

Unit 1 Floods and Floodplain Management — What Do They Mean to Your Community? _____

Floods are as much a part of the phenomena of the landscape as are hills and valleys; they are natural features to be lived with, features which require certain adjustments on our part.

Hoyt and Langbein, 1955
Floods

Unit Overview

Floodplain management is a process followed to develop the best mix of strategies and tools to reduce flood losses and protect natural resources and their functions. This unit describes the more common types of floods and floodplains as well as the evolution of strategies and tools for floodplain management.

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A. Introduction

This unit lays the groundwork for the course. It focuses on the concept of floodplain management, the evolution of floodplain management, and the strategies and tools for managing floodplains and reducing flood losses. It also introduces some basic terms used throughout the course.

Historically, people have been attracted to bodies of water as places for living, industry, commerce, and recreation. During the early settlement and development of the United States, locations near water were necessary for transportation, water supply, and waterpower. These areas also contained fertile soils, making them prime lands for agricultural use. This pattern of development continued as communities grew to their present form. More recently, development along waterways and shorelines has been spurred by the aesthetic and recreational values that these sites offer.

Floodplain development exposes a community to the risk of periodic flooding. Because of these trends, a substantial portion of this country's development is now subject to flooding. Floodplains account for seven percent of the nation's land, but they now include fifteen percent of our urban areas. Floodplains are the home to some 9.6 million households. In an average year, floods kill 150 people and cause over \$3 billion in property damage. Like the nation, Florida's average annual flood losses continue to increase because of a number of factors. Most presidentially declared disasters are flood related.

However, communities do not have to endure the dangers and damages that have resulted from unwise use of floodplains. There are many things that can be done to protect people and property from flooding. These can include preventing hazardous areas from being developed; requiring flood protection and control features in new developments; requiring flood-resistant construction; establishing flood warning and emergency response programs; and building flood control projects, such as levees and reservoirs.

Identifying and implementing proper development in floodprone areas is done through a process known as **floodplain management**. Good floodplain management entails "wise use" of floodprone areas consistent with the risk of social and economic losses and the loss of natural and beneficial floodplain resources. Where floodplain development is permitted, it results in development and construction measures that minimize the risk to life and property from floods and the risk to the floodplain's natural functions posed by human development.

New TermFloodplain
management

B. Floods and Floodplains

Flooding is part of the earth’s natural **hydrologic cycle**. The cycle circulates water throughout the environment (Figure 1-1). This process maintains an overall balance between water in the air, on the surface, and in the ground. Sometimes this system has local and temporary imbalances that send more water to an area than it can normally handle. This results in flooding.

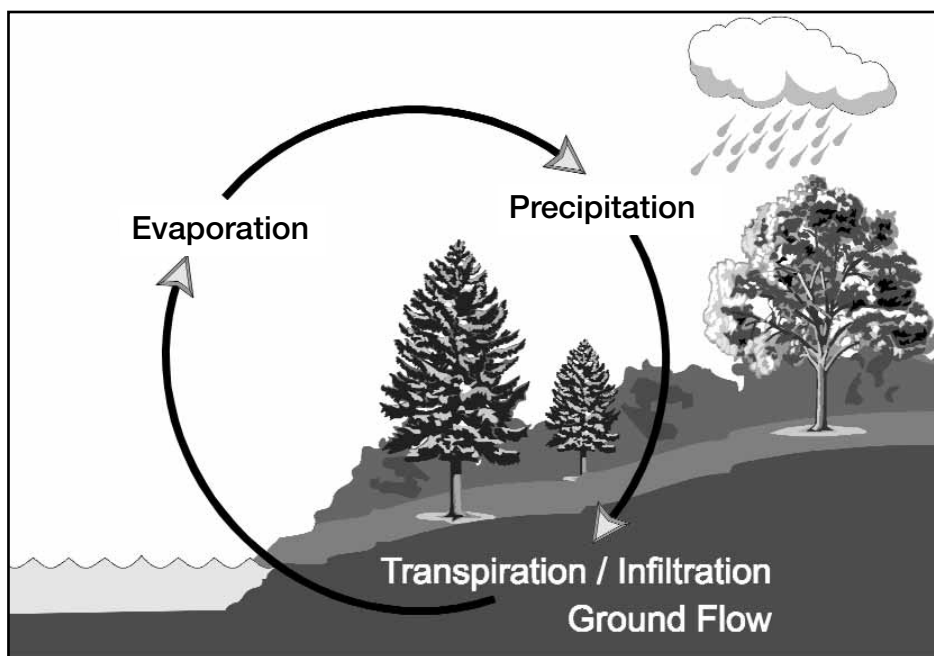
New Terms

- Hydrologic cycle
- Flooding
- Floodplain

Flooding occurs along major rivers and small streams, in coastal areas, and along the margins of some lakes. **Floodplains** are those areas commonly inundated by flooding. Floods result when water runoff exceeds the capacity of stream and river channels or lake basins. In coastal areas,

