

Chapter 1

Floods and Floodplains

Chapter Overview

Floods are a naturally occurring process. The lands they occupy on a temporary basis from time to time—floodplains—are often the locus of human occupancy and use, resulting in economic losses and diminution of natural resources and their functions. This chapter describes flooding as part of the human existence, the present situation regarding flood hazards, why good “floodplain management” is necessary, possible future roles of the student in the management process, and sets the overall tone and need for academic treatment of this subject matter.

Floods in the Human Existence

Creation Myths

Flooding has always been a part of human existence. It seems to have been so much a part of human development that the terror and renewal that accompanies flooding has become part of our cultural heritages. Diverse cultures from all over the globe incorporated flooding into their basic creation myths.

The Judeo-Christian heritage includes an account of God gathering the waters below the heavens into one place, letting the dry land appear. He called the dry land earth and the gathering of the waters He called seas.

To the ancient Egyptians, before there was any world, all was water. This watery existence was called Nun. Their creator god, called Ra or Amon-Ra, arose from this watery abyss and made the waters recede to expose the land. He created life on the dry land.

For the ancient Incas, the creator God was Viracothé. Displeased with the first creatures that inhabited the earth, he brought about a great flood that destroyed everything. The sun hid on a small island in the middle of Lake Titicaca. After the waters receded, he created people who then populated the earth.

Deluge Myths

A study of myths from various cultures around the globe reveals striking similarities concerning stories of the Great Flood. The following accounts are taken from a paper prepared by a University of Texas student.¹

Those of the Judeo-Christian faith are familiar with the Biblical account of the flood in which Noah is tasked with saving the various species of animals, and indeed the human race. The Qur'an also deals with the same theme. The common underlying message is one of human behavior incurring Divine Wrath in the form of a global deluge. The deluge was to destroy most of the living beings, and Noah was to ensure that there was sufficient representation of each of the species to allow a regeneration of life on earth. This would signal a return to a God-fearing population. This theme also becomes apparent in other cultures' stories of the flood.

Why was there a need for a flood to devastate the whole world? Among the American Indian cultures, a recurring theme is one of cycles of disaster. The Aztecs believed there was a conflict

¹ “Floods, Noah and Deluge Mythologies,” by Fazal Ahmad, University of Texas, circa 1995.

between the four deities at the corners of the Universe. This led to the first era ending with the world being consumed by Jaguars, the second was destroyed by a great hurricane, the third by fire, and the fourth (the latest catastrophe) destroyed by a flood. The Hopi assign the calamity to human behavior rather than a conflict between deities. They speak of the first world being destroyed by fire, the second by an ice age, and the third by a universal flood. The fate of the current era depends on the conduct of the human race. Elsewhere is also found mention of the flood in connection with human behavior. Among the stories from Australia, the flood was brought by a half-human python Yurlunggur to punish man for sexual transgression. The flood was intended to teach man the limits of human relationships. The Maoris tell of their god Tawaki who was angry about the sinful ways of mankind, so he broke the floor of heaven and let the waters pour through the hole to flood the earth. The Guarani of Paraguay tell of the incest of man leading to the flood that all but wiped out humanity. In virtually all of the stories of the flood, it is the sin of man that ultimately leads to the flood. The flood is never a natural disaster or occurrence, but is a Divine intervention to punish man and cleanse the earth.

Many myths provide accounts of the survival of certain members of the human race in an ark, or some kind of vessel. In the Greek myth, Deucalion and his wife Pyrrha, having been warned of the impending flood by Titan, built an ark in which they survived the deluge. There are several Babylonian stories, the most notable of which is the Gilgamesh Epic. In one story, humanity offended the gods so the god Enlil sent a flood. The god Enki told King Ziusudra to build a boat so that he and his family could survive. After surviving the seven-day flood, the king offered sacrifices to Enlil and was allowed to repopulate the earth. In the Hindu culture, Matsyu is one of the incarnations (Avatars) of Vishnu. Matsyu warns Manu, the first man, of an impending flood and instructs him to build a boat, and to stock it with representation of all species. The Arapahoe Indians of North America survived in a boat made of fungi and spider's webs. In almost all of these stories, the survivors were warned beforehand of a forthcoming deluge and given instructions to build a vessel in which to save the species. It is interesting to note just how many diverse stories follow the same theme: a Divine plan to send a flood and a warning about the flood, giving sufficient time to build an ark or other vessel to preserve life-forms.

