E0174: Hazus for Earthquake and Tsunami

Student Manual

Date Released: 08/2019

Contents

Lesson 1: Introductions and Course Overview

Visual 1: Lesson 1: Introductions and Course Overview

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Visual 2: Let's Get Acquainted!

Participant introductions

- Name
- Organization
- Role in organization
- GIS and hazard analysis experience
- Goals and expectations for this class

Instructor introduction

Visual 3: Course Agenda

Day 1: Earthquake Introduction, Inventories, Specific Building Types and Introduction to AEBM

Day 2: Hazard Parameters and Loss Models

Day 3: Analysis, Applications and Capstone Activity

Day 4: Capstone Activity Wrap-up

Visual 4: Agenda

Day 1

- Introduction and Review
- Earthquake Inventory
- Earthquake Specific Building Types
- Building Vulnerability and Introduction to AEBM

Day 2

- Earthquake Hazard Parameters
- Economic and Social Loss Models
- Bridge and Pipeline Loss Models

Day 3

- AEBM and Site Specific Inventory
- Tsunami Background and Analysis
- Advanced Tsunami Analysis
- Uncertainties and Sensitivity Analyses
- Applications for Hazus
- Capstone Activity

Day 4

- Capstone Activity — Continued
- Wrap- Up

Visual 5: Hints for Success

Ask LOTS of questions! There are NO "silly" questions.

Share your experiences with the rest of the class - they will learn from you and you from them.

Try to apply the concepts presented in class to your own needs. If you don't see applicability, ask for an example.

Practice the skills that you learn in class right away.

- In class (exercises and "experiments")
- After class (use it or lose it)

Visual 6: Goal and Objectives

Goal

This lesson will review the Hazus earthquake and tsunami models and introduce the major themes that will be covered in the remainder of the course.

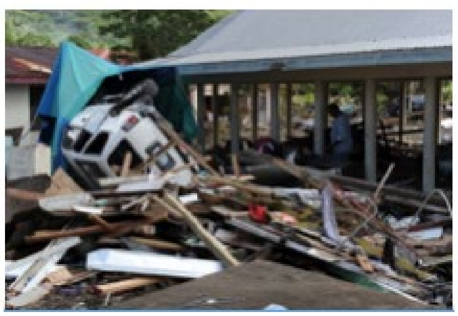
After completing this lesson, you will be able to:

- Explain the key features and intended purpose of the Hazus models
- Recognize various analysis applications
- Identify ways to improve the accuracy of the model results

Visual 7: Loss Estimation Process

- Produce maps, tables, and reports
- Analyze social and economic impacts
- Consider what is at risk
- Identify hazard
- Identify physical landscape

Social Impacts



Direct Damages

Visual 8: Site Specific Urban Search and Rescue Application

- Identify the building types that may sustain the most damage, driving the most casualties

Building Type	None	Slight	Moderate	Extensive	Complete	Collapse Rate for Complete Damage (%)	Total Collapsed
Wood	155,144	60,299	34,630	12,858	3,520	3	106
Steel	4,720	1,117	1,464	982	819	6	49
Concrete	3,927	1,113	845	499	450	10	45
Precast	1,396	277	391	194	70	13	9
Reinforced Masonry	115,543	26,092	28,035	20,495	6,466	10	647
Unreinforced Masonry	31,837	12,408	20,198	23,961	44,409	15	6,661
Manufactured Housing	9,775	2,321	2,266	1,001	508	3	15
TOTAL	**322,342**	**103,627**	**87,829**	**59,990**	**56,242**		**7,532**

Wasatch Front M7.0 Salt Lake Segment Scenario - Building Damage by Type

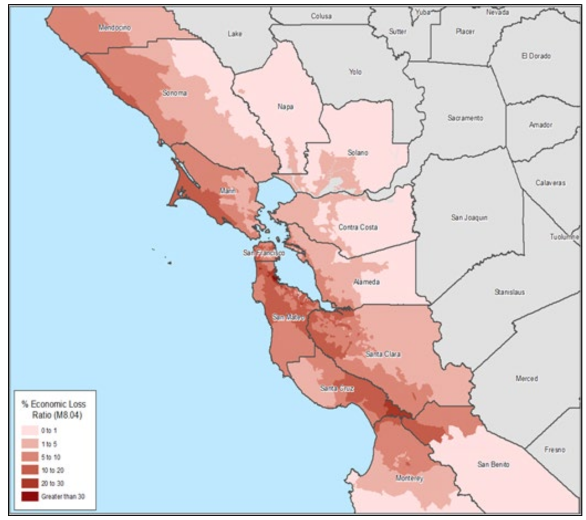
Visual 9: Site Specific Urban Search and Rescue Application

- Produce maps, tables, and reports
- Analyze impacts to buildings and victims
- Estimate number of injuries

Earthquake Timing	Minor Injuries	Requiring Hospital Treatment	Life-threatening Injuries	Fatalities
Night Time	27,524	8,122	1,272	2,502
Day Time	17,558	5,269	883	1,662
Commute Time	19,612	6,556	2,217	2,037

Wasatch Front M7.0 Salt Lake Segment Scenario - Estimated Victims of Building Collapse

Visual 10: When the Big One Strikes Again



Source: Hazus, USGS Shakemap 2019

Estimated losses due to a M8.04 earthquake scenario.

- 400,000 buildings at least moderately damaged
- 71,000 households displaced
- $108 billon total damage
- 500 – 3200 fatalities

Visual 11: Catastrophic Response Planning

Grays Harbor, Washington:

- Earthquake and Tsunami combined loss analysis
- Tsunami could be triggered by several events, Earthquakes are one trigger

	Structural Losses	Non-Structural Losses	Building Loss Ratio	Contents	Content Loss Ratio	Total Building Losses
Grays Harbor, Earthquake Only	$360,960,000	$1,267,352,000	21%	$458,383,000	9%	$2,086,695,000
Grays Harbor, Tsunami Only	$207,937,000	$382,284,000	8%	$590,984,000	12%	$1,181,205,000
Grays Harbor, Combined Losses	$456,633,000	$1,795,300,000	29%	$1,403,766,000	28%	$3,655,698,000

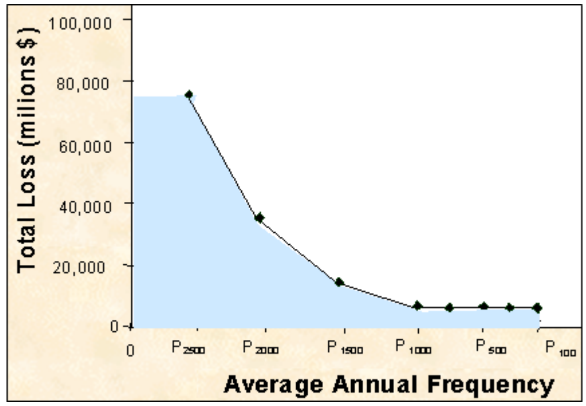
Visual 12: Computation of Annualized Losses

Approach

- Computes losses for 8 EQ's [100, 250, 500, 750, 1000, 1500, 2000, and 2500- year return period events]
- Approximate probability vs. loss curve
- Calculate the area under the curve to obtain AAL

Potential Use

- Response and recovery/mitigation



This option automated for the aggregate analyses. Manual work is required for site-specific analyses.

Visual 13: Annualized Earthquake Losses

From FEMA P-366: Hazus Estimated Annualized Earthquake Loss, 2017
https://www.fema.gov/media-library/assets/documents/132305

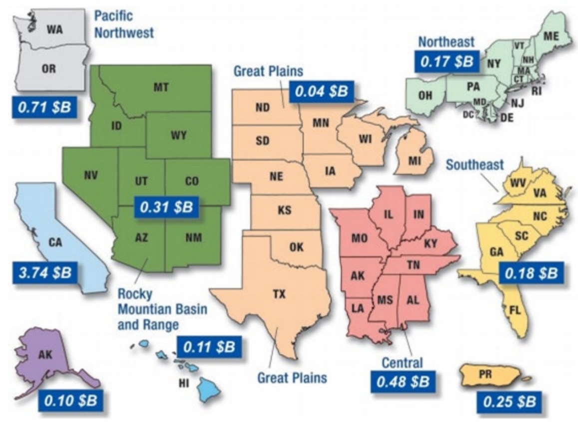


Figure E-1. Comparison of U.S. Regional Seismic Risk by Annualized Earthquake Losses (AEL).

Visual 14: Annualized Earthquake Loss Study

Annualized Earthquake Losses by County

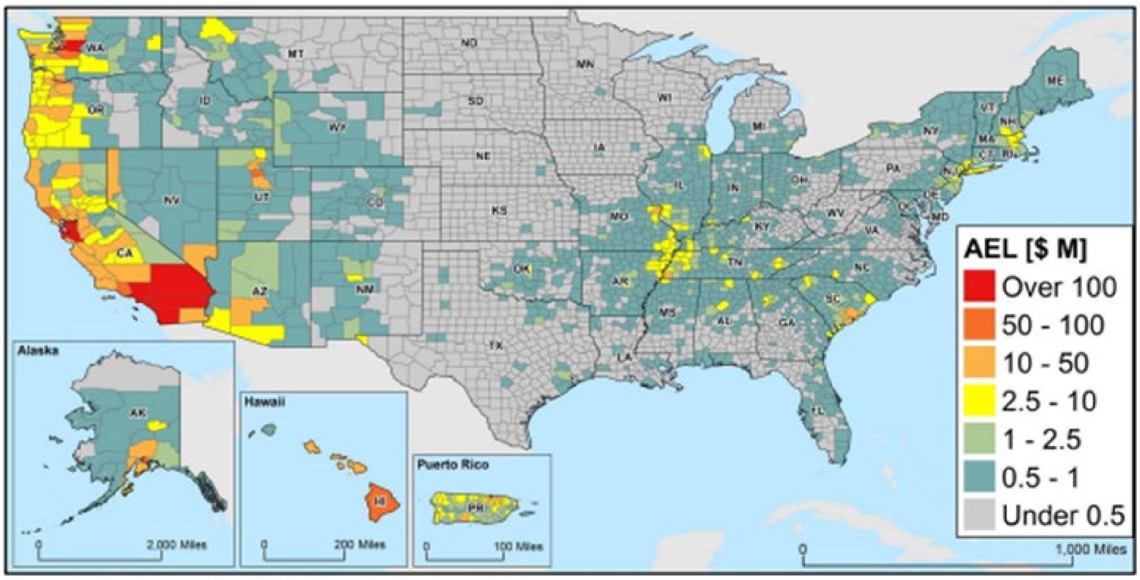


Figure 3-3. Annualized Earthquake Losses by County

Source: FEMA P-366, 2017

Visual 15: Annualized Earthquake Loss Ratios

Annualized Earthquake Loss Ratio

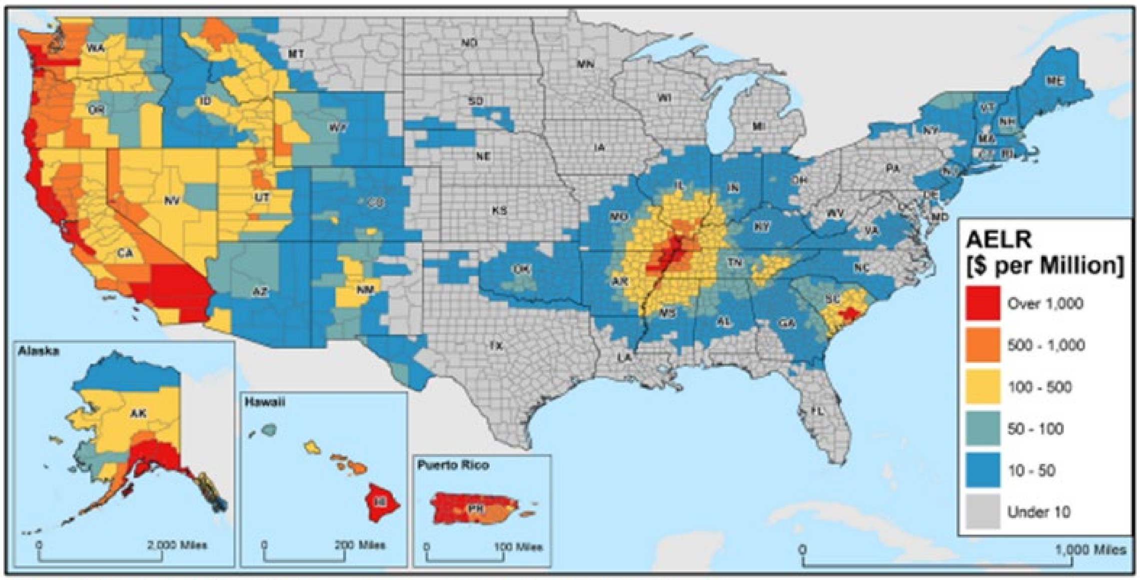


Figure 3-4. Annualized Earthquake Loss Ratios (AELR) by County

Source: FEMA P-366, 2017

Visual 16: Activity 1.1

Group Activity

Divide into Groups of 2 - 3

In this activity, you will use your computer's web browser to answer the questions on the next slide. The purpose of the activity is to familiarize yourself with important technical terms and some of the earthquake data sources on the web.

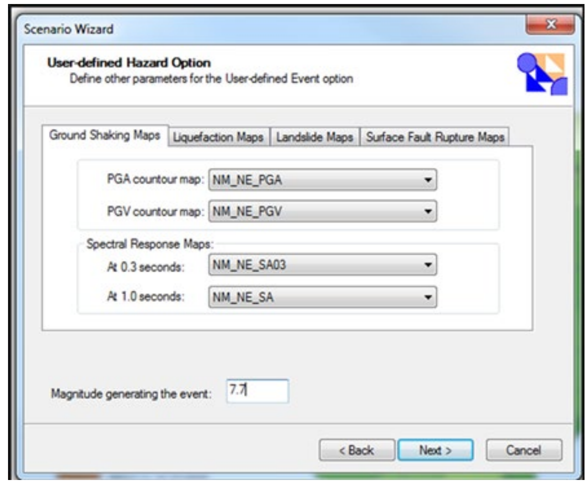
A good starting place for this activity is http://earthquake.usgs.gov. Feel free to use your favorite search engine, and work in groups to answer the questions.

Visual 17: Activity 1.1 (Cont'd.)

1. What is an epicenter?
2. What is amplification?
3. What is liquefaction?
4. What is earthquake magnitude?
5. At what earthquake magnitude does damage usually begin?
6. What is the Modified Mercalli Intensity Scale and what is it used for?
7. Where and when was the latest earthquake over a M5.0 in the US?
8. What are ShakeMaps?
9. Where can tsunami hazard maps be found?

Visual 18: Enhancing Hazard Data Modeling

- User-provided ground shaking maps from external models
- User-provided local conditions (e.g., liquefaction maps)
- Customized earthquake attenuation functions for deterministic scenarios
- USGS probabilistic event



Visual 19: Enhancing Vulnerability Modeling

Expert users can modify damage function parameters (fragility curves) in order to improve loss estimations for the building types within their study region.

Building Type	Design Level	Slight Median	Slight Beta	Moderate Median	Moderate Beta	Extensive Median	Extensive Beta
C1H	LC	2.16	0.7	3.46	0.81	8.64	0.89
C1L	LC	0.9	0.95	1.44	0.91	3.6	0.85
C1M	LC	1.5	0.71	2.4	0.74	6	0.86
C2H	LC	1.73	0.68	3.3	0.73	8.53	0.84
C2L	LC	0.72	1.04	1.37	1.02	3.55	0.99
C2M	LC	1.2	0.83	2.29	0.81	5.92	0.82
C3H	LC	1.3	0.71	2.59	0.74	6.48	0.9
C3L	LC	0.54	1.09	1.08	1.07	2.7	1.08

Structural Fragility Curves

Visual 20: Enhancing Inventory Data (Table Continued)

DATA SOURCE	RES	COM	IND	AGR	GOV	REL	EDU	TOTAL
Hazus	362,150	17,264	4,821	844	419	1,478	643	387,619
St. Louis County, MO	374,789	11,204	381	723	216	1,747	636	389,696
Difference	-3.5%	35.1%	92.1%	14.3%	-18.2%	48.4%	1.1%	-0.5%

Visual 21: Enhancing Inventory Data (Table Continued)

Building Loss by General Occupancy (in 1,000's)

DATA SOURCE	RES	COM	IND	AGR	GOV	REL	EDU	TOTAL
Hazus	$65,036	$14,692	$4,844	$208	$1,399	$394	$1,151	$87,726
St. Louis County, MO	$87,020	$20,408	$536	$45	$1,275	$835	$2,540	$112,657
Difference	-33.8%	-38.9%	88.9%	78.5%	8.8%	-111.7%	120.6%	-28.4%

Visual 22: Review

1. List three examples of types of studies to which the Hazus earthquake model can be applied.
2. What type of improvements are necessary to the Hazus earthquake model to perform an advanced analysis?
3. Name at least two applications for Hazus results.

Visual 23: Questions?

Lesson 2: Earthquake Inventory

Visual 1: Lesson 2: Earthquake Inventory

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Visual 2: Goal and Objectives

Goal

This lesson provides a review of the inventory data included with the earthquake model, as well as an overview of tools and processes to update the inventory data.

After completing this lesson you will be able to:

- Describe the types of aggregate and site-specific inventory supported by the Hazus earthquake model
- List the options that Hazus provides for updating the default inventory

Visual 3: Key Attributes

In general, earthquake results are sensitive to four categories of inventory parameters (among others):

- Location (longitude & latitude, whether site-specific or census-tract based)
- Classification (facility type, capacity, building type & other construction characteristics) with respect to earthquake vulnerability that affect seismic performance
- Valuation (cost of repair and replacement, business parameters)
- Societal (number of occupants)

Visual 4: Activity 2.1

The Instructor will lead the class in exploring the Inventory Menu.

Instructor Note

Activity 2.1
Type: Instructor-Led Activity
Time: 20 minutes

Instructor guidance:
Lead the class in exploring the Inventory Menu, including the following:

- View the various inventory types and demonstrate how they can be mapped and displayed in ArcMap.
- Explain how some types of inventory data such as AEBM or UDF, will most likely be empty since they are user-supplied (through CDMS).
- Explain how some category types such as High Potential Loss Facilities are empty due to security concerns.
- Demonstrate that it is possible to edit the Inventory data but explain how it is usually better to do that using CDMS, especially for large or bulk updates.

Allow the students to explore the inventory on their own for about 10 minutes.

Visual 5: What is the General Building Stock?

The GBS is an engineering based estimation of buildings for the US.

Represented by

- Floor area (Sq Ft)
- Replacement values ($)
- Building count

Data sources

- Residential from 2010 Census Data
- Commercial/Industrial from various sources

Northridge Earthquake, Calif., January 17, 1994 -- An aerial view of destruction caused by the 6.7 magnitude earthquake.

Visual 6: General Building Stock - Occupancies

- 7 General Occupancy Type Categories
- 33 Specific Occupancy Categories
- You can view the categories from the Inventory menu
- Values are reported by their aggregated boundary

Visual 7: General Building Stock - Building Types

General Building Types (All models)

- Concrete
- Steel
- Manufactured Housing
- Wood
- Masonry

Specific Building Types (Unique to each model)

- Flood
- Hurricane
- Earthquake
- Tsunami

Visual 8: Specific Building Types – Example

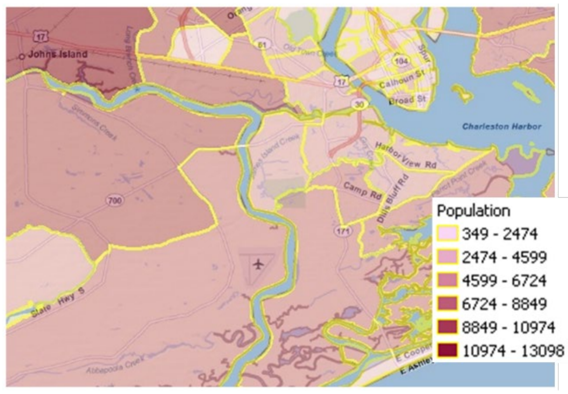
Specific Building Type	General Building Type	Description
C1H	Concrete	Concrete Moment Frame High-Rise
C1L	Concrete	Concrete Moment Frame Low-Rise
C1M	Concrete	Concrete Moment Frame Mid-Rise
C2H	Concrete	Concrete Shear Walls High-Rise
C2L	Concrete	Concrete Shear Walls Low-Rise
C2M	Concrete	Concrete Shear Walls Mid-Rise
C3H	Concrete	Concrete Frame with Unreinforced Masonry Infill Walls High-Rise

Visual 9: Demographic Data

Selected information about populations and buildings necessary for one or more of the analysis functions in Hazus

Detailed by:

- Age
- Income
- Ethnicity
- Ownership
- Gender



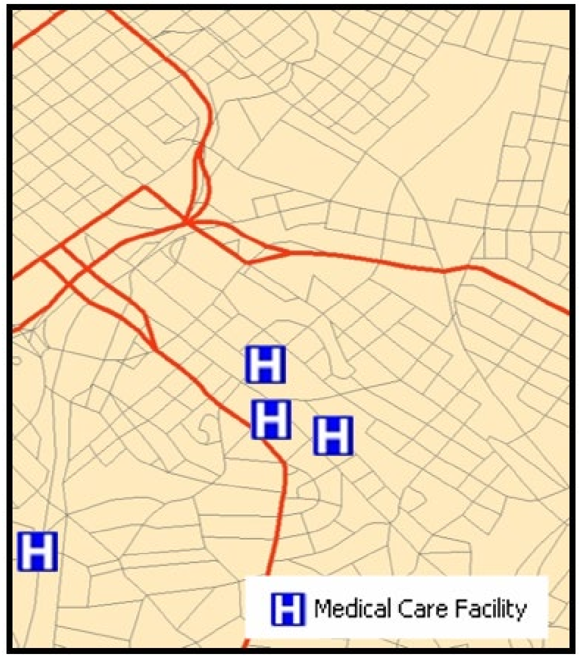
Visual 10: Activity 2.2

The Instructor will demonstrate how to:

- View General and Specific mapping schemes
- Modify a mapping scheme

Visual 11: Site-Specific Inventory

- Provides specific locations of facilities
- Enables user to generate site-specific loss estimates versus an aggregated count of damages and losses



Visual 12: Site-Specific Inventory Types

- Essential Facilities
- Transportation Systems
- Utility Systems
- User Defined Facilities
- Advanced Engineering Building Model (AEBM)

Visual 13: Essential Facility Classes

Occupancy Class	Category	Description	Building Type	Building Height	Specific Occupancy
EFHS	Medical Care	Small Hospital	Concrete	Low	COM6
EFHM	Medical Care	Medium Hospital	Concrete	Mid	COM6
EFHL	Medical Care	Large Hospital	Concrete	Mid	COM6
EFMC	Medical Care	Medical Center	Concrete	Low	COM7
EFFS	Emergency Response	Fire Station	Concrete	Low	GOV2
EFPS	Emergency Response	Police Station	Concrete	Low	GOV2
EFEO	Emergency Response	Emergency Operations	Concrete	Low	GOV2
EFS1	School	School	Brick	Low	EDU1
EFS2	School	University	Concrete	Low	EDU2

Visual 14: Transportation Systems

- Highway systems
- Railway systems
- Light rail systems
- Bus facilities
- Port facilities
- Ferry facilities
- Airport systems

* Each inventory grouping has multiple inventory items

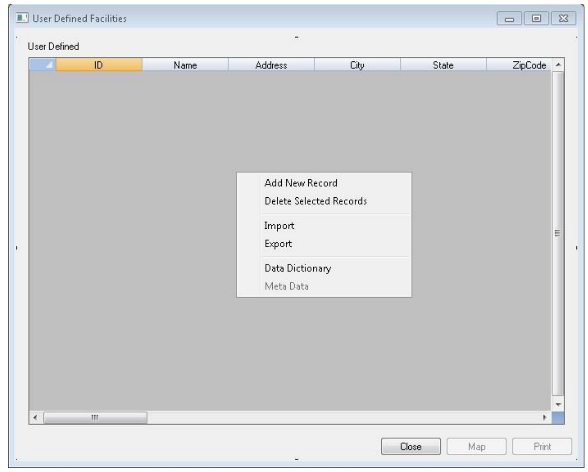
Visual 15: Utility Systems

- Potable water
- Waste water
- Oil
- Natural gas
- Electric power
- Communications

* Each inventory grouping has multiple inventory items

Visual 16: User Defined Facilities

Used to perform a more refined site-specific analysis of inventory found in the General Building Stock.



Instructor Note

You have the ability to add site-specific inventory into all four hazards. This will allow a user to calculate damages to individual facilities. It is always important to warn the students about trusting the results calculated on individual facilities represented in this table. Hazus was originally designed as a regional loss estimation model and recent advancements do allow for structure specific analysis. Still, it is not designed to analyze a specific building, so don't focus too much on a specific building. The most appropriate way to interpret losses generated from the User Defined Facilities table is considering the total for all facility losses as a portfolio (collection of facilities) rather than on a building by building basis. Users who wish to understand loss estimations on a building-by-building basis are best advised to use the Advanced Engineering Building Model (AEBM) discussed on the next slide.

This table is pre-populated for a few communities in some of the states, but not all. The states that do have data are Washington (Gray’s Harbor – 33,255 records), Oregon (Multnomah – 745 records, Tillamook – 27/371 records), and Alaska(Kenai – 28.559 records).

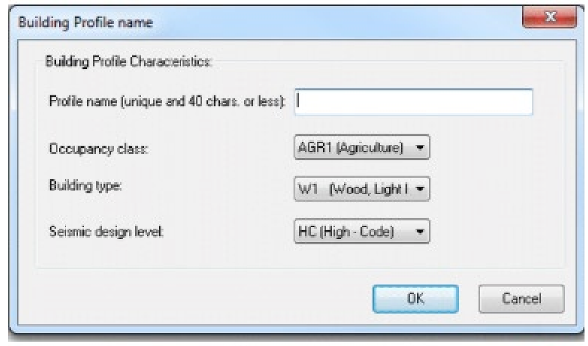
Visual 17: Advanced Engineering Building Model

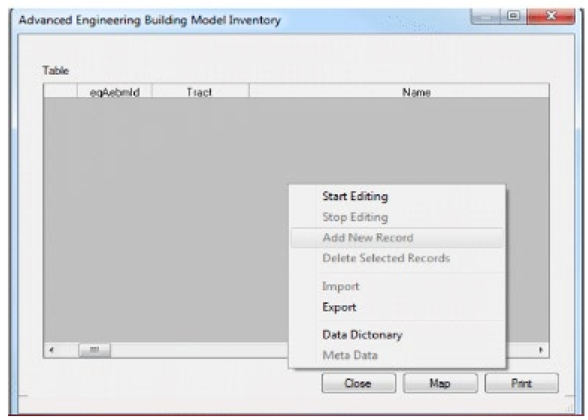
(AEBM)

Create unique building models by choosing from:

- Specific occupancy class
- Specific building type
- Design level

* More on this later in the course





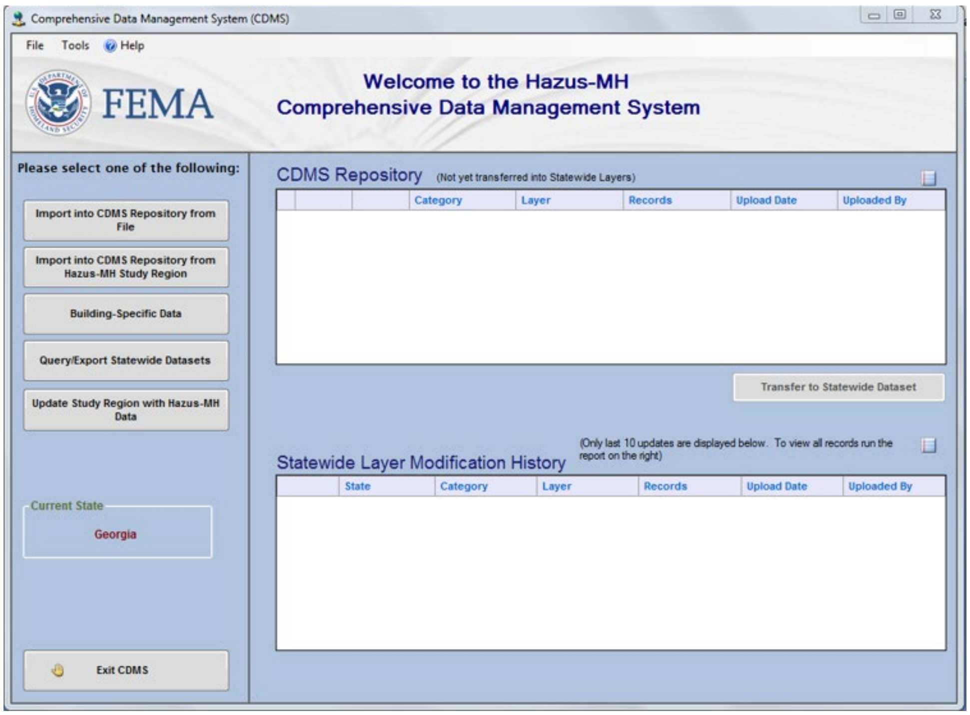
Visual 18: Inventory Update Options

- Comprehensive Data Management System (CDMS)
- Study Region Update Tools

**** The E0317: Comprehensive Data Management for Hazus course provides considerably more detail about inventory updates.**

Visual 19: CDMS

- System for integrating user provided site specific and aggregate data into the Hazus state databases.
- CDMS supported data includes:
    - Site-specific
    - Aggregate
    - Building specific



Instructor Note	Ensure that your students understand the significance of the CDMS. Many Hazus users have local data that could be used by Hazus for the purpose of conducting more credible estimates of losses from hurricane, earthquakes, tsunami and flood events. CDMS provides the tools that can make the integration of local data as smooth as possible. Special note to Microsoft Office 2007 users: CDMS does not have the ability to import or export files in Office 2007 format. Office 2007 users need to save their files to an Office 2003 format in order to import them into CDMS. If you're importing data into CDMS form Excel, it should be in the .xls format (which all versions of Office allow you to save as, even though it's not the default).

CDMS can be used to update both the Hazus state databases and individual study regions. Prior to the release of CDMS in the Fall of 2008, the only way to update the state databases was to use Microsoft Access or some other database tool. This was often beyond the capability of many Hazus users who did not possess these types of skills.

Visual 20: Study Region Update Tools

Edit Individual Records

- Most site specific and aggregate inventory tables can be edited within the Hazus study region Graphic User Interface (GUI).
- Useful for adding or editing individual records – not practical for large inventory update projects.

Import Inventory

- Import MS Access feature classes.
- Hazus provides field mapping capabilities.

Visual 21: Review

1. The aggregate data is summarized by what geographic extent in the earthquake model?
2. What is the difference between aggregate and site-specific inventory? List five examples each of aggregate and site-specific inventory.
3. Why is it important to review the default Hazus data prior to running a model?
4. How can the default data be updated?

Visual 22: Questions?

Lesson 3: Earthquake Specific Building Types

Visual 1: Lesson 3: Earthquake Specific Building Types

Visual 2: Goal and Objectives

Goal

- Develop an understanding of how and when earthquake-specific building types impact the loss estimation process.

After completing this lesson, you will be able to:

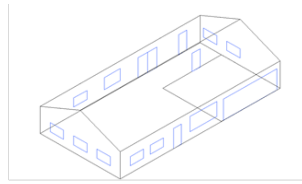
- Explain the major differences between the building types contained within the Hazus inventory.
- Define the limitations of building classifications.
- List options for overcoming limitations.

Visual 3: Importance of Specific Building Type

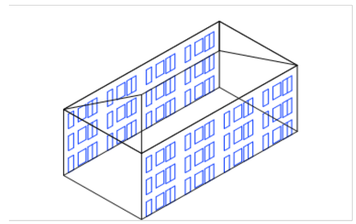
Specific Building Types (SBT) help identify in more detail:

- The type of framing
- Wall construction
- The building height (low, mid, high)
- Structural reinforcements

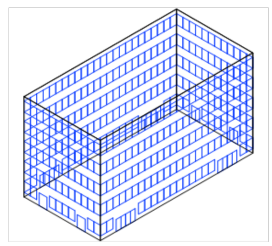
These components help us to better understand how a building will respond to ground shaking during an earthquake.



Single Family Residential



Multi-Family Residential



Office

Visual 4: EQ Specific Building Types

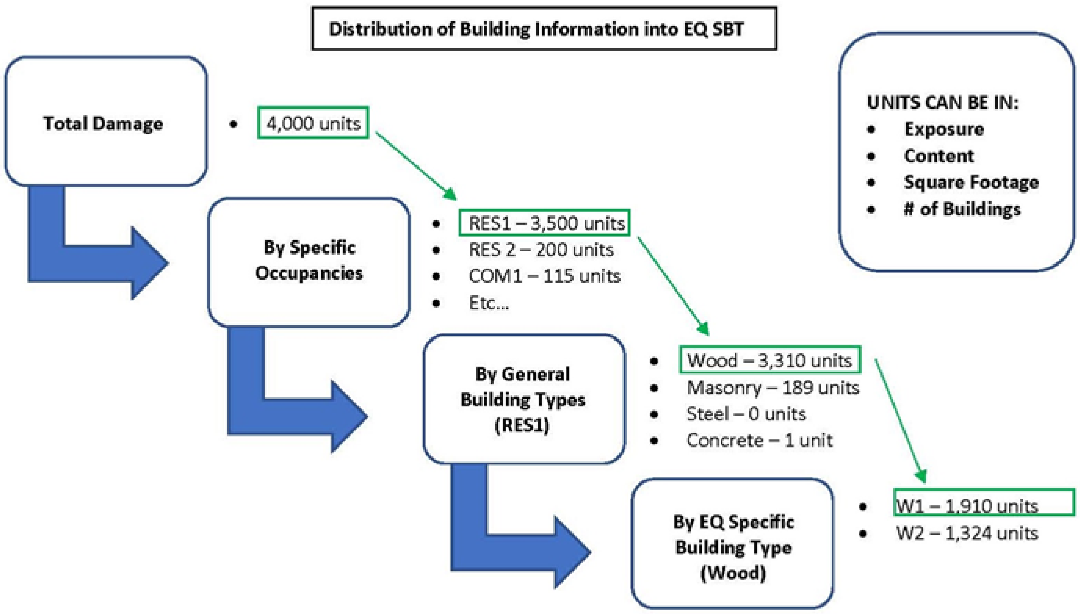
General Building Types are generally subdivided into SBT by:

- Number of stories
- Engineered / Non-engineered (design level, building quality)

Other implicit critical characteristics:

- Bracing
- Infill
- Cripple Walls
- Shear Walls
- Soft Story

Visual 5: Mapping Schemes



Visual 6: Building Height Classifications

Low Rise

- 1 – 3 Stories
- (except URM 1-2 stories)
- The default assumption for all buildings in the Hazus inventory is that they are low rise

Mid Rise

- 4 – 7 Stories
- (except URM 3+ stories)

High Rise

- 8 Stories or more

Visual 7: Design Levels

- Design Level reflects the relationship between quality and extent of damage…used to further classify each model building type.
- Design Levels:
  - Pre - Code
  - Low Seismic - Code
  - Moderate Seismic - Code
  - High Seismic - Code
  - Low Seismic - Special
  - Moderate Seismic - Special
  - High Seismic - Special

Visual 8: Summary of Model Building Types

Building Type	Description
W1	Wood, Light Frame
W2	Wood, Commercial and Industrial
S1	Steel Moment Frame
S2	Steel Braced Frame
S4	Steel Frame w/ Cast-in-Place Concrete Shear Walls
S5	Steel Frame w/ Unreinforced Masonry Infill Walls
C1	Reinforced Concrete Moment Resisting Frame
C2	Concrete Frame with Unreinforced Masonry Infill Walls Low-Rise
C3	Concrete Frame Buildings w/ Unreinforced Masonry Infill Walls
PC1	Precast-Concrete Tilt-Up Walls
PC2	Concrete Shear Walls
RM1	Reinforced Masonry Bearing Walls w/ Wood or Metal Deck
RM2	Reinforced Masonry Bearing Walls w/ Precast Concrete Diaphragms
URM	Unreinforced Masonry Bearing Walls
MH	Mobile Home

Visual 9: W1

Wood, Light Frame

- Usually residential
- Repetitive framing
- Often “conventional construction”
- Wood, plywood diaphragms
- Plywood, oriented strand board, wood, stucco, plaster, or gypsum board shear walls

Visual 10: W2

Wood, Commercial and Industrial

- 5000 square feet or more
- Few interior walls
- Beams or trusses over columns
- Plywood or wood diaphragms
- Shear walls or diagonal rod bracing

Visual 11: S1 - L, M, H

Steel Moment Frame

- Frames of steel columns and girders
- All or selected frame bays have moment-resisting column-girder joints
- Non-bearing, non-shear enclosure walls
- Relatively flexible for lateral drift

Visual 12: C1 - L, M, H

Reinforced Concrete Moment Resisting Frames

- Moment resisting frame of concrete columns and girders
- Older buildings generally have non-ductile frames
- Newer buildings generally have ductile frames
- Non-bearing, non-shear enclosure walls

Visual 13: PC1

Precast Concrete Tilt-Up Wall

- Wood or metal deck roof diaphragm
- Reinforced concrete wall panels cast on floor slab and tilted up
- Interior columns typically steel posts

Visual 14: PC2 - L, M, H

Precast Concrete Frames with Concrete Shear Walls

Precast Concrete Frames with Concrete Shear Walls

- Floor and roof diaphragms of precast elements with or without topping concrete
- Precast girders and columns for vertical loads
- Precast or cast-in-place concrete shear walls

Visual 15: RM1 - L, M

Reinforced Masonry Bearing Walls with Wood or Metal Deck Diaphragms

- Reinforced brick or Concrete Masonry Unit (CMU) shear and bearing exterior walls
- Wood, plywood, steel deck diaphragms with or without concrete fill
- Steel or wood vertical load interior framing

Visual 16: URM - L, M

Unreinforced Masonry Bearing Walls

- Unreinforced brick or concrete masonry unit shear and bearing exterior walls
- Wood or concrete diaphragms
- Wood, concrete or steel vertical load interior framing

Visual 17: MH

Mobile Homes

- Lightweight, prefabricated housing units of light metal, wood and plywood
- At site, often placed on jacks or masonry piers

Visual 18: Required Inventory Information

Occupancy Mapping

- By Building Type
- By Age (Year of Construction)
- By Seismic Design Level (Low, Moderate, High, Pre-Code)
- By Quality (Inferior, Typical, Superior)

Visual 19: Building Classification Limitations

Assumes Average Characteristics

- Overestimates damage for better buildings and underestimates damage for poorer buildings

Grouped At Centroid of Census Tract

- In large tracts, both soil type and other hazard information changes
- Distance to event source could vary dramatically

Atypical buildings are not explicitly modeled.

Visual 20: Overcoming Building Classification Limitations

- Add new building types
- Modify properties of a given building
- Model a hybrid building as a group of homogeneous buildings
- Sensitivity analyses
- Ground truthing

Visual 21: Review

1. Why is it important to understand the specific building types within the Earthquake Model?
2. How does building design level influence potential earthquake damages?
3. What are some of the limitations of building classification, and how can you overcome some of them? Think of a specific example.

Visual 22: Questions?

Lesson 4: Building Vulnerability and AEBM

Visual 1: Lesson 4: Building Vulnerability and AEBM

Visual 2: Goal and Objectives

Goal

- Explore the methodology by which Hazus assesses building vulnerability to earthquakes.

After completing this lesson, you will be able to:

- List the key parameters that affect the damage assessment of buildings in Hazus.

Visual 3: Earthquake Damage Influences

Generation

- Large earthquakes happen less often than small earthquakes

Attenuation

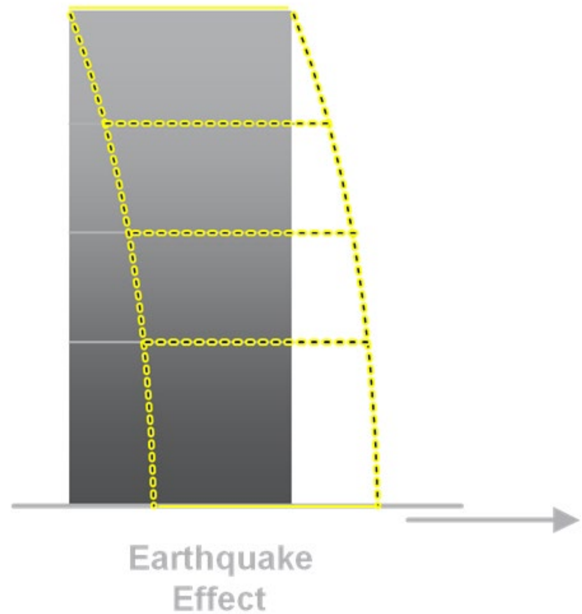
- Seismic waves decay as they travel

Vulnerability

- Buildings suffer damage based on the intensity of the ground motion and the design of the building

Visual 4: Earthquake Forces on Buildings

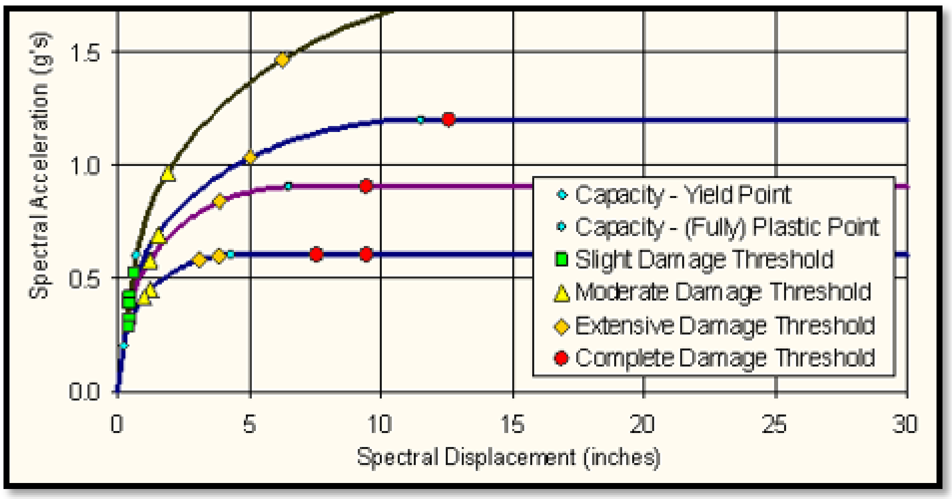
- Earthquakes only shake ground; they do NOT exert forces to buildings.
- Earthquake force is generated when super- and sub-structures ‘fight’.
- Substructures comply with shaking; superstructures do not.



Visual 5: Building Capacity Curve

Building damage is primarily a function of displacement. Capacity curves are described by:

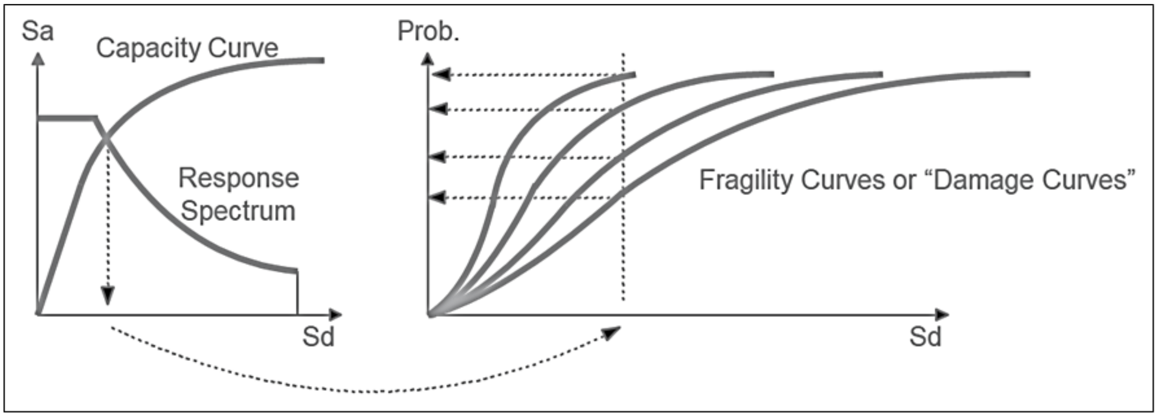
- Design capacity – strength of a building
- Yield capacity – point where a building experiences damage
- Ultimate capacity – point where a building is completely destroyed



Capacity curves plot building displacement versus earthquake force.

Visual 6: Response Spectrum Method

- Foundation of buildings EXACTLY copy the ground motion vibration.
- Tops of buildings vibrate ONLY at their own designated mode.
- Resonance happens when shaking & building mode match.



Visual 7: Fragility Curves

Fragility curves are damage functions for earthquakes.

Lognormal distribution of being in or exceeding damage state.

Considers variability of damage state due to:

- Uncertainty of damage state threshold
- Variability in building capacity
- Spatial variability of ground motion

Visual 8: Activity 4.1

The Instructor will explore:

- Damage function tables
- How to translate into these functions using beta and median values

Visual 9: Primary Factors Affecting Damage

Building Type

- Structural Type and Height

Design Levels

- Pre-Code, High-Code, Moderate-Code, Low-Code, High-Special, Moderate-Special, Low Special

Seismic Design Level	Superior Seismic Performance Level	Superior Seismic Performance Level	Inferior Seismic Performance Level
High (UBC Zone 4)	<u>Special High-Code</u> Maximum Strength Maximum Ductility	<u>High-Code</u> High Strength High Ductility	Moderate Strength Moderate/Low Ductility
Moderate (UBC Zone 2B)	<u>Special Moderate-Code</u> High/Moderate Strength High Ductility	<u>Moderate-Code</u> Moderate Strength Moderate Ductility	Low Strength Low Ductility
Low (UBC Zone 1)	<u>Special Low-Code</u> Moderate/Low Strength Moderate Ductility	<u>Low-Code</u> Low Strength Low Ductility	<u>Pre-Code</u> Minimal Strength Minimal Ductility

Visual 10: Nonstructural Damage

Nonstructural contents related to occupancy

- Repair costs
- Content value

Drift Sensitive

- Fragility curves of damage vs. displacement
- Varies by building type and design level

Acceleration Sensitive

- Fragility curves of damage vs. acceleration
- Varies by building type and design level

Visual 11: Building Damage From Ground Failure

Slight and moderate damage states implicit in ground shaking damage.

No fragility relationship for slight and moderate damage states.

Damage dependant on foundation type.

Relationship for shallow foundation:

- 10% extensive/complete for 2 inch settlement.
- 50% extensive/complete for 10 inch settlement.

Visual 12: Building Damage Guidelines

Likely Amount of Damage, Direct Economic Loss, or Building Condition

Damage State	Range of Possible Loss Ratios	Probability of Long-Term Building Closure	Probability of Partial or Full Collapse	Immediate Post-Earthquake Inspection
Slight	0 - 5%	P = 0	P = 0	Green Tag
Moderate	5 - 25%	P = 0	P = 0	Green Tag
Extensive	25 - 100%	P ≈ 0.5	P ≈ 0	Yellow Tag
Complete	100%	P ≈ 1.0	P > 0	Red Tag

Visual 13: Building Damage States

Damage State	Description
Slight	Small plaster cracks at corners f door and window openings and wall-ceiling intersections; small cracks in masonry chimneys and masonry veneer. Small cracks are to be assumed to be visible with a maximum width of less than 1/8 inch (cracks wider than 1/8 inch are referred to as "large" cracks).
Moderate	Large plaster or gypsum-board cracks at corners of door and window openings; small diagonal cracks across shear wall panels exhibited by small cracks in stucco and gypsum wall panels; large cracks in brick chimneys; toppling of all masonry chimneys.
Extensive	Large diagonal cracks across shear wall panels or large cracks at plywood joints; permanent lateral movement of floors and roof; toppling of most brick chimneys; cracks in foundations; splitting of wood sill plates and/or slippage of structure over foundations.
Complete	Structure may have large permanent lateral displacement, or be in imminent danger of collapse due to cripple wall failure or the failure of the lateral load resisting system; some structures may slip and fall off the foundations; large foundation cracks. Three percent of the total area of buildings with Complete damage is expected to be collapsed, on average.

