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.

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.

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

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.)										**Structure Loss + Content Loss + Function Loss ($)**
Name/ Description of Structure	Average Daily Operating Budget (Step 3) **($)**	x	Functional Downtime (Step 4) **(# of days)**	+	Displacement Cost per Day (Step 3) **($)**	x	Displacement Time (Step 4) **($)**	=	Structure Use & Function Loss **($)**		
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.

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.

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.

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

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.

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

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

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.

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.

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.

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.

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.

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.

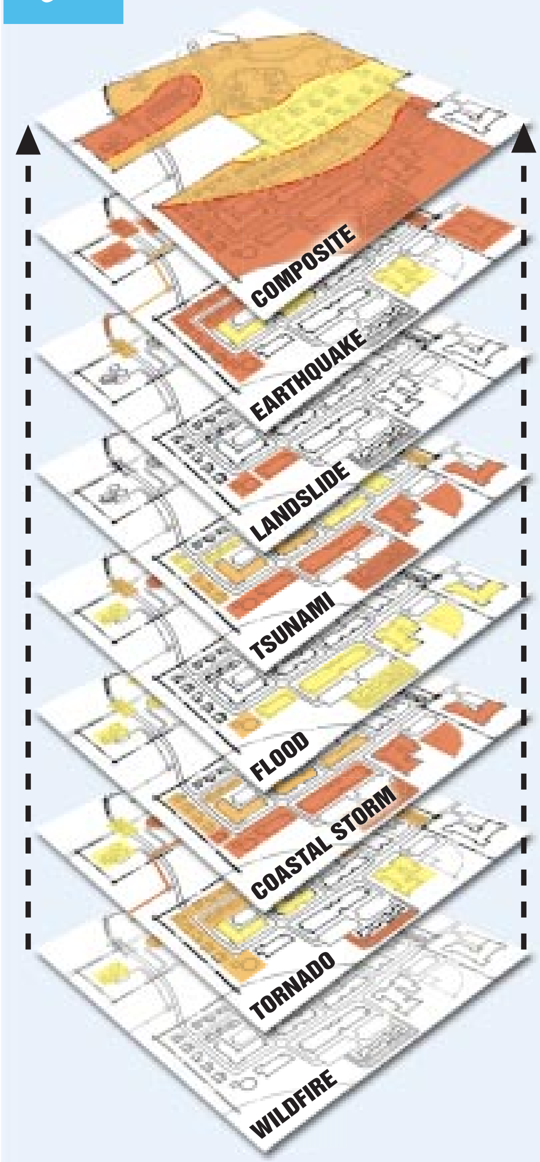
2. Calculate the estimated damages for each hazard event.

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)

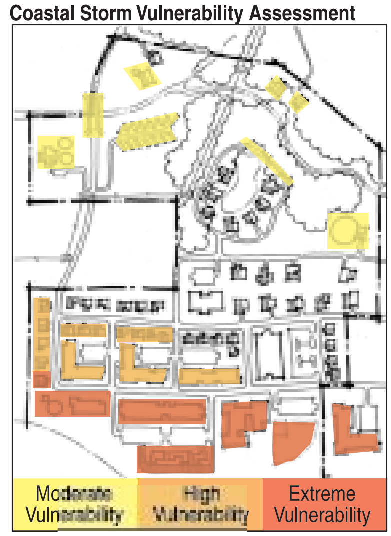
[Hazardville, EM] The members of the Town Council were stunned last night after learning the results of the risk assessment. At the public meeting to discuss the results, Joe Norris, lead planner of the Town of Hazardville Organization for Risk Reduction (THORR), reported that Hazardville certainly deserves 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.

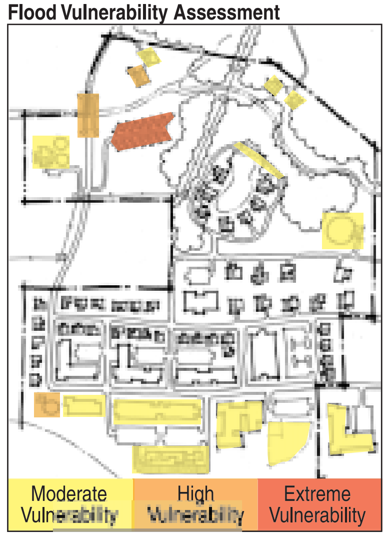
Mr. David Waters, head of the Flood and Coastal Storm Workgroup, testified to the Council that the town's manufactured home park has the greatest vulnerability of flood hazards due to the low elevation of the land in that area. "We estimated that a 100-year storm event would cause about two feet of flooding 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

