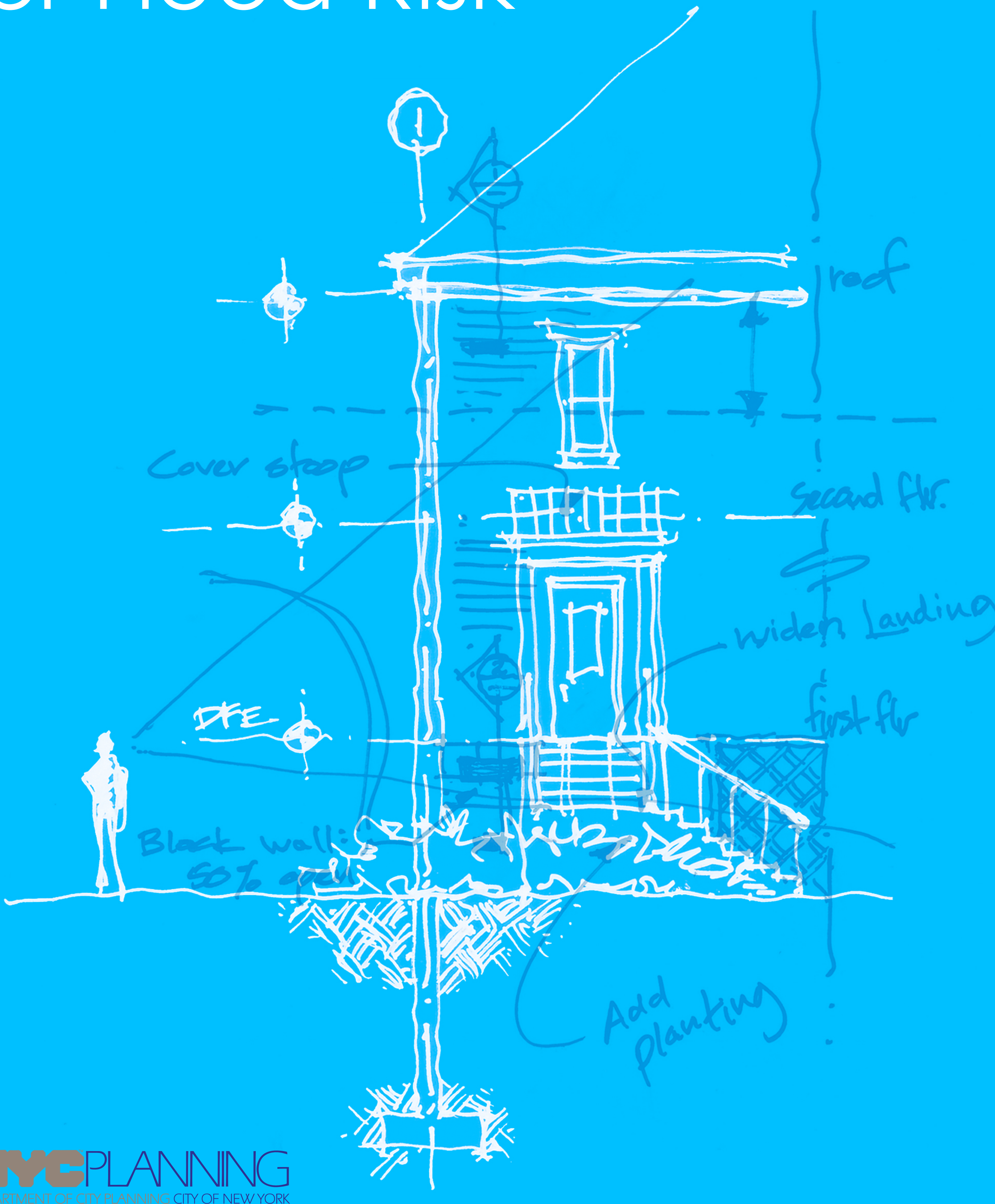
COASTAL CLIMATE RESILIENCE

Designing for Flood Risk



NYC PLANNING
DEPARTMENT OF CITY PLANNING CITY OF NEW YORK

This study was funded through a U.S. Department of Housing and Urban Development (HUD) Sustainable Communities Regional Planning Grant to the New York - Connecticut Sustainable Communities Consortium.

Cover design by Jeffrey Shumaker and Jesse Levin

COASTAL CLIMATE RESILIENCE

Designing for Flood Risk

THE CITY OF NEW YORK
MICHAEL R. BLOOMBERG, MAYOR

DEPARTMENT OF CITY PLANNING
AMANDA M. BURDEN, FAICP, COMMISSIONER

JUNE 2013

www.nyc.gov/designingforfloodrisk

Foreword by the Commissioner

New York is and will always be a waterfront city. At 520 miles, New York City's waterfront is the longest and most diverse of any city in the United States. This unique coastal geography is one the city's major assets but also poses particular challenges for the built environment, particularly in an era of ever-increasing climate risks.

The character of our streets, our neighborhoods and our public spaces is influenced by the character of the buildings at their edges. *Designing for Flood Risk* focuses on preparing buildings to withstand the threat of coastal flooding, while ensuring that they support everyday livability and quality of life. The devastation in waterfront communities brought by Hurricane Sandy has brought a new level of urgency to this work. The expansion of the FEMA flood zones and changes to the National Flood Insurance Program have made the demand to rebuild and retrofit properties both extensive and immediate. How can we ensure that buildings meet these higher flood protection standards while preserving the vitality of our neighborhoods?

To meet these challenges, reconstruction must be shaped by clear and tested design principles. *Designing for Flood Risk* is the first comprehensive design guide to address this challenge. It accompanies the recently introduced Flood Resilience Zoning Text Amendment, and its companion report for the New York-Connecticut Sustainable Communities Consortium on *Urban Waterfront Adaptive Strategies*. Together, this body of work presents a road map for supporting existing communities and providing for a sustainable future in our waterfront neighborhoods.

Designing for Flood Risk is the product of an intensive collaboration between City Planning and the architectural and design community. On behalf of the Department and the City of New York, I want to thank the New York chapter of the American Institute of Architects and all the individuals and groups that have donated their time and expertise to craft solutions to both protect the city and continue to enliven it. The principles outlined in this report can be used to guide both public- and private-sector efforts to rebuild following Hurricane Sandy in New York City, the broader region, and in other urban coastal communities. Continued close collaboration between government and the design community will be critical to address the many design challenges presented by the need for flood-resilient buildings in a dense urban context.

Amanda M. Burden, FAICP
Director, Department of City Planning
Chair, New York City Planning Commission

Foreword by the AIA New York Executive Director

The New York Chapter of the American Institute of Architects commends the NYC Department of City Planning for the publication of *Designing for Flood Risk*. The cogent and concise document spells out principles and recommendations, in the aftermath of Hurricane Sandy, that make sense for any coastal community facing the vulnerabilities caused by sea level rise and the risk of storm surge. Ideas in the book, based on the New York region's experience during the 2012 storm "inform efforts to create vibrant, active, and resilient neighborhoods everywhere."

While Sandy was a wake-up call for many, City Planning was already deeply engaged in risk assessment and design strategies to create flood-resistant structures. A half-day professional "Freeboard Charrette" took place in March of 2012, sponsored by the Department and the AIANY Design for Risk and Reconstruction Committee. Its transdisciplinary findings are summarized in the Flood Risk document and anticipate the research, analysis, and recommendations delineated in more detail throughout the report.

The "range of strategies and mechanisms" needed to promote more resilient coastal communities will not be easy to achieve all at once. But with this roadmap to a more resilient future, the City Planning Department, led by its inimitable Chair, Amanda Burden, has gone a long way to chart the way.

Rick Bell, FAIA
Executive Director, AIA New York

ABOUT THE STUDY

The New York City Department of City Planning (DCP), funded through the New York-Connecticut Sustainable Communities Consortium under a U.S. Department of Housing and Urban Development (HUD) Regional Planning Grant, is examining strategies for making buildings more resilient to the effects of climate change, in particular flooding. As part of this work, DCP has undertaken this study of the urban design implications of building-scale flood protection standards on neighborhoods within coastal areas. Also under this grant, DCP's Urban Waterfront Adaptive Strategies study will identify and evaluate potential adaptation strategies at different scales for resilience to coastal flooding in urban coastal communities.

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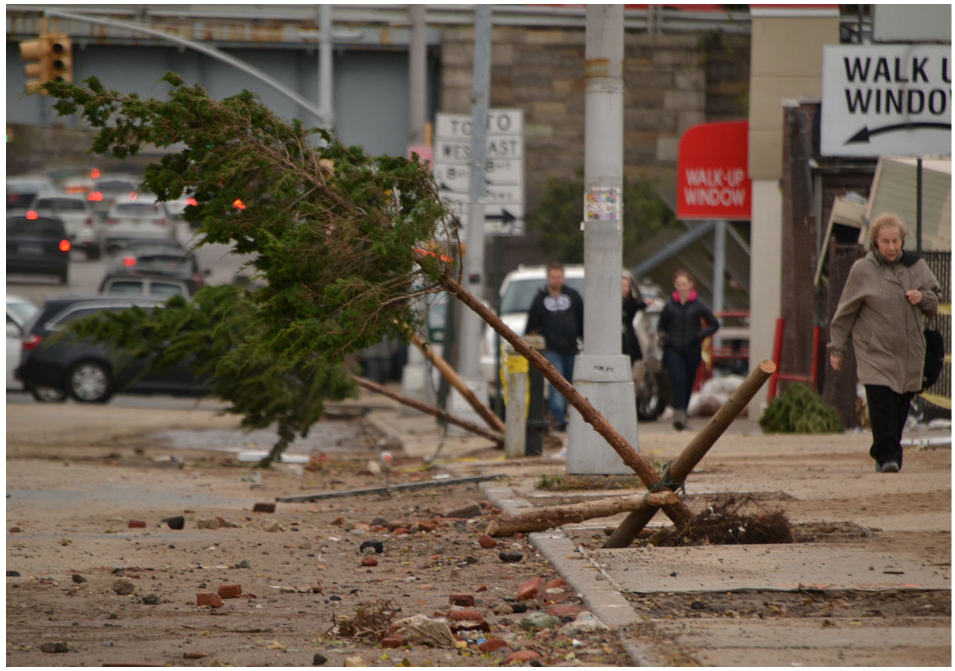
Power outage in Lower Manhattan after Hurricane Sandy

INTRODUCTION

Climate Resilience and Coastal Flooding in New York City

From its very beginnings, New York City has been a waterfront city. Its 520 miles of diverse coastline are one of its greatest assets, home to vibrant neighborhoods with tens of thousands of homes and businesses, as well as maritime activities, natural areas, and recreational facilities. The city's waterfront geography also means that it faces significant coastal flood risks from tropical storms, hurricanes, and Nor'easters. Currently about 218,000 New Yorkers live within the effective Federal Emergency Management Agency (FEMA)-designated 100-year floodplain, and FEMA preliminary work maps released in June 2013 have more than doubled this figure.

