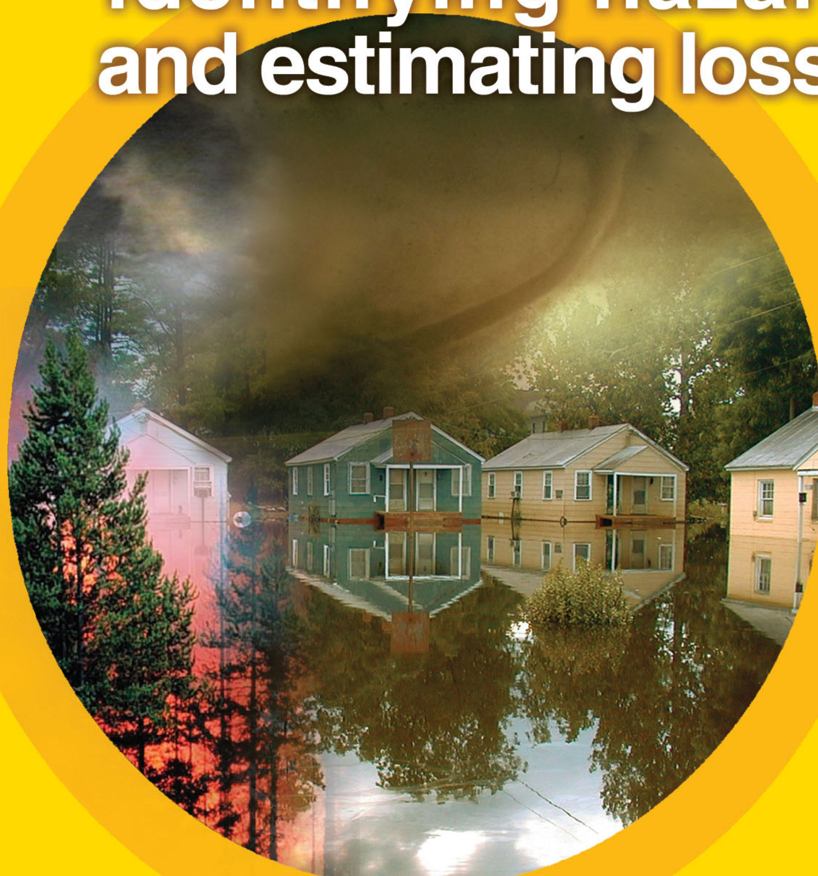
STATE AND LOCAL MITIGATION PLANNING
how-to guide

Understanding Your Risks

identifying hazards and estimating losses



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Contents

the natural hazard mitigation planning process

Natural hazard mitigation planning is the process of figuring out how to reduce or eliminate the loss of life and property damage resulting from natural hazards such as floods, earthquakes, and tornadoes. Four basic phases are described for the natural hazard mitigation planning process as shown in this diagram.

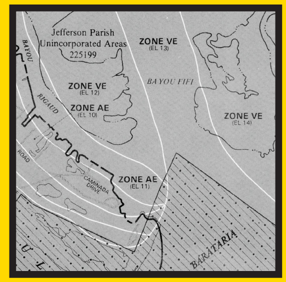
For illustration purposes, this diagram portrays a process that appears to proceed in a single direction. However, the mitigation planning process is rarely a linear process. It is not unusual that ideas developed while assessing risks should need revision and additional information while developing the mitigation plan, or that implementing the plan may result in new goals or additional risk assessment.

organize resources

From the start, communities should focus the resources needed for a successful mitigation planning process. Essential steps include identifying and organizing interested members of the community as well as the technical expertise required during the planning process.

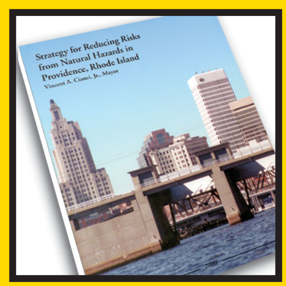
assess risks

Next, communities need to identify the characteristics and potential consequences of natural hazards. It is important to understand how much of the community can be affected by specific hazards and what the impacts would be for important community assets.



develop a mitigation plan

Armed with an understanding of the risks posed by natural hazards, communities need to determine what their priorities should be and then look at possible ways to avoid or minimize the undesired effects. The result is a natural hazard mitigation plan and strategy for implementation.



implement the plan and monitor progress

Communities can bring the plan to life in a variety of ways ranging from implementing specific mitigation projects to changes in the day-to-day operation of the local government. To ensure the success of an on-going program, it is critical that the plan remains effective. Thus, it is important to conduct periodic evaluations and make revisions as needed.

foreword

foreword

The Federal Emergency Management Agency (FEMA) has developed this series of mitigation planning "how-to" guides to assist states, communities, and tribes in enhancing their natural hazard mitigation planning capabilities.

These guides are designed to provide the type of information states and communities need to initiate and maintain a planning process that will result in safer communities. These guides are applicable to states and communities of various sizes and varying ranges of financial and technical resources.

This how-to series is not intended to be the last word on any of the subject matter covered; rather, it is meant to be an easy to understand guide for the field practitioner. In practice, these guides may be supplemented with more extensive technical data and the use of experts if possible.

The how-to guides cover the following topics:

- Getting started with the mitigation planning process including important considerations for how you can organize to develop a plan;
- Identifying hazards and assessing losses to your community and state;
- Setting mitigation priorities and goals for your community;
- Evaluating potential mitigation measures through the use of benefit-cost analysis and other techniques;
- Creating a mitigation plan and implementation strategy;
- Implementing the mitigation plan including project funding and revising the plan periodically as changes in the community occur; and
- Incorporating special circumstances in hazard mitigation planning for historic structures, among other topics.

mit-i-gate\ 1: to cause to become less harsh or hostile; **2:** to make less severe or painful

plan-ning\ : the act or process of making or carrying out plans; *specif:* the establishment of goals, policies and procedures for a social or economic unit

The Disaster Mitigation Act of 2000

The impetus for states and local governments to undertake natural hazard mitigation planning was given a significant boost on October 30, 2000, when the President signed the Disaster Mitigation Act of 2000 (Public Law 106-390). The law encourages and rewards local and state pre-disaster planning, promotes sustainability as a strategy for disaster resistance, and is intended to integrate state and local planning with the aim of strengthening statewide mitigation planning. This new approach facilitates cooperation between state and local authorities, prompting them to work together. This enhanced planning network enables local, tribal, and state governments to articulate accurate and specific needs for mitigation, resulting in faster allocation of funding and more effective risk reduction projects.

Why should you spend the time to read these guides?

- It simply costs too much to address the effects of natural disasters only after they happen;
- Neither communities nor their residents can be made whole by state and federal aid after disasters;
- You can prevent a surprising amount of damage from these hazards if you take the time to anticipate where and how these natural phenomena occur; and
- The most meaningful steps in avoiding the impacts of natural hazards are taken at the state and local levels by officials and community members who have a personal stake in the outcome and/or the ability to follow through on a sustained program of planning and implementation.

The guides focus on showing how mitigation planning:

- Can help your community become more *sustainable and disaster-resistant* through selecting the most appropriate mitigation measures, based on the knowledge you gain in the hazard identification and loss estimation process.
- Allows you to *focus your efforts on the hazard areas that are most important to you* by incorporating the concept of determining and setting priorities.
- Can *save you money* by providing a forum for engaging in partnerships that could provide technical, financial, and/or staff resources in your effort to reduce the effects, and hence the costs, of natural hazards.

Developing a successful natural hazard mitigation plan for your community depends on how well you understand the potential problems you face. This how-to guide is focused on the second phase of the natural hazard mitigation planning process and will help you estimate your losses from selected hazard events.

introduction

Risk assessment answers the fundamental question that fuels the natural hazard mitigation planning process: *"What would happen if a natural hazard event occurred in your community or state?"*

Risk assessment is the process of measuring the potential loss of life, personal injury, economic injury, and property damage resulting from natural hazards by assessing the vulnerability of people, buildings, and infrastructure to natural hazards.

Risk assessment provides the foundation for the rest of the mitigation planning process. The risk assessment process focuses your attention on areas most in need by evaluating which populations and facilities are most vulnerable to natural hazards and to what extent injuries and damages may occur. It tells you:

- The hazards to which your state or community is susceptible;
- What these hazards can do to physical, social, and economic assets;
- Which areas are most vulnerable to damage from these hazards; and
- The resulting cost of damages or costs avoided through future mitigation projects.

In addition to benefiting mitigation planning, risk assessment information also allows emergency management personnel to establish early response priorities by identifying potential hazards and vulnerable assets.

The steps in this how-to guide describe some methods you may use to develop this information. Subsequent guides assist you in determining priorities for mitigation and in deciding which assets in your community or state should be protected.

State and Local Risk Assessment

Risk assessment is a shared responsibility between states and local communities. Both states and communities should assess their risks from natural hazards as part of their respective planning processes. While local governments focus on the hazards, vulnerabilities, and risks on a local or regional scale, states should focus on the re-

haz-ard\ : a source of danger

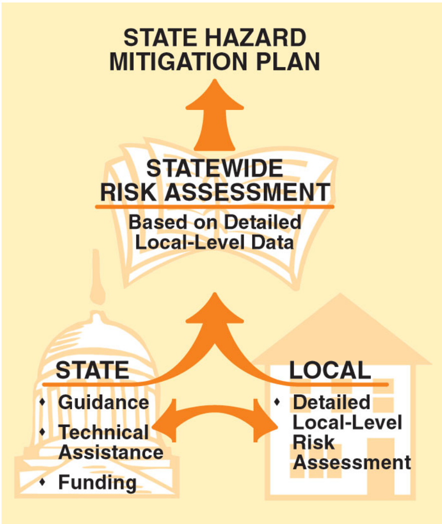
vul-ner-a-bil-i-ty\ : open to attack or damage

risk\ : possibility of loss or injury

Understanding Your Risks: Identifying Hazards & Estimating Losses is part of a series of guides that will help you identify, plan, and evaluate measures that can reduce the impacts of natural hazards in your community or state through a comprehensive and orderly process known as **Natural Hazard Mitigation Planning**.

As detailed in the Foreword, the process consists of four basic phases as shown below. The first phase consists of creating a mitigation planning team (referred to as the "Planning Team" in these guides) with representatives from the public and private sectors, citizen groups, colleges or universities, as well as non-profit agencies.

This guide, *Understanding Your Risks*, addresses the second phase of the planning process. Guides dealing with the third and fourth phases, “Develop a Mitigation Plan” and “Implement the Plan and Monitor Progress”, discuss establishing goals and priorities, selecting mitigation projects, conducting benefit-cost analyses, and writing, implementing, and revisiting the mitigation plan.



gional and statewide implications of hazards. The risk assessment process introduced in this guide encourages the reciprocity of information and support between states and local governments - states provide leadership and support to local communities, and local communities provide their states with local-level risk analyses. Through this exchange of information, statewide risk assessments based on detailed, local-level analysis are produced.

States can provide leadership early on by establishing guidelines, setting expectations, and providing incentives for local risk assessment and mitigation planning activities. To support and facilitate the risk assessment process, states should be able to provide communities with technical assistance, basic hazard data, and access to a range of state agency technical resources. Key decisions must be made by states to ensure a level of consistency in local risk data to facilitate statewide analysis.

As states gain a greater understanding of where the highest risks are across the state, they will be better prepared to decide where and how mitigation resources can be most effective. This information will become part of the state's mitigation plan, where mitigation priorities and criteria for those priorities are articulated.

How do you use this guide?

Understanding Your Risks provides detailed, step-by-step instructions on the procedures which are part of the Assessing Risks phase of the Natural Hazard Mitigation Planning Process. The recommended steps in this guide, shown here, are organized into four simple steps to estimate losses from a single hazard event. More complex risk assessment processes use complicated statistical analysis of a wide range of past hazard events and geological, climatic and meteorological data to determine probable losses on an annual basis. The intent of this how-to guide is to help you develop a baseline estimate of possible losses throughout your community or state from one event.

Losses, as used here, are represented as the monetary damage to structures and contents, interruption of services, and displacement of residents and businesses. The use of money as a measure of loss serves several purposes:

- It conveys the financial cost of a disaster to a community. It is important to note that there are other intangible losses that occur in a community such as losses of historic or cultural integrity or damage to the environment that are difficult to quantify. Other costs, including response and recovery costs, are often unrecoverable (these costs are not addressed in this guide).

- It provides an explicit representation of what a community or state stands to lose in a disaster. This is useful for elected officials and other decision makers who will need to balance the costs of mitigation against the costs of damage.
- It provides comparable measurements of losses across different hazards or different parts of the community. It assists a community in determining which hazards or what parts of the community to focus on.
- It provides a dollar amount to use as part of a benefit-cost analysis to be applied later (in subsequent how-to guides) in determining the cost-effectiveness of mitigation initiatives.

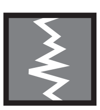
After you have estimated losses using one hazard event, you may find it necessary to conduct a comprehensive risk assessment by assessing the full range of hazard events. The work you produce here will serve as a good foundation for this additional effort if the need arises but will be of immediate benefit in helping set priorities and identifying mitigation projects in the next phase of the planning process – "Develop a Mitigation Plan".

Multi-Hazard Guidance

Where appropriate, this guide includes specific information to estimate losses for seven natural hazards, with a unique icon to identify each:

 **Floods**

 **Coastal Storms**

 **Earthquakes**

 **Landslides**

 **Tsunamis**

 **Wildfires**

 **Tornadoes**

Obviously, there are other hazards that can affect states and communities. While this guide does not provide specific direction for all hazards, the basic procedures explained here could be adapted for any natural hazard with variations that respond to

Comprehensive Risk Assessment

Later in the planning process (the third and fourth phases), you will have enough information to decide what mitigation actions you will pursue, and how they may be funded. Potential mitigation projects that will use federal funding require an analysis of benefits and costs across a broad range of hazard events. If you plan to use federal funding, it may be necessary to conduct a comprehensive hazard profile by considering all possible hazard events. For example, a devastating flood may occur every thousand years, however there's also a chance of a minor level of flooding every year, although the depth will obviously be much less. The small annual floods may result in far more damage than one big flood that may only occur once a century. In a rigorous risk assessment or benefit-cost analysis, mathematical calculations are used to determine the expected damages from the whole range of possible flood events, or other hazards that could impact an area. This provides a more accurate and complete picture of risk (and the benefits of avoiding it) than the "single-point" method. The procedures for doing an analysis with FEMA benefit-cost analysis software are simple and are discussed as part of the "how-to" guide for the third phase of the planning process, "Develop a Mitigation Plan".

the peculiar nature of each hazard. For a more complete description of the range of natural hazards that can affect the United States, please see *Multihazard Identification and Risk Assessment* published by FEMA.

State and Local Guidance

This guide is focused on providing guidance to communities, tribes, and states. While much of the hazard identification and loss estimation process operates in a similar fashion for each level of government, there are critical points where estimating losses for communities and tribes and states are different due to the differences in size. Therefore, throughout this document, guidance focused solely on the role of the **"States**" is identified as a sidebar with this icon. Furthermore, guidance focussing on communities includes tribes as well.

Types of Information

In addition to helpful hints and useful information identified by the **"Tips"** icon, this guide also provides a number of options that can be used in situations where detailed information is not readily available.

You should follow the main procedures outlined in this guide to produce your loss estimation. However, when you are unable to get desired information, such as the Flood Insurance Rate Map, or when a procedural shortcut may exist, the alternative method will be identified by the **"Basic"** icon.

In addition to the alternative method, advanced information has also been provided and will be identified by the **"Advanced"** icon. This method can be used to refine your loss estimation to improve your results or when specialists may be needed.

The **"HAZUS"** icon identifies suggestions for using the risk assessment tool, HAZUS (Hazards U.S.). In addition to estimating earthquake losses, HAZUS contains a database of economic, census, building stock, transportation facilities, local geology, and other information that can be used for a number of steps in the risk assessment process.

Finally, the **"Caution"** icon will alert you to important information about the risk assessment process.

Glossary

The **"Glossary"** icon identifies terms and concepts that need further explanation. These and other common risk assessment-related terms and phrases are defined in the Glossary included in Appendix A.

Library

In addition, a risk assessment **"Library"** has been included in Appendix B. The library has a wealth of information, including Web addresses, reference books, street addresses, and phone numbers to help you conduct your loss estimation. Each of the Websites and references listed in this how-to guide are included in the library.

Hazardville

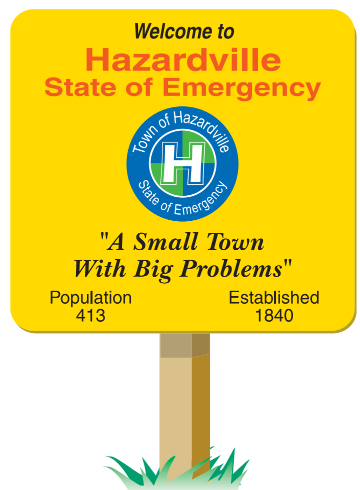
Applications of the various steps in the risk assessment process will be illustrated through a fictional community, the Town of Hazardville. Hazardville, located in the State of Emergency, is on a quest to develop a natural hazard mitigation plan, which includes an estimate of potential losses. Hazardville is a small community with limited resources and multiple hazards. When we left Hazardville after the first phase of the planning process, "Organize Resources," the town had just established its mitigation planning team, the Town of Hazardville Organization for Risk Reduction (THORR). Fictional newspaper accounts featuring the THORR will illustrate the various steps in the risk assessment process (see page xi).

Worksheets

Finally, to help you obtain the information you need at each step of the process, worksheets have been developed to correspond with the structure of this guide. In each step, examples of the type of information to be included in these worksheets are shown. All of the worksheets have also been included in Appendix C at the end of this guide. You should photocopy these forms and record your progress as you undertake this risk assessment process. Alternatively, you may use the worksheets as templates with which to set up your own computer spreadsheets, databases, or other applications.

During the development of a mitigation plan, you will need to gather information and data from a number of sources. As with any effort of this type, it is important to be aware of how different authors use terms. The easiest way is to make sure you look for specific definitions within the source documents to be sure you understand the intended meaning.

Please keep in mind that the World Wide Web is an ever-changing source of information and that web addresses and the information they contain will change over time.



Getting Started

Many Midwestern communities are located near the New Madrid fault, an area with a high seismic risk; however, most residents are not aware of this risk because the last significant earthquake occurred in the early 19th Century. In addition, many arid regions of the country face significant risk due to flooding, even though most of their watercourses are dry. When heavy rains occur in these areas, the storms can be very intense and cause flash floods on hillsides (alluvial fans) and in "dry" streambeds.

Even within the same hazard event, there can be different types of impacts. Hurricanes can cause flooding due to torrential rains across broad coastal and inland areas. However, along the shoreline, hurricanes and other coastal storms can cause an increase in the mean sea level, called a "storm surge".

As communities and states work together to generate statewide mitigation plans, many communities may want to update or revise their risk assessment to assess risks from several hazard events encompassing a range of intensities and/or frequencies or to determine future risks.

This guide will help you answer the following questions:

What kinds of natural hazards can affect your state or community?

What may have happened in the past that you should know about? Quite naturally, many people are only aware of the most obvious risks, usually as a result of a disaster that affected their community or state in the recent past such as a tornado, hurricane, or flood. In many cases, however, there are hazards most people are not aware of because they haven't affected the community or state during the lifetimes of current residents.

Step 1 of this guide – Identify Hazards – helps explain how to determine which natural hazards can affect you.

How bad can it get?

How "big" is each hazard's potential impact? Will it affect every area the same or will certain areas get hit harder than others? How often will each type of hazard impact your community or state?

It's important to know the location and amount of land area that may be affected by certain kinds of hazards. For example, there may be areas that can be affected repetitively by a hazard in one part of the community (such as floodplains adjacent to streams and rivers) or there may be potential community-wide impacts from events such as hurricanes or earthquakes. You should also note that a specific type of hazard can have varying effects on a community, depending on the severity of individual hazard events. For example, differences in the depth of floodwaters from discrete flood events will yield corresponding differences in the amount of damages.

Step 2 of this guide – Profile Hazard Events – will help you determine how bad a hazard can get.

What will be affected by these hazards?

Are there buildings, roads, and/or other facilities in the community that will be damaged or destroyed by these hazards? Are there concentrations of certain populations in hazard areas that are especially vulnerable, such as elderly or non-English speaking people?

An inventory will help you identify the assets that can be damaged or affected by the hazard event. For detailed assessments, the inventory will also include information on special populations and building characteristics like size, replacement value, content value, and occupancy. In many cases, community assets may be vulnerable to more than one type of hazard, and you may need to look at different characteristics of the same asset to understand its vulnerability to each type of hazard. For example, if a building is subject to both floods and earthquakes, you will be interested in the location and elevation of the building so you can tell how much of its structure and contents will be damaged by flooding. You will also be interested in the construction of the building and its ability to resist physical damage caused by the anticipated ground movements during an earthquake.

Step 3 of this guide – Inventory Assets – will help you determine where and/or to what extent these hazards will affect the assets of your community or state.

How will these hazards affect you?

What are the varying effects of different hazards on community assets? To what extent will assets be damaged by each hazard? If buildings and other structures are destroyed or damaged, how much will it cost to replace and/or repair them? If the contents of businesses and homes are also affected, how much cost would be added? If there are indirect effects, what is the accumulated cost of the losses?

Hazards create direct damages, indirect effects, and secondary hazards to the community. Direct damages are caused immediately by the event itself, such as a bridge washing out during a flood. Indirect effects usually involve interruptions in asset operations and community functions, also called functional use. For example, when a bridge is closed due to a flood, traffic is delayed or rerouted, which then impacts individuals, businesses, and public services, like fire and police departments that depend on the bridge for transportation. Secondary hazards are caused by the initial hazard event, such as when an earthquake causes a tsunami, landslide, or dam break. While these are disasters in their own right, their consequent damages should be included in the damage calculations of the initial hazard event. Your loss estimations will include a determination of the extent of direct damages to property, indirect effects on functional use, and the damages from secondary hazards for each of the hazards that threaten your community or state.

Step 4 of this guide – Estimate Losses – will help you determine how hazards will affect your community or state.

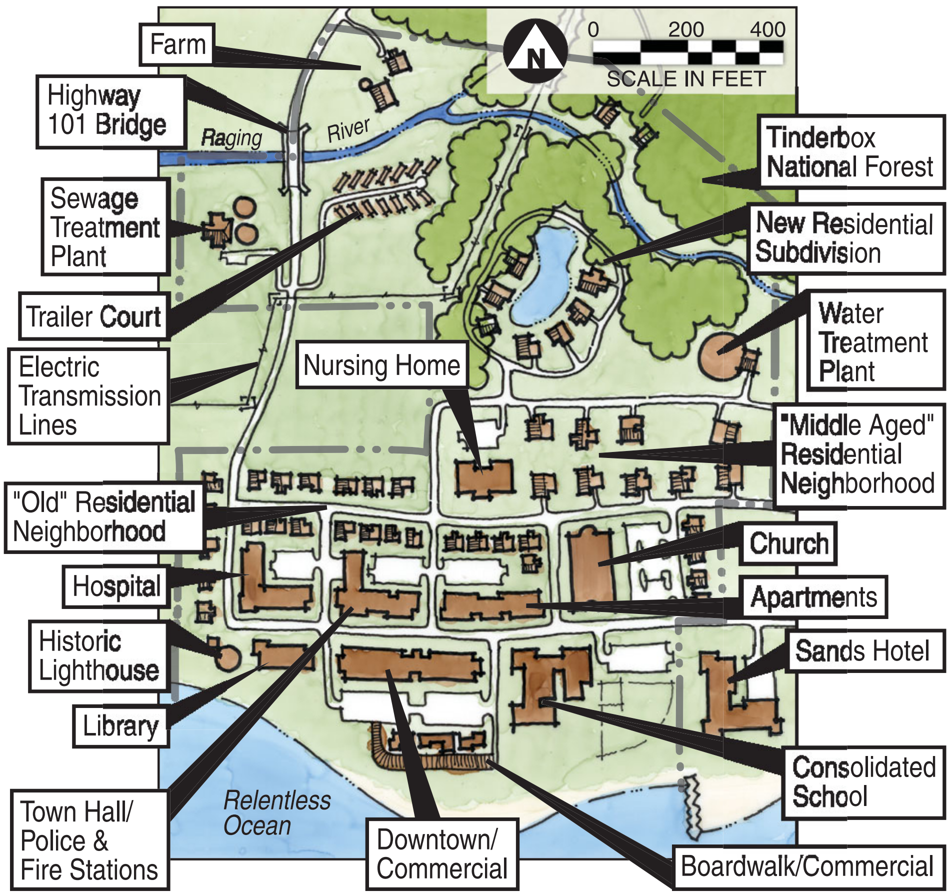
It is important to continually provide citizens with the information gained throughout the risk assessment process. This not only educates the community on their hazards and risks in an ongoing fashion, but facilitates wider involvement in the process. Holding public meetings to present the most recent findings after each major step in the risk assessment process allows the new information to be reviewed and validated. Making sure that media coverage of the process is regularly engaged is another technique for ensuring that no interested parties are left out of the process.

Go to Step 1

After you have read this *Introduction* and reconvened your Planning Team, go to Step 1. In Step 1, you will identify all of your potential hazards and determine which hazards are most prevalent in your community.

The Hazardville Post

Vol. CXI No. 65 Thursday, March 6, 2001



Risky Business

[Hazardville, EM] The Hazardville Town Council unanimously approved the creation of the Town of Hazardville Organization for Risk Reduction (THORR) at a meeting last night. In anticipation of the move, Mayor McDonald nominated THORR members last month. The THORR members will work with town staff to identify natural hazards that could threaten Hazardville and estimate their losses from those hazards. This process is known as risk assessment. As reported previously in the Post, THORR will include a number of prominent community and business leaders. Starting next month, the Post will launch a series of articles covering THORR's work on the risk assessment process.

step 1 identify hazards

2 profile hazard events

3 inventory assets

4 estimate losses

1 identify hazards

Overview

The first step in doing a risk assessment answers the question: *What kinds of natural hazards can affect your planning area?*

In this step, you will simply identify all the natural hazards that *might* affect your community or state and then narrow your list to the hazards that are most likely to impact you.

Bear in mind that although a hazard may not have affected you recently, it doesn't mean it won't in the future. You should look at the full range of potential hazards and assess whether they may affect the area you're including in your mitigation plan. While this might sound daunting, there is a relatively small list of hazards to consider.

Remember that all subsequent steps in the **Natural Hazard Mitigation Planning Process** are built on the information gathered during risk assessment. As you proceed, remember to keep records of what you've found and where you've found it. Your records may include copies of documents or maps, notes on whom you talked to and when you talked to them, Website references, and so forth. You'll need these later in the loss estimations and in the rest of the mitigation planning processes. Use **Worksheet #1: Identify the Hazards** in Appendix C (see example on page 1-2) to keep track of your research, and when you're finished with this step, you'll have a list of hazards that could affect your community or state.

St. Louis tornado damage, May 27, 1896.

Remember, for now you are simply compiling information about what hazards affect your state or community, but later you will be assessing the risks they pose. It's a good idea to read through the whole guide before starting to gather information, so you can get everything you need from the various sources and not have to return later for additional data.

Procedures & Techniques

Task A. List the hazards that may occur.

There is no one source for identifying which hazards may affect your state or community. However, the following techniques are methods that have worked for others and should at least provide you with a good starting point.

1. Research newspapers and other historical records.

These records will often contain dates, magnitudes of the events, damages, and further evidence of past natural disasters in your

Worksheet #1 — Identify the Hazards — step 1

Date: March, 2001

What kinds of natural hazards can affect you?

Task A. List the hazards that may occur.

1. *Research newspapers and other historical records.*
2. *Review existing plans and reports.*
3. *Talk to the experts in your community, state, or region.*
4. *Gather information on Internet Websites.*
5. *Next to the hazard list below, put a check mark in the Task A boxes beside all hazards that may occur in your community or state.*

Task B. Focus on the most prevalent hazards in your community or state.

1. *Go to hazard Websites.*
2. *Locate your community or state on the Website map.*
3. *Determine whether you are in a high-risk area. Get more localized information if necessary.*
4. *Next to the hazard list below, put a check mark in the Task B boxes beside all hazards that pose a significant threat.*

Hazard	Task A	Task B
Avalanche	☐	☐
Coastal Erosion	☑	☐
Coastal Storm	☑	☑
Dam Failure	☐	☐
Drought	☐	☐
Earthquake	☑	☑
Expansive Soils	☐	☐
Extreme Heat	☐	☐
Flood	☑	☑
Hailstorm	☑	☐
Hurricane	☑	☐
Land Subsidence	☐	☐
Landslide	☑	☑
Severe Winter Storm	☑	☐
Tornado	☑	☑
Tsunami	☑	☑
Volcano	☐	☐
Wildfire	☑	☑
Windstorm	☐	☐
Other____________	☐	☐
Other____________	☐	☐
Other____________	☐	☐

*Note: **Bolded** hazards are addressed in this How-To Guide.*

Use this space to record information you find for each of the hazards you will be researching. Attach additional pages as necessary.

Hazard or Event Description (type of hazard, date of event, number of injuries, cost and types of damage, etc.)	Source of Information	Map Available for this Hazard?	Scale of Map
Flood - June 1936. 500-year flood. One death, some corn & crop losses.	• Members of community • Newspaper • Floodplain manager	FIRM	1 : 6000
Hurricane Camille - Nov. 1969. One death. Flooding & wind caused $1.5 million in damages.	• Newspaper • Internet research	FIRM & storm surge map	1 : 6000 1 : 6000
Severe storm caused flooding & landslides - May 1973. $2 million in damages.	• Newspaper • State geologist	Topo-graphic & soils maps	1 : 24000
Severe storm & tornadoes - April 1980. Wind & flash floods caused $1.5 million in damages.	• Newspaper	No	
Wildfires - April 1981. 1,050 acres burned.	• Newspaper • State fire marshal	Topo-graphic USDA & fuel model maps.	1 : 24000

community or state. A public library may also have documentation on these events in the "local history" section. Local historical societies may also be good sources of information.

2. Review existing plans and reports.

The preceding techniques are focused on local sources of information that will likely provide a good start to the process. However, to ensure you are covering all of the possible hazards, you will want to broaden the contacts you make. There are many types of plans and documents that may have information on natural hazards in your community or state. Many states will already have mitigation plans, hazard identification reports, and/or risk assessment reports. State transportation, environmental, dam, or public works reports or plans may also contain relevant information. Although these may not contain a lot of details about local hazard conditions, they offer a good starting point for communities, and using them improves consistency among communities within the state. Review the plans for a list of hazards that can occur in the state or for a list of disasters that have occurred in the past.

Local comprehensive plans, land use plans, capital improvement plans, as well as building codes, land development regulations, and flood ordinances may contain hazard provisions that indicate the presence of local hazards. You should review these to determine whether a local hazard exists.

3. Talk to the experts in your community, state, or region.

There are many sources of hazard information in government, academia, and the private sector. Many local floodplain managers, departments of public works, engineering, planning and zoning, and transportation departments maintain information about natural hazards. Those who would have been involved with past natural hazard events such as the police and fire departments or the local emergency management staff are also excellent sources of information on past hazard events. Furthermore, state agencies, including water or natural resources, geological survey, and emergency management will have detailed knowledge about the nature and extent of hazards in your state. University departments, including planning, landscape architecture, geography, and engineering may already have hazard maps or can help you obtain them. Many local businesses that provide hazard related services might be willing to assist you.

Your best source of hazard information will often be your state. The State Hazard Mitigation Officer (SHMO) will know what hazards affect your state, and is also a good source for suggestions

The information you discover in the newspapers and on the Internet will help you when you talk to hazard experts in your community. It will provide you with technical terms and general factual information about the various hazards, in addition to helping you identify the appropriate experts to contact.

State emergency management departments are sometimes housed in larger agencies such as state police, military, or public safety.

Research past Presidentially declared disasters, as well as non-declared severe events that have occurred in your state and in other states within your region. You should inquire into the types of hazards that have occurred in the adjoining states as well. Communicate this information to your communities.

Search database or computerized archives with the following list of hazards as keywords. Narrow the search by using the name of your community, state, or surrounding states as keywords (the following list not meant to cover all known natural hazards).

- Avalanche
- Coastal Erosion
- Coastal Storm
- Dam Failure
- Debris Flow
- Drought
- Earthquake
- Expansive Soils
- Extreme Heat
- Flood
- Hailstorm
- Hurricane
- Land Subsidence
- Landslide
- Severe Winter Storm
- Tornado
- Tsunami
- Volcano
- Wildfire
- Windstorm

about where to go for more detailed information. Bear in mind that the SHMO may not have specific information about the hazards that affect a particular community but will probably be knowledgeable about your area of the state and will often be able to suggest other people to talk to or additional resources.

4. Gather information on Internet Websites.

The library at the end of this guide lists many such sites. These may be hazard-specific sites that provide general information about why particular hazard events happen, what the probabilities of occurrence are, and how hazards are measured. Other Websites will have state-specific, or even site-specific information about the hazards in a particular area and about the characteristics of the hazards, such as the probability, history of events, and expected severity.

Task B. Focus on the most prevalent hazards in your community or state.

If your preliminary research reveals that your community or state has been affected by a particular hazard or that experts consider your area to be threatened by that hazard, you will concentrate further research on it in later steps.

If your planning area has not experienced a hazard event in recent memory but one of the sources indicates it is a possibility, it may be worth a little extra effort to confirm that a particular hazard type is relevant.

1. Go to the indicated Websites for the seven major hazards to help you determine whether your community or state can be affected by the hazard.
2. Locate the approximate location of your community or state on the Website map.
3. Examine the map to determine whether you are located in a high-risk area for that hazard and to determine the chance it will occur in your planning area. You may need to get more localized information for some of the hazards.
4. You may find that you can delete some hazards from your list at this time; however, if you are unsure or uncomfortable with the chance of the hazard occurring, it's better to keep all potential hazards on the list, until you are certain that it is appropriate to remove it.

The Hazardville Post

Vol. CXI No. 100 Thursday, April 10, 2001

The Organization for Risk Reduction Seeks Danger

(Part 1 of a 4 Part Series on the Risk Assessment Process)

[Hazardville, EM] The Town of Hazardville Organization for Risk Reduction (THORR) is on a mission to find out about the natural hazards that threaten Hazardville. The task force, appointed by Mayor McDonald, will develop a hazard mitigation strategy to reduce the town's vulnerability to natural hazards such as floods, hurricanes, and earthquakes. While the process of researching the town's potential hazards is not exactly fraught with danger, "the task force is using a lot of different resources to discover the past and possibly future impacts from hazards," said Joe Norris, the task force lead planner.

THORR began researching past impacts from hazards simply by talking to people in the community. "You'd be surprised just how much information people know and remember about the disasters from years ago," said Norris. "We visited an elderly man who lives near Raging River who vividly recalled the Flood of 1936. While there was not much of a human toll because the Raging River area was largely rural, agricultural, and forested at the time, this man recalled that the fast-moving waters were apparently quite deep." Norris noted that a search of local newspaper archives confirmed the flood, as did a conversation with the Floodplain Manager. "She said that the flood was estimated to be a 500-year event - something that has only a 0.2% chance of happening annually."

Another resource the task force has tapped is the State Hazard Mitigation Officer (SHMO). The SHMO provided THORR with a copy of the state hazard mitigation plan, which discussed past disasters that have occurred in the State of Emergency. THORR has found the document to be useful in describing the likelihood that certain hazard events will occur in Emergency. An even more valuable resource provided by the SHMO has been contact with various hazard experts in state government. "They're free!" laughed Norris, alluding to a concern expressed by the Town Council that a risk assessment may be an expensive endeavor.

DATE	TYPE OF INCIDENT
November 7, 1969*	Hurricane Camille
April 9, 1970	Heavy Rain, Tornadoes, Flooding
March 27, 1973	Earthquake Tremors (offshore)
May 29, 1973*	Severe Storms, Landslides, Flooding
October 2, 1975	Severe Storms, Tornadoes, Flooding
April 9, 1977*	Landslides, Flooding
March-October, 1977	Drought
March 17, 1979*	Wildfire
April 18, 1979*	Storms, Wind, Flooding
April 20, 1980*	Severe Storms, Tornadoes, Flooding
April 10, 1981*	Wildfire
May 11, 1984	Earthquake Tremors
September 7, 1985*	Hurricane Elena
March 21, 1990	Severe Storms, Tornadoes, Flooding
January 4, 1991	Severe Storms. Flooding
March 3, 1994*	Severe Winter Storms, Freezing, Flooding
July 8, 1994*	Offshore Earthquake, Tsunami
April 21, 1995	Severe Storms, Landslides, Flooding
March 20, 1996*	Severe Storms, Landslides, Flooding
April 29, 1998*	Flooding (Tropical Storm Zoe)
September 15, 1999*	Wildfire
November 10, 1999	Earthquake, Aftershocks

* State or Presidentially declared disaster

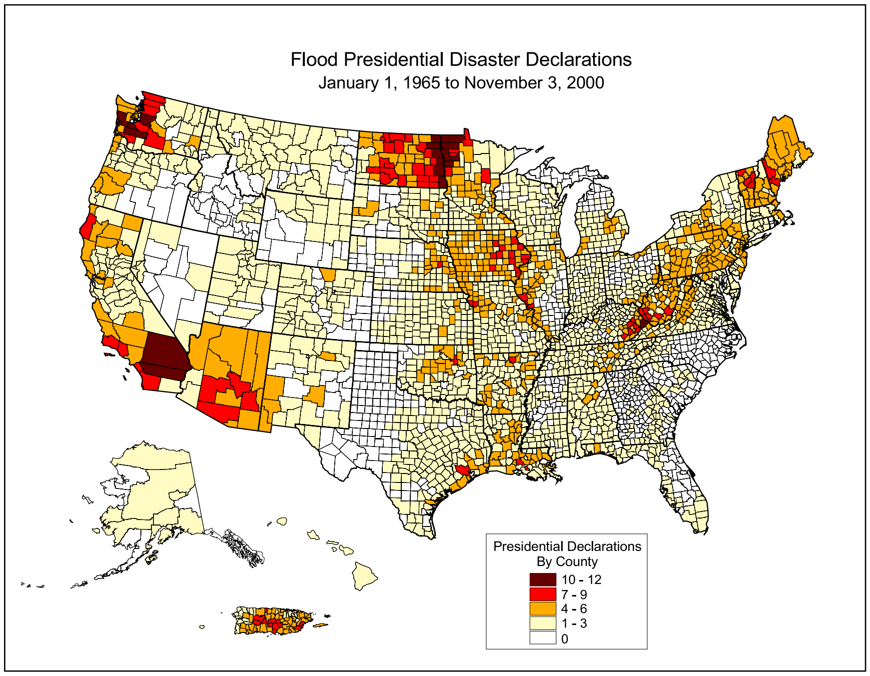
Norris remarked that THORR has found the State Geologist to be especially helpful in furnishing information on earthquakes and landslides. According to the State Geologist, Hazardville sits squarely in the middle of an earthquake zone, about 100 miles from the New Temptfate fault. "I know we've experienced a few tremors over the years, even some collapsed chimneys from one of the stronger tremors, but I had no idea the potential for stronger earthquakes existed in Hazardville."

Through its research, THORR has uncovered information on many large and small hazard events. In fact, on 13 occasions from 1969 to 1999, these events have met the criteria to be state or federally declared disasters. The list of events THORR has researched appears above.

When asked what the next steps are for THORR, Norris responded, "THORR will continue to research these hazards. The more information we have, the better our risk assessment will be."

Floods

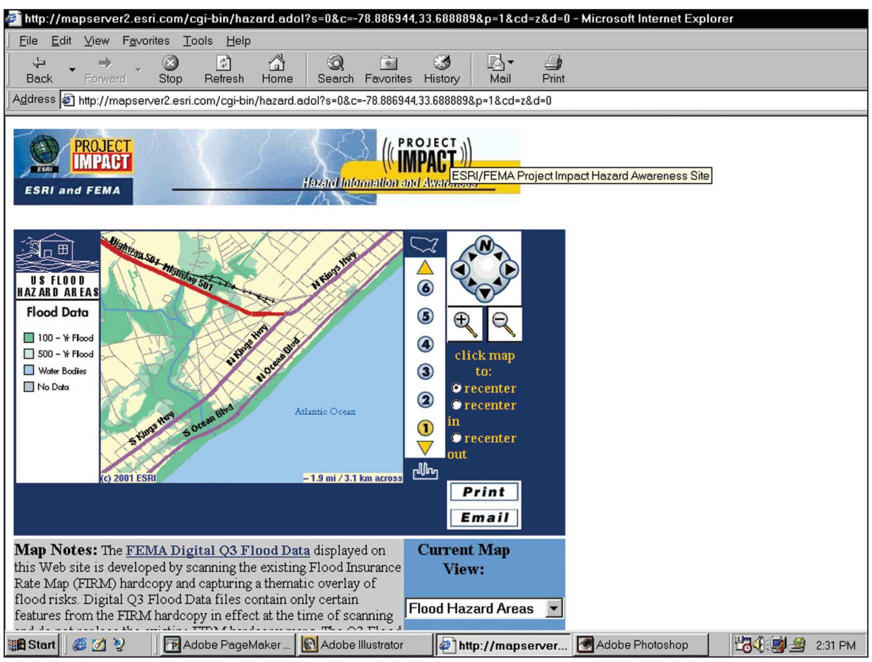
Floods are the most prevalent hazard in the United States. This map illustrates where there have been past Presidential declarations for flood events. FEMA has prepared Flood Insurance Studies (FIS) for floodprone communities. These FISs contain information on local flood history, local flood problems, and other flood studies that have been prepared for the community.



Source: FEMA

FEMA has also created Flood Insurance Rate Maps (FIRM) for more than 19,000 communities in the country as a part of the FIS. In addition to the 100-year floodplain, which is the area of the community with a 1% chance of flooding in any given year, the FIRM also illustrates coastal high hazard areas, the floodway, and the 500-year floodplain, which is the area of the community with a 0.2% chance of flooding in any given year.

Digital Quality Level 3 flood data (Q3) are available for 1,200 counties in CD-ROM format from FEMA. A list of counties is available at http://msc.fema.gov/MSC/statemap.htm The digital Q3 flood data are a digital representation of certain features on FIRMs and can also be viewed in HAZUS.

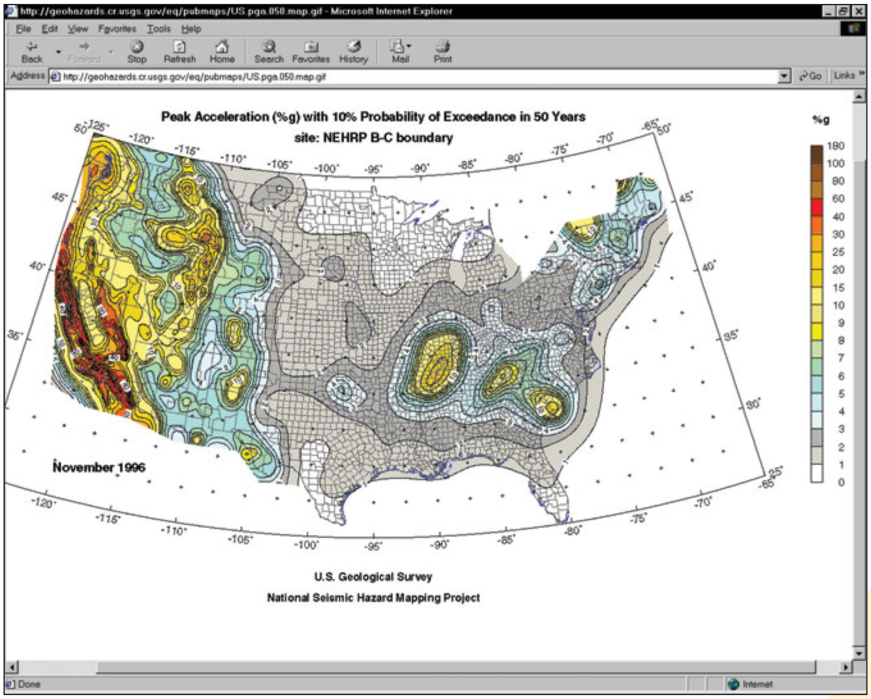


Source: http://www.esri.com/hazards/

1 Review your FIRM or Q3 to identify areas prone to flooding. Alternatively, go to www.esri.com/hazards to conduct a preliminary identification of flood hazards using digital Q3 flood data available online.