Visual 14: Review

1. What are the main factors affecting building damage?
2. Building damage is primarily a function of what?
3. What does the Capacity-Spectrum Method estimate?
4. What do fragility curves estimate?

Visual 15: Questions?

Lesson 5: Earthquake Hazard Parameters

Visual 1: Lesson 5: Earthquake Hazard Parameters

Visual 2: Goal and Objectives

Goal

- Provide an overview of hazard parameters within the Earthquake Model and review the various Earthquake Model scenario options.

After completing this lesson, you will be able to:

- Explain the parameters used in characterizing ground motion.
- Describe the different earthquake scenario options and when they should be used.

Visual 3: Earthquake Background

Hazard quantification is expressed as a function of:

- Size of event
- Location and depth of event
- Soil type
- Liquefaction susceptibility - amount of lateral spreading and settlement
- Water table depth
- Landslide susceptibility - amount of ground failure
- Proximity to fault and fault mechanism
- Regional attenuation characteristics of ground motion

Visual 4: Hazus Approach

Evaluates ground motion parameters for damage to structures:

- At the location for site-specific inventory
- At the centroid of the census tract for aggregate inventory

Ground shaking is characterized in terms of:

- Location-specific shaking
  - Spectral response
  - Peak ground values
- Regional attenuation functions
- Site-soil effects

Visual 5: Hazus Approach (cont.)

Ground failure is expressed in terms of amount of ground deformation. The model accounts for the potential for settlement lateral spreading, and landslides.

Liquefaction and lateral spreading occurred along the west side of Sunset Lake trailer park in Tumwater. (Photo courtesy of USGS)

Visual 6: Earthquake Hazard Parameters

- Attenuation Process
- Soil
    - Types
    - Classification
    - Amplification Factors
- Ground Failure Susceptibility
- Liquefaction Susceptibility
- Landslide Susceptibility

Caution: there are no warnings if soils data are loaded improperly.

Visual 7: Defining a New Earthquake Scenario

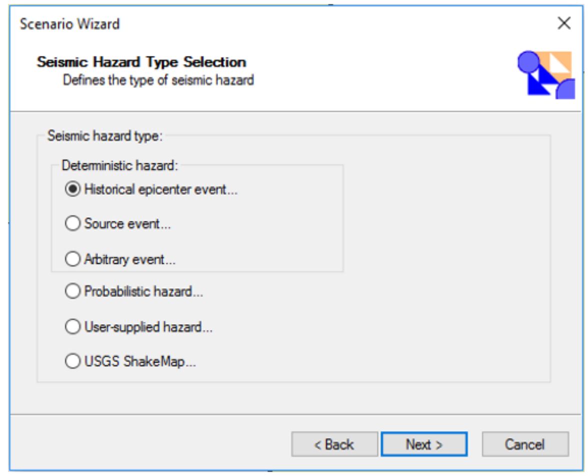
Deterministic

- USGS ShakeMap*
- Historical epicenter event
- Source event
- Arbitrary event

Probabilistic

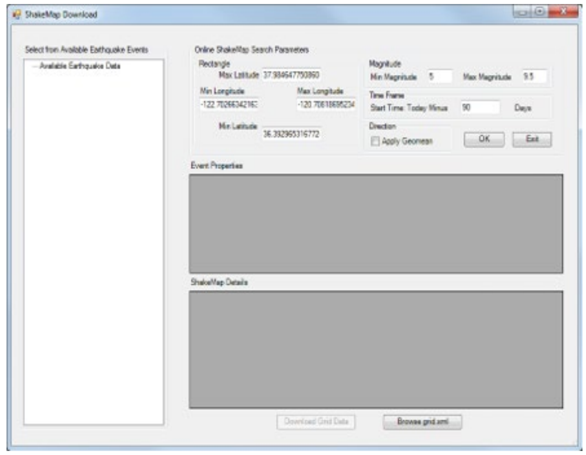
User-supplied

*Preferred method



Visual 8: ShakeMap Importing

- ShakeMap is a product of the USGS Earthquake Hazards Program in conjunction with regional seismic networks and additional localized data.
- Provides near-real-time maps and digital data of ground motion and shaking intensity following significant earthquakes.
- Hazus has the capability to dynamically input both scenario and event ShakeMaps.



A ShakeMap is a representation of ground shaking produced by an earthquake.

Visual 9: ShakeMap Importing (Cont.'d)

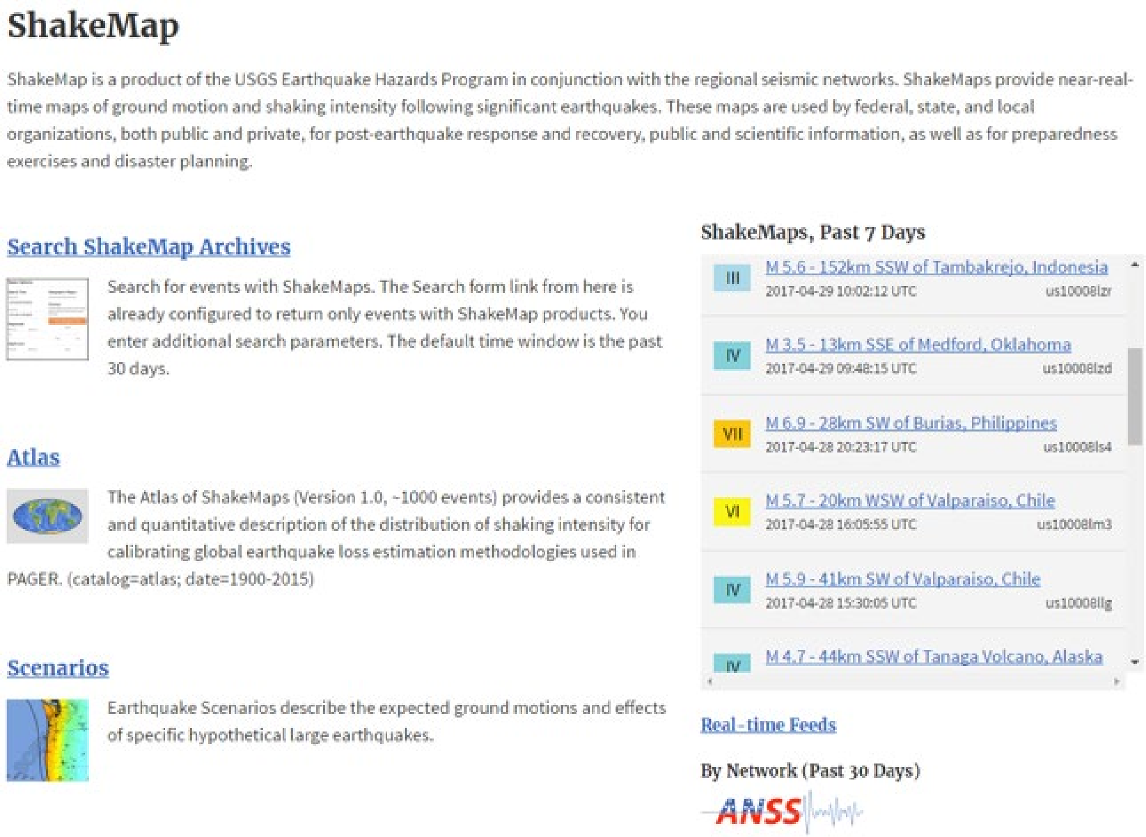
- Using ShakeMaps typically produces more credible analysis that can lead to a wider range of purposes for which Hazus is applicable.
- Hazus can download a grid.xml file from the USGS containing the earthquake parameters from the selected ShakeMap.

Visual 10: ShakeMaps for Hazus

- ShakeMaps for Hazus must include a minimum of 4 files:
    - peak ground acceleration (PGA)
    - peak ground velocity (PGV)
    - spectral acceleration at 1 second (psa10)
    - spectral acceleration at .03 seconds (psa03)
- Soil maps should not be used with ShakeMaps

Visual 11: Where to find ShakeMaps?

- USGS Shakemap website



Visual 12: Where to find ShakeMaps for California?

California Integrated Seismic Network (CISN)

Name/Epicenter	Date	Time	Lat	Long	Mag
15.9 km (9.9 mi) E of Oildale, CA	Jun 10, 2019	02:41:11 AM UTC	35.41	-118.84	3.5
12.4 km (7.7 mi) W of San Clemente Is. (SE tip), CA	Jun 6, 2019	11:25:36 AM UTC	32.84	-118.48	3.5
4.4 km (2.7 mi) NNW of Glen Avon, CA	Jun 6, 2019	12: 20:57 AM UTC	34.05	-117.51	3.2
14.9 km (9.3 mi) W of San Clemente Is. (SE tip), CA	Jun 5, 2019	02: 32:09 PM UTC	32.84	-118.50	4.3
12.9 km (8.0 mi) W of San Clemente Is. (SE tip), CA	Jun 5, 2019	10:47:18 AM UTC	32.82	-118.48	4.3

Sample of ShakeMaps currently available on the CISN website:

Visual 13: Activity 5.1

Student Activity

- Complete a scenario using ShakeMap

Visual 14: Additional Deterministic Events

Historical epicenter event

- Select the desired event from the Hazus database of 3,500 historical events.

Fault source event

- For the Western U.S., select the desired fault source from the Hazus database of faults.

Arbitrary event

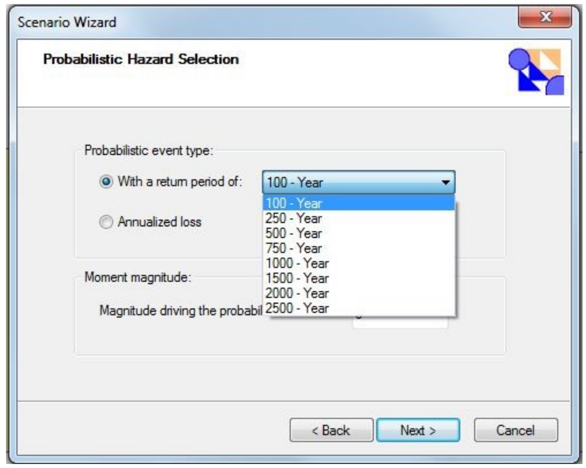
- Defined by the location of its epicenter and by its magnitude.
- Epicenter is defined either by entry of latitude and longitude or graphically or a map.

Visual 15: Probabilistic Scenarios

Probabilistic

- Specific Return Period
- Annualized Earthquake Loss (AEL)

Probabilistic seismic hazard contour maps developed by the USGS for the National Seismic Hazard Mapping Project

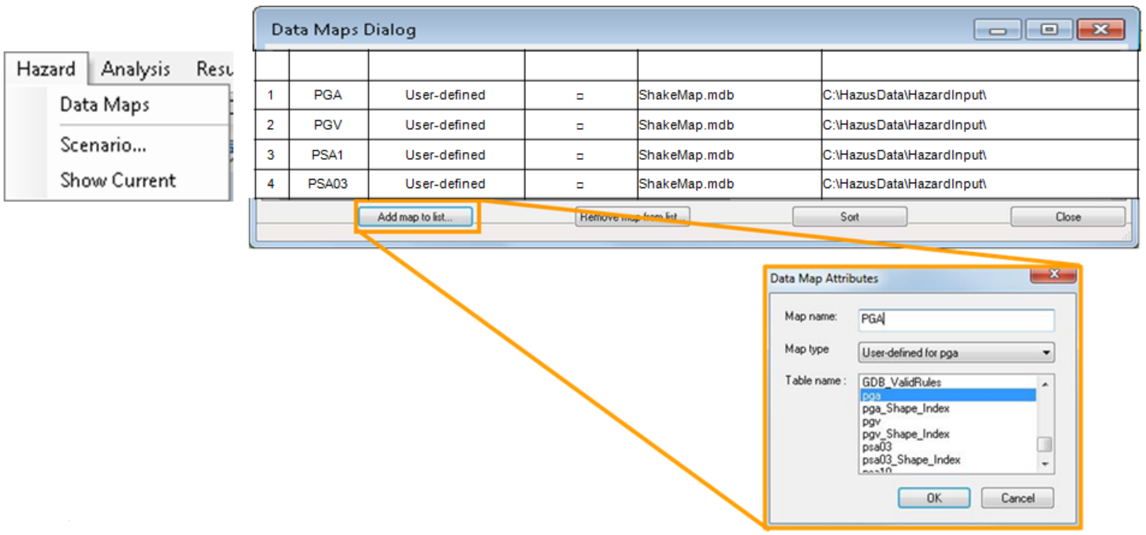


Visual 16: FEMA P366

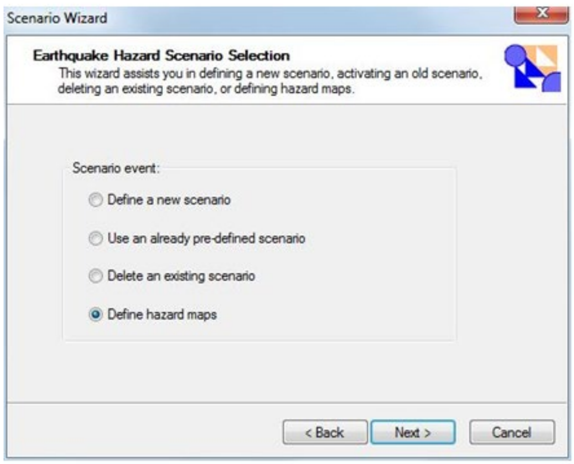
- FEMA P366 highlights the impacts of both high hazard and high exposure on losses caused by earthquakes.
- Access the FEMA P366 report here
- The P366 data can be viewed here

Visual 17: Importing Hazard Maps

- Import user-defined maps to create more detailed analysis.
- Expertly generated ground motion and soils maps can enhance the quality of your results.



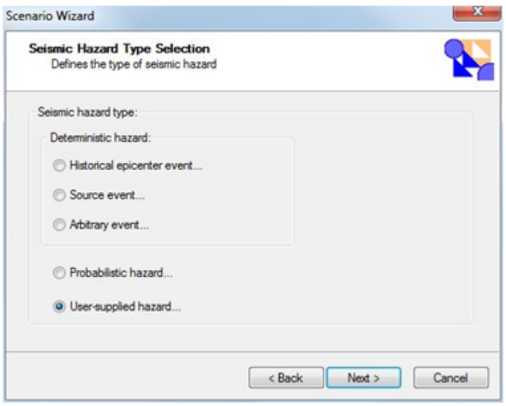
Visual 18: EQ User-Defined Hazard Option



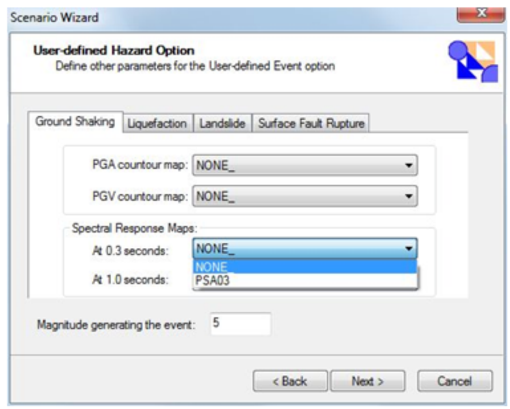
Hazard map options:

- **Apply same value to the entire region.**
- **Import hazard maps so that Hazus can generate more accurate ground motion data.**

Visual 19: EQ User-Defined Hazard Option (Cont.'d)



Allows you to import hazard maps created outside of Hazus that are related to a specific event.



These data can be brought into Hazus in order to generate more accurate loss estimations.

Visual 20: Scenario Applications

- Historical and ShakeMap - useful for validation, calibration, benchmarking, analysis of repeat earthquake events, and mitigation analysis.
- Arbitrary - useful for areas with very limited seismic activity, events defined by geologists or other experts, mitigation analysis, and response and recovery in the absence of user- defined maps.
- User-defined - most useful when ground motion maps are available (e.g., post-disaster event or level 3 studies).

Visual 21: Scenario Applications

- Probabilistic - useful for prioritization of seismic reduction measures and for simulating mitigation strategies.
- Annualized – useful for comparisons of risk for large regions, states and the nation.

Visual 22: Prioritizing EQ Hazard Data

Soil is most important:

- Affects shaking intensity

Liquefaction is important mostly for roads, tracks, tunnels, runways, bridges, and pipelines:

- Effect on buildings is very localized
- Water table depth affects the liquefaction potential

Landslide effects are localized and important mostly for roads, tracks, tunnels, bridges, and pipelines.

Visual 23: Model Sensitivity

Hazus results are most sensitive to ground motion.

If no data is available for soil or liquefaction, you should run sensitivity tests. Examples:

- See how losses change if soil type was B (compared to the default class of D). This will provide a lower-bound loss.
- See what effects liquefaction has on results by changing the default assumption from "no potential" to "very high" by selecting the soil type as "E." This will provide an upper bound loss.

Visual 24: Review

1. What are the five main EQ model scenario options?
2. What is a ShakeMap?
3. What is the most important hazard parameter to include and why?

Visual 25: Questions?

Lesson 6: Economics and Social Loss Models

Visual 1: Lesson 6: Economic and Social Loss Models

Visual 2: Goal and Objectives

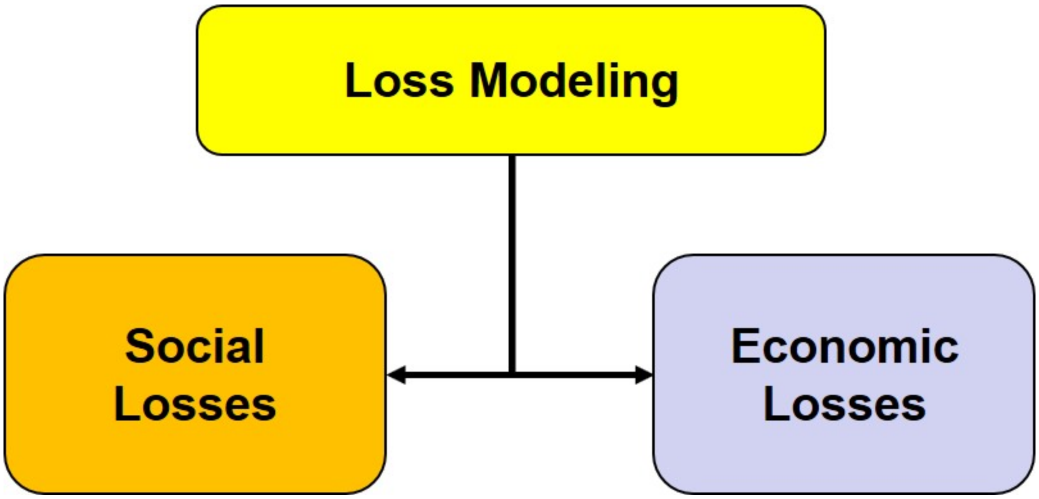
Goal

- To understand the parameters and possibilities of the social and economic loss models.

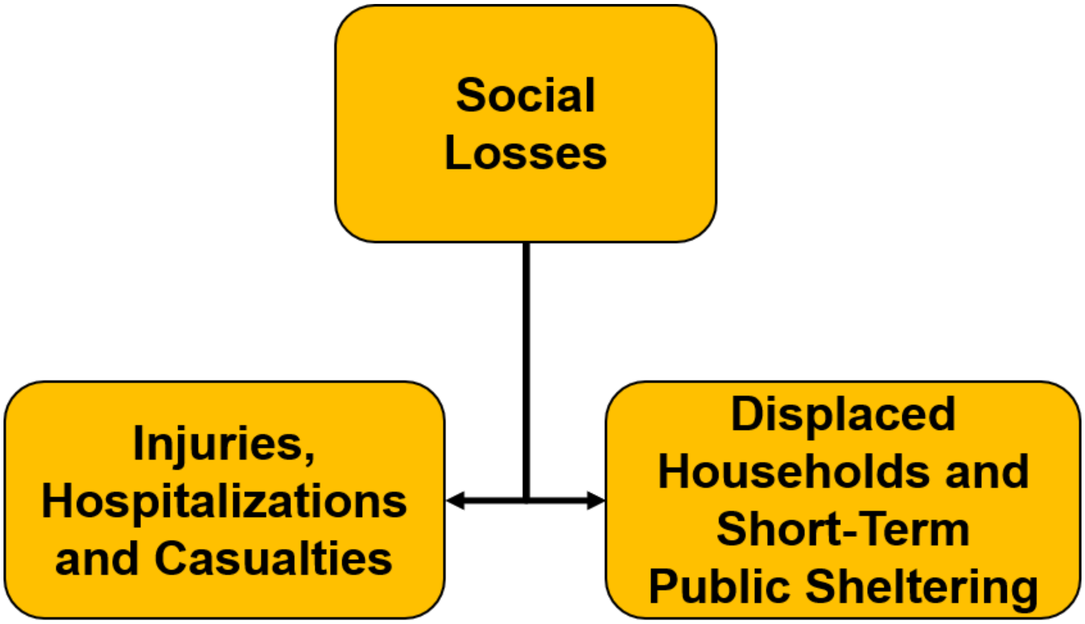
After this lesson you will be able to:

- Explain the methodology behind the social and economic impact assessment models in Hazus.
- List the key parameters of these models.

Visual 3: Economic and Social Loss Models



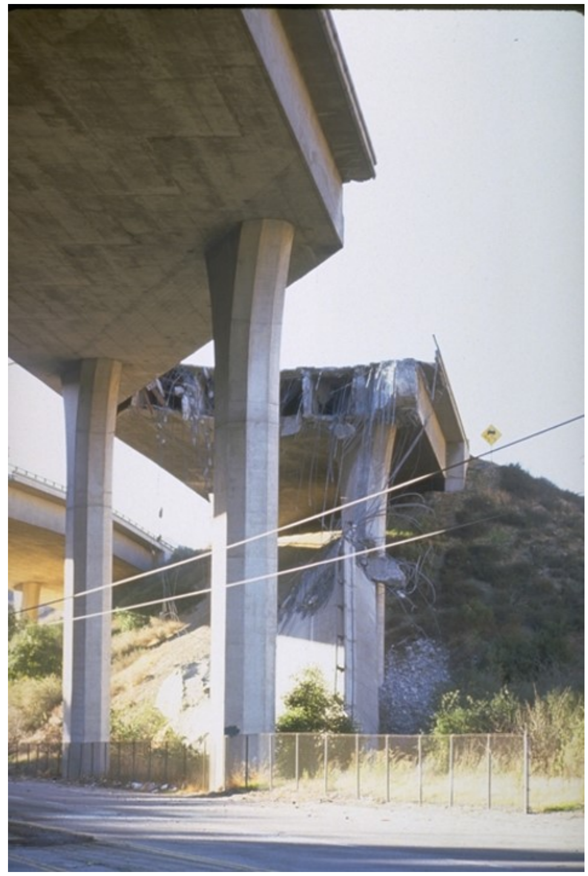
Visual 4: Social Loss Model



Visual 5: EQ Injury and Casualty Parameters

Parameters

- Damage to various Building Types (ex. Wood) by Specific Building Type (ex. W1)
- Bridge Damage Contribution
- Time, Occupancy, and Location (e.g., indoor) Dependent



Northridge Earthquake, Calif., January 17, 1994

Visual 6: EQ Injuries and Casualties (Cont.'d)

Casualties are calculated by:

- Indoor, Outdoor, Commuting
- Single Family, Other Residential, Commercial, Industrial, Education, Hotel, Commuting
- 2am (nighttime), 2pm (daytime), 5pm (commuting)

Injury Severity Level	Injury Description
Severity 1	Injuries requiring basic medical aid without requiring hospitalization
Severity 2	Injuries requiring a greater degree of medical care and hospitalization, but not expected to progress to a life-threatening status
Severity 3	Injuries that pose an immediate life-threatening condition if not treated adequately and expeditiously. Most of these injuries result from structural collapse and subsequent collapse or impairment of the occupants
Severity 4	Instantaneously killed or mortally injured

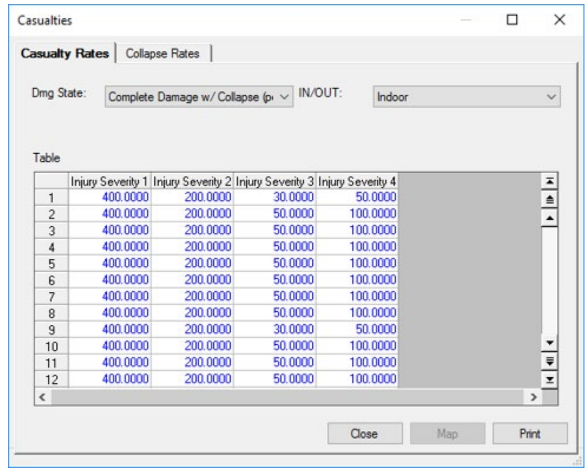
Visual 7: EQ Injuries and Casualties (cont.)

Dependent on:

a. Casualty Rates – determined by:

- Specific Model Building Types
- Severity level of building damage: (e.g., slight, moderate).

b. Collapse Rate based on probability of collapse given a complete damage state



	Injury Severity 1	Injury Severity 2	Injury Severity 3	Injury Severity 4
1	400.0000	200.0000	30.0000	50.0000
2	400.0000	200.0000	50.0000	100.0000
3	400.0000	200.0000	50.0000	100.0000
4	400.0000	200.0000	50.0000	100.0000
5	400.0000	200.0000	50.0000	100.0000
6	400.0000	200.0000	50.0000	100.0000
7	400.0000	200.0000	50.0000	100.0000
8	400.0000	200.0000	50.0000	100.0000
9	400.0000	200.0000	30.0000	50.0000
10	400.0000	200.0000	50.0000	100.0000
11	400.0000	200.0000	50.0000	100.0000
12	400.0000	200.0000	50.0000	100.0000

Visual 8: Short-Term Shelter Model Modification Factors

Modification Factors

- Add additional importance to sub-factors for each weighting factor
- Defaulted as the same value for every tract in the US and should be modified to reflect the importance in your study area

Class	Description	Factor
AM1	Population under 16 years old	0.40
AM2	Population between 16 and 65 years old	0.40
AM3	Population over 65 years old	0.40
EM1	White	0.24
EM2	Black	0.48
EM3	Hispanic	0.47
EM4	Asian	0.26
EM5	Native American	0.26
IM1	Household income < $10,000	0.62
IM2	$10,000 <= Household income < $20,000	0.42
IM3	$20,000 <= Household income < $30,000	0.29
IM4	$30,000 <= Household income < $40,000	0.22
IM5	$40,000 <= Household income	0.13
OM1	Owner occupied dwelling	0.40

Class	Description	Factor
OM2	Renter occupied dwelling	0.40

How would you modify these factors for your community?

Visual 9: EQ Shelter Parameters

Weighting Factors

- Based on demographic considerations (Age, Ethnicity, Income and Ownership)
- Accounts for Loss of Utility Services

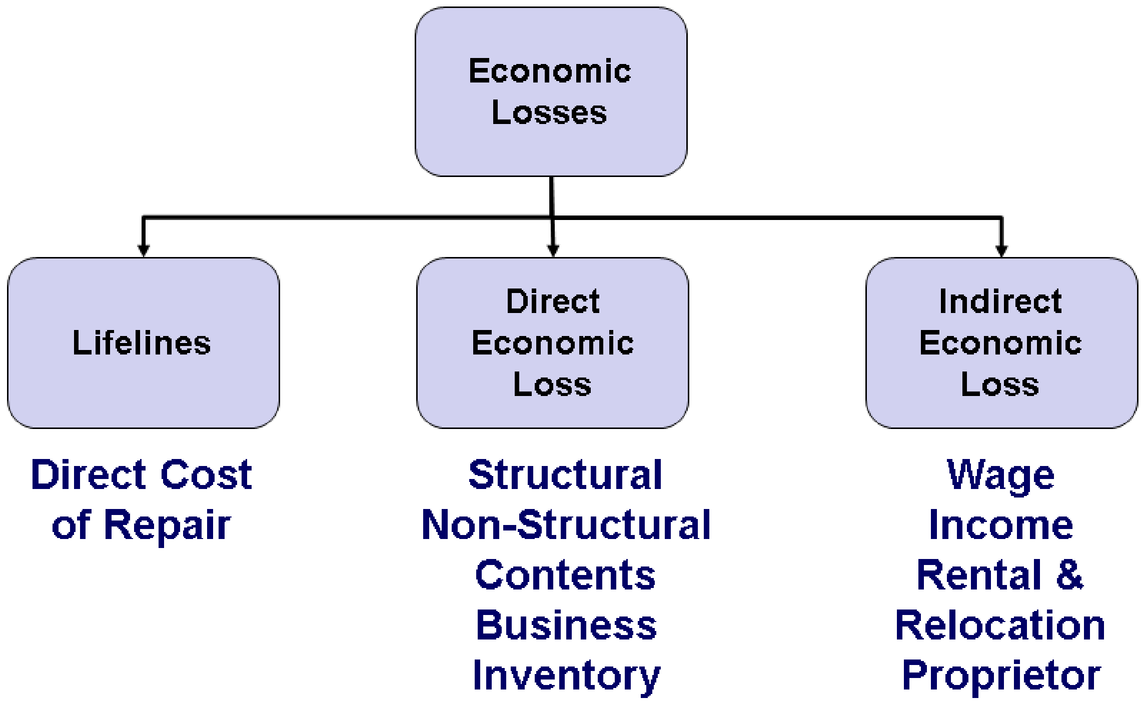
Weight Factor	Description	Importance Factor
AW	Age Weighting Factor	0
EW	Ethnic Weighting Factor	0.27
IW	Income Weighting Factor	0.73
OW	Ownership Weighting Factor	0

* These default assumptions may not represent the area you are modeling. Please adjust to your study area.

Visual 10: Limitations of the Social Loss Model

- No predefined population distribution by specific occupancy (e.g., no way of knowing age 65 and up work in a commercial building)
- No modeling for injuries due to non-structural damage
- No dynamic linkage between shelter parameters and demographic facts (including race, culture, etc.)
- No explicit results of estimated trapped victims in collapsed buildings

Visual 11: Economic Loss Model



Visual 12: Economic Loss Model (cont.)

Key Contributing Inventory Parameters:

- Content value (percent of building replacement cost) for different occupancies
- Annual gross sales by occupancy
- Typical rental costs and Relocation expenses
- Income by occupancy
- Replacement values for the various transportation and utility facilities

Occupancy	Description	% of Replacement Cost
RES1	Single Family Dwelling	50
RES2	Mobile Home	50
RES3	Multi Family Dwelling	50
RES4	Temporary Lodging	50
RES5	Institutional Dormitory	50
RES6	Nursing Home	50
COM1	Retail Trade	100
COM2	Wholesale Trade	100
COM3	Personal and Repair Services	100
COM4	Professional/Technical Services	100
COM5	Banks	100
COM6	Hospital	150
COM7	Medical Office/Clinic	100
COM8	Entertainment & Recreation	100

Occupancy	Description	% of Replacement Cost
COM9	Theaters	100
COM10	Parking	50

Visual 13: Economic Loss Model (cont.)

Occupancy	Description	% of Replacement Cost
IND1	Heavy	150
IND2	Light	150
IND3	Food/Drugs/Chemicals	150
IND4	Metals/Minerals Processing	150
IND5	High Technology	150
IND6	Construction	100
AGR1	Agriculture	100
REL1	Religious/Non-Profit	100
GOV1	Government General Services	100
GOV2	Government Emergency Response	150
EDU1	Grade Schools	100
EDU2	Colleges/Universities	150

Visual 14: Economic Loss Model (cont.)

Analysis Parameters – Business Interruption:

- Occupancies with inventory considerations: COM1, COM2, IND1-IND6, AGR1
- Annual gross sales based on 2002 data
- Restoration times based on building damage, clean-up, inspections, permits, contractor availability
- Income losses depend on restoration time for business operations

Visual 15: Limitations

- For a given damage state, cost of repair per square foot is the same for all types of buildings
- No explicit business interruption losses to lifelines (only cost to repair)
- For small earthquakes, business interruption parameters are conservative (result in higher losses) and may need adjustment
- Some parameters are based off of old datasets, which can be a limitation.

Visual 16: Summary

- Social Loss model: Casualties & Sheltering
- Economic Loss Model: Lifelines & Economic Losses
- Economic losses could be direct (immediate effects) or indirect (long-term effects)
- There are limitations in each model that should be considered

Visual 17: Review

1. What are the key parameters for the social and direct economic loss models?
2. What are some of the limitations of the social loss model?
3. Name three key contributing inventory parameters of the economic model.

Visual 18: Questions?

Lesson 7: Bridge and Pipeline Loss Models

Visual 1: Lesson 7: Bridge and Pipeline Loss Models

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Visual 2: <u>Goal and Objectives</u>

Goal

This lesson will discuss the components that operate the bridge and pipeline loss models and how to alter the various components.

After this lesson you will be able to:

- Explore the bridge classification system.
- Explore the bridge loss estimation methodology.
- Understand the pipeline model and key parameters.
- Explore options for customizing damage models for pipelines.

Visual 3: Key Components

Inventory

- Location information obtained from the National Bridge Inventory (NBI)

Classification/Damage Functions

- Some attributes based on characteristics per NBI data
- Other attributes developed based on historical seismic performance of bridges

Valuation (cost of repair & replacement)

Restoration functions

Economic loss of functions

Visual 4: Bridge Classification

National Bridge Inventory (NBI) data provides a variety of information.

- # Spans
- Structural Type
- Pier Type
- Abutment Type & Bearing Type
- Span Continuity

Visual 5: Bridge Classification (cont.)

Material and/or Construction

- Concrete, Steel, Masonry, etc...
- 10 classes

Bridge Type

- Slab, Tee Beam, Suspension, etc...
- 23 classes

*For further detail refer to the Earthquake Technical Guidance.

Visual 6: Bridge Classification (cont.)

Conventional Bridges

- Codes based on material and type
- Unique options for California
- Damage State Thresholds - Slight, Moderate, Extensive, Complete

Description	Codes	Non-California	California
Multi-column Bents, Simply Supported	101-106 301-306 501-506	0.26, 0.35, 0.44, 0.65	0.33, 0.46, 0.56, 0.83
Single-column Bents, Box Girders	205-206 605-606	Not Applicable	0.35, 0.42, 0.50, 0.74

Visual 7: Bridge Classification (cont.)

Seismically Designed Bridges

- Codes based on material and type
- Unique options for California due to earthquake susceptibility
- Damage State Thresholds - Slight, Moderate, Extensive, Complete

Description	Codes	Non-California	California
Multi-column Bents, Simply Supported	101-106 301-306 501-506	0.45, 0.76, 1.05, 1.53	
Single-column Bents, Box Girders	205-206 605-606	Not Applicable	0.54, 0.88, 1.22, 1.45

Visual 8: Bridge Classification (cont.)

3-D Effects on Bridges

- The 3-D effects refer to the "out-of-plane" motion that the bridge may feel during an earthquake that tends to cause more damage.

Description	Codes	Conventional	Seismic
Concrete	101-106	$1 + 0.25 / n_p$	$1 + 0.25 / n_p$
Continuous Concrete	201-206	$1 + 0.33 / n$	$1 + 0.33 / n_p$
Steel	301-310	$1 + 0.25 / n_p$; $L > 20m$ $1 + 0.25 / n_p$; $L < 20m$	$1 + 0.25 / n_p$

Visual 9: Hazus Simplified Classification

Class	Description	Code	Design	# Spans	MaxSpan
HWB1	Major Bridge	ALL	Conventional Seismic		> 150m
HWB2					> 150 m
HWB3	Single Span - (Not HWB1 or HWB2)	ALL	Conventional Seismic	1	
HWB4		ALL		1	
HWB5	Multi-Col. Bent, Simple Support - Concrete	101 - 106	Conventional Conventional Seismic		
HWB6					
HWB7					
HWB8	Single Col., Box Girder - Continuous Concrete	205 - 206	Conventional Seismic		
HWB9					
HWB10	Continuous Concrete - (Not HWB8 or HWB9)	201 - 206	Conventional Seismic		
HWB11					
HWB12	Multi-Col. Bent, Simple Support - Steel	301 - 306	Conventional Conventional Seismic		
HWB13					
HWB14					
HWB15	Continuous Steel	402 - 410	Conventional Seismic		
HWB16					
HWB17	Multi-Col. Bent, Simple Support - Prestressed Concrete	501 - 506	Conventional Conventional Seismic		
HWB18					
HWB19					
HWB20	Single Col., Box Girder - Prestressed Continuous Concrete	605 - 606	Conventional Seismic		
HWB21					
HWB22	Continuous Concrete - (Not HWB20 or HWB21)	601 - 607	Conventional Seismic		
HWB23					

Excerpt from Hazus Earthquake Technical Manual

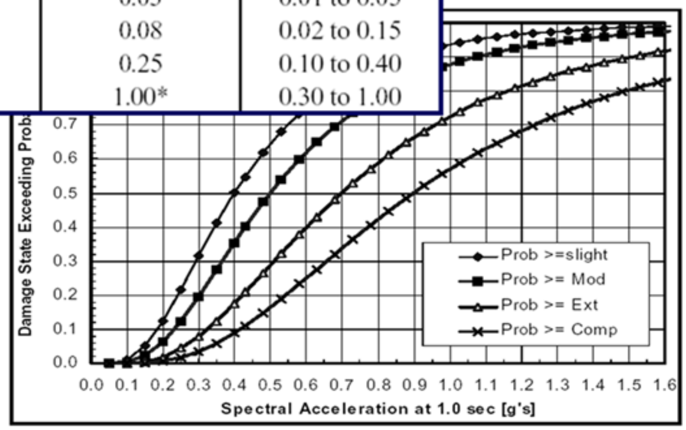
Visual 10: Hazus Damage Methodology

1. Know the location (lat & long)
2. Know the soil, liquefaction and landslide potential at that site.
3. Categorize the vulnerability by choosing the appropriate class.
4. Estimate the replacement cost of the bridge.
5. Compute the ground shaking and amount of ground failure expected at the site.
6. Assess the damage due to ground shaking and ground failure .
7. Translate the damage to loss of function and cost of repair .

Visual 11: Economic Loss Evaluation

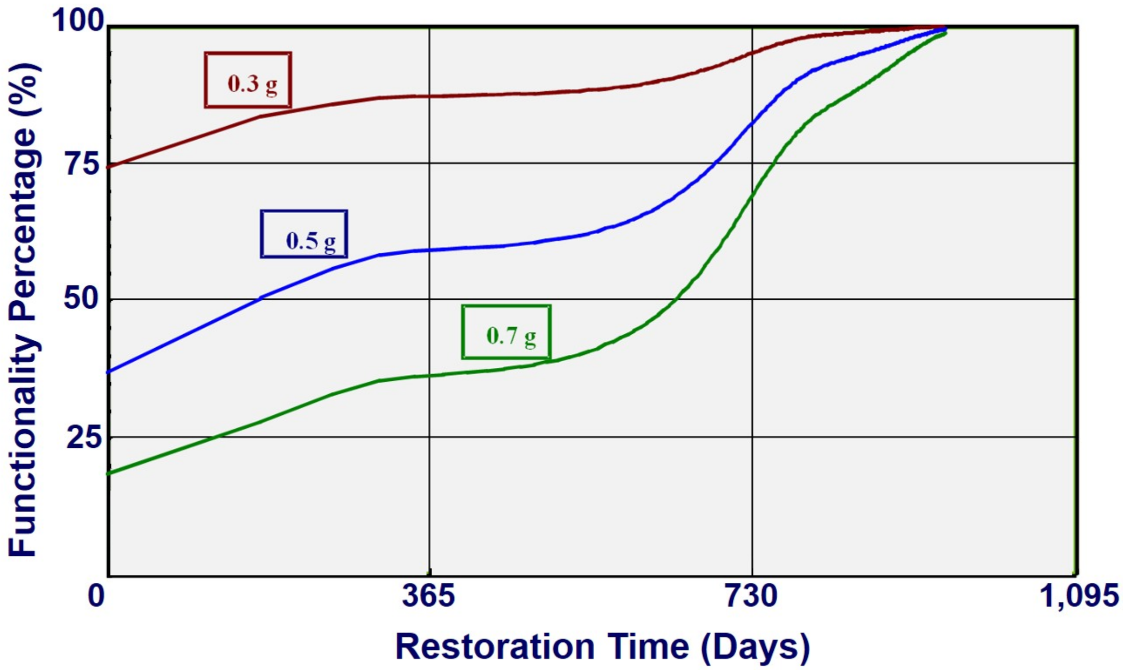
Repair cost of bridges is a computation of the replacement value with damage ratios that correspond to each damage states in a weighted average approach.

Bridges	slight moderate extensive complete	0.03 0.08 0.25 1.00*	0.01 to 0.03 0.02 to 0.15 0.10 to 0.40 0.30 to 1.00



*** If the number of spans is greater than two, then the best estimate damage ratio for complete damage is [2/(number of spans)].**

Visual 12: Restoration Function for Bridges



Visual 13: Activity 7.1

Student Activity

- Explore the effects of Different Parameters on Bridge Damage

Visual 14: Summary

- Background information presented on how the bridge model functions
- Key step is in assigning the right classification, which is based on attributes specific to a given bridge
- Default replacement values are editable and can be replaced
- Likewise, all other parameters (damage, loss of function and economic parameters) could be edited. This would be an advanced type of analysis.

Visual 15: About the Pipeline Model

Same methodology used in Hazus for:

- Potable water pipelines
- Storm water pipelines
- Sewers
- Crude oil pipelines
- Refined oil pipelines
- Natural gas pipelines

Understanding the architectural design of the model in the Hazus software will help you figure out how to refine the model when needed.

Visual 16: Key Components

Inventory

- No baseline site-specific data, only placeholders
- Users can add pipeline data if available locally
- Hazus will model damage if inventory is provided
- Aggregate data at 2010 census tract level is provided for water, sewer, & gas distribution pipelines (based on street proxy)

Classification / Damage Functions

- Over-simplified classification into brittle or ductile pipes
- Damage is expressed in terms of leaks and breaks

Visual 17: Key Components

Economic loss

- Cost of repair is a function of whether the pipe has suffered a leak or a break.

Functionality

- Restoration depends on the number of repair crews available.

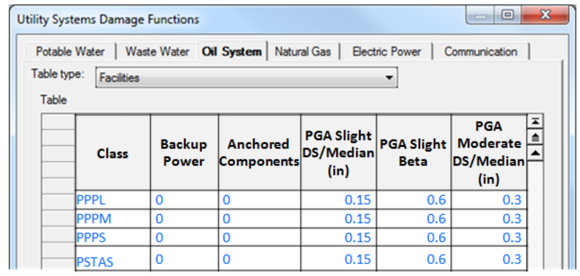
Visual 18: Key Pipeline Attributes

- Diameter (required)
- Elevation
- Pressure
- Flow
- Class (required)
  - Material (Type, Roughness, etc...)
  - Joint type
- Replacement value (required)
- Linkage to facilities

Visual 19: Damage Model

Damage model has two components

1. Ground shaking
   - PGV
2. Ground failure
   - Lateral spreading
   - Settlement
   - Landslide

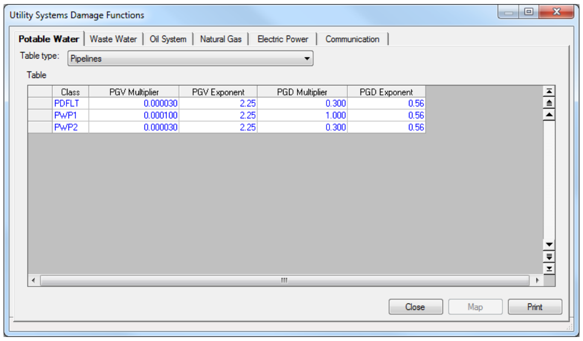


Class	Backup Power	Anchored Components	PGA Slight DS/Median (in)	PGA Slight Beta	PGA Moderate DS/Median (in)
PPPL	0	0	0.15	0.6	0.3
PPPM	0	0	0.15	0.6	0.3
PPPS	0	0	0.15	0.6	0.3
PSTAS	0	0	0.15	0.6	0.3

Damage = # Leaks + # Breaks

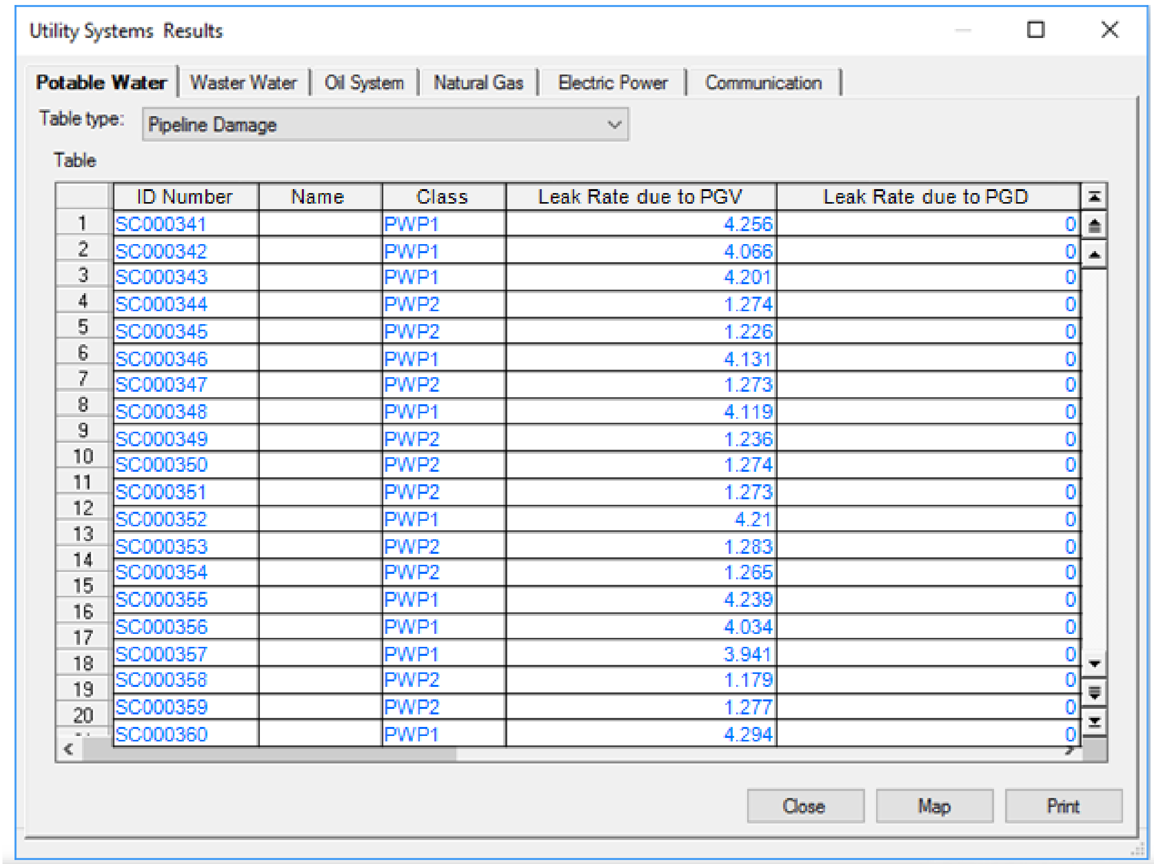
Visual 20: Functionality Model

Based on # of crews available



Visual 21: Economic Loss Model

Function of # leaks and # breaks



Utility Systems Results

Potable Water | Waster Water | Oil System | Natural Gas | Electric Power | Communication

Table type: Pipeline Damage

Table

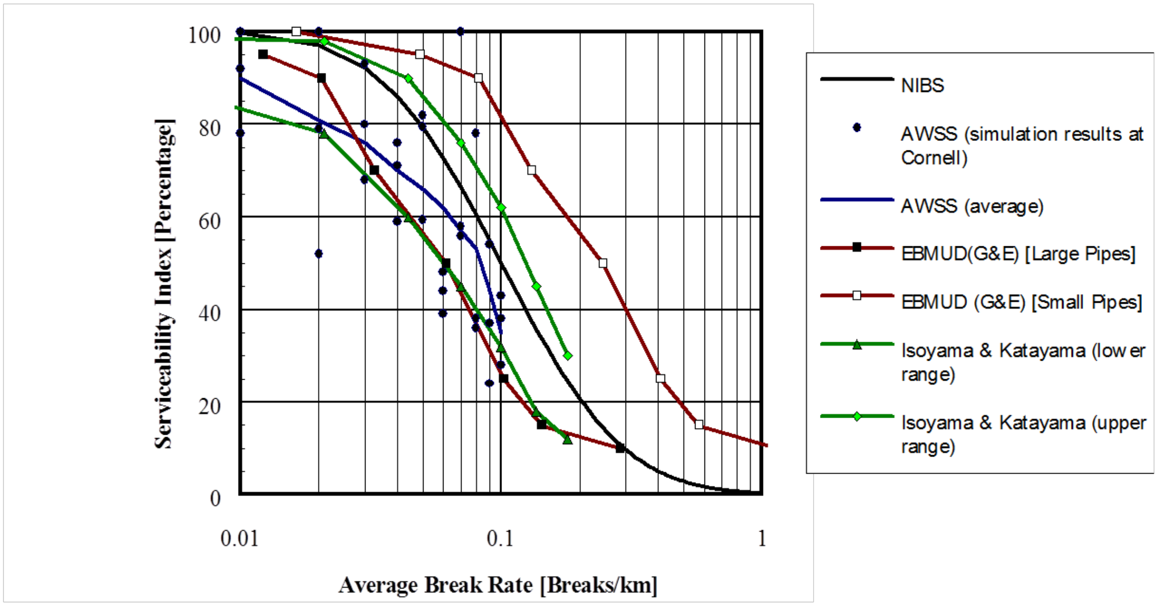
	ID Number	Name	Class	Leak Rate due to PGV	Leak Rate due to PGD
1	SC000341		PWP1	4.256	0
2	SC000342		PWP1	4.066	0
3	SC000343		PWP1	4.201	0
4	SC000344		PWP2	1.274	0
5	SC000345		PWP2	1.226	0
6	SC000346		PWP1	4.131	0
7	SC000347		PWP2	1.273	0
8	SC000348		PWP1	4.119	0
9	SC000349		PWP2	1.236	0
10	SC000350		PWP2	1.274	0
11	SC000351		PWP2	1.273	0
12	SC000352		PWP1	4.21	0
13	SC000353		PWP2	1.283	0
14	SC000354		PWP2	1.265	0
15	SC000355		PWP1	4.239	0
16	SC000356		PWP1	4.034	0
17	SC000357		PWP1	3.941	0
18	SC000358		PWP2	1.179	0
19	SC000359		PWP2	1.277	0
20	SC000360		PWP1	4.294	0

Close Map Print

Visual 22: System Performance

Potable water only

Households without water



Visual 23: Pipeline Loss Model Summary

- Background information presented on how the Pipeline Model works
- Key component of the critical utility infrastructure
- Challenging issues :
  - Obtaining actual data for pipelines
  - Expanding classes if needed
  - Defining the number of qualified crews available to do repair

Visual 24: Activity 7.2

Student Activity:

- Explore the effects of Pipeline Parameters on Damage

Visual 25: Review

1. What are some of the data types that the NBI provides?
2. Why are there unique codes for California compared to the rest of the United States for bridge classification?
3. How are the repair costs calculated for bridges?
4. How is damage expressed within the Pipeline Loss Model?
5. What are the two components that contribute to the damage model for pipelines?

