Town of Boothbay Harbor

Flood Impact Preliminary Engineering Study

Individual Property Report

71 Atlantic Avenue

Boothbay Harbor Fish Pier

Property Overview

71 Atlantic Avenue is a multi-building parcel owned by the Town of Boothbay Harbor. The site consists of three buildings within a cement pier built on wood pilings over water.

The Town leases space in the three buildings on the site to the following businesses:

- **Boothbay Harbor Fish Pier:** a two-story cement- and wood-frame structure built on a cement slab-on-grade foundation over land. The inland (eastern) side of the building is a high-ceilinged cold-storage area. The harbor (western) side of the building consists of offices. The offices section of the building has an elevated interior floor.

- **Atlantic Edge:** a two-story wood frame structure built within the pier area, over water. This structure is built on its own wood piling foundation, separate from the rest of the pier. This building houses tanks and other equipment for lobstering and other fishing activities. It pumps water from the harbor for its tanks. The building appears to have been built to be wet-floodproofed, though no flood vents where observed.

- **Harbor Bait**: a one-story wood-frame structure built on the pier, over water. It is unclear from field observation whether this structure is directly tied-in to the wood piling foundations, or if it is constructed on its own foundation. The building houses equipment for fishing operations. The building appears to have flood vents and to be wet-floodproofed.

Table 1: Property Summary

Feature	**Fish Pier**	**Atlantic Edge**	**Harbor Bait**
Foundation	Slab on Grade	Wood Piling	Wood Piling
Structure	Cement/Wood Frame	Wood Frame	Wood Frame
Stories	Two	Two	One
Use	Offices Cold Storage	Fishing/Lobstering ("Dependent Use")	Fishing/Lobstering ("Dependent Use")
Site	Over Land	Over Water	Over Water

Risk Framework

Table 2 lists the elevations, determined by the Lincoln County Sea Level Rise - Coastal Hazard Study conducted by the Lincoln County Regional Planning Commission (LCRPC) and Maine Geological Survey (MGS) in 2013. These elevations represent "stillwater" flood elevations from the effective FEMA Flood Insurance Study. Stillwater elevations are the basis for special flood hazard area (SFHA) elevation mapping, and do not include the effects of wave action or local variations. In order to be consistent with the LCRPC study, these elevations are used for the 1% annual chance storm flood planning in this report.

Table 2: LCRPC Sea Level Rise Scenarios

Scenario:	Highest Astronomical Tide	1% Annual Chance Storm
Current/Historical	**6.5** feet NAVD88	**9.5** feet NAVD88
+ 0.3 meter	**7.5** feet NAVD88	**10.5** feet NAVD88
+ 0.6 meter	**8.5** feet NAVD88	**11.5** feet NAVD88
+ 1.0 meter	**9.8** feet NAVD88	**12.8** feet NAVD88
+ 1.8 meter	**12.5** feet NAVD88	**15.5** feet NAVD88

The majority of this property is located within a **FEMA AE Special Flood Hazard Area (SFHA) with a base flood (1% annual chance storm) elevation (BFE) of 11 feet NAVD88**. The back, cold-storage section of the Fish Pier is outside of the SFHA.

Please note that the FEMA BFE addresses local variations and includes the effects of waves, wave setup, and wave runup; therefore this figure may be different than the "Current/Historical" scenario 1% chance storm elevation in Table 2, which is a stillwater elevation only. The FEMA BFE is derived from the 2015 Flood Insurance Rate Map update and is the regulatory elevation for purposes of new construction and flood insurance.

For the purposes of this report, findings and recommendations are based on the highest astronomical tide and 1% storm elevations presented in Table 2.

Elevations of key features of the main building at 71 Atlantic Avenue were surveyed or measured. The elevations of those features, and whether they were surveyed or estimated relative to a surveyed point, are presented in Table 3, below.

Feature elevations were compared to the LCRPC Sea Level Rise scenario figures in Table 2. If the elevation of a given feature is equal to or below a given LCRPC flood elevation, that feature is vulnerable to that LCRPC scenario. For example, if the first floor is 9.0 feet NAVD88, it is vulnerable to a 1% annual-chance storm under current conditions (9.5 feet NAVD88), and HAT under 3.3 feet of sea level rise (9.8 feet NAVD88). In Table 3, the HAT and 1% annual-chance flood vulnerability of each building feature is presented.

