

**Resilient  
Industry  
Mitigation  
and  
Preparedness  
in the  
City's  
Industrial  
Floodplain**

**NYC** PLANNING

**Coastal Climate Resiliency**



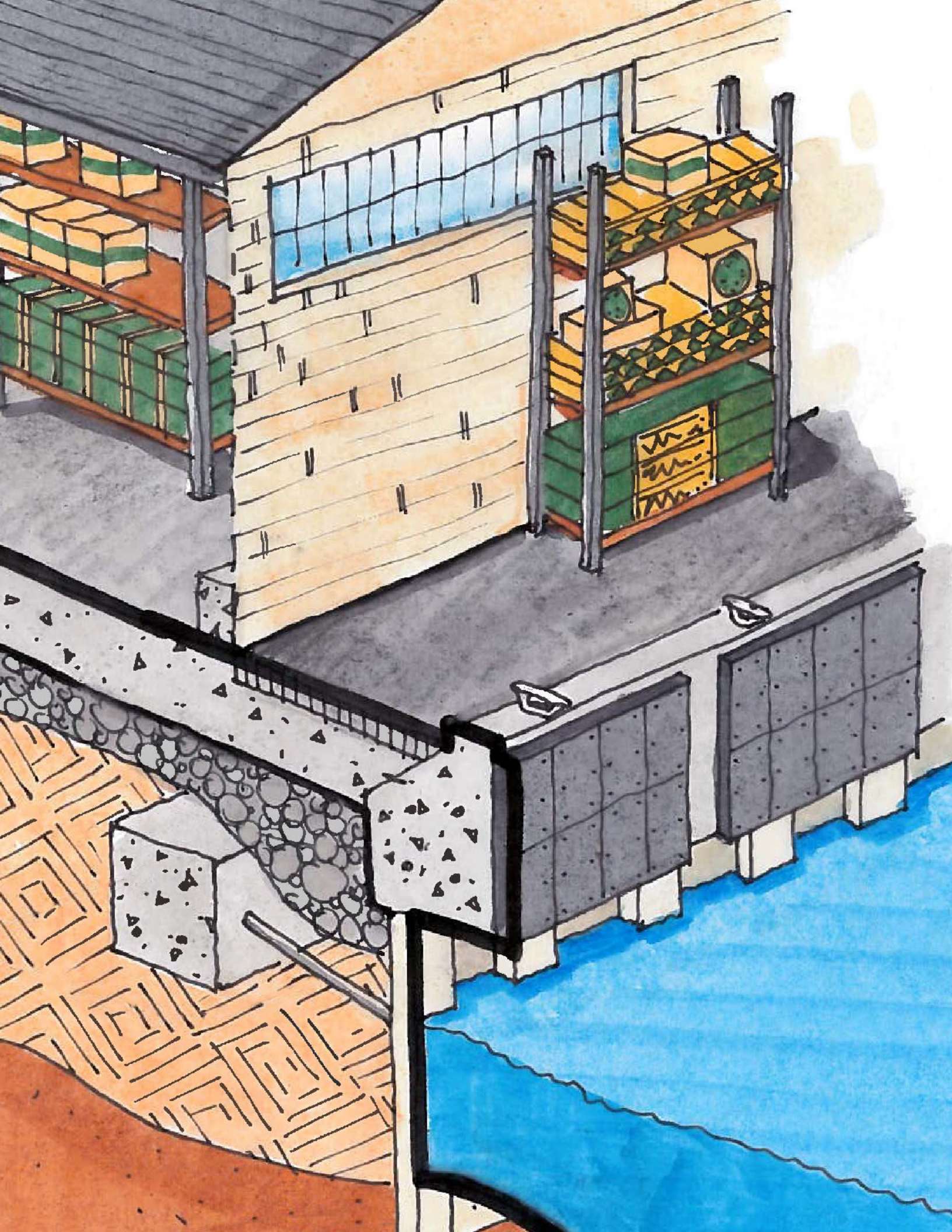
[www.nyc.gov/resilientindustry](http://www.nyc.gov/resilientindustry)

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## Foreword

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New York City's industrial and manufacturing sectors are crucial to our economy, providing more than half a million jobs and delivering essential services that sustain the city. Hurricane Sandy exposed the vulnerabilities of our coastal communities to flooding and storms, including many areas that contain large concentrations of industrial businesses. *Resilient Industry* identifies the unique challenges faced by these businesses and explores opportunities to minimize the impacts of future floods.

By encouraging actions that minimize flood risk on industrial facilities, *Resilient Industry* helps strengthen the industrial sector and supports the jobs these businesses provide. The recommendations and best practices described in this report further the goals of the *10 Point Industrial Action Plan* and the *New York Works* jobs plan to support existing, and spur new, quality industrial jobs.

This report relies on several illustrative case studies to highlight strategies to prepare for and mitigate flooding on industrial sites. It also demonstrates the limitations of the existing federal floodplain regulations in the context of the city's businesses and building stock,

and provides specific suggestions for alternative mitigation options that FEMA should explore.

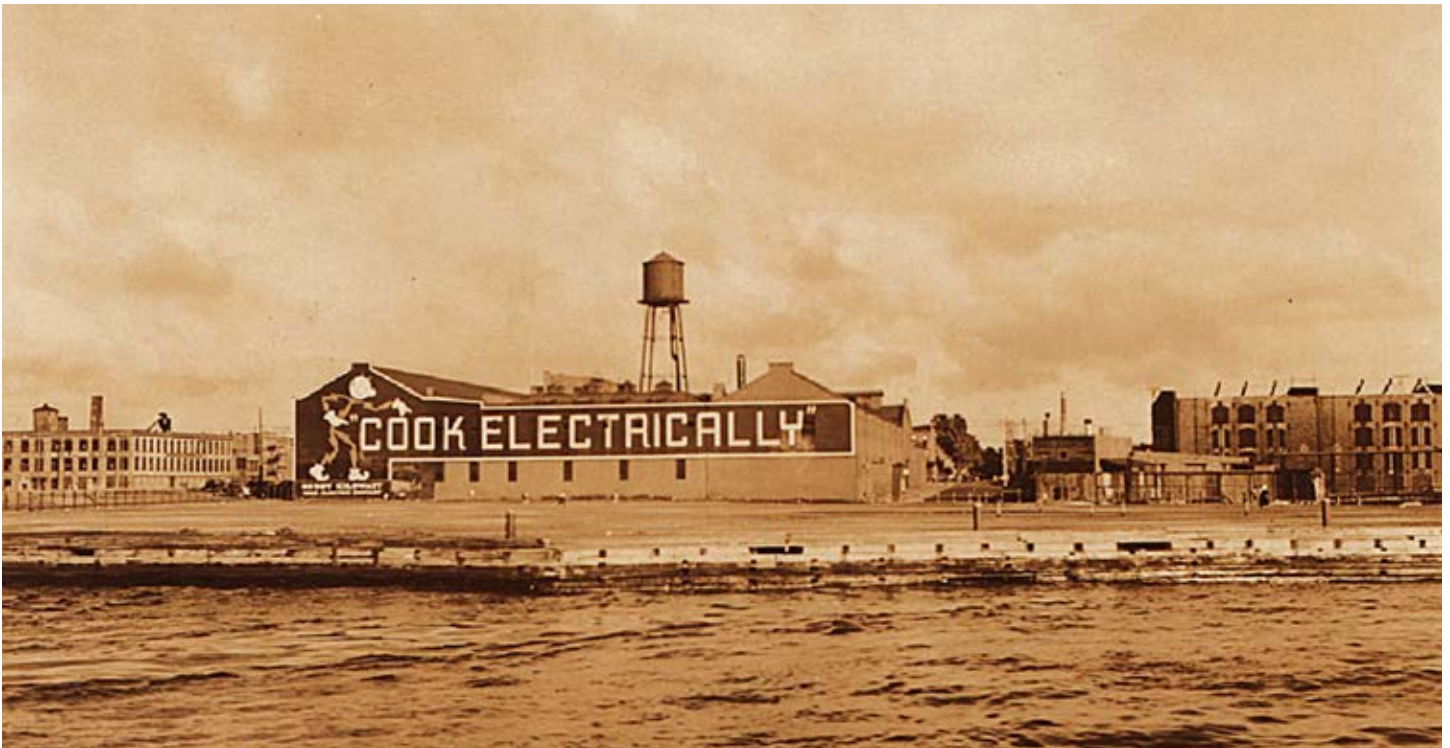
The recommendations presented here are informed by the valuable guidance and experiences of industrial businesses in New York City, as well as Industrial Business Services Providers, state and local government agencies, environmental and community justice advocates, and many others who are working to create a more sustainable and resilient city.

As climate change continues to increase the risk of flooding, approaches to better protect industrial facilities and minimize disruptions will become increasingly critical to supporting long-term community resilience and a stronger New York City. The Department of City Planning is committed to working with businesses and waterfront communities throughout the five boroughs to manage these risks and foster healthy and resilient communities in and around the floodplain.



Marisa Lago, Director  
Department of City Planning





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## Executive Summary

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**Industrial building located along the waterfront in Red Hook, Brooklyn that typifies New York City's aging industrial building stock.**

Citation: Irma and Paul Milstein of United States History, Local History and Genealogy, The New York Public Library. (1937). *Brooklyn: Ferris Street - Dikeman Street.*

Hurricane Sandy provided a powerful reminder of the vulnerabilities that New York City's residents and businesses face due to flooding and coastal storms. Due to historic development patterns that caused industrial businesses to locate in areas with maritime access, a significant portion of the low-lying neighborhoods heavily impacted by Hurricane Sandy, and in the floodplain generally, contain large concentrations of industrial businesses. These facilities, such as wholesale warehouses, construction yards, and recycling facilities, serve critical functions that support the city's growing population and economy.

Industrial businesses face several unique challenges related to flood protection. The city's industrial building stock is aging, with more than 87 percent of these facilities built before the City adopted its first flood maps or enacted floodplain regulations. The majority of these are single-story buildings with large floorplates that provide little flexibility to relocate equipment, inventory, or production space to areas with less risk of flood damage.



As part of the National Flood Insurance Program (NFIP) administered by the Federal Emergency Management Agency (FEMA), communities must comply with flood-resistant construction standards. Permitted strategies to retrofit nonresidential buildings include the following options:

- 1 Elevating the lowest floor above the expected flood elevation, or**
- 2 Dry floodproofing the entire building to prevent floodwaters from penetrating the exterior.**

However, for many industrial facilities in NYC, fully complying with these standards is cost prohibitive, or in some cases structurally infeasible. Compounding this challenge, few industrial businesses have active flood insurance policies, and for those that do, the coverage cap is frequently below the value of their assets in the floodplain.

### **Industrial Resiliency Best Practices**

Fortunately, many businesses have found ways to proactively address flood risk and prepare for future events. Others are looking for solutions that will protect their investments and ensure continuity of operations, even if they are unable to fully meet the required flood-resistant construction standards. These strategies include targeted protection of electrical and mechanical systems within buildings, such as elevated platforms or waterproof rooms to house substations, electrical panels, generators, HVAC systems, and other high-value building components.

**Large industrial facility in Gowanus, Brooklyn where structural elevation or dry floodproofing to comply with FEMA standards would be cost prohibitive.**



Elevated mezzanines give industrial businesses more flexibility to relocate equipment and inventory in advance of expected floods. Modifications to zoning and federal floodplain management requirements could encourage similar retrofits to improve industrial resiliency.



Preparedness planning is also an essential strategy to reduce risk and quickly resume operations following a storm. Truck relocation planning, clearly defined protocols to move inventory and equipment out of harm's way, and techniques to secure hazardous materials and unenclosed inventory can ensure that the industrial floodplain is more resilient to future floods and coastal storms.

Several opportunities exist for the public sector to encourage industrial businesses to pursue these resiliency strategies. Modifications to the City's zoning resolution could allow for more flexibility to create elevated space within existing buildings. Incorporating standards within the NYC Building Code for unenclosed storage of materials and equipment on industrial sites could help ensure that sites are adequately designed to address flood risk. Technical and financial assistance to support mitigation and preparedness could be designed to encourage continuity of operations planning and emergency truck relocation. At the federal level, modifications to FEMA's National Flood Insurance Program to recognize a wider range of flood mitigation actions could both promote resiliency retrofits and increase the number of businesses with active flood insurance policies.





Long Island City,  
Queens



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## Introduction

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Industrial businesses are intricately tied to New York City's history and development and continue to be an important component of the city's economy. From maritime businesses supporting the largest port on the East Coast to the network of food distribution businesses supplying groceries to millions of New Yorkers, the city relies on and benefits from a healthy industrial sector. Mayor de Blasio's **10 Point Industrial Action Plan**, released in November 2015, affirms the importance of supporting industrial businesses that provide a range of critical services to the city and jobs for hundreds of thousands of New Yorkers.

However, due in large part to historic development patterns and the transportation benefits of locating near the water, a large proportion of industrial businesses are located along or near the city's 520-mile coastline and are particularly vulnerable to the effects of flooding, coastal storms, and sea level rise. In fact, approximately 24 percent of the city's floodplain falls within districts zoned for manufacturing and industrial uses. These areas contain 3,600 businesses that employ 87,000 workers. The need to store and use hazardous materials as part of many industrial processes and operations adds another layer of risk for workers, neighboring businesses and the surrounding community, and poses potential environmental hazards.



## The average depth of flooding within the 5,500 industrial buildings in the Hurricane Sandy inundation area was 2.6 feet.

Hurricane Sandy's landfall on October 29<sup>th</sup> 2012, highlighted many of these vulnerabilities across the city's industrial sector, damaging buildings, equipment, inventory, and vehicles. The average depth of flooding within the 5,500 industrial buildings located in the Sandy inundation area was 2.6 feet. Many of these businesses were uninsured or underinsured for flood damage, forcing them to cover repairs and lost revenue out-of-pocket or through additional financing.

Despite the damage caused by Hurricane Sandy, few industrial buildings were damaged beyond repair, and most businesses were able to make the necessary investments to resume operations fairly quickly. Some businesses

took steps prior to Sandy to limit their losses. Others learned from their experience and developed operational plans or made physical investments to lessen damage in the future.

The experience responding to and recovering from Sandy revealed a number of lessons to help better prepare the city's industrial sector for future storms and mitigate losses. The Resilient Industry study is designed to address this need by identifying strategies to reduce vulnerability to flooding that are applicable across a broad spectrum of businesses active in industrial areas in New York City.

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### The study is guided by four overarching goals:



**1 Reduce flood hazards for businesses and residents in the city's industrial areas located within the floodplain.**



**2 Identify emergency preparedness guidelines for businesses in industrial areas located within the floodplain.**



**3 Promote cost-effective physical and operational strategies to protect businesses and the environment.**



**4 Identify financial and insurance challenges unique to businesses in industrial areas located within the floodplain.**



**Industrial facility site visit by NYC Department of City Planning staff to document resiliency challenges.**

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## Resiliency Planning in New York City

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Hurricane Sandy inundated New York City's five boroughs with extreme levels of coastal flooding and storm surge. While this was not the first major hurricane to cause flooding in the city, it resulted in a record \$19 billion in damages and economic loss for the city, claimed 44 lives, and prompted residents, businesses, and city government to more thoroughly consider strategies to reduce future flood risk. Following Sandy, the City developed a detailed action plan for rebuilding, called, "[A Stronger, More Resilient New York](#)" that focused on both post-disaster recovery and long-term resiliency for the city's coastal communities, buildings, and infrastructure. The City has made significant progress in implementing

the plan, funding a \$20 billion climate resiliency program and advancing rebuilding through initiatives such as Build it Back, as well as long-term resiliency through infrastructure investments and upgrades.

Drawing on this work and earlier planning efforts, in Spring 2015 the City released, "[OneNYC: The Plan for a Strong and Just City](#)" a long-term strategic plan to address the city's most pressing challenges, including a rapidly growing population, rising inequality, aging infrastructure, and climate change. During the following months and years, the New York City Department of City Planning and other agencies have conducted planning studies and initiatives to improve the resiliency of vulnerable communities, many of which are described in Chapter 2 of this report.





**Presentation of industrial resiliency strategies to business owners in Long Island City, Queens.**

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## Process

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The Resilient Industry study was guided by a Technical Advisory Committee (TAC) consisting of more than 60 stakeholders, comprised of business owners, state and local government agency representatives, environmental and community justice advocates, architects and engineers, and academics. The TAC met four times during the course of the study and meaningfully informed the scope, approach, and findings.

The Resilient Industry study began with an analysis of industrial vulnerability, including an assessment of Hurricane Sandy's impacts and the recovery process during the subsequent months and years. The study team developed a criterion to select case studies that cumulatively address a range of typical building features, site characteristics, and industrial uses central to New York City's

economy. Working in partnership with **Industrial Business Service Providers**, the team identified seven businesses to serve as case studies in which to evaluate specific resiliency challenges and best practices.

During the winter of 2015, city planners and urban designers visited the case study sites and interviewed business owners and operators to learn about physical and operational strategies they are pursuing to manage flood risk and barriers they are facing in becoming more resilient to flooding and coastal storms. Research about industrial mitigation and preparedness measures implemented in other cities in the U.S. and internationally further informed the analysis.



**Erie Basin in  
Red Hook,  
Brooklyn.**

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## **Using this Report**

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The Resilient Industry report is primarily designed as a resource for industrial businesses to help them consider both the risks that future flooding poses to their facilities and steps that can be taken to prevent or reduce damage. The seven case studies explored in the study describe physical retrofit options applicable at industrial sites with different challenges. The case studies also point to operational strategies that may be replicated to effectively prepare facilities when the potential for flooding exists. Although they were selected because they are broadly representative of the types of businesses and site conditions present in industrial areas, the types of interventions, including their cost and effectiveness, will vary based on unique site conditions and business operations. For this reason, the case studies are intended to be used as a guide to help businesses think through

their own vulnerability and prioritize investments that may be most effective on their sites. In addition to local businesses and property owners, the report is intended to be used by organizations supporting and advocating for a more resilient industrial sector in New York City. Many best practices described in Chapter 4 include cost estimates. Tables in the appendix provide additional detail about the cost of various resiliency measures.

The report also acknowledges opportunities for city, state, and federal programs and policies to more effectively support a vibrant and resilient industrial sector. Recommendations are geared toward policy-makers at multiple levels of government to provide targeted investments, incentives, and flexibility to allow new and existing industrial businesses to operate safely and effectively in the face of future flooding and coastal storms.





Newtown Creek,  
Greenpoint, Brooklyn

# 1

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## **New York City's Industrial Floodplain**

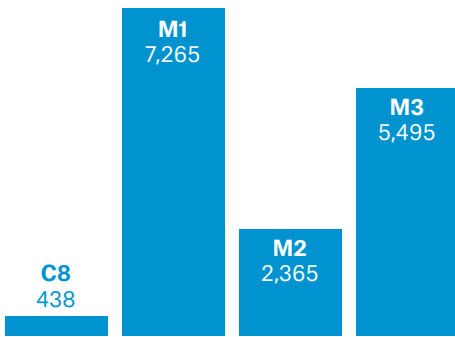
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The city relies on its manufacturing districts to locate high-impact, truck-dependent, and potentially hazardous operations that are best sited away from residences. These uses are often permitted only in manufacturing districts, which are typically mapped in low-lying areas in locations where industry has historically chosen to operate due to access to waterways and relative isolation from residences. Roughly half of the city's industrially zoned land falls within the 0.2 percent annual chance floodplain, areas subject to moderate risk of flooding. This amounts to more than 15,000 acres of industrially zoned land. Of this, 10,000 acres are within the high risk, 1 percent annual chance floodplain. In M2 and M3 districts, which tend to contain heavier industrial uses such as waste management and petrochemical distribution, the percentage of land that falls in the floodplain is approximately 70 percent. More detailed information about zoning in NYC can be found on page 43.

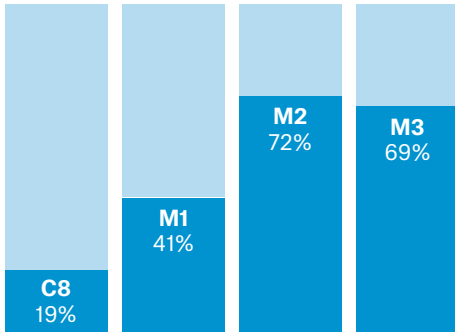


**Properties located in the V Zone and A Zone are in the 1 percent annual chance floodplain and are considered at high risk of flooding.**

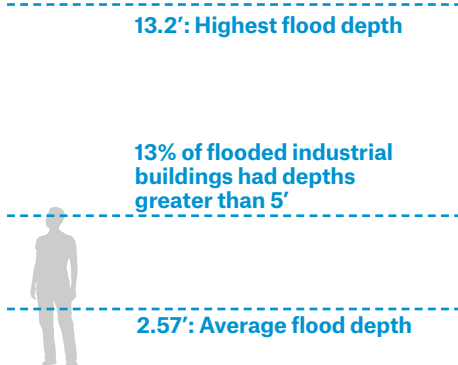
**Acres in Floodplain by Zoning District (X, A, V Zones)**

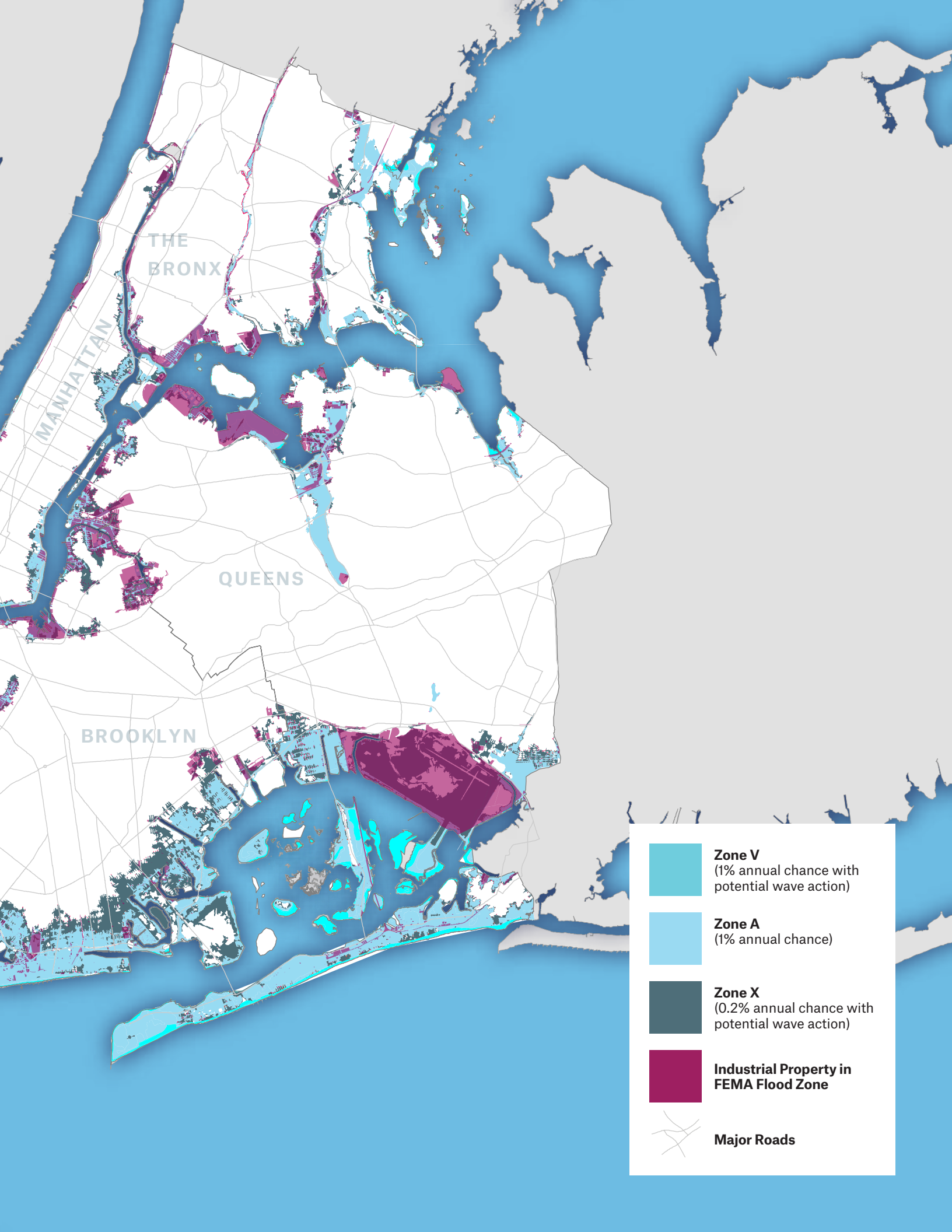


**Percent of Citywide Manufacturing Districts Located within the Floodplain by Zoning District**



**Flood Depths in Sandy Inundation Area**





THE  
BRONX

MANHATTAN

QUEENS


BROOKLYN

**Zone V**  
(1% annual chance with potential wave action)

**Zone A**  
(1% annual chance)

**Zone X**  
(0.2% annual chance with potential wave action)

**Industrial Property in FEMA Flood Zone**

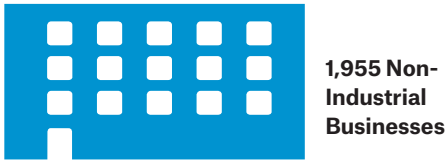
 **Major Roads**



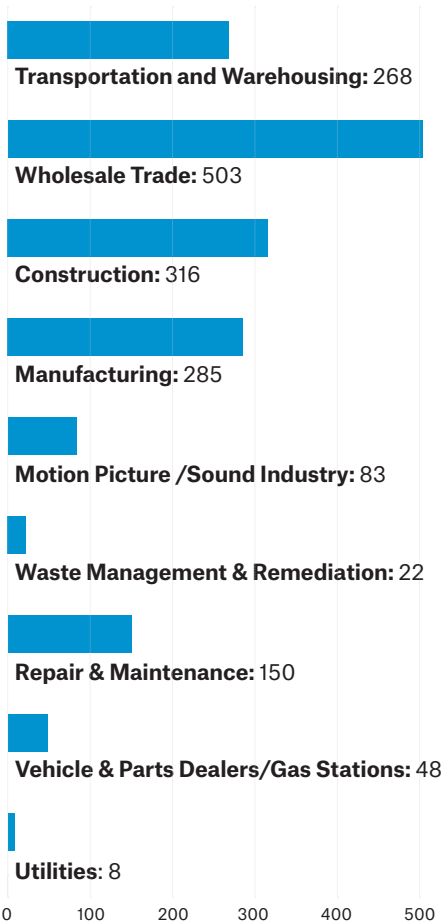
The city's industrial floodplain includes numerous facilities and operations that serve critical functions or provide for necessary, but difficult to site, services that support the growing population and economy, such as construction yards, utilities, distribution, and recycling.

Though a wide range of businesses operate within the city's floodplain, the industrial sectors that are most heavily represented include wholesale trade, transportation and warehousing, construction, and manufacturing. These four industrial sectors also provide the greatest employment within the floodplain, with transportation and warehousing businesses providing nearly half of industrial jobs, and a quarter of total jobs, within areas at high risk of flooding.

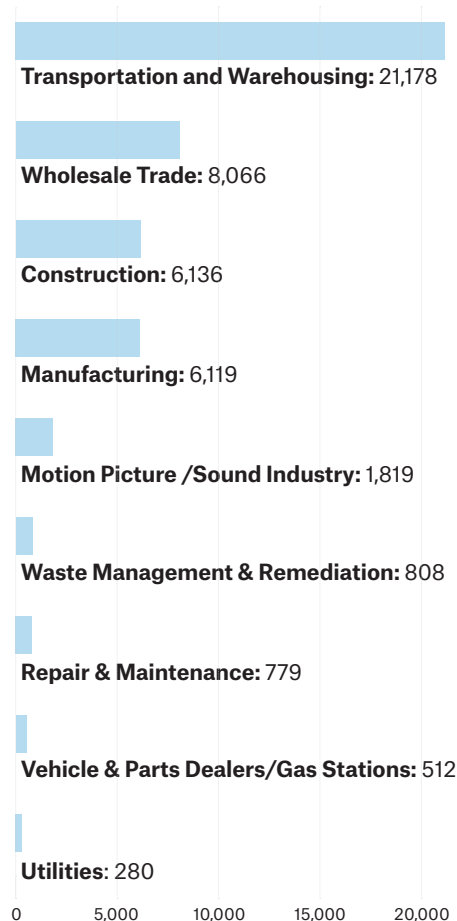
### Number of Business & Employees within the Industrial Floodplain



### Business in the Industrial Floodplain by Sector



### Employees in the Industrial Floodplain by Sector



In recent years, there has been considerable growth of specialty trade contractors, such as businesses that provide plumbing, heating, air conditioning, and electrical services. These companies support the construction industry and are essential for the maintenance of the city's large building stock. The grocery wholesale sector, a critical component of the city's food distribution supply chain, has also expanded in manufacturing areas of the city in recent years. While the manufacturing sector has experienced less overall growth, a burgeoning market for locally produced food and beverages has driven growth within food manufacturing, breweries, and distilleries. The film and television industry has also thrived over the last decade, leading to substantial use of the city's industrial floodplain for studios and production sites in industrial buildings with large floorplates and high ceilings.

In addition to the economic importance of the city's industrial sector, many industrial facilities are important to the emergency response and recovery effort following disruptions. For example, fuel distribution facilities, many of which are located along the water in low-lying areas, are essential to maintaining power, heat, and mobility of people and goods. Similarly, debris removal by the New York City Department of Sanitation and private waste management companies is vital early in the recovery process from many natural disasters. Local construction contractors and material distributors are essential to any rebuilding effort. Ensuring that these and other critical industrial facilities are resilient to future flooding and coastal storms is important for the city to maintain operations and support its citizens while responding to and recovering from future events.

Source: Bureau of Labor Statistics, Quarterly Census of Employment and Wages. 2015



## 87 percent of industrial buildings in the flood zone predate floodplain regulations

**Single-story industrial building constructed in 1950 in Gowanus, Brooklyn.**

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### Industrial Building Stock

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The city's industrial building stock is vulnerable to extreme weather events. The vast majority of these buildings predate requirements to elevate, floodproof, or otherwise mitigate risk. More than half of the warehouses and factory buildings that house the city's industry were built before 1946, and over 87 percent of industrial buildings in the floodplain were built prior to 1983 when New York City adopted its first flood maps and enacted floodplain regulations.

Furthermore, almost two-thirds of industrial properties in the floodplain are single-story warehouses, causing most industrial businesses to locate their entire operation on the ground floor. This offers little flexibility to relocate equipment, inventory, or production space to higher floors where there is less risk of flood damage.

Despite these vulnerabilities, industrial buildings do present many unique opportunities related to flood protection. Most notably, the high floor-to-ceiling heights and greater spacing between columns typical of many warehouses and manufacturing spaces allow for more flexibility to raise critical equipment, machinery, and inventory within existing building envelopes. Compared with commercial and residential buildings, the interiors of industrial buildings tend to have fewer investments in finished spaces and typically incorporate more flood-resistant construction materials, such as concrete, cement, and steel floor trusses and beams.<sup>2</sup> Strategies to enhance the resiliency of industrial businesses should be tailored to these unique challenges and opportunities faced by New York City's industrial businesses and the existing building stock they occupy.





**Concrete trucks parked along Newtown Creek in East Williamsburg, Brooklyn.**

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## **Commercial Vehicles**

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Many businesses that operate in the city's industrial floodplain rely on large fleets of commercial trucks, including food wholesale, freight trucking, construction, and film and television production. These vehicles represent a significant asset for many companies and are critical to their daily operation. During Hurricane Sandy, many businesses failed to relocate commercial trucks from parking lots in the floodplain, resulting in major losses. In fact, three of the seven businesses used as case studies within this report had more than half of their vehicles significantly damaged or destroyed by Hurricane Sandy. In addition to the

financial losses and lengthened timeline to resume operations, vehicle flooding can cause fuel and other hazardous materials to leak, potentially exposing employees, neighbors, and the surrounding environment to greater concentrations of harmful chemicals.

**Following Hurricane Sandy, there were 274 claims to the NFIP for damages to businesses within industrial areas, with an average claim of approximately \$288,000 for damages to buildings and \$447,000 for damages to building contents.**

## Hurricane Sandy Impacts

Hurricane Sandy caused significant damage and financial loss for many industrial businesses throughout the city. Most of these losses resulted from damage to building electrical and mechanical systems, flooded commercial truck fleets, submerged machinery and inventory within buildings, and lost revenue while normal operations were ceased or reduced.

In the aftermath of Hurricane Sandy, the NYC Department of Buildings performed an initial assessment of homes and businesses to determine which buildings sustained irreparable damage, requiring a partial or full demolition. Of the 1,130 industrial buildings evaluated during this assessment, only eight were considered irreparably damaged. Sixty-six were tagged as having received non-structural damage, and the remaining 1,056 were designated as having been affected by the storm, but receiving little evident damage. Although these post-storm assessments likely did not capture every industrial facility, they do suggest that relatively few industrial buildings were structurally damaged during Hurricane Sandy. A review of building permit data following Hurricane Sandy indicates that few permits were filed to repair industrial buildings. Of the 848 buildings permits classified as a substantial improvement in the floodplain, only five were industrial buildings located in M districts. A substantial improvement occurs when the cost of any repair, reconstruction, addition or improvement to a structure equals or exceeds 50 percent of the structure's market value.

Despite the low number of industrial buildings tagged by DOB as having received significant damage and the limited number of substantially improved industrial buildings, there were significant losses. Following Hurricane Sandy, there were 274 claims to the **National Flood Insurance Program (NFIP)** for damages to nonresidential buildings within industrial areas, with an average claim of approximately \$288,000 for damages to buildings and \$447,000 for damages to building contents. Notably, because NFIP caps coverage for commercial properties

at \$500,000 for both buildings and contents, the actual average losses from businesses likely exceeded these values. Additionally, a large portion of industrial businesses that were damaged by Hurricane Sandy were uninsured or held flood coverage through a private insurance or reinsurance carrier and are not captured by these claims.

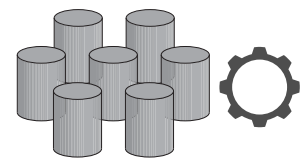
In the aftermath of Hurricane Sandy, the NYC Department of Environmental Protection (DEP) conducted inspections of facilities that store hazardous substances to identify and remediate chemical spills caused by the storm. Of the 367 firms initially identified in the flood zone, 48 facilities reported being severely affected, but reported no spills. Eleven facilities reported spills but were cleaned prior to DEP inspection, and seven facilities were completely washed out. A subsequent analysis identified an additional 650 facilities located within the floodplain, though the majority of these claimed that Hurricane Sandy had no impact on stored chemicals.<sup>3</sup> In addition, the New York State Department of Environmental Conservation maintains a Spill Database to document hazardous substance spills and leaks. Citywide, approximately 1,620 spills were attributed to Hurricane Sandy, primarily linked to motor fuel and oil tanks for heating supply, many of which occurred in residential buildings.<sup>4</sup>

**NFIP (National Flood Insurance Program) is a federal program that makes flood insurance available to property owners in municipalities that enforce floodplain management regulations.**

**NFIP nonresidential insurance policies have low coverage limits**



**ONLY \$500,000 FOR BUILDINGS**



**ONLY \$500,000 FOR CONTENTS**





**Repairing damage at a flooded dry cleaning facility following Hurricane Sandy.**

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## **New York City's Response to Hurricane Sandy**

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Hurricane Sandy drew a rapid response from fire, medical, police, and other emergency service crews who were dispatched across storm-impacted areas throughout the city. In addition to the emergency response, a variety of financial assistance programs were established to aid businesses in the recovery process. City agencies distributed \$28 million in up to \$25,000 low-interest loans and up to \$10,000 matching grants to nearly 650 businesses. More than \$1 million in micro-grants were also issued to more than 200 businesses. These emergency funds from private and public sources assisted businesses with working capital, damage repairs, and equipment and inventory replacement, among other things. To assist businesses with purchases of materials, equipment and personal property needed to rebuild after the storm, the NYC Industrial Development Agency provided more than \$2.8 million in sales tax exemptions. Additionally,

the City launched programs addressing storefront improvements, general business recovery services, and agency fee relief for impacted businesses.

In August 2013, the NYC Department of Small Business Services (SBS) launched the Hurricane Sandy Business Loan and Grant Program to assist small businesses with remaining unmet recovery need. The program has awarded approximately \$55.7 million to 352 business across New York City along three distinct award categories: working capital, inventory, and movable equipment. The most significant concentrations of grant and loan recipients were in Rockaway Beach, Sheepshead Bay, Coney Island, Lower Manhattan, Red Hook, and the East Shore of Staten Island. In November 2015, SBS introduced the Business Preparedness and Resiliency Program (Business PREP) to help small businesses better prepare for emergencies. Assistance includes business continuity workshops, on-site risk assessments with micro-grants to implement specific recommendations, and online resiliency resources.