2 Go to Step 2 for information on acquiring flood maps and on profiling your flood hazard.

Earthquakes



Source: http://geohazards.cr.usgs.gov/eq/pubmaps/US.pga.050.map.gif

1 Go to the http://geohazards.cr.usgs.gov/eq/pubmaps/US.pga.050.map.gif Website to determine whether you are located in an earthquake hazard zone.

2 Find the approximate location of your community or state on the seismic hazard map.

3 If you are located in an area with 2%g (peak acceleration) or less, then you have a relatively low seismic risk and can probably avoid conducting an earthquake risk assessment at this time. However, you should confirm your findings with your state geologist or emergency manager.

4 If you are located in an area with 3% g peak acceleration or more, then you should proceed to Step 2 to profile your earthquake hazard.

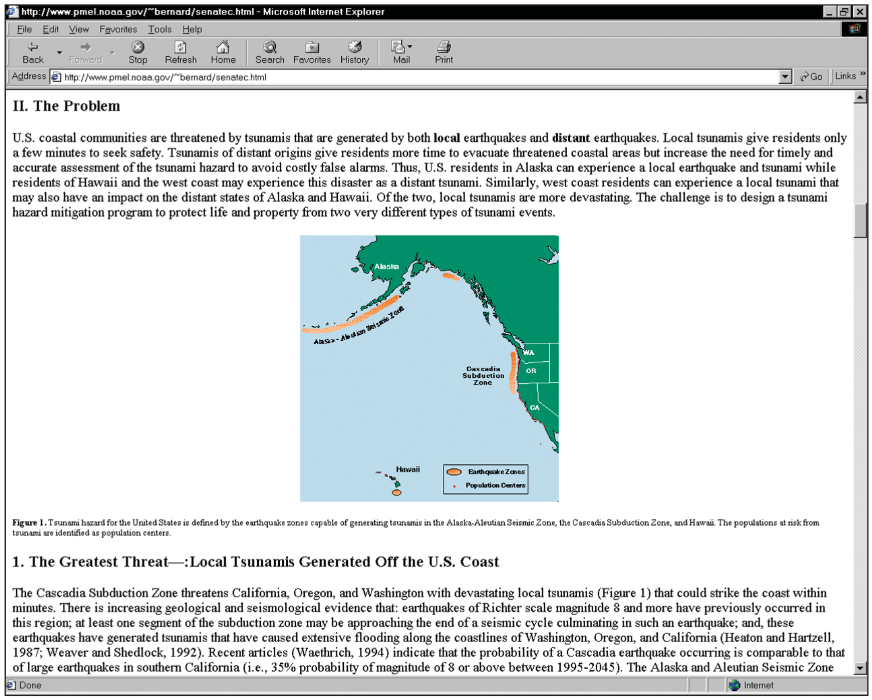
Tsunamis

1 Go to the http://www.pmel.noaa.gov/~bernard/senatec.html Website. This page will show population centers on the West Coast of the United States that are at risk of tsunamis.

2 Find the approximate location of your community or state on the tsunami map.

3 If you are not located on the West Coast, a Pacific Island, or a Caribbean Island*, then you have a relatively low tsunami risk and can probably avoid conducting a tsunami risk assessment at this time. However, you should confirm your findings with your state geologist or emergency manager.

4 If you are located in communities along the shoreline, along coastal estuaries, or along rivers affected by tides in Alaska, Washington, Oregon, California, Hawaii, or Puerto Rico, then you should proceed to Step 2 to profile your tsunami hazard.



II. The Problem

U.S. coastal communities are threatened by tsunamis that are generated by both **local** earthquakes and **distant** earthquakes. Local tsunamis give residents only a few minutes to seek safety. Tsunamis of distant origins give residents more time to evacuate threatened coastal areas but increase the need for timely and accurate assessment of the tsunami hazard to avoid costly false alarms. Thus, U.S. residents in Alaska can experience a local earthquake and tsunami while residents of Hawaii and the west coast may experience this disaster as a distant tsunami. Similarly, west coast residents can experience a local tsunami that may also have an impact on the distant states of Alaska and Hawaii. Of the two, local tsunamis are more devastating. The challenge is to design a tsunami hazard mitigation program to protect life and property from two very different types of tsunami events.

Figure 1. Tsunami hazard for the United States is defined by the earthquake zones capable of generating tsunamis in the Alaska-Aleutian Seismic Zone, the Cascadia Subduction Zone, and Hawaii. The populations at risk from tsunami are identified as population centers.

1. The Greatest Threat—:Local Tsunamis Generated Off the U.S. Coast

The Cascadia Subduction Zone threatens California, Oregon, and Washington with devastating local tsunamis (Figure 1) that could strike the coast within minutes. There is increasing geological and seismological evidence that: earthquakes of Richter scale magnitude 8 and more have previously occurred in this region; at least one segment of the subduction zone may be approaching the end of a seismic cycle culminating in such an earthquake; and, these earthquakes have generated tsunamis that have caused extensive flooding along the coastlines of Washington, Oregon, and California (Heaton and Hartzell, 1987; Weaver and Shedlock, 1992). Recent articles (Waethrich, 1994) indicate that the probability of a Cascadia earthquake occurring is comparable to that of large earthquakes in southern California (i.e., 35% probability of magnitude of 8 or above between 1995-2045). The Alaska and Aleutian Seismic Zone

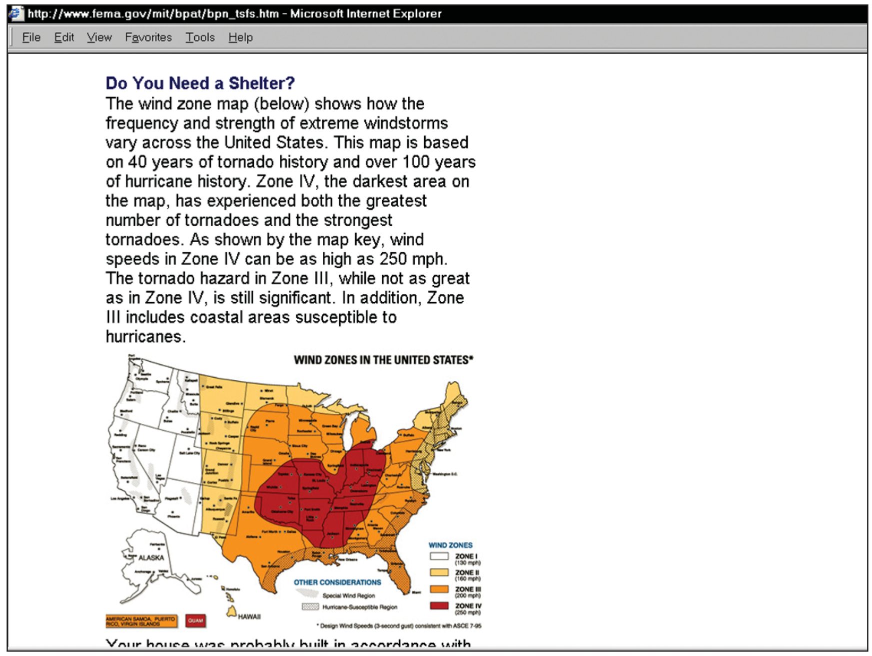
Source: http://www.pmel.noaa.gov/~bernard/senatec.html

**NOTE:*
Recent findings indicate that tsunamis are also possible along the Atlantic Ocean coastal areas of Virginia and North Carolina. As more information become available, these areas may also wish to include tsunamis in their risk assessment.

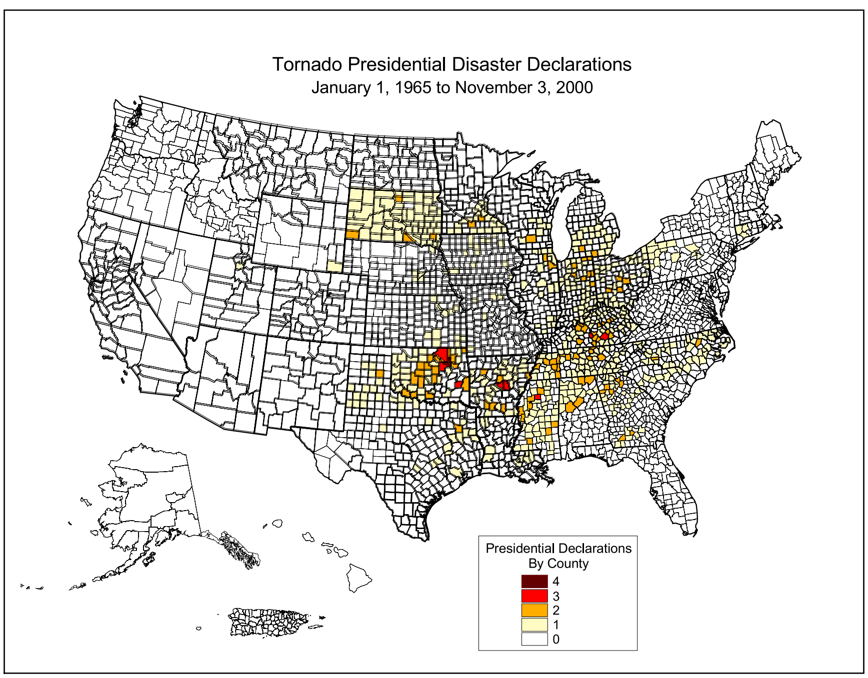
Tornadoes

1 Go to the http://www.fema.gov/graphics/library/wmap.gif Website. This page shows the wind zones throughout the United States. These wind zones are based on historical information on tornadoes and hurricanes. The map below illustrates areas where Presidential declarations have been issued for tornadoes in the past.

2 Locate your community or state on the US Wind Zone map.



Source: hhttp://www.fema.gov/graphics/library/wmap.gif



Source: FEMA

3 If you are not located in one of the four colored zones or special wind regions on the map above, you can probably avoid conducting a tornado risk assessment at this time. However, you should confirm your findings with your state meteorologist or emergency manager.

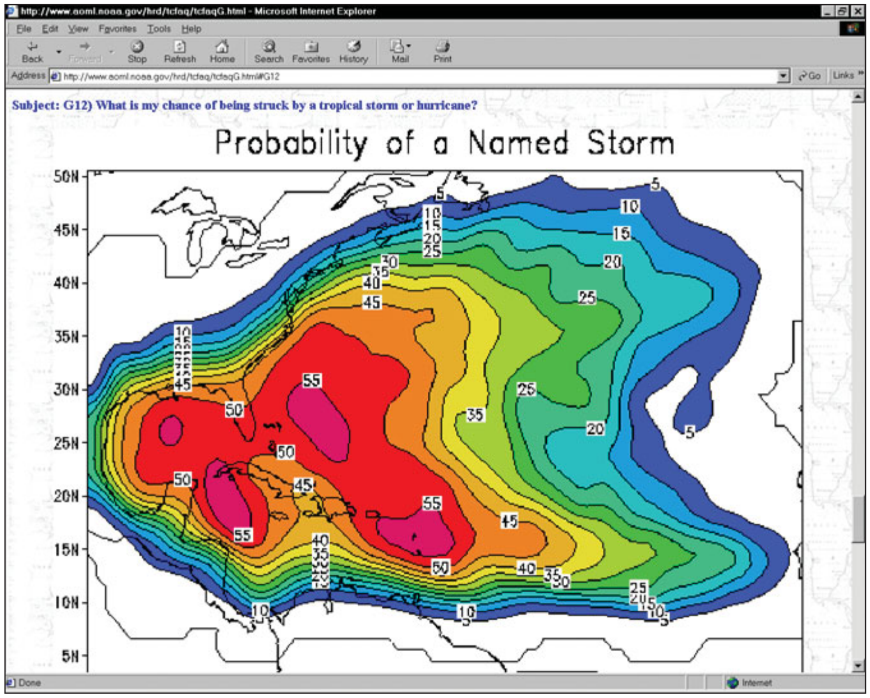
4 If you are located in one of the four colored zones or special wind regions on the map above, then you should proceed to Step 2 to profile your tornado hazard.

1 Go to the http://www.aoml.noaa.gov/hrd/tcfaq/tcfaqG.html#G12 Website. This page illustrates the probabilities of a named storm for the Atlantic Seaboard and the Gulf of Mexico. The map below illustrates where Presidential declarations have been issued for past hurricanes.

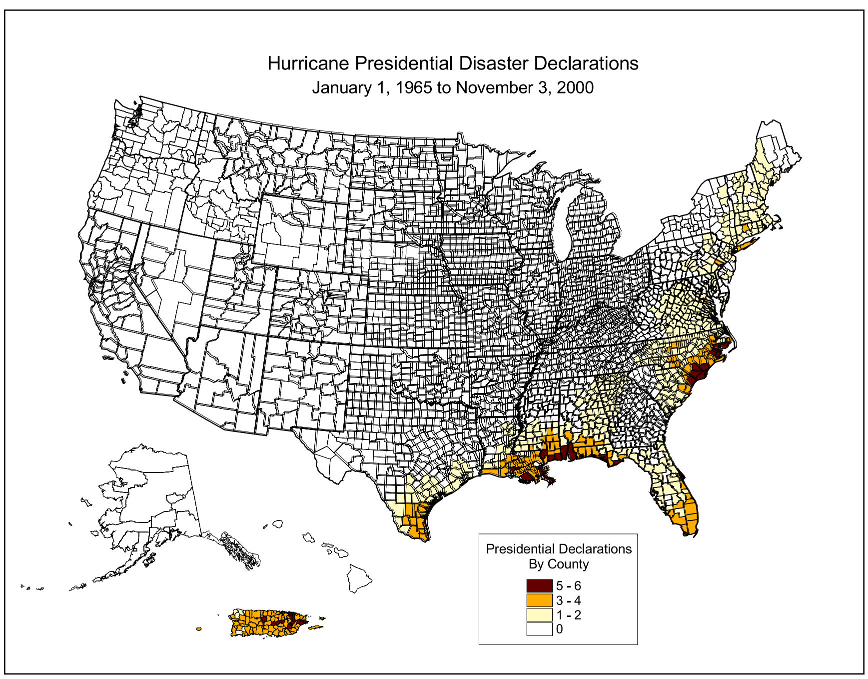
2 Locate your community or state on the coastal storm probability map.

3 If you are not located in a coastal storm probability zone you can probably avoid conducting a coastal storm risk assessment at this time. However, you should confirm your findings with your state coastal zone manager or floodplain manager.

4 If you are located in a coastal storm probability zone, then you should proceed to Step 2 to profile your coastal storm hazard.

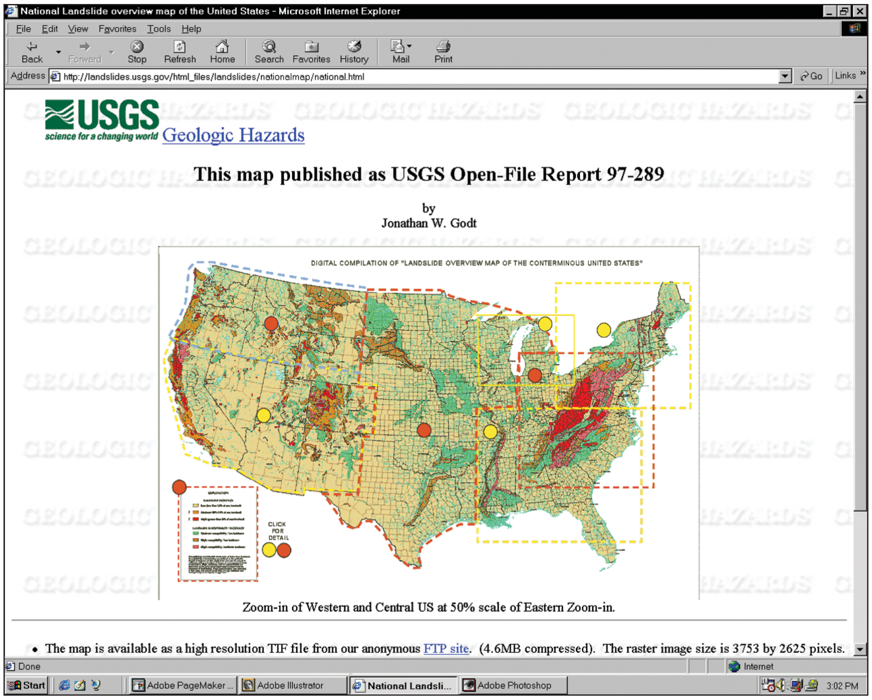


Source: http://www.aoml.noaa.gov/hrd/tcfaq/tcfaqG.html#G12



Source: FEMA

Landslides



Source: http://landslides.usgs.gov/html_files/landslides/nationalmap/national.html

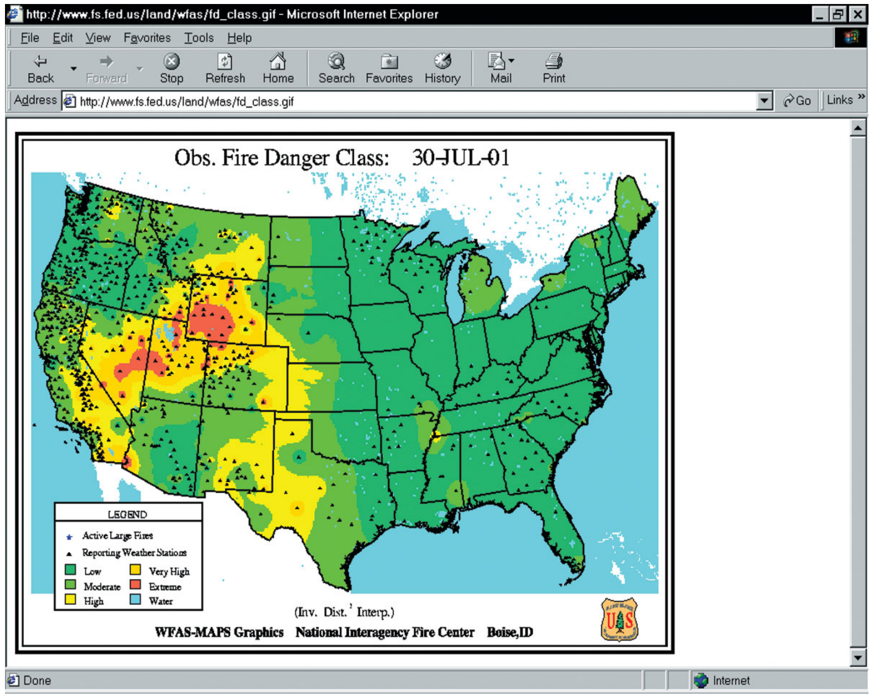
1 Go to the http://landslides.usgs.gov/html_files/landslides/nationalmap/national.html Website. This page illustrates large-scale landslide risk areas.

2 Locate your community or state on the landslide hazard map. The Website listed above allows you to zoom in to different regions for a closer look at the landslide risk. While this map gives a broad indication of large-scale risk at a national scale, it is important to know that landslides should be evaluated at a local scale. The map shown above is not suitable for small-scale, community-level hazard identification.

3 You should discuss landslide potential with your state geologist, who can be found at http://www.kgs.ukans.edu/AASG, and with your local public works director.

4 If either your state geologist or local public works director indicates a landslide risk in your community or state, you should proceed to Step 2.

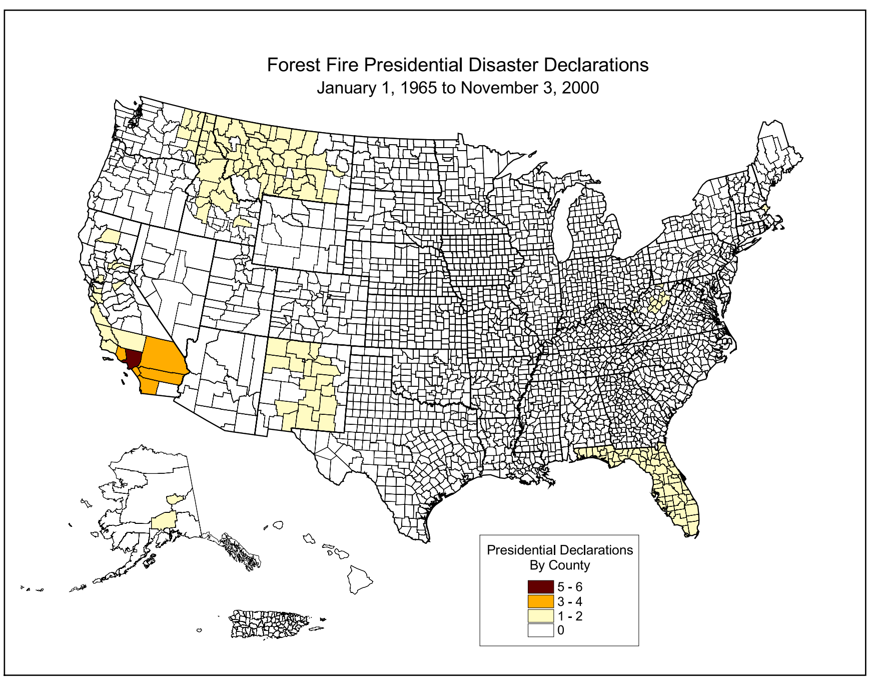
1 Go to the http://www.fs.fed.us/land/wfas/fd_class.gif Website. This page illustrates the current fire danger conditions and changes daily based on current and past weather, fuel types, and fuel moisture. The map below illustrates where Presidential declarations have been issued for forest fires in the past.



Source: http://www.fs.fed.us/land/wfas/fd_class.gif

2 Locate your community or state on the fire danger map.

3 If you are located in or near a low to moderate fire danger class and not located near forest, grasslands, or dense wooded areas then you have a relatively low wildfire risk and probably can avoid conducting a wildfire risk assessment at this time. However, you should confirm your findings with your state fire marshal, forestry department, natural resources department or park service.



Source: FEMA

4 If you are located in or near a dense woodland, forest or grassland area, or have a high to extreme fire danger class, have experienced a prolonged dry period, or have experienced past wildfires, you should proceed to Step 2 to profile your wildfire hazard.

Summary

When you're finished with Step 1, you'll have a list of hazards that could affect your community or state. At this point, it isn't necessary to know anything specific about the hazards except that they are likely to occur.

You will also have a list of plans, reports, Websites, articles, and other resources that can help you later in the process as you determine how these hazards can affect your community.

Through your research, you will begin to foster relationships with experts in the state and local community. This network will continue to be of use to the Planning Team as you continue to analyze the effects of the hazards, and throughout the planning process.

Keep your research handy because after your risk assessment is complete, you will use this information to help complete your hazard mitigation plan as part of the third phase in the Natural Hazard Mitigation Planning Process.

After you have identified all of your hazards and determined which hazards are most prevalent in your community or state

Go to Step 2

to use the information you have gathered to develop hazard profiles.

step 2 profile hazard events

1 identify hazards

2 profile hazard events

3 inventory assets

4 estimate losses

2

profile hazard events

Overview

With a list of potential hazards in hand from Step 1, the next step is to develop hazard event profiles, which answers the question: *How bad can it get?*

The information gathered in this step will help determine the assets in the hazard areas you will inventory in Step 3.

Each hazard type has unique characteristics that can impact your community or state. For example, an earthquake causes ground shaking that will affect a community much differently than the wind of a tornado. In addition, a given hazard type can produce different effects depending on its magnitude, duration, or intensity. For example, no two wildfires will impact a community in the same way twice because the wildfire is driven by distinct wind and fuel conditions, which can change very rapidly. Furthermore, the same hazard events will affect different communities in different ways, based on geography, development, population distribution, age of buildings, etc. A **hazard event** is a specific occurrence of a particular type of **hazard**.

For these reasons, the information you gather for each of your hazard event profiles will reflect these different characteristics. Some hazards, such as floods, coastal storms, wildfires, tsunamis, and landslides will be profiled by mapping the geographic extent of identifiable hazard events because they occur in predictable areas of the community or state. Once the extent of these events is mapped you will be able to determine which portion of your community or state is vulnerable in Step 3 and begin taking inventory of the elements that can be damaged. Other hazards, such as tornadoes (which can occur anywhere), may be profiled simply by recording the maximum potential wind speed. This type of information will be used in Step 4 to evaluate the potential impact to individual structures or elements in your jurisdiction.

This step is structured to explain the basic procedures and techniques for profiling hazard events. It then instructs you on how to gather specific hazard event profile information. Use **Worksheet #2: Profile Hazard Events** in Appendix C (see example on page 2-2) to help you record and keep track of your results.

Lee County, Georgia during the 1995 Spring floods.

The glossary in Appendix A explains the relationship between a hazard and hazard event.

Worksheet #2 — Profile Hazard Events — step 2

Date: May, 2001

How Bad Can It Get?

Task A. Obtain or create a base map.

You can use existing maps from:

- *Road maps*
- *USGS topographic maps or Digital Orthophoto Quarter Quads (DOQQ)*
- *Topographic and/or planimetric maps from other agencies*
- *Aerial topographic and/or planimetric maps*

OR you can create a base map using:

- *Field surveys*
- *GIS software*
- *CADD software*
- *Digitized paper maps*

Title of Map	Scale	Date
USGS topographic	1:24,000	1995

	Task B. Obtain a hazard event profile. Check box when complete and fill in source of information.	**Task C. Record your hazard event profile information.** Check box when complete.
Flood	[x] 1. Get a copy of your FIRM. FEMA Map Service Center [x] 2. Verify the FIRM is up-to-date and complete. Hazardville Planning Dept. & floodplain manager	[x] 1. Transfer the boundaries from your FIRM onto your base map (floodway, 100-yr flood, 500-yr flood). [x] 2. Transfer the BFEs onto your base map.
Earthquake	[x] 1. Go to the http://geohazards.cr.usgs.gov Website. [x] 2. Locate your planning area on the map. [x] 3. Determine your PGA.	[x] 1. Record your PGA: ____ [x] 2. If you have more than one PGA print, download or order your PGA map.
Tsunami	[x] 1. Get a copy of your tsunami inundation zone map. West Coast/Alaska Tsunami Warning Center of NOAA	[x] 1. Copy the boundary of your tsunami inundation zone onto your base map.
Tornado	[x] 1. Find your design wind speed. Hazardville Building Inspector/Building Code	[x] 1. Record your design wind speed: ____ [x] 2. If you have more than one design wind speed, print, download, or copy your design wind speed zones, copy the boundary of your design wind speed zones on your base map, then record the design wind speed zones on your base map.
Coastal Storm	[x] 1. Get a copy of your FIRM. FEMA Map Service Center [x] 2. Verify that the FIRM is up-to-date and complete. Hazardville Planning Dept. & floodplain manager [x] 3. Determine the annual rate of coastal erosion. State Coastal Zone Manager [x] 4. Find your design wind speed. Hazardville Building Inspector/Building Code	[x] 1. Transfer the boundaries of your coastal storm hazard areas onto your base map. [x] 2. Transfer the BFEs onto your base map. [x] 3. Record the erosion rates on your base map: ____ [x] 4. Record the design wind speed here and on your base map: ____
Landslide	[x] 1. Map location of previous landslides. University study [x] 2. Map the topography. USGS topographic maps [x] 3. Map the geology. U.S Natural Resources Conservation Service soil maps [x] 4. Identify the high-hazard areas on your map. ____	[x] 1. Mark the areas susceptible to landslides onto your base map.
Wildfire	[x] 1. Map the fuel models located within the urban-wildland interface areas. National Fire Danger Rating [x] 2. Map the topography. USGS topographic map [x] 3. Determine your critical fire weather frequency. State Fire Marshal [x] 4. Determine your fire hazard severity. How-To pg. 2-34	[x] 1. Draw the boundaries of your wildfire hazard areas onto your base map.
Other	[ ] 1. Map the hazard. ____	[ ] 1. Record hazard event info on your base map.

Procedures & Techniques

Task A. Obtain/create a base map.

When you start the hazard event profiling process, you should locate or create a base map so that you can show the areas that are subject to various hazards. A base map should be as complete, accurate, and current as possible and should be planimetric, which is a flat representation of information in true geographic relationship (to scale) with measurable horizontal distances. Other than distinguishable buildings, roads, rivers, coastlines, place names, and a north arrow, the map should be as uncluttered as possible. Use an existing map or controlled photograph as a base to avoid the cost of producing a new map.

Maps provide common frames of reference when describing where and how hazards can affect you. Your base map will be essential in Step 3 by showing the human and structural assets that should be inventoried. HAZUS should be considered first as your primary source of hazard data. (See "Tip" on page 2-5 for information on base maps.)

HAZUS

HAZUS – A Risk Assessment Tool

Hazards U.S. (HAZUS), is a standardized, nationally applicable earthquake loss estimation methodology that uses PC-based GIS software. HAZUS contains an extensive inventory of data that can help you conduct your loss estimation in a timely, cost-efficient manner.

Although HAZUS was originally designed to be used to estimate earthquake losses, it has a wider applicability to be used as a mapping and inventory collection tool. For example, you can use the HAZUS default data to identify the census tracts located in your community or state as your base map.

Default data contained in HAZUS

- Demographic data (population, age, ethnicity, and income);
- General building stock (square footage of occupancy classes for each census tract);
- Medical care facilities;
- Emergency response facilities (fire, police, emergency operation centers);
- Schools;
- Dams;
- Hazardous material facilities;
- Roads, airports, and other transportation facilities; and
- Electric power, oil, and gas lines and other utility facilities.

Minimum System Requirements for HAZUS99

- Intel Pentium® class IMP compatible, 400 MHz or greater is recommended
- CD-ROM drive
- Hard drive (minimum 1 GB free space required)
- Color printer or plotter
- Microsoft Windows® 95 or greater
- MapInfo® 5.5/5.0 software or ArcView® 3.2/3.1 GIS software

Minimum System Requirements for HAZUS97

- Intel 486® or greater IBM compatible computer, Pentium® preferred
- CD-ROM drive
- Hard drive (minimum 200 MB free space required)
- Color printer or plotter
- Microsoft Windows® 3.1 or greater
- MapInfo® 4.1.2 software or ArcView® 3.0 GIS software

HAZUS is available from the FEMA Distribution Center at http://www.fema.gov/hazus/

The HAZUS package contains a user manual to get you started. If your community does not have someone with the technical resources or expertise needed to use HAZUS ask your regional/or state planning, geology, or transportation department, or enlist the help of your local college or university geography, planning, or landscape architecture department to create the maps for you. You may also consider partnering with a private business in your planning area or hiring someone to assist you.

Level of Risk

If your planning team determines that the level of acceptable risk is different than the level identified by the suggested hazard event in this guide, it may be necessary to revise your risk assessment by profiling a lesser or greater hazard event. For example, you may choose to evaluate an area greater than the 100-year flood elevation established on the FIRM by assessing the 100-year flood elevation plus one additional foot (or other amount).

Practical Considerations when Using Maps

Hazard profile maps can range from simple traced maps to elaborate GIS productions. Both renditions will illustrate your hazard prone areas and will assist you in the next step of taking inventory of the elements that can be damaged.

Often the individual hazard maps to be used are at different scales. This may require an enlargement or reduction to the scale of the base map selected. Use of controlled photographic or computer mapping methods makes this process easy and accurate.

Copies of maps can be made on large format copying machines used by most reprographic companies. Maps also can be professionally photographed and transferred onto your base map.

Task B. Obtain hazard event profile information.

In each of the seven hazard-specific sections that follow, you will be given guidance on how to obtain, download, view, or order the relevant hazard map or other profile information. The suggested choice of return frequency for each hazard is based on the most commonly available information for a particular hazard.

You will purposely consider just one hazard event in each hazard section that follows to keep the process simple. For example, you will consider only the 100-year flood event. A more comprehensive hazard profile that considers all possible events, such as floods with different probabilities, may still be needed at some future date, but for now, this simplified version will be adequate to help you learn more about your community's risks and narrow your focus for future planning efforts.

Task C. Record your hazard event profile information.

Use **Worksheet #2: Profile Hazard Events** to record your research for each hazard profile. Keep track of where you found various maps, such as FIRMs, or hazard event data, such as your design wind speed.

The type of hazard will determine whether you will record the relevant data on the worksheet or copy the boundaries of the hazard event onto your base map.

Summary

When you are finished with this step, you'll either have a map showing the area impacted by each hazard type or you will have an important piece of data regarding the characteristics of hazard events affecting your planning area. In some cases, such as those involving floods, you will have both.

The hazard specific sections that follow contain step-by-step instructions to help you profile your hazards. Visit the library at the end of this guide for more information on specific hazards, contacts, or additional resources to help you profile your hazards.

When you have completed all of your hazard profiles

Go to Step 3

where you will inventory the assets in your planning area that can be damaged by the hazard events you profile.

Base Map Options

Different maps have different advantages and limitations. Some alternatives (listed in order of increasing price and utility) include:

- **Road maps.** There are usually detailed road maps available for areas in and around urban centers. It is important to verify the date the map was produced because it may be outdated and inaccurate. Also, although the street network will be depicted, it is unlikely that buildings will show up on the map. Therefore, you'll have to convert the map for use in risk assessment.
- **USGS Topographic Maps.** Maps showing topographic relief are available for the entire country at 1:24,000 scale (see Scale and Coverage below) from the United States Geological Survey (USGS). Some structures are indicated although not in great detail. Most roads are shown but few are identified. These maps can be obtained via the Internet at http://mapping.usgs.gov/mac/nimamaps/topo.html, or in hard copy from USGS by calling 1-888-ASK-USGS. These maps will have to be converted for use as a base map, just like the road maps. Like road maps, it is important to verify the date the mapping was completed to determine the relative accuracy of the mapped information.

USGS Digital Orthophoto Quarter Quad (DOQQ)

A DOQQ is a computer generated image of an aerial photograph in which displacements caused by camera orientation and terrain have been removed. These products combine the image characteristics of a photograph with the geometric qualities of a map and can be used in numerous GIS applications either alone or in combination with other digital data.

For more information on the USGS digital orthophoto program and DOQQ products visit the USGS Web site at http://mapping.usgs.gov/www/ndop/ or visit the National Mapping Information Web page at http://mapping.usgs.gov/index.html

- **Topographic and/or Planimetric Maps from other agencies.** Local agencies such as county or regional planning commissions often have maps. If there have been major roadwork or infrastructure projects within recent years, public works and transportation departments may have detailed maps that cover all or part of an area of interest.
- **Aerial Topographic and/or Planimetric Maps.** Communities can get new aerial topographic (indicating all built features as well as contour lines that represent the physical shape of the land) or planimetric (indicating built features only) from companies that specialize in aerial photography and photogrammetry. These days, this type of map is always produced in digital as well as reproducible formats. Topographic maps are usually more expensive but may be quite useful for other efforts including follow-up planning for mitigation projects identified later in the planning process. At a minimum, aerial photographs are useful in basic planning efforts as they provide a reliable, recognizable representation of the assets of the community at a reasonable cost.
- **Field Surveys.** In unusual circumstances, it may be practical to have field surveys done. However, for areas of any significant size, this option is more expensive than aerial topographic and planimetric maps and may not yield significantly better information for the mitigation planning efforts.

Scale and Coverage

Scale determines the area covered on the map. The scale is a proportion used in determining a dimensional relationship, which is the ratio of the distance between two points on a map and the actual distance between the two points on the earth's surface. For example, the scale 1:500,000 means that one centimeter on the map equals 500,000 centimeters (or 5,000 meters or 5 kilometers) on the ground. Small-scale maps show less detail for a large area. Smaller scales are more common for regional (1:500,000 through 1:50,000), and community plans (1:24,000 through 1:12,000).

The scale selected will depend upon the map's purpose. There are no best scales, only more appropriate ones to coincide with planning requirements. Consider the following scales for example:

- World: 1:30,000,000
- Continent: 1:5,000,000 to 1:2,000,000
- Region: 1:500,000 to 1:50,000
- Community or settlement: 1:24,000 to 1:12,000
- Building sites: 1:10,000 to 1:2,500

The level of detail, the hazards shown, and the format of a risk assessment map can range widely depending on the scale you choose. The scale used for a risk assessment is dependent upon not only the hazard information to be shown but also upon the scale of the base map. If a choice of scales is available, then the following factors become important in making the selection:

- Number of hazards to be shown.
- Hazard characteristics to be shown.
- Range of relative severity of hazards to be shown.
- Area to be covered.
- Use of the map in conjunction with other planning documents.
- Function of the map, for example, whether it is to be an index or detail map.

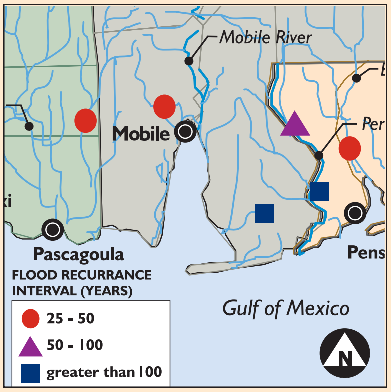
You may want to recommend that communities use a consistent base map, particularly if your state has already developed mapping at a suitable scale that can be used locally and covers the entire state. For example, a statewide Geographic Information System (GIS) would allow you to easily incorporate local information into state planning efforts.

As you proceed, keep in mind you will want to incorporate the results of individual communities' risk assessments into your own. This will give you more details on hazards and risks throughout the state. You may want to provide guidance to communities on the level of detail and return frequencies to use in local risk assessments in order to produce a uniformly consistent state risk assessment. You may also want to fill in the gaps for the areas of the state or communities that do not have local risk assessments.

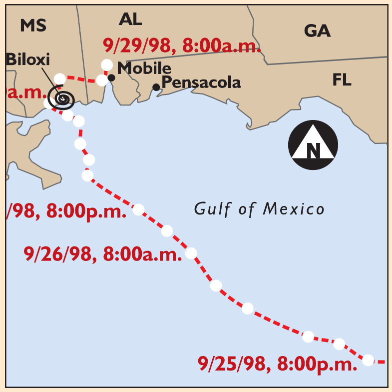
You will also need to decide whether you will conduct the loss estimation state properties or request that local governments do this as part of community-level planning. Either way, you should make sure communities are aware how to treat state-owned facilities in their loss estimation.

Map Symbols

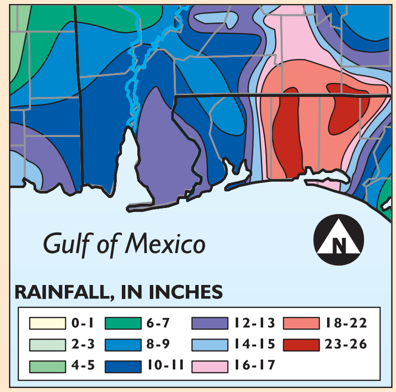
Mapped hazard areas can show various degrees of risk (e.g., seismic risk) or can identify a zone where risk is present (e.g., a floodplain). Map symbols represent reality by conveying a sense of the hazard. Symbols that represent hazard characteristics are selected for their legibility, clarity, and/or map production characteristics. There are three distinct map symbols: points, lines, and areas. The maps below depict characteristics of Hurricane Georges using points, lines, and areas.



Points can be used to show location of fire and police stations, hospitals, and emergency shelters, as well as points of impact from hurricanes, epicenters of earthquakes or locations of specific flood frequencies.



Lines can be used to separate areas of landslide frequency, to represent earthquake intensity, or to show tracks of storms, fault rupture, or tsunamis.



Areas can be used to show the extent of certain hazard conditions, such as flooding as well as erosion and wildfire zones.

Advanced computer programs have been developed for displaying and analyzing hazard identification data. Three of the most common computer programs used for hazard mapping are FEMA's Hazards U.S. (HAZUS), Geographic Information Systems (GIS), and Computer Aided Design & Drafting (CADD).

HAZUS

HAZUS contains an extensive inventory of data that communities can use and build upon as a loss estimation tool. HAZUS is currently being expanded into a multi-hazard methodology with new models for estimating potential losses from wind (hurricanes, thunderstorms, tornadoes, and extra-tropical cyclones) and flood (riverine and coastal) hazards. HAZUS is a flexible tool that has potential for use in risk assessment, response and recovery, and awareness and preparedness programs.

GIS

GIS is a computer-based tool for mapping and analyzing physical elements and events that occur on earth. GIS is a database that relates detailed information directly to a geographical area for mapping and analysis purposes. Software for GIS is available from many distributors. ArcView® and MapInfo® are two of the most commonly used sources of GIS software.

GIS allows users to overlay different kinds of data to determine relationships among them. Maps produced with GIS can help to explain hazard events, predict outcomes, visualize scenarios, and plan strategies. Some communities and regional planning authorities maintain GIS databases for planning land uses and managing utilities. GIS can map hazard areas and present hazard identification information, allowing the user to compare these areas with existing land uses. GIS also allows the user to:

- Import geographic data such as maps;
- Manipulate geographic data and update community zoning maps;
- Store and analyze attributes associated with geographic data;
- Perform queries and analyses to retrieve data (for example, show all child care centers within five miles of a fire station); and
- Display results as maps or graphs.

CADD

CADD is a computer system that allows users to perform drawing and design tasks, enabling quick and accurate electronic drawings. There are hundreds of CADD programs available in the CADD industry today, furnishing 2D drawings, 3D drawings, topographic base maps, site plans, and profiles/cross sections. Detailed hazard maps in a variety of dimensions can be made using CADD products on a computer.

Digitizing

Digitizing maps is the process of converting points, lines and area boundaries shown on maps into x, y coordinates (e.g. latitude and longitude, universal transverse mercator (UTM) or table coordinates). If your community does not already have this capability, you should contact local civil engineering or land surveying companies to investigate opportunities for contracting this work.

Data Availability

If a particular hazard map is not available for your planning area, you can create one using a variety of methods depending on the level of detail and accuracy required. The following examples range from simplest to the most complex.

Historical hazard event. The chosen event will determine the physical extent of the hazard and the severity. This method will provide a "snapshot" of one potential event. Later in this step, the hazard-specific sections that follow offer suggestions of how to gather information for historic hazard events.

Detailed hazard profile. You can create a detailed hazard profile by researching:

- how likely it is that hazard will impact the area (probability);
- how severe the hazard will be (magnitude);
- where hazards will affect the community or state (geographic extent); and
- conditions in the community that may increase or reduce the effects of hazards.

These elements are closely related, and are often combined in expressions linking probability (or frequency) and magnitude (or extent). Some examples of the types of factors that can exacerbate (increase) or mitigate (reduce) hazard effects are:

- topography (for most hazards)
- soil characteristics (earthquakes and landslides)
- soil saturation (floods and landslides)
- presence of fuel load (wildfires)
- presence of development in the hazard area (floods)
- existence of hazardous materials facilities in or near hazard zones (for all hazards)

Some of the factors are aspects of the planning area over which people have some control. For example, while you cannot control the duration of a hurricane, you can decide not to build on or near steep slopes. The hazard-specific sections that follow offer suggestions of how to gather information to conduct a detailed hazard profile, and the library in Appendix B offers suggestion of where to find more information on specific hazards. These factors will become important when planning the mitigation actions to protect your community or state from natural hazards in phase three of the natural hazard mitigation planning process.

