Reasonably Safe from Flooding Requirement for Building on Filled Land

Removed From the Special Flood Hazard Area

in Accordance with the National Flood Insurance Program

NFIP Technical Bulletin 10 / March 2023

FEMA

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Comments on the Technical Bulletins should be directed to:

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Federal Insurance and Mitigation Administration (FIMA) Risk Management Directorate
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Cover photo: New development elevated on fill and removed from the floodplain through a Letter of Map Revision based on Fill, Oak Creek, WI. Credit: Korndoerfer Homes

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Acronyms

ASCE	American Society of Civil Engineers
ASTM	ASTM International
BFE	base flood elevation
CFR	Code of Federal Regulations
CLOMR-F	Conditional Letter of Map Revision Based on Fill
DHS	Department of Homeland Security
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
IBC®	International Building Code®
ICC®	International Code Council®
I-Codes®	International Codes®
IEBC®	International Existing Building Code®
IRC®	International Residential Code®
LiMWA	Limit of Moderate Wave Action
LOMR	Letter of Map Revision
LOMR-F	Letter of Map Revision Based on Fill
NFIP	National Flood Insurance Program
SFHA	Special Flood Hazard Area

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1. Introduction

This Technical Bulletin provides guidance on the National Flood Insurance Program (NFIP) requirements related to determining that buildings constructed on fill will be reasonably safe from flooding during the occurrence of the base flood. Guidance is provided for the placement of fill and the parameters for the design and construction of buildings on filled land that has been removed from the Special Flood Hazard Area (SFHA) through the flood map revision process managed by the Federal Emergency Management Agency (FEMA). The SFHA is identified as Zone A (A, AE, A1-30, AH, AO, A99, and AR) and Zone V (V, VE, V1-30, and VO) on a community's Flood Insurance Rate Map (FIRM) prepared by FEMA. When permitted under applicable federal, state, and local laws, ordinances, and regulations, earthen fill is sometimes placed to reduce flood risk to structures located in Zone A. In Zone V, fill for the purpose of elevating buildings is not permitted, and use of fill for other purposes is limited because fill may obstruct the flow of floodwater and divert waves.

Under certain conditions, when structural fill (also called engineered fill) is placed to raise the surface of the ground to or above the base flood elevation (BFE), property owners and developers may submit requests to FEMA to revise FIRMs to remove filled land from the SFHA (see Figure 1). When a revision is warranted, after reviewing an application, FEMA may revise a FIRM by issuing a Letter of Map Revision Based on Fill (LOMR-F). The NFIP requirements include, as part of the LOMR-F application, that written assurance from the participating community include a determination that the site (filled area) and any existing, proposed or future development (buildings and structures on the filled land) to be removed from the SFHA are or will be "reasonably safe from flooding" as defined in Title 44 of the Code of Federal Regulations (CFR) Part 65, Identification and Mapping of Special Flood Hazard Areas (see Section 2 of this Technical Bulletin).

NFIP Technical Bulletin 0

NFIP Technical Bulletin 0, *User's Guide to Technical Bulletins*, should be used as a reference with this Technical Bulletin. Technical Bulletin 0 describes the purpose and use of the Technical Bulletins. It includes common concepts and terms, lists useful resources, and includes a crosswalk of the NFIP regulations by section and the applicable Technical Bulletin, as well as a subject index.

Readers are cautioned that the definitions of some of the terms that are used in the Technical Bulletins are not the same when used by the NFIP for the purpose of rating flood insurance policies.

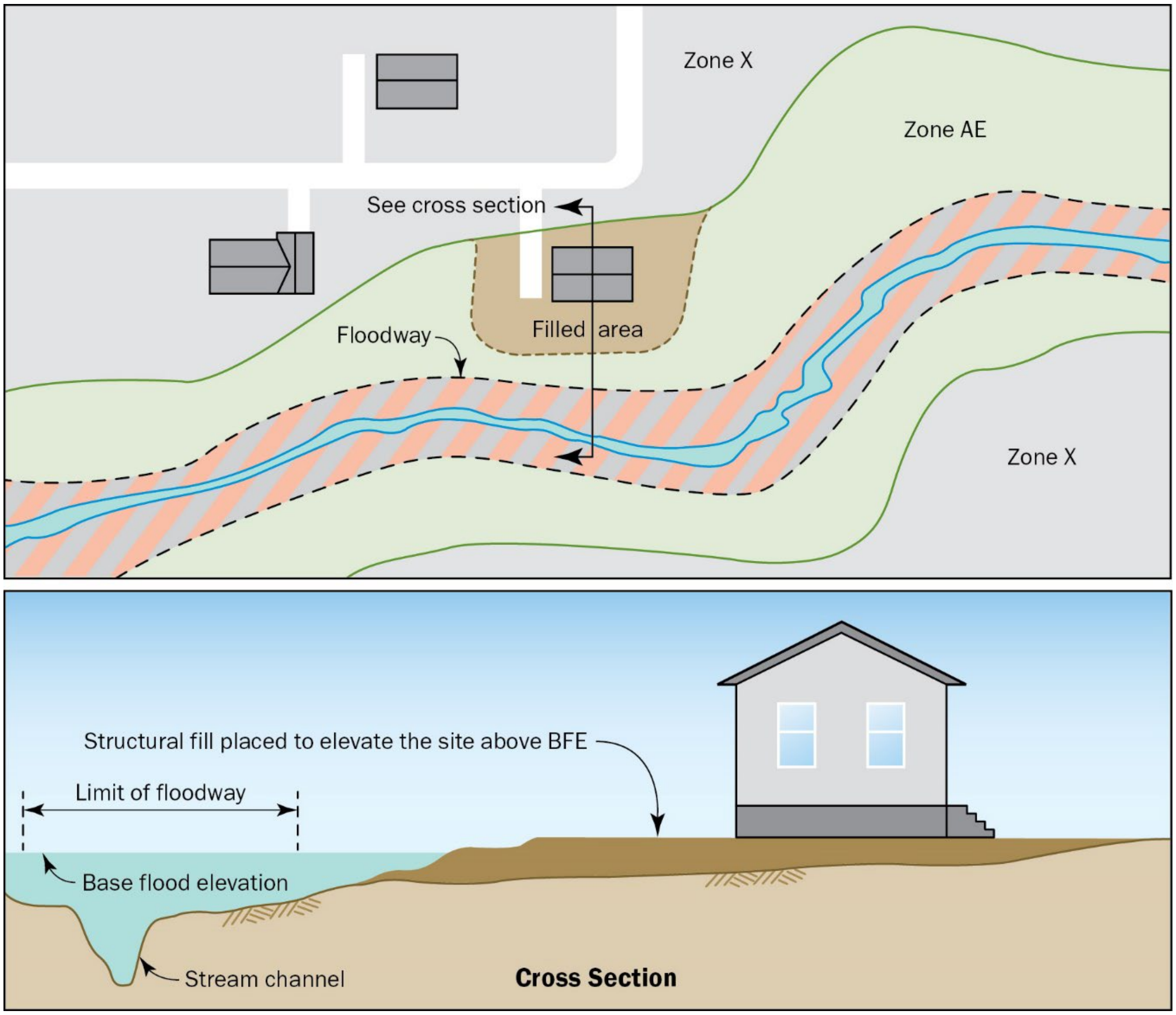


Figure 1: Building on site elevated by fill

1.1. History and Update of Technical Bulletin 10

In 2001, FEMA revised the NFIP regulations and the Letter of Map Revision (LOMR) and LOMR-F procedures, including the addition of the reasonably safe from flooding requirements to address concerns regarding the inconsistent and potentially hazardous practice of constructing on land removed from the SFHA. The additional requirements emphasized the long-standing requirement that NFIP communities must review all permit applications to determine whether proposed building sites will be reasonably safe from flooding [44 CFR 60.3(a)(3)]. FEMA issued the first edition of this Technical Bulletin in 2001 to provide guidance on how to make the determination that an area is reasonably safe from flooding. This updated Technical Bulletin reorganizes and clarifies the previous guidance but does not change any requirements or design approaches.

1.2. Letter of Map Revision Based on Fill

When fill has been placed **<u>and</u> a property owner wishes to have a structure or property removed from the SFHA**, the owner must submit a map revision request to FEMA for consideration. When fill is proposed but not yet placed, a Conditional Letter of Map Revision Based on Fill (CLOMR-F) can be requested from FEMA. A CLOMR-F is used to request FEMA's comments on a proposed project; it does not revise a FIRM and is not a permit or approval to perform the proposed filling. When FEMA approves a CLOMR-F, a subsequent as-built LOMR-F must be requested after construction before FEMA will officially revise the FIRM to remove the land from the SFHA. The FEMA MT-1 application is used to support a request for a LOMR-F or CLOMR-F. The application includes a Property Information Form (Form 1), Elevation Form (Form 2), and Community Acknowledgement Form (Form 3). By signing the Community Acknowledgement Form, the local official responsible for floodplain management in the community is acknowledging that they have reviewed the LOMR-F request and asserting that the project is reasonably safe from flooding. Additional guidance on the MT-1 application and supporting documentation to make this assertion is provided in this Technical Bulletin.

Performing Work After a CLOMR-F

If the scope of an as-built LOMR-F follow up to an approved CLOMR-F differs from the approved CLOMR-F, the LOMR-F application may be reviewed as a brand new application and may not result in an approval. Additionally, if the review determines that the as-built project is in violation of the floodplain management regulations, a potential violation memorandum may be issued by FEMA to the community.

1.3. Residual Risks

Constructing a building to the minimum NFIP requirements—or constructing a building on land adjacent to the SFHA—is no guarantee the building will be undamaged by flooding. To make informed decisions during planning, siting, and design of buildings, owners, design professionals, and local officials should understand the following:

- FIRMs are based on modeling of the best available topographic, hydrologic, hydraulic, and climate conditions data at the time of the Flood Insurance Study (FIS). There are inherent uncertainties in the modeling and analyses of BFEs and delineation of flood hazard zones. Some FIRMs, particularly older FIRMs, may no longer reasonably reflect the land characteristics and actual flood risk during base flood events. Current effective FIRMs do not convey the potential impacts of future conditions.

- Floods can and do exceed the BFE and can extend beyond the SFHA delineated on FIRMs. During notable flood events such as Hurricane Sandy in 2012, riverine flooding in Louisiana in 2017, and Hurricane Michael in 2018, flood elevations exceeded the BFEs by several feet in some areas and extended far beyond the SFHAs shown on the effective FIRMs.

- NFIP flood insurance premiums based on current flood modeling data and methodologies may change in the future if revised or newly acquired flood data indicate different flood risk.

Residual Risks

Residual risks associated with flooding may exist in areas elevated above the BFE by the placement of structural fill. Residual risks in these areas include subsurface flooding caused by saturated soils and surface flooding that exceeds base flood conditions.

Areas adjacent to SFHAs may have residual risks of flood damage like areas removed from SFHAs by the placement of fill. The guidance in Sections 8 and 9 of this Technical Bulletin should also be used when buildings with basements are constructed in areas adjacent to SFHAs.

1.4. Guidance in Technical Bulletin 10

This Technical Bulletin includes guidance on:

- NFIP regulations related to determining that buildings constructed on fill will be reasonably safe from flooding during the occurrence of the base flood (see Section 2 of this Technical Bulletin).
- Building codes and standards provisions related to the placement of fill in SFHAs (see Section 3 of this Technical Bulletin).
- NFIP flood insurance for buildings on land removed from SFHAs through the LOMR-F process (see Section 4 of this Technical Bulletin).
- Documentation and certification requirements to determine that buildings constructed on fill are reasonably safe from flooding (see Section 5 of this Technical Bulletin).
- Best practices for administrative procedures and more restrictive, higher regulatory standards (see Section 6 of this Technical Bulletin).
- Proper design and placement of fill (see Section 7 of this Technical Bulletin).
- Several types of foundations that are used for buildings on fill and the residual risk associated with non-basement foundations (see Section 8.1 of this Technical Bulletin) and basement foundations (see Section 8.2 of this Technical Bulletin).

Technical approaches to analyzing seepage into basements constructed into fill to satisfy the requirement that buildings on fill with basements are reasonably safe from flooding (see Section 9 of this Technical Bulletin).