## Climate change is expected to increase flood risk substantially in the coming decades.

## Climate Change and Extreme Weather

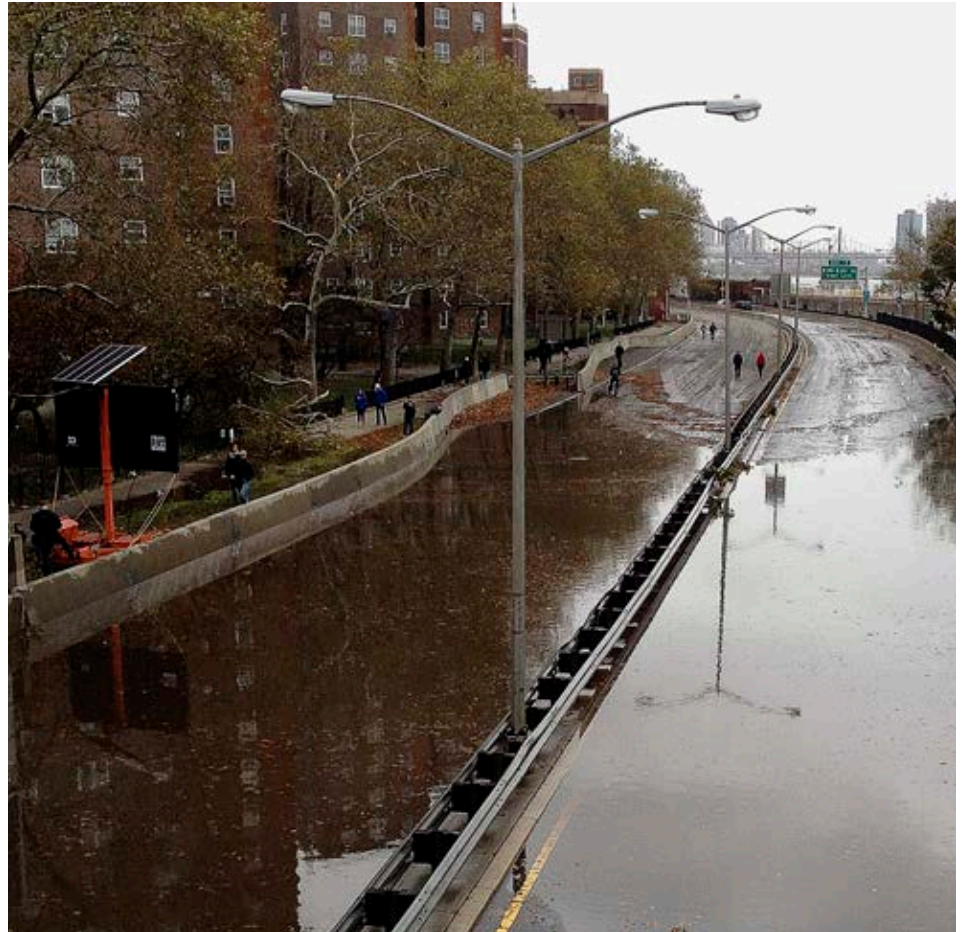
Hurricane Sandy reminded many New Yorkers of the risks that our diverse waterfront communities face from coastal storms and flooding. While these hazards are by no means new, climate change is altering the intensity and frequency of flooding events, and is expected to increase flood risk substantially in the coming decades.

The New York City Panel on Climate Change projects that by 2080 the average annual precipitation will increase between 5 and 13 percent. In addition to changes in rainfall averages, there will likely be more variability in heavy rainfall, leading to approximately one and a half times more extreme precipitation days per year by the 2080s compared to the current climate.<sup>5</sup> During this same time period, sea level is projected to increase 18 to 39 inches, and could reach as high as six feet by 2100. Even without any changes in storms themselves, projected sea level rise would at least double the frequency of current 100-year coastal floods by the 2080s and,

according to the higher-end estimates of sea level rise, could lead to a 10- to 15- fold increase in floods of this magnitude.

Hurricane Sandy is fresh on the minds of many New Yorkers, yet floods are not the only hazard that residents and businesses should plan and prepare for. For example, the frequency of heat waves is projected to triple by the 2080s, resulting in tremendous public health risks and potential power outages and equipment failures. Although this report focuses on flooding and coastal storms, industrial businesses should employ a similar process to evaluate their vulnerability to other likely hazards and implement strategies to prepare their facilities, protect their workers, and maintain operations. New York City Emergency Management prepared [NYC's Risk Landscape: A Guide to Hazard Mitigation](#) to outline key vulnerabilities and present strategies for managing these risks citywide.

**Flooding caused by Hurricane Sandy on FDR Drive in Manhattan.**







Newtown Creek,  
Greenpoint, Brooklyn

# 2

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## Planning Context and Recent Initiatives

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New York City's population has steadily increased in recent years, exceeding 8.5 million residents in 2016 for the first time in the city's history. The post-recession economy has also been expanding rapidly, with a staggering 600,000 private sector jobs added between 2010 and 2016.<sup>7</sup> Economic growth citywide is supported in many ways by industrial areas that contain private enterprise that facilitates the movement of goods and much of the critical infrastructure on which the city depends. To sustain this overall economic growth, the city has advanced a number of planning initiatives to support vibrant and healthy industrial activities. At the same time, a recognition of the vulnerabilities of much of the city to flooding, coastal storms, and climate change has led the City to embrace resiliency planning and promote strategies to reduce risk through several initiatives. The following chapter summarizes key planning efforts and programs that enhance the ability for industrial businesses in the floodplain to reduce disruptions.





## PlaNYC

The 2007 release of “**PlaNYC: A Greener, Greater New York**,” established the City’s first sustainability strategy and became a model for other large global cities. In addition to programs aimed at reducing greenhouse gas emissions, the initiative strengthened the City’s commitment to addressing aging infrastructure, launching brownfield cleanups, and improving air and water quality. The 2013 update following Hurricane Sandy, “**PlaNYC: A Stronger, More Resilient New York**,” laid out a strategy for the city to build back in the aftermath of Hurricane Sandy and adapt to projected climate change impacts, including rising sea levels and extreme weather events. The nearly \$20 billion plan described in the PlaNYC report included more than 250 initiatives ranging from major coastal defense infrastructure to a more resilient food wholesale and distribution network. Many of these resiliency or recovery projects are either completed or underway, and will help avoid or minimize damage from future storms.

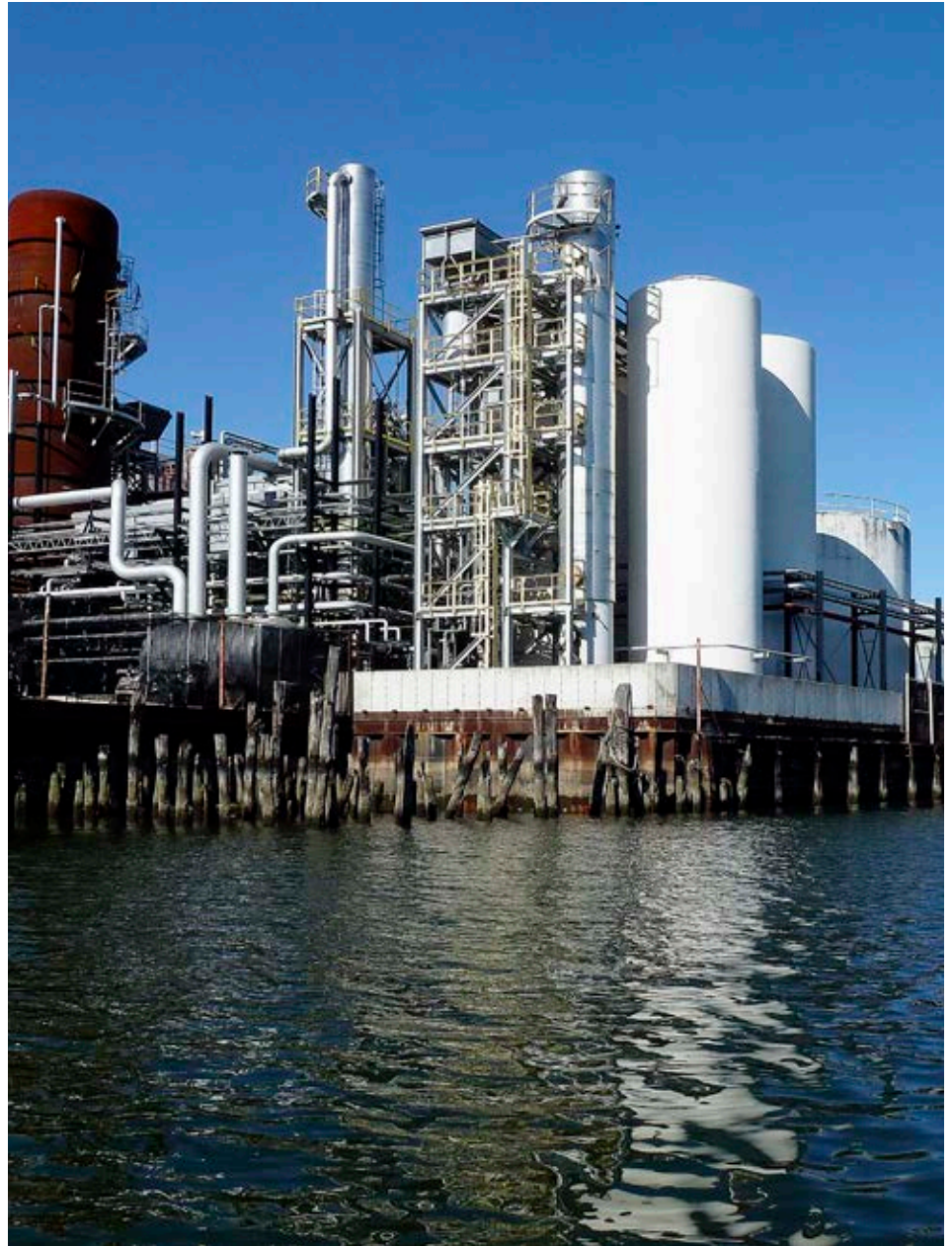
## OneNYC

The 2015 launch of “**One New York: The Plan for a Strong and Just City**,” established an approach to managing climate change while also addressing income inequality. Notably, the plan calls for investments in city-owned industrial assets, workforce development programs targeted at high-growth industries, and a reduction of regulatory burdens on small businesses. Sustainability initiatives include efforts to reduce waste while expanding recycling and composting, accelerate cleanup of brownfield sites, and further implement green infrastructure and smart design for stormwater management. A number of resiliency strategies are also documented in the plan, including improved emergency preparedness and investments in building resiliency, and efforts to work with FEMA to reform the National Flood Insurance Program. The efforts of the Resilient Industry study directly further the goals of OneNYC by supporting industrial jobs through measures to maintain the long-term viability of industrial businesses in areas of the city at risk of flooding.

**RISE : NYC is a OneNYC initiative to help deploy innovate resiliency technologies at Sandy-impacted businesses. Solatube Daylighting Systems deliver natural light into dark interior spaces, reducing energy demand, and in the event of a power outage, providing a daytime light source that conserves backup generator power for critical uses.**



Petrochemical facility with barge and pipeline access in Greenpoint, Brooklyn.



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## NYC Hazard Mitigation Plan

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With the goal of reducing long-term risk to human life, property, and infrastructure from hazards, New York City developed and regularly updates the [Hazard Mitigation Plan](#). The most recent plan, released in April 2014, addresses the risk assessment of coastal erosion, coastal storms, disease outbreaks, drought, earthquakes, extreme temperatures, flooding, severe weather, wildfire, winter

storms, infrastructure failure, hazardous materials, and chemical, biological, radiological, nuclear, and cyber threats. The Hazard Mitigation Plan evaluates risks that the city faces and proposes actions to lessen the impact from likely or consequential hazards. These actions, to be carried out by more than 40 agencies, non-profits, and utility providers, include disaster prevention, property protection, coastal and natural resource protection, emergency services, education and awareness, and infrastructure projects.



**Nearly 89 percent of industrially zoned land lies within the Coastal Zone, making the WRP an important tool in setting a direction for development within the industrial floodplain.**

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## **Waterfront Revitalization Program**

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The Waterfront Revitalization Program (WRP) is the city's principal coastal zone management tool, establishing the policies for development and use of the waterfront. Nearly 89 percent of the city's industrially zoned land lies within the Coastal Zone, making the WRP an important tool in setting a direction for development within the majority of the industrial floodplain.

When a proposed project is located within the Coastal Zone and requires a local, state, or federal discretionary action, a determination of the project's consistency with the policies and intent of the WRP must be made before the project can move forward. Among the WRP policies is a standard to "minimize loss of life, structure, infrastructure, and natural resources caused by flooding and erosion, and increase resilience to future conditions created by climate change." This policy is intended to identify risks posed by coastal hazards, including the impacts of climate change, and drive the city and businesses to explore adaptive measures to manage these risks. It also requires that the latest projections of climate change and sea level rise are integrated into the planning and design of projects in the city's Coastal Zone.

WRP provides an important opportunity to ensure that adaptive techniques are considered on a case-by-case basis. WRP consistency review can help ensure that critical facilities and infrastructure are adequately protected from flooding and the impacts of climate change by promoting standards, such as higher design elevations or more stringent flood protection, that exceed those established in current building codes.

In addition, the WRP also states an objective to "support water-dependent and industrial uses in NYC's coastal areas that are well-suited to their continued operation." Within this policy, the WRP designates seven Significant Maritime and Industrial Areas (SMIAs), which have high concentrations of water-dependent and industrial activity and are generally well-suited to these activities.

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## **Resiliency Planning and the Department of City Planning**

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The NYC Department of City Planning has undertaken a number of planning studies that highlight the scale of flood mitigation challenges and opportunities to encourage flood resiliency. The **Resilient Neighborhoods** initiative is working with communities to identify local zoning and land use strategies that reduce risks from flooding and coastal storms, while also fostering adaptable and vibrant communities. In July 2016, the Department of City Planning released the **Resilient Retail** report, identifying land use recommendations and proposed policy changes to facilitate building and corridor-wide strategies to increase the resiliency of commercial corridors in the floodplain. The focus on resiliency opportunities for nonresidential properties explored in the study provides an important foundation for the *Resilient Industry* study. Among the recommendations described in the *Resilient Retail* study is the need for greater flexibility to incorporate partial mitigation options for existing retail businesses in the floodplain.

The **Retrofitting Buildings for Flood Risk** manual, published in October 2014, provides a detailed analysis of how New York City's diverse building typologies are impacted by federal floodplain construction requirements and offers guidance to property owners on how to approach decisions about retrofitting buildings. The manual also advocates for regulatory reforms to facilitate mitigation. While some of these strategies apply to nonresidential buildings, the *Resilient Industry* study builds on this research to consider physical mitigation unique to the city's industrial building stock and operational preparedness tailored to industrial businesses.

Drawn together, these initiatives provide a framework for steering New York City toward a coordinated resiliency strategy that engages communities, advances land use policies, and builds off of other local, state and federal initiatives aimed at safeguarding where we live, work and experience the city.



Commercial vehicles parked along Newtown Creek in Long Island City, Queens.

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## Open Industrial Uses

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In 2014, the NYC Department of City Planning released for public comment a draft study of best management practices and pollution prevention controls for unenclosed industrial facilities. Open industrial uses perform a critical, but often overlooked, role in the city's economy. These facilities include activities that, unless managed properly, can have negative environmental and quality of life impacts for adjacent uses. The study developed potential strategies to improve standards in manufacturing zones, enhance economic development, create safer and cleaner environments, and safeguard facilities in the floodplain.

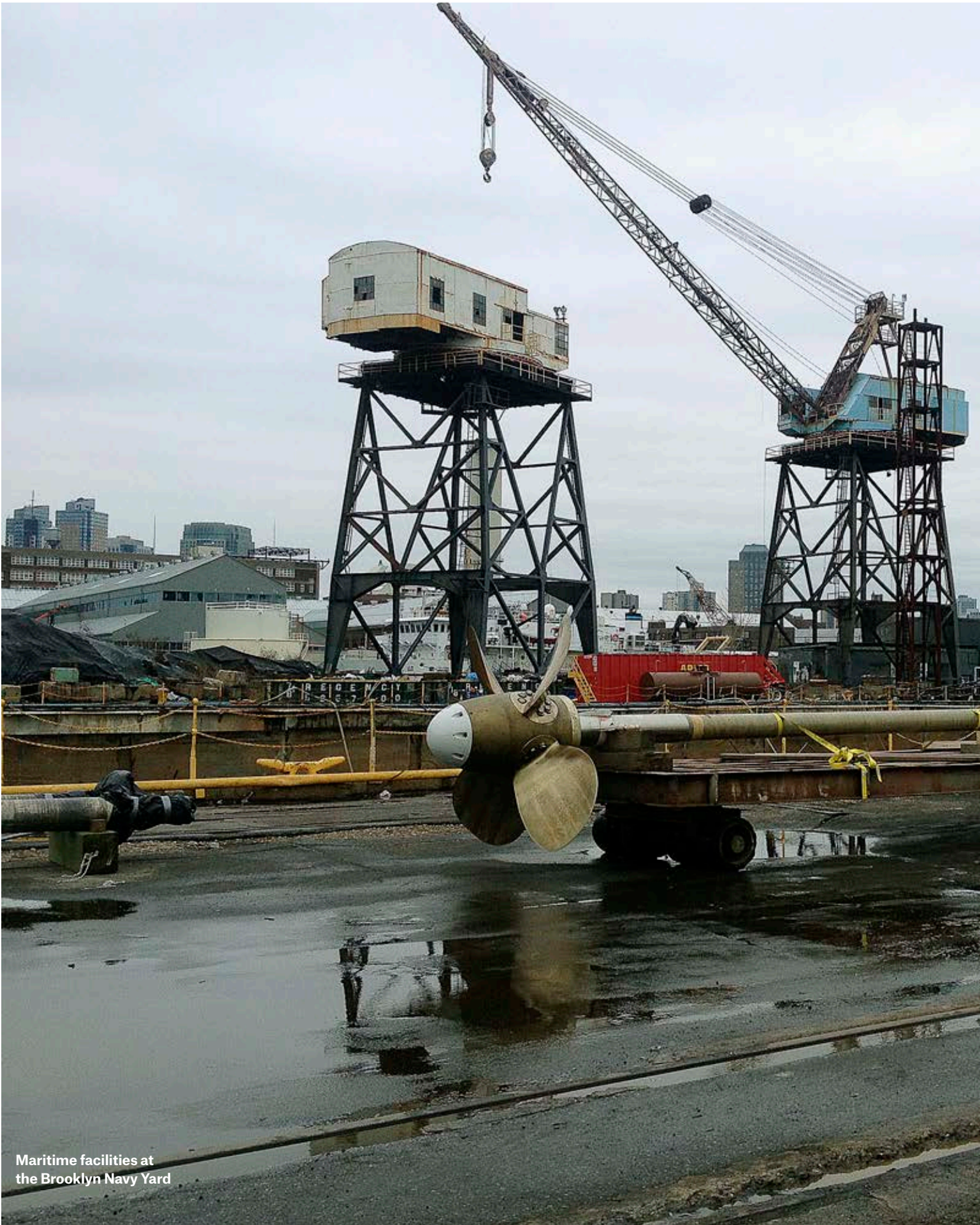
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## Industrial Action Plan

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The "[10-Point Industrial Action Plan](#)," released by Mayor de Blasio's administration in November 2015, is designed to support and grow the industrial sector by strengthening core industrial areas, investing in long-term development of industrial businesses, and preparing New Yorkers for industrial jobs of the future. Because the majority of the city's core industrial areas are located in the floodplain, resiliency investments are an important component of efforts to support, strengthen, and grow the industrial sector.





Maritime facilities at the Brooklyn Navy Yard





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## Supporting Businesses through Preparedness and Mitigation

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Several voluntary programs are available to help industrial businesses in New York City prepare for disruptions. These programs help businesses minimize the time to restore operations and reduce the possibility of damage in the event of flooding or other interruptions.

**Partners in Preparedness** is a free program offered by NYC Emergency Management that helps organizations prepare employees, services, and facilities for emergencies. The program provides businesses with real-time emergency alerts in advance of storms or other potential hazards. It also makes available on an ongoing basis information and resources about disaster preparedness through tabletop exercises, webinars, and other events. Businesses of all sizes and industries can enroll in Partners in Preparedness

The **Corporate Emergency Access System** (CEAS) authorizes essential employees to access restricted areas following an emergency, and is the only program recognized by the New York Police Department and NYC Emergency Management that allows for emergency access. CEAS-credentials can help businesses limit financial losses, retain customers, and restore normal operations more quickly. For example, CEAS may enable businesses to shut down technology systems or retrieve critical equipment and vital records.

**Business Preparedness and Resiliency Program** (Business PREP) offered by the NYC Department of Small Business Services is designed to help small businesses better prepare for emergencies. Business PREP provides a range of services, including business continuity workshops, on-site risk assessments with micro-grants to implement specific recommendations for qualifying businesses, and online resiliency resources.





# 3

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## **Regulatory Environment Influencing Industrial Resiliency**

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Government regulations and programs related to floodplain management, building construction, land use, flood insurance, and the storage of hazardous materials are important drivers of industrial resiliency. This chapter describes key city, state, and federal regulatory programs that require, encourage, or constrain actions by private industry to reduce flood risk in New York City.





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## Floodplain Regulations

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Floodplain regulation in New York City is tied to Flood Insurance Rate Maps and flood resistant construction standards developed by the Federal Emergency Management Agency (FEMA) and incorporated into the NYC Building Code.

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## Flood Insurance Rate Maps

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FEMA's Flood Insurance Rate Maps (FIRMs) are the official flood maps referenced in New York City's Building Code and Zoning Resolution. They are also used to set flood insurance premiums under the National Flood Insurance Program. Floodplains shown on FIRMs are classified according to levels of risk, with each zone indicating the severity or type of flooding.

Properties located in the V Zone, Coastal A Zone, or A Zone are in the 1 percent annual chance floodplain and are considered at high risk of flooding. The X Zone represents the 0.2 percent annual chance floodplain, areas that are considered to be at moderate risk of flooding and may also benefit from strategies that enhance flood resiliency. The FIRMs also convey the projected flood elevation of the 1 percent annual chance storm at most locations, known as the Base Flood Elevation.

New York City adopted its first FIRMs and floodplain regulations in 1983. Because many buildings predate these original FIRMs, floodplain regulations and NYC Building Code requirements distinguish between pre-FIRM buildings constructed before official flood maps were created, and post-FIRM buildings constructed after the City adopted these flood maps.

**The average construction year of industrial buildings in the 1 percent annual chance floodplain is 1946, and 87 percent are pre-FIRM buildings.**

**Flooding of industrial facilities during Hurricane Sandy in Maspeth, Queens.**

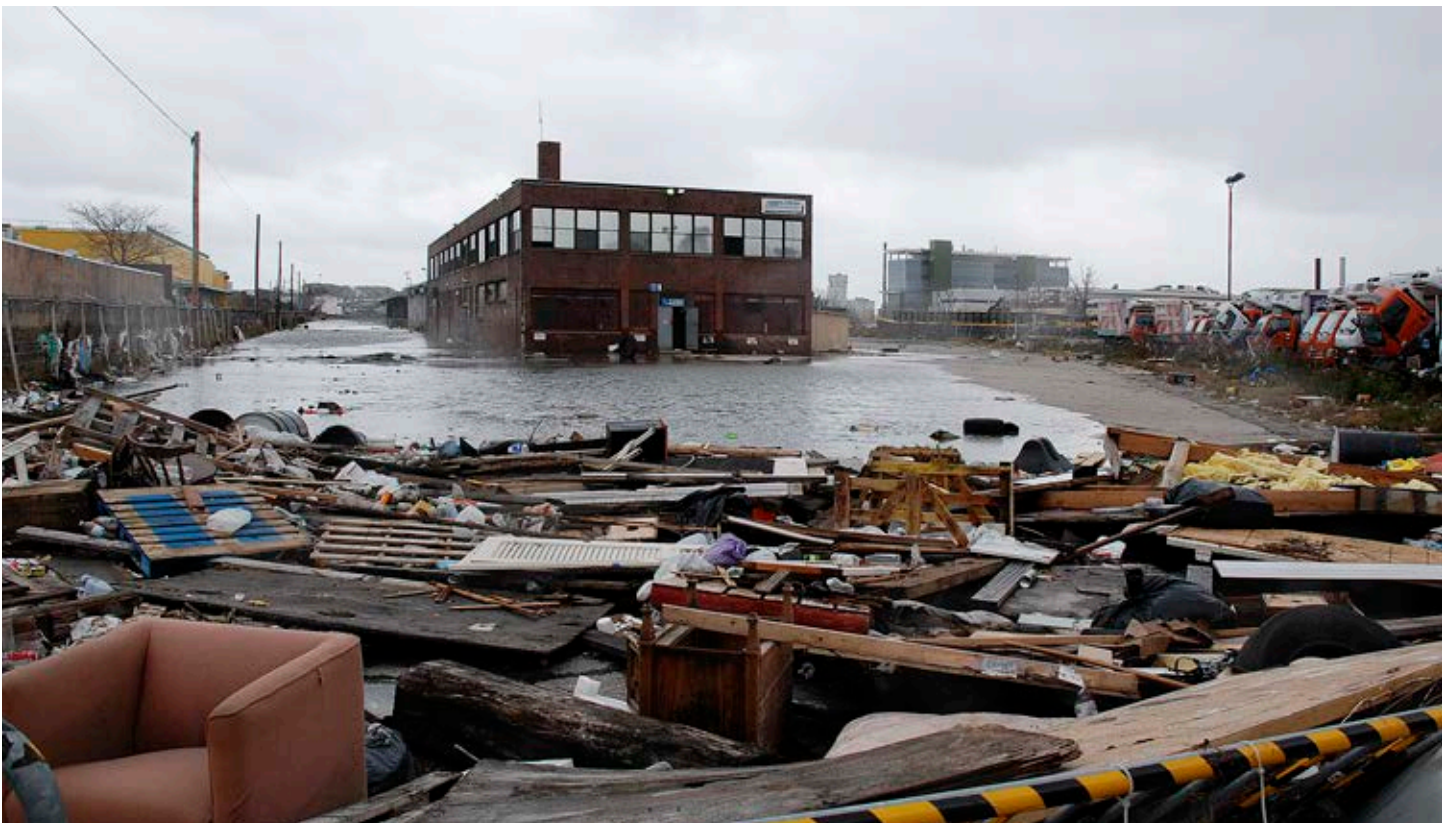
## **Flood-Resistant Construction Standards**

Design and construction of new buildings and major alterations in the floodplain are regulated in large part by FEMA, which establishes FIRMs and references the American Society of Civil Engineers (ASCE 24) as a minimum standard for floodplain construction. The NYC Department of Buildings is designated as the Floodplain Administrator and is tasked with enforcing Appendix G of the NYC Building Code, the section that prescribes standards for construction in the floodplain. Appendix G applies to post-FIRM buildings—those completed on or after the City adopted its first floodplain regulations—November 13, 1983. Appendix G also applies to pre-FIRM buildings where the footprint is being increased or where alterations to the building increase the degree of noncompliance with regard to flood-resiliency.

The flood-resistant construction standards in Appendix G also apply to structures that undergo Substantial Improvements, meaning that the cost of rehabilitation, addition, or improvement to a building equals or exceeds 50 percent of its

market value before the improvement starts. Similarly, repairs to structures that experience Substantial Damage, where the cost of restoring the structure to its pre-storm condition would equal or exceed 50 percent of the market value of the structure before the damage occurred, must also comply with Appendix G. If the building falls within either of these definitions it must be brought to current flood-resistant construction standards, in addition to other NYC Building Code requirements.

In reality, many industrial buildings in the city are not required to comply with requirements set forth in Appendix G. The majority of industrial buildings are existing pre-FIRM buildings, and where alterations or repairs do not trigger Appendix G applicability, such as Substantial Damage or Substantial Improvements, compliance with current flood-resistant construction standards is not required. The average construction year of industrial buildings in the 1 percent annual chance floodplain is 1946, and 87 percent are pre-FIRM buildings. For this reason, many industrial facilities continue to operate in facilities that are less flood-resilient than current NYC Building Code standards require for new construction.





## Efforts should be made to create consistent design standards for flood resiliency across local, state, and federal programs.

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### Freeboard Requirements

To ensure that buildings are sufficiently resilient with regard to expected flooding, Appendix G requires developments to provide an additional margin of safety above the FEMA-designated BFE. This additional margin of safety is known as “freeboard,” and varies depending on which flood zone the property is in, as well as the use of the building. For example, some industrial businesses that are considered critical facilities, such as bulk petroleum distribution, that are located in the A Zone have a freeboard requirement of two feet above the BFE, while other non-critical industrial uses may only have a freeboard requirement of one foot above the BFE.

The elevation of the BFE plus freeboard is called the Design Flood Elevation (DFE). As of 2017, these standards apply to the floodplain shown on FEMA’s Preliminary FIRMs or the 2007 Effective FIRMs, whichever of the two is more restrictive. To determine the freeboard requirement for a specific industrial use, consult Appendix G of the NYC Building Code.

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### State Freeboard Standards

New York State is in the process of developing guidance on flood risk management as it implements the Community Risk and Resiliency Act (CRRA) with the goal of ensuring that state funding and permits include consideration of the effects of climate risks and extreme-weather events. At present, the design standards are not entirely consistent among local, state, and federal frameworks. For example, after the CRRA is implemented, critical infrastructure in the A Zone that receives state funding may need to include three feet of freeboard or take into account climate change, while the same project without state funding may only need to include one or two feet of freeboard to comply with the NYC Building Code. Efforts should be made to create consistent design standards for flood resiliency across local, state, and federal programs.

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### Fully Compliant Mitigation Strategies

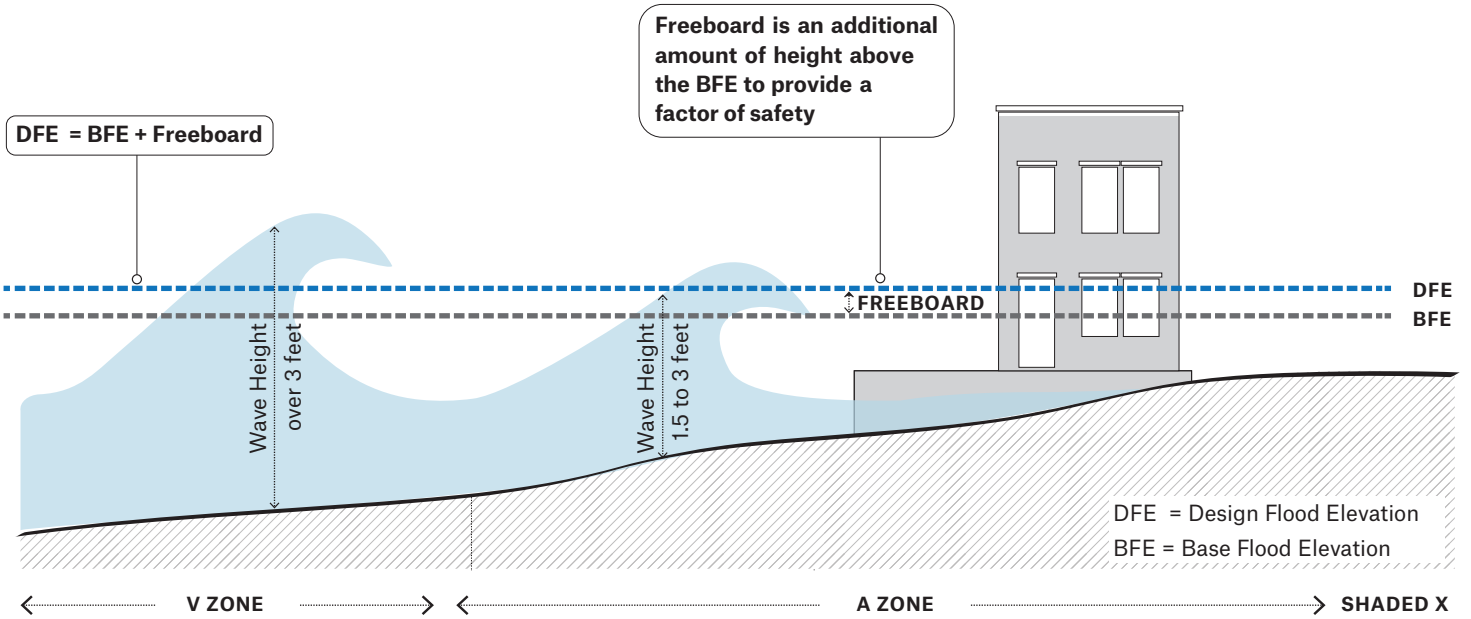
To be fully compliant with Appendix G, nonresidential structures in the 1 percent annual chance floodplain can pursue one of two options:

1. Elevate the lowest floor to the DFE or higher, with limited wet floodproofed spaces permitted below.
2. Dry floodproof to the DFE or higher.

Nonresidential buildings that are not Substantially Damaged or Substantially Improved are not required to meet NFIP and Appendix G requirements as long as changes to the building do not increase the degree of noncompliance. However, an owner and operator may voluntarily choose to take steps to reduce the building’s vulnerability to flooding to lower risk to the business, enable the building to be reoccupied more quickly in the aftermath of a storm, and in some cases reduce flood insurance premiums.

All new nonresidential development in the 1 percent annual chance floodplain is required to comply with Appendix G of the NYC Building Code, by dry floodproofing to a height equal to or exceeding the DFE. If the building is elevated, the area below the DFE can be used only for parking, building access or minor storage. If dry floodproofing is used to comply with Appendix G, the lowest occupiable floor may be located below the DFE and any nonresidential use is permitted in the dry floodproofed area below the DFE.

Within the V Zone, the 1 percent annual chance floodplain where wave heights are likely to exceed three feet, dry floodproofing is not permitted as an Appendix G compliant strategy for any structures. Buildings in Coastal A Zones, where expected waves heights during flood events are between 1.5 and 3 feet, are likely to have similar requirements to V Zones. However, Coastal A Zones have not yet been incorporated into the final FIRMs for New York City.



**ELEVATE**

Open Structure  
Eg. Open Lattice

**GROUND FLOOR CONFIGURATION**

Open Structure

Bottom of lowest structural member to be at or above Design Flood Elevation

**WET FLOODPROOF**

Water to run in/run out  
Eg. Flood Vents

1 inch of net open area per 1 sq.ft of enclosed area

Lowest occupiable floor  
To be at or above Design Flood Elevation. (Not permitted for non-residential buildings that are substantially damaged/improved)

**DRY FLOODPROOF**

Watertight Structure  
Eg. Flood Shields

Flood shields prevent water from entering

Lowest occupiable floor  
Allowed to be excavated below grade. (Not permitted for residential buildings)

- PERMITTED USES BELOW THE DFE**
- Parking
  - Access
  - Storage
  - Non-Residential
  - Residential

- Parking
- Access
- Storage
- Non-Residential
- Residential

- Parking
- Access
- Storage
- Non-Residential
- Residential





**Example of a large industrial building in Gowanus, Brooklyn where structural elevation would be impractical and exorbitantly costly.**

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## **Challenges to NFIP Compliance for Industrial Buildings**

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Elevating industrial buildings can be accomplished by either lifting the existing structure or by relocating the lowest floor above the DFE if the floor-to-ceiling clearance is sufficient. When elevating a building, areas below the DFE can be left open, or they can be wet floodproofed and used only for parking, building access, crawl space, or minor storage. Equipment, utility connections, and all interior utility systems including ductwork must also be relocated above the DFE.

Within New York City, there are many practical, economic, and structural challenges associated with elevating industrial buildings, particularly for retrofits of existing buildings. Because

many industrial buildings have large footprints and are designed to accommodate heavy loads, elevating the entire structure is often prohibitively costly. Where businesses occupy space in attached buildings with shared walls, elevation typically requires coordination with and disruption to adjacent businesses, creating an additional barrier for individual property owners wishing to retrofit.

Efficient access for truck loading is an essential component of many industrial spaces, and elevation may require a reconfiguration of loading docks. Where elevations are very high, truck-dependent businesses may experience reduced operational efficiency from having active spaces located far above grade, or be required to invest in lifts or conveyor systems to overcome these barriers.

## **Businesses with shared walls would also need to ensure that interior walls are watertight and reinforced should the adjacent business flood.**

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### **Non-Structural Elevation**

An alternative to structural elevation of buildings is the relocation of active uses above the DFE rather than physically lifting the superstructure to an appropriate elevation. Non-structural elevation in industrial buildings can be achieved by filling below grade space, such as existing basements or cellars, and abandoning the remaining occupiable floor(s) below the DFE. If this strategy is taken, all enclosed spaces below the DFE must be wet floodproofed and remain only as space for vehicular parking, building access, crawl space, and minor storage.

The tendency for industrial buildings to have high floor-to-ceiling heights makes non-structural elevation a viable option for some businesses. This is especially true for buildings with a low DFE, where access to loading docks and the street would not be significantly impacted by raising the level of the floor.

Industrial property owners that elevate-in-place must ensure that the superstructure and the foundation are able to adequately withstand flood related forces, including the pressure of wave action and flowing flood water (hydrodynamic), as well as the pressure exerted by pooled or standing water (hydrostatic) that are expected during flood events. By wet floodproofing the area below the DFE, flood waters are able to flow in and out of the building, which helps to equally distribute pressure.

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### **Dry Floodproofing**

The other NFIP-compliant resiliency option for industrial buildings is to dry floodproof by constructing or retrofitting building walls and foundations to be impermeable to water. When dry floodproofing a building, the superstructure and the foundation must be able to withstand the hydrodynamic and hydrostatic pressures expected during flood events. Other flood-related debris impacts and drainage considerations must also be taken into account when designing dry floodproofing measures to ensure that the building's load-bearing and structural integrity is maintained throughout a flood event.

Dry floodproofing treatments must ensure that a building remains watertight below the DFE and substantially impermeable to the passage of flood water. According to FEMA, dry floodproofing should not result in the accumulation of more than 4 inches of water depth during a 24-hour period. Additionally, sump pumps are required to be installed to control water seepage. Building material must also be flood resistant and all critical building systems must be designed or situated in such a way as to prevent water from entering during a flood event. FEMA also stresses that dry floodproofing is not a recommended strategy when the Base Flood Elevation exceed three feet or if flooding is expected to persist for more than 12 hours.

Floodproofing, including sealing any commercial uses below the DFE, enables businesses to remain at street level, an important consideration for many businesses that rely on access to trucks or forklifts for loading. However, due to the large perimeter of many industrial buildings, and the reality that many existing industrial buildings need structural reinforcement to effectively dry floodproof, this approach is often prohibitively costly. Additionally, businesses with shared walls would also need to ensure that interior walls are watertight and reinforced should the adjacent business flood. Dry floodproofing requires that basements be filled or protected against water entry.



## Installation of Floodproofing Technologies

Floodproofing technologies require periodic maintenance and, in many cases, require active installation in advance of a storm. Dry floodproofing strategies that are not passive or self-deploying require warning time to activate, install, or deploy. This can include time for evacuating residents and employees, coordinating with building personnel, transporting equipment from off-site storage facilities to the site, as well as time and resources required for the installation of flood panels and staircases for required egress. Some components must have a continuous source of electricity if required to operate during a flood event, including alternate power where primary power cannot be guaranteed. Effective dry floodproofing requires that all critical building systems, including electrical, plumbing, heating and ventilation or air conditioning systems be designed or situated in such a way as to prevent water from entering during flooding. Because waterproof doors require maintenance to remain reliable, some businesses may choose to invest in submarine rated doors in locations where the door is not needed for heavy daily use.

