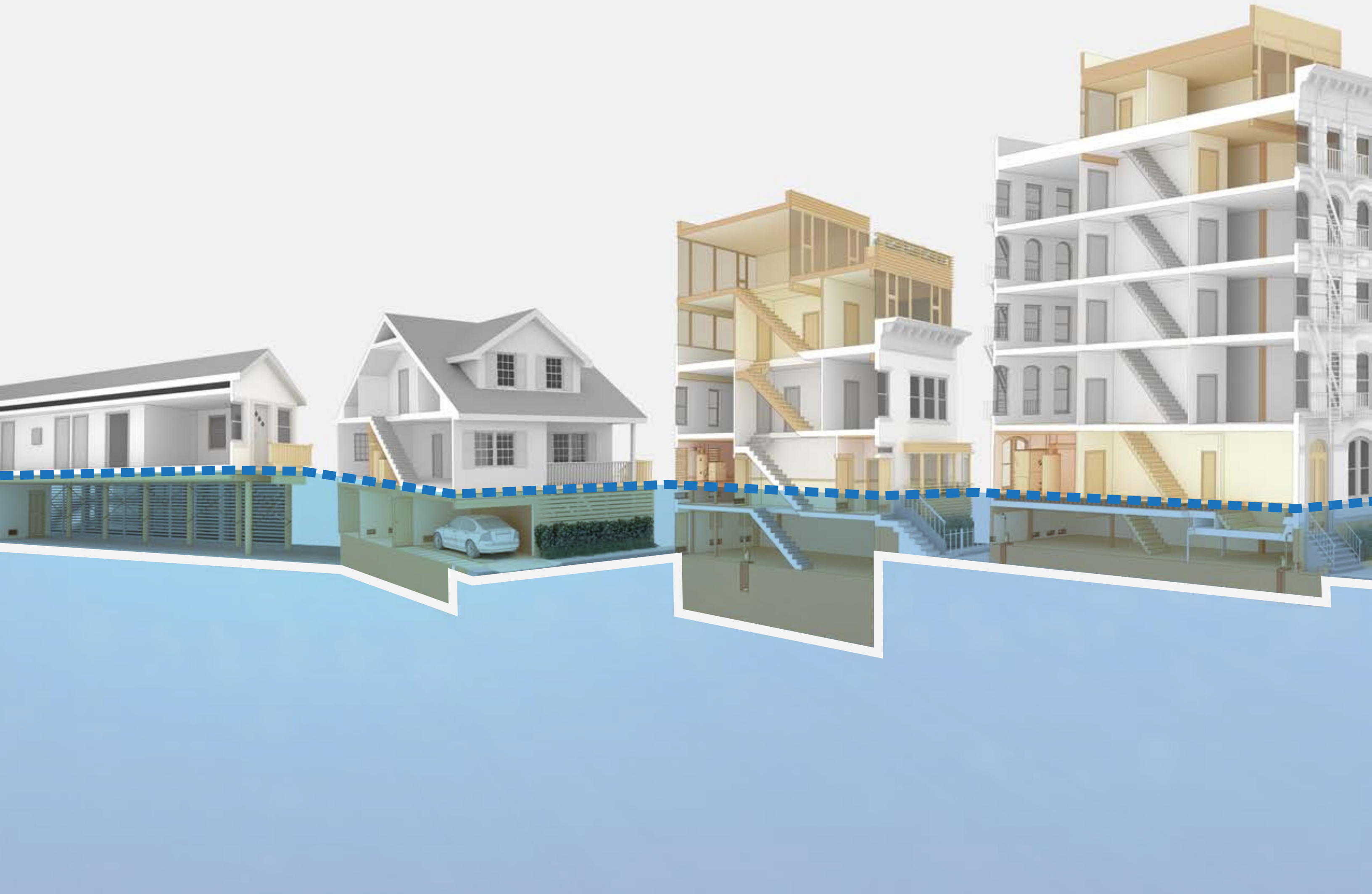
COASTAL CLIMATE RESILIENCY

Retrofitting Buildings for Flood Risk



NYC PLANNING
DEPARTMENT OF CITY PLANNING CITY OF NEW YORK

COASTAL CLIMATE RESILIENCY

Retrofitting Buildings for Flood Risk

THE CITY OF NEW YORK
MAYOR BILL DE BLASIO

DEPARTMENT OF CITY PLANNING
CARL WEISBROD, DIRECTOR

OCTOBER 2014
www.nyc.gov/retrofitting

FOREWORD

Among New York City's greatest assets are its 520 miles of shoreline and its waterfront communities. From the apartment buildings of the Lower East Side to the row houses of Canarsie and the detached homes of Midland Beach, New York City's diverse waterfront communities are an intrinsic part of the city's fabric and important to the overall economic health of the city.

Although New York City's waterfront communities are key to the shaping of the city's future, Hurricane Sandy has exposed our vulnerability to flooding, a risk that will keep on increasing as sea levels continue to rise. Understanding flood risks and the strategies available to protect buildings in the floodplain is a critical step in building more resilient communities and a stronger New York City.

Retrofitting Buildings for Flood Risk is a unique resource to help New Yorkers in the floodplain navigate the new regulatory landscape and learn how to adapt buildings for flood resiliency. By applying a clear step-by-step methodology on how to approach adaptation projects, the report shows a range of retrofit solutions for New York City's most common building types, from bungalows to multi-family residential structures and mixed-use buildings. The report will provide building professionals with a guide to inform their decisions and provide broad education for the architectural and construction communities about enhancing building resiliency. In addition, the report demonstrates limitations of the existing federal flood regulations that affect the city's dense building fabric, and provides specific suggestions for alternative solutions that FEMA should explore.

The report was developed through close coordination with the FEMA Hurricane Sandy Mitigation Assessment Team (MAT), the Department of Buildings, and the New York Chapter of the American Institute of Architects, who all provided professional expertise on flood mitigation strategies. This project also benefited from the guidance and experience of many New York City not-for-profits, who since Hurricane Sandy have worked to provide technical assistance to affected property owners and to advocate for the protection of the city's waterfront communities.

Building a more resilient city requires both building-scale solutions, described by *Retrofitting Buildings for Flood Risk*, and neighborhood-scale engagement and action. To make sure that communities play an active role in shaping their future, the Department of City Planning is pleased to release this report, and is working closely with waterfront residents and business owners in the five boroughs to identify neighborhood-wide strategies that support the vitality and resiliency of communities in the flood zone.

For New York City's waterfront communities to continue to thrive, they must be empowered to adapt to flood risks. *Retrofitting Buildings for Flood Risk* is a key step towards a more resilient New York and it can be extremely useful to other US waterfront cities as well.

Carl Weisbrod, Director
Department of City Planning

PREFACE

Climate change is expected to impact all New Yorkers in the coming decades, as its consequences continue to manifest themselves with increasing frequency. In response, the City has pursued an aggressive set of actions to combat climate change and prepare New York City for the risks of the future. In September 2014, Mayor Bill de Blasio released *One City: Built to Last*, which committed the City by 2050 to reduce its greenhouse gas emissions by 80%, making New York City the largest city in the world to adopt this aggressive target.

Hurricane Sandy highlighted New York City's vulnerability to the risks of coastal storms and climate change. 44 fatalities and over $19 billion in damages and lost economic activity make this point clear, and climate change is projected to only make events like this more likely in the future. Looking ahead, the number of residents in the floodplain is expected to double to almost 800,000 by 2050. The number of buildings in the floodplain, now at 71,500, will grow to 118,100. And the city's infrastructure and neighborhoods will see increased risk and impacts, unless action is taken.

In response, the City has evaluated its risks and developed a climate resiliency plan to reduce the city's vulnerabilities. That plan, *A Stronger, More Resilient* New York, is based on the best available science and lays out a comprehensive set of recommendations – over 250 in all – to strengthen the city's coastline, upgrade buildings, protect critical infrastructure and supply chains, and make neighborhoods safer and more vibrant. In March 2014, Mayor de Blasio released *One City: Rebuilding Together* and established a new Mayor's Office of Recovery and Resiliency (ORR), a first of its kind office focused on preparing the City for the risks of climate change. With the establishment of this office, the City has made a clear commitment to Sandy recovery and long-term climate resiliency.

In 2013, the Department of City Planning released its Flood Resilience Zoning Text Amendment, which clarified building and mechanical equipment elevation, freeboard requirements, alternative uses of ground floor space, and parking issues in the floodplain, and was critical in providing property owners with early options to protect their buildings.

With this latest guide—*Retrofitting Buildings for Flood Risk*—New York City, through the leadership of the Department of City Planning, has now conducted a comprehensive assessment of applicable federal, state and city regulations relating to flood risk, and has a playbook of solutions for resilient construction and retrofits. As homeowners and the professional community look for ways to enhance resiliency of the built environment, this guide will highlight the path forward.

Preparing New York City for the risks of climate change will require a variety of actions by a wide array of stakeholders. *Retrofitting Buildings for Flood Risk* plays a key role in assisting the City's efforts to upgrade and retrofit existing buildings as we continue to build a stronger, more resilient New York.

Daniel Zarrilli, PE, Director
Mayor's Office of Recovery and Resiliency

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EXECUTIVE SUMMARY

The damage and disruption of Hurricane Sandy and the ongoing process of storm recovery highlight the importance of adapting New York City's coastal neighborhoods to withstand and recover quickly from future storms and other climate events. Improving the resiliency of waterfront communities will support their continued vitality and contributions to the city's economy.

Like other American coastal cities -- but to an even greater degree given its size, density, and 520 miles of shoreline --New York City's waterfront neighborhoods face significant challenges in adapting to increased coastal flood risks. There are nearly 71,500 buildings, 532 million square feet of interior space, and 400,000 residents located within the city's 1% annual chance floodplain, as defined in the Federal Emergency Management Agency's (FEMA) 2013 Preliminary Flood Insurance Rate Maps (PFIRMs). While over time, new construction will replace some older buildings, wholesale replacement of the existing building stock would take decades, and would be prohibitively expensive and highly disruptive. Planned coastal protection projects, such as beach dunes and seawalls, will reduce flood risk in some areas, but timelines for their construction are frequently long. Taken together, these factors make it critically important to have guidance on how owners can retrofit buildings in ways that are economically viable and successfully reduce the risk of damage and disruption from coastal flooding.

The complex interaction between new Federal, State, and City codes has changed the regulatory landscape for buildings in the floodplain.

Since Hurricane Sandy, many Federal and local laws and regulations have been modified, with significant implications for the construction and retrofitting of buildings in the 1% annual chance floodplain:

- New Federal flood maps have added approximately 36,000 buildings to New York City's 1% annual chance floodplain, a 101% increase over the previous maps.
- Congressional changes to the National Flood Insurance Program (NFIP), enacted in 2012 and 2014, now require owners to pay higher flood insurance premiums for buildings that predate the flood maps, putting financial stress on many homeowners and property owners who cannot easily retrofit their buildings to meet NFIP standards.
- Changes to City codes, most notably Appendix G of the Building Code, have strengthened requirements for new and substantially improved buildings in the floodplain.

This report is the most detailed analysis to date of the interaction of these regulations and how they shape the available options for making New York City's housing stock more resilient to coastal flood risks.

New York City's wide variety of building types in the floodplain will require a range of retrofitting options. This report provides a step-by-step methodology for architects, developers and property owners to approach decisions about retrofits for many common types of buildings.

FEMA provides extensive guidance for retrofitting one-to-four family detached buildings on large lots, which represent the majority of housing in the United States. NFIP stand-

Midland Beach, Staten Island

ards were crafted largely with these buildings in mind rather than the dense, multi-story urban environment characteristic of New York City. Specifically, buildings in New York City's waterfront neighborhoods are frequently situated on relatively small lots, often attached or close to other buildings, and of masonry rather than light wood frame construction. It is often difficult or impractical for these buildings, which range from one-to-four family detached buildings, rowhouses, tenements or apartment buildings with or without ground-floor retail, to be retrofitted to comply with the NFIP requirements.

Structure, systems, context, regulations and other factors make each type of building easier or more difficult to retrofit in different ways. For instance, masonry buildings with sub-grade foundations have limited and very costly retrofitting options (even though these types of buildings are structurally strong and incurred little structural damage during Hurricane Sandy). Many buildings also share party-walls with other structures, so structural alterations to one building present potential structural implications for the neighboring building. This can make it difficult for individual property owners to take action independently.

This report analyzes and illustrates retrofitting options for ten real-world case study buildings reflecting many of the most prevalent typologies within New York City's floodplain, including the most challenging ones to retrofit. In developing each case study, common siting challenges encompassing a wide range of conditions were taken into account. Overall, a range of adaptation strategies are demonstrated to reflect variations in structural type or other building characteristics. For example, retrofitting strategies may differ for a detached wood frame building on non-structural footings and a detached wood frame home on a masonry foundation.

For each of the ten case studies, the report presents the site and block configuration and construction type. It also details the retrofitting measures available and any associated design challenges, as well as highlights potential regulatory constraints. The primary focus of this report is on strategies that qualify a building for reduced insurance premiums under the NFIP and satisfy the flood-resistant construction requirements of Appendix G of the New York City Building Code, which apply to new and substantially improved buildings. In addition, in recognition of the limited options available within the Federal standards, this report explores practical alternative strategies that would reduce risk for buildings, even though under current regulations these measures may not lower insurance premiums or comply with NFIP standards.

The range of options presented here is not exhaustive, but it is intended to provide New Yorkers living in the floodplain with additional tools to reduce the risks associated with coastal flooding. However, the report cannot replace the expertise provided by a professional architect or engineer. Property owners should always consult and hire an architect and/or structural engineer to verify which retrofit strategy is appropriate for their particular building. This is especially critical in New York City, where many buildings are older and attached or close to neighboring buildings, and where retrofitting options may require substantial structural alterations. Finally, increasing a building's resiliency to flood risk does not mean that residents can forego evacuation procedures. Life safety procedures should always be followed.

Neighborhood vitality and high quality public realm are critical to creating resilient neighborhoods.

In addition to code requirements and engineering considerations, this report recognizes the importance of good design to the city's buildings and neighborhoods. Whether a neighborhood is made up of primarily small frame houses, attached masonry rowhouses or larger, concrete apartment buildings, this built fabric helps define a neighborhood's physical character. The report presents best design practices intended not only to increase resiliency, but also to maintain and enhance the quality of the public realm and the vitality of neighborhoods.

This report highlights and supports ongoing efforts to reform the National Flood Insurance Program to take into account both the strengths and risks unique to the built environment of urban areas.

In addition to providing guidance to those considering options for flood resilient retrofits, this report informs ongoing efforts to incorporate into the NFIP recognition practical strategies for mitigating flood risk in urban areas. Building on the alternatives presented for each typology, the City, working with FEMA, will continue to develop cost-effective alternative methods of mitigation to reduce flood risk to residential buildings that cannot be elevated due to their structural characteristics, and work to ensure that these methods lower premium rates for NFIP flood insurance coverage. These types of changes would better enable New Yorkers to address both the physical and financial challenges of living in the floodplain.

KEY TERMS GLOSSARY

Retrofitting buildings in the floodplain requires the understanding of a number of key terms and concepts used throughout the relevant regulations, codes and guidelines.

Base Flood Elevation (BFE)

The computed elevation in feet to which floodwater is anticipated to rise during the 1% annual chance storm shown on the Flood Insurance Rate Maps (FIRMs) issued by the Federal Emergency Management Agency (FEMA). A building's flood insurance premium is determined by the relationship between the BFE and the level of the lowest floor of a structure.

Basement

As defined by Appendix G of the New York City Building Code, the portion of a building having its floor below the lowest adjacent grade on all sides. The New York City Zoning Resolution defines basement as a floor of a building having less than one-half its clear height below curb level or the base plane.

Cellar

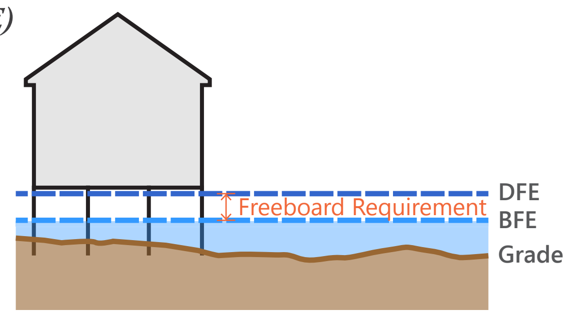
As defined by the New York City Zoning Resolution, the portion of a building that is partly or wholly underground, and having one-half or more of its clear height below curb level or the base plane.

1% Annual Chance Floodplain (100-Year Floodplain)

The area that has a 1% chance of flooding in any given year. It is indicated on FEMA's Flood Insurance Rate Maps (FIRMs) and is also referred to as the "Special Flood Hazard Areas" (see below).

Design Flood Elevation (DFE)

As defined by the New York City Building Code, the minimum elevation to which a structure must be elevated or floodproofed. It is the sum of the BFE and a specified amount of freeboard based on the building's structural category.



Fill

Materials such as soil, gravel or crushed stone placed in an area to increase ground elevations or change soil properties.

Flood Damage Resistant Materials

Any construction material, including finishes, capable of withstanding direct and prolonged contact with flood waters without sustaining any damage that requires more than cosmetic repair.

Flood Insurance Rate Maps (FIRMs)

The official flood map, on which FEMA has delineated the 1% Annual Chance Floodplain or Special Flood Hazard Area (SFHA), 0.2% annual floodplain (Shaded X zone), Base Flood Elevations (BFEs) and floodways.

Preliminary Flood Insurance Rate Maps (PFIRMs)

The Preliminary FIRMs are the current best available flood hazard data. FEMA is in the process of updating the Flood Insurance Rate Maps (FIRMs) for New York City and issued Preliminary FIRMs in December 2013 as part of this process. The New York City Building Code requires new and substantially improved buildings to use the Preliminary FIRMs (unless the Effective FIRMs are more restrictive) until the maps become effective following the public comment period.The Preliminary FIRMs, however, are not used to guide the requirements of the National Flood Insurance Program. Following a comment period and opportunity for appeals, FEMA is expected to issue final Effective FIRMs, which will trigger the expansion of flood insurance purchase requirements.

Floodproofing, Dry

A floodproofing technique that results in the building resisting penetration of flood water up to the DFE, with walls substantially impermeable to the passage of water and structural components having the capacity to resist specified loads. Under the NFIP standards, only non-residential buildings can use dry floodproofing.

Floodproofing, Wet

A floodproofing technique designed to permit parts of the structure below the DFE to intentionally flood, by equalizing hydrostatic pressures and by relying on the use of flood damage-resistant materials. With this technique, parts of the building below the DFE are only to be used for parking, storage, building access or crawl space.

Freeboard

An additional amount of height above the BFE to provide a factor of safety to address the modeling and mapping uncertainties associated with FIRMs, as well as a degree of anticipated future sea level rise. It is a risk reduction requirement found in Appendix G of the New York City Building Code and recognized by the NFIP as an insurance premium reduction factor. In New York City's A Zone, one foot of freeboard is required for commercial and multi-family buildings, and two feet for single- and two-family buildings.

STRUCTURAL OCCUPANCY CATEGORY II	DESIGN FLOOD ELEVATION
1-2 Family Dwellings	BFE + 2 ft
Multi-Family Dwellings	BFE + 1 ft
Commercial	BFE + 1 ft

*per New York City Building Code Appendix G

Lowest Adjacent Grade

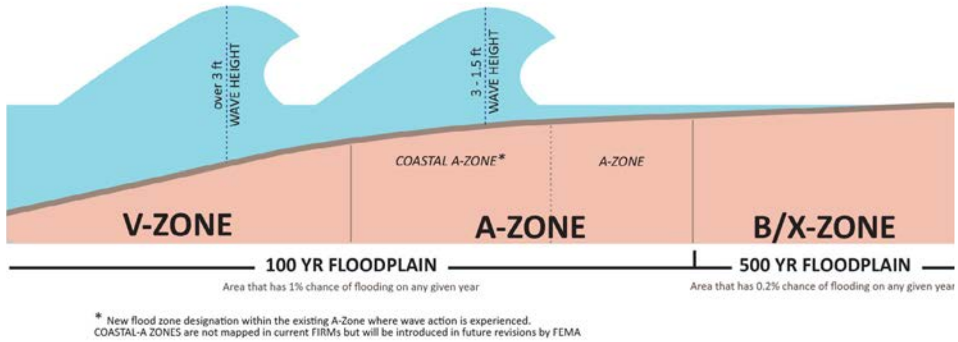
Elevation of the lowest natural or re-graded ground surface, or structural fill, abutting the walls of a building.

Lowest Occupiable Floor

The floor of the lowest enclosed area, including basements. Does not include any wet floodproofed spaces used solely for parking, access, storage or crawl space.

National Flood Insurance Program (NFIP)

Federal program that makes flood insurance available to municipalities that enact and enforce floodplain management regulations that meet or exceed the criteria established by FEMA. Under this program, properties within the floodplain with a federally backed or regulated mortgage, or those that receive federal housing subsidies, are required by law to buy flood insurance. Communities participating in the NFIP must incorporate flood-resistant construction standards into building codes.



Special Flood Hazard Areas (SFHA)

Area of the floodplain that has a 1% chance, or greater, risk of flooding in any given year. Also referred to as the 100-year floodplain or the 1% annual chance floodplain. FEMA uses the North American Vertical Datum 1988 (NAVD 88) for all the elevations. The SFHA is separated into zones depending on the level of hazard:

V Zone

The area of the SFHA subject to high-velocity wave action that can exceed 3 feet in height. More restrictive NYC Building Code standards apply.

Coastal A Zone

A sub-area of the A Zone that is subject to moderate wave action between 1.5 and 3 feet in height. Building regulations are more restrictive than in A Zones and can be similar to those standards that apply for V Zones.

A Zone

The area of the SFHA that is subject to waves under 1.5 feet and still-water inundation by the base flood with specific NYC Building Code standards.

Substantial Damage

Damage sustained by a building whereby the cost of restoring the structure to its pre-damaged condition would equal or exceed 50% of the market value before the damage occurred. When a building is substantially damaged or substantially improved (see below), it is required to comply with Appendix G of the Building Code.

Substantial Improvement

Any repair, reconstruction, rehabilitation, addition or improvement of a building with cost equaling or exceeding 50% of the current market value of the building. When a building is substantially improved, it is required to comply with the flood-resistant construction requirements of Appendix G of the New York City Building Code.

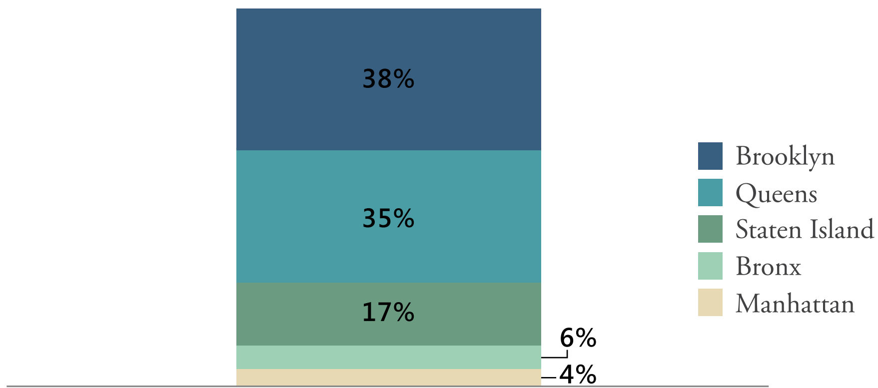
CHAPTER 2 **PROFILE OF NEW YORK CITY BUILDINGS IN THE FLOODPLAIN**

The Rockaway Peninsula, Queens

PROFILE OF BUILDINGS IN THE FLOODPLAIN

Understanding New York City's wide range of building conditions is key to developing the right set of adaptation solutions. The number of buildings in the floodplain in New York City is among the highest in any city in the United States. There are 71,500 buildings in the 1% annual chance floodplain in New York City (graphic below), as shown on FEMA's Preliminary Flood Insurance Rate Maps (PFIRMs) issued in December 2013. These buildings house roughly 400,000 people, making the population of New York City in the floodplain comparable to many mid-sized cities around the country. At this scale, developing retrofitting solutions for New York City buildings will be beneficial to many other older cities that share some of New York City's building typologies but in much smaller numbers.

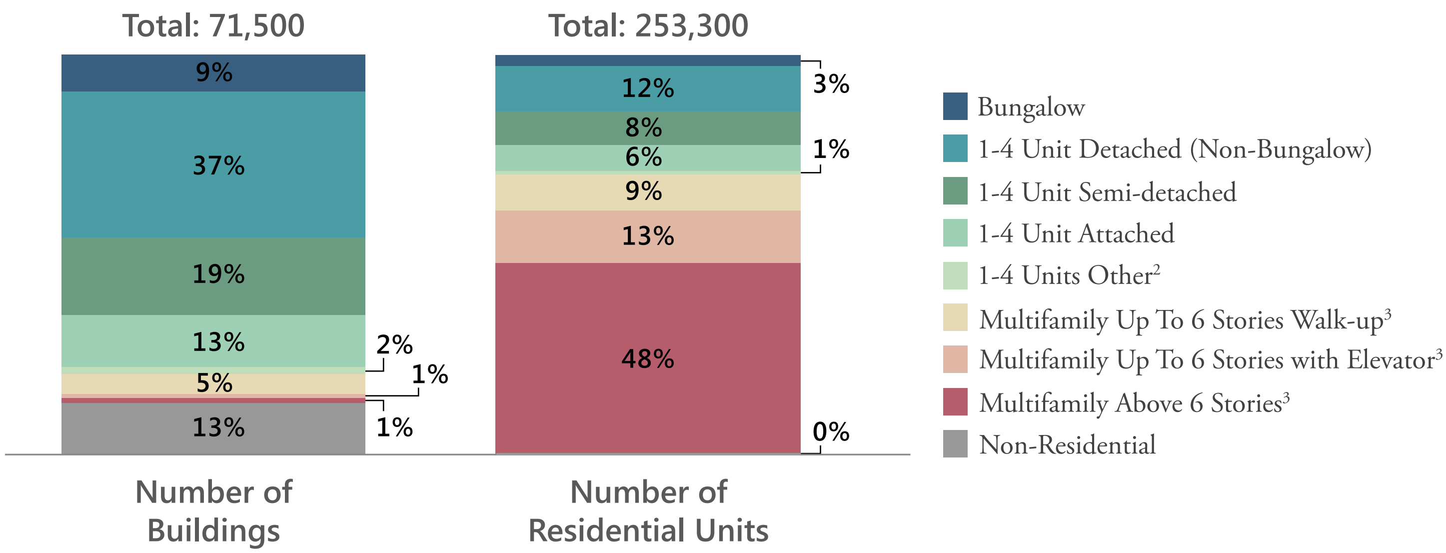
Total: 71,500



Number of Buildings in 1% Annual Chance Floodplain

The vast majority of buildings (97%) in the 1% annual chance floodplain in New York City are located in the A zone, where wave action above three feet is not expected. The large majority, 87%, include residential units (graphic on page 17). While construction in most of the coastal areas throughout the country, such as the Gulf Coast and the Southern Atlantic Coast, consists primarily of single-family detached wood frame homes on large lots, structures in New York City's floodplain include a substantial number of homes on narrow or shallow lots, as well as many higher density and often attached and mid-rise multi-family buildings with various construction types ranging from wood frame, unreinforced masonry, and reinforced concrete. Approximately 37% of the buildings within the floodplain in New York City are 1-4 family, detached buildings on standard lots, defined here as wider than 20 feet. **This means that about 63% of New York City's residential buildings in the floodplain will encounter additional challenges when retrofitting under the current federal regulations.**

The report's case studies are based on prevalent typologies within the floodplain that vary in their vulnerability to damage and in their retrofitting options. The report is focused on retrofitting options for residential and mixed-use buildings that contain residential units. It does not study commercial and manufacturing buildings. For residential buildings, the report does not include multi-family high-rise buildings, defined here as buildings with more than six stories. While high-rise structures only represent less than 2% of buildings in the floodplain, they contain 48% of the residential units (graphic on page 17). These buildings are by definition large and often located on large lots and therefore have more physical retrofitting options. A further study, separate from this report, is necessary to outline the retrofit options available to this building type. Furthermore, in New York City, many of these buildings provide affordable housing to low-income and vulnerable populations through the use of federal housing subsidies, which often limit their capacity to make significant capital investments.



For the purposes of this report, we have classified building types according to key factors that determine which adaptation strategies are feasible. The following physical elements relating to the building and its context were used to define the ten case studies: siting and adjacency, scale, construction type and use.

Siting & Adjacency

This is defined by the proximity of neighboring structures, size of yards and street and sidewalk widths. At a basic level, adjacency applies to building types through the categorization of Detached, Semi-Detached and Attached. A detached building is freestanding and characterized by yards surrounding the building. A semi-detached building typology shares a common bearing wall with another building, often referred to as a party-wall, and as a result, two properties share the same structural entity. Attached buildings share two party-walls, one on each side, making them structurally tied to each adjoining building.

With regards to construction, access to the structure and its foundation must be considered when selecting a retrofit strategy. Narrow streets, lots, and a neighboring building's relationship to the structure may affect the type of construction methods used. To select an appropriate architectural and urban design strategy, factors such as building access, vehicular parking, and streetscape must be considered in addition to a building's construction type and height. When one building adjusts its physical layout, it may have direct implications on its neighbor and the neighborhood as a whole.

Scale

At the individual building scale, building height and street frontage are defining factors. Low-rise (1-2 stories), Mid-rise (3-6 stories) and High-rise (more than 6 stories) are categories used to help define a building's structural characteristics for the purpose of this report. Building lots and their associated building widths are defined by their adjacencies (attached, semi-detached, detached). The length of the streetwall varies widely but generally follows the building typology; 14'-18' for narrow lots and bungalows, 18-20' for attached buildings, 25' for Old Law tenements and up to 100' for multi-family mid-rise buildings. In some cases, especially on narrow lots, it may be more efficient to address retrofitting in clusters of sites or at the block scale instead of retrofitting on the individual building scale.

Construction Type

The New York City Building Code and the International Building Code (IBC) categorize buildings by occupancy. This type of classification and fire separation distance determines minimum fire ratings and size of building. The *Special Initiative for Rebuilding and Resiliency* (SIRR) report lists two categories especially relevant to retrofitting strategies: Combustible buildings, which use light wood frame construction, or wood joists on masonry bearing walls; and Non-Combustible buildings that use steel, masonry, or concrete frames. Retrofitting may require an upgrade from combustible to non-combustible materials as well as the construction of a non-combustible first floor separation.

Use

Floodproofing techniques, as defined by federal, state and local jurisdictions, are regulated by building use. As defined in the Zoning Handbook, residential use is categorized into Single Family, Two-Family and Multi-family. A Mixed-use building is a building used partly for residential use and partly for community facility or commercial use. Under current federal standards, residential uses are not allowed to use dry floodproofing techniques, but community facility and commercial uses within a residential building may use dry floodproofing techniques.

The choice of building types, site locations and application of retrofit strategies are intended to show the most options for retrofit designs over the ten case studies. Therefore, the strategies illustrated may be one option of many, and were selected based on what is considered best practice. Each building and site condition is unique and it is up to the individual property owner to select the appropriate retrofit strategy based on the physical nature of the building and site while considering codes, regulations, and costs.

TYPOLOGY MAPPING

These maps, based on data from PLUTO and the Mass Appraisal System, represent concentrations of buildings in seven typologies within New York City's 1% annual chance floodplain as outlined by the FEMA 2013 Preliminary Flood Insurance Rate Maps. The areas shown in the brightest orange are locations in the city where a high number of buildings are of a particular typology, while areas shown in lighter orange have lower numbers of that typology. The call outs on the maps show the location of retrofitting case studies presented later in this publication.

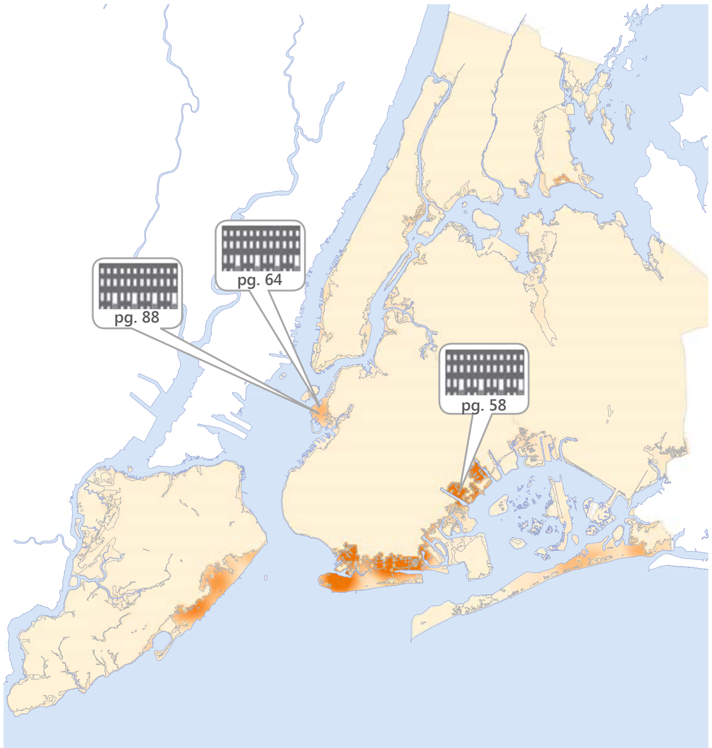
These maps can be used to develop a general understanding of the spatial distribution and extent of each building typology in the city; however, they should not be used for neighborhood-scale analysis or as a basis for comparisons of relative frequencies across different typologies.

[1] These maps do not include non-residential buildings, but that category has been factored into into the percentage of total buildings in the flood zone. All percentages have been rounded for clarity.

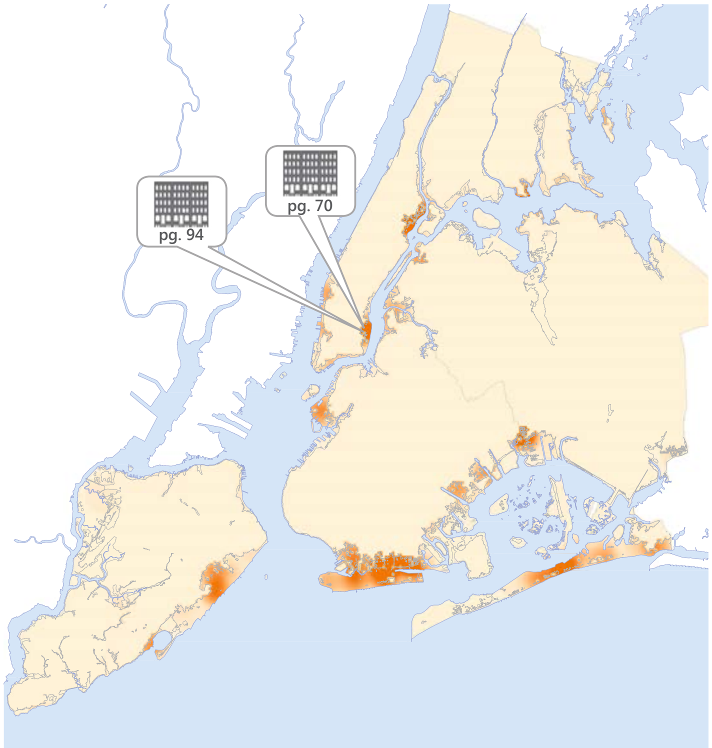
[2] The buildings represented here are narrow (less than 20 feet), single-family, detached homes of wood frame construction.

[3] The buildings represented here are defined as more than four residential units.

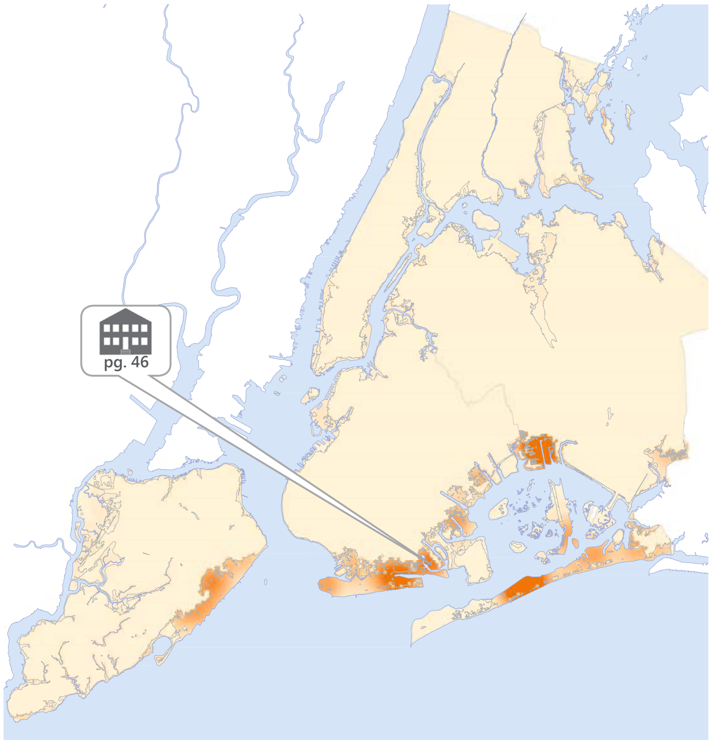
BUNGALOW[2]
6,354 buildings / 9% of total
6,354 residential units / 3% of total



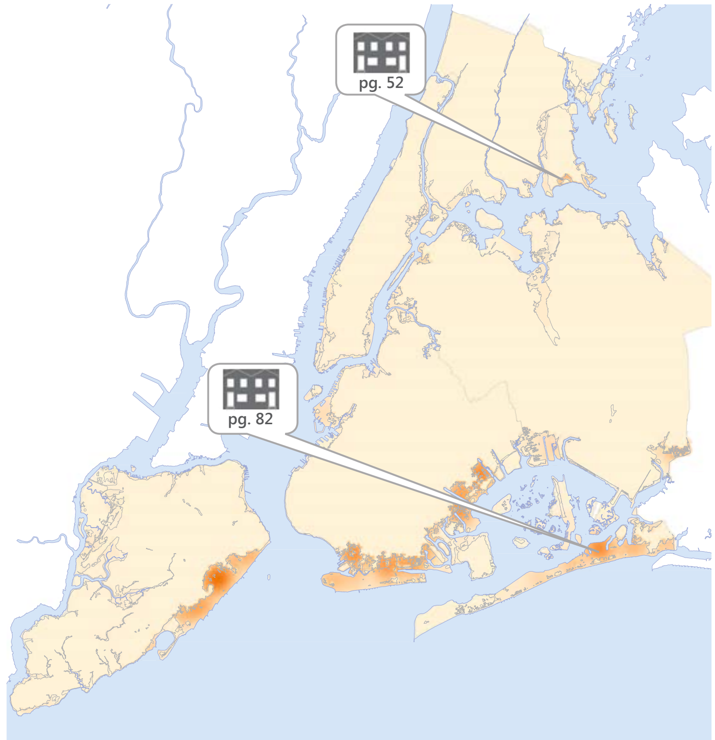
1-4 UNIT ATTACHED
9,320 buildings / 13% of total
16,450 residential units / 6% of total



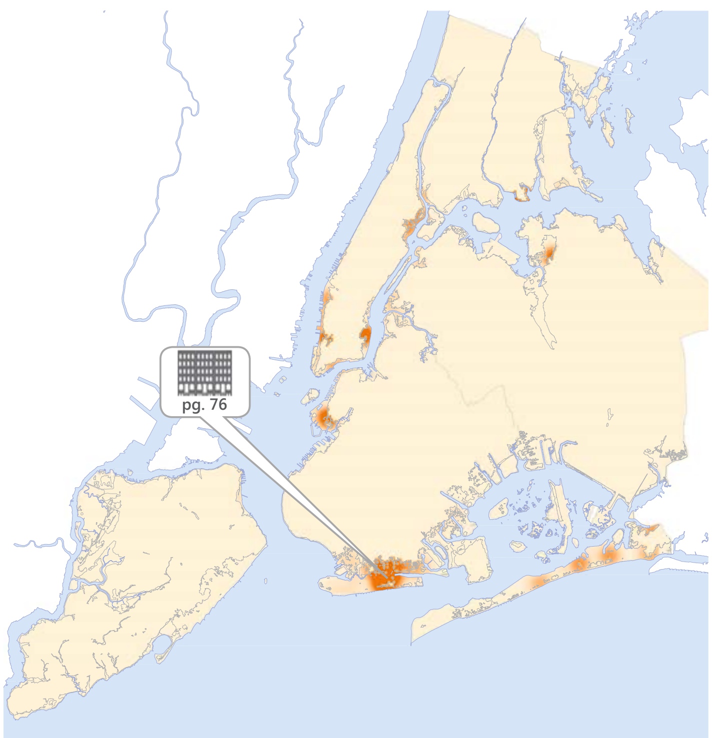
MULTI-FAMILY[3] 6 STORIES OR LESS, WALK-UP
3,480 buildings / 5% of total
22,570 residential units / 9% of total



1-4 UNIT DETACHED (NON-BUNGALOW)
25,860 buildings / 36% of total
29,310 residential units / 12% of total



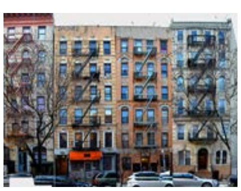
1-4 UNIT SEMI-DETACHED
13,690 buildings / 19% of total
20,990 residential units / 8% of total



MULTIFAMILY[3] 6 STORIES OR LESS WITH ELEVATOR
690 buildings / 1% of total
33,400 residential units / 13% of total

MULTIFAMILY[3] ABOVE 6 STORIES
920 buildings / 1% of total
121,650 residential units / 48% of total

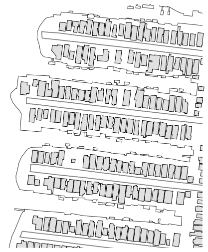
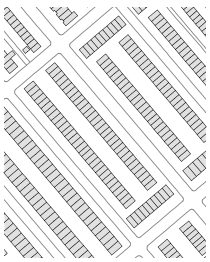
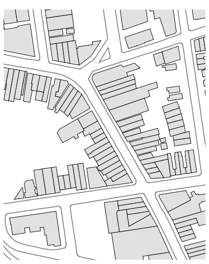
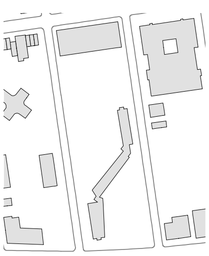
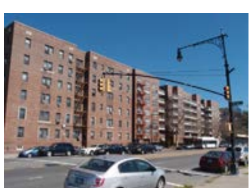
BUILDING TYPES

Building Type	Count within the Flood Zone[4]	Construction Type	Foundation Type	Subgrade Condition	Height
 Bungalow	6,350 buildings[5] 9% of total 6,350 units[5] 3% of total	Wood Frame	Shallow Masonry	None or Shallow Crawl Space	Single Story
 Detached	25,860 buildings[6] 36% of total 29,310 units[6] 12% of total 9% mixed-use[7]	Wood Frame	Masonry	Basement and/or Cellar	1-2 Story
 Semi-Detached	13,690 buildings[8] 19% of total 20,990 units[8] 8% of total 10% mixed-use[7]	Wood Frame or Masonry with Wood Joists	Masonry	Basement and/or Cellar	1-3 Story
 Attached	9,320 buildings[9] 13% of total 16,450 units[9] 7% of total 11% mixed-use[7]	Masonry with Wood Joists	Concrete or Masonry	Basement and/or Cellar	1-3 Story
 Mid-Rise Walk-up	3,480 buildings[10] 5% of total 88,570 units[10] 35% of total 27% mixed-use[7]	Masonry with Wood Joists	Masonry	Basement and/or Cellar	4-6 Story
 Mid Rise Elevator	690 buildings[11] 1% of total 33,400 units[11] 13% of total 6% mixed-use[7]	Steel & Concrete	Concrete or Masonry	Basement and/or Cellar	4-6 Story

[4] The count of building types are based on information from PLUTO and the Mass Appraisal System and are not representative of the specific construction types, foundation type or subgrade condition of each case study. This chart does not include residential buildings above 6 stories or non-residential buildings, but those categories have been factored into into the percentage of total buildings and residential units in the flood zone. Numbers have been rounded for clarity.