Engineering study. Hydraulic engineers calculate flood elevations through stream gauge data and information on drainage area, rainfall potential, characteristics of the source of flooding (usually a river or stream), and soil saturation. The hazard-specific sections that follow offer suggestions of various computer modeling programs, as well as information about who you should contact for additional help.

Data Limitation

Data about what's happened in the past is often used to estimate what's likely to happen in the future. For example, chances are that "tornado alley" in the midwest, will experience more tornadoes this year than other parts of the United States. This assumption is simply based on the fact that tornadoes have often impacted that area in the past. The same is true in a small town whose main street has flooded numerous times in the past. However, there's a big difference between a particular street being flooded and an entire state being impacted by tornadoes. There are a number of site-specific characteristics that determine flood potential. On the other hand, a state that has experienced an average of 100 tornadoes each year for the last 30 years does **not** mean that a tornado will hit any particular point in the state next year.

The Hazardville Post

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THORR Profiles Hazardville's Hazards

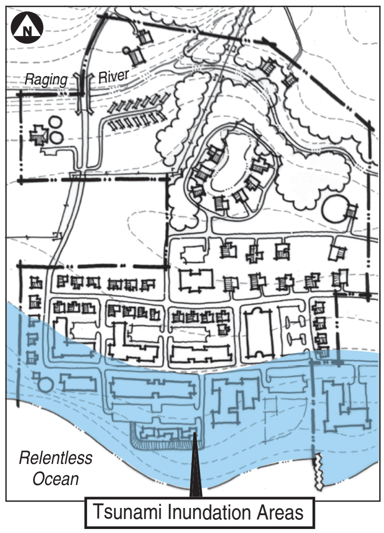
(Part 2 of a 4 Part Series on the Risk Assessment Process)

[Hazardville, EM] In April, the Hazardville Post reported the ongoing work of the Town of Hazardville Organization for Risk Reduction (THORR). THORR recently completed its hazard research and has developed a series of hazard profiles that represent the next big step in describing the problems.

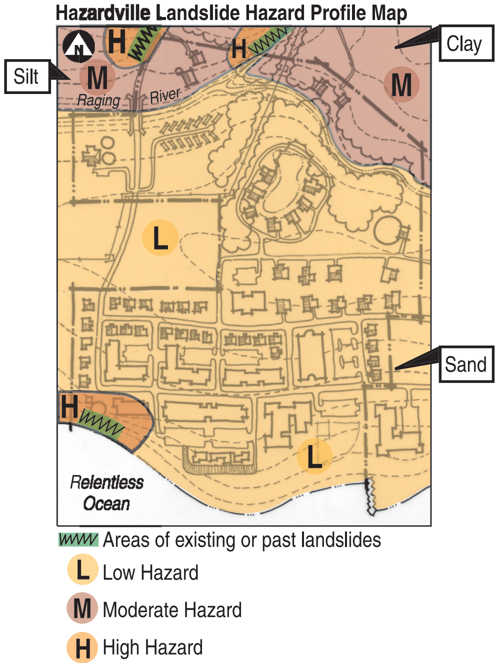
Joe Norris, lead planner of the task force, emphasized, "Our motto, 'A Small Town with Big Problems' is certainly accurate when it comes to natural hazards, but our recent efforts of identifying and profiling the hazards will help us deal with them effectively in the future." Norris said that a host of hazards, including floods, earthquakes, tsunamis, tornadoes, hurricanes, landslides, and wildfires, pose potential threats to the Town of Hazardville. THORR presented its hazard profiles at last night's Board of Supervisors meeting.

Mary Tremble, director of the Hazardville Emergency Management Agency (HEMA) and head of the Earthquake, Tsunami and Landslide Workgroup, revealed that Hazardville has a moderate earthquake threat. "After learning about our seismic potential from the state geologist, the Workgroup contacted Emergency State University's Geology Department for more information on seismicity. Using maps produced by the U.S. Geological Survey, we found that the entire town is within a seismic zone that has a 10% chance of exceeding 0.3g in 50 years." The %g refers to the percent of acceleration due to gravity and is used to measure the strength of ground movements.

Hazardville Tsunami Hazard Profile



Hazardville Landslide Hazard Profile Map



For Hazardville, that generally means that an earthquake of that size could cause moderate to severe damage according to Tremble. For example, it could cause moderate damage to structures with un-reinforced masonry chimneys or severe damage to poorly constructed buildings. A large off-shore earthquake could also cause a tsunami that could impact up to one-mile inland of the Hazardville coastline within 15 minutes of the quake.

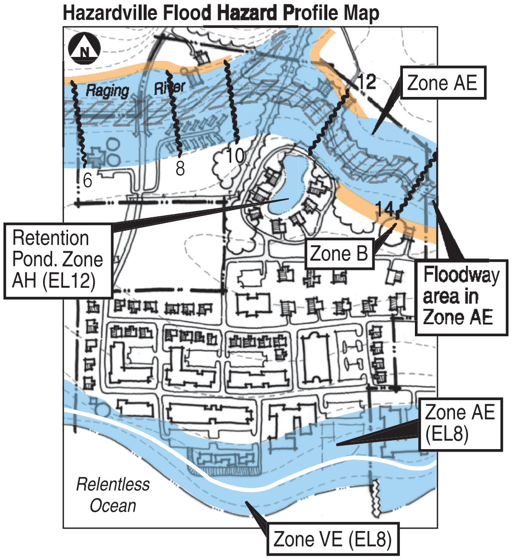
Tremble reported that the biggest concern for the Workgroup is the area of town that is susceptible to landslides. Several landslides have been recorded on the bluffs following heavy rains. These areas are susceptible to slides mostly because of ground saturation but also present a danger when earthquakes occur because of the steep slopes, Tremble said. Hazardville has three landslide zones. "The areas of past landslides are shown as high hazard areas," Ms. Tremble said. "The moderate hazard area is north of Raging River and includes areas with steep slopes and unstable soils."

Mr. David Waters, head of the Flood and Hurricane Workgroup, explained Hazardville's flood risk. Waters, who is also the town's Floodplain Manager, explained that Hazardville's Flood Insurance Rate Map (FIRM) shows the 100-year floodplain (areas with a 1% chance of flooding each year) in the coastal region to the south and in the vicin-

(continued on page 2-9)

(continued from page 2-8)

Hazardville Flood Hazard Profile Map



ity bordering Raging River in the northern part of town. The coastal region is designated as AE and VE zones, meaning that floods will have wave action and will travel quickly. A map of the town with its flood hazard zones illustrates that floods pose a threat to a significant portion of the community.

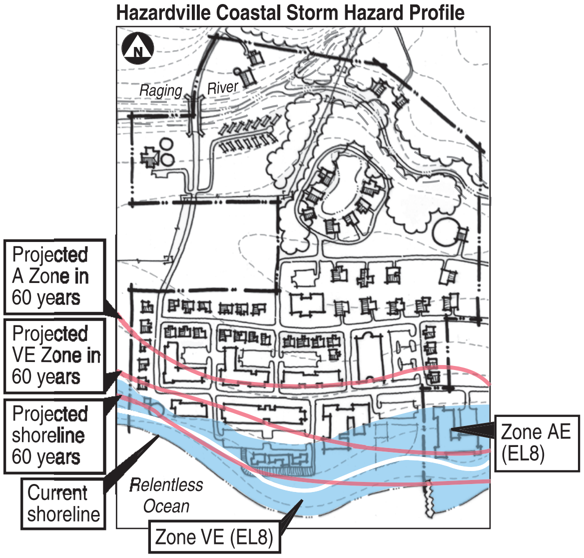
Ms. Wendy Soot, head of the Tornadoes and Wildfires Workgroup, cautioned that Hazardville is also susceptible to tornadoes. "Hazardville is located in a 200 mph wind zone, which means we could experience a severe (F3) tornado. A tornado of this severity could remove roofs, knock over walls, and even overturn cars and trains."

Soot, who is also the town's Fire Marshal, added that Hazardville has four wildfire zones. "We have an extreme and high wildfire hazard area on the northern edge of town due to the steep topography and heavy fuel of the forest," Ms. Soot said. "The area of town south of Raging River is considered a moderate and high wildfire hazard area, due to the light fuel and proximity to the forest.

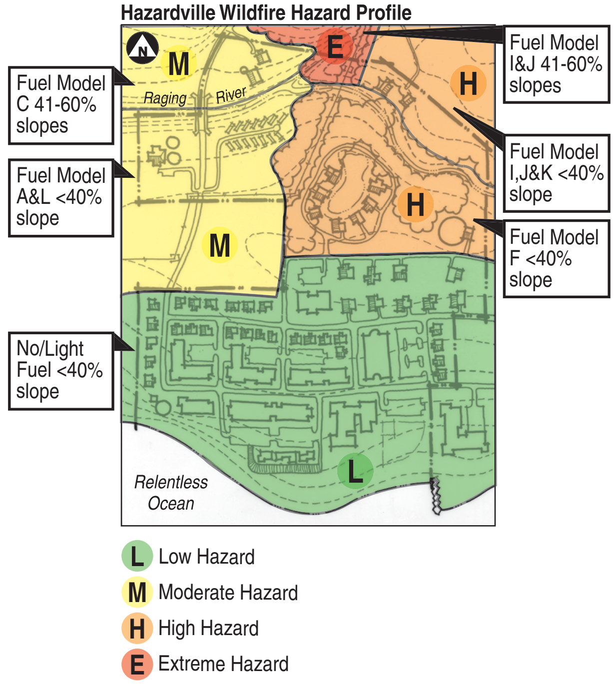
When asked about the professional look of the maps, Norris responded that all mapping was done using the town's own resources. "In fact," he explained, "the base was traced from a USGS map by the Hazardville Planning Office." The hazard profiles were compiled from various sources including soil maps, topography maps, and storm surge maps. A map specialist from the transportation department helped us trace the hazard profiles on to our base map. Some of the maps had to be reduced or enlarged on a copy machine to produce the same scale as the base map.

Norris expects the risk assessment process to continue to be successful. He credited the hard work of THORR members and the state and federal government workers who have assisted them. "This has been and will continue to be a truly cooperative effort," he said.

Hazardville Coastal Storm Hazard Profile



Hazardville Wildfire Hazard Profile



Floods

Task B. Obtain flood hazard event profile information.

The best source of local flood hazard information is the Flood Insurance Study (FIS) developed under the National Flood Insurance Program (NFIP) administered by FEMA. An FIS contains a Flood Insurance Rate Map (FIRM), which is an official map of a community that shows areas at risk from flooding from the base flood (see page 2-12 for more information on floods). Another element of the FIS is a graph, also known as a flood profile, which shows potential flood elevations plotted along the waterways. This information will help you delineate the boundaries of the floodplain in your planning area.

At the very least, you should research past or historic flood events. You can use old watermarks and eyewitness accounts to delineate the approximate flood boundaries and depths of flooding on your base map, or especially if there is not a FIRM or Q3 available for your community. Contact your state NFIP coordinator for more information on flooding in your area. In addition, the USGS, U.S. Army Corps of Engineers, or a civil engineer skilled in hydraulic analysis can help you conduct a flood study.

1. Get a copy of your FIRM.

By using a copy of the FIRM, you will evaluate the 100-year flood (a flood that has a 1 percent chance of occurring in any one year).

Copies of FIRMs can be requested by calling the FEMA Map Service Center at 1.800.358.9616, on the Internet at http://www.fema.gov/maps, or by contacting a FEMA Regional Office. Additionally, the NFIP's Guide to Flood Maps is

The following is the system FEMA uses on the FIRMs to categorize different floodplain areas.

Flood Zones

Zone A		The 100-year or base floodplain. There are six types of A zones:
	A	The base floodplain mapped by approximate methods, i.e., BFEs are not determined. This is often called an unnumbered A zone or an approximate A zone.
	A1-30	These are known as numbered A zones (e.g., A7 or A14). This is the base floodplain where the FIRM shows a BFE (old format).
	AE	The base floodplain where base flood elevations are provided. AE zones are now used on new format FIRMs instead of A1-A30 zones.
	AO	The base floodplain with sheet flow, ponding, or shallow flooding. Base flood depths (feet above ground) are provided.
	AH	Shallow flooding base floodplain. BFEs are provided.
	A99	Area to be protected from base flood by levees or Federal flood protection systems under construction. BFEs are not determined.
	AR	The base floodplain that results from the de-certification of a previously accredited flood protection system that is in the process of being restored to provide a 100-year or greater level of flood protection.
Zone V and VE	**V**	The coastal area subject to a velocity hazard (wave action) where BFEs are not determined on the FIRM.
	VE	The coastal area subject to a velocity hazard (wave action) where BFEs are provided on the FIRM.
Zone B and Zone X (shaded)		Area of moderate flood hazard, usually the area between the limits of the 100-year and 500-year floods. B zones are also used to designate base floodplains of lesser hazards, such as areas protected by levees from the 100-year flood, or shallow flooding areas with average depths of less than one foot or drainage areas less than 1 square mile.
Zone C and Zone X (unshaded)		Area of minimal flood hazard, usually depicted on FIRMs as exceeding the 500-year flood level. Zone C may have ponding and local drainage problems that do not warrant a detailed study or designation as base floodplain. Zone X is the area determined to be outside the 500-year flood.
Zone D		Area of undetermined but possible flood hazards.

available on the web at http://msc.fema.gov/MSC/hardcopy.htm, and flood risk and map information is available at http://www.fema.gov/nfip/fmapinfo.htm.

FEMA is currently involved in converting FIRMs to digital format (DFIRM). The DFIRM product will be designed to allow for the creation of interactive multi-hazard digital maps that can be used on a personal computer using GIS.

Digital Q3 flood data is available for 1,200 counties in CD-ROM format. The Q3s are digital representations of certain features of FIRMs and are intended for use with desktop mapping and GIS technology. The Q3s are used for hazard mitigation planning, floodplain management, land-use planning, natural resource and environmental analysis, and insurance target marketing. They are designed to provide the general location of the Special Flood Hazard Area (SFHA). The main differences between the Q3s and the official paper FIRMs is that the Q3s do not include the following:

- hydrographic features (streams and rivers, lake and coastal shorelines);
- base flood elevations;
- cross-section lines;
- roads, road names, or address ranges; and
- locations, elevations and descriptions of benchmarks and elevation reference marks.

The Digital Q3 Flood Data and DFIRMs are also available from the FEMA Map Service Center, in addition, the Q3 maps are available on the FEMA HAZUS CD.

If you participate in the NFIP you should have FIRMs locally. Contact your NFIP coordinator or floodplain manager, usually located in the planning, building, engineering, or natural resources department, or your state NFIP coordinator for copies of your FIRM or to help you identify areas that are prone to flooding. Your state NFIP coordinator or state floodplain manager can be found at http://www.floods.org/stcoor.html.

2. Verify that the FIRM is up-to-date and complete.

No map is perfect and floodplains change due to a number of reasons. From time to time, FEMA, communities or individuals may find it necessary for a FIRM to be updated, corrected, or changed.

Review the FIRM to determine whether any of the following circumstances apply to your planning area:

(continued on page 2-14)

Most flood information is provided on a community-wide scale. Rather than compiling a FIRM for each community in your state, you can use Q3s. The Q3 maps are available on the state-specific supplemental data CD ROMs for use with FEMA's GIS-based HAZUS Loss Estimation software program.

You should also be prepared to assist communities with obtaining flood mapping, and understanding the information presented on FIRMs.

FEMA uses two methods to make flood map changes. The first is to actually change the map and publish new copies. The other method is to issue a letter that describes the map change. There are two types of letters indicating map changes:

LOMR – Letter of Map Revision

LOMA – Letter of Map Amendment

These letters officially amend or revise the effective NFIP map. Contact your FEMA regional office for more information on map changes.

What is a flood?

A flood is a natural event for rivers and streams. Excess water from snowmelt, rainfall, or storm surge accumulates and overflows onto the banks and adjacent floodplains. Floodplains are lowlands, adjacent to rivers, lakes, and oceans that are subject to recurring floods. Hundreds of floods occur each year, making it one of the most common hazards in all 50 states and U.S. territories. Floods kill an average of 150 people a year nationwide. They can occur at any time of the year, in any part of the country, and at any time of day or night. Floodplains in the U.S. are home to over nine million households. Most injuries and deaths occur when people are swept away by flood currents, and most property damage results from inundation by sediment-filled water.

Several factors determine the severity of floods, including rainfall intensity (or other water source) and duration. A large amount of rainfall over a short time span can result in flash flood conditions. A small amount of rain can also result in floods in locations where the soil is saturated from a previous wet period or if the rain is concentrated in an area of impermeable surfaces such as large parking lots, paved roadways, or other impervious developed areas.

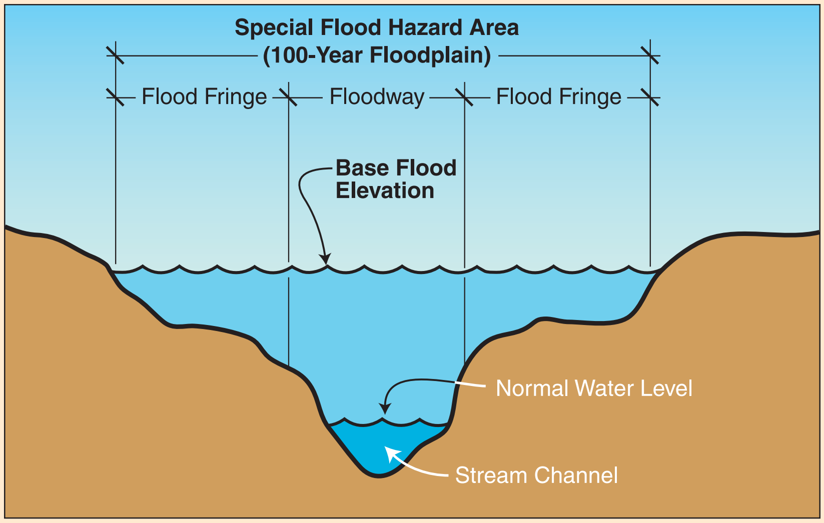
Topography and ground cover are also contributing factors for floods. Water runoff is greater in areas with steep slopes and little or no vegetative ground cover.

Frequency of inundation depends on the climate, soil, and channel slope. In regions where substantial precipitation occurs in a particular season each year, or in regions where annual flooding is derived principally from snowmelt, the floodplains may be inundated nearly every year. In regions without extended periods of below-freezing temperatures, floods usually occur in the season of highest precipitation. In areas where flooding is caused by melting snow, and occasionally compounded by rainfall, the flood season is spring or early summer.

Fortunately, most of the known floodplains in the United States have been mapped by FEMA, which administers the NFIP. When a flood study is completed for the NFIP, the information and maps are assembled into a Flood Insurance Study (FIS). An FIS is a compilation and presentation of flood risk data for specific watercourses, lakes, and coastal flood hazard areas within a community and includes causes of flooding.

The FIS report and associated maps delineate Special Flood Hazard Areas (SFHAs), designate flood risk zones, and establish base flood elevations (BFEs), based on the flood that has a 1% chance of occurring annually, or the 100-year flood. The study may have three components:

- The FIS – Flood Insurance Study text;
- The FIRM – Flood Insurance Rate Map; and
- A separate Flood Boundary and Floodway Map (FBFM) that was issued as a component of the FIS for each community studied prior to 1986. No BFE or flood zone names are shown on the floodway map and people often confuse the white floodway with the white area representing land that is free from flooding. FIS reports published since 1986 have corrected this problem by delineating the floodways as diagonally hatched areas on the FIRMs.



The **100-year flood** designation applies to the area that has a 1 percent chance, on average, of flooding in any given year. However, a 100-year flood could occur two years in a row, or once every 10 years. The 100-year flood is also referred to as the **base flood**. The base flood is the standard that has been adopted for the NFIP. It is a national standard that represents a compromise between minor floods and the greatest flood likely to occur in a given area and provides a useful benchmark.

Base Flood Elevation (BFE), as shown on the FIRM, is the elevation of the water surface resulting from a flood that has a 1% chance of occurring in any given year.

The BFE is the height of the base flood, usually in feet, in relation to the National Geodetic Vertical Datum (NGVD) of 1929, the North American Vertical Datum (NAVD) of 1988, or other datum referenced in the FIS report.

Special Flood Hazard Area (SFHA) is the shaded area on a FIRM that identifies an area that has a 1% chance of being flooded in any given year (100-year floodplain).

FIRMs show different floodplains with different zone designations. These are primarily for insurance rating purposes, but the zone differentiation can be very helpful for other floodplain planning purposes. The more common zones were listed in the table on page 2-10.

Floodway is the stream channel and that portion of the adjacent floodplain that must remain open to permit passage of the base flood without raising the water surface elevation by more than one foot.

NGVD – National Geodetic Vertical Datum of 1929, the national datum used by the NFIP. NGVD is based on mean sea level. It was known formerly as the "Mean Sea Level Datum of 1929 (MSL)." NAVD 88 = North American Vertical Datum of 1988 is being phased in.

It's important to recognize that there is actually a range of floods, other than just the 100-year flood, that could happen within your planning area. For example, a house located close to a flood source might experience some level of flooding every 5 to 10 years. The level or depth of flooding is determined by the probability.

The probability of a flood is based on a statistical chance of a particular size flood (expressed as cubic feet per second of water flow) occurring in any given year. The annual flood is usually considered the single greatest event expected to occur in any given year. The percent annual chance of floods is estimated based on watershed and climatic characteristics or watershed models, water surface elevations, and hydraulic models that reflect topographic characteristics.

The risk created by the 100-year flood would be much greater than the risk from the annual flood based on the amount of damages each event produces – once. But the annual flood would occur much more frequently and over time may in fact produce a much greater risk to the structure than the 100-year flood.

Flood frequencies can be determined by plotting a graph of the size of all known floods for an area and determining how often floods of a particular size may occur. In addition, hydrologic and hydraulic data gathered from rivers and streams is a valuable but time-consuming effort to calculate flood frequencies. If at least 20 years worth of data are available through stream gauging, models can be used to determine the statistical frequency of given flood events.

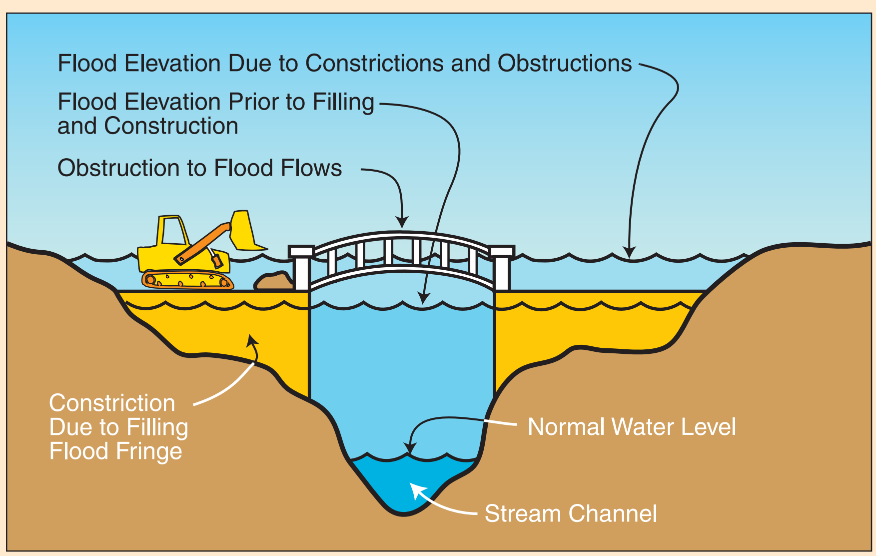
The USGS maintains river gauge records. Historical and current river gauge information can be observed at its Website at http://water.usgs.gov. Some local agencies may also have gauge records.

The process of conducting a more rigorous risk assessment to include all of the possible hazard events will be discussed in the "how-to" for the third phase of the Natural Hazard Mitigation Planning Process, "Develop a Mitigation Plan."

Conditions that may exacerbate or mitigate the effects of floods

The following factors will affect the severity of a flood:

- **Impermeable Surfaces:** Excessive amounts of paved areas or other surfaces upstream or in the community can increase the amount and rate of water runoff. Development affects the runoff of stormwater and snowmelt when buildings and parking lots replace the natural vegetation, which normally would absorb water. When rain falls in an undeveloped area, as much as 90 percent of it will infiltrate the ground; in a highly developed area, as much as 90 percent of it will run off.
- **Steeply sloped watersheds:** In hilly and mountainous areas, a flood may occur minutes after a heavy rain. These flash floods allow little or no warning time and are characterized by high velocities.
- **Constrictions:** Re-grading or filling within or on the edge of floodplains obstructs flood flows, backing up floodwaters onto upstream and adjacent properties. It also reduces the floodplain's ability to store excess water, sending more water downstream and causing floods to rise to higher levels. This also increases floodwater's velocity downstream of the constriction.
- **Obstructions:** Bridges, culverts and other obstructions can block flood flow and trap debris, causing increased flooding upstream and increased velocity downstream.
- **Debris:** Debris from the watershed, such as trees, rocks, and parts of damaged buildings, increases the hazard posed by moving water. Moving water will float, drag or roll objects, which then act as battering rams that can knock holes in walls and further exacerbate the effects of debris.
- **Contamination:** Few floods have clear floodwater, and the water will pick up whatever was on the ground within the floodplain, such as soil, road oil, farm and lawn chemicals, and animal waste. In addition, if a wastewater treatment plant was inundated, the floodwaters will likely include untreated sewage. Contamination is also caused by the presence of hazardous material storage in the floodplain and in the community, as well as upstream from the community.
- **Soil saturation:** Rainfall in areas already saturated with water will increase the runoff.
- **Velocity:** Flood velocity is the speed of moving water, measured in feet per second. High velocities (greater than 5 feet per second) can erode stream banks, lift buildings off their foundations, and scour away soils around bridge supports and buildings.



If you live in a community that could be affected if an upstream dam were overtopped or breached, contact your state dam safety official identified on the Website of the Association of State Dam Safety Officials (ASDSO), at http://crunch.tec.army.mil/nid/webpages/nid.cfm and click on "State Links". The state official will assist you in determining whether there are any large dams that could flood your community if breached or overtopped. There are thousands of significant and high-hazard potential dams in the U.S. About 60 percent have Emergency Action Plans, which delineate the inundation area if the dam fails or is overtopped. The inundation areas are usually much larger than the 100-year floodplain.

As you map your flood hazard areas and plan for mitigation of flood hazards, consider applying for credit for Community Floodplain Management Planning under FEMA's Community Rating System (CRS). If you are not currently enrolled in CRS, contact your state floodplain manager.

(continued from page 2-11)

- Significant construction has occurred within the already identified floodplains on your FIRM.
- Upstream communities have had significant development since the FIRM was published.
- There has been a flood for which inundation pattern indicates that the FIRM boundaries are no longer accurate.
- A major flood control project has been completed within your community, or upstream of your community.
- Changes in topography in or adjacent to existing mapped floodplains.

If the area you're considering is not within the 100-year floodplain, you may elect to concentrate on other hazards because your risk is, by definition, relatively small. However, you may still have flood risks that arise from one or more of the following, which are not shown on the FIRM:

- Drainage areas of less than one square mile;
- Sewer backup;
- Drainage system backup;
- Dam breaches; and
- Stormwater runoff problems.

Task C. Record your hazard event profile information.

1. Transfer the boundaries from your FIRM onto your base map.

2. Record the base flood elevations onto your base map.

Go to the next hazard on your list to profile

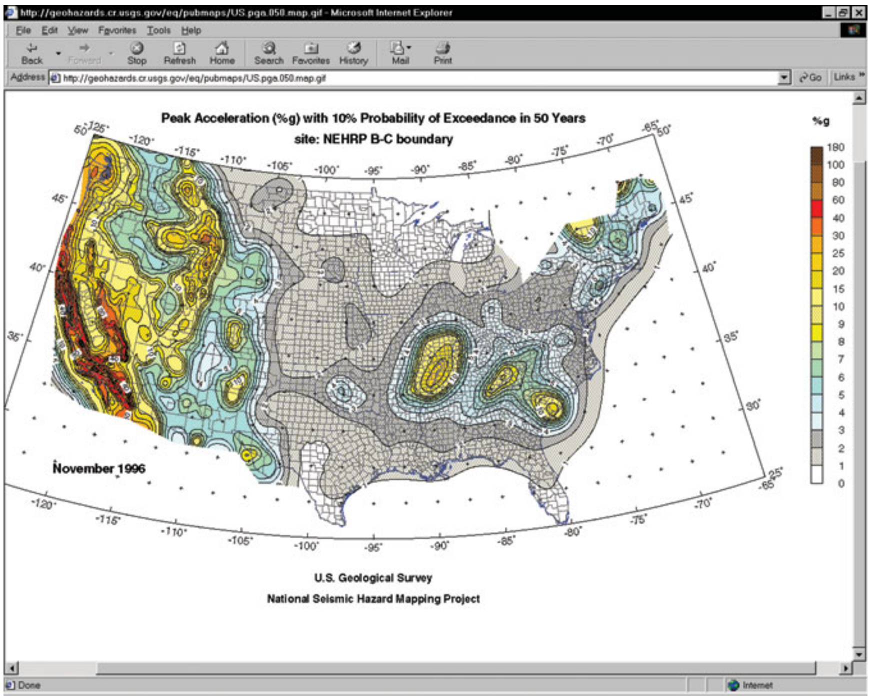
or if you are finished with all your hazard profiles

Go to Step 3

Earthquakes

Task B. Obtain earthquake hazard event profile information.

1. Go to the http://geohazards.cr.usgs.gov Website.



Source: http.geohazards.cr.usgs.gov/eq/pubmaps/US.pga.050.map.gif

The map shows the national Peak Ground Acceleration (PGA) values for the United States with a 10% chance of being exceeded over 50 years. This is a common earthquake measurement that shows three things: the geographic area affected (all colored areas on the map), the probability of an earthquake of each given level of severity (10% chance in 50 years), and the severity (the PGA is indicated by color).

2. Locate your planning area on the map.

You can also generate maps based on zip codes or longitude and latitude by following the directions on the Website.

3. Determine your Peak Ground Acceleration.

Determine the PGA zone(s) in which your planning area is located. This is done by identifying the color associated with your planning area and correlating it with the color key located on the map. Large planning areas may be located in more than one zone.

Peak ground acceleration (PGA) is a measure of the strength of ground movements. The PGA measures the rate in change of motion relative to the established rate of acceleration due to gravity (g) (980 cm/sec/sec). For example, in an earthquake with an acceleration of the ground surface of 244 cm/sec/sec, the PGA or rate in change of motion is 25%g where:

%g = Ground Surface Acceleration / Rate of Acceleration due to Gravity;

%g = 244 cm / sec/ sec/ 980 cm / sec / sec; and

%g = 25%

Seismic hazard maps are available for the whole country, as well as regional maps of Alaska, California, Nevada, and the Central and Eastern United States. For California, the USGS and the California Division of Mines and Geology have earthquake fault zone maps and seismic hazard zone maps. You can order these maps by calling USGS at 1-888-ASK-USGS. You should also contact your state geologist for additional hazard information.

What is an Earthquake?

Earthquakes are one of nature's most damaging hazards. An earthquake is a sudden motion or trembling that is caused by a release of strain accumulated within or along the edge of Earth's tectonic plates. The severity of these effects is dependent on the amount of energy released from the fault or epicenter. The effects of an earthquake can be felt far beyond the site of its occurrence. They usually occur without warning and after just a few seconds can cause massive damage and extensive casualties. Common effects of earthquakes are ground motion and shaking, surface fault ruptures, and ground failure.

Earthquakes are more widespread than is often realized. The area of greatest seismic activity in the United States is along the Pacific Coast in California and Alaska, but as many as 40 states can be characterized as having at least moderate earthquake risk. For example, seismic activity has been recorded in Boston, Massachusetts; New Madrid, Missouri; and Charleston, South Carolina, places not typically thought of as earthquake zones. Areas prone to earthquakes are relatively easy to identify in the Western United States based on known geologic formations; however, predicting exactly when and where earthquakes will occur is very difficult everywhere.

There are several common measures of earthquakes. These include Richter Magnitude, Modified Mercalli Intensity (MMI), Moment Magnitude and Peak Ground Acceleration (PGA), among others. For this guide, we're using PGA for measuring earthquake hazard.

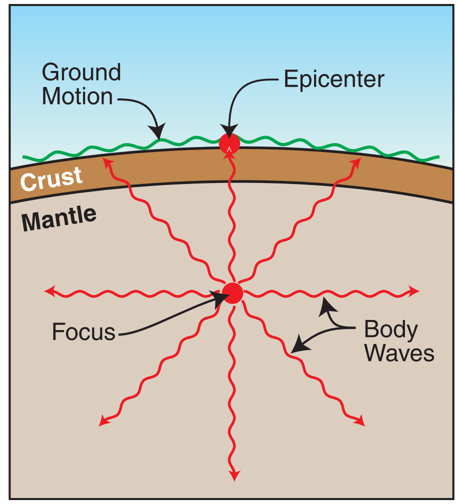
Acceleration: One way to express an earthquake's severity is to compare its acceleration to the normal acceleration due to gravity. If you're standing on the surface of the earth and drop an object (ignoring wind resistance), it will fall toward the earth faster and faster, until it reaches terminal velocity. This principle is known as acceleration and represents the rate at which speed is increasing. The acceleration due to gravity is often called "g", a term you may have heard associated with roller coasters, rockets, or even stock car racing. The acceleration due to gravity at the earth's surface is 9.8 meters (980 centimeters) per second squared. That means that every second that something falls toward the surface of earth its velocity increases by 9.8 meters per second. A 100% g earthquake is very severe.

An analogy would be if you floor your car's gas pedal and your groceries get smashed against the back of the trunk. The quicker you press on the gas, the more eggs are likely to get broken. That's because the quick acceleration caused the contents of your trunk to shift rapidly and violently, not slowly and smoothly. In fact, the eggs might not have moved at all if you had sped up slowly. The same thing is true in an earthquake. If ground acceleration is rapid, more things tend to break than if the shaking is relatively slow, even if the ground moves the same distance.

Earthquake Motion: The variables that characterize earthquakes are ground motion, surface faulting, ground failure, and seismic activity. **Ground motion** is the vibration or shaking of the ground during an earthquake. When a fault ruptures, seismic waves radiate, causing the ground to vibrate. The severity of the vibration increases with the amount of energy released and decreases with distance from the causative fault or epicenter, but soft soils can further amplify ground motions.

Surface faulting is the differential movement of two sides of a fracture – in other words, the location where the ground breaks apart. The length, width, and displacement of the ground characterize surface faults.

Liquefaction is the phenomenon that occurs when ground shaking causes loose soils to lose strength and act like viscous fluid. Liquefaction causes two types of **ground failure**: lateral spread and loss of bearing strength. **Lateral spreads** develop on gentle slopes and entail the sidelong movement of large masses of soil as an underlying layer liquefies. **Loss of bearing strength** results when the soil supporting structures liquefies. This can cause structures to tip and topple.



Definition sketch for earthquake.

The HAZUS Loss Estimation Tool

FEMA developed a standardized, nationally applicable earthquake loss estimation methodology. This methodology is implemented with PC-based software called HAZUS (Hazards U.S.),which runs on a Geographic Information System (GIS) platform.

The HAZUS loss estimation methodology is a software program that uses mathematical formulas and information about building stock, local geology and the location and size of potential earthquakes, economic data, and other information to estimate losses from a potential earthquake. HAZUS is capable of using two separate GIS systems (MapInfo® or ArcView®) to map and display ground shaking, the pattern of building damage, and demographic information about a community.

Once the location and size of a hypothetical earthquake are identified, HAZUS will estimate the violence of ground shaking, the number of buildings damaged, the number of casualties, the amount of damage to transportation systems, disruption to the electrical and water utilities, the number of people displaced from their homes, and the estimated cost of repairing projected damage and other effects.

- **Level 1** – All of the information needed to produce a rough estimate of losses from an earthquake is included in the HAZUS software. This is data from national databases and describes in general terms the geology of the region and the building inventory and economic structure of the community. The default data that HAZUS includes are used to provide a basic estimate of losses and are useful in mitigation planning.
- **Level 2** – More accurate estimates of losses require more detailed information about the community. To produce a Level 2 estimate of losses, detailed information will be required about local geology, an inventory of buildings in the community, and data about utilities and transportation systems. Assistance from geotechnical and structural engineers may be necessary for this analysis, as well as a GIS specialist to add the detailed information into the HAZUS model.
- **Level 3** – The most accurate estimate of loss will require detailed engineering and geotechnical input to customize the methodology to the specific conditions of the community.

While Level 1 HAZUS studies can typically be carried out by local government emergency services or planning staff, the assistance of structural engineers, geologists and GIS specialists is generally needed for Level 2 and Level 3 estimates.

Task C. Record your hazard event profile information.

1. Record your PGA value.

If you are located in only one PGA zone, note that zone on Step 2 Worksheet and go to the bottom of this page; otherwise, continue with part 2 of this task.

2. Print, download, or order your PGA map.

If you are located in more than one PGA zone, you will need a copy of your PGA map. Maps can be printed, downloaded or ordered from the USGS Website.

Unlike communities, states may have many different PGA zones. Your proximity to faults and soil and subsurface characteristics all affect the level of earthquake hazard. Here it is also important to note the pattern or gradation of seismic characteristics across the state.

3. Transfer the boundary of your PGA zones onto your base map.

4. Record the PGA value(s) on your worksheet.

Go to the next hazard on your list to profile

or if you are finished with all your hazard profiles,

Go to Step 3

Tsunamis

What is a Tsunami?

A tsunami is a series of long waves generated in the ocean by a sudden displacement of a large volume of water. Underwater earthquakes, landslides, volcanic eruptions, meteor impacts, or onshore slope failures can cause this displacement. Most tsunamis originate in the Pacific "Ring of Fire," the area of the Pacific bounded by the eastern coasts of Asia and Australia and the western coasts of North America and South America that is the most active seismic feature on earth. Tsunami waves can travel at speeds averaging 450 to 600 miles per hour. As a tsunami nears the coastline, its speed diminishes, its wavelength decreases, and its height increases greatly. Unusual heights have been known to be over 100 feet high. However, waves that are 10 to 20 feet high can be very destructive and cause many deaths and injuries.

After a major earthquake or other tsunami-inducing activity occurs, a tsunami could reach the shore within a few minutes. From the source of the tsunami-generating event, waves travel outward in all directions in ripples. As these waves approach coastal areas, the time between successive wave crests varies from 5 to 90 minutes. The first wave is usually not the largest in the series of waves, nor is it the most significant. One coastal community may experience no damaging waves while another may experience destructive deadly waves. Some low-lying areas could experience severe inland inundation of water and deposition of debris of more than 1000 feet inland.

Along the West Coast, the Cascadia Subduction Zone threatens California, Oregon, and Washington with devastating local tsunamis. Earthquakes of Richter scale magnitude of 8 or more have happened in the zone, and there is a 35 percent chance that an earthquake of this magnitude could occur before 2045 (estimated between the years 1995 and 2045). The Alaska and Aleutian Seismic Zone that threatens Alaska has a predicted occurrence (84 percent probability between 1988 to 2008) of an earthquake with magnitude greater than 7.4 in Alaska. If an earthquake of this magnitude occurs, Alaska's coastlines can be expected to flood within 15 minutes.

What are the Characteristics of Tsunamis?

Debris: As the tsunami wave comes ashore, it brings with it debris from the ocean, including man-made debris like boats, and as it strikes the shore, creates more on-shore debris. Debris can damage or destroy structures on land.

Distance from shore: Tsunamis can be both local and distant. Local tsunamis give residents only a few minutes to seek safety and cause more devastation. Distant tsunamis originating in places like Chile, Japan, Russia, or Alaska can also cause damage.

High tide: If a tsunami occurs during high tide, the water height will be greater and cause greater inland inundation, especially along flood control and other channels.

Outflow: Outflow following inundation creates strong currents, which rip at structures and pound them with debris, and erode beaches and coastal structures.

Water displacement: When a large mass of earth on the ocean bottom impulsively sinks or uplifts, the column of water directly above it is displaced, forming the tsunami wave. The rate of displacement, motion of the ocean floor at the earthquake epicenter, the amount of displacement of the rupture zone, and the depth of water above the rupture zone all contribute to the intensity of the tsunami.

Wave runup: Runup is the height that the wave extends up to on steep shorelines, measured above a reference level (the normal height of the sea, corrected to the state of the tide at the time of wave arrival).

Wave strength: Even small wave heights can cause strong, deadly surges. Waist-high surges can cause strong currents that float cars, small structures, and other debris.

Task B. Obtain tsunami hazard event profile information.

Get a copy of your tsunami inundation zone map.

Tsunami inundation zone maps show low-lying areas that could be affected by tsunamis. Communities can obtain state-level inundation maps and other information about tsunamis from:

- West Coast / Alaska Tsunami Warning Center of NOAA / NWS by calling 907.745.4212 or by writing 910 S. Felton Street, Palmer AK 99645-6552.
- Pacific Tsunami Warning Center in Hawaii at 808.689.8207 or 91-270 Fort Weaver Road, Ewa Beach, HI 96706.

Communities in Oregon can request maps from the Oregon Department of Geology and Mineral Industries (DOGAMI) by calling 503.731.4100 or by writing 800 NE Oregon Street, #28, Portland, OR 97232.

Washington and California communities should contact their state geologist for mapping information.

In addition, information is available from the following Websites:

- U.S. Geological Survey: www.usgs.gov/themes/coast.html
- University of Washington: www.geophys.washington.edu
- Pacific Marine Environmental Laboratory: www.pmel.noaa.gov

Task C. Record your hazard event profile information.

Transfer the boundary of your tsunami hazard area onto your base map.

Go to the next hazard on your list to profile

or if you are finished with all your hazard profiles,

Go to Step 3

If you cannot find the necesary information to produce a tsunami profile, research past tsunami events in your area and contact your state coastal zone manager for help identifying areas that would be susceptible to tsunami inundation. Indicate any areas threatened by tsunami waves on your base map.

Most tsunami mapping has been done at a statewide level. If no local-level mapping has been done, you may consider hiring a consultant to help develop or provide the following information:

- Historic tsunami sources;
- Potential future local and distant sources;
- Potential for ground failures and other geologic effects that could cause tsunamis;
- An estimate of the number of waves, their heights, arrival times, and inundation depths and distances;
- Calculations of water velocities and debris loads; and
- Estimates of the probabilities of occurrence and levels of certainty.

Conditions that may exacerbate or mitigate the effects of tsunamis

The following factors will affect the severity of a tsunami:

- **Coastline configuration**: Tsunamis impact long, low-lying stretches of linear coastlines, usually extending inland for relatively short distances. Concave shorelines, bays, sounds, inlets, rivers, streams, offshore canyons, and flood control channels may create effects that result in greater damage. Offshore canyons can focus tsunami wave energy, and islands can filter the energy. The orientation of the coastline determines whether the waves strike head-on or are refracted from other parts of the coastline. Tsunami waves entering flood control channels could reach a mile or more inland, especially if it enters at high tide.
- **Coral reefs**: Reefs surrounding islands in the western North Pacific and the South Pacific generally cause waves to break, providing some protection to the islands.
- **Earthquake characteristics**: Several characteristics of the earthquake that generates the tsunami contribute to the intensity of the tsunami, including the area and shape of the rupture zone, and:
  - **Fault movement**: Strike-slip movements that occur under the ocean create little or no tsunami hazard. However, vertical movements along a fault on the seafloor displace water and create a tsunami hazard.
  - **Magnitude and depth**: Earthquakes with greater magnitude cause more intense tsunamis. Shallow-focus earthquakes also have greater capacity to cause tsunamis.
  - **Human activity**: With increased development, property damage increases, multiplying the amount of debris available to damage or destroy other structures.