Figure 1-1
Hydrologic Cycle

The hydrologic cycle constantly circulates water throughout the earth’s environment.



floods result from storm surge and wave action, often caused by hurricanes or other storms.

Types of Floods

There are several different types of floods. Most communities experience only a few of them. The major types are riverine, surface water runoff, and coastal.

Riverine Flooding

Riverine flooding is associated with rivers, creeks, streams, or depressions that carry or store the runoff from rain in the watershed. Riverine

flooding results when water runoff from rain or snowmelt exceeds the capacity of channels or depressions and water overflows onto the adjacent low-lying areas called floodplains. Riverine flooding can also occur when there is an obstruction or blockage in a channel, such as debris. Figure 1-2 shows a riverine watershed and floodplain.

The dynamics of riverine flooding vary with terrain. In relatively flat areas, land may stay covered with shallow, slow-moving floodwater for days or even weeks. In hilly and mountainous areas, floods may come minutes after a heavy rain. The short notice, large depths, and high velocities of flash floods make these types of floods particularly dangerous. Among the common types of riverine flooding are:

Overbank flooding

This occurs when excess water leaves a defined channel, such as a river, stream or ditch. This is the most common type of riverine flooding and is illustrated in Figure 1-2.

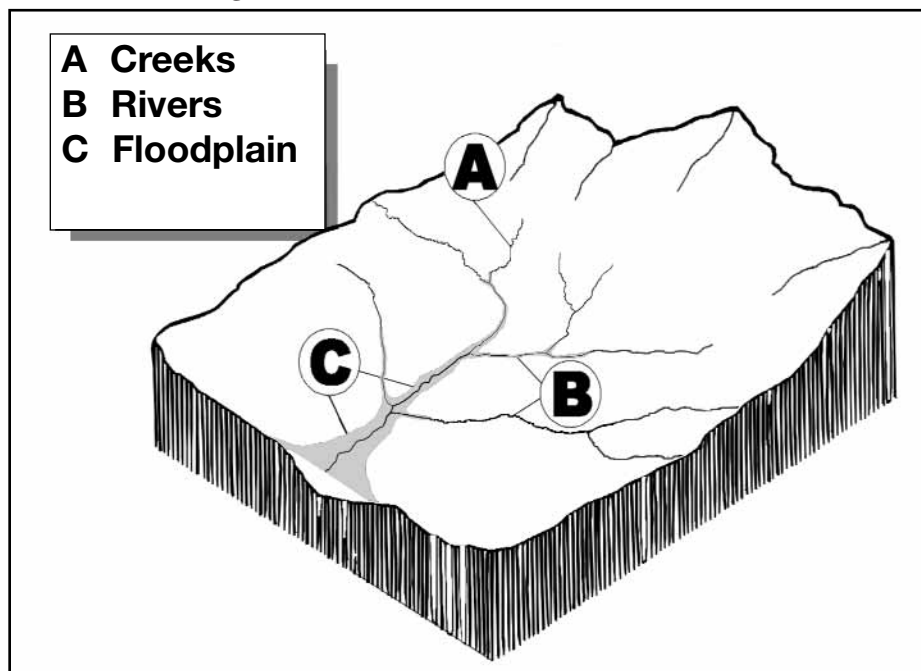


Figure 1-2
