-1). **For a simplified calculation, in this project, local DFEs will always be estimated as local DFE plus 1 ft.**

In Appendix G, "substantial improvement" is defined as any repair or improvement of the structure that costs more than 50% of its market value before the project. The "substantial improvement" threshold is used as a tool to gradually require the elevation of habitable spaces, along with the implementation of required floodproofing measures on waterfront structures.

5 For explanation on flood zone terms, please refer to *Digital Report 07: Terms & Full Bibliography*.

6 NPS's *Guidelines on Flood Adaptation* (2021) calls the Non-Structural Elevation method "Elevate the Interior Structure." Under the Non-Structural Elevation scenario, some alteration to the existing structure may still be needed, such as constructing an elevated floor plate above the original first floor, or taking out the second-floor's floor plate to create a double-height space.

New York City's Flood Zoning

To better support the elevation mandates set out in New York City's Post-Sandy Building Code and to remove zoning-level policy barriers, a series of citywide zoning amendments have come into place.

In October 2013, a temporary Flood Zoning Text Amendment was adopted, proposing new baselines for building height measurement within the 1% floodplain, and providing updated provisions for building envelope, access, floor area calculation, streetscape, building equipment, among other issues (NYCDCP 2013a; 2013b).

The 2013 Flood Zoning Amendment was further upgraded in 2019 into the report ***Zoning for Coastal Flood Resiliency: Planning for Resilient Neighborhoods***, which was in turn adopted in May 2021 as the current Flood Zoning of New York City (NYCDCP 2019a; 2019b; 2019c; 2019d). Besides making previous rules permanent and refining regulation provisions, this new flood zoning text is made applicable to the City's 0.2% annual chance floodplain – where Appendix G standards are not required – to further encourage flood-resistant construction and incremental building retrofitting.

Beyond coordinating changes brought by the Flood-Resistant Construction Standard to zoning parameters, New York City's Flood Zoning also seeks to incentivize flood retrofitting and flood-resilient new construction through zoning bonuses and floor area exemptions.

Moreover, **streetscape change** has also become a key consideration in New York City's Flood Zoning. The 2013 Flood Zoning Text Amendment developed streetscape design options for two typical rebuilding scenarios — the structural elevation of a 1-2 family detached home, and the new construction of a relatively large-scaled multi-family and community facility building (NYCDCP 2013b, 29-34). In the 2019-2021 Flood Zoning Amendment, **a point system** is introduced, requiring all buildings to incorporate a set of streetscape mitigation design features regarding building access and street-level expression when they are constructed or elevated. Although New York City's most recent Flood Zoning provides a greater variety of design options on streetscape mitigation, New York City's flood adaptation regulations still remain relatively preliminary in terms of streetscape control. **Especially, there haven't been any systematic streetscape design guidelines for historic structures, and design strategies developed for general construction or reconstruction projects seem to be far from adequate to deal with the flood retrofitting of historic buildings in historic urban context.** The tension between New York City's current streetscape mitigation regulation and waterfront streetscape changes will be further discussed in the next section; illustrations of streetscape mitigation guidelines in 2013 & 2019-2021 Flood Zoning Amendments may be found in *Digital Report 02 - Adaptive Streetscape: Concept & Framework*.

3.2 Streetscape Change as an Outcome

New York City's Post-Sandy Building Code and Flood Zoning have to a great extent redefined what neighborhoods look like in the City's floodplain. Accompanying the rapid execution of thousands of retrofit and new construction projects under Post-Sandy regulations, New York City's "floor-raising" strategy based on individual building retrofitting has caused various streetscape changes in multiple waterfront neighborhoods (e.g. Red Hook, Brooklyn and Breezy Point, Queens), where structures are often elevated or built upon concrete piles or blank street walls and accessed by out-of-context stairs, creating a passive and alienating streetscape.

These uncontrolled streetscape changes speak for the urgent need to develop flood retrofitting and streetscape mitigation strategies suitable for historic buildings and neighborhoods. As many waterfront historic properties are facing imminent flood threat, they will possibly experience major spatial interventions for flood resilience in the foreseeable future; with a lack of innovative design and policy solutions on the flood retrofitting of historic buildings and streetscapes, New York City's historic waterfront urban forms are being left at high stakes.

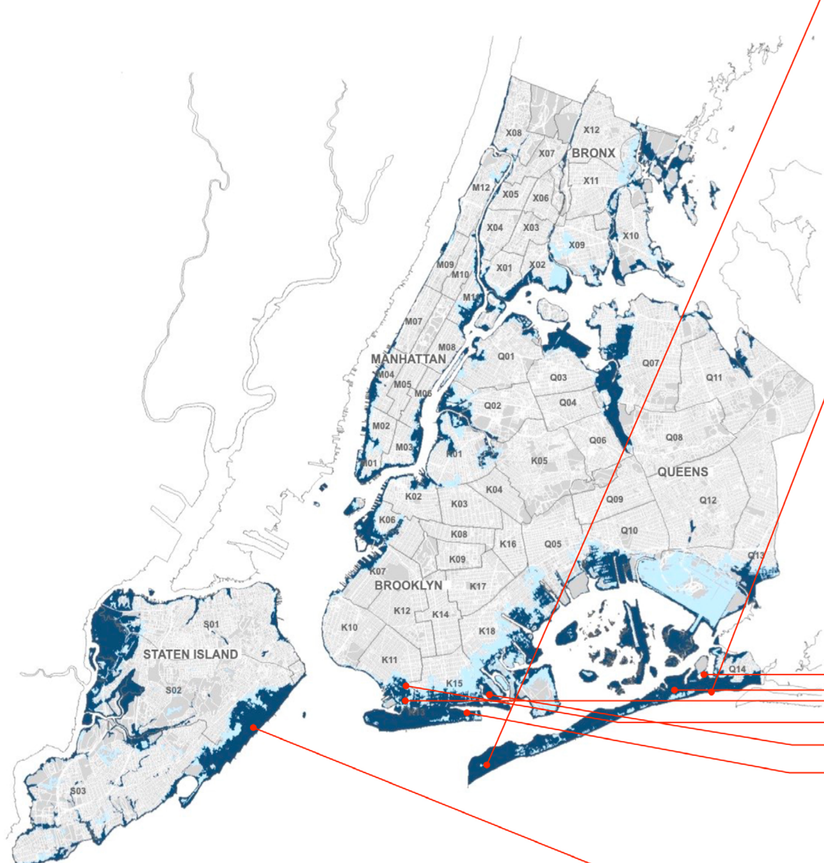
With local Post-Sandy built projects selected and illustrated on pages 30-31, this section examines the streetscape change brought by New York City's Post-Sandy flood regulation through several case studies.