Best Practice: Avoid Basements Below BFE

In some parts of the country, basements are a standard construction feature. Some owners may wish to construct basements into filled land after the site is removed from the SFHA. Buildings with basements have a higher risk of damage caused by subsurface flooding compared to buildings built on foundations that do not have below-grade areas. As a best practice to minimize risk of future flooding during base flood conditions, FEMA recommends that buildings constructed on land officially removed from SFHAs by issuance of LOMR-Fs be designed with the lowest floor (including basement) at or above the elevation of the BFE associated with the adjacent SFHA. Any basement with the lowest floor below the elevation of the BFE associated with the adjacent SFHA should only be used for parking of vehicles, building access, or storage, and not as living space.

This Technical Bulletin **does not apply** to situations in which other requirements or restrictions apply, including the following:

- Construction and filling in floodways with an increase in flood levels. The NFIP regulations prohibit encroachments in floodways that would result in an increase in flood levels [44 CFR § 60.3(d)(3)]. The LOMR-F process (MT-1) cannot be used for requests involving property and/or structures that have been elevated by fill placed within the regulatory floodway [44 CFR § 65.5(a)]. All Letter of Map Change requests involving the placement of fill in floodways must go through the CLOMR and LOMR processes using the MT-2 application [44 CFR § 65.7].

  This Technical Bulletin applies to proposed fill or grading in the floodway, and the CLOMR application review determines that the proposed encroachment will not result in any increase in flood levels. The community must ensure that the fill and any structures built or proposed in the filled area will be reasonably safe from flooding [44 CFR § 65.6(a)(14)].

- Construction in Coastal High Hazard Areas (Zone V). The NFIP regulations prohibit the use of structural fill for support of buildings in Coastal High Hazard Areas [44 CFR § 60.3(e)(6)]. While nonstructural fill for landscaping and drainage may be placed in Zone V, fill for those purposes does not qualify for a map revision. The LOMR-F process is not used to determine the acceptability of the placement of fill in Zone V [44 CFR § 65.5(a)].

- Construction in SFHAs subject to alluvial fan flooding, which are typically designated on FIRMs as Zone AO with depths and velocities [44 CFR § 65.13(b)]. Elevating a parcel of land or a structure by fill or other means will not serve as a basis for removing areas subject to alluvial fan flooding from the SFHA. Revision requests involving alluvial fans will only be considered through the LOMR (MT-2) process if a structural flood control measure is designed and/or constructed to provide protection against the base flood in compliance with 44 CFR § 65.13.

- Placement of fill around an existing residential or non-residential building where the lowest floor is below the BFE with the intent of changing the lowest adjacent grade to remove the building from the SFHA.

- Analysis of an existing residential or non-residential building with a basement that has its lowest floor below the BFE with the intent of using the analysis to determine that a building is "reasonably safe from flooding" in order to obtain a LOMR-F. Basements excavated into fill with the basement floor below the BFE are prohibited unless the land has been removed from the SFHA through the LOMR-F process prior to construction or the building is in an approved basement exception community.[1] In addition, post-construction testing to confirm geotechnical conditions beneath the building would likely involve testing that is destructive to the building.

Questions about requirements for placement of fill in SFHAs and LOMR-Fs should be directed to the appropriate local official, NFIP State Coordinating Office, or FEMA Regional Office.

Terms Used in This Technical Bulletin

Basement: "Any area of a building having its floor subgrade (below ground level) on all sides" (44 CFR § 59.1). The NFIP regulations do not allow basements to extend below the base flood elevation (BFE) except in dry-floodproofed, non-residential buildings.

Fill or earthen fill: Material from any source, such as soil, gravel, or crushed stone, that is placed to increase or raise ground elevations to or above the BFE.

Conditional Letter of Map Revision Based on Fill (CLOMR-F): An official letter issued by FEMA stating that a parcel of land or proposed structure that will be elevated by fill would not be inundated by the base flood if the fill is placed on the parcel as proposed or the structure is built as proposed. A CLOMR-F provides comment on the proposed plan and does not revise or amend the Flood Insurance Rate Map (FIRM).

Development: "Any manmade change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation or drilling operation or storage of equipment or materials" (44 CFR § 59.1).

Existing (Non NFIP definition): As used in this Technical Bulletin, existing building or existing fill refers to buildings or fill where construction or placement occurred prior to the date of the preparation of LOMR-F or LOMR application.

[1] Approximately 50 NFIP communities have obtained an exception from FEMA to allow residential buildings with floodproofed basements below the BFE (https://www.fema.gov/floodplain-management/manage-risk/residential-buildings-basements). This Technical Bulletin does not address the dry floodproofing requirements for basements in excepted communities [44 CFR § 60.6(b) or (c)].

Terms Used in This Technical Bulletin (continued)

Land removed from SFHA by placement of fill: Land that has been elevated by fill where an official determination (LOMR-F) has been issued by FEMA that the parcel of land will not be inundated by the base flood and the site or parcel is subsequently designated as being outside the SFHA.

Letter of Map Revision Based on Fill (LOMR-F): An official determination (letter) issued by FEMA stating that an existing structure or parcel of land that has been elevated by fill would not be inundated by the base flood. A LOMR-F revises the FIRM by designating filled land as being removed from the SFHA.

Reasonably safe from flooding: "Base flood waters will not inundate the land or damage structures to be removed from the SFHA and any subsurface waters related to the base flood will not damage existing or proposed buildings or structures" [44 CFR § 65.2(c)].

Special Flood Hazard Area (SFHA): Area subject to flooding by the base flood (1-%-annual-chance flood) and shown on FIRMs as Zones A or V.

Structural fill or engineered fill: Fill placed and compacted to a specified density to provide structural support or protection for buildings and structures as authorized by local officials.

Zone A: Flood zones shown on FIRMs as Zone A, AE, A1-30, AH, AO, A99, and AR.

Zone V: Flood zones shown on FIRMs as Zone V, VE, V1-30, and VO; also known as the Coastal High Hazard Area.

Other terms in this Technical Bulletin are defined in a glossary in Technical Bulletin 0.

2. National Flood Insurance Program Regulations

An important NFIP objective is protecting buildings constructed in SFHAs from damage caused by flooding. The SFHA is the land area subject to flooding by the base flood. SFHAs are shown on FIRMs prepared by FEMA as Zones A and V. The base flood is the flood that has a 1 % chance of being equaled or exceeded in any given year (commonly called the "100-year" flood). The NFIP floodplain management regulations include minimum building design criteria that apply to:

- New construction
- Work determined to be substantial improvements, including improvements, alterations, and additions
- Repair of buildings determined to have incurred substantial damage

The NFIP regulations for development in SFHAs, including filling, grading, excavation, and buildings and structures, are codified in 44 CFR Part 60, Criteria for Land Management and Use.

Section 59.1 defines "development" to mean (emphasis added):

> *... any manmade change to improved or unimproved real estate, including but not limited to **buildings or other structures**, mining, dredging, **filling**, **grading**, paving, **excavation** or drilling operation or storage of equipment or materials.*

The NFIP regulations for identification and mapping of SFHAs are set forth in 44 CFR Part 65, Identification and Mapping of Special Hazard Areas. Specific to revisions to SFHAs in accordance with the FEMA map revision process, Section 65.2(c) defines "reasonably safe from flooding" to mean:

> *... base flood waters will not inundate the land or damage structures to be removed from the SFHA and that any subsurface waters related to the base flood will not damage existing or proposed buildings.*

Section 60.3(a)(3) states that a community shall (emphasis added):

> *Review **all permit applications** to determine whether the proposed building sites will be **reasonably safe from flooding**. If a proposed building site is in a flood-prone area, all new construction and substantial improvements shall ... [meet specific listed performance requirements]*

Section 60.3(a)(4) states that a community shall (emphasis added):

> *Review subdivision proposals and other proposed new development, including manufactured home parks or subdivisions, to determine whether such proposals will be **reasonably safe from flooding**.*

When property owners submit requests to FEMA for map revisions that involve topographic changes by placement of engineered earthen fill (structural fill) but that do not change BFEs, Section 65.5(a)(4)(ii) requires that the request include written assurance from the community that they have (emphasis added):

> *... determined that the land and any existing or proposed structures removed from the SFHA are **"reasonably safe from flooding,"** and that they have on file, available upon request by FEMA, all supporting analyses and documentation used to make that determination.*

When property owners submit requests to FEMA for map revisions, including those that involve the placement of fill in floodways, that result in changes to BFEs, Section 65.6(a)(14)(ii) requires that the request include written assurance from the community that they have (emphasis added):

> *... determined that the land and any existing or proposed structures to be removed from the SFHA are **"reasonably safe from flooding,"** and that they have on file, available upon request by FEMA, all supporting analyses and documentation used to make that determination.*

When a regulatory floodway has not been identified, communities must review permit applications to evaluate cumulative effects of proposed development as specified in Section 60.3(c)(10):

> *Require until a regulatory floodway is designated, that no new construction, substantial improvements, or other development (including fill) shall be permitted within Zones A1-30 and AE on the community's FIRM, unless it is demonstrated that the cumulative effect of the proposed development, when combined with all other existing and anticipated development, will not increase the water surface elevation of the base flood more than one foot at any point within the community.*

NFIP Requirements and More Restrictive Regulatory Standards

Federal, State, and Local Requirements. Federal, state, or local requirements that are more restrictive or stringent than the minimum requirements of the NFIP take precedence. The Technical Bulletins and other FEMA publications provide guidance on the minimum requirements of the NFIP and describe best practices. Design professionals, builders, and property owners should contact local officials to determine whether more restrictive provisions apply to buildings or sites in question. All other applicable requirements of state or local building codes must also be met for buildings in flood hazard areas.

Substantial Improvement and Substantial Damage. As part of issuing permits, local officials must review not only proposals for new construction but also for work on existing and legal non-conforming buildings to determine whether the work constitutes substantial improvement or repair of substantial damage. If the work is determined to constitute substantial improvement or repair of substantial damage, the buildings must be brought into compliance with NFIP requirements for new construction. Some communities modify the definitions of substantial improvement and/or substantial damage to be more restrictive than the NFIP minimum requirements. For more information on substantial improvement and substantial damage, see FEMA P-758, *Substantial Improvement/Substantial Damage Desk Reference* (2010), and FEMA 213, *Answers to Questions About Substantially Improved/Substantially Damaged Buildings* (2018).

Elevation Above Minimum NFIP Requirements. Some states and communities require that buildings be elevated above the NFIP minimum requirement. The additional elevation is called freeboard. Design professionals, builders, and property owners should check with local officials to determine whether a community has freeboard requirements. References to building elevations in this Technical Bulletin should be construed as references to the community's elevation requirement where freeboard is required.

3. Building Codes and Standards

In addition to complying with NFIP requirements, all new construction, substantial improvements, and repair of substantial damage must comply with applicable building codes and standards that are adopted and enforced by states and communities.

The International Codes® (I-Codes®), published by the International Code Council® (ICC®), are a family of codes that includes the International Residential Code® (IRC®), International Building Code® (IBC®), International Existing Building Code® (IEBC®), and codes that govern the installation of mechanical, plumbing, fuel gas, and other aspects of building construction. FEMA has deemed that the latest published editions of the I-Codes generally meet or exceed NFIP requirements for buildings and structures. Excerpts of the flood provisions of the I-Codes are available on the FEMA Building Code webpage at https://www.fema.gov/emergency-managers/risk-management/building-science/building-codes.

3.1. International Residential Code

The International Residential Code (IRC) applies to one- and two-family dwellings and townhomes not more than three stories above grade plane.

International Residential Code Commentary

The ICC publishes companion commentary for the IRC. Although not regulatory, the commentary provides guidance that is useful in complying with, interpreting, and enforcing the requirements of the code.

Table 1 summarizes the 2021 IRC requirements related to fill in flood hazard areas, notes changes from the 2015 and 2018 editions, and compares the IRC provisions to the NFIP requirements. Subsequent editions of the IRC should include comparable requirements.