Tornadoes

What is a Tornado?

A tornado is a violently rotating column of air extending from a thunderstorm to the ground. The most violent tornadoes are capable of tremendous destruction with wind speeds of 250 mph or more. Damage paths can be in excess of 1 mile wide and 50 miles long.

Tornadoes are among the most unpredictable of weather phenomena. While tornadoes can occur almost anywhere in the world, they are most prevalent in the United States. According to the National Weather Service, about 42 people are killed because of tornadoes each year. Tornadoes can occur in any state but are more frequent in the Midwest, Southeast, and Southwest.

Tornado season runs ordinarily from March through August; however, tornadoes can strike at any time of the year if the essential conditions are present.

What Causes a Tornado?

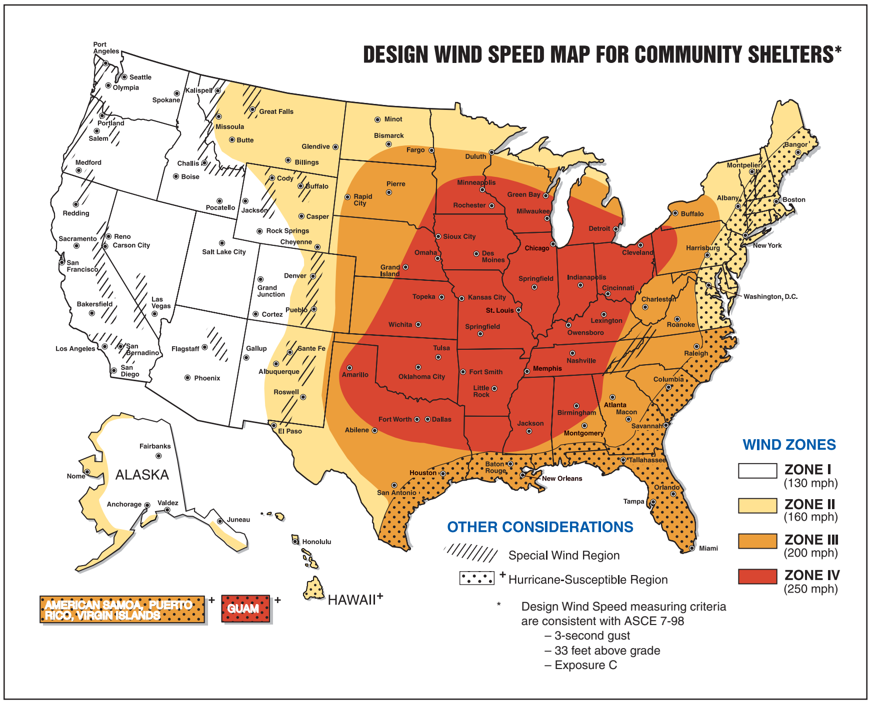
Thunderstorms and hurricanes spawn tornadoes when cold air overrides a layer of warm air, causing the warm air to rise rapidly. The winds produced from hurricanes, earthquake-induced fires, and wildfires have also been known to produce tornadoes.

The frequency of tornadoes in the nation's midsection is the result of the recurrent collision of moist, warm air moving north from the Gulf of Mexico with colder fronts moving east from the Rocky Mountains.

Task B. Obtain tornado hazard event profile information.

Find your design wind speed.

Find your planning area on the "Design Wind Speed" map from FEMA's ***Taking Shelter from the Storm: Building a Saferoom in Your House*** publication 320. This map is based on design wind speeds set forth by the American Society of Civil Engineers (ASCE).



Source: ASCE 7-98

(This publication can be viewed at http://www.fema.gov/fima/tsfs02.shtm or ordered from the FEMA Publication Center.) Look up the wind zone and indicated speed for your planning area. For example if you live in Fayetteville, North Carolina, you would find that you are located in wind zone III, which is associated with 200-mph wind speeds.

Unlike some other hazards, mapping the tornado risk is less important because it is unlikely that a community has variable tornado risks within its jurisdiction. In most cases, communities need only determine that they have a tornado risk (from Step 1) and then proceed to determine their design wind speed. (See "Tip" on page 2-21.)

States may have more than one wind speed designation. You can either represent all of the wind speeds on your base map or decide to use the higher wind speed for the whole state.

The nature of tornadoes is that they strike at random. While it is known that some areas of the country experience tornadoes more than others, predicting exactly what parts of your community or state have a greater chance of being struck by a tornado is difficult. The NOAA Website http://www.outlook.noaa.gov/tornadoes has tornado statistics broken out by state. It also identifies tornado events per 1,000 square miles.

In order to determine the likelihood and potential severity of tornado events in your state or community, you should ascertain the number of tornadoes that have affected the area in the past and their intensity. Take note, however, that the past number and severity of events is not necessarily a predictor of future occurrences.

To determine the magnitude of tornadoes that have affected your community or state in the past, go to www.tornadoproject.com, click on "All Tornadoes" in the navigation frame, and then click the link, "Every state in the USA." The site provides by state and county a list of all tornado occurrences and magnitudes for the years 1950 to 1995. Find your county and collect the recorded tornado history.

Tornadoes are categorized by damage pattern, F0 through F5. The table below shows the tornado category, expected damages, and corresponding wind speed.

Fujita Tornado Measurement Scale

Category F0	Gale tornado (40-72 mph)	Light damage. Some damage to chimneys; break branches off trees; push over shallow-rooted trees; damage to sign boards.
Category F1	Moderate tornado (73-112 mph)	Moderate damage. The lower limit is the beginning of hurricane wind speed; peel surface off roofs; mobile homes pushed off foundations or overturned; moving autos pushed off roads.
Category F2	Significant tornado (113-157 mph)	Considerable damage. Roofs torn off frame houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light-object missiles generated.
Category F3	Severe tornado (158-206 mph)	Severe damage. Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; cars lifted off ground and thrown.
Category F4	Devastating tornado (207-260 mph)	Devastating damage. Well-constructed houses leveled; structure with weak foundation blown off some distance; cars thrown and large missiles generated.
Category F5	Incredible tornado (261-318 mph)	Incredible damage. Strong frame houses lifted off foundations and carried considerable distance to disintegrate; automobile-sized missiles fly through the air in excess of 100 yards; trees debarked; incredible phenomena will occur.

The accuracy of expected damage at particular wind speeds has never been scientifically proven.

Task C. Record your hazard event profile information.

1. If you are located in only one Design Wind Speed zone, note that zone on Worksheet #2 and go to the bottom of this page, otherwise, continue with this task.

2. If you are located in more than one Design Wind Speed zone, you will need a copy of the Design Wind Speed maps.

3. Transfer the boundary of your Design Wind Speed zones on to your base map.

4. Record the Design Wind Speed zones on your base map.

Go to the next hazard on your list to profile

or if you are finished with all your hazard profiles

Go to Step 3

Coastal Storms

What is a Coastal Storm?

Coastal storms can cause increases in tidal elevations (called storm surge), wind speed, and erosion, caused by both extratropical events and tropical cyclones.

Extratropical events include **Nor'easters** and **severe winter low-pressure systems**. Both West and East coasts can experience these non-tropical storms that produce gale-force winds and precipitation in the form of heavy rain or snow. These cyclonic storms, commonly called Nor'easters on the East Coast because of the direction of the storm winds, can last for several days and can be very large – 1,000-mile wide storms are not uncommon.

A "tropical cyclone" is a generic term for a cyclonic, low-pressure system over tropical or sub-tropical waters. Tropical cyclones with maximum sustained winds of less than 39 mph are called **tropical depressions**. A **tropical storm** is a cyclone with maximum sustained winds greater than 39 mph and less than 74 mph, and **hurricanes** are intense tropical weather systems with maximum sustained winds of 74 mph or higher that develop over the north Atlantic Ocean, northeast Pacific Ocean, or the south Pacific Ocean east of 160E longitude. A special category of tropical cyclone is a **typhoon**, which is peculiar to the western North Pacific Basin, frequently affecting areas in the vicinity of Guam and the North Mariana Islands. Typhoons whose maximum sustained winds attain or exceed 150 miles per hour are called **super typhoons**.

The primary focus of this section is on the effects of hurricanes although all these types of coastal storms can have similar impacts in terms of wind damage, flooding and coastal erosion.

What is a Hurricane?

A hurricane is a category of tropical cyclone characterized by thunderstorms and defined surface wind circulation. Hurricanes develop over warm waters and are caused by the atmospheric instability created by the collision of warm air with cooler air.

Hurricane winds blow in a large spiral around a calm center called the eye, which can be 20-30 miles wide. When a hurricane nears land, it may bring torrential rains, high winds, storm surges, coastal flooding, inland flooding, and, sometimes, tornadoes. A single hurricane can last for more than two weeks over water and can extend outward 400 miles. The hurricane season for the Atlantic Coast and Gulf of Mexico is June 1 to November 30. On average, five hurricanes strike the United States every year. In a two-year period, an average of three significant (category 3 or higher; see Saffir-Simpson scale on page 2-23) hurricanes will strike the United States. Duration depends on the forward motion of the storm and the availability of a warm water source for energy.

Some hurricanes are characterized primarily by water – a rainy or wet hurricane – while others are primarily characterized by wind – a windy or dry hurricane. Wet hurricanes can flood both coastal and inland areas, even as the storm dissipates in wind strength, while windy hurricanes primarily affect coastal areas with their high winds and storm surge. You should, therefore, determine the location and the expected severity of flooding, storm surge, and winds from hurricanes and tropical storms that may affect the community or state by finding expected areas of flooding and peak gusts.

Because hurricanes are large, moving storm systems, they can affect entire states or entire coastlines. Not only will coastal development be affected, but also areas far inland can suffer direct impacts from hurricanes and tropical storms.

Task B. Obtain coastal storm hazard event profile information.

The state hurricane program manager, who usually works for the state emergency management office, will have information on hurricanes, Nor'easters, storm surge, and coastal erosion and can provide a history of storms that have affected the state. Another source of information or assistance is the state coastal zone manager who should have information on state coastal hazards including information on habitat and environmental resources that may be affected by such hazards.

Inland communities will be most concerned with the flooding aspect of coastal storms. Torrential rains of even Category One hurricanes and tropical storms have been known to cause 500-year floods (which have a 0.2% chance of occurring each year) and greater flooding in inland communities. Coastal communities will need to determine how severe the high winds, storm surge and erosion could be from their storm surge inundation map.

1. Get a copy of your FIRM.

Coastal flooding is shown on the FIRM. Copies of FIRMs can be requested by calling the FEMA Map Service Center at 1.800.358.9616, on the Internet at http://www.fema.gov/maps, or by contacting a FEMA Regional Office. Additionally, the National Flood Insurance Program

(NFIP) Guide to Flood Maps is available on the web at http://msc.fema.gov/MSC/hardcopy.htm and Flood Insurance Rate Map (FIRM) information is available at http://www.fema.gov/fmapinfo.htm. For more information on FIRMs, see page 2-10 to 2-14.

To request copies of your FIRM or to help you identify areas that are prone to coastal hazards and storm surge, contact your NFIP coordinator or floodplain manager. They usually work in the planning, building, engineering, or natural resources department.

Coastal communities or states with a coastline should determine areas of coastal flooding, characterized as V zones and A zones, oriented approximately parallel to the shoreline.

(continued on page 2-25)

Coastal A zones are not currently mapped or regulated by FEMA any differently than inland A zones; however, flood hazards in coastal A zones, like those in V zones, can include the effects of waves, velocity flow, and erosion (although the magnitude of these effects will be less than those in V zones.)

Saffir-Simpson Scale

Category	Wind Speed	Storm Surge (feet above normal sea level)	Expected Damage
1	74-95 mph	4-5 ft.	**Minimal:** Damage is done primarily to shrubbery and trees, unanchored mobile homes are damaged, some signs are damaged, no real damage is done to structures.
2	96-110 mph	6-8 ft.	**Moderate:** Some trees are toppled, some roof coverings are damaged, major damage is done to mobile homes.
3	111-130 mph	9-12 ft.	**Extensive:** Large trees are toppled, some structural damage is done to roofs, mobile homes are destroyed, structural damage is done to small homes and utility buildings.
4	131-155 mph	13-18 ft.	**Extreme:** Extensive damage is done to roofs, windows, and doors; roof systems on small buildings completely fail; some curtain walls fail.
5	> 155 mph	> 18 ft.	**Catastrophic:** Roof damage is considerable and widespread, window and door damage is severe, there are extensive glass failures, and entire buildings could fail.

Also, see page 3-26 for additional implications of coastal erosion on loss estimation.

How are Pacific Coast States Different than Atlantic and Gulf Coast States?

Eastern and Central Pacific hurricanes sometimes affect the West Coast of North America and the Hawaiian Islands. Easterly winds push tropical cyclones that form off the Mexican and Central American coasts out toward the Central Pacific. In the Eastern Pacific, hurricanes or tropical storms are more likely to bring heavy rains, flash floods, mudslides, and high winds to Mexico's Pacific Coast than the U.S southern California coast.

Although the California coast has not been hit by a hurricane-strength storm, it has experienced heavy rain from tropical storms and depressions in the past. While many hurricanes form off the west coast of Mexico, they tend to move seaward. Rarely, when a tropical cyclone reaches the extreme southern California coast, they tend to be weak compared to East Coast hurricanes. Remnant moisture from dissipated hurricanes or tropical storms sometimes brings monsoon-like rains to the Southwest.

Under tropical cyclone conditions, the Pacific Coast experiences storm surges of limited magnitude because of the great ocean depths close to shore.

What are the Characteristics of Coastal Storms?

Storm surge: The most dangerous and damaging feature of a coastal storm is storm surge. Storm surges are large waves of ocean water that sweep across coastlines where a storm makes landfall. The more intense the storm, the greater the height of the water. The higher the storm surge, the greater the damage to the coastline. Storm surges inundate coastal areas, wash out dunes, cause backwater flooding in rivers, and can flood streets and buildings in coastal communities. Storm surge areas can be mapped by the probability of storm surge occurrences using Sea, Lake, and Overland Surges from Hurricanes modeling (SLOSH) (see page 2-26).

Storm tide: If a storm surge occurs at the same time as high tide, the water height will be even greater. Storm tide is the combination of the storm surge and the normal tide. For example, a 15-foot storm surge along with the normal 2-foot high tide creates a storm tide of 17 feet.

Inland Flooding: In recent years, most deaths related to hurricane and tropical storm activity have been the result of inland flooding. As hurricanes move across land bringing torrential rains and backwater flooding from the ocean, rivers and streams overflow. Hurricanes and tropical storms have been known to cause floods whose elevations represent greater than a 500-year probability of occurring in inland areas.

Water force: During hurricanes and other coastal storms, coastal areas will experience flooding with velocity or "wave action," defined as areas subject to receiving waves on top of the rising water from coastal flooding. The velocity and the force of the water make flooding even more destructive. The velocity and wave action knock over buildings, move debris, erode dunes, scour the shoreline, and displace and redeposit sand. Areas subject to coastal flooding with velocity are designated as V or VE zones on FIRMs.

Wind velocity: The higher the wind speed, the greater the damage. Hurricane force winds can travel hundreds of miles inland, creating substantial damage to buildings, vegetation, and infrastructure.

Coastal erosion: Coastal erosion is the wearing away of coastal land. It is commonly used to describe the horizontal retreat of the shoreline along the ocean, or the vertical downcutting along the shores of the Great Lakes. Erosion is considered a function of larger processes of shoreline change, which includes erosion and accretion. Erosion results when more sediment is lost along a particular shoreline than is redeposited by the water body. Accretion results when more sediment is deposited along a particular shoreline than is lost. When these two processes are balanced, the shoreline is said to be stable.

In assessing the erosion hazard in your community or state, it is important to realize that there is a temporal, or time aspect associated with the average rate at which a shoreline is either eroding or accreting. Over a long-term period (years), a shoreline is considered either eroding, accreting or stable. When you evaluate coastal erosion in your community or state, you should focus on the long-term erosion situation. However, in the short-term, it is important to understand that storms can erode a shoreline that is, over the long-term, classified as accreting, and vice versa.

Erosion is measured as a rate, with respect to either a linear retreat (i.e., feet of shoreline recession per year) or volumetric loss (i.e., cubic yards of eroded sediment per linear foot of shoreline frontage per year). Erosion rates are not uniform, and vary over time at any single location. Annual variations are the result of seasonal changes in wave action and water levels.

Erosion is caused by coastal storms and flood events; changes in the geometry of tidal inlets, river outlets, and bay entrances; man-made structures and human activities such as shore protection structures and dredging; long-term erosion; and local scour around buildings and other structures.

Further information on coastal erosion can be found in FEMA-55, *Coastal Construction Manual*, FEMA's *Multihazard Identification and Risk Assessment*, *Evaluation of Erosion Hazards* published by The Heinz Center, and *Coastal Erosion Mapping and Management*, a special edition of the Journal of Coastal Research.

(continued from page 2-23)

2. Verify that the FIRM is up-to-date and complete.

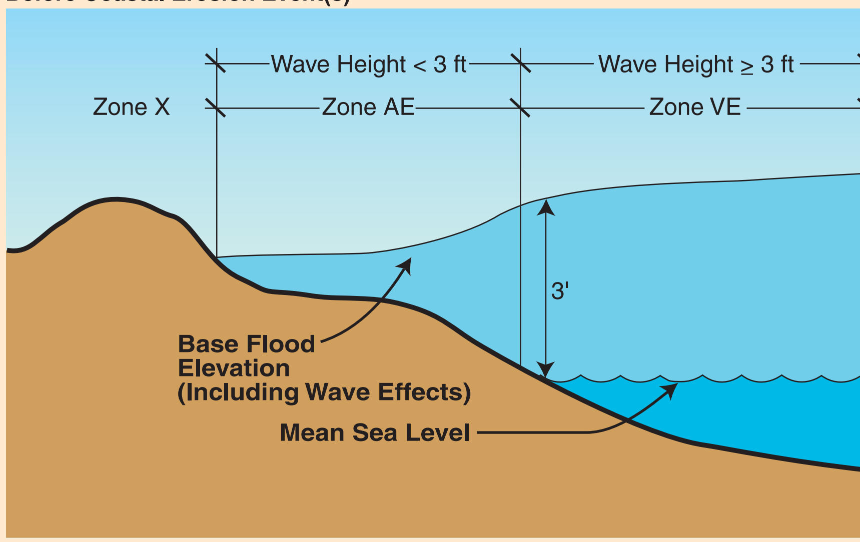
If there has been a coastal storm since the date of the FIRM, the coastline and hazard zones may no longer be accurate. Coastal storms can either erode or extend the coastline, possibly causing the flood hazard zones to change. Consult your local floodplain manager for further advice.

3. Determine the annual rate of coastal erosion in your coastal area.

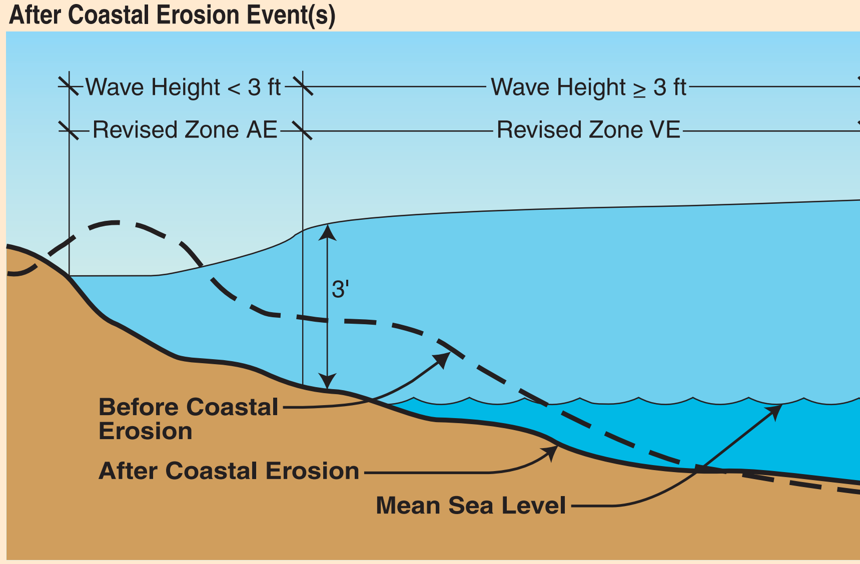
Contact your State Coastal Zone Management Program to determine the annual long-term erosion rate in your area of the state. This program may be housed in a separate coastal agency, an environmental agency, or a water resources agency. Once you know the annual rate, multiply this rate by the number of years over which you are planning. Most erosion maps consider a 30- or 60-year time frame. You would then measure the amount of erosion that would take place over the 30- or 60-year time-frame from the existing shoreline and mark this on your basemap.

When coastal erosion occurs, shoreline geometry changes, possibly causing flood hazard zones to change.

Before Coastal Erosion Event(s)



After Coastal Erosion Event(s)



4. Find your design wind speed.

Contact your state or local building code official to determine your design wind speed.

States should be prepared to assess the severity of a hurricane statewide. Considerations like sheltering and evacuation can be especially problematic because, although these may occur only along the coast, the repercussions of relocating thousands of people inland may be felt across the state.

Task C. Record your hazard event profile information.

1. Transfer the boundaries of your hurricane hazard areas (flooding erosion) onto your base map.

2. Record the base flood elevations and wind zones on your base map.

Go to the next hazard on your list to profile

or if you are finished with all your hazard profiles

Go to Step 3

For more in-depth analysis of the hurricane probability and effects in your area, you should contact your state coastal zone manager and/or your SHMO. Go to http://www.nhc.noaa.gov/aboutmeow.html to find information on the inland wind model, which estimates the maximum sustained surface wind as a storm moves inland. This model can be used to estimate the maximum inland strength of hurricane force winds (or any wind threshold) for a given initial storm intensity and forward storm motion. You can find examples of the Maximum Envelope of Winds (MEOW) based on the strength and forward motion of hurricanes in three tables shown on the Web page, one for each of the regions: Gulf Coast, East Coast, and Northeast Coast.

The National Hurricane Center (NHC), the U.S. Army Corps of Engineers (USACE), the National Oceanographic and Atmospheric Administration (NOAA), the Federal Emergency Management Agency (FEMA), and your state emergency management agency have detailed information about the hurricane risk in your community. These organizations are important when doing detailed analysis of hurricane probabilities through SLOSH modeling and Hurricane Evacuation Studies. SLOSH is a computerized model run by the NHC to estimate storm surge heights and winds resulting from historical, hypothetical, or predicted hurricanes by taking into account pressure, size, forward speed, track, and winds.

The SLOSH boundaries may differ from the base flood boundary on the FIRM. The SLOSH flood areas are determined by compositing the model surge values from 200-300 hypothetical hurricanes. The point of a hurricane's landfall is crucial to determining which areas will be inundated by the storm surge. Where the hurricane forecast track is inaccurate, SLOSH model results will be inaccurate. As a result, the SLOSH model is best used for defining the potential maximum surge for a location.

To determine whether a hurricane or tropical storm may affect your community or state, you should find historical evidence of hurricane or tropical storm activity. At http://www.nhc.noaa.gov/pastall.html you will find historical data and maps to locate past hurricane tracks that may have passed through or near your community or state. The maps show all Atlantic tropical cyclone tracks and their wind strength from 1927 to the present.

Conditions that may exacerbate or mitigate the effects of coastal storms

The following factors will affect the severity of a coastal storm:

- **Coastal shape:** Concave shoreline sections sustain more damage because the water is driven into a confined area by the advancing storm, thus increasing storm surge height and storm surge flooding.
- **Storm center velocity:** The slower the storm moves, the greater the damage. The worst possible situation is a storm that stalls along a coast, through several high tides.
- **Nature of coast:** Rocky coasts are least disturbed. Cliffs along coasts with sedimentary deposits can retreat by slumping or rock falls, but damage is most severe on low-lying barrier island shorelines because they are easily overwashed by storm waves and storm surge.
- **Previous storm damage:** A coast weakened by even a previous minor storm may be subject to proportionally greater damage in a subsequent storm.
- **Human activity:** With increased development, property damage increases, multiplying the amount of floating debris available to damage or destroy other structures.
- **Hardened sand and flood control structures:** Structures such as groins, jetties, or seawalls exacerbate localized scour and erosion and can be undermined, resulting in collapse (particularly seawalls).

Landslides

Task B. Obtain landslide hazard event profile information.

The best predictor of future landslides is past landslides because they tend to occur in the same places. Landslides, like other geologic hazards, are very complex and require someone with geologic expertise to conduct a geotechnical study. You should start by talking to your local or state geology, planning, public works or engineering departments, which should have information on past landslides. These agencies can provide maps, as well as information about causes, damage, deaths, injuries, and areas impacted by past landslides. If current maps are not available, the specialists mentioned above can help create one for your community.

It is important to consult with a local geologist or other professional familiar with past landslides in order to interpret landslide hazard information.

1. Identify high-hazard areas on your map.

Identify existing or old landslides:

- On or at the base of slopes;
- In or at the base of minor drainage hollows;
- At the base or top of an old fill slope;
- At the base or top of a steep cut slope; or
- Developed hillsides where leach field septic systems are used.

2. Map the topography.

Topographic maps can be obtained from the USGS or your state geologic survey. Specifically, you will need to know where the steep slopes are. Steeper slopes have a greater probability of landslides. Contact your state geological survey or natural resources department for more information or help in interpreting topographic maps.

3. Map the geology.

Underlying geology also plays an important part in the review of slope. In addition to slope angle, the presence of rock or soil that weakens when saturated, as well as poorly drained rock or soil are indicators of slope instability as well. Contact a local geologist or state geological survey for more information or assistance in identifying the various geological features of your community or state.

What is a Landslide?

Landslides are described as downward movement of a slope and materials under the force of gravity. The term landslide includes a wide range of ground movement, such as rock falls, deep failure of slopes, and shallow debris flows. Landslides are influenced by human activity (mining and construction of buildings, railroads, and highways) and natural factors (geology, precipitation, and topography). They are common all over the United States and its territories.

What Causes a Landslide?

Landslides occur when masses of rock, earth, or debris move down a slope. Therefore, gravity acting on an overly steep slope is the primary cause of a landslide. They are activated by storms, fires, and by human modifications to the land. New landslides occur as a result of rainstorms, earthquakes, volcanic eruptions, and various human activities.

Measures of Landslides

Mudflows (or debris flows) are flows of rock, earth, and other debris saturated with water. They develop when water rapidly accumulates in the ground, such as during heavy rainfall or rapid snowmelt, changing the earth into a flowing river of mud or "slurry."

Slurry can flow rapidly down slopes or through channels and can strike with little or no warning at avalanche speeds. Slurry can travel several miles from its source, growing in size as it picks up trees, cars, and other materials along the way.

Other types of landslides include: rock slides, slumps, mudslides, and earthflows. All of these differ in terms of content and flow.

The three most useful types of landslide maps are (1) landslide inventories, (2) landslide susceptibility maps, and (3) landslide hazard maps.

Landslide inventories identify areas that appear to have failed due to landslides, including debris flows and cut-and-fill failures. Detailed inventories depict and classify each landslide and show scarps, zones of depletion and accumulation, active versus inactive slides, geological age, rate of movement, and other pertinent data on the depth and type of materials involved in sliding. Overlaying a geologic map with an inventory map that shows existing landslides can identify specific landslide-prone geologic units. For this reason, a landslide inventory is essential for preparing a landslide susceptibility map.

Landslide susceptibility maps depict areas that have the potential for landslides by correlating some of the principal factors that contribute to landslides – steep slopes, geologic units that lose strength when saturated, and poorly drained rock or soil – with the past distribution of landslides. These maps indicate the relative stability of slopes; however, they do not make absolute predictions. More complex maps may include additional information such as slope angle, and drainage.

Landslide hazard maps show the real extent of the threat: where landslides have occurred in the past, where they are likely to occur now, and where they could occur in the future. They contain detailed information on the types of landslides, extent of slope subject to failure, and probable maximum extent of ground movement. These maps can be used to predict the relative degree of hazard in a landslide area.

Conditions that may exacerbate or mitigate the effects of landslides

The following factors will affect the severity of a landslide:

- **Erosion** – Erosion caused by rivers, glaciers, or ocean waves created by overly steep slopes.
- **Unstable slopes** – Rock and soil slopes are weakened through saturation by snowmelt or heavy rains.
- **Earthquakes** – The shaking from earthquakes creates stress that makes weak slopes fail.
- **Volcanic eruptions** – Eruptions produce loose ash deposits and debris flows.
- **Vibrations** – Machinery, traffic, blasting, and even thunder may cause vibrations that trigger failure of weak slopes.
- **Increase of load** – Weight of rain/snow, fills, vegetation, stockpiling of rock or ore from waste piles, or from man-made structures may cause weak slopes to fail.
- **Hydrologic factors** – Rain, high water tables, little or no ground cover, numerous freeze/thaw cycles may cause weak slopes to fail.
- **Human activity** – These include development activities such as cutting and filling along roads and removal of forest vegetation. Such activities are capable of greatly altering slope form and ground water conditions which can cause weak slopes to fail.
- **Removal of lateral and underlying support** – Erosion, previous slides, road cuts and quarries can trigger failure of weak slopes.
- **Increase of lateral pressures** – Hydraulic pressures, tree roots, crystallization, swelling of clay soil may cause weak slopes to fail.
- **Regional tilting** – Geological movements can trigger weak slopes to fail.

Task C. Record your hazard event profile information.

Mark the areas susceptible to landslides on your base map.

Go to the next hazard on your list to profile

or if you are finished with all your hazard profiles

Go to Step 3

Wildfires

Task B. Obtain wildfire hazard event profile information.

Wildfire hazard maps won't show the extent or range of where a wildfire will occur because they are dependent on the amount of fuel available, weather conditions, and wind speed and direction. On the other hand, wildfire hazard maps should show geographic locations of where wildfires have taken place in the past and areas that are prone to wildfires.

Contact your state forest service at http://www.stateforesters.org/sflist.html or your USFS Region office at http://www.fs.fed.us/intro/directory/orgdir.htm for wildfire mapping information.

1. Map the fuel models located within the urban-wildland interface area of your community.

Use the fuel model key (page 2-31)excerpted from the National Fire Danger Rating (NFDR) System, 1978, U.S. Department of Agriculture (USDA) Forest Service, as a guide, to determine the fuel model classifications within your community or state. It represents all wildfire fuels from Florida to Alaska and from the East Coast to California, so they are only general descriptions.

You can also download the USDA fuel model map from the Internet at: http://www.fs.fed.us/land/wfas/nfdr_map.htm. The USDA map was designed to assess fire danger across the continental United States and may not be site specific.

Using the fuel model key, map the various fuel classifications based on the following categories:

- **Heavy Fuel** is vegetation consisting of round wood 3 to 8 inches in diameter. **(fuel models G, I, J, K and U on the fuel model key)**
- **Medium Fuel** is vegetation consisting of round wood 1/3 to 3 inches in diameter. **(fuel models B, D, F, H, O, Q, and T on the fuel model key)**
- **Light Fuel** is vegetation consisting of herbaceous plants and round wood less than ¼ inch in diameter. **(fuel models A, C, E, L, N, P, R and S on the fuel model key)**

For more information or assistance contact your local arborist or state forestry or natural resources department.

What is a Wildfire?

A wildfire is an uncontrolled fire spreading through vegetative fuels, exposing and possibly consuming structures. They often begin unnoticed and spread quickly and are usually signaled by dense smoke that fills the area for miles around. Naturally occurring and non-native species of grasses, brush, and trees fuel wildfires.

A **wildland fire** is a wildfire in an area in which development is essentially nonexistent, except for roads, railroads, power lines and similar facilities. An **Urban-Wildland Interface fire** is a wildfire in a geographical area where structures and other human development meet or intermingle with wildland or vegetative fuels.

States with a large amount of wooded, brush and grassy areas, such as California, Colorado, New Mexico, Montana, Kansas, Mississippi, Louisiana, Georgia, Florida, the Carolinas, Tennessee, Massachusetts, and the national forests of the western United States are at highest risk of wildfires. Additionally, areas anywhere that have experienced prolonged droughts, or are excessively dry, are also at risk of wildfires.

People start more than four out of every five wildfires, usually as debris burns, arson, or carelessness. Lightning strikes are the next leading cause of wildfires.

Wildfire behavior is based on three primary factors:

- Fuel
- Topography
- Weather

The type, and amount of fuel, as well as its burning qualities and level of moisture affect wildfire potential and behavior. The continuity of fuels, expressed in both horizontal and vertical components is also a factor, in that it expresses the pattern of vegetative growth and open areas.

Topography is important because it affects the movement of air (and thus the fire) over the ground surface. The slope and shape of terrain can change the rate of speed at which the fire travels.

Weather affects the probability of wildfire and has a significant effect on its behavior. Temperature, humidity and wind (both short and long term) affect the severity and duration of wildfires.

Visit the USFS Website at http://www.fs.fed.us/links/maps.shtml/ or the USGS Website at http://mcmcweb. er.usgs.gov/topomaps/ for general information about topographic maps, finding and ordering topographic maps, and an explanation of topographic map symbols.

Most communities or regions should have one critical fire weather frequency number; however, states may have more than one zone depending on climatic and atmospheric conditions. The state forester should be prepared to assist communities in determining their critical fire weather frequency, as well as the type of fuel models to use, and the fuel loading levels.

If you cannot find the necessary information to produce a wildfire profile contact your fire marshall or state forest service for help identifying fire prone areas of grasslands or dense wooded areas. Research past or historic wildfire events and use eyewitness accounts to delineate the approximate wildfire boundaries. Indicate these areas on your base map as potential wildfire hazard areas.

2. Map the topography.

In general terms, the steeper the slope of the land, the faster a fire can spread up the slope. Using a topographic map, identify areas of your community or state with slopes less than 40%, between 41% and 60%, and greater than 61%, corresponding to low, moderate and steep gradients relative to the spread of wildfires.

Contact your state geological survey or natural resources department for more information or help with topographic maps.

3. Determine your critical fire weather frequency.

This is a set of weather conditions, usually a combination of low relative humidity and wind, whose effects on fire behavior make control difficult and threaten firefighter safety. The average number of days per year of critical fire weather experienced in your community or state can be obtained from your local or state fire marshal, forestry department, or department of natural resources. The National Weather Service or NOAA Websites can help you determine past weather conditions.

4. Determine your fire hazard severity.

Using the Fire Hazard Severity Table below, determine your fire hazard severity. You may have more than one classification in your community or state depending on the degrees of the slope and fuel models. For example, if you experience an average of five critical fire weather days per year, have heavy fuel, and less than 40° slopes, then you are in a high fire hazard area. If your average number of days of critical fire weather per year increases above eight, you would be in an extreme fire hazard area.

Task C. Record your hazard event profile information.

Draw the boundaries of your wildfire hazard areas onto your base map.

Fire Hazard Severity

	Critical Fire Weather Frequency								
	< 1 Day/Year			2 to 7 Days/Year			> 8 Days/Year		
	Slope (%)			Slope (%)			Slope (%)		
Fuel Classification	< 40	41-60	> 61	< 40	41-60	> 61	< 40	41-60	> 61
Light Fuel	M	M	M	M	M	M	M	M	H
Medium Fuel	M	M	H	H	H	H	E	E	E
Heavy Fuel	H	H	H	H	E	E	E	E	E

Source: Urban Wildland Interface Code: 2000

M = Moderate hazard H = High hazard E = Extreme hazard

Fuel Model Key

Source: Urban Wildland Interface Code: 2000

- I. Mosses, lichens, and low shrubs predominate ground fuels.
  - A. An overstory of conifers occupies more than one-third of the site: MODEL Q.
  - B. There is no overstory, or it occupies less than one-third of the site (tundra): MODEL S.
- II. Marsh grasses and/or reeds predominate: MODEL N.
- III. Grasses and/or forbs predominate.
  - A. There is an open overstory of conifer and/or hardwood trees: MODEL C.
  - B. There is no overstory.
    - 1. Woody shrubs occupy more than one-third, but less than two-thirds of the site; MODEL T.
    - 2. Woody shrubs occupy less than one-third of the site.
      - a. The grasses and forbs are primarily annuals; MODEL A.
      - b. The grasses and forbs are primarily perennials: MODEL L.
- IV. Brush, shrubs, tree reproduction or dwarf tree species predominate.
  - A. Average height of woody plants is 6 feet or greater.
    - 1. Woody plants occupy two-thirds or more of the site.
      - a. One-fourth or more of the woody foliage is dead.
        - (1) Mixed California chaparral: MODEL B.
        - (2) Other types of brush: MODEL F.
      - b. Up to one-fourth of the woody foliage is dead; MODEL Q.
      - c. Little dead foliage: MODEL O.
    - 2. Woody plants occupy less than two-thirds of the site: MODEL F.
  - B. Average height of woody plants is less than 6 feet.
    - 1. Woody plants occupy two-thirds or more of the site.
      - a. Western United States; MODEL F.
      - b. Eastern United States: MODEL O.
    - 2. Woody plants occupy less than two-thirds but more than one-third of the site.
      - a. Western United States; MODEL T.
      - b. Eastern United States; MODEL D.
    - 3. Woody plants occupy less than one-third of the site.
      - a. The grasses and forbs are primarily annuals: MODEL A.
      - b. The grasses and forbs are primarily perennials: MODEL L.
- V. Trees predominate.
  - A. Deciduous broadleaf species predominate.
    - 1. The area has been thinned or partially cut, leaving slash as the major fuel component; MODEL K.
    - 2. The area has not been thinned or partially cut.
      - a. The overstory is dormant; the leaves have fallen: MODEL E.
      - b. The overstory is in full leaf: MODEL R.
  - B. Conifer species predominate.
    - 1. Lichens, mosses, and low shrubs dominate as understory fuels: MODEL Q.
    - 2. Grasses and forbs are the primary ground fuels: MODEL C.
    - 3. Woody shrubs and/or reproduction dominate as understory fuels.
      - a. The understory burns readily.
        - (1) Western United States: MODEL T.
        - (2) Eastern United States:
          - (a) The understory is more than 6 feet tall: MODEL O.
          - (b) The understory is less than 6 feet tall: MODEL D.
      - b. The understory seldom burns; MODEL H.
    - 4. Duff and litter, branchwood, and tree boles are the primary ground fuels.
      - a. The overstory is overmature and decadent; there is a heavy accumulation of dead tree debris: MODEL G.
      - b. The overstory is not decadent; there is only nominal accumulation of debris.
        - (1) The needles are 2 inches or more in length (most pines).
          - (a) Eastern United States: MODEL P.
          - (b) Western United States: MODEL U.
        - (2) The needles are less than 2 inches long: MODEL H.
- VI. Slash is the predominant fuel.
  - A. The foliage is still attached; there has been little settling.
    - 1. The loading is 25 tons/acre or greater; MODEL I.
    - 2. The loading is less than 25 tons/acre but more than 15 tons/acre: MODEL J.
    - 3. The loading is less than 15 tons/acre: MODEL K.
  - B. Settling is evident; the foliage is falling off; grasses, forbs, and shrubs are invading the area.
    - 1. The loading is 25 tons/acre or greater: MODEL J.
    - 2. The loading is less than 25 tons/acre: MODEL K.

The Wildland Fire Assessment System (WFAS) was created to help evaluate risk factors, which vary depending on current and past weather conditions, fuel types and moisture. Observations are reported daily during peak wildfire season, from late winter to early spring, to the Weather Information Management System (WIMS). The information is processed by the National Fire Danger Rating System (NFDRS), which creates national maps of selected fire weather and fire danger components.

Copies of the maps can be viewed on the WFAS Website (the address is located in Appendix A).

The fire danger map described above indicates low to extreme fire danger values for the United States based on past and current weather, fuel types, and the presence of live and dead fuel moisture.

In addition to the fire danger maps referenced above, communities and states should map areas of past wildfire damages. This information is available from the local or state emergency management agency or fire department. Areas with significant fuel sources located adjacent to developed areas are prime risks for wildfire damage and should be mapped as well.

Even if your community is not especially close to a source of burning, you should be aware that fires in nearby areas could quickly and easily spread into your community.

Conditions that may exacerbate or mitigate the effects of wildfires

The following factors will affect the severity of a wildfire:

- **Climatic Considerations** – Areas of extreme climate conditions, including temperature, relative humidity, wind speed and duration of high velocity, precipitation, wind direction, fog and other atmospheric conditions.
- **Topographic Considerations** – elevation and ranges of elevation, location of ridges, drainages and escarpments, percent of grade (slope), location of roads, bridges and railroads.
- **Geographic Considerations** – Fuel types, concentration in a mosaic and distribution of fuel types, earthquake fault zones, hazardous material routes.
- **Flammable material** on structure exteriors.
- **Narrow roadways** leading to developed areas.
- **Inadequate hydrants** or poorly placed hydrants.
- **Combustible landscaping** or debris near structures.
- **Development** – increased development and human activity in and near the wildland interface.

Go to the next hazard on your list to profile

or if you are finished with all your hazard profiles

Go to Step 3

step 3 inventory assets

1. identify hazards
2. profile hazard events
3. inventory assets
4. estimate losses

3

inventory assets

Overview

The third step in the risk assessment process answers the question: What assets in the community or state will be affected by the hazard event?

Now that you know where natural hazard events can affect your community or state, you will conduct an inventory of the vulnerable assets. The inventory will help you understand what can be affected by the different hazard events.

You will first develop and map a general inventory of assets in your community or state. Then, using the maps developed previously in Step 2, you will identify the assets inside your hazard areas. For example, using your floodplain maps from Step 2, you will identify all of the assets within the 100-year floodplain boundary. However, some hazards can affect the entire community (such as earthquakes or tornadoes) and some will only affect limited areas. Thus, the unique combinations of hazards that can affect you will determine how much inventory collection will be appropriate. An initial inventory can be done very quickly and easily using the baseline data contained in HAZUS.

(continued on page 3-4)

HAZUS

HAZUS contains inventory information for every community in the United States. While HAZUS is currently used for generating earthquake loss estimates, it can also be used to inventory elements exposed to other hazards. The package includes GIS maps showing schools, street roadway maps at the county level, SLOSH basin maps outlining areas that can be inundated by hurricane surges, Q3 flood data maps indicating floodplains at the county level, and land use/land cover maps, among others.

HAZUS also allows users to update and add location-specific data. For more information on using HAZUS, see the HAZUS Users Manual or contact your FEMA regional office.

A GIS system will also allow your community to access and use the data available in HAZUS. For example, if you have a GIS flood layer, you may be able to estimate the number of people living in or near flood hazards areas by census tract or compute the current value of property located in the flood hazard area. In either case, two things are important:

Be consistent. In order to perform any comparisons in subsequent steps and phases of the mitigation planning, you should strive to use a consistent method for evaluating and recording information about elements of your community. This is especially important if more than one person will be gathering information. You want to avoid subjective opinions and judgments from the process as much as possible.

Keep good records. The information you collect at this phase will be of value throughout the remainder of the planning process.

Your community's assets may include hospitals, schools, museums, apartment buildings, and public infrastructure or utilities such as bridges or overhead power lines.

