



*National Flood Insurance Program*

# Flood Mitigation Measures for Multi-Family Buildings

*FEMA P-2037 / October 2019*

**Federal Emergency Management Agency**
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***On the Cover***
Top Left - Representative multi-family building (Boston, MA).
Top Middle - Representative multi-family building with at grade access, parking garage, and dwelling units (Tampa, FL).
Top Right – Representative new-construction and compliant elevated residential building with at grade parking that had minimal flood damage during Hurricane Florence (New Bern, NC).
Bottom Left – Residents evacuated from multi-family buildings during Hurricane Harvey (Houston, TX).
Bottom Right – Representative multi-family buildings along the Hudson River (Hudson County, NJ).

# ACRONYMS

The following acronyms are used in the document.

| | |
|---|---|
| ASCE | American Society of Civil Engineers |
| BFE | Base Flood Elevation |
| CAZ | Coastal A Zone |
| CFR | Code of Federal Regulations |
| DFE | Design Flood Elevation |
| FEMA | Federal Emergency Management Agency |
| FIRM | Flood Insurance Rate Map |
| FIS | Flood Insurance Study |
| FPL | Flood Protection Level |
| FPM | Floodplain Management |
| fps | feet per second |
| HVAC | heating, ventilation, and air conditioning |
| IBC® | International Building Code® |
| ICC | International Code Council, Inc. |
| I-Codes® | International Codes® |
| IT | Information Technology |
| LiMWA | Limit of Moderate Wave Action |
| MEP | mechanical, electrical, and plumbing |
| MFH | multi-family housing |
| MSC | (FEMA Flood) Map Service Center |
| NFIP | National Flood Insurance Program |
| RCBAP | Residential Condominium Building Association Policy |
| SD | Substantial Damage |
| SEI | Structural Engineering Institute |
| SFHA | Special Flood Hazard Area |
| SFIP | Standard Flood Insurance Policy |
| SI | Substantial Improvement |
| USACE | United States Army Corps of Engineers |

# TABLE OF CONTENTS

## ICONS

Cross Reference: Reference to another relevant part of the text or another source of information

Note: Contains important information

Terminology: Definition or explanation of pertinent terms

Warning: Highlights potential dangers or concerns, including warnings when measures do not meet minimum NFIP requirements for *new construction* and SI/SD buildings

# FIGURES

# TABLES

# INTRODUCTION

# 1

This publication provides guidance on flood risk evaluation and mitigation of large multi-family buildings, particularly in urban areas. The focus is mid-rise and high-rise buildings, although many of the approaches could be applied to low-rise buildings (see descriptions in Table 1-1 in Section 1.4). This publication is not intended to address rowhouses or townhouses, which could include three or more attached dwelling units, each separated by vertical structural or non-structural partition walls and generally having individual entrances and interior stairs.

Readers may use this guidance to help: (1) reduce future flood losses, (2) understand the National Flood Insurance Program (NFIP) regulatory requirements, and (3) reduce NFIP flood insurance premiums, or some combination of the three. Primarily, the publication focuses on the retrofit of *existing construction* (as defined in Section 1.4) to reduce or mitigate flood risk and provide readers background on floodplain management criteria that must be met during the retrofit process. However, *new construction* (as defined in Section 1.4) is also addressed including highlighting the floodplain management requirements that must be met to achieve a compliant building (see Section 2.2). An overview of how flood insurance applies to multi-family buildings is also included.

*TERMINOLOGY*

A **mid-rise** multi-family building has four to eight stories. A **high-rise** has nine or more stories. See descriptions in Table 1-1.

*TERMINOLOGY*

**Existing Construction** is a structure built before the community had adopted a Flood Insurance Rate Map (FIRM). **New Construction** is a structure built after the community's adoption of floodplain management regulations. Thus, *new construction* may refer to a structure that was built decades ago. See Section 1.4 for definitions.

## 1.1 BACKGROUND

Due to the size of mid- and high-rise multi-family buildings, mitigation measures to help protect them from coastal or riverine flooding may be limited. Traditional mitigation measures typically applied to single-family dwellings, such as retrofit elevation, are often not feasible for large multi-family buildings. Elevation of multi-family buildings in densely populated areas is rarely technically feasible because of the structural characteristics of the large building or the building location due to narrow or zero offsets to other buildings. If technically feasible, the retrofit elevation is typically cost prohibitive. Therefore, this publication provides additional mitigation measures to reduce flood risk.

*NOTE*

Due to construction practices such as shared partition walls between units and different ownership, **rowhouses, townhouses, duplexes,** and **multiplexes** are **not addressed** in this publication.

*NOTE*

Unless a multi-family building is **mixed-use** (i.e., has some commercial space), it would be treated as a residential building under the NFIP.

Floodplain management regulations cover all residential buildings and apply to single-family dwellings as well as multi-family buildings. Although most multi-family buildings are structurally similar to commercial buildings, unless a multi-family building is *mixed-use* (i.e., has some commercial space), it would be treated as residential under the NFIP. Therefore, mitigation measures available to commercial and other non-residential buildings, such as dry floodproofing, are not permitted for *new construction* or *substantially improved* (as defined in Section 1.4) multi-family buildings, or residential portions of mixed-use buildings.

## 1.2 OBJECTIVE AND ORGANIZATION

The primary objective of this publication is to encourage mitigation techniques that can better protect large multi-family buildings in urban areas. It is written to help readers gain an improved understanding of the essential considerations for making flood-prone, urban, multi-family buildings more resilient. While other existing Federal Emergency Management Agency (FEMA) publications address mitigation options for single-family residences and large commercial buildings, this publication provides insights unique to multi-family residential buildings.

To help readers develop a comprehensive mitigation approach, this publication describes the floodplain management regulatory framework, the process for determining flood risk, and potential mitigation measures to address that risk. The publication is organized in the following chapters:

- **Chapter 1 "Introduction"** outlines the audience, defines key terms used throughout the guidance, and describes how urban environments provide additional challenges for mitigating multi-family buildings.
- **Chapter 2 "Regulatory Framework"** outlines specific requirements for multi-family buildings based on NFIP requirements and model building codes.
- **Chapter 3 "Flood Risk"** discusses procedures for identifying the flood hazard, understanding flood loads, and evaluating a building's susceptibility to flood damage.
- **Chapter 4 "Flood Insurance Considerations"** provides an overview of the NFIP, how it applies to multi-family buildings, and includes guidance on determining how the lowest floor would be determined for insurance purposes.
- **Chapter 5 "Mitigation Measures"** describes common mitigation measures, includes a discussion of the advantages and disadvantages associated with each alternative, and refers readers to existing FEMA publications that provide more detail on those measures.
- **Chapter 6 "Representative Scenarios"** provides examples of multi-family buildings and how they could apply the mitigation measures described in Chapter 5.

NOTE

This publication does not cover the structural design of mitigation measures such as the determination of loads, sizing of building elements, and construction detailing. A crosswalk identifying pertinent publications that have more information on specific aspects of design is included in Appendix A.

Readers should consider other ways – in addition to those provided here – to retrofit their buildings to improve resiliency during the planning, design, and construction of the flood mitigation measures. These modifications may include energy efficiency improvements, mitigation for other natural hazards (e.g., high winds, seismic, drought, and high heat), and modifications to allow occupation of the building once floodwaters recede and while utility services such as power are being restored.

## 1.3 INTENDED AUDIENCE

This publication is intended for building owners, designers, investors, builders/contractors, institutional partners, housing agencies and residents, property and facility managers responsible for operating, designing, constructing, or maintaining multi-family buildings, and local officials responsible for enforcing floodplain management regulations or building codes.

## 1.4 KEY TERMS AND DEFINITIONS

Some key terms used in this document are defined in NFIP regulations (Title 44 Code of Federal Regulations [CFR] Section 59.1) and others are defined or described in other publications such as the NFIP Flood Insurance Manual (FEMA 2018c). The following are the definitions, for purposes of this publication, of key terms used in this document.

In this publication, **multi-family building** refers to a building with five or more dwelling units. Multi-family buildings typically have four stories or more above ground and may have one or more floors below ground. See Figure 1-1 for a representative multi-family building. The term includes condominium and apartment buildings in addition to congregate residences (e.g., nursing homes, assisted living facilities, dormitories, group homes, detoxification facilities, detention centers, sororities, and fraternities).

*TERMINOLOGY*

**Dwelling unit** is a single unit designed or intended to be used for human habitation, providing independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking, and sanitation facilities.

Figure 1-1. Representative multi-family building

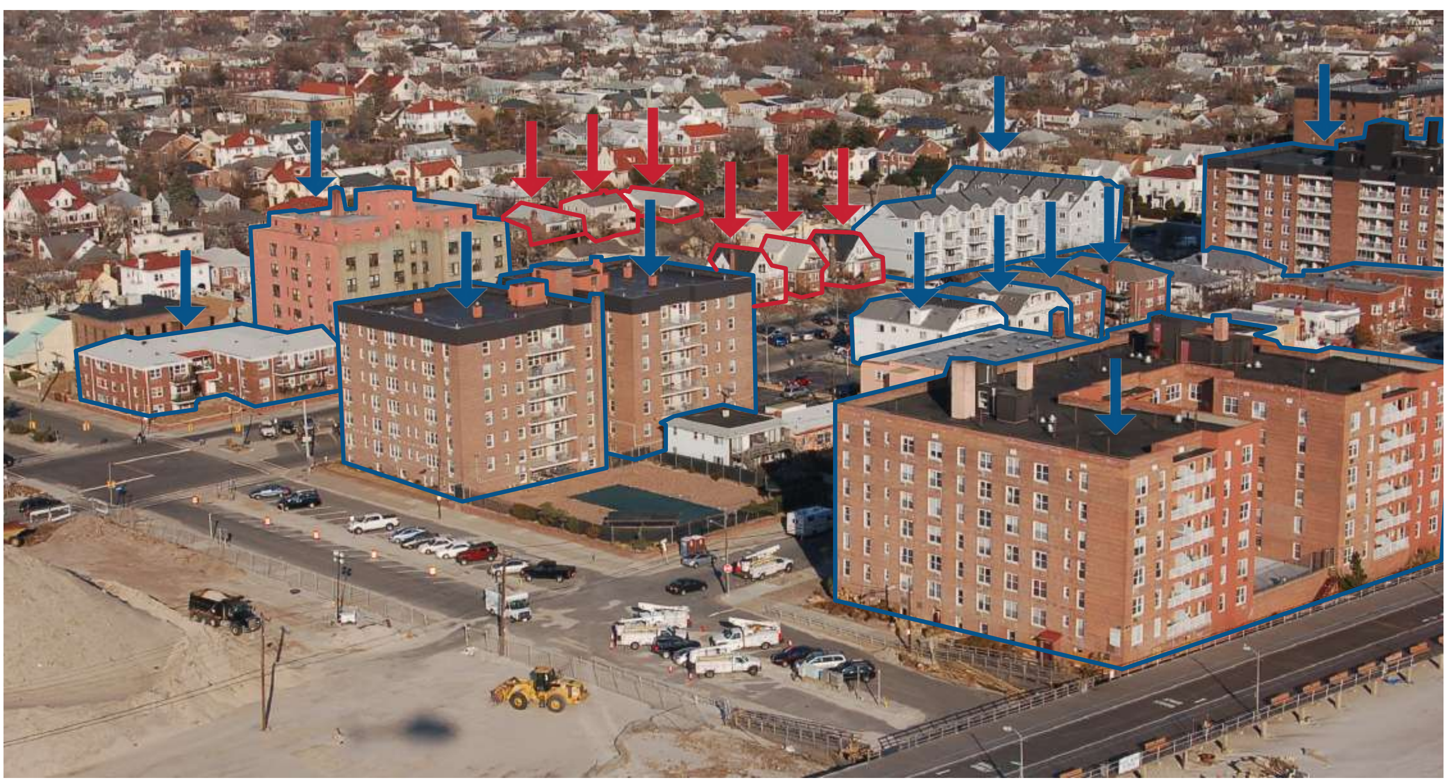


Figure 1-2. Multi-family buildings versus a detached dwelling unit.

The red arrows show single family homes, while the blue arrows show multi-family buildings.

Figure 1-2 illustrates a comparison of adjacent buildings. The buildings outlined in red indicate detached dwelling units which are outside the scope of this publication, while the apartment buildings outlined in blue indicate multi-family buildings which are within the scope of this publication. See Table 1-1 for a brief description of multi-family housing (MFH) and other common residential building types and whether the guidance in this publication is applicable. These general descriptions are for the purposes of this publication and are not intended to match local zoning or building code definitions.

Table 1-1. Applicability of this publication to various types of multi-family construction

| TYPE | DESCRIPTION/EXAMPLES | APPLICABILITY |
|---|---|---|
| High-Rise MFH | A freestanding structure with nine or more stories having at least five dwelling units. | Yes |
| Mid-Rise MFH | A freestanding structure with four to eight stories containing at least five dwelling units. | Yes |
| Walk-up MFH | A four- to six-story freestanding structure containing at least five dwelling units. Walk-up buildings do not have an elevator. | Yes |
| Low-Rise MFH | A building with less than four stories containing at least five dwelling units. | Applicable to two- to four-story buildings |
| Attached/Row Dwelling | Generally, a less than four-story structure containing three or more attached dwelling units, each separated by vertical walls and generally having individual entrances and interior stairs (e.g., a rowhouse or townhouse). | Not Applicable |
| Detached Dwelling | A structure consisting of one or two dwelling units that is freestanding or surrounded by permanent open spaces (i.e., a single-family or two-family home). | Not Applicable |
| Semi-Detached | A structure containing two dwelling units separated by a common vertical wall (e.g., a duplex). | Not Applicable |

**Base Flood Elevation (BFE):** The computed elevation to which floodwater is anticipated to equal or exceed during the base flood or the flood having a 1 percent chance of occurring in any given year (also referred to as the 100-year flood).

**Basement:** Any area of the building having its floor subgrade (below ground level) on all sides. Basements below the BFE in residential buildings are allowed only in communities that have obtained a basement exception from FEMA.

**Compliance:** Meeting the requirements of the locally adopted floodplain management regulations as required by the NFIP.

*NOTE*

Basements below the BFE in residential buildings in the floodplain are allowed only in communities that have obtained a **basement exception** from FEMA. Nonresidential buildings are allowed to have dry floodproofed basements.

**Development:** Any man-made change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation or drilling operations, or storage of equipment or materials.

**Dry floodproofing:** Any combination of structural and non-structural additions, changes, or adjustments to a structure that results in the structure being watertight, with walls that are substantially impermeable to the passage of water and structural components capable of resisting flood-related loads. Requirements for compliant dry floodproofing are described in Section 5.3.

**Elevated building:** For insurance purposes, a non-basement building that has its lowest elevated floor raised above ground level by foundation walls, shear walls, posts, piers, pilings, or columns.

*NOTE*

**Non-elevation design requirements** for multi-family buildings include adding flood openings and using flood damage-resistant materials for enclosed areas below the BFE.

**Enclosure:** An area that is enclosed on all sides by walls. Enclosed areas are permitted below the lowest floor provided the enclosed areas meet certain use restrictions (used only for parking of vehicles, building access, or storage) and construction requirements related to flood resistance, including use of flood damage-resistant materials and installation of openings to allow for automatic entry and exit of floodwater. More information can be found in NFIP Technical Bulletin 1, *Openings in Foundation Walls and Walls of Enclosures Below Elevated Buildings in Special Flood Hazard Areas in accordance with the National Flood Insurance Program* (FEMA 2008a).

**Existing construction:** For the purposes of determining (flood insurance) rates, structures for which the start of construction was before the effective date of the Flood Insurance Rate Map (FIRM) or before January 1, 1975, for FIRMs effective before that date. *Existing construction* may also be referred to as existing structures. Information for determining which NFIP requirements apply to *existing construction* can be found in Chapter 2 of this publication.

**Flood Mitigation Strategy:** A comprehensive approach to help protect a building from flood damage. Included in a flood mitigation strategy is a vulnerability assessment, determination of a flood protection elevation or level, and utilization of one or more mitigation measures to help minimize building damage by floodwater.

**Flood Protection Level (FPL):** The elevation of flood protection that a building will be retrofitted to resist. This level is determined either by a requirement in the NFIP, building codes, or locally adopted ordinances and used in design of any retrofits to the building and utility systems. The minimum FPL is the elevation required by the local floodplain management ordinance or building code. When owners and designers elect to provide a degree of protection greater than the minimum required, the FPL refers to the selected elevation above the minimum required.

**Legal non-conforming construction:** A structure that complied with floodplain requirements in effect when permitted, but BFEs or flood zones have since changed. Although a *legal non-conforming structure* may have been in compliance at the time it was constructed, it must come into compliance with current NFIP regulations or codes when a triggering event occurs, such as substantial improvement or substantial damage.

**Lowest floor:** The lowest floor of the lowest enclosed area (including the basement). An unfinished or flood-resistant enclosure, usable solely for parking of vehicles, building access, or storage in an area other than a basement area, is not considered a building's lowest floor, provided that such an enclosure is not built so as to render the structure in violation of the applicable non-elevation design requirements.

**Mixed-use building:** A building that has both residential and commercial uses.

**New construction:** For the purposes of determining (flood) insurance rates, structures for which the start of construction was on or after the effective date of an initial FIRM or after December 31, 1974, whichever is later and includes any subsequent improvements to such structures. For floodplain management purposes, *new construction* means structures for which the start of construction commenced on or after the effective date of a floodplain management regulation adopted by a community and includes any subsequent improvements to such structures. An existing building will be considered *new construction* if it is substantially improved or once it has been repaired after being substantially damaged/substantially improved. Information for determining which NFIP requirements apply to *new construction* can be found in Chapter 2 of this publication.

**Non-residential building:** A building that has a commercial or other non-residential use.

**Residential building:** A building designated for habitation. For insurance purposes, a non-commercial building designed for habitation by one or more families or a mixed-use building that qualifies as a single-family, 2–4 family, or other residential building.

**Substantial damage (SD):** Damage of any origin sustained by a structure whereby the cost of restoring the structure to its before-damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred.

CROSS REFERENCE

**Substantial improvement/ substantial damage** is triggered when the cost to repair, rehabilitate, alter, or add to the structure is greater than 50 percent of the market value of the building.

When buildings are determined to be SI/SD, the building must be retrofitted to conform to the current locally enforced floodplain management regulations.

SD determinations for multi-family buildings are based on the cost to repair all damage to the structure compared to the market value of the entire structure, regardless of the number of owners

See Section 2.2 for further information related to SI/SD.

**Substantial improvement (SI):** Any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the start of construction of the improvement. This term includes structures that have incurred substantial damage, regardless of the actual repair work performed.

**Wet floodproofing:** Permanent or temporary measures that allow floodwater to flow through a structure and only result in cosmetic repairs. Requirements for compliant wet floodproofing are described in Section 5.2.

## 1.5 MULTI-FAMILY BUILDINGS IN AN URBAN ENVIRONMENT

Multi-family buildings in urban environments are often confined by narrow lots. In some situations, buildings may share common walls with adjacent buildings. Many sites are too constrained to make site-related drainage improvements. Figure 1-3 shows a representative multi-family building in an urban environment.

Multi-family buildings typically have a useful life of 50 years or more and, over time, owners may change the occupancy classification of part or all of a building (e.g., convert some or all spaces to commercial). Conversions can generate other challenges such as dwelling units in a basement, dividing an apartment into single room occupancies, or creating a dwelling unit in a building originally designated for industrial or commercial use.

Long useful life and possible changes in occupancy present opportunities and challenges for bringing *existing construction* multi-family buildings into compliance with floodplain management requirements when triggered by SI/SD. Such improvements or damages can also trigger other requirements in building codes, such as fire system, electrical, or sustainability and energy upgrades.

Figure 1-3. Representative multi-family building in an urban environment

> NOTE
>
> Following Hurricane Sandy, the FEMA Mitigation Assessment Team observed that **inundation of building systems** was the most common type of building damage. This damage was observed primarily in buildings with unprotected systems located below the Sandy flood levels, **especially in subgrade enclosures**. Flooding rendered impacted building systems inoperable, which slowed recovery considerably.

Many *existing construction* multi-family buildings have one or more below-ground levels (basements) often for ancillary uses to optimize above-ground building space for residential use and to facilitate access to below-ground utility connections. Basements typically contain large areas with utilities and equipment such as mechanical, electrical, fuel gas, plumbing, heating, pumps, communications, security, fire control, and related components. In some cases, multi-family buildings also have below-ground parking. Below-ground areas typically have ventilation wells or ductwork to street level. Below-ground utilities require connection to surrounding underground utility infrastructure such as power, gas, and sewage.

Over the life of a typical multi-family building, below-ground access points for utilities or to adjacent buildings can be abandoned without being properly decommissioned and sealed. These common below-ground characteristics present challenges when considering retrofit flood mitigation strategies and should be identified during a building evaluation (see Appendix D).

## 1.6 MIXED-USE BUILDINGS

While the emphasis of this publication is on multi-family buildings, the publication also includes a look at mixed-use buildings. Mixed-use buildings are addressed when it is important to differentiate how they could be treated differently than buildings that are entirely of residential use. The NFIP regulations do not define mixed-use buildings. However, the NFIP Flood Insurance Manual (FEMA 2018c) defines a mixed-use building as a building that has both residential and non-residential uses. Mixed-use buildings create unique circumstances when considering flood mitigation approaches because the floodplain management requirements are applied to specific portions of the building based on whether the portions are used for residential or non-residential purposes. For example, while the NFIP regulations state that dry floodproofing of below-grade parking garages is allowed only for non-residential buildings in Zone A, professionally designed buildings that have both commercial (non-residential) and residential uses may be designed with floodproofed below-grade parking garages. See Figures 1-4 and 1-5 for representative mixed-use buildings.

Figure 1-5. Representative mixed-use building with commercial space throughout the ground floor on the left

Figure 1-4. Representative mixed-use building (for floodplain management and not insurance purposes)

## 1.7 ANCILLARY AREAS SUCH AS LOBBIES

Multi-family residential buildings normally include ancillary use areas such as lobbies, foyers, offices used by building management, and mail rooms for residents. It also includes common areas used by residents for non-residential purposes such as parking, storage, offices, meeting rooms, swimming pools, and exercise facilities. Lobbies are discussed in this section. From a floodplain management perspective, buildings with multiple dwelling units and ancillary use areas that support the dwelling units are not considered mixed-use buildings, so the entire building is considered residential.

For the purposes of this publication, a lobby refers to a space designed to provide separation and control access between public spaces and commercial or residential spaces, including access to dwelling units. The term includes vestibules, foyers, and spaces or areas that provide access to elevators. Lobbies are often the primary point of access/exit from large buildings to outside areas. Lobbies with furniture, sitting areas, trash receptacles, or other contents or fixtures change the use of the area to something other than strictly building access. Tenant mailboxes, security desks, and tenant services would be considered uses other than building access. If elevators are accessed through the lobby area, the elevators must comply, as applicable, with all requirements of NFIP Technical Bulletin 4, *Elevator Installation for Buildings Located in Special Flood Hazard Areas in accordance with the National Flood Insurance Program* (FEMA 2010c).

**Wet Floodproofing:** Lobbies that solely provide building access may be wet floodproofed provided that the space meets all necessary requirements for an enclosure below the BFE of an elevated building. The requirements include having sufficiently sized, located, and numbered flood openings; use of flood damage-resistant materials and finishes; elevating equipment, utilities, and building service components above the required FPL or designing them to prevent floodwater from accumulating within the components; and using space only for allowable enclosure uses (parking of vehicles, storage, and, in the case of lobbies, building access).

**Elevated Above the FPL:** Lobbies elevated above the required FPL within a compliant building are not restricted in terms of serving multiple uses, including tenant mailboxes, security desks, and other tenant services.

**Dry Floodproofing:** Lobbies that provide access to both commercial and residential spaces are allowed to be dry floodproofed, provided there is separate building access for the residential spaces that is either wet floodproofed or elevated above the required FPL. When properly designed, constructed, and certified to be dry floodproofed, the lowest floor of a mixed-use building is allowed below the BFE; however, the lowest floor can only be used for non-residential purposes. While access to the residential spaces is allowed from a dry floodproofed lobby that serves both commercial and residential spaces, the lowest floor of all residential areas must be elevated to or above the BFE. The residential areas include all residential dwelling units, building systems (including electrical, heating, ventilation, plumbing, air conditioning, and other service equipment), and other finished ancillary areas (including laundry rooms, offices, mail rooms, meeting rooms, and exercise rooms) that support the residential units in the building.

# REGULATORY FRAMEWORK

# 2

The NFIP is a federal program established by the National Flood Insurance Act of 1968. Property owners and tenants in communities that participate in the NFIP can purchase federal flood insurance as financial protection against flood losses. Private flood insurance may also be available for these individuals. NFIP flood insurance policies pay claims when damage is caused by a general condition of flooding, while federal disaster assistance is available only after events are declared major disasters by the President of the United States.

To participate in the NFIP, communities must adopt and enforce adequate floodplain management regulations that meet or exceed the NFIP requirements for floodplain management. The regulations include design and construction standards for *new construction* and substantially improved buildings located in the special flood hazard area (SFHA), which is identified on the NFIP FIRM.

*TERMINOLOGY*

**Substantial Improvement:** Any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the "start of construction" of the improvement. This term includes structures which have incurred "substantial damage", regardless of the actual repair work performed. The term does not, however, include either: (1) any project for improvement of a structure to correct existing violations of state or local health, sanitary, or safety code specifications which have been identified by the local code enforcement official and which are the minimum necessary to assure safe living conditions; or (2) any alteration of a "historic structure", provided that the alteration will not preclude the structure’s continued designation as a "historic structure".

**Substantial Damage**: Damage of any origin sustained by a structure whereby the cost of restoring the structure to its before damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred.

Buildings that meet the Substantial Improvement or Substantial Damage criteria must be brought into compliance with the current minimum locally enforced floodplain management requirements.

FEMA encourages communities to adopt floodplain management regulations that exceed NFIP regulations. The administration of NFIP-consistent requirements helps achieve the long-term objective of building disaster-resilient communities.

At the federal level, the NFIP is managed by FEMA in three main elements:

- **Hazard identification and mapping:** Conducts engineering studies and prepares flood maps and studies to delineate areas expected to be subject to flooding.
- **Floodplain management:** Establishes minimum requirements that participating communities must adopt and enforce on development in mapped flood hazard areas with the expectation that communities will recognize and address flood hazards throughout the land development process.
- **Flood insurance:** Provides some financial protection for property owners and tenants to cover flood-related damage to buildings and contents in communities that participate in the NFIP and enforce minimum floodplain management requirements.

The floodplain management building performance requirements for development in SFHAs are set forth in 44 CFR Parts 59 and 60. The requirements apply to residential and non-residential development proposed in SFHAs.

The NFIP broadly defines the term *development*. The requirements apply to development, *new construction* (buildings and structures), substantial improvement of *existing construction* (buildings and structures), and repair of *existing construction* (buildings and structures) that sustain substantial damage (see Section 1.4 for terminology).

## 2.1 DETERMINATION OF THE BUILDING DESIGNATION

An initial step in understanding the floodplain management requirements that apply to a building is the determination of whether the building is considered *new construction (including* SI /SD), *legal non-conforming*, or *existing construction*. Figure 2-1 provides an overview of the steps necessary to make a determination.

*TERMINOLOGY*

For NFIP insurance purposes:

- **Pre-FIRM** refers to buildings for which construction or substantial improvement occurred on or before December 31, 1974, or before the effective date of an initial FIRM.
- **Post-FIRM** refers to buildings for which construction or substantial improvement occurred after December 31, 1974, or after the effective date of an initial FIRM, whichever is later.

While the terms Pre- and Post-FIRM are often used for insurance rating purposes, they will not be used extensively throughout the publication; instead the building designation will either be *new construction* (including SI/SD), *legal non-conforming construction*, or *existing construction.*

| NOTES | BUILDING DESIGNATION |
|---|---|

*Access the NFIP Community Status Book to determine when the community joined the NFIP (in column titled "Reg-Emer Date") [https://www.fema.gov/national-flood-insurance-program-community-status-book](https://www.fema.gov/national-flood-insurance-program-community-status-book)*

*SI/SD is triggered when the cost to repair, rehabilitate, alter, or add to the structure equals or exceeds 50% of the market value of the building. More information to determine if the proposed work on the building triggers SI/SD is in Section 2.3.*

*NFIP requirements for new construction are shown in Section 2.2. The current requirements refer to the flood zone where the building is located.*

*Determine if the cost of repairs, improvements, or modifications to meet the current requirements equals or exceeds 50% of the market value of the building. More information is in Section 2.3.*

## REQUIREMENTS

***New Construction/SI/SD:*** Must conform with current FPM requirements.

***Legal Non-Conforming Construction:*** Unless SI/SD is triggered, conformance with current FPM requirements is not required, but compliance with the FPM requirements at the date of construction or date of previous SI must be maintained.

***Existing Construction:*** Buildings built before communities joined the NFIP are not required to comply with NFIP regulations unless they are being SI or have incurred SD. Existing buildings that have been included inside an expanded SFHA shown in an updated FIRM are also considered *Existing Construction*.

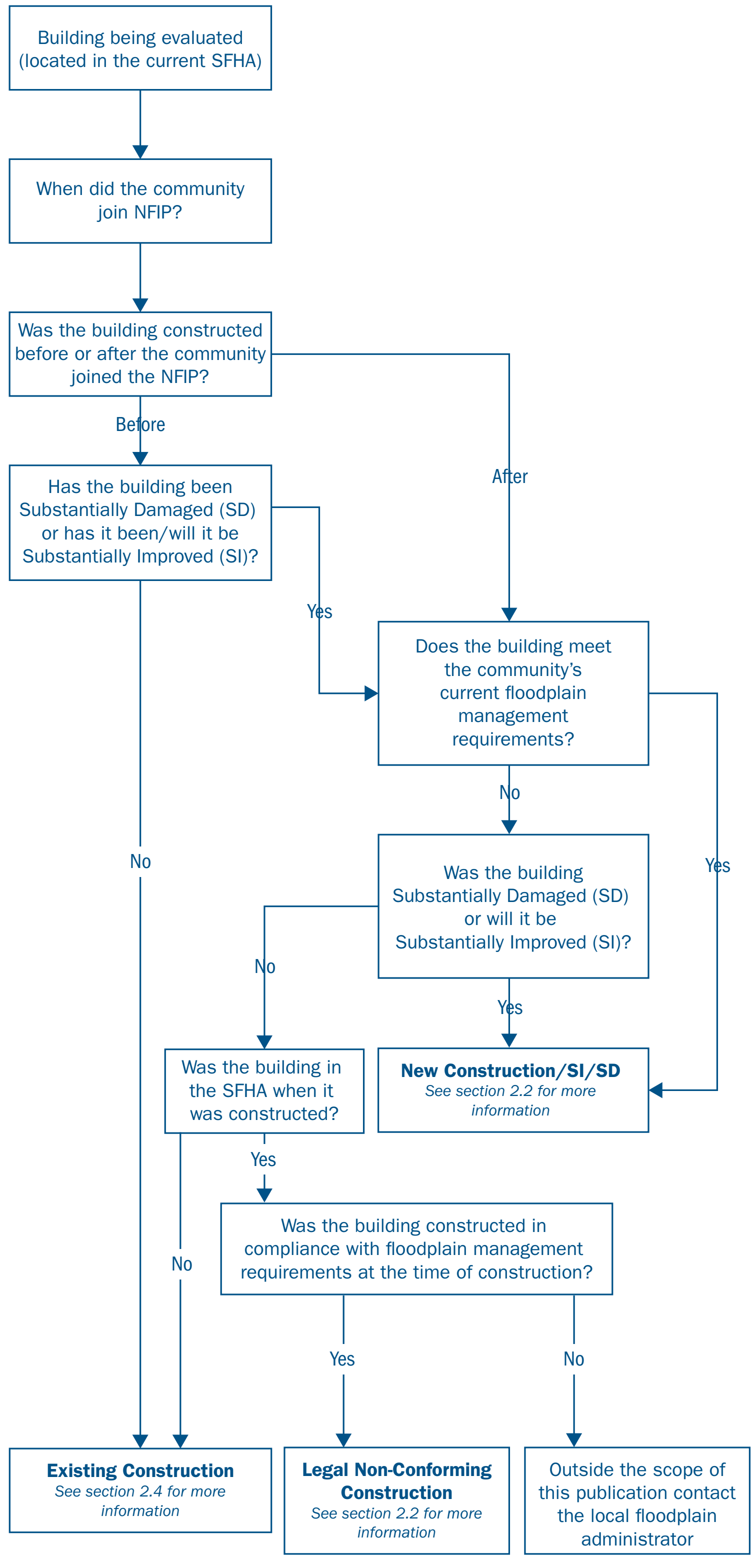



Figure 2-1. Determining the Building Designation

Once the building designation determination has been made, the flood zone must be determined. Information on flood zones can be found in Section 3.1. The following sections outline the requirements that apply to *new construction* (including substantially damaged/substantially improved buildings), *legal non-conforming construction*, and *existing construction*. This information will be helpful in determining the minimum FPL requirements in Section 3.6, understanding flood insurance considerations in Chapter 4, and determining which flood mitigation measures are allowable based on the building designation in Chapter 5.

## 2.2 NFIP MINIMUM REQUIREMENTS FOR NEW CONSTRUCTION AND SUBSTANTIALLY IMPROVED BUILDINGS

The NFIP's performance requirements for *new construction* and the substantial improvement or repair of substantial damage of *existing construction* in SFHAs specify:

- Buildings shall be designed and adequately anchored to prevent flotation, collapse, or lateral movement resulting from hydrodynamic and hydrostatic loads, including the effects of buoyancy.
- Building materials shall be resistant to flood damage.
- Buildings shall be constructed by methods and practices that minimize flood damage.
- Buildings shall be constructed with electrical, heating, ventilation, plumbing, and air conditioning equipment and other service facilities that are designed and/or located to prevent water from entering or accumulating within the components.

Beyond the general performance requirements, specific requirements for buildings depend on flood zone and flood characteristics that affect specific locations and occupancy (residential or non-residential). Requirements for SFHAs that are designated Zone A (including AE, A, A1–30, AO, and AH) are summarized in Section 2.2.1. Requirements for coastal high hazard areas that are designated Zone V (including VE and V1–30) are summarized in Section 2.2.2. Key differences in requirements for residential, non-residential, and mixed-use buildings are summarized in Section 2.2.3.