## Partial Mitigation Strategies

In addition to the NFIP-recognized strategies of elevation or dry floodproofing described previously, there are several partial mitigation strategies that business and property owners may implement to reduce damages. For example, elevating electrical systems within an existing building, without simultaneously elevating or dry floodproofing, can be described as partial mitigation. These strategies are described as “partial” because they would help mitigate flood risks for specific systems or portions of a building, but the building would still not meet the current flood-resistant construction standards. For this reason, they generally would not decrease insurance premiums through the NFIP. Despite these regulatory constraints and lack of incentives for partial floodproofing, this strategy can be an attainable, cost-effective, and practical solution for many businesses seeking to reduce flood risk by providing an increased level of protection for their existing buildings and their contents.

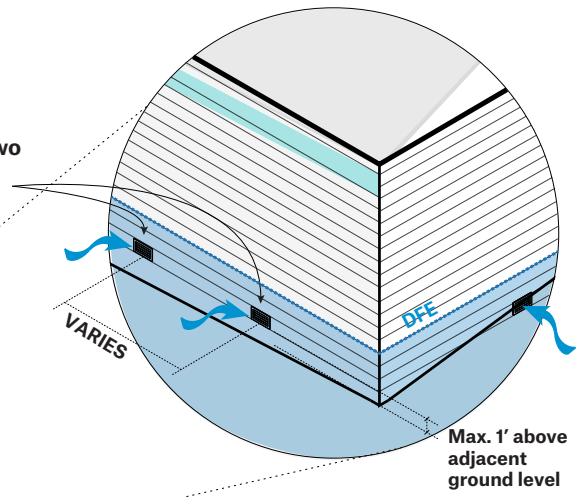
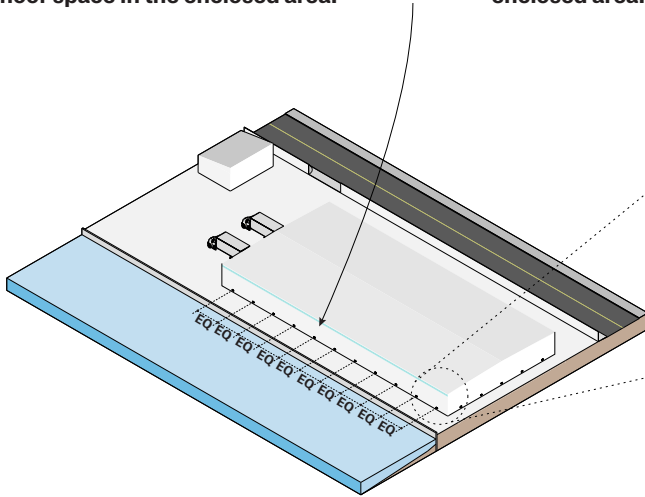
**Generator elevated above the DFE at a maritime facility in Red Hook, Brooklyn.**

DFE



Flood vents provide openings for flood water to enter and exit a building at the same rate as flood waters outside. At least two wall openings on separate walls must be provided for each enclosed area. The total size of openings must be equal to at least 1 square inch for every square foot of floor space in the enclosed area.

NYC Flood-Resistant Construction regulations require a minimum of two openings on different sides of each enclosed area.



### Wet Floodproofing Industrial Space

Wet floodproofing is a technique to prevent or reduce damage from flooding by intentionally allowing water to enter the structure during a storm or flood event. This involves the use of flood-damage resistant materials and installation of flood vents in areas of the building below the DFE. Although the NFIP and Appendix G of the NYC Building Code only allow wet floodproofing for building access, parking or minor storage, existing businesses in nonresidential buildings may choose to pursue this technique in regularly occupied spaces to minimize flood damage with fewer costs and less significant structural modifications.

While cellars and other below-grade spaces may still need to be filled, businesses can remain active on the ground floor by incorporating designs that elevate or seal shut outlets, electrical equipment, and sensitive inventory above the DFE. If the NFIP provided options for wet floodproofed nonresidential space as a means to minimize losses from floods, business owners may have a greater incentive to develop the creative solutions necessary to lower flood risk while maintaining functional industrial operations.

### Protecting Mechanical and Electrical Systems

One of the most significant sources of loss for many industrial businesses during Hurricane Sandy was damage to electrical and mechanical systems, including electrical substations, electrical panels, boilers, heating and air conditioning systems, and mechanical equipment used for industrial production.

If elevation or dry floodproofing options are not feasible, businesses may choose to prioritize flood protection for mechanical and electrical systems, such as enclosing electrical substations in reinforced concrete rooms with waterproof doors, elevating generators on concrete pads or steel platforms, or relocating HVAC systems to higher floors or the roof.

As noted earlier, local floodplain regulations, based on federal codes, require such systems to be elevated to at least the DFE as part of an NFIP-compliant strategy. If businesses do elevate mechanical systems, this action alone will not generally provide flood insurance reductions. Due to the constraints of full NFIP compliance and the benefits of these partial floodproofing strategies that protect core components of the building and business operations, these alternatives should be recognized for partial insurance credit and floodplain compliance.





**Post-Sandy claims suggest that the limit for coverage may be insufficient for many industrial businesses and that efforts to reduce content damage may be particularly valuable in reducing overall losses.**

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## **National Flood Insurance Program**

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The NFIP is intended to reduce the consequences of flooding by providing insurance to property owners and by encouraging communities to adopt and enforce floodplain management regulations to prevent losses. Flood insurance has the potential to be an important driver of resiliency, both as a way of minimizing long-term financial impacts for businesses and, if structured properly, as a way to create incentives to spur resilient construction and retrofits.

According to NFIP Damage Claim Data provided by FEMA in 2015, nonresidential NFIP policy holders, which include industrial businesses, were heavily impacted by Hurricane Sandy, with nearly \$215 million in reported building damage and \$60 million in content losses. Citywide, nonresidential building and content damage was compensated at a lower rate by NFIP than residential properties, suggesting that the federal flood insurance program is less equipped to meet the needs of many industrial and commercial businesses.

Nonresidential NFIP policies, which include industrial businesses, limit coverage to \$500,000 for structural damage to the building and \$500,000 for damage to contents. Notably, business tenants who rent space are only able to purchase content coverage. Businesses in manufacturing districts with active NFIP policies prior to Hurricane Sandy generally had building coverage up to the limit of \$500,000, and claims were generally below this limit. In contrast, content coverage for nonresidential property in industrial areas tended to be purchased below the \$500,000 limit, with an average of \$288,000. However, claims for contents were much more variable and in many cases exceeded the \$500,000 limit. These post-Sandy claims suggest that the limit for coverage may be insufficient for many industrial businesses and efforts to reduce content damage are particularly valuable in reducing overall losses.

Some industrial businesses are able to self-insure by setting aside funds that may be used during floods or other disruptions. In some instances, larger companies may choose to purchase flood insurance from private insurance or reinsurance markets. However, private insurance policies are typically available only to companies with significant assets, and generally have deductibles of \$500,000.

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## Zoning

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Zoning is the City's primary mechanism to regulate the bulk, use, and location of development. Zoning influences the subtle variations in building size and shape that help define a neighborhood's character and allows for the development of compatible uses alongside one another.

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### Zoning and Industrial Policy

The city is divided into three basic zoning districts: residential (R), commercial (C), and manufacturing (M). Manufacturing districts allow for a range of industrial activities important to New York City's economy—from warehouse and distribution centers, construction yards, and manufacturing businesses to film production studios, ferry and ship terminals, and essential municipal facilities like sewage treatment plants, train yards, and sanitation garages. In addition to these traditional and emerging industrial uses, manufacturing districts allow many commercial uses and, with some limitations, certain community facilities, such as ambulatory health care and houses of worship.

Industrial uses are permitted in the three manufacturing districts—M1, M2, and M3—according to the characteristics of their operations. Performance standards are tied to each district, limiting the

amount and type of industrial nuisances permitted within each district. Light manufacturing uses are permitted in all manufacturing districts, and uses that have the potential to be more noxious are generally limited to M3 districts, but may also locate in M1 and M2 districts if they comply with the higher performance standards of those districts.

The NYC Zoning Resolution separates industrial and residential areas to insulate residential communities from adverse impacts of industrial activities, such as noise or dust. Although new residences are not permitted in manufacturing districts, many existing residences remain in predominantly industrial areas because of historic land use patterns that predate the Zoning Resolution.

Consistent with the historical development of the city's industrial economy along the waterfront, zoning has codified many waterfront areas as manufacturing districts. Maintaining a thriving industrial sector in these waterfront areas requires zoning provisions that allow for innovative solutions to protect industrial operations against flood risk. Given the high proportion of existing, pre-FIRM industrial buildings in these areas and growing flood risks associated with climate change, zoning should not constrain, and where possible, encourage retrofits that reduce flood risk and strengthen the long-term viability of the city's industrial sector.

**M1-2 zoning district  
in Greenpoint,  
Brooklyn.**





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## Flood Resilience Zoning Text Amendment

As a means to facilitate more resilient development and reconstruction in the 1 percent annual chance floodplain following Hurricane Sandy, the NYC Department of City Planning adopted a zoning text amendment to address flood resilience in October 2013, codified in Article VI, Chapter 4 of the Zoning Resolution: Special Regulations Applying in Flood Hazard Areas. The zoning text amendment was designed to encourage flood-resilient construction throughout designated floodplains by removing regulatory barriers that hinder or prevent the reconstruction of storm-damaged properties. It also enables new and existing buildings to comply with new, higher flood elevations issued by FEMA, and to comply with new requirements in the NYC Building Code.

The Special Regulations Applying in Flood Hazard Areas text amendment was an emergency action to enable construction based on the best available flood hazard data. The proposed text amendment is scheduled to sunset within one year of the adoption of new, final FIRMs. This provision is designed to ensure that the NYC Department of City Planning pursues a long-term zoning solution based on the officially adopted maps.

The text amendment provides additional flexibility in building height, floor area, and other elements of zoning, and mostly applies to buildings that come into compliance with flood-resistant construction standards, as defined by Appendix G of the NYC Building Code. For example, nonresidential buildings that choose to retrofit and come into compliance with flood-resistant construction standards are able to measure building height from the DFE. Similarly, these provisions allow nonresidential buildings to exempt floor area that is dry floodproofed or used for entryways below the DFE, and provide more flexibility to locate mechanical equipment on the roof of buildings or in rear yards.

For many industrial businesses, the high cost of the necessary improvements to come into full compliance with Appendix G of the NYC Building Code makes it unlikely that many industrial property owners would take advantage of the zoning flexibility designed to encourage retrofits that enhance resiliency. Options that reduce zoning barriers to resilient retrofits, even if the building is not fully compliant with the NYC Building Code, would further encourage flood mitigation within the city's industrial floodplain.

**Construction materials distributor located in the floodplain.**





**Petrochemical facility along Newtown Creek in North Brooklyn.**

## **Hazardous Material in the Floodplain**

Many industrial processes pose hazards to public safety or environmental quality. Of the estimated 1,700 industrial businesses located in the city's 1 percent annual chance floodplain, many are in sectors that regularly store and use hazardous substances, such as auto repair, metal fabrication, waste management, and telecommunications. In addition to the inherent risks from stillwater flooding, the industrial businesses located within the V Zone and Coastal A Zone face the added risk of impacts from wave action during storm surge.<sup>8</sup>

## **Community Right-to-Know**

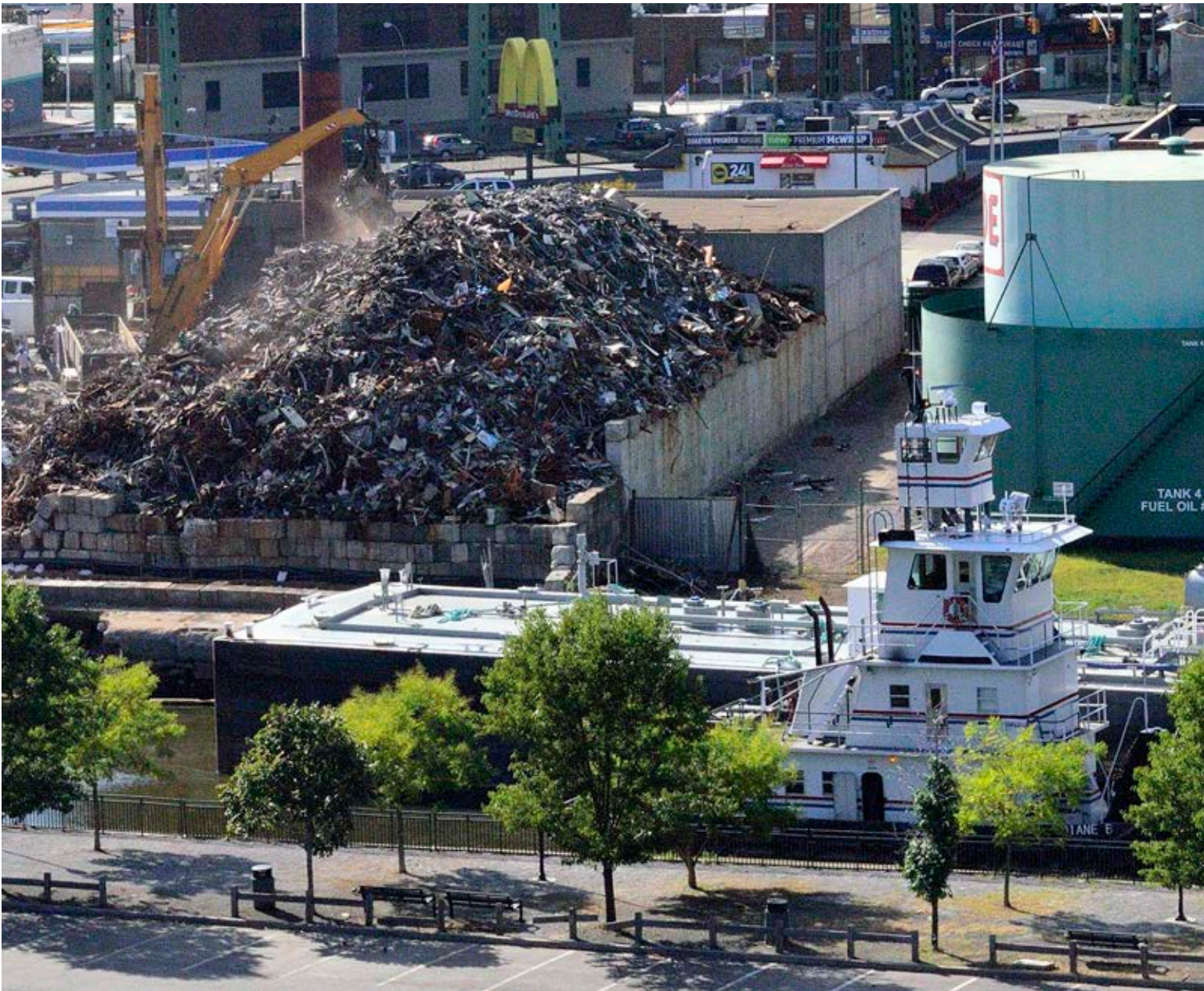
The Community Right-to-Know (RTK) Law requires the City to regulate the storage, use, and handling of hazardous substances. As part of the law, the NYC Department of Environmental Protection (DEP) oversees the use and storage of hazardous substances that pose a threat to public health and the environment in the city. The RTK program requires each business to annually file a report detailing the quantity, location, and chemical nature of every hazardous substances stored within their facility. In addition to maintaining a database of hazardous materials, DEP conducts inspections of facilities that store hazardous substances to ensure compliance under the RTK Law. In Fiscal Year 2016, DEP conducted over 11,000 of these inspections.<sup>9</sup>

Based on reporting of damage and spills following Hurricane Sandy, approximately 11 percent of all facilities within the RTK database were affected by the storm, and 18 facilities reported spills caused by Hurricane Sandy. To reduce the potential for future spills, DEP released recommendations in the wake of Hurricane Sandy about chemical safety and spill prevention during flood events.<sup>10</sup> During inspections of facilities located in the floodplain, DEP now recommends that business owners, operators, and managers take precautions to reduce chemical spills.

### **Recommendations for Spill Prevention During Flooding Events**

- Use appropriate storage containers
- Properly label all containers
- Segregate chemicals
- Minimize the amount of chemicals on site
- Properly elevate all materials
- Schedule pick-ups and deliveries appropriately
- Ensure inventory records are current
- Check weather forecasts regularly
- Review and implement emergency procedures if a Risk Management Plan is required for your facility





**The New York City Panel on Climate Change projects that rising sea levels will progressively expand the future 1% annual chance floodplain to include, among other things, an increasing number of industrial businesses.**





**Photo Credit:**  
Steven Pisano<sup>11</sup>

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### **Minimizing Hazardous Material Risks**

The NYC Special Initiative for Rebuilding and Resiliency (SIRR) Report, released in the aftermath of Hurricane Sandy, noted the importance of having facilities that store hazardous materials take into account the FEMA floodplain and identified a range of flood resiliency measures for mitigating flood risk in existing buildings.

The New York City Panel on Climate Change (NPCC) projects that rising sea levels will progressively expand the future 1% annual chance floodplain to include, among other things, increasing numbers of industrial businesses, while flooding

will likely become more frequent in some areas already subject to 100-year flood events.

Following Hurricane Sandy, DEP developed recommendations for the storage of hazardous materials in the floodplain and makes these available to businesses through the Community Right-to-Know Program. The City continues to work with industrial businesses to reduce the likelihood of future hazardous material leaks and spills due to flooding and other impacts of climate change.



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## **Chemical and Petroleum Bulk Storage Program**

The New York State Department of Environmental Conservation (DEC) implements the Chemical Bulk Storage and Petroleum Bulk Storage programs to establish requirements and conduct inspections to ensure safe storage and handling of large quantities of hazardous substances. DEC also implements a number of other programs related to the use and storage of hazardous substances, including Federal Underground Tank Regulations, the Major Oil Storage Facility Program, and the Liquefied Natural Gas Program.

These programs provide important regulations for hazardous substances in the city, and DEC inspection programs are active in the city to reduce the likelihood of spills or leaks. However, many of the industrial businesses in New York City's floodplain are small- and medium-sized establishments that do not meet the threshold to be regulated and inspected by DEC. In these cases, the Community RTK Program plays an important role in providing guidance and standards for the appropriate storage of hazardous materials in the floodplain.





**Petrochemical facility along Newtown Creek in Greenpoint, Brooklyn.**

**Vegetated shoreline along Arthur Kill in Staten Island.**

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## **Brownfield Remediation**

New York City has more than 7,000 properties subject to mandatory environmental study and management, and approximately 40 percent of these may be brownfield sites. Brownfield cleanup and redevelopment offers an important opportunity to more effectively use the existing stock of land in the city while reducing environmental contamination. Because brownfields in New York City and across the country are disproportionately located in low-income communities, brownfield remediation also plays an important role in alleviating social and environmental inequality. Brownfields can contain a wide variety of pollutants, including heavy metals and organic solvents, which remain from the city's legacy of industrial land uses and once lax pollution management practices that predated modern environmental and business standards.

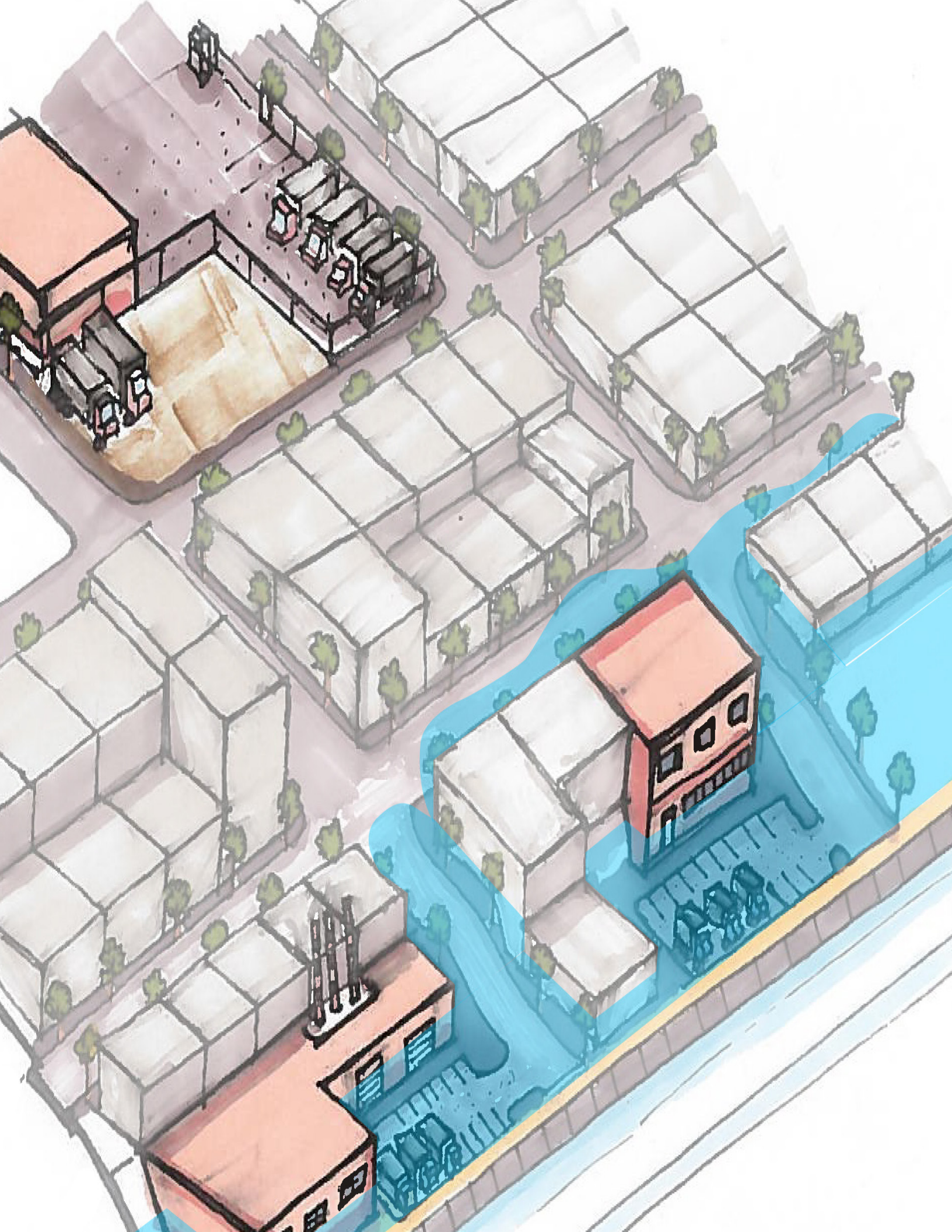
DEC created the Brownfield Opportunity Areas (BOA) program in 2003 to provide municipalities and community-based organizations with assistance, up to 90 percent of the eligible project costs, to complete revitalization plans and implementation strategies for areas or communities affected by the presence of

brownfield sites, and site assessments for strategic brownfield sites.

Building on the state's BOA program, New York City initiated the nation's first municipal brownfield cleanup program in 2007—the NYC Voluntary Cleanup Program. OneNYC expanded the City's commitment to brownfield cleanup, including a goal to clean up 750 properties within four years, broader support of community brownfield planning efforts, and an increased effort to facilitate cleanup of properties in the floodplain to reduce environmental risks from storm surge and erosion.

To accelerate cleanup of flood-prone brownfield areas, new small grants are being offered through the Voluntary Cleanup Program. Additionally, the City has established new regulations to strengthen standards for cleanup of industrial waterfront properties, which are intended to lessen the environmental impact of future storm surge and flooding events on communities in and near the city's industrial floodplain. Finally, the City has established four new community brownfield planning areas in neighborhoods heavily impacted by flooding during Hurricane Sandy.





# 4

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## Industrial Resiliency Case Studies

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New York City's industrial floodplain contains a wide range of businesses, all with unique resiliency challenges and opportunities. The following case studies are based on seven industrial businesses in the city's floodplain, most of which were damaged by Hurricane Sandy. They explore physical and operational strategies that could help reduce damage from future floods. Some case studies demonstrate best practices that have been implemented, while other case studies describe strategies that could be pursued in the future. Although each case study highlights different best practices, many of these resiliency strategies could be used more universally, and may apply across multiple different scenarios. Where strategies have fairly uniform costs across site, cost estimates are included to help businesses evaluate the tradeoffs between mitigation strategies. Ultimately, each business should consider its own physical investments, core business operations, and the risk posed by flooding and other hazards to prioritize the preparedness and mitigation actions that are most suitable to its facility.



# Construction Materials Distributor



## Site Characteristics

<b>Lot size</b>	Approximately 87,000 square feet
<b>Shoreline length</b>	650 feet
<b>Shoreline conditions</b>	Degraded bulkhead
<b>Design Flood Elevation above grade</b>	2-5 feet

## Business Profile

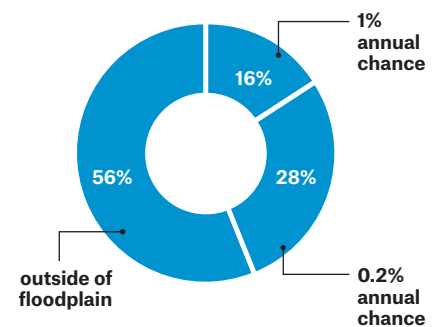
The construction industry is an important component of New York City's economy, accounting for more than 2,400 businesses and approximately 45,000 jobs, according to the Quarterly Census of Employment and Wages (2014). Employment in construction-related companies grew by almost 7 percent between 2010 and 2014 within the city's Manufacturing Districts, as defined through zoning. A healthy construction industry is vital for the maintenance of existing buildings within the city and to support new growth. Additionally, the construction industry serves an important role by allowing the city to more quickly recover from large-scale flooding and coastal storms.

A construction materials distributor was chosen as a case study to explore flood resiliency measures appropriate for large sites with unenclosed storage space. The company selected as a case study employs approximately 70 employees and operates on a site that is approximately two acres, with nearly 650 linear feet fronting the shoreline. The entire site is located within the 1% annual chance floodplain with a Design Flood Elevation ranging from two to five feet above grade. A range of buildings are located on the site, including corrugated metal warehouses, large sheds, and shipping containers used as permanent storage. In addition, lumber and other construction supplies are stacked on open-air shelving across much of the site.

## Flood Risk Profile

An estimated 16 percent of businesses in the building material and supply sector in NYC are located in the 1% annual chance floodplain, and 44 percent are located within the 0.2% annual chance floodplain.

## Flood risk among NYC's construction materials distributors



Construction materials distribution sites often contain a mix of unenclosed storage, enclosed warehouses, and office space. Unless properly secured, openly stored materials on these sites can become waterborne during flooding or are subject to wind damage during coastal storms, resulting in the loss of inventory and the potential for public health hazards, navigational hazards, and pollution of the city's waterways.

During Hurricane Sandy, one of the buildings on the case study site was damaged by floodwaters. More significantly, inundation of the site combined with poor soil conditions resulted in cavitation and collapse of the ground in several locations on the property. The poor condition of the bulkhead on the site contributed to this

## Employment in construction-related industries grew by almost 7 percent between 2010 and 2014 within the city's Manufacturing Districts.

problem by allowing water to saturate the soil and undermine the structure above. The foundation of one building was substantially undermined, requiring a costly repair (exceeding \$10,000), comprised of filling the ground with concrete to stabilize the structure.

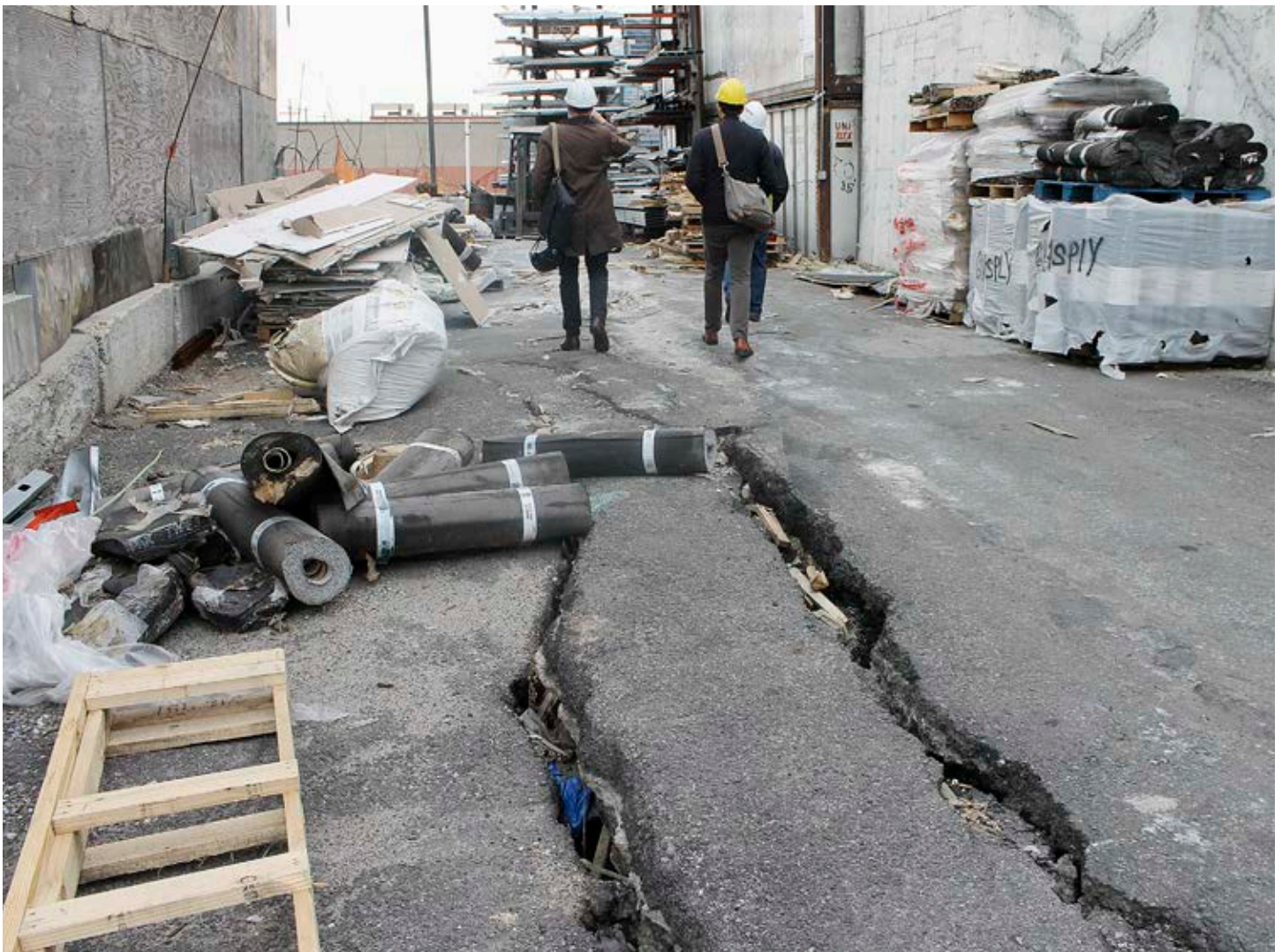
In advance of the storm, electrical equipment was connected to a backup power generator. However, because the generator was not elevated above the flood level, it was inundated and destroyed by floodwaters.

The construction materials distributor also experienced impacts from Hurricane Sandy due to disruptions beyond its site. A nearby drawbridge that was damaged during the storm caused significant delivery delays, often up to an hour. These delays, which persisted for several months following Hurricane Sandy, affected the ability of employees and customers to access the site.

Despite these various impacts to the business resulting from Hurricane Sandy, the business was able to resume operations the following day. Due to the need for construction materials as residents and businesses began the process of repairing and rebuilding across the city, the business was able to provide an important service in the wake of the storm, underscoring the extent to which the construction industry is important for the resiliency of the city as a whole.

### Challenges and Resiliency Measures

Construction materials distribution businesses, and many open industrial uses generally, have common characteristics that affect their exposure and vulnerability to flooding. The following resiliency challenges and best practices highlight a few strategies that similar businesses may pursue to manage the risk of flooding and coastal storms.

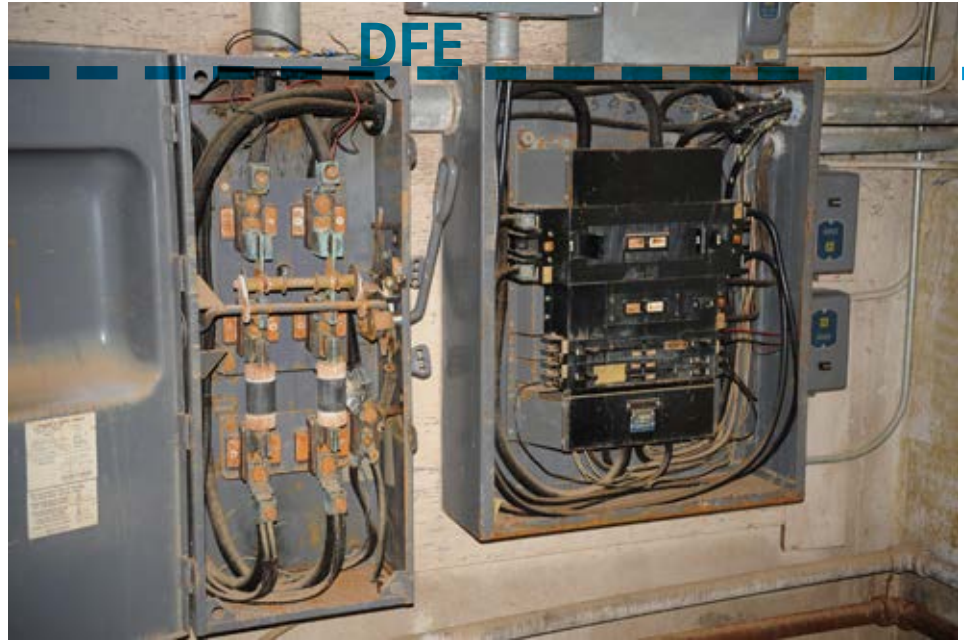




## RESILIENCY CHALLENGE

### Electrical and mechanical equipment below the DFE:

Floodwaters can cause significant damage to electrical and mechanical equipment, disrupting operations and leaving businesses prone to substantial repair or replacement costs. Construction and woodworking machinery, such as lathes and table saws, are particularly sensitive to flooding, especially by saltwater, which hastens corrosion.



## RESILIENCY MEASURE

### Elevate electrical and mechanical equipment:

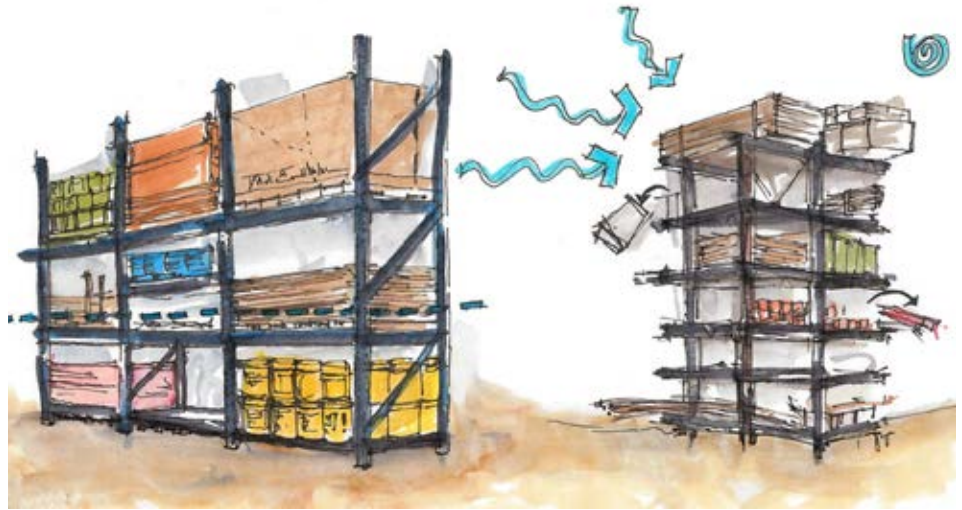
Elevating equipment above the DFE can reduce the likelihood of exposure and damage due to flooding. For machinery that could reasonably be temporarily relocated in advance of a storm, a facility preparedness plan should be developed that describes steps that should be taken, who is responsible, and the necessary timing to safely move equipment to higher locations on- or off-site.