Information regarding the amount of population and building stock located in the hazard areas can provide a powerful initial glimpse into the nature of the community's vulnerability to natural hazards. This can help secure political and community support and funding for mitigation planning and for the projects to be later identified.

Date: July, 2001

What will be affected by the hazard event?

Task A. Determine the proportion of buildings, the value of buildings, and the population in your community or state that are located in hazard areas.

Hazard Flood

Type of Structure (Occupancy Class)	Number of Structures			Value of Structures			Number of People		
	# in Community or State	# in Hazard Area	% in Hazard Area	$ in Community or State	$ in Hazard Area	% in Hazard Area	# in Community or State	# in Hazard Area	% in Hazard Area
Residential	61	16	25%	3,927,000	439,000	11%	403	69	7%
Commercial	5	4	80%	6,500,000	4,500,000	69%	570	345	61%
Industrial	0	0	0%	0	0	0	0	0	0
Agricultural	2	1	50%	175,000	90,000	51%	10	5	50%
Religious/ Non-profit	3	1	33%	3,450,000	1,500,000	43%	351	1	0.2%
Government	7	5	71%	7,055,000	2,555,000	36%	570	170	30%
Education	1	1	100%	500,000	500,000	100%	125	125	100%
Utilities	2	2	100%	2,750,000	2,750,000	100%	15	15	100%
Total	81	30	37%	24,351,000	11,884,000	49%	2,044	730	44%

Task B. Determine whether (and where) you want to collect additional inventory data.

	Y	N
1. Do you know where your greatest damages may occur in your hazard areas?	✓	
2. Do you know whether your critical facilities will be operational after a hazard event?		✓
3. Is there enough data to determine which assets are subject to the greatest potential damages?	?	
4. Is there enough data to determine whether significant elements of the community are vulnerable to potential hazards?	✓	
5. Is there enough data to determine whether certain areas of historic, environmental, political, or cultural significance are vulnerable to potential hazards?	✓	
6. Is there concern about a particular hazard because of its severity, repetitiveness, or likelihood of occurrence?	✓	
7. Is additional data needed to justify the expenditure of community or state funds for mitigation initiatives?	✓	

Joe, I think we need to do some more research.

Worksheet #3b Inventory Assets step 3

Date: August, 2001

What will be affected by the hazard event?

Task C. Compile a detailed inventory of what can be damaged by a hazard event.

Inventory the assets (critical facilities, businesses, historic, cultural, and natural resource areas, and areas of special consideration), that can be damaged by a hazard event.

Hazard Flood

Name or Description of Asset	Sources of Information	Critical Facility ✓	Vulnerable Populations ✓	Economic Assets ✓	Special Considerations ✓	Historic/Other Considerations ✓	Size of Building (sq ft)	Replacement Value ($)	Contents Value ($)	Function Use or Value ($)	Displacement Cost ($ per day)	Occupancy or Capacity (#)	Other Hazard Specific Information
Historic Lighthouse	Lighthouse Preservation Society					✓	3,000	$150,000	$1.5M	$0.5M	$500	1	
Bridge	Public Works	✓					250 ft long	$750,000	NA	$31,750	$12,000	20	
Sewage Treatment Plant	Public Works	✓					75,000	$2.5M	$2.5M	$30M	$200,000	10	
STP Outbuilding	Public Works	✓					10,000	$1M	$1.5M	$0.25M	$5,000	—	
STP Outbuilding	Public Works	✓					7,500	$75,000	$1.5M	$0.5M	$1,000	—	
Water Treatment Plant	Public Works	✓					3,000	$250,000	$1.25M	$1M	$2,000	5	
Hospital	Hospital	✓					45,000	$2.5M	$3.75M	$0.75M	$2,500	100	
Police/Fire Station	Police Dept.	✓					10,000	$2M	$3M	$0.35M	$2,000	150	

(continued from page 3-1)

HAZUS can summarize the number and value of structures in your jurisdiction by the types of structure or the occupancy class. For example, if you wanted to know how many residential or commercial structures were in your community or state, you would select a summary by the building occupancy class. If you wanted to know how many manufactured homes or wood framed buildings were in your community or state, you would select a summary by the building structure type.

After assessing the number and value of the buildings and the size of the population within the hazard areas, you will decide if you should end your inventory data collection or continue to gather additional information to identify the extent to which the assets would be damaged by the hazard events. If you decide to gather additional information, you will then collect details on specific types of population, building stock, infrastructure, and lifelines in the hazard areas in the order of their importance to the community. This information will be necessary to generate the loss estimations you will make in Step 4.

States can use worksheet #3 to compile the inventory data from each of the local community risk assessments.

You will use **Worksheet #3: Inventory Assets** in Appendix C (see example on pages 3-2 and 3-3) to keep track of the inventory data you will gather. Photocopy the worksheet for each hazard you are assessing. If you have many assets to inventory, you may want to use HAZUS databases or create a computerized spreadsheet to make your data collection efforts more manageable.

Procedures & Techniques

Task A. Determine the proportion of buildings, the value of buildings, and the population in your community or state that are located in hazard areas.

U.S. Census Bureau TIGER files are available from http://www.census.gov/geo/www/tiger.

1. Estimate or count the total number of buildings, value of buildings, and number of people in your community or state.

Using local resources, Census data, HAZUS, or other GIS capabilities, you will determine the total number and value of buildings and the population within your jurisdiction.

To estimate the total replacement value of the buildings in your community or state, multiply the average building replacement value by the number of buildings. HAZUS can help you.

a. **Determine the total number of buildings inside your community or state.** Identify the total number of buildings located within your community or state.

Remember that so far, you have only been considering one hazard event for each hazard type. Later in the process, you may find the need to assess additional or possibly all potential hazard events. This may expand or decrease your planning area.

This information can be grouped by occupancy class, such as residential, commercial, or industrial in HAZUS or can be gathered from a tax assessment map, aerial photograph or local planning document.

b. **Determine the total estimated value of the buildings inside your community or state.** Establish the total approximate replacement value of the buildings located inside the hazard area. This information is also estimated by occupancy class in HAZUS or can be gathered from the tax assessment values of individual buildings, or by developing an estimate for the area as a whole.

c. **Determine the number of people inside your community or state.** Estimate the current population inside your jurisdiction. Use HAZUS, current Census data, or local figures to estimate the current population. You should note whether or not you have large daytime, nighttime, or seasonal differences in your population.

2. Estimate the total number of buildings, total value of buildings, and number of people in each of your hazard zones.

You will now use HAZUS, GIS, or printed maps to overlay the hazard areas developed in Step 2 on top of your base map to determine the number and value of the buildings and the population that is vulnerable to the hazard events.

a. **Determine the total number of buildings inside the hazard area.** Establish the total number of buildings located inside the hazard area for each hazard type. You can use HAZUS to group the buildings by occupancy class or use GIS, a tax assessment map, or aerial photograph to determine the number of buildings in the hazard area.

b. **Determine the total estimated value of the buildings inside the hazard area.** Establish the total approximate replacement value of the buildings located inside the hazard area. You can use HAZUS, GIS, tax assessment values, or develop an estimate of the value of the buildings inside the hazard area as a whole.

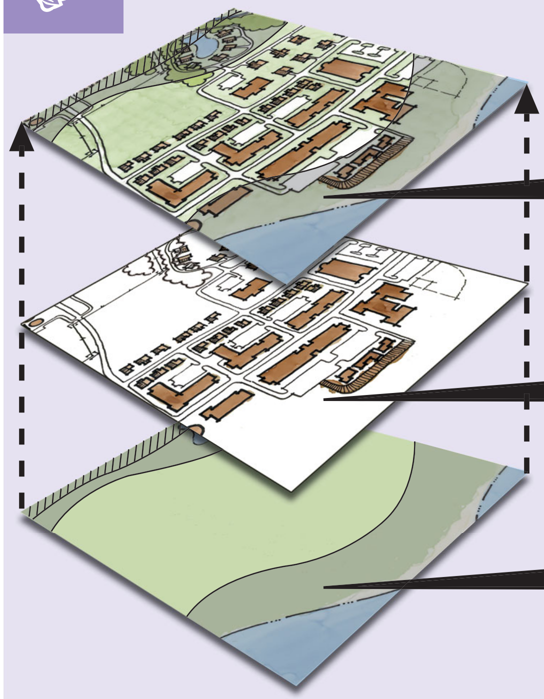
c. **Determine the number of people inside the hazard area.** Estimate the current population inside the hazard area. Use HAZUS, current Census data, local figures, or an estimate of the population. Once again, you should note if there is a large daytime, nighttime, or seasonal population change inside the hazard area.

Estimating future development will be addressed in the next phase of the Mitigation Planning Process. The phase "Develop a Mitigation Plan" will include how-to guidance on estimating future land use and population and will account for future risks. For now, you should note areas where future development or redevelopment may occur, to determine whether those areas are subject to hazards.

Your inventory should characterize a building and its contents, as well as its functions and the effect of the function on the buildings, its service to the community or state and its effect on the economy. You should ask yourself, what would happen to the community or state if the building's function were interrupted?

For example, providing drinking water is a normal function of local government, usually undertaken by the public works department. If your water treatment plant is located in a hazard area and can be damaged by a natural hazard event such as a flood or an earthquake, then it should be included in your inventory. In addition to the potential for physical damage to the plant itself, you should estimate the cost to businesses and residents for the period of time in which potable water might not be available.

An overlay can be produced by hand using a light table or through the use of GIS.



A map showing the location of the community's assets can be produced…

…by overlaying the base map for the community…

…with a map delineating hazard area boundaries.

Using a light table (or GIS if available), overlay this information to see which structures are located in more than one hazard zone and which areas of the community or state are more or less susceptible to different hazards.

This overlay mapping technique will also be helpful in looking at areas within the community that are not currently developed but could be in the future. There is no better time to avoid potential problems than before ground is broken for residential, commercial, or industrial land uses. By determining if any areas in the community that could be developed are prone to specific hazards, actions can be taken in advance that will serve to limit loss of life and property in the event of a disaster event.

3. Calculate the proportion of assets located in hazard areas.

To determine the proportion of structures, building value, or people in your hazard areas compared to your community or state, divide the number or value in your hazard area by the total number or value in your jurisdiction. For example, if you determined that you have 20 residential structures in your community and 10 of those are located in the 100-year floodplain, then 50 percent, or 10 divided by 20, of your residential structures are located in your flood hazard area.

States should inventory (or arrange for communities to perform these assessments as part of their inventories) state facilities (including critical facilities) and properties lying in hazard areas, including:

- Infrastructure such as highways, bridges, waterways, and utilities;
- Air, water, and other transportation terminals or ports;
- Lifelines and communication systems, such as phone lines and antennae, or water and sewage treatment plants; and
- Public recreation areas, parks, or forests.

As you complete your inventory, determine how you will incorporate the results into your statewide risk assessment.

You should begin to see the pattern of potential damage across the state as communities complete their individual inventories.

4. Determine the location of expected growth in your community.

By referring to your local comprehensive plan, or by talking with community officials, learn where future growth is expected to take place. Note whether these areas lie within hazard areas.

Task B. Determine whether (and where) you want to collect additional inventory data.

This is a critical juncture in your risk assessment. You may decide to end your inventory at this point, knowing the total estimated population, number of buildings, and value of buildings in the hazard areas, or you may decide to continue to gather additional inventory information described in Task C.

Ending your inventory now will only provide you a very broad picture of the potential extent of damage likely from a hazard event. When time, money, or other resources are scarce, a truncated inventory such as this can be helpful in demonstrating in a very broad sense what your community stands to lose during a hazard event. It can be particularly useful to convince decision-makers of the need for further study to determine potential losses from certain hazards. However, these figures will NOT allow you to specify the structures that are at greatest risk of damage, making objective determination of mitigation priorities difficult in the next phase of the planning process.

Collecting additional information will allow you to determine to what extent your assets can be damaged in a hazard event, giving you a more accurate estimate of the losses (cost of damages) to your community. At this time, loss estimation factors are available for floods, coastal storms, and earthquakes. In order to benefit from the use of these factors, you will need to gather additional inventory information.

The decision whether to gather additional information for some or all of your hazard areas is a subjective one. Your decision may be based on your need for detailed hazard- or site-specific information or the need to determine where to focus your information or the need to determine where to focus your mitigation efforts as part of the next phase of the Natural Hazard Mitigation Planning Process. As you decide how much information to collect, ask yourself these questions:

1. Is there enough data to determine which assets are subject to the greatest potential damages?
2. Is there enough data to determine whether significant elements of the community are vulnerable to potential hazards?
3. Is there enough data to determine whether certain areas of historic, environmental, political, or cultural significance are vulnerable to potential hazards?

Community Vulnerability Assessment Tool (CVAT) CD-ROM

The CVAT can be used to run a preliminary vulnerability assessment to help you determine whether or where you would like to spend more time or resources on collecting additional data. The CVAT provides guidance on conducting community-wide vulnerability assessments. It also provides a case study demonstrating the process for analyzing physical, social, economic, and environmental vulnerability to hazards at the local level. For more information, visit the NOAA Web site at http://www.csc.noaa.gov/products.

4. Is there concern about a particular hazard because of its severity, repetitiveness, or likelihood of occurrence?
5. Is additional data needed to justify the expenditure of community or state funds for mitigation initiatives?

You may want to gather detailed loss information on all of your potential hazards, one hazard, or a particular area or neighborhood affected by a hazard. You may also decide to gather detailed loss information for all your critical and essential facilities, or you may focus your attention on just the schools or hospitals. Additionally, if you plan to use the loss information to help you identify and/or prioritize mitigation projects in the next phase of the planning process, you may find it necessary to gather the additional information in order to perform a benefit-cost analysis.

If you wish to end your inventory collection at this point

Go to Summary (page 3-13)

Task C. Compile a detailed inventory of what can be damaged by a hazard event.

You will now begin to develop a more detailed inventory of the types of assets that are located in hazard areas, and the characteristics of those assets. Collecting data on these characteristics will help you determine the losses to these assets from different hazards.

1. Determine the priorities for your inventory collection efforts.

After you have determined for which hazard events you will gather additional information, you will determine your priorities for collecting the information. Choices about how much information you can reasonably gather may be particularly important for large communities or for areas with a dense concentration of assets. In some cases, the hazard profiles created in Step 2 will have already helped focus your efforts by eliminating areas without a significant hazard threat from your immediate concern.

HAZUS

HAZUS separates critical buildings and facilities into the five categories shown below based on their loss potential. For the purpose of this guide, all of the following elements are considered **critical facilities:**

- **Essential Facilities** are essential to the health and welfare of the whole population and are especially important following hazard events. The potential consequences of losing them are so great, that they should be carefully inventoried. Be sure to consider not only their structural integrity and content value, but also the effects on the interruption of their functions because the vulnerability is based on the service they provide rather than simply their physical aspects. Essential facilities include hospitals and other medical facilities, police and fire stations, emergency operations centers and evacuation shelters, and schools.
- **Transportation Systems** include airways – airports, heliports; highways – bridges, tunnels, roadbeds, overpasses, transfer centers; railways – trackage, tunnels, bridges, rail yards, depots; and waterways – canals, locks, seaports, ferries, harbors, drydocks, piers.
- **Lifeline Utility Systems** such as potable water, wastewater, oil, natural gas, electric power and communication systems.
- **High Potential Loss Facilities** are facilities that would have a high loss associated with them, such as nuclear power plants, dams, and military installations.
- **Hazardous Material Facilities** include facilities housing industrial/hazardous materials, such as corrosives, explosives, flammable materials, radioactive materials, and toxins.

Following are some ideas on how to focus your time and money on the most urgent and important elements within your community or state.

- Identify **critical facilities** that are important to your community or state. (See the definitions above).
- Identify **vulnerable populations** such as non-English speaking people or elderly people who may require special response assistance or special medical care after a disaster.
- Identify **economic elements** such as major employers and financial centers in your jurisdiction that could affect the local or regional economy if significantly disrupted.
- Identify areas with **special considerations** such as areas of high-density residential or commercial development that, if damaged, could result in high death tolls and injury rates.
- Identify **historic, cultural, and natural resource areas** including areas that may be identified and protected under state or federal law.
- Identify **other important facilities** which help ensure a full recovery of your community or state following a hazard event. These would include: government func-

tions, major employers, banks, and certain commercial establishments, such as grocery stores, hardware stores, and gas stations.

The type of hazard event will influence what information should be gathered in the inventory. In Steps 1 and 2 it became apparent that because there are fundamental differences in the hazard types, there are corresponding differences in the type of information and data you are collecting.

For example, floodwaters tend to inundate whatever is within a given area to a known consistent depth. However, hazard events such as tornadoes that are equally likely to occur anywhere in the community are usually profiled in terms of the magnitude (e.g., wind speed). Therefore, for hazard events such as floods, the information gathered will be based on the geographic area expected to be flooded, based on past experience. For a less predictable hazard such as a tornado, you will be less concerned with specific location; instead, you will focus on the construction characteristics for buildings throughout the community.

2. Gather building-specific information about the assets.

You will gather building-specific information regardless of the hazard that you are assessing. The list below discusses the type of information needed to calculate potential losses from different hazards in Step 4. You may want to gather this information for all of your hazards in combination with the hazard-specific information listed in the next step.

a. **Determine the size of the building.** Measured by the square foot, the size of the buildings is used to estimate both the replacement and function value of buildings. Sources of information include the tax assessment, building, zoning, or planning departments.

b. **Determine the replacement value.** This is usually expressed in terms of cost per square foot and reflects the present-day cost of labor and materials to construct a

The average replacement values were adjusted by the Consumer Price Index (CPI) to represent 2000 dollar figures.

The CPI is the ratio of the value of a basket of goods in the current year to the value of that same basket of goods in the previous year. It measures the average level of prices of the goods and services typically consumed by an urban American family. The http://woodrow.mpls.frb.fed us/research/data/us/calc/hist1800.cf Website can be used to adjust historic dollar figures to current year dollar figures.

Average Building Replacement Value per Square Foot

Occupancy Class	Total $/sq. ft.
Single Family Dwelling	77
Mobile Home	52
Multi-family Dwelling	98
Temporary Lodging	102
Institutional Dormitory	98
Nursing Home	89
Retail Trade	67
Wholesale Trade	53
Personal/Repair Services	92
Professional/Tech. Services	87
Banks	151
Hospital	145
Medical Office/Clinic	112
Entertainment & Recreation	131
Theaters	98
Parking	30
Heavy Industrial	69
Light Industrial	69
Food/Drugs/Chemicals	69
Metals/Minerals Processing	69
High Technology	69
Construction	69
Agriculture	26
Church/Non-Profit Offices	113
General Services	88
Emergency Response	130
Schools	91
Colleges/Universities	115

Source: HAZUS

building of a particular size, type, and quality. The replacement value is the current cost of returning a physical asset to its pre-damaged condition.

If you do not already have the replacement values from HAZUS or a local source use the table to the left and find the average replacement values per square foot. These costs are based on national averages for materials and installation and may need to be adjusted to account for regional differences. For example, building materials and supplies cost more in Hawaii than Kansas. Finally, multiply the cost per square foot by the size (in square feet) of the building you are assessing.

c. **Determine the content value.** If you do not already have the estimated content values from HAZUS or a local source, use the table at right to estimate the content value. Find the type of building you are assessing and determine the percent of the content replacement value. Multiply this percent by the building replacement value to calculate the content replacement value. Although there is not a standard cost variation table, you should keep in mind that some contents such as antiques or collectibles may be worth more than the average values. Increase your estimated content loss for these types of contents as you deem necessary.

Contents Value as Percentage of Building Replacement Value

Occupancy Class	Contents Value (%)
Residential (including temporary lodging, dormitory, and nursing homes)	50
Commercial (including retail, wholesale, professional, services, financial, entertainment & recreation)	100
Commercial (including hospital and medical office/clinic)	150
Commercial Parking	50
Industrial (including heavy, light, technology)	150
Industrial Construction	100
Agriculture	100
Religion/Non-Profit	100
Government Emergency Response	150
Government General Services	100
Education Schools/Libraries	100
Education Colleges/Universities	150

Source: HAZUS

d. **Determine the function use or value.** This represents the value of a building's use or function that would be lost if it were damaged or closed. A standard way to calculate the monetary damage from losing public functions is to use the budget of the service as a proxy for its value to the community. For private functions, the table on page 3-12 shows the average annual sales or production based on square footage. Using the table, find the type of function you are assessing and multiply the index by the structure size. The damages from "loss of function" are often much greater than physical damage to a structure.

Example 1

To find the annual sales from a 15,000 square foot grocery store, you would multiply the structure size by $30 per square foot (from the table at right).

15,000 x $30

The annual sales would be $450,000.

Example 2

If a public library will be lost for three months due to damage from a 100-year flood, you could determine the damages from the loss of function by multiplying the monthly budget of the library (overhead, rent, staff salaries, etc.) by three months.

Annual Gross Sales or Production (Dollars per Square Foot)

Occupancy Class	Annual Sales ($ / ft^2)
Commercial	
Retail Trade	30
Wholesale Trade	43
Industrial	
Heavy	400
Light	127
Food/Drugs/Chemicals	391
Metals/Minerals Processing	368
High Technology	245
Construction	431
Agriculture	
Agriculture	83

Source: HAZUS

e. **Determine the displacement cost.** The displacement cost is the dollar amount it would cost for the function (business or service) to be relocated to another structure because of a hazard event. These costs include rent for temporary building space per month, one-time displacement costs to set up operations in the new space, lost rent per month from all tenants, and other costs of displacement.

f. **Determine the occupancy or capacity.** Determine how many people the asset, such as a building or bridge, is designed to hold or service. Building capacities are available from local fire departments and/or fire marshal's offices. Bridge load ratings can be obtained from the responsible local, state, or federal transportation departments.

3. Gather hazard-specific information about the assets.

The pages that follow discuss the type of information needed to calculate potential losses from different hazards in Step 4. Because the characteristics of different hazards create the need for different types of data, you should review your unique combination of hazards to determine how you may want to approach data collection. The following table illustrates how different hazards may require different data.

Building Data Requirements By Hazard

Building Characteristics	Flood	Earthquake	Tsunami	Tornado	Coastal Storm	Landslide	Wildfire
Building Type / Type of Foundation	✓	✓	✓		✓		
Building Code Design Level / Date of Construction	✓	✓	✓	✓	✓		✓
Roof Material				✓	✓		✓
Roof Construction				✓	✓		✓
Vegetation							✓
Topography	✓				✓	✓	✓
Distance from the Hazard Zone	✓		✓		✓	✓	✓

Summary

After you have completed Step 3, you will know the quantity of buildings, people, and building values that lie in the different hazard areas and what proportion of the community this represents. If you decided to develop a more detailed inventory of what lies in these hazard areas, you will also know about many of the characteristics of the buildings and population. This will enable you to estimate losses resulting from hazard events and to determine where to best begin to address mitigation issues and focus your resources. Above all, you now have a better understanding of what is at risk in your community and an emerging picture of what your community stands to lose after a hazard event.

Step 3 most likely will present the greatest challenge in the loss estimation process and has the greatest potential to be a resource drain, but it is actually the most meaningful step. The degree to which you invest time and resources in the inventory will determine the quality of the loss estimation in Step 4, and ultimately your ability to prioritize mitigation actions during the next phase of the planning process.

If you have completed your inventory

Go to Step 4

to estimate the losses.

The Hazardville Post

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Hazardville Risk Assessment Back On Track

(Part 3 of a 4 part series on the Risk Assessment Process)

[Hazardville, EM] Town Council members held a special meeting Monday, upset that the inventory had not yet been completed. Joe Norris, the lead planner of the Town of Hazardville Organization for Risk Reduction (THORR), testified that the task force has been working since April to collect data on the hazards that could potentially affect Hazardville and assess the effects of those hazards on the town. Norris explained that collecting the initial information on the town and the hazards went fairly quickly.

Norris said, "The initial inventory was simplified due to the assistance offered by the State of Emergency Hazard Mitigation Officer." To get the ball rolling, the State of Emergency Office of Emergency Preparedness (EOEP), used a loss estimation tool developed by the Federal Emergency Management Agency, Hazards U.S. (HAZUS) to provide an initial inventory of critical facilities and buildings in the community. This information was added to the base map and assessed against each of the hazard zones. The final tally from the HAZUS inventory is shown in Table 1.

The slowdown came when the THORR reviewed the initial numbers and realized just how much and what was located in the hazard zones. Norris exclaimed, "Do you realize that all five commercial establishments and the only industrial plant in the Town of Hazardville can be impacted from four different hazards, and four out of the five business can be impacted by a fifth hazard?" The school, which substitutes as an emer-

(see **Risk**, page 3-15)

Table 1: HAZUS Inventory Totals

Occupancy Class	TOTAL ASSETS	Flood	Earthquake*	Tsunami	Coastal Storm	Tornado*	Wildfire	Landslide
Residential	62	16 (25%)	62	3 (4.8%)	18 (29%)	62	19 (30.6%)	2 (3.2%)
Commercial	5	4 (80%)	5	5 (100%)	5 (100%)	5	0	0
Industrial	1	0	1	1 (100%)	1 (100%)	1	0	0
Agricultural	2	1 (50%)	2	0	1 (100%)	2	2 (100%)	2 (100%)
Religion/ Non-Profit	4	1 (25%)	4	2 (50%)	4 (100%)	4	0	2 (50%)
Government	7	4 (57%)	7	1 (14%)	7 (100%)	7	5 (71%)	1 (14%)
Education	1	1 (100%)	1	1 (100%)	1 (100%)	1	0	
Number of Buildings	82	31 (37.8%)	82	14 (17%)	41 (50%)	82	29 (35%)	6 (7.3%)
Approximate Value ($M)	34.357	12.334 (35.8%)	34.357	12.396 (36%)	21.520 (62.6%)	34.357	6.641 (19%)	3.900 (11%)
Number of People	413	74 (18%)	413	9 (2.2%)	165 (40%)	413	29 (7%)	19 (4.6%)

* These hazards are random in nature and could affect any portion or the whole town.
Source: State of Emergency Office of Emergency Preparedness – HAZUS.

Hazardville Risk Assessment

Risk

(continued from page 3-14)

gency shelter, is vulnerable to five of seven hazards. In addition, over $21 million dollars in assets are vulnerable to coastal storms alone, including the police/fire department.

Based on the HAZUS data, THORR unanimously voted in favor of gathering additional inventory data on all of the town's critical facilities, as well as the historic lighthouse and buildings that have been flooded more than twice. Norris explained, "The THORR realized that more data was needed in order to determine where the highest loss could occur or what should be our top priority for mitigation; however, inventorying each of the buildings had been more time consuming than anticipated and identifying the number of buildings in the various hazard areas quickly overwhelmed the volunteers."

So, in addition to working with the EOEP, THORR worked with numerous volunteer and community groups to complete the inventory. The local Girl Scout troop verified the location of all the buildings in the 100-year floodplain, and the volunteer fire department conducted a sidewalk survey to inventory the wildfire hazard area, including the Clearview Acres Subdivision. Members of the University Geology Club inventoried the landslide hazard areas, and the department of Public Works received training in Rapid Visual Screening for seismic and wind vulnerability and inventoried all public buildings for earthquakes and tornadoes.

According to Norris, the final results of the loss estimation should be available in about two months after they complete the final step of estimating losses.

Task C. Compile a more detailed inventory of what can be damaged by a flood hazard event.

1. Determine priorities for your inventory collection efforts.

In large communities, you may choose to prioritize your inventory by selecting the more hazardous floodplains (based on Step 2) first, by starting with the older buildings, critical facilities, or the assets that are closest to the flood hazard such as those in the floodway. For example, buildings that were constructed before local or state floodplain ordinances went into effect will most likely not be elevated to or above the expected flood level, and are most susceptible to flood damage. Buildings whose structures or contents are most susceptible to flood damage, such as wood frame buildings, manufactured homes, or buildings with delicate contents or expensive machinery are also more vulnerable to flood damage. You should also identify repetitive loss properties as part of this activity.

2. Gather building-specific information about the assets.

Gather the building-specific information including size, replacement value, content value, function use or value, displacement cost, occupancy or capacity. For more information refer to Task C, number 2 on page 3-10.

Under NFIP guidelines, repetitive loss structures include any currently insured building with two or more flood losses (occurring more than ten days apart) greater than $1,000 in any 10-year period since 1978.

States should provide communities with information on historic floods throughout the state so communities will know what type of damage has occurred (even if it didn't occur within that particular community).

States should ensure that lists of repetitive loss properties are kept up to date and that communities have the most current list. States should contact their FEMA Regional Office for this information.

FEMA also maintains a national list of properties that comprise the "Repetitive Loss Target Group". These are repetitive loss properties that have either experienced four or more losses with the characteristics above, or have had losses that cumulatively exceed the property value of the building.

3. Gather hazard-specific information about the assets.

In addition to the items shown in the table below, the following information will be used later in Step 4 to determine flood vulnerability:

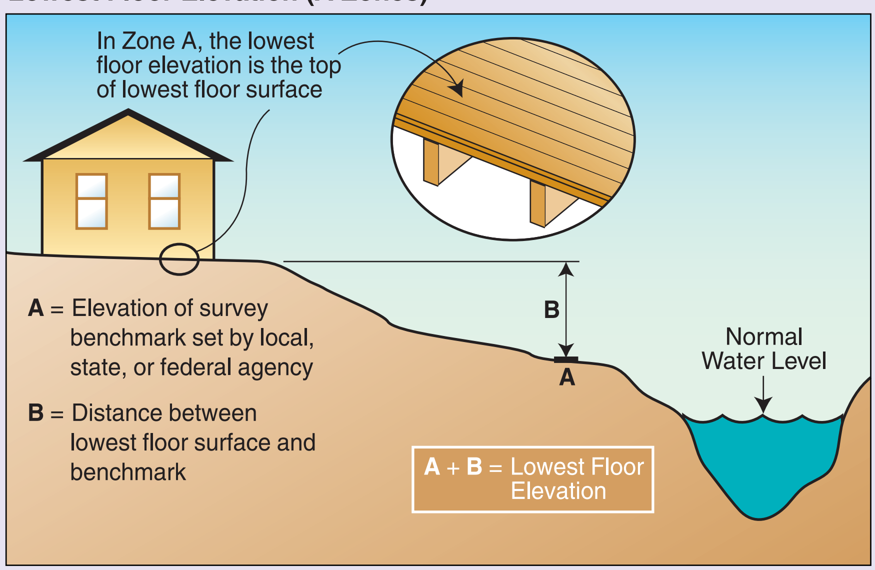
- **Lowest floor elevation.** Identify the elevation of the lowest floor of the lowest enclosed area (including basement). This information can be obtained from an elevation certificate (found in the office of the local NFIP administrator, who also often serves as the local building official or planner) if the building was constructed after your floodplain management ordinance was in force. It may also be available from a recorded subdivision plat, site survey, or building permit.

A basic approach to estimating the lowest floor elevation is to estimate the elevation for a whole block of similarly located buildings.

You may also consider generalizing your inventory by making an assumption that buildings constructed after the FIRM was published are above the base flood elevation and buildings constructed prior to the FIRM are below the base flood elevation.

If a lowest floor elevation has not been recorded, it can be determined in a number of ways. The most accurate way is to hire a professional land surveyor to field-measure the lowest floor elevation from a local surveying benchmark or other point of known elevation. Other less accurate methods include measuring (such as with a hand level) from a nearby benchmark, a neighbor's property that has been surveyed, or any other point of known elevation. Also, property owners who have experienced prior flooding may have marked the water level on the building. These property owners can check local records for the elevation of the flood during that storm and estimate the lowest-floor elevation relative to their high-water mark.

Lowest Floor Elevation (A Zones)



- **Base Flood Elevation.** The base flood elevation is the elevation (referenced to a datum) of the flood having a one percent chance of being equaled or exceeded in any given year. This information can be found on the FIRM and flood profile. The following diagram shows how to find the BFE at a given point in the floodplain.

To determine the BFE using the FIRM:

① bcate a feature(s) on the FIRM, near the site you are assessing, that also appears on the FIS Flood Profile, such as a bridge, highway, or cross-section.

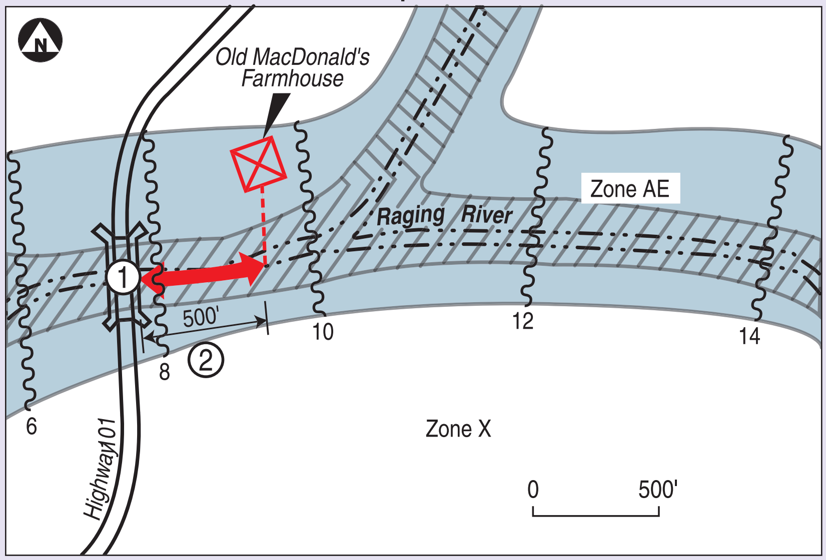
② Calculate the distance from the feature along the stream to the site you are assessing using the scale used on the FIRM.

③ Locate the site you are assessing on the FIS Flood Profile by using the scale on the FIS to measure the distance from the feature to the site.

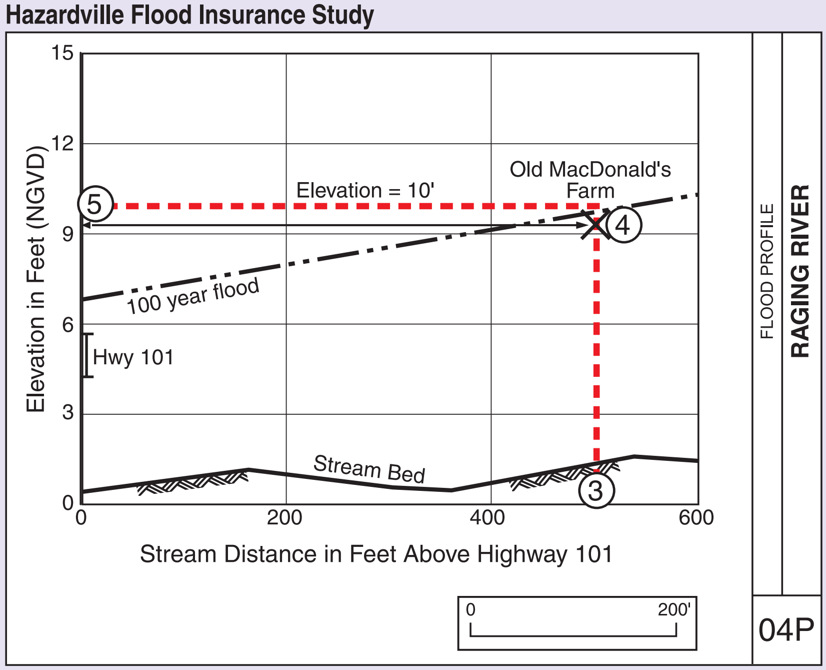
④ Follow a vertical line up to the water surface line on the Flood Profile.

⑤ Follow a horizontal line to the y-axis to read the elevation.

Hazardville Flood Insurance Rate Map



Hazardville Flood Insurance Study



Building Data Requirements By Hazard

Building Characteristics	Flood	Earthquake	Tsunami	Tornado	Coastal Storm	Landslide	Wildfire
Building Type / Type of Foundation	✓	✓	✓		✓		
Building Code Design Level / Date of Construction	✓	✓	✓	✓	✓		✓
Roof Material				✓	✓		✓
Roof Construction				✓	✓		✓
Vegetation							✓
Topography	✓				✓	✓	✓
Distance from the Hazard Zone	✓		✓		✓	✓	✓

Go to the next hazard on your list to inventory

or if you are finished with all your hazard inventories

Go to Step 4

Task C. Compile a more detailed inventory of what can be damaged by an earthquake hazard event.

1. Determine priorities for your inventory collection efforts.

Determining inventory priorities for earthquakes requires consideration of the potential intensity of the earth movements. For example, some buildings, such as those constructed of unreinforced masonry, perform very poorly in earthquakes. In addition, buildings constructed prior to seismic building code requirements or under low seismic building codes will also perform poorly in earthquakes of a given intensity. With this in mind, you might choose to inventory only those at first, to see what risks are evident before proceeding with a full inventory. This can be accomplished through a seismic evaluation of your buildings.

This method of selecting elements with the most apparent vulnerability determines whether there is sufficient vulnerability to justify additional evaluations. For example, if you initially include in your inventory only those buildings that would do poorly in an earthquake of a known intensity and/or those with high occupancy and conclude that there is still not much risk, you may wish to assume that other types of buildings or structures will be at even lower risk.

Code Seismic Design Level

States and communities change their building codes over time as more is learned about hazards and construction techniques. The determination of high, moderate, or low code levels can be considered subjective. You should talk with your local and/or state code officials to determine this aspect of vulnerability.

For example, in areas of high seismicity (e.g., coastal California), buildings of newer construction (e.g., post-1973) are best represented by High-Code damage functions, while buildings of older construction would be best represented by Moderate-Code damage functions, if built after about 1940, or by Pre-Code damage functions, if built before about 1940 (i.e., before seismic codes existed). Pre-Code damage functions are appropriate for modeling older buildings that were not designed for earthquake load, regardless of where they are located in the United States.

NEHRP Handbook for the Seismic Evaluation of Existing Buildings (FEMA 178) presents a nationally applicable method for engineers to identify buildings or building components that present unacceptable risks in an earthquake. Four structural subsystems in which deficits may exist are identified:

- Vertical elements resisting horizontal loads;
- Horizontal elements resisting lateral loads;
- Foundations; and
- Connections between structural elements or subsystems.

Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook (FEMA 154) and Supporting Documentation (FEMA 155) present a method for quickly identifying buildings posing risk of death, injury, or severe curtailment in use following an earthquake. Trained personnel can use the methodology known as "Rapid Screening Procedure (RSP)" to identify potentially hazardous buildings. This identification is based on a 15- to 30-minute exterior inspection, using a data collection form included in the handbook. Twelve basic structural categories are inspected, leading to a numerical "structural score" based on visual inspection. Building inspectors are the most likely group to implement an RSP, although this report is also intended for building officials, engineers, architects, building owners, emergency managers, and interested citizens. The supporting documentation reviews the literature and existing procedures for rapid visual screening.

2. Gather building-specific information about the assets.

Gather the building-specific information including size, replacement value, content value, function use or value, displacement cost, occupancy or capacity. For more information refer to Task C, number 2 on page 3-10.

3. Gather information about the assets.

In addition to the information shown in the table below, the following information will be needed to determine earthquake vulnerability as part of Step 4:

- **Seismic design building code.** One aspect of structure vulnerability is based on building codes. Older buildings constructed under a low seismic design building code or without any seismic considerations are more vulnerable to earthquakes of a given intensity than buildings constructed to a high or moderate seismic design building code. Determine the level (high, moderate, low, or pre-code) of seismic design building code that is currently in effect, when it went into effect, and what levels of seismic codes have been in effect in the past. Based on this information work with your building code department to determine under which code the buildings in your inventory were designed. Keep in mind that buildings built under a code with low seismic design provisions could have been subsequently retrofitted under a more stringent code.

HAZUS

If you are using HAZUS to estimate your earthquake losses, these calculations will be completed within the program.

Using HAZUS to identify buildings constructed before the adoption of seismic building codes can help you quickly identify buildings that will be vulnerable to earthquakes.

Intensity is a subjective measure of the strength of the shaking experienced in an earthquake. Intensity is based on the observed effects of ground shaking on people, buildings, and natural features. It varies from place to place within the disturbed region depending on the location of the observer with respect to the earthquake epicenter. The "intensity" reported at different points generally decreases away from the earthquake epicenter. Local geologic conditions strongly influence the intensity of an earthquake; commonly, sites on soft ground or alluvium have intensities 2 to 3 units higher than sites on bedrock. The **Modified Mercalli Scale** represents the local effect or damage caused by an earthquake.

It is possible to relate the PGA value you identified in Step 2 to the Mercalli scale. (See table.)

Modified Mercalli Intensity and PGA Equivalents

MMI	Acceleration (%g) (PGA)	Perceived Shaking	Potential Damage
I	< 0.17	Not Felt	None
II	0.17 - 1.4	Weak	None
III	0.17 - 1.4	Weak	None
IV	1.4 - 3.9	Light	None
V	3.9 - 9.2	Moderate	Very Light
VI	9.2 - 18	Strong	Light
VII	18 - 34	Very Strong	Moderate
VIII	34 - 65	Severe	Moderate to Heavy
IX	65 - 124	Violent	Heavy
X	> 124	Extreme	Very Heavy
XI	> 124	Extreme	Very Heavy
XII	> 124	Extreme	Very Heavy

Source: USGS

Building Data Requirements By Hazard

Building Characteristics	Flood	Earthquake	Tsunami	Tornado	Coastal Storm	Landslide	Wildfire
Building Type / Type of Foundation	✓	✓	✓		✓		
Building Code Design Level / Date of Construction	✓	✓	✓	✓	✓		✓
Roof Material				✓	✓		✓
Roof Construction				✓	✓		✓
Vegetation							✓
Topography	✓				✓	✓	✓
Distance from the Hazard Zone	✓		✓		✓	✓	✓

Go to the next hazard on your list to inventory

or, if you are finished with all your hazard inventories

Go to Step 4

Tsunamis

Task C. Compile a more detailed inventory of what can be damaged by a tsunami hazard event.

1. Determine priorities for your inventory collection efforts.

If your community has a relatively small tsunami area, you may decide to inventory all of the assets inside the hazard boundary on your base map. If you have a large tsunami area or if numerous buildings are located inside the hazard boundary, you may decide to prioritize your inventory by starting with those closest to the shoreline, and critical facilities.

2. Gather building-specific information about the assets.

Gather the building-specific information including size, replacement value, content value, function use or value, displacement cost, occupancy or capacity. For more information refer to Task C, number 2 on page 3-10.

3. Gather information about the assets.

After you have made a list of all the assets located inside the tsunami hazard area, you will need to gather information shown in the table below.

Building Data Requirements By Hazard

Building Characteristics	Flood	Earthquake	Tsunami	Tornado	Coastal Storm	Landslide	Wildfire
Building Type / Type of Foundation	✓	✓	✓		✓		
Building Code Design Level / Date of Construction	✓	✓	✓	✓	✓		✓
Roof Material				✓	✓		✓
Roof Construction				✓	✓		✓
Vegetation							✓
Topography	✓				✓	✓	✓
Distance from the Hazard Zone	✓		✓		✓	✓	✓

Go to the next hazard on your list to inventory

or, if you are finished with all your hazard inventories

Go to Step 4

Meteorologists use the Fujita scale to determine the intensity of tornadoes.

Most tornadoes are in the F0-F2 class. Building to modern wind standards provides significant property protection from these hazard events; however, a community in the direct path of a violent tornado may experience extensive damages. Designing buildings to extreme wind speeds, such as those associated with an F-3 or greater tornado is beyond the scope of current building codes.

The Building Performance Assessment Report for the Oklahoma and Kansas Tornadoes (FEMA 342) includes a good description of tornadoes and associated damage.

