E0177: Advanced Hazus Applications

Student Manual

Date Released: 03/2020

FEMA

Contents

Lesson 1: Introductions and Overview

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 activity data packaged with the course.

Type	Number	Description	Data Needed	Data Provided?
Exercise	2.1			Yes
Exercise	3.1			Yes
Exercise	4.1			Yes
Exercise	5.1			Yes
Exercise	6.1			Yes
Exercise	7.1			Yes
Exercise	8.1			Yes
Exercise	9.1			Yes
Exercise	10.1			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 provided with the course.

Type	Number	Data File(s) Provided	Folder Location
Exercise	2.1		
Exercise	3.1		
Exercise	4.1		

Type	Number	Data File(s) Provided	Folder Location
Exercise	5.1		
Exercise	6.1		
Exercise	7.1		
Exercise	8.1		
Exercise	9.1		
Exercise	10.1		

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.

A Note on Results

Please note that this course has been designed and created using Hazus 4.2 SP3 and the state datasets accompanying that release. Any images, results, answers, or other figures presented in these activities were made using those parameters and your answers may vary slightly if using a different version or state dataset.

Visual 1: Lesson 1: Introductions and Overview

HAZUS®

EARTHQUAKE • WIND • FLOOD • TSUNAMI

Visual 2: Let's Get Acquainted!

Participant introductions

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

Instructor introduction

Visual 3: Course Agenda

Day One

- Lesson 1: Introduction and Overview
- Lesson 2: Risk Assessment
- Lesson 3: Advanced Applications and Methodology
- Lesson 4: Hazus Inventory Data Options (Part 1)

Day Two

- Lesson 4: Hazus Inventory Data Options (Part 2)
- Lesson 5: Advanced Hurricane
- Lesson 6: Advanced Flood
- Lesson 7: Advanced Earthquake
- Lesson 8: Advanced Tsunami
- Exercise/Capstone Prep

Day Three

- Exercise/Capstone Prep
- Lesson 9: Advanced Parameter Data
- Lesson 10: Results and Outputs
- Capstone Prep

Day Four

- Capstone Prep
- Capstone Presentations
- Lesson 11: Course Wrap-Up

Visual 4: Course Prerequisites

- E0190: ArcGIS for Emergency Managers (or equivalent experience)
- E0313: Basic Hazus
- At least 2 of the following:
  - E0170: Hazus for Hurricane
    OR
  - E0172: Hazus for Flood
    OR
  - E0174: Hazus for Earthquake & Tsunami
- E0179: Hazus for Disaster Operations
- E0317: Comprehensive Data Management System for Hazus

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Course Prerequisites

- Information from National Preparedness Course Catalog Website. (https://www.firstrespondertraining.gov/frt/npccatalog/EMI#anc-search-results)

Visual 5: Course Tasks

- Lecture
- Discussion
- Demonstration: Instructor-Only
  - Students observe instructor completing task
- Activity: Instructor-Led
  - Guided Practice
  - Students follow along and complete task with instructor
- Exercise: Student-Led
  - Individual or Small Group Practice
  - Hands-on
  - Shows how to apply material from this course to an actual event

Visual 6: 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 activities)
- After class (use it or lose it)

Visual 7: Lesson 1: Goal and Objectives

Goal: To provide an overview of this course and what is expected with the capstone presentation.

After completing this lesson you will be able to:

- Identify how Hazus can support emergency management
- List the resources available in this class
- Describe the capstone exercise and final presentation requirements

Visual 8: Using Hazus to Support Emergency Management

- Identify vulnerable areas
- Estimate potential impacts of hazards
- Prioritize mitigation measures
- Assess level of readiness and preparedness
- Inform resource allocation
- Inform response and post-disaster recovery efforts

Visual 9: Loss Estimation Process

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

Visual 10: Integrating User-Provided Data

Inventory Data Integration Tools

- Comprehensive Data Management System (CDMS) enables integration of locally developed non-hazard data
- CDMS validates that user data are compliant with Hazus requirements
- ArcCatalog and SQL Server Management Studio enable the advanced user to make edits

Hazard Data Integration

- ShakeMap and Hurrevac hazard data integration
- Each model includes tools for integrating user-provided hazard data

Techniques for integrating user-provided data are covered in other courses

Visual 11: Hardware and Software Requirements

- Memory: 4 GB or higher
- Disk space: 10GB for one multi-hazard large urban study region, plus inventory data size (varies by state), or 70 GB to store entire U.S. inventory data
- Graphics Adaptor: 24-bit capable video card with at least 128 MB of video memory, resolution of 1078 x 768 or higher
- Operating Systems: Windows 10 Pro and Enterprise, Windows 8.1*, and Windows 7 Pro* (64-bit); only U.S. English version are supported for use**
- Supporting Software: Appropriate version of Esri ArcGIS for Desktop and the Spatial Analyst extension for the flood and tsunami models

*Hazus is no longer supported but still operates on these platforms

**Hazus can be installed on other windows operating systems/service packs, but Hazus may not operate as expected with those operating systems/service packs.

Visual 12: Resources Available in this Lab

- Microsoft Access, Excel, and Word
- ArcGIS Advanced (ArcInfo) license
- ArcGIS Pro
- Microsoft SQL Server Management Studio
- Internet access
- Shared drive (icon provided on desktop)
- Local data submitted before the course

Visual 13: Capstone Exercise Preview

Goal: Complete a Hazus risk assessment using advanced applications for the inventory, hazard, parameter, and results model components.

Planning:

- Day 1 - inventory applications
- Day 2 - hazard applications
- Day 3 - parameter and results applications
- Day 4 morning - self-guided

Presentation:

- Day 4 afternoon

Visual 14: Capstone Exercise Preview

- There is no written final exam for this course
- Participants will be evaluated based on:
    - Completeness of the final presentation
    - Use of the ideas learned in this class

Visual 15: Capstone Exercise Explanation

- Course was designed for you to leave with a product which will be useful to your organizations
- Although pre-processed data has been provided, it is recommended that you use your own data
- Capstone will be conducted individually or with coworkers in small groups (2-3 people)
- Advanced applications conducted are totally up to individual, making the course highly customizable

Visual 16: Capstone Exercise Explanation

Presentation Guidelines:

- Should be prepared using PowerPoint and include at least one slide each showing an inventory, hazard, parameter, and results advanced application.
- Include maps, tables, or other media you deem appropriate and helpful for conveying your message.
- Information should be primarily derived from Hazus, but may be supplemented by other sources.
- 10 minutes in length; allowing 5 minutes for questions.

Community Stakeholder Guidelines:

- Class and instructor will assume the role of risk-mitigation community stakeholders.
- Community stakeholder may ask questions related to the presentation.

Visual 17: Capstone Exercise Preparation

Goals:

- Divide into groups based on organization or complete as individual
- Ensure data submitted ahead of time can be accessed
- FEMA has a generic FTP site (https://www.floodmaps.fema.gov/ffx/) where users can share data for up to 7 days
  - Files must be under 2GB
- Time: 10 minutes

Visual 18: Lesson 1: Review

1. Identify four ways Hazus can be used to support emergency management.
2. List four resources which are available in the lab this week.
3. What four advanced application types are required in the final presentation?
4. List three presentation elements which may be used in the capstone.

Visual 19: Questions?

Lesson 2: Risk Assessment

Visual 1: Lesson 2: Risk Assessment Overview

Visual 2: Lesson 2: Goal and Objectives

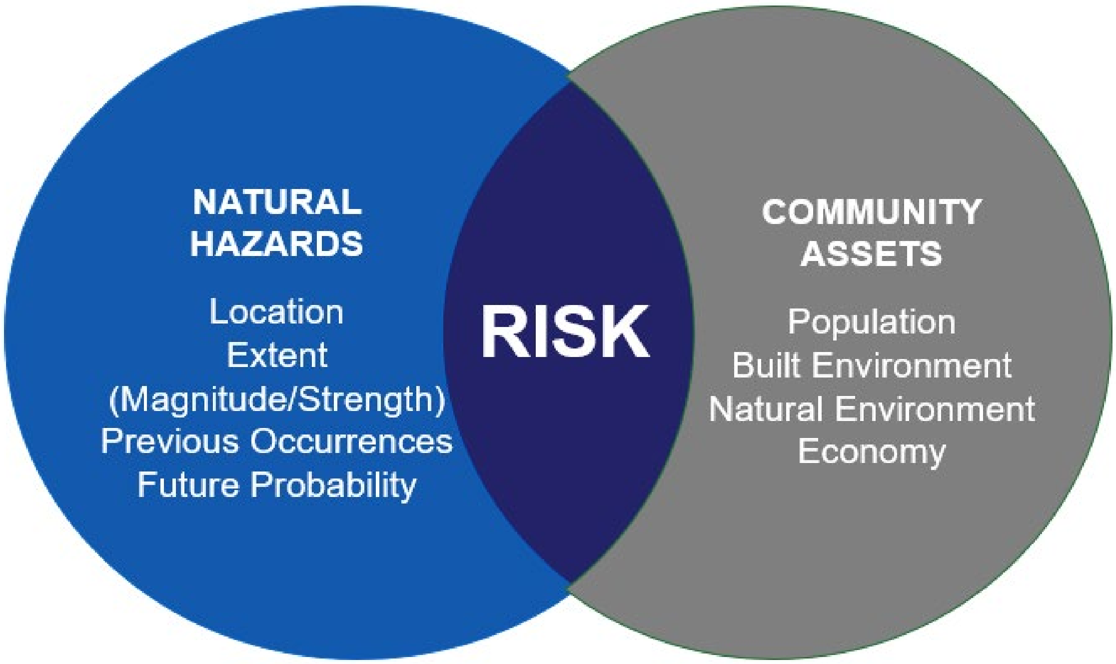
Goal: Better understand the risk assessment process and how it can support community planning efforts.

After completing this lesson you will be able to:

- Define natural hazard risk assessment.
- Identify how risk assessment may be used to support hazard mitigation, emergency preparedness, and other planning efforts.
- Use Hazus outputs to assess risk for your community.

Visual 3: What is Risk?

Risk definition: The potential for damage, loss, or other impacts created by the interaction of natural hazards with community assets.



Source: Local Mitigation Planning Handbook, FEMA 2013

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What is Risk?

Note: The diagram and definition comes from the Local Mitigation Planning Handbook on pg. 5-1 (FEMA, 2013). The diagram was modified from U.S. Geological Survey and Oregon Partnership for Disaster Resilience Models.

Visual 4: Basics of Risk Theory (Hazard)

- Hazard characterization
  - Location
  - Extent and magnitude
  - Likelihood
- Previous occurrences
  - Length of record
  - Impacts quantified
- Future conditions?

Visual 5: Basics of Risk Theory (Hazard)

- Deterministic hazard modeling considers the impact of a single hazard scenario, whereas probabilistic hazard modelling considers all possible scenarios.
- Probabilistic hazard assessments simulate those future disasters which, based on scientific evidence, are likely to occur. This helps resolve the problem posed by the limits of historical data.

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Basics of Risk Theory (Hazard)

Source: UNISDR (United Nations International Strategy for Disaster Reduction), 2015. Global Assessment Report on Disaster Risk Reduction 2015.

Visual 6: Basics of Risk Theory (Social Assets)

- Population
- Vulnerable characteristics – age, income, home ownership, disabled populations
- Community preparedness level
- Tourist and visitor population
- People confined to hospitals, prisons, and detention centers
- Cultural centers
- Pets

Visual 7: Basics of Risk Theory (Economic Assets)

- Critical and essential facilities
- Lifelines: safety/security, food/water/shelter, health/medical, energy, communications, transportation, hazardous materials
- Built environment
- Economic centers
- Agriculture
- Entertainment venues
- Tourism

Visual 8: Basics of Risk Theory (Env. Assets)

- Parks and recreational areas
- Beaches, lakes, and rivers
- Forest land
- Threatened and endangered species
- Wetlands and floodplains

Visual 9: What is Risk Assessment?

- Risk assessment definition: Product or process that collects information and assigns values to risks for the purpose of ranking priorities, developing or comparing courses of action, and informing decision making.

Source: Local Mitigation Planning Handbook, FEMA 2013.

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What is Risk Assessment?

Note: The definition comes from the Local Mitigation Planning Handbook on pg. 5-1 (FEMA, 2013).

Visual 10: Applications of Risk Assessment

- Hazard mitigation planning

Task 1	Determine the Planning Area and Resources
Task 2	Build the Planning Team
Task 3	Create and Outreach Strategy
Task 4	Build the Planning Team
Task 5	Conduct a Risk Assessment
Task 6	Develop a Mitigation Strategy
Task 7	Keep the Plan Current
Task 8	Review and Adopt the Plan
Task 9	Create a Safe and Resilient Community

Source: Local Mitigation Planning Handbook, FEMA 2013.

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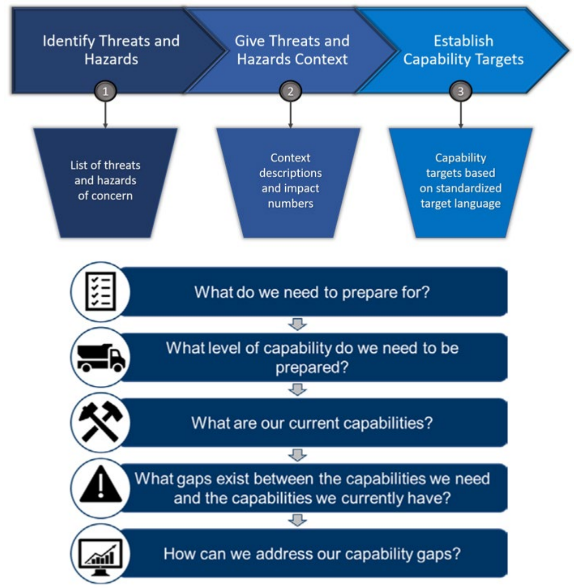
Applications of Risk Assessment

- Note: The definition comes from the Local Mitigation Planning Handbook on pg. I-3 (FEMA, 2013).
- States, counties, cities, tribes, planning districts, and other jurisdictions should update their hazard mitigation plans at least every five years. These plans provide the community with a roadmap to mitigating their risks.

Visual 11: Applications of Risk Assessment

- Threat and Hazard Identification and Risk Assessment (THIRA)
- Five key questions
- Capability gaps identified



Source: THIRA and SPR Guide, DHS 2018.

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Applications of Risk Assessment

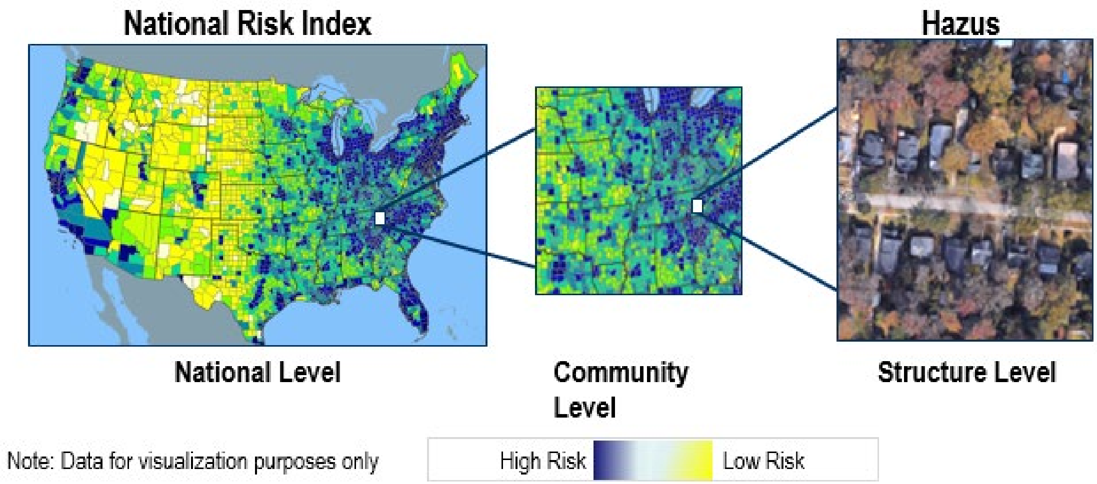
- Note: The graphics come from the Threat and Hazard Identification and Risk Assessment (THIRA) and Stakeholder Preparedness Review (SPR) Guide, 3rd Edition on pgs. 8 and 10 (DHS, 2018). The graphic on the right shows the three steps of a THIRA.
- In the THIRA, communities identify risks with the potential to most challenge their capabilities and expose areas in which the community which need additional focus. These capability gaps create barriers in a community's ability to prevent, protect against, mitigate, respond to, and recover from a threat or hazard. Understanding the risks they face will make it easier for communities to determine what level of capability they should plan to build and sustain.
- Communities update their THIRA every three years and use the data from the process to assess their capabilities in the SPR, which is an annual review.

Visual 12: Applications of Risk Assessment

- Response planning
- Exercise development for existing plans
- Comprehensive plans
- Land Use plans
- Insurance premiums
- Grant funding dispersal
- Climate change adaptation plans

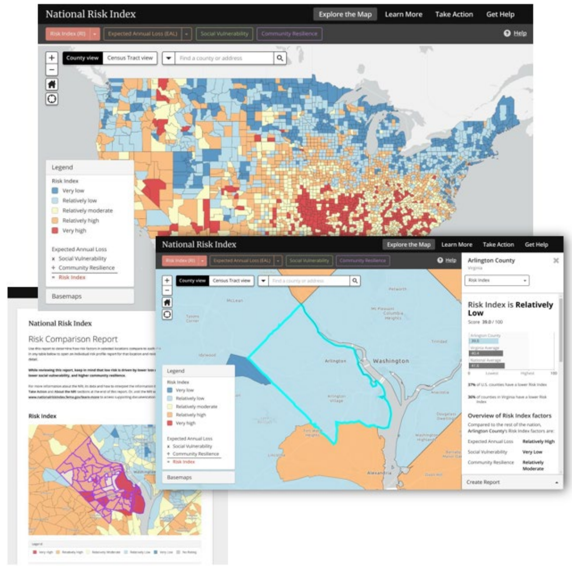
Visual 13: Risk Assessment Modeling

- Top-down vs. Bottom-up risk assessment



Visual 14: National Risk Index

- Began as a strategy for reducing cost and eliminating inconsistent risk assessments in planning
- Identifies areas that offer high return on mitigation investment
- Reduces the cost of risk assessment allowing community planners to prioritize action
- Provides pre-calculated, top-down national baseline risk assessment

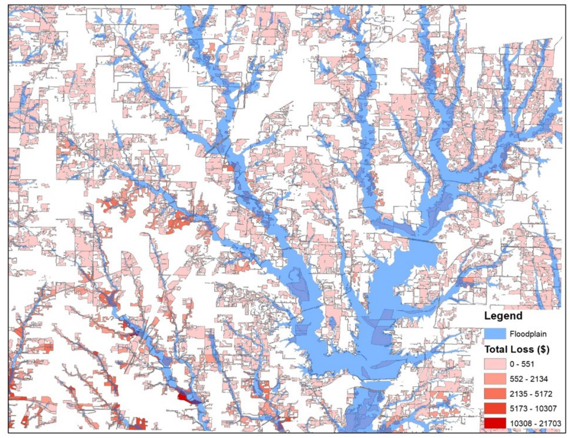


Visual 15: Intro to the National Risk Index (NRI)

- Instructor-led Demonstration (10 minutes)

Visual 16: Economic Losses from Risk Analyses

- Flood general building stock loss
- Dasymetric Census Block output



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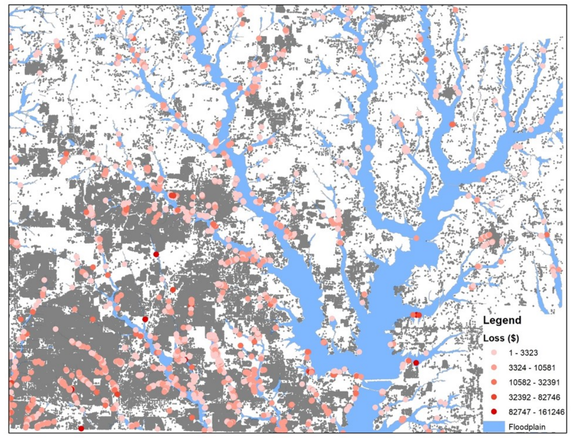
Economic Losses from Risk Analyses

This maps shows a 100-year flood for Collin County, Texas. The total loss has been mapped using dasymetric census block geometry.

Visual 17: Economic Losses from Risk Analyses

- Flood user-defined facility loss
- Structure level analysis



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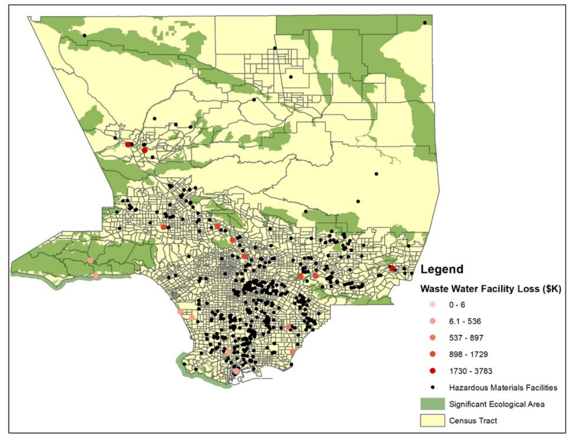
Economic Losses from Risk Analyses

This maps shows a 100-year flood for Collin County, Texas. The total loss has been mapped using user-defined facility (UDF) points.

Visual 18: Economic Losses from Risk Analyses

- Earthquake wastewater loss
- Hazardous Materials
- Impacts overlaid on Significant Ecological Areas



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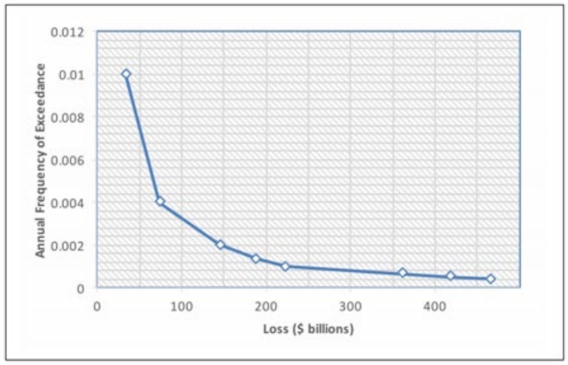
Economic Losses from Risk Analyses

This map shows the loss to waste water facilities for a magnitude 7.4 earthquake on the San Andreas fault for Los Angeles County, California. It also shows the hazardous material sites in the county along with the significant ecological areas provided by the County.

Visual 19: Economic Losses from Risk Analyses

- Probabilistic risk models can be presented in terms of standard measures such as average annual loss (AAL).
- AAL is the expected average loss per year considering all the events that could occur over a longer time frame.
- AAL has a low sensitivity to uncertainty.



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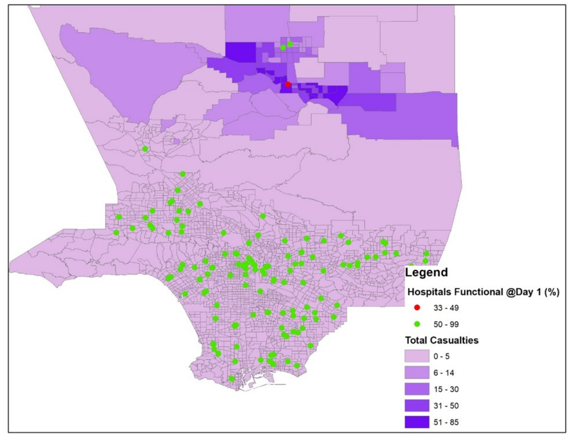
Economic Losses from Risk Analyses

Note: The graph comes from FEMA P-366 Hazus Estimated Annualized Earthquake Losses for the United States on pg. 76 (FEMA, 2017).

Visual 20: Social Losses from Risk Analyses

- Earthquake casualties
- Hospital functionality assessment



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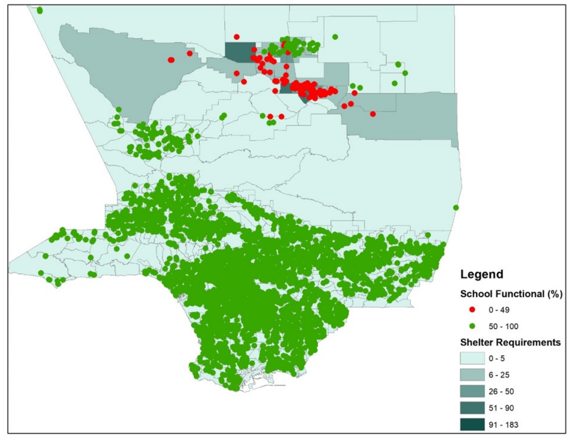
Social Losses from Risk Analyses

This map shows the total number of casualties for a magnitude 7.4 earthquake on the San Andreas fault for Los Angeles County, California. It also shows which hospitals are projected to be functional right after the earthquake.

Visual 21: Social Losses from Risk Analyses

- Shelter requirements
- School functionality assessment
- Schools are often used as shelters



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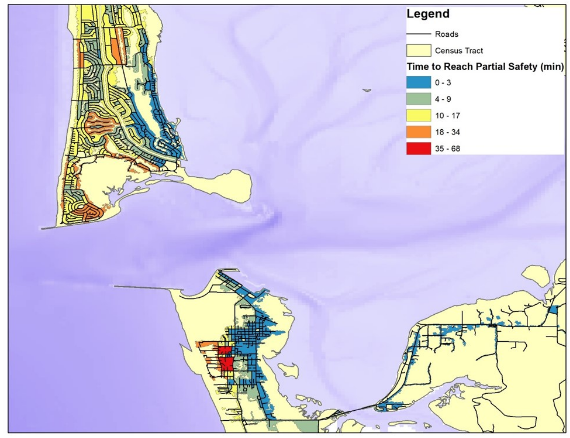
Social Losses from Risk Analyses

This map shows the short-term shelter requirements for a magnitude 7.4 earthquake on the San Andreas fault for Los Angeles County, California. It also shows which schools are projected to be functional right after the earthquake. Schools are often used as shelters.

Visual 22: Social Losses from Risk Analyses

- Evacuation times for tsunami hazard
- Number of minutes it would take someone to reach partial safety



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Social Losses from Risk Analyses

This map shows how long it would take a person to reach partial safety for a tsunami in Grays Harbor, Washington.

Visual 23: Exercise 2.1: Assessing Risk with Hazus Outputs

- Goals:
  - Navigate provided data in ArcGIS
  - Explore Hazus results data
  - Propose mitigation strategies based on results data
- Time: 50 minutes

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Exercise 2.1: Assessing Risk with Hazus Outputs

Goals:

- Navigate provided data in ArcGIS
- Explore Hazus results data
- Propose mitigation strategies based on results data

Time: 50 minutes

Exercise Steps:

1. Refer to Activities Document “2.1_Exercise_RiskAssessment.”
2. Listen to instructor’s directions.
3. Ask questions if clarification is needed.
4. Work individually on the goal.
5. Ask questions to the instructor if needed.
6. Complete the assigned goal.
7. Be prepared to share your answers/results.
8. Ask any final questions.

Visual 24: Exercise 2.1 Tasks

- Task 1: Select Hazard of Interest and Navigate GIS Data
- Task 2: Review the Loss Results
- Task 3: Identify Potential Mitigation Strategies

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Exercise 2.1: Tasks

Refer to Activities Document “2.1_Exercise_RiskAssessment”.

Exercise 2.1: Assessing Risk with Hazus Outputs

Type: Exercise

Time: 45 minutes with 5-minute debrief

Goals:

- Navigate provided data in ArcGIS
- Explore Hazus results data
- Propose mitigation strategies based on results data

Background:

Hazus supports hurricane, flood, earthquake, and tsunami risk assessments. This activity will help you identify risk in Maui, HI by reviewing Hazus outputs for hurricane, flood, earthquake, and tsunami hazards. You'll also have an opportunity to begin thinking about how to mitigate some of the risks identified. Although you won't be running the Hazus software, you will be using the results of the analysis. The study regions have been updated with local user-defined facility (UDF) data while all the other data have been provided in the Hazus state inventory.

Task 1: Select Hazard of Interest & Navigate GIS Data

1. Determine which hazard(s) are appropriate to assess for Maui, HI.

2. Browse to the inventory personal geodatabase "Inventory.mdb" located here: C:\E0177\Activity\2.1\.

3. The following inventory feature classes are available for you to reference during the analysis: bridge, communication facility, demographics, EOC, Fire Station, medical care, oil facility, police station, power facility, roads, school, UDF, and wastewater facility.

4. Select at least one hazard supported by Hazus and browse to that hazard's personal geodatabase located here: C:\E0177\Activity\2.1\.

- Hurricane_Results.mdb
- Flood_Results.mdb
- Earthquake_Results.mdb
- Tsunami_Results.mdb

Depending on which hazard you select to analyze, the personal geodatabase will contain the following feature classes as described below:

- Hurricane_Results.mdb – The following results were created using a user-defined scenario.
  - Debris_Results: Debris amount
  - EconomicLoss_x1000: building, content, inventory, and business interruption loss for all building
  - EOC_Results: Damage state probabilities and functionality assessment
  - FireStation_Results: Damage state probabilities and functionality assessment
  - GBS_Damage_Count_Results: Damage state probabilities for all building
  - MedicalCare_Results: Damage state probabilities and functionality assessment

- Police_Results: Damage state probabilities and functionality assessment
- Port_Results: Damage state probabilities and functionality assessment
- School_Results: Damage state probabilities and functionality assessment
- Social_Results: Displaced households and short-term shelter requirements
- UDF_Results: Damage state probabilities and functionality assessment
- Windspeeds: Windspeeds used to generate results shown by Census Tract.

- Flood_Results.mdb and FloodDepths.tif – The following results were created using a 500-year coastal flood event
  - Debris_Results: Debris amounts
  - EconomicLoss_x1000: building, content, inventory, and business interruption loss for all buildings
  - FireStation_Results_x1000: Damage, functionality assessment, and economic loss
  - Floodplain: Inundation area used to generate results
  - GBS_Damage_Count_Results: Damage state probabilities for all buildings
  - MedicalCare_Results_x1000: Damage, functionality assessment, and economic loss
  - OilFacility_Results_x1000: Damage, functionality assessment, and economic loss
  - School_Results_x1000: Damage, functionality assessment, and economic loss
  - Social_Results: Displaced households and short-term shelter requirements
  - UDF_Results: Damage, functionality assessment, and economic loss
  - VehicleLossDay: Vehicle economic loss if flood occurs during the day
  - VehicleLossNight: Vehicle economic loss if flood occurs during the night
  - FloodDepths.tif: Depth of water used to generate results
- Earthquake_Results.mdb – The following results were created using a 1500-year probabilistic event.
  - Airport_Results: Damage state probabilities and functionality assessment
  - Bridge_Results_x1000: Damage state probabilities, functionality assessment, and economic loss
  - Debris_Social_Results: Debris amounts, displaced households, short-term shelter results, and ground shaking
  - EconomicLoss_x1000: building, content, inventory, and business interruption loss for all buildings
  - EOC_Results: Damage state probabilities and functionality assessment
  - Ferry_Results: Damage state probabilities and functionality assessment
  - FireStation_Results: Damage state probabilities and functionality assessment
  - GBS_Damage_Count_Results: Damage state probabilities for all buildings
  - MedicalCare_Results: Damage state probabilities and functionality assessment
  - Police_Results: Damage state probabilities and functionality assessment
  - Port_Results: Damage state probabilities and functionality assessment
  - Road_Results_x1000: Damage state probabilities, functionality assessment, and economic loss
  - School_Results: Damage state probabilities and functionality assessment
  - UDF_Results: Damage state probabilities and functionality assessment

  - Wastewater_Results_x1000: Damage state probabilities, functionality assessment, and economic loss
- Tsunami_Results.mdb and TSDepths.tif – The following results were created using a deterministic tsunami event.
  - CasualtyDay: Number of injuries and fatalities if tsunami occurred during the day
  - CasualtyNight: Number of injuries and fatalities if tsunami occurred during the night
  - EconomicLoss_x1000: building, content, inventory, and business interruption loss for all buildings
  - GBS_Damage_Count_Results: Damage state probabilities for all buildings
  - InundationArea: Inundation area used to generate results
  - Momentum Flux: Momentum Flux used to generate results
  - TravelTime: Time it would take people to get to partial or total safety (in minutes)
  - UDF_Results_x1000: Damage state probabilities, functionality assessment, and economic loss
  - TSDepth.tif: Depth grid used to generate results

5. Add the GIS layers into an ArcMap document and explore the impacts from the associated hazard.
6. Map the results and zoom into the impacts.
7. Look at the result tables I the attribute tables and the .pdf files to better understand the magnitude of the event.
   - How do the GBS and UDF results compare to each other?

Task 2: Review the Loss Results

Now use the data you just reviewed to answer the questions below. Remember you may have to use data from the inventory personal geodatabase, the hazard specific personal geodatabase, and the Hazus reports to determine the correct answer. Hints have been provided below but try to answer the questions without using them first.

Question	Answer
1. Using the aggregate losses, calculate how many businesses will be impacted:	
2. sing the site-specific (UDF) losses, calculate how many businesses will be impacted:	
3. What percent of the loss will be caused by business interruption?	

Question	Answer
4. Which roads may be impacted by the hazard?	
5. Which utilities may be impacted by the hazard?	

Hint for #1: This question is asking for the general building stock results, count of buildings damaged with any COM occupancy. This information may be found in the global summary report.

Hint for #2: This question is similar to the first question but it is asking about the number of businesses impacted in the UDF results. The answer will require opening the UDF Results and querying the buildings with all the COM occupancies. For tsunami, the specific occupancy code for COM1 is 12.

Hint for #3: The answer to this question can only be found in the GBS results, specifically the economic loss. If you recall from previous classes, the business interruption components include: wage loss, rental income loss, income loss, and relocation loss. Please note that the earthquake model only includes three of the categories and does not separate rental income loss. The global summary report also provides the business interruption values.

Hint for #4: Although Hazus does not model road loss for most of the hazards, the inundation area may be combined with the road inventory to see potential impacts. For hurricane, tree debris often impacts roadways and can be combined with the road inventory to identify potential issues. Bridges may also be evaluated similarly.

Hint for #5: Again, there may not be specifically modeled impacts to utilities but overlaying the inventory with the hazard and other impacts may provide information on potential impacts.

Task 3: Identify Potential Mitigation Strategies

Now that you've explored some of the impacts to Maui, it's time to identify a few actions the community may want to take to mitigate those impacts. These actions could involve mitigating impacts not discussed in Task 2. You'll be expected to share at least one identified action with the class at the end of this activity.

Impact to Mitigate	Mitigation Action

Impact to Mitigate	Mitigation Action

Visual 25: Lesson: Review

1. Risk is made up of what two components?
2. How can risk assessment be used to support the mitigation planning process?
3. How can risk assessment be used to support the THIRA process?
4. What is Average Annualized Loss?

Visual 26: Questions?

Lesson 3: Advanced Applications

Visual 1: Lesson 3: Advanced Applications

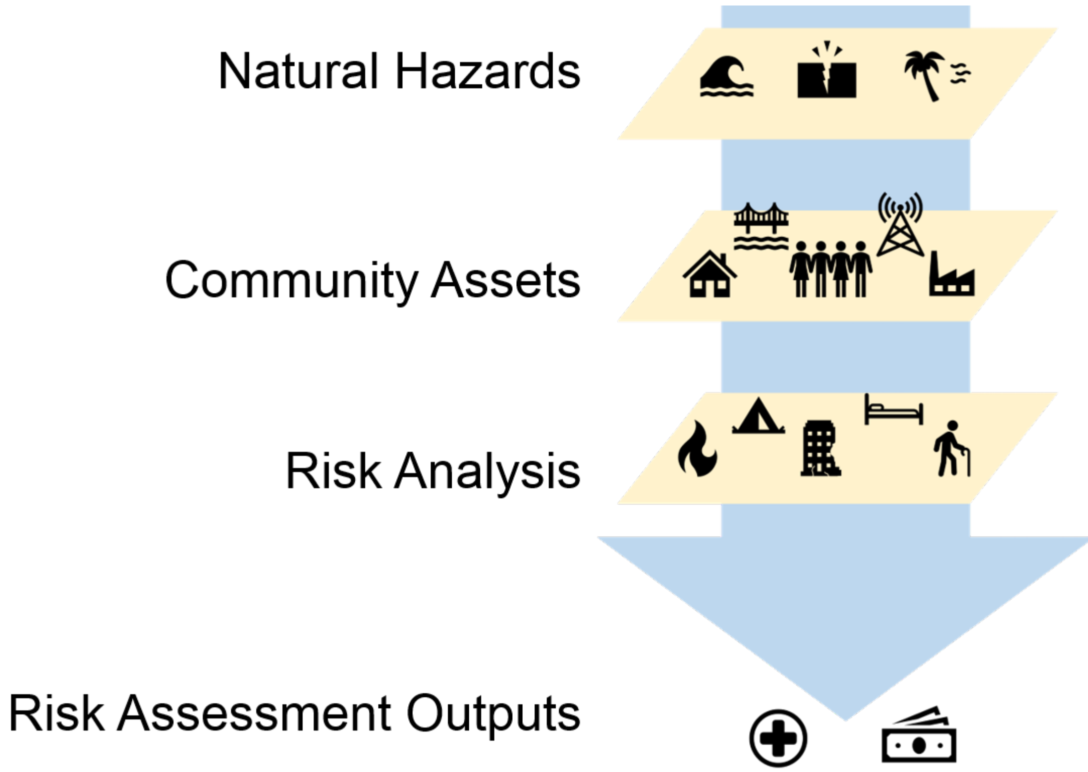
Visual 2: Lesson 3: Goal and Objectives

Goal: Recognize how using advanced applications to update inventory and parameters, integrate complex hazard data, and obtain enhanced results can benefit your organization.

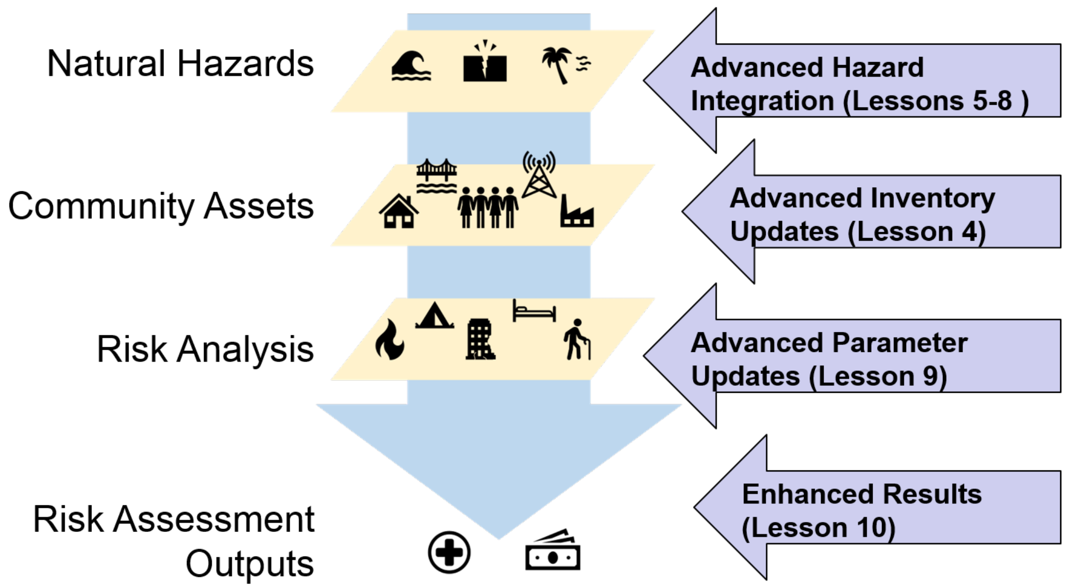
After completing this lesson you will be able to:

- Identify advanced application benefits
- Select which advanced applications to undertake in Capstone project.

Visual 3: Hazus Methodology



Visual 4: Where do Advanced Applications Fit?



Visual 5: Hazard Integration - Hurricane

- Modifying historical hurricane data or custom hurrevac scenario (what would have happened if the hurricane had changed course?)
- Creating your own .dat hurricane scenario file
- Integrating climate change into the analysis - combined Wind/Surge model using both user-defined wind fields and custom storm surge depth grids
- Updating tree and terrain database tables for recent community development

Visual 6: Hazard Integration - Flood

- Converting FEMA National Flood Hazard Layer data into a flood depth grid
- Modifying a third-party depth grid into Hazus-compliant depth grids
- Conducting a levee overtopping analysis with modified depth damage functions
- Integrating climate change data into the surge analysis

Visual 7: Hazard Integration - Earthquake

- Assessing risk in a low to moderate risk community (when the 2500-year event creates little damage)
- Creating a new building type
- Assigning earthquake damage functions
- Updating soil, landslide susceptibility, liquefaction susceptibility data, and water depth

Visual 8: Hazard Integration - Tsunami

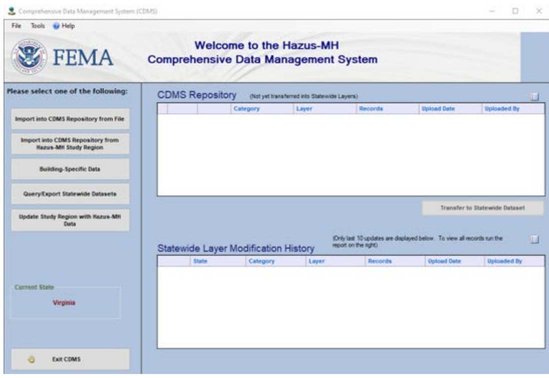
- Developing tsunami hazard data from a polygon inundation zone
- Conducting an advanced evacuation and casualty analysis
- Running an advanced earthquake/tsunami combination analysis
- Understanding tsunami damage functions and editing them

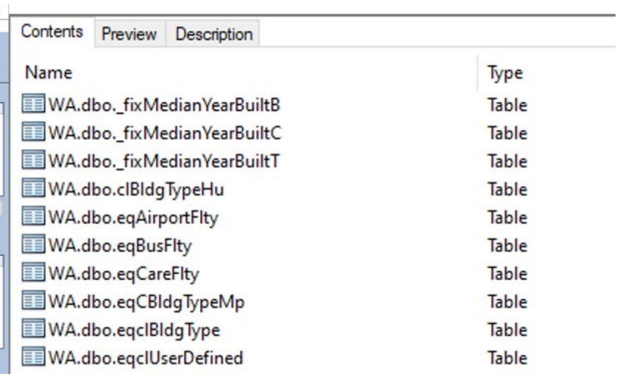
Visual 9: Advanced Inventory Updates

- Updating site specific data with local data: user-defined facilities, AEBM, essential facilities, utilities, transportation
- Updating aggregate data with local data: general building stock, demographics, agriculture, vehicles
- Updating mapping schemes

Visual 10: Advanced Inventory Updates

- Updating inventory data using CDMS
- Advanced updates using ArcCatalog and SQL Server Management Studio





Visual 11: Advanced Inventory Updates

- Developing UDF and GBS data from building footprints and parcel data
- Creating proxies for data not available

Visual 12: Adv. Parameter Updates - Social

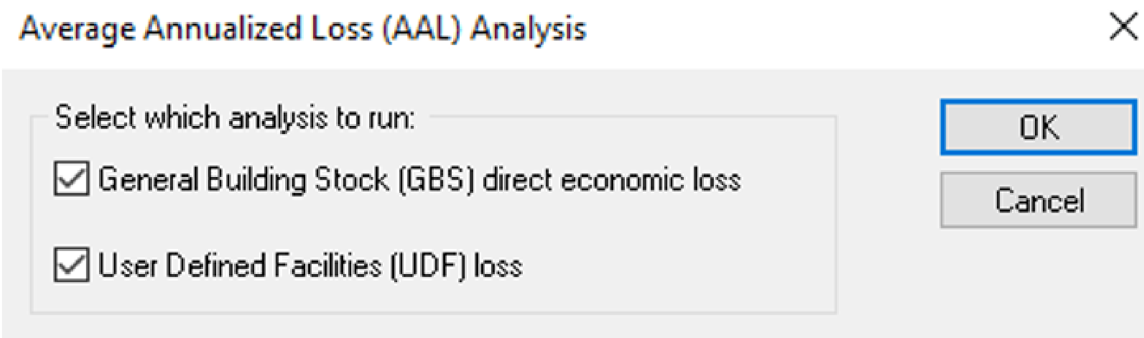
- Understanding weighting and modification factors for shelter requirement analysis and how the models differ from each other – flood, earthquake, and hurricane
- Identifying how displaced household results are determined for each hazard
- Updating casualty parameters in the earthquake model

Visual 13: Adv. Parameter Updates - Economic

- Identify where local and national economic data can be found
- Understand how business interruption values are calculated and how to edit the parameters
- Updating business inventory data in the software

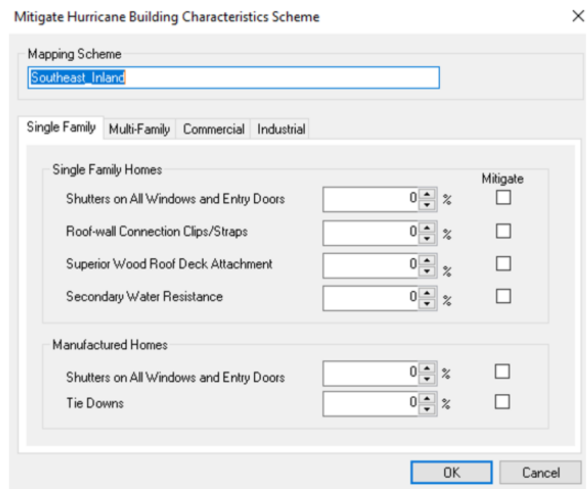
Visual 14: Enhanced Results – AAL Analysis

- Using the flood model to calculate AAL for UDF
- Calculating annualized earthquake loss using AEBM



Visual 15: Enhanced Results – Mitigation

- Calculating losses avoided
- Implementing mitigation actions in Hazus
  - Freeboard
  - Flood proofing
  - Acquisitions
  - Code Adoption
  - Others



Visual 16: Enhanced Results – Building Tags

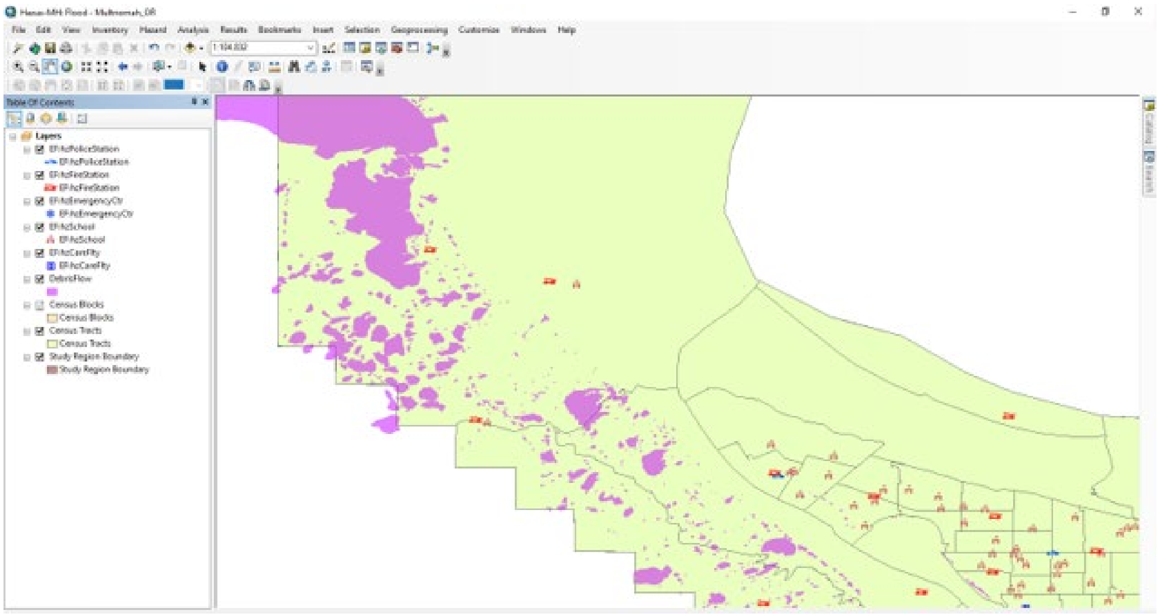
- Converting damage from Hazus analysis into a building tag as defined by ATC-20
- Aligning with Individual Assistance (IA) categories
- Using FEMA's SOP for Hazus Earthquake Data Preparation and Scenario Analysis (2019)
- Estimating inspection needs

Visual 17: Enhanced Results – Communication

- Knowing your audience (public and elected official friendly)
- Using Hazus results in a familiar format
- Normalizing results
- Exploring different ways to express results
- Avoiding common mistakes

Visual 18: Enhanced Results – Other Hazards

- Using Hazus inventory for an exposure analysis
- Identifying and obtaining other hazard data
- Considering cascading effects



Visual 19: Exercise 3.1: Advanced Applications

- Goal: Determine which study region to use in the capstone and which advanced applications are most relevant for you.
- Time: 15 minutes

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Exercise 3.1: Advanced Applications

Goal: Determine which study region to use in the capstone and which advanced applications are most relevant for you.

Time: 15 minutes

Exercise Steps:

1. Refer to Activities Document “3.1_Exercise_AdvancedApplications".
2. Listen to instructor’s directions.
3. Ask questions if clarification is needed.
4. Work individually on the goal.
5. Ask questions to the instructor if needed.
6. Complete the assigned goal.
7. Be prepared to share your answers/results.
8. Ask any final questions.

Visual 20: Exercise 3.1: Tasks

- Task 1: Select a Study Region and Hazard to Analyze
- Task 2: Identify Inventory and Parameters to Update
- Task 3: Identify Audience and Analysis's Purpose

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Exercise 3.1: Tasks

Refer to Activities Document “3.1_Exercise_AdvancedApplications”.

Exercise 3.1: Selecting Advanced Applications

Type: Activity

Time: 15 minutes

Goals:

- Task 1: Select a Study Region and Hazard to Analyze
- Task 2: Identify Inventory and Parameters to Update
- Task 3: Identify Audience and Analysis's Purpose

Background:

This course has been designed to allow participants to use their own data for their own communities and implement the advanced applications described in this introductory lesson. Upon completion of this activity, you will have an outline in place for which advanced application of Hazus you will complete for your final project.

If you don't have your own data or you come from a federal agency and don't have county or city level data, study region data will be provided for you. We strongly encourage people to work with their own data, however. Small groups (2-3) people may work together if they're from the same community or organization, but *everyone* in the group must complete an advanced application for (1) inventory, (2) hazard, (3) parameters, and (4) results. Participants are encouraged to take their completed data updates and study region exports back to their organizations.

Task 1: Select a Study Region and Hazard to Analyze

1. Identify the study region and hazard(s) you're planning to assess. This will be your own local community, a community which data you have collected, or the community provided as an example. It is important to note that not all communities support all four hazards. Please select one of the two options below:

- I have my own data or I have data for a community I wish to analyze.

Question	Answer
Community Name	
Community Boundary (County or Smaller Recommended)	
Hazard(s) to Analyze	

- I don't have data. Please select a community below to analyze.

□ Santa Cruz County, California earthquake and/or tsunami

□ City of Virginia Beach, Virginia earthquake, hurricane and/or flood

2. Identify which advanced hazard application you'll complete this week. Use the hazard(s) you have selected to determine which application to complete. Check the boxes below to select the advanced application.

Hurricane

□ Modifying historical hazard data to create a new route.

□ Creating your own .dat hurricane scenario

□ Integrating climate change into the analysis (the flood hazard must also be selected)

□ Updating the tree and terrain database tables

Flood

□ Converting the FEMA NFHL into a flood depth grid

□ Modifying a coastal depth grid into hazard compliant grids

□ Conducting a levee overtopping analysis

□ Integrating climate change into the surge model (the hurricane model must also be selected)

Earthquake

□ Assessing risk in a low to moderate risk community

□ Creating a unique building type

□ Assigning earthquake vulnerability functions

□ Updating landslide and liquefaction susceptibility data

Tsunami

□ Developing tsunami data from a polygon inundation zone

□ Conducting an advanced evacuation and casualty analysis

□ Running an advanced earthquake/tsunami combination analysis

□ Understanding the tsunami damage functions and editing them

Task 2: Identify Inventory and Parameters to Update

1. This step involves identifying which inventory to update. Check the box below to select the application you want to complete. Select only one for this step, but if time permits others can be completed. Some inventory can't be modeled by specific hazards and is not available.

□ Essential facilities (not available for tsunami hazard)

□ Utilities (not available for hurricane or tsunami hazards)

□ User-Defined Facilities (UDF)

□ General Building Stock (GBS)

2. This step involves identifying which parameter to update. Check the box below to select the application you want to complete.

- □ Economic parameters
- □ Social parameters

Task 3: Identify Audience and Analysis's Purpose

1. For the capstone presentation at the end of this course, identify your audience. This could be a specific group of decision-makers, politicians, supervisor(s), or the general public. When you create materials for your presentation, keep you audience in mind.

My audience is: ____

2. The final step for this activity is to identify an advanced result application to complete. Check the box below to select the application you want to complete. Select only one for this step, but if time permits others can be completed.

- □ Complete an AAL analysis (not available for tsunami)
- □ Model mitigation in Hazus
- □ Carry out a benefit cost analysis
- □ Conduct a building tag analysis

Visual 21: Lesson 3: Review

1. List four hazard advanced applications
2. List two inventory advanced applications
3. Which two general parameters will be updated?
4. List three advanced results

Visual 22: Questions?

Lesson 4: Hazus Inventory Data Options

Visual 1: Lesson 4: Hazus Inventory Data Options

HAZUS®

EARTHQUAKE • WIND • FLOOD • TSUNAMI

Visual 2: Lesson 4: Goal and Objectives

Goal: Better understand the inventory limitations and process to update the data

After completing this lesson you will be able to:

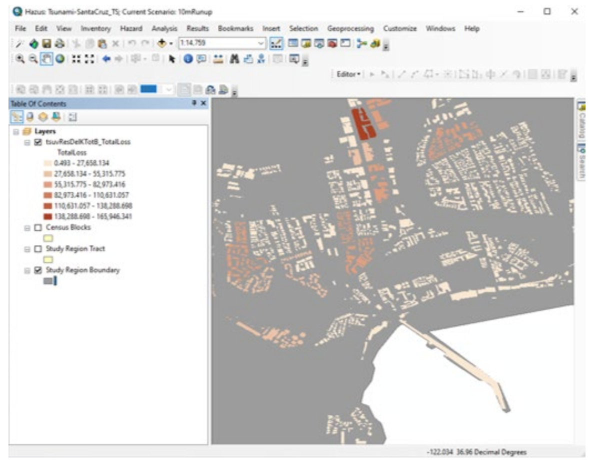
- Identify the limitations in the Hazus state data
- Review the Hazus inventory requirements for each hazard
- List sources of inventory data
- Navigate the SQL tables in the state data
- Update the Hazus inventory

Visual 3: Inventory – General Building Stock

- General building types and occupancies
  - Replacement costs, square footage, and count
  - Census Tract or Block level
- Specific building types (Hurricane and Earthquake)
- Hazard-specific mapping schemes
  - Flood – foundation types and elevations
  - Hurricane – wind building characteristics
- Tsunami uses National Structure Inventory (NSI), earthquake building types and flood specific occupancies

Visual 4: Creating Custom GBS Polygons

- Building footprints are used to replace existing dasymetric data in the State database
- GBS results are displayed using the footprint polygon geometries which are easily recognizable to communities
- Consider UDF analysis if only interested in building damages and economic loss
- Updating Census Tract Centroid to be over population in rural areas



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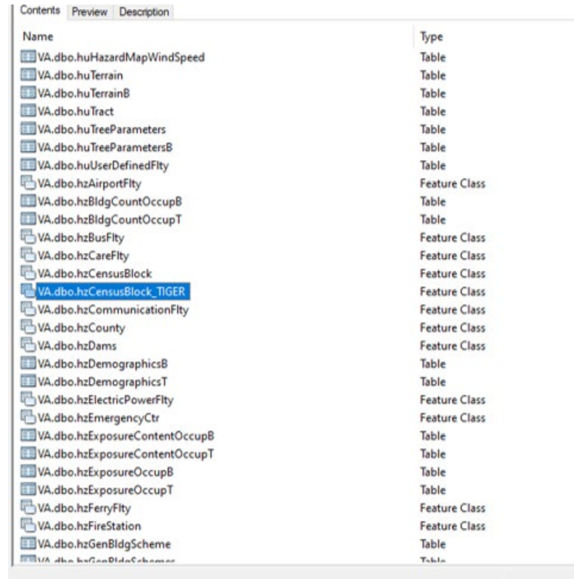
Creating Custom GBS Polygons

This is an example from Santa Cruz, California where a tsunami was run to identify impacts.

Visual 5: Creating Custom GBS Polygons

- Merge footprints (or local land use) into one shape
- Intersect the footprints with the hzCensusBlock_TIGER data
- Replace the hzCensusBlock data with the new intersect layer
  - Replacing the hzCensusBlock data will erase the default data
- Create a new study region



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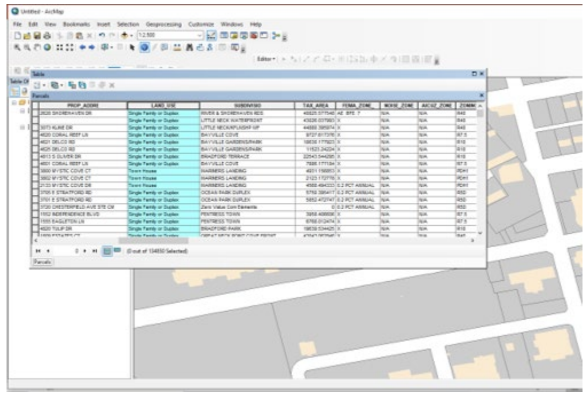
Creating Custom GBS Polygons

This is an ArcCatalog menu showing the State of Virginia data.

Visual 6: Updating GBS Polygons

- Parcel data or tax accessor data may contain:
    - Square footage
    - Building use
    - Building type
    - Year Built
    - Foundation type
- RSMeans (cost/sqft) and location factor can be used to update exposure
- Building footprints can be used to update number of buildings and height



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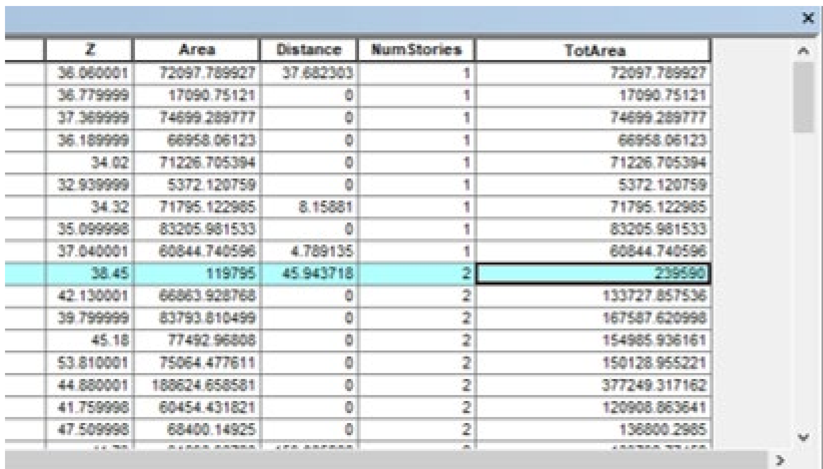
Updating GBS Polygons

This is an example from Virginia Beach which shows the parcel data provided to the public. Building use is highlighted.

Visual 7: Updating GBS Polygons

- Number of Stories = Total Square Footage/Building Footprint Area
- Total Square Footage = Building Footprint Area x Number of Stories (which can be derived from height)
- Remove building footprints with small areas to get rid of sheds and outbuildings



Z	Area	Distance	NumStories	TotArea
36.060001	72097.789927	37.682303	1	72097.789927
36.779999	17090.75121	0	1	17090.75121
37.369999	74699.289777	0	1	74699.289777
36.189999	66958.06123	0	1	66958.06123
34.02	71226.705394	0	1	71226.705394
32.939999	5372.120759	0	1	5372.120759
34.32	71795.122985	8.15881	1	71795.122985
35.099998	83205.981533	0	1	83205.981533
37.040001	60844.740596	4.789135	1	60844.740596
38.45	119795	45.943718	2	239590
42.130001	66863.928768	0	2	133727.857536
39.799999	83793.810499	0	2	167587.620998
45.18	77492.96808	0	2	154985.936161
53.810001	75064.477611	0	2	150128.955221
44.880001	188624.658581	0	2	377249.317162
41.759998	60454.431821	0	2	120908.863641
47.509998	68400.14925	0	2	136800.2985

Updating GBS Polygons

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This is an attribute table for the Virginia Beach footprint data which includes a height (Z) value.

Visual 8: Inventory – Site Level Data

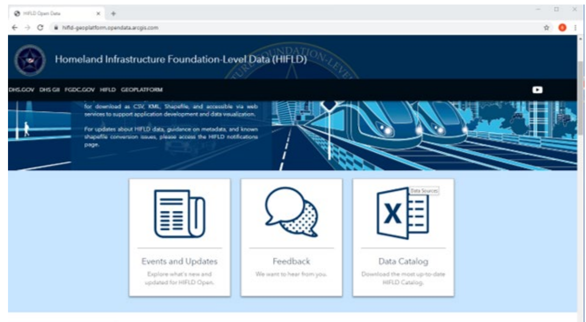
- Essential facilities – police, fire, emergency operations center, school
  - Modeled in HU, EQ, FL
  - Displayed in TS
- User-Defined Facilities (all hazards)
- Utilities (EQ and FL only)
- Transportation (EQ), flood models bridges
- High Potential Loss Facility (HPLF), earthquake models military only, other categories are for display
- Advanced Engineering Building Module (AEBM) (EQ)
- Hazardous materials facilities – display only

Visual 9: Data Sources

- Local government
  - Parcels, tax accessor data
  - Essential facilities, transportation, utilities
  - Building footprints
  - Typical construction
  - Lidar – building footprints and elevations
- University – facilities management, GIS
  - Building data
  - Transportation, utilities

Visual 10: Data Sources

- State government
- Essential facilities, transportation, utilities
- Building footprints
- Lidar – building footprints and elevations
- Federal - essential facilities, transportation, utilities
- Private – building footprints, parcels
- Google Street View



Visual 11: Data Sources - Building Footprints

- ORNL (https://gis.fema.gov/arcgis/rest/services/FEMA/ORNL_Building_Prototype)
- Microsoft building footprints (https://github.com/microsoft/USBuildingFootprints)
- GeoJSON format – can be converted using ArcGIS Pro or third-party application (e.g. ogr2ogr.exe)
- Probably won't have 100% coverage – additional analysis required

State	Number of Buildings	Un
Alabama	2,460,404	
Alaska	110,746	
Arizona	2,555,395	
Arkansas	1,508,657	
California	10,988,525	
Colorado	2,080,808	
Connecticut	1,190,229	
Delaware	345,907	
District Of Columbia	58,329	
Florida	6,903,772	
Georgia	3,873,560	
Hawaii	252,891	
Idaho	883,594	
Illinois	4,855,794	
Indiana	3,268,325	
Iowa	2,035,688	
Kansas	1,596,495	
Kentucky	2,384,214	

Visual 12: Common Inventory Data Issues

- Multiple footprints on one parcel
- Multiple parcels on one footprint
- Multi-use buildings
- Campus represented by one point
- Floodplain runs through corner of building footprint but not point representing structure
- Tax accessor data missing tax-exempt properties
- Converting specific occupancy

Visual 13: Fixing Centroid Concerns

- Use centroid of intersect between building footprint and floodplain
- Place point on lowest elevation value using DEM

Visual 14: Updating Footprints

- Use footprints in conjunction with parcel data to identify parcels which contain square footage but have no footprint on them
- Use satellite imagery to identify missing footprints

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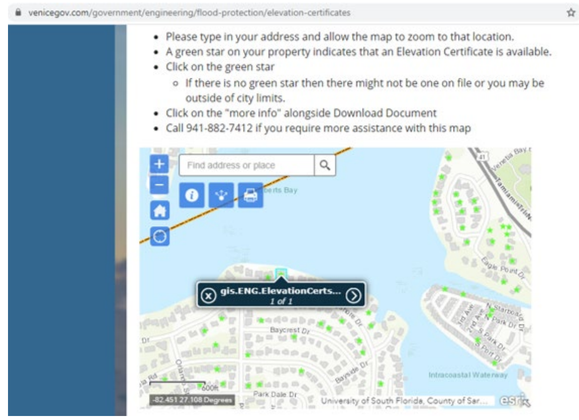
Updating Footprints

This is an online map of Florence, Florida. This community has added their elevation certificates to their online maps.

Visual 15: Updating Vulnerability Characteristics

- Elevation certificates provide:
- Address
- Year built
- First floor elevation



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Updating Vulnerability Characteristics

This is an online map of Florence, Florida. This community has added their elevation certificates to their online maps.

Visual 16: Updating Vulnerability Characteristics

- Google Street View supports updates – foundation type, first floor height, building type, height, etc.
- Steps should be between 4” and 7.75” – take number of steps and multiply by 0.5’ to get first floor height
- Flood model has table that matches foundation type with first floor height in Inventory/General Building Stock menu

Visual 17: Data Formatting

- Datum – WGS84, decimal degrees
- CDMS format requirement – shapefile, Access database (.mdb), Excel .xls file (not .xlsx)
- Field formats – use ArcCatalog to view the state data and the table properties (demo later in the lesson)
- Comprehensive and correct attribute data

Visual 18: How to Fill in the Gaps

- Use year built to determine seismic design level and post-firm buildings
- Use building footprint square footage and parcel square footage to determine number of stories
- Use RS Means, location factor, and square footage for exposure
- Use structure exposure to determine content exposure

Visual 19: Tax Accessor and Parcel Data

- Year built and BldgSchemesID in hzTract feature class to derive design level
- Design level is used in earthquake and tsunami damage modeling

BldgSchemesID	Year Built	Design Level
XX1	<1973	PC
XX1	1973-199	LC
XX1	2000+	LC
XX2	<1940	PC
XX2	1949 - 1972	LC
XX2	1973 - 1999	MC
XX2	2000+	HC
XX3	<1940	PC
XX3	1940 - 1959	LC
XX3	1960 - 1972	MC
XX3	1973 - 1999	HC
XX3	2000+	HS

Visual 20: Building Type Assumptions

- Building type based on occupancy, design level, State, and urban vs. rural environment
- Inventory tool provided in Lesson 4 activity

StateID	StateName	Rural (DL = MC, HC, HS)	Urban (DL = MC, HC, HS)	Rural (DL = PC, LC)	Urban (DL = PC, LC)
AK	Alaska	W1	RM1L	W1	URML
AZ	Arizona	W1	RM1L	W1	URML
CA	California	W1	RM1L	W1	URML
CO	Colorado	W1	RM1L	W1	URML
HI	Hawaii	W1	RM1L	W1	URML
ID	Idaho	W1	RM1L	W1	URML
MT	Montana	W1	RM1L	W1	URML
NV	Nevada	W1	RM1L	W1	URML
NM	New Mexico	W1	RM1L	W1	URML
OR	Oregon	W1	RM1L	W1	URML
UT	Utah	W1	RM1L	W1	URML
WA	Washington	W1	RM1L	W1	URML
AS	American Samoa (TS Only)	W1	RM1L	W1	URML
GU	Guam (TS Only)	W1	RM1L	W1	URML
MP	Northern Mariana	W1	RM1L	W1	URML

StateID	StateName	Rural (DL = MC, HC, HS)	Urban (DL = MC, HC, HS)	Rural (DL = PC, LC)	Urban (DL = PC, LC)
	Islands (TS Only)				
VI	Virgin Islands US (TS Only)	W1	RM1L	W1	URML
AL	Alabama	W1	RM1L	W1	URML
AR	Arkansas	RM1L	RM1L	URML	URML
CT	Connecticut	RM1L	RM1L	URML	URML

Visual 21: Inventory Tools

- Spreadsheet tools developed for the Hazus inventory – identify required fields and provide recommendations for filling in any gaps
- AEBM tool supports filling in required fields automatically

SECTION 1

Feature Class Name: hzUserDefinedFlty

Field Name	Data Type	Comment
UserDefinedFltyId	Text, 8	Required, Assigned by CDMS or User
Occupancy	Text, 5	Required
Tract	Text, 11	Required
Name	Text, 40	Required
Address	Text, 40	Not Needed
City	Text, 40	Not Needed
Statea	Text, 2	Not Needed
Zipcode	Text, 10	Not Needed
Contact	Text, 40	Not Needed
PhoneNumber	Text, 14	Not Needed
YearBuilt	Short Integer, precision 5	Recommended for EQ and TS
Cost	Double, precision 38, scale 8	($) Required, See Section 2
BackupPower	Short Integer, 5	Not Needed
NumStories	Short Integer, precision 5	Required
Area	Float	Required
ContentCost	Double, precision 19, scale 4	($) Required, See Section 3
ShelterCapacity	Short Integer, 5	Not Needed
Latitude	Double, precision 38, scale 8	Required, WGS84 DD
Longitude	Double, precision 38, scale 8	Required, WGS84 DD
Comment	Text, 40	Not Needed

Note: Year built can be used to help determine design level (See Section 4)

Note: NumStories can be used to help determine earthquake building type (See Section 5)

Table Name: flUserDefinedFlty

Field Name	Data Type	Comment
UserDefinedFltyId	Text, 8	Required, Assigned by CDMS or User
BldgType	Text, 15	Not Needed
DesignLevel	Text, 1	Not Needed
FoundationType	Text, 1	Required, See Section 4
FirstFloorHt	Double, precision 38, scale 8	Required, See Section 4
BldgDamageFnId	Double, precision 18, scale 0	Recommended in Coastal, See Section 5
ContDamageFnId	Double, precision 18, scale 0	Recommended in Coastal, See Section 5
InvDamageFnId	Double, precision 18, scale 0	Recommended in Coastal, See Section 5
FloodProtection	Long Integer, 10	Required if Available

Table Name: eqUserDefinedFlty

Field Name	Data Type	Comment
UserDefinedFltyId	Text, 8	Required, Assigned by CDMS or User
eqBldgType	Text, 4	Required, See Section 5
eqUdsClass	Text, 5	Required, Use UDFLT
DesignLevel	Text, 2	Required, See Section 4
FoundationType	Text, 1	Not Needed
SoilType	Text, 1	Recommended
LqfSusCat	Short Integer, 5	Recommended
LndSusCat	Short Integer, 5	Recommended
WaterDepth	Double, precision 38, scale 8	Recommended for Liquefaction

Table Name: huUserDefinedFlty

Field Name	Data Type	Comment
UserDefinedFltyId	Text, 8	Required, Assigned by CDMS or User

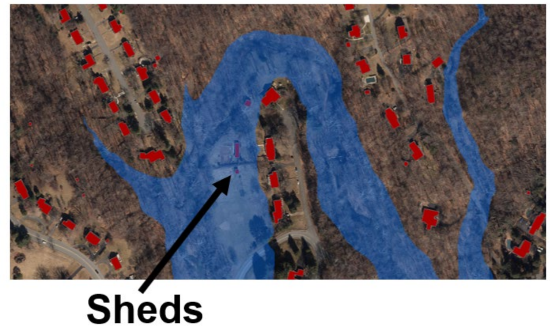
SECTION 2 STRUCTURE REPLACEM

Occupancy	Description
RES1	Single Family Dw
RES2	Manufactured Ho
RES3A	Multi Family Dwe
RES3B	Multi Family Dwe
RES3C	Multi Family Dwe
RES3D	Multi Family Dwe
RES3E	Multi Family Dwe
RES3F	Multi Family Dwe
RES4	Temp. Lodging
RES5	Institutional Dor
RES6	Nursing Home
COM1	Retail Trade
COM2	Wholesale Trade
COM3	Personal and Re
COM4	Professional/ Te
COM5	Banks
COM6	Hospital
COM7	Medical Office/C
COM8	Entertainment &
COM9	Theaters
COM10	Parking
IND1	Heavy
IND2	Light
IND3	Food/Drugs/Che
IND4	Metals/Minerals
IND5	High Technology

UDF | Common Occupancy Codes

Visual 22: Other Data to Collect

- Property vacancy
- Non-standard buildings – sheds, garages, etc.
- Local land use
- Renter vs. homeowner



Visual 23: CDMS Recommendations

- Get data ready before running CDMS
- Develop Field Matching Files (.fmp)
- Query and export Hazus state data first
- Focus on developing building data in the exposed to flood hazard or floodplain if flood is the only hazard
- Consider using the Open Source Flood Assessment Structure Tool (FAST), CDMS, ArcCatalog, or SQL for large UDF datasets
- Double check the CDMS import in new study region
    - Verify you have the correct number of records and that attributes are matched as anticipated

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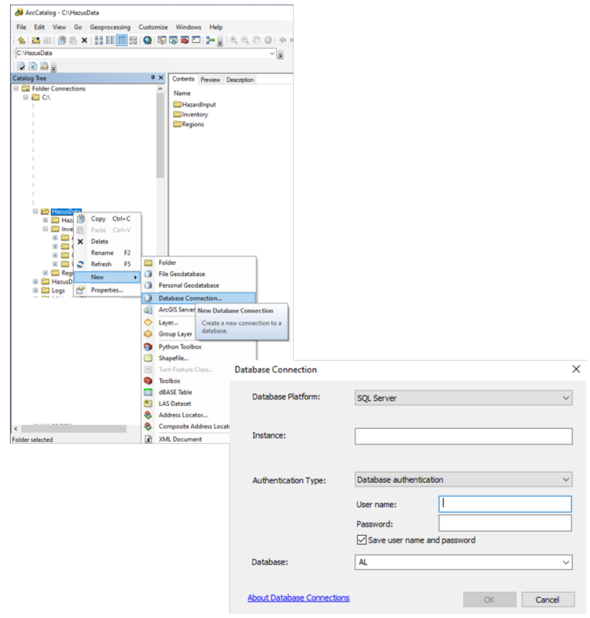
CDMS Recommendations

FAST (https://github.com/nhrap-hazus/FAST)

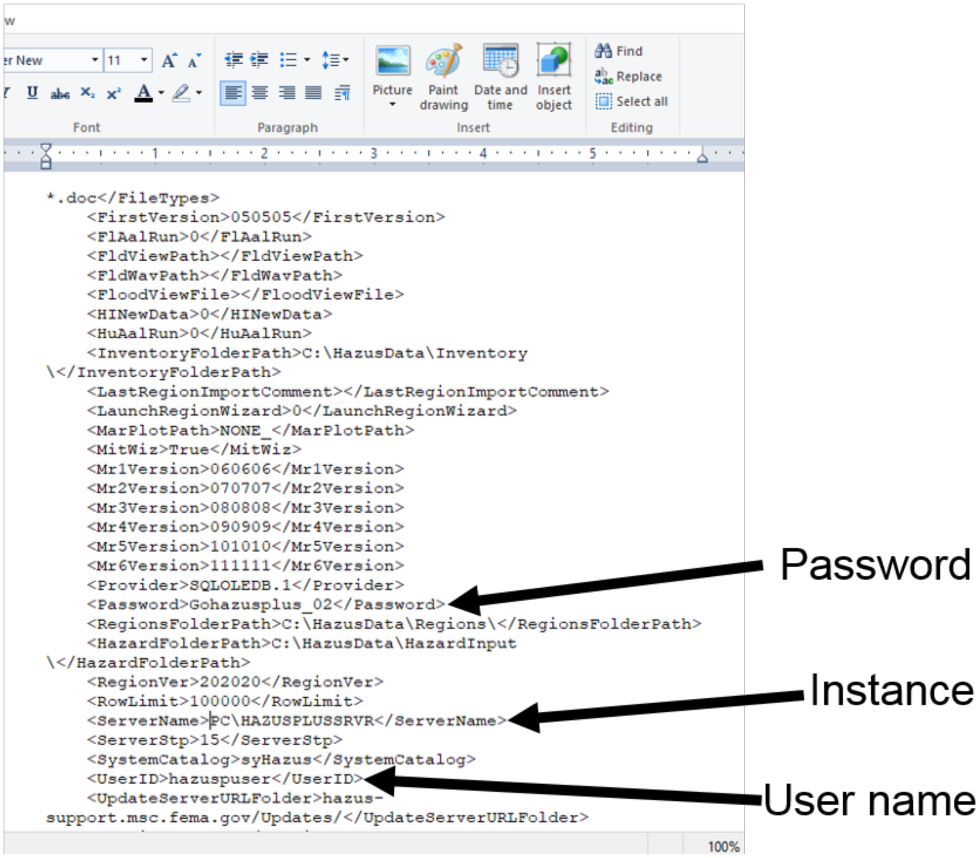
Visual 24: Viewing SQL data in ArcCatalog

- Create new database connection in ArcCatalog
- Fill in database platform (SQL Server), instance, user name, and password using the settings.xml file



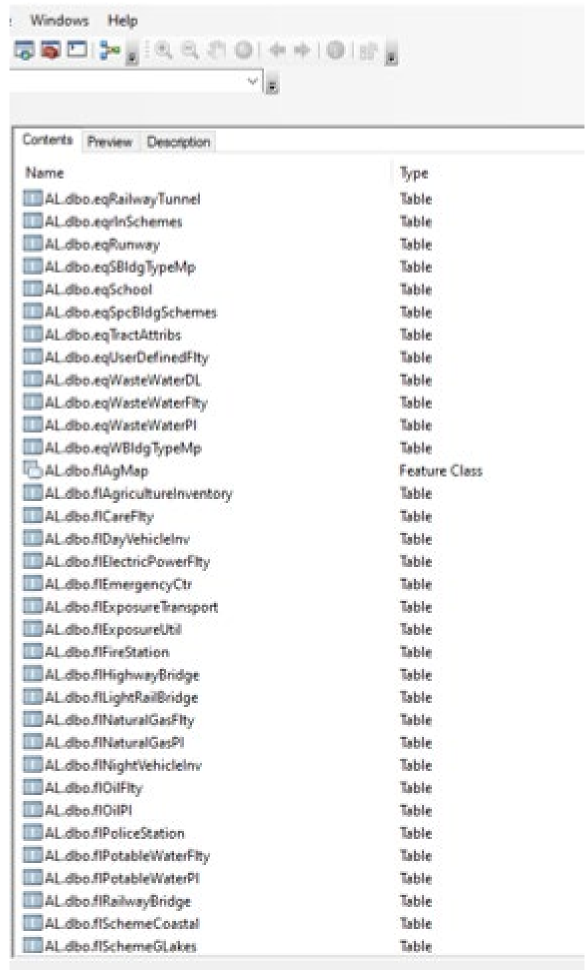
Visual 25: Viewing SQL data in ArcCatalog

C:\Program Files (x86)\Hazus-MH\Settings.xml



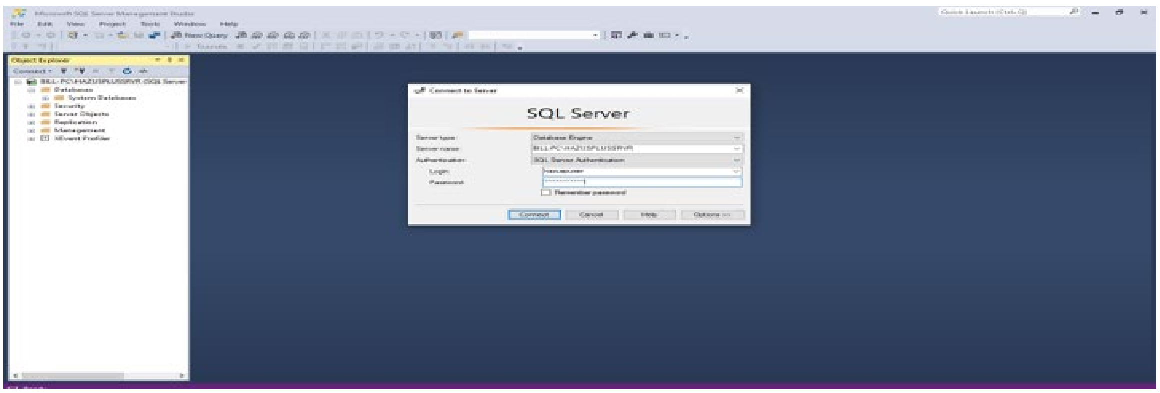
Visual 26: Viewing SQL data in ArcCatalog

- Select state database or study region database
- Right click on table or feature class to view or export



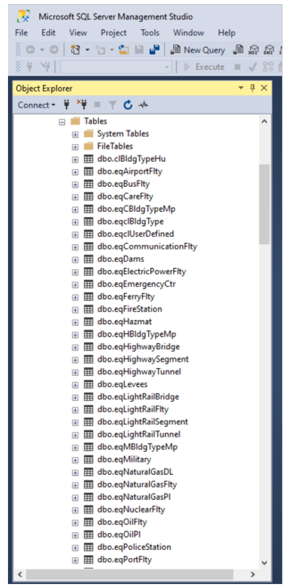
Visual 27: Viewing SQL Data in SQL Server Management Studio

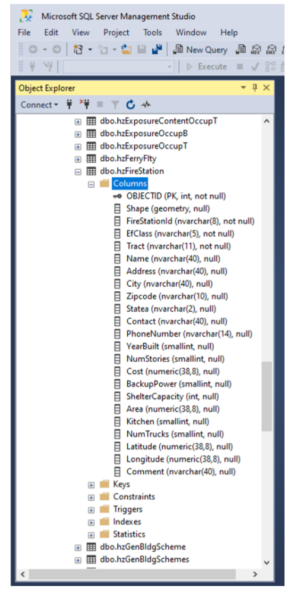
- Connect to SQL Server
- Use login from previous slides
- Functionality limitations – AS, IN, ON, and OR are reserved words in SQL which should not be used – connect in SSMS as _OR



Visual 28: Viewing SQL Data in SQL Server Management Studio

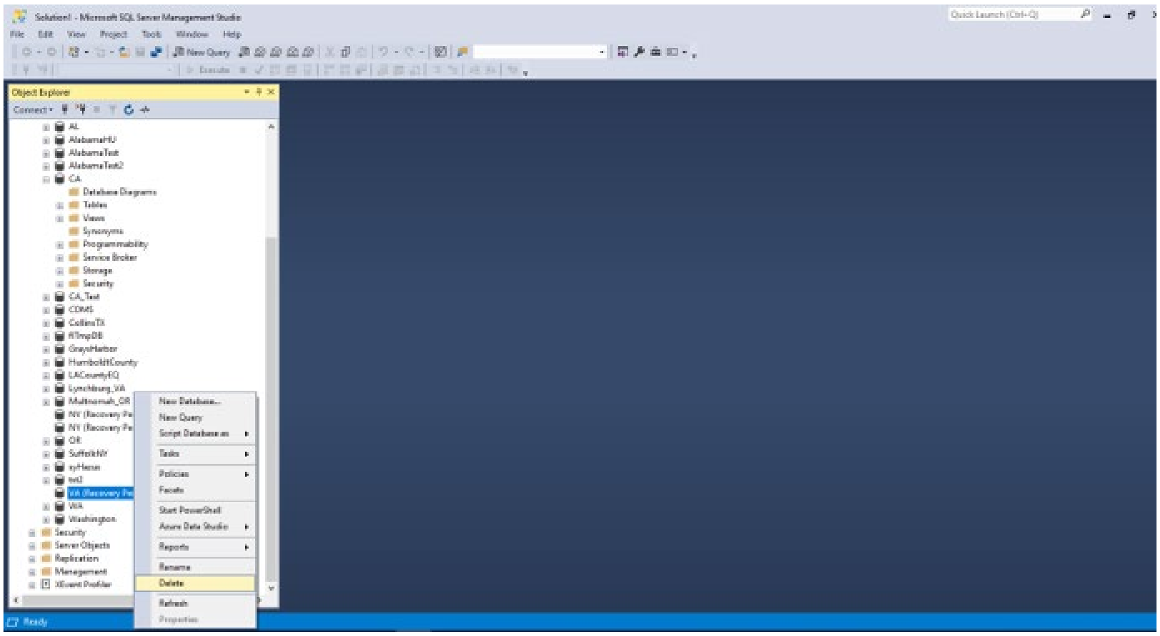
- View databases on the left
- Click on + next to Tables
- Click on + next to table name to see column details and other information





Visual 29: Viewing SQL Data in SQL Server Management Studio

- Can also be used to detach databases before deleting the State data



Visual 30: Instructor Led Demo

- Viewing and exporting SQL tables from ArcCatalog
- Viewing and exporting SQL tables from SQL Server Management Studio

Visual 31: Exercise 4.1: Hazus Inventory Data

- Goal: Update inventory data using local sources
- Time: 225 minutes

Student Manual

Exercise 4.1: Hazus Inventory Data

Goal: Update inventory data using local sources

Time: 180 minutes

Exercise Steps:

1. Refer to Activities Document “4.1_Exercise_HazusInventoryData".
2. Listen to instructor’s directions.
3. Ask questions if clarification is needed.
4. Work individually on the goal.
5. Ask questions to the instructor if needed.
6. Complete the assigned goal.
7. Be prepared to share your answers/results.
8. Ask any final questions.

Visual 32: Exercise 4.1: Tasks

- Task 1: Identify and collect local data
- Task 2: Format data
- Task 3: Update inventory
- Task 4: Document updated inventory

Student Manual

Exercise 4.1: Tasks

Refer to Activities Document "4.1_Exercise_HazusInventoryData".

Exercise 4.1: Hazus Inventory Data

Type: Exercise

Time: 225 minutes

Goals:

- Complete an Advanced Inventory Application
  - Application 1: Essential Facilities (Track 1: Flood and/or Hurricane, Track 2: Earthquake and/or Tsunami)
  - Application 2: Utilities (Flood and/or Earthquake)
  - Application 3: User-Defined Facilities
  - Application 4: General Building Stock
- Share results of the Advanced Inventory Application

Background:

This activity will help you update the inventory in your study region using local and other data sources. This activity has been organized by applications defined by the type of inventory which will be updated as well as the study region. Data has been provided for Virginia Beach, Virginia and Santa Cruz County, California. You are only required to follow one application and one hazard for this class activity. However, if you have time, you may complete additional applications once the first is finished. If you have your own data, just follow the application based on the hazard of interest for you while using your own data. Please note that there is an application in Exercise 7.1 which allows a user to update AEBM data in the earthquake model.

Before You Begin: Identify an Appropriate Advanced Hazard Application

There are four advanced inventory applications to select from in this activity. Select the one that is most beneficial to your community:

Application 1: Essential Facilities (Track 1: Flood/Hurricane, Track 2: Earthquake/Tsunami)

- Data Required: Essential Facility Locations
- Time Required: 120-180 Minutes
- Difficulty: Moderate

Application 2: Utilities

- Data Required: Utility Locations
- Time Required: 120-180 Minutes
- Difficulty: Easy-Moderate

Application 3: User-Defined Facilities

- Data Required: UDF locations (from building footprints), square footage (from building footprints or parcel data), and building occupancies (from parcel data). This application is going to require building footprints and parcel data. Building footprints for the U.S. can be found on GitHub: (https://github.com/microsoft/USBuildingFootprints).

Note: The tsunami model has the same requirements as the flood and earthquake model. Although the example below is in Virginia and not a tsunami-supported state, the application will be the same.

- Time Required: 180+ Minutes
- Difficulty: Hard

Application 4: General Building Stock

- Data Required: Parcel data (with square footage and occupancy) and building footprint data (for dasymetric update).
- Time Required: 40-50 Minutes
- Difficulty: Moderate

Application 1: Essential Facilities

Track 1: Flood and/or Hurricane

Task 1: Identify, Collect, and Validate Local Data

1. The first step is to locate the essential facility data. Local GIS websites are good sources of data. For Virginia Beach, the local schools data has already been identified and downloaded here: C:\E0177\Activity\4.1\VirginiaBeach\ and is called VBCPS_School_Facilities.shp. This is data that was downloaded from the City's GIS website: (https://gis.data.vbgov.com/). It is important to identify the metadata as well. In this case, the metadata is the xml file which is included. Open the xml file and read the description. You'll notice this file contains only public school information. If a more robust school data set is needed, you'll need to supplement the public school data with the private school data which may be downloaded from the Homeland Infrastructure Foundation-Level Data (HIFLD) website (https://hifld-geoplatform.opendata.arcgis.com/datasets/private-schools).

To help supplement our existing school data, we're also going to download building footprint and parcel data. If you don't have these datasets locally, that's okay. Virginia Beach had both sets of data for public download at the link above. This data has already been downloaded and is called building_footprints.shp and parcels.shp. Building footprints have been released by Microsoft for the entire U.S. They can be found on GitHub (https://github.com/microsoft/USBuildingFootprints). Your computer lab should have ArcPro which you can use to convert the json format into an ESRI-ready format.

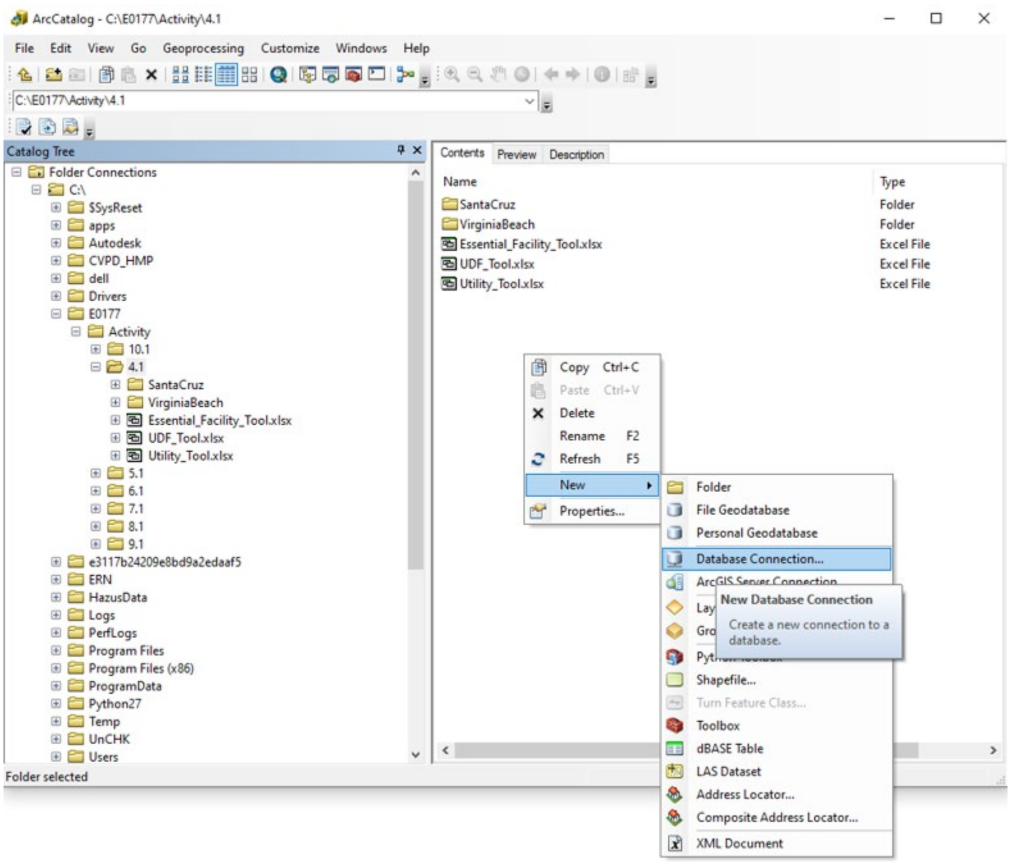
2. Create a new study region in Hazus called Temp. The study region should include your county/city and the hazards you want to model. When the study region has been created, close Hazus.

3. Open ArcMap and add the school data to the map.

4. Right click on the layer name and select properties. Then select the Source tab. The projected coordinate system will be provided: NAD83_HARN_Virginia_South_ftUS. If using your own data, make a note of the projected coordinate system.

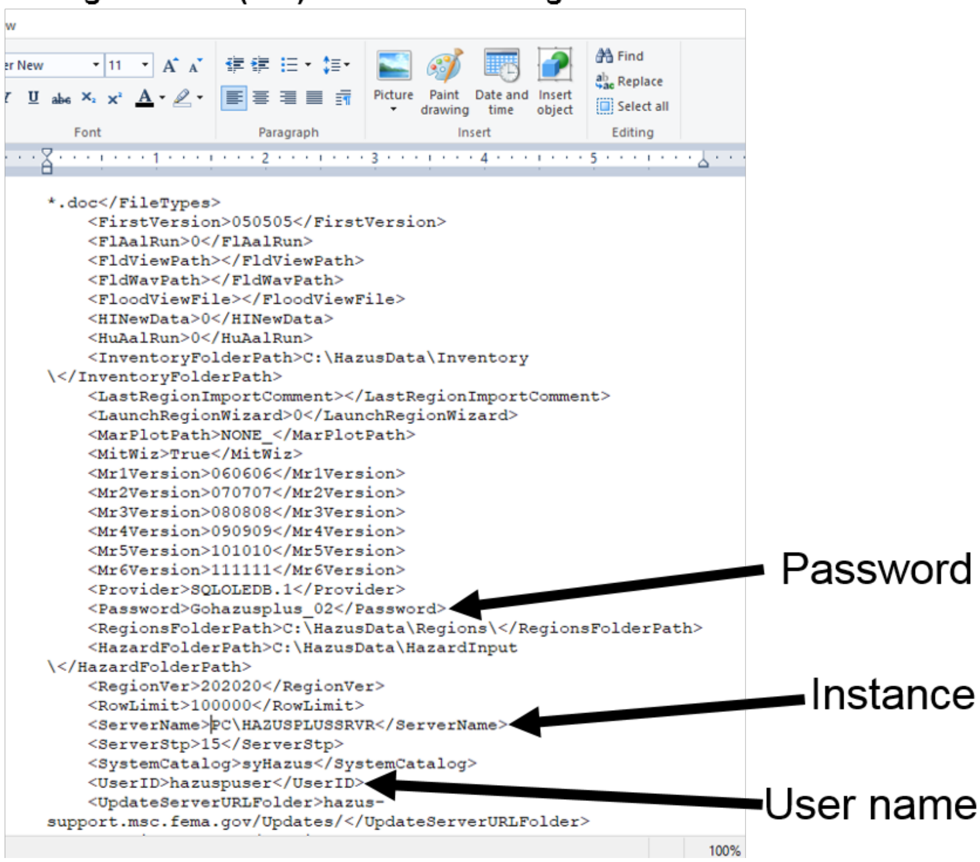
Task 2: Format Data

1. Create a new database connection at C:\E0177\Activity4.1\ using ArcCatalog.



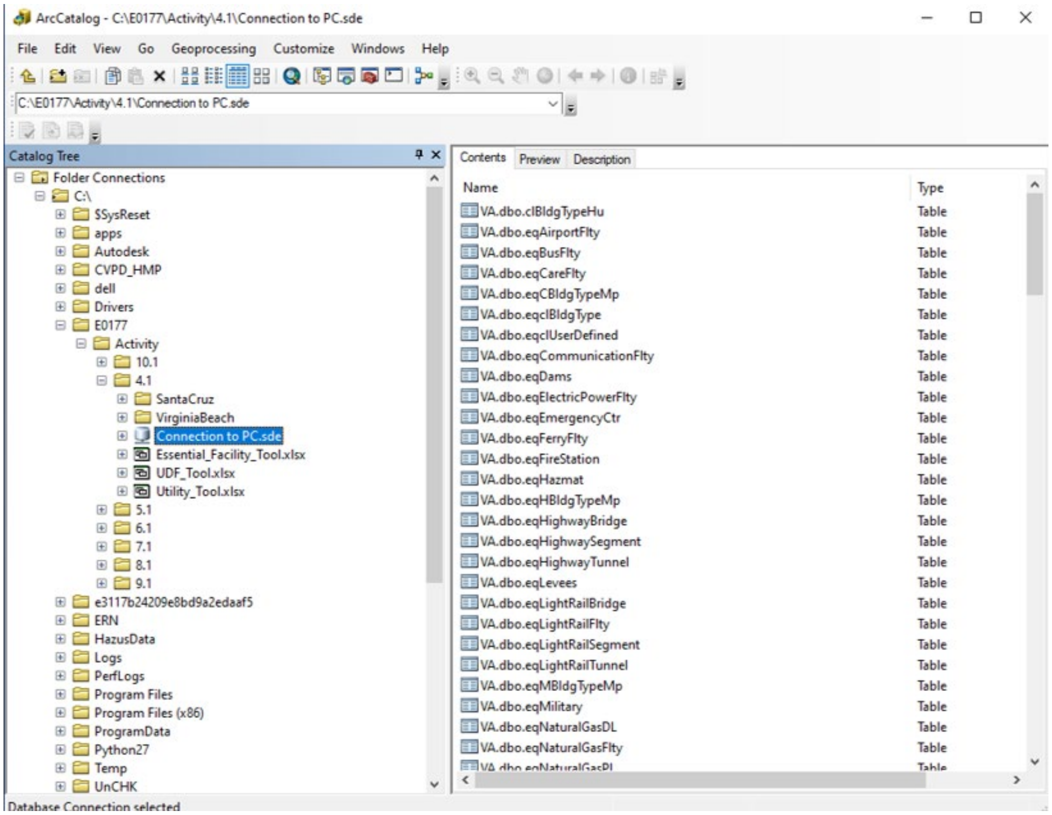
3. To figure out how to populate the Instance, User name, and Password, go to C:\Program Files (x86)\Hazus-MH\Settings.xml and open the file. The information shown in the xml file may be copied from the xml file and pasted into the ArcCatalog interface. The instance includes the computer name which can be long. Your computer name will be different than the example.

C:\Program Files (x86)\Hazus-MH\Settings.xml



4. Enter the password, instance, and user name into the ArcCatalog interface. Select SQL Server in the top dropdown.

5. Select VA in the database dropdown and then select OK. This will create a database connection with the default name: Connection to PC_Name.sde where PC_Name is the name provided in the instance. Double click on the new connection name to access the Hazus Virginia State data.



Reviewing the data in the state database, files that start with eq are associated with the earthquake model, fl is flood, hu is hurricane, ts is tsunami (for tsunami states, not Virginia), and hz is common across all hazards. For this activity, we are going to focus on flood, hurricane, and general data. For essential facilities, the data of interest is:

- EOC – VA.dbo.flEmergencyCtr and VA.dbo.hzEmergencyCtr. There is no hurricane file to update.
- Fire – VA.dbo.flFireStation and VA.dbo.hzFireStation. There is no hurricane file to update.
- Medical Care – VA.dbo.flCareFlty and VA.dbo.hzCareFlty. There is no hurricane file to update.
- Police – VA.dbo.flPoliceStation and VA.dbo.hzPoliceStation. There is no hurricane file to update. School – VA.dbo.flSchool and VA.dbo.hzSchool. There is no hurricane file to update.

This application is going to focus on updating the school data, but you may want to update other essential facilities using this same process.

6. Right click on VA.dbo.flSchool in ArcCatalog, then click Properties. Click on the Fields tab. The data type is provided in the right column. Click on Text next to SchoolID and you'll see the

size is 8 characters. All of the tables have already been characterized for you in the Essential Facility Tool found here: C:\E0177\Activity\4.1\EssentialFacilityTool.xlsx.

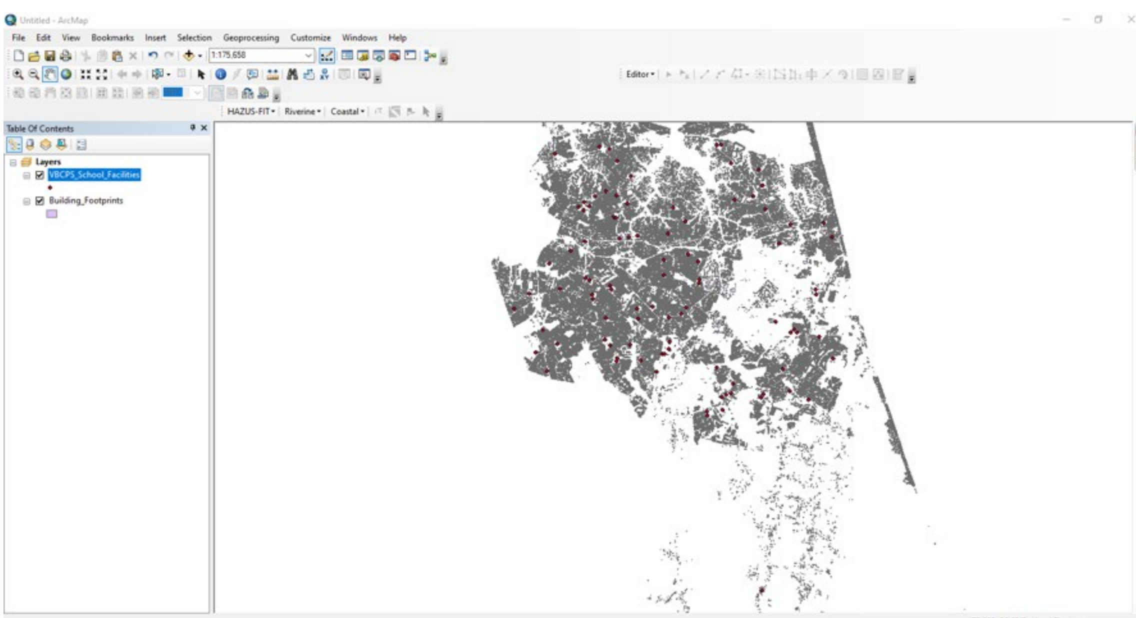
Open the Essential Facility Tool Excel spreadsheet and browse to the School tab. It will provide information on the field, data type, and whether or not it is required, recommended, or not needed for a Hazus analysis.

Task 3: Update Inventory

1. Now look at what data is required to run a Hazus analysis, compare it to what you already have, and then make inventory updates. Looking at the Virginia Beach data, we have the following fields: Name, Address, City, Zipcode, State, YearBuilt, contact, and phone. We'll still need to format these fields and we'll also need to create the following fields: EFClass, Tract, Cost, Latitude, Longitude, FoundationType, FirstFloorHt, BldgDamageFnID (because we're on the coast), and ContDamageFnID (because we're on the coast). The definition of these fields can be found in the Essential Facility Tool Excel spreadsheet.

2. Convert the shapefile into a new Personal Geodatabase and make sure the fields are formatted correctly. Open ArcMap to an untitled map. Right click in the map area and select Data Frame Properties… then click on the Coordinate System tab. Select the world icon, then Import…, and browse to the schools found here: C:\E0177\Activity\4.1\VirginiaBeach\School_Facilities.shp.

3. Select Building_Footprints.shp and click Add. Then click OK. Click on Add Data… and browse to the school facilities and building footprints to bring them into the map.

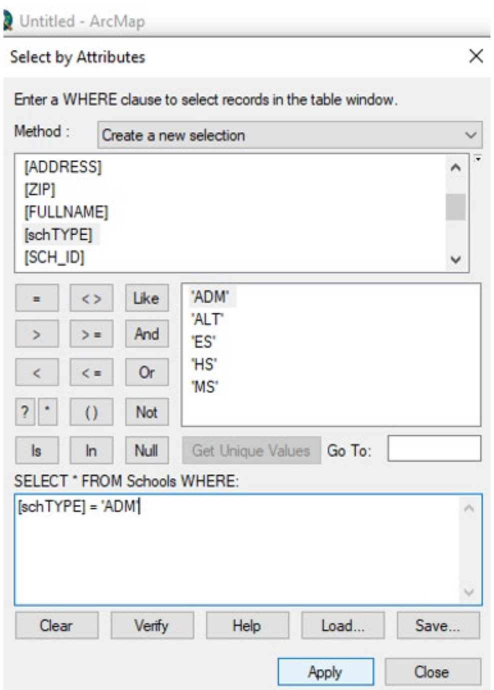


4. Turn the footprint layer off so it is not visible. Open ArcCatalog and browse to the C:\E0177\Activity\4.1\VirginiaBeach\ folder and right click on the folder to add a new personal geodatabase. Name it EssentialFacilities.mdb.

5. Close ArcCatalog and go back to ArcMap.

6. Right click on the school layer, then Data, then Export Data… and browse to the geodatabase you just created. Make sure Save as type: is set to File and Personal Geodatabase feature classes and type in the name as Schools. Then click Save, OK, and then Yes.

7. This may not be relevant to those who have their own data but we are interested in using the schools as public shelters, so we want to delete the administrative buildings. Right click on the schools layer and click on Open Attribute Table. Click on the button in the top left part of the attribute table, click Select by Attributes…, and then create a new selection. Click on [schTYPE], then = below it, and then select Get Unique Values and double click on 'ADM'. Click Apply.



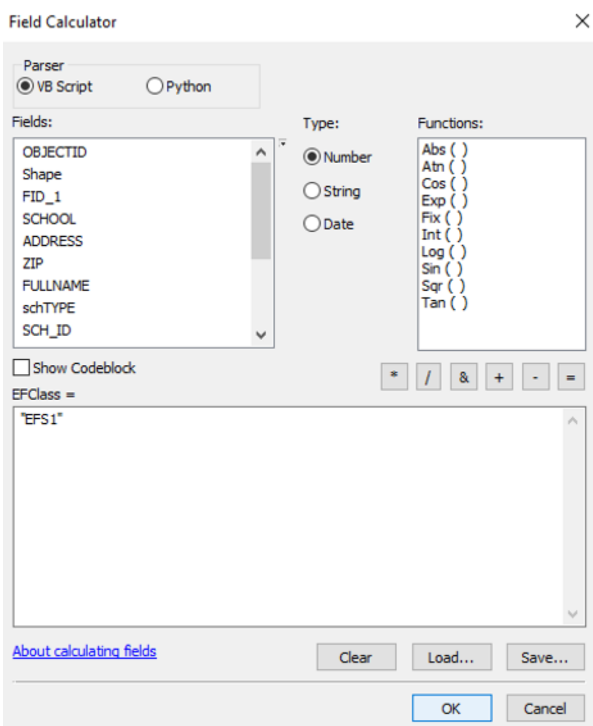
8. Close the Select by Attributes menu. Click on the Editor Toolbar and Start Editing. Click on Schools and then OK to edit that data. Click Continue when the warning comes up. Go to Edit at the top and then Delete. One of the buildings is a future site so we want to delete that one too. Find the school called "Future Princess Anne MS Site" and delete it too.

9. There should now only be 86 buildings. Go to the Editor toolbar and select Stop Editing. Select Yes when it asks you if you want to save your edit session.

10. Next, we'll create the EFClass field which is required by Hazus. The EFClass field is used by Hazus to determine which depth damage function to use in the flood model. Click the button in the top left of the attribute table and select Add Field.

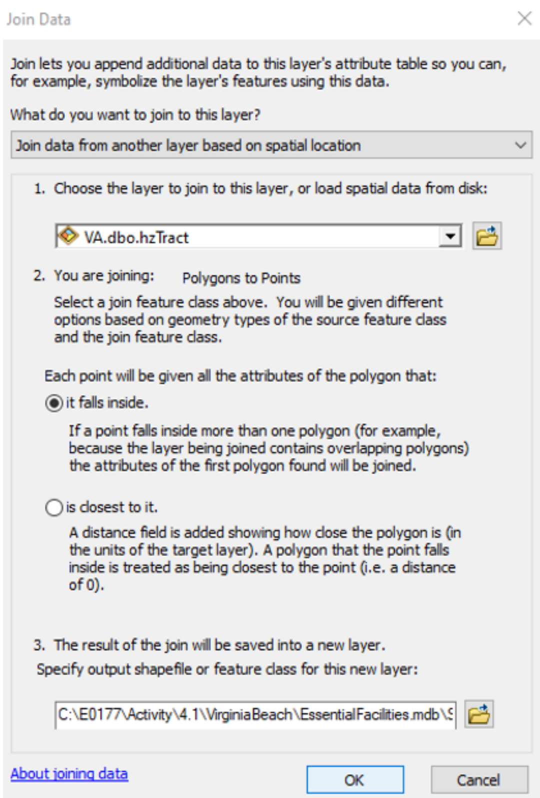
11. Name the field “EFClass” and make it a text field with a length of 5. Then click OK.

12. Since all the public shelters are K-12 schools and not universities, we’ll set the value to EFS1. Right click on the EFClass column header and click Field Calculator. Select Yes when the warning comes up. In the box below “EFClass =”, type “EFS1” and then OK.



13. Next, identify the Tract value for each school using a spatial join. Close the attribute table. Open ArcCatalog and browse to the database connection you created earlier. Left click on VA.dbo.hzTract and drag it to the ArcMap table of contents.

14. Click Close when the Geographic Coordinate Systems Warning comes up. Close ArcCatalog. Right click on the Schools layer, then Joins and Relates, and Join. In the top drop down, pick Join data from another layer based on spatial location, for section 1 select VA_dbo_hzTract, then it falls inside for part 2, and browse to the EssentialFacilities geodatabase and call the new layer Schools_Tract and click OK.

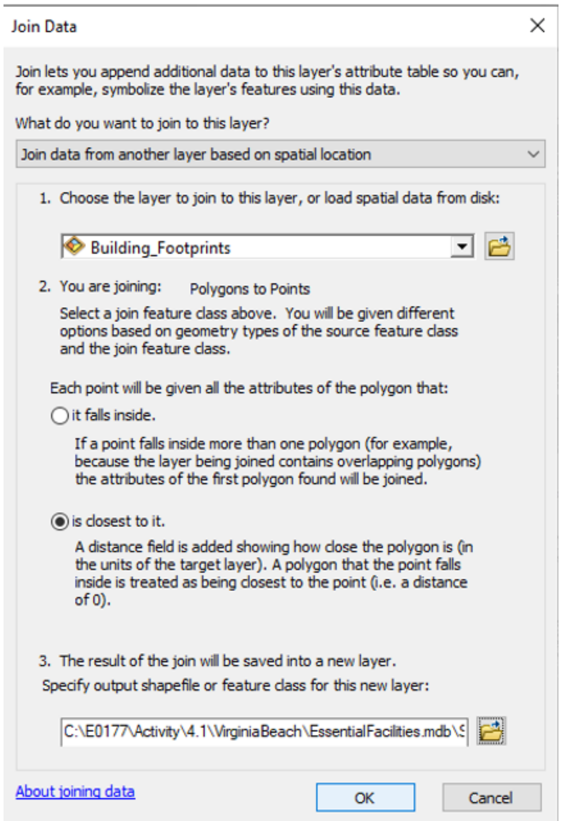


15. Remove the school and tract layers from the table of contents and open the attribute table of the Schools_Tract layer. Every school should now be assigned a Census Tract number and a County FIPS number (which we'll use later in this application). If your data doesn't have the tract number, you'll need to move the point so that it falls within a Census Tract. This can happen on shorelines or other water bodies where the point has been placed incorrectly or the tract was trimmed too much.

16. Next, create a cost value. If you are using this data for a hurricane only study region, cost is not required and you may skip this part. This is because the hurricane model only calculates the damage state probability and functionality of the essential facility and not the loss. To create replacement cost, we're going to use the building footprint and building footprint height. We'll first calculate the area of the building footprints. Right click on the Building_Footprints layer and open the attribute table. Add a new field called "Area" with a data type of double.

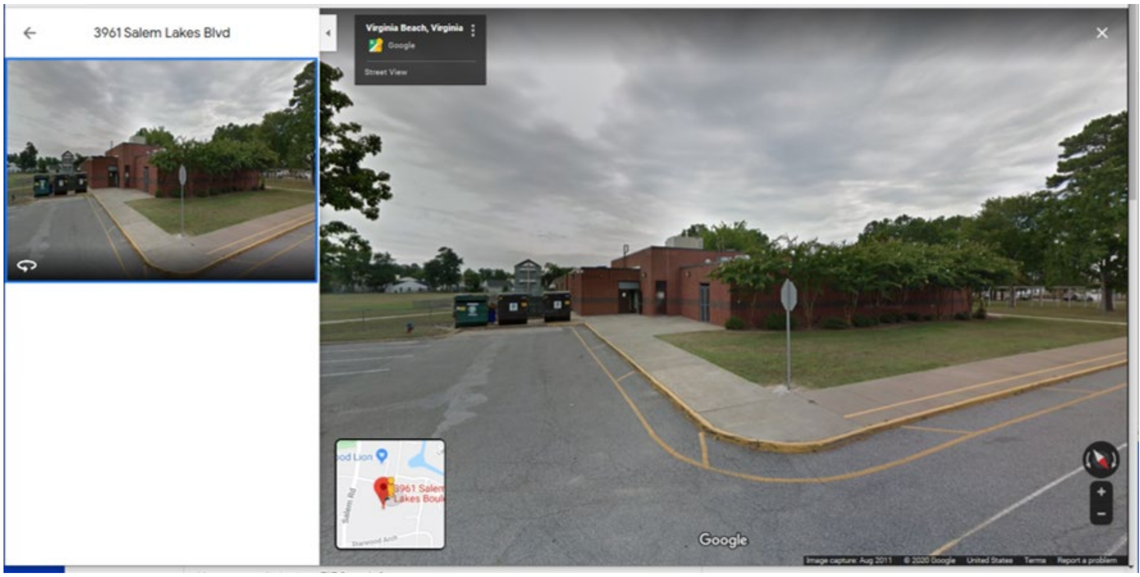
17. Right click on the Area column and select Calculate Geometry. Select Yes when the warning comes up. Select the Property: Area, use the Virginia Coordinate system and units of square feet. Then click OK at the bottom. Click Yes when the warning comes up.

18. Close the Building_Footprints attribute table. Make the building footprints visible on the map. Right click on the Schools_Tract layer and do another spatial join. Join the school points to the building footprints, select is closest to it since the points may not fall exactly on the footprint. Save it in the EssentialFacilities geodatabase and call it Schools_Area.



19. The building footprint that we used also has the building height (in feet) in the Z field. Use this height to calculate number of stories and total area. Create two new fields called NumStories and TotArea. Make the data type Short Integer for NumStories and Double for TotArea.

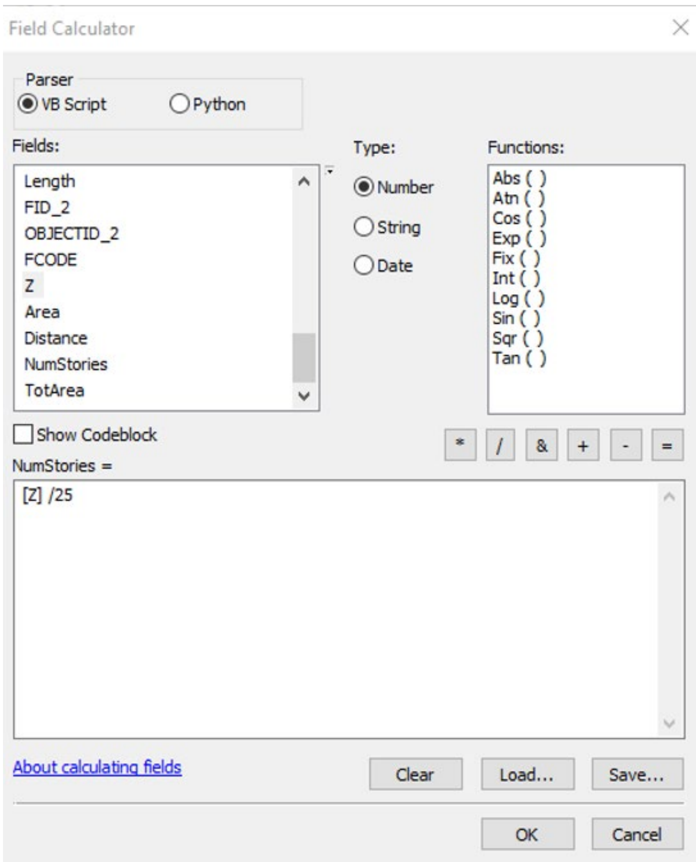
20. To figure out how the number of stories a school has, we'll check a few of the buildings using Google Street View. Let's look at Salem Elementary School first. Go to Google (www.google.com) and type in: 3961 Salem Lakes Blvd, Virginia Beach, VA. A map will come up in the search results. Click on the Street View.



21. The elementary school is a single-story structure and has a Z value of 36'. Let's check another building. Go through the same process for Bayside High School, it has a Z value of 53'.

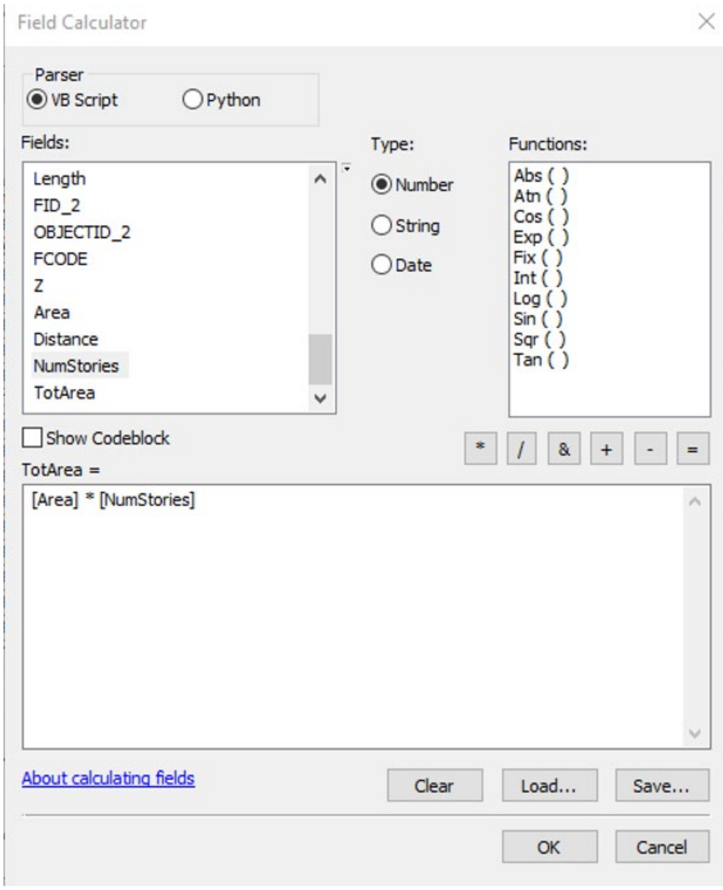
22. The image looks like a two-story building. Using these two images and corresponding Z values, we can use a value of around 25' per story to determine number of stories. If you have a small number of schools, it would be worth identifying each number of stories using Street View. These images also help to verify the foundation types and first floor heights.

23. Open the Schools layer attribute table, right click on NumStories and select Field Calculator and then Yes when the warning comes up. Double click on Z and then / and then 25. Then click OK at the bottom.

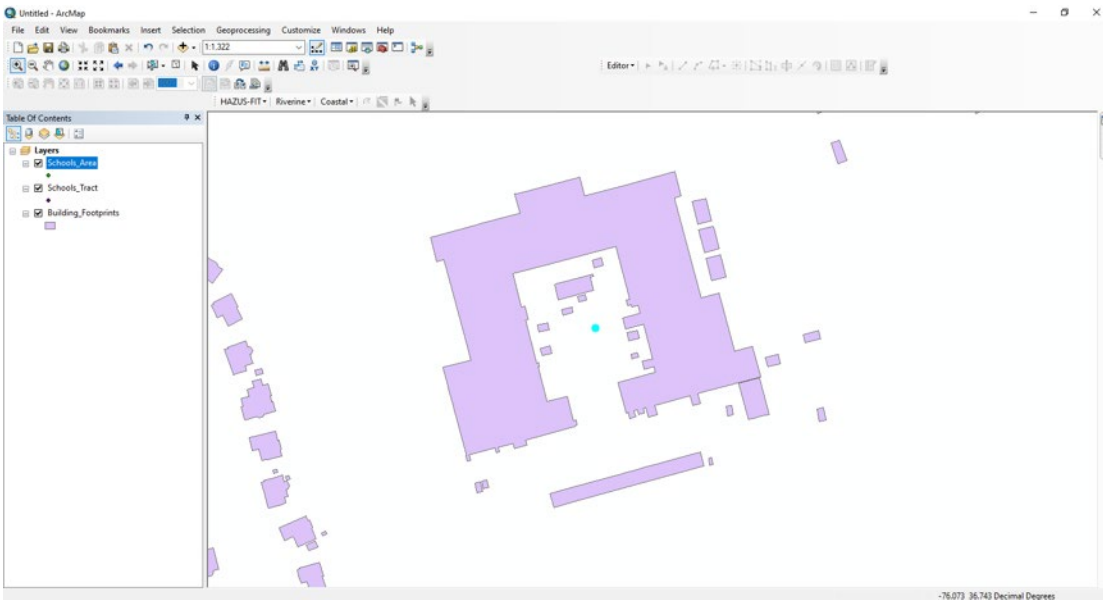


24. Confirm that all the school rows have a value for NumStories. You'll see that one school didn't have a Z value and now has a zero NumStories value. We'll need to assign a number of stories to the school. Since it is only one school, we can google the school (Old Donation School) and see it on Google Street View. It looks like it is a three-story school so we'll edit the table and add a three. Street View is a great source to help confirm building characteristics.

25. To calculate total area, right click on the TotArea heading and select Field Calculator and then Yes when the warning comes up. Click Clear to remove the previous entry. Double click Area and then click *, and then double click NumStories. Click OK.



26. The TotArea field should be populated with values greater than zero. Do a quick quality control check on the values before moving on. Did you find a suspect value? The Technical and Career Education Center is way too small to be a school, something is wrong with that entry. Zoom into that point. Do you see the issue? There are several small outbuildings inside the larger building horseshoe footprint and one of the outbuildings got assigned to the point. Since we only have one issue, it is easy enough to edit that one value.



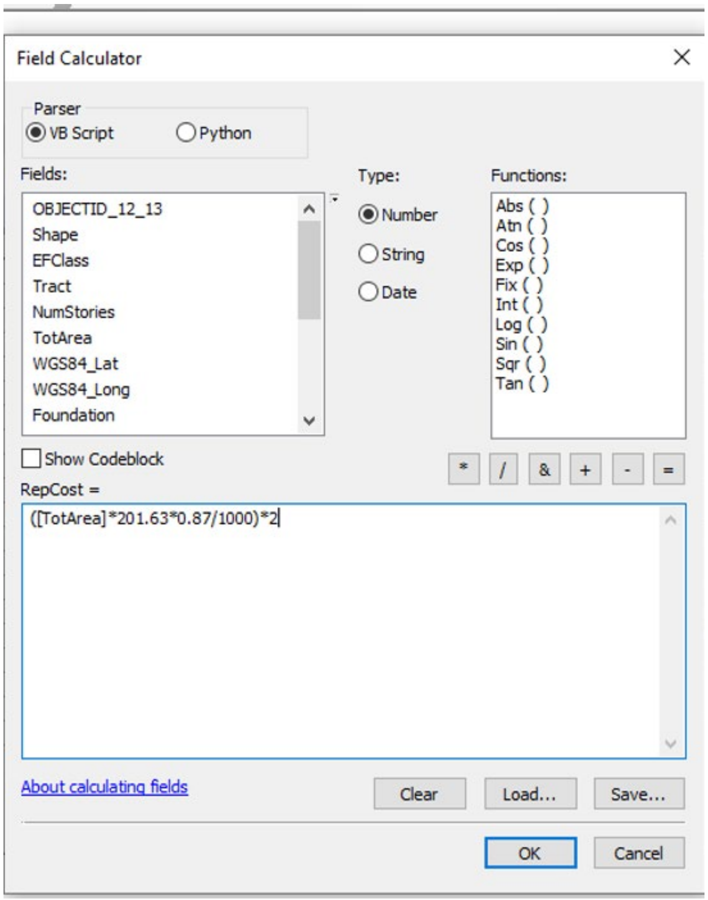
27. Use the Identify Tool to select the larger footprint. You'll find that the area is 119,795 square feet and the Z value is 38.45 feet which would indicate a two-story building. Multiplying the footprint by the number of stories would produce 239,590 total square feet of area. Add these values to the Schools_Area attribute table.

Z	Area	Distance	NumStories	TotArea
36.060001	72097.789927	37.682303	1	72097.789927
36.779999	17090.75121	0	1	17090.75121
37.369999	74699.289777	0	1	74699.289777
36.189999	66958.06123	0	1	66958.06123
34.02	71226.705394	0	1	71226.705394
32.939999	5372.120759	0	1	5372.120759
34.32	71795.122985	8.15881	1	71795.122985
35.099998	83205.981533	0	1	83205.981533
37.040001	60844.740596	4.789135	1	60844.740596
38.45	119795	45.943718	2	239590
42.130001	66863.928768	0	2	133727.857536
39.799999	83793.810499	0	2	167587.620998
45.18	77492.96808	0	2	154985.936161
53.810001	75064.477611	0	2	150128.955221
44.880001	188624.658581	0	2	377249.317162
41.759998	60454.431821	0	2	120908.863641
47.509998	68400.14925	0	2	136800.2985

28. Now that we have the total area, we can use it to calculate cost. Open the Essential Facility Tool Excel spreadsheet and look at the RSMeans replacement cost in Section 2. Since all of our data is EFS1, we are going to use one value: $201.63/sqft. If we had EFS2 data as well, we

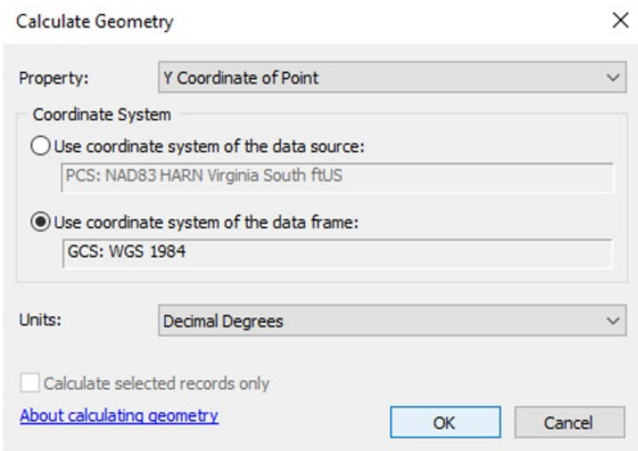
would need to run two queries to get the cost value. This RSMeans value is the national average and a regional multiplier is required. Open ArcCatalog (not the ArcCatalog accessed from ArcMap but the full version found in the ArcGIS folder) and browse to the state data and find the table called VA.dbo.hzMeansCountyLocationFactor. We know our county's FIPS code since it is attached to our data as the field CountyFips (it was added when we joined the Census Tract data to the school data). The county FIPS for Virginia Beach is 51810. Click on the table and then select the preview tab at the top. Browse through the data until you find the 51810 row and see the MeansAdjNonRes value of 0.87. This is the non-residential adjustment value from the national average.

29. Now we have all the information we need to calculate the replacement cost. Keep in mind for essential facilities, the replacement cost equals the structure and content value combined. This is different than UDF which has a separate field for contents. Review the Essential Facilities Tool, schools tab, Section 2 and notice that the content values are 100% of the replacement value for EFS1. Add a new field called RepCost and make the data type double. Right click on the RepCost column header and select Field Calculator. Click on Yes when the warning comes up. Double click on TotArea, then click on *, type 201.63, then click on *, and type 0.87. Hazus requires the replacement cost to be in thousands of dollars, so we'll divide by 1,000. To include the content values too, we'll multiply everything by 2 (since replacement cost is structure and content value combined, and they are equal to each other for EFS1). Click OK at the bottom of the screen.



30. The RepCost field should be populated now. Double check to make sure all values are populated and reasonable. For those using their own data, there are other places to get the square footage values. If you have parcel data with the square footage, you can do a spatial join with the parcel data and use the square footage directly without having to calculate number of stories or footprint areas. Also, building footprints have been released by Microsoft for the entire U.S. They can be found on GitHub (https://github.com/microsoft/USBuildingFootprints). Your computer lab should have ArcPro which you can use to convert the json format into an ESRI-ready format. Another option to find area is to use number of students. Area could be based on the total number of students, faculty and staff multiplied by the FEMA P58 peak day square footage estimate for EFS1 (71.4 sqft/person) and EFS2 (83.3 sqft/person) located in the cdms_AEBMParameters table. Number of students can also be found in the HIFLD data or at the U.S. Department of Education Data and Statistics website.

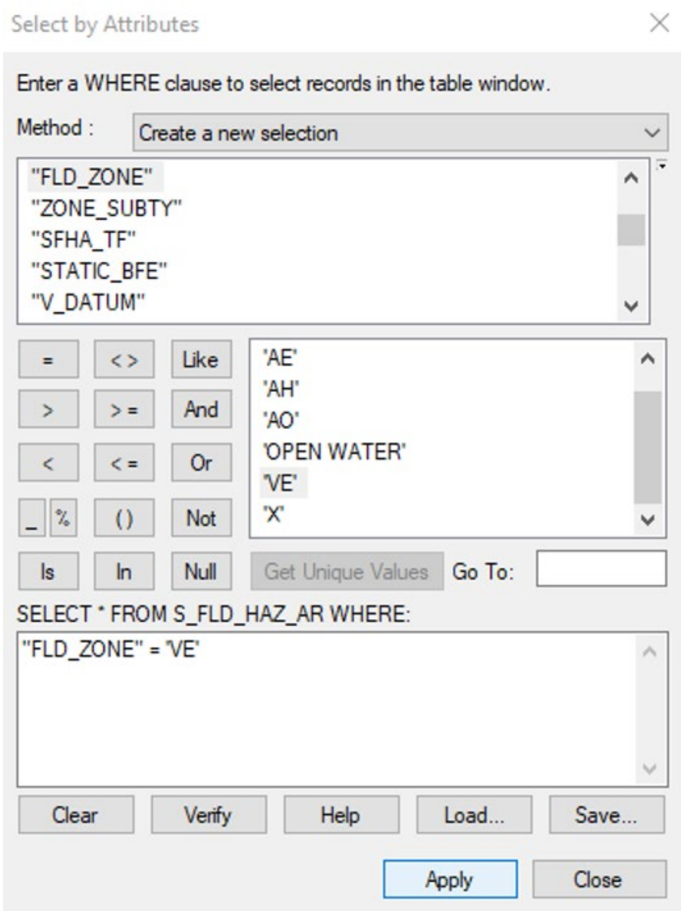
31. Now that the replacement cost has been calculated we need to identify the latitude and longitude in WGS84 decimal degrees. Right click on the map and select Data Frame Properties and then select the Coordinate System tab. Select the GCS_WGS_1984 coordinate system and click OK. Now open the Schools_Area attribute table and add two more fields called WGS84_Lat and WGS84_Long and make them both double for data type. Right click on the WGS84_Lat column header and select Calculate Geometry and select Yes when the warning message comes up. Set the Property to Y Coordinate of Point, the Coordinate System to GCS: WGS 1984, and units of Decimal Degrees. Click Yes when the warning comes up.



32. Now use Calculate Geometry to populate the longitude field using X Coordinate of Point. Verify that both WGS84_Lat and WGS84_Long fields are populated.

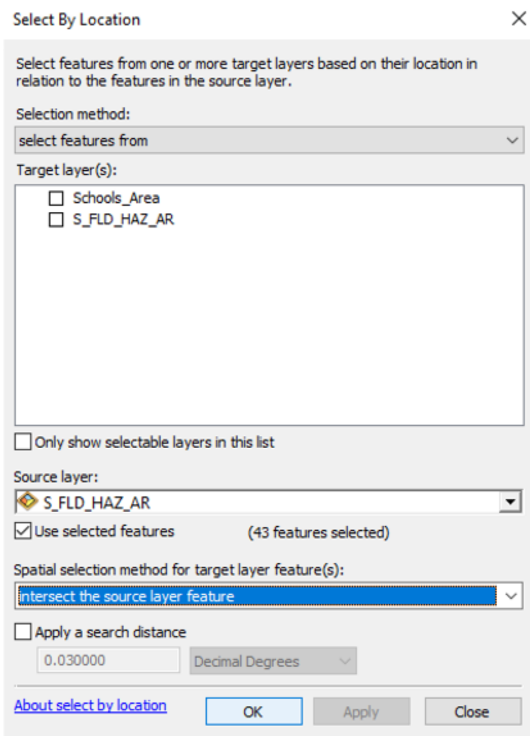
33. Because the City of Virginia Beach is on the coast, we are going to determine if any of the schools are in the coastal V zone. This information will help us determine which first floor height to use in Step 8 and which depth damage functions to use in Step 9. The FEMA Map Service Center has the floodplain information you'll need if you're using your own data. The Virginia Beach floodplain data has already been downloaded and can be found here: C:\E0177\Activity\4.1\VirginiaBeach\515531_20160229\. If you are using your own data, go to MSC (http://msc.fema.gov), click on Search All Products; then select your state, county, and community; and Search. Click on Effective Products and NFHL Data-County, then click on the DL button on the right.

34. Remove the building footprints from the map and add the S_FLD_HAZ_AR.shp file from the C:\E0177\Activity\4.1\VirginiaBeach\515531_20160229\ folder. This is the special flood hazard area and depicts the different flood zones. Open the attribute table for the S_FLD_HAZ_AR file and left click on the top left button. Click Select by Attributes, then double click on "FLD_Zone" then click = and Get Unique Values. Double click on 'VE' and then Apply. In some areas, it would be necessary to add the 'V' zone to the query as well. For Virginia Beach, we only have the VE coastal zone.



35. Part of the floodplain should now be highlighted. Now we need to determine if any of the schools are in the floodplain. Click Selection from the top menu, and then Select by Location.

36. For selection method, click select features from; for Target Layer(s):, select Schools_Area; for Source Layer, select S_FLD_HAZ_AR; click on the Use selected features box; and under Spatial selection method for target layer feature(s): select intersect the source layer feature. Click OK.



37. The query should come back empty. There shouldn't be any schools in the VE zone. If your data has schools in the V or VE zones, you'll need to add a field called "Zone" and populate those schools in the coastal zone as "V".

38. The next step is to determine the foundation type and first floor height. Some parcel data has foundation type in it, and some parcel data identifies whether the building on the parcel has a basement. If you have access to this information, use that data to determine the foundation type. For schools, we are going to assume slab on grade. Open the Essential Facility Tool Excel spreadsheet and go to Section 3. Because all of our schools are in the A flood zone or not in the floodplain at all and since they are all slab on grade, we are going to use the value 7 for foundation type and 1 for first floor height. These values can be found in the table.

39. Create two fields called Foundation and FFH_ft. Foundation should be a text field with a length of 1. If you forget the correct formatting, feel free to reference the Essential Facility Tool Excel spreadsheet. FFH_ft should be created as a double type. Right click on the Foundation header and click Field Calculator. Select Yes when the warning comes up and type 7 in the input box. Then click OK.

40. Now do the same thing with the FFH_ft field but assign it a value of 1. If any of the schools have flood protection, you'll need to add a field called FloodProt with data type short integer and put the return period in the field. If a building is protected up to 100-year events, put a 100 in the field.

41. This step is only for those users who have schools in the coastal flood zone. For the Virginia Beach example, this step may be skipped and you should proceed to Step 42. If you have a school in the coastal flood zone, create two additional fields called StrDDF and ContDDF. Query

on all the schools which fall in the coastal zone and assign them a value of 649 for structural and 483 for contents.

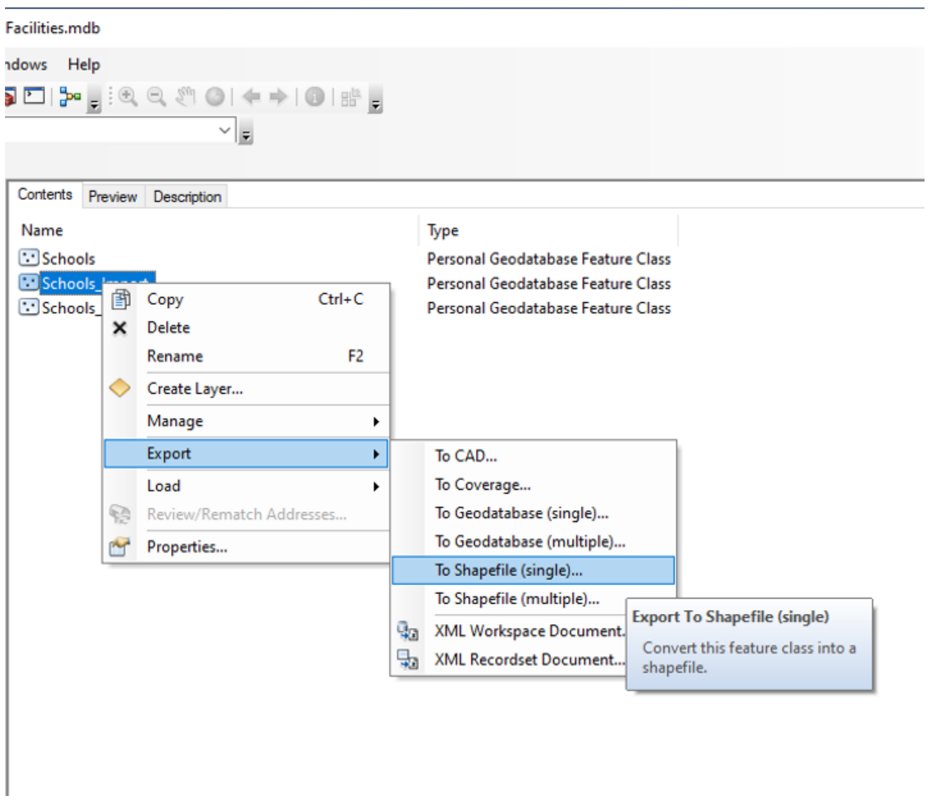
42. Now review the final import file before using CDMS. Remove the schools layer from ArcMap and then open ArcCatalog. Browse to the EssentialFacilities.mdb geodatabase and click on it. Select Schools_Area, right click on it and select Rename. Rename it to Schools_Import.

43. Add Schools_Import to ArcMap and delete the following fields: ObjectID_12, ObjectID, FID_1, Fullname, schType, Sp_Code, Website, Pdf, ObjectID_1, CountyFips, BldgSchemesID, Tract6, TractArea, NumAggrBocks, CenLat, CenLongit, Length, FID_2, ObjectID2, Fcode, Z, Area, and Distance.

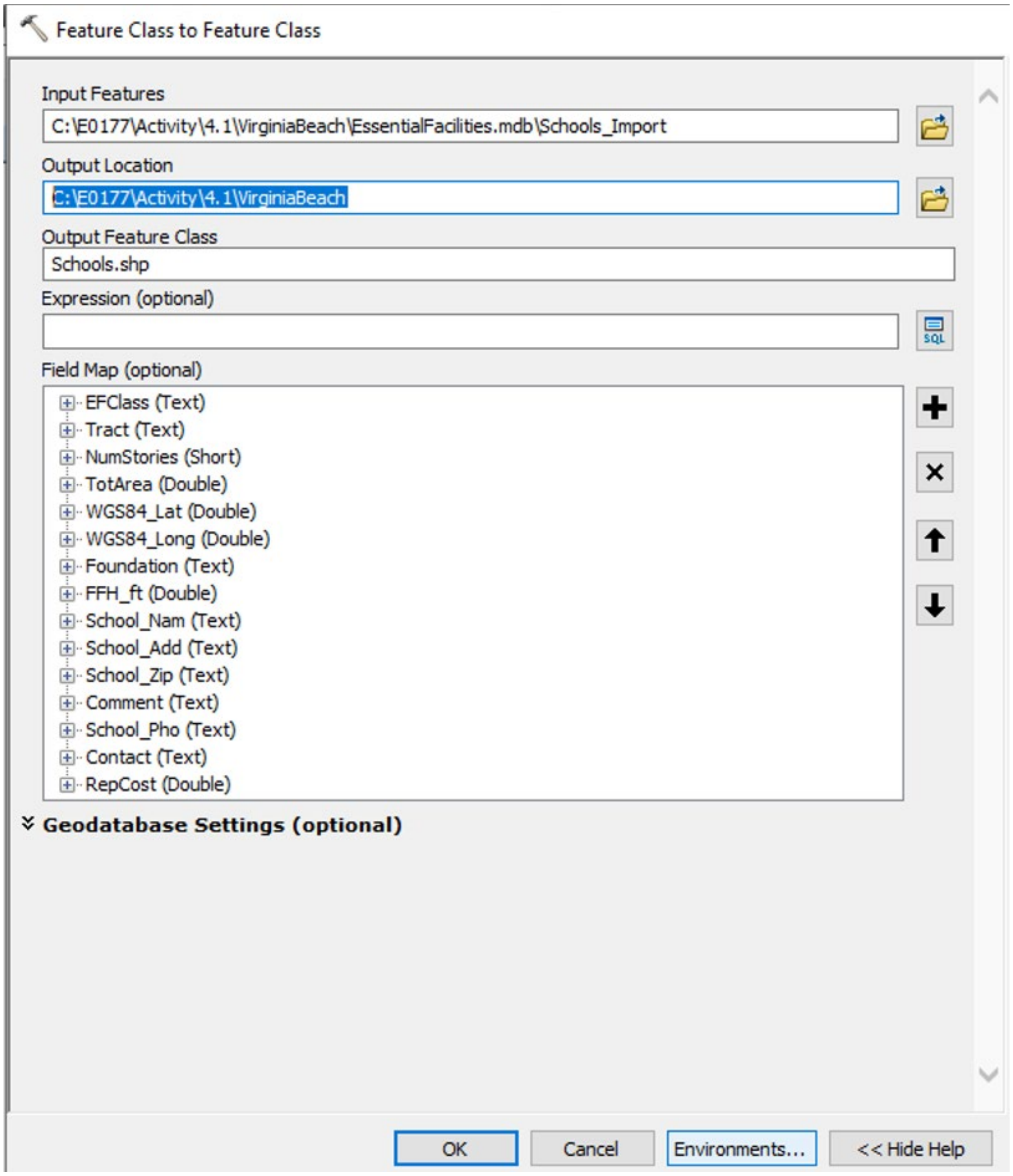
44. Several of the existing fields are not formatted correctly and will cause CDMS to fail if we try to import the data. Create the following fields: (1) School_Name (text, 40); (2) School_Address (text, 40); (3) School_Zip (text, 10); (4) Comment (text, 40); (5) School_Phone (text, 14); and (6) Contact (text, 40).

45. Now populate the new fields. Use the Field Calculator to set the School_Name value equal to School, School_Address equal to Address, School_Zip equal to Zip, Comment equal to Sch_ID, School_Phone equal to Phone, and Contact equal to Email. Now delete School, Address, Zip, Sch_ID, Phone, and Email.

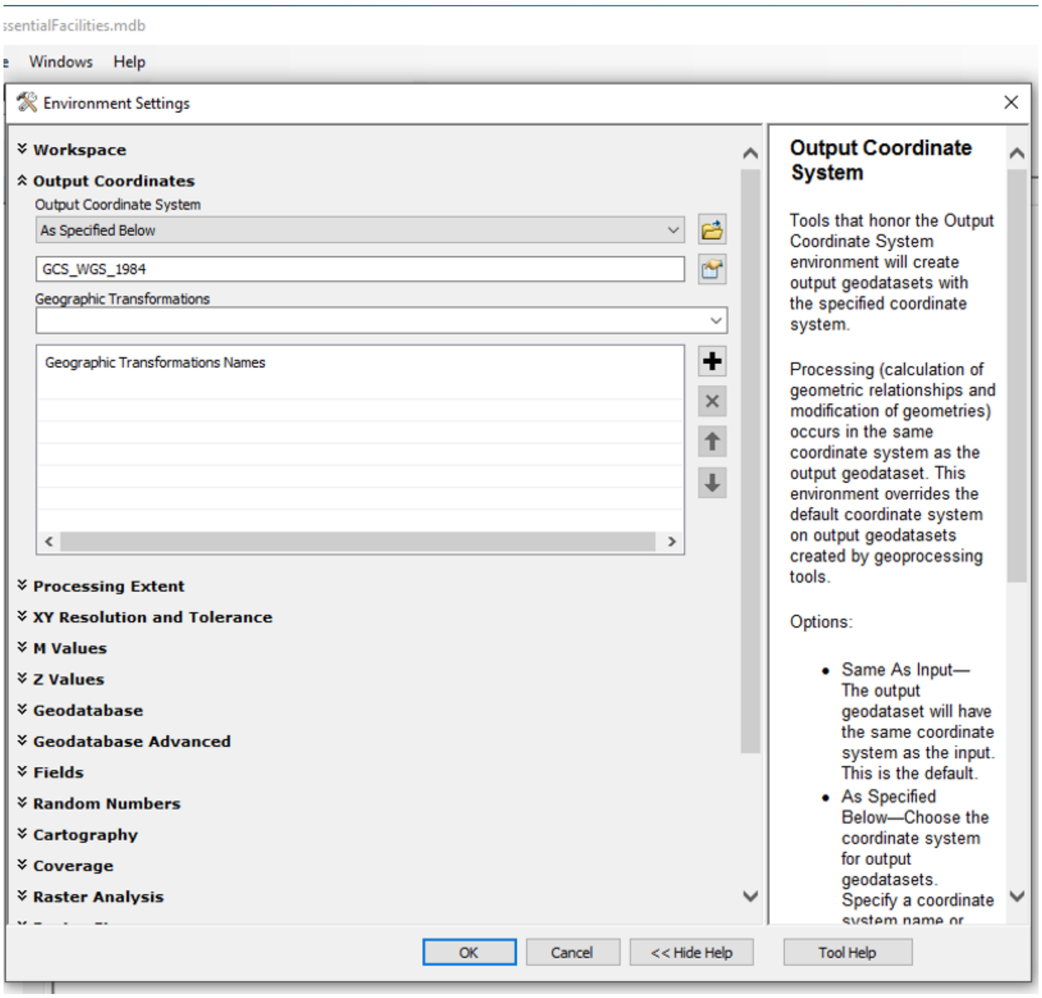
46. Unfortunately, the current version of the CDMS software has a defect importing personal geodatabases for essential facilities so we will convert the data into a shape file. Close ArcMap and open ArcCatalog. Browse to the EssentialFacilities.mdb geodatabase, then right click on the Schools_Import feature class and then click Export then to Shapefile (single).



47. Under Output Location browse to: C:\E0177\Activity\4.1\VirginiaBeach and under Output Feature Class type: Schools. Then select Environments at the bottom of the menu.