Visual 26: Questions?

Lesson 8: AEBM and Site Specific Inventory

Visual 1: Lesson 8: AEBM and Site Specific Inventory

Visual 2: Goal and Objectives

Goal

Explore the methodology used in the Advanced Engineering Building Model (AEBM).

After completing this lesson you will be able to:

- Describe the usefulness of the AEBM functionality in Hazus to do portfolio analyses to buildings.
- See how to create AEBM profiles and a portfolio of buildings.

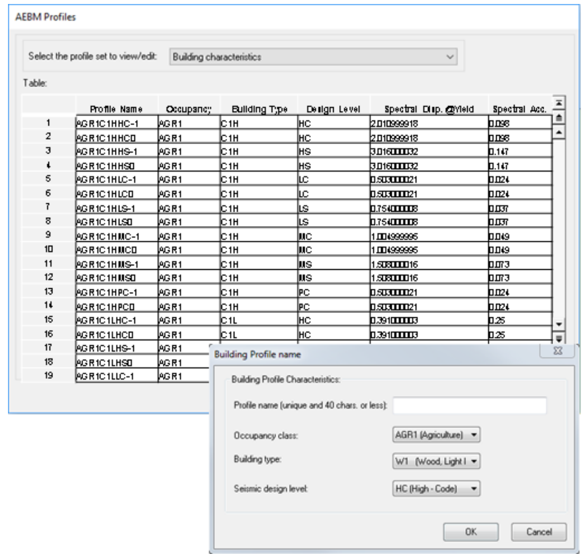
Visual 3: Introduction to AEBM Capabilities

Advanced Engineering Building Module (AEBM) allows site-specific analyses for a portfolio of buildings:

- Ground shaking and ground failure quantification
- Damage state probabilities assessment
- Economic loss computations
- Casualties estimates

Inventory items can be entered individually or imported through CDMS into State or Study Region databases.

Visual 4: AEBM: Choose or Define a Profile



Choose from over 16,000 unique building characteristics profiles.

Based upon:

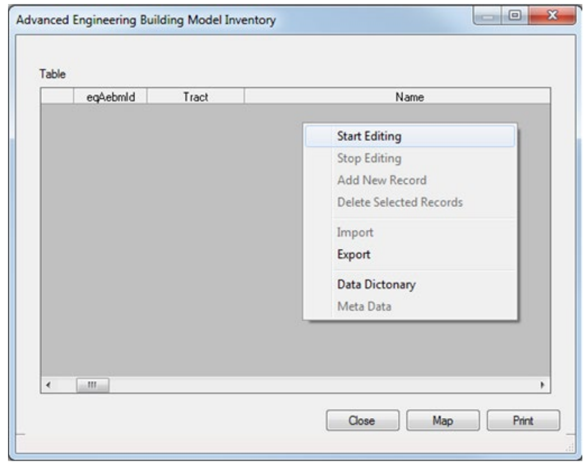
- Occupancy
- Building type
- Design level

Linked to:

- Capacity curves
- Fragility curves

Visual 5: AEBM: Creating a Portfolio

- Location-specific
- Must be linked to a previously created profile
- Input for square footage, number of occupants, and economic values (replacement value, content value, and business income)



Visual 6: AEBM: Betas - Shakemap vs. Any Other Scenario

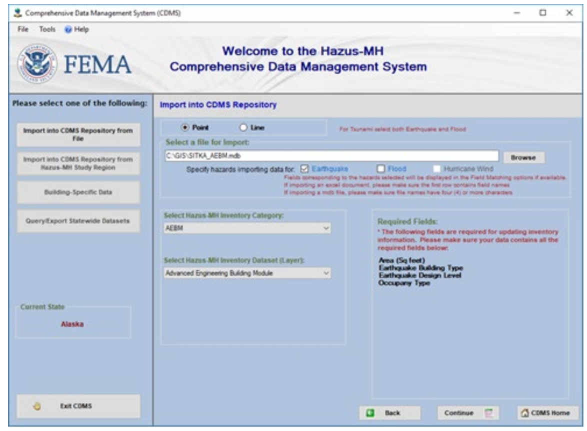
- Hazus building fragility functions employ lognormal standard deviation parameters, or “betas”
- Betas describe the total uncertainty of the fragility-curve damage states
- When populating ProfileName field in your AEBM database:
    - if using a Shakemap to analyze your AEBM inventory, you must use "-1" (ex. RES1W1MC-1)
    - if using any other Scenario to analyze your AEBM inventory, you must use "0" (ex. RES1W1MC0)

Visual 7: Merits of AEBM

- It can model any desired type or use of a building
- Total flexibility on defining the properties of buildings
- Fastest and most comprehensive way to analyze a portfolio of buildings with different characteristics
- Very powerful to use to estimate the benefits of a given mitigation strategy (eg., benefits of retrofitting a URM building, etc.)

Visual 8: Import AEBM with CDMS

- Use CDMS to import an AEBM inventory
- Update the State Data folder using CDMS with the imported AEBM inventory
- Create a Study Region with the updated State Data with AEBM
- The new Study Region will now contain an AEBM inventory



Visual 9: Activity 8.1

Student Activity:

- Building Type and Vulnerability Effects on Results

Visual 10: Review

1. How does an AEBM analysis differ from an aggregate earthquake analysis in Hazus, and for what types of investigations would the AEBM model be best suited?
2. What are building characteristic profiles based upon?
3. What are the two types of impact assessment that AEBM provides?

Visual 11: Questions?

Lesson 9: Tsunami Background and Analysis

Visual 1: Lesson 9: Tsunami Background and Analysis

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Visual 2: Goal and Objectives

Goal

This lesson will review the tsunami hazard, inventory, and analysis options in Hazus.

After completing this lesson you will be able to:

- Describe near and distance source tsunamis
- Understand tsunami-specific inventory
- Review tsunami analysis options

Visual 3: Background

- The Hazus Tsunami Model represents the first new disaster module for the Hazus software in almost 15 years.
- It is the culmination of work completed on the Hazus Tsunami Methodology Development (FEMA, 2013).
- The team consisted of tsunami experts, engineers, modelers, emergency planners, economists, social scientists, geographic information system (GIS) analysts, and software developers.

Visual 4: New Features

New features within the model include:

- **Territory Analysis:** This release represents the first time that analysis will be available for U.S. territories (Puerto Rico, Guam, American Samoa, Commonwealth of Northern Mariana Islands, and U.S. Virgin Islands).
- **New Point Format:** The Hazus General Building Stock (GBS) for the Tsunami release will use a new National Structure Inventory (NSI) point format (details in User Release Notes available with download).
- **Case Studies:** The Tsunami Module will require user-provided data, so the Hazus Team has provided five case study datasets for users, which will be available on the Map Service Center (MSC) download site.
- **Two Types of Damage Analysis:** Users will be able to run both near-source (Earthquake + Tsunami) and distant-source (Tsunami only) damage analysis.

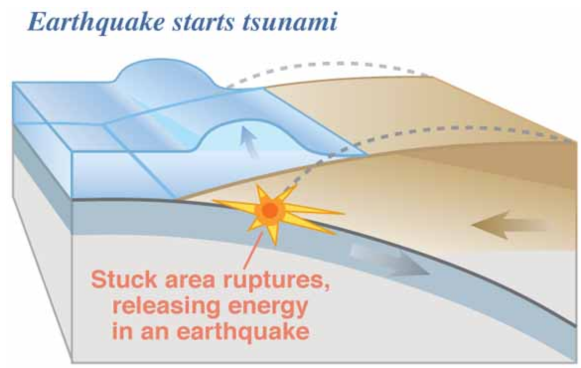
Visual 5: Hazus Tsunami Model

- Loss estimation model that provides state-of-the-art decision support software for estimating potential losses from tsunamis
- Available for five Very High-risk states (AK, WA, OR, CA, HI) and the five High-risk U.S. territories
- Combined Earthquake/Tsunami analysis functionality available for the five states and Puerto Rico

Visual 6: Tsunami – Near vs Distant Source

Near Source (local source)

- Those generated within 100 km of a locality of interest
- Earthquake ground shaking precedes the tsunami
- Earthquake damage possible
- Subsidence (lowering) of coastal area possible
- Lead time - a few minutes to an hour

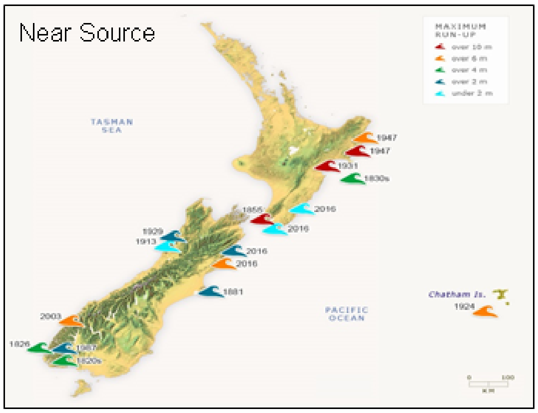


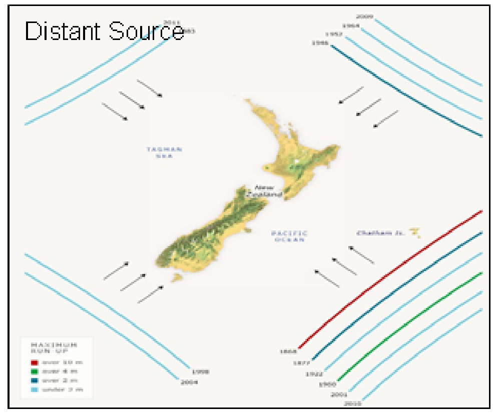
Credit: USGS

Visual 7: Tsunami – Near vs Distant Source (cont.)

Distant Source

- Those generated more than 1,000 km from a locality
- No ground shaking precedes the tsunami
- Lead time - few to several hours





Credit: USGS (Image: https://teara.govt.nz/en)

Visual 8: National Structure Inventory

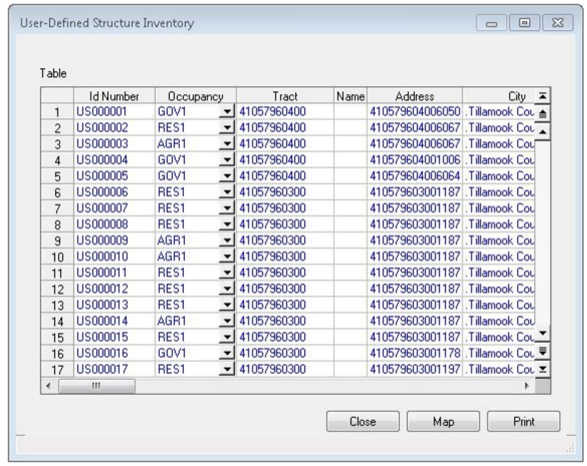
- U.S. Army Corp of Engineers' National Structural Inventory point data. Developed with FEMA.
- Creates notional structures, or 'points,' in the developed portion of each census block to represent the numbers and types of buildings that occur based on size, occupancy type, construction materials, etc.

Visual 9: National Structure Inventory (cont'd)

- Tsunami model General Building Stock (GBS) does not directly use the aggregated Census Tract or Block data.
- The tsunami loss model capability is not currently available for Essential Facilities.
- Users can evaluate Essential Facilities by incorporating them as User-Defined Facilities.

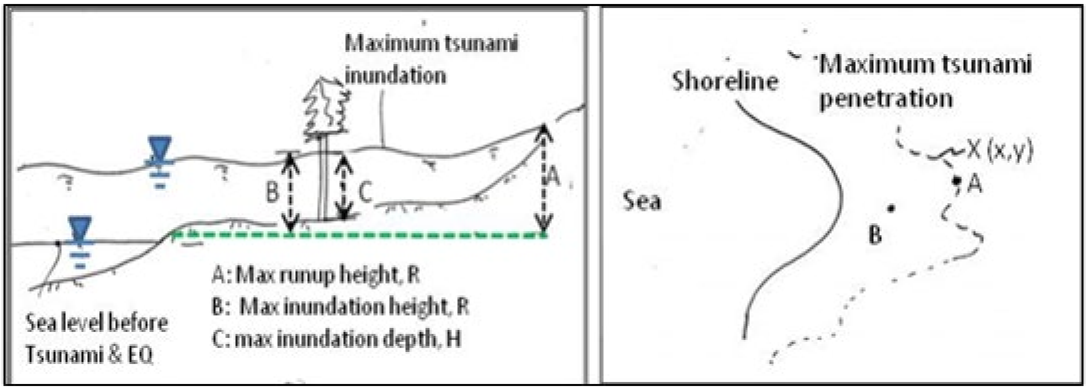
Visual 10: User Defined Facilities

- Enables user specific datasets to be analyzed through the Hazus methodologies providing more accurate results
- Use CDMS to assist in creation of your UDF database
- Attributes include:
  - Occupancy type
  - Earthquake building type
  - Design level
  - First floor height
  - Building replacement cost
  - Content replacement cost
  - Location of structure



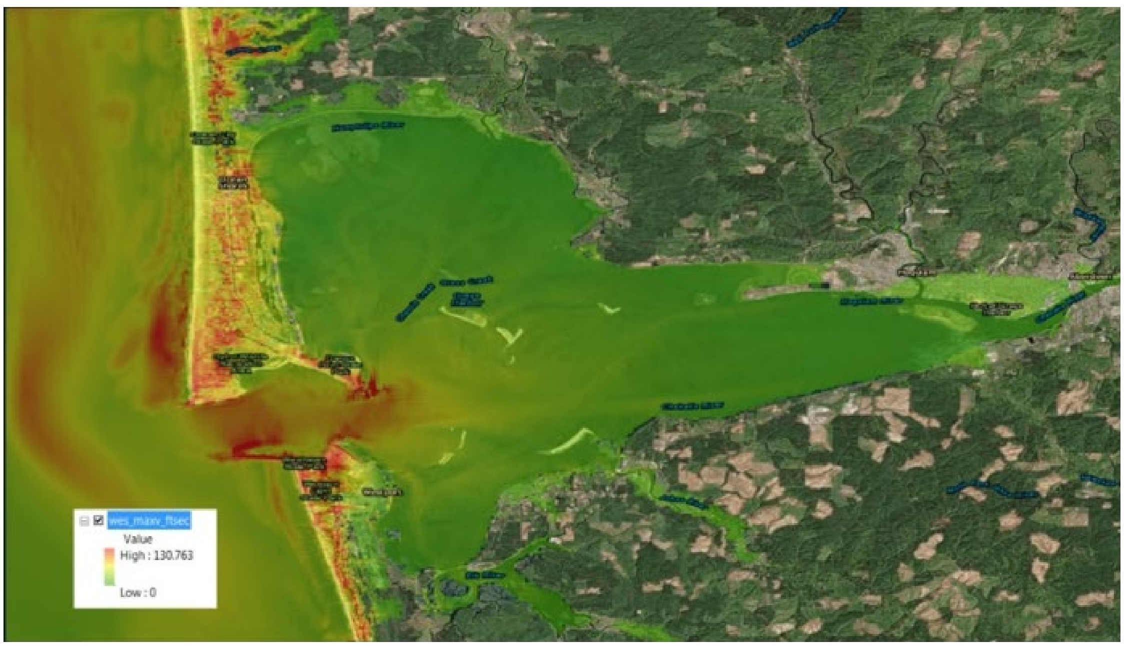
Visual 11: Tsunami Runup Height R

- The height at the maximum tsunami penetration
- Inundation/evacuation map boundaries
- For determining content and nonstructural losses - based on depth only



Visual 12: Momentum Flux (ft^3s^2)

- Rate of transfer of momentum across a unit area
- Used to determine structural damage to buildings
- Calculated by Hazus (Basic Analysis) using the maximum runup height and topography (DEM)
- Provided by user for Advanced Analysis - Level 2 and 3
- SIFT (Short-term Inundation Forecasting for Tsunamis) system is the numerical estimate of amplitude, travel time, and additional tsunami properties using an inundation model constrained by real-time tsunami observations.



SIFT model velocity grid for Westport, WA

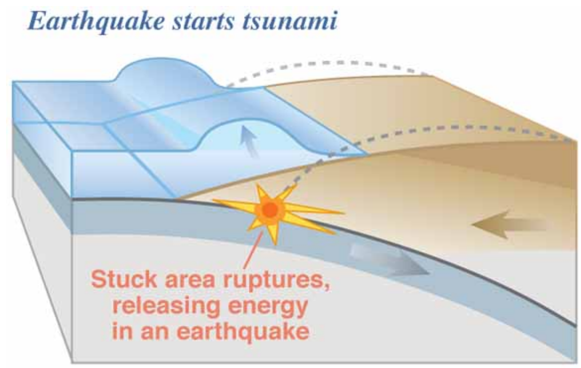
Visual 13: Digital Elevation Model (DEM)

Determine Required DEM extent:

- Merge the DEMs if there is more than one for the area of interest.
- Mask the DEM to the study region, which is a time saving technique especially useful for island regions.

Visual 14: Near Source – Deformed DEM

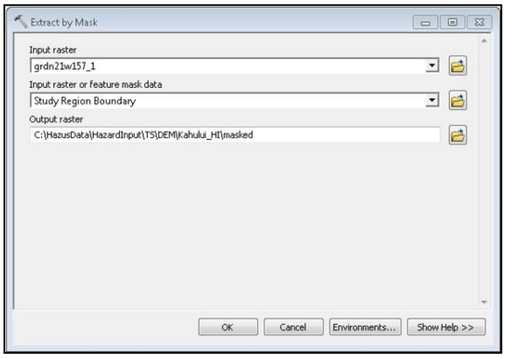
- Post-earthquake event deformed topography should be used in the case of a near source scenario.
- Earthquake could result in several meters of ground deformation, which may substantially change the inundation area and affect potential losses resulting from a tsunami.

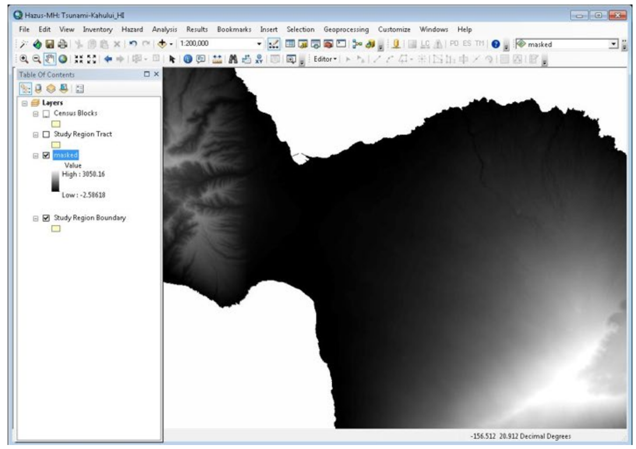


Visual 15: Masking DEM

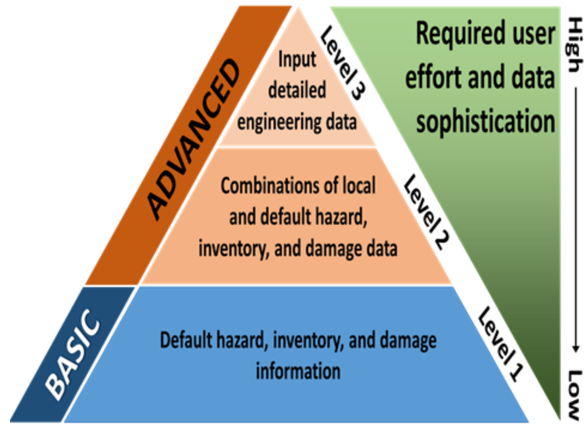
ESRI ArcMap Extract by Mask tool:

- Clips the DEM to the Study Region Boundary
- Removes all of shore sections
- Reduces processing time





Visual 16: Levels of Tsunami Analysis



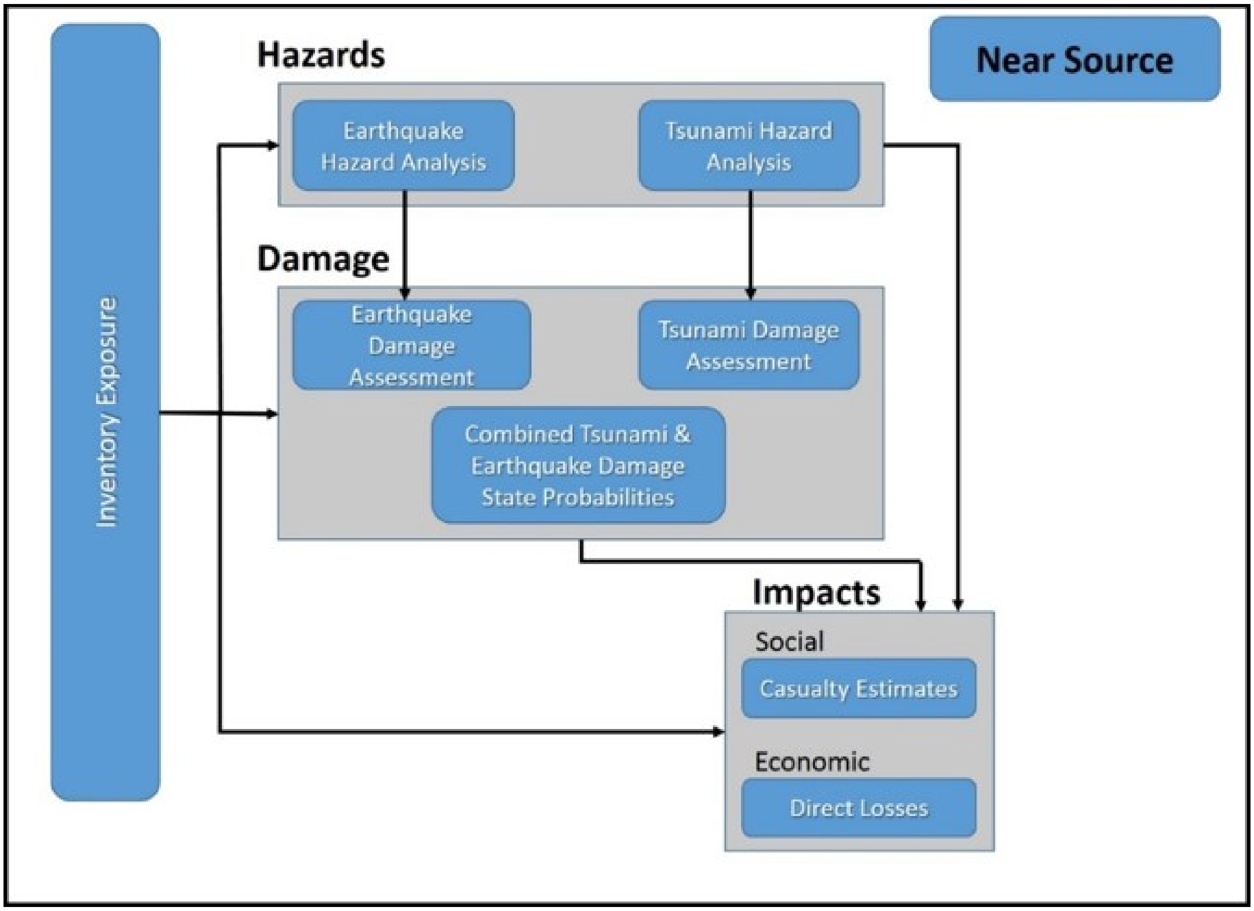
Basic (Level 1)

- Out-of-the-box default infrastructure
- Basic user input

Advanced (Level 2/3)

- User-provided data - more accurate to the region
- Data provided by third-party studies/hazard models

Visual 17: Hazus Analysis Components



Visual 18: Hazus Analysis Components (Cont.'d)

Hazard Input

- Tsunami inundation depth
- Velocity or momentum flux
- Topography

Infrastructure

- NSI data (point location aggregated)
- User defined structures

Damage and Losses

- Direct damage to structures, contents and nonstructural elements
- Direct economic losses

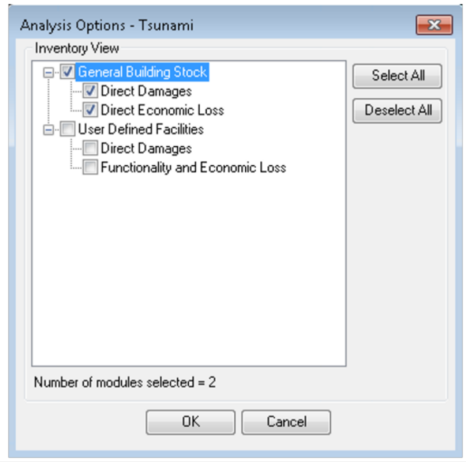
Casualties

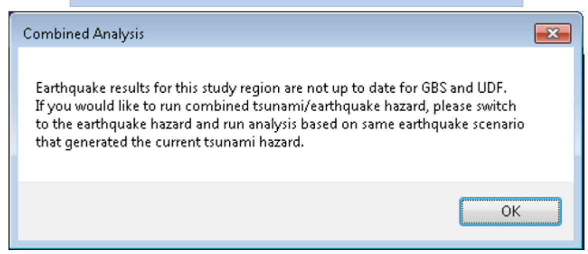
- Evacuation times
- Injury/Fatality estimates
    - Age, time of day, community preparedness

Visual 19: Analysis Options - Tsunami

Options:

- General Building Stock
  - Direct Damages
  - Direct Economic Loss
- User Defined Facilities
  - Direct Damages
  - Functionality and Economic Loss





Visual 20: Results

Tsunami Inundation layers

- Inundation/Hazard Boundary polygon (depth>0)
- Fatality Boundary (depth >= 2m)

General Building Stock

- Direct Damages
- Direct and Indirect Economic Losses

User Defined Facilities

- Infrastructure damage probabilities
- Direct and Indirect Economic Losses

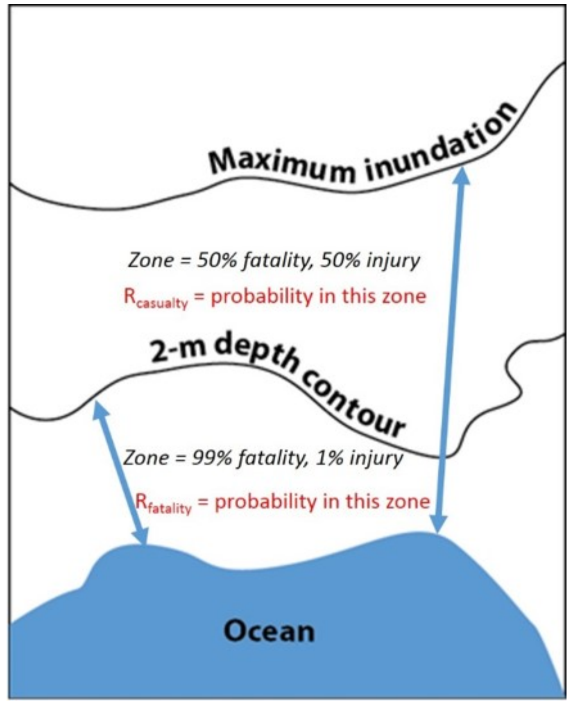
Visual 21: Casualty Scenario

Level 1 - Input:

- Fatality Boundary (depth > 2m)
- Hazard Boundary (Depth > 0)
- Road Network Data
- Topography (DEM)
- Estimated time of tsunami arrival and maximum runup

Level 2 - Input:

- Output travel time results provided by the USGS Pedestrian Evacuation Analyst Tool



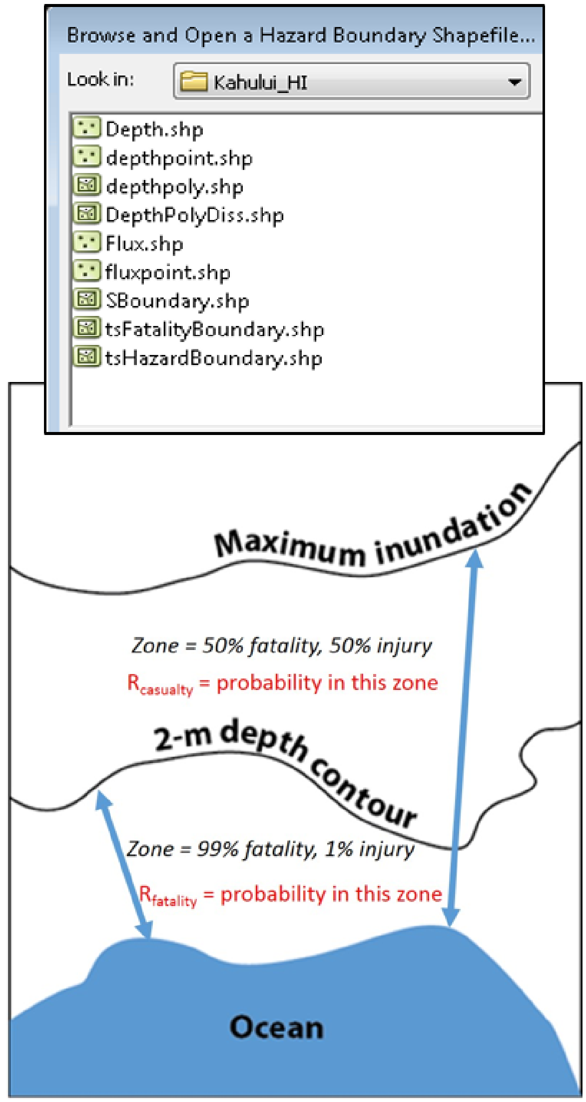
Visual 22: Hazard/Fatality Boundary Layers

Hazard Boundary

- Entire Inundation area
- Where depth > 0
- Zone with 50% fatality and 50% injury

Fatality Boundary

- Where depth >= 2m
- Zone with 99% fatality and 1% injury



Visual 23: Available Case Studies

NOAA PMEL Sample Data

Community	County	Scenario	Level 1	Level 2	Level 3
Homer, AK	Kenai	M 9.2 1964 Alaska	hom_dem_ft hom_maxR_ft	hom_maxdg_ft hom_maxv_ftsec	hom_dg_ft_median hom_flux_ft3sec2_median
Crescent City, CA	Del Norte	M 9.0 Cascadia	crc_dem_ft crc_maxR_ft	crc_maxdg_ft crc_maxv_ftsec	crc_dg_ft_median crc_flux_ft3sec2_median
Kahului, HI	Maui	M 9.0 Cascadia	kah_dem_ft kah_maxR_ft	kah_maxdg_ft kah_maxv_ftsec	kah_dg_ft_median kah_flux_ft3sec2_median
Garibaldi, OR	Tillamook	M 9.0 Cascadia	gar_dem_ft gar_maxR_ft	gar_maxdg_ft gar_maxv_ftsec	gar_dg_ft_median gar_flux_ft3sec2_median
Westport, WA	Grays Harbor	M 9.0 Cascadia	wes_dem_ft wes_maxR_ft	wes_maxdg_ft wes_maxv_ftsec	wes_dg_ft_median wes_flux_ft3sec2_median

Available for download here:
http://tools.hazards.fema.gov/hazus/maps/data/HazardSampleData.zip

Visual 24: Where To Find Level 1 & 2 Data

- A sample of level 2 data are available here: https://tools.hazards.fema.gov/hazus/maps/data/HazardSampleData.zip
- Other data sources, FEMA, NOAA PMEL, Tsunami Warning Center, and State and Local Evacuation Plans

Visual 25: Additional Resources

- https://www.fema.gov/hazus
  - Hazus Tsunami Manuals
    - Hazus Tsunami Model User Guidance
    - Hazus Tsunami Technical Guidance
  - Hazus Support (hazus-support@riskmapcds.com)
    - FAQs
    - Help Desk

Visual 26: Review

1. How might a tsunami be triggered?
2. What is the difference between a near and distant source tsunami?
3. Which type of tsunami offers the most warning time?
4. Describe the tsunami-specific inventory in Hazus.
5. What states/territories are included in the Hazus tsunami model?
6. Name the two analysis options of the tsunami hazard model.

Visual 27: Questions?

Lesson 10: Advanced Tsunami Analysis

Visual 1: Lesson 10: Advanced Tsunami Analysis

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Visual 2: Goal and Objectives

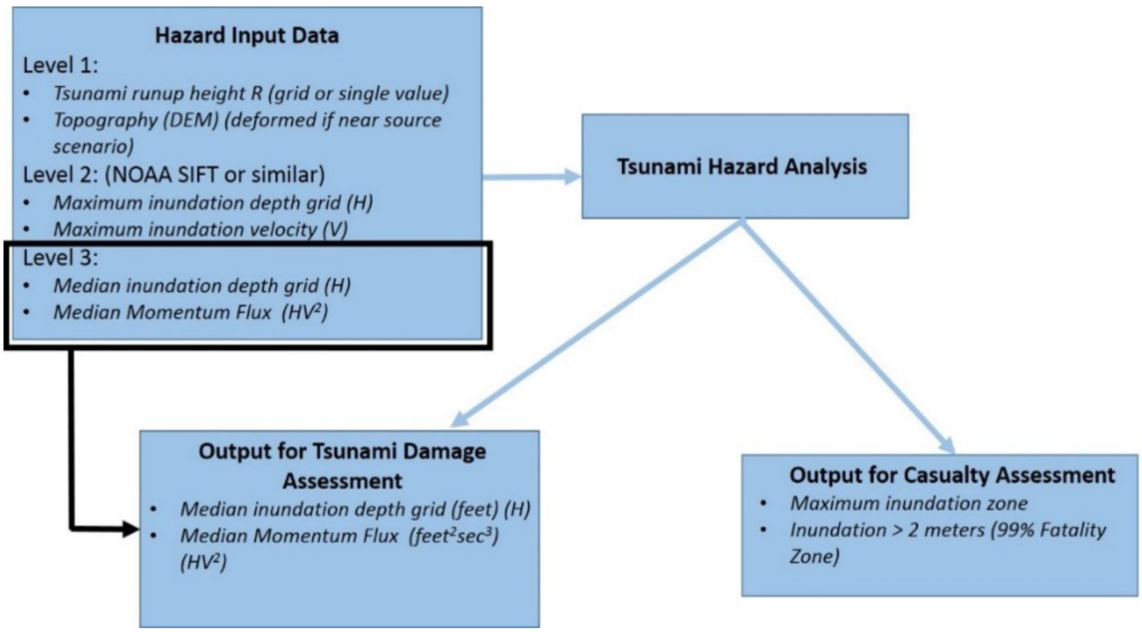
Goal

This lesson will describe how to conduct advanced tsunami analyses for losses and casualties.

After completing this lesson you will be able to:

- Discuss advanced tsunami analysis options
- List parameters that may be edited
- Understand inputs for combined earthquake tsunami scenarios

Visual 3: Hazard Analysis – User Input



Visual 4: User Defined Inventory Data

- Inventory | User-defined Facilities menu option enables user-specific datasets to be analyzed through the Hazus methodologies, providing more accurate results.
- Use CDMS to populate the UDF tables.
- On aggregation, the data will be added to a new tsunami UDF table (tsUserDefinedFlty).

Visual 5: User Defined Inventory Data (cont.)

Attribute	Description	Why is it needed?
Record Identifier (ID)	A unique identifier for each record. Hazus will create its own primary key (it does not prompt the user for one since there is no guarantee it is unique). Map this identifier to any column that is not used: COMMENT is a good candidate.	Hazus will output all results keyed by the ID it generates on import. If a join to the original data is needed, this attribute will be the only way to link the results to the original data.
Occupancy	Occupancy type per the Hazus classification. Map it to OCCUPANCY.	Analyses are based on the occupancy and/or building type.
Building Type	Occupancy type per the Hazus classification. Map it to OCCUPANCY.	Analyses are based on the occupancy and/or building type.
Design Level	Seismic Design Level. Map to DesignLevel. CDMS default is PC.	To assess lateral strength of structure – for building damage.
First floor height	Top of Finished Floor Relative to Adjacent Grade (ft). Map to FirstFloorHt. CDMS default is 1, which represents slab on grade.	To assess content damage.
Building replacement cost	Cost ($) to replace the building in case of damage. Used by economic loss model. Map it to COST. CDMS will estimate based on RS Means table.	To assess building economic loss.
Content replacement cost	As above (in Building replacement cost) relating to building content. Map to Content Cost. CDMS will estimate based on % of building replacement.	To assess content economic loss.

Attribute	Description	Why is it needed?
Location	The location of the structure/facility can be supplied as latitude/longitude (in that case, Hazus will create the geospatial points), or directly when the table imported is a feature class.	Hazus needs location of structure to calculate the hazard. Hazus uses the location at import time to filter the points that do not fall within the study region (i.e., discarding any point that falls outside the study region).

Visual 6: User Defined Depth Grids

- Sample Data are prepared for each level of analysis based on data provided for five of the PMEL forecast inundation model communities: http://nctr.pmel.noaa.gov/sim.html
- The hazard data (runup and velocity) were developed using NOAA's SIFT (Short-term Inundation Forecasting for Tsunamis) system found at http://nctr.pmel.noaa.gov/tsunami-forecast.html
- For additional information, including access to SIFT products, see http://nctr.pmel.noaa.gov.

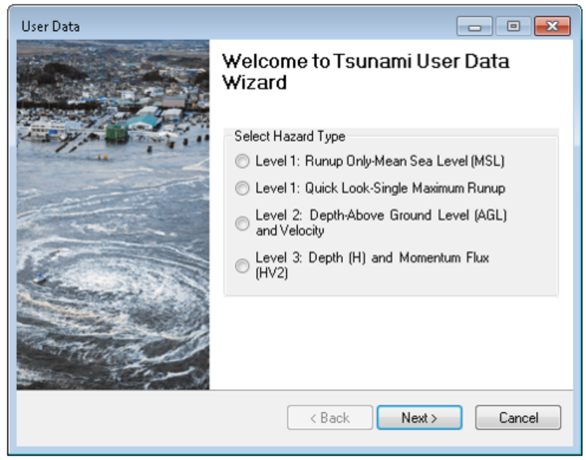
Visual 7: User Defined Casualty Data

- The Level 2 Casualty Analysis leverages the output from the USGS Pedestrian Evacuation Analyst (PED) ArcGIS tool, which assesses evacuation times to high ground.
- The tool can be found at: http://geography.wr.usgs.gov/science/vulnerability/tools.html
- Input data required:
    - Travel Time to Safe Zone (depth = 0)
    - Travel Time to Partially Safe Zone (depth < 2 meters)

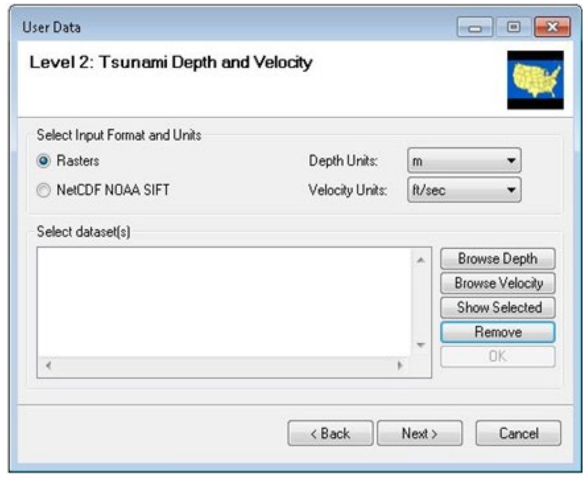
Visual 8: Advanced Tsunami Scenarios

Level 2: Depth-Above Ground Level (AGL) and Velocity

Level 3: Depth (H) and Momentum Flux (HV2)



Visual 9: AGL and Velocity (Level 2)

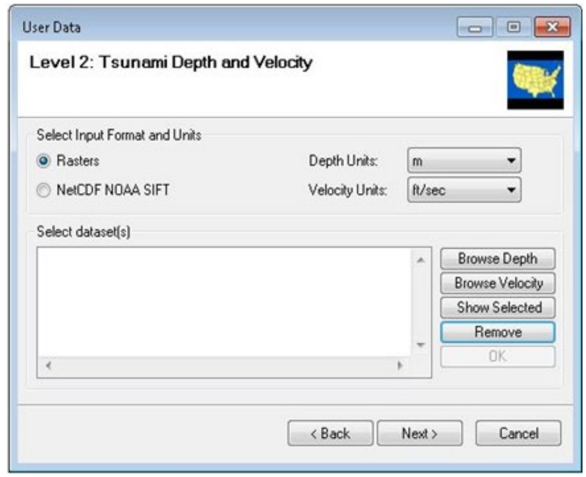


Input:

- Maximum Depth grid and Velocity grid dat in raster format, OR
- Maximum Depth and Velocity NetCDF NOAA SIFT (.nc) files

Units are defined using the drop down tabs under Metadata.

Visual 10: Depth and Momentum Flux (Level 3)



Input:

- Median Depth grid in raster format
- Median Momentum flux grid

Must be in raster format.

Assumes user-provided data are already in required units.

Visual 11: Activity 10.1

Student Activity

- In this activity, you will run a Level 2 and 3 Tsunami scenario.

Visual 12: Casualty and Evacuation Parameters

Casualty Estimation Parameters

- The travel time for people to evacuate tsunami danger zones (evacuation travel time).
- Evacuation travel time provides information on how long it will take people to safely reach higher ground.
- Travel time can be estimated once a safe haven is identified.

Evacuation Parameters

- Only pedestrian evacuation is considered
- Critical factors:
    - Prior experience and knowledge of tsunamis
    - Educating people to evacuate in a timely manner
    - Effective tsunami warning systems

Visual 13: Modifying Analysis Factors

- Analysis | Parameters menu allows the user to define casualty and building economic loss parameters.
- Casualty Parameters:
    - Community Preparedness Level
    - Walking Speed and Walking Speed Reduction
- Building Economic Parameters
    - Percent Loss
    - Repair Time
    - Building Contents
    - Income Loss Data
    - Business Inventory Damage

Visual 14: Community Preparedness Level

- Based on FEMA's methodology, concerning the time required between the warning and the evacuation of the community.
- The classifications of Good, Fair, or Poor are based on tsunami hazard preparedness level.
    - Determined based on factors such as the condition of shore-protection structures, emergency loud speakers, preparation of evacuation routes and signs, a community's risk management level, and/or the education level for tsunami awareness.

Visual 15: Walking Speed

Based on the USGS Pedestrian Evacuation Analyst Tool for populations under age 65.

Walking Speed Reduction Parameter

- Included to account for the difference in evacuation walking speed for population over 65 years old.
- Can be used to reduce walking speeds for either category to represent local or post-earthquake conditions.

Visual 16: Percent Loss

- Replacement costs (damage state = complete) were derived from Means Square Foot Costs, for Residential, Commercial, Industrial, and Institutional Buildings.
- Selected Means models have been chosen that represent the 33 occupancy types.
- Dollar values shown should only be used to represent costs of large aggregations of building types. If costs for single buildings or small groups (such as a college campus) are desired for more detailed loss analysis, local building-specific cost estimates should be used.
- Since a building has both structural and non-structural repair costs, those are provided for each occupancy type by damage state.