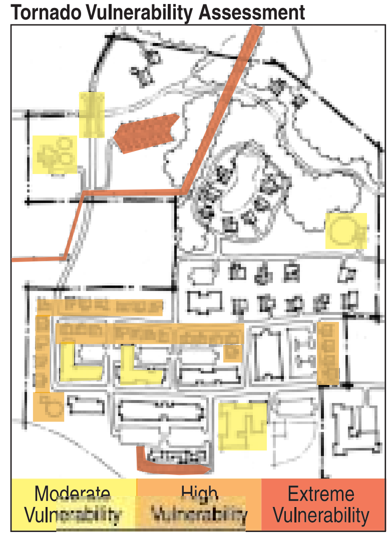
Coastal Storm Vulnerability Assessment



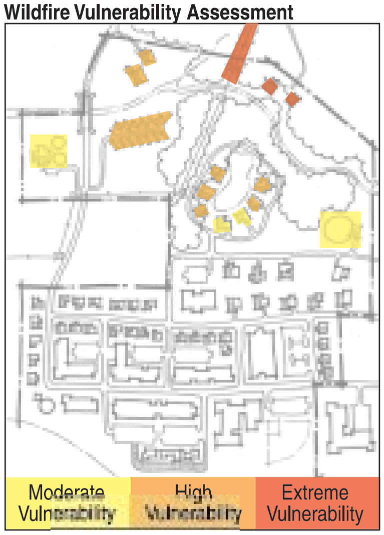
Flood Vulnerability Assessment



Tornado Vulnerability Assessment



Wildfire Vulnerability Assessment



are vulnerable to wildfires.

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.

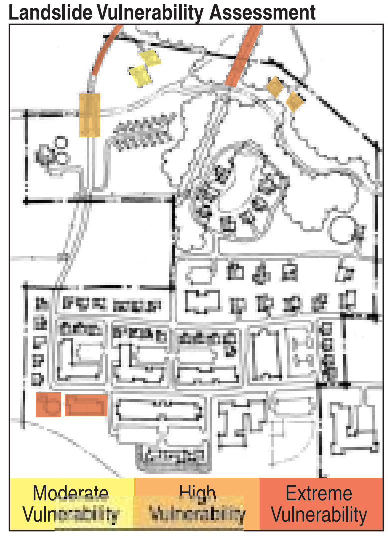
Tsunami Vulnerability Assessment

"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 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."

Earthquake Vulnerability Assessment

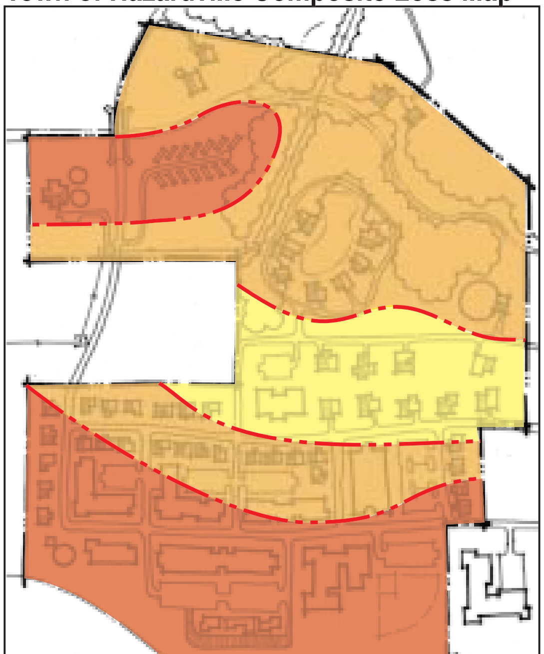
Landslide Vulnerability Assessment



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 shore-line (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.

Floods

Task A. Determine the extent of damages from floods.