Table 3: Property Elevations (NAVD88)

		Lowest Horizontal Member	Lowest Deck or Adjacent Grade	First Finished Floor	Lowest Opening
Fish Pier	*Elevation*		9.10	12.04	9.10

	Source		Estimate	Survey	Survey
	1% Storm Vulnerability		Current	+ 1.0 m	Current
	HAT Vulnerability		+ 1.0 m	+ 1.8 m	+ 1.0 m
Atlantic Edge	*Elevation*	7.5	8.26	9.0	9.01
	Source	Estimate	Survey	Estimate	Survey
	1% Storm Vulnerability	Current	Current	Current	Current
	HAT Vulnerability	+ 0.3 m	+ 1.0 m	+ 1.0 m	+ 1.0 m
Harbor Bait	*Elevation*	7.5	8.32	8.35	8.34
	Source	Estimate	Survey	Estimate	Survey
	1% Storm Vulnerability	Current	Current	Current	Current
	HAT Vulnerability	+0.3 m	+ 0.6 m	+ 1.0 m	+ 1.0 m

Attachment 1 displays the property, the location of key features, and the surveyed elevations.

Building Vulnerabilities

Foundation Degradation

Two buildings on this property (Atlantic Edge and Harbor Bait) are constructed completely over water on wooden foundational pilings that are inundated during every high tide. Impacts to those foundations by waves or currents is possible during high energy events. Regular exposure to water will lead to degradation of the foundations over time.

No visual observation of pilings or thorough geotechnical evaluation of conditions was performed.

Risk of degradation of the Fish Pier slab-on-grade foundation is considered to be minimal.

Risk of damage to the wood piling foundations on this property is considered to be relatively low.

Structural Damage

All of the buildings on this property are between 8.3 and 9.5 feet elevation, NAVD88. During current 1% annual-chance flood conditions, high water may interact with the structures, posing some risk of structural damage. Given the heavy cement pier surrounding the buildings and the location of the property within a FEMA AE zone, any such interaction is expected to be relatively low-energy, minimizing the risk of structural damage.

Note the following:

- **Boothbay Harbor Fish Pier** is only partly located in a FEMA AE zone, and has cement siding at the base of the wall. Risk of structural damage is **relatively minimal**.
- **Atlantic Edge** is wood frame and does not have flood vents. During a flood, the hydrostatic force of high water on the outside of the building may present a **relatively low risk** of damage to the building's structure.
- **Harbor Bait** has flood vents, but of the buildings on this property it is located farthest out into the harbor. It is not clear whether this building is directly tied-in to foundations. There is a **relatively moderate** risk of structural damage to this building, and there may exist some risk of the building being removed from its foundations.

As sea levels rise, these risks will increase, and may be compounded by increasing wave heights that are possible in deeper water.

Risk of damage to structures of the buildings on this property is considered to be relatively low.

Erosion

The land into which this building's pilings have been driven may potentially be at risk from erosive forces. No erosion was observed at this site. Geotechnical methods such as soil load testing were **not** employed during field observations.

Risk of damage from erosion is relatively minimal.

Hydrostatic Forcing

The lowest horizontal structural beam of this property is below the level of the current 1% annual-chance storm stillwater flood elevation, and therefore some risk of damage to buildings over water from hydrostatic forces during such an event exists.

The Harbor Bait building appears to be located on top of the cement pier structure, and that heavy material, along with the building's flood vents, will minimize the risk posed by hydrostatic forces.

The Atlantic Edge building is on a separate foundation that may be more at-risk from hydrostatic forces than the cement pier.

The Fish Pier building is over land and has cement siding and is at relatively minimal risk of impact from hydrostatic forces.

Risk of damage from hydrostatic forces is considered to be relatively moderate.

Interior Inundation

The buildings on this site appear to have been floodproofed:

- **Boothbay Harbor Fish Pier:** only the eastern edge of this building falls within a flood zone; the interior floor has been elevated above 12 feet NAVD88, and the space below that is lined with cement, indicating that it is dry-floodproofed.
- **Atlantic Edge** is clearly designed to be floodable, with limited storage and equipment in the first floor area, and many floor drains. Water from the harbor is regularly pumped into tanks in the building and later flushed out. Though floodable, installation of flood vents is necessary to make the space truly wet-floodproofed.
- **Harbor Bait:** like Atlantic Edge, this building is clearly designed to be floodable. This structure does have flood vents, and has been determined to be wet-floodproofed.

While the buildings on this property appear to be able to withstand inundation, a large amount of equipment and storage, and many utility systems and fuel tanks, were observed on the property in locations at risk of inundation.

Most of the property is below 1% annual-chance stillwater flood elevations under current conditions, so the risk of inundation is relatively high, despite the property's susceptibility to inundation being relatively low. The combination creates an **inundation-damage risk that is relatively moderate.**

Utility Damage

As noted above, many utilities and fuel tanks were observed on the property that were not stored in flood resistant locations. Some utilities were elevated.

Risk of damage to utilities is considered to be relatively low.

Operation

These buildings have been designed to flood, and inundation is not expected to have a major impact on the capability of these businesses to operate.

The risk of disruption of this property's operations is relatively minimal.