Riverine
Watershed
and
Floodplain

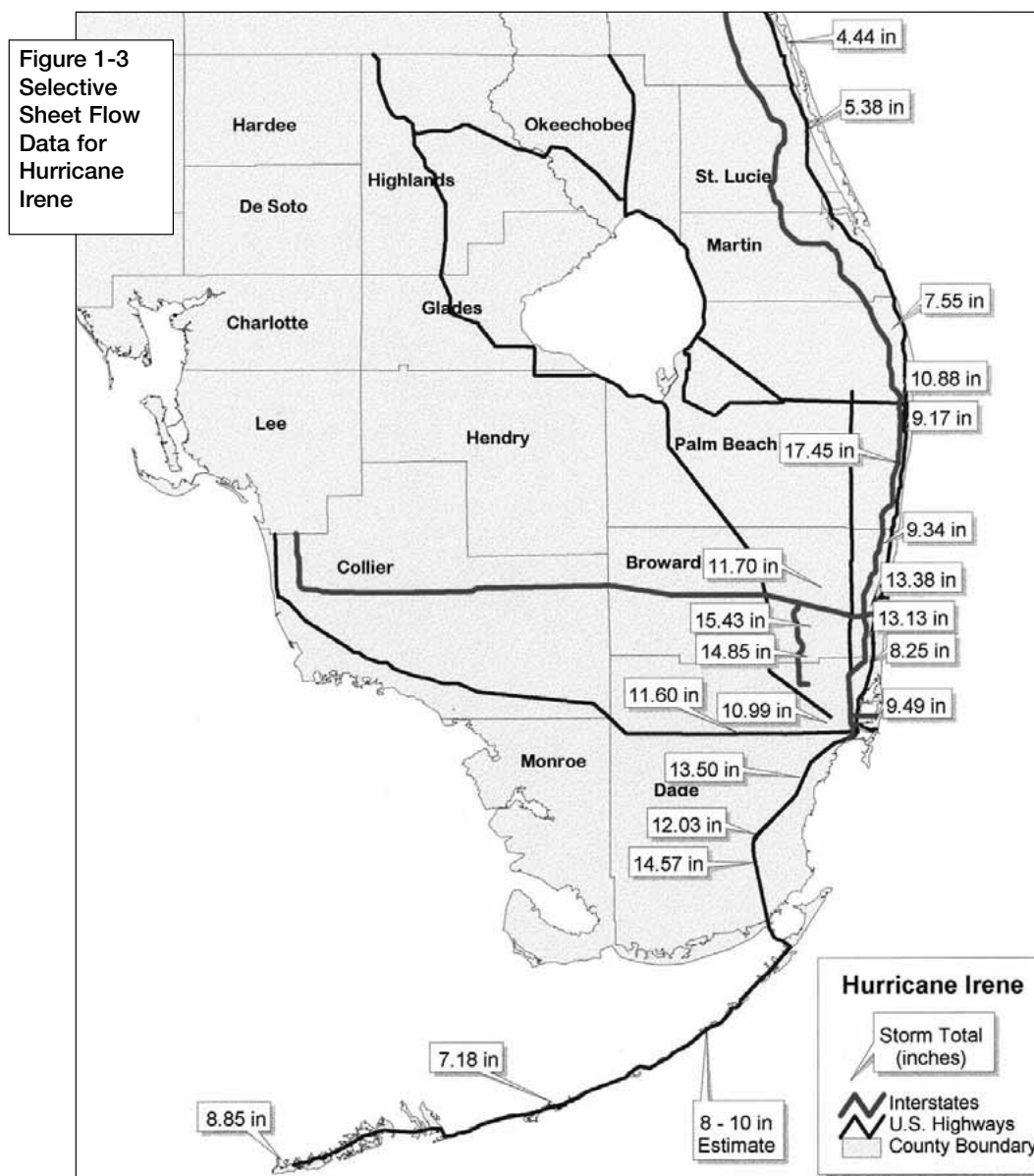
Sheet flow

Where there are no defined channels, floodwater spreads out over a large area at a somewhat uniform depth, called sheet flow. This is common in Florida, which has relatively flat land such as the Kissimmee River floodplain and the Florida Everglades. Following intense or prolonged

**New
Term**
Sheet flow

rainfall, the rain cannot soak into the ground because it is already saturated, and because of the flatness of the land water moves very slowly into drainage canals.

This type of topography does not promote water flow into the drainage canals over the surface but rather through the ground water and then into the drainage canal. If the drainage canal system is full and the ground saturated, this water will stand in these low lying areas until drainage is possible. Figure 1-3 shows sheet flow depths at selected locations resulting from Hurricane Irene in 1999.



Ponding

In flat areas, runoff collects in depressions and cannot drain out, creating a **ponding** effect. Floodwater must infiltrate into the soil or evaporate.

Flash Floods

Flash floods occur in all fifty states and are usually the result of severe localized weather systems that deposit a significant amount of rainfall in a very short period of time. Areas with steep slopes and narrow stream valleys are particularly vulnerable to these events, as are small tributary streams. Dam failure, release of ice jams, and collapse of debris dams also can cause flash floods.