Post-Sandy Retrofitting & Reconstruction Projects

- **Breezy Point Streetscape, 2021.** The structures along Rockaway Point Boulevard in Breezy Point, Queens are elevated onto exposed concrete pile foundations, and accessed by out-of-context stairs. Some foundations are covered by blank concrete walls or lattices on street front, while structures not yet elevated and those elevated to slightly different heights form an inconsistent, alternating pattern ("the lollipopping effect"). These conditions to a great extent diminish the streetscape's visual and experiential qualities, altering the proportion and context of the original urban fabrics.

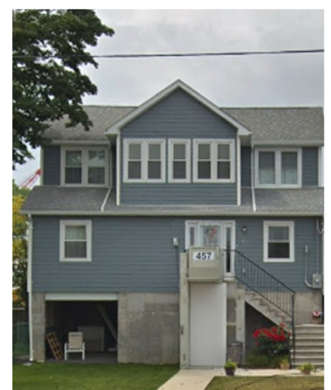
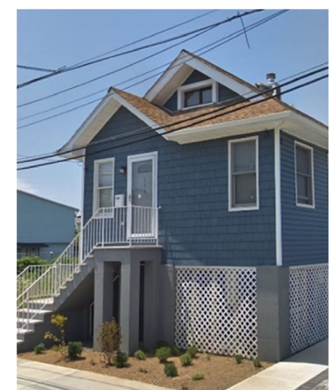
- **NYC Build It Back Projects, 2016-2019.** Since its start from 2013, NYC Mayor's Office of Housing Recovery Operations (HRO)'s Build It Back program has provided assistance to around 32,000 households impacted by Hurricane Sandy as of 2021, and "has rebuilt and elevated over 1,300 homes to today's stringent regulations for flood compliance" (NYC Recovery 2021; NYC Mayor's Office of Housing Recovery Operations n.d.). These up-to-standard rebuilt projects are often elevated on concrete foundations up to 10 to 14 ft above sea level — an exorbitant height that may bring significant negative streetscape impacts without adequate mitigation. Similar to houses in Breezy Point, the blank concrete walls or piles diminish the vigor, intimacy and human scale of street

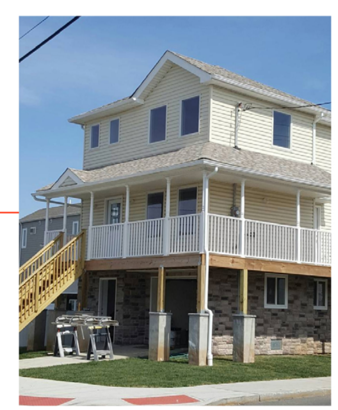
Post-Sandy Built Projects & Associated Streetscape Change



New York City's 1% Floodplain
(2007 FIRM & 2015 PFIRM Combined)