Table 1: Comparison of Selected 2021 IRC Requirements with NFIP Requirements

Topic	Summary of Selected 2021 IRC Requirements and Changes from 2015 and 2018 Editions	Comparison with NFIP Requirements
Fill supporting foundations and nonstructural fill (Zone V and Coastal A Zones)	**Section R322.3.2 [Coastal high-hazard areas (including V Zones and Coastal A Zones, where designated)] Elevation requirements.** Prohibits the use of fill for structural support. Allows minor quantities of nonstructural fill for grading, landscaping, drainage, and to support parking slabs, pool decks, patios, and walkways. Change from 2018 to 2021: No change. Change from 2015 to 2018: No change.	Equivalent to NFIP 44 CFR § 60.3(e)(6) in Zone V and exceeds NFIP by prohibiting structural fill in Coastal A Zones. More specific than NFIP by specifying allowed uses of nonstructural fill.

Topic	Summary of Selected 2021 IRC Requirements and Changes from 2015 and 2018 Editions	Comparison with NFIP Requirements
Fill supporting foundations (in and out of FHA)	**Section R401.2 [Foundations] Requirements.** Requires fill soils supporting foundations to be designed, installed, and tested in accordance with accepted engineering practice. **Section R506.2.1 [Concrete Floors (on Ground)] Fill.** Requires fill material to be free of vegetation and foreign material and compacted to ensure support of slabs. Unless otherwise approved, specific maximum fill depths apply. <u>Change from 2018 to 2021</u>: No change. <u>Change from 2015 to 2018</u>: No change.	Equivalent to NFIP 44 CFR § 60.3(a)(3)(i) requirements for stability, with specific requirements for design, placement, content, and compaction of fill.
Site drainage (in and out of FHA)	**Section R401.3 [Foundations] Drainage.** Requires surface drainage to be diverted away from foundation walls to a collection point and specifies a minimum grade of 6 inches of fall within the first 10 feet, with exceptions. <u>Change from 2018 to 2021</u>: No change. <u>Change from 2015 to 2018</u>: No change.	Exceeds NFIP 44 CFR § 60.3(c)(11) by requiring drainage away from all dwellings, instead of only those in Zone AO and Zone AH, and by specifying minimum slopes for drainage.
Foundations (in and out of FHA)	**Section R404 Foundations and Retaining Walls.** Requires concrete and masonry foundation walls to be designed in accordance with accepted engineering practice where walls are subject to hydrostatic pressure from groundwater or where walls supporting more than 48 inches of unbalanced backfill do not have permanent lateral support. Foundation requirements are based on height of unbalanced backfill. **Section R405 Foundation Drainage.** Specifies requirements for foundation drainage for foundations that enclose habitable or usable space located below grade based on foundation material. **Section R406 Foundation Waterproofing and Dampproofing.** Specifies requirements for waterproofing and dampproofing of interior spaces and floors below grade based on foundation material. <u>Change from 2018 to 2021</u>: Requirements in Section R404 based on maximum unsupported wall height rather than maximum wall height. <u>Change from 2015 to 2018</u>: No significant changes.	Equivalent to NFIP 44 CFR § 60.3(a)(3)(i) requirements for stability, with specific requirements for foundation design. Equivalent to 44 CFR § 60.3(a)(3)(iii) with specific requirements for drainage and waterproofing.

3.2. International Building Code and ASCE 24

The International Building Code (IBC) applies to all applicable buildings and structures. While used primarily for buildings and structures other than dwellings within the scope of the IRC, the IBC may also be used to design dwellings.

The flood provisions of the latest published editions of the IBC generally meet or exceed NFIP requirements for buildings through reference to the standard ASCE 24, *Flood Resistant Design and Construction*. ASCE 24 is developed by the American Society of Civil Engineers (ASCE) and applies to structures that are subject to building code requirements.

International Building Code and ASCE 24 Commentaries

The ICC publishes companion commentary for the IBC, and ASCE publishes companion commentary for ASCE 24. Although not regulatory, the commentaries provide information and guidance that are useful in complying with, interpreting, and enforcing requirements of the code.

Table 2 summarizes the 2021 IBC and ASCE 24-14 requirements related to fill in flood hazard areas, notes changes from 2015 and 2018 IBC editions, and compares those provisions to the NFIP requirements. Subsequent editions of the IBC and ASCE 24 should include comparable requirements.

Table 2: Comparison of Selected 2021 IBC and ASCE 24-14 Requirements with NFIP Requirements

Topic	Summary of Selected 2021 IBC / ASCE 24-14 Requirements and Changes from 2015 and 2018 IBC	Comparison with NFIP Requirements
Testing of site soils and fill (in and out of FHA)	**IBC Section 1705.6 [Required Special Inspections and Tests] Soils.** Requires special inspections and tests of existing site soil conditions, fill placement, and load-bearing requirements, including continuous inspection of fill density and lift thickness during fill placement. Change from 2018 to 2021 IBC: Added specificity to fill inspection. Change from 2015 to 2018 IBC: No change.	Exceeds NFIP by requiring inspections and testing during placement of fill.

Topic	Summary of Selected 2021 IBC / ASCE 24-14 Requirements and Changes from 2015 and 2018 IBC	Comparison with NFIP Requirements
Soils and foundations (in and out of FHA)	**IBC Chapter 18 Soils and Foundations.** Specifies requirements for geotechnical investigations (Sec. 1803); excavation, grading, and fill (Sec. 1804); dampproofing and waterproofing (Sec. 1805); and unsupported height of backfilled foundation walls (Sec. 1807). Change from 2018 to 2021 IBC: No significant changes. Change from 2015 to 2018 IBC: See "Site grading" in this table.	Equivalent to NFIP 44 CFR § 60.3(a)(3)(i) requirements for stability, with specific requirements for foundation design. Equivalent to NFIP 44 CFR § 60.3(a)(3)(iii) with specific requirements for drainage and waterproofing.
Site grading (in and out of FHA)	**IBC Section 1804.4 [Excavation, Grading and Fill] Site grading.** Requires ground to be sloped away from foundations at a minimum 5% slope, with exceptions. Change from 2018 to 2021 IBC: No change. Change from 2015 to 2018 IBC: Added exception for certain door landings and ramps.	Exceeds NFIP 44 CFR § 60.3(c)(11) by requiring drainage away from all buildings, instead of only those in Zone AO and Zone AH, and by specifying minimum slopes for drainage.
Fill (in FHA)	**IBC Section 1804.5 [Excavation, Grading and Fill] Grading and fill in flood hazard areas.** Requires fill to be placed, compacted, and sloped to minimize shifting, slumping, and erosion during the rise and fall of floodwater and, as applicable, wave action. Prohibits fill in floodways unless analysis shows the fill will not cause any increase in flood levels. Prohibits fill in coastal high hazard areas unless fill is placed to avoid diverting water and waves toward buildings. [See "Fill in Zone V and Coastal A Zones" in this table] Change from 2018 to 2021 IBC: No change. Change from 2015 to 2018 IBC: No change.	Equivalent to NFIP 44 CFR § 60.3(a)(3)(i) with more specific requirements for performance under flood conditions. Equivalent to NFIP 44 CFR § 60.3(c)(10) and § 60.3(d)(3) floodway encroachment requirements. Equivalent to NFIP 44 CFR § 60.3(e)(6) prohibiting structural fill in Zone V.

Topic	Summary of Selected 2021 IBC / ASCE 24-14 Requirements and Changes from 2015 and 2018 IBC	Comparison with NFIP Requirements
Definition of fill	**ASCE 24 Section 1.2 Definitions.** Defines fill as "material such as soil, gravel, or crushed stone that is placed in an area to increase ground elevations." Defines structural fill as "fill placed and compacted to a specified density to provide structural support or protection to a structure."	Exceeds NFIP 44 CFR § 59.1 by defining fill and structural fill.
Geotechnical considerations and stability of fill (in all FHA)	**ASCE 24 Section 1.5.3.1 Geotechnical Considerations.** Requires foundation designs to be based on geotechnical characteristics of the soils and strata below the structure. **ASCE 24 Section 1.5.4 Use of Fill.** Requires fill to be stable under flood conditions, including rapid rise and rapid drawdown of floodwaters, prolonged inundation, and flood-related erosion and scour.	Equivalent to NFIP 44 CFR § 60.3(a)(3)(i) requirements for stability, with more specific requirements for performance under flood conditions.
Fill in floodways	**ASCE 24 Section 2.2 Development in Floodways.** Prohibits fill in floodways unless analysis shows the fill will not cause any increase in flood levels.	Equivalent to NFIP 44 CFR § 60.3(d)(3) and § 60.3(c)(10) floodway encroachment requirements.
Fill in Zone A	**ASCE 24 Section 2.4.1 Structural Fill.** In flood hazard areas other than Coastal High Hazard Areas and Coastal A Zones (i.e., in Zone A), permits structural fill if designed to account for soil consolidation and settlement, slope stability, and erosion control. Specifies maximum 12-inch lifts, compaction densities, and maximum side slope ratio of 1:1.5.	Equivalent to NFIP 44 CFR § 60.3(a)(3)(i) requirements for stability, with specific requirements for design, placement, content, and compaction of fill.
Fill in Zone V and Coastal A Zones	**ASCE 24 Section 4.5.4 Use of Fill.** Prohibits structural fill in Coastal High Hazard Areas and Coastal A Zones. Allows nonstructural fill for minimal site grading, landscaping, local drainage, and limited dune construction/reconstruction.	Equivalent to NFIP 44 CFR § 60.3(e)(6) in Zone V and exceeds by requiring prohibition in Coastal A Zones. More specific than NFIP by specifying allowed uses of nonstructural fill.

4. NFIP Flood Insurance Implications

NFIP flood insurance coverage is available for all eligible buildings in participating communities, including buildings located outside the SFHA. NFIP flood insurance rates are based on several flood risk factors, such as distance and elevation relative to flooding sources, first floor height above grade, building occupancy (residential, non-residential, other residential), foundation type, number of floors, and whether a basement or enclosure is below elevated buildings. In general, buildings with basements will have a higher premium due to an increase in risk than buildings on other foundation types if all other rating variables are the same.

The purchase of flood insurance is mandatory for federally backed mortgages on buildings in SFHAs in NFIP participating communities. The mandatory purchase requirement does not apply after FEMA officially removes filled land from the SFHA through the LOMR-F process. However, removal of filled land from the SFHA does not mean all risk of flooding is eliminated. Historically, approximately 25% of all claims paid by the NFIP have been for buildings located outside the SFHA. It is the lending institution’s prerogative to require flood insurance as a condition of a loan if it deems such action appropriate. FEMA encourages property owners and tenants to purchase flood insurance even when not required by mortgage lenders.

Designers, builders, and owners may wish to contact a qualified insurance agent or carrier with flood insurance experience for more information about policy coverage, coverage limits, and premium costs.

5. Documentation and Certification Requirements

Communities that participate in the NFIP are required to make a determination that applications for development in SFHAs comply with local floodplain management regulations. Permit applicants submit site plans, building plans, required documentation, analyses, and certifications. Local officials are responsible for reviewing applications for compliance.

To request a LOMR-F or CLOMR-F, permit applicants must prepare the MT-1 application forms, which help applicants gather the information that FEMA needs to determine whether the land or structures are likely to be flooded during a base flood event. The MT-1 application forms include a Community Acknowledgement Form to be signed by the local official responsible for floodplain management (Section 5.1 of this Technical Bulletin). To support the application review, local officials typically require permit applicants to submit supporting documentation, including a signed statement or certificate that the filled land and existing or proposed structures are or will be reasonably safe from flooding (Section 5.2 of this Technical Bulletin). At minimum, permit applicants must submit professionally certified elevation information (Section 5.3 of this Technical Bulletin).

Only FEMA can revise or amend FIRMs by issuing Letters of Map Change, including LOMR-Fs. Although a local official may conclude that a proposal to fill land is reasonably safe from flooding, the filled area must continue to be regulated as an SFHA until and unless FEMA issues a LOMR-F for the project. When fill is proposed but not yet placed, a CLOMR-F should be requested. A CLOMR-F does not revise the FIRM, nor does it suggest that FEMA has determined that the proposed building on fill will be reasonably safe from flooding. Therefore, issuance of a LOMR-F subsequent to an approved CLOMR-F to remove a building built in the SFHA with the lowest floor below the BFE is not guaranteed. To revise the FIRM, after construction is completed, the property owner must submit a subsequent LOMR-F application to document the as-built conditions. A basement with the basement floor below the BFE must not be excavated into fill where only a CLOMR-F has been issued, unless the building is in an approved basement exception community.