For these reasons, flash floods are hazardous and very destructive. They rank first as the cause of flood-related deaths in the United States. Over three-quarters of all federally declared disasters involve flash flooding. The National Weather Service (NWS) has identified 2,000 communities across the country with potential flash-flood problems.

More than 800 localities nationwide have adopted flash flood warning, evacuation planning, or other mitigation efforts to deal with flash flooding.

Surface Water Runoff

Locally heavy rainfall may produce flooding in areas other than mapped floodplains. If local drainage conditions are inadequate to accommodate rainfall through a combination of infiltration into the ground and surface runoff, accumulation of water in certain areas may cause flooding problems. Flooding problems resulting from runoff of surface water generally increase as areas become more urbanized.

Greater population density generally increases the amount of impervious area, e.g., pavement and buildings. This reduction in the amount of natural ground that can absorb rainfall results in an increase in the amount of surface runoff generated. Uncontrolled, this runoff may be channeled to areas that cause flooding of structures and roadways. This may be especially true where the predevelopment land surface has a gently sloping surface with no defined channels. Such areas are subject to shallow sheet flooding during storms, but urbanization and other development speeds the accumulation of floodwater.

New Terms

- Ponding
- Flash floods

Urban Drainage

A second major change that occurs as a result of urbanization is the development of a drainage network to control the increased runoff. The straightening and lining of channels, and the construction of sewers, culverts, and other means of controlling runoff, result in improved **hydraulic efficiency** of the local drainage network. In other words, the time required for surface runoff to reach a stream channel is reduced. Unless the drainage network is specifically designed to counteract this increase in rate of runoff from the watershed, the result is likely to be an increase in flood peaks. Thus flooding will happen more quickly and usually to greater depths than before urban development occurred.

New Terms

- Hydraulic efficiency
- Storm water management

Controlling and regulating urban runoff is called **stormwater management**. It is a part of floodplain management, conducted on a street by street, even a building by building, basis.

Dam and Levee Failure

Some of the most significant losses due to the failure of flood control structures can be attributed to the construction of inadequate dams and levees or to a flood which exceeds the design protection level. Many private or locally built levees and dams may provide only limited flood protection or are sometimes poorly designed and maintained. Many were built with no design standards. Levee overtopping or failure typically occurs when floods exceed the levee's design capacity.

Dam failure can often be traced either to a poor decision made during design and construction and or to inadequate maintenance or operational mismanagement. Failure may also result from natural hazards, such as earthquakes, or from flow volumes that exceed capacity (Figure 1-4). Damage from dam failure is especially severe because of the high velocity of floodwater. Breaching often occurs within hours after the first visible signs of dam failure, leaving little or no time for evacuation.

Coastal Flooding and Erosion

Coastal flooding is generally caused by hurricanes or severe winter storms. Persistent high wind and air pressure changes push water toward the shore, causing a **storm surge** that can raise the level of the ocean by several feet.

New Term

Storm surge

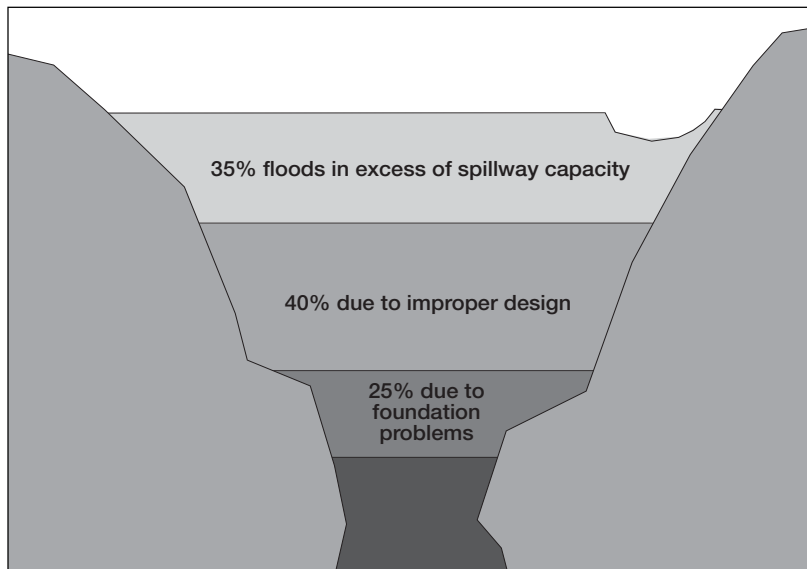


Figure 1-4
Causes of
Dam Failure

The effects of coastal flooding can vary with the tides. An increase in the level of the ocean during high tide can flood large areas. Waves can be very destructive as they batter beach structures and undermine them by eroding the sand.