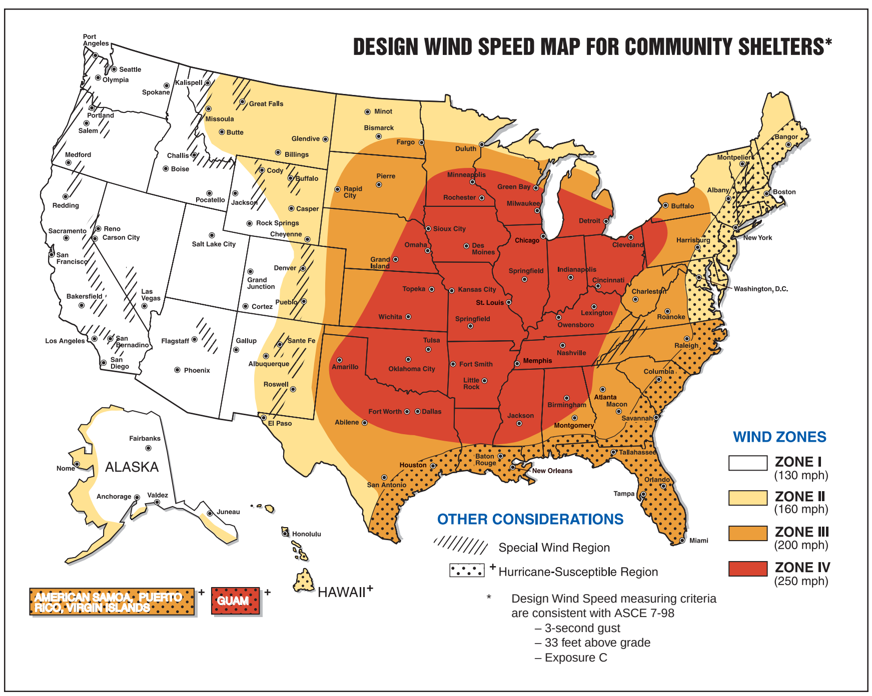
Communities should build new shelters or reinforce existing shelters to withstand the design wind speeds described in Step 2.

Task C. Compile a more detailed inventory of what can be damaged by a tornado hazard event.

1. Determine priorities for your inventory collection efforts.

Since tornadoes can possibly affect the whole community or state, it is very important to set some priorities because inventorying everything could be very labor and time intensive. If necessary, communities and states should narrow their inventory to assets that are of particular importance from a public safety, historical, economic, or environmental standpoint.

Communities that want to begin by identifying the assets that are not built to withstand the design wind speed, or assets that typically get damaged in tornadoes should examine the date of construction. For example, buildings that were constructed before local or state building codes went into effect, and/or buildings built to codes whose wind speed standards are below those indicated on the Design Wind Speed map shown below are more vulnerable to tornadoes.



2. Gather building-specific information about the assets.

Gather the building-specific information including size, replacement value, content value, function use or value, displacement cost, occupancy or capacity. For more information refer to Task C, number 2 on page 3-10.

3. Gather information about the assets.

After you have made a list of all the assets you wish to include inside the tornado hazard area, you will need to gather the information shown in the table below.

Building Data Requirements By Hazard

Building Characteristics	Flood	Earthquake	Tsunami	Tornado	Coastal Storm	Landslide	Wildfire
Building Type / Type of Foundation	✓	✓	✓		✓		
Building Code Design Level / Date of Construction	✓	✓	✓	✓	✓		✓
Roof Material				✓	✓		✓
Roof Construction				✓	✓		✓
Vegetation							✓
Topography	✓				✓	✓	✓
Distance from the Hazard Zone	✓		✓		✓	✓	✓

Go to the next hazard on your list to inventory

or if you are finished with all your hazard inventories

Go to Step 4

Task C. Compile a more detailed inventory of what can be damaged by a coastal storm hazard event.

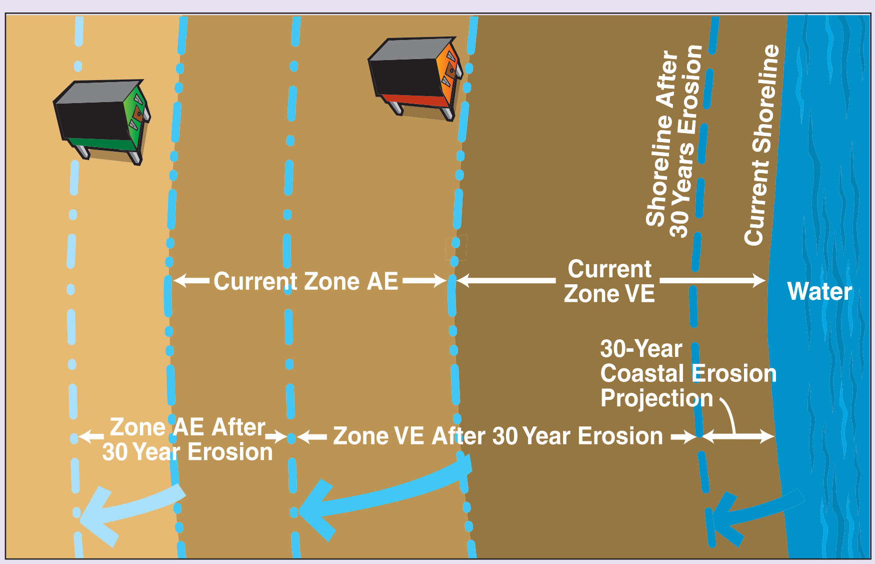
1. Determine priorities for your inventory collection efforts.

In addition to identifying critical facilities, you may further prioritize your inventory items by starting with buildings and other assets closest to the coastal storm hazard area or at the lowest elevations and prone to the highest potential flood and tidal surge levels, wave velocities, and erosion hazards.

Because hurricane-strength winds would likely affect whole communities or large portions of your state, conducting an inventory of every building subject to coastal storm winds would be very time and labor intensive. Therefore, if necessary, you should identify solely buildings or areas that may be more prone to wind hazards. The condition, age, and primary building materials can be indications of the building's physical vulnerability to wind and water hazards. Knowing the wind provisions of the building code and the floodplain management regulations in effect at the time of construction are essential in determining buildings' vulnerability to coastal storms.

Identify the assets that may be exposed to coastal storm hazards according to your priority system. For example, buildings or structures built before local floodplain ordinances went into effect most likely will not be elevated to or above the expected flood level or

Coastal flooding, high winds, and often erosion will affect the coastal storm hazard area in your community. Keep in mind that the flood zones and boundaries shown on the FIRM are based on conditions at the time the study was completed. As shoreline erosion occurs, the location of these zones and boundaries will change. For example, the red house, currently in Zone AE may be located in Zone VE within 30 years and the green house, currently out of the floodplain entirely, may be located in Zone AE within 30 years.



may have obstructions or an enclosed space below the elevated structure making them most susceptible to flood, wind, or storm surge damage. Also, buildings or structures built on high bluffs above the oceans or high cliffs such as those along the Great Lakes are susceptible to erosion of the land beneath the foundation. Once the erosion reaches the foundation, the house will be lost or damaged sufficiently to become uninhabitable.

2. Gather building-specific information about the assets.

Gather the building-specific information including size, replacement value, content value, function use or value, displacement cost, occupancy or capacity. For more information refer to Task C, number 2 on page 3-10.

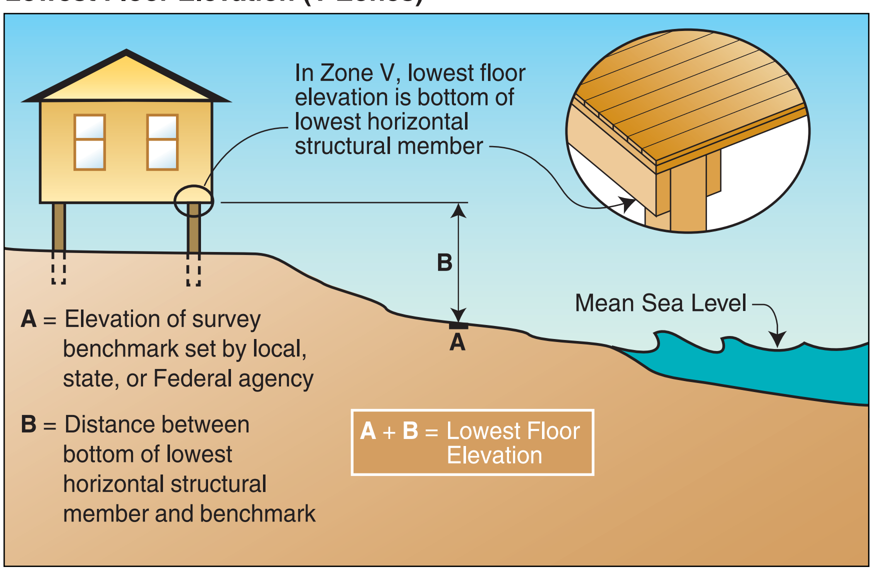
3. Gather Information about the assets.

In addition to the items listed in the table on the next page, the following information will be used in Step 4 to determine vulnerability to coastal storms:

- **Lowest floor elevation.** For V zones, the relevant elevation is that of the bottom of the lowest horizontal structural member, NOT the top of the lowest finished floor as used in non-coastal flood assessments. This definition is used for consistency with NFIP minimum floodplain management requirements.

A basic approach to estimating the lowest floor elevation is to estimate the elevation for a whole block of similarly located buildings.

Lowest Floor Elevation (V Zones)



This information can be obtained from an elevation certificate if the building was built after your community's floodplain management ordinance was in force. It also may be available from a recorded subdivision plat, site survey, or building permit.

- **Base Flood Elevation.** The base flood elevation is the elevation (referenced to a datum) of the flood having a one percent chance of being equaled or exceeded in any given year. This information can be found on the FIRM.

Building Data Requirements By Hazard

Building Characteristics	Flood	Earthquake	Tsunami	Tornado	Coastal Storm	Landslide	Wildfire
Building Type / Type of Foundation	✓	✓	✓		✓		
Building Code Design Level / Date of Construction	✓	✓	✓	✓	✓		✓
Roof Material				✓	✓		✓
Roof Construction				✓	✓		✓
Vegetation							✓
Topography	✓				✓	✓	✓
Distance from the Hazard Zone	✓		✓		✓	✓	✓

Go to the next hazard on your list to inventory

or, if you are finished with all your hazard inventories

Go to Step 4

Landslides

Task C. Compile a more detailed inventory of what can be damaged by a landslide hazard event.

1. Determine priorities for your inventory collection efforts.

Landslides usually affect infrastructure such as roads and bridges, but they can also affect individual buildings and businesses. If your community has a relatively small landslide area, you may decide to inventory all of the assets inside the hazard boundary on your base map. If you have a large landslide area or if numerous buildings are located inside the hazard boundary, you may decide to prioritize your inventory by starting with the critical facilities.

2. Gather building-specific information about the assets.

Gather the building-specific information including size, replacement value, content value, function use or value, displacement cost, occupancy or capacity. For more information refer to Task C, number 2 on page 3-10.

3. Gather information about the assets.

After you have made a list of all the assets located inside the landslide hazard area, gather the data listed in the table below.

Building Data Requirements By Hazard

Building Characteristics	Flood	Earthquake	Tsunami	Tornado	Coastal Storm	Landslide	Wildfire
Building Type / Type of Foundation	✓	✓	✓		✓		
Building Code Design Level / Date of Construction	✓	✓	✓	✓	✓		✓
Roof Material				✓	✓		✓
Roof Construction				✓	✓		✓
Vegetation							✓
Topography	✓				✓	✓	✓
Distance from the Hazard Zone	✓		✓		✓	✓	✓

Go to the next hazard on your list to inventory

or if you are finished with all your hazard inventories

Go to Step 4

Wildfires

Task C. Compile a more detailed inventory of what can be damaged by a wildfire hazard event.

1. Determine priorities for your inventory collection efforts.

If your wildfire hazard area is relatively small, you may decide to inventory all of the assets within your wildfire hazard boundary on your base map. If you have a large wildfire hazard area or if you have many assets within your hazard area, you may decide to prioritize your inventory by starting with the critical facilities. You can also prioritize by first inventorying the extreme wildfire hazard area and then as time and money permit, inventorying the high and moderate hazard areas.

Information about buildings that were constructed before local or state fire codes were adopted or upgraded can be gathered from the building permit or planning office.

2. Gather building-specific information about the assets.

Gather the building-specific information including size, replacement value, content value, function use or value, displacement cost, occupancy or capacity. For more information refer to Task C, number 2 on page 3-10.

3. Gather Information about the assets.

After you have made a list of all the assets located inside the wildfire hazard area, gather the data listed in the table below.

Building Data Requirements By Hazard

Building Characteristics	Flood	Earthquake	Tsunami	Tornado	Coastal Storm	Landslide	Wildfire
Building Type / Type of Foundation	✓	✓	✓		✓		
Building Code Design Level / Date of Construction	✓	✓	✓	✓	✓		✓
Roof Material				✓	✓		✓
Roof Construction				✓	✓		✓
Vegetation							✓
Topography	✓				✓	✓	✓
Distance from the Hazard Zone	✓		✓		✓	✓	✓

Go to the next hazard on your list to inventory

or if you are finished with all your hazard inventories

Go to Step 4

1 identify hazards

2 profile hazard events

3 inventory assets

step 4 estimate losses

4 estimate losses

Overview

The fourth step in the loss estimation process answers the question: *How will the community's assets be affected by the hazard event?*

So far, you have determined that one or more hazards may affect your planning area (Step 1), profiled the hazard events (Step 2), and inventoried the assets that can be damaged by the hazard event (Step 3). In this step, you will bring this information together to estimate your losses in terms of the expected losses from hazard events to people, buildings, and other important assets. Some buildings, infrastructure, or functions will be damaged more than others in the same hazard event because they are more vulnerable—their location or construction makes them more susceptible to damage from the hazard event. For example, two bridges of similar construction that are exposed to the same flood hazard event may experience different levels of damage. One bridge may be built to lower construction standards, be older, or have a lower elevation, thus suffering greater damage than the other bridge.

Remember, a true "risk assessment" takes into account all of the possible hazard events rather than just a single event. For the purpose of this planning guide, the losses will be calculated from a selected hazard event.

To complete the loss estimation, you will first assess the level of damage from a hazard event, both as a percentage of the asset's structural and content replacement value and as a function. To illustrate, your investigation may find that in a 100-year flood event, a particular building could suffer damage at a level equal to 50 percent of its total value. Next, you will calculate the potential loss by multiplying the value of the structure, contents, or use that you gathered in

This elementary school suffered devastating losses during tropical storm Alberto in 1994.

The most convenient way to express the expected losses is in terms of dollars. This will provide a relative ranking of risk to different elements of the planning area from different hazards. They are extremely rough estimates that should not be used for any other purpose.

If you conducted an abbreviated inventory in Step 3, you will not assess the level of damage for each asset in the inventory (Task A). Instead, you will determine a level of damage from each hazard for the entire hazard area using historical evidence of damage and data on population growth.

For example, assume that in Step 1, you discovered that a flood in 1955 caused $1,000,000 in damages and affected 1,000 residents in the floodplain. In the years since the 1955 flood, census data reveal that the community population has grown 70 percent. By comparing aerial photographs of the same area taken in the 1950's and in the 1990's, you estimate that floodplain development has increased by 50 percent. Therefore, you conclude that the same flood today would cause $1,500,000 in damage, or rather, $9,881,423 when adjusted to 2001 dollars. In addition, you estimate the number of affected residents would be about 1,700.

If you discovered in Steps 1 and 2 that you are threatened by a hazard that has not occurred in recent memory, then you can base your estimate of risk on some general rules of thumb identified in the hazard specific sections which follow.

After you have estimated the amount of damage and number of affected residents for your abbreviated inventory, **skip to Task B** to complete Step 4.

Worksheet #4 — Estimate Losses — step 4

Date: October, 2001

How will these hazards affect you?

Hazard Flood

	Structure Loss (Task A.1.)					Contents Loss (Task A.2.)				
Name/ Description of Structure	Structure Replacement Value (Step 3) **($)**	x	Percent Damage (Step 4) **(%)**	=	Loss to Structure **($)**	Replacement Value of Contents (Step 3) **($)**	x	Percent Damage (Step 4) **(%)**	=	Loss to Contents **($)**
Historic Lighthouse	1,500,000	x	18	=	270,000	50,000	x	27	=	13,500
Bridge	750,000	x	20	=	150,000	N/A	x	N/A	=	N/A
Sewage Treatment Plant	2,500,000	x	13	=	325,000	2,500,000	x	19.5	=	487,500
STP Outbuilding	1,000,000	x	13	=	130,000	1,500,000	x	19.5	=	292,500
STP Outbuilding	750,000	x	13	=	97,500	1,500,000	x	19.5	=	292,500
Water Treatment Plant	250,000	x	5	=	12,500	250,000	x	7.5	=	18,750
Hospital	2,500,000	x	5	=	125,000	3,750,000	x	7.5	=	281,250
Police & Fire Station	2,000,000	x	5	=	100,000	3,000,000	x	7.5	=	225,000
Total Loss to Structure					$1,210,000	**Total Loss to Contents**				$1,611,000

	Structure Use and Function Loss (Task A.3.)										
Name/ Description of Structure	Average Daily Operating Budget (Step 3) **($)**	x	Functional Downtime (Step 4) **(# of days)**	+	Displacement Cost per Day (Step 3) **($)**	x	Displacement Time (Step 4) **($)**	=	Structure Use & Function Loss **($)**	**Structure Loss + Content Loss + Function Loss ($)**
Historic Lighthouse	2,191	x	7	+	500	x	2	=	16,337	299,837
Bridge	31,740	x	4	+	12,000	x	4	=	174,960	324,960
Sewage Treatment Plant	82,191	x	3	+	200,000	x	3	=	846,573	1,659,073
STP Outbuilding	684	x	2	+	5,000	x	2	=	11,368	433,868
STP Outbuilding	684	x	2	+	1,000	x	2	=	3,368	393,368
Water Treatment Plant	2,740	x	1	+	2,000	x	0	=	2,740	33,990
Hospital	2,055	x	0	+	2,500	x	0	=	0	406,250
Police & Fire Station	960	x	1	+	2,000	x	0	=	960	325,960
Total Loss to Structure Use & Function									$1,056,306	$3,877,306 **Total Loss for Hazard Event (Task B.2.)**

Step 3 by the percent of damage expected from the hazard event. It is important to remember that a comprehensive loss estimation should include the contents and functions of the buildings in addition to the risk to the structure itself. Also, please note that this can become more complex as you attempt to account for a wider range of possible effects from one or more hazards. Therefore, you should use **Worksheet #4: Estimate Losses** in Appendix C(see example on page 4-2) to keep track of your results. If you used a computerized spreadsheet or GIS database for your inventory in Step 3, then you may want to continue to use that same method for this step.

Procedures & Techniques

Task A. Determine the extent of damages.

The hazard-specific sections that follow will help you estimate the potential losses to your assets from the hazards that can affect you. You will find that some of the hazards have definitive loss estimation tables while others do not. In the cases where loss estimation tables are not currently available, you can use the full value of the assets that are in the hazard area, or base your assumptions on your past experiences with those hazards in your planning area. For example, if your planning area is susceptible to wildfires and you inventoried all of the assets that can be damaged by a wildfire, then you would assess the vulnerability by estimating the number of assets that would be destroyed in a wildfire based on past wildfires.

1. Estimate the losses to structures.

Determine how the various hazard events will affect the structures within your planning area. Use the structure loss estimation tables to determine the estimated percent of damage from the various hazard events. The estimated damages are expressed as a percentage of structure replacement value. Multiply the structure replacement value (Step 3) by the expected percent damage (provided in the hazard-specific sections that follow) to determine the loss to the structure in a particular hazard event.

For example, if the library's structure replacement value equals $100,000 and the expected damage from a 100-year flood is 40 percent of the structure, then the loss to this structure from a flood is $40,000.

2. Estimate the losses to contents.

Determine the expected amount of damage to the contents of the structures you inventoried. Multiply the replacement value of the

A loss estimation table is a projection of likely damage by magnitude of the hazard (expressed as a percentage of replacement cost), based on observed past damages.

In this how-to guide floods, earthquakes, and coastal storms have loss estimation tables (tornadoes, landslides, tsunamis, and wildfires do not). These tables are from various sources including the Means Square Foot Cost publication, HAZUS, and FEMA's Benefit-Cost Analysis module. They have been simplified and represent generalized information. For more detailed analysis, go to the source listed for each table.

Loss to structure = (structure replacement value) x (percent damage)

Loss to contents = (content replacement value) x (percent damage)

A basic approach to overcome limited time or resources is to start by estimating the losses to all the structures and then, as resources allow, calculate the content loss, and then the function loss, etc.

Functional downtime is the average time (in days) during which a function (business or service) is unable to provide its services due to a hazard event.

Functional downtime may also be associated with a bridge, road, or utility that can be damaged by a hazard, and each of their several components may have a different associated vulnerability. Consider a gas pipeline exposed to a wildfire: the various parts of the gas transmission system—the piping, the pumps, the monitoring system, and end-distribution pieces—will likely react differently under the same level of pressure from the heat of the wildfire and will have different effects when they fail. If the gas pipeline fails, the results will probably reach far beyond physical damages to the pipe – there could be large-scale business disruption, people might have to leave their homes, the leaking gas could lead to additional fires, and so on. Use your best judgment and experience to determine functional downtime for functions with many components.

Displacement time is the average time (in days) that the building's occupants typically must operate from a temporary location while repairs are made to the original building due to damages resulting from a hazard event.

contents (Step 3) by the expected percent damage to determine the losses to the contents from a particular hazard event.

For example, if the library's content replacement value equals $225,000 and the expected damage from a 100-year flood is 10 percent of the contents, then the losses to these contents from a flood is $22,500.

3. Estimate the losses to structure use and function.

First, you will determine functional downtime, or the time (in days) that the function would be disrupted from a hazard event. If a hazard specific loss estimation table is not available, research past damage in your area and determine the average number of days various functions were unavailable following a hazard event. Next, estimate the daily cost of the functional downtime. Divide the average annual budget or sales (Step 3) by 365 to determine the average daily operating budget or sales. Multiply the average daily operating budget or sales by the functional downtime to determine the cost of the loss of function for the period that the business or service was unable to operate due to the hazard event.

For example, if an ice cream shop had daily sales of $2,500 during the summertime and was forced to close for two weeks because of damages from a hazard event, their function loss would be $35,000 ($2,500 x 14 days).

If you are assessing a public facility, such as a library with an annual budget of $600,000 and an average daily budget of $1,644 ($600,000 / 365), you could estimate the losses by using the annual budget as a proxy for the value of the service to the community. For example, if the library were closed for seven days due to a flood event, then the cost for the loss of use for seven days would be $11,508.

Next, you will determine the displacement time, or the time (in days) that a function may need to operate from a temporary location due to a hazard event. For example, if the library was closed for 7 days (functional downtime) and then resumed operations from an empty trailer for the next 90 days until they could repair the damages to the existing building, then the displacement time would be 90 days. Note that not all functions would require displacement before resuming operation.

Multiply the displacement cost (Step 3) by the displacement time to determine the cost of the displacement from the regular place of business due to the hazard event.

When you are determining losses to other kinds of community functions, such as government services, public works, or business activity, you use the same procedure. First, determine the cost of loss of function to the community based on its "normal" condition (functional downtime cost). Then assess the cost of displacement because of a hazard event (displacement cost). The sum of these two numbers will tell you the losses as a result of losing the function in a particular event.

Losses to functions = (functional downtime costs) + (displacement time costs)

For example, the losses to the library's structure, use and function are the total of the functional downtime costs ($11,508) plus the displacement costs ($34,400), or $45,908.

4. Calculating human losses.

There are credible estimates available from HAZUS (for earthquakes) and other sources estimating the number of people that may be hurt or killed in various types of buildings under different hazard conditions. For the risk assessment it is important to note that the likelihood of people being injured or killed depends upon factors such as warning time and the characteristics of the hazard itself. However, this guide does not place a dollar value on human lives; rather, you should note areas that can be improved to help save lives and reduce injuries in future hazard events.

5. Complete Task A on Worksheet #4.

Task B. Calculate the loss from each hazard event.

1. Calculate the losses to each asset.

Loss = structure loss + content loss + function loss

To determine which individual assets could sustain the largest potential losses, add the structure loss, content loss, and function loss for each asset to determine the total loss. For example, you expect your town library to be damaged by a 100-year flood and the structural damage is estimated at $40,000. The content damage to the books and other equipment is estimated at $22,500, and the loss from having to close the library for a week and the displacement for 90 days is estimated at $45,908. By adding each loss, the total flood loss for the library from a 100-year flood would be $108,408.

This information help you begin to form a picture of the damages that could be sustained in a hazard. You now know how individual hazard events can impact the various assists of your community or state.

After you have calculated the losses, you may want to assign a rank or relative priority to the losses to determine your mitigation priorities. In fact, there have been numerous attempts by academicians, communities, and states to develop quantitative methods to produce such rankings, ranging from the very simple to the very complex, particularly when losses were calculated using different probabilities of occurrence.

Experience has shown, however, that most communities do not rely on the relative ranking of losses as the primary determinant of priorities in beginning to address mitigation approaches. While quantitative processes form the basis of the risk determinations, political issues drive the decisions on which mitigation initiatives are pursued first. In other words, decisions involving mitigation initiatives are usually (and should be) discussed in the context of other ongoing planning processes that include consideration of non-hazard-related community goals as well as those related to emergency management. This will be discussed further in the next phase of the Natural Hazard Mitigation Planning Process.

Coastal hazard areas often present multiple risks at the same time. For example, hurricanes may simultaneously create wind, inland and coastal flooding, and erosion losses. Logically, the presence of multiple risks complicates the analysis process. Sometimes these risks do not influence each other at all in the same hazard event and losses may be analyzed separately and simply added up to get a picture of the total losses. At other times risks may exacerbate or nullify each other. There is no single “best” approach to assessing multiple risks. In general, it’s important first to understand the losses created by individual hazards, then try to determine the interaction among them.

It is perfectly legitimate from a statistical standpoint to add losses from different hazards of the same frequency (and from different frequencies if the level of damage is normalized by probability calculations). For example, if a coastal house would experience $14,000 damage in a 50-year wind event and $4,500 damage in a 50-year flood, then the house has $18,500 combined 50-year losses.

It’s also true that one hazard can cancel another out at some point. For example, let’s assume our coastal house would be destroyed by a 100-year wind event and a 100-year flood would result in three feet of water in the same house. In this case, the effect of flooding is negligible at the 100-year frequency since the house is presumably already destroyed by the wind.

Combinations of risk are most often addressed by adjusting standard damage curves to indicate the interactivity between or among risks.

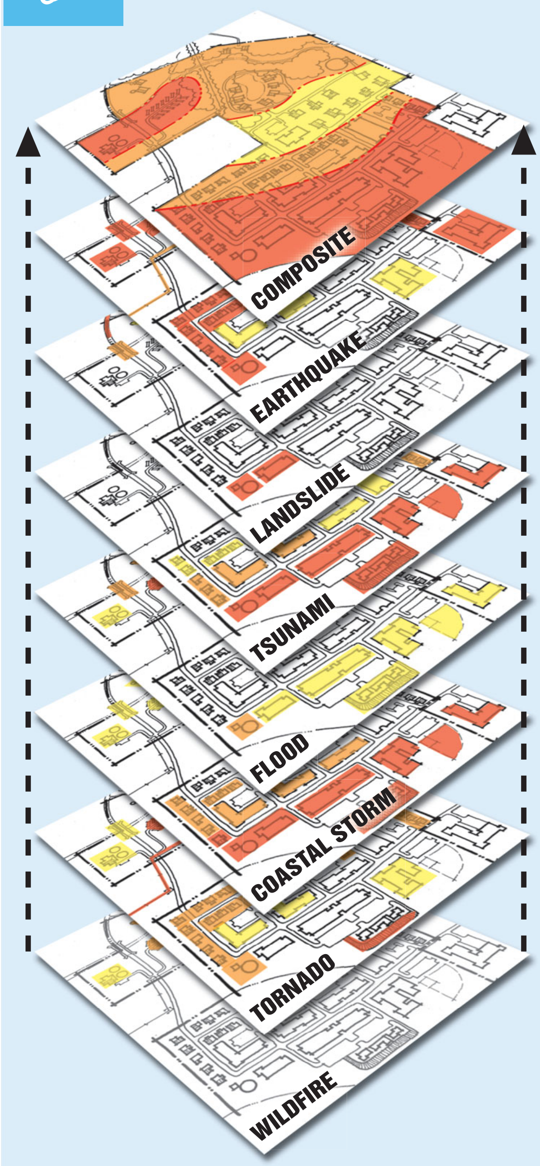
2. Calculate the estimated damages for each hazard event.

To find out which hazard event could have the largest economic losses for your community or state, total the loss from each hazard event type. For example, if there are three buildings located in the 100-year floodplain with estimated total flood losses of $10,000, $5,000, and $2,500, then your estimated flood loss from the 100-year flood event is $17,500.

Next, to find out which hazard event would likely impact the greatest proportion of the community or state, calculate the percent of the value of the assets susceptible to damage from each hazard. Divide the total hazard losses, by the total value of the assets you assessed for that hazard (from Step 3). For example, if your flood losses are estimated at $17,500 and the value of the three buildings you assessed is $100,250, then your flood losses would be approximately $17,500 divided by $100,250 or 17 percent of the value of the assets.

3. Create a composite map.

Prepare a map that shows a composite of the areas of highest loss (from Worksheet #4). You may want to indicate areas affected by multiple hazards as your high loss potential areas and the areas with one or no hazards as moderate or low potential loss. Another alternative is to identify areas with multiple critical facilities, major employers, repetitively damaged structures, and infrastructure as high potential loss areas.



A composite loss map can be created by overlaying results of individual hazard maps to determine areas with relatively more assets at risk than others.

Although this process can be enhanced by "weighting" the individual hazard results, any method that helps the community visualize areas with multiple concerns can be helpful.

This process is best accomplished with GIS but manual overlays with light tables and tracing paper will suffice.

The state should compile local risk assessments for a comprehensive summary and analysis of potential disaster losses. This should combine the state's risk assessment of state-owned structures as well as those from the local risk assessments. The information provided from the local risk assessments should also be referenced in the statewide mitigation plan.

For these reasons, you may consider specifying a general format for the information to be provided from the local communities as well as offering technical assistance to ensure the quality of the data. This might include help or training in benefit-cost analysis and HAZUS, development expertise in interpreting damage curves and estimating economic effects of lost functions for large-scale damages.

Summary

After this step you should have a good idea of which assets are subject to the greatest potential damages and which hazard event is likely to produce the greatest potential losses.

After you have estimated the expected losses from each of your hazard events

Go to the afterword

for information pertaining to the next step of the Natural Hazard Mitigation Planning Process.

The Hazardville Post

Vol. CXI No. 319 Thursday, November 15, 2001

Town Council Alarmed by Risk Assessment Results

(Part 4 of a 4 part series on the Risk Assessment Process)

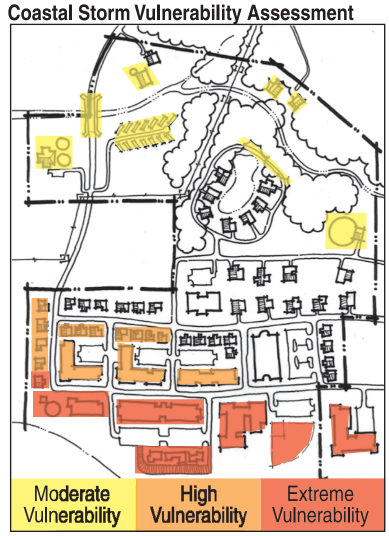
[Hazardville, EM] The members of the Town Council were stunned last night after learning the results of the risk assessment. At the public meeting to discuss the results, Joe Norris, lead planner of the Town of Hazardville Organization for Risk Reduction (THORR), reported that Hazardville certainly deserves its name. Norris said that since the last board meeting on December 4, 2001, THORR has computed the risk from seven separate hazards (floods, earthquakes, tsunamis, tornadoes, coastal storms, landslides, and wildfires).

"After taking an inventory of all of the assets in the community that lay within the hazard zones, the team estimated the amount of damage the assets would sustain based on the selected magnitude of the hazard events," Norris explained. "Using information we gleaned from maps and tax assessment records, we judged the possible structural damage, content damage, and consequences of the loss of function or structure use, then calculated the likely cost of this damage to the community." As the Town Council members questioned Norris and the THORR workgroup leaders, each disclosed the dangers to which the town is subject.

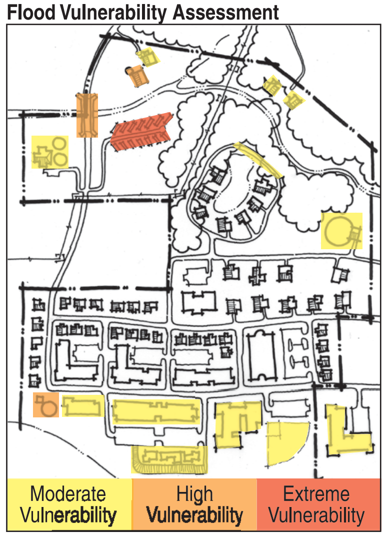
Mr. David Waters, head of the Flood and Coastal Storm Workgroup, testified to the Council that the town's manufactured home park has the greatest vulnerability of flood hazards due to the low elevation of the land in that area. "We estimated that a 100-year storm event would cause about two feet of flooding inside many of the homes in the park, which would result in about 63 percent total damage," he reported. A 100-year flood can also damage the bridge crossing the Raging River, especially if debris like timber and large rocks are swept away by the running water. Waters stated that the coastal region is vulnerable to coastal storms, but the inland areas can be flooded as well. "But the biggest threat from coastal storms is the erosion," stressed Waters. We estimated that with the current rate of erosion at five feet per year, the Hazardville boardwalk would be consumed by the Relentless Ocean within 60 years."

According to Ms. Wendy Soot, head of the Tornadoes and Wildfires Workgroup, erosion and flooding are not the only threats to the manufactured home park, the older areas of town, and the boardwalk. She explained that these areas are the most vulnerable assets to tornadoes in town, however a tornado could remove roofs, knock over walls, and even overturn cars and trains in any area of town. Soot, the town's Fire Marshal, added that a wildfire could spread very quickly in the Tinderbox National Forest and that a number of buildings in that area are vulnerable to wildfires.

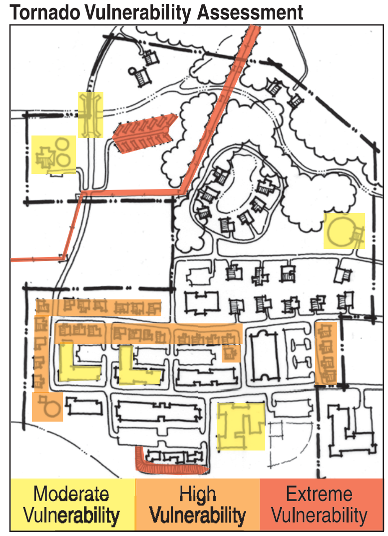
Coastal Storm Vulnerability Assessment



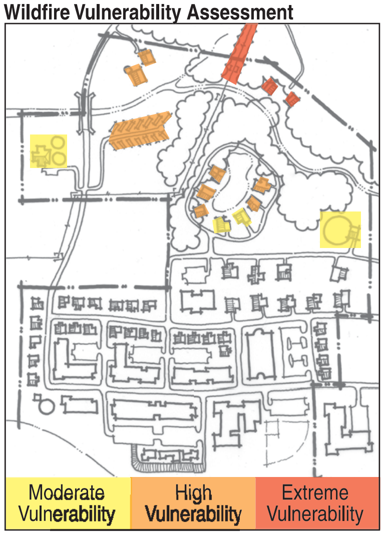
Flood Vulnerability Assessment



Tornado Vulnerability Assessment

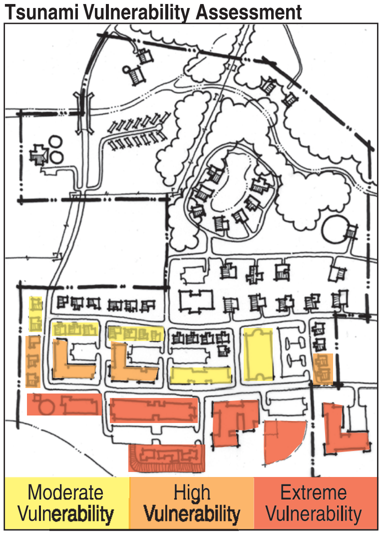


Wildfire Vulnerability Assessment



Mary Tremble, director of the Hazardville Emergency Management Agency (HEMA) and head of the THORR's Earthquake, Tsunami, and Landslide Workgroup, testified that Hazardville has a number of older unreinforced masonry buildings that are extremely vulnerable to earthquakes. In addition, earthquakes could disrupt the power and water supply to town by fracturing the lines or causing leaks. "Using HAZUS, we determined that an earthquake with 0.3g could result in about $4 million in damages." An offshore earthquake that produces a tsunami could also result in major damage to the coastal areas and moderate damage to the Town's police and fire department.

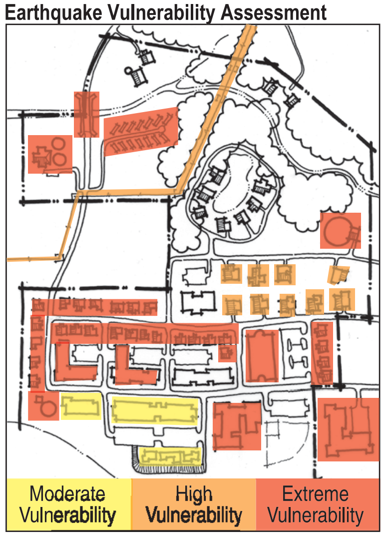
Tsunami Vulnerability Assessment



"The biggest initial concern for the Workgroup, which was landslides, turned out to be a very minor hazard in comparison," Tremble said. "A large landslide could destroy the lighthouse on the southwest shore of town and threaten the only road out of town, but it does not appear that landslides would cause the widespread damage once imagined."

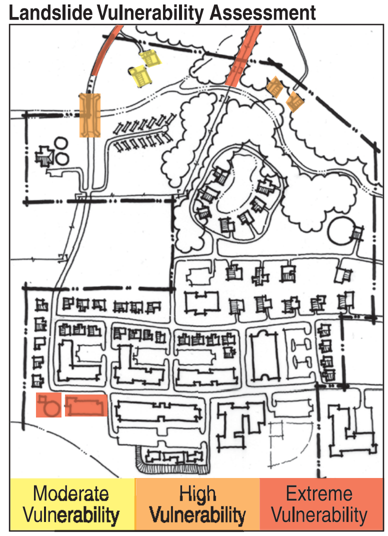
When asked what the cost of these potential damages could be to the town, Norris submitted to the Council a copy of the team's composite loss map and several hazard maps with a chart describing the criteria for determining the levels of potential loss to the hazards (see accompanying figures). The hazard maps exhibited the structures that

Earthquake Vulnerability Assessment



the team considered to be at moderate, high, and extreme potential for loss to each hazard. For each structure, the team determined the vulnerability thresholds based on the vulnerability of structures to the hazard and the probability of each hazard occurring. "Our results show that individually, each of these hazards shows a significant risk to the town." The accompanying chart demonstrated the criteria by which team determined which loss category the structures belonged. "Because of the importance to the community during or after a disaster, a critical facility that exhibited potential vulnerability to the hazard we determined should be in the 'high' or 'extreme' category."

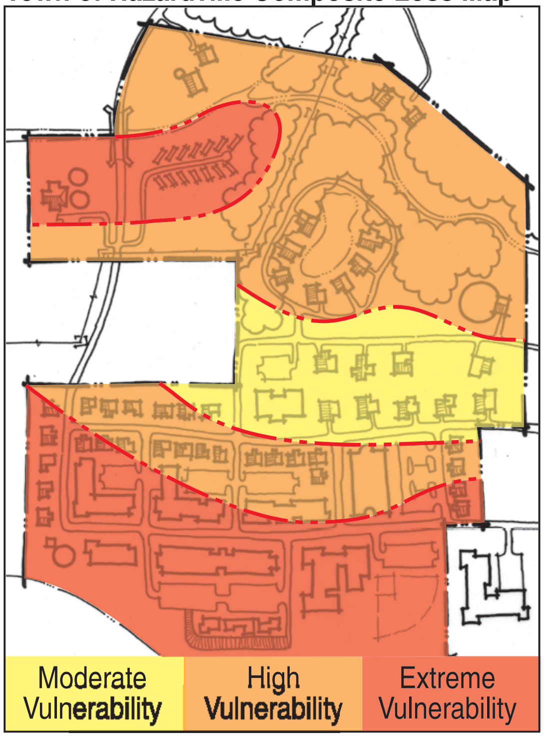
Landslide Vulnerability Assessment



Norris explained that the team then produced a Composite Loss Map (see graphic opposite) by relating the potential losses across hazards. "The team noticed that much the shoreline faced moderate, high, and extreme vulnerability to nearly every hazard. With so many different hazards presenting a high potential loss for this area, we decided that their overall exposure to loss was 'extreme'. On the other hand, the Middle Aged Residential Neighborhood has a moderate vulnerability only to earthquakes; therefore, we decided that their composite potential loss was 'moderate'." Norris cautioned that the loss values should not be compared across hazards because each has a different probability of occurrence, "however, the composite loss map demonstrates which areas of the community have the greatest potential of loss from the greatest number of hazards."

When asked about the next steps for the town in light of the risk assessment, Norris replied, "Even though completing the risk assessment was challenging, it will be the foundation for our hazard mitigation plan. Now that we know what is susceptible to the different hazards, and what those hazards will do to the buildings, infrastructure, and economy of Hazardville, we can start answering the question of how to deal with it."