On October 29, 2012, Hurricane Sandy made landfall south and west of the city, bringing with it a record-breaking storm surge that flooded large portions of the city which brought severe damage to coastal neighborhoods. This occurred just over a year after Tropical Storm Irene brought heavy

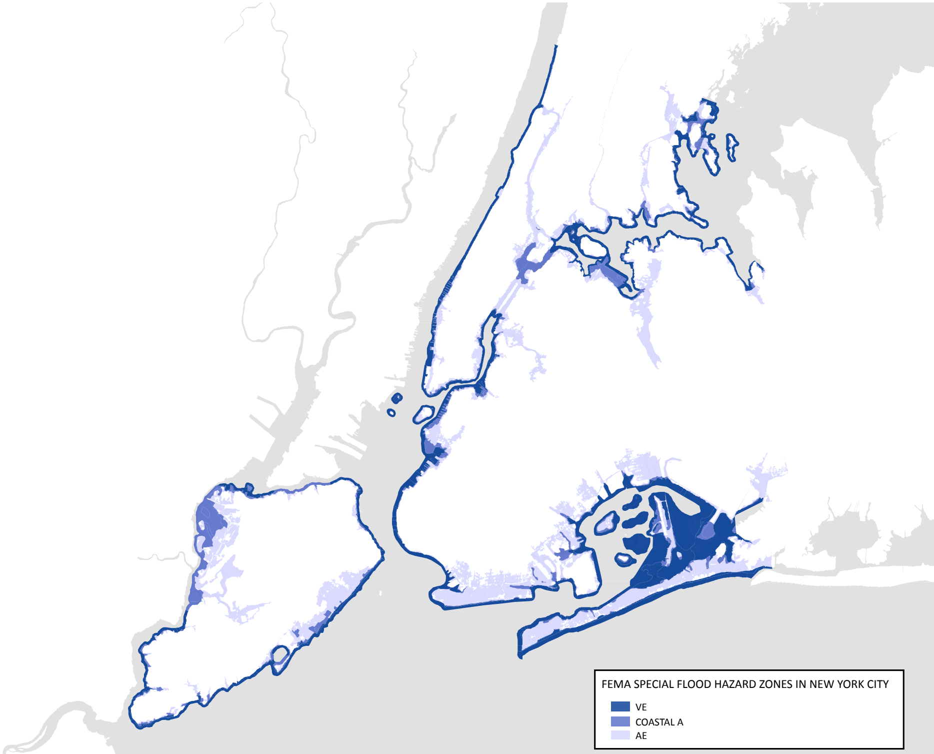


Hurricane Sandy damage in Brooklyn

rains, flooding, and the first emergency shutdown of the entire New York City subway system. Hurricane Sandy was the most damaging storm in the city's history, but because of climate change and sea level rise, the city's risks from the most intense hurricanes and coastal flooding are expected to increase. The New York City Panel on Climate Change (NPCC), a group of climate scientists and risk management experts first convened by Mayor Bloomberg in 2008, projects that the city's sea levels could rise by more than two feet by the 2050s, and that the most intense hurricanes are likely to become more frequent. Sea level rise will increase the size of the city's flood zones, putting new areas at risk of coastal flooding, and leading to greater impacts in areas already at risk.

While it may be impossible to eliminate all risks associated with coastal flooding and storms, the City can plan for these risks and become more resilient – better able to withstand and recover from extreme events and environmental changes. A key element of these resilience efforts will be ensuring that buildings in the flood zone are constructed and retrofitted to better manage coastal flood risks. The city's building code requires that new buildings in the FEMA-designated flood zone elevate or floodproof occupied space below the FEMA-designated flood elevation. To increase flood protection, the building code requires further raising this elevation by one or two feet—a practice known as adding "freeboard." Use of freeboard provides an added margin of safety for addressing the uncertainties of flood modeling and potential changes, such as sea level rise.

However, elevating buildings also poses challenges to maintaining a vibrant public realm. Elevated ground floors can detract from the quality of pedestrian experience and character of neighborhoods by losing visual connectivity with the street, creating voids or awkward access elements, or deviating from characteristic patterns. New York City's public realm is integral to the city's economic and cultural vitality, making it a place that people want to live, work, and play. The interaction among construction codes, the New York City Zoning Resolution, and the work of individual architects and designers critically shapes the relationship between individual buildings



FEMA, Preliminary Work Maps 2013

and the public realm to create a vibrant streetscape environment. Efforts to increase the resilience of buildings must be accomplished in a way that maintains and enhances the quality of the public realm, by using the best tools available to influence the built environment.

Purpose of this Study

The purpose of this study is to identify urban design principles to guide new construction that adheres to flood protection standards, as well recommendations for how zoning can incorporate these principles.

This report begins by providing background on the regulatory context for flood-resilient design under the National Flood Insurance Program. It then describes the urban design impacts of resiliency standards using a set of urban design principles and common parameters, such as building typology and expected flood elevation. The report explores desirable design solutions for new construction and substantially improved buildings. Based on this analysis, the report then identifies certain zoning rules that may create challenges for building and retrofitting of flood-resistant buildings in vulnerable areas. Finally, it describes proposed changes to the Zoning Resolution that could make the construction of flood-resistant buildings not only more practical, but also supportive of neighborhood character and a vibrant public realm.

While this analysis focuses on New York City and its regulations, the issues and strategies identified here have relevance to other dense, urban environments as well. Most flood-zone construction in the United States occurs in lower density areas, and FEMA publications and guidance tend to focus on the building types common in these areas, such as single-family construction. With its density and variety of building types, New York City requires a more wide-ranging analysis and a diverse set of strategies for integrating flood resilience into the neighborhoods and buildings of the city.

These same analyses and strategies

Hurricane Sandy damage in Queens

Hurricane Sandy damage in Staten Island

will be applicable elsewhere within the metropolitan region, particularly in areas with denser, transit-oriented development patterns. The activities of the New York-Connecticut Sustainable Communities Consortium include numerous place-based projects to promote transit-oriented development within urban centers throughout the region. Because much of the regional transportation network is located near the coastline, many opportunities for sustainable growth in the region will need to incorporate flood-resistant construction measures. The principles outlined in this study can inform these efforts to create vibrant, active, and resilient neighborhoods.

Battery Park City along the Hudson River

FLOOD RESILIENT CONSTRUCTION

The Importance of Codes to Coastal Resilience

As both sound policy to protect life and property and condition of the City's participation in the ***National Flood Insurance Program* (NFIP)**, the New York City Building Code includes requirements for flood resistant construction for new and substantially improved buildings in FEMA-designated flood zones. These standards require buildings to incorporate flood-resistant techniques below the ***Base Flood Elevation* (BFE)**, the anticipated height of floodwaters in a storm that has a 1-percent annual chance of occurring.

The area inundated by Hurricane Sandy extended beyond the current FEMA-designated flood zone and above its flood elevations. While thousands of buildings suffered flooding during the storm, newer buildings constructed to more recent code requirements fared better, demonstrating that these requirements are an effective tool for flood protection. Most construction in coastal areas in New York City predates flood-resistant construction standards. Approximately 84% of the buildings within Hurricane Sandy's inundation area were built before 1983, when the first ***Flood Insurance Rate Maps*** **(FIRMs)** were issued for the city. These buildings are unlikely to have been constructed above flood elevations or using flood resistant construction techniques, and often have other features like basements or cellars that expose them to higher risks today. The vast majority of buildings destroyed by the storm (98%) or severely structurally damaged (94%) were built before 1983.

Flood Hazard Zones

To identify and understand the flood risk and vulnerability of coastal communities within the NFIP, FEMA conducts hazard studies published as Flood Insurance Studies (FISs) and Flood Insurance Rate Maps (FIRMs). These documents provide the necessary information for the participating communities to manage and enforce requirements within their designated flood zones.

Coastal FISs determine mean water levels and wave elevation for the ***Special Flood Hazard Areas*** **(SFHA)**, defined as the land in the floodplain subject to a 1-percent or greater chance of flooding in any given year. This area is also known as the "base floodplain" or "100-year floodplain." The flood hazard for each area is determined based on statistical analysis of historical tides, also taking into account characteristics of the adjacent water body, potential erosion, topography and bathymetry of the floodplain. Storm surge and wave models are implemented to determine the BFE.

FIRMs specify the limits of the SFHA, which is divided into two separate insurance zone designations: "A" and "V." These are generally referred to as flood zones (see Figure 01), and are accompanied by BFE contours. The specific zone designations describe the extent and severity of the coastal flood hazard.

