

Part IV

Site-Specific Tools and Techniques

Part IV of this guide narrows the focus to techniques that can be applied to one house at a time, and even by individual property owners, to reduce potential flood damage or better cope with it when it occurs. This part covers retrofitting and flood insurance.

Part IV:

Chapter 10. Retrofitting

Chapter 11. Flood Insurance



Retrofitting

This chapter outlines retrofitting techniques and some of the precautions that should be followed before they are implemented. Retrofitting a building is implemented by the building's owner, but the community also has an important role, which is discussed in the last section of this chapter.

Introduction

Retrofitting is defined as making changes to an existing structure to reduce or eliminate the possibility of flood damage. As a flood mitigation technique, retrofitting can have several advantages:

- It can be implemented on a building-by-building basis.
- It can be relatively inexpensive.
- It can be the most cost-effective approach for certain types of structures subject to shallow flooding.
- It can be implemented by the individual building owner; it does not have to wait for government funding.
- It can improve the market value of the property.
- Properly designed, it would not disrupt the neighborhood or natural streams.
- It retains the tax base and community integrity.

Retrofitting Techniques

This section presents six retrofitting techniques:

- Elevation;
- Barriers;
- Yard improvements;

- Dry floodproofing;
- Sewer backup protection; and
- Wet floodproofing.

They are listed in order from what is generally considered the most effective and dependable technique—elevation—to the least desirable—wet floodproofing. For each technique, this section will explain how the retrofitting method works, where it should and should not be used, and its advantages and disadvantages.

There are two other ways to mitigate flood damage to a building that are not covered in this chapter. The most effective way to permanently protect a building from flooding is to relocate it out of the floodplain, which is discussed in Chapter 9. The other way is called “emergency measures,” which means waiting for the flood and then moving things out of the way. Emergency measures are temporary and are not considered a dependable mitigation approach. They are discussed under “Site-Specific Responses” in Chapter 6.

Elevation

If a building is to remain in place, elevating it to prevent flood waters from reaching vulnerable areas is considered the most effective retrofitting technique. The structure typically is raised so that the lowest floor is at or above the design flood elevation (DFE).



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This compact wood frame house on a crawlspace only had to be elevated 2 feet to be 1 foot above the 100-year flood level in this shallow, repetitively flooded area. The cost to the owner was under \$10,000 in 1985.

Raising a building above the flood level on an open foundation (e.g., piles, piers, or posts) is an effective on-site property protection method. Water flows under the building, causing little or no damage to the structure or its contents.

Alternatives are to elevate on continuous foundation walls (creating an enclosed space below the building) or on compacted earthen fill. Although elevating on compacted fill is sometimes the most desirable elevation solution, it is a complicated alternative. The building has to be temporarily moved so the fill can be placed and properly compacted; the building is then moved back to the site. This process may make elevating on fill more costly than elevating on an open foundation or continuous foundation walls.

The ease with which an elevation project can be accomplished usually depends on the building’s construction type. A large or rambling masonry building is more difficult to elevate than a smaller, compact wood-frame structure. The type of foundation is the most important factor—the contractor must use equipment to raise the building off its foundation. There are four types of foundations:

1. Crawlspace construction (easiest to elevate);
2. Piers, posts, and pile construction;
3. Basement construction; and
4. Slab-on-grade construction (hardest to elevate).

The design flood elevation, or DFE, is the specified level of protection to which a structure will be protected by the retrofitting project. Selecting the DFE is discussed on page 10-16.

One of the difficulties with elevation is that when newly created lower levels are used for storage, the stored items can be damaged by flooding. If the building is elevated 8 feet or more, the owner may be tempted to convert the lower area into a habitable living space, complete with carpet, insulation, and furniture, which can increase the cost of a flood and negate the benefits of the elevation project.

One way to help prevent conversions is to have the owner sign a nonconversion agreement. The owner and the Recorder of Deeds sign the form indicating that the restrictions on the enclosure have been recorded on the deed to the property. Since the deed follows the property, future homebuyers are informed of the restrictions.

Advantages of elevation

- ▶ Elevation is the most dependable way to protect the structure and contents; everything subject to damage is above the flood level.
- ▶ If the property is in the Special Flood Hazard Area (SFHA), elevation is the only way to bring a substantially improved or substantially damaged building into compliance with the National Flood Insurance Program (NFIP) regulations.
- ▶ Elevation can reduce flood insurance premiums.
- ▶ Elevation techniques are well known, and qualified contractors are often readily available.
- ▶ Elevation does not require the additional land that may be needed for floodwalls or levees.

Disadvantages of elevation

- ▶ Elevation can be expensive, especially for buildings on slab foundations.
- ▶ The appearance of the structure may be adversely affected.
- ▶ Stairs may be required to access the building.
- ▶ Elevation is not appropriate in areas with high-velocity water flow, fast-moving ice or debris flow, or erosion, unless special measures are taken.
- ▶ Some zoning ordinances and subdivision covenants prohibit buildings above a certain height.
- ▶ Owners may lose their basements.



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The owner who built this low floodwall landscaped it with stones and grading to minimize its visual impact. The design depends on human intervention to close the driveway opening.

Barriers

When properly designed and constructed, local barriers, such as floodwalls and levees, can be effective devices for repelling flood waters. Both levees and floodwalls can hold back flood waters, but they differ in their design and construction, appearance, and application. Levees are embankments of compacted soil, and floodwalls are built of concrete, masonry, or steel.

The sides of a levee are sloped to provide stability and resist erosion, thus the width is usually 6 to 8 times its height. As a result, the taller the levee, the more space is required. Since a floodwall does not rely as much on its mass to resist flood forces, it requires less space than a levee of similar height.

