## 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.

<table>
<thead>
<tr>
<th>Technique</th>
<th>Cost per linear foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulkhead with landside access for construction</td>
<td>$2,000</td>
</tr>
<tr>
<td>Bulkhead with waterside access for construction</td>
<td>$2,500</td>
</tr>
<tr>
<td>Rip Rap revetment</td>
<td>$500</td>
</tr>
<tr>
<td>Concrete platform over rip rap</td>
<td>$1,400</td>
</tr>
</tbody>
</table>

**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.

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Total cost (500 sf)</th>
<th>Cost per square foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>4’</td>
<td>$94,000</td>
<td>$188</td>
</tr>
<tr>
<td>6’</td>
<td>$112,000</td>
<td>$224</td>
</tr>
<tr>
<td>8’</td>
<td>$129,000</td>
<td>$258</td>
</tr>
</tbody>
</table>

**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.

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Total cost (500 sf)</th>
<th>Cost per square foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>4’</td>
<td>$197,000</td>
<td>$394</td>
</tr>
<tr>
<td>6’</td>
<td>$214,000</td>
<td>$428</td>
</tr>
<tr>
<td>8’</td>
<td>$232,000</td>
<td>$464</td>
</tr>
</tbody>
</table>

**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.

<table>
<thead>
<tr>
<th>Construction Type</th>
<th>Total cost (500 sf)</th>
<th>Cost per square foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Build small rooftop addition</td>
<td>$214,000</td>
<td>$428</td>
</tr>
<tr>
<td>Install modular building on roof</td>
<td>$206,000</td>
<td>$412</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Total cost</th>
<th>Cost per linear foot in elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>4’</td>
<td>$40,000</td>
<td>$10,000</td>
</tr>
<tr>
<td>6’</td>
<td>$56,000</td>
<td>$9,300</td>
</tr>
<tr>
<td>8’</td>
<td>$72,000</td>
<td>$9,000</td>
</tr>
</tbody>
</table>

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

Elevate Mechanical or Electrical Equipment
Construct 200 square foot steel-framed platform with open steel grate and perimeter rails.

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Cost per square foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>4’</td>
<td>$277</td>
</tr>
<tr>
<td>6’</td>
<td>$304</td>
</tr>
<tr>
<td>8’</td>
<td>$330</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Room size (square feet)</th>
<th>Total cost</th>
<th>Cost per square foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>$73,000</td>
<td>$365</td>
</tr>
<tr>
<td>400</td>
<td>$129,000</td>
<td>$323</td>
</tr>
</tbody>
</table>

Flood Damage-Resistant Materials
Install flood damage-resistant finishes within existing industrial facilities

<table>
<thead>
<tr>
<th>Finishes</th>
<th>Cost per square foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flooring</td>
<td></td>
</tr>
<tr>
<td>Epoxy Painted Flooring</td>
<td>$5</td>
</tr>
<tr>
<td>Sheet Vinyl Flooring</td>
<td>$8</td>
</tr>
<tr>
<td>“Dexotex” Built-up Epoxy Flooring</td>
<td>$13</td>
</tr>
<tr>
<td>Tile Flooring</td>
<td>$19</td>
</tr>
<tr>
<td>Walls</td>
<td></td>
</tr>
<tr>
<td>Mold Resistant Wall Board</td>
<td>$30</td>
</tr>
<tr>
<td>Cement Board</td>
<td>$35</td>
</tr>
<tr>
<td>Water Resistant Wainscott on Existing Wall</td>
<td>$40</td>
</tr>
</tbody>
</table>
Flood Vents
Install flood vents as a component of wet floodproofing

<table>
<thead>
<tr>
<th>Number of vents</th>
<th>Total cost</th>
<th>Cost per flood vent</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>$17,500</td>
<td>$1,750</td>
</tr>
<tr>
<td>25</td>
<td>$44,000</td>
<td>$1,760</td>
</tr>
</tbody>
</table>

Dry Floodproofing
Construct reinforced concrete flood walls around exterior walls of buildings

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Cost per square foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>2’</td>
<td>$37</td>
</tr>
<tr>
<td>4’</td>
<td>$43</td>
</tr>
<tr>
<td>6’</td>
<td>$52</td>
</tr>
<tr>
<td>8’</td>
<td>$59</td>
</tr>
</tbody>
</table>