Summary

71 Atlantic Avenue risks are summarized in the table below.

Table 4: Risk Summary

Risk	**Vulnerability**	**Scenario of Concern**		**Notes**
		HAT	***1% Storm***	
Foundation Degradation	Low	Current	Current	Piling degradation from water exposure
Structural Damage	Low	+ 1.0 m	Current	Risk of damage to building frame of Atlantic Edge and dislodgement of Harbor Bait
Erosion	Minimal	None	None	None
Hydrostatic Forcing	Moderate	+ 0.3 m	Current	Damage to Atlantic Edge and Harbor Bait
Interior Inundation	Moderate	+1.0 m	Current	Improperly stored or located equipment and fuel
Utility Damage	Low	+1.0 m	Current	Improperly stored or located equipment and fuel
Business Operation	Minimal	None	None	Floodable structures

Adaptation Alternatives

Adaption alternatives are intended to build resilience; that is, to increase the capability of a building to adapt to, resist, absorb, and recover from coastal hazards. To that end, the following factors were considered when developing alternatives:

- **Adapt** – alter structure to avoid hazard
- **Resist** – strengthen structure to withstand floods
- **Absorb** – design structure, contents, and operations to minimize damage from floods
- **Recover** – design structure, contents, and operations to allow for fast recovery from floods

Additionally, different alternatives have different goals, as follows:

- **Short Term**: can be applied relatively quickly to protect against immediate threats, but is intended to be replaced by a longer-term approach over time.
- **Long Term**: may not be achievable immediately, but will eventually be necessary as sea level rise and climate change exacerbate hazardous conditions
- **Insurance Reduction**: solely intended to lower insurance premiums, based on National Flood Insurance Program Requirements

A "Flood Damage Reduction Matrix" developed by the US Army Corps of Engineers is available as Attachment 2; this worksheet can be used to help guide decision-making with regards to appropriate adaptation alternatives for a site.

Cost Estimates

Flood mitigation project costs vary depending on

- Building size (square footage of footprint, number of stories)
- Building construction material (wood-frame, masonry, brick, etc.)
- Foundation type (basement, crawlspace, slab-on-grade, pilings)
- Flood depth at the site (the higher the floodwaters, the more expensive the project)
- The local availability of resources and professionals (this will affect the cost of labor and materials)
- Other variables (including the costs of surveys, design work, permits, and maintenance_

These factors makes providing meaningful cost estimates difficult. Nevertheless, rough concept-level cost estimates for different alternative were developed for this project based on:

- A variety of FEMA publications, including P-259, P-551, and P-1037
- "Selecting Floodproofing Techniques - Financial Considerations" prepared by the Southern Tier Central Regional Planning and Development Board (STCRPDB)
- ClimateTechWiki (www.climatetechwiki.org, accessed 9/26/2017; authored by Matthew M. Linham and Robert J. Nicholls, School of Civil Engineering and the Environment, University of Southampton, UK.)
- Information gleaned from previous Milone & MacBroom, Inc. experience

These cost estimates are summarized in Table 5, below:

Table 5: Adaptation Alternatives Cost Estimates

Measure	Description	Cost ($)	Unit	Additional Costs	Source
Elevation	Raise structure so first floor is above the water surface elevation during a flood event.	**$29.00 to $96.00**	Per Square Foot		ClimateTechWiki STCRPDB
Wet Floodproof	Building is retrofitted to allow flooding without being damaged.	**$2.20 to $17.00**	Per Square Foot		ClimateTechWiki STCRPDB
Dry Floodproof	Building is retrofitted to withstand flooding.	**$5.50 to $16.80**	Per Linear Foot of Wall	$3,000 for drainage and check valves $400-1230 per door	ClimateTechWiki STCRPDB
Floodwalls	Walls built to protect against flooding. Control gates are open to allow access under normal conditions, and are closed during storms.	**$100.00 to $5,000.00**	Per Linear Foot	$5,000 interior drainage $2,000-$5,000 per opening	STCRPDB NOAA
Rearrange Property	Relocate building or sections within parcel	**$29.00 to $77.00**	Per Square Foot	Demolition & new construction.	STCRPDB

More Information on cost estimates is available through Attachment 3, "Selecting Floodproofing Techniques - Financial Considerations" prepared by the Southern Tier Central Regional Planning and Development Board.

It is important to note that any project that triggers "Substantial Improvement" will require that the building be made compliant with the local flood damage prevention ordinance. "Substantial Improvement" is defined in the Boothbay Harbor ordinances as improvements that cost more than 50% of the value of the property before the improvements were made. Review the Boothbay Harbor ordinances (§ 170-95.5: Definitions) or contact the Town of Boothbay Harbor for more information.