Town of Hazardville Composite Loss Map



Significant Portions of the Hazardville Community are at "High" or "Extreme" Vulnerability to Hazards

Hazardville Loss Estimation Criteria

Hazard Type	Moderate Criteria (Yellow)	High Criteria (Orange)	Extreme Criteria (Red)
Floods	• Structures prone to less than 1 foot flooding	• Structures prone to 1 to 4 feet flooding • Mobile homes in floodplain • Critical facilities in floodplain	• Structures in floodway, or prone to >4 feet flooding or velocities >3 feet per second • Critical facilities prone to >2 feet flooding or velocities >3 feet per second • Mobile homes prone to >2 feet flooding or velocities >3 feet per second • Repetitive flood loss structures
Earthquakes	• Wood-frame structures	• Pre-seismic code structures • Unreinforced masonry buildings	• Structures on or near soils prone to liquefaction • Critical facilities built pre-seismic code
Tsunamis	• Structures near the coast	• Critical facilities near the coast • Pre-seismic or pre-flood code structures near the coast	• Pre-seismic or pre-flood code structures adjacent to the shoreline
Tornadoes	• Pre-wind code structures	• Historic buildings • Critical facilities	• Mobile homes • Pre-wind code critical facilities • Overhead power lines
Coastal Storms	• Structures near the shoreline • Structures in the 100-year floodplain	• Pre-flood or pre-wind code structures near the shoreline (including A or X zones) • Critical facilities near the shoreline (including A or X zones)	• Structures located in coastal V zones, seaward of dunes, or in areas with high erosion rates • Pre-flood or pre-wind code critical facilities
Landslides	• Structures near steep slopes	• Structures near steep slopes prone to erosion	• Structures near steep slopes that have soils prone to liquefaction • Structures near previous landslide areas
Wildfires	• Structures in close proximity to areas with light or medium fuels with slopes less than 40%	• Structures in close proximity to areas with medium fuels with slopes 41-60%	• Critical facilities in close proximity to areas with medium fuels and slopes 41 percent+ • Other structures in close proximity to areas with medium fuels and slopes 61 percent+ • Other structures in close proximity to areas with heavy fuels and slopes 41 percent+

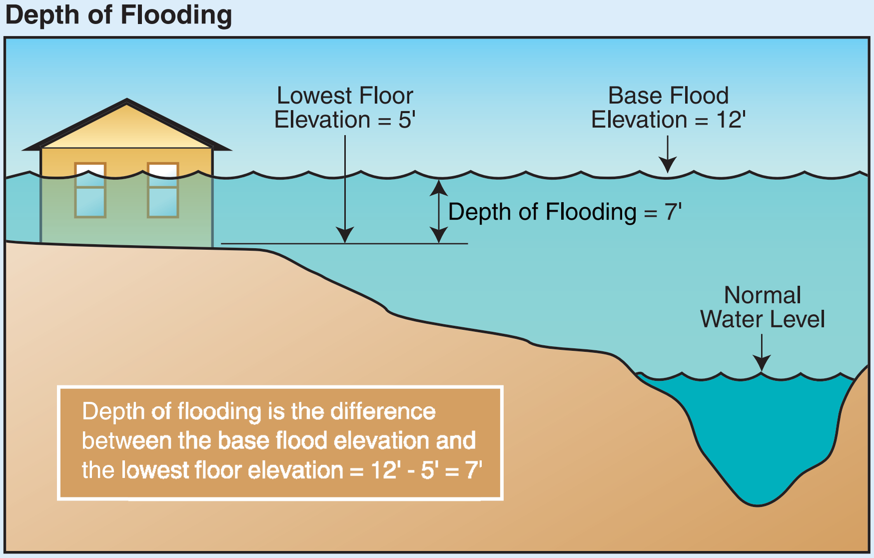
Floods

Flood vulnerability is the likelihood of something to be damaged in a flood. Generally, it is measured by how much something will be damaged as a percentage of its replacement value. For example, the Federal Insurance Administration database shows that a particular kind of house will get 35 percent damage if 4 feet of water inundated it. Another building gets 20 percent damage at the same flood depth. The building that gets the 35 percent damage is *more vulnerable* to flood damage. Remember that this is only one of the components of risk. Later in this section, you'll learn how to use this information to determine the expected future damages from one or more floods.

There are two things that determine vulnerability to a flood. The first is the tendency of physical things to get damaged. The second is the potential loss of function from losing certain elements of a community because of a flood. These are combined in the discussion at right, although they must be separately counted.

In this example, the first floor elevation is 5 feet above mean sea level; therefore, this structure would experience approximately 7 feet of flooding in a 100-year flood event.

Depth of Flooding



Floods

Task A. Determine the extent of damages from floods.

These loss estimation tables provide only very broad estimates based on historical trends. To get a better idea of the likely damage associated with a given flood level, you should conduct further research on the structure by talking with a structural engineer.

1. Calculate losses to structures due to floods.

In assessing physical vulnerability, the most important factor is the extent to which structures get damaged when they are exposed to water, high velocity, and debris impact. As compared to some of the other hazards considered in this guide, the effect of floods on building performance is fairly well understood and documented. The Flood Building Loss Estimation Table at right depicts the extent of damage from various flood depths on different kinds of structures. This table is from the FEMA Benefit-Cost Analysis Module and has been compiled based on flood damage across the country. This table provides a rule of thumb and may need to be adjusted for extenuating circumstances. There are many sources of this kind of information, often called "damage curves." The library (Appendix B) provides several references.

Depth of Flooding. Using the information you gathered previously, estimate the base flood depth at the location you are assessing by subtracting the lowest floor elevation from the base flood elevation.

Percent Structural Damage. Using the Flood Building Loss Estimation Table at right, find the type of structure you're assessing, match it with the estimated flood depth and determine the percent damage expected to that particular building.

For example, a two-story residential building without a basement that had 7 feet of flooding is estimated to result in 26 percent structural damage. But a manufactured home with 7 feet of flooding would result in 82 percent structural damage.

2. Calculate losses to contents due to floods.

The Flood Contents Loss Estimation Table shown here provides a simplified indication of the percent damage to building contents for various depths of flooding.

Percent Contents Damage. Using the depth of flooding determined above, find the type of building you're assessing on the Flood Contents Loss Estimation Table, match it with the estimated depth of flooding for that area of your community, and determine the percent contents damage. For example, a two-story residential building without a basement that had 7 feet of flooding is estimated to result in 39 percent contents damage, whereas a manufac-

It is important to note that this table is based on data from a wide range of building uses, including public/nonprofit, commercial, residential, and mixed buildings. It can also be used to evaluate infrastructure projects.

Flood Building Loss Estimation Table

Flood Depth (feet)	**One Story No Basement** (% Building Damage)	**Two Story No Basement** (% Building damage)	**One or Two Story With Basement** (% Building damage)	**Manufactured Home** (% Building damage)
-2	0	0	4	0
-1	0	0	8	0
0	9	5	11	8
1	14	9	15	44
2	22	13	20	63
3	27	18	23	73
4	29	20	28	78
5	30	22	33	80
6	40	24	38	81
7	43	26	44	82
8	44	29	49	82
>8	45	33	51	82

Source: FEMA Benefit-Cost Analysis Full Data Module 3/10/99

Flood Contents Loss Estimation Table

Flood Depth (feet)	**One Story No Basement** (% Contents Damage)	**Two Story No Basement** (% Contents damage)	**One or Two Story With Basement** (% Contents damage)	**Manufactured Home** (% Contents damage)
-2	0	0	6	0
-1	0	0	12	0
0	13.5	7.5	16.5	12
1	21	13.5	22.5	66
2	33	19.5	30	90
3	40.5	27	34.5	90
4	43.5	30	42	90
5	45	33	49.5	90
6	60	36	57	90
7	64.5	39	66	90
8	66	43.5	73.5	90
>8	67.5	49.5	76.5	90

Source: FEMA Benefit-Cost Analysis Full Data Module 3/10/99 tured home with 7 feet of flooding would result in 90 percent contents damage.

States should remember to include the contents from state owned facilities that are located in the floodplain, including vehicles and equipment.

Since the contents damage chart has been established over many flood events, the values are for generic contents. If you know that a particular building would endure an extraordinary amount of contents damage due to the particular contents, you should increase this value. For example, you should increase the amount of contents damage if a residence located in the floodplain contained valuable antiques or if you know an area is prone to excessively muddy water or contamination.

3. Calculate losses to building use and function due to floods.

The tables shown below and at right provide a simplified indication of functional downtime and displacement time for buildings due to various depths of flooding.

V Zone Flood Functional Downtime Table

Flood depth (feet)	Building without obstructions (functional downtime in days)	Building with obstructions (functional downtime in days)
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	10	20
-1	12	22
0	15	24
1	23	29
2	30	30
3	30	30
4	30	30
5	30	30
6	30	30
7	30	30
8	30	30
>8	36	30

Source: FEMA Benefit-Cost Analysis Coastal V Zone Module 2/28/99

Functional Downtime. Using the depth of flooding determined previously, find the type of building you're assessing on the Flood Functional Downtime Table, match it with the estimated depth of flooding for that area of your community, and determine the functional downtime.

For example, a business in a two-story building without a basement that had 7 feet of flooding would be closed for approximately 26 days before business can resume in another location. By contrast, a business in a manufactured home with 7 feet of flooding would be closed for 30 days before resuming business in another location.

Displacement Time. Using the depth of flooding determined above, find the type of building you're assessing on the Flood Displacement Time Table, match it with the estimated depth of flooding for that area of your community, and determine the displacement time.

For example, a business located in a two-story building without a basement that had 7 feet of flooding would be displaced from its regular building for approximately 158 days, while a business located in a manufactured home with 7 feet of flooding would be displaced for 365 days.

4. Consider human losses due to floods.

In the event that an area is subject to flash flooding where there are insufficient warning systems, it is possible that in basements or lower areas of homes, deaths can occur, especially if flash flooding occurs overnight. This situation (flash flooding) can also add to the contents damage of some buildings if there is not enough time to move contents to upper floors.

Storm surge, tsunamis, and flash floods can result in casualties, but deaths or injuries from non-flash riverine floods are relatively uncommon and are not considered in the guide.

V Zone Flood Displacement Time Table

Flood depth (feet)	Building without obstructions (displacement time in days)	Building with obstructions
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	30	110
-1	46	122
0	70	142
1	134	182
2	230	246
3	365	365
4	365	365
5	365	365
6	365	365
7	365	365
8	365	365
>8	365	365

Source: FEMA Benefit-Cost Analysis Coastal V Zone Module 2/28/99

Go to the next hazard on your list to estimate losses

or if you are finished with all your assessments

Go to the afterword

The quickest and easiest method of calculating risk from an earthquake is through the use of HAZUS. You will need to select a scenario earthquake or to base your analysis on a historic event; otherwise, all of the calculations and mapping will be completed for you.

Vulnerability of Contents

Building contents are also vulnerable to damage during an earthquake. Contents are most often damaged by falling, so an assessment will gauge not only if contents will fall under certain shaking conditions, but also whether they will break if they do fall. Remember, a full-blown risk assessment might include visits to many unique buildings in community, but for ordinary buildings such as residences, the vulnerability of contents will be quite similar from place to place.

Task A. Determine the extent of damages from earthquakes.

There are a number of factors that determine a building's performance in an earthquake. Mostly these have to do with the structural system, but things like height, the design of the first story, and building materials are also factors. In assessing the physical vulnerability of structures, the most important factor is how fragile they are. Fragility is the tendency of something to deform or break when it is subjected to stress. The more fragile something is, the more vulnerable it is. For example, most communities have some buildings that are constructed of unreinforced masonry. These buildings are often made of brick or stone and lack steel reinforcing to resist the effects of earthquakes.

When the earth is still, most of the forces on the walls of a masonry building are compressive, but in an earthquake, tension is introduced into structures from side-to-side movements such as swaying. Brick and stone are good at resisting compression or crushing, but are poor in resisting the effects of tension, which occurs when a building is being pulled apart. Unreinforced masonry buildings have little resistance to this kind of force, and often collapse under relatively light ground shaking.

1. Calculate losses to structures due to earthquakes.

The tables on the following pages provide a simplified indication of the damages to different kinds of buildings at various PGA values. For each building in your inventory, find the type of building you are assessing on the correct table and match the PGA value with the seismic design level (discussed in Step 3) to determine the estimated percent structural damage.

For example, if you are assessing a wood-framed single-family home constructed to high seismic building codes, in a 0.5 g PGA zone, you would estimate the structure to sustain 10 percent damage in an earthquake. However, the same structure built prior to any seismic building codes would sustain 32 percent structural damage.

2. Calculate the losses to contents due to earthquakes.

Building contents are often vulnerable to damage during an earthquake. Your risk assessment should estimate the likely value of contents within buildings that are similar, such as residences. You

(continued on page 4-23)

Earthquake Single Family Residence Loss Estimation Tables

PGA (g)	Building Damage Ratio (%)**									
	Wood Frame Construction				Reinforced Masonry				Unreinforced Masonry	
	High*	Moderate*	Low*	Precode*	High*	Moderate*	Low*	Precode*	Low*	Precode*
0.55	11.6	16.1	30.6	36.8	11.5	27.7	43.9	53.1	45.0	55.6
0.50	10.2	14.0	26.0	31.7	9.6	22.8	36.6	46.1	38.5	46.8
0.45	8.7	11.6	21.1	27.1	8.3	19.7	31.7	40.8	34.0	41.2
0.40	6.1	7.6	13.1	16.7	6.1	12.1	18.6	25.1	22.8	28.1
0.35	4.4	6.3	10.1	12.8	4.9	8.8	15.2	20.8	18.9	23.8
0.30	2.9	3.9	7.2	9.4	3.5	6.1	11.4	16.3	15.4	19.7
0.25	2.3	3.2	4.6	6.1	2.4	3.9	8.7	12.4	10.2	14.9
0.20	1.3	1.7	2.8	3.3	1.3	2.5	6.1	9.0	6.5	9.4
0.15	0.7	1.0	1.3	1.8	0.4	1.5	2.4	4.1	3.0	4.3
0.10	0.3	0.4	0.6	0.7	0.3	0.5	0.8	1.1	1.3	2.0
0.07	0.1	0.2	0.3	0.4	0.1	0.2	0.4	0.5	0.6	1.0
0.05	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.2	0.2	0.5
0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2

PGA (g)	Loss of Function (# of Days)									
	Wood Frame Construction				Reinforced Masonry				Unreinforced Masonry	
	High*	Moderate*	Low*	Precode*	High*	Moderate*	Low*	Precode*	Low*	Precode*
0.55	40	79	195	283	61	246	430	542	459	549
0.50	31	69	159	241	51	198	365	484	399	500
0.45	23	51	119	201	44	169	318	439	356	457
0.40	14	27	68	111	24	95	184	276	238	326
0.35	9	23	47	80	18	67	153	236	201	281
0.30	4	10	30	55	14	46	117	189	161	239
0.25	3	8	17	34	9	26	91	150	104	185
0.20	2	3	9	15	4	16	58	106	64	114
0.15	1	2	3	8	1	8	24	51	26	49
0.10	0	1	1	3	1	2	7	14	10	27
0.07	0	0	1	1	0	1	2	7	6	12
0.05	0	0	0	1	0	0	1	1	1	7
0.03	0	0	0	0	0	0	0	1	1	1

* High, Moderate, Low and Precode refer to the general seismic design level

**Building Damage Ratio = Repair Cost / Replacement Value

Source: HAZUS

Earthquake Apartment Building Loss Estimation Tables

PGA (g)	Building Damage Ratio (%)**									
	Wood Frame Construction				Reinforced Masonry				Unreinforced Masonry	
	High*	Moderate*	Low*	Precode*	High*	Moderate*	Low*	Precode*	Low*	Precode*
0.55	11.7	15.0	25.5	30.2	12.2	24.5	36.4	43.4	37.9	43.7
0.50	10.2	13.2	22.2	26.5	10.2	20.4	30.3	37.7	32.6	38.4
0.45	8.9	11.1	18.6	22.0	8.9	17.8	26.4	33.1	28.8	34.1
0.40	6.6	8.1	12.5	12.6	6.9	11.4	16.1	20.9	19.8	23.7
0.35	4.8	6.7	9.7	10.0	5.5	8.6	13.1	17.3	16.4	20.0
0.30	3.3	4.2	7.3	7.6	4.0	6.0	9.9	13.4	13.5	16.5
0.25	2.5	3.5	4.9	5.1	2.7	4.0	7.6	10.2	9.1	12.6
0.20	1.5	1.9	3.0	3.2	1.5	2.6	5.4	6.9	5.5	7.5
0.15	0.7	1.1	1.5	1.6	0.5	1.6	2.3	3.4	2.9	3.5
0.10	0.3	0.4	0.5	0.6	0.3	0.5	0.8	1.0	1.2	1.7
0.07	0.1	0.2	0.3	0.3	0.1	0.2	0.4	0.5	0.6	0.8
0.05	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.2	0.2	0.3
0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1

PGA (g)	Loss of Function (# of Days)									
	Wood Frame Construction				Reinforced Masonry				Unreinforced Masonry	
	High*	Moderate*	Low*	Precode*	High*	Moderate*	Low*	Precode*	Low*	Precode*
0.55	45	81	205	314	74	321	505	720	608	730
0.50	35	72	169	272	61	257	426	642	527	663
0.45	25	57	130	218	53	219	369	582	470	606
0.40	14	30	75	125	28	121	215	363	312	405
0.35	10	26	51	92	21	84	177	309	262	351
0.30	4	10	33	63	16	57	135	247	209	298
0.25	3	9	19	39	10	31	104	195	133	230
0.20	2	3	10	16	4	19	72	129	76	147
0.15	1	2	3	9	1	9	28	59	32	65
0.10	0	1	1	3	1	2	8	16	12	32
0.07	0	0	1	1	0	1	2	8	7	13
0.05	0	0	0	1	0	0	1	1	1	7
0.03	0	0	0	0	0	0	0	0	0	1

* High, Moderate, Low and Precode refer to the general seismic design level

**Building Damage Ratio = Repair Cost / Replacement Value

Source: HAZUS

Earthquake Professional Office Building Loss Estimation Tables

PGA (g)	Building Damage Ratio (%)**							
	Concrete Wall Construction				Steel Frame (Braced)			
	High*	Moderate*	Low*	Precode*	High*	Moderate*	Low*	Precode*
0.55	14.0	23.7	37.0	43.7	14.5	18.6	31.2	38.3
0.50	12.0	20.0	31.0	39.1	12.1	15.2	25.0	32.1
0.45	9.9	17.2	27.2	34.2	10.5	13.3	20.8	27.6
0.40	7.2	11.4	16.5	22.0	7.9	9.1	13.1	17.5
0.35	5.4	9.4	13.5	18.4	6.5	7.3	10.0	13.6
0.30	4.2	7.2	10.0	14.2	4.7	5.4	7.5	10.1
0.25	3.0	4.7	7.8	11.0	3.7	4.0	5.3	7.4
0.20	2.0	2.9	5.6	8.1	2.5	2.9	3.7	5.2
0.15	1.0	1.8	3.2	5.4	1.5	1.7	2.4	3.2
0.10	0.4	0.6	1.0	1.5	0.5	0.7	0.9	1.3
0.07	0.2	0.3	0.4	0.6	0.2	0.3	0.4	0.5
0.05	0.0	0.1	0.2	0.2	0.0	0.1	0.2	0.2
0.03	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0

PGA (g)	Loss of Function (# of Days)							
	PreCast Concrete Tilt-up				Light Metal Building			
	High*	Moderate*	Low*	Precode*	High*	Moderate*	Low*	Precode*
0.55	14	44	87	110	16	32	73	99
0.50	12	35	73	99	13	26	57	85
0.45	9	30	64	89	10	22	47	74
0.40	5	17	35	55	7	12	25	43
0.35	4	14	29	46	5	9	18	33
0.30	3	10	21	36	3	7	13	25
0.25	2	6	16	28	3	4	8	17
0.20	1	3	11	21	2	3	5	11
0.15	1	2	6	14	1	1	3	7
0.10	0	0	1	3	0	0	1	2
0.07	0	0	0	1	0	0	0	1
0.05	0	0	0	0	0	0	0	0
0.03	0	0	0	0	0	0	0	0

* High, Moderate, Low and Precode refer to the general seismic design level

**Building Damage Ratio = Repair Cost / Replacement Value

Source: HAZUS

Earthquake Retail Trade Building Loss Estimation Tables

PGA (g)	Building Damage Ratio (%)**									
	Steel Frame (Braced)				Reinforced Masonry				Unreinforced Masonry	
	High*	Moderate*	Low*	Precode*	High*	Moderate*	Low*	Precode*	Low*	Precode*
0.55	14.2	19.0	33.3	41.6	11.9	25.0	37.7	45.4	40.0	46.2
0.50	11.8	15.5	26.7	35.0	10.0	20.9	31.6	39.9	34.8	41.3
0.45	10.1	13.5	22.1	30.2	8.8	18.2	27.7	35.4	30.9	37.1
0.40	7.5	9.1	13.6	19.0	6.7	11.6	17.0	22.8	21.5	26.4
0.35	6.1	7.2	10.4	14.8	5.3	8.7	14.0	19.1	17.9	22.5
0.30	4.4	5.4	7.7	11.0	3.9	6.1	10.6	15.0	14.7	18.9
0.25	3.5	3.9	5.4	8.0	2.6	4.1	8.3	11.7	9.9	14.5
0.20	2.4	2.8	3.8	5.6	1.5	2.7	5.9	8.3	6.1	8.7
0.15	1.4	1.6	2.4	3.5	0.5	1.5	2.6	4.2	3.1	4.3
0.10	0.5	0.6	0.9	1.4	0.3	0.5	0.9	1.2	1.3	2.1
0.07	0.2	0.3	0.4	0.5	0.1	0.2	0.4	0.6	0.7	1.0
0.05	0.0	0.1	0.2	0.2	0.0	0.1	0.1	0.2	0.2	0.5
0.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1

PGA (g)	Loss of Function (# of Days)									
	Steel Frame (Braced)				Reinforced Masonry				Unreinforced Masonry	
	High*	Moderate*	Low*	Precode*	High*	Moderate*	Low*	Precode*	Low*	Precode*
0.55	17	34	76	102	12	51	88	110	94	115
0.50	14	28	61	88	10	41	76	99	82	104
0.45	11	23	49	77	9	36	66	90	73	93
0.40	7	13	27	45	5	20	38	57	49	67
0.35	5	10	19	35	4	14	32	49	41	58
0.30	3	8	14	26	3	9	25	39	33	49
0.25	2	4	9	18	2	5	19	31	21	38
0.20	2	3	6	12	1	3	12	22	14	24
0.15	1	1	3	7	0	2	5	10	6	12
0.10	0	0	1	2	0	0	1	3	2	6
0.07	0	0	0	0	0	0	0	1	1	2
0.05	0	0	0	0	0	0	0	0	0	1
0.03	0	0	0	0	0	0	0	0	0	0

* High, Moderate, Low and Precode refer to the general seismic design level

**Building Damage Ratio = Repair Cost / Replacement Value

Source: HAZUS

Earthquake Wholesale Trade Warehouse Loss Estimation Tables

PGA (g)	Building Damage Ratio (%)**							
	PreCast Concrete Tilt-up				Light Metal Building			
	High*	Moderate*	Low*	Precode*	High*	Moderate*	Low*	Precode*
0.55	15.9	26.8	32.9	35.8	25.5	33.8	50.3	56.0
0.50	14.1	23.5	29.6	33.0	21.8	29.1	44.5	51.7
0.45	12.2	21.1	26.5	30.0	18.2	25.5	40.0	47.7
0.40	9.4	14.8	18.9	22.1	12.5	16.9	26.3	32.6
0.35	7.9	11.8	16.2	19.4	9.8	14.2	21.9	28.3
0.30	5.8	8.5	13.5	16.4	7.4	11.4	17.5	23.3
0.25	4.2	6.1	10.9	13.7	5.6	9.1	13.6	19.0
0.20	2.6	4.1	8.3	10.8	3.8	5.4	10.3	14.8
0.15	1.5	2.2	4.3	6.7	2.1	3.1	7.1	10.4
0.10	0.6	1.0	1.7	2.4	0.9	1.4	2.7	5.2
0.07	0.2	0.4	0.5	0.6	0.4	0.7	1.0	1.6
0.05	0.1	0.1	0.2	0.5	0.1	0.2	0.3	0.6
0.03	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.2

PGA (g)	Loss of Function (# of Days)							
	PreCast Concrete Tilt-up				Light Metal Building			
	High*	Moderate*	Low*	Precode*	High*	Moderate*	Low*	Precode*
0.55	27	69	102	120	52	78	117	132
0.50	23	60	90	111	44	68	107	125
0.45	20	54	81	103	37	60	97	118
0.40	14	35	53	72	24	40	65	83
0.35	11	26	45	63	18	34	56	75
0.30	8	18	37	54	14	28	45	64
0.25	5	12	30	45	10	22	36	54
0.20	4	8	22	36	6	13	28	43
0.15	2	4	11	21	4	7	20	32
0.10	1	2	4	7	2	3	8	17
0.07	0	1	1	2	1	2	3	6
0.05	0	0	0	1	0	0	1	2
0.03	0	0	0	0	0	0	0	0

* High, Moderate, Low and Precode refer to the general seismic design level

**Building Damage Ratio = Repair Cost / Replacement Value

Source: HAZUS

Earthquake Light Industrial Facility Loss Estimation Tables

PGA (g)	Building Damage Ratio (%)**			
	PreCast Concrete Construction			
	High*	Moderate*	Low*	Precode*
0.55	15.7	21.4	24.0	25.9
0.50	14.1	18.9	21.6	23.7
0.45	12.3	16.9	18.9	21.0
0.40	10.0	12.4	14.4	16.3
0.35	8.5	10.3	12.4	14.2
0.30	6.1	7.7	10.1	11.8
0.25	4.3	5.5	8.0	9.6
0.20	2.6	3.9	6.0	7.4
0.15	1.5	2.1	3.3	4.7
0.10	0.5	0.8	1.4	1.8
0.07	0.1	0.4	0.4	0.5
0.05	0.1	0.1	0.2	0.3
0.03	0.0	0.0	0.1	0.1

PGA (g)	Loss of Function (# of Days)			
	PreCast Concrete Tilt-up			
	High*	Moderate*	Low*	Precode*
0.55	26	65	99	118
0.50	22	56	87	109
0.45	19	51	78	101
0.40	13	33	51	69
0.35	11	25	43	60
0.30	7	17	35	51
0.25	5	11	28	43
0.20	4	7	21	34
0.15	2	3	10	19
0.10	1	2	4	6
0.07	0	1	1	2
0.05	0	0	0	2
0.03	0	0	0	0

* High, Moderate, Low, and Precode refer to the general seismic design level

**Building Damage Ratio = Repair Cost / Replacement Value

Source: HAZUS

(continued from page 4-16)

might also want to conduct site visits of buildings with unique or especially valuable community assets.

Contents loss estimation tables are not currently available for earthquake damage. Your estimated contents loss should be based on the replacement value of the contents, the potential of the contents to break or fall and the estimated percent structural damage. As a rule, the percent contents damage will usually be one half of the percent structural damage.

For example, if you were assessing a residential building with an estimated 40 percent building damage, you would estimate that the contents damage would be 20 percent of the building's replacement value.

Estimating the contents losses due to earthquakes can be a difficult process and in many cases may be counter intuitive to non-technical users. For example, buildings designed under high seismic building codes may actually have a higher proportion of content damage than older/weaker buildings, because they are designed to sway and absorb the motion of the ground movements.

Earthquake contents damage ratios are generally around half of the building's damage ratios. This relative proportion is slightly higher for structures built using higher seismic design codes and decreases for buildings constructed under low seismic design codes, although these differences are not major. HAZUS will give you more accurate estimates of potential contents damage from earthquakes.

3. Calculate the losses to building use and function due to earthquakes.

In this step you will assess community or state vulnerability in terms of loss of function. In this area, vulnerability is directly related to how long a function will be interrupted due to an earthquake. You will estimate how long particular functions in the community will be interrupted because of an earthquake.

Building loss of function times (in days) are presented in the tables on the preceding pages. These times represent estimates of the average time for actual cleanup and repair, or reconstruction. These estimates should be extended to account for delays in decision-making, financing, inspection etc., as necessary. For each building in your inventory, find the type of structure you are assessing on the correct table and match the PGA value with the seismic design level to determine the estimated loss of function (in days).

For example, if you were assessing a wood-framed single-family home constructed to high seismic building codes, subject to 0.5 g PGA, you would estimate 31 days of lost function. However the same structure built prior to any seismic building codes would sustain 241 days of lost function.

HAZUS

For earthquake hazards, HAZUS provides users with estimates of:

- Physical damage to buildings and critical facilities;
- Direct and indirect economic losses;
- Repair and replacement losses; and
- Social impacts.

4. Calculate human losses due to earthquakes.

While direct deaths and injuries from an earthquake are unlikely, they can occur as an indirect result when structures collapse. Evaluate your current and previous seismic building codes to determine the number of people living in buildings constructed before the seismic building code was adopted, or in buildings located in densely populated areas.

Go to the next hazard on your list to estimate losses

or if you are finished with all your assessments

Go to the afterword

Tsunamis

Task A. Determine the extent of damage from tsunamis.

In assessing physical vulnerability, the most important factor is the extent to which structures get damaged when they are exposed to tsunamis. Structures located in coastal areas with known offshore faults are at the greatest risk of damage from tsunamis.

1. Calculate losses to structures due to tsunamis.

Since there are not any standard loss estimation models and tables for tsunamis, your estimated structure vulnerability will be based on the proximity of the structure to the shoreline, and/or past occurrences of tsunamis.

If you hired a geologist or other expert to create your community's tsunami hazard map, he or she may also be able to estimate the potential damage for you.

2. Calculate losses to contents due to tsunamis.

Again, there are not any standard loss estimation models and tables for contents damage from tsunamis. Your estimated contents loss should be based on the structural damage you just determined.

3. Calculate losses to structure use and function due to tsunamis.

Vulnerability is directly related to how long a function will be interrupted due to a tsunami. Since there are not any standard displacement time or functional downtime tables for tsunamis, such as there are for floods, you must estimate how long particular functions will be interrupted because of a tsunami hazard event. Go to page 4-4, "Estimate the losses to structure use and function" to find specific advice on how to assess the displacement time and functional downtime.

4. Calculate human losses due to tsunamis.

In the event that an area is subject to tsunamis, it is possible that deaths can occur. You may need to rely on statistics from past tsunamis in your area to determine the vulnerability of the population to tsunamis.

The state should focus on areas where tsunamis may inundate major transportation routes, and state-owned facilities, or impact facilities that would have statewide effects, such as airports, ports, and critical facilities that serve large areas.

As a rule of thumb, use the vulnerability assumptions and figures that you will use for the flood component of coastal storms and increase them if necessary.

Go to the next hazard on your list to estimate losses

or if you are finished with all your assessments,

Go to the afterword

Tornadoes

Task A. Determine the extent of damage from tornadoes.

In assessing vulnerability, the most important factor is how likely structures are to fail when they are subjected to wind loads that exceed their design or to flying debris that penetrates the building. Structural damages from tornadoes are a function of the building's location relative to the tornado vortex, which cannot be predicted or mapped. In general, building damages can range from cosmetic to complete structural failure, depending on wind speed and location of the building with respect to the tornado path. Only a qualified architect or structural engineer can do more than the most rudimentary analysis of a building's capacity to resist the effects of tornadoes.

The state should focus on state buildings and facilities that, if damaged or destroyed by a tornado, would have statewide effects, such as critical facilities, transportation terminals, and state government buildings.

1. Calculate losses to structures due to tornadoes.

Since there are not any standard loss estimation models and tables for tornadoes, your estimated structure vulnerability will be based on past occurrences of tornadoes and the design wind speed you determined in Step 2.

2. Calculate losses to contents due to tornadoes.

Again, there are not any standard loss estimation models and tables for content damage from tornadoes. Your estimated content losses should be based on the amount of damage to the structures.

3. Calculate losses to structure use and function due to tornadoes.

Vulnerability is directly related to how long a function will be interrupted due to a tornado. Since there are not any standard displacement time or functional downtime tables for tornadoes, you will estimate how long particular functions will be interrupted because of a tornado hazard event. Go to page 4-4, "Estimate the losses to structure use and function" to find specific advice on how to assess the displacement time and functional downtime.

4. Calculate human losses due to tornadoes.

The safest place for people during a tornado is in a safe-room or storm shelter designed to specific performance criteria. Communities should assess the number, location, capacity, and strength of shelters throughout the community to ensure they are able to house residents and withstand the design wind speed. This is primarily the responsibility of the emergency manager.

Go to the next hazard on your list to estimate losses

or if you are finished with all your assessments,

Go to the afterword

Coastal Storms

Task A. Determine the extent of damage from coastal storms.

There are numerous factors to consider when assessing the vulnerability of buildings in coastal storms. Physical vulnerability refers to a building's capacity to withstand:

- high-velocity storm surge flooding,
- erosion or scour, and
- strong winds

For example, the end walls of homes with gabled roofs receive much of the force of winds, and if trusses are not properly braced, roofs can fail. However, only a qualified architect or structural engineer can do more than the most rudimentary analysis of a building's structural integrity, so for the purposes of this loss estimate, use common sense strategies for determining a building's capacity to withstand wind and water.

1. Calculate losses to structures due to coastal storms.

In assessing physical vulnerability, the most important factor is the extent to which structures get damaged when they are exposed to water, erosion/scour, high velocity wind, and debris impact.

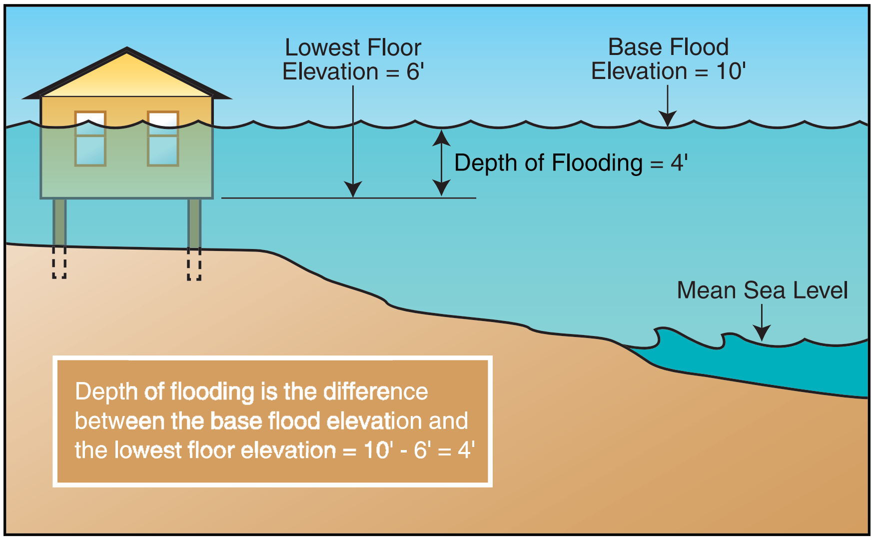
Flood Damage. The V Zone Flood Building Loss Estimation Table shown at right is an example of the extent of damage from various flood depths in coastal V zones on different kinds of buildings. This table is from the FEMA Benefit-Cost Analysis software and has been compiled based on coastal damage in the United States. This table may need to be adjusted for extenuating circumstances. The V zone is usually only the first two or three blocks of homes closest to the flooding source. You will also need to assess the vulnerability for structures in coastal A zones as

V Zone Flood Building Loss Estimation Table

Flood depth (feet)	Building without obstructions (% building damage)	Building with obstructions
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	10	20
-1	12	22
0	15	24
1	23	29
2	35	37
3	50	54
4	58	61
5	63	65
6	67	68
7	70	70
8	72	72
>8	76	76

Source: FEMA Benefit-Cost Analysis Coastal V Zone Module 2/28/99

Depth of Flooding



well. Use the tables beginning on page 4-13 as the basis to assess the coastal A zones. You may wish to increase the figures slightly to account for greater velocities in coastal A zones than in riverine A zones.

- Estimate depth of flooding: Using the information you gathered previously, estimate the flood depth at the location you are assessing by subtracting the lowest floor elevation from the flood elevation, as shown in the illustration.
- Determine percent structural damage: Using the V Zone Flood Building Loss Estimation Table, find the type of building you're assessing, match it with the estimated flood depth, and determine the expected damage to that particular building. For example, a building 4 feet below the base flood, without any obstructions under the lowest floor, would be estimated to have 58 percent structural damage. But a structure with obstructions below the base flood elevation would result in 61 percent structural damage.

Erosion Damage. Unfortunately, current standard loss estimation models and tables for erosion damages are not available. As a result, you may wish to simplify your consideration of structure damage so that buildings are assumed to be either undamaged or severely damaged due to erosion. Although slight or moderate damage can occur due to erosion, the likelihood of this level of damage is considered small. Your estimated structure loss from erosion should be based on past experience, the location of the structure within the hazard area, rate of erosion, and the structure replacement value.

Wind Damage. There are currently no standard loss estimation models or tables for wind damage. You should consult with your building official to help determine the amount of damage to be expected to your community's assets as a result of the design wind speed you determined in Step 2.

2. Calculate losses to contents due to coastal storms.

Building contents are often vulnerable to damage by wind and water during a coastal storm; therefore, your assessment should take into account the fact that contents on lower levels of buildings may receive water damage, while those on upper floors may receive wind damage. Your risk assessment should estimate the likely value of contents within buildings that are similar, such as residences. You also may want to conduct site visits to buildings with unique or especially valuable community assets.

Flood Damage. Using the depth of flooding determined previously, find the type of structure you're assessing on the V Zone Flood Contents Loss Estimation Table, match it with the estimated depth of flooding for that area of your community, and determine the percent contents damage.

Since the contents damage chart has been established over many coastal flood events, the values are for generic contents. If you know that a particular structure would endure an extraordinary amount of contents damage, you should increase this value. You should also increase the amount of contents damage if a residence located in the floodplain is known to contain valuable items or if you know an area is prone to excessively muddy water or contamination.

Erosion Damage. Again, there are no standard loss estimation models and tables for contents damage from erosion.

Your estimated contents loss should be based on the structural damage from erosion, location of the structure within the hazard area, and rate of erosion.

V Zone Flood Contents Loss Estimation Table

Flood depth (feet)	Building without obstructions (% contents damage)	Building with obstructions
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	0	0
-1	6	11
0	15	24
1	23	29
2	35	37
3	50	54
4	58	61
5	63	65
6	67	68
7	70	70
8	72	72
>8	76	76

Source: FEMA Benefit-Cost Analysis Coastal V Zone Module 2/28/99

V Zone Flood Functional Downtime Table

Flood depth (feet)	Building without obstructions (functional downtime in days)	Building with obstructions
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	10	20
-1	12	22
0	15	24
1	23	29
2	30	30
3	30	30
4	30	30
5	30	30
6	30	30
7	30	30
8	30	30
>8	36	30

Source: FEMA Benefit-Cost Analysis Coastal V Zone Module 2/28/99

V Zone Flood Displacement Time Table

Flood depth	Building without obstructions	Building with obstructions
(feet)	(displacement time in days)	
-8	0	0
-7	0	0
-6	0	0
-5	0	0
-4	0	0
-3	0	0
-2	30	110
-1	46	122
0	70	142
1	134	182
2	230	246
3	365	365
4	365	365
5	365	365
6	365	365
7	365	365
8	365	365
>8	365	365

Source: FEMA Benefit-Cost Analysis Coastal V Zone Module 2/28/99

States should remember to include the contents from state owned facilities that are located in the coastal floodplain, including vehicles and equipment.

Wind Damage. There are currently no standard loss estimation models and tables for contents damage from coastal storm winds. You should base your estimates on the structural damage from wind, and the location of the building within the hazard area.

3. Calculate losses to structure use and function due to coastal storms.

In this step you will assess community or state vulnerability in terms of loss of function. In this area, vulnerability is directly related to how long a function will be interrupted due to a coastal storm, so you will estimate how long particular functions in the community will be interrupted. Depending on the severity of the coastal storm and the amount of damage a building or other structure is likely to sustain, it is possible the function could be completely eliminated.

The tables on the previous pages provide a simplified indication of functional downtime and displacement time for structures due to various depths of flooding.

Functional Downtime: Using the depth of flooding determined earlier, find the type of building you're assessing on the V Zone Flood Functional Downtime Table, match it with the estimated depth of flooding for that area of your community, and determine the function downtime.

For example, a building that had 4 feet of flooding is estimated to result in 30 days of downtime before business can resume in another location.

Displacement Time: Using the depth of flooding determined earlier, find the type of building you're assessing on the V Zone Flood Displacement Time Table, match it with the estimated depth of flooding for that area of your community, and determine the displacement time.

For example, a building that had 4 feet of flooding is estimated to result in 365 days of displacement time.

4. Calculate human losses due to coastal storms.

Increased development in coastal areas has placed a high number of people at risk of hurricanes and coastal storms. Fortunately, most hurricanes and other coastal hazards are predictable and take a number of days to develop, which allows adequate warning time. However, deaths still can occur, especially when evacuation orders are ignored.

Go to the next hazard on your list to estimate losses

or if you are finished with all your assessments

Go to the afterword

Landslides

The state should focus on landslides that will block major transportation routes, bury state-owned facilities, or impact facilities that would have statewide effects, such as airports, ports, and critical facilities that serve large areas.

Task A. Determine the extent of damage from landslides.

In assessing physical vulnerability, the most important factor is the extent to which structures get damaged when they are exposed to landslides. Structures located close to dangerous topographic features such as the tops or bases of slopes or in valleys are at a greater risk of damage from landslides.

1. Calculate losses to structures due to landslides.

Unfortunately, current standard loss estimation models and tables only tabulate damages for landslides resulting from earthquakes. (See the earthquakes resource list in Appendix B or HAZUS for more information.) Your estimated structure loss should therefore be based on the location of the structure within the hazard area and past occurrences of landslides. If you hired a geologist or other expert to create your community's landslide hazard map, he or she may also be able to estimate the potential damage for you. If not, assessing vulnerability to structures can be simplified so that they are assumed to be either undamaged or severely damaged due to landslides. Although slight or moderate damage can occur due to landslides, the likelihood of this level of damage is considered small. You may wish to consult with your building official to help estimate structural damage.

The acceleration required to initiate slope movement is a complex function of slope geology, steepness, groundwater conditions, type of landslide, and history of previous slope performance. A generally accepted relationship or simplified methodology for estimating slope movements has not been developed yet.

2. Calculate losses to contents due to landslides.

Again, there are no standard loss estimation models and tables for content damage from landslides.

Your estimated contents loss should be based on the location of the structure and its contents within the hazard area and past occurrences of landslides.

3. Calculate losses to structure use and function due to landslides.

Vulnerability is directly related to how long a function will be interrupted due to a landslide. Since there are not any standard displacement time or functional downtime tables for landslides, you will estimate how long particular functions in the community will be interrupted because of a particular level of damage. Go to page 4-4, "Estimate the losses to structure use and function," to find specific advice on how to assess the displacement time and functional downtime.

4. Calculate human losses due to landslides.

In the event that an area is subject to earthquakes, rapid snowmelt, or mudflows, or where there are insufficient warning systems, it is possible that deaths can occur, especially if roads are damaged. You may need to rely on statistics from past landslides in your area to determine the vulnerability of the population to landslides.

Go to the next hazard on your list to estimate losses

or if you are finished with all your assessments

Go to the afterword

Wildfires

States should focus on state buildings and facilities that, if damaged or destroyed by wildfires, would have statewide effects. Contact your state forester or the U.S. Forest Service (see Appendix B).

Use the Wildfire Hazard Rating Form on page 4-37 to calculate the hazard to subdivisions within the community. You may also wish to use it to evaluate all areas near the urban wildland interface. Contact your local fire department or engineer for assistance with this form.

Task A. Determine the extent of damage from wildfires.

In assessing physical vulnerability, the most important factor is the extent to which structures get damaged when they are exposed to fire and heat. Structures located near the urban-wildland interface area are at the greatest risk of damage from wildfires.

1. Calculate losses to structures due to wildfires.

Current standard loss estimation tables do not exist for wildfires. You may wish to contact your local fire department to help estimate structural vulnerability.

2. Calculate losses to contents due to wildfires.

There are not any standard loss estimation models and tables for contents damage. Assumptions about damage to contents should be increased for contents that are sensitive to heat such as electronics, and contents that would be damaged as a result of the fire suppression efforts (i.e., water damage) such as books or paper files.

3. Calculate losses to structure use and function due to wildfires.

Vulnerability is directly related to how long a function will be interrupted due to a wildfire. Since there are no standard displacement time or functional downtime tables for wildfires, you will need to estimate how long particular functions will be interrupted because of a wildfire hazard event. Go to page 4-4, "Estimate the losses to structure use and function," to find specific advice on how to assess the displacement time and functional downtime.

4. Calculate human losses due to wildfires.

Most wildfire related deaths occur as the result of fire suppression activities. However, if roads are damaged or there is insufficient warning time, other injuries and deaths can occur. Since there are no death or injury curves for wildfires, estimate the number of injuries or deaths based on past wildfire events.