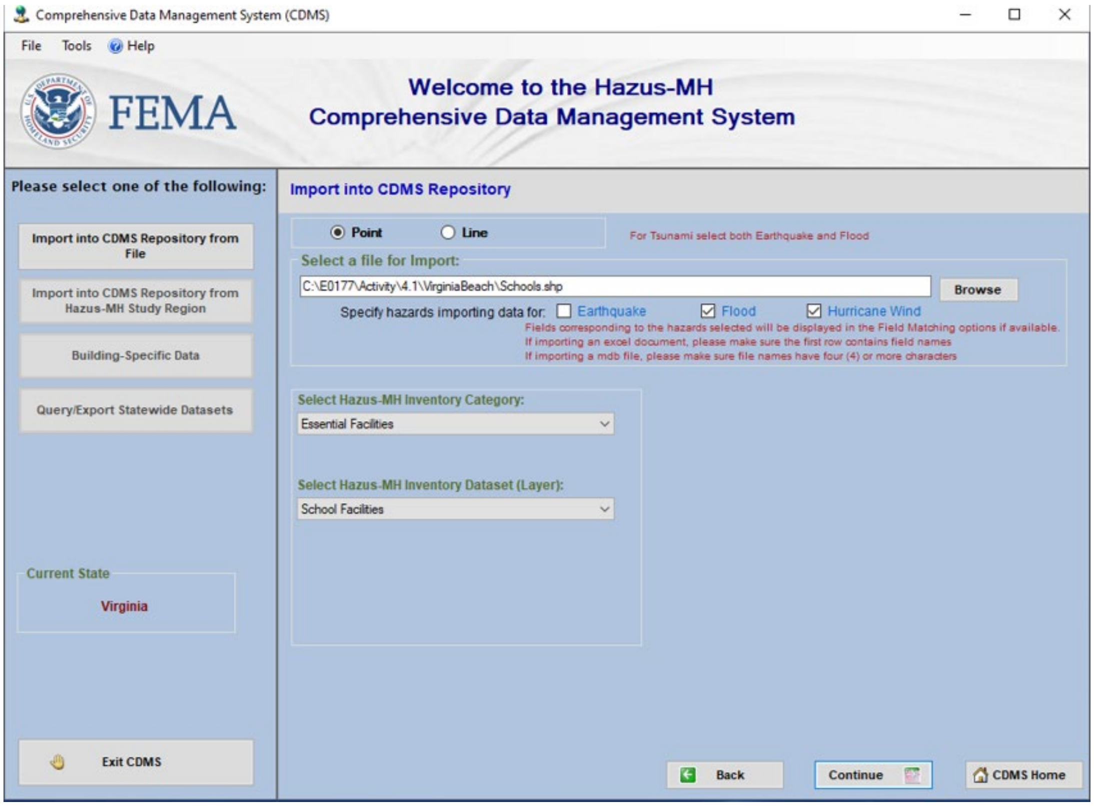
48. Under Output Coordinates, select As Specified Below then click the icon to the right of the white space to select the coordinate system. Select GCS_WGS_1984 and then OK. Then click OK again.



49. Then click OK one more time. After a few seconds of processing, there should be a new shapefile called Schools.shp in the VirginiaBeach folder. Close ArcCatalog.

50. Now use CDMS to bring in the school data. Open CDMS. Go to Tools and then Specify Hazus-MH Data Location. Browse to the Virginia data and click on the VA folder (this is the state database located in the Inventory folder). Then click OK and OK again. Note: If the CDMS menu is cut off, please change your computer's screen resolution or ask an instructor to help you.

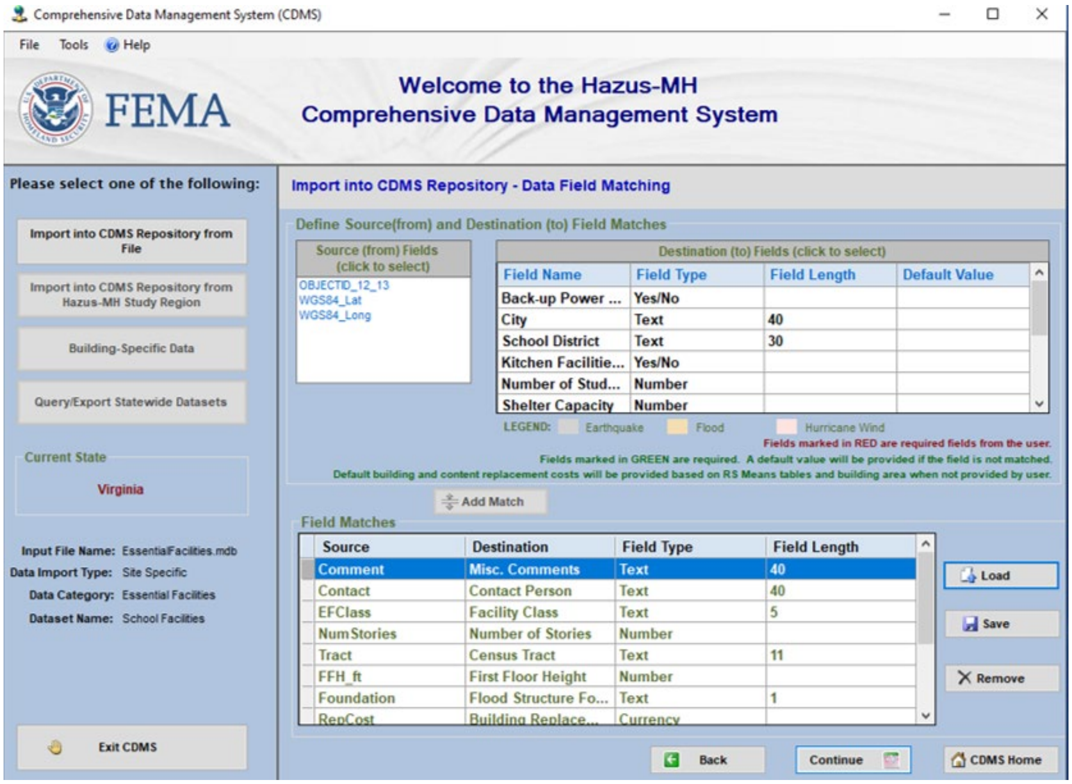
51. Select Import into CDMS Repository from File on the left side of CDMS. Unselect Earthquake. Then click Browse and find the Schools.shp file (you'll need to change the file type). Under Select Hazus-MH Inventory Category: select Essential Facilities, then under Select Hazus-MH Inventory Dataset (Layer): select School Facilities.



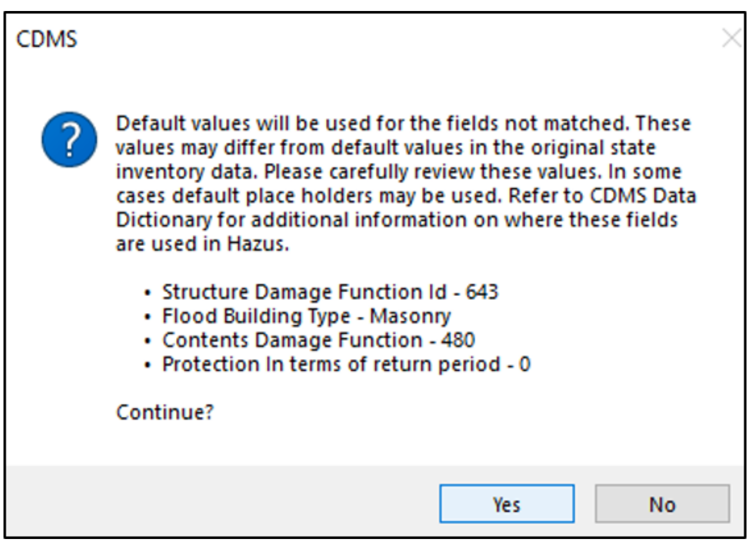
52. Select Continue. Under Select Import Table: Schools will be selected and under Select HAZUS-ID Field** (if available): select No Hazus ID. Click Continue.

53. Match the fields from Schools data to the Hazus fields. Match the following:

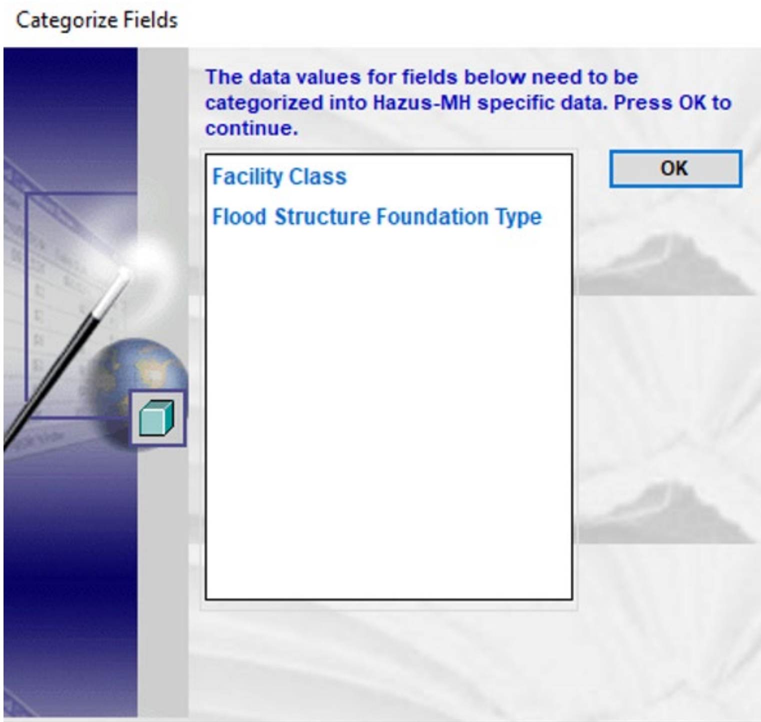
- FFH_ft -> First Floor Height
- Foundation -> Flood Structure Foundation Type
- RepCost -> Building Replacement Cost (thous. $)
- School_Add -> Address • School_Nam -> Facility Name
- School_Pho -> Phone Number • School_Zip -> ZIP Code
- TotArea -> Area (Sq feet)



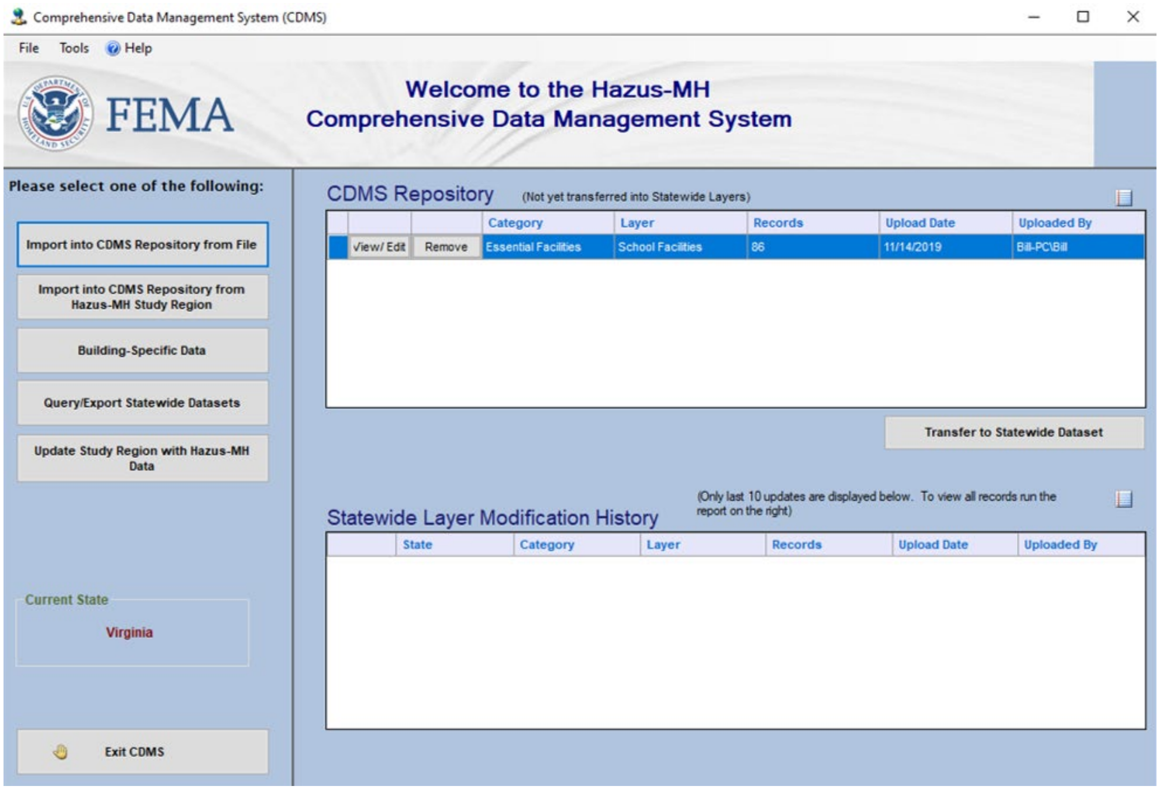
54. Click Continue. The following message comes up:



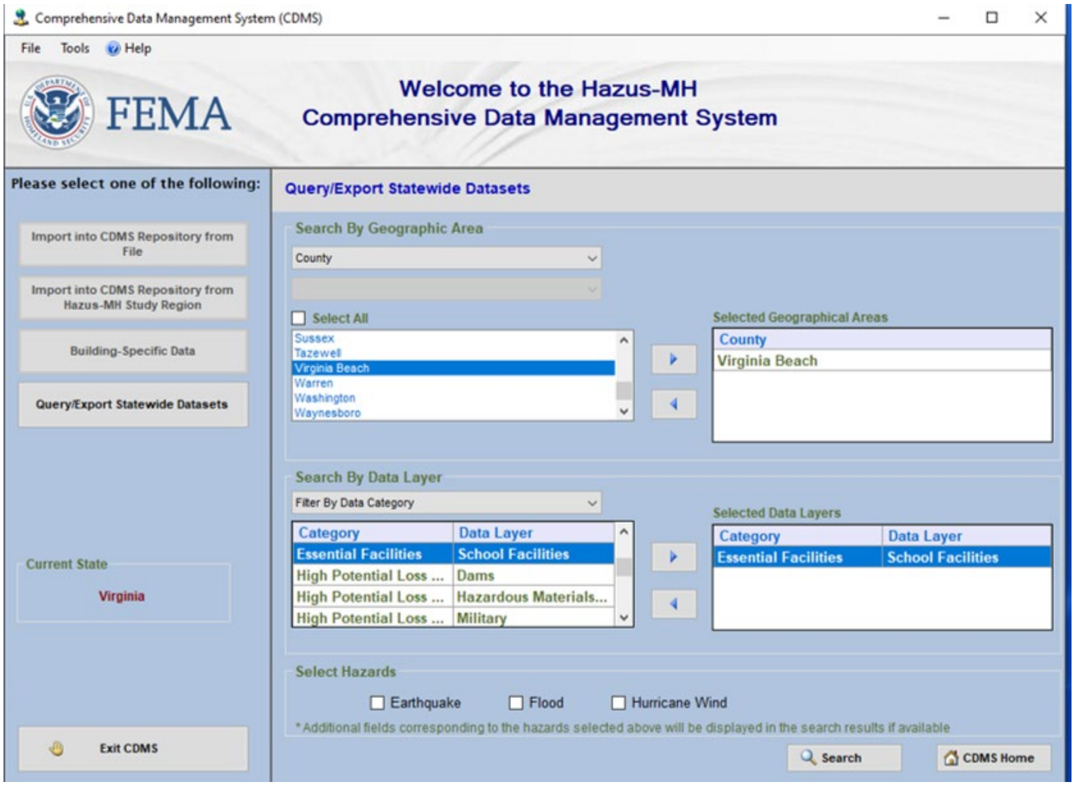
55. Click Yes. Then the Categorize Fields menu comes up.



56. Click OK. Then click Continue when the Facility Class categorization comes up and Continue when the Flood Structure Foundation Type categorization comes up. CDMS will process for several seconds and the Import Success message should come up. Click OK. The school data should show up in the CDMS Repository.



57. Before you update the state data, let’s get rid of the existing data. Select Query/Export Statewide Datasets on the left. In Search by Geographic Area, select County, then select Virginia Beach in the list of Counties/Cities, and click on the right arrow. Under Search By Data Layer, click on Essential Facilities and School Facilities, and then select the right arrow.



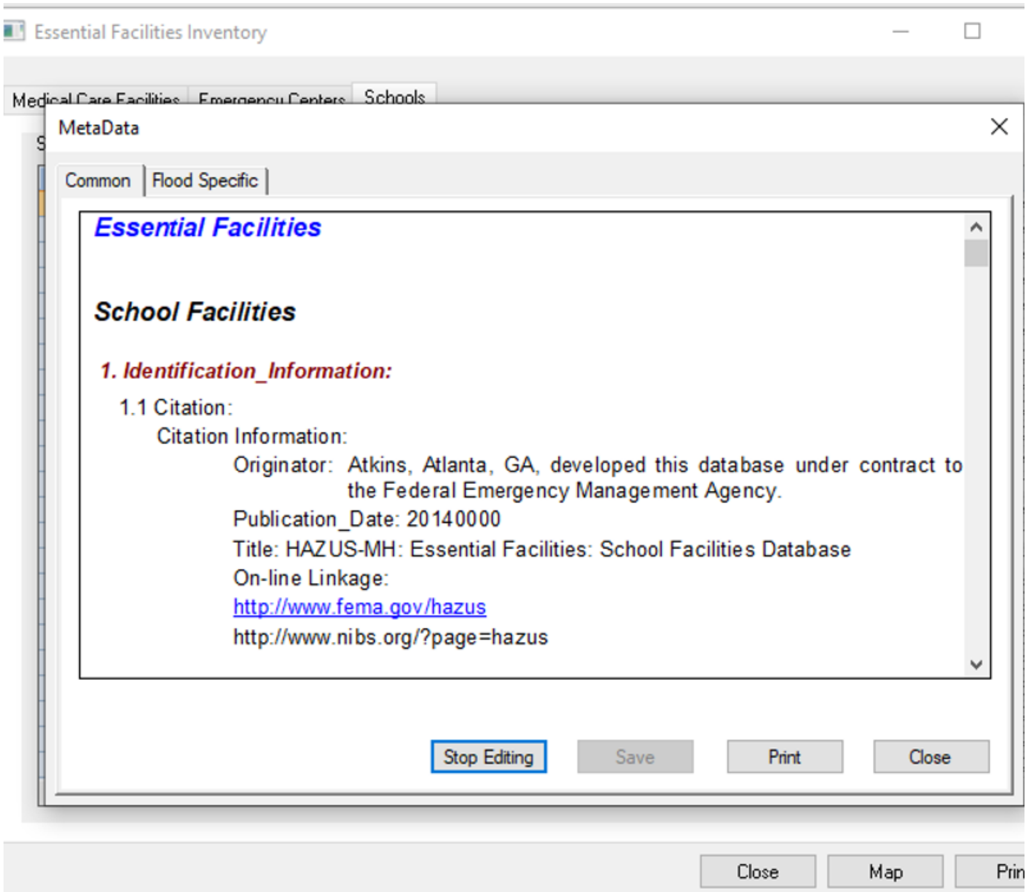
58. Click Search. The query will provide all the existing school data. Select Delete All Records for Selected Inventory. Click Yes when the warning message comes up. Then click CDMS Home. Now click Transfer to Statewide Dataset. Then select Replace Data and Submit. Finally, select Yes when the warning message comes up. Close CDMS.

59. Create a new study region. Create a flood and hurricane study region for Virginia Beach, Virginia and call it VA_Beach_FL_HU. After Hazus aggregates the region, open the flood hazard. Select Inventory and then Essential Facilities. Click on the Schools tab. There should be 86 schools in the table and the fields you brought in using CDMS should be populated. Switch to the hurricane hazard and open the school inventory table. Hazus adds a field called Wind Building Scheme Name and populates that field based on the location of the study region. This data does not reside in the state database, but does reside in the study region database. If you want to make changes to a large set of essential facilities at once, establish a connection to the study region – VA_Beach_FL_HU and browse to the table called VA_Beach_FL_HU.dbo.huSchool and edit the data there. More information on updating SQL tables in ArcCatalog is presented in Application 3.

Task 4: Document Updated Inventory

1. Document the edits you made. For essential facility edits, browse to the school table, right click in the data, and select Meta Data. Click Start Editing at the bottom. Now delete the originator information and add yourself, update the abstract to include a description of where you got the data (source) by consulting the Virginia Beach GIS website, then add information on what you did to the data. How did you calculate cost, etc. When you're done, select Stop Editing.

If you're more comfortable editing this information in Word, go to the study region folder and open this document: C:\HazusData\Regions\VA_Beach_FL_HU\hzSchool_md.rtf.



Essential Facilities Data for Flood and/or Hurricane have been updated.

Application 1: Essential Facilities

Track 2: Earthquake and/or Tsunami

Note that updating the Essential facilities for tsunami is for display purposes only as it is not modeled. To model losses for essential facilities in Tsunami, go to Application 4 and import as UDF.

Task 1: Identify, Collect, and Validate Local Data

1. The first step is to locate the essential facility data. Local GIS websites are good sources of data. For Santa Cruz, the local essential facility data has already been identified and downloaded here: C:\E0177\Activity\4.1\SantaCruz\ and is called General_Plan_Public_Facilities.shp. This data was downloaded from the County's website (https://www.co.santa-

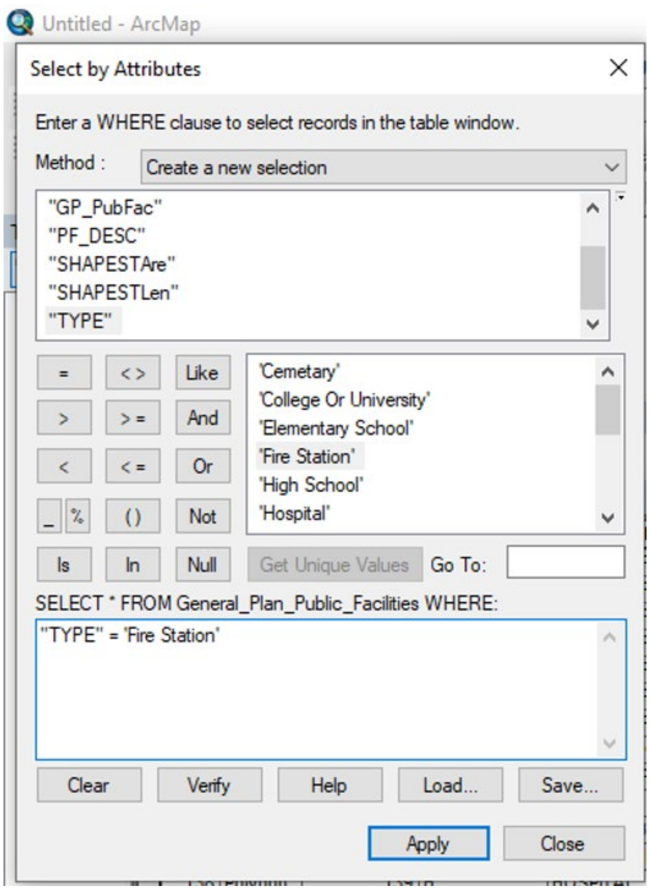
cruz.ca.us/Departments/GeographicInformationSystems(GIS).aspx). It is important to identify the metadata as well. In this case, the metadata is provided on the website above.

To help supplement the existing essential facility data, we're also going to download parcel data. If you don't have this dataset locally, that's okay. Santa Cruz has the data for public download at the link above. This data has already been downloaded and is called assessor_parcels.shp.

2. Create a new study region in Hazus called Temp. The study region should include your county/city and the hazards you want to model. When the study region has been created, close Hazus

3. Open ArcMap and add the general_plan_public_facilities data to the map.

4. Right click on the layer name and select Open Attribute Table. Review the Type field, you'll see fire stations, schools, utilities, and other facilities. In this activity, you are going to update the fire stations for the County. Click on the button in the top left corner and click Select by Attributes. The Select by Attributes menu should come up. For Method, select Create a new selection, double click on "TYPE", then =, and then click on Get Unique Values. Double click "Fire Station" and then Apply.

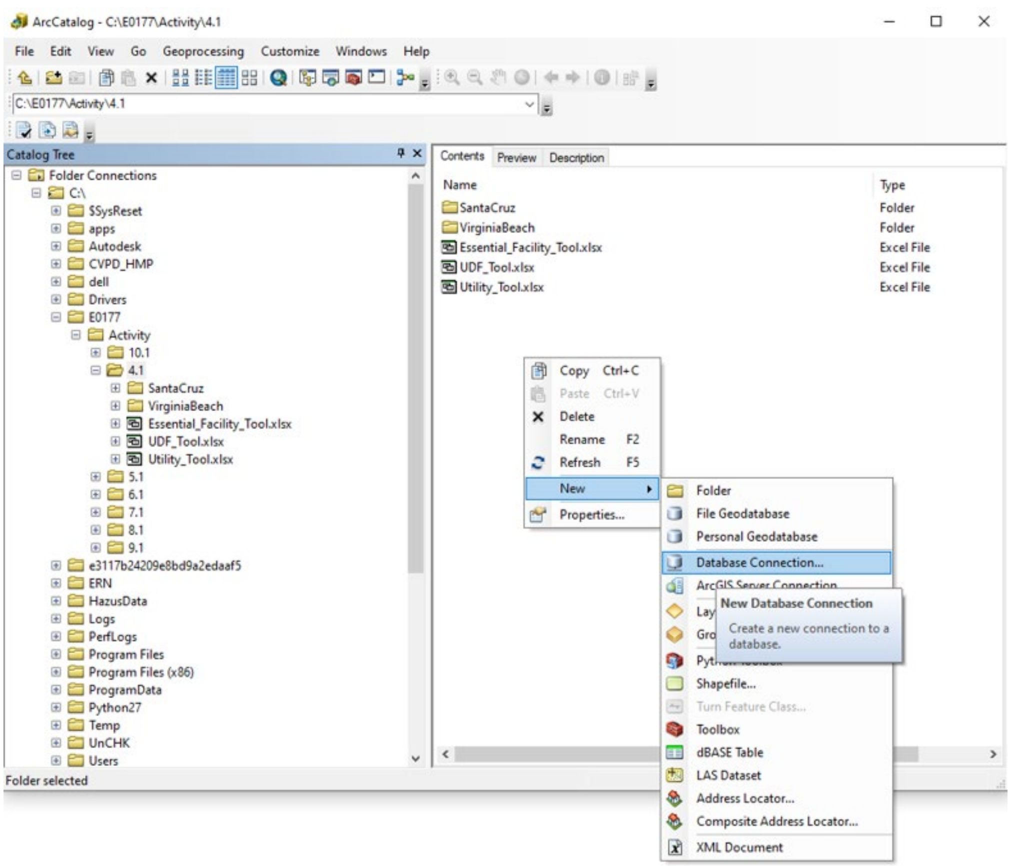


5. Close the attribute table. You'll notice 19 fire stations have been selected. Right click on General_ Plan_Public_Facilities go to Data and then Export Data. Save the selected features as: C:\E0177\Activity\4.1\SantaCruz\FireStations.shp.

6. Click OK. When the warning comes up, click Yes. Remove the General_Plan_Public_Facilities layers.

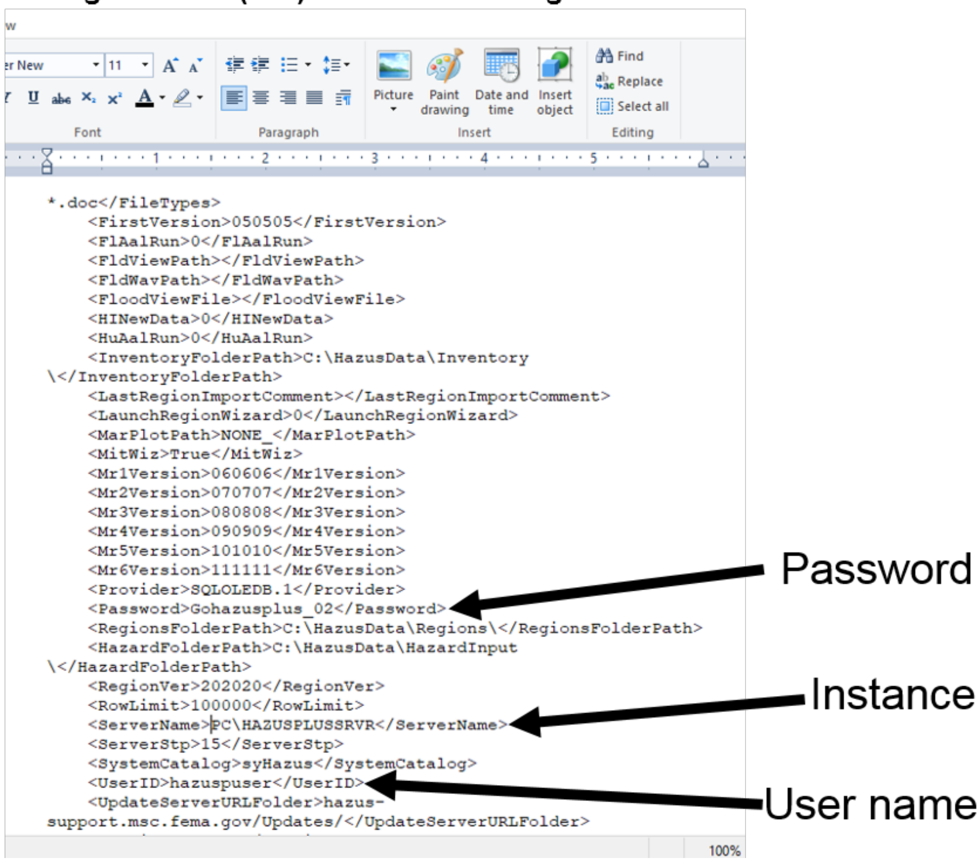
Task 2: Format Data

1. Create a new database connection at C:\E0177\Activity4.1\ using ArcCatalog.



3. To figure out how to populate the Instance, User name, and Password, go to C:\Program Files (x86)\Hazus-MH\Settings.xml and open the file. The information shown in the xml file may be copied from the xml file and pasted into the ArcCatalog interface. The instance includes the computer name which can be long. Your computer name will be different than the example.

C:\Program Files (x86)\Hazus-MH\Settings.xml



```
*.doc</FileTypes>
    <FirstVersion>050505</FirstVersion>
    <FlAalRun>0</FlAalRun>
    <FldViewPath></FldViewPath>
    <FldWavPath></FldWavPath>
    <FloodViewFile></FloodViewFile>
    <HINewData>0</HINewData>
    <HuAalRun>0</HuAalRun>
    <InventoryFolderPath>C:\HazusData\Inventory
\</InventoryFolderPath>
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    <LaunchRegionWizard>0</LaunchRegionWizard>
    <MarPlotPath>NONE_</MarPlotPath>
    <MitWiz>True</MitWiz>
    <Mr1Version>060606</Mr1Version>
    <Mr2Version>070707</Mr2Version>
    <Mr3Version>080808</Mr3Version>
    <Mr4Version>090909</Mr4Version>
    <Mr5Version>101010</Mr5Version>
    <Mr6Version>111111</Mr6Version>
    <Provider>SQLOLEDB.1</Provider>
    <Password>Gohazusplus_02</Password>
    <RegionsFolderPath>C:\HazusData\Regions\</RegionsFolderPath>
    <HazardFolderPath>C:\HazusData\HazardInput
\</HazardFolderPath>
    <RegionVer>202020</RegionVer>
    <RowLimit>100000</RowLimit>
    <ServerName>PC\HAZUSPLUSSRVR</ServerName>
    <ServerStp>15</ServerStp>
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    <UserID>hazuspuser</UserID>
    <UpdateServerURLFolder>hazus-
support.msc.fema.gov/Updates/</UpdateServerURLFolder>
```
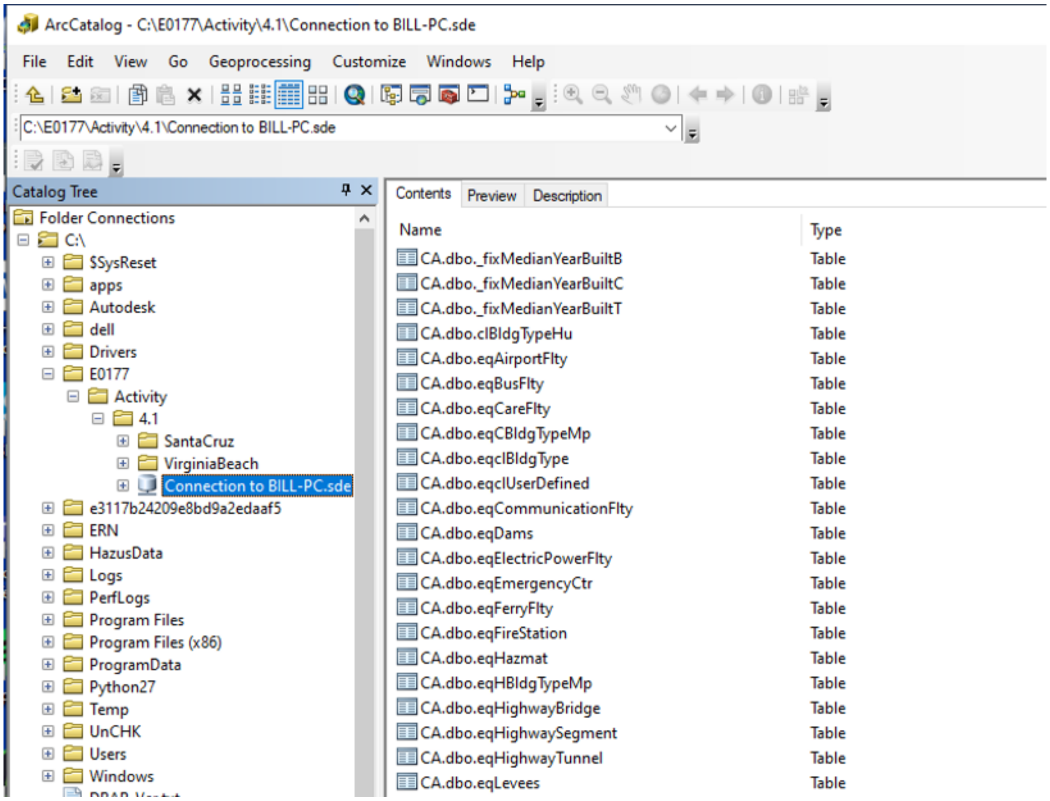


4. Enter the password, instance, and user name into the ArcCatalog interface. Select SQL Server in the top dropdown.

5. Select CA in the database dropdown and then select OK. This will create a database connection with the default name: Connection to PC_Name.sde where PC_Name is the name provided in the instance. Double click on the new connection name to access the Hazus California State data.



6. Reviewing the data in the state database, files that start with eq are associated with the earthquake model, fl is flood, hu is hurricane, ts is tsunami (for tsunami states only), and hz is common across all hazards. For this activity, we are going to focus on earthquake and general data. For essential facilities, the data of interest is:

- EOC – CA.dbo.eqEmergencyCtr and CA.dbo.hzEmergencyCtr.
- Fire – CA.dbo.eqFireStation and CA.dbo.hzFireStation.
- Medical Care – CA.dbo.eqCareFlty and CA.dbo.hzCareFlty.
- Police – CA.dbo.eqPoliceStation and CA.dbo.hzPoliceStation.
- School – CA.dbo.eqSchool and CA.dbo.hzSchool.

7. Right click on CA.dbo.eqFireStation in ArcCatalog, then click Properties. Click on the Fields tab. The data type is provided in the right column. Click on Text next to FireStationID and you'll see the size is 8 characters. All of the tables have already been characterized for you in the Essential Facility Tool found here: C:\E0177\Activity\4.1\EssentialFacilityTool.xlsx.

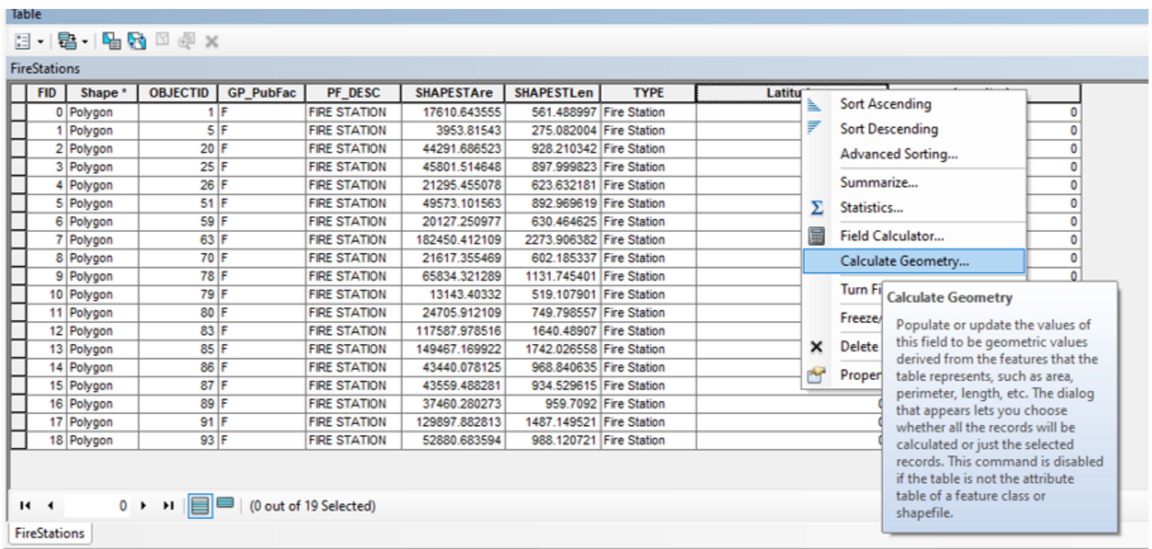
8. Open the Essential Facility Tool Excel spreadsheet and browse to the Fire tab. It will provide information on the field, data type, and whether or not it is required, recommended, or not needed for a Hazus analysis.

Task 3: Update Inventory

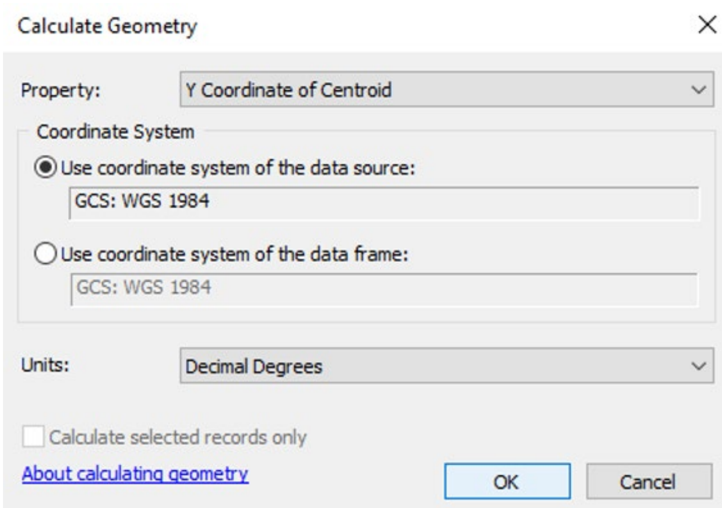
1. In this step, you're going to look at what data is required to run a Hazus analysis, compare it to what you already have, and then make inventory updates. Looking at the Santa Cruz data, we

have very few fields. However, there are several fields in the Assessor_Parcels data we can use. These fields include: Address, City, Zipcode, and Area. We'll still need to format these fields and we'll also need to create the following fields: EFClass, Tract, Cost, Latitude, Longitude, EQBldgType, and DesignLevel. We'll discuss how to find and add soil type, liquefaction susceptibility, landslide susceptibility, and water depth in the next activity. These hazard maps may be added after you've updated the inventory in Hazus.

2. This process will start by creating a point file and joining the parcel data to it. Open ArcMap to an untitled map. Add the following two datasets: FireStations and Assessor_Parcels. Right click on FireStations and click Open Attribute Table. You're going to add two fields, called Latitude and Longitude with a double data type. Next, right click on the new Latitude field and select Calculate Geometry.



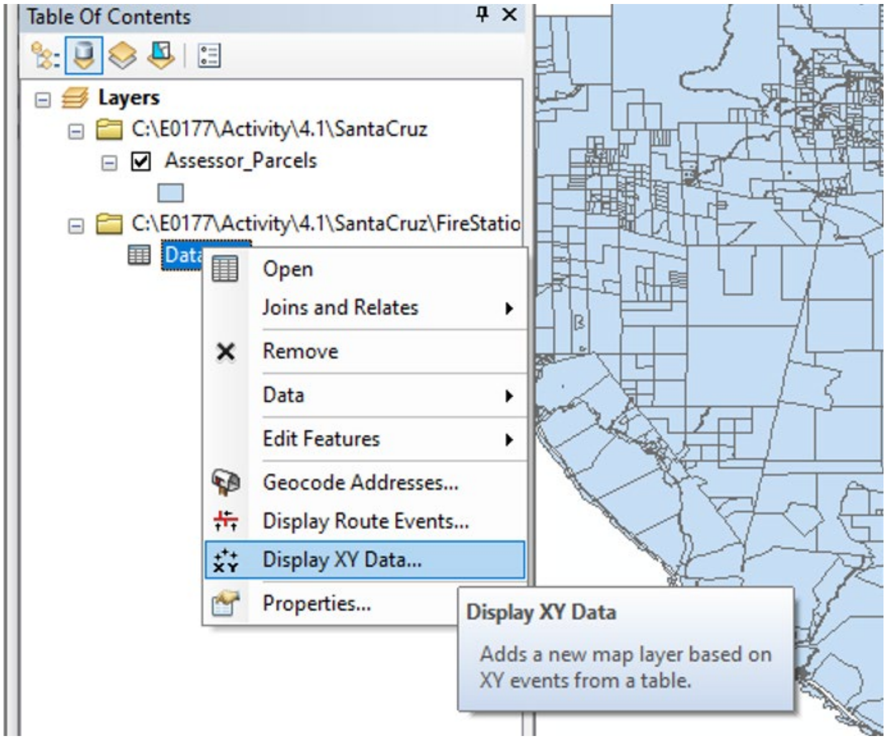
3. Click Yes when the warning comes up. This will be the Y Coordinate of Centroid using GCS:WGS_1984 with units of Decimal Degrees.



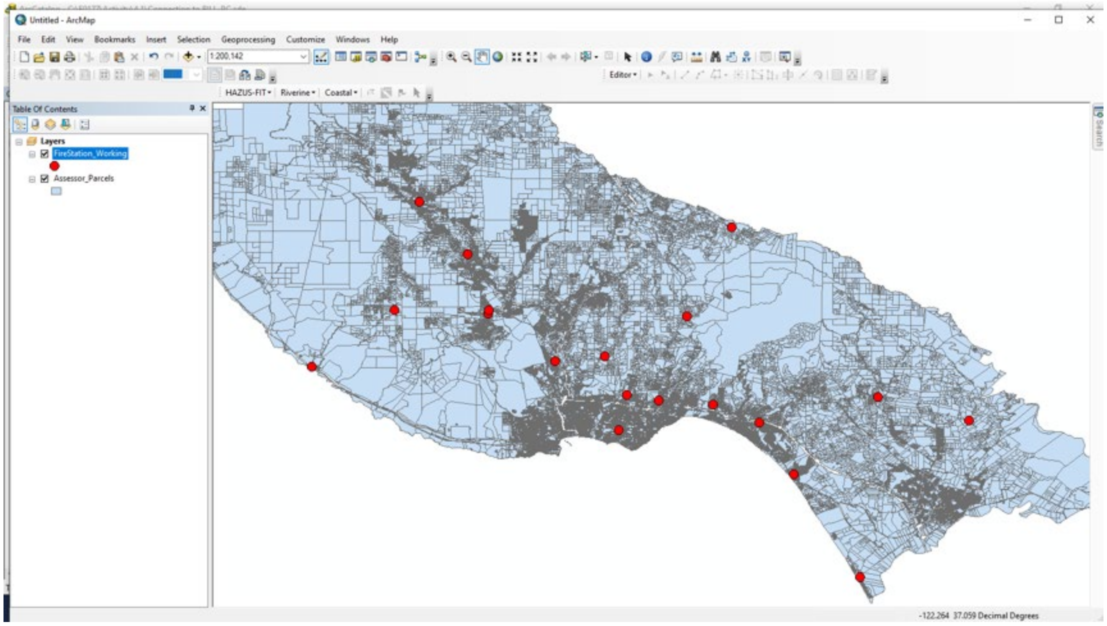
4. Click OK and then Yes when the warning comes up. Do the same thing for the Longitude field but select X Coordinate of Centroid.

5. Remove the FireStations layer. Open the folder which has the FireStations layer in it and open FireStations.dbf in Excel. The file should be here: C:\E0177\Activity\4.1\SantaCruz\.

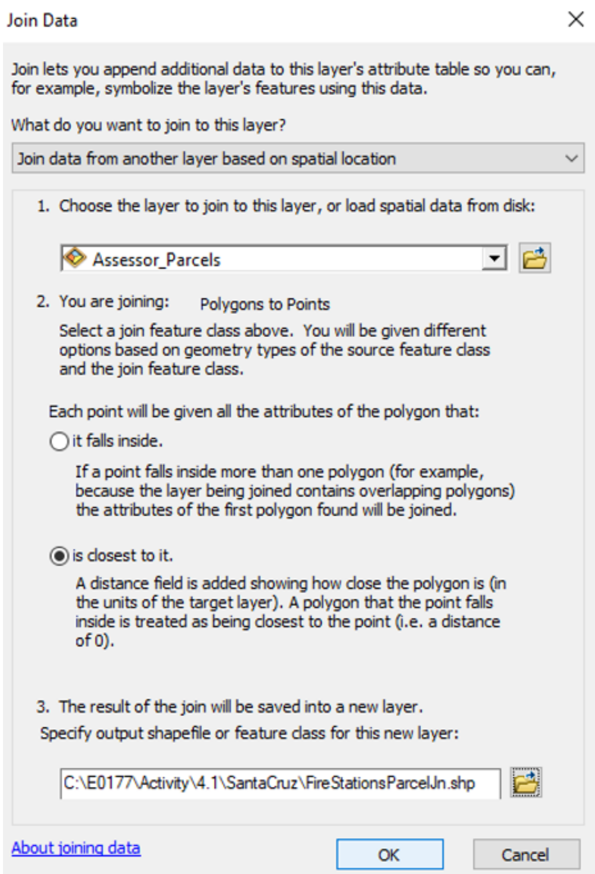
6. Once FireStations.dbf has been opened in Excel. Go to File and Save As and save it as a .xls file call it FireStations.xls. Go back to ArcMap and add the new .xls file to the map. Select the Database Excel Table and click Add. Right click on Database and select Display XY Data.



7. Make sure the X Field is set to Longitude and the Y Field is set to Latitude. Then click OK. Click OK when the warning comes up. Right click on the new layer called Database Events and export this data to C:\E0177\Activity\4.1\SantaCruz\ and call it FireStation_Working.shp. Add it to the map and remove the Database Events and the xls file from ArcMap. You should now have 19 points on top of the parcel layer.

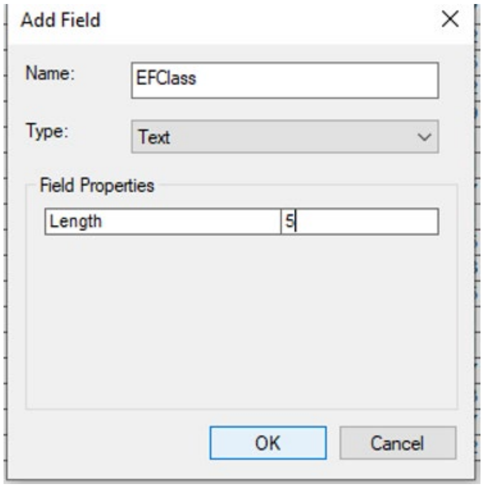


8. Right click on the FireStation_Working layer and select Joins and Relates and then Join. In the top dropdown menu, select Join data from another layer based on spatial location. For the next box, select Assessor_Parcels, then select is closest to it, and finally save the new layer as C:\E0177\Activity\4.1\SantaCruz\FireStationParcelJn.shp. Is closest to it was selected because some of the fire station points might fall between the parcel data polygons.

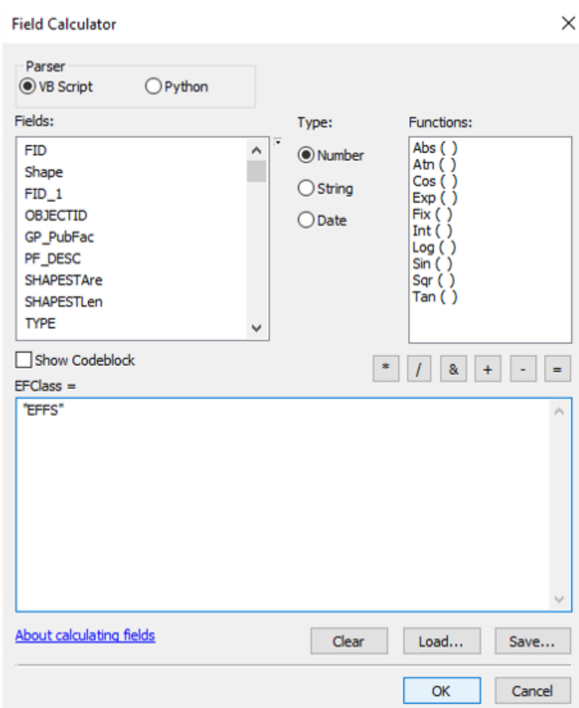


9. Then click OK. Remove the FireStation_Working layer. Open the attribute table of the FireStationsParcelJn layer and make sure that all the fire stations have successfully been joined to the parcel data.

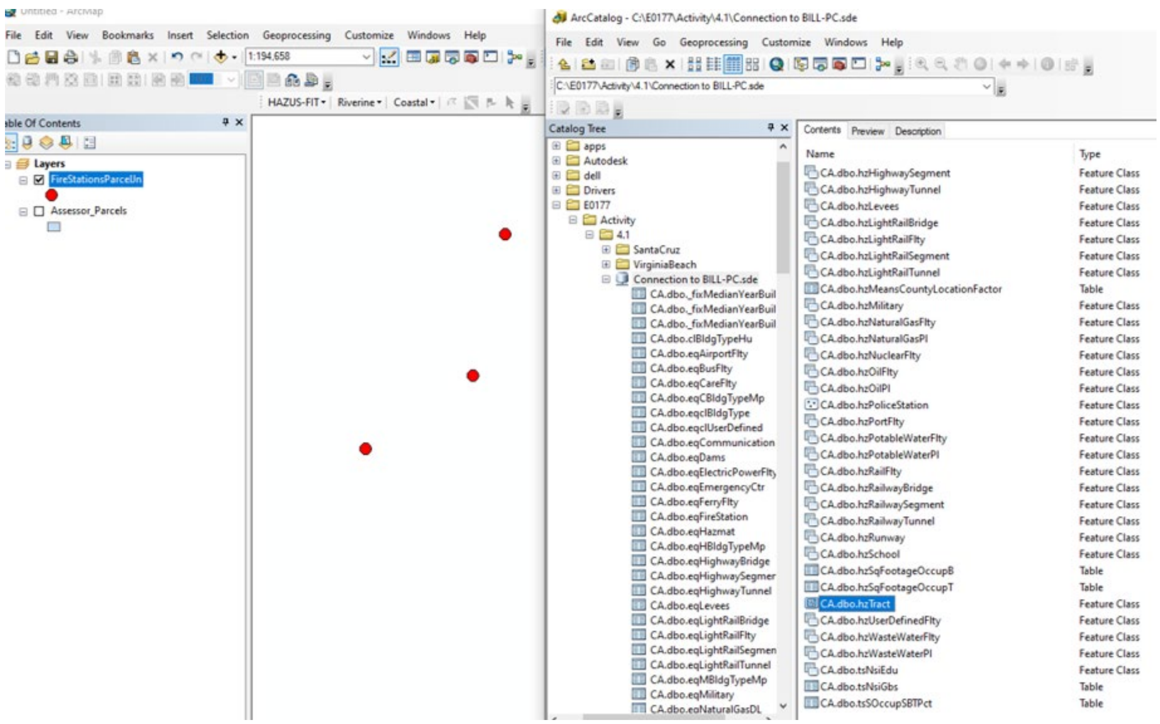
10. Next, create and name a field “EFClass” and make it a text field with a length of 5. Then click OK.



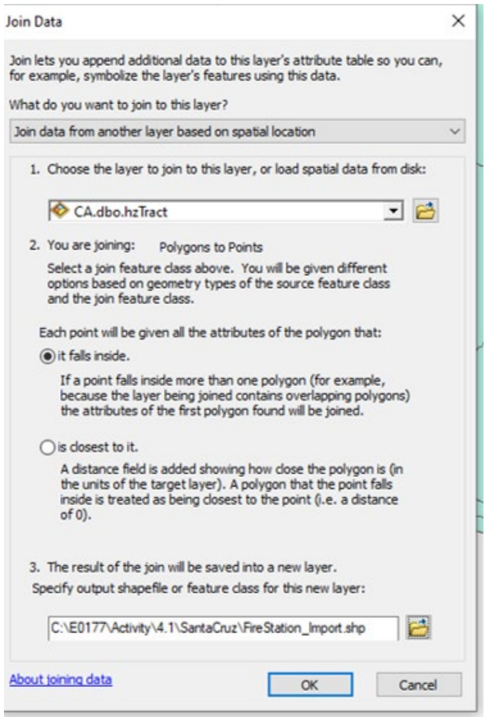
11. Since fire stations all have the same classification code, we'll set the value to EFFS. Right click on the EFClass column header and click Field Calculator. Select Yes when the warning comes up. Where EFClass = shows up, type "EFFS" and then click OK.



12. Next, identify the Tract value for each fire station using a spatial join. Close the attribute table. Open ArcCatalog and browse to the database connection you created earlier. Left click on CA.dbo.hzTract and drag it to the ArcMap table of contents.



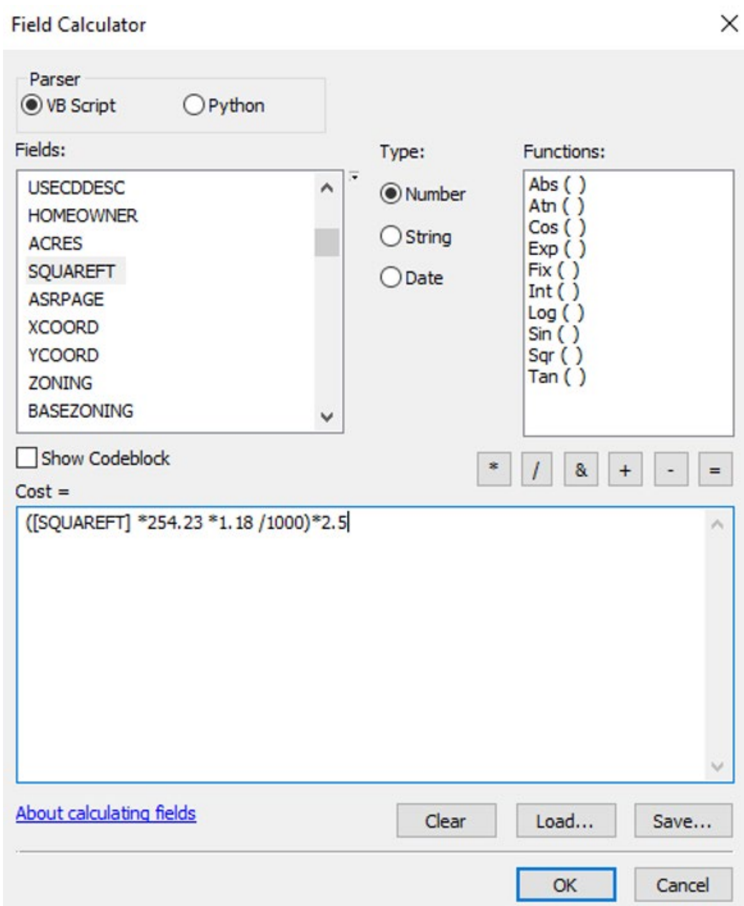
13. Click Close when the Geographic Coordinate Systems Warning comes up. Close ArcCatalog. Right click on the FireStationsParcelJn layer, then Joins and Relates, and Join. In the top drop down, pick Join data from another layer based on spatial location, for item 1 select CA_dbo_hzTract, then it falls inside for item 2, and browse to C:\E0177\Activity\4.1\SantaCruz\ and call it FireStation_Import.shp and click OK.



14. Remove the FireStationsParcelJn, CA.dbo.hzTract, and Assessor_Parcels from the table of contents and open the attribute table of the FireStation_Import layer. Every fire station should now be assigned a Census Tract number, a County FIPS number (which we'll use later in this application), and an EFClass. If your data doesn't have the tract number, you'll need to move the point so that it falls within a Census Tract. This can happen on shorelines or other water bodies where the point has been placed incorrectly or the tract was trimmed too much.

15. Next, create a cost value. Cost is not required for earthquake modeling but it's good to know what the building's economic exposure is to an earthquake event. Also, if you decide to add the fire station data as a UDF for the tsunami model, you will already have the cost information. Cost is not a requirement because the earthquake model only calculates the damage state probability and functionality of the essential facility and not the loss. To create replacement cost, we're going to use the building parcel data which is already joined to our fire stations. Right click on the FireStation_Import layer and open the attribute table. Add a new field called "Cost" with a data type of double. We have the building square footage from the field called SQUAREFT. We'll get the RSMeans value from the Essential Facility Tool excel spreadsheet in Section 2. The value is $254.23 per square foot. This RSMeans value is the national average and a regional multiplier is required. Open ArcCatalog (not the ArcCatalog accessed from ArcMap but the full version found in the ArcGIS folder) and browse to the state data and find the table called CA.dbo.hzMeansCountyLocationFactor. We know our county's FIPS code since it is attached to our data as the field CountyFips (it was added when we joined the Census Tract data to the fire station data). The county FIPS for Santa Cruz is 06087. Click on the table and then select the preview tab at the top. Browse through the data until you find the 06087 row and see the MeansAdjNonRes value of 1.18. This is the non-residential adjustment value from the national average.

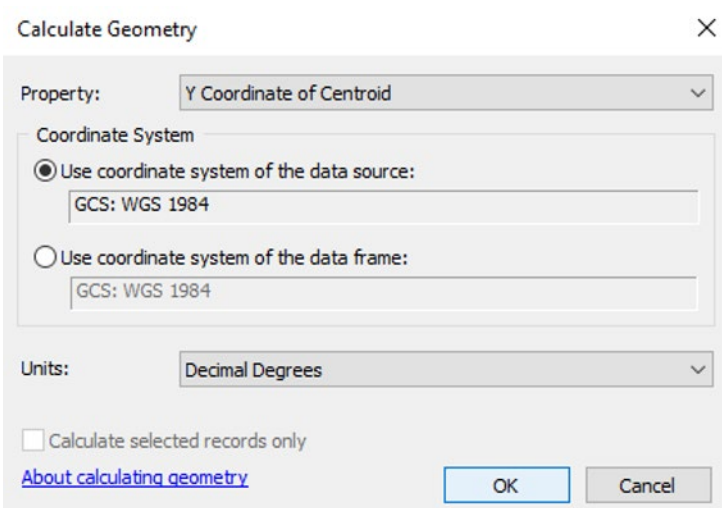
16. Now we have all the information we need to calculate the replacement cost. Keep in mind for essential facilities, the replacement cost is equal to the structure and content values combined. This is different than UDF which has a separate field for contents. Review the Essential Facilities Tool, Fire Station tab, Section 2 and notice that the content values are 150% of the replacement value for EFS1. Right click on the Cost column header and select Field Calculator. Click on Yes when the warning comes up. Double click on SQUAREFT, then click on *, type 254.23, then click on *, and type 1.18. Hazus requires the replacement cost to be in thousands of dollars, so we'll divide by 1000. Finally, we'll multiple everything by 2.5 to account for the contents and structure. Click OK at the bottom of the screen.



17. The Cost field should now be populated. Double check to make sure all values are populated and reasonable. For those using their own data, there are other places to get the square footage values. If you have building footprint data with number of stories or elevation, you can do a spatial join with the footprint data and then calculate total area by multiplying the footprint area by the number of stories. Building footprints have been released by Microsoft for the entire U.S. They can be found on GitHub: (https://github.com/microsoft/USBuildingFootprints). Your

computer lab should have ArcPro which you can use to convert the json format into an ESRI-ready format.

18. Now that the replacement cost has been calculated we need to identify the latitude and longitude in WGS84 decimal degrees. Right click on the map and select Data Frame Properties and then select the Coordinate System tab. Select the GCS_WGS_1984 coordinate system and click OK. Now open the FireStation_Import attribute table and add two more fields called WGS84_Lat and WGS84_Long and make them both double for data type. Right click on the WGS84_Lat column header and select Calculate Geometry and select Yes when the warning message comes up. Set the Property to Y Coordinate of Point, the Coordinate System to GCS: WGS 1984, and units of Decimal Degrees. Click Yes when the warning comes up.



19. Now use Calculate Geometry to populate the longitude field using X Coordinate of Point. Verify that both WGS84_Lat and WGS84_Long fields are populated.

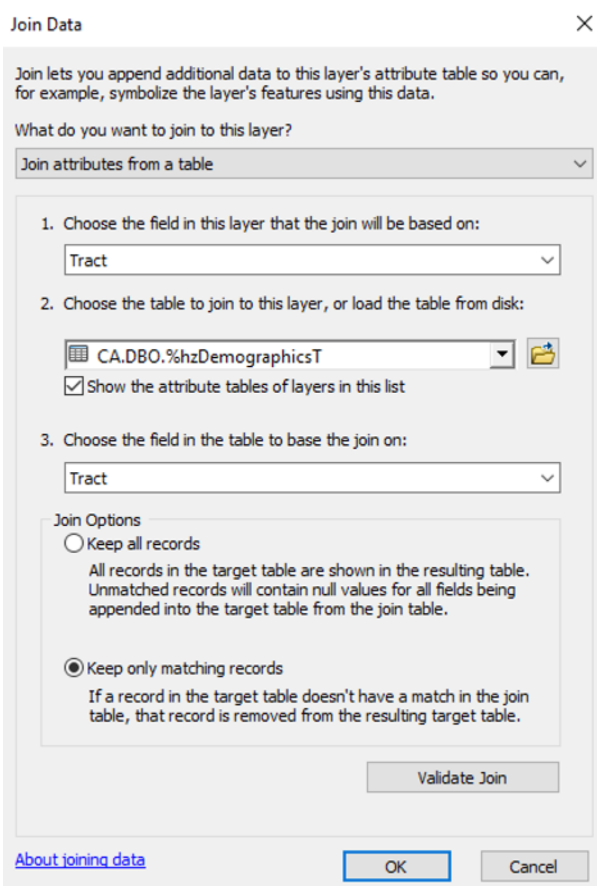
20. The next step is to determine the design level and earthquake building type of the buildings. The year built can be used to determine the design level which can then be used to determine the earthquake building type if it isn't in the parcel data. Open the Essential Facility Tool excel spreadsheet if it isn't already open. Sections 4 and 5 provide information on the design level and the earthquake building type. In Section 4, there is a column called BldgSchemesID with XX and then a number. The XX in our case will be CA for California.

21. Open the FireStation_Import attribute table and scroll over to BldgScheme. You'll notice all the values are CA3. Close the attribute table and go back to Section 4 and notice that there are five entries for XX3 with corresponding years and design levels. For examples, everything built before 1940 should be assigned a PC value for Design Level.

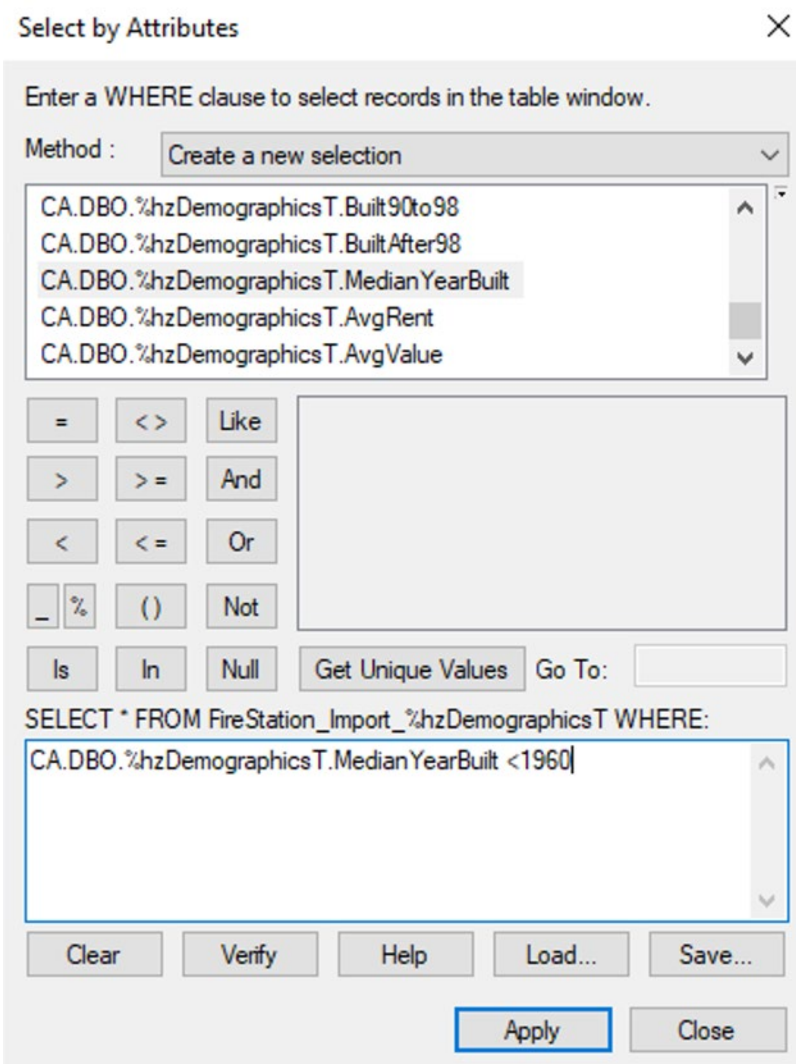
22. If your local parcel data has year built data you can set up queries to assign the design level by the year built. Unfortunately, our data does not have the year built so we'll need to find it from a different source.

23. ArcCatalog and browse to the following table in the California state data: CA.dbo.hzDemographicsT. Drag the table into ArcMap. When the New Query Layer message comes up, click Finish. This table is the demographics data that comes with Hazus and it includes a median year built for all Census Tracts. We'll assign the median year built to the fire stations which fall inside the tracts.

24. Right click on FireStation_Import and click Joins and Relates, then Join. Select Join attributes from a table, then Tract in first box, CA.DBO.%hzDemographicsT in box 2, Tract in box 3, Keep only matching records under Join Options. Then select OK.

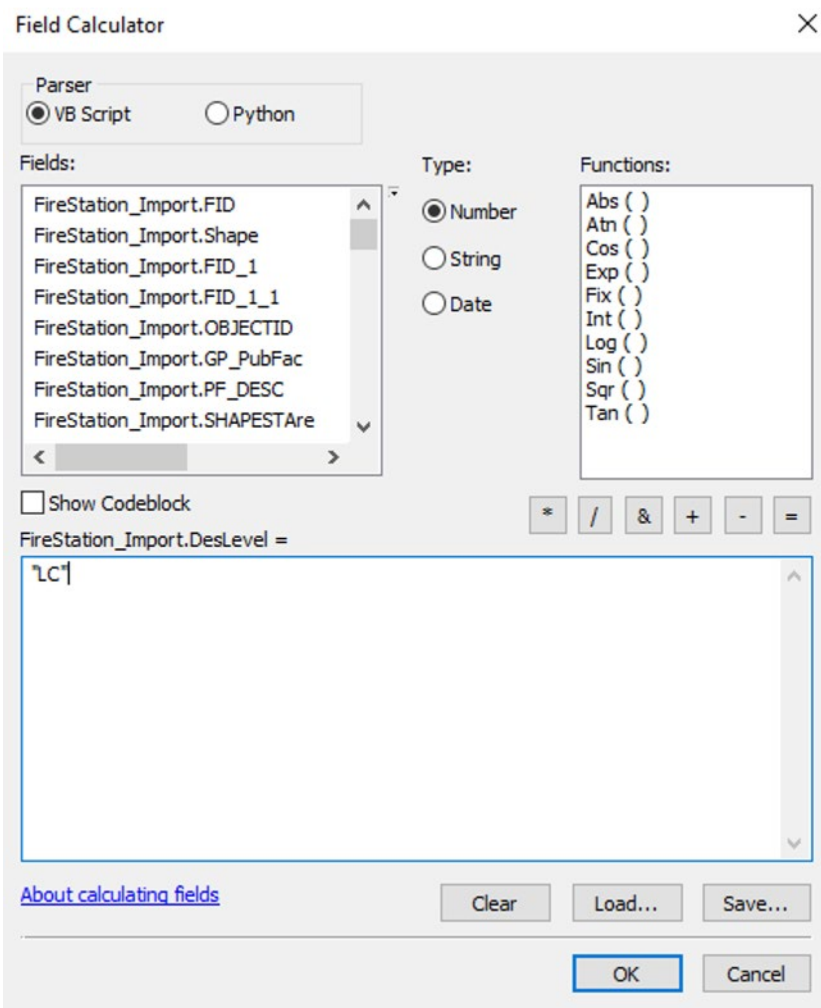


25. When the warning message comes up, select Perform Join Now Without Index. Open the FireStation_Import attribute table and confirm all entries have a median year built column. Add a column called DesLevel that is text data with 2 characters. Now we'll run a query based on median year built. Left click on the top left button and click Select by Attributes. Scroll down to CA.DBO.%hzDemographicsT.MedianYearBuilt and double click on it. Take a quick look at the attribute field, the oldest year there is 1953 and the newest is 1978. Consulting the Essential Facilities Tool, it looks like there will be three queries to run: <1960, 1960-1972, and >1972. Set up the first query as: CA.DBO.%hzDemographicsT.MedianYearBuilt <1960 and click Apply.

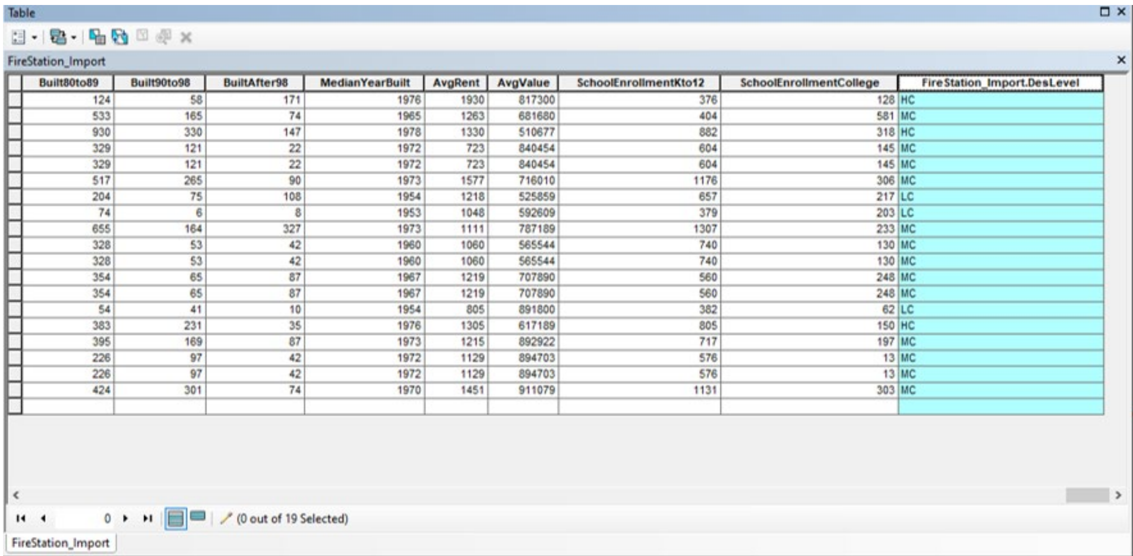


26. Note that three rows are selected. Next, select Editor from the Editor Toolbar and select Start Editing. Then select the FireStation_Import layer to edit.

27. Right click on FireStation_Import.DesLevel and use the Field Calculator to assign a value of "LC" to those three rows.



28. Create two additional queries and assign the values below:
    - CA.DBO.%hzDemographicsT.MedianYearBuilt >=1960 AND CA.DBO.%hzDemographicsT.MedianYearBuilt <1976. Set these equal to a DesLevel of MC
    - CA.DBO.%hzDemographicsT.MedianYearBuilt >=1976. Set these equal to a DesLevel of HC
29. After you've assigned values to all the fire stations, check the attribute table to make sure there are DesLevel values in each record. Select Editor and Stop Editing. Save your edits.

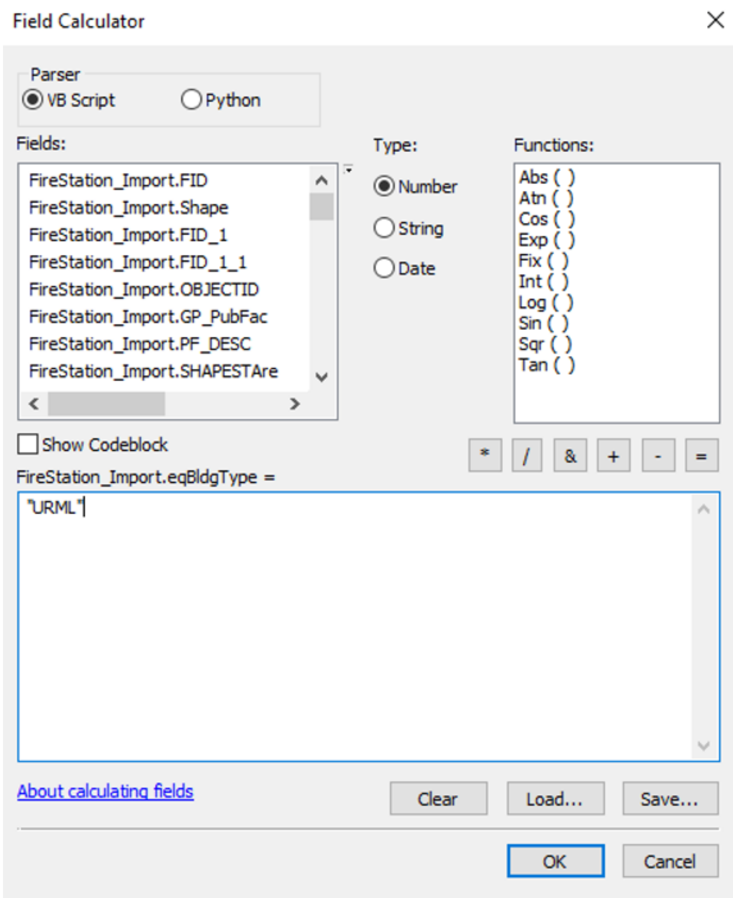


Built80to89	Built90to98	BuiltAfter98	MedianYearBuilt	AvgRent	AvgValue	SchoolEnrollmentKto12	SchoolEnrollmentCollege	FireStation_Import.DesLevel
124	58	171	1976	1930	817300	376	128	HC
533	165	74	1965	1263	681680	404	581	MC
930	330	147	1978	1330	510677	882	318	HC
329	121	22	1972	723	840454	604	145	MC
329	121	22	1972	723	840454	604	145	MC
517	265	90	1973	1577	716010	1176	306	MC
204	75	108	1954	1218	525859	657	217	LC
74	6	8	1953	1048	592609	379	203	LC
655	164	327	1973	1111	787189	1307	233	MC
328	53	42	1960	1060	565544	740	130	MC
328	53	42	1960	1060	565544	740	130	MC
354	65	87	1967	1219	707890	560	248	MC
354	65	87	1967	1219	707890	560	248	MC
54	41	10	1954	805	891800	382	62	LC
383	231	35	1976	1305	617189	805	150	HC
395	169	87	1973	1215	892922	717	197	MC
226	97	42	1972	1129	894703	576	13	MC
226	97	42	1972	1129	894703	576	13	MC
424	301	74	1970	1451	911079	1131	303	MC

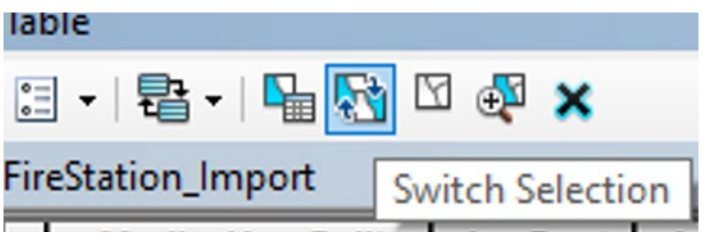
30. Now, the earthquake building type can be assigned. Your local parcel data may have this information but Santa Cruz's data does not so we'll use the Essential Facility Tool again. Open the tool to the Fire Station tab and scroll over to Section 5. This table will give you an idea of what the fire station should be assigned. First determine if you are in an urban or rural area, then find your state in the first two columns. Then find your design level at the top and identify the likely building type. For urban California, RM1L and URML are most likely.

31. Create a new field called eqBldgType with text data that is 4 characters long. Select the top left button on the attribute table and click Select by Attributes. Clear the current query by clicking Clear. Create a new selection by scrolling to the bottom of the fields to FireStation_Import.DesLev and double clicking on it. Then select = and Get Unique Values.

32. Double click on LC and then click Apply. Three records will be selected. Click on Editor from the Editor Toolbar again and select Start Editing and select FireStation_Import as the layer to edit. Right click on the top of the eqBldgType column and select Field Calculator. Click Clear to get rid of the current query. Type "URML" and then OK.

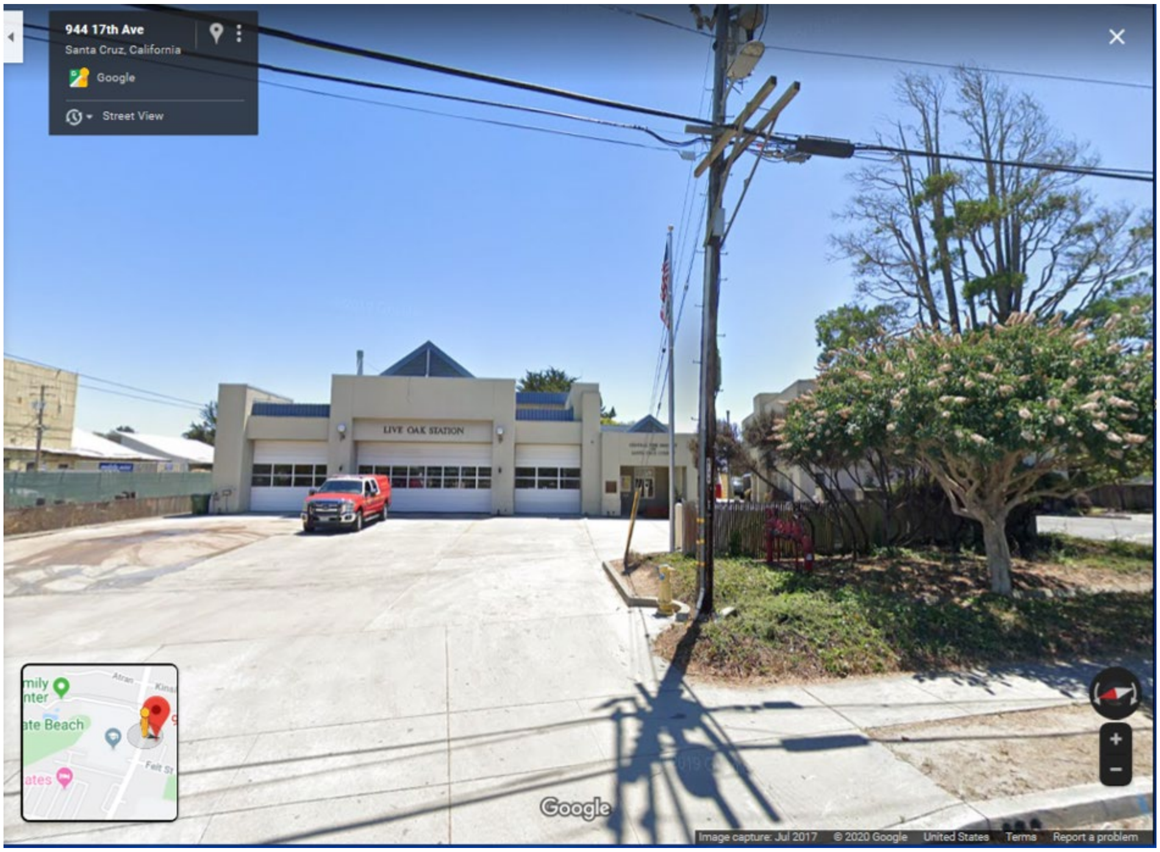


33. Now click on the switch selection button.



34. Right click on the eqBldgType field and select Field Calculator. Clear the existing query, add the query: “RM1L”, and click OK. Clear the selection and stop editing. Confirm that the entire eqBldgType field is populated.

35. Now, let's check to make sure these building types look okay. To do that, we’ll use Google Street View. Go to Google (www.google.com) and type in the address: 930 17th Ave, Santa Cruz, CA. This looks like a new reinforced masonry structure and it was probably built after 1976 so the design level should be switched to HC from MC.

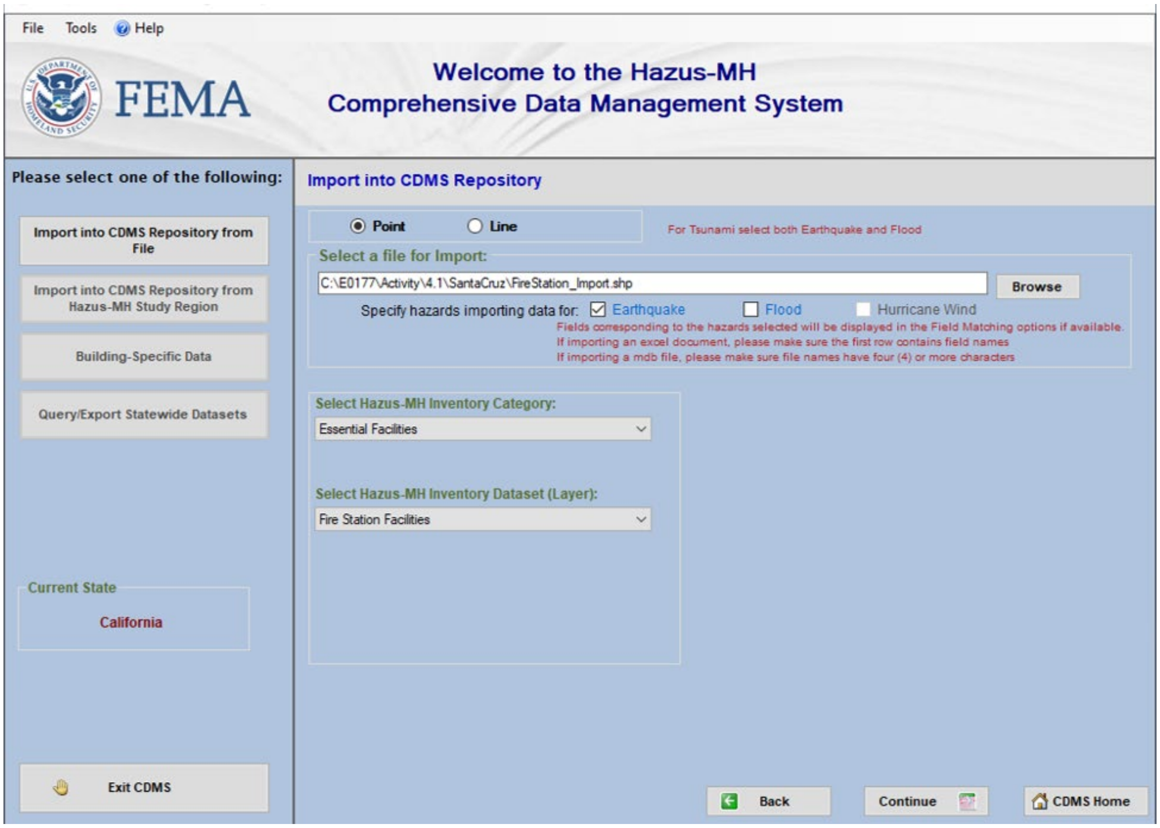


36. Let's check another entry. Type in the address: 13230 Central Ave, Boulder Creek, CA. This was listed as one of the older fire stations, but the image shows us it is probably much newer than the other buildings in the Census Block. This building is probably reinforced masonry and was probably also built after 1976, so the building type should be changed to RM1L from URML and the design level should be changed to HC. Since there are only 19 fire stations, it probably makes sense to validate each one. You may also want to talk to the municipality to determine the construction types and age of construction if it is difficult to determine from the image. Street View is a powerful tool which can be used to help identify foundation types and first floor heights too.

37. Once the building design levels and building types have been validated. Now we'll use CDMS to bring in the fire station data. Right click on FireStation_Import, then select Joins and Relates, then Remove Joins, and Remove All Joins. Close ArcMap and open CDMS. Ensure that the CA statewide dataset is still selected.

38. Select Import into CDMS Repository from File on the left side of CDMS.

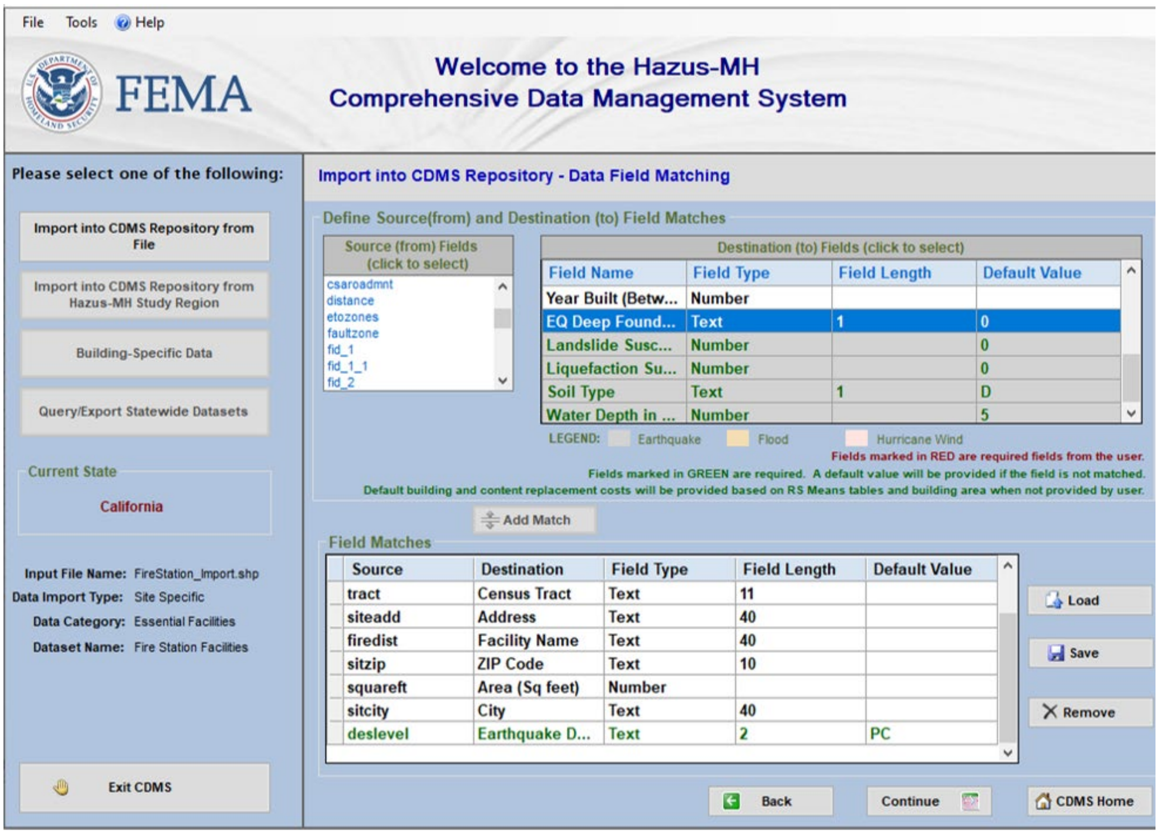
39. Unselect Flood. Then click Browse and find the FireStations_Import.shp file (you'll need to change the file type). Under Select Hazus-MH Inventory Category: select Essential Facilities, then under Select Hazus-MH Inventory Dataset (Layer): select Fire Station Facilities.



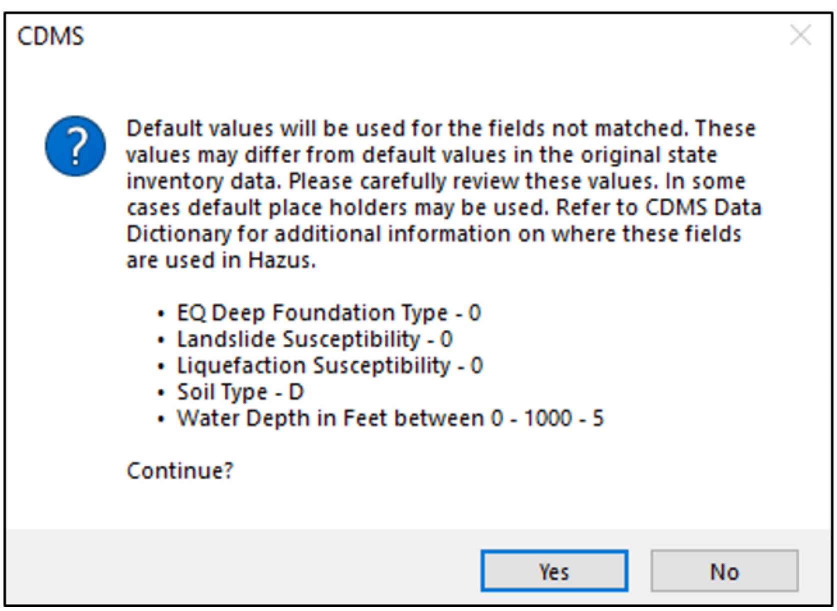
40. Select Continue. Under Select Import Table: FireStation_Import will be selected and under Select HAZUS-ID Field** (if available): select No Hazus ID. Click Continue.

41. Match the fields from FireStation_Import data to the Hazus fields. Notice the following fields have already been matched correctly: Cost to Building Replacement Cost, EFClass to Facility Class, eqbldgtype to Earthquake Building Type, and tract to Census Tract. Match the following yourself:

- siteadd -> Address
- firedist -> Facility Name
- sitzip -> ZIP Code
- squareft -> Area (Sq feet)
- sitcity -> City
- deslevel -> Earthquake Design Level



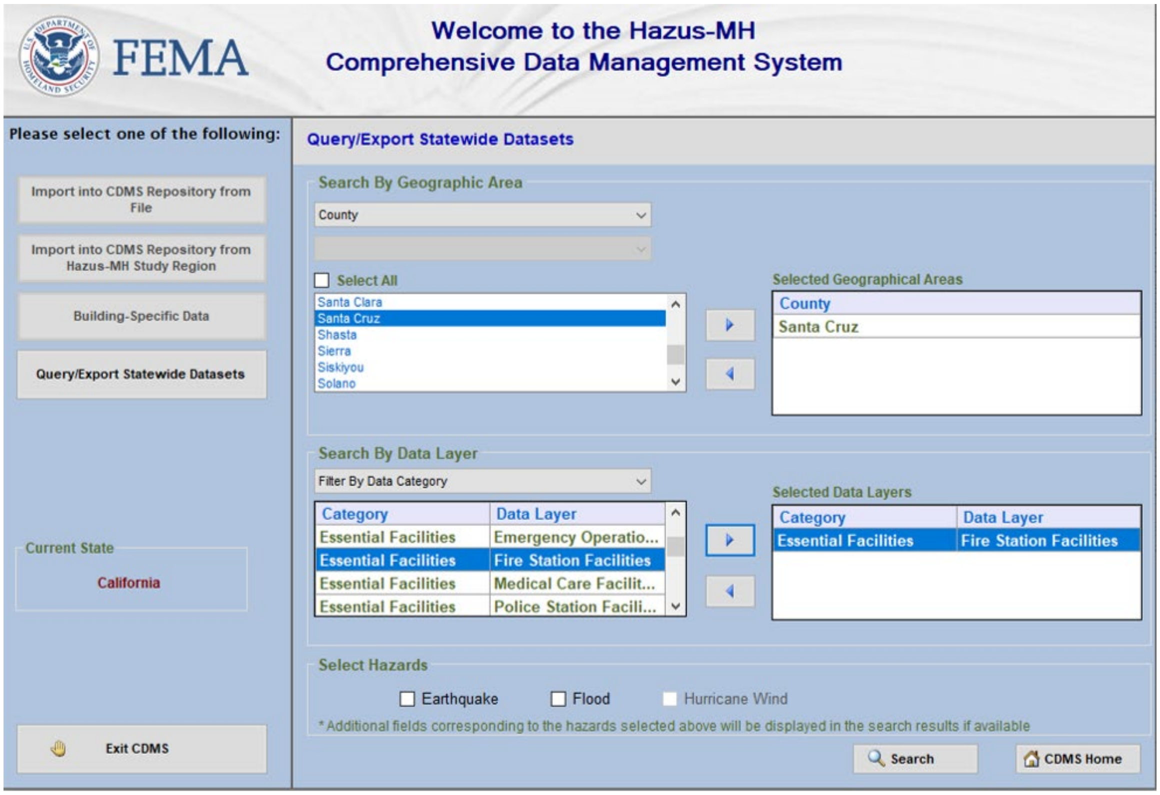
42. Click Continue. The following message comes up:



43. Click Yes. Then the Categorize Fields menu comes up.

44. Click OK. Then click Continue when the Facility Class categorization comes up, Continue when the Earthquake Building Type categorization comes up, and Continue when the Earthquake Design Level categorization comes up. CDMS will process for several seconds and the Import Success message should come up. Click OK. The fire station data should show up in the CDMS Repository.

45. Before you update the state data, let’s get rid of the existing data. Select Query/Export Statewide Datasets on the left. In Search by Geographic Area, select County, then select Santa Cruz in the list of Counties/Cities, and click on the right arrow. Under Search By Data Layer, click on Essential Facilities and Fire Station Facilities, and then select the right arrow.

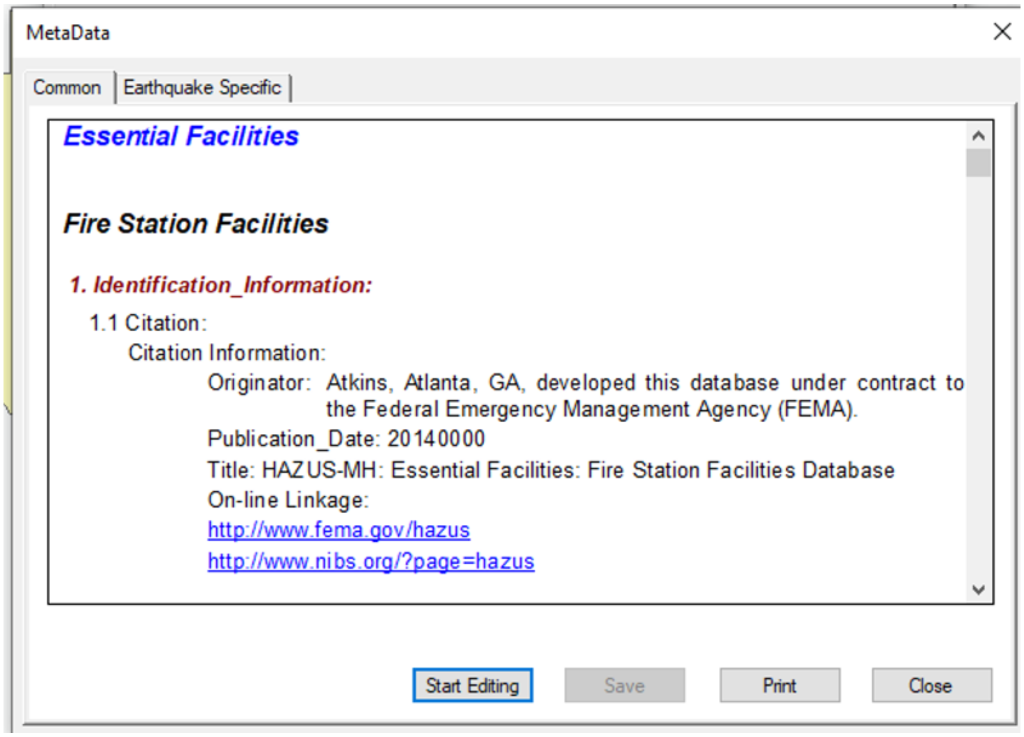


46. Click Search. The query will provide all the existing school data. Select Delete All Records for Selected Inventory. Click Yes when the warning message comes up. Then click CDMS Home. Now click Transfer to Statewide Dataset. Then select Replace Data and Submit. Finally, select Yes when the warning message comes up. Close CDMS.

47. Now create a new study region. Create an earthquake and tsunami study region for Santa Cruz, California and call it SantaCruz_EQ_TS. After Hazus aggregates the region, open the earthquake hazard. Select Inventory and then Essential Facilities. Click on the Emergency Response and then the Fire Stations drop down menu. There should be 19 fire stations in the table and the fields you brought in using CDMS should be populated. Switch to the tsunami hazard and open the fire station inventory table. Make sure there are 19 fire stations. Although the tsunami model does not model essential facilities, they can be used for your own analysis.

Task 4: Document Updated Inventory

1. Document the edits you made. For essential facility edits, browse to the fire station table, right click in the data, and select Meta Data. Click Start Editing at the bottom. Now delete the originator information and add yourself, update the abstract to include a description of where you got the data (source) by consulting the Santa Cruz GIS website, then add information on what you did to the data. How did you calculate cost, etc. When you're done, select Stop Editing. If you're more comfortable editing this information in Word, go to the study region folder and open this document: C:\HazusData\Regions\SantaCruz_EQ_TS\hzFireStation_md.rtf.



Essential Facilities Data for Earthquake and/or Tsunami have been updated.

Application 2: Utilities (Flood and/or Earthquake)

Task 1: Identify, Collect, and Validate Local Data

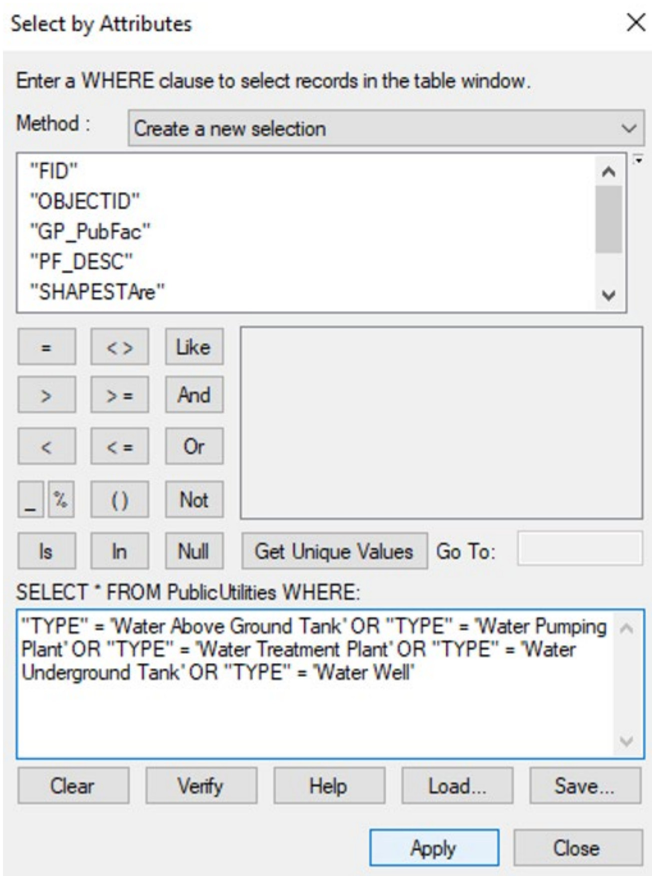
1. First locate the utility data. Local GIS websites are good sources of data. For Santa Cruz, the local public utility data has already been identified and downloaded here: C:\E0177\Activity\4.1\SantaCruz\ and is called PublicUtilities.shp. This is data that was downloaded from the City's GIS website (https://www.co.santa-cruz.ca.us/Departments/GeographicInformationSystems(GIS).aspx). It is important to identify the metadata as well. In this case, the metadata is provided on the Santa Cruz website.

2. Create a new study region in Hazus called Temp. You'll delete this study region later and is only being created so that the state SQL data can be accessed. The study region should include your county/city and the hazards you want to model. When the study region has been created, close Hazus.

3. Open ArcMap and add the public utilities data to the map.

4. Right click on the layer name and select Open Attribute Table. Review the Type field, you'll see electric, natural gas, water, and wastewater utilities listed. In this activity, you are going to update the water utilities for the County. Click on the button in the top left corner and click Select by Attributes. The Select by Attributes menu should come up. For Method, select Create a new selection, double click on "TYPE", then =, and then click on Get Unique Values. Set up the following query: "TYPE" = 'Water Above Ground Tank' OR "TYPE" = 'Water Pumping Plant'

OR "TYPE" = 'Water Treatment Plant' OR "TYPE" = 'Water Underground Tank' OR "TYPE" = 'Water Well' and then click Apply.



5. Close the attribute table. You'll notice 10 water utilities have been selected. Right click on PublicUtilities go to Data and then Export Data. Save the selected features as: C:\E0177\Activity\4.1\SantaCruz\WaterUtilities.shp.

6. Click OK. When the warning comes up, click Yes. Remove the PublicUtilities layer.

Task 2: Format Data

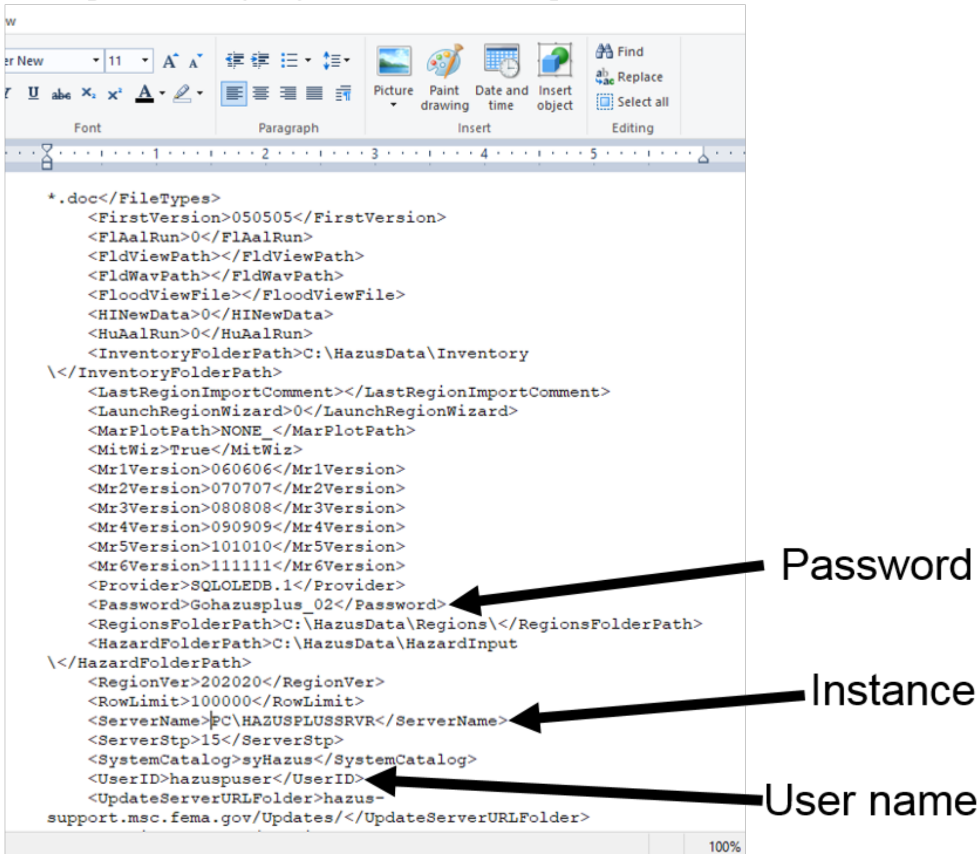
1. Identify the required fields and the formatting of those fields. To do this, we will review the SQL tables using ArcCatalog. Open ArcCatalog. Then browse to C:\E0177\Activity\4.1\ using ArcCatalog. Right click in the white box under the file name, SantaCruz.

2. Select New and then Database Connection.

3. To figure out how to populate the Instance, User name, and Password, go to C:\Program Files (x86)\Hazus-MH\Settings.xml and open the file. The information shown in the xml file may be

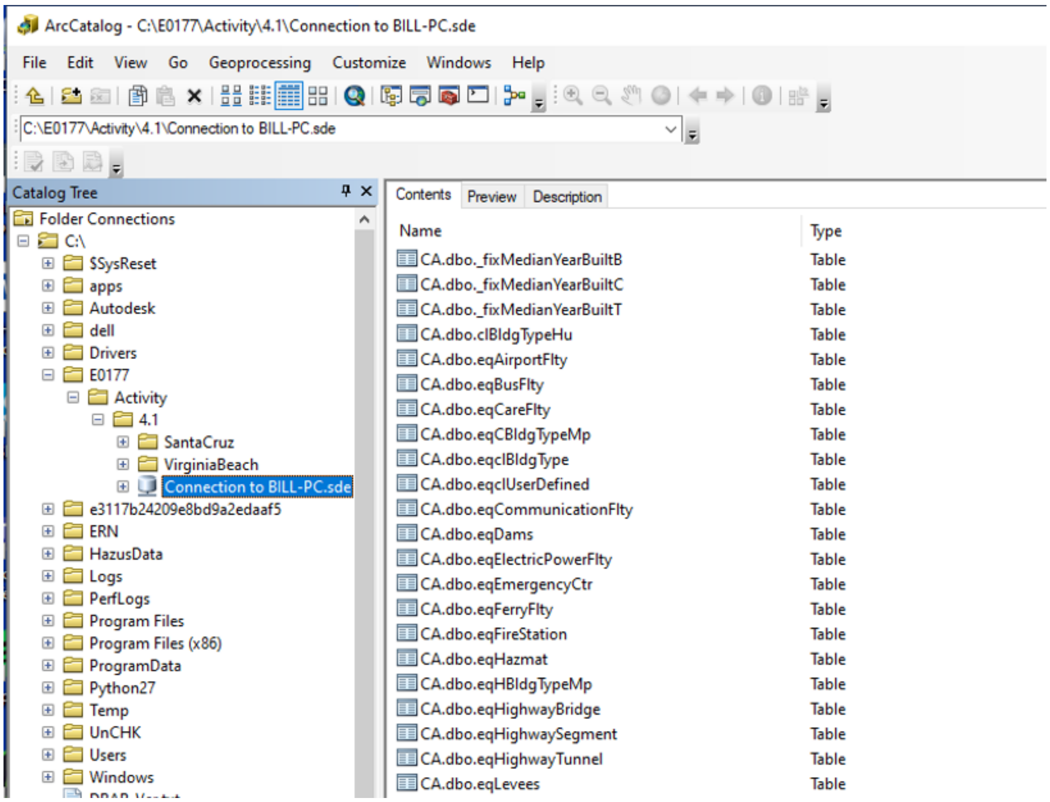
copied from the xml file and pasted into the ArcCatalog interface. The instance includes the computer name which can be long. Your computer name will be different than the example.

C:\Program Files (x86)\Hazus-MH\Settings.xml



4. Enter the password, instance, and user name into the ArcCatalog interface. Select SQL Server in the top dropdown.

5. Select CA in the database dropdown and then select OK. This will create a database connection with the default name: Connection to PC_Name.sde where PC_Name is the name provided in the instance. Double click on the new connection name to access the Hazus California State data.



6. Reviewing the data in the state database, files that start with eq are associated with the earthquake model, fl is flood, hu is hurricane, ts is tsunami (for tsunami states only), and hz is common across all hazards. For this activity, we are going to focus on earthquake, flood, and general data. For utility facilities, the data of interest is:

- Communication – CA.dbo.eqCommunicationFlty and CA.dbo. hzCommunicationFlty. Notice there is no flood table so the flood model doesn't produce communication results.
- Electric – CA.dbo.eqElectricPowerFlty, CA.dbo.flElectricPowerFlty, and CA.dbo.hzElectricPowerFlty.
- Gas – CA.dbo.eqNaturalGasFlty, CA.dbo.flNaturalGasFlty, and CA.dbo.hzNaturalGasFlty.
- Oil – VA.dbo.eqOilFlty, VA.dbo.flOilFlty, and VA.dbo.hzOilFlty.
- Potable Water – VA.dbo.eqPotableWaterFlty, VA.dboflPotableWaterFlty, and VA.dbo.hzSchool.
- Waste Water – VA.dbo.eqWasteWaterFlty, VA.dbo.flWasteWaterFlty, and VA.dbo.hzWasteWaterFlty

7. This activity is going to focus on updating the water utility data, but you may want to update other utilities using this same application.

8. Right click on CA.dbo.eqPotableWaterFlty in ArcCatalog, then click Properties. Click on the Fields tab. The data type is provided in the right column. Click on Text next to PotableWaterFltyId and you'll see the size is 8 characters. All of the tables have already been characterized for you in the Utility Tool found here: C:\E0177\Activity\4.1\UtilityTool.xlsx.

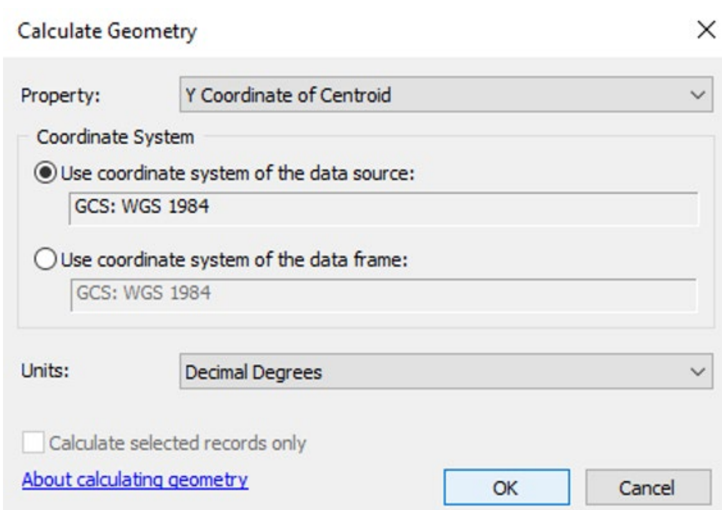
9. Open the Utility Tool Excel spreadsheet and browse to the Potable Water Facility tab. It will provide information on the field, data type, and whether or not it is required, recommended, or not needed for a Hazus analysis.

Task 3: Update Inventory

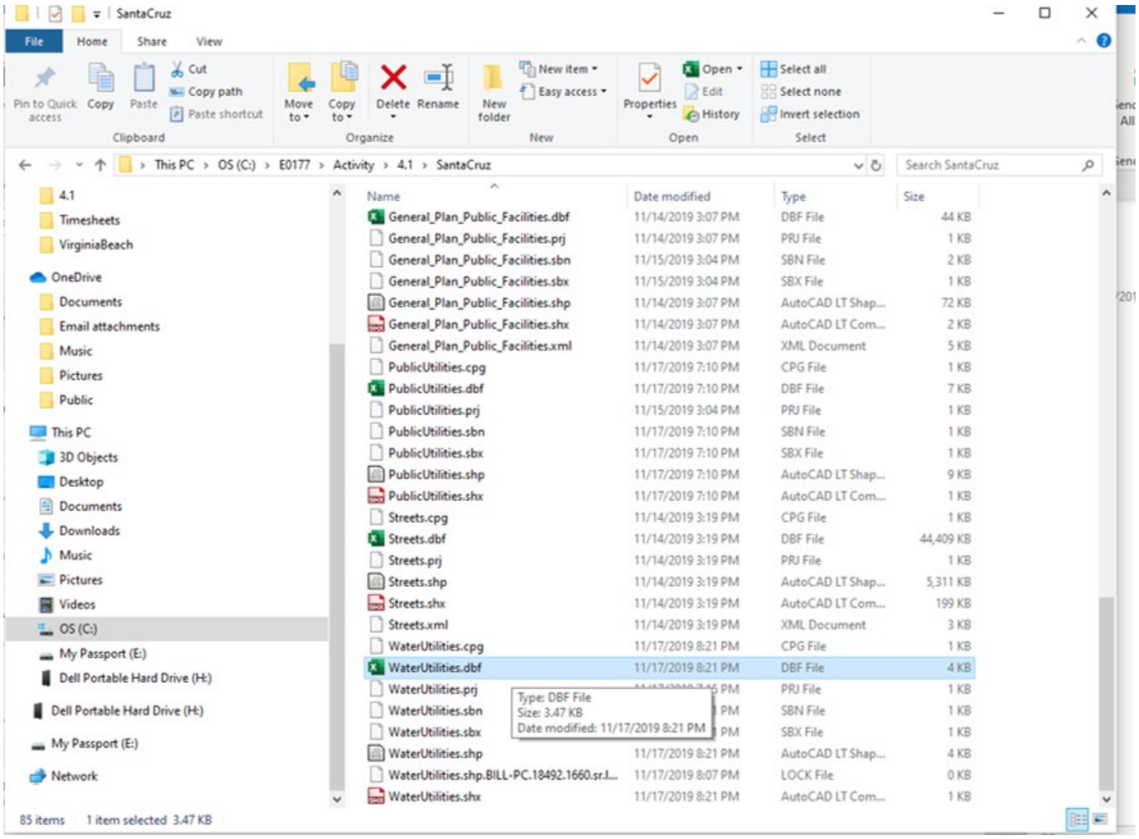
1. In this step, you're going to look at what data is required to run a Hazus analysis, compare it to what you already have, and then make inventory updates. Looking at the Santa Cruz water utility data, we have very few fields. However, there are some fields in the Assessor_Parcels data we can use. These fields include: Address, City, and Zipcode. We'll still need to format these fields and we'll also need to create the following fields: UtilFcltyClass, Tract, Cost, Latitude, Longitude, FoundationType, EquipmentHt, EQBldgType, and DesignLevel. We'll discuss how to find and add soil type, liquefaction susceptibility, landslide susceptibility, and water depth in the next activity. These hazard maps may be added after you've updated the inventory in Hazus.

2. Create a point file and joining the parcel data to it. Go back to ArcMap with the water utility data in it. Add the Assessor_Parcels. Right click on WaterUtilities and click Open Attribute Table. You're going to add two fields, called latitude and longitude with a double data type. Click on the button in the top left of the attribute table and select Add Field. Name the first one Latitude and assign it a Double data type and click OK, then add a second field called Longitude with a Double data type. Next, right click on Latitude and select Calculate Geometry.

3. Click Yes when the warning comes up. This will be the Y Coordinate of Centroid using GCS:WGS_1984 with units of Decimal Degrees.

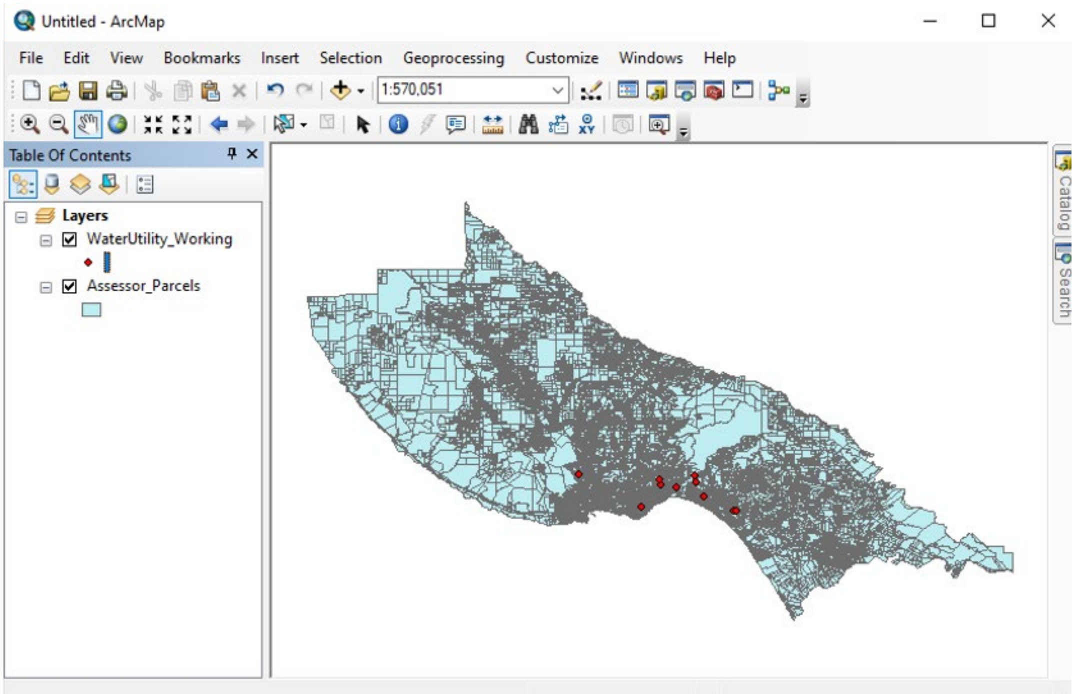


4. Click OK and then Yes when the warning comes up. Do the same thing for the Longitude field but select X Coordinate of Centroid. Remove the WaterUtility layer. Open the folder which has the WaterUtility layer in it and open WaterUtilities.dbf in Excel. The file should be here: C:\E0177\Activity\4.1\SantaCruz.

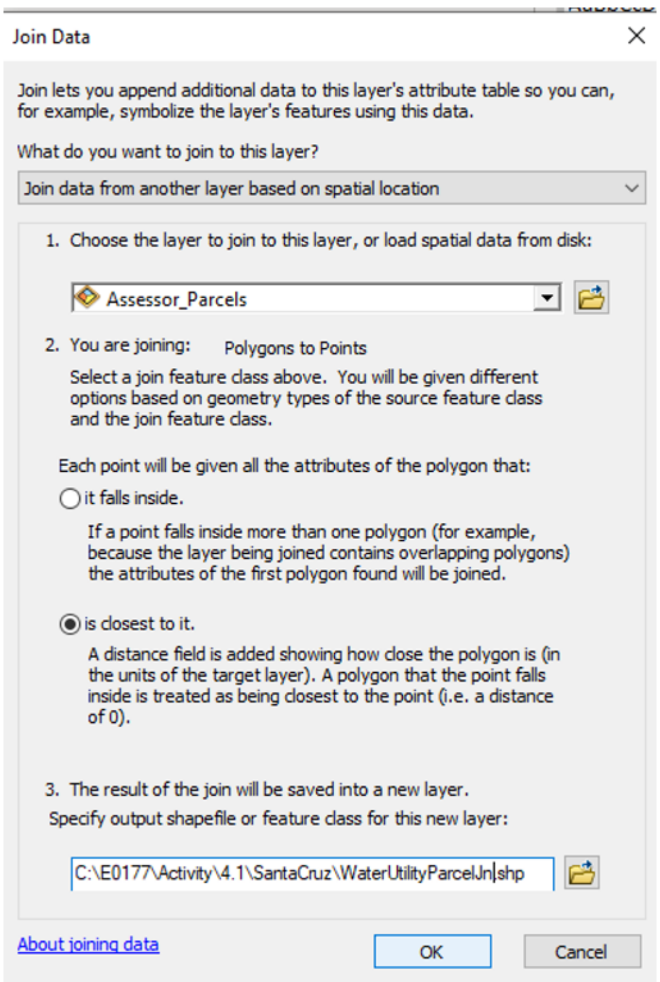


5. Once WaterUtilities.dbf has been opened in Excel. Go to File and Save As and save it as a .xls file call it WaterUtilities.xls. Go back to ArcMap and add the new .xls file to the map. Select the Database Excel Table and click Add. Right click on Database and select Display XY Data.

6. Make sure the X Field is set to Longitude and the Y Field is set to Latitude. Then click OK. Click OK when the warning comes up. Right click on the new layer called Database Events and export this data to C:\E0177\Activity\4.1\SantaCruz\ and call it WaterUtility_Working.shp. Add it to the map and remove the Database Events and the xls file from ArcMap. You should now have 10 points on top of the parcel layer.



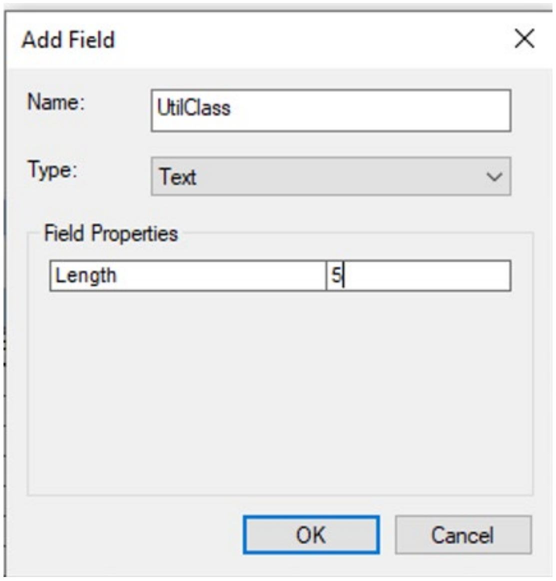
7. Right click on the WaterUtility_Working layer and select Joins and Relates and then Join. In the top dropdown menu, select Join data from another layer based on spatial location. For the next box, select Assessor_Parcels, then select is closest to it, and finally save the new layer as C:\E0177\Activity\4.1\SantaCruz\WaterUtilityParcelJn.shp. Is closest to it was selected because some of the water utility points might fall between the parcel data polygons.



8. Then click OK. Remove the WaterUtility_Working layer. Open the attribute table of the WaterUtilityParcelJn layer and make sure that all the water utilities have successfully been joined to the parcel data.

9. Next create the UtilFcltyClass field which is required by Hazus. Click the button in the top left of the attribute table and select Add Field.

10. Name the field “UtilClass” and make it a text field with a length of 5. Then click OK.



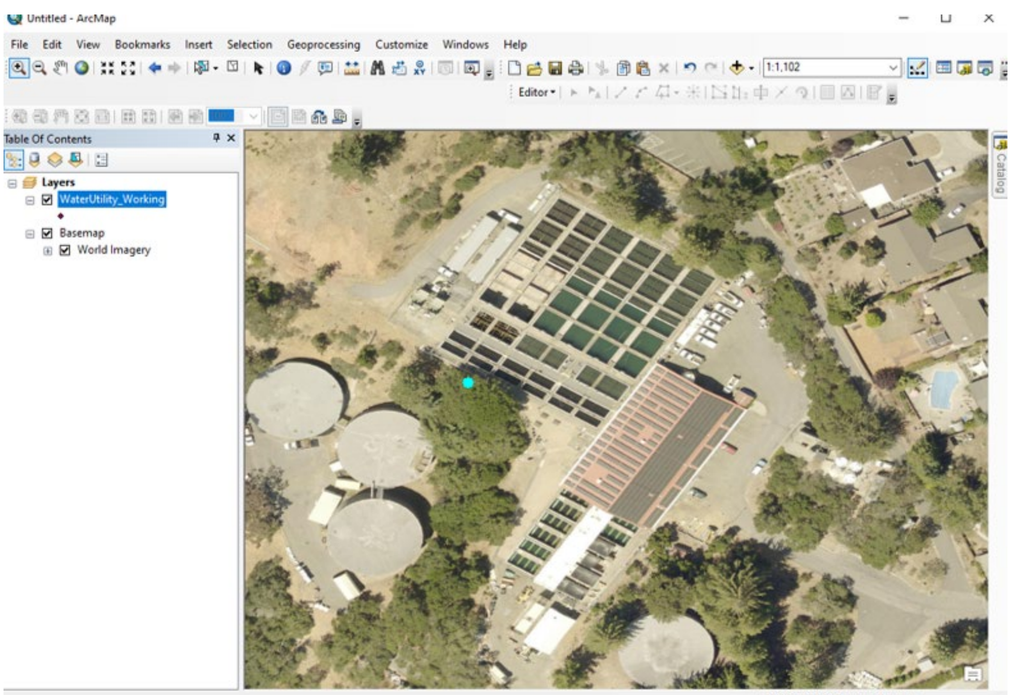
11. Add a second field called “Cost” which is the replacement cost and has a Double data type with a precision of 38 and a scale of 8. Add “BackupPwr” which shows whether the utility has a backup power source and has a Short Integer data type with a precision of 5. Add “FoundTyp” which is the structure’s foundation type required for the flood model and has a Text data type with a length of 1. Add “EquipHt” which is the equipment height in the utility that has a Double data type with a precision of 38 and scale of 8.

12. Since there are only ten records, edit the attribute table directly without setting up queries. Using the editor toolbar, select Start Editing and then select the WaterUtilityParcelJn layer. Click on the TYPE field header and drag it over to the right side of the attribute table. Use this field to assign the utility classification code.

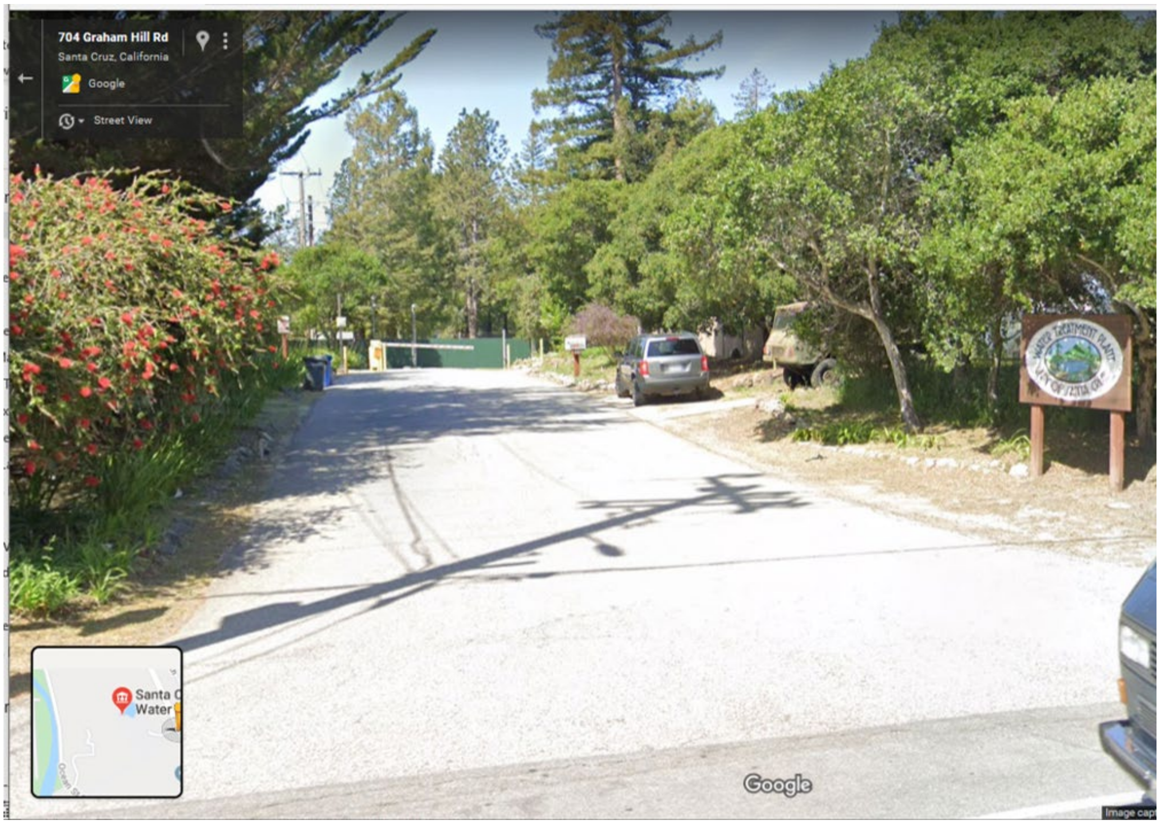
13. Open the Utility Tool Excel spreadsheet if it isn’t already open and go to Section 2. Every record will need a code from the efClass column and a cost from the avg. cost column. For example, wells are PWE and have an average cost of $100,000. Use the average costs for all these utilities since we have such limited data about the utility. If we knew how many millions of gallons per day (MGD) the water treatment plant produced, we could use the tool to develop a better cost. For the BackupPwr field, use zero. For the FoundTyp field use 7 which is slab on grade (found in Section 3 of the utility tool Excel spreadsheet). For the EquipHt, use zero. Zero is used for equipment height because the damage functions start at three feet instead of zero feet. If you put a 3 in the field, Hazus assumes the equipment height is actually 6 feet above grade. Once the table has been populated, stop editing.

nce	UtilClass	Cost	BackupPwr	FoundTyp	EquipHt	TYPE
0	PWE	100	0	7	0	Water Well
0	PWE	100	0	7	0	Water Well
0	PPPL	5000	0	7	0	Water Pumping Plant
0	PSTBC	250	0	7	0	Water Underground Tank
0	PSTGS	200	0	7	0	Water Above Ground Tank
0	PWE	100	0	7	0	Water Well
0	PWE	100	0	7	0	Water Well
0	PSTGS	200	0	7	0	Water Above Ground Tank
0	PWE	100	0	7	0	Water Well
0	PWTL	100000	0	7	0	Water Treatment Plant

14. If you didn't know the water utility type, Google Street View and satellite imagery could be used. For utilities, the world imagery basemap is a great tool to use. Add the imagery basemap and zoom into the water treatment plant.

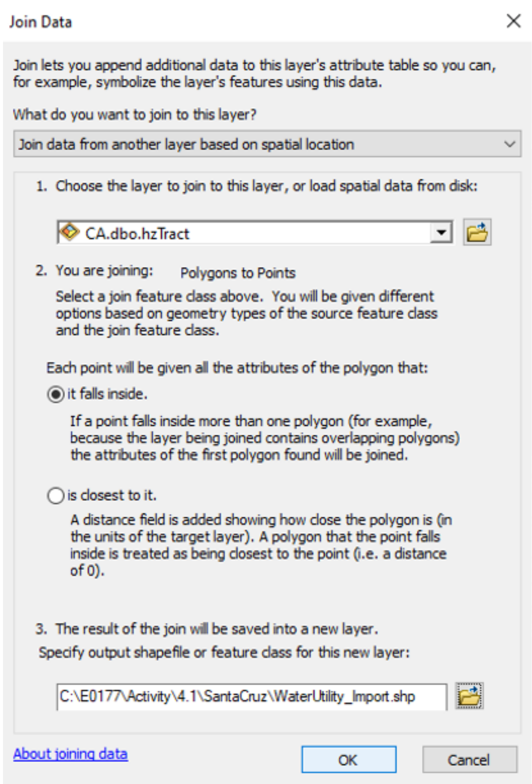


15. Go to [Google](www.google.com) (www.google.com) and type in Santa Cruz to bring up a map. Click on the map and zoom into the area that is supposed to be a water treatment plant. Click on the figurine icon to get to Street View. Utilities can be difficult to see from roads, but sometimes they're there.



16. Identify the Tract value for each water utility using a spatial join. Close the attribute table. Open ArcCatalog and browse to the database connection you created earlier. Left click on CA.dbo.hzTract and drag it to the ArcMap table of contents.

17. Close ArcCatalog. Right click on the WaterUtilityParcelJn layer, then Joins and Relates, and Join. In the top drop down, pick Join data from another layer based on spatial location, for item 1 select CA_dbo_hzTract, then it falls inside for item 2, and browse to C:\E0177\Activity\4.1\SantaCruz\ and call it WaterUtility_Import.shp and click OK.



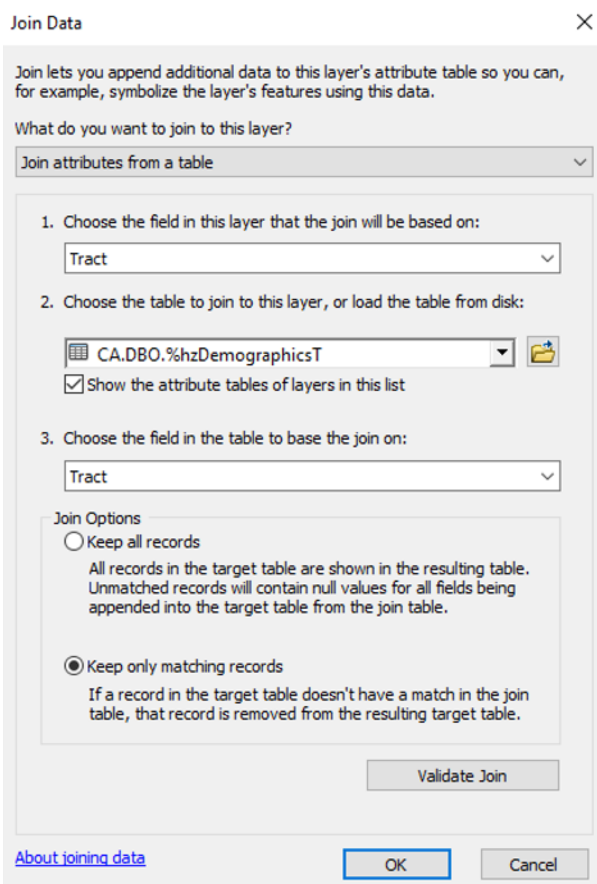
18. Remove the WaterUtilityParcelJn, CA.dbo.hzTract, and Assessor_Parcels from the table of contents and open the attribute table of the WaterUtility_Import layer. Every water utility should now be assigned a Census Tract number and a BldgScheme (which we'll use later in this application). If your data doesn't have the tract number, you'll need to move the point so that it falls within a Census Tract. This can happen on shorelines or other water bodies where the point has been placed incorrectly or the tract was trimmed too much.

19. The next step is to determine the design level and earthquake building type of the utilities. The year built can be used to determine the design level. Open the Utility Tool Excel spreadsheet if it isn't already open. Section 4 provides information on the design level and the earthquake building type. In Section 4, there is a column called BldgSchemesID with XX and then a number. The XX in our case will be CA for California.

20. Open the WaterUtility_Import attribute table and scroll over to BldgScheme. You'll notice all the values are CA3. Close the attribute table and go back to Section 4 and notice that there are five entries for XX3 with corresponding years and design levels. For example, everything built before 1940 should be assigned a PC value for Design Level. If your local parcel data has year built you can set up queries to assign the design level by the year built. Unfortunately, the Santa Cruz data does not have the year built so we'll need to find it from a different source.

21. Open ArcCatalog and browse to the following table in the California state data: CA.dbo.hzDemographicsT. Drag the table into ArcMap. When the New Query Layer message comes up, click Finish. This table is the demographics data that comes with Hazus and it includes a median year built for all Census Tracts. We'll assign the median year built to the water utilities which fall inside the tracts.

22. Right click on WaterUtility_Import and click Joins and Relates, then Join. Select Join attributes from a table, then Tract in first box, CA.DBO.%hzDemographicsT in box 2, Tract in box 3, Keep only matching records under Join Options. Then select OK.



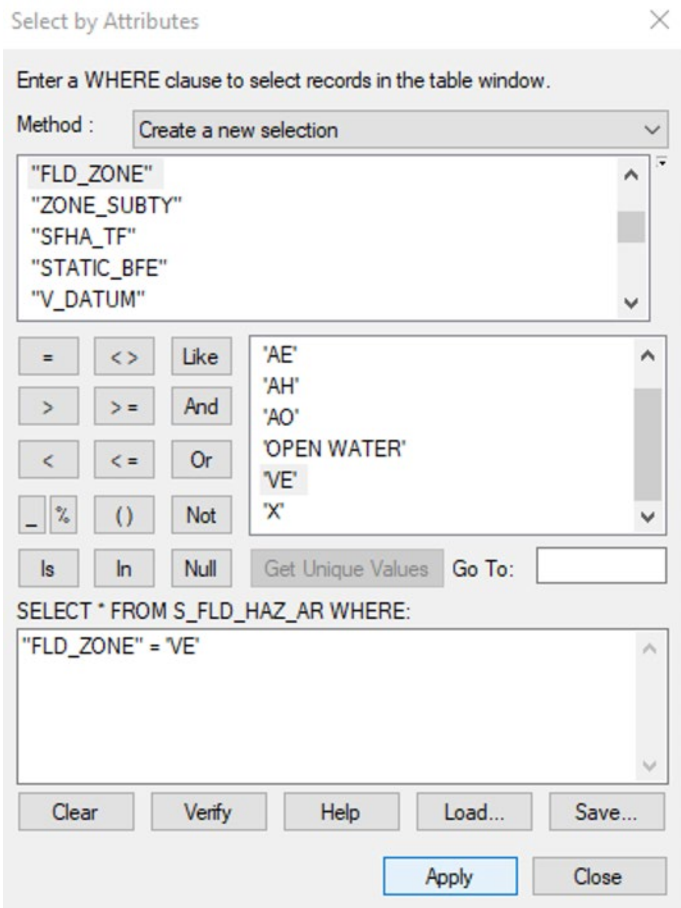
23. When the warning message comes up, select Perform Join Now Without Index. Open the WaterUtility_Import attribute table and confirm all entries have a median year built column. Add a column called DesLevel that is text data with 2 characters. Since there are only ten records, we can just add the design level by editing the table. Click Start Editing using the Editor and populate the DesLevel field using the Utility Tool. Once you're finished, click Stop Editing.

Built90to98	BuiltAfter98	MedianYearBuilt	AvgRent	AvgValue	SchoolEnrollmentKto12	SchoolEnrollmentCollege	WaterUtility_Import.DesLevel
58	171	1976	1930	817300	376	128	HC
58	171	1976	1930	817300	376	128	HC
330	147	1978	1330	510677	882	318	HC
330	147	1978	1330	510677	882	318	HC
330	147	1978	1330	510677	882	318	HC
131	392	1966	1339	557337	698	166	MC
77	197	1953	1170	590330	672	657	LC
169	87	1973	1215	892922	717	197	HC
169	87	1973	1215	892922	717	197	HC
169	87	1973	1215	892922	717	197	HC

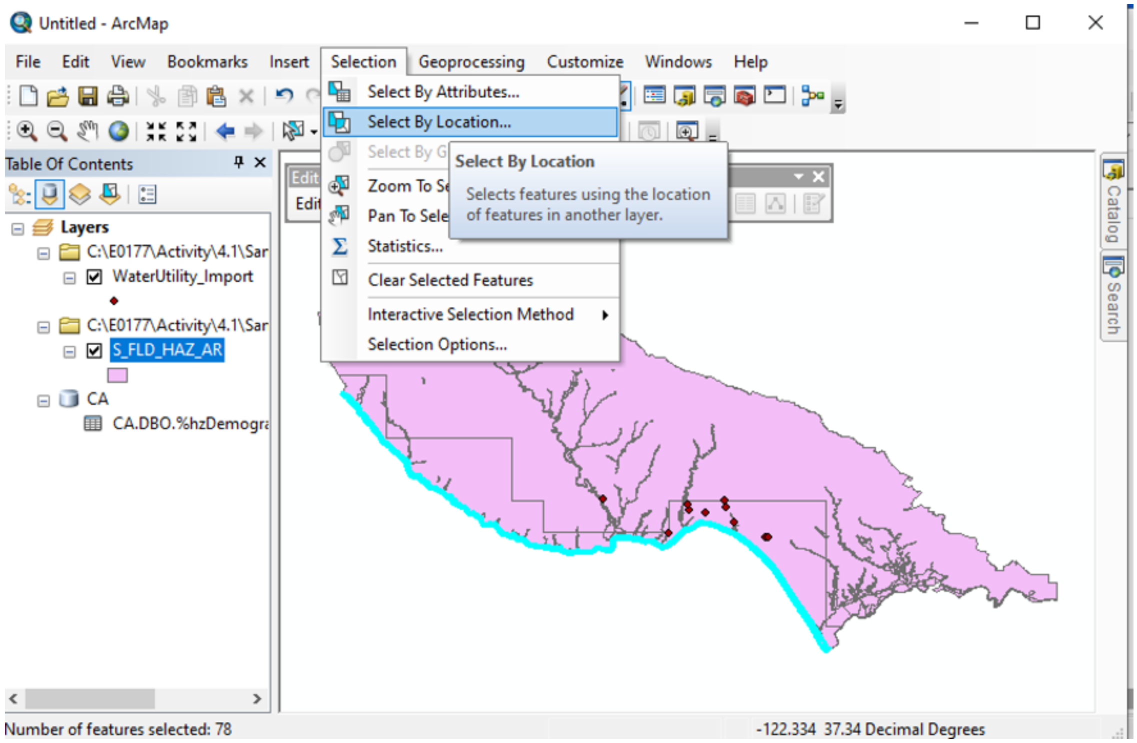
24. Now, assign the earthquake building type. Create a new field called “eqBldgType” with text data that is 4 characters long. Populate the field with the DFLT value. This is different than most of the inventory which requires an actual building construction type.

25. Because Santa Cruz County is on the coast, we are going to determine if any of the water utilities are in the coastal V zone. This information will help us determine whether we need to assign a coastal depth damage function to use. The FEMA Map Service Center has the floodplain information you’ll need if you’re using your own data. The Santa Cruz floodplain data has already been downloaded and can be found here: C:\E0177\Activity\4.1\SantaCruz\06087C_20190710. If you are using your own data, go to the MSC website (https://msc.fema.gov), click on Search All Products; then select your state, county, and community; and Search. Click on Effective Products and NFHL Data-County, then click on the DL button on the right.

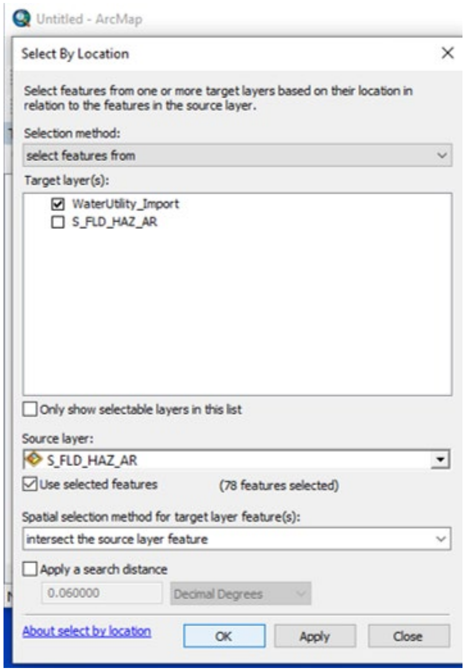
26. Add the S_FLD_HAZ_AR.shp file from the C:\E0177\Activity\4.1\SantaCruz\06087C_20190710 folder. This is the special flood hazard area and depicts the different flood zones. Open the attribute table for the S_FLD_HAZ_AR file and left click on the top left button. Click Select by Attributes, then double click on “FLD_Zone” then click = and Get Unique Values. Double click on ‘VE’ and then Apply. In some areas, it would be necessary to add the ‘V’ zone to the query as well. For Santa Cruz, we only have the VE coastal zone.



27. Part of the floodplain should now be highlighted. Now we need to determine if any of the water utilities are in the floodplain. Click Selection from the top menu, and then Select by Location.



28. For selection method, click select features from; for Target Layer(s):, select WaterUtility_Import; for Source Layer, select S_FLD_HAZ_AR; click on the Use selected features box; and under Spatial selection method for target layer feature(s): select intersect the source layer feature. Click OK.

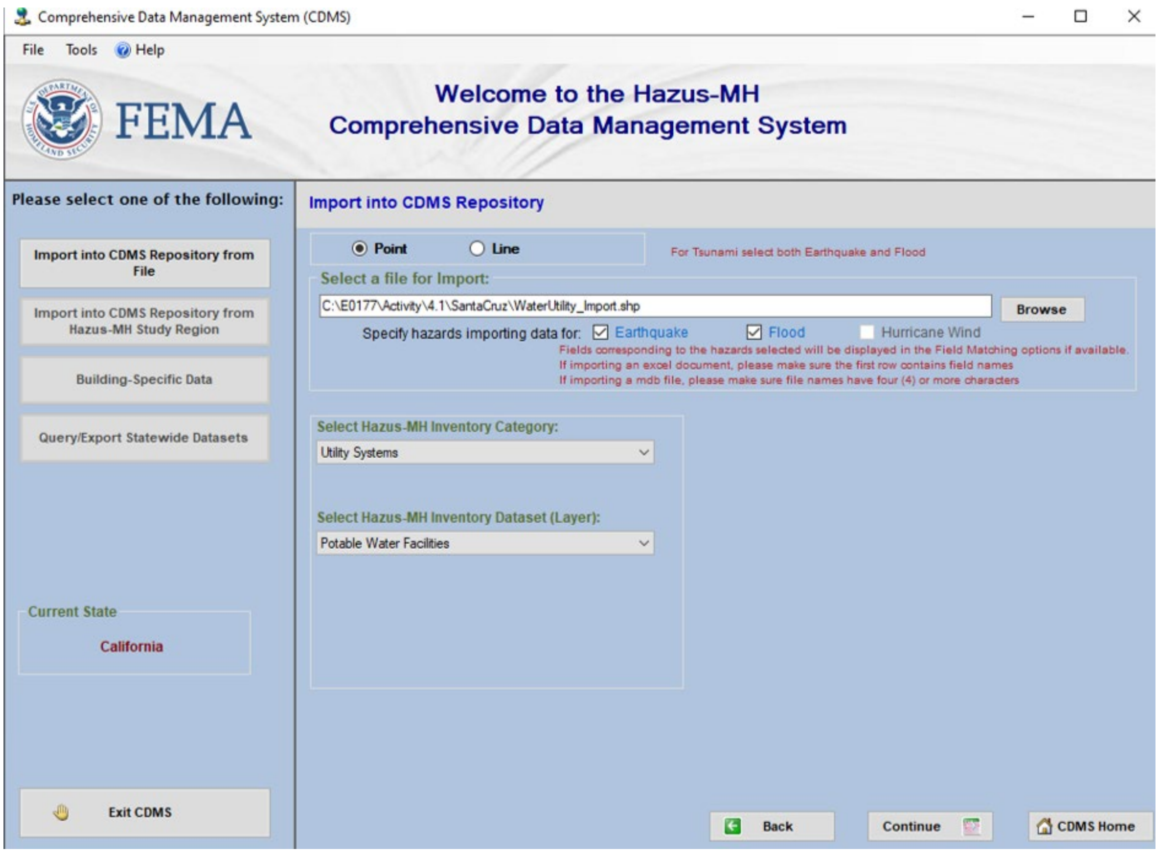


29. The query should come back empty. There shouldn't be any water utilities in the VE zone. If your data has water utilities in the V or VE zones, you'll need to add a field called "Cst_DDF" and populate those water utilities with a "460" which is the coastal depth damage function ID for water utilities (also found in the Utility Tool Excel spreadsheet).

30. Now use CDMS to bring in the water utility data. Right click on WaterUtility_Import, then select Joins and Relates, then Remove Joins, and Remove All Joins. Close ArcMap and open CDMS. Verify that the Current State in CDMS is California. If not, go to Tools and then Specify Hazus-MH Data Location. Browse to the California data and click on the CA folder. Then click OK and OK again.

