8.0 Barriers

Levees and floodwalls are types of flood protection barriers. A levee is typically a compacted earthen structure; a floodwall is an engineered structure usually built of concrete, masonry, or a combination of both (Figure 8-1). Barriers can be built to protect a single structure or multiple structures. Types of barriers include levees, floodwalls, and temporary barriers.

Table 8-1 includes a summary of advantages and disadvantages for using barriers as a mitigation measure.

WARNING

Floodwalls and levees are not permitted to address Substantial Improvement/Damage and do not bring new buildings into compliance with NFIP regulations unless they are accredited per 44 CFR § 65.10.

Furthermore, the floodwalls and levees described in this chapter will not lower your flood insurance premium cost.

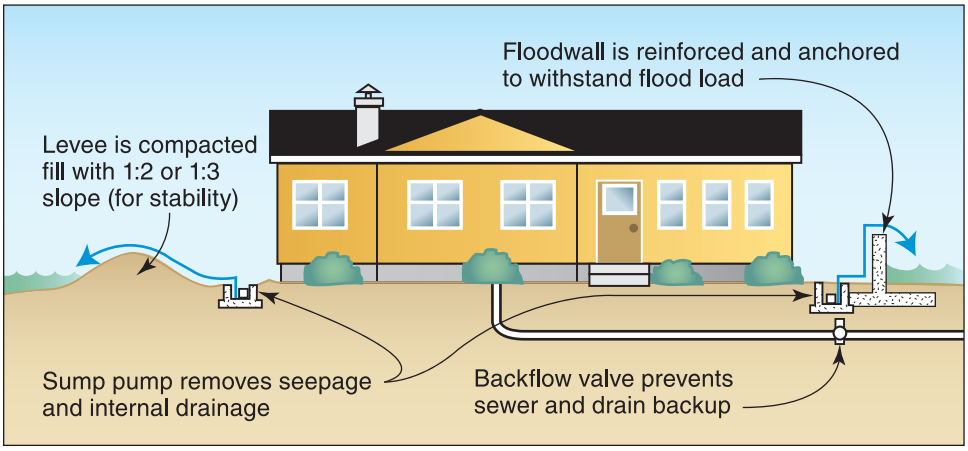


Figure 8-1. Structure protected by levee (on left) and floodwall (on right).

NOTE

For more information about barriers refer to FEMA 511, *Reducing Damage from Localized Flooding. USACE's Floodproofing – How to Evaluate your Options (FEMA.2005)* document is also a good source for barrier options.

Table 8-1. Considerations for Using Barriers

Advantages	Disadvantages
• Floodwaters cannot reach the structure(s) in the protected area and, therefore, will not cause damage through inundation, hydrodynamic pressure, erosion, scour, or debris impact. • The structure and the area around it will be protected from inundation, and no significant changes to the structure will be required.	• Barriers may not be used to bring a Substantially Damaged or Substantially Improved structure into compliance with the community's floodplain management ordinance or regulation. • Cost may be prohibitive, as a large area may be required for construction. • Periodic maintenance is required. • Local drainage can be affected, possibly creating or worsening flood problems for others.

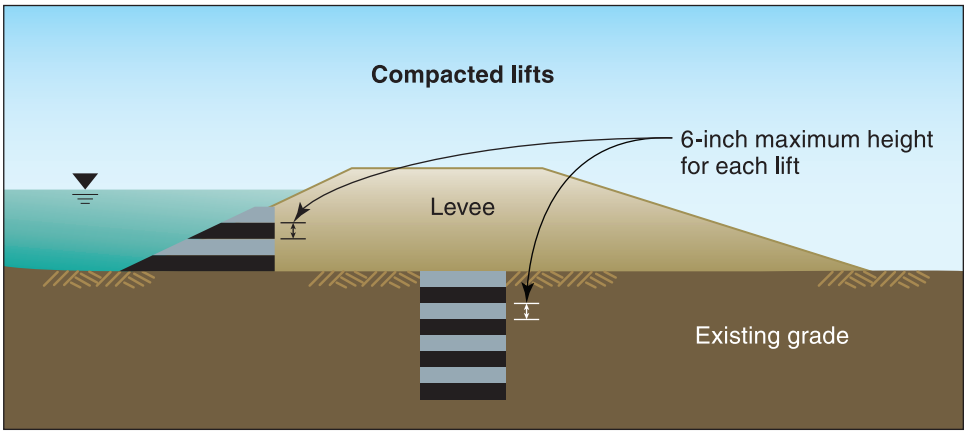
8.1 Levees

Levees are embankments or structures constructed of compacted earthen materials. Construction of a levee begins with excavating and inspecting the **cutoff trench**. This gives the designer a better look at the subsurface soil conditions, so that the presence of roots, utility lines, and animal burrows, or changes in soil conditions can be considered during the design process. The interior of the levee is composed of an impermeable core, usually clay. The lifts of impervious clay fill are placed in 6-inch layers, with each lift compacted to the density specified by the designer (Figure 8-2). As with large floodwalls, a licensed Professional Engineer should perform the levee design and certification.