Local Permits Required

Communities that participate in the NFIP are responsible for regulating development in SFHAs by requiring and reviewing permit applications for compliance and issuing permits when in compliance with the permit requirements. Submission of an MT-1 application to FEMA is not an application for a permit, and FEMA's issuance of a LOMR-F or CLOMR-F is not authorization to perform the work described in the MT-1 application.

5.1. Community Acknowledgement Form (Signed by Local Official)

Property owners and developers seeking LOMR-Fs and CLOMR-Fs must ask local officials to sign the MT-1 Community Acknowledgement Form (Form 3). The Community Acknowledgement Form statement for requests involving the placement of fill includes the following:

> *As the community official responsible for floodplain management, I hereby acknowledge that we have received and reviewed this Letter of Map Revision Based on Fill (LOMR-F) or Conditional LOMR-F request. Based upon the community's review, we find the completed or proposed project meets or is designed to meet all of the community floodplain management requirements, including the requirement that no fill be placed in the regulatory floodway, and that all necessary Federal, State, and local permits have been, or in the case of a Conditional LOMR-F, will be obtained. … In addition, we have determined that the land and any existing or proposed structures to be removed from the SFHA are or will be reasonably safe from flooding as defined in 44 CFR 65.2(c), and that we have available upon request by DHS-FEMA, all analyses and documentation used to make this determination. For LOMR-F requests, we understand that this request is being forwarded to DHS-FEMA for a possible map revision.*

Environmental Compliance

In some areas, the placement of fill has been identified as a contributor to loss of habitat critical to endangered species. The Community Acknowledgement Form includes a statement about meeting the federal Endangered Species Act (ESA) requirements. Documentation of compliance with the ESA requirements is required to be submitted to FEMA prior to issuance of a CLOMR-F, or the local official must acknowledge that the ESA requirements were complied with independently of the FEMA process for LOMR-F requests. In addition, the local official must acknowledge that all necessary federal, state, and local permits have been or will be obtained, which may include environmental impacts such as wetlands development permits or local tree removal permits.

In order to complete the Community Acknowledgment Form, the local official must review the MT-1 application and accompanying documentation. If the local official can attest that the applicant has met or will meet the local floodplain management requirements including that the land and any existing or proposed structures to be removed from the SFHA are or will be reasonably safe from flooding, the local official should sign the Community Acknowledgement Form. If the local official is unable to sign the statement, for example if a proposal does not meet local requirements, the applicant's supporting documentation is insufficient to make a reasonably safe from flooding determination, or the local official concludes that a structure on filled land is not, or will not be, reasonably safe from flooding, the local official should not sign the Community Acknowledgement Form. MT-1 applications submitted for CLOMR-Fs/LOMR-Fs without the local official's signed Community Acknowledgement Form are incomplete and FEMA will suspend processing of the request. The permit applicant can then work with the local official to modify the project or submit additional documentation to achieve compliance.

5.2. Reasonably Safe from Flooding Documentation (Signed by Design Professional)

Local officials who have the authority to make determinations as to whether filled sites are reasonably safe from flooding should require permit applicants to submit appropriate information such as that described in this Technical Bulletin to review and to make the determination. A common practice is to require a signed statement or certificate by a qualified design professional to indicate that all land and existing or proposed structures to be removed from the SFHA, are or will be reasonably safe from flooding, according to the criteria described in this Technical Bulletin. An example certificate is shown in Figure 2.

NFIP Community Identification Number and Name

Project Name and Location (address, parcel number, lot and plat)

I, ______________________ certify that the plans and design for the aforementioned development is reasonably safe from flooding in accordance with the requirements of the community in which the project is located and the guidance provided in the latest edition of NFIP Technical Bulletin 10 related to ensuring that structures built on fill in or near SFHAs are reasonably safe from flooding.

I certify that the design and specifications for the placement of fill are in accordance with accepted professional practices.

The foundation type is: ☐ non-basement or ☐ basement

For basements, the determination is based on: ☐ simplified approach, or
☐ engineered analysis, or
☐ basement floor at or above BFE

Documents attached are: ______________________________

____

____

Certifier's Name	License Number	
Title		PLACE SEAL HERE
Company Name		
Address		

City	State	Zip Code	
Signature	Date	Telephone	Ext

Figure 2: Example certification for reasonably safe from flooding

Certifications may be provided by professional engineers, professional geologists, professional soil scientists, or other design professionals qualified to make such evaluations. Local officials should have the certification and its supporting documentation submitted with permit applications to be able to make reasonably safe from flooding determinations before issuing building or floodplain development permits. When developers propose fill in SFHAs in all or part of subdivisions, certifications by appropriate professionals should be required for each individually filled lot or proposed structure location. After reviewing MT-1 applications for LOMR-Fs/CLOMR-Fs, FEMA may require additional supporting data that supports the reasonably safe from flooding determination, such as the information outlined in this Technical Bulletin. The local official charged with reviewing the application and signing the Community Acknowledgement form should not sign the form unless the applicant provides sufficient documentation of the assumptions, analyses, and approaches used.

5.3. Elevation Form (Signed by Surveyor or Design Professional)

MT-1 applications must include elevation information certified by a licensed land surveyor, registered professional engineer, or architect authorized by state law to certify elevation information. The MT-1 application includes the Elevation Form (Form 2) to provide information that local officials can use in making the reasonably safe from flooding determination. The Elevation Form may be used for one property or multiple lots in subdivisions. If the LOMR-F request is to make a determination on a structure and the NFIP Elevation Certificate has already been completed, it can be submitted in lieu of the Elevation Form.

The local official can request additional elevation information, such as that provided on the NFIP Elevation Certificate, to use in making the reasonably safe from flooding determination. For requests that involve the proposed construction of buildings elevated on fill, the local official should use the elevation information to make sure that both the lowest adjacent grade elevation and the lowest floor elevation (including basement and crawlspace floors) are at or above the regulated BFE.

6. Best Practices for Administrative Procedures and Higher Regulatory Standards

Communities may choose to implement administrative procedures and adopt regulations to assist with gathering information to increase flood resistance of proposed development and to determine whether a proposed development is reasonably safe from flooding. Administrative procedures can help to alert plan reviewers of sites that have been removed from the SFHA by a LOMR-F so that proposed development on the site is reasonably safe from flooding and conforms to the LOMR-F application. Communities may also adopt higher regulatory standards to further reduce flood risk to buildings on land removed from the SFHA through the LOMR-F process, or to restrict development on or involving fill.

Regulatory Requirements May Exceed NFIP Requirements

Communities are encouraged to adopt local floodplain management regulations to reduce flood risk associated with development on filled areas removed from the SFHA by LOMR-Fs. The NFIP regulations specifically acknowledge that communities are encouraged to exceed the minimum criteria by adopting more comprehensive or higher standards [44 CFR § 60.1(d)] than the minimum criteria [44 CFR § 60.3]. In particular, the regulations note that local officials may have access to information or knowledge of conditions that warrant higher standards and encourage communities to adopt more restrictive criteria. The regulations explicitly state that any floodplain management regulations adopted by a state or community that are more restrictive than NFIP requirements shall take precedence.

The following are examples of administrative procedures and more restrictive or more specific requirements related to placement of fill in SFHAs:

- Stipulate that LOMR-Fs do not remove the land from the regulated flood hazard area for the purposes of floodplain management regulations. The mandatory flood insurance purchase requirement would be removed, but buildings would have to meet all building performance requirements, including that the lowest floor (including basement) be at or above the BFE.

- Develop a checklist of permit application submittals that are necessary when applicants propose placing fill in SFHAs and a checklist of plan review requirements to facilitate a thorough review of the submitted materials.

- When issuing permits for the placement of fill only (no building or structures), stipulate that no buildings can be built on the filled area without a subsequent building permit or floodplain development permit that includes consideration of residual risk, described in Section 1.4 of this Technical Bulletin and ensuring that the lowest floor elevation is at or above the elevation of the BFE that existed at the site prior to the LOMR-F.

- Require building sites that have been or will be filled to have building footprints identified on construction plans and on preliminary and final plats for subdivisions and other developments, and then evaluate those sites using the guidance described in this Technical Bulletin.

- Require grading plans that delineate filled building sites and building footprints as a condition of issuing fill permits and evaluate those building sites using the guidance described in this Technical Bulletin.

- Where building codes are not adopted, modify local floodplain management regulations to incorporate the design and placement of fill requirements of the I-Codes, summarized in Section 3 of this Technical Bulletin.

- Adopt buffer zones or setback zones around the perimeter of fill pads or at the edge of the floodplain and establish limits on construction in these zones.

- Require pilings or columns rather than fill, for the elevation of structures in the SFHA, in order to maintain the storage capacity of the floodplain and to minimize the potential for negative impacts to sensitive ecological areas [44 CFR § 60.22(c)(17)].

- Require applicants to demonstrate that the quantity of fill and area to be filled are the minimum necessary to achieve the intended objective. Limiting the quantity and area of fill limits environmental impacts by minimizing tree and vegetation removal and alteration of natural drainage and infiltration processes.

Floodplain Fill and Loss of Storage and Conveyance

Placing fill in SFHAs along riverine waterways can cause increases in BFEs by reducing the ability of the floodplain to store and convey floodwater. This can result in increased flood damage to both upstream and downstream properties. To reduce the risk of increased damage, some communities prohibit fill, require compensatory storage volume to offset the impact of filled areas, or identify a more restrictive floodway than is shown on FIRMs. At a minimum, the NFIP regulations regarding cumulative development in the SFHA and encroachment in the regulatory floodway must be met. Details of these requirements can be found in 44 CFR §§ 60.3(c)(10) and 60.3(d).

- Control development of filled areas and land that is immediately adjacent to floodplains but higher than the BFE to satisfy the requirement that future buildings in these areas are reasonably safe from flooding by adopting regulations to require permit applicants to sign legally binding agreements before the local official signs the MT-1 Community Acknowledgement Form. Communities may adopt higher standards to further reduce the risk of flooding. Conditions that can be included in binding agreements include:
    - Require, as a condition of final subdivision plat approval, that no basements can be built into filled lots or filled building sites
    - Specifically require that construction be designed, permitted, and constructed in accordance with the guidance in this Technical Bulletin
    - Prohibit excavation of fill for basements with floors below the BFE that existed prior to the placement of fill and the issuance of the LOMR-F
    - Require an agreement prohibiting basement apartments, or limiting basement use to parking of vehicles, building access, and storage
    - Prohibit locating critical facilities on land removed from the SFHA by LOMR-F

- Adopt requirements for areas proposed to be filled for building sites to be designed to have the top grade of the fill (after compaction and settlement) to be above the BFE (not “at the BFE”), especially when communities already require buildings to be elevated higher than the BFE (see Figure 3). Reasons for requiring additional elevation (called freeboard) above the BFE include:

- To better protect buildings when flooding rises higher than the BFE
- When newly available technical information indicates higher flood risk than what is shown in the effective FIRM or FIS or when existing conditions have changed that could increase flooding
- When an increase in upland development and the addition of impervious surfaces results in greater runoff that increases flood risk
- To account for future changes that may increase the BFE, including sea level rise and increased rainfall intensity or duration

- For communities that adopt freeboard above the BFE for lowest floor elevation, stipulate that the top grade of the fill must be at or above the elevation required for lowest floors.
- Adopt regulations to limit or prohibit the use of fill in Coastal A Zones, which are areas seaward of the Limit of Moderate Wave Action (LiMWA) delineated by FEMA on FIRMs. The LiMWA delineates where waves associated with coastal flooding are expected to be between 1.5 and 3 feet high during base flood conditions.
- Adopt regulations to limit or prohibit the use of fill in high risk flood hazard areas (e.g., areas prone to flooding from alluvial fans, flash floods, erosion, ice jams, debris, mudslides, high velocity flow, and wave action).
- Modify the sample Reasonably Safe From Flooding Certificate (Figure 2 in Section 5.2 of this Technical Bulletin) to stipulate that the design is reasonably safe from future flooding to a specific year (such as sea level or rainfall projections 50 years from the date of the application) or flooding associated with a higher mean recurrence interval, such as the 500-year flood.