[5] These numbers are based on the number of narrow (less than 20 feet),

NEIGHBORHOOD TYPES

Neighborhood Fabric	Neighborhood Type	Lot Size	Lot Coverage	Street Width	Parking
	 **Low Rise Residential Small Lots**	Narrow width & Shallow to Standard depth	Small front & side yards, small to standard rear yard	Narrow or Pedestrian Path Only	Street
	 **Low Rise Residential Semi-Detached**	Small width, standard depth	Small to Medium front/side/rear yards	Narrow, Medium or Pedestrian Path Only	Street, Driveway, Garage or Rear Alley Access
	 **Low Rise Residential Rowhouse**	Small width, standard depth	Small to Medium front & side yards, Small to standard rear yard	Narrow, Medium or Pedestrian Path Only	Street, Driveway, Garage or Rear Alley Access
	 **Low Rise Mixed Use**	Narrow to wide width & shallow to standard depth	Relative to Contextual Density	Medium	Garage or Rear Alley Access
	 **Mid Rise Mixed Use**	Medium to wide width & standard depth	Small or No front/side yard, Small to Medium rear yard	Medium to Wide	Rear Alley Access
	 **Mid Rise Residential**	Medium to wide width & standard depth	Small to Medium front/rear yards, No side yard	Medium to Wide	Garage

single-family, detached homes of wood frame construction.

[6] 1-4 unit detached buildings other than those captured in the "bunagalow" category.

[7] The precentage of lots in this category that contain at least 500 square feet of commercial flood area.

[8] 1-4 unit semi-detached buildings.

[9] 1-4 unit attached buildings.

[10] Buildings with 5 or more units, less than 6 stories, and no elevator.

[11] Buildings with 5 or more units, less than 6 stories, and an elevator.

CHAPTER 3 **RETROFITTING METHODOLOGY**

To best understand a building's flood risk and opportunities for adaptation, one must be able to identify the building typology and specific flood risks, the construction methods best suited to protect the structure, as well as the appropriate codes and regulations that control adaptation techniques. The report proposes the following methodology to facilitate informed decision-making.

Broad Channel, Queens

STEP 1 IDENTIFY YOUR FLOOD RISK

STEP 2 IDENTIFY YOUR FLOOD ELEVATION

STEP 3 REVIEW RELEVANT REGULATIONS

STEP 4 IDENTIFY YOUR ADAPTATION STRATEGY

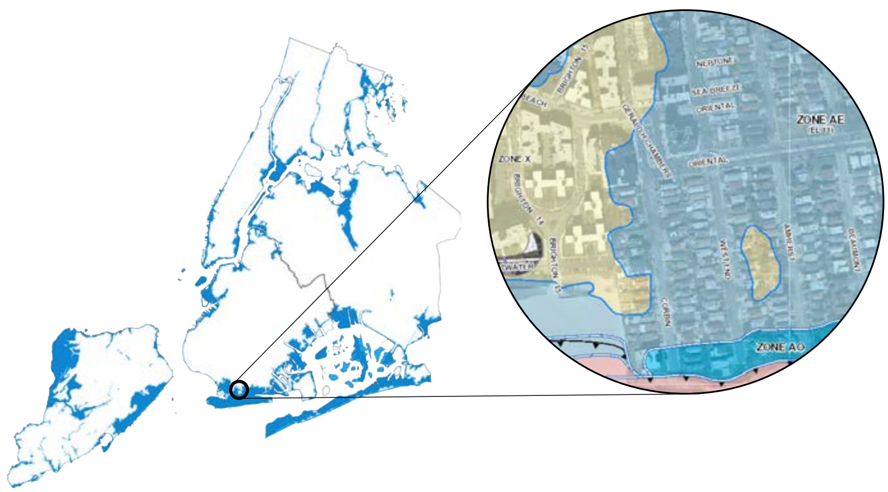
STEP 5 DESIGN YOUR STRATEGY

STEP 1 IDENTIFY YOUR FLOOD RISK

To identify the floodplain of your property, consult FEMA's Flood Insurance Rate Maps (FIRMs) http://www.region2coastal.com/preliminaryfirms. FIRMs are FEMA's official maps of special flood hazard areas for flood insurance applicable to a specific city. Floodplains shown on the map are geographic areas classified according to levels of flood risk, with each zone indicating the severity and/or type of flooding.

If the property is located within the V Zone, Coastal A Zone, or A Zone, it is considered at high risk of flooding. The FIRMs also tell you the projected flood elevation of the 1% annual chance storm in the area in which your property sits. This is the height to which water is expected to rise in a "100 year flood event." Flood elevations are measured from a fixed zero elevation point, called a datum. In the case of the 2013 Preliminary FIRMs, it is the 1988 North American Vertical Datum (NAVD88).

If a property is not in the 1% annual chance floodplain, it does not mean that it is necessarily protected from future flooding. FEMA estimates that about 25% of flood claims come from properties outside the 1% annual chance floodplain. Properties located in the 0.2% annual chance floodplain, also called the 500-year floodplain, may also want to consider retrofitting.



Use FEMA maps to determine your flood zone and flood elevation

Special Flood Hazard Areas (SFHA)

Area of the floodplain that has a 1% chance, or greater, risk of flooding in any given year. Also referred to as the 100-year floodplain or the 1% annual chance floodplain. FEMA uses the North American Vertical Datum 1988 (NAVD 88) for all the elevations. The SFHA is separated into zones depending on the level of hazard:

V Zone
The area of the SFHA subject to high-velocity wave action that can exceed 3 feet in height. More restrictive NYC Building Code standards apply.

Coastal A Zone
A sub-area of the A Zone that is subject to moderate wave action between 1.5 and 3 feet in height. Building regulations are more restrictive than in A Zones and can be similar to those standards that apply for V Zones.

A Zone
The area of the SFHA that is subject to waves under 1.5 feet and still-water inundation by the base flood with specific NYC Building Code standards.

STEP 2 IDENTIFY YOUR FLOOD ELEVATION

Understanding where your building is in relation to grade and the flood elevation is critical in determining what floodproofing measures must be taken. This involves (1) locating the lowest adjacent grade elevation on your property, (2) the lowest floor of your building, and (3) the Design Flood Elevation (DFE) for your building. The Design Flood Elevation is the elevation at which the lowest occupiable floor must be located or the height to which dry floodproofing must be installed.

The Design Flood Elevation is calculated by adding Freeboard to the Base Flood Elevation noted on the FEMA flood maps. In New York City, the Building Code requires that buildings apply "Freeboard" to their base flood elevation to include an additional margin of safety to protect against more severe storms and increased future flood risks from rising sea levels. Freeboard is one foot for commercial and multi-family buildings and two feet for single- and two-family buildings.

The most effective way to identify the flood level of a building is to obtain an Elevation Certificate from a professional engineer, architect or land surveyor. An Elevation Certificate officially documents the building's elevation and its relationships to the Base Flood Elevation. It is one of the key documents to provide in order to purchase flood insurance and it provides all the basic critical information to determine the appropriate retrofit strategy.

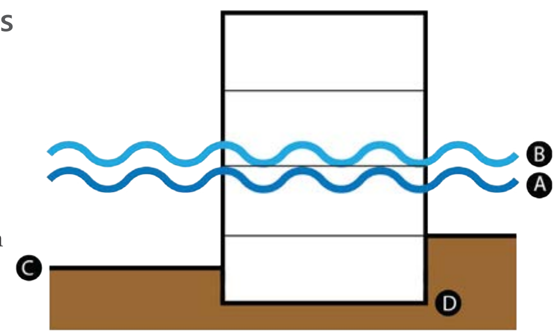
Determine critical elevations for your building

A Base Flood Elevation (BFE)

B Design Flood Elevation (DFE)
=BFE + Freeboard

C Lowest Adjacent Grade Elevation

D Lowest Floor Elevation



STEP 3 REVIEW RELEVANT REGULATIONS

Regulatory Tools

Knowing the codes and regulations at the federal, state and local level will structure your approach to retrofitting for resiliency. Flood retrofitting design and construction is regulated by FEMA's FIRMs, State and City building code, as well as City zoning regulations and other local laws. FEMA sets standards for floodplain management at the federal level, which is enforced through state and local regulations. FEMA also administers the NFIP. In order for homeowner and property owners in the city to receive flood insurance as part of the NFIP, the City is required to adopt these federal standards into its building code. Local standards are also required to be as stringent as state codes. At the state level, the New York State Department of Environmental Conservation (DEC) is the State Floodplain Administrator.

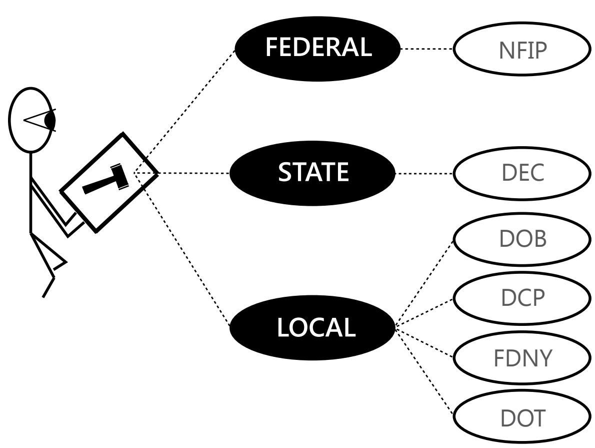
At the local level, The New York City Department of Buildings is designated as the City's Floodplain Administrator and is tasked with enforcing Appendix G of the NYC Building Code, which prescribes standards for flood-resistant construction in accordance with federal mandates. On January 31, 2013, the New York City Building Code was updated to match New York State standards for flood protection. And in October 2013, the Department of City Planning updated its Zoning Resolution with a Flood Resilience Zoning

Text Amendment to remove regulatory barriers that hinder or prevent the reconstruction of storm-damaged properties in compliance with the NYC Building Code. The amendment enables new and existing buildings to comply with new, higher flood elevations issued by FEMA, and to new freeboard requirements in the New York City Building Code. Constructing to these new standards reduces vulnerability to future flood events, as well as helps property owners avoid higher flood insurance premiums. The zoning text amendment also introduces regulations to mitigate potential negative effects of flood-resistant construction on the streetscape and public realm.

Threshold For Compliance

One of the most important factors in identifying retrofitting strategies is to determine whether a building is Substantially Damaged or Improved. A building is considered substantially damaged when the cost to repair or restore the structure to its pre-damaged condition would equal or exceed 50% of the market value of the structure before the damage occurred. Additionally, even if the home is not substantially damaged, if the cost of improvements to the property, including any repair, reconstruction, rehabilitation, or addition to a building equals or exceeds 50% of the market value before the improvement starts, the building is considered Substantially Improved. If the building falls within either of these definitions it must be completely brought up to current flood resistant construction standards set forth in Appendix G, as well as other requirements of the NYC Building Code. If a building is not Substantially Damaged or Improved, it has access to many more options for mitigation. But these strategies may not reduce flood insurance premiums and may not offer full protection.

Understand how Federal, State and City floodplain regulations impact your options



National Flood Insurance Program

Flood insurance costs are expected to rise for homes that do not meet the resiliency standards set forth by the National Flood Insurance Program (NFIP), which is administered by FEMA. Homeowner and property owners of buildings in the 100 year floodplain with a mortgage from a federally insured bank are mandated by law to buy flood insurance. Buildings receiving subsidies as part of a federal housing program are also required to carry flood insurance. Recent reforms to the NFIP that reduce subsidies to homeowner and property owners will cause premiums to increase significantly. The cost of flood insurance for residential buildings is based on a number of factors, one of the most important of which is the distance between the lowest occupied floor and the Base Flood Elevation (BFE). Therefore, it is advantageous, in terms of insurance cost, to have the lowest occupied floor above the BFE. Locating critical systems above the BFE can also provide a premium reduction, but the savings are greatest only when combined with elevation. For buildings that are not substantially improved, retrofitting is at the discretion of the owner.

If a residential building is substantially damaged, or improved, it is required by the NFIP to fill sub-grade spaces to the level of the lowest adjacent grade. For building typologies with one or more shared party-walls, this will result in a challenging retrofit strategy. NFIP regulations restrict the use of residential areas located below the BFE, and the NYC Building Code restricts uses below the Design Flood Elevation (DFE), to building access, crawl space, storage, and vehicular parking for new and substantially improved structures. For residential buildings, appliances, heating and cooling equipment are not allowed below the DFE.

The Role Of The Fire Code

The New York City Fire Code is a City law that establishes fire safety requirements for buildings. Depending on the height of the home, its occupancy, and the width of the street on which it is located, sprinklers may be required. In some circumstances, exceptions to some Fire Code requirements can be requested when elevating an existing building, but it is at the discretion of the New York City Fire Department.

Other Considerations

Depending on the specific circumstances of the property and retrofitting strategy, other agencies with relevant codes may need to be involved, as well. For example, if the property is within a Historic District or is a designated landmark, the NYC Landmark Preservation Commission (LPC) would need to review the proposed project. Similarly, listing on the National or State Registers of Historic Places makes some structures exempt from certain NFIP standards, but these should be reviewed in coordination with LPC and the State Historic Preservation Office. There are also relevant State regulations, such as the Coastal Erosion Hazard Area and Wetland Regulations, which may prescribe specific requirements in certain areas. If some of the features of the retrofit strategy encroach in the public right-of-way, the NYC Department of Transportation would need to get engaged and a revocable consent may be needed. If a property needs to connect to existing sewer infrastructure, a permit with the Department of Environmental Protection may also be necessary. Finally, if a building contains rent stabilized or other subsidized units, and the retrofit strategy involves making significant changes to these units or removing some, it will be important to check the appropriate housing subsidy program rules.

Floodproofing Measures

To provide guidance, regulatory agencies divide retrofit strategies into four categories: Relocate, Elevate, Wet Floodpoof and Dry Floodproof. These strategies address designing for resiliency through location and use of structural systems (the superstructure and the foundation), critical systems (mechanical, electrical and plumbing systems) and materials. FEMA's Building Science division provides technical design guidance for all categories of floodproofing construction standards through various publications, such as the *Engineering Principles and Practices of Retrofitting Floodprone Residential Structures, Floodproofing Non-Residential Buildings, Coastal Construction Manual, Reducing Flood Losses through the International Code Series* and other resources. Refer to http://www.fema.gov/building-science for the support documents appropriate to different mitigation strategies.

Use is a key determinant in identifying retrofitting strategies. Under current federal standards, residential buildings are not allowed to dry or wet floodproof habitable spaces. Commercial uses are not allowed to be wet floodproofed. Factors such as technical parameters, code requirements, cost, homeowner preference, urban design and are also key elements in identifying appropriate retrofitting measures. Property owners should consult a structural engineer or design professional to verify which retrofit strategy is appropriate for their structure.

RELOCATE

This measure can offer the greatest security from flooding but may be impossible to achieve in dense, historic urban centers like New York City. Finding a site to relocate outside the floodplain on the existing lot or to relocate the building to an entirely different lot is rarely a viable option.

ELEVATE

Elevation of Structure

Elevating the lowest occupied floor of a building above the Design Flood Elevation (DFE) is a widely recognized best practice. This can be accomplished by lifting the existing superstructure or by relocating the lowest floor to above the DFE if the floor to ceiling height is sufficient. The most critical steps to elevating the superstructure involve construction of a new foundation. When elevating a building, areas below the DFE can be used only for vehicular parking, building access, crawl space and storage. Equipment, utility connections and all interior utility systems including ductwork must be relocated above the DFE.

In New York City, elevation is likely a limited strategy because of the pre-existing adjacencies and structural challenges related to the building typology. Because the uses under the lowest occupied floor are very limited, elevation also challenges New York's traditional relationship between buildings and the street, potentially resulting in safety and urban design issues. These particular urban challenges will be discussed later in more details. However, within the existing federal framework for building resiliency, elevation offers the benefit of reducing risks and flood insurance premiums.

PROS	CONS
Reduces flood insurance premiums Reduces risk to structure and contents by providing complete protection against water damage	Difficult or infeasible for semi- and attached buildings Is expensive, sometimes more expensive than the value of the building Requires temporary relocation of inhabitants May have adverse impacts on streetscape Requires new access

Fill Basement and or Cellar (non-structural elevation)

Related to structural elevation, filling a sub-grade basement or cellar of certain building types can achieve the same effect as structural elevation from an insurance standpoint, without some of its disadvantages. This strategy may need to be combined with the elevation of utilities and mechanical systems. A significant drawback is the loss of floor area resulting from the filling, which can make a notable impact if the space was occupied or generated rental income. When filling a sub-grade space that has one or more party-walls, consideration of impact on the adjacent property must be given. This strategy is most effective when the DFE is at or below the first occupiable floor.

PROS	CONS
Reduces risk Can have limited impact on neighborhood fabric May provide reduced insurance premiums	May result in loss of floor area in basement; loss of parking; loss of income from rental unit Depending on neighbor's strategy, may create problems of hydrostatic pressure if building shares walls with adjacent structures Significant cost required to protect against hydrostatic pressure located in high water table Existing foundation may settle or fail due to surcharge associated with fill placement

Abandon Lowest Occupied Floor and Wet Floodproof (non-structural elevation)

Similar to filling sub-grade spaces, elevation may be achieved by filling the below grade space and abandoning the remaining occupiable floor(s) below the DFE. If this strategy is taken, all enclosed spaces below the DFE and at or above grade must be wet floodproofed.

Elevation of Critical Systems

Elevating mechanical and plumbing systems, electrical utilities and other building system components increases a household's overall resiliency to flooding by reducing the amount of time before key systems are operational again after a flood.

PROS	CONS
Reduces cost of repairs when flooding occurs Reduces the time it takes to get back home after a flood Depending on configuration, can be easy to implement as compared to other adaptive strategies Provide minimal credits for flood insurance policies	May result in loss of usable space Significant costs may be associated with complying with code provisions and required structural reinforcement May require temporary relocation of inhabitants

WET FLOODPROOF

As stated in FEMA *Engineering Principles and Practices*, wet floodproofing may be used for structures that cannot physically be elevated, such as buildings with shared bearing walls. It entails allowing floodwaters to enter and exit the building in order to equalize hydrostatic pressure, reduce the danger of buoyancy from hydrostatic uplift forces, and limit damages to the structure and finishes. Utilities, controls and equipment must be elevated above the DFE. Such measures may require alteration of a structure's design and construction, use of flood-resistant materials, adjustment of building operations and maintenance procedures, and relocation and modification of equipment and contents. The design should address how the required number of openings and their locations will be achieved since openings need to be installed on at least two sides of the building.

Uses permitted within wet floodproofed construction are limited to vehicular parking, crawl space, building access and storage. To limit the loss of useable floor area, the Flood Resilience zoning text amendment permits building owners who wet floodproof their ground floor to add an equivalent amount of space above the DFE within the existing zoning building envelope. Wet floodproofing commercial spaces is prohibited.

Openings for water penetration and exit must be engineered according to ASCE 24 requirements. A minimum of two openings is required for each enclosed area below the DFE, to be installed on at least two sides of each enclosed area. Each opening must be located no higher than one foot above the grade immediately under the opening. If interior grade is different from exterior grade, reference for the placement of the opening is taken from the higher of the two.

PROS	CONS
Can be combined with other adaptive measures to drastically reduce damage from flooding	Can mean loss of useable floor area
Accounts for hydrostatic pressure	May be difficult to retrofit existing structures to meet wet floodproofing requirements
May be inexpensive	May have adverse visual impact on streetscape

DRY FLOODPROOF

Dry floodproofing involves making a building, or an area within a building, substantially impermeable to the passage of water. This translates to no more than 4 inches of water accumulating during a 24 hour period. Dry floodproofing of residential buildings or dwelling units within non-residential buildings is prohibited.

Buildings in poor structural condition may not be able to be dry floodproofed as this technique would put extreme pressure on exterior walls during a flood and cause structural failure. In general, dry floodproofing techniques are challenging and costly to implement. All buildings require an assessment to determine their structural integrity relative to the site's DFE.

Several measures need to be implemented to dry floodproof a building:

- Strengthening the foundation, floor slabs and walls to resist hydrostatic loads and buoyant forces
- Installing backflow preventers
- Applying a waterproof and impermeable coating or membrane to exterior walls
- Sealing all wall penetrations including windows, doors and locations where utilities enter the building
- Strengthening walls to withstand flood water pressures and flood debris

Although FEMA does not recognize dry floodproofing as an acceptable strategy for residential structures, it can be appropriate for commercial uses, building access in existing mixed residential and commercial use buildings, as well as for community facility use.

PROS	CONS
Can have limited impact on building design and neighborhood fabric Can provide reduced insurance premiums for some uses Can be combined with other adaptive measures to reduce damage from flooding	May be costly as it requires a structural retrofit Not approved for new or substantially improved residential buildings Need to account for flood waters entering through shared structural walls Wood frame buildings may not be able to withstand dry floodproofing Building may require structural reinforcement to accept flood load pressure All means of egress that are blocked must be replaced with alternate means of egress above the DFE, making this option extremely challenging for many urban properties located at or close to the lot line and/or with narrow streetwalls

Deployable flood barriers

Deployable flood barriers in windows and doors are often considered part of a dry floodproofing approach. To be compliant with the NYC Building Code, flood barriers must be integrated within the building structure. Freestanding flood barriers that can be deployed around an entire site or group of sites to achieve protection beyond the site are categorized as “active” floodproofing measures because they require human intervention. They are currently not allowed for new or substantially improved buildings and result in lesser flood insurance premium reductions than passive flood barriers that are part of the structure of the building.

PROS	CONS
May have limited impact on building’s structure and appearance May be less expensive depending on the structure and site conditions Can be combined with other adaptive measures to reduce damage from flooding May be applied at block-scale	Not approved by FEMA for residential buildings Can cause structural damage if not correctly sized for exerted loads or capacity of existing building Does not protect against water penetrating from adjacent buildings or through sewer systems Protects against short-term flooding only Requires advance notice of coming floodwaters and installation expertise, time, expense Vulnerable to human error since barriers require a set up in advance of a flood event Most flood barriers require a storage space within or close to the building

STEP 5 DESIGN YOUR STRATEGY

When designing a retrofit strategy, several criteria must be taken into account to inform the decisions. *Technical Criteria* relate to the buildings skeleton and organs, in other words, what makes it stand and operate. *Urban Design Criteria* relate to the character of the building and its relationship to the public street, its neighbors and the neighborhood as a whole.

Identify the physical and operational characteristics to inform design decisions and best practices

Identify building type

Select approach

Substantial Damage
Substantial Improvement

Alternative
Strategies

Assess Feasibility

Insurance and Filing

Individual or Communal

Fees and Construction Cost

TECHNICAL CONSIDERATIONS

A building is a structure divided into two distinct elements, the superstructure and the foundation. For a building to withstand dead and live loads, there must be a continuous load path from the roof through the superstructure to the foundation. The structure alone does not make a building complete. It relies on its critical systems to function. Mechanical, electrical and plumbing systems are the foundation of the critical systems. Enabling an inhabitant to stay in a structure depends on the continuous function of the critical systems to provide them with access to food, water, and heat while the structure provides them with shelter.

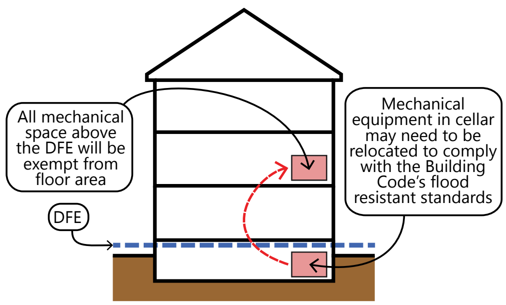
STRUCTURAL SYSTEMS

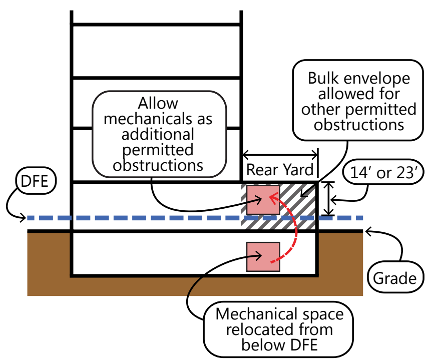
Physical characteristics associated with structural systems serve as predictors for flood damage. Sandy demonstrated that buildings tied to sub grade foundation and especially masonry structures can resist flood impact loads significantly better than other structures. In addition, many buildings in the floodplain are either attached (sharing one or both structural bearing walls) or mid to large scale detached structures. These building types are sufficiently heavy and connected to their foundations and thus suffered little to no structural damage. Much of the damage to this type of building was to interior finishes, critical systems and contents. The *FEMA Mitigation Assessment Team* (MAT) report concluded that few major structural issues related to damage of basement and sub-grade areas were encountered during Sandy. The structural integrity of foundation and masonry buildings was an important consideration to the development of alternative adaptation measures for the case studies. The buildings that are most vulnerable to flood damage, and that comprised the majority of structural failures during Sandy, are one story combustible structures such as bungalows and small detached homes.

CRITICAL SYSTEMS

Like organs to the body, building systems are critical to the everyday functioning of any building type. As stated in the FEMA MAT report, these systems include Mechanical, Electrical, and Plumbing (MEP), elevators, emergency power systems, fuel tanks, sump pumps and other related equipment such as communication and alarm systems. The inundation of critical systems can cause the building to be uninhabitable or to have limited functionality for weeks or even months. This in turn poses significant risk to the occupants of the buildings, especially vulnerable populations such as the elderly and people with disabilities. Many buildings that did not incur substantial damage during Hurricane Sandy did experience damage to the building's systems such as furnaces, boilers, water heaters, and electrical panels.

Building systems are often placed, or centralized, on the lowest floor of the building (often sub-grade) due to building code requirements or simply because the upper floors are more desirable for occupiable or rentable space. Appendix G of the New York City Building Code requires that all new and substantially improved buildings locate utilities and equipment at or above the DFE as specified by ASCE 24, Table 7-1, or be designed, constructed, and installed to prevent water from entering or accumulating within the components. A description of the most common elements of critical building systems found within New York City low to medium density residential and mixed-use typologies is found in the appendix section of this report as well as Appendix I of the Building Code.





Although it is not required for buildings that are not substantially improved, FEMA recommends that all buildings elevate critical utility systems to the BFE or higher. If space on a higher floor is not available, NYC Building Code allows equipment to be relocated to a platform as part of an addition to the building. If equipment cannot be relocated above the DFE it should be raised as high as possible in its current location and protected from water inundation by code compliant encapsulation techniques. For additional information on mechanical specifications, refer to the New York City Building Code. The Department of City Planning's recent Flood Resilience zoning text amendment provides additional flexibility for the location of such equipment.

Due to the unique nature of each system and its relation to the physical structure of the building, careful consideration must be taken to the particular approach to mitigate flood risk through location of the critical systems. This is especially important in dense environments like New York City where additional structural loads, clearance and ventilation requirements and/or loss of usable space may have other repercussions on existing systems as well as on the economic viability of the building. Relocating critical systems can be an opportunity to also upgrade systems and improve energy efficiency.

COST CONSIDERATIONS

Cost will be an important consideration in the design process for retrofitting buildings. In addition to the construction costs and fees associated with the different professionals, often including structural engineers, who will be involved, property owners may be faced with the loss of usable square footage. The loss of floor area related to the wet floodproofing of the ground floor and the inability to replace basements, cellars or ground floor spaces may be a severe challenge, especially for homeowner and property owners who need rental income to support their mortgage payments. However, retrofitting a building will decrease flood insurance rates and increase the resale value of the building.

URBAN DESIGN CONSIDERATIONS

Retrofitting buildings to better withstand extreme weather is essential, but it shouldn't come at the expense of a vibrant streetscape. Mitigating the potential negative impacts of some retrofit strategies and thinking of the building within the context of its immediate environment and the public realm is critical to ensuring the continued vibrancy of the community. This is especially important in historic and dense urban environments like New York City with strong and cherished neighborhood characters.

The Department of City Planning, in its 2013 *Designing for Flood Risk* report and Flood Resilience zoning text amendment, has outlined key urban design principles for designing buildings in a floodplain. They are detailed in four categories: use, access, parking and streetscape and visual connectivity.

DUMBO, Brooklyn

USE

Buildings often contribute to the character of a place by offering human-scale architectural elements associated with their use, particularly on the first floor. When buildings are elevated and the area below the building is wet floodproofed — in which case, the use below the DFE is converted to crawl space, parking, access, or storage — the result may be blank walls at grade. Using screening, landscaping and/or other creative design solutions can help mitigate these issues.

Broad Channel, Queens

ACCESS

Inviting access and enhanced connectivity must be provided when relocating access points. Due to new flood-resistant construction standards, first floors in the floodplain will typically be elevated above sidewalk grade and, if spaces are reconfigured, access points may need to be added, removed, or reconfigured. This elevation results in longer stairs or ramps, and the potential need for lifts. Where dry floodproofing is allowed, doorways at grade and window openings below the DFE will need to be protected by temporary flood barriers erected before a storm event, or be constructed with impermeable materials.

Elevated buildings pose challenges for accessibility. Ramps can be difficult to accommodate, particularly on smaller lots. Even smaller buildings that are not required to meet Americans with Disabilities Act (ADA) standards, have the challenge of integrating longer runs of stairs into building or landscape design.

Where possible, building entrances should be located as close to the sidewalk level as possible in order to provide visual and physical connectivity to the street. The Flood Resilience zoning text amendment encourages the placement of stairs and vertical circulation within the building by exempting such space from counting towards floor area.

PARKING

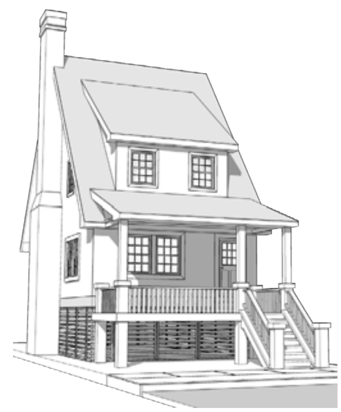
The location of parked vehicles and curb cuts has the potential to disconnect the visual and physical continuity of the streetscape and to adversely affect the pedestrian experience. To minimize these impacts, designers should locate parking, garage entries, and curb cuts strategically. If ground-level parking is the only feasible option, then garage doors and curb cuts should be designed to minimize their impact on the pedestrian realm. For instance, if possible, a garage door should be set back underneath a porch rather than projecting to the face of the building. Where parking is provided underneath a building, it should be screened from view on the street.

STREETSCAPE & VISUAL CONNECTIVITY

Ground-floor level windows and doors facing the street have been historically prevalent features of buildings in New York City and can create a sense of security and comfort for pedestrians. These architectural elements also provide visual interest, which in turn promotes a walkable, vibrant neighborhood. Elevating the first floor of a building can limit this visual connectivity. When elevating buildings in residential neighborhoods, designers should consider adding elements that enhance visual connectivity to the street. In accordance with the above principles, the New York City Zoning Resolution requires homes to provide specific streetscape mitigations such as planting along the streetwall, open or covered porches, stair turns, or raised yards.

Landscape Plantings

Stair Turn



Covered Porch

The addition of these elements can help mitigate the visual disconnection caused by elevating buildings and help preserve the safety, comfort, and visual interest of the streetscape. On commercial streets, this visual connectivity, in addition to physical access, is important to the viability of retail. Where dry floodproofing is feasible, the commercial space can remain at sidewalk level. Where it is not feasible, but retailers are interested in either elevating their first floor or moving to a second floor, designers will need to find new ways to maintain visual access and engagement between the inside of the building and the sidewalk, while providing the necessary physical access.

Neighborhood Character

As the building stock in New York City's floodplains becomes more resilient, the form of neighborhoods will change. However, this change in building height and first floor elevations does not have to mean that neighborhoods will lose their sense of character. Designers should respect a neighborhood's character by taking cues from the existing context and built form including fenestration, rooflines, and other architectural elements. Most of all, they should get to know the place and its people to design a building that suits the neighborhood, while meeting the standards of flood protection.

SHORT-TERM ADAPTATION MEASURES

Developing a retrofitting solution that works for the unique conditions of each building will take time, effort, and money. However, it does not mean that homeowners and property owners cannot take the small but significant steps to learn more about assessing their risk and adapting their buildings. Below is a summary of best practices assembled by FEMA and New York City's Office of Emergency Management (OEM). Many of these best practices can be found in FEMA *Flood Preparation and Safety*, released in 2008 and FEMA P-312 *Homeowner's Guide to Retrofitting 3rd Edition*, released in 2014.

Determine your risk

The most important step a homeowner can take is understanding their building's flood risk. Getting an elevation certificate, which contains an accurate determination of Floodplain and BFE; ground elevations adjacent to structure foundation; and elevation of lowest floor, lowest occupiable floor, and mechanical equipment, is a significant first step. The certificate must be completed by a land surveyor, engineer, or architect who is licensed by the state of New York and is required by the National Flood Insurance Program to certify the reference level of a specific building within a floodplain for insurance rating purposes.

Understand your insurance needs and purchase requirements

Flood damage is not covered by a basic homeowner's policy. Homeowner and property owners can protect their home by purchasing flood insurance. Most insurance is provided through the federal government's National Flood Insurance Program (NFIP) and goes into effect 30 days after purchase. To estimate your premium, or learn more about flood insurance, visit the NFIP's website, www.floodsmart.gov.

Homeowner and property owners in the 1% annual chance floodplain with a Federally-backed mortgage are required by law to purchase flood insurance.

Keep good records of your possessions

In the event of a flood, insurance providers require property owners to provide documentation to justify their claims. New Yorkers living in the floodplain should keep copies of their most important documents (mortgage papers, deed, passport, bank information, vehicle titles, and receipts for major appliances) in a secure place outside the home and the floodplain. Taking photos of valuable possessions and keeping receipts for any expensive household items are also important.

Elevate service equipment to minimize damage

If elevating critical systems is not feasible in the short term, homeowner and property owners can try to elevate service equipment installed outside the building, such as an electric meter or incoming electric, telephone, and cable television lines. These can generally be installed on the same wall at a higher level. When moving electrical panels to an elevation above the lowest floor, additional components, such as a service disconnect, may need to be incorporated into the system to meet the requirements of the National Electrical Code. Equipment typically placed on the ground (e.g., air conditioning compressors, heat pumps) can also be raised above the DFE on pedestals or platforms. Inside the home, raising the main electric switch box is also a good idea.

Install backflow valves to prevent reverse-flow flood damages

When flooding occurs, it can inundate and overload sanitary sewer systems, combined sanitary/storm sewer systems, and lead to water entry in buildings through sewer lines, toilets or drains. The best solution to this problem is usually to install a backflow valve. These valves include check backflow valves, which prevent water from flowing back into the home. In order to perform, valves must be inspected regularly and cleaned as necessary. It is also recommended to try to keep storm drains clear of debris to facilitate the flow of water during a flood.

Minimize structural damage from heavy equipment

In the event of a flood, structural damage to a building can be caused by heavy equipment dislodging and moving within or outside the house. To avoid these issues, washing machines and dryers can be elevated on masonry or pressure-treated lumber at least one foot above the projected flood level. If this is not possible, heavy equipment or furniture should be anchored to the home as much as possible. Anchoring the fuel tank by running straps over it and attaching the straps to ground anchors is a good option.

Coastal flooding in New York City is generally predicted, giving time to homeowner and property owners to prepare their home. When a flood event is announced, homeowner and property owners will reduce flood damage by moving essential items or large furniture and equipment to an upper floor, bringing outside furniture inside the home and driving their car to higher ground, outside of the floodplain.

Follow evacuation procedures

Retrofitting and resiliency strategies are designed to protect buildings and their contents, not lives. The most important decision residents living in the floodplain need to make must be based on life safety. That means strictly follow evacuation procedures. OEM's Know Your Zone campaign and website (http://www.nyc.gov/html/oem/html/get_prepared/know_your_zone/knowyourzone.html) provides New Yorkers with a template for flood emergency evacuation. Every resident living in the floodplain should be familiar with these best practices and have a plan.

Adapting to flood risk is a long process. Education and an understanding of risks and best practices is essential in increasing preparedness. To learn more, refer to http://www.ready.gov/floods and http://www.nyc.gov/html/oem/html/ready/flooding_guide.shtml.

CHAPTER 4 **CASE STUDIES**

To understand the risks and opportunities for mitigation each case study illustrates the *Existing Conditions*, the *Illustrative Retrofit Strategy* and a selection of *Alternative Strategies*.

Existing Conditions present the building in relation to the Design Flood Elevation (DFE), and its adjusted zoning envelope, and it introduces the technical and design criteria specific to the building typology that must be considered.

Illustrative Retrofit Strategy treats the building as if it is substantially improved and shows a combination of mitigation strategies fully compliant with required codes and regulations. This means that the applied mitigation strategies bring the building into full compliance with the NYC Building Code, including *Appendix G*, as well as with the NFIP regulations to achieve the highest premium reductions.

Alternative Strategies present mitigation strategies for buildings that are not substantially damaged or improved and thus, not required to be in compliance with *Appendix G*. These strategies also present mitigation options that will not necessarily provide the most premium reductions through the NFIP, but that can provide property owners with cost-effective and practical adaptation measures. They also present potential opportunities for federal regulatory reform and the development of a broader range of adaptation measures for urban typologies. Specific opportunities are detailed after the case studies on page 102.

The notes provided with the *Existing Conditions, Retrofit Strategy* and *Alternative Strategies* are formatted with action icons which correspond to the floodproofing strategies and technical and design criteria outlined earlier in the document. This allows the reader to navigate the text and the case studies together.

Sheepshead Bay, Brooklyn

BUNGALOW

The bungalow example described here is a structural type that is not entirely dissimilar to the structures anticipated by NFIP standards — a lightweight wood-frame building without a sub-grade foundation — but site conditions are highly constrained, making retrofitting (as well as reconstruction) difficult.

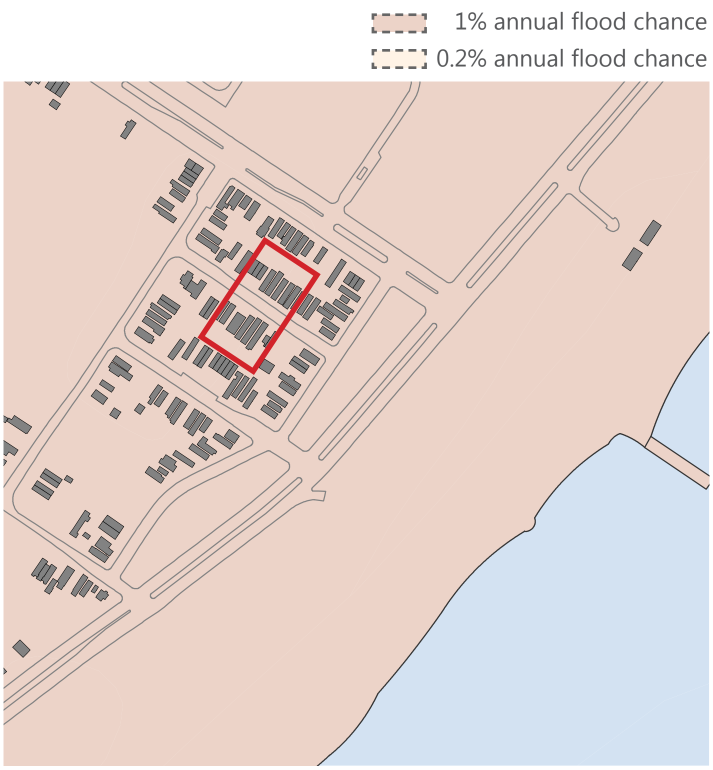
Retrofit strategies that will result in full NFIP reduction in flood insurance premiums include elevating the structure and shifting it to the rear yard to make room for new stair access in the front yard. The area below the elevated structure can be left open or enclosed and wet floodproofed. Critical systems can be elevated within an enclosure at the rear of the building or simply be elevated within the building. The costs associated with elevation are high considering the small size of the resulting building.

The vulnerability of the wood frame structure limits alternative adaptation strategies, which might include elevating critical systems to minimize damage and disruption.

Even though the light structure is conducive to elevation, the proximity of neighboring buildings may make it difficult to stage construction. Successful elevation requires assessment of the building's structural integrity and any implications of site excavation for the neighboring buildings.