Visual 17: Repair Time

- Default building repair and clean-up times are provided within Hazus.
- Presented as a function of both amount of damage and occupancy class.
- Default values are broken into two parts:
  - Construction time (the time to do the actual construction or repair)
  - Extended time (includes construction plus all of the additional delays)

Visual 18: Building Contents

- Furniture or equipment that is not integral within the structure, computers and supplies.
- Does not include inventory or non-structural components (e.g., lighting, ceilings, mechanical/electrical equipment).
- Damage expressed in terms of the % damage based on depth of water at the building relative to the finished floor.
- Assumptions (complete damage state):
    - EQ complete damage state - 50% of contents can be retrieved.
    - Tsunami - as the saturated or washed away contents are less likely to be salvaged, it is assumed that 100% of the contents are lost.

Visual 19: Income Loss Data

- Hazus only considers disruption costs that may include the cost of shifting and transferring and the rental of temporary space.
- Relocation expenses are assumed to be incurred only by building owners and measured in $/sf/month.
- Income losses occur when building damage disrupts commercial activity.
    - Income will vary considerably depending on regional economic conditions.
    - U.S. Department of Commerce's Bureau of Economic Analysis reports regional estimates of capital-related income by economic sector.

Visual 20: Business Inventory Damage

- Business inventories vary by occupancy.
- Default values are derived from annual gross sales by assuming that business inventory is some percentage of annual gross sales.

Visual 21: Activity 10.2

Student Activity

- In this activity, you will change analysis parameters and see the difference between the results.

Visual 22: Post-Earthquake DEM

When a Tsunami analysis involves a Near Source earthquake, it is recommended that the DEM used in the scenario be based on deformed (post-earthquake) topography.

- Allows for more accurate inundation modeling by factoring in any ground deformation caused by the earthquake.
- If the ground surface elevations relative to sea-level have decreased, the inundation and losses could be more extensive.
- See the Tsunami Model Technical Guidance document for more information.

Visual 23: Combined EQ and Tsunami Scenario

- Build a multi-hazard (earthquake and tsunami) study region that includes a shoreline (i.e., must be a coastal region).
- Available for Near Source tsunami hazards, where the earthquake ground shaking impacts the study region in:
  - Alaska
  - Oregon
  - Washington
  - California
  - Hawaii
  - Puerto Rico

Visual 24: Combined EQ and Tsunami Scenario (cont.)

- Results can be viewed only in the Tsunami Model.
- Output is in the form of results tables, maps, and reports.
- Accessible from the Results menu on the toolbar for
  - Combined GBS
  - Combined User Defined Facilities
  - Casualties

Visual 25: Combined Analysis Reports

- Combined Analysis reports are available under the following tabs in the Summary Report window:
- Losses
  - Combined Direct Economic Losses for Building
  - Combined User Defined Facility Economic Loss Report by General Occupancy
  - Combined User Defined Facility Economic Loss Report by Building Type
- Other
  - Combined Earthquake and Tsunami Global Risk Report

Visual 26: Combined Direct Economic Losses

- Capital Stock Losses
  - Structural and Non-structural Damage
  - Contents Damage
  - Inventory Loss
- Income Losses
  - Relocation Losses
  - Capital Related Losses
  - Wage Losses
  - Rental Income Loss
- Total Loss

Visual 27: Combined UDF Economic Loss

Displays the combined exposure and losses by general occupancy or building type for:

- Capital Stock Exposure (Building and Contents)
- Capital Stock Losses (Building, Non-Structural, Contents, Total)
- Loss Ratio (Building % and Content %)

Visual 28: Activity 10.3

Student Activity

- In this activity, you will create a combined earthquake and tsunami region and run the analysis.

Visual 29: Review

1. List the analysis parameters that may be edited.
2. What does the current version of the Tsunami Model NOT estimate?

Visual 30: Questions?

Lesson 11: Uncertainties and Sensitivity Analyses

Visual 1: Lesson 11: Uncertainties and Sensitivity Analyses

Visual 2: Goal and Objectives

Goal

This lesson identifies ways to address the uncertainties associated with modeling.

After completing this lesson you will be able to:

- Understand the difference between error and uncertainty.
- Understand potential sources of uncertainty in Hazus analyses.
- Develop a good sense of what meaningful sensitivity analyses to perform.

Visual 3: Error versus Uncertainty

Error is generally defined as the deviation of a measurement from the “correct” value. However in modeling, error is generally considered a recognizable deficiency in any phase or activity of modeling that is not due to lack of knowledge.

- Systematic error – error that is constant from one measurement to another (easily corrected).
- Random error – error that is NOT constant from one measurement to another (very difficult to address).

Uncertainty is a potential deficiency in any phase or activity of the modeling process that is due to lack of knowledge.

Errors in data lead to “uncertainty” in model results.

Uncertainty in model results also arises from modeling assumptions.

Visual 4: Uncertainty and Modeling

Models like Hazus, which try to predict a future event or condition, generally have the greatest uncertainty because parameterization of the model requires many assumptions that have cascading effects for the model results.

Due to all of the assumptions within the Hazus earthquake loss methodology and the modeler's selected hazard scenario, even when there is validation of model estimations with observed damages, losses, and/or casualties, the difference should be referred to as uncertainty and not 'error.'

Visual 5: Sources of Uncertainty

1. Modeling assumptions
2. Empirical approach
3. Default data
4. Interpretation
5. Incidental error

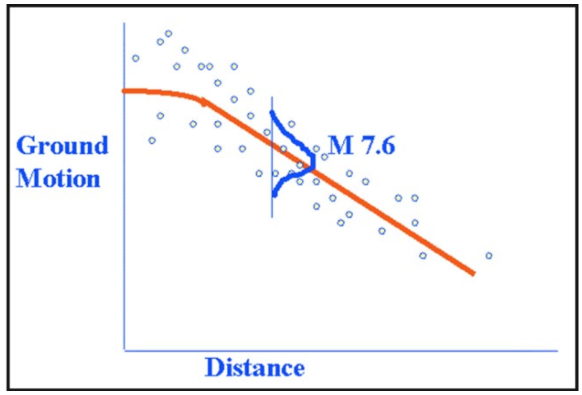
Visual 6: Sources of Uncertainty (cont.)

Modeling assumptions

- Occupancy to model building type relationships
- Default classifications for site specific data

Empirical approach

- Ground motion computation
- Damage models



Simplified example of an attenuation function

Visual 7: Sources of Uncertainty (cont.)

Default data

- Outdated information [e.g., building age distribution]
- Positional accuracy [e.g., hospitals, runways, faults, etc.]
- Incomplete GIS data [e.g., schools, fire stations, utility facilities, etc.]
- Default replacement values for some economic data

Visual 8: Sources of Uncertainty (cont.)

Interpretation

- Classification of hazard or any other inventory data
- Interpretation of damage states

Incidental errors

- Assigning wrong projection system for GIS data

Visual 9: Treatment of Uncertainties

Hazus produces “credible results,” but no explicit treatment of uncertainties.

Variability of models is best evaluated by conducting multiple sensitivity analyses.

- Use different attenuation functions.
- Use a mix of occupancy to building type distribution matrices.
- Use different soil assumptions if no such data is available.

Visual 10: Treatment of Uncertainties (cont.)

- Understand dependency of modules and parameters
- Enhance inventory data
- Replace predicted results with observed results
    - e.g., use the USGS's ShakeMap 'observed' ground shaking data

Visual 11: Sensitivity Analyses

- Hazard Parameters
- Fragility Curves
- Capacity Curves
- General Building Stock
- Casualty Rates
- Restoration Functions
- Economic Data
- Sheltering Factors

Visual 12: Loss Ratio

Loss Ratio = total loss / total exposure

- Represents the impact of the disaster by normalizing the losses.
- Can be used as “Ball Park” Uncertainty Metric for Loss Estimates.

Losses < $20 Million and loss ratio < 1% Noise

5% < loss ratio < 20% -Results off by as much as 200%

20% < loss ratio < 50% -Results off by as much as 150%

50% < loss ratio < 75% -Results off by as much as 100%

75% < loss ratio < 100% -Results off by as much as 50%

Visual 13: Summary: Important Parameters

- Completeness of inventory data
- Use of observed ground motion data that reflects soil conditions and potential for ground failure
- Vulnerability classification for inventory data (e.g., correct building type or appropriate mix of building types for aggregate data)
- Stakeholders’ data:
    - Economic (cost to repair and/or replace, content value, income data, etc.)
    - Social (number of occupants, shelter capacity, etc.)
    - Functionality (contingency planning)

Visual 14: Review

1. What is the difference between error and uncertainty?
2. Identify the major sources of uncertainty in the Hazus earthquake model.
3. What is a sensitivity analysis and how can it be use to describe or quantify the uncertainty in Hazus earthquake loss estimations?

Visual 15: Questions?

Lesson 12: Applications for Hazus and Capstone Exercise

Visual 1: Lesson 12: Applications for Hazus and Capstone Activity

Visual 2: Goals and Objectives

Goals

- To explore the applicability of Hazus for mitigation.
- To understand the capacity of Hazus in response and recovery applications.

After this lesson, you will be able to:

- Explain the usefulness of probabilistic scenarios.
- Identify the type of analyses to run to simulate potential benefits that help in the assessment of mitigation alternatives.
- List examples of how Hazus results can be used to support decisions in post-disaster situations.
- Complete a Capstone Activity.

Visual 3: What is Mitigation?

- Mitigation is the effort to reduce loss of life and property by lessening the impact of disasters.
- This is achieved through risk analysis, which results in information that provides a foundation for mitigation activities that reduce risk.
- Hazus provides the opportunity for detailed risk assessment useful for mitigation applications.

Visual 4: Using Hazus in Mitigation Applications

Probabilistic Scenarios

- Mitigation implies cost-effectiveness solutions, which implies the acceptance of some risk, thus the probabilistic approach.

Use in order to minimize bias in decision support:

- Resource allocation [e.g., for response and recovery]
- Cost-effectiveness analyses

Best approach may be Average Annualized Loss (AAL)

Visual 5: About Mitigation Activities

- May consist of physical projects that directly reduce future risk and disruption
  - Acquisition
  - Retrofitting
- Other activities consist of processes that lead to policies
  - Floodplain management
  - Building code updates
- Some risk is inevitable
- Eliminating all losses and disruption is not feasible

Visual 6: About Mitigation Activities (cont.)

Mitigation activities are aimed at reducing losses to the built environment

- Keep buildings as undamaged and accessible as possible.
- Keep lifelines intact and functional.
- Save lives and protect people.

Visual 7: Cost-Effectiveness Evaluation

Mitigation Project:

- Address specific targeted buildings (site-specific).
- Cost-effectiveness is localized.
- Only direct economic savings can be calculated.
- Could use AEBM
- Increase community preparedness.
- Add an evacuation route.

Mitigation Activity:

- Site-specific & aggregate
- Cost-effectiveness is regional
- Direct economic, social, and indirect economic consequences can be assessed

Visual 8: Assessing a Mitigation Strategy

- Use AAL to evaluate the net benefits of the strategy for the targeted categories.
- Consider the cost to implement this strategy.
- Decision making also affected by:
  - Time horizon (note that demographics, infrastructure, and economic facts vary with time)
  - Targeted stakeholders
- Estimate the cost-effectiveness using the benefit-cost ratio.

Visual 9: Cost-effectiveness Example

Given the costs below, is it beneficial to perform a retrofitting of tilt-up buildings?

Building Type	Cost ($ / sq ft.)
Tilt-Up	1 to 2
Steel Frame	10 to 15
Concrete Frame	25 to 30
Historical Building	100

Example of retrofitting costs

Cost-effectiveness Example

Parameter	Original Buildings	Retrofitted Buildings
Number	100	100
Total Sq. Ft.	1,000,000	1,200,000
Replacement Cost ($)	$125 million	$150 million
Average Annualized Loss	$0.40 million	$0.05 million

Example of 100 tilt-up buildings

Visual 10: Hazus for Mitigation - Summary

What Hazus can do?

- Compute benefits as part of cost-effectiveness studies
- Identify sources of vulnerability in the infrastructure
- Model effects of future land use & development trends
- Evaluate and prioritize different mitigation alternatives

Several mitigation actions clearly supported:

- Building code regulations and enforcement
- Land use regulations and planning
- Prioritization for seismic upgrading, strengthening, retrofitting, and/or remodeling of targeted buildings

Visual 11: Post-Earthquake Needs

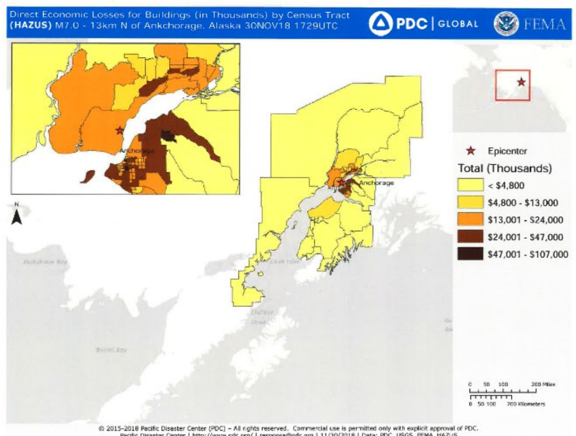
- Understanding of magnitude and extent of impact.
- Assessment of social effects and shelter needs.
- Evaluation of economic consequences.
- Assessment of the status of critical infrastructure:
  - Transportation
  - Utilities
  - Essential facilities
- Identification of additional emergency care needs.
- Drawing effective recovery plans.

Visual 12: Post-Earthquake Applications - PDA

Hazus was deployed to support response to the M7.0 Alaskan Earthquake that struck near Anchorage on November 30, 2018.

Hazus analysis was incorporated into Alaskan Governor Dunleavy's Official Request to the White House for a Presidential Disaster Declaration.

FEMA IA leadership confirmed: "Hazus estimates of building damage for the event (Hazus = Destroyed 5; Major 250) are a reasonable estimate of what is being found in the Preliminary Damage Assessments (PDA = 46 destroyed, 643 major) submitted by the State."



Visual 13: Support for Recovery Applications

Visual 14: Support for Recovery Applications (Cont.'d)

- Boundaries of damage from the earthquake ground shaking or tsunami inundation
- Understand which geographical areas need immediate attention
- E0179: Hazus for Disaster Operations has much more information about how Hazus can be used for response and recovery

Visual 15: Damaged Structures & Utilities

- Residential, commercial, industrial, and non-residential buildings
- Essential and critical facility damage & functionality
- Utility systems impacts

Visual 16: Community Needs

- Population at risk from hazardous materials releases
- Displaced population and shelter needs
- Hospital capacity to host injured victims
- Adequate shelter locations for displaced households
- Emergency water, power and ice for households without utilities
- Evacuation zones and routes

Visual 17: Induced Hazards & Impacts

Inundation - Areas of flooding (potential dam or levee failure, etc.)

Debris - Information provided about the debris generated during the seismic event enabling users to prepare and to rapidly and efficiently manage debris removal and disposal

Visual 18: Mitigation & Economic Recovery

- Residential and non-residential building repair and replacement costs
- Residential and non-residential contents losses
- Business interruption losses
- Transportation and utility system repair and replacement costs

Visual 19: Hazus for R&R - Summary

The critical role of Hazus in supporting response and recovery activities is becoming more evident as disasters keep happening and the model evolves.

There is a need to automate some of these support functions to bridge the gap between:

- Technical details and expertise required to run Hazus effectively and efficiently, including modeling some of the critical parameters correctly.
- Easy-to-disseminate information in the most useful format for non-technical decision makers.

Visual 20: Capstone Activity

- Break into groups of 4-6 persons.
- Use the Hazus Earthquake and/or Tsunami Model tools to address the scenario on the following slides.
- Deliver group presentations on the last day of class.
- The presentations will serve as the final exam for this course.

Visual 21: Capstone Activity (Cont’d.)

- You will assume the role of consultants who have been asked by a county* how they should mitigate potential earthquake and/or tsunami damages and losses in their community
- You, as Hazus experts, have decided to use that tool to analyze the community’s earthquake and/or tsunami risk.
- The results of your study will be presented at the monthly commissioners meeting (which happens to coincide with the last day of the class).

* The study area may be one of the class examples, or another example of your choosing.

Visual 22: Capstone Activity (Cont'd.)

Required questions to answer:
(Do not limit yourselves to these questions)

- What are the economic losses avoided?
- What are the number of lives saved?
- What is the reduction in the number of days the schools are potentially non-functional?
- What is the reduction in the number of students potentially needing shelter?

Visual 23: Capstone Activity (Cont'd.)

Presenter guidelines

- Presentation should be prepared using PowerPoint slides and may include maps, tables, or other media as you deem appropriate.
- Information should be primarily derived from Hazus but may be supplemented by other sources.
- 10 to 15 minutes in length

Commissioner's guidelines

- Class will assume the role of 'commissioners'.
- 'Commissioners' may ask any questions that they like related to the presentations.

Visual 24: Review

1. What is mitigation? How can Hazus be used in mitigation applications?
2. What is the benefit of using a probabilistic scenario for mitigation projects in Hazus?
3. What are five areas that Hazus can support in response and recovery after a disaster?
4. How could Hazus be improved to be more efficient in response and recovery applications after a disaster?

Visual 25: Questions?

Lesson 13: Course Wrap-Up

Visual 1: Lesson 13: Course Wrap-Up

HAZUS®

EARTHQUAKE • WIND • FLOOD • TSUNAMI

Visual 2: Goal and Objectives

Goal

Review the major themes of the course and discuss opportunities for learning more about Hazus.

After completing this lesson, you will be able to:

- Identify the courses that are available for enhancing your Hazus skills.
- Identify additional resources that are available for you to explore to enhance your Hazus experience.

Visual 3: Course Wrap-Up

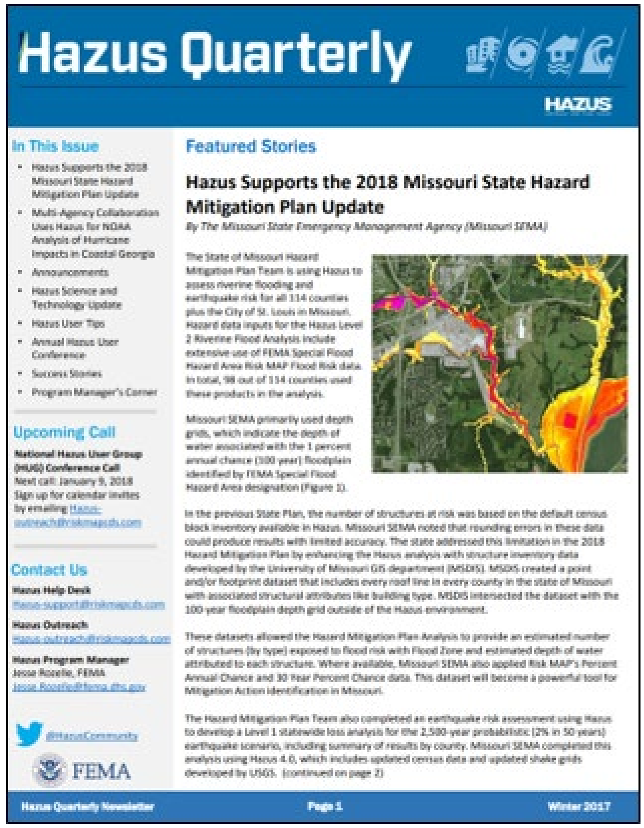
- The Hazus earthquake and tsunami models provide a vast array of options that can enable communities to more effectively plan for and prevent earthquake and tsunami induced losses.
- Hazus provides the greatest benefit to those who understand its limitations as well as its benefits.

Visual 4: Become A Hazus Expert!

- Hazus Trained User
  - E0190 ArcGIS for Emergency Managers (or prior GIS experience may substitute)
  - E0313 Basic Hazus
  - E0317 Comprehensive Data Management (CDMS)
  - Minimum of Two of the follow:
    - E0170 Hazus for Hurricanes
    - E0172 Hazus for Floods
    - E0174 Hazus for Earthquakes and Tsunami
- Hazus Practitioner
  - E0190 ArcGIS for Emergency Managers (or prior GIS experience may substitute)
  - E0313 Basic Hazus
  - E0317 Comprehensive Data Management (CDMS)
  - Minimum of two of the follow:
    - E0170 Hazus for Hurricanes
    - E0172 Hazus for Floods
    - E0174 Hazus for Earthquakes and Tsunami
  - E0177 Advanced Hazus Applications
  - E0179 Hazus for Disaster Operations

Visual 5: Hazus Community Participation

- Annual Hazus User Conference Hazus
- Quarterly Newsletter
- National Hazus User Group calls
- Local Hazus User Groups
- Hazus Outreach Email: hazus-outreach@riskmapcds.com



Hazus Quarterly

HAZUS

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- Hazus Supports the 2018 Missouri State Hazard Mitigation Plan Update
- Multi-Agency Collaboration Uses Hazus for NOAA Analysis of Hurricane Impacts in Coastal Georgia
- Announcements
- Hazus Science and Technology Update
- Hazus User Tips
- Annual Hazus User Conference
- Success Stories
- Program Manager's Corner

Upcoming Call

National Hazus User Group (HUG) Conference Call
Next call: January 9, 2018
Sign up for calendar invites by emailing Hazus-outreach@riskmapcds.com

Contact Us

Hazus Help Desk
Hazus-support@riskmapcds.com

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FEMA

Featured Stories

Hazus Supports the 2018 Missouri State Hazard Mitigation Plan Update

By The Missouri State Emergency Management Agency (Missouri SEMA)

The State of Missouri Hazard Mitigation Plan Team is using Hazus to assess riverine flooding and earthquake risk for all 114 counties plus the City of St. Louis in Missouri. Hazard data inputs for the Hazus Level 2 Riverine Flood Analysis include extensive use of FEMA Special Flood Hazard Area Risk MAP Flood Risk data. In total, 98 out of 114 counties used these products in the analysis.

Missouri SEMA primarily used depth grids, which indicate the depth of water associated with the 1 percent annual chance (100 year) floodplain identified by FEMA Special Flood Hazard Area designation (Figure 1).

In the previous State Plan, the number of structures at risk was based on the default census block inventory available in Hazus. Missouri SEMA noted that rounding errors in these data could produce results with limited accuracy. The state addressed this limitation in the 2018 Hazard Mitigation Plan by enhancing the Hazus analysis with structure inventory data developed by the University of Missouri GIS department (MSDIS). MSDIS created a point and/or footprint dataset that includes every roof line in every county in the state of Missouri with associated structural attributes like building type. MSDIS intersected the dataset with the 100 year floodplain depth grid outside of the Hazus environment.

These datasets allowed the Hazard Mitigation Plan Analysis to provide an estimated number of structures (by type) exposed to flood risk with Flood Zone and estimated depth of water attributed to each structure. Where available, Missouri SEMA also applied Risk MAP's Percent Annual Chance and 30 Year Percent Chance data. This dataset will become a powerful tool for Mitigation Action identification in Missouri.

The Hazard Mitigation Plan Team also completed an earthquake risk assessment using Hazus to develop a Level 1 statewide loss analysis for the 2,500-year probabilistic (2% in 50 years) earthquake scenario, including summary of results by county. Missouri SEMA completed this analysis using Hazus 4.0, which includes updated census data and updated shake grids developed by USGS. (continued on page 2)

Hazus Quarterly Newsletter Page 1 Winter 2017

Visual 6: Getting Help

Hazus Help Desk - email

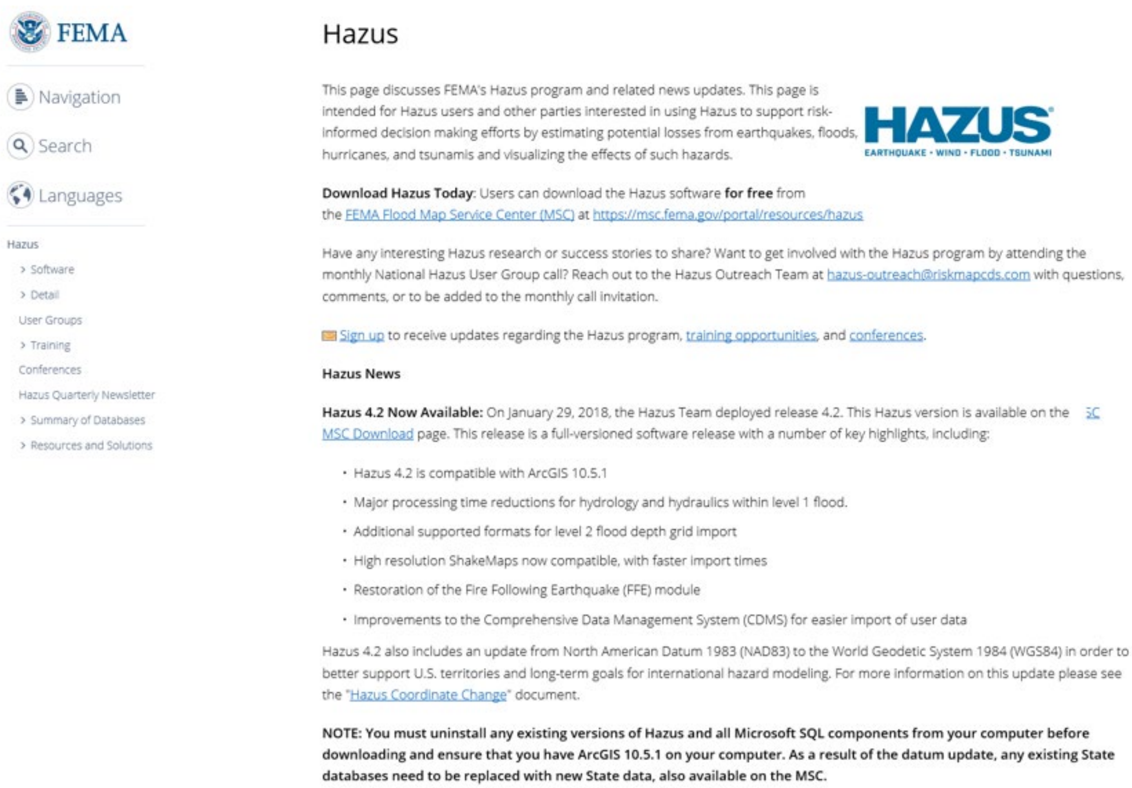
hazus-support@riskmapcds.com

Consult the User Manuals and Technical Manuals

https://www.fema.gov/hazus-mh-user-technical-manuals

Visual 7: FEMA Hazus Website

Primary FEMA resource for updated Hazus information



FEMA

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- Summary of Databases
- Resources and Solutions

Hazus

This page discusses FEMA's Hazus program and related news updates. This page is intended for Hazus users and other parties interested in using Hazus to support risk-informed decision making efforts by estimating potential losses from earthquakes, floods, hurricanes, and tsunamis and visualizing the effects of such hazards.

Download Hazus Today: Users can download the Hazus software **for free** from the FEMA Flood Map Service Center (MSC) at https://msc.fema.gov/portal/resources/hazus

Have any interesting Hazus research or success stories to share? Want to get involved with the Hazus program by attending the monthly National Hazus User Group call? Reach out to the Hazus Outreach Team at hazus-outreach@riskmapcds.com with questions, comments, or to be added to the monthly call invitation.

Sign up to receive updates regarding the Hazus program, training opportunities, and conferences.

Hazus News

Hazus 4.2 Now Available: On January 29, 2018, the Hazus Team deployed release 4.2. This Hazus version is available on the MSC Download page. This release is a full-versioned software release with a number of key highlights, including:

- Hazus 4.2 is compatible with ArcGIS 10.5.1
- Major processing time reductions for hydrology and hydraulics within level 1 flood.
- Additional supported formats for level 2 flood depth grid import
- High resolution ShakeMaps now compatible, with faster import times
- Restoration of the Fire Following Earthquake (FFE) module
- Improvements to the Comprehensive Data Management System (CDMS) for easier import of user data

Hazus 4.2 also includes an update from North American Datum 1983 (NAD83) to the World Geodetic System 1984 (WGS84) in order to better support U.S. territories and long-term goals for international hazard modeling. For more information on this update please see the "Hazus Coordinate Change" document.

NOTE: You must uninstall any existing versions of Hazus and all Microsoft SQL components from your computer before downloading and ensure that you have ArcGIS 10.5.1 on your computer. As a result of the datum update, any existing State databases need to be replaced with new State data, also available on the MSC.

Visual 8: So in closing...

What is Hazus and why should you use it?

Visual 9: Questions?

Handouts: Reference Material

Handouts Outline

The table below contains the type, number, and description of each handout. The data needed column identifies major datasets required to complete the activity. The data provided column identifies if that dataset is provided in the zip folder E0174_ActivityData for download.

Type	Number	Data Needed	Data Provided?
Activity	5.1	.hpr and grid.xml	Yes
Activity	7.1	.hpr and grid.xml	Yes
Activity	7.2	.hpr	Yes
Activity	8.1	.hpr and grid.xml	Yes
Activity	10.1	.hpr and grid.xml	Yes
Activity	10.2	hpr, shp, xml, dem	Yes
Activity	10.3	gdb, shp, hpr, grid.xml	Yes

Data Dictionary

The table below contains the type, number, and data file name for each exercise. The data provided can be found in the zip folder E0174_ActivityData for download.

Type	Number	Data File(s) Provided	Folder Location
Activity	5.1	grid.xml, Shakemap_Scenario.hpr	E0174_ActivityData\Student_Activities\Activity5.1
Activity	7.1	grid.xml, Inventory_Update.hpr	E0174_ActivityData\Student_Activities\Activity7.1
Activity	7.2	Inventory_Update.h	E0174_ActivityData\

Type	Number	Data File(s) Provided	Folder Location
		pr	Student_Activities\Activity7.2
Activity	8.1	grid.xml, Inventory_Update.hpr	E0174_ActivityData\Student_Activities\Activity8.1
Activity	10.1	Activity10_1.hpr, Level2.gdb, Level3.gdb	E0174_ActivityData\Student_Activities\Activity10.1
Activity	10.2	Tillamook DEM, tl_2016_41057_roads.shp, tsFatalityBoundary,shp, tsHazardBoundary.shp, Activity10_1.hpr, grid.xml	E0174_ActivityData\Student_Activities\Activity10.2
Activity	10.3	Tillamook DEM, tl_2016_41057_roads.shp, tsFatalityBoundary,shp, tsHazardBoundary.shp, Activity10_2.hpr, grid.xml	E0174_ActivityData\Student_Activities\Activity10.3

A Note on Understanding Images

Please note that many of these documents contain images that assist in the completion of the activities. These images are explained both by the surrounding text and by the alt text provided with the image. For individuals accessing the course with the relevant technology, please read the surrounding text and the alt text to gain a full understanding of the image.

Activity 5.1– CREATE A SCENARIO USING SHAKEMAP

Type: Student Activity

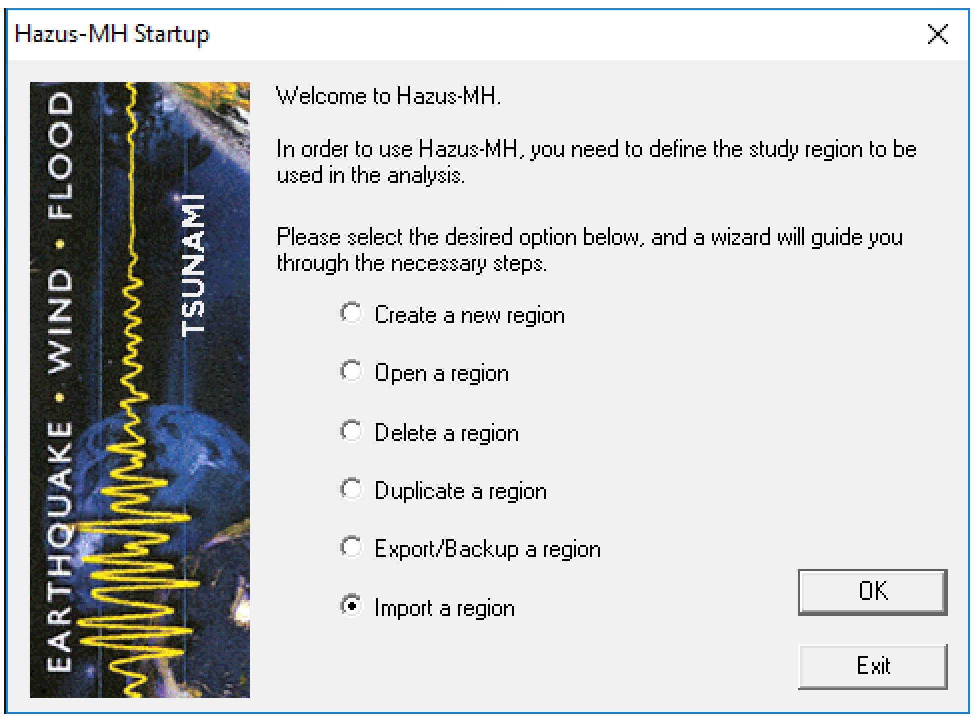
Time: 30 minutes

Objective

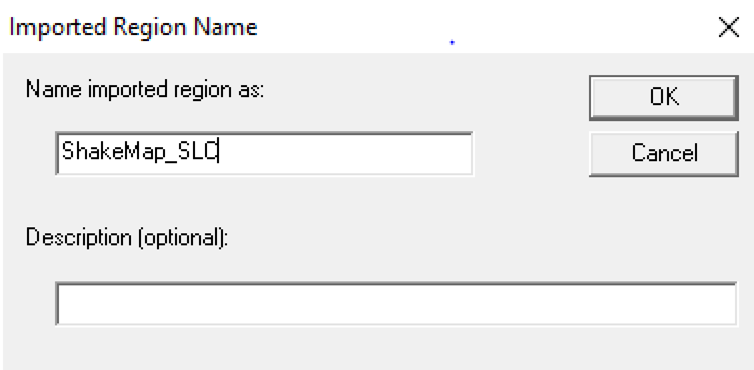
In this activity, you will create two scenarios--an Arbitrary scenario and import a ShakeMap—and compare the results.

Task 1: Open Hazus 4.2 and import an hpr file

Import the ShakeMap_Scenario hpr located in the Activity 5.1 folder.



Name the new region ShakeMap_SLC

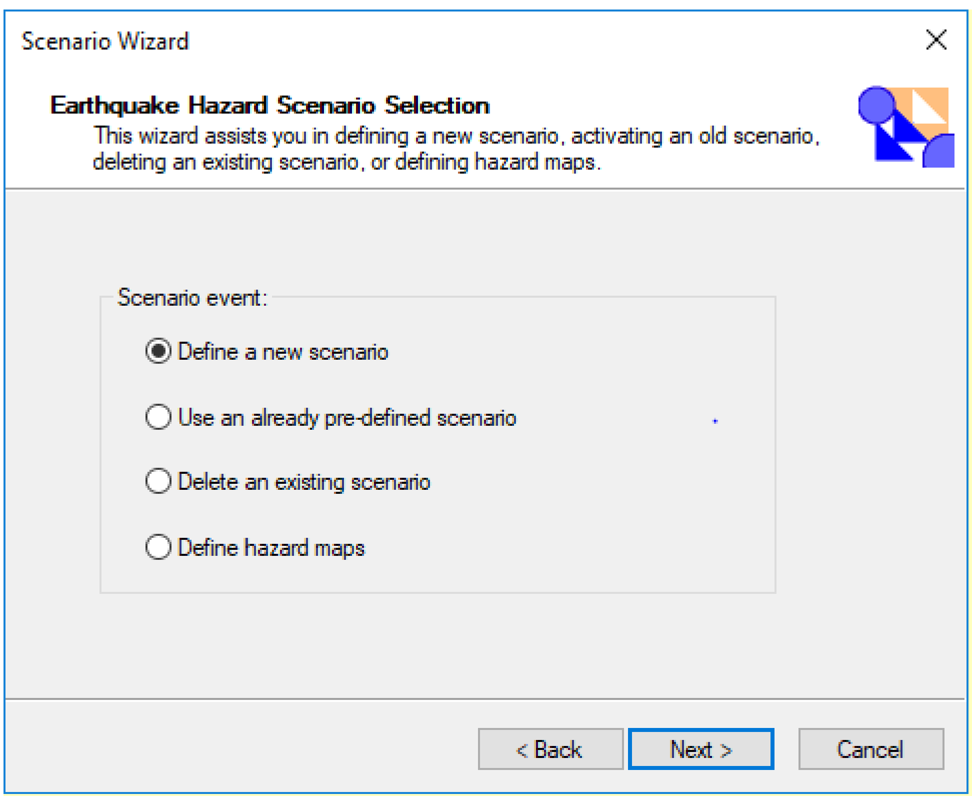


When the import is complete, open the region.

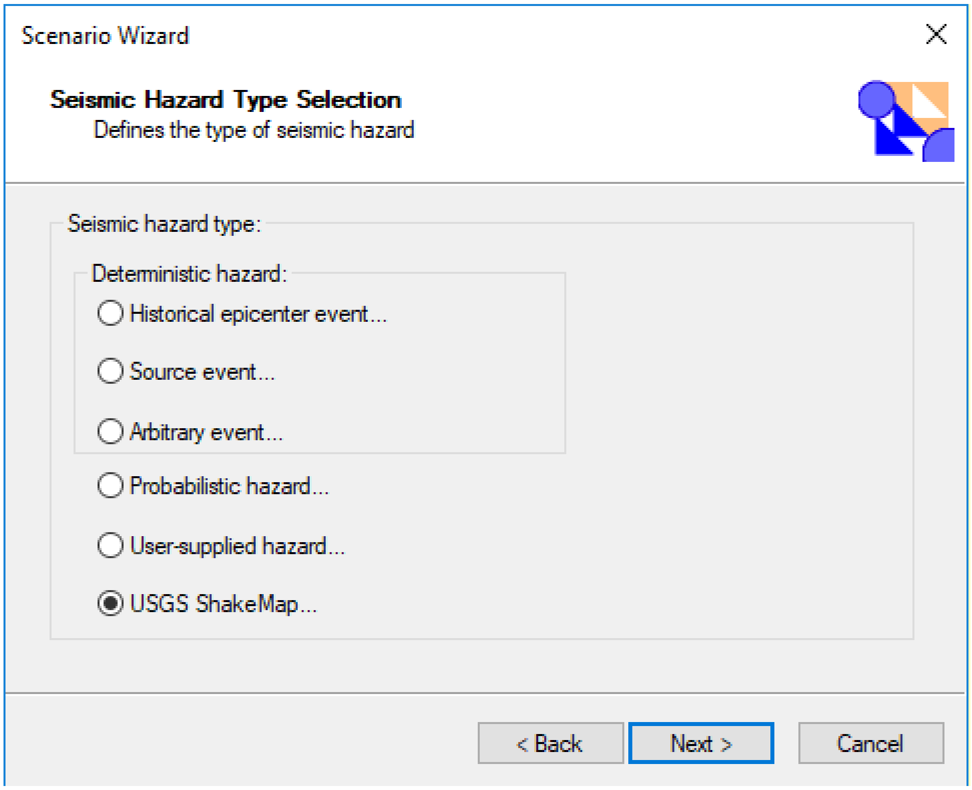
Task 2: Import the ShakeMap

To create the ShakeMap scenario click Hazard -> Scenario -> Next.

Select Define a new scenario from the Earthquake Hazard Scenario Selection window that appears and click Next.

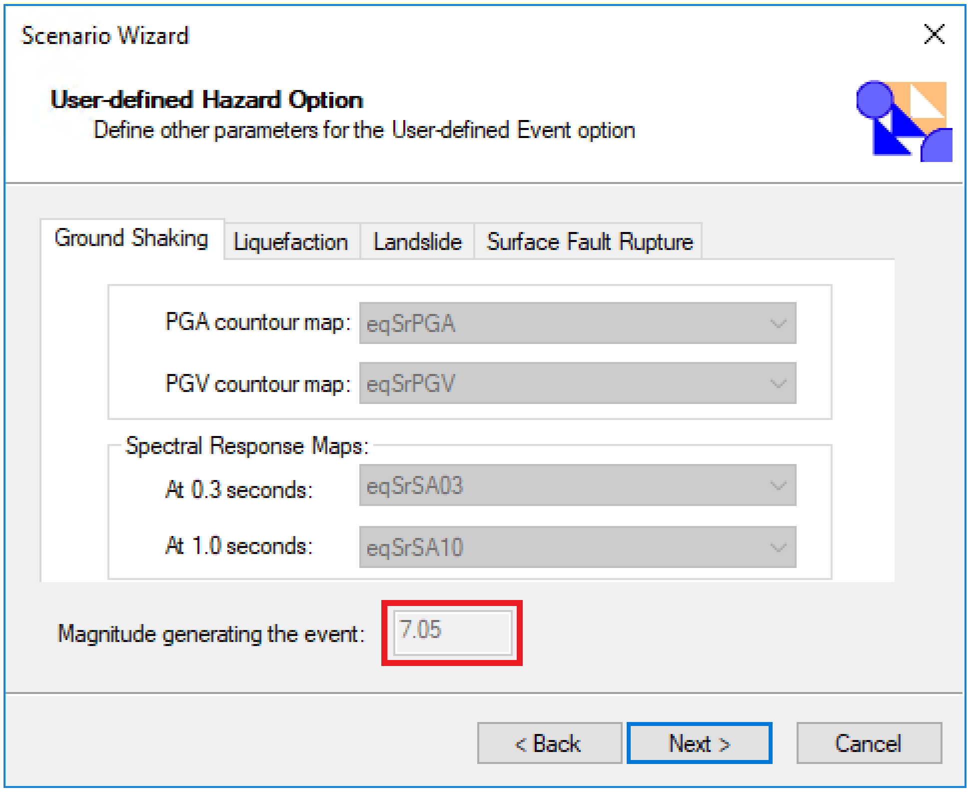


Select USGS ShakeMap from the Seismic Hazard Type Selection and click Next.

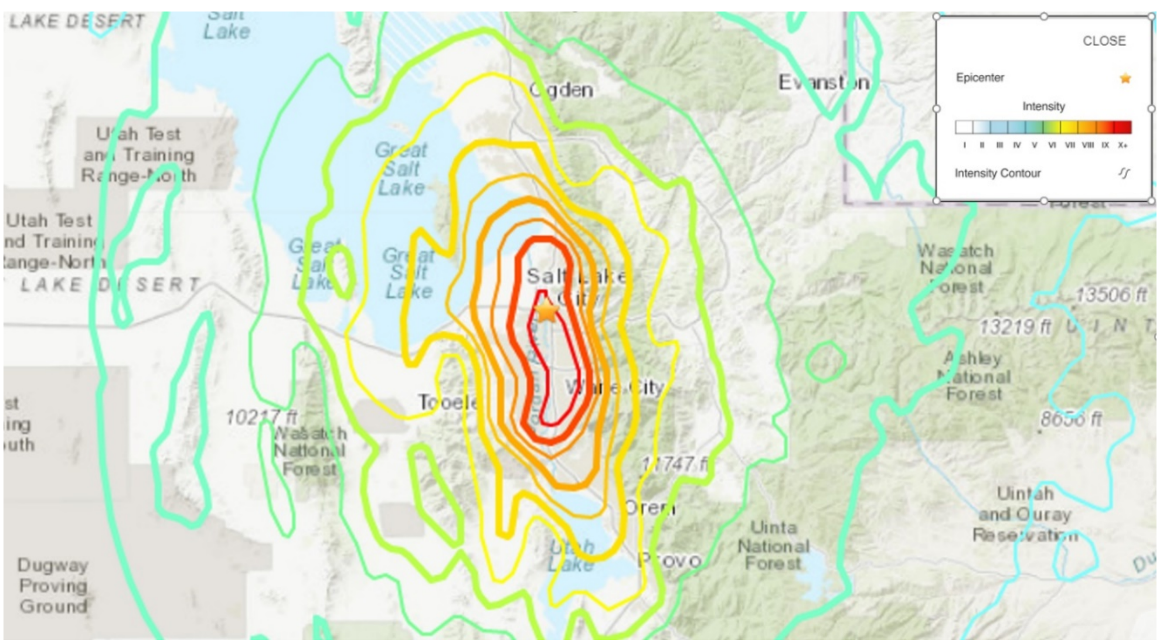


The ShakeMap Download form will appear. This menu will allow you to search for ShakeMaps that exist for the geographic extent of the region and other parameters. For this exercise, you will browse for an existing ShakeMap that has already been downloaded.

Select Browse for Existing ShakeMap Grid Data. Navigate to the Activity5.1 folder and select the grid.xml file. Once imported, the User-defined Hazard Option form will appear with the required parameters filled in. Review the values and notice that the magnitude is 7.05 Select Next.



Take a moment to view a map of the Shakemap.



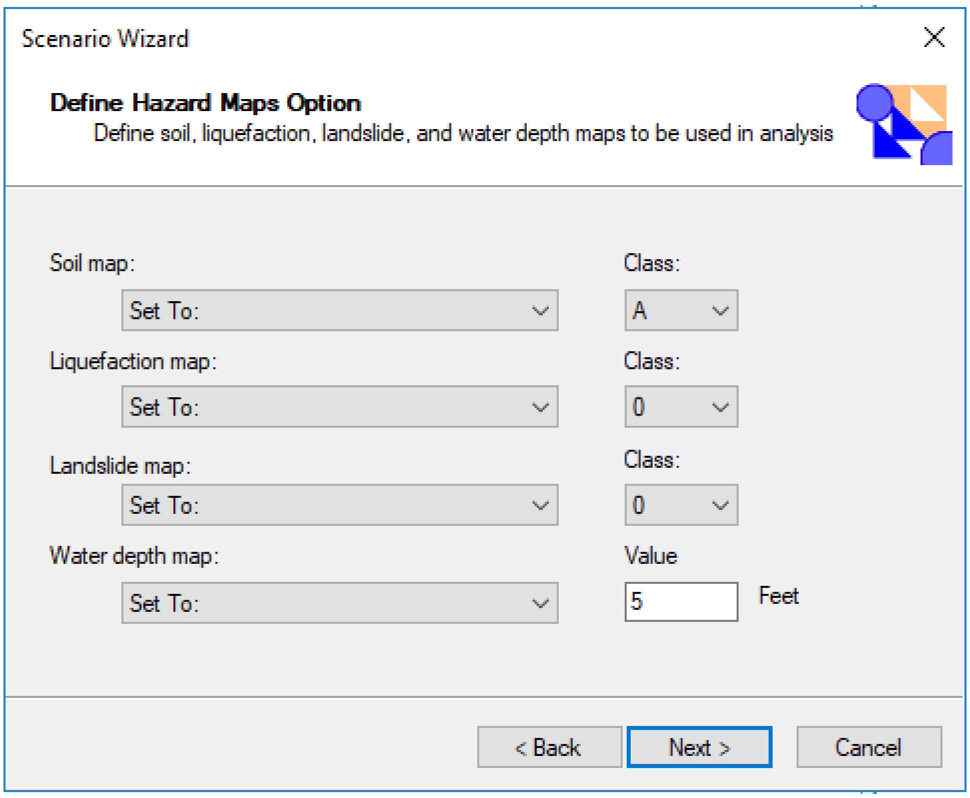
Click Next, click Next again and then click Finish.

Task 3: Modify the Data Map parameters for soils type

Select Hazard -> Scenario and then click Next.

Select Define Hazard Maps and click Next.

Change the Soil map Class to A and click Next. Then, click Finish. The processing may take a few moments to complete.



