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.