*TERMINOLOGY*

**Zone A:** Areas subject to the 1-percent chance or greater flood event in any given year.

**Zone V:** An area of special flood hazard extending from offshore to the inland limit of a primary frontal dune along an open coast and any other area subject to high velocity wave action from storms or seismic sources. These coastal areas are subject to the 1-percent chance or greater flood event in any given year having waves 3 feet or higher.

**AE or VE:** Zones with engineering analysis so that BFEs are available. See Section 3.1 for more details.

*CROSS REFERENCE*

Section 3.1 addresses flood zones shown on FIRMs

CROSS REFERENCES

**Legal Non-conforming Construction**

Buildings that were initially constructed as *new construction* may become *legal non-conforming construction* when there are changes such as:

- the flood zone(s) that the building is located within changes to a more restrictive zone (e.g., Zone A becomes Zone V)
- there is an increase to the BFE that exceeds the elevation requirements to which the building was constructed
- there are more restrictive floodplain management requirements

In these instances, there can be no modifications to the building that will make it no longer compliant with the adopted local floodplain management requirements that were enforced at the time of construction. In the event that the building is substantially improved, or the building is substantially damaged, the building must be brought into compliance with the current requirements.

## 2.2.1 NFIP MINIMUM DESIGN REQUIREMENTS FOR BUILDINGS IN ZONE A

The NFIP requirements specify that the lowest floors, including basements, of *new construction* and substantially improved residential buildings (including buildings that have sustained substantial damage) must be elevated to or above the BFE. There are no limitations on the type of foundation used to elevate buildings. Buildings may be elevated on solid perimeter walls (crawlspace), filled stem walls, monolithic slabs, columns, piers, pilings, or slabs on earthen fill.

The NFIP requirements specify that areas below the lowest floor in new and substantially improved buildings may be enclosed; however, the use of enclosures is restricted to parking of vehicles, building access, or storage. The walls of enclosures below the lowest floor, even non-load-bearing walls, are required to have flood openings to allow the automatic entry and exit of floodwater so that interior and exterior hydrostatic pressures can equalize during flooding. See NFIP Technical Bulletin 1, *Openings in Foundation Walls and Walls of Enclosures Below Elevated Buildings in Special Flood Hazard Areas in accordance with the National Flood Insurance Program* (FEMA 2008a).

If a parking garage area is at or above grade, it can be wet floodproofed. Below grade parking garages for residential buildings within SFHA are prohibited by the NFIP.

TERMINOLOGY

The NFIP defines **lowest floor** as "the lowest enclosed area (including basement). An unfinished or flood-resistant enclosure, usable solely for parking of vehicles, building access, or storage in an area other than a basement area, is not considered a building's lowest floor, provided, that such enclosure is not built so as to render the structure in violation of the applicable non-elevation design requirements of 44 CFR Section 60.3."

WARNING

When compliance is required, below-grade parking garages are prohibited beneath residential buildings in the SFHA.

## 2.2.2 NFIP MINIMUM DESIGN REQUIREMENTS FOR BUILDINGS IN ZONE V

SFHAs identified as Zone V extend from offshore to the inland limit of a primary frontal dune along an open coast and any other area subject to high velocity wave action. The NFIP minimum requirements for buildings and structures in Zone V specify the level of protection (elevation), type of foundation, and limitations on obstructions and enclosures below elevated buildings.

Buildings must be anchored to foundations to resist flotation, collapse, or lateral movement from the effects of wind and flood loads acting simultaneously on all building components. Designs and methods of construction must be developed, reviewed, and certified by registered design professionals.

In Zone V, NFIP requirements specify the bottom of the lowest horizontal structural member of the lowest floor must be at or above the BFE. Vertical foundation pilings or columns may be below the BFE but with no obstructions so that floodwater may pass through it freely.

NFIP requirements specify the space below the lowest floor of elevated buildings must be free of obstructions. The intent is to minimize obstructions that could interfere with the free passage of floodwater and debris underneath the buildings. Areas below the lowest floor may be enclosed using breakaway walls, but the use of enclosures is restricted to vehicle parking, building access, or storage. Utility systems are not allowed below the lowest floor unless it is designed or located to prevent water from entering or accumulating within it during flooding conditions.

Concrete slabs, including patios, walkways, pool decks, and slabs used as the floor of enclosures, are required to be structurally independent or, if attached, building foundations are required to be designed to account for the added loads and effects of wave action. If structurally attached to a foundation and depending upon design specifications the presence of a concrete slab may be considered the building's lowest floor for flood insurance rating purposes and might also be considered a violation of the local floodplain management requirements.

*TERMINOLOGY*

**Base Flood Elevation** is the elevation of the base flood relative to the datum specified on a community's FIRM. In any given year, there is a 1-percent-annual-chance that the base flood will be equaled or exceeded. The BFE is the NFIP's minimum elevation used for design and construction of buildings. Areas affected by the base flood are shown as an SFHA on a FIRM.

*WARNING*

In areas designated as Zone V, a concrete slab such as a patio, pool deck, or the floor of an enclosure must be structurally independent of the building foundation. If it is structurally attached to the foundation, based on the specific design, it may be considered the lowest floor. In such cases, annual insurance cost premiums would increase accordingly, and the building would be considered a violation of the minimum NFIP requirements in the local floodplain management ordinance.

Walls of enclosures, if any, are required to be non-supporting breakaway walls, open wood lattice-work, or insect screening intended to collapse under wind and base flood or lesser conditions without causing structural collapse, displacement, or damage to the elevated building or supporting foundation. When walls collapse under specific lateral loads, floodwater can flow through column or pile foundations without obstruction. See NFIP Technical Bulletin 9, *Design and Construction Guidance for Breakaway Walls Below Elevated Buildings Located in Coastal High Hazard Areas in accordance with the National Flood Insurance Program* (FEMA 2008d).

Obstructions are to be avoided or minimized and constructed to meet the performance requirements. Obstructions may include but are not limit ed to: stairs and ramps, decks and patios, equipment attached to foundation elements, foundation bracing, grade beams, shear walls, and slabs.

Other site development that may create obstructions includes accessory structures, erosion control structures, fences and privacy walls, fill used for landscaping, septic systems, swimming pools and spas. See NFIP Technical Bulletin 5, *Free-of-Obstruction Requirements for Buildings Located in Coastal High Hazard Areas in accordance with the National Flood Insurance Program* (FEMA 2008c).

### 2.2.3 NFIP REQUIREMENTS FOR NEW CONSTRUCTION – RESIDENTIAL, NON-RESIDENTIAL, AND MIXED-USE BUILDINGS

NFIP regulations for *new construction* require the lowest floors of residential buildings to be elevated to or above the BFE. Non-residential buildings must either be elevated to or above the BFE or dry floodproofed above the BFE. Although NFIP regulations do not explicitly address mixed-use buildings, FEMA guidance indicates non-residential portions of mixed-use buildings may be dry floodproofed although some limitations apply. Table 2-1 summarizes NFIP requirements that vary based on whether a building is residential, non-residential, or mixed-use.

Table 2-1. NFIP requirements that vary based on occupancy

| DESCRIPTION | RESIDENTIAL | NON-RESIDENTIAL | MIXED-USE |
|---|---|---|---|
| Wet floodproofed enclosures below the BFE (elevated building) | Allowed[1] for parking, storage, and building access | Allowed[1] for parking, storage, and building access | Allowed[1] for parking, storage, and building access |
| Below-grade areas (basements) | Prohibited | Allowed[1] if dry floodproofed | Allowed[1] for non-residential portions, if dry floodproofed |
| Below-grade parking | Prohibited | Allowed[1] if dry floodproofed | Allowed[1] for non-residential portions, if dry floodproofed |
| Dry floodproofed areas below the BFE | Prohibited for dwelling units and areas that support dwelling units, including but not limited to: lobbies, foyers, and other ancillary areas (including offices, mail rooms, meeting rooms, and exercise rooms) | Allowed[1] for all areas | Allowed[1] for non-residential portions |
| Mechanical, Electrical, and Plumbing Systems | Located at or above the BFE or, if below the BFE, designed to resist flood loads and prevent water from entering or accumulating within the components | Located at or above the BFE or, if below the BFE, designed and/or located to prevent water from entering or accumulating within the components; can be within a dry floodproofed area[1] | Located at or above the BFE or, if below the BFE, designed and/or located to prevent water from entering or accumulating within the components; only components associated with non-residential uses can be within a dry floodproofed area[1] |

[1] Allowed means in compliance with NFIP requirements. Dry floodproofing a building is only allowed in Zone A.

To demonstrate the minimum floodplain management requirements, Figures 2-2 through 2-5 illustrate representative multi-family buildings located in SFHAs identified as Zone A.

Figure 2-2 represents a residential building designed and constructed with the lowest floor in compliance with floodplain management requirements. These buildings are commonly constructed on stemwall foundations where there is a perimeter wall surrounding fill material and the concrete slab for the lowest floor is constructed on top of the fill material and ties into the perimeter wall. If there is an enclosure below the lowest floor, it must comply with the enclosure requirements for the flood zone in which the building is located.

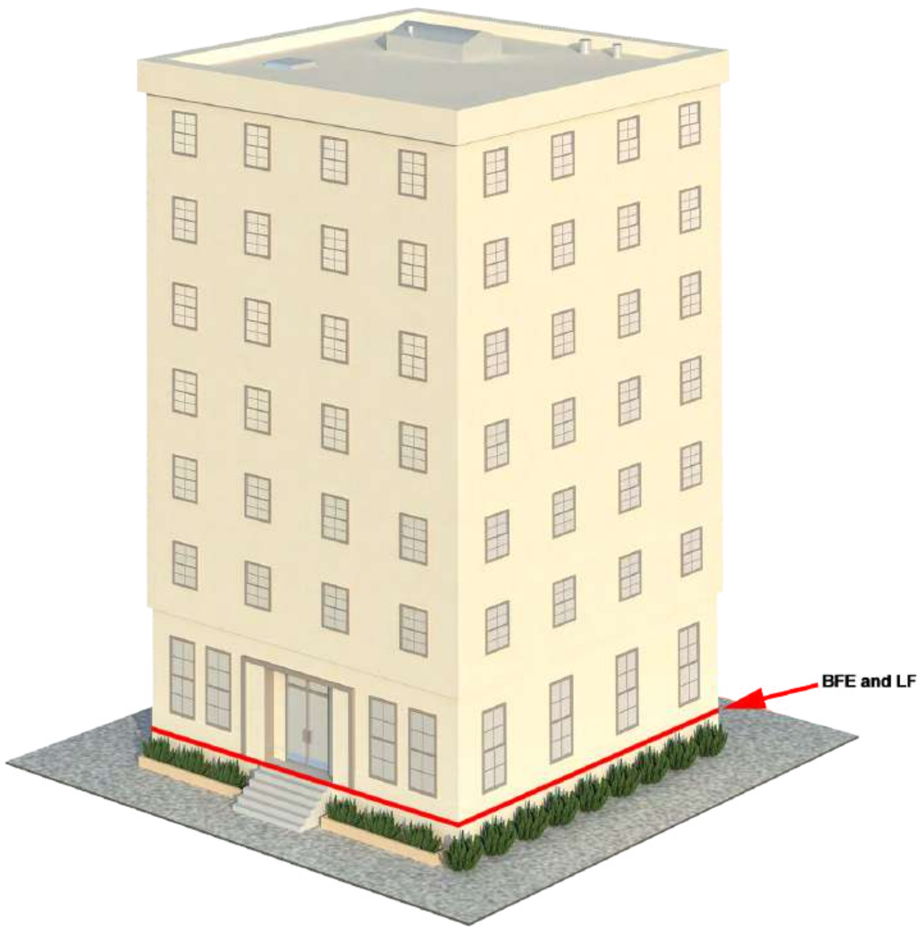



Figure 2-2. Example of a multi-family building constructed to a compliant elevation

Figure 2-3 represents an apartment building with building access, storage, and parking for residents at ground level. The ground floor complies with NFIP floodplain requirements if it is built with flood damage-resistant materials, has flood openings designed to allow the automatic entry and exit of floodwater, and the use of enclosed areas remains limited to access, storage, and vehicle parking (when applicable). This configuration and use of areas shown in Figure 2-3 is allowed when NFIP compliance is required, whether for *new construction* or when substantial improvements are proposed, or to make the building compliant after the building is substantially damaged. The configuration shown in Figure 2-3 also could include ground-level enclosed areas used for parking. Below-ground parking, storage and access (basement) is not permitted for residential buildings.

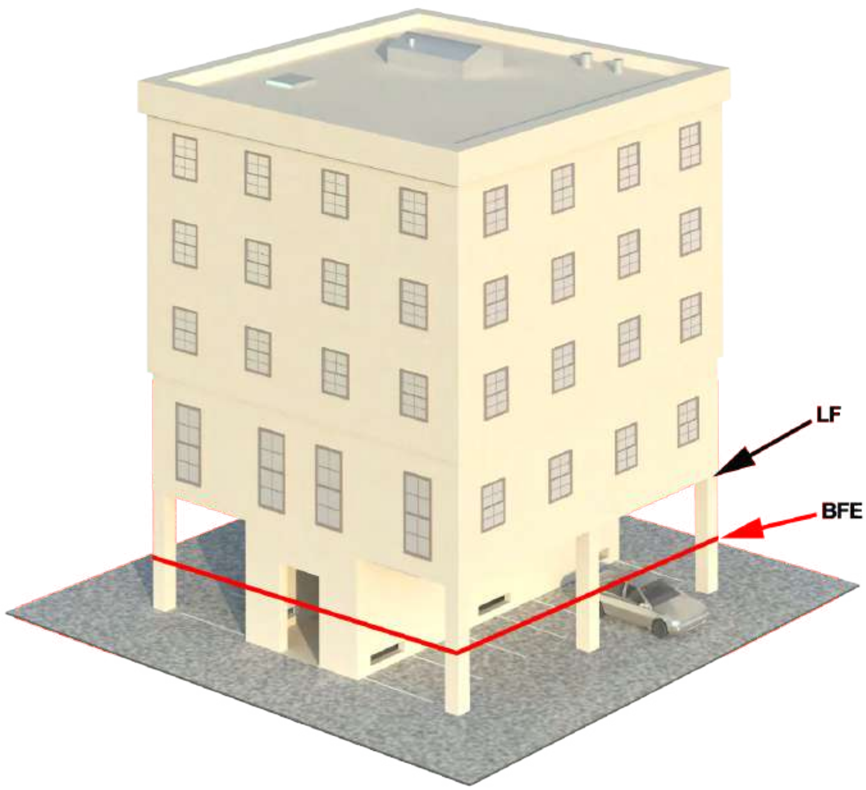



Figure 2-3. An apartment building with entrance, storage, and parking below BFE

Figure 2-4 represents an *existing construction* residential building with a mail room, management office, and exercise room on the ground floor. It does not have a basement, and all the apartments and dwelling units are located above the BFE. If proposed work does not constitute substantial improvement or repair of substantial damage, which would trigger compliance with the NFIP requirements for *new construction*, then below-BFE areas may be wet floodproofed or dry floodproofed.

If NFIP compliance is required, the area below the BFE may be wet floodproofed only. The configuration and use of areas below BFE shown in Figure 2-4 would not be permitted when compliance is required. Areas below the BFE are only permitted to be used solely for parking, storage, and building access and must be wet floodproofed. Dry floodproofing any portion of a residential building below the BFE is not permitted.

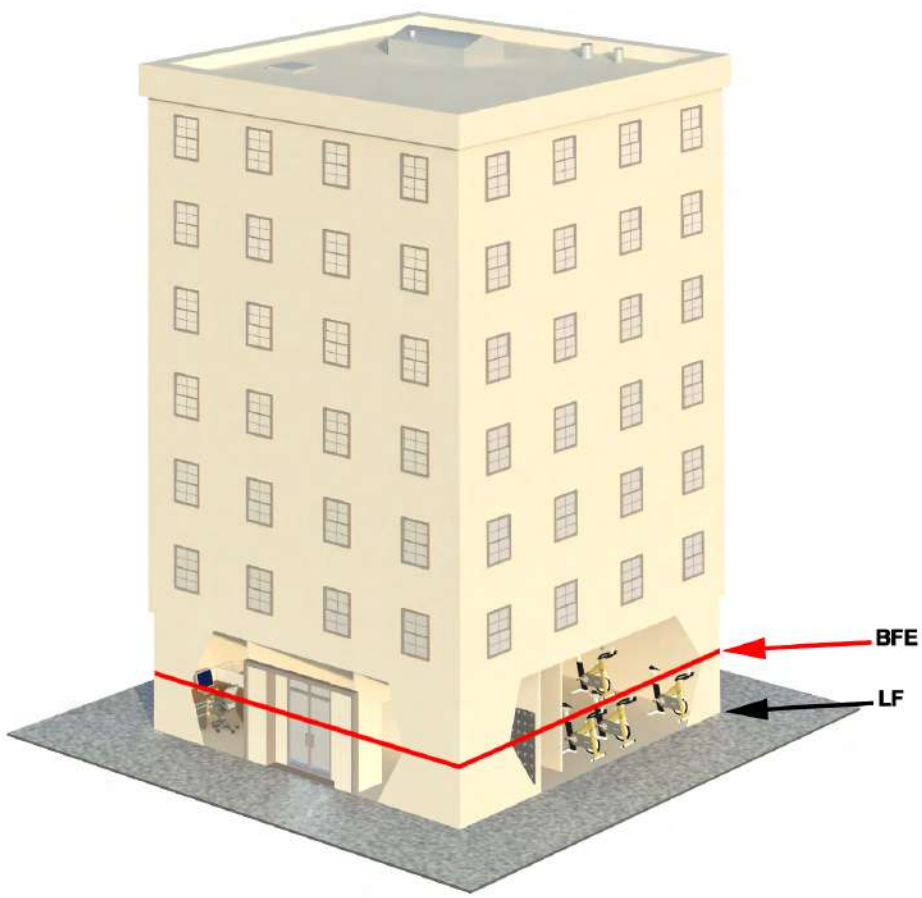



Figure 2-4. An *existing construction* apartment building with a mail room, office, and exercise room below BFE (to illustrate use of the space, exterior walls are not shown)

Figure 2-5 represents a mixed-use building with the following on the ground floor: commercial retail space, a restaurant, and access to residential dwellings on the upper floors. The building does not have a basement, and all the dwelling units and areas that support residents are located above the BFE.

Non-residential portions of mixed-use buildings may be dry floodproofed, so portions of the ground floor are dry floodproofed in compliance with NFIP floodplain requirements. The walls and floor slab are substantially impermeable to the passage of water and have structural components capable of resisting hydrostatic and hydrodynamic loads and effects of buoyancy.

For mixed-use buildings, lobby areas that serve both the residential and non-residential areas may be dry floodproofed, provided there is a separate building access area that serves the dwelling units above the BFE. This access area must either be elevated above the BFE or wet floodproofed, having flood damage-resistant materials, flood openings designed to allow the automatic entry and exit of floodwater, and meet all other applicable requirements of the local floodplain management ordinance.

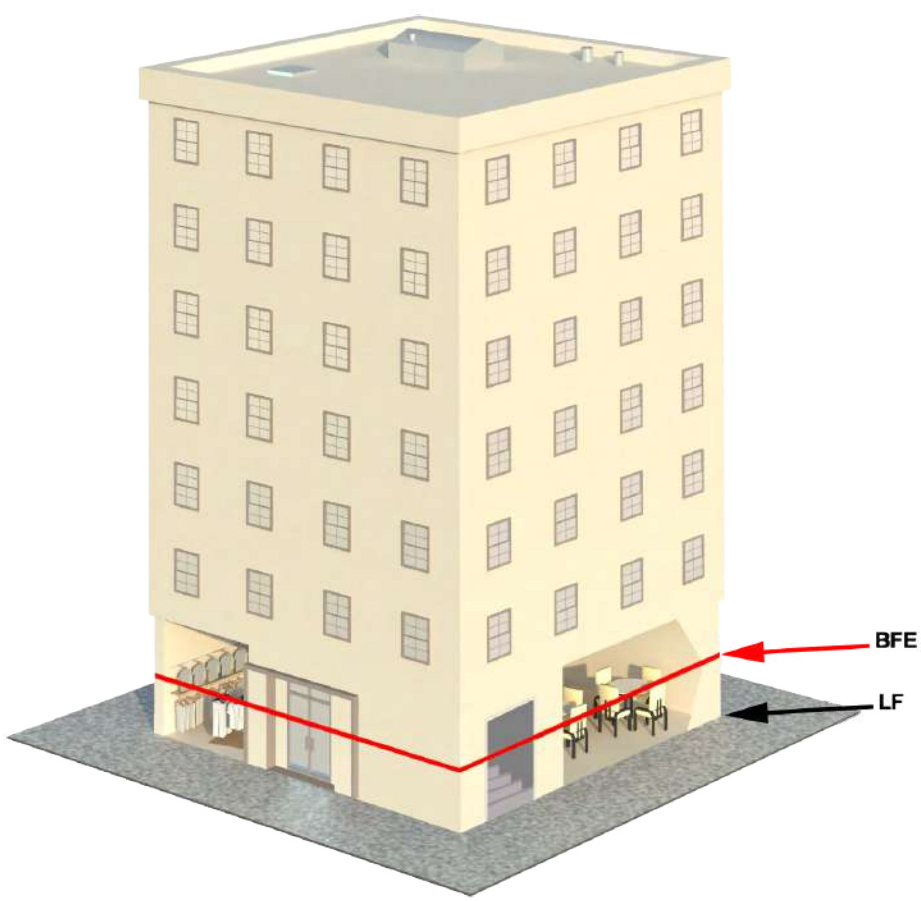



Figure 2-5. A mixed-use building with retail and restaurant below BFE
(non-residential areas may be dry floodproofed)

# 2.3 APPLYING SUBSTANTIAL IMPROVEMENT AND SUBSTANTIAL DAMAGE TO MULTI-FAMILY BUILDINGS

It is important to consider that minimum NFIP requirements apply to *new construction* and substantially improved buildings, including those that have sustained substantial damage. If work on buildings constitutes SI/SD (see Figure 2-6 for an overview of the SI/SD process), then structures must be brought into compliance with local floodplain management requirements for *new construction*. These requirements are designed to reduce future flood damage to *existing construction* buildings.

**CROSS REFERENCE**

See FEMA P-758, *Substantial Improvement/ Substantial Damage Desk Reference* (2010b) for further information and guidance on SI/SD requirements.

Local officials administering the SI/SD requirements will perform four major actions:

1. Determine cost of improvements or repairs
2. Determine market value of buildings (excluding land)
3. Make SI/SD determinations – Does the cost exceed 50 percent of the market value of the building? (State or local regulations may have more stringent requirements, e.g. triggers less than 50% of market value)
4. Require owners to obtain permits to bring substantially improved or substantially damaged buildings into compliance with the floodplain management requirements

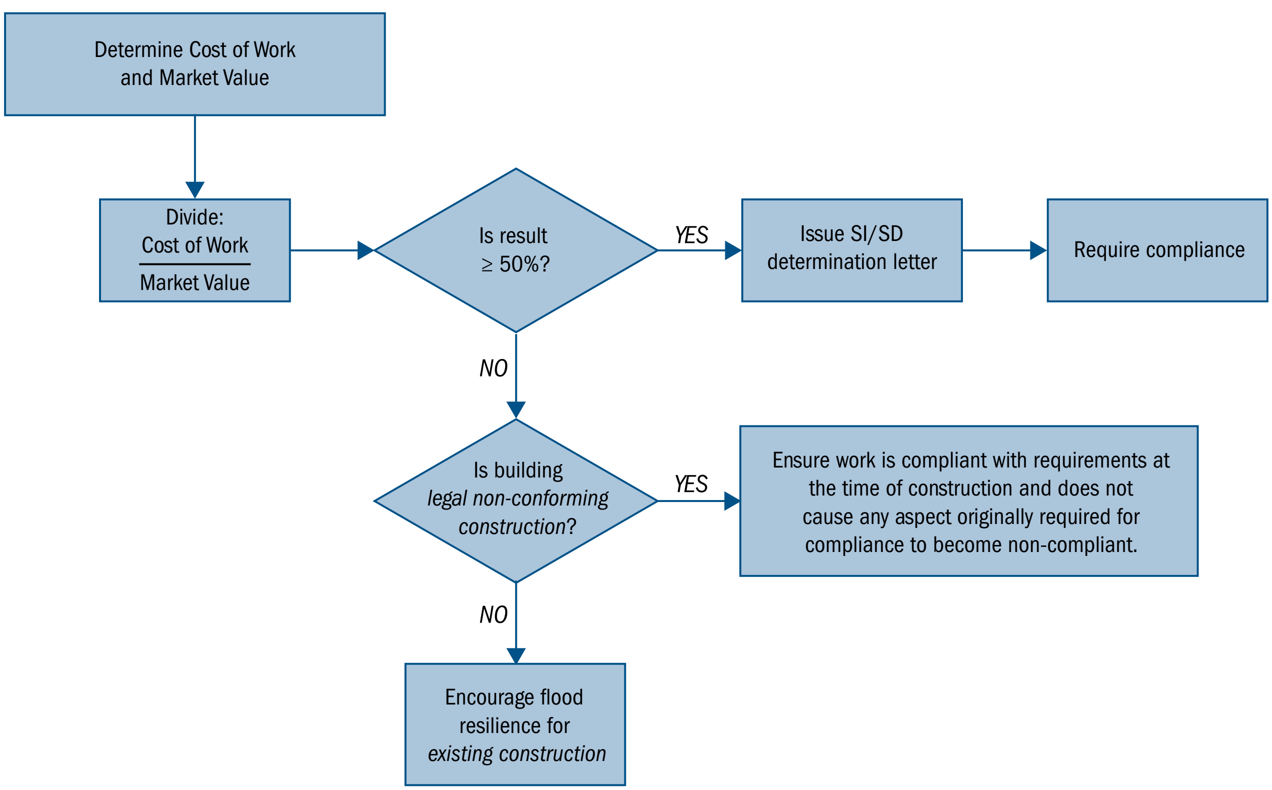



Figure 2-6. Overview of the SI/SD determination process

Local officials should develop written procedures to make and document consistent determinations and improve efficiency and effectiveness. This will be especially helpful in the post-disaster period when large numbers of buildings may be damaged.

> *NOTE*
>
> The definition of SI provides an exclusion for any project to correct existing violations of state or local health, sanitary, or safety code specifications that have been identified by the local code enforcement official and that are the minimum necessary to assure safe living conditions.

The first step is to determine and review estimates of the improvement or repair costs. This step involves deciding which costs to include and exclude. Included costs typically include materials, labor, site preparation, demolition costs, costs to comply with codes triggered by work, contractor markups, and taxes. Excluded costs include cleanup and trash removal, temporary stabilization of the building, cost to prepare plans, surveying, permit and inspection fees, carpeting, outside improvements, repairs to detached structures, cost to correct existing violations, and plug-in appliances.

Next, the market value of the structure must be determined. There is more than one way to determine repair costs and market value. The local official should examine the costs and values for reasonableness and accuracy. Then, the costs are divided by market value and the result examined to determine whether it equals or exceeds 50 percent. Finally, the local official informs by a written letter, the owner of the SI/SD determination.

> *TERMINOLOGY*
>
> **Depth-Damage Function** is a method of expressing expected flood damage for various types of buildings, their contents, or their functions at different water depths. This relationship is expressed as flood depth versus damage expressed as a percentage of value.

Typically, large buildings, including high-rise multi-family buildings, would have to sustain extensive damage (likely structural damage) or experience significant improvements to trigger SI/SD. Figure 2-7 illustrates a depth damage function for a 10-story urban high-rise building. This suggests that even with 10 feet of flooding, the expected damage would unlikely exceed 30 percent of the structure value.

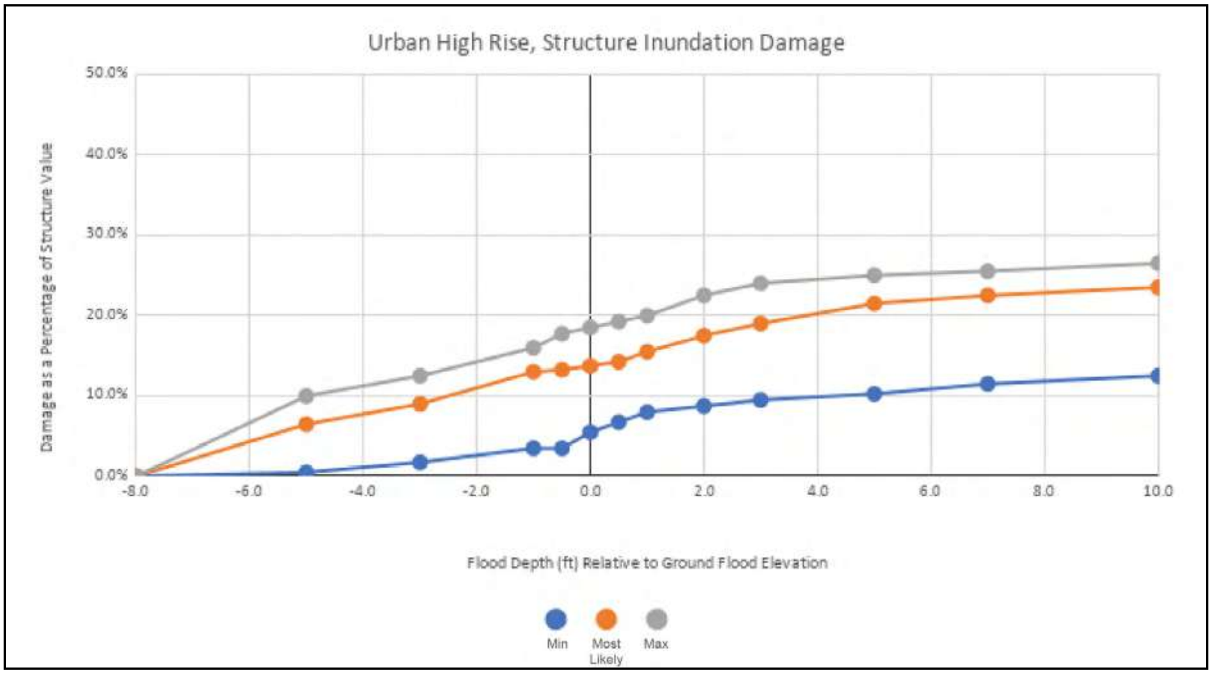



Figure 2-7. Depth damage function for a 10-story urban high-rise building (Source: USACE 2015)

Multi-family buildings provide unique challenges with respect to SI/SD determinations, especially for condominiums or cooperatives that have multiple owners. For example, consider owners of inundated apartments on the ground level of an older 10-story cooperative building. While the ground-floor dwelling units may have experienced extensive damage, it is likely no other damage was sustained. In this case, it would be likely that the comparison of repair costs to market value would not reach 50 percent. Individually owned apartments may need to be completely repaired, but compliance with the floodplain management requirements are not triggered because the SI/SD determination is based on the entire building.

> *NOTE*
>
> SI/SD determinations in multi-family buildings are based on the total improvement or repair costs compared to the entire building's market value, irrespective of ownership. FEMA provides a free Substantial Damage Estimator tool to community officials and the public to assist in calculating costs.

Some states and communities have adopted requirements for SI/SD that exceed NFIP minimum requirements to better protect their citizens and property. For example:

- Adopting a lower threshold, such as 40 percent or 30 percent
- Considering cumulative improvement and repairs over a specific period of time
- Specifying a certain number of flood damage/claims regardless of threshold (triggered by repetitive flooding)
- Basing the SD determination on the repair cost and the market value of the portion of the building that is below the BFE (as opposed to the cost and value for the entire building)
- Triggering SI/SD whenever there is a change of occupancy classification, which also can trigger requirements related to fire protection and means of egress systems

## 2.4 EXISTING CONSTRUCTION MULTI-FAMILY BUILDINGS, NO SUBSTANTIAL IMPROVEMENT OR SUBSTANTIAL DAMAGE – NFIP COMPLIANCE NOT REQUIRED

*Existing construction* multi-family buildings built before communities joined the NFIP are not required to comply with NFIP regulations unless they are undergoing renovations that result in them being substantially improved or have incurred substantial damage. Owners of these *existing construction* buildings may elect to implement mitigation measures that reduce flood risk, minimize the costs of post-flood repairs and utility system restoration, and facilitate post-flood recovery and re-occupancy.

Where NFIP compliance is not required, partial protection of buildings can be achieved using a variety of measures, including wet and dry floodproofing, repurposing the ground floor, protection of utility system components, or other measures that provide partial flood protection.

> *NOTE*
>
> The measures described in this publication can be used to reduce flood damage in areas subject to flooding even if those areas are not shown as special flood hazard areas on FIRMs.
>
> FEMA reports that more than 20 percent of NFIP flood insurance claims are paid for damage to buildings located in areas identified as moderate and low risk (outside of the SFHA).

Lower-cost partial methods of protection include using flood damage-resistant materials, implementing utility system component protection, and employing emergency measures such as sandbags, temporary flood barriers, and flood wrapping systems. Especially in areas subject to repetitive low-level flooding, owners may find these approaches beneficial.

## 2.5 BUILDING CODES AND STANDARDS

Model building codes are developed by independent organizations such as the International Code Council, Inc. (ICC). States and local jurisdictions then often adopt them, modifying if needed, to serve as their building code. The model building codes include provisions pertaining to anticipated hazards such as flood, wind, seismic, snow, and soil conditions. Typically, they are adopted by states and communities to standardize enforcement of safe building practices. Users should check with applicable authorities to determine whether and how adopted codes in their state or community vary from the model codes.

An adopted building code establishes legal requirements for building design and construction. In many states, the codes are adopted at the state level and local enforcement is mandated. Conversely, some states do not adopt codes at the state level but enable communities to do so at the local level.

ICC develops and publishes the International Codes® (I-Codes®) and conducts a comprehensive training and certification program. FEMA has determined that the flood provisions of the I-Codes meet or exceed NFIP requirements for buildings and structures in the SFHA.