"***V Zone***" is a portion of the SFHA directly along the coast. This area is subject to inundation by the 1% annual chance flood event with the added hazard of high-velocity wave action,

THE EDGE, WILLIAMSBURG
BROOKLYN

AVERNE BY THE SEA, THE ROCKAWAYS
QUEENS

IKEA, RED HOOK
BROOKLYN

Examples of recent developments that suffered little damage during Hurricane Sandy with a projected wave height of 3 feet or more.

An "***A Zone***" is located either inland of a V Zone or adjacent to open water where no V Zones are mapped. This area is subject to the same 1% annual chance of inundation as a V Zone, but without wave action from waves of 3 feet or more. FIRMs specify the water level expected during the flood event, or BFE, for both A and V Zones.

FIRMs are revised and updated when new coastal FISs are available. The FEMA preliminary work maps (2013) for New York City show not only updated boundaries of V and A zones, but also introduce a new area defined as the "***Coastal A Zone***," designated by a boundary called the Limit of Moderate Wave Action (LiMWA). This zone is the portion of an A Zone where moderate wave action with projected wave heights between 1.5 and 3 feet is expected during the base flood event. No design and construction specifications are yet prescribed within the NFIP for Coastal A Zones; however, FEMA encourages jurisdictions to apply more precautionary standards in such areas, and requirements are being incorporated in model building codes.

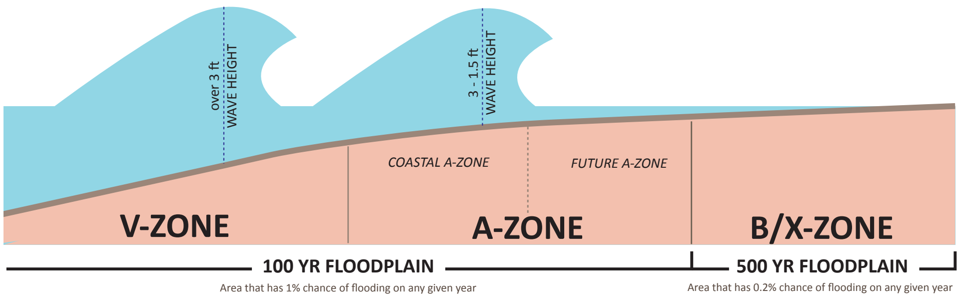


Figure 01. FEMA FIRMs designations

THE NATIONAL FLOOD INSURANCE PROGRAM

FEMA administers the National Flood Insurance Program (NFIP), through which private properties' flood losses are covered by insurance premiums paid by property owners. New or substantially improved buildings in the 100-year flood zone are required to maintain flood insurance to obtain loans from federally insured banks, as well as to be eligible for federal disaster assistance. At the same time, coastal communities participating in the NFIP are required to match their local codes with FEMA's requirements. FEMA reports that, as of May 2011, over 20,000 communities in coastal areas are participating in the NFIP, including New York City.

Elevated home in Breezy Point, Queens

Beyond the 100-year floodplain and therefore outside the SFHA, FIRMs show the area subject to a 0.2% annual chance of inundation during a flood event, also known as the 500-year floodplain. The base flood elevation for this area is not identified on the FIRMs, though it is provided in the FIS, and there are no design requirements specified by the NFIP for this zone.

Flood Resistant Building Design

Consistent with FEMA requirements, the New York City Building Code establishes minimum structural and programmatic requirements for all new and substantially improved buildings in SFHAs, with requirements based on specific zones within the SFHA.

The BFE designated on FEMA flood maps serves as the standard to which flood-resistant construction requirements apply. Where the BFE exceeds the elevation of the building site, it is necessary to elevate or floodproof (where permitted) the first occupiable floor to ensure that buildings remain structurally sound and to protect building contents during the flood event.

Freeboard provides an added margin of safety, usually expressed in feet above a flood level, to address the uncertainties of flood modeling and often compensates for the many unknown factors that could contribute to flood heights, including sea level rise. The NYC Building Code defines the ***Design Flood Elevation*** **(DFE)** as the BFE plus the designated amount of freeboard. (See Figure 02) On January 31, 2013, the Commissioner of Buildings issued an emergency rule to require one or two feet of freeboard (depending on the building category) for buildings in the flood zones.

In general, all mechanical equipment from electrical, heating, ventilation, plumbing and air conditioning systems must be located above the DFE or designed to prevent water from enter-

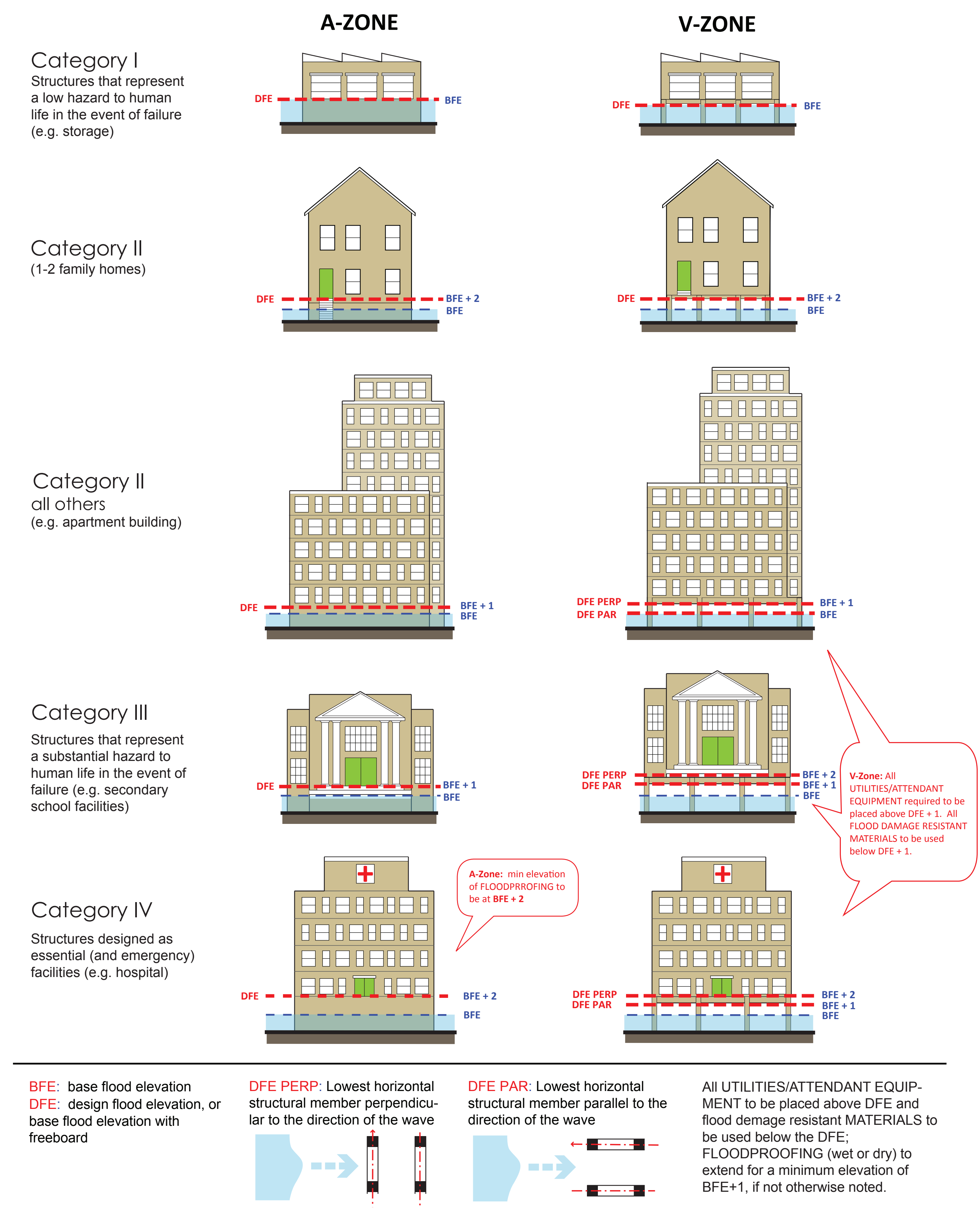


Figure 02. Minimum elevation requirements for buildings in flood zones by structure occupancy category - NYC Building Code 2008

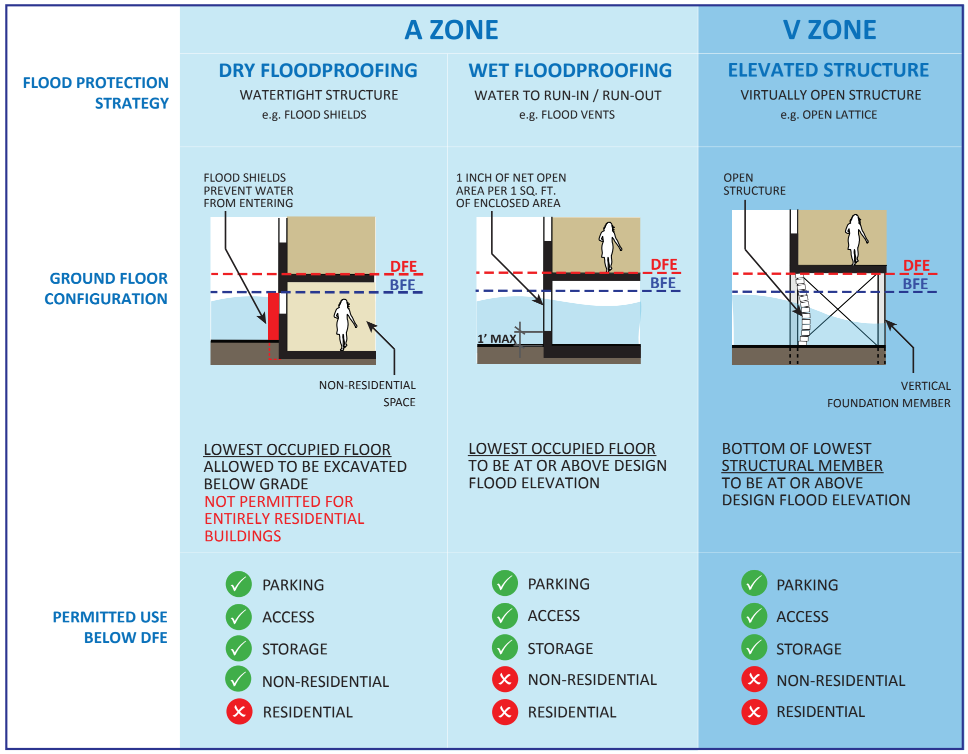


Figure 03. Design and Construction requirements for buildings in the SFHAs

ing. Below the projected flood levels, flood damage-resistant materials are required (Some variations apply - See figure 02). Uses below the lowest occupiable floor are limited by the NFIP. Parking, minor storage and building access are the only uses allowed below the DFE, except for dry-floodproofed non-residential spaces, as described later. No dwelling units can be located below the DFE.