KEY CHARACTERISTICS

FLOOD RISK	
Flood Zone/BFE	AE +12′
Grade Elevation	+4′ at sidewalk and property
Design Flood Elevation (DFE)	+14′ (10′ above sidewalk grade)
Lowest Occupiable Floor	+5.5′ (1.5′ above sidewalk grade)
Cellar Elevation	N/A
Critical Systems Location	Accessory structure at rear
TYPOLOGY	
Lot Size	20′ x 100′
Building Size	13′ x 60′
Yards	5′ front; 2′ side; 4′ side; 35′ rear
Construction Type	Wood frame
Foundation Type	Shallow masonry footing
Year Built	1915
Stories	1
Residential Floor Area	800 s.f.
Residential Units	1
Elevator	N/A
SITE CONDITIONS	
Sidewalk Width	12′
Roadbed Width	30′
Zoning District	R3-2, Residential District



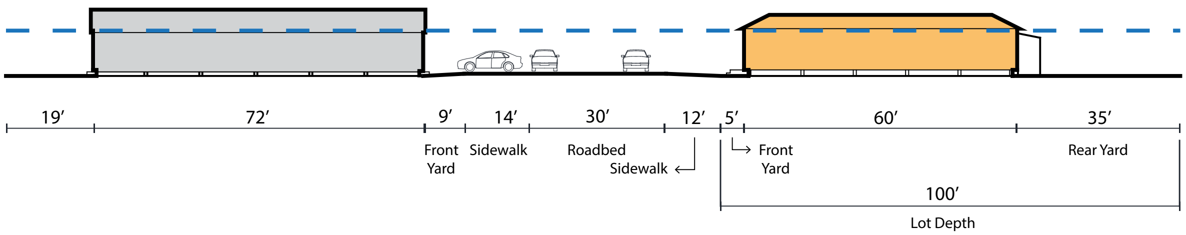
SITE & BUILDING CONDITIONS

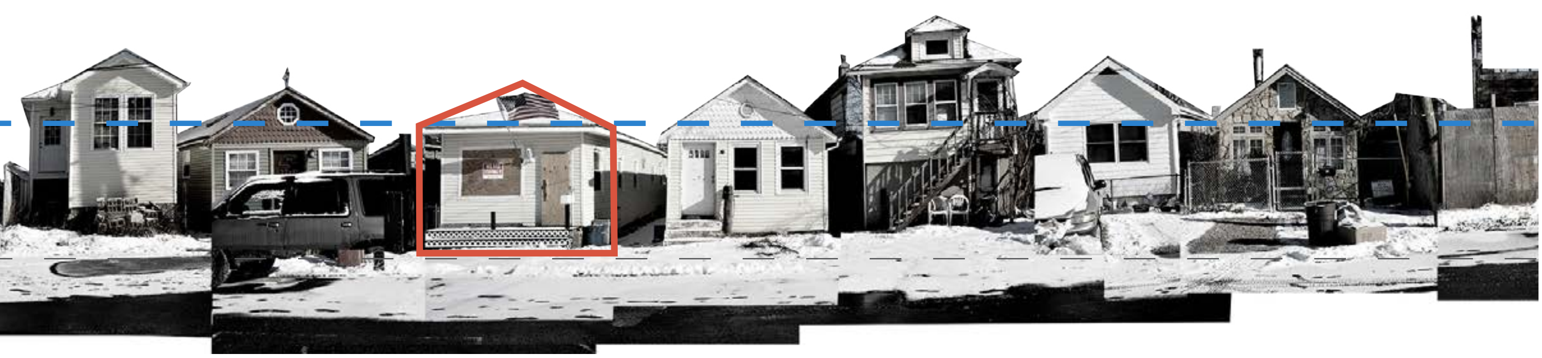
SITE CONDITIONS

Sites with a narrow lot size with high building coverage, and limited side and front yards that lead to tight building adjacencies. Streets are typically of sub-standard width and sidewalks are not always provided.

BUILDING TYPOLOGY

Buildings are one-story wood frame structure with a shallow spread footing foundation. The structure is not sufficiently tied to the foundation and has no basement or cellar. Critical systems are located in an accessory structure or within the building.

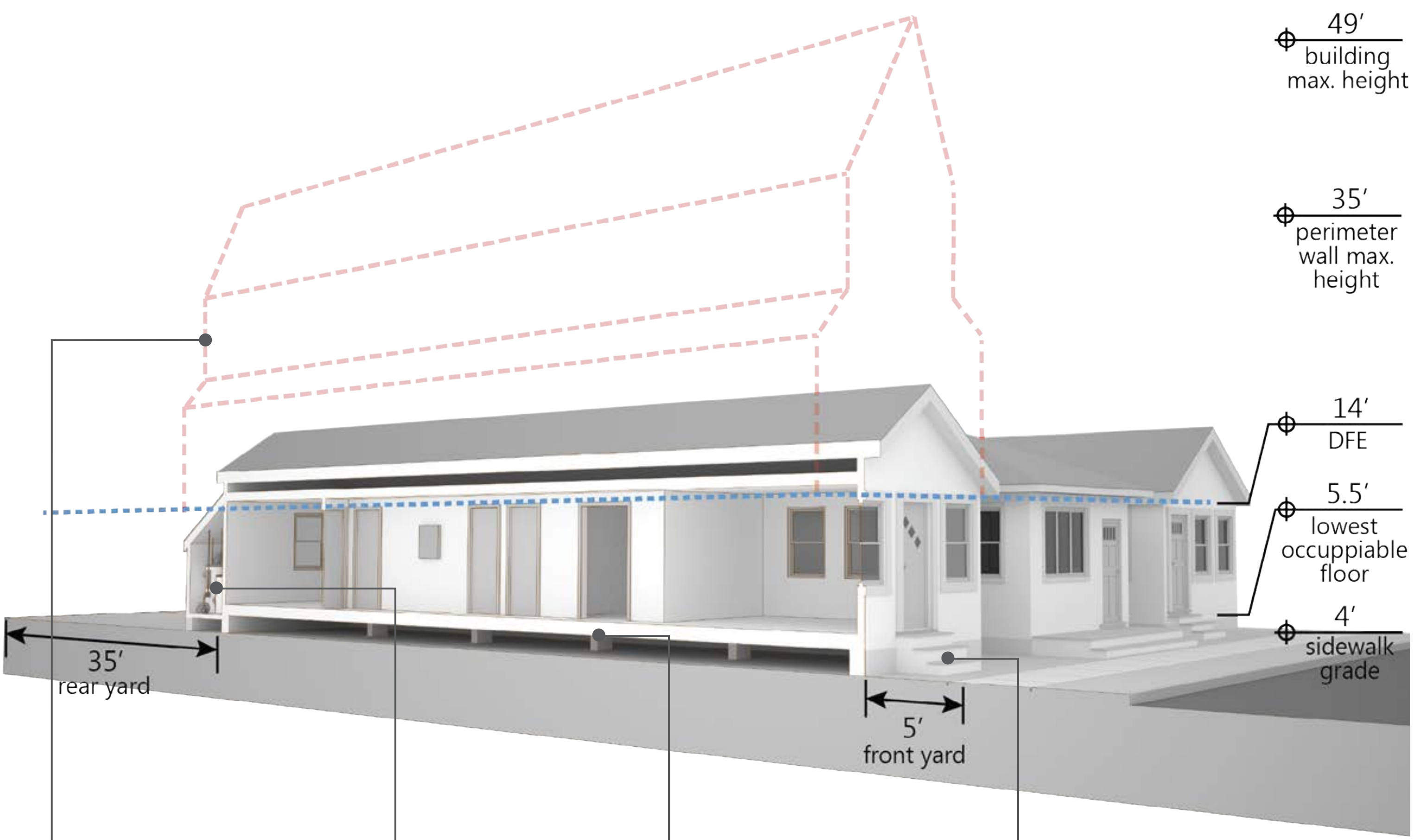




EXISTING CONDITIONS

FLOOD ELEVATION

14′ DFE = BFE + freeboard
= 8.5′ above lowest occupiable floor
= 10′ above lowest property grade



ZONING ENVELOPE

The allowable building height is measured from the DFE.

The existing building has non-compliant front and side yards, and does not provide required parking. These non-compliances must be considered when retrofitting.

The floor area is not maximized. 200 square feet can be added pursuant to underlying floor area ratio and within the adjusted bulk envelope.

CRITICAL SYSTEMS

All systems are located in a rear enclosure below the DFE.

STRUCTURAL SYSTEMS

Single story wood frame combustible construction type on shallow unreinforced masonry foundation. The wood structure is not sufficiently tied to the foundation.

ACCESS

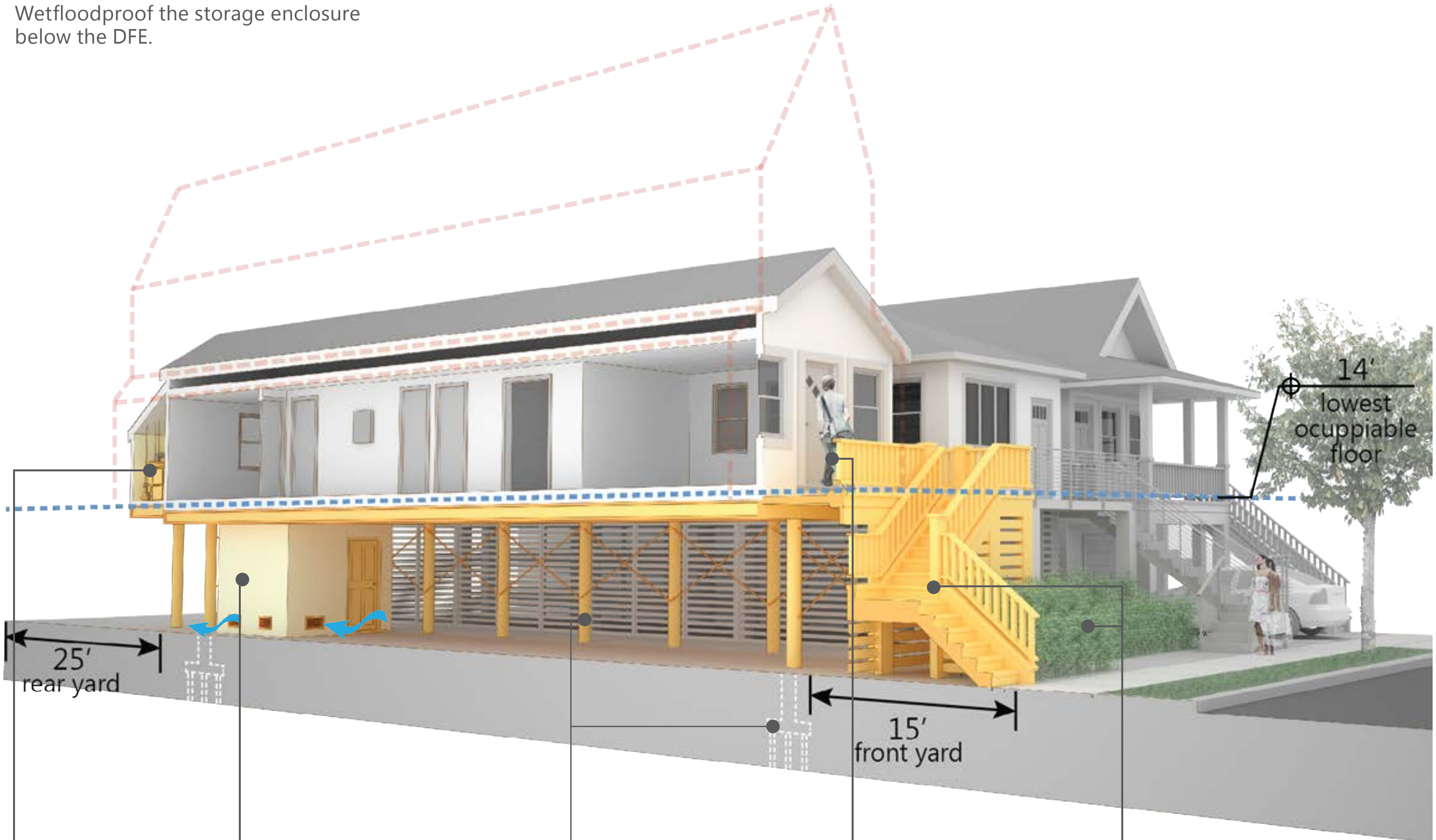
Building access is provided at the front and rear entrances 1.5′ above the sidewalk grade.

ELEVATE & WET FLOODPROOF

Elevate the existing structure on a new foundation system to bring the lowest occupiable floor above the DFE. To accommodate access to the elevated structure, shift the existing building footprint back from the front property line into the rear yard.

Elevate critical systems above the DFE.

Wetfloodproof the storage enclosure below the DFE.



CRITICAL SYSTEMS

Elevate systems above the DFE within a fireproofed and vented accessory structure at the rear.

USE

There is no loss of usable space because the existing home is elevated in place.

If loss of usable space occurs by relocation of access or critical systems within habitable space, that loss of usable floor area can be recaptured as an addition within the permitted bulk envelope.

The non-compliant yards remain.

The wet floodproofed area below the structure may only be used for vehicular parking, crawl space, storage or access.

STRUCTURAL SYSTEMS

Elevate the structure on columns with a spread footing foundation system. Piles may be required depending on soil conditions or by the flood hazard area designation.

Elevate the accessory structure containing the critical systems on structural columns or piles.

Insulate and fireproof underside of lowest floor to enclose building envelope.

ACCESS

The building entrance is relocated to 10' above sidewalk grade. The stairs may be located underneath or adjacent to the structure depending on available yard space and clearance underneath the structure. Here the building is shifted towards the rear property line to accommodate the stair run and porch depth.

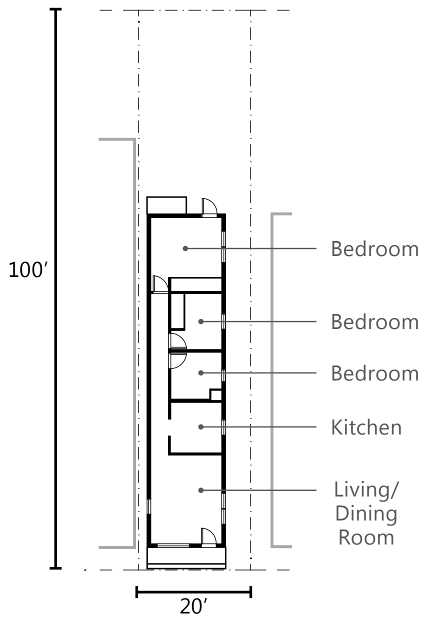
STREETSCAPE

As per the Zoning Resolution, homes elevated over 5' above the sidewalk grade require one streetscape mitigation, and over 9' require two. These enhancements can be selected from a list of options specified in the Zoning Resolution, such as: plantings, covered and uncovered porches, stairs with 90-degree turns, or elevated front yards. Here, plantings and the stair turn are counted toward streetscape mitigations.

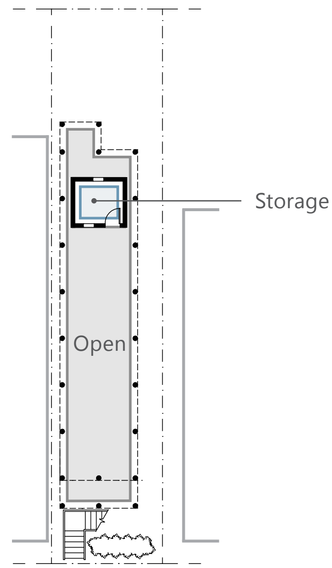
RETROFIT FLOOR PLAN

CHANGE OF USE

EXISTING
Ground Level



PROPOSED
Ground Level



Ground Level
Parking, access, and storage.

Two required streetscape mitigations: plantings and stair turn.

Level One
This becomes the lowest occupiable floor.

The critical systems are relocated within an accessory structure.

Additional streetscape mitigation: porch.

In order to drive wood piles or rebuild a foundation, typically the building must be moved out of the way and then back onto the new foundation. Where site conditions make elevation difficult due to restricted access to the building, consider elevating several buildings at once in order to accomodate the project equipment requirements.

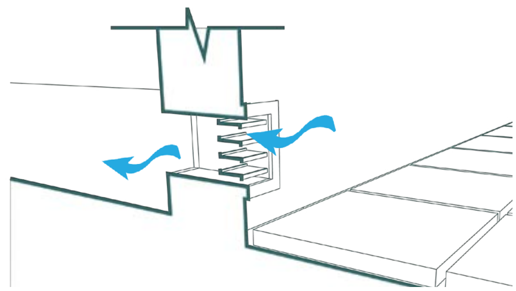
ADAPTATION CONSIDERATIONS

ACCESS

Materials within non-complying side yards must be of fire rated construction type.

When elevating buildings in residential neighborhoods, designers should consider adding elements that enhance visual connectivity to the street. Zoning requires homes to provide specific streetscape mitigations such as planting along the streetwall, open or covered porches, stair turns, or raised yards.

WET FLOODPROOFING



When wet floodproofing, openings for water penetration and exit must be engineered according to ASCE 24 requirements. A minimum of two openings is required for each enclosed area below the DFE, to be installed on at least two sides of each enclosed area. The opening should be located no higher than 1 foot above the grade immediately under each opening.

STREETSCAPE

NON-SUBSTANTIAL DAMAGE/IMPROVEMENT STRATEGIES

Non-substantially improved buildings within the floodplain are not required to comply with Appendix G of the NYC Building Code. This allows for greater flexibility in adapting buildings for flood resiliency. The alternatives illustrated below lower the risk for buildings and provide practical pathways for adaptation. Under current NFIP regulations, these measures may not lower insurance premiums.

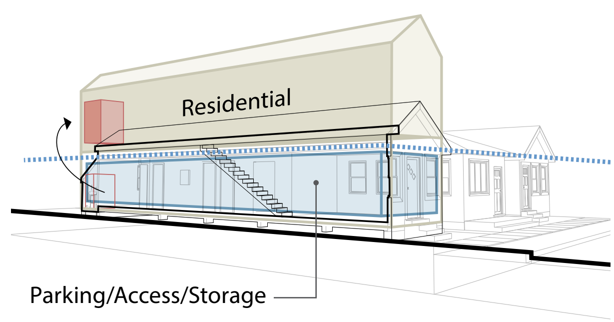
The blue icons below illustrate adaptive measures that receive full reduction of NFIP premiums. Icons in gray indicate strategies that improve building resilience, but receive no or partial reduction of NFIP premiums.

If the lowest occupiable floor is left below the DFE, life safety must be considered. Residents should always follow evacuation procedures.

- Occupied Space
- Critical Systems
- Dry Floodproof
- Wet Floodproof
- Open Structure
- NFIP Premium Reduction

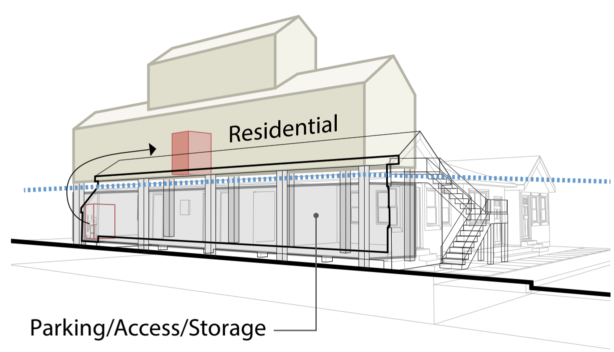
- Elevate the lowest floor above the DFE. Wet floodproof enclosed area below the DFE by installing flood vents and flood damage-resistant materials.
- New addition of mechanical room at rear is within the adjusted bulk envelope. Restrict all uses below the DFE to parking, crawl space, access or storage.
- Elevate the entire structure on a new foundation system. Walls below the DFE have openings to allow automatic entry and exit of flood waters.
- Elevate critical systems above the DFE. Relocate to new mechanical room at rear.
- Stair access provided from below the elevated building within the wet floodproofed enclosure.
- Due to the elevated height of the lowest occupiable floor 10 feet above the sidewalk grade, two streetscape mitigations are required.

Full NFIP premium reduction.



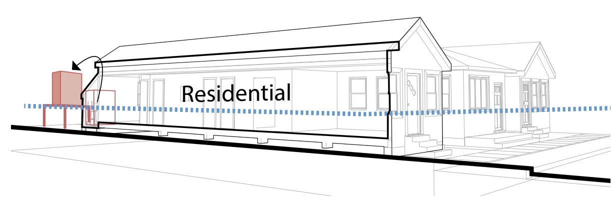
- Elevate the lowest floor above the DFE. Open structure below the DFE may be used as parking, access, crawl space or storage.
- Relocate floor area lost to mechanical room to a new second story addition within the adjusted bulk envelope. Restrict all uses below the DFE to parking, crawl space, access or storage.
- Elevate the entire structure on a new foundation system.
- Elevate critical systems above the DFE. Relocate to new mechanical room within existing structure.
- Stair access provided from below, adjacent to or in front of the elevated building.
- Due to the elevated height of the lowest occupiable floor 10 feet above the sidewalk grade, two streetscape mitigations are required.

Full NFIP premium reduction.



No or partial reduction in NFIP premiums. Residential use and lowest occupiable floor remain located below the DFE.

- Protect systems by elevating the systems above the DFE.
- If the DFE is within a few feet of the lowest occupiable floor consider keeping the strucure in place and using flood damage-resistant materials below the DFE.
- Due to the wood frame construction type, extensive structural damage may occur. Create a continuous load path by connection of the frame to the roof and foundation.



DETACHED

The detached building type closely resembles the typology for which federal floodproofing regulations are designed. It is a lightweight wood-frame structure with a masonry foundation, but its tight site conditions in the urban context can make retrofitting and staging construction difficult.

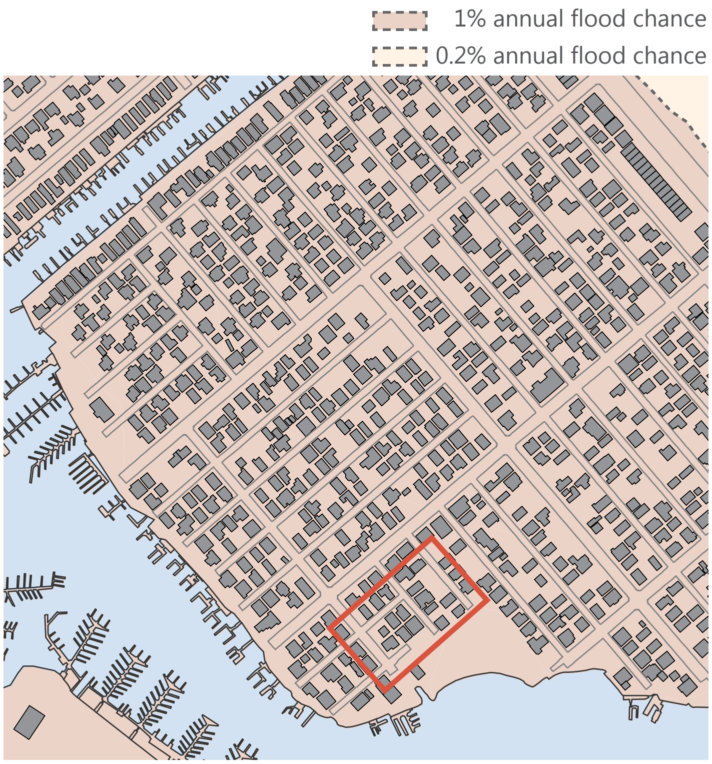
Retrofit strategies that will result in full NFIP reduction in flood insurance premiums include elevating the structure on a new foundation and filling the basement/cellar to the lowest adjacent grade. The area below the elevated structure can be left open or enclosed and wet floodproofed for use as parking, crawl space, access, and storage. Critical systems can be elevated within the building in a fire-rated mechanical room or in the yard, though in shallow lots clearance is rarely provided.

Here, like the bungalow case study, the vulnerability of the wood frame structure limits alternative adaptation strategies, which include elevating critical systems to minimize damage and disruption.

Elevation requires assessment of the building's structural integrity and any implications of site excavation for the neighboring buildings.

KEY CHARACTERISTICS

FLOOD RISK	
Flood Zone/BFE	AE +11′
Grade Elevation	+5′ at sidewalk; +3′ at property
Design Flood Elevation (DFE)	+13′ (10′ above sidewalk grade)
Lowest Occupiable Floor	+5′ (level with sidewalk grade)
Cellar Elevation	-3′ (8′ below sidewalk grade)
Critical Systems Location	Cellar
TYPOLOGY	
Lot Size	40′ x 45′
Building Size	30′ x 40′
Yards	3′ front; 2′ rear; 3′ side; 7′ side
Construction Type	Wood Frame
Foundation Type	Masonry
Year Built	1920
Stories	1.5 + cellar
Residential Floor Area	1800 s.f.
Residential Units	1
Elevator	N/A
SITE CONDITIONS	
Sidewalk Width	3′
Roadbed Width	17′
Zoning District	R4, Residential



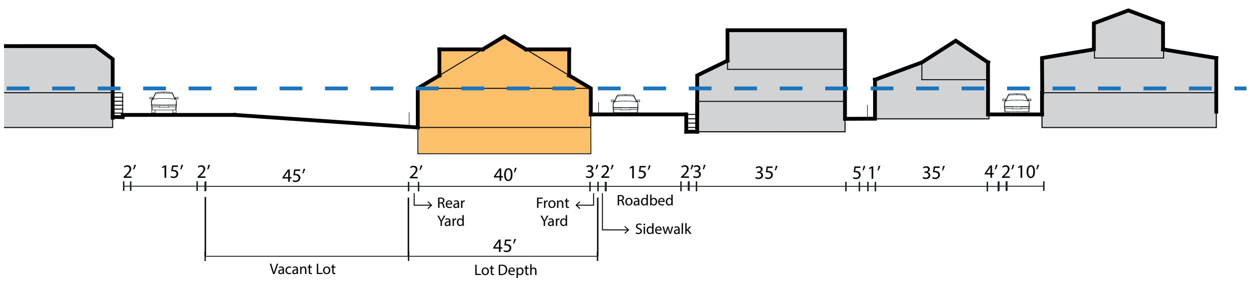
SITE & BUILDING CONDITIONS

SITE CONDITIONS

Sites with a shallow lot size with high building coverage, and limited side, front and rear yards that lead to tight building adjacencies. Property grade is often a few feet below the sidewalk grade. Streets are typically of sub-standard width with narrow or no sidewalks.

BUILDING TYPOLOGY

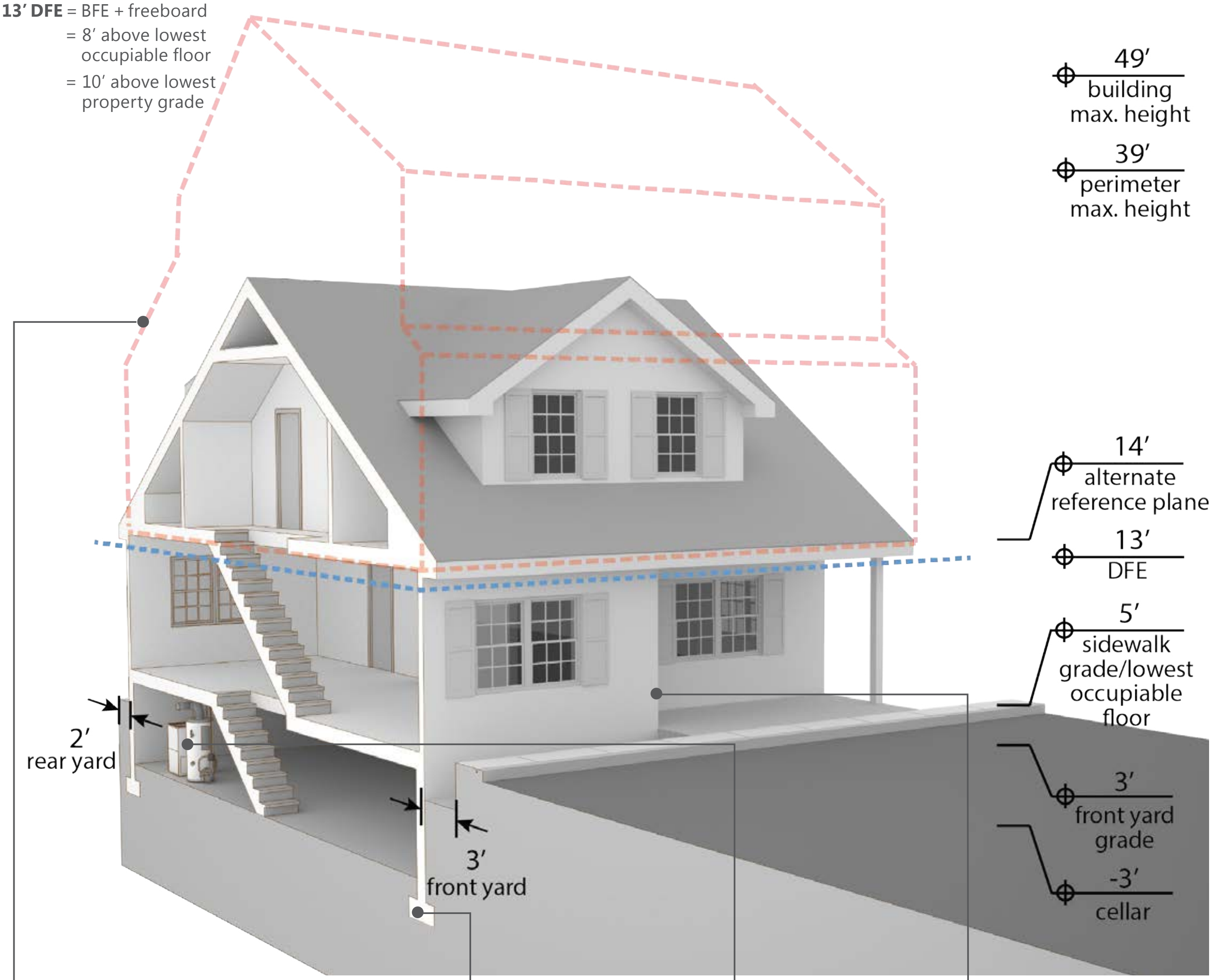
Buildings are one- to two-story wood frame structure with a masonry foundation. The structure is not sufficiently tied to the foundation. Critical systems are located in the cellar/basement.



EXISTING CONDITIONS

FLOOD ELEVATION

13′ DFE = BFE + freeboard
= 8′ above lowest occupiable floor
= 10′ above lowest property grade



ZONING ENVELOPE

The building has non-compliant front, rear, and one side yard, and does not provide the required parking. Existing non-compliances must be considered when retrofitting buildings.

Per zoning, the allowable building height is measured from 9′ above the sidewalk grade by application of the Alternate Reference Plane rule, which permits the building envelope base height to be shifted above the DFE in order to accommodate usable parking, access, or storage. This rule is available where the DFE is between 6′-9′ above sidewalk grade.

The floor area is overbuilt which is an existing non-compliance. Zoning allows the relocation of existing non-compliant floor area above the DFE within the adjusted bulk envelope.

STRUCTURAL SYSTEMS

One-and-a-half story wood frame combustible construction type on unreinforced masonry foundation. The wood structure is not sufficiently tied to the foundation.

CRITICAL SYSTEMS

The electrical panels and the hot water heater are located in the cellar.

The fuel tank is located in the rear yard at grade.

ACCESS

Building access is provided at the front and rear entrances, both at sidewalk grade, which is 2′ above property grade.

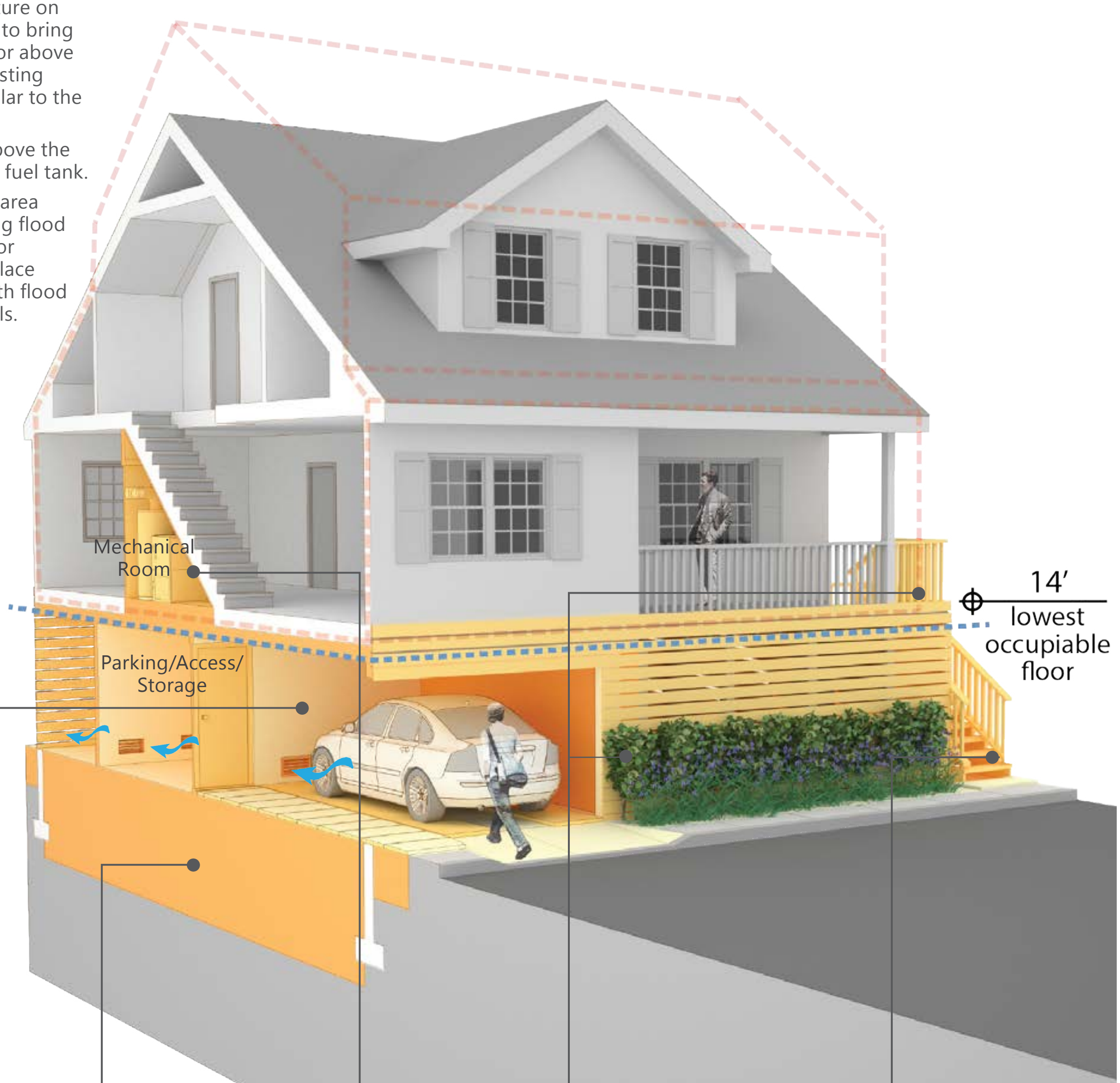
ILLUSTRATIVE RETROFIT STRATEGY

ELEVATE & WET FLOODPROOF

Elevate the existing structure on a new foundation system to bring the lowest occupiable floor above the DFE. Demolish the existing foundation and fill the cellar to the lowest adjacent grade.

Elevate critical systems above the DFE with exception of the fuel tank.

Wet floodproof enclosed area below the DFE by installing flood vents located at all exterior and interior walls and replace construction materials with flood damage resistant materials.



USE

The existing non-compliant yards and overbuilt square footage remain.

Relocation of the critical systems to above the DFE within the building envelope results in a 90 s.f. area loss. Zoning allows for the square footage to be relocated to a new addition within the bulk envelope.

Use below the DFE is for vehicular parking and storage.

The application of the Alternate Reference Plane rule provides necessary height for parking clearance.

STRUCTURAL SYSTEMS

Elevate the structure on new reinforced concrete or masonry unit foundation and columns. Fill the site to the lowest adjacent grade.

The relocation of the critical systems may require additional structural support.

Insulate and fireproof the underside of lowest level to enclose building envelope.

CRITICAL SYSTEMS

Elevate systems above the DFE to an interior fireproofed and vented enclosure; Install isolation and/or vibrations pads as needed.

Fuel tank may remain at grade; fasten as required to resist buoyancy and load pressure from water and debris.

STREETSCAPE

The application of the Alternate Reference Plane Rule requires two zoning streetscape mitigations. Note, these requirements may be waived if the front setback is less than 3 feet.

The planting along 60% of the width of the lot frontage fulfills one zoning mitigation requirement.

The stair turn at the front entry provides the second mitigation measure.

Lattice located below the DFE provides visual transition at the streetwall.

ACCESS

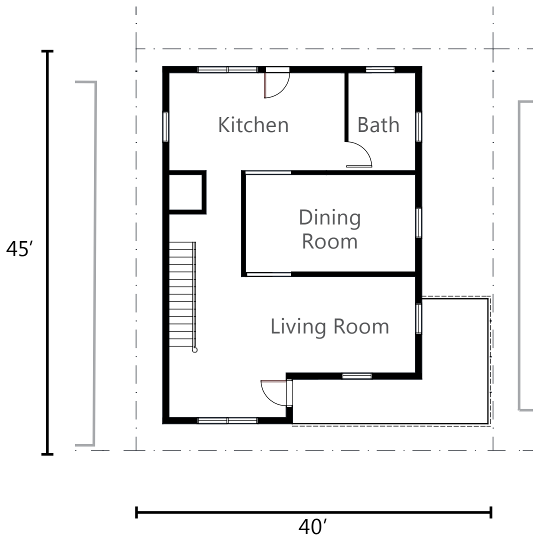
The building entrance is relocated to 9’ above sidewalk grade. The stairs may be located underneath or adjacent to the structure depending on available yard space and clearance underneath the structure. Here the access may be located at the side yard.

Install a curb cut for parking at the new garage.

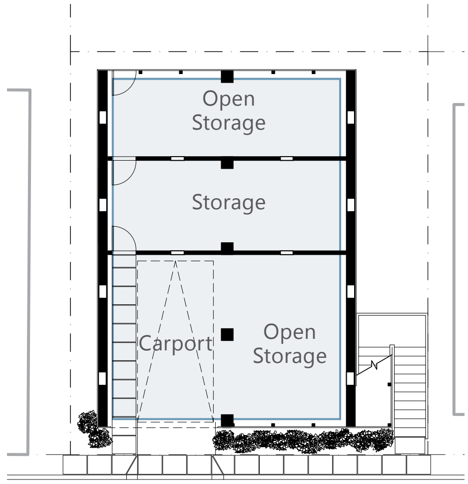
RETROFIT FLOOR PLAN

CHANGE OF USE

EXISTING
Ground Level



PROPOSED
Ground Level



Cellar
Fill to lowest adjacent grade. Loss of storage and mechanical room.

Ground Level
New parking, access, and storage.

Two required streetscape mitigations: plantings and stair turn.

Level One
This becomes the lowest occupiable floor.

The critical systems relocate to a new mechanical room within the existing structure.

In order to drive wood piles or rebuild a foundation, typically the building must be moved out of the way and then back onto the new foundation. Where site conditions make elevation difficult due to restricted access to the building, consider elevating several buildings at once in order to accomodate the project equipment requirements.

ADAPTATION CONSIDERATIONS

ACCESS

When elevating buildings, add elements that enhance visual connectivity to the street. The Zoning Resolution requires homes to provide specific streetscape mitigations such as planting along the streetwall, open or covered porches, stair turns, porch or raised yards.

FIREPROOFING

When elevating buildings, consideration must be given to fire-rated walls and floors within the mechanical rooms and parking areas, as well as at exterior walls where neighboring buildings are in close proximity and the underside of exposed floor plates.

Materials within non-conforming side yards must be of fire rated construction type.

STREETSCAPE

NON-SUBSTANTIAL DAMAGE/IMPROVEMENT STRATEGIES

Non-substantially improved buildings within the floodplain are not required to comply with Appendix G of the NYC Building Code. This allows for greater flexibility in adapting buildings for flood resiliency. The alternatives illustrated below lower the risk for buildings and provide practical pathways for adaptation. Under current NFIP regulations, these measures may not lower insurance premiums.

The blue icons below illustrate adaptive measures that receive full reduction of NFIP premiums. Icons in gray indicate strategies that improve building resilience, but receive no or partial reduction of NFIP premiums.

If the lowest occupiable floor is left below the DFE, life safety must be considered. Residents should always follow evacuation procedures.

- Occupied Space
- Critical Systems
- Dry Floodproof
- Wet Floodproof
- Open Structure
- NFIP Premium Reduction

Elevate the lowest floor above the DFE. Wet floodproof enclosed area below DFE by installing flood vents and flood-damage-resistant materials.

Restrict all uses below the DFE to parking, crawl space, access, or storage.

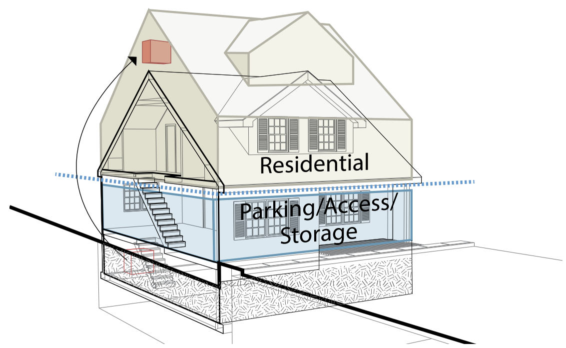
Elevate the entire structure on a new foundation system. Fill the cellar to the lowest adjacent grade.

Elevate critical systems above the DFE. Relocate to new mechanical room within the existing structure.

Entry stair access locations are limited due to the small size of the existing yards. Provide stair entry from below with the wet floodproof enclosure.

Due to the elevated height of the lowest occupiable floor 9 feet above the sidewalk grade, two streetscape mitigations are required.

Full NFIP premium reduction.



Elevate the lowest floor above the DFE. Open area below the DFE may be used as parking, access, crawl space, or storage.

Restrict all uses below the DFE to parking, crawl space, access or storage. Relocate floor area used for new mechanical room to a new addition within adjusted bulk envelope.