On sandy shorelines, coastal storms create their own landforms. Sand dunes, bluffs, and barrier islands are produced by the action of wind and waves. They are also moved and reshaped by subsequent storms, making sandy coastal floodplains particularly unstable places to develop. On the other hand, sand dunes, bluffs, and barrier islands provide natural buffers from the effects of a storm, so their preservation is important to the protection of inland development.

Coastal erosion is also a natural process in areas where ocean forces are greater than sediment (sand) supply. Coastal erosion can be accelerated by:

- Hurricanes
- Winter storms
- Rising sea levels
- Human intervention, such as construction of groins or seawalls, the dredging of channels, and placement of sandbags—all of which can alter natural sand transport systems

Beach and dune erosion is most serious along portions of the eastern seaboard (see Figure 1-5).

Figure 1-5
Beach erosion threatens tens of thousands of structures on barrier islands along the Atlantic Coast.



Floodplains

Floodplains are the relatively low areas adjacent to rivers, lakes, and oceans that are periodically inundated when water flows over the banks of rivers and streams or beyond the shores of lakes and oceans. They are part of the natural water system: their function is to help carry and store riverine floodwaters or to dampen the energy of coastal storms.

Throughout time, floods have shaped the floodplain landscape. These areas are still being actively shaped by the forces of water, i.e., being eroded or built up through sediment deposition.

Not only do floodplains have special features that play an important role in our natural environment, they are also the focus of a variety of human activities, including commerce, agriculture, residential, and infrastructure. The natural and human environments in the floodplain constantly interact, and often adversely affect, their respective uses.

Development and Floodplains

Riverine floodplain development has a direct impact on flooding dynamics. Construction and regrading of the floodplain can obstruct or divert water to other areas. Filling reduces the floodplain's ability to store excess water, sending more floodwater downstream and causing floodwater to rise to higher levels. This also increases velocity of floodwater. As illustrated in Figure 1-6, properties that used to be flood-free can flood because of unwise development.

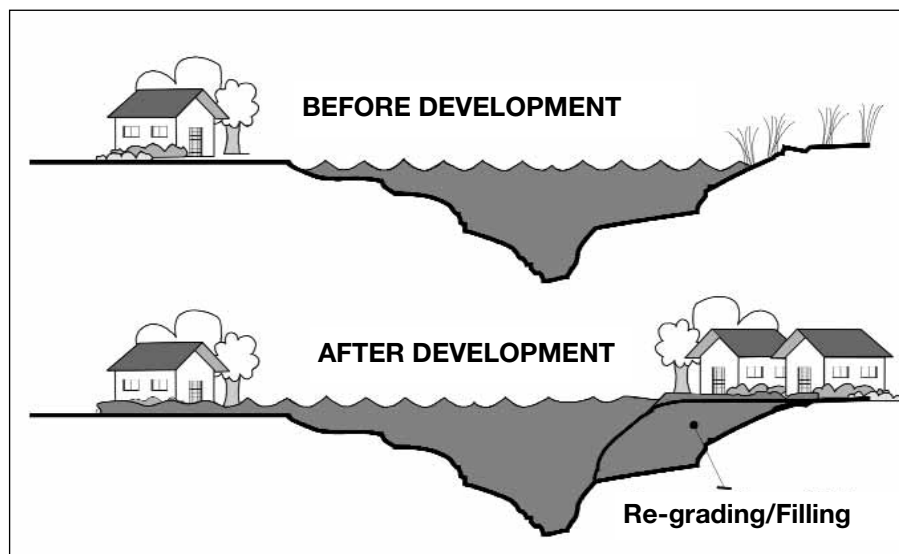


Figure 1-6
Effects of
Development
on a Riverine
Floodplain

Development in riverine watersheds affects the runoff of stormwater. Buildings and parking lots replace the natural vegetation that otherwise would absorb water. While in a natural setting, as much as ninety percent of the rain will infiltrate the ground; in an urbanized area, as much as ninety percent will run off.

Storm sewers, and more efficient ditches that come with urban drainage systems, speed flood flows. The result of urbanization is that there is more runoff in the watershed and it moves faster, increasing flooding downstream.