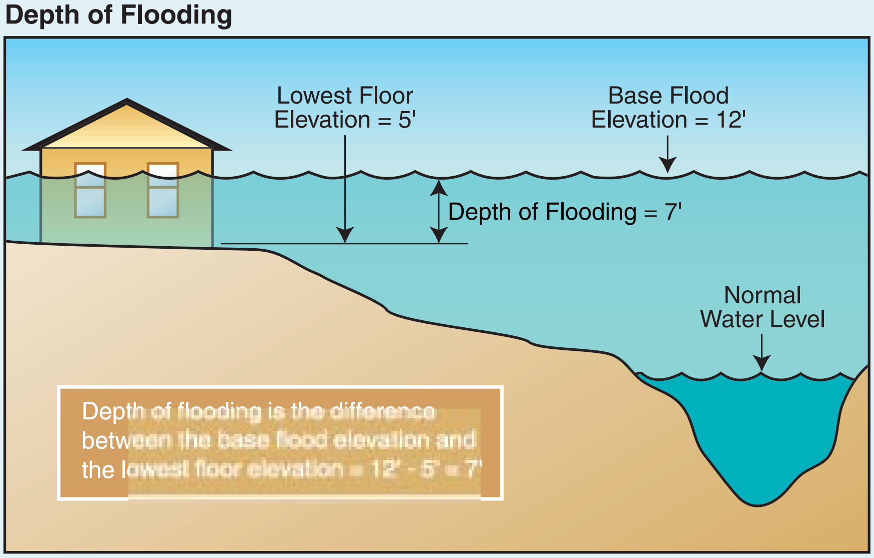
These loss estimation tables provide only very broad estimates based on historical trends. To get a better idea of the likely damage associated with a given flood level, you should conduct further research on the structure by talking with a structural engineer.

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.

Depth of Flooding



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.

Flood Functional Downtime Table

Flood Depth (feet)	**One Story No Basement** (Functional Downtime in Days)	**Two Story No Basement** (Functional Downtime in Days)	**One or Two Story With Basement** (Functional Downtime in Days)	**Manufactured Home** (Functional Downtime in Days)
-2	0	0	4	0
-1	0	0	8	0
0	9	5	11	8
1	14	9	15	30
2	22	13	20	30
3	27	18	23	30
4	29	20	28	30
5	30	22	30	30
6	30	24	30	30
7	30	26	30	30
8	30	29	30	30
>8	30	30	30	30

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

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.

Flood Displacement Time Table

Flood Depth (feet)	**One Story No Basement** (Displacement Time in Days)	**Two Story No Basement** (Displacement Time in Days)	**One or Two Story With Basement** (Displacement Time in Days)	**Manufactured Home** (Displacement Time in Days)
-2	0	0	0	0
-1	0	0	0	0
0	0	0	38	0
1	62	0	70	302
2	126	54	110	365
3	166	94	134	365
4	182	110	174	365
5	190	126	214	365
6	270	142	254	365
7	294	158	302	365
8	302	182	342	365
>8	310	214	365	365

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

Go to the next hazard on your list to estimate losses

or if you are finished with all your assessments

Go to the afterword

Task A. Determine the extent of damages from earthquakes.

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.

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.

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.

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.

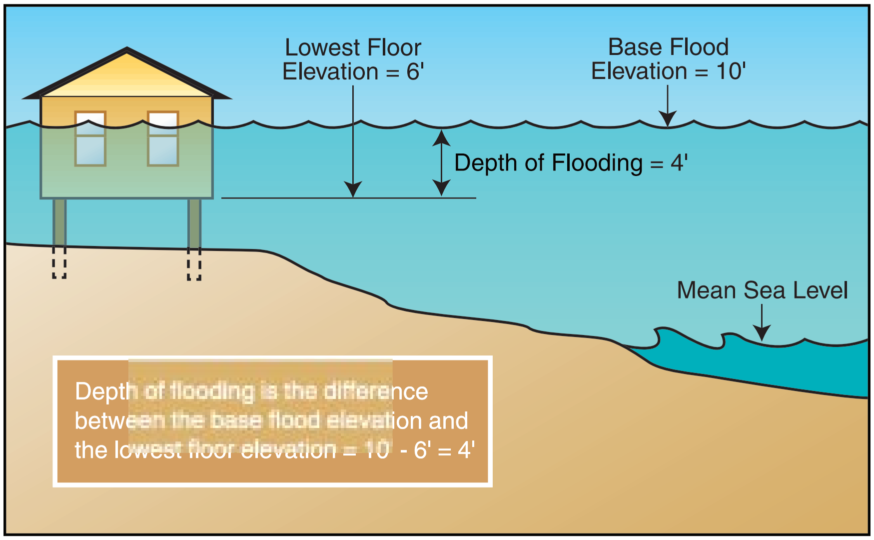
Flood Damage. The V Zone Flood Building Loss Estimation Table shown at right is an example of the extent of damage from various flood depths in coastal V zones on different kinds of buildings. This table is from the FEMA Benefit-Cost Analysis software and has been compiled based on coastal damage in 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+**