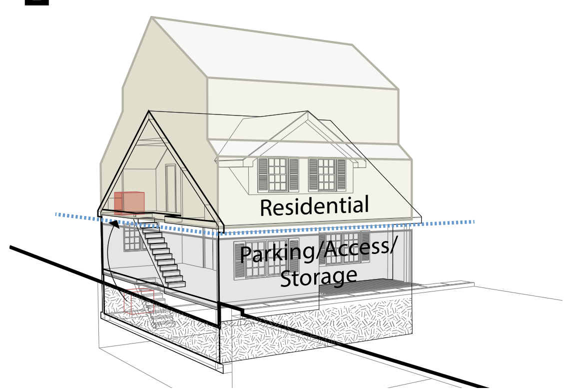
Elevate the entire structure on a new foundation system. Fill cellar to lowest adjacent grade.

Elevate critical systems above the DFE. Relocate to new mechanical room within existing structure.

Entry stair access locations are limited due to the small size of the existing yards. Provide stair entry from below.

Due to the elevated height of the lowest occupiable floor 9 feet above the sidewalk grade, two streetscape mitigations are required.

Full NFIP premium reduction.

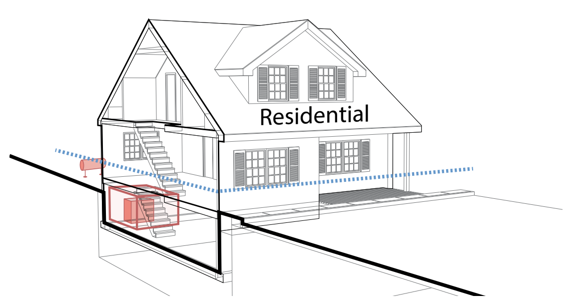


No or partial reduction in NFIP premiums. Residential use and critical systems remain located below the DFE and the structure is not filled to lowest adjacent grade. Lowest occupiable floor is below the DFE.

Protect systems by dry floodproofing in place.

If the DFE is within a few feet of the lowest occupiable floor consider keeping the strucure in place and using flood damage-resistant materials below the DFE.

Due to the wood frame construction type, extensive structural damage may occur. Create a continuous load path by connection of the frame to the roof and foundation.



SEMI-DETACHED

This semi-detached case study begins to demonstrate the complexity of the federal regulations when applied to urban typologies. This building is an unreinforced masonry structure with a shallow foundation, one party-wall, and critical systems located on the first level. The structure is attached on one side and therefore not suitable for elevation.

Retrofit strategies resulting in full NFIP reduction in flood insurance premiums require extensive modifications to the building structure and program, which would result in the loss of useable space and have structural integrity implications for the neighboring property.

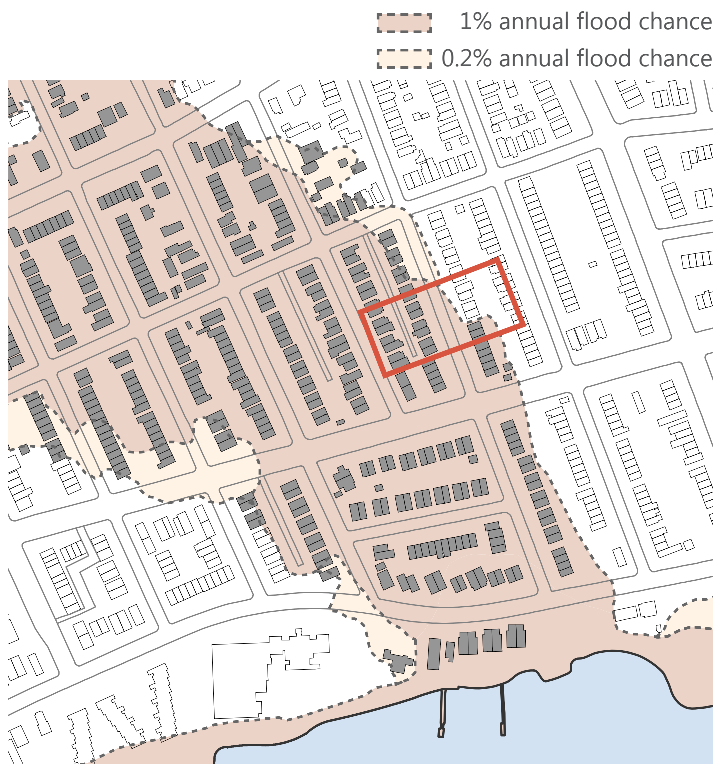
NFIP premium reduction options include wet floodproofing the ground floor, converting it into a garage, access and storage area, and building a new addition on the second and third levels to minimize loss of square footage. These changes require substantial structural reinforcement.

Alternative adaptation strategies, currently not recognized by NFIP, include leaving existing uses in place and either wet or dry floodproofing below the DFE.

Partial adaptation could be limited to elevating or floodproofing the critical systems. Dry and wet floodproofing solutions also require assessment of the building's structural integrity and implications of changes on the neighboring buildings.

KEY CHARACTERISTICS

FLOOD RISK	
Flood Zone/BFE	AE +13'
Grade Elevation	+11' at sidewalk and property
Design Flood Elevation (DFE)	+15' (4' above sidewalk grade)
Lowest Occupiable Floor	+11.5' (6" above property grade)
Cellar Elevation	N/A
Critical Systems Location	Ground Level
TYPOLOGY	
Lot Size	25' x 80'
Building Size	20' x 35'
Yards	20' front; 25' rear, including alley
Construction Type	Masonry with wood joists
Foundation Type	Shallow Masonry
Year Built	1925
Stories	3
Residential Floor Area	2,000 s.f.
Residential Units	1
Elevator	N/A
SITE CONDITIONS	
Sidewalk Width	15'
Roadbed Width	34'
Zoning District	R4-1, Residential



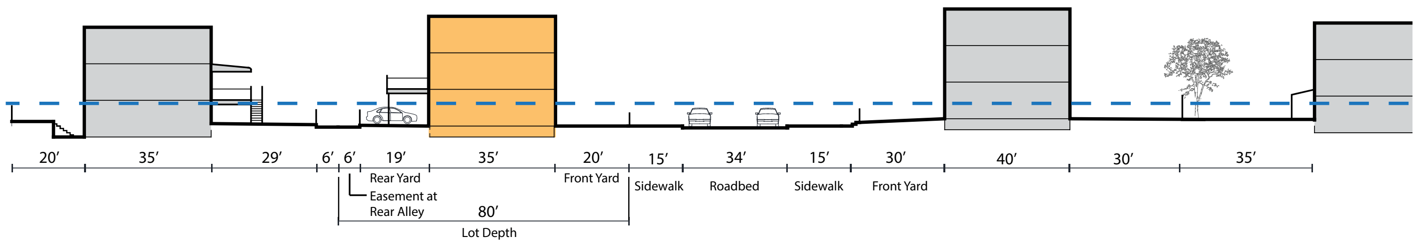
SITE & BUILDING CONDITIONS

SITE CONDITIONS

Sites with standard lot size, one side yard and may have rear alley access. Streets and sidewalks are typically of standard width.

BUILDING TYPOLOGY

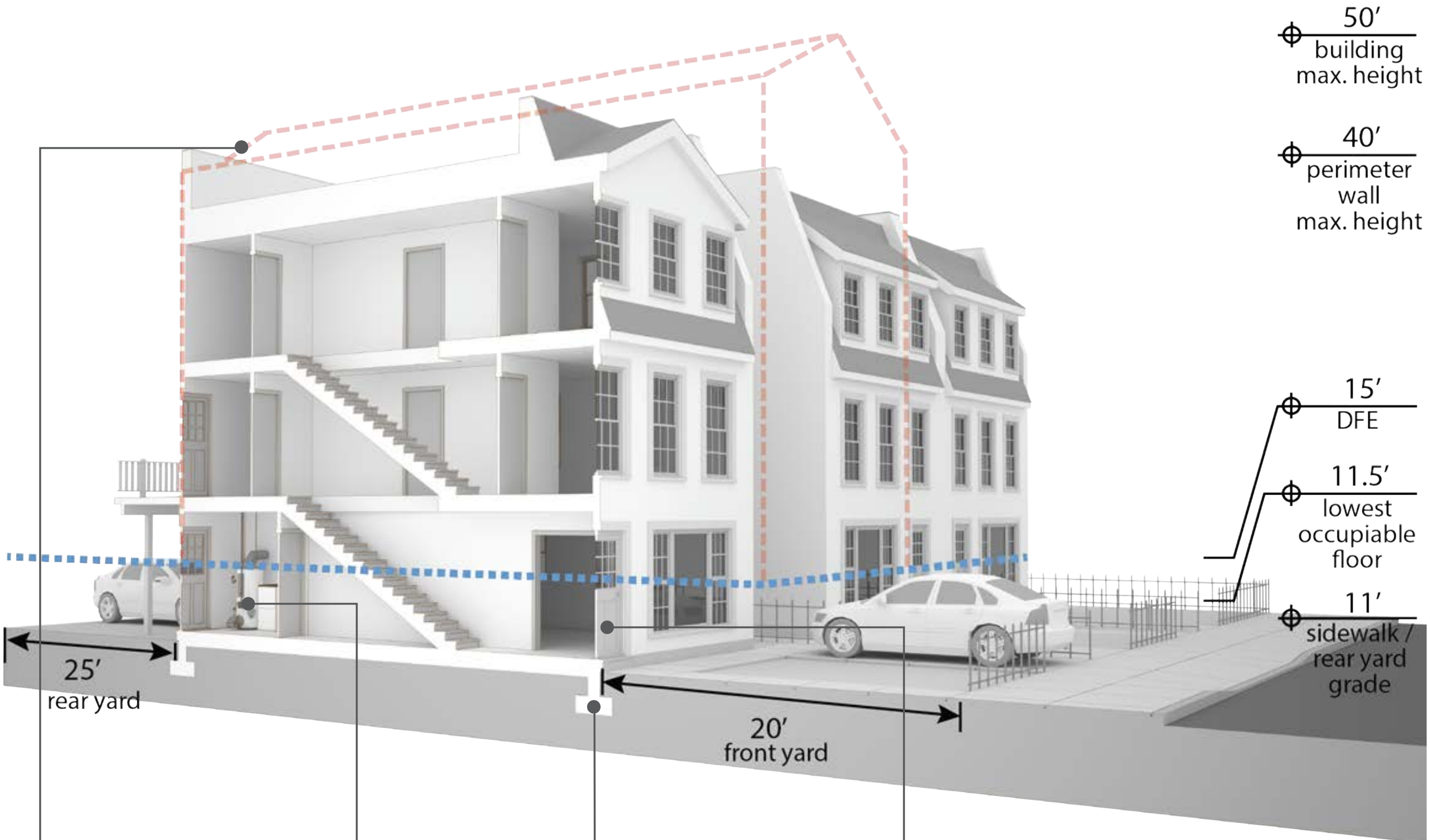
Buildings are two to three-story masonry party-wall with wood joists and a masonry foundation. Critical systems are located in the basement/cellar or at grade.



EXISTING CONDITIONS

FLOOD ELEVATION

15′ DFE = BFE + freeboard
= 3.5′ above lowest occupiable floor
= 4′ above lowest property grade



ZONING ENVELOPE

The allowable building height is measured from the DFE.

The building has a non-compliant rear yard of less than 30 feet.

Parking is compliant in the rear yard and non-compliant in the front yard.

The building is built to the maximum allowable floor area. To comply with the flood resistant construction standards, the floor area below the DFE can be relocated within the adjusted building bulk envelope.

CRITICAL SYSTEMS

All systems are located in a mechanical room on the lowest floor.

STRUCTURAL SYSTEMS

Three-story combustible construction with an unreinforced masonry bearing party-wall and wood joists on a shallow masonry foundation.

ACCESS

Building access is provided at the front and rear entrances at sidewalk grade.

There is an alley easement along the rear property line for vehicular access and parking.

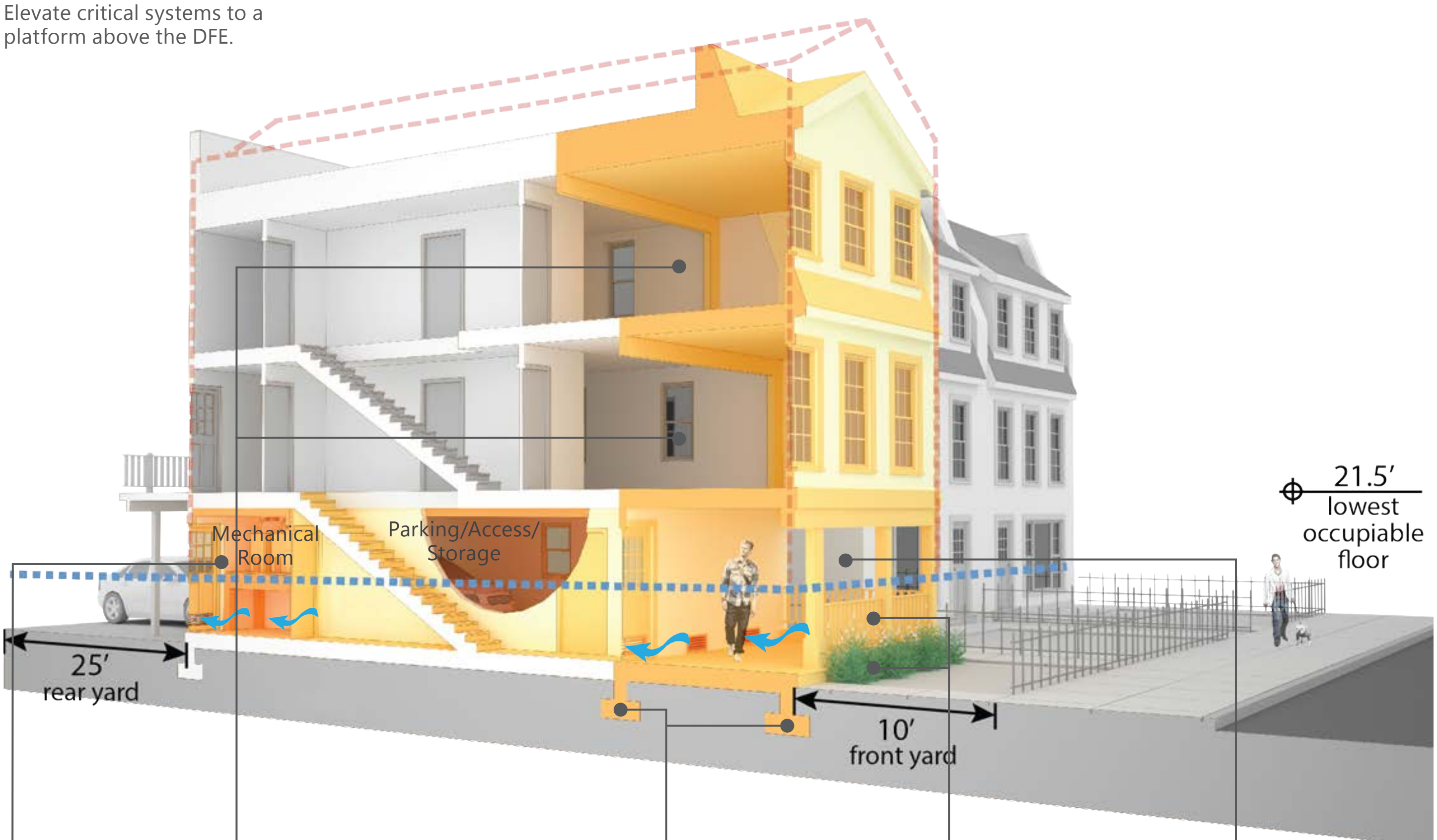
ILLUSTRATIVE RETROFIT STRATEGY

ELEVATE & WET FLOODPROOF

Wet floodproof area below the DFE by installing flood vents located at exterior and interior walls and replacing all windows, doors, structure and finishes with flood damage-resistant materials.

Relocate the square footage from the areas below the DFE to the new addition on second and third level.

Elevate critical systems to a platform above the DFE.



CRITICAL SYSTEMS

Elevate systems on a platform above the DFE within the existing mechanical room. Replace existing systems to fit within limited height clearance, as required.

USE

Per Zoning, wet floodproofing the ground floor allows the lost floor area below the DFE to be relocated within the building bulk envelope to the new addition on the second and third levels. There is a total loss of 180 s.f. of floor area.

Relocate the front yard parking to the rear and convert the partial interior floor area below the DFE to a garage and storage. The mechanical room remains.

A new porch is added at grade below the addition.

If zoning regulations require the streetwall to align with adjacent buildings, a BSA special permit may be required.

STRUCTURAL SYSTEMS

Add a new foundation system to support the addition.

Reinforce the party-wall and the associated foundation system as required.

Locating parking within the building requires new fire-rated walls, ceiling assemblies and slab reinforcement.

STREETSCAPE

Due to the construction of a new streetwall, where the lowest occupiable floor is over 9′ above the sidewalk grade, the Zoning Resolution requires two streetscape mitigations be implemented. These enhancements can be selected from a list of options specified in the Zoning Resolution. Here plantings, and a covered porch fulfill the requirements.

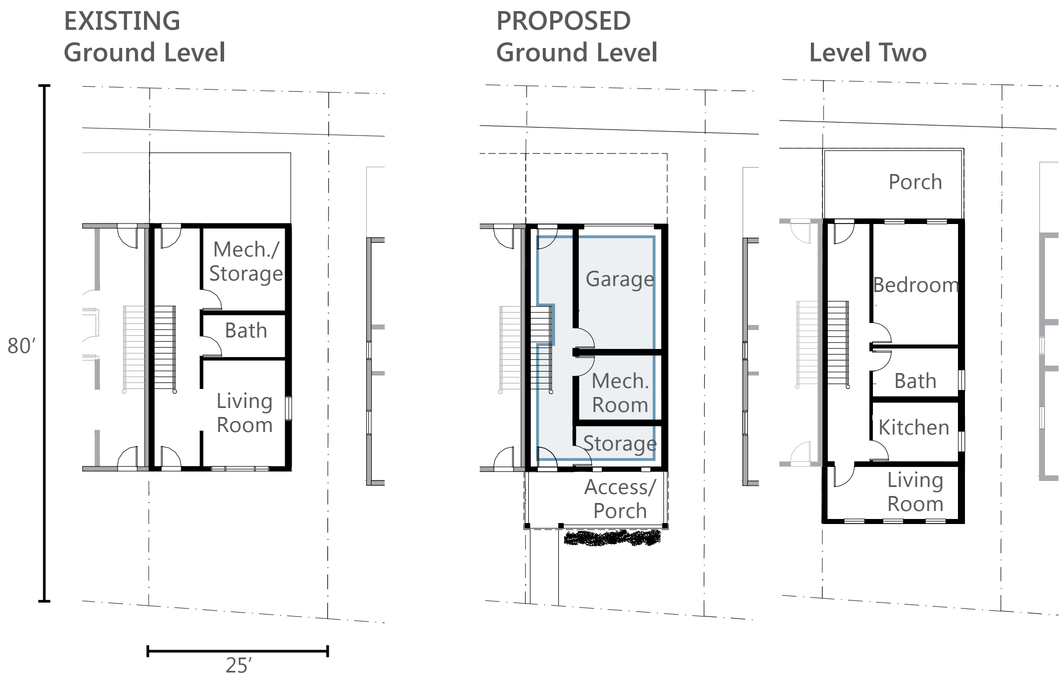
ACCESS

New porch below the new addition provides access at grade to existing front entrance.

At rear, existing entrance to remain with the addition of an entry point at the new garage door.

RETROFIT FLOOR PLAN

CHANGE OF USE



Ground Level
New parking, access, storage, and mechanical room.

Two required streetscape mitigations - covered porch. Additional streetscape mitigation - plantings.

Elevated critical systems in existing mechanical room.

Levels Two and Three
Level two becomes the lowest occupiable floor.

Existing use remains with addition of relocated floor area from the ground level to the new addition at the second and third stories.

ADAPTATION CONSIDERATIONS

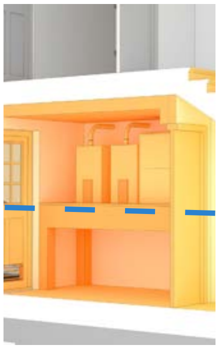
ACCESS

Inviting access and a strong relationship with the streetscape are important design elements when relocating access points. Zoning requires homes to provide specific streetscape mitigations such as plantings along the streetwall, open or covered porches, stair turns, or raised yards.

CRITICAL SYSTEMS

Heating system components are vulnerable to flood damage. Relocating boilers, furnaces or other forced air systems to an upper story is ideal but may not be practical. If relocation is infeasible, try to elevate as high as possible at the current location.

Property owners should consider required equipment clearances and venting before determining if and where to relocate.



STREETSCAPE

NON-SUBSTANTIAL DAMAGE/IMPROVEMENT STRATEGIES

Non-substantially improved buildings within the floodplain are not required to comply with Appendix G of the NYC Building Code. This allows for greater flexibility in adapting buildings for flood resiliency. The alternatives illustrated below lower the risk for buildings and provide practical pathways for adaptation. Under current NFIP regulations, these measures may not lower insurance premiums.

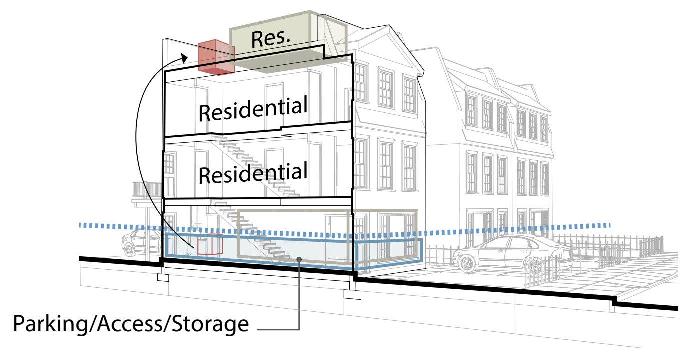
The blue icons below illustrate adaptive measures that receive full reduction of NFIP premiums. Icons in gray indicate strategies that improve building resilience, but receive no or partial reduction of NFIP premiums.

If the lowest occupiable floor is left below the DFE, life safety must be considered. Residents should always follow evacuation procedures.

- Occupied Space
- Critical Systems
- Dry Floodproof
- Wet Floodproof
- Open Structure
- NFIP Premium Reduction

- Elevate critical systems and lowest occupiable floor above the DFE.
- Wet floodproof enclosed area below the DFE by installing flood vents and replace all windows, doors and finishes with flood damage-resistant materials.
- Relocate partial ground floor area to a new fourth floor addition within adjusted bulk envelope. Restrict all uses below DFE to parking, crawl space, access, and storage.
- Add structural reinforcement for additional structural loads on the roof. Ensure changes to party-wall do not impact neighboring propety's structural integrity.
- Relocate partial critical systems to the roof within a fire-rated and vented enclosure. Raise electrical utilities above DFE at the existing location.
- Due to the elevated height of the lowest occupiable floor 9 feet above sidewalk grade, two streetscape mitigations are required.

Full NFIP premium reduction.

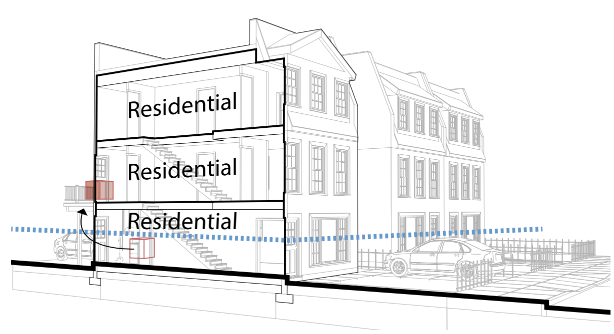


- Dry floodproof below the DFE by strengthening the foundation, floors and walls and sealing all penetrations. Provide temporary flood shields at all windows and doors.
- Retain existing first floor residential use.
- Strengthen foundation, floors and walls to withstand flood loads below and above grade. Ensure changes to party-wall do not impact neighboring propety's structural integrity.
- Critical systems to remain in place within dry floodproofed mechanical room. Provide emergency shut off above the DFE. Raise electrical utilities above DFE at the existing location.

No or partial reduction in NFIP premiums. Residential use and critical systems remain located below the DFE. Dry floodproofing is not permitted at residential use. Lowest occupiable floor is below the DFE.

- Elevate the systems above the DFE within a fire-rated and vented enclosure in the rear yard.
- Retain existing first floor residential use. Loss of occupiable space may occur if systems location requires a window to be infilled.
- Add structural support to new location of critical systems.

No or partial reduction in NFIP premiums. Residential use remains located below the DFE. Lowest occupiable floor is below the DFE.



ATTACHED

This row house example is a reinforced masonry structure with party-walls, concrete foundation and a garage, recreational room and half bathroom on the ground floor. This structure has two shared bearing walls and is not suitable for structural elevation.

Retrofit strategies that will result in full NFIP reduction in flood insurance premiums require filling the basement/cellar to the lowest adjacent grade, and wet floodproofing the ground floor below the DFE, which results in substantial loss of residential square footage. The amount of lost usable square footage can increase if the ground floor use is not counted towards the floor area, as it is often the case in this typology, since it cannot be relocated. If it is counted towards floor area there may be opportunities to replace a portion of this lost space in a new addition on the roof.

Filling the cellar to the lowest adjacent grade requires foundation, party-wall and slab reinforcement as well as structural interventions that will protect the party-walls. Critical systems can be relocated on the roof or in the backyard in an enclosure if clearance is provided but may incur loss of habitable space if location blocks a window.

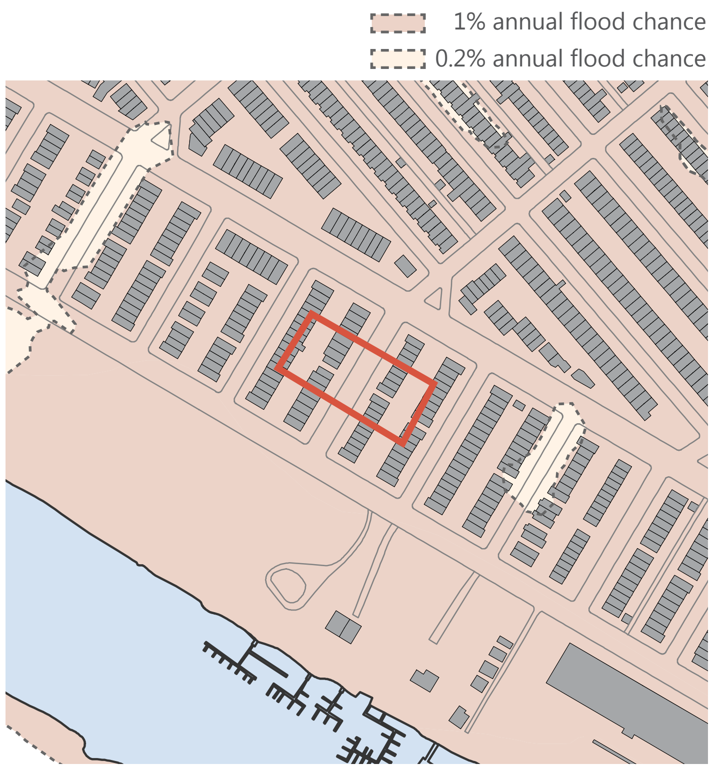
Alternative adaptation strategies, currently not recognized by NFIP, include leaving existing residential uses on the ground floor, enclosing critical systems in the cellar within a floodproof enclosure, and dry floodproofing below the DFE.

Partial adaptation could be limited to elevating the critical systems.

All floodproofing solutions require assessment of the building's structural integrity and the implications of changes on the neighboring buildings.

KEY CHARACTERISTICS

FLOOD RISK	
Flood Zone/BFE	AE +10′
Grade Elevation	+5′ at sidewalk, +3′ at rear property
Design Flood Elevation (DFE)	+12′ (7′ above sidewalk grade)
Lowest Occupiable Floor	+3′ (2′ below sidewalk grade)
Cellar Elevation	- 4′ (9′ below sidewalk grade)
Critical Systems Location	Cellar
TYPOLOGY	
Lot Size	20′ x 100′
Building Size	20′ x 50′
Yards	24′ front; 30′ rear
Construction Type	Masonry with Wood Joists
Foundation Type	Concrete
Year Built	1965
Stories	2 + basement and cellar
Residential Floor Area	2000 s.f. total
Residential Units	2
Elevator	N/A
SITE CONDITIONS	
Sidewalk Width	8′
Roadbed Width	34′
Zoning District	R5, Residential



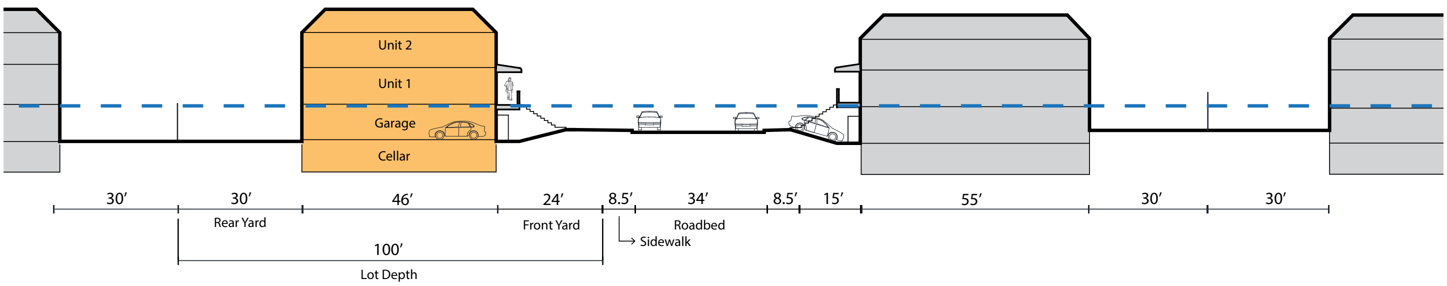
SITE & BUILDING CONDITIONS

SITE CONDITIONS

Sites with standard lot size and rear yards that are 0 to 6 feet below sidewalk grade, and front yard sloping down to sub-grade garage level. No side yards are provided. Streets and sidewalks are typically of standard width.

BUILDING TYPOLOGY

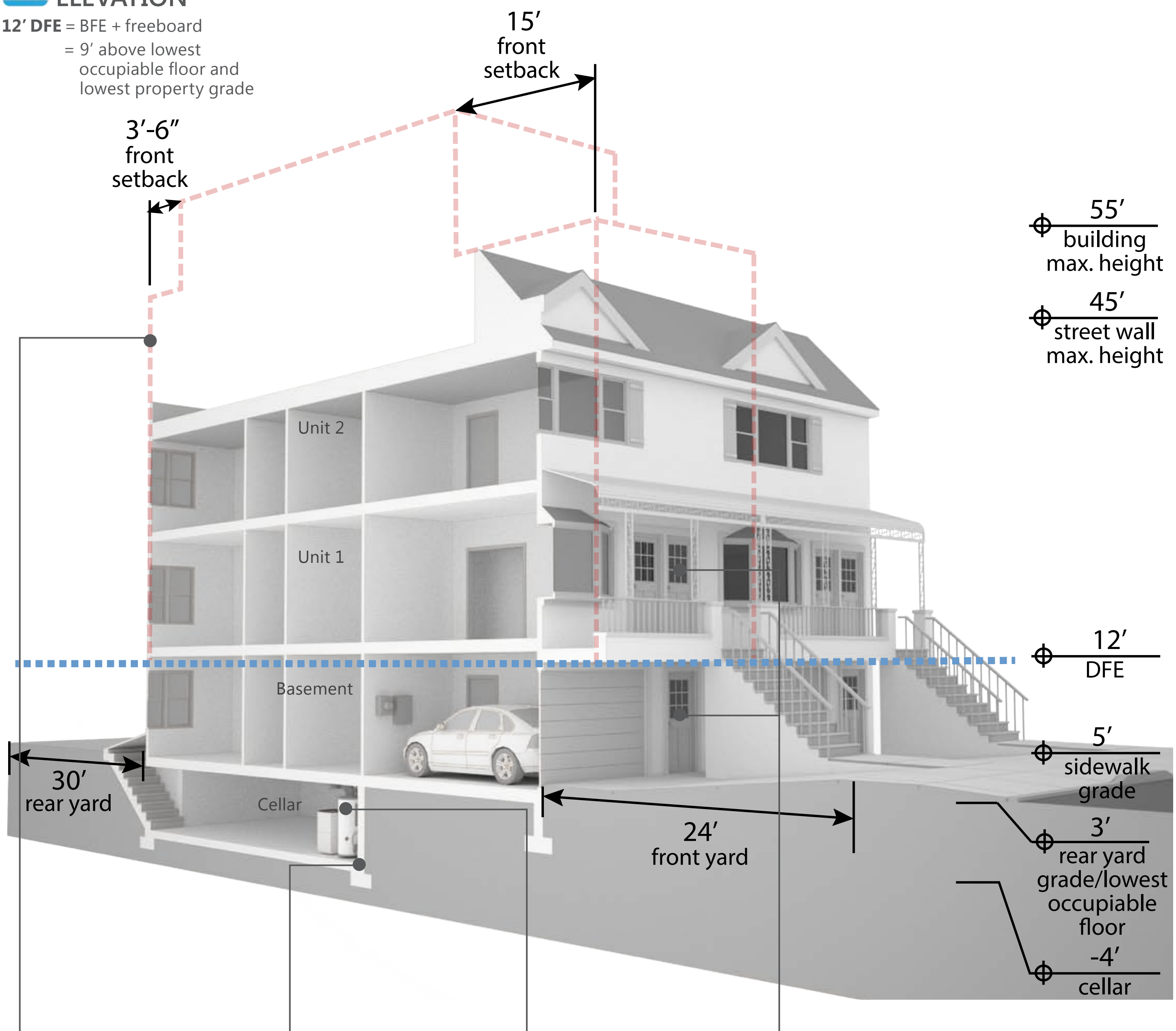
Buildings are two to four-story masonry party-walls with wood joists and concrete foundation. Critical systems are located in the basement or cellar. Entrances are located above and below the sidewalk and property grade.



EXISTING CONDITIONS

FLOOD ELEVATION

12′ DFE = BFE + freeboard
= 9′ above lowest occupiable floor and lowest property grade



ZONING ENVELOPE

The allowable building height is measured from the DFE.

The building is fully compliant with zoning regulations.

The building is built to the maximum allowable floor area, but the ground floor was exempted from floor area due to its use as garage and recreational room.
This prevents the ability to relocate this floor area above the DFE within the adjusted bulk envelope.

STRUCTURAL SYSTEMS

Three-story combustible construction with masonry bearing party-walls and wood joists on a concrete foundation.

CRITICAL SYSTEMS

All systems are located in the cellar with the exception of the electrical panels which are located in the garage.

ACCESS

Building access is provided at two front entrances; one located 8′ above sidewalk grade and the second located 2′ below sidewalk grade.

The building access at the rear yard is provided at two locations, both at rear yard grade.

Garage access provided at front 2′ below the sidewalk grade.

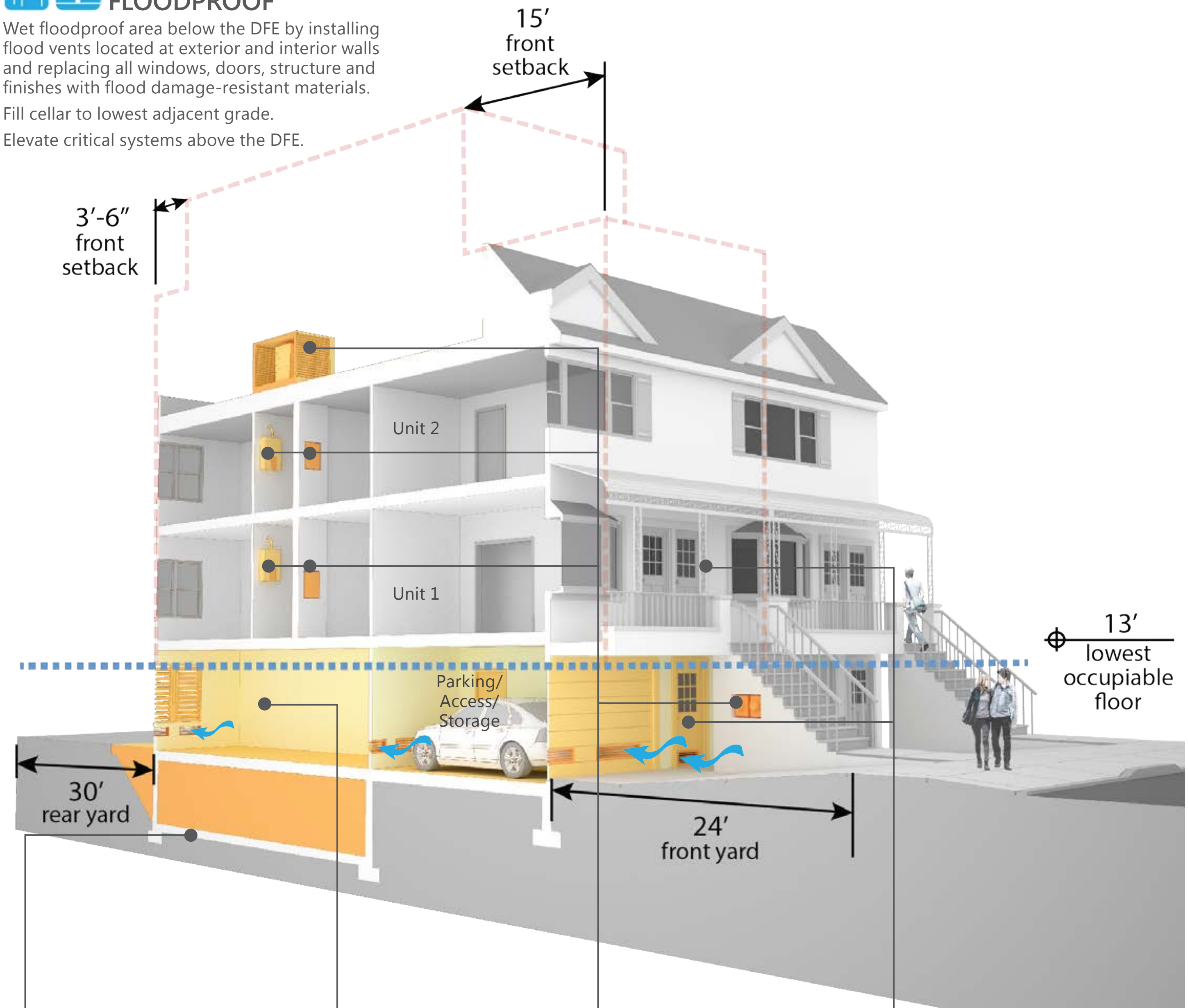
ILLUSTRATIVE RETROFIT STRATEGY

ELEVATE & WET FLOODPROOF

Wet floodproof area below the DFE by installing flood vents located at exterior and interior walls and replacing all windows, doors, structure and finishes with flood damage-resistant materials.

Fill cellar to lowest adjacent grade.

Elevate critical systems above the DFE.



STRUCTURAL SYSTEMS

Fill the cellar and the rear yard access opening to the lowest adjacent grade. Reinforce the foundation walls and modify the slab in the cellar where fill is added. Tie ground floor structure to walls.

If adjacent properties are not infilling their shared party-wall areas reinforce the foundation walls to account for new load.

Add reinforcement under relocated critical systems.

USE

Garage level to be converted to storage where the existing use of vehicular parking or access is not programmed.

Approximately 600 s.f. of usable space cannot be relocated because the ground floor area was not accounted for as floor area and the building is at the maximum allowable floor area.

CRITICAL SYSTEMS

Install individual compact in-unit hot water systems.

Elevate partial systems to roof within fireproof and vented enclosure. Isolation and/or vibration pads may be required.

Relocate utility services to front yard within encapsulated enclosure. Re-route apartment feeders and branch circuits accordingly.

ACCESS

All doors below the DFE are required to be wet floodproofed by installation of flood vents.

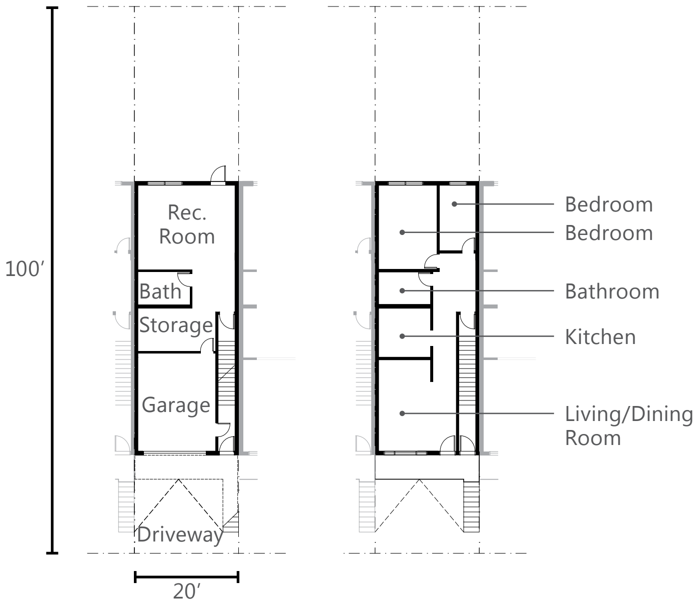
Remove cellar hatch at the rear yard access.

Existing entrances above the DFE to remain.

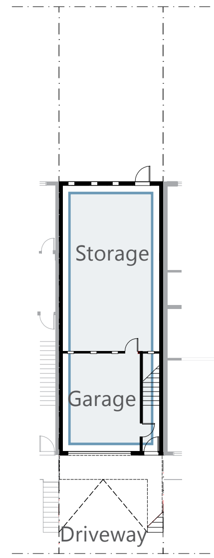
RETROFIT FLOOR PLANS

CHANGE OF USE

EXISTING
Garage Level   Level One



PROPOSED
Garage Level



Cellar
Fill to lowest adjacent grade.

Loss of storage and mechanical room.

Garage Level
Reconfigured parking, storage, and access.

Loss of recreation room and bathroom. Enlarge garage to accomodate two parking spaces.

Levels One and Two
Level one becomes the lowest occupiable floor.

Existing use remains.

ADAPTATION CONSIDERATIONS

CRITICAL SYSTEMS

When encapsulating electrical equipment stainless steel enclosures provide a certain degree of flood protection for equipment below the DFE. This is temporary protection intended for a flood event. The wiring should be encased in a non-corrosive metal or plastic conduit when allowed by code.