A floodwall or levee can surround an entire structure or, depending on the flood levels, topography, and design preferences, it can protect isolated structure openings such as doors, windows, and basements. In some shallow flooding areas, this may be all that is needed to protect a vulnerable portion of the structure. An example is shown in the photos at the top of the facing page.

The costs of floodwalls and levees can vary greatly depending on the height, length, availability of construction materials, labor, access closures, and the interior drainage system. Maintenance of the barrier must also be performed on a scheduled basis to monitor and address settling or cracking that may occur over time. Other concerns are tree roots and burrowing animals that build tunnels through or under the levee or wall.



Marsha Hilmes Robinson



Marsha Hilmes Robinson

This house has a barrier around the stairwell that protects it from shallow and short-duration flooding. This barrier requires several precautions, explained later in this chapter: a structural investigation is needed to ensure the walls will withstand the water pressures, and warning time is needed to slide the board into place (an example of human intervention).



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Although this neighborhood is in an X Zone, these two typical homes have experienced repeated floods. Heavy local rains fill the streets with water once or twice a year. The water rises above the curbs and sidewalks and pours down the driveway to the sunken garages.

The owner on the left raised the driveway retaining wall, cut grooves in it, and placed a board in the grooves when rains threatened the house. The board has rubber gaskets and hangs on the wall in the background. The owner of the house on the right opted to raise the retaining walls and the sidewalk to act as a permanent barrier to street flooding.

The photo on the left was taken in the 1980s. Since that time, the owner has abandoned the approach that relies on human intervention and has also raised the sidewalk in front of his driveway.

Cost, complexity, and space requirements generally limit localized levees and floodwalls to a height of 6 feet. Keep in mind that levees, floodwalls, and any other measure, can always be overtopped by a flood higher than expected. Overtopping allows water into the protected area, and the resulting damage to the structure can be as great as if it had not been protected at all.

Another important design consideration is the effect that a levee or floodwall can have on other properties, because they divert water away from the protected structure. Such barriers must be kept out of the conveyance portion of the overbank area and back from required property line setbacks and drainage easements.

Advantages of barriers

- ▶ Barriers can protect multiple structures.
- ▶ Occupants usually do not have to leave the structure during construction.
- ▶ Barriers are usually less expensive than elevating or relocating the entire structure.
- ▶ Property inside the barrier will be protected from inundation without significant changes to the structure.

Disadvantages of barriers

- ▶ Barriers may require land to construct.
- ▶ They must be maintained to be reliable.
- ▶ Depending on the size, they can be very expensive.
- ▶ Barriers will not reduce flood insurance premiums.
- ▶ Overtopping or failure eliminates any protection provided.
- ▶ Barriers may have openings, thus human intervention may be required.
- ▶ They may restrict access to the structure.
- ▶ Interior drainage must be provided.

Yard Improvements

Shallow flooding can often be kept away from a structure if some simple improvements are made to the yard. Sometimes structures are built at the bottom of a hill or in a natural drainageway or storage area, so that water naturally flows toward them.

One solution is to regrade the yard. If water flows toward the building, a new swale or wall can direct the flow to the street or a drainageway. Filling and grading next to the building can also direct shallow flooding away. Although water may remain in the yard temporarily, it is kept away from the structure. When these types of drainage modifications are made, care must be taken not to adversely affect the drainage patterns of adjacent properties.

Often water flows to a low entry point, such as a basement stairwell or patio door. A low wall or regrading around this point can keep water away, as illustrated in the photos to the right. If the water level does not recede within a few hours, an internal drainage system with a pump may be needed to handle seepage.

A related common problem results from disruption of the local drainage system. In most cases, subdivisions are designed for surface water to flow away from the structure to the lot line. A 5- or 10-foot easement on the lot line is designed to keep the area open, so water can flow to the front yard and into a drainage ditch or storm sewer or to a drainage swale in the back yard (as discussed on page 8-16).

Over time, the swales along the lot lines or in the back yard may get filled in. Property owners build fences, garages, sheds, swimming pools, and other obstructions up to the lot line. The photos on page 2-7 illustrate this problem. These drainage problems can be fixed by removing the obstructions and restoring the swales so they will carry water away from the building.

Advantages of yard improvements

- ▶ They are very effective when dealing with shallow flooding.
- ▶ They are low cost. Many projects can be built by the owner.
- ▶ Removing one obstruction may reduce flooding on several lots.

Disadvantages of yard improvements

- ▶ Adjacent owners must cooperate and be instructed on the need not to build new obstructions.
- ▶ They will not affect flood insurance premiums.

Dry Floodproofing

Dry floodproofing involves sealing the exterior of a building to prevent the entry of flood waters. Unlike a barrier, dry floodproofing relies on the structure to hold waters out. Dry floodproofing a building involves:

- Using sealants or plastic membranes to prevent seepage of flood water through the walls;
- Installing watertight shields over doors and windows; and
- Installing measures to prevent sewer backup.

Because most structures were not designed or built to withstand water pressures, dry floodproofing is appropriate only for structures that face low-level flooding. The general rule is that this measure should not be used if a flood could exceed 2 or 3 feet in depth, unless a thorough investigation is made by a structural engineer.

Because dry floodproofing depends on plastic membranes and sealants, there is always the threat of seepage during a flood. Therefore, it may not be reliable if flood waters recede slowly.



Fairfax County Stormwater Management Division

This house in Fairfax County, Virginia, has a patio lower than the rest of the yard. Localized flooding flowed across the yard, onto the patio and into the house. The County helped the owner raise the stairwell and grade the site so water flows away from the house.