Recommended Alternatives:

Short Term

- **Clean Up Equipment:** Permanently place all equipment, fuel tanks, and utilities on elevated platforms, high on building walls, or at the inland extent of the property to protect from current and future high water events.
- **Wet Floodproof Atlantic Edge** by installing flood vents in the walls
- **Maintain Floodability** of all buildings by ensuring wet- and dry-floodproofing materials and techniques are operational and up to code

Long Term

- **Monitor Sea Level Rise** and elevate buildings and pier further, as needed
- **Elevate Utilities** to protect from future flood events

Lower Insurance

- **Rearrange Site** to minimize the amount of structure located over water. Two of the buildings on this property are currently over water at high tide, and the National Flood Insurance Program does not insure such properties as a matter of policy. While these properties may be exempt from many floodplain regulations due to their water-dependent nature, that exemption does *not* come with a decrease in flood insurance.

Cost Estimate

Table 6: Cost Estimate for Recommended Alternatives

Alternative	Details	Cost	Frequency
Clean Up Equipment	Miscellaneous Equipment, Utilities, and Fuel Tanks	Total $3,000	Once (within 5 years)
Wet Floodproof Atlantic Edge	Install Flood Vents Minimal Floodproofing Expected ~2,800 square feet	$2.20/ft^2 floodproof Total $6,160	Once (within 5 years)
Maintain Floodability	Inspection and Maintenance	$2,000 per building Total $4,000	Every Five Years
Elevate Utilities	Assume 1 system for each building	$1,000 per system Total $3,000	Once (within 15 years)
Monitor Sea Level Rise	Professional survey every 5 years	Total $1,000	Every Five Years
	Total Cost	**$14,160** **$27,160** **$42,160**	**Over 5 years** **Over 15 years** **Over 30 years**

Cost estimates are not provided for the "Rearrange and Elevate" alternatives. The complexities and uncertainties of this measure, which may include building demolition and construction as well as relocation, are such that any cost estimates produced for that action would be highly unreliable in this situation. Costs would likely exceed $1 million.

Note that implementation of the measures above **may trigger the "Substantial Improvement" requirements** described earlier in this report. In such a case, the building being adapted may need to be brought into compliance with local floodplain ordinances, including the requirement that it **be located entirely over land, and be compliant with VE-zone construction standards**. These requirements may

significantly increase the costs of, or **entirely preclude**, those measures. Variances may be granted for water-dependent uses.

Summary

This property is currently at risk of damage to its equipment and utilities from inundation during a 1% annual-chance storm under present-day conditions.

Two of the buildings on this property are also at risk of damage from the hydrostatic forces generated by a 1% annual-chance storm.

The most immediate threat to this property is damage to its equipment and utilities.

It is recommended that utilities, equipment, and fuel tanks on this property be permanently located to elevated or landward areas outside of the flood zone.

It is also recommended that the Atlantic Edge building be completely wet-floodproofed through installation of flood vents in its walls.

Resources

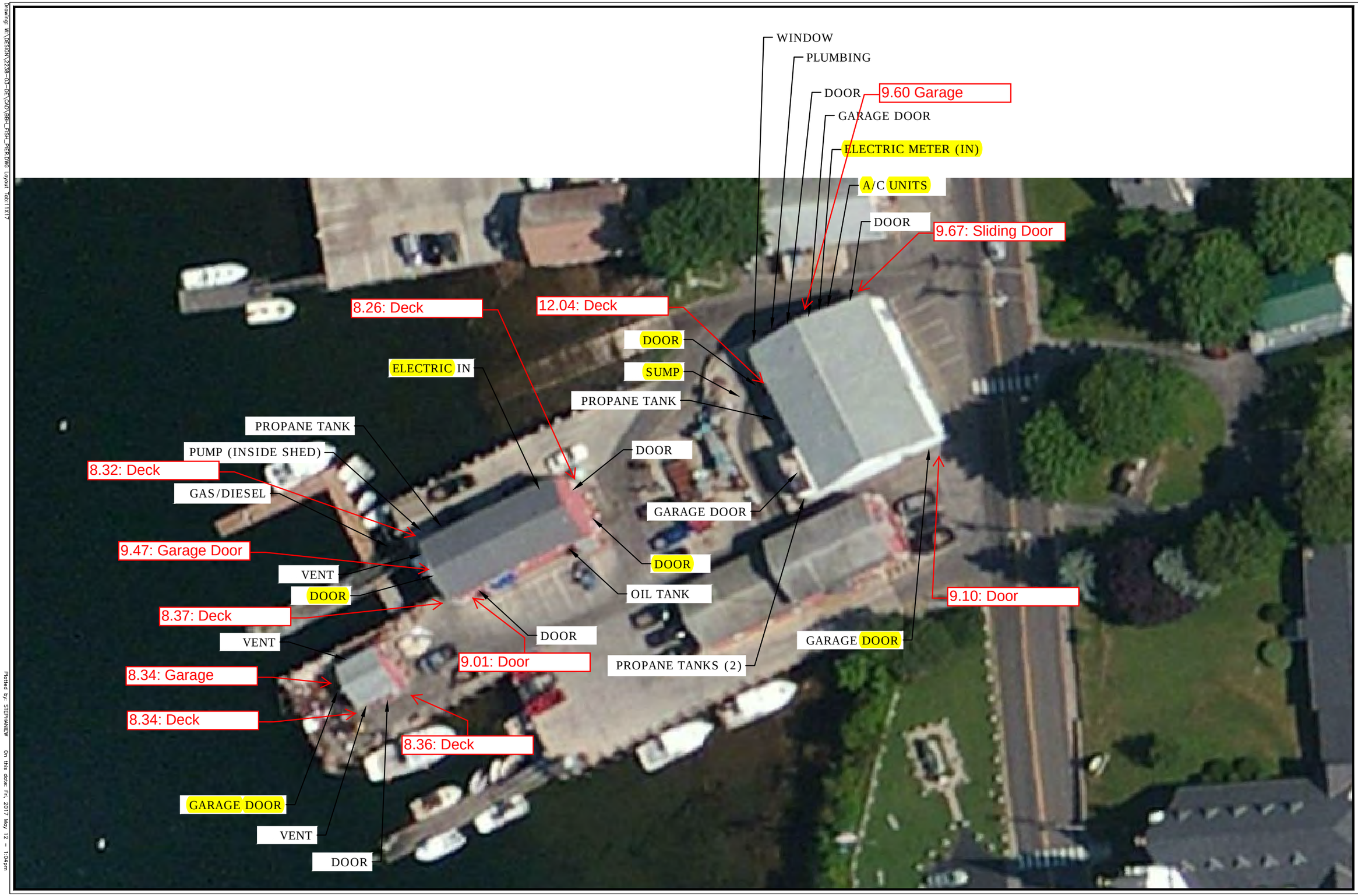
Low, DK., Mills, D., Quinn, R., Reeder, A., and J. Squerciati, 2017. "**Protecting building Utility Systems from Flood Damage; Principles and Practices for the Design and Construction of Flood Resistant Building Utility Systems.**" FEMA P-348, Edition 2 / February 2017.