Breezy Point Streetscape, 2021

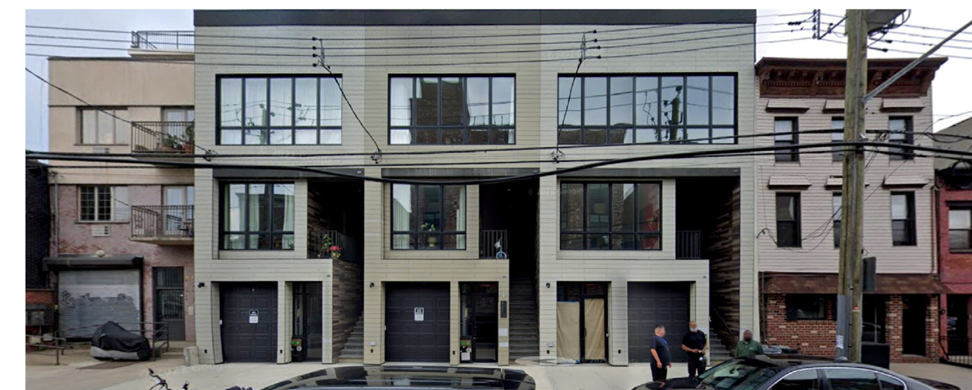





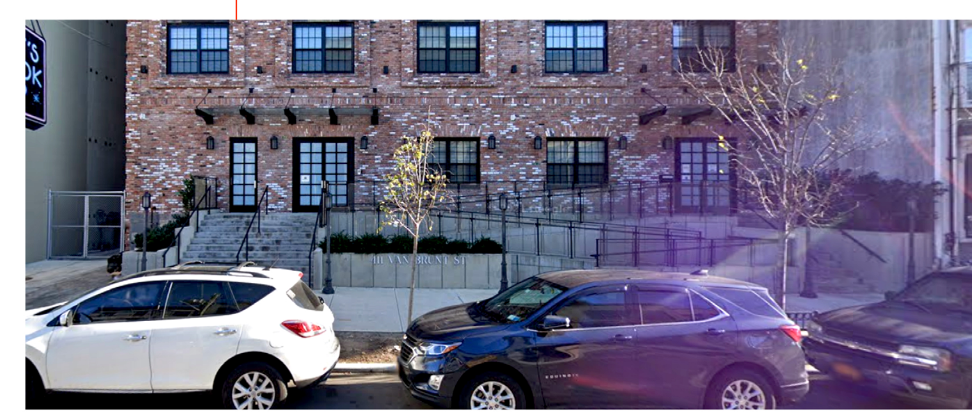
Selected NYC *Build It Back* Projects, 2016-2019

Post-Sandy Retrofitting and Reconstructions

Hotel, 2013, Far Rockaway



Walk-Up Residential Houses, 2018, Red Hook



Community Facility, 2017, Red Hook

Post-Sandy New Constructions

Image Sources: NYCDCP 2019d, 4 (floodplain map); Instagram @nycbuilditback; Google Maps.
Compiled by Ziming Wang, Aug. 2022.

interface, creating a passive streetscape where pedestrians are flanked by open foundations, blank street walls and inactive uses (such as storage and parking).

Post-Sandy New Construction Projects

- **A Hotel Built in Far Rockaway, Queens, 2013.** To elevate all interior spaces above flood elevation, the building encompasses a solid, blank wall all around its parameters on street level. As this is a block-scaled development, such treatment has led to a block-long unfriendly and alienating streetscape.

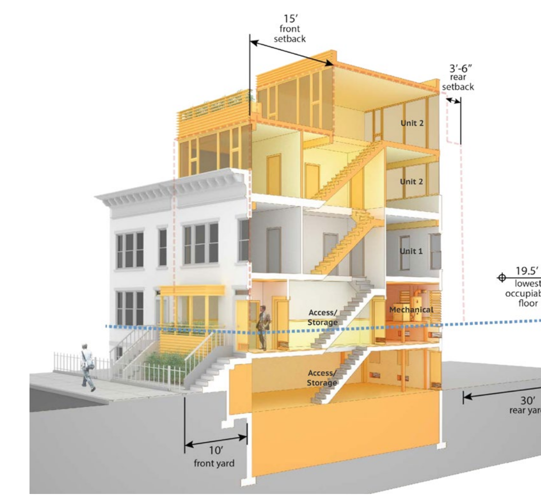
- **A Set of Walk-Up Residential Houses Built in Red Hook, Brooklyn, 2018.** To accommodate Building Code regulations, all residential spaces have been located on or above the second floor. Although this project has incorporated some of the streetscape mitigation treatments encouraged by New York City's Flood Zoning (recessed stairs and covered parking, etc.), the out-of-context form of stairs and the existence of non-transparent parking function on street level have still created streetscape changes incompatible with the neighborhood's historic urban characteristics. These incompatible streetscape expressions showcase further potentials in the project's streetscape design, which would be an even more important issue for the retrofitting of historic structures or constructions in historic districts.

- **A Community Facility Built in Red Hook, Brooklyn, 2017.** This project was praised as a successful example in terms of streetscape mitigation in New York City's 2019 *Zoning for Coastal Flood Resiliency* study (NYCDCP 2019c, 57). Although the project has created a smooth access from street level by incorporating a comprehensively designed stair and ramp system with plantings, the street wall is offset, and the interface between street space and the building's interior is still interrupted by the massive access system. In historic neighborhoods and districts with continuous street walls and intimate streetscapes, stairs and ramps may be placed within the building, if possible, to better preserve the street relationship.

The cases selected and discussed above reveal how passive and alienating streetscape may result from flood retrofitting interventions and the implementation of flood-resistant building standards. Although these cases aren't necessarily retrofitting projects on historic buildings or within historic districts, since not much resilience policy-making has been made for New York City's historic fabric, the City doesn't seem to have a plan to bring its historic resources to flood resilience, while avoiding some of the negative streetscape changes currently present in the city's waterfront neighborhoods.

3.3
Lack of Flood Adaptation Design & Policy Guidelines on Historic Properties

As discussed in Section 3.2, thousands of structures in New York City's waterfront areas have been elevated and retrofitted under the City's Post-Sandy flood regulation framework, causing uncontrolled streetscape changes in waterfront communities. Nevertheless, historic districts, neighborhoods and structures have been to a great extent left out of the flood resilience discourse: **there haven't been any systematic design guidelines for the flood retrofitting of the city's historic structures, nor neighborhood-level flood resilience studies targeted at the city's historic built environment.**



Retrofitting Guidelines for General Building Stock May Not Be Appropriate for Historic Buildings.
Source: NYCDCP 2014, 67.