## RESILIENCY CHALLENGE

### Open uses and uncovered inventory exposed to wind and flooding:

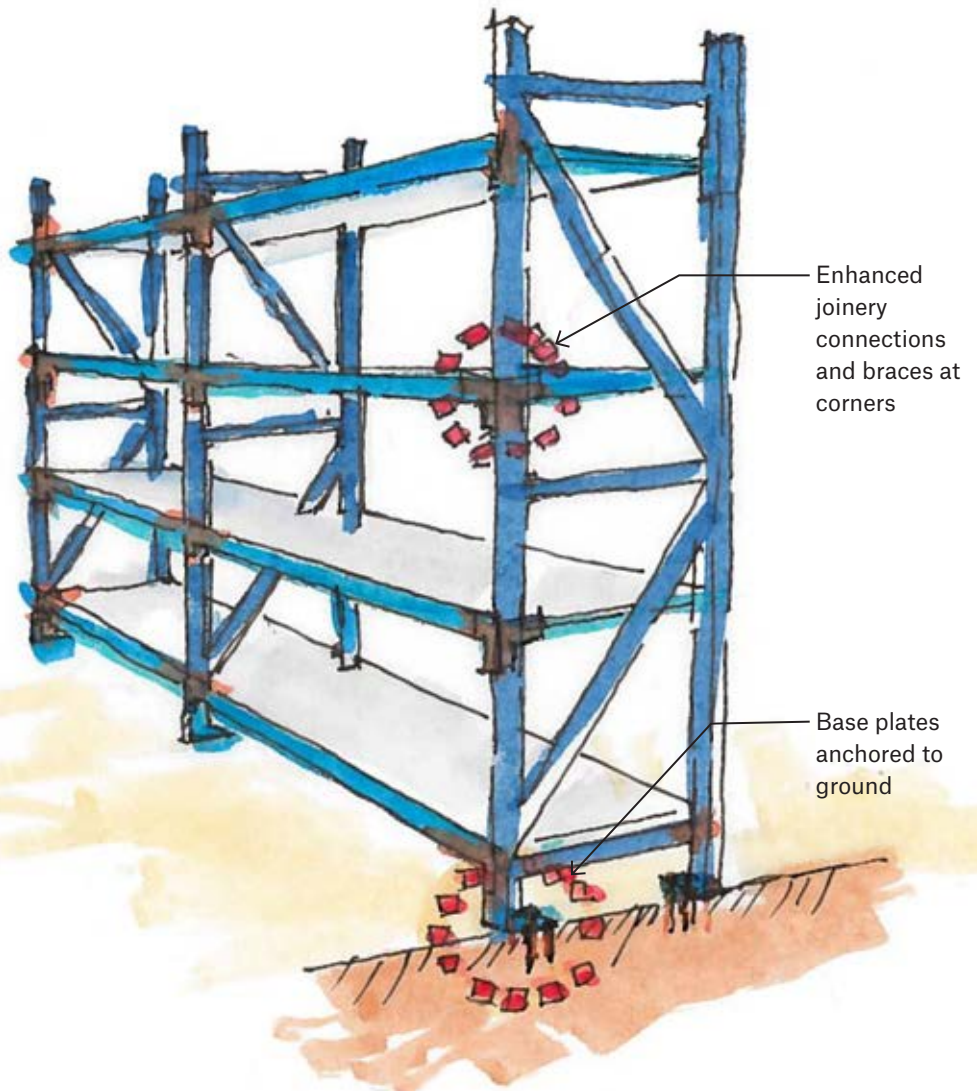
If stored improperly, unenclosed construction materials may be dislodged by wind, flooding, or storm surge. In addition to damaged or destroyed inventory, the potential exists for materials such as wood, rebar, paint, and other heavy items to become debris and cause further damage on the site or on neighboring properties. Importantly, business contents stored outside of buildings are not eligible to be covered by content insurance through the NFIP, making it especially important to reduce the potential for damage to inventory stored outside.



## RESILIENCY MEASURE

### Properly anchor to secure unenclosed storage:

Outdoor shelving and storage racks should be appropriately designed with base plates anchored to the ground to mitigate damage from both flooding and wind. Similarly, outdoor shelving on industrial sites is more likely to withstand wind damage with enhanced joinery connections and braces at the corners of each shelf. For materials that remain on shelving during storms, tie-down straps can be used to reduce the likelihood that materials will become dislodged or airborne.

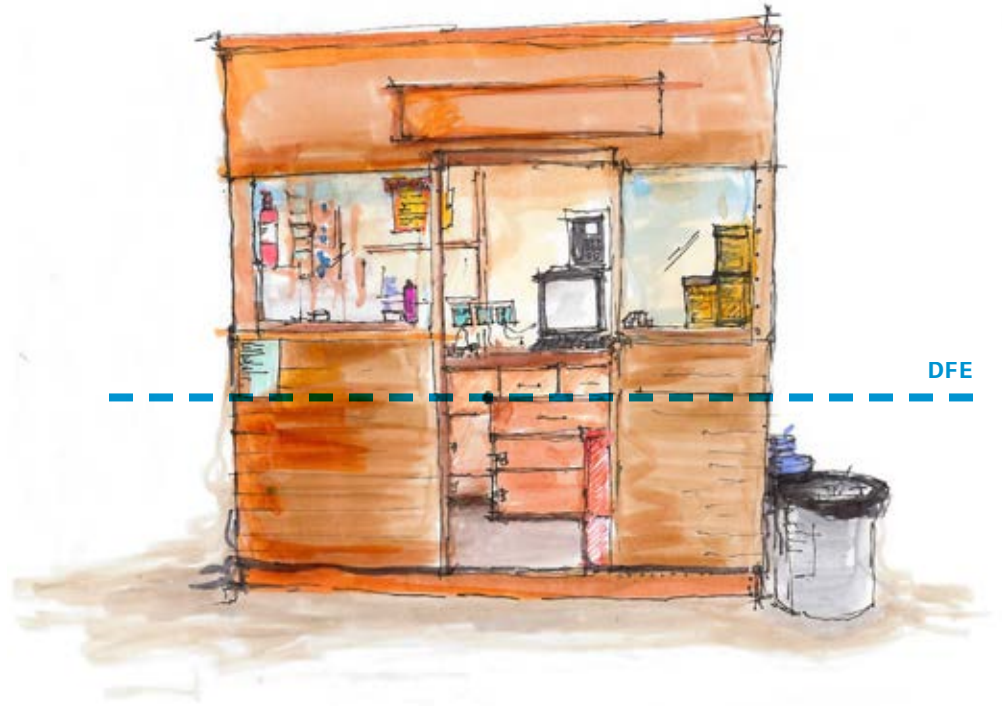




## RESILIENCY CHALLENGE

### Work stations and ancillary structures not designed to withstand flooding:

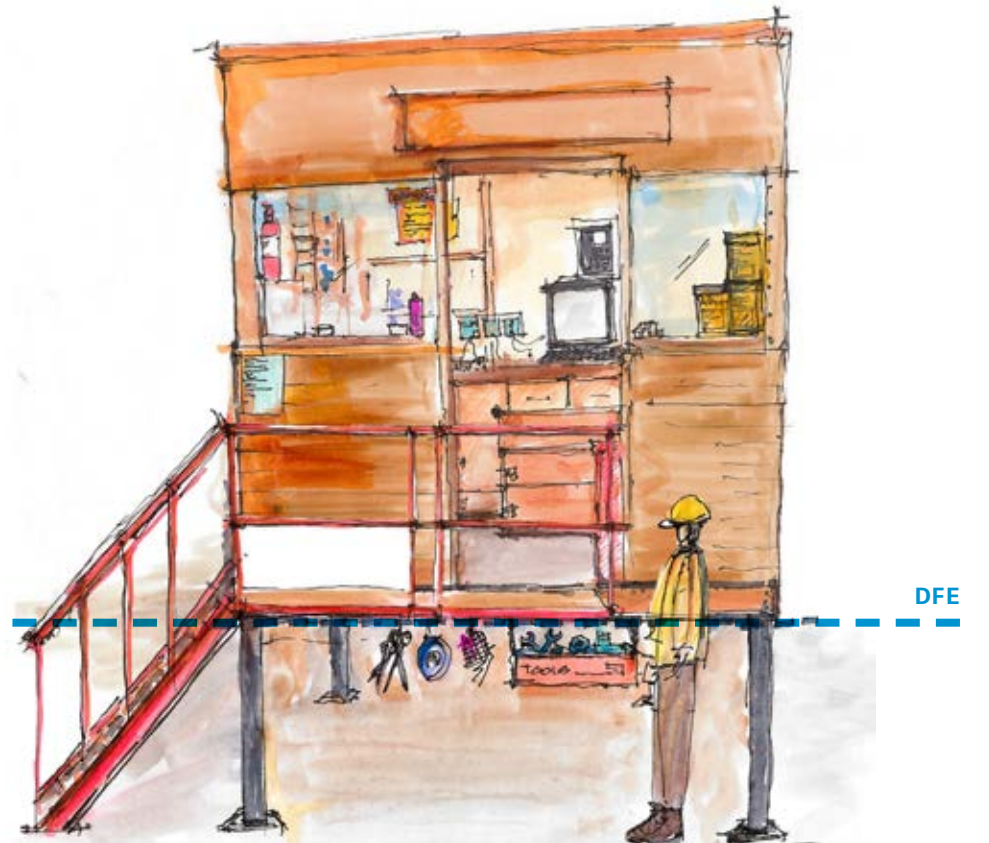
Unenclosed work stations and other small structures that tend to be dispersed across larger industrial sites are particularly susceptible to damage during flooding, as these are often constructed with lightweight building materials. Without reinforcements and anchors, these structures may not be able to withstand lateral pressure from flooding and are more likely to be displaced and destroyed. Given their function in maintaining normal business operations, unprotected work stations and ancillary structures may hinder the ability for businesses to recover quickly from flooding.



## RESILIENCY MEASURE

### Elevate structures in yard:

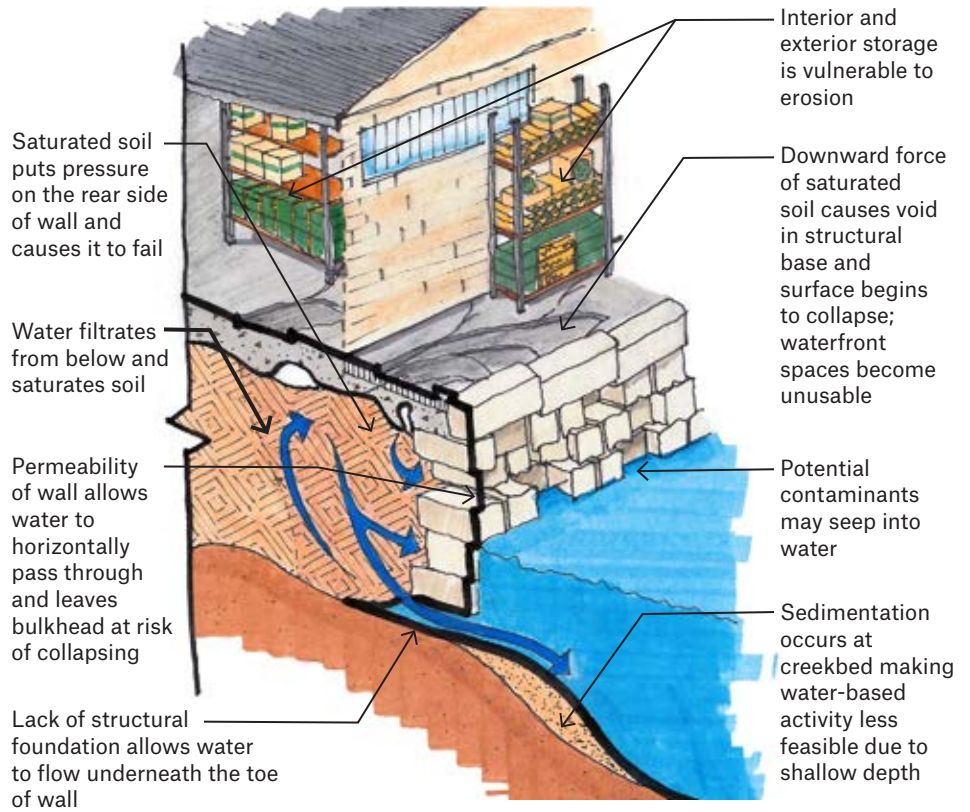
Elevating work stations and structures above flood levels can reduce the risk of flood damage and help businesses restore operations more quickly. Components of structures below the DFE should use flood resistant construction materials.



## RESILIENCY CHALLENGE

### Poor bulkhead conditions:

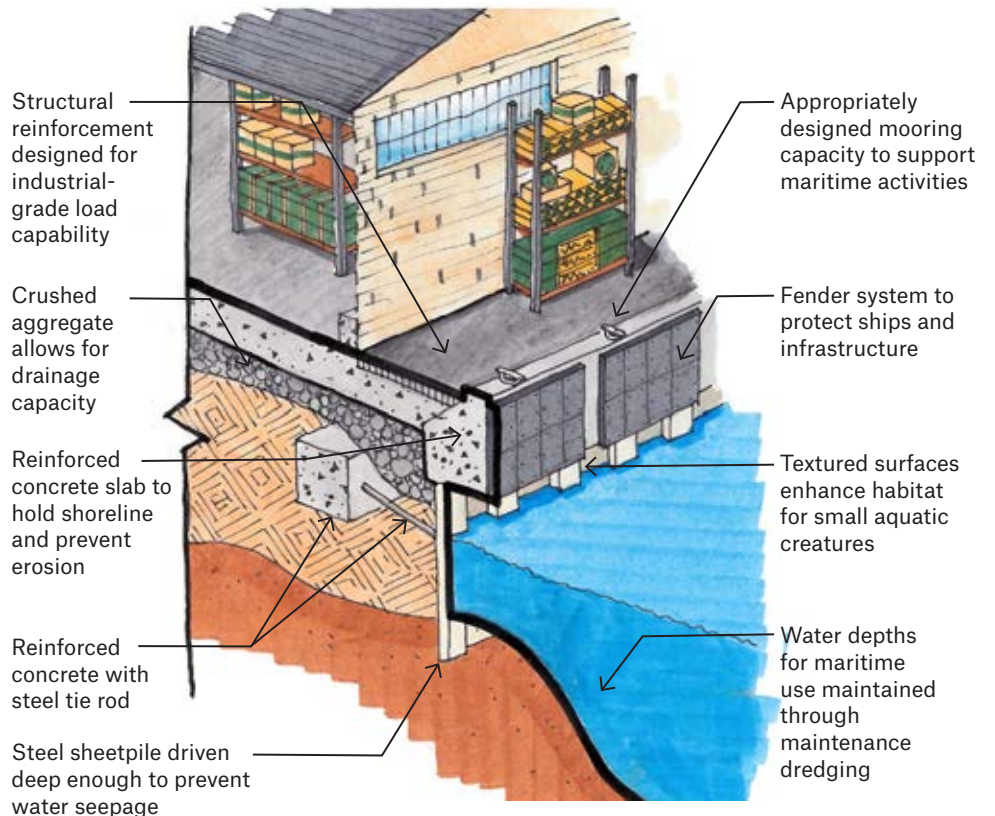
Bulkheads serve a number of functions on industrial properties along the water, including retaining land and resisting erosion in order to stabilize a site. In some cases bulkheads also provide access to vessels. In the event of a coastal storm, storm surge may overtop bulkheads, which can lead to structural failure when the soil behind the bulkhead becomes saturated and water levels recede, creating pressure between the soil water and sea water. If a bulkhead is in poor condition, the ground landward of the bulkhead may be unstable and prone to future erosion and loss of usable space.



## RESILIENCY MEASURE

### Bulkhead repair:

Structurally repairing bulkheads that are in poor condition or constructing new bulkheads provide for better grade load capacity, drainage capacity, and help protect against soil erosion and water seepage. In New York City, the construction of new bulkheads, or replacement and repair of existing structures, often requires permits from multiple entities, including the NYS Department of Environmental Conservation and the U.S. Army Corps of Engineers. Businesses should consult the [Waterfront Navigator: NYC's One Stop Waterfront Permit Planner](#) for additional information.



**APPROXIMATE COST\***  
**~\$2,500 per linear foot**

*\*See cost estimation on pg. 110 for more info*



## RESILIENCY MEASURE

### Revetment:

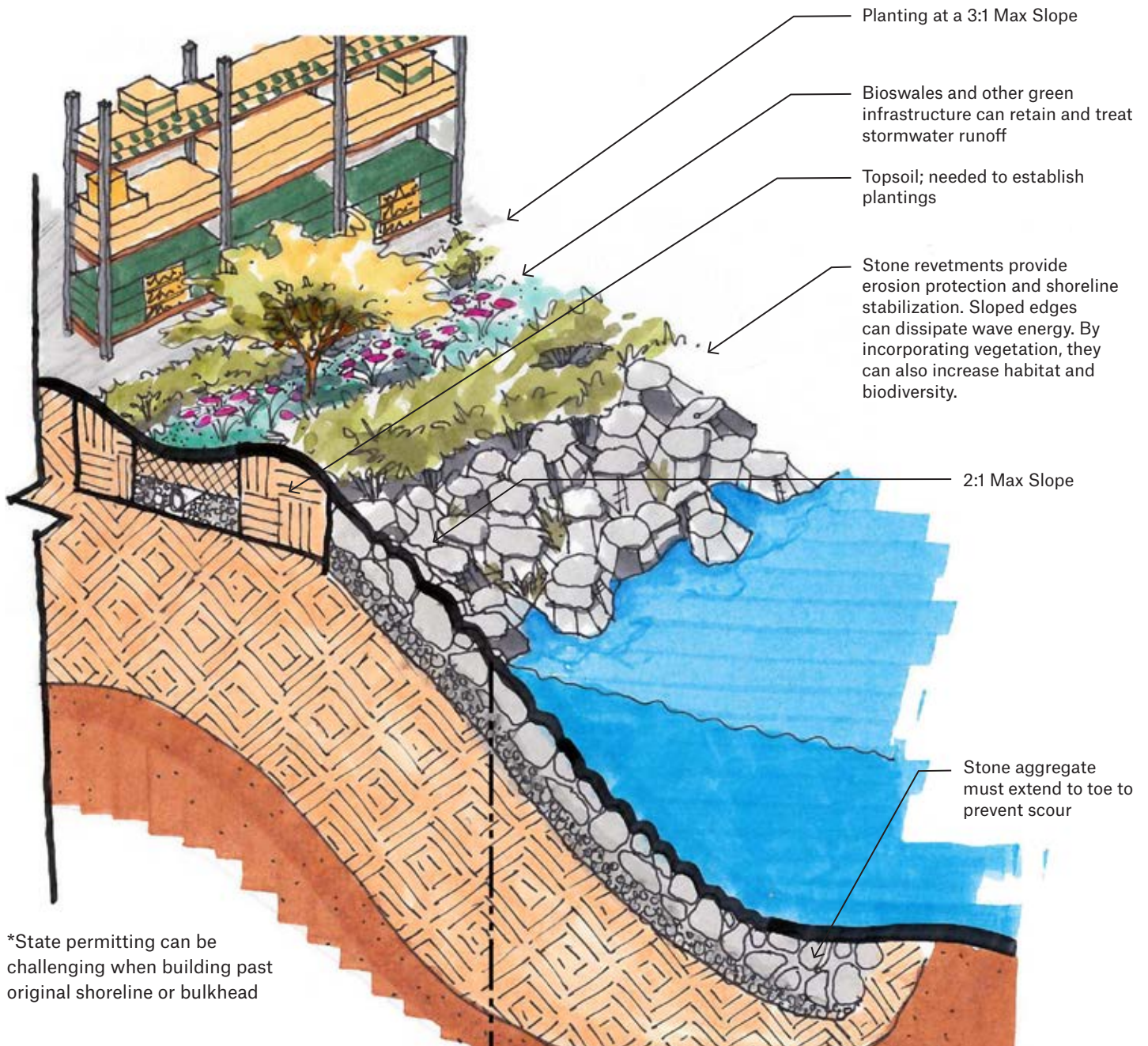
Revetments are a lower cost alternative to bulkheads and provide similar protection against water filtration and soil erosion. Revetments help mitigate wave action and provide erosion protection on steeper slopes. An array of materials can be used to construct revetments, including stone or concrete blocks. Revetments can also be designed to include shoreline vegetation to help filter stormwater and improve water quality, reduce erosion, enhance habitat, and improve the

aesthetic nature of the shoreline. The sloped design and rough surface of most revetments have a lesser erosion and scour impact on adjacent sites as compared to completely vertical structures such as bulkheads and seawalls. For industrial facilities that currently use their shoreline for maritime access, at least a portion of the shoreline would likely need to remain a bulkhead with water depth sufficient for barges and ships.

### APPROXIMATE COST\*

**~\$500 per linear foot**

*\*See cost estimation on pg. 110 for more info*



\*State permitting can be challenging when building past original shoreline or bulkhead

## Brewery



### Site Characteristics

<b>Lot size</b>	8,200 square feet
<b>Building floor area</b>	8,000 square feet
<b>Year built</b>	1931
<b>Design Flood Elevation (DFE) above grade</b>	5-7 feet

### Business Profile

Food and beverage manufacturing are growing industries in New York City, and the number of breweries in particular has increased significantly in recent years. A brewery was selected to explore flood resiliency measures within this growing sector and to better understand resiliency strategies suitable for industrial sites in moderately-sized manufacturing buildings that share walls with neighboring facilities, a particularly common condition in the city's older industrial areas.

The brewery selected as a prototypical site occupied an 8,000 square foot, masonry building that was constructed in 1931. A small rear patio is used for additional seating during the warmer months and a side alley is used for loading. The company employs more than 20 full-time staff and sells approximately 8,000 barrels of beer annually. The building has a large, open area for storage and fermentation, processing, and bottling, with direct access to the loading dock for delivery. The building also contains a small tasting room with indoor seating and an office located on the second floor above the tasting room.

### Flood Risk Profile

The entire brewery building is located within the 1% annual chance floodplain with a DFE of five to seven feet above grade. Despite the potential for significant flooding at this location, the company was not aware of damage to the building that occurred during Hurricane Sandy, which

occurred before it occupied the space. However, the company did experience minor flooding of a few inches due to a heavy rainfall event in the winter of 2016 and is interested in taking steps to mitigate future flooding.

After moving into the space, the brewery installed a new drainage system and updated much of the building's electric and water infrastructure. The company has also invested in several large, stainless steel brewing tanks, canning lines, and other valuable equipment. Tanks are bolted into the ground and are generally undamaged by water. However, the brewing equipment does include some electrical equipment, pumps, valves, and other components that are more sensitive to the effect of water. The company also retains large inventories of raw materials and ingredients, notably barley, malt, hops, and yeast.

The brewery has a blanket insurance policy through a company that offers an insurance product specifically tailored to microbreweries, which bundles insurance coverage for risks commonly faced by businesses within a certain industry, such as product spoilage in the case of a brewery. These specialized policies are called Business Owners Policies or BOPs. This brewery's insurance policy includes flood insurance, and the insurance company requires that all policy-holders are insured-to-value.





The insurance company also conducts loss control visits intended to promote actions that minimize risk, which can compel businesses to make physical modifications to their space or embrace operational improvements such as emergency preparedness trainings.

#### **Operational Resiliency**

Some craft breweries establish partnerships with contract brewers, companies that have equipment to reproduce beer recipes in a different location. This is typically done to help meet demand, especially if there are surges because of popular seasonal beers, or to ensure that beer supplies remain steady if there are disruptions to supply, such as a spoiled batch or equipment malfunctions. Even if demand can typically be met with in-house brewing, working with contract brewers can be a valuable form of continuity of operations planning and can serve a dual purpose to provide resiliency to flooding and other hazards. Similarly, for other companies that produce or manufacture food or beverages, especially those that operate on a smaller scale, developing relationships with external

kitchens or spaces that may be usable to maintain supply during a disruption can help reduce costs associated with lost operation and revenue.

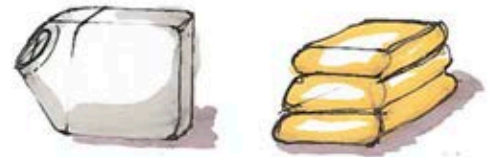
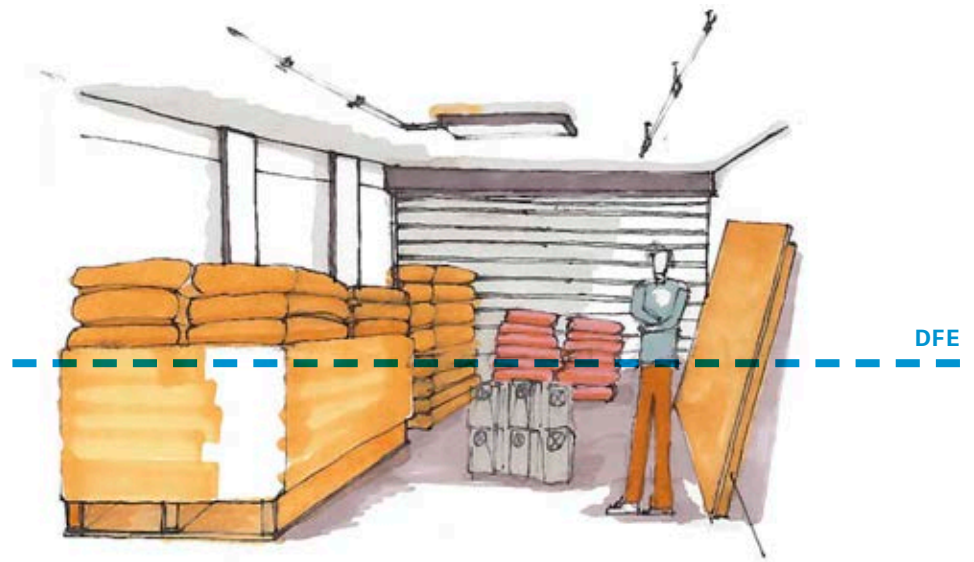
#### **Challenges and Resiliency Measures**

Breweries and other food and beverage manufacturers have common characteristics that affect their vulnerability to flooding. The following examples demonstrate strategies to minimize damage from flooding that may apply to a range of similar industrial businesses in New York City.

## RESILIENCY CHALLENGE

### Ingredients stored below the DFE may be spoiled by flooding:

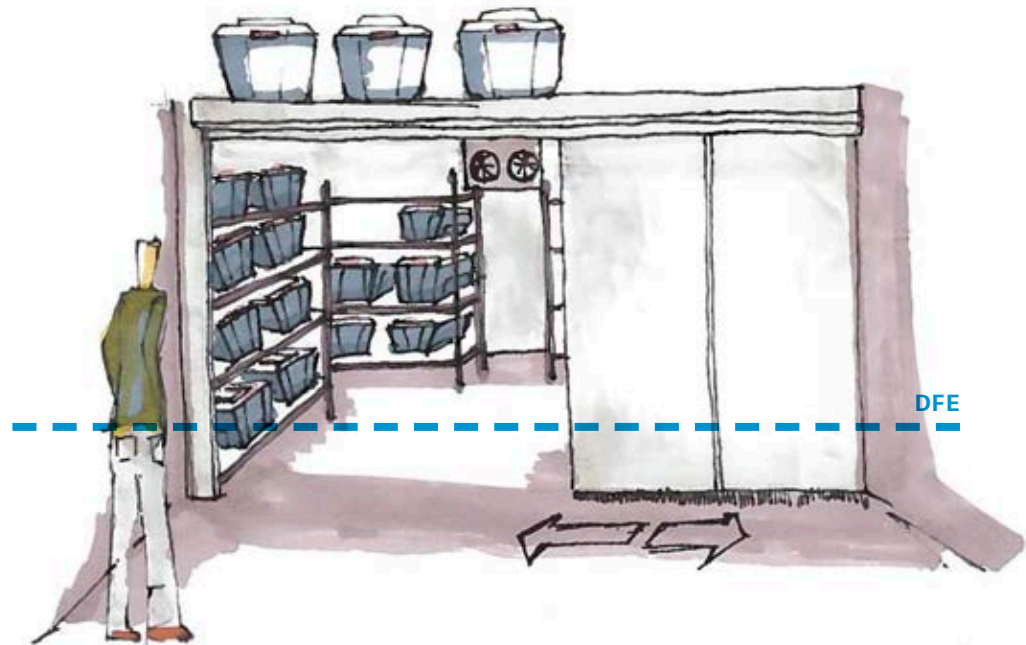
When raw ingredients and perishable goods, such as barley, malt, yeast, and hops, are stored below the DFE they are likely to be compromised during floods. Many breweries store their inventory in cardboard containers on wooden pallets or on shelving. In addition to the potential cost to replace damaged inventory, the time necessary to order and replace damaged inventory may prolong the recovery time and result in a significant loss of revenue.



## RESILIENCY MEASURES

### Store ingredients in waterproof containers and move above the DFE:

Storing raw ingredients and other perishable goods in waterproof containers can reduce the risk of flood damage, helping businesses to reduce the cost of replacing inventory and minimizing recovery times. Businesses with limited space for storage above the DFE should prioritize storage locations. Valuable or highly perishable inventory should be stored at higher locations, while ingredients that are easier or inexpensive to replace may be stored at lower elevations.





## RESILIENCY CHALLENGE

**Building structure, electrical components, and brewing equipment are vulnerable to flooding:** The building that the brewery occupies is vulnerable to hydrostatic pressure from floodwater, since it is not designed to withstand floodwaters or allow water to enter the building without significant damage. The building's electrical components, including panels and conduits, are

situated below the DFE. Damage to these devices would affect the power supply to production machinery. Additionally, brewing systems, including mills, tanks, and bottling or canning equipment, have electrical components that are vulnerable to flooding. Damage to this machinery would result in high costs for repair and replacement. Any delay in production would also result in lost operating revenue.

## RESILIENCY MEASURE

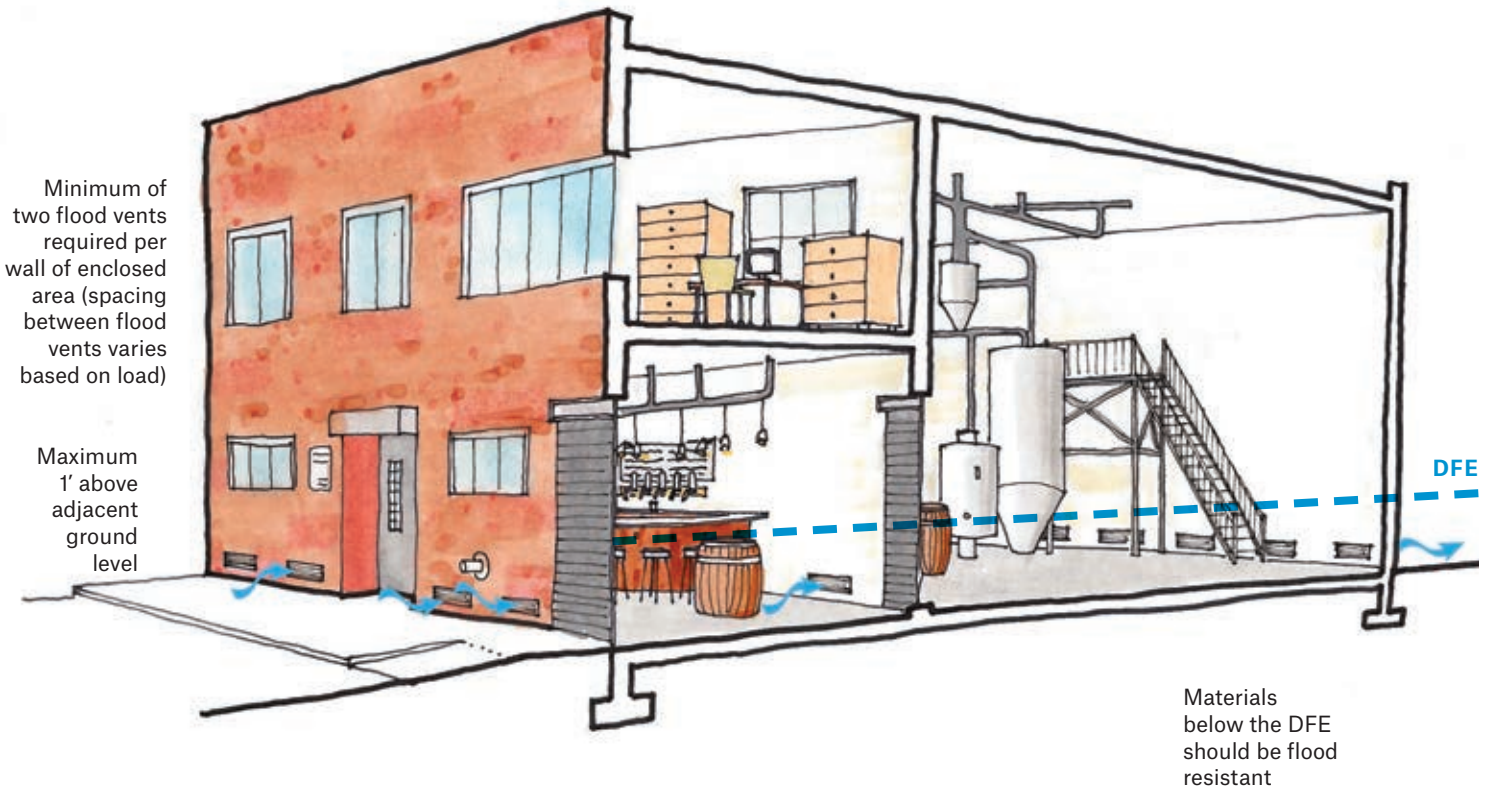
**Wet floodproof:** Wet floodproofing includes measures applied to a structure or its contents that prevent or provide resistance to damage from flooding while allowing floodwaters to enter the structure. This includes installing sufficient flood vents or other opening to allow floodwaters to enter, using flood-resistant construction materials below the DFE, and taking steps to protect mechanical and electrical equipment. Wet floodproofing is not an NFIP-compliant strategy for nonresidential structures and, therefore, is not recognized within the NYC Building

Code as a strategy for new construction of industrial buildings or for retrofits of buildings that have been substantially damaged or substantially improved. For this reason, wet floodproofing does not result in insurance premium reductions for buildings insured through the NFIP. Nonetheless, for businesses that are not able to come into full compliance through dry floodproofing or elevating their structures, wet floodproofing may be a cost-effective strategy to reduce impacts of flooding and coastal storms.

### APPROXIMATE COST\*

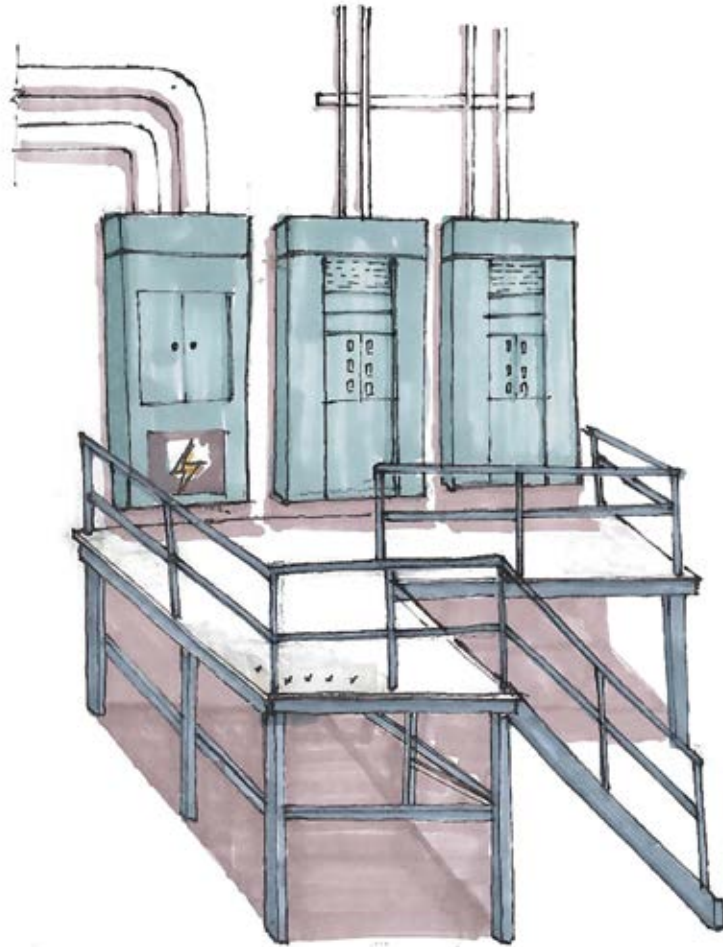
**Cost per flood vent = ~\$1,750**

*\*See cost estimation on pg. 110 for more info*



## RESILIENCY MEASURE

**Elevate electrical panels:** Locating electrical panels and other central components of the electricity supply system above the DFE may prevent damage to electrical systems and power outages. The location of electrical equipment should take into account regulations under the National Electrical Code (NEC). The NEC places limits on where electrical service equipment can be located, including clearance requirements and working space around electrical service components.

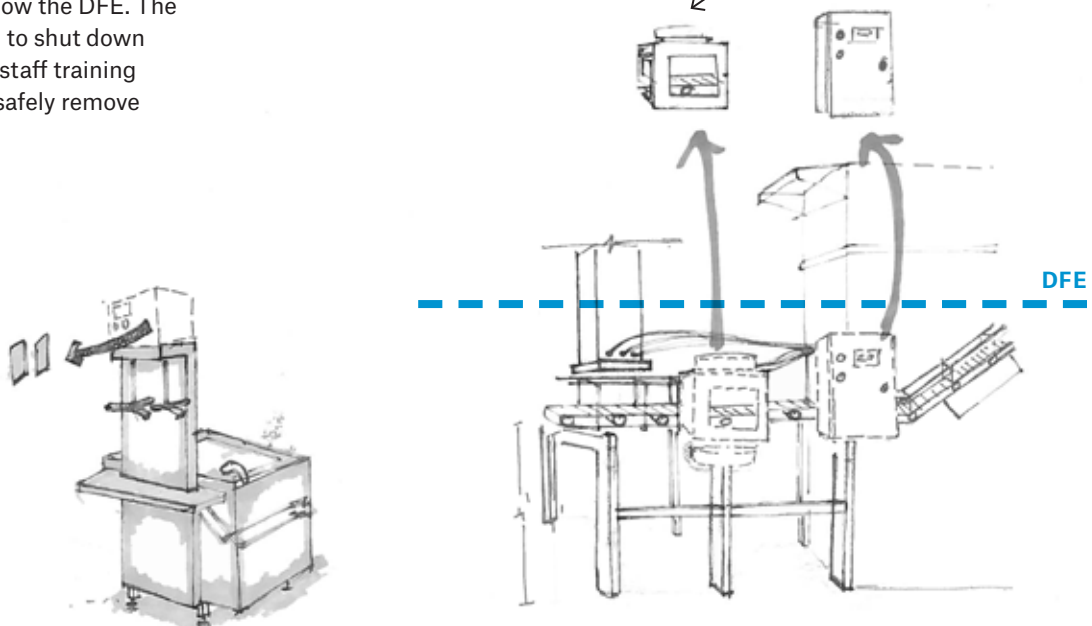


## RESILIENCY MEASURE

**Develop a preparedness plan to protect brewing equipment:**

Where possible, electrical components of machinery and other equipment may be removed and stored in safe locations when flooding is forecast. For example, circuit panels on canning lines may be quickly removed and stored on the second floor to prevent damage to the system. A facility preparedness plan should include an inventory of removable equipment or components that are below the DFE. The plan should clarify when to shut down operations and periodic staff training should include steps to safely remove vulnerable components.