Conrad, D., Kapur, O., Mahadevia, A., Maldonado, D., Moline, J., Overcash, G., Passman, S., Perotin, M., Reeder, A., Seitz, L., Sheldon, A., and J Squerciati, 2012. "**Engineering Principles and Practices for Retrofitting Flood-Prone Residential Structures.**" FEMA P-259 3rd Edition / January 2012

Frost-Tift, S., Mahadevia, A., Mills, D., Reeder, A., Sheldon, A., and J. Squerciati, 2014. "**Homeowner's Guide to Retrofitting: Six Ways to Protect Your Home From Flooding.**" FEMA P-312, 3rd Edition / June 2014.

US Army Corps of Engineers National Nonstructural Flood Proofing Committee, March 2016. "**Flood Damage Reduction Matrix."** <http://www.usace.army.mil/Missions/Civil-Works/Project-Planning/nfpc/>

Attachment 1: Key Features and Elevations



MILONE & MACBROOM®
121 Middle Street
Suite 201
Portland, Maine 04101
(207) 541-9544 Fax (207) 541-9548
www.miloneandmacbroom.com

REVISIONS

BBH FISH PIER

PROJECT NAME 1

71 ATLANTIC AVENUE
BOOTHBAY HARBOR, MAINE

--	---	--
DESIGNED	DRAWN	CHECKED

SCALE: 1"=40'

DATE: MAY 11, 2017

PROJECT NO.: 2238-03

SHEET NO.: PROP-14

Copyright Milone & MacBroom, Inc - 2017

Drawing: W:\DESIGN\2238-03-DE\CAD\BBH_FISH_PIER.DWG Layout Tab:11X17
Plotted by: STEPHANIEW On this date: Fri, 2017 May 12 - 1:04pm