The rate of rise of flood waters and the amount of warning time for the site is also important, because dry floodproofing often relies on human intervention to put the shields and closures in place.

Advantages of dry floodproofing

- ▶ Dry floodproofing may be less expensive than other retrofitting methods.
- ▶ It does not require the extra space needed for barriers.
- ▶ It retains the structure in its present environment.
- ▶ Dry floodproofing can avoid significant changes in appearance.
- ▶ It can reduce flood insurance premiums for non-residential structures.

Disadvantages of dry floodproofing

- ▶ Dry floodproofing is not dependable for deep flooding, so it is usually not recommended for buildings with basements.
- ▶ It is not dependable for long-duration flooding.
- ▶ If design loads are exceeded, walls may collapse, floors may buckle, and the structure may even float, potentially resulting in more damage than would occur if the house were simply allowed to flood.



W.A. Wilson Consulting Services

This house on a slab was dry floodproofed. The first 1.5 feet of the brick walls were covered with plastic sheeting, which was covered with facing brick to protect it from debris impact and damage by sunlight. A steel gate with rubber gaskets provides access at the doorway.



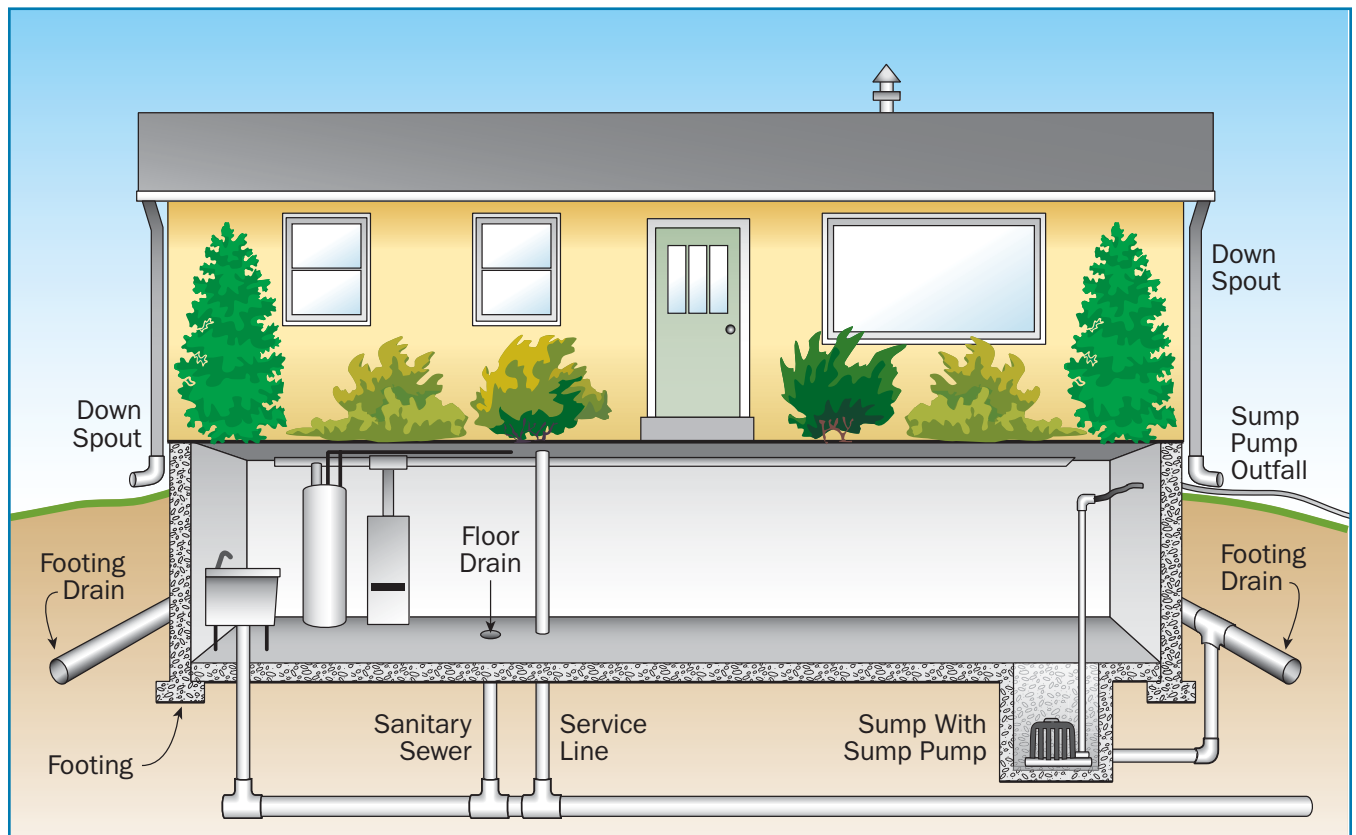
French & Associates

The original design for this apartment building had the air conditioner below the center window for each unit. After repetitive shallow floods poured through the air conditioners on the lowest floor, the owner hired an engineer. The engineer concluded that if the air conditioners were moved up and the hole sealed, the structure could withstand the water pressures that accompany flooding. The modification is an excellent example of dry floodproofing.

- ▶ Dry floodproofing may be subject to leakage, which could damage the structure and its contents.
- ▶ It usually requires human intervention and adequate warning time for installation of protective measures.
- ▶ Using this technique requires periodic maintenance.
- ▶ It will not reduce flood insurance premiums for residential structures.
- ▶ It does not protect a structure from the force of flowing water, erosion and scour, the impact of ice and other floodborne debris, or wave action.