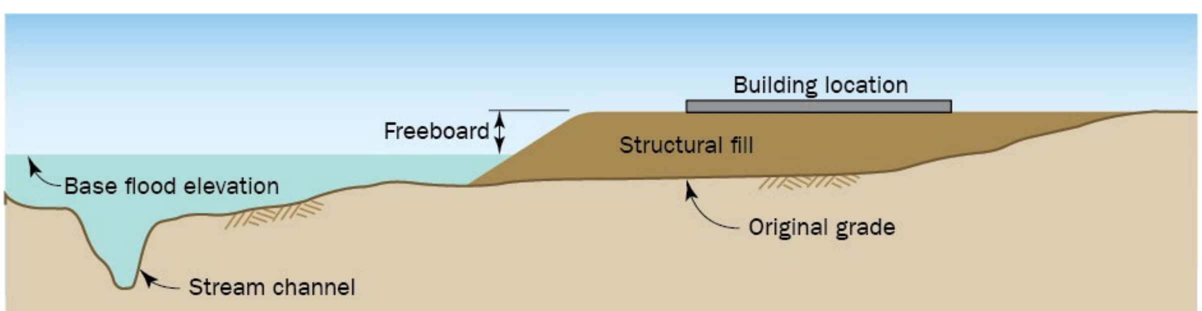


Figure 3: Filled site with freeboard above BFE

7. Proper Design and Placement of Fill

Proper design and placement of fill requires an understanding of soil mechanics, local site conditions, the specific characteristics of the earthen materials being placed, methods to place and compact the fill to achieve the desired characteristics, and soil testing procedures. Standard engineering and soil mechanics texts cover these subjects in detail.

Communities, property owners, designers, and builders should follow best practices when specifying the design and placement of structural fill. The NFIP does not specify requirements for the design and placement of fill in SFHAs, but the general performance requirements of the NFIP must be satisfied. The I-Codes and ASCE 24 have specifications for site grading, fill compaction, side slopes, protection of slopes from erosion during flooding, and design and performance of structural fill (see Section 3 of this Technical Bulletin). Where building codes are not adopted, the fill provisions of the I-Codes and ASCE 24 should be used as best practices or adopted into local floodplain management regulations.

Qualified professionals may be required to design the placement of fill in SFHAs intended to support buildings, and communities may require submission of the signed and sealed certification form described in Section 5.2 of this Technical Bulletin. Property owners should work with a licensed professional engineer, geotechnical engineer, engineering geologist, or other qualified professional licensed in the state in which the building is located to design the fill. The performance of filled areas should consider, but is not limited to, the following fill material characteristics:

- Engineering properties of existing and proposed fill material—soil classification, shear strength, compressive strength, maximum density, permeability, erodibility, liquefaction potential, etc.
- Geotechnical conditions at the site before placement of fill—bearing capacity, groundwater levels, presence of expansive soils or sinkholes, etc.
- Stratification between fill material and underlying soil
- Potential consolidation over time of the existing soil under the weight of added fill
- Effect of consolidation, settlement, or differential settlement of the fill
- Ability of the fill material and side slopes to resist flood-related erosion and scour, especially in SFHAs where base flood velocities exceed 5 feet per second (side slopes should be protected from erosion)
- Ability of fill material and side slopes to withstand rapid drawdown, which could alter the stability of the remaining fill
- How the permeability of fill material and underlying soil affects water infiltration into the fill, which may affect structures built on the site, especially buildings with below-grade basements

Permit application documents should include specifications for the placement of fill, including:

- Proper preparation of the site before fill placement (e.g., grading and compacting, moisture control)
- Thickness of lifts (layers of soil after compaction) and compaction densities
- Side slope ratios and slope stabilization methods
- Placement of fill such that the final top surface of the fill (after compaction and settlement) is at or above the BFE, or higher if freeboard is required, illustrated in Figure 3
- Final grading to drain surface runoff away from buildings

8. Constructing on Land Removed from SFHAs by Placement of Fill

Buildings that are constructed on land removed from the SFHA by the placement of fill have the lowest residual risk of flooding when the entire building (excluding subsurface foundation elements) is elevated above the BFE that existed prior to the placement of fill. Designs that place the lowest floor and below-grade areas at, rather than above, the BFE have a greater degree of residual risk even when flooding rises only slightly higher than the BFE. Designs that place the lowest floor (including a basement floor) below the BFE have the highest degree of risk, with an increased risk of subsurface flooding and damage from flooding that exceeds the BFE. Residual risks of flooding are described in Section 1.3 of this Technical Bulletin and relative residual risks by foundation type are summarized in Section 8.3 of this Technical Bulletin.

8.1. Non-Basement Foundations

Non-basement foundations do not have any enclosed area that extends below grade on all sides. Non-basement foundations consist of open, stem wall, perimeter walls (crawlspace), and slab-on-grade foundations. Non-basement foundations on fill are illustrated in Figure 4:

- **Open foundations (piles, columns, piers).** Open foundations provide a high degree of flood protection because the piles/columns/piers are used to raise the lowest floor above the surrounding grade and the area under the elevated building allows free flow of floodwater when flooding rises higher than the top surface of the fill. Unless footings extend into undisturbed soil, the fill must be placed to support the more concentrated loads under footings, which may need to be larger than footings that bear on undisturbed soil. This approach can provide freeboard and less resistance to flood forces when the area below the lowest floor is not enclosed. Constructing an open foundation and raising the lowest floor above the BFE provides the highest degree of flood protection especially in areas subject to coastal flooding and areas with high velocity floodwater.

- **Backfilled stem walls.** Stem walls backfilled with fill or gravel raise a floor above the surrounding grade. Backfilled stem wall foundations on fill provide a high degree of flood protection even when the top surface of the fill is at the BFE. Placing fill on the site prior to constructing a backfilled stem wall can provide freeboard for an additional degree of flood protection.

- **Perimeter walls.** Perimeter walls that form crawlspaces raise the floor above the surrounding grade. Perimeter wall foundations on fill provide a high degree of protection when flooding rises above the top surface of the fill. Installing flood openings in the perimeter walls is recommended to allow floodwater to enter the enclosed area to equalize hydrostatic pressure on foundation walls in the event of flooding that exceeds the BFE (see NFIP Technical Bulletin 1, *Requirements for Flood Openings in Foundation Walls and Walls of Enclosures*). Perimeter wall construction is less preferred than the backfilled stem wall construction as an enclosure is created.

- **Slab-on-grade.** Slab-on-grade foundations constructed on fill provide the least flood protection of the non-basement foundations because the floor of the building typically is not elevated above the adjacent grade more than a few inches. Water will enter slab-on-grade buildings when flooding rises higher than a few inches above the top surface of the fill. Placing additional structural fill beneath the building footprint to a level above the BFE increases flood protection.

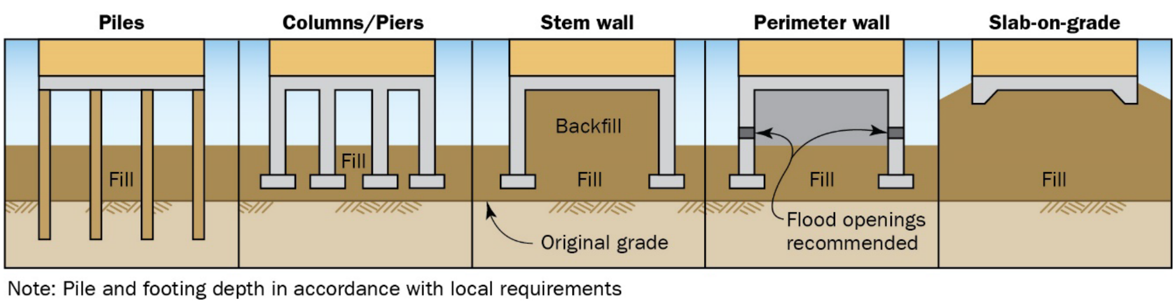


Figure 4: Non-basement foundation types

8.2. Basement Foundations

NFIP minimum floodplain management requirements generally do not allow basements (any areas that are below-grade on all sides) in SFHAs because of the increased risk of flood damage. However, if FEMA approves the removal of land from the SFHA by the LOMR-F process, floodplain management requirements for buildings in SFHAs no longer apply. Although not recommended, builders and property owners who build on land removed from the SFHA through the LOMR-F process sometimes elect to construct basements. Basements excavated in fill are at higher risk of flood damage than the non-basement foundation types described in Section 8.1 of this Technical Bulletin.

Regulating Excavated Basements for Buildings Elevated on Fill

Filled areas must be regulated as being in the SFHA unless or until FEMA issues the LOMR-F or LOMR, which will remove the filled area from the SFHA. That means that LOMR-F applications involving constructing buildings with basements and simultaneously placing fill (where the land has not yet been removed from the SFHA) are a violation and will not be approved unless the basement floor is at or above the BFE.

In other words, basements with the lowest floor below the BFE, excavated into fill, are prohibited unless the land is first removed from the SFHA through the LOMR-F process prior to construction commencing (or in an approved basement exception community). Additionally, basements that are part of engineered, dry floodproofed non-residential buildings (in Zone A only) are allowed in the SFHA.

Basement foundations enclose areas that extend below grade on all sides. The scenarios described in this section are listed in order of increasing risk of flood damage. Basement foundations in fill are illustrated in Figure 5:

- **Basement floor at or above BFE.** Placing the floor of a basement in fill at or above the BFE effectively eliminates risk of damage when flooding rises to the BFE. In general, the higher the basement floor is relative to the BFE, the lower the risk of damage from seepage and hydrostatic pressure caused by saturated soils.

- **Basement floor below BFE.** Placing the floor of a basement in fill below the BFE may expose the basement walls and floor to damage from seepage and hydrostatic pressure caused by saturated soils when flooding rises up to or higher than the BFE.

- **Lowest opening above BFE.** Regardless of where the floor of a basement in fill is placed, risk of flood damage is increased when an opening (window well or exterior doorway) is located below-grade, even when positioned above the BFE. When below-grade openings are located above the BFE, then seepage associated with soils saturated by flood up to the BFE would not enter the basement through those openings. However, below-grade openings would allow surface water into the basement when flooding rises higher than the top of the fill.

- **Lowest opening at or below BFE.** Placing the floor of a basement in fill below the BFE with a below-grade opening (window well or exterior door) also located below the BFE increases the risk of damage. If the fill becomes saturated when flooding rises up to or higher than the BFE, the below-grade openings could allow seepage to enter the basement. Below-grade openings would also allow surface water into the basement when flooding rises higher than the top of the fill.

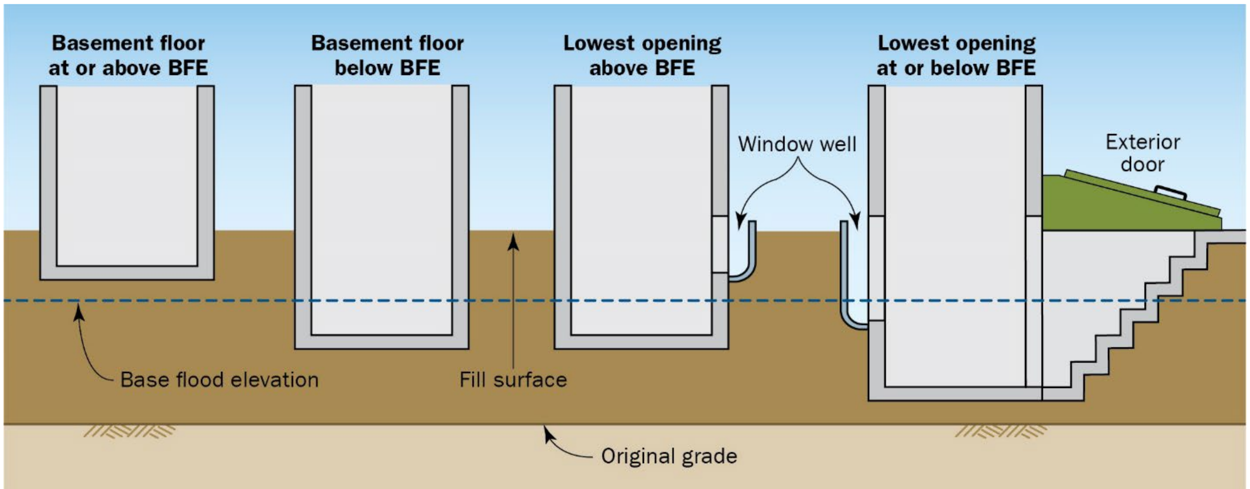


Figure 5: Four scenarios of basements built into fill

Number of Sides Below Grade

An enclosure that is below the exterior ground level on all sides is a basement regardless of the depth below grade or the height of the enclosure (headroom). An area of a building that is below grade on two or three sides (i.e., the floor or interior grade is at or above the exterior grade along at least one entire side) is not a basement, although the area may be called a walkout basement, daylight basement, or terrace or garden level.