Tank-less water heaters are located adjacent to the fixture that requires heating. They work instantaneously but have little storage capacity, and therefore take up less space making it easier to retrofit buildings using these systems. Natural gas systems require little work for conversion, though electrical systems may require upgrades to provide more power for the system.

NON-SUBSTANTIAL DAMAGE/IMPROVEMENT STRATEGIES

Non-substantially improved buildings within the floodplain are not required to comply with Appendix G of the NYC Building Code. This allows for greater flexibility in adapting buildings for flood resiliency. The alternatives illustrated below lower the risk for buildings and provide practical pathways for adaptation. Under current NFIP regulations, these measures may not lower insurance premiums.

The blue icons below illustrate adaptive measures that receive full reduction of NFIP premiums. Icons in gray indicate strategies that improve building resilience, but receive no or partial reduction of NFIP premiums.

If the lowest occupiable floor is left below the DFE, life safety must be considered. Residents should always follow evacuation procedures.

- Occupied Space
- Critical Systems
- Dry Floodproof
- Wet Floodproof
- Open Structure
- NFIP Premium Reduction

Elevate the critical systems above the DFE. Fill the structure to the lowest adjacent grade.

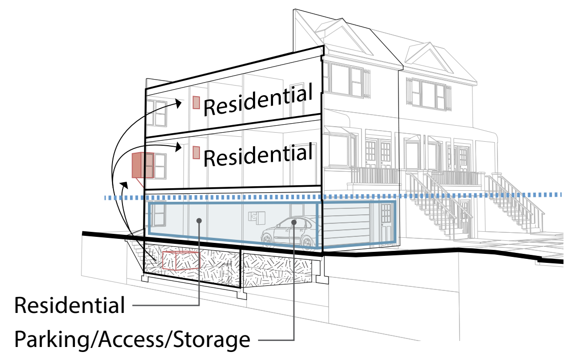
Wet floodproof garage level. Install flood vents and replace all windows, doors and finishes with flood damage-resistant materials.

Existing residential use remains with exception of loss of use at the cellar.

Fill cellar to the lowest adjacent grade. Add reinforcement to foundation walls. Ensure changes to party-walls do not impact neighboring propety's structural integrity.

Elevate the systems above the DFE within a fire-rated and vented enclosure in the rear yard. Install in-unit hot water systems.

No or partial reduction in NFIP premiums. Residential use remains located below the DFE. Lowest occupiable floor is below the DFE.



Elevate the lowest occupiable floor above the DFE.

Wet floodproof partial garage level. Install flood vents and replace all windows, doors, and finishes with flood damage-resistant materials.

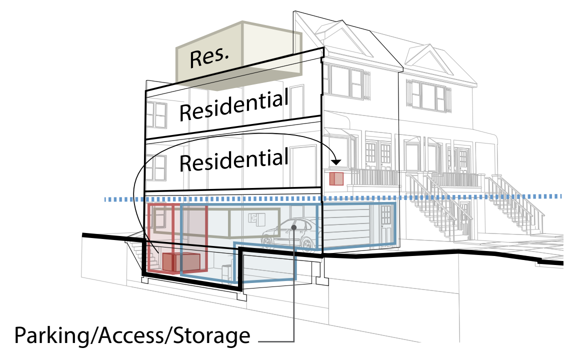
Dry floodproof cellar and partial garage level below the DFE by strengthening the foundation, floors and walls and sealing all penetrations. Provide temporary flood shields at windows and doors.

If floor area at the garage level is within allowable floor area, relocate to addition on the roof. Restrict uses at wet floodproofed areas to parking, crawl space, access, and storage.

Add reinforcement to roof, party-walls, exterior walls, and foundation walls and slab. Ensure changes to party-walls do not impact neighboring propety's structural integrity.

Critical systems to remain in place within dry floodproofed mechanical room. Provide emergency shut off above the DFE. Elevate electrical utilities above the DFE.

No or partial reduction in NFIP premiums. Critical systems remain located below the DFE. Existing cellar use remains. Dry floodproofing is not permitted at residential use.



Dry floodproof cellar and partial garage level below the DFE by strengthening the foundation, floors and walls and sealing all penetrations. Provide temporary flood shields at windows and doors.

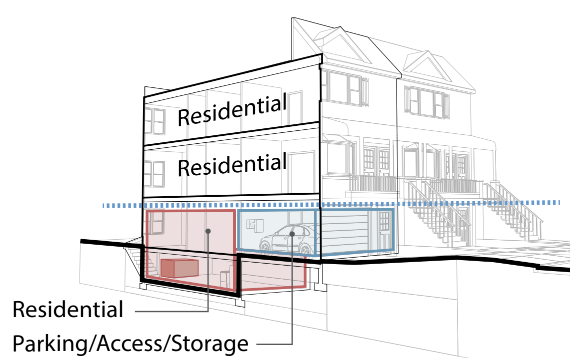
Wet floodproof partial garage level. Install flood vents and replace all windows, doors, and finishes with flood damage-resistant materials.

All existing uses remain.

Add reinforcement to roof, party-walls, exterior walls, foundation walls and slab. Ensure changes to party-walls do not impact neighboring propety's structural integrity.

Critical systems to remain in place within dry floodproofed mechanical room. Provide emergency shut off above the DFE.

No or partial reduction in NFIP premiums. Critical systems and residential use remain located below the DFE. Existing cellar use remains. Dry floodproofing is not permitted at residential use. Lowest occupiable floor is below the DFE.



ATTACHED

This row house example is an unreinforced masonry structure with party-walls, rubble foundation and a garden level residential unit. This structure has two shared bearing walls and is not suited for structural elevation.

Retrofit strategies that will result in full NFIP reduction in flood insurance premiums require extensive modifications to the building structure and program, which results in the loss of useable space, and may have structural integrity implications for the neighboring properties.

NFIP premium reduction options include filling the cellar and the basement to the lowest adjacent grade, converting that space to storage and access, and converting the first residential level to storage and a new mechanical room. Replacing most of the lost residential space would require a new, two-story addition, which also requires significant structural modifications.

Alternative adaptation strategies, currently not recognized by NFIP, include leaving existing uses in place and dry or wet floodproofing below the DFE.

Partial adaptation could be limited to elevating or dry floodproofing the critical systems in place.

All floodproofing solutions require assessment of the building's structural integrity and the implications of the changes on the neighboring buildings.

KEY CHARACTERISTICS

FLOOD RISK	
Flood Zone/BFE	AE +12'
Grade Elevation	+6' at sidewalk, +2' at rear property
Design Flood Elevation (DFE)	+14' (8' above sidewalk grade)
Lowest Occupiable Floor	+2' (4' below sidewalk grade)
Cellar Elevation	-5' (11' below sidewalk grade)
Critical Systems Location	Cellar
TYPOLOGY	
Lot Size	20' x 100'
Building Size	20' x 50'
Yards	10' front; 40' rear
Construction Type	Masonry with wood joists
Foundation Type	Rubble
Year Built	1900
Stories	2 + basement and cellar
Residential Floor Area	3,000 s.f. total
Residential Units	1 single storey, 1 duplex
Elevator	N/A
SITE CONDITIONS	
Sidewalk Width	8'
Roadbed Width	32'
Zoning District	R5, Residential

1% annual flood chance
0.2% annual flood chance

DFE +14'
Grade +6'

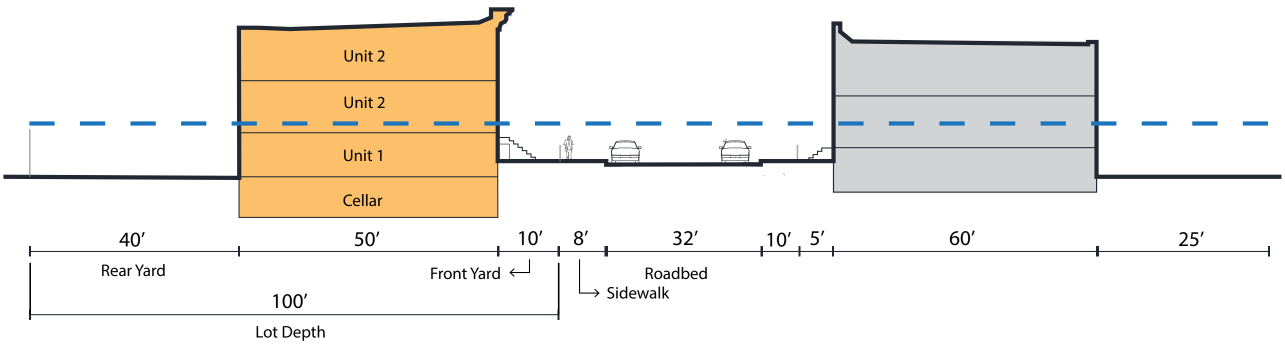
SITE & BUILDING CONDITIONS

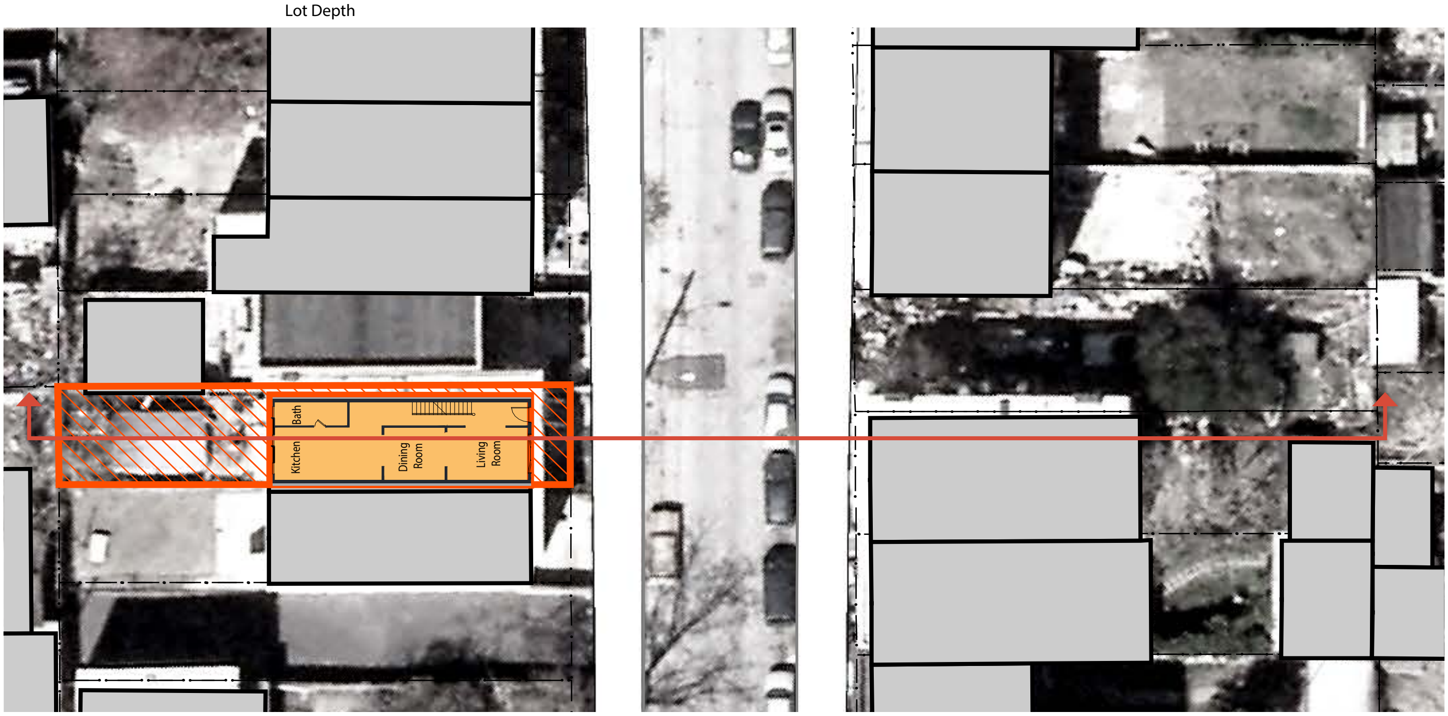
SITE CONDITIONS

Sites with standard lot size and rear yards that are 0 to 6 feet below sidewalk grade. No side yards are provided. Streets and sidewalks are typically of standard width.

BUILDING TYPOLOGY

Buildings are two to four-story masonry party-walls with wood joists and a rubble foundation. Critical systems are located in the basement or cellar. Entrances are located above and below the sidewalk and property grade.

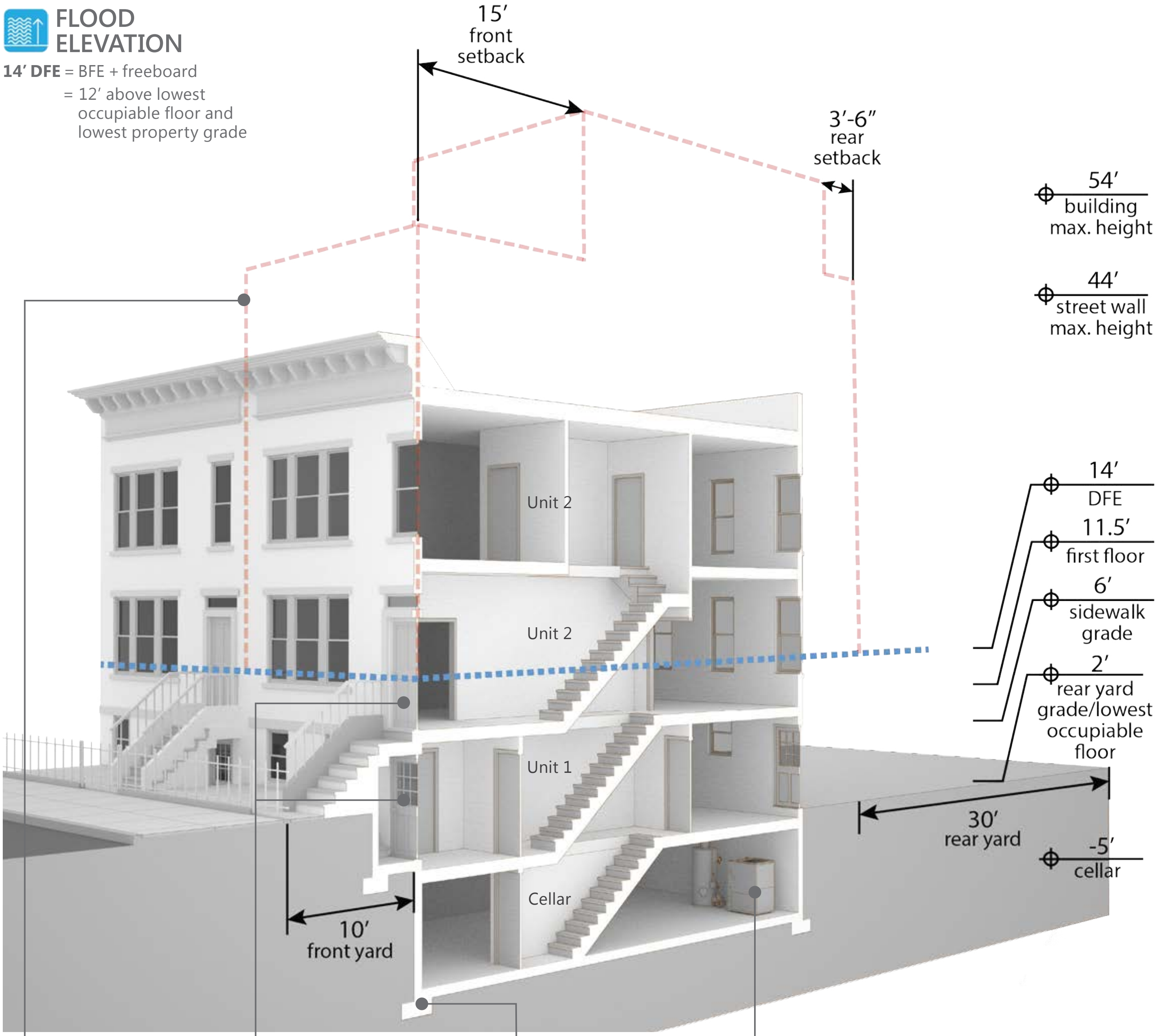




EXISTING CONDITIONS

FLOOD ELEVATION

14′ DFE = BFE + freeboard
= 12′ above lowest occupiable floor and lowest property grade



ZONING ENVELOPE

The allowable building height is measured from the DFE.

The floor area is overbuilt, which is an existing non-compliance. Zoning allows the relocation of existing non-compliant floor area to above the DFE within the adjusted bulk envelope.

ACCESS

Building access is provided at two front entrances, one located 5′ above sidewalk grade and the second located 4′ below sidewalk grade.

The building access at the rear yard is provided at rear grade, 4′ below the sidewalk grade.

STRUCTURAL SYSTEMS

Three-story combustible construction with unreinforced masonry bearing party-walls and wood joists on a rubble foundation.

CRITICAL SYSTEMS

All systems are located in the cellar.

ILLUSTRATIVE RETROFIT STRATEGY

ATTACHED

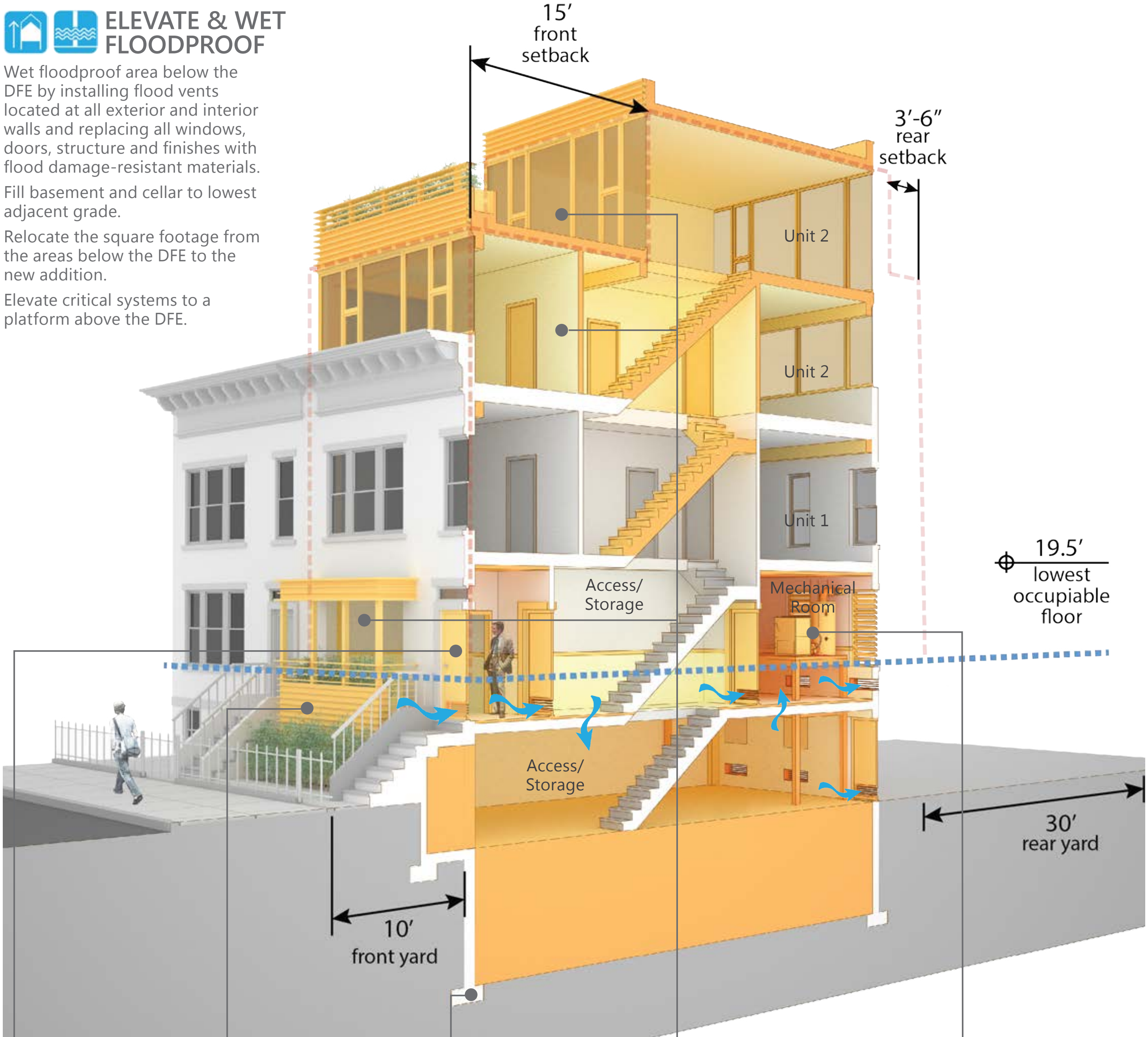
ELEVATE & WET FLOODPROOF

Wet floodproof area below the DFE by installing flood vents located at all exterior and interior walls and replacing all windows, doors, structure and finishes with flood damage-resistant materials.

Fill basement and cellar to lowest adjacent grade.

Relocate the square footage from the areas below the DFE to the new addition.

Elevate critical systems to a platform above the DFE.



ACCESS

All doors below the DFE are required to be wet floodproofed by installation of flood vents.

Modify the height of the rear building entry to the adjusted lowest level.

Existing entrance at the front stairs to remain. Interior layout of this entrance reconfigured to accommodate the new vestibule, front porch and circulation.

STREETSCAPE

Add plantings and porch to fulfill the zoning streetscape mitigation requirements.

Replace windows at streetwall elevation below the DFE with flood damage-resistant materials and install planters at the front facade.

STRUCTURAL SYSTEMS

Remove existing floor plate and slab, and fill the cellar and basement to lowest adjacent grade. Add reinforcement to the foundation walls. If the adjacent properties are not infilling their shared party wall areas, reinforce the foundation walls to account for new load.

New addition at roof and platform for critical systems require additional structural support.

USE

Relocate uses from the basement level and first level to the two story addition.

Convert first level to porch, storage, access and mechanical room.

The building remains 2-family. Relocate the garden level unit to the second story and the duplex unit to the new third and fourth stories.

New entry vestibule to allow for reconfigured circulation.

There is a total loss of 370 s.f. of floor area due to reconfigured unit and new interior access layout.

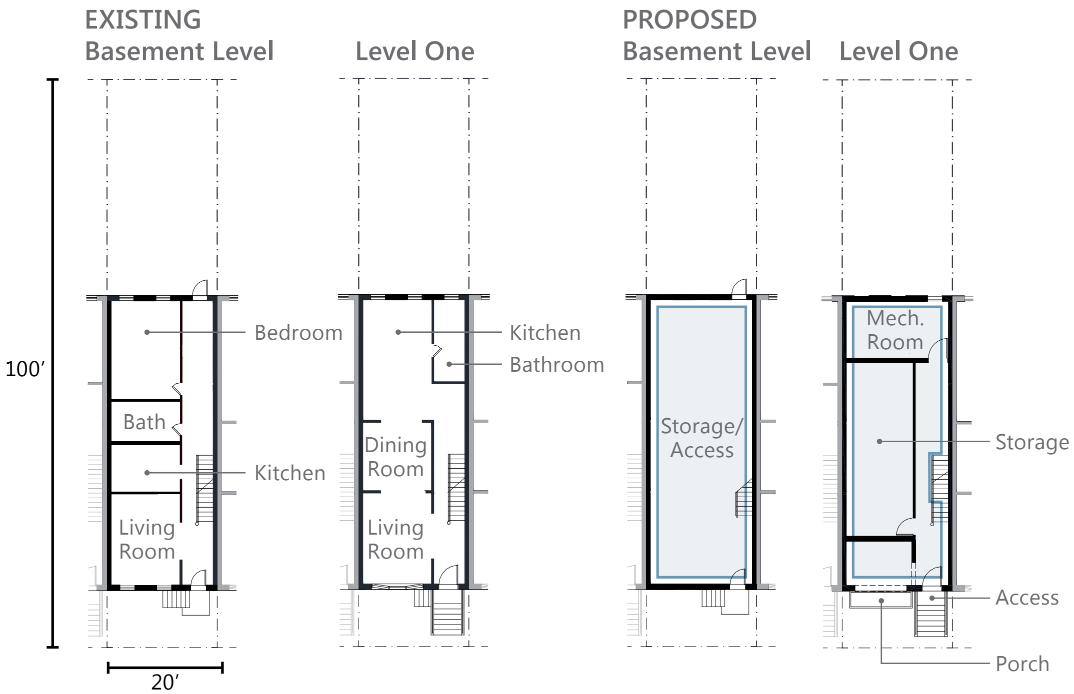
CRITICAL SYSTEMS

Elevate systems on a platform above the DFE within new fireproof and vented mechanical room.

New building height requires installation of sprinkler system.

RETROFIT FLOOR PLAN

CHANGE OF USE



Cellar
Fill to lowest adjacent grade.
Loss of storage and mechanical room.

Basement Level
New storage and access.

Loss of rental unit.

Level One
New storage, access, porch and mechanical room.

Loss of first story of duplex unit.

Elevate the critical systems to new mechanical room within existing structure.

Two required streetscape mitigations: covered porch.

Level Two
Level two becomes the lowest occupiable floor.

New relocated single story rental unit.

Levels Three and Four (New)
New relocated duplex unit. Lost occupiable floor area from level one and basement.

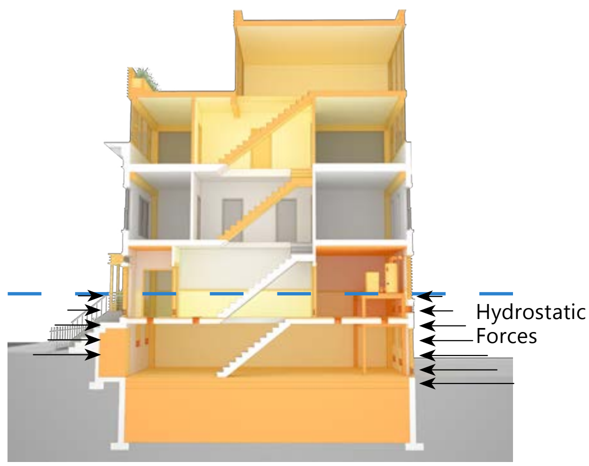
ADAPTATION CONSIDERATIONS

WET FLOODPROOFING

When wet floodproofing between two floors, important steps must be taken to ensure the floor plate does not collapse.

All wet floodproofed areas must be constructed of approved materials and contain vents to allow water to flow horizontally and vertically. It is important to prohibit buoyancy loads to build up in air pockets that could form in between the floor framing. A new floor framing system below the DFE constructed with flood damage-resistant materials may be required.

This 1900-era construction type and the fact that the rear yard grade is lower than the sidewalk grade could prove to be problematic with load path issues associated with flooding and the additional rooftop structure. Front walls may need to be strengthened to handle surge or high flood elevation loads. Rear walls may need to be reinforced as well to deal with the loads of the sitting floodwaters in the rear yard.



ACCESS & STREETSCAPE

NON-SUBSTANTIAL DAMAGE/IMPROVEMENT STRATEGIES

Non-substantially improved buildings within the floodplain are not required to comply with Appendix G of the NYC Building Code. This allows for greater flexibility in adapting buildings for flood resiliency. The alternatives illustrated below lower the risk for buildings and provide practical pathways for adaptation. Under current NFIP regulations, these measures may not lower insurance premiums.

The blue icons below illustrate adaptive measures that receive full reduction of NFIP premiums. Icons in gray indicate strategies that improve building resilience, but receive no or partial reduction of NFIP premiums.

If the lowest occupiable floor is left below the DFE, life safety must be considered. Residents should always follow evacuation procedures.

- Occupied Space
- Critical Systems
- Dry Floodproof
- Wet Floodproof
- Open Structure
- NFIP Premium Reduction

No or partial reduction in NFIP premiums. Residential use remains located below the DFE and the structure is not filled to the lowest adjacent grade.

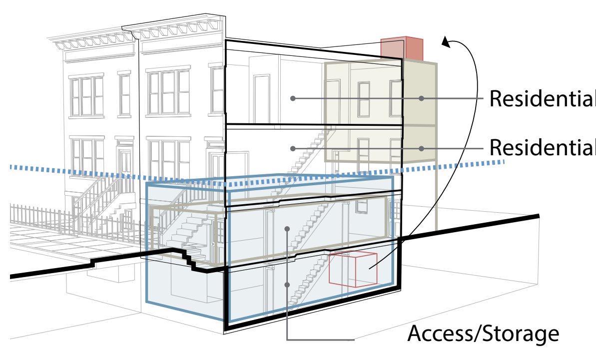
Elevate the critical systems and residential use above the DFE.

Wet floodproof below the DFE. Install flood vents at walls and floors to ensure vertical and horizontal water flow. Replace all windows, doors and finishes with flood damage-resistant materials.

Relocate basement level floor area to new addition on rear of second and third stories. Basement and cellar use as access and/or storage. Residential use remains at first and second stories.

Add reinforcement for addition at rear. Ensure wet floodproofing at party-wall locations does not impact neighboring property's structural integrity.

Relocate critical systems within fire-rated and vented enclosure on roof of the rear addition.



No or partial reduction in NFIP premiums. Residential use remains located below the DFE and the structure is not filled to the lowest adjacent grade. Lowest occupiable floor is below the DFE.

Elevate the critical systems above the DFE within a fire-rated and vented enclosure in the rear yard.

Existing residential use remains. Loss of occupiable space may occur if systems location requires a window to be infilled.

Add structural support to accommodate relocated critical systems.

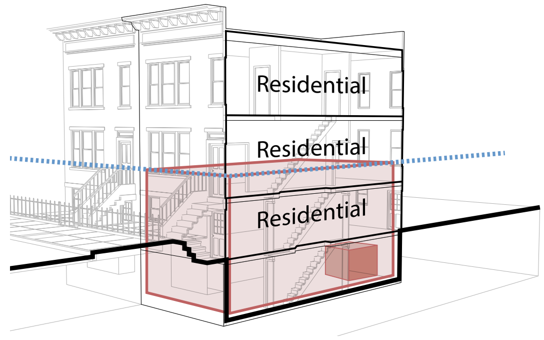
No or partial reduction in NFIP premiums. Critical systems and residential use remain located below the DFE and the structure is not filled to the lowest adjacent grade. Dry floodproofing is not permitted at residential use. Lowest occupiable floor is below the DFE.

Dry floodproof cellar, basement and part of level one below the DFE by strengthening the foundation, floors and walls and sealing all penetrations. Provide temporary flood shields at windows and doors.

All existing uses remain.

Add reinforcement to roof, party-walls, exterior walls, foundation walls and slab. Ensure changes to party-walls do not impact neighboring property's structural integrity.

Critical systems to remain in place within dry floodproofed mechanical room. Provide emergency shut off above the DFE.



MID-RISE WALK-UP

The mid-rise walkup case study described here is a multi-story unreinforced masonry structure with masonry rubble foundation. Because the structure is so large and in such close proximity to the neighboring building, it is unsuitable for elevation.

Retrofit strategies that will result in full NFIP reduction in flood insurance premiums require filling the basement to the lowest adjacent grade and wet floodproofing below the DFE, leading to the loss of two units, additional first level floor construction and the reconfiguration of the entry vestibule. The loss of 20 percent of the building's units exemplifies the implications and limitations of existing federal regulations when applied to urban typologies. This strategy also requires structural reinforcement to allow filling the basement, adding a new floor to the existing first level, relocating the critical systems to a new mechanical room, and building an addition on the roof, where a portion of the lost residential square footage can be replaced. It also requires a fire-rated separation at the new mechanical room.

Alternative adaptation strategies, currently not recognized by NFIP, include leaving existing residential uses in the basement and first floor, wet floodproofing below the DFE, and enclosing the critical systems within a floodproof enclosure.

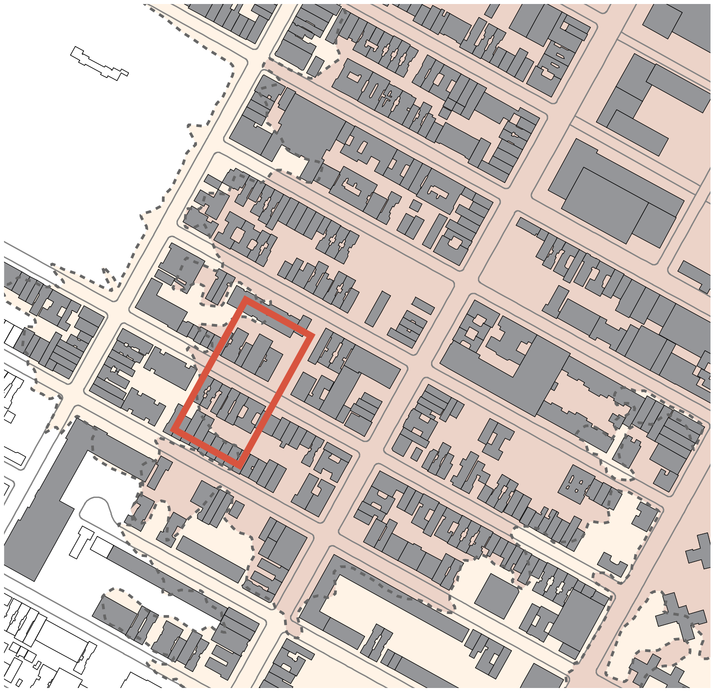
Partial adaptation is limited to elevating or dry floodproofing the critical systems in place.

All floodproofing solutions require assessment of the building's structural integrity and a thorough consideration of the implications for neighboring buildings.

KEY CHARACTERISTICS

FLOOD RISK	
Flood Zone/BFE	AE +11'
Grade Elevation	+2' at sidewalk and property
Design Flood Elevation (DFE)	+12' (10' above sidewalk grade)
Lowest Occupiable Floor	- 2' (4' below sidewalk grade)
Cellar Elevation	- 2' (4' below sidewalk grade)
Critical Systems Location	Basement
TYPOLOGY	
Lot Size	25' x 100'
Building Size	25' x 80'
Yards	5' front; 15' rear
Construction Type	Masonry with wood joists
Foundation Type	Rubble
Year Built	1900
Stories	5 + basement
Residential Floor Area	11,000 s.f.
Residential Units	10 single story, 2 duplex
Elevator	N/A
SITE CONDITIONS	
Sidewalk Width	13'
Roadbed Width	34'
Zoning District	R8B, Residential

1% annual flood chance
0.2% annual flood chance



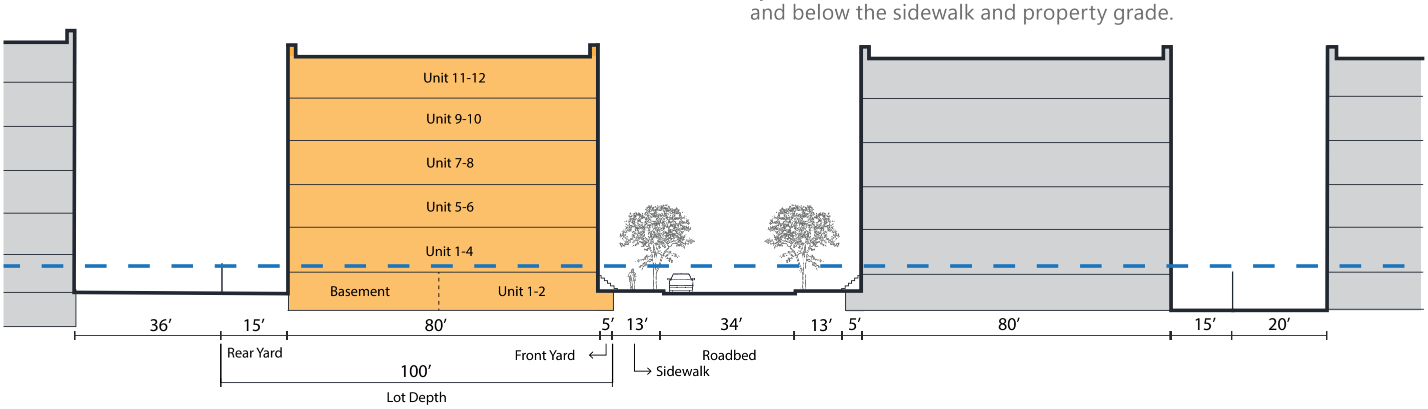
SITE & BUILDING CONDITIONS

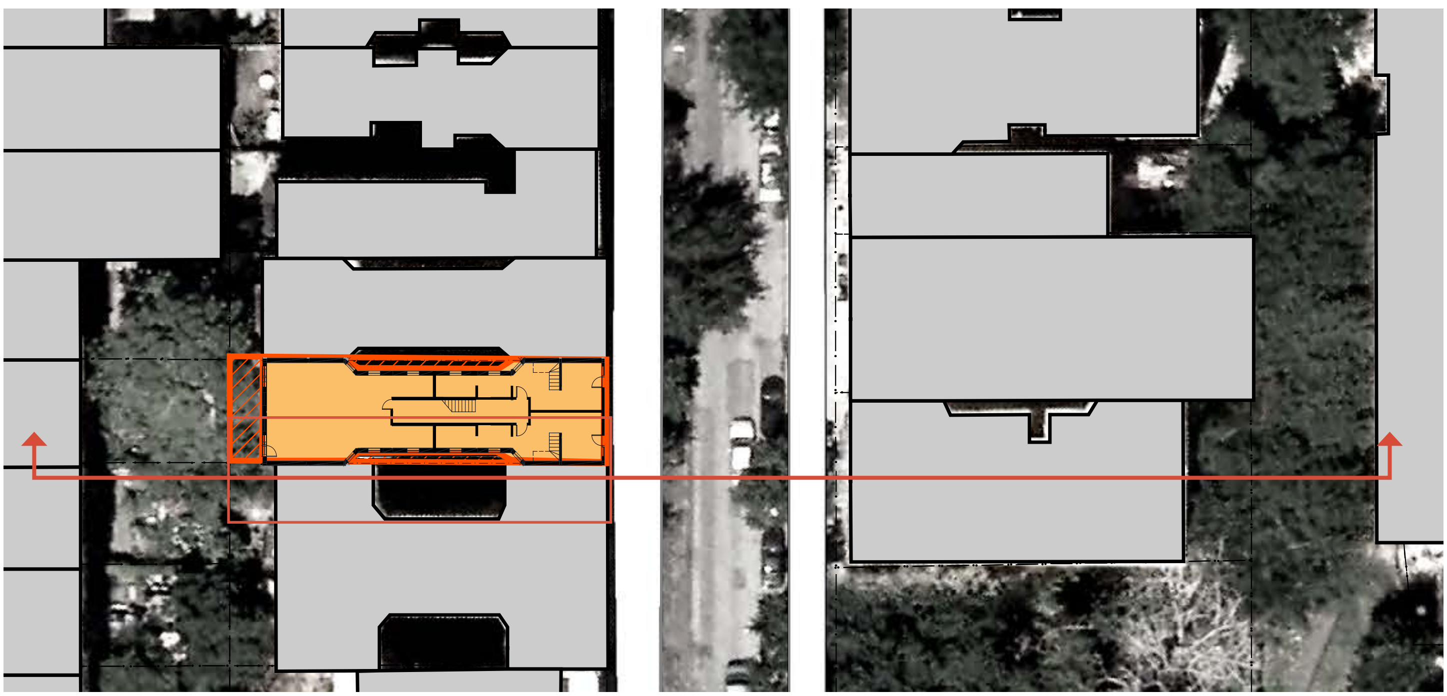
SITE CONDITIONS

Sites with narrow lot size and shallow rear yard depth. Rear yards typically range from 0 to 6 feet below the sidewalk grade. No side yards are provided, and streets and sidewalks are typically of standard width.

BUILDING TYPOLOGY

Buildings are four to six-story unreinforced masonry bearing walls with wood joists and rubble foundation. Vertical circulation is provided by stairs and egress is provided by fire escapes. Critical systems are located in the basement/cellar. Entrances located above and below the sidewalk and property grade.

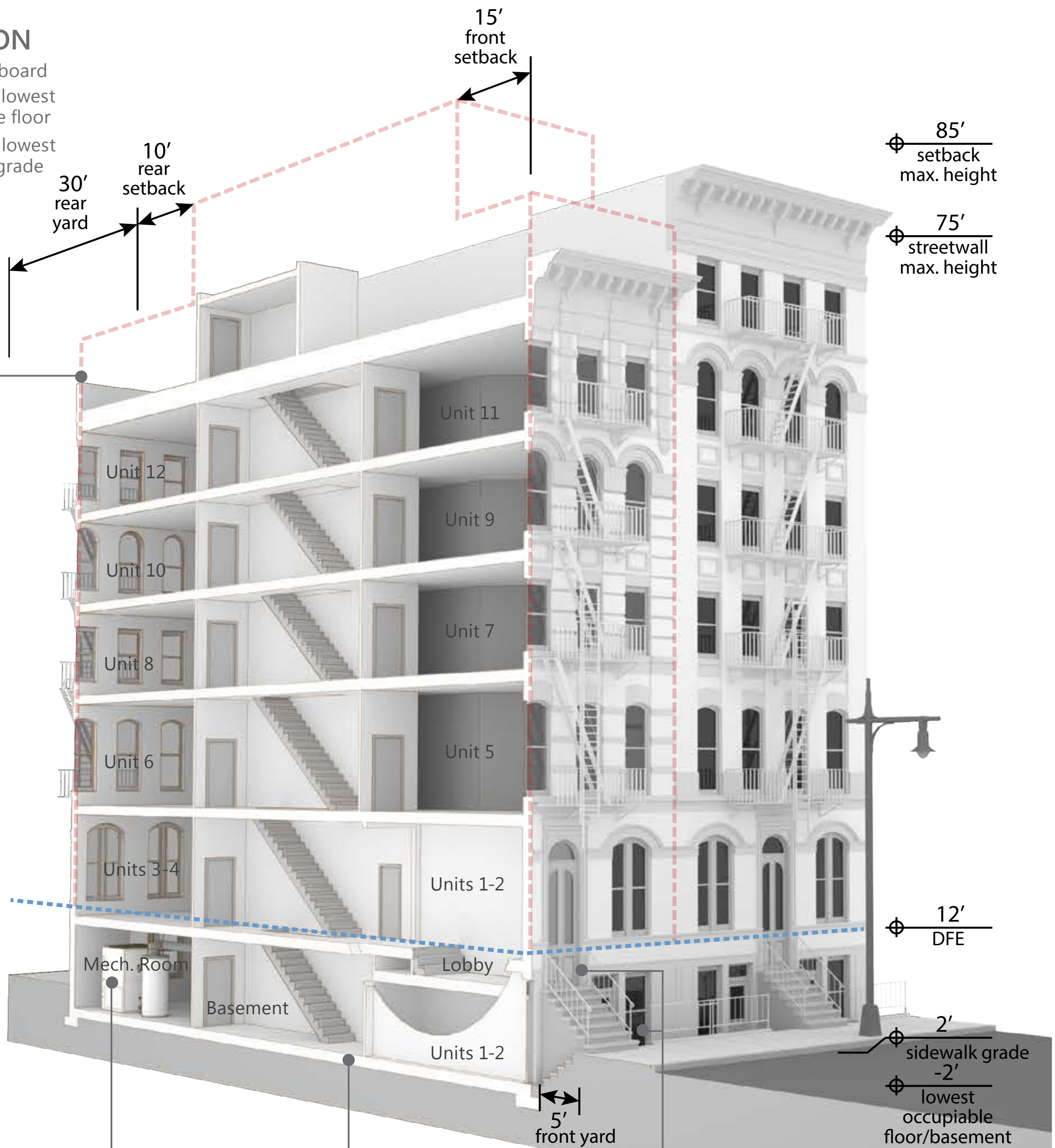




EXISTING CONDITIONS

FLOOD ELEVATION

12′ DFE = BFE + freeboard
= 14′ above lowest occupiable floor
= 10′ above lowest property grade



ZONING ENVELOPE

The allowable building height is measured from the DFE.