Sewer Backup Protection

In many urban areas, sewer backup is the major cause of repetitive flooding. As illustrated below, a typical house has a sanitary sewer that drains toilet waste, laundry tubs, and, in some cases, the floor drain to the sanitary sewer main in the street. Clean stormwater and groundwater are handled by downspouts, footing drains, and sump pumps.



Typical basement drain and sewer arrangement.

Note: The floor drain may or may not be connected to the sanitary sewer line.

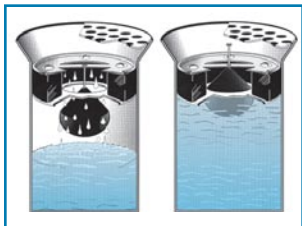


Sammy Says: Don't cause your own flood! Keep your sewer lines clear.

- Keep out roots from trees and shrubs with root killer.
- Make sure your yard clean-out vent will keep debris out.
- Don't pour dangerous liquids down the drain (motor oil, paint, pesticides, poisons, epoxies, etc.).
- Don't pour grease, fat, or cooking oil down the drain. They solidify later.
- Don't flush large solids, such as diapers, down the toilet.

Sewer backups can be caused by events not related to storms or flooding. Individual service lines can be plugged by grease, waste, tree roots, breaks in the pipe, or saturated ground. Proper maintenance can prevent most of these problems. This public information warning is from **Lansing, Illinois**, and is designed to encourage people to take steps to protect themselves from flooding. Lansing has a variety of materials displaying its flood protection mascot, Sammy Sandbag.

Often flooding is caused by these two sewer systems being interconnected. In older cities, some sanitary sewage and stormwater systems drain to a combined sewer system. In newer areas, some downspouts, footing drains, and sump pumps have been illegally connected to the sanitary sewer service. During a heavy rain, stormwater enters the sanitary sewers, overloading the main lines and causing the sewage to back up into basements and other low areas of buildings.



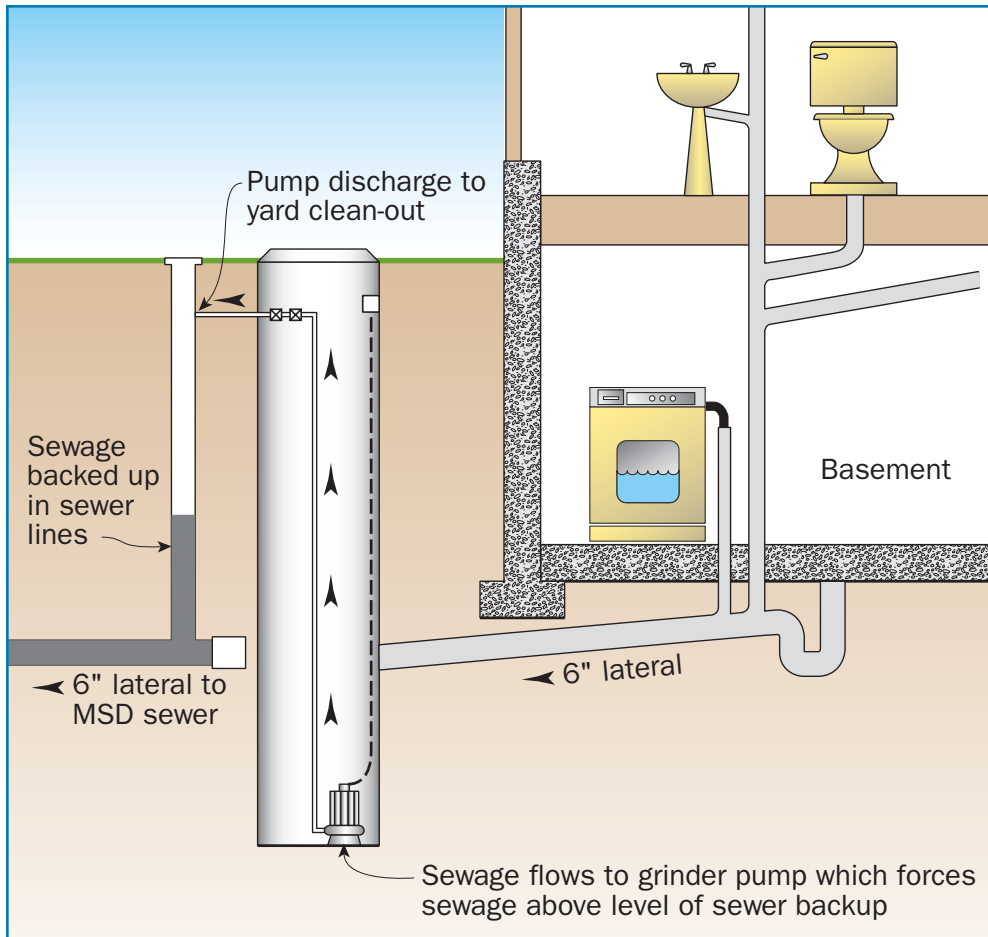
Floor drain float plug.

There are four main approaches to protect a structure against sewer backup: floor drain plugs, floor drain standpipes, backup valves, and overhead sewers. The first two devices keep water from flowing out of the lowest opening in the building, the floor drain. They typically cost less than \$25; but if water becomes deep enough in the sewer system, it can flow out of the next-lowest opening in the basement, such as a toilet or laundry tub.

Backup valves and overhead sewer lines are more secure, but are also more expensive (\$3,000–\$5,000). A backwater protection valve allows sewage to flow out while preventing backups from flowing into the building.