There are a wide range of stories, myths, and religious "facts" on the subject of the Great Flood, said to destroy all life except those spared by Divine intervention. (The above accounts represent only a fraction found in the world's cultures.) Is there an element of truth in the accounts? It seems highly unlikely that such diverse cultures, with only limited contact until very recently in historic times, could independently concoct such strikingly similar tales.

Of Floods and Floodplains

From majestic rivers to country creeks, from mountain rills to the tiny trickles that occasionally dampen otherwise arid wastelands, every water body on earth is subject to flooding, at some time, under certain conditions. Of all natural hazards, "floods" (yet to be defined for purposes of this course) are the most far-flung – and the most ruinous to life and property.

Despite their clear potential for peril, "floodplains" (also yet to be defined) have always held an irresistible attraction for humans. Historically, we have been attracted to bodies of water as places for living, industry, commerce, and recreation. The earliest recorded civilizations, such as those in Egypt and Mesopotamia, sprang up along the life-giving Nile and the Tigris and Euphrates Rivers that periodically overflowed their banks and spread fertile soil and moisture in which crops could flourish.

Human inhabitants, called "Indians" by Europeans, had occupied North American for around 13,000 years before the latter arrived on the continent. Their presence had minimal impact on

lands adjacent to water. Most tribes and bands were primarily hunters and gatherers, although a few had developed limited agriculture in some locations. They traveled from area to area, usually in a yearly cycle, following the food supply.



Painting of Native American Village, National Museum of American Art.

The Europeans brought Old World culture to the Americas. They had long established traditions that tied them to a specific plot of land, whether in towns and cities for commerce and industry or in farming practices. During the early European settlement and subsequent development of the United States, permanent 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.

The physical diversity of the United States, in terms of climatic zones and geomorphic, hydrometeorologic, and other factors, gives rise to a broad range of riverine, coastal and lacustrine (lake) flood situations. At one extreme are high-magnitude – high-intensity storms that occur in mountainous regions and produce flash floods. Notable examples in recent decades include Rapid City, SD (1972) with a loss of 236 lives, and the Big Thompson Canyon, CO (1976) with a loss of 145 lives. At the other extreme are long-duration storms of low intensity that occur in relatively flat regions of high vegetation density and that generate long periods of high water discharge. A recent example is the 1993 Midwest floods covering portions of nine states and lasting for several months. Although flooding is common in all 50 states, the type and frequency of flooding vary considerably from state to state and geographically within each state.



Photograph of building moved off foundation by flash flood.

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 cause deaths to 150 people and over \$3 billion in property damage. Average annual flood losses continue to increase because of a number of factors. Most Presidential-declared disasters are flood related.

Water is found in many forms and locations. For perhaps three billion years the total amount of water on the earth and in its atmosphere has been almost exactly constant. The oceans and sea ice presently contain 97% of all water on earth. Glaciers and ice caps contain 2%. The remaining 1% is distributed among groundwater, inland lakes, streams, and the atmosphere.²

With the help of the sun's heat and the pull of gravity, it is forever recycled, now evaporating and entering the air as vapor, then condensing and falling back to earth as rain or snow. Thus the water used to cook today's meal may be the same as that once drawn from the Nile for Cleopatra's bath.

Flooding is part of the earth's natural **hydrologic cycle**. This is represented in Figure 1-1.