Targeted at the general building stock in New York City's floodplain, New York City's Department of City Planning (DCP) has published a series of retrofitting design guidelines and resilience planning studies, including the 2014 *Retrofitting Buildings for Flood Risk* report. The *Retrofitting* report serves as a key document for property owners to plan for appropriate retrofitting interventions on various properties, as well as for planners and researchers to envision future waterfront urban form change. Although the *Retrofitting* report has successfully put forward 10 real-world flood retrofitting design case studies that cover New York City's floodplain building types and a wide range of considerations (Use, Access, Structural Systems, Critical Systems, Parking, and Streetscape & Visual Connectivity; see NYCDCP 2014, 32-36), **its streetscape design schemes seem insufficient for the flood retrofitting of historic structures.** For example, interventions such as elevating detached houses on latticed pile foundations and new, out-of-context additions atop row houses may not seem to be a big deal for general existing buildings, but could cause significant damage to the characters of historic buildings. Without design guidelines dedicated to historic structures, unplanned and uncontrolled adverse impact may happen when historic structures undergo physical interventions within the flood retrofitting process.

Similarly, since 2013, DCP has published a series of neighborhood-level resilience studies under its "Climate Resiliency" Initiative, each focusing on a type of urban space (e.g. *Resilient Art Spaces*, 2015; *Resilient Retail*, 2016; and *Resilient Industry*, 2018) or a specific neighborhood (e.g. West Chelsea, 2016; East Village, 2016; and Canarsie, 2017). Nevertheless, in this series, there hasn't been a study dedicated to the preservation and adaptation of a historic neighborhood.[7] **Without neighborhood-level adaptation studies, preservationists and planners will be unable to develop strategies that coordinate streetscape change across multiple properties, or envision urban form change on neighborhood scale beyond a building-by-building approach.**

The Landmarks Preservation Commission (LPC) is New York City's municipal agency responsible for safeguarding the city's historic landmarks and historic districts. **Although LPC has recognized the need for flood retrofitting historic properties, its policy and guideline-making remains largely preliminary.** Currently, LPC has published two technical memos on relocating mechanical equipment from below BFE to the roof, and installing flood shields on building openings. These interventions have also been incorporated into LPC's current (2019) version of *Permit Guidebook*; but beyond these piecemeal treatments, no further design and policy guidelines are found towards the comprehensive retrofitting of historic buildings for flood resilience.

To steward New York City's historic built environment towards flood resilience, we need not only building and neighborhood-scaled design guidelines, but also reforms in preservation policies and procedures. In New York City, alterations to all locally designated historic buildings are subject to LPC's design review process. Since major retrofitting interventions — such as structural elevation and non-structural elevation — may involve substantial reworking on a building's historic fabrics, they are not likely to be able to pass the design review under current standards. New York City's landmark design review standards may need to be further updated to facilitate the systematic flood retrofitting of historic buildings, just like how New York City's zoning regulation has been revised to accommodate the Post-Sandy Building Code. Furthermore, financial incentives such as historic preservation tax credits shall be explored as a means to stimulate the flood retrofitting of historic structures, and neighborhood-level preservation plan systems (such as LPC's historic district master plans) may adopt policies to encourage flood adaptation and coordinate streetscape change.

Luckily, although New York City's design and policy framework on the flood retrofitting of historic structures and neighborhoods remains preliminary, in recent years, flood retrofitting and streetscape mitigation strategies have been actively developed by various policy-making entities on local, state and Federal levels across the United States. Some local municipalities such as Charleston, SC have published design guidelines for the elevation of historic detached homes, identifying streetscape change as a core issue and developing localized design strategies to ensure human-scaled and context-sensitive streetscape expression; New Jersey and Maryland's State Historic Preservation Offices (SHPOs) have developed guiding documents on the flood mitigation of historic structures, listing different retrofitting options and exploring retrofit outcomes through illustrative design studies; on the Federal level, National Park Service has published *Guidelines on Flood Adaptation for Rehabilitating Historic Buildings* (2nd ed., 2021), which provides comprehensive guidance on a wide range of temporal and permanent flood adaptation treatments on historic properties. All these research and policy-making efforts may serve as a valuable reference for New York City's future flood adaptation and historic preservation standards, and inform how the City's historic buildings and neighborhoods may be transformed towards flood resilience.

Synthesizing issues and resources identified in this section, *Digital Report 03: Streetscape-Sensitive Design Strategies* will further develop retrofitting design tools responsive to historic streetscapes based on New York City's floodplain building stock, and *Digital Report 06: Policy & Procedural Recommendations* will further discuss key policy agendas that help bridge the discourses of flood adaptation and historic preservation in New York City's context.

7 Although some of the neighborhoods covered in DCP's study series (such as West Chelsea) are historic neighborhoods or overlap with designated historic districts, not much discussion has been made on historic preservation considerations.

3.4
Lack of Incentives & Exemption from Retrofitting Mandates

Beyond the lack of design guidelines and policy procedures as analyzed in Section 3.3, historic property owners may also be less motivated to flood retrofit their historic structures due to the lack of financial incentives and the exemption of historic structures from retrofitting mandates. **Both NFIP's floodplain management standard and New York City's Building Code provide pathways through which designated historic structures may be exempted from the "substantial improvement" regulation, which means that property owners don't have to elevate or retrofit even when they carry out extensive renovation on their historic properties.** Furthermore, unelevated historic structures may continue to secure subsidized flood insurance premium, which may make historic property owners feel less financially compelled to flood retrofit their historic structures.