An overhead sewer acts like a standpipe but without the shortcomings. A sump is installed under the basement floor to intercept sewage flowing from basement fixtures and the basement floor drain. An ejector pump in the sump pushes sewage up above the flood level. From there it can drain by gravity into the sewer service line. Plumbing fixtures on the first floor continue to drain by gravity to the service line.

In the unlikely event that the sewers back up above ground level, a check valve in the pipe from the ejector pump keeps it in the pipes. Backed-up sewage is enclosed in the sewer pipes and doesn't overflow laundry tubs or basement toilets. Hydrostatic pressure is kept in the pipes outside the building walls, so if a break were to occur, it would be easier to fix than if the pipe burst under the building.



Adapted from Metropolitan St. Louis Sewer District

Called a “grinder pump,” this is a variation on the backup valve and overhead sewer. The Metropolitan St. Louis, Missouri, Sewer District has funded the installation of many such pumps to prevent sewer backup in its service area.

During a power outage, the ejector pump will not work unless a backup generator is provided. An outage would only limit the use of the facilities in the basement that need the pump. The upstairs plumbing would still work, and the sewer would still be prevented from backing up.

Advantages of sewer backup protection

- ▶ The floor drain plug and standpipe are inexpensive ways to prevent sewer backup.
- ▶ The automatic sewer backup valve and overhead sewer are almost 100-percent dependable and require no human intervention.

Disadvantages of sewer backup protection

- ▶ The floor drain plug and standpipe need to be removed to allow any spillage on the floor to drain. This requires someone to put it in place when it rains (human intervention).

- ▶ The floor drain plug and standpipe do not stop backup from coming out of the next-lowest opening, like a laundry tub or toilet.
- ▶ The floor drain plug and standpipe do not reduce the hydrostatic pressure on the sewer lines. If the line under the floor is not cast iron, it may break under pressure.
- ▶ Sewer backup can equalize hydrostatic pressures on the basement walls and floor, preventing them from collapsing due to outside water pressures. Therefore, although stopping sewer backup keeps sewage out, it may also increase the risk of structural damage.
- ▶ The sewer backup valve and overhead sewer require periodic maintenance, something that is easy to forget because they are often placed out of sight.

Wet Floodproofing

Wet floodproofing is a term that covers various ways to protect a structure, its utilities, and its contents, while allowing flood waters to enter the structure. Wet floodproofing is the complement of dry floodproofing—the latter keeps water out, but at risk of

damaging the structure from water pressures (see the photograph of the basement floor on the left). Wet floodproofing prevents such damage by letting the water in, so the pressures will be the same on both sides of the walls and floors.

Wet floodproofing is usually one of the most cost-effective means of reducing exposure to flood damage. Virtually any activity to reduce the number of things exposed to water damage is a wet floodproofing measure. This can be as simple as picking the television set up and setting it on a table or rolling up the carpet in the basement and taking it upstairs. A tall water heater installed on the floor can be replaced by a shorter, fatter one on a pedestal (see the photograph).

All construction and finishing materials in the areas of the structure that can get wet must be resistant to damage caused by direct and possibly prolonged contact with flood waters. Since areas used for living space contain materials that are easily damaged by water, such as furniture, appliances, and carpeting, wet floodproofing is practical only for those portions of a structure that do not need to be finished. It is generally used on enclosures below elevated buildings, basements, crawlspaces, garages, and utilities and service equipment inside and outside the building.

Wet floodproofing requires human intervention in most cases. To reduce this need, the interior finishes



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This basement floor in the photograph on the left buckled when the building was surrounded by flood waters. It is testament to the pressure water puts on a structure. If the basement had been wet floodproofed, the flood water allowed into the building would have equalized the pressures on the outside, and this damage would not have happened. The photograph on the right is an example of a wet floodproofed garage, i.e., an area that can be flooded with little or no damage to the structure or contents. Note the elevated water heater and unfinished walls. (In this case, gypsum wallboard is required under the local fire code.)

can be changed to improve their resistance to flood damage. Gypsum wallboard can be removed, and epoxy or other impervious paints can be applied to the walls and floors to reduce the likelihood of contaminants seeping into concrete. This will also make cleanup easier after the flood. See the various measures that were taken to wet floodproof the demonstration house in South Carolina shown on page 5-7.

Advantages of wet floodproofing

- ▶ Wet floodproofing reduces the potential of structural damage by minimizing flood forces on the structure due to standing water and buoyancy.
- ▶ Many wet floodproofing actions can be accomplished for a minimal cost.

Disadvantages of wet floodproofing

- ▶ Wet floodproofing usually requires human intervention and, therefore, warning time.
- ▶ It does not reduce the cost of flood insurance for residential structures.
- ▶ It is most effective when the building is constructed of flood-resistant materials, e.g., concrete or block floors and walls.
- ▶ The wet floodproofed area will be inundated by dirty floodwater and will need to be cleaned, sanitized, and dried out.

Precautions and Parameters

The retrofitting measures presented in the previous section will not work everywhere. There are certain technical precautions and design parameters that affect whether and how a measure should be used.

Precautions

There are some limitations to all retrofitting measures and some precautions that apply only to some of them. The following should be understood before the community or the property owner undertakes a project.

Safety. The property will still be subject to flooding after the building is retrofitted. It should not be occupied during a flood. Even if the structure is high and dry or protected by a barrier, entering or exiting the structure presents a safety hazard. Riding out the flood may sound safe, but the occupants should consider the possibility of an emergency and whether an ambulance can get to the building through the flooded streets.

Human intervention. Human intervention means that the retrofitting measure needs someone to take action in order for it to work. Examples include closing an opening, relocating contents, or turning on a pump. Other examples are seen on page 10-5 in the pair of photos at the top, and the bottom left photo. Projects that

do not need human intervention are illustrated on pages 10-2, 10-5 (bottom right photo), 10-7, and 10-8.