The building has a non-compliant rear yard.

The building is built to the maximum allowable floor area. To comply with the Zoning standards, the floor area below the DFE can be relocated within the adjusted bulk envelope.

CRITICAL SYSTEMS

All systems are located in a mechanical room in the basement.

STRUCTURAL SYSTEMS

Five-story combustible construction with unreinforced masonry bearing party-walls and wood joists on a rubble foundation.

ACCESS

Building access is provided at two front entrances, one located 5′ above sidewalk grade and the second located 4′ below sidewalk grade.

The building access at the rear yard is provided 3′ below the rear yard grade.

ILLUSTRATIVE RETROFIT STRATEGY

MID-RISE WALK-UP

ELEVATE & WET FLOODPROOF

Wet floodproof area below the DFE by installing flood vents located at exterior and interior walls and replacing all windows, doors, strucutre and finishes with flood damage-resistant materials.

Fill basement and cellar to lowest adjacent grade.

Relocate the square footage from areas below the DFE to new addition at the roof.

Elevate critical systems above the DFE.

CRITICAL SYSTEMS

Elevate systems on a platform above the DFE within a fireproof and vented mechanical room.

Isolation and/or vibration pads may be required.

STRUCTURAL SYSTEMS

Fill basement to lowest adjacent grade. Reinforce foundation walls as required in basement, where fill is added. If adjacent properties are not infilling their shared party wall areas, reinforce the foundation walls to account for new load.

New addition at the roof and the platform for the critical systems require additional structural support.

USE

Basement level becomes crawl space and storage, if clearance permits.

Relocate basement level duplex unit to new addition, reconfigure existing 5th floor single story unit as a duplex unit.

Relocate critical systems to first story, reconfigure unit as required.

Reconfigure entry vestibule to accommodate required size for wet floodproofing.

Raise existing first floor level to the DFE by installing additional stairs and floor construction.

Loss of 1,200 s.f. due to relocation and reconfigured units.

ACCESS

Remove the door below sidewalk grade and infill with flood damage-resistant building materials.

Additional stairs at lobby to meet new first floor elevation.

Add rear access above the DFE adjacent to the mechanical room.

STREETSCAPE

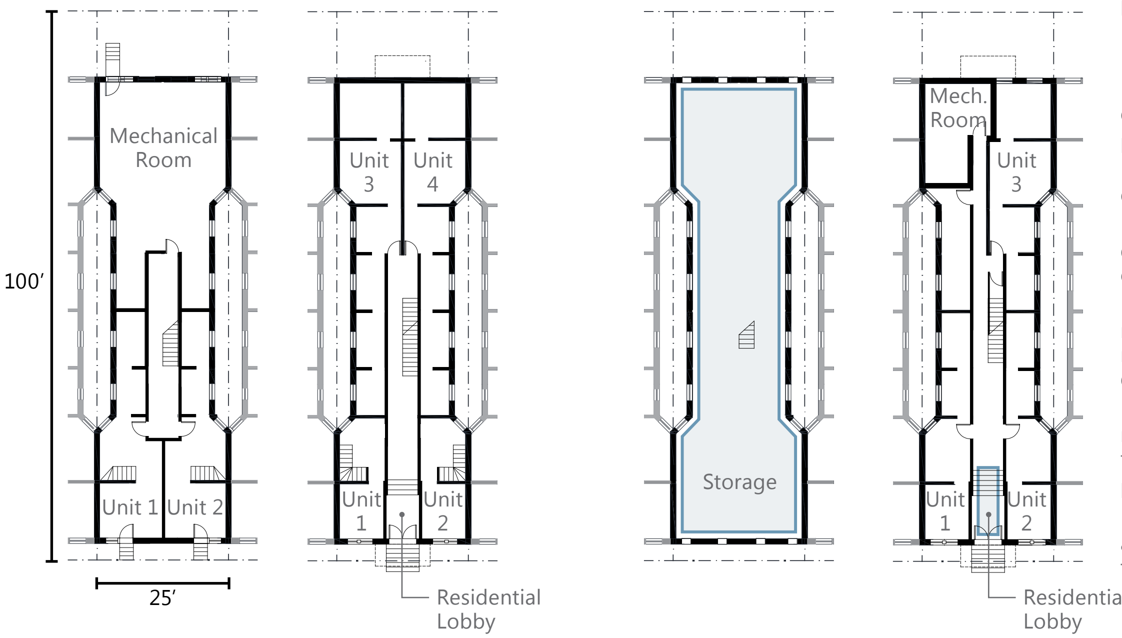
Replace windows at the streetwall elevation below the DFE with flood damage resistant materials and install planters in front of building facade.

RETROFIT FLOOR PLAN

CHANGE OF USE

EXISTING Basement Level | Level One

PROPOSED Basement Level | Level One



Basement Level
New storage and crawl space.

Fill to lowest adjacent grade. Loss of mechanical room and occupiable space of two units.

Level One
Level one becomes the lowest occupiable floor.

New mechanical room within existing structure for elevated critical systems.

Loss of one rear unit to new mechanical room. Convert and reconfigure two front units from duplex to single-story.

Residential lobby remains; reconfigure per wet floodproofing requirements.

Level Six (New)
Relocate lost occupiable floor area from the basement level to the new additon.

ADAPTATION CONSIDERATIONS

CRITICAL SYSTEMS

It is important to consider the weight of the mechanical equipment on the building structure when elevating equipment to a higher floor. The additional load may require structural reinforcement of the space where the equipment is being relocated.

Oil- or gas-fueled boilers, furnace and water heaters require adequate combustion air and venting of exhaust gases. Venting and fire-rated enclosure requirements may affect if and how equipment can be elevated.

Before relocating equipment, ample consideration must be given to minimum clearances required for equipment, conduits, piping and duct work in order to maintain the horizontal and vertical clearances as required by building code, the National Electric Code and as recommended by manufacturers. Designing for the minimum clearance is important to maintain air circulation; to meet insurance or code requirements related to the equipment's requirements; and to maintain distance from combustible building materials. The use of heat shields as specified by code may reduce clearance requirements. Failure to maintain clearances can result in safety issues, such as fire, and can void equipment warranties.

ACCESS & STREETSCAPE

NON-SUBSTANTIAL DAMAGE/IMPROVEMENT STRATEGIES

Non-substantially improved buildings within the floodplain are not required to comply with Appendix G of the NYC Building Code. This allows for greater flexibility in adapting buildings for flood resiliency. The alternatives illustrated below lower the risk for buildings and provide practical pathways for adaptation. Under current NFIP regulations, these measures may not lower insurance premiums.

The blue icons below illustrate adaptive measures that receive full reduction of NFIP premiums. Icons in gray indicate strategies that improve building resilience, but receive no or partial reduction of NFIP premiums.

If the lowest occupiable floor is left below the DFE, life safety must be considered. Residents should always follow evacuation procedures.

- Occupied Space
- Critical Systems
- Dry Floodproof
- Wet Floodproof
- Open Structure
- NFIP Premium Reduction

No or partial reduction in NFIP premiums. The structure is not filled to the lowest adjacent grade. Wet floodproofing is not permitted at residential use. Lowest occupiable floor is below the DFE.

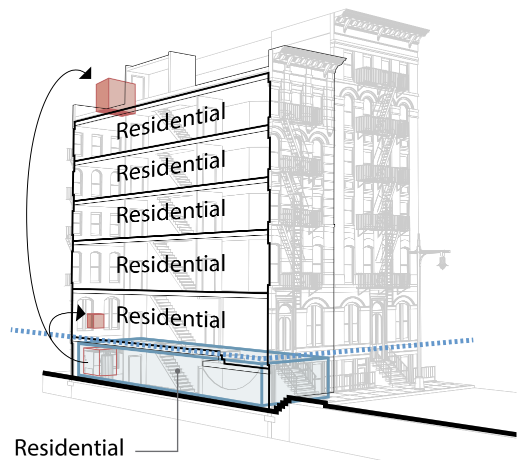
Elevate critical systems above the DFE.

Wet floodproof below the DFE. Install flood vents and replace all windows, doors and finishes with flood damage-resistant materials.

All residential uses remain. Convert mechanical room to storage.

Add structural support for relocated critical systems.

Relocate critical systems to the roof within a fire-rated and vented enclosure. Raise electrical utilities above DFE at building rear.



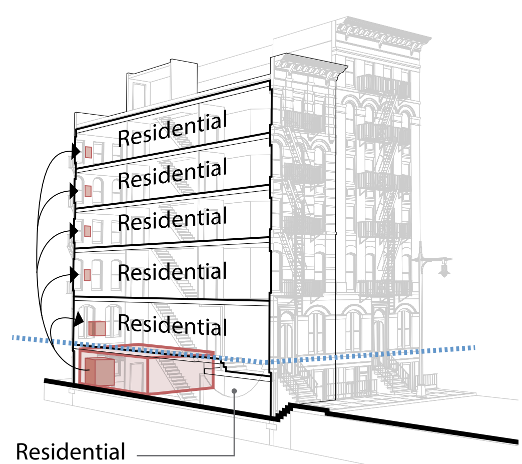
No or partial reduction in NFIP premiums. Critical systems remain located below the DFE and the structure is not filled to the lowest adjacent grade. Dry floodproofing is not permitted at residential use. Lowest occupiable floor is below the DFE.

Dry floodproof partial basement level at mechanical room.

Residential use at basement and level one remains below the DFE.

Add reinforcement to party-walls, exterior walls and foundation slab at dry floodproof enclosure, and ensure changes do not impact neighboring property's structural integrity.

Critical systems to remain in place within dry floodproofed mechanical room. Provide emergency shut off above the DFE. Install in-unit hot water systems at each residential unit.



MID-RISE ELEVATOR

The mid-rise elevator case study described here is a steel and concrete structure with a concrete foundation. This structural type is heavy and in very close proximity to the neighboring structure therefore not suitable for elevation.

The retrofit strategy that will result in full NFIP reduction in flood insurance premiums requires filling the basement to the lowest adjacent grade, changing the first floor use from residential to community facility to allow for dry floodproofing the areas below the DFE, and wet floodproofing the residential lobby. Elevator equipment must be relocated above the DFE and the pit must be wet floodproofed. These mitigation strategies require significant structural reinforcement and lead to the loss of six units and the gain of additional community facility space, a reconfiguration that has implications for the property's financial viability. Additionally, because of the limited need for new community facility space, this strategy may not be applicable at a neighborhood scale, further restricting options for this typology. Critical systems can also be elevated within the building, on the roof, or in the rear yard if clearance is provided.

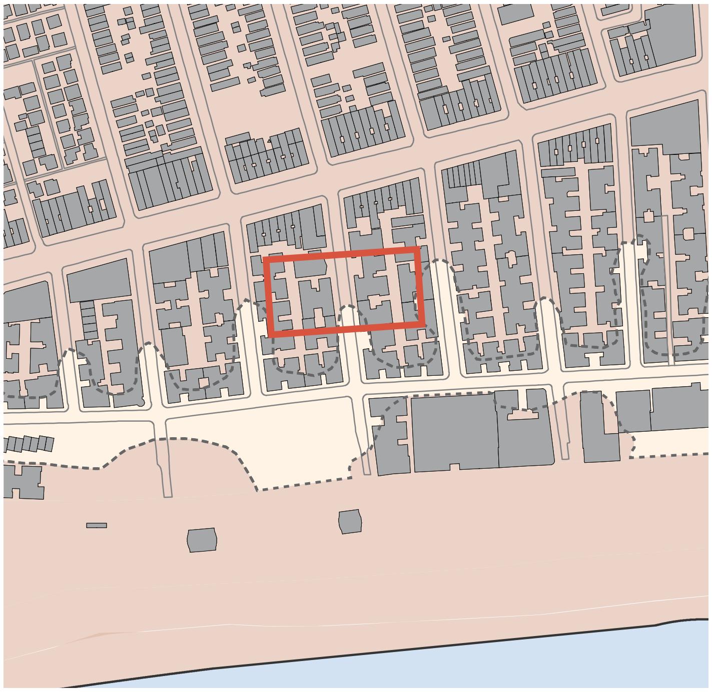
Alternative adaptation strategies, currently not recognized by NFIP, include leaving existing residential uses in the cellar and first floor, critical systems in the basement within a foodproof enclosure, and wet floodproofing below the DFE.

All floodproofing solutions require assessment of the building's structural integrity and a consideration of the impacts and implications for neighboring buildings.

KEY CHARACTERISTICS

FLOOD RISK	
Flood Zone/BFE	AE +11′
Grade Elevation	+6′ at sidewalk and property
Design Flood Elevation (DFE)	+12′ (6′ above sidewalk grade)
Lowest Occupiable Floor	+10′ (4′ above sidewalk grade)
Cellar Elevation	-1′ (7′ below sidewalk grade)
Critical Systems Location	Cellar
TYPOLOGY	
Lot Size	100′ x 100′
Building Size	100′ x 84′
Yards	3′ front; 14′ rear
Construction Type	Steel frame/concrete slab
Foundation Type	Concrete
Year Built	1930
Stories	6 + cellar
Residential Floor Area	50,400 s.f.
Residential Units	36
Elevator	Yes
SITE CONDITIONS	
Sidewalk Width	15′
Roadbed Width	34′
Zoning District	R7-1, Residential

1% annual flood chance
0.2% annual flood chance



DFE +12′
Grade +2′

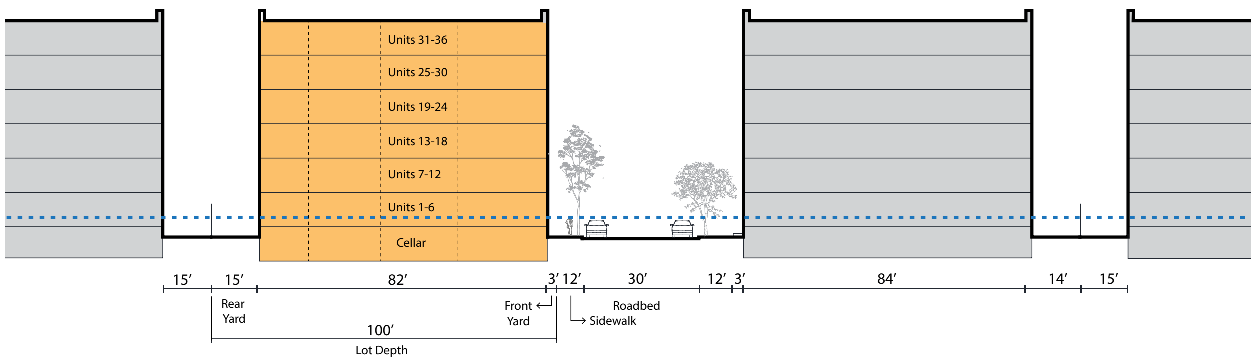
SITE & BUILDING CONDITIONS

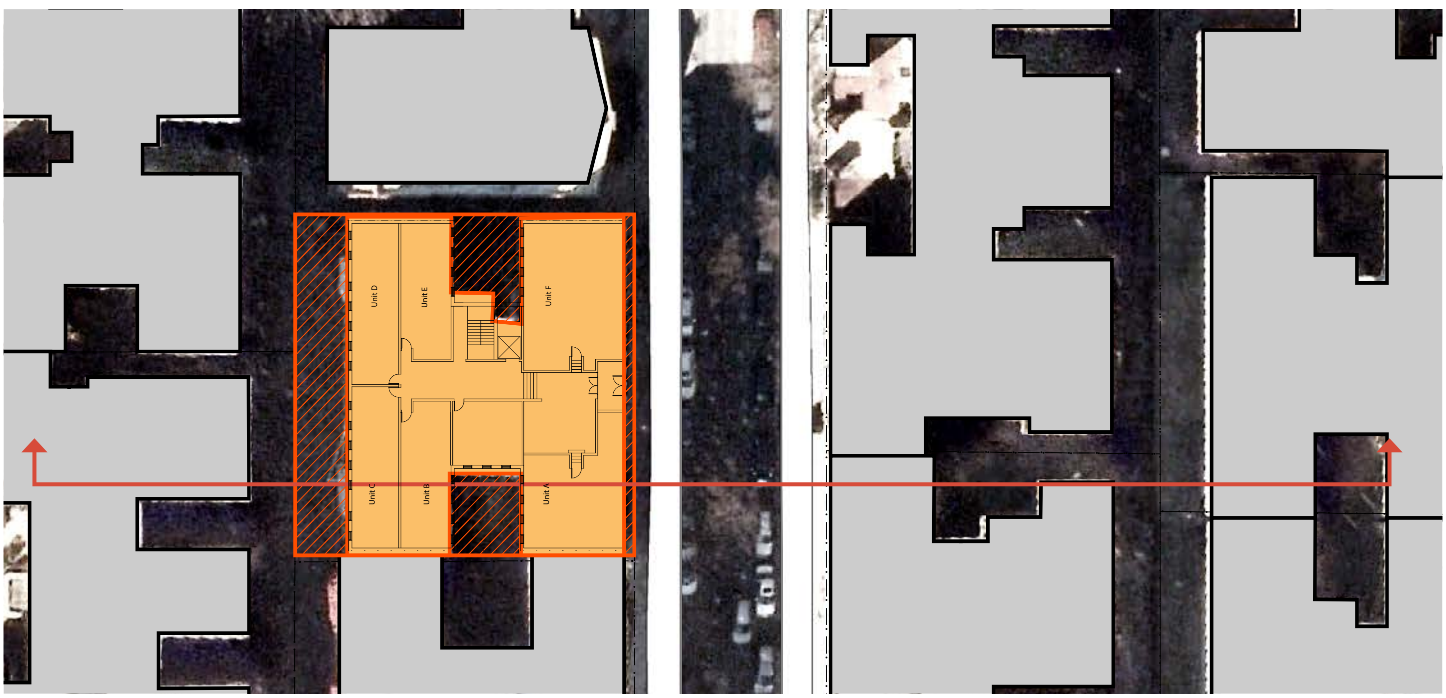
SITE CONDITIONS

Sites with wide lot size and shallow rear yard depth. Rear yards typically range from 0 to 6 feet below the sidewalk grade. No side yards are provided, and streets and sidewalks are typically of standard width.

BUILDING TYPOLOGY

Buildings are five to six-story steel encased in concrete structure and masonry or concrete foundation. Vertical circulation is provided by an elevator and stairs, and egress is provided by fire escapes and pathway through the fire-separated cellar. Critical systems are located in the basement/cellar. Entrances located at or above the sidewalk grade.

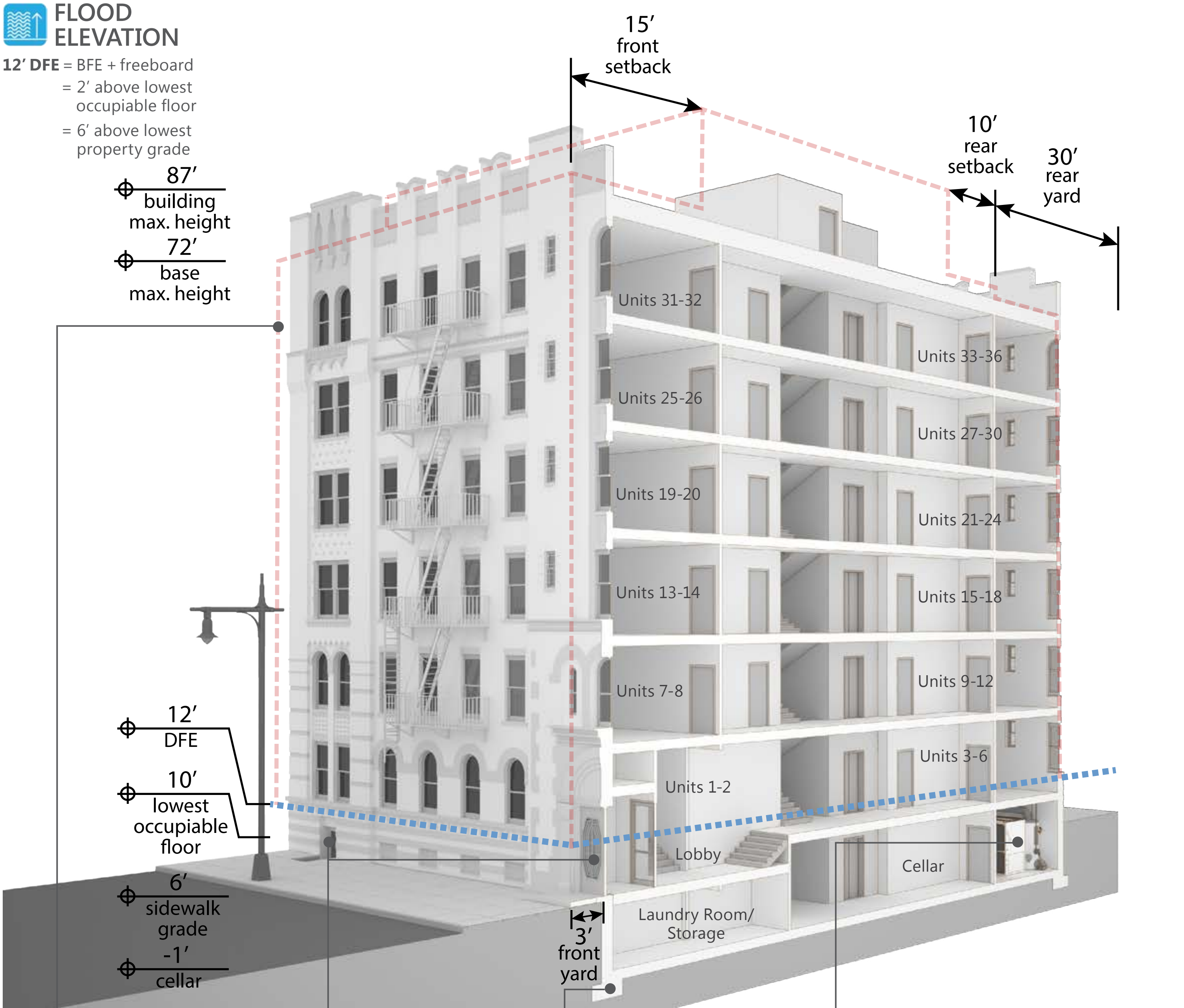




EXISTING CONDITIONS

FLOOD ELEVATION

12′ DFE = BFE + freeboard
= 2′ above lowest occupiable floor
= 6′ above lowest property grade



ZONING ENVELOPE

The allowable building height is measured from the DFE.

The building has a non-compliant rear yard.

The building is built to the maximum allowable floor area. To comply with zoning standards, the floor area below the DFE can be relocated within the adjusted bulk envelope.

ACCESS

Building access is provided at three front entrances; one residential lobby entrance at 1′ above the sidewalk grade; two egress doors are located 5′ below the sidewalk grade.

The building access at the rear yard is provided 5′ below the rear yard grade and serves as the required egress path.

STRUCTURAL SYSTEMS

Six-story non-combustible steel frame structure on a concrete foundation. All steel is encased in concrete.

CRITICAL SYSTEMS

All systems are located in the mechanical room in the basement.

ILLUSTRATIVE RETROFIT STRATEGY

MID-RISE ELEVATOR

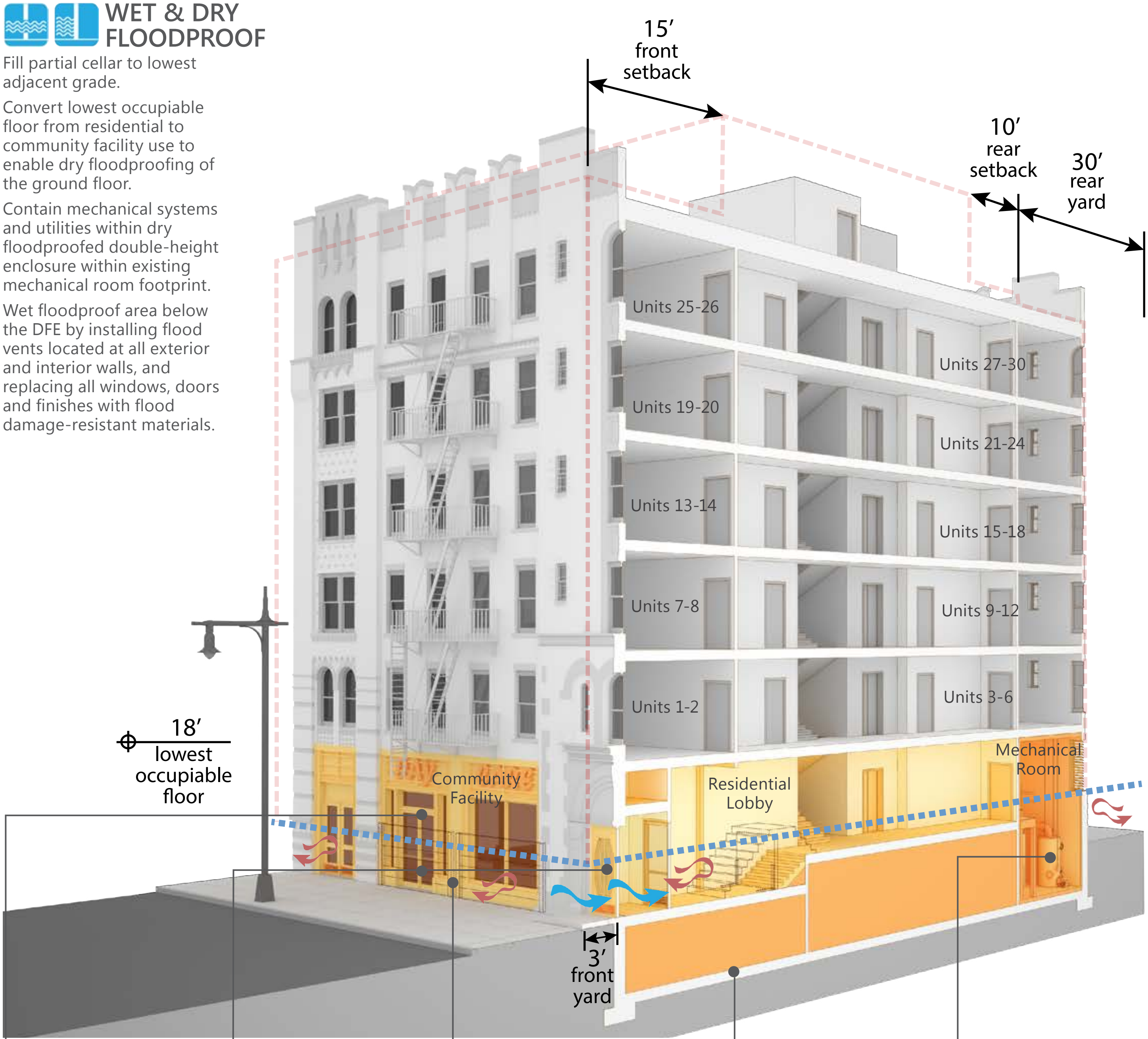
WET & DRY FLOODPROOF

Fill partial cellar to lowest adjacent grade.

Convert lowest occupiable floor from residential to community facility use to enable dry floodproofing of the ground floor.

Contain mechanical systems and utilities within dry floodproofed double-height enclosure within existing mechanical room footprint.

Wet floodproof area below the DFE by installing flood vents located at all exterior and interior walls, and replacing all windows, doors and finishes with flood damage-resistant materials.



STREETSCAPE

Converting to community facility use activates the ground floor and increases transparency.

ACCESS

Residential lobby to remain. Install deployable flood shields and stairs 24 hours prior to flood event.

Two new access points at grade for community facility use.

One new residential egress route is provided to replace existing exit discharge to the street.

USE

Convert lowest level residential units to community facility with separate entrances from residential lobby. Residential lobby to remain.

Partial loss of floor area at the cellar storage and laundry facility where it has been filled to grade

Reconfigure mechanical room to double height space with mezzanine level.

Loss of 6,000 s.f. residential floor area, or six units, due to conversion to community facility; Gain 5,000 s.f. of community facility use.

STRUCTURAL SYSTEMS

Fill cellar, with exception of the mechanical room, to the lowest adjacent grade. Reinforce the foundation walls and modify the floor slab as required in cellar to account for new load.

Ensure structure at the mechanical room meets structural loads required for dry floodproofing.

Reinforce interior walls separating wet and dry floodproof areas.

CRITICAL SYSTEMS

Systems to remain in place; reconfigure mechanical space to include a mezzanine level in double-height dry floodproofed enclosure.

Fire-rated walls required.

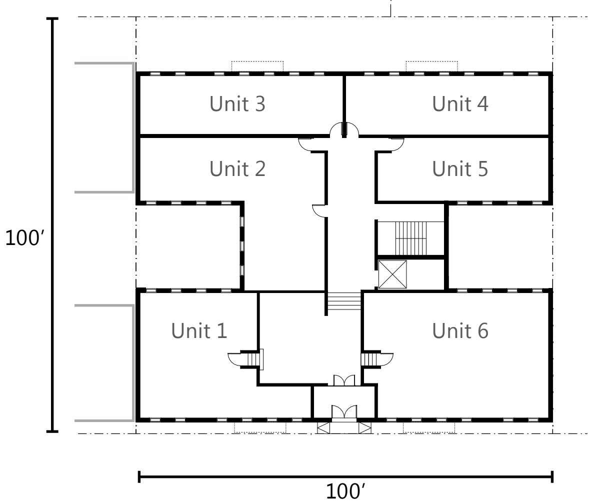
Relocate electrical panels to mezzanine level above the DFE.

Natural air intake or ventilation located above the DFE.

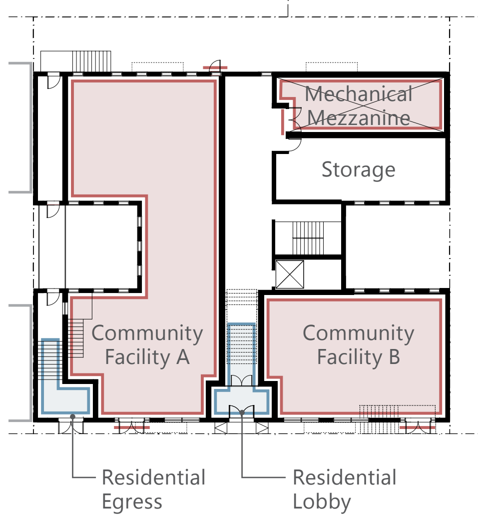
RETROFIT FLOOR PLAN

CHANGE OF USE

EXISTING
Level One



PROPOSED
Level One



Cellar Level
Fill to the lowest adjacent grade with expection of the mechanical room (modified to remain) and the elevator pit (remains).

Loss of storage, laundry room and egress path from rear.

Level One
Level one becomes the lowest occupiable floor.

Residential lobby to remain; reconfigure to accomodate new community facility layout.

New community facility spaces, storage, egress path and mechanical room mezzanine.

ADAPTATION CONSIDERATIONS

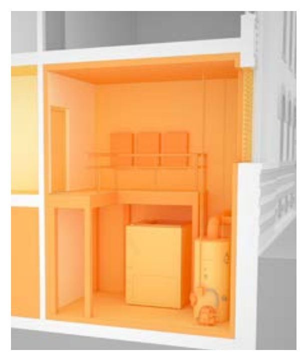
ACCESS

Converting the residential use to community facility use activates the ground floor of the building. The new facade on the public street creates a sense of security and comfort for pedestrians.

CRITICAL SYSTEMS

Converting a mechanical room to a dry floodproofed enclosure involves:

- Reinforcing spaces to limit water infiltration by hydrostatic and hydrodynamic loads
- Converting walls, floors, and ceilings to fire-rated enclosures
- Locating ventilation above the DFE



STREETSCAPE

NON-SUBSTANTIAL DAMAGE/IMPROVEMENT STRATEGIES

Non-substantially improved buildings within the floodplain are not required to comply with Appendix G of the NYC Building Code. This allows for greater flexibility in adapting buildings for flood resiliency. The alternatives illustrated below lower the risk for buildings and provide practical pathways for adaptation. Under current NFIP regulations, these measures may not lower insurance premiums.

The blue icons below illustrate adaptive measures that receive full reduction of NFIP premiums. Icons in gray indicate strategies that improve building resilience, but receive no or partial reduction of NFIP premiums.

If the lowest occupiable floor is left below the DFE, life safety must be considered. Residents should always follow evacuation procedures.

- Occupied Space
- Critical Systems
- Dry Floodproof
- Wet Floodproof
- Open Structure
- NFIP Premium Reduction

No or partial reduction in NFIP premiums. Residential use remains located below the DFE and the structure is not filled to the lowest adjacent grade. Wet floodproofing is not permitted at residential use. Lowest occupiable floor is below the DFE.

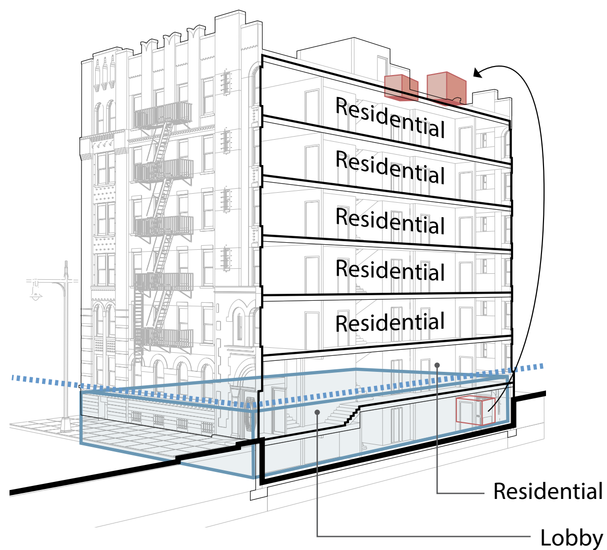
Elevate critical systems above the DFE.

Wet floodproof below the DFE. Install flood vents and replace all windows, doors and finishes with flood damage-resistant materials.

All existing uses to remain.

Add reinforcement at roof to support relocated critical systems.

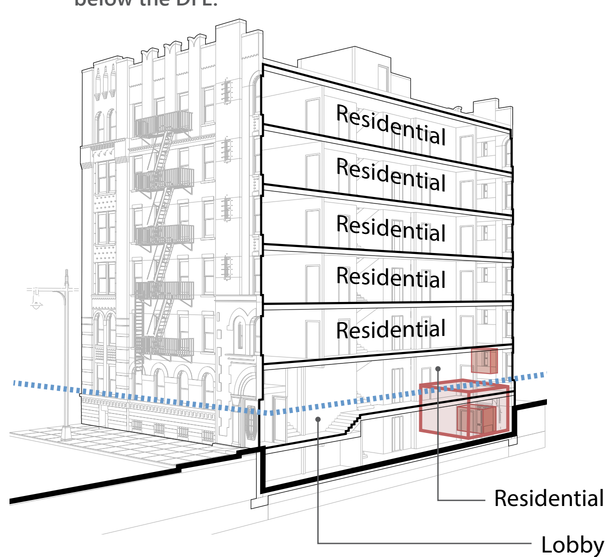
Relocate critical systems to the roof within a fire-rated and vented enclosure. Raise electrical utilities above the DFE.



No or partial reduction in NFIP premiums. Residential use and partial critical systems remain located below the DFE and the structure is not filled to the lowest adjacent grade. Dry floodproofing is not permitted at residential use. Lowest occupiable floor is below the DFE.

Systems to remain in place below the DFE in dry floodproofed enclosure. Install outdoor natural gas emergency generator in rear yard to backup essential electrical infrastructure.

All existing building uses below the DFE remain.



MIXED-USE SEMI-DETACHED

This mixed-use example is a two-story wood frame structure with a party-wall and rubble foundation. The structure has one shared bearing wall and is not suitable for elevation.

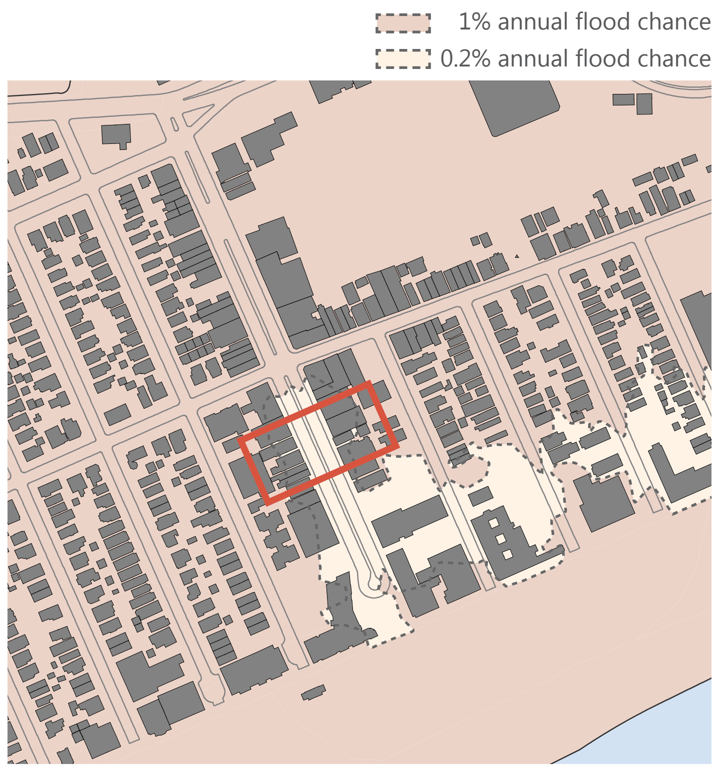
Retrofit strategies that will result in full NFIP reduction in premiums require filling the basement to the lowest adjacent grade and reconfiguring the commercial space to a new elevated floor above the DFE. This strategy results in the relocation of the critical systems, partial loss of storage space for the commercial tenants and relocation of the active commercial space further away from the street frontage, which can be a major impediment to the viable operation of retail space. The residential space is relocated to a third story addition and the critical systems are placed in a rear addition or can be placed on the roof. All of these strategies require significant structural reinforcement.

Another approach, which would also lower premiums, would be to dry floodproof the commercial space through the use of flood shields integral to the building structure, fill the cellar, add reinforcement, and relocate critical systems to the roof.

Alternative adaptation strategies, currently not recognized by FEMA and NFIP, include leaving existing commercial uses in place, wet floodproofing below the DFE, and relocating the critical systems within a rear-yard addition above the DFE. This would maintain the usability of the retail space but would allow the flooding of the basement and storage space in the event of a storm. Another alternative solution would be to leave all uses in place and dry floodproof the cellar.