Coastal development similarly impacts the dynamics of coastal flooding. Removing the sand from beaches and dunes removes the natural barrier built up by flood forces over the years and exposes inland areas to increased risk of flooding. Construction of buildings, seawalls, and groins can have an adverse impact on the severity of coastal flooding over the long run. They put stationary elements into the shoreline's natural dynamic system so the water and sand can no longer move the way they would normally move.

Coastal development can be damaged by:

- Wave action and velocity water
- Inundation due to storm surge in areas protected from waves
- Erosion
- Wind
- Any combination of these forces

Natural Resources of Floodplains

Floodplain lands and adjacent waters combine to form a complex, dynamic physical and biological system found nowhere else. Natural or relatively undisturbed floodplains:

- Limit flooding naturally by temporarily storing floodwater
- Maintain water quality by filtering sediments, nutrients, and impurities
- Preserve and recharge groundwater supply
- Support natural vegetation
- Provide fish and wildlife habitat
- Provide many kinds of recreational opportunities
- Contain places for outdoor education and scientific study

When portions of floodplains are left in or restored to a natural state, they provide a wide variety of benefits to both human and natural systems. These benefits take many forms: some are static conditions (such as providing aesthetic pleasure) and some are active processes (such as reducing the number and severity of floods, helping handle stormwater runoff and minimizing non-point sources of water pollution). By allowing floodwater to slow down, sediments settle out, thus maintaining water quality. The natural vegetation filters out impurities and uses excess nutrients. Use of natural processes costs **far less** than it would take to build facilities to correct flood, stormwater, water quality and other community problems.

The natural resources of floodplains can be grouped into three general categories: water resources, living resources, and societal resources. Within each category are a number of natural and beneficial functions, as illustrated in Table 1-1.

Table 1-1. Natural Resources of Floodplains	
Water Resources and Functions	
Natural Flood and Erosion Control	<ul style="list-style-type: none"> - Provide flood storage and conveyance - Reduce flood velocities - Reduce flood peaks - Reduce sedimentation
Water Quality Maintenance	<ul style="list-style-type: none"> - Filter nutrients and impurities from runoff - Process organic wastes - Moderate temperature fluctuations
Groundwater Recharge	<ul style="list-style-type: none"> - Promote infiltration and aquifer recharge - Reduce frequency and duration of low surface flows
Water Resources and Functions	
Biological Productivity	<ul style="list-style-type: none"> - Support a high rate of plant growth in floodplains - Maintain biodiversity - Maintain integrity of ecosystems
Fish and Wildlife Habitats	<ul style="list-style-type: none"> - Provide breeding and feeding grounds - Create and enhance waterfowl habitats - Protect habitats for rare and endangered species
Societal Resources and Functions	
Harvest of Wild and Cultivated Products	<ul style="list-style-type: none"> - Enhance agricultural lands - Provide open space - Restore and enhance forest lands
Recreational Opportunities	<ul style="list-style-type: none"> - Provide areas for active and passive uses - Provide open space - Provide aesthetic pleasure
Areas for Scientific Study and Outdoor Education	<ul style="list-style-type: none"> - Contain cultural resources (historic, archeological sites) - Provide opportunities for environmental, other studies

These natural resources and functions can increase a community's overall quality of life. This role has been undervalued all too frequently in the past. Substantial gains can be made by transforming stream and river floodplains from problems areas into value-added community assets. Parks, bikepaths, open spaces, wildlife conservation areas, and aesthetic features are important quality-of-life issues to today's citizens. Assets like these make the community more appealing to potential employers, investors, residents, property owners, and tourists.



The use of stream and river corridors and coastal lands as greenways or greenbelts were first applied in an extensive fashion nationally around the mid-1970s. Examples of greenways in Florida include the Etoniah/Cross Florida Greenway in Putnam County, the Florida Springs Coastal Greenway in Citrus County, and the Wekiva-Ocala Greenway corridor in Lake County.

Too little attention has been given to integrating measures to protect floodplain resources and functions with those designed to reduce economic losses as a consequence of flooding. As outlined above and discussed in subsequent units of this document, there is considerable benefit to the community in integrating these measures in their floodplain management regulations and in other programs. Such actions can realize a number of community goals and needs, and build public and political interest and support for flood damage reduction measures that would otherwise not exist (refer to *Using Multi-Objective Management to Reduce Flood Losses in Your Watershed*, ASFPM, 1996).