31. Select Import into CDMS Repository from File on the left side of CDMS.

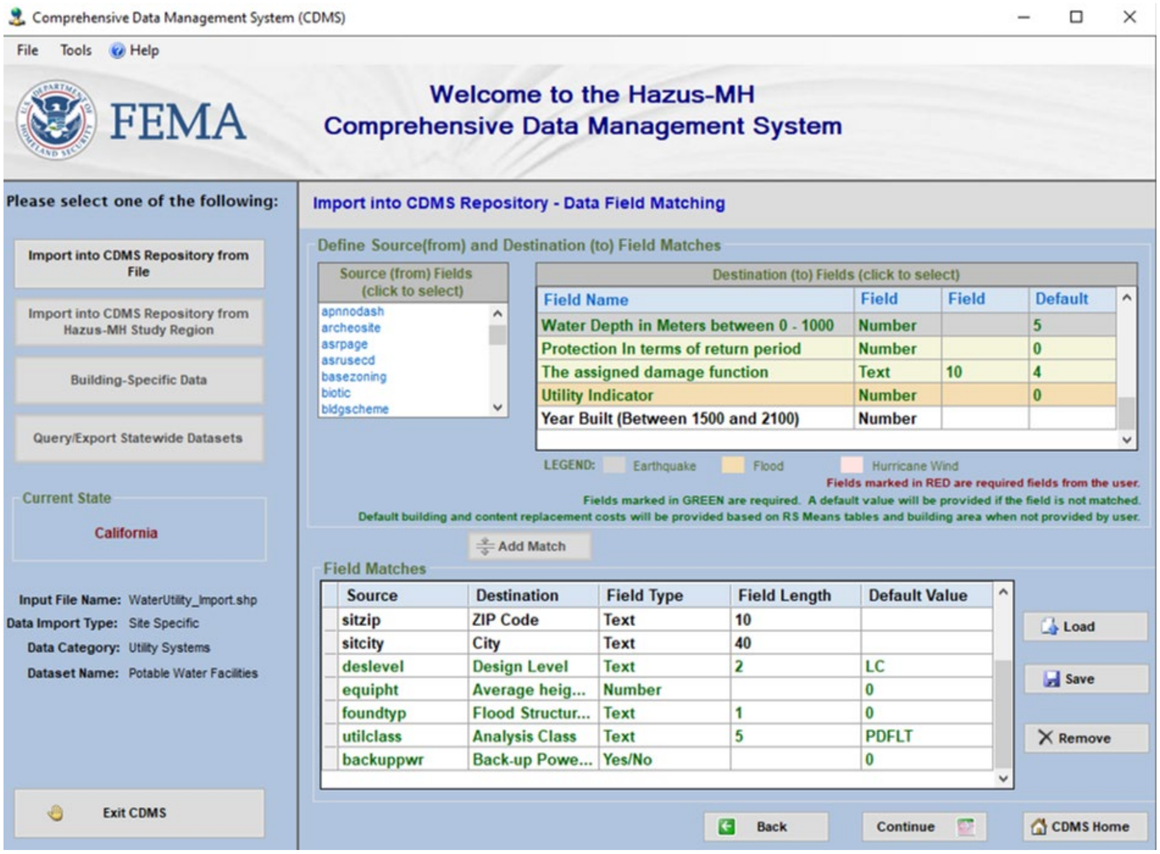
32. Then click Browse and find the WaterUtility_Import.shp file (you'll need to change the file type). Under Select Hazus-MH Inventory Category: select Utility Systems, then under Select Hazus-MH Inventory Dataset (Layer): select Potable Water Facilities.



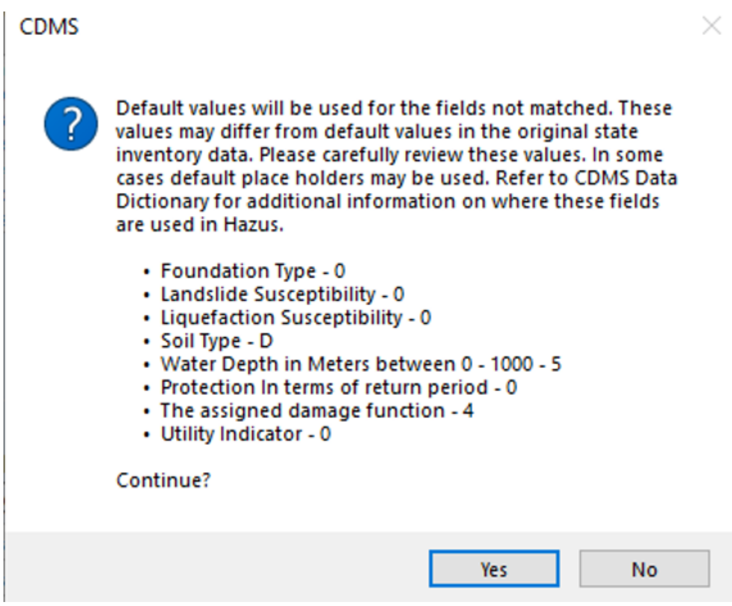
33. Select Continue. Under Select Import Table: WaterUtility_Import will be selected and under Select HAZUS-ID Field** (if available): select No Hazus ID. Click Continue.

34. Match the fields from WaterUtility_Import data to the Hazus fields. Notice the following fields have already been matched correctly: Cost to Building Replacement Cost, eqbldgtype to Earthquake Building Type, and tract to Census Tract. Match the following yourself:

- siteadd -> Address
- type -> Facility Name
- sitzip -> ZIP Code
- sitcity -> City
- deslevel -> Design Level
- equipht -> Average height of electrical equipment
- foundtyp -> Flood Structure Foundation Type
- utilclass -> Analysis Class
- backuppwr -> Back-up Power (Yes or No)

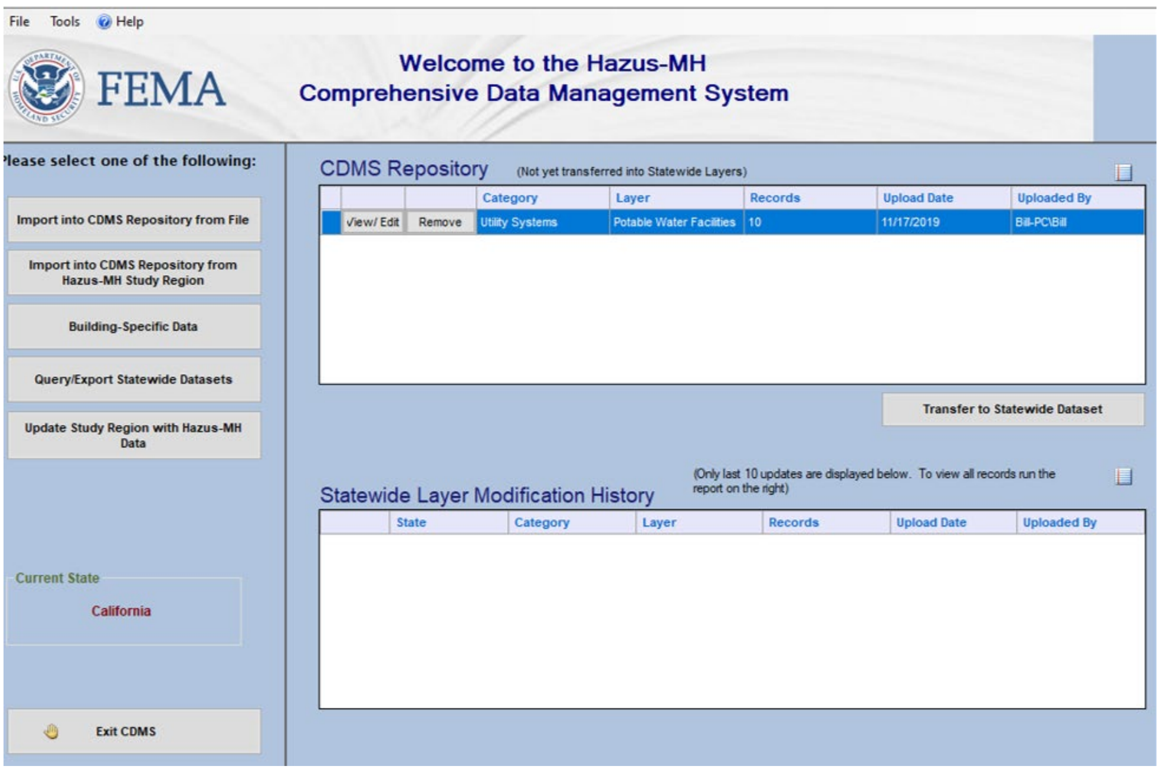


35. Click Continue. The following message comes up:

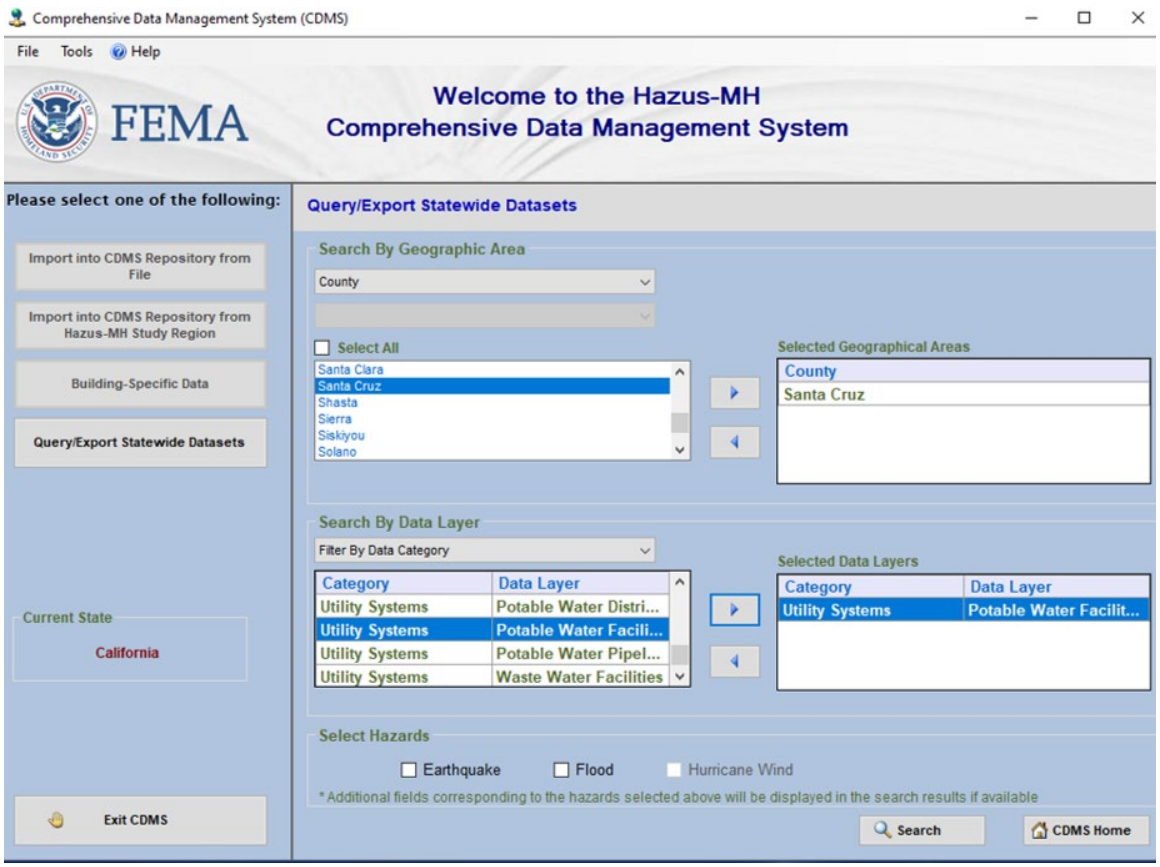


36. Click Yes. Then the Categorize Fields menu comes up.

37. Click OK. Then click Continue when the Earthquake Building Type categorization comes up, Continue when the Earthquake Design Level categorization comes up, Continue when the Flood Structure Foundation Type comes up, Continue when the Analysis Class categorization comes up, and Continue when the Back-up Power (Yes or No) categorization comes up. CDMS will process for several seconds and the Import Success message should come up. Click OK. The water utility data should show up in the CDMS Repository.



38. Before you update the state data, let's get rid of the existing data. Select Query/Export Statewide Datasets on the left. In Search by Geographic Area, select County, then select Santa Cruz in the list of Counties/Cities, and click on the right arrow. Under Search By Data Layer, click on Utility Systems and Potable Water Facilities, and then select the right arrow.



39. Click Search. The query will provide all the existing school data. If there are any records, select Delete All Records for Selected Inventory. Click Yes when the warning message comes up. Then click CDMS Home.

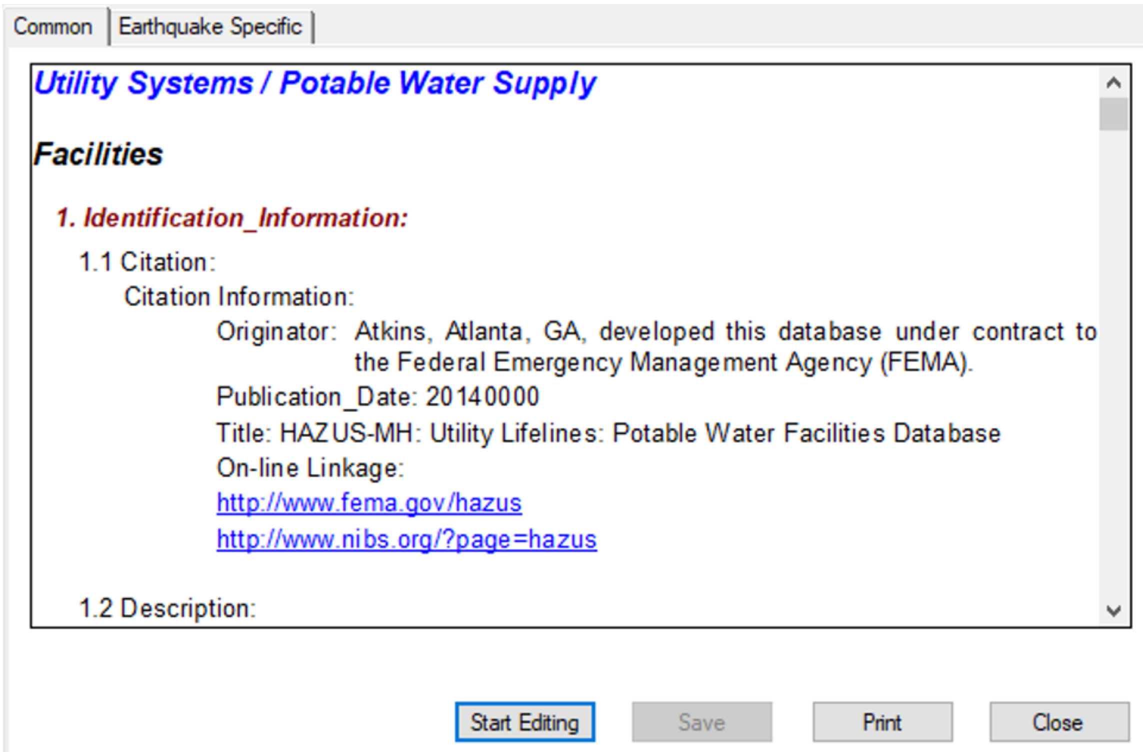
40. Click Transfer to Statewide Dataset. Then select Replace Data and Submit. Finally, select Yes when the warning message comes up. Close CDMS.

41. Create a new study region. Create an earthquake and tsunami study region for Santa Cruz, California and call it SantaCruz_EQ_FL. After Hazus aggregates the region, open the earthquake hazard. Select Inventory and then Utility Systems. Click on the Potable Water tab and then the Potable Water System Facilities Dropdown. There should be 10 potable water facilities in the table and the fields you brought in using CDMS should be populated. Switch to the flood hazard and open the potable water facilities inventory table. Make sure there are 10 water facilities.

Task 4: Document Updated Inventory

1. Document the edits you made. For utility facility edits, browse to the water facility table, right click in the data, and select Meta Data. Click Start Editing at the bottom. Now delete the originator information and add yourself, update the abstract to include a description of where you got the data (source) by consulting the Santa Cruz GIS website, then add information on what you did to the data. How did you calculate cost, etc. When you're done, select Stop Editing. If

you're more comfortable editing this information in Word, go to the study region folder and open this document: C:\HazusData\Regions\SantaCruz_EQ_FL\ hzPotableWaterFlty_md.rtf.



The utilities have been updated.

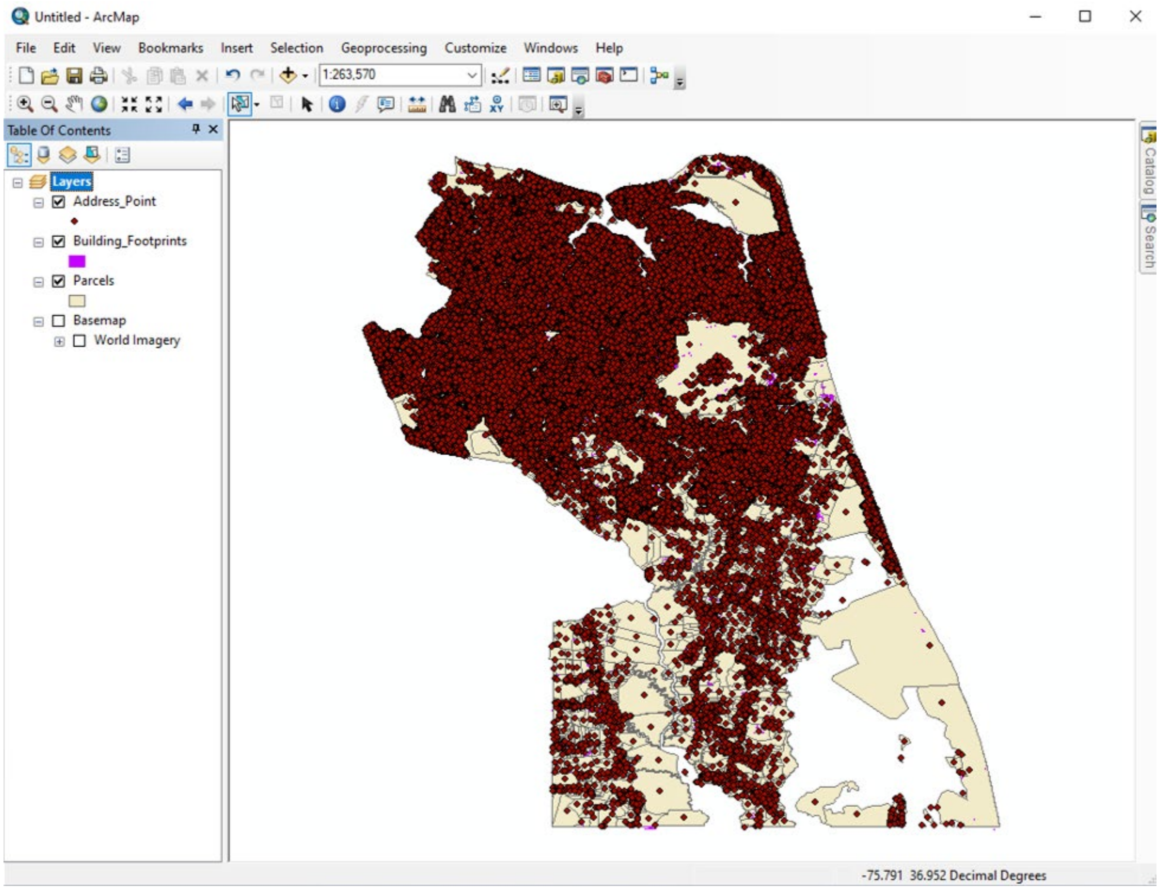
Application 3: User-Defined Facilities (All Hazards)

Task 1: Identify, Collect, and Validate Local Data

1. First locate the building footprint and parcel data. Local GIS websites are good sources of data. For Virginia Beach, the local building footprint, address points, and parcel data have already been identified and downloaded here: C:\E0177\Activity\4.1\VirginiaBeach\ and are called Building_Footprints.shp, Address_Point.shp, and Parcels.shp. This is data that was downloaded from the City's GIS website (https://gis.data.vbgov.com/). It is important to identify the metadata as well. In this case, the metadata is located on the website.

2. Create a new earthquake, flood, hurricane study region in Hazus called Temp. The study region should include your county/city and the hazards you want to model. When the study region has been created, close Hazus.

3. Open ArcMap and add the building footprint, address point, and parcel data to the map.



4. Right click on the building footprint name and select Open Attribute Table. These building footprints contain both height (in feet) and area (in square feet) as separate fields as well as a field describing building use. If your building footprint data doesn't have area already calculated, use the Calculate Geometry tool. To calculate area, you may have to change the coordinate system of the data frame.

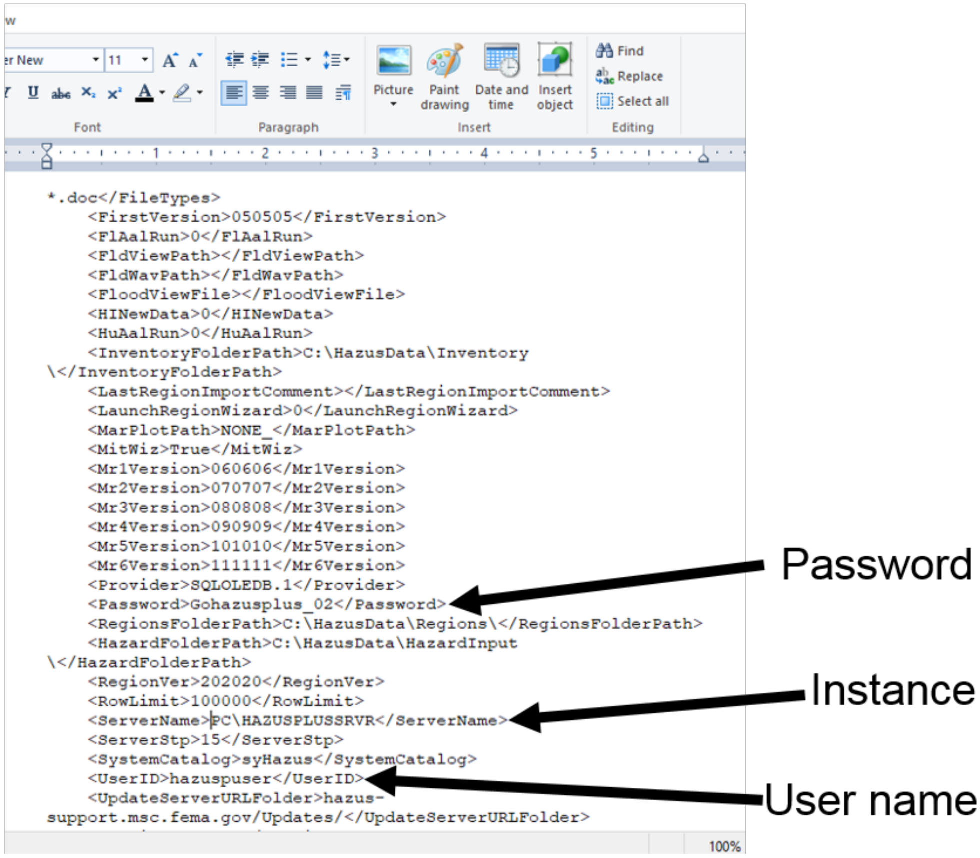
Task 2: Format Data

1. Identify the required fields and the formatting of those fields. To do this, we will review the SQL tables using ArcCatalog. Open ArcCatalog. Then browse to C:\E0177\Activity\4.1\ using ArcCatalog. Right click in the white box under the file name, VirginiaBeach.

2. Select New and then Database Connection. The Database Connection menu will appear.

3. To figure out how to populate the Instance, User name, and Password, go to C:\Program Files (x86)\Hazus-MH\Settings.xml and open the file. The information shown in the xml file may be copied from the xml file and pasted into the ArcCatalog interface. The instance includes the computer name which can be long. Your computer name will be different than the example.

C:\Program Files (x86)\Hazus-MH\Settings.xml



```
*.doc</FileTypes>
    <FirstVersion>050505</FirstVersion>
    <FlAalRun>0</FlAalRun>
    <FldViewPath></FldViewPath>
    <FldWavPath></FldWavPath>
    <FloodViewFile></FloodViewFile>
    <HINewData>0</HINewData>
    <HuAalRun>0</HuAalRun>
    <InventoryFolderPath>C:\HazusData\Inventory
\</InventoryFolderPath>
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    <LaunchRegionWizard>0</LaunchRegionWizard>
    <MarPlotPath>NONE_</MarPlotPath>
    <MitWiz>True</MitWiz>
    <Mr1Version>060606</Mr1Version>
    <Mr2Version>070707</Mr2Version>
    <Mr3Version>080808</Mr3Version>
    <Mr4Version>090909</Mr4Version>
    <Mr5Version>101010</Mr5Version>
    <Mr6Version>111111</Mr6Version>
    <Provider>SQLOLEDB.1</Provider>
    <Password>Gohazusplus_02</Password>
    <RegionsFolderPath>C:\HazusData\Regions\</RegionsFolderPath>
    <HazardFolderPath>C:\HazusData\HazardInput
\</HazardFolderPath>
    <RegionVer>202020</RegionVer>
    <RowLimit>100000</RowLimit>
    <ServerName>PC\HAZUSPLUSSRVR</ServerName>
    <ServerStp>15</ServerStp>
    <SystemCatalog>syHazus</SystemCatalog>
    <UserID>hazuspuser</UserID>
    <UpdateServerURLFolder>hazus-
support.msc.fema.gov/Updates/</UpdateServerURLFolder>
```
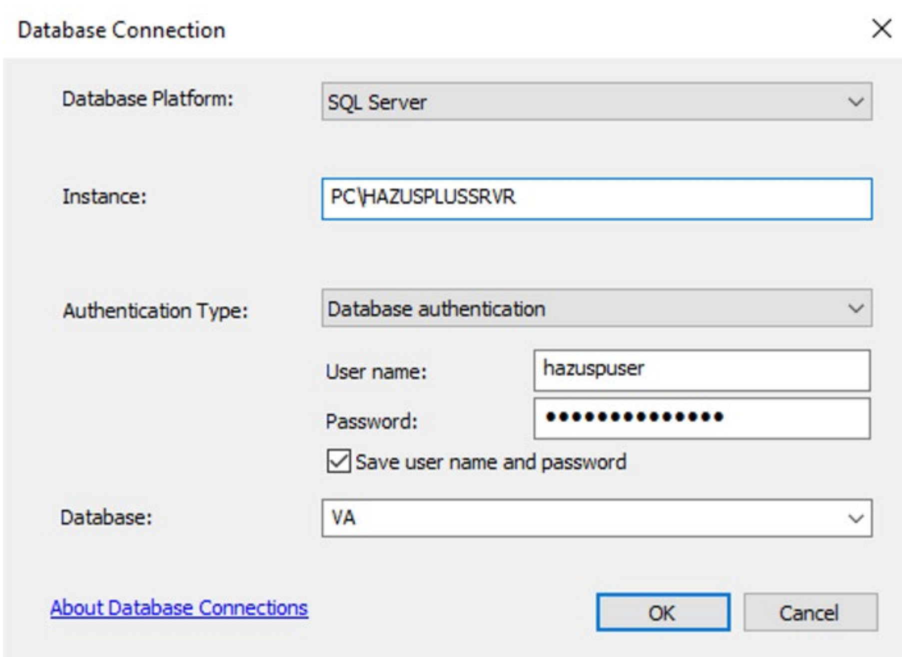


4. Enter the password, instance, and user name into the ArcCatalog interface. Select SQL Server in the top dropdown.

5. Select VA in the database dropdown and then select OK. This will create a database connection with the default name: Connection to PC_Name.sde where PC_Name is the name provided in the instance. Double click on the new connection name to access the Hazus Virginia State data.



5. Select VA in the database dropdown and then select OK. This will create a database connection with the default name: Connection to PC_Name.sde where PC_Name is the name provided in the instance. Double click on the new connection name to access the Hazus Virginia State data.

6. Reviewing the data in the state database, files that start with eq are associated with the earthquake model, fl is flood, hu is hurricane, ts is tsunami (for tsunami states not Virginia), and hz is common across all hazards. For this activity, we are going to focus on the UDF files:

- hzUserDefinedFlty (general UDF characteristics)
- eqUserDefinedFlty (earthquake UDF characteristics)
- flUserDefinedFlty (flood UDF characteristics)
- huUserDefinedFlty (hurricane UDF characteristics)

7. Right click on VA.dbo.hzUserDefinedFlty in ArcCatalog, then click Properties. Click on the Fields tab. The data type is provided in the right column. Click on Text next to UserDefinedFltyID and you'll see the size is 8 characters. All of the tables have already been characterized for you in the UDF Tool found here: C:\E0177\Activity\4.1\UDFTool.xlsx.

8. Open the UDF Tool Excel spreadsheet. It will provide information on the field, data type, and whether or not it is required, recommended, or not needed for a Hazus analysis.

Task 3: Update Inventory

1. In this step, you're going to look at what data is required to run a Hazus analysis, compare it to what you already have, plan an approach, and then make inventory updates. Looking at the Virginia Beach parcel data, we have the following fields: Name, Address, City, Zipcode, State, contact, and phone. The Virginia Beach address point data has the year built in it. We'll still need to format these fields and we'll also need to create the following fields: occupancy, tract, cost,

number of stories, latitude, longitude, foundation type, first floor height, building damage Function ID (because we're on the coast), content damage function ID (because we're on the coast), inventory damage function ID (because we're on the coast), design level, earthquake building type, UDS class, and hurricane building scheme name.

2. If you are not running an earthquake or tsunami analysis, you do not need to collect design level, earthquake building type, UDS class, or anything else in the eqUserDefinedFlty table. If you are not running a hurricane analysis, you do not need to collect hurricane building scheme name or anything else in the huUserDefinedFlty table. If you are not running a flood or tsunami analysis, you do not need to collect foundation type, first floor height, damage function ID, or anything else in the flUserDefinedFlty table.

3. Now create a plan to populate the required fields with the local data.

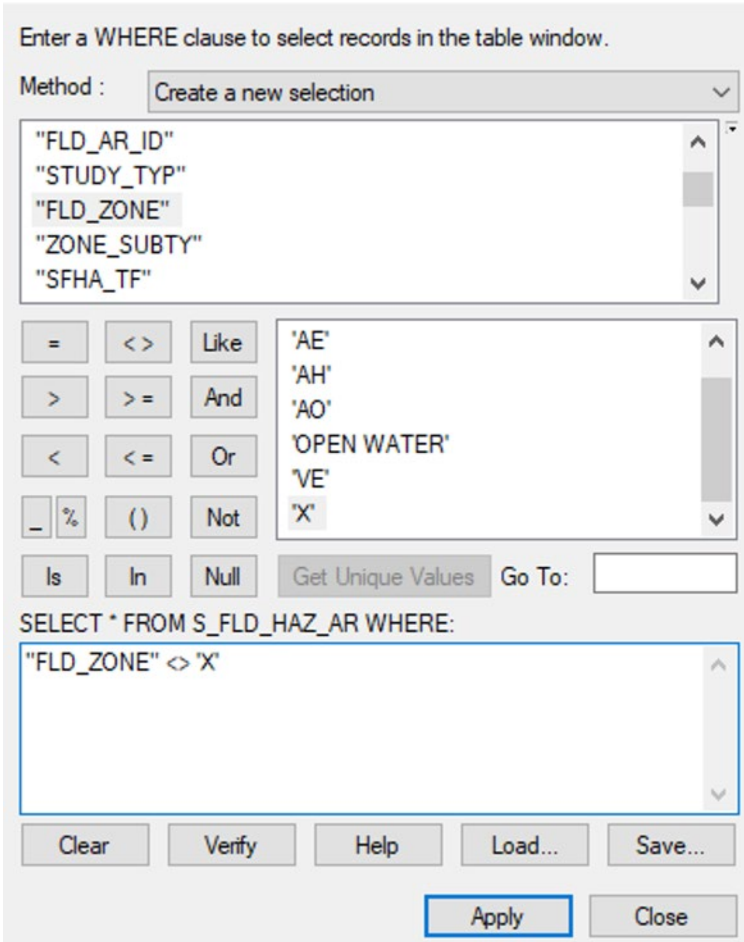
- Latitude and Longitude: You'll need to represent each building with a single latitude and longitude. If a floodplain passes through the corner of a building, and the latitude and longitude chosen is in the centroid, Hazus will show the building as not being impacted. We'll need to create a way to ensure all damage is registered.
- Occupancy: In the parcel data, we have a Land_Use field which helps describe the property's purpose. In the building footprint data, we have a FCode field which describes the building. You'll need to figure out how to convert the two codes into a Hazus specific occupancy. Mixed use buildings will also need to be modeled correctly.
- Tract: Tract can be created by joining the building to the Census Tract layer. If your data already has Census Tract data, confirm it is the 2010 Census Tracts and it is formatted correctly. The UDF tool can be used to check formatting.
- Cost: This is structural replacement cost and can be created using the building's square footage, the RSMeans values found in the UDF Tool Excel Spreadsheet, and the regional multiplier found in the state data.
- Number of Stories: Number of stories can be used to help determine building type and it is also used by the flood model to determine the depth damage function.
- Foundation Type: The flood model uses this field to determine whether a building has a basement or not. If the value is 4, Hazus will use a basement depth damage function. If it is any other value, Hazus will use a no basement depth damage function.
- First Floor Height: Some communities have first floor elevations for building in the floodplain and store that information in an elevation certificate. Buildings built after the Flood Insurance Rate Map (FIRM) has been adopted, will have a height greater than the flood elevation. First floor height can be approximated using the foundation type described in the flood tool. The foundation type is regional with more buildings in the north having basements than in the south. This foundation distribution is also shown in the UDF Tool. Google Street View can also be used to help identify foundation type and first floor height.
- Damage Functions: Buildings located in the coastal floodplain (V or VE zones) should be assigned a coastal depth damage function which is provided in the UDF Tool. This ensures the correct depth damage function is applied to the inventory.
- Design Level: The design level can be developed knowing the year built for the building and the geographic location.
- Earthquake Building Type: The earthquake building type will differ based on the occupancy, geographic region, and year built. Some communities maintain this

information in their parcel data. Virginia Beach does not. We will have the number of stories which helps make up the building type and we have the default mapping schemes provided in Hazus.

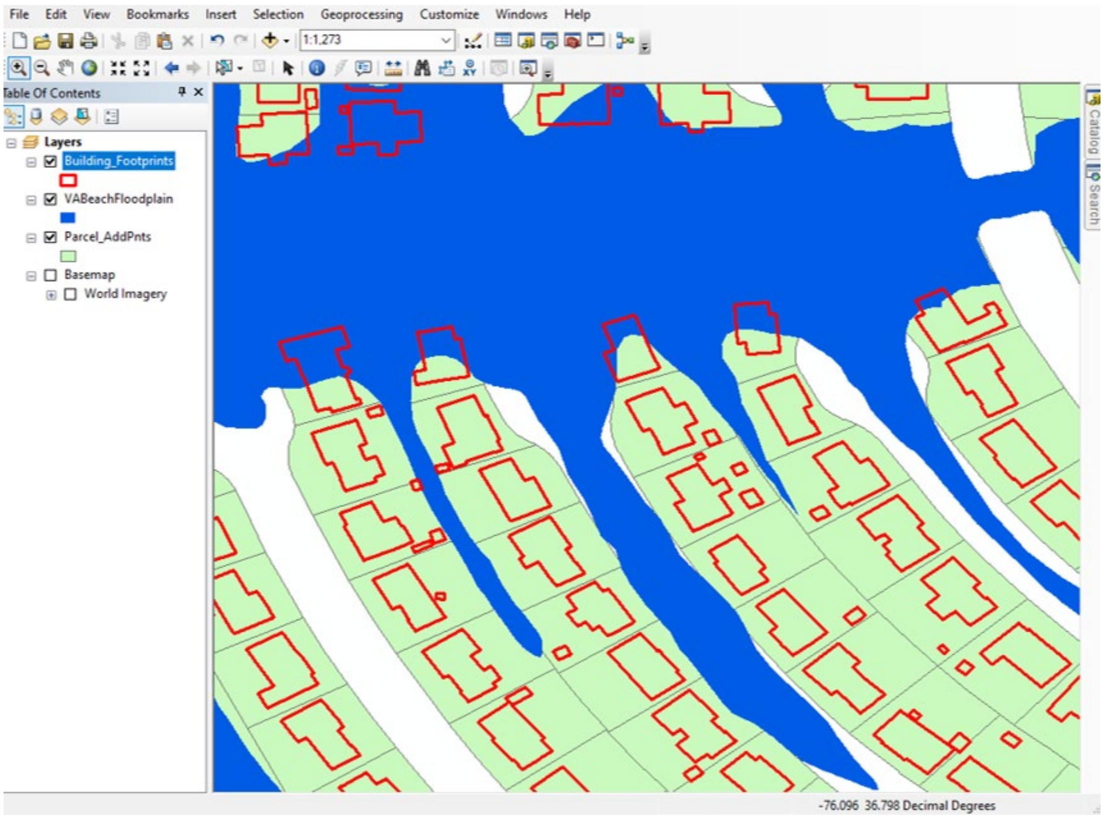
- UDS Class: Although this field is required by the earthquake model, a single value of UDFLT is used.
- Hurricane Building Scheme: This scheme will be assigned based on where your study region is located. A list of the schemes can be found in the UDF Tool.

4. This step will focus on converting parcel, footprint, and address point data into a single dataset that will represent the location of the buildings. First, you'll convert the building footprints into a point layer. If we add a latitude and longitude at the centroid of the building footprint, some of the buildings may not be placed in the floodplain when they should be flooded. To get around this issue, you'll need to use the FEMA floodplain. The FEMA Map Service Center has the floodplain information you'll need if you're using your own data. The Virginia Beach floodplain data has already been downloaded and can be found here: C:\E0177\Activity\4.1\VirginiaBeach\515531_20160229\. If you are using your own data, go to the MSC website (https://msc.fema.gov), click on Search All Products; then select your state, county, and community; and Search. Click on Effective Products and NFHL Data-County, then click on the DL button on the right.

5. Go to the C:\E0177\Activity\4.1\VirginiaBeach\515531_20160229\ and add the S_FLDLHAZ_AR.shp file. This is the special flood hazard area and depicts the different flood zones. Open the attribute table for the S_FLD_HAZ_AR file and left click on the top left button. Click Select by Attributes, then double click on "FLD_Zone" then click <> and Get Unique Values. Double click on 'x' and then Apply. This will query everything that is not the X zone. The X zones is outside the 100-year event.



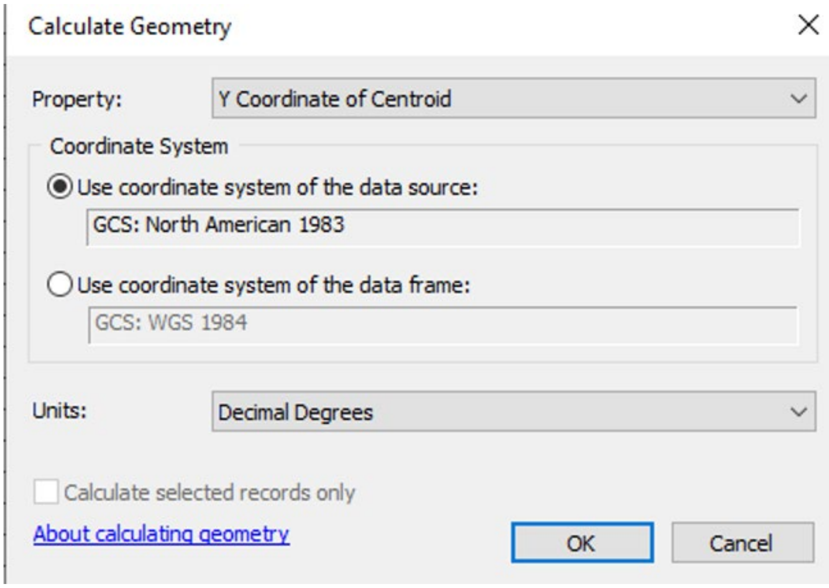
6. Right click on the S_FLD_HAZ_AR and select Data and then Export Data. Call the new layer VABeachFloodplain and save it here: C:\E0177\Activity\4.1\VirginiaBeach\VABeachFloodplain.shp. Add the layer to the map. If you zoom into the floodplain, you can see buildings that have their centroid outside of the floodplain while the footprint is partially inside. Use the editor toolbar to edit the VABeachFloodplain layer, select all the records and merge them into one polygon.



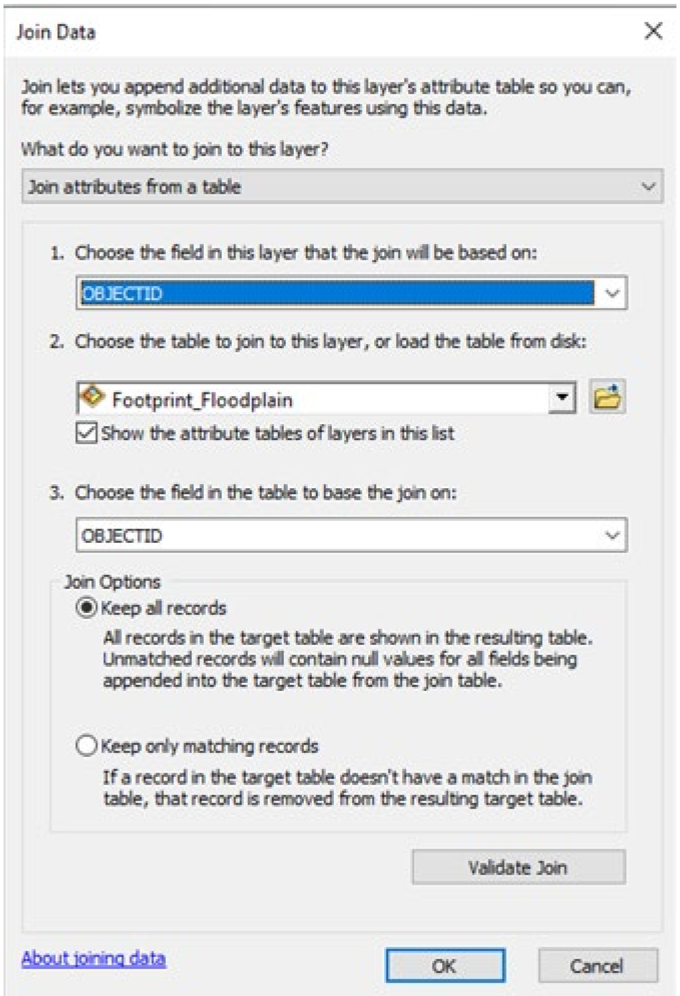
7. Next, conduct an intersect between the floodplain and the building footprints. First go to ArcCatalog and create a new personal geodatabase called VABeach_UDF. Close ArcCatalog and go to ArcToolbox, then select Analysis Tools, Overlay, and Intersect.

8. Under Input Features, select Building_Footprints and VABeachFloodplain. For Output Feature Class, browse to: C:\E0177\Activity\4.1\VirginiaBeach\VABeach_UDF.mdb\Footprint_Floodplain. Then click OK.

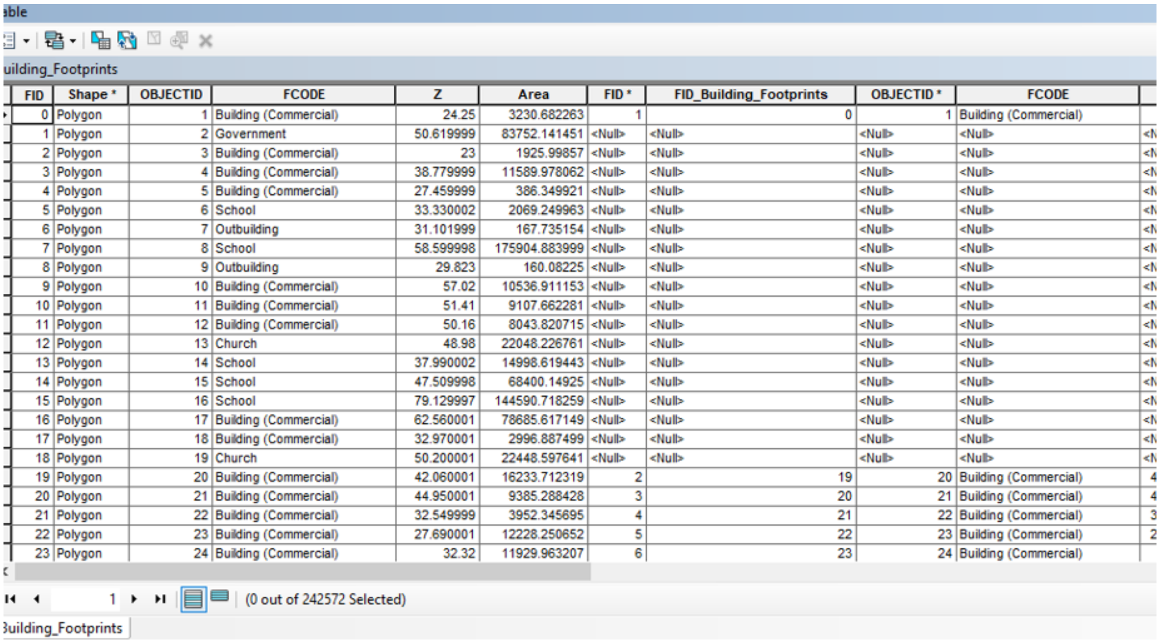
9. The layer Footprint_Floodplain should be added to your map automatically. Close ArcToolbox. Open the attribute table for Footprint_Floodplain and add two fields called Latitude and Longitude with a data type of Double. Scroll over to the Latitude and Longitude fields. Right click on Latitude and select Calculate Geometry. Select Yes when the warning message comes up. Select Y Coordinate of Centroid and for the coordinate system: GCS: WGS 1984 with units of decimal degrees. Then select OK. Click Yes when the warning message comes up.



10. Calculate the X coordinate for the Longitude field. Close the attribute table. The building footprints which overlap the floodplain now have a latitude and longitude, but the rest of the building footprints need those fields too. Right click on Building_Footprints and select Relates and Joins and then Joins. Select Join attributes from a table, then OBJECTID, then Footprint_Floodplain, OBJECTID, and Keep all records. Then click OK.



11. Select Yes when the warning comes up. Open the Building_Footprints attribute table. You'll notice that the buildings that overlapped the floodplain have values in the fields right of Area while the other footprints do not.



able

uilding_Footprints

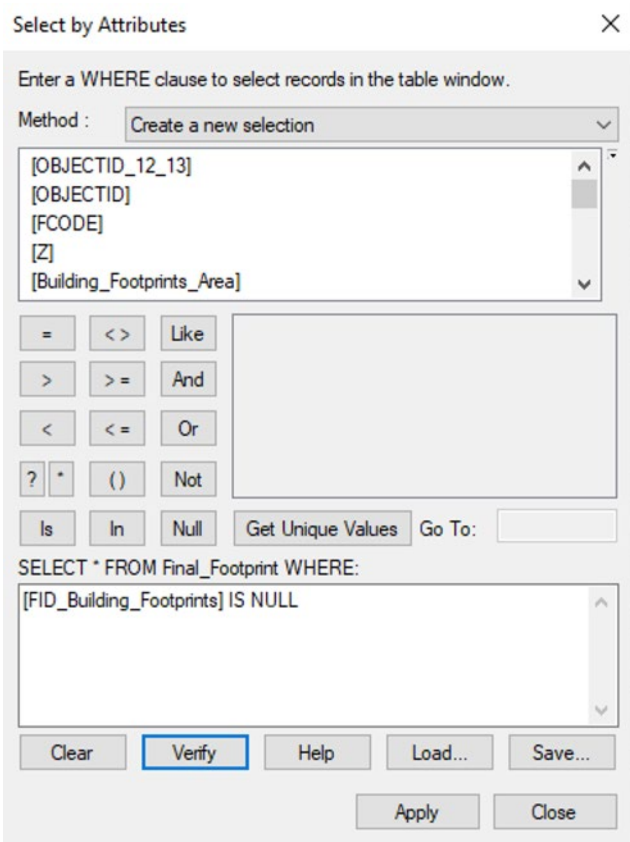
FID	Shape *	OBJECTID	FCODE	Z	Area	FID *	FID_Building_Footprints	OBJECTID *	FCODE	
0	Polygon	1	Building (Commercial)	24.25	3230.682263	1	0	1	Building (Commercial)	
1	Polygon	2	Government	50.619999	83752.141451	<Null>	<Null>	<Null>	<Null>	<N
2	Polygon	3	Building (Commercial)	23	1925.99857	<Null>	<Null>	<Null>	<Null>	<N
3	Polygon	4	Building (Commercial)	38.779999	11589.978062	<Null>	<Null>	<Null>	<Null>	<N
4	Polygon	5	Building (Commercial)	27.459999	386.349921	<Null>	<Null>	<Null>	<Null>	<N
5	Polygon	6	School	33.330002	2069.249963	<Null>	<Null>	<Null>	<Null>	<N
6	Polygon	7	Outbuilding	31.101999	167.735154	<Null>	<Null>	<Null>	<Null>	<N
7	Polygon	8	School	58.599998	175904.883999	<Null>	<Null>	<Null>	<Null>	<N
8	Polygon	9	Outbuilding	29.823	160.08225	<Null>	<Null>	<Null>	<Null>	<N
9	Polygon	10	Building (Commercial)	57.02	10536.911153	<Null>	<Null>	<Null>	<Null>	<N
10	Polygon	11	Building (Commercial)	51.41	9107.662281	<Null>	<Null>	<Null>	<Null>	<N
11	Polygon	12	Building (Commercial)	50.16	8043.820715	<Null>	<Null>	<Null>	<Null>	<N
12	Polygon	13	Church	48.98	22048.226761	<Null>	<Null>	<Null>	<Null>	<N
13	Polygon	14	School	37.990002	14998.619443	<Null>	<Null>	<Null>	<Null>	<N
14	Polygon	15	School	47.509998	68400.14925	<Null>	<Null>	<Null>	<Null>	<N
15	Polygon	16	School	79.129997	144590.718259	<Null>	<Null>	<Null>	<Null>	<N
16	Polygon	17	Building (Commercial)	62.560001	78685.617149	<Null>	<Null>	<Null>	<Null>	<N
17	Polygon	18	Building (Commercial)	32.970001	2996.887499	<Null>	<Null>	<Null>	<Null>	<N
18	Polygon	19	Church	50.200001	22448.597641	<Null>	<Null>	<Null>	<Null>	<N
19	Polygon	20	Building (Commercial)	42.060001	16233.712319	2	19	20	Building (Commercial)	4
20	Polygon	21	Building (Commercial)	44.950001	9385.288428	3	20	21	Building (Commercial)	4
21	Polygon	22	Building (Commercial)	32.549999	3952.345695	4	21	22	Building (Commercial)	3
22	Polygon	23	Building (Commercial)	27.690001	12228.250652	5	22	23	Building (Commercial)	2
23	Polygon	24	Building (Commercial)	32.32	11929.963207	6	23	24	Building (Commercial)	

1 (0 out of 242572 Selected)

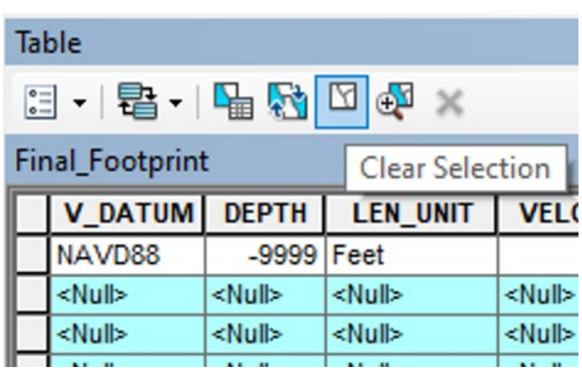
Building_Footprints

12. Close the attribute table. Right click on Building_Footprints and select Data and then Export Data. Change the file type to geodatabase and double click on VABeach_UDF and save the file as Final_Footprint. Click Save and then OK. Click Yes when asked if you want to add the layer to the map. Remove Footprint_Floodplain and Building_Footprints from the map.

13. Now add the latitude and longitude values to the building footprints that don't already have them. Click on the top left button and click Select by Attributes. Select Method as Create a new selection, double click on the field: (FID_Building_Footprints], then select Is and then select Null.



14. Click Apply. Scroll over to the Latitude field. Right click on the Latitude header and then select Calculate Geometry. Click Yes when the warning comes up. Select Y Coordinate of Centroid, coordinate system is GCS: WGS 1984 and decimal degrees. Make sure the Calculate selected records only is checked. Then select OK and Yes when the warning message comes up. Now do the same thing with the Longitude field. Click on the Clear Selection button on the top of the attribute table.



15. Now clean up the attribute table and get rid of the fields which are not needed. The fields to save are: OBJECTID_12_13*, Shape, OBJECTID, FCODE, Z, Building_Footprints_Area, FLD_ZONE, Latitude, Longitude, Shape_Length, and Shape_Area. Delete the other fields.

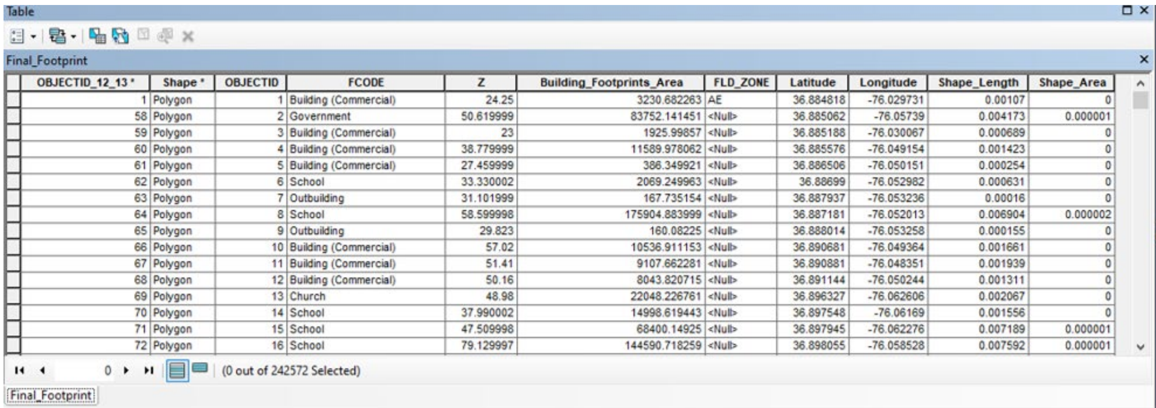
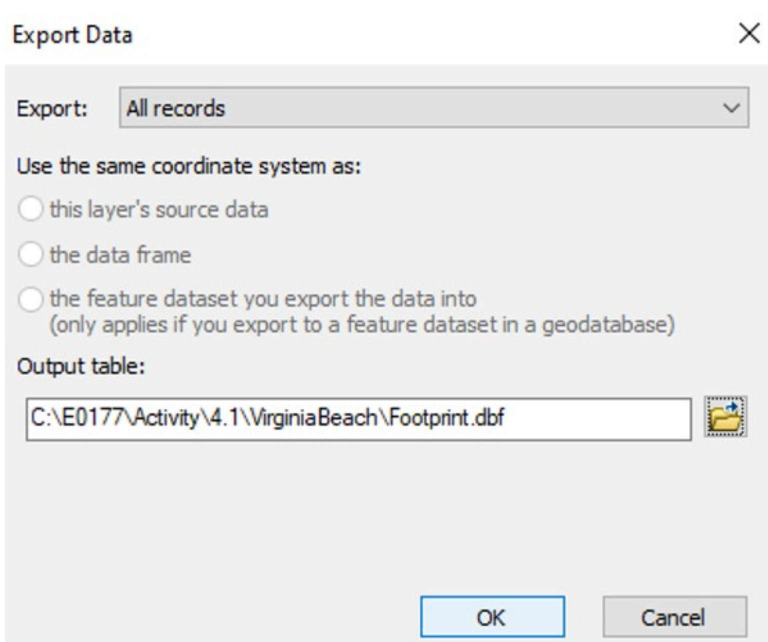


Table
Final_Footprint

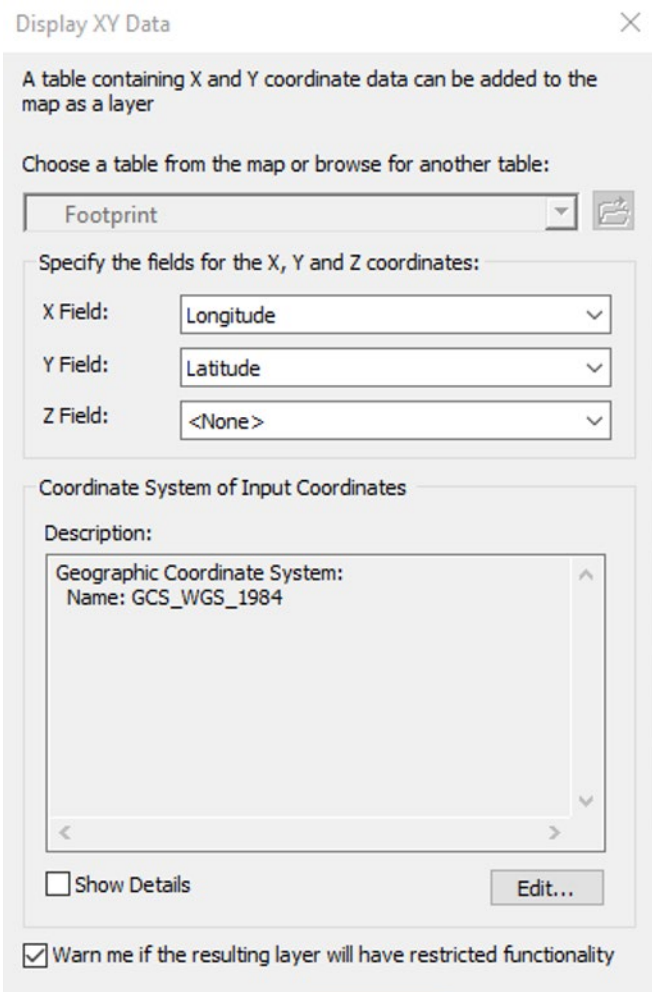
OBJECTID_12_13 *	Shape *	OBJECTID	FCODE	Z	Building_Footprints_Area	FLD_ZONE	Latitude	Longitude	Shape_Length	Shape_Area
1	Polygon	1	Building (Commercial)	24.25	3230.682263	AE	36.884818	-76.029731	0.00107	0
58	Polygon	2	Government	50.619999	83752.141451	<Null>	36.885062	-76.05739	0.004173	0.000001
59	Polygon	3	Building (Commercial)	23	1925.99857	<Null>	36.885188	-76.030067	0.000689	0
60	Polygon	4	Building (Commercial)	38.779999	11589.978062	<Null>	36.885576	-76.049154	0.001423	0
61	Polygon	5	Building (Commercial)	27.459999	386.349921	<Null>	36.886506	-76.050151	0.000254	0
62	Polygon	6	School	33.330002	2069.249963	<Null>	36.88699	-76.052982	0.000631	0
63	Polygon	7	Outbuilding	31.101999	167.735154	<Null>	36.887937	-76.053236	0.00016	0
64	Polygon	8	School	58.599998	175904.883999	<Null>	36.887181	-76.052013	0.006904	0.000002
65	Polygon	9	Outbuilding	29.823	160.08225	<Null>	36.888014	-76.053258	0.000155	0
66	Polygon	10	Building (Commercial)	57.02	10536.911153	<Null>	36.890681	-76.049364	0.001661	0
67	Polygon	11	Building (Commercial)	51.41	9107.662281	<Null>	36.890881	-76.048351	0.001939	0
68	Polygon	12	Building (Commercial)	50.16	8043.820715	<Null>	36.891144	-76.050244	0.001311	0
69	Polygon	13	Church	48.98	22048.226761	<Null>	36.896327	-76.062606	0.002067	0
70	Polygon	14	School	37.990002	14998.619443	<Null>	36.897548	-76.06169	0.001556	0
71	Polygon	15	School	47.509998	68400.14925	<Null>	36.897945	-76.062276	0.007189	0.000001
72	Polygon	16	School	79.129997	144590.718259	<Null>	36.898055	-76.058528	0.007592	0.000001

(0 out of 242572 Selected)
Final_Footprint

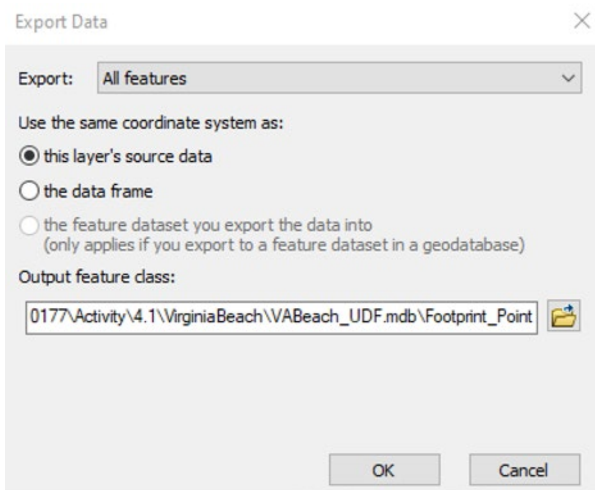
16. Now create a point feature class with the latitude and longitude values. Click on the top left button and select Export. Export all records and save the file as a dbf here: C:\E0177\Activity\4.1\VirginiaBeach\Footprint.dbf. Click Yes when asked to add to current map.



17. Remove the Final_Footprint layer from the map. Right click on the Footprint dbf file and select Display XY data. Set the X field to Longitude, the Y field to Latitude, then Edit the Geographic Coordinate System to GCS_WGS_1984 and click OK.



18. Right click on Footprint Events, then select Data, and Export Data. Save the file as a feature class here: C:\E0177\Activity\4.1\VirginiaBeach\VABeach_UDF.mdb\Footprint_Point. Click Yes when the message comes up asking if you want to add to map.



19. Remove the Footprint Events and Final_Footprint layers and Footprint dbf file from the table of contents. Now, you're going to combine the footprint points and the parcel data using a spatial join. Right click on the Footprint_Point layer and select Joins and Relates and then select Join. From the top, select Join data from another layer based on spatial location. Select Parcels in the next dropdown box, then Each point will be given all the attributes of the polygon that: is closest to it. In the last box, browse to the VABeach_UDF geodatabase and call it: UDF_Working. This will take several minutes to process. Remove the Footprint_Point and Parcels layers from the map.

20. Now add the required fields and delete the fields that are not needed. Open the attribute table for UDF_Working and add the following fields:

- UserDefinedFltyId, text (8)
- Occupancy, text (5)
- Tract, Text (11)
- Name, Text (40)
- Address, Text (40)
- City, Text (40)
- Statea, Text (2)
- Zipcode, Text (10)
- YearBuilt, Short Integer
- Cost, Double
- NumStories, Short Integer (5)
- Area, Float
- ContentCost, Double
- FoundationType, Text (1)
- FirstFloorHt, Double
- BldgDamageFnId, Double
- ContDamageFnId, Double
- InvDamageFnId, Double
- eqBldgType, Text (4)

- eqUdsClass, Text (5)
- DesignLevel, Text (2)

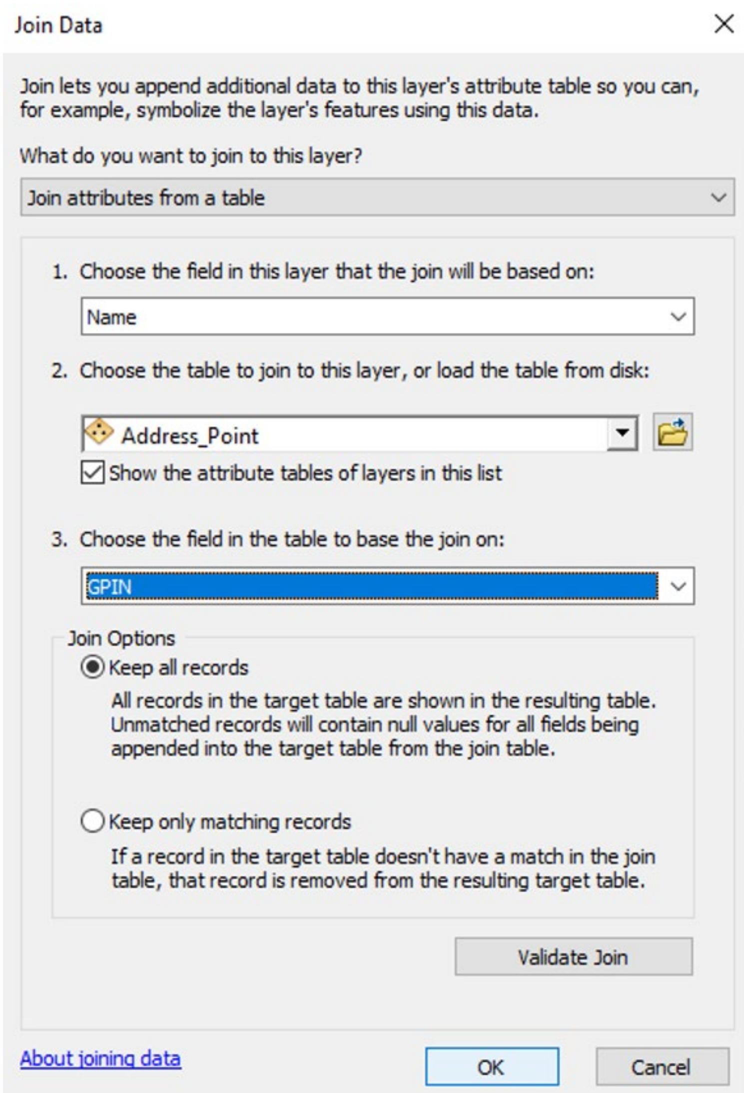
21. Delete the following fields which are not needed: OBJECTID_12, OBJECTID_1, Shape_Leng, FID_1, OBJECTID_2, ST_NUM, ST_NAME, ST_TYPE, ST_DIR, SUBDIVISIO, TAX_AREA, FEMA_ZONE_, NOISE_ZONE, AICUZ_ZONE, MAP_BOOK, MAP_PAGE, INSTRUMENT, SOIL_TYPE, SOIL_DESC, WATERSHED, CENSUS_TRA, CENSUS_BLO, CENSUS_BLK, VOTING_DIS, VOTING_D_1, VOTING_PRE, AGRID, GP_COMP, GP_10K, GP_TAX, SP_X, SP_Y, LATITUDE_1, LONGITUDE_1, POLICE_PRE, POLICE_PAT, RECORDED_G, LOT_NUMBER, TAX_DISTRI, TAX_DIST_1, PLANNING_S, PLANNING_1, FULL_ADDR, PROP_ADD_1, SHAPEarea, and Distance.

22. Populate the fields. Select a column and use the Field Calculator to make the following updates:

- UserDefinedFltyId = OBJECTID
- Name = Par_GPIN
- Address = PROP_ADDRE
- City = “Virginia Beach”. Virginia Beach is the value to put in each record in the City field.
- Statea = “VA”. VA is the value to put in each record in the Statea field.
- Zipcode = ZIP
- eqUdsClass = “UDFLT”. UDFLT is the value to put in each record in the eqUdsClass field.

23. Delete OBJECTID, Par_GPIN, PROP_ADDRE, and ZIP. Close the attribute table.

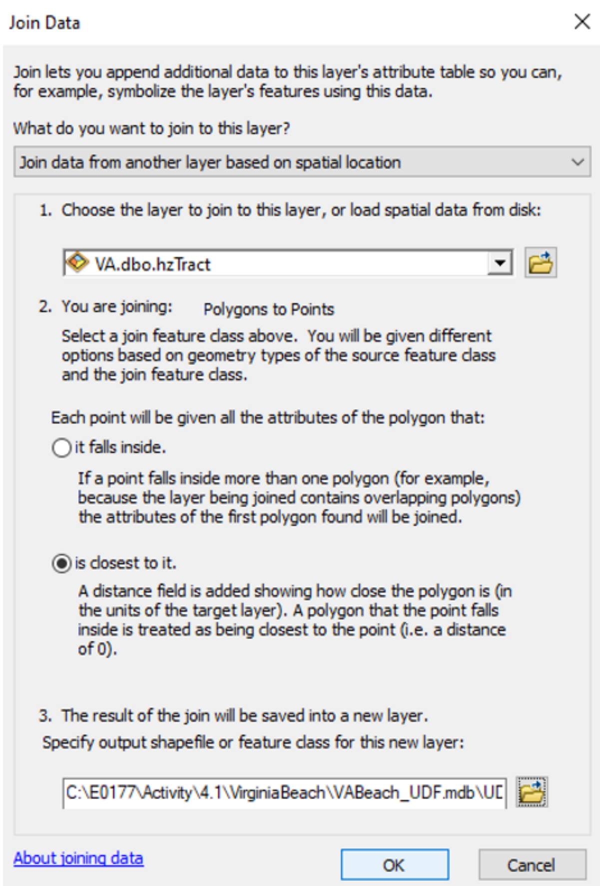
24. Update the year built with the address points. Add Address_Point to the map. Right click on UDF_Working and select Joins and Relates and then Join. Select Join attributes from a table, then Name, Address_Point, GPIN, and Keep all records. Click OK. Then click Yes when the warning message comes up.



25. Open the UDF_Working attribute table and right click on YearBuilt and select Field Calculator. Click Yes when the warning comes up. Browse down the Fields list to Address_Point.YEAR_BUILT double click on the field name. Then click OK. Click Yes when the warning comes up. Close the attribute table. Right click on UDF_Working, click Joins and Relates, Remove Joins, and then Address_Point. Now remove the Address_Point layer. Query the YearBuilt field for all values <1700 or Null using: [YearBuilt] <1700 OR [YearBuilt] IS NULL and assign those values as 1700 to be conservative. Since we now have duplicates of the UserDefinedFltyId, we'll need to run the Field Calculator on that field and make it equal to the OBJECTID_12 field.

26. Next, add the Census Tract data to the UDF_Working layer. Open ArcCatalog and browse to the database connection you created earlier. Left click on VA.dbo.hzTract and drag it to the ArcMap table of contents. Click Close when the Geographic Coordinate Systems Warning comes up. Close ArcCatalog.

27. Right click on the UDF_Working layer, then Joins and Relates, and Join. In the top drop down, pick Join data from another layer based on spatial location, for section 1 select VA_dbo_hzTract, then is closest to it for part 2, and browse to the VABeach_UDF geodatabase and call the new layer UDF_Working2 and click OK. This will take several minutes for larger datasets.



28. Remove the UDF_Working and VA.dbo.hzTract layers from the table of contents and open the attribute table of the UDF_Working2 layer. Every record should now be assigned a Census Tract number and a County FIPS number (which we'll use later in this application). Is closest to it was selected because many of the points fall outside of the Census Tract area which happens sometimes in coastal areas. We'll address this concern later in the application. Right click on the Tract field and select Field Calculator. Click Yes when the warning comes up. Browse down the Field names to Tract_1 and double click on it. Then click OK. Remove UDF_Working2 from the map and then reopen it. Close ArcCatalog. Keep CountyFips, and BldgSchemesId, but delete the following fields: OBJECTID_1, Tract_1, Tract6, TractArea, NumAggrBocks, CenLat, CenLongit, Length, and Distance.

29. Create an occupancy code, number of stories, area, and cost values. If you are using this data for a hurricane only study region, cost is not required and you may skip this part. This is because the hurricane model only calculates the damage state probability and functionality of the essential facility and not the loss.

30. To create replacement cost, we're going to use the building footprint and building footprint height. Since cost is based on occupancy, you'll need to assign that first. Explore your data and figure out how many different types of landuse or occupany values you have in your local data. In the Virginia Beach example, there are 13 different FCODE values and 19 different Land_Use values. You'll need to map your local values to the Hazus occupancy codes. Open the UDF Tool and review Section 2 concerning the occupancy classifications and descriptions. Looking at Land_Use and FCODE, FCODE seems to be more specific but it is missing values. So we'll assign values based on Land_Use first and then FCODE second (this way FCODE overwrites Land_Use).

Land Use Mapping

Land_Use	Hazus
Agriculture - Cropland	AGR1
Agriculture - Pasture	AGR1
Approved Being Developed	
Commercial	COM1
Forest	
Industrial	IND1
Marsh	
Military Base	GOV1
Multi Family	RES3C-RES3F based on square footage
Office	COM7
Park	COM8
Proposed Development	

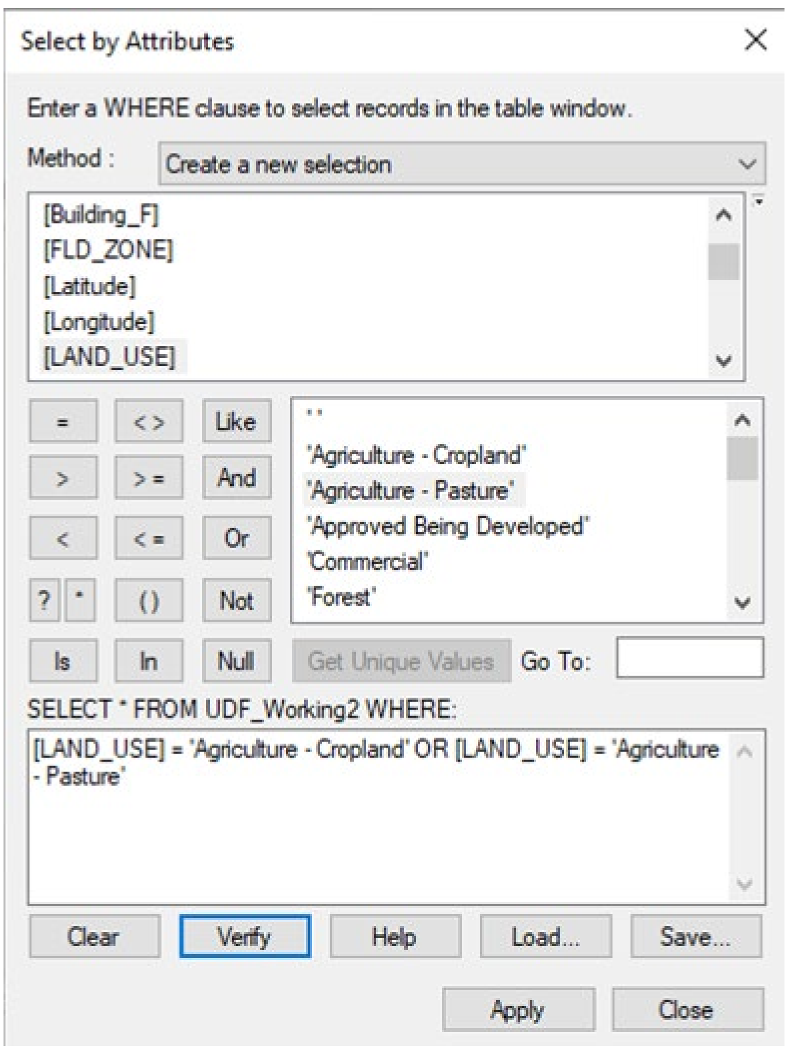
Land_Use	Hazus
Public/Semi Public	GOV1
Single Family or Duplex	RES1
Street Network	
Town House	RES3B
Undeveloped	
Urban Mixed Use	Spec - Flag this for additional edits
Water	

FCODE Mapping

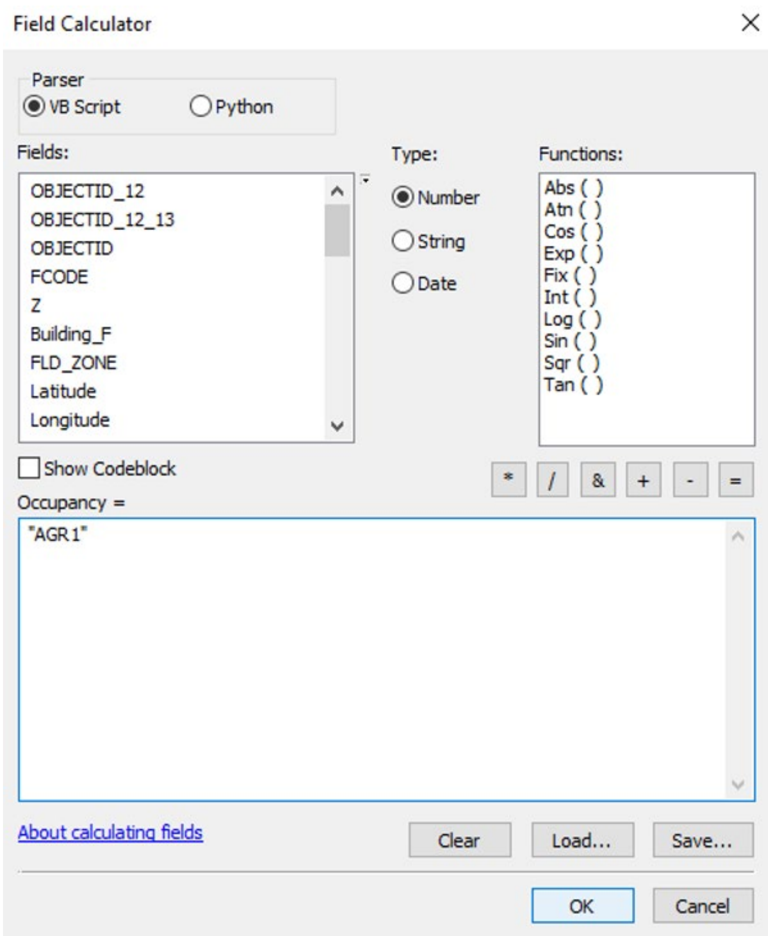
FCODE	Hazus
Airplane Hanger	COM4
Building (Commercial)	
Building (Mobile Home)	RES2
Church	REL1
Gazebo_Greenhouse	COM1
Government	GOV1
Outbuilding	RES2 with name change
Overhead Rooftop/Canopy	
Parking Garage	COM10
Pump Station	COM4

FCODE	Hazus
School	EDU1 or EDU2
SubStation	COM4

31. The UDF Tool Excel Spreadsheet has a second tab called Common Occupancy Codes. Feel free to use this table when assigning specific occupancies to your own data. For the Virginia Beach data, start at the top of Land Use and work your way down. Open the UDF_Working2 attribute table, click on the top left button and click Select by Attributes. Then select Create a new selection, [LAND_USE], = sign, Get Unique Values, then Agriculture – Cropland, then OR, [LAND_USE], = sign, then Agriculture – Pasture. Click Apply.



32. This should select 2,632 points. Scroll over to the Occupancy field, right click and select Field Calculator. Click “Yes” when the warning message comes up. Clear any existing values from the box and type “AGR1”.



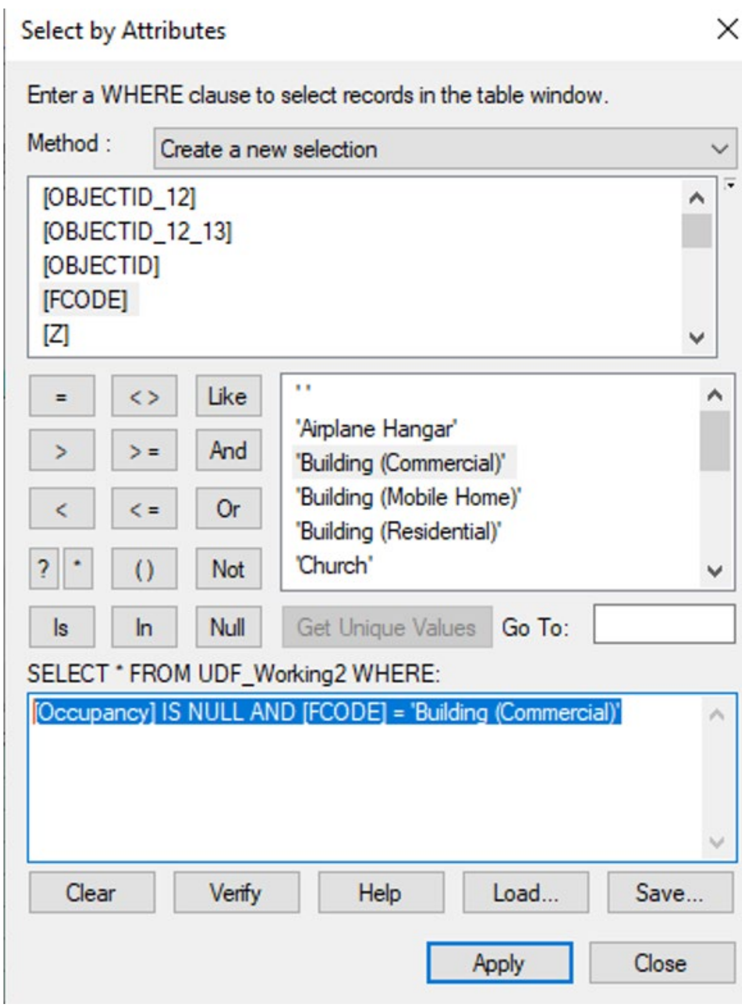
33. Now repeat the same process for Commercial (COM1), Industrial (IND1), Military Base (GOV1), Office (COM7), Park (COM8), Public/Semi Public (GOV1), Single Family (RES1), and Town House (RES3B). For Multi Family, assign the values as “RES3C” and you’ll revisit it later. For Urban Mixed Use, assign it “Mixed” which you’ll also revisit later.

34. Continue with this same process but query the FCODE field to assign values to Airplane Hanger (COM4), Building (Mobile Home) (RES2), Church (REL1), Gazebo_Greenhouse (COM1), Government (GOV1), Parking Garage (COM10), Pump Station (COM4), School (EDU1), and Substation (COM4).

35. Now query the FCODE field for Outbuilding. There should be 83,988 objects selected. Right click on Occupancy and use Field Calculator to add “RES2” to the entries. Then, right click on

Name and use Field Calculator to rename those records “Outbuilding”. This will help you track which entries are outbuildings and which are mobile homes.

36. There should still be several thousand that do not have an occupancy yet. You’ll need to create more queries to populate the values. Open the select by attributes menu and use the following query: [Occupancy] IS NULL AND [FCODE] = 'Building (Commercial)'. This will identify those occupancy values which are null and those that have been designated commercial in the FCODE.



37. Right click on the Occupancy field and use the Field Calculator to populate the value with: “COM1”.

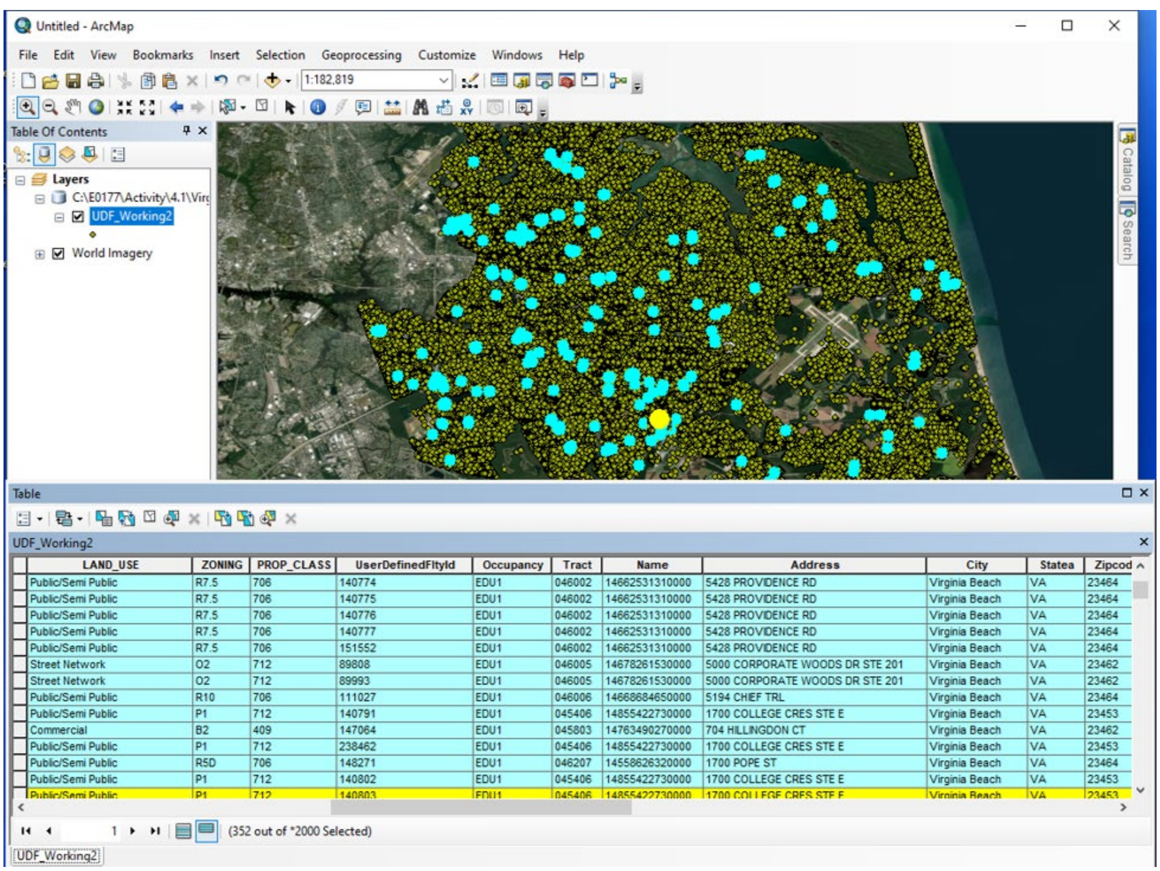
38. Continue to query by attributes and use the following queries:

- [Occupancy] IS NULL AND [FCODE] = 'Building (Residential)' AND [Z] <50 to identify single family homes. Use the Field Calculator to populate these with a value of “RES1”.

- [Occupancy] IS NULL AND [FCODE] = 'Building (Residential)' AND [Z] >= 50 to identify multi-family homes. Populate these with a value of RES3C.
- [Occupancy] IS NULL AND [Building_F] <500 to identify outbuildings. Populate occupancy with a value of RES2 and change the name to Outbuilding. If your local data set does not have outbuildings separated out from regular buildings, query out those buildings with under 500 square feed to footprint and designate outbuilding.
- [Occupancy] IS NULL AND [Z] <50 to identify the single family homes. Use the Field Calculator to populate these with a value of “RES1”.
- [Occupancy] IS NULL AND [Z] >=50 to identify multi-family homes. Populate these with a value of RES3C.

39. After running this final query, all the values in the occupancy field should be populated. There are some occupancies which need to be further clarified: RES3C, EDU1, and Mixed. The mixed use buildings will be updated at the end of this application, the others fixed now.

40. Run the attribute query and select all the EDU1 buildings. Looking at the Virginia Beach website, they have one community college campus which should be designated as EDU2. Browsing through the EDU1 selection, there are several buildings on College Cres Ste. Clicking on one of the buildings, a yellow point is highlighted on the map. We’ll need to zoom into this area and select the campus buildings.



41. Clear the selection and just select those buildings on the campus. Use the Field Calculator to change the occupancy value to EDU2. Clear the selection.

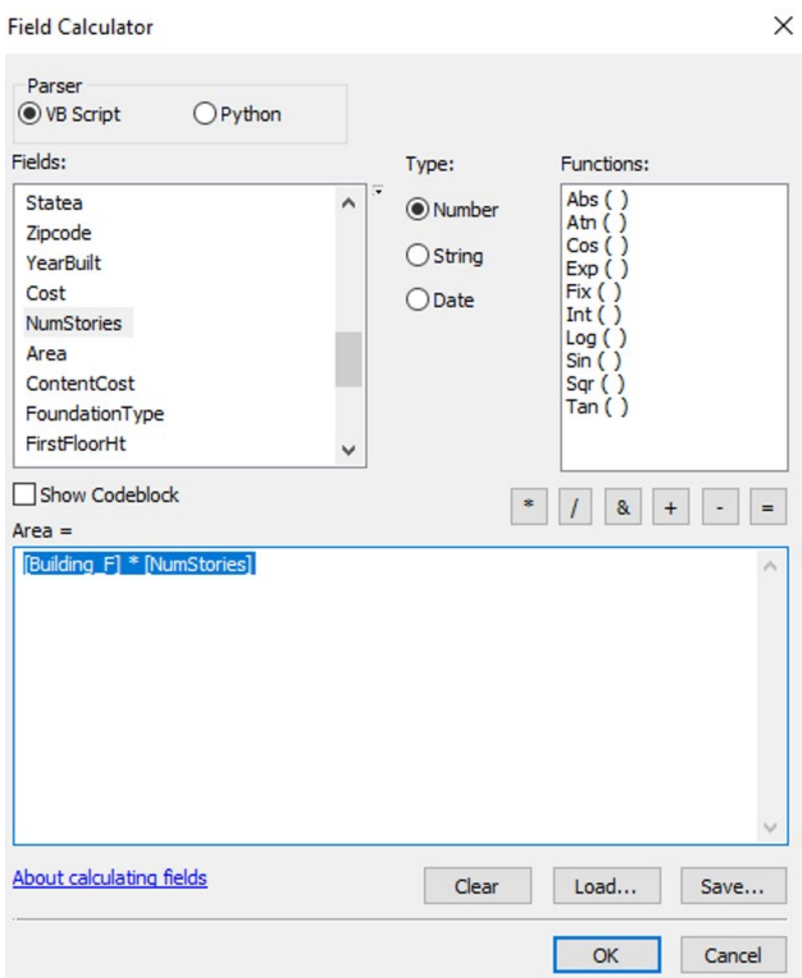
42. In order to further break down the RES3C buildings, their size needs to be better understood. The next step is to calculate number of stories. Run the attribute query and select all the buildings with a Z value less than or equal to 25. [Z] <=25. Then browse to NumStories and use the Field Calculator to assign a value of "1". Run the following queries:

- [Z] > 25 AND [Z] <=40 and assign a NumStories value of 2.
- [Z] > 40 AND [Z] <=55 and assign a NumStories value of 3.
- [Z] > 55 AND [Z] <=70 and assign a NumStories value of 4.
- [Z] > 70 AND [Z] <=85 and assign a NumStories value of 5.
- [Z] > 85 AND [Z] <=100 and assign a NumStories value of 6.
- [Z] > 100 AND [Z] <=115 and assign a NumStories value of 7.
- [Z] > 115 AND [Z] <=130 and assign a NumStories value of 8.
- [Z] > 130 AND [Z] <=145 and assign a NumStories value of 9.
- [Z] > 145 AND [Z] <=160 and assign a NumStories value of 10.
- [Z] > 160 AND [Z] <=175 and assign a NumStories value of 11.
- [Z] > 175 AND [Z] <=190 and assign a NumStories value of 12.
- [Z] > 190 AND [Z] <=205 and assign a NumStories value of 13.
- [Z] > 205 AND [Z] <=220 and assign a NumStories value of 14.

43. There should be only two buildings without a number of stories, 228 Central Park Ave. and 4545 Commerce St. Assign the building on Central Park a number of stories equal to 19 and assign the building on Commerce street a number of stories equal to 27. Google Street View could also be used to confirm the number of stories for some of these structures. Just go to Google (www.google.com), type in the address of the building, click on the map, and then click on the figurine icon.

Name	Address	City	Statea	Zipcode	YearBuilt	Cost	NumStories	Area	Content
14775540310000	228 CENTRAL PARK AVE	Virginia Beach	VA	23462	0	<Null>	19	<Null>	<Null>
14774475100000	4545 COMMERCE ST	Virginia Beach	VA	23462	0	<Null>	27	<Null>	<Null>

44. Clear the selection in the attribute table. Right click on the Area field and select Field Calculator. Click Yes when the warning message comes up. Under Area = write [Building_F] * [NumStories] then click OK.



45. Now you'll refine the RES3C buildings. Run the following attribute queries and assign the values using the Field Calculator:

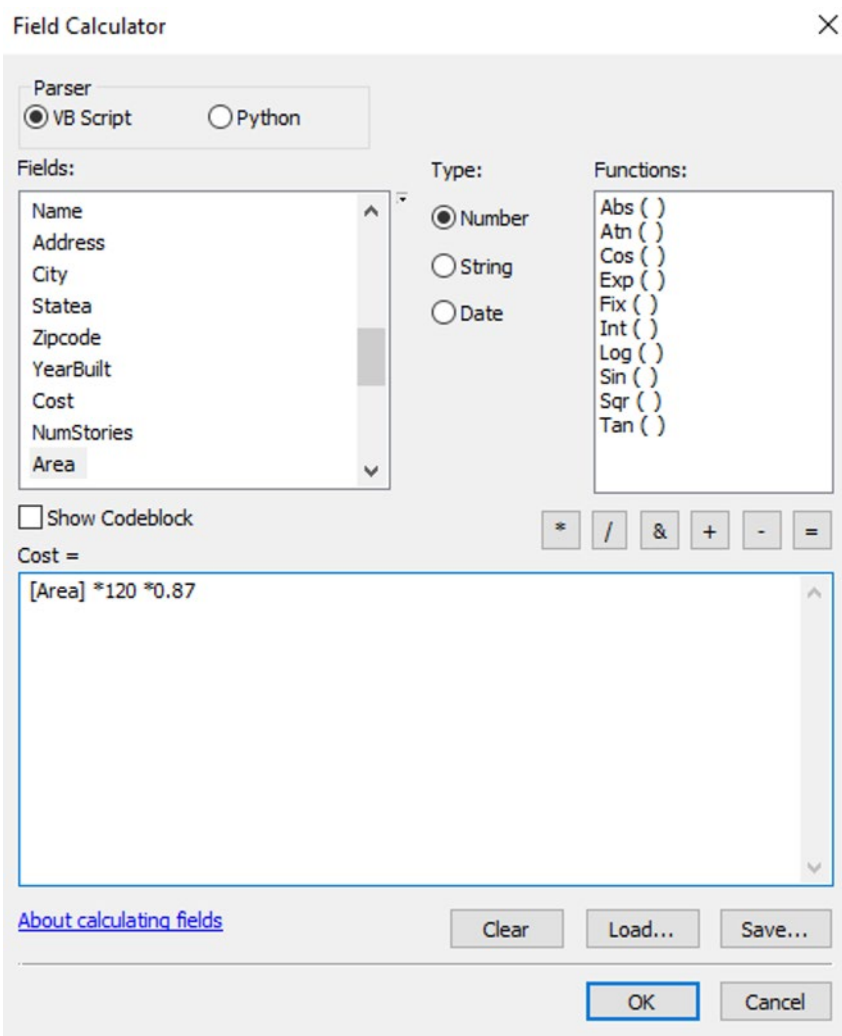
- [Occupancy] = 'RES3C' AND [Area] > 6000 AND [Area] <=12000 and assign Occupancy of RES3D
- [Occupancy] = 'RES3C' AND [Area] > 12000 AND [Area] <=30000 and assign Occupancy of RES3E
- [Occupancy] = 'RES3C' AND [Area] > 30000 and assign Occupancy of RES3F

The RES3C that are less than 6000 square feet remain RES3C.

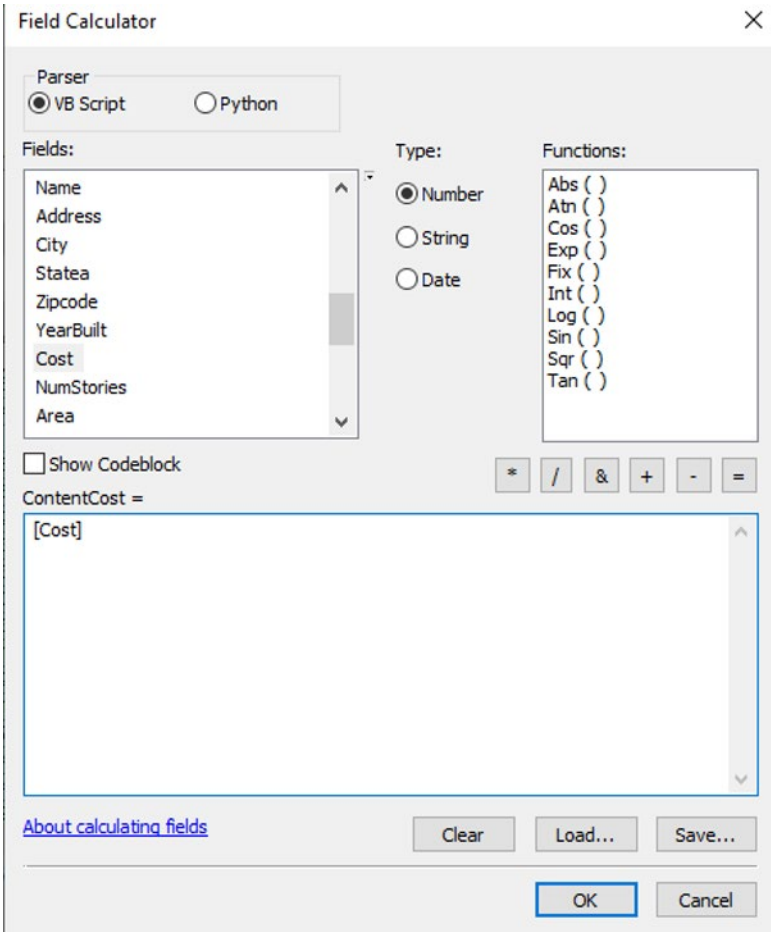
46. Now that we have the total area, we can use it to calculate cost. Open the UDF Tool Excel spreadsheet and look at the RSMeans replacement cost in Section 2. The RSMeans value is the national average and a regional multiplier is required. Open ArcCatalog (not the ArcCatalog accessed from ArcMap but the full version found in the ArcGIS folder) and browse to the state data and find the table called VA.dbo.hzMeansCountyLocationFactor. We know our county's FIPS code since it is attached to our data as the field CountyFips (it was added when we joined the Census Tract data to the UDF data). The county FIPS for Virginia Beach is 51810. Click on the table and then select the preview tab at the top. Browse through the data until you find the

51810 row and see the MeansAdjRes is 0.95 and MeansAdjNonRes is 0.87. This is the residential and non-residential adjustment values from the national average.

47. While you're updating the replacement values, update the content values as well. Query each occupancy using Select by Attributes. The first query is: [Occupancy] = 'AGR1'. Right click on Cost and select Field Calculator. Select Yes when the warning comes up. Add the following expression: [Area] *120 *0.87.



48. The Cost field should be populated for the AGR1 occupancy buildings. Double check to make sure all values are populated and reasonable. Now right click on ContentCost and use the Field Calculator to populate the field with the Cost values. The content costs can be found in the UDF Tool in Section 3.

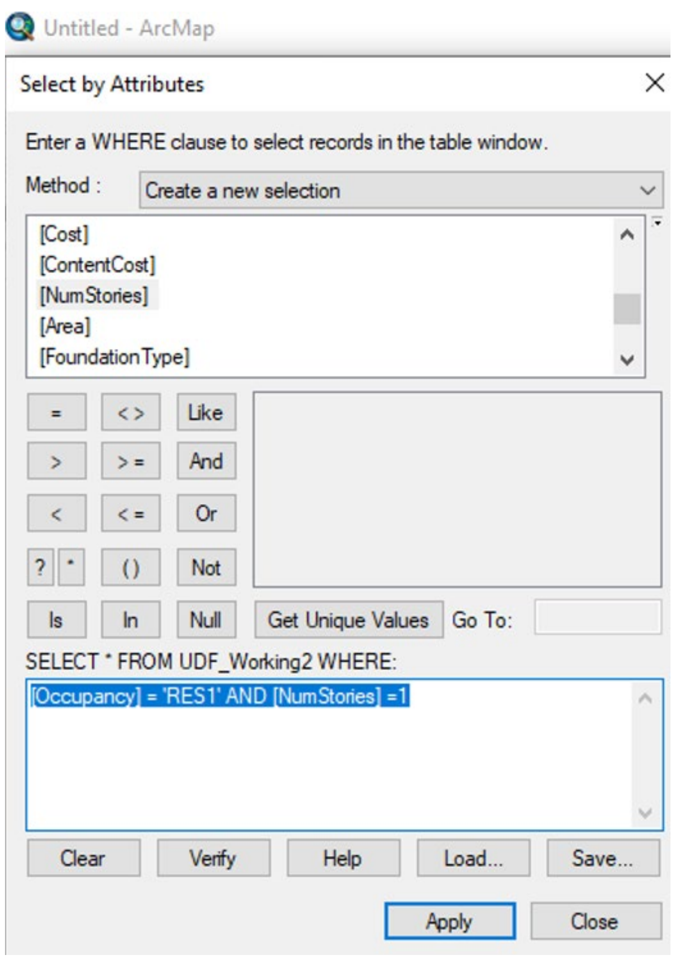


49. Now run the following Select by Attribute queries and make the following calculations:

- Query: [Occupancy] = 'COM1' ; Cost = [Area] *114.47*0.87 ; ContentCost = [Cost]
- Query: [Occupancy] = 'COM10' ; Cost = [Area] *80.59*0.87; ContentCost = [Cost] *0.5
- Query: [Occupancy] = 'COM4' ; Cost = [Area] *176.29*0.87; ContentCost = [Cost]
- Query: [Occupancy] = 'COM7' ; Cost = [Area] *176.29*0.87; ContentCost = [Cost] *1.5
- Query: [Occupancy] = 'COM8' ; Cost = [Area] *227.53*0.87 ; ContentCost = [Cost]
- Query: [Occupancy] = 'EDU1' ; Cost = [Area] *201.63*0.87 ; ContentCost = [Cost]
- Query: [Occupancy] = 'EDU2' ; Cost = [Area] * 171.05*0.87 ; ContentCost = [Cost] *1.5
- Query: [Occupancy] = 'GOV1' ; Cost = [Area] * 149.83*0.87 ; ContentCost = [Cost]
- Query: [Occupancy] = 'IND1' ; Cost = [Area] * 133.03*0.87 ; ContentCost = [Cost] *1.5
- Query: [Occupancy] = 'REL1' ; Cost = [Area] * 190.53*0.87 ; ContentCost = [Cost]
- Query: [Occupancy] = 'RES2' ; Cost = [Area] * 48.86*0.95 ; ContentCost = [Cost] *0.5
- Query: [Occupancy] = 'RES3B' ; Cost = [Area] * 109.66*0.95 ; ContentCost = [Cost] *0.5
- Query: [Occupancy] = 'RES3C' ; Cost = [Area] * 201.33*0.95 ; ContentCost = [Cost] *0.5

- Query: [Occupancy] = 'RES3D' ; Cost = [Area] * 187.75*0.95 ; ContentCost = [Cost] *0.5
- Query: [Occupancy] = 'RES3E' ; Cost = [Area] * 188.48*0.95 ; ContentCost = [Cost] *0.5
- Query: [Occupancy] = 'RES3F' ; Cost = [Area] * 174.53*0.95 ; ContentCost = [Cost] *0.5

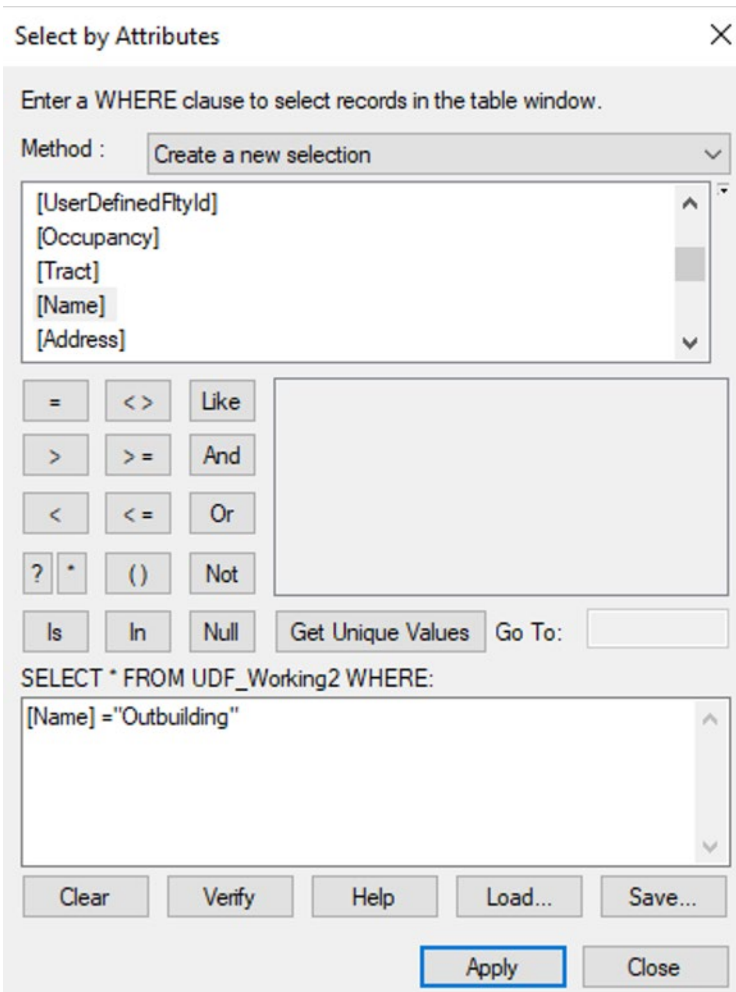
50. For the RES1 occupancies, you'll need to develop a slightly more complex query based on occupancy and number of stories. [Occupancy] = 'RES1' AND [NumStories] =1. Then click OK.



51. Calculate the cost as: Cost = [Area] * 116.66*0.95 and the ContentCost = [Cost] *0.5. Run the following queries and make the following calculations:

- Query: [Occupancy] = 'RES1' AND [NumStories] =2; Cost = [Area] * 122.75*0.95 ; ContentCost = [Cost] *0.5
- Query: [Occupancy] = 'RES1' AND [NumStories] >2; Cost = [Area] * 127.94*0.95 ; ContentCost = [Cost] *0.5

52. To make sure we don't assign too high of a value to the outbuildings, use the Select by Attribute to query the buildings with the name "Outbuildings". [Name] ="Outbuilding".

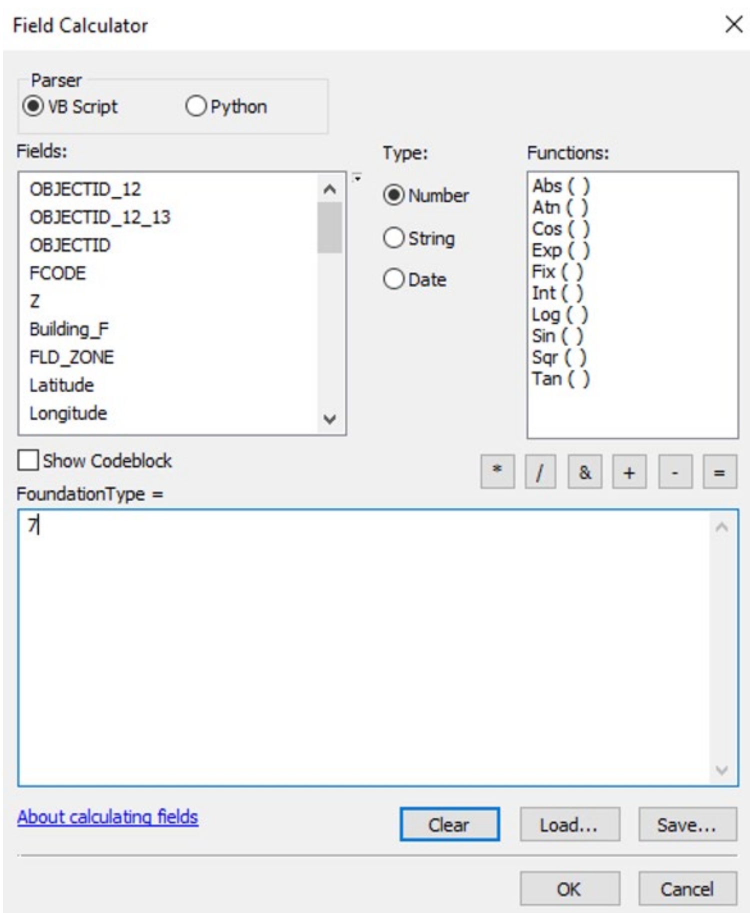


53. Right click on Cost and use the Field Calculator to make Cost = [Area]*15. Fifteen dollars a square foot is an approximation for a typical outbuilding. Make the ContentCost equal one half of the structure cost. Clear the selection.

54. The next step is to determine the foundation type and first floor height. Some parcel data has foundation type in it, and some parcel data identifies whether the building on the parcel has a basement. If you have access to this information, use that data to determine the foundation type. Unfortunately, the Virginia Beach data does not have that information. For modeling purposes, we'll assign a foundation type as 7 (slab on grade) with a first-floor height of 1 foot. Hazus only uses the foundation type to determine whether to use basement or no basement damage functions. We will update these values for buildings in the floodplain in the next step. Elevation certificates are a good source of data for first floor elevations. Google Street View can also be

used to confirm building foundation types and first floor heights. If you use Street View, focus the data collection on neighborhoods which are in the floodplain.

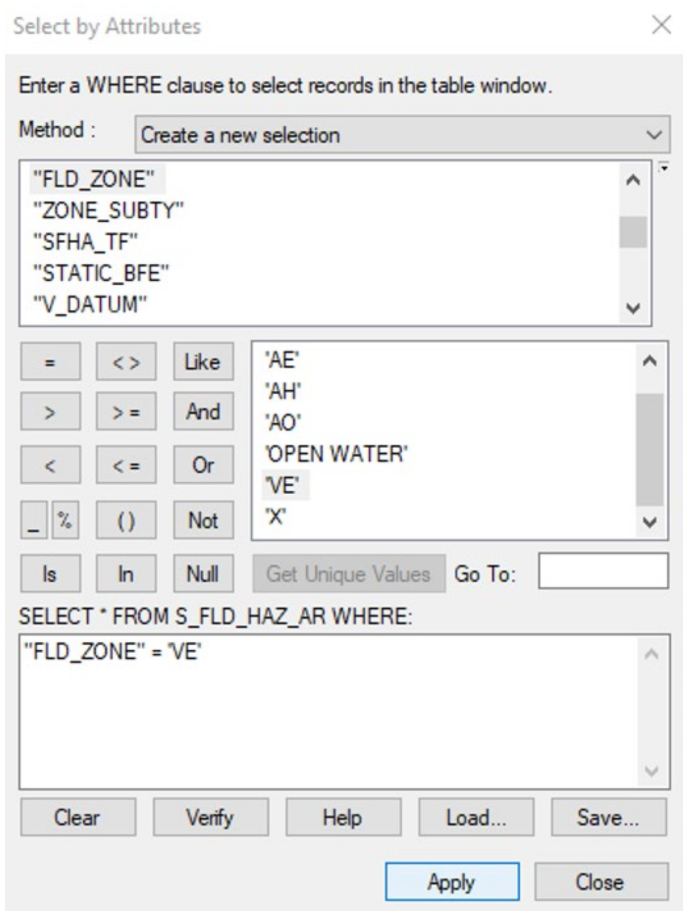
55. Right click on the FoundationType field and click on Field Calculator. Add a value of 7 to the field calculator.



56. Next, set the FirstFloorHt to 1 using the Field Calculator. You will revisit the first floor elevations in the next step.

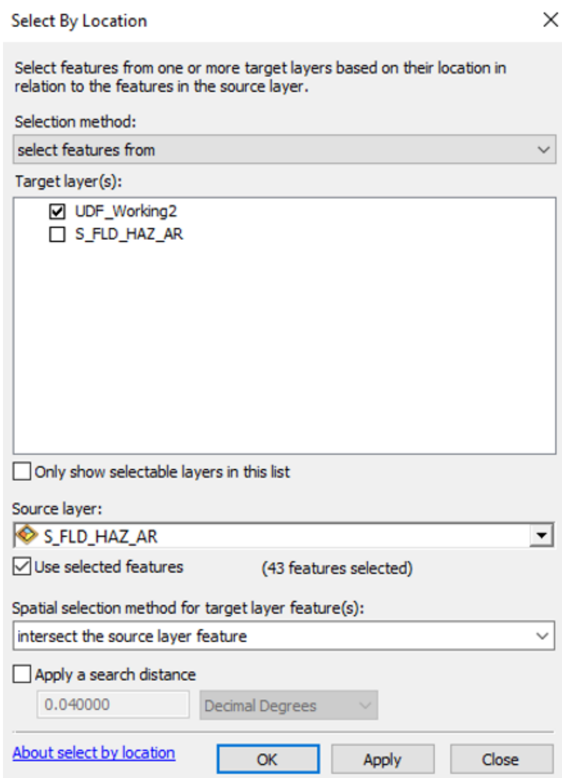
57. Because the City of Virginia Beach is on the coast, we are going to determine if any of the UDFs are in the coastal V zone. This information will help us determine which first floor height to use and which depth damage functions to use. The FEMA Map Service Center has the floodplain information you'll need if you're using your own data. The Virginia Beach floodplain data has already been downloaded and can be found here: C:\E0177\Activity\4.1\VirginiaBeach\515531_20160229\. If you are using your own data, go to the MSC website (https://msc.fema.gov), click on Search All Products; then select your state, county, and community; and Search. Click on Effective Products and NFHL Data-County, then click on the DL button on the right.

58. Add the the S_FLD_HAZ_AR.shp file from the C:\E0177\Activity\4.1\VirginiaBeach\515531_20160229\ folder. This is the special flood hazard area and depicts the different flood zones. Open the attribute table for the S_FLD_HAZ_AR file and left click on the top left button. Click Select by Attributes, then double click on “FLD_Zone” then click = and Get Unique Values. Double click on ‘VE’ and then Apply. In some areas, it would be necessary to add the ‘V’ zone to the query as well. For Virginia Beach, we only have the VE coastal zone.



59. Part of the floodplain should now be highlighted. Now we need to determine if any of the UDFs are in the coastal floodplain. Click Selection from the top menu, and then Select by Location.

60. For selection method, click select features from; for Target Layer(s):, select UDF_Working2; for Source Layer, select S_FLD_HAZ_AR; click on the Use selected features box; and under Spatial selection method for target layer feature(s): select intersect the source layer feature. Click OK.

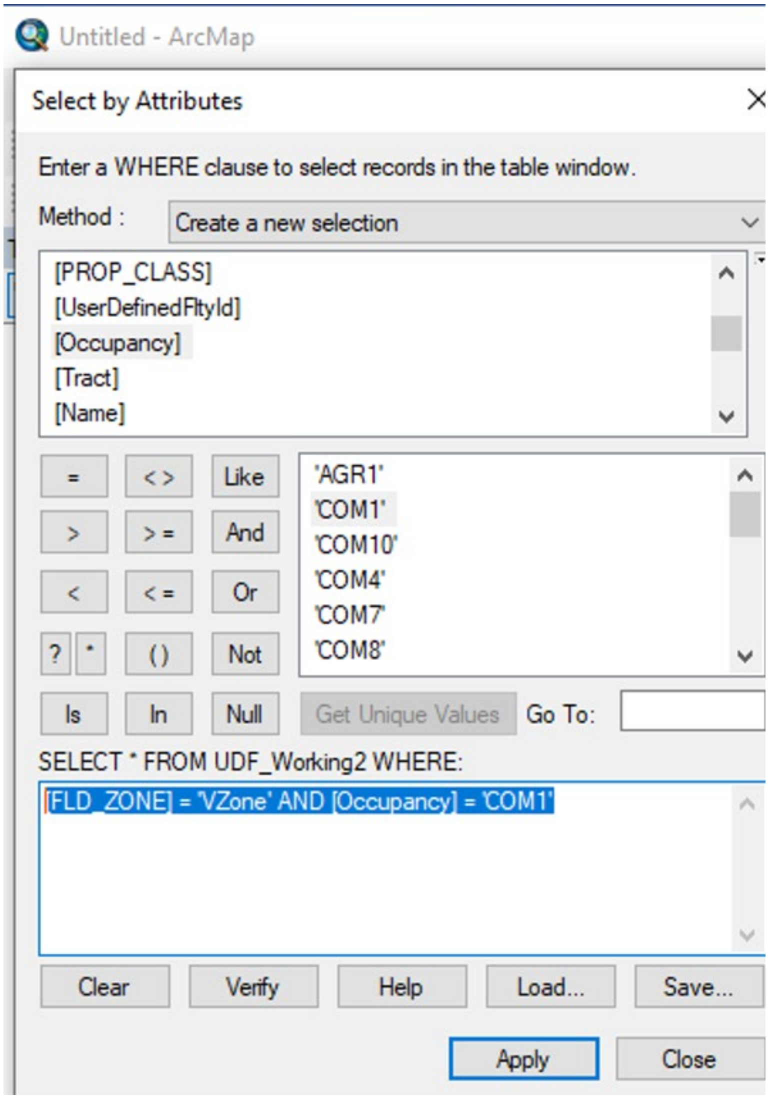


61. The query should come back with 567 buildings in the V Zone. Open the UDF_Working2 attribute table and browse until you see the field FLD_ZONE. Right click on the field name and use the Field Calculator to add a value of "VZone" for all the selected records. Clear the selection from the UDF points and remove the S_FLD_HAZ_AR layer.

62. Reviewing the Map Service Center historic products, it looks like the first FIRM was adopted in 1996. This means all buildings built after 1996 in the floodplain should be above the base flood elevation. Next, you'll query the data based on year and whether it's in the floodplain to update the first-floor heights. You'll also add a comment field.

63. Open the Attribute table for UDF_Working2. Use the Select by Attributes tool to query all buildings in the V Zone. [FLD_ZONE] = 'VZone'. There should be 567 buildings selected. Open the UDF Tool Excel spreadsheet and review Section 5 on coastal depth damage functions. Now look at the occupancies that are highlighted as being in the V Zone – COM1, COM10, GOV1, RES1, RES2, RES3C, RES3D, and RES3F.

64. Use the Select by Attributes tool to query all buildings in the V Zone and having a COM1 Occupancy: [FLD_ZONE] = 'VZone' AND [Occupancy] = 'COM1'. Then click Apply.

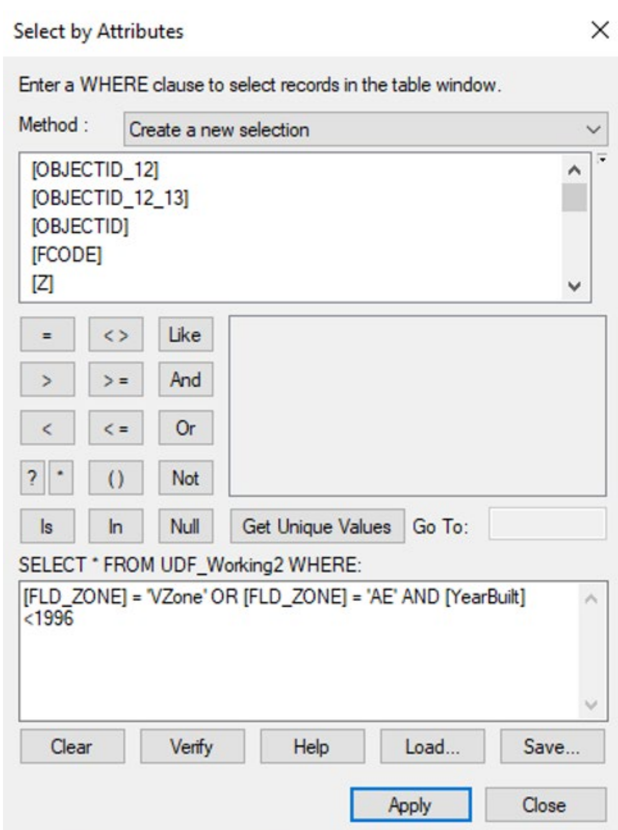


65. Scroll over to BldgDamageFnId and refer to the UDF tool for COM1 coastal depth damage functions. There are: structural: 288, contents: 173, and inventory: 47. Use the field calculator to populate the BldgDamageFnId, ContDamageFnId, and the InvDamageFnId. Not all of the occupancies have inventory. Now set up the following queries and add the following data:

- Query: [FLD_ZONE] = 'VZone' AND [Occupancy] = 'COM10'; BldgDamageFnId = 544 ; ContDamageFnId = 357
- Query: [FLD_ZONE] = 'VZone' AND [Occupancy] = 'GOV1'; BldgDamageFnId = 636 ; ContDamageFnId = 475
- Query: [FLD_ZONE] = 'VZone' AND [Occupancy] = 'RES2'; BldgDamageFnId = 190 ; ContDamageFnId = 75
- Query: [FLD_ZONE] = 'VZone' AND [Occupancy] = 'RES3C'; BldgDamageFnId = 659 ; ContDamageFnId = 489
- Query: [FLD_ZONE] = 'VZone' AND [Occupancy] = 'RES3D'; BldgDamageFnId = 659 ; ContDamageFnId = 489

- Query: [FLD_ZONE] = 'VZone' AND [Occupancy] = 'RES3F'; BldgDamageFnId = 659 ; ContDamageFnId = 489
- Query: [FLD_ZONE] = 'VZone' AND [Occupancy] = 'RES1' AND [NumStories] =1'; BldgDamageFnId = 113 ; ContDamageFnId = 29
- Query: [FLD_ZONE] = 'VZone' AND [Occupancy] = 'RES1' AND [NumStories] =2'; BldgDamageFnId = 115 ; ContDamageFnId = 31
- Query: [FLD_ZONE] = 'VZone' AND [Occupancy] = 'RES1' AND [NumStories] >2'; BldgDamageFnId = 117 ; ContDamageFnId = 33

66. All the structure and content damage function fields should be populated for all buildings in the V Zone. Now, add a new field called Comment with a data type of Text that is 40 characters long. You're going to use this field to identify those structures that are pre- and post-FIRM. Use the Select by Attributes tool to select all buildings in the floodplain that were built before 1996. ([FLD_ZONE] = 'VZone' OR [FLD_ZONE] = 'AE') AND [YearBuilt] <1996. Click Apply.



67. Right click on the Comment field header and select Field Calculator. Assign a value of "Pre-FIRM". Now run a query on the UDF points in the floodplain that were built in 1996 and afterwards. ([FLD_ZONE] = 'VZone' OR [FLD_ZONE] = 'AE') AND [YearBuilt] >= 1996. Assign a value of "Post-FIRM". Also, while this query has selected results, right click on the

FirstFloorHt field header and change the value using Field Calculator to 5. This will simulate structure elevation for buildings built after 1996. Clear the selection.

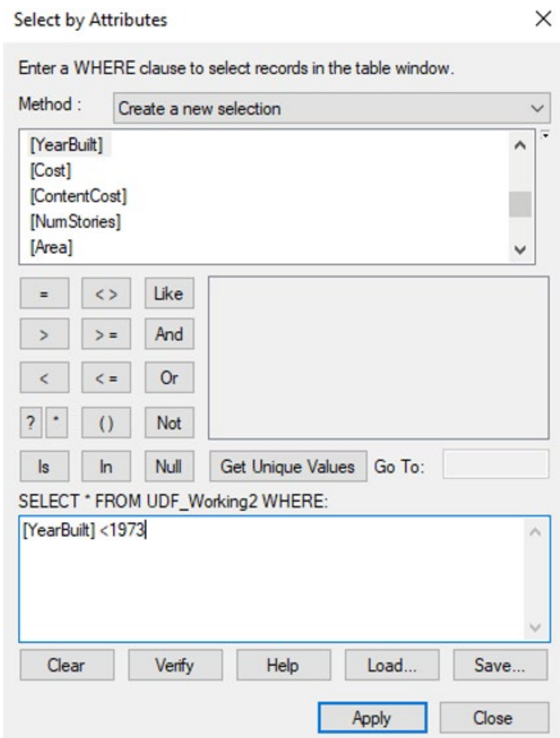
68. Update the design level and earthquake. If you're not using UDF for earthquake, you may skip this section and resume at Step 89. The year built can be used to determine the design level. Some parcel data does contain information about the construction materials and type. The Virginia Beach data does not have this information. If your data does have that information, you'll need to map the local data to the Hazus required building type codes (found in Section 7 of the UDF Tool).

69. Open the UDF Tool if it isn't already open. Sections 6 and 7 provide information on the design level and the earthquake building type. In Section 6, there is a column called BldgSchemesID which XX and then a number. The XX in our case will be VA for Virginia.

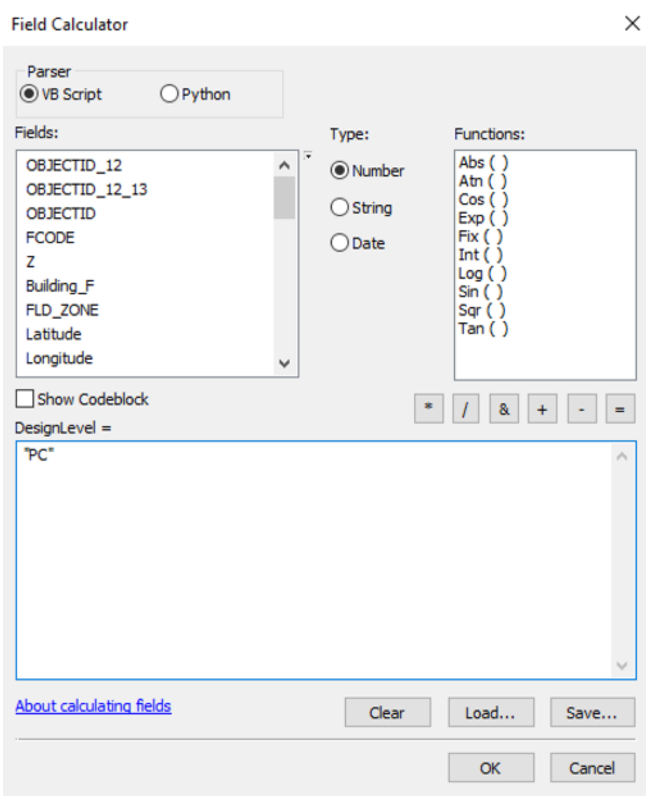
70. Open the UDF_Working2 attribute table and scroll over to BldgScheme. You'll notice all the values are VA1. Close the attribute table and go back to Section 6 and notice that there are three entries for XX1 with corresponding years and design levels. For example, everything built before 1973 should be assigned a PC (pre-code) value for Design Level.

71. If your local parcel data has year built you can set up queries to assign the design level by the year built. Fortunately, our data does have the year built so we'll use it. A local planner may know which sections of the community were built during which years.

72. Now we'll run a query based on year built. Left click on the top left button and click Select by Attributes. Scroll down to YearBuilt and double click on it. Consulting the UDF Tool, it looks like there will be three queries to run: <1973, 1973-1999, and >2000. Set up the first query as: YearBuilt <1960 and click Apply.



73. Notice that 93045 rows are selected. Next, select Editor from the Editor Toolbar and select Start Editing. Right click on the field DesignLevel and use the Field Calculator to assign a value of "PC" to those rows.

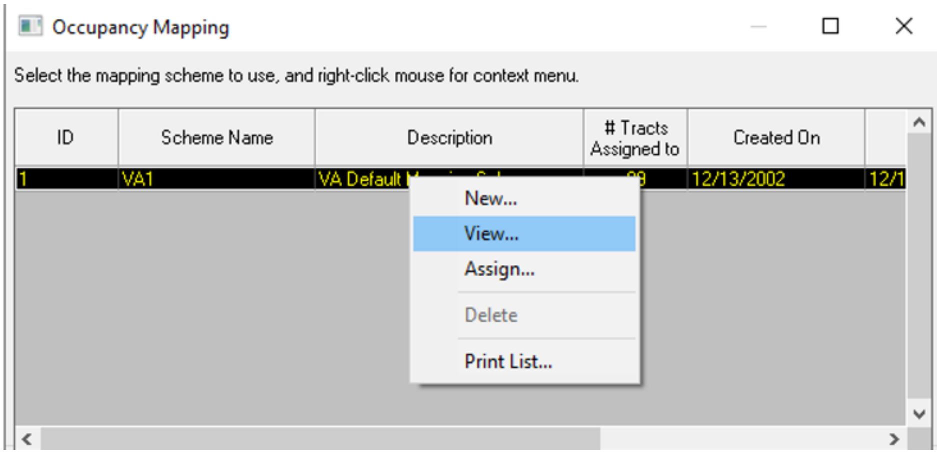


74. Now set up two additional queries and assign the values below:

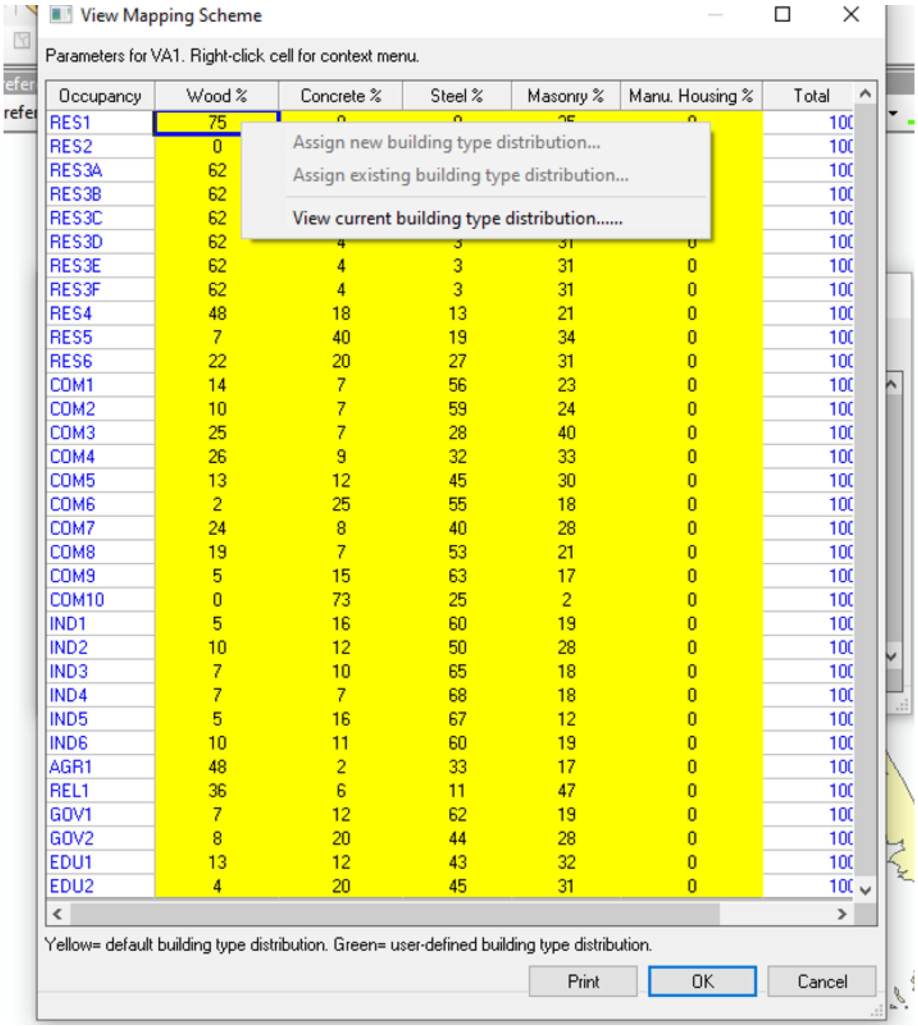
- Query: [YearBuilt] >=1973 AND [YearBuilt] <2000
  - Set these equal to a DesignLevel of LC
- Query: [YearBuilt] >= 2000
  - Set these equal to a DesignLevel of MC
- Query: [YearBuilt] IS NULL
  - Set these equal to a DesignLevel of PC

75. After you've assigned values to all the UDF buildings, check the attribute table to make sure there are DesignLevel values in each record.

76. Now, the earthquake building type can be assigned. Your local parcel data may have this information but Virginia Beach's data does not so we'll look at the Hazus building type mapping scheme and determine which building types are most likely with the design level. You have number of stories which factors into the building type too. Open the Hazus study region, called Temp, you created at the beginning of this activity. Go to Inventory, then General Building Stock, and then Occupancy Mapping. Right click on the scheme name (called VA1) and View.



77. The default occupancy mapping scheme will show how the specific occupancies are mapped to the general building types (wood, concrete, steel, masonry, and manufactured housing). Next right click in one of the populated values (in the example RES1 Wood was selected).



Occupancy	Wood %	Concrete %	Steel %	Masonry %	Manu. Housing %	Total
RES1	75	0	0	25	0	100
RES2	0					100
RES3A	62					100
RES3B	62					100
RES3C	62					100
RES3D	62	4	3	31	0	100
RES3E	62	4	3	31	0	100
RES3F	62	4	3	31	0	100
RES4	48	18	13	21	0	100
RES5	7	40	19	34	0	100
RES6	22	20	27	31	0	100
COM1	14	7	56	23	0	100
COM2	10	7	59	24	0	100
COM3	25	7	28	40	0	100
COM4	26	9	32	33	0	100
COM5	13	12	45	30	0	100
COM6	2	25	55	18	0	100
COM7	24	8	40	28	0	100
COM8	19	7	53	21	0	100
COM9	5	15	63	17	0	100
COM10	0	73	25	2	0	100
IND1	5	16	60	19	0	100
IND2	10	12	50	28	0	100
IND3	7	10	65	18	0	100
IND4	7	7	68	18	0	100
IND5	5	16	67	12	0	100
IND6	10	11	60	19	0	100
AGR1	48	2	33	17	0	100
REL1	36	6	11	47	0	100
GOV1	7	12	62	19	0	100
GOV2	8	20	44	28	0	100
EDU1	13	12	43	32	0	100
EDU2	4	20	45	31	0	100

78. Click View Current Building Type Distribution and you'll see that 100 percent of the inventory is considered W1 (5000 sqft or less). Since we have the actual square feet of the homes, this can be updated. Click Cancel. You'll need to browse through this table and put together an approach to distributing the building types based on the specific occupancy and design level. Many times, older buildings will be unreinforced masonry (URM). Also, talk to local officials about building practices. Reviewing the mapping schemes in Virginia Beach, here is an approach:

Specific Occupancy	Breakdown
RES1 - PC,LC	W1/W2 (LC-MC), URM (PC)
RES2	MH (100%)

Specific Occupancy	Breakdown
RES3X	W1/W2 (LC-MC), URM (PC)
COM1	RM1 (LC-MC), URM (PC)
COM4	RM1 (LC-MC), URM (PC)
COM7	S1
COM8	S1
COM10	C1
IND1	S1
AGR1	W1/W2
REL1	URM
GOV1	S1
EDU1	S1
EDU2	S1

79. You'll need to set up a series of queries to assign these building types:

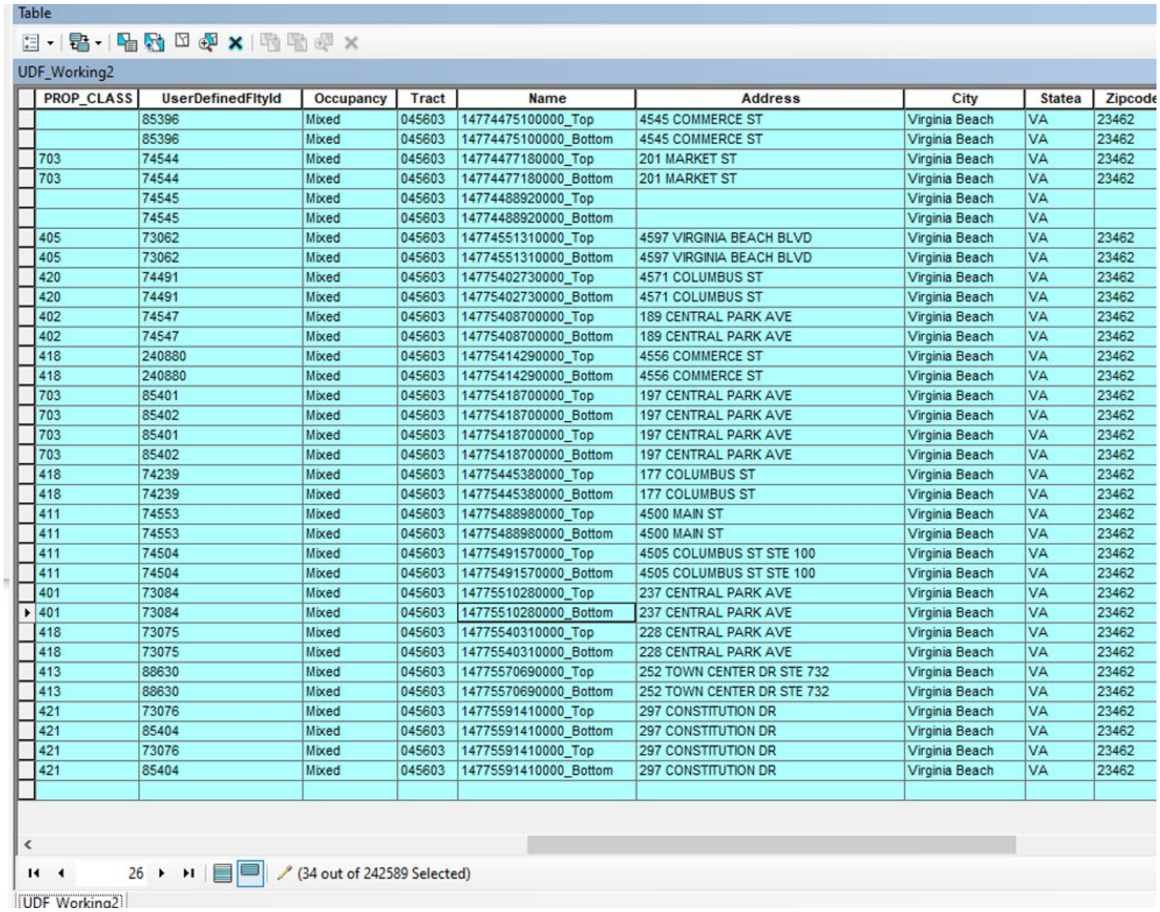
- Query: [Occupancy] = 'RES1' AND [DesignLevel] = 'PC' AND [NumStories] <3
  - Field Calculator: eqBldgType = URML
- Query: [Occupancy] = 'RES1' AND [DesignLevel] = 'PC' AND [NumStories] >=3
  - Field Calculator: eqBldgType = URMM
- Query: [Occupancy] = 'RES1' AND ([DesignLevel] = 'LC' OR [DesignLevel] = 'MC') AND [Area] <=5000
  - Field Calculator: eqBldgType = W1
- Query: [Occupancy] = 'RES1' AND ([DesignLevel] = 'LC' OR [DesignLevel] = 'MC') AND [Area] >5000
  - Field Calculator: eqBldgType = W2

- Query: [Occupancy] = 'RES2'
  - Field Calculator: eqBldgType = MH
- Query: ([Occupancy] = 'RES3B' OR [Occupancy] = 'RES3C' OR [Occupancy] = 'RES3D' OR [Occupancy] = 'RES3E' OR [Occupancy] = 'RES3F') AND [DesignLevel] = 'PC' AND [NumStories] <3
  - Field Calculator: eqBldgType = URML
- Query: ([Occupancy] = 'RES3B' OR [Occupancy] = 'RES3C' OR [Occupancy] = 'RES3D' OR [Occupancy] = 'RES3E' OR [Occupancy] = 'RES3F') AND [DesignLevel] = 'PC' AND [NumStories] >= 3
  - Field Calculator: eqBldgType = URMM
- Query: ([Occupancy] = 'RES3B' OR [Occupancy] = 'RES3C' OR [Occupancy] = 'RES3D' OR [Occupancy] = 'RES3E' OR [Occupancy] = 'RES3F') AND ([DesignLevel] = 'LC' OR [DesignLevel] = 'MC') AND [Area] <=5000
  - Field Calculator: eqBldgType = W1
- Query: ([Occupancy] = 'RES3B' OR [Occupancy] = 'RES3C' OR [Occupancy] = 'RES3D' OR [Occupancy] = 'RES3E' OR [Occupancy] = 'RES3F') AND ([DesignLevel] = 'LC' OR [DesignLevel] = 'MC') AND [Area] >5000
  - Field Calculator: eqBldgType = W2
- Query: ([Occupancy] = 'COM1' OR [Occupancy] = 'COM4') AND [DesignLevel] = 'PC' AND [NumStories] <3
  - Field Calculator: eqBldgType = URML
- Query: ([Occupancy] = 'COM1' OR [Occupancy] = 'COM4') AND [DesignLevel] = 'PC' AND [NumStories] >=3
  - Field Calculator: eqBldgType = URMM
- Query: ([Occupancy] = 'COM1' OR [Occupancy] = 'COM4') AND ([DesignLevel] = 'LC' OR [DesignLevel] = 'MC') AND [NumStories] < 4
  - Field Calculator: eqBldgType = RM1L
- Query: ([Occupancy] = 'COM1' OR [Occupancy] = 'COM4') AND ([DesignLevel] = 'LC' OR [DesignLevel] = 'MC') AND [NumStories] > 3
  - Field Calculator: eqBldgType = RM1M
  - Note: There is no RM1H.
- Query: ([Occupancy] = 'COM7' OR [Occupancy] = 'COM8' OR [Occupancy] = 'IND1' OR [Occupancy] = 'GOV1' OR [Occupancy] = 'EDU1' OR [Occupancy] = 'EDU2') AND [NumStories] <4
  - Field Calculator: eqBldgType = S1L
- Query: ([Occupancy] = 'COM7' OR [Occupancy] = 'COM8' OR [Occupancy] = 'IND1' OR [Occupancy] = 'GOV1' OR [Occupancy] = 'EDU1' OR [Occupancy] = 'EDU2') AND ([NumStories] >3 AND [NumStories] <8)

  - Field Calculator: eqBldgType = S1M
- Query: ([Occupancy] = 'COM7' OR [Occupancy] = 'COM8' OR [Occupancy] = 'IND1' OR [Occupancy] = 'GOV1' OR [Occupancy] = 'EDU1' OR [Occupancy] = 'EDU2') AND [NumStories] >7
  - Field Calculator: eqBldgType = S1H
- Query: [Occupancy] = 'COM10' AND [NumStories] <4
  - Field Calculator: eqBldgType = C1L
- Query: [Occupancy] = 'COM10' AND ([NumStories] >3 AND [NumStories] <8)
  - Field Calculator: eqBldgType = C1M
- Query: [Occupancy] = 'COM10' AND [NumStories] >7 o Field Calculator: eqBldgType = C1H • Query: [Occupancy] = 'AGR1' AND [Area] <=5000
  - Field Calculator: eqBldgType = W1
- Query: [Occupancy] = 'AGR1' AND [Area] >5000
  - Field Calculator: eqBldgType = W2
- Query: [Occupancy] = 'REL1' AND [NumStories] <3
  - Field Calculator: eqBldgType = URML
- Query: [Occupancy] = 'REL1' AND [NumStories] >=3
  - Field Calculator: eqBldgType = URMM

80. All of the earthquake building types should now be assigned except for the mixed used buildings. Use the Select by Attributes tool to select the mixed occupancies. These buildings have commercial businesses on the first floor and residences on the upper floors. Click on Editor on the Editor Toolbar and Start Editing. Then go to “Edit” and “Copy”.

81. Then click Edit Paste. Select UDF_Working2 as the target and click OK. Rerun the query for occupancy = mixed. There should now be 34 selected buildings. Sort by building name so that the duplicates are next to each other. Change the name to add the word “top” and “bottom” for each entry.



PROP_CLASS	UserDefinedFltyId	Occupancy	Tract	Name	Address	City	Statea	Zipcode
	85396	Mixed	045603	14774475100000_Top	4545 COMMERCE ST	Virginia Beach	VA	23462
	85396	Mixed	045603	14774475100000_Bottom	4545 COMMERCE ST	Virginia Beach	VA	23462
703	74544	Mixed	045603	14774477180000_Top	201 MARKET ST	Virginia Beach	VA	23462
703	74544	Mixed	045603	14774477180000_Bottom	201 MARKET ST	Virginia Beach	VA	23462
	74545	Mixed	045603	14774488920000_Top		Virginia Beach	VA	
	74545	Mixed	045603	14774488920000_Bottom		Virginia Beach	VA	
405	73062	Mixed	045603	14774551310000_Top	4597 VIRGINIA BEACH BLVD	Virginia Beach	VA	23462
405	73062	Mixed	045603	14774551310000_Bottom	4597 VIRGINIA BEACH BLVD	Virginia Beach	VA	23462
420	74491	Mixed	045603	14775402730000_Top	4571 COLUMBUS ST	Virginia Beach	VA	23462
420	74491	Mixed	045603	14775402730000_Bottom	4571 COLUMBUS ST	Virginia Beach	VA	23462
402	74547	Mixed	045603	14775408700000_Top	189 CENTRAL PARK AVE	Virginia Beach	VA	23462
402	74547	Mixed	045603	14775408700000_Bottom	189 CENTRAL PARK AVE	Virginia Beach	VA	23462
418	240880	Mixed	045603	14775414290000_Top	4556 COMMERCE ST	Virginia Beach	VA	23462
418	240880	Mixed	045603	14775414290000_Bottom	4556 COMMERCE ST	Virginia Beach	VA	23462
703	85401	Mixed	045603	14775418700000_Top	197 CENTRAL PARK AVE	Virginia Beach	VA	23462
703	85402	Mixed	045603	14775418700000_Bottom	197 CENTRAL PARK AVE	Virginia Beach	VA	23462
703	85401	Mixed	045603	14775418700000_Top	197 CENTRAL PARK AVE	Virginia Beach	VA	23462
703	85402	Mixed	045603	14775418700000_Bottom	197 CENTRAL PARK AVE	Virginia Beach	VA	23462
418	74239	Mixed	045603	14775445380000_Top	177 COLUMBUS ST	Virginia Beach	VA	23462
418	74239	Mixed	045603	14775445380000_Bottom	177 COLUMBUS ST	Virginia Beach	VA	23462
411	74553	Mixed	045603	14775488980000_Top	4500 MAIN ST	Virginia Beach	VA	23462
411	74553	Mixed	045603	14775488980000_Bottom	4500 MAIN ST	Virginia Beach	VA	23462
411	74504	Mixed	045603	14775491570000_Top	4505 COLUMBUS ST STE 100	Virginia Beach	VA	23462
411	74504	Mixed	045603	14775491570000_Bottom	4505 COLUMBUS ST STE 100	Virginia Beach	VA	23462
401	73084	Mixed	045603	14775510280000_Top	237 CENTRAL PARK AVE	Virginia Beach	VA	23462
401	73084	Mixed	045603	14775510280000_Bottom	237 CENTRAL PARK AVE	Virginia Beach	VA	23462
418	73075	Mixed	045603	14775540310000_Top	228 CENTRAL PARK AVE	Virginia Beach	VA	23462
418	73075	Mixed	045603	14775540310000_Bottom	228 CENTRAL PARK AVE	Virginia Beach	VA	23462
413	88630	Mixed	045603	14775570690000_Top	252 TOWN CENTER DR STE 732	Virginia Beach	VA	23462
413	88630	Mixed	045603	14775570690000_Bottom	252 TOWN CENTER DR STE 732	Virginia Beach	VA	23462
421	73076	Mixed	045603	14775591410000_Top	297 CONSTITUTION DR	Virginia Beach	VA	23462
421	85404	Mixed	045603	14775591410000_Bottom	297 CONSTITUTION DR	Virginia Beach	VA	23462
421	73076	Mixed	045603	14775591410000_Top	297 CONSTITUTION DR	Virginia Beach	VA	23462
421	85404	Mixed	045603	14775591410000_Bottom	297 CONSTITUTION DR	Virginia Beach	VA	23462

82. Now you're going to change the number of stories for each entry. The bottom record will consist of 1 story while the top record will consist of 'total stories minus 1'. Click in the number of stories entries and change the values.