² Federal Emergency Management Agency, Emergency Management Institute, "Floodplain Management Course (Graduate Level)," Session 4

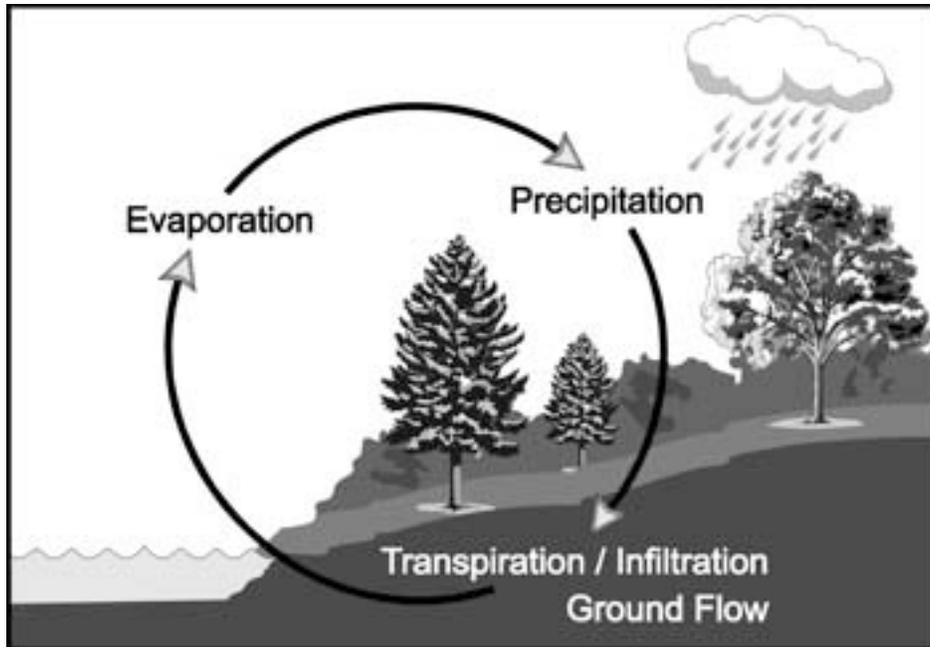


Figure 1-1. Hydrologic Cycle. The hydrologic cycle constantly circulates water throughout the earth's environment.³

Modern man's Biblical forefathers had at least an inkling of this phenomenon. "All the rivers flow into the sea, yet the sea is never full. To the place from whence the rivers flow, there they flow again." (Ecclesiastes 1:7) The cycle circulates water throughout the environment. 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.

Flooding occurs along both major rivers and small streams, in coastal areas, and along the margins of some lakes. Other flood-prone areas include alluvial fans and other types of unstable and meandering channels, ground failure areas, and areas influenced by structural measures. Riverine flooding can develop from heavy rainfall and rapid snowmelt as well as from dam and levee failure, ice jams, and channel migration. Coastal flooding can be caused by hurricanes, winter storms, tsunamis, and rising sea levels. Individual storms and long-term climate variations are among the causes of lacustrine flooding. In addition, flooding due to surface runoff and locally inadequate drainage can be a major problem, particularly in rapidly urbanizing areas.

Today, in the United States, most people define floods by the damage they do. When water levels rise, those who live nearby may worry, but they do not call the rise a flood unless it causes damage or disruption. Unfortunately, the damage-centered definition of a flood implies somehow that it is associated only with people and not with the water body. In reality the reverse is true. Flooding, as ancient civilizations recognized, is a capricious manifestation of natural forces. Flooding is part of the normal behavior of a water body. The definition of a flood, then, is arbitrary. Usually a flood is defined as the stage of height of water above some given datum such as the banks of a river channel or sea level. In this sense, a flood occurs whenever the river or stream overflows its banks; lake levels rise; or in coastal areas, from storm surge and wave action, often caused by hurricanes or other storms.

³ "Carrying Out Floodplain Management in Your Locality: Home Study Course for North Carolina Community Officials," November 1997, North Carolina Division of Emergency Management and Federal Emergency Management Agency.

The expected levels or heights of floods can be determined in many ways: from records of historic events; from gauging records; from differences in soils, vegetation, and landforms; and from indirect computational methods based on meteorologic and hydraulic information. Soils, vegetation, and landforms, such as floodplains and terraces, provide a basis for delineating flood-prone lands not only because the river forms the land adjacent to it, but because the movement of the river channel in the valley changes over a long period of time and its flooding create distinctive soils, vegetation, and landforms.