Retrofitting measures that require human intervention should be avoided. One reason elevation is the most desired retrofitting approach is because it does not need human intervention. During a flood, no one needs to do anything to make it work. Property owners can go to sleep at night or they can go on vacation without worrying about something that needs to be done during a thunderstorm.

Passive retrofitting that requires no human intervention is not, unfortunately, always possible. Building or funding constraints may dictate some human intervention in the design. Although not the most dependable approach, a measure that uses human intervention may be the most economical one and, if the required actions are taken when needed, it can be effective.

Work done by the owner. Some of the retrofitting measures, such as building a levee in the backyard and moving furniture upstairs, may be simple and straightforward enough for the owner to manage. However, some measures may not be as easy as they appear. A contractor, or even an architect or engineer, is recommended for the more complicated projects, such as elevation and dry floodproofing a structure. The community should also publicize where local codes require an engineer, a licensed plumber, or other professionals.

Level of protection. One of the most important steps in the process of retrofitting a structure is determining the level of protection. This process is more challenging for structures located in B, C, and X Zones where flood data are not available from the Flood Insurance Study or Flood Insurance Rate Map (FIRM). Ways to determine flood elevations are discussed in Chapter 4.

The specified elevation to which a structure is going to be protected through retrofitting (the DFE) is not necessarily the same as the regulatory flood elevation. If the property is located in a regulated floodplain (either the SFHA or a floodplain adopted in the community's ordinance) and the project will be a substantial improvement, then the design must comply with the regulations. In this case, the design protection level must be at or above the regulatory flood elevation.

However, if the project will not be a substantial improvement or it is not in a regulated floodplain, then the owner or designer is free to determine the DFE. Protecting to the 100-year flood level is highly recommended. However, there may be instances where protection to a lower level is more practical. An example would be a large masonry commercial structure on a slab foundation. The cost to elevate it could be hundreds of thousands of dollars, but the cost to dry floodproof the first 3 feet (the maximum height recommended) could be only \$10,000 or \$20,000.

It must be remembered that the DFE can always be exceeded by a higher flood. In general, the cost of retrofitting increases as the design protection level increases. In choosing the level of protection, the community and the owner must consider not only how much they are willing to pay, but also the level of risk they are willing to accept. Depending on the retrofitting technique and the level of protection, there will be some residual risk of flooding. No retrofitting technique completely eliminates that risk.

Other hazards. Although the focus of this chapter is retrofitting structures affected by flooding, the community and the owner should consider that retrofitting a structure influences how that structure reacts to other hazards. For example, an elevated building may be more at risk to wind damage or shaking from an earthquake.

Flood Insurance

In the SFHA, flood insurance rates for new buildings are based on the building's exposure to flooding by the base flood. Retrofitting a building outside the SFHA will not affect the owner's insurance premiums. If the building is in the SFHA, there are three instances in which the retrofitting project will affect flood insurance rates.

1. If a building in the SFHA is elevated above the base flood elevation, the owner can submit an Elevation Certificate to receive lower rates. The table shows how much lower the premium can be for an elevated building compared to the cost of insurance for an older (pre-FIRM) building that benefits from the subsidized rate.
2. If a non-residential building in the SFHA is dry floodproofed to or above the base flood elevation, the owner can submit the certificate needed to receive lower rates.
3. If the building is in the SFHA and the project is a substantial improvement, then the building must be protected to the base flood and the rates would be reduced accordingly.

Example NFIP Flood Insurance Premiums

(as of May 1, 2005)

Annual premium for \$150,000 in building coverage and \$60,000 in contents coverage for a one-story house with no basement and a \$500 deductible.

Note that premiums are lower in CRS communities.

Policy/Building Exposure	Premium
<i>Outside the SFHA:</i>	
Standard Flood Insurance Policy	\$794
<i>Within the SFHA:</i>	
Pre-FIRM ("subsidized") rate	\$1,372
Post-FIRM (actuarial) rates	
2 feet above base flood elevation	\$400
1 foot above base flood elevation	\$577
At base flood elevation	\$924
1 foot below base flood elevation	\$3,288

It can be seen that protecting a pre-FIRM structure (one built before the date of the original FIRM for the community) to a level 2 feet above the base flood can save the owner about \$1,000 annually in reduced insurance premiums. However, if the project is a substantial improvement in the SFHA and the building is not protected to the base flood elevation, the owner may be required to pay over \$3,000 annually in flood insurance premiums.

It should be remembered that even if the current owner does not want insurance (e.g., if he or she thinks that the project will protect the building from all floods), future owners may need to purchase a policy as a condition of a mortgage. The current owner has an incentive to make sure that a future owner can afford the required flood insurance.

Design Parameters

There are many different factors that affect whether a building should be retrofitted and what measure to use. Because of this, a building contractor and a design professional, such as an engineer or architect, would be helpful. The owner and the design professional need to consider important characteristics before a measure is selected and detailed plans are prepared. Many of these conditions vary greatly from one building to another, so gaining as much information about these characteristics as possible will help the design professional determine the most appropriate retrofitting techniques.

Building condition and type. A dilapidated structure may not be worth protecting. A foundation that has settled and cracked will present problems if the building is to be elevated or dry floodproofed. As noted above, certain types of buildings are easier to retrofit than others. Buildings on crawlspaces are the most cost-effective to elevate, but generally they cannot be dry floodproofed because the floor is not watertight.

Design protection elevation. As stated earlier, the owner or designer has some flexibility in setting the DFE. If the protection level is less than 3 feet deep over the floor, dry floodproofing becomes feasible, although it may not result in protection to the base flood elevation.