Remember that there are two ways of looking at floodplains. As areas of land that are periodically covered by water, they can be dangerous to people and property. On the other hand, in their natural state, floodplains help people and support certain types of human enterprises, such as tourism, commerce, and agriculture. Unwise development can alter the floodplain and the dynamics of flooding. Managing development in floodplains is the theme of the next part of this unit.

C. Floodplain Management

With this introduction to floodplains and how they can be adversely impacted, attention can be directed to available floodplain management measures. First, it might be worthwhile to look at where we have been. The history of government flood programs reflects an evolution in government policy regarding flood control in general, as well as an evolution in the roles of federal, state, and local governments in reducing flood losses.

The Evolution of Floodplain Management

In the United States, the federal government’s involvement in floodplain management began in the late 1800s, with an interest in maintaining the navigability of rivers to facilitate interstate commerce. In the mid-twentieth century, **structural flood control** projects were seen as the primary way to reduce flood losses. Public policy emphasized that controlling floodwater with dams, levees, and floodwalls could curb flood losses.

Following the “Great Flood of 1927” on the Mississippi River, the federal government became a major player in flood control. The Flood Control Acts of 1928 and 1936 defined the approach. The 1936 act alone authorized construction of some 250 projects for both flood control and relief work. The role of government agencies was to build massive flood control structures to control the great rivers, protect coastal areas, and prevent flash flooding.

After many years of this approach, people began to question the effectiveness of this single solution. Studies during the 1960s concluded that flood losses were increasing, in spite of the number of flood control structures that had been built. Disaster relief expenses were going up, making all taxpayers pay more to provide relief to those with property in floodplains. One of the main reasons for this was that people continued to build in floodplains. As a result, federal, state, and local agencies began to develop policies and programs with a “nonstructural” emphasis, i.e., not employing projects that control or redirect the path of floods.

The history of floodplain management since the 1960s has been one of moving from heavy reliance on flood control, or structural measures, to one using a combination of many different tools.

Nonstructural flood protection measures include regulation of development, requiring flood-resistant construction, acquisition and relocation of buildings in high hazard areas, flood warning systems, control of stormwater runoff, comprehensive coastal zone management programs, and self-help advice to property owners.

The creation of the National Flood Insurance Program in 1968 was a landmark step in this evolution. It established both an insurance program, as an alternative to disaster relief, and a national standard for regulating new development in floodplains. It also began a comprehensive floodplain mapping program and the start of a shared responsibility for floodplain management at all government levels and in the private sector.

New Terms

- Structural flood control
- Nonstructural flood protection

Concurrently, during the 1960s and 1970s, interest increased in protecting and restoring the environment, including the natural resources and functions of floodplains. Coordinating flood-loss reduction programs with environmental protection and watershed management programs has since become a major goal of federal, state, and local programs.

As a result of this evolution, we no longer depend solely on structural projects to control floodwater. Our floodplain policies are now multi-purpose and result in different solutions for different situations.

Floodplain Management
 Floodplain management can be defined as a continuous process of making decisions about how and whether floodplain lands and waters are to be used.

The Concept of Floodplain Management

Floodplain management can be defined as “a continuous process of making decisions about whether and how floodplain lands and waters are to be used” (Federal Interagency Floodplain Management Task Force 1994). The result of good floodplain management will be the wise use of floodplains, in terms of both reduced flood losses and protection of the natural resources and functions of floodplains.

Floodplain Management

Floodplain management is a decision making process that aims to achieve the wise use of the nation’s floodplains.

Goals of Floodplain Management

- Reduce loss of life, disruption, and damages caused by floods
- Preserve and restore the natural resources of floodplains

Floodplain management needs the cooperation and participation of all levels of government, the private sector, and the affected individuals. Many factors need to be considered, including regional needs, hazard protection, environmental quality, and economic efficiency. The process is never ending. Floodplain management activities need to be continuously evaluated and adjusted to meet changing conditions.

Strategies and Tools

Floodplain management involves four basic strategies to achieve its goals of reducing economic losses from flooding and reducing the losses of natural and beneficial floodplain resources. Each strategy is supported by an array of tools. The strategies and tools are summarized here and many of the tools can be used in more than one strategy.