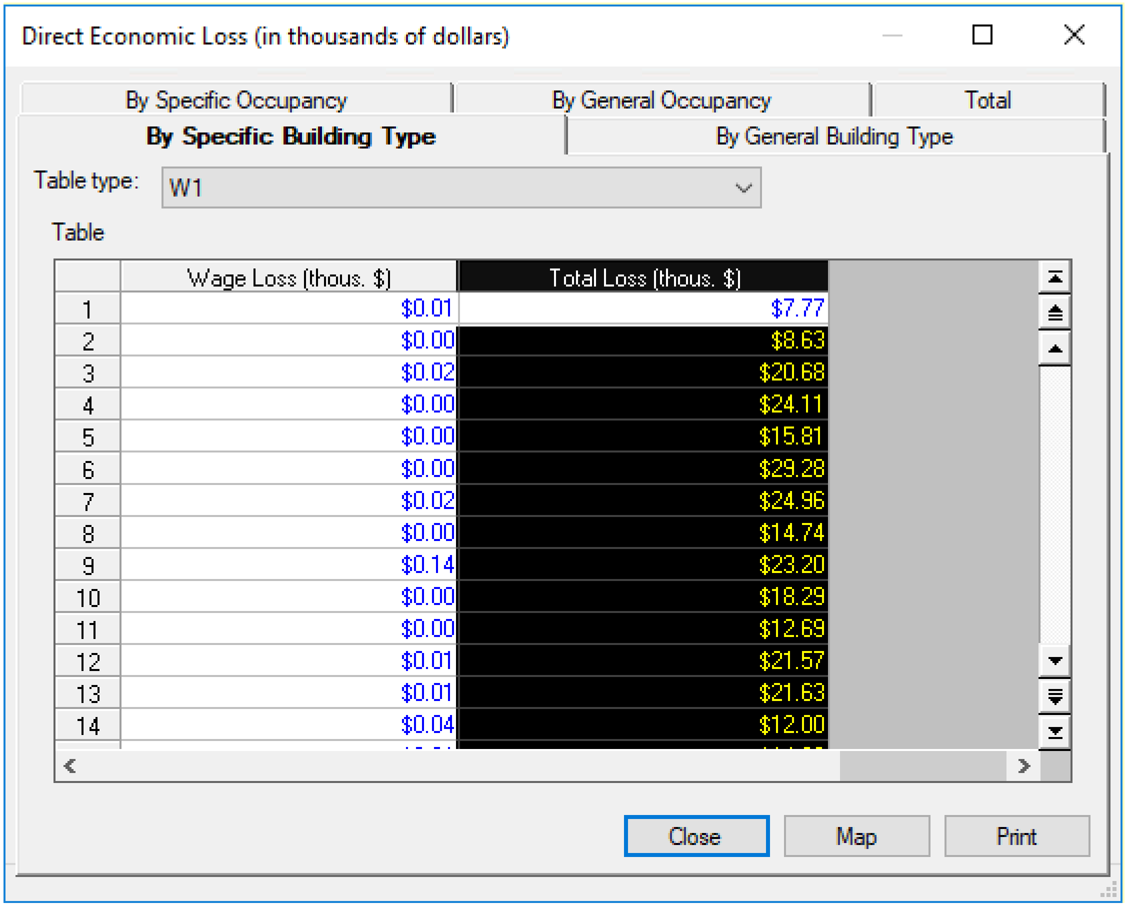
Task 4: Run the Analysis

Select Analysis -> Run and then select General Buildings. Click Yes to run the analysis. The analysis may take a few moments to complete. Click OK when complete.

Task 5: View the results

Select Results -> General Building Stock -> Building Economic Loss -> Direct Economic Loss.

Select the column “Total Loss (thou. $)” and click Map at the bottom.



Right click the RES_DEL_W1_TotalLoss layer in the ArcMap legend and select Open Attribute Table.

Right click the TotalLoss column on the right side of the table and select Statistics.

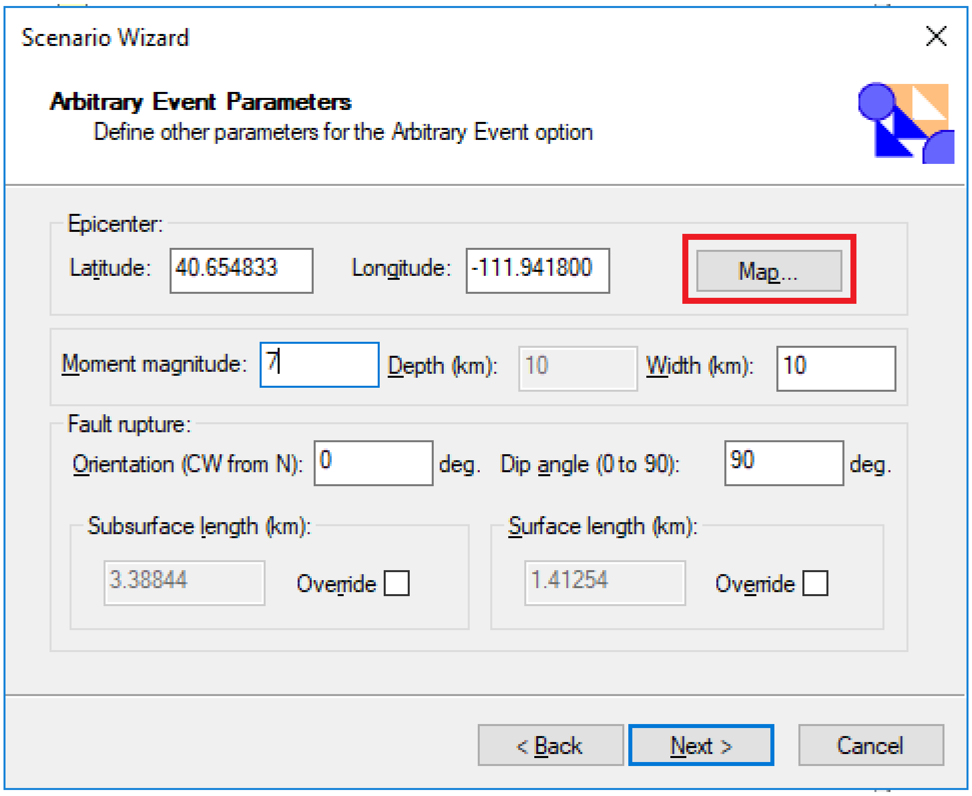
Remove the layer when complete.

Write down the number in the Sum field in the box below. ***Remember, the results are in thousands of dollars***.

SUM:	$5,570,727

Task 6: Create an Arbitrary Scenario

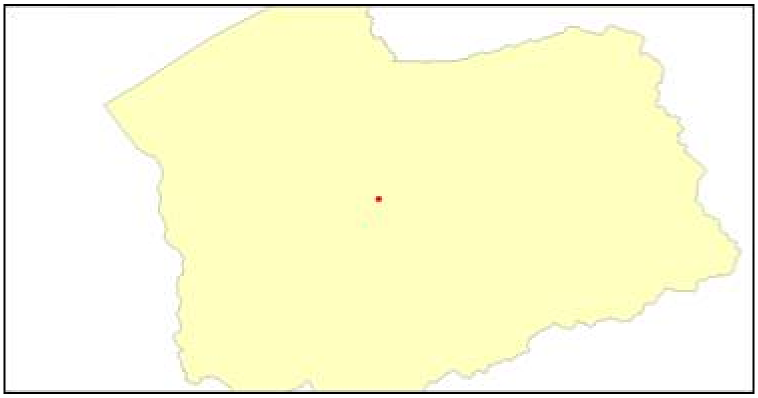
Select Hazard -> Scenario and then click Next.
Click “Define a new scenario” on the Scenario Wizard.
Select “Arbitrary” and click Next.
Keep the defaults and click Next when the attenuation function select appears.
On the Arbitrary Event Parameters screen, click Map in the upper right corner.



Enter 7 for the Moment Magnitude.
The Scenario Wizard screen should resemble the image below. Click Next.

Task 6: Create an Arbitrary Scenario

Click in the polygon on the map (see the graphic below for the location to click) that appears to define the epicenter for the arbitrary scenario and then click Selection Done. See the graphic below.

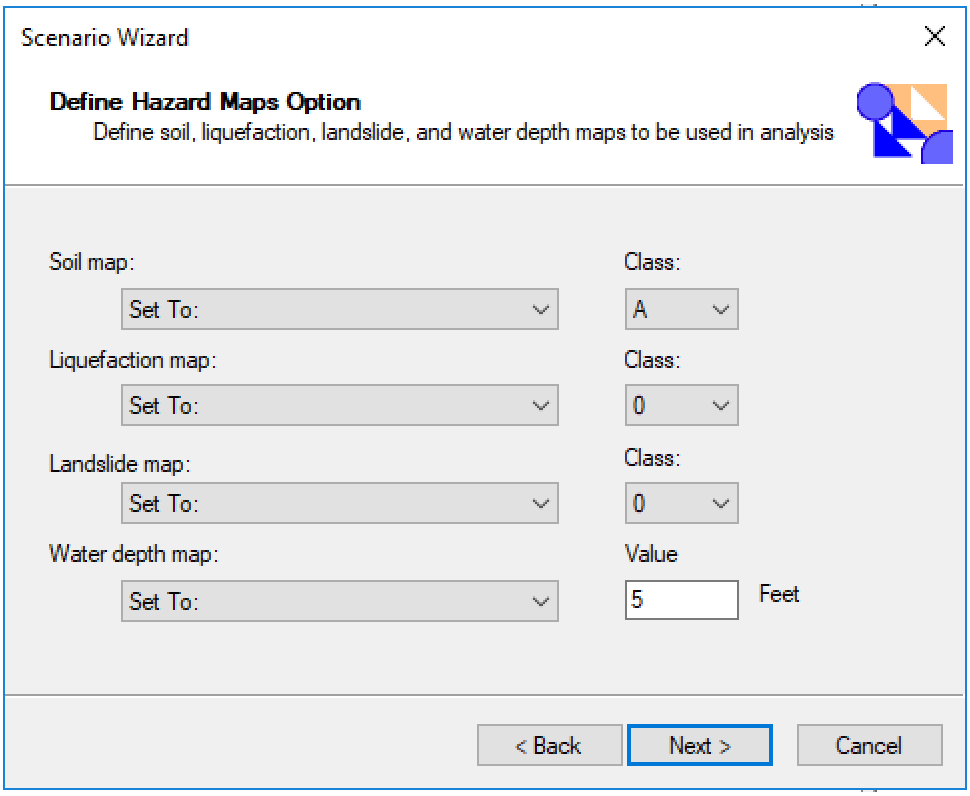


Enter 7 for the Moment Magnitude.

The Scenario Wizard screen should resemble the image below. Click Next.

Enter 7 for the Moment Magnitude.

The Scenario Wizard screen should resemble the image below. Click Next.



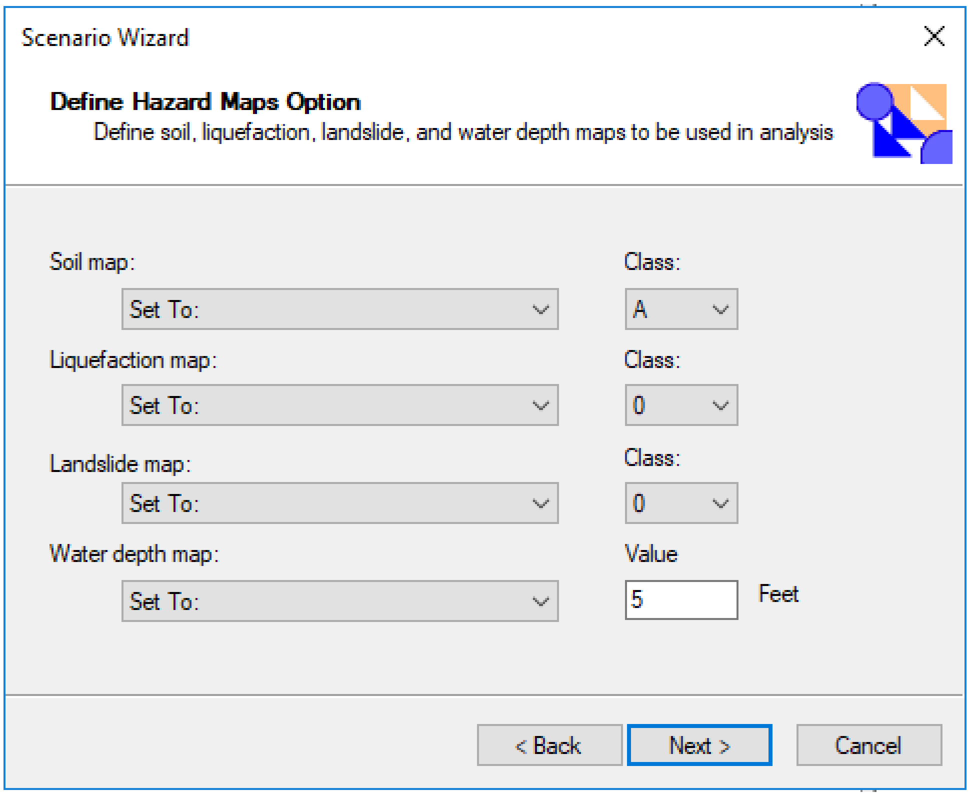
Name the scenario SLC_Arbitrary. Click Next. Click Finish.

Task 7: Modify the Data Map parameters for soils type

Select Hazard -> Scenario and then click Next.

Select Define Hazard Maps and click Next.

Change the Soil map Class to A and click Next and then Finish. The processing may take a few moments to complete.



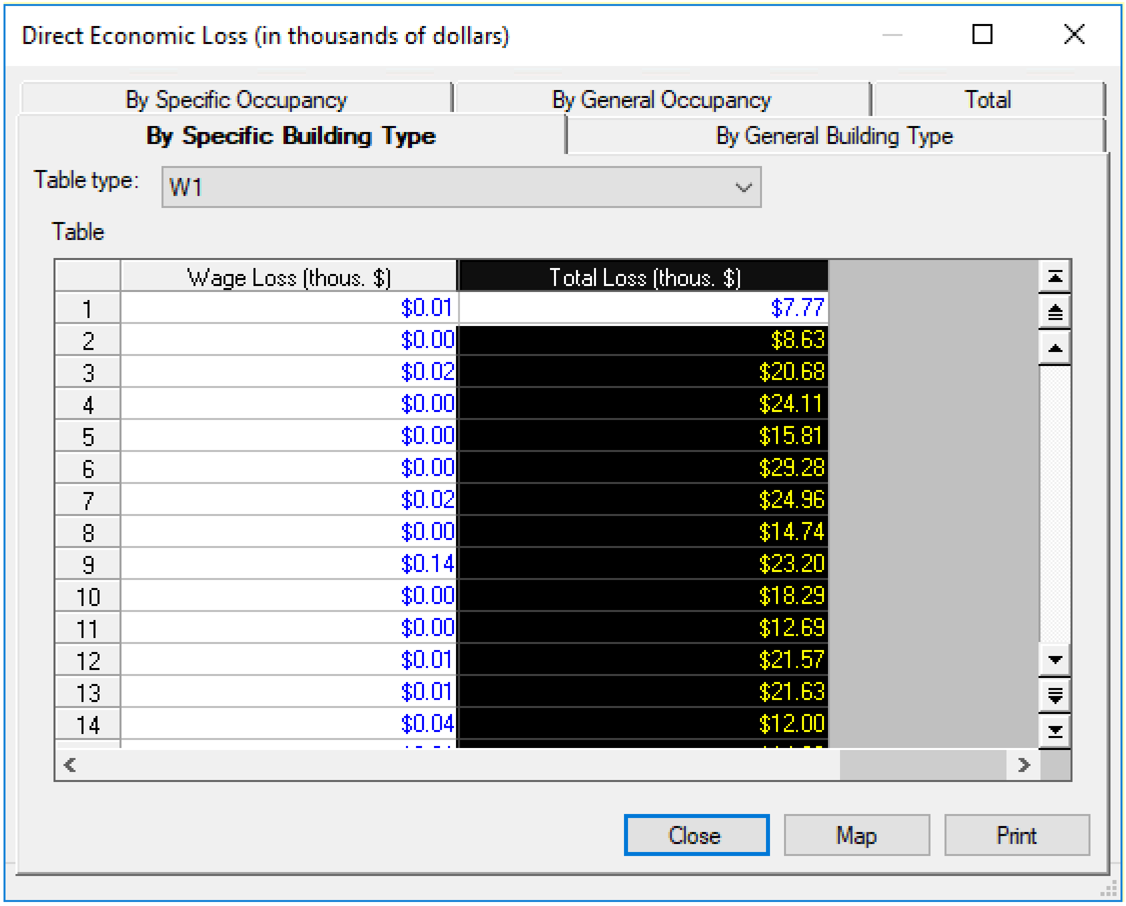
Task 8: Run the Analysis

Select Analysis|Run and then select General Buildings. Click OK to run the analysis. The analysis may take a few moments to complete. Click OK when complete.

Task 9: View the results

Select Results -> General Building Stock -> Building Economic Loss ->Direct Economic Loss.

Select the column Total Loss (thou. $) and click Map.



Right click the RES_DEL_W1_TotalLoss layer in the ArcMap legend and select Open Attribute Table.

Right click the Total Loss column on the right side of the table and select Statistics.

Write down the number in the Sum field in the box below. ***Remember the results are in thousands of dollars.***

SUM:	

Task 10: Compare the Scenarios

Now, compare the two scenarios you just completed.

- What are the differences between the data used in the two scenarios?
- Which data can lead to more accurate results? Why?

ACTIVITY 7.1 – EFFECTS OF DIFFERENT PARAMETERS ON BRIDGE DAMAGE

Type: Student Activity

Time: 25 minutes

Background

This activity examines the impact that modifying model input parameters can have on damage estimates for bridges. This activity reinforces some of the key sensitivity parameters that impact the results of bridge analysis. The baseline case will be the same scenario used in activities 4.1 and 5.1.

Four parameters are important and can have an impact on bridge analysis:

- Soil Type
- Liquefaction Effects
- Attenuation Function
- Magnitude

In particular, you will look at the effect of the following parameters:

- Soil Type
- Liquefaction Effects

This activity is divided into four tasks. One that involves importing an hpr and creating a scenario and the other three modifying a different parameter to assess the impact of an earthquake on bridges in the study region. At the end of the activity, you will compare the results that you obtained in each task so you can better understand which parameters have the most significant impact. *Responses to each task are to be entered into the table found at the end of the activity.*

Task 1: Import a study region and create a scenario

Import the Inventory_Update.hpr file located in the Activity 7.1 data folder and name it Inv_Update. Open the study region when complete.

From the Hazard menu, choose Scenario to open the Scenario wizard.

Click Next to move to the Earthquake Hazard Scenario Selection window.

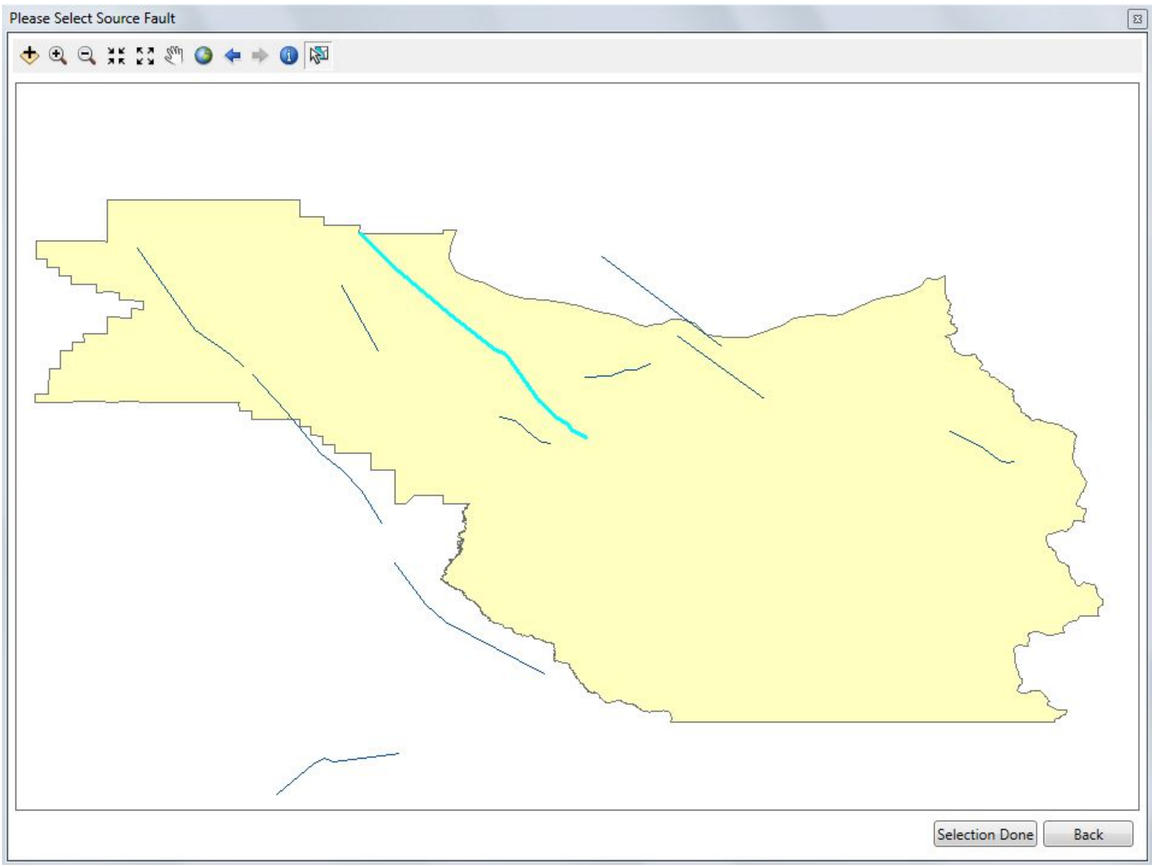
Choose Define a new scenario then click Next to view the Seismic Hazard Type Selection window.

Select Source Event then click Next to view the Source Event Database.

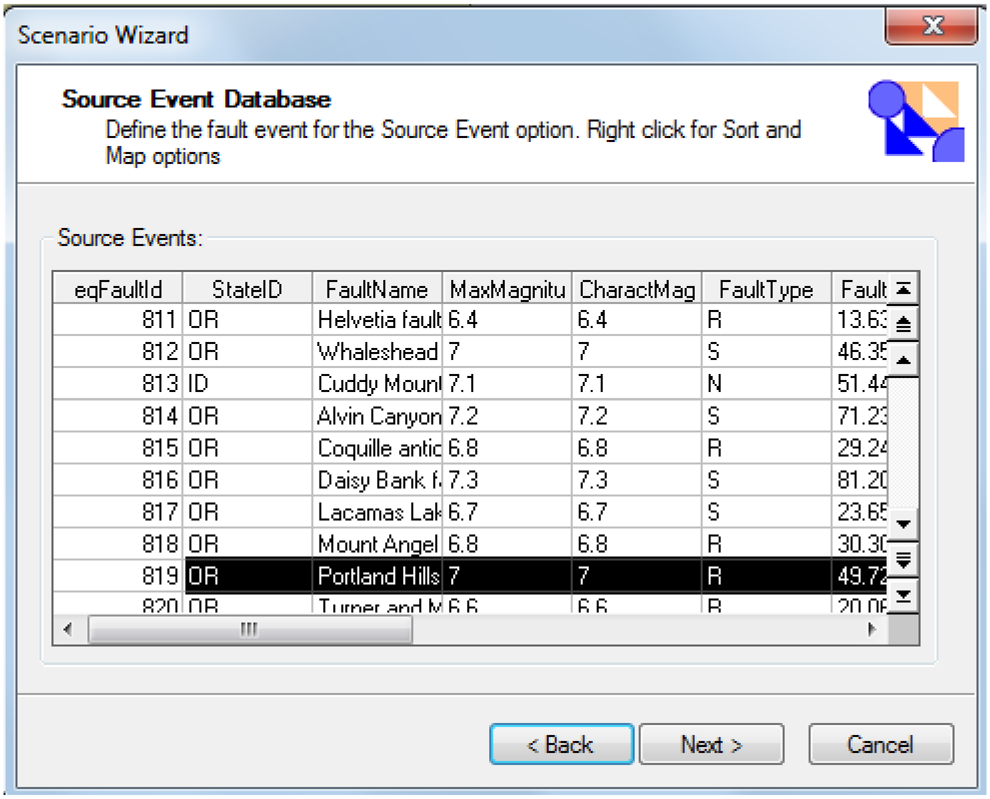
When you click the Source event option the first time that you define a source event, you will see a statement appear that provides a disclaimer about the source of this data. Click the Accept button to move to the Source Event Database window.

Right-click on the source event database table and click on Map to display the faults.

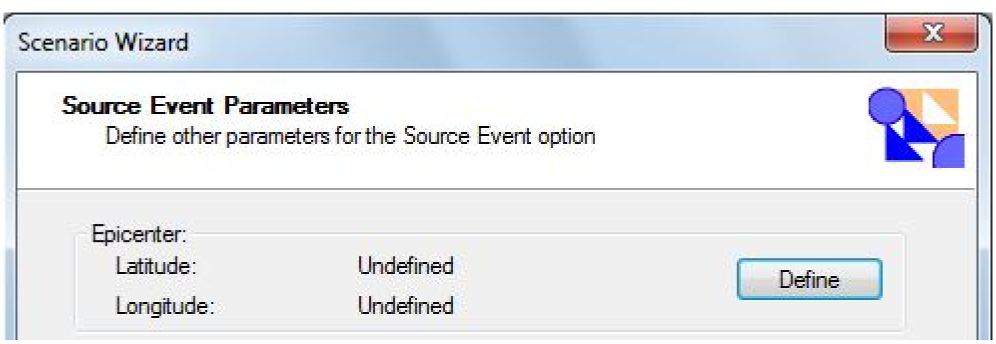
Zoom into the study area – located along the top edge of the map – and select the fault indicated by the arrow in the figure below.



Click on Selection Done. The Portland Hills fault should be highlighted as shown in the following graphic.

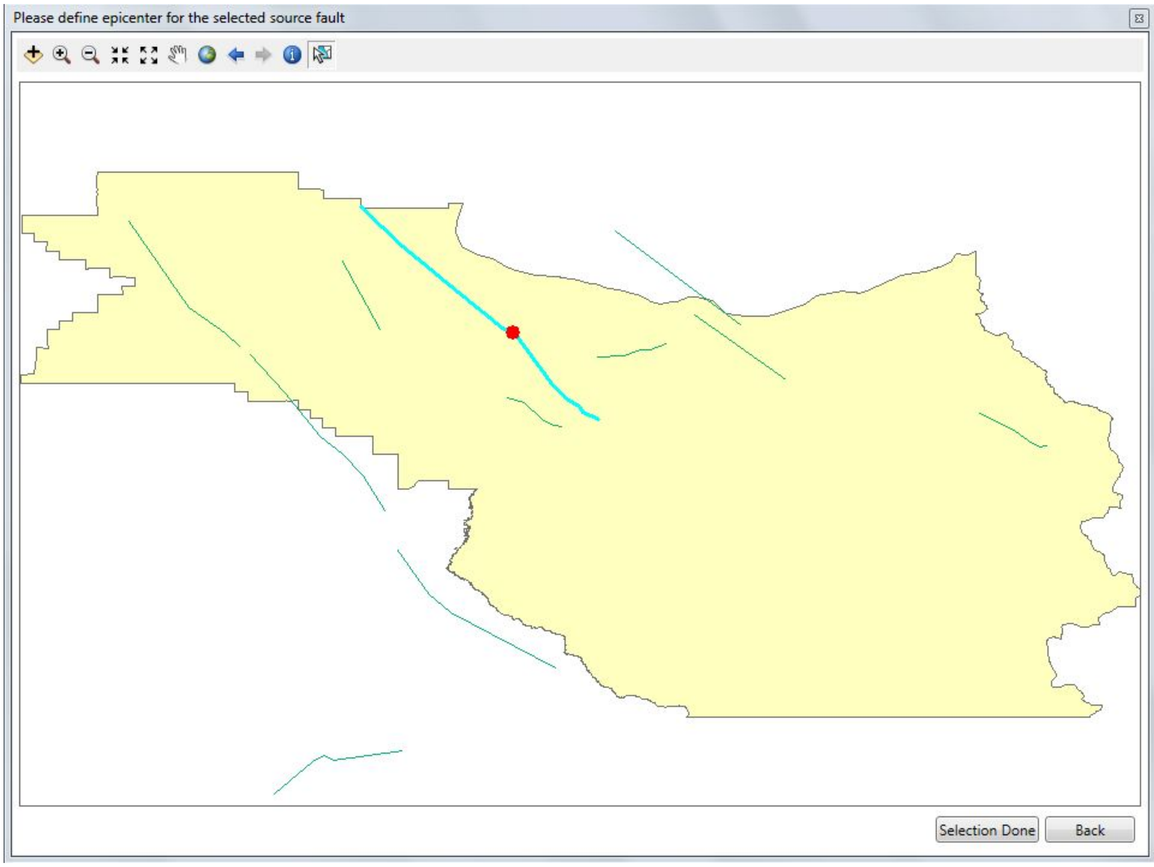


Click Next to proceed to the Source Event Parameters window.



You now need to define the location of the epicenter on this fault. Click on Define to open the Please define epicenter for the selected source fault window.

Select the point closest to where the fault line changes direction as shown in the following example.

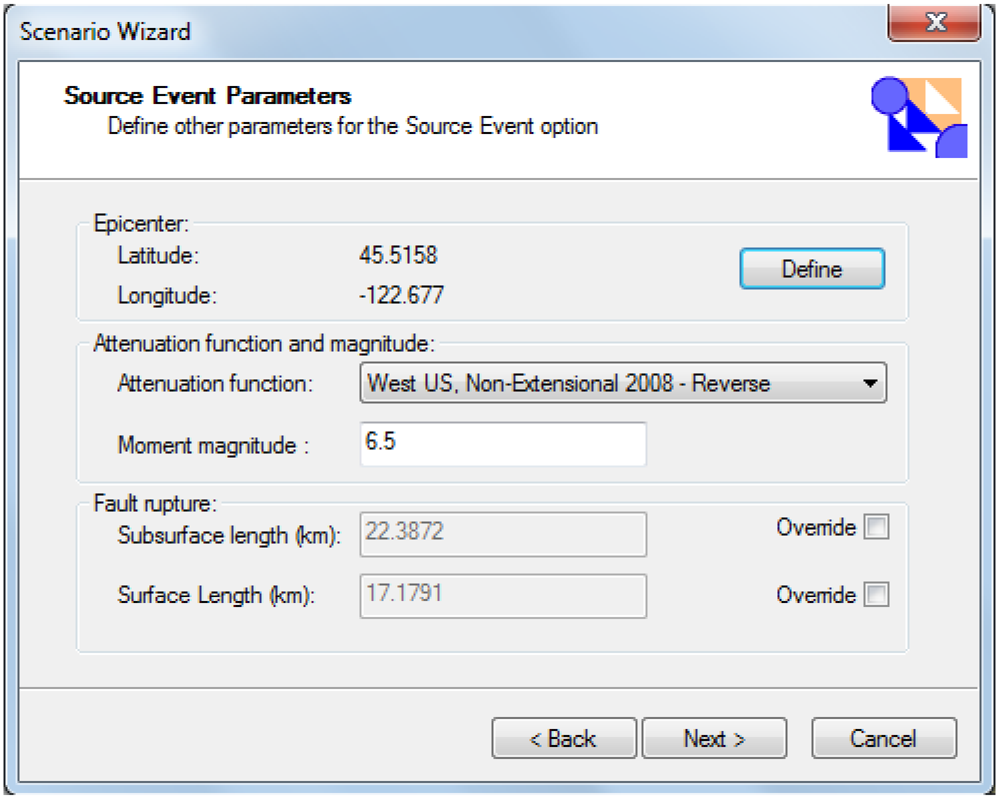


Click on Selection Done to close the map.

The Source Event Parameters window should now appear as shown in the following example. It's OK if your coordinates differ slightly from what is shown below.

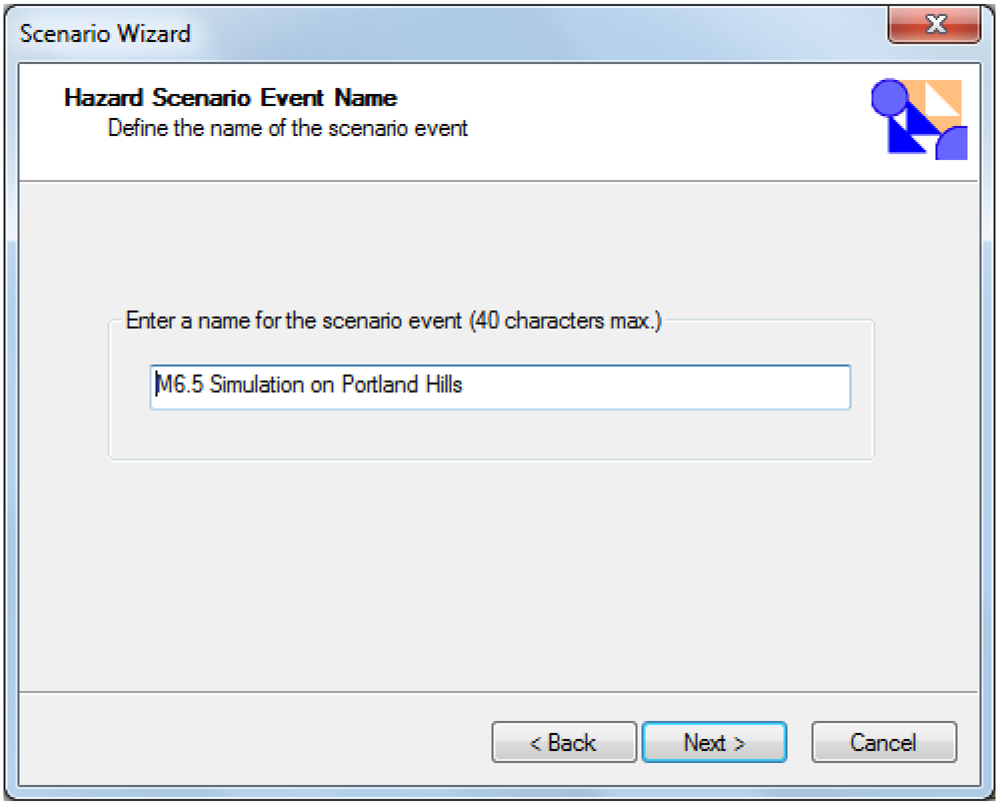
Change the Attenuation Function to West US. Non-Extensional 2008- Reverse.

Change the moment magnitude to 6.5.



Click Next to move to the Hazard Scenario Event Name window.

Name your scenario M6.5 Simulation on Portland Hills.



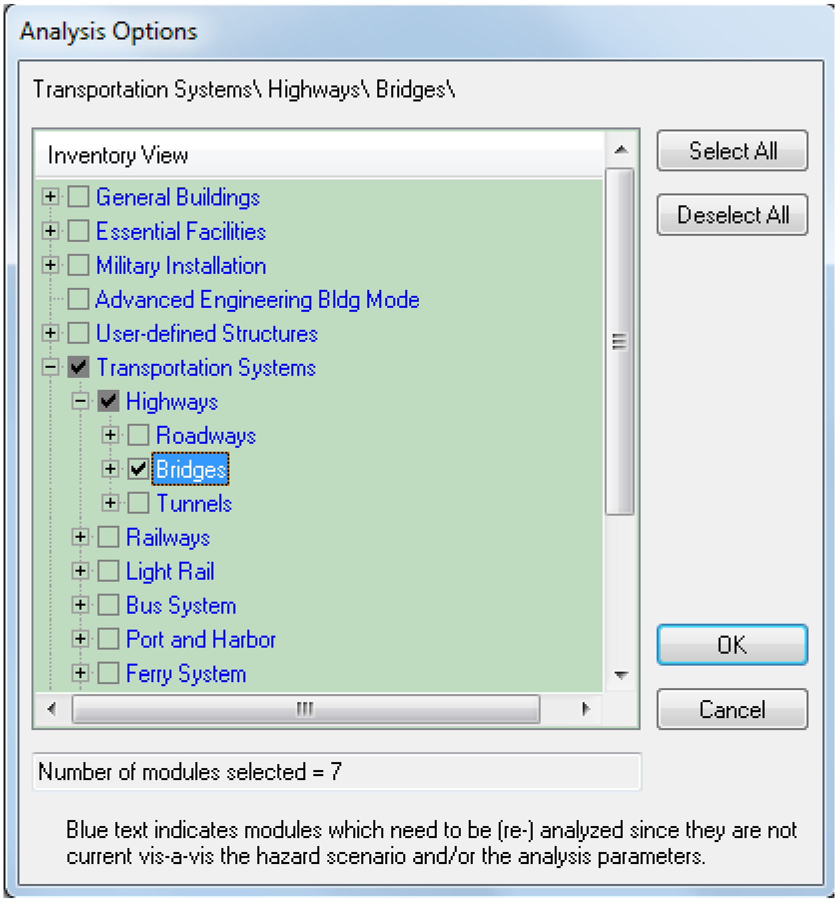
Click the Next button and then click the Finish button.

The scenario that you will use in this activity has now been successfully defined.

Task 2: Run a baseline scenario

From the Analysis menu, choose Run to open the Analysis window.

Check ONLY the Transportation Systems > Highways > Bridges option as shown in the following example.



Click OK and then click Yes when prompted to indicate that you want to run the analysis with the options selected. Click OK when the analysis has finished. The analysis may take a few moments to complete.

Open the results for the bridge analysis by choosing Results > Summary Reports.

Click on the Lifelines tab. Select the Damage button. Click the Highway Bridge Damage report and click the View button. This report reviews damages to the bridge inventory.

Browse the Highway Bridge Damage Report. Fill in the information in the first row labeled Original Magnitude 6.5 Scenario of the Bridge Analysis Results table found at the end of this activity.

Close the report and click on the Functionality button under the Lifelines tab.

Click on the Highway Bridge Functionality report and then click View.

Browse the Highway Bridge Functionality Report. Fill in the information in the last two columns of the row labeled “Original Magnitude 6.5 Scenario” of the Bridge Analysis Results table found at the end of this activity.

Close all reports and the Summary Reports window.

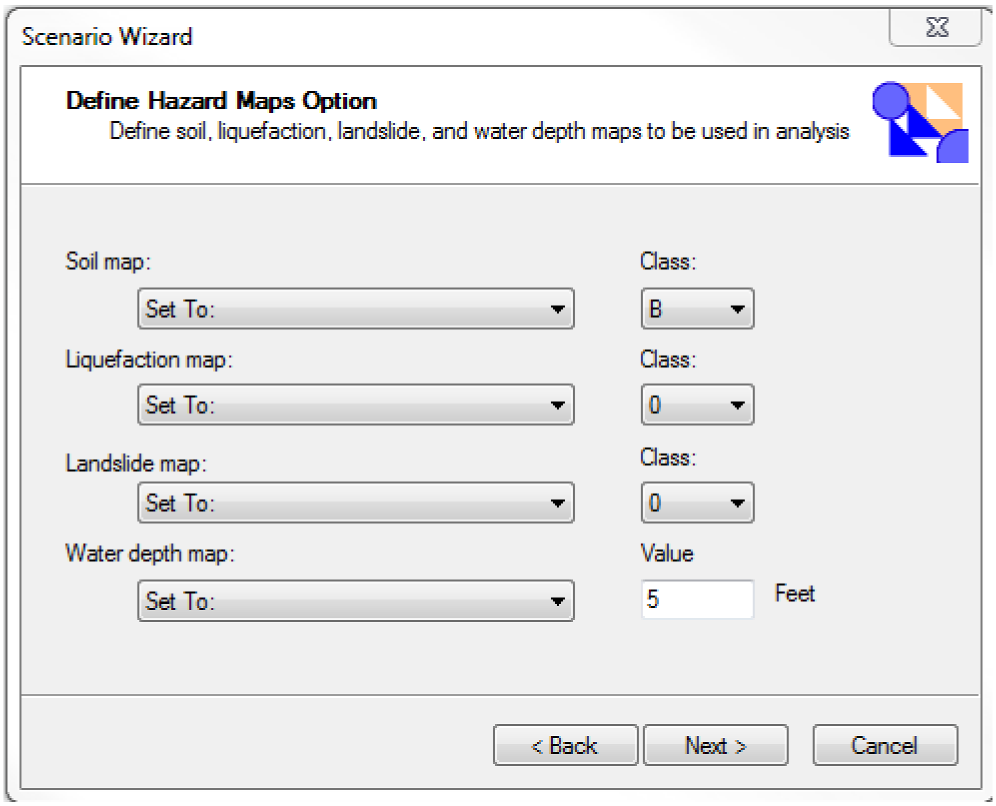
Task 3: Explore the impact of soil effects

From the Hazard menu, choose Scenario to open the Scenario wizard.

Click Next to move to the Earthquake Hazard Scenario Selection window.

Select Define hazard maps and then click Next to move to the Define Hazard Maps option window.

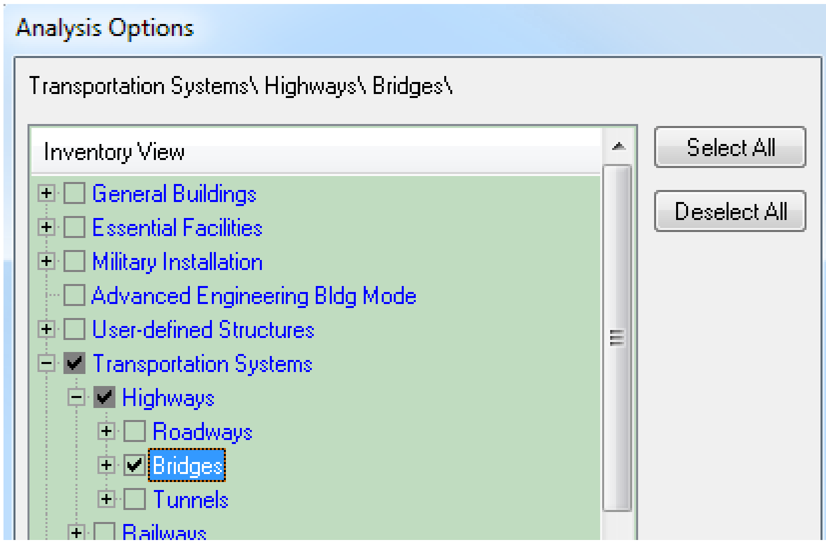
Change the default soil class to B as shown below.



Click on the Next button to view the scenario summary and then click the Finish button to close the Scenario Wizard.

From the Analysis menu choose Run to open the Analysis window.

Check <u>ONLY</u> the Transportation Systems > Highways > Bridges option as shown in the following example.



Click OK and then click Yes when prompted to indicate that you want to run the analysis with the options selected. Click OK when the analysis has finished. The analysis may take a few moments to complete.

Open the results for the bridge analysis by choosing Results > Summary Reports.

Click on the Lifelines tab. Select the Damage button. Click the Highway Bridge Damage report and click the View button.

Browse the Highway Bridge Damage Report. Fill in the information in the first two columns of the row labeled “Soil Type Change” of the Bridge Analysis Results table found at the end of this activity.

Close the report and click on the Functionality button under the Lifelines tab.

Click on the Highway Bridge Functionality report and then click View.

Browse the Highway Bridge Functionality Report. Fill in the information in the last two columns of the row labeled “Soil Type Change” of the Bridge Analysis Results table found at the end of this activity.

Close all reports and the Summary Reports window.

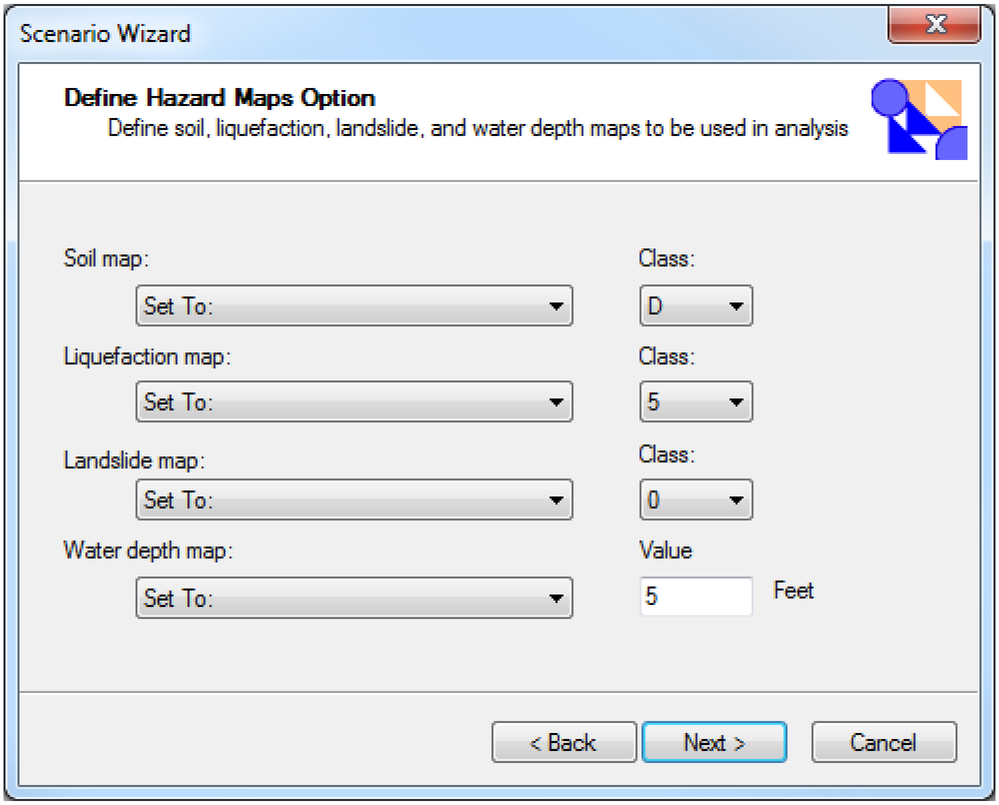
Task 4: Explore the impact of liquefaction

From the Hazard menu, choose Scenario to open the Scenario wizard.

Click Next to move to the Earthquake Hazard Scenario Selection window.

Select Define hazard maps and then click Next to move to the Define Hazard Maps Option window.

Set the soil class to D and Liquefaction Class to 5 (Very High) as shown below.



Click on the Next button to view the scenario summary and then click the Finish button to close the Scenario Wizard.

Run the analysis only for the highway bridges as you did in the previous scenarios.

Open the results for the bridge analysis by choosing Results > Summary Reports.

Click on the Lifelines tab. Select the Damage button. Click the Highway Bridge Damage report and click the View button. This report reviews damages to the bridge inventory.

Browse the Highway Bridge Damage Report. Fill in the information in the first two columns of the row labeled "Liquefaction Change" of the Bridge Analysis Results table found at the end of this activity.

Close the report and click on the Functionality button under the Lifelines tab.

Click on the Highway Bridge Functionality report and then click View.

Browse the Highway Bridge Functionality Report. Fill in the information in the last two columns of the row labeled "Liquefaction Change" of the Bridge Analysis Results table found at the end of this activity.

Close all reports and the Summary Reports window.

Browse the Highway Bridge Damage and Highway Bridge Functionality reports. Fill in the information in the row labeled "Attenuation Change" of the Bridge Analysis Results table found at the end of this activity.

Close all reports and the Summary Reports window.

Results Table:

Task	Moderate Damage State	Complete Damage State	Regional Total At Day 1	Regional Total At Day 90
1- Original Magnitude 6.5 Scenario				
2- Soil Type Change				
3- Liquefaction Change				

1. Which parameter change had the most influence on damage?

ACTIVITY 7.2 – EFFECTS OF PARAMETERS ON PIPELINE DAMAGE

Type: Student Activity

Time: 30 minutes

Background

This activity will help students learn how to modify some of the parametric values to assess their effects on the estimations that Hazus generates for pipeline damage (sensitivity studies). At the end of the activity, review the findings to help students develop a better sense of how to interpret the results.