8.2.1. RISK OF SUBSURFACE FLOODING

Constructing a basement foundation in filled land is not recommended because the basement floor and portions of the basement walls can be subject to subsurface flooding. High groundwater at a site with a basement can result in water infiltrating the basement or significantly increasing hydrostatic pressures on the walls and basement slab, which can cause failure or permanent deformation of the walls (see Figure 6). Approaches to analyzing seepage (saturation and infiltration) of water into filled soils are described in Section 9 of this Technical Bulletin. Even when surface floodwater has not reached buildings with basements, FEMA has seen numerous examples of flooded basements, bowed basement floors, and collapsed basement walls caused by high groundwater associated with nearby flooding.

Figure 6: Unreinforced masonry walls of a basement that failed because of the pressure exerted by water and saturated soil

Another reason why constructing basement foundations in filled land is not recommended is because when flooding rises higher than the top of the filled area, the basement area may be completely inundated, especially if the basement has window wells or an exterior entrance. When builders and building owners decide to accept the additional risk associated with basement construction on filled land, they need to satisfy the requirement that the basement and the rest of the building are reasonably safe from flooding.

8.2.2. RECOMMENDATIONS TO REDUCE RISK OF SUBSURFACE FLOODING

To be reasonably safe from flooding during base flood conditions, proposed or existing structures on filled land must not be vulnerable to damage by subsurface flooding. This means that during base flood conditions, the basements are dry, structurally sound, and not exposed to lateral hydrostatic and uplift pressure (buoyancy loads) and saturated soil loads that either exceed the structural capacity of walls and floors or that cause unacceptable deflections.

This Technical Bulletin does not address the structural design of foundations and basement walls, nor does it address the design of drainage systems. Floors, slabs, and walls should be designed for the hydrostatic pressures that can occur during conditions of flooding. For structural design, it is recommended that the full hydrostatic pressures be assumed as unrelieved by a subsurface drainage system. Foundation walls that are not designed for full hydrostatic pressures should not be used. Soils around the basement should have low permeability to minimize or stop water infiltration into the basement walls and floor. Regardless of the permeability of the fill soils, water that infiltrates to the basement should be removed by a drainage system on the outside (soil side) of the basement. Sump pumps to remove seepage into below-grade areas should also be considered.

To minimize the additional risk of subsurface flooding, the following site planning and construction practices are recommended:

- Locate structures as far from the SFHA as possible (farther back from the edge of the fill closest to the flooding source).
- Elevate basement floors as much as possible, preferably to or above the BFE. As the elevation of the basement floor increases, the risk of subsurface flooding decreases.
- For below-grade areas, implement flood-resistant construction practices, including fill material specifications and compaction, and use of flood damage-resistant materials, properly sized sump pumps, and foundation drainage.
- For below-grade areas, to stop the capillary transmission of water from soil to concrete, provide a capillary break (a physical gap between the water or wet soil and the foundation wall). This can be a waterproof membrane, a layer of granular fill (gravel or crushed stone), or a manufactured drainage membrane against the basement wall.
- Grade the surrounding area to slope away from the structure.
- Implement construction practices or requirements based on local knowledge of conditions and the risk of subsurface flooding.

Warning about Pumping Basements

Owners and occupants should take precautions before pumping out water from flooded basements. When floodwater is rapidly pumped from basements and the soil surrounding the basement walls is still saturated, the walls can collapse, and the floor can be pushed up or cracked. As the water level in the basement drops, the outside pressure on the basement walls and floor can become greater than the inside pressure.

When basements are flooded, owners should contact experienced contractors to determine when and how best to safely pump out basements.

8.3. Relative Residual Risk by Foundation Type

Residual risks are described in Section 1.3 of this Technical Bulletin. The degree of residual risk that a foundation built on or in fill is exposed to depends on the proper design and placement of fill (see Section 7 of this Technical Bulletin), site-specific conditions (such as soil mechanics, hydrology, and topography), and the following building-related factors:

- The foundation type
- The elevation of the foundation or floor relative to the BFE

- The elevation of fill relative to the BFE
- The location of windows, window wells, doors, or other openings (basement foundations only)

Table 3 and Table 4 summarize the features of non-basement foundations (see Figure 4) and basement foundations (see Figure 5) that are described in Sections 8.1 and 8.2 of this Technical Bulletin and rank the combinations of elevation and foundation types in terms of relative residual risk compared with open foundations, which have the lowest degree of risk. The tables indicate whether each combination results in buildings that are reasonably safe from flooding. Where noted in Table 4, some combinations are reasonably safe from flooding only when seepage analyses are prepared by a qualified professional as described in Section 9 of this Technical Bulletin.

Table 3: Non-Basement Foundations: Relative Residual Risk Based on Foundation Type and Elevations

Relative Residual Risk	Foundation Type	Fill Elevation	Lowest Floor Elevation	Reasonably Safe from Flooding?
None	Piles, columns, piers	Above BFE	Above BFE	Yes
		At BFE	Above BFE	Yes
Minor	Backfilled stem wall	Above BFE	Above BFE	Yes
		At BFE	Above BFE	Yes[1]
Minor	Perimeter wall (crawlspace)	Above BFE	Above BFE	Yes
		At BFE	Above BFE	Yes[1]
Moderate	Slab-on-grade	Above BFE	Above BFE	Yes
		At BFE	At BFE	Yes[1]

(1) Non-basement foundations with fill elevation at the BFE are not recommended because buildings are vulnerable when flooding rises higher than BFE

Table 4: Basement Foundations: Relative Residual Risk Based on Elevations

Relative Residual Risk	Fill Elevation	Basement Floor Elevation	Opening Location	Reasonably Safe from Flooding?
Minor	Above BFE	Above BFE	Above BFE	Yes
	Above BFE	At BFE	Above BFE	Yes
Moderate	Above BFE	Below BFE	Above BFE	Only when using simplified approach or verified by engineering analysis (see Section 9 of this Technical Bulletin).

Relative Residual Risk	Fill Elevation	Basement Floor Elevation	Opening Location	Reasonably Safe from Flooding?
High	At BFE	Below BFE	Above BFE	Only when using simplified approach or verified by engineering analysis (see Section 9 of this Technical Bulletin).
	At BFE	Below BFE	At BFE	Only when using simplified approach or verified by engineering analysis (see Section 9 of this Technical Bulletin).
	Above BFE	Below BFE	Below BFE	No
	At BFE	Below BFE	Below BFE	No

Note: Basement foundations are not recommended because buildings are vulnerable when flooding rises higher than the BFE. Basements excavated into fill are prohibited below the BFE, unless the land has been removed from the SFHA by LOMR-Fs or LOMRs prior to construction (or in an approved basement exception community).

Elevator Pits Below Grade on All Sides

NFIP Technical Bulletin 4, *Elevator Installation*, provides guidance for construction of elevator pits. When elevator pits are the minimum size necessary and are designed in accordance with the guidance, the pits are not considered basements.

9. Basement Foundations: Technical Approaches to Seepage Analysis to Determine Reasonably Safe from Flooding

This section provides guidance on seepage analysis and measures that can be taken when building owners desire to construct basements in land that has been filled and removed from the SFHA by a LOMR-F. The guidance will help protect and satisfy the requirement that the basements are reasonably safe from flooding. Local officials should be cautious about allowing excavation for basements in filled areas without consideration of seepage during flood events, even when the filled areas are officially removed from the SFHA.

The guidance in this section is not to be used to make a determination that existing structures with the lowest floor (basement) below the BFE are reasonably safe from flooding.

Communities must regulate filled areas as SFHAs, unless the filled areas are officially removed from the SFHA by FEMA. Non-basement foundations (open foundations, backfilled stem wall, perimeter wall, slab-on-grade) and basement foundations with basement floors at or above the BFE can be used and are assumed to be reasonably safe from flooding (see Section 8.3 of this Technical

Bulletin). However, basements with floors proposed below the BFE are not permitted for residential buildings if the filled areas are still in the SFHAs. Non-residential buildings in SFHAs may have basements provided the floodplain management requirements for dry floodproofing are satisfied.

Limitations

The guidance in this section does not apply to:

- New construction or substantially improved buildings in SFHAs (not removed through the LOMR-F process). The NFIP regulations require buildings and structures in SFHAs to have the lowest floors, including basements, at or above the BFE. In effect, areas that are below grade on all sides (basements) are not permitted (unless authorized as part of dry floodproofed non-residential buildings).
- Placement of fill around existing residential or non-residential buildings where the lowest floor is below the BFE with the intent of changing the lowest adjacent grade to remove the building from the SFHA.

The first step in determining whether a basement will be reasonably safe from flooding is to analyze seepage that may occur during base flood conditions. For a local official to deem a building reasonably safe from flooding, the analysis must show that base floodwater will not inundate the land or damage structures and that any subsurface waters related to the base flood will not damage buildings.

The two approaches to seepage analysis described in this section—the simplified approach and the engineered analysis approach—may be used to evaluate proposed buildings with basement floors below the BFE in filled areas. The simplified approach is presented first. When the design requirements, limitations, and assumptions for the simplified approach are not met or are not applicable, the engineered analysis approach must be used.

Some possible means for evaluating whether the limitations and requirements of the approaches are met may require soil tests and investigations, including soil borings and hand augers; field records from the time the fill was placed; and soil surveys. If the standards of practice, design requirements, and conditions for use of the simplified approach are not met, a licensed professional engineer, geotechnical engineer, engineering geologist, or other qualified professional must perform the more detailed analysis described for the engineered analysis approach. More extensive soil investigations and testing will likely be necessary to complete the analysis and demonstrate that buildings will be reasonably safe from flooding.

Documentation to Submit

Documentation of the approach used, including assumptions and analysis performed, should be submitted to the local official so the local official can make the reasonably safe from flooding determination. Local officials responsible for signing the Community Acknowledgment Form can use the requirements and limitations of the simplified and engineered analysis approaches as an aid to determine whether sufficient analyses and documentation are provided (see Section 5.1 of this Technical Bulletin).

9.1. Simplified Approach

The simplified approach is a set of design requirements and limitations (see Section 9.1.1 of this Technical Bulletin) for basement foundations excavated in fill with basement floors below the BFE. If the design requirements and limitations are satisfied, the buildings are reasonably safe from flooding. Section 9.1.2 of this Technical Bulletin outlines the assumptions for the simplified approach.

If any one of the design requirements, limitations, or assumptions of the simplified approach are not satisfied, the more detailed engineered analysis approach described in Section 9.2 of this Technical Bulletin must be performed to determine whether a building with a basement floor below the BFE can be considered reasonably safe from flooding.

9.1.1. DESIGN REQUIREMENTS AND LIMITATIONS

The simplified approach does not eliminate the need for soil tests and investigations, which will likely require a licensed professional engineer, geotechnical engineer, engineering geologist, or other qualified professional. A qualified professional should consider the proposed building design and should investigate and document proposed fill material characteristics and the site conditions. The design requirements and limitations of the simplified approach are presented in this section and grouped as building design, fill placement, fill material characteristics, and site conditions. Figure 7 illustrates these requirements and limitations.

Limiting Assumption for the Simplified Approach

The simplified approach assumes there will be no hydrostatic pressure on the foundation because a standard drainage system is provided. The drainage system must include a sump pump that discharges above the BFE and has backup power to function during floods.

Building Design

To use the simplified approach:

- The footprint of the basement must be less than or equal to 1,200 square feet.