Strategy 1

Modify human susceptibility to flood damage and disruption by avoiding hazardous, uneconomic, or unwise use of floodplains. Tools include:

- Floodplain regulations (e.g., zoning to steer development away from hazardous areas or natural areas deserving preservation; subdivision regulations; and building, health and sanitary codes)
- Development and redevelopment policies on the design and location of public services, utilities, and critical facilities; land acquisition; open space preservation; and permanent relocation of buildings
- Floodproofing of new buildings and retrofitting of existing ones
- Flood forecasting, warning systems, and emergency plans that prepare people and property for flooding
- Preservation and restoration of the natural resources and functions of floodplains

Strategy 2

Modify the impact of flooding by assisting individuals and communities to prepare for, respond to, and recover from floods. Tools include:

- Information and education to assist self-help and protection measures;
- Flood emergency measures to protect people and property during a flood
- Disaster assistance, flood insurance, and tax adjustments to reduce the financial impact of flooding
- Post-flood recovery plans and programs to help people rebuild and implement mitigation measures to protect against future floods

Strategy 3

Modify flooding through projects that control floodwater. Tools include:

- Dams and reservoirs that store excess waters upstream of development
- Dikes, levees, and floodwalls that keep water away from developed areas
- Channel alterations that make the channel more efficient, so overbank flooding will be less frequent;
- High flow diversions that direct excess water around developed areas
- Land treatment to hold as much rain as possible where it falls, so it can infiltrate instead of running off

- On-site detention measures to store excess runoff
- Shoreline protection measures that protect inland development and account for the natural movement of shoreline features
- Measures to control runoff from developing areas outside the floodplain.

Strategy 4

Preserve and restore the natural resources and functions of floodplains by maintaining and reestablishing floodplain environments in their natural state. Tools include:

- Floodplain, wetlands, and coastal barrier resources regulations, e.g., land use regulations, such as zoning, to steer development away from hazardous or sensitive areas or natural areas deserving preservation
- Development and redevelopment policies on the design and location of public services, utilities, and critical facilities; land acquisition; open space preservation; permanent relocation of buildings; restoration of floodplains and wetlands; and preservation of natural functions and habitats
- Information and education to make people aware of natural floodplain resources and functions and how to protect them
- Tax adjustments to provide a financial initiative for preserving lands or restoring lands to their natural state
- Beach nourishment and dune building to protect inland development by maintaining the natural flood protection features

Economic growth, hazard mitigation, and environmental protection are not mutually exclusive.

In most cases, a combination of these tools is needed to reduce risks and protect natural resources and functions. Floodplain management is the process that selects the best mix of tools that are appropriate for the local floodplain, the needs of the local population, and the capabilities and resources of the implementing agencies.

Because floodplain management is a process, there is no one “best” set of tools or one single “wise use” of the floodplain. The important message from this definition of floodplain management is to consider all the options and account for both the hazard and the natural values before developing or implementing an action that will change the floodplain.

Please complete the Unit Learning Exercise before proceeding.



Unit Learning Exercise



Purpose: To review what you have learned in this unit.

Directions: Answer the following questions.

1. This unit described a number of types of floods. Which types occur in your community?

2. Define the term **floodplain**.

3. List at least three benefits that floodplains, in a relatively undisturbed condition, actually contribute or could contribute to your community.

4. What is **floodplain management**?

5. What are the two primary goals of floodplain management?

6. List at least six “tools” that are available, for use in your community, to carry out floodplain management measures.

Answers to Unit Learning Exercise

1. This unit described a number of types of floods. Which types occur in your community?

Depends on the community

2. Define the term floodplain.

Floodplains are the relatively low areas adjacent to rivers, lakes, and oceans that are periodically inundated by water.

3. List at least three benefits that floodplains, in a relatively undisturbed condition, actually contribute or could contribute to your community.

Although this depends on the community, there are a large number of benefits they could potentially provide. These potential benefits are listed in Table 1-2.

4. What is floodplain management?

A continuous process for making decisions about how floodplain land and water are to be used. The result of good floodplain management will be the wise use of floodplains to benefit the community.

5. What are the two primary goals of floodplain management?

The two primary goals for floodplain management are: (1) to reduce the loss of life, disruption, and damage caused by floods; and (2) to preserve and restore the natural resources and functions of floodplains.

6. List at least six “tools” that are available for use in your community to carry out floodplain management measures.

You have many tools at your disposal. Among the most commonly used are floodplain regulations, structural adjustments to buildings, flood insurance, flood forecasting and warning, and acquisition of properties and lands to reduce future flood losses while meeting a number of other community needs.