New York City's Building Code Appendix G is made in accordance with requirements from NFIP's floodplain management standards, since New York City is a participating community of the NFIP program (NYCDCP 2019b, 2). **Although NFIP requires local communities to elevate residential spaces up to BFE when buildings are constructed or renovated, it also provides two pathways through which such mandate may be exempted or variable for structures** listed on National Register, eligible to be listed on National Register, or determined as a contributing structure to a National Register historic district — These structures may either be totally exempted from the "substantial improvement" provision and the associated elevation mandate, or they may be included under the provision, while permitted to gain FEMA variances that serve to loosen the rules on a case-by-case basis (FEMA 2008, 4). Both pathways are based on the condition that the proposed renovation project will not result in the delisting of the historic structure; **among these two pathways, New York City has chosen to exempt properties with either the National Register or LPC designation from the "substantial improvement" provision,**

without providing an alternative local framework that regulates the resilience of historic structures (see Appendix G, Section G201).[8] By exempting designated historic structures from flood retrofitting mandates, thorny issues regarding flood resilience and historic characters may be avoided; nevertheless, it only adds up to the long-term flood risk of historic buildings and neighborhoods, as these historic resources are now left exposed to increasing flood risk without a framework of solutions towards flood resilience.

As the nationwide property flood insurance administered by FEMA, the National Flood Insurance Program (NFIP) is currently required only for properties in the 1% floodplain which have Federally-backed mortgages or received Federal assistance for acquisition or construction; it can also be voluntarily purchased by owners of flood-threatened residential or non-residential properties (FEMA 2021, 1-1; NYCDCP 2016a). **Since a building's flood insurance premium is generally determined by the height difference between BFE and the level of its lowest floor, property owners will likely receive a significantly lower insurance premium after flood retrofitting. On the other hand, buildings not properly elevated will be charged a much higher premium** (NYCDCP 2014, 11; FEMA 2014, 3-5; FEMA 2008, 8).[9] Therefore, many property owners are incentivized to retrofit for the potential decline in flood insurance rates, and whether a retrofitting strategy qualifies for "NFIP Premium Full Reduction" has become one of the key considerations in New York City's flood adaptation planning studies such as DCP's *Retrofitting Buildings for Flood Risk* (2014) and *Resilient Retail* (2016).

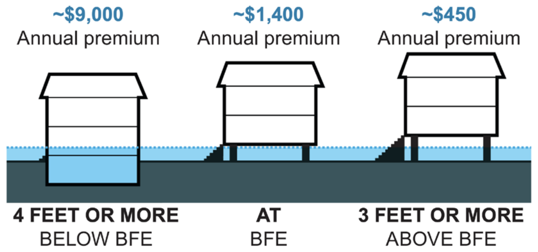


Diagram Showing the Relationship between NFIP Premium and Lowest Floor Elevation.
Source: NYCDCP 2016a.

Nevertheless, under this framework, **NFIP has made subsidized flood insurance rates available to all Federally designated historic structures, whether they are elevated or not** (FEMA 2008, 8-9). This policy is originally designed to encourage historic property owners to retain the National Register status of their properties; but in fact, it may disincentivize property owners to flood retrofit their properties even when they carry out major renovations, as they won't lose the benefit of subsidized insurance rates anyways (see NPS 2021, 22).

The lack of flood retrofitting mandates (from local Building Code) and financial incentives (from insurance policies) may be part of the reason why there haven't been systematic retrofitting design guidelines and policy procedures for historic structures in New York City. If the aforementioned mandates and incentives are adopted, they may encourage historic property owners to flood retrofit, and even push local planning and preservation agencies to put forward design and policy guidelines that help regulate retrofitting projects.

8 Although New York City's Building Code exempts all designated historic buildings from the "substantial improvement" provision, it nevertheless includes a variance-granting mechanism (see Section G107.2.1). However, if historic property owners choose to use the exemption, then no resilience measures will be compulsory.

9 FEMA's *Homeowner's Guide to Retrofitting* states that if homeowners elevate a certain structure to 2 feet higher than BFE, the premium would be 70% lower than if they elevate the structure exactly at BFE (FEMA 2014, 3-5).

04

Case Studies:

Heritage Under Water

In the previous chapters, the author has mapped the physical flood risk faced by New York City's historic built environment, and analyzed how such physical risk is compounded by underdeveloped flood adaptation and historic preservation policies. To supplement these findings, this chapter features several real-world cases and visualization projects that help us better conceptualize the impact of sea level rise and floodwater on historic buildings, neighborhoods, and streetscapes.

Empire Stores, Brooklyn

From Top to Bottom:

Location of Empire Stores.
Source: Author's Illustration.

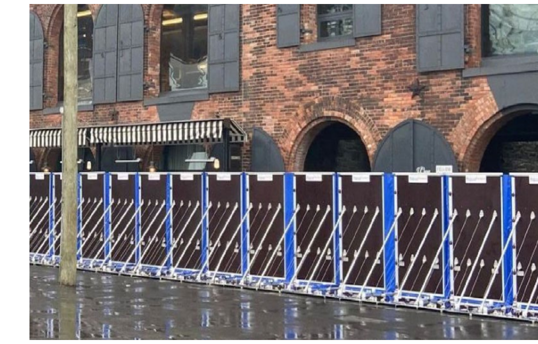
Berenice Abbott, "Warehouse at Water Street and Dock Street, May 22, 1936."
Source: Brooklyn Historical Society.

The Empire Stores in Novermber 2012 after Hurricane Sandy.
Source: Frost 2012b.