Presumably, there are limits to the amount of water the atmosphere can hold and release in one place at one time. However, we do not know if these hypothesized limits have been reached and the record suggests that the greatest amounts in many places have not yet been recorded. It is important to add that the brevity of the record of floods in most places (usually only a few decades) and the fact that the possible magnitude of the largest floods is unknown means that much uncertainty remains regarding the true extent of the frequency of various flood events.

Flood—A general and temporary condition of partial or complete inundation of normally dry land areas from overflow of inland or tidal waters or from the unusual and rapid accumulation of surface runoff from any source. (A National Flood Insurance Program definition.)

Floodplains are those areas commonly inundated by flooding. Both the natural processes themselves and the human experiences with floods make it abundantly clear that floodplains are part of river or stream bottoms, coastal areas, and margins of lakes, a fact of immense importance to individuals and society.

The term “floodplain” may take on different meanings, depending on a particular discipline.

- To the **geologist** it represents the complex interaction, through time, of channel morphology, climatic change, world-wide changes in sea level and changes in the earth’s crust, and is best characterized in the present as the landform along a river, lake or coastal area subject to periodic overflow.
- To the **biologist** the floodplain is a veritable treasure-land of habitat where flora and fauna mix in myriad forms of diversity.
- To the **hydrologist** it may be the area that could be subject to inundation by the maximum possible flood event (i.e., the largest flood that theoretically can occur at a given site during the present geologic and climatic era.). To a lesser degree, it may be based on an estimate of the area required to carry the runoff resulting from precipitation of a particular magnitude (in terms of intensity and duration) and frequency.
- To the **earth scientist** floods are dynamic agents that can change sediment patterns and thereby alter the physical geography.
- To the **layperson** it may be that area that was flooded by some event of recent, but rapidly fading, memory.
- **Law** and/or **common usage** among those who have statutory-established agency authorities involving floodplain areas may also define the term.

For most management purposes in the United States today, floodplains are defined as the low lands adjoining the channel of a river, stream or watercourse, or adjoining the shore of an ocean, lake or other body of standing water, which have been or may be inundated by flood water. Floodplains are further categorized by the frequency of flooding (discussed in more detail in a subsequent chapter). A common standard is the flood with a one percent chance of being equaled or exceeded in any given year – commonly referred to as the “one percent flood” and often

inappropriately labeled the “100-year” flood. Floods, of course, are not confined to the area inundated by the one percent flood. Larger floods may, and have often, occurred, but since the 1960s the one percent flood has been generally accepted as a standard for regulation of most additional development in identified flood-prone areas.

Floods and Floodplains

- *Streambeds and adjacent floodplains are integral parts of every natural watercourse*
- *Typically, the stream uses some portion of its floodplain about once in two to three years (In natural systems, channel carving and sizing is based on this frequency of water flow.)*
- *At less frequent intervals, the stream may inundate its entire floodplain to considerable depth*
- *The flood potential differs greatly from one area or region to another. The size and frequency of flooding depends on:*
 - *Amount and nature of rainfall or snowmelt*
 - *Vegetative cover*
 - *Watershed topography*
 - *Other factors*
- *Historically, no region of the country has been immune from flooding*

Issues and Situations

The following issues and situations will likely have to be addressed in any program or project dealing with floodplain land use.

Floodplains provide amenities, risks and rewards. It can be argued that over a long enough period of time, the occupant of the floodplain will always lose, i.e., the risk will exceed whatever advantage derived from living on the floodplain.

People want to live near and/or play in water. A number of businesses require a waterfront location. Most do not.

As mentioned above, the rate of growth along our watercourses and coasts are about double the national growth rate. The population at large is increasingly at risk from the consequences of floods.

Many management approaches involve or affect private ownership of property. When you try to manage or protect the lands along rivers, streams, and coastlines, you touch on one of the most intimate relationships that people have— with their property, their land.

You affect their expectation about what they can do with the land. Activities that involve enforcement or litigation are contentious. People who presently own land basically want to do with it as they choose. Those who buy land have various reasons and expectations – it may be cheap, level and capable of being used or developed without a lot of site development expenses; it may be purchased for speculation and profit.

As the population increases along with comparable land demands, former marginal lands that were undeveloped or underdeveloped become more attractive and its increased value attracts sellers. Then too, today’s mobile society may not be aware or adequately informed concerning natural hazards.