Attachment 2: Flood Damage Reduction Matrix

US Army Corps of Engineers ®

Flood Damage Reduction

National Nonstructural/ Flood Proofing Committee

March 2016

	FLOOD DAMAGE REDUCTION MEASURES												
	NONSTRUCTURAL MITIGATION MEASURES												
											NFIP		
FLOOD DAMAGE REDUCTION MATRIX	Elevation on Foundation Walls	Elevation on Piers	Elevation on Posts or Columns	Elevation on Piles	Elevation on Fill	Relocation	Buyout/ Acquisition	Dry Flood Proofing	Wet Flood Proofing	Flood Warning Preparedness	Flood Plain Regulation	Flood Insurance	Flood Mitigation 1
Flooding Characteristics													
Flood Depth													
Shallow (<3 ft)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Moderate (3 to 6 ft)	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y
Deep (greater than 6 ft)	Y	N	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y
Flood Velocity													
Slow (less than 3 fps)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Moderate (3 to 5 fps)	N	N	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y
Fast (greater than 5 fps)	N	N	N	Y	N	Y	Y	N	N	Y	Y	Y	Y
Flash Flooding													
Yes (less than 1 hour)	Y	Y	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y
No	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Ice and Debris Flow													
Yes	N	N	N	Y	Y	Y	Y	N	N	Y	Y	Y	Y
No	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Site Characteristics													
Site Location													
Coastal Flood Plain													
Beach Front	N	N	N	Y	N	Y	Y	N	N	Y	Y	Y	Y
Interior (Low Velocity)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Riverine Flood Plain	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Soil Type													
Permeable	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y
Impermeable	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Building Characteristics													
Structure Foundation													
Slab on Grade	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Crawl Space	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y
Basement	Y	N	N	N	N	Y	Y	N	Y	Y	y	Y	Y
Structure Construction													
Concrete or Masonry	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Metal	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Wood	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Structure Condition													
Excellent to Good	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Fair to Poor	N	N	N	N	N	N	Y	N	N	Y	Y	Y	2
NED/NER/Recreation/Social Characteristics													
Economic													
Structure Protected	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	4	N	Y
Cost to Implement	M	M	M	M	M	H	H	L	L	L	L	L	H/M
Potential Flood Insurance Cost Reduction (Residential)	Y	Y	Y	Y	Y	Y	Y	N	N	N	Y	-	Y
Potential Flood Insurance Cost Reduction (Commercial)	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	-	Y
Potential Adverse Flooding Impact on Other Property	N	N	N	N	Y	N	N	N	N	N	Y	N	N
Reduction in Admin Costs of NFIP	N	N	N	N	Y	Y	Y	N	N	N	5	-	2
Reduction in Costs of Disaster Relief	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Reduction in Emergency Costs	N	N	N	N	N	Y	Y	N	N	N	N	N	2
Reduction in Damage to Public Infrastructure	N	N	N	N	N	Y	Y	N	N	N	N	N	2
Potential for Catastrophic Damages if Design Elevation Exceeded	N	N	N	N	N	N	N	Y	N	N	N	N	N
Promotes Flood Plain Development	N	N	N	N	N	N	N	N	N	N	N	6	N
Environmental													
Ecosystem Restoration Possible	N	N	N	N	N	Y	Y	N	N	N	N	N	N
Potential Adverse Environmental Impact	N	N	N	N	N	N	N	N	N	N	N	N	N
Recreation													
Recreation Potential	N	N	N	N	N	Y	Y	N	N	N	N	N	2
Social													
Community Remains Intact	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	3
Population Protected	N	N	N	N	N	Y	Y	N	N	Y	N	N	2
Potential Structure Marketability Increase	Y	Y	Y	Y	Y	Y	N	Y	Y	N	4	N	Y

1 NFIP Flood Mitigation may vary by structure
2 Buyout/acquisition only
3 Elevation only
4 Post FIRM construction only
5 Post FIRM structures elevation on fill
6 Yes, if in floodplains less frequent than the 100-year

Y-Yes L-Low
N-No M-Med
H-High

The US Army Corps of Engineers National Nonstructural/Flood Proofing Committee [NFPC] is available to assist in any aspect of formulating and implementing nonstructural flood damage reduction measures and realizing the opportunities that exist with nonstructural.

For more information, please contact the NFPC Chairman and committee members at: dll-cenwo-nfpc@usace.army.mil
or visit the NFPC website at: http://www.usace.army.mil/Missions/CivilWorks/ProjectPlanning/nfpc.aspx

US Army Corps of Engineers
Nonstructural - Flood Proofing
National Nonstructural / Flood Proofing Committee

Structure Inventory Data Requirements
(Note: bold/shaded cells represent most pertinent data requirements)

Structure Data	Data Definition
Building Identification Number	**Specific to Structure (geo referenced, coordinates, etc.)**
Structure Address	**Specific Postal Location of Structure**
Critical Facility	**Yes / No**
Lowest Adjacent Ground Elevation	**Elevation of Lowest Ground at Structure**
First Floor Elevation	**Elevation of Finished First Floor**
Structure Category	**Residential, Commercial, Industrial, Public**
Structure Use	What is the Specific Use of Structure
Total Stories	Total Number of Floors Above Grade
Structure Footprint	**Total Square Foot Area of At-Grade Floor**
Number of Structural Corners	**Total Number of Corners in Perimeter**
Structure Foundation Type	**Slab, Reinforced Slab, CMU, Piers, Columns, Posts, Stone**
Structure Perimeter Distance	**Total Length of All Exterior Sides of Structure**
Exterior Wall Construction	**Wood, Masonry, Brick, Metal, Stone, Concrete, Other**
Structure Visual Condition	**Good / Fair / Poor**
Garage	**Attached, Detached, None**
Doorways	**Number of Pedestrian Doorways**
Basement	**Full Basement, Half, Crawl Space, None**
Structure Photos	**Photograph of Four Sides of Structure**
Utilities Location	**Electrical, Gas, Water, Sewer, Oil, Propane, Coal, Other**
Structure Value	**Assessed Value of Structure**
Fireplace	Yes / No
Structure Owner	Who Owns the Structure
Year Structure Built	Year Structure was Constructed (Any Historic Significance)
Water Surface Elevation	Elevation or Depth of Water at Structure (H&H activity)
Water Velocity	Erosive Potential of Flood Waters (H&H activity)