DEFINITION

A **cutoff trench** is a core located below the base of a dam or levee structure. The trench is filled with an impervious material, such as clay, to form a watertight barrier to prevent under-levee seepage.

Figure 8-2. Levee construction.



Levees can be used to completely circle a building. However, they require a lot of space and a large quantity of earthen fill. Unless the fill is readily available nearby, hauling it to the site may prove to be cost-prohibitive. Integrating parts of the new levee into existing ground that is close to or above the levee's design elevation can help reduce construction costs.

8.2 Floodwalls

A floodwall is an engineered structure made of reinforced concrete or reinforced concrete block. A typical residential floodwall usually varies from 1 foot to 4 feet in height and can surround a structure or, depending on flood depths, site topography, and design preferences, protect building openings, such as doors, windows, and basement entrances, including entry doors and garage doors. When built with decorative bricks or blocks or as part of garden areas, floodwalls can be attractive architectural or landscaping features. They can also be built solely for utility, usually at a much lower cost.

Because a floodwall is made of concrete or masonry rather than compacted earth, it is more resistant to erosion than a levee and requires less space than a levee that provides the same level of protection. However, floodwalls are often more expensive. As a result, floodwalls are normally considered only for sites where there is not enough space for a levee or where high-velocity flows may erode a levee. Also, some property owners prefer floodwalls because they can be more aesthetically pleasing and allow for the preservation of existing site features, such as landscaping and trees, or covered with a decorative stone finish (Figure 8-3).

Figure 8-3. Structure protected by a floodwall with decorative stone finish.

8.3 Temporary Barriers

Several types of temporary barriers are available to address typical flooding problems. They work with the same principles as permanent barriers, such as floodwalls or levees, but can be removed, stored, and reused in subsequent flood events. Most of these barriers are meant to take the place of sandbag floodwalls and may also be used to reinforce existing permanent barriers such as levees (Figure 8-4).

Temporary barrier products are designed so that they can be used numerous times. The Association of State Floodplain Managers (ASFPM) worked with the USACE and Underwriters Laboratories (UL) to establish a testing/certification program for temporary flood barriers. ASFPM, UL, and USACE initiated program development, and FM Approvals (a division of FM Global) developed an approval system for recognizing temporary barriers as flood

abatement equipment for their policyholders. In 2006, FM Approvals published FM Standard 2510, *Approval Standard for Flood Abatement Equipment* (2006). The current FM Approvals test protocols are for self-supporting, temporary barriers designed to protect against riverine flood depths up to 3 feet. These barriers are not tested for coastal flooding applications, where the presence of saltwater may hinder their performance. Because saltwater is denser than freshwater, a barrier filled with freshwater in a coastal location may float instead of providing protection against flooding.

Figure 8-4. Two-foot-high water-filled temporary barrier protecting a residence from flooding (2010 – Courtesy of Hydrological Solutions, Inc.).

8.4 Technical Considerations

The factors discussed in the following sections affect the type of a barrier best suited for your home and should be considered before making a barrier selection.

8.4.1 Height of Barrier

When barriers are built to protect a single structure, they are referred to as "residential," "individual," "on-site," or "local" levees and floodwalls. Levees and floodwalls should be built to protect the residence from predicted flood heights as depicted on FEMA FIRMs, in FISs, or local flood vulnerability analyses. If the height of the levee or floodwall would make the project cost-prohibitive, then elevation or relocation of the residence should be considered. The practical, cost-effective heights of these levees and floodwalls are usually limited to 6 feet and 4 feet, respectively. These limits are the result of the following considerations:

- The higher the levee or floodwall, the greater the depth of water that builds behind it and the greater the water pressure exerted on the barrier. Taller levees and floodwalls must be designed and constructed to withstand the increased pressures. Meeting this need for additional strength greatly increases the cost of the levee or floodwall, usually beyond what an individual property owner can afford.
- Because taller levees and floodwalls must be stronger, they must also be more massive, so they usually require more space than is likely to be available on an individual lot. This is especially true of levees.
- Local zoning and building codes may also restrict the use, size, and location.

Local floodplain management ordinances and regulations may require a "no-rise" study to prove that the barrier system will not increase flood heights downstream of the barrier structure.

If the flood depth at the project site is above the practical height limits of available barriers, an alternative mitigation method, such as elevation, should be considered. The levee or floodwall can always be overtopped by a higher-than-expected flood regardless of the height of the barrier. Overtopping is a greater concern for a levee than a floodwall because a small amount of overtopping can cause erosion at the top of the levee and cause it to fail.

8.4.2 Basement Foundations

Special design considerations are necessary when levees or floodwalls are built to protect a structure with a basement. Even though the surface water is kept from coming into contact with the structure, the soil below the levee or floodwall and around the structure can become saturated, especially during floods of long duration. The resulting pressure on basement walls and floors can cause them to crack, buckle, or even collapse. An analysis by a qualified soils engineer can help to determine a sufficient distance for the floodwall or barrier from the structure to lessen or alleviate this pressure.