There are two basic techniques of floodproofing allowed under FEMA standards: dry floodproofing and wet floodproofing. Both techniques could be used in A Zones, depending on the building use. (See Figure 03)

Dry floodproofing makes a structure watertight up to at least the level of the DFE through the implementation of a sealant, flood shields, aquarium glass, strengthening structural components to resist hydrostatic forces from floodwaters, and protecting utilities from flood damage. Unlike wet floodproofing, the first floor of a dry-floodproofed structure can be at an elevation below grade or below the base flood elevation. Through dry floodproofing, building access can be maintained at grade with no apparent differences from a non-floodproofed condition. Any of these conditions will generally entail higher construction costs. Dry floodproofing can present safety hazards during a flood event by blocking egress, so it is not allowed in entirely residential buildings.

Wet floodproofing allows buildings in the A Zone to be designed to allow floodwaters to enter and leave the structure without the use of any mechanical equipment. Spaces that are below grade on all sides are prohibited, and the lowest occupiable floor is required to be elevated above the BFE. To prevent the collapse of building walls, a wet-floodproofed building allows for the equalization of hydrostatic forces on both sides of the wall during a flood event. This is achieved with openings at the ground


Recent waterfront development in Williamsburg, Brooklyn

floor that allow water to flow in and out at an appropriate rate. Openings should be provided on at least two sides of the enclosed space and the bottom of each opening should not be more than 1 foot above grade level. Non-engineered openings need to provide at least 1 square inch of net open area for each square foot of enclosed space. Engineered openings are required to be certified by a registered professional and designed according to specific provisions. Buildings must also use flood damage-resistant materials up to a level one inch above the DFE.

As a fairly common practice in New York City, new mixed-use buildings in A zones have combined wet and dry floodproofed areas at the ground floor. With this solution, portions of the building are sealed at the ground floor to keep floodwaters out, while lobbies and entryways are designed to accommodate flooding.

In V Zones, more stringent standards apply to prevent the damaging force of waves from being transmitted to the structure of the building. For new or substantially improved buildings, the bottom of the lowest horizontal structural member must be elevated above the DFE. Below the DFE, the structure has to be largely open, and walls of enclosures must be designed to collapse under the flood loads (breakaway walls). The New York City Building Code requires enclosures to be of an open-lattice type and not solid. Excavation below grade and the use of structural fill are not allowed in a V Zone.

Land Use and Buildings in New York City's Flood Zones

Every portion of New York City's 520 miles of shoreline is mapped within a flood zone, though the distance these flood zones extend inland varies depending on topography and other factors.

The vast majority of New York City's 100-year flood plain lies within A zones. V zones are limited in New York City, found only on the most exposed coastal reaches, including beaches on the Rockaways, Coney Island, Staten Island and on Long Island Sound.

Nationally, the overwhelming majority of buildings in flood zones are small homes. In New York City, too, most buildings in flood zones are one- or two-family homes. However, multi-story buildings make up the largest percentage of built area (square footage) in New York City's coastal area. While 73% of the buildings within flood zones in New York City are one-and two-family residential buildings, 35% of floor area is within multi-family buildings, and an additional 16% in commercial/ office buildings.

In New York City there are approximately 400,000 residents, 340,000 jobs, and more than 16,000 companies within the FEMA Preliminary Work Maps' 100-year floodplain.** With projected sea level rise, the number of residents and businesses affected by the risk of coastal flooding will increase substantially. Addressing these risks, while maintaining the vitality and diversity of uses in the city's coastal neighborhoods is a central focus of the city's climate resilience planning.

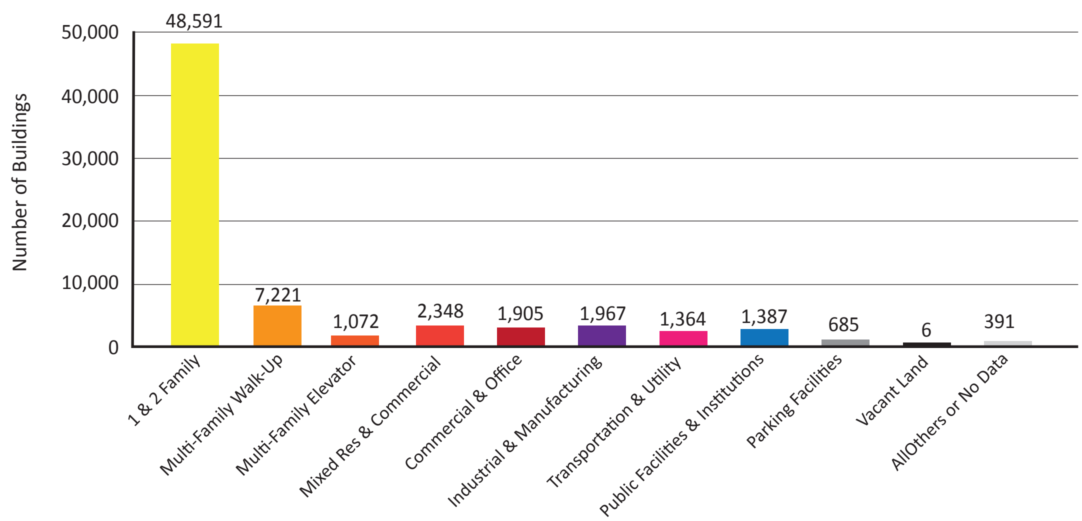


Figure 04. Number of buildings in the 100-year flood zone in New York City by land use

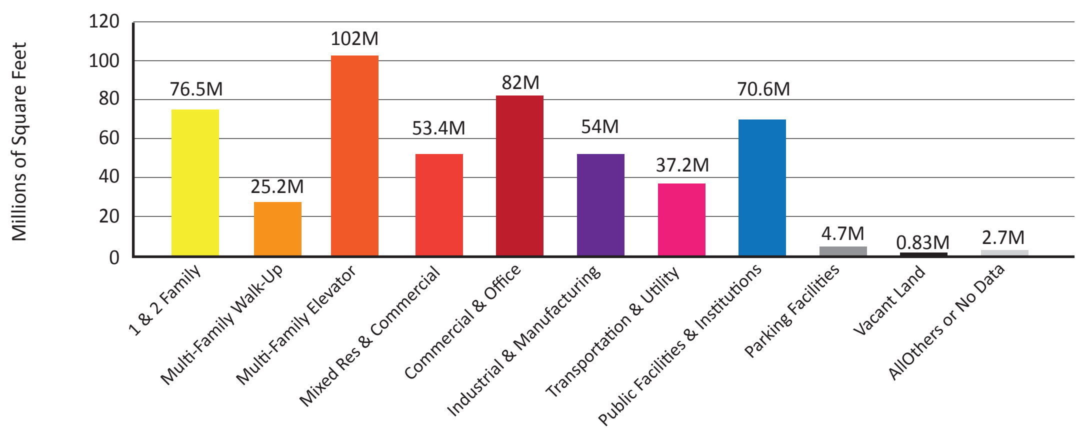


Figure 05. Amount of floor area in the 100-year flood zone in New York City by land use

*Data provided in this section based on FEMA Preliminary Work Maps (2013) and DCP MapPluto 12v2.

**NYS DOL, 2010 Q3 QCEW. The data reflect firms whose addresses fall within the flood zones and their employees, and the proportion of jobs allocated to Census Tracts within those flood zones for records that could not be assigned to a specific address.

DESIGN CHARRETTE / pre-Sandy

On March 23, 2012, the Design for Risk and Reconstruction Committee of the American institute of Architects (AIA) New York Chapter and the Department of City Planning co-hosted a half-day professional charrette exploring design strategies for flood resistant buildings in New York City. The charrette took place at AIANY's Center for Architecture, and was attended by about fifty leading members of the design community as well as representatives of City Planning, Department of Buildings, and the Mayor's Office of Long Term Planning and Sustainability.