Vulnerable electrical components can be removed and stored above the DFE in advance of a flood





# Film Studio



## Site Characteristics

<b>Lot size</b>	52,000 square feet
<b>Building floor area</b>	41,000 square feet
<b>Year built</b>	1950
<b>Design Flood Elevation (DFE) above grade</b>	3 feet

## Business Profile

Film and television studios are one of the fastest growing industries in the city's manufacturing districts.<sup>12</sup> New York City and New York State have created a number of programs, including tax credits, workforce development, and use of city-owned space for production, to encourage growth within the film industry. A film studio was selected to explore flood resiliency measures applicable specifically to this sector, and generally to industrial businesses with high-value inventory and assets in industrial warehouses.

The studio is situated on three sites located adjacent to or near the water. Two of these buildings are used as stages for filming. The third building is used as an office and for equipment storage to operate a rental business for production lighting and sound equipment. For the purposes of this analysis, the focus is on the largest and primary building, which is used as a stage.

The stages occupy existing, single-story industrial warehouses that have been repurposed for use as a studio. These modifications included installing an HVAC system on the roof to minimize ambient noise during filming. The company employs approximately 30 full-time staff members, however, more than 250 people are often on-site during filming. For this reason, in addition to a building with wide column spacing and high ceilings, access to transit and parking were key considerations for the location of the

studio. The company maintains a fleet of 16 vehicles, most of which are customized trucks for film equipment and power generation.

## Flood Risk Profile

Film studios often contain expensive assets and equipment. In addition to cameras, lighting, and sound equipment, the sets used for film and television are a significant investment for production companies. Any delay in filming due to a damaged set could set back a filming schedule and result in costly disruptions for the studio and its client. Film sets are typically constructed a couple of feet above the floor of the warehouse, providing sufficient space beneath the set to run cables.

The studio evaluated as a case study is located in the 1% annual chance floodplain with a DFE of approximately three feet. During Hurricane Sandy, the company suffered approximately \$2.8 million in equipment damage. Floodwaters inundated lighting and sound devices, causing corrosion and destroying electrical components and fixtures. While the warehouse structure was largely unaffected, mold occurred almost immediately on interior walls and fabrics that were not constructed with flood-resistant materials. Despite unplugging equipment and placing computers on top of desks prior to the hurricane, some computers were still destroyed as flood heights exceeded this level in some parts of the building. Eight trucks, valued at

## During Hurricane Sandy, the company suffered approximately \$2.8 million in equipment damages.

\$400,000, were also flooded beyond repair during the storm

Prior to Hurricane Sandy, the studio had a private, universal coverage insurance policy, which included flood coverage. The business also maintained NFIP content coverage for all of its buildings, with the maximum coverage limit offered under the program of \$500,000.

Following Hurricane Sandy, the private coverage reimbursed equipment losses, but much of the company's investment in a leased building was not covered by insurance, forcing the studio to cover repairs out-of-pocket. The FEMA reimbursement process for building contents was considered by the studio to be tedious and costly, requiring an external remediation company to attempt to fix each item or, where applicable, document that each item could not be repaired before reimbursement. New models of equipment could only be purchased with detailed justification. The company was fully paid out by FEMA after nine months. Although the company maintained vehicle insurance on all of its commercial trucks, it learned in the aftermath of Hurricane Sandy that its vehicle insurance covered only the value of the trucks prior to being

customized for the film industry. In many cases, trucks that initially cost \$25,000 had an additional \$30,000 invested in modifications, such as shelving, lighting, generators, and storage. Since Hurricane Sandy, the company has included these types of vehicle customizations within its property coverage to avoid similar uninsured losses.

Even though insurance did eventually pay for replacement of much of the damaged equipment, the studio was forced to rent equipment from other lighting companies to maintain operations. The higher operating cost during the recovery period resulted in lost revenue due to the storm. In total, the studio felt that it took 18 months to recover from Hurricane Sandy.

### Challenges and Resiliency Measures

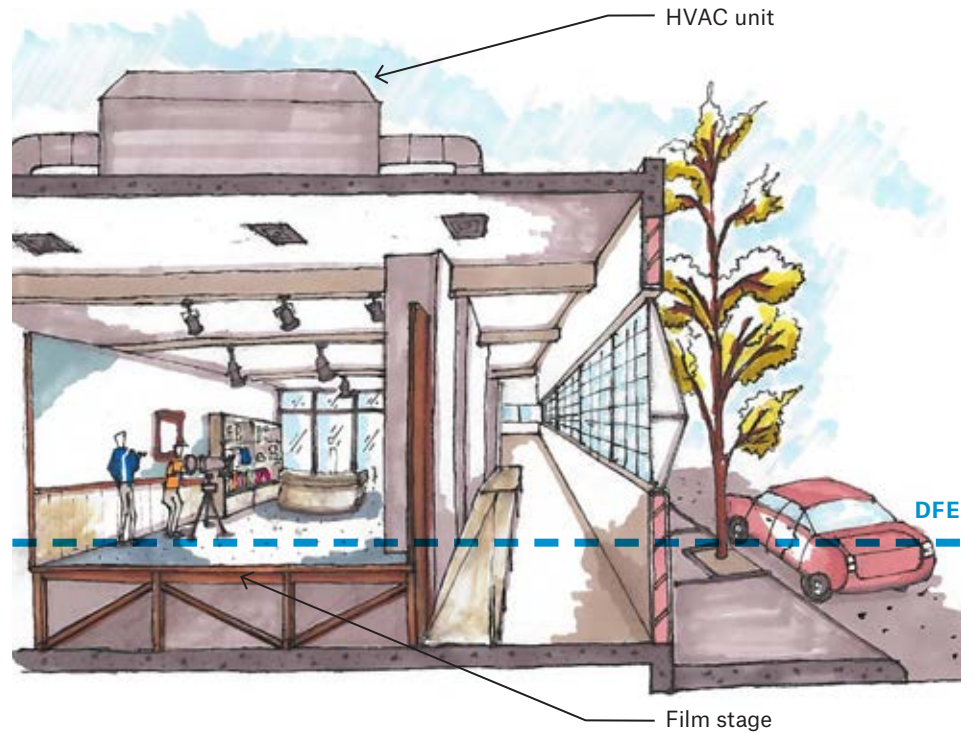
Film and television studios have common characteristics that affect their vulnerability to flooding. The following examples demonstrate strategies to minimize damage from flooding that may apply to a range of similar industrial businesses in New York City.





## RESILIENCY CHALLENGE

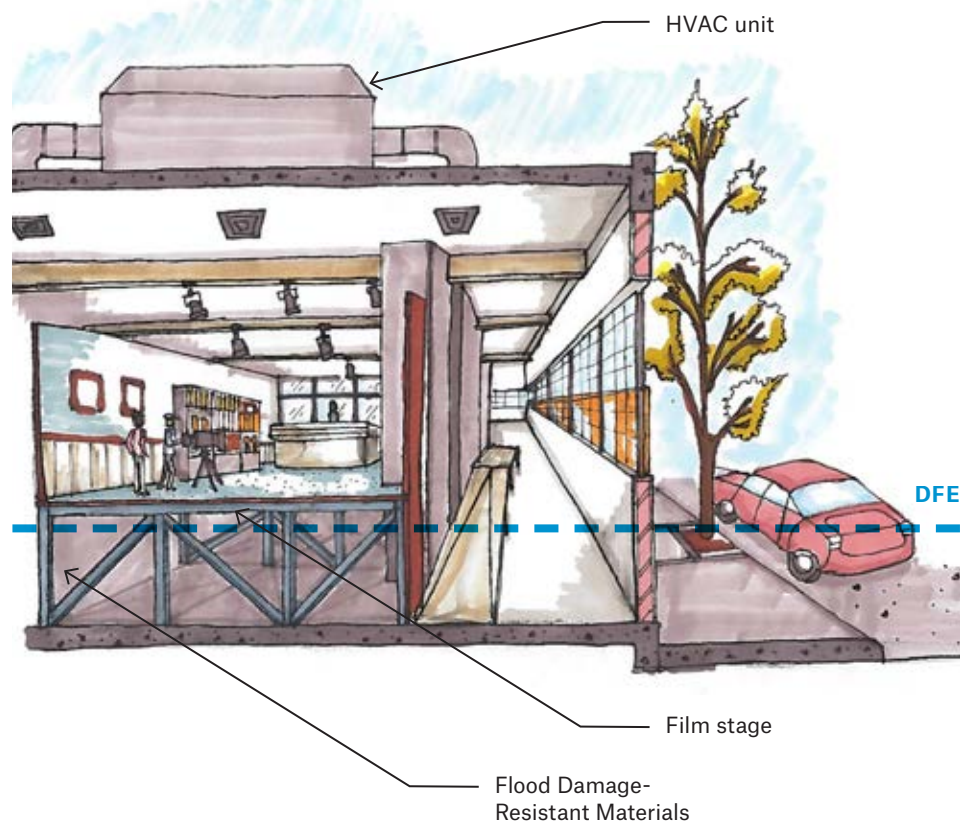
**Film sets are immovable and highly vulnerable to flood damage:** Film sets are significant investments for film studios and, once constructed, cannot be easily moved or relocated. If situated below the DFE, sets and large props may be susceptible to flood damage. Film sets and props are particularly vulnerable to floodwater, as they are often designed and constructed with more temporary, less resilient materials. A disruption in a production schedule to repair or replace an active set could result in significant costs for the studio and tarnish the company's reputation.



## RESILIENCY MEASURES

**Add freeboard to the set floor within the building:** If the building has sufficient ceiling heights, film studios should consider increasing the elevation of stages and sets to meet or exceed the DFE. Even if floodwaters enter a building, a set that is elevated above the DFE may be able to reduce damage and resume operation quickly. In addition, the area below the set should utilize flood-resistant construction materials.

**Install the HVAC system on the building roof:** Locating the HVAC system on the roof of a building as opposed to installing it at-grade reduces the likelihood of exposure to floodwaters. For film and television studios that tend to modify buildings to reduce ambient noise caused by mechanical systems, installation on the roof can also help meet these goals. Due to the potential for high winds during coastal storms, HVAC systems and other mechanical equipment installed on the roof should be properly anchored and secured.



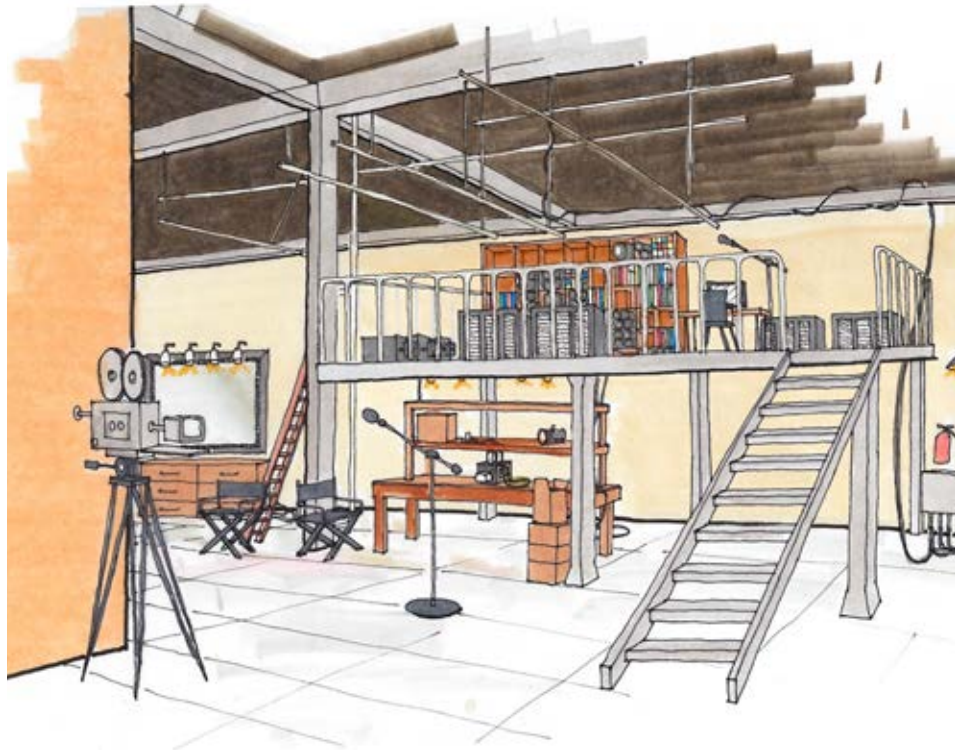
## RESILIENCY CHALLENGE

**Film-making equipment highly vulnerable to flood damage:** Cameras, microphones, lights, stands, cables, and other equipment are often stored at grade within production studios so they can be easily accessed and used. Without storage space above the DFE, this equipment is likely to be inundated during flood events. Damage to these assets not only results in high replacement or repair costs, but can also hinder operations and delay production.



## RESILIENCY MEASURES

**Construct a mezzanine for protected storage and office space:** Many industrial spaces have sufficient floor-to-ceiling height to construct mezzanines to create office or storage space. The availability of space above the DFE allows for permanent storage or temporary relocation of valuable equipment during floods, significantly reducing risk for businesses that have major investments in assets and equipment. Mezzanines can double as offices where business records can be safely stored and protected from flooding. A facility emergency preparedness plan should also be developed to clarify which equipment should be stored above grade, when it should be relocated, and who is responsible for taking these steps.



### APPROXIMATE COST\*

**500 sf mezzanine = ~\$112,000**

*\*See cost estimation on pg. 110 for more info*



## RESILIENCY MEASURES

**Construct a second floor storage space on roof deck:** The availability of storage spaces above the DFE allows for permanent storage or temporary relocation of valuable equipment during floods, significantly reducing risk for businesses that have major investments in assets and equipment. These spaces can also double as offices where business records can be safely stored

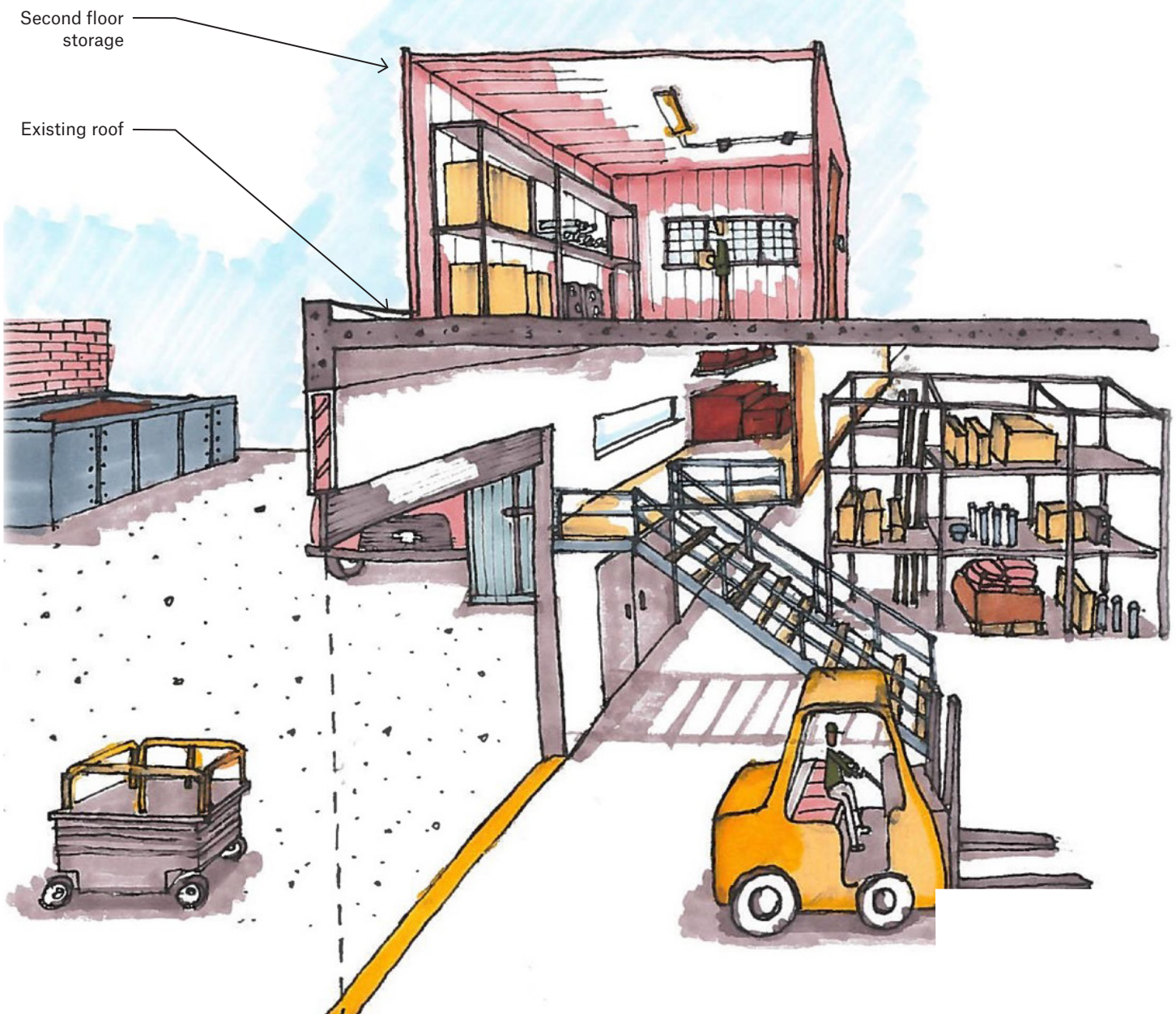
and protected from flooding. Additionally, insurance availability can be enhanced and premiums can be reduced by having storage space above the floodplain. A facility emergency preparedness plan should also be developed to clarify which equipment should be stored above grade, when it should be relocated, and who is responsible for taking these steps.

In some zoning districts, floor area or height restrictions may limit the ability to construct second floor additions. A more detailed discussion of these zoning considerations can be found on page 102.

### APPROXIMATE COST\*

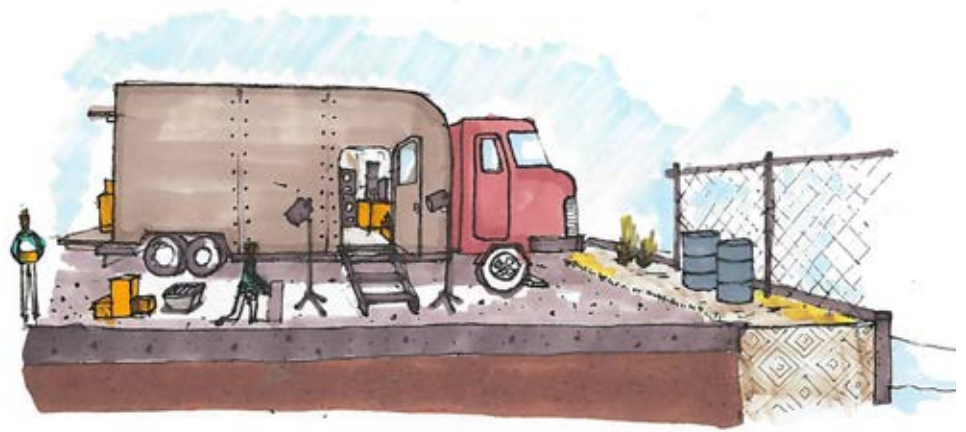
**500 sf rooftop addition = ~\$214,000.**

*\*See cost estimation on pg. 110 for more info*



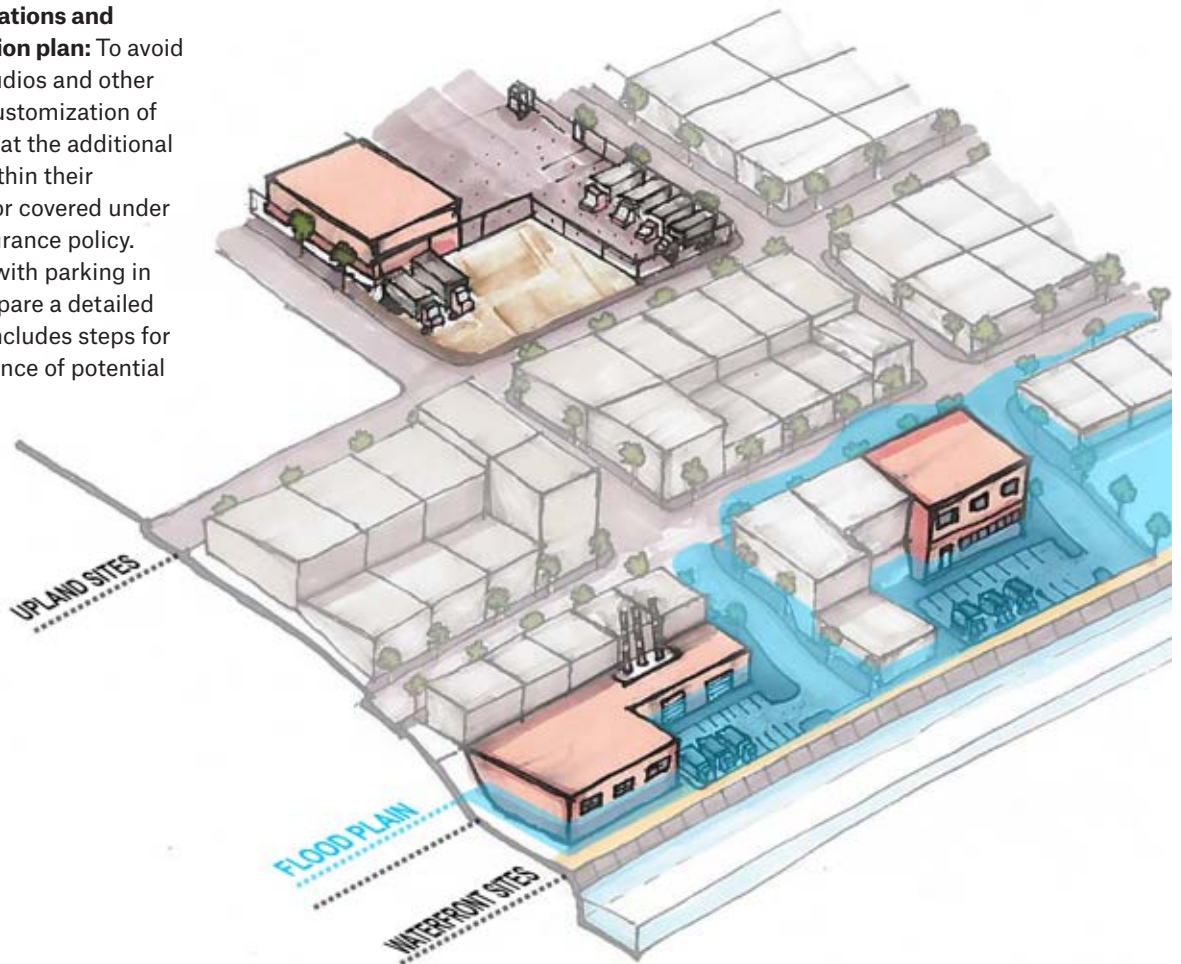
## RESILIENCY CHALLENGE

**Commercial vehicles parked in the floodplain may be damaged during storms:** For many industrial companies, vehicle fleets that are parked in the floodplain are a significant liability. Trucks used in the film industry also tend to be customized with additional storage, lighting, and generators, increasing their value and making these vehicles more difficult to replace. Vehicle insurance policies often cover only the cost of the vehicle before modification.



## RESILIENCY MEASURES

**Insure vehicle customizations and prepare parking relocation plan:** To avoid uninsured losses, film studios and other companies that rely on customization of vehicles should ensure that the additional cost is either included within their vehicle insurance policy or covered under the general business insurance policy. Additionally, companies with parking in the floodplain should prepare a detailed preparedness plan that includes steps for vehicle relocation in advance of potential flood events.





## Food Distributor



### Site Characteristics

<b>Lot size</b>	200,000 square feet
<b>Building floor area</b>	180,000 square feet
<b>Year built</b>	1960
<b>Design Flood Elevation (DFE) above grade</b>	3-7 feet

### Business Profile

A large food distribution business located in the city's industrial floodplain was selected as a prototypical site, representing a major industry in the city that continues to grow as the population expands. In 2014, more than 750 food distribution facilities were located in manufacturing districts, employing more than 15,000 employees. These businesses are concentrated in Hunts Point, Maspeth, and East Williamsburg, many of them located in areas vulnerable to flooding.<sup>13</sup>

Ensuring that the city's food distribution network is resilient to disruptions is critical to the city's overall resilience. The 2016 New York City Food Distribution & Resiliency Study, conducted by the Mayor's Office of Recovery and Resiliency and the Economic Development Corporation, found that the city's point-of-sale outlets typically keep between four and five days of food in stock, making it imperative that food distribution businesses have the ability to maintain or quickly resume operation following a flood, coastal storm, or other disruption.<sup>14</sup>

The company evaluated as a prototype of large food distributors employs more than 3,000 people in New York City and operates out of approximately 350,000 square feet of warehouse space that is spread across three separate buildings. All deliveries to and from the site are conducted by the company's fleet of 250 commercial trucks.

### Flood Risk Profile

Two of the three buildings occupied by the food distributor prototype are located in the 1% annual chance floodplain. The largest building, which has a footprint of more than 180,000 square feet, has a DFE that ranges from three to seven feet above grade.

During Hurricane Sandy, one building flooded with two feet of water and another had approximately six inches of floodwater. Despite flooding in these buildings, physical damage to the building was relatively minimal, requiring the business to replace carpet, drywall, and flooring in some parts of the buildings—primarily in spaces used for offices. Removing debris during the recovery period was a significant financial burden, as the company was compelled to rent approximately 30 dumpsters per day

for several days during the clean-up. More significantly, the company's entire fleet of trucks was parked within the floodplain during Hurricane Sandy. One hundred and sixty of their 250 trucks were flooded beyond repair, forcing the company to quickly find suitable replacements or short-term rentals before it could resume operations.

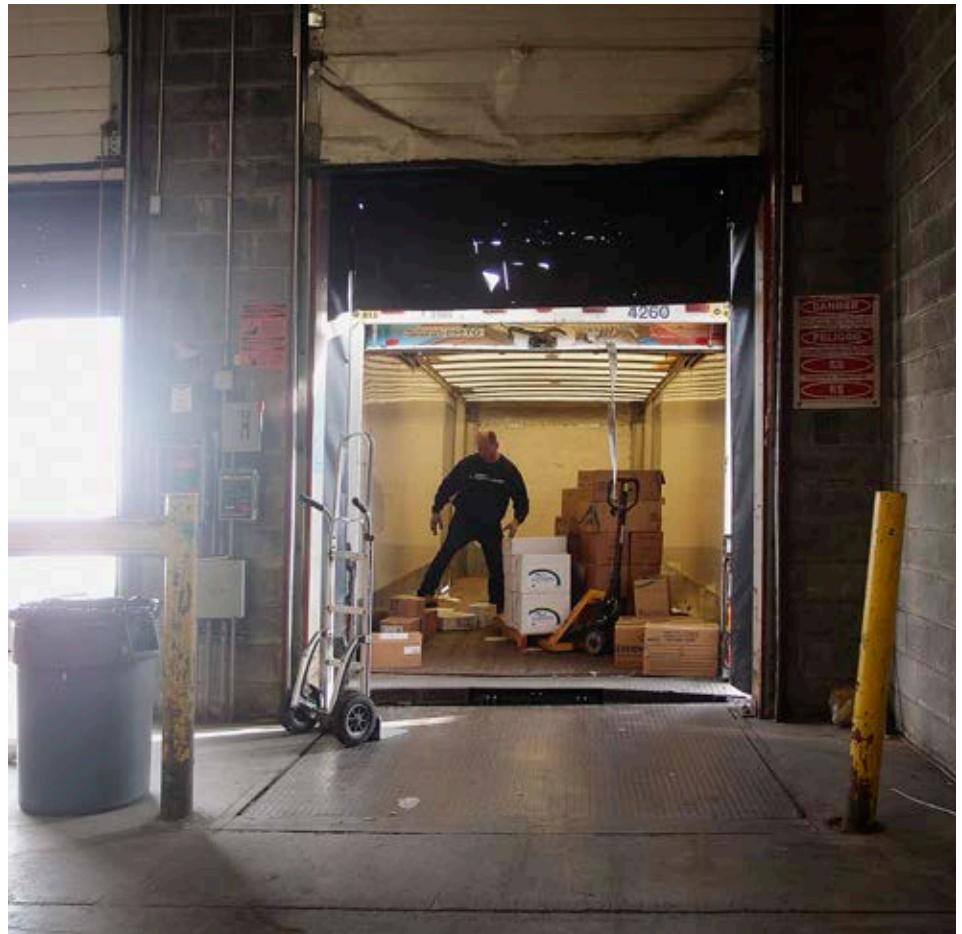
A significant concern for the company is the need to maintain refrigeration for large quantities of perishable foods. During Hurricane Sandy, electricity was uninterrupted for the duration of the storm. The business had a 500 KW generator that was installed six inches above grade and was inundated by floodwaters. Had the business lost power, the damage to their backup generator would have resulted to additional losses and delays in restoring operations.

The company maintains a large, private insurance policy from a major reinsurance

company, which includes continuity of operations coverage. This policy covered most physical damages from Hurricane Sandy and reimbursed roughly half of lost sales. The company does not have coverage through the NFIP. Most of the trucks were leased and insured. Of the \$10 million in losses due to vehicle damage, the company was reimbursed approximately \$8 million by insurance. In the aftermath of Hurricane Sandy, the company's premium increased and its insurer required a detailed plan describing preparedness strategies for future events.

### **Challenges and Resiliency Measures**

Food distribution sites and other transportation and warehousing facilities have common characteristics that affect their vulnerability to flooding. The following examples demonstrate strategies to minimize damage from flooding that may apply to a range of similar industrial businesses in New York City.





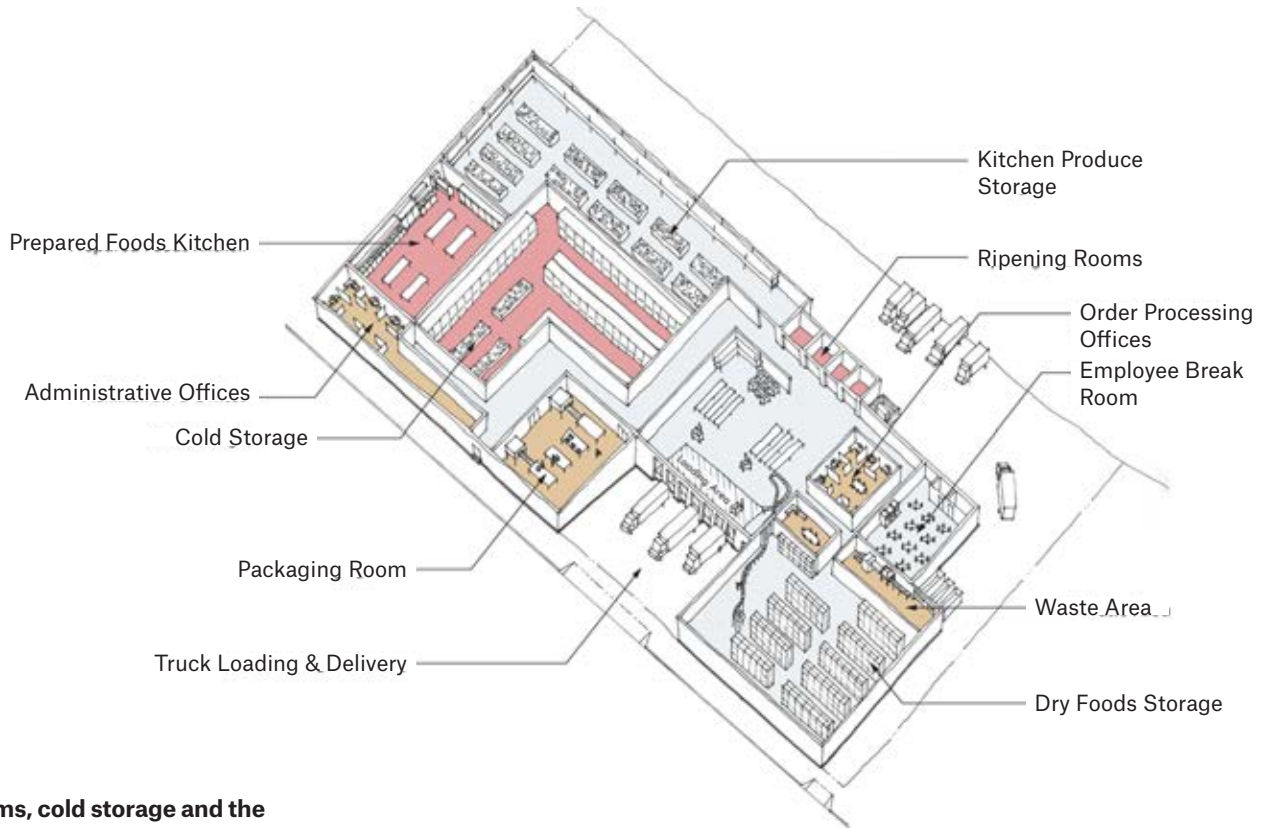
**RESILIENCY CHALLENGE**

**Critical rooms within the facility are particularly vulnerable to flooding:**

Certain spaces within the facility contain significant investments in equipment and inventory, while other spaces are less vulnerable to flooding. For example,

rooms colored in red, such as cold storage or ripening rooms, are disproportionately vulnerable to flooding due to high-value equipment. Rooms in yellow, such as packaging rooms, are slightly less vulnerable. The rooms in gray are the least

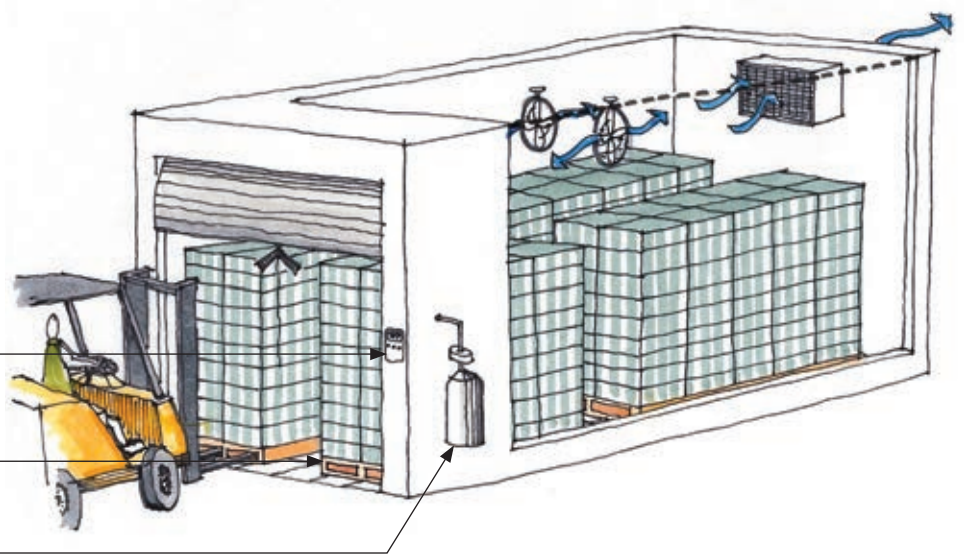
vulnerable. Due to the large size of the facility, fully protecting the entire building from flooding would be prohibitively costly.



**Ripening rooms, cold storage and the prepared foods kitchen have significant investments in equipment:**

Ripening rooms are key components of the distributor's operation and tend to contain more investments in equipment that could be damaged by floodwaters. While it may not be cost-effective for the business to fully protect the entire facility, the potential for flooding within key areas of the building that contain more sophisticated equipment is a significant risk.

- Temperature and humidity control systems are reliant on power source
- Inventory that is left below the DFE is subject to flood damage
- Hazardous materials, such as ethylene gas used in ripening rooms, may pose environmental threats during floods.



## RESILIENCY MEASURES

### Floodproof critical warehouse spaces:

Although it may not be feasible or cost-effective to dry floodproof the entire warehouse space for many large distribution businesses, some businesses may choose to floodproof critical spaces within the structure to ensure that protected space exists for valuable inventory or equipment. This strategy, known as partial floodproofing, can involve a combination of elevating floors within the structure, dry floodproofing, or wet floodproofing.

The first example illustrates elevating the floor within a specific room. Elevating floors provide space that is permanently protected from floods up to the elevation of the floor. This strategy is only feasible if there are sufficient ceiling heights within the building. The second option illustrates dry floodproofing with a deployable flood barrier. This strategy requires that walls are sufficiently reinforced to manage hydrostratic pressure during floods.

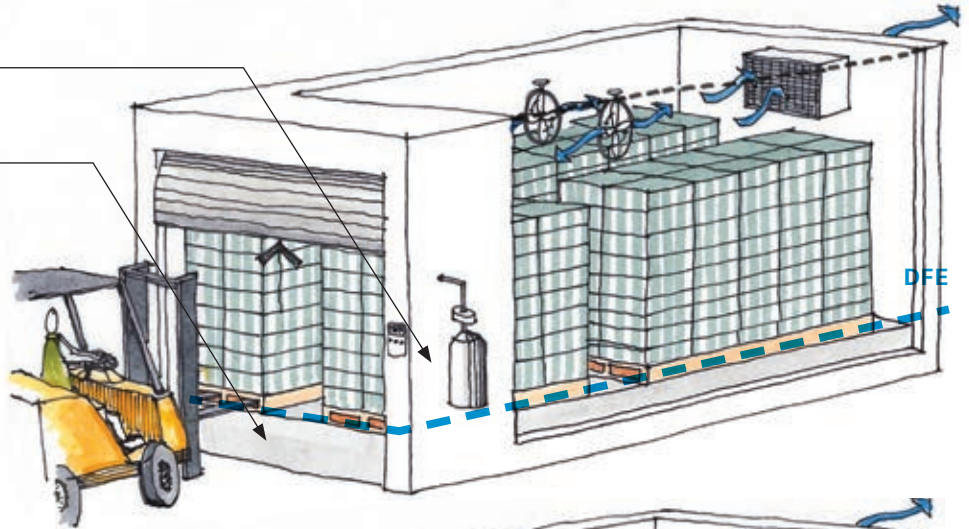
Additionally, space is needed within the building to store flood barriers, and staff must be trained to successfully install barriers in advance of flooding. The third option describes wet floodproofing, which involves raising electrical and mechanical devices above the DFE and installing flood resistant materials. Because inventory could not be protected with this method, a preparedness plan should describe steps to reduce inventory in advance of potential floods.