KEY CHARACTERISTICS

FLOOD RISK	
Flood Zone/BFE	AE +10′
Grade Elevation	+4′ at sidewalk and property
Design Flood Elevation (DFE)	+11′ (7′ above sidewalk grade)
Lowest Occupiable Floor	+5′ (1′ above sidewalk grade)
Cellar Elevation	-2′ (6′ below sidewalk grade)
Critical Systems Location	Cellar
TYPOLOGY	
Lot Size	40′ x 100′
Building Size	37′ x 65′
Yards	2′ front; 35′ rear; 2′ at each side
Construction Type	Wood Frame
Foundation Type	Rubble
Year Built	1900
Stories	2 + cellar
Residential Floor Area	2,400 s.f. total
Residential Units	2
Commercial Floor Area	2,400 s.f. total
Commercial Units	2
SITE CONDITIONS	
Sidewalk Width	8′
Roadbed Width	70′
Zoning District	R7A + C1-3 Overlay, Mixed-Use



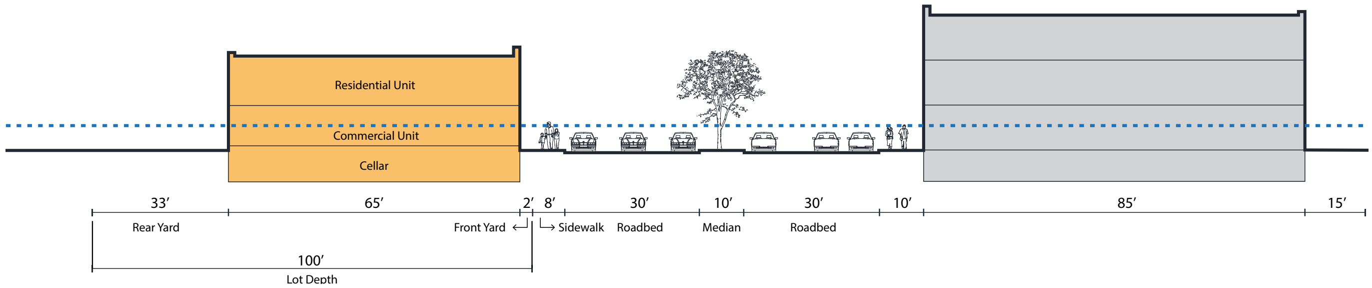
SITE & BUILDING CONDITIONS

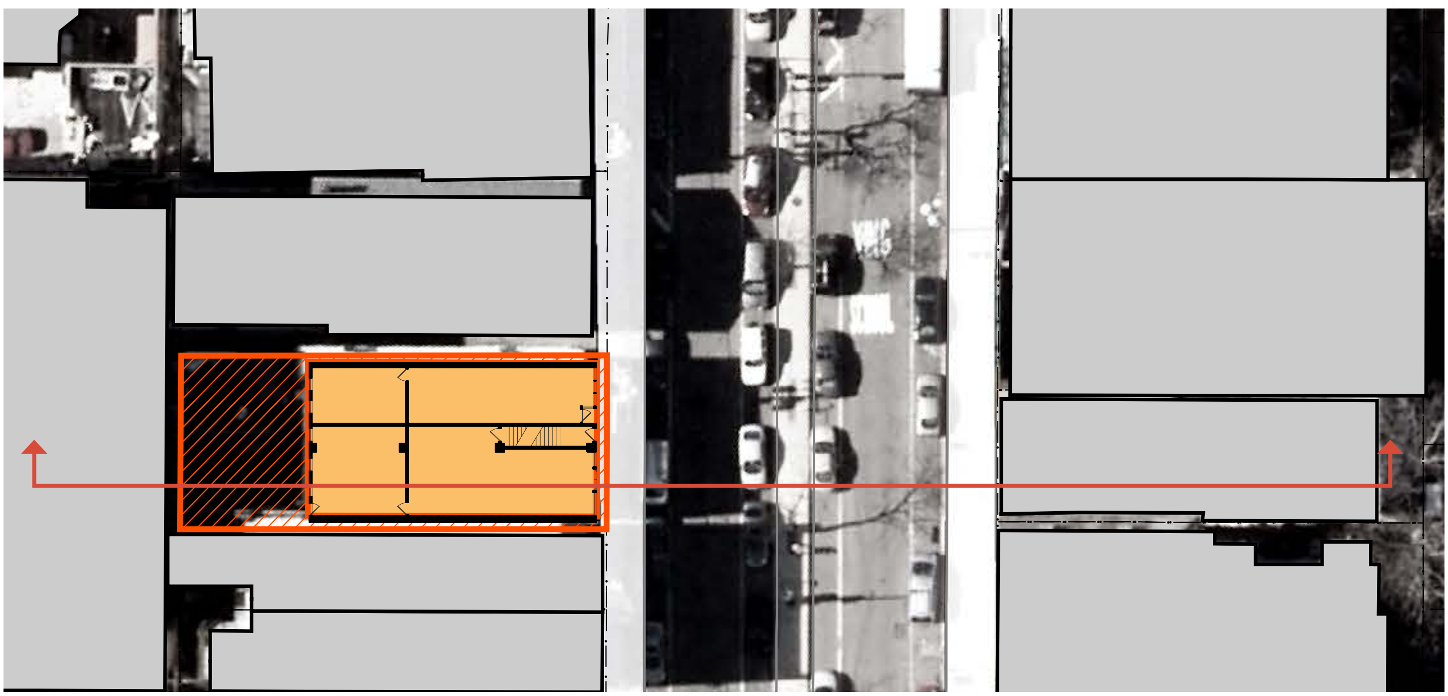
SITE CONDITIONS

Sites with standard lot size and one side yard. Wide public streets and sidewalks are typical of this commercial corridor typology. On-street parking with no on-site parking is most common.

BUILDING TYPOLOGY

Commercial use and residential lobby is located at the ground floor with residential use above. Buildings are two to three-story with masonry or wood frame party-wall and wood joists on a rubble foundation. Critical systems are located in the cellar with the commercial space storage. Entrances are provided at or above sidewalk grade.

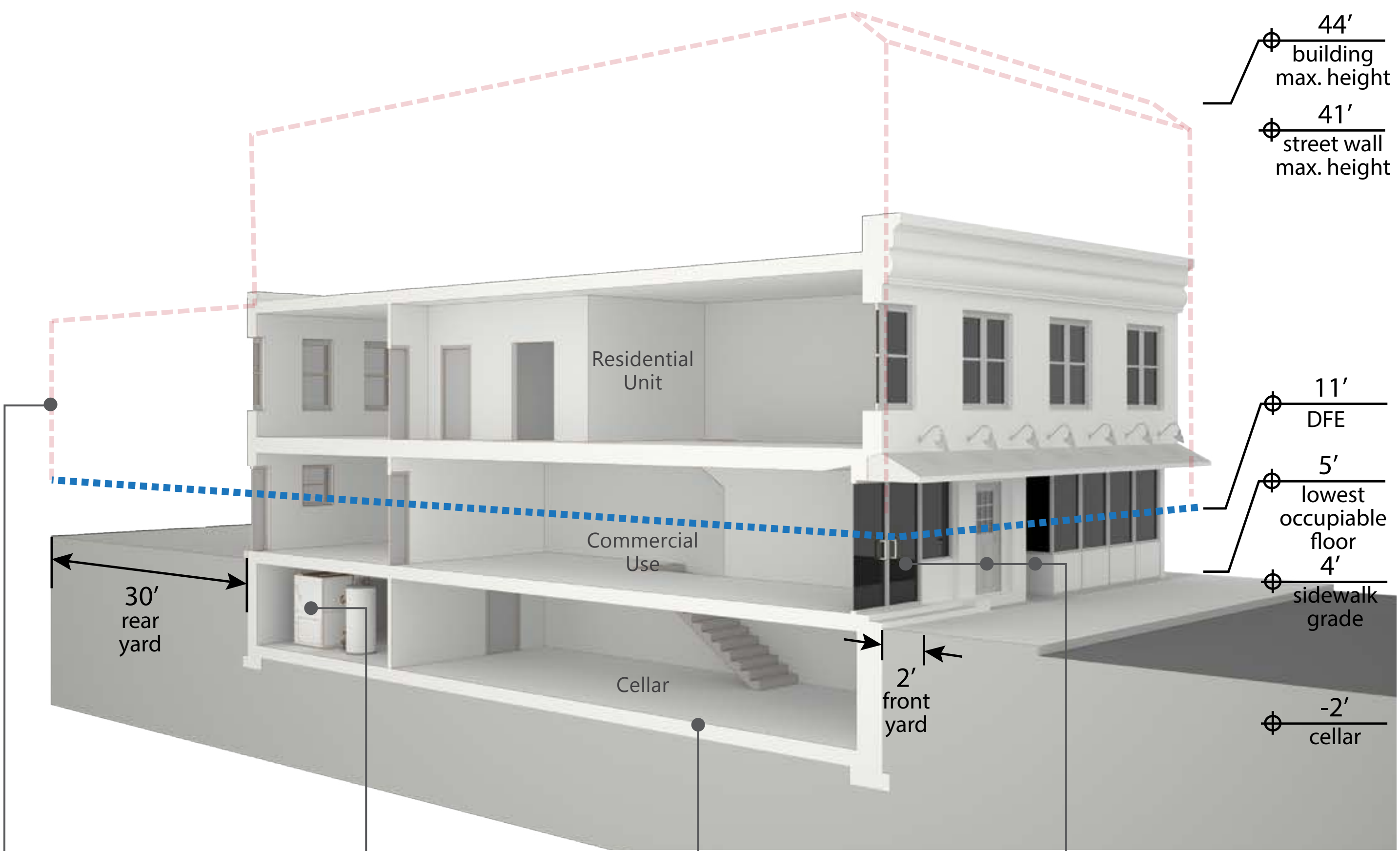




EXISTING CONDITIONS

FLOOD ELEVATION

11′ DFE = BFE + freeboard
= 6′ above lowest occupiable floor
= 7′ above lowest property grade



ZONING ENVELOPE

The allowable building height is measured from the DFE.

The building has a non-compliant rear yard.

The building is built to the maximum allowable floor area. In compliance with zoning, the floor area below the DFE can be relocated within the adjusted bulk envelope.

CRITICAL SYSTEMS

All systems are located in a mechanical room in the cellar.

STRUCTURAL SYSTEMS

Two-story combustible construction with wood frame party-wall and wood joists on a rubble foundation.

ACCESS

Building access is provided at three front entry locations - two commercial uses and one residential lobby - at 1′ above the sidewalk grade.

The building access at the rear yard is provided at two locations, both 1′ above the rear yard grade.

ILLUSTRATIVE RETROFIT STRATEGY

MIXED-USE SEMI-DETACHED

ELEVATE & WET FLOODPROOF

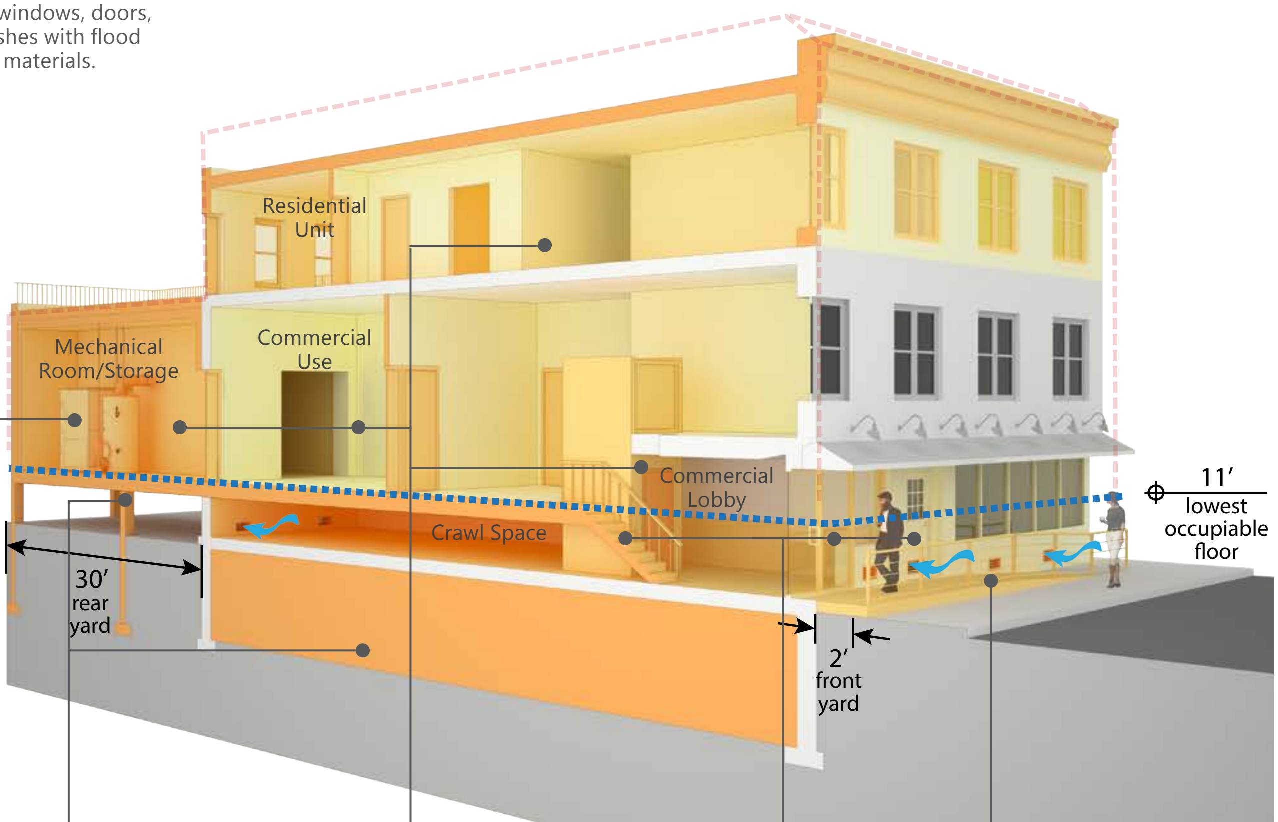
Elevate the commercial floor to the DFE by relocating a portion of the floorplate, creating a double height space and mezzanine level for both commercial spaces.

Fill cellar to lowest adjacent grade

Elevate critical systems above the DFE at rear addition.

Relocate residential unit to new addition at third story

Wet floodproof area below the DFE by installing flood vents located at all exterior and interior walls and replacing all windows, doors, structure and finishes with flood damage resistant materials.



CRITICAL SYSTEMS

Relocate systems to rear addition within fireproof and vented mechanical room.

Tie all systems back into building systems following re-location.

Install isolation and/or vibration pads as required.

STRUCTURAL SYSTEMS

Fill cellar to grade. Reinforce foundation walls and modify floor slab, as required, in cellar where fill is added. If adjacent properties are not infilling their sub-grade spaces, reinforce foundation walls to account for new load.

Reinforce foundation for new addition on roof.

Add new foundation system for addition at rear.

Relocate existing joists from the existing second story to the new lowest floor level and add support as required.

USE

Relocate the two commercial spaces to elevated floor with one entrance lobby and showpit area for both commercial spaces.

Addition at rear for critical systems and storage. This addition results in loss of rear yard and addition of terrace for residential use.

Relocate residential space to new third story addition.

There is a total loss of 400 s.f. of commercial use plus 2,400 s.f. of storage and systems use in the cellar. Gain of 1,000 s.f. for systems and storage at the new rear addition.

ACCESS

Residential lobby to remain. Reconfigure if necessary for wet floodproofing requirements

New access for commercial uses in new interior lobby accessible via ramp at streetwall entry.

Commercial spaces accessible by stair or lift at commercial lobby.

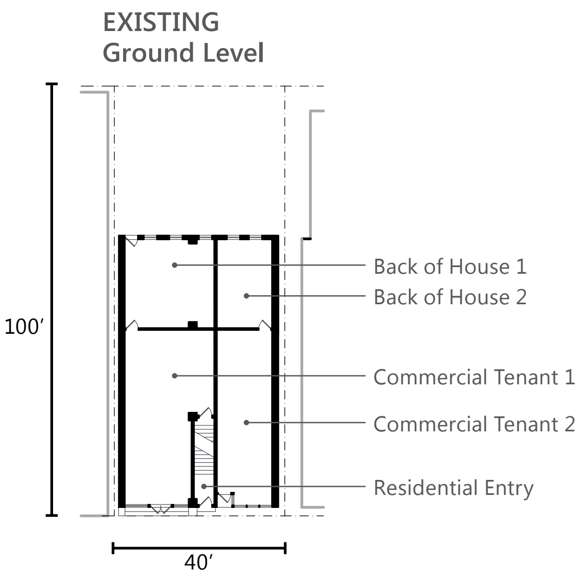
STREETSCAPE

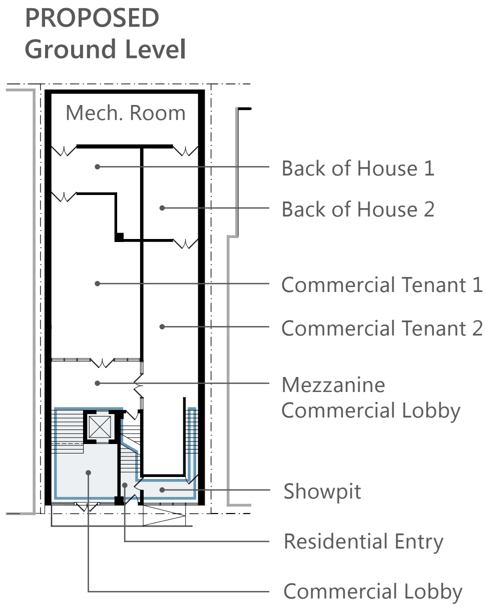
Add ramp to commercial and residential entries.

Convert one commercial entry to showpit area and replace all windows, doors and finishes with flood damage-resistant materials.

RETROFIT FLOOR PLAN

CHANGE OF USE





Cellar Level
Fill to lowest adjacent grade.

Loss of mechanical room and commercial storage.

Lower Ground Level
New commercial lobby, egress path and showpit area.

Residential lobby remains, reconfigure per wet floodproofing requirements.

Upper Ground Level
The raised ground level story becomes the lowest occupiable floor.

Relocate commercial units to elevated floor.

Relocate mechanical room and commercial storage to new commercial addition at rear.

Level Two (New)
Relocate residential units.

ADAPTATION CONSIDERATIONS

ACCESS & STREETSCAPE

An active streetscape along a retail corridor is a key aspect to its economic strength. While the challenges of adhering to new flood regulations can be counter to this, there are a number of ways property owners can meet the requirements while still providing transparency and activity at the ground level.

Here, the illustrated alternative strategy applies wet floodproofing to the space below the DFE in the application of flood damage-resistant materials yet the use of this area as a seating area is non-compliant.

ACCESS & STREETSCAPE

NON-SUBSTANTIAL DAMAGE/IMPROVEMENT STRATEGIES

Non-substantially improved buildings within the floodplain are not required to comply with Appendix G of the NYC Building Code. This allows for greater flexibility in adapting buildings for flood resiliency. The alternatives illustrated below lower the risk for buildings and provide practical pathways for adaptation. Under current NFIP regulations, these measures may not lower insurance premiums.

The blue icons below illustrate adaptive measures that receive full reduction of NFIP premiums. Icons in gray indicate strategies that improve building resilience, but receive no or partial reduction of NFIP premiums.

If the lowest occupiable floor is left below the DFE, life safety must be considered. Residents should always follow evacuation procedures.

- Occupied Space
- Critical Systems
- Dry Floodproof
- Wet Floodproof
- Open Structure
- NFIP Premium Reduction

Dry floodproof commercial space. Install deployable flood shields at front and rear openings below the DFE. Provide alternate means of egress through residential lobby.

Wet floodproof residential lobby. Install flood vents and replace all windows, doors, and finishes with flood damage-resistant materials.

Fill the cellar to lowest adjacent grade. Elevate the critical systems above the DFE.

Loss of use at the cellar. Existing commercial space and residential lobby uses below the DFE are to remain.

Fill cellar to the lowest adjacent grade, remove cellar slab and add reinforcement. Ensure changes to party-walls do not impact neighboring property's structural integrity. Add support at roof for relocated systems.

Relocate critical systems to the roof within a fire-rated and vented enclosure. Raise electrical utilities above DFE within an electrical closet on the ground level.

Full NFIP premium reduction.

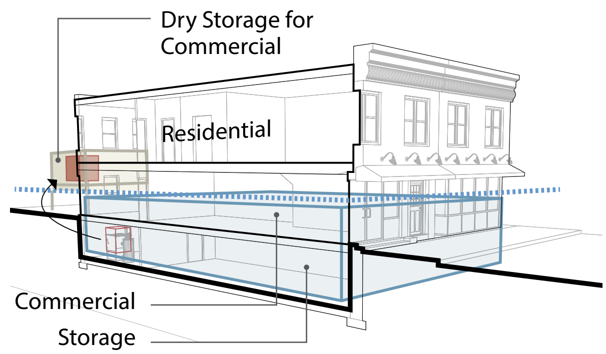
No or partial reduction in NFIP premiums. The structure is not filled to the lowest adjacent grade. Wet floodproofing is not permitted at commercial use.

Wet floodproof below the DFE. Install flood vents and replace all windows, doors and finishes with flood-damage-resistant materials.

New addition at rear used as mechanical room and dry storage. Existing commercial, storage and residential lobby uses below the DFE are to remain. Cellar to remain.

Relocate critical systems within fire-rated and vented enclosure at rear-yard addition above the DFE.

Commercial entrances and residential lobby to remain, Reconfigure residential lobby as required per wet floodproofing engineering requirements.



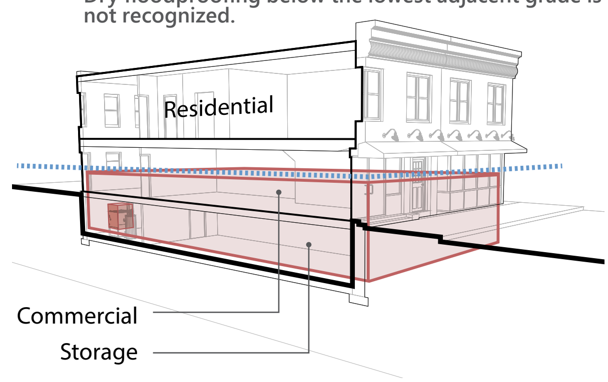
No or partial reduction in NFIP premiums. The critical systems remain located below the DFE and the structure is not filled to the lowest adjacent grade. Dry floodproofing below the lowest adjacent grade is not recognized.

Dry floodproof below the DFE by strengthening the foundation, floors and walls and sealing all penetrations. Install deployable flood shields, front and rear windows, and doors.

Existing commercial, residential lobby and cellar uses below the DFE are to remain. Provide egress route up and over flood shields at commercial and residential uses.

Add reinforcement to party walls, exterior walls and foundation slab at dry floodproof enclosure, and ensure changes do not impact neighboring property's structural integrity.

Critical systems to remain in place within dry floodproofed enclosure. Provide emergency shut off above the DFE.



MIXED-USE ATTACHED

This example is a three-story masonry building with party-walls and a mix of commercial and residential space on the ground-floor and two stories of residential units above.

Retrofit strategies that will result in partial NFIP reduction in flood insurance premiums require filling the basement to the lowest adjacent grade and limiting the ground-floor space to commercial use to allow for dry floodproofing. The ground-floor residential unit is relocated to an addition at the roof within the building bulk envelope. The commercial storage is relocated to a new addition in the rear.

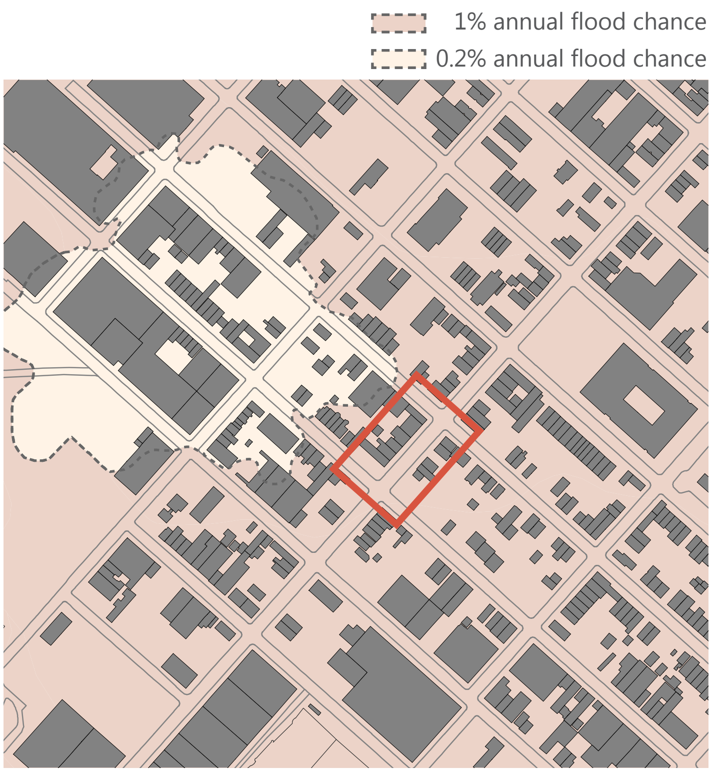
Due to the high flood elevation, resulting in undue hardship for egress from the building, the property owner can file for a variance to install deployable flood shields around the building façade as long as these are structurally integral to the building foundation. Temporary emergency egress stairs must be deployed over the gates.

This retrofit strategy minimizes the loss of commercial and residential floor area but requires significant structural reinforcement of the entire structure, as well as attention to structural reinforcement at party-walls so as not to affect neighbors' property.

Alternative adaptation strategies, currently not recognized by FEMA and NFIP, include simply relocating critical systems to a new rear addition, or leaving existing commercial and residential uses on the ground floor and wet or dry floodproofing below the DFE.

KEY CHARACTERISTICS

FLOOD RISK	
Flood Zone/BFE	AE +11′
Grade Elevation	+4′ at sidewalk, +0′ at rear property
Design Flood Elevation (DFE)	+12′ (8′ above sidewalk grade)
Lowest Occupiable Floor	+5.5′ (1.5′ above grade)
Cellar Elevation	-2′ (6′ below sidewalk grade)
Critical Systems Location	Cellar
TYPOLOGY	
Lot Size	33′ x 66′
Building Size	33′ x 48′
Yards	2′ front; 15′ rear
Construction Type	Masonry with wood joists
Foundation Type	Rubble
Year Built	1925
Stories	3 + cellar
Residential Floor Area	4,000 s.f. total
Residential Units	2 single storey, 1 triplex
Commercial Floor Area	800 s.f.
Commercial Units	1
SITE CONDITIONS	
Sidewalk Width	12′
Roadbed Width	37′
Zoning District	R5 + C1-3 Overlay, Mixed Use



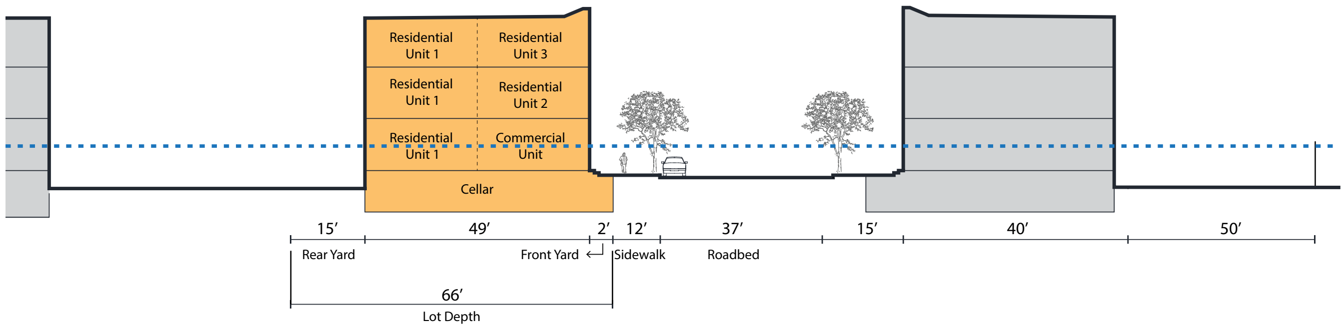
SITE & BUILDING CONDITIONS

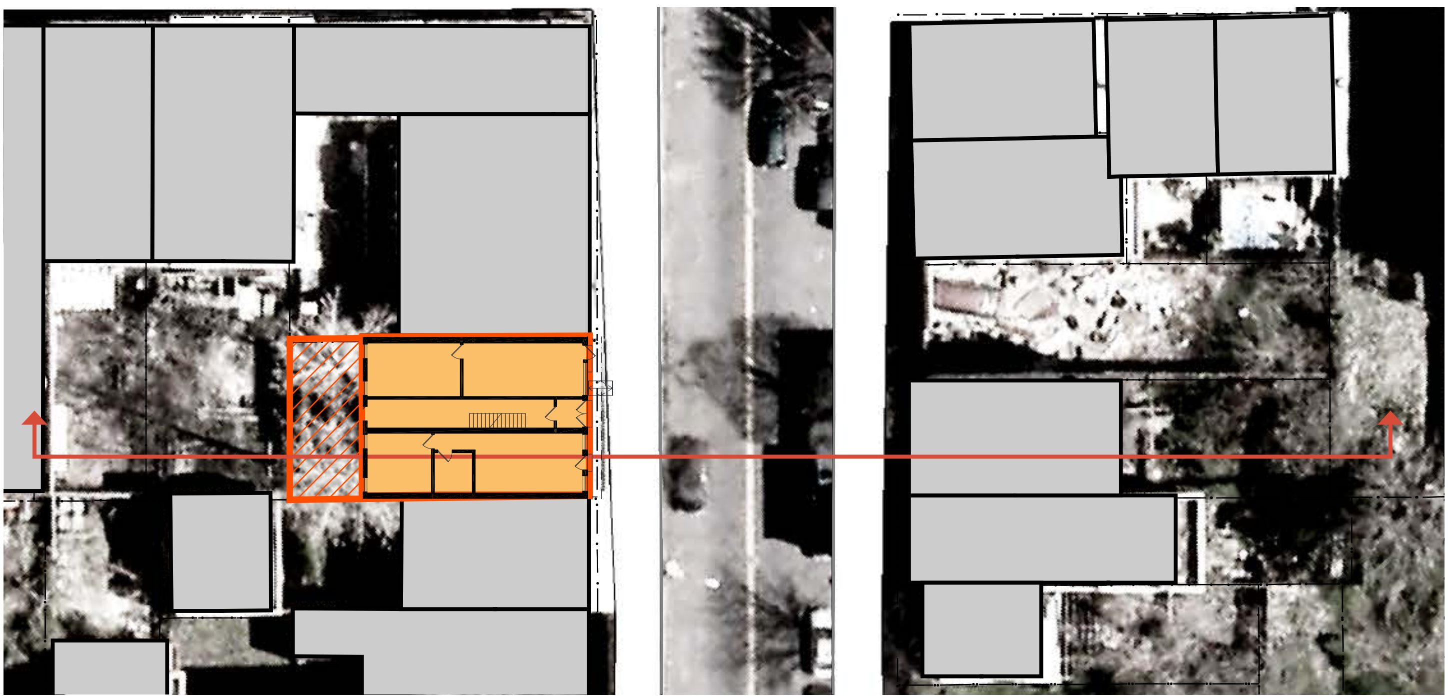
SITE CONDITIONS

Sites with standard lot size and no side yards. Rear yards typically range from 0 to 6 feet below the sidewalk grade. Standard width public streets and sidewalks are typical of this commercial corridor typology.

BUILDING TYPOLOGY

Commercial and residential use is located at the ground floor with residential use above. Buildings are two to four-story masonry party-wall with wood joists and a rubble foundation. Critical systems are located in cellar with commercial space storage. Entrances are provided at or above sidewalk grade.

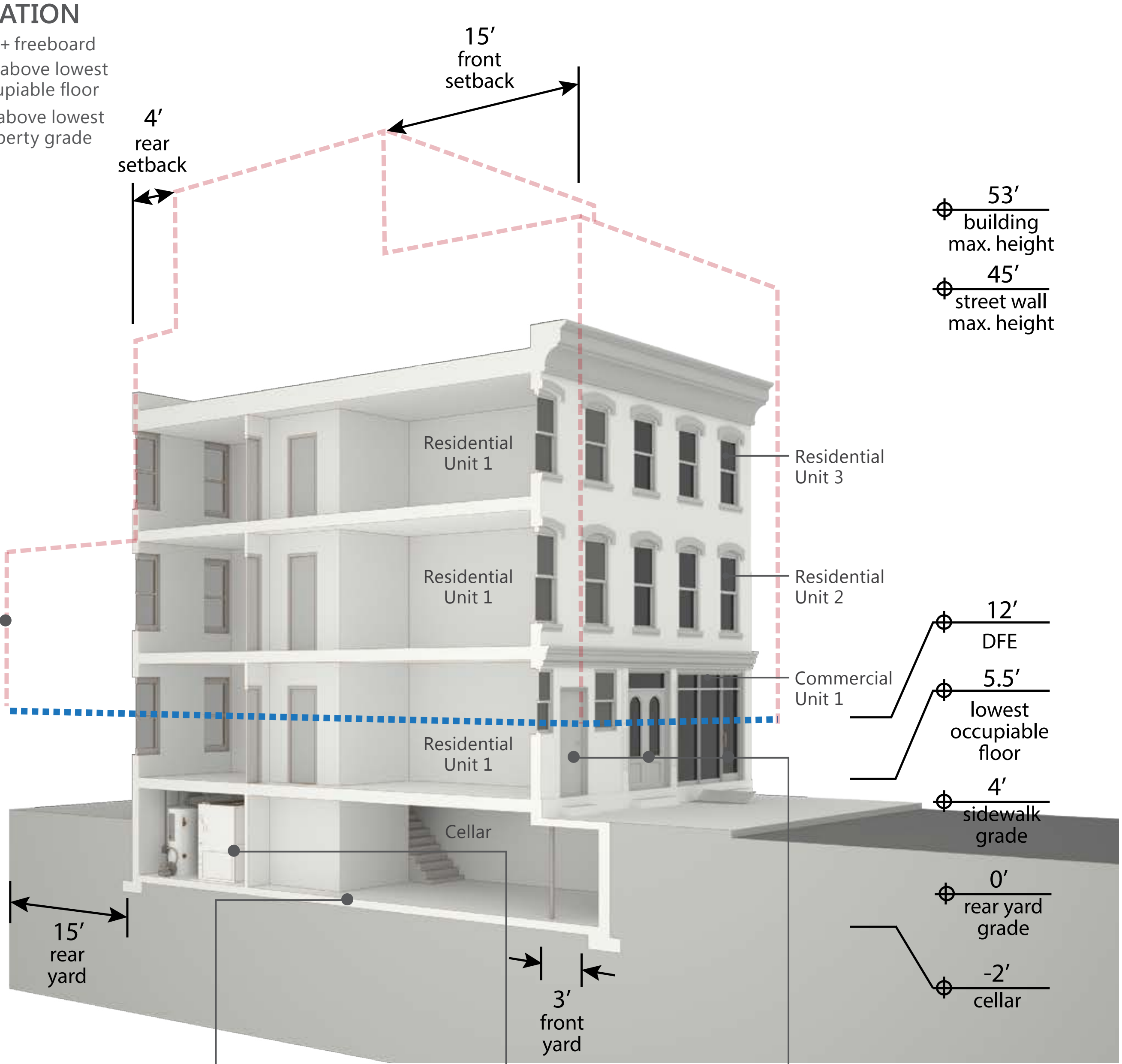




EXISTING CONDITIONS

FLOOD ELEVATION

12′ DFE = BFE + freeboard
= 6.5′ above lowest occupiable floor
= 12′ above lowest property grade



ZONING ENVELOPE

The allowable building height is measured from the DFE.

The building is built to the maximum allowable floor area. In compliance with zoning, the floor area below the DFE can be relocated within the adjusted bulk envelope.

STRUCTURAL SYSTEMS

Three-story combustible construction with unreinforced masonry bearing party-walls and wood joists on a rubble foundation.

CRITICAL SYSTEMS

All systems are located in a mechanical room in the cellar.

ACCESS

Building access is provided at three front locations - one commercial entrance, one residential lobby and one residential entrance, all at 1.5′ above the sidewalk grade.

The building access at the rear yard is provided at two locations - one 4′ above and the second 5′ below the rear yard grade.

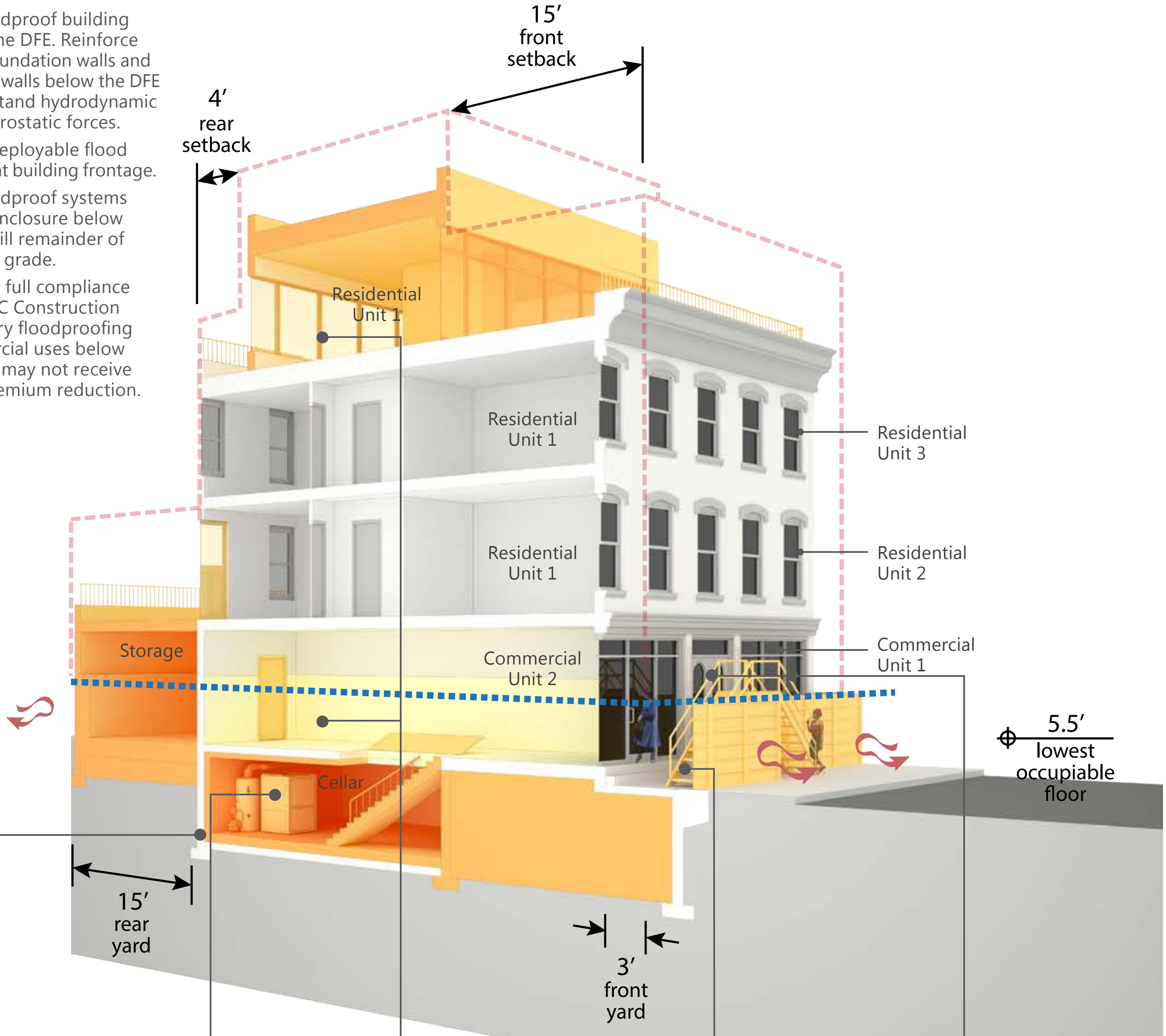
ELEVATE & DRY FLOODPROOF

Dry floodproof building below the DFE. Reinforce slabs, foundation walls and exterior walls below the DFE to withstand hydrodynamic and hydrostatic forces.

Install deployable flood shields at building frontage.

Dry floodproof systems within enclosure below grade. Fill remainder of cellar to grade.

While in full compliance with NYC Construction Code, dry floodproofing commercial uses below the DFE may not receive NFIP premium reduction.



STRUCTURAL SYSTEMS

Fill partial cellar to lowest adjacent grade. Infilling and dry floodproofing all areas below the DFE requires reinforcing the foundation walls and slab. If adjacent properties are not infilling their sub-grade spaces, reinforce foundation walls to account for new load.

Add new foundation system for addition at rear.

Add reinforcement at foundation wall below the sidewalk and at the building facade for flood shields.

CRITICAL SYSTEMS

Systems to remain in place within dry floodproofed enclosure. Provide new stair access from commercial space. Locate remote emergency shut-off above the DFE.

Install waterproof damper at the combustible air intake in mechanical room.

USE

Convert residential use below the DFE to commercial use and maximize the allowable floor area with a new addition at the rear. New addition involves loss of rear yard.

Loss of use of the cellar with the exception of the mechanical room.

Relocate the residential area below the DFE to the new 4th story addition.

Gain 600 s.f. of commercial space.

STREETSCAPE

Existing residential lobby access to remain.

Provide accessible entry at new commercial entries. Convert facade design of old residential use to comply with commercial streetscape mitigation requirements.

Deployable flood shields and temporary stairs installed in public right of way per DOT revocable consent regulations.

ACCESS

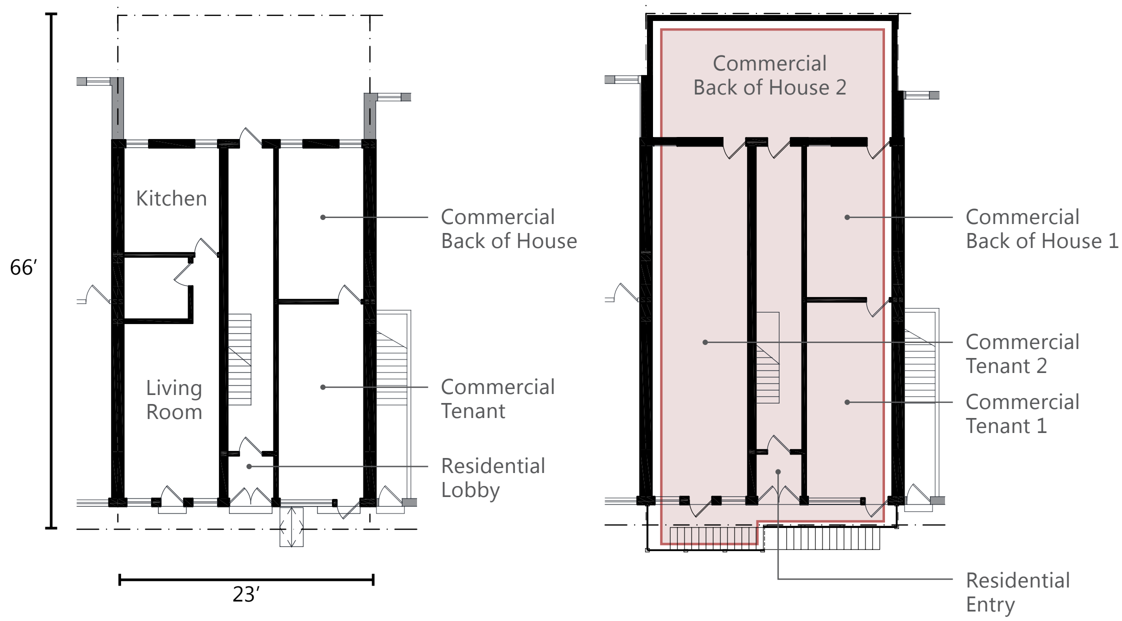
Residential lobby to remain.

Provide accessible entry at new commercial storefront.

When deployable flood shields are in use, all egress paths must be provided via temporary stairs up and over the gates. Obtain DOT permit as required.

RETROFIT FLOOR PLAN

CHANGE OF USE



Cellar Level
Mechanical room to remain.

Fill storage area to lowest adjacent grade.

Loss of storage.

Ground Level
Convert residential to commercial use.

Residential lobby remains.

New commercial dry storage at rear addition.