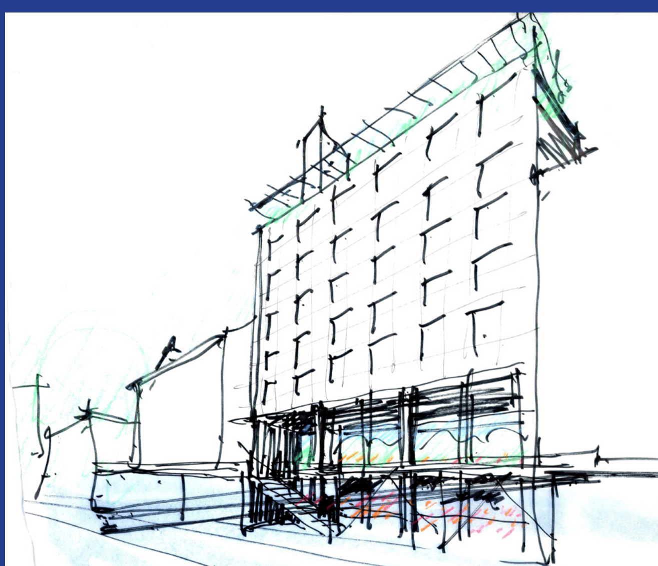
After a brief presentation on current regulations that govern building in the flood plain, the participants formed eight teams. Each team investigated a scenario in which a hypothetical new building must adapt to a high flood elevation. DCP provided detailed underlay drawings showing context, topography, infrastructure, and flood elevation. The teams worked iteratively through a design process, using hand drawing, and considering a full spectrum of issues including streetscape continuity, accessibility, drainage, structural requirements, and land use program.

Participants outlined a wide range of creative design strategies during the charrette. The most prominent recurring theme was the need to create a vibrant, attractive environment while satisfying all applicable safety standards.

All of the teams grappled with how the buildings interfaced with the public realm. Some of the teams developed design strategies for creating spaces below buildings that would be open to the elements per flood regulations, but also attractive and inviting elements of the streetscape.

Acknowledging that an inviting space below buildings is difficult to create with a low ceiling and limited access to daylight, some teams sculpted the building mass to allow greater solar access to these open spaces.

A second idea that was explored through the charrette was the potential use of temporary program in areas below the flood elevation, such as pop-up retail or community facilities, which could be enclosed in a mobile structure.



Building access requirements also posed a significant constraint on the designers. All the sites except the one- and two-family homes required ADA access. The required ramps not only consumed large amounts of floor space, but were also a prominent element of the building's façade. This prompted some to emphasize the circulation elements as virtuous element of the design, a semi-public entryway to the building's first occupied floor.

Another recurring theme throughout the charrette was that flood protection may not be easily addressed at the building scale, particularly where flood elevations are substantially above grade. Interventions at a larger scale, such as seawalls, levees, or surge barriers may offer less disruptive and more economical means of reducing flood risk. Several teams also sought to explore neighborhood-scale strategies that fall in between the scale of the individual property and that of larger infrastructure.

A common suggestion was to raise streets and infrastructure, which would require a long-term coordinated investment and effort among property owners and public agencies.

To avoid the lengthy coordinated reconstruction of all adjacent structures that would be required to elevate a street, one team proposed to put public pedestrian circulation inboard of the block, in effect inverting the public and private faces of every building on the street.

There was a clear, broad consensus among the participants that this charrette opened an important conversation about designing for future floods while maintaining high quality urban design. Many hoped that this conversation could continue at a wider scale and engage broader questions about infrastructure and neighborhood-scale flood protection strategies. While many broader questions about design for flood resilience remained unanswered, the principles to which charrette participants adhered were used to shape the urban design principles that have guided subsequent work.

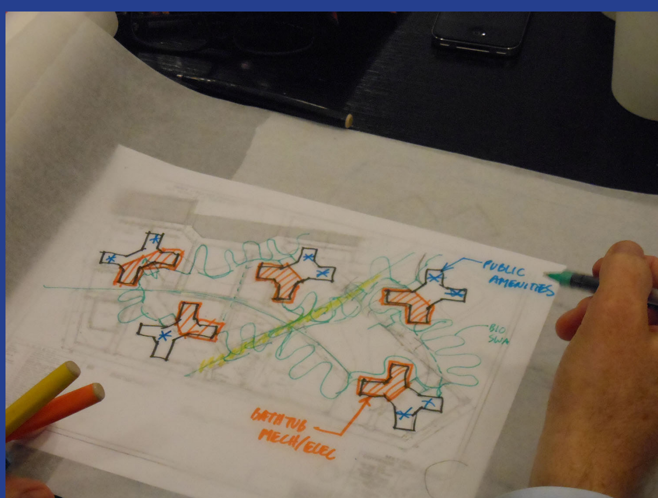
DESIGN CHARRETTE / post-Sandy

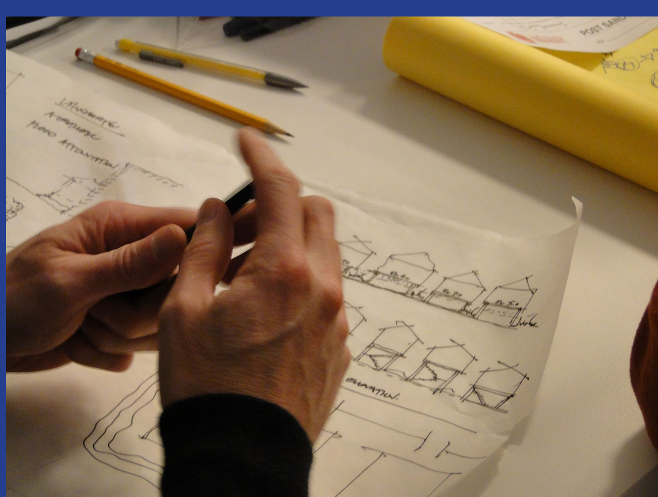
On February 23, 2013, the Post Sandy Task Force organized by the AIA New York Chapter hosted a second professional charrette to examine housing design and zoning issues in the wake of Hurricane Sandy. The workshop was held at the Center for Architecture, and brought together architects, structural engineers, landscape architects, and representatives from the Department of Buildings, the Office of Emergency Management, the Mayor's Office and FEMA. DCP provided technical assistance before and during the event.

Participants were divided into six teams, each looking at different building types representative of the diverse urban environment of New York City. Teams explored solutions to either retrofit or rebuild to higher flood protection standards the assigned typology while considering implications on massing, integration of building access, and the effects of the new design on the creation of quality streetscape, while overall ensuring compliance with flood resilience standards.

While all participants tried to incorporate the flood resilience standards, several proposals highlighted the need for a more flexible building envelope. They requested the flexibility for expansion of the building envelope both horizontally and vertically to relocate residential units, relocate mechanical equipment that would be displaced from the lowest floors, and to accommodate access elements. A second idea proposed to raise the height of the ground floor above the minimum design flood elevation requirements as an incentive for the provision of a full floor at grade that could facilitate activation through the permitted uses, although limited to parking, building access, or storage.

All teams highlighted the importance of having a lively





Images: AIA New York

streetscape and ensuring activity at the street level. However, when designing for high flood elevations, having dry floodproofed retail at grade level was described as likely to be economically infeasible and difficult to implement. Several solutions opted for lobbies at grade or public open space and pop-up programs in lieu of abandoning the lowest floors.

Several teams suggested the use of architectural elements, such as decks, terraces, canopies and porches to help protect building entrances while adding movement to the façade and to help engage the pedestrian visually. On a similar approach, other teams explored landscaping and site design solutions to not only mitigate the effects of elevated buildings (aesthetics and accessibility), but also to provide an added measure of safety by dissipating the wave energy, for example by integrating berms on larger sites. While more difficult to implement, teams recognized the opportunity, where possible, to go beyond the scale of individual buildings or lots and proposed solutions that integrate multiple properties in order to solve the challenge of flood protection and building access. A proposal for an “elevated urban sidewalk” would provide a shared ramp that could ease ADA accessibility compliance and create an added public space.

It was also suggested to extend some flood protection requirements and zoning relief to buildings in the 500-year floodplain as well.

Overall, the event highlighted the necessity to update and align regulations for buildings in flood zones to accommodate flood resilience measures made more urgent by Hurricane Sandy and ongoing rebuilding efforts.

Integrated streetscape design elements in Soho

URBAN DESIGN PRINCIPLES

Neighborhoods and buildings should be designed to survive a flood event, but also be functional during normal non-flood conditions which will prevail the vast majority of the time. Public streets and sidewalks should provide continuous and varied pedestrian experiences that sustain a wide range of vibrant and walkable neighborhoods.

To support this, building design should foster:

- **Visual connectivity**
- **Facade articulation**
- **Inviting access**
- **Neighborhood character**

In this manner, efforts to improve the resilience of buildings can enable the city to adapt to climate change while supporting, not compromising, quality of life.

With this purpose, design solutions for resiliency should take into consideration a set of **physical and programmatic parameters**:

First Floor Elevation

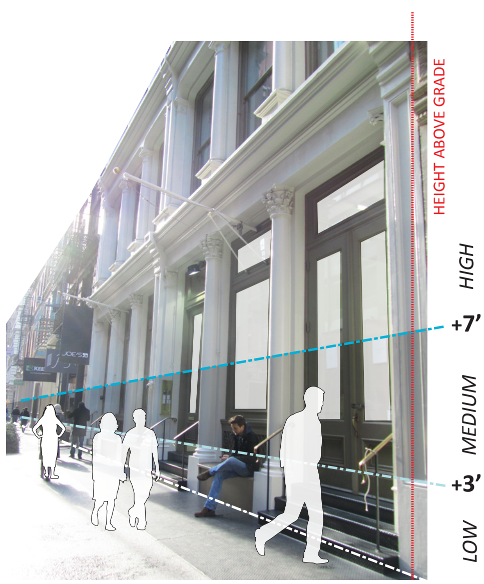
Raising a building's first occupied floor by a relatively small height is often possible without adverse effects on the streetscape or deviating from common building forms. While this can pose access challenges for some buildings on small or narrow lots, there are many design solutions that can be used when constructing a building that is elevated up to roughly three feet above adjacent grade.