The multi-family buildings covered in this publication are governed by the International Building Code (IBC). The IBC is largely a performance-based model code with some prescriptive requirements. Performance-based codes state the intended functional result of a requirement and separate the intent from the means of compliance.

> NOTE
>
> While model building codes are neither federal laws nor regulations, in September 2016, FEMA adopted the Disaster Risk Reduction Minimum Codes and Standards policy. The policy encourages and, to the extent permitted by law, requires integration and use of nationally recognized voluntary consensus-based building codes and standards consistently across FEMA programs.

The IBC addresses flood loads and flood-resistant construction primarily in Section 1612, Flood Loads, which refers to the American Society of Civil Engineers (ASCE) 24 *Flood Resistant Design and Construction*, for specific requirements for buildings and structures in flood hazard areas.

ASCE 24 is part of a series of standards published by the American Society of Civil Engineers. ASCE 24 provides minimum requirements for flood-resistant design and construction of structures located totally or partially in flood hazard areas, including alluvial fans, flash flood areas, mudslide areas, erosion-prone areas, and high-velocity flow areas.

> CROSS REFERENCE
>
> FEMA has prepared excerpts of the flood provisions from the I-Codes and highlights of ASCE 24, which are available for download at https://www.fema.gov/building-code-resources.

The IBC specifies, "The design and construction of buildings and structures located in flood hazard areas, including areas subject to high velocity wave action, shall be in accordance with ASCE 24." ASCE 24 specifies minimum requirements for building performance (flood loads and elevation), wet or dry floodproofing, flood damage-resistant materials, and siting considerations. ASCE 24 references ASCE/SEI 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*, for all flood load requirements. The 2018 IBC uses the 2016 edition of ASCE 7 and this edition is compatible with ASCE 24.

ASCE/SEI 7-16 outlines methods to determine design loads and load combinations in flood hazard areas, including hydrostatic, hydrodynamic, wave, and debris impact loads. To compute the loads and load combinations, the designer must identify site-specific characteristics, including flood depths, velocities, waves, and the potential for debris impacts. These site and flood characteristics will assist the designer in determining what flood loads need to be considered.

# FLOOD RISK

3

Flood risk can be defined as the expected economic loss from flooding. This is based on the likelihood and severity of flooding at a given location, the natural and man-made assets at risk, and the consequences to those assets (modified from Schwab et al. 1998).

A building's flood risk depends on two principal factors: (1) the site's flood hazard and (2) the building characteristics, especially the building elevation compared to the flood elevation. Together these determine the likelihood of flooding and the vulnerability of a building to flood damage.

*NOTE*

SFHAs shown on FIRMs indicate areas subject to floodplain management regulations. SFHAs are where the purchase of flood insurance is mandatory for buildings financed through federally regulated and insured lenders.

*NOTE*

Physical flood damage to buildings occurs in one of three basic ways:

- Inundation or wetting of water-sensitive building components
- Displacement, failure, or collapse of structural or non-structural components and/or utility systems due to forces caused by standing water, flowing water, waves, or debris or due to undermining by erosion or scour
- Corrosion or contamination of building components

However, the extent of damage is not only the immediate physical cost but also the operational impact. A building that cannot be occupied for even a month or two can have tremendous loss of revenue for owners or require owners and tenants to find space elsewhere at potential significant cost until repairs occur. Costs associated with disruption, interruption, and relocation are often higher than costs associated with physical damage.

The potential success or failure of flood mitigation measures should consider all these factors and costs.

The federal government established the standard for mapping and regulating flood risk to be the 1-percent-annual-chance flood, also referred to as the base flood or the 100-year flood. The base flood represents a magnitude and frequency that has a 1 percent chance of being equaled or exceeded in any given year. Areas affected by the base flood are delineated as SFHAs on FIRMs and used to regulate development.

Given the long life-span of most multi-family buildings and given possible future changes to flood hazards, owners, designers, and planners of new buildings should consider designing to a higher flood elevation than what is required by the NFIP and in the model building codes. FIRMs show delineated flood hazard zones and BFEs based on flood hazards identified when the Flood Insurance Study (FIS) was prepared. The FIS is based on past floods, so they do not account for or predict future flood conditions (as conditions change, they are captured by updates to the FIRM). See Section 3.4 for a discussion of future flood conditions.

Flood hazard data are developed based on an annual chance that a given flood elevation will be equaled or exceeded. As the flood elevation at a site increases, the flood magnitude increases and the flood frequency decreases (higher, more severe floods occur less frequently). It is important to consider, over a period of years, the cumulative probability increases for occurrence of a flood of a given magnitude. For instance, over a 30-year period (typical duration of a residential mortgage), there is a 26 percent chance of a base flood occurring. Over a 50-year period, there is a 39 percent chance of a base flood occurring (see Table 3-1 for a summary of cumulative probabilities for various flood frequencies (magnitudes) and different time periods). Figure 3-1 shows cumulative flood frequencies over a 30-year period.

Considering the life-span of many multi-family buildings (over 100 years in some cases) and considering many of these buildings are decades old, 50 years is often a reasonable time frame for a retrofit project to be designed for these buildings. The 50-year row in Table 3-1 shows the probabilities of different flood frequencies (magnitudes) occurring during that 50-year period: 99.5 percent chance of a 10-percent-annual-chance (10-year) flood occurring, 64 percent chance of 2-percent-annual-chance (50-year) flood occurring, 39 percent chance of a 1-percent-annual-chance (100-year) flood occurring, and a 10 percent chance of a 0.2-percent-annual-chance (500-year) flood occurring.

Table 3-1. Probability of a recurrence interval occurring during a given period

| | | ANNUAL FREQUENCY – RECURRENCE INTERVAL | | | | | |
|---|---|---|---|---|---|---|---|
| | | 10% (10-YEAR) | 4% (25-YEAR) | 2% (50-YEAR) | 1% (100-YEAR) | .2% (500-YEAR) | .1% (1,000-YEAR) |
| PERIOD OF TIME (YEARS) | 1[1] | 10% | 4% | 2% | 1% | 0.2% | 0.1% |
| | 10 | 65% | 34% | 18% | 10%[2] | 2% | 1% |
| | 20 | 88% | 56% | 33% | 18%[3] | 4% | 2% |
| | 25 | 93% | 64% | 40% | 22% | 5% | 2% |
| | 30 | 96% | 71% | 45% | 26% | 6% | 3% |
| | 50 | 99.5% | 87% | 64% | 39%[4] | 10% | 5% |
| | 70 | 99.94% | 94% | 76% | 51% | 13% | 7% |
| | 100 | 99.997% | 98% | 87% | 63% | 18% | 10% |

**Notes:** *% – percent-annual-chance*

[1] *The percentages in this row are the percent-annual-chance that the "X-year flood" will be equaled or exceeded, where X ranges from 10 to 1,000.*

[2] *A 1-percent-annual-chance-flood, the base flood, has a 10 percent chance of occurring over a period of 10 years.*

[3] *A 1-percent-annual-chance-flood, the base flood, has an 18 percent chance, or almost a 1 in 5 chance, of occurring over a period of 20 years.*

[4] *A 1-percent-annual-chance-flood, the base flood, has a 39 percent chance of being equaled or exceeded over a period of 50 years.*

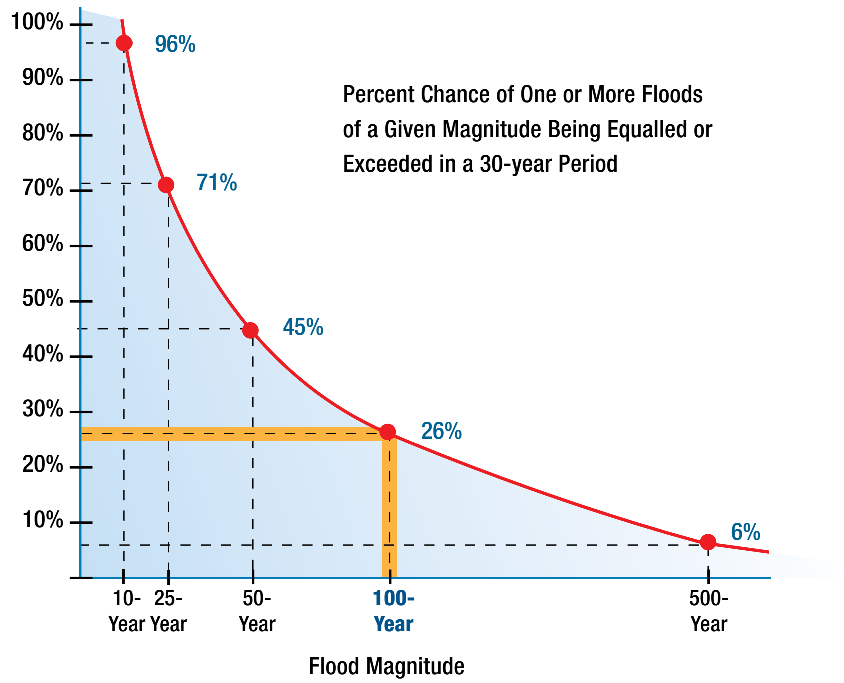



Figure 3-1. Relationship between flood recurrence intervals and probability of an event occurring within a given period (taken from P-936 [FEMA 2013a])

## 3.1 FLOOD ZONES DELINEATED ON FIRMS

Flood zone designations reflect the nature and severity of the flood conditions expected during the base flood (see Figure 3-2). Coastal SFHAs identified as Zone V are subject to inundation and wave heights of 3 feet and higher, whereas all other coastal SFHAs and inland river SFHAs are delineated as some variation on Zone A. FIRMs also show shaded Zone X areas that are outside the SFHA, but subject to flooding with a 0.2-percent-annual-chance of occurrence (also called the 500-year flood). Unshaded Zone X areas are land areas at higher elevations than SFHAs and shaded Zone X areas and are outside the 0.2-percent-annual-chance flood area.

Some FIRMs show floodways along rivers and streams for which detailed studies have been prepared. Floodways are channels and adjacent land areas that must be reserved to convey the base flood without cumulatively increasing the water surface elevation more than a designated height (usually 1 foot or less).

> *WARNING*
>
> Buildings located across multiple flood zone designations within the SFHA (e.g., portion in Zone V and portion in Zone A) must comply with the most restrictive floodplain management requirements.

In 2009, FEMA began delineating the Limit of Moderate Wave Action (LiMWA) on FIRMs (see Figure 3-3). The LiMWA is the inland limit of the 1.5-foot base flood wave height. The Zone A area seaward of the LiMWA is known as a Coastal A Zone (CAZ). In the CAZ, wave heights between 1.5 and 3 feet are expected during the base flood.

The FEMA Flood Map Service Center (MSC) is the official public source for flood hazard information produced in support of the NFIP. Use of the MSC enables owners, engineers, architects, builders, government officials, and other stakeholders to find and download official FISs and FIRMs, access a range of other flood hazard products, and take advantage of tools to better understand the flood risks associated with specific structures and sites. The MSC is available at http://msc.fema.gov/portal. Technical support is available at 1-877-FEMA-MAP or 1-877-336-2627 from 8:00 AM to 6:30 PM, Eastern Time, Monday through Friday.

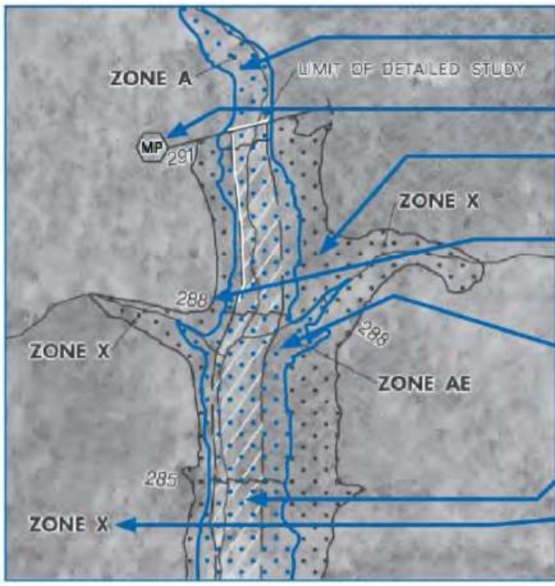



Figure 3-2. Conceptual FIRM showing representative riverine flood zone designations


Figure 3-3. Conceptual FIRM showing representative coastal flood zone designations

# 3.2 FLOOD HAZARD CHARACTERISTICS AND FLOOD LOADS

The flood hazard at a site is more than evaluating whether it is in or out of the SFHA and determining the BFE. It is a detailed description of the nature, probability, and severity of flooding. The NFIP and building codes require that buildings located in SFHAs resist flotation, collapse, and lateral movement associated with flooding. This section is an overview of flooding characteristics that determine flood loads—the forces that act on inundated buildings and building elements.

**Hydrostatic Loads:** Hydrostatic loads are forces or pressures that are associated with standing or slow-moving floodwater and are one of the main causes of flood damage. Hydrostatic loads can cause severe deflection or displacement of buildings and utility components if water levels on opposite sides of the component (inside and outside buildings) are substantially different (Figure 3-4):

- **Lateral hydrostatic load:** Standing water or slow-moving water can induce horizontal hydrostatic forces against a structure if floodwater levels on both sides of a wall are not equal.
- **Vertical hydrostatic load (buoyancy):** Building elements that are lighter than water are subject to buoyancy, and, if designed to be watertight (substantially impermeable), submerged portions of buildings and building system components are subject to uplift and flotation.

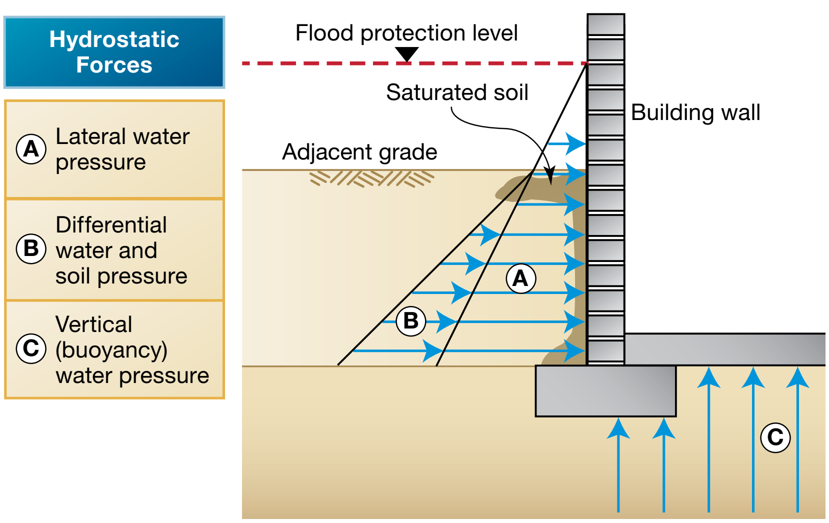



Figure 3-4. Hydrostatic loads

CROSS REFERENCE

Additional information on flood hazard characteristics, flood load calculations, design requirements and guidance is available in:

- ASCE/SEI 7-16, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*
- ASCE 24-14, *Flood Resistant Design and Construction*
- FEMA P-936, *Floodproofing Non-Residential Buildings*
- FEMA P-55, *Coastal Construction Manual: Principles and Practices of Planning, Siting, Designing, Constructing, and Maintaining Residential Buildings in Coastal Areas*
- FEMA P-259, *Engineering Principles and Practices of Retrofitting Flood-Prone Residential Structures*

WARNING

Most multi-family buildings are inherently resistant to buoyancy based on their size and weight. However, foundations, specifically slabs, are especially susceptible to hydrostatic uplift failures that must be accounted for in the design of the slab.

**Hydrodynamic Loads:** Hydrodynamic loads are imposed on an object, such as a building or building component, by moving water flowing against and around it. Load-inducing forces (see Figure 3-5) include positive frontal pressure against the structure, drag (friction) along the sides, and negative pressure on the downstream side. Hydrodynamic forces are one of the main causes of flood damage. Hydrodynamic forces are of concern along rivers and streams with high-velocity floodwater and in coastal and other areas subject to storm surge.

Moving floodwater imposes hydrodynamic forces on submerged foundations and building elements, including utility system components located below flood levels. Hydrodynamic forces can destroy solid walls and dislodge buildings with inadequate connections or load paths. Moving floodwater also can transport large quantities of sediment and debris, causing additional damage.

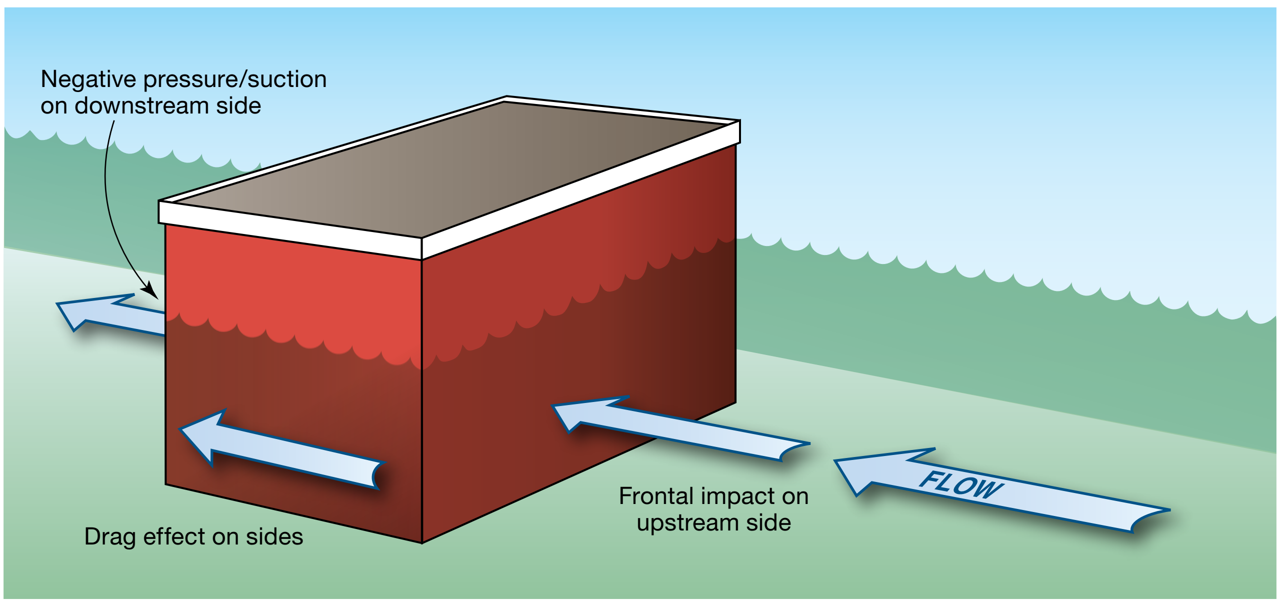



Figure 3-5. Hydrodynamic loads

In coastal areas, moving floodwater is usually associated with one or more of the following:

- Storm surge and wave runup flowing landward through breaks in sand dunes, levees, or across low-lying areas
- Outflow (seaward flow) of floodwater driven into bay or upland areas returning to the sea
- Strong currents along the shoreline driven by storm waves moving in an angular direction to the shore

**Wave Action:** Wave action describes the behavior of wind-driven waves traveling across the water surface. Waves can affect buildings in many ways:

- **Breaking wave loads:** The force created by waves breaking against a vertical surface causes the most severe damage to coastal buildings and is often 10 or more times greater than the force created by high winds during a storm event. For this reason, elevated coastal structures supported on open foundations (piles or columns) that are free of underlying obstructions and have minimal exposure to breaking waves withstand coastal storms better than non-elevated coastal structures on other types of foundations.

- **Wave runup and wave slam:** Wave runup occurs as waves break and run up beaches, sloping surfaces, and vertical surfaces. Wave runup can drive large volumes of water against or around coastal buildings, creating hydrodynamic forces that, although generally smaller than breaking wave forces and drag forces associated with high velocity water, can cause localized erosion and scour. The action of wave crests striking the elevated portion of a structure is known as wave slam. Wave slam introduces potentially large lateral and vertical loads on the lower portions of elevated structures, typically resulting in damaged floor systems.

*WARNING*

Wind-driven wave action also can occur along lakeshores and wide riverine floodplains, where there is sufficient open water or fetch. See ASCE/SEI 24, *Flood Resistant Design and Construction*, Commentary C1.5 for more information.

**Flood-borne Debris Impact:** Flood-borne debris produced by floods and coastal storms typically includes materials from damaged buildings, shipping containers, fuel tanks, vehicles, boats, piles and dock decking, fences, destroyed erosion control structures, and a variety of smaller objects. Typical flood-borne debris is capable of damaging or destroying unreinforced or inadequately reinforced masonry or concrete walls, light wood frame construction, and small-diameter posts and piles and the structural components they support. Debris trapped by cross-bracing, closely spaced piles, grade beams, or other building components is capable of transferring flood and wave loads to the foundation of an elevated structure. Impact loads can also be imparted by ice, trees, and other objects transported by floodwater.

**Erosion and Scour:** Erosion refers to the wearing or washing away of riverbanks, shorelines, and land surfaces. It is part of the larger process of fluvial morphology and shoreline change. Due to the dynamic nature of erosion, it is one of the most complex hazards to understand and is difficult to accurately predict at a specific flood-prone site. Scour is localized erosion that occurs when waters move around foundation elements and other obstructions. Determining potential scour is critical in designing foundations to ensure the foundation does not fail because of a loss in either bearing capacity, embedment depth, or anchoring.

**Duration and Rate of Rise:**

- **Duration:** Duration is the measure of how long flooding remains above normal levels. The duration of riverine flooding is primarily a function of watershed size and the steepness of valley topography. Rivers that drain large watersheds and those with relatively flat topography experience high water for weeks or months. Coastal flooding typically is of shorter duration—usually only one or two tide cycles, depending on how fast storms move through affected areas. Prolonged contact with floodwater may make it difficult to achieve the required or desired level of flood protection because of damage to building materials, mold, and seepage.
- **Rate of Rise:** Rate of rise is the measure of how quickly floodwater rises above normal levels. Areas with steep topography and small drainage areas may experience flash flooding during which floodwater can rise quickly with little or no warning. Large rivers typically rise more slowly. In coastal areas, the rate of rise at specific locations may be affected by how fast storms approach the shore, offshore bathymetry, and the shape of the land. Building protection measures that require active intervention by building managers or occupants may not be appropriate in areas with rapid rates of rise (faster than 5 feet per hour).

**Contaminants in Floodwater:** Residents, business owners, and property managers should assume that anything touched by floodwater is contaminated and should be disinfected or discarded. Mud or sediments left by floodwater may contain chemicals from landscaping to agricultural to household to industrial sources. All materials, building components, and building systems contacted by floodwater should be cleaned, disinfected, and dried as quickly as possible. Improper cleaning can lead to secondary damage such as mold and mildew, creating environmental hazards that impact indoor air quality. Contaminated floodwater can complicate wet floodproofing schemes by making flood cleanup more difficult and expensive.

- **Chemical (heavy metals, petroleum products, pesticides, and industrial and agricultural chemicals):** Floodwater carries chemical contaminants. In urban areas, stormwater runoff and floodwater carry chemicals; heavy metals from industrial sites and vehicles; petrochemicals such as oil, grease, and gasoline; herbicides; and pesticides. Similarly, flooding in rural agricultural areas carries petrochemicals, sediment, heavy metals, and pesticides and herbicides from farming operations.
- **Biological (bacterial and fungal):** Bacterial contamination can come from dead animals, sewage treatment plants, on-site septic systems that are overwhelmed or inadequate to handle flooding and livestock farming operations nearby. Biological contaminants carry the risk of streptococcus and pneumococcus infections along with tetanus and other diseases. When floodwater recedes, exposed surfaces usually

*WARNING*

After flooding, it is critical that all inundated buildings be thoroughly inspected for damage to determine whether they are safe to be reoccupied. Simply pumping out the floodwater may not be adequate to prevent the potential negative health effects of contamination or mold or the threat of fire from corroded utility system components.

host various fungal contaminants (molds), including species with potentially serious health impacts. Of great concern are mold-infected heating, ventilation, and air conditioning (HVAC) ductwork, which can exacerbate lung and breathing conditions if not properly cleaned or replaced.

- **Salt water contamination:** Salt water is corrosive and can cause damage and weakening of important building system and utility components and connectors. Salt water can be especially damaging to electrical conductors and other metal components in contact with floodwater. Salt water also weighs more than fresh water, thus increasing hydrostatic and hydrodynamic loads.

## 3.3 SITE CHARACTERISTICS THAT INFLUENCE FLOOD RISK

The flood conditions at a building site are affected by the flood source(s) driving water onto or over the land, the local topography, and upland development, which can affect the movement of floodwater. Evaluation of potential flood mitigation measures for a building must consider local flood conditions, as influenced by site characteristics.

In analyzing the flood hazard of a building, FIRMs primarily reflect flooding from excessive rainfall over an extended period, snow melt that causes a river to exceed its banks, or coastal flooding caused by extreme tides or storm surge. In urban environments, it is important to consider localized and surface water flooding, which occurs when intense rainfall exceeds the combined capacity of infiltration and urban drainage systems. Localized flooding concerns would be addressed in a separate engineering study, as these details are not typically included in FISs or FIRMs, which address general flooding at a coarser scale over a large geographic area.

Especially in urban areas, water flows at a site are often influenced by surrounding buildings. In some instances, nearby buildings can provide some level of protection by knocking down waves while in other situations the orientation of buildings may funnel or channel the flow of water directly into a building. Surrounding buildings may provide an obstruction for outgoing waters, increasing the duration of flooding in and around a building site once the storm has passed. Damage to surrounding buildings could contribute to flood-borne debris.

Topography also plays a major role. Low-lying areas in urban settings are vulnerable during general flooding from nearby bodies of water and during severe rain events. During developing flood conditions, low-lying areas could be flooded quickly by either storm surge or riverine flooding, causing pumps or storm water sewers to be easily overwhelmed. The topography surrounding a building site should be considered to determine where water may pool around the building, which areas of the building could be submerged more deeply, and how these areas may influence the selection of mitigation measures.

## 3.4 FUTURE CONDITIONS THAT INFLUENCE FLOOD RISK

Determining the amount of additional height (freeboard) above the current requirements that is sufficient to address future conditions will require a more detailed analysis than what is provided on a FIRM or potentially freeboard requirements currently enforced by a community or design standard.

> NOTE
>
> When evaluating future conditions in a coastal area, consider that deeper floodwater from coastal inundation could produce higher wave heights and thus change flood zones. An area currently identified as Zone A could become a CAZ, and a CAZ could become Zone V. This will cause increased flood loads, and any foundation modifications should consider the potential for more severe flood conditions.

A FIRM, as currently developed, represents topographic, land use, and hydrologic and hydraulic conditions in effect at the time of the analysis (explained in the FIS). This is known as a *static* or *stationary analysis*.

The FIRMs do not consider future development, which could increase runoff or change local flood characteristics, and they do not address future changes in rainfall or snowfall patterns or amounts, future sea level changes, subsidence of the ground, erosion, or other changes that could affect base flood heights and extents. Although in some locations drainage improvements can reduce flood depths, such improvements are unlikely to adequately address most future flooding conditions. The potential for increased flood depths should be a consideration when evaluating how much freeboard to incorporate into a mitigation design.

Figure 3-6 compares a coastal building protected to the BFE with one that is protected higher than the BFE. The graph illustrates the probability of various flood events with the expected elevation based on current conditions along with modeled future conditions in year 2044 and 2069 (current BFE is 10; 2044 BFE is 10.5; and 2069 BFE is 11.3 feet). Sometime before 2044, Building A is projected to be overtopped by a flood less than the 1-percent-annual-chance flood (100-year flood) and by 2069 will be susceptible to a 2-percent-annual-chance flood (50-year flood). The graph in Figure 3-6 illustrates the impact and value freeboard can have in helping to better protect a building, its contents, and associated utilities and to reduce consequences of designing to today's minimum requirements.

Flooding under future conditions will vary depending on locations around the country and where a building is located within the floodplain. Figure 3-6 shows how proactive 50-year building design life-span decisions made today will impact future building performance even as external factors change. Selecting an FPL above the BFE provides not only an immediate cost savings in annual NFIP flood insurance premiums today but also helps eliminate or alleviate increased annual premiums into the future, if flood risk worsens. It also provides immediate additional protection for floods that exceed the BFE.

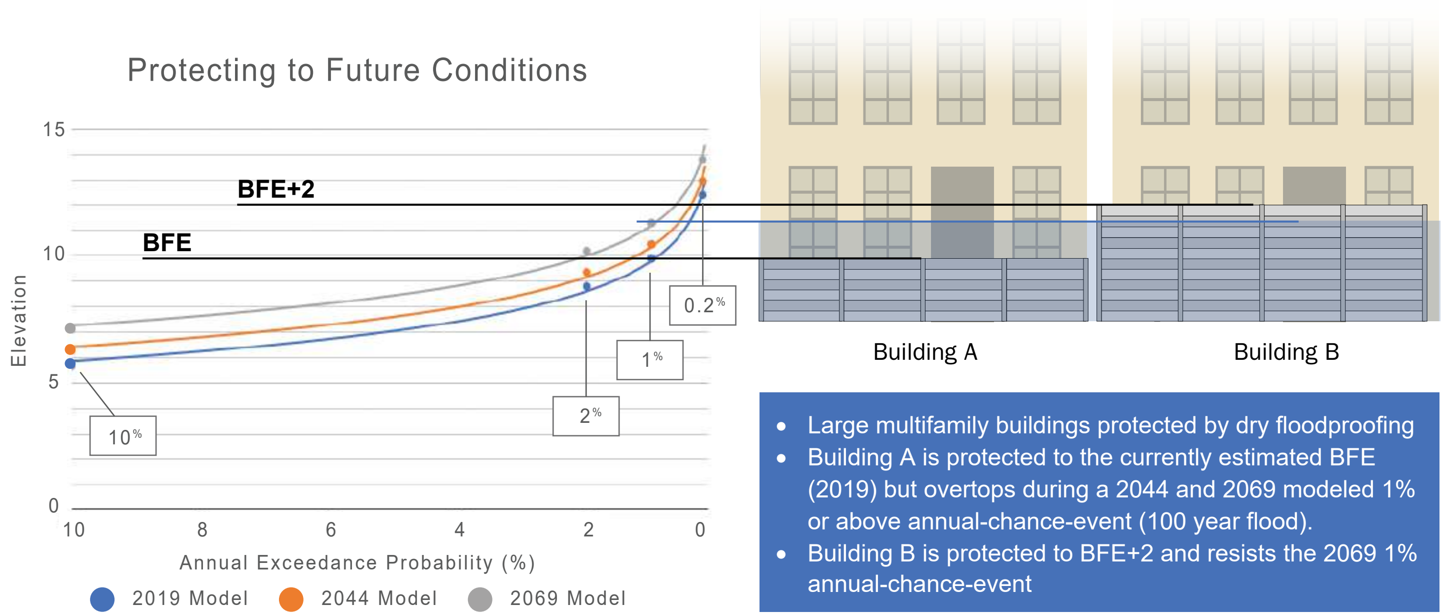



Figure 3-6. Value of freeboard to address future conditions; this example assumes 39 inches of flood level rise by 2100 and includes wave action.

## 3.5 COMMON CHARACTERISTICS OF EXISTING CONSTRUCTION MULTI-FAMILY BUILDINGS THAT INFLUENCE VULNERABILITY TO FLOOD DAMAGE

While the proper mitigation of *existing construction* multi-family buildings in flood hazard areas requires knowledge about the flood hazard, it also requires knowledge about how the buildings were constructed and their ability to resist flood loads. The most common method for assessing a building's strength and resistance to flood damage is to conduct a vulnerability assessment.

Such an assessment will provide the building owner with valuable information about the likelihood of building damage during floods of varying magnitudes. This can be done for an *existing construction* building or while designing new buildings. For *existing construction* buildings, vulnerability assessments provide a starting point for long-term maintenance projects that may reduce those vulnerabilities or for development of comprehensive mitigation plans. The latter can focus on capital improvements to increase flood resistance or enhance overall building and utility resilience for multiple hazards. For new buildings, various design alternatives can be considered to reduce vulnerability to flood damage.