This activity uses the Inv_Update study region and a magnitude 6.5 Portland Hills event. In this activity, students will run 3 simulations and compare their results.

Task 1: Open Inv_Update study region and run the baseline scenario

Open the Inv_Update study region that was used in Activity 7.1.

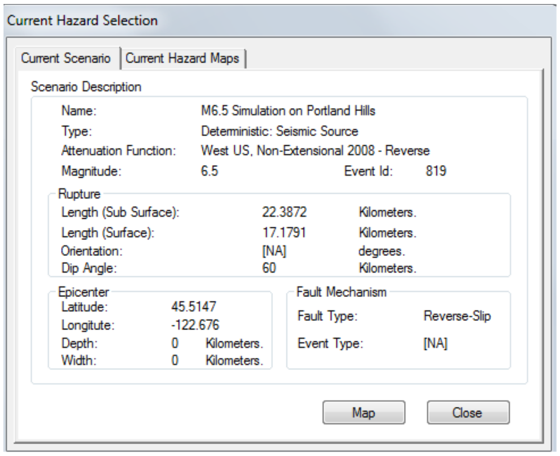
If you were unable to successfully complete the previous activity, you should import the InventoryUpdaate.HPR file which is found in the Activity 7.2 folder.

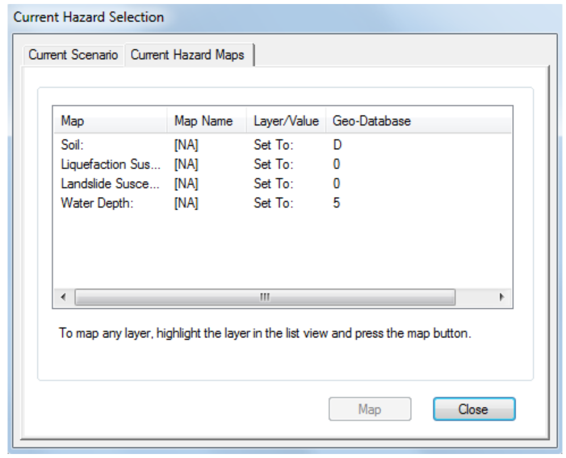
From Hazard > Scenario choose to Use an Already pre-defined scenario.

Choose the M6.5 Simulation of Portland Hills and complete the wizard.

If the scenario does not exist, create a new scenario or define an existing scenario with the settings shown in the following graphics.

As the course continues, you will be provided with fewer instructions about the process for setting up an earthquake scenario since this is a basic skill that you are anticipated to have mastered by this point in the course. However, if you are having difficulty with this process, do not hesitate to ask your instructor for assistance.

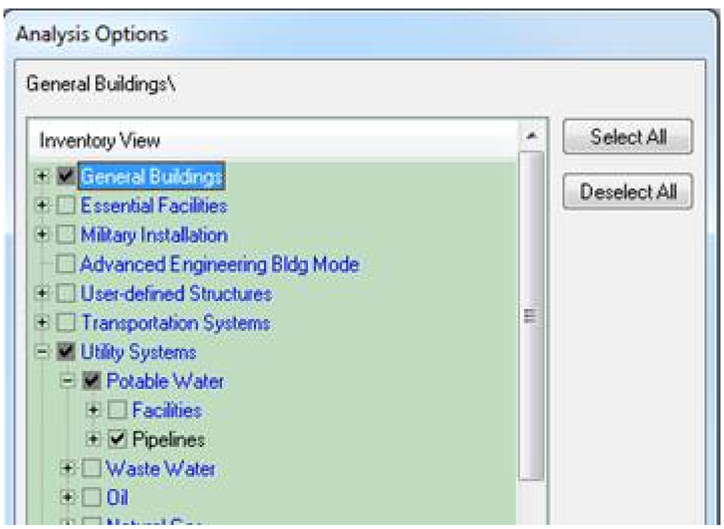




From the Analysis menu choose Run to open the Analysis window.

Check ONLY the Utility Systems > Potable Water > Pipelines option as shown in the following example.

When selecting Pipelines, Hazus will alert you that the General Building Stock will also be selected. This is required for pipeline analysis.



Click OK and then click Yes when prompted to indicate whether you want to run the analysis with the options selected. Click OK when the analysis has finished. *The analysis should complete in less than two minutes.*

Open the results for the Potable Water Pipeline analysis by choosing Results > Summary Reports > Lifelines.

Click on the Damage button under the Lifelines tab.

Click on the Potable Water Pipeline Damage report and then click View. This report reviews damages to the pipeline inventory.

Browse the report. Fill in the first two columns of the "Original Magnitude 6.5 Scenario" row of the Pipeline Analysis Results table at the end of the activity.

Close the report and click on the Performance button under the Lifelines tab.

Click on the Potable Water System Performance report and then click View.

Browse the report. Fill in the last two columns of the "Original Magnitude 6.5 Scenario" row of the Pipeline Analysis Results table at the end of the activity.

Close all reports and the Summary Reports window.

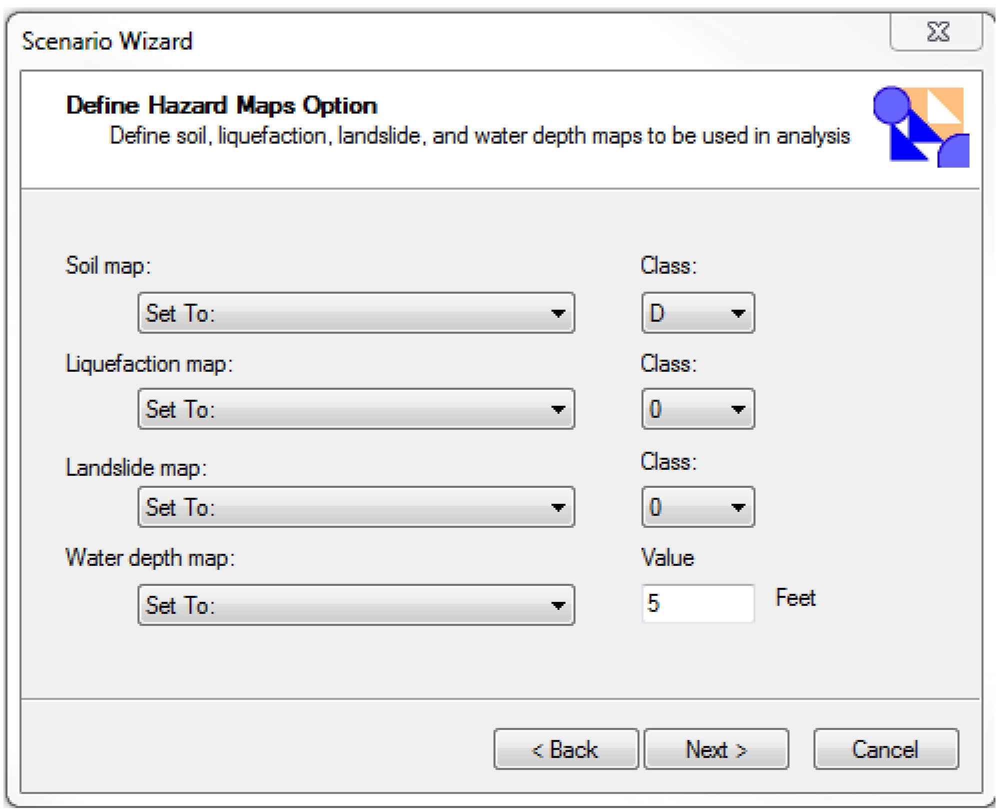
Task 2: Explore the impact of attenuation functions

From the Hazard menu, choose Scenario to open the Scenario wizard.

Click Next to move to the Earthquake Hazard Scenario Selection window.

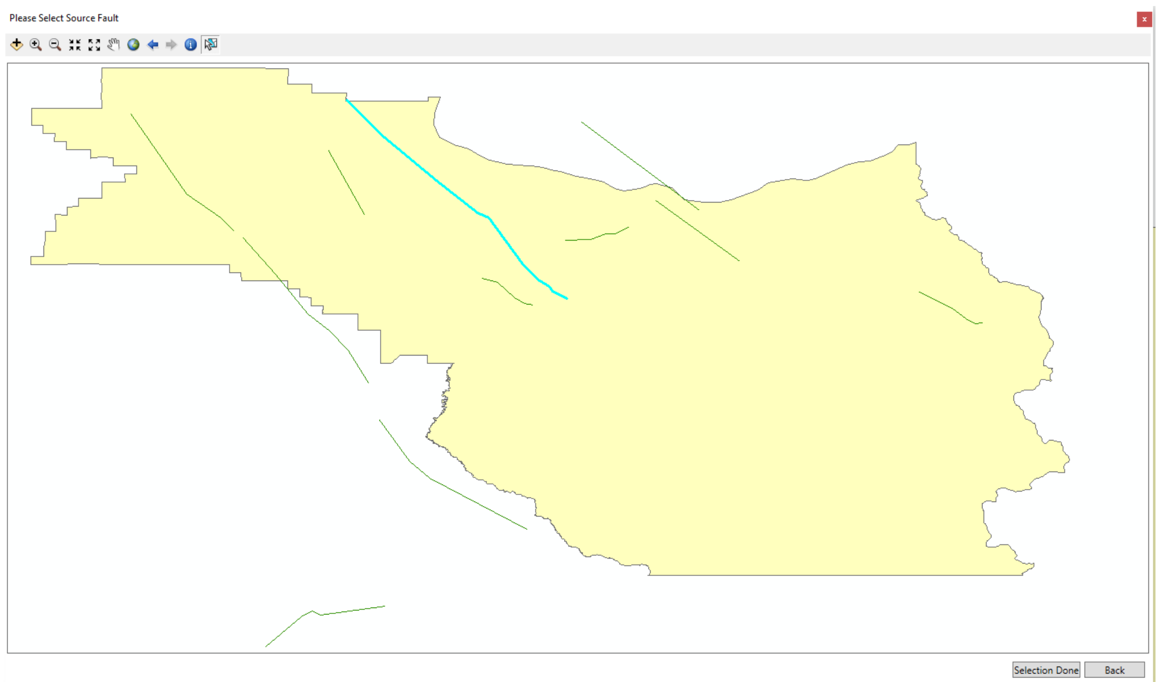
Select Define hazard maps and then click Next to move to the Define Hazard Maps option window.

Set the default soil class to D and no liquefaction (value of 0), as shown below.



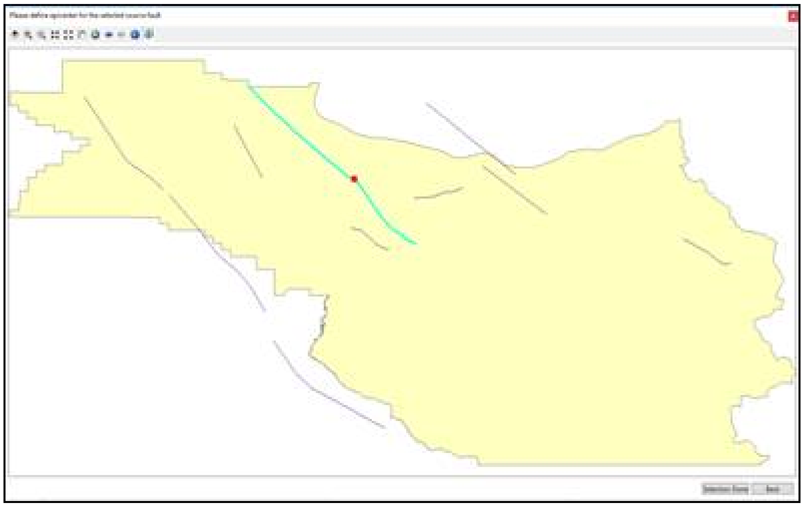
Click on the Next button to view the scenario summary and then click the Finish button to close the Scenario Wizard.

From the Hazard menu, choose Scenario to open the Scenario wizard.
Click Next to move to the Earthquake Hazard Scenario Selection window.
Choose Define a new scenario, then click Next.
Select Source event.
Right click on the Source Event table and select Map.
Zoom to the polygon on the map.
Select the line selected in the graphic below and click Selection Done.



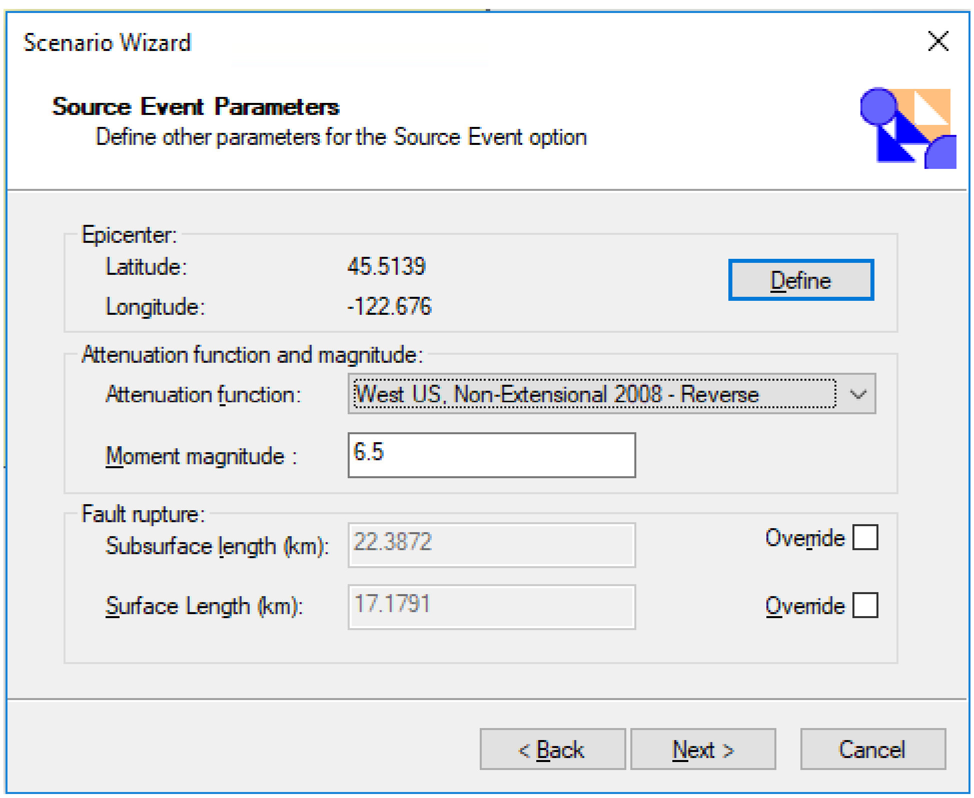
Click Next.

Click Define and create a point near the location in the graphic below.



Change the Moment magnitude to 6.5.

Select West US Non-Extensional 2008 – Reverse for the Attenuation function.



Click Next.

Name the scenario M6.5 Attenuation Simulation.

Click Next and Finish.

Run the analysis only on the Potable Water Pipelines.

If you do not remember how to run the analysis, refer to the beginning of the activity.

Record the results found the Potable Water Pipeline Damage report and the Potable Water System Performance report in the “Attenuation Function Change” row of the Pipeline Analysis Results table at the end of the activity.

If you do not remember where to find these reports, refer to the earlier portions of the activity.

Close all reports and the Summary Reports window

Task 3: Explore the impact of magnitude changes

From the Hazard menu, choose Scenario to open the Scenario wizard.

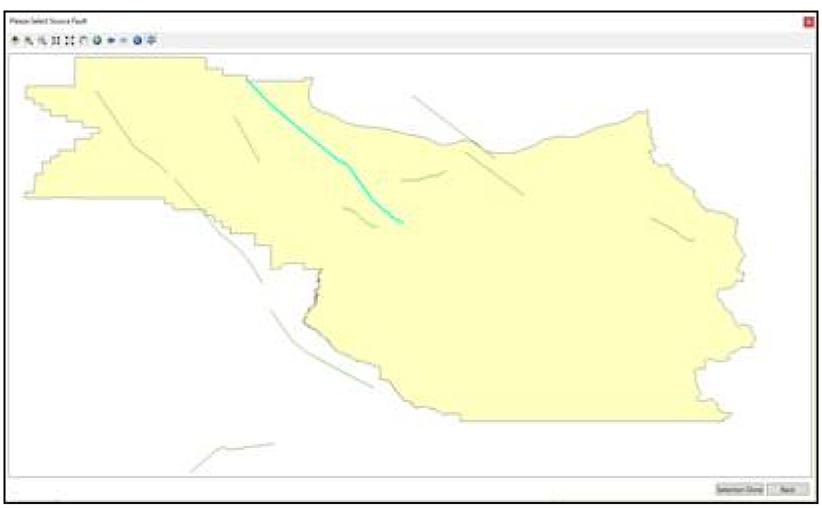
Click Next to move to the Earthquake Hazard Scenario Selection window.

Choose Define a New Scenario and click Source Event.

Right click in the Source Event table and select Map.

Zoom to the polygon located on the map.

Select the line like you see in the graphic below.

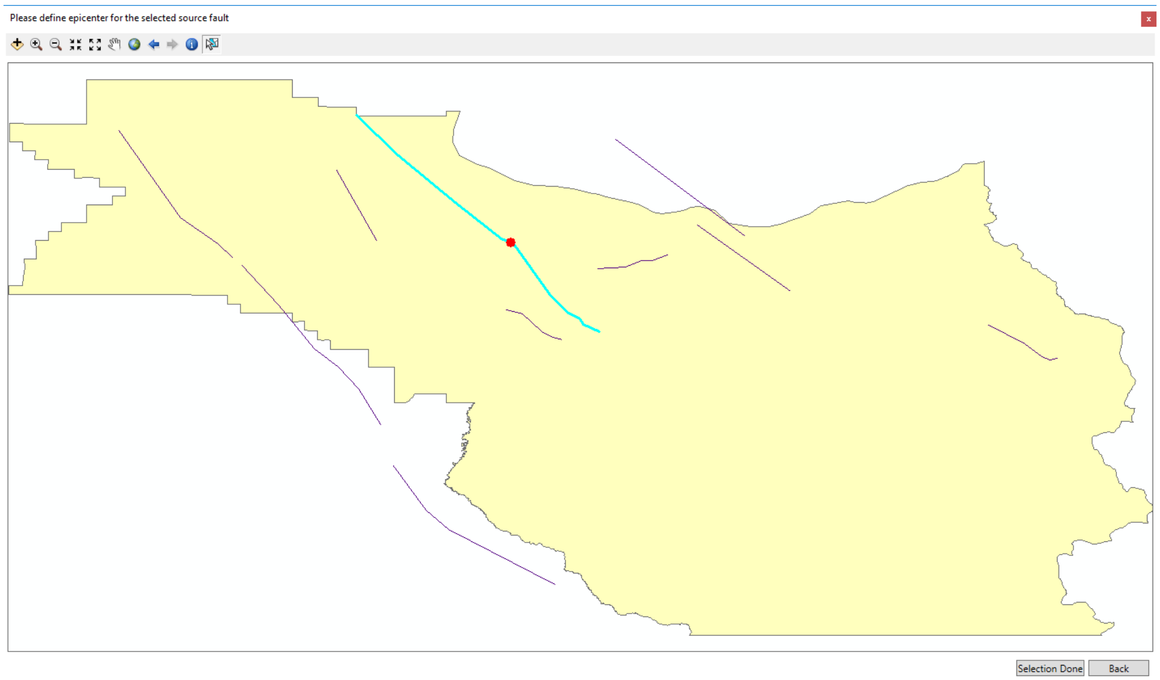


Click Selection Done when complete.

Click Next.

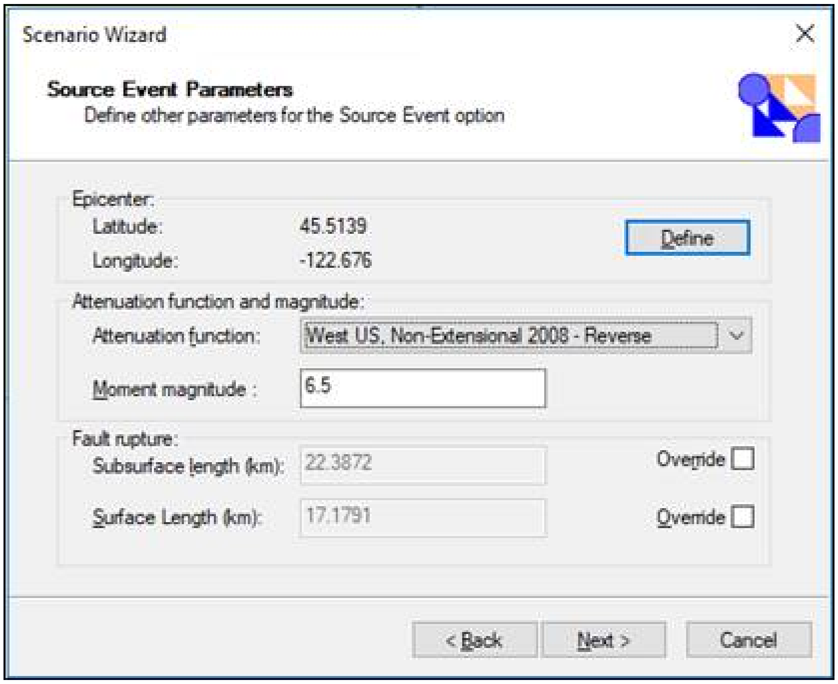
Change the Moment Magnitude to 6.

Click the Define button and place the epicenter point near the location on the map in the graphic below.



Click Selection Done when finished.

The completed form should resemble the graphic below.



Click Next.

Name the scenario M6.0 Simulation and click Next and then Finish.

Run the analysis only on the Potable Water Pipelines.

If you do not remember how to run the analysis, refer to the beginning of the activity.

Record the results found in the Potable Water Pipeline Damage report and the Potable Water System Performance report in the “Magnitude Change” row of the Pipeline Analysis Results table at the end of the activity.

When students are finished, they may exit Hazus.

Pipeline Analysis Results:

Task	Total Number of Leaks	Total Number of Breaks	% of Households without Water (Day 1)	% of Households without Water (Day 7)
1- Original 6.5				

Scenario				
2- Attenuation Function Change				
3- Magnitude Change				

Review

This exercise is intended to demonstrate that potable water systems can be susceptible to earthquake damage. Hazus considers two damage states for pipelines: leaks and breaks. Generally, when a pipe is damaged due to ground failure (PGD), the type of damage is likely to be a break, while when a pipe is damaged due to seismic wave propagation (PGV), the type of damage is likely to be joint pull-out or crushing at the bell. Varying parameters such as magnitude, soil type, etc, can affect the amount damage to pipelines and systems.

ACTIVITY 8.1 - BUILDING TYPE AND VULNERABILITY EFFECTS ON RESULTS

Type: Student Activity

Time: 30 minutes

Background

Following your review of the types of buildings in Lesson 3 that are available in Hazus and how the damage assessment to a building is evaluated, it would be interesting to see how these buildings compare in performance to each other. The objective of this activity is to explore building and damage assessment for a study scenario in which students will change the building characteristics while keeping all the other parameters the same. For this purpose, students will use a ShakeMap on the Portland Hills fault and use the AEBM option to investigate the outcome.

Task 1: Open Hazus and define a new hazard scenario

Open the Inv_Update study region. If the region does not exist import the Inventory_Update.hpr in the Activity 8.1 folder.

Select Hazard → Scenario and click Next.

Select Define a new scenario.

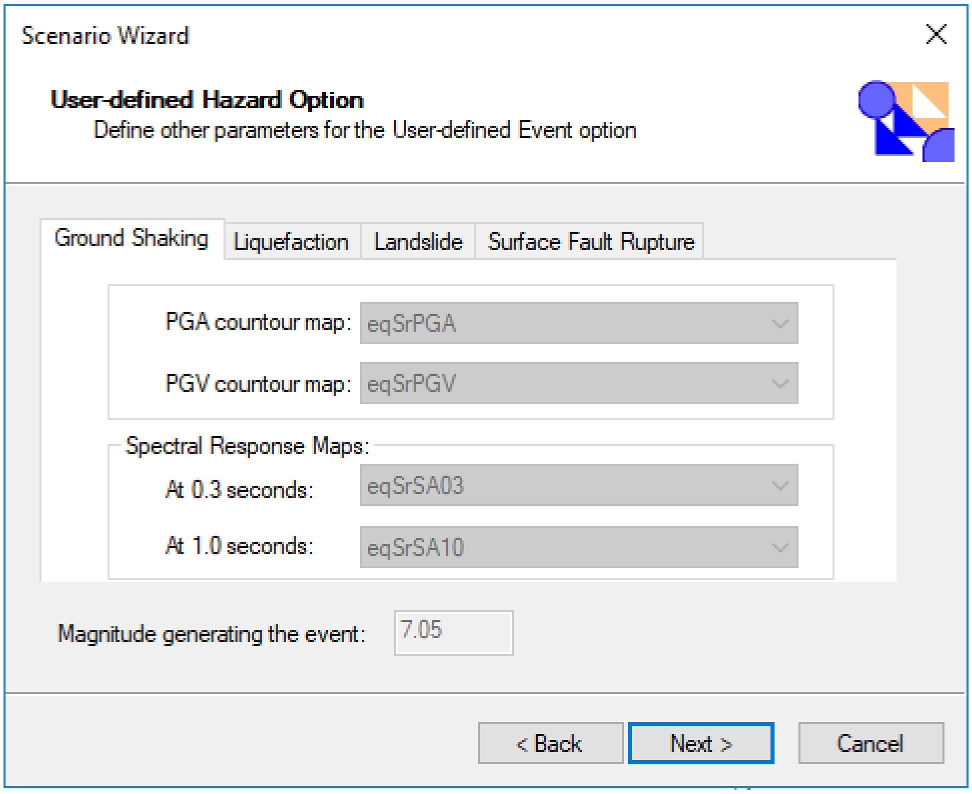
Select USGS ShakeMap.

Select Browse for Existing ShakeMap Grid Data.

Browse to Activity 8.1 and select the grid.xml file.

It may take a few moments to process the grid file.

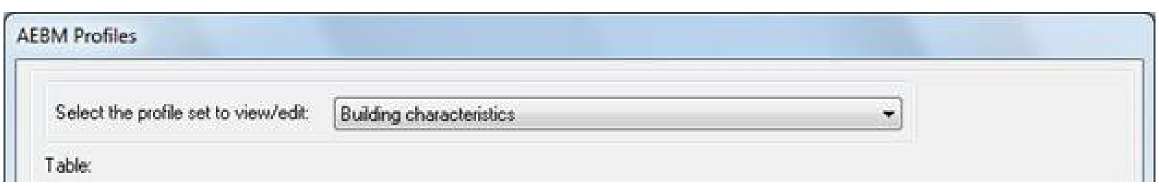
When the import is complete, the Scenario Wizard should resemble the image below.



Click Next and Finish to activate the scenario.

Task 2: Preview the AEBM profiles

From the Inventory menu, choose AEBM and then Profiles to open the AEBM Profiles name window.



Scroll down the list to profile row id 3789. This is a COM6 (Hospital) building with a RM2M (Reinforced Masonry Bearing Walls with Precast Concrete Diaphragms Mid-Rise) construction and Moderate Code (MC) design level. You will be using this profile to create a new facility in the AEBM inventory. Profiles are created by concatenating the Occupancy (COM6), Building Type (RM2M) and Design Level (MC) of a record.

Close the AEBM profiles window.

Task 2: Preview the AEBM profiles

From the Inventory menu, choose AEBM and then Inventory to open the Advanced Engineering Building Model Inventory window.

Data has already been loaded into the AEBM Inventory using the Comprehensive Data Management System (CDMS). CDMS is the preferred method for loading data in to the Hazus statewide databases.

Scroll down the list and view the inventory and parameters associated with each. Take special note at the economic related data (ex: Building Value, Content Value, Business Income) for each facility.

Each facility is listed as COM6 (Hospital).

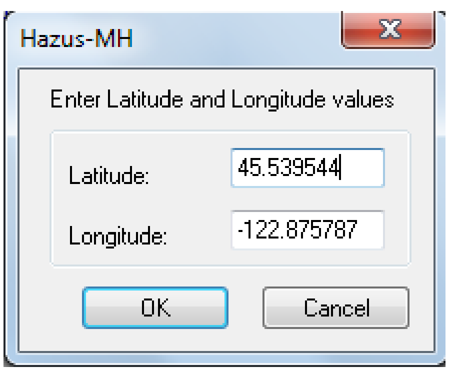
Task 4: Define the necessary AEBM inventory

Right-click in the Advanced Engineering Building Model Inventory window and choose Start Editing.

Right-click on the Advanced Engineering Building Model Inventory window and choose Add New Record.

When prompted, enter the longitude and latitude as shown on the following graphic.

Be VERY sure to use a negative value for the longitude.



Click OK to save the record.

Carefully enter the rest of the information in the Advanced Engineering Building Model inventory window as shown below:

Be aware that you need to enter the Profile Name very carefully. Hazus will hang up if you enter a profile in the inventory that does not match one of the profiles that you created. Note, the AEBM Profile is created by concatenating the following AEBM fields: Occupancy, Building Type, Design Level and Building Quality.

EqAebmID – automatically populated by Hazus when you stop editing

Tract – automatically populated by Hazus when you stop editing

Name - Kaiser Westside Medical Center

ProfileName - COM6RM2MMC-1

Address - 2875 NW STUCKI AVE

City - HILLSBORO

State - OR

ZipCode - 97124

Daytime Occupants - 410

Nighttime Occupants - 205

Building Area - 41.00

Building Value - 12,890.81

Content Value - 12,890.81

Business Income - 299.31

Wages Paid - 59.04

Relocation Disruption Costs - 50.00

Rental Cost - 14.61

Add two additional records with the same Latitude and Longitude coordinates that you used for the first record (for a total of 3 records). Also, use the same information included above to populate the fields. The profiles will be different, the Occupancy will remain the same, but the Building Type and Design Level will vary. For the second record, use the profile COM6RM2MLC-1 and for the third profile use COM6RM1MMC-1. You may be able to copy and paste the first record into the 2nd and 3rd rows by clicking on the row number and then using the Copy / Paste shortcut keys.

When entering records make the window as big as needed, if you touch the scroll bar you maybe prompted to save and may receive an error when clicking Yes to save

Make sure the soil type is set to D, LqfSusCat and LndSusCat are set to 0, with WaterDepth set to 5 for all three records.

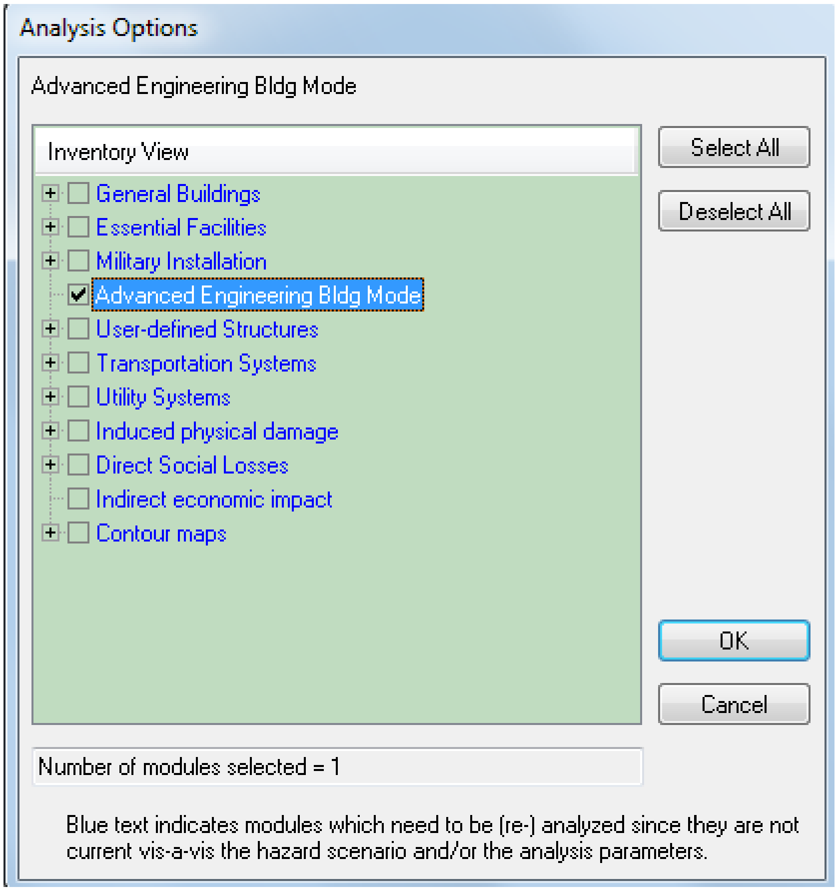
Right-click and choose Stop Editing. If prompted, click YES to save your changes.

Click the Close button to close the Advanced Engineering Building Model Inventory window. Choose Yes when prompted to save changes.

Task 5: Run the analysis

From the Analysis menu choose Run.

Select only the Advanced Engineering Bldg Mode option.



Click OK to begin the analysis and click Yes when prompted to indicate that you wish to run the analysis with the modules selected.

The analysis process should take only a moment to complete on a computer having the recommended specifications provided with the Hazus software.

Once the analysis is done, click OK to close the analysis time window. You can preview the results by choosing the Advanced Engineering Building Mode (AEBM) option from the Results menu.

Think about the type of conclusions that you can draw from the results obtained such as which buildings had the highest losses and why? Your instructor will go over the results with the class after everyone has completed the analysis.

Once you have finished reviewing the activity, save your changes.

Students may close the study region unless otherwise indicated by the instructor.

Task 6: Review

- Name a critical attribute that must be populated correctly for the AEBM import to work.

- What is the preferred methodology for loading data in to the AEBM Inventory?

- What four fields are used to create the AEBM Profile?

ACTIVITY 10.1 – CREATE LEVEL 2 AND 3 TSUNAMI SCENARIOS AND RUN ANALYSIS

Type: Student Activity

Time: 20 minutes

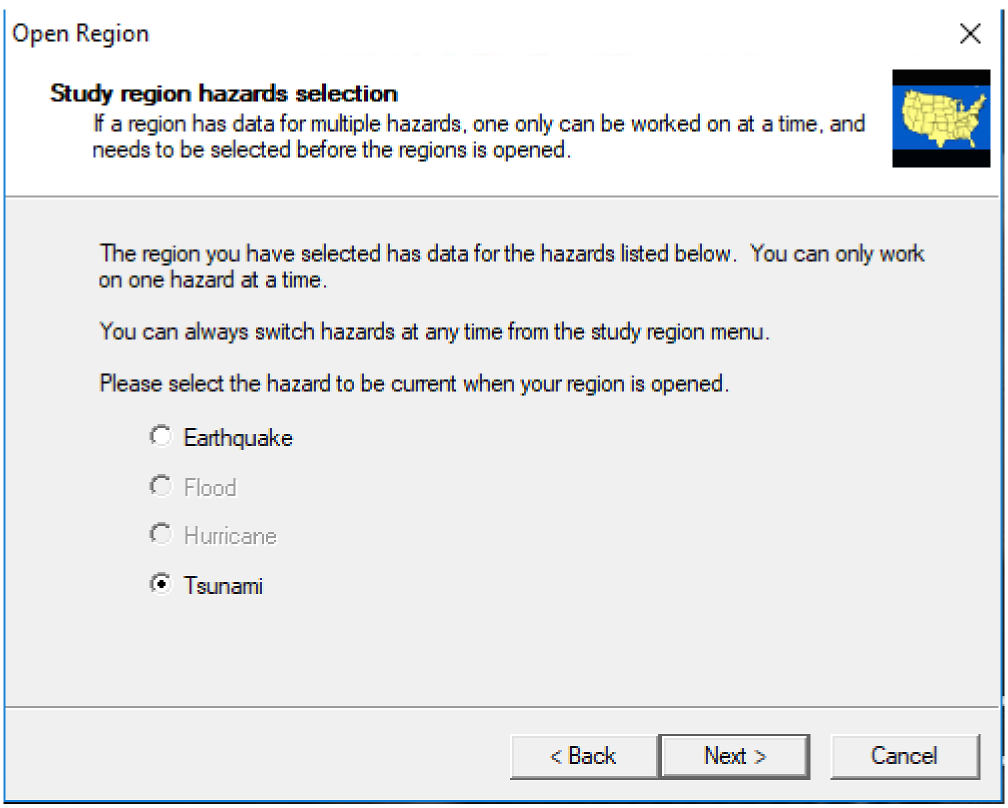
Background

The purpose of this activity is to practice creating advanced tsunami scenarios and run the analyses. Complete the seven tasks to walk you through the process.

Task 1: Open Hazus and import a .hpr file

Open Hazus and import the Activity 10.1.hpr from Activity 10.1 folder. Give the region a name and when the import is complete open the new region.

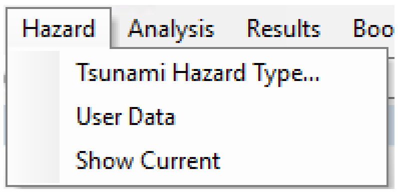
Select the Tsunami hazard from the Study region hazard selection window and click Next.



Click Finish. It may take a moment for the region to open completely.

Task 2: Select Tsunami Type and Create Level 2 Scenario

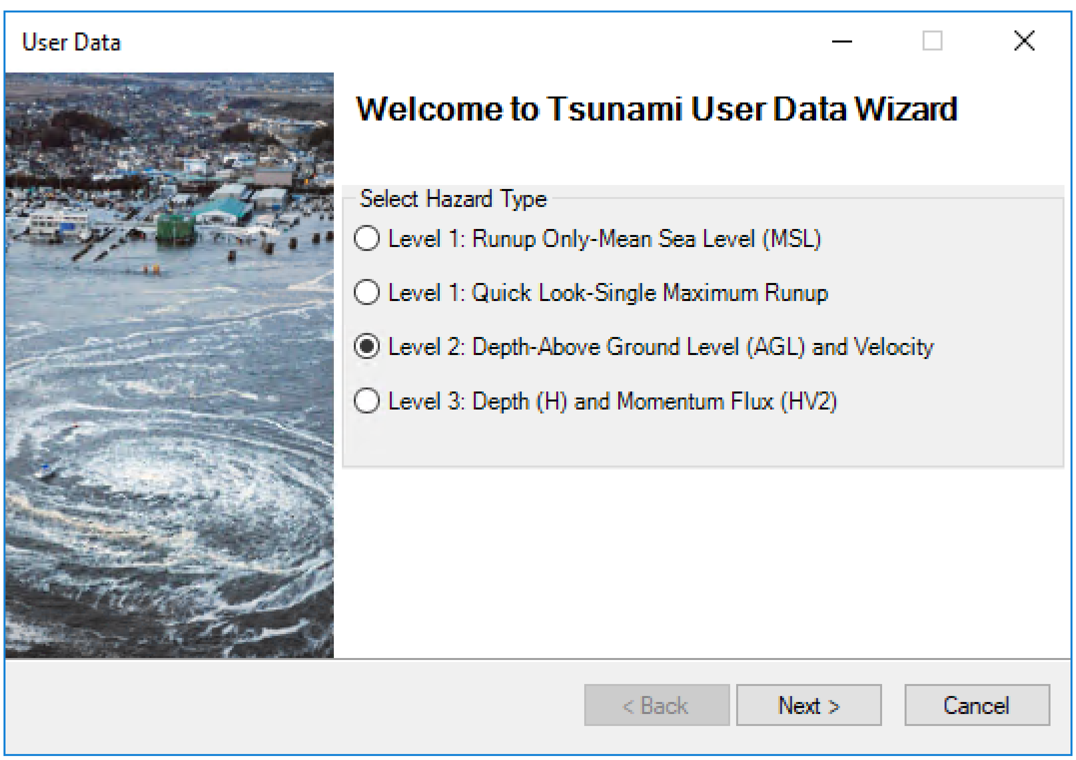
Select Hazard and then Tsunami Hazard Type.



Select Near Source Only and click OK.

Select Hazard and then User Data.

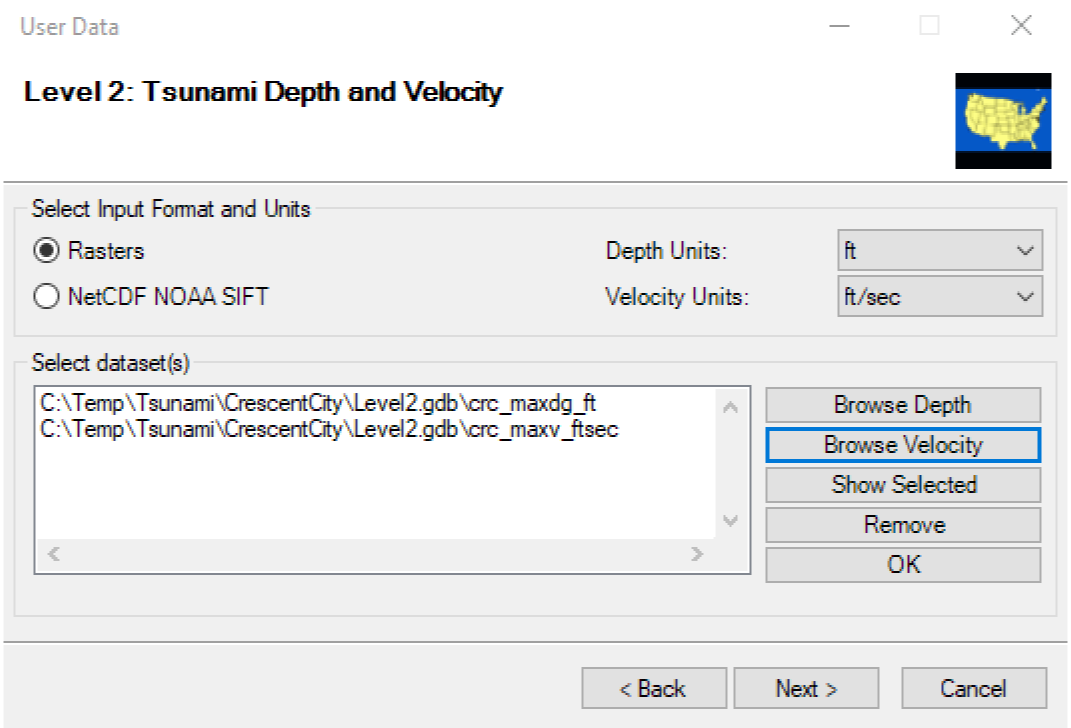
Select Level 2 from the Tsunami User Data Wizard and click Next.



For the Level 2 wizard, enter the following:

- Select: **Rasters**
- Depth Units: **ft**
- Velocity Units: **ft/sec**
- Browse Depth: C:\DMGT\Activities\Activity10.1\CrescentCity\Level2.gdb\crc_maxdg_ft
- Browse Velocity: C:\ C:\DMGT\Activities\Activity10.1\CrescentCity\Level2.gdb\crc_maxv_ftsec

The final input should resemble the following screenshot.



Click OK when finished entering the input values. The processing may take a few moments to complete.

When the processing is complete, click Next.

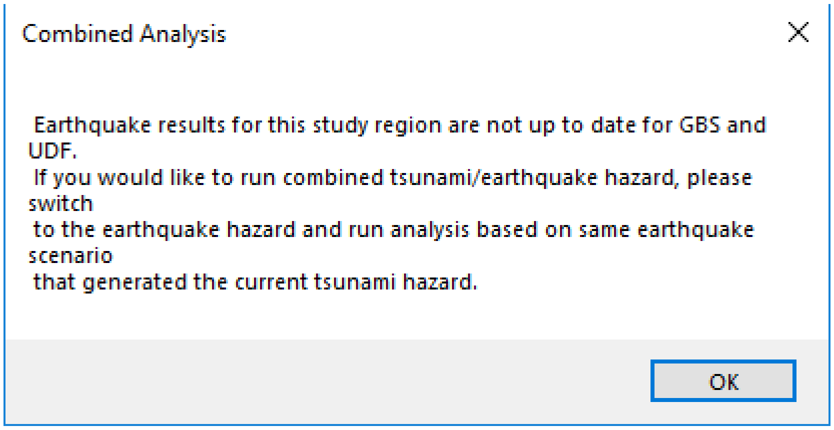
Enter Level2 for the scenario name. Click Next. The processing may take a moment to complete.

When complete click OK.

Task 3: Run the Analysis on the Level 2 Scenario

Select Analysis and then select Run.

Click OK when you see the following message appear.

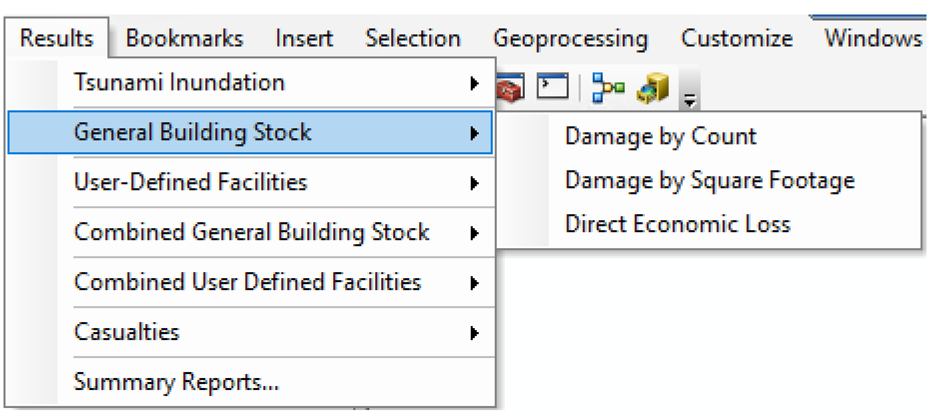


Select General Building Stock in the Analysis Options – Tsunami window and click OK.