Move ethylene gas supply above the DFE

Elevate inventory to a concrete pad or platform above the DFE; structural reinforcement may be required to relieve additional load on existing walls

**APPROXIMATE COST\***  
Elevated floor (24") = ~\$4,800

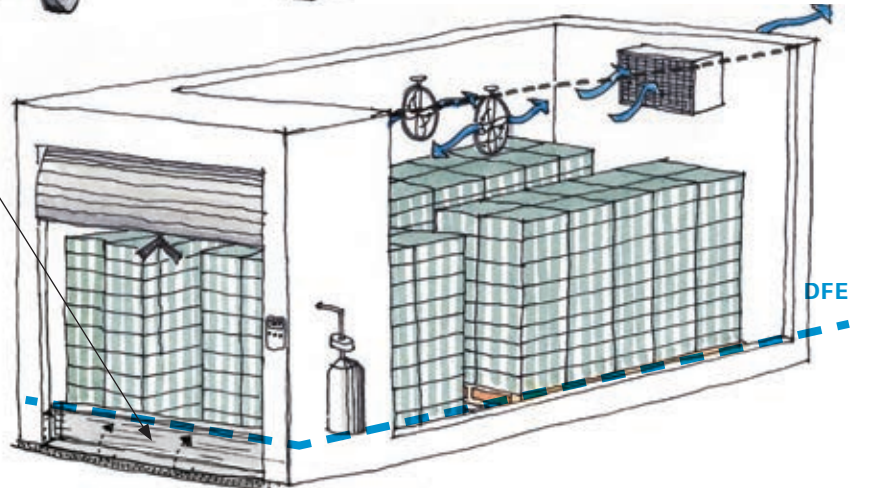
\*See cost estimation on pg. 110 for more info



Install deployable flood gates at opening of each ripening room and seal exterior walls so that they are impermeable to water.

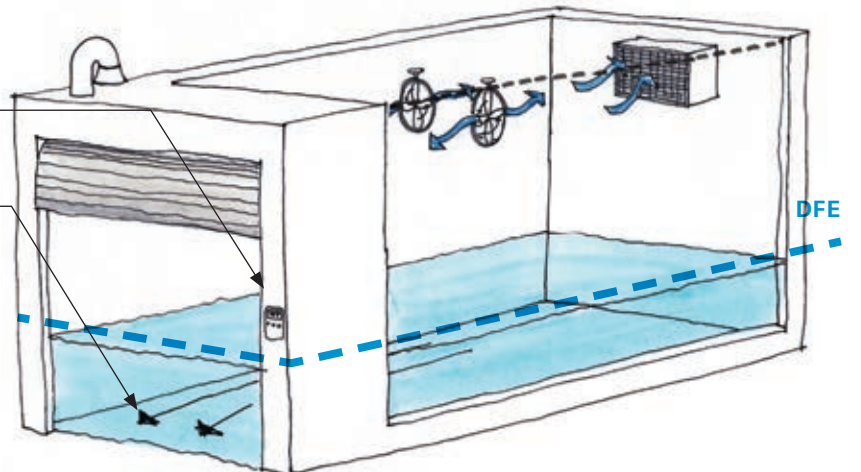
**APPROXIMATE COST\***  
Deployable flood barrier = ~\$1,200

\*See cost estimation on pg. 110 for more info



Move ethylene gas supply above the DFE

Ensure positive drainage out of ripening room





## RESILIENCY CHALLENGE

**Office space is particularly vulnerable to flooding:** Offices are typically constructed with fewer flood-resistant construction materials than warehouse spaces, yet they pose additional risk to companies that rely heavily on logistics. In particular, damage to computers or other business records could result in a major disruption to long-term operations.



## RESILIENCY MEASURES

**Wet floodproof office space:** Wet floodproofing tends to be a less expensive alternative than dry floodproofing. Rather than preventing flood water from entering the area, wet floodproofing involves installing flood-resistant construction materials below the DFE and flood vents that allow water to enter the structure. Creating systems that allow floodwater to enter more freely causes forces on either side of the structure's walls to equalize, minimizing the chance of more significant structural damage. A list of flood-resistant construction materials is provided in FEMA Technical Bulletin 2-08, Flood Damage-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas in accordance with the NFIP.



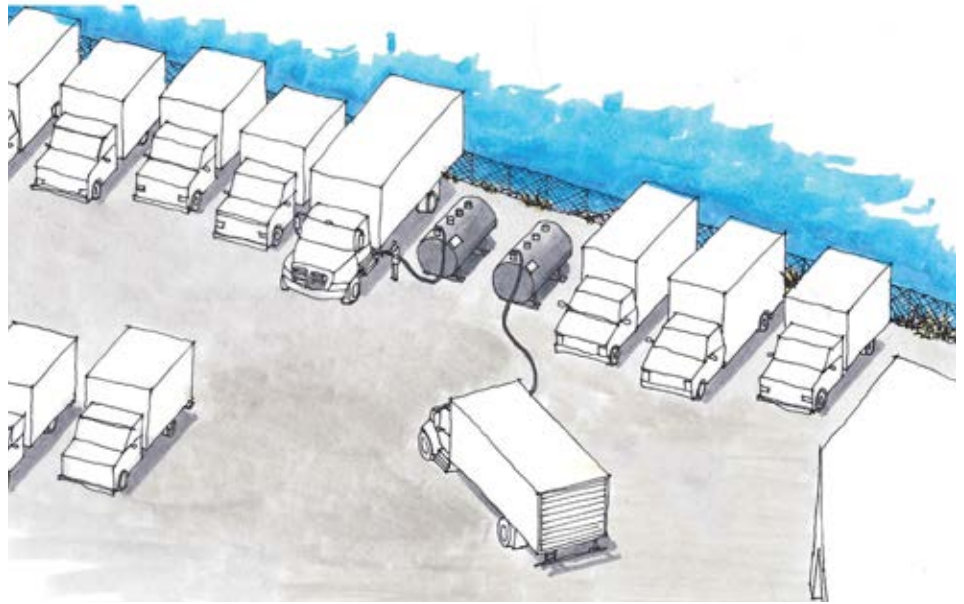
### APPROXIMATE COST\*

**Cost per flood vent = ~\$1,750**

*\*See cost estimation on pg. 110 for more info*

## RESILIENCY CHALLENGE

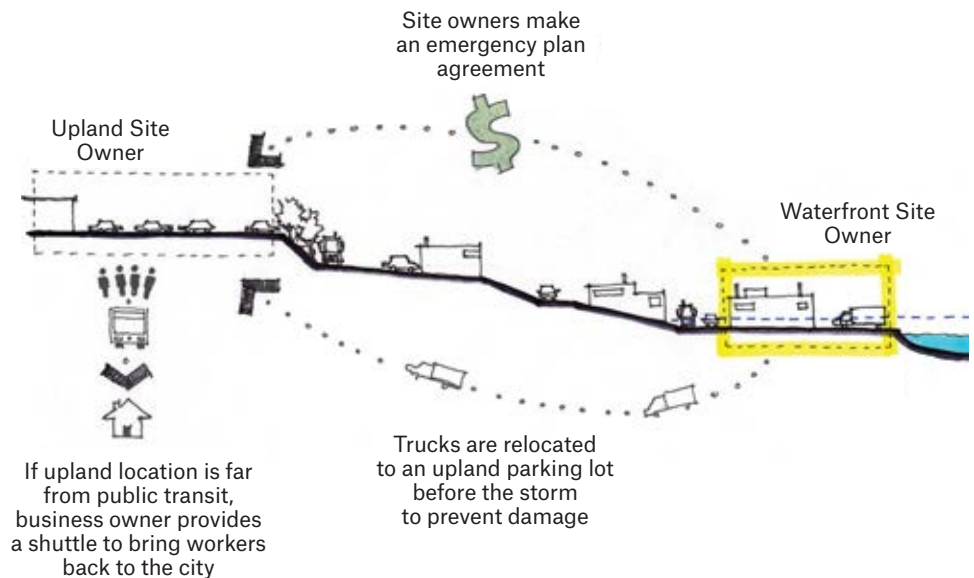
**Truck fleets parked within the flood zone:** Delivery trucks and other vehicles such as fueling tankers are regularly parked within the floodplain. Without sufficient planning to relocate fleets of trucks in advance of coastal storms and potential flooding events, the potential damage to vehicles may cause a significant financial burden and an impediment to resuming operations. The fuel, oil, and other hazardous substances within commercial trucks also pose an environmental risk, as flooding can result in spills and leaks.



## RESILIENCY MEASURES

### Preparedness plan to relocate trucks:

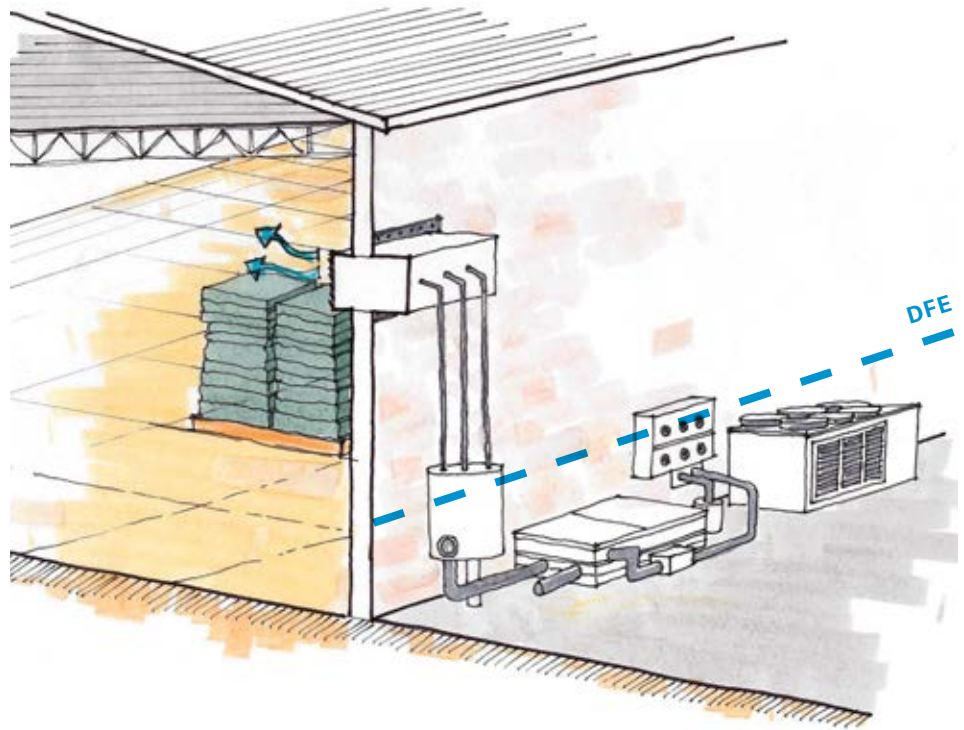
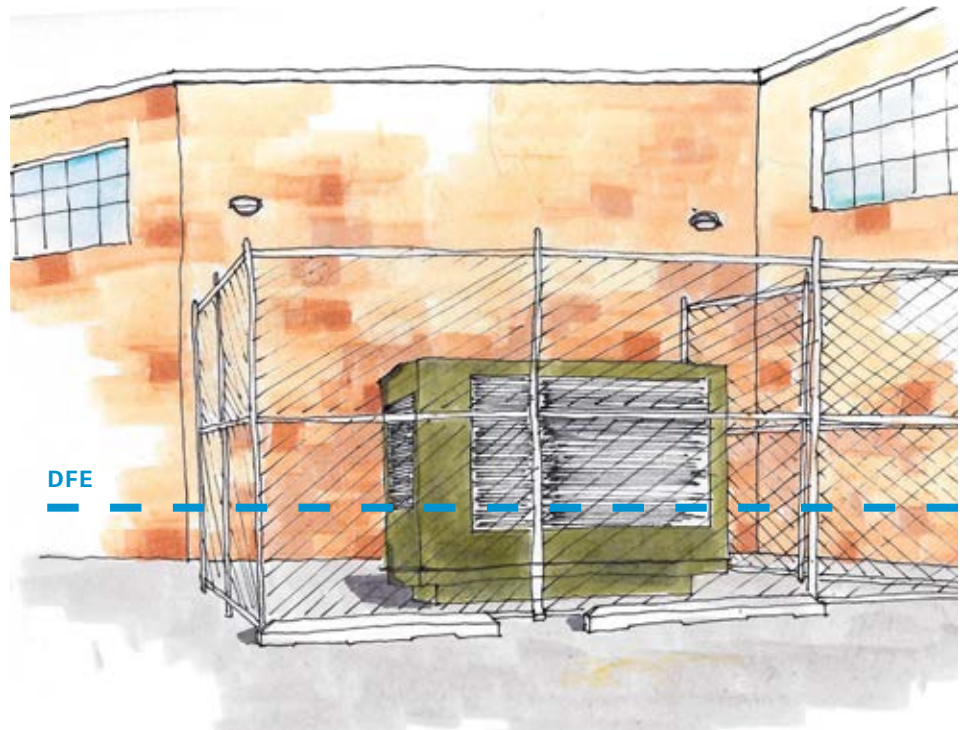
Facility preparedness plans should include steps to relocate vehicles to higher ground before a potential flood. Specifically, the plan should identify areas where trucks and other vehicles may be relocated, the timing of relocation as a storm approaches, how the trucks will be relocated, and by whom. The food distributor evaluated as a case study has prearranged with a company outside of New York City to rent excess parking space for future storms. At the end of the final shift before the company ceases operations for the storm, staff members would drive all 250 trucks to the designated parking area and several prearranged buses would shuttle drivers back to the food distributor's facility.





## RESILIENCY CHALLENGE

**Backup generators located below the Design Flood Elevation:** Backup power generators can play an important role in ensuring continuity of operations for industrial businesses. For food distributors that rely on refrigeration, reducing interruptions in power supply can prevent spoiled inventory. Generators installed at or near grade in the floodplain are often damaged and unable to serve their intended purpose in the event of flooding.



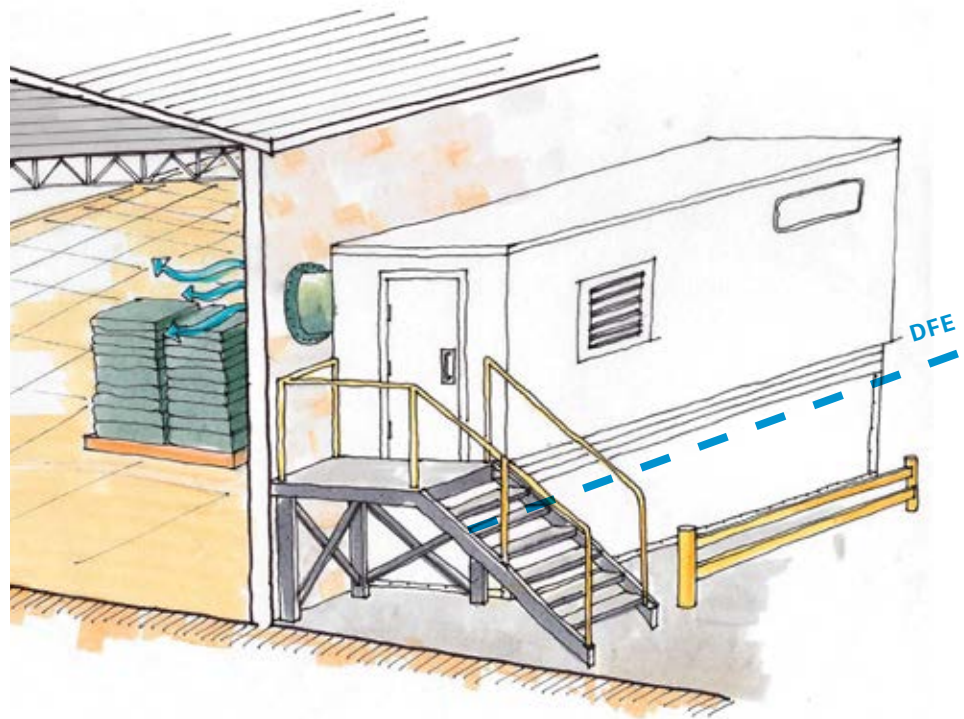
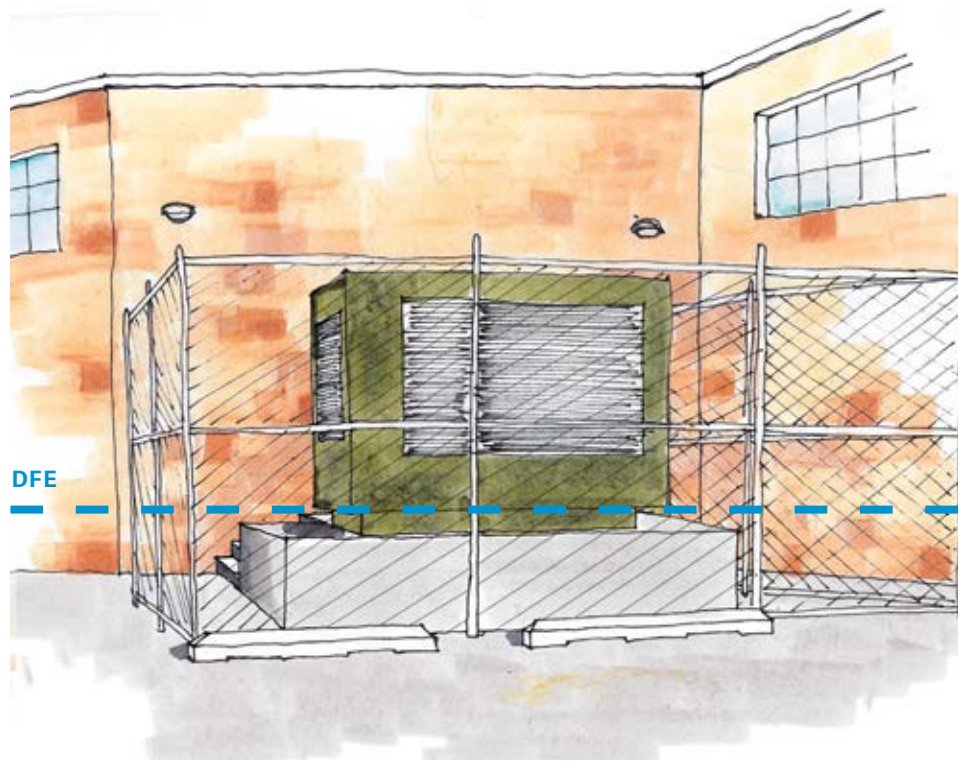
## RESILIENCY MEASURES

**Elevate generators above the DFE:** Power generators within the floodplain should be located above the DFE or adequately enclosed in a dry floodproofed space. Generators can be raised on concrete pads or steel platforms. All components of the emergency power system, such as transfer switches or pumps, should also be elevated. Where backup power systems are incapable of meeting the full operational demand of the facility, distribution systems should be directed toward key areas of the site to minimize losses and ensure that critical operations may continue or resume quickly. Companies that rely on refrigeration but do not have a generator on-site at all times should consider establishing a lease contract for an emergency generator and ensure that a transfer switch is installed in the building.

### APPROXIMATE COST\*

**Concrete platform to raise generator = ~\$41,800**

*\*See cost estimation on pg. 110 for more info*





# Ship Maintenance and Repair Facility



### Site Characteristics

<b>Shoreline length</b>	3,600 feet
<b>Floating dry docks</b>	7
<b>Design Flood Elevation (DFE) above grade</b>	3-11 feet

### Business Profile

A ship maintenance and repair facility was selected as a case study to explore flood resiliency measures for large industrial sites that provide maritime-support services. Many businesses within the maritime-support services sector facilitate operations of the Port of New York and New Jersey, the largest port on the East Coast. These are particularly prevalent along the north shore of Staten Island, as well as Sunset Park and Red Hook in southwest Brooklyn.

The business selected for the study is one of the largest ship maintenance and repair facilities in the region, with seven floating dry docks and several piers and floating barges used for pier-side repair work. More than 300 small to medium sized vessels are serviced at this site annually. The business employs more than 200 full-time employees.

### Flood Risk Profile

The majority of the property is located within the 1% annual chance floodplain, with small parts of the upland site located in the 0.2% annual chance floodplain. Beginning several days in advance of the storm, the business began taking steps to prepare the site and minimize damage. Staff unbolted and removed heavy machinery from piers, secured and anchored other immovable equipment, and relocated the business' fleet of more than 50 vehicles to higher elevations.

Despite these preparedness steps, the business experienced significant flooding and damage during Hurricane Sandy that resulted in more than \$3 million in losses. While the business does carry property insurance, it has decided not to maintain a flood insurance policy, choosing instead to self-insure. Therefore, all of the Hurricane Sandy recovery costs were absorbed by the business.

Major electrical systems, including several 500 KW and 1,000 KW substations, were severely damaged or destroyed. Similarly sized backup generators that were located on piers were also flooded.

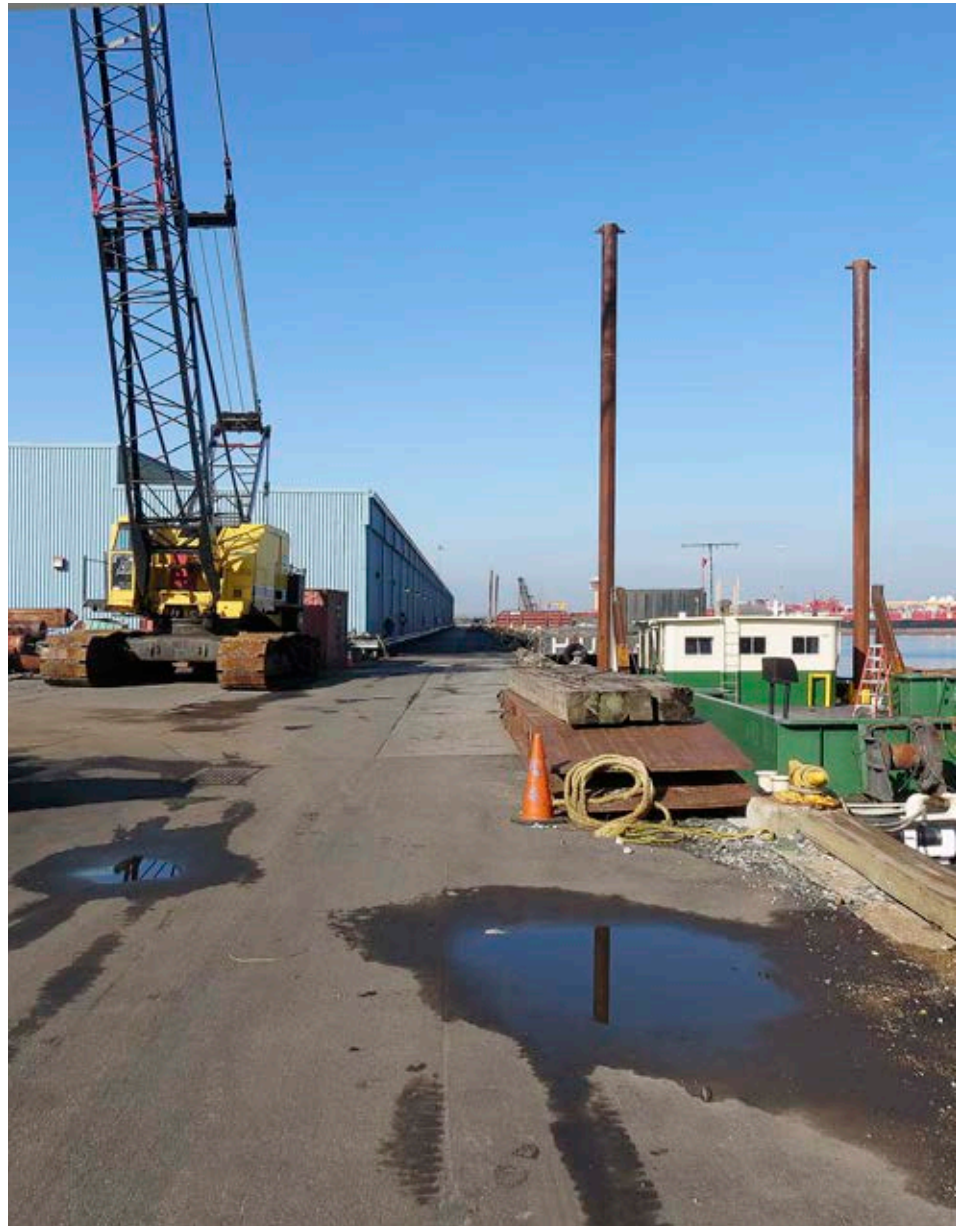
Fortunately, there was no significant damage to dry docks or floating piers. Unlike floating piers, which were able to safely rise with storm surge, stationary piers were overtopped and several were damaged during Hurricane Sandy.

Since most dry docks were installed with 500 KW generators, the facility was able to resume operating the following day by running power from these generators landward to power the site. The facility also has a modern oil barge on-site, which

was undamaged during Hurricane Sandy. The fuel on-hand in this barge was critical for powering generators and equipment, despite regional fuel distribution shortages and power outages.

#### **Challenges and Resiliency Measures**

Ship repair and other maritime support services such as tug and barge operations have common characteristics that affect their vulnerability to flooding. The following examples demonstrate strategies to minimize damage from flooding that may apply to a range of similar industrial businesses in New York City.





## RESILIENCY CHALLENGE

### Electrical substations below the DFE:

Many industrial sites install and maintain one or more electrical substations on-site for electrical distribution. When operating below expected flood levels, critical components of substations, including switching, protection and control equipment, and transformers, may be exposed to floodwater and permanently damaged. In addition to repair or replacements costs, which can be extremely high, loss of high-capacity electrical supply for industrial activities can hinder operations.



## RESILIENCY MEASURES

### Elevate electrical substations:

Substations and other permanent electrical equipment can be elevated above the DFE, either on elevated platforms or on concrete pads where flood elevations are lower. Substations can be elevated most cost-effectively during the initial installation or when electrical equipment is replaced over time. However, this can also be accomplished as a retrofit for existing equipment to mitigate flood damage.



### APPROXIMATE COST\*

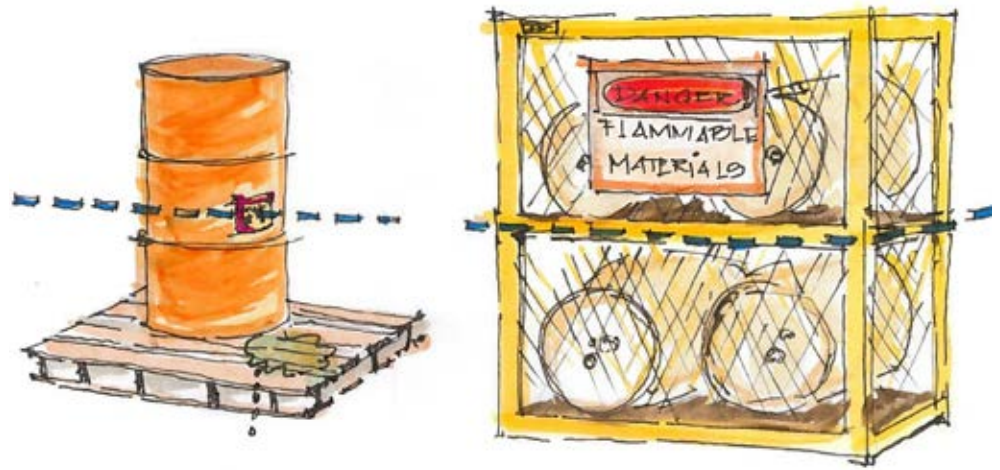
**100 sf steel platform = ~\$27,700**

*\*See cost estimation on pg. 110 for more info*

## RESILIENCY CHALLENGE

### Unprotected hazardous substances:

Most industrial processes require storage and use of hazardous substances to facilitate daily operation. Improper storage of hazardous substances can result in leaks or spills that can degrade the environment and put workers or neighboring communities at risk. If not properly secured, tanks, barrels, or other containers of hazardous substances may be undermined or displaced by flooding. In addition to the potential for leaks due to ruptured containers or inadequate seals, unexpected harmful consequences such as explosions resulting from the accumulation of gases from ruptured tanks can pose a significant risk.



## RESILIENCY MEASURES

### Safely store hazardous substances to reduce leaks or spills:

Where possible, hazardous substances should be permanently stored in areas outside of the floodplain. To prevent leaks during everyday operations, containment bunds can be purchased to place beneath barrels or other containers with hazardous substances. Storage containers should be watertight, sheltered from rain, isolated from stormwater runoff, and stored using overpacks to prevent spills. For smaller containers, flammable and acid cabinets can help secure and contain hazardous substances. Where infeasible to relocate outside of the floodplain, containers and tanks that contain hazardous substances should be elevated, safely secured, and anchored to prevent spills and leaks. Appendix G of the NYC Building Code requires that above-ground tanks be elevated to the DFE and designed to prevent flotation, collapse, and lateral movement. Petrochemical fuel tanks may also be installed on trailers, making it easier to relocate to higher locations on-site, or to safe locations off-site, in advance of a potential flood or coastal storm.





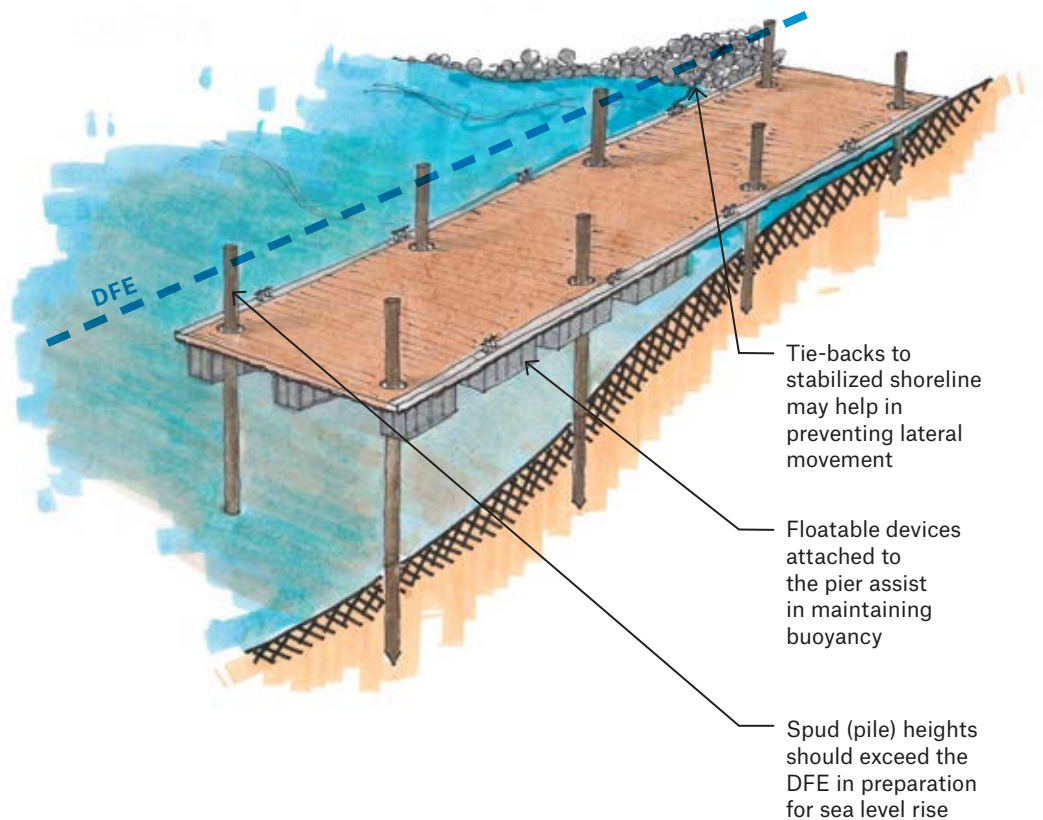
## RESILIENCY CHALLENGE

**Stationary piers vulnerable to flood damage:** Piers are an essential asset to many maritime businesses, including tug and barge operations and ship maintenance and repair. Stationary piers are situated above the water line and mounted on pilings driven in the ground. During coastal storms with storm surge, stationary piers may be overtopped or damaged by wave action. As sea levels rise, existing stationary piers are likely to be inundated by floodwaters more frequently. Damage to piers, or damage to equipment and machinery located on these structures, can hinder operations of the city's port and maritime industry.



## RESILIENCY MEASURES

**Replace stationary piers with flexible piers on spuds:** When stationary piers are damaged or need to be replaced, mechanisms that allow piers to safely rise and fall with water levels can be an effective form of flood mitigation and sea level rise adaptation. The ship repair and maintenance facility used as a case study has chosen to replace several stationary piers with rail barges that are mounted on spuds through the deck. Flexible piers or barges on spuds are more resilient to flooding by allowing for tidal fluctuations, storm surge, and sea level rise.



# Automobile Dismantler



## Site Description

<b>Lot size</b>	5 acres
<b>Design Flood Elevation (DFE) above grade</b>	1-7 feet
<b>Shoreline conditions</b>	Rip-rap revetment

## Business Profile

An automobile dismantler was selected as a prototypical site to explore flood resiliency challenges and mitigation measures for large, unenclosed industrial sites that contain immovable machinery and equipment. The selected business occupies a site that is approximately five acres and located entirely within the 1% annual chance floodplain. The business purchases inoperative cars from auto shops and private individuals. The cars are then dismantled and used auto parts and scrap metal (copper, lead, aluminum, etc.) are sorted, stored, and resold. Prior to Hurricane Sandy, the business employed approximately ten workers. In large part because of damage caused by Hurricane Sandy, the business has downsized to approximately three full-time staff.

## Flood Risk Profile

The DFE on the automobile dismantler's site is very high, ranging from approximately one to seven feet above grade. Due to the nature of the business, the size of the site, and the number of cars and heavy parts, it is very difficult to protect the business's inventory from flooding. In addition to the potential for damage during floods, the presence of hazardous substances, such as oils, gasoline, and transmission fluid, pose an environmental and public health risk. The business does not carry a flood insurance policy.

During Hurricane Sandy, the automobile dismantler's property was inundated by five to eight feet of water. The majority of the business's inventory of cars and auto parts was destroyed. The flooding also damaged several pieces of equipment, including a car crusher and a forklift. A small office on the property was also destroyed by Hurricane Sandy and subsequently replaced by a temporary trailer. In total, the business estimated that the storm damage totaled \$500,000. While it is possible that hazardous substances leaked out of some cars that were inundated by flooding from Hurricane Sandy, the company did take steps in advance of the storm to have its tanks of used oils and automotive fluids emptied, which amount to several hundred gallons of hazardous substances that were removed from the facility before the storm.

## Challenges and Resiliency Measures

Auto dismantlers, scrap metal recycling facilities, and other large, unenclosed industrial sites have common characteristics that affect their vulnerability to flooding. The following examples demonstrate strategies to minimize damage from flooding that may apply to a range of similar industrial businesses in New York City.



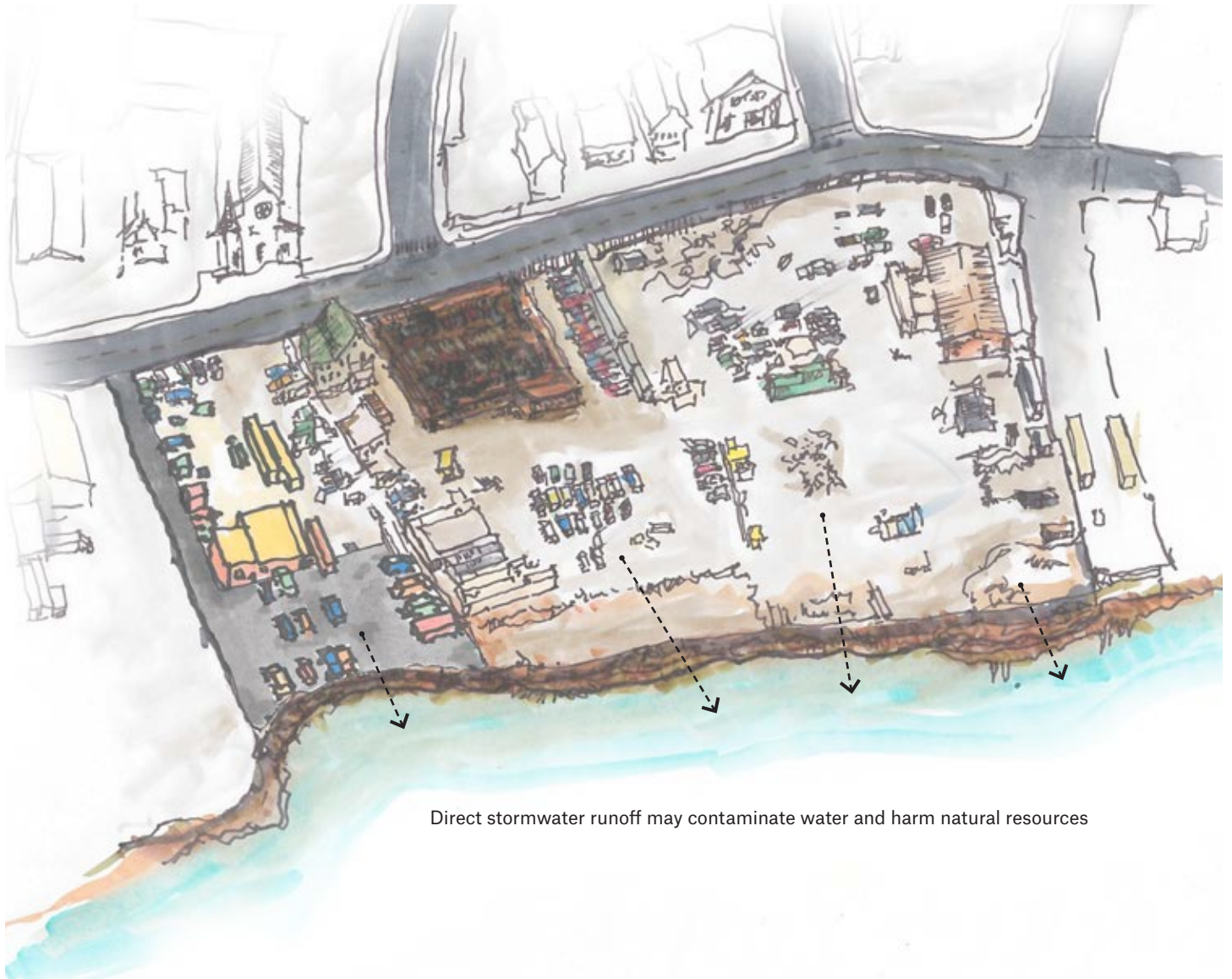
## RESILIENCY CHALLENGE

### Stormwater runoff:

Open industrial facilities can contribute to water contamination when stormwater runoff is exposed to unenclosed materials. The absence of appropriately installed stormwater treatment systems can create a wide range of impacts. Stormwater runoff can pick up oils, grease, sediment, bacteria, debris, litter, and other contaminants and convey them into a storm sewer, a combined storm and sanitary sewer, or directly into coastal or riverine waters, depending on the location of the site. Hazardous materials carried by stormwater can also leach into the

soil or ground water, contaminating the soil and underground aquifers. Leaching of chemicals and other pollutants often occurs when dismantled cars and discarded appliances are stockpiled in open yards. Open industrial sites that drain directly into the city's municipal sewer infrastructure can create costly maintenance problems. For example, concrete dust and other particulate matter can block city drains, triggering a system backup and flooding in the streets or on private property. Without proper controls, open industrial uses located adjacent to waterways or in the floodplains can pose

further threats to coastal waters and tributaries during a severe storm or flood as a result of strong winds or elevated waters that can disperse unsecured materials off-site.