Go to the next hazard on your list to estimate losses

or if you are finished with all your assessments

Go to the afterword

Wildfire Hazard Rating Form

-Subdivision-

Name of Subdivision ______________________ Date ____________

County ____________ Size (Acres) ______________ #Lots ____________

Rating ____________ Comments ______________________

A. Subdivision Design — **Points**

1. Ingress/Egress
   - Two or more primary roads .... **1** ________
   - One Road .... **3** ________
   - One-way in, one-way out .... **5** ________

2. Width of Primary Road ....
   - 20 feet or more .... **1** ________
   - 20 feet or less .... **3** ________

3. Accessibility ....
   - Road Grade 5% or less .... **1** ________
   - Road Grade 5% or more .... **3** ________

4. Secondary Road Terminus: ....
   - Loop roads, cul-de-sacs with outside turning radius of 45 feet or greater .... **1** ________
   - Cul-de-sac turnaround radius is less than 45 feet .... **2** ________
   - Dead-end roads 200 feet or less in length .... **3** ________
   - Dead-end roads greater than 200 feet in length .... **5** ________

5. Average lot size
   - 10 acres or larger .... **1** ________
   - Larger than 1 acre, but less than 10 acres .... **3** ________
   - 1 acre or less .... **5** ________

6. Street signs
   - Present .... **1** ________
   - Not present .... **5** ________

B. Vegetation

1. Fuel Types
   - Light .... **1** ________
   - Medium .... **5** ________
   - Heavy .... **10** ________

2. Defensible Space
   - 70% or more of site .... **1** ________
   - 30% or more, but less than 70% .... **3** ________
   - Less than 30% of site .... **5** ________

Source: Urban Wildland Interface Code, 2000

C. Topography — **Points**

1. Predominant Slope
   - 8% or less .... **1** ________
   - More than 8%, but less than 20%.... **4** ________
   - 20% or more, but less than 30% .... **7** ________
   - 30% or more .... **10** ________

D. Roofing Material

- Class A Rated .... **1** ________
- Class B Rated .... **3** ________
- Class C Rated .... **5** ________
- Non-Rated .... **10** ________

E. Fire Protection – Water Source

- 500 GPM Hydrant within 1,000 feet ...... **1** ________
- Hydrant farther than 1,000 feet or draft site .... **2** ________
- Water source within 20 minutes or less, round trip .... **5** ________
- Water source farther than 20 minutes, and but less than 45 minutes round trip **7** ________
- Water source farther than 45 minutes round trip .... **10** ________

F. Existing Building Construction Materials

- Noncombustible siding/deck .... **1** ________
- Noncombustible siding/combustible deck .... **5** ________
- Combustible siding and deck .... **10** ________

G. Utilities

- All underground utilities .... **1** ________
- One underground, one above ground .... **3** ________
- All above ground .... **5** ________

TOTAL FOR SUBDIVISION ________

RATING SCALE:

MODERATE HAZARD	**40-59**
HIGH HAZARD	**60-74**
EXTREME HAZARDS	**75+**

afterword

afterword

You have completed your loss estimate. Now what?

Your loss estimate is the foundation upon which you will develop a state or local mitigation plan. With it, you should be able to identify what areas of your community or state are susceptible to each hazard, where the highest losses would occur, how much a hazard may cost were it to occur, and how the lives and quality of life in your community or state might be affected in the aftermath of a disaster. You also now have a factual basis for developing a mitigation strategy for your community or state. This will be important data necessary to support future mitigation decisions.

It is therefore important to compile the results of your work into a written report. This report should be presented to citizens and elected officials. The State Hazard Mitigation Officer should be aware of the completion of your loss estimate because the State may want to use it as part of its statewide risk assessment.

The results of your risk assessment will likely draw interest from a wide range of sectors in the community or state. Business owners and residents will want to know what the results of the risk assessment mean for them and what to do next. You have an opportunity to use the results of the risk assessment as a tool to galvanize the community and to secure interest and support for the remainder of the hazard mitigation planning process. The risk assessment can be an effective tool for public education, disaster response and recovery, and economic development. For example, you can use the results of the risk assessment to:

- Promote flood insurance by targeting at-risk properties;
- Support a public hazard awareness initiative;
- Encourage elected officials to approve and implement a hazard mitigation plan;
- Support economic development decisions by allowing hazards to be mitigated when new development takes place; and

As detailed in the Foreword, the Natural Hazard Mitigation Planning process consists of four basic phases.

The next how-to in the series, *Develop a Mitigation Plan*, will directly build on the work you have just completed.

- Reduce costs spent on disaster response and recovery through pre-identification of at-risk populations or areas, and implementation of mitigation initiatives.

By gathering information from a variety of state and local resources, you have begun to forge relations within your community and state that will continue to be nurtured throughout the planning process.

In the next phase of the Natural Hazard Mitigation Planning Process, *Develop a Mitigation Plan,* you will find solutions to address the potential impacts of natural hazards in your community or state by developing a strategy to reduce the effects of the hazards. The mitigation strategy will be based on the risk assessment you just completed in the second phase of the Natural Hazard Mitigation Planning process and will provide a comprehensive strategy to address the mitigation priorities within your community or state.

appendix a

glossary

Acceleration
The rate of change of velocity with respect to time. Acceleration due to gravity at the earth's surface is 9.8 meters per second squared. That means that every second that something falls toward the surface of earth its velocity increases by 9.8 meters per second.

Asset
Any manmade or natural feature that has value, including, but not limited to people; buildings; infrastructure like bridges, roads, and sewer and water systems; lifelines like electricity and communication resources; or environmental, cultural, or recreational features like parks, dunes, wetlands, or landmarks.

Base Flood
Flood that has a 1 percent probability of being equaled or exceeded in any given year. Also known as the 100-year flood.

Base Flood Elevation (BFE)
Elevation of the base flood in relation to a specified datum, such as the National Geodetic Vertical Datum of 1929. The Base Flood Elevation is used as the standard for the National Flood Insurance Program.

Bedrock
The solid rock that underlies loose material, such as soil, sand, clay, or gravel.

Building
A structure that is walled and roofed, principally above ground and permanently affixed to a site. The term includes a manufactured home on a permanent foundation on which the wheels and axles carry no weight.

Coastal High Hazard Area
Area, usually along an open coast, bay, or inlet, that is subject to inundation by storm surge and, in some instances, wave action caused by storms or seismic sources.

Coastal Zones
The area along the shore where the ocean meets the land as the surface of the land rises above the ocean. This land/water interface includes barrier islands, estuaries, beaches, coastal wetlands, and land areas having direct drainage to the ocean.

Community Rating System (CRS)
An NFIP program that provides incentives for NFIP communities to complete activities that reduce flood hazard risk. When the community completes specified activities, the insurance premiums of policyholders in these communities are reduced.

Computer-Aided Design And Drafting (CADD)
A computerized system enabling quick and accurate electronic 2-D and 3-D drawings, topographic mapping, site plans, and profile/cross-section drawings.

Contour
A line of equal ground elevation on a topographic (contour) map.

Critical Facility Facilities that are critical to the health and welfare of the population and that are especially important following hazard events. Critical facilities include, but are not limited to, shelters, police and fire stations, and hospitals.

Debris The scattered remains of assets broken or destroyed in a hazard event. Debris caused by a wind or water hazard event can cause additional damage to other assets.

Digitize To convert electronically points, lines, and area boundaries shown on maps into x, y coordinates (e.g., latitude and longitude, universal transverse mercator (UTM), or table coordinates) for use in computer applications.

Displacement Time The average time (in days) which the building's occupants typically must operate from a temporary location while repairs are made to the original building due to damages resulting from a hazard event.

Duration How long a hazard event lasts.

Earthquake A sudden motion or trembling that is caused by a release of strain accumulated within or along the edge of earth's tectonic plates.

Erosion Wearing away of the land surface by detachment and movement of soil and rock fragments, during a flood or storm or over a period of years, through the action of wind, water, or other geologic processes.

Erosion Hazard Area Area anticipated to be lost to shoreline retreat over a given period of time. The projected inland extent of the area is measured by multiplying the average annual long-term recession rate by the number of years desired.

Essential Facility Elements that are important to ensure a full recovery of a community or state following a hazard event. These would include: government functions, major employers, banks, schools, and certain commercial establishments, such as grocery stores, hardware stores, and gas stations.

Extent The size of an area affected by a hazard or hazard event.

Extratropical Cyclone Cyclonic storm events like Nor'easters and severe winter low-pressure systems. Both West and East coasts can experience these non-tropical storms that produce gale-force winds and precipitation in the form of heavy rain or snow. These cyclonic storms, commonly called Nor'easters on the East Coast because of the direction of the storm winds, can last for several days and can be very large – 1,000-mile wide storms are not uncommon.

Fault A fracture in the continuity of a rock formation caused by a shifting or dislodging of the earth's crust, in which adjacent surfaces are differentially displaced parallel to the plane of fracture.

Federal Emergency Management Agency (FEMA) Independent agency created in 1978 to provide a single point of accountability for all Federal activities related to disaster mitigation and emergency preparedness, response and recovery.

Fire Potential Index (FPI) Developed by USGS and USFS to assess and map fire hazard potential over broad areas. Based on such geographic information, national policy makers and on-the-ground fire managers established priorities for prevention activities in the defined area to reduce the risk of managed and wildfire ignition and spread. Prediction of fire hazard shortens the time between fire ignition and initial attack by enabling fire managers to pre-allocate and stage suppression forces to high fire risk areas.

Flash Flood A flood event occurring with little or no warning where water levels rise at an extremely fast rate.

Flood A general and temporary condition of partial or complete inundation of normally dry land areas from (1) the overflow of inland or tidal waters, (2) the unusual and rapid accumulation or runoff of surface waters from any source, or (3) mudflows or the sudden collapse of shoreline land.

Flood Depth Height of the flood water surface above the ground surface.

Flood Elevation Elevation of the water surface above an established datum, e.g. National Geodetic Vertical Datum of 1929, North American Vertical Datum of 1988, or Mean Sea Level.

Flood Hazard Area The area shown to be inundated by a flood of a given magnitude on a map.

Flood Insurance Rate Map (FIRM) Map of a community, prepared by the Federal Emergency Management Agency, that shows both the special flood hazard areas and the risk premium zones applicable to the community.

Flood Insurance Study (FIS) A study that provides an examination, evaluation, and determination of flood hazards and, if appropriate, corresponding water surface elevations in a community or communities.

Floodplain Any land area, including watercourse, susceptible to partial or complete inundation by water from any source.

Frequency A measure of how often events of a particular magnitude are expected to occur. Frequency describes how often a hazard of a specific magnitude, duration, and/or extent typically occurs, on average. Statistically, a hazard with a 100-year recurrence interval is expected to occur once every 100 years on average, and would have a 1 percent chance – its probability – of happening in any given year. The reliability of this information varies depending on the kind of hazard being considered.

Fujita Scale of Tornado Intensity Rates tornadoes with numeric values from F0 to F5 based on tornado windspeed and damage sustained. An F0 indicates minimal damage such as broken tree limbs or signs, while and F5 indicated severe damage sustained.

Functional Downtime The average time (in days) during which a function (business or service) is unable to provide its services due to a hazard event.

Geographic Area Impacted The physical area in which the effects of the hazard are experienced.

Geographic Information Systems (GIS)	A computer software application that relates physical features on the earth to a database to be used for mapping and analysis.
Ground Motion	The vibration or shaking of the ground during an earthquake. When a fault ruptures, seismic waves radiate, causing the ground to vibrate. The severity of the vibration increases with the amount of energy released and decreases with distance from the causative fault or epicenter, but soft soils can further amplify ground motions
Hazard	A source of potential danger or adverse condition. Hazards in this how-to series will include naturally occurring events such as floods, earthquakes, tornadoes, tsunami, coastal storms, landslides, and wildfires that strike populated areas. A natural event is a hazard when it has the potential to harm people or property.
Hazard Event	A specific occurrence of a particular type of hazard.
Hazard Identification	The process of identifying hazards that threaten an area.
Hazard Mitigation	Sustained actions taken to reduce or eliminate long-term risk from hazards and their effects.
Hazard Profile	A description of the physical characteristics of hazards and a determination of various descriptors including magnitude, duration, frequency, probability, and extent. In most cases, a community can most easily use these descriptors when they are recorded and displayed as maps.
HAZUS (Hazards U.S.)	A GIS-based nationally standardized earthquake loss estimation tool developed by FEMA.
Hurricane	An intense tropical cyclone, formed in the atmosphere over warm ocean areas, in which wind speeds reach 74-miles-per-hour or more and blow in a large spiral around a relatively calm center or "eye." Hurricanes develop over the north Atlantic Ocean, northeast Pacific Ocean, or the south Pacific Ocean east of 160°E longitude. Hurricane circulation is counter-clockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere.
Hydrology	The science of dealing with the waters of the earth. A flood discharge is developed by a hydrologic study.
Infrastructure	Refers to the public services of a community that have a direct impact on the quality of life. Infrastructure includes communication technology such as phone lines or Internet access, vital services such as public water supplies and sewer treatment facilities, and includes an area's transportation system such as airports, heliports; highways, bridges, tunnels, roadbeds, overpasses, railways, bridges, rail yards, depots; and waterways, canals, locks, seaports, ferries, harbors, drydocks, piers and regional dams.
Intensity	A measure of the effects of a hazard event at a particular place.
Landslide	Downward movement of a slope and materials under the force of gravity.

Lateral Spreads	Develop on gentle slopes and entail the sidelong movement of large masses of soil as an underlying layer liquefies in a seismic event.
Liquefaction	The phenomenon that occurs when ground shaking causes loose soils to lose strength and act like viscous fluid. Liquefaction causes two types of ground failure: lateral spread and loss of bearing strength.
Loss of Bearing Strength	Results when the soil supporting structures liquefies. This can cause structures to tip and topple.
Lowest Floor	Under the NFIP, the lowest floor of the lowest enclosed area (including basement) of a structure.
Magnitude	A measure of the strength of a hazard event. The magnitude (also referred to as severity) of a given hazard event is usually determined using technical measures specific to the hazard.
Mitigation Plan	A systematic evaluation of the nature and extent of vulnerability to the effects of natural hazards typically present in the state and includes a description of actions to minimize future vulnerability to hazards.
National Flood Insurance Program (NFIP)	Federal program created by Congress in 1968 that makes flood insurance available in communities that enact minimum floodplain management regulations in 44 CFR §60.3.
National Geodetic Vertical Datum of 1929 (NGVD)	Datum established in 1929 and used in the NFIP as a basis for measuring flood, ground, and structural elevations, previously referred to as Sea Level Datum or Mean Sea Level. The Base Flood Elevations shown on most of the Flood Insurance Rate Maps issued by the Federal Emergency Management Agency are referenced to NGVD.
National Weather Service (NWS)	Prepares and issues flood, severe weather, and coastal storm warnings and can provide technical assistance to Federal and state entities in preparing weather and flood warning plans.
Nor'easter	An extra-tropical cyclone producing gale-force winds and precipitation in the form of heavy snow or rain.
Outflow	Follows water inundation creating strong currents that rip at structures and pound them with debris, and erode beaches and coastal structures.
Planimetric	Describes maps that indicate only man-made features like buildings.
Planning	The act or process of making or carrying out plans; the establishment of goals, policies and procedures for a social or economic unit.
Probability	A statistical measure of the likelihood that a hazard event will occur.
Recurrence Interval	The time between hazard events of similar size in a given location. It is based on the probability that the given event will be equaled or exceeded in any given year.
Repetitive Loss Property	A property that is currently insured for which two or more National Flood Insurance Program losses (occurring more than ten days apart) of at least $1000 each have been paid within any 10-year period since 1978.

Replacement Value The cost of rebuilding a structure. This is usually expressed in terms of cost per square foot, and reflects the present-day cost of labor and materials to construct a building of a particular size, type and quality.

Richter Scale A numerical scale of earthquake magnitude devised by seismologist C.F. Richter in 1935.

Risk The estimated impact that a hazard would have on people, services, facilities, and structures in a community; the likelihood of a hazard event resulting in an adverse condition that causes injury or damage. Risk is often expressed in relative terms such as a high, moderate or low likelihood of sustaining damage above a particular threshold due to a specific type of hazard event. It also can be expressed in terms of potential monetary losses associated with the intensity of the hazard.

Riverine Of or produced by a river.

Scale A proportion used in determining a dimensional relationship; the ratio of the distance between two points on a map and the actual distance between the two points on the earth's surface.

Scarp A steep slope.

Scour Removal of soil or fill material by the flow of flood waters. The term is frequently used to describe storm-induced, localized conical erosion around pilings and other foundation supports where the obstruction of flow increases turbulence.

Seismicity Describes the likelihood of an area being subject to earthquakes.

Special Flood Hazard Area (SFHA) An area within a floodplain having a 1 percent or greater chance of flood occurrence in any given year (100-year floodplain); represented on Flood Insurance Rate Maps by darkly shaded areas with zone designations that include the letter A or V.

Stafford Act The Robert T. Stafford Disaster Relief and Emergency Assistance Act, PL 100-107 was signed into law November 23, 1988 and amended the Disaster Relief Act of 1974, PL 93-288. The Stafford Act is the statutory authority for most Federal disaster response activities, especially as they pertain to FEMA and its programs.

State Hazard Mitigation Officer (SHMO) The representative of state government who is the primary point of contact with FEMA, other state and Federal agencies, and local units of government in the planning and implementation of pre- and post-disaster mitigation activities.

Storm Surge Rise in the water surface above normal water level on the open coast due to the action of wind stress and atmospheric pressure on the water surface.

Structure Something constructed. (See also Building)

Substantial Damage	Damage of any origin sustained by a structure in a Special Flood Hazard Area whereby the cost of restoring the structure to its before-damaged condition would equal or exceed 50 percent of the market value of the structure before the damage.
Super Typhoon	A typhoon with maximum sustained winds of 150 mph or more.
Surface Faulting	The differential movement of two sides of a fracture – in other words, the location where the ground breaks apart. The length, width, and displacement of the ground characterize surface faults.
Tectonic Plate	Torsionally rigid, thin segments of the earth's lithosphere that may be assumed to move horizontally and adjoin other plates. It is the friction between plate boundaries that cause seismic activity.
Topographic	Characterizes maps that show natural features and indicate the physical shape of the land using contour lines. These maps may also include manmade features.
Tornado	A violently rotating column of air extending from a thunderstorm to the ground.
Tropical Cyclone	A generic term for a cyclonic, low-pressure system over tropical or sub-tropical waters.
Tropical Depression	A tropical cyclone with maximum sustained winds of less than 39 mph.
Tropical Storm	A tropical cyclone with maximum sustained winds greater than 39 mph and less than 74 mph.
Tsunami	Great sea wave produced by submarine earth movement or volcanic eruption.
Typhoon	A special category of tropical cyclone peculiar to the western North Pacific Basin, frequently affecting areas in the vicinity of Guam and the North Mariana Islands. Typhoons whose maximum sustained winds attain or exceed 150 mph are called super typhoons.
Vulnerability	Describes how exposed or susceptible to damage an asset is. Vulnerability depends on an asset's construction, contents, and the economic value of its functions. Like indirect damages, the vulnerability of one element of the community is often related to the vulnerability of another. For example, many businesses depend on uninterrupted electrical power – if an electric substation is flooded, it will affect not only the substation itself, but a number of businesses as well. Often, indirect effects can be much more widespread and damaging than direct ones.
Vulnerability Assessment	The extent of injury and damage that may result from a hazard event of a given intensity in a given area. The vulnerability assessment should address impacts of hazard events on the existing and future built environment.

Water Displacement

When a large mass of earth on the ocean bottom sinks or uplifts, the column of water directly above it is displaced, forming the tsunami wave. The rate of displacement, motion of the ocean floor at the epicenter, the amount of displacement of the rupture zone, and the depth of water above the rupture zone all contribute to the intensity of the tsunami.

Wave Runup

The height that the wave extends up to on steep shorelines, measured above a reference level (the normal height of the sea, corrected to the state of the tide at the time of wave arrival).

Wildfire

An uncontrolled fire spreading through vegetative fuels, exposing and possibly consuming structures.

Zone

A geographical area shown on a Flood Insurance Rate Map (FIRM) that reflects the severity or type of flooding in the area.

appendix b
library

General Contact Information

Federal Emergency Management Agency (FEMA)	http://www.fema.gov FEMA Headquarters: 500 C Street, SW, Washington, D.C. 20472 Phone: (202) 646-4600
FEMA Publications Warehouse	800-480-2520
FEMA Mitigation Planning	http://www.fema.gov/fima/planning.htm
American Planning Association	http://www.planning.org
Institute for Business and Home Safety	http://www.ibhs.org
National Hurricane Center	http://www.nhc.noaa.gov
National Institute of Building Sciences (NIBS)	http://www.nibs.org/
National Institute of Standards and Technology (NIST)	http://www.nist.gov
National Oceanographic and Atmospheric Administration (NOAA)	http://www.noaa.gov
National Weather Service	http://www.nws.noaa.gov
U.S. Army Corps of Engineers Regional Sites and Districts	http://www.usace.army.mil/organizations.htm#Divisions
United States Geological Survey (USGS) Homepage	http://www.usgs.gov/ (888-ASK-USGS)

1
identify hazards

American Red Cross – local chapters	http://www.redcross.org/where/where.html
Disaster Center	http://www.disastercenter.com
Digital Q3 Flood Data	http://msc.fema.gov/MSC/statemap.htm
ESRI	http://www.esri.com/hazards
Federal Emergency Management Agency	Multi-Hazard Identification and Risk Assessment: A Cornerstone of the National Mitigation Strategy. 1997 Planning for Post-Disaster Recovery and Reconstruction. FEMA and American Planning Association. Planning Advisory Service (PAS) Report Number 483/484. 1998.

Landslide Risk Areas	http://landslides.usgs.gov/html_files/landslides/nationalmap/national.html
National Weather Service (NWS) – Regional Offices	http://weather.gov/organization.html
Natural Hazards Center	http://www.Colorado.EDU/hazards/sites/costs.html
Natural Hazards Statistics	http://www.noaa.gov/om/hazstats.shtml
NOAA, Central Library	http://www.lib.noaa.gov
NOAA, National Geophysical Data Center	http://www.ngdc.noaa.gov/seg/hazard/resource
State Emergency Management Agencies	http://www.fema.gov/fema/statedr.shtm
	http://www.ak-prepared.com/statelinks.htm
State Geologists	http://www.kgs.ukans.edu/AASG/AASG.html
State Hazard Mitigation Officers	http://www.floods.org/shmos.htm
	http://www.hazmit.net/
State Historic Preservation Officers	http://www.sso.org/ncshpo/shpolist.htm
Tsunami Hazard Mitigation	http://www.pmel.noaa.gov/~bernard/senatec.html
U.S. Geological Survey	http://geohazards.cr.usgs.gov/
Wildfire Danger Conditions	http://www.fs.fed.us/land/wfas/fd_class.gif
Wind Zones	http://www.fema.gov/graphics/library/wmap.gif
World Wide Weather and Climate Events	http://www.ncdc.noaa.gov/ol/reports/weather-events.html#STORM

2 profile hazard events

Association of State Dam Safety Officials	http://www.damsafety.org
Coastal and lake bathymetry and climate – NOAA National Data Center	http://www.ngdc.noaa.gov/mgg/bathymetry
Elevation, hydrology, land use, transportation, etc. – USGS National Mapping Information	http://mapping.usgs.gov
Endangered species, etc. – U.S. National Biological Information Infrastructure	http://www.nbii.gov
Federal Lands – Bureau of Land Management (BLM) Geospatial Home Page	http://www.blm.gov/gis

FEMA Map Service Center	http://www.fema.gov/maps/
Flood Risk and Map Information	http://www.fema.gov/nfip/fmapinfo.htm
Forestry Service Contacts	
State:	http://www.stateforesters.org/sflist.html
Regional:	http://www.fs.fed.us/intro/directory/orgdir.html
GIS Data Sources for Forest Areas – USDA Forest Service (USFS)	http://www.fs.fed.us
HAZUS instruction and technical information	http://www.fema.gov/hazus/
	HAZUS99 User's Manual and HAZUS99 Technical Manual, Vols. 1, 2, & 3. FEMA-366
National parks – National Park Service (NPS)	http://www.nps.gov/gis
National Wetlands Inventory – U.S. Fish and Wildlife Service (USFWS)	http://www.nwi.fws.gov
NFIP Guide to Flood Maps	http://msc.fema.gov/MSC/hardcopy.htm
NFIP State Coordinators	http://www.floods.org/stcoor.htm
Seismic hazards – USGS National Seismic Hazard Mapping Project	http://geohazards.cr.usgs.gov/eq
Spatial Data Resources by State	http://www.csc.noaa.gov/products/nchaz/htm/dinfo_6.htm
U.S. Army Corps of Engineers	http://www.usace.army.mil/
USDA Wildfire Fuel Model Map	http://www.fs.fed.us/land/wfas/nfdr_map.htm
USDA Natural Resource Conservation Service (NRCS) – National Cartography and Geospatial Center (NCGC)	http://www.statlab.iastate.edu/soils/nsdaf
USGS Topographic Maps	http://mapping.usgs.gov/mac/nimamaps/topo.html http://mcmcweb.er.usgs.gov/topomaps/

3 inventory assets

Bureau of Labor Statistics	http://stats.bls.gov/datahome.htm
Census Information	http://factfinder.census.gov/servlet/BasicFactsServlet http://www.census.gov/geo/www/tiger/
Consumer Price Index	http://woodrow.mpls.frb.fed.us/research/data/us/calc/
FEMA Publication on Substantial Damage	Guidance on Estimating Substantial Damage. FEMA-311

HAZUS instruction and technical information	http://www.fema.gov/hazus/ HAZUS99 User's Manual and HAZUS99 Technical Manual, Vols. 1, 2, & 3. FEMA-
Socio-Economic Data Resources	http://www.csc.noaa.gov/products/nchaz/htm/dinfo_4.htm
USDA, Natural Resources Conservation Service	http://www.nhq.nrcs.usda.gov/

4 assess risk

Building construction costs.	Building Construction Cost Data, 2001. Means. 2001.
Commercial and residential cost per square foot.	Repair & Remodeling Cost Data, Commercial, Residential. Means. 1999.
Residential cost per square foot.	Residential Cost Data, 2000. Means. Howard M. Chandler (Editor). 2000.

General Hazard Information

Floods

Association of State Dam Safety Officials	http://www.damsafety.org/
Copies of FIRMs, FISs, DFIRMs, Digital Q3 Flood Data, and FHBMs	http://www.fema.gov/maps/ FEMA Map Service Center 800.358.9616
Flash-Flood Safety Rules	http://srh.noaa.gov/oun/severewx/safety.html#flashflood
Flood Risk and Map Information	http://www.fema.gov/nfip/fmapinfo.htm
Flood Safety Rules	http://www.nws.noaa.gov/om/brochures/nh-flood.htm
Floodplain Management Association	http://www.floodplain.org
General Flood Information	http://www.nfpa.org/Education/TalkingAboutDisaster/FloodFlash/FloodFlash.asp
Guide to Flood Maps on the web	http://msc.fema.gov/MSC/hardcopy.htm
Latest hydrological information (flooding, droughts, snow conditions, and water supply)	http://www.nws.noaa.gov/oh/hic/conds.html

Real-time hydrologic data page	http://water.usgs.gov/realtime.html
Regional River Forecast Centers	http://www.crh.noaa.gov/ahps/rfc.html
State Floodplain Managers	http://www.floods.org/stcoor.htm
United States Army Corps of Engineers (USACE)	http://www.usace.army.mil/inet/functions/cw
USGS Streamflow Data Historical	http://water.usgs.gov/usa/nwis/sw

Earthquakes

Building Seismic Safety Council	http://www.bssconline.org
California Division of Mines and Geology	http://www.consrv.ca.gov/dmg/shezp/index.htm
Earthquake hazard history, by state	http://wwwneic.cr.usgs.gov/neis/states/states.html
Earthquake maps and information	http://www.abag.ca.gov/bayarea/eqmaps/eqmaps.html
FEMA HAZUS homepage	http://www.fema.gov/hazus/
FEMA Publications	Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook. FEMA-154. Supporting documentation. FEMA-155. NEHRP Handbook for the Seismic Evaluation of Existing Buildings: A Pre-Standard. FEMA-310.
GIS data available on earthquakes	http://geohazards.cr.usgs.gov/eq/html/genmap.html
USGS Earthquake homepage	http://quake.wr.usgs.gov/
USGS National and regional custom earthquake risk maps	http://geohazards.cr.usgs.gov/eq http://eqint.cr.usgs.gov/eq/html/custom.shtml United States Geological Survey 888-ASK-USGS

Tsunamis

General Tsunami Information	http://www.nfpa.org/Education/TalkingAboutDisaster/Tsunami/tsunami..asp
National Tsunami Hazard Mitigation Program	http://www.pmel.noaa.gov/tsunami-hazard/
Oregon Department of Geology and Mineral Industries (DOGAMI)	503.731.4100 800 NE Oregon Street, #28 Portland OR 97232
Pacific Marine Environmental Laboratory	http://www.pmel.noaa.gov

Pacific Tsunami Warning Center	808.689.8207 91-270 Fort Weaver Road Ewa Beach HI 96706
Tsunami Inundation Mapping	http://newport.pmel.noaa.gov/time/reports/may2000stat.html
U.S.Geological Survey	http://www.usgs.gov/themes/coast.html
University of Washington	http://www.geophys.washington.edu
West Coast/Alaska Tsunami Warning Center of NOAA/NWS	907.745.4212 910 S. Felton Street Palmer AK 99645-6552

Tornadoes

ASCE Wind Speed Maps	http://www.ascepub.infor.com/windload.html
General Tornado Information	http://www.nfpa.org/Education/TalkingAboutDisaster/Tornado/tornado.asp
Tornado Project Online	http://www.tornadoproject.com
Tornado Safe Room Program	http://www.fema.gov/mit/saferoom/

Coastal Storms

500-year and 100-year return peak gust hurricane wind speeds	http://www.fema.gov/hazards/hurricanes/hurfacts.shtm
ASCE Wind Speed Maps	http://www.ascepub.infor.com/windload.html
Coastal zone management programs by state	http://www.ocrm.nos.noaa.gov/czm/czmsitelist.html
FAQ: Hurricanes, Typhoons, and Tropical Storms	http://www.aoml.noaa.gov/hrd/tcfaq/tcfaqG.html#G12
FEMA Publications	Coastal Construction Manual. FEMA-55 Multihazard Identification and Risk Assessment. http://www.fema.gov/mit/tsd/ft_mhira.htm Evaluation of Erosion Hazards. The Heinz Center. http://www.fema.gov/nwz00/erosion.shtm

General Hurricane Information	http://www.nfpa.org/Education/TalkingAboutDisaster/Hurricane/hurricane.asp
Great Lakes Commission	http://www.glc.org
Historical data and maps on past hurricane tracks	http://www.nhc.noaa.gov/pastall.html
Hurricane Safety Rules	http://www.nws.noaa.gov/om/brochures/nh-hurr.htm
Inland Wind Model estimates maximum winds of landfalling hurricanes	http://www.nhc.noaa.gov/aboutmeow.html
United States Army Corps of Engineers (USACE)	http://www.usace.army.mil/inet/functions/cw

Landslides

American Planning Association – Landslide Hazards and Planning	http://www.planning.org/Landslides
General Landslide Information	http://www.nfpa.org/Education/TalkingAboutDisaster/Landslide/Landslide.asp
How to do landslide hazard analysis	http://www.itc.nl/ilwis/
Landslide and Mudflow Fact Sheet	http://www.fema.gov/hazards/landslides/landslif.shtm
Landslide hazard maps (San Francisco Bay Area)	http://wrgis.wr.usgs.gov/open-file/of97-745
Landslide overview map of US	http://landslide.usgs.gov/html_files/landslides/nationalmap/national.html
	http://landslides.usgs.gov/html_files/nlic/maporder.html

Wildfires

Firewise	http://www.firewise.org
General Wildfire Information	http://www.nfpa.org/Education/TalkingAboutDisaster/Wildfire/wildfire.asp
Local wildfire observations and trend forecasts for fire weather forecasts zones.	http://www.fs.fed.us/land/wfas/fd_class.gif
NOAA Fire Event Satellite Photos	http://www.osei.noaa.gov/Events/Fires/

Resolution Fire Danger Rating Fuel Model Map	http://www.fs.fed.us/land/wfas/nfdr_map.htm
U. S. Forest Service, USDA	http://www.fs.fed.us/
USGS Topographic Maps	http://mcmcweb.er.usgs.gov/topomaps/
Wildland Fire Assessment System	http://www.fs.fed.us/land/wfas/
Wildland Fire Updates	http://www.nifc.gov/fireinfo/nfn.html

Other Hazards

Avalanches	http://www.avalanche.org
Dam Safety	http://www.usbr.gov/laws/damguide.html
Dam Safety Program – FEMA	http://www.fema.gov/fima/damsafe/
Drought – USDA	http://www.drought.unl.edu/dm/index.html
Drought – USGS	http://www.usgs.gov
Extreme Heat Fact Sheet	http://www.fema.gov/hazards/extremeheat/heatf.shtm
General Heat Wave Information	http://www.nfpa.org/Education/TalkingAboutDisaster/HeatWave/HeatWave.asp
General Severe Thunderstorm Information	http://www.nfpa.org/Education/TalkingAboutDisaster/Thunderstorm/Thunderstorm.asp
General Volcano Information	http://www.nfpa.org/Education/TalkingAboutDisaster/Volcano/volcano.asp
General Winter Storm Information	http://www.nfpa.org/Education/TalkingAboutDisaster/Winter/Winter.asp
National Severe Weather Laboratory estimates the likelihood of severe thunderstorm hazards in the United States.	http://www.nssl.noaa.gov/hazard
Smithsonian Institution Global Volcanism Program	http://www.volcano.si.edu/
Snow and Ice – National Snow and Ice Data Center, University of Colorado	http://www-nsidc.colorado.edu
Volcano Hazard Maps	http://volcanoes.usgs.gov

Miscellaneous Risk Assessment Information

Alabama Coastal Hazard Assessment	http://www.csc.noaa.gov/products/alabama/startup.htm
Association of Dam Safety Officials	http://crunch.tec.army.mil/nid/webpages/nid.cfm
Multi-hazard map production with GIS emphasis	http://www.esri.com/hazards
National Institute of Standards and Technology	http://www.nist.gov
National Science Foundation	http://www.nsf.gov
Natural Hazards Research and Applications Information Center, University of Colorado	http://www.colorado.edu/hazards
New Hanover County, NC Hazard Identification/Risk Assessment	http://www.csc.noaa.gov/products/nchaz/htm/case1.htm
USDA, Natural Resources Conservation Service	http://www.nrcs.usda.gov/
Vulnerability Assessment Techniques and Applications	http://www.csc.noaa.gov/vata/

State Resources:

- Coastal Zone Management
- Emergency Management
- Environmental Protection
- Health
- Labor
- Natural Resources Management
- Planning
- Transportation

Non-Governmental Resources:

- American Red Cross
- Salvation Army
- GaResourcestric Companies

Local Resources:

- Emergency Management
- Environmental Management
- Fire Department
- Floodplain Management
- Historical Society
- Planning
- Public Works Department

appendix c

worksheets

Worksheet #1	Identify the Hazards
Worksheet #2	Profile Hazard Events
Worksheet #3a	Inventory Assets (Tasks A and B)
Worksheet #3b	Inventory Assets (Task C)
Worksheet #4	Estimate Losses

Worksheet #1 Identify the Hazards

Date:

What kinds of natural hazards can affect you?

Task A. List the hazards that may occur.

1. *Research newspapers and other historical records.*
2. *Review existing plans and reports.*
3. *Talk to the experts in your community, state, or region.*
4. *Gather information on Internet Websites.*
5. *Next to the hazard list below, put a check mark in the Task A boxes beside all hazards that may occur in your community or state.*

Task B. Focus on the most prevalent hazards in your community or state.

1. *Go to hazard Websites.*
2. *Locate your community or state on the Website map.*
3. *Determine whether you are in a high-risk area. Get more localized information if necessary.*
4. *Next to the hazard list below, put a check mark in the Task B boxes beside all hazards that pose a significant threat.*

	Task A	Task B
Avalanche	☐	☐
Coastal Erosion	☐	☐
Coastal Storm	☐	☐
Dam Failure	☐	☐
Drought	☐	☐
Earthquake	☐	☐
Expansive Soils	☐	☐
Extreme Heat	☐	☐
Flood	☐	☐
Hailstorm	☐	☐
Hurricane	☐	☐
Land Subsidence	☐	☐
Landslide	☐	☐
Severe Winter Storm	☐	☐
Tornado	☐	☐
Tsunami	☐	☐
Volcano	☐	☐
Wildfire	☐	☐
Windstorm	☐	☐
Other____________	☐	☐
Other____________	☐	☐
Other____________	☐	☐

*Note: **Bolded** hazards are addressed in this How-To Guide.*

Use this space to record information you find for each of the hazards you will be researching. Attach additional pages as necessary.

Hazard or Event Description (type of hazard, date of event, number of injuries, cost and types of damage, etc.)	**Source of Information**	**Map Available for this Hazard?**	**Scale of Map**

Worksheet #2 — Profile Hazard Events — step 2

Date:

How Bad Can It Get?

Task A. Obtain or create a base map.

You can use existing maps from:

- *Road maps*
- *USGS topographic maps or Digital Orthophoto Quarter Quads (DOQQ)*
- *Topographic and/or planimetric maps from other agencies*
- *Aerial topographic and/or planimetric maps*

OR you can create a base map using:

- *Field surveys*
- *GIS software*
- *CADD software*
- *Digitized paper maps*

Title of Map	Scale	Date

Flood	☐ 1. Get a copy of your FIRM. ______ ☐ 2. Verify the FIRM is up-to-date and complete. ______	☐ 1. Transfer the boundaries from your FIRM onto your base map (floodway, 100-yr flood, 500-yr flood). ☐ 2. Transfer the BFEs onto your base map.
Earth-quake	☐ 1. Go to the http://geohazards.cr.usgs.gov Website. ☐ 2. Locate your planning area on the map. ☐ 3. Determine your PGA.	☐ 1. Record your PGA: ______ ☐ 2. If you have more than one PGA print, download or order your PGA map.
Tsunami	☐ 1. Get a copy of your tsunami inundation zone map. ______	☐ 1. Copy the boundary of your tsunami inundation zone onto your base map.
Tornado	☐ 1. Find your design wind speed. ______	☐ 1. Record your design wind speed: ______ ☐ 2. If you have more than one design wind speed, print, download, or copy your design wind speed zones, copy the boundary of your design wind speed zones on your base map, then record the design wind speed zones on your base map.
Coastal Storm	☐ 1. Get a copy of your FIRM. ______ ☐ 2. Verify that the FIRM is up-to-date and complete. ______ ☐ 3. Determine the annual rate of coastal erosion. ______ ☐ 4. Find your design wind speed. ______	☐ 1. Transfer the boundaries of your coastal storm hazard areas onto your base map. ☐ 2. Transfer the BFEs onto your base map. ☐ 3. Record the erosion rates on your base map: ______ ☐ 4. Record the design wind speed here and on your base map: ______
Land-slide	☐ 1. Map location of previous landslides. ______ ☐ 2. Map the topography. ______ ☐ 3. Map the geology. ______ ☐ 4. Identify the high-hazard areas on your map. ______	☐ 1. Mark the areas susceptible to landslides onto your base map.
Wildfire	☐ 1. Map the fuel models located within the urban-wildland interface areas. ______ ☐ 2. Map the topography. ______ ☐ 3. Determine your critical fire weather frequency. ______ ☐ 4. Determine your fire hazard severity. ______	☐ 1. Draw the boundaries of your wildfire hazard areas onto your base map.
Other	☐ 1. Map the hazard. ______	☐ 1. Record hazard event info on your base map.

Worksheet #3a — Inventory Assets

Date:

What will be affected by the hazard event?

Task A. Determine the proportion of buildings, the value of buildings, and the population in your community or state that are located in hazard areas.

Hazard ______________________________________

Type of Structure (Occupancy Class)	Number of Structures			Value of Structures			Number of People		
	# in Community or State	# in Hazard Area	% in Hazard Area	$ in Community or State	$ in Hazard Area	% in Hazard Area	# in Community or State	# in Hazard Area	% in Hazard Area
Residential									
Commercial									
Industrial									
Agricultural									
Religious/ Non-profit									
Government									
Education									
Utilities									
Total									

Task B. Determine whether (and where) you want to collect additional inventory data.

	Y	N
1. Do you know where your greatest damages may occur in your hazard areas?	_____	_____
2. Do you know whether your critical facilities will be operational after a hazard event?	_____	_____
3. Is there enough data to determine which assets are subject to the greatest potential damages?	_____	_____
4. Is there enough data to determine whether significant elements of the community are vulnerable to potential hazards?	_____	_____
5. Is there enough data to determine whether certain areas of historic, environmental, political, or cultural significance are vulnerable to potential hazards?	_____	_____
6. Is there concern about a particular hazard because of its severity, repetitiveness, or likelihood of occurrence?	_____	_____
7. Is additional data needed to justify the expenditure of community or state funds for mitigation initiatives?	_____	_____

Worksheet #3b Inventory Assets step 3

Date: *What will be affected by the hazard event?*

Task C. Compile a detailed inventory of what can be damaged by a hazard event.

Inventory the assets (critical facilities, businesses, historic, cultural, and natural resource areas, and areas of special consideration), that can be damaged by a hazard event.

Hazard ____

Name or Description of Asset	Sources of Information	Critical Facility ✓	Vulnerable Populations ✓	Economic Assets ✓	Special Considerations ✓	Historic/Other Considerations ✓	Size of Building (sq ft)	Replacement Value ($)	Contents Value ($)	Function Use or Value ($)	Displacement Cost ($ per day)	Occupancy or Capacity (#)	Other Hazard Specific Information

Worksheet #4 Estimate Losses step 4

Date:

How will these hazards affect you?

Hazard ________________________________

	Structure Loss (Task A.1.)					Contents Loss (Task A.2.)				
Name/ Description of Structure	Structure Replacement Value (Step 3) **($)**	x	Percent Damage (Step 4) **(%)**	=	Loss to Structure **($)**	Replacement Value of Contents (Step 3) **($)**	x	Percent Damage (Step 4) **(%)**	=	Loss to Contents **($)**
		x		=			x		=	
		x		=			x		=	
		x		=			x		=	
		x		=			x		=	
		x		=			x		=	
		x		=			x		=	
		x		=			x		=	
		x		=			x		=	
				Total Loss to Structure					**Total Loss to Contents**	

	Structure Use and Function Loss (Task A.3.)								
Name/ Description of Structure	Average Daily Operating Budget (Step 3) **($)**	x	Functional Downtime (Step 4) **(# of days)**	+	Displacement Cost per Day (Step 3) **($)**	x	Displacement Time (Step 4) **($)**	=	Structure Use & Function Loss **($)**
		x		+		x		=	
		x		+		x		=	
		x		+		x		=	
		x		+		x		=	
		x		+		x		=	
		x		+		x		=	
		x		+		x		=	
		x		+		x		=	
								Total Loss to Structure Use & Function	

Structure Loss + Content Loss + Function Loss ($)
Total Loss for Hazard Event (Task B.2.)

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Those who cannot remember the past are condemned to repeat it

George Santayana

FEMA

August 2001
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