Table

UDF_Working2

Name	Address	City	Statea	Zipcode	YearBuilt	Cost	ContentCost	NumStories	Area	Found
14774475100000_Top	4545 COMMERCE ST	Virginia Beach	VA	23462	0	<Null>	<Null>	2	5156.935835	7
14774475100000_Bottom	4545 COMMERCE ST	Virginia Beach	VA	23462	0	<Null>	<Null>	1	5156.935835	7
14774477180000_Top	201 MARKET ST	Virginia Beach	VA	23462	2007	<Null>	<Null>	6	321581.7509	7
14774477180000_Bottom	201 MARKET ST	Virginia Beach	VA	23462	2007	<Null>	<Null>	1	321581.7509	7
14774488920000_Top		Virginia Beach	VA		0	<Null>	<Null>	6	105882.0433	7
14774488920000_Bottom		Virginia Beach	VA		0	<Null>	<Null>	1	105882.0433	7
14774551310000_Top	4597 VIRGINIA BEACH BLVD	Virginia Beach	VA	23462	1990	<Null>	<Null>	1	6414.818352	7
14774551310000_Bottom	4597 VIRGINIA BEACH BLVD	Virginia Beach	VA	23462	1990	<Null>	<Null>	1	6414.818352	7
14775402730000_Top	4571 COLUMBUS ST	Virginia Beach	VA	23462	1983	<Null>	<Null>	1	5277.127147	7
14775402730000_Bottom	4571 COLUMBUS ST	Virginia Beach	VA	23462	1983	<Null>	<Null>	1	5277.127147	7
14775408700000_Top	189 CENTRAL PARK AVE	Virginia Beach	VA	23462	2004	<Null>	<Null>	3	99575.41080	7
14775408700000_Bottom	189 CENTRAL PARK AVE	Virginia Beach	VA	23462	2004	<Null>	<Null>	1	99575.41080	7
14775414290000_Top	4556 COMMERCE ST	Virginia Beach	VA	23462	0	<Null>	<Null>	3	47402.51657	7
14775414290000_Bottom	4556 COMMERCE ST	Virginia Beach	VA	23462	0	<Null>	<Null>	1	47402.51657	7
14775418700000_Top	197 CENTRAL PARK AVE	Virginia Beach	VA	23462	2004	<Null>	<Null>	3	122.465914	7
14775418700000_Bottom	197 CENTRAL PARK AVE	Virginia Beach	VA	23462	2004	<Null>	<Null>	1	266.05773	7
14775418700000_Top	197 CENTRAL PARK AVE	Virginia Beach	VA	23462	2004	<Null>	<Null>	2	122.465914	7
14775418700000_Bottom	197 CENTRAL PARK AVE	Virginia Beach	VA	23462	2004	<Null>	<Null>	1	266.05773	7
14775445380000_Top	177 COLUMBUS ST	Virginia Beach	VA	23462	0	<Null>	<Null>	11	1095701.625	7
14775445380000_Bottom	177 COLUMBUS ST	Virginia Beach	VA	23462	0	<Null>	<Null>	1	1095701.625	7
14775488980000_Top	4500 MAIN ST	Virginia Beach	VA	23462	2010	<Null>	<Null>	6	146041.5841	7
14775488980000_Bottom	4500 MAIN ST	Virginia Beach	VA	23462	2010	<Null>	<Null>	1	146041.5841	7
14775491570000_Top	4505 COLUMBUS ST STE 100	Virginia Beach	VA	23462	2000	<Null>	<Null>	2	79021.99109	7
14775491570000_Bottom	4505 COLUMBUS ST STE 100	Virginia Beach	VA	23462	2000	<Null>	<Null>	1	79021.99109	7
14775510280000_Top	237 CENTRAL PARK AVE	Virginia Beach	VA	23462	2005	<Null>	<Null>	3	173042.5844	7
14775510280000_Bottom	237 CENTRAL PARK AVE	Virginia Beach	VA	23462	2005	<Null>	<Null>	1	173042.5844	7
14775540310000_Top	228 CENTRAL PARK AVE	Virginia Beach	VA	23462	0	<Null>	<Null>	18	1817674.182	7
14775540310000_Bottom	228 CENTRAL PARK AVE	Virginia Beach	VA	23462	0	<Null>	<Null>	1	1817674.182	7
14775570690000_Top	252 TOWN CENTER DR STE 732	Virginia Beach	VA	23462	2003	<Null>	<Null>	6	134102.9883	7
14775570690000_Bottom	252 TOWN CENTER DR STE 732	Virginia Beach	VA	23462	2003	<Null>	<Null>	1	134102.9883	7
14775591410000_Bottom	297 CONSTITUTION DR	Virginia Beach	VA	23462	2004	<Null>	<Null>	1	35770.75178	7
14775591410000_Bottom	297 CONSTITUTION DR	Virginia Beach	VA	23462	2004	<Null>	<Null>	1	1834.3737	7
14775591410000_Top	297 CONSTITUTION DR	Virginia Beach	VA	23462	2004	<Null>	<Null>	3	35770.75178	7
14775591410000_Top	297 CONSTITUTION DR	Virginia Beach	VA	23462	2004	<Null>	<Null>	1	1834.3737	7

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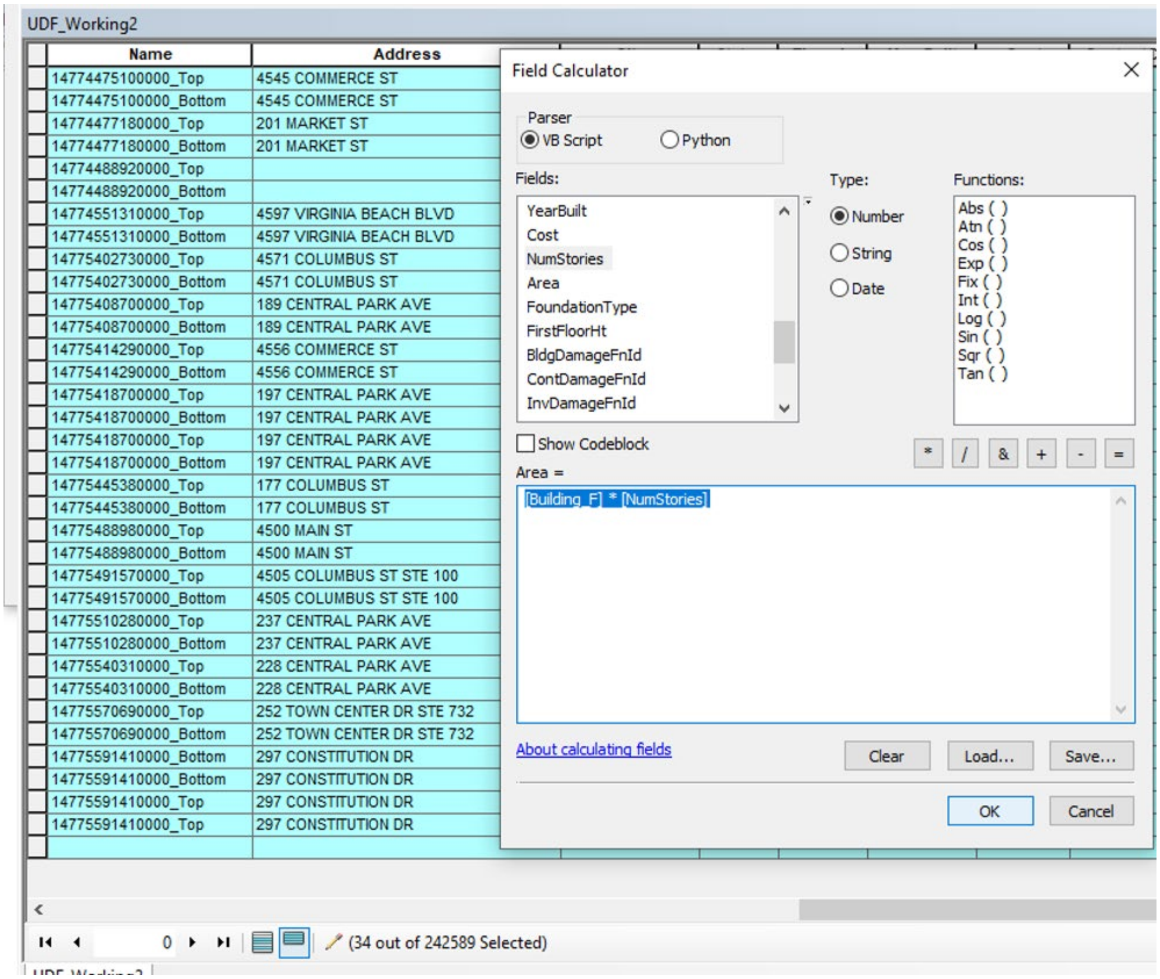
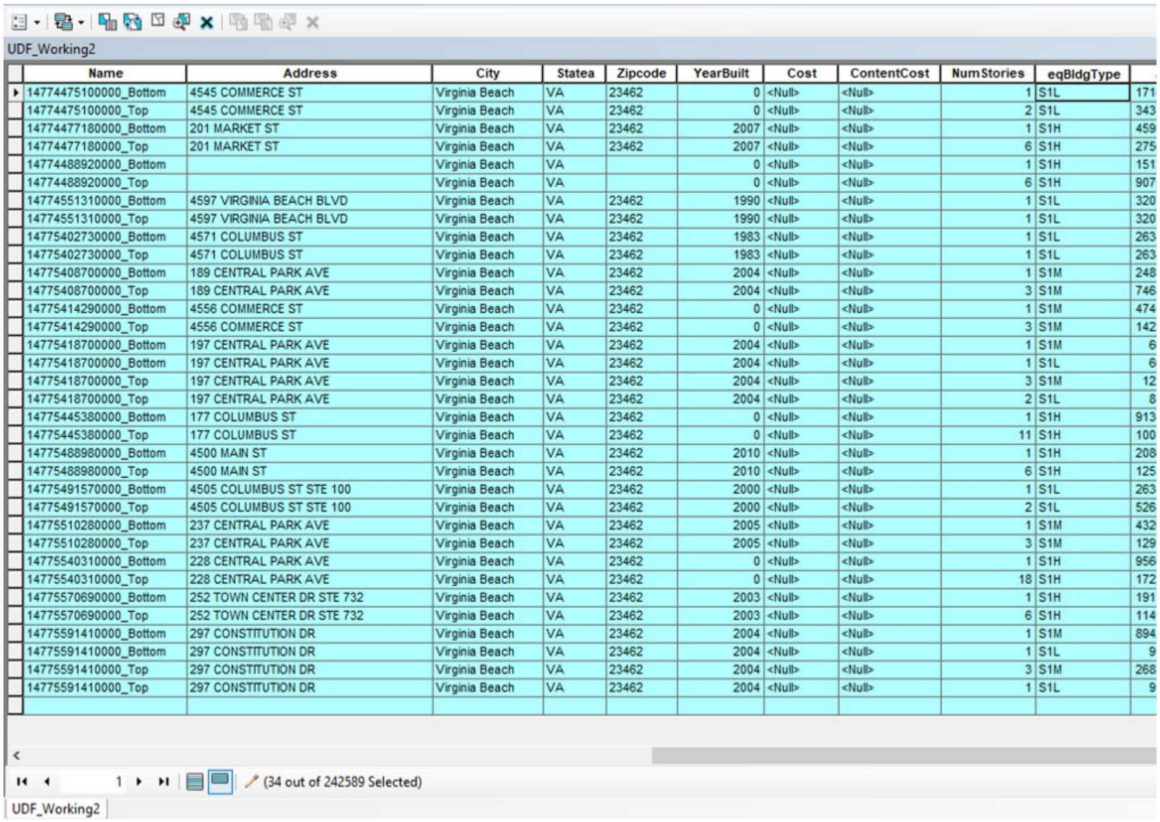
83. Right click on Area and Field Calculator. Edit the Area field to equal [Building F] * [NumStories] and click OK.



84. Now update the earthquake building type for these buildings. The building type heights should be determined by the total number of stories and not the new values. For example, 201 Market St has 6 stories of residences and 1 story of commercial so it would be considered a mid-rise building (4-7 stories). We'll designate these buildings as S1L, S1M, and S1H. Type in the values based on the number of stories (1-3 is S1L, 4-7 is S1M, and 8+ is S1H).



UDF_Working2

Name	Address	City	Statea	Zipcode	YearBuilt	Cost	ContentCost	NumStories	eqBldgType	
14774475100000_Bottom	4545 COMMERCE ST	Virginia Beach	VA	23462	0	<Null>	<Null>	1	S1L	171
14774475100000_Top	4545 COMMERCE ST	Virginia Beach	VA	23462	0	<Null>	<Null>	2	S1L	343
14774477180000_Bottom	201 MARKET ST	Virginia Beach	VA	23462	2007	<Null>	<Null>	1	S1H	459
14774477180000_Top	201 MARKET ST	Virginia Beach	VA	23462	2007	<Null>	<Null>	6	S1H	275
14774488920000_Bottom		Virginia Beach	VA		0	<Null>	<Null>	1	S1H	151
14774488920000_Top		Virginia Beach	VA		0	<Null>	<Null>	6	S1H	907
14774551310000_Bottom	4597 VIRGINIA BEACH BLVD	Virginia Beach	VA	23462	1990	<Null>	<Null>	1	S1L	320
14774551310000_Top	4597 VIRGINIA BEACH BLVD	Virginia Beach	VA	23462	1990	<Null>	<Null>	1	S1L	320
14775402730000_Bottom	4571 COLUMBUS ST	Virginia Beach	VA	23462	1983	<Null>	<Null>	1	S1L	263
14775402730000_Top	4571 COLUMBUS ST	Virginia Beach	VA	23462	1983	<Null>	<Null>	1	S1L	263
14775408700000_Bottom	189 CENTRAL PARK AVE	Virginia Beach	VA	23462	2004	<Null>	<Null>	1	S1M	248
14775408700000_Top	189 CENTRAL PARK AVE	Virginia Beach	VA	23462	2004	<Null>	<Null>	3	S1M	746
14775414290000_Bottom	4556 COMMERCE ST	Virginia Beach	VA	23462	0	<Null>	<Null>	1	S1M	474
14775414290000_Top	4556 COMMERCE ST	Virginia Beach	VA	23462	0	<Null>	<Null>	3	S1M	142
14775418700000_Bottom	197 CENTRAL PARK AVE	Virginia Beach	VA	23462	2004	<Null>	<Null>	1	S1M	6
14775418700000_Bottom	197 CENTRAL PARK AVE	Virginia Beach	VA	23462	2004	<Null>	<Null>	1	S1L	6
14775418700000_Top	197 CENTRAL PARK AVE	Virginia Beach	VA	23462	2004	<Null>	<Null>	3	S1M	12
14775418700000_Top	197 CENTRAL PARK AVE	Virginia Beach	VA	23462	2004	<Null>	<Null>	2	S1L	8
14775445380000_Bottom	177 COLUMBUS ST	Virginia Beach	VA	23462	0	<Null>	<Null>	1	S1H	913
14775445380000_Top	177 COLUMBUS ST	Virginia Beach	VA	23462	0	<Null>	<Null>	11	S1H	100
14775488980000_Bottom	4500 MAIN ST	Virginia Beach	VA	23462	2010	<Null>	<Null>	1	S1H	208
14775488980000_Top	4500 MAIN ST	Virginia Beach	VA	23462	2010	<Null>	<Null>	6	S1H	125
14775491570000_Bottom	4505 COLUMBUS ST STE 100	Virginia Beach	VA	23462	2000	<Null>	<Null>	1	S1L	263
14775491570000_Top	4505 COLUMBUS ST STE 100	Virginia Beach	VA	23462	2000	<Null>	<Null>	2	S1L	526
14775510280000_Bottom	237 CENTRAL PARK AVE	Virginia Beach	VA	23462	2005	<Null>	<Null>	1	S1M	432
14775510280000_Top	237 CENTRAL PARK AVE	Virginia Beach	VA	23462	2005	<Null>	<Null>	3	S1M	129
14775540310000_Bottom	228 CENTRAL PARK AVE	Virginia Beach	VA	23462	0	<Null>	<Null>	1	S1H	956
14775540310000_Top	228 CENTRAL PARK AVE	Virginia Beach	VA	23462	0	<Null>	<Null>	18	S1H	172
14775570690000_Bottom	252 TOWN CENTER DR STE 732	Virginia Beach	VA	23462	2003	<Null>	<Null>	1	S1H	191
14775570690000_Top	252 TOWN CENTER DR STE 732	Virginia Beach	VA	23462	2003	<Null>	<Null>	6	S1H	114
14775591410000_Bottom	297 CONSTITUTION DR	Virginia Beach	VA	23462	2004	<Null>	<Null>	1	S1M	894
14775591410000_Bottom	297 CONSTITUTION DR	Virginia Beach	VA	23462	2004	<Null>	<Null>	1	S1L	9
14775591410000_Top	297 CONSTITUTION DR	Virginia Beach	VA	23462	2004	<Null>	<Null>	3	S1M	268
14775591410000_Top	297 CONSTITUTION DR	Virginia Beach	VA	23462	2004	<Null>	<Null>	1	S1L	9

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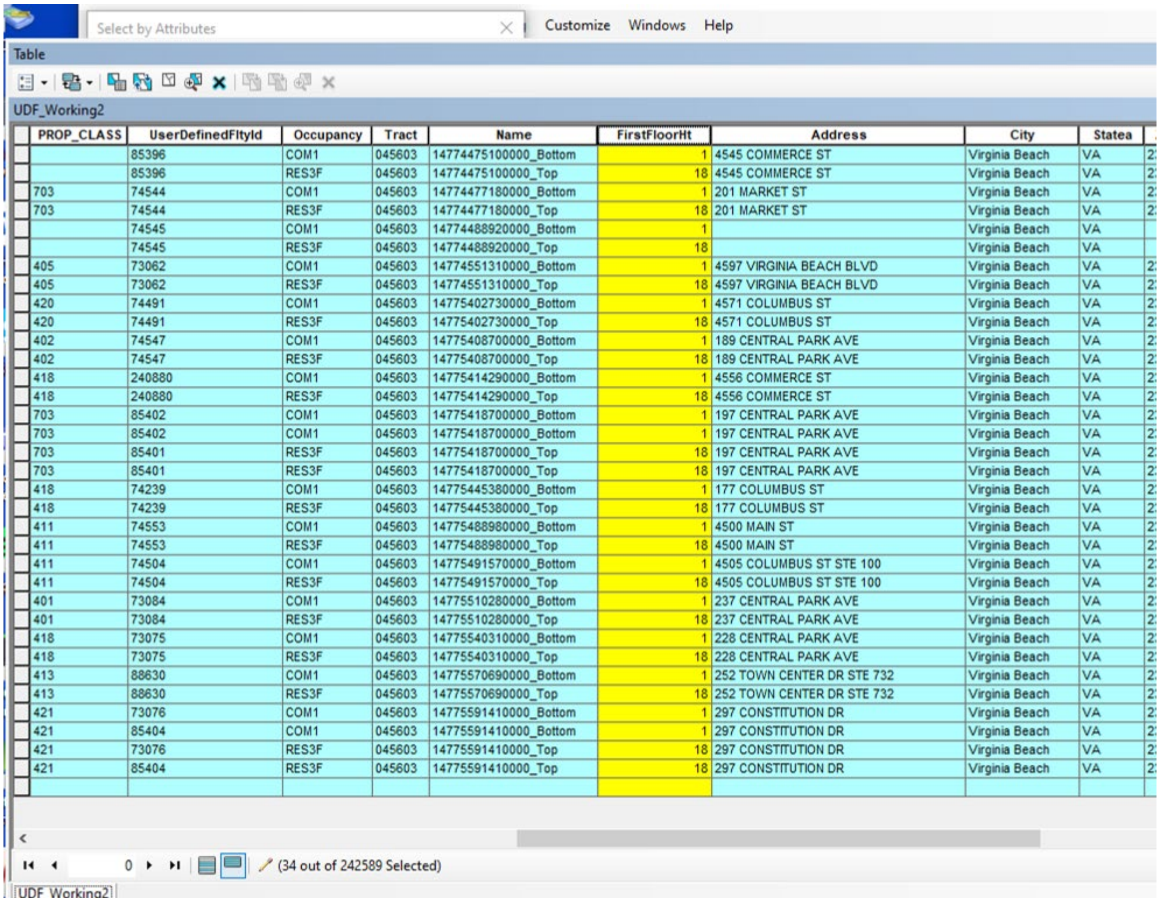
85. Now edit the Occupancy to either COM1 or RES3F depending on whether it is bottom (COM1) or top (RES3F). Change the FirstFloorHt values. The residential values should be set at 18 feet to account for the commercial business underneath it. It is not necessary to update foundation type since none of the buildings have basements.



UDF_Working2

PROP_CLASS	UserDefinedFltyId	Occupancy	Tract	Name	FirstFloorHt	Address	City	Statea
	85396	COM1	045603	14774475100000_Bottom	1	4545 COMMERCE ST	Virginia Beach	VA
	85396	RES3F	045603	14774475100000_Top	18	4545 COMMERCE ST	Virginia Beach	VA
703	74544	COM1	045603	14774477180000_Bottom	1	201 MARKET ST	Virginia Beach	VA
703	74544	RES3F	045603	14774477180000_Top	18	201 MARKET ST	Virginia Beach	VA
	74545	COM1	045603	14774488920000_Bottom	1		Virginia Beach	VA
	74545	RES3F	045603	14774488920000_Top	18		Virginia Beach	VA
405	73062	COM1	045603	14774551310000_Bottom	1	4597 VIRGINIA BEACH BLVD	Virginia Beach	VA
405	73062	RES3F	045603	14774551310000_Top	18	4597 VIRGINIA BEACH BLVD	Virginia Beach	VA
420	74491	COM1	045603	14775402730000_Bottom	1	4571 COLUMBUS ST	Virginia Beach	VA
420	74491	RES3F	045603	14775402730000_Top	18	4571 COLUMBUS ST	Virginia Beach	VA
402	74547	COM1	045603	14775408700000_Bottom	1	189 CENTRAL PARK AVE	Virginia Beach	VA
402	74547	RES3F	045603	14775408700000_Top	18	189 CENTRAL PARK AVE	Virginia Beach	VA
418	240880	COM1	045603	14775414290000_Bottom	1	4556 COMMERCE ST	Virginia Beach	VA
418	240880	RES3F	045603	14775414290000_Top	18	4556 COMMERCE ST	Virginia Beach	VA
703	85402	COM1	045603	14775418700000_Bottom	1	197 CENTRAL PARK AVE	Virginia Beach	VA
703	85402	COM1	045603	14775418700000_Bottom	1	197 CENTRAL PARK AVE	Virginia Beach	VA
703	85401	RES3F	045603	14775418700000_Top	18	197 CENTRAL PARK AVE	Virginia Beach	VA
703	85401	RES3F	045603	14775418700000_Top	18	197 CENTRAL PARK AVE	Virginia Beach	VA
418	74239	COM1	045603	14775445380000_Bottom	1	177 COLUMBUS ST	Virginia Beach	VA
418	74239	RES3F	045603	14775445380000_Top	18	177 COLUMBUS ST	Virginia Beach	VA
411	74553	COM1	045603	14775488980000_Bottom	1	4500 MAIN ST	Virginia Beach	VA
411	74553	RES3F	045603	14775488980000_Top	18	4500 MAIN ST	Virginia Beach	VA
411	74504	COM1	045603	14775491570000_Bottom	1	4505 COLUMBUS ST STE 100	Virginia Beach	VA
411	74504	RES3F	045603	14775491570000_Top	18	4505 COLUMBUS ST STE 100	Virginia Beach	VA
401	73084	COM1	045603	14775510280000_Bottom	1	237 CENTRAL PARK AVE	Virginia Beach	VA
401	73084	RES3F	045603	14775510280000_Top	18	237 CENTRAL PARK AVE	Virginia Beach	VA
418	73075	COM1	045603	14775540310000_Bottom	1	228 CENTRAL PARK AVE	Virginia Beach	VA
418	73075	RES3F	045603	14775540310000_Top	18	228 CENTRAL PARK AVE	Virginia Beach	VA
413	88630	COM1	045603	14775570690000_Bottom	1	252 TOWN CENTER DR STE 732	Virginia Beach	VA
413	88630	RES3F	045603	14775570690000_Top	18	252 TOWN CENTER DR STE 732	Virginia Beach	VA
421	73076	COM1	045603	14775591410000_Bottom	1	297 CONSTITUTION DR	Virginia Beach	VA
421	85404	COM1	045603	14775591410000_Bottom	1	297 CONSTITUTION DR	Virginia Beach	VA
421	73076	RES3F	045603	14775591410000_Top	18	297 CONSTITUTION DR	Virginia Beach	VA
421	85404	RES3F	045603	14775591410000_Top	18	297 CONSTITUTION DR	Virginia Beach	VA

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86. Now let's update the cost and contentcost fields. Use the Select by Attribute to create the following query: [Occupancy] = 'COM1' AND [Cost] IS NULL. Use the Field Calculator for the following calculations:

- Cost field: Cost = [Area] *114.47*0.87
- ContentCost Field: ContentCost = [Cost]

87. Use the Select by Attribute to create the following query: [Occupancy] = 'RES3F' AND [Cost] IS NULL. Use the Field Calculator for the following calculations:

- Cost field: Cost = [Area] *174.53*0.95
- ContentCost Field: ContentCost = [Cost] *0.5

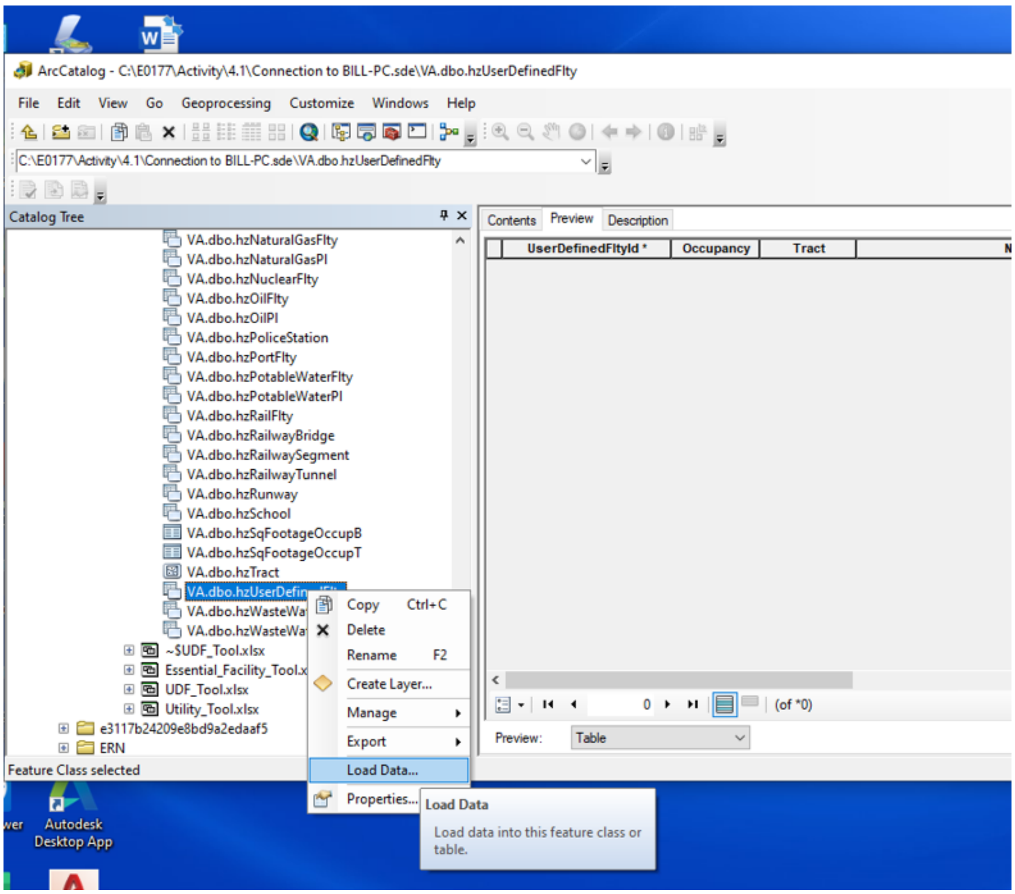
88. Since the mixed-use properties do not fall in the coastal floodplain, the depth damage fields can remain unpopulated. Go to Editor and Stop Editing.

89. There are two additional changes you need to make to the data involving changing all the RES2 number of stories to 1 and changing the RES1 building greater than 3 stories to 3 stories. The Hazus flood model will crash if the number of stories for a RES2 structure (mobile home) is greater than 1.

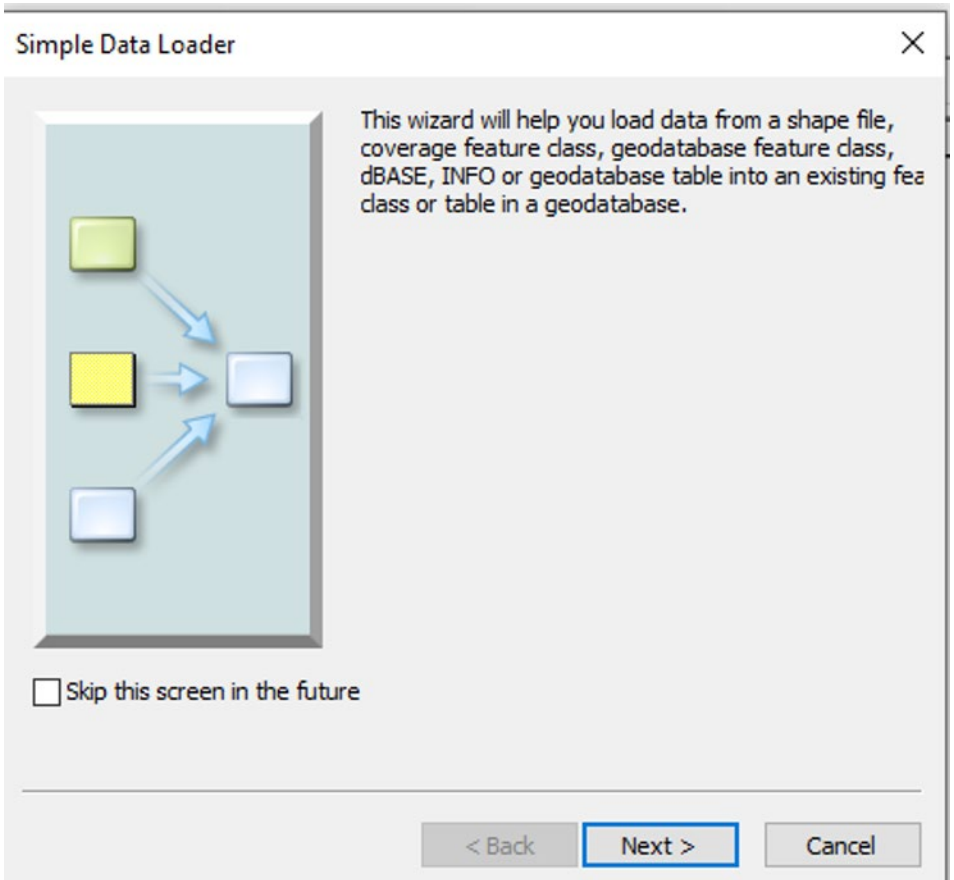
90. Use Select by Attribute to select all RES2 structures: [Occupancy] = 'RES2' and use Field Calculator to make everything a 1 story building. NumStories = 1. Then use Select by Attribute to select all RES1 structures: [Occupancy] = 'RES1' AND [NumStories]>3 and use Field

Calculator to make everything 3 stories. NumStories = 3. At this point the data is ready to be imported.

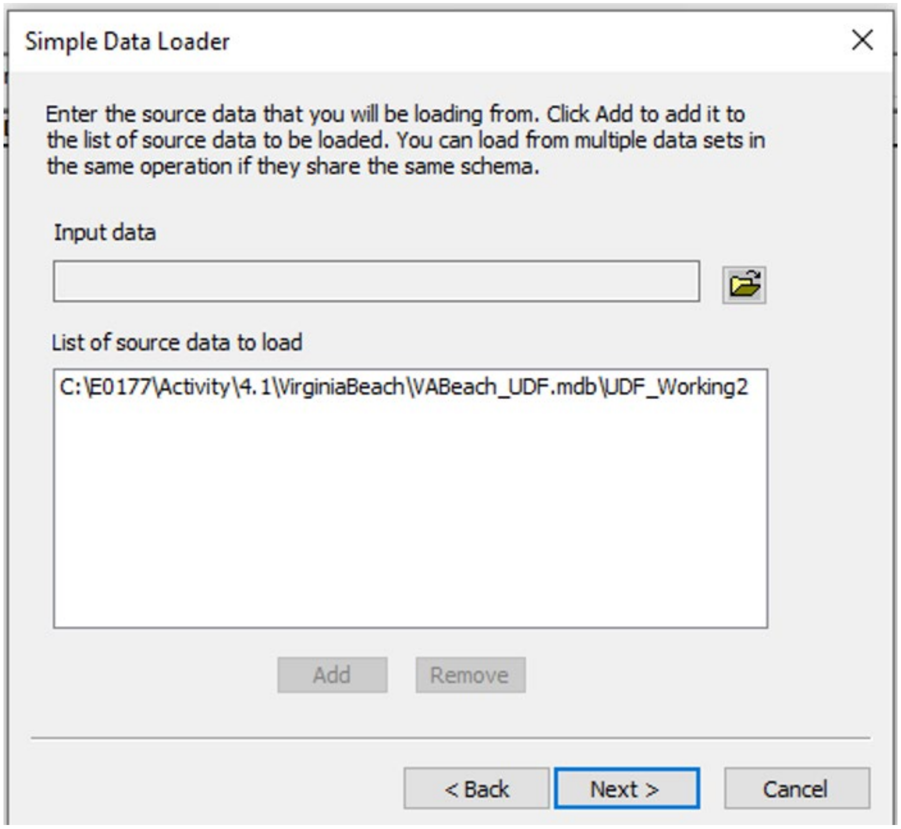
91. CDMS may be used to update the UDF facility data in the state database. However, the program can take a very long time with large numbers of records. The Virginia Beach dataset would take many hours to import. To get around this limitation, we're going to use ArcCatalog to load the data directly. Open ArcCatalog and browse to VA.dbo.hzUserDefinedFlty and right click on it. Select Load Data.



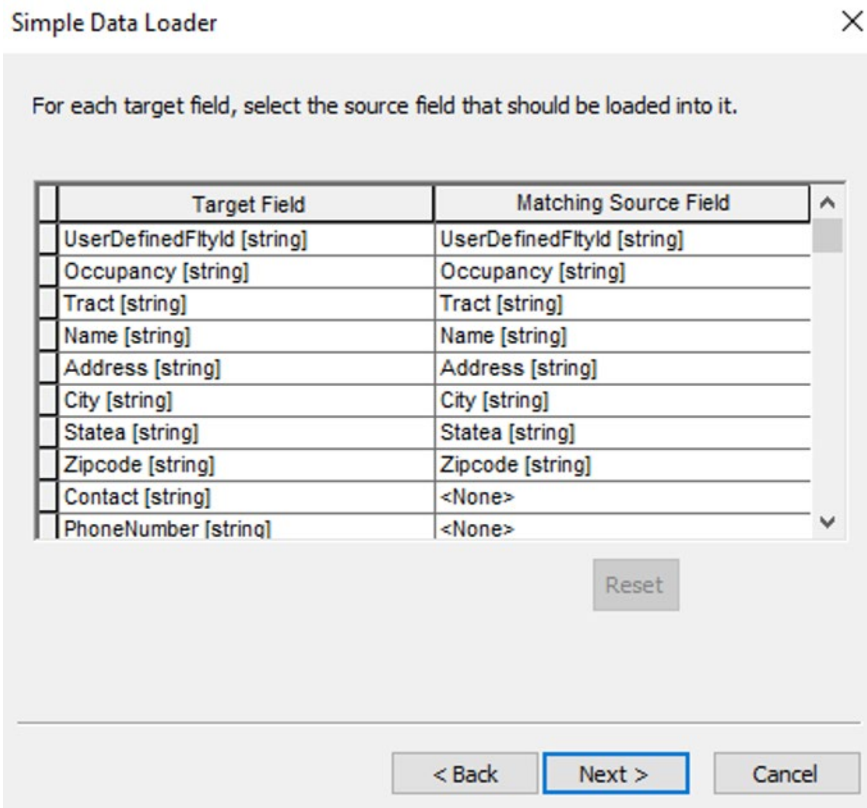
92.Click Next when the Simple Data Loader menu comes up.



93.Browse to the UDF feature class here: C:\E0177\Activity\4.1\VirginiaBeach\VABeach_UDF.mdb\UDF_Working2. Then click Add. Then click Next.



94.The next menu will show a box with the Target Fields on the left and Source Field on the right. Since the name and data type all match, everything should match up correctly. Click Next.



95. Select Load all of the source data. Then select Next and Finish.

96. This will take several minutes but will be much faster than using CDMS. Next, we'll need to update the eqUserDefinedFlty table. Right click on the table and follow the directions above on how to import the data. The final table to update is the flUserDefinedFlty table. Again, follow the directions above to update this table.

97. Now create a new study region. Create a flood and earthquake study region for Virginia Beach, Virginia and call it VA_Beach_FL_EQ. After Hazus aggregates the region, open the flood hazard. Select Inventory and then User Defined Facilities. Map the facilities and open the attribute table. There should be 242589 UDFs in the table and the fields you brought in using ArcCatalog should be populated. Switch to the earthquake hazard and open the UDF inventory table. Hazus adds a field called Wind Building Scheme Name and populates that field based on the location of the study region. This data does not reside in the state database, but does reside in the study region database.

Task 4: Document Updated Inventory

1. Now document the edits you made. For user-defined facility edits, use ArcCatalog to browse to the UDF feature class, then click on the Description tab. Then click Edit. Add a brief summary and description of the GIS layer. When you're done, save the file.

2. You have successfully updated the UDF inventory and documented the update.

Application 4: General Building Stock (All Hazards)

Task 1: Identify, Collect, and Validate Local Data

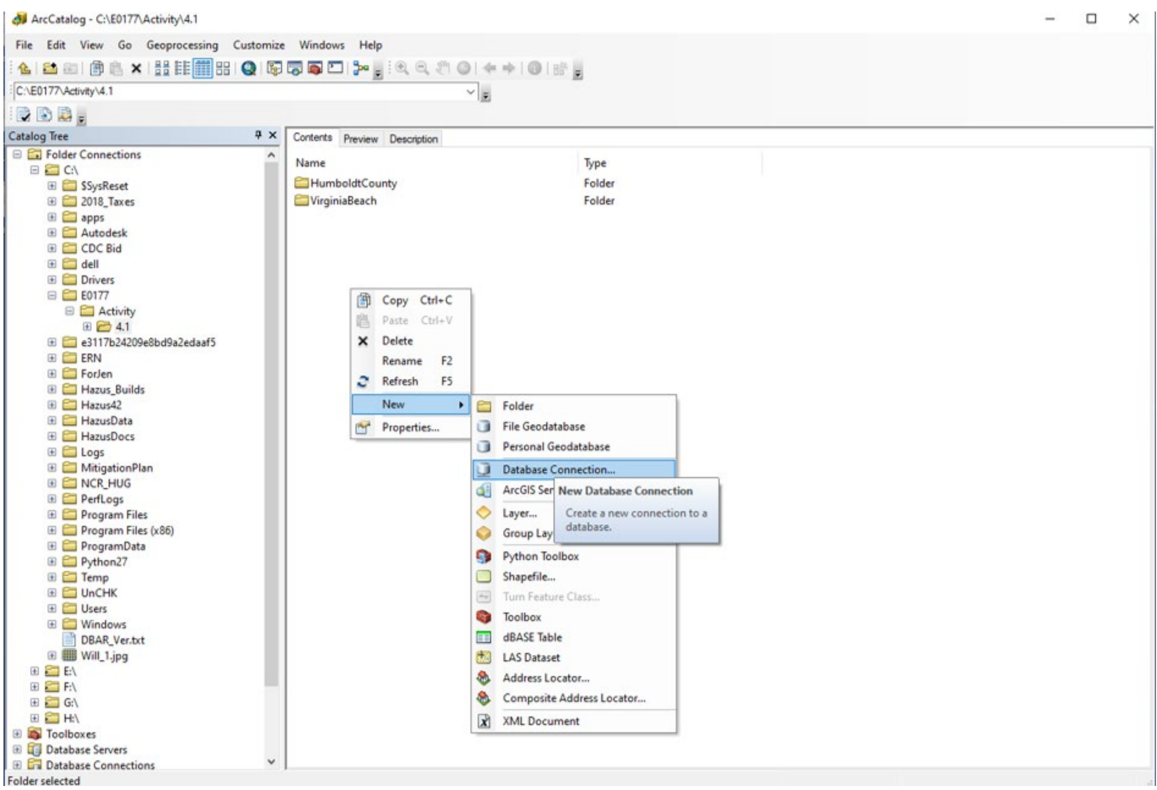
1. First locate the parcel data. Local GIS websites are good sources of data. For Santa Cruz, the local parcel data has already been identified and downloaded here: C:\E0177\Activity\4.1\SantaCruz\ and is called assessor_parcels.shp. This data was downloaded from the County's website here: https://www.co.santa-cruz.ca.us/Departments/GeographicInformationSystems(GIS).aspx. It is important to identify the metadata as well. In this case, the metadata is provided on the website above.

To help supplement our existing parcel data, we're going to query the Census Tract data using CDMS.

2. Open CDMS and set the statewide database to California.

3. Select Query/Export Statewide Datasets and Export to Geodatabase the Santa Cruz Building Square Footage by Census Block, Exposure Content layer to C:\E0177\Activity\4.1\SantaCruz\ and call the file GBS.mdb.

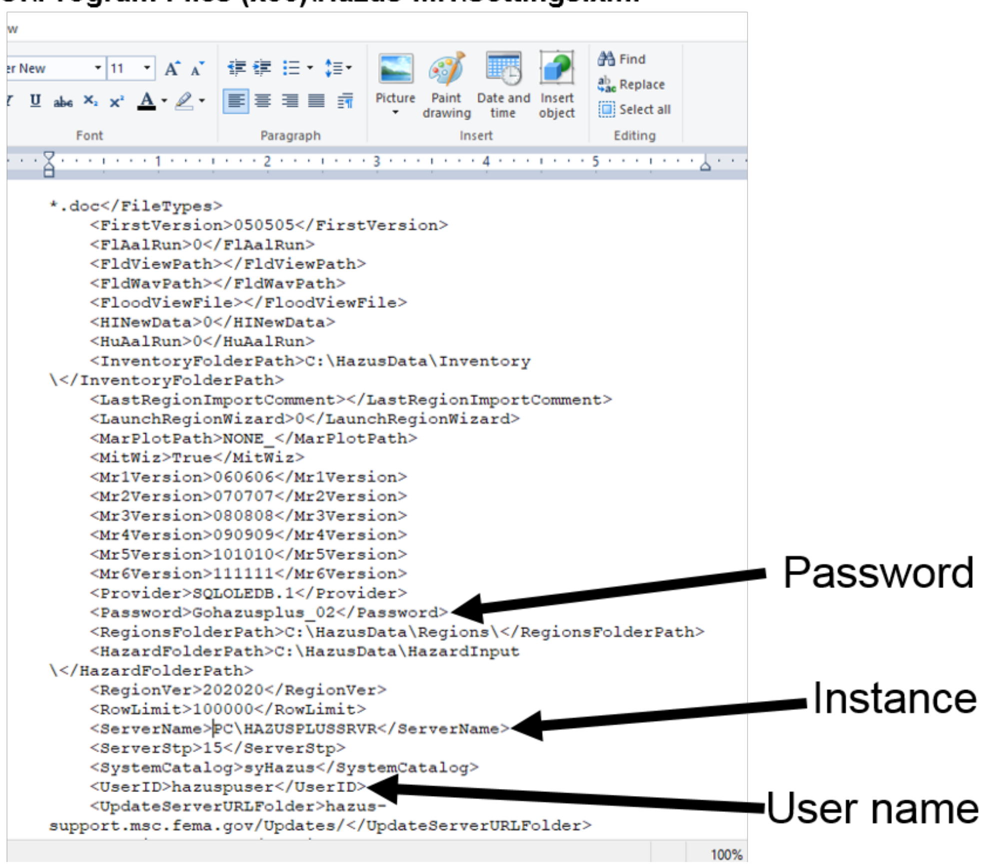
4. Now bring in the Census Block Data. Using ArcCatalog, create a new database connection to C:\E0177\Activity\4.1\.



5. The Database Connection dialog box will appear.

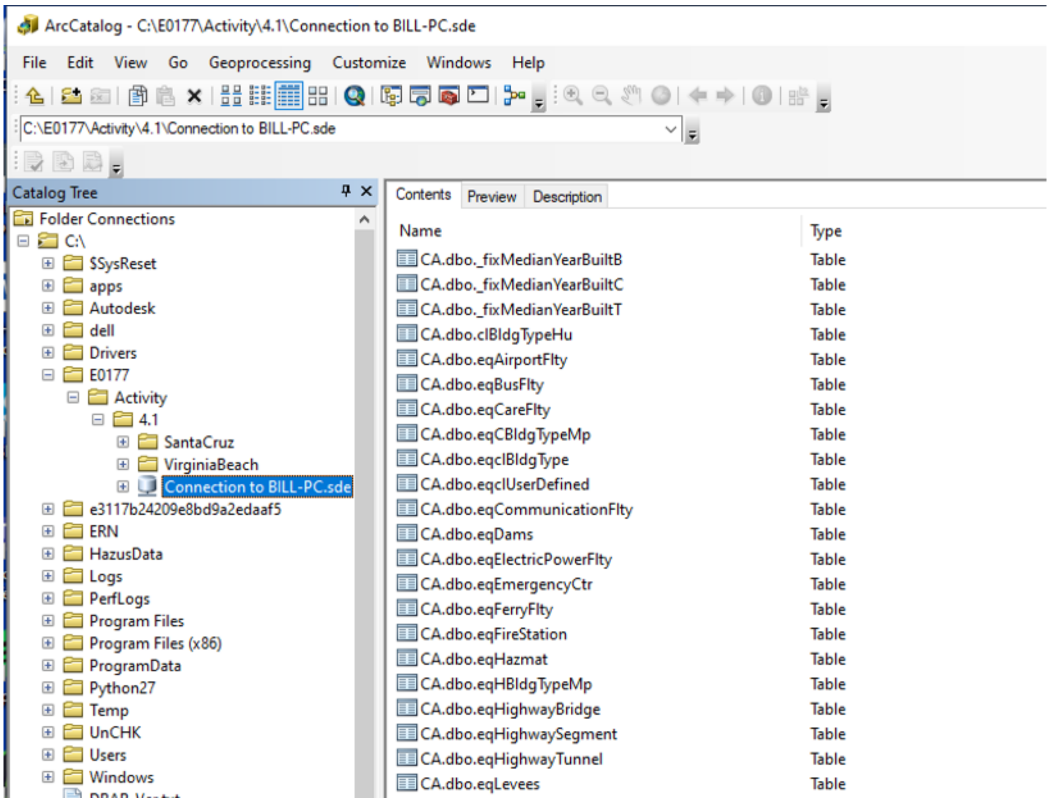
6. To figure out how to populate the Instance, User name, and Password, go to C:\Program Files (x86)\Hazus-MH\Settings.xml and open the file. The information shown in the xml file may be copied from the xml file and pasted into the ArcCatalog interface. The instance includes the computer name which can be long. Your computer name will be different than the example.

C:\Program Files (x86)\Hazus-MH\Settings.xml



7. Enter the password, instance, and user name into the ArcCatalog interface. Select SQL Server in the top dropdown.

8. Select CA in the database dropdown and then select OK. This will create a database connection with the default name: Connection to PC_Name.sde where PC_Name is the name provided in the instance. Double click on the new connection name to access the Hazus California State data.



9. Reviewing the data in the state database, files that start with eq are associated with the earthquake model, fl is flood, hu is hurricane, ts is tsunami (for tsunami states not Virginia), and hz is common across all hazards. For this activity, we are going to use the Census Block data. Since a spatial join will be used, select the Census Blocks that haven't been clipped into dasymetric blocks. This block feature class is called: CA.dbo.hzCensusBlock_TIGER.

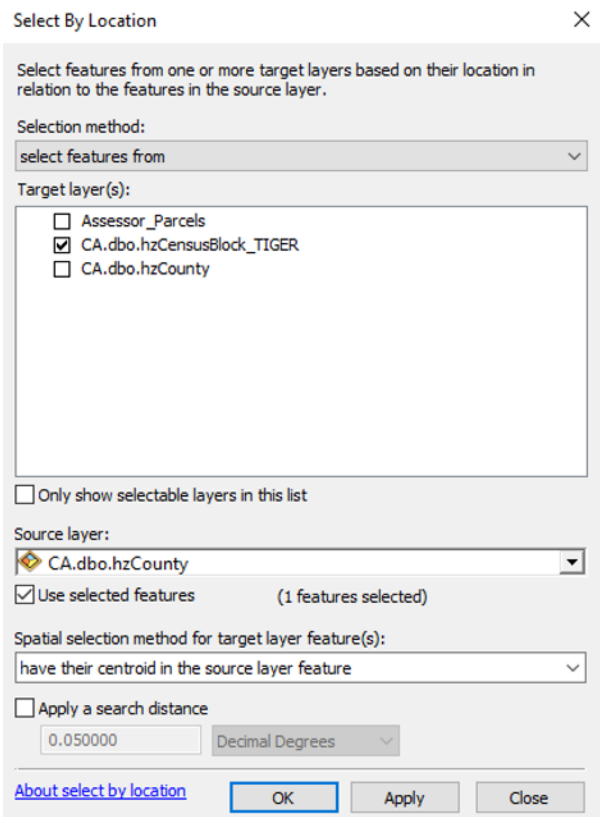
10. Open ArcMap to an untitled map. Bring in the Santa Cruz parcel data. Go to ArcCatalog and left click CA.dbo.hzCensusBlock_TIGER and drag it into the ArcMap Table of contents.

11. The Census Block data consists of all of California so a query for the section that is relevant to Santa Cruz will need to be executed. Drag CA.dbo.hzCounty into ArcMap.

12. From the top menu, click Selection and then Select by Attributes. Select CA.dbo.hzCounty next to Layer: then select Create a new Selection next to method: then double click on CountyName, then = and then 'Santa Cruz'. Click OK and then Close.

13. From the top menu, click Selection and then Select by Location.

14. Click select features from under Selection method. Under Target layer(s), select CA.dbo.hzCensusBlockTIGER. Under Source layer: select CA.dbo.hzCounty. Click on the button to Use selected features and under Spatial selection method for target layer feature(s): select have their centroid in the source layer feature. Then click OK.

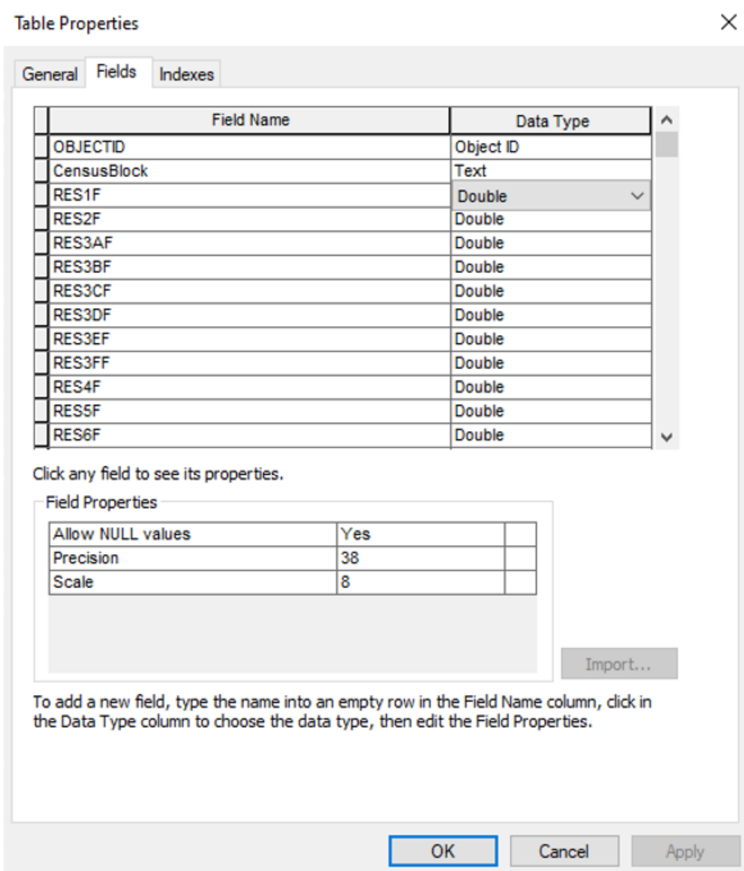


15. Once the query finishes processing, right click on CA.dbo.hzCensusBlockTIGER, then click Data and Export Data. Browse to the GBS geodatabase created above. Double click on GBS.mdb and call this feature class: TIGER_Blocks. Then click Save and OK.

16. Clear the selection and remove the CA.dbo.hzCensusBlock_TIGER and the CA.dbo.hzCounty layers.

Task 2: Format Data

1. Identify the required fields and the formatting of those fields. To do this, review the SQL tables using ArcCatalog. Open ArcCatalog and then click on the database connection. Right click on CA.dbo.hzSqFootageOccupB in ArcCatalog, then click Properties. Click on the Fields tab. The data type is provided in the right column. Click on Double next to RES1F and the precision is shown as 38 and scale is 8. Each specific occupancy has a separate field with the same formatting except for CensusBlock which is a Text field with a 50 character length.



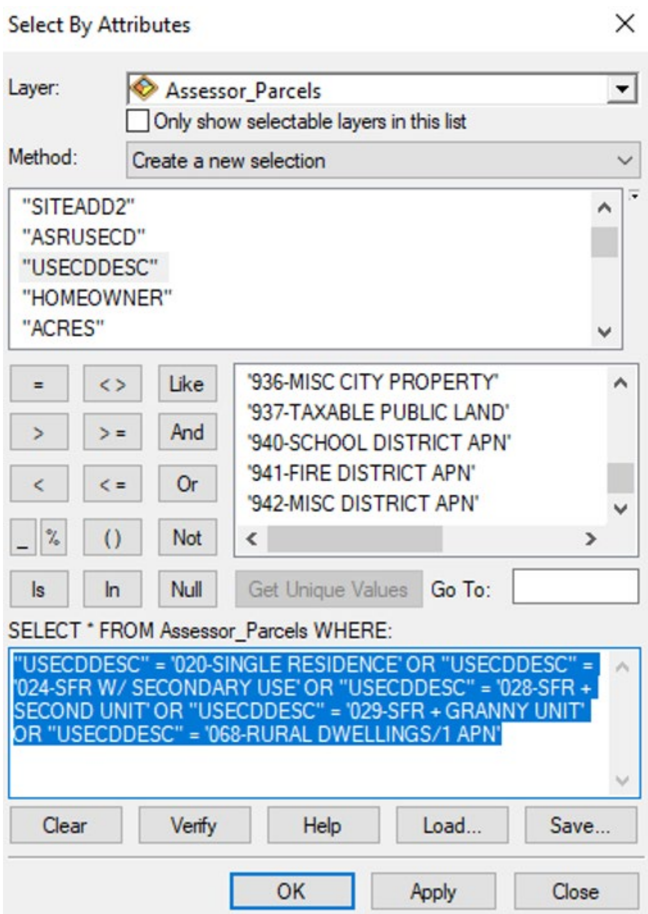
2. In this activity, the following tables will be updated: CA.dbo.hzSqFootageOccupB, CA.dbo.hzExposureOccupB, CA.dbo.hzExposureContentOccupB, and CA.dbo.hzBldgCountOccupB. Reviewing the fields for all of these tables shows that the formatting requirements are all the same.

Task 3: Update Inventory

1. In this task, you're going to look at what data is required to run a Hazus analysis, compare it to what you already have, and then make inventory updates. Looking at the Santa Cruz data, there is parcel data containing an occupancy code which needs to be matched up with the Hazus specific occupancy, number of buildings, and square footage. The square footage can be used to derive the replacement and content costs.

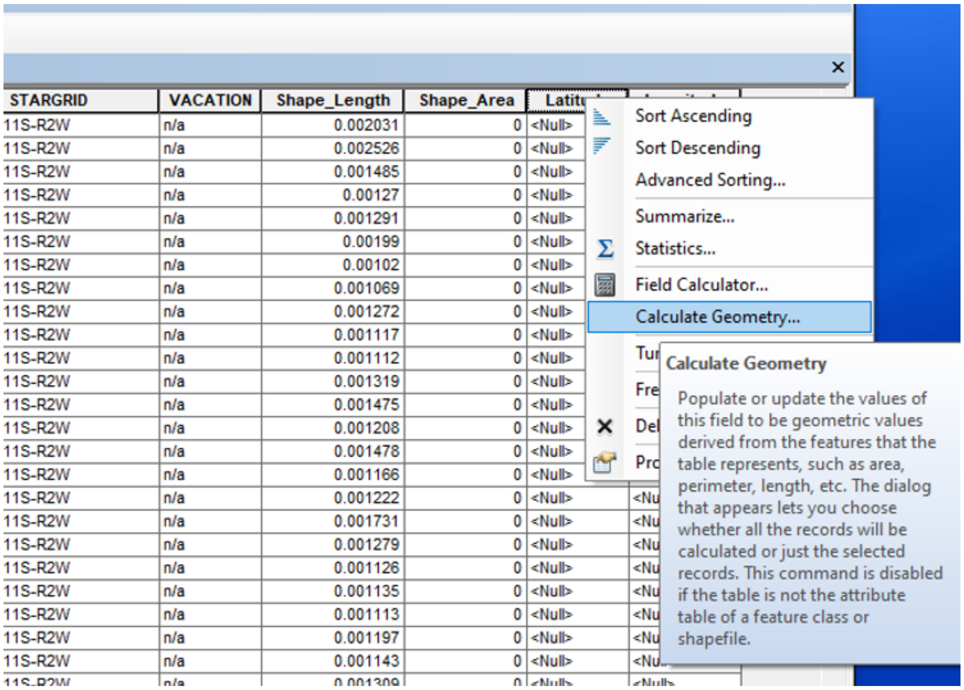
2. Format the parcel data so that it can be transferred to the TIGER block data. Under Selection in the top menu, click Select by Attributes. For the Assessor_Parcels layer, click Create a new selection, then "USECDDESC", then the = sign, and Get Unique Values. Scroll through the options and identify any RES1 descriptions: 020-Single Residence, 024-SFR W/Secondary Use, 028-SFR+Second Unit, 029-SFR+Granny Unit, 068-Rural Dwellings/1APN. Create the following expression: "USECDDESC" = '020-SINGLE RESIDENCE' OR "USECDDESC" = '024-SFR W/ SECONDARY USE' OR "USECDDESC" = '028-SFR + SECOND UNIT' OR

"USECDDESC" = '029-SFR + GRANNY UNIT' OR "USECDDESC" = '068-RURAL DWELLINGS/1 APN' and click OK.

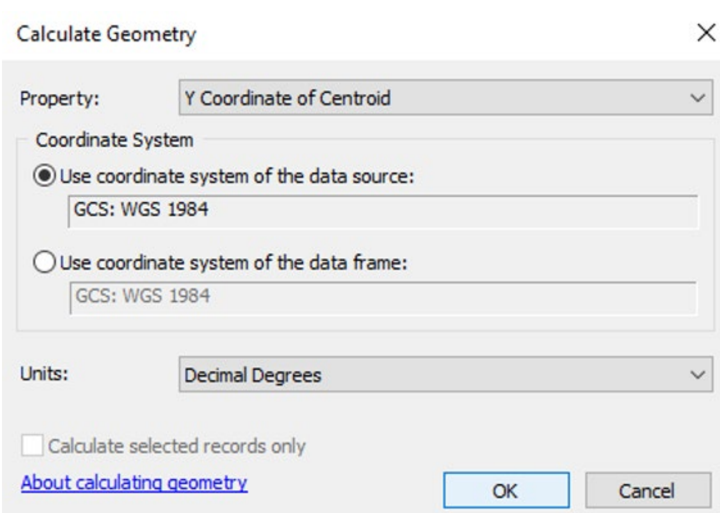


3. Right click on the Assessor_Parcels layer and select Data, then Export Data. Export selected features and browse to the GBS geodatabase and name it RES1_Parcels as a feature class. Click Save and then OK.

4. Remove the Assessor_Parcels layer from the table of contents. Right click on RES1_Parcels and click Open Attribute Table. Add two fields, called latitude and longitude with a double data type. Click on the button in the top left of the attribute table and select Add Field. Name the first one Latitude and assign it a Double data type and click OK, then add a second field called Longitude with a Double data type. Next, right click on Latitude and select Calculate Geometry.



5. Click Yes when the warning comes up. This will be the Y Coordinate of Centroid using GCS:WGS_1984 with units of Decimal Degrees.

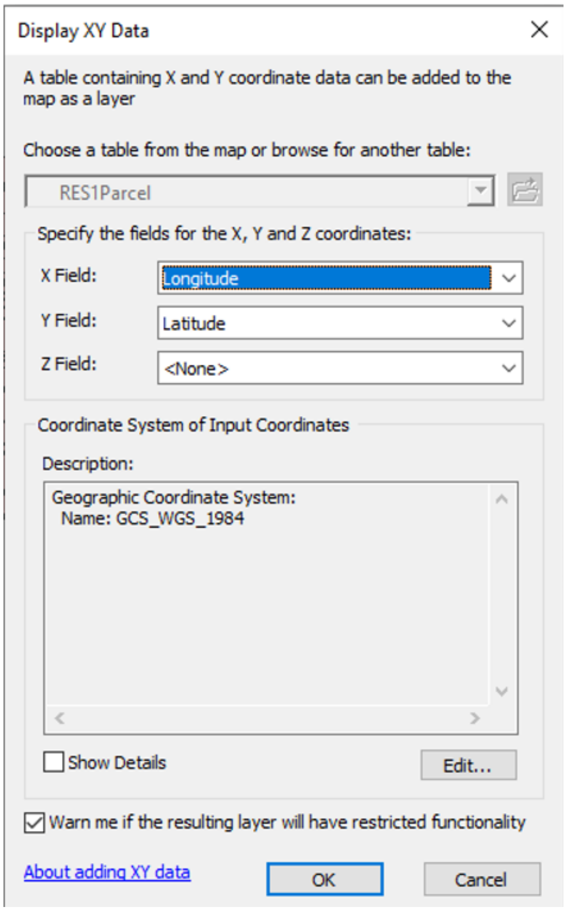


6. Click OK and then Yes when the warning comes up. Do the same thing for the Longitude field but select X Coordinate of Centroid.

7. While the RES1_Parcels attribute table is still open, left click on the top left button and select export. Then click the browse folder button and change the file type to dBASE Table. Save the

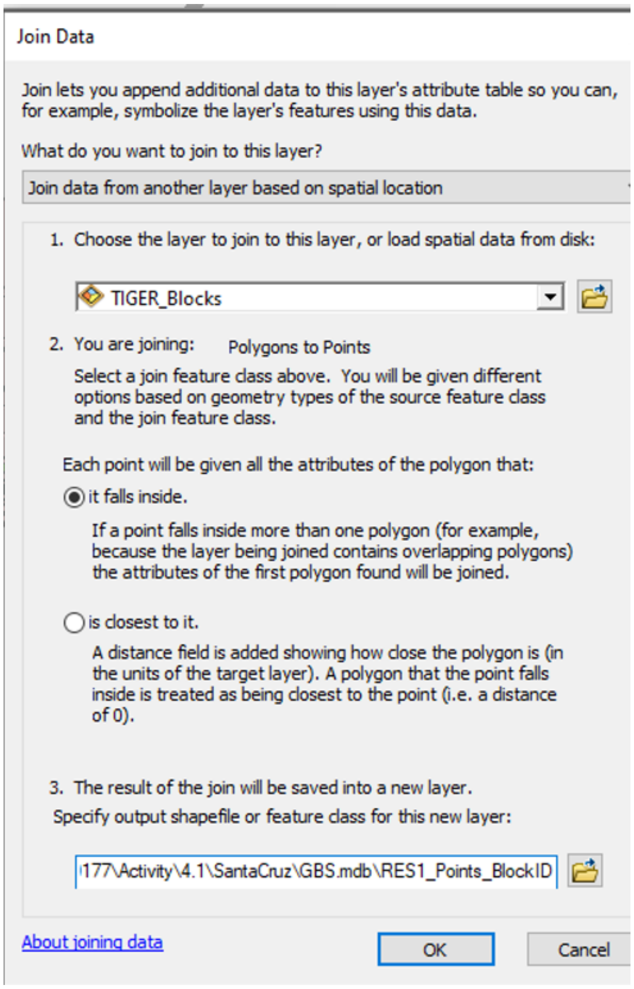
file as RES1Parcel.dbf. Then click Save and OK. Click Yes when the message comes up about adding it to the map.

8. Right click on the RES1Parcel table and select Display XY Data. Make sure Longitude is selected for the X Field and Latitude is selected for the Y Field. Then click OK.

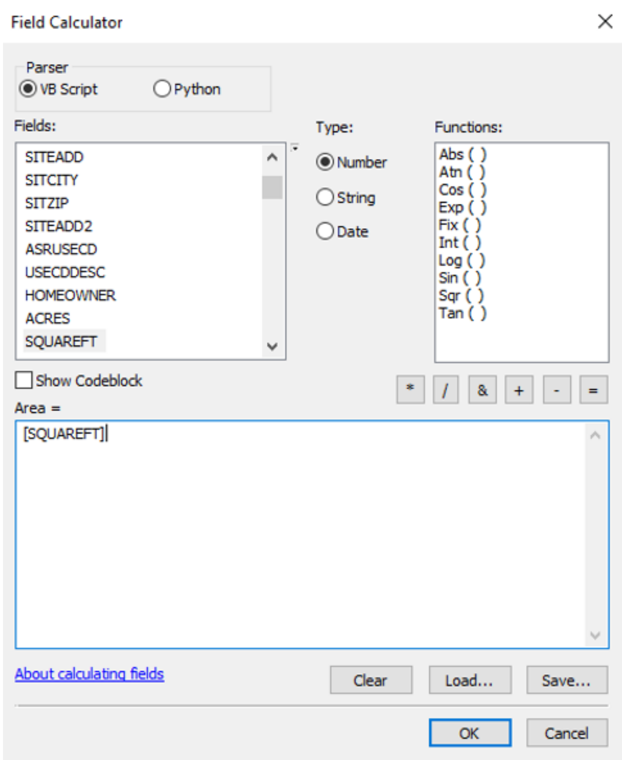


9. Now, right click on the RES1Parcel Events layer and then select Data and Export Data. Save the layer as a feature class in the GBS geodatabase called: RES1_Points. When the message comes up asking to add as a layer to the map, click Yes. Remove the RES1Parcel Events layer, RES1_Parcels layer, and the RES1Parcel table from the map.

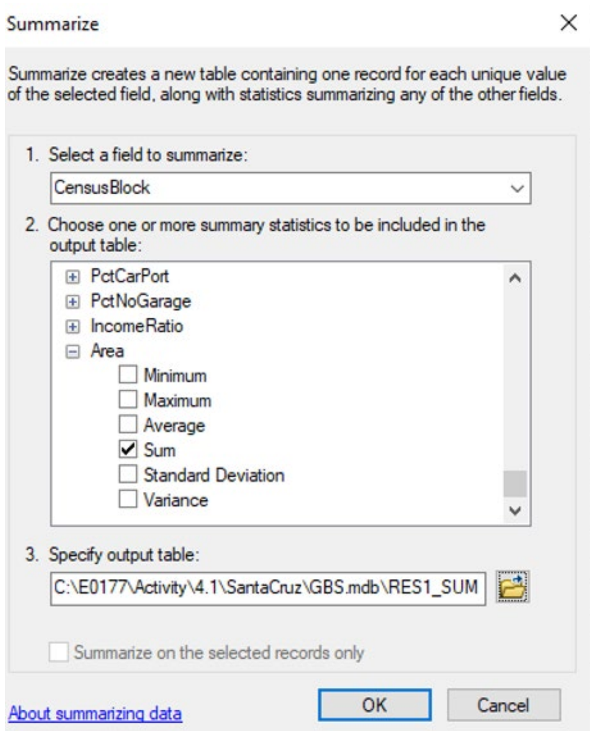
10. Join the Census Block value to the RES1_Points. Right click on RES1_Points and select Joins and Relates, then Joins. In the top dropdown, select Join data from another layer based on spatial location. Then select TIGER_Blocks, then is closest to it, browse to the GBS geodatabase and name the new file: RES1_Points_BlockID. Click OK.



11. Remove RES1_Points from the map. Open the RES1_Points_BlockID attribute table and add a field called: Area with a Double data type. Right click on the Area column header and select Field Calculator. Click Yes when the warning message comes up. Make Area = SQUAREFT. Click OK and Yes when the warning comes up. Since the building square footage was set as a string data type in the original data, it needs to be converted to a numeric value.

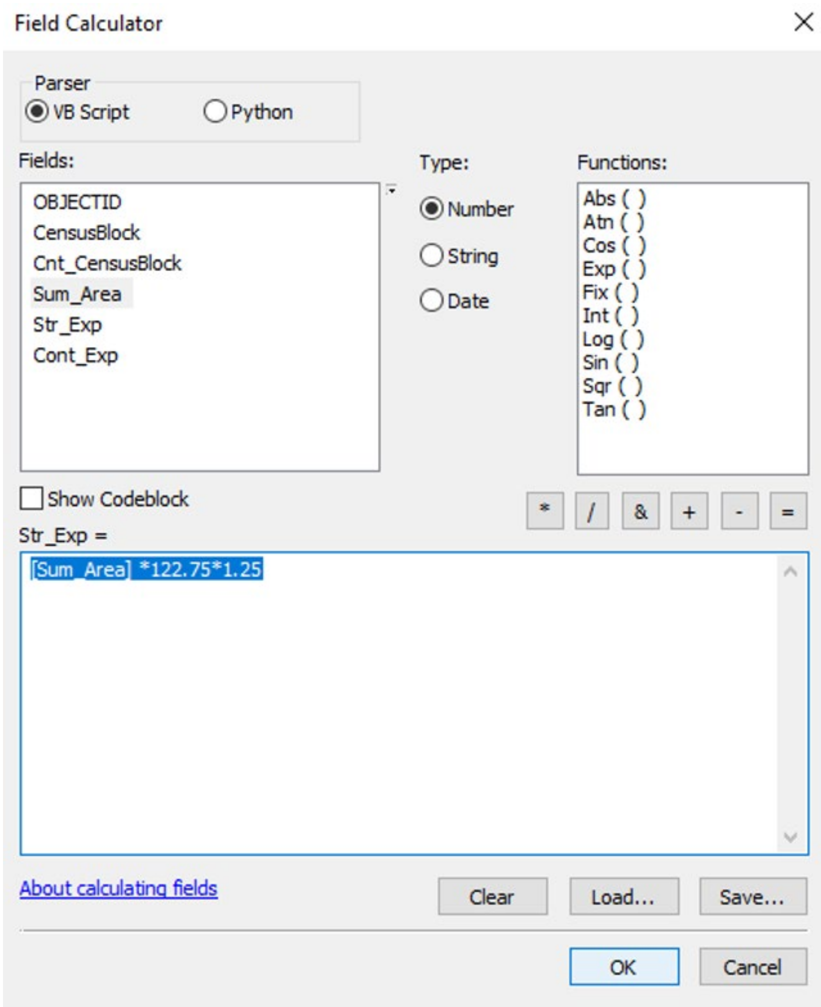


12. Right click on the CensusBlock column header and select Summarize. Scroll down to Area under Choose one or more summary statistics to be included in the output table:. Then select the plus sign next to Area and select Sum. Save the file in the GBS geodatabase called RES1_SUM.



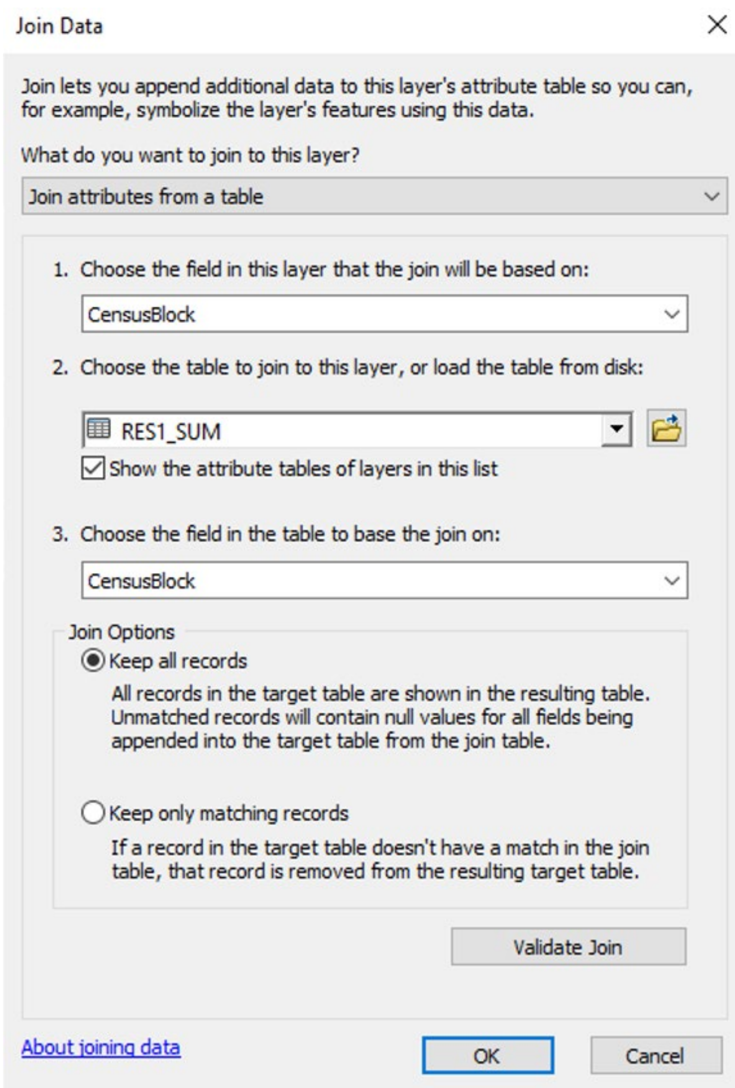
13. Calculate values. Right click on RES1_SUM and select Open. There should be a field with the Census Block, the count, and the total area. Now we'll need to calculate exposure and content exposure values. Click on the top left button and select Add Field. Name it Str_Exp and define it as a Double data type field. Then add a field called Cont_Exp and define it as a Double data type field.

14. Right click on the Str_Exp column and select Field Calculator. Click Yes when the warning message comes up. Open the UDF Tool spreadsheet from the activity folder. Go to Section 2 and look at the RES1 replacement values. We're going to use the average RES1 two story value of $122.75/square foot. This RSMeans value is the national average and a regional multiplier is required. Open ArcCatalog (not the ArcCatalog accessed from ArcMap but the full version found in the ArcGIS folder) and browse to the state data and find the table called CA.dbo.hzMeansCountyLocationFactor. The county FIPS for Santa Cruz is 06087. Click on the table and then select the preview tab at the top. Browse through the data until you find the 06087 row and see the MeansAdjRes value of 1.25. This is the residential adjustment value from the national average. In the Field Calculator use: Str_Exp = [Sum_Area] *122.75*1.25. Click OK.



15. Set the content exposure value. Right click on the Cont_Exp column header and select Field Calculator. Content costs are typically one half of the exposure costs for residential structures. So use: Cont_Exp = [Str_Exp]*0.5. Close the table.

16. Click the Add Data button and browse to Bldg Counts by Block in the GBS geodatabase. Add the table to the map. Right click on the TIGER_Blocks layer, then select Joins and Relates, and then Join. Select Join attributes from a table in the top dropdown, then CensusBlock, Bldg Counts by Block, CensusBlock, and Keep all records. Click OK. Click Yes when the warning message comes up.



17. Now transfer the data between layers. Right click on the TIGER_Blocks layer, then select Joins and Relates, and then Join. Select Join attributes from a table in the top dropdown, then CensusBlock, RES1_SUM, CensusBlock, and Keep all records. Click OK. Right click on TIGER_blocks and export the data as the feature class Building Count in the GBS geodatabase. Click Save and then OK.

18. Click Yes to add it to the map when the notice comes up. Open the BuildingCount attribute table and scroll to the right until you see RES1SingleFamilyDwelling. Right click on the column heading and select Field Calculator. Click Yes when the warning message comes up. Make RES1SingleFamilyDwelling = [Cnt_CensusBlock]. Then click OK.

19. Use the Select by Attribute tool to select all the RES1SingleFamilyDwelling values that are Null: [RES1SingleFamilyDwelling] IS NULL. Then use the Field Calculator to make those null values zeroes. Click OK.

20. Remove the Census Blocks with Null values for the rest of the fields. Go the Editor tool bar and select Editor and Start Editing. Click Continue when the warning comes up. Use the Select

by Attribute tool to select all the AGR1Agriculture values that are Null: [AGR1Agriculture] IS NULL. Four records should be selected. Press the Delete key to delete the four records. Click Editor and then Stop Editing.

21. Create three additional, similar layers for building area, building exposure, and building content exposure. Use Add Data to add the following tables from the GBS geodatabase: Exposure by Block, Exposure Content by Block, and Building sqft by Block. Remove the BuildingCounty layer.

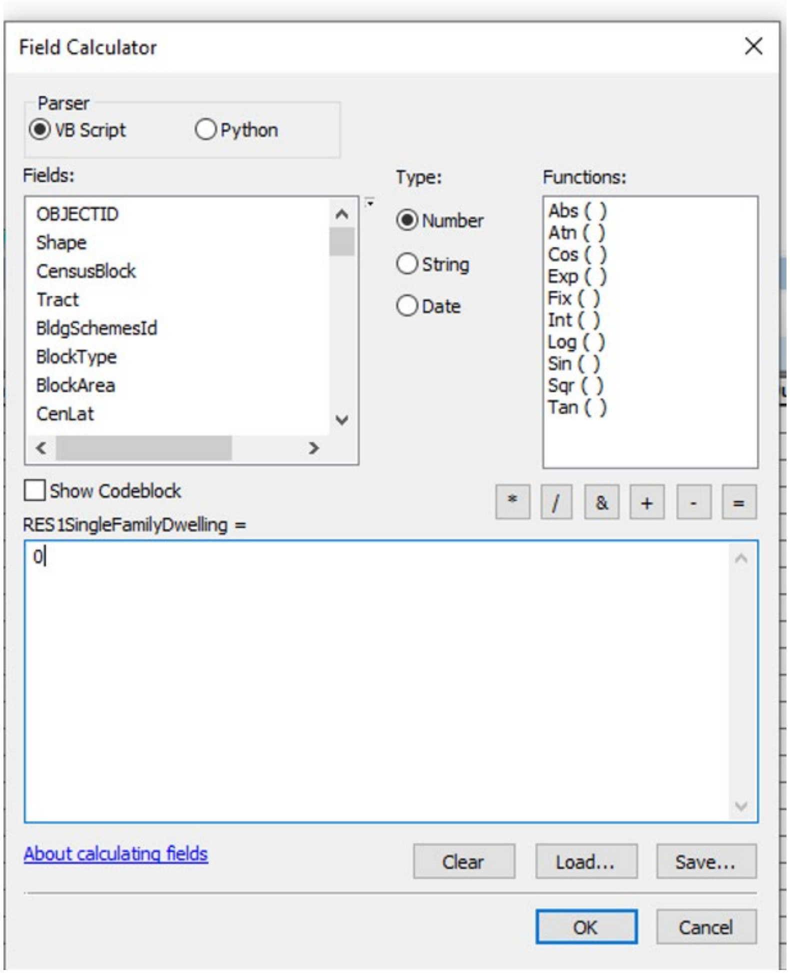
22. Right click on TIGER_Blocks and select Joins and Relates, then Remove Joins, and remove Building Counts by Blocks. Then right click again and select Joins and Relates, then Join. Join attributes from a table, CensusBlock, Building sqft by Block, and CensusBlock. Keep all records. Then click OK. Click Yes when the warning comes up.

23. Right click on TIGER_blocks and export the data as the feature class BuildingArea in the GBS geodatabase. Click Save and then OK. Click Yes to add it to the map when the notice comes up.

24. Open the BuildingArea attribute table and scroll to the right until you see RES1SingleFamilyDwelling. Right click on the column heading and select Field Calculator. Click Yes when the warning message comes up. Make RES1SingleFamilyDwelling = [Sum_Area]/1000. Then click OK.

NOTE: Make sure you divide the square footage by 1000 because Hazus only accepts thousands of square feet and not square feet. This should be done for the exposure and content exposure too.

25. Use the Select by Attribute tool to select all the RES1SingleFamilyDwelling values that are Null: [RES1SingleFamilyDwelling] IS NULL. Then use the Field Calculator to make those null values zeroes. Click OK.

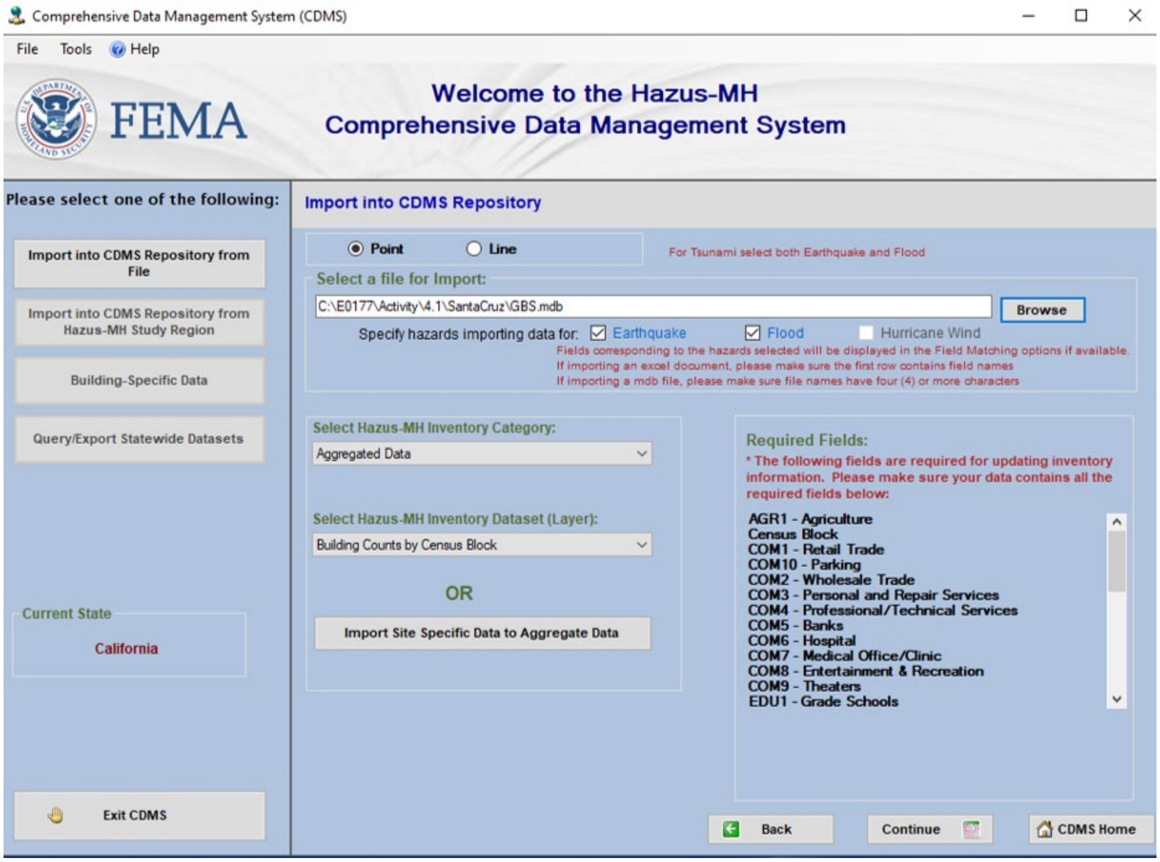


26. Remove the Census Blocks with Null values for the rest of the fields. Go the Editor tool bar and select Editor and Start Editing. Click Continue when the warning comes up. Use the Select by Attribute tool to select all the AGR1Agriculture values that are Null: [AGR1Agriculture] IS NULL. Four records should be selected. Press the Delete key to delete the four records. Click Editor and then Stop Editing. Remove BuildingArea from the map. The files are now ready to be imported into CDMS.

27. Try to do the next two files by yourself: StructureExposure and ContentExposure. Make sure you divide the RES1_SUM values by 1000 since Hazus requires thousands of dollars as an input.

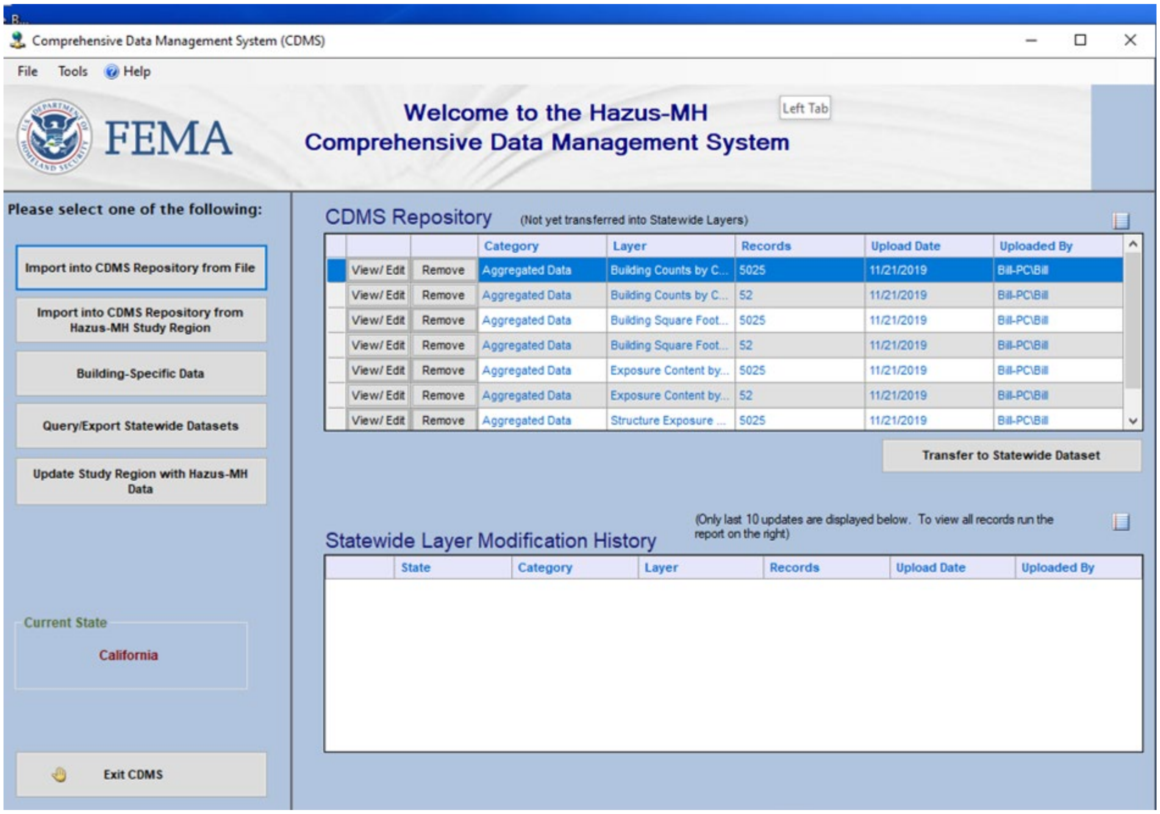
28. Once the four files are ready, close ArcMap and open CDMS. Ensure that the California Statewide Dataset is the current state.

29. Select Import into CDMS Repository from File on the left side of CDMS. Click Browse and find the GBS.mdb file. Under Select Hazus-MH Inventory Category: select Aggregated Data, then under Select Hazus-MH Inventory Dataset (Layer): select Building Counts by Census Block.



30. Select Continue. Under Select Import Table: BuildingCounty will be selected. Click Continue. All the fields should be matched up automatically. Now select Continue. A message comes up asking whether you want to roll the data up to the tract level. Select Yes. Then click OK.

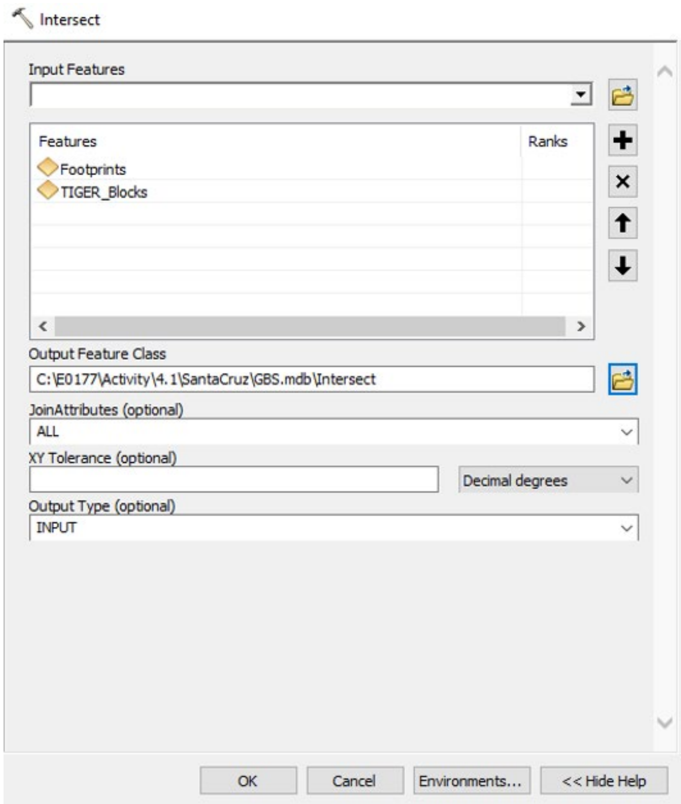
31. Two statewide layers are ready to be transferred to the state database. Now do the same process for the other three files: BuildingArea, StructureExposure, and ContentExposure. When you're done with the four files, click Transfer to Statewide Dataset and select Yes when the warning message comes up. Click OK once the successful message comes up. You'll need to do this for all eight datasets.



32. Now, update the dasymetric data. Open ArcMap and add the building footprint layer which his found here: C:\E0177\Activity\4.1\SantaCruz\BuildingFootprints.

33. Run a Select by Attributes on the building footprints and select the footprints which have an area of 250 or greater. Export this query as footprints to the GBS.mdb personal geodatabase created earlier.

34. Remove the building footprint layer. Add the TIGER_Blocks layer to the map. Open ArcToolbox, select Analysis Tools, Overlay, and Intersect. For Input Features, select TIGER_Blocks and Footprints. For the Output Feature Class, browse here: C:\E0177\Activity\4.1\SantaCruz\GBS.mdb\Intersect.



35. Open ArcCatalog, right click on Connection.sde for the California State data. Select New and then Feature Class. Name the new feature class: HzCensusBlockNew. Then click Next. For the coordinate system, select GCS_WGS_1984, then Next. For the fields, select Import and browse to the TIGER_Blocks feature class. Then click Finish.

36. Right click on CA.dbo.HZCENSUSBLOCKNew, then select Load Data. Click Next, browse to the Intersect feature class, then Add, and then Next. Make sure all the matching source fields are populated and then click Next. Next again and Finish.

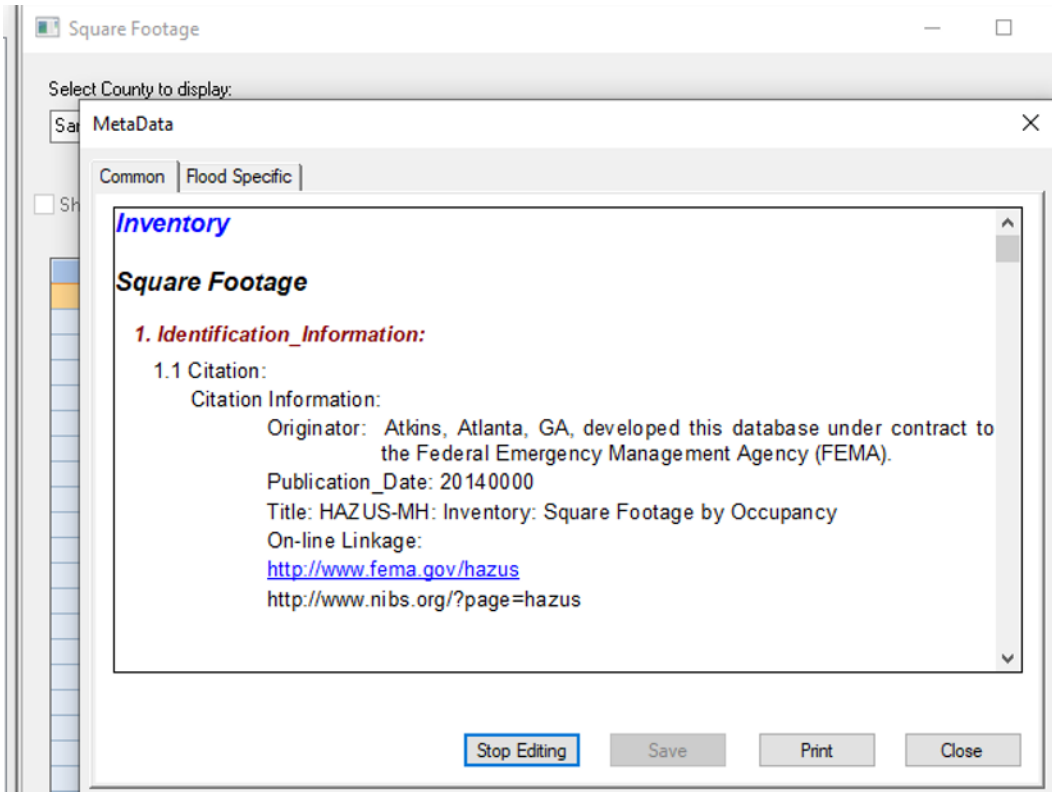
37. Delete CA.dbo.hzCensusBlock and rename CA.dbo.HZCENSUSBLOCKNew to CA.dbo.HZCENSUSBLOCK. The dasymetric data has now been replaced by building footprints.

38. Now create a flood and earthquake study region for Santa Cruz, California and call it SantaCruz_FL_EQ. After Hazus aggregates the region, open the flood hazard. Select Inventory and then General Building Stock and check the square footage, building count, and exposure values with the geodatabases.

Task 4: Document Updated Inventory

1. Document the edits you made. For general building stock edits, browse to the GBS table, right click in the data, and select Meta Data. Click Start Editing at the bottom. Now delete the originator information and add yourself, update the abstract to include a description of where you got the data (source) by consulting the Santa Cruz GIS website, then add information on what

you did to the data. How did you calculate cost, etc. When you're done, select Stop Editing. If you're more comfortable editing this information in Word, go to the study region folder and open this document: C:\HazusData\Regions\SantaCruz_FL_EQ\ hzSqFootageOccupB_md.rtf.



The GBS has been updated.

Visual 33: Lesson 4: Review

1. What are some of the limitations in the GBS inventory? Site level inventory?
2. What datum is used by Hazus?
3. Identify four sources of inventory data.
4. Where can a user find the Hazus SQL database login information?

Visual 34: Questions?

Lesson 5: Advanced Hurricane

Visual 1: Lesson 5: Advanced Hurricane

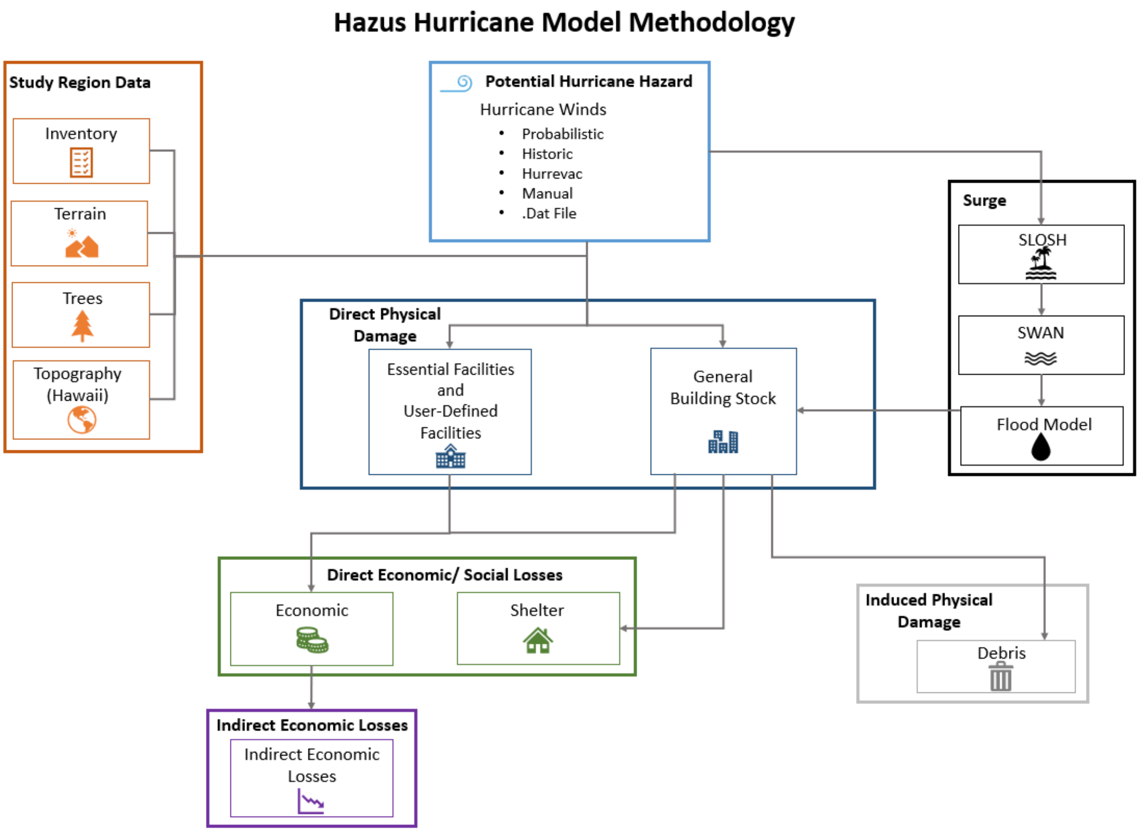
Visual 2: Lesson 5: Goal and Objectives

Goal: Better understand how advanced applications can help mitigate hurricane model limitations and generate more robust and accurate results.

After completing this lesson you will be able to:

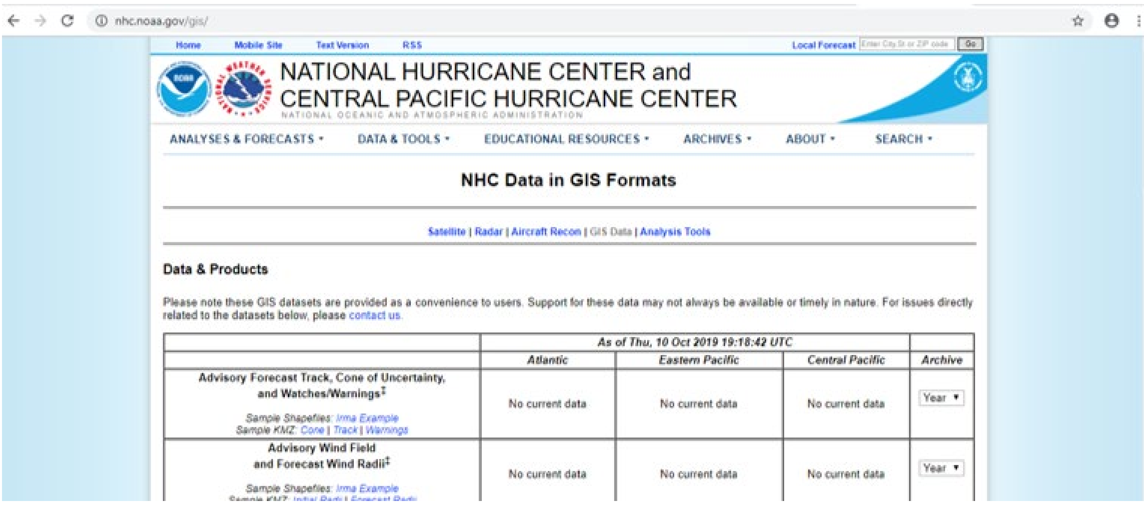
- List sources of hurricane data
- Identify the steps to model surge
- Identify four advanced applications for the hurricane hazard model
- Conduct an advanced application if applicable to your community

Visual 3: Hurricane Review



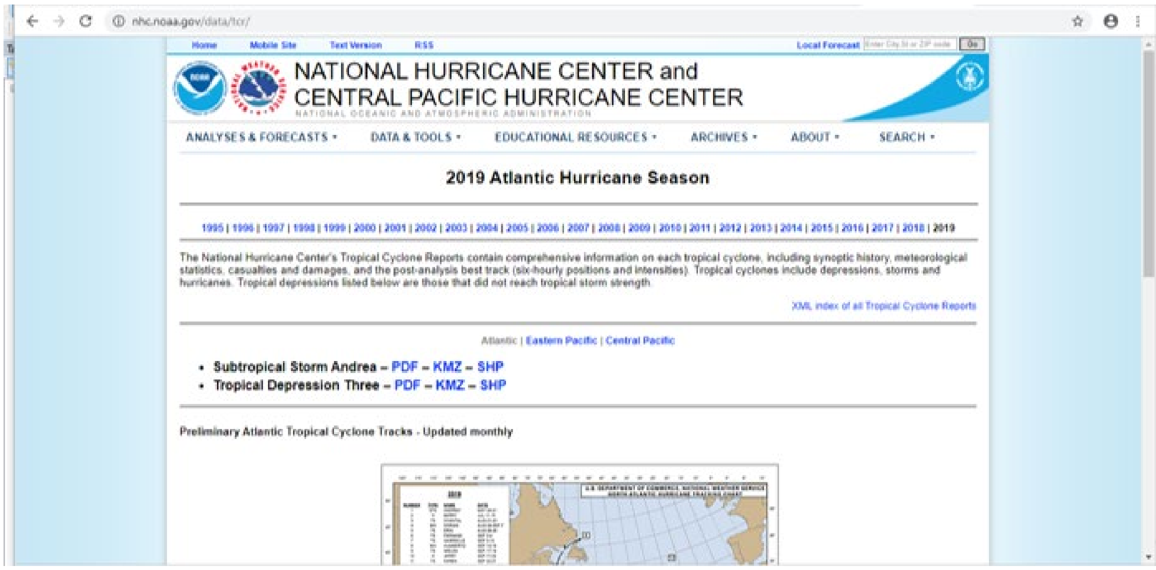
Visual 4: Data Sources

- NOAA National Hurricane Center GIS data
- Advisory track, best track, storm surge
- National Hurricane Center GIS Data (https://www.nhc.noaa.gov/gis/)



Visual 5: Data Sources

- National Hurricane Center - final best tracks
- National Hurricane Center Tropical Cyclone Reports (https://www.nhc.noaa.gov/data/tcr/)

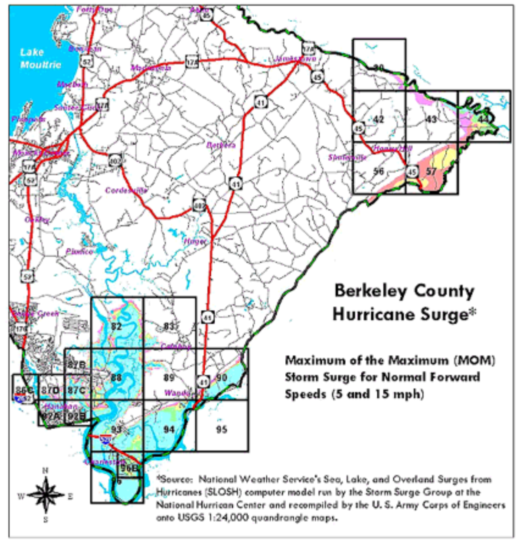


Visual 6: Data Sources

- NOAA surge products
- National Hurricane Center Storm Surge Products Link (https://www.nhc.noaa.gov/surge/products.php)
- Requires username and password

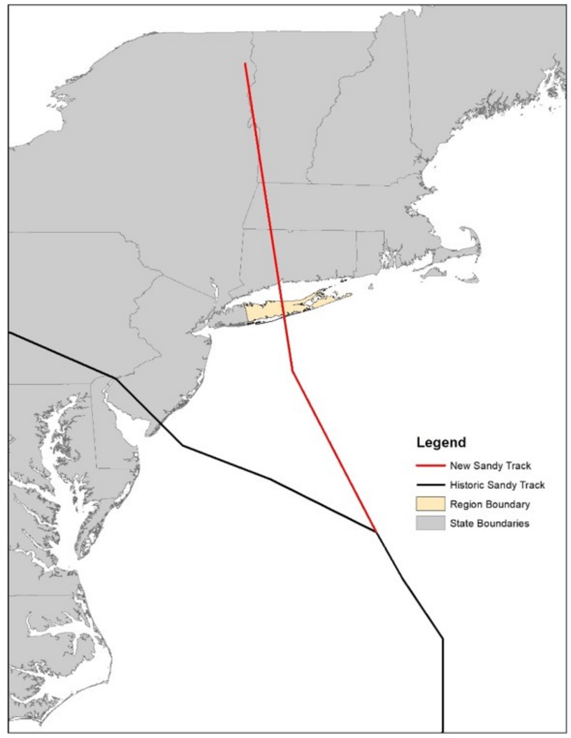
Visual 7: Data Sources

- Local – Hazard Mitigation Plan, Emergency Management
- State – State Emergency Management Agency, State GIS portals
- Universities



Visual 8: Adv. App.: Modifying Scenario Data

- What if the hurricane had hit our community instead of turning west?
- Application involves taking a historical hurricane and altering the track, so it impacts a specific community



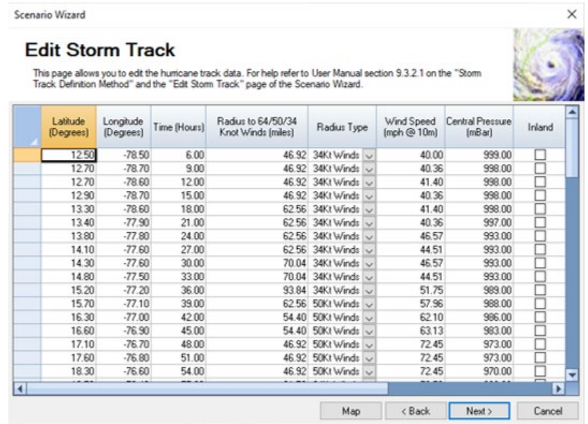
Student Manual

Adv. App.: Modifying Scenario Data

The map shows the Hurricane Sandy track which was moving northwest and then started moving more westward. The red track show what may have happened if Hurricane Sandy had maintained its course to Long Island.

Visual 9: Adv. App.: Modifying Scenario Data

- Import Hurrevac storm advisory
- Click on historical event and then click Edit
- Change the latitude and longitude after mapping
- Create a custom Hurrevac .stm file as other option



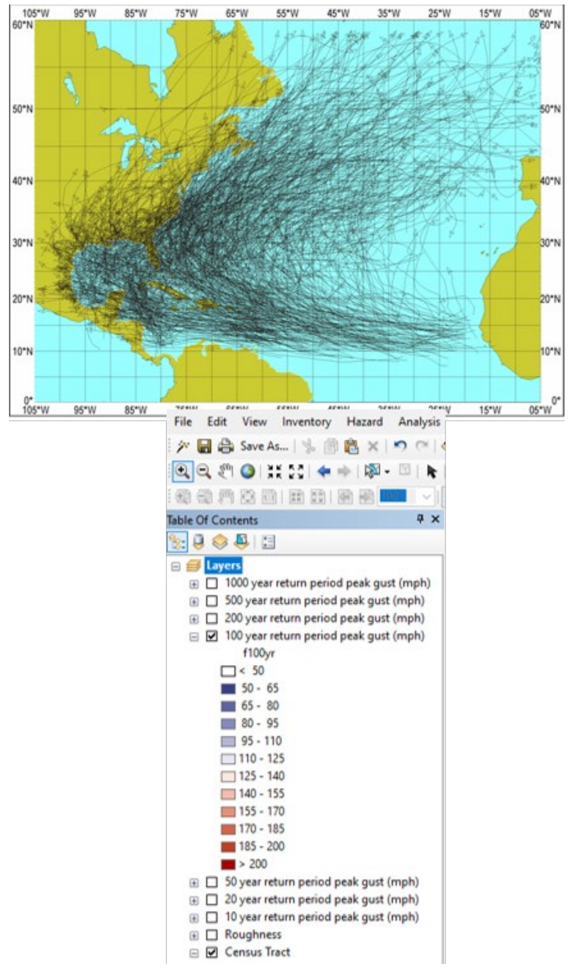
Visual 10: Hurricane Probabilistic Analysis

Probabilistic wind speed database:

- 100,000 years of simulated storms

Table of contents probabilistic wind speeds:

- ASCE 7 wind speeds



Visual 11: Converted Wind Speeds

Saffir Simpson Scale	1 Min Mean (mph)	3 Sec Gust (mph)	Min Central Pressure (mb)
1	74-95	90-116	980 and up
2	96-110	117-134	965-979
3	111-129	135-159	945-964
4	130-156	160-189	920-944
5	157+	189+	920 and below

Visual 12: Adv. App.: Creating a .Dat Scenario File

- I like the way the earthquake model handles the probabilistic analysis, can the hurricane model be used the same way?
- Application will provide guidance on creating a .Dat file with the probabilistic windspeeds for the study region
  - Allows for custom or user defined wind speeds for each census tract.

Visual 13: Adv. App.: Creating a .Dat Scenario File

- Use .Dat template provided
- Convert 3-second gust into a 1-minute mean using the table
- Identify the centroid of the Census Tract
  - Use the HZTract centroid

Exposure at +10m Class	Exposure at +10m Description	Reference Period To (s)	Gust Factor (Gr, To) for Gust Duration 3 (s)	Gust Factor (Gr, To) for Gust Duration 60 (s)	Gust Factor (Gr, To) for Gust Duration 120 (s)	Gust Factor (Gr, To) for Gust Duration 180 (s)	Gust Factor (Gr, To) for Gust Duration 600 (s)
In-Land	Roughly open terrain	3600	1.75	1.28	1.19	1.15	1.08
In-Land	Roughly open terrain	600	1.66	1.21	1.12	1.09	1.00
In-Land	Roughly open terrain	180	1.58	1.15	1.07	1.00	
In-Land	Roughly open terrain	120	1.55	1.13	1.00		
In-Land	Roughly open terrain	60	1.49	1.00			

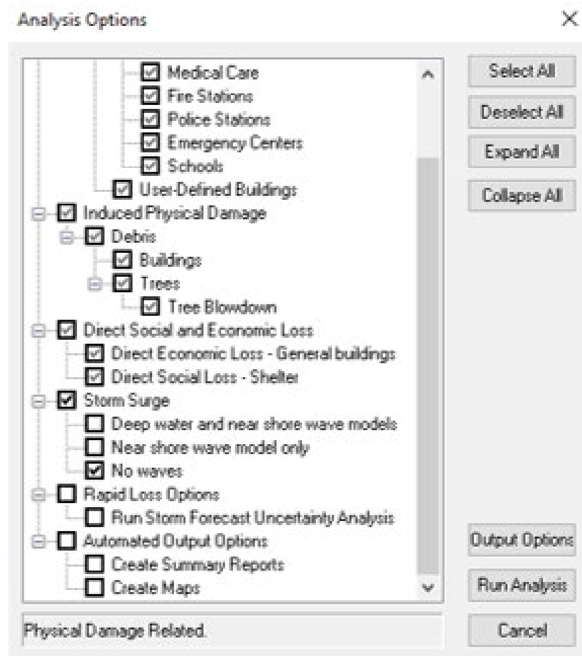
Visual 14: Adv. App.: Creating a .Dat Scenario File

- Open the .Dat template in Excel
- Open the Census Tract .dbf file in Excel
- Edit the .Dat template using the .dbf file data
- Save as a text file and rename .Dat

ident	elon	nlat	ux	vy	w (m/s)
48007950200	-97.0258	28.0335	60.09902	0.00000	60.09902
48007950100	-96.9358	28.1951	59.80851	0.00000	59.80851
48007950300	-97.0703	28.0420	58.96188	0.00000	58.96188
48007950500	-97.1250	27.9898	58.75390	0.00000	58.75390
48391950400	-97.1421	28.2955	58.69426	0.00000	58.69426
48355005102	-97.0891	27.8208	58.68427	0.00000	58.68427
48007950400	-97.0709	28.0171	58.39342	0.00000	58.39342
48409010201	-97.1569	27.8942	55.69689	0.00000	55.69689
48409010202	-97.1677	27.9147	55.56515	0.00000	55.56515
48391950200	-97.2237	28.4396	54.39036	0.00000	54.39036
48409010301	-97.2039	27.9009	53.91611	0.00000	53.91611
48355006200	-97.1733	27.7542	50.36707	0.00000	50.36707
48409010302	-97.2032	27.8496	50.08435	0.00000	50.08435
48409010500	-97.2901	27.9349	49.28694	0.00000	49.28694
48469001300	-97.0552	28.6151	48.07534	0.00000	48.07534
48409010700	-97.3523	27.9954	47.20178	0.00000	47.20178
48409010603	-97.3029	27.8853	44.47748	0.00000	44.47748
48057000500	-96.6474	28.3635	43.95716	0.00000	43.95716
48409010602	-97.3339	27.9003	43.81188	0.00000	43.81188
48469001700	-96.9185	28.6840	43.67693	0.00000	43.67693
48409010604	-97.3350	27.8664	43.36499	0.00000	43.36499
48409010800	-97.3847	27.9843	43.03087	0.00000	43.03087
48175960200	-97.4669	28.6077	42.29156	0.00000	42.29156
48175960100	-97.3189	28.7723	42.24495	0.00000	42.24495
48355003101	-97.2707	27.6261	42.14618	0.00000	42.14618
48469000100	-97.0048	28.7966	41.20545	0.00000	41.20545
48469000301	-96.9983	28.7729	41.20545	0.00000	41.20545
48409010601	-97.3536	27.8855	41.11627	0.00000	41.11627
48355003001	-97.2508	27.6592	40.89159	0.00000	40.89159
48469000202	-96.9730	28.7991	40.81531	0.00000	40.81531
48469000302	-96.9789	28.7806	40.81531	0.00000	40.81531
48355002900	-97.2725	27.6896	40.32490	0.00000	40.32490
48469000400	-97.0140	28.8170	40.22652	0.00000	40.22652

Visual 15: Surge Modelling

- User-defined surge grids can support all wind scenarios except probabilistic
- Hazus-generated surge (using SLOSH and SWAN) support the following wind scenarios: Historic, User-Defined, Hurrevac Import, and Hazus Import
- Hazus-generated surge analysis options:
  - Surge with coupled deep water and near shore waves (SLOSH + SWAN)
  - Surge with coupled near shore waves (SLOSH + SWAN)
  - Surge only (SLOSH only)



Visual 16: Adv. App. – Adding Climate Change

- How can climate change be added to the analysis?
  - Sea level rise and erosion – described in the flood hazard lesson
  - Slowdown of hurricane translation speed (16% Atlantic, 21% Pacific) – (Nature, 2018)
  - Increase in magnitude 3-5% increase in windspeed per degree of Celsius increase of tropical sea surface temperatures (IPCC AR5)

Student Manual

Adv. App. – Adding Climate Change

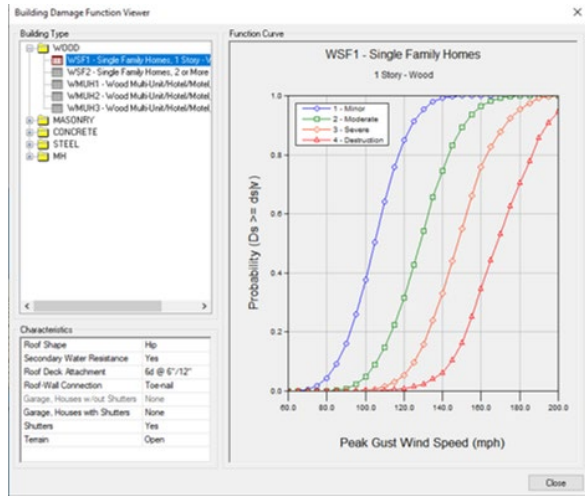
For additional information NOAA GFDL (https://www.gfdl.noaa.gov/global-warming-and-hurricanes/)

Visual 17: Adv. App. – Adding Climate Change

- Open historical or other deterministic scenario the community has been using to assess risk
- If community does not have deterministic event, create one using the process in the first advanced application
- Reduce translation speed by 16% for CONUS or 21% for Hawaii
- Increase windspeed by 5% for each record

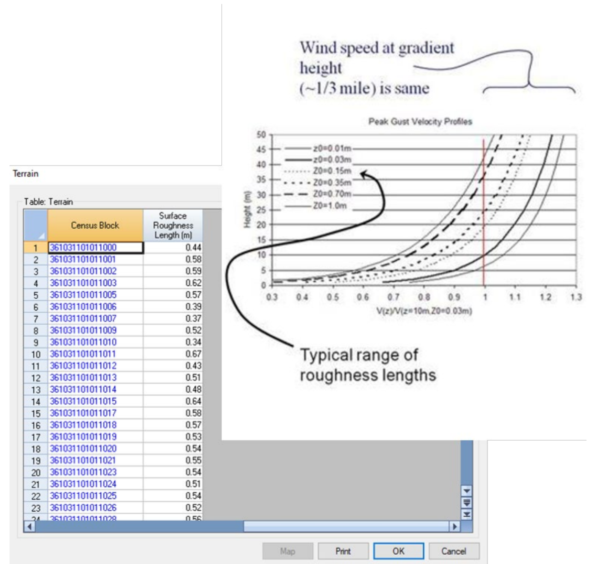
Visual 18: Damage, Loss, Loss of Use and Debris Functions

- Function viewer is provided
- Functions can not be edited like the other models
- Values in the characteristics box can be changed to shift curves



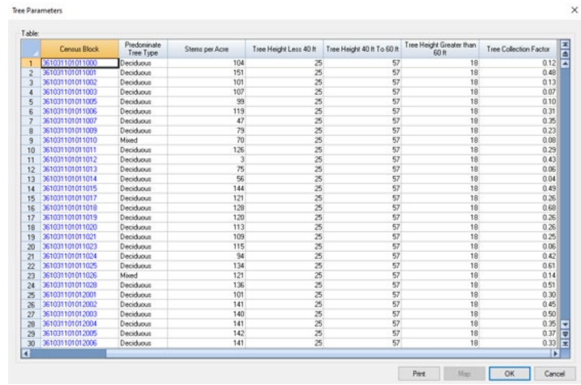
Visual 19: Hurricane Hazard Parameters

- Roughness parameter
- Higher roughness creates more drag at surface, which yields lower wind speeds at surface
- Wind increases with height



Visual 20: Hurricane Hazard Parameters

- Tree database
- Includes stems per acre, tree type, height class and collection factor
- Block or tract level data



	Census Block	Predominate Tree Type	Stems per Acre	Tree Height Less 40 ft	Tree Height 40 ft To 60 ft	Tree Height Greater than 60 ft	Tree Collection Factor
1	361031101011000	Deciduous	104	25	57	18	0.12
2	361031101011001	Deciduous	151	25	57	18	0.48
3	361031101011002	Deciduous	101	25	57	18	0.13
4	361031101011003	Deciduous	107	25	57	18	0.07
5	361031101011005	Deciduous	99	25	57	18	0.10
6	361031101011006	Deciduous	119	25	57	18	0.31
7	361031101011007	Deciduous	47	25	57	18	0.35
8	361031101011009	Deciduous	79	25	57	18	0.23
9	361031101011010	Mixed	70	25	57	18	0.08
10	361031101011011	Deciduous	126	25	57	18	0.29
11	361031101011012	Deciduous	3	25	57	18	0.43
12	361031101011013	Deciduous	75	25	57	18	0.06
13	361031101011014	Deciduous	56	25	57	18	0.04
14	361031101011015	Deciduous	144	25	57	18	0.49
15	361031101011017	Deciduous	121	25	57	18	0.26
16	361031101011018	Deciduous	128	25	57	18	0.68
17	361031101011019	Deciduous	120	25	57	18	0.26
18	361031101011020	Deciduous	113	25	57	18	0.26
19	361031101011021	Deciduous	109	25	57	18	0.25
20	361031101011023	Deciduous	115	25	57	18	0.06
21	361031101011024	Deciduous	94	25	57	18	0.42
22	361031101011025	Deciduous	134	25	57	18	0.61
23	361031101011026	Mixed	121	25	57	18	0.14
24	361031101011028	Deciduous	136	25	57	18	0.51
25	361031101012001	Deciduous	101	25	57	18	0.30
26	361031101012002	Deciduous	141	25	57	18	0.45
27	361031101012003	Deciduous	140	25	57	18	0.50
28	361031101012004	Deciduous	141	25	57	18	0.35
29	361031101012005	Deciduous	142	25	57	18	0.37
30	361031101012006	Deciduous	141	25	57	18	0.33

Visual 21: Adv. App. – Updating Terrain Data

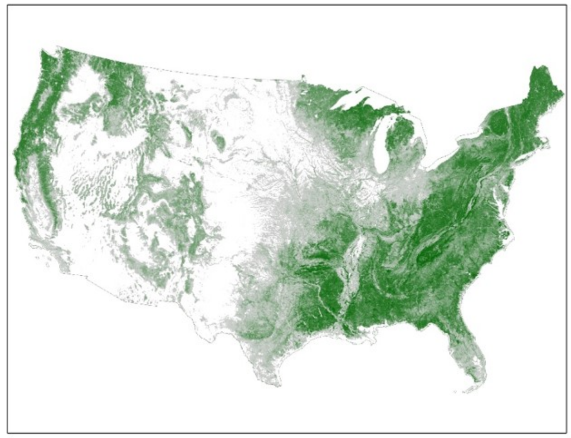
- Download the NLCD or identify areas in the community that have had a land use change
- NLCD (https://www.mrlc.gov/data)
- Clip the data based on the study region
- Convert the land use code into a terrain value
- Calculate the average value for the block

Table 3.5. NLCD Land Cover Classification vs Surface Roughness Length

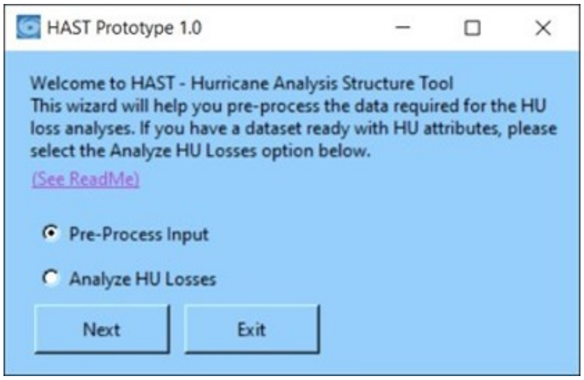
MRLC-NLCD Land Cover Classification and Numerical Coding	Land Surface Roughness Length, z_0 (m)					Number of Sub-Regions Used
	Used	Avg.	COV	Max.	Min.	
Water						
11 Open Water	**0.010**	0.013	0.612	0.030	0.010	6
12 Perennial Ice/Snow	**0.012**					0
Developed						
21 Low Intensity Residential	**0.350**	0.307	0.496	0.600	0.010	51
22 High Intensity Residential	**0.600**	0.401	0.498	0.800	0.080	39
23 Commercial/Industrial/Transportation	**0.350**	0.265	0.605	0.600	0.030	28
Barren						
31 Bare Rock/Sand/Clay	**0.200**	0.300				1
32 Quarries/Strip Mines/Gravel Pits	**0.400**					0
33 Transitional	**0.400**	0.400	0.661	0.600	0.100	3
Forested Upland						
41 Deciduous Forest	**0.600**					0
42 Evergreen Forest	**0.600**	0.500				1
43 Mixed Forest	**0.600**					0
Shrubland						
51 Shrubland	**0.060**	0.040				1
Non-natural Woody						
61 Orchards/Vineyards/Other	**0.210**	0.213	0.777	0.400	0.050	4
Herbaceous Upland						
71 Grasslands/Herbaceous	**0.150**	0.193	0.662	0.300	0.050	4
Herbaceous Planted/Cultivated						
81 Pasture/Hay	**0.150**	0.160	1.301	0.400	0.030	3
82 Row Crops	**0.100**	0.100	0.913	0.300	0.030	8
83 Small Grains	**0.030**					0
84 Fallow	**0.030**					0
85 Urban/Recreational Grasses	**0.150**	0.155	0.514	0.250	0.030	6
Wetlands						
91 Woody Wetlands	**0.300**	0.545	0.594	1.100	0.300	10
92 Emergent Herbaceous Wetlands	**0.030**	0.188	0.959	0.600	0.050	10

Visual 22: Adv. App. – Updating Terrain Data

- Use NLCD data, tree canopy data, and Forest Inventory Analysis (FIA) data or local data
- Clip the data based on the study region
- Determine density and size using forest canopy and FIA data
- Determine type using NLCD data

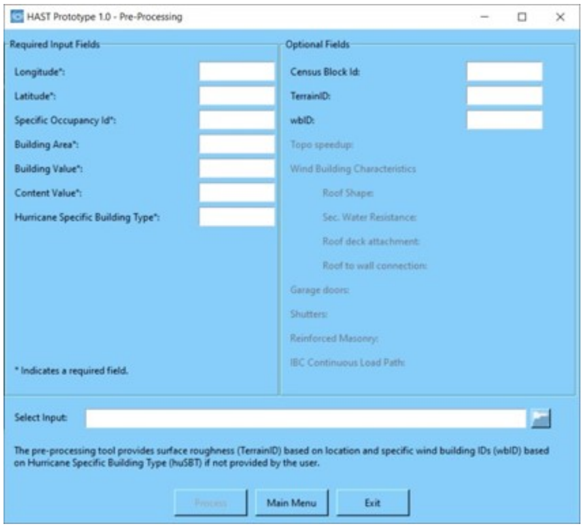


Visual 23: Hazus Hurricane Assessment Structure Tool (HAST)



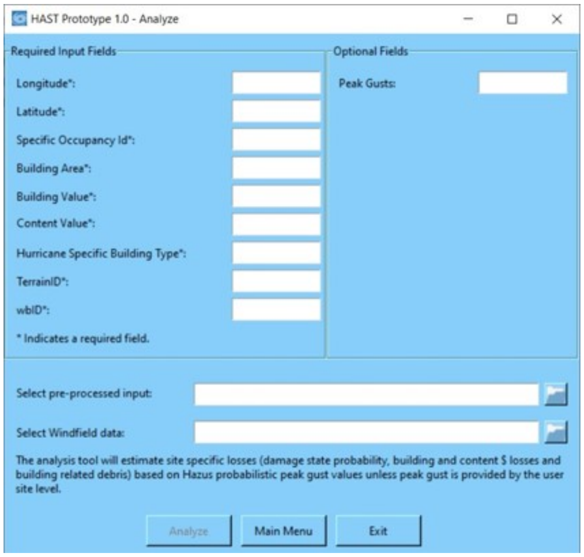
- Open-source Hazus tool for hurricane analyses
- Two parts:
  - Pre-processing tool
  - Analysis tool
- Provides probabilistic analysis of site-specific data

Visual 24: HAST Pre-Processing Tool



- Prepares the inventory data for the Analysis Tool
- Assigns terrain and wind building attributes
- Works at the census block level

Visual 25: HAST Analysis Tool



- Probabilistic analysis of site-specific return data using:
  - Return period
  - Wind speeds
  - Already-assigned peak gusts

Visual 26: Exercise 5.1: Advanced Hurricane Applications

- Goal: Use the Hazus hurricane model to complete one of the advanced applications
- Time: 225 minutes (for all hazard advanced applications)

(The exercise will be completed after Lesson 8)

Student Manual

Exercise 5.1 Advanced Hurricane Applications

Goal:

- Complete an Advanced Hurricane Application
- Share the results of the Advanced Hurricane Application(s)

Time: 225 minutes

Exercise Steps:

1. Refer to Activities Document “5.1_Exercise_AdvancedHurricane".
2. Listen to instructor’s directions.
3. Ask questions if clarification is needed.
4. Work individually on the goal.
5. Ask questions to the instructor if needed.
6. Complete the assigned goal.
7. Be prepared to share your answers/results.
8. Ask any final questions.

Visual 27: Exercise 5.1: Tasks

- Pre-Task: Select Application
- Task 1: Implement Advanced Application
- Task 2: Share results
- Repeat For Additional Applications

Student Manual

Exercise 5.1: Tasks

Refer to Activities Document “5.1_Exercise_AdvancedEarthquake”.

Exercise 5.1: Advanced Hurricane Applications

Type: Activity

Time: You will have 225 minutes for all selected applications and hazard applications. You may select any of the four hazards and any of the applications for each hazard in the 225 minutes.

Goals:

- Identify an appropriate advanced hazard application
- Implement that advanced hazard application
- Discuss the results during the capstone presentation

Background: This activity will help you identify and implement an advanced hurricane application. If hurricanes do not impact your community, you do not need to do an advanced hurricane application just choose a different hazard. In the first task, the four advanced applications will be provided to you and you'll select the one (or more) that would be most beneficial to your community. If you finish the first application and still have time, feel free to work through another application. Approximate times have been provided for each application so just be aware of the time allotted for each activity. Data has been provided for Virginia Beach, Virginia but you may use your own study region for the capstone presentation.

Before you Begin: Identify an Appropriate Advanced Hazard Application

There are four advanced hurricane applications to select from in this activity. Select the one that is most beneficial to your community:

Application 1: But what if the hurricane had hit my community?

Many communities wonder what would happen if the hurricane coming up the coast were to change paths and hit them. In this application, you'll be taking a historic event and changing the direction and parameters of the hurricane track, so it hits your community. This is a common question communities ask and easy for the public to understand.

- Data Required: None
- Time Required: 35-45 Minutes
- Difficulty: Easy - Moderate

Application 2: Can I run a probabilistic analysis similar to the way the earthquake model works?

The probabilistic analysis in the hurricane and earthquake models differ in their approach. The hurricane probabilistic analysis uses a database of modeled events and selects the return period based on losses. The earthquake model uses probabilistic ground motion parameters from the USGS. There are pros and cons to each methodology. The hurricane model does provide probabilistic windspeeds for each Census Tract from ASCE 7 in the table of contents. In this application, you'll take those tract windspeeds and develop your own .dat scenario file to run. This will give you an output similar to the earthquake model.

- Data Required: None
- Time Required: 30-40 Minutes
- Difficulty: Easy - Moderate

Application 3: How do I add climate change to my analysis?

This application is part 1 of 2. The second part is in Activity 6: Advanced Flood Applications and includes using the surge model. This application will show you how to change your hurricane parameters to better prepare for climate change.

- Data Required: None
- Time Required: 60-90 Minutes
- Difficulty: Moderate

Application 4: How do I update my tree and terrain data?

Hazus users often ask how the tree and terrain data was developed and how can they update it. This application will walk you through updating these two datasets with more up to date national sources.

- Data Required: Land use, land cover, or zoning data
- Time Required: 100-130 Minutes
- Difficulty: Hard

Once you have chosen an Application, navigate to that section and begin the activity.

Application 1: But what If the hurricane had hit my community?

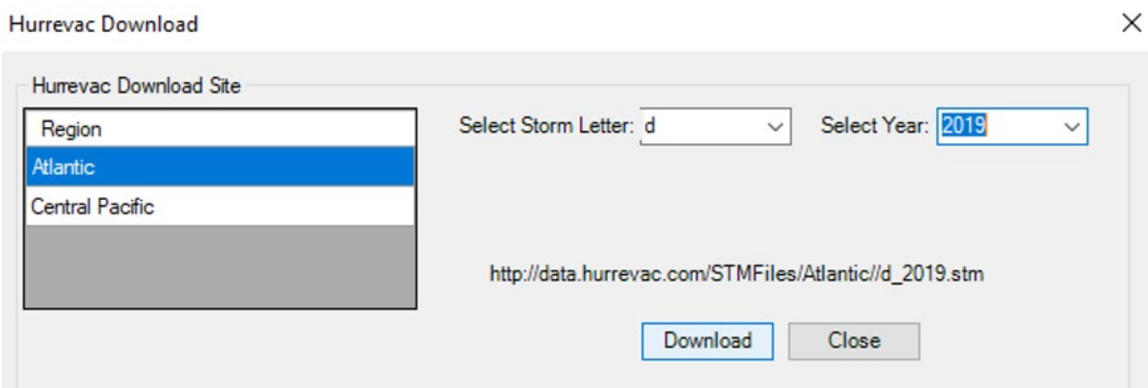
In 2019, Hurricane Dorian traveled up the east coast after impacting the Bahamas, Lesser Antilles, and Puerto Rico. Florida, Georgia, South Carolina, North Carolina, and Virginia all declared a state of emergency and many coastal counties issues mandatory evacuation orders. It's highest 1-minute sustained windspeed was 185 mph with a pressure of 910 mbar. Although Hurricane Dorian did not impact Virginia Beach very much, it could have changed directions and picked up windspeed. In Application 1, you will download the storm track for Hurricane Dorian, alter the track, and run the modified storm. If you are using your own hurricane study region, you may select a different storm to modify.

Task 1: Implement advanced hazard application

1. Create a Virginia Beach, Virginia hurricane study region. Name the study region something you can remember.

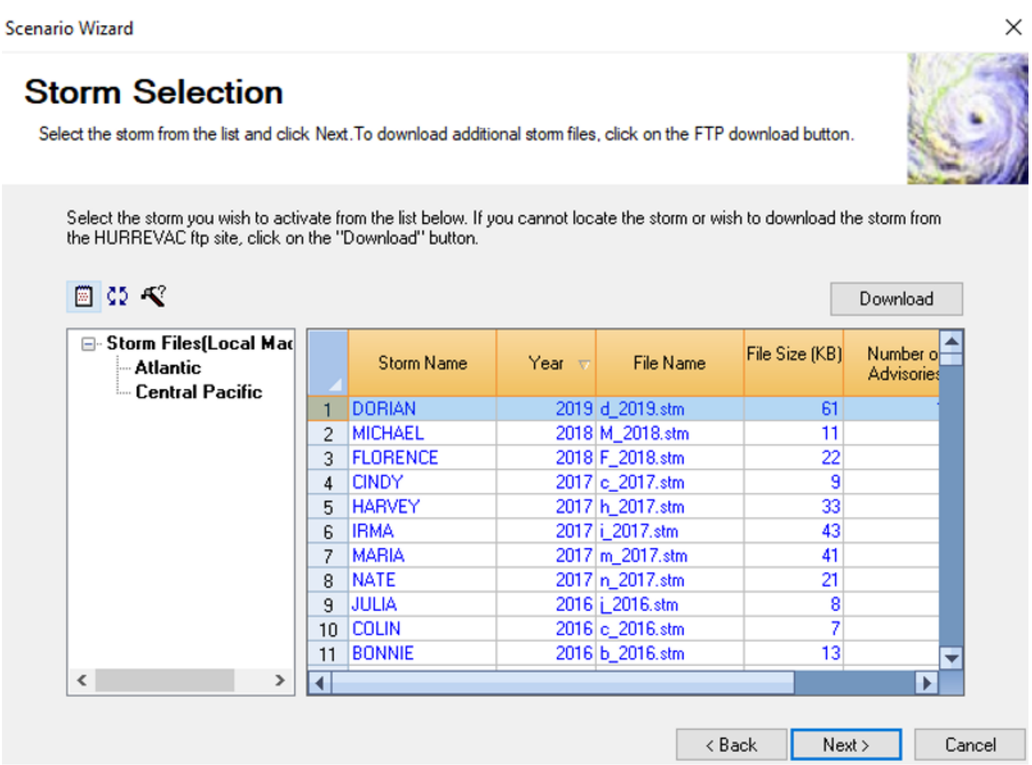
2. Review the existing hurricane data. Go to Hazard -> Scenario -> Next, select and then Next. Select the Import Hurrevac storm advisory option and then click Next. When the Storm Selection menu comes up, click on Atlantic. Sort by year by clicking on the Year column heading. Click on year again so that the 2018 storms (Hurricanes Michael and Florence) are at the top. You'll notice that Hurricane Dorian is missing. Click on the download button on the top.

3. Select Atlantic, then next to Select Storm Letter: select D and for Select Year: select 2019.



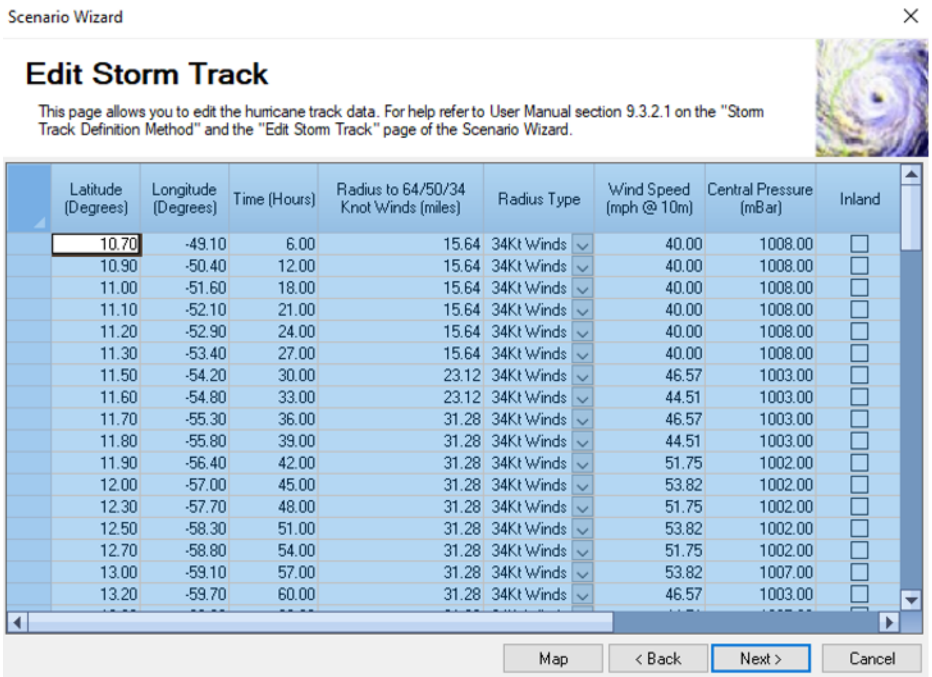
Accessing the Hurrevac Download Site through Hazus

4. Click on the Download button. This will take you back to the Storm Selection menu. Click on the



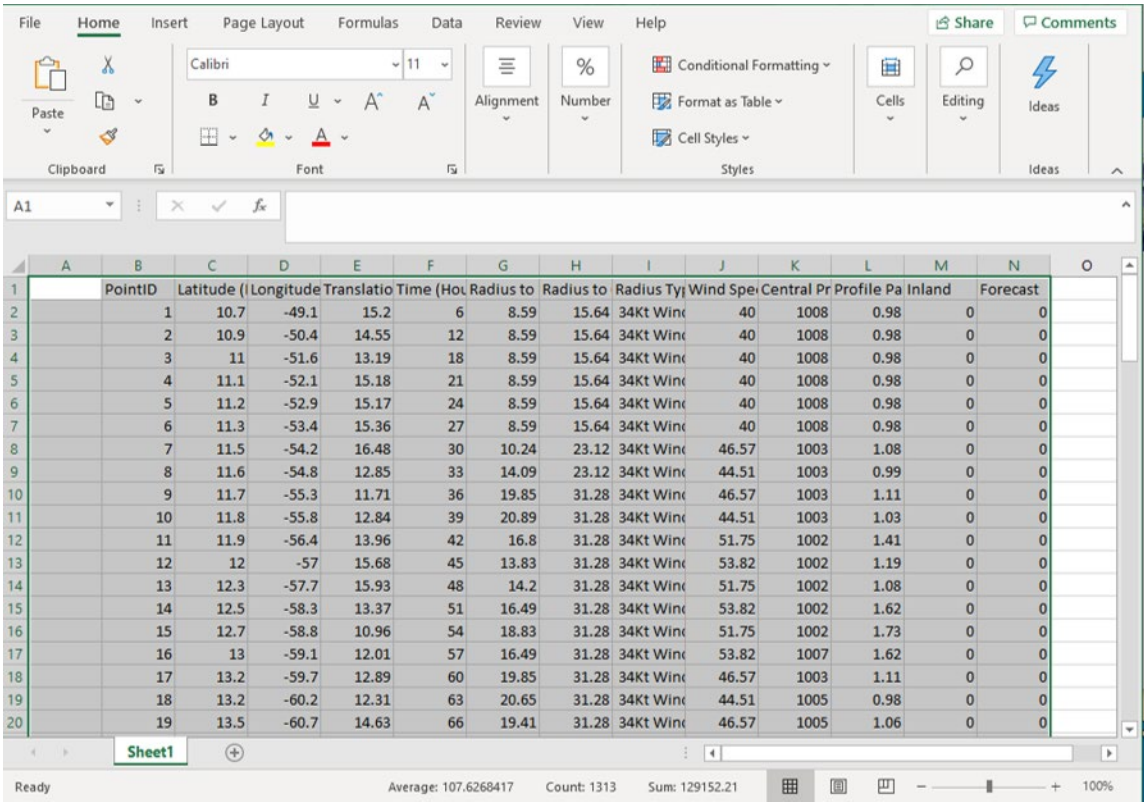
Hurricane Dorian added to Hurrevac list

5. Click on Next. The Edit Storm Track Scenario Wizard menu comes up with hurricane characteristics for a series of points. Left click in the top left square of the table and everything should become highlighted. Press Ctrl+C to copy all the data.



Storm Track table is highlighted after clicking in the top left corner of the table

6. Open an empty Excel spreadsheet. In the top left cell of the spreadsheet (A1), press Ctrl+V to paste the values into the table.



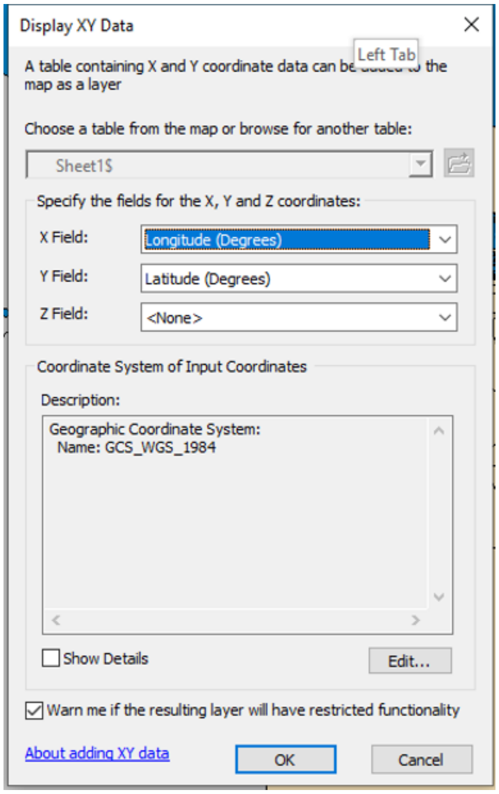
PointID	Latitude (I	Longitude	Translatio	Time (Hou	Radius to	Radius to	Radius Ty	Wind Spe	Central Pr	Profile Pa	Inland	Forecast
1	10.7	-49.1	15.2	6	8.59	15.64	34Kt Win	40	1008	0.98	0	0
2	10.9	-50.4	14.55	12	8.59	15.64	34Kt Win	40	1008	0.98	0	0
3	11	-51.6	13.19	18	8.59	15.64	34Kt Win	40	1008	0.98	0	0
4	11.1	-52.1	15.18	21	8.59	15.64	34Kt Win	40	1008	0.98	0	0
5	11.2	-52.9	15.17	24	8.59	15.64	34Kt Win	40	1008	0.98	0	0
6	11.3	-53.4	15.36	27	8.59	15.64	34Kt Win	40	1008	0.98	0	0
7	11.5	-54.2	16.48	30	10.24	23.12	34Kt Win	46.57	1003	1.08	0	0
8	11.6	-54.8	12.85	33	14.09	23.12	34Kt Win	44.51	1003	0.99	0	0
9	11.7	-55.3	11.71	36	19.85	31.28	34Kt Win	46.57	1003	1.11	0	0
10	11.8	-55.8	12.84	39	20.89	31.28	34Kt Win	44.51	1003	1.03	0	0
11	11.9	-56.4	13.96	42	16.8	31.28	34Kt Win	51.75	1002	1.41	0	0
12	12	-57	15.68	45	13.83	31.28	34Kt Win	53.82	1002	1.19	0	0
13	12.3	-57.7	15.93	48	14.2	31.28	34Kt Win	51.75	1002	1.08	0	0
14	12.5	-58.3	13.37	51	16.49	31.28	34Kt Win	53.82	1002	1.62	0	0
15	12.7	-58.8	10.96	54	18.83	31.28	34Kt Win	51.75	1002	1.73	0	0
16	13	-59.1	12.01	57	16.49	31.28	34Kt Win	53.82	1007	1.62	0	0
17	13.2	-59.7	12.89	60	19.85	31.28	34Kt Win	46.57	1003	1.11	0	0
18	13.2	-60.2	12.31	63	20.65	31.28	34Kt Win	44.51	1005	0.98	0	0
19	13.5	-60.7	14.63	66	19.41	31.28	34Kt Win	46.57	1005	1.06	0	0

Pasting hurricane track values into Excel

7. In Excel, select File, and Save As. Then save the file here: C:\E0177\Activity\5.1\ as Dorian.xlsx. Close Excel and go back to Hazus. Click Cancel in the Edit Storm Track menu. Click Yes when the warning messages comes up.