Risk awareness and risk assessment are other factors to be dealt with. The public at large may not understand the risk involved in using a parcel of land. They may not have received, or understood, or accepted information that will cause them to make an informed decision or a decision that a prudent person would be expected to make. The information may be too technical. We may not explain it well enough. We may not be believed or taken seriously.

There will always remain some segment of the population that will not take preventative actions in response to flood risk information. Some people will not understand or accept information on risk provided to them, particularly if they have not personally experienced a flood. Others understand the risk but are willing to take that risk and feel they have the right to do so. Often their strong desire to live near a river or coast overrides concern for personal safety and damage to property.

We humans do not want to deal with, either in our thoughts or decision-making processes, low probability – high consequences events (seat belts, firearms, unsafe sex, DUI). Understanding human behavior and decision-making processes is very important. There are many socio-economic issues and situations constantly in play within flood-hazard areas. Poverty is one, as demonstrated in the aftermath of Hurricane Katrina in the New Orleans area. Those in poverty may not be indifferent to the possibility of flooding, but the everyday conditions of work or finding employment, life support, and social and mental security require all of their risk-avoiding and risk-taking energies.

Finally, there is the possibility of governmental intervention, transferring ultimate responsibility for the consequences of decision-making from the individual to the public at large through disaster response and recovery. Governmental intervention will be covered in a number of subsequent chapters.

Floodplain Development and Use

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. Human activities frequently interfere with the natural floodplain processes, suffering inconvenience or catastrophe as a consequence

Riverine floodplain development has a direct impact on flooding dynamics. Construction and re-grading 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. Properties that used to be flood-free now flood because of unwise development.

Development in riverine watersheds affects the runoff of stormwater and snowmelt. 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 conveyance systems, e.g., curbs, inlets, ditches, pipes, 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 water 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.

Problems created by flooding events impacting human activities have several unique characteristics:

- Flooding normally affects only a small part of the total citizens in a community, those who happen to live near its stream banks or shorelines.
- In many cases, those citizens that are damaged by flooding are the same ones who enjoy the benefits of the river, stream, or other water body during non-flooding periods.
- During or shortly after flooding events, interest and public sympathy is high for those affected, but quickly diminishes with time.
- Flood-prone areas offer many advantages for development in spite of the potential dangers (e.g., aesthetic qualities of waterfront locations, relatively flat easily developable land)
- Major flooding events may occur very rarely, with long periods where flood-prone areas are unaffected by floodwaters.

Selected Statistics

- Our nation has over 3.5 million miles of rivers and streams, 12,500 miles of general coastline, and nearly 5,000 miles of Great Lakes shoreline.
- Including shorelines of offshore islands, sounds, and bays, the total tidal coastline is around 90,000 miles.
- About seven percent of the land area (around 175 million acres) is subject to periodic flooding.
- These “floodplains” contain an abundance of water, living, and cultural resources (described in a subsequent chapter) of immense value.
- Most wetlands are located in floodplains (95 million acres of wetlands), comprising about five percent of the nation’s land area. About 300,000 acres vanish annually.
- There are approximately 20,000 to 21,000 flood-prone communities.
- Fifteen percent of urban areas are subject to flooding. Over half of urban floodplains have been already developed.
- Floodplains contain approximately 10 million households and \$800 to \$900 billion in property subject to flood risk.
- Floods are the nation’s greatest natural disaster, causing an estimated \$3 to \$5 billion in average annual damages (actual figures have never been compiled).
- Annual growth in coastal and riverine floodplains is roughly twice that of the country as a whole. Over 350,000 structures have been built within 500 feet of U.S. coasts.
- Over one-half of original wetlands have been destroyed since European settlement.
- Out of the original 75 to 100 million acres of indigenous, woody-riparian habitat, 35 million acres remain.
- In response to flooding, since 1935 with the advent of major federal involvement:
 - \$25 billion has been spent on projects to “control” flooding.
 - Nearly \$3 billion has been spent on mapping the nation’s flood hazard areas. Annual expenditures are around \$200 million.
 - Federal and state agencies are spending in excess of \$100 million annually on technical and planning assistance.
 - Hundreds of millions of dollars are spent in most years on flood disaster relief and recovery assistance.