As part of a thorough vulnerability assessment of *existing construction*, a qualified design professional, or team of them, should investigate flood characteristics at the building site and flood damage potential to the building structure and its functions. The areas of focus might include:

- The building envelope
- Areas subject to potential debris damage
- Key attachments to the building that could be damaged by floodwater
- Areas below the FPL such as penetrations, elevator shafts, and utility systems that service the building (electrical, natural gas, water, sewage, IT, HVAC, fire control)
- Evaluation of the maintenance and operations plans for dry floodproofing and backup power systems
- Anything else needed for the building to fully function

Common characteristics observed in multi-family buildings that can either increase or decrease vulnerability to flood damage include:

- Elevation of lower floors of the building, including basements
- Elevation of lowest dwelling units
- Openings and pathways for the entrance of floodwater (see Figure 3-7 for common examples) including doors, windows, and garages; sidewalk hatch or below-ground exits; non-structural connections with other buildings; utility penetrations through the building envelope; ventilation for mechanical systems; and drains in the floor slabs
- Structural capacity of building elements to withstand flood loads
- Ability of building materials to resist damage if wet
- Locations and elevations of utility systems and equipment relative to the FPL
- Location and depth of elevator shafts and location of the elevator controls
- Elevation of plumbing fixtures compared to the flood surcharge
- Porosity of the building foundation, walls, doors, windows, shields, and other elements keeping out floodwater
- Availability of emergency water supply, such as a rooftop tank, if power for the building's water pump or local water service is unavailable
- Location and elevation of emergency power supply along with fuel source and pump
- Connectivity for emergency utility system connection (e.g., ability to mobilize and connect emergency power, water, heating, air conditioning, fuel)
- Functionality of sump pumps and interior drainage channels

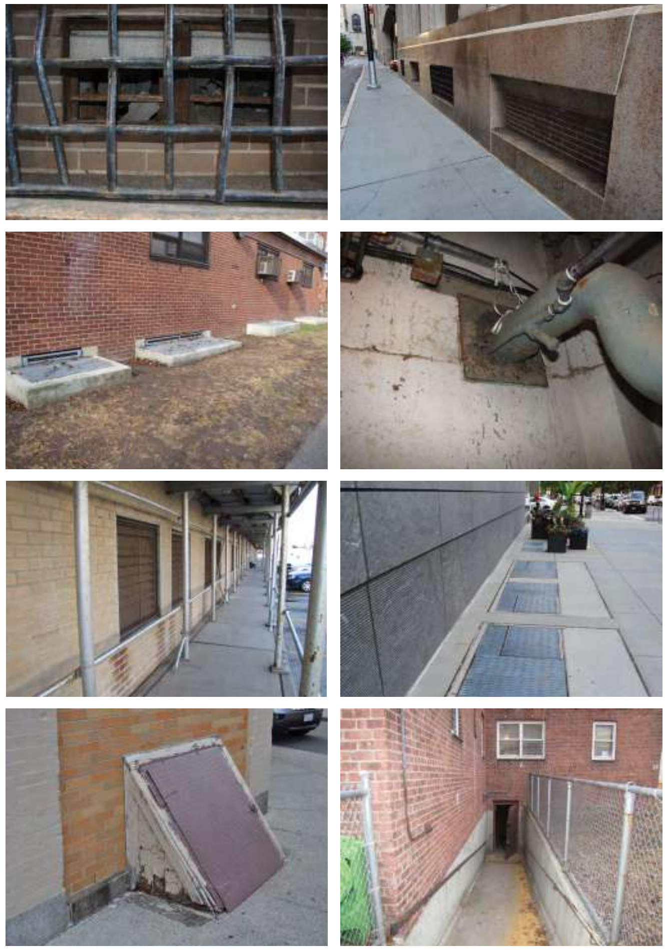


Figure 3-7. Example openings and pathways for water entry to multi-family buildings in urban environments

In addition to building features, it is important to consider operational characteristics when evaluating the flood risk for *existing construction* multi-family buildings. For example, owners, facility managers, and design professionals should carefully evaluate the following:

- Local zoning and code requirements, especially with respect to exits, fire command and control, and streetscape requirements
- Number of residents and tenants, building type (e.g., apartment, assisted living, dormitories), ownership (single owner versus cooperative or condominium), and availability of an on-site property or facilities manager
- Resident and tenant mobility and preparedness, as certain populations may have needs that require significant notification and planning
- Dedicated facilities managers and staff to execute maintenance, conduct routine inspections, and implement emergency operations plans, including any dry floodproofing measures
- Partnerships, memorandums of agreement, compacts, and pre-event contracts related to facility emergency preparedness and recovery assistance with other entities
- Ability to timely access and remove vehicles and storage in wet floodproofed areas

# 3.6 DETERMINING A FLOOD PROTECTION LEVEL

One of the most, if not the most, important determinations that must be made when developing a flood mitigation strategy for a specific building is the elevation to which the building will be protected (i.e., the FPL). If floodwater rises higher than this elevation, buildings are expected to be damaged. For *new construction* and when buildings are substantially improved or have incurred substantial damage, the minimum FPL is the most restrictive of the required elevations specified on a FIRM, in the local floodplain management ordinance or the adopted building codes. Typically, regulations and codes specify the elevation (or protection level) as a function of the BFE. The I-Codes, and many communities, require additional elevation above the BFE.

*TERMINOLOGY*

**Flood Protection Level** is the elevation required by the NFIP, building codes, or locally adopted regulations and used in design of buildings and utility systems.

When owners and designers elect to provide a higher degree of protection than the minimum required, FPL refers to that selected elevation.

Building owners and design professionals should examine whether the minimum requirements in the local floodplain management ordinance and applicable building codes offer a sufficient level of protection given possible economic loss if a flood event exceeds the minimum elevation.

*TERMINOLOGY*

**Freeboard** incorporated into the design provides additional protection for the owner and tenants, even when they carry a flood insurance policy. NFIP flood insurance policies provide coverage on the building structure and the contents of the building (see Chapter 4 for coverage limits) but do not provide coverage for displacement from the building following a flood or loss of use of the building. Additional freeboard can help to reduce the risk of being displaced from the building after a flood.

When owners examine retrofit flood protection for *existing construction* buildings and NFIP compliance is not required (i.e., not substantially improved or substantially damaged), then building owners and design professionals should weigh several criteria when determining the FPL. This section provides some criteria to help determine the elevation to which a building should be protected. The following is a list of considerations that influence the selection of an appropriate FPL and associated mitigation measures:

- NFIP and building code requirements (for *new construction* and *existing construction* that are substantially improved or repaired after incurring substantial damage)
- The flood hazard, including depth, flood zone, velocity, waves, debris, erosion and scour, duration, rate of rise, and warning time
- Anticipated future flood conditions
- Building strength and capacity to resist flood loads, including debris impact
- Building floor plan and uses at ground level and below grade, vulnerability of lower levels to flood damage, and the consequences of inundation
- Operational factors, such as time and resources, necessary to activate mitigation measures that require human intervention

- Budget available for implementing and maintaining mitigation measures compared to cost of alternatives
- Annual flood insurance premium reductions due to increased freeboard or higher FPL elevations (+1 foot, +2 feet, etc.)
- Vulnerability assessment of the building itself, its utility systems, and its functions compared to various flood elevation or risk scenarios
- Damage cost estimate, loss of benefits, loss of revenue due to the vulnerability, and damage assessments for the given flood elevation or risk scenarios
- Losses avoided study due to FPL and mitigation measure options when compared to given flood elevation or risk scenarios

In determining the FPL and which mitigation measures are appropriate for *existing construction* buildings, owners and design professionals should examine building characteristics and available resources while balancing the costs and benefits of mitigation alternatives. For example:

- It is not recommended to dry floodproof an *existing construction* building where the existing basement walls or floor cannot withstand the flood loads associated with dry floodproofing. Reinforcing a structure to withstand such loads could be cost prohibitive, and it is likely more cost-effective to examine other mitigation measures such as replacing materials with flood damage-resistant materials and elevating utility equipment (i.e., wet floodproofing).
- Wet floodproofing common spaces in *existing construction* buildings, such as parking garages, lobbies, building entrances, and other non-dwelling spaces, may be a better option for older buildings if the structural capacity (and the ability to accommodate dry floodproofing small compartmentalized equipment rooms) cannot be determined with high confidence or it is cost prohibitive to dry floodproof.
- Below- and above-ground utility connections and egress to other buildings should be considered. It makes little sense to floodproof one building to a selected FPL if the building can be flooded via its connections to other buildings subject to flooding below the FPL. Connections include access corridors, shared underground parking garages, and utility connections.

Consider the following actions when determining the FPL for individual buildings:

- Determine the BFE using the current FIRM
- Research whether FEMA developed a preliminary FIS and FIRM. If yes, compare to the current BFE, and, if the preliminary FIRM has a higher BFE, use that value
- Consider increased runoff from local site development changes that were not included in the FIS and FIRM
- Review all available flood and site data not part of the FIS and FIRM

- Determine if there were any historic floods that exceeded the BFE or identifiable highwater marks. Consider using those flood depths to help establish the FPL
- The future life-span of the building should help motivate an owner to get a better understanding of two aspects of flood risk:
    - ◊ Probability of a base flood or higher flood occurring over time (shown in Table 3-1)
    - ◊ Potential for flood elevations to rise above the BFE over time
- Determine the extent of damage for different FPLs and the effects different FPLs have on occupying the building immediately after a flood
- Determine the financial impacts of losing occupancy or function in the building based on the different FPL or risk scenarios being considered
- Determine how different FPLs may affect flood insurance costs (generally, the higher the FPL is above the BFE, the lower the premiums)
- Determine the return on mitigation investment
- Determine losses avoided due to a mitigation measure(s) for given flood elevation or risk scenario(s)
- Based on some preliminary costs to mitigate the building, determine the FPL that provides a return on investment and achieves the appropriate level of long-term reduction in damage

Appendix D provides a flood vulnerability checklist for multi-family buildings. While it does not cover every situation, it should serve as a guide to help gather important information needed to make an assessment. Information regarding the vulnerabilities of a building could be used as a guide to create a capital improvement plan for the building that specifically addresses flood vulnerabilities leading to reduced recovery time and improved resilience to future flood events.

## 3.7 RESIDUAL RISK

Owners should understand that with any building in or near the floodplain, there is some residual or remaining risk in the event floodwater exceeds the FPL selected. The severity of the impacts varies depending on the mitigation measure selected. Even though areas in a building that are higher than the FPL should have minimal damage during design flood conditions, if floodwater exceeds the elevation of a dry floodproofing measure and it is overtopped, it is reasonable to expect severe damage. Once floodwater overtops dry floodproofing measures, they quickly fill any areas previously protected by shields and substantially impermeable walls and floors.

One way to further mitigate residual risk is by limiting exposure in a building's lowest floor or by further protecting dry floodproofed areas. For example, using flood-resistant materials in a dry floodproofed enclosure would limit repair times after events that overtop the dry floodproofing. In addition, limiting the area below the FPL to parking may reduce the displacement durations. If a dry floodproofed area contains building functions or equipment required for the building to operate, such as having a fire control center in a dry floodproofed enclosure, then a flood that overtops it can potentially result in extended displacement times. Fire control is required before a multi-family building can be reoccupied, and that equipment normally has long lead times.

# FLOOD INSURANCE CONSIDERATIONS

# 4

NFIP flood insurance policies provide coverage for two types of insurable property—building and contents. The program has three options for Standard Flood Insurance Policy (SFIP) forms that include:

1. Dwelling Policy Form
2. General Property Form
3. Residential Condominium Building Association Policy (RCBAP) Form

*NOTE*

Designers and building owners should consult with insurance agents to determine how design options may affect the rating of NFIP flood insurance policies, when policies may be purchased, and the nature and limitations of coverage.

Depending on ownership, multi-family buildings addressed in this publication can qualify either for the SFIP General Property Form or RCBAP Form. Except for a Preferred Risk Policy (for buildings at low to moderate flood risk – outside the SFHA with a limited loss history), coverage for the building and contents are separate, and appear on the same policy. NFIP coverage limits as of April 2018 are provided in Table 4-1; the multi-family buildings addressed this publication are considered "Other Residential" buildings.

*TERMINOLOGY*

**Non-residential building:** For NFIP flood insurance purposes, the term refers to a commercial or mixed-use building where the primary use is commercial or non-habitational.

**Residential building:** For NFIP flood insurance purposes, the term refers to a non-commercial building designed for habitation by one or more families or a mixed-use building that qualifies as a single-family, 2–4 family, or other residential building.

**Other Residential Building:** For NFIP flood insurance purposes, the term refers to a residential building that is designed for use as a residential space for five or more families or a mixed-use building in which the total floor area devoted to non-residential uses is less than 25 percent of the total floor area within the building.

Table 4-1. NFIP flood insurance coverage limit

| OCCUPANCY | MAXIMUM BUILDING LIMIT | MAXIMUM CONTENTS LIMIT |
|---|---|---|
| 1-4 Family Residential | $250,000 | $100,000 |
| Other Residential | $500,000 | $100,000 |
| Non-Residential Business | $500,000 | $500,000 |
| Other Non-Residential | $500,000 | $500,000 |
| Residential Condominium Building Association | $250,000 x Number of Units | $100,000 |

Building coverage includes:

- The insured building and its foundation
- Electrical and plumbing systems
- Central air conditioning equipment, furnaces, and water heaters
- Refrigerators, cooking stoves, and built-in appliances such as dishwashers
- Permanently installed carpeting over unfinished flooring

Contents coverage includes:

- Clothing, furniture, and electronic equipment
- Portable and window air conditioners
- Portable microwaves and dishwashers
- Carpeting that is not already included in building coverage
- Clothing washers and dryers

What is **not covered**:

- Damage caused by moisture, mildew, or mold that could have been avoided by the property owner
- Currency, precious metals, and valuable papers such as stock certificates
- Property and belongings outside of an insured building such as trees, plants, wells, septic systems, sidewalks, decks, patios, fences, seawalls, hot tubs, and swimming pools
- Living expenses such as temporary housing
- Financial losses caused by business interruption or loss of use of the insured property
- Most self-propelled vehicles such as cars, including their parts

The NFIP writes flood insurance policies on all buildings, regardless of whether the buildings conform to the floodplain management requirements for *new construction*. Building and contents coverage is limited in basements regardless of flood zone or date of construction. It is also limited in enclosed areas below the lowest elevated floor (for more information in determining the lowest floor for rating purposes, see Section 4.1), depending on the flood zone and date of construction.

*NOTE*

For more information regarding NFIP flood insurance, visit https://www.fema.gov/NFIP

Residential contents-only coverage is available for residents of multi-unit residential buildings, up to $100,000 per unit. Businesses that lease space can get up to $500,000 in contents-only coverage.

The NFIP coverage is sold through licensed insurance agents who either write directly with the NFIP or with an insurance company that writes NFIP policies on behalf of FEMA. Some insurance companies that are not part of the NFIP may offer coverage as part of their commercial policy (e.g., coverage for flood damage exceeding NFIP limits) or may offer a stand-alone (non-NFIP) flood insurance policy.

*NOTE*

For flood insurance purposes, multi-family buildings addressed in this publication are considered **Other Residential Buildings** by the NFIP

For insurance rating purposes, the NFIP has five building occupancies:

1. Single-Family Dwelling,
2. 2–4 Family Building,
3. Other Residential Building,
4. Non-Residential Business, and
5. Other Non-Residential.

The following are three of the five occupancy classifications as described in the NFIP Flood Insurance Manual (FEMA 2018c):

- **Other Residential Building**: A residential building that is designed for use as a residential space for five or more families or a mixed-use building in which the total floor area devoted to non-residential uses is less than 25 percent of the total floor area within the building. This category includes condominium and apartment buildings, as well as hotels, motels, tourist homes, and rooming houses where the normal occupancy of a guest is six months or more. Additional examples of other residential buildings include dormitories and assisted-living facilities.
- **Non-Residential Business:** A building in which the named insured is a commercial enterprise primarily carried out to generate income and the coverage is for:
    - ◊ A building designed as a non-habitational building
    - ◊ A mixed-use building in which the total floor area devoted to residential uses is:
        - ° 50 percent or less of the total floor area within the building if the residential building is a single-family property; or
        - ° 75 percent or less of the total floor area within the building for all other residential properties

*NOTE*

When buildings are mitigated, even if not required to meet current floodplain management compliance and if the mitigation would not result in NFIP premium reductions, owners should determine whether a non-NFIP (private) flood insurance policy will result in lower premiums.

  - ◊ A building designed for use as office or retail space, wholesale space, hospitality space, or for similar uses.

- **Other Non-Residential**: This is a subcategory of non-residential buildings; a non-habitational building that does not qualify as a business building or a mixed-use building that does not qualify as a residential building. This category includes churches, schools, farm buildings (including grain bins and silos), garages, pool houses, club houses, and recreational buildings. A small business cannot use this category.

The determination of occupancy for the purposes of NFIP flood insurance is important to consider when deliberating mitigation measures described in Chapter 5 because dry floodproofing credit under an SFIP General Property Form cannot be used for Other Residential Buildings.

For example, a 10-story dry floodproofed mixed-use non-elevated building with the ground floor occupied by commercial retail and the remaining floors used as dwelling units is considered an occupancy of “Other Residential Building” because it is 90 percent residential. Therefore, dry floodproofing credit cannot be applied when rating. In this example, the building owner may want to investigate a non-NFIP flood insurance policy to see if the owner can receive a credit for the dry floodproofing and hence a lower premium.

Building owners should consult with their insurance representative and know the insurance options available to them with commensurate implications in order to make more informed decisions on which mitigation measures would best serve their short- and long-term needs.

The NFIP has four methods for rating condominiums. Each method has its own eligibility requirements for condominium type. Only residential buildings that possess a condominium association form of ownership are eligible for the RCBAP Form. Refer to the Condominiums section of the NFIP Flood Insurance Manual (FEMA 2018c) for further details.

Successful completion of a mitigation project that also meets all the necessary insurance requirements to have the lowest floor elevation rated as being at the BFE or higher can have important insurance benefits. Owners should be aware that NFIP flood insurance rates are not static and rate increases are expected over time.

With proper planning, mitigating risks for *existing construction* buildings could save owners on annual flood insurance premiums, especially when an FPL is selected with freeboard above the BFE. In addition to reducing future damage, reductions in annual premiums should be considered as offsetting the cost of a mitigation project even in the years without a flood event. With mitigation, owners will be less likely to have to pay the deductible and pay for repairs not covered by insurance, and more likely to avoid other expenses such as a loss of rental income.

Buildings initially rated as pre-FIRM could see significant premium savings if they can qualify for post-FIRM rates. Post-FIRM rates depend on the elevation of specific points of a building relative to the BFE. See Note for descriptions of the terms pre-FIRM and post-FIRM. Figure 4-1 illustrates the expected savings based on the rates established in the April 2018 edition of the NFIP Flood Insurance Manual (FEMA 2018c). The rates were initially calculated using the pre-FIRM rates, with the resulting premiums designated as zero or the starting point to better illustrate the annual premium savings. Premium savings for various building conditions are shown, with the savings compared to the zero (pre-FIRM) rate shown for protecting to the BFE and four FPL (freeboard) scenarios up to BFE +4 feet.

*TERMINOLOGY*

For NFIP insurance purposes:

- **Pre-FIRM** refers to buildings for which construction or substantial improvement occurred on or before December 31, 1974, or before the effective date of an initial FIRM.
- **Post-FIRM** refers to buildings for which construction or substantial improvement occurred after December 31, 1974, or after the effective date of an initial FIRM, whichever is later.

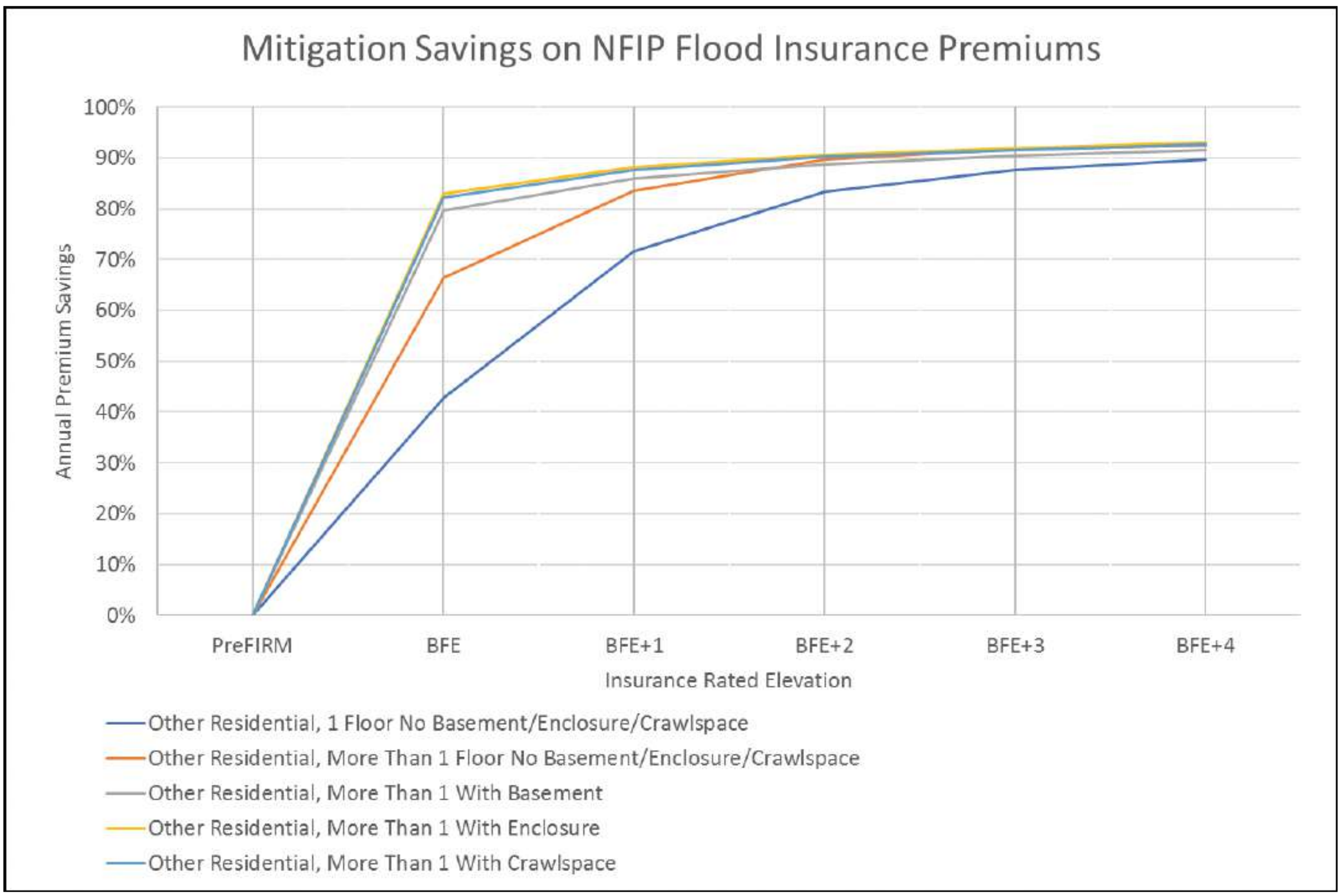



Figure 4-1. Annual savings in building coverage on NFIP flood insurance premiums in Zone A for Other Residential Buildings with freeboard scenarios shown as a percentage of the pre-FIRM rate (April 2018 rates)

Figure 4-1 represents annual savings associated with $500,000 in coverage for a building policy. Additional savings could be gained if a contents policy also was calculated. These combined savings could be used to compare with various mitigation measures to determine if the savings on flood insurance premiums makes increasing the FPL by adding freeboard more cost-effective.

*TERMINOLOGY*

**Lowest adjacent grade** is the lowest point of the ground level immediately next to a building

There are several factors that may influence NFIP flood insurance premiums. These include:

- Flood zone
- Structure and foundation type
- Elevation of the lowest floor

Factors that may influence an NFIP dry floodproofing credit include:

- **Passive (preferred) versus active mitigation measures**: Differentiate whether the flood protection measure is permanent, automatic, or requires human intervention such as installing flood shields. Since human intervention may not actually occur as intended, these measures have more risk with associated insurance implications.
- **Total versus partial building protection:** Is the entire structure protected by the same mitigation measure to a uniform FPL? Note that, in order to receive a dry floodproofing credit for rating purposes, the entire building perimeter must be dry floodproofed; otherwise, the building will be subject to special rating considerations.
- **Depth of flood protection:** This is the difference between the lowest adjacent grade and the FPL. It must be at least BFE +1 foot for dry floodproofing measures; otherwise, a credit will not be given.
- Having an operations and maintenance plan consistent with the requirements of ASCE 24 – ASCE 24 refers to it as a flood emergency plan.
- **Past performance:** Look at the extent of flood damage during prior floods.

Freeboard, or the additional height expressed in feet that the lowest floor is above the BFE, or dry floodproofing protection above the BFE, typically generates the greatest savings in premiums. Section 4.1 provides more details about how the lowest floor is determined.

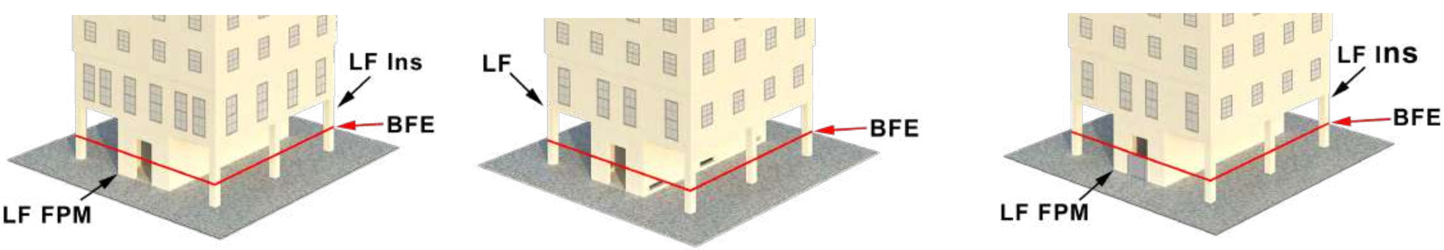
# 4.1 LOWEST FLOOR GUIDANCE FOR MULTI-FAMILY BUILDINGS

As described in Section 1.4, the lowest floor refers to the lowest floor of the lowest enclosed area (including the basement). An unfinished or flood-resistant enclosure, usable solely for parking of vehicles, building access, or storage in an area other than a basement area (i.e., is not below ground), is not considered a building's lowest floor if that enclosure is built in compliance with the requirements for enclosures below elevated buildings (see Section 2.2).

This term is applied for both floodplain management purposes and flood insurance purposes. In a dry floodproofed building, for flood insurance purposes, if a non-elevated building is dry floodproofed to 1 foot or above the BFE and meets the criteria for Non-Residential Business or Other Non-Residential (described earlier in Chapter 4), then the building is rated as having a "0" elevation difference from the BFE.

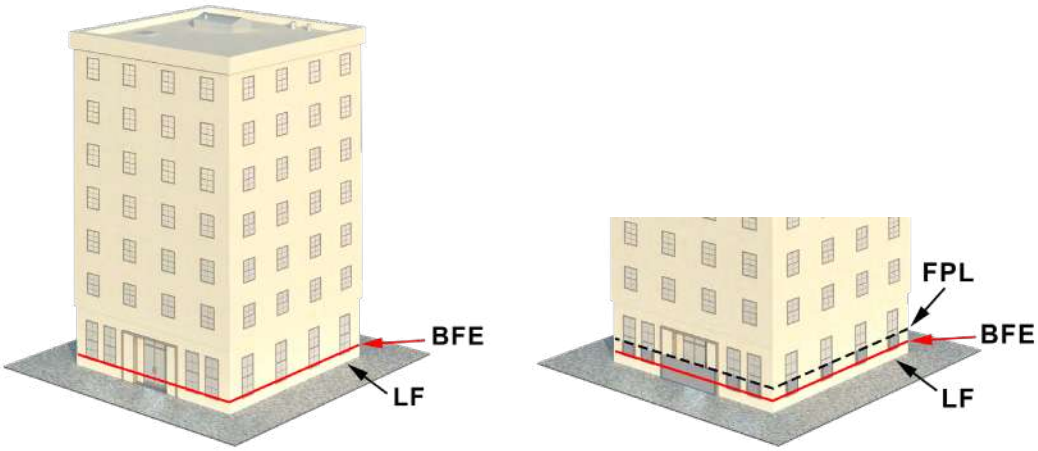
> *CROSS REFERENCE*
>
> See Chapter 5 for more information on dry flooding and other mitigation measures.

To further illustrate, if a non-elevated Non-Residential Business or Other Non-Residential building is certified to be dry floodproofed to 2 feet above the BFE, then it is credited for floodproofing and is to be treated for rating purposes as having a +1-foot elevation. To clarify how the lowest floor is determined, Figures 4-2 through 4-6 provide examples of lowest floor determinations for floodplain management compliance and insurance rating purposes. See the NFIP Flood Insurance Manual (FEMA 2018c) for further information.




| | | |
| --- | --- | --- |
| Existing Building (elevated building - for insurance purposes) without mitigation | Mitigation: Wet floodproofed ground level moves the lowest floor up one level, which is above the BFE<br><br>Other Residential: Insurance credit available<br><br>Non-Residential Business: Insurance credit available<br><br>FPM Compliance: Provided the space meets all necessary requirements for an enclosure below the BFE | Mitigation: Dry floodproofed ground level with FPL at least BFE +1 ft<br><br>Other Residential: No insurance credit<br><br>Non-Residential Business: Elevated buildings do not qualify for the dry floodproofing credit.<br><br>FPM Compliance: Provided the use of the dry floodproofed space is limited to non-residential purposes and there is separate building access for the residential spaces that is either wet floodproofed or elevated above the required FPL |

Figure 4-2. Image (left) shows the lowest floor of a multi-family building with parking and access at ground level (no mitigation measures) and images (center and right) reflect two mitigation approaches (LF = lowest floor)




Existing Building (no mitigation)

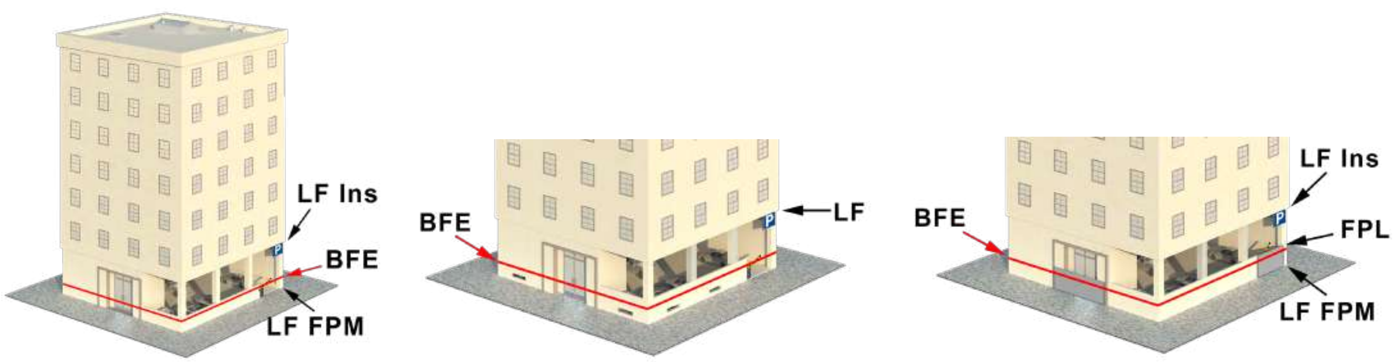
Mitigation: Dry floodproofed ground level (FPL>BFE +1 ft)

Other Residential: No insurance credit

Non-Residential Business: Insurance credit available

FPM Compliance: Same as Figure 4-2 (right)

Figure 4-3. Image (left) shows the lowest floor of a multi-family non-elevated building (no mitigation measures), and image (right) shows dry floodproofing of the ground floor, which is non-elevated and non-residential




Existing Building (elevated building - for insurance purposes) without mitigation

Mitigation: Wet floodproofed ground level moves the lowest floor up one level, which is above the BFE

Other Residential: Insurance credit available

Non-Residential Business: Insurance credit available

FPM Compliance: Same as Figure 4-2 (center)

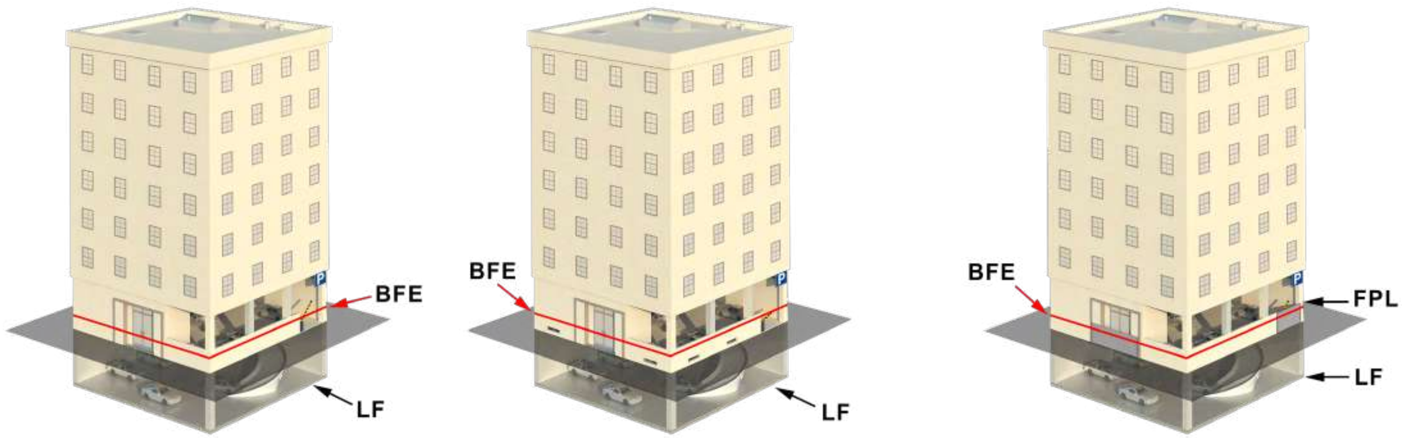
Mitigation: Dry floodproofed ground level (FPL>BFE+1 ft)

Other Residential: No insurance credit

Non-Residential Business: Elevated buildings do not qualify for the dry floodproofing credit.

FPM Compliance: Same as Figure 4-2 (right)

Figure 4-4. Image (left) shows the lowest floor of a multi-family building with parking and access at ground level (no mitigation measures), image (center) shows the lowest floor with a compliant wet floodproofed enclosure, and image (right) shows dry floodproofing of the ground floor, which is all non-residential




Existing Building (no mitigation)

Mitigation: Wet floodproofed ground level

Other Residential: No insurance credit

Non-Residential Business: No insurance credit

FPM Compliance: No, wet floodproofed basements do not comply with the NFIP requirements

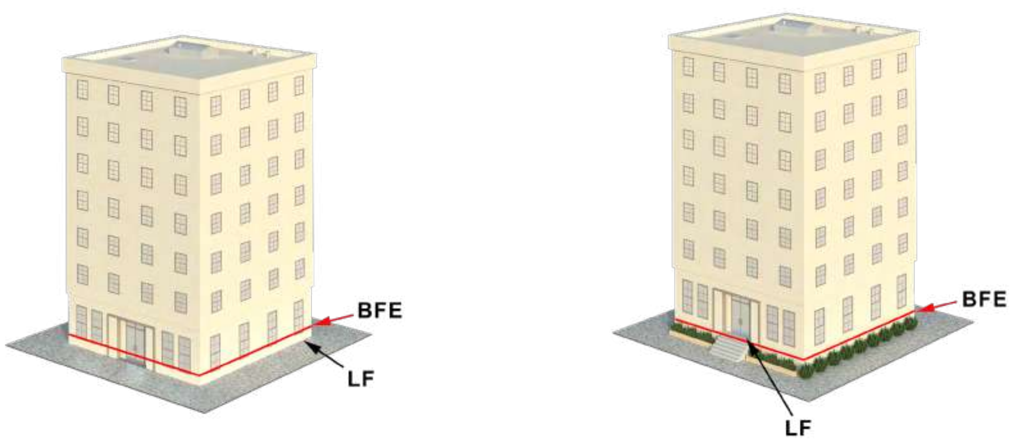
Mitigation: Dry floodproofed ground level (FPL>BFE +1 ft)

Other Residential: No insurance credit

Non-Residential Business: Insurance credit available

FPM Compliance: Same as Figure 4-2 (right)

Figure 4-5. Image (left) shows the lowest floor of a multi-family building with pedestrian access and below grade parking access at ground level (no mitigation measures), image (center) shows the lowest floor with a noncompliant wet floodproofed enclosure, and image (right) shows the dry floodproofing of the ground floor, which is all non-residential




Existing Building (no mitigation)

Mitigation: Elevated foundation with lowest floor at BFE

Other Residential: Reduced insurance premium

Non-Residential Business: Reduced insurance premium

FPM Compliance: Yes, provided the lowest floor is at or above the BFE

Figure 4-6. Image (left) shows the lowest floor of a multi-family building built at ground level (no mitigation) and image (right) shows the same building constructed elevated on fill

# MITIGATION MEASURES

# 5

This chapter illustrates flood mitigation measures that comply with local floodplain management requirements, apply primarily to *existing construction,* and provide options for the consideration of owners who want to reduce the potential for flood damage, even when NFIP compliance is not required.