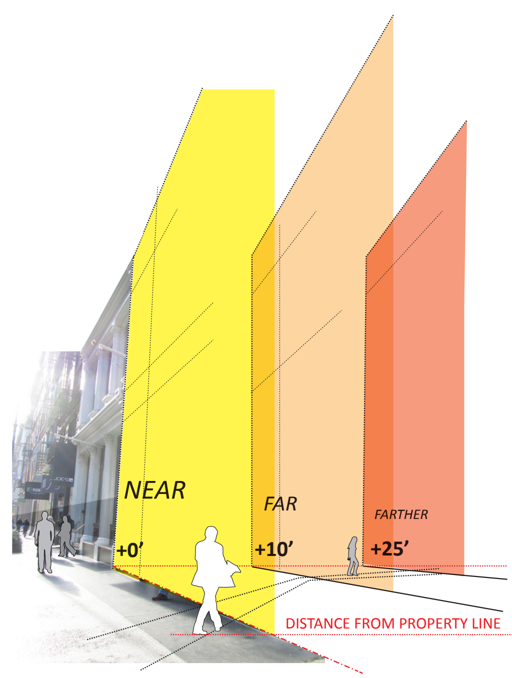
Above this height, issues of access and visual connectivity become more difficult to address – it becomes difficult to accommodate larger ramps and stairs while maintaining unique architectural features and visual connectivity with ground-floor uses. Where the difference between design flood elevation and adjacent grade becomes higher than five feet, design options are increasingly limited, therefore making building-scale resilience strategies that support a vibrant public realm a significant challenge.

Distance from Street Line

In New York City and other dense urban environments, buildings that are directly adjacent to the public sidewalk are better situated to support an active streetscape. However, when buildings in flood zones are located close to the street line (property line), the effects of elevating a building – blank walls, disconnection of retail from the sidewalk – can be more severe. Buildings set further back from the street may have opportunities for reconciling grades, accommodating access elements, and mitigating the effect of blank walls or voids.

Every neighborhood street may have a different set of considerations when evaluating appropriate proximity between sidewalk and building. A commercial corridor may depend on that close proximity for viability of the retail; whereas, a lower density residential street may benefit from the wider setback to accommodate landscaping and porches.





Program and Uses

Dry flood proofing is a technique that can help keep retail or other active uses closer to the sidewalk level, preserving a familiar streetscape and a stronger physical and visual connection to the public realm. Dry flood proofing may be costly or impractical, especially at higher flood elevations, and is not allowed in purely residential buildings, where FEMA and building code allow only parking, building access or storage below the base flood elevation. In these situations, creative design solutions will be needed to maintain connections between the building and the sidewalk, supporting the vibrancy of our City streets and maintaining engagement and a sense of safety for the pedestrian.

Density and Diversity

In New York City, many different neighborhoods and building typologies are subject to flood zone regulations. Because of their structural characteristics, some building types can accommodate resiliency strategies better than others (e.g. one-two family detached homes with front yards, tower-in-the-park, larger scale buildings). Buildings with fewer constraints from site or adjacent buildings can more easily articulate lower portions of the structure, accommodate access elements within the site or building envelope, and better reconcile the first habitable/active floor with the sidewalk level while still ensuring a vibrant and active street frontage. This becomes more challenging for infill developments and attached and semi-detached buildings in contextual neighborhoods where street life and activity at the street level is necessary for the continued vibrancy of a neighborhood.

Efforts to improve the resilience of buildings must also take into account the effects on public space and quality of life.

Lower density residential neighborhood in College Point, Queens

Commercial street in Downtown Brooklyn

Visual Connectivity / Active Street Frontage

Designers should maximize visual connectivity between the sidewalk and elevated ground floor to support pedestrian-friendly streets and neighborhoods.

Buildings should engage the sidewalk. Sidewalks with activity on adjacent buildings support pedestrian-friendly neighborhoods.

Building elements such as windows and doors are proportional to the human scale, are recognizable to the passer-by and create a sense of security and comfort.

Buildings with elevated first floors can lose visual connection with the street. First floor elevations roughly up to three feet are common and do not differ significantly from common conditions throughout the city. When first floors are two or three steps above grade, pedestrians still have full visual access of the first active level of a building. A clear visual connection between the inside and the outside of the building is still possible.

When flood protection necessitates first floors to be more than three feet above grade, sidewalks may lose this animating active edge and visual connection.

One mitigation for these blank walls along the sidewalk is to encourage the use of human scaled architectural elements, such as landscaping and articulated facades.

Where zoning and site planning allow, setting the building back several feet from the street line may alleviate the effects of inactive frontages abutting the sidewalk. Generally, the further from the street line, the easier it is to mitigate higher differentials between grade level and the active first floor. Grading and landscaping or adding stoops and porches can create visual interest for the pedestrian. This visual interest enlivens the sidewalk.

While setting back from the street line can help mitigate issues deriving from this height differential, first floors that are far from the sidewalk are particularly problematic for commercial streets where foot traffic and immediate access and visibility is integral to economic viability. This is especially true when such conditions become extended along a city block.

When active uses are limited or distant from the sidewalk level design elements defining the facade of a building should be used to create lively and interesting streetscapes.

Architecture should contribute to a lively and interesting streetscape, especially within the immediate field of view of the pedestrian. Good architecture comes in many forms, but variations in solids and voids, a play of light and shadow across variegated facades, and where possible, transparency into the activity of a building have all been proven to enliven a streetscape. Long expanses of uniform materials typically contribute to a deadening of the streetscape.

Buildings that elevate the lowest floor to gain flood resilience are limited to contain only garages, building access, storage, or crawl space below the flood elevation; all of which can lend themselves to featureless facades. Whereas windows and doors have a natural relation to the human scale, garage doors typically relate only to the scale of cars. Storage and crawl space demand no proportion. Lobbies and other types of building access can give designers an opportunity to create a human-scaled facade in a portion of a building's ground floor; however, lobbies have limited economic value compared with parking and storage.

When a building is at or close to the property line, façade articulation is particularly important because of the proximity to the sidewalk. In this situation the design of the base of the building together with the use of screenings and planting can help break the monotony of a façade and is most important in defining the pedestrian experience. Further from the street line, the integration of other elements like plantings, stairs or porches and changes in grade level, would help contribute to a more dynamic streetscape.

Inviting Access

Access elements should be integrated in the overall design of the building and to appear more inviting to the people walking by.

The transition between public and private space is defined largely by the design, proportions, and location of the building's access elements, such as stairs, stoops, ramps and lifts. Because of the nature of flood resilient construction, access elements to elevated floors has become a key architectural feature of the lowest portion of a building, while also representing the physical and visual connection from the sidewalk. Access elements that are poorly scaled to surroundings or awkwardly recessed can make a building appear disconnected and a streetscape less welcoming. These elements should be integrated into the building and site design as seamlessly as possible, offering a gradual and legible connection to the observer.

Building Code generally requires new buildings to have entryways accessible to persons with disabilities, except small homes and some non-residential buildings (with limitations to the non-accessible square footage), through ramps or, in some cases, elevators.

Even at lower design elevations, ramps and access elements still require significant physical space (ramps require a length of 30 feet for a rise of 30 inches). Integration of these elements within the building or site is still manageable and common at low DFEs. However, at medium to high design elevations the physical space required to fit the access elements grows proportionally, making it difficult to reconcile grade level and first floor when accessible entryways are required to be provided.

When the building frontage is at or close to the street line, common practice is to incorporate access within the building envelope. This solution has to be skillfully integrated in the articulation of the façade to avoid blank walls. If setting back from the street, access elements can be more easily incorporated in the street frontage with turns, landings, recesses, landscaping, and other site-design solutions.

On local retail streets with smaller commercial spaces, floor area can be limited and the integration of accessible ramps may not be feasible. Smaller businesses may prefer to avoid setting back from the streetline in order to keep a presence on the street. Where floor plan allows it, access could be solved inside while still ensuring a visual connection to the sidewalk.

Designers should respect a neighborhood's character by taking cues from existing context in building massing, fenestration, rooflines, and other architectural elements.

Many streets and neighborhoods derive character and a sense of place from the relative uniformity of building massing and materials. The City has regulations to protect the value, historical significance, and social cohesion that arises from neighborhood character through contextual zoning and in some cases, landmark district designation. Neighborhoods' different characters are often defined by prevailing heights or street wall alignments. When designing for greater flood protection, buildings may have to exceed the height of neighboring buildings or else set back to accommodate access elements.

While some variation in building form can contribute to the creation of a diverse and vibrant neighborhood fabric, infill and reconstructed buildings that deviate too much from characteristic patterns can seem out of context and detract from the streetscape.

In residential districts, particularly lower density with detached homes with BFEs below five feet above grade, existing housing typologies may well accommodate flood resilience standards while being consistent with the built context. In medium density contextual neighborhoods, given the constraints of the built context, typical proportions may change; new infill developments may differ in height, introduce different access configurations and overall have larger impacts on the distinct character of a neighborhood.

Designers can respect a neighborhood's character by taking cues from existing context in building massing, fenestration, rooflines and other architectural elements.

On local retail corridors in the flood zone, businesses may be greatly affected by resiliency standards. Some may altogether disappear because of the expense and constructabilty hurdles of implementation of such resiliency measures. If these businesses disappear, this could have grave long-term consequences for the character and ultimately the sustainability of neighborhoods.

Elevated retail in Soho

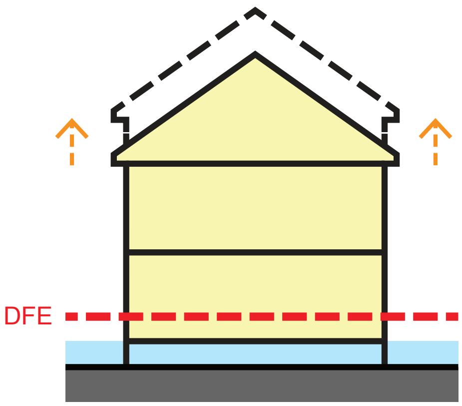
RECOMMENDATIONS

Many coastal communities have become accustomed to the form buildings must take in an area of coastal flood risk – buildings without basements or cellars, or sometimes raised on piles. New York City by and large has not yet made this adjustment from its traditional building forms.