- The basement must have no open penetration through the wall or floor.
- The basement floor must be less than 5 feet below the BFE. The depth of the basement floor can be shallower to achieve more favorable conditions.
- There must be a granular drainage layer beneath the floor slab. If a granular soil (typically gravel or sand) is used as the drainage layer below the slab, the gradation of the drainage material should be designed to be compatible with the gradation of the fill material to reduce movement of fines. Crushed stone wrapped with filter fabric below the slab and around the perimeter of the foundation may be an option.
- A minimum of at least one single ¼-horsepower sump pump with a backup power supply must be provided to remove seepage from the drainage layer. More than one sump pump or a sump pump with higher capacity (the horsepower requirement, also called “size”) may be necessary. The total pump capacity must be calculated based on the quantity of seepage flow, which depends on soil permeability and other site conditions (see Figure 8 and Equation 1 in Section 9.1.2 of this Technical Bulletin). The pump must be rated at four times the estimated seepage rate and must discharge above the BFE and away from the building. This arrangement is essential to prevent build-up of hydrostatic pressure against the basement walls and uplift of the floor under the effect of the seepage pressure.
- The drainage system must be equipped with a positive means of preventing backflow.

I-Code Exception for Foundation Drainage

The I-Codes generally allow foundation drains to discharge through either mechanical means or gravity drains and do not require drainage systems in well-drained soils (gravel or sand/gravel mixture). In or near floodplains, well-drained soils can increase groundwater flow toward the building foundation during conditions of flooding. Therefore, this exception should not apply in or near floodplains.

Fill Placement

To use the simplified approach:

- The filled ground surface around the building and within a defined setback distance from the new edge of the SFHA must be at or above the BFE. The setback distance is measured from the new edge of the SFHA to the nearest wall of the basement. The minimum allowable setback distance is 20 feet.
- The fill material—or existing underlying soil of similar classification and degree of permeability as the fill material—must extend to at least 5 feet below the bottom of the basement floor slab.
- The fill material must be compacted to at least 95% of its maximum standard proctor density according to ASTM International (ASTM) Standard D698, *Standard Test Methods for Laboratory*

Compaction Characteristics of Soil Using Standard Effort (ASTM 2021a). Alternatively, the fill material must be compacted to at least 90% of its maximum modified proctor density according to ASTM Standard D1557, *Standard Text Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort* (ASTM 2021b).

Fill Material Characteristics

To use the simplified approach:

- The fill material must be homogeneous and isotropic, which means the fill material must be all of one material, and the engineering properties must be the same in all directions.
- Fill soils must be fine-grained soils of low permeability, such as those classified as CH, CL, SC, or ML according to ASTM Standard D2487, *Standard Practice for Classification of Soils for Engineering Purposes* (ASTM 2020). See IRC Table R405.1 for descriptions of these soil types.

Site Conditions

To use the simplified approach:

- The normal and seasonal high water table (including perched water table) must be lower than the proposed floor of the basement.
- There must be a constant soil type and density over the seepage flow zone (measured horizontally by the setback distance between the building and the edge of the SFHA and vertically from the BFE to the base of the seepage flow zone). The underlying soils at the site must not have stratified soil layers.
- The depth of the base of the seepage flow zone must be able to be defined (see Figure 8 in Section 9.1.2 of this Technical Bulletin). This depth is needed in the calculation of the quantity of seepage flow, which is necessary to determine the total quantity of seepage that determines the required sump pump capacity.
  - If the base of the seepage flow zone is not known, its depth below the bottom of the basement floor slab can be conservatively approximated as one-half of the building width most nearly perpendicular to the shoreline or bank of the source of flooding. This would approximate the boundary effects of the three-dimensional seepage flow in that it would represent the flow coming in from all sides and meeting in the center beneath the floor slab.

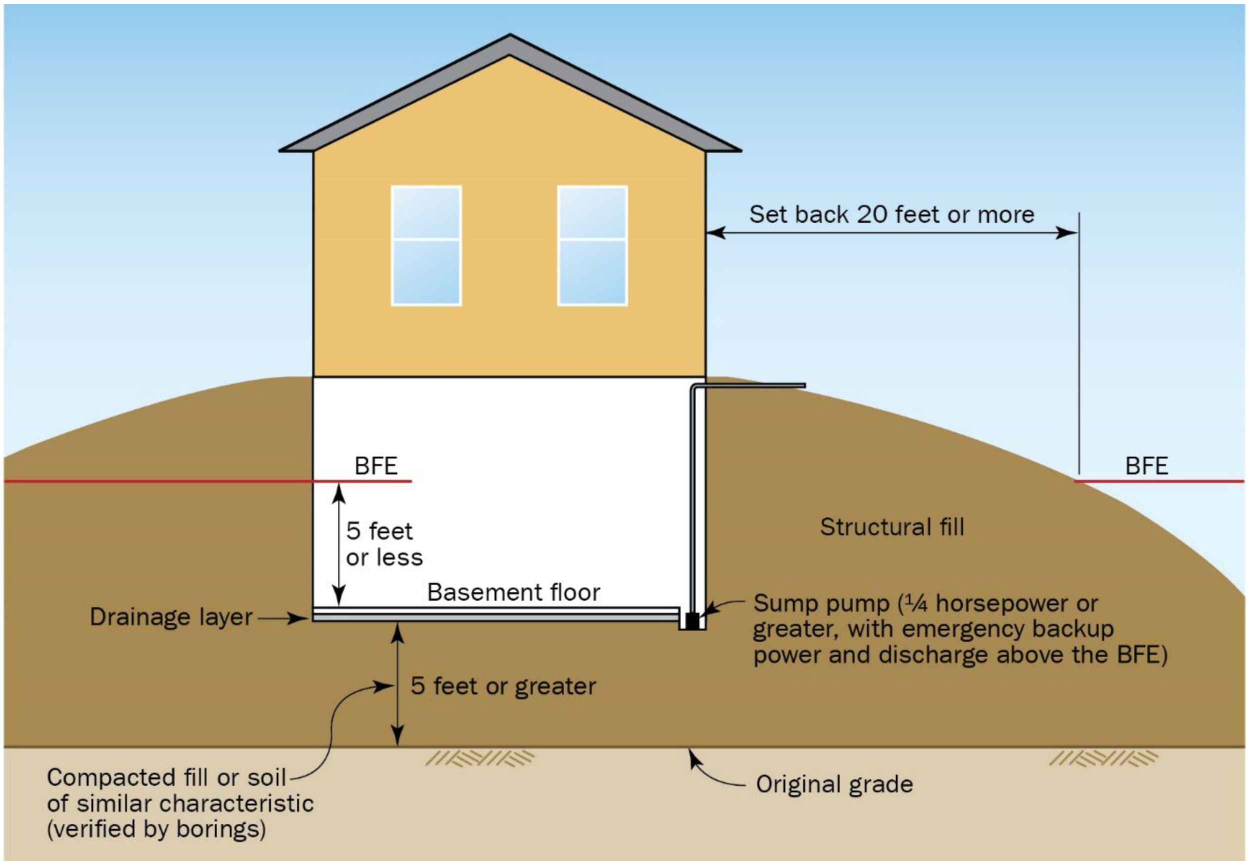


Figure 7: Limitations on the use of the simplified approach to basement construction

9.1.2. ASSUMPTIONS FOR THE SIMPLIFIED APPROACH

The simplified approach is based on the following assumptions:

- The soil is saturated. Using this assumption means there will be no time lag in the development of the seepage pattern with a change in flood levels. The groundwater table in many floodplains is shallow and fine-grained soils have a substantial potential for maintaining saturation above the water table by capillary rise.

- The tailwater level is at the elevation of the BFE. For this Technical Bulletin, “tailwater” is defined as the groundwater level on the side of the building away from the flooding source. This is a reasonably conservative assumption because the groundwater level is expected to rise during flooding conditions. In some cases, the tailwater level can be higher than the flood level because there is higher ground, such as a valley wall, that drains groundwater into the floodplain soils.

- The quantity of seepage flow can be calculated by the Dupuit equation for flow in an unconfined aquifer, in this case for flow in fill. The Dupuit equation uses Darcy’s law with specific physical characteristics. A more detailed description of these equations and their application can be found in standard references for soil mechanics and groundwater hydrology. The Dupuit equation and the values used in the Dupuit equation are illustrated in Figure 8.

- The entry surface, with hydraulic head "*a*," is a vertical line measured beginning where the BFE intersects the fill, extending down to the base of seepage flow zone.

- The exit surface, with hydraulic head "*b*," is a vertical line measured beginning from the basement floor closest to the fill slope, extending down to the base of seepage flow zone.

- The length of the flow path, "*L*," is the setback distance.

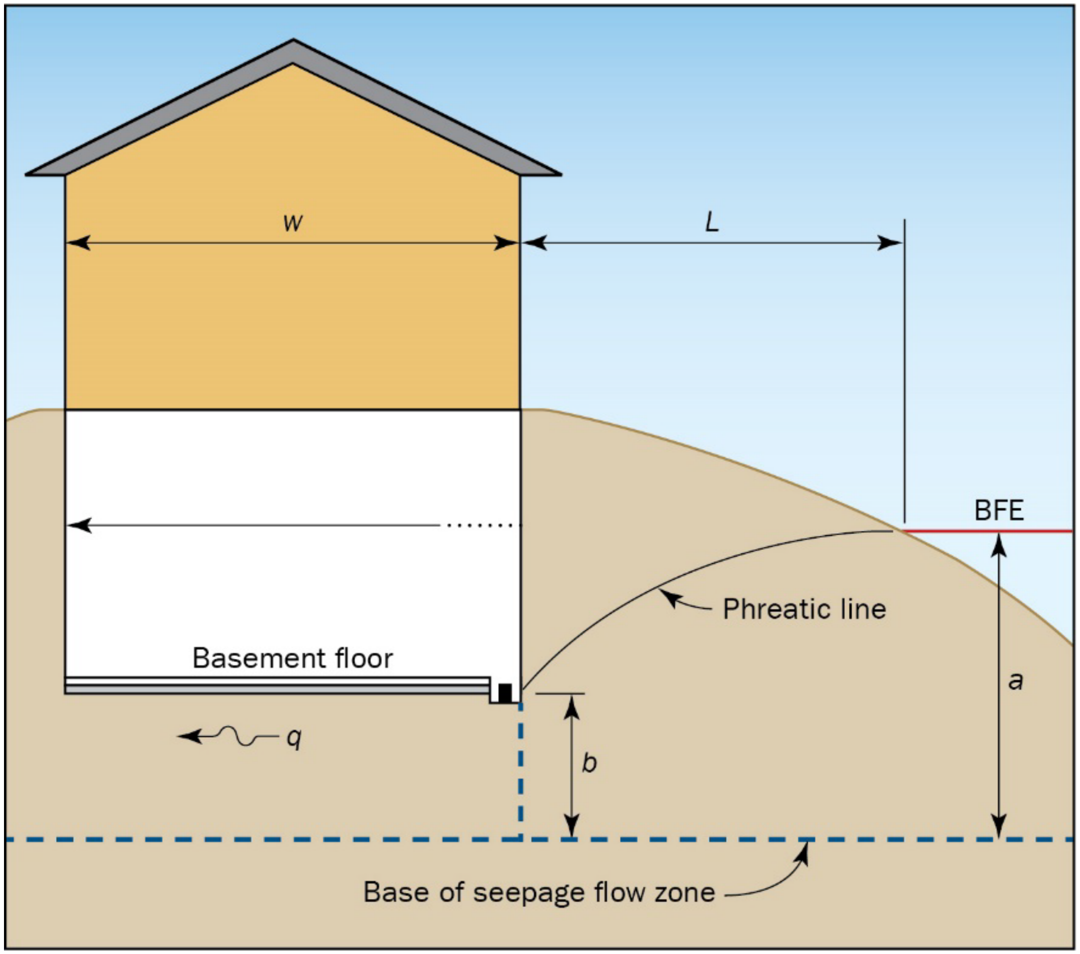
- Flow is assumed to be horizontal. For simplicity, the small, inclined entry zone at the edge of the water source and the exit zone below the basement floor are ignored. This is a reasonably conservative measure.

- The soil permeability, "*k*," is based on the type of fill soils. Because the soils must be homogeneous and seepage flow is assumed to be horizontal, only one value for "*k*" is used.

- The phreatic line (the line below which the seepage flow occurs), extends from the edge of the fill in contact with floodwater to the bottom of the basement floor slab. If the exit zone below the basement floor was included, the hydraulic head at "*b*" would be higher. As shown in Figure 8, the phreatic line is not a straight line, but within the limits of the boundary values assumed for the simplified approach, it is close to a straight line.