Floodplain Management

Floodplain management is a decision-making process with the goal of achieving *wise use* of lands subject to flooding. What is “wise use” may depend on personal views, goals and objectives. But it should encompass any activity(ies) compatible with the risk to:

- The natural and beneficial functions served by floodplains, and
- The human life and property on the floodplain

Compatibility with natural and beneficial functions is achieved through the basic strategies of preservation, restoration, and creation. *Compatibility* with human life and property is achieved through the basic strategies of modifying flood waters, susceptibility to flood waters, and impact of flood waters. Each strategy is supported by an array of loss reduction (to natural functions and property) “tools,” e.g., hazard identification programs, development/redevelopment plans, local ordinances, control structures, etc. These strategies and tools will be covered in detail in subsequent chapters.

In summary, floodplain management is:

- A decision-making process seeking wise land use
- Wise use is compatible with risk to human and natural resources
- Risk is reduced through loss reduction strategies and tools
- The best mix of strategies and tools must be sought for each individual floodplain, and even for a given floodplain site.

You and Floods

In just about any discipline you will have to deal with flood problems. The civil engineer as a private consultant or working in the public sector in structural design, highway design, environmental, hydraulics, hydrology; other engineering professions; planners; administrators; lawyers; lenders; insurers; and architects. An understanding of the problems, programs, policies, processes and procedures should benefit you and your employer.

Communication

Each profession has terms and concepts that are specific to that profession, and by extension to the general public. The practice of floodplain management is no exception. As professionals, we must adequately understand the meaning of terms so we can more effectively communicate with other professionals, local decision-makers, and the general public. You are serving as the interpreter (translator) of technical concepts for others with little if any training, experience, or background in floodplain management. Never assume that they have the same understanding of terms you frequently use, such as “100-year flood” and “floodway” or acronyms such as “FIRMs” and “BFEs.” (By the time you complete this course you will be exposed to these and a number of other acronyms commonly used by the floodplain management profession.)

Chapter Homework Assignment

Consider the reports of a great flood found in numerous cultural and regional stories, myths, and legends from around the world and also found in the Biblical account of the flood (Genesis, Chapters 7:11 – 8:14). Based on your religious beliefs and scientific reasoning, conclude whether this was a large regional or a world-wide flood. Prepare a well-reasoned, written defense of your conclusion.

Field Trip Structure

Our next class session will consist of a field trip to view floodplains along portions of several local streams. Prior to the session, your instructor will identify the stream reaches that will be visited. Wear comfortable, casual clothes with suitable walking shoes.

To prepare for the trip, print out maps showing areas subject to flooding along the stream reaches that will be visited.

To obtain these maps, go to the following Internet Website:

www.fema.gov/hazard/map/firm.shtm

FIRM (which takes you to “Map Service Center) At the FEMA Map Service Center, click on “Firmettes” and review the tutorial.

Product Catalog

FEMA-Issued Flood Maps

Select state, county, city where streams are located

Get FEMA Issued Flood Maps

At the FEMA Issued Flood Map site, using the “Make a FIRMette” tool, find and print out maps covering the selected stream reaches from the Flood Insurance Rate Map (FIRM) panels, using the green “view” feature.

Itinerary:

Walk along each stream within the selected reaches. Record your observations for completion of the field trip homework.

Field Trip Homework:

Prepare a written report on your observations of the visit to each stream. In your report you may wish to include the following:

- Size of watershed drainage area
- Topographic features of the stream and floodplain
- A description of natural functions of the stream and floodplain
- A description of an impacted system
 - Water quality
 - Sedimentation
 - Debris flushed downstream and thrown by pedestrians
 - Human activities—bridge, landscaping, channel modifications
- Habitat
 - Trees
 - Brush and other growth
 - Evidence of wildlife—some species need larger habitats or areas to survive
- Evidence of recent flooding such as stream bank erosion, flood “marks” such as sediment or trash lines
- What is the present and potential use of the land adjoining the stream?

In “managing” this area what type of information would you need?