Situated within Brooklyn's Fulton Ferry Historic District only 20 feet away from East River, the Empire Stores overlooks the Brooklyn Bridge Park and is considered a jewel in the neighborhood. A warehouse complex built on landfill consisting of seven adjacent brick buildings built in circa 1870, the Empire Stores was originally used for "general storage of raw materials" such as sugar and coffee beans, and is renowned for the rows of massive round-arched windows and gates along its facade, covered with operable iron shutters (Dunlap 2017; Laslow 2016; ULI n.d.; NYCLPC 1977a).

When **Hurricane Sandy hit in 2012**, Brooklyn Bridge Park Development Corporation — the owner of Empire Stores — was in the process of calling for proposals to rehabilitate the complex. Local residents in the DUMBO area recalled a flood elevation of 4 to 5 feet inside waterfront buildings resulting from storm surge brought by Sandy; flood also inundated the nearby Jane's Carousel in Brooklyn Bridge Park. (Dunlap 2017; Frost 2012a; Frost 2012b). Flood in Empire Stores was said to "come up to the scaffolding," while photographic evidence shows that the shutters were torn from their hinges after Hurricane Sandy (Frost 2012a; Frost 2012b).

In 2013, Midtown Equities joined force with HK Organization to redevelop the site, with architectural firm Studio V working on building and landscape design. Learning lessons from Hurricane Sandy, the redesigned Empire Stores features a new concrete foundation, and a 1100-foot-long deployable flood shield system which will be transported to the site and installed before anticipated extreme flood events. Some tenants also chose to relocate electrical systems and locate storage and office spaces on higher floors, leaving the street floor to less critical uses (Dunlap 2017; ULI n.d.). The renovated Empire Stores opened in 2017, providing 36,000 square feet of restaurant, retail, office, and event space (Empire Stores n.d.). Its retrofitting strategy demonstrates the possibility of using dry-floodproofing measures to provide a flexible layer of protection to mixed-use buildings, without jeopardizing critical storefront spaces.

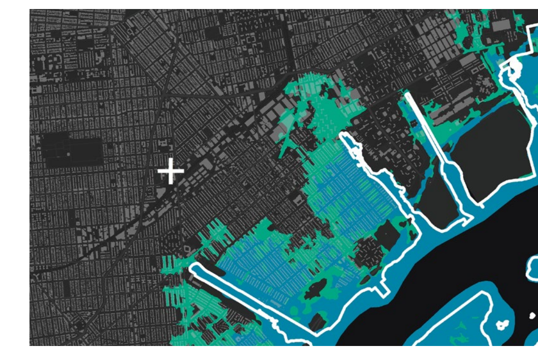


The Deployable Flood Shield System Protecting the Empire Stores.
Source: Twitter Posting of AquaFence.

Wyckoff Farmhouse Museum, Brooklyn

Built before 1641, the Wyckoff House is found to be the oldest building in New York City and State; in 1965, it became the subject of NYC Landmarks Preservation Commission's first landmark designation. The single-story farmhouse, standing on its original site, is a rare example of "the Flemish Medieval Survival and the Dutch Colonial styles of architecture" (LPC 1965; Wyckoff House Museum n.d.).

The Wyckoff Farmhouse Museum is located in the southeast corner of East Flatbush, beside the neighborhood of Canarsie. **Although it is technically outside New York City's current (PFIRM) 1% and 0.2% floodplains, the structure was severely impacted by Hurricane Ida in 2021.** According to the museum's online postings and news report by ABC7NY, the historic house's sub celler witnessed as much as seven feet of water, while the upper cellar was inundated by about five feet of water. Flood water in the cellars completely submerged the museum's HVAC and water heater systems, and ruined a great amount of farm equipment stored underground worthing several thousand dollars (ABC7NY 2021; Wyckoff House Museum 2021a; 2021b). The extent of structural damage was unclear; but observing from pictures posted by the museum on Facebook, flood water had inundated the historic rubble walls of the building's cellars, and reached a height only several feet away from the wood beams underneath the cellar's ceiling. To make things worse, it was reported that most of the flood water was sewage water, thus causing the inundated area to be "contaminated with a toxic film" (ABC7NY 2021).



Upper:
Location of Wyckoff House Museum.
Source: Author's Illustration.

Lower:
The Wyckoff House in 2017.
Source: Lore Croghan for *Brooklyn Daily Eagle*.

The management team of the Wyckoff House Museum attributed the severe flood impact partly to the "back-to-back" storms that the site faced in the week of Hurricane Ida (Wyckoff House Museum 2021b). Shortly after the hurricane, a matching fund campaign was set up on IOBY, a Brooklyn-based non-profit platform (ABC7NY 2021). **As of Jun. 1, 2022, the Wyckoff House remains closed for public tours, as its HVAC and electrical systems have to be repaired or replaced** (Wyckoff House Museum 2022).

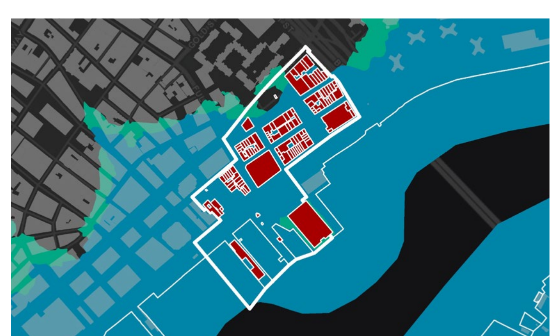
Inundation in Wyckoff House's cellars caused by Hurricane Ida.
Source: Wyckoff House Museum 2021b.