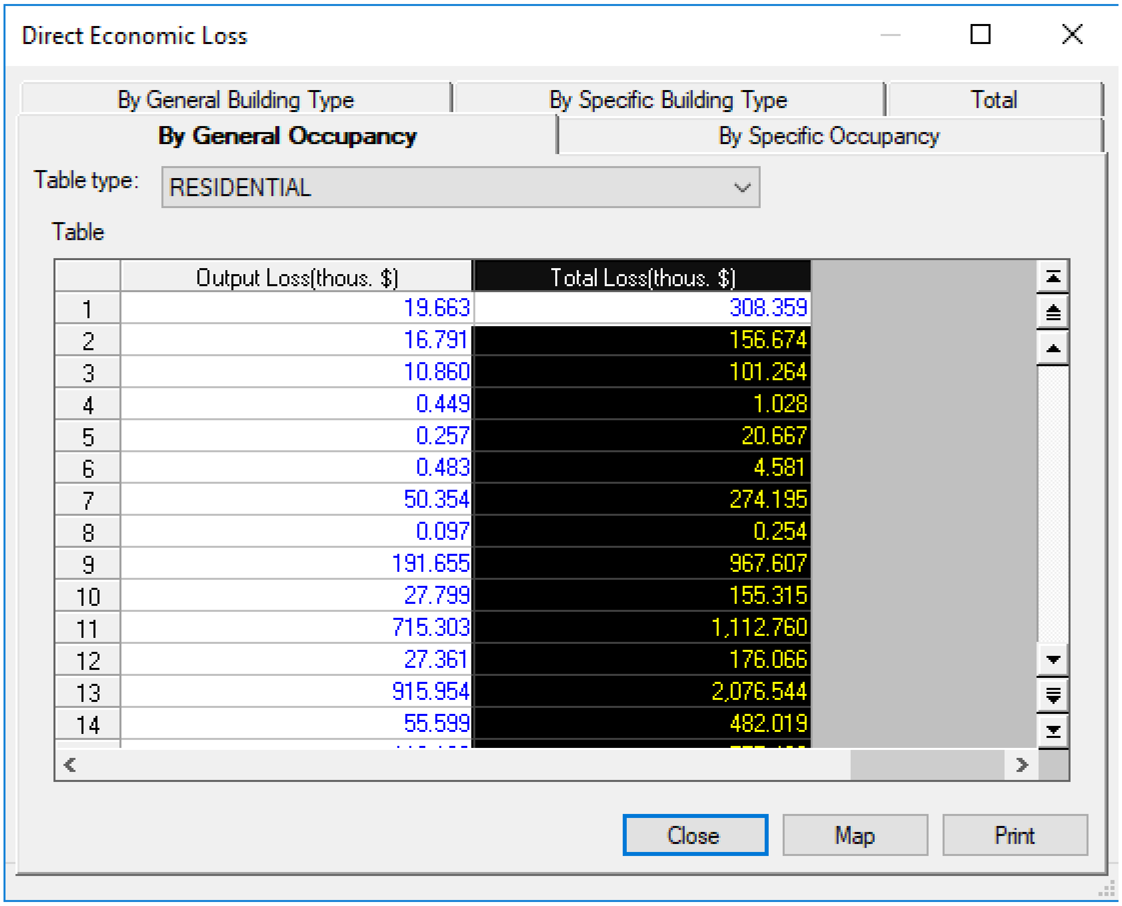
The Analysis processing should take a moment to complete.

Task 4: View the Analysis results

Select Results, General Building Stock (GBS) and then Direct Economic Losses.



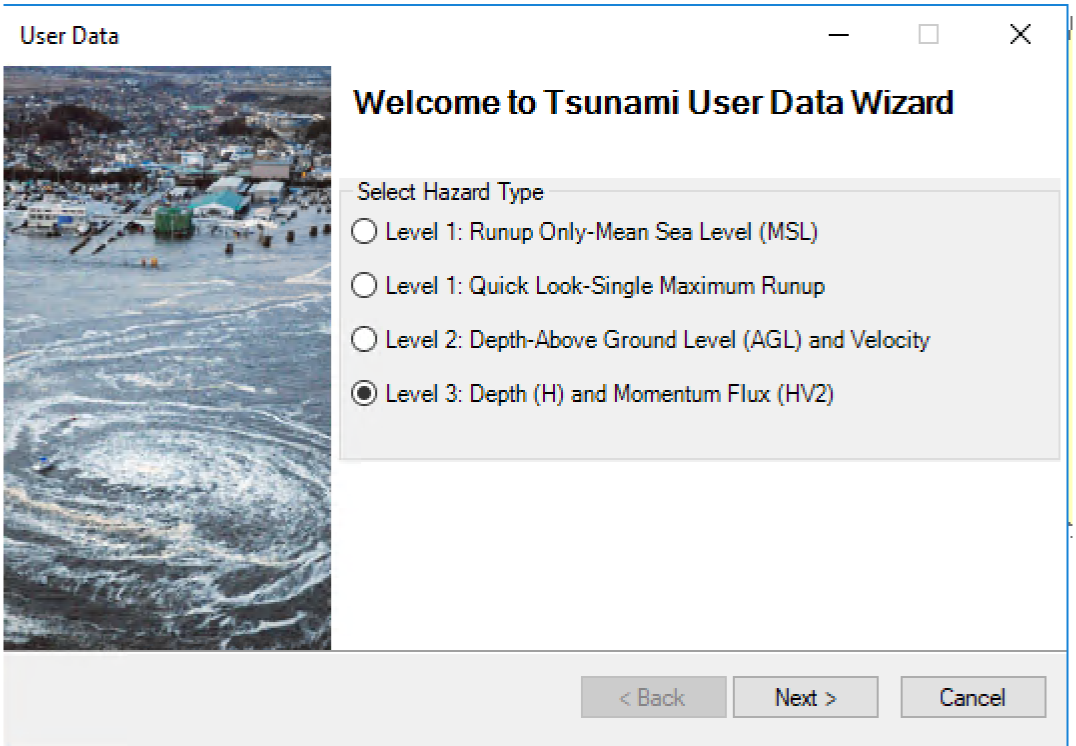
Map the results of the Direct Economic Loss for the Residential occupancy class by Total Loss for By General Occupancy. Name the output layer Level2.



	Output Loss(thous. $)	Total Loss(thous. $)
1	19.663	308.359
2	16.791	156.674
3	10.860	101.264
4	0.449	1.028
5	0.257	20.667
6	0.483	4.581
7	50.354	274.195
8	0.097	0.254
9	191.655	967.607
10	27.799	155.315
11	715.303	1,112.760
12	27.361	176.066
13	915.954	2,076.544
14	55.599	482.019

Task 5: Create the Level 3 Scenario

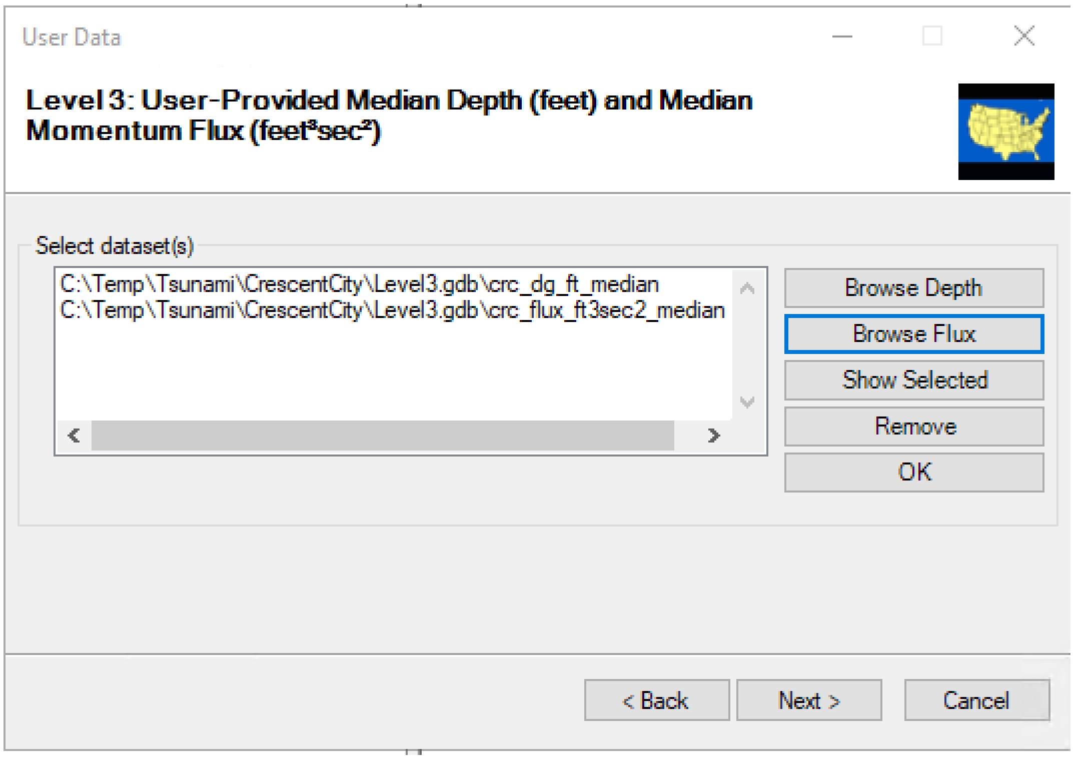
Select Hazard and then select User Data. The Tsunami User Data Wizard will appear. Select Level 3 and click Next.



The Level 3 User Data Wizard will appear.

Task 5: Create the Level 3 Scenario

Enter the following parameters:
Depth: C:\DMGT\Activities\Activity10_1\crc_gd_ft_median
Flux: C:\DMGT\Activities\Activity10_1\crc_flux_ft3sec_median
When complete, the wizard should resemble something like the screenshot below.



Click OK. The processing may take a few moments. When the processing is complete click Next.

Name the Tsunami Scenario Level3.

Click Next.

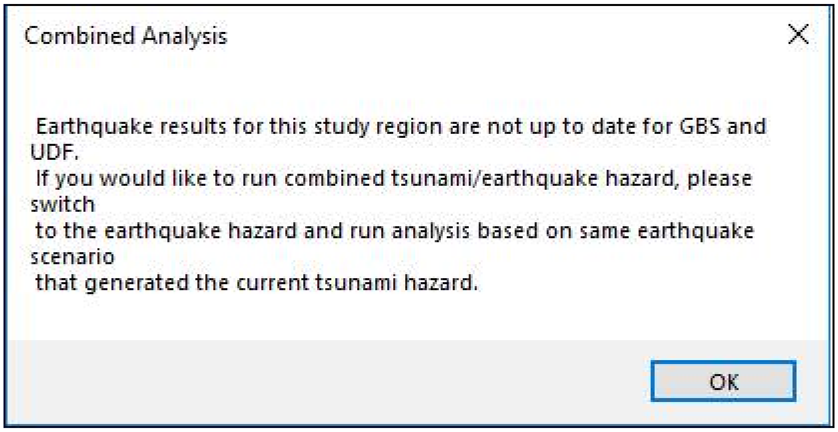
The processing may take a minute or so.

Click Ok when the processing is complete.

Task 6: Run the Analysis on the Level 3 Scenario

Select Hazard and then select User Data. The Tsunami User Data Wizard will appear.

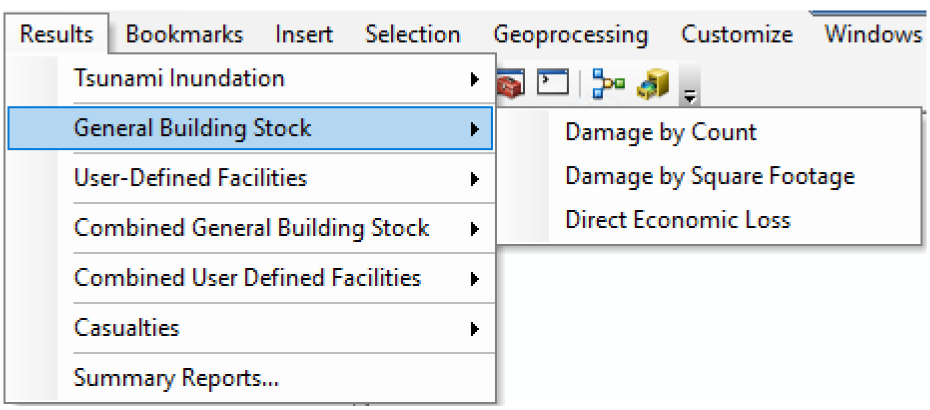
Select Level 3 and click Next.



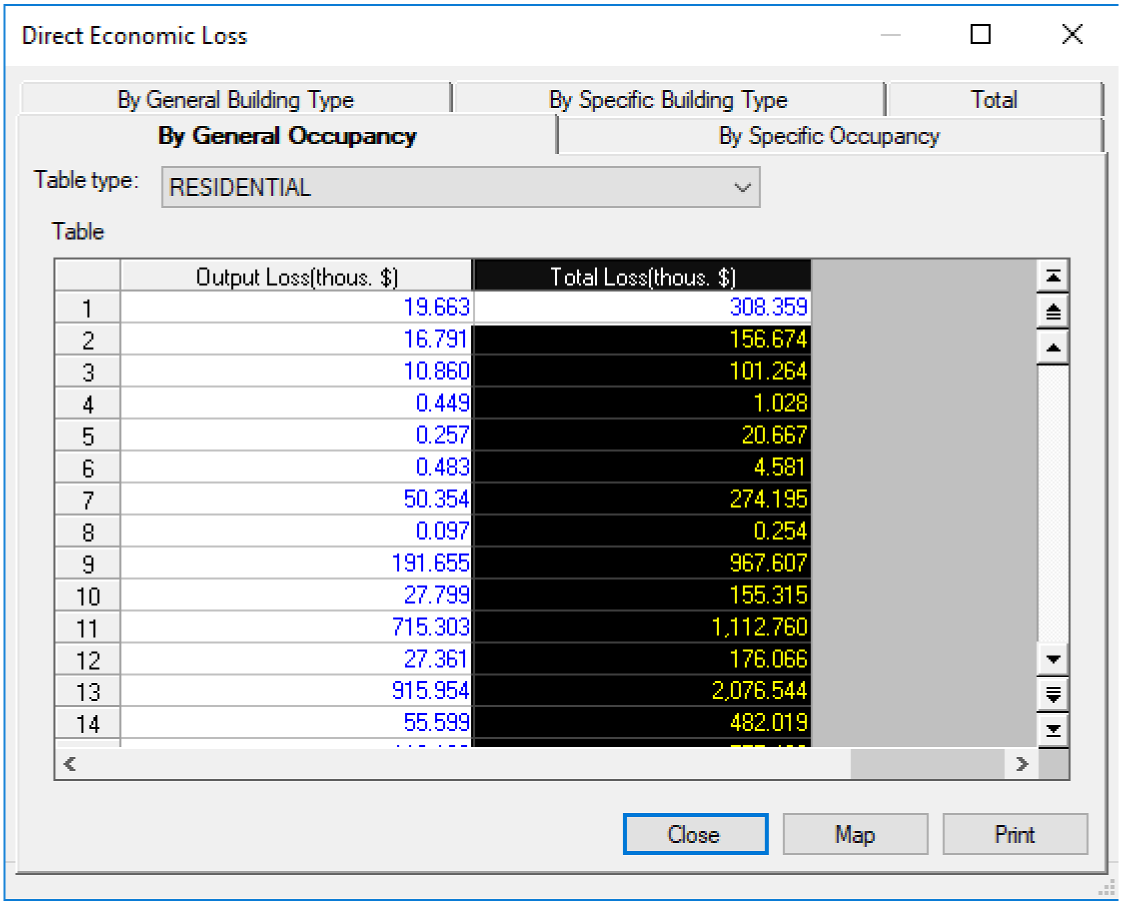
Select General Building Stock in the Analysis Options – Tsunami window and click OK. The Analysis processing should take about a minute to complete.

Task 7: View the Analysis results

Select Results, General Building Stock (GBS) and then Direct Economic Losses.



Map the results of the Direct Economic Loss for the Residential occupancy class by Total Loss for By General Occupancy.



	Output Loss(thous. $)	Total Loss(thous. $)
1	19.663	308.359
2	16.791	156.674
3	10.860	101.264
4	0.449	1.028
5	0.257	20.667
6	0.483	4.581
7	50.354	274.195
8	0.097	0.254
9	191.655	967.607
10	27.799	155.315
11	715.303	1,112.760
12	27.361	176.066
13	915.954	2,076.544
14	55.599	482.019

The Instructor will lead a discussion about the differences between each scenario and how they impact the results.

Activity 10.2 – Change Casualty Analysis Parameters

Type: Student Activity

Time: 30 minutes

Background

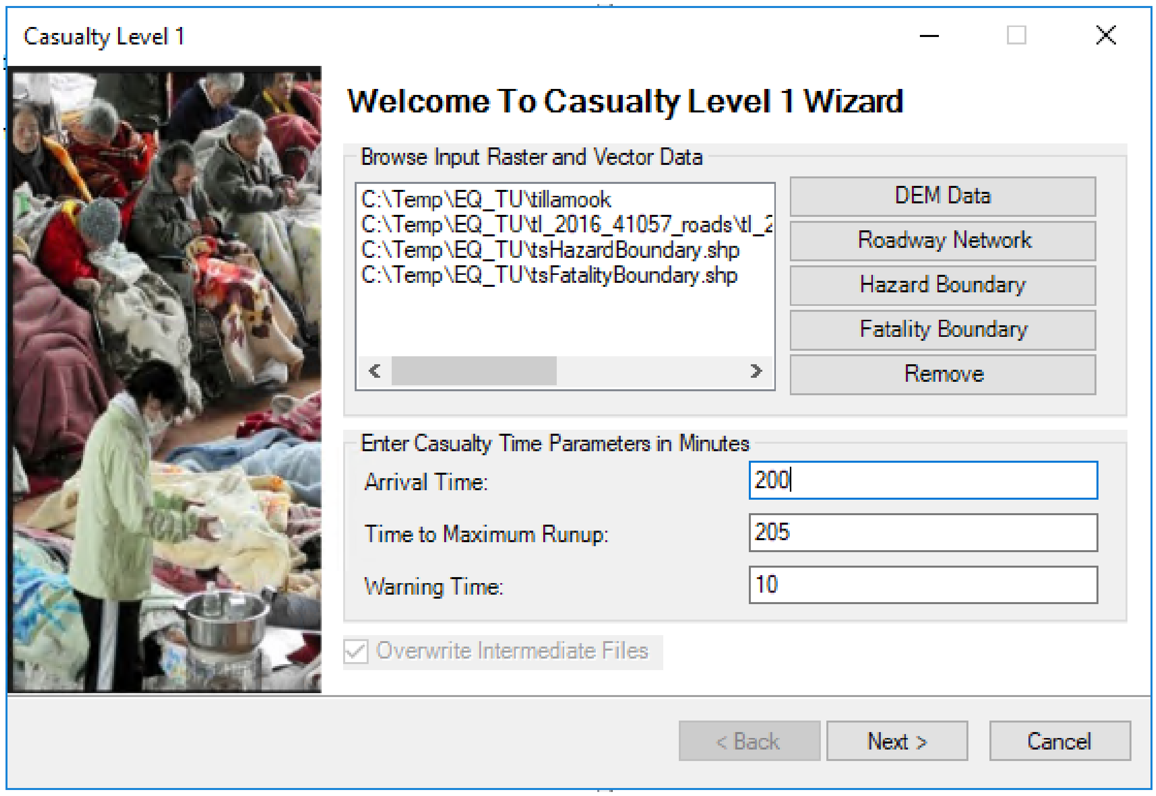
The purpose of this activity is to change the Casualty Analysis parameters to see how they impact the Casualty results. The parameter that will be adjusted is Cprep, which measures the level of community tsunami preparedness. Cprep is a multiplier that measures the median community response/reaction time to the tsunami warning. How quickly a community reacts has a significant impact on casualty results.

Task 1: Open Hazus, import a .hpr file

Open Hazus and import the Activity 10.2.hpr from the Activity 10_2 folder. Give the study region a name and, when the import is complete, open the new region. Select Tsunami hazard.

Task 2: Run the Casualty Analysis

Next, select Analysis|Casualty|Casualty Level 1



All data is located the student data folder for Activity 10.2.

DEM Data: tillamook

Roadway Network: t_2016_41057_roads.shp

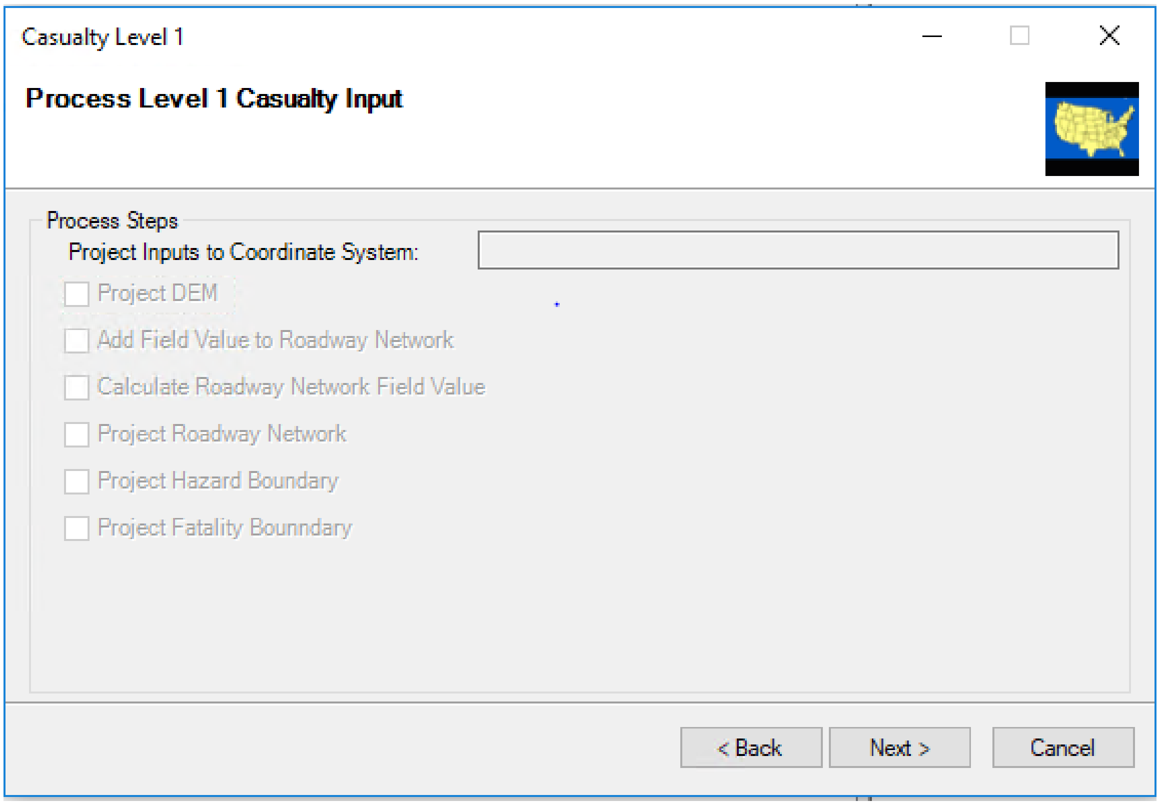
Hazard Boundary: tsHazardBoundary.shp

Fatality Boundary: tsFatalityBoundary.shp

Arrival Time: 200

The remaining parameters will be auto-populated based on the Arrival Time value.

Click Next.

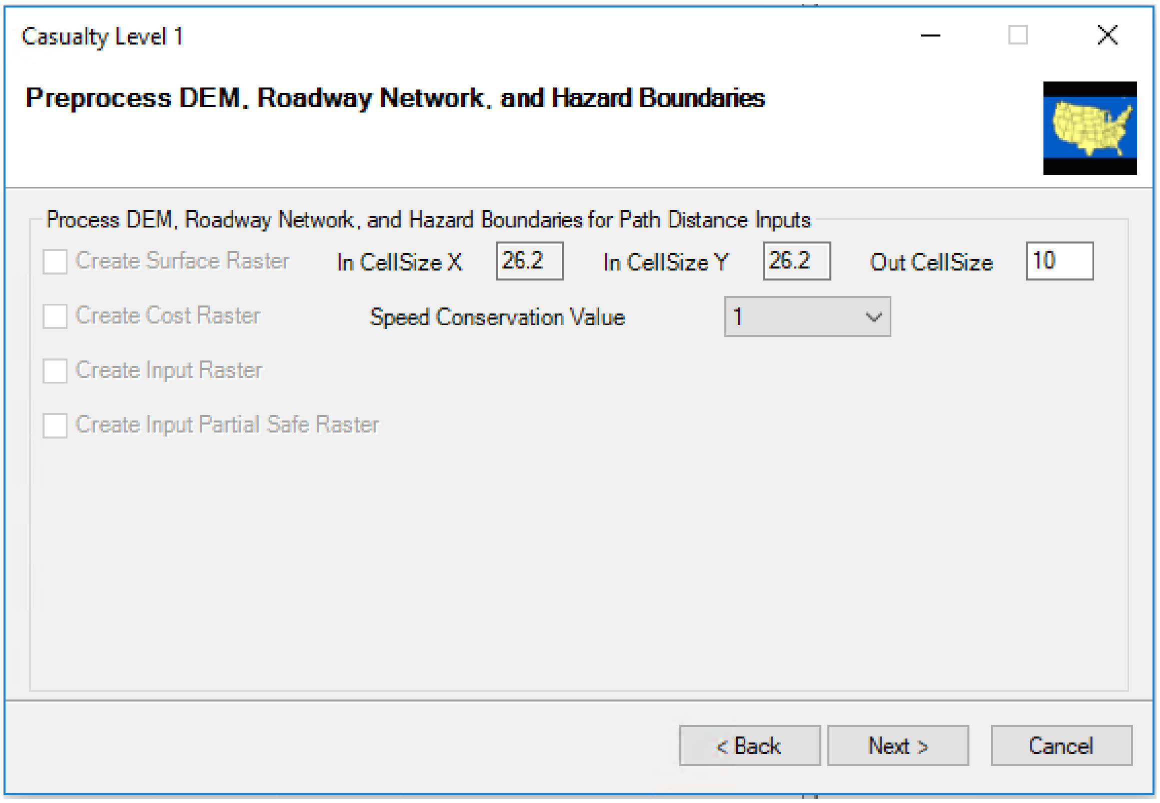


Click Next.

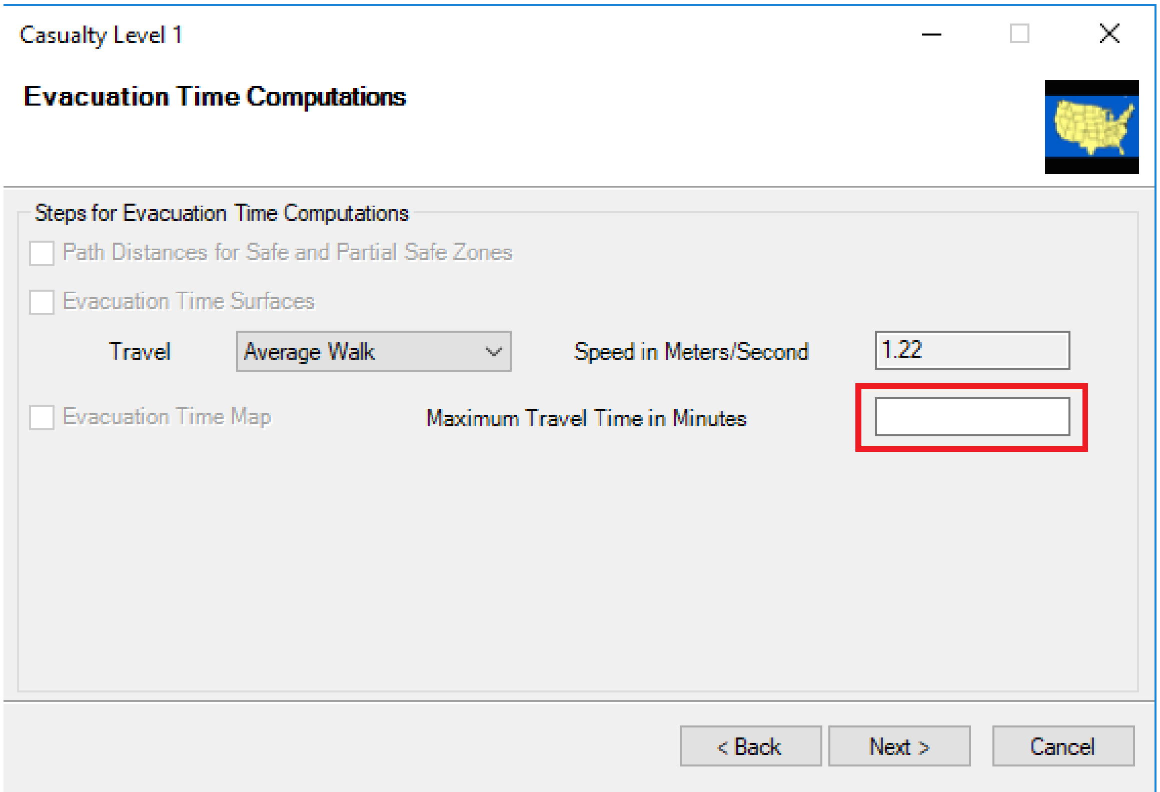
The processing may take a few moments.

Click Next.

The processing may take a few moments

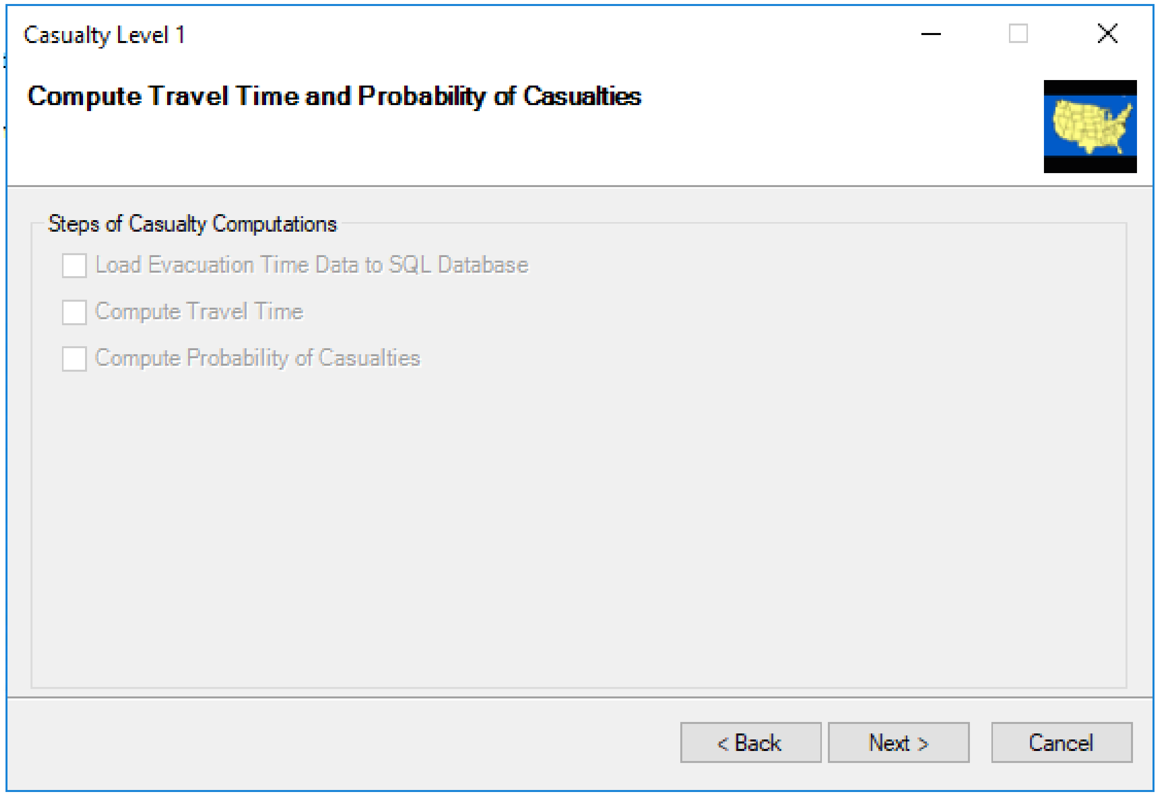


Maximum Travel Time in Minutes: **60**



Click Next.

The processing may take a few moments.



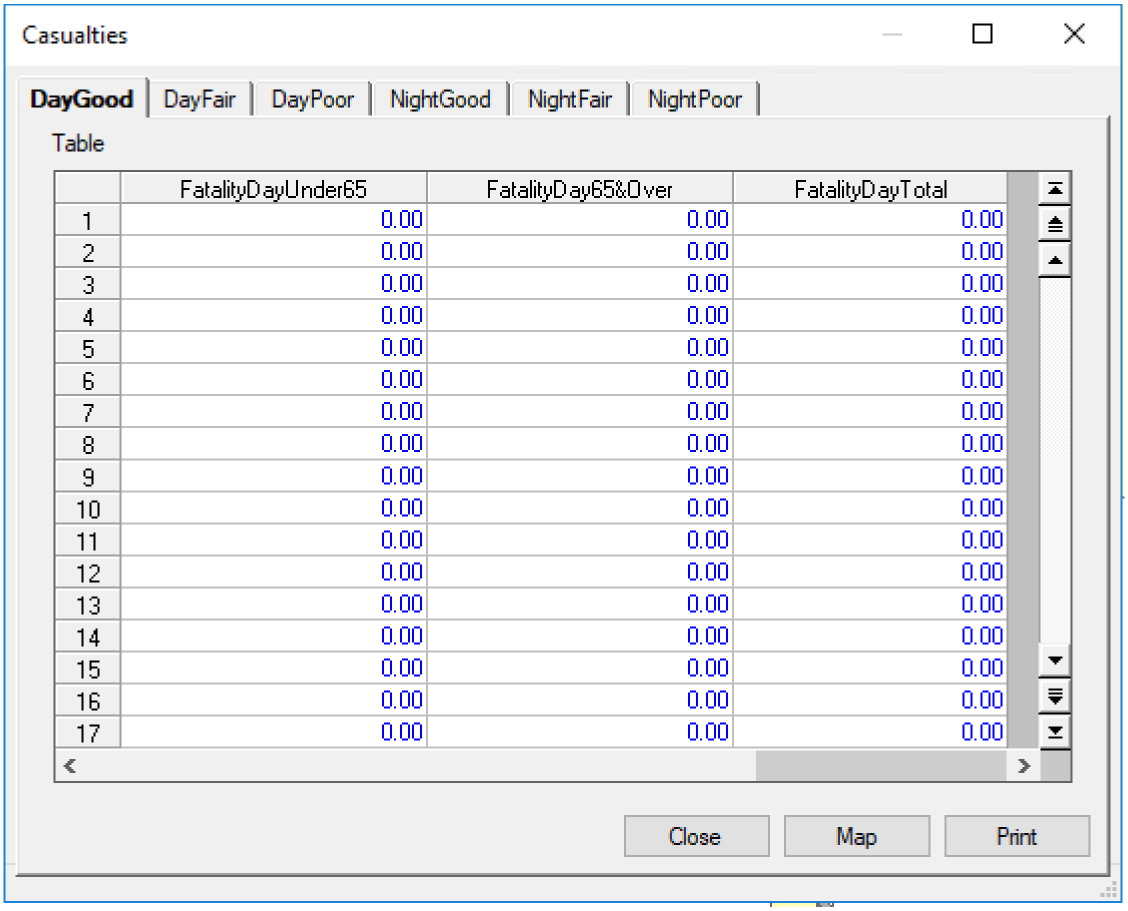
Click Next on the Compute Travel Time and Probability of Casualties window.

Click OK when the processing is complete.

Task 3: View the Casualty Analysis Results

Select Results|Casualties|Probability of Casualties

Scroll to the right on the Casualties results and observe the FatalityDayTotal column values.



Select the FatalityDayTotal column and click Map to add the layer to ArcMap and keep it there for the Task 5.

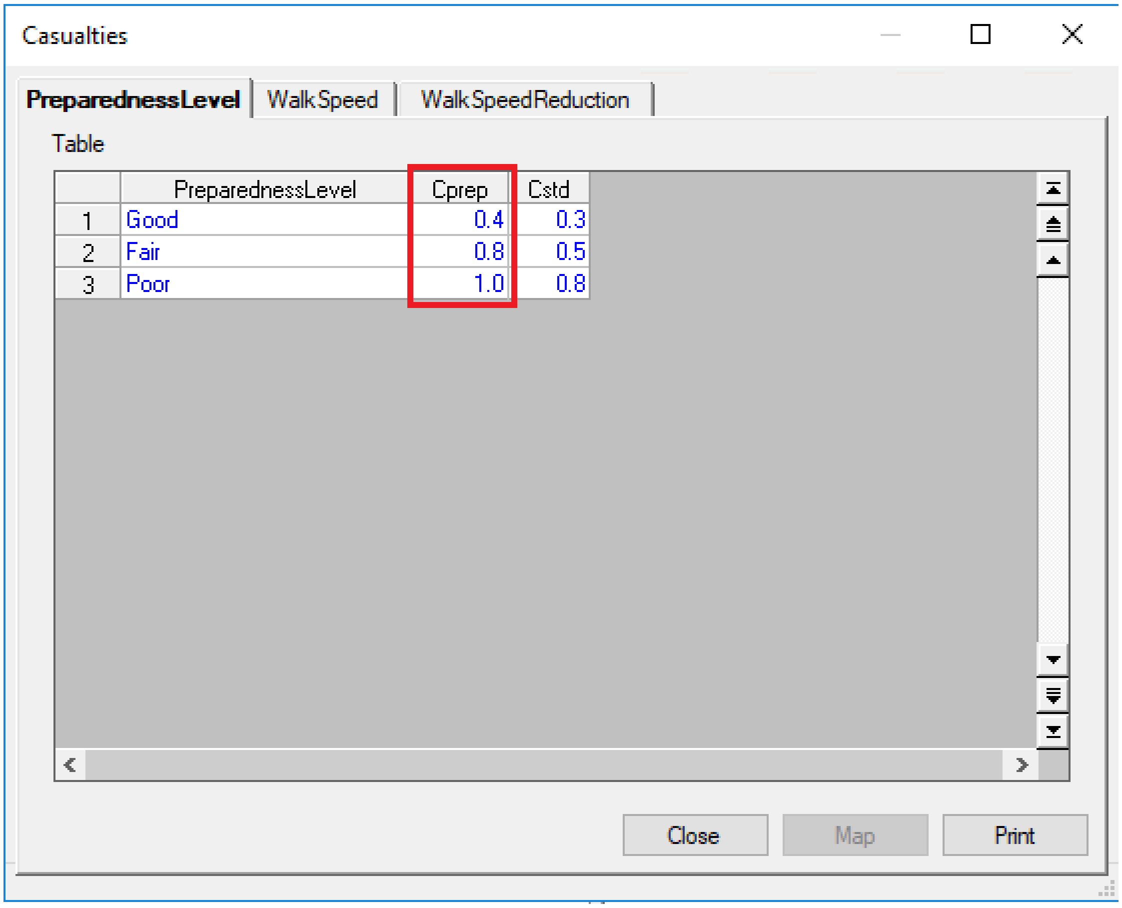
Click Close.

Task 4: Modify the Cprep Parameter and Run the Casualty Analysis again.

Select Analysis|Parameters|Casualties.

The Casualties parameters window will appear. Right click the window and select Start Editing.

Change the default value to match the ones in the screenshot below.



When complete right click and select Stop Editing.

Click Close and click yes to save edits if prompted.

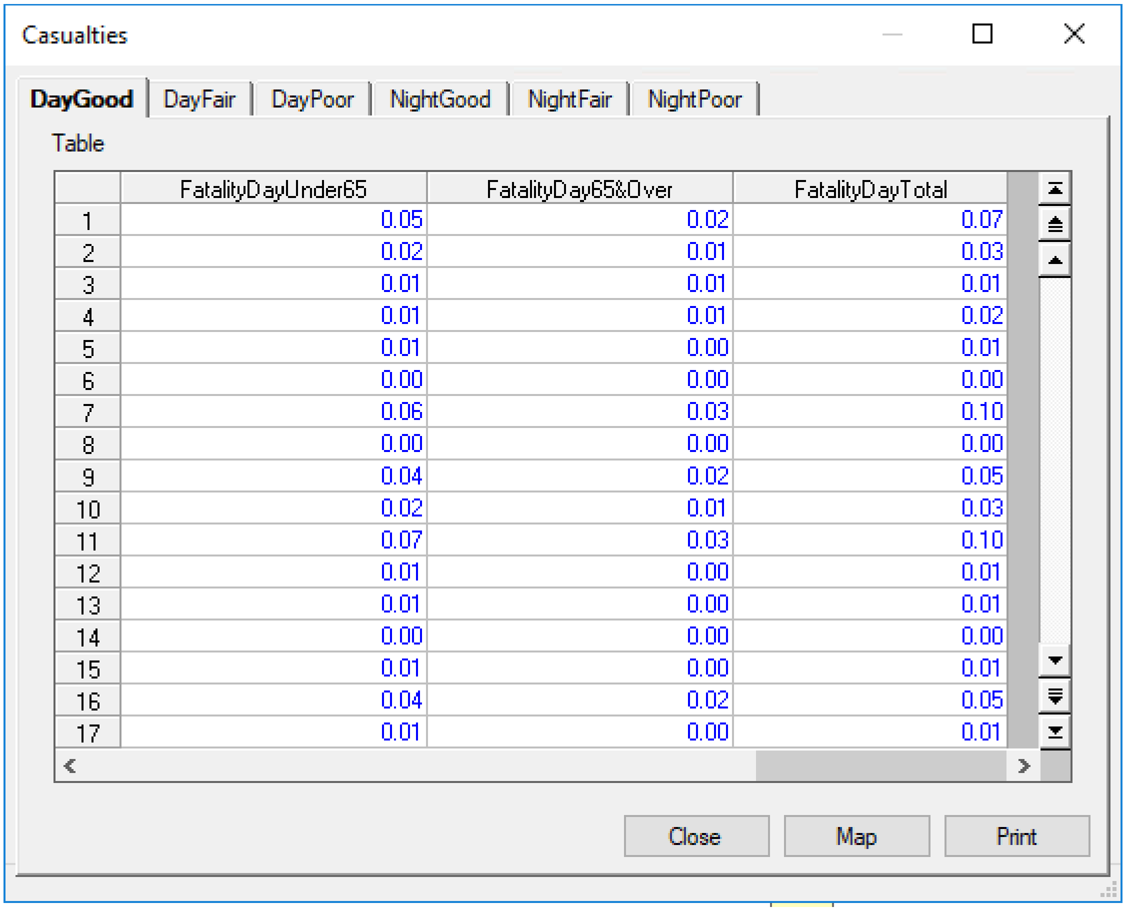
Run the Level 1 Casualty Analysis again using the steps in Task 2 if needed.

Task 5: View the Modified Parameter Analysis Results

Select **Results|Casualties|Probability of Casualties**

Scroll to the right of the results window and view the values in the FatalityDayTotal column. Compare that to the values to the original parameter values.

Select the FatalityDayTotal and click Map to add the layer to ArcMap. Compare the results to the layer created in Task 3.



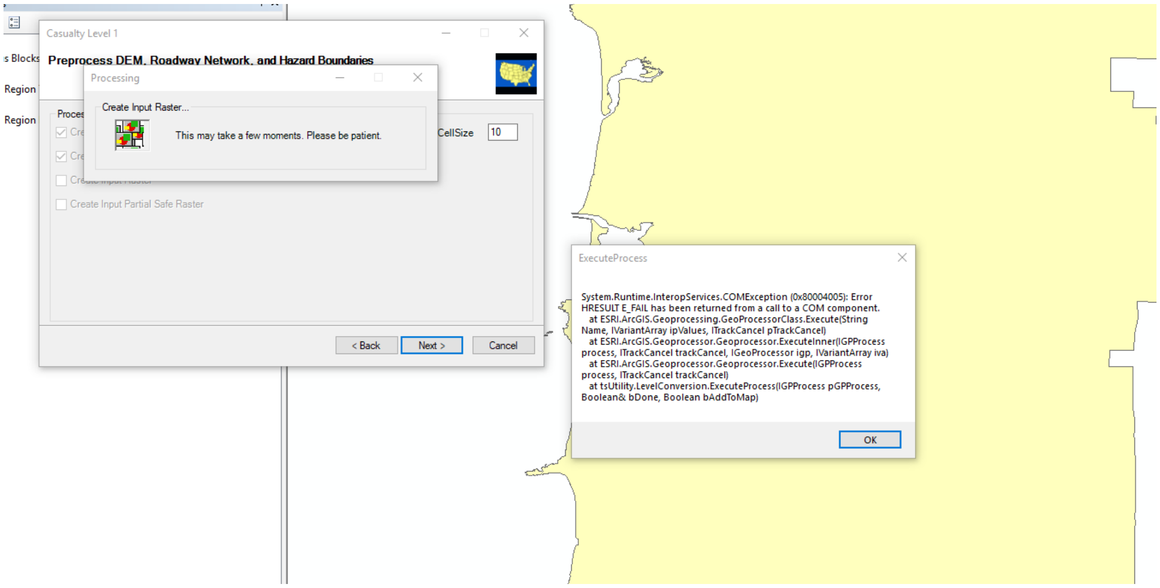
	FatalityDayUnder65	FatalityDay65&Over	FatalityDayTotal
1	0.05	0.02	0.07
2	0.02	0.01	0.03
3	0.01	0.01	0.01
4	0.01	0.01	0.02
5	0.01	0.00	0.01
6	0.00	0.00	0.00
7	0.06	0.03	0.10
8	0.00	0.00	0.00
9	0.04	0.02	0.05
10	0.02	0.01	0.03
11	0.07	0.03	0.10
12	0.01	0.00	0.01
13	0.01	0.00	0.01
14	0.00	0.00	0.00
15	0.01	0.00	0.01
16	0.04	0.02	0.05
17	0.01	0.00	0.01

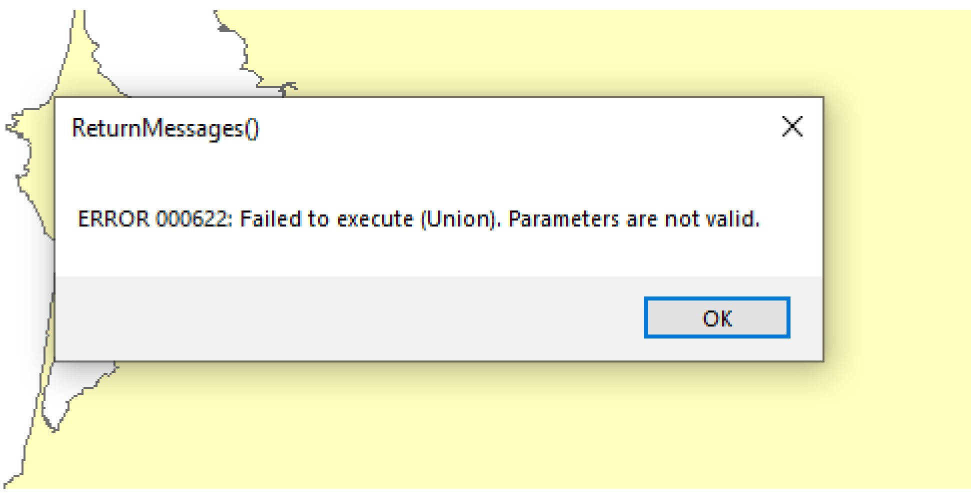
Notice that in the Task 5 results the values for most of the rows will no longer be 0 and are different than those in Task 4.. This is because the Cprep (Preparedness Level) Casualty Analysis parameter was modified in Task 4.

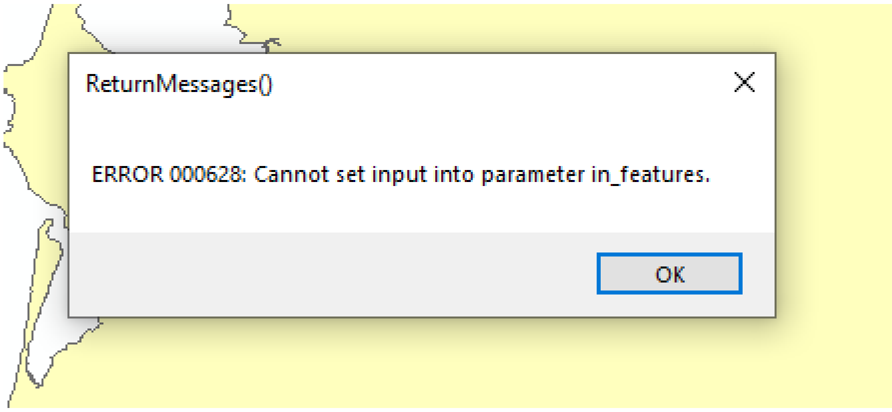
Review

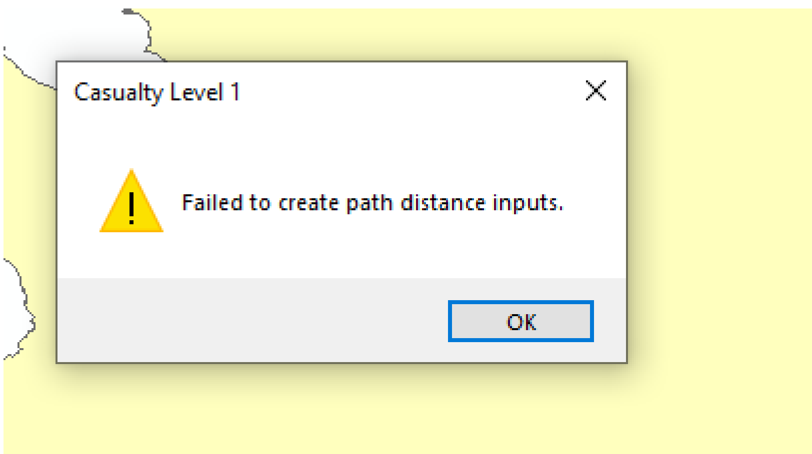
1. Which set of results had more casualties?