If the owner would like Federal financial assistance to retrofit, he or she must show that the benefits of the project exceed the cost. This is done using a benefit-cost program that compares the long-term risk and potential for damage to the cost of the project. To do this, the program needs an accurate elevation of the lowest floor, which is compared to the elevation of the 10- and 100-year floods.

Therefore, if financial assistance is sought, it may be worthwhile to conduct a study to calculate the various flood elevations before selecting the DFE. (See also the discussion on setting a regulatory flood elevation in Chapter 4.)

Buildings in an SFHA that are being substantially improved (or have been substantially damaged) must be elevated to or above a DFE that is at least as high as the base flood elevation (BFE) and possibly higher, depending on the local ordinance. Even if the proposed modification is not a substantial improvement, it makes little sense not to elevate to at least the BFE even if it is not required. Usually it will not cost much more and will yield the added benefit of post-FIRM insurance rates, which are usually lower

For more about designing a retrofitting project, designers should consult *Engineering Principles and Practices for Retrofitting Flood Prone Residential Buildings* (FEMA 259).

than pre-FIRM rates. In localized flooding areas where there is no readily available BFE, other types of retrofitting could be designed to a DFE that may be lower than the BFE. Owners and designers should bear in mind the precautions and parameters noted above when selecting a DFE.

Hydrodynamic forces. Hydrodynamic forces include velocity and debris that can batter a structure. Higher velocities can cause erosion and scour a levee or the soil supporting the building. Debris can include trees, portions of flood-damaged buildings, mobile homes, storage tanks, and in cold climates, sheets or chunks of ice. The potential for debris to damage the structure is difficult to predict, but some data on velocities can be found in the Flood Insurance Study. If there are no studies, the forces can be estimated from previous floods.

In most localized flooding situations, velocity and debris are usually a minimal concern. However, the owner and designer need to consider special precautions if velocities exceed 5 feet per second or if there is a history of higher velocities or debris during previous local floods.

Warning time and rate of rise. How fast a flood rises determines whether human intervention measures are feasible. In areas of steep topography, in places with a high degree of urbanization and impervious surfaces, or in small drainage areas, floodwaters can rise very quickly with little or no warning. If there is a fast rate of rise but no public warning, measures dependent on human intervention should be avoided. (Flood warning systems are covered in Chapter 6.)

There are ways to close openings and turn on pumps without human intervention. Doorways can be kept closed rather than open, as is done with the gate shown on page 10-8. Pumps can be activated when a sensor gets wet. These passive measures work, but they can increase the cost of the project and add to the likelihood of problems when the flood comes.

Flood duration. Floods of long duration may hinder access to the structure, but more importantly for retrofitting, they may affect the amount of time the water is interacting with the structure. Long periods of inundation are more likely to cause significant damage than short ones. Certain retrofitting techniques, such as dry floodproofing, may be inappropriate in long-lasting flooding due to the increased chance of seepage, wicking, or other moisture damage caused by prolonged exposure to flood waters.

Regulations. Local building codes and floodplain regulations are critical parameters in the design of a retrofitting project. (Refer to Chapter 4 for a more detailed discussion of regulations.) Here are some common constraints that must be checked:

- Barriers are prohibited in the regulatory floodway and on drainage easements where they can divert flood waters onto other properties.
- If the project is a substantial improvement in the regulatory floodplain, a residential building will have to be elevated and a nonresidential building will have to be elevated or dry floodproofed.
- Zoning ordinances often have restrictions on the height of buildings, especially in residential areas. For example, the zoning ordinance may prohibit a house to be built more than 30 feet high. If a two-story house is

already 28 feet high, it would be difficult obtain a permit to elevate it much higher.

- Barriers may be prohibited if the regulations include a compensatory storage requirement or prohibit bringing new fill into the floodplain.
- Some building codes require that if an older building has electrical work, all the wiring and the service must be brought up to the current electrical code. While this is an excellent requirement, it adds more expense to a floodproofing project.

Regulatory standards that are not NFIP requirements may be amended by the community. It may be appropriate to modify a flood protection requirement in order to facilitate protecting a building from flooding. For example, some communities' compensatory storage requirements exempt floodwalls that are constructed within 10 feet of the building, thereby permitting a flood protection measure while minimizing the amount of lost flood storage.

Owner preference. A project to alter a building will not succeed without the support of the property owner(s). Owners should agree to a project only after they review these concerns and receive satisfactory answers:

- How much will the project cost?
- How will the construction project affect them?
- How secure will they be from future flood damage?
- What are their responsibilities in the project?



French & Associates

This library was built on flood-prone land donated by a developer. After flooding in 1986, 1987, 1989, and 1990, the library was relocated. The building was given to the fire department for a headquarters and training facility, and the village built this levee. The levee surrounds the building and has no openings requiring human intervention. The top is 2 feet above the 100-year flood.

- How will the project affect the appearance of their property?

It is important for the owners to understand that no project will provide total security from any future flood. A project can fail for a variety of reasons, such as:

- The flood exceeded the project's design level;
- The owners did not properly maintain the project after it was constructed; or
- The owners failed to take the appropriate actions during the flood, such as installing a closure, or they were away when the home flooded.

These last two items underscore the need for owners not just to agree to the project, but also to understand their long-term responsibilities to ensure that the measure will work when it's needed.

The owners' concern about how their homes and businesses will look after the project is completed is the most common reason for delays in projects, particularly elevation projects. There are many ways the designer can improve the appearance of the building, especially with landscaping. One example is the attractive floodwall on page 10-4.