The damages happened at Wyckoff House Museum reflect some intricate challenges posed by flood on historic properties. First of all, although new construction codes can easily ban basements or cellars in flood-prone areas, in many cases, the basements and cellars of historic properties may still need to remain, as they serve as an integral part of a structure's historic fabrics and contribute to its historic significance. Moreover, the construction of historic structures may to a considerable extent limit the floodproofing options available — for example, wood-frame buildings are generally excluded from the dry-floodproofing option as wooden walls tend to be neither strong enough nor watertight enough to hold off flood water (MDSHPO 2018, 3.29). Under these unique challenges, Intensive research and policy-making are needed to develop design solutions and permit procedures that help retrofit historic structures towards flood resilience.

According to ABC's news report, the management team of the Wyckoff House Museum expressed their awareness of the necessity of "more aggressive preventive measures," as well as a better understanding of "flood abatement options" as flood risks increase. Reporting its flood damage to the public, the Wyckoff House Museum wrote on Facebook that "climate change is very real, and historic structures are especially vulnerable to increased rainfall and serious flooding" (Wyckoff House Museum 2021a; ABC 2021).

South Street Seaport, Manhattan

South Street Seaport is a commercial historic district in Lower Manhattan's waterfront featuring warehouses, stores and mid-rise buildings commonly built with red or yellow bricks in the first half of the 19th Century. Known as one of the first commercial blocks in New York City, South Street Seaport represents the rise of New York City as it grew from "a small cluster of wharves" to "an important part of the leading port of the nation," all upon successive landfills (NYCLPC 1977b). The South Street Seaport area remains as a vibrant tourist attraction today with museums, restaurants, markets, retail stores, and nightlife.



Hurricane Sandy of 2012 hit the South Street Seaport area hard. According to New York City's Post-Sandy report, "waters flowed directly off of the East River and into the South Street Seaport area," "rising in some areas to eight feet in depth" (The City of New York 2013, 374). The local South Street Seaport Museum reports a water surge up to six feet in its lobby, with flood carrying "debris and signs and barricades and pieces of timber and in some cases vehicles along"; flooding in the museum also drenched more than 200 drawers of antique wood and metal type (Pogrebin 2012). Near the museum, eleven feet of water entered the historic Fraunces Tavern cafe, a New York City landmark (Pearson 2013).

Since many retail storefronts were located on street level and had low-lying storage, kitchen or electrical systems, the impact of Hurricane Sandy was detrimental. Most ground-floor businesses were still closed months after the storm, and many of them had yet reopened nearly one year after Hurricane Sandy (The City of New York 2013, 375; New York Curbed 2013). Nevertheless, the flood impact on South Street Seaport has aroused a wide attention, and stimulated governmental actions on multiple levels: As of 2015, the South Street Seaport Museum had acquired a funding of $10.4 million from Federal government to recover from Hurricane Sandy; in 2021, NYCEDC and Mayor's Office of Climate Resiliency (MOCR) published the *Financial District and Seaport Climate Resilience Master Plan*, which was reported to be "a blueprint for comprehensive flood defense infrastructure"; in recent years, temporary flood barriers are also seen in the area as a form of

On Left Page:

Location of South Street Seaport Historic District.
Source: Author's Illustration.

From Top to Bottom:

South Street Seaport Streetscape in 2012, before Hurricane Sandy.
Source: Harvey Barrison; *New York Business Journal*.

Inundation and Flooding of South Street Seaport during Hurricane Sandy.
Source: BrooklynVegan.

Closed Stores in South Street Seaport, Feb. 2013.
Source: Tina Fineberg for the Associated Press.

"interim protection measures" provided by the city (Arnott 2015; NYC Lower Manhattan Coastal Resiliency n.d.; NYCEDC, MOCR, and Arcadis 2021; Glassman 2019; Marsh, Mongelli, and Steinbuch 2020). As a historic neighborhood selected for this project's retrofitting design studies, the flood adaptation of South Street Seaport's historic streetscape will be further discussed in Digital Report 04 - *Adaptation Design Study: South Street Seaport*.

Temporary Flood Barriers in South Street Seaport Area, Jun. 2022. Source: Photograph by the Author.

Resilient Nantucket: Sea Level Rise Visualization

Resilient Nantucket: 3D Digital Documentation and Sea Level Rise Visualization is a project published in 2019 under the Resilient Nantucket Initiative, as a collaboration between the Town of Nantucket, Nantucket Preservation Trust, and University of Florida Preservation Institute Nantucket (University of Florida 2019; McGrath n.d.; UF Historic Preservation Program n.d.; Town & County of Nantucket n.d.). Combining 3D laser scanning, GIS and digital visualization techniques, this project was able to achieve several goals towards resilience planning and public education:

- By scanning around 300 buildings in Nantucket's historic Downtown and Brant Point areas and collecting essential attribute data including historic status and elevation measurements, a database was constructed for the purposes of resilience planning, vulnerability analysis and heritage monitoring.

- Point cloud data produced by laser scanning were then related to ground elevation data acquired from the state, and unified under the NAVD88 elevation datum. This allows researchers to visualize inundation scenarios based on NOAA's sea level rise projections, and to create public education materials consisting of photorealistic images of historic Nantucket under future seawater.

GIS Mapping of Buildings Impacted by Flooding by the Year 2100, under NOAA's Intermediate High Scenario. Source: University of Florida 2019.

- The GIS database created from local heritage survey was used to perform spatial analysis and vulnerability assessment, to help planners identify structures impacted by sea level rise by the years of 2040, 2060, 2080, and 2100 (see University of Florida 2019).