Flood Doors
Replace existing building openings with flood door or flood panels

<table>
<thead>
<tr>
<th>Technique</th>
<th>Each</th>
</tr>
</thead>
<tbody>
<tr>
<td>3’ x 7’ floodproof “submarine” doors and frames</td>
<td>$26,000</td>
</tr>
<tr>
<td>Install flood panels at door openings</td>
<td>$15,000</td>
</tr>
<tr>
<td>Install flood panels at roll-up gate opening</td>
<td>$21,000</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Distance to Discharge Spot</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 ft.</td>
<td>$24,500</td>
</tr>
<tr>
<td>50 ft.</td>
<td>$26,200</td>
</tr>
<tr>
<td>100 ft.</td>
<td>$28,900</td>
</tr>
</tbody>
</table>

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 |

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 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
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):

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Total Cost</th>
<th>Cost per sf to Raise 100 KW Generator</th>
</tr>
</thead>
<tbody>
<tr>
<td>2’</td>
<td>$35,400</td>
<td>$1,475</td>
</tr>
<tr>
<td>4’</td>
<td>$41,800</td>
<td>$1,742</td>
</tr>
<tr>
<td>6’</td>
<td>$50,000</td>
<td>$2,083</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Elevation</th>
<th>Total Cost to Raise 500 KW Generator</th>
<th>Cost per sf to Raise 500 KW Generator</th>
</tr>
</thead>
<tbody>
<tr>
<td>2’</td>
<td>$65,200</td>
<td>$1,090</td>
</tr>
<tr>
<td>4’</td>
<td>$76,200</td>
<td>$1,270</td>
</tr>
<tr>
<td>6’</td>
<td>$87,600</td>
<td>$1,460</td>
</tr>
<tr>
<td>8’</td>
<td>$108,100</td>
<td>$1,800</td>
</tr>
</tbody>
</table>

Hazardous Material Spill Prevention
Install storage cabinet or cage to contain hazardous materials

<table>
<thead>
<tr>
<th>Technique</th>
<th>Total Cost</th>
<th>Cost Per Square Foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prefabricated 6’ x 3’ x 2’ Storage Unit (Acid Cabinet)</td>
<td>$8,500</td>
<td>$472</td>
</tr>
<tr>
<td>Wire Mesh Cabinets with Shelves: 6’ x 3’ x 2’</td>
<td>$7,300</td>
<td>$406</td>
</tr>
<tr>
<td>Raised Pallets with Tie-Down Straps: 6’ x 3’</td>
<td>$4,300</td>
<td>$239</td>
</tr>
</tbody>
</table>
Glossary

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.


8. New York State, Department of Labor, Quarterly Census of Employment and Wages. 2015.


Informational Resources

OneNYC
nyc.gov/onenyc

Mayor’s Office of Recovery and Resiliency
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

Technical Guidance

Federal Emergency Management Agency
Floodproofing for Non-Residential Buildings
/ July 2013
fema.gov/media-library/assets/
documents/34270

Technical Bulletin 3, Non-Residential
Floodproofing - Requirements and
Certification (1993)
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

Flood Insurance Manual, Effective
November 1, 2015
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

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

Urban Waterfront Adaptive Strategies
nyc.gov/uwas

Resilient Retail
nyc.gov/resilientretail
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NYC Economic Development Corporation (EDC)
NYC Department of Small Business Services (SBS)
NYS Department of Environmental Conservation (DEC)
Port Authority of New York and New Jersey
United States Coast Guard
Maritime Association
Sandy Hook Pilots
United Metro Energy
NYC Environmental Justice Alliance
Waterfront Alliance
Hudson Riverkeeper
New York University, International Center for Enterprise Preparedness
College of Staten Island
Brooklyn Navy Yard
Staten Island Economic Development Corporation
SoBRO
Evergreen
Southwest Brooklyn Industrial Development Corporation
Long Island City Partnership
THE POINT CDC
El Puente
UPROSE
HR&A
Assured Partners NL
OptiRTC
Glen Cutrona Architects
Ellen Neises, RANGE / PennDesign
Judd Schechtman, NYU Tandon School of Engineering

Key Data Sources
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
Coastal Climate Resiliency

NYC Planning

Coastal Climate Resiliency