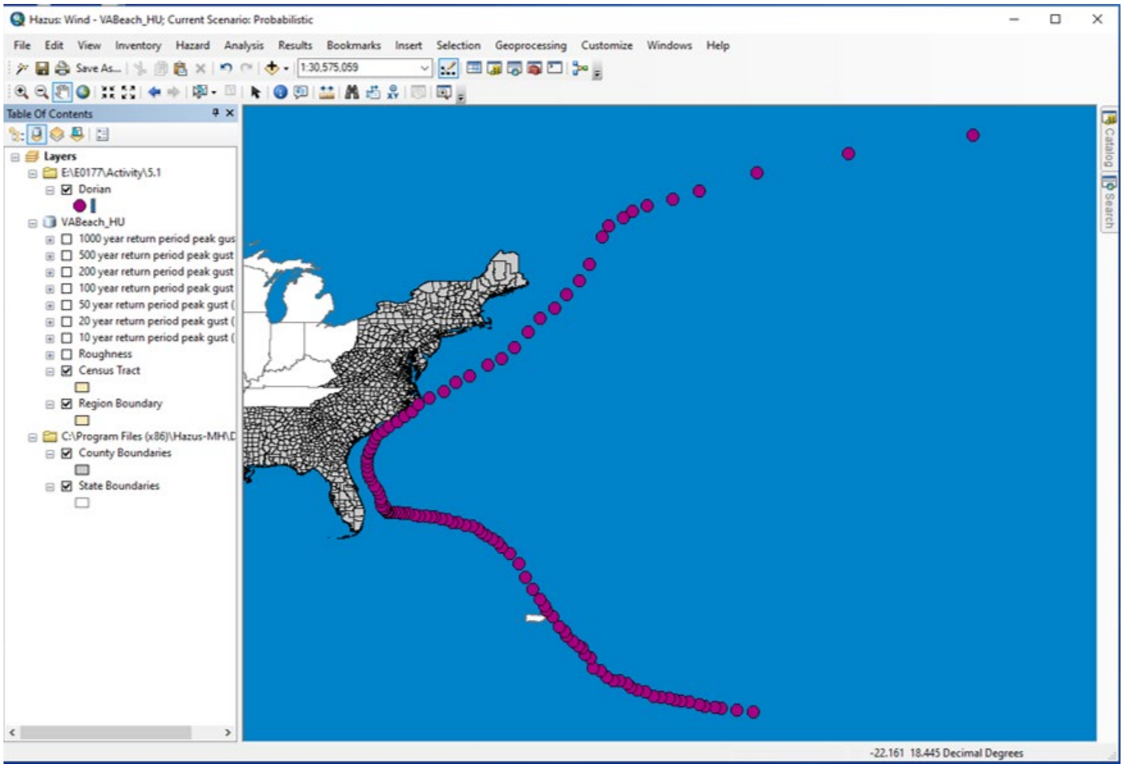
8. Add data and browse to the Excel file you just created: Dorian.xlsx. Click Sheet1$ when it asks to identify the Excel Table. Then click Add.

9. Right click on Sheet1$ and select Display XY Data. Make sure the X Field is designated as Longitude and the Y Field is designated Latitude. Then click OK. Click OK again when the warning message comes up. Close the ArcMap Drawing Errors box.



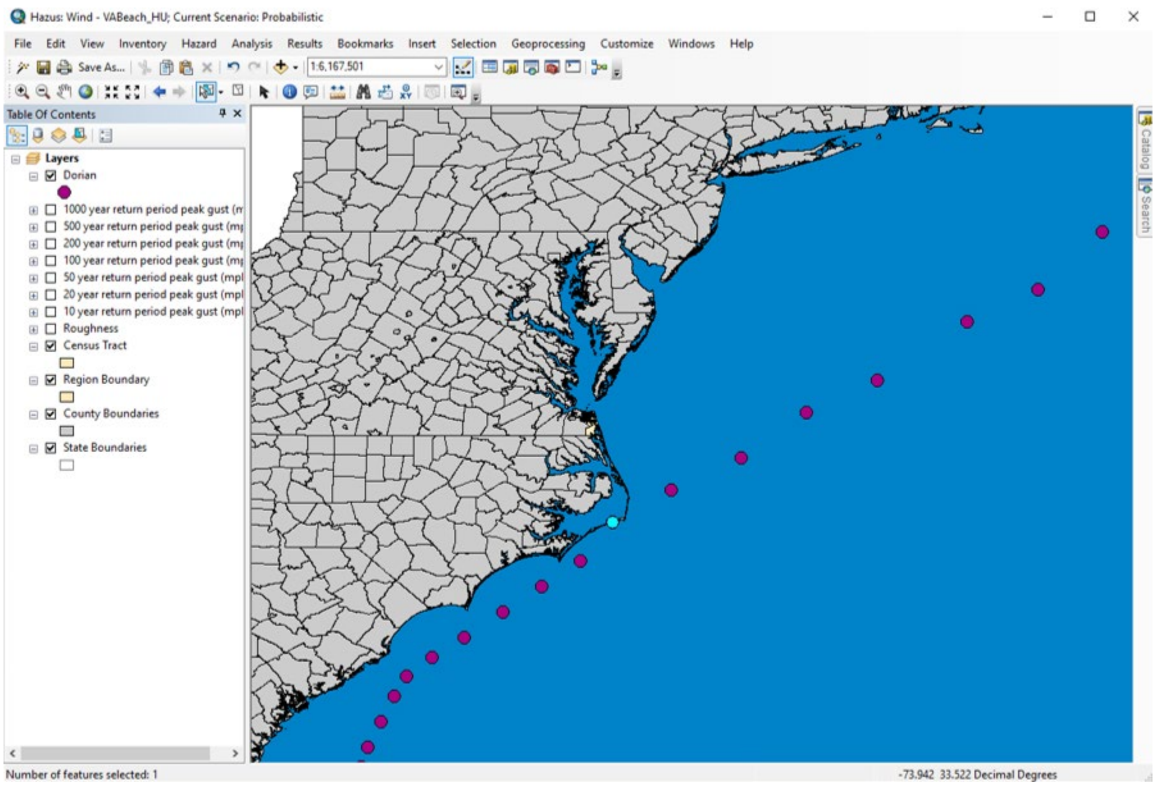
Displaying XY Data from the Excel file

10. Right click on Sheet1$ Events and go to Data and then Export Data. Save the layer as C:\E0177\Activity\5.1\Dorian.shp. Click Yes when the message comes up asking whether to add to map. Remove the Sheet1$ events and the Sheet1$ table from the table of contents. Right click on the Dorian layer and select Zoom to Layer.



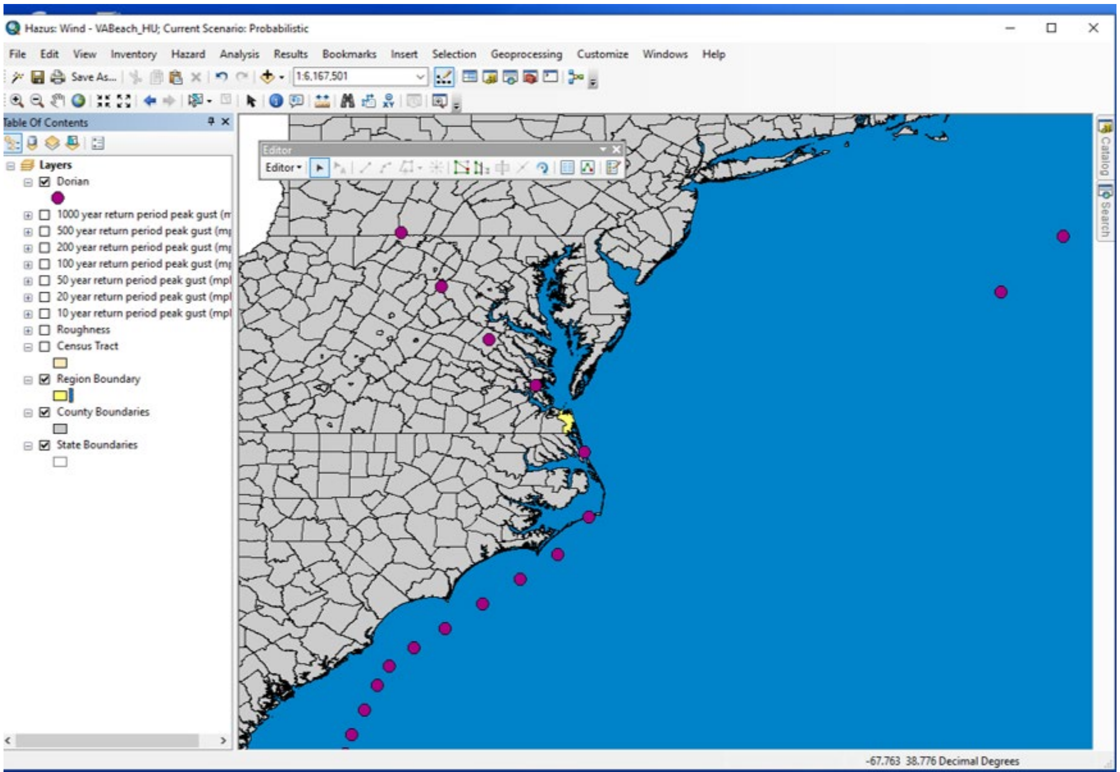
Hurricane Dorian track

11. Now, it’s time to alter the track. Zoom into the Mid-Atlantic and identify the location when the track should start moving towards the study region. Use the selection tool to select the point.



Hurricane Dorian track in the Mid-Atlantic

12. Open the attribute table to identify the time at which the track should start to diverge. The selected point has a point ID of 96. Now, start moving the points that fall northeast to the northwest. Close the attribute table and use the editor toolbar to edit the location of the points. Click on Editor and then Start Editing. Click on the Dorian layer and then OK. Use the edit tool arrow to move the next five points so that the track crosses the study region. You may want to change the study region color so you can see it easier. Make sure the new track goes well beyond the study region



Changing the Hurricane Dorian Track

13. There may be some points at the end of the historic track that will need to be deleted later. In the example there are points off to the top right which will need to be deleted later. Select the five points that you have moved and then open the Dorian layer's attribute table. Right click on Latitude_ and select Calculate Geometry. Use Y Coordinate of Point, coordinate system of GCS: WGS 1984, and Decimal Degrees for units. Then select OK. Right click on Longitude and use X Coordinate of Point, coordinate system of GCS: WGS 1984, and Decimal Degrees for units. Then select OK. The five points that were moved should now have new latitude and longitude values.

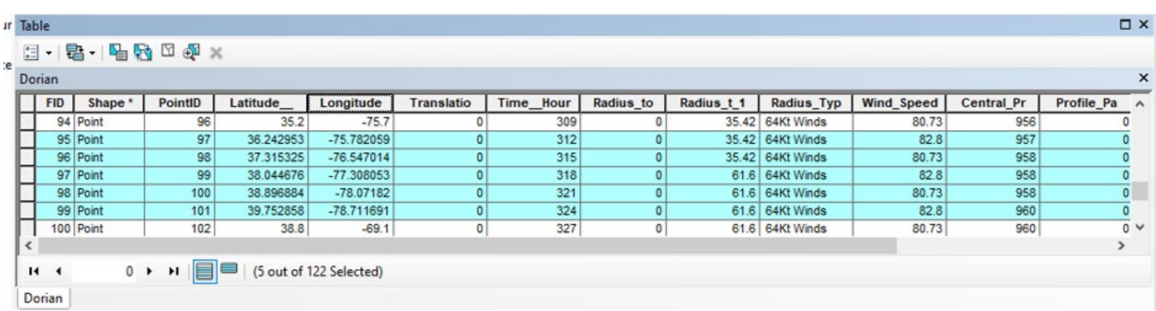


Table
Dorian

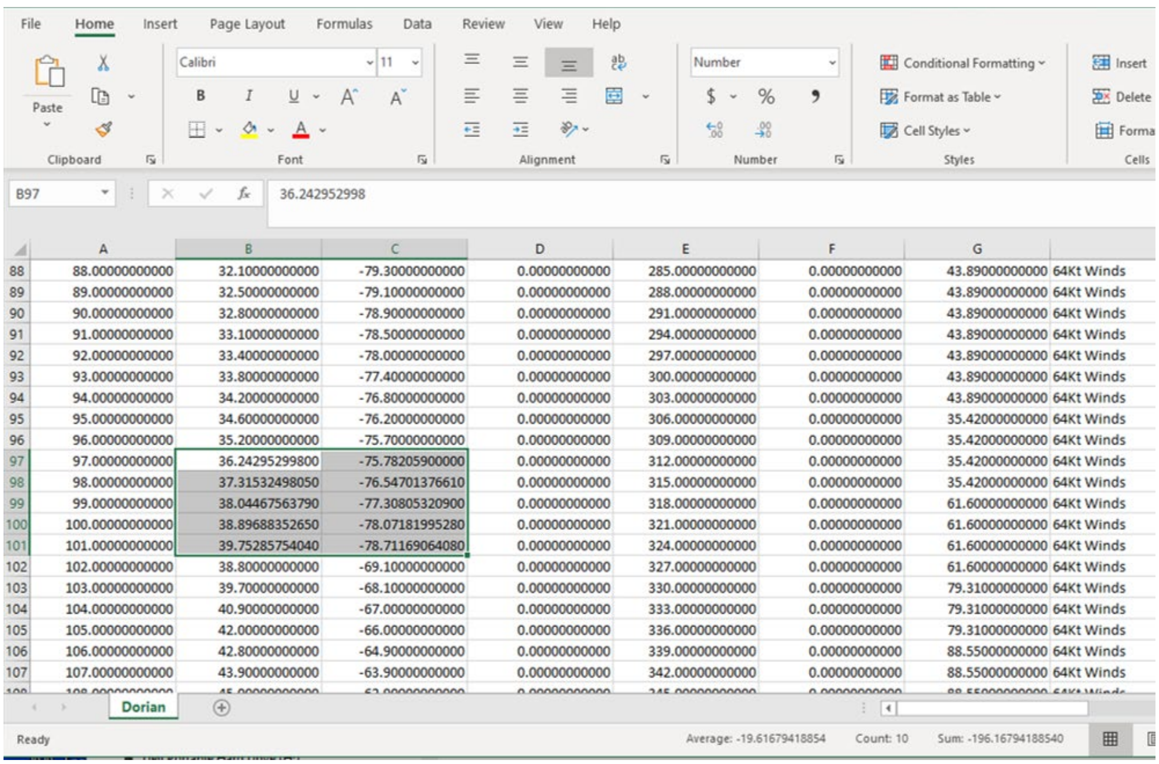
FID	Shape *	PointID	Latitude__	Longitude	Translatio	Time__Hour	Radius_to	Radius_t_1	Radius_Typ	Wind_Speed	Central_Pr	Profile_Pa
94	Point	96	35.2	-75.7	0	309	0	35.42	64Kt Winds	80.73	956	0
95	Point	97	36.242953	-75.782059	0	312	0	35.42	64Kt Winds	82.8	957	0
96	Point	98	37.315325	-76.547014	0	315	0	35.42	64Kt Winds	80.73	958	0
97	Point	99	38.044676	-77.308053	0	318	0	61.6	64Kt Winds	82.8	958	0
98	Point	100	38.896884	-78.07182	0	321	0	61.6	64Kt Winds	80.73	958	0
99	Point	101	39.752858	-78.711691	0	324	0	61.6	64Kt Winds	82.8	960	0
100	Point	102	38.8	-69.1	0	327	0	61.6	64Kt Winds	80.73	960	0

(5 out of 122 Selected)
Dorian

New latitude and longitudes for five updated points

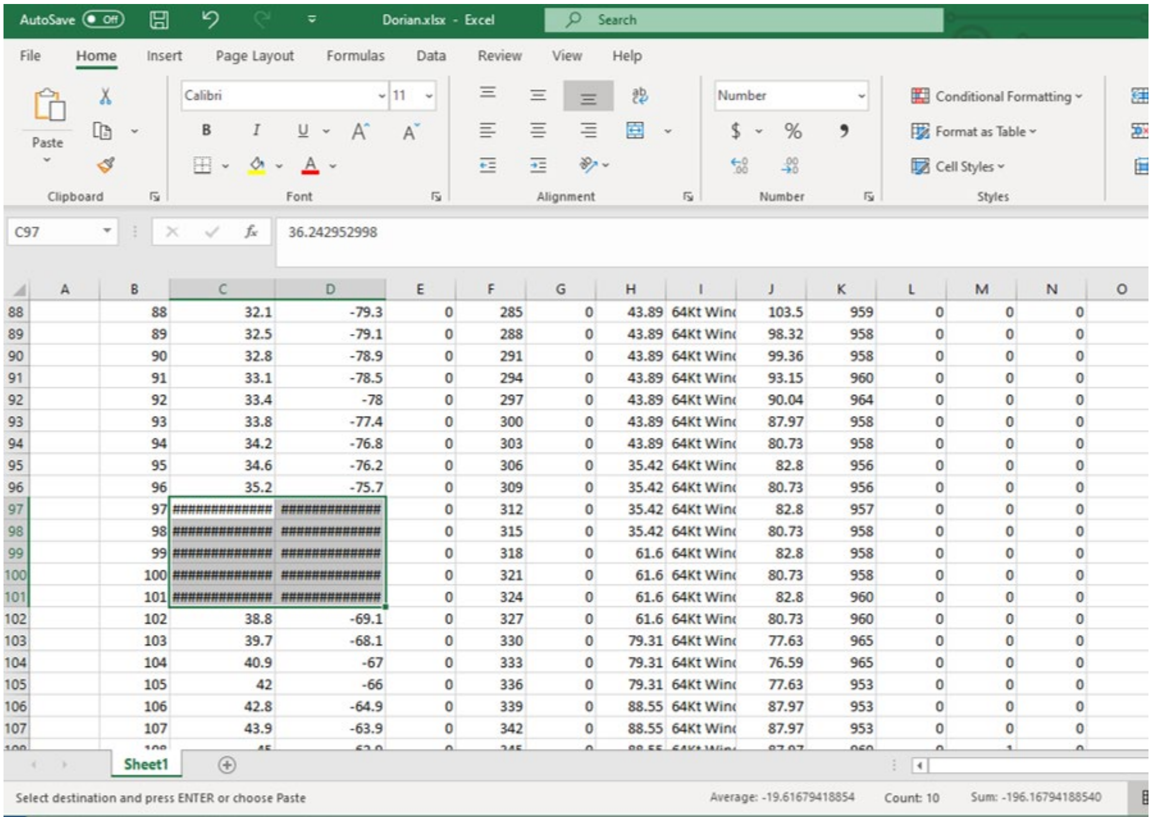
14. Close the attribute table, click Stop Editing to save the edits. Then remove the Dorian layer from the table of contents.

15. Open the Dorian.xlsx file. Then open the Dorian.dbf file in Excel. In the dbf file scroll down to the five new latitude and longitude values, next to points 97-101. Highlight those five latitudes and longitudes.



Highlighting the new latitudes and longitudes in the DBF file

16. Press Ctrl+C and then switch to the Dorian.xlsx file. Highlight the corresponding cells in the .xlsx file starting with point 97 and going through point 101. Use Ctrl+V to paste the new coordinates in the .xlsx file.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
88		88	32.1	-79.3	0	285	0	43.89	64Kt Winc	103.5	959	0	0	0	
89		89	32.5	-79.1	0	288	0	43.89	64Kt Winc	98.32	958	0	0	0	
90		90	32.8	-78.9	0	291	0	43.89	64Kt Winc	99.36	958	0	0	0	
91		91	33.1	-78.5	0	294	0	43.89	64Kt Winc	93.15	960	0	0	0	
92		92	33.4	-78	0	297	0	43.89	64Kt Winc	90.04	964	0	0	0	
93		93	33.8	-77.4	0	300	0	43.89	64Kt Winc	87.97	958	0	0	0	
94		94	34.2	-76.8	0	303	0	43.89	64Kt Winc	80.73	958	0	0	0	
95		95	34.6	-76.2	0	306	0	35.42	64Kt Winc	82.8	956	0	0	0	
96		96	35.2	-75.7	0	309	0	35.42	64Kt Winc	80.73	956	0	0	0	
97		97	#############	#############	0	312	0	35.42	64Kt Winc	82.8	957	0	0	0	
98		98	#############	#############	0	315	0	35.42	64Kt Winc	80.73	958	0	0	0	
99		99	#############	#############	0	318	0	61.6	64Kt Winc	82.8	958	0	0	0	
100		100	#############	#############	0	321	0	61.6	64Kt Winc	80.73	958	0	0	0	
101		101	#############	#############	0	324	0	61.6	64Kt Winc	82.8	960	0	0	0	
102		102	38.8	-69.1	0	327	0	61.6	64Kt Winc	80.73	960	0	0	0	
103		103	39.7	-68.1	0	330	0	79.31	64Kt Winc	77.63	965	0	0	0	
104		104	40.9	-67	0	333	0	79.31	64Kt Winc	76.59	965	0	0	0	
105		105	42	-66	0	336	0	79.31	64Kt Winc	77.63	953	0	0	0	
106		106	42.8	-64.9	0	339	0	88.55	64Kt Winc	87.97	953	0	0	0	
107		107	43.9	-63.9	0	342	0	88.55	64Kt Winc	87.97	953	0	0	0	

Highlighting the new latitudes and longitudes in the XLSX file

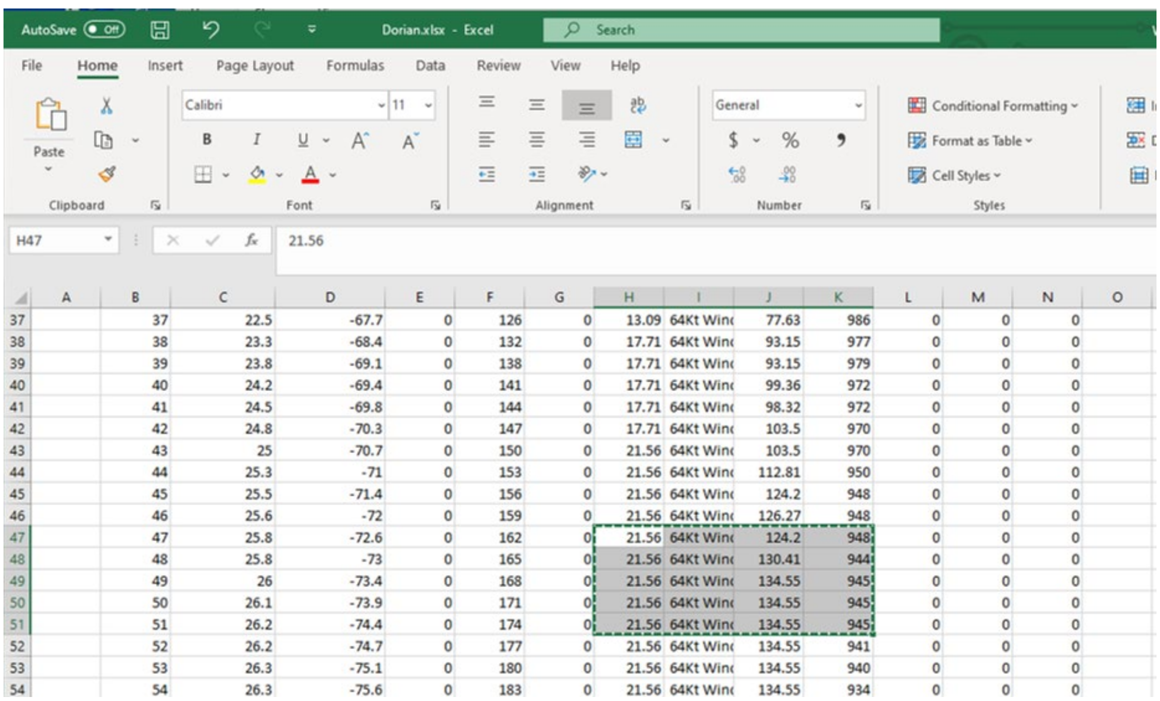
17. After the new cells have been pasted into the table, make sure the formatting matches the other cells. There should only be one digit right of the period.

18. Now, edit the hurricane parameters. To show a worst-case scenario, use earlier windspeeds which were higher and use those parameters before the change in direction too. Also, remember that the Hazus input windspeeds are 1-minute mean while the output is a 3-second gust which will be higher. Here is a table which shows the two types of windspeeds and their associated pressure ranges.

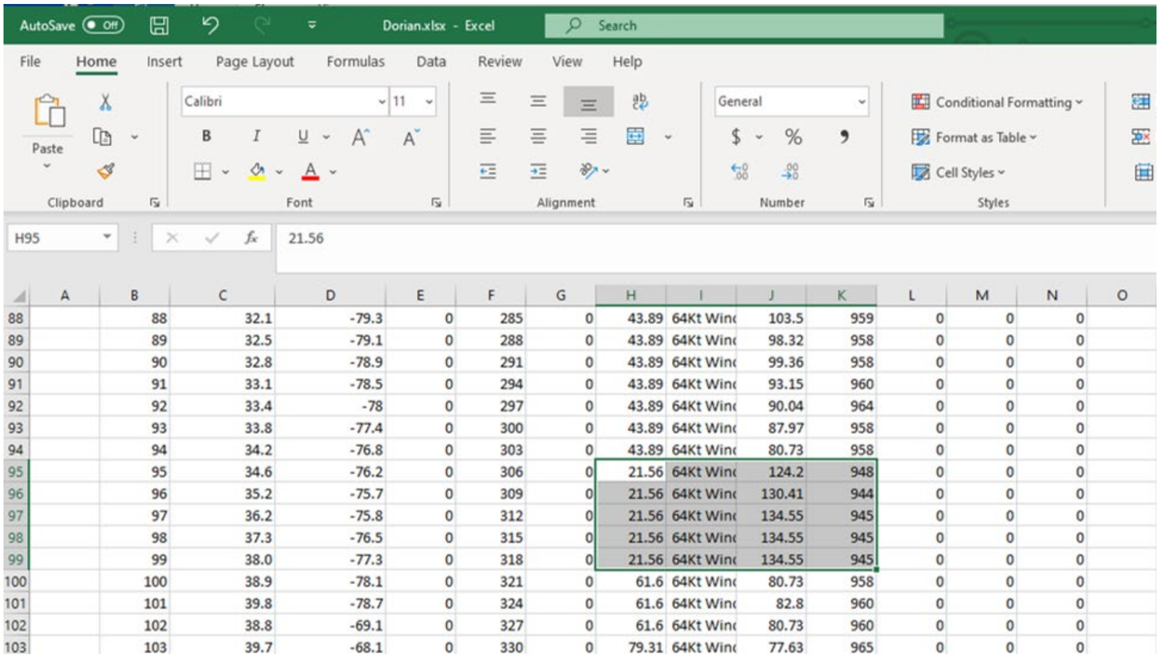
Hazus Input Windspeeds (1 Min Mean) · Hazus Output Windspeeds (3 Sec Gust)

Saffir Simpson Scale	1 Min Mean (mph)	3 Sec Gust (mph)	Min Central Pressure (mb)
1	74-95	90-116	980 and up
2	96-110	117-134	965-979
3	111-129	135-159	945-964
4	130-156	160-189	920-944
5	157+	189+	920 and below

19. For the Hurricane Dorian data, scroll to point 47 which is where the storms starts to pick up speed and select columns H, I, J, and K for points 47, 48, 49, 50, and 51. Press Ctrl+C to copy the data.



20. Scroll down to point 95 and paste the copied cells from H95 to K99.

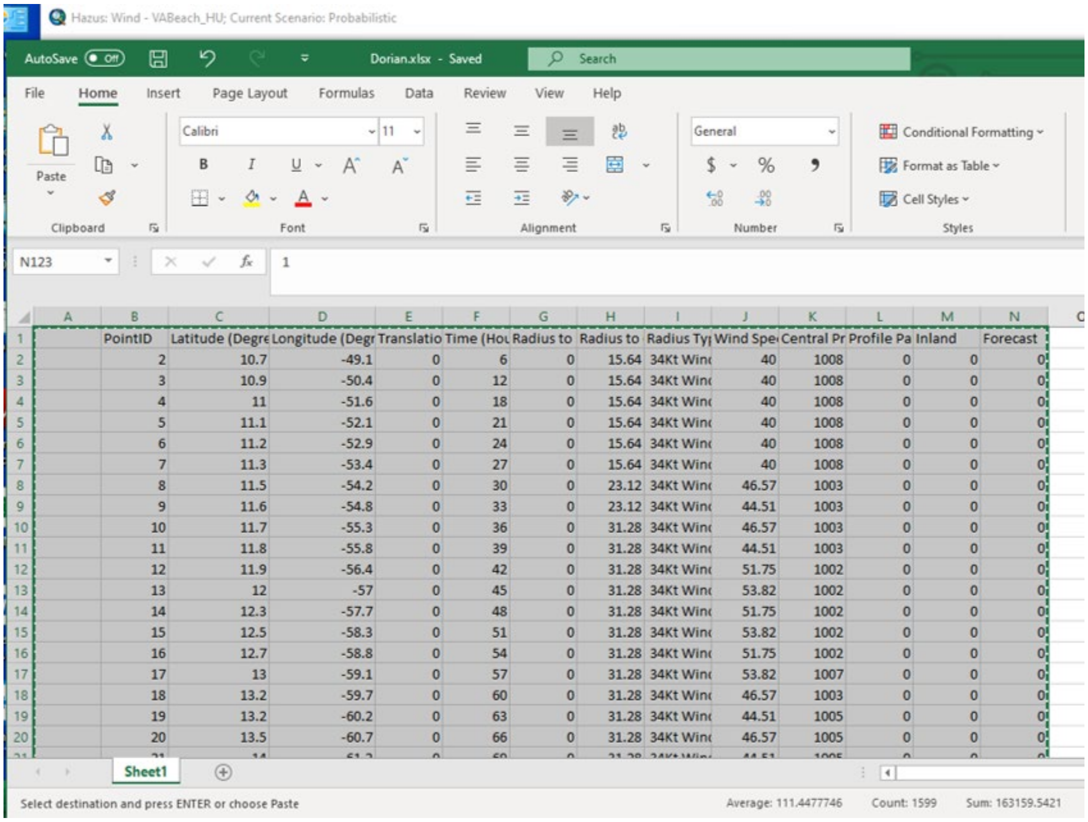


	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
88		88	32.1	-79.3	0	285	0	43.89	64Kt Winc	103.5	959	0	0	0	
89		89	32.5	-79.1	0	288	0	43.89	64Kt Winc	98.32	958	0	0	0	
90		90	32.8	-78.9	0	291	0	43.89	64Kt Winc	99.36	958	0	0	0	
91		91	33.1	-78.5	0	294	0	43.89	64Kt Winc	93.15	960	0	0	0	
92		92	33.4	-78	0	297	0	43.89	64Kt Winc	90.04	964	0	0	0	
93		93	33.8	-77.4	0	300	0	43.89	64Kt Winc	87.97	958	0	0	0	
94		94	34.2	-76.8	0	303	0	43.89	64Kt Winc	80.73	958	0	0	0	
95		95	34.6	-76.2	0	306	0	21.56	64Kt Winc	124.2	948	0	0	0	
96		96	35.2	-75.7	0	309	0	21.56	64Kt Winc	130.41	944	0	0	0	
97		97	36.2	-75.8	0	312	0	21.56	64Kt Winc	134.55	945	0	0	0	
98		98	37.3	-76.5	0	315	0	21.56	64Kt Winc	134.55	945	0	0	0	
99		99	38.0	-77.3	0	318	0	21.56	64Kt Winc	134.55	945	0	0	0	
100		100	38.9	-78.1	0	321	0	61.6	64Kt Winc	80.73	958	0	0	0	
101		101	39.8	-78.7	0	324	0	61.6	64Kt Winc	82.8	960	0	0	0	
102		102	38.8	-69.1	0	327	0	61.6	64Kt Winc	80.73	960	0	0	0	
103		103	39.7	-68.1	0	330	0	79.31	64Kt Winc	77.63	965	0	0	0	

Pasting the higher windspeeds into the track location when it enters the study region

21. Save the spreadsheet but don’t close it. Close the .dbf file.

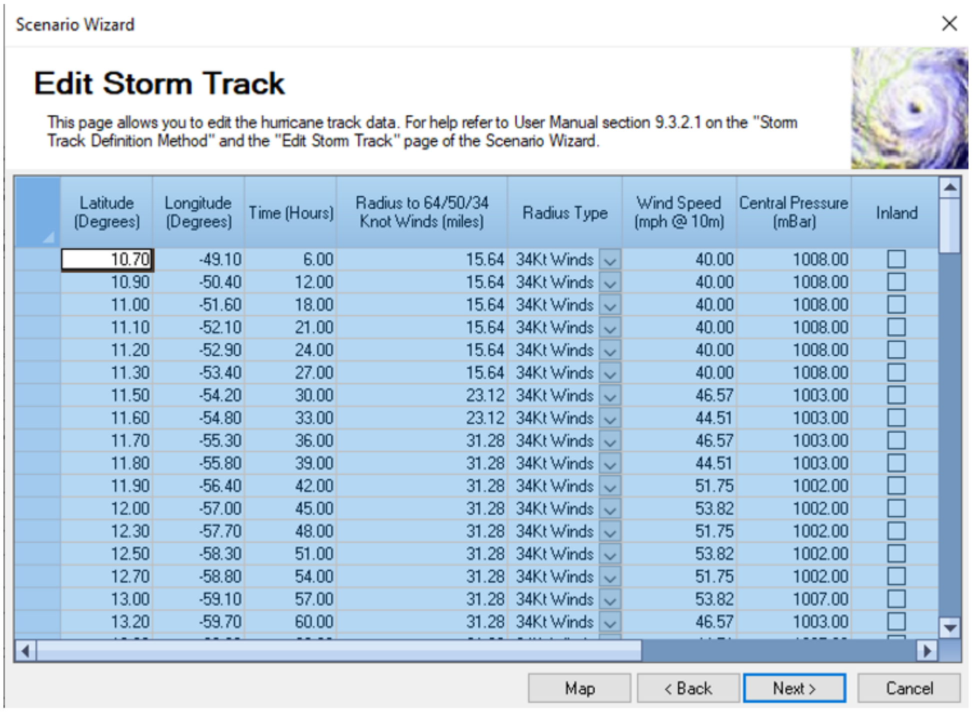
22. Enter the data back into Hazus. Open the Virginia Beach hurricane study region if it’s not already open. Go to Hazard, then Scenario, and Next. Click on DORIAN_2019_stm, then select Edit and Next. Then click Next again. Go back to the Dorian.xlsx file and starting at the bottom right of the table select everything to the top left including the blank column A. Click Ctrl+C to copy the cells.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1		PointID	Latitude (Degre	Longitude (Degr	Translatio	Time (Hou	Radius to	Radius to	Radius Ty	Wind Spe	Central Pr	Profile Pa	Inland	Forecast
2		2	10.7	-49.1	0	6	0	15.64	34Kt Win	40	1008	0	0	0
3		3	10.9	-50.4	0	12	0	15.64	34Kt Win	40	1008	0	0	0
4		4	11	-51.6	0	18	0	15.64	34Kt Win	40	1008	0	0	0
5		5	11.1	-52.1	0	21	0	15.64	34Kt Win	40	1008	0	0	0
6		6	11.2	-52.9	0	24	0	15.64	34Kt Win	40	1008	0	0	0
7		7	11.3	-53.4	0	27	0	15.64	34Kt Win	40	1008	0	0	0
8		8	11.5	-54.2	0	30	0	23.12	34Kt Win	46.57	1003	0	0	0
9		9	11.6	-54.8	0	33	0	23.12	34Kt Win	44.51	1003	0	0	0
10		10	11.7	-55.3	0	36	0	31.28	34Kt Win	46.57	1003	0	0	0
11		11	11.8	-55.8	0	39	0	31.28	34Kt Win	44.51	1003	0	0	0
12		12	11.9	-56.4	0	42	0	31.28	34Kt Win	51.75	1002	0	0	0
13		13	12	-57	0	45	0	31.28	34Kt Win	53.82	1002	0	0	0
14		14	12.3	-57.7	0	48	0	31.28	34Kt Win	51.75	1002	0	0	0
15		15	12.5	-58.3	0	51	0	31.28	34Kt Win	53.82	1002	0	0	0
16		16	12.7	-58.8	0	54	0	31.28	34Kt Win	51.75	1002	0	0	0
17		17	13	-59.1	0	57	0	31.28	34Kt Win	53.82	1007	0	0	0
18		18	13.2	-59.7	0	60	0	31.28	34Kt Win	46.57	1003	0	0	0
19		19	13.2	-60.2	0	63	0	31.28	34Kt Win	44.51	1005	0	0	0
20		20	13.5	-60.7	0	66	0	31.28	34Kt Win	46.57	1005	0	0	0

Copying data from the xlsx file

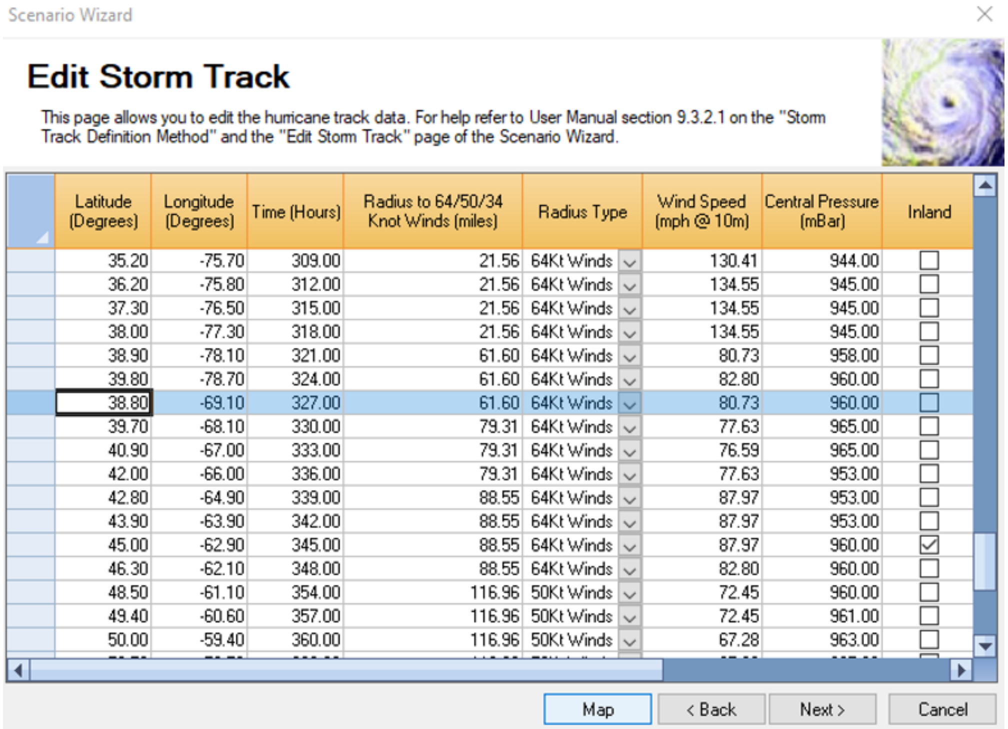
23. Go back to Hazus and select the entire table by clicking on the top left square.



Latitude (Degrees)	Longitude (Degrees)	Time (Hours)	Radius to 64/50/34 Knot Winds (miles)	Radius Type	Wind Speed (mph @ 10m)	Central Pressure (mBar)	Inland
10.70	-49.10	6.00	15.64	34Kt Winds	40.00	1008.00	
10.90	-50.40	12.00	15.64	34Kt Winds	40.00	1008.00	
11.00	-51.60	18.00	15.64	34Kt Winds	40.00	1008.00	
11.10	-52.10	21.00	15.64	34Kt Winds	40.00	1008.00	
11.20	-52.90	24.00	15.64	34Kt Winds	40.00	1008.00	
11.30	-53.40	27.00	15.64	34Kt Winds	40.00	1008.00	
11.50	-54.20	30.00	23.12	34Kt Winds	46.57	1003.00	
11.60	-54.80	33.00	23.12	34Kt Winds	44.51	1003.00	
11.70	-55.30	36.00	31.28	34Kt Winds	46.57	1003.00	
11.80	-55.80	39.00	31.28	34Kt Winds	44.51	1003.00	
11.90	-56.40	42.00	31.28	34Kt Winds	51.75	1002.00	
12.00	-57.00	45.00	31.28	34Kt Winds	53.82	1002.00	
12.30	-57.70	48.00	31.28	34Kt Winds	51.75	1002.00	
12.50	-58.30	51.00	31.28	34Kt Winds	53.82	1002.00	
12.70	-58.80	54.00	31.28	34Kt Winds	51.75	1002.00	
13.00	-59.10	57.00	31.28	34Kt Winds	53.82	1007.00	
13.20	-59.70	60.00	31.28	34Kt Winds	46.57	1003.00	

Pasting data into Edit Storm Track menu

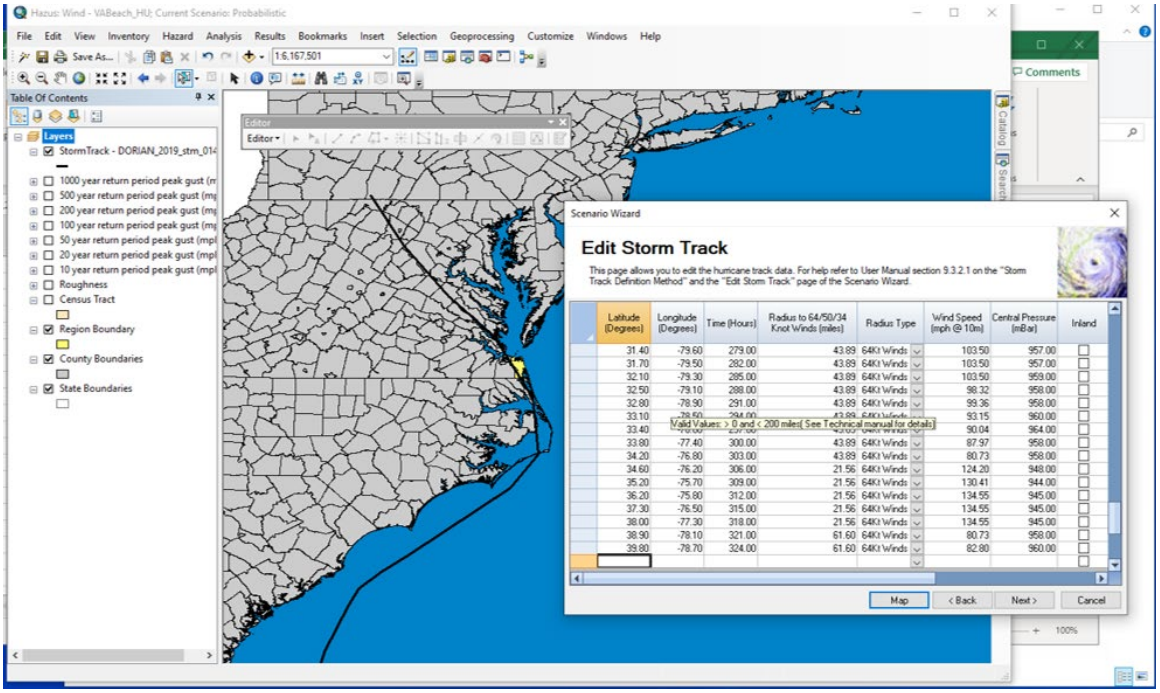
24. Confirm that the records which were edited in the spreadsheet are updated in Hazus. Next, delete all the records once the longitude switches from -78.70 to -69.10.



Latitude (Degrees)	Longitude (Degrees)	Time (Hours)	Radius to 64/50/34 Knot Winds (miles)	Radius Type	Wind Speed (mph @ 10m)	Central Pressure (mBar)	Inland
35.20	-75.70	309.00	21.56	64Kt Winds	130.41	944.00	☐
36.20	-75.80	312.00	21.56	64Kt Winds	134.55	945.00	☐
37.30	-76.50	315.00	21.56	64Kt Winds	134.55	945.00	☐
38.00	-77.30	318.00	21.56	64Kt Winds	134.55	945.00	☐
38.90	-78.10	321.00	61.60	64Kt Winds	80.73	958.00	☐
39.80	-78.70	324.00	61.60	64Kt Winds	82.80	960.00	☐
38.80	-69.10	327.00	61.60	64Kt Winds	80.73	960.00	☐
39.70	-68.10	330.00	79.31	64Kt Winds	77.63	965.00	☐
40.90	-67.00	333.00	79.31	64Kt Winds	76.59	965.00	☐
42.00	-66.00	336.00	79.31	64Kt Winds	77.63	953.00	☐
42.80	-64.90	339.00	88.55	64Kt Winds	87.97	953.00	☐
43.90	-63.90	342.00	88.55	64Kt Winds	87.97	953.00	☐
45.00	-62.90	345.00	88.55	64Kt Winds	87.97	960.00	☑
46.30	-62.10	348.00	88.55	64Kt Winds	82.80	960.00	☐
48.50	-61.10	354.00	116.96	50Kt Winds	72.45	960.00	☐
49.40	-60.60	357.00	116.96	50Kt Winds	72.45	961.00	☐
50.00	-59.40	360.00	116.96	50Kt Winds	67.28	963.00	☐

Modified data pasted into the Edit Storm Track menu.

25. Click on the Map button on the bottom bar. Moving the menu to the side, makes the new Dorian track visible. It should now be going through the Virginia Beach study region.



New Hurricane Dorian Track

26. Click on Next. Then Hazus will validate the storm. If there are issues with the storm parameters, Hazus will generate an error message and the issue will need to be fixed. Once the Windfield Calculation is finished, click Next, then Next again, then Next again, and Next to make the scenario active. Finally, click Finish.

27. Run Hazus with the new scenario. Go to Analysis and Run. Then select Run Analysis. The analysis will take a few minutes to run. Once it's complete, go to the results and make sure they're populated.

Task 2: Prepare to Discuss Results

1. Create a slide in PPT to provide information on which storm was selected, why it was selected and what kinds of losses were modeled. Export some of the results of interest to a separate folder in case you want to come back to the scenario results later. Try using the Hazus Export Tool (located in the ArcToolbox) to save the results to one geodatabase.

Note: These slides may be used in the final capstone presentation at the end of the class.

Application 2: Can I run a probabilistic analysis similar to the earthquake model?

In this application, you'll have the opportunity to create your own .Dat file which is a hurricane input file which has a windspeed associated with each Census Tract. These files are often created using observed windspeeds from an actual hurricane that has moved through an area. In this exercise, you won't be creating an observed event, instead you'll be inputting the probabilistic windspeeds from ASCE 7 which come up in your table of contents when opening a hurricane study region. Since the ASCE 7 windspeeds are 3-second gust windspeeds and Hazus requires 1-minute mean windspeeds, a conversion will need to be conducted. This application may be completed for any hurricane study region and you don't need any additional, local data.

Task 1: Implement advanced hazard application

1. Create a Virginia Beach, Virginia hurricane study region. Name the study region something you can remember.

2. Open the new study region and review the probabilistic windspeeds in the table of contents. Identify one to use. If there is time at the end, an additional set of windspeeds can be selected. Right click and label the features to get a better idea of how the windspeeds change as the study region moves inland. For the Virginia Beach example, this application will evaluate the 500-year windspeeds. Keep in mind that the damage will be spread over the study region more evenly and does not reflect an actual hurricane which would have higher windspeeds in the front right quadrant of the track. In this application there is no hurricane track, the windspeed is simply applied to everything in the tract.

3. Open the 500-year return period peak gust (mph) attribute table. Click on the top right button and select Export. Browse to C:\E0177\Activity\5.1\ and change the file type to dBASE Table and save as 500Year.dbf. Click Save and then OK. When the message comes up to add the table to the current map, click No. Close the attribute table and minimize Hazus.

4. Open the 500Year.dbf file using Excel. All of the data needed is in this dbf file, it just needs to be formatted differently. Delete the following columns: CountyFips, BldgScheme, Tract6, TractArea, Length, NumAggrBoc, ESRI_OID, Tract_1, f10yr, f20yr, f50yr, f100yr, f200yr, f1000yr. Change the name of Tract to ident, CenLat to nlat, and CenLongit to elon. Then create three new fields called ux, vy (which is populated with zeroes), and w (m/s). Save the file as 500year.xlsx.

	A	B	C	D	E	F	G	H	I
1	ident	elon	nlat	f500yr	ux	vy	w (m/s)		
2	51810040000	-76.16394900000	36.91114600000	107.30000000000		0.00000000000			
3	51810040200	-76.18745100000	36.88498300000	106.20000000000		0.00000000000			
4	51810040402	-76.16938700000	36.86734100000	106.30000000000		0.00000000000			
5	51810040403	-76.17131800000	36.89731900000	106.60000000000		0.00000000000			
6	51810040404	-76.16304900000	36.88054100000	106.20000000000		0.00000000000			
7	51810040600	-76.16592500000	36.85267600000	106.50000000000		0.00000000000			
8	51810040801	-76.13964400000	36.86656000000	106.70000000000		0.00000000000			
9	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]			

500-year spreadsheet table with tract ID, tract centroid latitude and longitude, and 500-year windspeeds

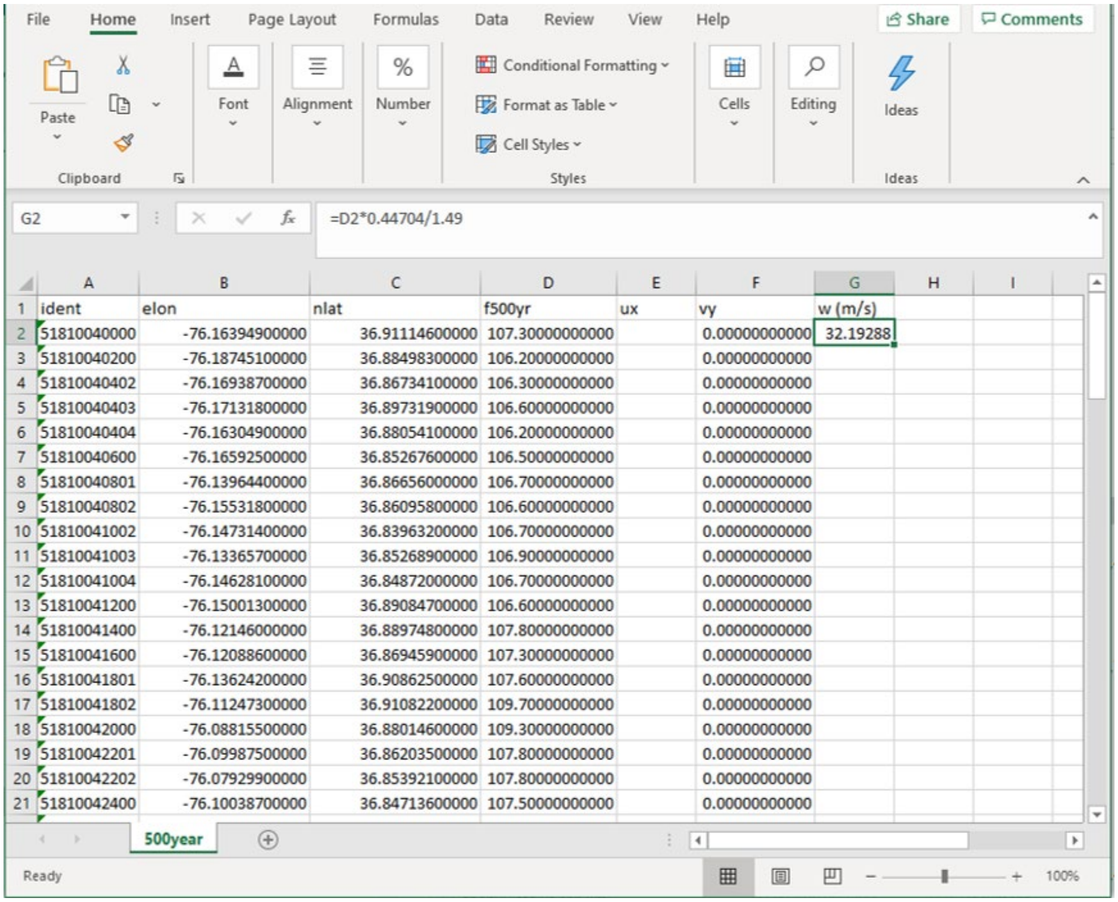
5. Calculate the windspeeds. F500yr is provided as a 3-second gust. The .dat file requires the 1-minute mean in meters per second so two conversions are needed. The table below can be used to convert 3-second gusts to a 1-minute mean. Look at the 60 second value under Reference

Period and go one to the right to 3-second gust and see 1.49. The conversion is 1/1.49 to go from 3-second gust to 1-minute mean.

Exposure at +10 m		Reference Period T_o (s)	Gust Factor $G_{\tau,To}$				
			Gust Duration τ (s)				
Class	Description		*3*	*60*	*120*	*180*	*600*
In-Land	Roughly open terrain	3600	1.75	1.28	1.19	1.15	1.08
		600	1.66	1.21	1.12	1.09	1.00
		180	1.58	1.15	1.07	1.00	
		120	1.55	1.13	1.00		
		60	1.49	1.00			

Conversion from a mean value to a gust value

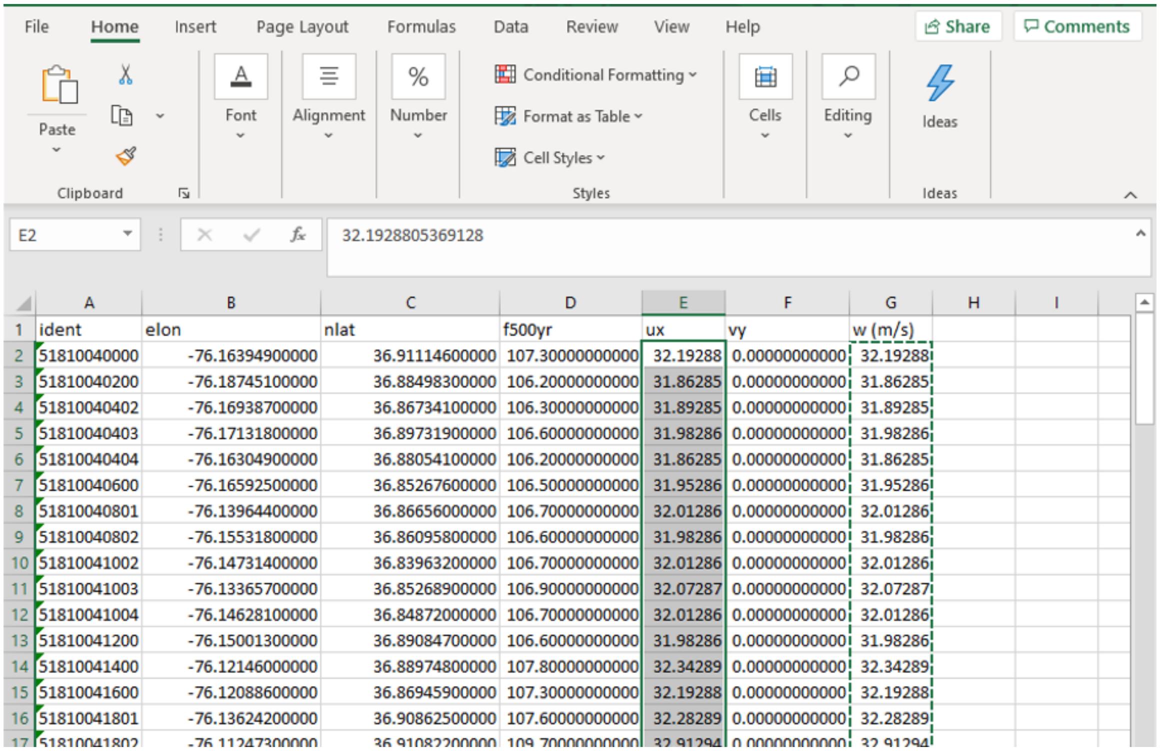
6. The conversion from miles per hour to meters per second is 0.44704. Under the w (m/s) column set up an expression in Excel to multiply the f500yr cell by 0.44704 and then divide it by 1.49.



	A	B	C	D	E	F	G	H	I
1	ident	elon	nlat	f500yr	ux	vy	w (m/s)		
2	51810040000	-76.16394900000	36.91114600000	107.30000000000		0.00000000000	32.19288		
3	51810040200	-76.18745100000	36.88498300000	106.20000000000		0.00000000000			
4	51810040402	-76.16938700000	36.86734100000	106.30000000000		0.00000000000			
5	51810040403	-76.17131800000	36.89731900000	106.60000000000		0.00000000000			
6	51810040404	-76.16304900000	36.88054100000	106.20000000000		0.00000000000			
7	51810040600	-76.16592500000	36.85267600000	106.50000000000		0.00000000000			
8	51810040801	-76.13964400000	36.86656000000	106.70000000000		0.00000000000			
9	51810040802	-76.15531800000	36.86095800000	106.60000000000		0.00000000000			
10	51810041002	-76.14731400000	36.83963200000	106.70000000000		0.00000000000			
11	51810041003	-76.13365700000	36.85268900000	106.90000000000		0.00000000000			
12	51810041004	-76.14628100000	36.84872000000	106.70000000000		0.00000000000			
13	51810041200	-76.15001300000	36.89084700000	106.60000000000		0.00000000000			
14	51810041400	-76.12146000000	36.88974800000	107.80000000000		0.00000000000			
15	51810041600	-76.12088600000	36.86945900000	107.30000000000		0.00000000000			
16	51810041801	-76.13624200000	36.90862500000	107.60000000000		0.00000000000			
17	51810041802	-76.11247300000	36.91082200000	109.70000000000		0.00000000000			
18	51810042000	-76.08815500000	36.88014600000	109.30000000000		0.00000000000			
19	51810042201	-76.09987500000	36.86203500000	107.80000000000		0.00000000000			
20	51810042202	-76.07929900000	36.85392100000	107.80000000000		0.00000000000			
21	51810042400	-76.10038700000	36.84713600000	107.50000000000		0.00000000000			

Converting windspeeds in Excel

7. Copy the G2 cell down to the end of the table. Copy the G column values and paste under ux, but use paste special and just paste the values and not the formula.



	A	B	C	D	E	F	G
1	ident	elon	nlat	f500yr	ux	vy	w (m/s)
2	51810040000	-76.16394900000	36.91114600000	107.30000000000	32.19288	0.00000000000	32.19288
3	51810040200	-76.18745100000	36.88498300000	106.20000000000	31.86285	0.00000000000	31.86285
4	51810040402	-76.16938700000	36.86734100000	106.30000000000	31.89285	0.00000000000	31.89285
5	51810040403	-76.17131800000	36.89731900000	106.60000000000	31.98286	0.00000000000	31.98286
6	51810040404	-76.16304900000	36.88054100000	106.20000000000	31.86285	0.00000000000	31.86285
7	51810040600	-76.16592500000	36.85267600000	106.50000000000	31.95286	0.00000000000	31.95286
8	51810040801	-76.13964400000	36.86656000000	106.70000000000	32.01286	0.00000000000	32.01286
9	51810040802	-76.15531800000	36.86095800000	106.60000000000	31.98286	0.00000000000	31.98286
10	51810041002	-76.14731400000	36.83963200000	106.70000000000	32.01286	0.00000000000	32.01286
11	51810041003	-76.13365700000	36.85268900000	106.90000000000	32.07287	0.00000000000	32.07287
12	51810041004	-76.14628100000	36.84872000000	106.70000000000	32.01286	0.00000000000	32.01286
13	51810041200	-76.15001300000	36.89084700000	106.60000000000	31.98286	0.00000000000	31.98286
14	51810041400	-76.12146000000	36.88974800000	107.80000000000	32.34289	0.00000000000	32.34289
15	51810041600	-76.12088600000	36.86945900000	107.30000000000	32.19288	0.00000000000	32.19288
16	51810041801	-76.13624200000	36.90862500000	107.60000000000	32.28289	0.00000000000	32.28289
17	51810041802	-76.11247300000	36.91082200000	109.70000000000	32.91294	0.00000000000	32.91294

Populating the ux column

8. Format the cells. Format the elon, nlat, and vy columns so that they have four decimal places to the right of the period while ux and w (m/x) have five. Copy the ux values under w (m/s) and then delete the f500yr column.

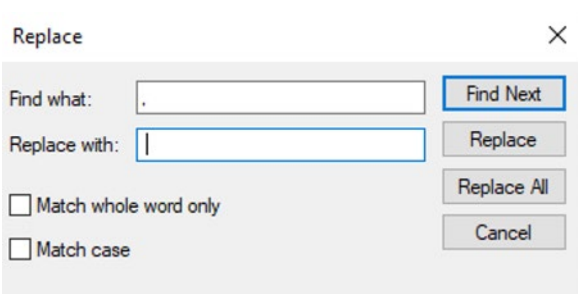
	A	B	C	D	E	F
1	ident	elon	nlat	ux	vy	w (m/s)
2	51810040000	36.9111	-76.1639	32.19288	0.0000	32.19288
3	51810040200	36.8850	-76.1875	31.86285	0.0000	31.86285
4	51810040402	36.8673	-76.1694	31.89285	0.0000	31.89285
5	51810040403	36.8973	-76.1713	31.98286	0.0000	31.98286
6	51810040404	36.8805	-76.1630	31.86285	0.0000	31.86285
7	51810040600	36.8527	-76.1659	31.95286	0.0000	31.95286
8	51810040801	36.8666	-76.1396	32.01286	0.0000	32.01286
9	51810040802	36.8610	-76.1553	31.98286	0.0000	31.98286
10	51810041002	36.8396	-76.1473	32.01286	0.0000	32.01286
11	51810041003	36.8527	-76.1337	32.07287	0.0000	32.07287
12	51810041004	36.8487	-76.1463	32.01286	0.0000	32.01286
13	51810041200	36.8908	-76.1500	31.98286	0.0000	31.98286
14	51810041400	36.8897	-76.1215	32.34289	0.0000	32.34289
15	51810041600	36.8695	-76.1209	32.19288	0.0000	32.19288
16	51810041801	36.9086	-76.1362	32.28289	0.0000	32.28289
17	51810041802	36.9108	-76.1125	32.91294	0.0000	32.91294
18	51810042000	36.8801	-76.0882	32.79293	0.0000	32.79293
19	51810042201	36.8620	-76.0999	32.34289	0.0000	32.34289

500year

Final table values

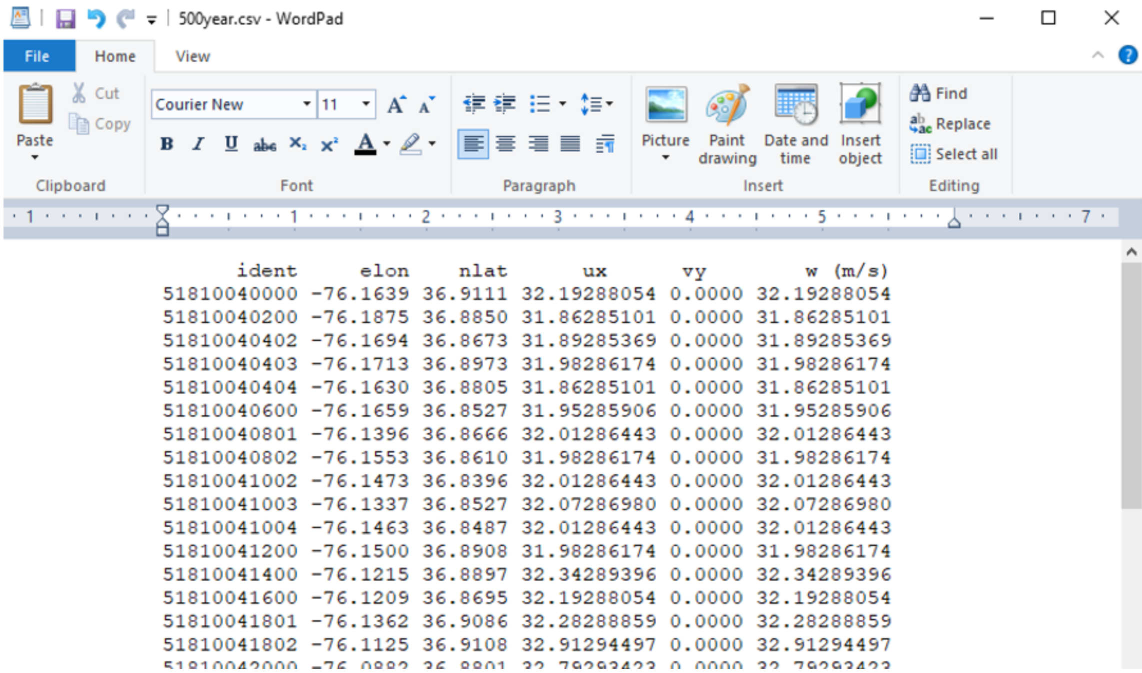
9. Convert the .xlsx file to a .dat file. Go to File, then Save As and save the file as a comma delimited file (.csv). Call it 500year.csv. Close Excel.

10. In Windows Explorer, browse to the 500year.csv file, right click then select Open with, and then WordPad. Once WordPad is open select Replace on the top menu. The Replace menu will come up. In the Find what box type, and in the Replace with box add a space. Then click Replace All.



Replace Menu – replacing commas with spaces

11. Click OK once it's finished processing. Then click Cancel to leave the Replace menu. Use the space bar to move the column headers over the columns they represent.



Final formatting in WordPad

12. Click File, then Save As, and then select Other Formats. Call the file 500year.dat and click Save. Close WordPad.

13. Open Hazus if it isn't already open. Go to Hazard, then Scenario, and Next. Select and then Next. Then select Import Census Tract Data file (e.g. H*Wind) and click Next. Enter a new name for the scenario. Call it 500yearASCE then click Next. Browse to 500year.dat and click Open and then Next. Then click Next and Next again. When the menu asks to make the scenario active, click Next and then Finish. Go to Analysis and Run. Run the analysis.

Task 2: Prepare to Discuss Results

1. Create a slide in PPT to provide information on which probabilistic storm was selected, why it was selected and what kind of losses were modeled. Export some of the results of interest to a separate folder in case you want to come back to the scenario results later. Try using the Hazus Export Tool (located in the ArcToolbox) to save the results to one geodatabase.

Try running the probabilistic analysis in Hazus and compare the ASCE 500-year with the Hazus-generated 500-year. How do the results differ?

Note: These slides may be used in the final capstone presentation at the end of the class.

Application 3: How do I integrate climate change into my analysis?

In this application, you'll have the opportunity to integrate climate change into your analysis. You'll investigate how climate change may alter typical hurricane characteristics. Many local communities and some states have a Climate Adaptation Plan where they've discussed how climate change may impact the community or state. Investigate your own community to determine if they have one of these plans or if their Hazard Mitigation Plan covers climate change.

For Virginia Beach, the City is currently developing their Climate Change Adaptation Plan website (https://www.vbgov.com/government/departments/public-works/comp-sea-level-rise/Pages/default.aspx) concerning sea-level rise.

There are other sources of information concerning the impacts of climate change at the national level. Here are some of them:

- NOAA (https://www.gfdl.noaa.gov/global-warming-and-hurricanes/)
- IPCC AR5 (https://www.ipcc.ch/report/ar5/wg1/)
- University of Wisconsin-Madison. "Hurricanes are slowing down, and that's bad news." ScienceDaily. ScienceDaily, 8 June 2018. www.sciencedaily.com/releases/2018/06/180608003209.htm

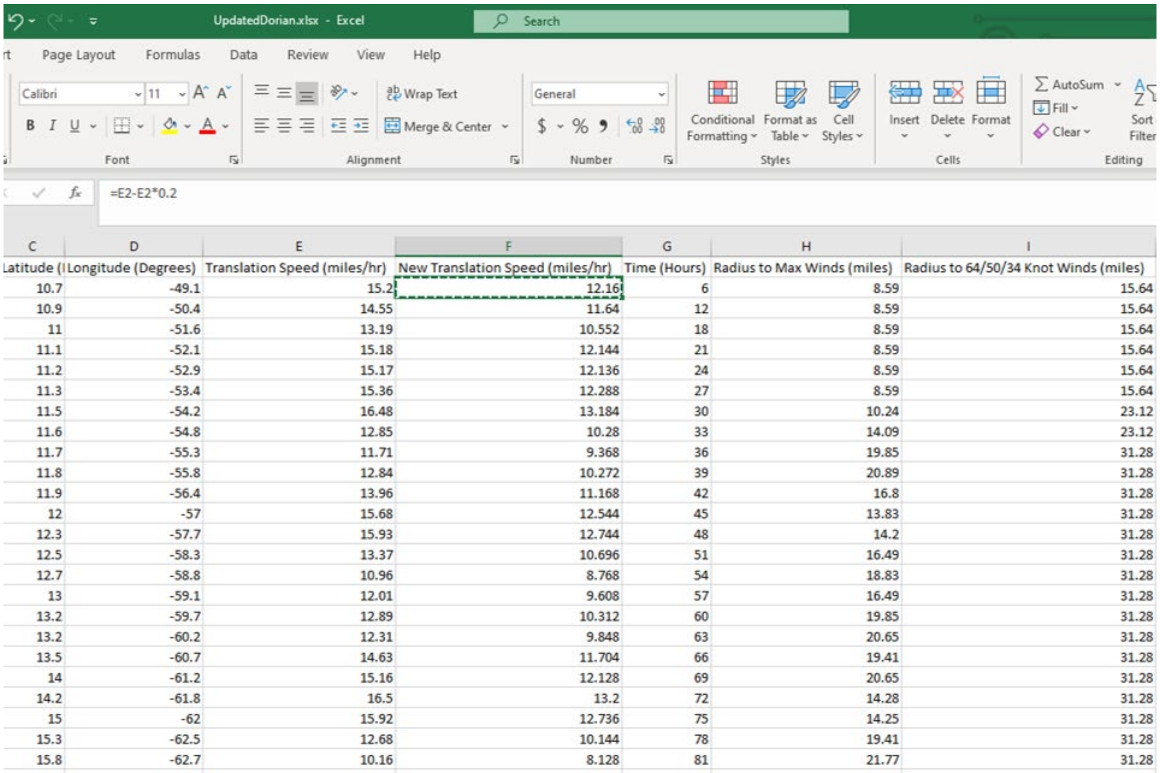
For this activity, you're going to identify a historical hurricane that has impacted your community and you're going to adjust the hurricane's parameters so that it is exacerbated by climate change. If your community is inland, this means a slower hurricane with a higher magnitude and if your community is on the coast, this also means additional surge from sea-level rise.

Task 1: Implement advanced hazard application

1. Create a Virginia Beach, Virginia hurricane and flood study region or create a region for your community. Name the study region something you can remember.

2. In Application 1, Hurricane Dorian was updated so that it went through the Virginia Beach study region. In Application 3, the translation speeds (the forward movement of the hurricane) and windspeeds are going to be altered to incorporate climate change. Since this task will continue into the flood section and a storm surge analysis is being conducted, probabilistic and .dat scenarios can't be used. A hurrevac storm may also be used for this task. Just select the storm and then edit it. In this example, we're going to use a hurricane scenario which has already been altered. It may be found here: C:\E0177\Activity\5.1\UpdatedDorian.xlsx.

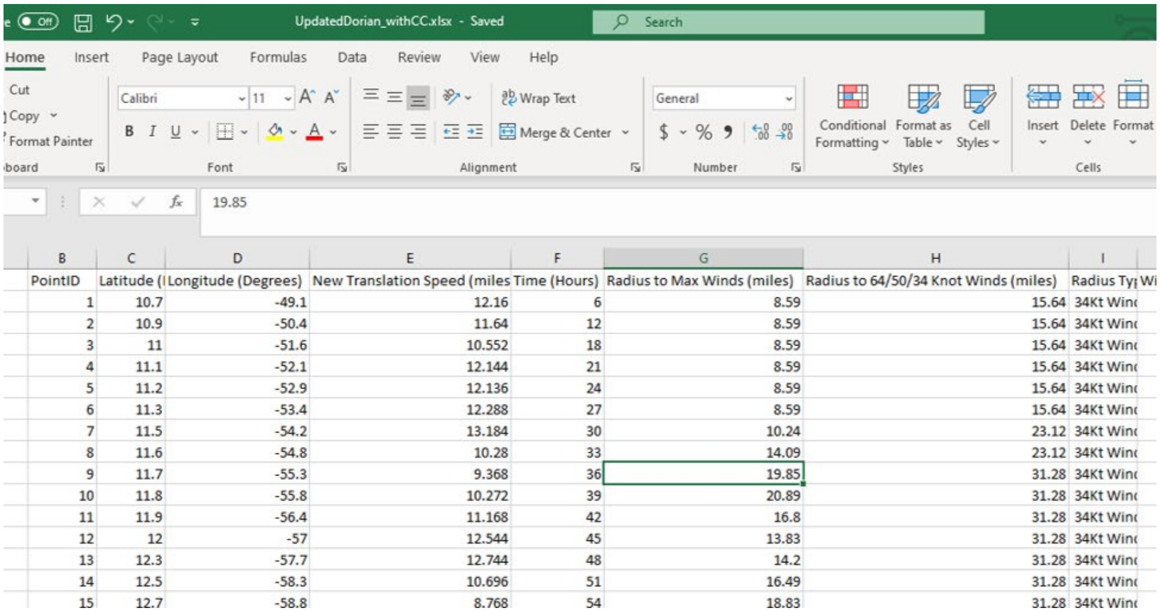
3. Open UpdatedDorian.xlsx in Excel. Add a column after E also called New Translation Speed (miles/hr). Under the New Translation Speed (miles/hr) column, make the cell F2 = E2-E2*0.20. This would reduce the translation speed by 20 percent. This translation speed reduction is calculated using the Science Daily article linked to above. The article notes that the North Atlantic has already seen an average of 6% reduction in the hurricane translation speeds over the last 68 years and as high as a 20% reduction. A 10% slowdown can occur with 1 degree Celsius of global warming. The Pacific hurricanes can be reduced as much as 30 percent. Use this article to help determine the total reduction for your study region.



Latitude (I	Longitude (Degrees)	Translation Speed (miles/hr)	New Translation Speed (miles/hr)	Time (Hours)	Radius to Max Winds (miles)	Radius to 64/50/34 Knot Winds (miles)
10.7	-49.1	15.2	12.16	6	8.59	15.64
10.9	-50.4	14.55	11.64	12	8.59	15.64
11	-51.6	13.19	10.552	18	8.59	15.64
11.1	-52.1	15.18	12.144	21	8.59	15.64
11.2	-52.9	15.17	12.136	24	8.59	15.64
11.3	-53.4	15.36	12.288	27	8.59	15.64
11.5	-54.2	16.48	13.184	30	10.24	23.12
11.6	-54.8	12.85	10.28	33	14.09	23.12
11.7	-55.3	11.71	9.368	36	19.85	31.28
11.8	-55.8	12.84	10.272	39	20.89	31.28
11.9	-56.4	13.96	11.168	42	16.8	31.28
12	-57	15.68	12.544	45	13.83	31.28
12.3	-57.7	15.93	12.744	48	14.2	31.28
12.5	-58.3	13.37	10.696	51	16.49	31.28
12.7	-58.8	10.96	8.768	54	18.83	31.28
13	-59.1	12.01	9.608	57	16.49	31.28
13.2	-59.7	12.89	10.312	60	19.85	31.28
13.2	-60.2	12.31	9.848	63	20.65	31.28
13.5	-60.7	14.63	11.704	66	19.41	31.28
14	-61.2	15.16	12.128	69	20.65	31.28
14.2	-61.8	16.5	13.2	72	14.28	31.28
15	-62	15.92	12.736	75	14.25	31.28
15.3	-62.5	12.68	10.144	78	19.41	31.28
15.8	-62.7	10.16	8.128	81	21.77	31.28

Decreasing the translation speed in Excel.

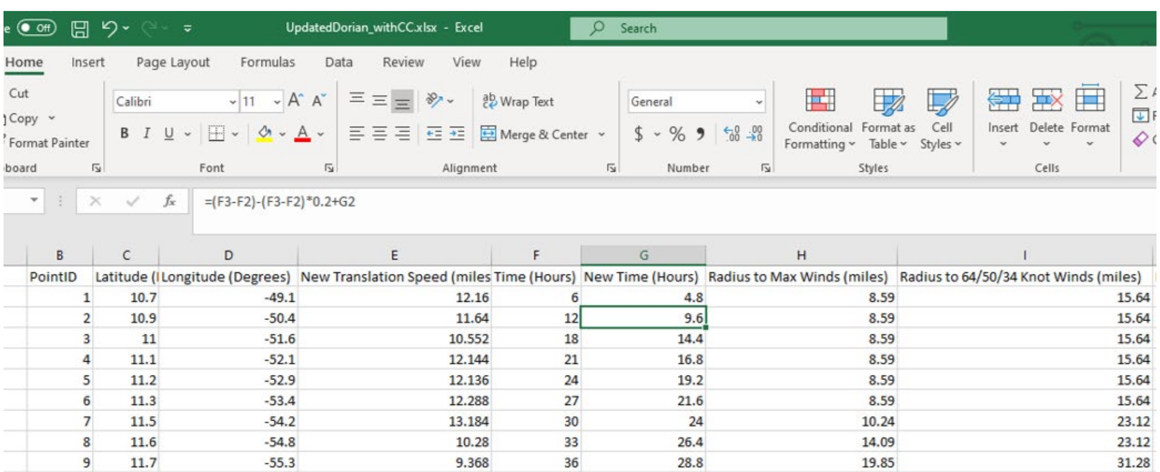
4. Copy the cells in column F and then paste the cells as values into column E. Delete column F. Save the Excel as UpdatedDorian_withCC.xlsx.



PointID	Latitude (I	Longitude (Degrees)	New Translation Speed (miles	Time (Hours)	Radius to Max Winds (miles)	Radius to 64/50/34 Knot Winds (miles)	Radius Ty|	Wi
1	10.7	-49.1	12.16	6	8.59	15.64	34Kt Winc	
2	10.9	-50.4	11.64	12	8.59	15.64	34Kt Winc	
3	11	-51.6	10.552	18	8.59	15.64	34Kt Winc	
4	11.1	-52.1	12.144	21	8.59	15.64	34Kt Winc	
5	11.2	-52.9	12.136	24	8.59	15.64	34Kt Winc	
6	11.3	-53.4	12.288	27	8.59	15.64	34Kt Winc	
7	11.5	-54.2	13.184	30	10.24	23.12	34Kt Winc	
8	11.6	-54.8	10.28	33	14.09	23.12	34Kt Winc	
9	11.7	-55.3	9.368	36	19.85	31.28	34Kt Winc	
10	11.8	-55.8	10.272	39	20.89	31.28	34Kt Winc	
11	11.9	-56.4	11.168	42	16.8	31.28	34Kt Winc	
12	12	-57	12.544	45	13.83	31.28	34Kt Winc	
13	12.3	-57.7	12.744	48	14.2	31.28	34Kt Winc	
14	12.5	-58.3	10.696	51	16.49	31.28	34Kt Winc	
15	12.7	-58.8	8.768	54	18.83	31.28	34Kt Winc	

Updated translation speed in Excel

5. Next, add a column after F and call it New Time (Hours). In cell G2, write the expression: =F2-F2*0.20 and in cell G3, write the expression: =(F3-F2)-(F3-F2)*0.20+G2. This will reduce the time by 20 percent as well. Then copy G3 down through G101.

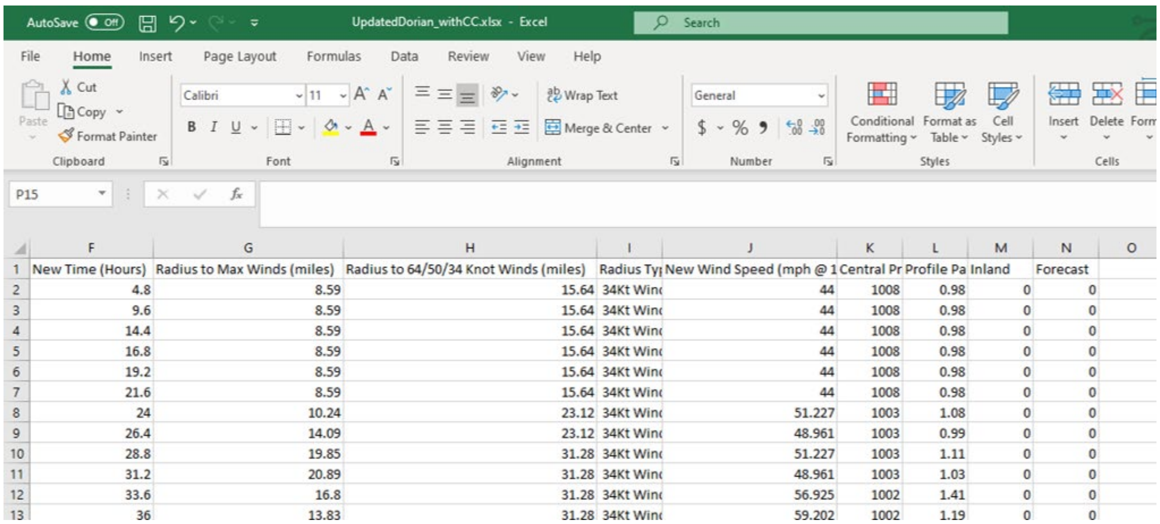


PointID	Latitude (I	Longitude (Degrees)	New Translation Speed (miles	Time (Hours)	New Time (Hours)	Radius to Max Winds (miles)	Radius to 64/50/34 Knot Winds (miles)
1	10.7	-49.1	12.16	6	4.8	8.59	15.64
2	10.9	-50.4	11.64	12	9.6	8.59	15.64
3	11	-51.6	10.552	18	14.4	8.59	15.64
4	11.1	-52.1	12.144	21	16.8	8.59	15.64
5	11.2	-52.9	12.136	24	19.2	8.59	15.64
6	11.3	-53.4	12.288	27	21.6	8.59	15.64
7	11.5	-54.2	13.184	30	24	10.24	23.12
8	11.6	-54.8	10.28	33	26.4	14.09	23.12
9	11.7	-55.3	9.368	36	28.8	19.85	31.28

Updated translation time in Excel

6. Copy the values of column G to column H. Then copy column H and overwrite column F. Delete columns G and H. Copy the cells in column G and then paste the cells as values into column F. Delete column G.

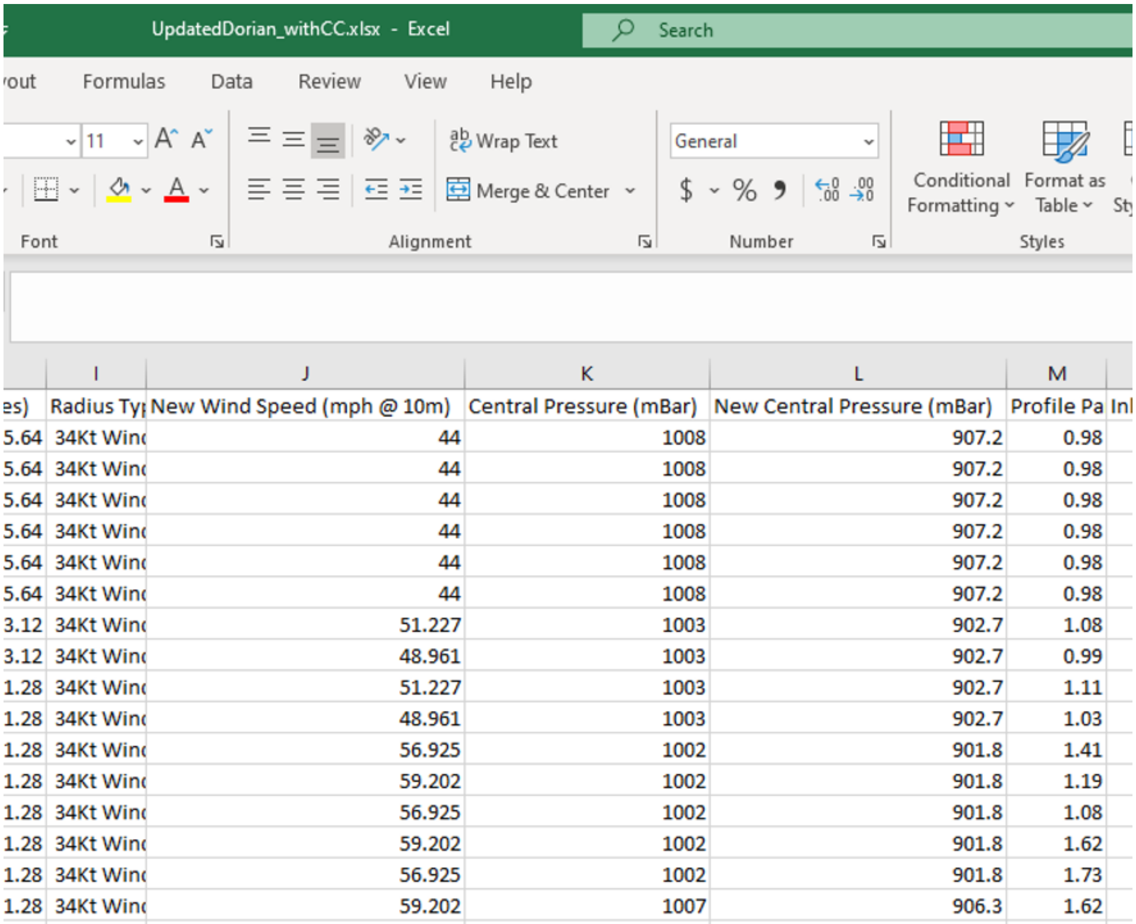
7. Add a new column after column J and call it New Wind Speed (mph @ 10m). In cell K2, write: =J2+J2*0.1. This will increase the windspeed by 10 percent. In the NOAA website linked to above, the tropical cyclone intensities will likely increase 1 to 10 percent for a 2-degree Celsius change. Copy the expression through K101. Copy the cells in column K and then paste the cells as values into column J. Delete column K.



	F	G	H	I	J	K	L	M	N	O
1	New Time (Hours)	Radius to Max Winds (miles)	Radius to 64/50/34 Knot Winds (miles)	Radius Ty	New Wind Speed (mph @ 1	Central Pr	Profile Pa	Inland	Forecast	
2	4.8	8.59	15.64	34Kt Winc	44	1008	0.98	0	0	
3	9.6	8.59	15.64	34Kt Winc	44	1008	0.98	0	0	
4	14.4	8.59	15.64	34Kt Winc	44	1008	0.98	0	0	
5	16.8	8.59	15.64	34Kt Winc	44	1008	0.98	0	0	
6	19.2	8.59	15.64	34Kt Winc	44	1008	0.98	0	0	
7	21.6	8.59	15.64	34Kt Winc	44	1008	0.98	0	0	
8	24	10.24	23.12	34Kt Winc	51.227	1003	1.08	0	0	
9	26.4	14.09	23.12	34Kt Winc	48.961	1003	0.99	0	0	
10	28.8	19.85	31.28	34Kt Winc	51.227	1003	1.11	0	0	
11	31.2	20.89	31.28	34Kt Winc	48.961	1003	1.03	0	0	
12	33.6	16.8	31.28	34Kt Winc	56.925	1002	1.41	0	0	
13	36	13.83	31.28	34Kt Winc	59.202	1002	1.19	0	0	

Updated wind speed in Excel

8. Add a new column after column K and call it New Central Pressure (mBar). In cell L2, write: =K2-K2*0.1. This will decrease the pressure by 10 percent. In the NOAA website linked to above, the tropical cyclone intensities will likely increase 1 to 10 percent for a 2 degree Celsius change. Copy the expression through L101. Copy the cells in column L and then paste the cells as values into column K. Delete column L.



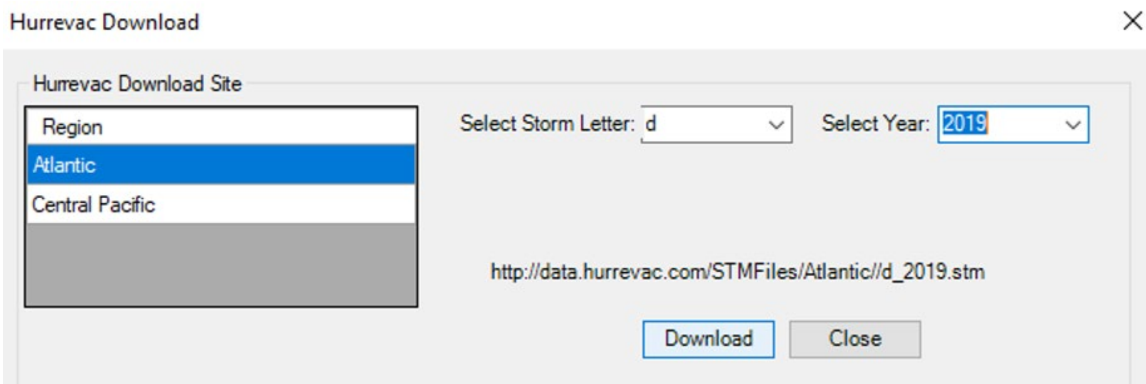
es)	Radius Ty	New Wind Speed (mph @ 10m)	Central Pressure (mBar)	New Central Pressure (mBar)	Profile Pa	Inl
5.64	34Kt Win	44	1008	907.2	0.98	
5.64	34Kt Win	44	1008	907.2	0.98	
5.64	34Kt Win	44	1008	907.2	0.98	
5.64	34Kt Win	44	1008	907.2	0.98	
5.64	34Kt Win	44	1008	907.2	0.98	
5.64	34Kt Win	44	1008	907.2	0.98	
3.12	34Kt Win	51.227	1003	902.7	1.08	
3.12	34Kt Win	48.961	1003	902.7	0.99	
1.28	34Kt Win	51.227	1003	902.7	1.11	
1.28	34Kt Win	48.961	1003	902.7	1.03	
1.28	34Kt Win	56.925	1002	901.8	1.41	
1.28	34Kt Win	59.202	1002	901.8	1.19	
1.28	34Kt Win	56.925	1002	901.8	1.08	
1.28	34Kt Win	59.202	1002	901.8	1.62	
1.28	34Kt Win	56.925	1002	901.8	1.73	
1.28	34Kt Win	59.202	1007	906.3	1.62	

Updated central pressure in Excel

9. Rename column E from New Translation Speed (miles/hr) to Translation Speed (miles/hr), then rename New Time (Hours) to Time (Hours), New Wind Speed (mph @ 10m) to Wind Speed (mph @ 10m), and New Central Pressure (mBar) to Central Pressure (mBar). This way the Excel columns match the Hazus columns.

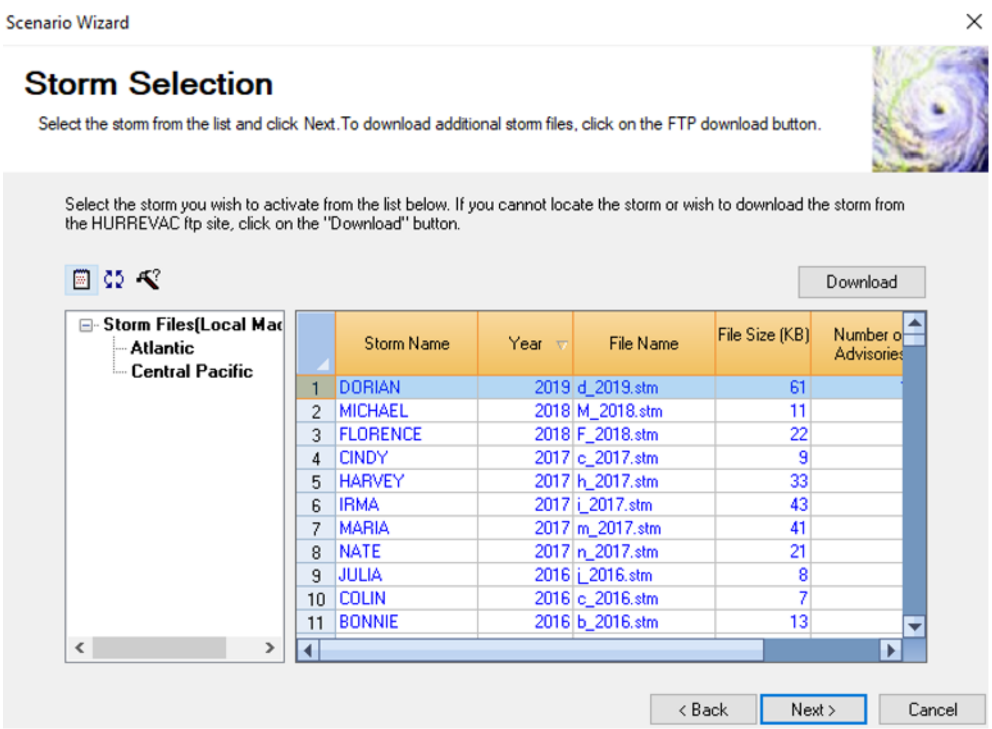
10. Save the file. Open the study region and select the hurricane hazard.

11. Go to Hazard -> Scenario -> Next and select and then Next. Select the Import Hurrevac storm advisory option and then click Next. When the Storm Selection menu comes up, click on Atlantic. Sort by year by clicking on the Year column heading. Click again so that the 2018 storms (Hurricanes Michael and Florence) are at the top. You'll notice that Hurricane Dorian is missing. Click on the download button on the top. 12. Select Atlantic, then next to Select Storm Letter: select D and for Select Year: select 2019.



Accessing the Hurrevac Download Site through Hazus

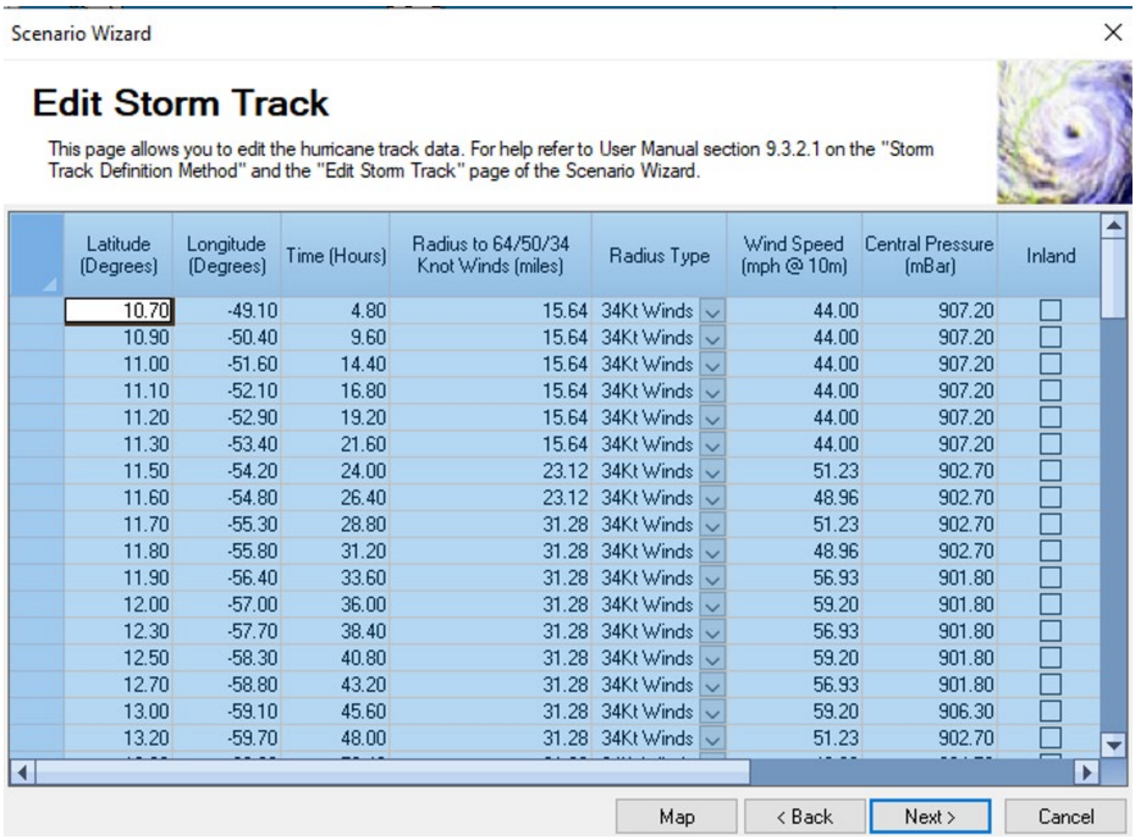
13. Click on the Download button. This will take you back to the Storm Selection menu. Click on the



Hurricane Dorian added to Hurrevac list

14. Click Next. The Edit Storm Track Scenario Wizard menu comes up with hurricane characteristics for a series of points. Left click in the top left square of the table and everything should become highlighted. Go back to Excel and highlight all cells from N101 to A1 and press

Ctrl+C to copy the table (please note that column A is selected even though it is blank). Go back to Hazus and click Ctrl+V to paste the values.



Latitude (Degrees)	Longitude (Degrees)	Time (Hours)	Radius to 64/50/34 Knot Winds (miles)	Radius Type	Wind Speed (mph @ 10m)	Central Pressure (mBar)	Inland
10.70	-49.10	4.80	15.64	34Kt Winds	44.00	907.20	
10.90	-50.40	9.60	15.64	34Kt Winds	44.00	907.20	
11.00	-51.60	14.40	15.64	34Kt Winds	44.00	907.20	
11.10	-52.10	16.80	15.64	34Kt Winds	44.00	907.20	
11.20	-52.90	19.20	15.64	34Kt Winds	44.00	907.20	
11.30	-53.40	21.60	15.64	34Kt Winds	44.00	907.20	
11.50	-54.20	24.00	23.12	34Kt Winds	51.23	902.70	
11.60	-54.80	26.40	23.12	34Kt Winds	48.96	902.70	
11.70	-55.30	28.80	31.28	34Kt Winds	51.23	902.70	
11.80	-55.80	31.20	31.28	34Kt Winds	48.96	902.70	
11.90	-56.40	33.60	31.28	34Kt Winds	56.93	901.80	
12.00	-57.00	36.00	31.28	34Kt Winds	59.20	901.80	
12.30	-57.70	38.40	31.28	34Kt Winds	56.93	901.80	
12.50	-58.30	40.80	31.28	34Kt Winds	59.20	901.80	
12.70	-58.80	43.20	31.28	34Kt Winds	56.93	901.80	
13.00	-59.10	45.60	31.28	34Kt Winds	59.20	906.30	
13.20	-59.70	48.00	31.28	34Kt Winds	51.23	902.70	

Hurricane Dorian with updated wind speed and time.

15. Then click on Next. Hazus will take a few minutes to validate the new track and data. Click Next again. Then click Next when the review screen comes up, then Next, and Next again, and then Finish.

16. Click Analysis and Run. Then select No Waves. Then select Run Analysis.

17. Hazus will ask for an input initial water level in feet above or below mean sea level. Open a web browser and go to the NOAA Tides and Currents website (https://tidesandcurrents.noaa.gov/). A map of the U.S. will come up. Select the State of Virginia. Then select the closest instrument location which is Cape Henry. Select More Data and Tide Predictions. Look at the high tide water levels. This graph will change depending on what day your viewing the data. Type 3.5 as the initial water level since that will be a conservative high tide value. Then click OK. This processing will take time to complete (about 30 minutes).

Task 2: Prepare to Discuss Results

1. Create a slide in PPT to provide information on which storm was selected, why it was selected and what kind of losses were modeled. Export some of the results of interest to a separate folder in case you want to come back to the scenario results later. Try using the Hazus Export Tool (located in the ArcToolbox) to save the results to one geodatabase.

Additional results will be modeled in the flood section. Go to Exercise 6.1 Application 4 to complete this application.

Note: These slides may be used in the final capstone presentation at the end of the class.

Application 4: How do I update my tree and terrain data?

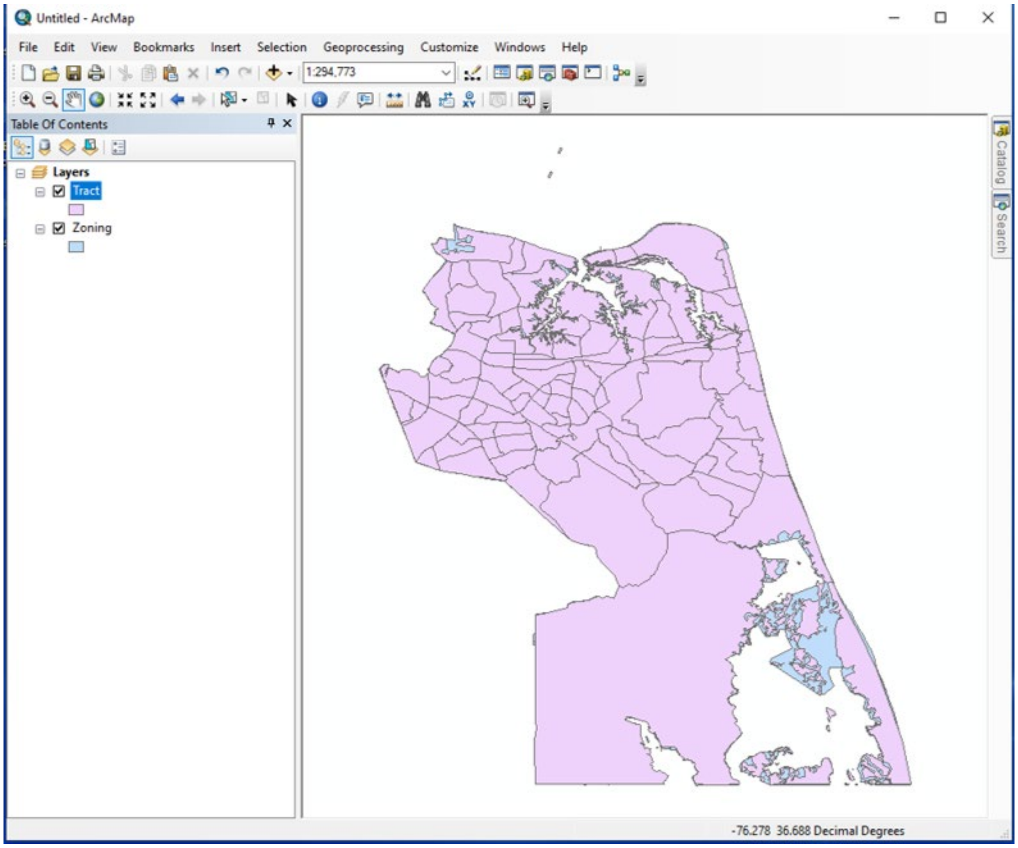
In this application, you'll going to take local land use data and use it to update the terrain value in the hurricane model. Then you're going to use the Forest Inventory Analysis (FIA) tool and a landcover dataset to update the tree inventory database.

Please note that the application below was created for a hurricane only study region and the analysis will update the terrain and tree values at the Census Tract level. However, if you create a hurricane and flood region, this analysis could be conducted at the Census Block level. This would take more time to do the processing and run the analysis at the end.

Task 1: Update the Terrain Database

1. Create a Virginia Beach, Virginia hurricane study region or create a region for your community. Name the study region something you can remember. Minimize Hazus.

2. Open ArcMap and bring in your local land use or zoning data. Data for Virginia Beach can be found here: C:\E0177\Activity\5.1\Zoning.shp. Open the Hazus study region just created. Right click on the Census Tract, then select Data and Export Data. Browse to the 5.1 Activity folder and save the file as: C:\E0177\Activity\5.1\Tract.shp. Then click OK. Add the tract layer to the ArcMap document with the zoning layer.



Final formatting in WordPad

3. Prepare the zoning data. Open the attribute table for the Zoning layer. Add a new field called Surface and assign it a Double data type. Now open the zoningdistricts.pdf file. Both the zoning layer and pdf files were downloaded from the Virginia Beach website. The zoningdistricts.pdf file contains a description of the codes used in the Zoning layer. Now review the table below which comes from the Hazus Hurricane Model Technical Manual. The zoning code needs to be converted into a surface roughness.

NLCD Land Cover Classification vs. Surface Roughness Length

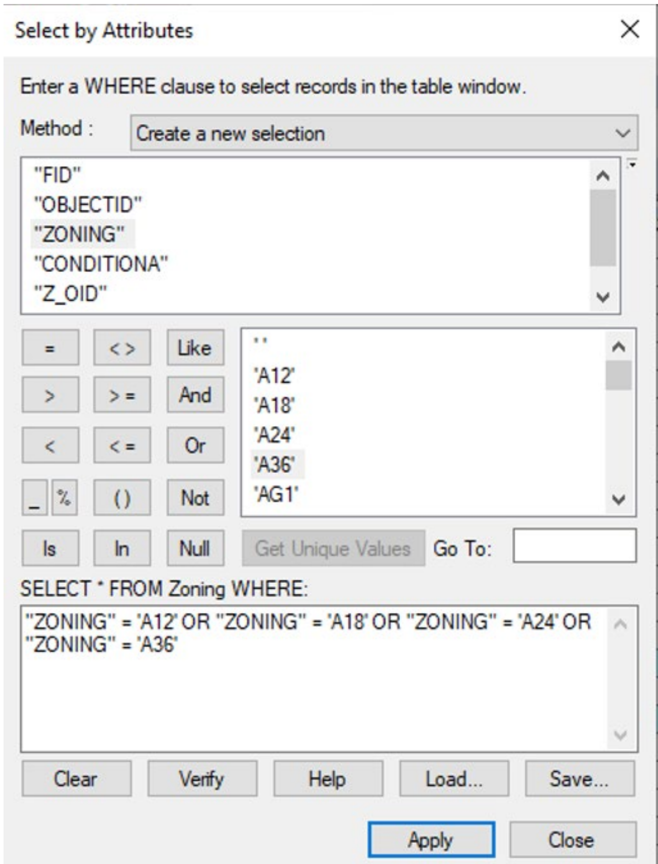
Source: the Hazus Hurricane Model Technical Manual

MRLC-NCLD Land Cover Classification and Numerical Coding	Land Surface Roughness Length, (m) Used	Land Surface Roughness Length, (m) Avg.	Land Surface Roughness Length, (m) COV	Land Surface Roughness Length, (m) Max.	Land Surface Roughness Length, (m) Min.	Number of Sub-Regions Used

MRLC-NCLD Land Cover Classification and Numerical Coding	Land Surface Roughness Length, (m) Used	Land Surface Roughness Length, (m) Avg.	Land Surface Roughness Length, (m) COV	Land Surface Roughness Length, (m) Max.	Land Surface Roughness Length, (m) Min.	Number of Sub-Regions Used
11 Open Water	0.010	0.013	0.612	0.030	0.010	6
12 Perennial Ice/Snow	0.012					0
21 Low Intensity Residential	0.350	0.307	0.496	0.600	0.010	51
22 High Intensity Residential	0.600	0.401	0.498	0.800	0.080	39
23 Commercial/Industrial/Transportation	0.350	0.265	0.605	0.600	0.030	28
31 Bare Rock/Sand/Clay	0.200	0.300				1
32 Quarries/Strip Mines/Gravel Pits	0.400					0
33 Transitional	0.400	0.400	0.661	0.600	0.100	3
41 Deciduous Forest	0.600					0
42 Evergreen Forest	0.600	0.500				1
43 Mixed Forest	0.600					0
51 Shrubland	0.060	0.040				1
61 Orchards/Vineyards/Other	0.210	0.213	0.777	0.400	0.050	4
71 Grasslands/Herbaceous	0.150	0.93	0.662	0.300	0.050	4

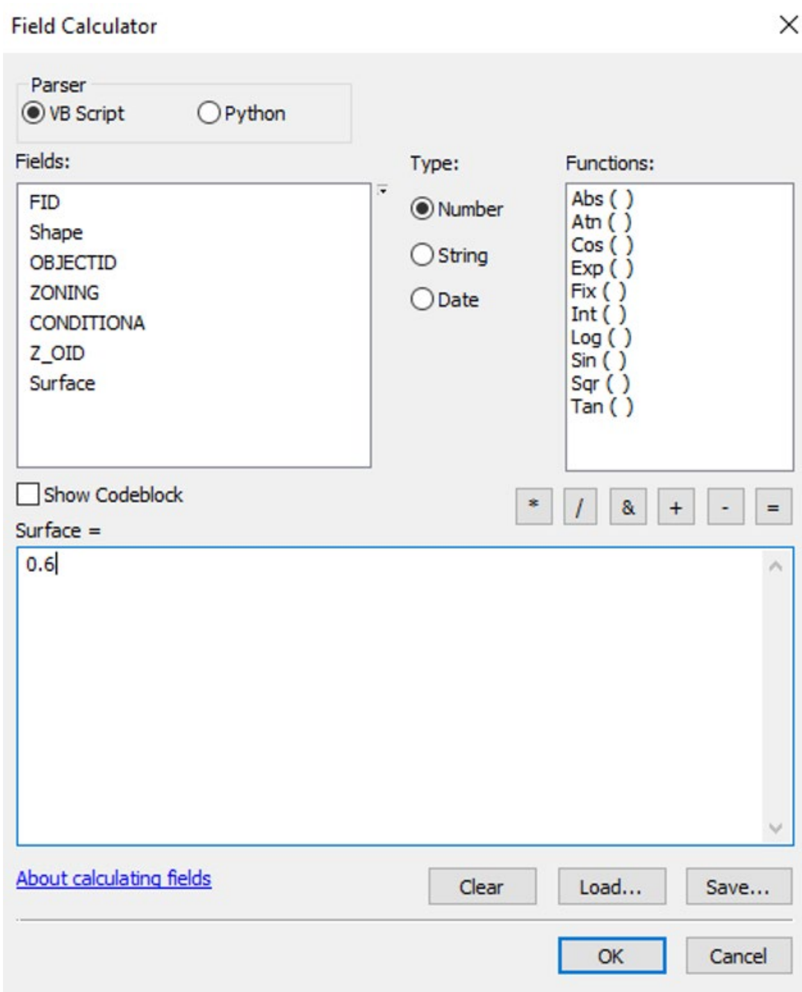
MRLC-NCLD Land Cover Classification and Numerical Coding	Land Surface Roughness Length, (m) Used	Land Surface Roughness Length, (m) Avg.	Land Surface Roughness Length, (m) COV	Land Surface Roughness Length, (m) Max.	Land Surface Roughness Length, (m) Min.	Number of Sub-Regions Used
81 Pasture/Hay	0.150	0.160	1.301	0.400	0.030	3
82 Row Crops	0.100	0.100	0.913	0.300	0.030	8
83 Small Grains	0.030					0
84 Fallow	0.030					0
85 Urban/Recreational Grasses	0.150	0.155	0.514	0.250	0.030	6
91 Woody Wetlands	0.300	0.545	0.594	1.100	0.300	10
92 Emergent Herbaceous Wetlands	0.030	0.188	0.959	0.600	0.050	10

4. Identify the surface roughness values. Go back to the Zoning layer attribute table. Left click the top left button in the attribute table, and then click Select by Attributes. For Method: select Create a new selection, double click the “Zoning” field, then “=”, and then select Get Unique Values. Double click ‘A12’. Continue to select the other apartment values (A18, A24, and A36), high density commercial (B3), and high density industrial (I2). The final query should look like this: "ZONING" = 'A12' OR "ZONING" = 'A18' OR "ZONING" = 'A24' OR "ZONING" = 'A36' OR "ZONING" = 'B3' OR "ZONING" = 'I2'. Then click “Apply”.



Identifying the high density apartment areas

5. Now right click on the Surface heading and use the Field Calculator. Click Yes when the warning message comes up. Make the surface equal to 0.6. Then click OK.

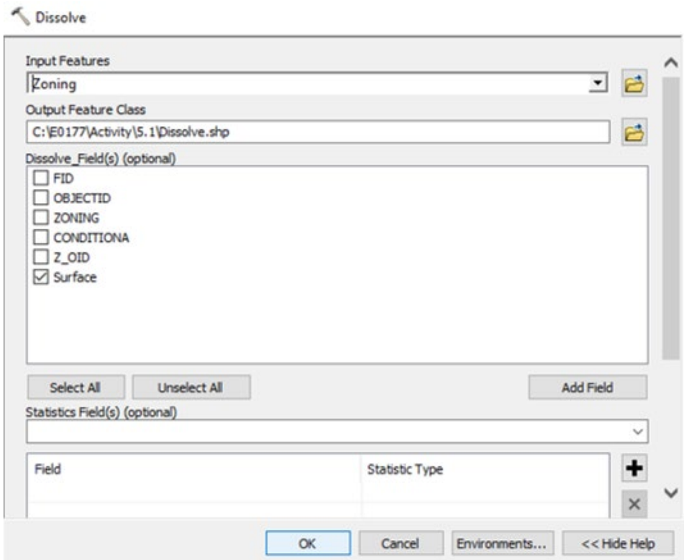


Assigning a high density surface roughness

6. Set up the following attribute queries and field calculator assignments:

- "ZONING" = 'AG1' OR "ZONING" = 'AG2' OR "ZONING" = 'P1'
    - Surface = 0.15
- "Surface" = 0
    - Surface = 0.35

7. Clear the selection and close the attribute table. Click on ArcToolbox, then Data Management Tools, then Generalization, and then double click on Dissolve. The Dissolve menu will then come up. For input features, select Zoning, for output feature class browse here: C:\E0177\Activity\5.1\Dissolve.shp. For Dissolve_Field(s) select Surface. Then click OK. Close ArcToolbox.

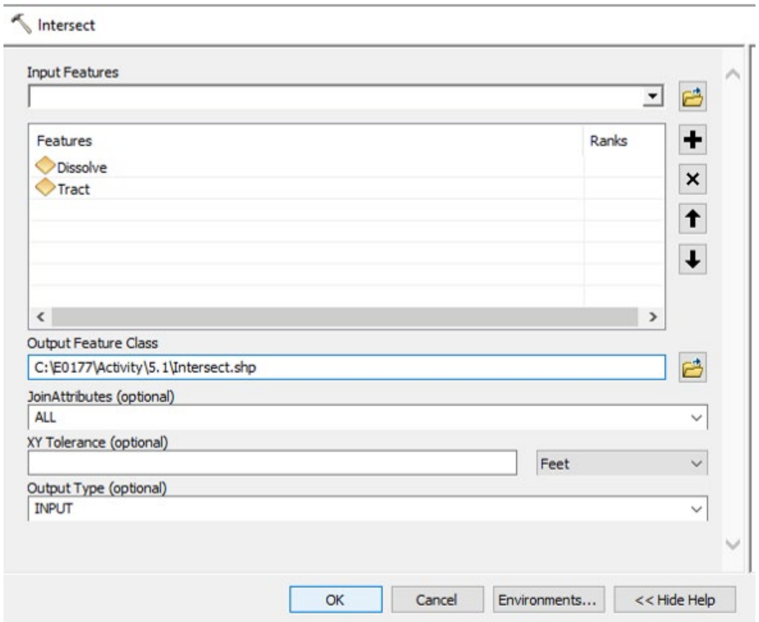


Running the Dissolve Tool for surface roughness

8. Remove the Zoning layer from ArcMap. Combine the dissolved surface roughness and the Tract data. Right click in the map area and select Data Frame Properties, then click on the Coordinate System Tab. Select NAD83_HARN_Virginia_South_ftUS then OK. Click Yes when the warning comes up.

9. Right click on the Tract layer and open the attribute table. Right click on TractArea and select Calculate Geometry, then Yes when the warning comes up, select Square Miles US and then OK. Click Yes when the warning message comes up.

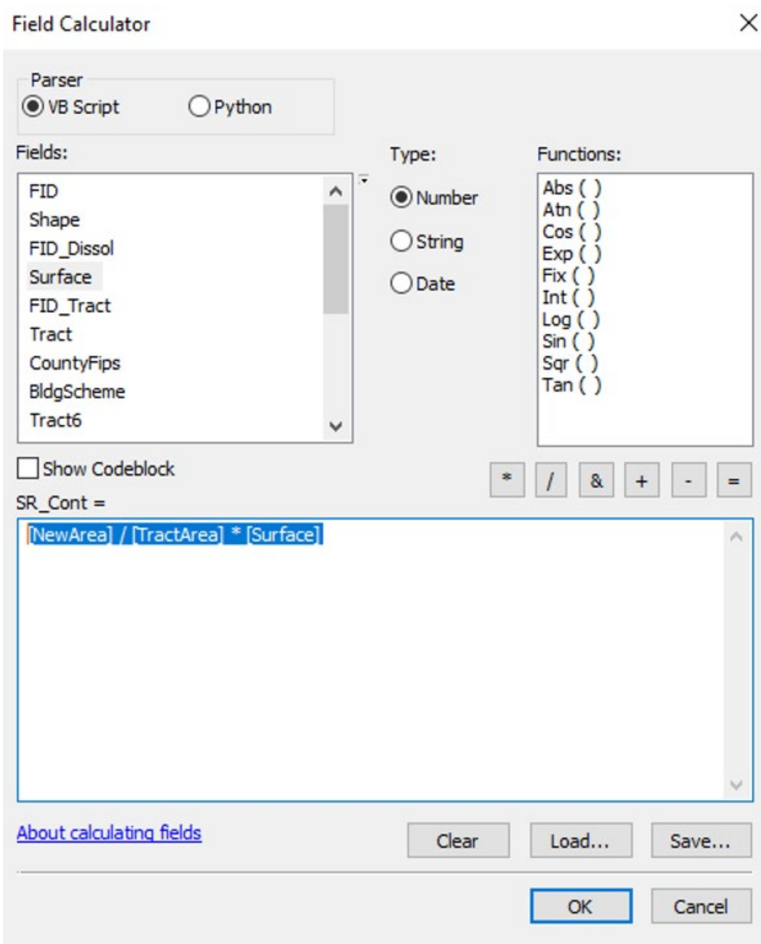
10. Open ArcToolbox, select Overlay, and double click on Intersect. For input features, select the Dissolve and Tract layers. For Output Feature Class, browse to: C:\E0177\Activity\5.1\Intersect.shp. Then click OK.



Running the Intersect Tool for the Census Tract and Dissolved layers

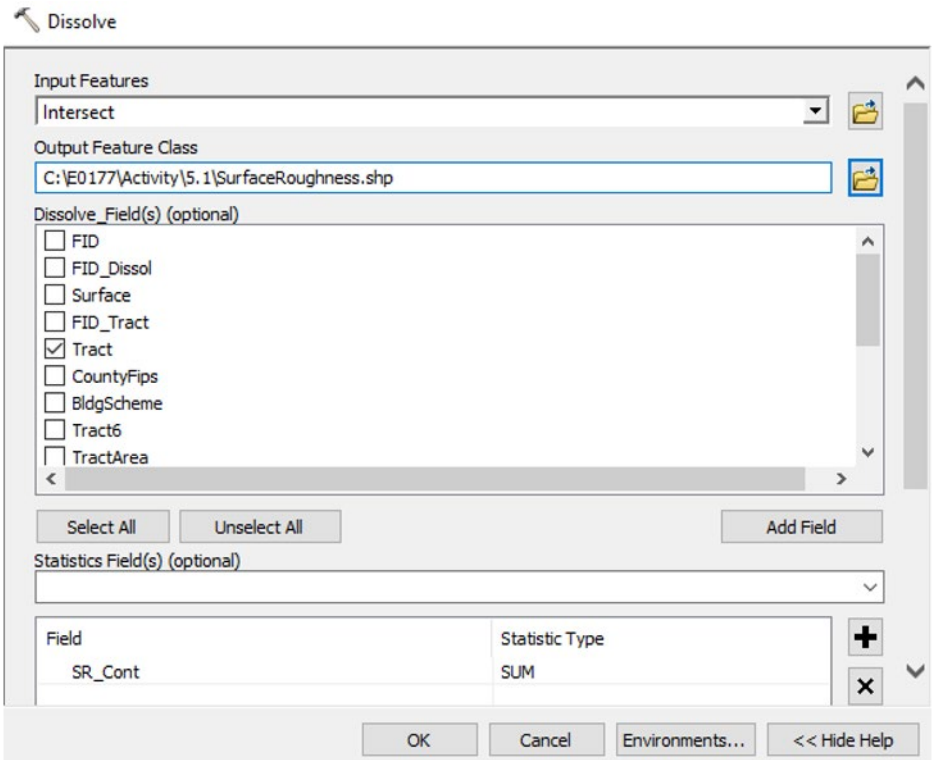
11. Close ArcToolbox. The Intersect layer should automatically be added to the Table of Contents. Remove the Dissolve layer. Open the Intersect layer's attribute table and add a new field called NewArea with a Double data type. Right click on the NewArea field heading and use Calculate Geometry to calculate the area in square miles (US). Click Yes when the warning message comes up and then click OK. Click Yes again when the other warning message comes up.

12. Calculate the surface roughness. Add a field to the Intersect attribute table called SR_Cont with data type Double. This will be the contribution to the surface roughness. Divide the new area by the old area and then multiply that number by the associated surface roughness. Then all the contributions will be added together for a total surface roughness by Census Tract. After adding the new field, right click on the SR_Cont header and select Field Calculator. Click Yes when the warning comes up. Set SR_Cont = [NewArea] / [TractArea] * [Surface].



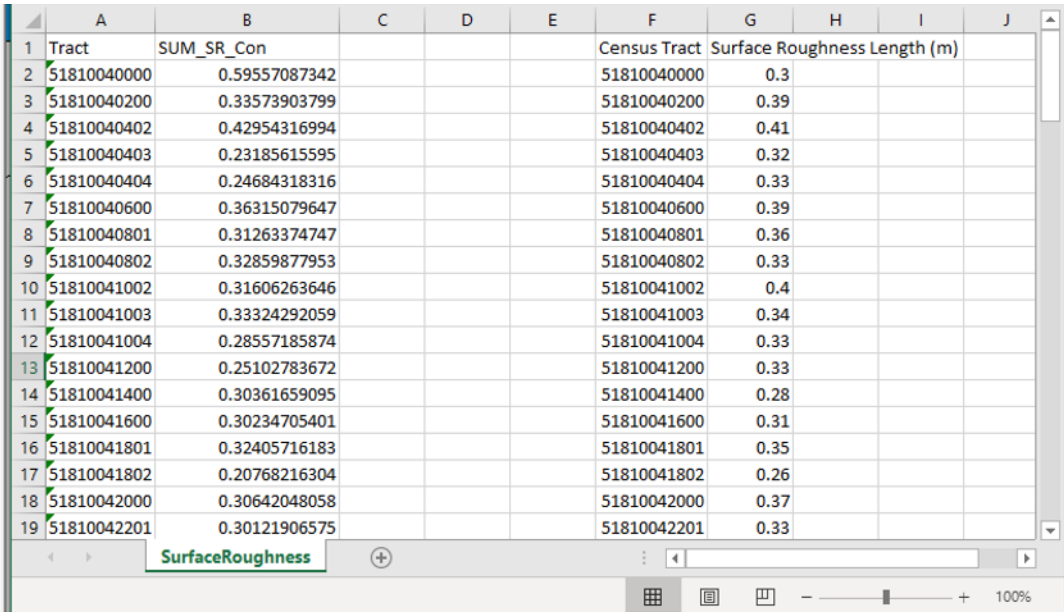
Calculating the surface roughness contribution from each polygon

13. Click on ArcToolbox, then Data Management Tools, then Generalization, and then double click on Dissolve. The Dissolve menu will then come up. For input features, select Intersect, for output feature class browse here: C:\E0177\Activity\5.1\SurfaceRoughness.shp. For Dissolve_Field(s) select Tract. For Statistics Field, use SR_Cont and for Statistic Type use SUM. Then click OK. Close ArcToolbox. You should now have a layer called SurfaceRoughness which contains fields on the Census Tract and surface roughness value. Close ArcMap.



Dissolving the Intersect layer and combining the surface roughness contributions

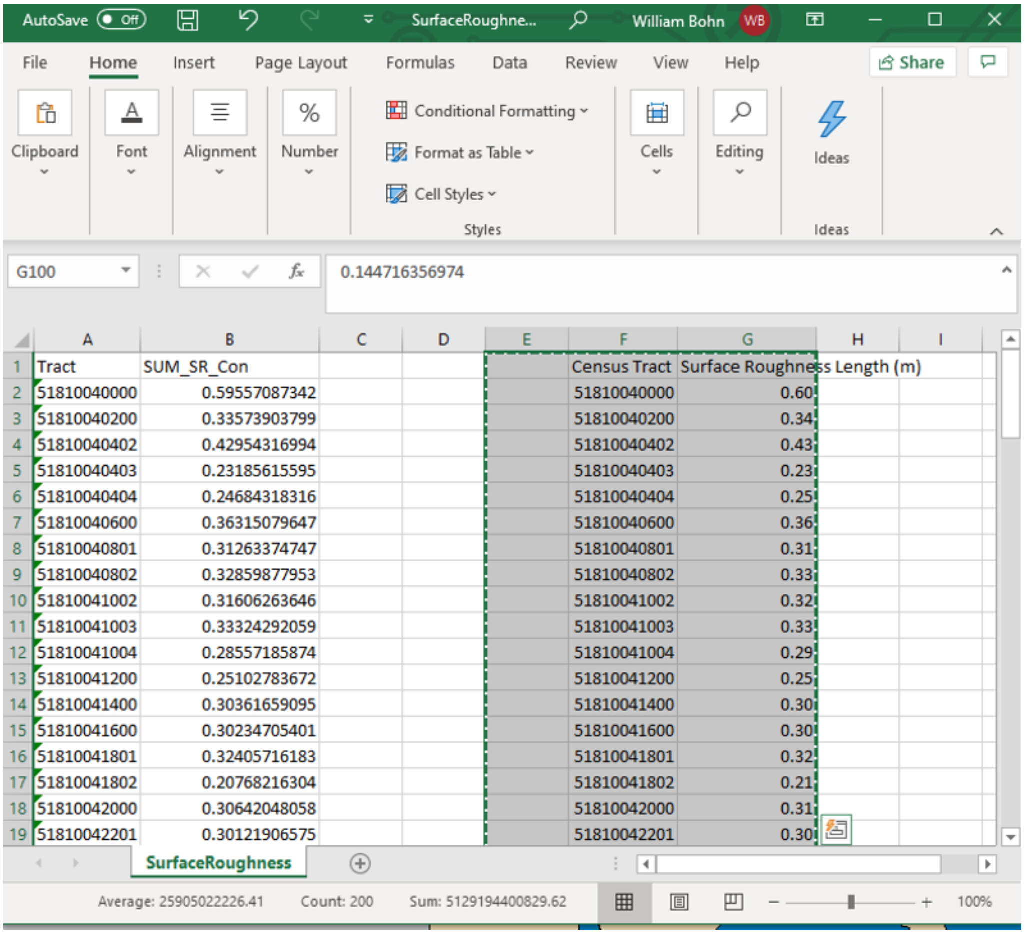
14. Browse to the SurfaceRoughness.dbf file in Windows Explorer and open it in Excel. Open Hazus if it's not already open. Go to Analysis, then Parameters, and Terrain. Click in the top left box to select the entire terrain table. Press Control+C and go back to Excel. Click in the E1 box in Excel and press Control+V. Both columns should be ascending in value so the Census Tract IDs match up.



	A	B	C	D	E	F	G	H	I	J
1	Tract	SUM_SR_Con				Census Tract	Surface Roughness Length (m)			
2	51810040000	0.59557087342				51810040000	0.3			
3	51810040200	0.33573903799				51810040200	0.39			
4	51810040402	0.42954316994				51810040402	0.41			
5	51810040403	0.23185615595				51810040403	0.32			
6	51810040404	0.24684318316				51810040404	0.33			
7	51810040600	0.36315079647				51810040600	0.39			
8	51810040801	0.31263374747				51810040801	0.36			
9	51810040802	0.32859877953				51810040802	0.33			
10	51810041002	0.31606263646				51810041002	0.4			
11	51810041003	0.33324292059				51810041003	0.34			
12	51810041004	0.28557185874				51810041004	0.33			
13	51810041200	0.25102783672				51810041200	0.33			
14	51810041400	0.30361659095				51810041400	0.28			
15	51810041600	0.30234705401				51810041600	0.31			
16	51810041801	0.32405716183				51810041801	0.35			
17	51810041802	0.20768216304				51810041802	0.26			
18	51810042000	0.30642048058				51810042000	0.37			
19	51810042201	0.30121906575				51810042201	0.33			

Comparing the old values (on right) to the new values (on left)

15. Replace the values in the G column with the values in the B column. Change the formatting in the G column to two decimal places to the right. Now copy the cells from E1 to G100.



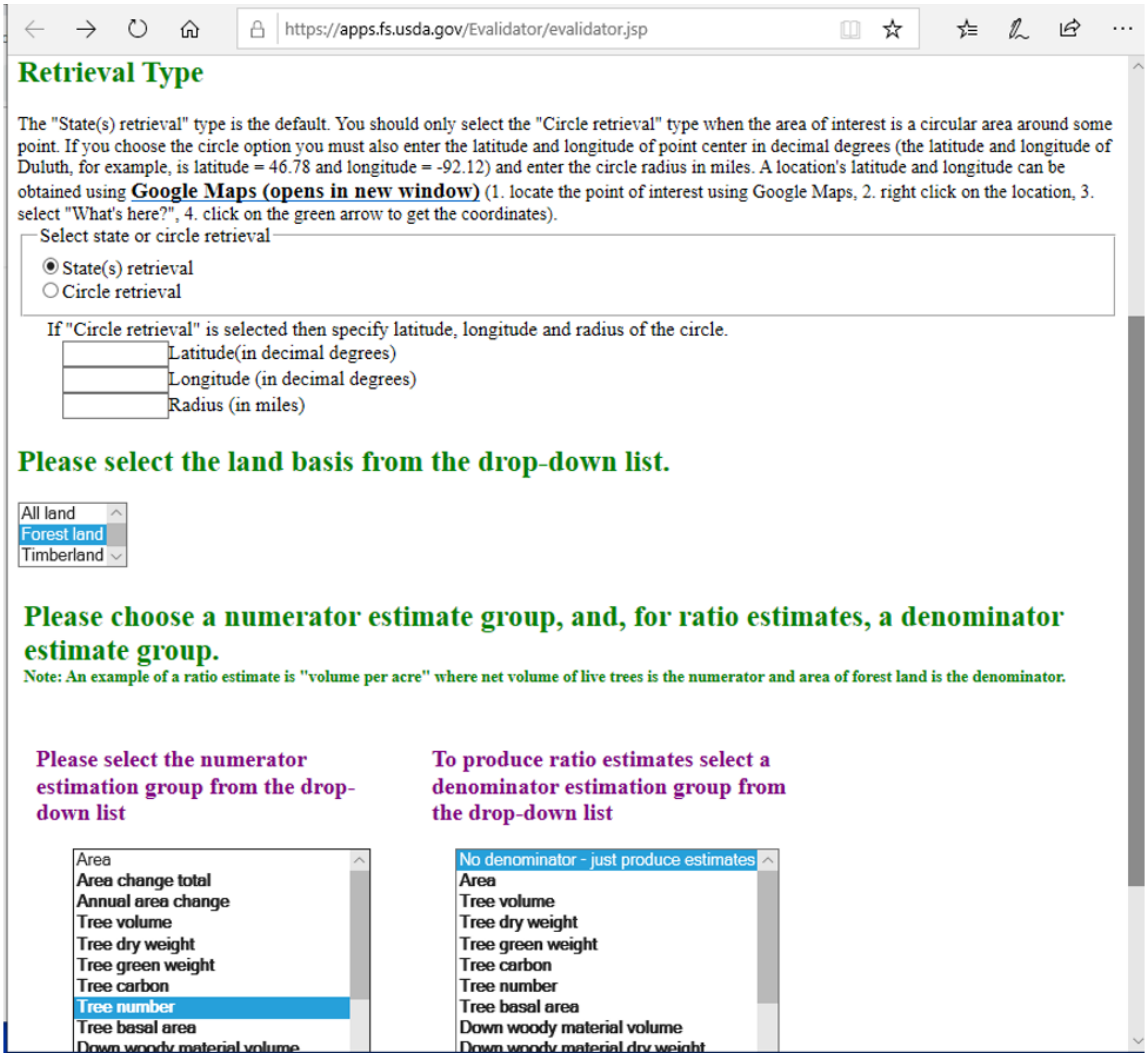
Updating the old values to the new values and formatting

16. Go back into Hazus and paste the cells into the Terrain table. Make sure the whole table is selected before pasting. The values should now all be updated. Click OK and when the message comes up to modify data, click Yes.

Task 2: Update the Tree Inventory

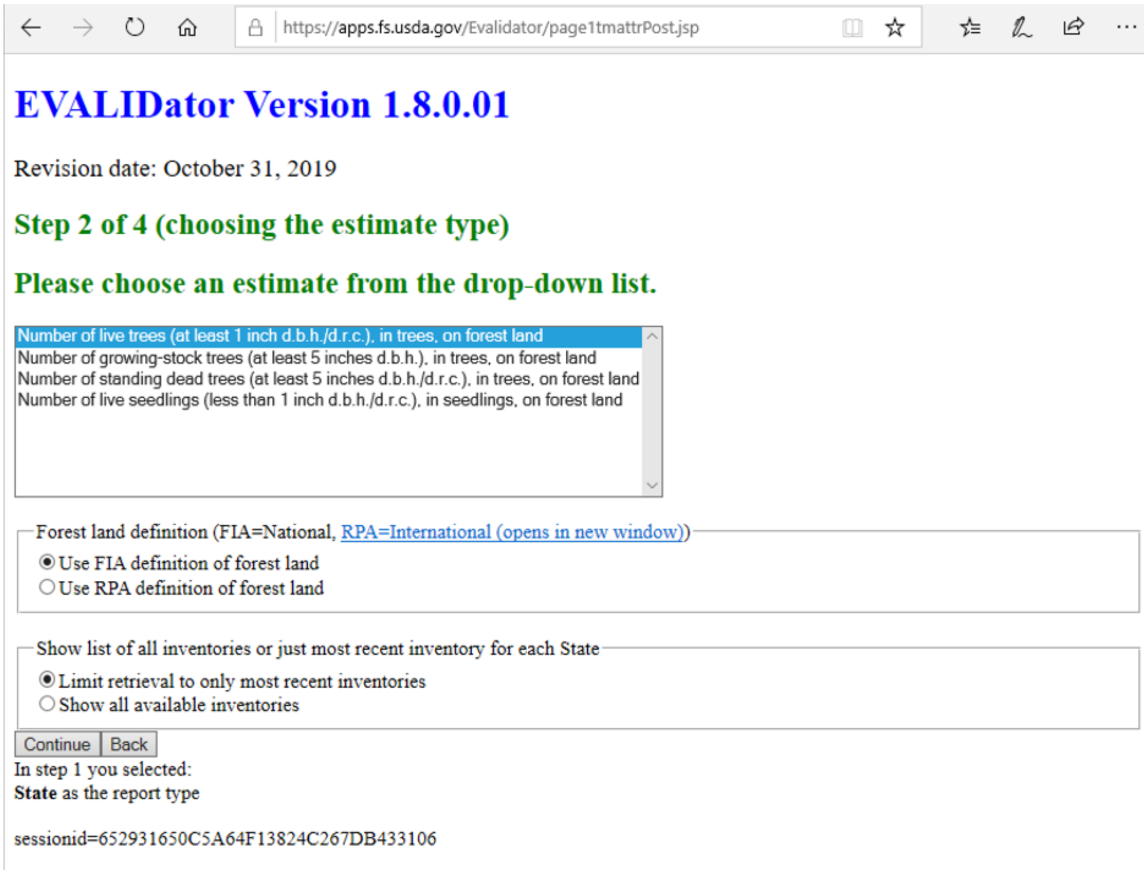
1. Now update the tree inventory. Open a web browser and go to the [Forest Service's EVALIDator website](https://apps.fs.usda.gov/Evalidator/evalidator.jsp) (https://apps.fs.usda.gov/Evalidator/evalidator.jsp).

2. For Retrieval Type, select State(s) retrieval (counties will be selected later). Under land basis, select Forest Land. For estimate group, select Tree number in the left column. In the right column, make sure No denominator is selected. Click Continue.



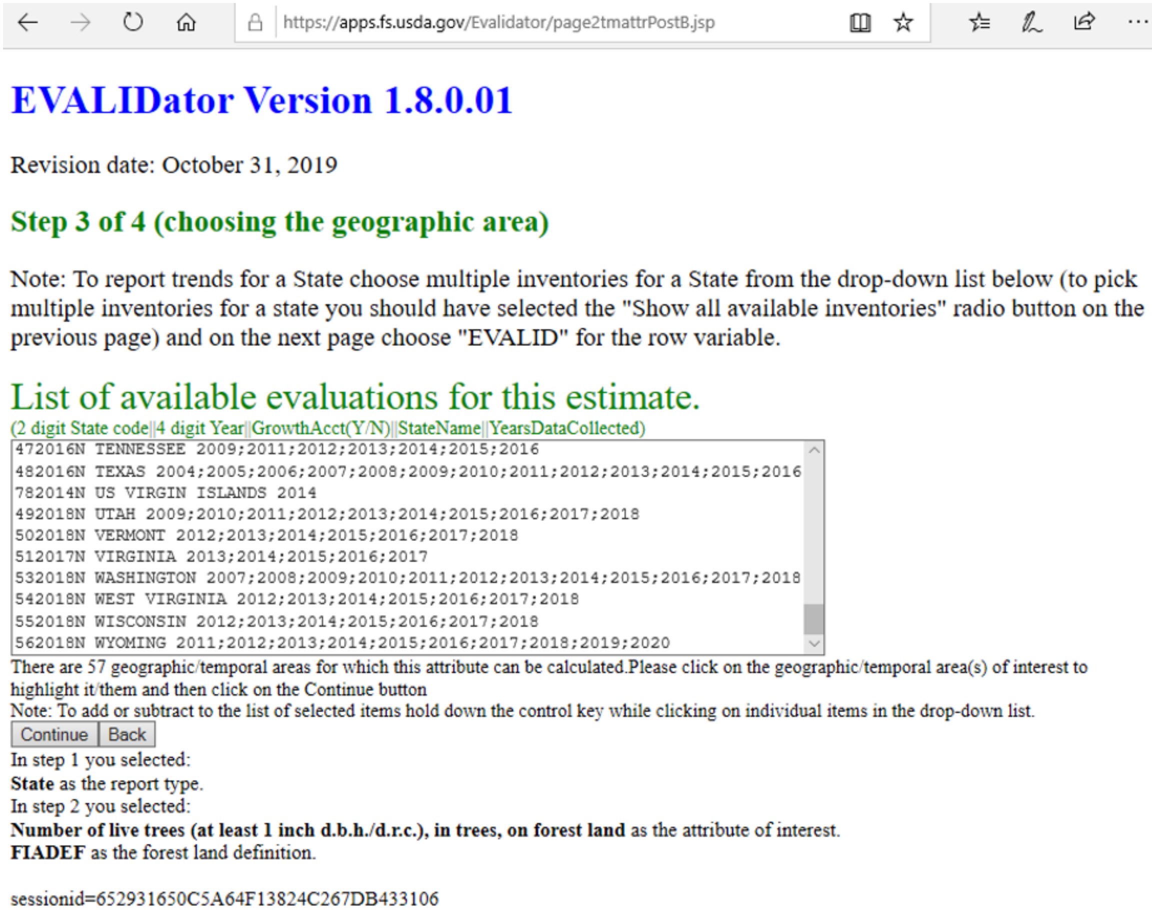
Extracting tree number from the USFS and USDA forest inventory database (Step 1)

3. On the second page, select Number of live trees (at least 1 inch d.b.h./d.r.c.) in trees, on forest land. Under Forest land definition, select Use FIA definition of forest land. Under Show list of all inventories or just most recent inventory for each State, select Limit retrieval to only most recent inventories. Then click Continue.



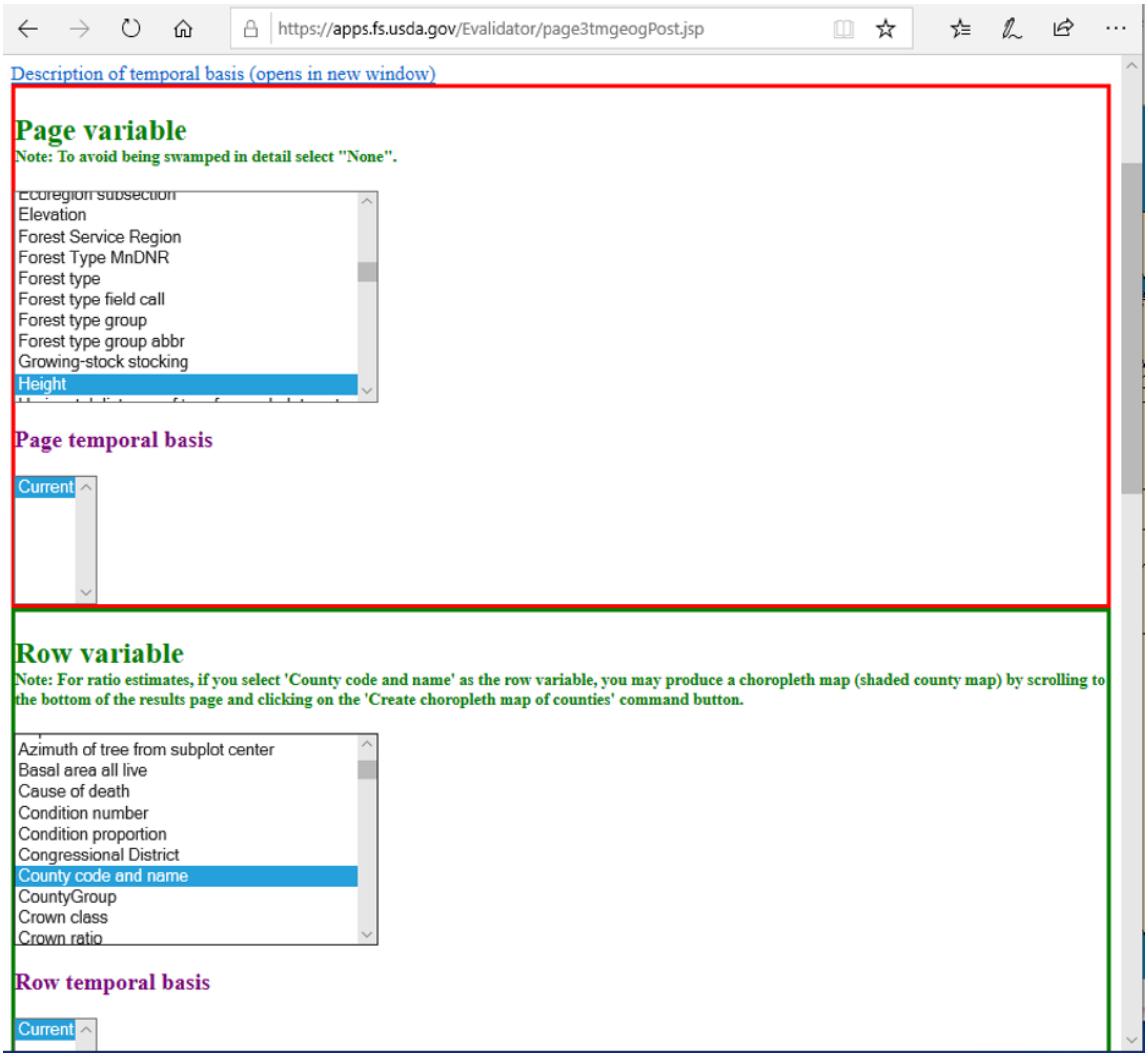
Extracting tree number from the USFS and USDA forest inventory database (Step 2)

4. Under List of available evaluations for this estimate, select 512017N Virginia 2013; 2014; 2015; 2016; 2017. If you're getting data for your own community, select the relevant State. Then click Continue.



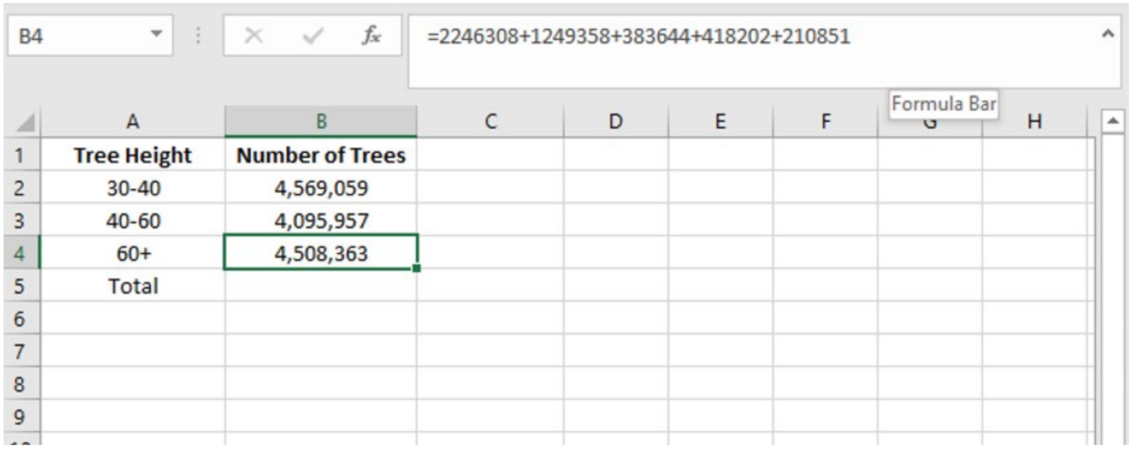
Extracting tree number from the USFS and USDA forest inventory database (Step 3)

5. Under Page variable, select Height. Under Row variable, select County code and name. Under Column variable, select all live stocking. Click the Show results option and Output estimates. Then click Continue.



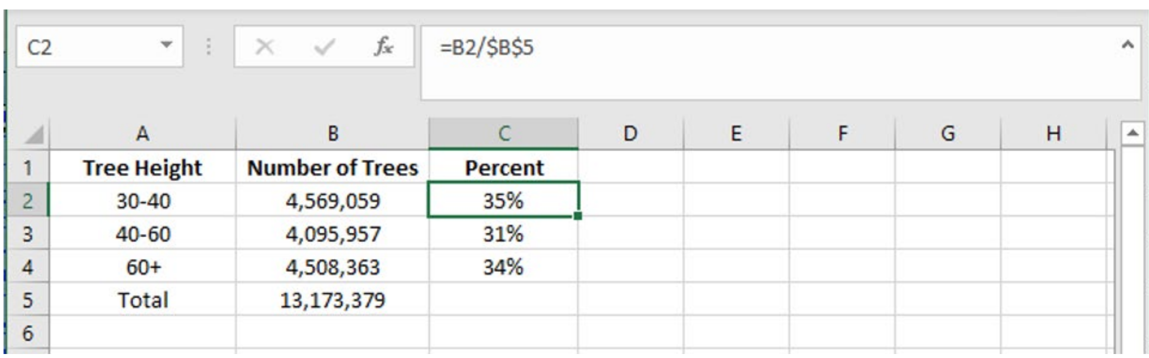
Extracting tree number from the USFS and USDA forest inventory database (Step 4)

6. Hazus categorizes the trees as <40’, 40’-60’, and >60’. The <40’ category is actually 30’-40’ with everything less than 20’ not counted. Open Excel and create a column called tree height with four entries: 30-40, 40-60, 60+, and Total. Add up the totals reported from the forest inventory tool and insert them into Excel. Only use the Virginia Beach data (51810 VA Virginia Beach city).



Categorizing the tree heights

7. Make Total equal to the sum of the three values above it. Add a column header above the numbers called Number of Trees and a header to the right of that one called Percent. Have the percent cell, C2, equal to B2/$B$5.



Calculating the Percentages

8. Copy the C2 cell down to C3 and C4. Then change the formatting of C2-C4 to a percentage. Save the Excel file as: C:\E0177\Activity\5.1\TreeData.xlsx.