- To obtain the total quantity seepage flow in cubic feet per second, the value "*Q*," the unit quantity of seepage, "*q*," is multiplied by the length around the perimeter of the below-grade portion of the building, "*P*."

Soil permeability, "*k*," has a significant effect on the quantity of seepage that must be collected and discharged by the drainage layer and sump pump. The calculation of "*Q*" determines the number and capacity of sump pumps (the horsepower requirement, also called "size"). To allow for possible errors in the estimation of soil permeability, the pump or pumps should have a capacity of at least four times the calculated value of "*Q*." As noted in Section 9.1.1 of this Technical Bulletin, a minimum of at least one standard sump pump of ¼ horsepower is needed to satisfy the requirements of seepage removal for the conditions described in this section for use of the simplified approach. Equation 1 shows an example calculation of sump pump capacity.



The Dupuit equation for the quantity of seepage flow is:

$q = k(a^2 - b^2)/2L$

where: q = flow in cubic feet per second for a 1-foot width of seepage zone

k = soil permeability in feet per second (fps) (maximum value of k is 1×10^{-3} fps)

a = hydraulic head at entry surface in feet ($a < b + 5$)

b = hydraulic head at drain surface in feet

L = length of the seepage zone (setback distance) in feet ($L > 20$ feet)

The equation for the total seepage flow is:

$Q = Pq$

Q = total seepage flow in cubic feet per second

P = length around the perimeter of the below-grade portion of the structure

Required sump pump capacity is:

Capacity = $4Q$

Figure 8: Method of calculating quantity of seepage flow using the Dupuit equation

The following is an example calculation of sump pump capacity within the limits of the simplified approach. The variables are defined in Figure 8.

Equation 1:

$$q = \frac{k\left(a^2 - b^2\right)}{2L} = 1 \times 10^{-3} \times \frac{81 - 25}{40} = 0.0014 \text{ cubic feet per second per linear foot}$$

$$Q = P \times q = 140 \times 0.0014 = 0.196 \text{ cubic feet per second}$$

$$\text{Capacity} = 4Q = 4(0.196) = 0.784 \text{ cubic feet per second}$$

Where:

k = 1x10^{-3} feet per second

a = 9 feet

b = 5 feet

L = 20 feet

P = 140 feet (length = 40 feet; width = 30 feet)

9.2. Engineered Analysis Approach

The engineered analysis approach is an evaluation of proposed fill soils and seepage when basements are excavated into fill. When the design requirements, limitations, and assumptions described for the simplified approach (Section 9.1 of this Technical Bulletin) cannot be satisfied, detailed engineering analyses must be prepared by a licensed professional engineer, geotechnical engineer, engineering geologist, or other qualified professional. Reports of the results of the analyses help local officials to determine whether proposed buildings with basements constructed in fill with the basement floor below the BFE will be reasonably safe from flooding, which is needed for the local official to be able to sign the MT-1 Community Acknowledgement Form. Detailed engineering analyses should consider, but are not limited to, the issues described in the following sections.

9.2.1. DEPTH, TYPE, AND STRATIFICATION OF SOILS

The combination of depth of soil, soil type, and stratification of soils at specific sites may be complex, whether the soils are natural soils or fill material. An engineering analysis of whether a basement will be reasonably safe from flooding must account for variations in soils as part of applying the Dupuit equation to estimate the total amount of seepage that must be collected and discharged by the drainage layer and sump pump (see Figure 8 and Equation 1). The total amount of seepage determines the number and size (or capacity) of sump pumps necessary.

Terminology: Pervious and Impervious Soils

In the Dupuit equation, soil permeability, "k," varies based on the characteristics of the soils:

- **Pervious soils**, also called well drained soils, allow relatively free movement of water.
- **Impervious soils** have low infiltration rates and offer resistance to the movement of water.

It is common for natural floodplain soils to be stratified in layers of different soil compositions. Four general cases illustrating how soil types and stratification affect seepage into basements are shown in Figure 9. Case A and Case B show homogeneous soils and Case C and Case D show simple stratified soils:

- **Case A** illustrates impervious clayey soils, either fill or natural deposits or a combination, which are more or less homogeneous and have similar engineering properties, including low permeability. If an adequate setback distance is provided (see "L" in Figure 8), the quantity of seepage flow ("*q*") into a basement would be relatively low, and uplift pressure beneath the slab could be controlled by a drainage layer and adequately sized sump pump.

- **Case B** illustrates pervious sandy soils, either fill or natural soil deposits or a combination, which are more or less homogeneous and have similar engineering properties, including high permeability. The quantity of seepage flow ("*q*") into a basement could be fairly large, in which case attention would have to be given to the setback distance and to the design of the drainage layer and an adequately sized sump pump to prevent excessive uplift pressure beneath the floor slab.

- **Case C** illustrates stratified soils with the contact between the two strata at some distance below a proposed basement floor. The quantity of seepage flow would be moderate, depending on the thickness ("*d*") of the layer of impervious soils below the basement floor. There is also potential for uplift pressure beneath the floor slab, at the level of the bottom of the impervious stratum. These factors must be considered when specifying the drainage layer and when determining an adequate number and size (capacity) of sump pumps.

- **Case D** shows impervious soils overlying pervious soils, with the contact between the soil strata at some distance above the basement floor. Depending on how deep into the pervious layer the basement extends, there could be a large quantity of seepage ("*q*") and potential for excessive uplift beneath the basement floor, which must be controlled by installing a drainage layer and an adequate number and size (capacity) of sump pumps.

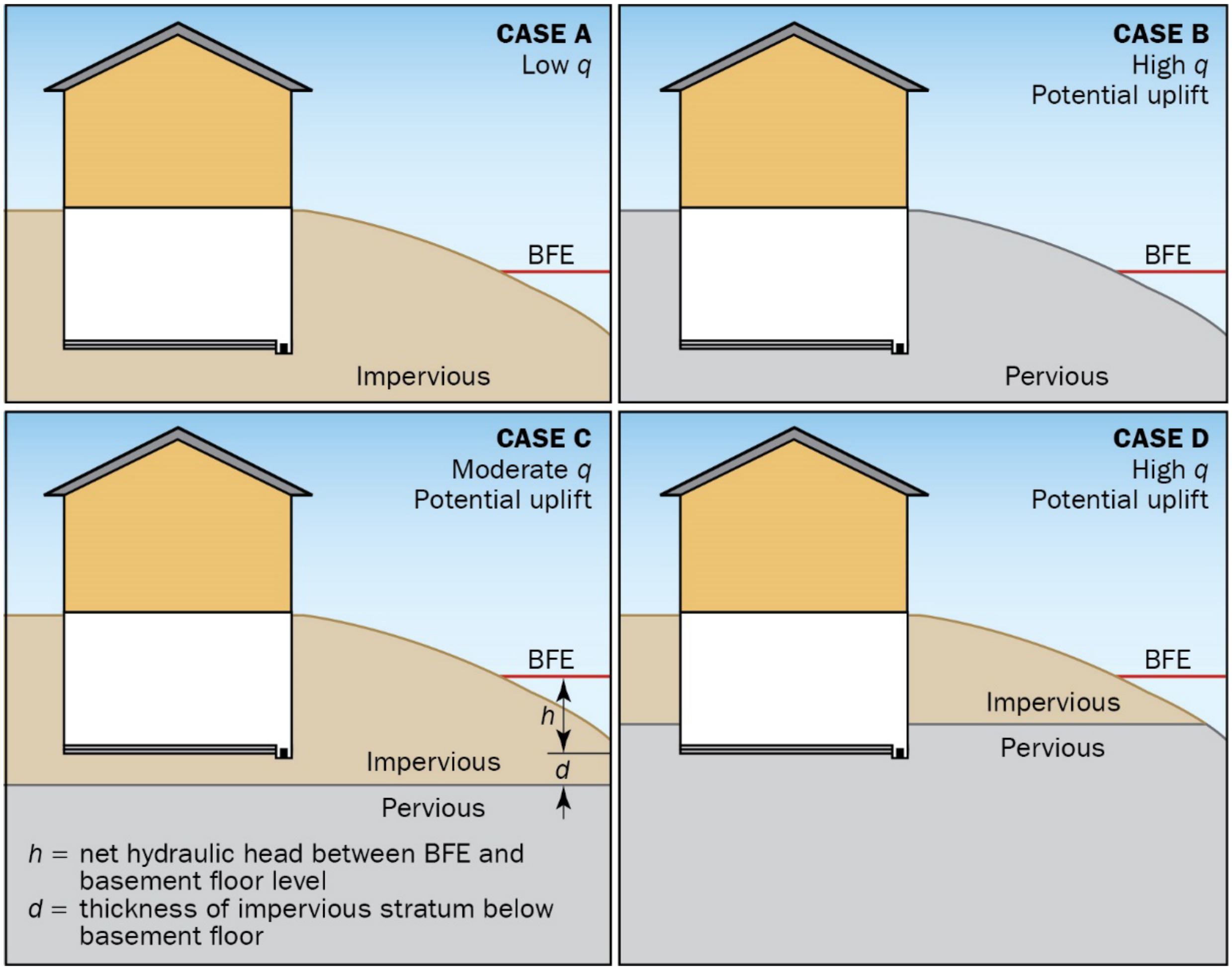


Figure 9: Generalized scenarios with homogeneous (Cases A and B) and stratified (Cases C and D) soils affecting quantity of seepage ("q") into basements

9.2.2. GEOTECHNICAL INVESTIGATIONS FOR ENGINEERING ANALYSES

In addition to the engineering design of regular foundations, the design professional who prepares an engineering analysis may require geotechnical investigations to determine whether a building with a basement in fill, with the basement floor below the BFE, will be reasonably safe from flooding. Information that is needed to prepare an engineering analysis includes:

- A flow net that accounts for all boundary conditions may be required for analysis of uplift pressures. Uplift pressures may be more significant in stratified soils than in homogeneous soils.
- The BFE, which is to be used as the floodwater entry surface for calculating expected seepage. The entry surface, with hydraulic head, "a," is a vertical line measured beginning where the BFE intersects the fill, extending down to the base of seepage flow zone (see Figure 8).
- The depth below grade of the bottom of the basement floor, which is to be used as the exit or drainage surface. The foundation design should be adjusted as needed to decrease the depth of the basement floor to achieve more suitable conditions. The exit surface, with hydraulic head,

"b," is a vertical line measured beginning from the basement floor closest to the fill slope, extending down to the base of seepage flow zone (see Figure 8).

- The setback distance from the edge of the SFHA to the nearest wall of the basement, shown as "L" in Figure 8. The location of the building can be moved farther away from the flooding source to achieve more suitable seepage control. The design professional will determine the length of the flow path which, at a minimum, is the setback distance. Figure 8
- The elevation of the groundwater table and its seasonal variations. It may not be feasible to have basements when sites have normally high water tables, even without the added seepage that may occur during flood events.
- The stratification of the subsurface materials, for both natural and fill soils (see Section 9.2.1 of this Technical Bulletin). In general, borings should be drilled to a depth below the proposed bottom of the basement floor slab, extending at least two times the depth of the floor slab below the BFE.
- The engineering classification of the soils, for both the natural underlying soils and the fill soils. The classification should be determined in accordance with ASTM D2487, *Standard Practice for Classification of Soils for Engineering Purposes* (Unified Soil Classification System), which is used throughout the United States. Typical local or county agricultural soil survey maps may not be sufficient because they do not give site-specific information at a small enough scale to provide detailed location and depth of soils, and their designations are not pertinent to use for engineering designs.
- Subsurface conditions landward from the building, away from the source of flooding. Conditions of interest include the location of the groundwater table (whether it is higher or lower than the BFE) and whether there is any penetration of soil layers, such as ponds, that are sources of subsurface water. Attention should be given to the possibility that higher ground, such as valley walls, could contribute to the groundwater level in the floodplain, either perennially or during periods of heavy rain.
- Whether a proposed basement will have penetrations through the basement walls, such as utility lines and other openings. Unless specifically sealed to prevent infiltration, penetrations may allow seepage that is not accounted for when determining the number and size (capacity) of sump pumps.

10. References

This section lists references cited in the Technical Bulletin. Additional resources related to NFIP requirements are provided in Technical Bulletin 0.

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