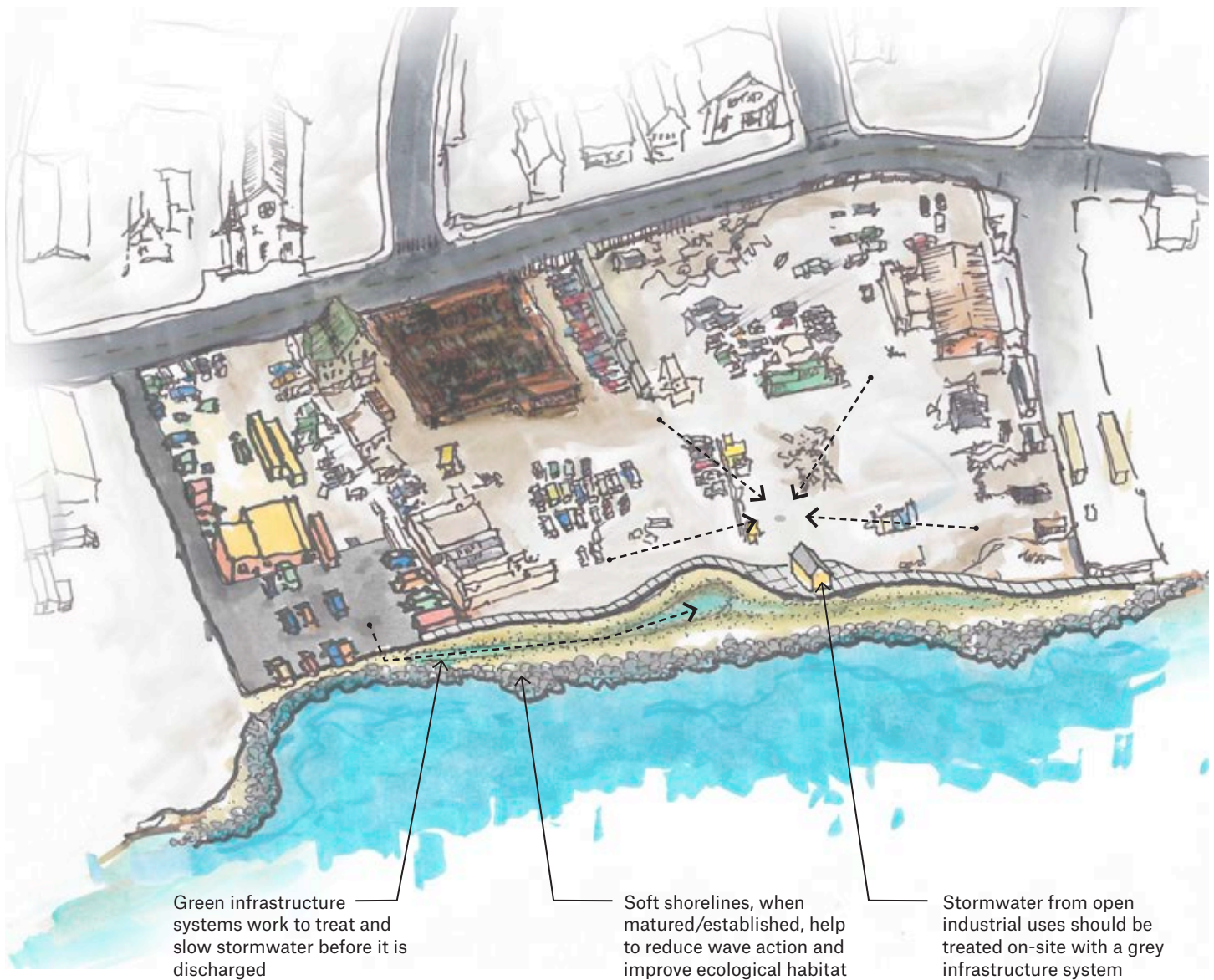
Direct stormwater runoff may contaminate water and harm natural resources

## RESILIENCY MEASURES

**Green infrastructure to manage stormwater runoff:** Green infrastructure can be a valuable solution for absorbing or storing stormwater runoff. However, it should be carefully sited to avoid accidentally infiltrating pollutants into the surrounding soil, ground water, and surface waters. Green infrastructure should not be placed in areas with the potential for high concentrations of pollutants, such as heavy metals, oil and grease, chemicals, or other hazardous

materials. Generally, this means placing green infrastructure up-gradient of process and storage areas on industrial sites and redirecting contaminated stormwater away from green infrastructure. In the example below, green infrastructure may be effective for managing stormwater resulting from an employee parking area. Green infrastructure, such as native vegetation, bioswales, and green space can increase permeability of the infiltration system, absorb rainfall, and

prevent water from overwhelming the stormwater system. The intention of green infrastructure for stormwater management is to decrease the volume of water that enters waterways as direct runoff through a combination of practices that infiltrate, evapotranspire, or store runoff for beneficial use. In areas affected by coastal flooding, green infrastructure and open space preservation can complement grey infrastructure approaches to further reduce damage to infrastructure and property.





## RESILIENCY CHALLENGE

**Unenclosed and unsecured inventory vulnerable to flooding:** Auto parts and valuable salvaged materials that are submerged due to flooding, especially with saltwater, are likely to develop rust or be destroyed, eliminating their resale value. In addition to damaged inventory, unsecured auto parts and scrap metal that are dislodged by flooding can severely harm structures or equipment on the property and create similar hazards for nearby properties.



## RESILIENCY MEASURES

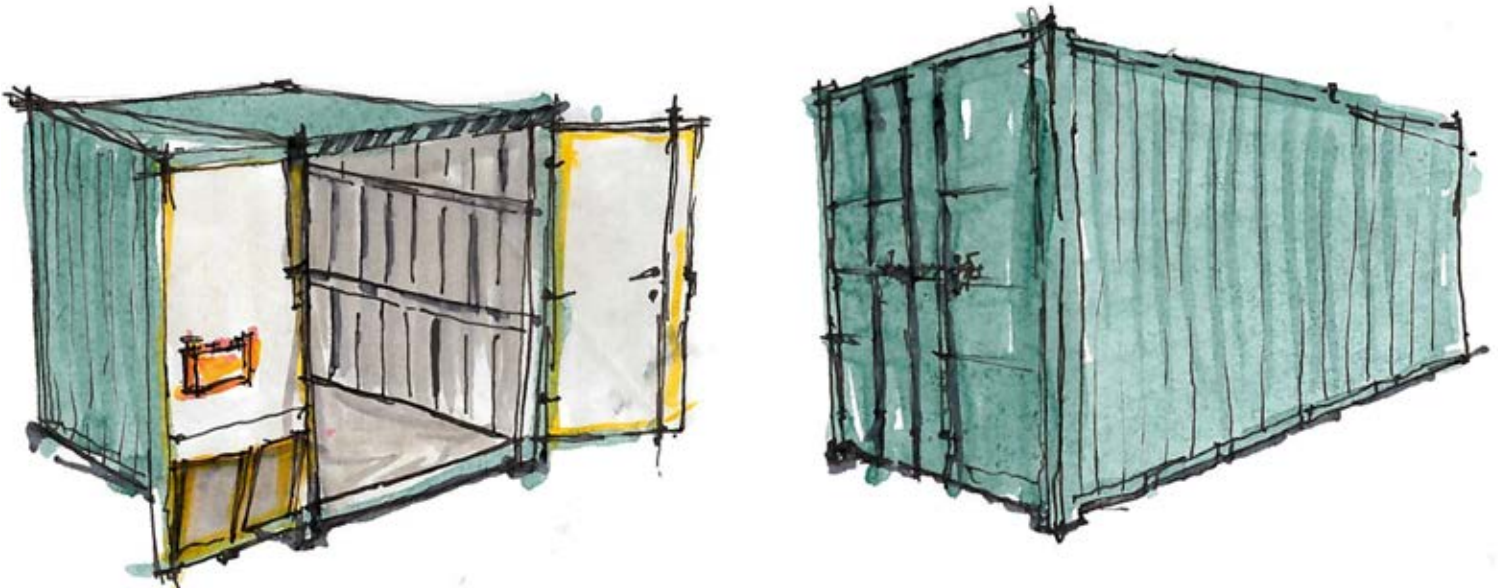
**Store inventory in anchored shipping containers:** Because of their low cost and durability, many industrial companies use shipping containers as makeshift storage structures. Shipping containers with water-tight doors can be purchased for approximately \$2,500. The automobile dismantler case study installed shelving within the container and uses upper shelving to store more valuable

equipment, such as salvaged catalytic converters or transmissions. Enclosed storage also protects valuable inventory from being displaced by wind. It is important to note that shipping containers used for permanent storage are required to comply with Appendix G of the NYC Building Code and should be secured to the ground.

### APPROXIMATE COST

Shipping containers = ~\$2,500

Elevate and anchor shipping container on 2' foundation = ~\$11,200



## RESILIENCY MEASURES

### Install outdoor shelving to organize and secure inventory off the ground:

Securing auto parts above grade with anchored shelving can help minimize damage from flooding. Higher value auto parts or other inventory that are most sensitive to flooding or saltwater should be prioritized and stored at higher elevations or moved to enclosed storage in advance of expected flooding.





# Industrial Dry Cleaner



## Site Description

<b>Building floor area</b>	3,900 square feet
<b>Year built</b>	1898
<b>Design Flood Elevation (DFE) above grade</b>	3-5 feet

## Business Profile

Many dry cleaners and wet garment cleaners are located in industrial areas of New York City. The industry is trending toward larger, consolidated cleaning facilities with separate retail storefronts or pick-up and delivery service. Industrial scale cleaners provide an important service that supports other thriving sectors of the city's economy, including restaurants, hotels, and airports.

A dry cleaner was selected to better understand flood resiliency measures applicable to modestly sized industrial facilities with high-value, immovable equipment. The selected site has two retail storefronts located within the city, and also provides pick-up and delivery service to retailers and individual clients with a fleet of three large vans. The dry cleaning space operates out of a two-story, masonry building constructed in the 1890s. Cleaning equipment is all located on the ground floor, while finishing (e.g., ironing and bagging) occurs on the second floor. A modified shipping container is attached to the rear of the building and contains the boiler, air compressors, and additional supplies. Nearly 20 people are employed on-site, with additional employees located at the retail locations.

## Flood Risk Profile

The dry cleaner used as a case study is located entirely in the 1% annual chance floodplain, with a DFE of approximately three to five feet above grade. During Hurricane Sandy, floodwaters rose nearly five feet within the building, inundating both dry cleaning machines and wet cleaning machines located on the first floor. Some electrical components and motors of dry cleaning machines were damaged. Because of the high risk associated with perchloroethylene (PERC), these machines are bolted to the ground and operate on a sealed, closed-loop system. Therefore, floodwaters did not enter the dry cleaning machines, which left them mostly undamaged. Several wet cleaning machines were destroyed by flooding, which cost approximately \$25,000 each to replace.

Within the shipping container attached to the rear of the building, air compressors were destroyed and a boiler became buoyant and was destroyed during Hurricane Sandy. Water soluble solvents and detergents were uncontained and spilled during the flood. All three vans owned by the company were parked outside the business and were totaled by the storm. These were covered and replaced by individual vehicle insurance policies. In total, the business estimated damages to be approximately \$575,000.

The business did not have flood insurance prior to Hurricane Sandy, which the owner was unaware of until after the storm. However, the business has since decided not to carry a flood insurance policy because the quoted premium of \$100,000 annually seemed too high relative to potential damages from future storms. Instead the business is interested in minimizing losses by improving preparedness planning and investing in flood mitigation.

### **Operational Resiliency**

Based on its experience during Hurricane Sandy, the dry cleaner has developed a preparedness plan to reduce damages during future predicted flooding events and ensure continuity of operations. The plan specifies that, in advance of a storm, electrical components such as pumps and controls will be removed from dry and wet cleaning equipment and stored on the second floor or in another location

outside of the floodplain. Staff receive regular training to safely remove these components.

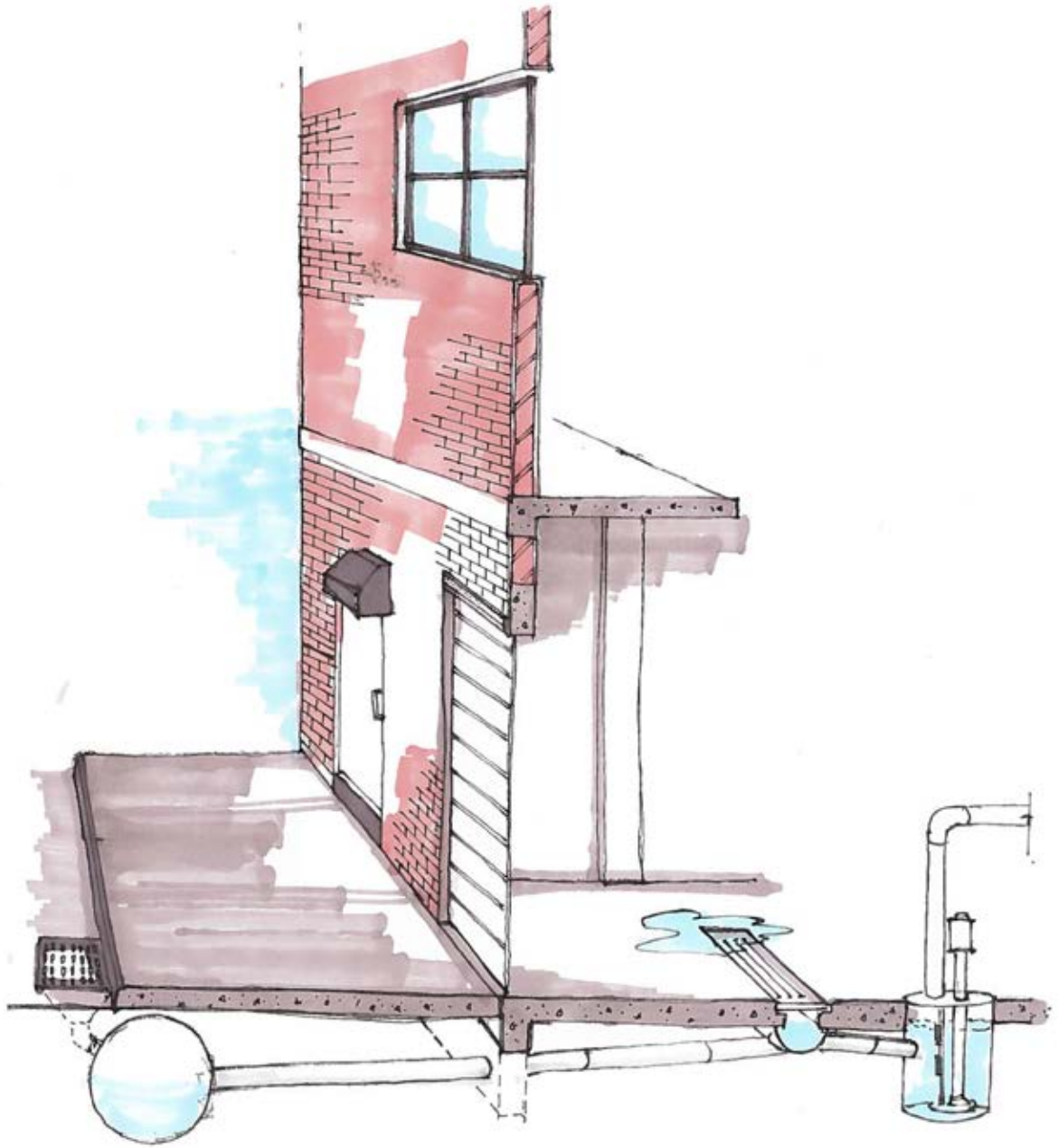
In addition, the dry cleaner has created an agreement with another dry cleaning business located outside of the floodplain to be able to temporarily use its facility in the event of future flooding or another type of disruption. The preparedness plan describes staffing arrangements to operate at night while the temporary facility is not in use.

### **Challenges and Resiliency Measures**

Industrial dry cleaners and other smaller industrial spaces containing high-value equipment have common characteristics that affect their vulnerability to flooding. The following examples demonstrate strategies to minimize damage from flooding that may apply to a range of similar industrial businesses in New York City.







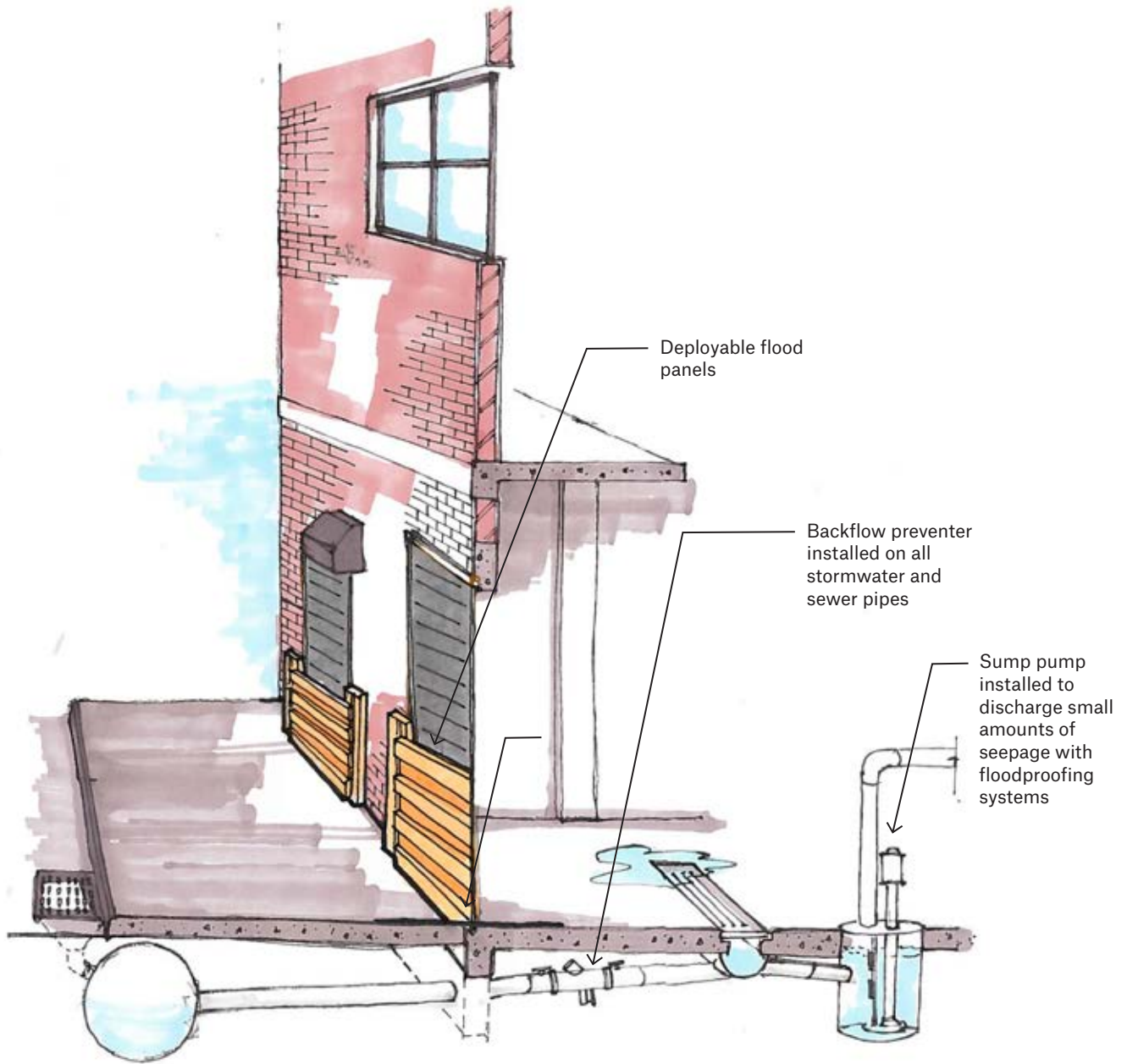
## RESILIENCY CHALLENGES

### **Valuable and immovable dry cleaning equipment unprotected from flooding:**

The dry cleaning and wet cleaning machines are the most valuable physical assets of the case study business. These are unprotected and uninsured from flooding. Damage to this equipment poses a significant financial risk for the business and has the potential to delay recovery time following storms. The use of hazardous materials for dry cleaning operations increases the risk of this equipment being located below the DFE.

### **Stormwater backflow can result in interior flooding despite dry floodproofing:**

Even if buildings are dry floodproofed to prevent floodwater from entering, coastal storms and flooding can overwhelm drainage systems, resulting in stormwater backflow that causes flooding from within the structure.



## RESILIENCY MEASURES

### Dry floodproof exterior of building:

The relatively small footprint of the dry cleaner and the high potential cost for flooding makes dry floodproofing an option that should be considered to improve flood resilience. Dry floodproofing typically involves sealing a building's exterior and openings to prevent water from infiltrating in the event of a flood. Many different products exist for dry floodproofing, including flood panels, waterproof membranes for walls, and waterproof doors and gates. If dry

floodproofing systems must be manually deployed in advance of a flood, regular training of staff and maintenance of equipment should be conducted to ensure systems remain effective.

### Install sump pumps to remove excess water:

Sump pumps are able to remove small amounts of water that leak into a building and are an important component of dry floodproofing systems. Sump pumps are installed below the ground floor and consist of drainage pumps that automatically remove water from sump pits through discharge pipes.

### Install backflow preventer on stormwater pipes:

Backflow preventers, also called backflow valves, ensure that stormwater is only able to flow in one direction, away from the building's stormwater drain.

#### APPROXIMATE COST\*

**Flood panels at door openings = ~\$15,000 each**

**Flood panels at roll-up gates = ~\$21,000 each**

**Install backflow preventer = ~\$15,800**

**Install sump pump = ~\$24,500**

*\*See cost estimation on pg. 110 for more info*



## RESILIENCY CHALLENGE

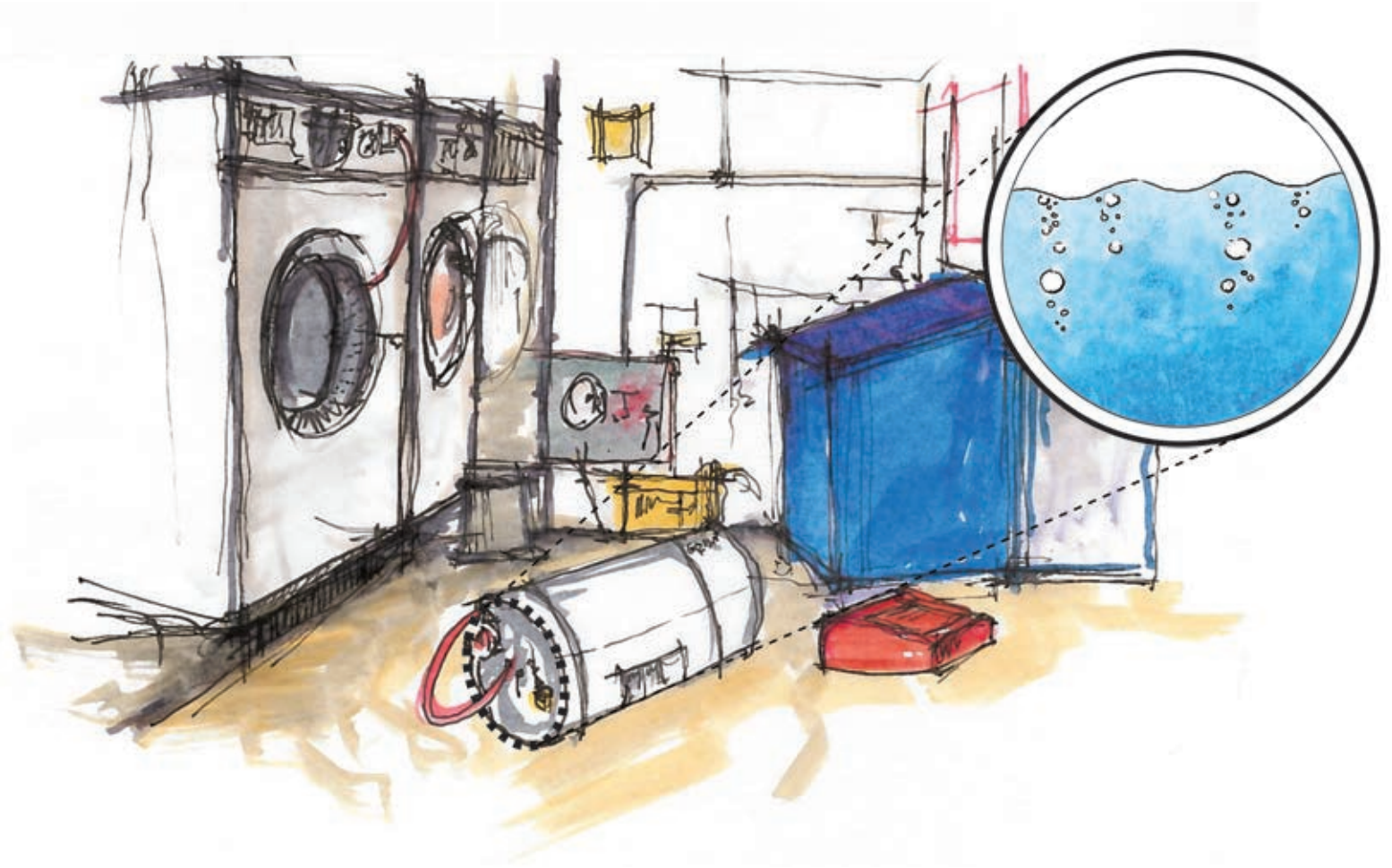
### **Debris impact load resulting from equipment dislodged by floodwater:**

Dislodged equipment during floods can become debris, which can cause further structural damage to the property. Unfilled water tanks and boilers may be removed from their locations by hydrodynamic forces and become buoyant. Depending on the weight of the object and water velocity, this can create additional damage to other equipment and structures on site.

## RESILIENCY MEASURE

### **Fill water tank to prevent buoyancy:**

To reduce the likelihood of water tanks being dislodged by floodwater and minimize risk of additional debris load, water storage tanks, particularly elevated tanks, should be filled in advance of storm events. This serves to maintain fully pressurized water mains during the storm, provide backup water supply in the event of power outages, and weigh down elevated tanks that may be affected by heavy winds and flooding.





503





New York Container  
Terminal in Staten Island



# 5

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## Operational Best Practices

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Preparedness planning is a key component of resiliency for any business. This is particularly true for New York City's industrial businesses, many of which have significant investments in vehicles, equipment, and inventory that can be moved out of harm's way with proper foresight and planning. The experience of industrial businesses during and following Hurricane Sandy reinforced the importance of operational strategies to minimize flood losses, and demonstrated the challenges that many existing businesses faced in entirely floodproofing facilities or locating outside of the floodplain.

Unlike physical mitigation and building retrofits, many operational strategies require minimal time or money and can prevent significant damage to businesses. These strategies do, however, require that a business evaluates its unique vulnerabilities, develops and maintains plans, and regularly trains staff members to execute emergency plans when the business is faced with a potential hazard. The following steps outline key actions to help ensure that businesses continue to operate during and after a flooding emergency.



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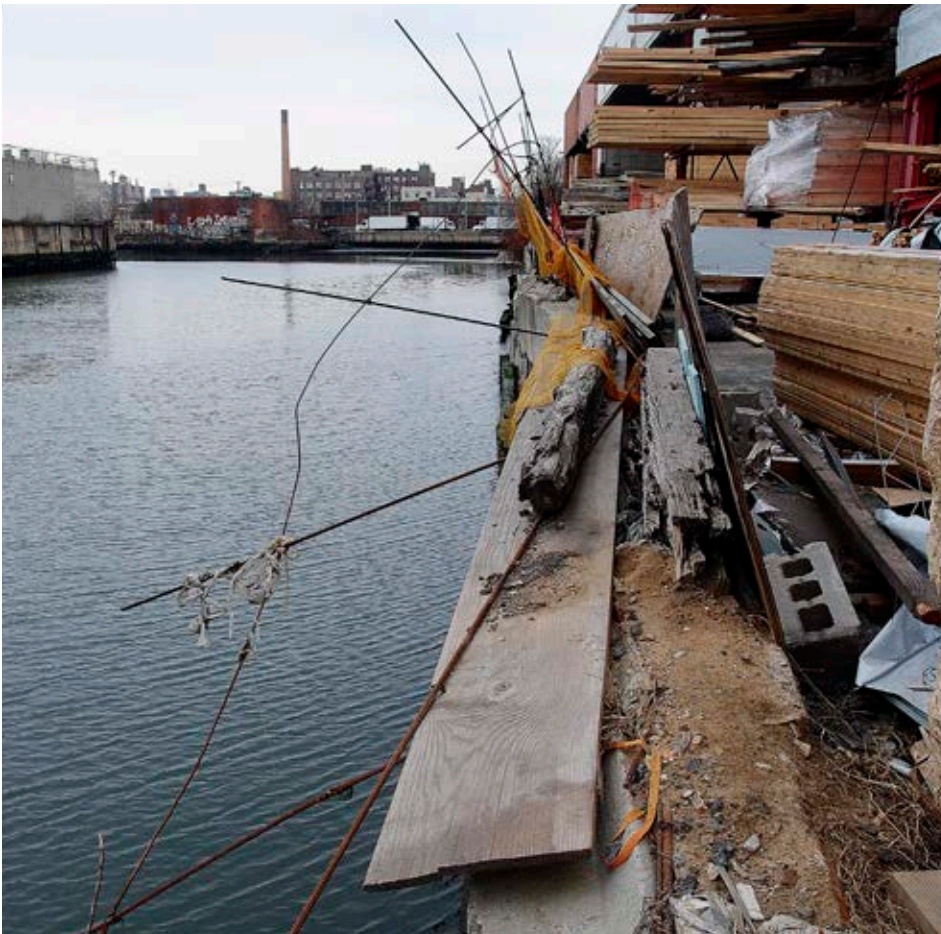
## Step 1 Assess the Hazards

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Businesses should consider how potential emergencies, such as flooding or transportation disruptions, may affect their ability to function efficiently. For example, if a power outage may affect the ability to pump fuel, businesses that rely on fuel to operate should consider whether manual pumping mechanisms or backup power systems could be installed to maintain operations. NYC Emergency Management's resource [NYC's Risk Landscape: A Guide to Hazard Mitigation](#) provides an overview of the primary hazards and potential impacts affecting the city.

The FIRMs are the first step for businesses to understand their flood risk. These can be accessed from [NYC Flood Maps](#). For real-time weather information, forecasts, and warnings, businesses should consult [NYC Severe Weather](#) or the [National Weather Service](#) and stay informed about local emergencies through [Notify NYC](#).

**Businesses should assess potential flood risks through preparedness planning and take steps to protect inventory.**



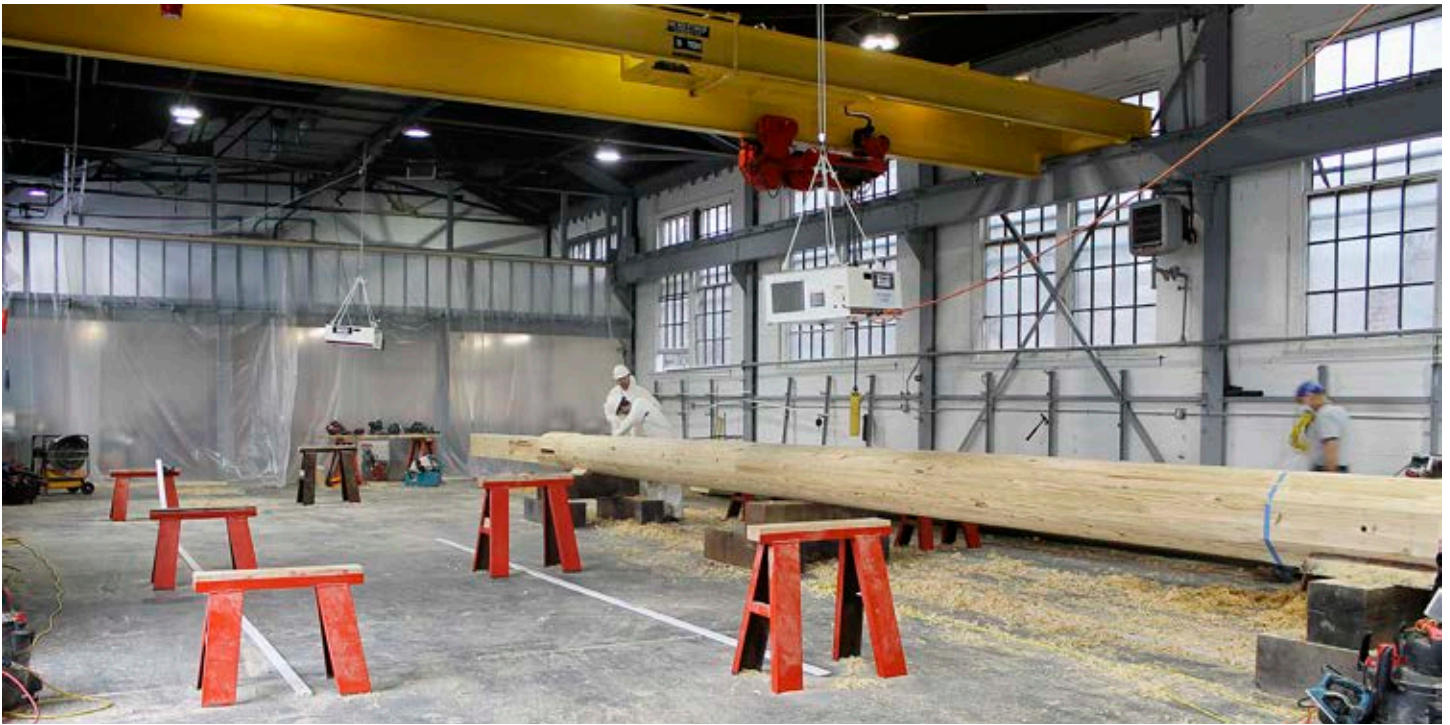
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## Step 2 Plan to Stay in Business

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Planning before a disaster can help businesses return to operations more quickly, or even avoid interruptions altogether. Businesses should start by taking the following steps:

- Identify operations that are critical to business functions and recovery. Determine which staff, materials, procedures, contacts, and equipment are absolutely necessary to keep the organization operating.
- Make a list of the most important contacts and clients, and plan ways to communicate with them during and after a disaster.
- Coordinate with vendors, suppliers, and other organizations and people that the business depends upon.
- Keep copies of important records that may be needed to rebuild the business in a portable container that is both waterproof and fireproof. Digital records should also be updated and saved on the cloud or an off-site computer. A second set of these records should also be stored at an off-site location.
- Review preparedness plans annually. Just as the business changes over time, so do preparedness needs. When hiring new employees, or when there are changes in how the company functions, plans should be updated and staff informed of changes.
- Businesses are encouraged to enroll in the [Corporate Emergency Access System \(CEAS\)](#). CEAS authorizes essential employees to access restricted areas following an emergency.
- Preparedness plans should also note key actions to take if the business is damaged. This includes taking photographs of the building, equipment and contents from different angles, and documenting details about any damaged equipment or inventory that can later be used to support insurance claims.



**Core investments can be suspended from the ceiling or elevated to avoid flood damage.**

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### **Step 3 Communicate with Staff**

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Employees are a business's most valuable asset. It is important to talk to employees often about what to do before, during, and after a flooding emergency. Businesses should consider establishing a call tree, an email alert, or a call-in voice recording to communicate with employees. When creating a plan, employees' special needs should be considered. Businesses should also encourage employees to prepare for emergencies at home. One of the best methods to ensure a company's recovery is to provide for its staff's well-being.

Following disruptions, preparedness plans and protocols should be evaluated and revised based on lessons learned. Many industrial businesses require a day or two to fully prepare for flooding, which may include relocating vehicle fleets, moving equipment to higher elevations on-site or to different locations, securing and adequately sealing hazardous materials, removing electrical components from equipment, and communicating with clients and vendors to alter delivery schedules. Staff should be aware of their responsibilities when floods are predicted, and trained to accomplish tasks that are not within their normal range of duties, such as installing deployable flood panels.