2. What is the reason that one set of casualties is higher than the other?


Casualty Level 1
Preprocess DEM, Roadway Network, and Hazard Boundaries
Processing
Create Input Raster...
This may take a few moments. Please be patient.
CellSize
10
Create Input Partial Safe Raster
< Back
Next >
Cancel
ExecuteProcess
System.Runtime.InteropServices.COMException (0x80004005): Error HRESULT E_FAIL has been returned from a call to a COM component.
at ESRI.ArcGIS.Geoprocessing.GeoProcessorClass.Execute(String Name, IVariantArray ipValues, ITrackCancel pTrackCancel)
at ESRI.ArcGIS.Geoprocessor.Geoprocessor.ExecuteInner(IGPProcess process, ITrackCancel trackCancel, IGeoProcessor igp, IVariantArray iva)
at ESRI.ArcGIS.Geoprocessor.Geoprocessor.Execute(IGPProcess process, ITrackCancel trackCancel)
at tsUtility.LevelConversion.ExecuteProcess(IGPProcess pGPProcess, Boolean& bDone, Boolean bAddToMap)
OK


ReturnMessages()
ERROR 000622: Failed to execute (Union). Parameters are not valid.
OK


ReturnMessages()
ERROR 000628: Cannot set input into parameter in_features.
OK


Casualty Level 1
Failed to create path distance inputs.
OK

Activity 10.3 – Create a Combined Earthquake and Tsunami Activity

Type: Student Activity

Time: 45 minutes

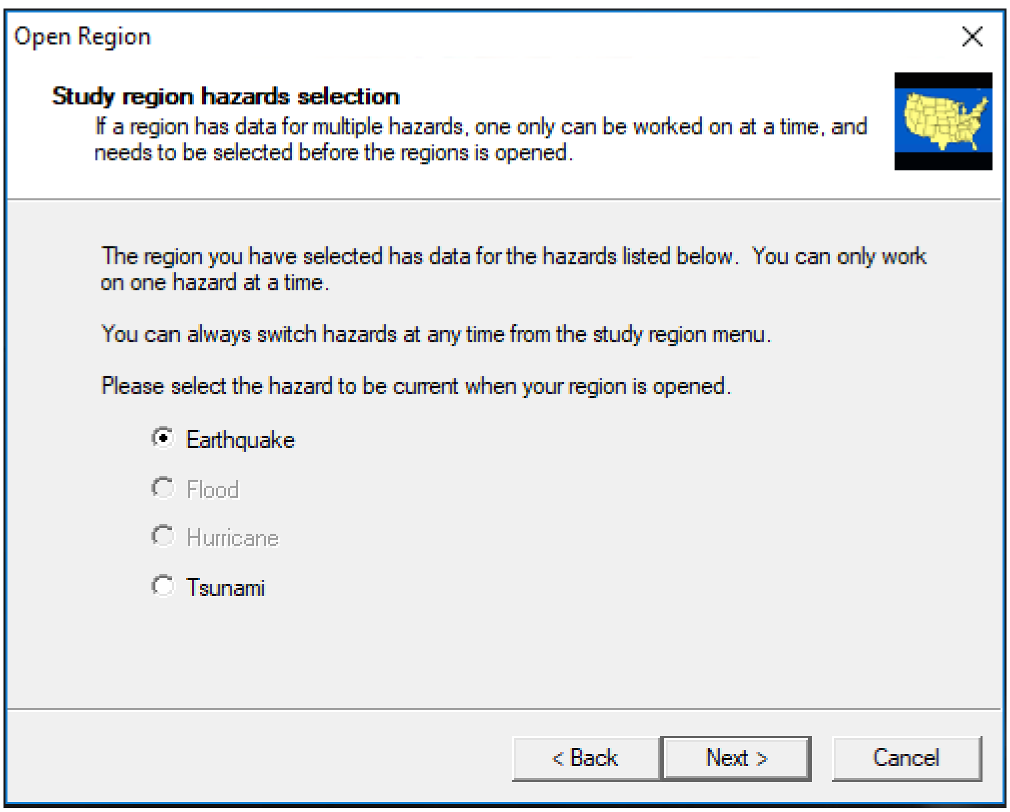
Background

In this activity, students will practice creating a combined earthquake and tsunami scenario.

Task 1: Open Hazus and import a .hpr file

Open Hazus and import the Activity 10.3.hpr from Activity 10.3 folder. Give the study region a name and when the import is complete open the new region.

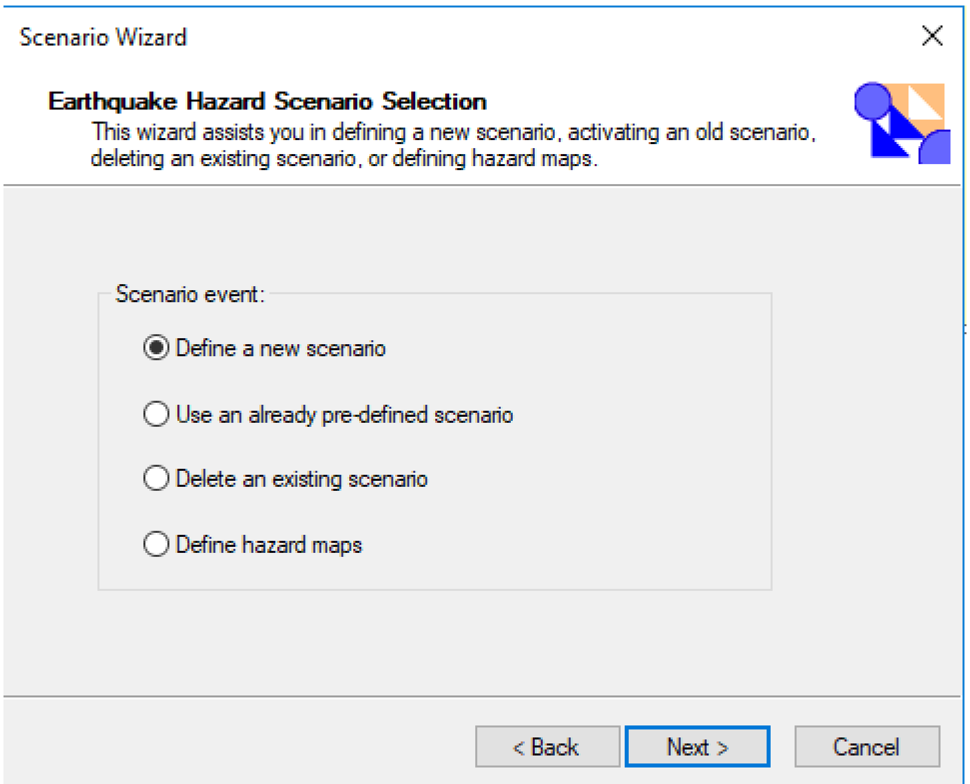
Select the Earthquake hazard from the Study region hazard selection window and click Next.



Click Finish. It may take a moment for the region to open completely.

Task 2: Create Earthquake Scenario from a ShakeMap

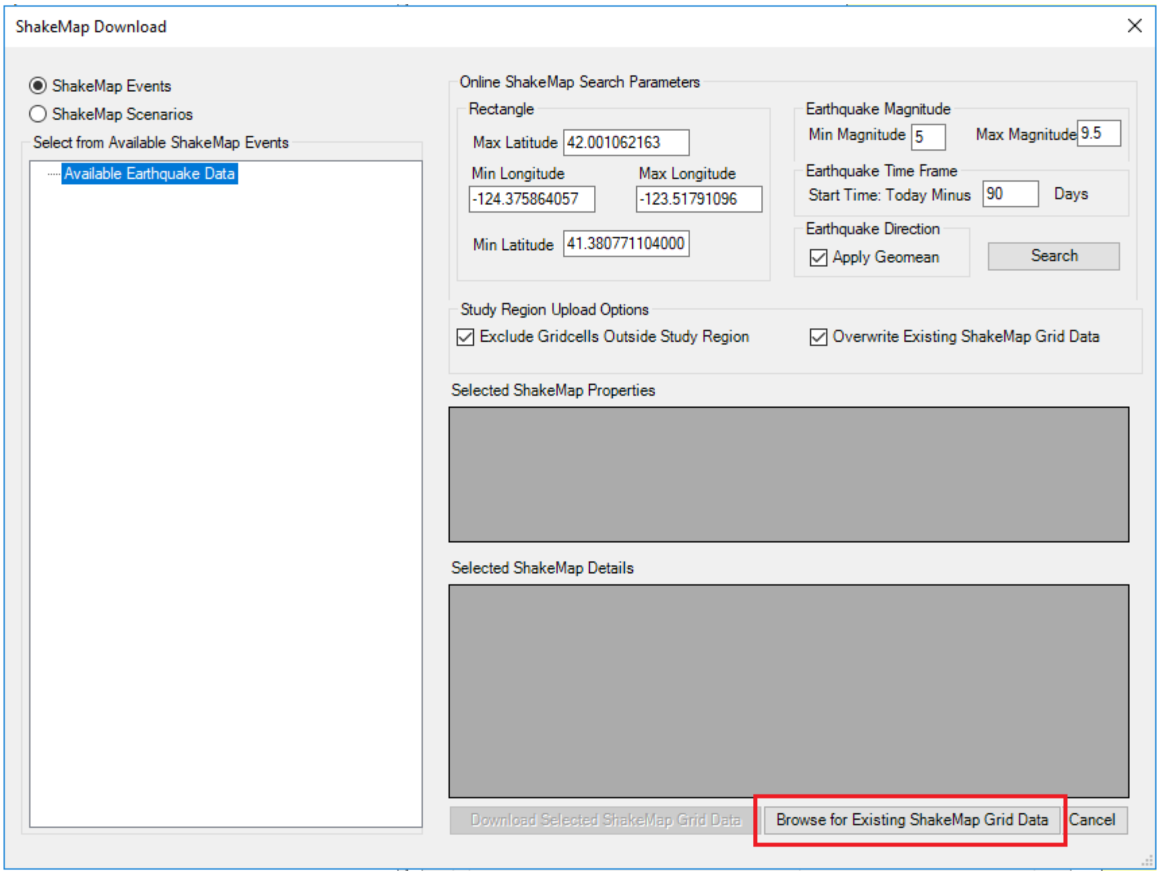
Select Hazard and then Scenario.
Select Define a new scenario from the wizard.



Select USGS ShakeMap from the next wizard that appears and click Next.

Task 2: Create Earthquake Scenario from a ShakeMap

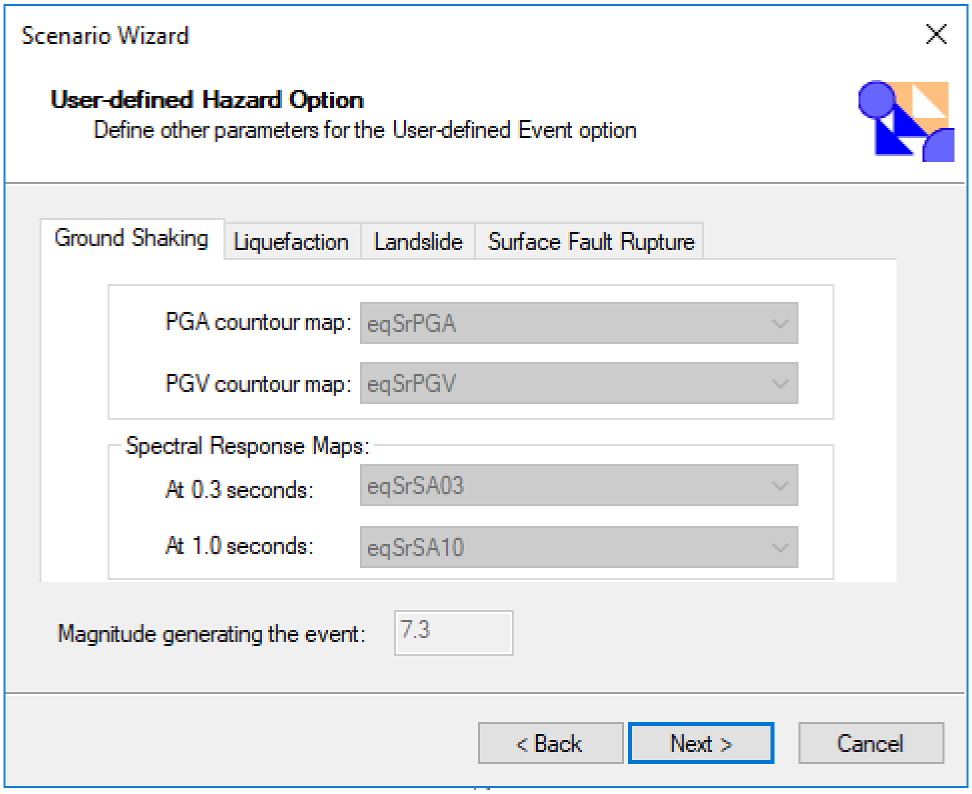
Select Browse for Exisiting Shakemap Grid Data.



Navigate to \Activity10_3 and select grid.xml. Click Open when complete.

Task 2: Create Earthquake Scenario from a ShakeMap

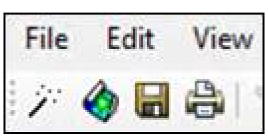
The xml grid processing may take a few moments. When complete, it will resemble the screenshot below.



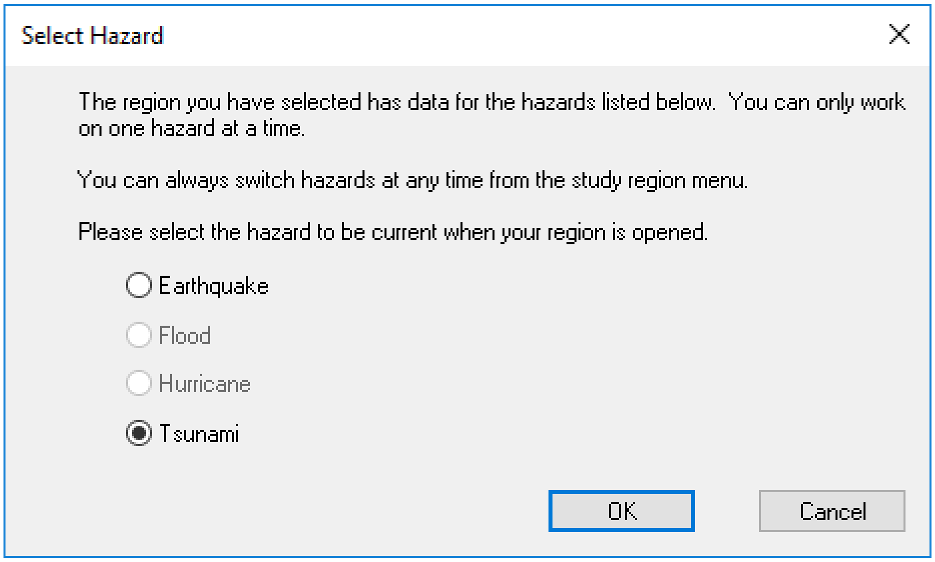
Click Next two more times and then click Finish.

Task 3: Switch to the Tsunami Hazard

To switch to the Tsunami hazard, click the Switch Hazard button located in the top left corner of ArcMap.



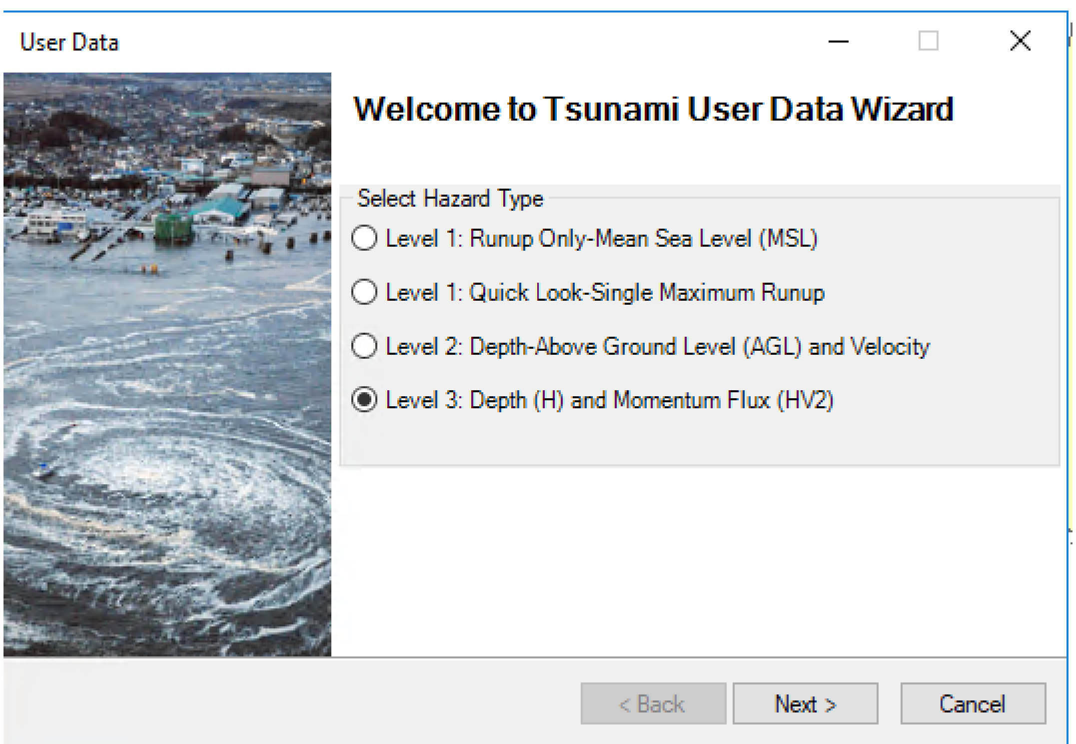
Click Tsunami in the Select Hazard window that appears and then click OK.



It may take a few minutes for Hazus to switch hazards.

Task 4: Create the Level 3 Tsunami Scenario

Select Hazard and then User Data. The Tsunami User Data Wizard will appear. Select Level 3 and click Next



The Level 3 User Data Wizard will appear.

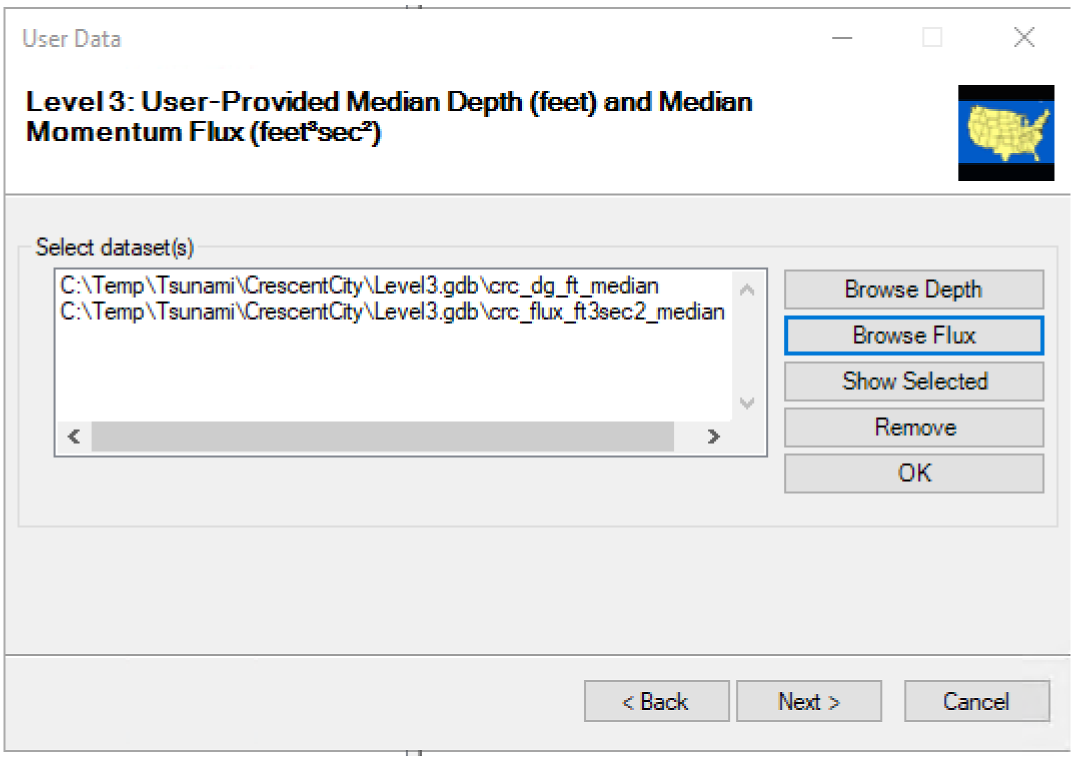
Task 4: Create the Level 3 Tsunami Scenario

Enter the following parameters:

Depth: Activity10_3\Level3.gdb\crc_gd_ft_median

Flux: Activity10_3\Level3.gdb\crc_flux_ft3sec_median

When complete the wizard should resemble something like the screenshot below.



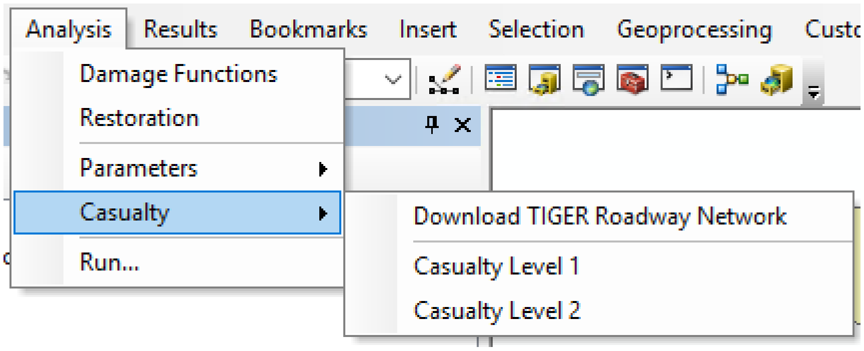
Click OK. The processing may take a few moments. When the processing is complete click Next.

Name the Tsunami Scenario Level3. Click Next

The processing may take a moment. Click OK when the processing is complete.

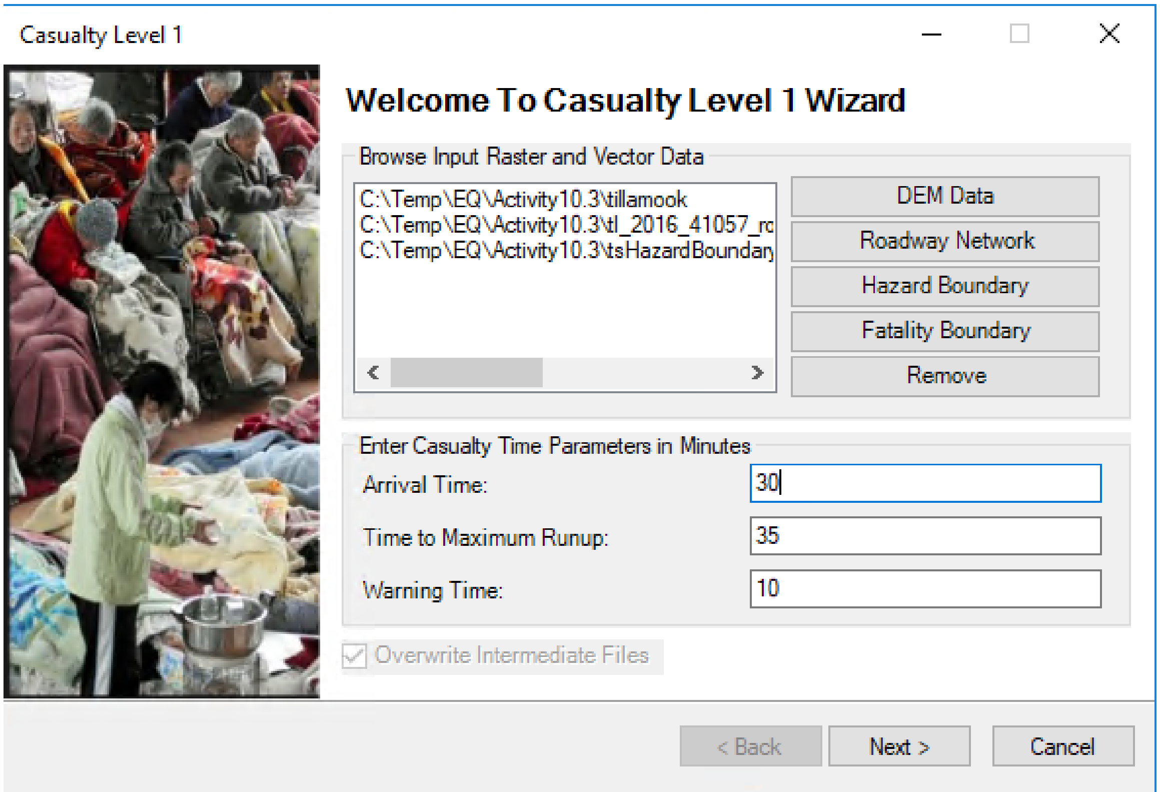
Task 5: Run a Level 1 Casualty Analysis

Select Analysis -> Casualty -> Casualty Level 1



Attribute the parameters with the following data located at C:\DMGT\Activities\Activity10.3.

- **DEM Data:** Tillamook
- **Roadway Network:** t_2016_41057.shp
- **Hazard Boundary:** tsHazardBoundary
- **Fatality Boundary:** tsFatalityBoundary
- **Arrival Time:** 30



Click Next and OK when prompted until the processing is complete. The processing will take several minutes.

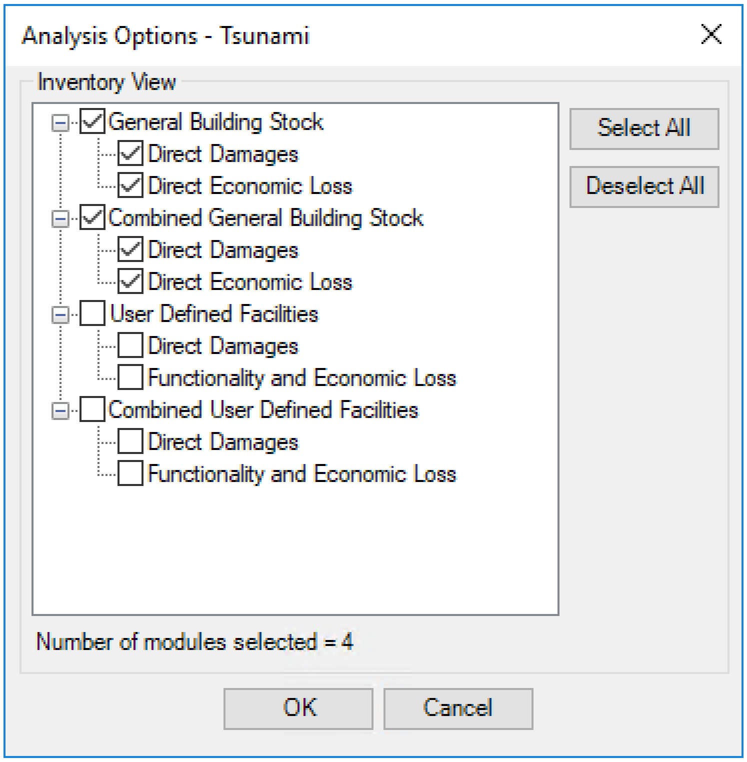
When prompted enter 30 for Maximum Travel Time in Minutes and click Next.

Click Next again when the processing is complete. Click Ok to finish the analysis.

Task 6: Run the Combined Hazard Analysis

From the Analysis menu, select Run.

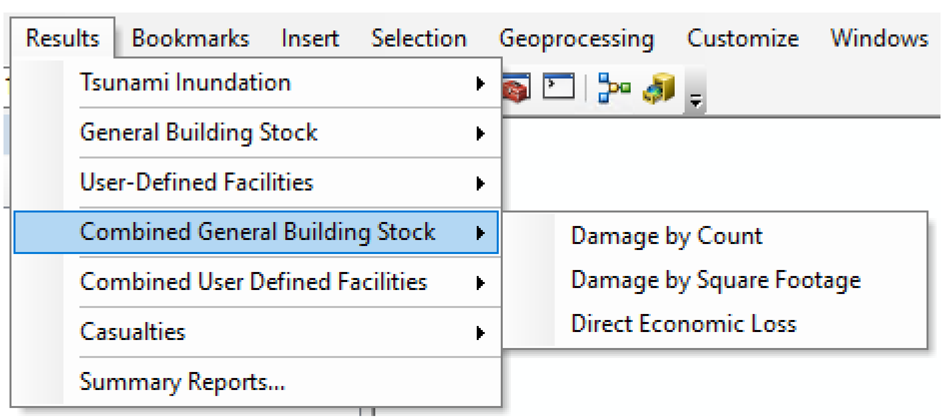
On the Analysis Options – Tsunami menu, select Combined General Building Stock which will also select the regular General Building Stock. Click OK.



The analysis may take about two minutes.

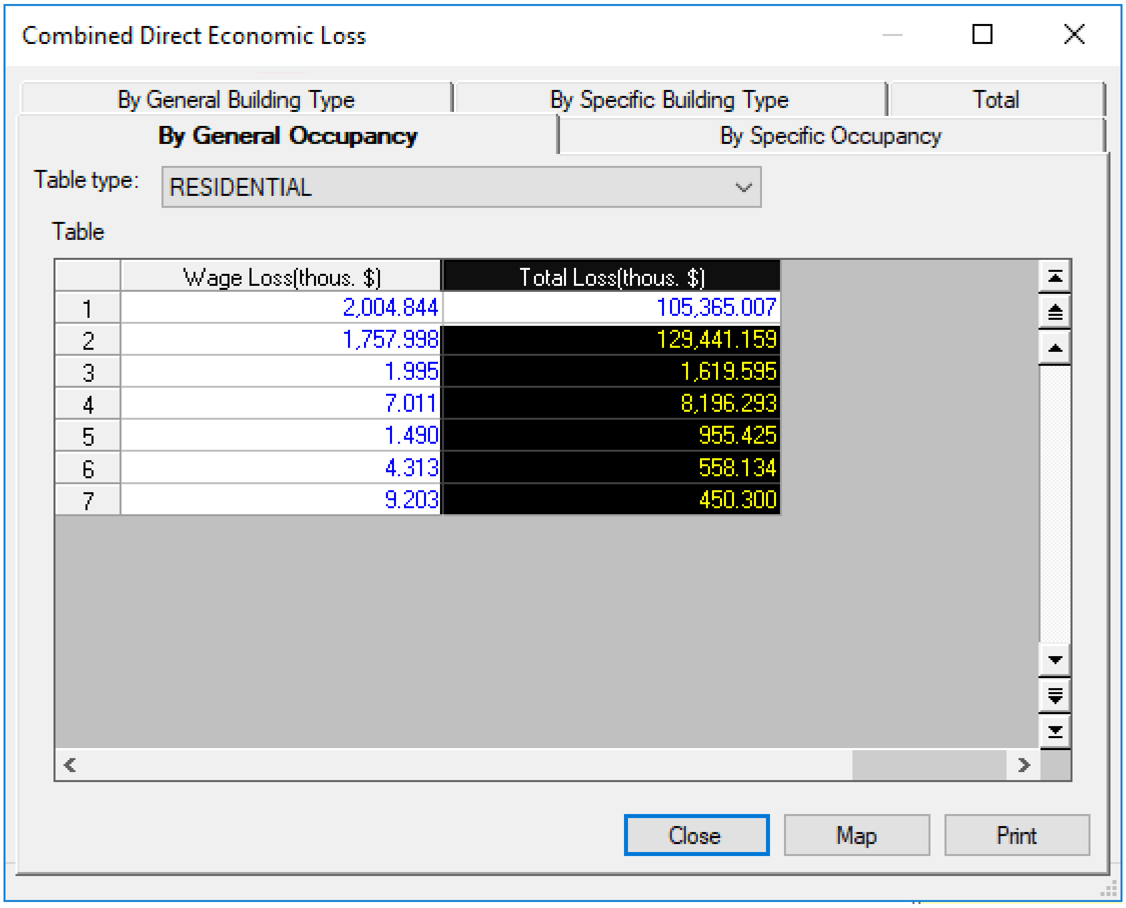
Task 7: View the Combined Analysis Results

Select Results -> Combined General Building Stock -> Direct Economic Loss.



Task 7: View the Combined Analysis Results

Map the Combined Direct Economic Loss by Total Loss.

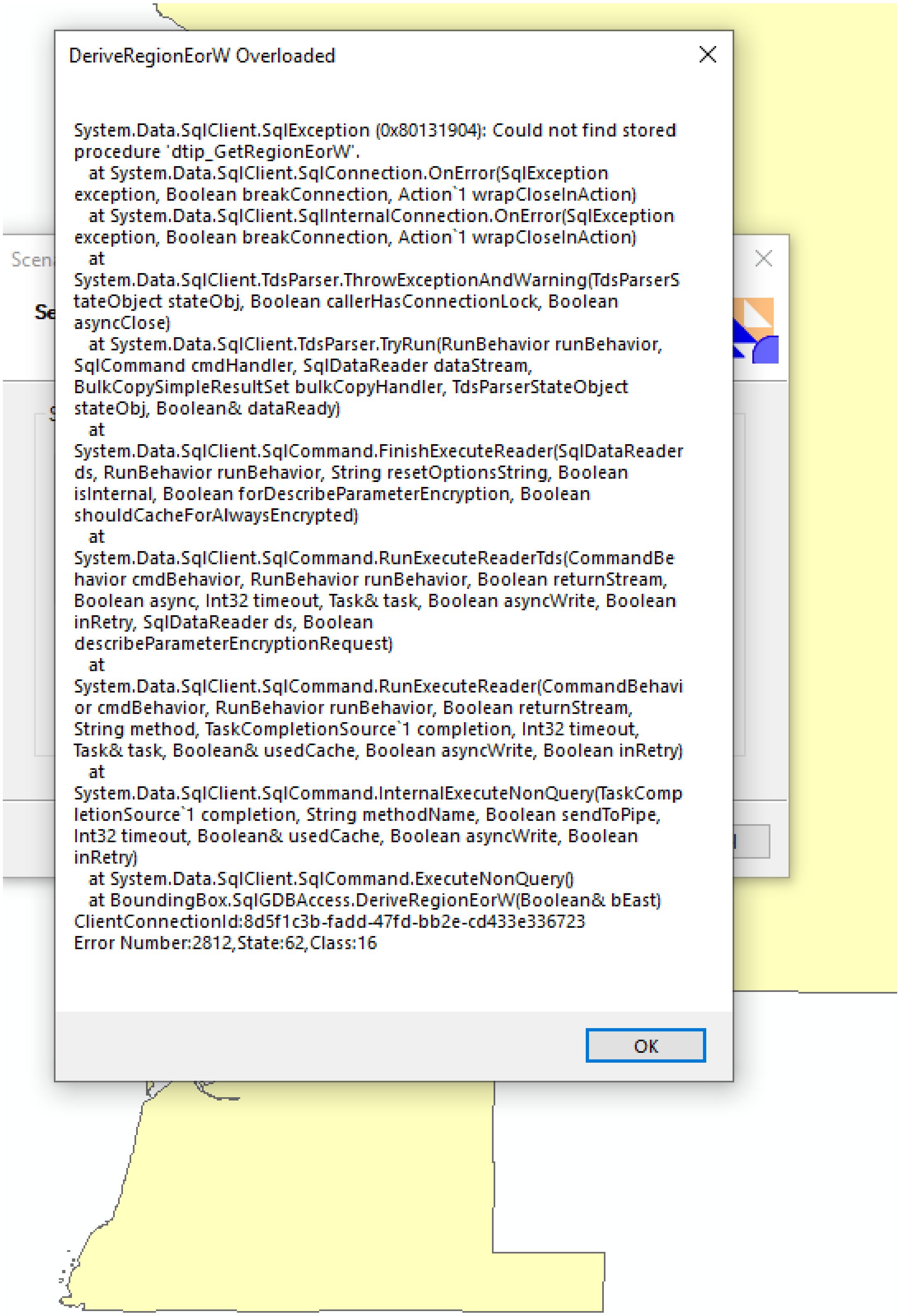


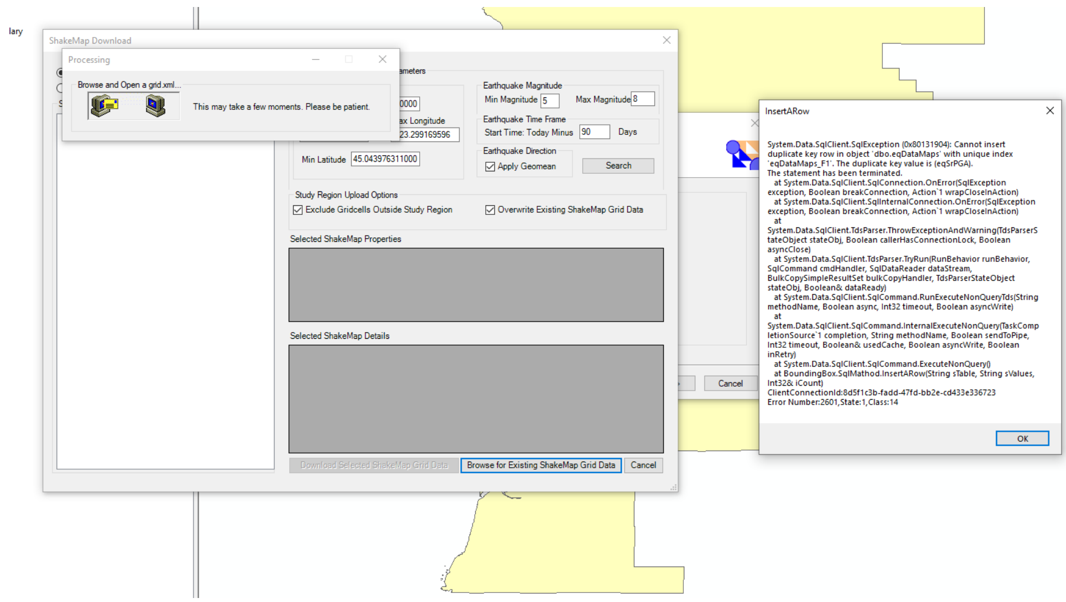
View the results in the layer that appears in ArcMap and think about what they might indicate. Have a discussion with the Instructor about hat the results might mean. Based on the above graphic what are the other possible ways in which the results can be viewed (by Occupancy, Building Type)? How can those results be useful to communities, planners and government officials?

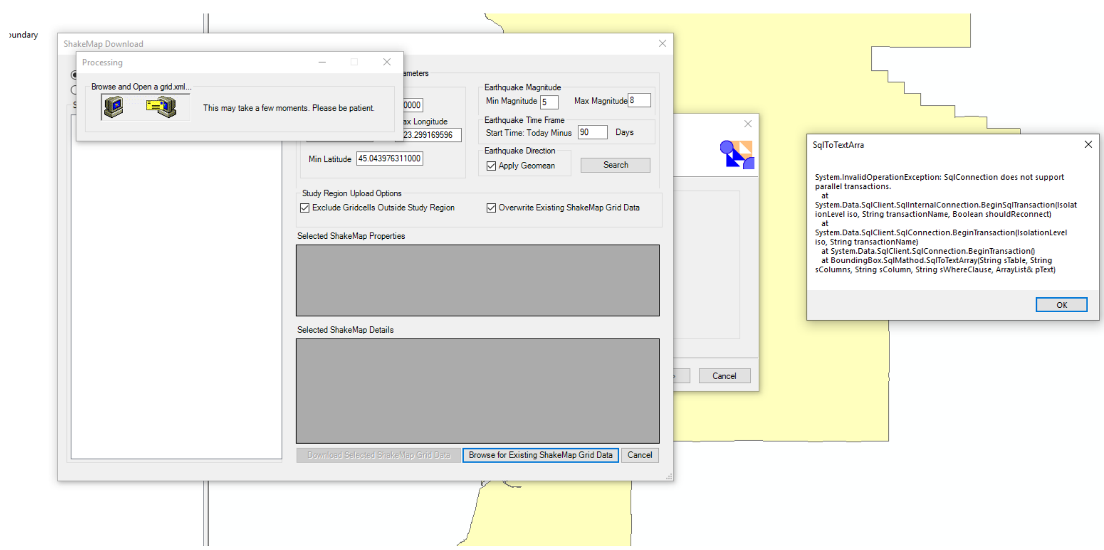
Review

In this activity you used a USGS Shakemap to create an Earthquake scenario and then ran the Analysis. You then switched to the Tsunami module and you created a Level 3

Tsunami Scenario and a Level 1 Casualty Analysis. Finally, you ran the Combined Analysis and viewed the results for the General Building Stock.


DeriveRegionEorW Overloaded
System.Data.SqlClient.SqlException (0x80131904): Could not find stored procedure 'dtip_GetRegionEorW'.
at System.Data.SqlClient.SqlConnection.OnError(SqlException exception, Boolean breakConnection, Action`1 wrapCloseInAction)
at System.Data.SqlClient.SqlInternalConnection.OnError(SqlException exception, Boolean breakConnection, Action`1 wrapCloseInAction)
at System.Data.SqlClient.TdsParser.ThrowExceptionAndWarning(TdsParserStateObject stateObj, Boolean callerHasConnectionLock, Boolean asyncClose)
at System.Data.SqlClient.TdsParser.TryRun(RunBehavior runBehavior, SqlCommand cmdHandler, SqlDataReader dataStream, BulkCopySimpleResultSet bulkCopyHandler, TdsParserStateObject stateObj, Boolean& dataReady)
at System.Data.SqlClient.SqlCommand.FinishExecuteReader(SqlDataReader ds, RunBehavior runBehavior, String resetOptionsString, Boolean isInternal, Boolean forDescribeParameterEncryption, Boolean shouldCacheForAlwaysEncrypted)
at System.Data.SqlClient.SqlCommand.RunExecuteReaderTds(CommandBehavior cmdBehavior, RunBehavior runBehavior, Boolean returnStream, Boolean async, Int32 timeout, Task& task, Boolean asyncWrite, Boolean inRetry, SqlDataReader ds, Boolean describeParameterEncryptionRequest)
at System.Data.SqlClient.SqlCommand.RunExecuteReader(CommandBehavior cmdBehavior, RunBehavior runBehavior, Boolean returnStream, String method, TaskCompletionSource`1 completion, Int32 timeout, Task& task, Boolean& usedCache, Boolean asyncWrite, Boolean inRetry)
at System.Data.SqlClient.SqlCommand.InternalExecuteNonQuery(TaskCompletionSource`1 completion, String methodName, Boolean sendToPipe, Int32 timeout, Boolean& usedCache, Boolean asyncWrite, Boolean inRetry)
at System.Data.SqlClient.SqlCommand.ExecuteNonQuery()
at BoundingBox.SqlGDBAccess.DeriveRegionEorW(Boolean& bEast)
ClientConnectionId:8d5f1c3b-fadd-47fd-bb2e-cd433e336723
Error Number:2812,State:62,Class:16
OK


ShakeMap Download
Processing
Browse and Open a grid.xml...
This may take a few moments. Please be patient.
Earthquake Magnitude
Min Magnitude 5
Max Magnitude 8
Earthquake Time Frame
Start Time: Today Minus 90 Days
Min Latitude 45.043976311000
Earthquake Direction
Apply Geomean
Search
Study Region Upload Options
Exclude Gridcells Outside Study Region
Overwrite Existing ShakeMap Grid Data
Selected ShakeMap Properties
Selected ShakeMap Details
Download Selected ShakeMap Grid Data
Browse for Existing ShakeMap Grid Data
Cancel
InsertARow
System.Data.SqlClient.SqlException (0x80131904): Cannot insert duplicate key row in object 'dbo.eqDataMaps' with unique index 'eqDataMaps_F1'. The duplicate key value is (eqSrPGA).
The statement has been terminated.
at System.Data.SqlClient.SqlConnection.OnError(SqlException exception, Boolean breakConnection, Action`1 wrapCloseInAction)
at System.Data.SqlClient.SqlInternalConnection.OnError(SqlException exception, Boolean breakConnection, Action`1 wrapCloseInAction)
at System.Data.SqlClient.TdsParser.ThrowExceptionAndWarning(TdsParserStateObject stateObj, Boolean callerHasConnectionLock, Boolean asyncClose)
at System.Data.SqlClient.TdsParser.TryRun(RunBehavior runBehavior, SqlCommand cmdHandler, SqlDataReader dataStream, BulkCopySimpleResultSet bulkCopyHandler, TdsParserStateObject stateObj, Boolean& dataReady)
at System.Data.SqlClient.SqlCommand.RunExecuteNonQueryTds(String methodName, Boolean async, Int32 timeout, Boolean asyncWrite)
at System.Data.SqlClient.SqlCommand.InternalExecuteNonQuery(TaskCompletionSource`1 completion, String methodName, Boolean sendToPipe, Int32 timeout, Boolean& usedCache, Boolean asyncWrite, Boolean inRetry)
at System.Data.SqlClient.SqlCommand.ExecuteNonQuery()
at BoundingBox.SqlMathod.InsertARow(String sTable, String sValues, Int32& iCount)
ClientConnectionId:8d5f1c3b-fadd-47fd-bb2e-cd433e336723
Error Number:2601,State:1,Class:14
OK


ShakeMap Download
Processing
Browse and Open a grid.xml...
This may take a few moments. Please be patient.
Earthquake Magnitude
Min Magnitude 5
Max Magnitude 8
Earthquake Time Frame
Start Time: Today Minus 90 Days
Min Latitude 45.043976311000
Earthquake Direction
Apply Geomean
Search
Study Region Upload Options
Exclude Gridcells Outside Study Region
Overwrite Existing ShakeMap Grid Data
Selected ShakeMap Properties
Selected ShakeMap Details
Download Selected ShakeMap Grid Data
Browse for Existing ShakeMap Grid Data
Cancel
SqlToTextArra
System.InvalidOperationException: SqlConnection does not support parallel transactions.
at System.Data.SqlClient.SqlInternalConnection.BeginSqlTransaction(IsolationLevel iso, String transactionName, Boolean shouldReconnect)
at System.Data.SqlClient.SqlConnection.BeginTransaction(IsolationLevel iso, String transactionName)
at System.Data.SqlClient.SqlConnection.BeginTransaction()
at BoundingBox.SqlMathod.SqlToTextArray(String sTable, String sColumns, String sColumn, String sWhereClause, ArrayList& pText)
OK

Appendix: Activity Data Zip File

Activity Data