Each mitigation measure is introduced and followed by a table that indicates the buildings for which the mitigation measures would be allowed. Since some measures are better suited to specific flood conditions, each measure also has a brief description of which flood conditions are appropriate for the mitigation measure. A general overview of each of the primary mitigation measures is provided along with advantages and disadvantages. This is followed by recommended FEMA references with further details on planning, designing, and implementing the mitigation measure. In addition to these primary measures, a list of secondary measures that could be incorporated into any of the primary mitigation measures is provided in Section 5.8, Common Secondary Mitigation Measures for Multi-Family Buildings. At the conclusion of the chapter, there is a section on selecting and combining mitigation measures. Readers can then take the information they have learned about their flood risk (see Chapter 3), the information from the site and building evaluation (see Appendix D), and the information on the mitigation measures to create a comprehensive flood mitigation strategy or plan to help protect the building from future flooding. See Appendix A for a crosswalk of technical resources to help develop a comprehensive mitigation strategy. Building owners can then coordinate with local floodplain administrators and building officials to determine permit requirements before implementing their mitigation strategy.

> *NOTE*
>
> Users of this publication also should consider designing and/or retrofitting buildings to be compliant with the latest edition of ASCE/SEI 24, Flood Resistant Design and Construction.

Although the measures outlined in this publication could be applied to a variety of different types of building construction, in different settings, it is important to highlight the unique aspects of large multifamily buildings and how the mitigation measures may be different for these buildings. Potential mitigation measures for larger multi-family buildings in urban areas may differ from measures often used for smaller, light-frame construction buildings due to several factors, such as:

- Large buildings are engineered structures, or at least more robustly constructed than light frame, and the wall systems are more likely to resist flood loads.
- Large buildings typically have professional property and facilities managers either on-site or assigned to the building, and repairs and maintenance are performed by someone familiar with the construction trades. These dedicated facilities managers and their staff can perform maintenance, conduct routine inspections, and implement emergency operations plans.

- In mixed-use buildings, basements can provide space for parking which allows for the above-grade floors to be used for commercial and residential space.
- In mixed-use buildings, mechanical, electrical, and plumbing (MEP) systems typically occupy large areas and may be housed in basement areas to facilitate access to utility connections and to maintain valuable aboveground space for tenants.
- Fuel tanks are often housed in basements or lower levels of buildings.
- There may be underground connections between buildings (e.g., shared parking, access corridors joining buildings).

The intent of the mitigation measures described in this publication is to reduce flood damage and to facilitate recovery. Occupant protection is best achieved by evacuation, and it is highly recommended that owners and managers of multi-family buildings develop plans to evacuate all occupants well in advance of a flood event. The following are important measures to consider regarding occupant protection:

- If floodwater is likely to reach a multi-family building and block evacuation routes, provisions should be made for the evacuation of all occupants before the building becomes isolated from its infrastructure support systems (e.g., roads, bridges, tunnels, utilities).
- When warnings are issued, and voluntary evacuations are recommended by state or local government officials, it is prudent for residents to follow these warnings. When mandatory evacuations are ordered, the orders must be followed.
- Proactive planning, coordination, preparedness, and early evacuation of tenants will reduce the risk of personal injury and may reduce response or recovery time. Property managers can focus on preparing the building and safeguarding utility systems prior to an event without worrying about tenant needs or repairing the facility afterwards.
- During events, tenants may decide that sheltering-in-place is no longer viable and then may attempt to evacuate, which may prompt removal of protective shields or other measures exposing the building to floodwater.

Some utility systems may be best protected by shutting them down prior to an event to minimize damage. This may either be more difficult to accomplish with un-evacuated tenants present or may result in those tenants not having those utilities available until they are restored again. These are just some challenges to consider if tenants do not evacuate in a timely fashion when the situation calls for them to do so.

# 5.1 ELEVATION

**Elevation**: The term refers to raising buildings on the same footprint, so the lowest floor is at or above the elevation required by building codes or local floodplain management requirements.

| BUILDING DESIGNATION | COMPLIANT MITIGATION MEASURE |
| --- | --- |
| New Construction/SI/SD | ✓ |
| Legal Non-Conforming Construction (Not SI/SD) | ✓ |
| Existing Construction (Not SI/SD) | ✓ |

NOTE

For *new construction*, meeting elevation requirements is accomplished with an engineered foundation. See Section 2.2.3 for information on requirements for *new construction*.

**Flood conditions, when it is appropriate:** Elevating a building is the most resilient mitigation measure when relocating the building is not an option. This is because an adequately elevated building with a compliant enclosure below the BFE is least at risk to flood damage when compared to a non-elevated building.

NOTE

It may be possible to relocate small buildings to sites outside of SFHAs, placing the buildings on new foundations.

**Considerations for successful elevation:** During the elevation process, *existing construction* buildings can be detached from existing foundations and elevated onto higher foundations to reduce exposure to flooding. This requires significant engineering and equipment, including lifting jacks. In general, the larger the building and the more complex its design and shape, the more difficult it will be to lift on jacks. Large multi-story buildings are more difficult to stabilize during the lifting process, and as the dimensions and weight of the buildings increase, so do the required numbers of jacks and other pieces of lifting equipment. In dense urban areas, closeness to other buildings may additionally complicate or preclude elevation projects. Because of size, elevation-in-place or relocation of large buildings such as multi-family buildings are rarely technically or economically feasible because of their structural characteristics and location. Smaller multi-family buildings could be viable candidates for elevation.

In most urban environments, it is important to consider zoning limitation on roof heights and streetscape and visual connectivity requirements at ground level when considering implementing elevation of *existing construction*. Maintaining ground level access can be addressed using elevators, lifts, and ramps. In dense urban environments, elevated buildings pose challenges for accessibility, as ramps are difficult to accommodate on the exterior of buildings and may need to be addressed inside the building. Typically, the most challenging aspects of elevation as a mitigation measure are height restrictions, structural challenges of lifting large buildings, or overall cost. Height restrictions often can be addressed with zoning variances to allow for elevation projects. Whenever possible, dwelling units in a multi-family building should be located above the FPL since this provides the best mitigation measure in terms of reduced risk, economic benefit, and tenant re-occupancy. When compliance is required for *new construction*, substantial damage, or substantial improvements, dwelling units must be at or above the required FPL.

Table 5-1. Elevation advantages and disadvantages

| FLOOD MITIGATION STRATEGY – ELEVATION | |
|---|---|
| **ADVANTAGES** | **DISADVANTAGES** |
| • Reduces risk to structure and contents by providing protection for flooding up to the FPL<br>• Most resilient strategy<br>• Reduces insurance premium | • In some cases, technically infeasible due to structural characteristics and/or location<br>• Typically cost prohibitive for large buildings |
| **Recommended FEMA Resource:** FEMA P-259, *Engineering Principles and Practices for Retrofitting Floodprone Residential Structures* (FEMA 2012) (although written primarily for detached single-family residential dwellings, many of the concepts are applicable to large multi-family buildings) | |

## 5.2 WET FLOODPROOFING

**Wet floodproofing**: A retrofit that involves the use of flood damage-resistant materials and construction techniques to minimize flood damage to areas that are intentionally allowed to flood.

| BUILDING DESIGNATION | COMPLIANT MITIGATION MEASURE | | |
|---|---|---|---|
| | **Wet Floodproof Above Grade Areas (allowable uses)** | **Wet Floodproof Above Grade Areas (other uses)** | **Wet Floodproof Below Grade Areas** |
| New Construction/SI/SD | ✓ | | |
| Legal Non-Conforming Construction (Not SI/SD) | ✓ | Possible[1] | |
| Existing Construction (Not SI/SD) | ✓ | ✓ | ✓ |

[1] Allowable if it is above the required elevation at time of construction (i.e., BFE or locally adopted elevation that exceeds the BFE)

**Flood conditions, when it is appropriate:** Wet floodproofing is most appropriate when there is low-velocity floodwater (less than 5 feet per second) and short-duration floods (less than 3 days). There should also be sufficient warning time to move contents from the wet floodproofed areas.

**Considerations for successful wet floodproofing:** For compliance, wet floodproofing requires flood openings to allow the automatic entry and exit of floodwaters from above-grade spaces during design flood conditions. When considering using wet floodproofing measures to retrofit *existing construction* with basements or additional levels below the FPL, it is important to consider allowing water to flow between floors to minimize hydrostatic loads. For residential *new construction*, below-grade areas (basements) are not permitted and wet floodproofing is permitted only for enclosed areas below elevated buildings, provided the enclosures are at- or above-grade and used only for parking of vehicles, storage, or building access. Unlike dry floodproofing measures, certification of design is not required for wet floodproofing; however, it is recommended that owners ask their designer to verify the wet floodproofed area is designed and constructed correctly. Figure 5-1 shows a wet floodproofed wall section for a masonry wall system and a wet floodproofed wall section for a cold formed steel channel wall system. Figure 5-2 shows a representative wet floodproofed building. Wet floodproofing might include some or all the recommendations below:

- Raising/relocating utility systems and critical contents currently located below BFE or subject to flood damage, to or above the FPL. Discussion of mitigation for utility systems can be found in FEMA P-348, *Protecting Building Utility Systems from Flood Damage* (FEMA 2017a).
- Designing or selecting materials, components, or systems below the FPL, such as utility systems or equipment, to be capable of withstanding direct and prolonged contact with floodwaters without sustaining significant damage (e.g., submersible pumps). See FEMA P-348 (FEMA 2017a).

*TERMINOLOGY*

**Flood damage-resistant material** refers to any building product (material, component, or system) capable of withstanding direct and prolonged contact with floodwaters without sustaining significant damage.

**Prolonged Contact** means at least 72 hours.

**Significant Damage** means any damage requiring more than cosmetic repair.

*WARNING*

When compliance is required, below-grade parking and utility rooms are prohibited beneath residential buildings in Zone A since areas below-grade on all sides are basements and basements are not permitted (44 CFR Section 60.3(c)(2)) by the NFIP.

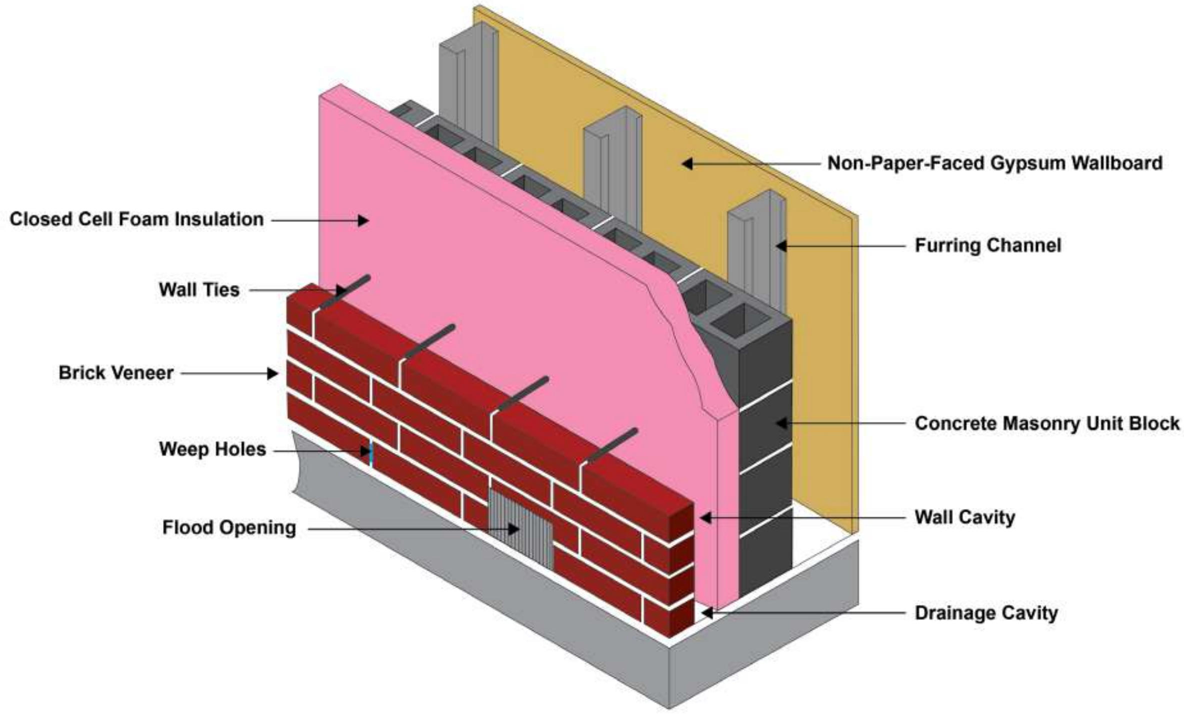
*NOTE*

Buildings may have areas that are currently used for parking, building access, or storage below the BFE and may only require the incorporation of flood openings, modification of materials to flood damage-resistant materials, or some other minor modification to become a conforming space. Once complete, it may be possible to have a new Elevation Certificate completed and change the Lowest Floor Elevation. Recognition of the lowest floor being higher can result in annual reductions in flood insurance premiums.

- For any systems that will remain below the FPL, installing and configuring electrical and mechanical systems to minimize disruptions and facilitate repairs. Since it is expected that some of this equipment will be damaged by floodwaters, it is recommended to completely isolate portions of a building system that serve wet floodproofed areas. See FEMA P-348 (FEMA 2017a).
- Installing flood openings to automatically equalize the hydrostatic pressure exerted by floodwater. In colder climates insulated engineered flood openings are available. See NFIP Technical Bulletin 1, *Openings in Foundation Walls and Walls of Enclosures Below Elevated Buildings in Special Flood Hazard Areas in accordance with the National Flood Insurance Program* (FEMA 2008a).
- Using flood damage-resistant materials throughout areas below the FPL. A list of tested flood damage-resistant materials can be found in NFIP Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas in accordance with the National Flood Insurance Program* (2008b).

> *WARNING*
>
> NFIP regulations **do not** permit wet floodproofing to be used to bring SI/SD structures into compliance with local floodplain requirements unless the wet floodproofed area is used solely for parking, building access, or storage (44 CFR Section 60.3(c)(5)).

- Using pre-storm event floor drainage or floodwater collection design, or installation of pumps, to efficiently and effectively remove floodwater gradually from basement areas after flooding and avoid building damage from unequal interior versus exterior hydrostatic loads (does not apply to *new construction* since residential basements are prohibited and would not be present).
- Adequately anchoring equipment or utilities below the FPL or susceptible to flood damage to counter anticipated hydrodynamic and buoyant loads during flooding and avoid these items serving as potential sources of debris within the building. Anchoring is only one aspect of wet floodproofing. See the other bullets herein to address other important aspects to properly wet floodproofing equipment and utilities below the FPL.
- Developing building emergency operations, maintenance, inspection, and preparedness plans that adequately address the building and its associated utility systems' wet floodproofing needs or requirements.



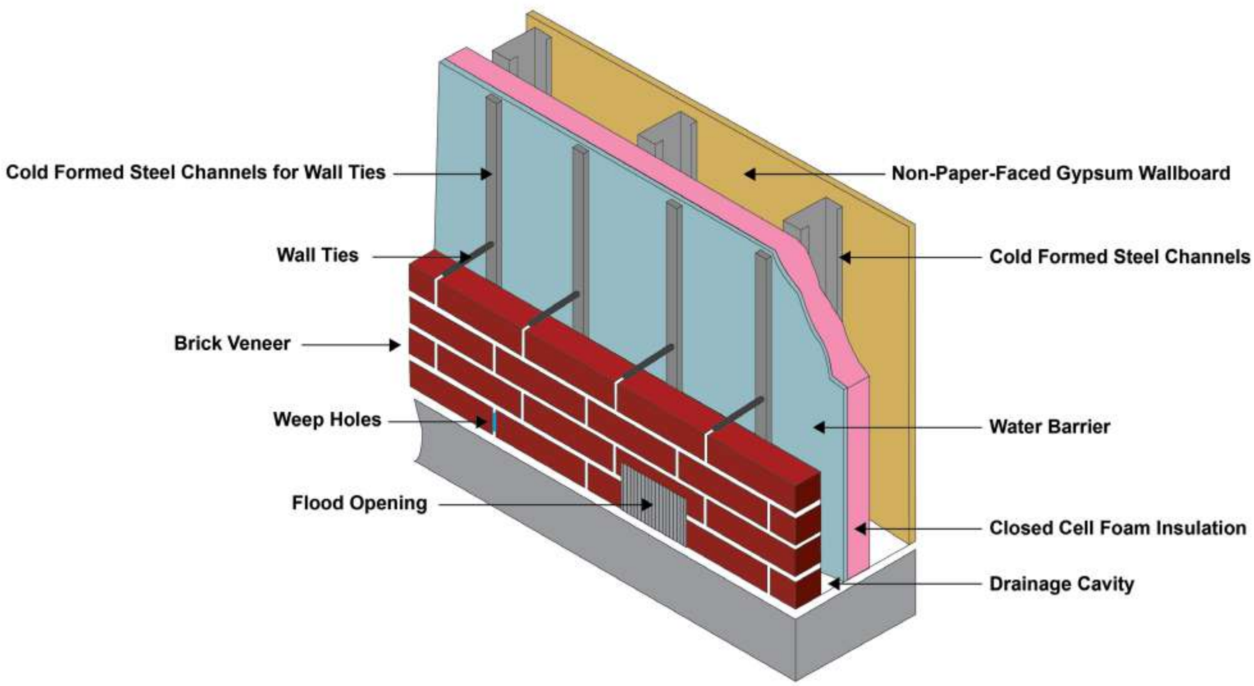




Figure 5-1. Examples of a wet floodproofed wall sections for a masonry wall system and a cold formed steel channel wall system

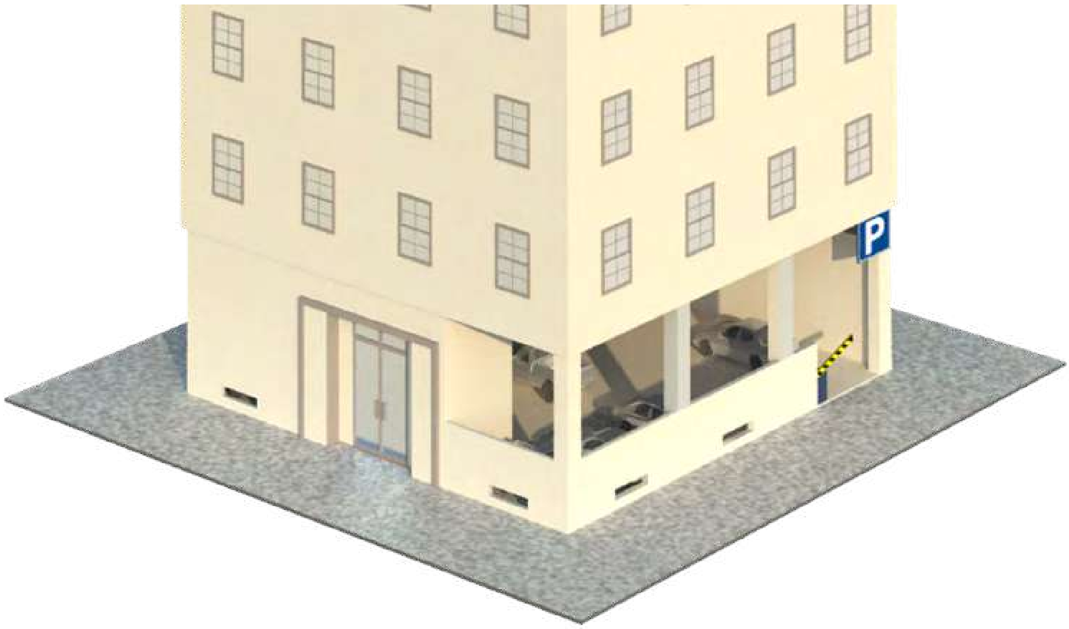


Figure 5-2. Example of a wet floodproofed multi-family building (note flood openings around the ground level of the building)

While retrofitting with wet floodproofing measures can reduce damage and recovery time, it is important to consider the impacts on repair and recovery of the ground floor and basement levels that are filled with floodwater, especially if the floodwater is contaminated (e.g., fuel, oil, sewage). These conditions may hinder use of the entire building until the risk of exposure to hazardous contaminants is reduced or eliminated. If tenants or building employees will enter through wet floodproofed areas, owners should assume wet floodproofed areas will be unusable immediately following floods and take preventive measures to reduce loss of function of the remainder of the building.

*WARNING*

While there may be a rush to reoccupy, pumping out wet floodproofed areas too quickly may cause structural damage, including collapse, due to unbalanced hydrostatic pressure on the foundation and basement walls.

Table 5-2. Wet floodproofing advantages and disadvantages

| FLOOD MITIGATION STRATEGY – WET FLOODPROOFING | |
|---|---|
| **ADVANTAGES** | **DISADVANTAGES** |
| • Minimal impact to dwelling units on upper floors<br>• Maintains a street presence and could minimize retrofits exterior to the building<br>• Minimal upfront costs to implement, as compared to many other measures (often costly cleanup after an event compared to other measures)<br>• Adding engineered flood openings may reduce NFIP annual flood insurance premiums | • Can limit post-flood use of floor area below the FPL until those areas can be restored<br>• Difficult to retrofit *existing construction* multi-family buildings based on current use of ground floor<br>• Potential long-duration flooding within a building<br>• Areas will need cleaning and potential decontamination of hazardous materials before re-occupancy<br>• Most wet floodproofing does not result in lower NFIP flood insurance premiums for non-elevated buildings |
| **Recommended FEMA Resources:** FEMA P-936, *Floodproofing Non-Residential Buildings*; FEMA P-259, *Engineering Principles and Practices for Retrofitting Floodprone Residential Structures* (FEMA 2012); NFIP Technical Bulletin 1 - *Openings in Foundation Walls and Walls of Enclosures Below Elevated Buildings in Special Flood Hazard Areas in accordance with the National Flood Insurance Program*; NFIP Technical Bulletin 2 - *Flood Damage-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas in accordance with the National Flood Insurance Program;* NFIP Technical Bulletin 7 - *Wet Floodproofing Requirements for Structures Located in Special Flood Hazard Areas in accordance with the National Flood Insurance Program* | |

## 5.3 DRY FLOODPROOFING

**Dry floodproofing**: A combination of measures that result in a structure being watertight with all elements substantially impermeable to the entrance of floodwater below the FPL and with structural components (including walls and slabs) having the capacity to withstand flood loads.

| BUILDING DESIGNATION | COMPLIANT MITIGATION MEASURE | | |
|---|---|---|---|
| | **Dry Floodproof Commercial Areas of Mixed-Use Buildings** | **Dry Floodproof Residential Areas of Buildings** | **Dry Floodproof Below Grade Parking Areas** |
| New Construction/SI/SD | ✓ | | Only Mixed-use Buildings |
| Legal Non-Conforming Construction (Not SI/SD) | ✓ | Possible[1] | Only Mixed-use Buildings |
| Existing Construction (Not SI/SD) | ✓ | ✓ | ✓ |

[1] Allowable if it is above the required elevation at time of construction (i.e., BFE or locally adopted elevation that exceeds the BFE)

**Flood conditions, when it is appropriate:** Dry floodproofing is most appropriate when there is low-velocity floodwater (less than 5 feet per second) and short-duration floods (less than 3 days). There should also be at least 12 hours of warning time to allow for the installation of flood protection measures. More warning time may be necessary for complex flood protection measures.

*NOTE*

For purposes of dry floodproofing, a shield includes covers, panels, and doors that prevent the intrusion of water into dry floodproofed areas. These can either be removable or permanently attached to the opening they are protecting.

**Considerations for successful dry floodproofing:** Although entirely passive dry floodproofing (not requiring human action) is preferred, many dry floodproofing designs incorporate active measures, such as shields, to be installed over windows, doors, and other openings below the FPL. If not already present or not adequately designed, this mitigation strategy may require the installation of below-grade waterproofing systems and drainage channels to divert groundwater to sump pits. Because of seepage and accumulation of moisture, the NFIP (and ASCE 24, when applicable) requires incorporation of sump pumps into the design when NFIP compliance is required.

*WARNING*

Under certain circumstances, dry floodproofing residential areas in *legal non-conforming* and *existing construction* is possibly allowable. When properly designed, failure or overtopping is a low-probability event, however when the measures fail it can cause catastrophic damage. The mitigation measures are not intended to allow tenants and occupants to shelter-in-place during a flood event. Dry-floodproofed buildings should not be occupied during flood events. Therefore, emergency operations plans must include evacuation procedures whenever the measures are implemented.

If an annual insurance premium credit is pursued, the Floodproofing Certificate requires adherence to ASCE 24, so sump pumps must be provided to address inevitable seepage through the dry floodproofing system. Most dry floodproofing measures also require standby power generation to run pumps and maintain power to building utility systems. Figure 5-3 shows a dry floodproofed building.

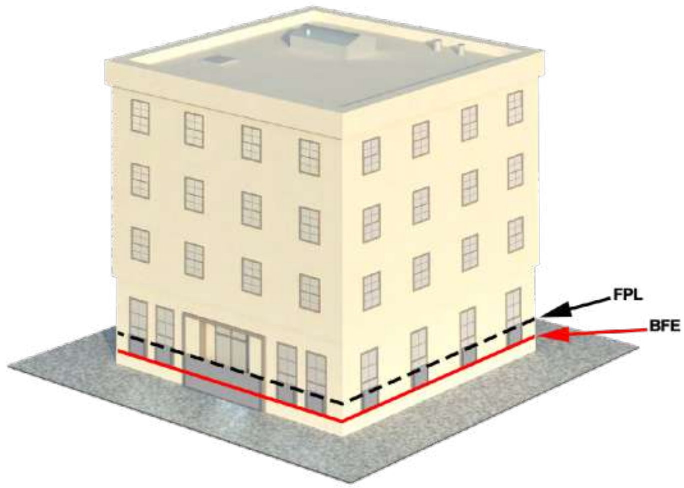



Figure 5-3. Example of dry floodproofed multi-family building (FPL must be at BFE for compliance with the minimum NFIP requirements and greater than BFE +1 ft for insurance credit)

For NFIP compliance, dry floodproofing is permitted for *new construction* that have a non-residential occupancy and for non-residential buildings that are undergoing substantial improvement or have incurred substantial damage. It is not permitted for *new construction* when the occupancy is residential or residential buildings that are undergoing substantial improvement or have incurred substantial damage since the NFIP does not permit dry floodproofing for residential buildings, when compliance is required.

Many *existing construction* large multi-family buildings can often withstand the loads associated with dry floodproofing. *Existing construction* that is not substantially improved or substantially damaged or meets the previously stated requirements for mixed-use, should be structurally evaluated to ensure the structural components can resist the expected forces (see Appendix D). If it is determined that the building is not structurally adequate, either additional retrofits to the structural components may be necessary before floodproofing work begins or the building should not be dry floodproofed. See Section 3.5 for additional guidance for conducting vulnerability assessments of *existing construction.*

**WARNING**

The NFIP regulations specify the use of dry floodproofing measures only for non-residential structures. By policy, FEMA permits non-residential portions of mixed-use buildings to be dry floodproofed provided all dwelling units are above the BFE. See FEMA NFIP Technical Bulletins 3 and 6.

**CROSS REFERENCE**

Following the 2017 hurricanes, FEMA developed additional guidance on dry floodproofing based on observations from FEMA Mitigation Assessment Teams. See Hurricane Harvey Recovery Advisory 1 on *Dry Floodproofing: Planning and Design Considerations* (FEMA 2018) and Hurricane Irma Recovery Advisory 1 on *Dry Floodproofing: Operational Considerations* (FEMA 2018).

Designing dry floodproofing measures for buildings with below-grade spaces should include an analysis to evaluate groundwater levels. In some urban areas, the shutdown of water supply wells that were pumped for decades resulted in the water table rebounding and basements being subject to flooding. Dry floodproofing techniques used on buildings with basements generally consist of installing a barrier-type membrane that is adhered to the interior or exterior surfaces of the basement walls. Typical applications are to the interior surfaces because of ease of access, which generally results in less cost. Various types of adhered-barrier membrane products are available for use, and system design depends on the type and condition of the existing basement walls, utility penetrations, and other factors.

> *WARNING*
>
> Dry floodproofing is not recommended where flooding is expected to persist for a long period. Prolonged contact with floodwaters increases the chance of seepage and structural failure in floodproofed buildings.

For below-grade spaces that require additional protection against water penetration, a cavity drainage system consisting of dimpled drainage membrane can be installed on the interior surfaces of basement walls. The cavity drainage system captures any groundwater, which can bypass the adhered barrier membrane system, and diverts it to floor drainage channels, which in turn flow to a sump pit for removal. Below-grade areas are often where water services enter the building and sewer services exit the building. Modifications, such as the installation of backflow prevention valves and, in some cases, ejector pumps to allow the ejection of sewage during times when sewer lines may be pressurized by floodwater, are often required.

Protection of the building depends on sealing openings, such as doors, windows, and utility penetrations, as well as sealing walls and slabs, which often were not originally designed to be watertight or resist flood loads. In most cases, shields are used that must be installed prior to anticipated flooding.

All dry floodproofing measures require periodic inspection and maintenance plans to ensure they are kept in working order and timed deployment drills to ensure operations plans can be implemented in a timely fashion. Inspection is suggested at least every 12 months and after every flood event impacting the system or its operation.

> *NOTE*
>
> When considering the use of dry floodproofing measures for basements or additional levels below the FPL, it is important to consider allowing water to flow between floors to minimize hydrostatic loads should the dry floodproofing measures be overtopped or fail.

Table 5-3. Dry floodproofing advantages and disadvantages

| FLOOD MITIGATION STRATEGY – DRY FLOODPROOFING | |
|---|---|
| **ADVANTAGES** | **DISADVANTAGES** |
| • Can be used to protect against more frequent flooding even if it is not cost-effective to floodproof to the BFE/FPL<br>• Where applicable, helps protect buildings with a lowest level below the FPL, including basements<br>• Maintains streetscapes<br>• May allow building utility systems to remain in below-grade floors where above-grade space could be maintained for occupants<br>• Can provide lower NFIP flood insurance premiums, if FPL is at least BFE +1 ft | • Not applicable for flash flood or any flooding situation that occurs with limited or no warning<br>• Limited applicability based on a building's structural system and walls capable of withstanding FPL associated flood loads<br>• Overlooking an entry point of water can negate the entire mitigation measure<br>• Typically requires human intervention to be successful<br>• Incomplete measures, poor installation, or poor maintenance can result in total system failure or significant seepage<br>• Potential failure of walls or floor slabs due to flood loads<br>• Property damage and loss of function if a flood event is greater than the FPL<br>• Standby power systems are required due to sump pump need<br>• Dry floodproofing measures generally cannot be tested in advance, until an actual flood occurs<br>• Dry floodproofed enclosures are complex systems that are often difficult to achieve successfully |
| **Recommended FEMA Resources:** FEMA P-936, *Floodproofing Non-Residential Buildings* (FEMA 2013a); Hurricane Irma in Florida Recovery Advisory 1 – *Dry Floodproofing: Operational Consideration*. (FEMA 2018a); Hurricane Harvey in Texas Recovery Advisory 1 – *Dry Floodproofing: Planning and Design Considerations* (FEMA 2018b); NFIP Technical Bulletin 3 - *Non-Residential Floodproofing — Requirements and Certification for Buildings Located in Special Flood Hazard Areas in accordance with the National Flood Insurance Program*; NFIP Technical Bulletin 6 - *Below-Grade Parking Requirements for Buildings Located in Special Flood Hazard Areas in accordance with the National Flood Insurance Program* | |

In addition to seeking reduced flood damage, owners are often interested in reducing their flood insurance premiums. The introduction to Chapter 4 includes descriptions of occupancy classifications used for NFIP insurance rating, including non-residential business. For a dry floodproofed non-residential building classified as a non-residential business to receive insurance rating credit, it must be certified as dry floodproofed to at least 1 foot above the BFE. To obtain insurance rating credits, the building must be:

- Entirely non-habitational, or
- mixed-use, which means for insurance purposes, it must have greater than 25 percent of the total floor area devoted to non-residential uses (e.g., commercial parking, restaurants, offices, retail space).

This will enable the building to be considered a non-residential business occupancy and receive dry floodproofing credit through the NFIP. For example, an *existing construction* 10-story dry floodproofed apartment building with one story of retail and two stories of commercial parking garage (30 percent of total floor area) would receive flood insurance credit while the same building with only one story of retail and one story of commercial parking (20 percent of total floor area) would not.

Certification is required when retrofit dry floodproofing measures are used to meet the minimum NFIP requirements for *existing construction* that is substantially improved or repaired after incurring substantial damage. FEMA recommends that communities require certification for all retrofit dry floodproofing projects, even when compliance is not required. The recommended form to use for this purpose is the FEMA Floodproofing Certificate for Non-Residential Structures (FEMA Form 086-0-34). This form is required for dry floodproofing measures to be recognized for NFIP flood insurance purposes. During the design and certification process, design professionals should consider having a peer review of plans and specifications performed for dry floodproofed systems to help ensure that potential failure points have been properly identified and addressed.