Attachment 3: Selecting Floodproofing Techniques- Financial Considerations

Selecting Floodproofing Techniques – Financial Considerations

Floodproofing costs money. Generally, a higher level of flood protection costs more. Prior to selecting a floodproofing method, it is necessary to evaluate the benefits of a proposed project and the anticipated cost of achieving those benefits. The following information can be used as general guidance for evaluating floodproofing options.[1]

Benefits

Floodproofing is principally a means for **reducing damages from future floods**. This includes the cost of repairing the building and its utility systems, repair or replacement of damaged contents, the time and expense for cleanup, the cost of housing during periods when the structure cannot be occupied, and loss of income if flood cleanup and repairs require time off from work. The tables on the following page can be used to estimate potential damages to buildings and contents based on the depth of flooding. The history of previous damages can also help with this assessment. Keep in mind that the damages from frequent events may be prevented numerous times over the life of the building. Because no floodproofing project can prevent all potential flood damages, the expected project benefit is the difference between the expected damages without the project and the expected damages if the project is implemented.

Additional benefits of floodproofing include:

- **Increased safety:** Floodproofing reduces health and safety impacts associated with reentry into a flooded structure. Relocation away from the flood hazard area precludes the need to evacuate and is thus even safer.
- **Reduced flood insurance premiums:** The cost of flood insurance for buildings that do not comply with floodplain development standards (at the time of construction) is generally quite high. Actuarial rates are based on the height of the first floor (or dry floodproofing of non-residential buildings) relative to the height of the 100-year flood. A project that brings a building into compliance and/or increases the level of protection can significantly reduce the annual cost of flood insurance.
- **Increased resale value**.
- **Intangible benefits** result from reducing the annoyance, inconvenience, and stress associated with preparation for and recovery from flood events.

Project Costs

General information about construction costs for retrofitting projects is provided on the following pages. These values are only appropriate for preliminary planning purposes. Once a floodproofing method has been selected and the project is designed, a more accurate cost estimate can be developed. Make sure that the detailed cost estimate includes all of the project elements, such as temporary housing during construction, landscaping, and annual maintenance expenses.

---

[1] Additional information for assessing the financial benefits of a floodproofing project is provided in *Chapter V: Benefit / Cost Analysis and Alternative Selection*, in FEMA 259, *Engineering Principles and Practices of Retrofitting Flood-Prone Residential Structures (2001) at* http://www.fema.gov/library/viewRecord.do?id=1645.

Depth-Damage Tables

The following tables can be used to estimate the damage that may be sustained each time a building is flooded, based on the depth of flooding relative to the top of the first floor (excluding the basement, which is defined as any portion of the building with its floor below grade on all sides).

Flood Depth	**Building Damage Percent by Building Type** (based on Building Replacement Value)						
	1 Story without Basement	2 or More Stories without Basement	Split Level without Basement	1 Story with Basement	2 or More Stories with Basement	Split Level with Basement	Mobile Home*
-2	0.0	0.0	0.0	13.8	10.2	10.4	0.0
-1	2.5	3.0	6.4	19.4	13.9	14.2	0.0
0	13.4	9.3	7.2	25.5	17.9	18.5	8.0
1	23.3	15.2	9.4	32.0	22.3	23.2	44.0
2	32.1	20.9	12.9	38.7	27.0	28.2	63.0
3	40.1	26.3	17.4	45.5	31.9	33.4	73.0
4	47.1	31.4	22.8	52.2	36.9	38.6	78.0
5	53.2	36.2	28.9	58.6	41.9	43.8	80.0
6	58.6	40.7	35.5	64.5	46.9	48.8	81.0
7	63.2	44.9	42.3	69.8	51.8	53.5	82.0
8	67.2	48.8	49.2	74.2	56.4	57.8	82.0
9	70.5	52.4	56.1	77.7	60.8	61.6	82.0
10	73.2	55.7	62.6	80.1	64.8	64.8	82.0
11	75.4	58.7	68.6	81.1	68.4	67.2	82.0
12	77.2	61.4	73.9	81.1	71.4	68.8	82.0
13	78.5	63.8	78.4	81.1	73.7	69.3	82.0
14	79.5	65.9	81.7	81.1	75.4	69.3	82.0
15	80.2	67.7	83.8	81.1	76.4	69.3	82.0

Source: "Default Building Depth-Damage Functions: Residential Buildings" from FEMA Retrofitting Flood-Prone Residential Buildings Training (January 2009).