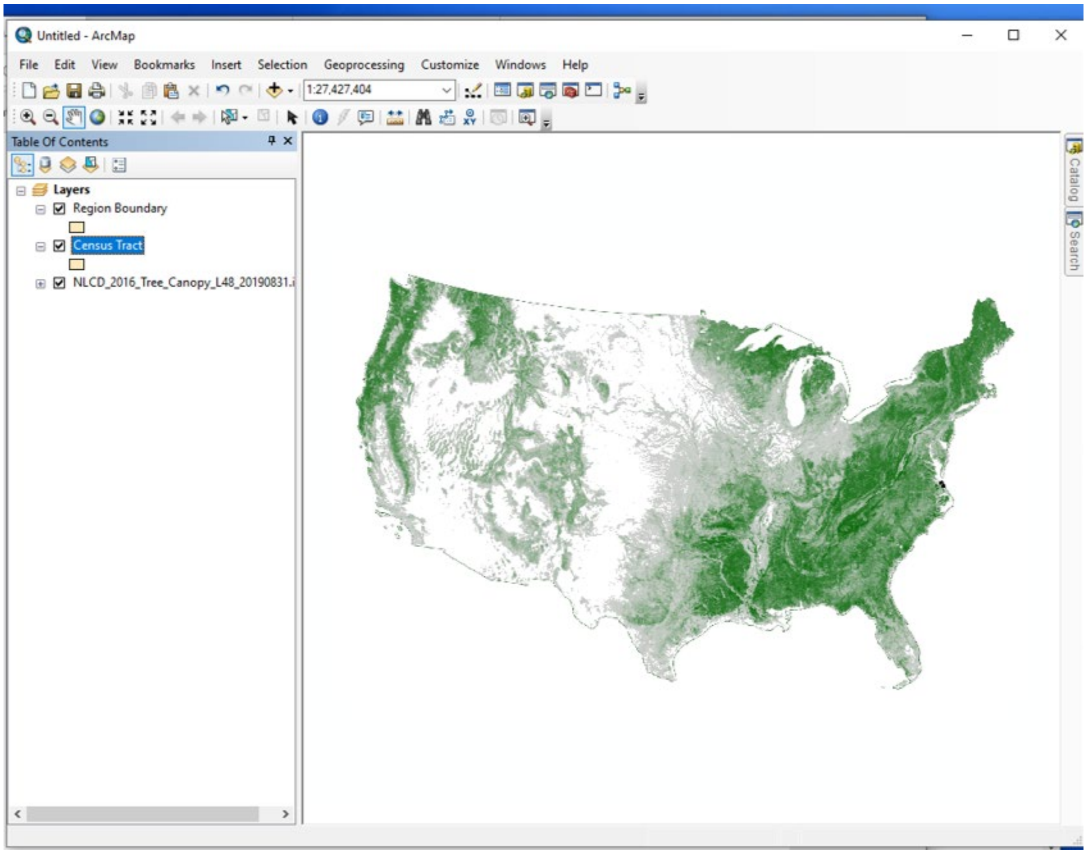
9. The last piece of information needed from the Forest Inventory and Analysis (FIA) Tool is the amount of forest land in Virginia Beach. Go back to Step 1 on the website. Select State for retrieval, then under numerator estimation group, select Area and then Continue. Click Continue for Step 2. Select Virginia for Step 3 and Continue. For Step 4, under Row variable, select County code and name and then Continue. Scroll down to VA Virginia Beach city and see the total acreage is 34,908 acres. Add that value to the spreadsheet and find the average stems per acre by taking the total tree value and dividing by 34908.

B10 =B5/B9

	A	B	C	D	E
1	**Tree Height**	**Number of Trees**	**Percent**		
2	30-40	4,569,059	35%		
3	40-60	4,095,957	31%		
4	60+	4,508,363	34%		
5	Total	13,173,379			
6					
7					
8					
9	**Total Forested Area:**	34908	Acres		
10	Average Tree Density:	377.37	Stems per Acre		
11					
12					

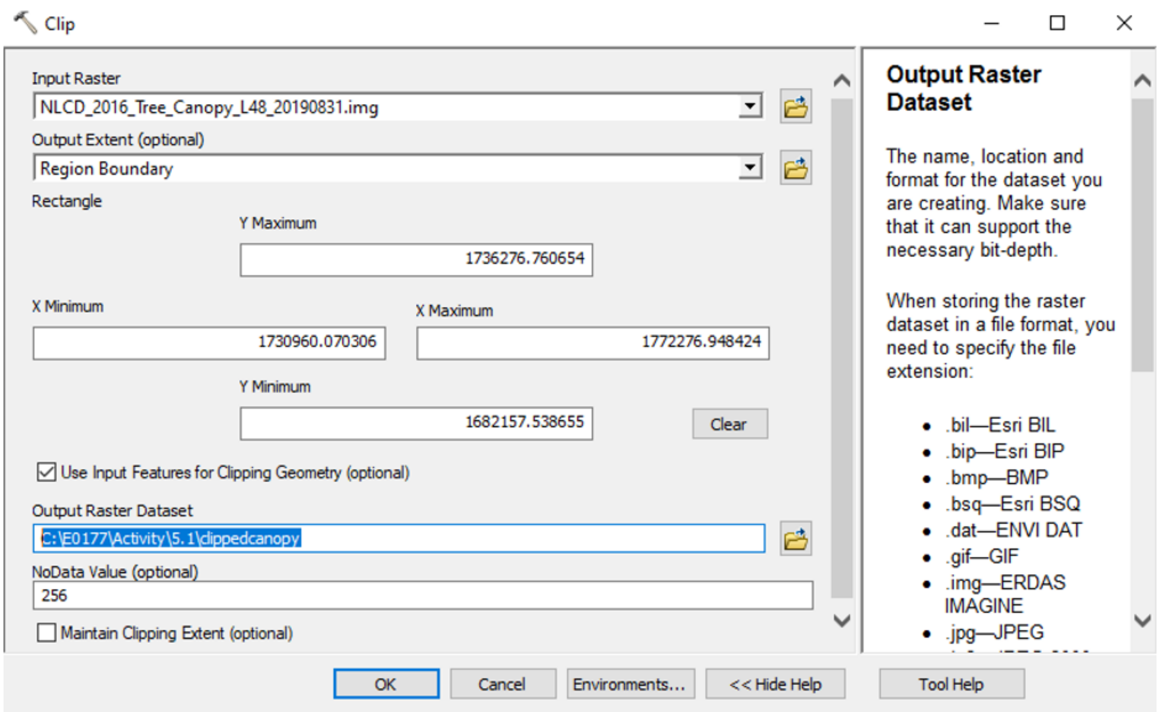
Average Stems per Acre

10. Determine average and 100% tree canopy. Open the study region in Hazus and then open ArcMap separately. In ArcMap, add the tree canopy layer found here: C:\E0177\Activity\5.1\NLCD_2016_Tree_Canopy_L48_20190831.img. Copy the study region boundary and Census Tract layer from Hazus into ArcMap. The tree canopy data was downloaded from the Multi-Resolution Land Characteristics Consortium (https://www.mrlc.gov/data). Close Hazus.



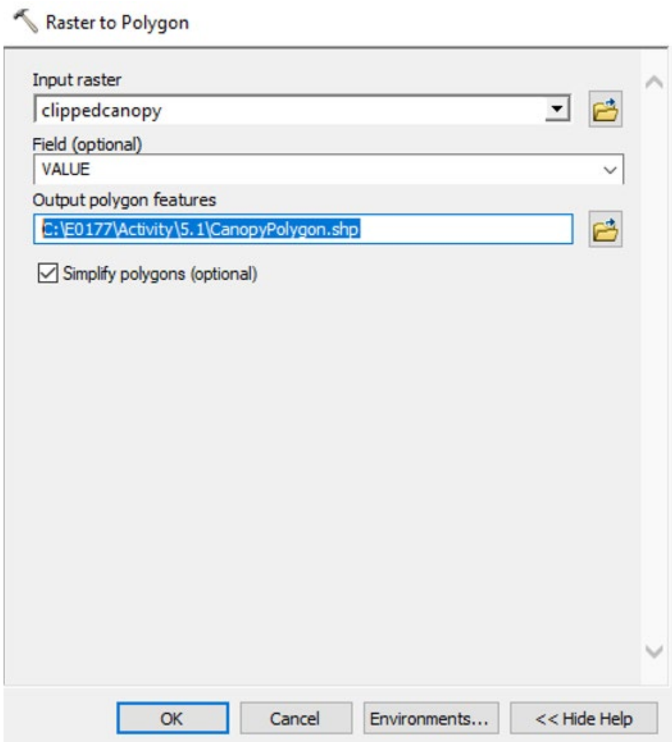
Tree Canopy Data from NLCD

11. Open ArcToolbox, then select Data Management, Raster, Raster Processing and Clip. For the input raster, select NLCD_2016_Tree_Canopy_L48_20190831.img; for output extent, select Region Boundary; and make sure the box for Use Input Features for Clipping Geometry is checked. Under Output Raster Dataset, browse here: C:\E0177\Activity\5.1\ and save as clippedcanopy. Then click OK.



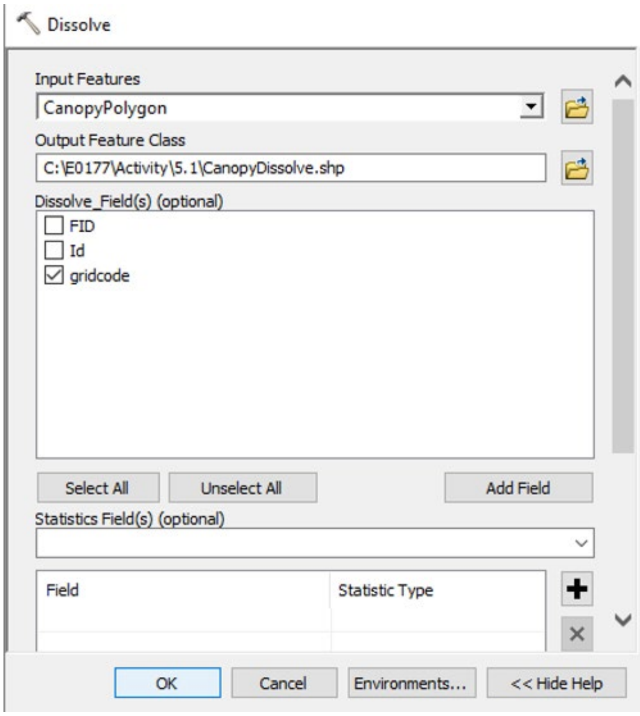
Clipping the tree canopy data based on the study region

12. Remove the NLCD_2016_Tree_Canopy_L48_20190831.img layer. Next, you'll dissolve the data so it is easier to manipulate. Open ArcToolbox, select Conversion Tools, then From Raster, and Raster to Polygon. For the input raster, select clippedcanopy, for output polygon features, browse here: C:\E0177\Activity\5.1\CanopyPolygon.shp. Click OK.



Converting clipped raster canopy to a polygon layer

13. While ArcToolbox is open, click Data Management, Generalization, and Dissolve. Use the CanopyPolygon as the input features, for output feature class browse here: C:\E0177\Activity\5.1\CanopyDissolve.shp, and for Dissolve_Field(s) select gridcode. Click OK.

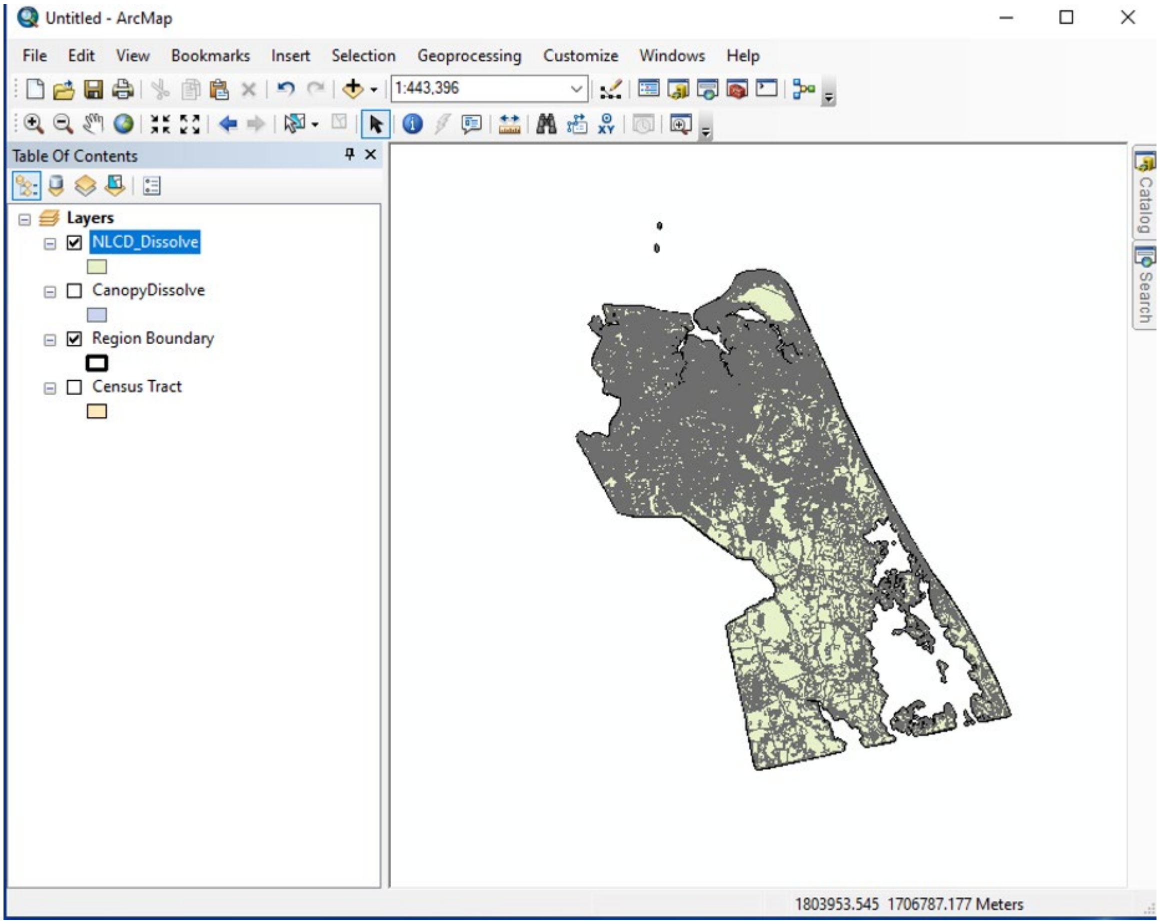


Final formatting in WordPad

14. Open the CanopyDissolve attribute table, and select Start Editing from the Editor toolbar. Click on CanopyDissolve when selecting the layer to edit and then OK. Click Continue when the warning comes up. Select the row which has a gridcode of 0, right click on it and select Delete Selected. Go to Editor and Stop Editing. Click Yes when the message comes up about saving your edits. Close the attribute table and ArcToolbox.

15. Now open the national landcover data which has already been downloaded for you here: C:\E0177\Activity\5.1\NLCD_2016_Land_Cover_L48_20190424.img. The landcover data was downloaded from the MRLC website (https://www.mrlc.gov/data).

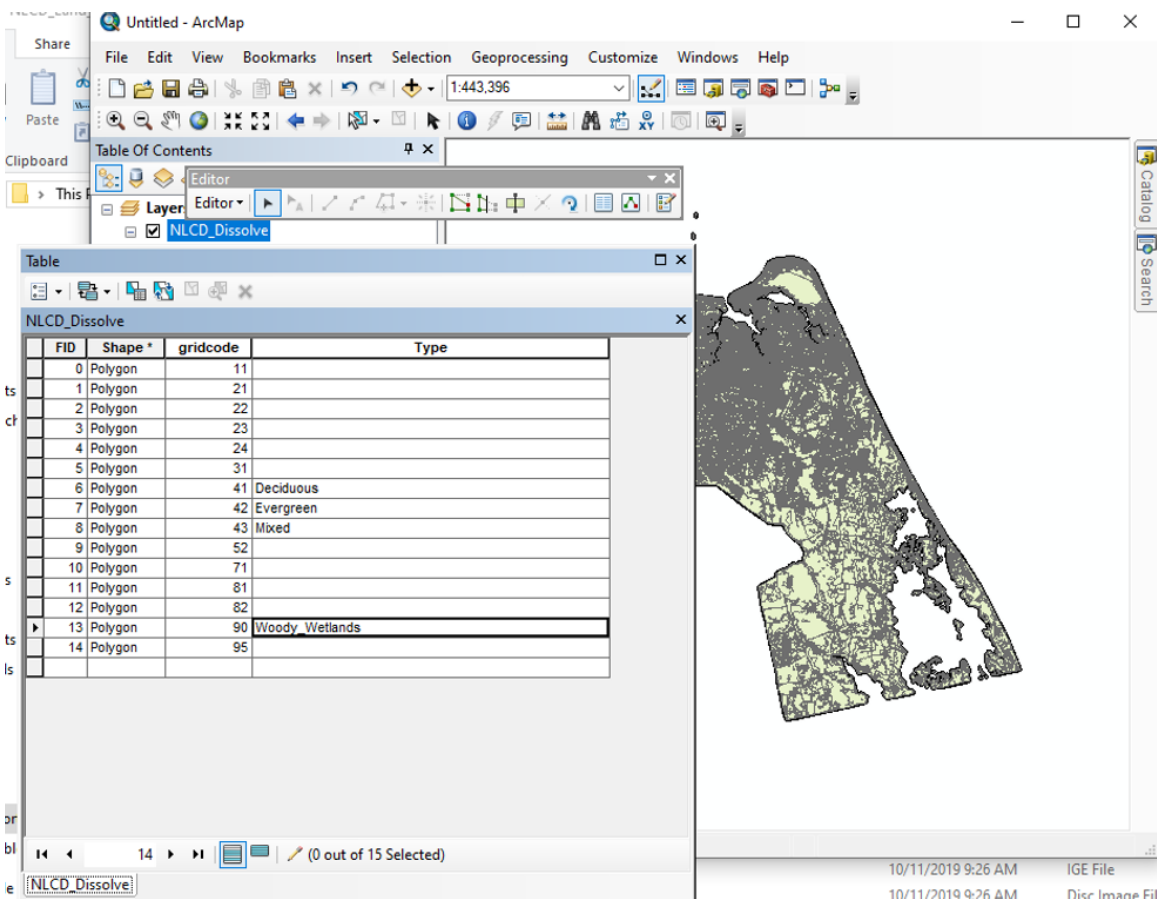
16. Next, use ArcToolbox to clip, convert to polygon, and dissolve the NLCD_2016_Land_Cover_L48_20190424.img layer. Call the final layer NLCD_Dissolve. Refer to the steps above if you forget how to complete a step. Remove all the layers except NLCD_Dissolve, CanopyDissolve, Region Boundary, and Census Tract.



Dissolved NLCD and Canopy layers

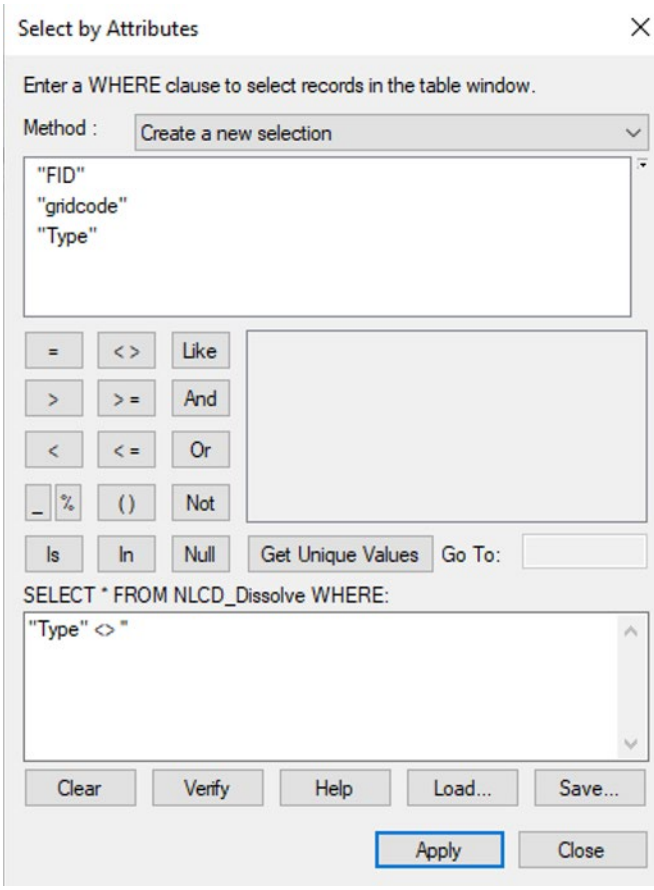
17. Now, determine what the NLCD codes stand for in the data. Open C:\E0177\Activity\5.1\National_Land_Cover_Database_(NLCD)_Land_Cover_Collection.xml. Scroll down until the grid codes are defined. Look for: evergreen forest (42), deciduous forest (41), mixed forest (43), and woody wetlands (90).

18. Open the NLCD_Dissolve attribute table and add a new field called Type with a data type of Text that is 40 characters long. Then click OK. Then go to Editor and Start Editing. Select NLCD_Dissolve to edit and click OK. Select Continue when the warning message comes up. Find the 42 value in the gridcode and type Evergreen under Type - 41 is Deciduous, 43 is Mixed, and 90 is Woody_Wetlands.



Assigning landcover types to the gridcodes

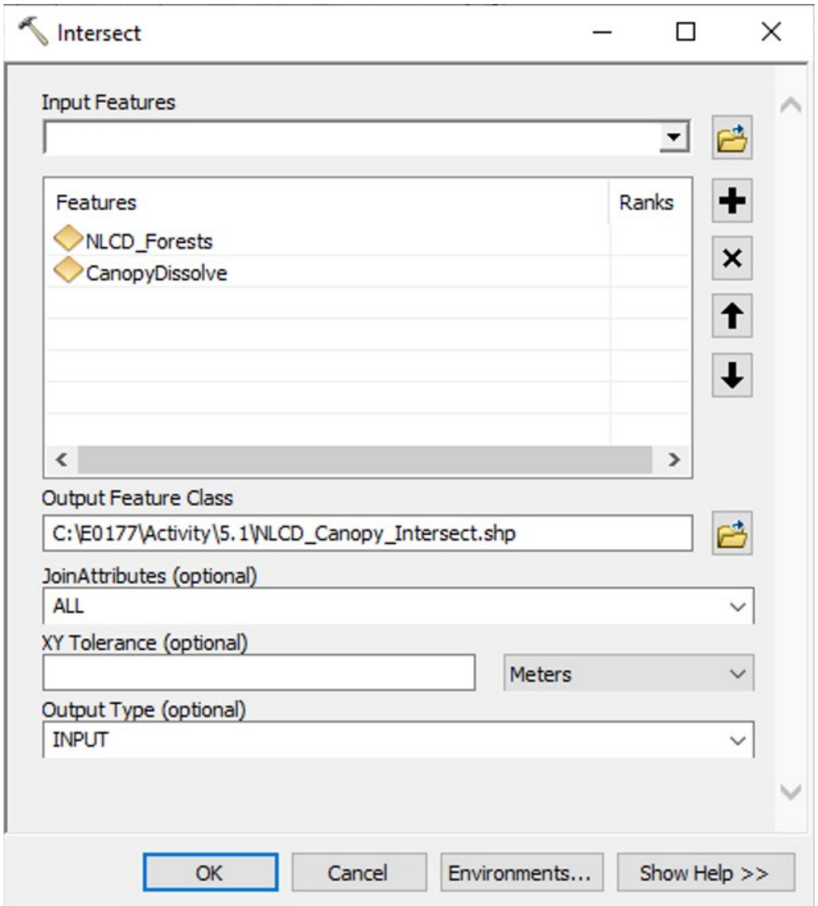
19. Click Editor and Stop Editing. Click Yes to save the edits. From the attribute table, run Select by Attributes, Method is Create a new selection, double click on the Type field, then Get Unique Values, click on the <> symbol, and then double click on the " value in the box.



Final formatting in WordPad

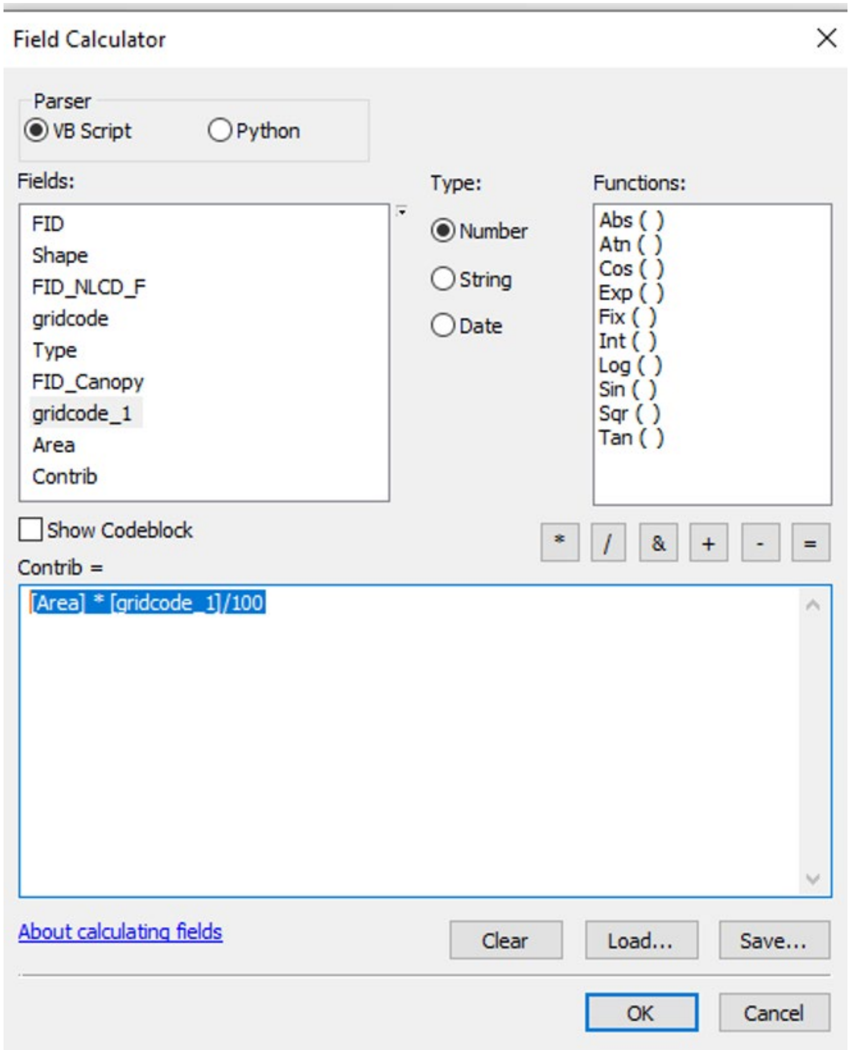
20. The four records with values under Type should now be selected. This is the forested area. Right click on NLCD_Dissolve and export as C:\E0177\Activity\5.1\NLCD_Forests.shp. Add the layer to the map. Close the attribute table and remove the NLCD_Dissolve layer from the table of contents.

21. Open ArcToolbox and click Analysis Tools, Overlay, and Intersect. Select NLCD_Forests and CanopyDissolve as the Input Features. Save the output feature class as: C:\E0177\Activity\5.1\NLCD_Canopy_Intersect.shp. Then click OK.



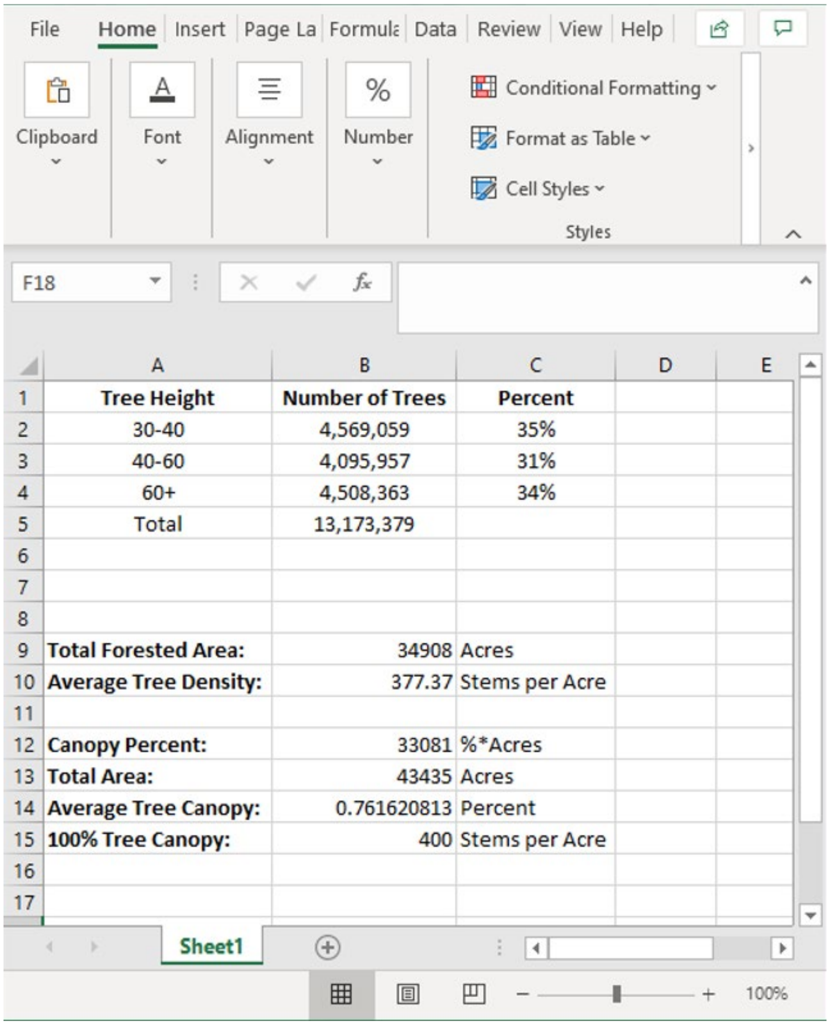
Intersecting the canopy data with the forested areas

22. Open the attribute table for NLCD_Canopy_Intersect. Now calculate the average canopy percentage in the forested areas. Add two fields called Area and Contrib with a Double data type. Right click on Area and select Calculate Geometry. Click Yes when the warning message comes up. The property will be Area using the PCS: WGS 1984 Albers coordinate system and the units will be Acres US. Then click OK and Yes when the warning message comes up. The field called gridcode_1 is the percent of forest canopy. Use the field calculator on the Contrib field. Make Contrib = [Area] * [gridcode_1]/100. Divide by 100 because the grid value is a percentage. Click Ok.



Calculating the average canopy coverage for the county

23. Right click on the Contrib column header and select Statistics and record the sum in the Excel spreadsheet as Canopy Percent, then right click on the Area column header and select Statistics and record the sum in the Excel spreadsheet as Total Area. In the spreadsheet, take the Canopy Percent and divide it by the Total Area to get Average Tree Canopy. So if the average stems per acre is 377 which is at a 76% canopy to get to 100% canopy: 377/.76 = 496 stems per acre. The Hazus developers capped stems per acre at 400 so that is the value you'll use.



	A	B	C	D	E
1	Tree Height	Number of Trees	Percent		
2	30-40	4,569,059	35%		
3	40-60	4,095,957	31%		
4	60+	4,508,363	34%		
5	Total	13,173,379			
6					
7					
8					
9	Total Forested Area:	34908	Acres		
10	Average Tree Density:	377.37	Stems per Acre		
11					
12	Canopy Percent:	33081	%*Acres		
13	Total Area:	43435	Acres		
14	Average Tree Canopy:	0.761620813	Percent		
15	100% Tree Canopy:	400	Stems per Acre		
16					
17					

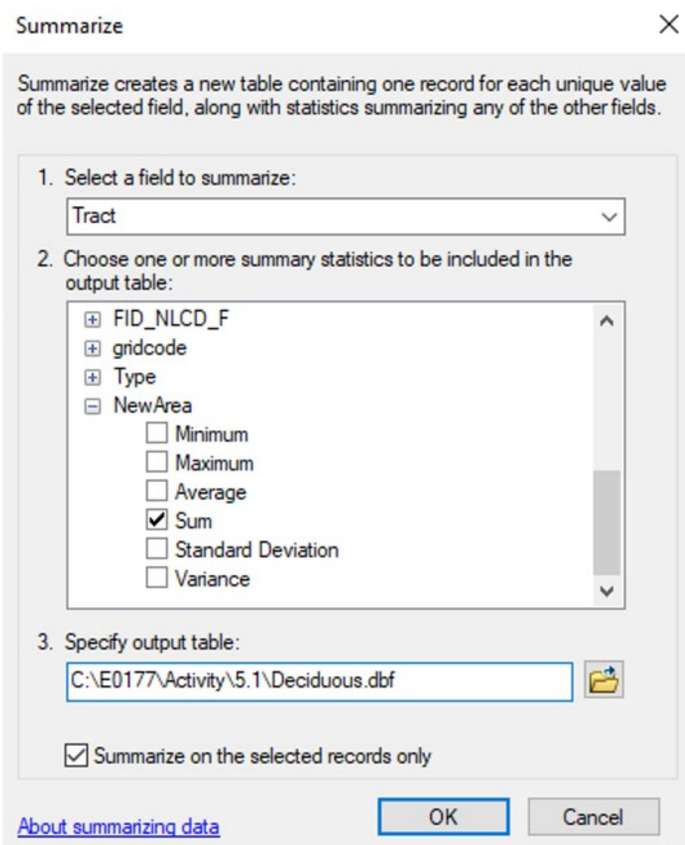
Average tree canopy in forested areas

24. Assign tree parameters to Census Tracts. Go back to ArcMap and export the Census Tract layer to C:\E0177\Activity\5.1\Tract.shp and add it to the map. Open the attribute table of the Tract layer and right click on TractArea and use Calculate Geometry to calculate the area in Acres US. Close the attribute table.

25. Open ArcToolbox and perform an Intersect between Tract and NLCD_Forests and call it: C:\E0177\Activity\5.1\Tract_ForestType_Intersect.shp. Close ArcToolbox.

26. Open the attribute table of Tract_ForestType_Intersect and add a new field called NewArea with a Double data type. Then use Calculate Geometery to calculate the area in Acres US.

27. Create a query using Select by Attribute to select all records with the "Type" = 'Deciduous'. Next right click on Tract and select Summarize. For Select a field to summarize: use Tract, for summary statistics, click on NewArea and check the box next to Sum. For Specify output table: choose C:\E0177\Activity\5.1\Deciduous.dbf. Change the Save as type: to dBASE table. Make sure the box next to Summarize on the selected records only is checked.

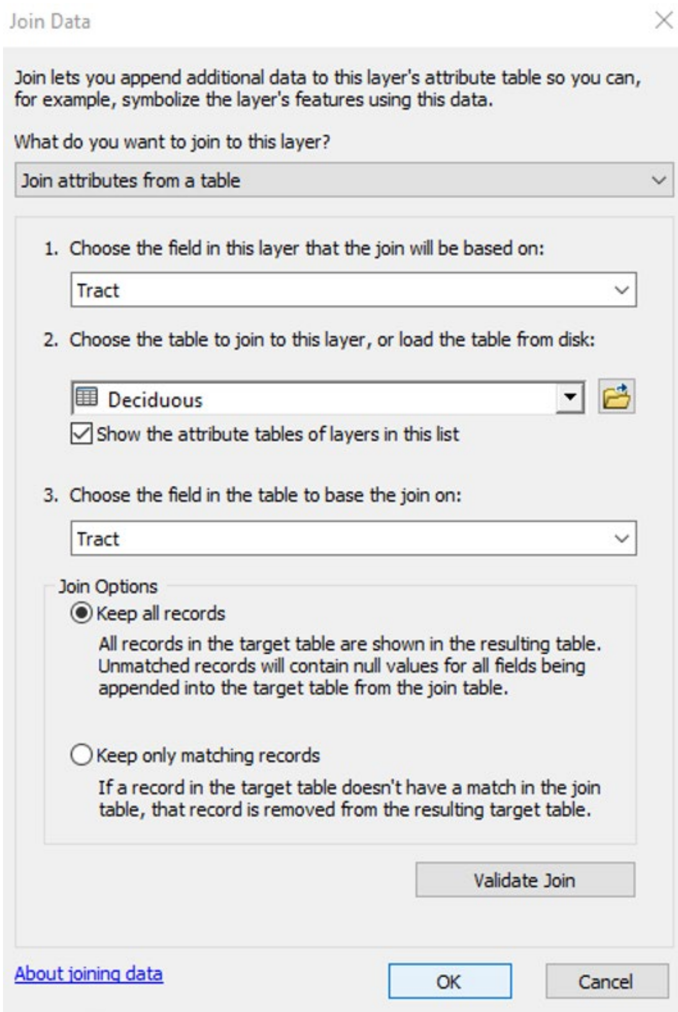


Area of deciduous trees

28. Add the result to the map. Now run the same process for Evergreen and name the file Evergreen.dbf. Now clear the selection and run a summarize for the whole table and call it ForestedAreas.dbf.

29. Right click on the Deciduous dbf file in ArcMap and select Properties. Click on the Fields tab. Change the Alias of Sum_NewArea to Dec_Area. Then click OK. Now do the same thing with the Evergreen dbf file and change the field alias to EG_Area. Change the Sum_NewArea in the ForestedAreas dbf to Forest_Area.

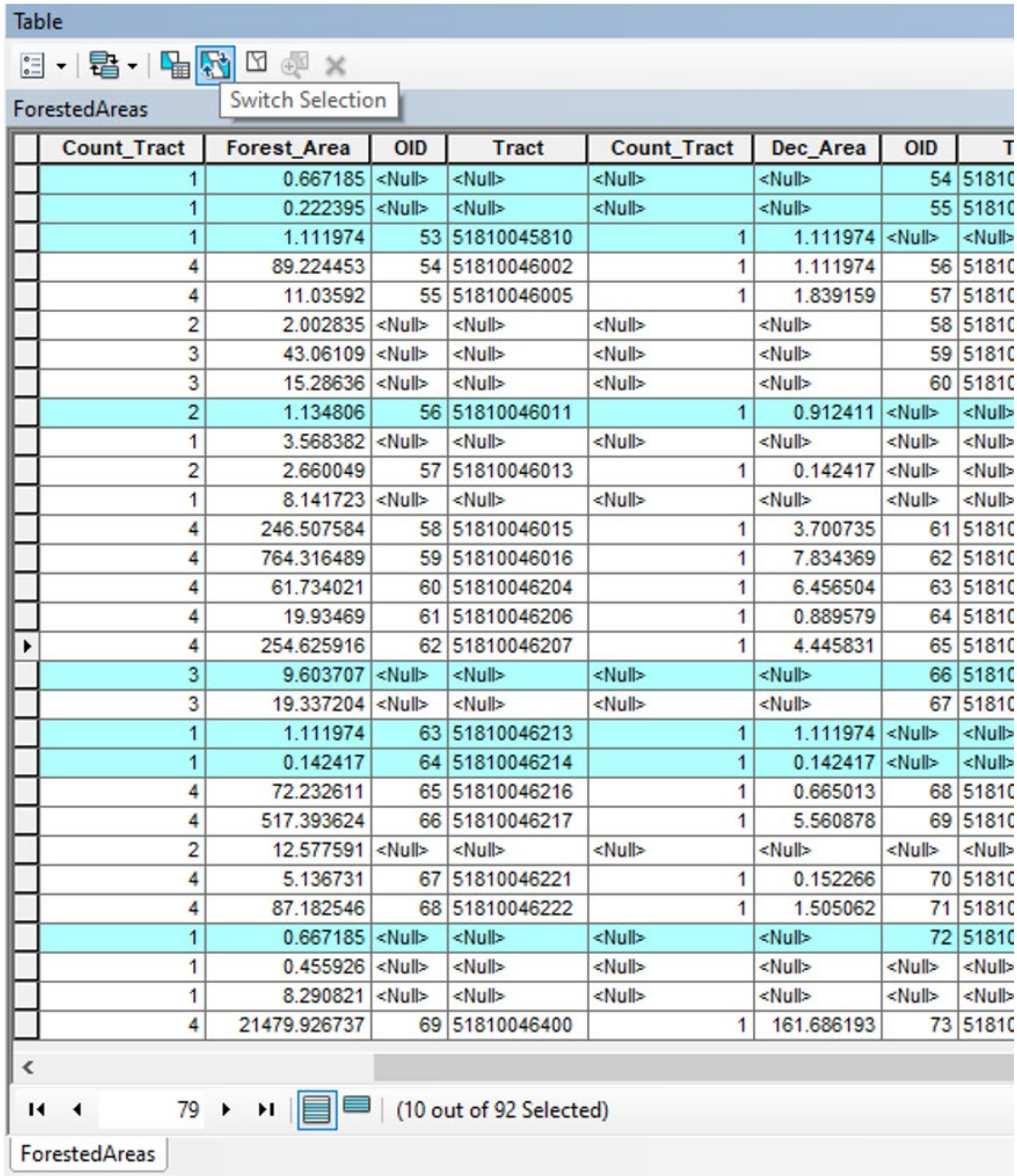
30. Right click on ForestedAreas and then click Joins and Relates and then Join. Select Join attributes from a table, then select the Tract field, then Deciduous layer, then Tract field, Keep all records, and OK.



Joining the ForestedAreas table to the Deciduous Table

31. Join ForestedAreas to the Evergreen table using the same process. Open the ForestedAreas table and create two new fields: Dec_Perc and EG_Perc both with a Double data type. Use the Field Calculator on the Dec_Perc field: [Deciduous.Sum_NewAre] / [ForestedAreas.Sum_NewAre]. Now use the Field Calculator on the EG_Perc field: [Evergreen.Sum_NewAre] / [ForestedAreas.Sum_NewAre].

32. Create a new field called Type with a data type of Text that is 30 characters long. Select by Attribute for "ForestedAreas.Dec_Perc" >=.75. Four records should be selected. Now use Field Calculator on the Type field and assign these four selected records a value of “Deciduous”. Select by Attribute for "ForestedAreas.EG_Perc" >=.75. Six records should be selected. Use Field Calculator on the Type field and assign these four selected records a value of “Coniferous”, which is the Hazus terminology. Use Select by Attribute to select all the records which were previously selected: "ForestedAreas.EG_Perc" >=.75 OR "ForestedAreas.Dec_Perc" >=.75. Then click on the switch selection button.



Count_Tract	Forest_Area	OID	Tract	Count_Tract	Dec_Area	OID	T
1	0.667185	<Null>	<Null>	<Null>	<Null>	54	51810
1	0.222395	<Null>	<Null>	<Null>	<Null>	55	51810
1	1.111974	53	51810045810	1	1.111974	<Null>	<Null>
4	89.224453	54	51810046002	1	1.111974	56	51810
4	11.03592	55	51810046005	1	1.839159	57	51810
2	2.002835	<Null>	<Null>	<Null>	<Null>	58	51810
3	43.06109	<Null>	<Null>	<Null>	<Null>	59	51810
3	15.28636	<Null>	<Null>	<Null>	<Null>	60	51810
2	1.134806	56	51810046011	1	0.912411	<Null>	<Null>
1	3.568382	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
2	2.660049	57	51810046013	1	0.142417	<Null>	<Null>
1	8.141723	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
4	246.507584	58	51810046015	1	3.700735	61	51810
4	764.316489	59	51810046016	1	7.834369	62	51810
4	61.734021	60	51810046204	1	6.456504	63	51810
4	19.93469	61	51810046206	1	0.889579	64	51810
4	254.625916	62	51810046207	1	4.445831	65	51810
3	9.603707	<Null>	<Null>	<Null>	<Null>	66	51810
3	19.337204	<Null>	<Null>	<Null>	<Null>	67	51810
1	1.111974	63	51810046213	1	1.111974	<Null>	<Null>
1	0.142417	64	51810046214	1	0.142417	<Null>	<Null>
4	72.232611	65	51810046216	1	0.665013	68	51810
4	517.393624	66	51810046217	1	5.560878	69	51810
2	12.577591	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
4	5.136731	67	51810046221	1	0.152266	70	51810
4	87.182546	68	51810046222	1	1.505062	71	51810
1	0.667185	<Null>	<Null>	<Null>	<Null>	72	51810
1	0.455926	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
1	8.290821	<Null>	<Null>	<Null>	<Null>	<Null>	<Null>
4	21479.926737	69	51810046400	1	161.686193	73	51810

Switching the selection

33. Use the field calculator on the Type field to assign a value of "Mixed" for the selected records. Clear the selection, close the table, and remove all joins from ForestedAreas. Open the attribute table for ForestedAreas. Add three fields: Hgt_LT_40, Hgt_40to60, Hgt_GT_60 and make the data type Short Integer. Review the treedata.xlsx and percent 30-40 (35%), 40-60 (31%), and 60+ (34%). Use the Field Calculator to add these values in the three fields for every record.

Table

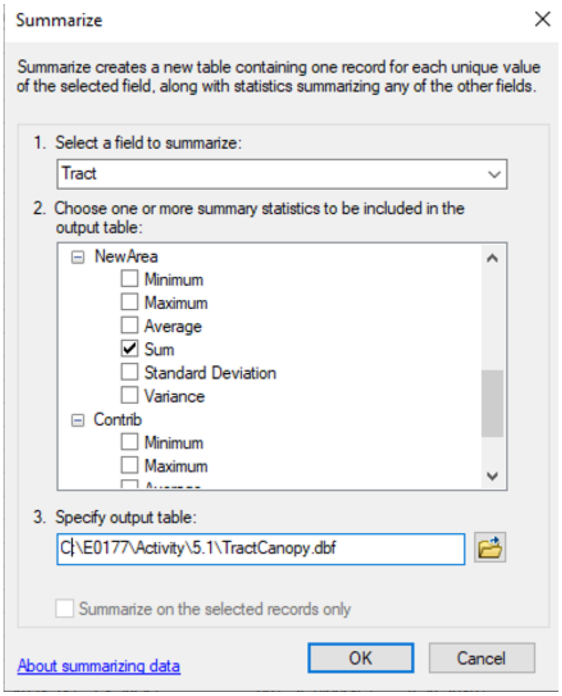
ForestedAreas

OID	Tract	Count_Tract	Forest_Area	ForestedAreas.Dec_Perc	ForestedAreas.EG_Perc	Type	Hgt_LT_40	Hgt_40to60	Hgt_GT_60
0	51810040000	4	160.765684	0.001383	0.420208	Mixed	35	31	34
1	51810040200	4	105.148301	0.022505	0.207999	Mixed	35	31	34
2	51810040402	2	6.587738	0	0	Mixed	35	31	34
3	51810040403	4	55.636943	0.007995	0.271651	Mixed	35	31	34
4	51810040404	4	128.748019	0.040171	0.273059	Mixed	35	31	34
5	51810040600	4	36.44292	0.036615	0.311104	Mixed	35	31	34
6	51810040801	1	1.779159	0	0	Mixed	35	31	34
7	51810040802	1	3.560197	0	0	Mixed	35	31	34
8	51810041003	3	5.185514	0	0.042497	Mixed	35	31	34
9	51810041200	4	223.849618	0.025549	0.436138	Mixed	35	31	34
10	51810041400	4	125.153156	0.014835	0.648942	Mixed	35	31	34
11	51810041600	4	90.009399	0.080177	0.599469	Mixed	35	31	34
12	51810041801	4	65.619577	0.060749	0.175956	Mixed	35	31	34
13	51810041802	4	52.184412	0.079325	0.431672	Mixed	35	31	34
14	51810042000	4	569.434076	0.020903	0.603955	Mixed	35	31	34

Adding tree height percentages

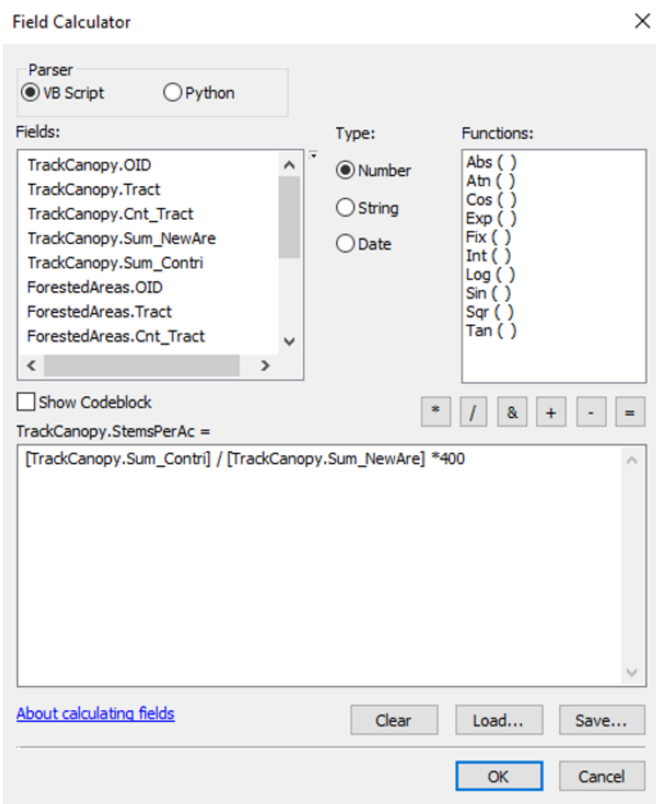
34. Close the attribute table. Open ArcToolbox and run a Dissolve on CanopyPolygon (gridcode field) and called it CanopyDissolveTotal.shp. Now complete an Intersect between CanopyDissolveTotal and the Tract layer and call it Canopy_Tract_Intersect.shp.

35. Open the attribute table of Canopy_Tract_Intersect and create a new field called NewArea with a Double data type. Then use Calculate Geometry to calculate the area in Acres US. Add a new column called Contrib and make it a Double data type. Use the Field Calculator to make Contrib = [NewArea] * [gridcode]/100. This will provide the average tree canopy for the Census Tract. Right click on Tract and use Summarize to summarize the Tract field and for summary statistics select SUM next to Contrib and NewArea. Save the file as: C:\E0177\Activity\5.1\TractCanopy.dbf. Add it to the map.



Summarizing the tree canopy values

36. Right click on TractCanopy and join it to ForestedAreas using the Tract fields. Open the TractCanopy table. Add a new field called StemsPerAc with a Short Integer data type. Right click on the field and use Field Calculator to make it equal to: [TractCanopy.Sum_Contri] / [TractCanopy.Sum_NewAre] *400. The 400 value comes from the spreadsheet as the stems per acre for 100% canopy.

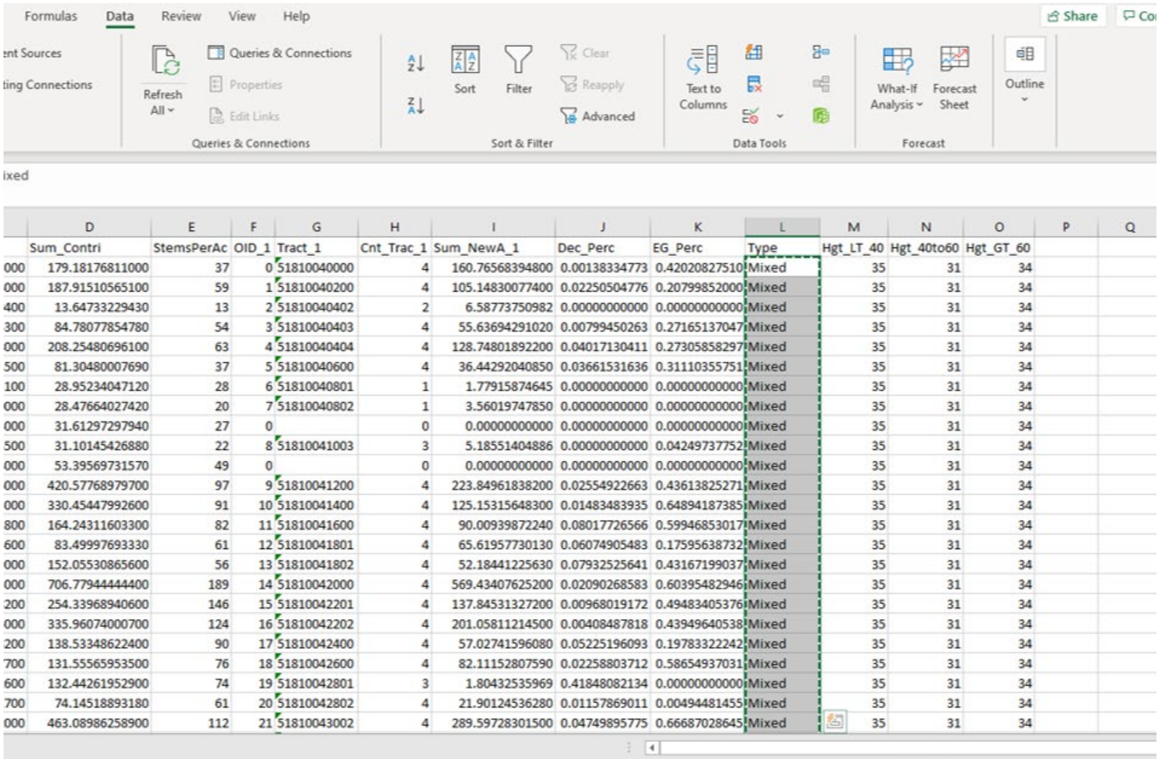


37. Close the attribute table and remove the joins. Right click on TrackCanopy and export as C:\E0177\Activity\5.1\TreeData.dbf and add it to the existing map.

38. Now populate the Null values. Run a Select by Attribute for "Type" = ' '. This should select 7 records. Now use the Field Calculator to assign a value of Mixed to Type, 35 to Hgt_LT_40, 31 to Hgt_40to60, and 34 to Hgt_GT_60. Everything required to update the Hazus data is now available. Clear the selection and close the attribute table.

39. Integrate data into Hazus. Close ArcMap and go back to the Hazus study region. Go to Analysis, then Parameters, and Trees. Select the top left box to highlight the entire table. Press Ctrl+C and then go back to the treedata spreadsheet. Add a second sheet and paste the value into that sheet. You'll notice that column A is blank. Do not delete column A. Now open TreeData.dbf with Excel. Looking at the two datasets, there should be 99 records and the Tract ID is ascending in both cases. If this is not the case, go to the Data tab and use the Sort functionality.

40. Copy the tree type data from the .dbf file to the .xlsx file. Do not copy the column header.

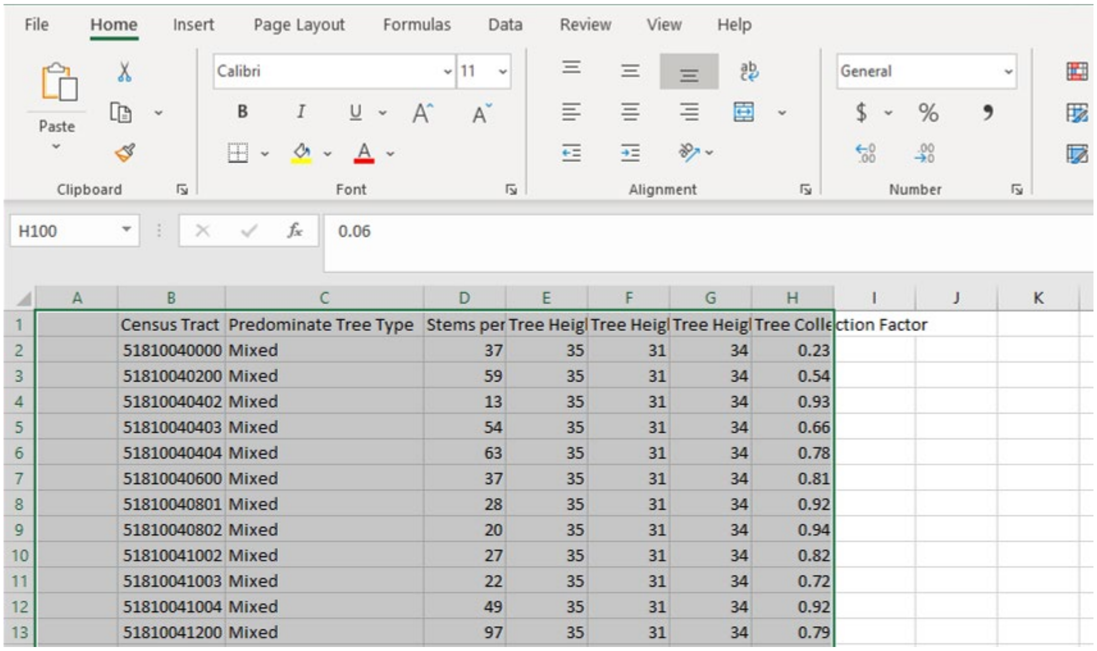


	Sum_Contri	StemsPerAc	OID_1	Tract_1	Cnt_Trac_1	Sum_NewA_1	Dec_Perc	EG_Perc	Type	Hgt_LT_40	Hgt_40to60	Hgt_GT_60
000	179.18176811000	37	0	51810040000	4	160.76568394800	0.00138334773	0.42020827510	Mixed	35	31	34
000	187.91510565100	59	1	51810040200	4	105.14830077400	0.02250504776	0.20799852000	Mixed	35	31	34
400	13.64733229430	13	2	51810040402	2	6.58773750982	0.00000000000	0.00000000000	Mixed	35	31	34
300	84.78077854780	54	3	51810040403	4	55.63694291020	0.00799450263	0.27165137047	Mixed	35	31	34
000	208.25480696100	63	4	51810040404	4	128.74801892200	0.04017130411	0.27305858297	Mixed	35	31	34
500	81.30480007690	37	5	51810040600	4	36.44292040850	0.03661531636	0.31110355751	Mixed	35	31	34
100	28.95234047120	28	6	51810040801	1	1.77915874645	0.00000000000	0.00000000000	Mixed	35	31	34
000	28.47664027420	20	7	51810040802	1	3.56019747850	0.00000000000	0.00000000000	Mixed	35	31	34
000	31.61297297940	27	0		0	0.00000000000	0.00000000000	0.00000000000	Mixed	35	31	34
500	31.10145426880	22	8	51810041003	3	5.18551404886	0.00000000000	0.04249737752	Mixed	35	31	34
000	53.39569731570	49	0		0	0.00000000000	0.00000000000	0.00000000000	Mixed	35	31	34
000	420.57768979700	97	9	51810041200	4	223.84961838200	0.02554922663	0.43613825271	Mixed	35	31	34
000	330.45447992600	91	10	51810041400	4	125.15315648300	0.01483483935	0.64894187385	Mixed	35	31	34
800	164.24311603300	82	11	51810041600	4	90.00939872240	0.08017726566	0.59946853017	Mixed	35	31	34
600	83.49997693330	61	12	51810041801	4	65.61957730130	0.06074905483	0.17595638732	Mixed	35	31	34
000	152.05530865600	56	13	51810041802	4	52.18441225630	0.07932525641	0.43167199037	Mixed	35	31	34
000	706.77944444400	189	14	51810042000	4	569.43407625200	0.02090268583	0.60395482946	Mixed	35	31	34
200	254.33968940600	146	15	51810042201	4	137.84531327200	0.00968019172	0.49483405376	Mixed	35	31	34
000	335.96074000700	124	16	51810042202	4	201.05811214500	0.00408487818	0.43949640538	Mixed	35	31	34
200	138.53348622400	90	17	51810042400	4	57.02741596080	0.05225196093	0.19783322242	Mixed	35	31	34
700	131.55565953500	76	18	51810042600	4	82.11152807590	0.02258803712	0.58654937031	Mixed	35	31	34
600	132.44261952900	74	19	51810042801	3	1.80432535969	0.41848082134	0.00000000000	Mixed	35	31	34
700	74.14518893180	61	20	51810042802	4	21.90124536280	0.01157869011	0.00494481455	Mixed	35	31	34
000	463.08986258900	112	21	51810043002	4	289.59728301500	0.04749895775	0.66687028645	Mixed	35	31	34

Copying data from the .dbf file

41. Now paste the data into the .xlsx file under the word Predominate Tree Type. Next, copy and paste the three tree height columns and the stems per acre column.

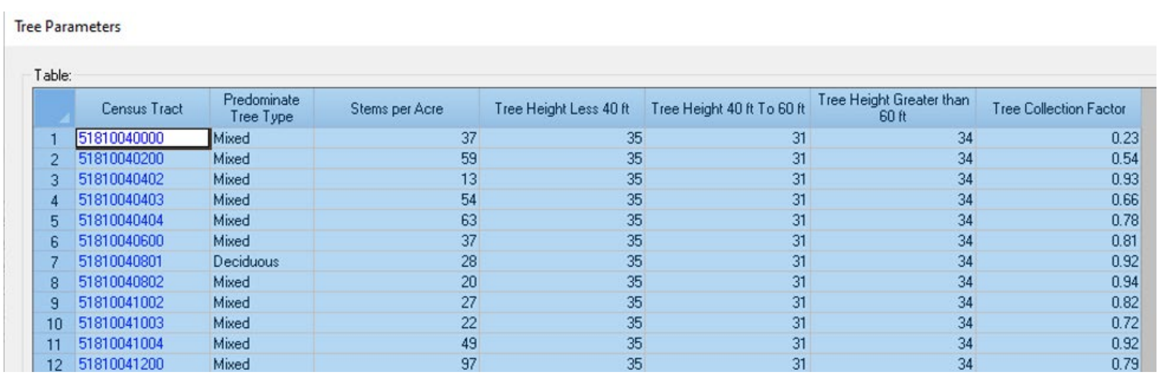
42. Go to the TreeData.xlsx table and select all cells from H100 to A1. Copy these cells.



	Census Tract	Predominate Tree Type	Stems per	Tree Heigl	Tree Heigl	Tree Heigl	Tree Collection Factor
2	51810040000	Mixed	37	35	31	34	0.23
3	51810040200	Mixed	59	35	31	34	0.54
4	51810040402	Mixed	13	35	31	34	0.93
5	51810040403	Mixed	54	35	31	34	0.66
6	51810040404	Mixed	63	35	31	34	0.78
7	51810040600	Mixed	37	35	31	34	0.81
8	51810040801	Mixed	28	35	31	34	0.92
9	51810040802	Mixed	20	35	31	34	0.94
10	51810041002	Mixed	27	35	31	34	0.82
11	51810041003	Mixed	22	35	31	34	0.72
12	51810041004	Mixed	49	35	31	34	0.92
13	51810041200	Mixed	97	35	31	34	0.79

Updated Hazus tree parameter data

43. Go back into Hazus and paste the values into the tree parameter table by clicking on the top left cell to highlight the entire table and pressing CTRL+V. Click OK and select Yes to the modified data.



	Census Tract	Predominate Tree Type	Stems per Acre	Tree Height Less 40 ft	Tree Height 40 ft To 60 ft	Tree Height Greater than 60 ft	Tree Collection Factor
1	51810040000	Mixed	37	35	31	34	0.23
2	51810040200	Mixed	59	35	31	34	0.54
3	51810040402	Mixed	13	35	31	34	0.93
4	51810040403	Mixed	54	35	31	34	0.66
5	51810040404	Mixed	63	35	31	34	0.78
6	51810040600	Mixed	37	35	31	34	0.81
7	51810040801	Deciduous	28	35	31	34	0.92
8	51810040802	Mixed	20	35	31	34	0.94
9	51810041002	Mixed	27	35	31	34	0.82
10	51810041003	Mixed	22	35	31	34	0.72
11	51810041004	Mixed	49	35	31	34	0.92
12	51810041200	Mixed	97	35	31	34	0.79

Tree Parameters table

Task 3: Prepare to Discuss Results

1. Create a slide in PPT to provide information on what data was used to update the terrain and tree databases. You can run a probabilistic analysis before and after the change to identify what kind of different this update made on your results. Export some of the results of interest to a separate folder in case you want to come back to the scenario results later.

Note: These slides may be used in the final capstone presentation at the end of the class.

Visual 28: Lesson 5: Review

1. List three sources of hurricane data
2. Identify two hurricane hazard parameters
3. True or False, Hazus can model a probabilistic wind/surge analysis?
4. What is a MEOW surge? A MOM surge?
5. What kind of windspeed is used for Hazus inputs (3-second gust, 1-minute mean, or 10-minute mean)?
6. What kind of windspeed is used for Hazus outputs (3-second gust, 1-minute mean, or 10-minute mean)?

Visual 29: Questions?

Lesson 6: Advanced Flood

Visual 1: Lesson 6: Advanced Flood

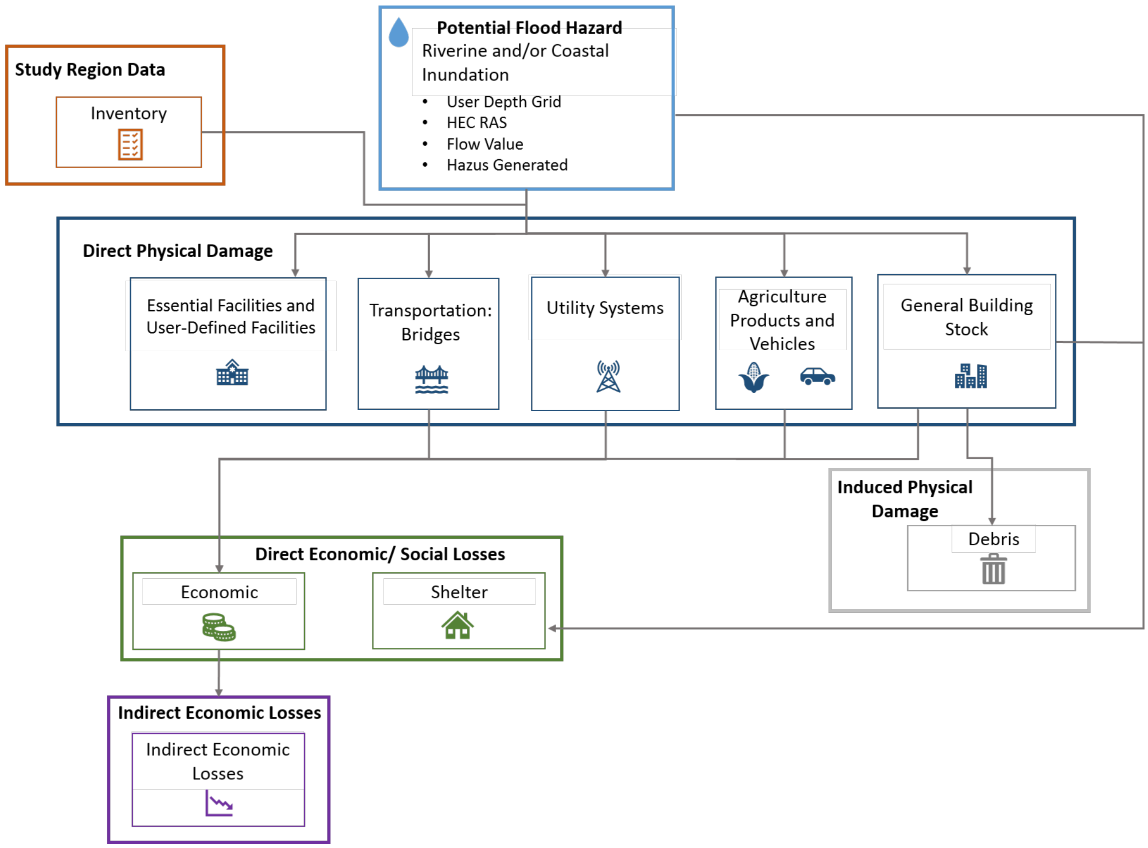
Visual 2: Lesson 6: Goal and Objectives

Goal: Better understand how advanced applications can help mitigate flood model limitations and generate more robust and accurate results.

After completing this lesson you will be able to:

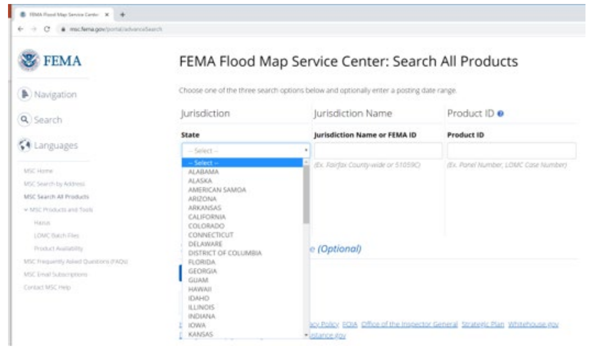
- List sources of flood data
- Identify an appropriate depth damage function
- Describe the methodology used to model A and V flood zones
- Conduct an advanced application if applicable to your community

Visual 3: Flood Review



Visual 4: Data Sources

- FEMA Map Service Center (https://msc.fema.gov/portal/home)
    - National Flood Hazard Layer
    - DFIRM
    - Letter Of Map Change (LOMC or any DFIRM changes)



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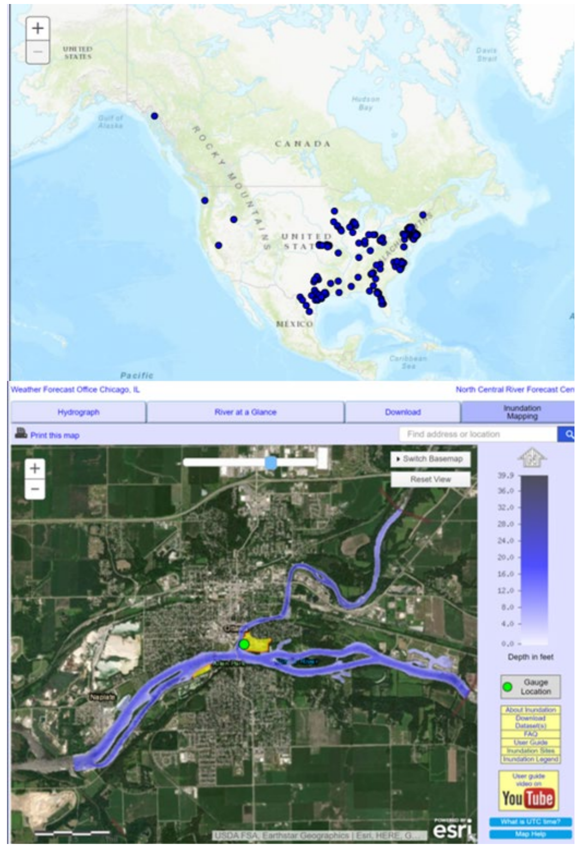
Data Sources

FEMA Map Service Center (https://msc.fema.gov/portal/home)

Visual 5: Data Sources

- National Weather Service (https://water.weather.gov/ahps/inundation.php)
- USGS FIM (https://fim.wim.usgs.gov/fim/)
- Advanced Hydrologic Prediction Service (AHPS)
- Inundation mapping for selected gauges
- USGS Flood Event Viewer for High Water Marks - (https://stn.wim.usgs.gov/fev/)
- Data download



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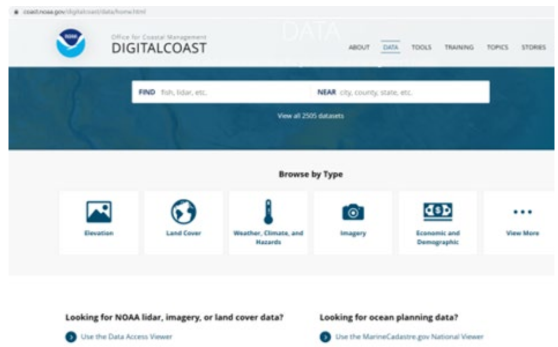
Data Sources

National Weather Service (https://water.weather.gov/ahps/inundation.php)

Visual 6: Data Sources

- NOAA Digital Coast (https://coast.noaa.gov/digitalcoast/data/home.html)
  - Links to hazard data for U.S. coastline
  - Elevation Data
  - Economic Data
  - Social Data
  - Climate change



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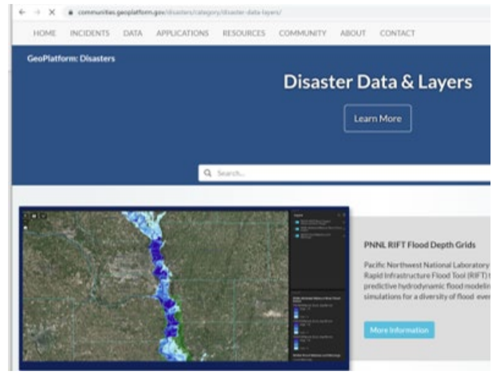
Data Sources

NOAA Digital Coast (https://coast.noaa.gov/digitalcoast/data/home.html)

Visual 7: Data Sources



- Disasters.GeoPlatform.gov (https://communities.geoplatform.gov/disasters/category/disaster-data-layers/)
  - Depth grids and other hazard data
  - Several partners including FEMA
  - Data and resources for preparedness, response, recovery and mitigation

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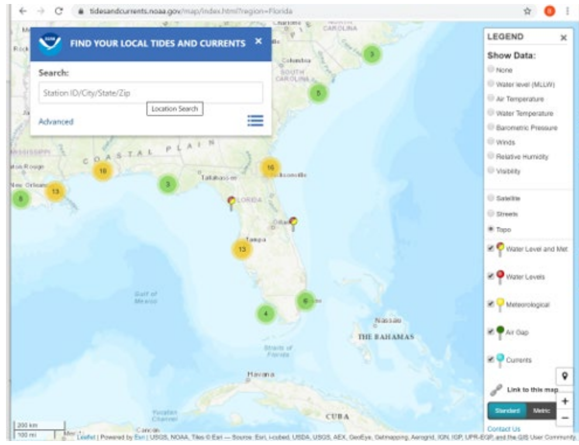
Data Sources

Disasters.GeoPlatform.gov (https://communities.geoplatform.gov/disasters/category/disaster-data-layers/)

Visual 8: Data Sources

- [NOAA tides and currents site:](https://tidesandcurrents.noaa.gov/) (https://tidesandcurrents.noaa.gov/)
  - Coastal tide station data
  - Water levels
  - Predicted levels



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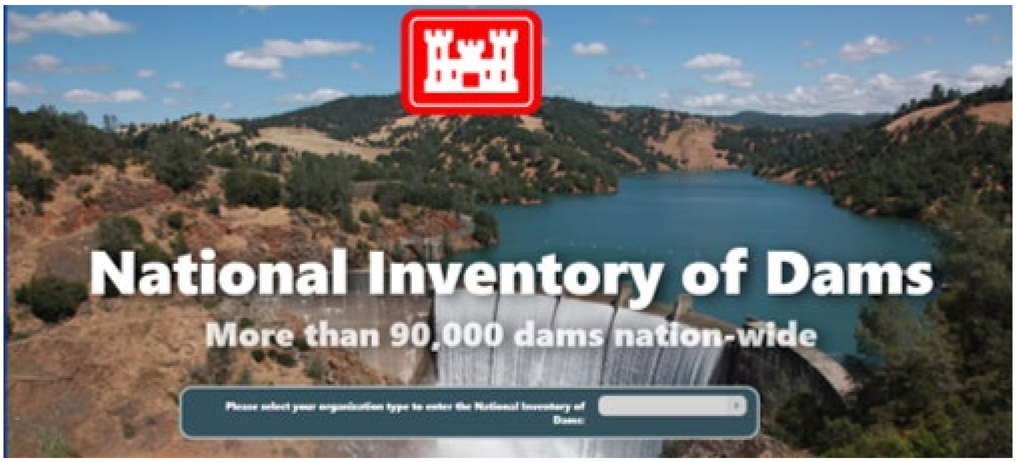
Data Sources

[NOAA tides and currents site](https://tidesandcurrents.noaa.gov/): (https://tidesandcurrents.noaa.gov/)

Visual 9: Data Sources

- Local hazard mitigation plan
- Dam info – USACE National Inventory of Dams: (https://nid.sec.usace.army.mil/)
- Dam inundation – Individual Dam Emergency Action Plan (EAP)



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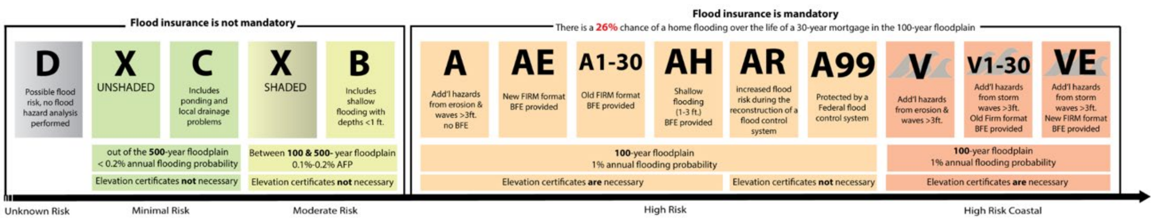
Data Sources

USACE National Inventory of Dams: (https://nid.sec.usace.army.mil/)

Visual 10: Adv. App. - Developing Depth Grids

- How to convert a 2-D polygon map into a Hazus required depth grid
- FEMA Map Service Center provides the National Flood Hazard Layer (NFHL) and base flood elevations when available
- Overall approach requires assessment of each zone of the floodplain



Visual 11: Adv. App. - Developing Depth Grids

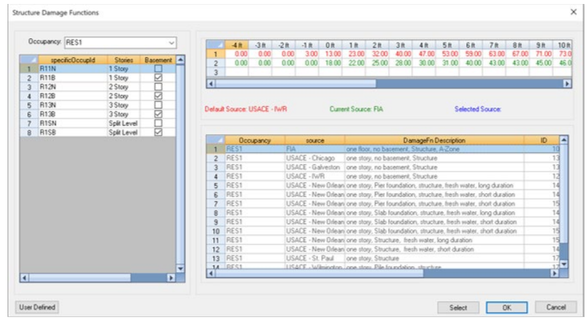
- AE zones require the base flood elevations which will be included in the NFHL data as a polyline file
- VE zones have static elevation values
- Other zones may also have static values – AO, AH, etc.
- Some zones will only consist of a polygon such as the A zones

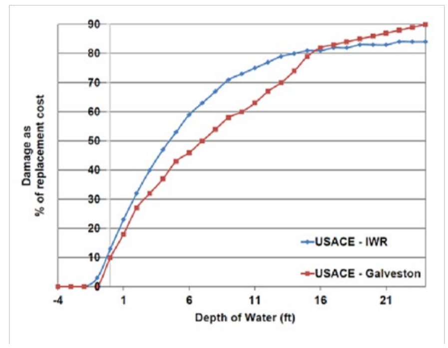
Visual 12: Adv. App. - Developing Depth Grids

- Methodology developed to use BFE, AE zones, and DEM to create depth grid by creating a flood surface, subtracting it from the DEM, and clipping it
- Static value methodology requires conversion to flood surface based on values and then subtracting from DEM
- Zones with no value may require 3D Analyst to generate the surface and/or Level 1 Hazus approach

Visual 13: Depth Damage Functions

- Hazus provides a library of depth damage functions
- Descriptions are provided in the menu
- Users can also create their own depth damage functions



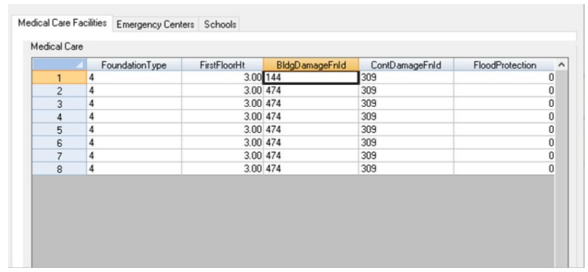


Visual 14: Adv. App. – Long Term Flooding

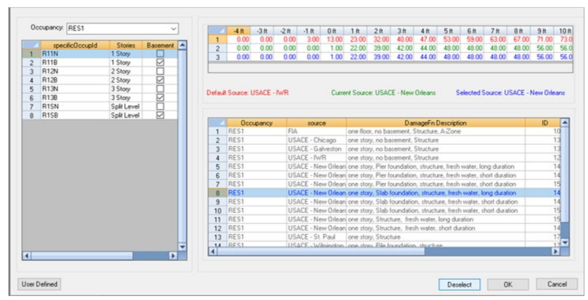
- Long term flooding can be modeled by using the long duration flood depth damage functions (DDF)
- Modelling can be done at the site level by assigning the long duration DDF to the DDF ID fields
- Long duration can also be implemented by assigning the long duration DDF as the default values

Visual 15: Adv. App. – Long Term Flooding

- Site level change to DDF

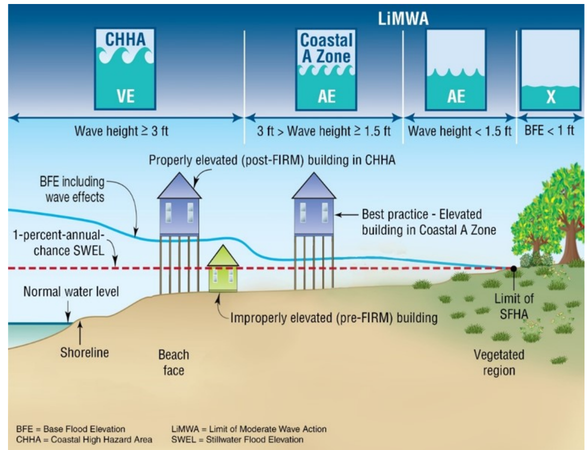


- Study region change to DDF



Visual 16: A and V Zone Methodology

- Separate damage function menu for each of the three zones: Riverine, Coastal A, and Coastal V
- Coastal A has wave heights from 1.5’ - 3’



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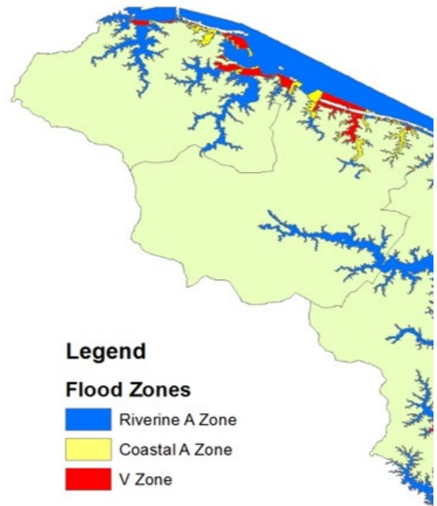
A and V Zone Methodology

Source: FEMA Region II (http://www.region2coastal.com/resources/coastal-mapping-basics/)

Visual 17: A and V Zone Methodology

How does Hazus determine which damage function to use?

- Using Hazus generated floodplains – a feature class with the three zones is created here: C:\HazusData\Regions\studyregionname\scenarioname\Coastal\Caseoutput.mdb called ZoneRP
- Using depth grids – if riverine grid is used, riverine DDF; if coastal grid is used, coastal DDF
- Using site level data, DDF ID is used if populated



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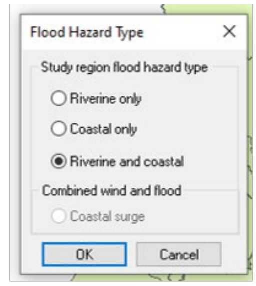
A and V Zone Methodology

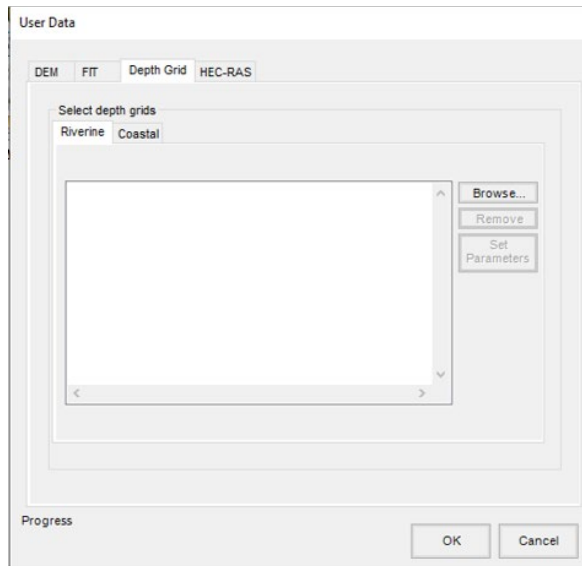
Map shows the ZoneRP feature class for a Hazus study region on the Virginia shoreline. The ZoneRP file is created when Hazus completes the coastal flood modelling.

Visual 18: Adv. App. – A and V Zone Modeling



For GBS and site data using a custom depth grid:

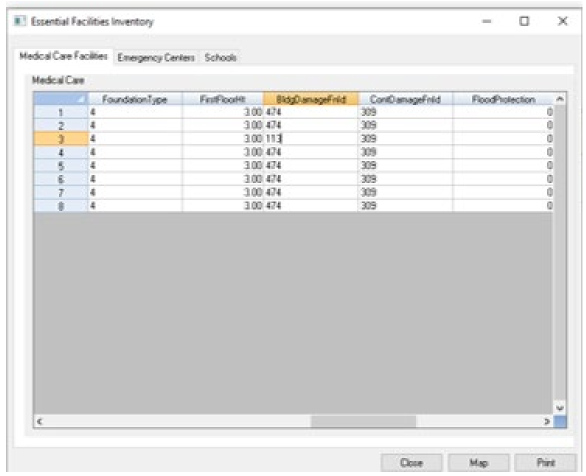
- Download NFHL and query out coastal vs riverine into two polygons
- Clip depth grid so there is a coastal and riverine depth grid and simplify
- Identify Flood Hazard Type as Riverine and Coastal
- Open User Data and bring in the two depth grids under the corresponding tab



Visual 19: Adv. App. – A and V Zone Modeling

For site level data only:

- Download NFHL and query the coastal zones into a polygon layer
- Query the site level inventory which falls into the coastal zones
- Assign coastal DDF to the coastal inventory
- Simplify large grids with complex geometries
- Bring the depth grid in as a riverine depth grid



Visual 20: Surge Modeling

- Storm surge runs in the Hurricane Model during the damage and analysis or can be added as a user-defined surge
- Surge is imported (automatically) into the Flood Model
- DEM is combined with flood elevations for a final depth grid
- Flood damages and losses are created
- Combined wind and flood damages and losses are analyzed in the Flood Model (viewable in both models)

Visual 21: Discussion 6.0 – Assessing Future Conditions

Time: 10 minutes

- What are Future Conditions?
- Which aspects of Hazus modeling need to be updated?
    - What else besides the hazard data?

Visual 22: Assessing Future Conditions

Integration of climate change into the surge model requires:

- Sea level rise estimate(s)
- Eroded Digital Elevation Model

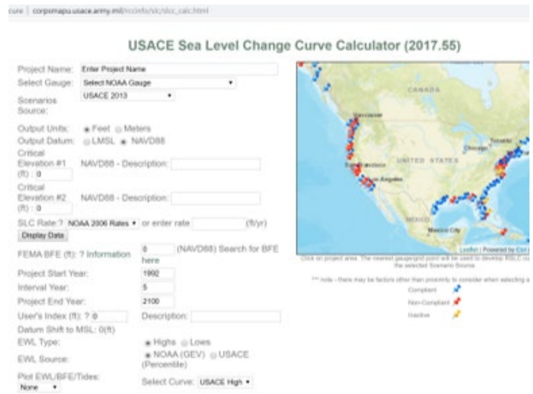
Visual 23: Adv. App. – Assessing Future Conditions for Surge

USACE Sea Level Rise Calculator: (http://corpsmapu.usace.army.mil/rccinfo/slc/slcc_calc.html)

- Uses local gauge data and national climate scenario data
- Requires project lifespan

Once the sea level rise (SLR) value has been identified, the DEM will be altered by:

- Using Subtract to reduce the DEM by the SLR amount(s)



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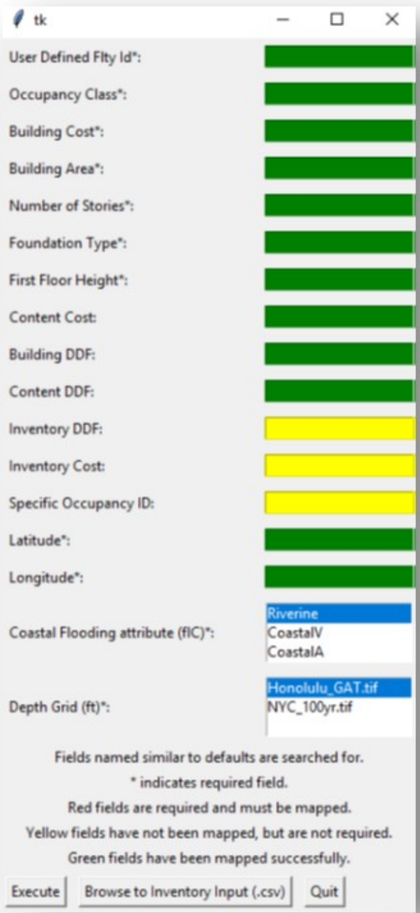
Adv. App. – Assessing Future Conditions for Surge

USACE Sea Level Rise Calculator: (http://corpsmapu.usace.army.mil/rccinfo/slc/slcc_calc.html)

Visual 24: Hazus Flood Assessment Structure Tool (FAST)



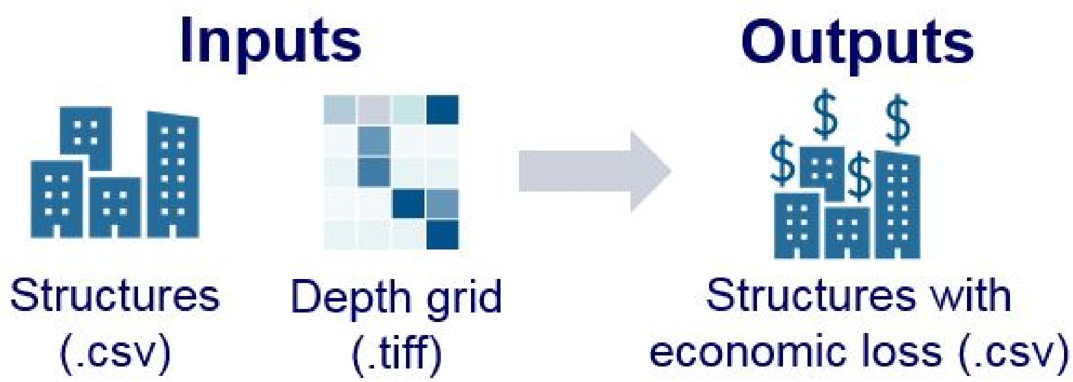
- Open source, standalone flood risk assessment tool
- Uses Hazus depth damage functions to calculate flood impacts at structures
- No software or mapp

ing skills required

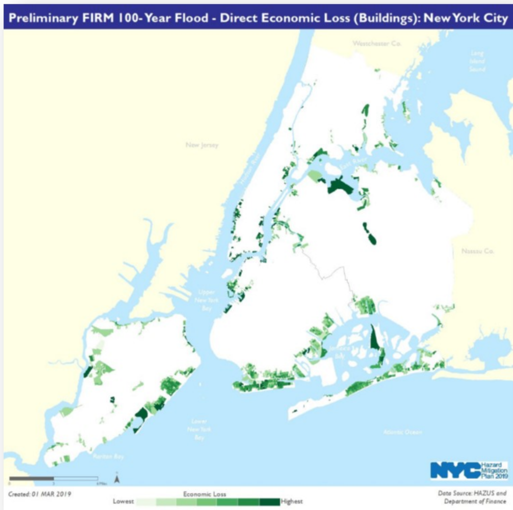
- Makes flood risk assessment faster, cheaper, & simpler

Visual 25: FAST - The Specs

- Planned to be hosted on GitHub
- Calculates 10,000 structures/second



Visual 26: FAST Case Study - NYC Mitigation Plan Update



- NYC mitigation plan update required a citywide multi-hazard risk assessment
- Planners used a regulatory 100-year depth grid from FEMA and an 800K structure dataset from tax assessor
- FAST calculated 100-year economic losses at all NYC structures in under a minute and a half
- FAST results help planners strategically distribute risk reduction efforts to the highest-risk areas

Visual 27: Exercise 6.1: Advanced Flood Applications

- Goal: Use the Hazus flood model to complete one of the advanced applications
- Time: 225 minutes

(The exercise will be completed after Lesson 8)

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Exercise 6.1: Advanced Flood Applications

Goals:

- Complete an Advanced Flood Application
- Share the results of the Advanced Flood Application(s)

Time: 225 minutes

Exercise Steps:

1. Refer to Activities Document "6.1_Exercise_AdvancedFlood."
2. Listen to instructor's directions.
3. Ask questions if clarification is needed.
4. Work individually on the goal.
5. Ask questions to the instructor if needed.
6. Complete the assigned goal.
7. Be prepared to share your answers/results.
8. Ask any final questions.

Visual 28: Exercise 6.1: Tasks

- Pre-Task: Select Application
- Task 1: Implement Advanced Application
- Task 2: Share results
- Repeat For Additional Applications

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Exercise 6.1: Tasks

Refer to Activities Document “6.1_Exercise_AdvancedFlood”.

Exercise 6.1: Advanced Flood Applications

Type: Exercise

Time: 225 minutes for all hazard applications

Goals:

- Complete an Advanced Flood Application
  - Application 1: Create an Event using the NFHL
  - Application 2: Model Long-term Flooding
  - Application 3: Model a Combined User-Defined Riverine & Coastal Flood
  - Application 4: Integrate Climate Change Into An Analysis
- Share results of the Advanced Tsunami Application

Background: This activity will help you identify and implement an advanced flood application. If floods are not a priority to your community, you do not need to do an advanced flood application just choose a different hazard's activity to complete. Before you begin, the four advanced applications will be provided to you and you'll select the one (or more) that would be most beneficial to your community. If you finish one application and still have time, feel free to work through another. Approximate times have been provided for each option so just be aware of the time allotted for the activity. Data has been provided for Virginia Beach, Virginia but you may use your own study region for the capstone presentation.

Before You Begin: Identify an Appropriate Advanced Hazard Application

There are four advanced flood applications to select from in this activity. Select the one that is most beneficial to your community:

Application 1: Create an Event using the NFHL

How do I convert the National Flood Hazard Layer (NFHL) into something Hazus can use? Many communities use the 1% annual chance flood to help determine their flood risk but they need a flood depth grid for Hazus.

- Data Required: None
- Time Required: 45-60 Minutes
- Difficulty: Moderate - Hard

Application 2: Model Long Term Flooding

How do I model long term flooding such as a levee or dam breach? Long term flooding can cause more damage than typical riverine flooding and Hazus has a library of damage functions which can support the analysis.

- Data Required: None
- Time Required: 30-45 Minutes
- Difficulty: Moderate

Application 3: Model a Combined Riverine & Coastal Flood

How do I properly model a user-defined coastal and riverine flood in the same analysis? It's important for users to model coastal and riverine correctly since the depth damage functions are different.

- Data Required: Land Use or Land Cover data
- Time Required: 40-50 Minutes
- Difficulty: Easy

Application 4: Integrate Climate Change Into An Analysis (Part 2)

How do I add climate change to my analysis? This application is part 2 of 2. The first part is in Application 3 of Exercise 5.1: Advanced Hurricane Applications and includes using the surge model. This application will show you how to change your flood parameters to integrate climate change into your analysis.

- Data Required: None
- Time Required: 60-90 Minutes
- Difficulty: Moderate

Once you have chosen an Application, navigate to that section and begin the activity.

Application 1: Create an Event using the NFHL

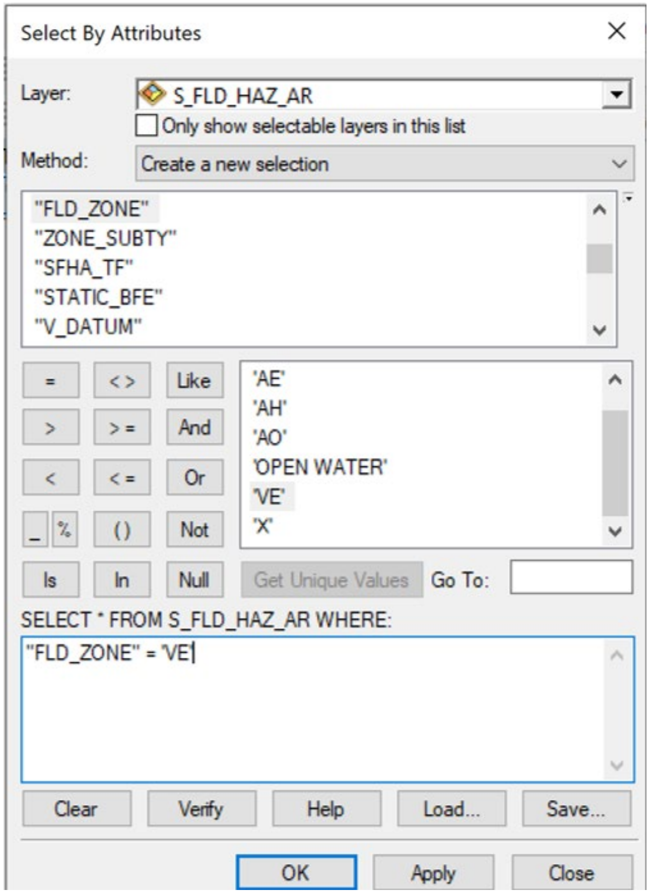
The Virginia Beach NFHL can be downloaded from the MSC website (https://msc.fema.gov/portal/advanceSearch). The data has already been downloaded and can be found here: C:\E0177\Activity\4.1\VirginiaBeach\515531_20160229\. Although this activity example is for Virginia Beach, you may use your own flood data by going to the Map Service Center (MSC) link above and selecting your State and County. The Virginia Beach example will have both coastal and riverine flood zones, but your community may only have riverine flood zones. If that's the case, just skip the coastal sections in the example.

Task 1: Query Flood Zone Data

1. Create a Virginia Beach, Virginia flood study region. Name the study region something you can remember.

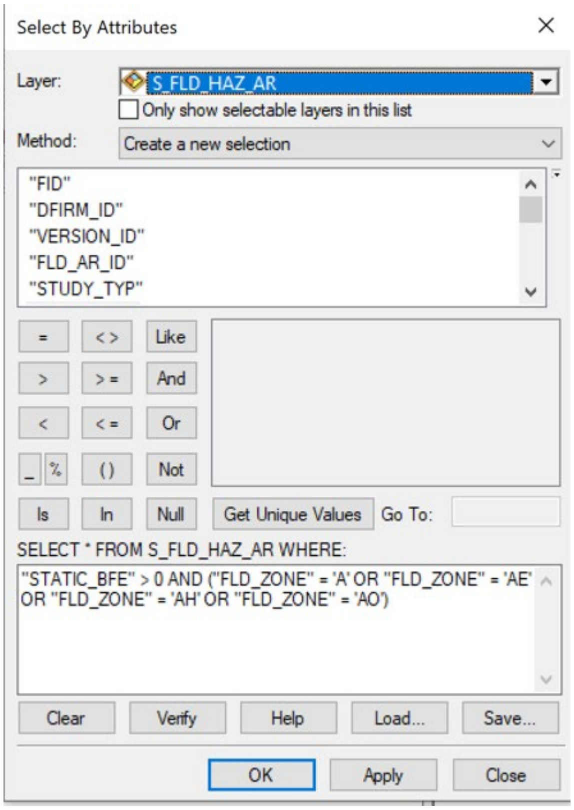
2. Open ArcMap and add the following layer to your map: C:\E0177\Activity\4.1\VirginiaBeach\515531_20160229\S_FLD_HAZ_AR.shp. This layer is the special flood hazard area which displays the different flood zones in your community.

3. Now, query the coastal flood zones with base flood elevations (VE Zone). If you don't have a coastal zone in your community, go to number 5. Go to Selection and Select by Attributes. Next to Layer:, select S_FLD_HAZ_AR; and next to Method:, select Create a new selection. For the field, double click "FLD_Zone", then select =, click Get Unique Values, and then double click 'VE'. Select OK.



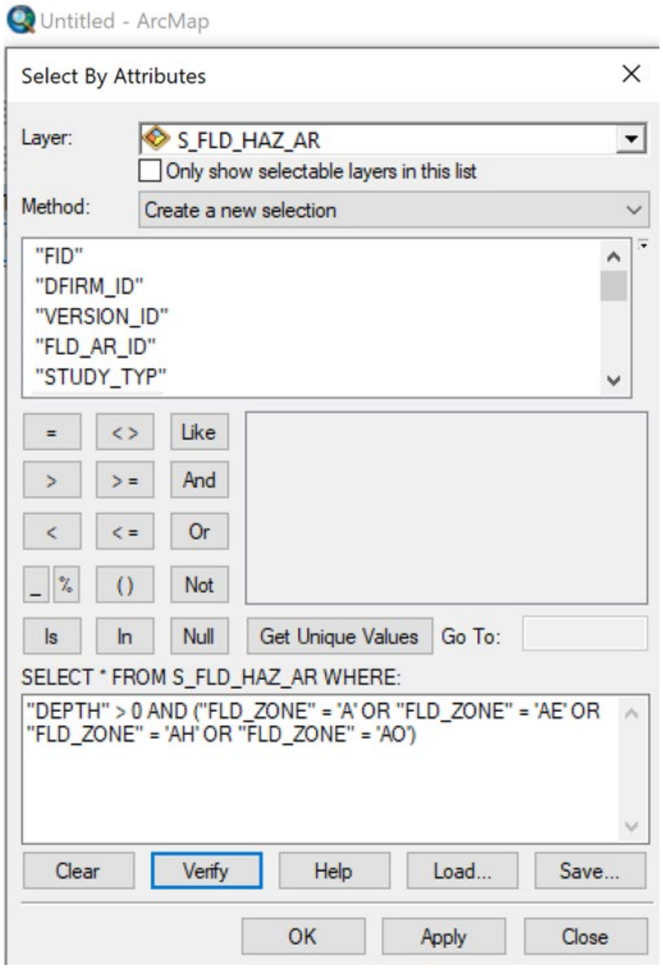
4. Right click on the S_FLD_HAZ_AR layer, go to Data and Export Data. Then save the layer as: C:\E0177\Activity\6.1\VE_Zone.shp. Add the layer to the map. Click Selection, then Clear Selected Features.

5. Run a Select by Attributes on the S_FLD_HAZ_AR layer for "STATIC_BFE" > 0 AND ("FLD_ZONE" = 'A' OR "FLD_ZONE" = 'AE' OR "FLD_ZONE" = 'AH' OR "FLD_ZONE" = 'AO'). This will query the data for all the A zones where a static base flood elevation exists in the data. If your community has other A zones, add those to the query as well.



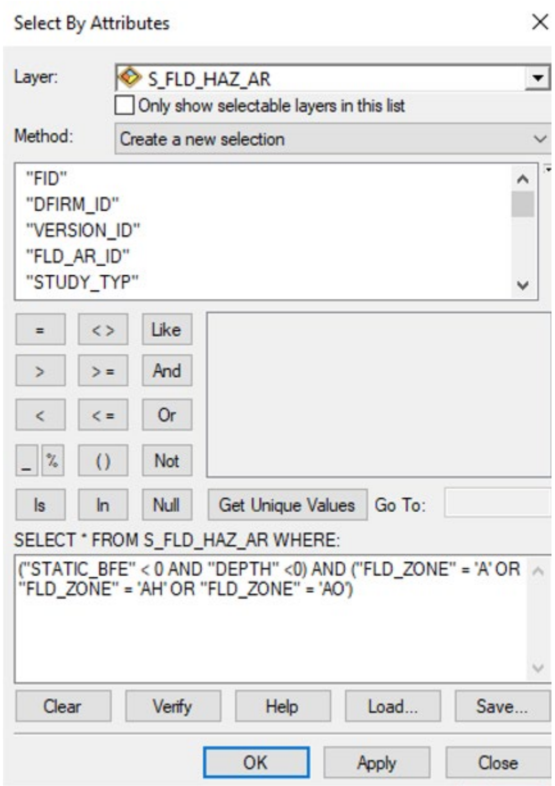
6. Right click on the S_FLD_HAZ_AR layer, go to Data and Export Data. Then save the layer as: C:\E0177\Activity\6.1\Static_Elev_A_Zone.shp. Add the layer to the map. Click Selection, then Clear Selected Features.

7. Run a Select by Attributes on the S_FLD_HAZ_AR layer for "DEPTH" > 0 AND ("FLD_ZONE" = 'A' OR "FLD_ZONE" = 'AE' OR "FLD_ZONE" = 'AH' OR "FLD_ZONE" = 'AO'). This will query the data for all the A zones where a static depth exists in the data. If your community has other A zones, add those to the query as well.



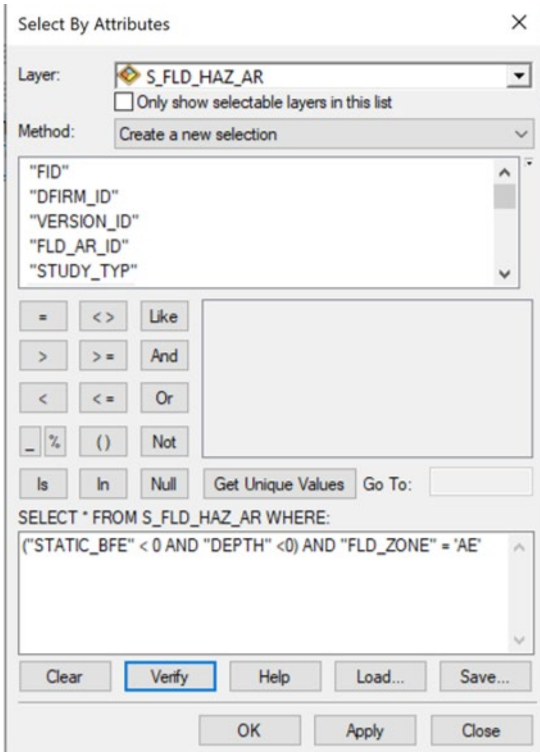
8. Right click on the S_FLD_HAZ_AR layer, go to Data and Export Data. Then save the layer as: C:\E0177\Activity\6.1\Static_Depth_A_Zone.shp. Add the layer to the map. Click Selection, then Clear Selected Features.

9. Run a Select by Attributes for ("STATIC_BFE" < 0 AND "DEPTH" <0) AND ("FLD_ZONE" = 'A' OR "FLD_ZONE" = 'AH' OR "FLD_ZONE" = 'AO') on the S_FLD_HAZ_AR layer. This will query the data for all the zones where a static base flood elevation does not exist in the data. If your community has other A zones, add those to the query as well.



10. Right click on the S_FLD_HAZ_AR layer, go to Data and Export Data. Then save the layer as: C:\E0177\Activity\6.1\A_Zone.shp. Add the layer to the map. Click Selection, then Clear Selected Features. If your community has other A zones, add those to the query as well.

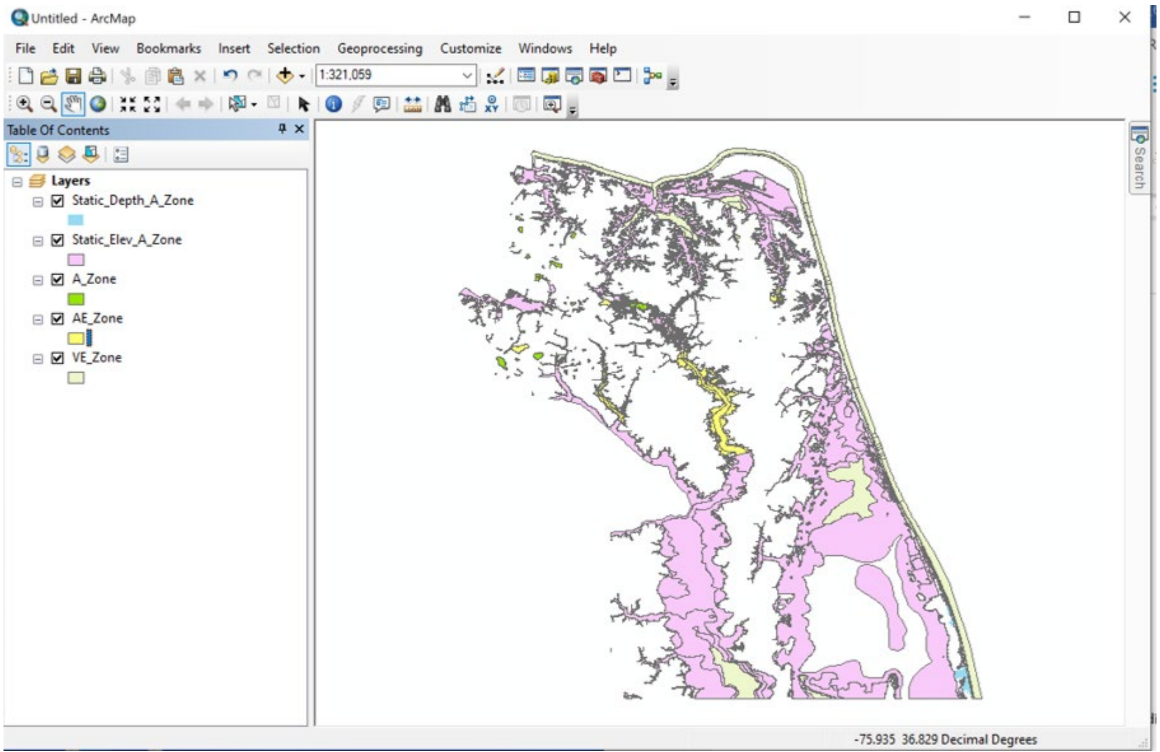
11. Run a Select by Attributes for ("STATIC_BFE" < 0 AND "DEPTH" <0) AND "FLD_ZONE" = 'AE' on the S_FLD_HAZ_AR layer. This will query the data for the AE zones where a static base flood elevation does not exist in the data.



12. Right click on the S_FLD_HAZ_AR layer, go to Data and Export Data. Then save the layer as: C:\E0177\Activity\6.1\AE_Zone.shp. Add the layer to the map. Click Selection, then Clear Selected Features.

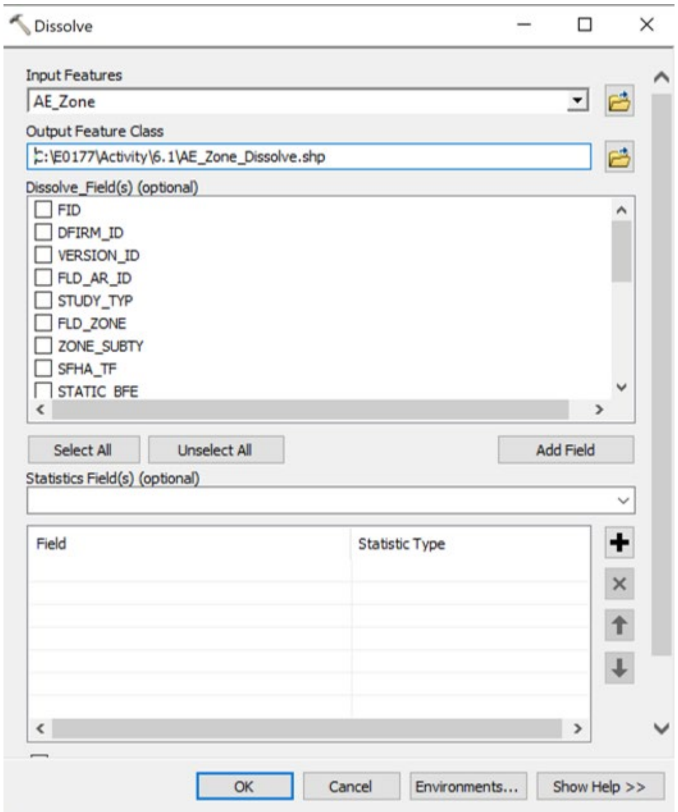
13. If your community has a V zone (not to be confused with the VE zone which has elevation associated with the coastal flood) in the S_FLD_HAZ_AR, query the V zone and save it as V_Zone.shp. The structures in the V zone are subjected to wave action during a flood and sustain higher damages than those subjected to A zone flooding.

14. Remove the S_FLD_HAZ_AR layer from the map.

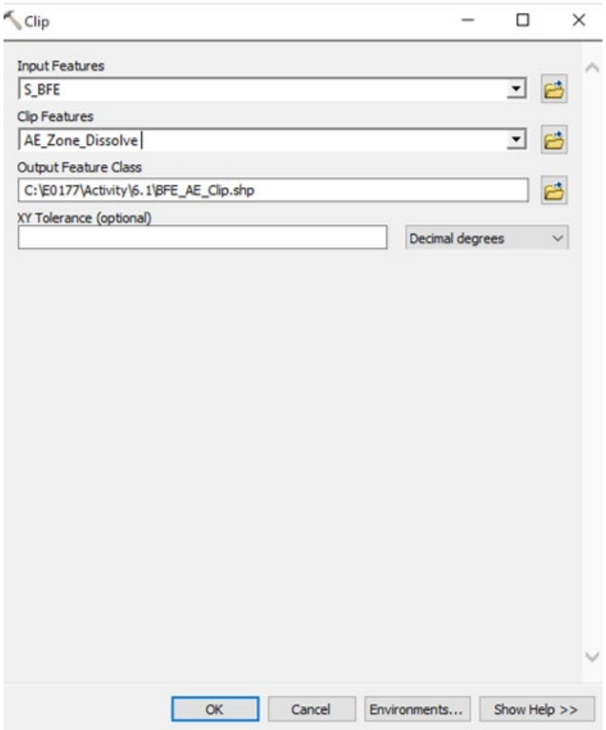


Task 2: Develop the AE Zone Depth Grid

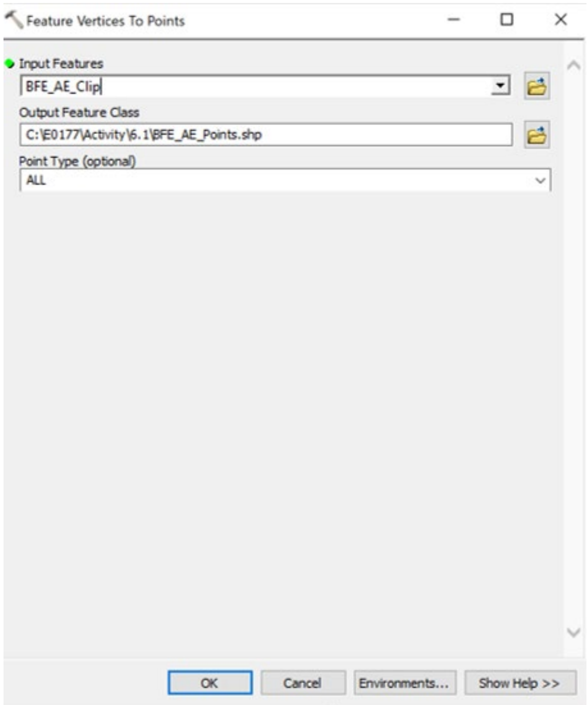
1. Go to Geoprocessing, then Dissolve. Input Features are AE_Zone and output data is: C:\E0177\Activity\6.1\AE_Zone_Dissolve.shp. Then click OK. Remove the AE_Zone layer.



2. Add the base flood elevation polyline layer found here: C:\E0177\Activity\4.1\VirginiaBeach\515531_20160229\S_BFE.shp. Go to Geoprocessing, then Clip. Input Features should be set to S_BFE, Clip Features should be set to AE_Zone_Dissolve and the Output Feature Class should be set to: C:\E0177\Activity\6.1\BFE_AE_Clip.shp. Click OK.

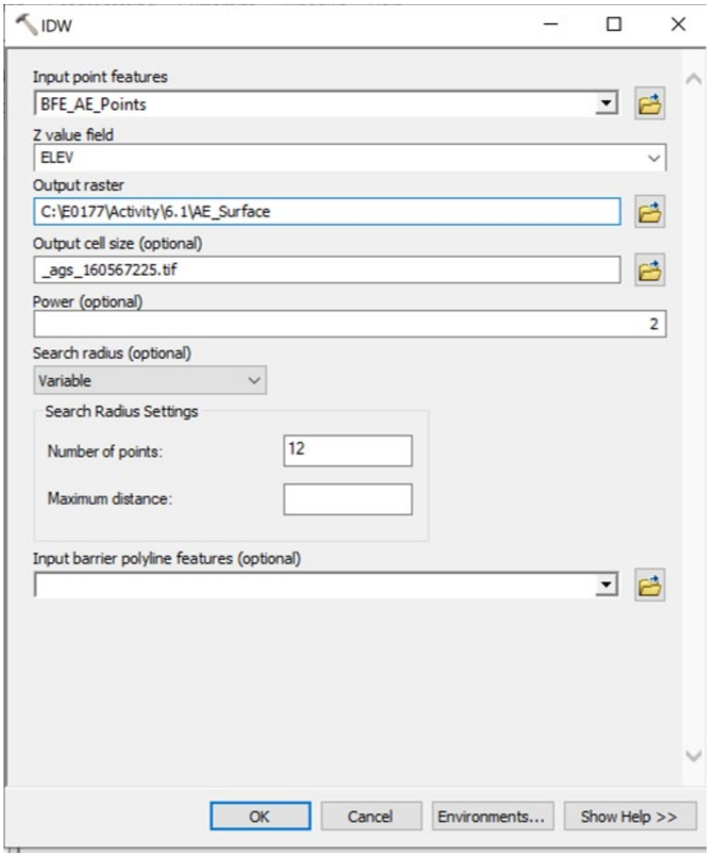


3. Remove the S_BFE layer. Open ArcToolbox and navigate to Data Management Tools, then Features, and Feature Vertices To Points tool. The global search function may also be used to search for tools instead of navigating through the ArcToolbox. For the Input Features, add BFE_AE_Clip, and save the output as: C:\E0177\Activity\6.1\BFE_AE_Points.shp. Click OK.

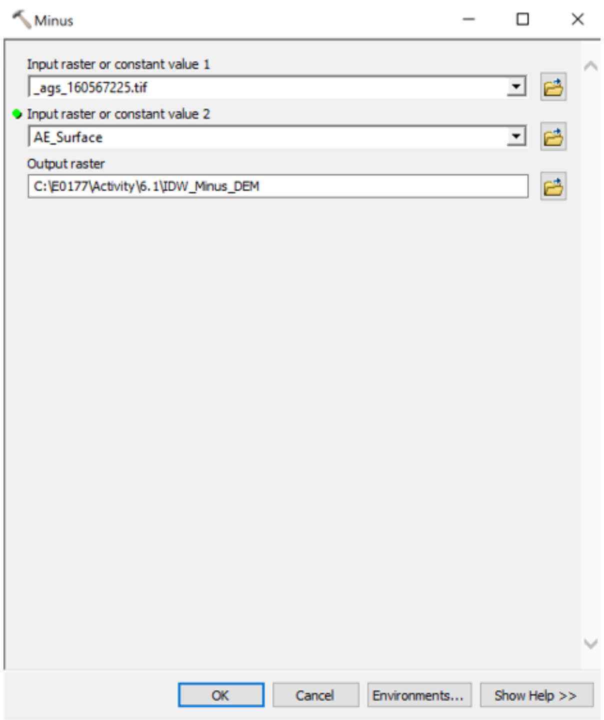


4. Remove the BFE_AE_Clip layer. Add a Digital Elevation Model to the map. There are several sources of data for the DEM: USGS National Map (https://viewer.nationalmap.gov/advanced-viewer/), NOAA Digital Coast (https://coast.noaa.gov/digitalcoast/data/) for communities on the coastline, some State GIS portals, and local GIS websites. For Virginia Beach, the local GIS website (https://gis.data.vbgov.com/datasets/baeeafde159641fc85b1d020861c1d82) has a LiDAR derived DEM. For this application, it has already been downloaded here: C:\E0177\Activity\6.1_ags_160567225.tif.

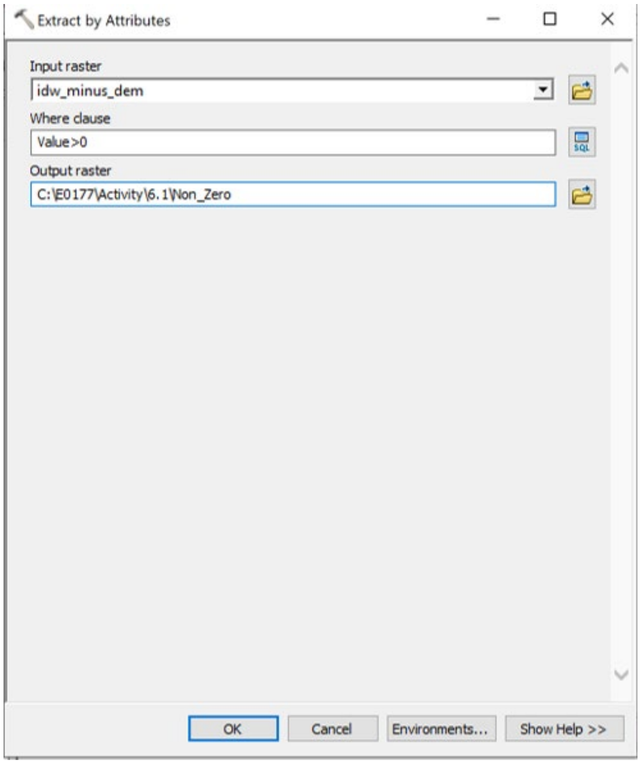
5. In ArcToolbox, go to Spatial Analyst Tools, the Interpolation Toolset, then IDW. For Input point features, use BFE_AE_Points; for Z value field, use ELEV; for Output raster, use: C:\E0177\Activity\6.1\AE_Surface. Drag and drop the DEM into the Output cell size. Then click the Environments button and from the Processing Extent option, choose Same as layer _ags_160567225.tif. Click OK. Click OK again to run.



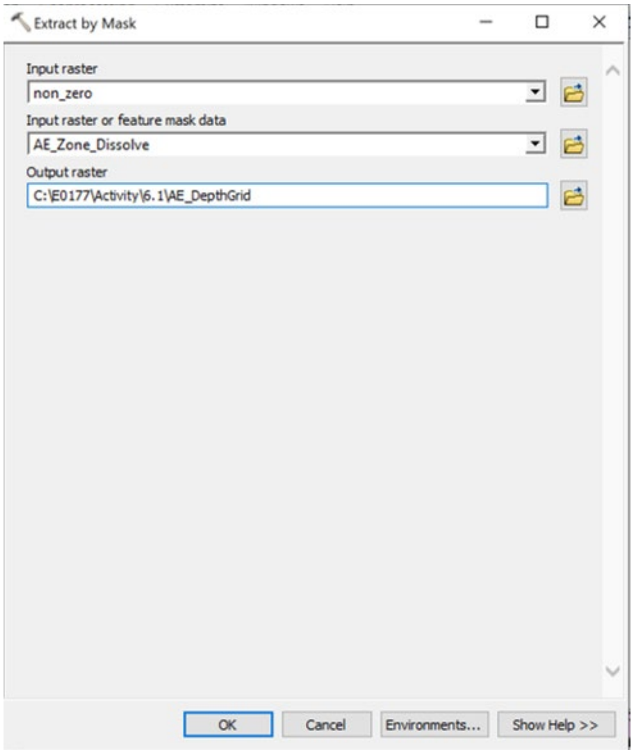
6. Save the Map as C:\E0177\Activity\6.1\NFHL_Grid.mxd. In ArcToolbox, open Spatial Analyst Tools, then Math, and then Minus. Insert AE_Surface under the first Input raster and _ags_160567225.tif in the second Input raster. For the output raster, use: C:\E0177\Activity\6.1\IDW_Minus_DEM. Then click OK.



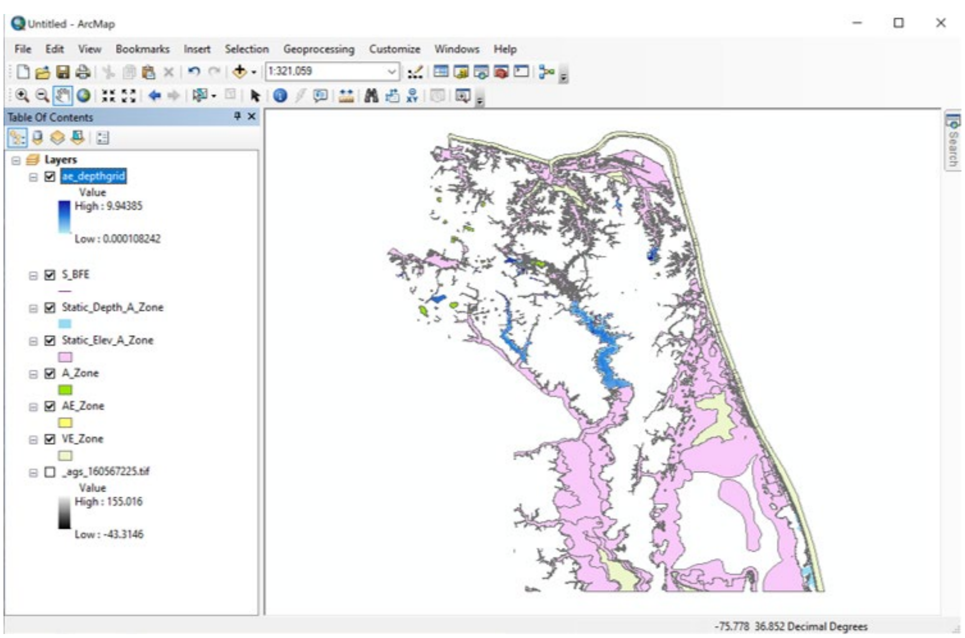
7. In ArcToolbox, navigate to Spatial Analyst Tools, then Extraction, and Extract by Attributes tool. For Input Raster, select IDW_Minus_DEM; for the Where clause, use: Value>0; and for output raster use: C:\E0177\Activity\6.1\Non_Zero. Removing the negative values will leave the areas of flooding.



8. Navigate to Spatial Analyst Tools, then Extraction, then Extract by Mask tool. For input raster, select Non_Zero; for Input raster or feature mask data, select AE_Zone_Dissolve; and for Output raster, select: C:\E0177\Activity\6.1\AE_DepthGrid. Then click OK.

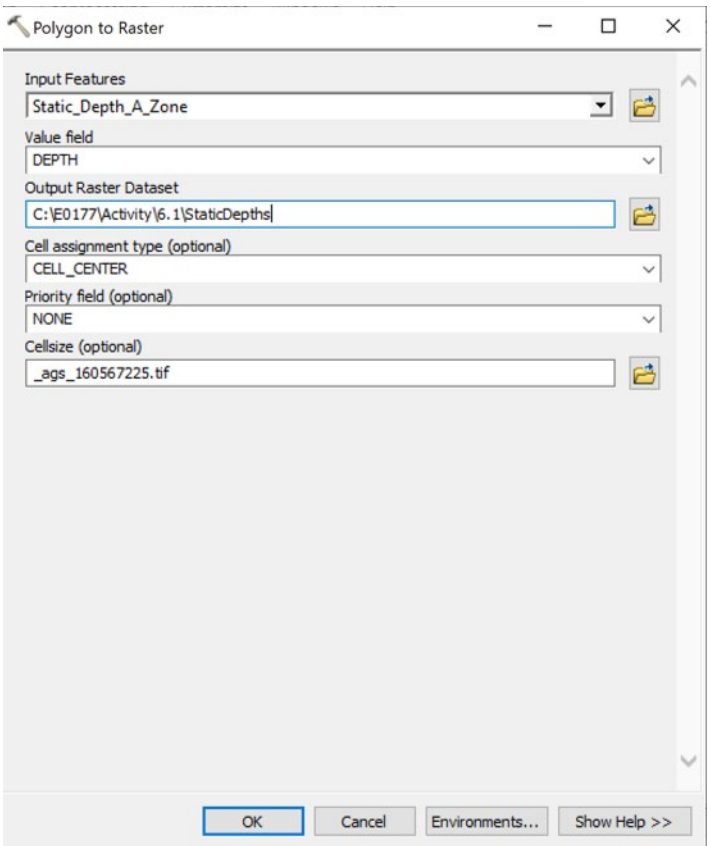


9. Remove the following layers: BFE_AE_Points, Non_Zero, IDW_Minus_DEM, AE_Surface, and AE_Zone_Dissolve.



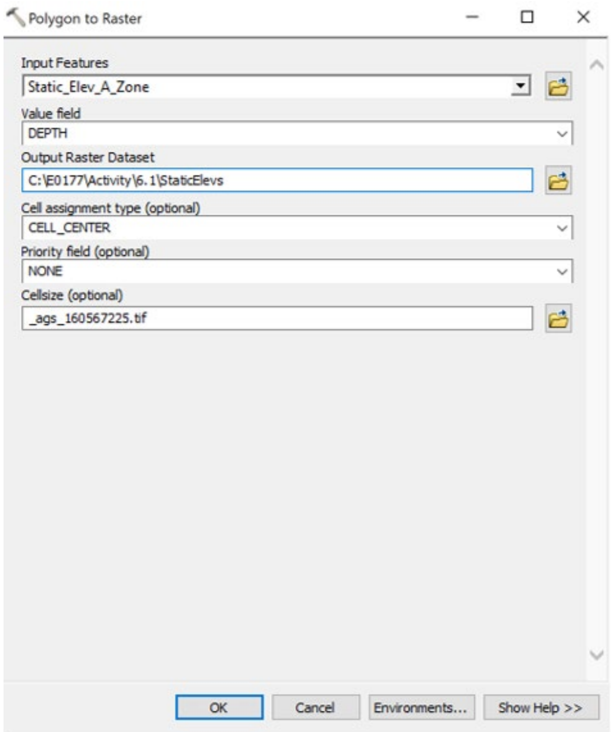
Task 3: Develop the A Zone Depth Grid

1. First develop the static depth A zone depth grid. Open ArcToolbox, then Conversion Tools, then To Raster, and Polygon to Raster. Under Input Features, select Static_Depth_A_Zone; for Value field, select Depth; under Output Raster Dataset, select C:\E0177\Activity\6.1\StaticDepths; and drag the _ags_160567225.tif into Cellsize. Then click OK.

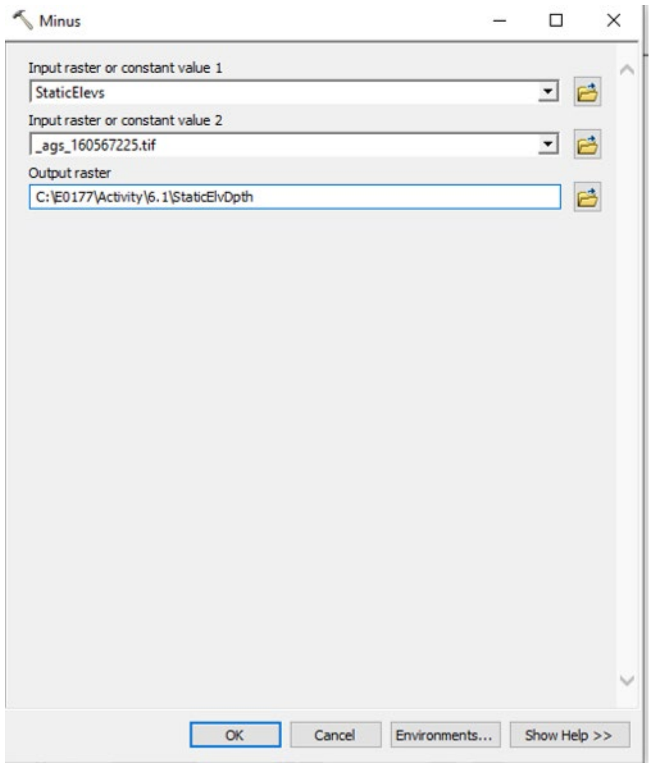


2. Remove the Static_Depth_A_Zone layer.

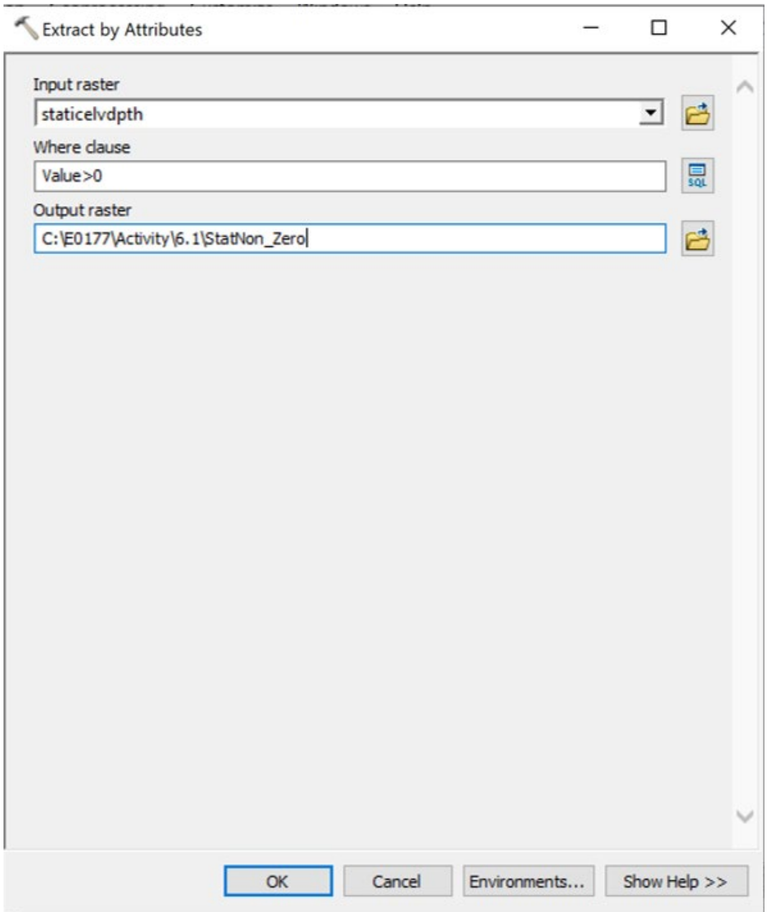
3. Now, develop the static elevation A depth grid. Open ArcToolbox, then Conversion Tools, then To Raster, and Polygon to Raster. Under Input Features, select Static_Elev_A_Zone; for Value field, select STATIC_BFE; under Output Raster Dataset, select C:\E0177\Activity\6.1\StaticElevs; and drag the _ags_160567225.tif into Cellsize. Then click OK.



4. In ArcToolbox, open Spatial Analyst Tools, then Math, and then Minus. Insert StaticElevs under the first Input raster and _ags_160567225.tif in the second Input raster. For the output raster, use: C:\E0177\Activity\6.1\StaticElvDpth. Then click OK.

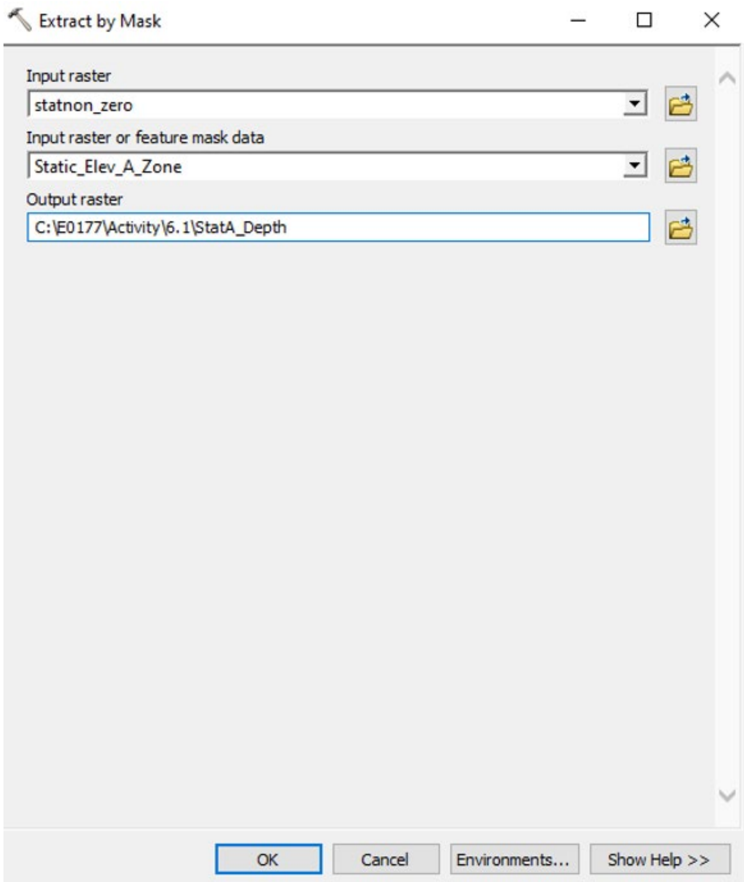


5. In ArcToolbox, navigate to Spatial Analyst Tools, then Extraction, and Extract by Attributes tool. For Input Raster, select StaticElvDpth; for the Where clause, use: Value>0; and for output raster use: C:\E0177\Activity\6.1\StatNon_Zero. This Removes the negative values and will leave the areas of flooding.



6. Merge the Static_Elev_A_Zone polygons together. Go to Editor and select Start Editing for the Static_Elev_A_Zone layer, select all the records, and then go to Editor and Merge. Stop editing and save your edits.

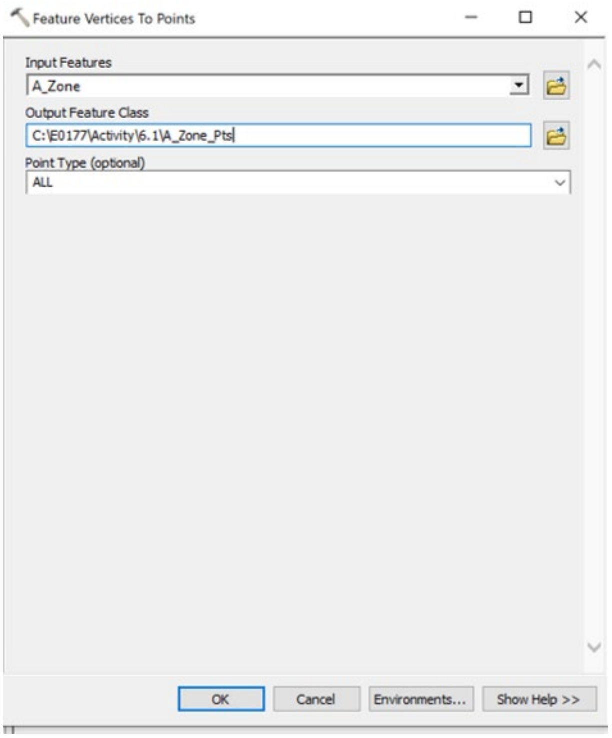
7. Navigate to Spatial Analyst Tools, then Extraction, then Extract by Mask tool. For input raster, select StatNon_Zero; for Input raster or feature mask data, select Static_Elev_A_Zone; and for Output raster, select: C:\E0177\Activity\6.1\StatA_Depth. Then click OK.



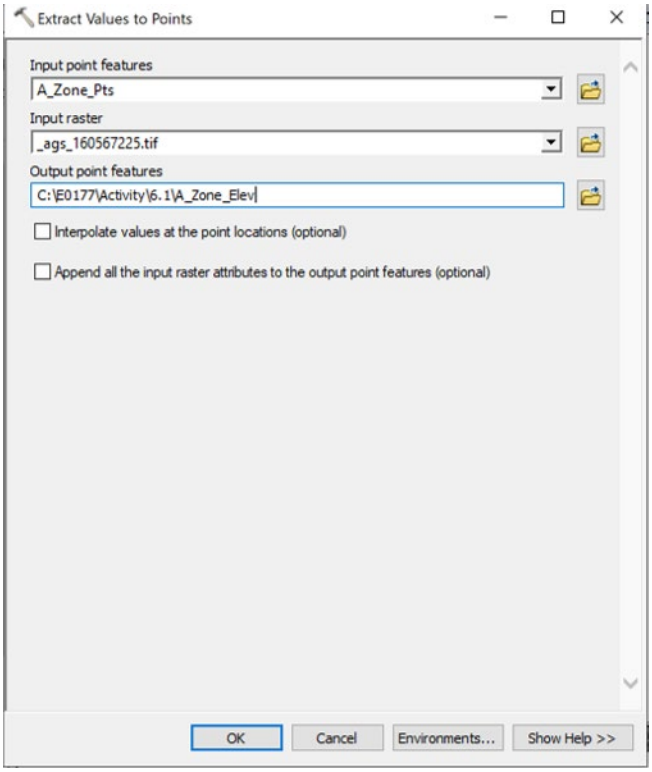
8. Remove the following layers: StatNon_Zero, Staticelvdpth, StaticElevs, and Static_Elev_A_Zone.

9. Now, develop the A zone depth grid. There are a few different ways to model the A zone when elevation data is not available. The process below creates a depth grid when the A zone areas are smaller and represent a small part of the overall floodplain. If the areas are bigger, you can use the enhanced quick look tool or run Hazus at a level one and extract by mask the Hazus generated floodplain using the floodplain boundary.

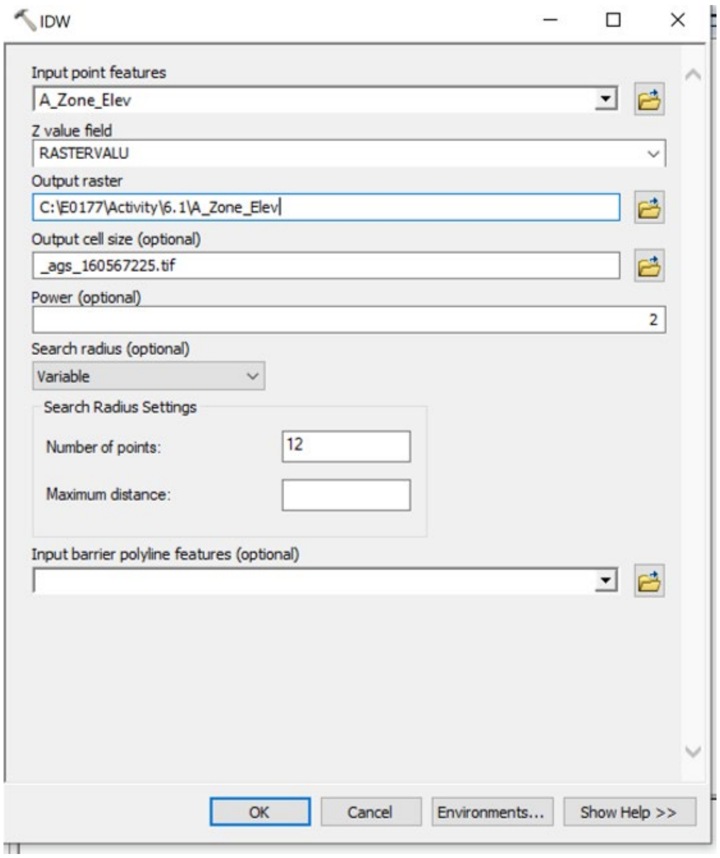
10. Open ArcToolbox, then Data Management Tools, then Features, and Feature Vertices to Points. For Input Features, use the A_Zone layer; for Output Feature Class, use C:\E0177\Activity\6.1\A_Zone_Pts.shp. Then click OK.



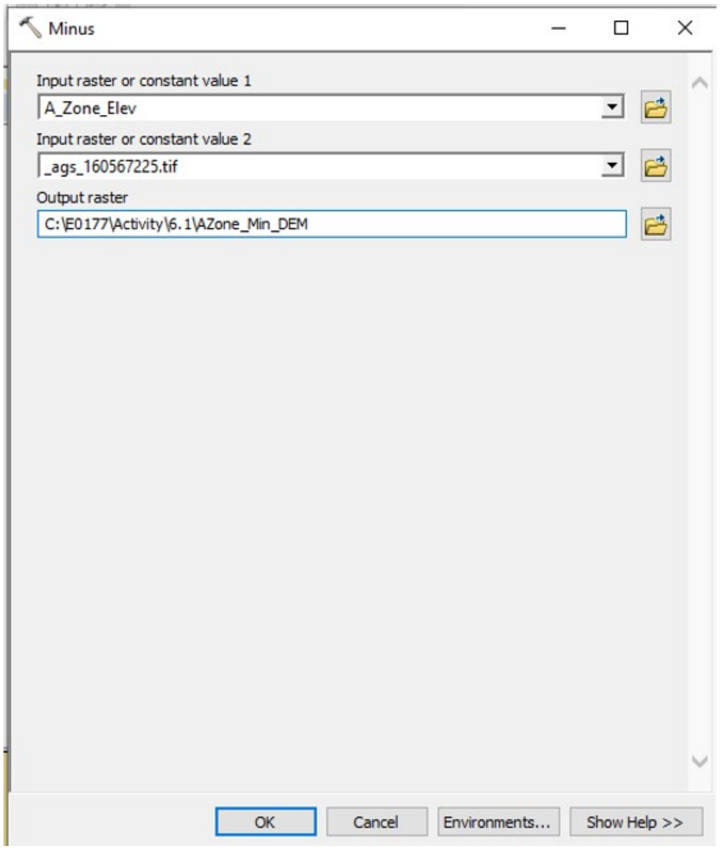
11. In ArcToolbox, go to Spatial Analyst Tools, then Extraction, and then Extract Values to Points. For Input point features, use A_Zone_Pts; for input raster, use _ags_160567225.tif; for Output point features, use: C:\E0177\Activity\6.1\A_Zone_Elev.shp. Then click OK.



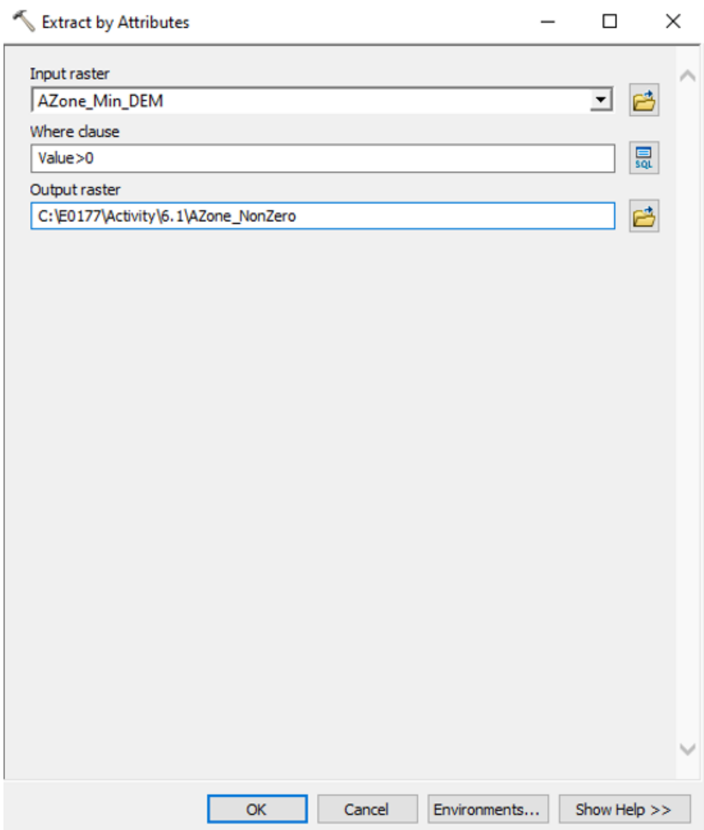
12. In ArcToolbox, go to Spatial Analyst Tools, the Interpolation Toolset, then IDW Tool. For Input point features, use A_Zone_Elev; for Z value field, use RASTERVALU; and for Output raster, use: C:\E0177\Activity\6.1\A_Zone_Elev. Drag and drop the _ags_160567225.tif DEM into the Output cell size. Then click the Environments button and from the Processing Extent option, choose Same as layer _ags_160567225.tif. Then click OK.