*NOTE*

Design professionals should be aware of several requirements that may not be explicitly noted on FEMA dry floodproofing certificates. Specifically, designers must:

- Provide interior drainage (pumps) to control seepage into buildings
- Provide a continuous source of electricity to operate any necessary floodproofing components
- Specify flood damage-resistant materials in areas where seepage is expected to occur
- Conduct planning, including developing flood emergency operations plans and inspection and maintenance plans

Further, designers should sign the floodproofing certificate stating that they have reviewed the emergency operations plan and inspection and maintenance plan and that they are adequate.

# 5.4 ELEVATING OR RELOCATING EQUIPMENT

**Elevating or Relocating Equipment**: Refers to relocating MEP equipment from lower flood-prone areas of the building up to higher floors or elevating the equipment on platforms within a utility system room.

| BUILDING DESIGNATION | COMPLIANT MITIGATION MEASURE |
|---|---|
| New Construction/SI/SD | ✓ |
| Legal Non-Conforming Construction (Not SI/SD) | ✓ |
| Existing Construction (Not SI/SD) | ✓ |

**Flood conditions, when it is appropriate:** Similar to elevating the building, elevating equipment is not restricted by flood conditions. If the equipment is relocated from a lower floor, then consideration should be given to how those areas will be retrofitted. The selected mitigation for these areas should be appropriate for the flood conditions.

**Considerations for successful elevation or relocation of equipment:** The most common location for equipment such as MEP, fuel gas, HVAC, communications, security, fire control, and related components in *existing construction* multi-family buildings is the ground floor or basement. These systems tend to occupy large areas and are housed at ground level or in basements to optimize above-grade building space for residential use and to facilitate access to below-grade utility connections. In dense urban environments, equipment is typically in basements to facilitate access to below-grade utility connections. In some cases, because of limited space, improvements over the life of the building or other factors, equipment is often located outside, along the perimeter immediately adjacent to the building and is therefore especially susceptible to flooding (see Figure 5-4).

Figure 5-4. Exterior mechanical and electrical equipment

Dwelling units cannot be occupied after flood events, unless MEP and other utility systems are functioning. To reduce the risk of flood damage and the time associated with repairing critical equipment, the equipment either should be elevated or relocated. Some equipment, such as fuel tanks, may not be possible to relocate to higher floors. In some cases, structural retrofits are required to support the loads associated with elevated or relocated equipment, or existing utility systems may be replaced with smaller and lighter equipment to reduce the extent of structural retrofits. Fire codes and other restrictions may prevent the relocation of equipment, which potentially could either intensify future fires or cause increased probability of fire outbreak. Some state and local regulations also have specific requirements for the location of fire protection systems and equipment.

*NOTE*

Platforms and pedestals used to elevate equipment must resist flood loads and other applicable loads. Outdoor platforms and pedestals or rooftop penthouses must be designed to resist applicable wind and seismic loads. Equipment also must be anchored to resist these loads.

If components of a building utility system cannot be elevated, relocated, or protected with component protection measures, another mitigation measure is to install or retrofit these elements in a manner that allows for quick isolation and cost-efficient replacement if damaged. One example of this approach is electrically isolating components installed in areas subject to flooding from components at higher elevations. Another example is installing separate branch circuits or feeders that are isolated from the rest of the electrical system and protected using ground fault circuit interrupters.

Table 5-4. Elevating/relocating equipment advantages and disadvantages

| FLOOD MITIGATION STRATEGY – DRY FLOODPROOFING | |
|---|---|
| **ADVANTAGES** | **DISADVANTAGES** |
| • Eliminates or reduces damage to equipment or systems<br>• Enables systems to continue functioning if properly designed to do so during flood events<br>• Reduces recovery time and occupant displacement | • Can have substantial costs to implement, depending on the equipment or system (costs will have varying returns on investment compared to avoided damage and loss of function)<br>• Could result in loss of usable space in upper stories<br>• Rarely results in lower NFIP flood insurance premiums |
| **Recommended FEMA Resources:** P-348, *Protecting Building Utility Systems from Flood Damage – Principles and Practices for the Design and Construction of Flood Resistant Building Utility Systems (FEMA 2017a); FEMA P-942, Mitigation Assessment Team Report, Hurricane Sandy in New Jersey and New York: Building Performance Observations, Recommendations, and Technical Guidance (FEMA 2013b); FEMA Hurricane Sandy Recovery Advisory No. 3, Resorting Mechanical, Electrical, and Plumbing Systems (FEMA 2013e); FEMA Hurricane Sandy Recovery Advisory No. 4, Reducing Interruptions to Mid- and High-Rise Buildings During Floods (FEMA 2013f); FEMA Hurricane Sandy Recovery Advisory No. 6, Protecting Building Fuel Systems from Flood Damage (FEMA 2013g)* | |

# 5.5 DRY FLOODPROOFING BUILDING UTILITY SYSTEM ROOMS AND CREATING VAULTS

**Dry Floodproofing Building Utility System Rooms**: A process of dry floodproofing equipment rooms that are subject to flooding while other flood-prone areas may be wet floodproofed.

| BUILDING DESIGNATION | COMPLIANT MITIGATION MEASURE | |
|---|---|---|
| | **Dry Floodproof Equipment Rooms Associated with Commercial Areas of Mixed-Use Buildings** | **Dry Floodproof Equipment Rooms Associated with Residential Areas of Buildings** |
| New Construction/SI/SD | ✓ | |
| Legal Non-Conforming Construction (Not SI/SD) | ✓ | Possible[1] |
| Existing Construction (Not SI/SD) | ✓ | ✓ |

[1] Allowable if it is above the required elevation at time of construction (i.e., BFE or locally adopted elevation that exceeds the BFE)

**Flood conditions, when it is appropriate:** Dry floodproofing building utility system rooms is appropriate for the same conditions as dry floodproofing the building perimeter. There should be low-velocity floodwaters (less than 5 feet per second) and short-duration floods (less than 3 days). There should also be at least 12 hours of warning time to allow for the installation of flood protection measures. More warning time may be necessary for complex flood protection measures. Timing the actual installation of the dry floodproofing system during annual exercises is highly recommended. This knowledge will help to determine the time needed, with extra time added as a buffer and additional time added to evacuate, for planning how long in advance the system must be installed prior to a flood event.

**Considerations for successful dry floodproofing building utility system rooms:** In some instances, it may not be cost effective or feasible to dry floodproof an entire building. Dry floodproofing only a portion of a building may be a viable option for *existing construction* multi-family buildings and a consideration for improving building resilience. The measure includes the installation of flood-resistant vaults below ground or modifying only some areas that can be made substantially impermeable to floodwater to protect vulnerable MEP systems or other critical components of the building. See Figure 5-5 for a representative vault. The cost and feasibility of this measure may depend on how deep the floodwater may be around the equipment room that needs to be dry floodproofed. In some instances, the dry floodproofing protection may only be a few feet deep while in other situations the equipment room could be two or three stories below ground. The equipment room, well below grade, will involve a more complex solution since the flood forces will be much greater and it will not be possible to access the equipment room during a flood event. See the FEMA Hurricane Sandy MAT RA2, *Reducing Flood Effects in Critical Facilities*, for an example of how flood pressures may impact below grade systems.

Since vault rooms far below grade elevation would become completely submerged during a flood, the walls, ceiling, and floor slab of the equipment room may need to be strengthened to resist being submerged in deep water. The equipment inside the room would also need to be evaluated to determine whether the vault is intended to only protect the equipment from flood damage or whether the equipment may need to be used prior to all of the surrounding water being pumped out from around the room. If the equipment needs to be used during a flood event, then flood resistant utility chases and ventilation systems may need to be incorporated into the design. Special fire suppression systems may also need to be installed to make running the equipment during a flood possible. Carefully studying whether the equipment in the room can be relocated is advisable before considering a vault well below the ground. There may be instances where a vault is the most cost-effective method of flood protection for equipment that cannot be relocated. FEMA P-936, *Floodproofing Non-Residential Buildings* (FEMA 2013a) provides a detailed discussion of all considerations for a below-ground vault system. As with any dry floodproofing measure, the success is contingent upon making sure all the details, such as flood loads, waterproofing, and sealing of any openings and penetrations through the vault, are addressed in the design process and that an active maintenance program is in place to make sure that the area can stay properly sealed during a flood event.


Figure 5-5. Dry floodproofed fuel tank enclosure in basement of a high-rise building

Table 5-5. Dry floodproofing MEP/components advantages and disadvantages

| FLOOD MITIGATION STRATEGY – DRY FLOODPROOFING | |
|---|---|
| **ADVANTAGES** | **DISADVANTAGES** |
| • Reduces recovery time and occupant displacement<br>• Enables protected utilities to remain on lower levels while providing some level of flood protection<br>• Usually much less costly than dry floodproofing an entire building | • Not applicable for flash flood or any flooding situation that occurs with limited or no warning<br>• Limited by structural capacity of *existing construction* building<br>• Can be expensive to implement<br>• Vaults are complex systems, often protected in all directions and having submarine doors; vaults are difficult to achieve successfully<br>• Typically requires human intervention to be successful<br>• Typically cannot be tested in advance, i.e., cannot be tested until an actual event occurs<br>• Does not result in lower NFIP flood insurance premiums |
| **Recommended Resources:** ASCE 24-14, *Flood Resistant Design and Construction*; FEMA P-936, *Floodproofing Non-Residential Buildings (FEMA 2013a); FEMA Hurricane Sandy Recovery Advisory No. 2, Reducing Flood Effects in Critical Facilities (FEMA 2013h)* | |

# 5.6 REPURPOSED LOWEST FLOOR

**Repurposed Lowest Floor**: Repurposing or changing the use of ground level areas could be implemented in conjunction with wet floodproofing or dry floodproofing. Repurposing involves converting the ground floor to parking, storage, or building access and applying wet floodproofing measures (see Section 5.2).

| BUILDING DESIGNATION | COMPLIANT MITIGATION MEASURE | | |
|---|---|---|---|
| | **Converting the lowest floor into parking, building access, or storage and wet floodproofing** | **Converting the lowest floor to commercial space and dry floodproofing** | **Filling basement areas** |
| New Construction/SI/SD | ✓ (SI/SD) | ✓ (SI/SD) | ✓ (SI/SD) |
| Legal Non-Conforming Construction (Not SI/SD) | ✓ | ✓ | ✓ |
| Existing Construction (Not SI/SD) | ✓ | ✓ | ✓ |

**Flood conditions, when it is appropriate:** The appropriate conditions for a repurposed lowest floor will depend on which floodproofing measure is used to protect the space. These would be the same conditions as dry floodproofing the building perimeter or those for wet floodproofed areas. There should be low-velocity floodwaters (less than 5 feet per second) and short-duration floods (less than 3 days).

**Considerations for successful repurposing of the lowest floor:** When buildings have ground-level dwelling units, one mitigation option is to convert the ground floor into commercial space, which then converts a multi-family building to mixed-use. The commercial spaces then could be dry floodproofed (see Section 5.3), which becomes an allowable mitigation measure for commercial mixed-use areas. Owners should be aware that this means that if the dry floodproofing is overtopped or breached, there will still be damage to the building and likely loss of use of the space while repairs are being made, even though this measure is allowable.

A method to make large reductions in the flood risk to a building is to eliminate areas from being flood-damaged. Repurposing the lowest floor could include filling below-ground areas with soil, so they no longer pose a risk for flood damage. If equipment or uses in basement areas can be relocated to higher floors and leave the space vacant, then it may be possible to fill basement spaces. Many utility services enter urban buildings through the basement, so work must be done to retrofit these services so that maintenance can still be done on the utility lines as needed while reducing the exposure of the building to flood damage as much as possible. Basement areas should be filled in such a manner as to prevent floodwater from saturating the filled area for a long-term duration. If soil is placed in a basement area without accounting for drainage, the floodwater will seep into the soil and the basement walls will prevent it from draining. Although this can be a complex task, the elimination of a basement area will change how the lowest floor is designated on the building, and this can have some positive impacts on flood insurance premiums. In some instances, this may allow a building that has a pre-FIRM rate to seek a new elevation rated post-FIRM. If the designated lowest floor is at or above the BFE, then post-FIRM rates are lower than pre-FIRM flood insurance rates.

Table 5-6. Repurposed lowest floor advantages and disadvantages

| FLOOD MITIGATION STRATEGY – REPURPOSED LOWEST FLOOR | |
|---|---|
| **ADVANTAGES** | **DISADVANTAGES** |
| • Could be implemented to comply with floodplain management requirements for *new construction* or SI/SD building<br>• May result in eligibility for credit as dry floodproofed buildings for NFIP flood insurance policies<br>• Could be implemented to reduce risk from flood damage or improve building resilience to flooding | • Could require major structural renovations to replace lost residential space on repurposed lower floors to upper floors<br>• Could require major structural renovations to add another story on upper floors to replace lost residential space on repurposed lower floor<br>• Potential zoning issues with both use and height restrictions<br>• Potential loss of usable space, especially dwelling units |
| **Recommended FEMA Resource:** FEMA P-936, *Floodproofing Non-Residential Buildings (FEMA 2013a)* | |

## 5.7 PERIMETER FLOODWALL

**Perimeter Floodwalls**: A mitigation measure that uses a continuous floodwall that is structurally independent, protecting an individual building or a group of buildings. Figure 5-6 is a representative campus with several multi-family buildings protected by a perimeter floodwall. This approach could incorporate not only floodwall systems but also earthen berms or levees.

> *WARNING*
>
> Floodwalls cannot be used to bring buildings into compliance with NFIP requirements for SI/SD.

| BUILDING DESIGNATION | COMPLIANT MITIGATION MEASURE |
|---|---|
| New Construction/SI/SD | Possible[1] |
| Legal Non-Conforming Construction (Not SI/SD) | Possible[1] |
| Existing Construction (Not SI/SD) | Possible[1] |

*[1] Requires a Floodplain Development Permit (which typically requires a Hydrology and Hydraulics (H&H) Study), while potentially allowable to provide additional flood protection, the floodwall cannot be used to bring a building into compliance.*

**Flood conditions, when it is appropriate:** Perimeter flood walls can resist a variety of flood conditions. Walls and the wall foundation would need to be designed to resist high-velocity floodwater, and in situations where there is wave action, the wall may need to be higher to address overtopping by waves and more robust foundations to resist the wave loads.

**Considerations for successful perimeter floodwalls:** Applicability in urban environments may be limited because of available surrounding land, right-of-way, and other constraints. Although floodwalls can be used to keep floodwater away from buildings, implementing this mitigation measure will not be credited by the NFIP for rating flood insurance policies.

Floodwall systems usually require shields across openings required for both pedestrian and vehicle access. This means that there are often numerous gates, and vehicle gates are often much more complex measures in terms of maintenance since gates are often left exposed to the weather and are subject to damage from daily use. Vehicle gates are often large permanently attached measures, so they can be swung into position or in some cases lifted into position automatically as soon as floodwaters reach the opening in the wall. Without periodic maintenance to make sure that there is no damage to the gate and no obstructions that may prevent proper operation and to verify gaskets will prevent leaks, these large gates can leak and potentially allow large volumes of water inside the walled area.

Floodwall systems must have the means to handle accumulated rainfall within the protected area and leakage, typically requiring high-volume pumps to handle accumulated water and standby power generation to run pumps. When floods are caused by heavy rainfall such as hurricanes, consideration must be given to the size of the walled area, including the rain that will accumulate on the roofs of buildings within the walled area. Large sump pumps capable of removing this volume of water may need to be large. Large pumps will require larger standby power needs, and the standby power must be sufficient to provide the pumps with power for the duration of the flood event. Since the area will be isolated during a flood event, it will be unlikely that it will be possible to refuel the standby power system during the flood. Pumps may also need to run regularly since perimeter walls often impede the drainage of common rainstorms and require the pumps to run every time it rains. Although an alternative might be to erect a temporary wall system around the area, the erection of a large-scale floodwall would likely take significant warning time to construct and would likely require manpower that would need to be verified as available in the days before a flood.


Figure 5-6. Example of perimeter floodwall around multi-family buildings (Note temporary shields are required for the openings)

Table 5-7. Perimeter flood wall advantages and disadvantages

| FLOOD MITIGATION STRATEGY – PERIMETER FLOODWALL | |
|---|---|
| **ADVANTAGES** | **DISADVANTAGES** |
| • Requires minimal building modification<br>• Enables building systems to remain below grade<br>• Enables potential future modifications to provide for additional protection if risk increases | • Requires considerable land area<br>• Could impact/limit building access<br>• Operations and maintenance<br>• Probable human intervention required to seal off entries<br>• Costly measure to implement<br>• Typically cannot be tested in advance, i.e., cannot be tested until an actual event occurs<br>• Does not result in lower NFIP flood insurance premiums |
| **Recommended FEMA Resource:** FEMA P-936, F*loodproofing Non-Residential Buildings (FEMA 2013a)* | |

# 5.8 MITIGATION MEASURES ABOVE THE REQUIRED ELEVATION

While the previous measures discussed in this chapter apply to areas below the required FPL, this section will discuss opportunities for flood protection measures above the FPL. These measures are intended to provide owners and tenants with protection above the locally enforced floodplain management requirements. For *new construction*/SI/SD buildings, this would be considering measures above the currently enforced minimum elevation requirements. All buildings can implement these measures above the compliant-required elevation either at the time of construction or based on the latest effective FIRM, adopted building code or local floodplain management ordinance requirements. *Existing construction* buildings may not have an applicable minimum elevation requirement but could incorporate these techniques above their selected FPL.

*WARNING*

If a non-compliant building is substantially improved or substantially damaged, then it must be brought into compliance with the NFIP and current local floodplain management requirements as applicable. This may require removal of any mitigation measures that are not compliant with the current requirements.

While these approaches will provide additional protection for the building and its contents, designers should consider that they will need to evaluate flood conditions to the top of the flood protection. These deeper flood depths may change flood conditions; the building should be evaluated for the higher flood conditions and a determination made whether retrofits providing additional strength to the building are necessary to ensure the mitigation measure will successfully resist the flood forces.

## 5.8.1 WET FLOODPROOFING ABOVE THE REQUIRED ELEVATION

Wet floodproofing techniques outlined in Section 5.2 can be incorporated into the design of buildings above the minimum elevation requirements. This measure will not result in reduced flood insurance premiums but may reduce damage or down time from flood events that exceed the required elevation and will help to mitigate against future changing conditions.

| BUILDING DESIGNATION | COMPLIANT MITIGATION MEASURE |
|---|---|
| New Construction/SI/SD | ✓ |
| Legal Non-Conforming Construction (Not SI/SD) | ✓ |
| Existing Construction (Not SI/SD) | ✓ |

**Flood conditions, when it is appropriate:** Wet floodproofing either below or above the required elevation is most appropriate when there are low-velocity floodwaters (less than 5 feet per second) and short-duration floods (less than 3 days). There should also be sufficient warning time to move contents from the wet floodproofed areas.

**Considerations for successful wet floodproofing above the required elevation:** The considerations discussed in Section 5.2 should also be applied for wet floodproofing above the required elevation. When wet floodproofing above the required elevation owners may often consider incorporating the wet floodproofing to residential use areas of the building that would normally not be allowed to be wet floodproofed. These areas may include lobby areas with uses or features in addition to just building access. These areas might include sitting areas, security desks, or mailrooms. Tenant management offices, exercise rooms, and other residential uses might also be considered for wet floodproofing. Owners should carefully consider the risks associated with the displacement of tenants before considering wet floodproofing of dwelling units. The wet floodproofing should be relegated to areas that are not essential for the occupancy of tenants.

> *WARNING*
>
> While wet floodproofing of dwelling units above the required elevation is not prohibited, it is strongly discouraged due to many of the reasons already described in applicable sections above.

## 5.8.2 DRY FLOODPROOFING ABOVE THE REQUIRED ELEVATION

Dry floodproofing residential areas above the required elevation is allowable for *new construction* and *legal non-conforming construction* if the dry floodproofing is done completely above the required elevation. If the dry floodproofing extends below the required elevation, it would violate the NFIP and local floodplain management requirements and would not be allowable. This measure will not result in reduced flood insurance premiums but may reduce damage from flood events that exceed the required elevation and will help to mitigate against future conditions.

| BUILDING DESIGNATION | COMPLIANT MITIGATION MEASURE |
|---|---|
| New Construction/SI/SD | ✓ |
| Legal Non-Conforming Construction (Not SI/SD) | ✓ |
| Existing Construction (Not SI/SD) | ✓ |

> ⚠ *WARNING*
>
> Dry floodproofed areas above wet floodproofed enclosures will require an evaluation by a structural engineer to determine if the slab is strong enough to resist buoyancy (uplift) forces.

**Flood conditions, when it is appropriate:** Dry floodproofing is most appropriate when there are low-velocity floodwaters (less than 5 feet per second) and short-duration floods (less than 3 days). There should also be at least 12 hours of warning time to allow for the installation of flood protection measures. More warning time may be necessary for complex flood protection measures. Guidance for dry floodproofing, previously provided within this document, recommends timing the actual installation of the dry floodproofing system during annual exercises. This knowledge will help to determine the time needed and additional time added to evacuate, for planning how long in advance the system must be installed prior to a flood event.

**Considerations for successful dry floodproofing above the required elevation:** Dry floodproofing techniques outlined in Section 5.3 will have limited application for residential areas above the required elevation. Buildings would either need to have dry floodproofing for areas below the required elevation (non-residential portions of the building) or the dry floodproofed area would need to be on fill or on a stemwall (perimeter wall and fill) foundation. Wet floodproofed enclosures below a dry floodproofed area would require the slab of the dry floodproofed area to be designed for buoyancy. These buoyancy loads would overstress most concrete slabs and would require a structural engineer to specifically design the slab for this situation. Even slabs on stemwall foundations may need minor strengthening and should be evaluated by a structural engineer with the help of a geotechnical engineer who could help evaluate the slab's susceptibility to buoyancy loads. It is important to review Section 5.3 to understand all the necessary considerations and supplemental resources necessary to successfully dry floodproof a building or portion of a building.

## 5.9 COMMON SECONDARY MITIGATION MEASURES FOR MULTI-FAMILY BUILDINGS

In addition to the primary mitigation measures discussed in this chapter, there are secondary measures that could be incorporated into any of the primary measures. Secondary measures help improve resiliency of buildings and, while individually they do not provide sufficient mitigation to be considered a primary measure, help improve the performance of the primary measures. Note that some secondary measures may also be used for *new construction*. The following are common secondary mitigation measures associated with developing flood mitigation strategies for multi-family buildings:

- Isolating utilities should be considered when dry floodproofing measures are used to separate protected areas from the remainder of the building if the area is inundated with floodwaters. It is important to properly shut down services as quickly as possible to avoid further damage and to protect against fire or other hazards. Automatic shutoff valves can be used for natural gas and water sensors can be used to turn off electricity. Circuits powering emergency sump pumps should not be shut off.

- Installing backflow prevention valves to help prevent water flowing from the exterior to the interior of a building through the sanitary sewer or water drainage systems.
- Installing ejector pumps can allow buildings with staff that are not required to evacuate to maintain operations, while sanitary sewer systems are pressurized by floodwater that would prevent normal gravity flow building drains to operate properly.
- Installing sump pumps with dedicated emergency power supply to handle seepage and dewater internal drainage systems and below-grade areas. In dry floodproofing applications, sump pumps are used to prevent accumulated water from causing damage to the building and handle the inevitable small leaks that occur around shields, sealed openings, or through adhered barrier-type waterproofing systems.
- Using flood damage-resistant materials below the FPL regardless of the floodproofing application.
- Identifying, evaluating, and addressing openings below the FPL, including louvers, window wells, utility connections, and all other openings such as pipe penetrations through walls.
- Implementing mitigation measures for conveyances—elevators and lifts—in accordance with NFIP Technical Bulletin 4, *Elevator Installation for Buildings Located in Special Flood Hazard Areas in accordance with the National Flood Insurance Program* (FEMA 2010c).
- Installing backup power systems to provide power during power loss. Generators should be sized in accordance with the appropriate energy load (operational load plus peak load) required for emergencies and may include power for elevator, emergency lighting, security systems, and plug-in load.
- Combining inspections of flood mitigation measures with routine inspections that are performed to assess and mitigate potential fire and life safety hazards in buildings. All flood shields and gaskets on shields and doors and all installed dry floodproofing measures, such as a barrier-type membrane system and/or a cavity drainage system, should be inspected and maintenance and repairs should be performed on a regular basis.
- Conducting at least annual training and exercising of the proper installation of flood shields and other measures that require human intervention.

# 5.10 DEVELOPING A MITIGATION STRATEGY

This publication has provided readers an overview of the primary steps necessary to develop an overall mitigation strategy (see Figure 5-7). The mitigation strategy is intended to be a comprehensive plan that uses a series of steps to properly plan a mitigation project and give it a higher likelihood of being successfully implemented. The reader should initially determine which building designation applies to their building(s). New buildings and existing buildings should be treated differently from each other. It is important for any flood protection measure being considered to not result in the building becoming in violation of NFIP and local floodplain management requirements.

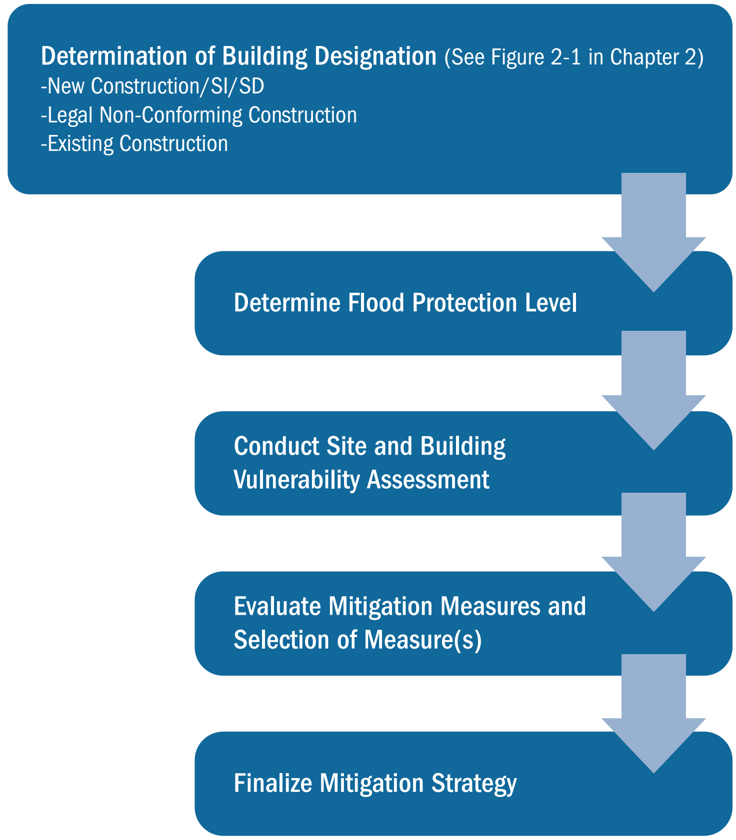



Figure 5-7. Mitigation strategy development process

An evaluation of the flood risk should be made as discussed in Chapter 3, including a determination of what FPL is appropriate for the building. In some instances, the FPL will be regulatory and in other instances, the owner may elect to protect the building above the minimum elevation requirements. Once the elevation is selected, a vulnerability assessment of the site and building can be conducted to identify where the building may need to be strengthened and where floodwater could potentially enter the building. Flood mitigation measures, or combination of measures can then be evaluated and selected. The steps outlined above can help one develop a comprehensive mitigation strategy to reduce their building's vulnerability and improve its resilience to flood damage.

*WARNING*

Floodproofing measures that involve human intervention take time to activate or deploy well in advance of floodwater affecting a site. Adequate warning time estimates should include the time necessary for evacuation, notification of key personnel, travel time to the site if key personnel are not located on-site, implementation of the measure(s), and evacuation of key personnel.

Retrofitting a multi-family building is a complex and, in most cases, expensive undertaking that requires thorough analysis and attention to detail in the design to help protect the buildings against flood damage. A single floodproofing measure may provide only limited protection. Sometimes combining methods is the best way to provide maximum protection given site-specific constraints, feasibility, and cost factors. Consequently, limiting dry floodproofing measures to the most critical elements or operations of a facility that cannot be elevated may be more technically feasible and cost effective than attempting to dry floodproof an entire building. In general, wet floodproofing flood-prone areas of *existing construction* buildings while dry floodproofing smaller compartments is simpler to design and construct and will probably be more effective than the reverse, which is dry floodproofing most of the building with some wet floodproofed areas. For combined strategies to succeed, the walls separating these areas must be capable of withstanding any unbalanced hydrostatic flood loads that might exist during the designed flood scenario. See Figure 5-8 for an example of a basement that combined mitigation measures described in this publication. Building managers and owners can focus on elevating other critical areas and wet floodproofing lower-level areas that are less critical. On the other hand, elevating critical elements and dry floodproofing areas below the FPL may be the most appropriate or cost-effective approach. Ultimately, repurposing lower levels for non-residential use and wet floodproofing below the FPL may be a more effective and preferred approach for many *existing construction* multi-family buildings.

Figure 5-8. Example of basement that integrated wet and dry floodproofing techniques. The area in front had about 6 inches of floodwater, and the dry floodproofed fuel pump room (visible through doorway) continued to operate.

Tables 5-8 and 5-9 provide a summary of the mitigation measures introduced in this chapter; Table 5-9 indicates whether the measure satisfies minimum floodplain management requirements for bringing a multi-family building into compliance (SI/SD compliance). Table 5-8 provides an overview of each mitigation measure and whether it is allowable for *new construction* or *existing construction*. Table 5-9 describes, in general and relative terms, whether each mitigation measure as a stand-alone primary measure is eligible for an NFIP flood insurance credit, whether the measure requires active human intervention to provide protection, how much protection can be expected from the measure, the cost of the measure relative to other measures, and the operation and maintenance costs necessary to maintain mitigation effectiveness. These tables are intended to help readers make a final determination of which measure, or measures, are most appropriate.

Table 5-8. Summary of the mitigation measures and regulatory allowances based on building designation

| MITIGATION MEASURE | NEW CONSTRUCTION/SI/SD | | | | LEGAL NON-CONFORMING CONSTRUCTION | | | | EXISTING CONSTRUCTION | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Mixed-Use Building | | | | Mixed-Use Building | | | | Mixed-Use Building | |
| | RB | NRB | RA | NRA | RB | NRB | RA | NRA | RB | NRB | RA | NRA |
| **5.1** Elevation Retrofit | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **5.2** Wet Floodproofing (parking, access, and above-grade storage areas) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Wet Floodproofing (below-grade areas) | | | | | | | | | ✓ | ✓ | ✓ | ✓ |
| **5.8** Above required elevation (regardless of parking, storage, and access) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **5.3** Dry Floodproofing | | ✓ | | ✓ | | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ |
| • Below-grade areas (basements) | | ✓ | | ✓ | | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ |
| • Below-grade parking | | ✓ | M | ✓ | | ✓ | M | ✓ | ✓ | ✓ | ✓ | ✓ |
| • Above required elevation | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **5.4** Elevating/ Relocating Equipment | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **5.5** Dry Floodproofing MEP/ Components (Vaults) | | ✓ | | ✓ | ✓[1] | ✓ | ✓[1] | ✓ | ✓ | ✓ | ✓ | ✓ |
| **5.6** Repurposed Lowest Floor (dry floodproofing to be used for non-residential use) | ✓ (SI/SD) | ✓ (SI/SD) | ✓ (SI/SD) | ✓ (SI/SD) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Repurposed Lowest Floor (wet floodproofed to be used for parking, access, and storage) | ✓ (SI/SD) | ✓ (SI/SD) | ✓ (SI/SD) | ✓ (SI/SD) | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **5.7** Perimeter Floodwall | ✓[2] | ✓[2] | ✓[2] | ✓[2] | ✓[2] | ✓[2] | ✓[2] | ✓[2] | ✓[2] | ✓[2] | ✓[2] | ✓[2] |

RB = Residential Building
NRB = Non-Residential Building
RA = Residential-use Areas of Mixed-Use Structures
NRA = Non-residential-use Areas of Mixed-Use Structures
M = Only allowed in Mixed-Use Building with combined residential and non-residential use parking
1 = As long as MEP is conforming/above required elevation at time of construction
2 = Will require a Floodplain Development Permit, cannot be used to bring a building into compliance

Table 5-9. Summary of multi-family and mixed-use building mitigation measure considerations

| MITIGATION MEASURE | NEW CONSTRUCTION AND SI/SD[1] COMPLIANCE | | OTHER FACTORS FOR CONSIDERATION | | | | |
|---|---|---|---|---|---|---|---|
| | ZONE A | ZONE V | NFIP INSURANCE RATING CREDIT | ACTIVE OR PASSIVE[2] | DEGREE OF PROTECTION[3] | RELATIVE COST[4] | O&M[4] |
| Elevation | ✓ | ✓ | Yes | Passive | High | $$$ | $ |
| Wet Floodproofing | ✓ Yes, applied only to parking, storage, or access | | None, but if used in conjunction with a repurposed lowest floor it can reduce premiums | Passive | Moderate | $$ | $$ |
| Dry Floodproofing (residential areas) | X | X | None | Active or Passive | Moderate[5] | $$ | $$$ |
| Dry Floodproofing (non-residential areas of mixed use buildings) | ✓ | X | Possible[6] | Active or Passive | Moderate[5] | $$ | $$$ |
| Elevating/ Relocating Equipment | ✓ Elevating and relocating equipment alone rarely bring a building into compliance but can drastically improve building resilience. Other measures are usually required to meet compliance. | | None | Passive | Moderate or High, depending upon how high one elevates | $$ | $ |

| MITIGATION MEASURE | NEW CONSTRUCTION AND SI/SD[1] COMPLIANCE | | OTHER FACTORS FOR CONSIDERATION | | | | |
|---|---|---|---|---|---|---|---|
| | ZONE A | ZONE V | NFIP INSURANCE RATING CREDIT | ACTIVE OR PASSIVE[2] | DEGREE OF PROTECTION[3] | RELATIVE COST[4] | O&M[4] |
| Dry Floodproofing MEP/ Components (Vaults) | ✓[7] | X | None | Active or Passive | Low | $$ | $$ |
| Repurposed Lowest Floor (combined with wet or dry floodproofing) | ✓ | ✓[8] | Possible[6] | Passive | Moderate[5] | $$ | $ |
| Perimeter Floodwall | X | X | None | Active or Passive | Moderate | $$$ | $$$ |

1 ✓– Meets NFIP requirements for *new construction* and SI/SD
X – Does not meet NFIP requirements for *new construction* and SI/SD
2 **Active or Passive**
Active – Requires human intervention and flood warning time to be effective
Passive – Does not require human intervention or flood warning time to be effective
3 **Degree of Protection**
**Low** – Typically effective for lower flood depths (less than 3 feet) and lower flood velocities (less than 5 feet per second)
**Moderate** – Typically effective for moderate flood depths (4 to 6 feet) and moderate flood velocities (5 to 10 feet per second)
**High** – Typically effective for higher flood depths (8 feet or more) and higher velocities (10 feet per second or more) or wave action
4 **Relative Cost and O&M (Operations and Maintenance)**
$ – Generally low cost relative to other measures
$$ – Generally moderate cost relative to other measures
$$$ – Generally high cost relative to other measures
5 Dry floodproofing is generally only recommended in areas where flood velocities are less than 5 feet per second
6 In order to receive insurance credits a mixed-use building must meet the requirements for an occupancy designation of a Non-Residential Business as outlined in Chapter 4 as well as meeting all other insurance requirements for dry floodproofed buildings
7 Only components associated with non-residential areas in mixed-use building
8 Only when the area is wet floodproofed and used for parking, building access, or storage. Enclosure walls must be breakaway

# REPRESENTATIVE SCENARIOS 6

The intent of this chapter is to provide the reader an idea of how mitigation measures described in Chapter 5 can be applied to multi-family buildings and highlight some of the implications of different mitigation approaches. Each scenario describes a building and the flood characteristics at the site. While scenarios 1 through 5 represent *existing construction* and Scenario 6 represents *legal non-conforming construction*, after each scenario there is table that provides information on how the described mitigation measures would apply to:

- ***Existing Construction***: Buildings constructed prior to the community joining the NFIP, where those buildings are not required to comply because they are not substantially improved or have not incurred substantial damage. Buildings that have been included inside an expanded SFHA shown in an updated FIRM are also considered *Existing Construction*.
- ***Legal Non-Conforming Construction***: Buildings that were constructed after the community joined the NFIP and built in compliance with local floodplain management regulations, but no longer conform to the current local floodplain management requirements. Compliance with the FPM requirements at the date of construction or date of previous SI must be maintained. It must come into compliance with current NFIP regulations or codes when a triggering event occurs, such as substantial improvement or substantial damage.
- ***New Construction/SI/SD***: Buildings constructed after the community joined the NFIP and that comply with current local floodplain management requirements. It also includes buildings that have been substantially improved or repaired after being substantially damaged and comply with the current local floodplain management requirements.