Flood Depth	**Contents Damage Percent by Building Type** (based on total value of contents)					
	1 Story without Basement	2 Story without Basement	Split Level without Basement	1 or 2 Story with Basement	Split Level with Basement	Mobile Home
-2	0	0	0	6	5	0
-1	0	0	0	12	8	0
0	14	8	5	17	9	12
1	21	14	14	23	24	66
2	33	20	20	30	29	90
3	41	27	38	35	33	90
4	44	30	41	42	41	90
5	45	33	42	50	48	90
6	60	36	50	57	53	90
7	65	39	51	66	54	90
8	66	44	62	74	66	90
>8	68	50	65	77	72	90

Source: FEMA 259, *Engineering Principles and Practices of Retrofitting Flood-Prone Residential Structures (2001).*

Floodproofing Cost Estimates

The following cost estimates are for preliminary planning purposes only. They are based on nationwide averages and published in 2001.[2]

Elevation:

2-foot raise: Wood frame building with basement or crawlspace – $18 per square foot
Wood frame building with slab-on-grade foundation – $50 per square foot
Masonry building with basement or crawlspace – $37 per square foot
Masonry building with slab-on-grade foundation – $50 per square foot

3- to 8-foot raise – add $0.80 per square foot for each additional foot of elevation
Above 8 feet – add $1.05 per square foot
Wood frame with brick veneer on walls – add 10 percent

These costs include foundation, existing utilities, and miscellaneous items. Large buildings (3 or more stories and those with footprints more than 2,500 square feet) and those with complex shapes are technically more difficult to elevate and may thus be more costly.

Displacement costs – Additional expenses will be incurred to remove and store contents and for temporary living quarters during construction, which may last 2 to 3 weeks.

Relocation:

Relocation costs: Wood frame building with basement – $34 per square foot
Wood frame building with crawlspace – $29 per square foot
Wood frame building with slab-on-grade foundation – $54 per square foot
Masonry building with basement – $52 per square foot
Masonry building with crawlspace – $34 per square foot
Masonry building with slab-on-grade foundation – $65 per square foot

Wood frame with brick veneer on walls – add 10 percent
Restoration of old site: $12 per square foot of building footprint

These costs include off-site relocation (less than 5 miles) and new site development for a 1,000 square foot building. Extrapolation of this unit cost to larger buildings may result in artificially high estimates because the costs of relocation do not increase proportionally with building size. However, if the building has 3 or more stories, a footprint greater than 2,500 square feet, or a complex shape, technical challenges may result in increased costs.

Displacement costs – Additional expenses will be incurred to remove and store contents and for temporary living quarters during construction, which may last 3 to 4 weeks.

[2] Source: FEMA 259, *Engineering Principles and Practices of Retrofitting Flood-Prone Residential Structures (2001).*

Dry Floodproofing
Sprayed-on cement (above grade) – $3.50 per square foot
Waterproof membrane (above grade) – $1.17 per square foot
Asphalt (2 coats below grade; not including cost of excavation) – $1.17 per square foot
Perimeter drainage – $33 per linear foot
Plumbing check valve – $660 lump sum
Sump pump (with backup battery) – $1,060 lump sum
Metal flood shield – $77 per square foot
Wood flood shield – $24 per square foot
Sprayed-on cement (above grade) – $3.50 per square foot

Wet Floodproofing
Unfinished basement: 2 feet height (above basement floor) – $1.80 per square foot of house footprint
4 feet height (above basement floor) – $3.70 per square foot of house footprint
8 feet height (above basement floor) – $10.60 per square foot of house footprint
Crawlspace: 2 feet height (above lowest adjacent grade) – $1.40 per square foot of house footprint
4 feet height (above lowest adjacent grade) – $3.45 per square foot of house footprint

Floodwalls and Levees
Floodwalls: 2 feet above ground level – $90 per linear foot
4 feet above ground level – $132 per linear foot
Levees: 2 feet above ground level – $39 per linear foot
4 feet above ground level – $73 per linear foot
6 feet above ground level – $122 per linear foot
Interior drainage – $4,500 lump sum
Closures – $77 per square foot
Riprap – $33 per cubic yard
Seeding of disturbed areas – $0.05 per square foot

Floodwall costs are based upon typical foundation depth of 30 inches. Levee costs are based upon typical foundation depth of one foot, 5-foot top width, and 1:3 side slopes. Levee costs include seeding and stabilization.

Additional Costs
- Compliance with building codes – These estimates do not include additional expenditures that may be required to bring the building into compliance with building codes.
- Professional or architectural design – 10% of estimated costs
- Contractors' profit – 10% of estimated costs
- Contingency to account for unknown or unusual conditions
- Annual maintenance expenses – Levees, floodwalls, dry floodproofing, and wet floodproofing projects all require ongoing maintenance.

Additional Information
- **FEMA's Benefit-Cost Analysis** methodology and tools can be used to evaluate the cost effectiveness of proposed retrofitting projects (http://www.fema.gov/government/grant/bca.shtm).