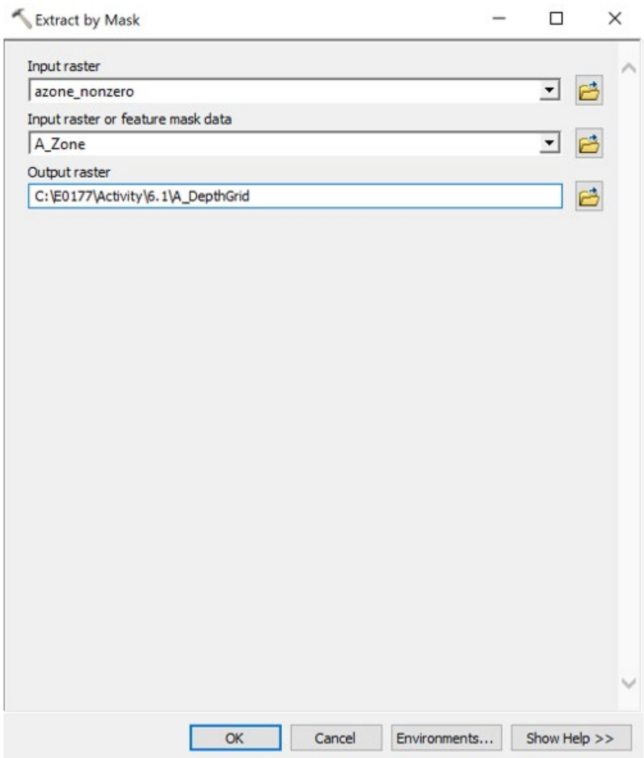
13. In ArcToolbox, open Spatial Analyst Tools, then Math, and then Minus. Insert A_Zone_Elev under the first Input raster and _ags_160567225.tif in the second Input raster. For the output raster, use: C:\E0177\Activity\6.1\AZone_Min_DEM. Then click OK.



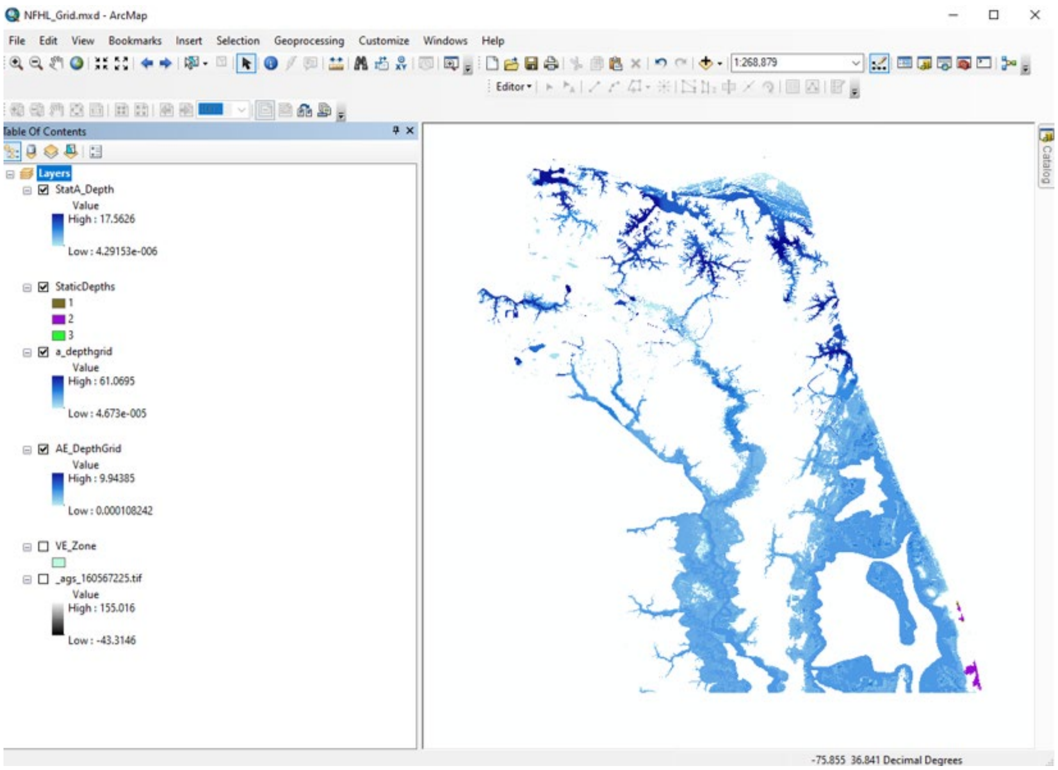
14. In ArcToolbox, navigate to Spatial Analyst Tools, then Extraction, and Extract by Attributes tool. For Input Raster, select AZone_Min_DEM; for the Where clause, use: Value>0; and for output raster use: C:\E0177\Activity\6.1\AZone_NonZero. Removing the negative values will leave the areas of flooding. Then click OK.



15. Navigate to Spatial Analyst Tools, then Extraction, then Extract by Mask tool. For input raster, select AZone_NonZero; for Input raster or feature mask data, select A_Zone; and for Output raster, select: C:\E0177\Activity\6.1\A_DepthGrid. Then click OK.

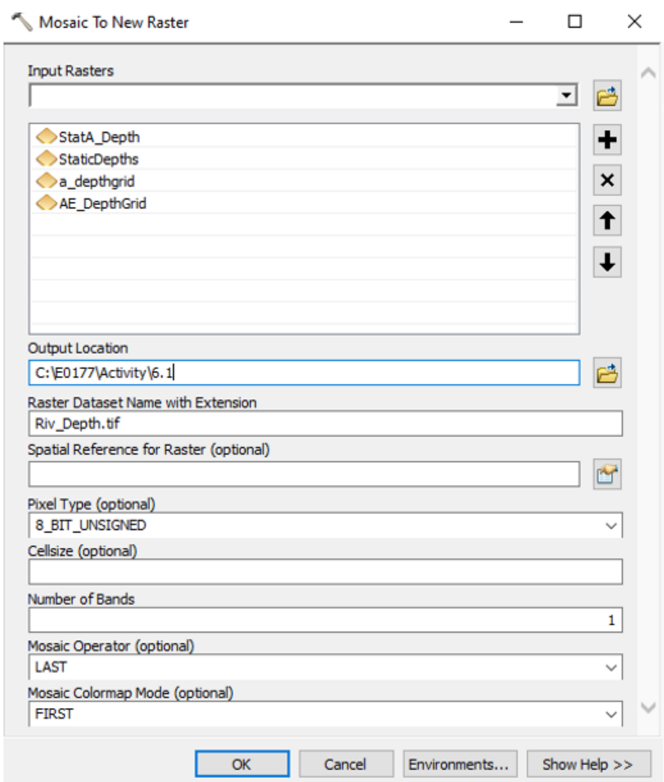


16. Remove the following layers: A_Zone_Elev, A_Zone_Pts, AZone_NonZero, AZone_Min_DEM, A_Zone_Elev, StatNon_Zero, and A_Zone.



Task 4: Develop Riverine Depth Grid

1. Now, develop the total riverine depth grid. In ArcToolbox, go to Data Management Tools, Raster, Raster Dataset, and Mosaic To New Raster. In the Input Rasters box, select: a_depthgrid, StatA_Depth, StaticDepths, and AE_DepthGrid. The Output Location: C:\E0177\Activity\6.1 and Raster Dataset Name with Extension: Riv_Depth.tif. For Number of Bands, select 1. Then click OK. This will create the combined Riverine Depth Grid.



2. Remove the a_depthgrid, StatA_Depth, StaticDepths, and AE_DepthGrid layers. Change the symbology to a blue color ramp.

Task 5: Develop Coastal Depth Grid

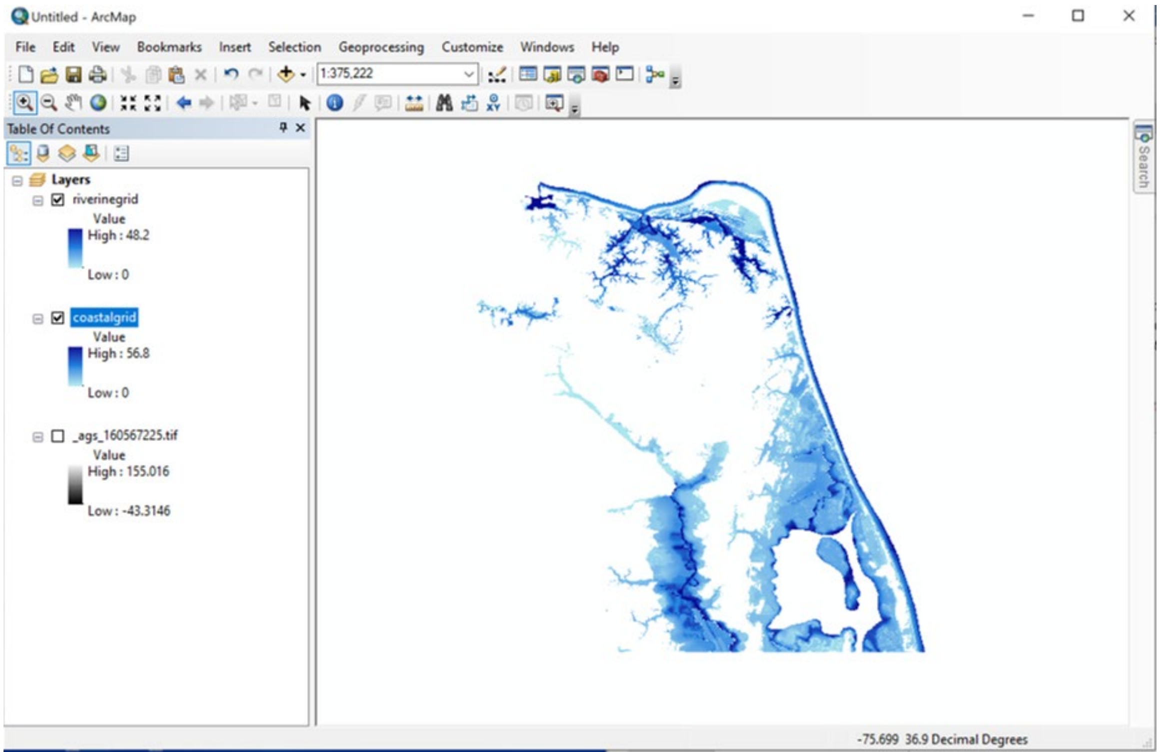
1. Now develop the coastal depth grid. This will be the same process used for the A zone static elevation zones. Open ArcToolbox, then Conversion Tools, then To Raster, and Polygon to Raster. Under Input Features, select VE_Zone; for Value field, select STATIC_BFE; under Output Raster Dataset, select C:\E0177\Activity\6.1\VZoneElev; and drag the _ags_160567225.tif into Cellsize. Then click OK.

2. In ArcToolbox, open Spatial Analyst Tools, then Math, and then Minus. Insert StaticElevs under the first Input raster and _ags_160567225.tif in the second Input raster. For the output raster, use: C:\E0177\Activity\6.1\VZone_Min_DEM. Then click OK.

3. ArcToolbox, navigate to Spatial Analyst Tools, then Extraction, and Extract by Attributes tool. For Input Raster, select StaticElvDpth; for the Where clause, use: Value>0; and for output raster use: C:\E0177\Activity\6.1\VZone_NonZero. This Removes the negative values and will leave the areas of flooding.

4. Navigate to Spatial Analyst Tools, then Extraction, then Extract by Mask tool. For input raster, select AZone_NonZero; for Input raster or feature mask data, select A_Zone; and for Output raster, select: C:\E0177\Activity\6.1\A_DepthGrid. Then click OK.

5. Remove the following layers: VZone_NonZero, VZone_Min_DEM, VZoneElev, and VE_Zone.



Task 6: Run a Hazus Analysis

1. In Hazus, go to Hazard and Flood Hazard Type, then select Riverine and coastal. Then click OK.

2. Go to Hazard, and User Data. Then select the Depth Grid tab. The Riverine tab should be selected. Browse to the RiverineGrid raster and click the Parameters tab. Set the Units to Feet and Return Period to 100. Then click OK and OK again.

3. Go to Hazard, and User Data. Then select the Depth Grid tab. The Coastal tab should be selected. Browse to the CoastalGrid raster. Click the Parameters tab. Set the Units to Feet and Return Period to 100. Then click OK and OK again.

4. Go to Hazard, Scenario, and New. Type in a scenario name. Make sure the scenario name has no spaces in it. Select the two depth grids for the scenario.

5. Go to Hazard, Riverine, and Delineate Floodplain. Then OK and Yes.

6. Go to Hazard, Coastal, and Delineate Floodplain. Then OK and Yes.

7. Run the Hazus analysis.

Task 7: Prepare to Discuss Results

1. Create a slide in PPT to provide information on this process you selected. Include which zones your community has in it, describe the zones and how they were modeled, and share your results.

Note: These slides may be used in the final capstone presentation at the end of the class.

Application 2: Model Long Term Flooding

The damage and loss produced by long term flooding caused by a levee or dam breach may be modeled in Hazus with the appropriate depth-damage functions and flood depth grid. This application will walk you through developing a flood depth grid for an inundation area and assigning long-term flood depth-damage functions.

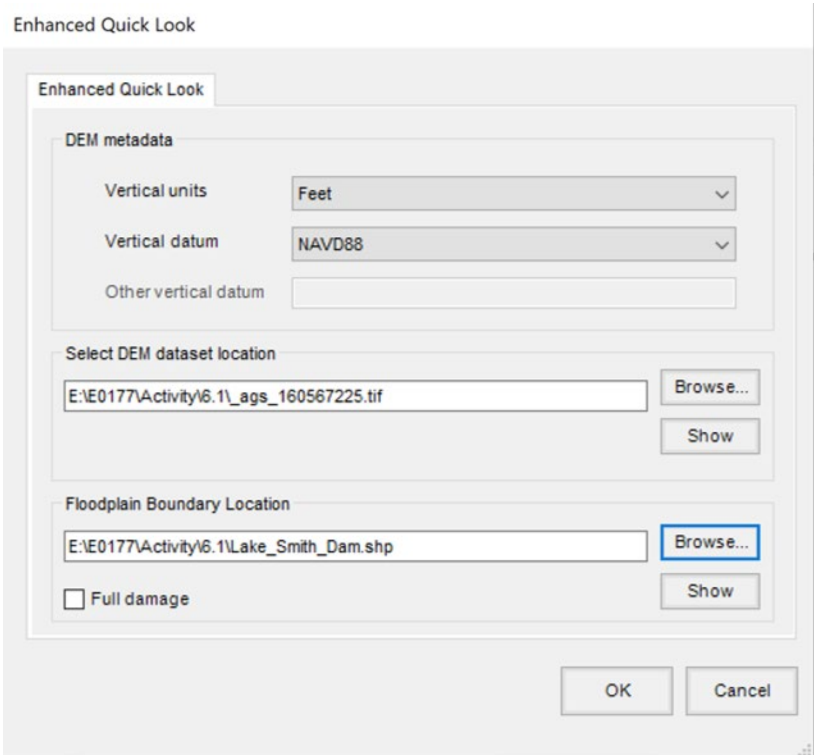
Task 1: Create a Scenario From a Dam Breach Depth Grid

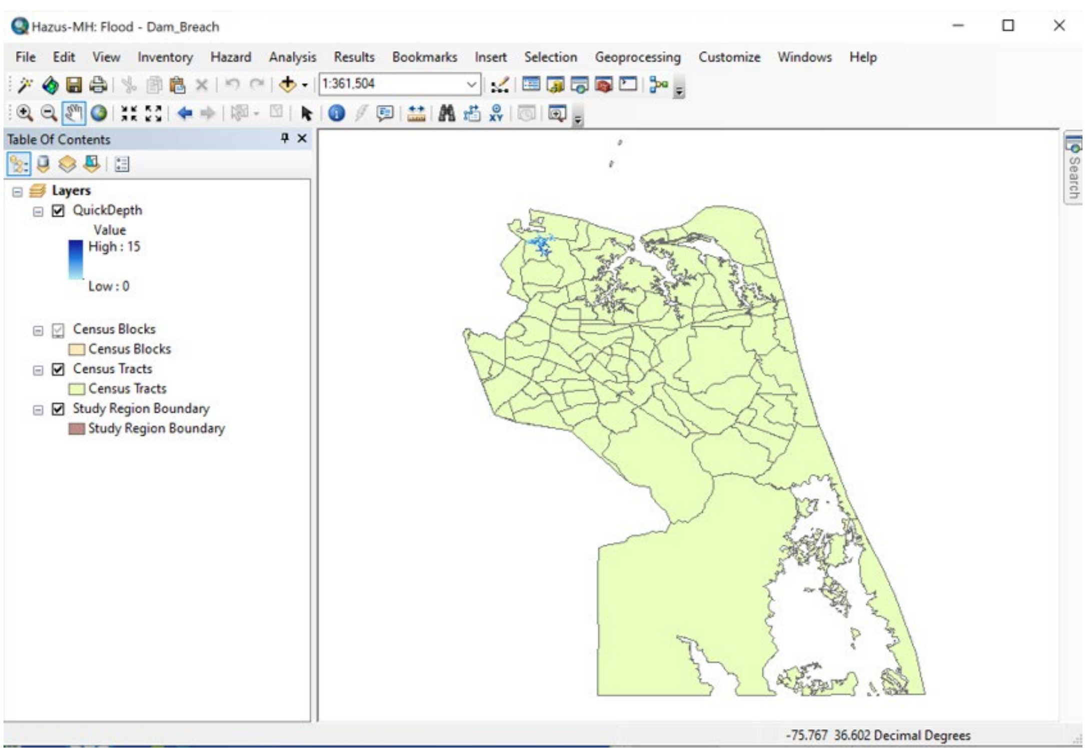
1. Create a Virginia Beach, Virginia flood study region. Name the study region something you can remember.

2. Download the inundation polygons. The dam inundation polygons from Virginia Beach may be downloaded from their website: https://gis.data.vbgov.com/datasets/5d32a08e90a341e583f348794daf1010_17. The data has already been downloaded and placed here: C:\E0177\Activity\6.1\Dam_Break_Inundation_Zones.shp. Every high hazard dam should have an Emergency Action Plan (EAP) where an inundation area is defined. If you're using this application with your local data, see if you can find an inundation map from the EAP.

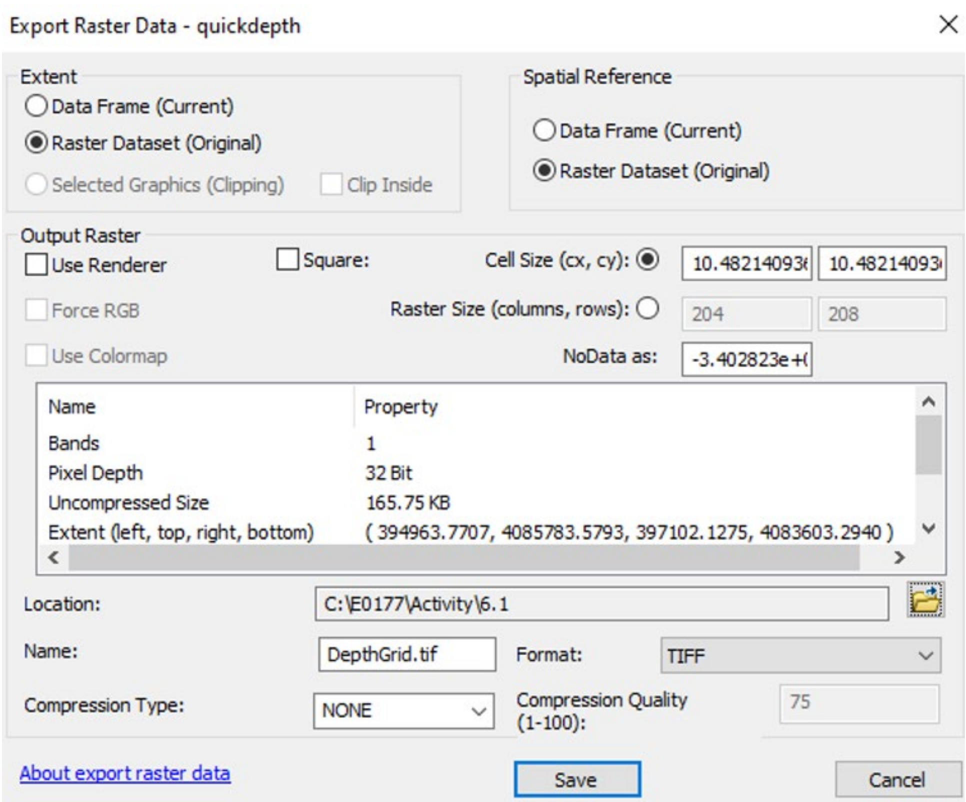
3. Add this shape file to the map in Hazus. The layer consists of three polygons for three separate dams. Select the most northernly polygon which is the Lake Smith Dam. Export this layer as C:\E0177\Activity\6.1\Lake_Smith_Dam.shp. Add the layer to the map and remove the Dam_Break_Inundation_Zones layer.

4. In Hazus, go to Hazard, then Flood Hazard Type, and select Riverine only. Then select Hazard, Quick Analysis, and Enhanced Quick Look. In the Enhanced Quick Look menu, next to Vertical units, select Feet; Vertical datum should be set to NAVD88; the DEM dataset location is C:\E0177\Activity\6.1_ags_160567225.tif; and the Floodplain Boundary Location is C:\E0177\Activity\6.1\Lake_Smith_Dam.shp. Click OK.


Enhanced Quick Look
Enhanced Quick Look
DEM metadata
Vertical units
Feet
Vertical datum
NAVD88
Other vertical datum
Select DEM dataset location
E:\E0177\Activity\6.1_ags_160567225.tif
Browse...
Show
Floodplain Boundary Location
E:\E0177\Activity\6.1\Lake_Smith_Dam.shp
Browse...
Full damage
Show
OK
Cancel


Hazus-MH: Flood - Dam_Breach
File Edit View Inventory Hazard Analysis Results Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:361,504
Table Of Contents
Layers
QuickDepth
Value
High : 15
Low : 0
Census Blocks
Census Blocks
Census Tracts
Census Tracts
Study Region Boundary
Study Region Boundary
Search
-75.767 36.602 Decimal Degrees

5. Export the quickdepth layer to: C:\E0177\Activity\6.1\DepthGrid.tif. Right click on the quickdepth grid, go to Data, and Export Data.



6. Click "Save".

7. Add the layer to the map and remove the quickdepth layer. Go to Hazard, User Data, Depth Grid tab, and browse to DepthGrid.tif. Set the parameters to feet with no return period selected. Then click OK. Please note that a warning will come up if the return period is not entered. Click Yes when the warning comes up.

8. Go to Hazard, Scenario, and New. Call the scenario Dam_Breach and select the depth grid as part of the scenario. Click Save selection and OK. Then go to Hazard, Riverine, and Delineate Floodplain. When the Riverine Hydraulic Analysis menu comes up, click OK. Then click Yes. When the process is complete, click OK.

Task 2: Update Depth Damage Functions

1. First you need to figure out which specific occupancies will be impacted by the dam breach. Go to Inventory, General Building Stock, and Dollar Exposure (Replacement Value). Under Table Type, select Specific Occupancy Type, select the building dropdown to change to Total,

and select the TotalExposure column. Then click Map and then Close. This will create a layer called: absv_InvGBSExposureTotalSOccup.

2. Go to Selection and Select by Location. Under selection method, click select features from. Then select absv_InvGBSExposureTotalSOccup under Target layers(s). Under Source layer, select BoundaryPolygon and under Spatial selection method for target layer feature(s), select intersect the source layer feature. Then click OK.

3. Open the attribute table and make a note of all the specific occupancies which are located under the dam depth grid. For this example in Virginia Beach, the following specific occupancies are present: RES1, RES2, RES3A, RES3B, RES3C, RES3D, RES3E, RES4, RES5, COM1, COM2, COM3, COM4, COM5, COM7, COM8, IND1, IND2, IND3, IND4, IND6, AGR1, REL1, GOV1, and EDU1. These are the damage functions which will need to be updated.

4. Go to Analysis, then Damage Functions, and Buildings. Click on Library in the bottom left of the menu. RES1 should be selected in the top left dropdown. In the table on the bottom right of the screen increase the size of the DamageFn Description column. Select row number 11 and notice that a row appears in green in the top right. This is the current selection (row 11) and above it, the default function. Notice that the damage is much higher with row number 11. Click on Select to set it as the default function for RES1, 1 story, no basement. This process assigns a long duration depth damage function to the structure. Now, the other specific occupancies need to have the long duration functions assigned. For each specific occupancy click on the row in the table below and then Select. Make the following changes:

Specific Occupancy	Row Number
R11B	5
R12N	11
R12B	4
R13N	No Change
R13B	No Change
R1SN	3
R1SB	No Change
R21N	4
R21B	4

Specific Occupancy	Row Number
All RES3A-E w/base	4
All RES3-A-E no base	3
RES4	4
RES5	No Change
COM1	52
COM2	24
COM3	16
COM4	14
COM5	4
COM7	7
COM8	21
IND1	4
IND2	7
IND3	3
IND4	5
IND6	16
AGR1	4
REL1	3
GOV1	5

Specific Occupancy	Row Number
EDU1	5

5. The structural damage functions have now been updated, now the content depth damage functions need to be updated. Click on the Contents tab. Then the Library button. Make the following changes to the Contents depth damage function:

Specific Occupancy	Row Number
R11N	3
R11B	4
R12N	6
R12B	4
R13N	No Change
R13B	No Change
R1SN	3
R1SB	4
R21N	4
R21B	4
All RES3A-E w/base	2
All RES3-A-E no base	3
RES4	No Change
RES5	No Change

Specific Occupancy	Row Number
COM1	83
COM2	20
COM3	2
COM4	20
COM5	4
COM7	7
COM8	No Change
IND1	16
IND2	8
IND3	8
IND4	No Change
IND6	8
AGR1	5
REL1	No Change
GOV1	2
EDU1	3

6. Now click on the Inventory tab. Then the Library button. Make the following changes to the Contents depth damage function:

Specific Occupancy	Row Number
COM1	2
COM2	19
IND1	3
IND2	8
IND3	6
IND4	No Change
IND6	2
AGR1	No Change

7. Click OK. Click Close.

Task 3: Run Hazus

1. Go to Analysis and Run. Click Select All and OK.

Task 4: Prepare to Discuss Results

1. Create a slide in PPT to provide information on this process you selected. Include which long term flooding was considered, the kind of inventory in the inundation area, and the results. If you have time, consider running the analysis using the default depth damage functions as well and compare the results to the modified analysis.

Note: These slides may be used in the final capstone presentation at the end of the class.

Application 3: Model a Combined Riverine and Coastal Flood

The Risk Mapping, Assessment and Planning (Risk MAP) Program develops advanced flood products for some U.S. communities. These products can contain flood depth grids and UDF data among other data. For the example below, you're going to go to the Map Service Center (https://msc.fema.gov/portal/home) and download the Flood Risk Database (FRD). Use the link above to go to the MSC. On the website, click on Search All Products. Then under state, select Virginia; under County, select Virginia Beach City; and under Community, select Virginia Beach, City of. Then select Search. Click on the Flood Risk Products folder and then the Flood Risk Database folder. The flood depth grid can be seen here: FRD_515531_Coastal_GeoTIFFS.

This file has already been downloaded for you here: C:\E0177\Activity\6.1\FRD_515531_Coastal_GeoDatabase_20160212.gdb. The depth grid that is provided to you includes both AE and VE zones. We'll want to split the grid in two so that we can bring it in as a riverine and coastal grid. All the site inventory data located in the coastal grid should also have the coastal depth damage functions associated with them.

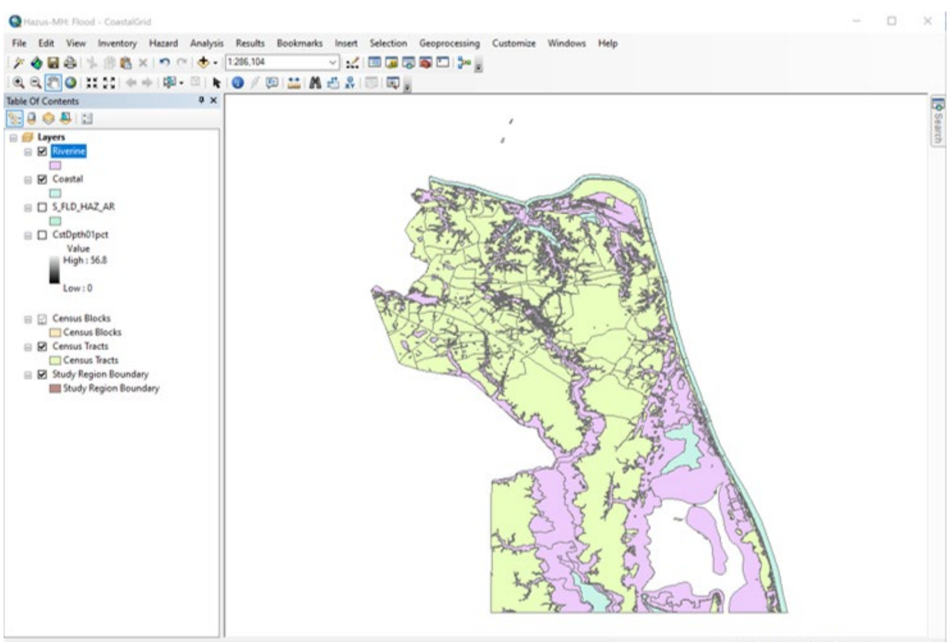
Task 1: Query Flood Data

1. Create a Virginia Beach, Virginia flood study region. Name the study region something you can remember.

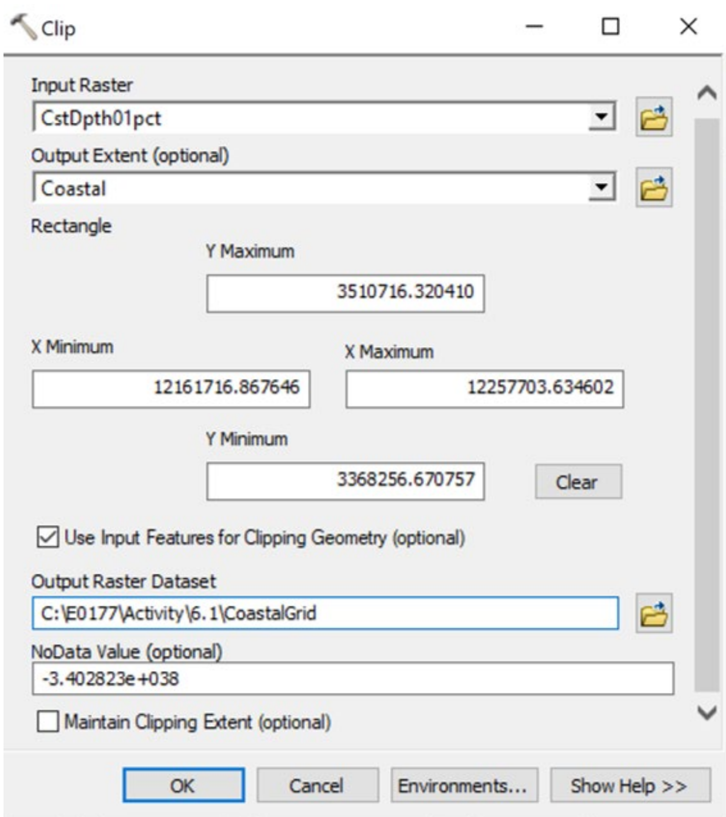
2. Add the raster layer found here: C:\E0177\Activity\6.1\FRD_515531_Coastal_GeoDatabase_20160212.gdb\CstDpth01pct. Next, add the Special Flood Hazard Layer: (C:\E0177\Activity\4.1\VirginiaBeach\515531_20160229\S_FLD_HAZ_AR.shp) to the map.

3. Run a Select by Attribute on the S_FLD_HAZ_AR and use the following query: "FLD_ZONE" = 'VE'. Save the selected polygons as C:\E0177\Activity\6.1\Coastal.shp.

4. Run a Select by Attribute on the S_FLD_HAZ_AR and use the following query: "FLD_ZONE" = 'A' OR "FLD_ZONE" = 'AE' OR "FLD_ZONE" = 'AH' OR "FLD_ZONE" = 'AO'. Save the selected polygons as C:\E0177\Activity\6.1\Riverine.shp.



5. Open ArcToolbox, then select Data Management Tools, Raster, Raster Processing, and Clip. For Input Raster, select CstDpth01pct; set Output Extent (optional) to coastal, click on the Use Input Features for Clipping Geometry box, and set the Output Raster Dataset to: C:\E0177\Activity\6.1\CoastalGrid. Then select OK.



6. Run the Clip tool again. For Input Raster, select CstDpth01pct; set Output Extent (optional) to riverine, click on the Use Input Features for Clipping Geometry box, and set the Output Raster Dataset to: C:\E0177\Activity\6.1\RiverineGrid. Then select OK. This process will take some time and you may want to take a break at this time.

7. Remove layers: Riverine, Coastal, S_FLD_HAZ_AR, RiverineGrid, CoastalGrid, and CstDpth01pct.

Task 2: Integrate Depth Grids in Hazus

1. In Hazus, go to Hazard and Flood Hazard Type, then select Riverine and coastal. Then click OK.

2. Go to Hazard, and User Data. Then select the Depth Grid tab. The Riverine tab should be selected. Browse to the RiverineGrid raster. Click the Parameters tab. Set the Units to Feet and Return Period to 100. Then click OK and OK again.

3. Go to Hazard, and User Data. Then select the Depth Grid tab. The Coastal tab should be selected. Browse to the CoastalGrid raster. Click the Parameters tab. Set the Units to Feet and Return Period to 100. Then click OK and OK again.

4. Go to Hazard, Scenario, and New. Type in a scenario name. Make sure the scenario name has no spaces in it. Select the two depth grids for the scenario.

5. Go to Hazard, Riverine, and Delineate Floodplain. Then OK and Yes.

6. Go to Hazard, Coastal, and Delineate Floodplain. Then OK and Yes.

7. Identify inventory in the coastal floodplain. Map the essential facilities to see if any fall in the coastal zone, if they do change the depth damage function ID in their table to the VE zone damage function. In the Virginia Beach example, there are no facilities in the VE zone. Review Activity 4 Application 1 if the depth damage functions need to be changed for your local inventory.

8. Run the Hazus analysis.

Note: Export some of the results of interest to a separate folder in case you want to come back to the results later. Try using the Hazus Export Tool to save the results to one geodatabase.

Task 3: Prepare to Discuss Results

1. Create a slide in PPT to provide information on this process you selected. Include the coastal and riverine grids, the kind of inventory in the inundation area, and the results.

Note: These slides may be used in the final capstone presentation at the end of the class.

Application 4: Integrate Climate Change Into An Analysis (Part 2)

This application is part two of two of the climate change activity. You must start with part one in the hurricane activities (Application 3 in Exercise 5.1). This continues the modified Hurricane Dorian storm surge activity.

Task 1: Prepare the Digital Elevation Model (DEM)

1. Find the study region that was created in Exercise 5.1 and make sure the hurricane wind analysis has completed. Open the main Hazus menu (before opening a region) and select Export/Backup a Region and click OK. Save the file here: C:\E0177\Activity\6.1\CC.hpr. Click Export/Backup. Then select OK when the process is complete. This will create a backup of the hurricane surge study region which you'll use later in this application. Exit from the Hazus menu.

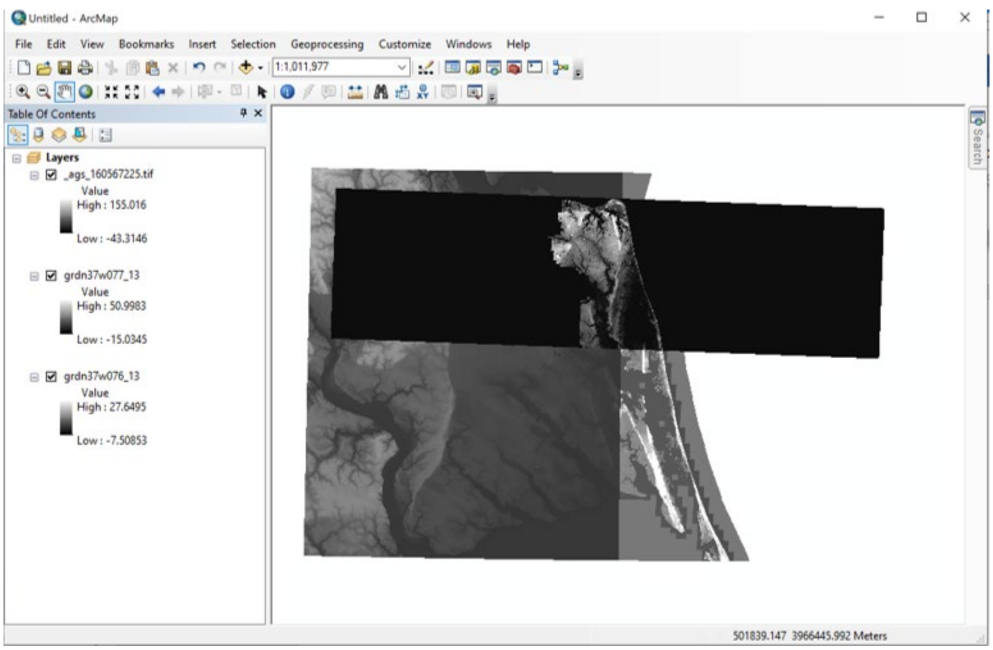
2. Identify the sea level rise value the community wants to integrate into their planning. For the Virginia Beach example, the City has identified a range of sea level values found in this council brief link: (https://www.vbgov.com/government/departments/public-works/comp-sea-level-rise/Documents/slr-rf-plan-study-policy-strat-council-brief-1-15-19.pdf). Slide nine shows two values (1.5 and 3.0 feet) for municipal and long-term planning. Slide 10 shows the upper limits of planning of 6.0 feet as the worst-case scenario. It's worth exploring what the community has already looked at for climate change scenarios. Many times, they've already engaged experts to help with the community planning.

3. If your community has not identified a sea level rise value to plan to, go to the US Army Corps of Engineers site: http://corpsmapu.usace.army.mil/rccinfo/slc/slcc_calc.html. Scroll down and enter a project name, zoom into the map around your community and select the closest tide gauge, then enter project start years and end years, and then scroll down and look at the projections. Select the high and intermediate projections for planning.

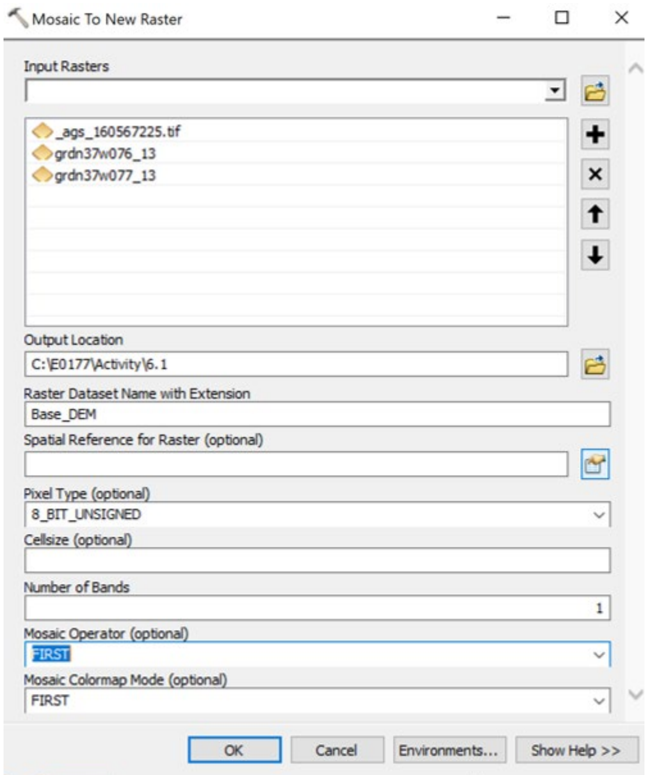
4. Open the modified Hurricane Dorian study region in the flood hazard. Go to Hazard, then Flood Hazard Type, and select Coastal Surge. Then click OK.

5. Go to Hazard and User Data. Select Determine required DEM extent button. Click on the 1/3 arcsecond resolution and then select Download and unzip all. When the save and unzip menu comes up, click OK. When the “automatically incorporate DEM” message comes up, click No. Close the User Data menu and close Hazus.

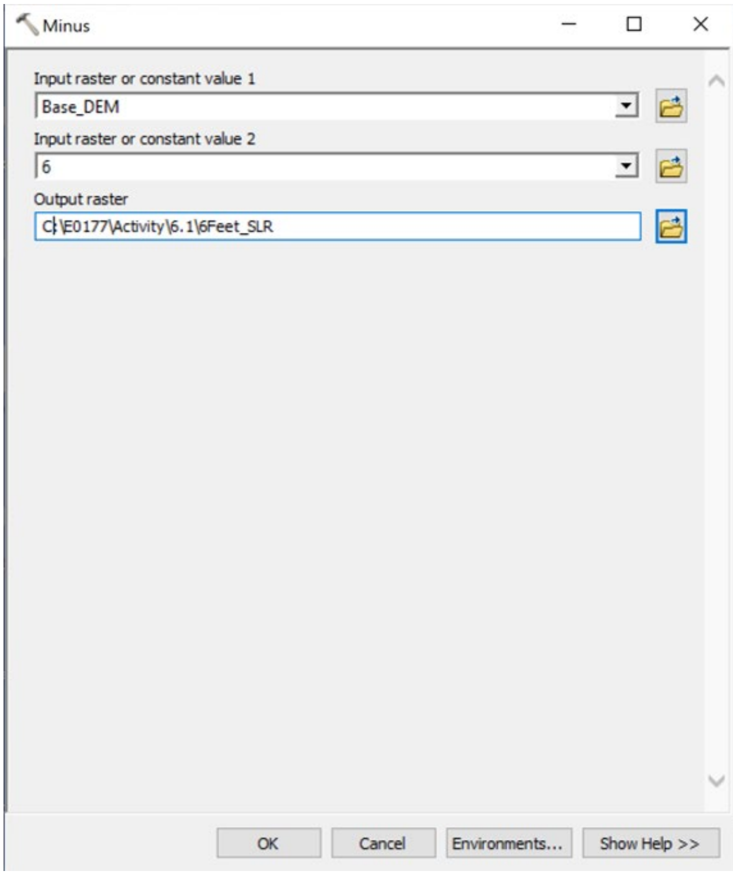
6. Open ArcMap and bring in the local DEM and the DEMs downloaded using the Hazus interface. The DEMs get downloaded here: C:\HazusData\HazardInput\Flood\DEM\VABeach_CC for a study region named VABeach_CC.



7. Open ArcToolbox, then Data Management Tools, Raster, Raster Dataset, and Mosaic To New Raster. Select the DEMs and make sure you select the local DEM first (for the Virginia Beach example that would be _ags_160567225.tif). Under output location, select: C:\E0177\Activity\6.1; for the Dataset name, select Base_DEM; for Number of Bands, type 1; and for Mosaic Operator, select First. Then click OK.



8. Open ArcToolbox, select Spatial Analyst Tools, then Math, and Minus. Select Base_DEM as the Input raster or constant value 1. For Input raster or constant value 2, select 6 and for Output raster: C:\E0177\Activity\6.1\6Feet_SLR. Then click OK.



9. Run the minus tool again for 3 feet (as the Input raster or constant value 2 set to 3) and call the new grid: 3Feet_SLR. Close ArcMap.

Task 2: Run the Coastal Flood Model for 6 Feet.

1. Open the main Hazus menu and select Import a region. Browse to the CC.hpr file and import it. Name the import SLR_6Feet and then click OK. Click OK again once the import process is complete. Open the SLR_6Feet study region in the flood hazard.

2. Go to Hazard, then Flood Hazard Type, and select Coastal Surge. Then click OK.

3. Go to Hazard and User Data. Under the DEM tab, browse to the 6Feet_SLR DEM. Click OK and Yes.

4.Go to Hazard, Scenario, and New. Name the new scenario 6FeetSLR and then click OK. Select Next, set the wave exposure to Minimal exposure to the southern shoreline and Open coast to the main shoreline. Then click Finish.

5. Go to Hazard, Coastal, Delineate Floodplain. After the processing completes, click OK.

6. Go to Analysis and Run. Then click Select All. Unselect What-If and Agricultural Products. Then click OK.

7. Explore the results and close Hazus. Try using the Hazus Export Tool (located in the ArcToolbox) to save the results to one geodatabase.

Task 3: Run the Coastal Flood Model for 3 Feet.

1. Open the main Hazus menu and select Import a region. Browse to the CC.hpr file and import it. Name the import SLR_3Feet and then click OK. Click OK again once the import process is complete. Open the SLR_3Feet study region in the flood hazard.

2. Go to Hazard, then Flood Hazard Type, and select Coastal Surge. Then click OK.

3. Go to Hazard and User Data. Under the DEM tab, browse to the 3Feet_SLR DEM. Click OK and Yes.

4.Go to Hazard, Scenario, and New. Name the new scenario 3FeetSLR and then click OK. Select Next, set the wave exposure to Minimal exposure to the southern shoreline and Open coast to the main shoreline. Then click Finish.

5. Go to Hazard, Coastal, Delineate Floodplain. After the processing completes, click OK.

6. Go to Analysis and Run. Then click Select All. Unselect What-If and Agricultural Products. Then click OK.

7. Explore the results and close Hazus. Try using the Hazus Export Tool (located in the ArcToolbox) to save the results to one geodatabase.

Note: Base level results could be generated using the Base_DEM elevation model.

Task 4: Prepare to Discuss Results

1. Create a slide in PPT to provide information on this process you selected.
Include which climate change scenario you used and the kind of results you modeled. Show results for different time horizons along with the baseline results and how those losses change.

Note: These slides may be used in the final capstone presentation at the end of the class.

Visual 29: Lesson 6: Review

1. List four sources for flood data
2. What is the difference between an A zone and a V zone?
3. What is the process for running a surge?
4. Where can I find an estimate for sea-level rise?

Visual 30: Questions?

Lesson 7: Advanced Earthquake

Visual 1: Lesson 7: Advanced Earthquake

HAZUS®
EARTHQUAKE • WIND • FLOOD • TSUNAMI

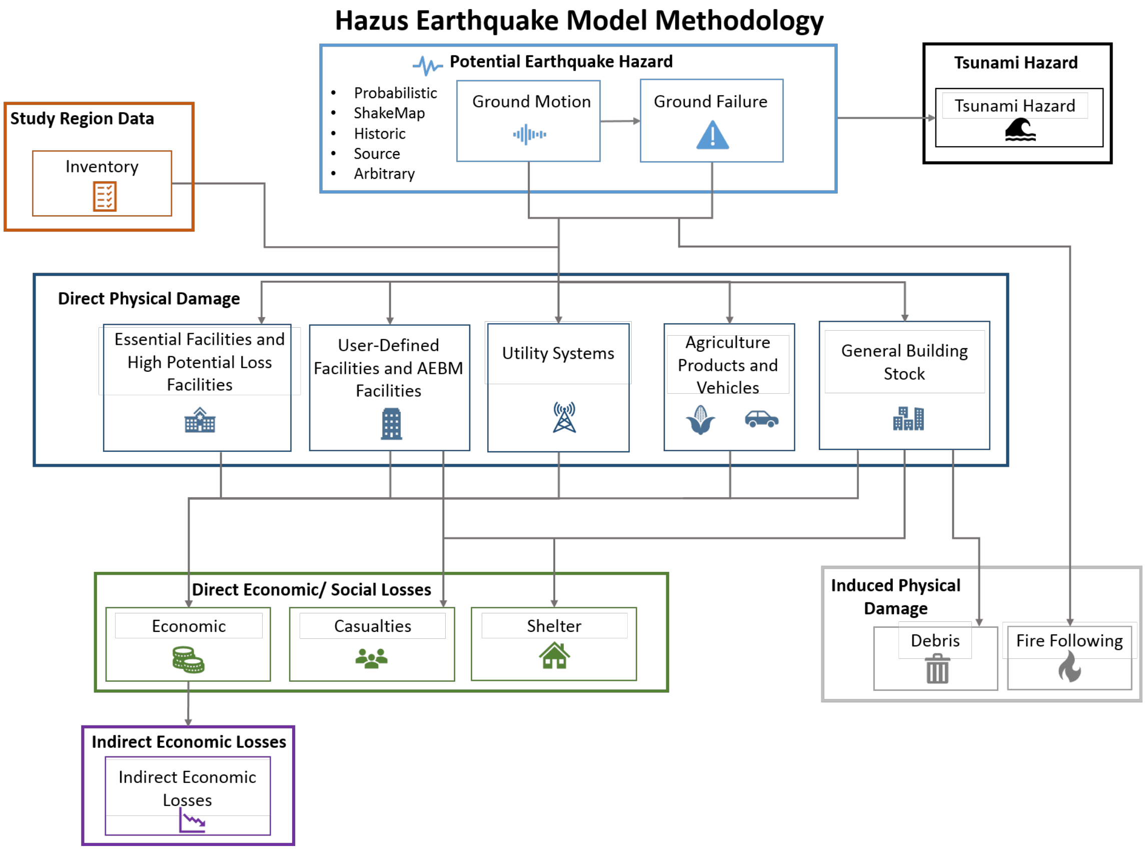
Visual 2: Lesson 7: Goal and Objectives

Goal: Better understand how advanced applications can help mitigate earthquake model limitations and generate more robust and accurate results.

After completing this lesson you will be able to:

- List sources of earthquake data
- Define the parameters unique to the earthquake model
- Identify four advanced applications for the earthquake hazard model
- Conduct an advanced application if applicable to your community

Visual 3: Earthquake Review



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Earthquake Review

Source: Earthquake Technical Manual, pg. 2-2, Figure 2.1 Flowchart of the Earthquake Loss Estimation Methodology.

Visual 4: Data Sources - USGS

- USGS ShakeMap: (https://earthquake.usgs.gov/data/shakemap/)
  - Atlas - ~6200 events
  - Scenarios – hypothetical large earthquakes

Earthquake catalog: (https://earthquake.usgs.gov/earthquakes/search/)

- Landslide catalog: (https://www.usgs.gov/natural-hazards/landslide-hazards)
- Soils data*: (https://earthquake.usgs.gov/data/vs30/)

*Do not use external soil data when using a USGS ShakeMap

Visual 5: Data Sources – Earthquake Engineering Research Institute (EERI)

- Non-profit focused on reducing earthquake risk
- Earthquake scenarios: (https://www.eeri.org/projects/earthquake-scenarios/)
- Help creating scenarios: (http://www.nehrpscenario.org/)
- Completed scenarios: (http://www.nehrpscenario.org/completed/)
- Scenarios underway: (http://www.nehrpscenario.org/underway/)

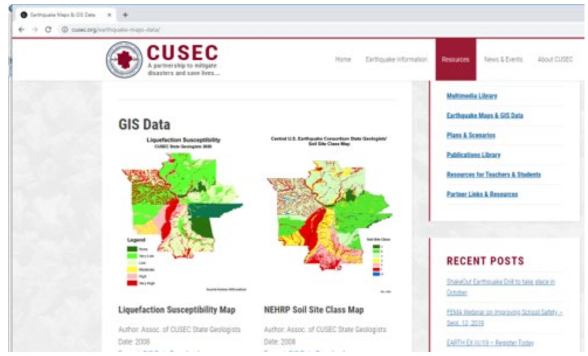
Visual 6: Data Sources – Regional Organizations

[Cascadia Region Earthquake Workgroup (CREW):](https://crew.org/) (https://crew.org/)

[Central United States Earthquake Consortium (CUSEC):](https://cusec.org/earthquake-maps-data) (https://cusec.org/earthquake-maps-data)

[Northeast States Emergency Consortium (NESEC)](http://nesec.org/): (http://nesec.org/)

[Western States Seismic Policy Council (WSSPC): (](https://www.wsspc.org/)https://www.wsspc.org/)



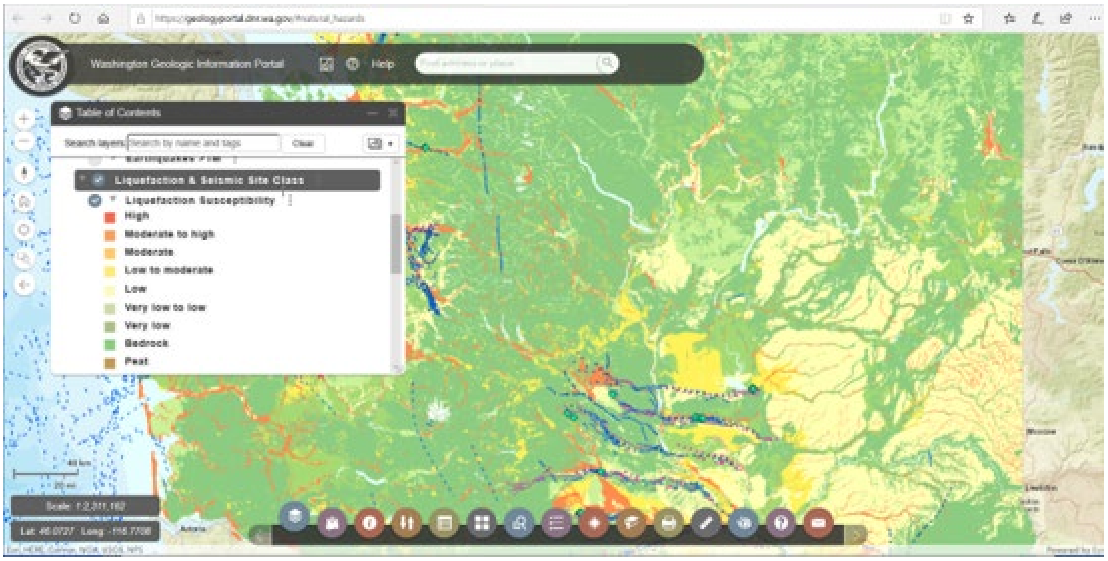
Data Sources – Regional Organizations

Student Manual

- Cascadia Region Earthquake Workgroup includes California, Oregon, and Washington.
- Central United States Earthquake Consortium includes Alabama, Arkansas, Illinois, Indiana, Kentucky, Mississippi, and Tennessee
- Northeast States Emergency Consortium includes Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont
- Western States Seismic Policy Council includes Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming, American Samoa, Guam, and Northern Mariana Islands.

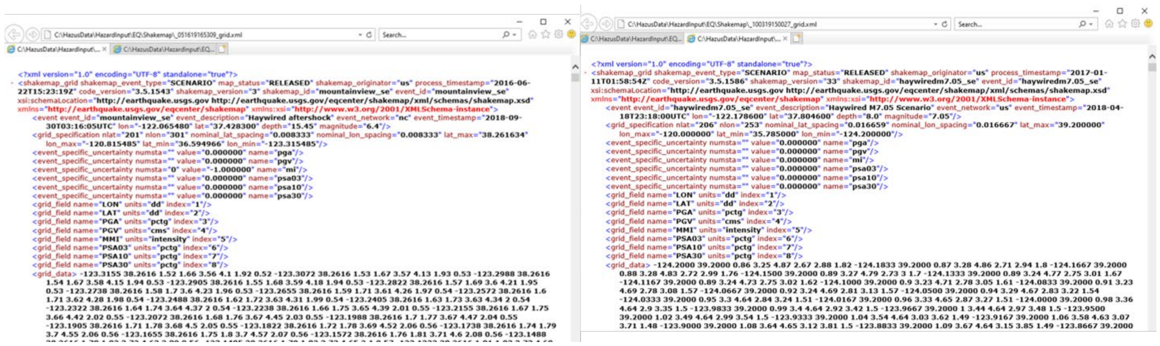
Visual 7: Data Sources - State

- Washington DNR: (https://www.dnr.wa.gov/programs-and-services/geology/geologic-hazards/geologic-hazard-maps)
- USGS State Contacts: (https://www.usgs.gov/natural-hazards/earthquake-hazards/earthquakes)



Visual 8: .XML Data Review

- Examples of .xml ShakeMaps are shown below
- Header provides information on the event name, date, magnitude, version, and location
- Event Type = SCENARIO or ACTUAL drives the application of Shake betas for fragilities if ACTUAL
- Body contains latitude, longitude, PGA, PGV, MMI, PSA03, PSA10, and PSA30



Visual 9: Using Local Soil Data

- Hazus requires specific soils map types, field name, and Datum *except for ShakeMap*
- Soil map: NEHRP soils
- File type: ESRI Personal Geodatabase
- Datum: World Geodetic System 1984 (WGS84)
- Field name: Type
- Field type: Text (1) Field values: A, B, C, D, or E
- Hazus analysis: Area weighted across Census Tract

Visual 10: Using Local Landslide Data

- Hazus requires a specific field name, values, and Datum
- Landslide map: landslide susceptibility
- File type: ESRI Personal Geodatabase
- Datum: World Geodetic System 1984 (WGS84)
- Field name: Type
- Field type: Numeric (2,0)
- Field values: 0-10

Visual 11: Using Local Liquefaction Data

- Hazus requires a specific field name, values, and Datum
- Liquefaction map: liquefaction susceptibility
- File type: ESRI Personal Geodatabase
- Datum: World Geodetic System 1984 (WGS84)
- Field name: Type
- Field type: Numeric (1,0)
- Field values: 0-5

Visual 12: Using Water Depth Data

- Hazus requires a specific field name, values, and Datum
- Only used if the liquefaction map is used
- File type: ESRI Personal Geodatabase
- Datum: World Geodetic System 1984 (WGS84)
- Field name: Type
- Field type: Decimal
- Field values: greater than 0 (in feet)

Visual 13: Adv. App. – Updating Soil Parameters

- Soil values can only contain one letter, not AB, CD, etc.
- Shear wave velocity may need to be converted to site class
- Dataset may need to be dissolved based on Type field

Site Class	Site Class Description	Shear Wave Velocity (m/sec) Minimum	Shear Wave Velocity (m/sec) Maximum
A	**Hard Rock** Eastern United States sites only	1500	
B	**Rock**	760	1500
C	**Very Dense Soil and Soft Rock** Undrained shear strength u, >= 2,000 psf (u, >= 100 kPa) or N >= 50 blows/ft	360	760
D	**Stiff Soils** Stiff soil with undrained shear strength 1,000 psf <= u, <= 2,000 psf (50 kPa <- u, <= 100 kPa) or 15 <= N <= 50 blows/ft	180	360
E	Soft Soils Profile with more than 10 ft (3 m) of soft clay defines as soil with plasticity index PI > 20, moisture content w > 40% and undrained shear strength u, < 1,000 psf (50 kPa) or N<50 blows/ft		180

Visual 14: Adv. App. – Updating Landslide Parameters

- Slope data (derived from a DEM) and soil data may be used to create a landslide map
- Dissolve should be used on the Type field

Geologic Group	Description	0-10	10-15	15-20	20-30	30-40	>40
		Slope Angle, degrees					
(a) DRY (groundwater below level of sliding)							
A	Strongly Cemented Rocks (Crystalline rocks and wet-cemented sandstone)	None	None	I	II	IV	VI
B	Weakly Cemented Rocks and Soils (sandy soils and poorly cemented sandstone)	None	III	IV	V	VI	VII
C	Argillaceous Rocks (shales, clayey soil, existing landslides, and	V	VI	VII	IX	IX	IX

Geologic Group	Description	0-10	10-15	15-20	20-30	30-40	>40
	poorly compacted fills)						
(b) WET (groundwater level at ground surface)							
A	Strongly Cemented Rocks (crystalline rocks and well-cemented sandstone)	None	III	VI	VII	VIII	VIII
B	Weakly Cemented Rocks and Soils (sandy soils and poorly cemented sandstone)	V	VIII	IX	IX	IX	X
C	Argillaceous Rocks (shales, clayey soil, existing landslides, and poorly compacted fills)	VII	IX	X	X	X	X

Landslide susceptibility is measured on a scale of I to X, with X being the most susceptible

Visual 15: Adv. App. – Updating Liquefaction Parameters

- Deposit types and age can be used to assess liquefaction susceptibility
- Dissolve should be used on the type field

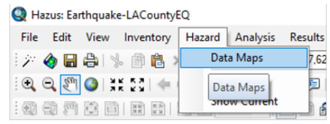
Type of Deposit	General Distribution of Cohesionless Sediments in Deposits	Modern <500 yr	Holocene < 11 ka	Pleistocene 11 ka - 2 Ma	Pre-Pleistocene 11 ka - 2 Ma
(a) Continental Deposits					
River channel	Locally variable	Very High	High	Low	Very Low
Flood plain	Locally variable	High	Moderate	Low	Very Low
Alluvial fan and plain	Widespread	Moderate	Low	Low	Very Low
Marine terraces and plains	Widespread	-	Low	Very Low	Very Low
Delta and fan-delta	Widespread	High	Moderate	Low	Very Low
Lacustrine and playa	Variable	High	Moderate	Low	Very Low
Colluvium	Variable	High	Moderate	Low	Very Lw
Talus	Widespread	Low	Low	Very Low	Very Low
Dunes	Widespread	High	Moderate	Low	Very Low
Loess	Variable	High	High	High	Unknown

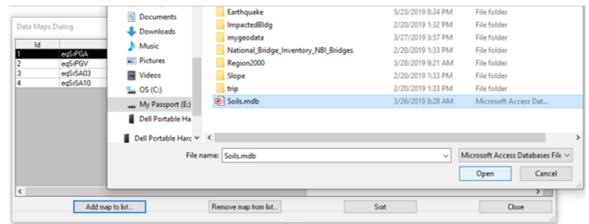
Type of Deposit	General Distribution of Cohesionless Sediments in Deposits	Modern <500 yr	Holocene < 11 ka	Pleistocene 11 ka - 2 Ma	Pre-Pleistocene 11 ka - 2 Ma
Glacial till	Variable	Low	Low	Very Low	Very Low
Tuff	Rare	Low	Low	Very Low	Very Low
Tephra	Widespread	High	High	?	?
Residual soils	Rare	Low	Low	Very Low	Very Low
Sebka	Locally variable	High	Moderate	Low	Very Low
(b) Coastal Zone					
Delta	Widespread	Very High	High	Low	Very low
Estaurine	Locally variable	High	Moerate	Low	Very Low
Beach - High Wave Energy	Widespread	Moderate	Low	Very Low	Very Low
Beach - Low Wave Energy	Widespread	High	Moderate	Low	Very Low
Lagoonal	Locally variable	High	Moderate	Low	Very Low
Fore shore	Locally variable	High	Moderate	Low	Very Low
(c) Artificial					
Uncompacted	Variable	Very High	-	-	-

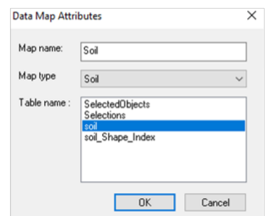
Type of Deposit	General Distribution of Cohesionless Sediments in Deposits	Modern <500 yr	Holocene < 11 ka	Pleistocene 11 ka - 2 Ma	Pre-Pleistocene 11 ka - 2 Ma
Fill					
Compacted Fill	Variable	Low	-	-	-

Visual 16: Adv. App. – Updating Hazard Parameters

- Select Data Maps under Hazard
- Click Add Map to List on bottom left
- Browse to personal geodatabase and select feature class
- Define map's name and click OK

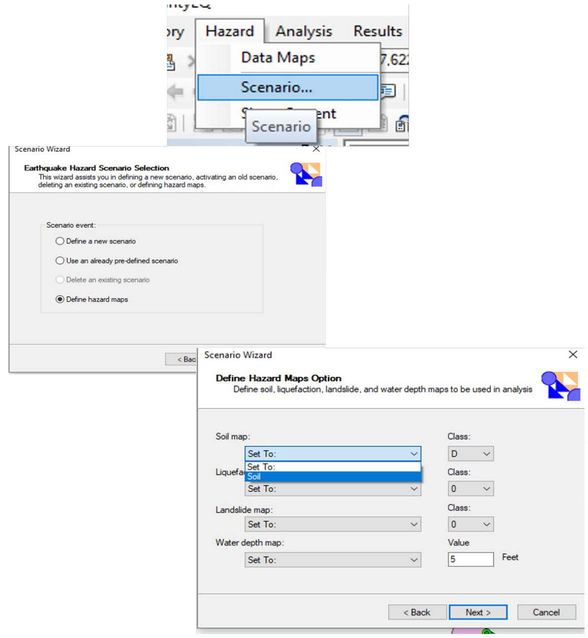






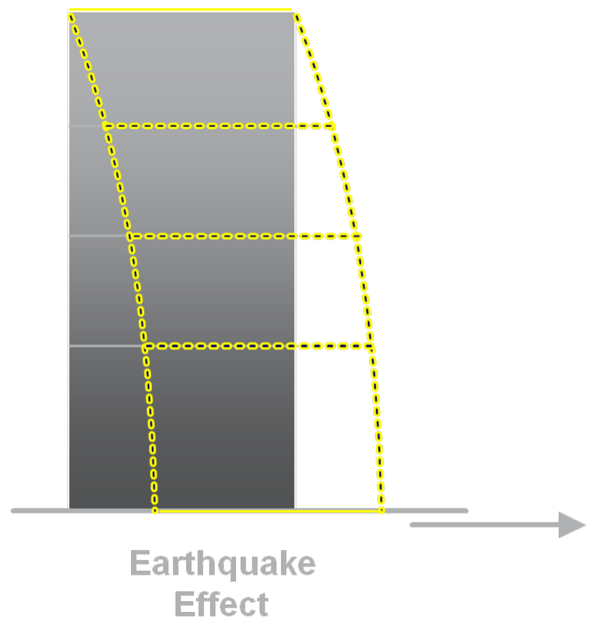
Visual 17: Adv. App. – Updating Hazard Parameters

- Select Hazard and then Scenario
- Click Define hazard maps and then Next
- Select each map to be updated and see the map name you created



Visual 18: Earthquake Forces on Buildings

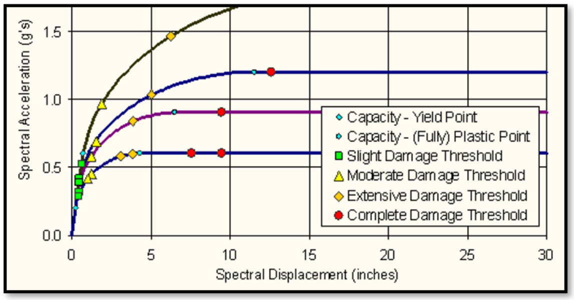
- Earthquakes only shake ground; they do NOT exert forces to buildings
- Earthquake force is generated when super- and sub-structures ‘fight’
- Substructures comply with shaking; superstructures do not



Visual 19: Building Capacity Curve

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

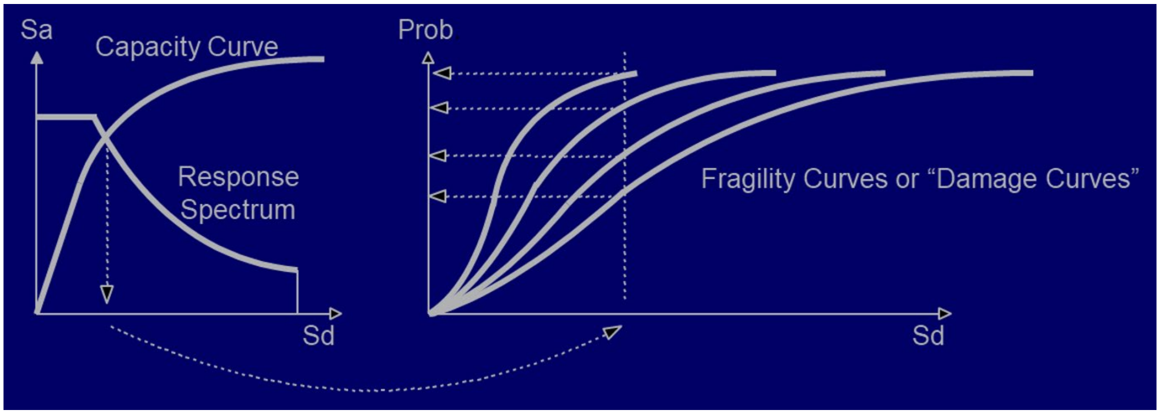
- Design capacity – strength of a building
- Yield capacity – point where a building experiences damage
- Ultimate capacity – point where a building is completely destroyed



Capacity curves plot building displacement versus earthquake force.

Visual 20: 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 21: Fragility Curves

Fragility curves are damage functions for earthquakes

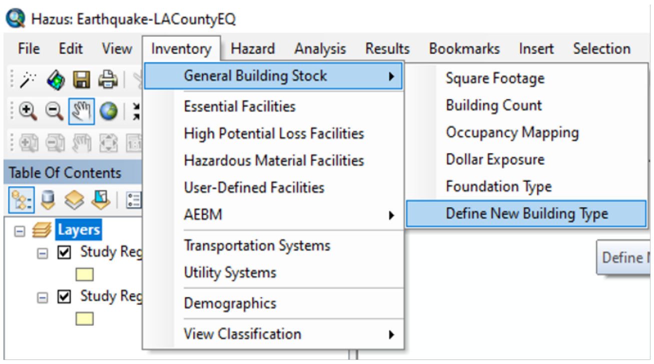
Lognormal distribution of being in or exceeding damage state

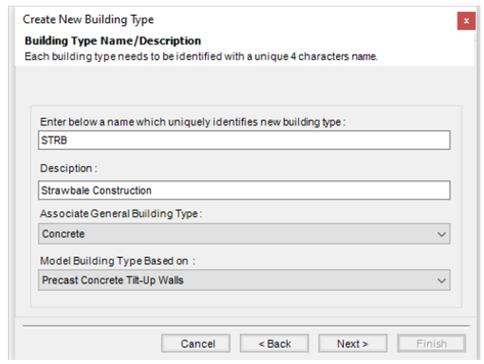
Considers variability of damage state due to:

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

Visual 22: Adv. App. - Developing New Building Types

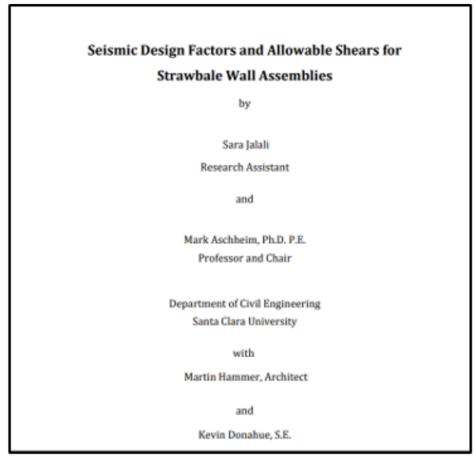
- Allows user to model unique buildings not included in the Hazus inventory
- Requires capacity curves and fragility curves (structural and non-structural), debris functions, and casualty rates





Visual 23: Adv. App. - Developing New Building Types

- Requires engineering expertise for the building parameters
- Capacity curve and fragility curve parameters are required
- New building type gets assigned to site level inventory not GBS


Seismic Design Factors and Allowable Shears for Strawbale Wall Assemblies

by

Sara Jalali
Research Assistant

and

Mark Aschheim, Ph.D. P.E.
Professor and Chair

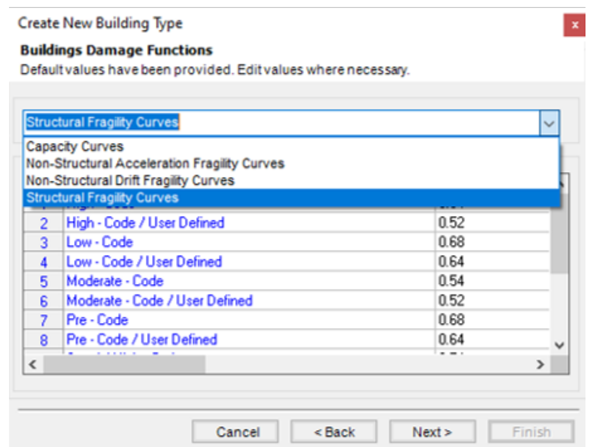
Department of Civil Engineering
Santa Clara University

with

Martin Hammer, Architect

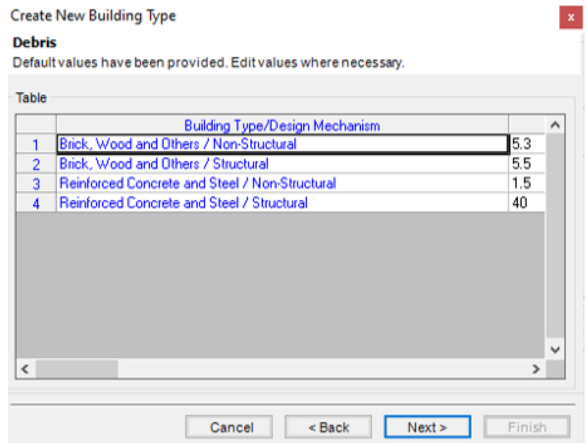
and

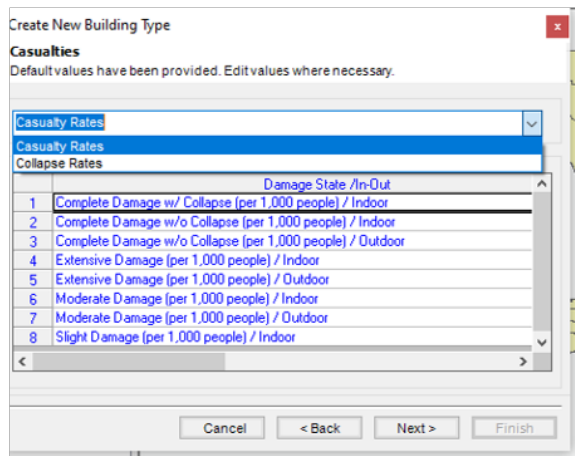
Kevin Donahue, S.E.



Visual 24: Adv. App. - Developing New Building Types

- Other building parameter values are also required
- Debris damage function parameters
- Casualty rate and collapse rate parameters





Visual 25: Selecting Damage Functions

- Methodology assigns seismic design level based on the study region location and not the age of the structures.
- Advanced users may update the seismic design level based on the building codes applicable to their community during different years.

Seismic Design Level	Seismic Performance Level Superior	Seismic Performance Level Ordinary	Seismic Performance Level Inferior
High **(UBC Zone 4)**	Special High-Code *Maximum Strength* *Maximum Ductility*	High-Code *High Strength* *High Ductility*	*Moderate Strength* *Mod./Low Ductility*
Moderate **(UBC Zone 2B)**	Special Moderate-Code *High/Mod. Strength* *High Ductility*	Moderate-Code *Moderate Strength* *Moderate Ductility*	*Low Strength* *Low Ductility*
Low **(UBC Zone 1)**	Special Low-Code *Mod./Low Strength* *Moderate Ductility*	Low-Code *Low Strength* *Low Ductility*	Pre-Code *Minimal Strength* *Minimal Ductility*

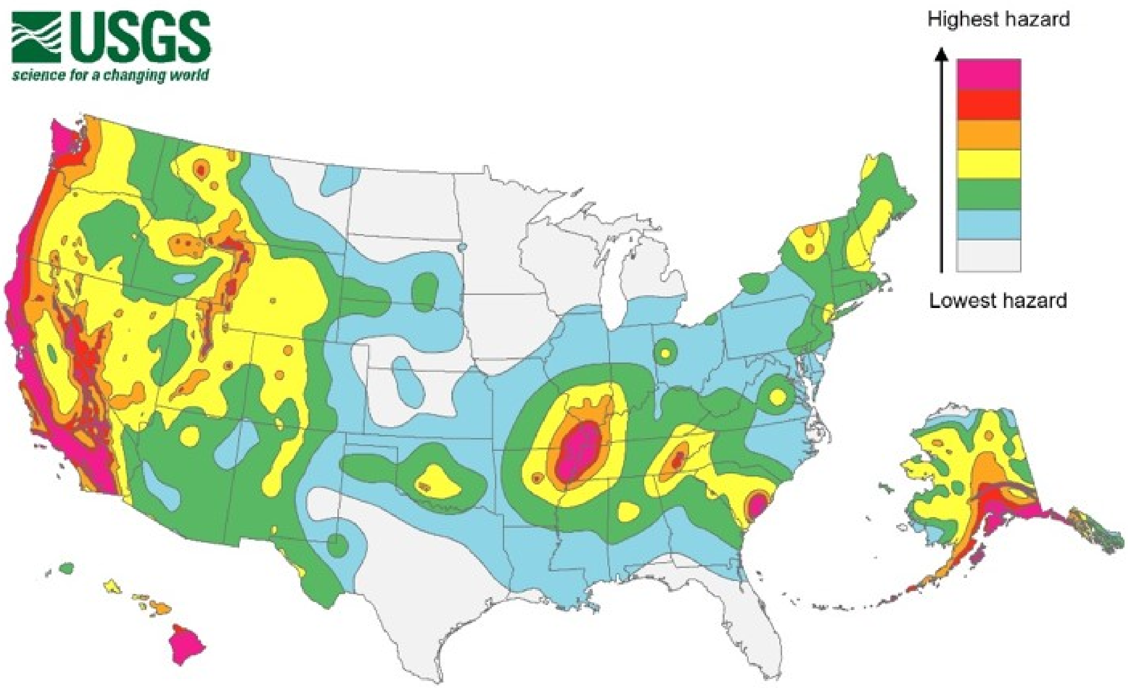
Visual 26: Adv. App. – Assigning Damage Functions

- Use parcel level data to update seismic levels in inventory
- Run queries to define GBS percentages or model at site level

UBC Seismic Zone (NEHRP Map Aea)	Post-1975	1941-1975	Pre-1941
Zone 4 (Map Area 7)	High-Code	Moderate-Code	Pre-Code (W1 = Moderate-Code)
Zone 3 (Map Area 6)	Moderate-Code	Moderate-Code	Pre-Code (W1 = Moderate-Code)
Zone 2B (Map Area 5)	Moderate-Code	Low-Code	Pre-Code (W1 = Low-Code)
Zone 2A (Map Area 4)	Low-Code	Low-Code	Pre-Code (W1 = Low-Code)
Zone 1 (Map Area 2/3)	Low-Code	Pre-Code (W1 = Low-Code)	Pre-Code (W1 = Low-Code)
Zone 0 (Map Area 1)	Pre-Code (W1 = Low-Code)	Pre-Code (W1 = Low-Code)	Pre-Code (W1 = Low-Code)

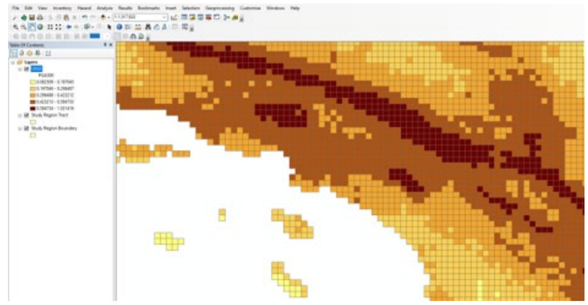
Visual 27: Adv. App. – Assigning Damage Functions

- Update mapping schemes using parcel data
- Update seismic design level in UDF or AEBM inventory



Visual 28: Earthquake Probabilistic Analysis

- Hazus earthquake uses the USGS probabilistic ground motion grids
- GBS now uses the area weighted value across the Census Tract rather than the centroid of the Tract
- Different than the hurricane model which selects a single event



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Earthquake Probabilistic Analysis

This is a map of coastal California which shows the probabilistic ground shaking parameters from USGS. A Faultline may be seen where the color gets darker.

Visual 29: Adv. App. – Assessing Risk in Low/Mod Risk Areas

- Deterministic events have more damage nearer the source (fault or epicenter) while the probabilistic model has lesser damage spread across study region.
- When historical earthquakes do much more damage than the 2500-year event, it makes sense to model a deterministic event (historical or scenario driven) along with a probabilistic analysis.
- Users should always use a ShakeMap if available as the first option

Visual 30: Adv. App. – Assessing Risk in Low/Mod Risk Areas

- Although earthquake may not be a high priority for a study region, vulnerable areas can still be identified within the community.
- When determining what kind of deterministic event to model, consult experts at the State and Federal level along with historical records.

Visual 31: Exercise 7.1: Advanced Earthquake Applications

- Goal: Implement an advanced application for the earthquake hazard
- Time: 225 minutes

(The exercise will be completed after Lesson 8)

Student Manual

Exercise 7.1 Advanced Earthquake Applications

Goal:

- Complete an Advanced Earthquake Application
- Share the results of the Advanced Earthquake Application(s)

Time: 225 minutes

Exercise Steps:

1. Refer to Activities Document “7.1_Exercise_AdvancedEarthquake".
2. Listen to instructor’s directions.
3. Ask questions if clarification is needed.
4. Work individually on the goal.
5. Ask questions to the instructor if needed.
6. Complete the assigned goal.
7. Be prepared to share your answers/results.
8. Ask any final questions.

Visual 32: Exercise 7.1: Tasks

- Pre-Task: Select Application
- Task 1: Implement Advanced Application
- Task 2: Share results
- Repeat For Additional Applications

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Exercise 7.1 Tasks

Refer to Activities Document “7.1_Exercise_AdvancedEarthquake”.

Exercise 7.1: Advanced Earthquake Applications

Type: Exercise

Time: 225 minutes for all hazard applications

Goals:

- Complete an Advanced Earthquake Application
  - Application 1: Update Earthquake Hazard Parameters
  - Application 2: Create a New Building Type
  - Application 3: Modify Vulnerability Functions
  - Application 4: Assessing Risk in a Low-to-Moderate Earthquake Risk Area
- Share results of the Advanced Earthquake Application

Background: This activity will help you identify and implement an advanced earthquake application. If earthquakes are not a priority to your community, you do not need to do an advanced earthquake application just choose a different hazard's activity to complete. Before you begin, the four advanced applications will be provided to you and you'll select the one (or more) that would be most beneficial to your community. If you finish one application and still have time, feel free to work through another. Approximate times have been provided for each option so just be aware of the time allotted for the activity. Data has been provided for Santa Cruz, California and Richmond, Virginia but you may use your own study region for the capstone presentation.

Before You Begin: Identify an Appropriate Advanced Hazard Application

There are four advanced flood applications to select from in this activity. Select the one that is most beneficial to your community:

Application 1: Update Earthquake Hazard Parameters

How do I update local soil, landslide, and liquefaction parameters in the earthquake model? Local and national data may be used to develop Hazus earthquake hazard maps. This process will walk you through the steps to update your own local data and integrate it into Hazus.

- Data Required: Digital Elevation Model, Soils, and Liquefaction (if available)
- Time Required: 60-90 Minutes
- Difficulty: Moderate - Hard

Application 2: Create a New Building Type

How do I create a new building type in the earthquake model? Although Hazus contains building types which cover the majority of building stock in our communities, occasionally there is a unique building type which needs to be modeled. This process will walk you through creating a new building type in Hazus and assigning it to inventory.

- Data Required: None
- Time Required: 15-20 Minutes
- Difficulty: Easy (process), Hard (Building Research)

Application 3: Modify Vulnerability Functions

How do I assign appropriate vulnerability functions to my earthquake inventory? This process expands on Activity 4.1 Application 4 and walks you through using local inventory data to update seismic design level and building type including building mapping schemes and AEBM.

- Data Required: Land Use or Land Cover data
- Time Required: 100-120 Minutes
- Difficulty Level: Hard

Application 4: Assessing Risk in Low-to-Moderate Earthquake Risk Areas

How do I assess earthquake risk in a low to moderate risk area? When I run the probabilistic earthquake analysis for my hazard mitigation plan, only the 2500-year event is generating damage and loss.

- Data Required: None
- Time Required: 20-30 Minutes
- Difficulty Level: Low-Moderate

Once you have chosen an Application, navigate to that section and begin the activity.

Application 1: Update Earthquake Hazard Parameters

For this activity, you'll need a high-resolution DEM, a floodplain map from the Map Service Center, a soils map, and any local landslide or liquefaction susceptibility data. The example provided in Task 1 uses data from Santa Cruz, California.

For the soils data, you'll need the National Earthquake Hazard Reduction Program (NEHRP) soil type map. If that hasn't been created at the local or State level, the Vs30 (time-averaged shear-wave velocity to 30 m depth) data may be used. It can be downloaded from the USGS Website: (https://earthquake.usgs.gov/data/vs30/). This data has already been downloaded for you and placed here: C:\E0177\Activity\7.1\global_vs30.tif.

For the landslide data, you'll use a high-resolution DEM. Lidar data can be downloaded from NOAA's Digital Coast website (https://coast.noaa.gov/digitalcoast/). Search for the area name and elevation. The data has already been downloaded and placed here: C:\E0177\Activity\7.1\DEM.

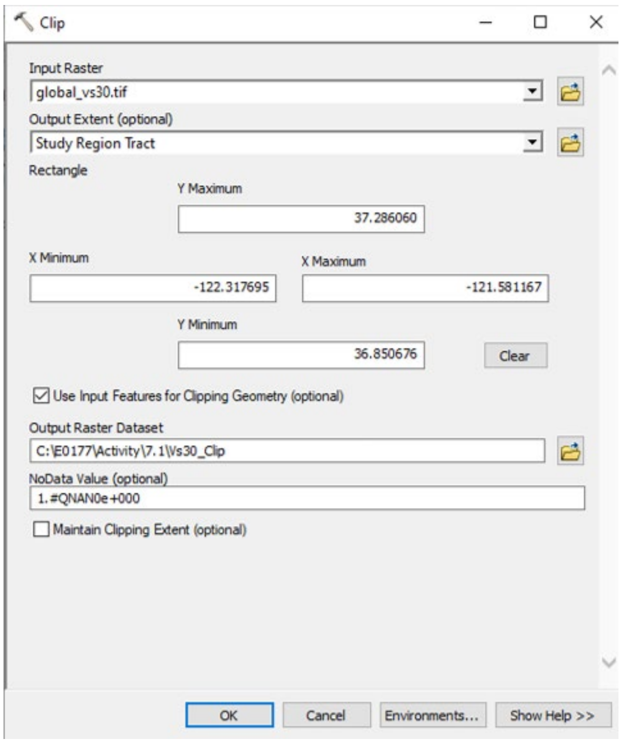
For the liquefaction data, you'll download county liquefaction data from the Santa Cruz County website (https://www.co.santa-cruz.ca.us/Departments/GeographicInformationSystems(GIS).aspx) and the National Flood Hazard Layer (NFHL) data from the Map Service Center (https://msc.fema.gov/portal/home). The liquefaction data has already been downloaded and placed here: C:\E0177\Activity\7.1\Liquefaction_Areas.shp and the floodplain data has been downloaded and placed here: C:\E0177\Activity\4.1\SantaCruz\06087C_20190710\.

Task 1: Create a NEHRP Soils Map

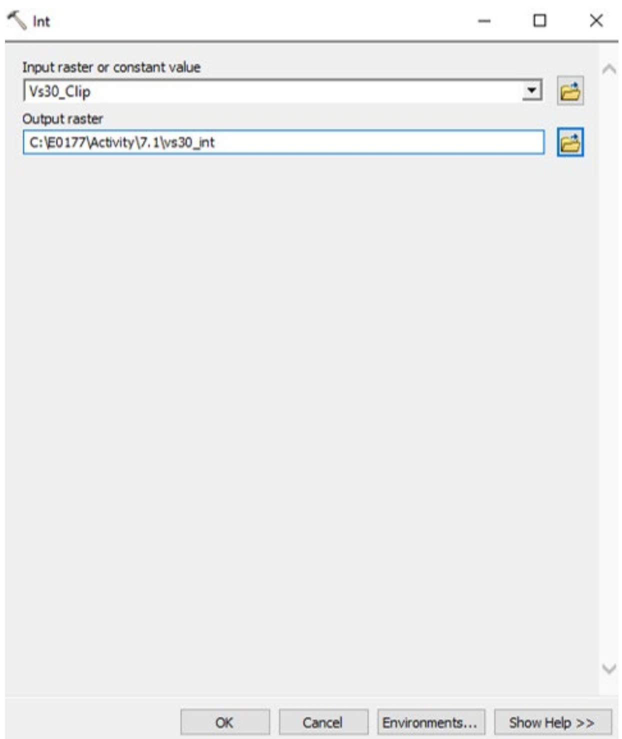
1. Create a Santa Cruz, California tsunami study region. Name the study region something you can remember. If you're creating your own study region, select that county and State.

2. Create a NEHRP soils map. Open the Hazus earthquake study region and add the following layer to your map: C:\E0177\Activity\7.1\global_vs30.tif. This data will cover any Hazus study region and is not just for Santa Cruz.

3. Open ArcToolbox, select Data Management Tools, Raster, Raster Processing, and Clip. For Input Raster, select global_vs30.tif; for Output Extent, select Study Region Tract; check the box next to Use Input Features for Clipping Geometry; and set the Output Raster Dataset to: C:\E0177\Activity\7.1\Vs30_Clip. Then click OK.



4. Remove the global_vs30.tif layer. Convert the grid into an integer grid so that it is easier to reclassify the values. In ArcToolbox, select Spatial Analyst Tools, Math, and double click on Int. For the Input raster or constant value, select Vs30_Clip and for Output raster, select C:\E0177\Activity\7.1\vs30_int. Click OK.

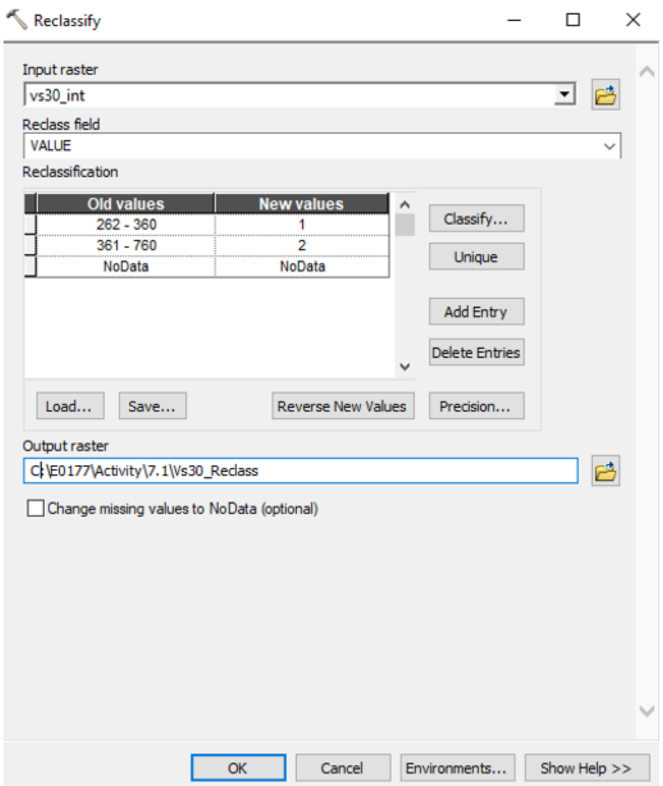


5. In ArcToolbox, select Spatial Analyst Tools, then Reclass, and double click on Reclassify. For Input raster, select Vs30_int; for Reclass field, select VALUE; and for Output raster, use: C:\E0177\Activity\7.1\Vs30_Reclass. For the reclassification, use the table below.

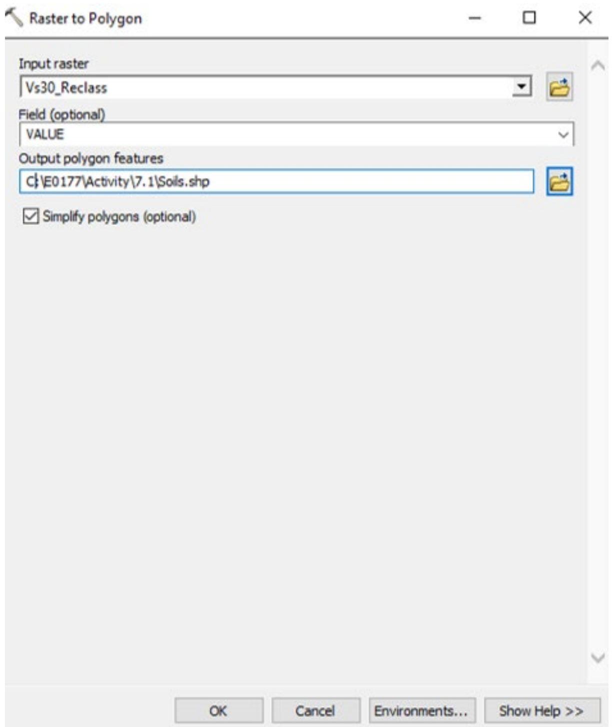
Site Class	Site Class Description	Minimum Shear Wave Velocity (m/sec)	Maximum Shear Wave Velocity (m/sec)
A	**Hard Rock** Eastern United States only	1500	
B	**Rock**	760	1500
C	**Very Dense Soil and Soft Rock** Undrained shear strength us >= 2,000 psf (us >= 100 kPa) or N>= 50 blows/ft.	360	760

Site Class	Site Class Description	Minimum Shear Wave Velocity (m/sec)	Maximum Shear Wave Velocity (m/sec)
D	**Stiff Soils** Stiff soil with undrained shear strength 1,000 psf =< us =< 2,000 psf (50 kPa =< us =< 100kPa) or 15=< N 50 blows/ft	180	360
E	**Soft Soils** Profile with more than 10 ft (3m) of soft clay defines as soil with plasticity index PI > 20, moisture content x > 40% and undrained shear strength us < 1,000 psf (50 kPa) or N<50 blows/ft.		180

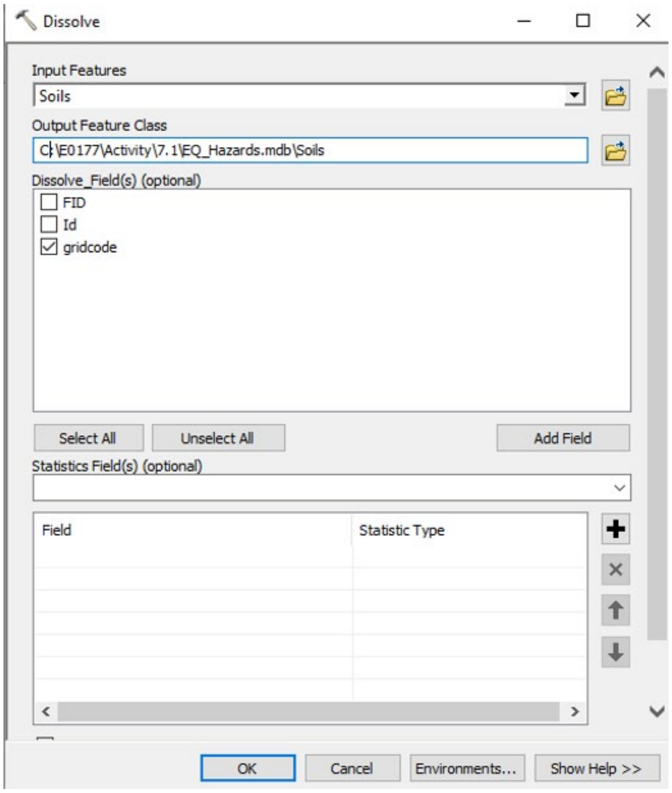
6. The values in the Vs30 data represent the Shear Wave Velocity shown in the table. Values less than or equal to 180 should be categorized together, and values 180 to 360 should be categorize together, etc. Some datasets may only have two or three classifications. The Santa Cruz data only has two categories, C and D. Set the old values and new values to the numbers shown below. Then click OK. A value of 1 will indicate stiff soils (D) and a value of 2 will indicate very dense soil and soft rock (C). Your local data may have more classifications.



7. Remove the Vs30_int and Vs30_Clip raster layers. In ArcToolbox, go to Conversion Tools, From Raster, and double click Raster to Polygon. For Input raster, select Vs30_Reclass; for Field, select VALUE; and for Output polygon features, select C:\E0177\Activity\7.1\Soils.shp. Then click OK.

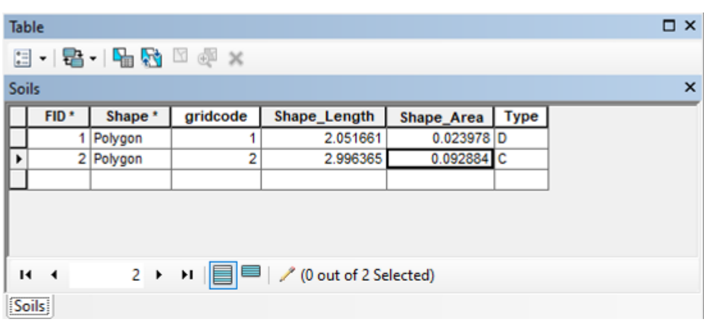


8. Open ArcCatalog and browse to C:\E0177\Activity\7.1 and create a new personal geodatabase called EQ_Hazards. Close ArcCatalog. In ArcToolbox, select Data Management Tools, then Generalization, and double click Dissolve. For Input Features, select Soils; for Output Feature Class, select C:\E0177\Activity\7.1\EQ_Hazards.mdb\Soils; and for the Dissolve Field(s), select gridcode. Then click OK.



9. Remove the soils.shp and Vs30_Reclass layers from the table of contents. Open the attribute table for the feature class soils layer. Add a new field called Type which is a text field with a character length of 1.

10. In the Editor Toolbar, select Start Editing. Select Soils and then OK. Select Continue when the warning comes up. Add a value of D where the gridcode is 1 and a value of C where the gridcode is 2. Go to the Editor Toolbar and select Stop Editing. Save the edits.



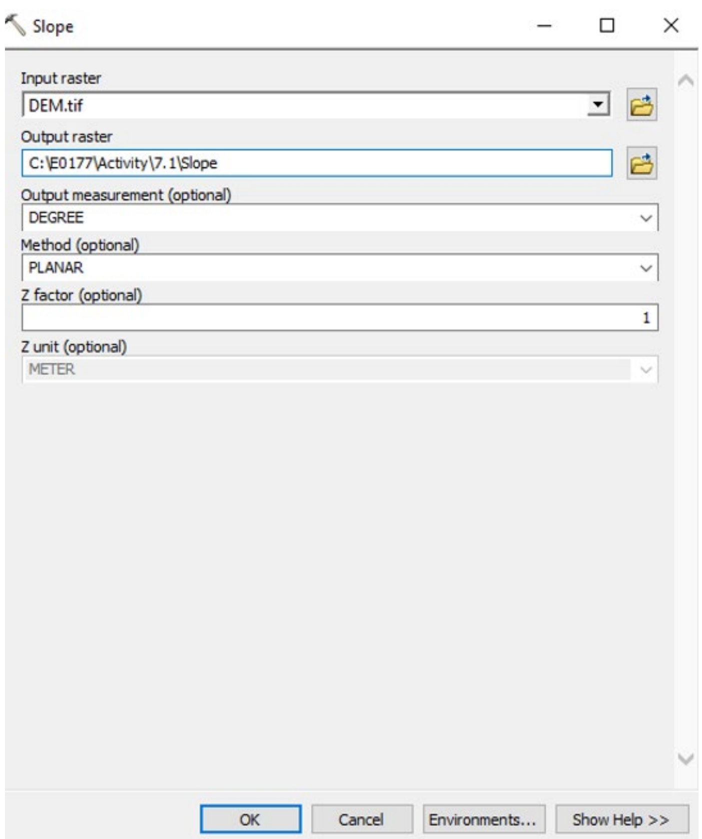
11. Remove the soils layer. Open ArcCatalog and browse to the Soils feature class in the EQ_Hazards geodatabase. Right click on Soils and select Properties. Click on the XY Coordinate

System tab and set the coordinate system to GCS_WGS_1984. Then click OK and close ArcCatalog. If a warning comes up indicating the soils layer is locked, close Hazus and try again.

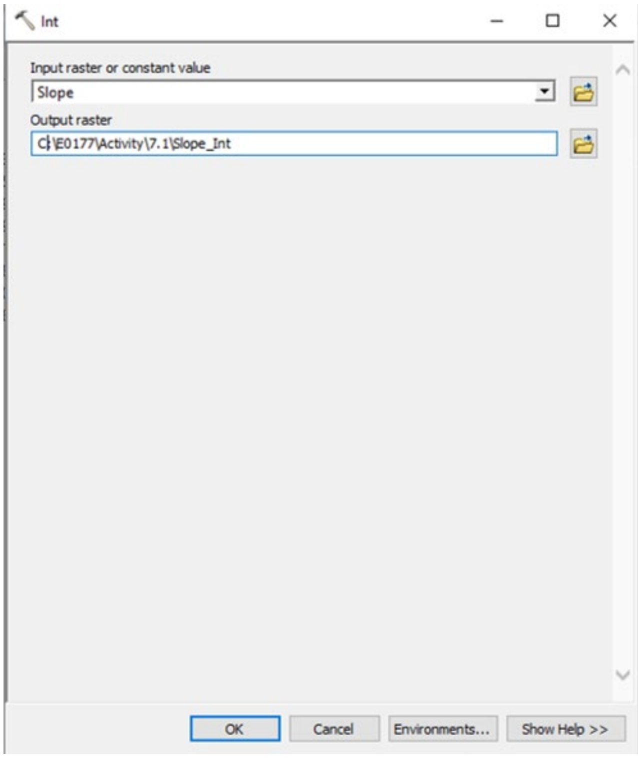
Task 2: Create a Landslide Map

1. Now, create a landslide map. Open ArcMap and add the DEM layer to the map. The DEM layer can be found here: C:\E0177\Activity\7.1\DEM.tif.

2. Open ArcToolbox and select Spatial Analyst Tools, Surface, and double click Slope. For the Input raster, select DEM.tif; and for the Output raster, select: C:\E0177\Activity\7.1\Slope. Click OK.



3. Convert the grid into an integer grid so that it is easier to reclassify the values. In ArcToolbox, select Spatial Analyst Tools, Math, and double click on Int. For the Input raster or constant value, select Slope and for Output raster, select C:\E0177\Activity\7.1\Slope_Int. Click OK.



4. In ArcToolbox, select Spatial Analyst Tools, then Reclass, and double click on Reclassify. For Input raster, select Slope_Int; for Reclass field, select VALUE; and for Output raster, use: C:\E0177\Activity\7.1\Vs30_Reclass. For the reclassification, use the table below.

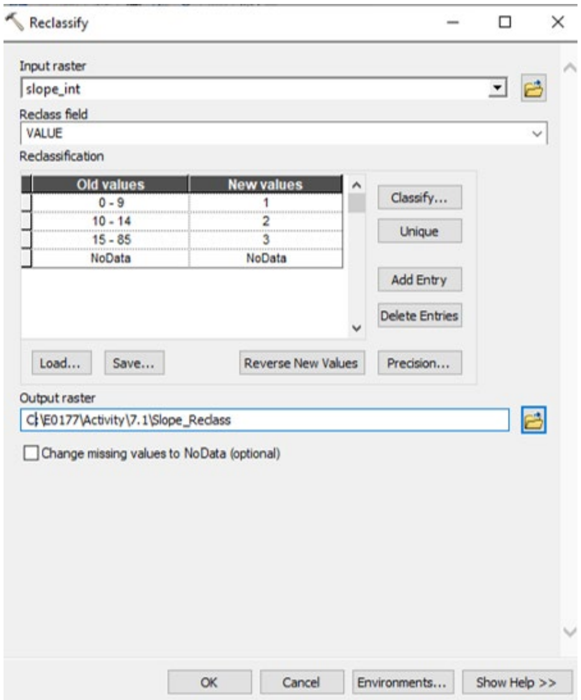
Geologic Group	Geologic Group Description	Slope Angle 0-10 degrees	Slope Angle 10-15 degrees	Slope Angle 15-20 degrees	Slope Angle 20-30 degrees	Slope Angle 30-40 degrees	Slope Angle > 40 degrees
A (dry)	Strongly Cemented Rocks (crystalline rocks and well-cemented sandstone)	None	None	I	II	IV	VI
B (dry)	Weakly Cemented	None	III	IV	V	VI	VII

Geologic Group	Geologic Group Description	Slope Angle 0-10 degrees	Slope Angle 10-15 degrees	Slope Angle 15-20 degrees	Slope Angle 20-30 degrees	Slope Angle 30-40 degrees	Slope Angle > 40 degrees
	Rocks and Soils (sandy soils and poorly cemented sandstone).						
C (dry)	Argillaceous Rocks (shales, clayey soil, existing landslides, and poorly compacted fills)	V	VI	VII	IX	IX	IX
A (wet)	Strongly Cemented Rocks (crystalline rocks and well-cemented sandstone)	None	III	VI	VII	VIII	VIII
B (wet)	Weakly Cemented Rocks and Soils (sandy soils and poorly	V	VIII	IX	IX	IX	X

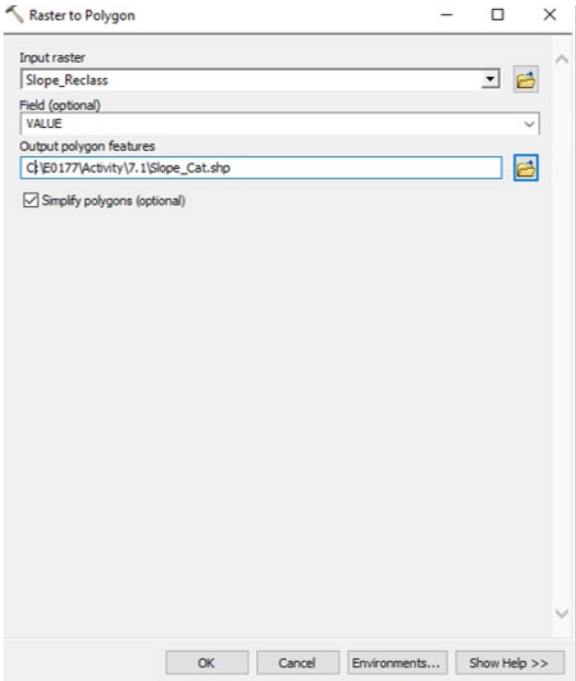
Geologic Group	Geologic Group De scription	Slope Angle 0-10 degrees	Slope Angle 10-15 degrees	Slope Angle 15-20 degrees	Slope Angle 20-30 degrees	Slope Angle 30-40 degrees	Slope Angle > 40 degrees
	cemented sandstone)						
C (wet)	Argillaceous Rocks (shales, clayey soil, existing landslides, and poorly compacted fills)	VII	IX	X	X	X	X

Landslide susceptibility is measured on a scale of I to X, with X being the most susceptible.

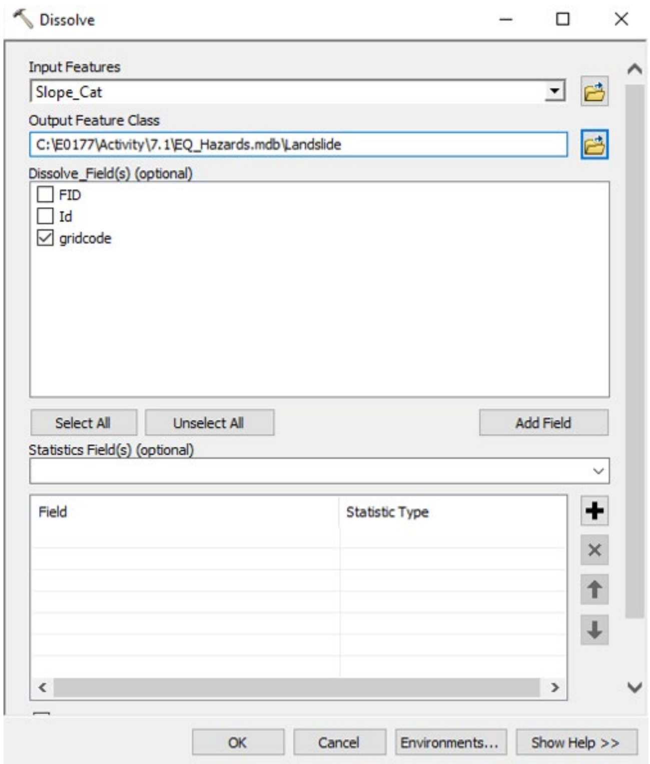
5. There should be six slope categories defined by the values in the table. Some datasets may have fewer classifications. Set the old values and new values to the numbers shown below. Then click OK. A value of 1 will indicate slope values between 0 and 9 degrees, 2 is 10 to 14 degrees, and 3 is 15+. Additional categorization is not required because all the soil types in the county are C and D which means 15-20, 20-30, 30-40, and 40+ are all assigned a ten value.



6. Remove the Slope_Int, Slope, and DEM layers. In ArcToolbox, go to Conversion Tools, From Raster, and double click Raster to Polygon. For Input raster, select Slope_Reclass; for Field, select VALUE; and for Output polygon features, select C:\E0177\Activity\7.1\Slope_Cat.shp. Then click OK.

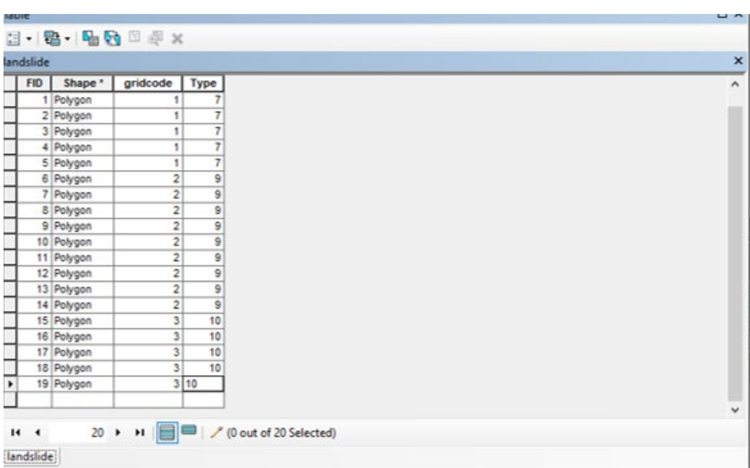


7. In ArcToolbox, select Data Management Tools, then Generalization, and double click Dissolve. For Input Features, select Soils; for Output Feature Class, select C:\E0177\Activity\7.1\EQ_Hazards.mdb\Landslide; and for the Dissolve Field(s), select gridcode. Then click OK.



8. Remove the Slope_Cat, Slope_Reclass, and Slope_Int layers from the table of contents. Open the attribute table for the landslide layer. Add a new field called Type which is a small integer data type.

9. In the Editor Toolbar, select Start Editing. Add a value of 7 where the gridcode is 1, a value of 9 where the gridcode is 2, and a value of 10 where the gridcode is 3. Go to the Editor Toolbar and select Stop Editing. Save the edits.



FID	Shape *	gridcode	Type
1	Polygon	1	7
2	Polygon	1	7
3	Polygon	1	7
4	Polygon	1	7
5	Polygon	1	7
6	Polygon	2	9
7	Polygon	2	9
8	Polygon	2	9
9	Polygon	2	9
10	Polygon	2	9
11	Polygon	2	9
12	Polygon	2	9
13	Polygon	2	9
14	Polygon	2	9
15	Polygon	3	10
16	Polygon	3	10
17	Polygon	3	10
18	Polygon	3	10
19	Polygon	3	10

10. Open ArcCatalog and browse to the Landslide feature class in the EQ_Hazards geodatabase. Right click on Landslide and select Properties. Click on the XY Coordinate System tab and set the coordinate system to GCS_WGS_1984. Then click OK and close ArcCatalog. If a warning comes up indicating the soils layer is locked, close Hazus and try again.

Task 3: Create a Liquefaction Map

1. Now, create a liquefaction map. Open ArcMap and add the liquefaction layer to the map. The layer can be found here: C:\E0177\Activity\7.1\Liquefaction_Areas.shp. The attribute table has a field called LIQPOTZN with values from A to D. First, figure out what these values mean in terms of susceptibility to liquefaction. Go to the Santa Cruz GIS site https://www.co.santa-cruz.ca.us/Departments/GeographicInformationSystems(GIS).aspx click on Data on the right hand side and search for liquefaction. Under About on the right, select gis.santacruzcounty.us. This will open a new window. Scroll down in the new window until you see Drawing Info. The values are described in this section. A is very high and D is low.

2. If your community doesn't have liquefaction zones mapped out, there may be other sources of information you can use. The table below provides examples of areas that have a liquefaction potential. In the Santa Cruz example, there are mapped floodplains and beach areas we can use.

Type of Deposit	Distribution of Cohesionless Sediments in Deposits	Susceptibility to Liquefaction Modern < 500 yr	Susceptibility to Liquefaction Holocene < 11 ka	Susceptibility to Liquefaction Pleistocene 11 ka - 2 Ma	Susceptibility to Liquefaction Pre-Pleistocene 11 ka - 2 Ma
Continental Deposits:					
River Channel	Locally variable	Very High	High	Low	Very Low
Flood Plain	Locally variable	High	Moderate	Low	Very Low
Alluvial fan and plain	Widespread	Moderate	Low	Low	Very Low
Marine terraces and	Widespread	--	Low	Very Low	Very Low

Type of Deposit	Distribution of Cohesionless Sediments in Deposits	Susceptibility to Liquefaction Modern < 500 yr	Susceptibility to Liquefaction Holocene < 11 ka	Susceptibility to Liquefaction Pleistocene 11 ka - 2 Ma	Susceptibility to Liquefaction Pre-Pleistocene 11 ka - 2 Ma
plains					
Delta and fan-delta	Widespread	High	Moderate	Low	Very Low
Lacustrine and playa	Variable	High	Moderate	Low	Very Low
Colluvium	Variable	High	Moderate	Low	Very Low
Talus	Widespread	Low	Low	Very Low	Very Low
Dunes	Widespread	High	Moderate	Low	Very Low
Loess	Variable	High	High	High	Unknown
Glacial till	Variable	Low	Low	Very Low	Very Low
Tuff	Rare	Low	Low	Very Low	Very Low
Tephra	Widespread	High	High	?	?
Residual Soils	Rare	Low	Low	Very Low	Very Low
Sebka	Locally Variable	High	Moderate	Low	Very Low
Coastal Zones:					
Delta	Widespread	Very High	High	Low	Very Low

Type of Deposit	Distribution of Cohesionless Sediments in Deposits	Susceptibility to Liquefaction Modern < 500 yr	Susceptibility to Liquefaction Holocene < 11 ka	Susceptibility to Liquefaction Pleistocene 11 ka - 2 Ma	Susceptibility to Liquefaction Pre-Pleistocene 11 ka - 2 Ma
Estuarine	Locally Variable	High	Moderate	Low	Very Low
Beach - High Wave Energy	Widespread	Moderate	Low	Very Low	Very Low
Beach - Low Wave Energy	Widespread	High	Moderate	Low	Very Low
Lagoonal	Locally Variable	High	Moderate	Low	Very Low
Fore Shore	Locally Variable	High	Moderate	Low	Very Low
Artificial:					
Uncompacted Fill	Variable	Very High	--	--	--
Compacted Fill	Variable	Low	--	--	--

3. In ArcMap, add the special flood hazard area to the map. It can be found here: C:\E0177\Activity\4.1\SantaCruz\06087C_20190710\S_FLD_HAZ_AR.shp.

4. Run a Select by Attributes on the S_FLD_HAZ_AR layer and select the following from the FLD_ZONE field: "FLD_ZONE" = 'A' OR "FLD_ZONE" = 'A99' OR "FLD_ZONE" = 'AE' OR "FLD_ZONE" = 'AH' OR "FLD_ZONE" = 'AO' OR "FLD_ZONE" = 'VE'. Right click and export the selection as: C:\E0177\Activity\7.1\Floodplain.shp. Add the floodplain layer to the map and remove the S_FLD_HAZ_AR layer.

5. Open the Floodplain attribute table and select all the records. In the Editor toolbar, select Start Editing. Then go to Editor and Merge. Click OK. Go to Editor and Stop Editing and save your

edits. Add a field called Type and make it a short integer. Then use the Field Calculator to make the Type field equal 4 which corresponds to a high liquefaction value. Close the attribute table.

6. Open the Liquefaction_Areas attribute table. Create a new field called Type that is a short integer data type. Use Select by Attributes to select all records with a LIQPOTZN value of A and then use Field Calculator to assign a value of 5. Use the same procedure to assign a value of 4 to B, 3 to C, 2 to D, and 1 to Unkn. Then clear the selection.

7. Go to Editor and Start Editing. Select the floodplain polygon and then click Edit and Copy. Then Open the Liquefaction_Areas attribute table and click Edit and Paste. Add the selected features to the Liquefaction_Areas layer. While the single record is still selected, click Editor and Clip. Then click OK. Select Editor from the Editor Toolbar and Stop Editing. Save the edits.

8. Open ArcToolbox, select Data Management, Generalization, and Dissolve. For Input Features, select Liquefaction_Areas; for Output Feature Class, select C:\E0177\Activity\7.1\EQ_Hazards.mdb\Liq; and for Dissolve_Field(s), select Type. Then click OK.

Task 4: Integrate the Maps into Hazus

1. Open Hazus. Go to Hazard and Data Maps. Click Add map to list. Browse to C:\E0177\Activity\7.1\EQ_Hazards.mdb, then select Soils, name it Soils, and make sure the map type is Soil. Then click OK. Do the same thing with landslide and liquefaction. Then close the dialog box.

2. Go to Hazard and Scenario. Click Next, then Define hazard map, and Next. Under the Soil map select the drop down and then select Soils. Update Liquefaction and Landslide, then select Next and then Finish.

3. To make sure the hazard maps have been integrated, go to Hazard and Show Current. Click on the Current Hazard Maps tab. The geodatabase for each hazard map should be shown. Click on the map row to map it.

Task 5: Prepare to Discuss Results

1. Create a slide in PPT to provide information on which data your community had and how you created the maps. If you have time, you may want to run the analysis with and without the hazard maps to see how much it changes the results.

Note: These slides may be used in the final capstone presentation at the end of the class.

Application 2: Create a New Building Type

Although Hazus contains detailed information on many kinds of building types, there may be times when a new building type needs to be added. In this example, straw bale construction will be added to Hazus.

Task 1: Develop Curve Data

1. Create a Santa Cruz, California tsunami study region. Name the study region something you can remember. If you’re creating your own study region, select that county and State.

2. Identify the required inputs to create capacity curves, fragility curves, debris generation, and collapse rates. The data required to create a new building type is shown in the tables below.

Capacity Curves

Building Design /Quality	Sd Yield (inches)	Sa Yield (g)	Sd Ultimate (inches)	Sa Ultimate (g)	Kappa / Short Dur.	Kappa / Medium Dur.	Kappa / Long Dur.	Damping	Fraction
High - Code									
Low - Code									
Moderate - Code									
Pre - Code									
Special High - Code									
Special Low - Code									
Special Moderate - Code									

Non-Structural Acceleration Fragility Curves

Building Design/ Quality	Slight Median	Slight Beta	Moderate Median	Moderate Beta	Extensive Median	Extensive Beta	Complete Median	Complete Beta
High - Code								
High - Code / User-Defined								
Low - Code								
Low - Code / User-Defined								
Moderate - Code								
Moderate - Code . User-Defined								
Pre - Code								
Pre-Code / User-Defined								
Special High - Code								
Special High -								

Building Design/ Quality	Slight Median	Slight Beta	Moderate Median	Moderate Beta	Extensive Median	Extensive Beta	Complete Median	Complete Beta
Code / User-Defined								
Special Low - Code								
Special Low - Code / User-Defined								
Special Moderate - Code								
Special Moderate - Code / User-Defined								

Non-Structural Drift Fragility Curves

Building Design/ Quality	Slight Median	Slight Beta	Moderate Median	Moderate Beta	Extensive Median	Extensive Beta	Complete Median	Complete Beta
High - Code								
High - Code / User-Defined								

Building Design/ Quality	Slight Median	Slight Beta	Moderate Median	Moderate Beta	Extensive Median	Extensive Beta	Complete Median	Complete Beta
Low - Code								
Low - Code / User-Defined								
Moderate - Code								
Moderate - Code . User-Defined								
Pre - Code								
Pre-Code / User-Defined								
Special High - Code								
Special High - Code / User-Defined								
Special Low - Code								

Building Design/ Quality	Slight Median	Slight Beta	Moderate Median	Moderate Beta	Extensive Median	Extensive Beta	Complete Median	Complete Beta
Special Low - Code / User-Defined								
Special Moderate - Code								
Special Moderate - Code / User-Defined								

Structural Fragility Curves

Building Design/ Quality	Slight Median	Slight Beta	Moderate Median	Moderate Beta	Extensive Median	Extensive Beta	Complete Median	Complete Beta
High - Code								
High - Code / User-Defined								
Low - Code								
Low - Code / User-Defined								

Building Design/ Quality	Slight Median	Slight Beta	Moderate Median	Moderate Beta	Extensive Median	Extensive Beta	Complete Median	Complete Beta
Moderate - Code								
Moderate - Code . User-Defined								
Pre - Code								
Pre-Code / User-Defined								
Special High - Code								
Special High - Code / User-Defined								
Special Low - Code								
Special Low - Code / User-Defined								
Special Moderat								

Building Design/ Quality	Slight Median	Slight Beta	Moderate Median	Moderate Beta	Extensive Median	Extensive Beta	Complete Median	Complete Beta
e - Code								
Special Moderate - Code / User-Defined								

Debris Parameters

Building Type/Design Mechanism	Unit Weight)tons/1000 sq. ft.)	Slight Ds (% of weight)	Moderate Ds (% of weight)	Extensive Ds (% of weight)	Complete Ds (% of weight)
Brick, Wood, and Others / Non-Structural					
Brick, Wood, and Others / Structural					
Reinforces Concrete and Steel / Non-Structural					
Reinforced Concrete and Steel / Structural					

Casualty Rates

Damage State/In-Out	Injury Severity 1	Injury Severity 2	Injury Severity 3	Injury Severity 4
Complete Damage w/ Collapse (per 1,000 people) / Indoor				
Complete Damage w/o Collapse (per 1,000 people) / Indoor				
Complete Damage w/o Collapse (per 1,000 people) / Outdoor				
Extensive Damage (per 1,000 people) / Indoor				
Extensive Damage (per 1,000 people) / Outdoor				
Moderate Damage (per 1,000 people) / Indoor				
Moderate Damage (per 1,000 people) / Outdoor				
Slight Damage (per 1,000				

Damage State/In-Out	Injury Severity 1	Injury Severity 2	Injury Severity 3	Injury Severity 4
people) / Indoor				

Collapse Rate

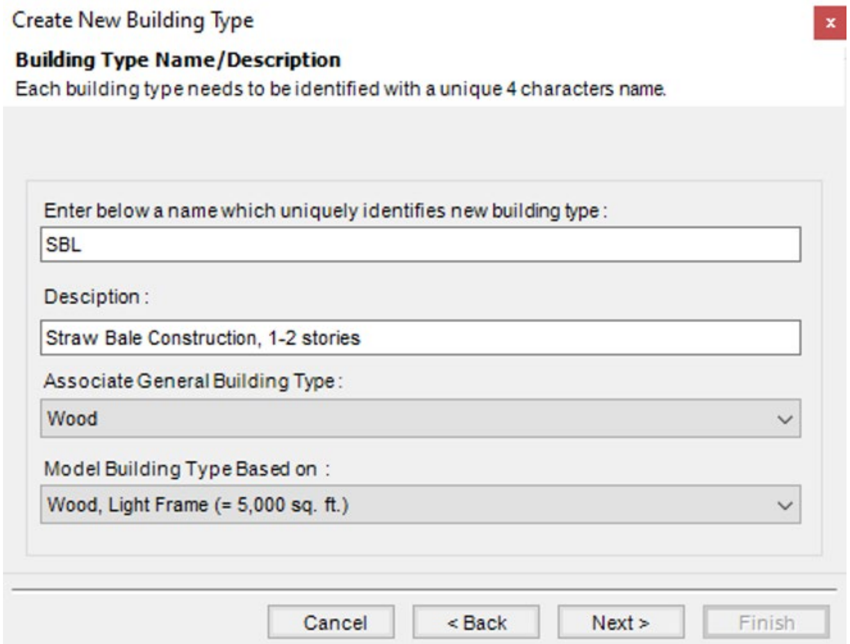
% Collapsed

3. Work with a structural engineer to identify the entries for the tables above. In some cases, proxies will need to be created for data that is unknown such as debris amounts. Information on straw bale construction may be found here: C:\E0177\Activity\7.1\Seismic-Design-Factors-and-Allowable-Shears-for-Strawbale-Wall-Assemblies.September.26.2013.pdf and here: C:\E0177\Activity\7.1\Load-Bearing_SB_Construction_King_2003.pdf. Although these documents don't have all the answers to the requirements, they are a start.

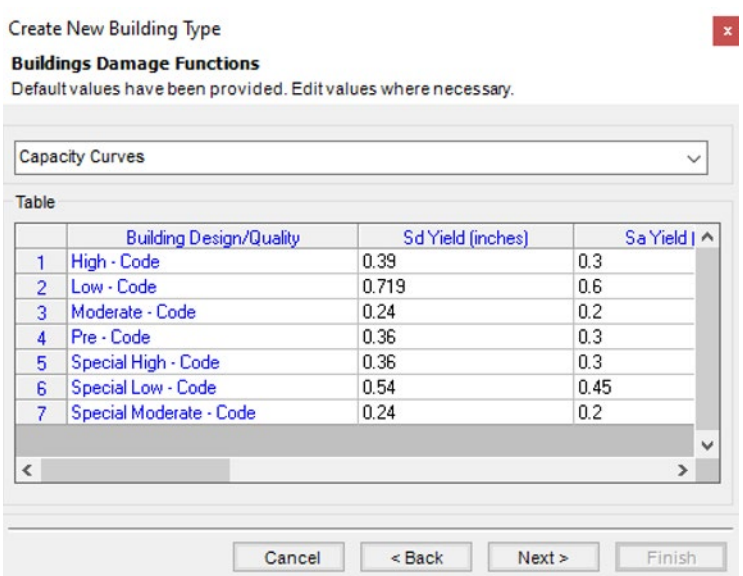
4. Open Hazus if it's not already opened. Go to Inventory, General Building Stock, and Define New Building Type. Click Next when the New Building Type Wizard dialog box comes up. Enter a name of SBL, and a description of Straw Bale Construction, 1-2 stories. Since straw bale construction is similar to wood construction, use that for the Associate General Building Type and Wood, Light Frame for the Model Building Type Based on. Click Next.

Task 2: Develop Curve Data

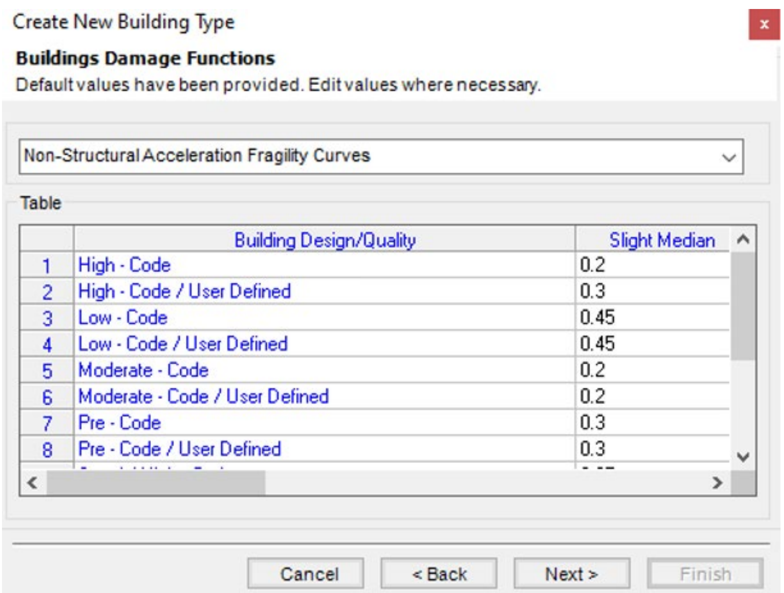
1. Open Hazus if it's not already opened. Go to Inventory, General Building Stock, and Define New Building Type. Click Next when the New Building Type Wizard dialog box comes up. Enter a name of SBL, and a description of Straw Bale Construction, 1-2 stories. Since straw bale construction is similar to wood construction, use that for the Associate General Building Type and Wood, Light Frame for the Model Building Type Based on. Click Next.



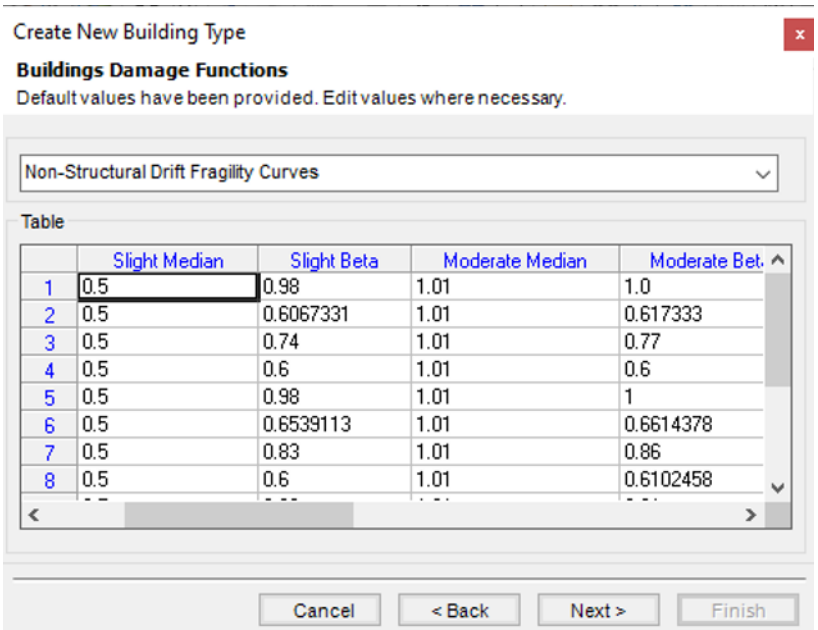
2. In the Santa Cruz example, there is a new school which has been constructed with straw bale construction. The focus of the inputs will be for a high-code, 1-story straw bale school. Therefore, it is not necessary to populate the other building design code parameters. With Capacity Curves selected in the dropdown, edit the row next to High – Code. Sd Yield (inches) set to: .39, for Sa Yield (g's) set to: 0.3, for Sd Ultimate (inches) set to: 1.0, for Kappa/Short Dur. set to: 1.0, Kappa/Medium Dur. set to 0.8, Kappa/Long Dur. Set to 0.5, damping set to 15, and Fraction set to 0.5.



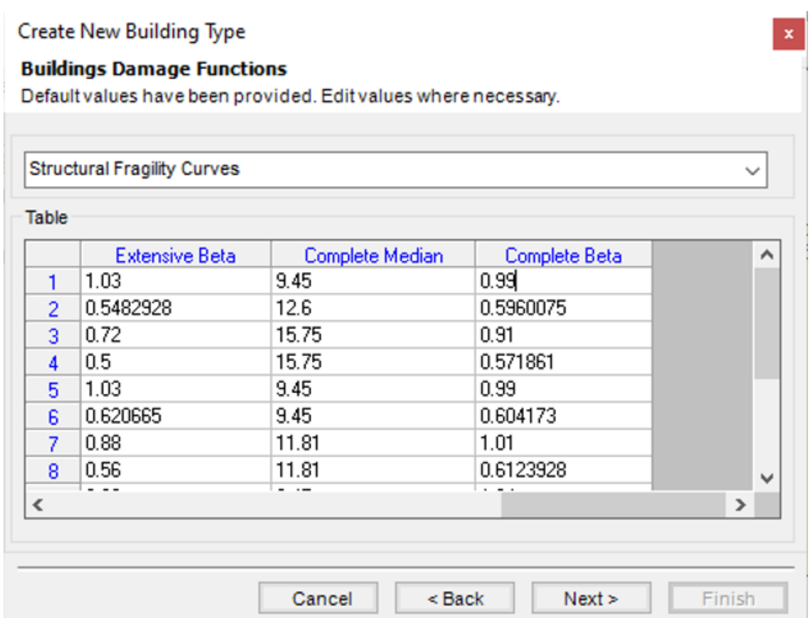
3. In the dropdown box, select Non-Structural Acceleration Fragility Curves. Next to High – Code, add 0.2 under Slight Median, 0.71 under Slight Beta, 0.4 under Moderate Median, 0.68 under Moderate Beta, 0.8 under Extensive Median, 0.66 under Extensive Beta, 1.6 under Complete Median, and 0.66 under Complete Beta.



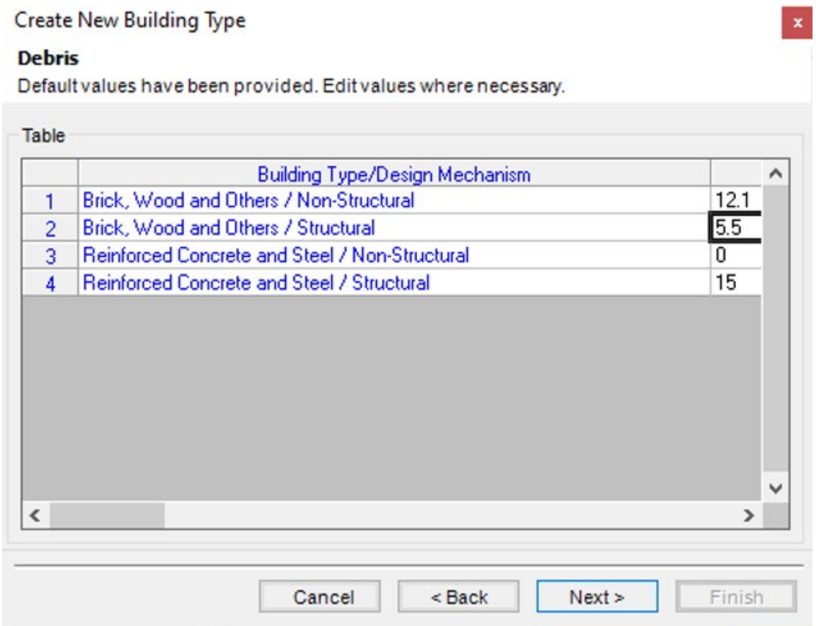
4. In the dropdown box, select Non-Structural Drift Fragility Curves. Next to High – Code, add 0.5 under Slight Median, 0.98 under Slight Beta, 1.01 under Moderate Median, 1.0 under Moderate Beta, 3.15 under Extensive Median, 1.02 under Extensive Beta, 6.3 under Complete Median, and 1.09 under Complete Beta.



5. In the dropdown box, select Structural Fragility Curves. Next to High – Code, add 0.5 under Slight Median, 0.93 under Slight Beta, 1.25 under Moderate Median, 0.97 under Moderate Beta, 3.86 under Extensive Median, 1.03 under Extensive Beta, 9.45 under Complete Median, and 0.99 under Complete Beta. Click Next.



6. The debris parameters will now be editable. Straw bale construction usually requires about 15% less weight than wood construction so in the second row next to Brick, Wood and Others / Structural, put: 5.5. Keep all the other values the same. Click Next.



7. The casualty's parameters menu dialog comes up. Casualty Rates will come up in the dropdown menu. Leave the values unedited. Change the dropdown to Collapse Rates. Change the value from 3 to 10. Click Next. Then click Finish.

8. In Hazus, go to Inventory, then Essential Facilities, and then the Schools tab. Right click on the schools table and select Start Editing. For the first row, San Lorenzo Valley Elementary, scroll to the right to Building Type and Design Level. For Design Level, select HC for high code. For Building Type, use the drop down to select SBL. Click Close and Yes to save changes.

Task 3: Prepare to Discuss Results

1. Create a slide in PPT to provide information on which new building type you created and where you might be able to find information on the parameters if you don't have the data. How does changing the building type affect the results?

Note: These slides may be used in the final capstone presentation at the end of the class.

Application 3: Modify Vulnerability Functions

This process expands on Activity 4 Application 4 and walks you through using local inventory data to update seismic design level and building type including building mapping schemes and

AEBM. The best way to assign the appropriate vulnerability functions to the inventory, is to ensure the inventory itself has the correct design level and earthquake building type. The data provided comes from Santa Cruz, California.

Task 1: Prepare Building Data

1. Create a Santa Cruz, California tsunami study region. Name the study region something you can remember. If you're creating your own study region, select that county and State.

2. Close Hazus and open ArcMap.

3. The City has decided to model a part of their downtown as AEBM inventory. They have parcel and footprint data for the area. These can be found here: C:\E0177\Activity\7.1\BusDist_Footprints.shp and here: C:\E0177\Activity\7.1\BusDist_Parcels.shp. Add these two layers to the map.

4. Remove the sheds from the footprint data first. Open the BusDist_Footprints attribute table, use a Select by Attributes to identify all footprints with an area less than 150 square feet: "Area" <150. Then select Apply. Click on Editor on the Editor Toolbar and Start Editing. Then select Delete Selected in the attribute table.

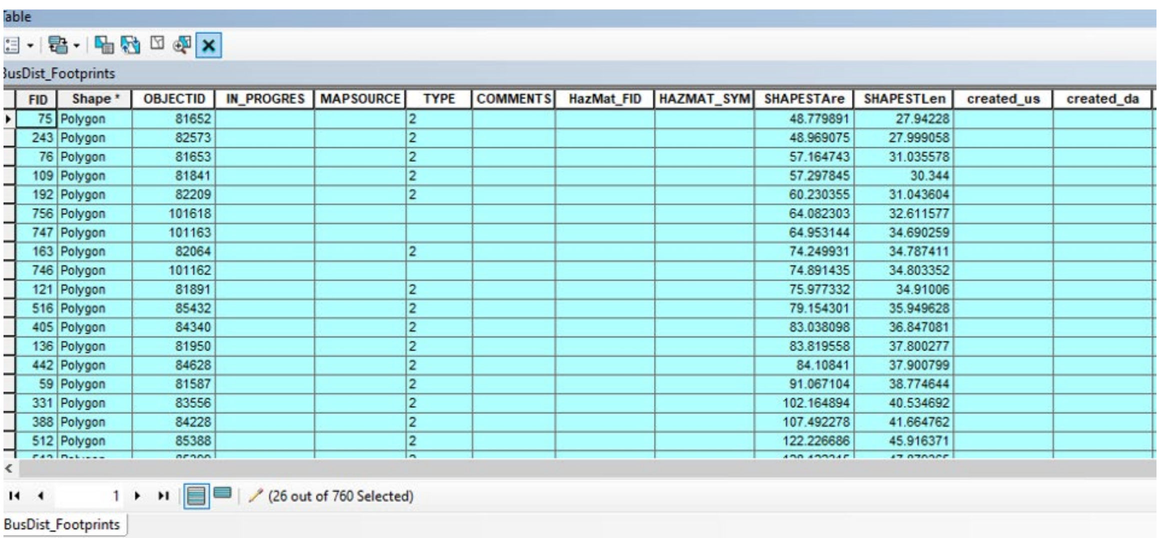


Table
BusDist_Footprints

FID	Shape *	OBJECTID	IN_PROGRES	MAPSOURCE	TYPE	COMMENTS	HazMat_FID	HAZMAT_SYM	SHAPESTAre	SHAPESTLen	created_us	created_da
75	Polygon	81652			2				48.779891	27.94228		
243	Polygon	82573			2				48.969075	27.999058		
76	Polygon	81653			2				57.164743	31.035578		
109	Polygon	81841			2				57.297845	30.344		
192	Polygon	82209			2				60.230355	31.043604		
756	Polygon	101618							64.082303	32.611577		
747	Polygon	101163							64.953144	34.690259		
163	Polygon	82064			2				74.249931	34.787411		
746	Polygon	101162							74.891435	34.803352		
121	Polygon	81891			2				75.977332	34.91006		
516	Polygon	85432			2				79.154301	35.949628		
405	Polygon	84340			2				83.038098	36.847081		
136	Polygon	81950			2				83.819558	37.800277		
442	Polygon	84628			2				84.10841	37.900799		
59	Polygon	81587			2				91.067104	38.774644		
331	Polygon	83556			2				102.164894	40.534692		
388	Polygon	84228			2				107.492278	41.664762		
512	Polygon	85388			2				122.226686	45.916371		

(26 out of 760 Selected)
BusDist_Footprints

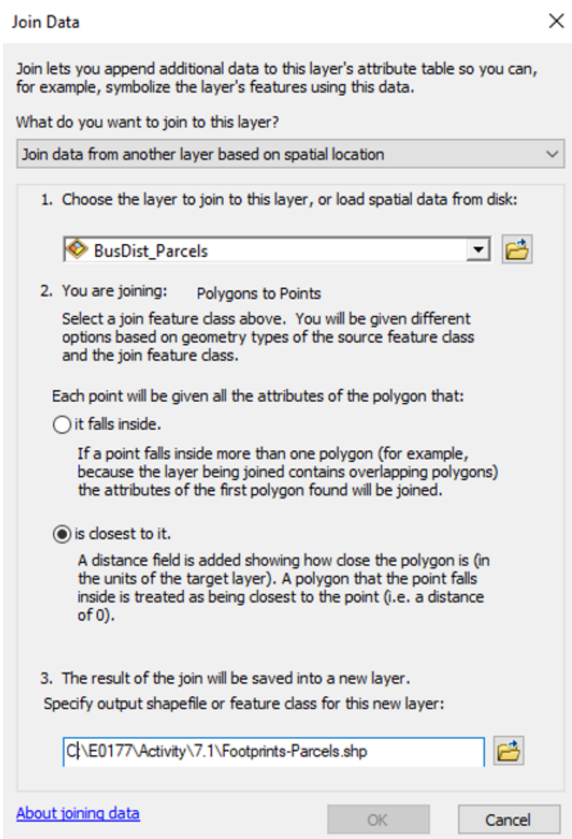
5. Select Editor, Stop Editing and save your edits. There is already an attribute table with the X and Y value. If your local data doesn't have X and Y fields, create them and use Calculate Geometry to populate. Remove the BusDist_Footprints layer from ArcMap.

6. Use File Explorer to browse to C:\E0177\Activity\7.1\BusDist_Footprints.dbf and open it in Excel. Go to File and Save as C:\E0177\Activity\7.1\BusDist_Footprints.xlsx.

7. In ArcMap, add BusDist_Footprints.xlsx to the map as a table. Right click on it and select Display XY Data. For the X Field, select X and for the Y Field, select Y. Then click OK. Click OK again when the warning comes up.

8. Right click on BusDist_Footprints$ Events, then Data and Export Data, and export as C:\E0177\Activity\7.1\BusDist_FootprintsPts.shp. Add the new layer to the map and remove the Events and the table from the table of contents.

9. Right click on BusDist_FootprintsPts, select Joins and Relates, and then Joins. Complete a spatial join with BusDist_Parcels with is closest to it selected and output to C:\E0177\Activity\7.1\Footprints-Parcels.shp. Then click OK.

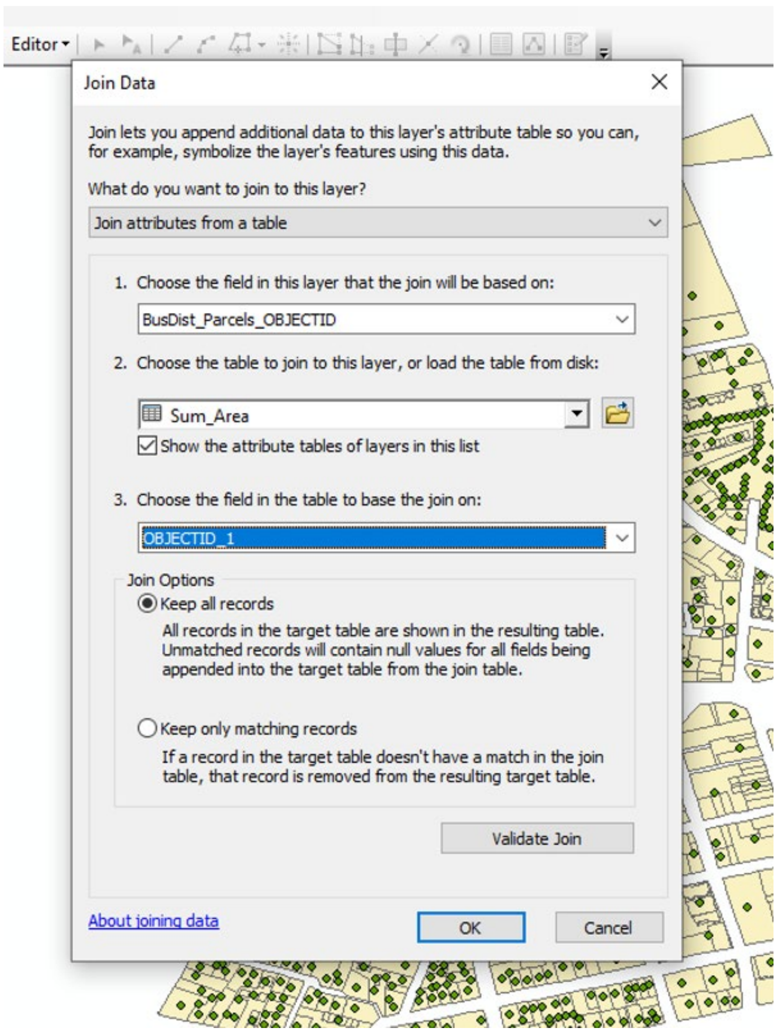


10. Remove BusDist_FootprintsPts from the table of contents. Open the Footprints-Parcel attribute table. Notice that there are several buildings in the same parcel. In order to get the number of stories for the buildings, a summarize will be used with the footprint area to identify total footprint area per parcel.

11. Right click on BusDist_Parcels_OBJECTID (this is the parcel layer unique identifier), then select Summarize. The first dropdown should be set to OBJECTID_1; in the second input box, click the plus sign next to Area and then select Sum; and in the third input box, save the file as: C:\E0177\Activity\7.1\Sum_Area.dbf. Then click OK. Select Yes when the warning message comes up. Now join the sum area file to the Footprints-Parcels layer.

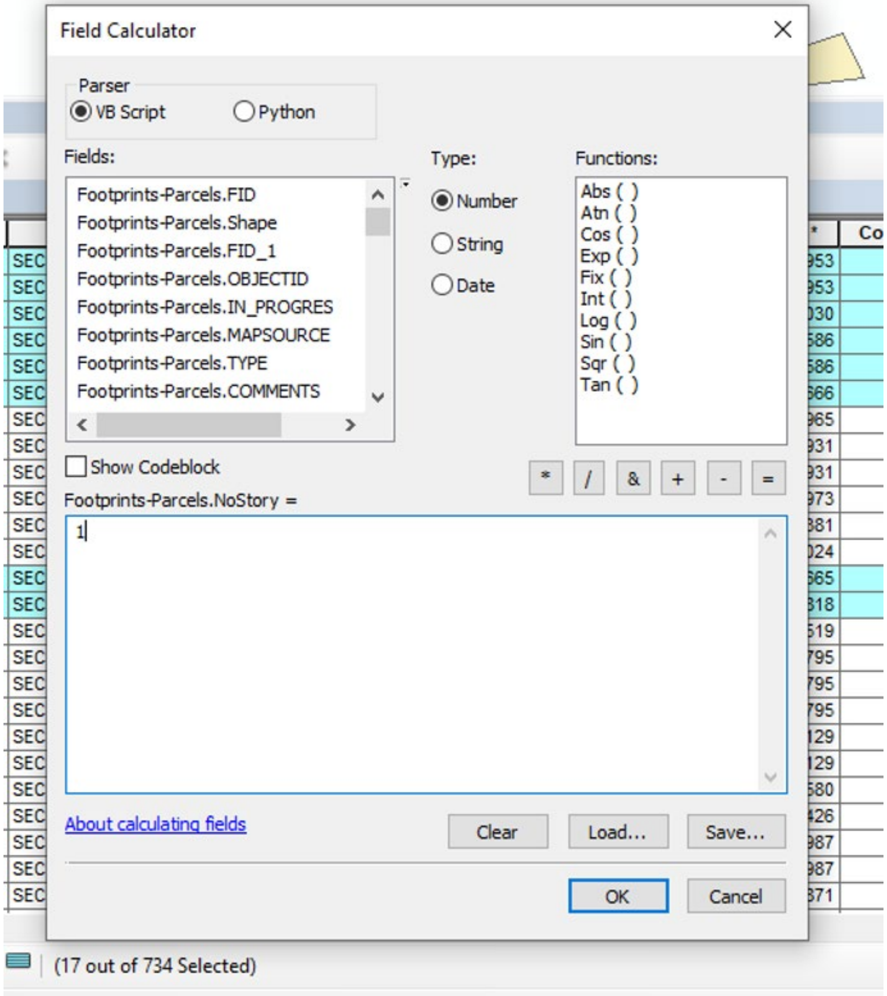
12. Right click on Footprints-Parcels, select Joins and Relates, and then Joins. Under what do you want to join to this layer, select Join attributes from a table; under the first input, select

BusDist_Parcels_OBJECTID; under the second input, select Sum_Area; and under the third input, select OBJECTID_1. Make sure Keep all records is selected. Then click OK.