Tables for each scenario indicate whether the proposed mitigation measures:

A) Are allowed by floodplain management requirements

B) Will bring the building into compliance with current floodplain management requirements or maintain compliance with the floodplain management requirements under which it was constructed

C) Are costly to implement using a relative scale comparing rough order of magnitude cost of each mitigation measure in relation to other measures

D) Provide NFIP flood insurance credits for each mitigation measure and whether the measures will potentially reduce annual flood insurance premiums

The following scenarios are presented:

| SCENARIO | MITIGATION MEASURE |
|---|---|
| Scenario 1 | Equipment Relocation |
| Scenario 2 | Repurposed Ground Level and Dry Floodproofing |
| Scenario 3 | Dry Floodproofed Equipment Room and Wet Floodproofing |
| Scenario 4 | Basement Dry Floodproofing (Building Outside the SFHA) |
| Scenario 5 | Dry floodproofed Below Grade Parking |
| Scenario 6 | Dry Floodproofing above a compliant lowest floor elevation |

Note the mitigation measures presented in these scenarios are intended to reduce building damage, reduce damage to contents inside the buildings, reduce loss of use or downtime following a flood event, and, when possible, reduce flood insurance premiums. The applicability is limited to a situation where the building owner is seeking to reduce flood risk and his or her building is not required to comply with floodplain management requirements because it is *existing construction* or *legal non-conforming construction* that is not substantially improved or has not incurred substantial damage. The mitigation measures are not intended to allow tenants and occupants to shelter-in-place during a flood event. Buildings should not be occupied during flood events.

## Scenario 1: Equipment Relocation

**Building Location:** The site is in a dense urban area designated as Zone AE (BFE is 14 ft above datum) with a coastal flood source and has a lowest adjacent grade of 12 feet.

**Building Description:** A seven-story apartment building with parking and primary mechanical room on the ground floor. There is a ground floor lobby area that includes a security desk, which also provides tenant services.

**Building Site Flood Characteristics:**

| FLOOD CHARACTERISTIC | DESCRIPTION OF FLOODING |
|---|---|
| Source(s) of Floodwater | Coastal |
| Floodwater Velocity | Low velocity (<5 fps) floodwater – shielded by other buildings |
| Base Flood Elevation | 14 ft, BFE is 2 ft above-ground |
| Expected Duration of Flooding | Less than 24 hours |
| Wave Conditions During Design Event | Less than 1.5-foot wave heights |
| Erosion/Scour Risk from Flooding | None due to low-velocity floodwater |
| Flood-borne Debris Potential | Minor debris due to low-velocity floodwater |
| Floodwater Rate of Rise | <5 ft per hour |

**Proposed Mitigation Option:** The owner intends to relocate as much of the MEP equipment as possible to a higher floor and eliminate the need for a building-wide furnace located on the lowest floor by converting the system to ductless heating and air conditioning units. The current mechanical room will be repurposed into a storage area and wet floodproofed. The lobby area will be wet floodproofed with raised power outlets and flood damage-resistant materials on the floor and lower walls. Human intervention is not necessary for implementation. Long-term maintenance is required to enable wet floodproofing measures to be effective. These include but are not limited to keeping flood openings un-obstructed and replacing flood damage resistant materials as needed.

**Flood Mitigation Objectives:** Relocation of the mechanical equipment from the ground floor will eliminate equipment damage and allow re-occupancy more quickly after flood events. Wet floodproofing the lobby and security area and the repurposed equipment room allows re-occupancy with minimal cleanup. Future damage will be minimal unless flooding rises significantly above BFE.

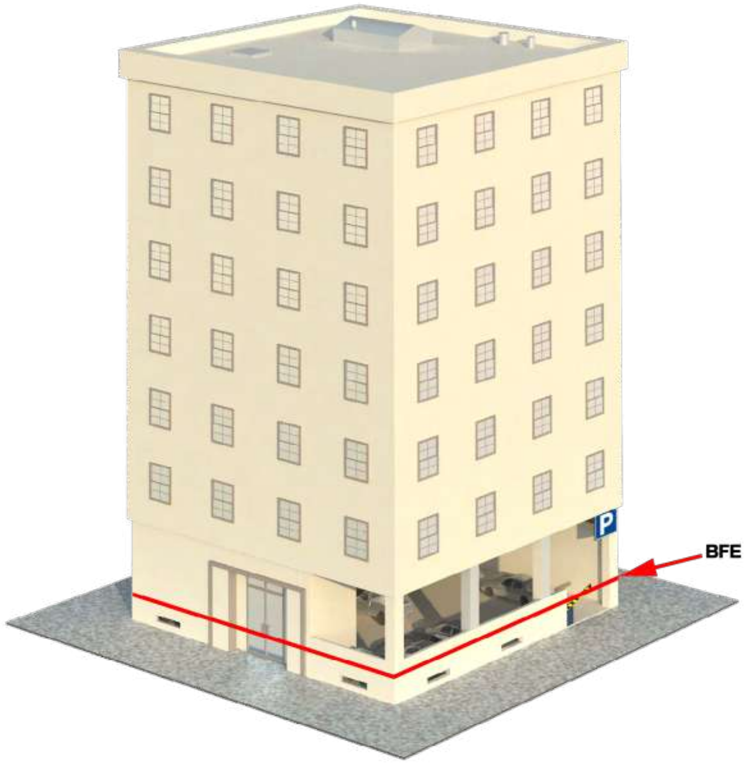



Figure 6-1. Illustration of Scenario 1 – Wet floodproofed storage room on the ground level

Table 6-1. Compliance and Insurance Summary for Scenario 1

| | FLOODPLAIN MANAGEMENT ALLOWANCE | PROVIDES CURRENT CONFORMANCE | COST TO IMPLEMENT | INSURANCE PREMIUM | INSURANCE CREDIT |
|---|---|---|---|---|---|
| *Existing Construction (Not SI/SD)* | ✓ | X | $$ | No Change | X |
| *Legal Non-Conforming Construction (Not SI/SD)* | ✓* | X | N/A | N/A | N/A |
| *New Construction/ SI/SD* | X | X | N/A | N/A | N/A |

N/A = Not Applicable

* The measure is allowable assuming that the top of the lowest floor was at or above the minimum required elevation when the building was constructed.

**Benefits:** Relocating mechanical equipment to higher floors will reduce the potential downtime of the building following a flood event and help avoid that equipment from being damaged during an event. Replacing an older furnace with independent ductless heating and air conditioning units will reduce the amount of room necessary for the new relocated mechanical room and may make the entire building more energy efficient. Additionally, wet floodproofing the lobby will reduce the downtime following a flood event.

**Residual Risk:** Contents inside the storage area could be damaged if not moved prior to a flood event. Contents inside the lobby area such as the security and tenant assistance desk and associated equipment used by the building security staff in the lobby also could be damaged.

**Considerations:** This mitigation approach has lobby area functions (security and tenant assistance) that are not strictly being used for building access, storage, or parking purposes. From an NFIP regulatory perspective, this building is not strictly in compliance with current floodplain management requirements. However, the building owner could evaluate using an alternative building security approach and relocate tenant assistance services to the second floor. This would result in the lobby only being used for building access, storage, or parking and would bring the building into compliance with the current requirements. This would then enable the owner to potentially be eligible for annual insurance credits and premium reductions that would not be available otherwise. In this case, the premium reduction generally means the lowest floor was changed to the second floor and it now is considered an elevated building, so insurance coverage on the first floor is greatly limited. If this building is mitigated as the owner is currently considering and it were to later be SI/SD, then the NFIP requirements restricting use below BFE would be triggered and functions other than parking, access, and storage (security and tenant assistance) would be prohibited.

## Scenario 2: Repurposed Ground Level and Dry Floodproofing

**Building Location:** The site is in a dense urban area designated as Zone AE (BFE is 14 ft above datum) with a coastal flood source and has a lowest adjacent grade of 12 ft.

**Building Description:** A four-story apartment building with apartments on the ground level.

**Building Site Flood Characteristics:**

| FLOOD CHARACTERISTIC | DESCRIPTION OF FLOODING |
|---|---|
| Source(s) of Floodwater | Coastal |
| Floodwater Velocity | Low velocity (<5 fps) floodwater – shielded by other buildings |
| Base Flood Elevation | 14 ft, BFE is 2 ft above-ground |
| Expected Duration of Flooding | Less than 24 hours |
| Wave Conditions During Design Event | Less than 1.5-foot wave heights |
| Erosion/Scour Risk from Flooding | None due to low-velocity floodwater |
| Flood-borne Debris Potential | Minor debris due to low-velocity floodwater |
| Floodwater Rate of Rise | <5 ft per hour |

**Proposed Mitigation Option:** The owner intends to convert the building to mixed-use by changing the ground floor from residential use (apartments) to commercial use (retail space) and dry floodproofing the ground level commercial spaces. If the main lobby is within the dry floodproofed area, compliance with floodplain management requirements will require a separate access to the apartments on upper floors. The second access point could be an independent elevator entrance or stairwell provided that it is either wet floodproofed or provides an exit route above the BFE or required elevation. Since approximately 25 percent or greater of the building square footage area will be for non-residential use, the building can also be considered for a non-residential business occupancy[1] and eligible for dry floodproofing credit.

**Flood Mitigation Objectives:** The building owner has elected to dry floodproof to an FPL of BFE plus 1 foot (or an elevation of 15 feet in this scenario) to qualify for NFIP floodproofing policy credit. From an NFIP insurance perspective, failure to provide this freeboard would result in higher annual flood insurance premiums because the building must be floodproofed to +1 foot to receive a rate equivalent to a building with its lowest floor elevated to the BFE.

[1] See NFIP Flood Insurance Manual (FEMA 2018c) for rules applying to a non-residential business occupancy

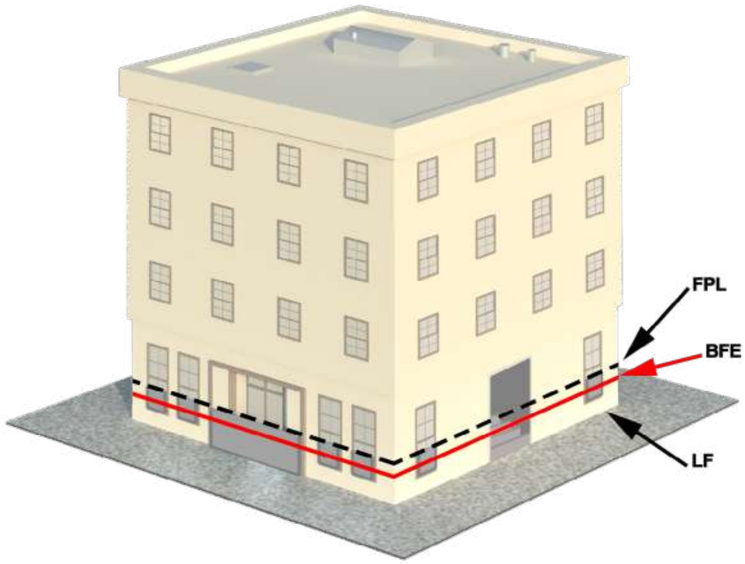



Figure 6-2. Illustration of Scenario 2 –Dry floodproofed ground level

Table 6-2. Compliance and Insurance Summary for Scenario 2

| | FLOODPLAIN MANAGEMENT ALLOWANCE | PROVIDES CURRENT CONFORMANCE | COST TO IMPLEMENT | INSURANCE PREMIUM | INSURANCE CREDIT[1] |
|---|---|---|---|---|---|
| *Existing Construction (Not SI/SD)* | ✓ | ✓[2] | $$$$ | Reduced | ✓ |
| *Legal Non-Conforming Construction (Not SI/SD)* | ✓* | ✓[2] | $$$$ | Reduced | ✓ |
| *New Construction/ SI/SD* | ✓[2] | ✓[2] | $$$$ | Possible[3] | ✓ |

* The measure is allowable assuming that the top of the lowest floor was at or above the minimum required elevation when the building was constructed.

[1] A dry floodproofing credit is available since the building meets the requirements for a non-residential business occupancy. Since the dry floodproofing measure includes 1 foot of freeboard above the BFE and the entire perimeter of the building is dry floodproofed, the building is eligible for a dry floodproofing credit. The non-residential business occupancy is based on at least 25 percent or greater of the total floor area being used for commercial uses.

[2]This measure is only compliant provided that the building has separate building access to the residential areas, which is either constructed at or above the required FPL or is wet floodproofed. See Section 1.7 for more information.

[3] *New construction* would not have been constructed below the BFE unless the lowest floor was initially constructed with a commercial use and the area dry floodproofed. SI/SD buildings may see a reduction in flood insurance premiums.

**Benefits:** Repurposing the lowest floor allows the building owner to maintain use of the lowest floor. This approach also allows the lobby serving both the residents and the commercial businesses to be dry floodproofed. Dry floodproofing of the entire footprint of the lowest floor to BFE + 1 foot allows the owner to be eligible for a dry floodproofing credit. If proper maintenance is done on the system, for floods that do not exceed the design flood height, the downtime following the flood should be minimal.

**Residual Risk:** Dry floodproofing can be overtopped by events more severe than designed. This proposed design scenario does not address future conditions when factors such as sea level rise or future development could increase flood heights.

**Considerations:** The design professional overseeing the design must be sure that the floodproofing system (walls, floor, opening protection, and required equipment) meets ASCE/SEI 24 requirements to complete the Floodproofing Certificate. Maintenance of the system is a key requirement, and the owner must strictly follow the operations plan prior to a flood event. To make the measure compliant with floodplain management regulations, a separate building access to the residential areas must be provided; it must be either located at or above required FPL or wet floodproofed. See Section 1.7 for more information. To meet floodplain management regulations, unless the building has an exterior stairwell, a pedestrian bridge from another building/location, a separate/stand-alone enclosure (wet floodproofing is required) leading to elevated access, or other unenclosed method for residential access, a mixed-used building will not receive dry floodproofing credit and will be subject to special rating considerations.

*CROSS REFERENCE*

See Hurricane Harvey Recovery Advisory 1 (TX-RA1) on *Dry Floodproofing: Planning and Design Considerations* (FEMA 2018) and Hurricane Irma Recovery Advisory 1 (FL-RA1) on *Dry Floodproofing: Operational Considerations* (FEMA 2018).

## Scenario 3: Dry Floodproofed Equipment Room and Wet Floodproofing

**Building Location:** The site is in a dense urban area designated as Zone AE (BFE is 14 ft above datum) with a coastal flood source and has a lowest adjacent grade of 13 ft.

**Building Description:** A four-story apartment building with an equipment room on the ground level and some storage and vehicle parking on the ground level. There is an elevator and staircase on the ground floor providing access to the apartments all located on upper floors.

**Building Site Flood Characteristics:**

| FLOOD CHARACTERISTIC | DESCRIPTION OF FLOODING |
|---|---|
| Source(s) of Floodwater | Coastal |
| Floodwater Velocity | Low velocity (<5 fps) floodwater – shielded by other buildings |
| Base Flood Elevation | 14 ft, BFE is 1 ft above-ground |
| Expected Duration of Flooding | Less than 24 hours |
| Wave Conditions During Design Event | Less than 1.5-foot wave heights |
| Erosion/Scour Risk from Flooding | None due to low-velocity floodwater |
| Flood-borne Debris Potential | Minor debris due to low-velocity floodwater |
| Floodwater Rate of Rise | <5 ft per hour |

**Proposed Mitigation Option:** Because of limited space on upper floors, the owner cannot relocate the mechanical equipment. The owner intends to dry floodproof the MEP equipment room on the ground floor. All areas used for parking, building access, and storage will be wet floodproofed by the owner.

**Flood Mitigation Objectives:** The owner will dry floodproof the MEP equipment room to BFE + 2 feet of freeboard to limit potential flood damage that could shut down the entire building during future flood events. Parking, building access, and storage areas have minimal exposure due to being wet floodproofed and using flood damage-resistant materials.

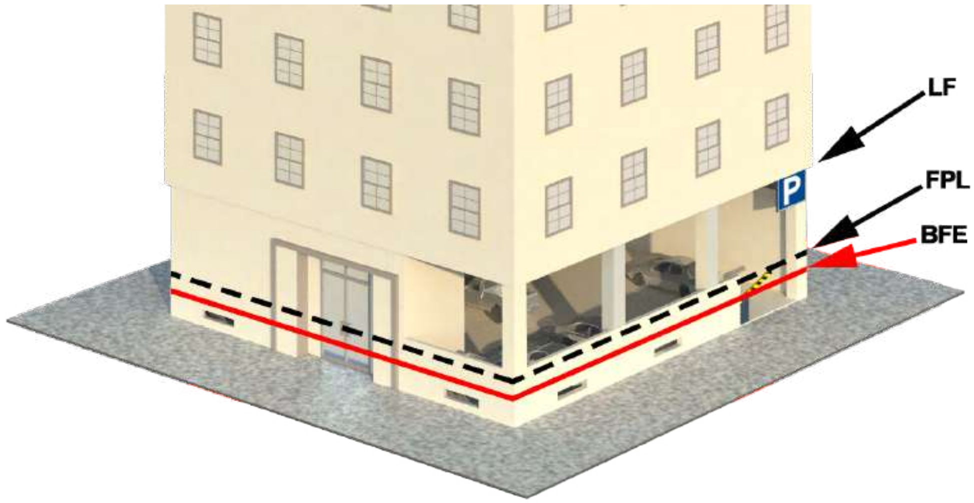



Figure 6-3. Illustration of Scenario 3 – Dry floodproofed ground level interior equipment room (not shown) and wet floodproofed parking, building access, and storage areas

Table 6-3. Compliance and Insurance Summary for Scenario 3

| | FLOODPLAIN MANAGEMENT ALLOWANCE | PROVIDES CURRENT CONFORMANCE | COST TO IMPLEMENT | INSURANCE PREMIUM | INSURANCE CREDIT[1] |
|---|---|---|---|---|---|
| *Existing Construction (Not SI/SD)* | ✓ | X | $$$ | No Change | X |
| *Legal Non-Conforming Construction (Not SI/SD)* | ✓* | X | $$$ | No Change | X |
| *New Construction/ SI/SD* | X | X | N/A | N/A | N/A |

N/A = Not Applicable

* The measure is allowable assuming that the top of the lowest floor was at or above the minimum required elevation when the building was constructed.

[1] A dry floodproofing credit is not available since the building does not meet the requirements for a non-residential business occupancy and the entire perimeter of the building is not dry floodproofed. The non-residential business occupancy is based on at least 25 percent or greater of the total floor area being used for commercial uses.

**Benefits:** Wet floodproofing of the parking area, building access, and storage areas will minimize damage to finishes, contents damage, and cleaning/disinfecting of areas following the flood event. Dry floodproofing of the equipment room will reduce the potential for the building systems to be damaged and help to prevent extended loss of building function following a flood event.

**Residual Risk:** This proposed design scenario does include additional freeboard, which would protect against some changes to future flood conditions. Although the owner had the system designed with 2 feet of freeboard above the BFE, there is a possibility that this level of protection could still be overtopped.

**Considerations:** From an NFIP regulatory perspective, this building is not strictly in compliance with current floodplain management requirements because building systems that support the residential units cannot be dry floodproofed. The design professional overseeing the design should be sure that the floodproofing system (walls, floor, penetrations) meets ASCE/SEI 24 requirements for a flood up to the stated level of protection. Maintenance of the system is a key requirement and the owner must strictly follow the operations plan prior to a flood event.

## Scenario 4: Basement Dry Floodproofing for a Building Located Outside the SFHA

**Building Location:** The site is in a dense urban area designated as Zone X with a coastal flood source and has a lowest adjacent grade of 14.2 feet above datum. A recently released preliminary FIRM indicates the site may change from Zone X to Zone AE with a BFE of 15.

**Building Description:** A four-story apartment building with an equipment room and storage, laundry, and tenant exercise rooms located in the basement one-story below ground. There are elevators and staircases that provide access to the basement with all tenant spaces on the ground level and upper floors.

**Building Site Flood Characteristics:**

| FLOOD CHARACTERISTIC | DESCRIPTION OF FLOODING |
|---|---|
| Source(s) of Floodwater | Coastal |
| Floodwater Velocity | Very low-velocity waters reaching the edge of the SFHA |
| Base Flood Elevation | Nearest BFE is 14 ft, however preliminary map indicates the building will be in a Zone AE with a BFE of 15 feet |
| Expected Duration of Flooding | Less than 24 hours |
| Wave Conditions During Design Event | No waves during a design event |
| Erosion/Scour Risk from Flooding | None due to low-velocity floodwater |
| Flood-borne Debris Potential | Minor debris due to low-velocity floodwater |
| Floodwater Rate of Rise | <5 ft per hour |

**Proposed Mitigation Option:** The owner intends to dry floodproof the entire basement area to prevent the potential for increased water intrusion into the basement during an event slightly above the base flood. This also includes modifications such as backflow preventers and sealing wall penetrations to prevent nearby floodwater from entering the building through pipes, conduits, or ductwork.

**Flood Mitigation Objectives:** The owner will dry floodproof the basement area to an FPL of 17 feet, approximately 3 feet above ground level (this will also provide protection to the preliminary map BFE + 2 foot, should that designation become effective).

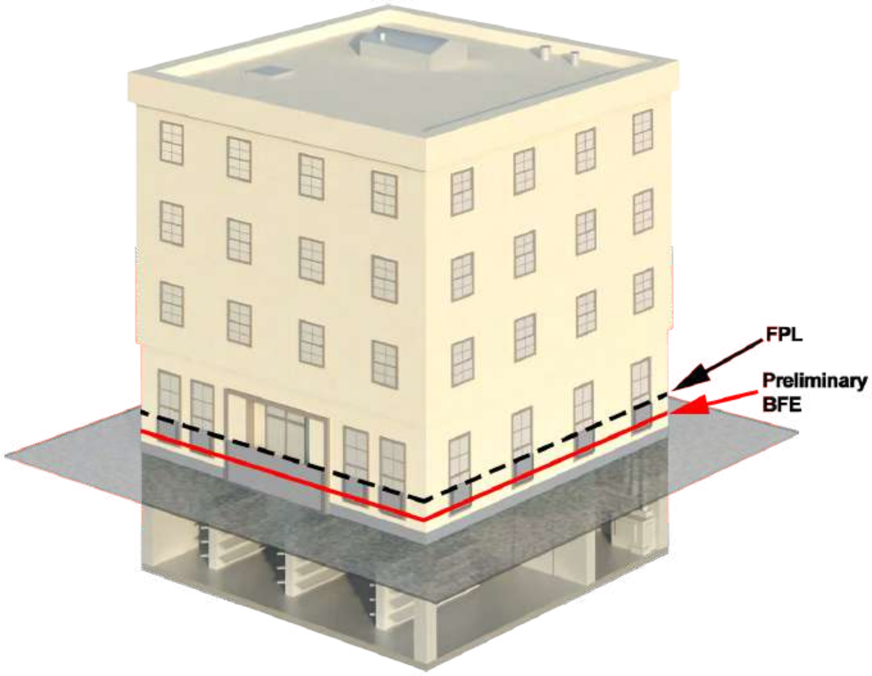



Figure 6-4. Illustration of Scenario 4 – Dry floodproofed basement areas for a building outside the SFHA

Table 6-4. Compliance and Insurance Summary for Scenario 4

| | FLOODPLAIN MANAGEMENT ALLOWANCE | PROVIDES CURRENT CONFORMANCE | COST TO IMPLEMENT | INSURANCE PREMIUM | INSURANCE CREDIT[3] |
|---|---|---|---|---|---|
| *Existing Construction (Not SI/SD)* | ✓ | N/A | $$ | No Change | X |
| Legal Non-Conforming Construction (Not SI/SD)[1] | N/A | N/A | N/A | N/A | N/A |
| *New Construction/ SI/SD*[2] | N/A | N/A | N/A | N/A | N/A |

N/A = Not Applicable

[1] Conformance requirements do not apply since the building is currently located outside of the SFHA.

[2] Requirements for *new construction*/SI/SD do not apply since the building is currently located outside the SFHA.

[3] A dry floodproofing credit is not available since the building is currently located outside of the SFHA and the policy is not rated on the elevation of the lowest floor.

**Benefits:** Dry floodproofing of the basement will reduce the risk that an event slightly above the base flood will flood the basement area of the building. Because equipment is in the basement, there is potential that flooding this area would require evacuation of the building until the basement could be pumped out and equipment repaired. Protection of storage areas, the laundry room, and exercise room will avoid damage to the building and the contents. Dry floodproofing the entire basement also will reduce the need to pump these areas out if floodwater did enter the building.

**Residual Risk:** This proposed design scenario does include additional freeboard, which would protect the building against an event slightly higher than a base flood event. It is unclear exactly what that event is, since it would likely not be cost-effective for this owner to perform a hydrology and hydraulics study to make this determination. If floodwater did reach the building, then there is potential to flood the entire basement area.

**Considerations:** While the specific requirements do not necessarily apply because the building is outside the regulatory floodplain, the design professional overseeing the design should consider designing the floodproofing system (walls, floor, penetrations, etc.) to ASCE/SEI 24 standards up to the stated flood protection level. Attention should be paid to penetrations, pipes, conduits, and ductwork that may provide entry points for nearby floodwater to enter the basement. Maintenance of the system is a key requirement and the owner should strictly follow the operations plan prior to a flood event.

## Scenario 5: Below Ground Parking Dry Floodproofed

**Building Location:** The site is in a dense urban area designated as Zone AE (BFE is 14 ft above datum) with a coastal flood source and has a lowest adjacent grade of 12 ft.

**Building Description:** This is a five-story apartment building (ground floor plus an additional four stories all above ground) with a parking entrance at ground level and two floors of below ground parking (Below-ground parking areas for residential buildings are considered basement areas and not allowed for new buildings and are not compliant for SI/SD buildings). There are elevators and staircases on the ground level, which continue down into the two below-ground parking areas providing access to the apartments all located on upper floors. The building was originally an office building but converted to apartments within the past five years (without triggering a substantial improvement).

**Building Site Flood Characteristics:**

| FLOOD CHARACTERISTIC | DESCRIPTION OF FLOODING |
|---|---|
| Source(s) of Floodwater | Coastal |
| Floodwater Velocity | Low velocity (<5 fps) floodwater – shielded by other buildings |
| Base Flood Elevation | 14 ft, BFE is 2 ft above-ground |
| Expected Duration of Flooding | Less than 24 hours |
| Wave Conditions During Design Event | Less than 1.5-foot wave heights |
| Erosion/Scour Risk from Flooding | None due to low-velocity floodwater |
| Flood-borne Debris Potential | Minor debris due to low-velocity floodwater |
| Floodwater Rate of Rise | <5 ft per hour |

**Proposed Mitigation Option:** The owner intends to dry floodproof the entire ground floor area and any below-ground parking areas.

**Flood Mitigation Objectives:** The owner will dry floodproof to BFE + 1 foot of freeboard to reduce the potential for the below-ground parking areas to flood. Lobby areas on the ground floor must be dry floodproofed to prevent floodwater from reaching the below-ground parking areas through elevator shafts and staircases.

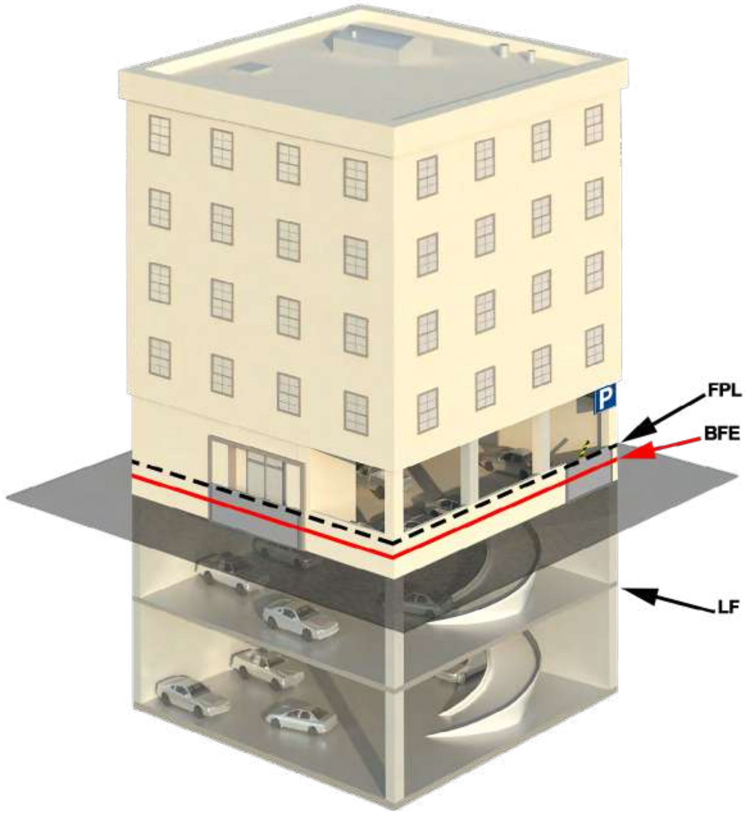



Figure 6-5. Illustration of Scenario 5 – Dry floodproofed below ground parking area

Table 6-5. Compliance and Insurance Summary for Scenario 5

| | FLOODPLAIN MANAGEMENT ALLOWANCE | PROVIDES CURRENT CONFORMANCE | COST TO IMPLEMENT | INSURANCE PREMIUM | INSURANCE CREDIT[1] |
|---|---|---|---|---|---|
| *Existing Construction (Not SI/SD)* | ✓ | X | $$ | Reduced | ✓ |
| *Legal Non-Conforming Construction (Not SI/SD)* | X | X | N/A | N/A | N/A |
| *New Construction/ SI/SD* | X | X | N/A | N/A | N/A |

N/A = Not Applicable

[1] A dry floodproofing credit is available since the building is eligible for consideration as a non-residential business occupancy. The non-residential business occupancy is based on at least 25 percent or greater of the total floor area being used for commercial uses, which the below-ground parking area would be considered.

**Benefits:** Dry floodproofing of the below-ground parking areas will reduce the risk that a base flood will flood the parking area of the building. Pumping out these areas could be a significant expense and require replacement of ventilation systems and electrical systems associated with the parking area. This approach will help protect the elevator shafts and staircases in the below-ground and ground floor areas. Towing numerous flood-damaged vehicles out of flooded parking decks can be a challenge and this will help protect vehicles in the below ground parking area if tenants are unable to evacuate them prior to a flood event. Dry floodproofing of the ground floor lobby area will reduce potential damages to lobby finishes and floor coverings and will also minimize the loss of use to the building following a flood event.

**Residual Risk:** This proposed design scenario only provides minimal protection for floods above a base flood. If overtopped, the entire below-ground parking area and the ground level lobby area would be flooded. Overtopping waters flowing down two levels of parking deck could potentially cause structural damage to the parking floor slab system separating the two levels.

**Considerations:** This approach is not compliant for SI/SD or *new construction* because the residential building will have below-ground parking, and it will not have separate building access to the residential areas either that is constructed at or above the required FPL or that is wet floodproofed. Restrictions include converting a non-residential building allowed to have a dry floodproofed basement at the time of construction to a residential use. The design professional overseeing the design should be sure that the floodproofing system (walls, floor, penetrations) meets ASCE/SEI 24 requirements for a flood up to the stated level of protection. Attention should be paid to penetrations, pipes, conduits, and ductwork that may provide entry points for nearby floodwater to enter the basement. Maintenance of the system is a key requirement, and the owner must strictly follow the operations plan prior to a flood event.