Flood resilience can be achieved through a range of solutions and at different scales of intervention by incorporating a combination of strategies. Adapting a dense, urban environment like New York City to increased flood risk requires a broader set of design strategies than in lower density environments.

Zoning is an important tool for shaping buildings, and can promote good design alongside increased flood protection. This report describes proposed amendments to New York City's Zoning Resolution to enable more versatile and desirable design solutions to accommodate flood-resilient construction.

Change the method of measuring building height to allow added elevation for safety (freeboard).



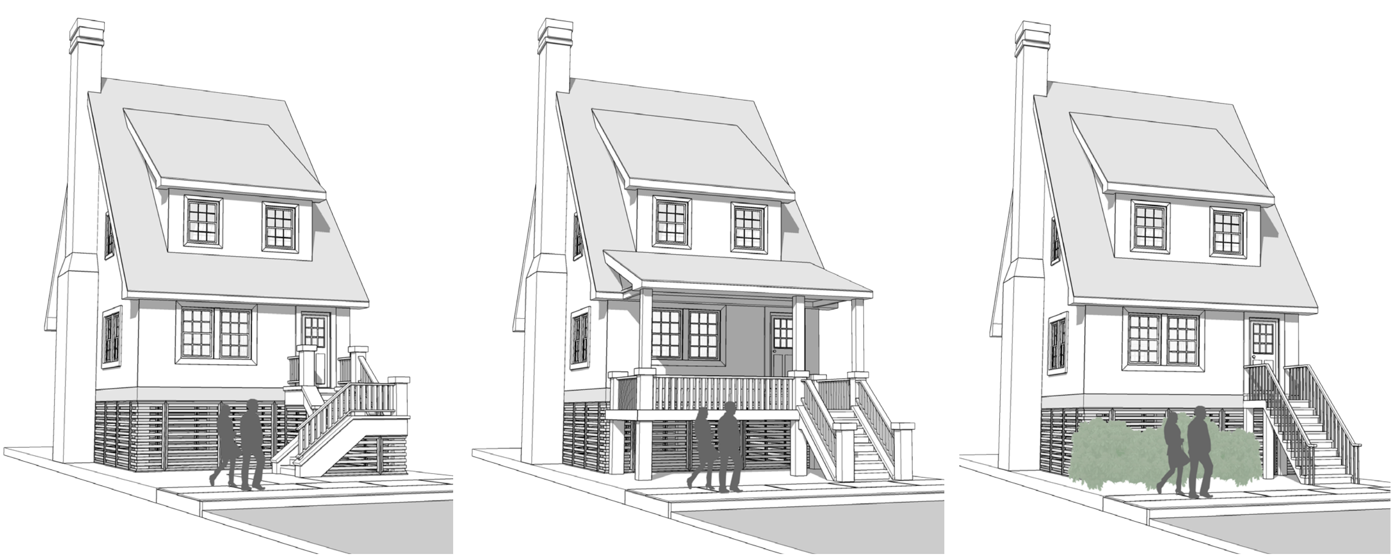
In New York City, zoning measures building heights from different "zero points" in different districts. None of these currently reflect the recent changes to Building Code to require freeboard above the designated base flood elevation. Because of this, elevating the first floor of a building to accommodate the most recent FEMA flood elevations plus freeboard reduces the height available to the building, and may even prevent use of the full floor area allowed. In districts where building height is regulated by the sky exposure plane, which is measured from curb level, street walls may need to be set back from the street line to accommodate the additional height.

To allow the construction of the full building height and floor area while minimizing the need for streetwall setbacks, height could be measured from the elevation at which the lowest floor is placed – the base flood elevation plus freeboard.

Allow – and in some instances require – for architectural elements and streetscape provisions to mitigate visual disconnection between the elevated first floor and the street.

A streetscape that engages the pedestrian is important to the perceived level of comfort and security on the street. When flood-resistant construction requirements prevent active use at the lowest levels of a building, blank walls may result at street level. To alleviate the potential for negative effects on the pedestrian environment, zoning can encourage, and in some cases require design features that promote a vibrant streetscape.

A planting buffer with shrubs or trees, combined with other façade treatments such as vertical articulation, can mitigate limited ground-floor activity. Architectural elements like turns in an entry stair, porches or



Architectural elements can be used to mitigate the visual effects of elevated first floors on the streetscape decks for one and two family buildings can mitigate the distance between grade and the first occupied floor of a building, introduce an additional horizontal visual feature that gives the façade more of a pedestrian scale, and bring "eyes on the street" with a semi-private space closer to the sidewalk.

Where spaces below the DFE have sufficient clearance to become more than a crawlspace, the limited activities allowed (parking, storage, or building access) can still bring some activity to the street, mitigating what otherwise could be a blank wall. For one- and two-family homes in zones with medium to high DFEs (more than 6 feet above grade), zoning could allow additional elevation (to 9 feet above grade) to accommodate a full-height space for parking, storage, or access .

Zoning currently requires minimum street wall transparency on some commercial corridors, to promote a dynamic and pedestrian-friendly retail environment. There are multiple options for maximizing the contribution of the façade to the retail environment. Dry floodproofing, where feasible, can bring not only fenestration but also entrances and retail floor space down to the pedestrian level. Some degree of dry floodproofing can also minimize the degree to which buildings must be elevated. In addition, hybrid strategies are possible involving elevation of interior space with wet floodproofing of entrances and a shallow area near windows, which can serve as display space. The feasibility of each of these options will depend on many factors, including the level of the DFE and the cost of different floodproofing options. Zoning can allow for a variety of solutions, including raising the level at which transparency is required to accommodate elevation of the building.

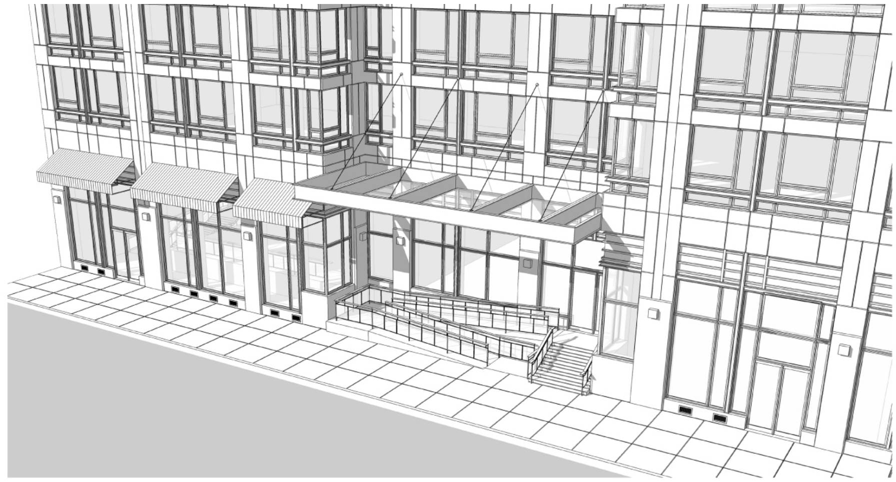
Hybrid floodproofing strategy with commercial display space closer to the pedestrian level

Modify street wall requirements, floor area regulations, and height regulations to allow larger building access elements to be placed outside or inside the building, as needed.

Where elevated buildings are located close to the street line, two options are available for resolving the difference in elevation: stairs and ramps can be located outside the building, or inside the building. Zoning issues can arise with either option. In many zoning districts, a building's streetwall is required to line up with adjacent buildings or be located within a certain distance of the street line, to support neighborhood character or promote an active commercial environment. This restricts the location of access elements on the exterior of the building. Alternatively, when stairs and ramps are located inside the building, they count towards floor area, reducing the amount of usable area within the building. Adjustments to zoning could relieve both of these problems.

Allowing greater flexibility to recess portions of the street wall would allow exterior stairs and ramps to provide access to an elevated first floor. These recesses would also provide an opportunity to better integrate access elements into the building's articulation and site design.

Long expanses of exterior ramping can create a disconnection between the building and the adjacent public



Access elements integrated outside the building facade

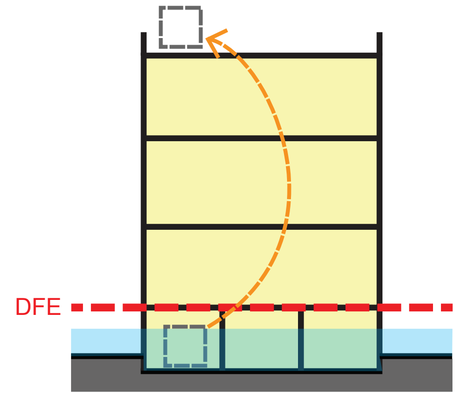
realm and make building access cumbersome. The negative implications for the streetscape can be alleviated by allowing the space necessary for ramps and stairs to be exempted from floor area when placed inside the building. By allowing 100 square feet to be deducted for each one foot of elevation above sidewalk level, zoning could enable buildings to bring these access elements into the building without reducing the amount of usable space allowed.

Where the DFE is substantially above grade but less than a full story above it, the lengthy switchback ramps and stairs located outside the building can dominate the streetscape and divorce the building from the street. If located inside the building, these access elements can make ground floor layout difficult or impossible, especially for narrow sites or for medium to small commercial spaces. In these situations, allowing additional height sufficient to create a full-height ground-floor space could enable accessible entry at grade from the sidewalk, and make possible other enhancements to the streetscape.

Access elements inside the building envelope help preserve streetwall alignment

Allow additional flexibility for placing mechanical equipment above the flood elevation.