The primary thing to remember about owners' preferences is that if the owners do not like the looks of a proposed project, the building may never be retrofitted. Similarly, if the owners are publicly displeased with the finished project, it may be hard to convince others of the merits of a similar retrofitting project.

Community Support

Usually, retrofitting measures are considered the responsibility of the property owner. However, local governments should have some involvement in all strategies that can reduce flood losses. Additionally, the community can play various roles in encouraging and supporting these projects. These opportunities are covered in more detail in the U.S. Army Corps of Engineers' *Local Flood Proofing Programs*.

Government Facilities

One of the first duties of a local government is to protect its own facilities. Fire stations, water treatment plants, and other critical facilities should be a high priority for retrofitting. This also sets an example and provides models for private property owners.

Public Information

The next step in supporting property protection measures is providing basic information to property owners. Owners need information about measures they can take, and they need to see examples, preferably from nearby neighborhoods or towns. Public information activities that can promote and support property

In Activities 330 and 350 (Outreach Projects and Flood Protection Information), the

CRS provides credit for distributing technical information on property protection to citizens through newsletters, presentations, displays, library references, Web sites, and other means. Activity 360 (Flood Protection Assistance) encourages and provides credit for community visits to flood-prone properties and for giving the owner site-specific advice on retrofitting and other protection measures.



protection are discussed in Chapter 5. They are also eligible for credit under the Community Rating System.

Financial Assistance

The local government can be a pass-through and administrator for State or Federal funding programs, or it can contribute its own funds to allow for more locally appropriate arrangements. Financial assistance can range from full funding of a project to helping residents find money from other sources.

Some communities assume responsibility for situations that arise from an inadequate public sewer or drainage system—sewer backups, street flooding, and other problems. Rather than face loss of staff time, legal costs, and ill will over assigning blame, the Metropolitan St. Louis, Missouri, Sewer District fully funds the sewer backup prevention measures shown on page 10-11.

Two community-supported programs are low-interest loans and rebates. These approaches do not fully fund a protection project, but they decrease costs to the community treasury and increase the owner's commitment to the project. Often, small amounts of money act as a catalyst to pique the owner's interest and get a self-protection project underway (described in the box on the facing page).

The more common outside funding sources are listed below. Unfortunately, some are available only after a flood or disaster declaration.

- Three Federal Emergency Management Agency (FEMA) programs, discussed in the acquisition section in Chapter 9, fund retrofitting and acquisition projects: Pre-Disaster Mitigation, Flood Mitigation Assistance grants, and the Hazard Mitigation Grant Program.
- After a flood or other type of disaster that warrants a Presidential disaster declaration, damaged public and nonprofit properties can be eligible for funds that help pay for retrofitting measures that mitigate against future damage as part of funding repairs and reconstruction. However, the amount of assistance will be reduced by the amount of flood insurance that the public agency should be carrying on the property.
- A Presidential disaster declaration may also trigger funds for limited home repairs and unmet needs for disaster victims. Sometimes these programs include wet floodproofing measures, such as replacing a flooded furnace in the basement with a furnace at a higher, flood-free, level.
- Community Development Block Grants are provided to larger cities and counties; smaller communities can apply to the State community development agency.
- The U.S. Army Corps of Engineers will support elevation projects as part of a larger flood protection program. The Corps works with the community, not directly with the property owner.
- Flood insurance claims can include Increased Cost of Compliance (ICC) funding. This provision increases a flood insurance claim payment to help

underwrite a flood protection project required by code as a condition to rebuild the flooded building. It can also be used to help pay the non-Federal portion of a cost-shared retrofitting project.

- After a disaster declaration, the Small Business Administration may provide disaster loans for non-governmental properties. There is a provision for additional funds for retrofitting.

Where to Get Help

- Two helpful resources for making flood-resistant modifications to houses are *Homeowner's Guide to Retrofitting: Six Ways to Protect Your House from Flooding*, Federal Emergency Management Agency, FEMA 312, 1998, which is available at <http://www.fema.gov/hazards/hurricanes/rfit.shtm> and *Engineering Principles and Practices for Retrofitting Flood Prone Residential Buildings*, Federal Emergency Management Agency, FEMA 259, 1996.
- FEMA's retrofitting publications can be found at <http://www.fema.gov/hazards/floods/whatshouldidoprotect.shtm>.
- The Regional Office is the best place for information about FEMA mitigation funding.
- The Corps of Engineers' National Nonstructural/Flood Proofing Committee's Web site, <http://www.usace.army.mil/inet/functions/cw/cecwp/NFPC/nfpc.htm>, lists retrofitting references. The Corps' District offices may be able to provide technical advice on retrofitting measures.
- The most extensive retrofitting Web site is Louisiana State University's (LSU) Extension Center, <http://www.louisianafloods.org>. In addition to listing LSU's many publications, the site offers advice on floodproofing and flood insurance, and a link to the national Extension Disaster Education Network. There are also links to online shopping for retrofitting products, contractors, and professional services, and to examples of installations.

Additional resources are listed in Appendixes A and B.

Property Protection Rebates

The Village of **South Holland, Illinois**, has a rebate program to help property owners fund retrofitting projects to protect against surface and subsurface flooding. If a project is approved, installed, and inspected, the Village will reimburse the owner 25% of the cost up to \$2,500. About 650 floodproofing and sewer backup protection projects have been completed under this program. Perhaps not surprisingly, contractors have become some of the best agents to publicize this program.

Lexington-Fayette Urban County, Kentucky, has had a rebate program since 1992. It funds up to 50% of the cost of a project. It has distributed nearly \$1,250,000 to protect 340 homes from surface flooding.