## Scenario 6: Dry Floodproofing Above a Compliant Lowest Floor Elevation

**Building Location:** The site is in a dense urban area that during construction of the building was designated as Zone AE (BFE is 12 feet above datum) with a coastal flood source and has a lowest adjacent grade of 10 feet. The newly released FIRM designates the current BFE is 14 feet above datum.

**Building Description:** This is a seven-story apartment building with apartments on the ground level. The building was constructed as a compliant building with the lowest floor at elevation 12 feet. The building is constructed of reinforced concrete and windows are located approximately 3 feet above the lowest floor. All mechanical equipment is located on the rooftop.

**Building Site Flood Characteristics:**

| FLOOD CHARACTERISTIC | DESCRIPTION OF FLOODING |
|---|---|
| Source(s) of Floodwater | Coastal |
| Floodwater Velocity | Low velocity (<5 fps) floodwater – shielded by other buildings |
| Base Flood Elevation | 14 ft, BFE is 4 ft above-lowest adjacent grade |
| Expected Duration of Flooding | Less than 24 hours |
| Wave Conditions During Design Event | Less than 1.5-foot wave heights |
| Erosion/Scour Risk from Flooding | None due to low-velocity floodwater |
| Flood-borne Debris Potential | Minor debris due to low-velocity floodwater |
| Floodwater Rate of Rise | <5 ft per hour |

**Proposed Mitigation Option:** The owner intends to dry floodproof the ground floor to protect to the BFE shown on the current maps. The cost of the dry floodproofing system does not constitute an SI.

**Flood Mitigation Objectives:** The owner will dry floodproof the ground floor area to the current BFE + 1 foot of freeboard to limit potential flood damage to the ground floor areas. The owner decided that dry floodproofing above elevation 15 feet would greatly increase maintenance costs and deployment times because this would require shield systems over any ground level windows.

WARNING

Under certain circumstances, dry floodproofing residential areas in *legal non-conforming* and *existing construction* is possibly allowable. When properly designed, failure or overtopping is a low-probability event, however when the measures fail it can cause catastrophic damage. The mitigation measures are not intended to allow tenants and occupants to shelter-in-place during a flood event. Dry-floodproofed buildings should not be occupied during flood events. Therefore, emergency operations plans must include evacuation procedures whenever the measures are implemented.

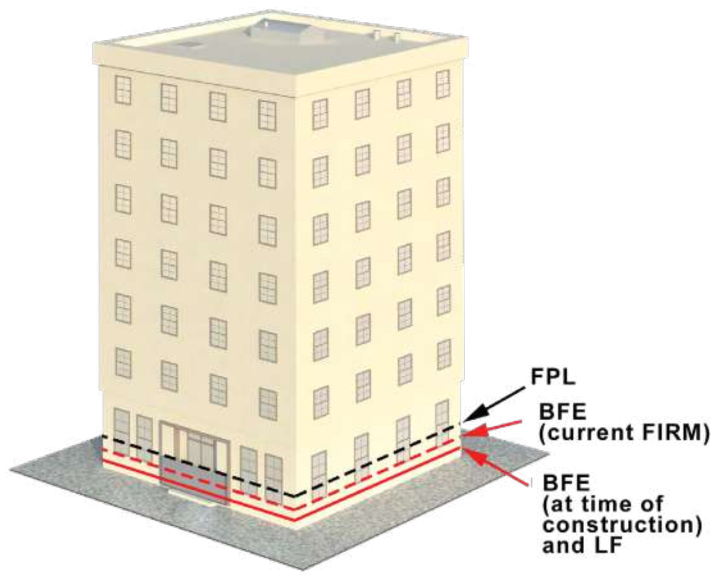



Figure 6-6. Illustration of Scenario 6 – Dry floodproofed ground level of *legal non-conforming construction*

Table 6-6. Compliance and Insurance Summary for Scenario 6

| | FLOODPLAIN MANAGEMENT ALLOWANCE | PROVIDES CURRENT CONFORMANCE | COST TO IMPLEMENT | INSURANCE PREMIUM | INSURANCE CREDIT |
|---|---|---|---|---|---|
| *Existing Construction* (Not SI/SD) | ✓ | X | $$ | No Change | X |
| Legal Non-Conforming Construction (Not SI/SD)[1] | ✓ | X | $$ | No Change | X |
| *New Construction/ SI/SD*[1] | X | X | N/A | N/A | N/A |

N/A = Not Applicable

[1] Improvements can be made to *legal non-conforming construction* to protect against higher flood events as long as they are compliant with the adopted local floodplain management requirements that were enforced at the time of construction; an SI would result in needing to conform to the currently adopted FIRM.

**Benefits:** Dry floodproofing of the ground floor level will reduce the potential for damage of the building and its contents if floodwater reach the lowest floor. If proper maintenance is done on the system, for floods that do not exceed the design flood elevation, the downtime following the flood should be minimal.

**Residual Risk:** Dry floodproofing can be overtopped by events more severe than designed. This proposed design scenario does not address future conditions when factors such as sea level rise or future development could increase flood heights.

**Considerations:** The work on *legal non-conforming construction* is allowed because the lowest floor is compliant with the BFE at the time of construction and the dry floodproofing is above the BFE. While dry floodproofing of areas below the BFE in residential buildings is not permitted, there are no restrictions on dry floodproofing above the BFE for additional protection if the lowest floor complies with the BFE. The design professional overseeing the design should be sure that the floodproofing system (walls, floor, opening protection, and required equipment) meets ASCE/SEI 24 requirements. Maintenance of the system is a key requirement, and the owner should strictly follow the operations plan prior to a flood event.

*WARNING*

In Scenario 6, the FIRM maintained a designation of Zone AE and wave heights were predicted to be minimal. If the new FIRM had shown the LiMWA line near the building, crossing through the building footprint, or the entire building within the LiMWA, then wave heights would be significant. If the dry floodproofing did not result in an SI, then the owner still would be able to dry floodproof the area above the compliant lowest floor. The owner should be aware that in this scenario waves could increase damage to the building and wave runup on the dry floodproofing measures could overtop any shields. In this situation, the owner should expect a level of protection less than a flood reaching an elevation of 14 feet (a BFE as shown on the new FIRM). An SI to this building would require compliance with the current FIRM and, if triggered, by building codes, compliance with Coastal A Zone building requirements. In the event that the building was substantially damaged, repairs made to the building would require it to be brought into compliance to the new FIRM. This would require dismantling or non-usage of the dry floodproofing system, since it would not be permitted in a residential building.

# APPENDICIES

## APPENDIX A: TECHNICAL RESOURCE CROSSWALK

The following table provides a crosswalk to several technical resources to assist the reader in developing a comprehensive mitigation strategy. A list of primary topics and resources is provided, with some differentiation between coastal and riverine flooding conditions.

**Technical Resource Crosswalk**

| TOPIC | COASTAL | RIVERINE |
|---|---|---|
| Determination of Flood Protection Level | Hurricane Sandy Recovery Advisory 5 | Iowa Floods of 2016 Recovery Advisory 1 |
| Future Conditions | Hurricane Sandy Recovery Advisory 5 | Iowa Floods of 2016 Recovery Advisory 1 |
| Flood Insurance Rate Maps | Map Service Center – https://msc.fema.gov/portal/ | |
| Flood Insurance Studies | Map Service Center – https://msc.fema.gov/portal/ | |
| Siting | FEMA P-55 | FEMA P-936 |
| Design | FEMA P-936 | FEMA P-936 |
| Dry Floodproofing | ASCE/SEI 24; FEMA P-936; NFIP Technical Bulletins 3 and 6; Hurricane Sandy MAT Report P-942 Recovery Advisory 2; Hurricane Harvey MAT Report P-2022 Recovery Advisory 1; Hurricane Irma MAT Report P-2023 Recovery Advisory 1 | |
| Wet Floodproofing | ASCE/SEI 24; FEMA P-936; FEMA P-259; NFIP Technical Bulletins 1, 2, & 7 | |
| Floodwalls | ASCE/SEI 24; FEMA P-936 | |
| Elevating/Relocation of Equipment | FEMA P-348; Hurricane Sandy MAT Report P-942 Recovery Advisories 3, 4, and 6 | |
| Flood Loads | ASCE/SEI 24; ASCE/SEI 7; FEMA P-936 | |
| Substantial Improvement/ Substantial Damage (SI/SD) | FEMA P-758 | |
| Flood Damage-Resistant Materials | NFIP Technical Bulletin 2 | |
| Elevators | NFIP Technical Bulletin 4 | |
| Utility Retrofits | FEMA P-348 | |
| Elevation Certificate | https://www.fema.gov/media-library/assets/documents/160 | |
| Floodproofing Certificate | https://www.fema.gov/media-library/assets/documents/2748; NFIP Technical Bulletin 3 | |
| Grants | HMA Guidance – https://www.fema.gov/media-library/assets/documents/103279 | |
| BCA | FEMA P-936; FEMA BCA Guidance – https://www.fema.gov/media-library/assets/documents/18870 | |

# APPENDIX B: EXTERNAL REFERENCES AND RESOURCES

American Institute of Architects New York Chapter (AIANY). “Post-Sandy Initiative. Building Better, Building Smarter: Opportunities for Design and Development.” Design for Risk and Reconstruction Committee (DfRR) (2013)

Building Owners & Managers Association New York (BOMA NY), “Hurricane Sandy: Lessons Learned Study.” Preparedness Committee Hurricane Sandy Lessons Learned Task Force. (2013)

Boynton, Adria, “Retrofitting Boston Buildings for Flooding: Potential Strategies.” Boston Planning & Development Agency (BPDA) Planning Department, (2016)

Hawkes-Nepean Floodplain Management Steering Committee, "Reducing Vulnerability of Buildings to Flood Damage: Guidance on Building in Flood Prone Areas." Parramatta: Hawkes-Nepean Floodplain Management Steering Committee, (2006)

Hoboken Community Development Department, “Resilient Building Design Guidelines.” (2015)

HR&A, Enterprise, BJH Advisors LLC, ARUP, Willis, “Multifamily Flood Insurance Affordability Study.” (2016)

NYC Planning, Department of City Planning City of New York, New York City Fire Department, and FEMA, “Post-Sandy Housing Reconstruction Analysis.” (2013)

NYC Planning, Department of City Planning City of New York, “Coastal Climate Resilience: Urban Waterfront Adaptive Strategies.” (2013)

NYC Planning, Department of City Planning City of New York, “Coastal Climate Resiliency: Retrofitting Buildings for Flood Risk.” (2014)

Kevin Findlan, Vrunda Vaghela, Max Weselcouch, Jessica Yager, “The Price of Resilience: Can Multifamily Housing Afford to Adapt?” NYU Furman Center with Enterprise and AIA NY (2014)

Schoeman, Laurie, “Disaster Preparedness for Affordable Housing Organizations. Ready to Respond: Strategies for Multifamily Building Resilience.” Enterprise Community Partners, Inc., (2015)

Schwab, James, Kenneth C. Topping, Charles C. Eadie, Robert E. Deyle, Richard A. Smith, “Planning for Post-Disaster Recovery and Reconstruction, PAS Report 483/484.” (1998)

U.S. Army Corps of Engineers (USACE), “North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk – Physical Depth Damage Function Summary Report.” (2015)

# APPENDIX C: ADDITIONAL REFERENCES AND RESOURCES

FEMA. 2019. FEMA National Flood Insurance Program Community Status Book. Available at https://www.fema.gov/national-flood-insurance-program-community-status-book

FEMA. 2018a. FEMA Hurricane Irma in Florida Recovery Advisory 1 – Dry Floodproofing: Operational Consideration. Available at https://www.fema.gov/media-library/assets/documents/158123.

FEMA. 2018b. FEMA Hurricane Harvey in Texas Recovery Advisory 1 – Dry Floodproofing: Planning and Design Consideration. Available at https://www.fema.gov/media-library/assets/documents/158123.

FEMA. 2018c. FEMA Flood Insurance Manual. Effective April 1, 2018. Available at https://www.fema.gov/media-library/assets/documents/162601.

FEMA. 2018d. FEMA National Flood Insurance Program Elevation Certificate and Instructions. Available at https://www.fema.gov/media-library/assets/documents/160.

FEMA. 2017a. FEMA P-348, Edition 2 Protecting Building Utility System from Flood Damage: Principles and Practices for the Design and Construction of Flood Resistant Building Utility Systems. Available at https://www.fema.gov/media-library/assets/documents/3729.

FEMA. 2017b. FEMA 2016 Fall Flooding in Iowa Recovery Advisory No. 1, Elevating Floodprone Buildings Above the Minimum NFIP Requirements. Available at https://www.fema.gov/media-library/assets/documents/130555.

FEMA. 2015. FEMA NFIP Flood Insurance Floodproofing Certificate for Non-Residential Structures. Available at https://www.fema.gov/media-library/assets/documents/2748.

FEMA. 2013a. FEMA P-936, Floodproofing Non-Residential Buildings. Available at http://www.fema.gov/media-library/assets/documents/34270.

FEMA. 2013b. FEMA P-942, Mitigation Assessment Team Report, Hurricane Sandy in New Jersey and New York: Building Performance Observations, Recommendations, and Technical Guidance. Available at https://www.fema.gov/media-library/assets/documents/85922.

FEMA. 2013c. FEMA Hurricane Sandy RA No. 5, Designing for Flood Levels Above the BFE After Hurricane Sandy. Available at https://www.fema.gov/media-library/assets/documents/30966.

FEMA. 2013d. FEMA Hurricane Sandy Recovery Advisory No. 7, Reducing Flood Risk and Flood Insurance Premiums for Existing Residential Buildings in Zone A. Available at https://www.fema.gov/media-library/assets/documents/30966.

FEMA. 2013e. FEMA Hurricane Sandy Recovery Advisory No. 3, Resorting Mechanical, Electrical, and Plumbing Systems. Available at https://www.fema.gov/media-library/assets/documents/30966.

FEMA. 2013f. FEMA Hurricane Sandy Recovery Advisory No. 4, Reducing Interruptions to Mid- and High-Rise Buildings During Floods. Available at https://www.fema.gov/media-library/assets/documents/30966.

FEMA. 2013g. FEMA Hurricane Sandy Recovery Advisory No. 6, Protecting Building Fuel Systems from Flood Damage. Available at https://www.fema.gov/media-library/assets/documents/30966.

FEMA. 2013h. FEMA Hurricane Sandy Recovery Advisory No. 2, Reducing Flood Effects in Critical Facilities. Available at https://www.fema.gov/media-library/assets/documents/30966.

FEMA. 2012. FEMA P-259, Engineering Principles and Practices for Retrofitting Floodprone Residential Structures, Third Edition. Available at https://www.fema.gov/media-library/assets/documents/3001.

FEMA. 2011. FEMA P-55, Coastal Construction Manual: Principles and Practices of Planning, Siting, Designing, Constructing, and Maintaining Residential Buildings in Coastal Areas, 4th Edition. Available at https://www.fema.gov/media-library/assets/documents/3293.

FEMA. 2010a. FEMA P-499, Home Builder's Guide to Coastal Construction, https://www.fema.gov/media-library/assets/documents/6131.

FEMA. 2010b. FEMA P-758, Substantial Improvement/Substantial Damage Desk Reference. Available at https://www.fema.gov/media-library/assets/documents/18562.

FEMA. 2010c. NFIP Technical Bulletin 4, Elevator Installation for Buildings Located in Special Flood Hazard Areas in accordance with the National Flood Insurance Program. Available at https://www.fema.gov/nfip-technical-bulletins.

FEMA. 2009. FEMA P-550, Recommended Residential Construction for Coastal Areas: Building on Strong and Safe Foundations. Available at https://www.fema.gov/media-library/assets/documents/3972.

FEMA. 2008a. NFIP Technical Bulletin 1, Openings in Foundation Walls and Walls of Enclosures Below Elevated Buildings in Special Flood Hazard Areas in accordance with the National Flood Insurance Program. Available at https://www.fema.gov/nfip-technical-bulletins.

FEMA. 2008b. NFIP Technical Bulletin 2, Flood Damage-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas in accordance with the National Flood Insurance Program. Available at https://www.fema.gov/nfip-technical-bulletins.

FEMA. 2008c. NFIP Technical Bulletin 5, Free-of-Obstruction Requirements for Buildings Located in Coastal High Hazard Areas in accordance with the National Flood Insurance Program. Available at https://www.fema.gov/nfip-technical-bulletins.

FEMA. 2008d. NFIP Technical Bulletin 9, Design and Construction Guidance for Breakaway Walls Below Elevated Buildings Located in Coastal High Hazard Areas in accordance with the National Flood Insurance Program. Available at https://www.fema.gov/nfip-technical-bulletins.

FEMA. 2007. FEMA 543, Risk Management Series: Design Guide for Improving Critical Facility Safety from Flooding and High Winds. Available at https://www.fema.gov/media-library/assets/documents/8811.

FEMA. 2005. FEMA 480, Floodplain Management Requirements: A Study Guide and Desk Reference for Local Officials. Available at https://www.fema.gov/media-library/assets/documents/902.

FEMA. 1993. NFIP Technical Bulletin 6, Below-Grade Parking Requirements for Buildings Located in Special Flood Hazard Areas in accordance with the National Flood Insurance Program. Available at https://www.fema.gov/nfip-technical-bulletins.

# APPENDIX D: CHECKLIST FOR VULNERABILITY OF FLOOD-PRONE SITES AND MULTI-FAMILY BUILDINGS

The *Checklist for Vulnerability of Flood-Prone Sites and Multi-Family Buildings* (based on the checklist in FEMA 543, *Design Guide for Improving Critical Facility Safety from Flooding and High Winds*) can be used to assess site-specific flood hazards and building vulnerability. The checklist is organized by specialty area, and each section can be assigned to a subject matter expert in that specialty for greater accuracy and completeness of the assessment. The results should be integrated into a master vulnerability assessment to guide the design process and choice of appropriate mitigation measures.

**Checklist for Vulnerability of Flood-Prone Sites and Multi-Family Buildings**

| VULNERABILITY CONSIDERATIONS | OBSERVATION | GUIDANCE |
|---|---|---|
| **SITING CONDITIONS** | | |
| Is the site near a body of water (with or without a mapped flood hazard area)?<br><br>Is the site in a flood hazard area shown on the community's map (FIRM, other adopted map, or a preliminary FIRM)? If so, what is the flood zone?<br><br>Is the site affected by a regulatory floodway? | | All bodies of water are subject to flooding but not all have been designated as a floodplain on FIRMs.<br><br>Flood hazard maps are usually available for review in local planning and permit offices. Electronic versions of the FIRMs may be available online at http://msc.fema.gov. Paper maps can be ordered by calling (800) 358-9616.<br><br>Multi-family building development should not occur in or near floodways.<br><br>Floodwalls and levees are not permitted in floodways per NFIP regulations. Multi-family building development behind floodwalls or levees should be considered high risk due to the catastrophic damage that can occur if they fail. |
| Is the site in a storm surge inundation zone (or tsunami inundation area)? | | In coastal communities, even sites at some distance inland from the shoreline can be exposed to extreme storm surge flooding. Storm surge maps may be available at state or local emergency management offices.<br><br>ASCE 24, *Flood Resistant Design and Construction*, and NFIP regulations do not allow dry floodproofing in Coastal High Hazard Areas. Further, ASCE 24 does not allow dry floodproofing in Coastal A Zones or in High Risk Flood Hazard Areas.<br><br>Multi-family buildings may be constructed in high hazard areas, but the elevation of the residential floors must meet the elevation requirements of ASCE 24 at a minimum. |

| VULNERABILITY CONSIDERATIONS | OBSERVATION | GUIDANCE |
|---|---|---|
| **SITING CONDITIONS** | | |
| What is the Flood Protection Level (or does an analysis have to be done to determine the FPL)? What is the minimum protection level required by regulatory authorities?<br><br>Has FEMA issued post-disaster advisory flood elevations and maps?<br><br>What are the expected depths of flooding at the site (determined using flood elevations and ground elevations)? | | Refer to the FEMA FIS for flood profiles and data tables. Electronic versions of the FIS may be available online at http://msc.fema.gov. Site-specific analyses should be performed by qualified engineers.<br><br>Check with regulatory authorities to determine the required level of protection. In some cases this may require using the BFE, a locally adopted Design Flood Elevation (DFE), or utilizing ASCE 24 required elevations.<br><br>If a major flood event has affected the community, FEMA may have issued new flood hazard information, especially if areas not shown on the FIRMs have been affected. Sometimes, these maps are adopted and replace the FIRMs; sometimes the new data are advisory only. |
| Has the site been affected by past flood events? What is the flood of record? | | Records of actual flooding augment studies that predict flooding, especially if historical events resulted in deeper or more widespread flooding. Information may be available from local planning, emergency management, and public works agencies, state agencies, the U.S. Army Corps of Engineers, or the Natural Resources Conservation Service.<br><br>The flood of record is often a lower probability event (with higher flood elevations) than the 100-year flood. |
| What is the expected velocity of floodwater on the site? | | Velocity is a factor in computing loads associated with hydrodynamic forces, including drag on building surfaces.<br><br>Approximations of velocity may be interpolated from data in the FIS Study Floodway Data Table if the waterway was studied using detailed methods, application of approximation methods based on continuity, local observations and sources, or site-specific studies.<br><br>ASCE 24 limits dry floodproofing to areas where flood velocities are less than or equal to 5 feet per second, which for low velocity flow would require a depth of 5 feet of floodwater. |

| VULNERABILITY CONSIDERATIONS | OBSERVATION | GUIDANCE |
|---|---|---|
| **SITING CONDITIONS** | | |
| Are waves expected to affect the site? | | Waves can exert considerable dynamic forces on buildings and contribute to erosion and scour. Wind-driven waves occur in areas subject to coastal flooding and where unobstructed winds affect wide floodplains (large lakes and major rivers). In riverine floodplains with high velocities, standing waves may occur.<br><br>ASCE 24 and NFIP regulations do not allow floodproofing in Coastal High Hazard Areas. ASCE 24 also does not allow dry floodproofing in Coastal A Zones.<br><br>Multi-family buildings may be constructed in high hazard areas, but the elevation of the residential floors must meet the required elevation, which may include the ASCE 24 minimum elevation requirements. |
| Is there information on how quickly floodwater may affect the site?<br><br>What is the expected duration of flooding? | | Warning time is a key factor in the safe and orderly evacuation of multi-family buildings.<br><br>For dry floodproofing, ASCE 24 specifies minimum warning times when human intervention is necessary based on whether the community has a warning system and emergency plan.<br><br>Duration has bearing on the stability of earthen fills, access to a site and emergency response, and durability of materials that come into contact with water. Records of actual flooding are the best indicator of duration because most floodplain analyses do not include an examination of duration. |
| Is there a history of flood- related debris problems or erosion on the site? | | Floodproofing design should account for deposition of debris and sediment and the potential for erosion-related movement of the shoreline or waterway as appropriate. Buildings exposed to debris impact or undermining by scour and erosion should be designed to account for these conditions.<br><br>Buildings with basements or deep foundations are less susceptible to erosion or scour damage. |

| VULNERABILITY CONSIDERATIONS | OBSERVATION | GUIDANCE |
|---|---|---|
| **SITING CONDITIONS** | | |
| Is the site in an area predicted to flood if a levee or floodwall fails or is overtopped?<br><br>Is the site in an area predicted to be inundated if an upstream dam failed? | | Flood protection works may be distant from the sites being assessed and not readily observable. Although if properly designed, failure or overtopping is a low-probability event, it can cause unexpected and catastrophic damage because the protected lands are not regulated as flood hazard areas.<br><br>The effects of an upstream dam failure are not shown on the FIRMs or most flood hazard maps prepared locally. Although dam failure is generally considered an unlikely event, the potential threat should be evaluated because of the catastrophic consequences. |
| Does the surrounding topography contribute to the flooding at the site?<br><br>Is there a history of local surface drainage problems due to inadequate site drainage? | | If areas with poor local drainage and frequent flooding cannot be avoided, filling, re-grading, and installation of storm drainage facilities may be required. |
| Given the nature of anticipated flooding and soils, is scour around and under the foundation likely? | | Scour-prone sites should be avoided in part because of likely long-term maintenance requirements. Flooding that is high velocity or accompanied by waves is more likely to cause scour, especially on fill or where local soils are unconsolidated and subject to erosion. |
| Has water from other sources entered the building (e.g., high groundwater, water main breaks, sewer backup)?<br><br>Is there a history of water intrusion through floor slabs or wall-floor connections?<br><br>Are there underground utility systems or areaways that can contribute to basement flooding?<br><br>Are there stormwater sewer manholes upslope of window areas or openings that allow local drainage to enter the basement/lower floor areas? | | The entire building envelope, including below-ground areas, should be examined to identify potential water damage.<br><br>These questions pertain to existing facilities that may be impaired by water from sources other than the primary source of flooding. |

| VULNERABILITY CONSIDERATIONS | OBSERVATION | GUIDANCE |
|---|---|---|
| **SITING CONDITIONS** | | |
| Is at least one access road to the site/building passable during flood events?<br><br>Are ground-level parking lots located in flood-prone areas?<br><br>Are below-ground parking areas susceptible to flooding? | | The longer the duration of the flood, the more important access is. For the safety of occupants, most multi-family buildings should not be occupied during flood events.<br><br>Areas where vehicles could be affected should have signage to warn users, including bus drivers, of the flooding risk. Emergency response plans should include instructions on notifying car owners. |
| **ARCHITECTURAL** | | |
| Are any critical building functions occupying space below the elevation of the FPL?<br><br>Can critical functions be relocated to upper levels that are above predicted flood elevations?<br><br>If critical functions cannot be relocated, is floodproofing feasible?<br><br>If critical functions must continue during a flood event, have power, supplies, and access issues been addressed? | | New multi-family buildings in flood hazard areas should not have any functions that support the dwelling units, occupy flood-prone spaces other than parking, building access, and limited storage.<br><br>Existing facilities in floodplains should be examined carefully to identify the best options for protecting functionality and the structure itself.<br><br>Significant damage has occurred to critical functions located in lower building levels from recent floods. Elevating these functions above the FPL (at a minimum) should be a consideration for a capital improvement priority. |
| Are any critical contents (files, computers, servers, equipment, or data) on levels of the facility below the FPL?<br><br>Are critical records maintained off site? | | Existing facilities that are located in flood hazard areas may require continued use of flood-prone space. However, the potential for flooding should be recognized and steps taken to minimize loss of expensive equipment and irreplaceable data.<br><br>If critical contents cannot be permanently located on higher floors, a flood response plan should consider the time and attention needed to move such contents safely. |
| **STRUCTURAL SYSTEMS** | | |
| What is the construction type and foundation type and what is the load-bearing capacity?<br><br>Has the foundation been designed to resist hydrostatic and hydrodynamic flood loads? | | If siting in a floodplain is unavoidable, new facilities should be designed to account for all loads and load combinations, including flood loads.<br><br>Building components may need to be strengthened to withstand flood forces and the loads imposed by dry floodproofing components. |

| VULNERABILITY CONSIDERATIONS | OBSERVATION | GUIDANCE |
|---|---|---|
| **STRUCTURAL SYSTEMS** | | |
| If the building has below-ground areas (basements), are the lower floor slabs subject to cracking and uplift? | | Below-ground spaces and their contents are the most vulnerable to flooding and local drainage problems. Rapid pump-out of below-ground spaces can unbalance forces if the surrounding soil is saturated, leading to structural failure. If below-ground spaces are intended to be dry floodproofed, the design must account for buoyancy (uplift forces).<br><br>Building spaces below the design flood level can be dry floodproofed, but higher flood levels can overtop the protection measures and result in severe damage. Dry floodproofing can create large unbalanced forces that can jeopardize walls and foundations that are not designed to resist the hydrostatic and hydrodynamic loads. |
| Are any portions of the building below the FPL?<br><br>Has the building been damaged in previous floods? | | For existing buildings, it is important to determine which portions are vulnerable in order to evaluate floodproofing options.<br><br>Alternative floodproofing options include modifying the use of flood-prone areas. |
| If the building is elevated on a crawlspace or on an open foundation, are there any enclosed areas? | | New buildings may have enclosures below the FPL if the use of the enclosures is limited to parking, building access, and limited storage. In addition, the enclosures must have flood openings to allow inflow and outflow of floodwaters to minimize differential hydrostatic pressure.<br><br>Existing buildings that are elevated and have enclosures below the flood elevation can be retrofitted with flood openings. |
| For an existing building with high-value uses below the FPL, is the building suitable for elevation in-place? | | While this approach tends to be technically infeasible due to structural characteristics and/or location, elevating a building provides better protection than dry floodproofing so it should not automatically be ruled out. |
| For an existing building, are there through-the-wall penetrations of conduit, pipes, wires, or utilities? | | If floodproofing of the area below the FPL is to be accomplished, the penetrations must be sealed to prevent water leakage. |

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|---|---|---|
| **BUILDING ENVELOPE** | | |
| Are there existing floodproofing measures below the FPL? What is the nature of the measures and in what condition are they? Is there an annual inspection and maintenance plan?<br><br>Is there an action plan to implement floodproofing measures when flooding is predicted? Do the building operators/occupants know what to do when a flood warning is issued? | | Floodproofing measures are only as good as their design and current condition, especially if many years have passed since initial installation.<br><br>Floodproofing measures that require human intervention are entirely dependent on the adequacy of advance warning and the availability and ability of personnel to install the measures properly. |
| For existing buildings, what types of openings penetrate the building envelope below the FPL (e.g., doors, windows, cracks, vent openings, plumbing fixtures, floor drains)? | | For dry floodproofing to be effective, every opening must be identified and either permanently sealed or covered with special barriers to resist infiltration.<br><br>Sewage backflow can enter through unprotected plumbing fixtures. |
| Are flood-resistant materials used for structural and non-structural components and finishes below the FPL, including in lobbies or service areas for the building? | | Flood-resistant materials are capable of withstanding direct and prolonged contact with floodwaters without sustaining damage that requires more than cosmetic repair.<br><br>Contact is considered to be prolonged if it is 72 hours or longer in freshwater flooding areas or 12 hours or longer in areas subject to coastal flooding. |
| What are the wall materials on the building envelope?<br><br>Is there a way to collect water seepage and pump it out of the building? | | Seepage through openings and the exterior of the building envelope must be controlled (minimized) by coatings on the wall materials.<br><br>There needs to be a water seepage collection system inside the building, including a sump pump that can pump the collected water out of the building. |
| **UTILITY SYSTEMS** | | |
| Is the potable water supply for the facility protected from flooding?<br><br>If served by a well, is the wellhead protected? | | Operators of multi-family buildings that depend on freshwater for continued functionality should learn about the vulnerability of the local water supply system and the utility owner's plans for recovery of service in the event of a flood. |

| VULNERABILITY CONSIDERATIONS | OBSERVATION | GUIDANCE |
|---|---|---|
| **UTILITY SYSTEMS** | | |
| Is the wastewater service for the building protected from flooding?<br><br>Are any manholes below the FPL?<br><br>Is infiltration of floodwater into sewer lines a problem?<br><br>If the site is served by an onsite system that is located in a flood-prone area, have backflow valves been installed? | | Most waste lines exit buildings at the lowest elevation.<br><br>Even buildings that are outside the floodplain can be affected by sewage backups during floods.<br><br>Backflow valves should be considered on any building in or near a floodprone area.<br><br>Ejector pumps may be required when sewer lines are located in floodprone areas and may be surcharged with floodwater. |
| Are there any aboveground or underground tanks on the site in flood hazard areas?<br><br>Are they installed and anchored to resist flotation during the design flood?<br><br>Are tank openings and vents elevated above the FPL, or are they otherwise protected to prevent entry of floodwater or release of product during a flood event? | | Dislodged tanks become floating debris that poses special hazards during recovery.<br><br>Lost fuel or chemicals causes environmental damage. Functionality may be impaired if tanks for heating fuel, propane, or fuel for emergency generators are lost or damaged. |
| **MECHANICAL SYSTEMS** | | |
| Are air handlers, HVAC systems, ductwork, and other mechanical equipment and systems located above the FPL?<br><br>Are the vents and inlets located above the flood level or sealed to prevent entry of floodwater?<br><br>Are elevators provided with emergency power? Where are the elevator controls located? | | In existing buildings, utility equipment that is critical for functionality should be relocated to higher floors or elevated additions, including elevator controls.<br><br>Evaluate potential openings and pathways for the entrance of floodwater including doors, windows, and garages; sidewalk hatch/below-ground exits; non-structural connections with other buildings; utility penetrations through the building envelope; ventilation for mechanical systems; and drains in the floor slabs.<br><br>Recommend implementing mitigation measures for elevators in accordance with NFIP Technical Bulletin 4 – *Elevator Installation for Buildings Located in Special Flood Hazard Areas in accordance with the National Flood Insurance Program.* |

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|---|---|---|
| **ELECTRICAL SYSTEMS** | | |
| Are electrical systems, including backup power generators, panels, and primary service equipment, located above the FPL?<br><br>Are electrical stand-by equipment and generators equipped with circuits to turn off power to areas below the FPL?<br><br>Are the switches and wiring required for safety (minimal lighting, door openers) below the flood level designed for use in damp locations? | | In existing buildings, utility equipment that is critical for functionality should be relocated to higher floors or elevated additions.<br><br>Isolate electrical components installed in areas subject to flooding from components at higher elevations or install separate branch circuits or feeders that are isolated from the rest of the electrical system and protected using ground fault circuit interrupters. Wet floodproofed areas should be turned off prior to the event and dry floodproofed areas should be able to be isolated if the flood protection is overtopped or breached.<br><br>Reference FEMA P-1019, *Emergency Power Systems for Critical Facilities: A Best Practices Approach to Improving Reliability*, for additional guidance. |
| **FIRE ALARM SYSTEMS** | | |
| Is the fire alarm system located above the FPL? | | In existing buildings, utility equipment that is critical for functionality should be relocated to higher floors or elevated additions. |
| **COMMUNICATIONS AND IT SYSTEMS** | | |
| Are the communication/IT/security systems located above FPL? | | In existing buildings, communications, security, and information technology systems critical for functionality should be considered for relocation to higher floors or elevated additions. |