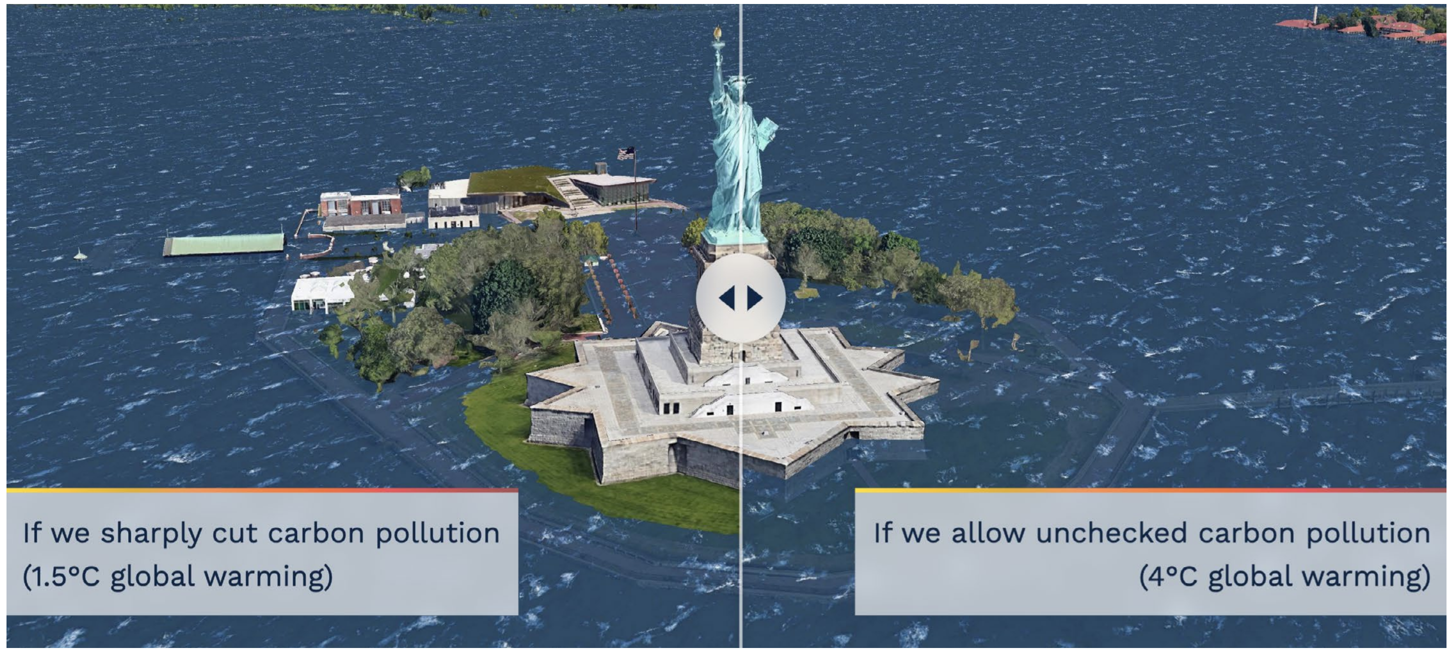
This project is an excellent example of how digital methods may be used to visualize built heritage under flooding and sea level rise, and thus raising the public awareness on historic preservation and resilience planning. Besides being featured at multiple conferences, the project was also presented in a public-facing workshop in Newport, RI in 2019 under the Keeping History Above Water initiative (Newport Restoration Foundation 2019).

Digital Visualization of Old North Wharf, Nantucket under Sea Level Rise in 2080. Sea Level was Estimated under NOAA's Intermediate-High Projection, which Establishes 2080 Sea Level at 6.14 ft above NAVD88 datum.
Source: University of Florida 2019.

Speculative Renderings: New York City Under Rising Sea & Floodwater

Some renderings similar to the *Resilient Nantucket* project introduced above have also been made in New York City's context. In *New York Magazine*'s 2016 article "This is New York in the Not-so-distant Future," several renderings made by MDI Digital were featured, depicting the flooding scenario caused by both sea level rise and a hundred-year storm "decades from now." The Meatpacking District and Calatrava's Oculus were selected as subjects of visualization, accompanying warnings from Klaus Jacob — a professor at Columbia University's Lamont-Doherty Earth Observatory — that routine inundation and flash floods will become far more likely to happen in New York City as global warming and sea level rise continue (Rice 2016). Although the data baselines behind these visualizations remain not fully clear, they provide us with a visual understanding of what could happen when our heritage — and the whole waterfront urban space — becomes under water.

Also of interest is "Picturing Our Future," an online sea level rise visualization project made by Climate Central that covers 189 locations across the world — including heritage sites, city landmarks, airports and stadiums. In each visualization, the project interface enables visitors to toggle the value of global temperature rise, and examine how these sites are inundated by higher seawater as global warming gets more severe. The project has featured the Statue of Liberty as a representative of New York City, and depicts the sea level rise brought by a 4°C global warming to almost inundate Fort Wood — the 11-point-star shaped fort which serves as the Statue's foundation (Climate Central n.d.).



Upper:
"A speculative rendering showing what a hundred-year storm could briefly do to the Meatpacking District decades from now, when sea levels have risen several feet."
Photo-illustration: MDI Digital/Jonny Maxfield/Cultura Exclusive/Getty Images. Source: *New York Magazine*.

Lower:
Renderings of the Statue of Liberty under Two Sea Level Rise Scenarios brought by Different Extents of Global Warming.
Source: Climate Central.

05

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