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### **Step 4 Protect Core Investments**

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Facility preparedness plans should identify physical and virtual assets that are essential to business operations and take steps to prioritize protection of these core assets. For physical machinery and equipment, the business should document a process to obtain replacements or replacement parts if the equipment is damaged. Every organization depends on utilities such as electricity, gas, telecommunications, and sewers. Preparedness plans should identify steps that should be taken if these services are disrupted.

Protecting data and information technology systems is also a key component of business continuity. Backups of all critical information (e.g., vendor lists, payroll, leases, and insurance policies) should be created, updated regularly, and stored in a safe location off-site.

At regular intervals, businesses should review insurance coverage, and understand what the policy or policies cover. Businesses should consider expanding insurance to include coverage for direct and indirect costs associated with a disaster. Examples of indirect costs include business interruption/continuation policy insurance, business income insurance, and extra expense insurance.





Photo Credit:  
Sunghwan Yoon<sup>15</sup>





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## Step 5

### Know How to Respond

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Every business should have an emergency action plan. This plan focuses on alerting employees to an emergency or an evacuation, the method for reporting emergencies to local officials, and evacuation plans. Businesses should regularly conduct evacuation drills and other emergency exercises.

Emergency action plans should consider opportunities to reduce interruptions by coordinating with other businesses or organizations. For example, industrial businesses may consider developing relationships with other businesses to share generators, assist with the installation of flood barriers or equipment relocation, or even arrange to temporarily rent other business's facilities in the event of flood damage.

For information about hurricane evacuation zones and additional information to prepare for coastal storms, businesses should visit the [Know Your Zone](#) website maintained by New York City Emergency Management.

#### More Resources for Businesses:

- Join [Partners in Preparedness](#) to receive additional support and resources to prepare for business interruptions.
- Learn more about personal preparedness from [Ready New York](#).
- Join [CorpNet](#) to receive current information about emergencies to enhance awareness and aid decision-making.
- Learn about various types of insurance from the [Insurance Information Institute](#).
- Prepare for cybersecurity risks with the U.S. Department of Homeland Security's [United States Computer Emergency Readiness Team](#).
- Avoid chemical spills during flooding by following [spill prevention recommendations](#) from the NYC Department of Environmental Protection.





# 6

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## **Policy Recommendations**

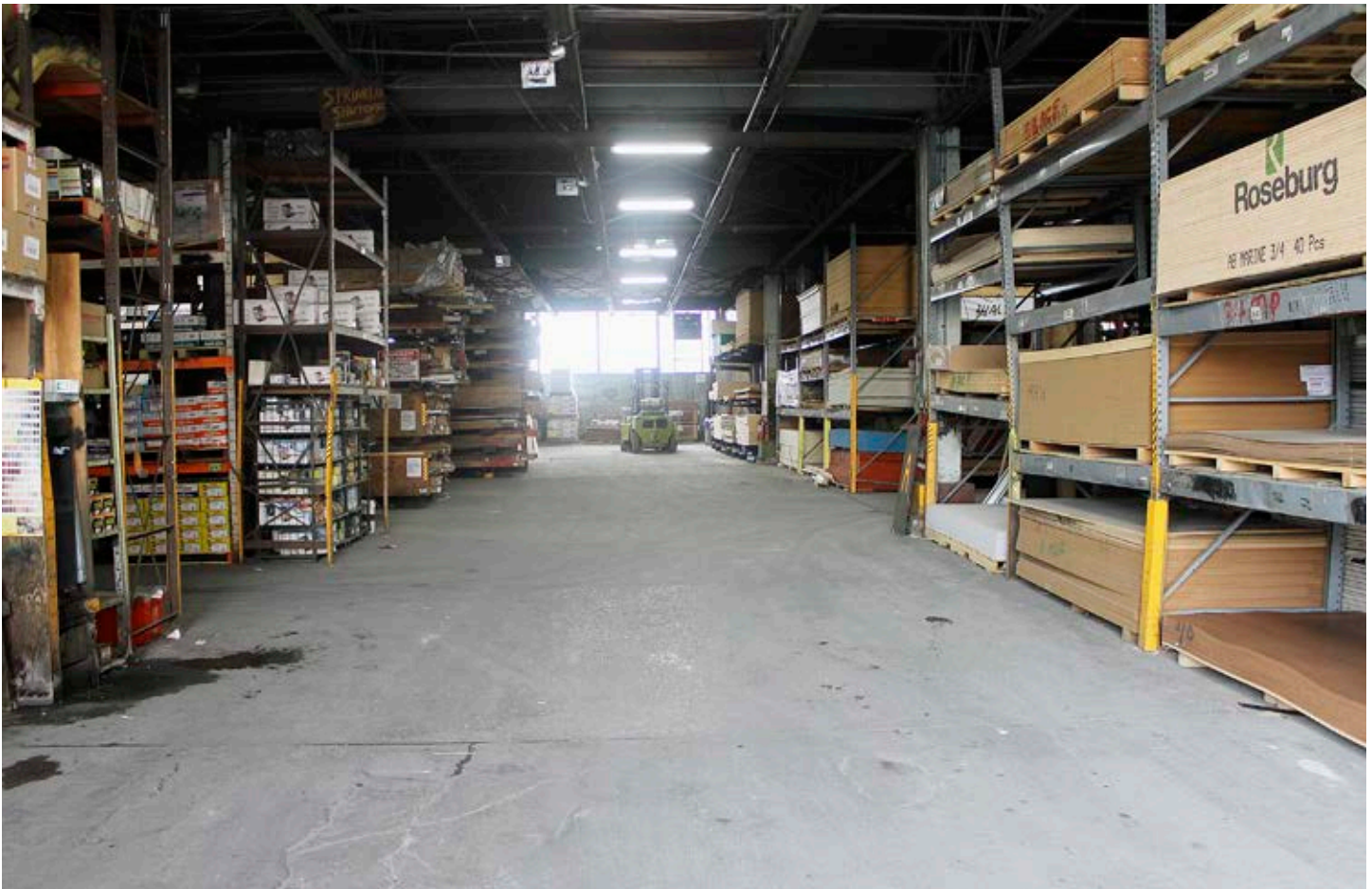
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In addition to the physical mitigation and preparedness strategies described in the previous two chapters, the study identified several regulatory strategies and policy recommendations to better promote industrial resiliency.

- 1 Modifications to the City’s zoning and building code regulations**
- 2 Technical and financial assistance to support mitigation and preparedness within the private sector**
- 3 Changes to the National Flood Insurance Program that would broaden flood insurance coverage and create more effective incentives to reduce risk**

The following policies and regulatory changes are recommended for consideration in order to remove existing barriers to flood resiliency and encourage private business to take steps to further reduce flood risk.





**Floor area limitations and parking requirements make it difficult for some businesses to add a second floor or mezzanine to existing structures.**

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## **Vertical enlargement of industrial buildings in the floodplain**

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Second story additions can provide protected space for offices and storage of valuable equipment and materials in the event of a flood. In addition, the NFIP typically offers lower rates for content insurance for nonresidential space with a second floor located above the DFE.

In some manufacturing zoning districts, floor area limitations or parking requirements make it difficult or impossible for some businesses to add a second floor or mezzanine to existing structures. In the city's lowest density manufacturing zones (M1-1 districts), where the permitted floor area ratio (FAR) is limited to the lot area (1.0), there are approximately 140 buildings in the floodplain that have a built FAR between 0.7 and 1.0. Many of these buildings are unlikely to have sufficient remaining development rights to expand vertically to create storage or office space above the DFE.

Exemptions to the existing floor area limits that are offered through the 2013 flood resilience zoning text amendment (Article VI, Chapter 4) may only be applied if the building comes into full compliance with flood-resistant construction standards in Appendix G of the NYC Building Code. Because full compliance through dry floodproofing or elevation is cost-prohibitive for many industrial businesses, amendments to the flood resilience zoning text should be considered to create more flexibility for modest FAR exemptions for industrial buildings in the floodplain to create protected second floor or mezzanine space to allow for storage, relocation of equipment, or protected office space. This flexibility should be considered even if the building is not coming into full compliance with Appendix G. Such amendments to the Zoning Resolution would be subject to a complete public land use and environmental review process. Appendix G of the NYC Building Code would continue to require that an addition resulting in a substantial improvement to a building would need to comply with floodproofing requirement.

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## Standards for unenclosed uses on industrial facilities within Appendix G of the Building Code

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A range of unenclosed industrial uses are permitted and exist within manufacturing districts, including auto dismantling, recycling, processing of construction and demolition debris, asphalt and cement manufacturing, scrap metal processing, and general storage of equipment and aggregate. Approximately 30 percent of the city's estimated 630 unenclosed industrial uses are located within the 1 percent annual chance floodplain.

Appendix G of the NYC Building Code applies to site improvements, which includes temporary or permanent storage of materials, mining, dredging, filling, grading, paving, excavations, and other land disturbing activities. However, the standards for flood resilient design and construction that are referenced in Appendix G (ASCE 24) apply only to buildings, structures, and tanks. These standards are largely inapplicable to unenclosed uses, which are a key component of many industrial sites in the city's floodplain.

During the Building Code revision process, standards for the appropriate storage of materials and equipment on unenclosed industrial sites in the floodplain should be considered for inclusion within Appendix G. These standards could draw on analyses conducted by the Department of City Planning and other agencies, and should comply with NFIP requirements and be designed to help reduce risk and prevent pollution from unenclosed facilities in the floodplain. To supplement standards for unenclosed industrial sites within Appendix G, resources can be sought to support outreach and technical assistance to businesses with unenclosed facilities seeking to comply with Appendix G and other relevant resiliency, stormwater management, and pollution prevention regulations and guidelines.

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## Consideration of flood risk due to climate change in siting and design of critical infrastructure

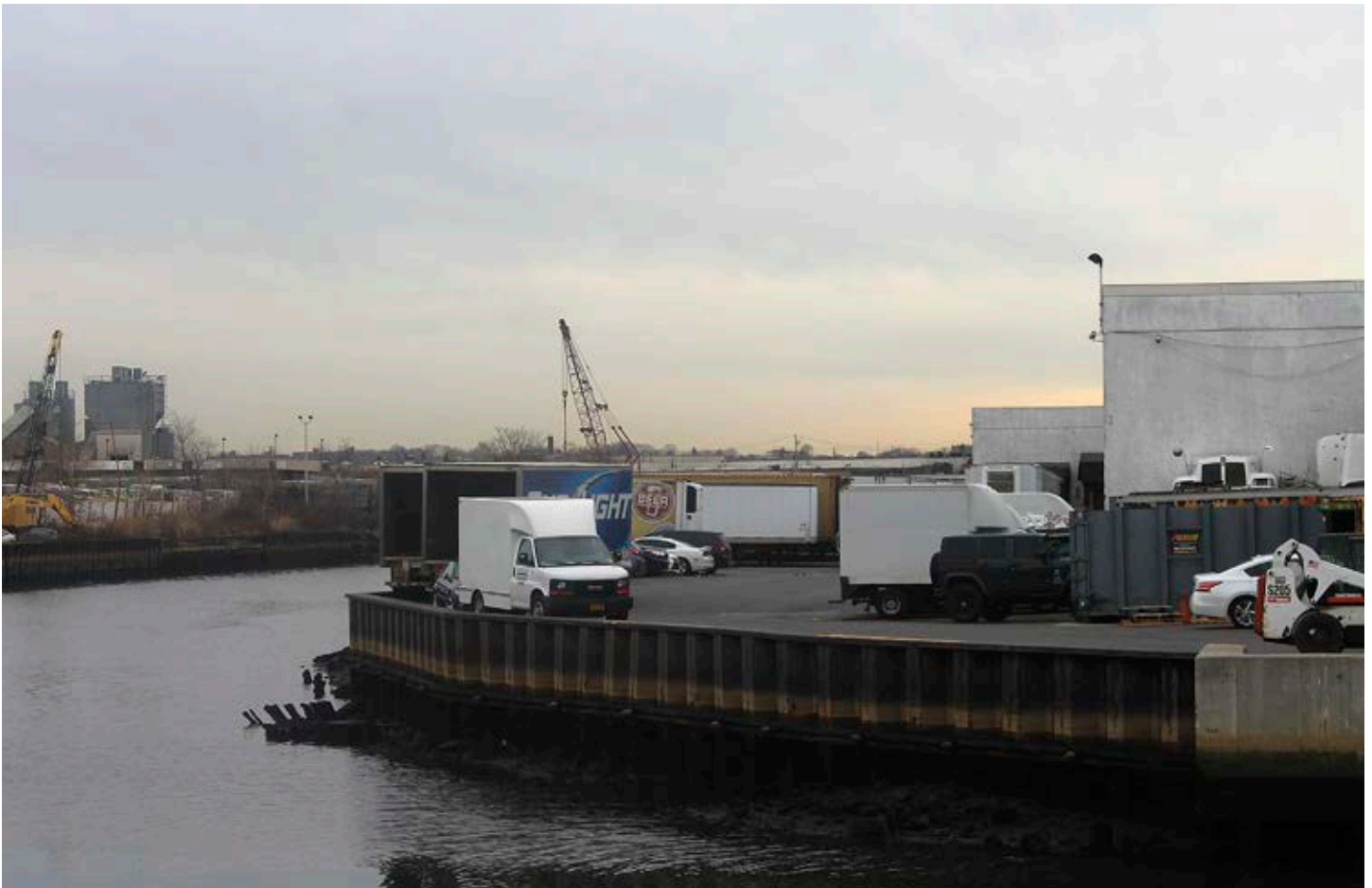
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Facilities considered to be critical infrastructure by the U.S. Department of Homeland Security include the energy sector, transportation systems, water and wastewater systems, and the communications sector, and others. All exist in locations along the city's waterfront. Due to the need to maintain or quickly restore operations of city facilities and critical infrastructure following a flood event, these activities should be protected from flooding by ensuring that the siting and design takes into account the potential for wave action and future climate change impacts.

At the federal level, Executive Order 13690: "Establishing a Federal Flood Risk Management Standard and a Process for Further Solicitation and Considering Stakeholder Input" required critical facilities that receive federal funding to be designed based on a climate-informed science approach or to include additional freeboard to mitigate risk. However, the repeal of this executive order in 2017 has removed these additional flood mitigation requirements for critical facilities.

In the absence of federal standards for siting critical facilities in the floodplain, the Waterfront Revitalization Program can be used in New York City to ensure that critical facility siting and design is sufficiently protective with regard to flood risk. Specifically, the Climate Change Guidance (Policy 6.2) within the Waterfront Revitalization Program establishes a critical facility site selection and planning framework, which can be used to continue to apply protective design standards like those described in Executive Order 13690, consistent with the Climate Resiliency Design Guidelines currently being developed by the NYC Mayor's Office of Recovery and Resiliency.





**The City can identify opportunities to promote inter-business agreements to support resiliency.**

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## **Commercial vehicle relocation in advance of flooding**

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Truck-dependent industries are a core component of New York City's industrial sector. In addition to the transportation and warehousing industry, sectors such as concrete and asphalt manufacturing, fuel distribution, construction, and film and television production rely on commercial vehicles. Since many of these industries tend to be located in the floodplain, large fleets of commercial trucks and vehicles are regularly parked near the waterfront or in areas subject to flooding.

To avoid flood damage to commercial vehicles and the lost revenue caused by this disruption, businesses with parking areas located in the floodplain can create preparedness plans and agreements to use available parking outside of the floodplain. Because space within New York City is limited and emergency response vehicles and equipment have staging needs, this

may involve creating connections with businesses in the broader region with available parking outside of the floodplain.

Opportunities may exist for the City to support these inter-business agreements to support resiliency. For example, the NYC Department of Small Business Services or a partner organization could make available to businesses a model contract for emergency use of space for truck parking. Similarly, trainings to Industrial Business Service Providers and other industrial trade groups regarding emergency truck relocation planning and other preparedness strategies would support the City's broader resiliency goals. Beyond truck relocation, trainings should encourage businesses to consider other mechanisms to share resources or coordinate during interruptions, such as contingency plans to temporarily rent unused electrical generators or a portion of another company's warehouse space.

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## **On-street parking regulations and policies to allow emergency parking for businesses whose vehicles are a critical part of the supply chain and emergency response**

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Many businesses operating in the city's industrial floodplain rely on fleets of commercial vehicles. During Hurricane Sandy, a number of businesses suffered major losses from flood damage to trucks and other vehicles that are regularly parked in the floodplain. Replacing vehicles and securing temporary alternatives in the immediate aftermath of a storm can have significant costs and challenges and can result in operational delays. In addition, vehicle flooding can also cause fuel and other hazardous materials to leak, potentially exposing employees, neighbors, and the surrounding environment to greater concentrations of harmful chemicals. Relocation of commercial vehicles to safe areas in advance of flooding can be challenging for industrial businesses. Section 4-08k of New York City Traffic Rules sets restrictions for short-term and overnight parking, and on-street storage. With a few exceptions, commercial parking is generally not allowed on

residential streets and prohibited in residential districts at night (between 9PM and 5AM). When parking rules are not otherwise specified, commercial vehicles are limited to three hours of parking in any area of the city and at any given time, effectively prohibiting street storage of such vehicles. However, during inclement weather events, the Department of Transportation does have authority to suspend certain parking regulations.

To help minimize potential damage and loss of commercial vehicle fleets, emergency preparedness strategies can be explored to relax regulations related to on-street parking changes. Any such changes should ensure that commercial vehicles are not being parked in residential areas, and designate specific on-street locations that are best suited for emergency vehicle storage during floods. Priority may be considered for businesses whose vehicles are a critical part of the supply chain and emergency response, such as fuel and food distribution, and waste management.

**Beverage distribution company parking vehicles in the 1 percent annual chance floodplain.**

**Commercial trucks parked in the floodplain in Maspeth, Queens.**





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## Expansion of the Business PREP program to serve more businesses

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The New York City Department of Small Business Services administers the Business Preparedness and Resiliency Program (Business PREP), designed to help small businesses prepare for emergencies and enhance resiliency of operations, assets, and physical space. The program offers on-site, one-on-one resiliency assessments for businesses operating in New York City. These resiliency assessments are designed to:

- 1. Help business owners, operators, and staff identify and understand physical, operational, and financial risks faced by the business**
- 2. Provide personalized recommendations to improve business preparedness and resiliency**
- 3. Make businesses eligible for a grant of up to \$3,000 toward recommended items or equipment to prepare for interruptions and reduce risk.**

Eligibility to participate in the Business PREP program is limited to businesses that experienced flooding or power outage during Hurricane Sandy. The requirement related to Hurricane Sandy impact is a constraint related to the program's federal funding source. If FEMA mitigation funding or an alternative funding source can be identified, the program could be expanded to provide site-specific resiliency assessments to other businesses in the city interested in preparing for and mitigating against a variety of hazards and business interruptions.

In addition to resiliency assessments being offered through the Business PREP program, the Department of Small Business Services is providing disaster preparedness workshops and developing a website with materials to help guide businesses through continuity and preparedness planning. City agencies providing disaster resiliency resources and guidance to businesses can use this website as a platform to disseminate this information to businesses. In addition to materials developed through the Business PREP program, this website can include

links to flood maps and forecast systems, guidance provided by NYC Emergency Management, a link to participate in the Partners in Preparedness program, and resources from the Resilient Retail and Resilient Industry studies produced by the Department of City Planning.

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## Broader participation in emergency alert systems and guidance materials about flood forecast resources

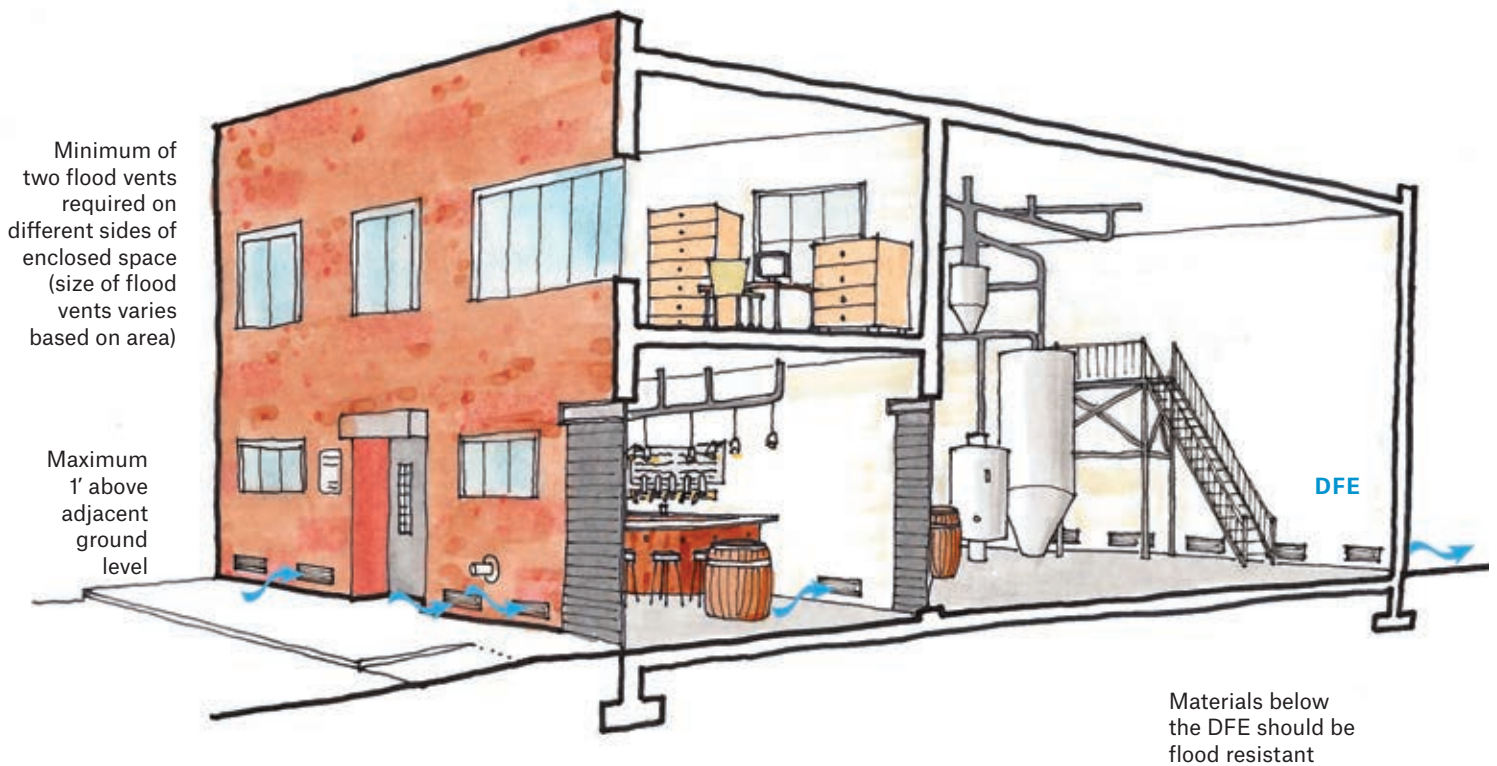
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A number of resources and alert systems currently exist that provide flood forecasts and warnings in advance of coastal storms and potential flooding events. These include:

- 1. Forecasts from the National Weather Service and National Hurricane Center**
- 2. Notify NYC, Partners in Preparedness, and CorpNet, operated by NYC Emergency Management**
- 3. Stevens Flood Advisory System, maintained by the Urban Ocean Observatory at Davidson Laboratory at the Stevens Institute of Technology**

Despite these and other resources being available to businesses, many of them are unaware of the best sources of flood forecasts and alerts. Since industrial businesses often require multiple days to fully prepare their facilities for a storm, it is even more important that businesses are aware of, and have access to, the most accurate and locally-specific forecast information available.

The Mayor's Office of Recovery and Resiliency, NYC Emergency Management, and the Department of Small Business Services should collaboratively identify opportunities to increase business participation in existing emergency alert systems, and develop and disseminate guidance materials about where businesses should turn for forecasts, including locally specific coastal inundation.



**Wet floodproofing and other partial floodproofing measures can be a cost-effective strategy to reduce risk.**

## **Great flexibility within the NFIP to encourage partial floodproofing for nonresidential structures**

The Flood Insurance Manual produced by the NFIP does not recognize wet floodproofing or partial mitigation as an acceptable method of flood mitigation for enclosed areas of nonresidential structures below the DFE. Exemptions, which result in lower insurance premiums, can be achieved only through elevation or dry floodproofing.

For many existing industrial businesses, dry floodproofing or elevation to comply with the NFIP are cost-prohibitive. Wet floodproofing of parking, building access, and limited storage spaces in nonresidential structures is currently permitted. Investments in partial floodproofing or wet floodproofing to occupied spaces or other spaces enclosing substantial storage or equipment in existing industrial buildings could result

in more flood resilient buildings and reduce the amount of time for businesses to resume operations. However, because these improvements are not currently recognized by FEMA, businesses are less likely to invest in these retrofits that would enhance flood resiliency. For example, industrial businesses that choose to elevate electrical or mechanical equipment may substantially reduce their losses in the event of a flood, but these investments would have no effect on insurance rates through the NFIP.

By providing more flexibility within the NFIP and incentivizing a wider range of resiliency measures, FEMA could more effectively encourage mitigation and expand insurance take-up by making rate reductions possible. FEMA should conduct a study of nonresidential flood retrofits to identify partial mitigation strategies that satisfy benefit-cost ratio eligibility requirements.







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# Appendix

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## Resiliency Best Practice Cost Estimation

The following tables describe estimated costs of a range of resiliency strategies described in the industrial business case studies in Chapter 4. These were developed by a professional cost estimation consultant with experience working in New York City on a range of resiliency projects.

For many resiliency strategies described below, costs may vary substantially from one site to the next, based on flood vulnerability, specific characteristics of the site and building, and the level of work that may be conducted in-house, among other factors. For this reason, the tables below are intended to be used by businesses to gain a general understanding of strategies or a suite of strategies that may be cost-effective based on their vulnerability. Businesses should work with certified contractors and vendors to obtain site-specific estimates. Where applicable, key sensitivity factors that influence the actual cost for each intervention are listed briefly beside each table.

### Shoreline Stabilization

Average construction costs for a range of shoreline stabilization projects ranging from sheet pile bulkheads to revetments.

Technique	Cost per linear foot
Bulkhead with landside access for construction	\$2,000
Bulkhead with waterside access for construction	\$2,500
Rip Rap revetment	\$500
Concrete platform over rip rap	\$1,400

#### Key sensitivity factors:

- Mobilization cost are similar for large and small projects
- Depth of sheet piling influences cost substantially
- Depth of water impacts viability of water access
- Platform materials (e.g., wood or concrete) will impact initial capital cost and life cycle cost
- Use of rip rap can result in lost usable space on the property

### Elevated Structural Mezzanine Within Existing Building

Construct an elevated steel platform with open riser steel stairs for protected storage or to locate mechanical equipment.

Elevation	Total cost (500 sf)	Cost per square foot
4'	\$94,000	\$188
6'	\$112,000	\$224
8'	\$129,000	\$258

#### Key sensitivity factors:

- Height within existing building will determine highest elevation achievable
- Weight and size of stored materials will impact size and cost of steel frame

### Elevated Office Space Within Existing Building

Construct an elevated and enclosed office area within an existing structure, including finishes, HVAC, light and power, etc.

Elevation	Total cost (500 sf)	Cost per square foot
4'	\$197,000	\$394
6'	\$214,000	\$428
8'	\$232,000	\$464

#### Key sensitivity factors:

- Footprint area of office will impact cost per square foot
- Finishes and facility choices will impact cost
- Height within existing building will determine highest elevation achievable

## Rooftop Addition on Existing Building

Build a small second floor addition to an existing industrial building for protected storage, office, or to house mechanical equipment.

Construction Type	Total cost (500 sf)	Cost per square foot
Build small rooftop addition	\$214,000	\$428
Install modular building on roof	\$206,000	\$412

### Key sensitivity factors:

- Bearing capacity of existing roof structure will need to be evaluated prior to introducing more weight to the roof

## Accessible Lifts

Install handicap lift to improve access to elevated storage or office spaces.

Elevation	Total cost	Cost per linear foot in elevation
4'	\$40,000	\$10,000
6'	\$56,000	\$9,300
8'	\$72,000	\$9,000

## Elevate Mechanical or Electrical Equipment

Construct 200 square foot steel-framed platform with open steel grate and perimeter rails.

Elevation	Cost per square foot
4'	\$277
6'	\$304
8'	\$330

### Key sensitivity factors:

- Weight and size of equipment will impact size and cost of steel frame
- Height within existing building will determine highest elevation achievable

## Internal Waterproof Room

Build a waterproof room on 12" concrete platform to house critical equipment or store valuable items during a storm event.

Room size (square feet)	Total cost	Cost per square foot
200	\$73,000	\$365
400	\$129,000	\$323

## Flood Damage-Resistant Materials

Install flood damage-resistant finishes within existing industrial facilities

Finishes	Cost per square foot
<b>Flooring</b>	
Epoxy Painted Flooring	\$5
Sheet Vinyl Flooring	\$8
"Dexotex" Built-up Epoxy Flooring	\$13
Tile Flooring	\$19
<b>Walls</b>	
Mold Resistant Wall Board	\$30
Cement Board	\$35
Water Resistant Wainscott on Existing Wall	\$40



## Flood Vents

Install flood vents as a component of wet floodproofing

Number of vents	Total cost	Cost per flood vent
10	\$17,500	\$1,750
25	\$44,000	\$1,760

## Dry Floodproofing

Construct reinforced concrete flood walls around exterior walls of buildings

Elevation	Cost per square foot
2'	\$37
4'	\$43
6'	\$52
8'	\$59

## Flood Doors

Replace existing building openings with flood door or flood panels

Technique	Each
3' x 7' floodproof "submarine" doors and frames	\$26,000
Install flood panels at door openings	\$15,000
Install flood panels at roll-up gate opening	\$21,000

### Key sensitivity factors:

- Depth of potential flood waters and expected hydrostatic pressure will impact the design of walls
- Costs for flood panels vary depending on the size of the opening and anticipated depth of flood waters

## Sump Pump

Install 3' sump pit and pump, including power and discharge piping to remove moderate amounts of seepage or floodwaters

Distance to Discharge Spot	Total Cost
20 ft.	\$24,500
50 ft.	\$26,200
100 ft.	\$28,900

### Key sensitivity factors:

- Sump pumps will only be effective in conjunction with other measures such as perimeter walls and flood barriers
- Size of area to be evacuated of floodwaters will impact size and cost of pump

## Backflow Preventer

Install stormwater backflow preventer on sewer or stormwater line of existing building to prevent back-up from exterior.

Cost Per Backflow Preventer	\$15,800
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## Elevate Electrical Generator

Construct a platform to raise electrical generators above the DFE. Estimate does not include generator cost.

Build concrete platform to elevate a 100 KW Generator (assumes 4' x 6' platform):

Elevation	Total Cost	Cost per sf to Raise 100 KW Generator
2'	\$35,400	\$1,475
4'	\$41,800	\$1,742
6'	\$50,000	\$2,083

Build elevated steel platform to house a 500 KW Generator (assumes 10' x 6' platform and 10,000 lb generator):

Elevation	Total Cost to Raise 500 KW Generator	Cost per sf to Raise 500 KW Generator
2'	\$65,200	\$1,090
4'	\$76,200	\$1,270
6'	\$87,600	\$1,460
8'	\$108,100	\$1,800

## Hazardous Material Spill Prevention

Install storage cabinet or cage to contain hazardous materials

Technique	Total Cost	Cost Per Square Foot
Prefabricated 6' x 3' x 2' Storage Unit (Acid Cabinet)	\$8,500	\$472
Wire Mesh Cabinets with Shelves: 6' x 3' x 2'	\$7,300	\$406
Raised Pallets with Tie-Down Straps: 6' x 3'	\$4,300	\$239



**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 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.

**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). See "Special Flood Hazard Areas," below.

**Design Flood Elevation (DFE)**

As defined by the NYC Building Code, the DFE is 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 (see definition below) based on the building's structural category.

**Flood Insurance Rate Maps (FIRMs)**

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

**Floodproofing, Dry**

For nonresidential buildings, a flood resilient construction or retrofitting technique that results in the building resisting penetration of floodwater up to the DFE, with walls substantially impermeable to the passage of water and structural components having the capacity to resist specified loads.

**Floodproofing, Wet**

A flood resilient construction or retrofitting 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 NYC Building Code and recognized by NFIP as an insurance premium reduction factor. In New York City, one to three feet of freeboard is required for commercial buildings, depending on the structural occupancy of the building and the flood zone.

**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 SFHA with a federally backed or regulated mortgage are required 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, of flooding in any given year. Also referred to as the 100-year floodplain or the 1% annual chance floodplain. 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 three 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 three feet in height. Current building regulations are the same in A Zones and Coastal A Zones in NYC.

**A Zone**

The area of the SFHA that is subject to 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 percent 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 NYC Building Code as if it were a post-FIRM structure.

**Substantial Improvement**

Any repair, reconstruction, rehabilitation, addition or improvement of a building with cost equaling or exceeding 50 percent 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 NYC Building Code.

**Wave Action**

A condition in which wave heights or wave runup depths can result in velocity flooding, leading to greater damage to structures than equivalent flood depths without velocity flooding.



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# Endnotes

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- 1 New York City Department of City Planning, "Employment in New York City's Manufacturing Districts: Employment trends in M districts outside Manhattan: 2000-2014," 2016.
- 2 Federal Emergency Management Agency, "Flood Damage-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas in accordance with the National Flood Insurance Program," Technical Bulletin 2, 2008.
- 3 New York City Office of the Mayor, "A Stronger, More Resilient New York," developed for the Special Initiative for Rebuilding and Resiliency. 2013.
- 4 New York City Department of City Planning, "Draft Open Industrial Uses Study," 2014.
- 5 New York City Panel on Climate Change, "Climate Change Adaptation in New York City: Building a Risk Management Response," 2010.
- 6 New York City Panel on Climate Change, "Climate Change Adaptation in New York City: Building a Risk Management Response," 2010.
- 7 New York State, Department of Labor, Quarterly Census of Employment and Wages. 2010, 2016.
- 8 New York State, Department of Labor, Quarterly Census of Employment and Wages. 2015.
- 9 Hazardous Materials Management in New York City: 2016 Annual Report. NYC Department of Environmental Protection. [http://www.nyc.gov/html/dep/pdf/derta/dep\\_hazmat\\_annual\\_report\\_2016.pdf](http://www.nyc.gov/html/dep/pdf/derta/dep_hazmat_annual_report_2016.pdf)
- 10 New York City Community Right-to-Know: Recommendations for Chemical Safety and Spill Prevention during Flooding Events. NYC Department of Environmental Protection. [http://www.nyc.gov/html/dep/pdf/tier2/flood\\_safety.pdf](http://www.nyc.gov/html/dep/pdf/tier2/flood_safety.pdf)
- 11 Pisano, Steven. NYC Street Scenes - Brooklyn. <https://tinyurl.com/y9az9zh6>
- 12 New York City Department of City Planning, "Employment in New York City's Manufacturing Districts: Employment trends in M districts outside Manhattan: 2000-2014," 2016.
- 13 New York City Department of City Planning, "Employment in New York City's Manufacturing Districts: Employment trends in M districts outside Manhattan: 2000-2014," 2016.
- 14 New York City Economic Development Corporation, "Five Borough Food Flow: New York City Food Distribution and Resiliency Study Results." 2016.
- 15 Yoon, Sunghwan. 2013. <http://www.flickr.com/photos/jacopast/9993381765/in/album-72157635999594303/>
- 16 Yoon, Sunghwan. 2013. <https://tinyurl.com/y9g3fx2a>

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# Informational Resources

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## Informational Resources

OneNYC  
[nyc.gov/onenyc](http://nyc.gov/onenyc)

Mayor's Office of Recovery and Resiliency  
[www.nyc.gov/resiliency](http://www.nyc.gov/resiliency)

New York City Emergency Management  
<https://www1.nyc.gov/site/em/about/overview.page>

New York City Panel on Climate Change  
[onlinelibrary.wiley.com/doi/10.1111/nyas.2015.1336.issue-1/issuetoc](http://onlinelibrary.wiley.com/doi/10.1111/nyas.2015.1336.issue-1/issuetoc)

## Technical Guidance

**Federal Emergency Management Agency**  
Floodproofing for Non-Residential Buildings  
/ July 2013  
[fema.gov/media-library/assets/documents/34270](http://fema.gov/media-library/assets/documents/34270)

Technical Bulletin 3, Non-Residential  
Floodproofing - Requirements and  
Certification (1993)  
[fema.gov/media-library/assets/documents/3473](http://fema.gov/media-library/assets/documents/3473)

Technical Bulletin 2, Flood Damage-  
Resistant Materials Requirements (2008)  
[fema.gov/zh-hans/media-library/assets/documents/2655](http://fema.gov/zh-hans/media-library/assets/documents/2655)

Flood Insurance Manual, Effective  
November 1, 2015  
[fema.gov/media-library/assets/documents/110085](http://fema.gov/media-library/assets/documents/110085)

**New York City Department of Buildings**  
Building Code Appendix G Flood-Resistant  
Construction  
[nyc.gov/html/dob/html/codes\\_and\\_reference\\_materials/reference.shtml](http://nyc.gov/html/dob/html/codes_and_reference_materials/reference.shtml)

**New York City Department of  
City Planning**  
Retrofitting Buildings for Flood Risk  
<https://www1.nyc.gov/site/planning/plans/retrofitting-buildings/retrofitting-buildings.page>

Designing for Flood Risk  
[nyc.gov/designingforfloodrisk](http://nyc.gov/designingforfloodrisk)

Urban Waterfront Adaptive Strategies  
[nyc.gov/uwas](http://nyc.gov/uwas)

Resilient Retail  
[nyc.gov/resilientretail](http://nyc.gov/resilientretail)



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Waterfront Alliance  
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## **Key Data Sources**

National Flood Insurance Program,  
Preliminary Flood Insurance Rate Maps  
(2015)  
Federal Emergency Management Agency,  
NFIP Hurricane Sandy Claims Data  
NYS Department of Labor, Quarterly  
Census of Employment and Wages  
Primary Land Use Tax Lot Outputs  
(PLUTO)  
NYC Panel on Climate Change





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