It is usually prohibited and, as proved by the aftermath of Hurricane Sandy, inadvisable to locate mechanical equipment below the projected flood elevation. Without the ability to house such equipment below grade, buildings must find places to locate them inside the building, on a rooftop, or in a yard. Zoning can allow greater flexibility for this in several ways. Mechanical equipment could be exempted from floor area calculations within a building, as it currently is in most but not all zoning districts in New York City. Additional space could also be allowed on rooftops for mechanical equipment, and in rear yards or other open spaces where it would not block required windows.



Allow more flexibility for the grading of sites to resolve differences between curb level and flood elevation.

As discussed earlier, when a building is elevated significantly above sidewalk level, the first occupied floor can become disconnected from the street, and longer, more space-consuming access elements are necessary. New York City's zoning currently prohibits raising a required yard above curb level. Allowing for additional flexibility to raise yards to resolve the difference between existing grade and DFE could make it possible to resolve the height differential between the building entrance and street level more gradually, improving the visual and physical connection between the two. This technique is more likely to be applicable at lower densities and on larger lots with deeper front yards. Access elements such as stairs and ramps can be integrated into the landscaping to make a more seamless transition from sidewalk to building. Grading should be designed in a manner that does not create drainage problems for adjacent properties in a

Terraced front yard with plantings can help mitigate effects of elevated first floors flood event.

Similarly, regulations for waterfront sites currently prohibit raising the level of the waterfront yard above the existing natural grade. Such limitations constrain the range of options for resilient site design that can prevent flooding further inland. Allowing yards to be raised, especially on larger sites, could also allow for more design options to mitigate the height differential between grade and the first occupied floor, especially on portions of waterfront sites where DFEs are higher. This solution could help avoid inactive spaces at the pedestrian level and bring activity to public waterfront spaces.

Adjust ground-floor use requirements to maintain street-activating uses where possible in cases where ground floors are substantially above adjacent grade.

Waterfront zoning includes requirements for active ground-floor use in many locations, specifying that any floor within 5 feet of grade must include some active use. However, because permitted uses are constrained within spaces below the DFE, it can be difficult to bring activity to the pedestrian level where DFE is significantly above grade. While it can be more difficult to activate the street level with elevated uses, it is important to retain a level of activity in the portion of the building facing the sidewalk or other publicly accessible area, rather than surrender the entire façade to parking or other activities that contribute little to public realm. Active uses could be required on the lowest floor above the DFE. For the floor below the DFE, requirements for planting and screening could mitigate the negative impacts of blank walls on the pedestrian realm.

Conduct further study of challenging flood zone design issues.

New York City's neighborhoods are diverse in character, built form, and in the uses that front on its streets. There exists a mutually supporting relationship between form, use, and character. Further studies to understand targeted issues will be necessary.

Assembling an inventory of resilient strategies for the City's wide range of buildings and architectural types will facilitate addressing the diversity and complexity of its neighborhoods. These strategies should be analyzed for the affordability, constructability, urban design impact, and most of all their reduction to risk from flooding.

Understanding the structural constraints and feasible design strategies for active retail corridors will help ensure the viability of dynamic street frontages and mix of uses along commercial streets in the flood zones. Additional strategies to activate ground floors that are restricted in use should also be identified.


View of the Hudson River and Manhattan's West Side

SUMMARY OF CONCLUSIONS

New York City, like other communities in the region, has substantial existing populations and infrastructure located within flood zones. These neighborhoods support the maintenance and growth of sustainable communities. Hurricane Sandy has served as a harsh reminder of the importance of flood-resistant construction standards in coastal areas. Even though elevating new buildings is inarguably beneficial to the protection of buildings and populations, it is important also to recognize the challenges created by flood-resistant construction requirements both in terms of affordability to property owners and potential negative impacts to long term planning and urban design. Future investments in these areas need to take into account flood risks, while upholding design principles that support the vitality and desirability of these communities.

This report has identified key design principles to guide architecture, design, and public policy in flood zones, along with several key proposed changes to New York City's zoning that will promote practical, high-quality flood-resistant buildings that may differ from earlier, less resilient construction but are sensitive to the existing context and built heritage of neighborhoods.

As the City works with designers and homeowners to rebuild hundreds of damaged buildings from Hurricane Sandy, the proposed changes to New York City's zoning described here will help realize these objectives for new buildings in the flood zone. But within any set of regulations, it will also be important for designers to find innovative ways to make buildings work within codes and incorporate best practices in flood-resistant building design. To this end, DCP will continue to work with the design community to improve regulations and develop guidelines for flood-resistant buildings in New York City.

Within New York City's large and diverse coastal area, as well as the coastal area within the surrounding region, a range of strategies and mechanisms will be needed to promote more resilient coastal communities. As communities throughout the region continue to promote transit-oriented development around a robust existing transit infrastructure, zoning will be one of many tools to shape communities that are resilient without compromising the quality of the public realm. As communities consider changes to zoning and other regulations as a result of higher flood elevations, they can refer to the urban design principles and the technical strategies outlined in this report as a guide to incorporating greater flood resilience while also improving livability.

GLOSSARY

100 YEAR FLOOD

The 100-year flood, also known as the base flood, is a flood having a 1-percent annual chance of being equaled or exceeded in any given year. Base flood is the national standard used by NFIP (see below) and all federal agencies for the purposes of requiring the purchase of flood insurance and regulating new development.

500 YEAR FLOOD

The flood that has a 0.2-percent annual chance of being equaled or exceeded in any given year.

A-ZONE

Areas subject to inundation by the 1-percent annual chance flood event without velocity (wave action).

BASE FLOOD

(See 100-year flood)

BASE FLOOD ELEVATION (BFE)

The BFE, the computed elevation in feet to which floodwater is anticipated to rise during the base flood, is the regulatory requirement for the elevation or floodproofing of structures. A building's flood insurance premium is determined by the relationship between the BFE and a structure's elevation.

BREAKAWAY WALL

A wall that is not part of the structural support of the building to which it is attached and is intended through its design and construction to collapse under specific loading forces without causing damage to the elevated portion of the building or the supporting foundation system.

B/X (SHADED) ZONE

Areas of moderate flood hazard subject to inundation by the 0.2-percent annual change flood event. Also called the 500-year flood zone.

COASTAL A-ZONE

Areas landward of a V-Zone or landward of an open coast without a mapped V-Zone, subject to inundation by the 1-percent annual chance flood event with additional hazards associated with storm-induced waves between 1.5 and 3 ft. high. (These zones are not mapped in the 2007 effective FEMA FIRMs, but are included in the Advisory Base Flood Elevation maps and will be included in future FEMA FIRMs for the New York Region.)

DESIGN FLOOD ELEVATION (DFE)

The elevation above the BFE including the height of freeboard.

DRY FLOODPROOFING

Dry floodproofing renders a building watertight below the DFE so that floodwaters cannot enter. Dryproofing often entails sealing walls with waterproof coatings, impermeable membranes, or supplemental layers of masonry or concrete; equipping doors, windows, and other openings below the DFE with permanent or removable shields, and installing backflow valves in sewer lines and drains.

FEMA ADVISORY BASE FLOOD ELEVATION

Following severe flood events, FEMA creates Advisory Base Flood Elevations (ABFEs) to show a more current picture of flood risk for certain affected communities. Following Hurricane Sandy, the known flood risk has changed since the last effective community Flood Insurance Rate Map (FIRM) for many communities in New Jersey and New York. The Advisory information can help communities better understand current flood risks and ensure structures are rebuilt stronger and safer to reduce the impact of similar events in the future. Adopting standards based on Advisory information will not change current flood insurance rates within a community. Flood insurance policies are rated using the zones and flood elevations on the current effective FIRM.

FEMA FLOOD INSURANCE RATE MAP (FIRM)

FIRMs are FEMA's official maps of special flood hazard areas and risk premium zones for flood insurance applicable a specific community. Flood zones shown on the map are geographic areas classified according to levels of flood risk, with each zone reflecting the severity and/or type of flooding.

FEMA SPECIAL FLOOD HAZARD AREAS (SFHA)

The SFHA is the portion of the floodplain subject to a 1-percent or greater annual chance of inundation by the base flood, designated Zone A, AE, V, VE on a FIRM. Mandatory flood insurance purchase requirements and floodplain management standards apply. It is also called the 100-year flood zone.

FLOOD PLAIN

A floodplain is the normally dry land area adjoining rivers, streams, lakes, bays or oceans that is inundated during flood events.

FREEBOARD

Freeboard is an additional amount of height above the BFE to provide an additional factor of safety to address the flood modeling and mapping uncertainties associated with FIRMs. Since elevations on FIRMs do not include sea level rise, freeboard can help keep structures above floodwaters as storm surge elevations increase. Recognizing that freeboard reduces flood risk, FEMA provides substantial reductions in flood insurance premiums for structures incorporating freeboard.

NATIONAL FLOOD INSURANCE PROGRAM (NFIP)

NFIP sets national building design and construction standards for new construction and substantial improvements (including buildings that have been substantially damaged) more than or equal to 50-percent of the value of the building in Special Flood Hazard Areas. NFIP underwrites flood insurance coverage only in communities that adopt and enforce floodplain regulations that meet or exceed NFIP criteria.

V-ZONE

Areas along coasts subject to inundation by the 1-percent annual chance flood event with additional hazards associated with storm-induced waves over 3 ft. high.

WAVE ACTION

The characteristics and effects of waves that move inland from an ocean, bay, or other large body of water. Large, fast-moving waves can cause extreme erosion and scour, and their impact on buildings can cause severe damage.

WET FLOODPROOFING

Wet floodproofing includes permanent and contingent measures applied to a structure or its contents that provide resistance to damage from flooding while allowing floodwaters to enter the structure or area. Generally, this includes properly anchoring the structure, using flood resistant materials below the BFE, protection of mechanical and utility equipment, and use of openings or breakaway walls.

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