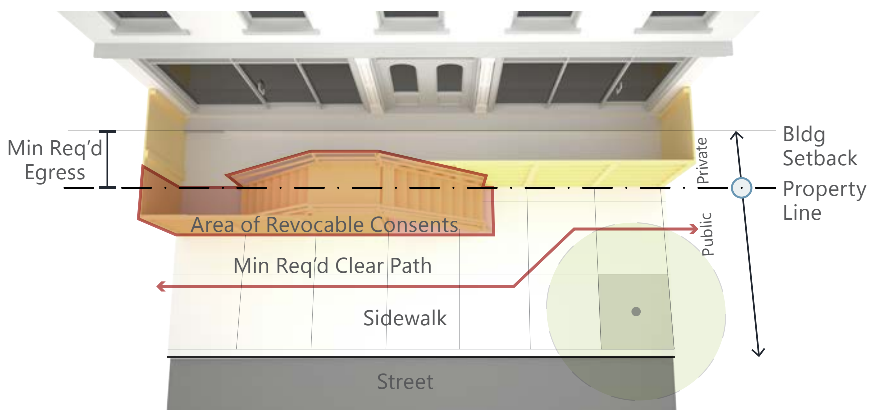
Level Four (New)
Relocate lost ground floor residential use.

ADAPTATION CONSIDERATIONS

DRY FLOODPROOFING

Temporary flood shields and egress stairs deployed in front of a building are subject to building code requirements as well as the Department of Transportation (DOT) requirements where shields and/or stairs are partially or fully in the public right of way.

NYC DOB requirements for building access, width of egress, structural stability, headroom, and clearance height are tied to the building's occupancy and use, while NYC DOT has requirements and clearances for the public right of way – streets and sidewalks. Given that a portion of the flood shield assembly and stairs falls into the sidewalk, the property owner would be required to apply for revocable consents from the City which, if approved, grants the right to an individual or organization to construct and maintain certain structures on, over or under the inalienable property of the City – the streets and sidewalks.



ACCESS & STREETSCAPE

NON-SUBSTANTIAL DAMAGE/IMPROVEMENT STRATEGIES

Non-substantially improved buildings within the floodplain are not required to comply with Appendix G of the NYC Building Code. This allows for greater flexibility in adapting buildings for flood resiliency. The alternatives illustrated below lower the risk for buildings and provide practical pathways for adaptation. Under current NFIP regulations, these measures may not lower insurance premiums.

The blue icons below illustrate adaptive measures that receive full reduction of NFIP premiums. Icons in gray indicate strategies that improve building resilience, but receive no or partial reduction of NFIP premiums.

If the lowest occupiable floor is left below the DFE, life safety must be considered. Residents should always follow evacuation procedures.

- Occupied Space
- Critical Systems
- Dry Floodproof
- Wet Floodproof
- Open Structure
- NFIP Premium Reduction

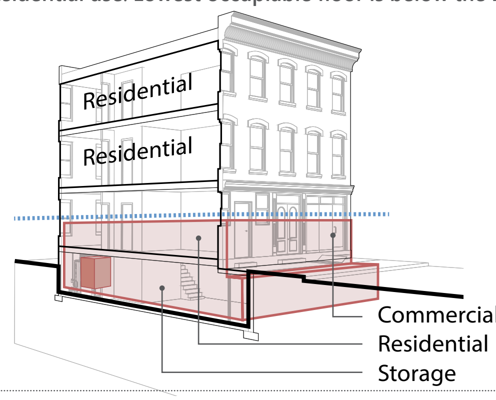
No or partial reduction in NFIP premiums. Critical systems and residential uses remain below the DFE. Cellar remains. Dry floodproofing is not permitted at residential use. Lowest occupiable floor is below the DFE.

Dry floodproof below DFE. Install deployable flood shields at front and rear prior to flood event. Provide alternate means of egress over flood shields.

Existing residential, residential lobby, commercial and storage use below DFE are to remain. Cellar below lowest adjacent grade to remain.

Add reinforcement to party walls, exterior walls and foundation slab at dry floodproof enclosure and ensure changes do not impact neighboring property's structural integrity.

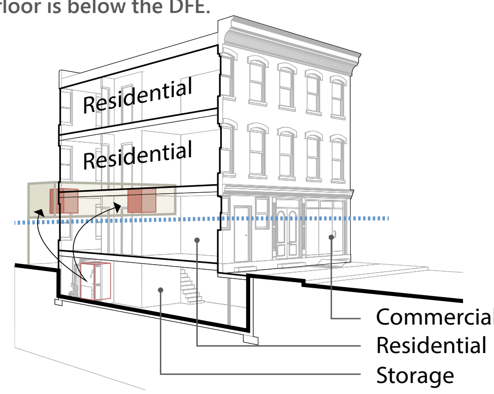
Critical systems to remain in place within dry floodproofed enclosure. Provide emergency shut off above the DFE.



No or partial reduction in NFIP premiums. Residential use remains located below the DFE and the structure is not filled to the lowest adjacent grade. Lowest occupiable floor is below the DFE.

Relocate residential and commercial systems within fire-rated and vented enclosure in rear-yard addition above the DFE.

Addition in rear for mechanical room and dry storage. Cellar below lowest adjacent grade to remain. Residential, commercial, and storage uses below the DFE remain.

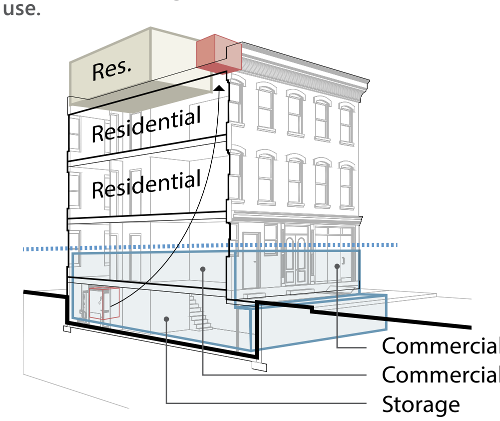


No or partial reduction in NFIP premiums. The structure is not filled to the lowest adjacent grade. Wet floodproofing is not permitted at commercial use.

Wet floodproof below the DFE. Install flood vents and replace all windows, doors and finishes with flood damage-resistant materials.

Convert residential space below the DFE to commercial use. Cellar below lowest adjacent grade to remain. Relocated residential use and critical systems to roof addition.

Relocate critical systems to the roof within a fire-rated and vented enclosure. Raise electrical utilities above DFE within electrical closet on the ground level.



MIXED-USE MID-RISE WALK-UP

This mixed-use attached example is a five-story unreinforced masonry building with ground-floor retail, a residential lobby and residential units above. Because the structure is so heavy and in such close proximity to the neighboring building, it is unsuitable for elevation.

Retrofit strategies that will result in partial NFIP reduction in flood insurance premiums and full NYC Construction Code compliance involve dry floodproofing all areas below the DFE through structural reinforcement and the use of flood shields at the commercial façade. Where flood shields are used egress is provided through the residential lobby. At the residential lobby wet floodproofing is used and requires reconfiguration of the layout to accommodate for engineering requirements of the flood vents as well as egress from the commercial unit.

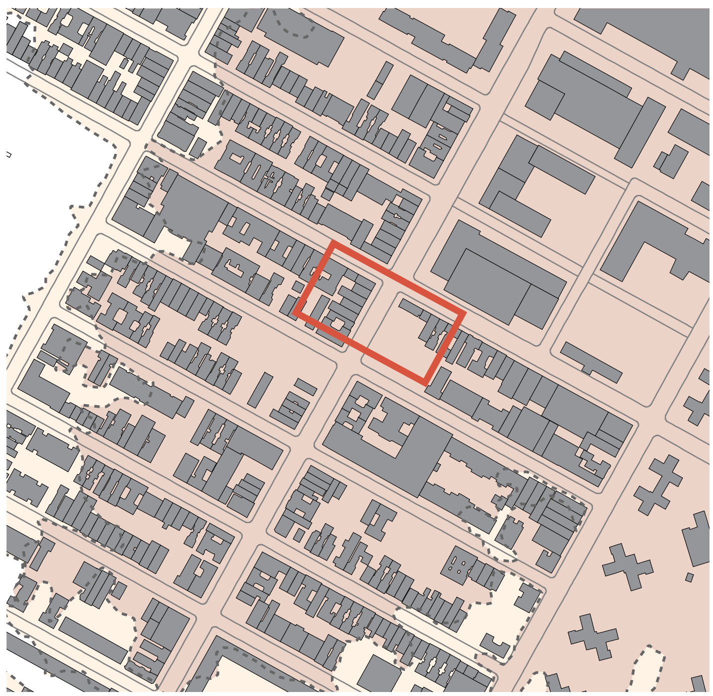
Existing federal regulations do not foresee the co-existence of residential spaces or lobbies and commercial spaces on the same floor, which complicates retrofit strategies for mixed-use buildings.

Alternative adaptation strategies, currently not recognized by FEMA and NFIP, include leaving existing commercial uses on the ground-floor as is or wet floodproofing.

KEY CHARACTERISTICS

FLOOD RISK	
Flood Zone/BFE	AE +11′
Grade Elevation	+7′ at sidewalk, +2′ at rear property
Design Flood Elevation (DFE)	+12′ (5′ above sidewalk grade)
Lowest Occupiable Floor	+8′ (1′ above sidewalk grade)
Cellar Elevation	+1′ (6′ below sidewalk grade)
Critical Systems Location	Cellar
TYPOLOGY	
Lot Size	23′ x 83′
Building Size	23′ x 54′
Yards	5′ front; 30′ rear
Construction Type	Masonry with wood joists
Foundation Type	Rubble
Year Built	1900
Stories	5 + cellar
Residential Floor Area	4,800 s.f. total
Residential Units	8
Commercial Floor Area	1,000 s.f. total
Commercial Units	1
SITE CONDITIONS	
Sidewalk Width	12′
Roadbed Width	45′
Zoning District	R7A + C1-5 Overlay, Mixed Use

1% annual flood chance
0.2% annual flood chance



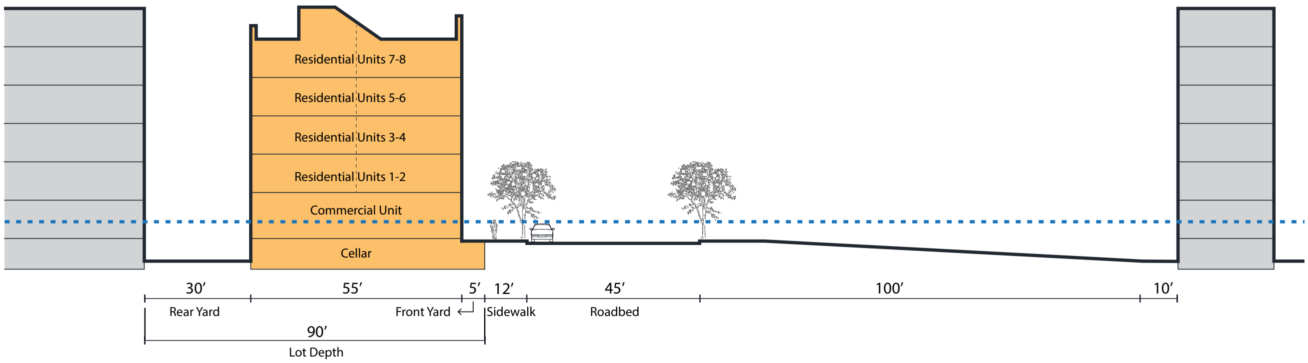
SITE & BUILDING CONDITIONS

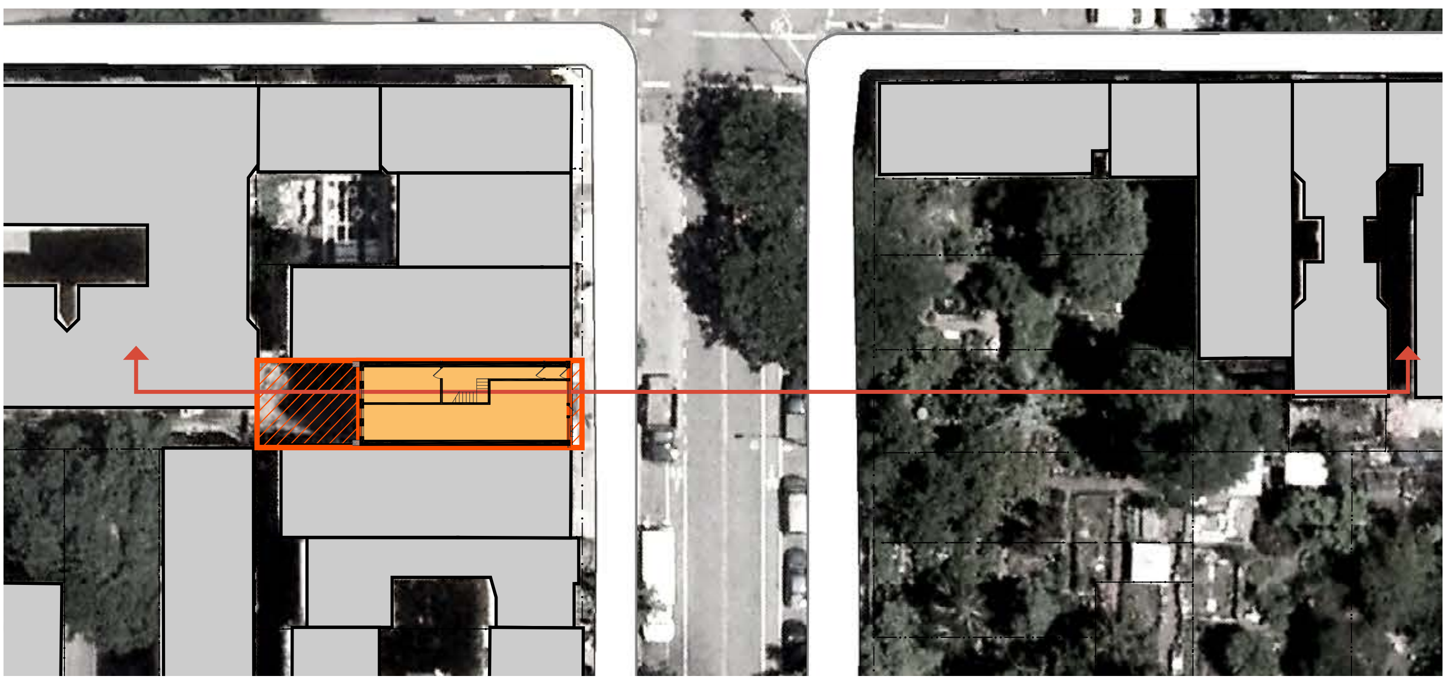
SITE CONDITIONS

Sites with narrow lot size and shallow rear yard depth. Rear yards typically range from 0 to 6 feet below the sidewalk grade. No side yards are provided. Standard width public streets and standard to wide sidewalk widths are typical of this commercial corridor typology.

BUILDING TYPOLOGY

Commercial and residential use is located at the ground floor with residential use above. Buildings are four to six-story masonry party-walls with wood joists and a rubble foundation. Vertical circulation is provided by stairs and egress is provided by fire escapes. Critical systems are located in the basement/cellar. Entrances located above and below the sidewalk and property grade.

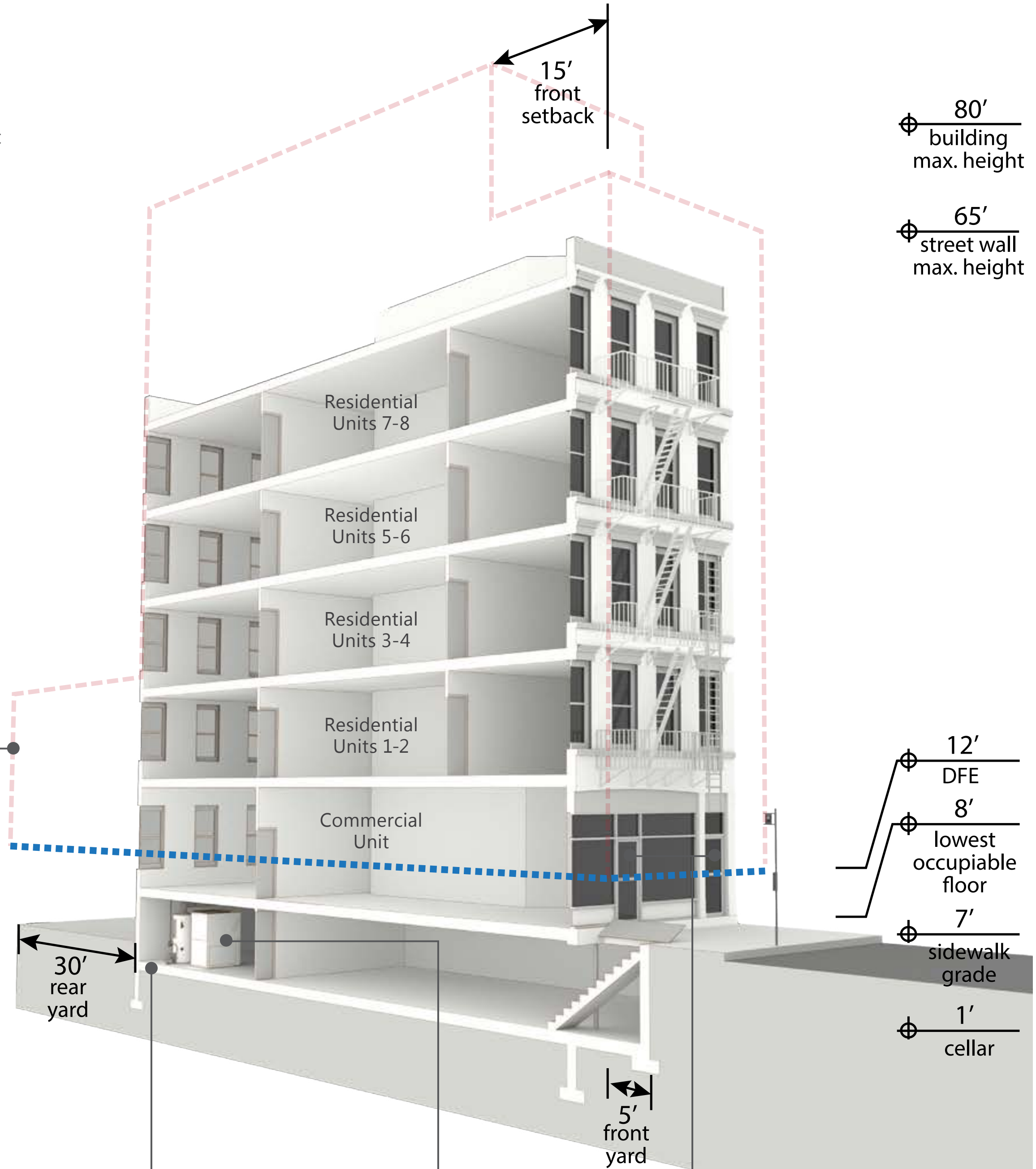




EXISTING CONDITIONS

FLOOD ELEVATION

12′ DFE = BFE + freeboard
= 4′ above lowest occupiable floor
= 10′ above lowest property grade



ZONING ENVELOPE

The allowable building height is measured from the DFE.

The building is built to the maximum allowable floor area. In compliance with zoning, the floor area below the DFE can be relocated within the adjusted bulk envelope.

STRUCTURAL SYSTEMS

Five-story combustible construction with unreinforced masonry bearing party-walls and wood joists on a rubble foundation.

CRITICAL SYSTEMS

All systems are located in a mechanical room in the basement.

ACCESS

Building access is provided at two front locations - one for commercial use and one residential lobby, both 1′ above the sidewalk grade.

The building access at the rear yard is provided at two locations,one 5′ above rear yard grade and the other 3′ below the rear yard grade.

ILLUSTRATIVE RETROFIT STRATEGY

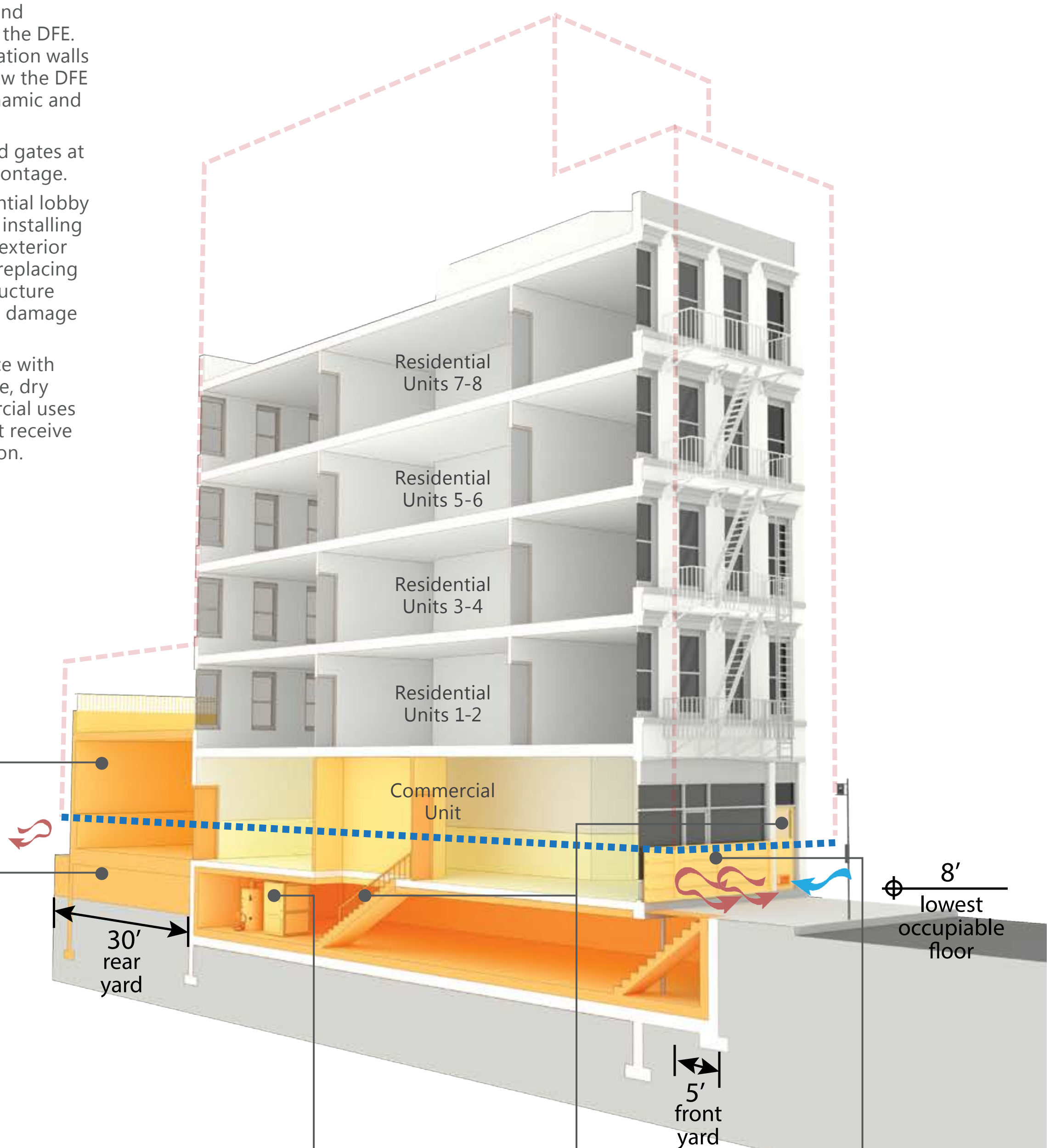
DRY & WET FLOODPROOF

Dry floodproof cellar and commercial use below the DFE. Reinforce slabs, foundation walls and exterior walls below the DFE to withstand hydrodynamic and hydrostatic forces.

Install deployable flood gates at commercial building frontage.

Wet floodproof residential lobby area below the DFE by installing flood vents located at exterior and interior walls and replacing all windows, doors, structure and finishes with flood damage resistant materials.

While in full compliance with NYC Construction Code, dry floodproofing commercial uses below the DFE may not receive NFIP premium reduction.



USE

Maximize commercial use with new addition at rear.

There is a total gain of 700 s.f. of commercial use.

STRUCTURAL SYSTEMS

Dry floodproofing all areas below the DFE requires reinforcing the foundation walls and slab. Underpin slab with helical piles. Repoint stone walls and fill all voids prior to membrane application. Fill all voids between joists with approved insulation membrane. New reinforced concrete slabs and walls poured over membranes. Reinforce interior and exterior walls above grade to withstand flood loads and flood gates.

Reinforce interior walls separating wet and dry floodproof areas.

CRITICAL SYSTEMS

Systems to remain in place within dry floodproofed cellar. Provide new stair access from commercial space. Locate remote emergency shut-off above the DFE.

Install waterproof damper at the combustible air intake in mechanical room.

ACCESS

Reconfigure residential lobby per wet floodproofing requirements.

Provide new interior access to cellar.

Replace access hatch at sidewalk with floodproof compliant model.

When deployable flood shields are in use all egress paths must be provided via temporary stairs up and over the gates. Obtain DOT permit as required.

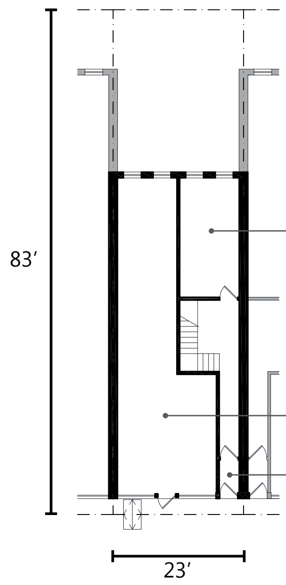
STREETSCAPE

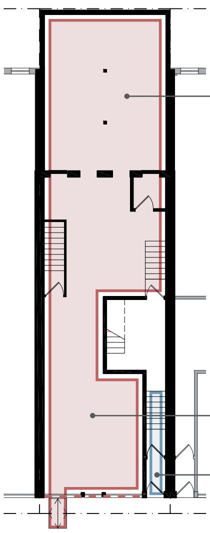
Residential and commercial storefront entries to remain.

Deployable flood shields and temporary stairs installed per DOT revocable consent regulations.

RETROFIT FLOOR PLAN

CHANGE OF USE





Cellar Level
Storage and mechanical room to remain.

Ground Level
Commercial use remains. Reconfigure to accomodate egress and mechanical access requirements.

New commercial storage at rear addition.

Residential lobby remains; reconfigure per wet floodproofing requirements.

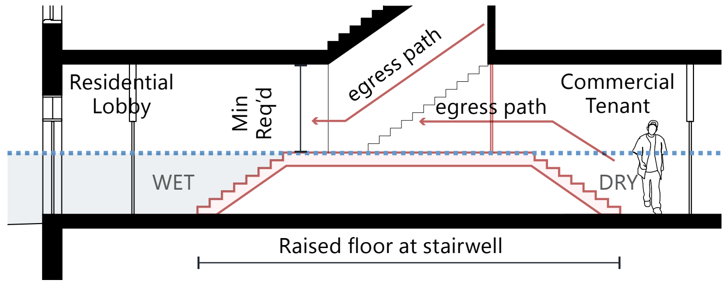
ADAPTATION CONSIDERATIONS

ACCESS

Emergency ingress and egress must be provided when use of temporary flood shields have been deployed. The temporary stairs shown at right provide such access provided it meets code requirements for stair width, step rise and run, landing, head room height and access doorway clearances. Tie downs are required as well to ensure the stairs and platform resist buoyancy in a flood event.

WET & DRY FLOODPROOFING

In this example, a raised floor and stair in the residential lobby space connects to the existing stair for residential units above while providing a new egress route for the commercial tenant. Both residential and commercial tenants share egress from the hallway to the residential entry. The lobby space adjacent to the entry is wet floodproofed while the rest of the ground floor commercial space is dry floodproofed.



ACCESS & STREETSCAPE

NON-SUBSTANTIAL DAMAGE/IMPROVEMENT STRATEGIES

Non-substantially improved buildings within the floodplain are not required to comply with Appendix G of the NYC Building Code. This allows for greater flexibility in adapting buildings for flood resiliency. The alternatives illustrated below lower the risk for buildings and provide practical pathways for adaptation. Under current NFIP regulations, these measures may not lower insurance premiums.

The blue icons below illustrate adaptive measures that receive full reduction of NFIP premiums. Icons in gray indicate strategies that improve building resilience, but receive no or partial reduction of NFIP premiums.

If the lowest occupiable floor is left below the DFE, life safety must be considered. Residents should always follow evacuation procedures.

- Occupied Space
- Critical Systems
- Dry Floodproof
- Wet Floodproof
- Open Structure
- NFIP Premium Reduction

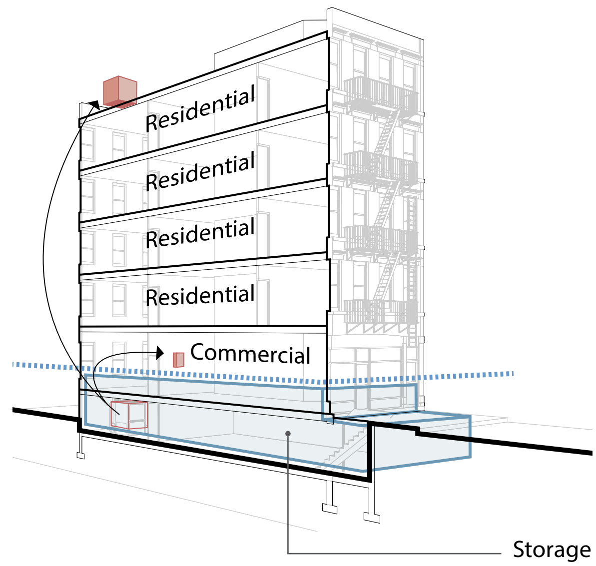
No or partial reduction in NFIP premiums. The structure is not filled to the lowest adjacent grade. Wet floodproofing is not permitted at commercial use or below the lowest adjacent grade.

Wet floodproof below the DFE. Install flood vents and replace all windows, doors and finishes with flood damage-resistant materials.

Restrict cellar use to storage. Ground floor commercial and residential lobby uses remain.

Add reinforcement for relocated systems on roof.

Relocate critical systems to the roof within a fireproof and vented enclosure. Raise electrical utilities above the DFE.



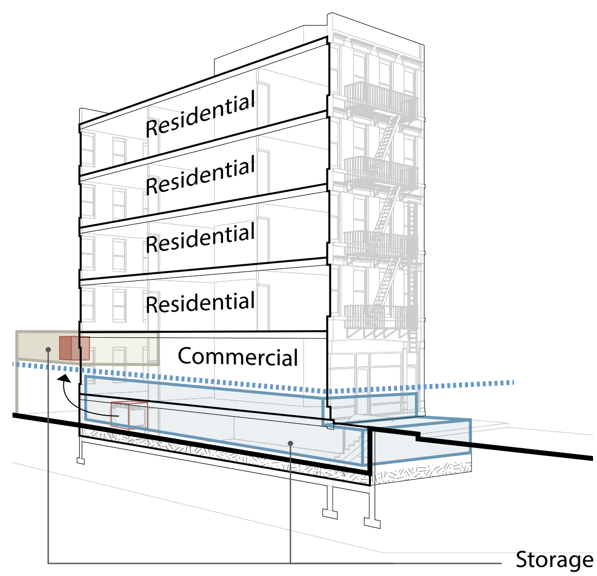
No or partial reduction in NFIP premiums. Wet floodproofing is not permitted at commercial use or below the lowest adjacent grade.

Wet floodproof below the DFE. Install flood vents and replace all windows, doors and finishes with flood damage-resistant materials.

Addition in rear for mechanical room and dry storage. Existing commercial, storage and residential lobby uses below the DFE remain. Basement filled to lowest adjacent grade and converted to crawl space.

Fill basement to the lowest adjacent grade. Ensure changes to party-walls do not impact neighboring property's structural integrity.

Relocate systems to rear addition.



CHAPTER 5 **URBAN MITIGATION ALTERNATIVES: OPPORTUNITIES FOR NFIP REFORM**

The Rockaway Peninsula, Queens

OPPORTUNITIES FOR NFIP REFORM

The case studies and detailed analysis of retrofitting options for the most vulnerable building typologies in New York City have brought to light a series of specific challenges that can make retrofitting projects physically or financially infeasible. Understanding the applicability of current federal regulations to the diversity of buildings found in New York City is a first step towards developing cost-effective solutions that can be implemented by homeowner and property owners.

The Homeowner Flood Insurance Affordability Act, enacted by Congress in 2014, requires FEMA to provide guidance for cost-effective alternative methods of mitigation for urban areas where buildings cannot be elevated because of their structural characteristics. FEMA must take these new alternative methods into account in calculating premium rates for flood insurance coverage. This chapter identifies several opportunities for potential alternative methods of mitigation that merit further research, based on sound building science and actuarial analysis, by engineers, actuaries, and policymakers at FEMA to determine whether they can effectively reduce risk where other methods are not practical. In addition, further FEMA guidance would aid the effective application of wet and dry floodproofing methods to the building types characteristic of New York City and other cities. The City looks forward to continuing to work with FEMA on further research and to explore these and other opportunities to provide cost-effective and practical solutions for a wider range of buildings in New York City and other urban areas.

The City is also conducting its own research assessing the implications of the NFIP's increasing flood insurance premiums on housing affordability in the floodplain in New York City. Specifically, the city is conducting two studies, one focused on one-to-four family buildings and another one on multi-family buildings, to better understand and communicate the impact that rising flood insurance costs and an expanded floodplain will have on New Yorkers, and to make policy proposals to both reduce risk and maintain affordable insurance.

SUGGESTED ALTERNATIVE MITIGATION METHODS

Explore allowing wet floodproofing of a wider range of uses below the DFE for masonry buildings with foundations that demonstrate strong structural integrity

Masonry buildings with foundations, which are very often semi-detached or attached, largely avoided substantial structural damage during Sandy. However, federal regulations (also incorporated into the local building code) require basements and cellars to be filled to lowest adjacent grade and non-residential spaces below the DFE to be elevated or dry floodproofed, with the exception of such spaces used as parking, crawl space, access and storage. These are also the only options recognized by the National Flood Insurance Program towards insurance premium reductions.

In addition to being complicated and costly retrofitting projects that few owners are likely to take on, the current required set of options may unintentionally increase the risk of damage to the structure and its neighbors. In many cases, these buildings survived flooding from Sandy without structural damage, apparently because water entering the structures helped equalize hydrostatic pressure. Filling in below-grade spaces and preventing the water from entering the building by dry floodproofing may create new structural risks for attached buildings. In a case where, for example, only one of two attached buildings elects to dry floodproof, structural modeling would be necessary to make sure that the dry floodproofed areas are structurally independent of the adjacent building and resistant to the lateral pressure that would come from water-filled basements on either side of the building. The consequences of the application of different floodproofing measures on buildings that have historically been structurally linked are unknown and potentially problematic.

For these structurally heavier buildings, allowing the water to flow through the structure may be the safest strategy to protect its structural integrity. Combined with the elevation or dry floodproofing of critical systems, this alternative strategy may be an effective, simpler and cheaper way to adapt many of the buildings in New York City. If these wet floodproofed spaces are designed with flood damage-resistant materials, recovery can be accelerated. This report recommends that FEMA investigate the structural viability of this option, and analyze from an actuarial perspective the level of damage that these buildings have incurred during actual flood events.

Exploring wet floodproofing active uses is especially important for commercial corridors, which in dense urban neighborhoods provide essential services to communities during normal conditions or following times of emergency. The only currently available options for adaptation are elevation, which in an urban context fundamentally jeopardizes retail viability, and dry-floodproofing, which is extremely costly and raises serious structural integrity questions presented above. Alternative strategies, such as wet floodproofing commercial space, should be explored to allow commercial corridors in the floodplain to be both physically and economically resilient to flood hazards. Combined with the right set of operational adaptations and procedures in place, wet floodproofing can also minimize business disruption during a flood event and help neighborhoods as a whole recover more quickly.

Explore allowing critical systems to remain in place below the DFE within enclosures that prevent the water from entering

In a dense environment with older buildings like New York City, relocating critical systems to locations outside the building or on the roof is often not possible. As a result, the only place to relocate critical systems is within the building, which can result in the loss of usable floor area for single-family buildings and housing units for multifamily buildings. The loss of floor area and units may deter owners from retrofitting their buildings, leaving them and their occupants at risk.

Technology enables the design of waterproof enclosures around critical systems, allowing owners to protect their systems in place below the DFE and minimize the loss of floor area. While FEMA encourages these practices, they do not currently account for the reduced risk of flood damage in their flood insurance premiums under the NFIP. With attention to life safety issues, and emergency access and egress needs, this option should be explored to provide owners with a workable solution that maintains the viability of the building. This report recommends that the NFIP recognize safe waterproof enclosures as an adaptation measure to establish its ratings.

NEED FOR FEMA GUIDANCE ON HOW TO APPLY EXISTING METHODS TO URBAN TYPOLOGIES

Develop guidance for dry floodproofing masonry buildings

Existing FEMA guidance for dry floodproofing is geared towards wood-frame buildings. Based on their structural integrity, masonry buildings may require less extensive construction to dry floodproof and, in some cases, be limited to installing a dry floodproof membrane under the skin of the building without structural reinforcement.

Understanding the range of dry floodproofing techniques for masonry buildings may make it possible to safely dry floodproof certain residential buildings, especially where the floodproofed elevation is only slightly above grade, or for those buildings where only a portion of the residential floor is below the DFE and where adding a means of emergency egress above the DFE may be feasible.

Develop guidance for retrofitting attached buildings

Existing FEMA guidance is focused on detached buildings, making many of the regulations difficult to apply to the numerous attached buildings found in New York City. Current regulations such as the requirement to fill basements and cellars to the lowest adjacent grade or to dry floodproof commercial spaces, present structural challenges, as discussed above. Elevating a building that shares one or two party-walls is difficult and often costs more than the value of the building, making retrofitting investments unlikely.

Guidance for attached typologies should take into account challenges related not only to the structure but also to its site and context, such as sites where the rear yard is located at a lower level than street grade, complicating the ability of floodwaters to drain passively from the site. This research may lead to more cost-effective solutions for building owners as well as potential strategies to jointly improve multiple contiguous buildings.

Develop guidance for retrofitting mixed-use buildings

Existing FEMA regulations are not designed to provide solutions for mixed-use buildings. Retrofit strategies are constrained by use and in many cases can work against each other when they need to be applied side by side on the same floor. In New York City, which contains many mixed-use buildings, this translates in wet floodproofing a residential lobby and dry floodproofing the adjacent commercial space. In order for these strategies to perform, the partition/wall separating the two spaces needs to be strong enough to withstand unbalanced hydrostatic loads, which may require reinforcement. Additionally, the wet floodproofed residential lobby needs to be large enough to accommodate the expected volume of water and therefore may need to be reconfigured or widened. Guidance for mixed-use buildings should take into account these challenges and offer solutions that minimize structural reinforcement and redesign of spaces. Developing one single consistent retrofit strategy for mixed-use buildings is critical to protecting many urban buildings.

APPENDIX I: CRITICAL SYSTEMS

Boiler, Furnace and Forced Air Heating Systems

Many components to heating systems are vulnerable to flood damage. Relocating boilers, furnaces or other forced air systems to an upper story is ideal but may not be practical. If relocation is infeasible, try to elevate as high as possible at the current location. Property owners should consider required equipment clearances and venting before determining if and where to relocate. Systems using a storage tank require the tank to be anchored to resist buoyancy and lateral loads.

Clearances

Before relocating equipment, ample consideration must be given to minimum clearances required for equipment, conduits, piping and duct work in order to maintain the recommended horizontal and vertical clearances as required by building code, the National Electric Code (NEC) or as recommended by manufacturers. Designing for the minimum clearance is important to maintain air circulation; to meet insurance or code requirements related to the equipment's requirements; and to maintain distance from combustible building materials. The use of heat shields as specified by code may reduce clearance requirements. Failure to maintain clearances can result in safety issues, such as fire, and can void equipment warranties.

Electrical Panels

Electrical panels should be relocated above the DFE. If a location above the DFE cannot be readily accessed, panels may be located in a closet within a living space. An emergency service disconnect may need to be incorporated into the system to meet National Electrical Code requirements. Relocation may also require significant rewiring to bring up to code. To protect against temporary inundation encapsulated strategies may be used, as discussed below.

Encapsulate Electrical Equipment

Stainless steel enclosures provide a certain degree of flood protection for equipment below the DFE. However, this is only intended for temporary protection during a flood event due to the fact that enclosures can fail after prolonged submersion. Enclosure does not provide guaranteed protection against water damage. Wiring should be encased in a non-corrosive metal or plastic conduit when allowed by code.

Fuel Tanks

When located below the DFE, fuel tanks should be contained within dry floodproofed enclosures per ASCE 24, be bolted down, or heavy enough to resist buoyancy pressure of water and debris. Above-grade vents for below grade storage tanks must be located a minimum distance above the DFE to prevent fuel contamination of water and vice versa. When fuel tanks are located above the DFE in interior spaces, their enclosure must comply with the Department of Building and Fire Code requirements. This may require up to a three-hour rated enclosure within an additional fire-rated enclosure, as well as additional structure to support the new loads.

Structural Implications

It is important to consider the weight of the mechanical equipment (referred to in technical terms as the dead load) on the building structure when elevating equipment to a higher floor. The additional load may require structural reinforcement of the space where the equipment is being relocated.

Sump Pump

Sump pumps help to remove flood waters below grade in combination with other mitigation measures. Installation of the pump may require demolition of a portion of the basement floor. Install a sump pump with a battery backup system to keep the pump working in the event of a power failure. To be effective, the sump pump needs to be away from the basement walls and have positive drainage away from the building.

Tankless Water Heater

When relocating a traditional water heater is not feasible, tankless water heaters should be considered. Tankless water heaters are located adjacent to the fixture that requires heating, and work instantaneously but providing little storage capacity. Therefore, they take up less space making it easier to retrofit buildings using these systems. Natural gas systems require little work for conversion, though electrical systems may require upgrades to provide more power for the system.

Venting

Oil- or gas-fueled boilers, furnace and water heaters require adequate combustion air and venting of exhaust gases. Venting requirements may affect if and how equipment can be elevated. Use of impact resistant louvers is required.

Washer/Dryer Units

Elevation of these systemes to an upper story or attaching them to a permanent pad or platform will prevent becoming risk to debris force. However, it will not prevent damage to the equipment.

Water Heaters

As with all systems, the safest option is to elevate the water heater above the DFE, though relocation will require additional plumbing and electrical work. Oil or gas-fired heaters will require ventilation. Water heaters often require a small pad or platform to sit upon.

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