8.4.3 Soil Conditions

The type of soils encountered may have a significant impact on the choice of barriers as a flood protection option. This is true regardless of the choice of a permanent barrier or a temporary barrier. The following soil characteristics must be considered:

- **Bearing capacity.** This is the capacity of a soil to support applied loads. Permanent barriers such as levees and floodwalls, as well as many temporary barriers, are very heavy. If the soil type has low bearing capacity, the barrier may either fail structurally or begin to sink, losing its design protection height and capability. In this instance, alternative mitigation, such as elevation, relocation, or floodproofing should be considered.
- **Permeability.** Barriers should be deployed on tight, impermeable soils. If the soils are permeable, such as sand or sandy loam, steps need to be taken to counteract the seepage of water under or through the barriers. These steps include installing an impervious core for a levee and a cutoff trench filled with impermeable bentonite clay soil. Bentonite clay should also line the levee surface. A cutoff trench is a below-grade core of bentonite clay that prevents movement of pervious materials, such as loose sand and gravel, which can compromise the levee's performance.

8.4.4 Duration of Flooding

All barriers exposed to floodwaters for an extended period of time will be subject to seepage or leakage. If the duration of flooding is relatively short (less than 1 day) and the depth of flooding is relatively low (less than 1 foot), many barriers will at least slow down the effects of inundation. Longer exposures require barriers that are better engineered and more carefully constructed or deployed. Likewise, deeper flood depths also need to be considered as a result of the extremely high forces exerted on the barriers by the weight of the floodwaters.

8.5 Additional Considerations

The factors discussed in the following sections involve practical considerations affecting barrier selection.

8.5.1 Annual Maintenance

A barrier requires periodic inspections and maintenance to address any necessary repairs. Otherwise, small problems, such as cracks, loss of surface vegetation, erosion and scour, animal tunnels, and trees and shrubs can quickly become large problems during a flood event. The barrier should be inspected at a minimum each spring and fall, before each impending flood, and after each flood event. To facilitate slope stability as well as maintenance and safe grass mowing, the side slopes of most levees should not be steeper than 1 foot vertically to 2.5 feet horizontally (1:2.5) on the floodwater side and 1 foot vertically to 3 feet horizontally (1:3) on the land side. In general, driveways positioned to provide access over a protective levee that circles a residence should not be steeper than 1:3. Trees and large shrubs should not be located on barriers as they can be overturned during high-wind events and compromise the structural integrity of the levee. When trees and shrubs die, their roots decay, leaving cavities for water to pass through, which can cause the barrier to fail.

Homeowners interested in additional information on inspection of levees can refer to the following technical manuals available for download from the FEMA Website at http://www.fema.gov/technical-manuals-and-guides: *Technical Manual for Dam Owners: Impacts of Animals on Earthen Dams* (FEMA 473) and *Technical Manual for Dam Owners: Impact of Plants on Earthen Dams* (FEMA 534). Although these manuals were developed for dam owners, they contain many principles that are applicable to levees.

8.5.2 Housing of Occupants

Although a residence can be used during construction of a barrier, the residence should not be occupied during a flood event. Levees and floodwalls may give the homeowner a false sense of security. Every flood is different and one that exceeds the height of the barrier could occur at any time. If water overtops the barrier, the protected area will fill rapidly. Homeowners should evacuate when a flood warning is first issued.

8.5.3 Access to Structure

Barriers can make access to the structure difficult. Openings must be created or provided for driveways, sidewalks, and other entrances. These openings must be closed prior to the flood event, as floodwaters can rise rapidly enough to prevent an opening from being closed. Examples of these closure mechanisms for floodwalls include shields similar to the ones used in dry floodproofing or prefabricated panels and permanently mounted, hinged, or sliding flood gates and prefabricated stop logs or panels for levee openings. Unless the gates remain in the closed position at all times, human intervention is required to close an entry point to prevent rising floodwaters from entering the structure (Figure 8-5).

8.5.4 Human Intervention

As described in Section 8.5.3, openings in the barrier must be closed prior to a flood event. Putting the closure mechanisms in place requires human intervention. The barrier will not protect the structure from flooding unless the property owner is willing and able to operate all closures before the flooding begins.

Figure 8-5. The City of Boulder, CO, installed a "pop up" closure to this floodwall at a City office building subject to flash floods. The closure floats up into place automatically when the site is flooded.

8.5.5 Interior Drainage

A barrier that keeps floodwater out of the protected area also will keep water in. Drains and sump pumps should be installed to remove water collected inside the barrier. In addition, caution must be taken to ensure that local drainage patterns in the area are not disrupted. An interior drainage system, including a sump pump (Figure 8-6), must be installed in an area protected by a levee or floodwall.

Figure 8-6. Small patio floodwall with sump pump.