13. Click Yes when the warning message comes up. Create a new field called NoStory and make it a small integer field. Use Select by Attributes to select records where SQUAREFT is not a blank value: "Footprints-Parcels.SQUAREFT" <> ' '. Then use Field Calculator on NoStory to make it equal to [Footprints-Parcels.SQUAREFT] / [Sum_Area.Sum_Area].

14. Now, use Select by Attributes to select NoStory=0: "Footprints-Parcels.NoStory" = 0. Then use Field Calculator to set the NoStory=1. Click OK.



Task 2: Assign Hazus Attributes

1. Clear the selection and remove the join. Take the number of stories and the building footprint area to create a new total area field. Create a new field that is a double data type called TotArea. Use the Field Calculator to make TotArea= [NoStory] * [Area].

2. Next, convert the USECDDESC to a Hazus specific occupancy. Create a new field called SpOcc that is a text data type with a size of 5. Then create a field called EQBldg as a text data type with a size of 4. Use Google StreetView to help identify building types. Most of the structures are masonry or concrete. Since the masonry structures are not very old, there probably won't be any unreinforced masonry. Use Select by Attributes and Field Calculator to assign the following Hazus specific occupancies and earthquake building type using the associated USECDDESC field. This will only be the first part of the building type and not the low-, medium-, and high-rise designation which will require the number of stories.

USECDDESC	SpOcc	EQBldg
015-LOT/MISC RES IMPS	RES1	RM1
016-BUILDING IN PROGRES	RES1	RM1
020-SINGLE RESIDENCE	RES1	RM1
021-CONDOMINIUM UNIT	RES3D	PC2
023-NON-CONFIRMING RES	RES1	RM1
024-SFR W/ SECONDARY USE	RES1	RM1
027-TOWNHOUSE	RES3B	RM1
028-SFR + SECOND UNIT	RES1	RM1
030-SINGLE DUPLEX	RES3A	RM1
031-TWO SFRS/1 APN	RES1	RM1
032-3 OR 4 UNITS/2+ BLDGS	RES3B	PC2
033-TRIPLEX	RES3B	PC2
032-FOUR-PLEX	RES3B	PC2
041-5 - 10 UNITS	RES3C	PC2
042-11 - 20 UNITS	RES3D	PC2
043-21 - 40 UNITS	RES3E	PC2
080-HOTEL	RES4	RM1
083-CONVENT/RECTORY/ROOMS	RES4	RM1
085-BED AND BREAKFAST	RES4	RM1

USECDDESC	SpOcc	EQBldg
090-COMMON AREA/NO IMPS	RES1	RM1
101-RESIDENT OWNED MH PARK	RES2	MH
110-VACANT COMMERCIAL LAND	COM1	C2
115-COMMERCIAL LAND/MISC IMPS	COM1	C2
116-COMM/IND/AGR/INCOMP	COM1	C2
120-SINGLE STORE	COM1	C2
121-MULTI STORES/1 BLDG	COM4	C2
122-STORE W/ LIVING UNIT	COM1	C2
131-MULTI STORES/OFFICES	COM4	C2
160-MAJOR SHOPPING CENTER	COM2	C2
170-SINGLE OFFICE	COM4	C2
171-MULTI OFFICES/1 BLDG	COM4	C2
173-COMMON AREA/OFFICES	COM4	C2
180-MEDICAL OFFICE	COM7	C2
181-DENTAL OFFICE	COM7	C2
183-VETERINARY CLINIC	COM7	C2
190-MISC MULTI USE	COM1	C2
191-OTHER COMMERICAL USE	COM1	C2
200-RESTAURANT	COM8	C2

USECDDESC	SpOcc	EQBldg
210-BANK	COM5	C2
211-SAVINGS 7 LOAN	COM5	C2
220-FULL SERVICE STATION	COM1	C2
223-GAS STATION W/ STORE	COM1	C2
250-AUTO/TRUCK REPAIR	COM3	C2
251-CAR SERVICE/SPECIALTY	COM3	C2
260-RETAIL NURSERY	COM1	C2
310-MANUFACTURING	IND1	S2
323-STORAGE YARD	COM2	C2
353-LIGHT INDUSTRY	IND2	S2
600-THEATER	COM9	RM2
615-OTHER SPORTS CENTER	COM8	RM2
710-CHURCH	REL1	RM1
711-OTHER CHURCH PROPERTY	REL1	RM1
720-PRIVATE SCHOOL	EDU2	W2
721-RELIGIOUS SCHOOL	EDU1	RM1
800-ASSESSED BY SBE	COM1	C2
830-TOKEN VALUE PROPERTY	COM1	C2
901-FDERAL BUILDING	GOV1	C2

USECDDESC	SpOcc	EQBldg
913-STATE PARK/RECREATION	COM8	C2
921-COUNTY BUILDING	GOV1	C2
930-VACANT CITY LAND	GOV1	C2
931-CITY BUILDING	GOV1	C2
935-CITY PARKING LOT	COM10	C2
936-MISC CITY PROPERTY	GOV1	C2
940-SCHOOL DISTRICT APN	EDU1	RM1

3. If you're having trouble assigning the building descriptions to Hazus values using your own data, open the AEBM tool located here: C:\E0177\Activity\7.1\AEBM_Tool.xlsx. The second tab is called Common Occupancy Codes and has common codes localities use.

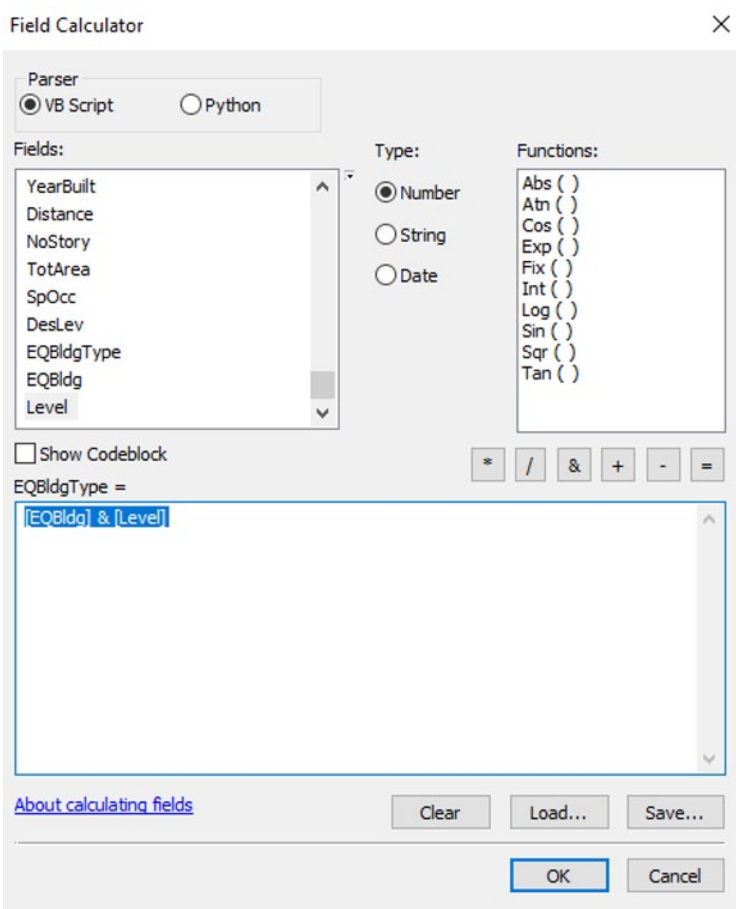
4. Close the attribute table. Now, assign the design level to each building. Open the Santa Cruz earthquake study region in Hazus (keep ArcMap open). Open the attribute table for the Study Region Tract layer. Look at the BldgSchemesID* values. The study region has only values of CA3. Next, make a note of the County FIPS code (06087). Close Hazus. Open the AEBM_Tool.xlsx and go to the first tab called AEBM. In Section 4 there is Earthquake Design Level and the first column show the BldgSchemesID. The one to use for Santa Cruz is XX3. Your community may also be one of the other two. All building built before 1940 will be assigned a value of PC, everything built from 1940 to 1959 will be assigned LC, etc.

5. Go back to ArcMap and open the Footprints-Parcels attribute table. Create a new field called DesLev with a text data type which is 2 characters long. Set up Select by Attribute queries based on year built to determine design level. There are no buildings built before 1954 so set the first query to "YearBuilt" >=1940 AND "YearBuilt" <1960. Sixty-six buildings are selected. Now use Field Calculator to set the values to LC for low code. Use the AEBM tool to create the rest of the queries and assign design level values.

6. Now, complete the earthquake building type. Create a new field called level and make it a text field with 1 character. Use a Select by Attributes query to select “NoStory” <4 and then use Field Calculator to assign a value of L. Then select "NoStory" >=4 AND "NoStory" <7 and assign it a value of M. Then select "NoStory" >6 and assign it a value of H.

7. Create a new field called EQBldgType and make it a text data type with a 4 character size. Use a Select by Attributes to select all specific occupancies except for MH: "EQBldg" <> 'MH'. Manufactured housing, wood structures, and unreinforced masonry have different low, medium, and high values or no values at all. Use Field Calculator to make EQBldgType = [EQBldg] &

[Level]. This will merge those two columns into one code. For example, C2 and H will become C2H. Click OK and close the attribute table.



8. Hazus requires a great deal of economic information especially for commercial and industrial buildings. To support the development of economic values, the AEBM tool has been created. Open the AEBM_Tool.xlsx and go to the third tab called Calculations. This tool creates the values required by Hazus using the specific occupancy and building area values. To use this tool open Footprints-Parcels.dbf in Excel. Put the FID_1, SpOcc, and TotArea fields next to each other.

	A	B	C	D	E	F	G
1	FID_1	SpOcc	TotArea	OBJECTID	IN_PROGRES	MAPSOURCE	TYPE
2	185	REL1	3985.04154236000	82242.00000000000			3
3	186	REL1	45889.46555970000	82244.00000000000			3
4	187	REL1	1653.76248927000	82254.00000000000			2
5	188	REL1	36267.30633740000	82256.00000000000			3
6	191	REL1	4990.69291425000	82271.00000000000			2
7	192	REL1	7294.81661328000	82289.00000000000			2
8	709	RES3C	12881.39771360000	100357.00000000000			
9	710	RES3C	13021.85618730000	100358.00000000000			
10	721	RES3C	3866.07583914000	101157.00000000000			
11	722	RES3C	2231.25359930000	101158.00000000000			
12	119	COM8	6094.97197006000	81905.00000000000			3
13	128	COM8	1353.77662470000	81949.00000000000			3
14	104	RES1	555.86070452100	81839.00000000000			2
15	111	RES1	1585.12752378000	81873.00000000000			1
16	120	RES1	4238.51692128000	81907.00000000000			1
17	96	RES1	5179.97296974000	81792.00000000000			1
18	91	RES3C	2732.62817990000	81757.00000000000			1
19	105	RES3C	5609.89083260000	81843.00000000000			1
20	673	IND1	18369.60829420000	98744.00000000000			3
21	83	RES3B	3634.44812970000	81729.00000000000			1

Footprints-Parcels

Ready 100%

9. Copy the three fields and paste them into the AEBM_Tool. Use ArcCatalog to view the CA.dbo.hzMeansCountyLocationFactor and find the FIPS code for Santa Cruz. Then copy the residential (1.25) and non-residential (1.18) values into the AEBM tool.

RES Loc Factor	Non-Res Loc Factor	FID_1	SpOcc	TotArea	BldgValue	ContentValue	BusinessInv (x$1000)	BusinessIncome (x$1000)	WagesPaid	RelocationDisruptCost	RentalCost	RatioOwnerOccupied
1.25	1.18	185	REL1	3985.04154236000	895.9385588	895.9385588	0	0.637606647	1.49439058	0.154088273	0.1594017	0.9
		186	REL1	45889.46555970000	8743.319873	8743.319873	0	7.34231449	17.2085496	1.774392668	1.8355786	0.9
		187	REL1	1653.76248927000	315.0913671	315.0913671	0	0.264601998	0.62016093	0.063945483	0.0661505	0.9
		188	REL1	36267.30633740000	6910.009876	6910.009876	0	5.802769014	13.6002399	1.402335845	1.4506923	0.9
		191	REL1	4990.69291425000	950.876721	950.876721	0	0.798510866	1.87150984	0.192973459	0.1996277	0.9
		192	REL1	7294.81661328000	1389.881409	1389.881409	0	1.167170658	2.73555623	0.282066242	0.2917927	0.9
		709	RES3C	12881.39771360000	2593.411802	1296.705901	0	0	0	0.425086125	0.257628	0.35
		710	RES3C	13021.85618730000	2621.690306	1310.845153	0	0	0	0.429721254	0.2604371	0.35
		721	RES3C	3866.07583914000	778.3570487	389.1785243	0	0	0	0.127580503	0.0773215	0.35
		722	RES3C	2231.25359930000	449.2182871	224.6091436	0	0	0	0.073631369	0.0446251	0.35
		119	COM8	6094.97197006000	1386.788972	1386.788972	0	4.461519482	3.54727369	0	0.426648	0.55
		128	COM8	1353.77662470000	308.0247954	308.0247954	0	0.990964489	0.787898	0	0.0947644	0.55
		104	RES1	555.86070452100	68.23190148	34.11595074	0	0	0	0.018343403	0.0166758	0.75
		111	RES1	1585.12752378000	194.5744035	97.28720177	0	0	0	0.052309208	0.0475538	0.75
		120	RES1	4238.51692128000	520.2779521	260.138976	0	0	0	0.139871058	0.1271555	0.75
		96	RES1	5179.97296974000	635.841682	317.920841	0	0	0	0.170939108	0.1553992	0.75
		91	RES3C	2732.62817990000	550.1600315	275.0800157	0	0	0	0.09017673	0.0546526	0.35
		105	RES3C	5609.89083260000	1129.439321	564.7196607	0	0	0	0.185126397	0.1121978	0.35
		673	IND1	18369.60829420000	2443.708991	3665.563487	688.860311	5.565991313	9.20317376	0	0.1836961	0.75
		83	RES3B	3634.44812970000	398.5535819	199.276791	0	0	0	0.119936788	0.072689	0.35
		89	RES3B	3603.71116875000	395.1829668	197.5914834	0	0	0	0.118922469	0.0720742	0.35
		98	RES3B	2351.37617615000	257.8519115	128.9259557	0	0	0	0.077595414	0.0470275	0.35
		110	RES3B	2444.72482929000	268.0885248	134.0442624	0	0	0	0.080675919	0.0488945	0.35
		90	RES3C	9952.55278521000	2003.747452	1001.873726	0	0	0	0.328434242	0.1990511	0.35
		77	RES3B	5028.56466885000	551.4324016	275.7162008	0	0	0	0.165942634	0.1005713	0.35

10. Copy the table into another Excel spreadsheet. Go down to the bottom right corner of the table (for this example it is K735) and select everything to A1. Press Ctrl+C to copy the table. Go to File and New and create a blank workbook. Go to Paste Values and select Values. Then save the spreadsheet as C:\E0177\Activity\7.1\AEBM_Values.xlsx. Close the dbf file and the AEBM Tool.

11. In ArcMap, add the AEBM_Values.xlsx table to the table of contents. Right click on Footprints-Parcels, then Joins and Relates, and then Join. Do a Join attributes from a table, field is FID, join it to Sheet1$ using the FID_1 field. Select the Keep all records option and select OK.

12. Open ArcCatalog and create a personal geodatabase called: C:\E0177\Activity\7.1\AEBM.mdb.

13. Export the joined Footprints-Parcels layer as a feature class in the AEBM geodatabase here: E:\E0177\Activity\7.1\AEBM.mdb\AEBM. Add it as a layer. Remove the other layers.

14. Open the attribute layer and add a field called Tract with a data type of text and a length of 11 characters. All of the buildings fall into the same tract so use the Field Calculator to populate all the records with the value: 06087100700. For your data, you may have to do a spatial join with the tract layers in the Hazus study region.

15. Add two more fields called DayOccupants and NightOccupants and make them Long Integers. Use Select by Attributes to select all the non-residential buildings. Then use the Field Calculator to make the DayOccupants = TotArea/194. Then switch selection and use the Field Calculator to make the residential values 0 for DayOccupants. 194 is the national average for commercial buildings, but we'll use it for the other non-residential occupancies here.

16. Use Select by Attributes to select all the RES1 and RES2 occupancies. Then use the Field Calculator to add a value of 3 in all the records for NightOccupants. Select the rest of the residential occupancies (except RES4) and use the Field Calculator to make the NightOccupants = TotArea/650*3. This is assuming that the average apartment is 650 square feet and family size is three. Now use Select by Attributes to select the RES4 buildings and make NightOccupants = Tot/Area/650*0.5 - one person per room at half occupancy. Select all the other occupancies and make the NightOccupants value zero.

Task 3: Update the Study Region and Run Analysis

1. Close ArcMap and open CDMS. Make sure that California is selected as your current state. Select Import into CDMS Repository from File. Unselect flood and browse to the AEBM geodatabase. Select AEBM in the first drop down and Advanced Engineering Building Module in the second drop down. Then select Continue. Under Select Import Table, click AEBM; and under Select Hazus-ID Field, click No Hazus ID. Then select Continue. Several of the fields have already been matched. Match the following fields:

- TotArea -> Area (Sq Feet)
- DesLev -> Earthquake Design Level
- SpOcc -> Occupancy Type
- SITEADD -> Address
- BusinessIncome_x_1000 -> BusinessIncome
- BusinessInv_x_1000 -> BusinessInv
- SITCITY -> City
- SITZIP -> ZipCode
- FID_1 -> Name

2. Select Continue and then Yes. Click OK to categorize fields. Match the RM1H to the RM1M value. Then click Continue. Then Continue two more times. When the message comes up if the loss modeling is based on USGS ShakeMap, select Yes. Then click OK. Transfer the data to the Statewide Dataset using a Replace Data. Then click Submit and Yes.

3. Now update the general building stock. While in CDMS, go to Import into CDMS Repository from File and browse to the AEBM database again. Unselect flood, in the first drop down select Aggregated Data and click Import Site Specific Data to Aggregate Data. Click Yes when the warning message comes up. In the dropdown, select AEBM and then OK.

4. Most of the fields will be matched and finish matching the following:

- SpOcc -> Occupancy
- X -> Longitude
- Y -> Latitude
- DesLev -> Earthquake Design Level
- NoStory -> Num Stories

5. Click Continue. For the Categorization, field is not in thousands of square feet so use the .001 conversion and click OK. The building value field is in thousands to click OK, content values are in thousands to click OK, Number of Stories field is as is so click OK, Year Built is in the 4-digit format so click OK, match the EQ Building Types by removing the L, M, and H values (for example C2H matches to C2) and click Continue. The EQ Design Level should match correctly, so click Continue, the occupancy class should match correctly so click Continue, and then select Submit. Transfer the data to the Statewide Dataset. Click Yes when the warning comes up. Click Select All on the right, then select Process only imported tracts/blocks and then select Update General Building Mapping Schemes and click OK. Select Replace all occupancies for this statewide transfer and then Continue. Then click OK when the process is complete.

6. Create a new Santa Cruz Earthquake study region. Make sure the AEBM inventory table is populated and map them. Then go to General Building Stock and Occupancy Mapping. Notice there is a new Occupancy Mapping Scheme assigned to the Census Tract that was updated.

7. Run the M 7.2 ShakeMap scenario called Santa Andreas (Santa Cruz Mts). Select the first scenario version when that menu comes up. Export the results and then run the same scenario with your original study region without the edits and compare the results.

Task 4: Prepare to Discuss Results

1. Create a slide in PPT to explain how you updated the study region with local data and how that changed the results from the defaults.

Note: These slides may be used in the final capstone presentation at the end of the class.

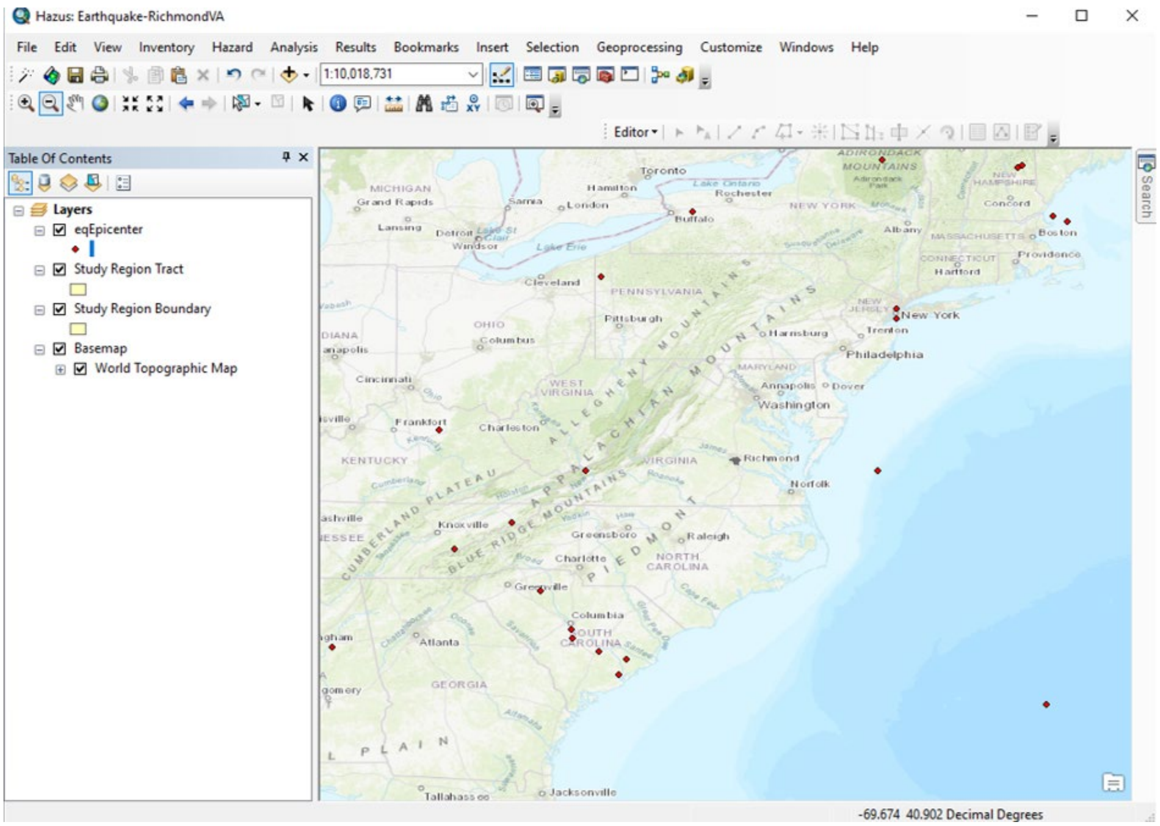
Application 4: Assessing Risk in Low-to-Moderate Earthquake Risk Areas

This process involves creating an east coast study region and running an earthquake risk assessment for it. Many areas in the country have seismic activity that is not well defined and the USGS probabilistic ground shaking values produce little damage. When an actual earthquake occurs, the damages and injuries are higher in certain areas than the probabilistic model. This process involves looking at the probabilistic results along with a realistic deterministic event.

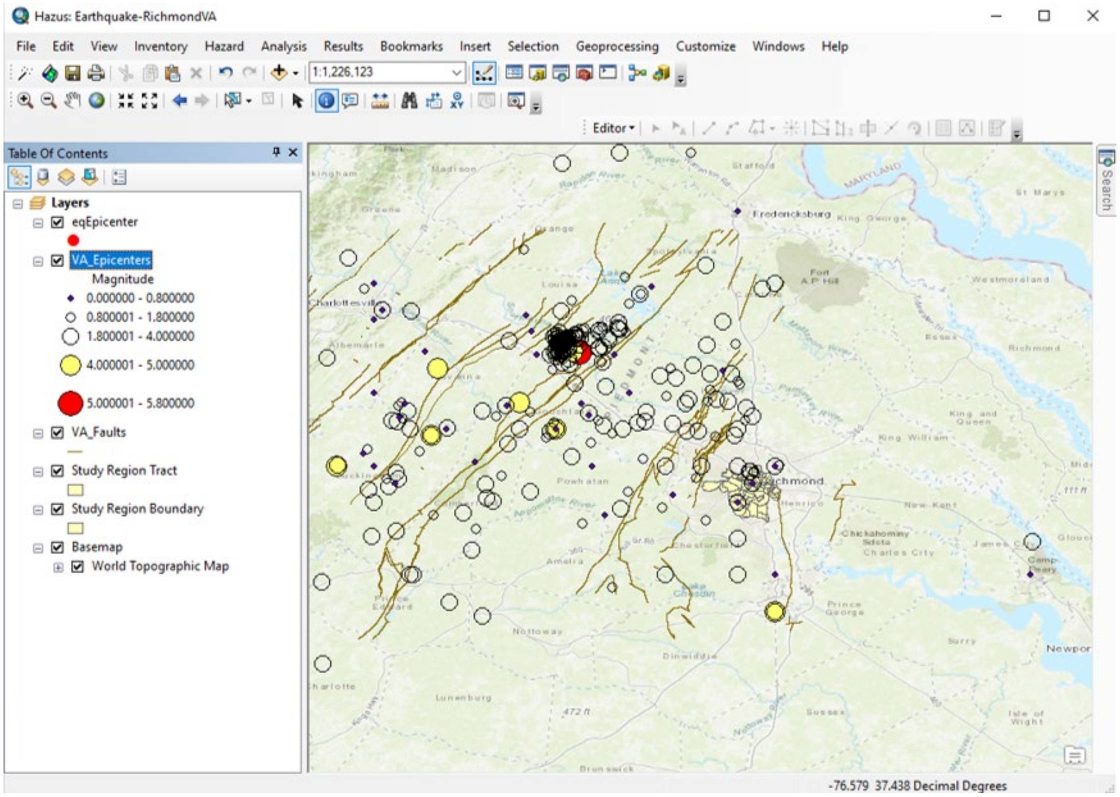
Task 1: Investigate Earthquake Events

1. Create a new earthquake study region in the City of Richmond, Virginia. Open the region.

2. Add the following data: C:\Program Files (x86)\Hazus-MH\Data\EQ\Scenario.mdb\eqEpicenter. This feature class contains historical earthquake events that have a magnitude of 5 or greater. The dataset is out of date and contains few earthquakes on the east coast. Add a Topographic basemap and zoom out to the State.



3. Several states have their own database of events – even states who haven't been impacted by earthquakes in recent memory. Using FEMA funding, the Virginia Division of Geology and Mineral Resources has developed an epicenter and Faultline database for the State. This data can be found here: https://www.dmme.virginia.gov/dgmr/FEMAFaultMapping.shtml. The database has already been downloaded and can be found here: C:\E0177\Activity\7.1\ VA_Faults.shp and here: C:\E0177\Activity\7.1\VA_Epicenters.shp. Add the two datasets to the map and zoom into Richmond. Change the symbology of the VA_Epicenters layer so that it is using the magnitude field to do graduated symbols. Select Classify to make the breaks 5-5.8, 4-5, 1.8-4, and <1.8. Then change the color of the 5-5.8 to red and 4-5 to yellow.



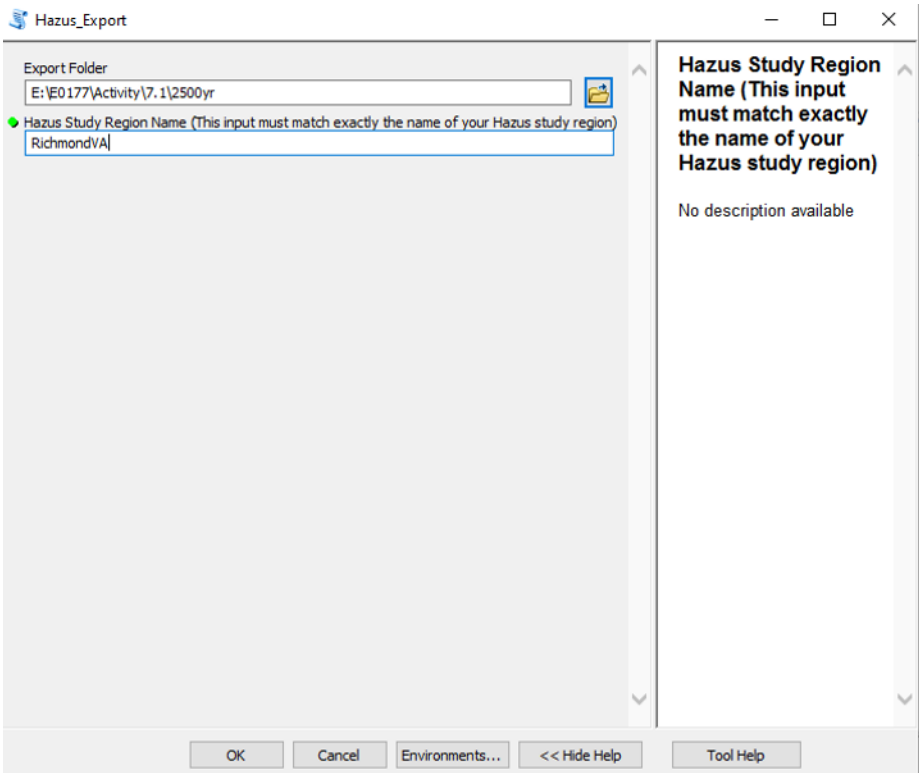
4. Notice that the closest yellow dot is about 18 miles away while the closest red dot is about 30 miles away. Make a note of these two locations, they will be used to set up scenarios. Next, look at the depths of the larger earthquakes.

Task 2: Begin Analyses

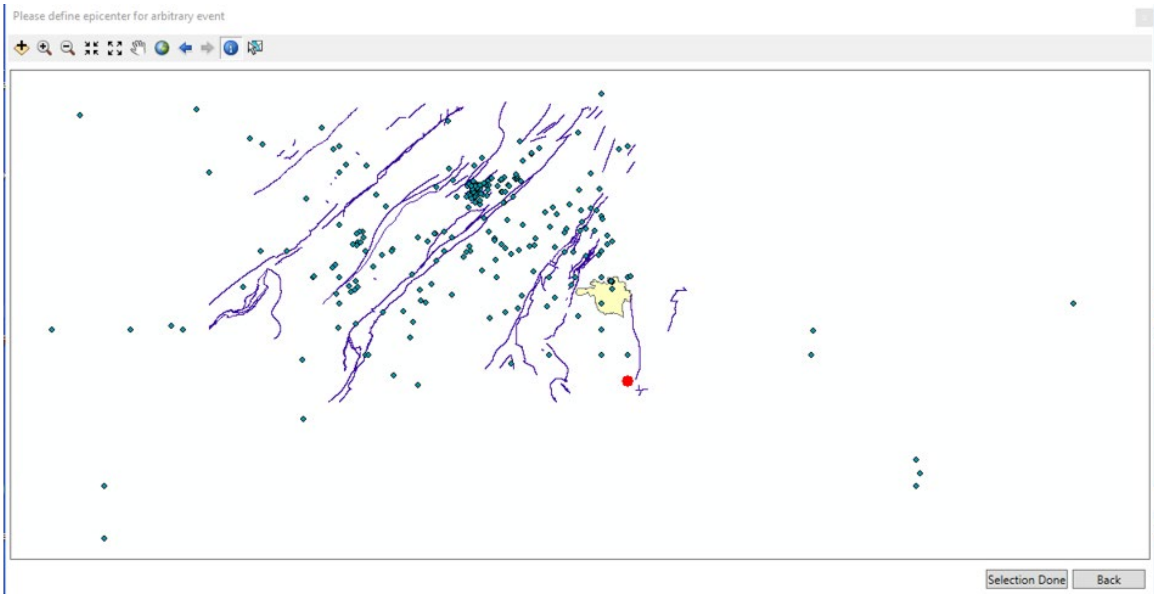
1. First, run a probabilistic analysis. The probabilistic analysis uses the ground shaking from the USGS and it doesn't represent what happens during a real event. The ground shaking parameters are derived from the historical ground shaking in the region and the values themselves don't vary much across the region. In a real earthquake there is higher ground shaking closer to the epicenter and the motion decays as it travels from that location. Go to Hazard, Scenario, Next, Define a new scenario, Next, probabilistic event, Next, add a return period of 2500-year with a magnitude 6 driving it. Then click Next. Name it 2500year and click Next and then Finish.

2. Go to Analysis and Run. Click Select All and then OK. Click Yes when the warning comes up.

3. Click OK when the completion message comes up. Go to results and summary reports. Click on the Other tab and view the Global Summary Report. Save the report as C:\E0177\Activity\7.1\2500year.pdf. Go to ArcToolbox and double click Hazus_Export. Select an export folder location: C:\E0177\Activity\7.1\2500yr\ and then type in the study region name. Then click OK.



4. Now, create a manual earthquake. Go to Hazard, Scenario, Next, Define a new scenario, Next, arbitrary event, Next, select the Central & East US (CEUS 2008) attenuation function. Click Next. In the Arbitrary Event Parameters screen, select Map. The City boundary comes up. Click the add data button in the top left. Then add the VA_Epicenter and VA_Faults to the map. Zoom out until the epicenters are visible. Select the epicenter with a magnitude of 4.5 to the south. Then click Selection Done.



5. For the Moment magnitude, select 5 and for the depth, select 6 km. Then select Next. Call it Magnitude5 and click Next. Then Finish. Go to Analysis and Run. Click Select All and then OK. Click Yes when the warning comes up.

6. Click OK when the completion message comes up. Go to results and summary reports. Click on the Other tab and view the Global Summary Report. Save the report as C:\E0177\Activity\7.1\Magnitude5.pdf. Go to ArcToolbox and double click Hazus_Export. Select an export folder location: C:\E0177\Activity\7.1\Mag5\ and then type in the study region name. Then click OK.

7. Now, create another manual earthquake. Go to Hazard, Scenario, Next, Define a new scenario, Next, arbitrary event, Next, select the Central & East US (CEUS 2008) attenuation function. Click Next. In the Arbitrary Event Parameters screen, select Map. The City boundary comes up. Click the add data button in the top left. Then add the VA_Epicenter and VA_Faults to the map. Zoom out until the epicenters are visible. Select an epicenter near the group of larger earthquakes to the northwest. Then click Selection Done.

8. For the Moment magnitude, select 6 and for the depth, select 6 km. Then select Next. Call it Magnitude6 and click Next. Then Finish. Go to Analysis and Run. Click Select All and then OK. Click Yes when the warning comes up.

9. Click OK when the completion message comes up. Go to results and summary reports. Click on the Other tab and view the Global Summary Report. Save the report as C:\E0177\Activity\7.1\Magnitude6.pdf. Go to ArcToolbox and double click Hazus_Export. Select an export folder location: C:\E0177\Activity\7.1\Mag6\ and then type in the study region name. Then click OK.

10. There will be three different results to compare now. How do the deterministic results different from the probabilistic (besides the total losses)?

Task 3: Prepare to Discuss Results

1. Create a slide in PPT to provide information on which earthquake scenarios were used and what kind of results were modeled. What were some of the differences between the probabilistic and deterministic modeling?

Note: These slides may be used in the final capstone presentation at the end of the class.

Visual 33: Lesson 7: Review

1. List 3 sources of earthquake data
2. Identify four hazard maps for the earthquake model
3. What is the file format of the hazard maps? What field name is required?
4. Can a new building type be developed for general building stock?

Visual 34: Questions?

Lesson 8: Advanced Tsunami

Visual 1: Lesson 8: Advanced Tsunami

Visual 2: Lesson 8: Goal and Objectives

Goal: Better understand how advanced applications can help mitigate tsunami model limitations and generate more accurate results.

After completing this lesson you will be able to:

- List sources of tsunami data
- Identify earthquake characteristics which will be more likely to produce a tsunami
- Identify four advanced applications for the tsunami hazard model
- Conduct an advanced application if applicable to your community

Visual 3: Tsunami Review

- Available for 5 Very High-risk states (AK, WA, OR, CA, HI) and the 5 High Risk U.S. territories
- Combined Earthquake/Tsunami analysis functionality available for the 5 states and PR
- Uses NSI data for the general building stock
- Deterministic only

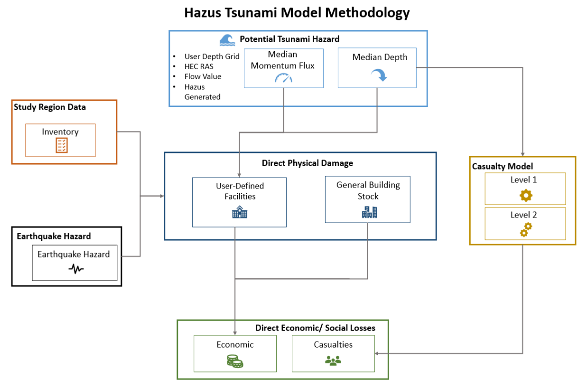
Visual 4: EQ/TS Analysis - Review

Hazard Input

- Tsunami inundation depth
- Velocity or momentum flux
- Topography
- Earthquake scenario

Infrastructure

- NSI data (point location – aggregated) and GBS
- User defined structures



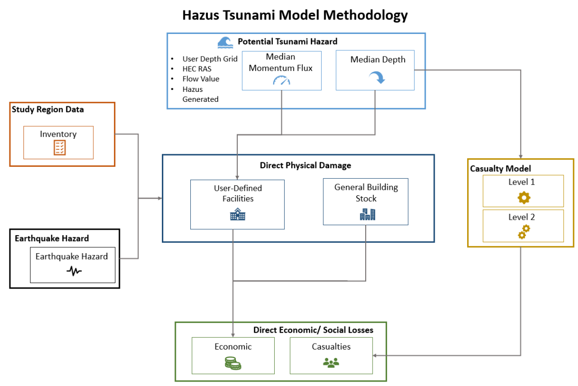
Visual 5: EQ/TS Analysis - Review

Damage and Losses

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

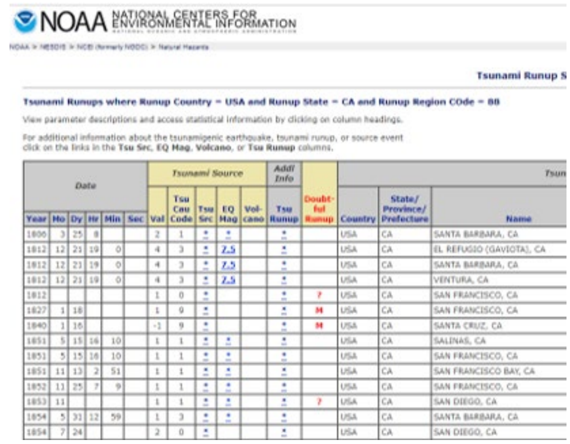
Casualties

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



Visual 6: Hazard Data Sources - Federal

- NOAA National Centers for Environmental Information (https://www.ngdc.noaa.gov/hazard/tsu_db.shtml)
- NGDC/WDS tsunami runup and source database
- Provides source info, max. height, travel time, inundation horizontal distance, and impacts



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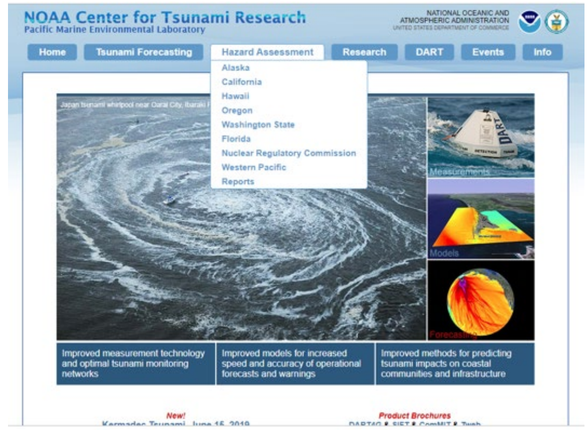
Hazard Data Sources - Federal

- National Geophysical Data Center / World Data Service (NGDC/WDS): Global Historical Tsunami Database. National Geophysical Data Center, NOAA. doi:10.7289/V5PN93H7 [accessed on October 8, 2019] (https://www.ngdc.noaa.gov/hazard/tsu_db.shtml)

Visual 7: Hazard Data Sources - Federal

- NOAA Center for Tsunami Research - (https://nctr.pmel.noaa.gov)
- Tsunami modeling and research - (https://nctr.pmel.noaa.gov/model.html)
- NOAA's Center for Tsunami Research has developed forecast inundation models (http://nctr.pmel.noaa.gov/sim.html) for 75 communities in the U.S., but they are not available to the public yet



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Hazard Data Sources - Federal

- National Geophysical Data Center / World Data Service (NGDC/WDS): Global Historical Tsunami Database. National Geophysical Data Center, NOAA. doi:10.7289/V5PN93H7 [accessed on October 8, 2019] https://www.ngdc.noaa.gov/hazard/tsu_db.shtml

Visual 8: Hazard Data Sources - State

- Oregon HazVu -
  - https://gis.dogami.oregon.gov/maps/hazvu/
- Oregon Tsunami Clearinghouse:
  - https://www.oregongeology.org/tsuclearinghouse/thmp.htm
- Hawaii tsunami wave heights
  - http://geoportal.hawaii.gov/datasets/tsunami-wave-heights and evacuation zones: http://geoportal.hawaii.gov/datasets/tsunami-evacuation-zones
- Hawaii (Pacioos) tsunami run-up inundation
  - http://geo.pacioos.hawaii.edu/geoserver/web/

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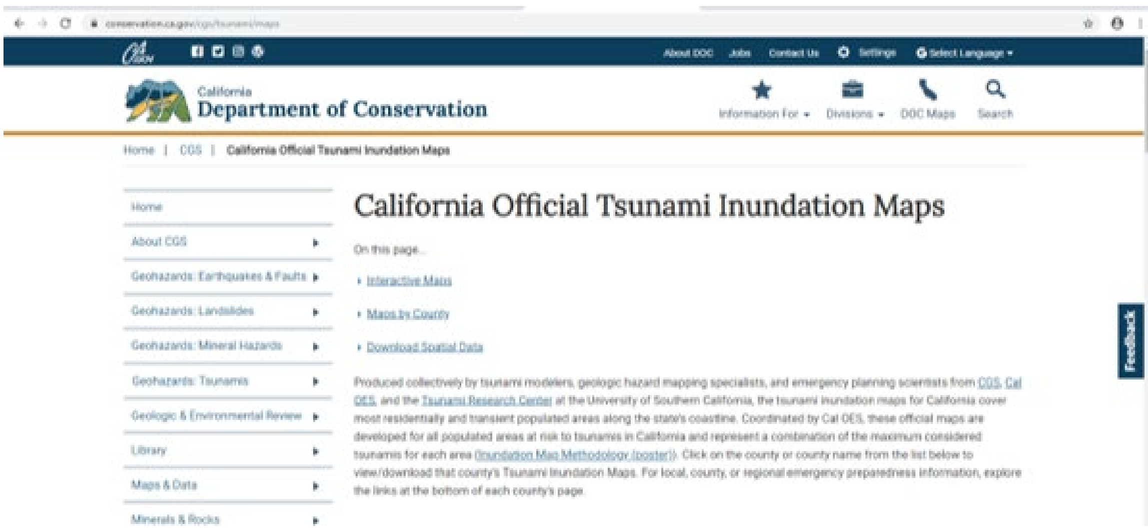
Hazard Data Sources - State

- Oregon HazVu - https://gis.dogami.oregon.gov/maps/hazvu/
- Oregon Tsunami Clearinghouse - https://www.oregongeology.org/tsuclearinghouse/thmp.htm
- Hawaii Tsunami Wave Height- http://geoportal.hawaii.gov/dataset/tsunami-wave-heights
- Hawaii Evac Zones - http://geoportal.hawaii.gov/datasets/tsunami-evacuation-zones
- Hawaii - http://geo.pacioos.hawaii.edu/geoserver/web/

Visual 9: Hazard Data Sources - State

- Washington- https://www.dnr.wa.gov/programs-and-services/geology/geologic-hazards/Tsunamis
- California - https://www.conservation.ca.gov/cgs/tsunami/maps
- Alaska - http://earthquake.alaska.edu/tsunamis



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Hazard Data Sources - State

- Washington Tsunamis - https://www.dnr.wa.gov/programs-and-services/geology/geologic-hazards/Tsunamis
- Washington Data Download - https://www.dnr.wa.gov/programs-and-services/geology/publications-and-data/gis-data-and-databases
- California - https://www.conservation.ca.gov/cgs/tsunami/maps
- Alaska - http://earthquake.alaska.edu/tsunamis

Visual 10: Hazard Data Sources - Territory

- American Samoa - http://portal.gis.doc.as/flexviewers/Hazards/
- Guam – https://ghs.guam.gov/programs/natural-disasters/tsunamis
- Puerto Rico - http://redsismica.uprm.edu/English/tsunami/tsunamiprogram/prc/maps/all.php
- U.S. Virgin Islands - http://www.vitema.vi.gov/plan-prepare/tsunamis

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Hazard Data Sources - Territory

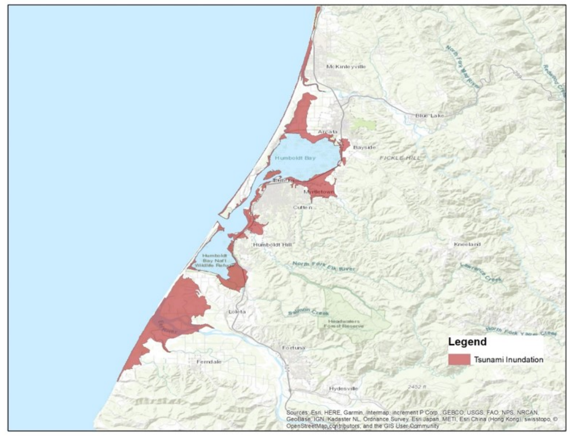
- American Samoa - http://portal.gis.doc.as/flexviewers/Hazards/
- Guam - https://ghs.guam.gov/programs/natural-disasters/tsunamis
- Puerto Rico - http://redsismica.uprm.edu/English/tsunami/tsunamiprogram/prc/gisdataenglish.php
- USVI - http://www.vitema.vi.gov/plan-prepare/tsunamis
- Government Data - http://data.gov

Visual 11: Hazard Data Sources - Local

- Hazard Mitigation Plan
- Emergency Management Agency
- Local planning department

Visual 12: Advanced App. – Inundation Maps

- How to use an inundation map in the Hazus Tsunami model
- Level 1 tsunami requires: (1) DEM and (2) maximum runup



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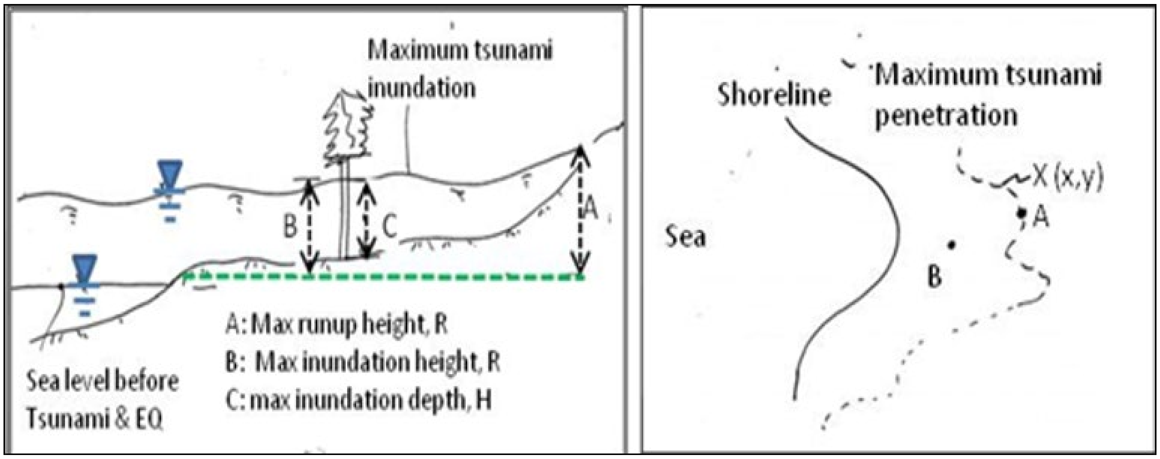
Advanced App. – Inundation Maps

This is a map of Humboldt County, California showing the tsunami inundation area provided by the State's Dept of Conservation website: https://www.conservation.ca.gov/cgs/tsunami/maps

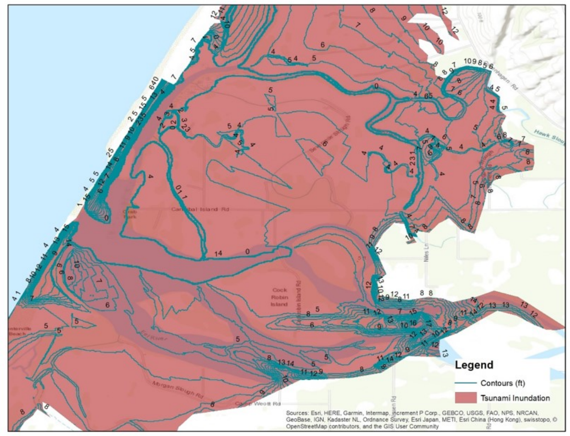
Visual 13: Advanced App. – Inundation Maps

- The height at the maximum tsunami penetration
- Inundation/evacuation map boundaries



Visual 14: Advanced App. – Inundation Maps

- Generate contours for DEM under inundation area
- Identify maximum runup value
- Run a Level 1 tsunami with single maximum runup value



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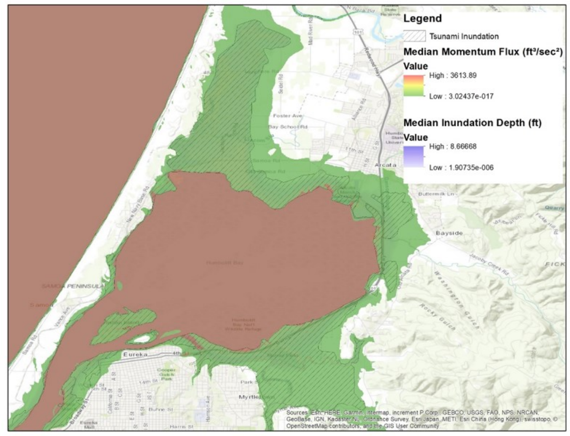
Advanced App. – Inundation Maps

This is a map of Humboldt County, California showing the tsunami inundation area and contour lines which have been generated using a local DEM.

Visual 15: Advanced App. – Inundation Maps

- Clip momentum flux and inundation depth grids
- Run Level 3 tsunami with clipped raster data



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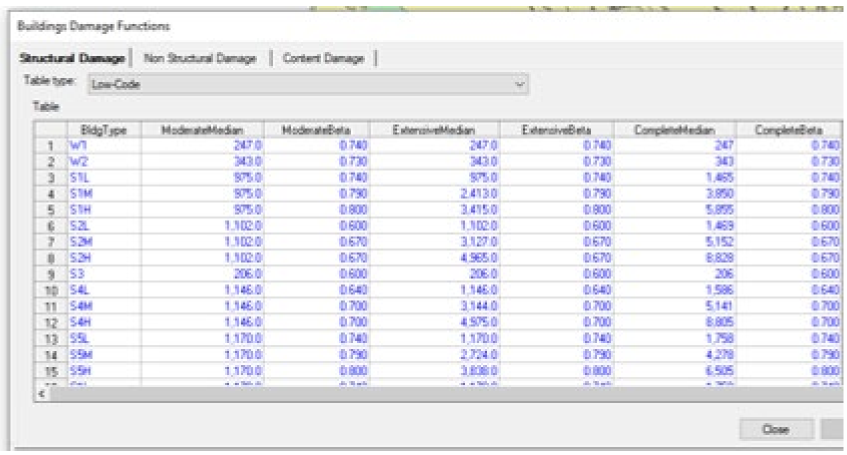
Advanced App. – Inundation Maps

This is a map of Humboldt County, California showing the tsunami inundation area (hatched) and the result of a Level 1 tsunami analysis.

Visual 16: Damage Functions

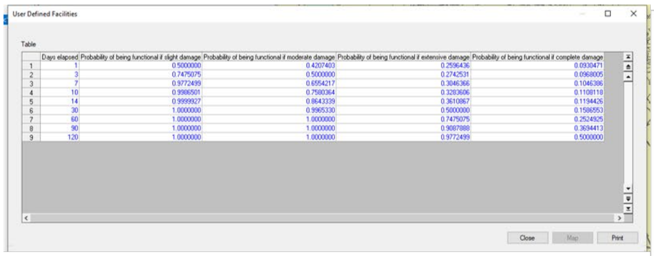
- Structural, non-structural, and content damage functions
- Similar to earthquake (which is why damage can be combined) but without slight damage
- Based on building type and design level



	BldgType	ModerateMedian	ModerateBeta	ExtensiveMedian	ExtensiveBeta	CompleteMedian	CompleteBeta
1	W1	247.0	0.740	247.0	0.740	247	0.740
2	W2	343.0	0.730	343.0	0.730	343	0.730
3	S1L	975.0	0.740	975.0	0.740	1,465	0.740
4	S1M	975.0	0.790	2,413.0	0.790	3,850	0.790
5	S1H	975.0	0.800	3,415.0	0.800	5,855	0.800
6	S2L	1,102.0	0.600	1,102.0	0.600	1,469	0.600
7	S2M	1,102.0	0.670	3,127.0	0.670	5,152	0.670
8	S2H	1,102.0	0.670	4,965.0	0.670	8,828	0.670
9	S3	206.0	0.600	206.0	0.600	206	0.600
10	S4L	1,146.0	0.640	1,146.0	0.640	1,586	0.640
11	S4M	1,146.0	0.700	3,144.0	0.700	5,141	0.700
12	S4H	1,146.0	0.700	4,975.0	0.700	8,805	0.700
13	S5L	1,170.0	0.740	1,170.0	0.740	1,758	0.740
14	S5M	1,170.0	0.790	2,724.0	0.790	4,278	0.790
15	S5H	1,170.0	0.800	3,838.0	0.800	6,505	0.800

Visual 17: Restoration Curves

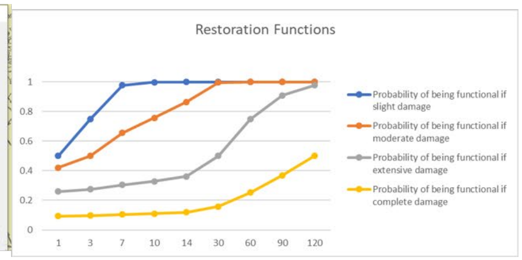
- Based on damage state probability and number of days after the event


User Defined Facilities

Table

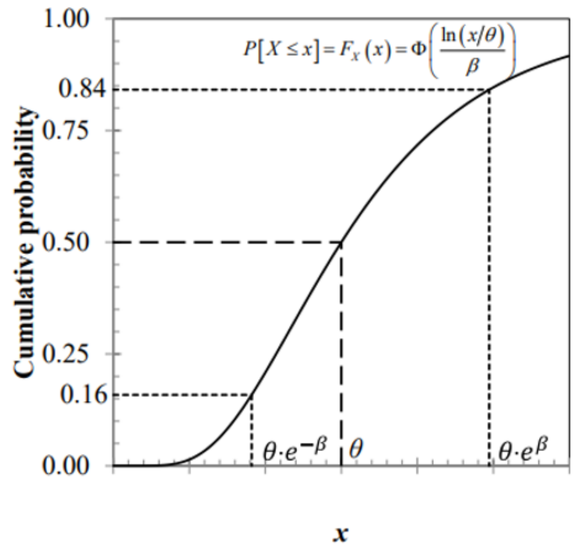
	Days elapsed	Probability of being functional if slight damage	Probability of being functional if moderate damage	Probability of being functional if extensive damage	Probability of being functional if complete damage
1	1	0.5000000	0.4207403	0.2596436	0.0930471
2	3	0.7475075	0.5000000	0.2742531	0.0968005
3	7	0.9772499	0.6554217	0.3046366	0.1046386
4	10	0.9986501	0.7580364	0.3283606	0.1108118
5	14	0.9999927	0.8643339	0.3610867	0.1194426
6	30	1.0000000	0.9965330	0.5000000	0.1586553
7	60	1.0000000	1.0000000	0.7475075	0.2524925
8	90	1.0000000	1.0000000	0.9087888	0.3694413
9	120	1.0000000	1.0000000	0.9772499	0.5000000

Close Map Print



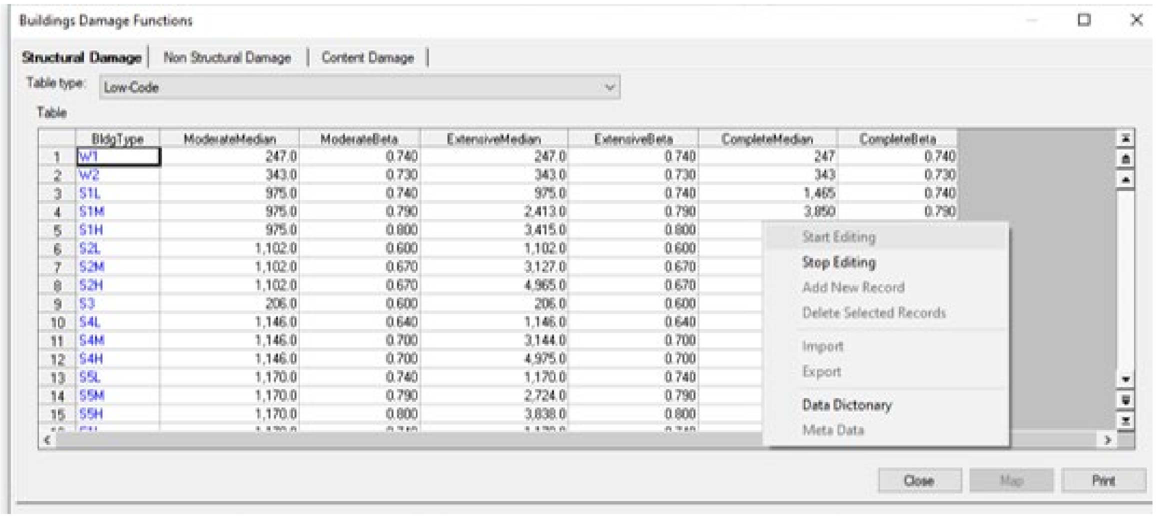
Visual 18: Adv. App. – Editing Damage Function

- Use the Hazus damage function parameters to define the damage function shape
- Use NORMDIST function in Excel
- Plot moderate, extensive, and complete functions



Visual 19: Adv. App. – Editing Damage Function

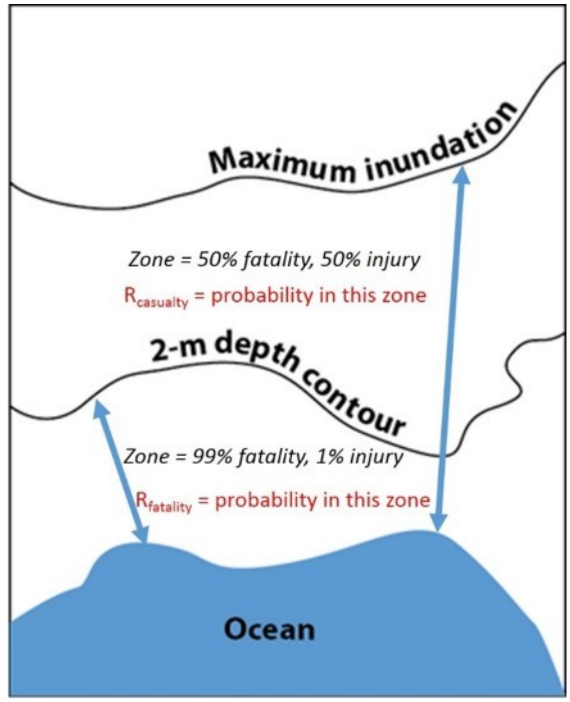
- Right click on the damage function table and select Start Editing
- Insert new medians and betas for a tsunami-hardened community building



	BldgType	ModerateMedian	ModerateBeta	ExtensiveMedian	ExtensiveBeta	CompleteMedian	CompleteBeta
1	W1	247.0	0.740	247.0	0.740	247	0.740
2	W2	343.0	0.730	343.0	0.730	343	0.730
3	S1L	975.0	0.740	975.0	0.740	1,465	0.740
4	S1M	975.0	0.790	2,413.0	0.790	3,850	0.790
5	S1H	975.0	0.800	3,415.0	0.800		
6	S2L	1,102.0	0.600	1,102.0	0.600		
7	S2M	1,102.0	0.670	3,127.0	0.670		
8	S2H	1,102.0	0.670	4,965.0	0.670		
9	S3	206.0	0.600	206.0	0.600		
10	S4L	1,146.0	0.640	1,146.0	0.640		
11	S4M	1,146.0	0.700	3,144.0	0.700		
12	S4H	1,146.0	0.700	4,975.0	0.700		
13	S5L	1,170.0	0.740	1,170.0	0.740		
14	S5M	1,170.0	0.790	2,724.0	0.790		
15	S5H	1,170.0	0.800	3,838.0	0.800		

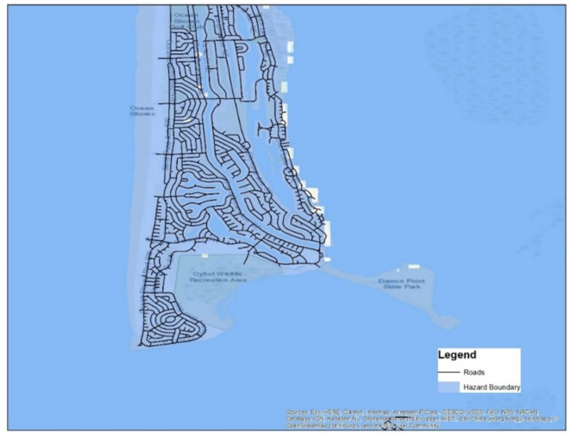
Visual 20: Evacuation Inputs

- Level 1 Input: (1) fatality boundary (depth > 2m), hazard boundary (depth > 0), road network data, topography (DEM), estimated time of tsunami arrival and maximum runup
- Level 2 Input: (1) safe zones, (2) partially safe zones, (3) estimated time of tsunami arrival and maximum runup
- Level 2 output travel time results provided by the USGS Pedestrian Evacuation Analyst Tool



Visual 21: Adv. App. – Evac. and Casualty Analysis

- Integrate local data into analysis
  - Road network
  - Digital elevation model
- Update Hazus generated layers for better accuracy
  - Hazard boundary
  - Fatality boundary



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Adv. App. – Evac. and Casualty Analysis

This map of Westport, Washington shows the hazard boundary which has been created by Hazus for the study region. There are some islands shown which should be removed so Hazus doesn't think people will evacuate to them.

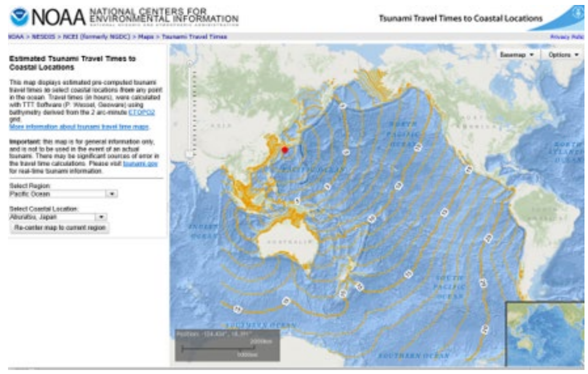
Visual 22: Advanced App. – EQ/TS Analysis

Identifying an appropriate earthquake for the analysis - magnitude, fault type, epicenter depth (shallow), and within 100 km of study region).

Magnitude	Effect
< 6.5	Earthquakes of this magnitude are very unlikely to trigger a tsunami.
6.5 - 7.5	Earthquakes of this size do not usually produce destructive tsunamis. However, small sea level changes may be observed in the vicinity of the epicenter. Tsunamis capable of producing damage or casualties are rare in this magnitude range, but have occurred due to secondary effects such as landslides or submarine slumps.
7.6 - 7.8	Earthquakes of this size may produce destructive tsunamis, especially near the epicenter; at greater distances, small sea level changes may be observed. Tsunamis capable of producing damage at great distances are rare in this magnitude range.
> 7.8	Destructive local tsunamis are possible near the epicenter and significant sea level changes and damage may occur in a broader region. Note that with a magnitude 9.0 earthquake that the probability of an aftershock with a magnitude exceeding 7.5 is not negligible.

Visual 23: Advanced App. – EQ/TS Analysis

- Identifying the tsunami (earthquake and tsunami must be deterministic since probabilistic analysis for tsunami doesn't exist)
  - Reviewing historical events to identify appropriate data or runup values - NGDC/WDS tsunami runup and source database
- Calculating arrival and warning time - https://nctr.pmel.noaa.gov/propagation-database.html



Visual 24: Exercise 8.1: Advanced Tsunami Application

- Goal: Use the Hazus tsunami model to complete one of the advanced applications
- Time: 225 minutes

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Exercise 8.1 Advanced Tsunami Applications

Goal:

- Complete an Advanced Tsunami Application
- Share the results of the Advanced Tsunami Application(s)

Time: 225 minutes

Exercise Steps:

1. Refer to Activities Document “8.1_Exercise_AdvancedTsunami.
2. Listen to instructor’s directions.
3. Ask questions if clarification is needed.
4. Work individually on the goal.
5. Ask questions to the instructor if needed.
6. Complete the assigned goal.
7. Be prepared to share your answers/results.
8. Ask any final questions.

Visual 25: Exercise 8.1: Tasks

- Pre-Task: Select Application
- Task 1: Implement Advanced Application
- Task 2: Share results
- Repeat For Additional Applications

Student Manual

Exercise 8.1 Tasks

Refer to Activities Document "8.1_Exercise_AdvancedTsunami".

Exercise 8.1: Advanced Tsunami Applications

Type: Exercise

Time: 225 minutes for all hazard applications

Goals:

- Complete an Advanced Flood Application
  - Application 1: Run an Analysis with Only an Inundation Zone
  - Application 2: Edit Tsunami Damage Functions
  - Application 3: Run an Advanced Evacuation and Casualty Analysis
  - Application 4: Run a User-Defined Near-Source Tsunami Analysis
- Share results of the Advanced Tsunami Application

Background: This activity will help you identify and implement an advanced tsunami application. If tsunamis are not a priority to your community, you do not need to do an advanced tsunami application, just choose a different hazard's activity to complete. Also, remember that the tsunami model only runs in select States and the Territories. Before you begin, the four advanced applications will be provided to you and you'll select the one (or more) that would be most beneficial to your community. If you finish one application and still have time, feel free to work through another. Approximate times have been provided for each option so just be aware of the time allotted for the activity. Data has been provided for Santa Cruz, California but you may use your own study region for the capstone presentation.

Before You Begin: Identify an Appropriate Advanced Hazard Application

There are four advanced tsunami applications to select from in this activity. Select the one that is most beneficial to your community:

Application 1: Run an Analysis with Only an Inundation Zone

I want to run the tsunami hazard, but my community only has a tsunami inundation zone. Can I still use Hazus? This process will walk you through the steps to identify an appropriate DEM and identifying the maximum runup.

- Data Required: Tsunami inundation zone
- Time Required: 35-45 Minutes
- Difficulty: Moderate

Application 2: Edit Tsunami Damage Functions

What do these tsunami damage functions look like and how do I edit them? The flood damage functions can be plotted easily and hurricane comes plotted in the software itself, but what do tsunami and earthquake fragility curves look like? This process will walk you through graphing fragility curves and making edits in the Hazus GUI.

- Data Required: None
- Time Required: 20-30 Minutes
- Difficulty: Easy-Moderate

Application 3: Run an Advanced Evacuation and Casualty Analysis

How do I run an advanced evacuation and casualty analysis? Can I use my own road data? This process will walk you through using the evacuation and casualty analysis in the tsunami model and to identify any model limitations.

- Data Required: Local road network
- Time Required: 45 Minutes
- Difficulty: Moderate

Application 4: Run a User-Defined Near-Source Tsunami

How do I assess an earthquake followed by tsunami in my community? What kind of earthquake do I select and how do I set up an appropriate tsunami?

- Data Required: None
- Time Required: 45-60 Minutes
- Difficulty Level: Moderate

Once you have chosen an Application, navigate to that section and begin the activity.

The final 20 minutes of the activity have been set aside for you and your classmates to share the results from the applications you have completed. Be prepared to present the application(s) you chose and your results.

Application 1: Run an Analysis with Only an Inundation Zone

For this activity, you'll need a DEM covering the coastal area and a tsunami inundation zone.

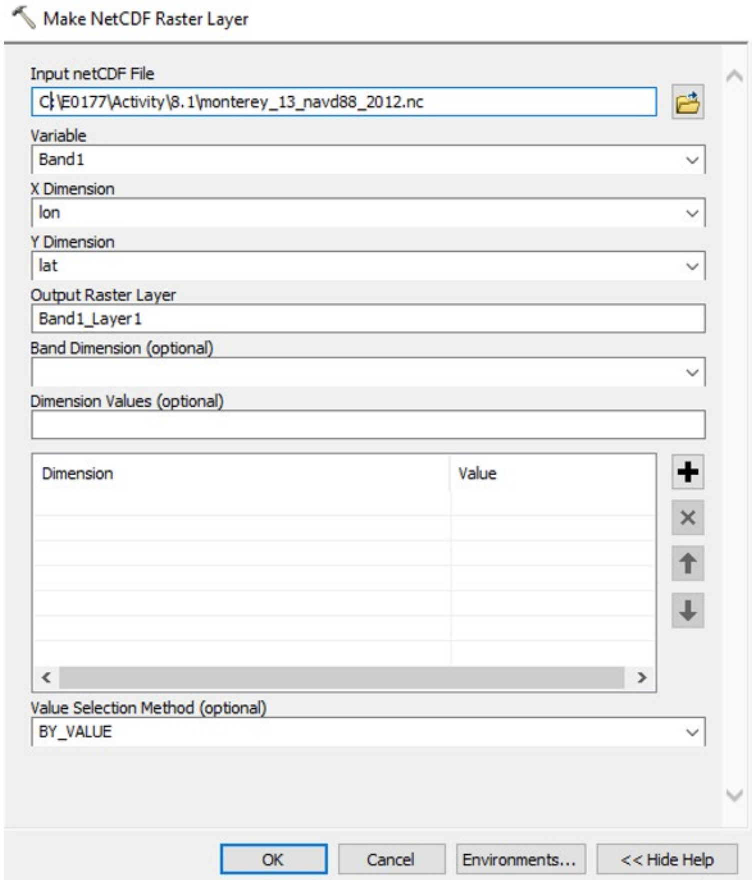
Task 1: Identify the DEM

1. Create a a Santa Cruz, California tsunami study region. Name the study region something you can remember. If you're creating your own study region, select that county and State (only Alaska, California, Hawaii, Oregon, Washington, and the Territories are supported by the tsunami model).

2. Identify an appropriate DEM. The DEM used in the earthquake analysis found here: C:\E0177\Activity\7.1\DEM.tif has a high resolution, but has no data is some places along the shoreline. For tsunami modeling, a DEM must cover the entire coastline. To support tsunami modeling, NOAA has developed a website which lists appropriate DEMs: https://www.ngdc.noaa.gov/mgg/coastal/coastal.html. There is a link on the left side which allows for selection using a map. For the County of Santa Cruz, select the Monterey DEM from 2012 (found on the fourth page). Click Data/Details on the right.

3. In the Download Data section, right click on Download NetCDF File and select Save link as. The download has already been completed and saved here: C:\E0177\Activity\8.1\monterey_13_NAVD88_2012.nc. There is a link on the top right of the website called ISO 19115-2 Metadata, select this link and then click on XML to view the metadata. See that the vertical datum is NAVD88 and the units are in meters.

4. Open the tsunami study region. Open ArcToolbox, then select Multidimension Tools and Make NetCDF Raster Layer. For Input netCDF file, select C:\E0177\Activity\8.1\monterey_13_NAVD88_2012.nc; for Variable, select Band1; for X Dimension, select lon; for Y Dimension, select lat; and for Output Raster Layer, select Band1_Layer1. Click OK.

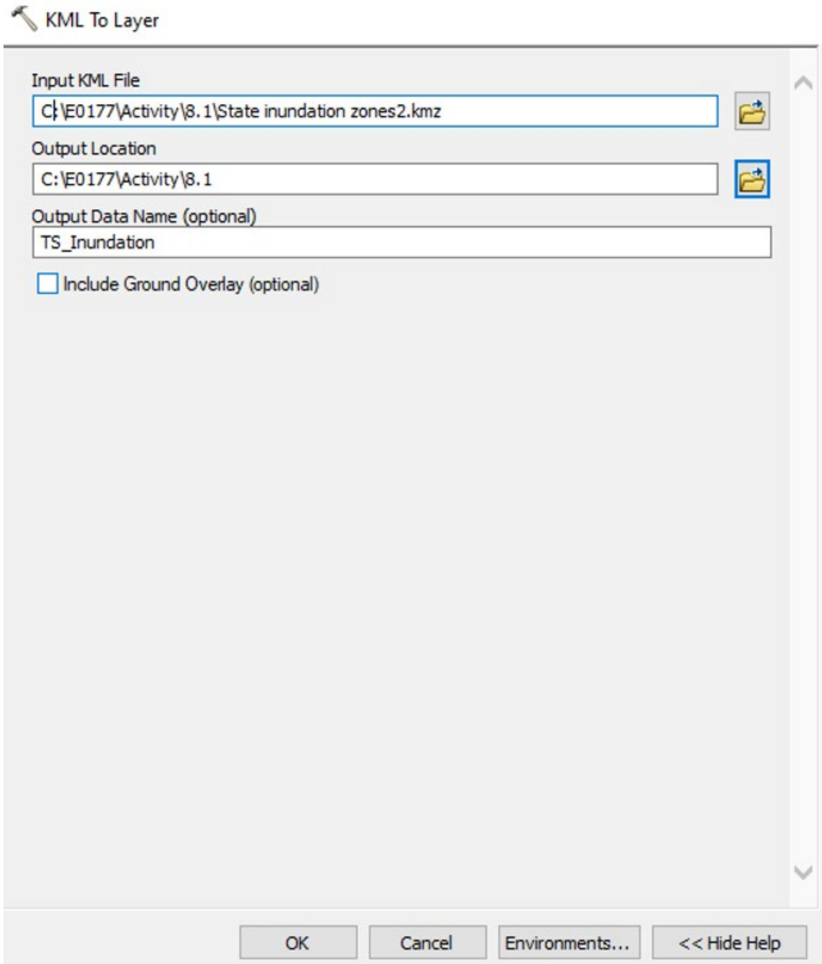


5. A new layer called Band1_Layer1 should be added to the table of contents in Hazus. The DEM doesn't cover the entire study region, but it does cover the entire shoreline and can be used for the tsunami modeling. Right click on Band1_Layer1 and export the layer as: C:\E0177\Activity\8.1\NOAA_DEM. Add NOAA_DEM to the table of contents and remove Band1_Layer1.

Task 2: Identify the Inundation Zone

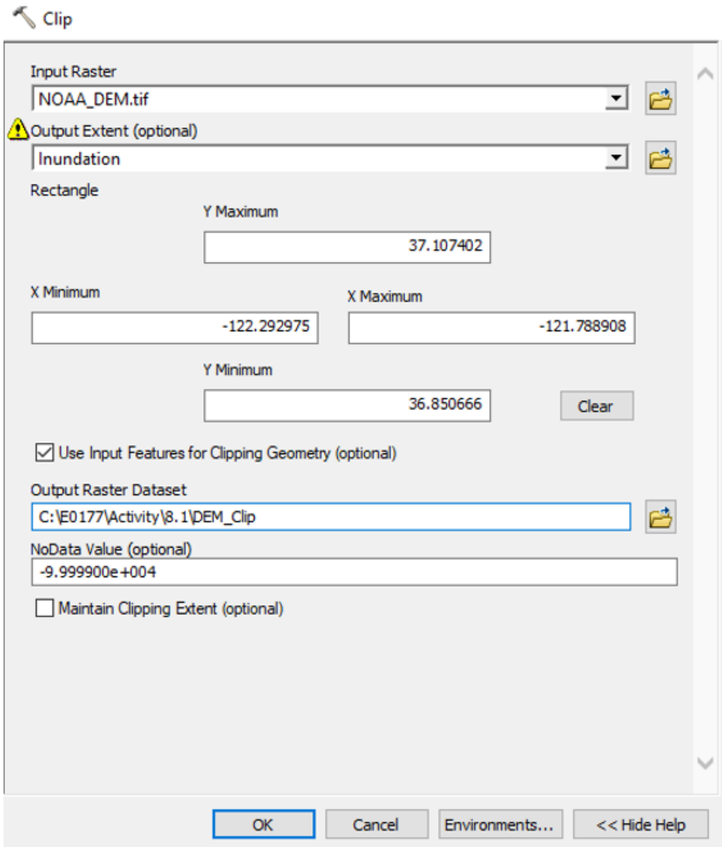
1. Using the links for the State tsunami data provided in class, go to: https://www.conservation.ca.gov/cgs/tsunami/maps. Then select Download Spatial Data and Download will begin downloading the .kmz file for the State of California. It is called State inundation zones2.kmz and has already been downloaded here: C:\E0177\Activity\8.1\.

2. In ArcToolbox, go to Conversion Tools, From KML, and double click on KML to Layer. For Input KML File, select C:\E0177\Activity\8.1\State inundation zones2.kmz; for Output Location, select C:\E0177\Activity\8.1; and Output Data Name is TS_Inundation. Then click OK.



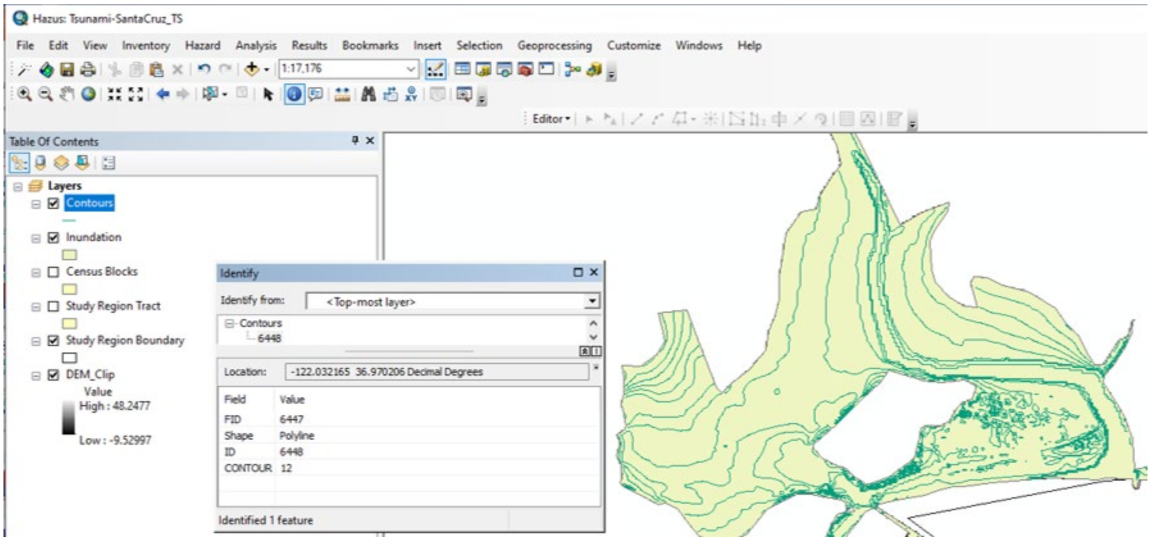
3. The inundation area covers the entire State of California so it'll need to be edited using the County limits. In ArcToolbox, select Analysis Tools, Overlay, and double click on Intersect. For the Input Features, select TS_Inundation\Polygons and Study Region Boundary and for Output Feature Class, select C:\E0177\Activity\8.1\Inundation.shp. Then click OK.

4. The Inundation layer should be added to the Table of Contents. Remove the TS_Inundation layer. Identify the highest elevation that is inundated. In ArcToolbox, go to Data Management Tools, Raster, and Raster Processing. Then double click on Clip. For the Input Raster, select NOAA_DEM.tif; for the Output Extent, select Inundation; check the box next to Use Input Features for Clipping Geometry; and for the Output Raster Dataset, use: C:\E0177\Activity\8.1\DEM_Clip. Then click OK.



5. Remove NOAA_DEM. In ArcToolbox, select Spatial Analyst Tools, then Surface, and double click on Contour. For Input raster, select DEM_Clip; for Output polyline features, use C:\E0177\Activity\8.1\Contours.shp; and for contour interval, use 1. Click OK.

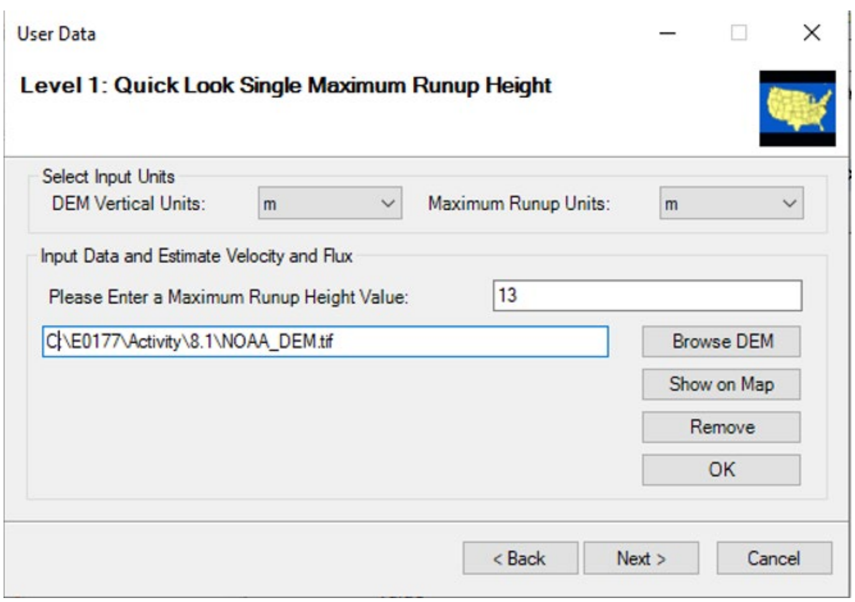
6. Close ArcToolbox and zoom into some of the inundated areas. Use the Identify tool to identify the higher elevations. Make a note of the highest value. For Santa Cruz, use 13.



Task 3: Create Tsunami Hazard

1. Go to Hazard and click Tsunami Hazard Type. Use the Distant Source option and click OK.

2. Go to Hazard and User Data. Click Level 1: Quick Look-Single Maximum Runup and then Next. For DEM Vertical Units, select m for meters; for Maximum Runup Units, select m for meters; for the Maximum Runup Height Value, enter 13; and for Browse DEM, use NOAA_DEM. Click OK to start the processing.



3. Click Next when the processing is complete. Enter the name as 13FeetRunup and click Next. Click OK once the final processing is complete. This process may need to be run again using a higher runup if the major inundation areas are not covered.

4. Right click on Median Momentum Flux and export it as C:\E0177\Activity\8.1\MM_Flux.tif. Add the new layer to the Table of Contents. Remove Median Momentum Flux from the Table of Contents. Export Median Inundation Depth to C:\E0177\Activity\8.1\Depth.tif. Add the new layer to the Table of Contents and delete Median Inundation Depth.

5. Open ArcToolbox, select Data Management Tools, Raster, Raster Processing, and double click Clip. For Input Raster, use MM_Flux.tif; for Output Extent, select Inundation; check the box next to Use Input Features for Clipping Geometry; and for Output Raster Dataset, select C:\E0177\Activity\8.1\MM_Flux_Imp. Then click OK.

6. Complete the same Clip process but use the Depth.tif. Call the new file Depth_Imp. Close ArcToolbox.

7. Go to Hazard, then User Data, and select Level 3: Depth (H) and Momentum Flux (HV2) and click Next. Select Browse Depth and find the depth_imp raster, then select Browse Flux and find the mm_flux_imp raster. Then click OK. Then select Next. Name the new event: TS_Inundation_Zone and select Next. Hazus will spend a few minutes processing the data.

8. Select Analysis and Run. When the combined analysis warning comes up, click OK. Select General Building Stock and OK. Click OK when the analysis is finished. There should now be results for general building stock.

Task 4: Prepare to Discuss Results

1. Create a slide in PPT to provide information on which data your community had and how you created the maps. Save the losses in a separate folder to be used for later.

Note: These slides may be used in the final capstone presentation at the end of the class.

Application 2: Edit Tsunami Damage Functions

What do these tsunami damage functions look like and how do I edit them? The flood damage functions can be plotted easily and hurricane comes plotted in the software itself, but what do tsunami and earthquake fragility curves look like?

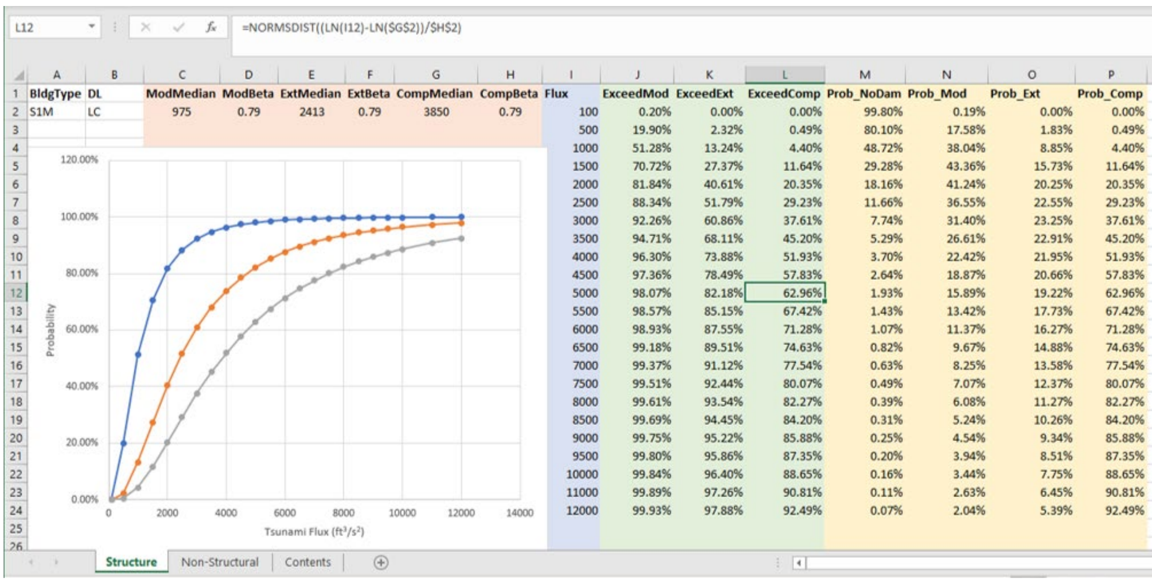
Task 1: View the Damage Functions

1. Create a Santa Cruz, California tsunami study region. Name the study region something you can remember. If you're creating your own study region, select that county and State (only Alaska, California, Hawaii, Oregon, Washington, and the Territories are supported by the tsunami model).

2. Review the damage function parameters. Go to Analysis and Damage Functions. Select Low-Code in the dropdown menu and browse down to S1M which is the earthquake building type: Steel Moment Frame Mid-Rise. The Moderate Median value is 975, Moderate Beta value is 0.79, Extensive Median value is 2413, Extensive Beta value is 0.79, Complete Median value is 3850, and Complete Beta is 0.79. Hazus uses the tsunami momentum flux to determine structural

damage so the median values are in ft3/s2 while the beta values are unitless. Close the Buildings Damage Functions tables.

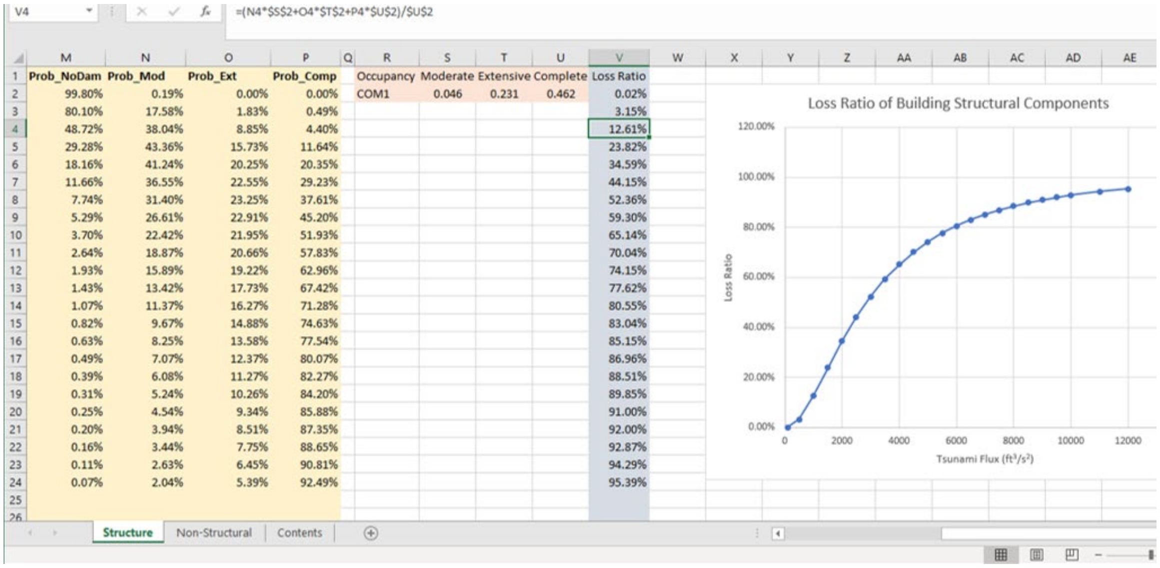
3. Open C:\E0177\Activity\8.1\damagefunctions.xlsx. There are three tabs in this spreadsheet. The first is labeled Structure and contains the structural exceedance probabilities for moderate, extensive, and complete damage states. The median and beta values can be added in the top left to see how the graph shifts. The flux values from 100 to 12000 are provided and the equations used to identify the probability of obtaining certain damage states are provided. The NORMDIST function in Excel is used in the equation. Median and beta values can be copied and pasted from Hazus to update the values and graph. This will help give you an idea of high flux values too since that concept is more obscure.



BldgType	DL	ModMedian	ModBeta	ExtMedian	ExtBeta	CompMedian	CompBeta
S1M	LC	975	0.79	2413	0.79	3850	0.79

Flux	ExceedMod	ExceedExt	ExceedComp	Prob_NoDam	Prob_Mod	Prob_Ext	Prob_Comp
100	0.20%	0.00%	0.00%	99.80%	0.19%	0.00%	0.00%
500	19.90%	2.32%	0.49%	80.10%	17.58%	1.83%	0.49%
1000	51.28%	13.24%	4.40%	48.72%	38.04%	8.85%	4.40%
1500	70.72%	27.37%	11.64%	29.28%	43.36%	15.73%	11.64%
2000	81.84%	40.61%	20.35%	18.16%	41.24%	20.25%	20.35%
2500	88.34%	51.79%	29.23%	11.66%	36.55%	22.55%	29.23%
3000	92.26%	60.86%	37.61%	7.74%	31.40%	23.25%	37.61%
3500	94.71%	68.11%	45.20%	5.29%	26.61%	22.91%	45.20%
4000	96.30%	73.88%	51.93%	3.70%	22.42%	21.95%	51.93%
4500	97.36%	78.49%	57.83%	2.64%	18.87%	20.66%	57.83%
5000	98.07%	82.18%	62.96%	1.93%	15.89%	19.22%	62.96%
5500	98.57%	85.15%	67.42%	1.43%	13.42%	17.73%	67.42%
6000	98.93%	87.55%	71.28%	1.07%	11.37%	16.27%	71.28%
6500	99.18%	89.51%	74.63%	0.82%	9.67%	14.88%	74.63%
7000	99.37%	91.12%	77.54%	0.63%	8.25%	13.58%	77.54%
7500	99.51%	92.44%	80.07%	0.49%	7.07%	12.37%	80.07%
8000	99.61%	93.54%	82.27%	0.39%	6.08%	11.27%	82.27%
8500	99.69%	94.45%	84.20%	0.31%	5.24%	10.26%	84.20%
9000	99.75%	95.22%	85.88%	0.25%	4.54%	9.34%	85.88%
9500	99.80%	95.86%	87.35%	0.20%	3.94%	8.51%	87.35%
10000	99.84%	96.40%	88.65%	0.16%	3.44%	7.75%	88.65%
11000	99.89%	97.26%	90.81%	0.11%	2.63%	6.45%	90.81%
12000	99.93%	97.88%	92.49%	0.07%	2.04%	5.39%	92.49%

4. Go back to Hazus and select Analysis, then Parameters, and Building Economic. Look at the first tab, Percent Loss, and make sure the dropdown displays Structural Damage. Here are the three damage states supported by tsunami – moderate, extensive, and complete. There is a percent assigned to each damage state based on the building's occupancy. The AGR1 buildings consist of more structural components than the COM1 occupancy - complete damage is 46.2% vs. 29.4%. Go back to the spreadsheet and scroll to the right until the loss information is shown. The COM1 occupancy has been selected for the default example. The loss ratio is calculated using the percentages in the table and the damage state probabilities.



Prob_NoDam	Prob_Mod	Prob_Ext	Prob_Comp	Occupancy	Moderate	Extensive	Complete	Loss Ratio
99.80%	0.19%	0.00%	0.00%	COM1	0.046	0.231	0.462	0.02%
80.10%	17.58%	1.83%	0.49%					3.15%
48.72%	38.04%	8.85%	4.40%					12.61%
29.28%	43.36%	15.73%	11.64%					23.82%
18.16%	41.24%	20.25%	20.35%					34.59%
11.66%	36.55%	22.55%	29.23%					44.15%
7.74%	31.40%	23.25%	37.61%					52.36%
5.29%	26.61%	22.91%	45.20%					59.30%
3.70%	22.42%	21.95%	51.93%					65.14%
2.64%	18.87%	20.66%	57.83%					70.04%
1.93%	15.89%	19.22%	62.96%					74.15%
1.43%	13.42%	17.73%	67.42%					77.62%
1.07%	11.37%	16.27%	71.28%					80.55%
0.82%	9.67%	14.88%	74.63%					83.04%
0.63%	8.25%	13.58%	77.54%					85.15%
0.49%	7.07%	12.37%	80.07%					86.96%
0.39%	6.08%	11.27%	82.27%					88.51%
0.31%	5.24%	10.26%	84.20%					89.85%
0.25%	4.54%	9.34%	85.88%					91.00%
0.20%	3.94%	8.51%	87.35%					92.00%
0.16%	3.44%	7.75%	88.65%					92.87%
0.11%	2.63%	6.45%	90.81%					94.29%
0.07%	2.04%	5.39%	92.49%					95.39%

5. Go to Analysis and Damage Functions. Select the Non Structural Damage tab and browse down to S1M. The Moderate Median value is 12, Moderate Beta value is 0.62, Extensive Median value is 36, Extensive Beta value is 0.33, Complete Median value is 60, and Complete Beta is 0.35. Hazus uses the tsunami depth to determine non-structural damage so the median values are in ft while the beta values are unitless. Go to the Contents tab and notice the median and beta values – these are also based on tsunami depths. Close the Buildings Damage Functions tables.

6. In Hazus, go to the Building Economic Loss Parameters and select the Non-Structural Sensitive Damage. Combining the total values of the complete number for structural and non-structural should equal 100% of the building value. For example, COM1 has a complete structural value of 0.294 while COM1 has a complete non-structural value of 0.706. Combining these two values is 1.0. The content damage for each damage state is found under the Content Damage tab. Complete content damage results in 100% loss.

7. Go back to the damagefunctions.xlsx and click on the Non-Structural tab. The data is going to look similar to that of the structure tab but the hazard value of interest is tsunami median depth instead of momentum flux. Replace the median and beta values using the Hazus tables to see how that impacts the exceedance curves. In the software, there is also a check which occurs on the structural damage. If the structural damage, is greater than 70%, the non-structural and content damage is assumed to be 100%.

8. To edit the tsunami damage functions in Hazus, open the damage function table, right click and select Start Editing. After the edits have been made, right click and select Stop Editing. Before making any changes, use the spreadsheet to determine how your edits will impact the damages and losses.

Task 2: Prepare to Discuss Results

1. Create a slide in PPT to provide information on how you changed the damage functions and how those changes impacted the final results.

Note: These slides may be used in the final capstone presentation at the end of the class.

Application 3: Run an Advanced Evacuation and Casualty Analysis

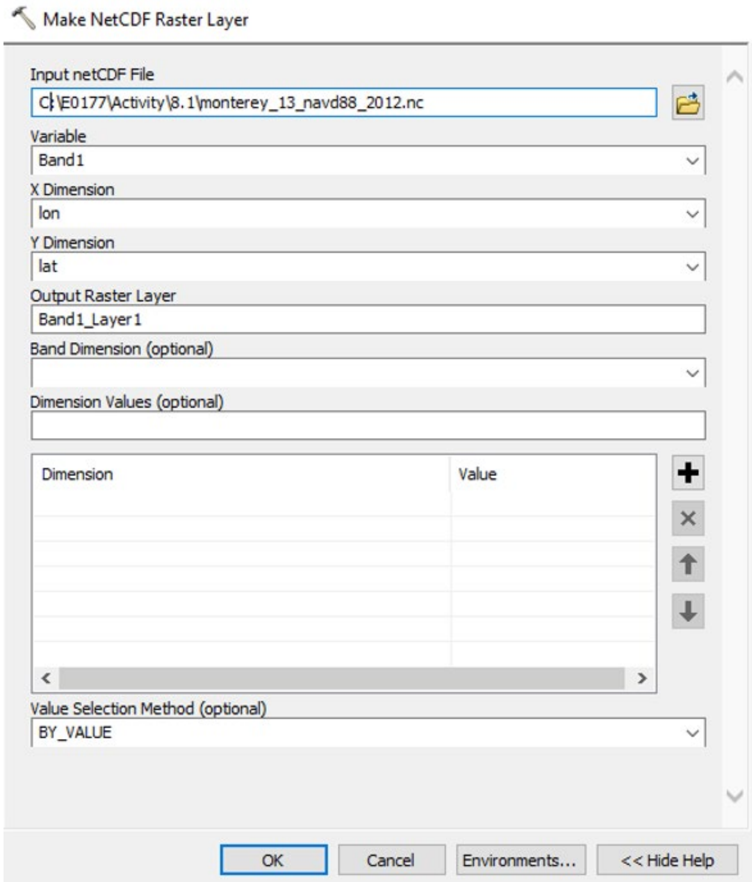
This process walks you through integrating your own road network into the evacuation and casualty analysis as well as identifying potential model limitations and mitigating those limitations.

Task 1: Prepare the DEM

1. Create a Santa Cruz, California tsunami study region. Name the study region something you can remember. If you're creating your own study region, select that county and State (only Alaska, California, Hawaii, Oregon, Washington, and the Territories are supported by the tsunami model).

2. Before the evacuation and casualty analysis can be completed, the tsunami hazard needs to be identified. Go to Hazard and Tsunami Hazard Type, then select Distant Source and click OK.

3. A DEM has already been downloaded for the region but it first must be converted to something the model can use. Open ArcToolbox, then select Multidimension Tools, then Make NetCDF Raster Layer. For Input netCDF file, select C:\E0177\Activity\8.1\monterey_13_NAVD88_2012.nc; for Variable, select Band1; for X Dimension, select lon; for Y Dimension, select lat; and for Output Raster Layer, select Band1_Layer1. Click OK.



4. A new layer called Band1_Layer1 should be added to the table of contents in Hazus. The DEM doesn't cover the entire study region, but it does cover the entire shoreline and can be used for the tsunami modeling. Right click on Band1_Layer1 and export the layer as: C:\E0177\Activity\8.1\NOAA_DEM. Add NOAA_DEM to the table of contents and remove Band1_Layer1.

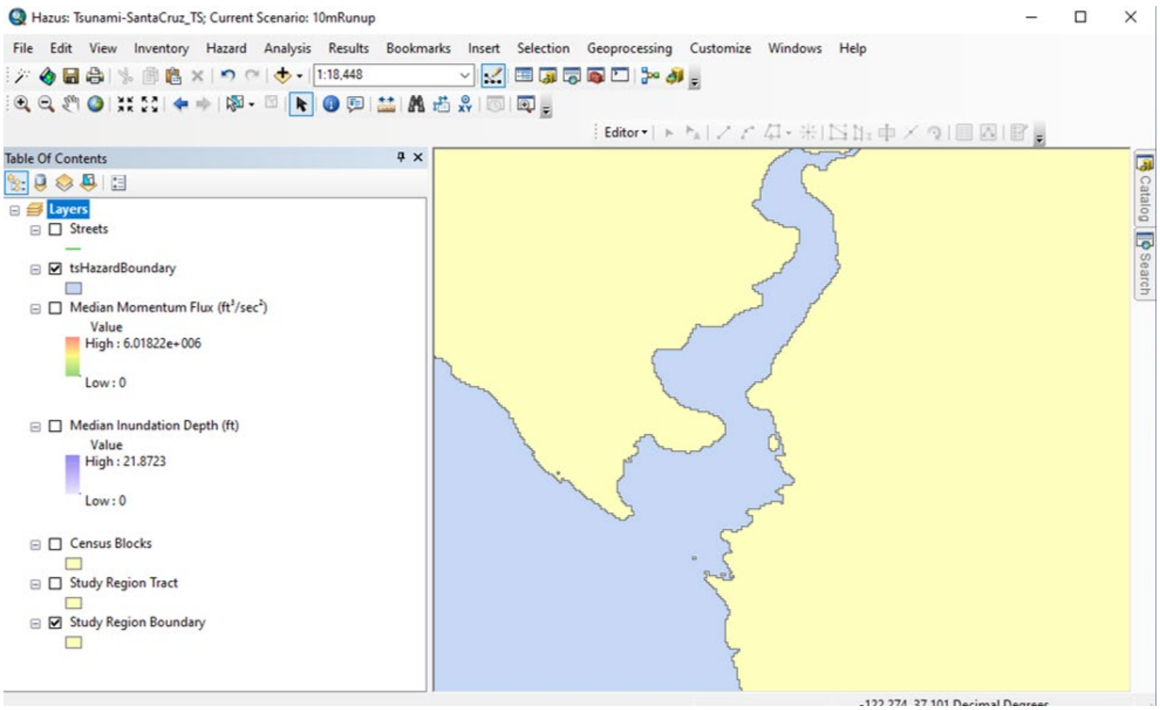
Task 2: Prepare the Hazard Boundary

1. Go to Hazard and User Data. Select Level 1: Quick Look-Single Maximum Runup and then Next. Identify the DEM Vertical Units as m (meters); Maximum Runup Units as m (meters); and the Maximum Runup Height Value as 10. Browse to the NOAA_DEM.tif DEM. Then select OK. After a few minutes of processing, select Next. Name the tsunami event 10mRunup and select Next. Then click OK when the processing is finished.

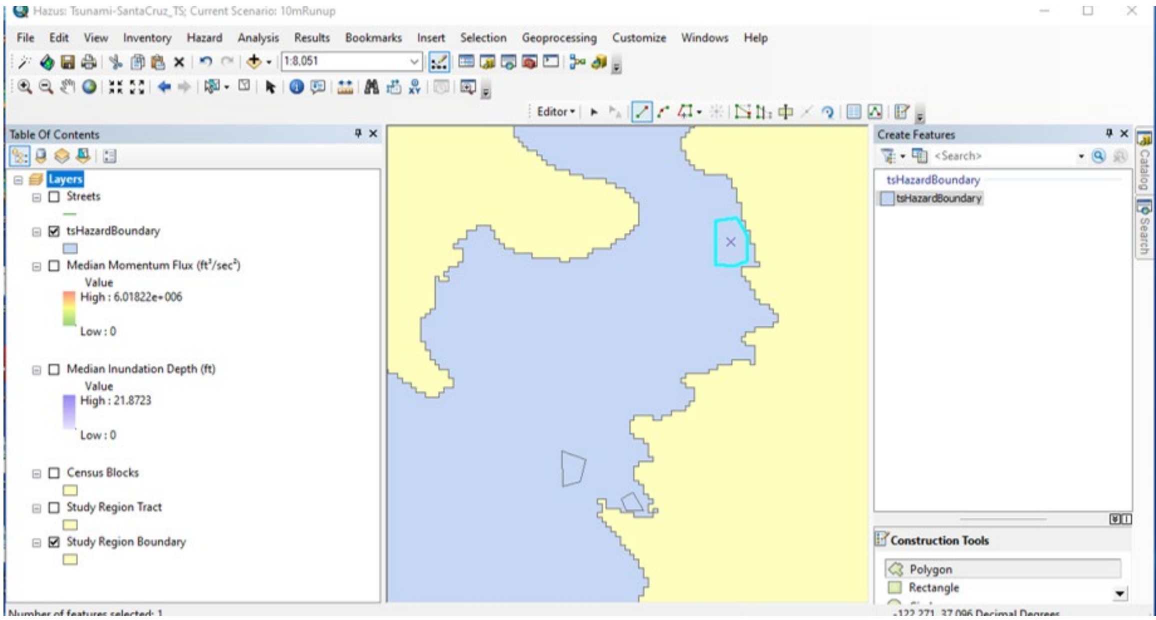
2. When the hazard event is created, Hazus generates two layers which will be used in the evacuation and casualty analysis: tsHazardBoundary.shp and tsFatalityBoundary.shp. These files can be found in the study region folder under C:\HazusData\Regions\.

3. Add the tsHazardBoundary layer to Hazus. Zoom into the northern boundary of the shoreline and notice that there are some islands created in the layer. People are not going to evacuate to

these islands, they are going to evacuate away from the total inundation layer. The islands need to be filled in.



4. Go to the Editor Toolbar and select Start Editing. Click on tsHazardBoundary and then OK. Zoom into the island areas and add polygons to fill the islands. Go to Editor, then Editing Windows, and Create Features.



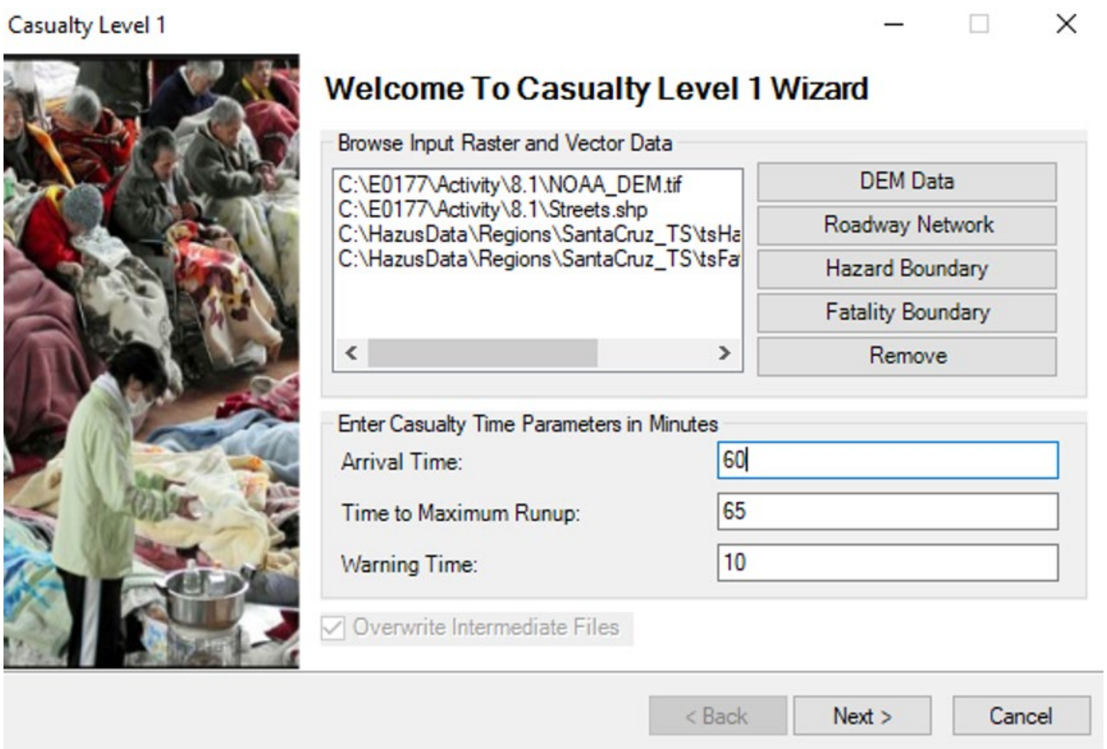
5. After all of the polygons have been added, open the attribute table and select all the records. Then select Editor and Merge. Click OK. Now there should only be one record. Select Editor and Stop Editing. Save the edits. Close the attribute table and remove the tsHazardBoundary layer from the Table of Contents.

Task 3: Identify Street Data

1. Santa Cruz has posted their street data on their GIS website: https://www.co.santa-cruz.ca.us/Departments/GeographicInformationSystems(GIS).aspx. Click on Data on the top right, then Transportation, and the Streets layer will be the last one listed on page two. The data has already been downloaded here: C:\E0177\Activity\8.1\Streets.shp. The road data does not need to be formatted and no fields are required. Hazus is simply going to use the road geometry for the analysis.

Task 4: Run The Analysis

1. Go to Analysis, then Casualty, and then Casualty Level 1. Identify the DEM Data: C:\E0177\Activity\8.1\NOAA_DEM.tif, Roadway Network: C:\E0177\Activity\8.1\Streets.shp, Hazard Boundary: C:\HazusData\Regions\SantaCruz_TS\tsHazardBoundary.shp, and Fatality Boundary: C:\HazusData\Regions\SantaCruz_TS\tsFatalityBoundary.shp where SantaCruz_TS is the name of the study region. For Arrival Time: enter 60. Then click Next and Next again.



2. After some of the processing is complete, select Next again. For Evacuation Time Computation, add 45 to Maximum Travel Time in Minutes. Then select Next. Select Next again. Then select OK.

3. Go to Results, Casualties, and Evacuation Travel Time. This table provides population estimates for different times of day and different ages. It also provides evacuation time in minutes for different ages to partial safety and full safety. Select a column and click Map to create a layer in the Table of Contents.

4. Go to Results, Casualties, and Probability of Casualties. This table provides casualty probabilities for different age categories at different community preparedness levels. It also provides injury and fatality estimates by age and community preparedness level. Select a column and click Map to create a layer in the Table of Contents.

Task 5: Prepare to Discuss Results

1. Create a slide in PPT to explain how you ran the evacuation and casualty analysis and your results. Try running the analysis without editing the hazard boundary and using the TIGER data instead of the local road network. How did your results change?

Note: These slides may be used in the final capstone presentation at the end of the class.

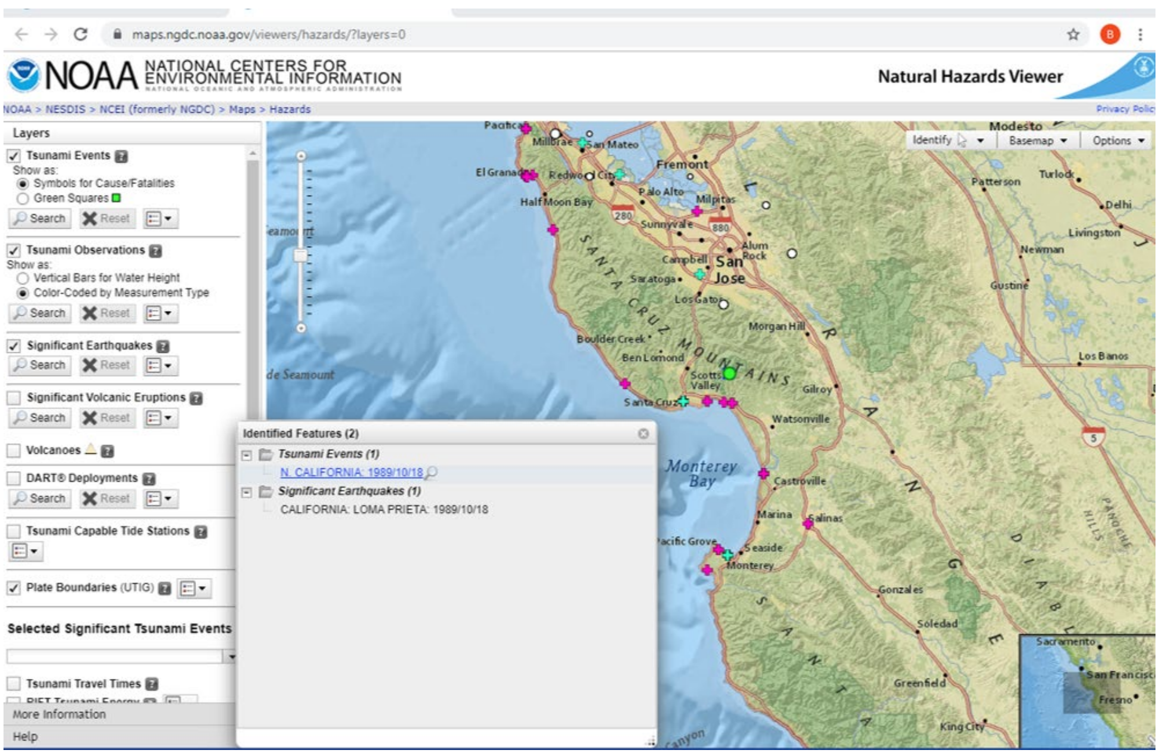
Application 4: Run a User-Defined Near-Source Application

What kind(s) of earthquakes should I select and how do I set up an appropriate tsunami?

Task 1: Prepare an Earthquake Event

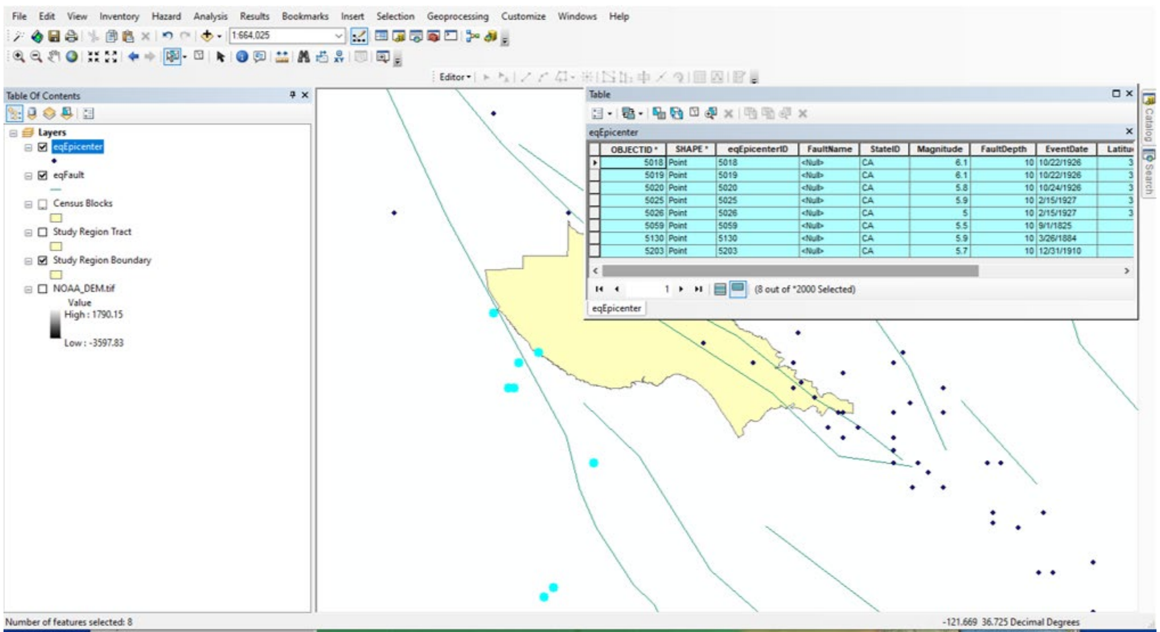
1. Create a new earthquake and tsunami study region for Santa Cruz, California. If you're using your own data, create your own study region and just make sure both earthquake and tsunami are selected. Open the region.

2. Identify an appropriate earthquake. Go to [NOAA's National Center for Environmental Information](https://www.ngdc.noaa.gov/hazard/tsu_db.shtml) (https://www.ngdc.noaa.gov/hazard/tsu_db.shtml). On the left click on Natural Hazards Interactive Map. Zoom into Santa Cruz, California or your local study region. On the left side check Tsunami Observations and Significant Earthquakes. Then click on the icons on the map. Clicking on the white dot in the Santa Cruz Mountains produces information on a tsunami event (1989 event) and a significant earthquake (Loma Prieta). Clicking on the name provides additional information concerning the event. The Loma Prieta event triggered the tsunami event which had a small runup (<1 meters) and did limited damage. The earthquake had a magnitude of 6.9. The additional info link provides data on the tsunami and earthquake impacts. Explore and document the other events.

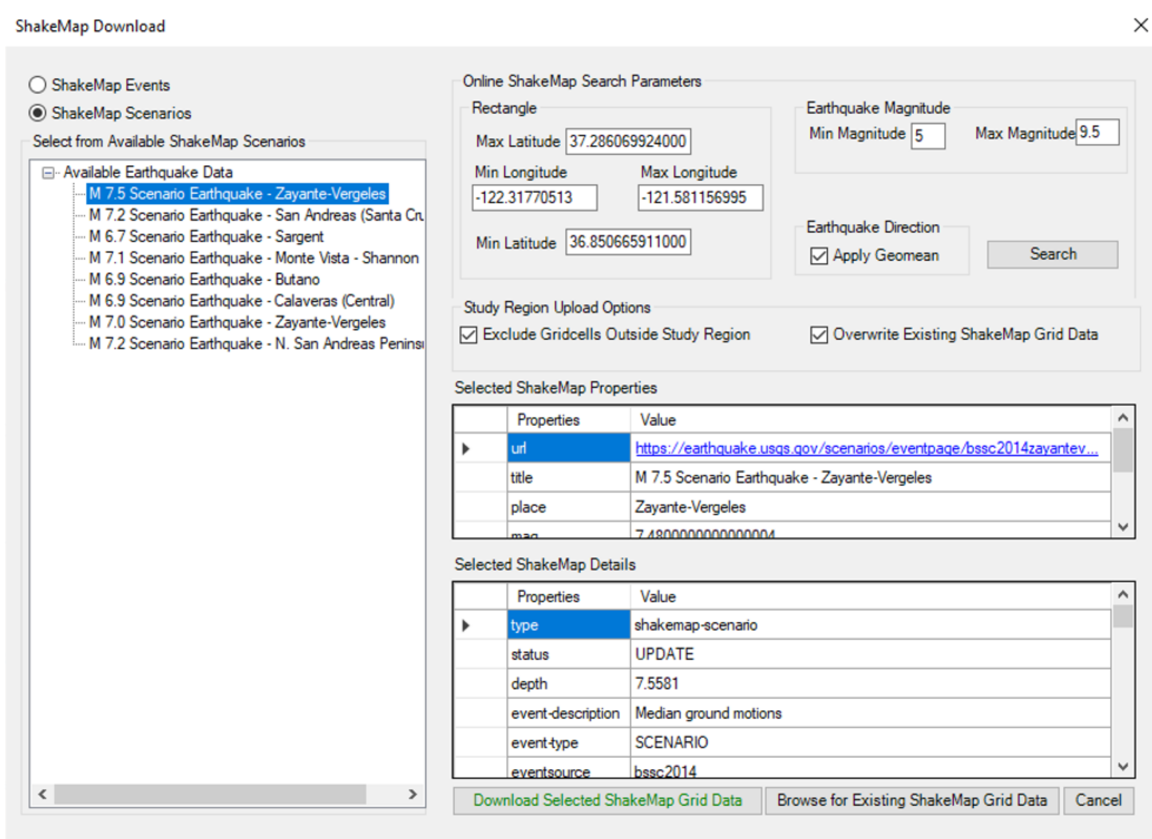


3. Under Selected Significant Tsunami Events, there is one for the Cascadia Subduction Zone which would impact this study region. Add that to the map and review the tsunami travel times. The contour in Monterey Bay is at 2 hours. This could result in a major tsunami but the earthquake damage would be negligible. The community should plan for this kind of event where there is a two-hour warning for a significant tsunami event. However, for this exercise, identify a damaging earthquake and tsunami.

4. Open Hazus to the earthquake hazard and add the following layers: C:\Program Files (x86)\Hazus-MH\Data\EQ\SCENARIO.mdb\eqEpicenter and C:\Program Files (x86)\Hazus-MH\Data\EQ\SCENARIO.mdb\eqFault. Identify the epicenters off the coast of Santa Cruz.



5. Notice the earthquakes are all 6.1 and smaller. Referring back to the slide in class (#22), the table shows that earthquakes smaller than 6.5 don't usually trigger tsunamis. There is the potential for larger earthquakes inland, however. Go to Hazard, then Scenario, then Define a new scenario and click Next. Then select USGS ShakeMap and click Next. In the top left of the menu, select ShakeMap Scenarios. Although these scenarios don't occur in the water, they could produce landslides which could create tsunamis. These scenarios are not historical events but they were developed by experts to help communities plan. Select the first option: M 7.5 Scenario Earthquake – Zayante-Vergeles. Then select Download Selected ShakeMap Grid Data and select the 14th version when that option comes up on top of the list. Then select OK. This will take a few minutes to process. Select Next, then Next again, and Finish.



6. Select Analysis and then Run. Select all of the options and click OK. This will take a few minutes to process. This would be a good time to take a break.

7. Confirm that the general building stock loss is populated in the results menu. Then switch to the tsunami hazard.

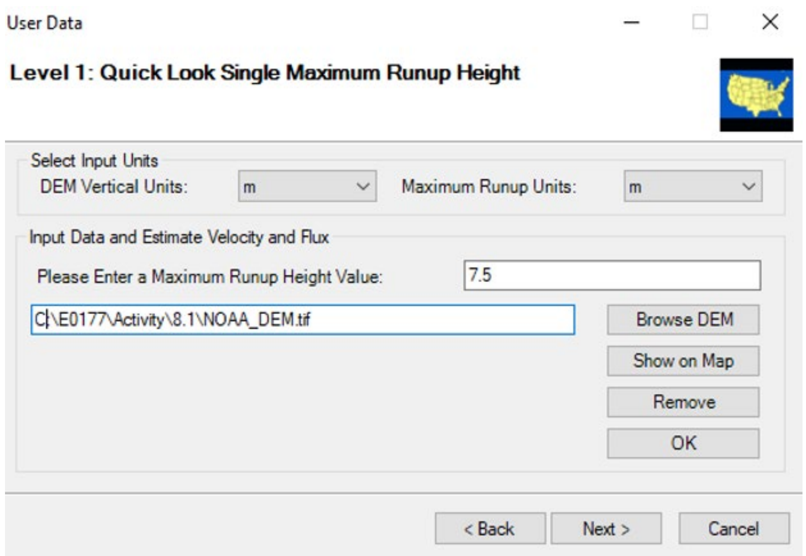
Task 2: Prepare the Tsunami Hazard Event

1. Assume that the earthquake is going to cause a landslide so take a look at the NOAA_DEM which also includes the bathymetry. Add the NOAA_DEM layer to the map. There are some extreme elevation changes underwater about twenty to thirty miles from the study region. To help determine tsunami runup values, some research is required. Information on tsunamis in California may be found in this Berkeley paper: (https://peer.berkeley.edu/sites/default/files/usslu_synolakis_peer_17june20101.pdf). A return period runup has been assigned to different parts of California. Santa Cruz is closest to San Francisco to use that curve. A 100-year event is at almost 2 meters while a 500 year event is at about 7.5 meters.

2. Let’s use the 500-year runup. Select Hazard, then Tsunami Hazard Type, and Near Source Only. Then click OK.

3. Go to Hazard and User Data. Select Level 1: Quick Look-Single Maximum Runup and then Next. For DEM Vertical Units, select m (meters); for Maximum Runup Units, select m (meters);

for the Maximum Runup Height Value, use 7.5; and for the DEM browse here: C:\E0177\Activity\8.1\NOAA_DEM.tif. Then click OK and Next after the processing is finished.



4. Name the tsunami 500year and click Next. Once the processing is done, select Analysis and Run. Then click Select All and OK to run all the possible results. This will take several minutes to process so you may want to take a break at this point. Go to the results and make sure the general building stock and combined general building stock are populated.

5. If you want to run a casualty analysis, go to Application 3 and start at step 6. Select a very short arrival time since the tsunami would begin only 30 miles away. From NOAA (https://www.st.nmfs.noaa.gov/Assets/Nemo/documents/lessons/Lesson_9/Lesson_9-Teacher's_Guide.pdf pgs. 4-5) use the tsunami speed = square root of (g x depth of disturbance). Use 9.81 m/s2 for g and using the bathymetry data, set the depth to 600 meters. The speed would equal 76.7 m/s. If the landslide happens 30 miles away that would equate to 48,280 meters so the time it would take the tsunami to travel to Santa Cruz is 48,280/76.7 = 629 seconds or 10.5 minutes.

Task 3: Prepare to Discuss Results

1. Create a slide in PPT to provide information on which earthquake and tsunami scenarios were used and their results. Break the results into earthquake and tsunami contributions.

Note: These slides may be used in the final capstone presentation at the end of the class.

Visual 26: Lesson 8: Review

1. List four sources of tsunami data.
2. Identify three characteristics of an earthquake which are more likely to produce a tsunami .
3. What are the five inputs for the level 1 evacuation/casualty analysis?

Visual 27: Questions?

Visual 28: Hazard-Specific Activity Time

- Use the rest of the day (~2 hours) to work on the hazard-specific activities (5.1, 6.1, 7.1 or 8.1).
    - Choose a hazard that you will use in your capstone.
    - You may choose multiple applications and multiple hazards, mirroring your desired capstone.
- More time will be provided at the beginning of tomorrow (~1.5 hours).
- You may also use this time to prepare for your capstone.

Lesson 9: Advanced Parameter Updates

Visual 1: Lesson 9: Advanced Parameter Updates

Visual 2: Lesson 9: Goal and Objectives

Goal: Better understand how social and economic parameters are used in the Hazus methodology and how to update them.

After completing this lesson you will be able to:

- Explain how displaced households and shelter requirements are calculated
- Identify the business interruption components and which parameters impact them
- List the sources which can be used to update parameters
- Update the social and economic parameter tables

Visual 3: Social Impact Outputs

- Displaced households
- Shelter requirements
- Casualties (earthquake and tsunami only)
- Evacuation numbers (covered in tsunami lesson)

Visual 4: Social Parameters – HU Methodology

- Displaced household requirements:
  - Building loss ratio
  - Demographics
- Shelter requirements:
  - Demographics
  - Displaced households
  - Weighting and modification factors

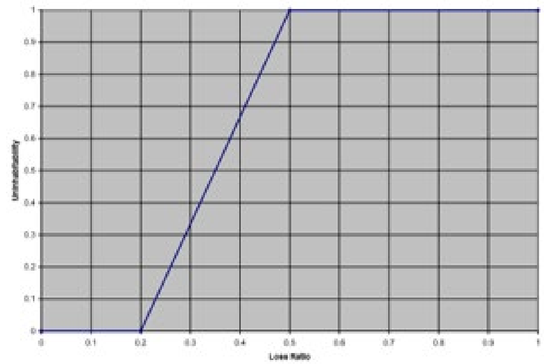


Figure 11.3. Empirical Un-Inhabitability Function for Single-Family Buildings.

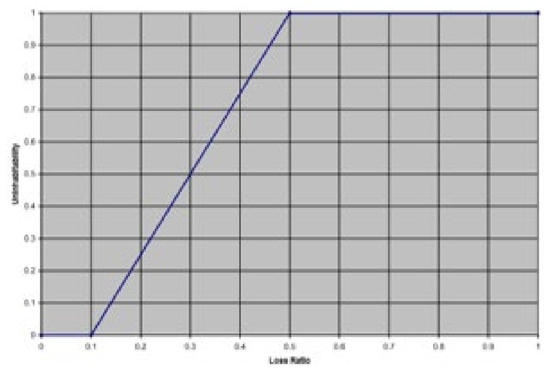
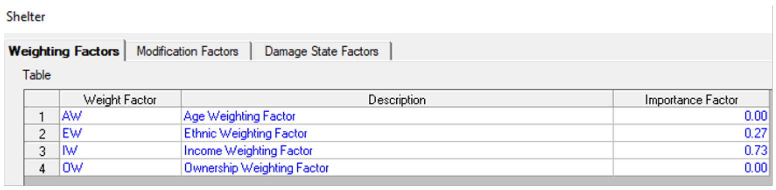


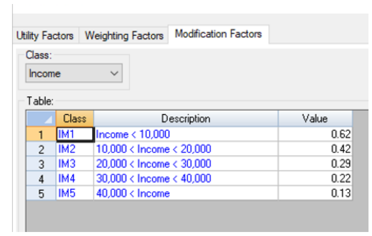
Figure 11.4. Empirical Un-Inhabitability Function for Multi-Family Buildings.

Visual 5: Social Parameters – HU Methodology

- Shelter requirements use income (.73) and ethnicity (.27) as default weighting factors
- Ownership and age could be weighting factors
- Each weighting factor has a modification factor



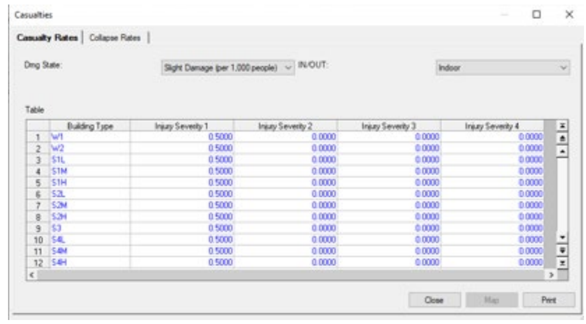
	Weight Factor	Description	Importance Factor
1	AW	Age Weighting Factor	0.00
2	EW	Ethnic Weighting Factor	0.27
3	IW	Income Weighting Factor	0.73
4	OW	Ownership Weighting Factor	0.00



	Class	Description	Value
1	IM1	Income < 10,000	0.62
2	IM2	10,000 < Income < 20,000	0.42
3	IM3	20,000 < Income < 30,000	0.29
4	IM4	30,000 < Income < 40,000	0.22
5	IM5	40,000 < Income	0.13

Visual 6: Social Parameters – EQ Methodology

- Displaced household requirements:
  - Building damage states
  - Demographics
- Shelter requirements:
  - Demographics
  - Displaced households
  - Weighting, modification, and damage state factors
- Casualty requirements:
  - Building damage states
  - Building collapse rates
  - Demographics



Visual 7: Social Parameters – EQ Methodology

- Shelter requirements use income (.73) and ethnicity (.27) as default weighting factors
- Ownership and age could be weighting factors
- Damage state factor is high for complete and extensive damage

Shelter

Weighting Factors | Modification Factors | Damage State Factors

Table

	Weight Factor	Description	Importance Factor
1	AW	Age Weighting Factor	0.00
2	EW	Ethnic Weighting Factor	0.27
3	IW	Income Weighting Factor	0.73
4	OW	Ownership Weighting Factor	0.00

Weighting Factors | **Modification Factors** | Damage State Factors

Table

	Class	Description	Factor
1	AM1	Population Under 16 Years Old	0.40
2	AM2	Population Between 16 and 65 Years Old	0.40
3	AM3	Population Over 65 Years Old	0.40
4	EM1	White	0.24
5	EM2	Black	0.48
6	EM3	Hispanic	0.47
7	EM4	Asian	0.26
8	EM5	Native American	0.26
9	IM1	Household Income < $10000	0.62
10	IM2	$10,000<= Household Income <$20,000	0.42
11	IM3	$20,000<= Household Income <$30,000	0.29
12	IM4	$30,000<= Household Income <$40,000	0.22
13	IM5	$40,000<= Household Income	0.13
14	OM1	Owner Occupied Dwelling	0.40
15	OM2	Renter Occupied Dwelling	0.40

Shelter

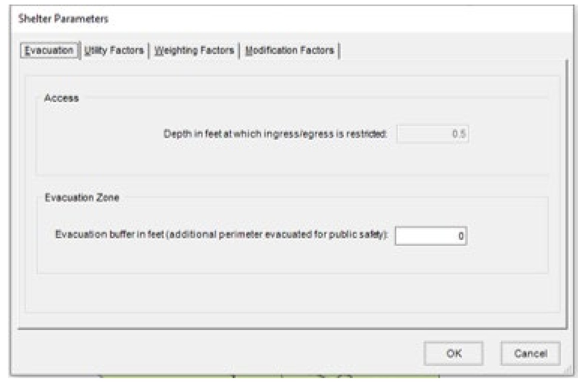
Weighting Factors | Modification Factors | **Damage State Factors**

Table

	Class	Description	Value
1	wMFC	Weight for Multi-Family Dwelling - Complete Damage	1.00
2	wMFE	Weight for Multi-Family Dwelling - Extensive Damage	0.90
3	wMFM	Weight for Multi-Family Dwelling - Moderate Damage	0.00
4	wSFC	Weight for Single Family Dwelling - Complete Damage	1.00
5	wSFE	Weight for Single Family Dwelling - Extensive Damage	0.00
6	wSFM	Weight for Single Family Dwelling - Moderate Damage	0.00

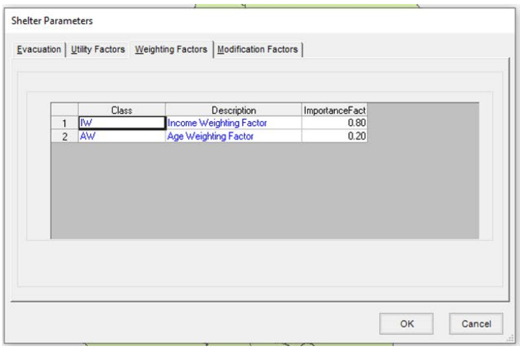
Visual 8: Social Parameters – FL Methodology

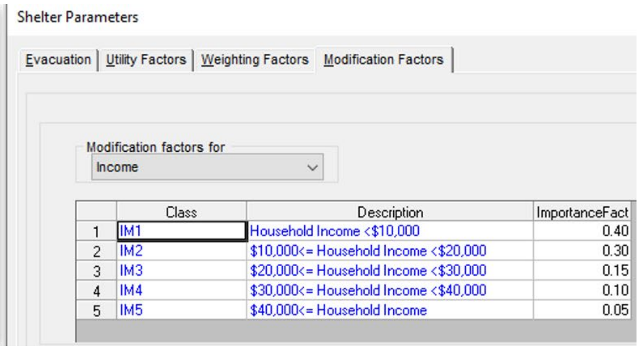
- Displaced household requirements:
  - Inundation area
  - Buffer (if provided)
  - Demographics
- Shelter requirements:
  - Demographics
  - Displaced households
  - Weighting and modification factors



Visual 9: Social Parameters – FL Methodology

- Shelter requirements use income (.80) and age (.20) as default factors
- Ownership and ethnicity can’t be factors





Visual 10: Social Parameters – Where to Find Data?

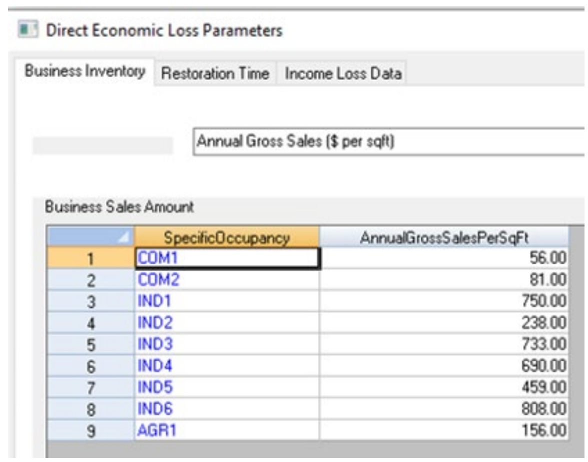
- Previous event – Does the community have numbers for shelter requirements for a historical event? Did the press release numbers?
- Local and State emergency management agency
- Red Cross

Visual 11: Economic Outputs

- Building loss (structural/non-structural) and content loss – directly calculated
- Inventory loss
- Relocation loss (business interruption)
- Income loss (business interruption)
- Rental income loss (business interruption)
- Wage loss (business interruption)

Visual 12: Economic Parameters – Inventory Loss

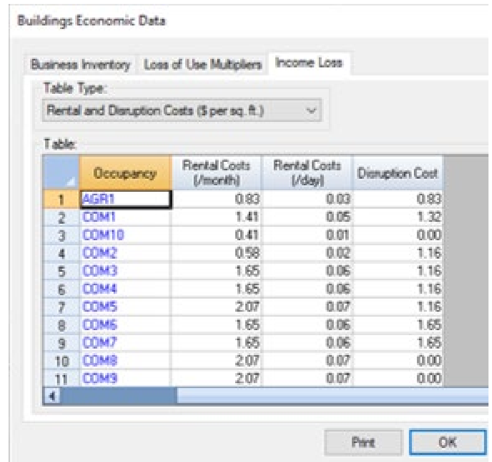
- Required inputs:
  - Square footage – SF (from GBS)
  - Annual gross sales - AGS
  - Business inventory - BI (percentage of annual gross sales)
- Equations:
  - FL: INV = ∑Úm(Inv) * SF * AGS * BI
  - EQ/TS/HU: INV = SF * AGS * BI * ∑DamSt Prob*%InvDam



	SpecificOccupancy	AnnualGrossSalesPerSqFt
1	COM1	56.00
2	COM2	81.00
3	IND1	750.00
4	IND2	238.00
5	IND3	733.00
6	IND4	690.00
7	IND5	459.00
8	IND6	808.00
9	AGR1	156.00

Visual 13: Economic Parameters – Relocation Loss

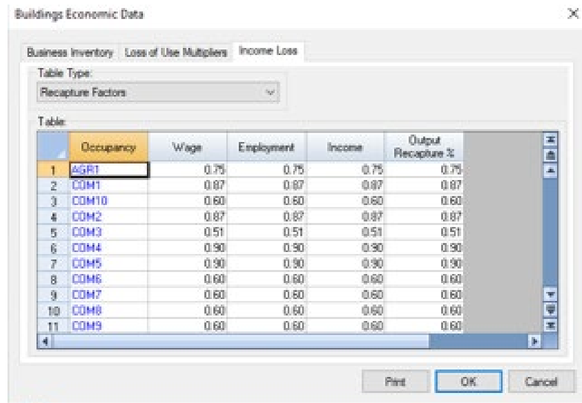
- Required inputs:
  - Square footage – SF (from GBS)
  - Disruption costs – DC - \$/ft2
  - Recovery time – RT – days
  - Percent owner occupied – POO
  - Rental cost – RC - \$/ft2/day
- Equation:
  - REL=SF((1-POO)*∑ProbDamSt*DC+POO*∑ProbDamSt*(DC+RC*RT))



	Occupancy	Rental Costs (/month)	Rental Costs (/day)	Disruption Cost
1	AGR1	0.83	0.03	0.83
2	COM1	1.41	0.05	1.32
3	COM10	0.41	0.01	0.00
4	COM2	0.58	0.02	1.16
5	COM3	1.65	0.06	1.16
6	COM4	1.65	0.06	1.16
7	COM5	2.07	0.07	1.16
8	COM6	1.65	0.06	1.65
9	COM7	1.65	0.06	1.65
10	COM8	2.07	0.07	0.00
11	COM9	2.07	0.07	0.00

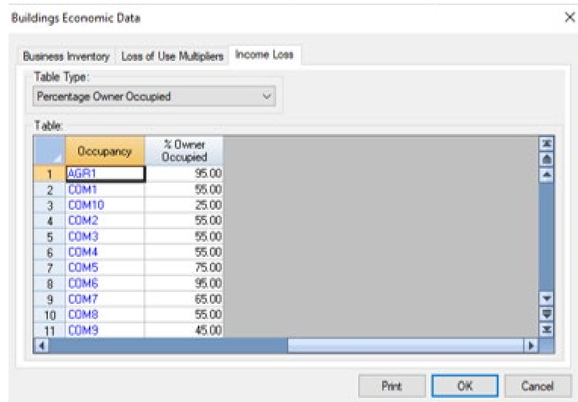
Visual 14: Economic Parameters – Income Loss

- Required inputs:
  - Square footage – SF (from GBS)
  - Income per day – INC - $/ft2
  - Building construction/clean up time – BCT – days
  - Construction time modifiers - MOD
  - Recapture factor– RF
- Equation:
  - YLOS=SF*(1-RF)*INC*∑ProbDamSt*BCT*MOD



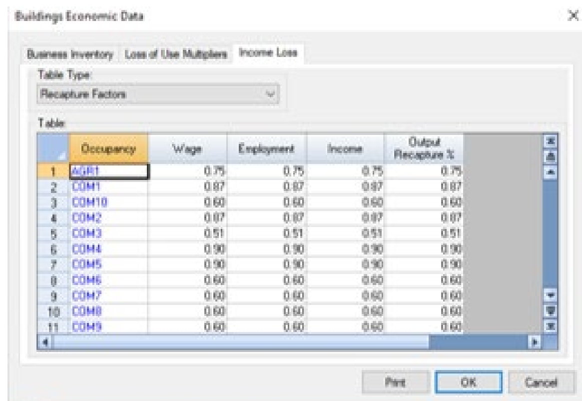
Visual 15: Economic Parameters – Rental Income Loss

- Required inputs:
  - Square footage – SF (from GBS)
  - Percent owner occupied – POO
  - Rental cost – RC - $/ft2/day
  - Recovery time – RT – days
- Equation:
  - RY=SF*(1-POO)*RC*∑ProbDamSt*RT



Visual 16: Economic Parameters – Wage Loss

- Required inputs:
  - Square footage – SF (from GBS)
  - Wage per day – WA - $/ft2
  - Building construction/clean up time – BCT – days
  - Construction time modifiers - MOD
  - Recapture factor– RF
- Equation:
  - WLOS=SF*(1-RF)*WA*∑ProbDamSt*BCT*MOD

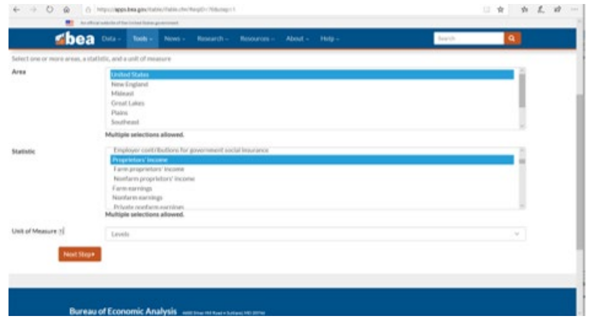


Visual 17: Where to Find the Data?

- Bureau of Labor Statistics (https://www.bls.gov/data/)
- City/County level data
- Business type provided

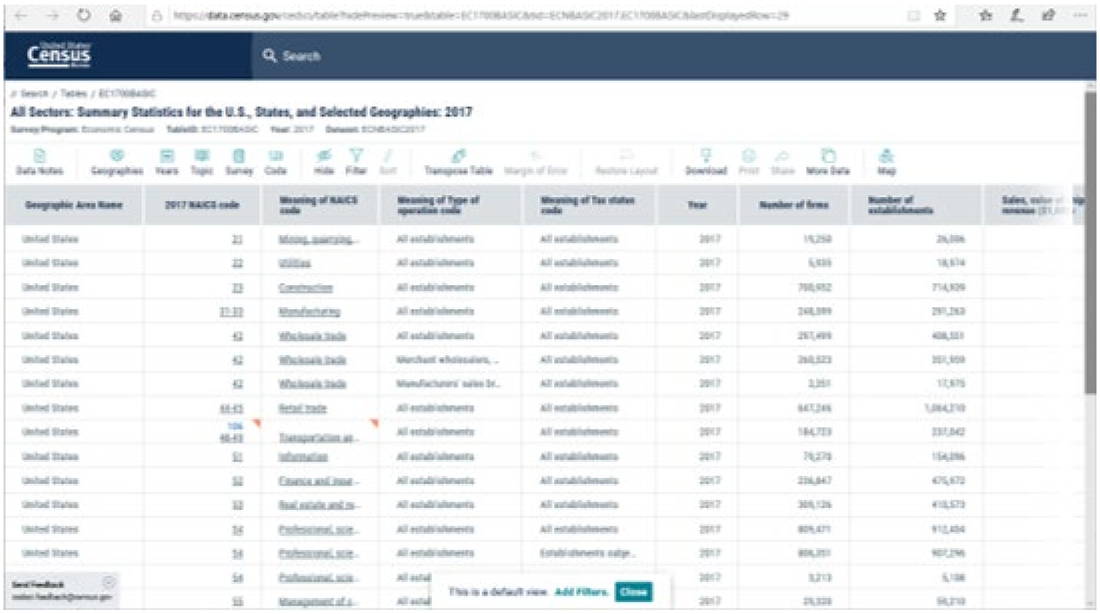
Visual 18: Where to Find the Data?

- Bureau of Economic Analysis - (https://www.bea.gov/)
- Most national, but some county level data
- Wage and income data



Visual 19: Where to Find the Data?

- U.S. Census Bureau (https://www.census.gov/programs-surveys/economic-census.html)



Visual 20: Where to Find the Data?

- Rental data: Department of Housing and Urban Development (HUD) https://www.huduser.gov/portal/datasets/fmr.html

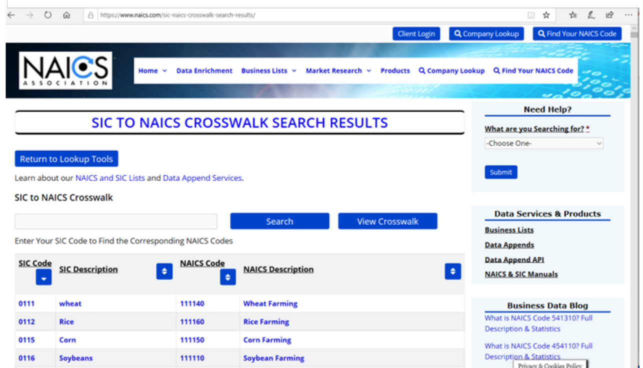
Visual 21: Where to Find the Data?

- Local parcel data – square footage, specific occupancy, and owner occupied (sometimes)
- Local Chamber of Commerce and local government
- Business surveys
- Historical data – how long did it take businesses to get up and running again?

Visual 22: How to Get Specific Occupancy

Table 3.27: Mapping of Standard Industrial Codes, Conversion Factors to Estimate Occupancy Square Footage and Square Footage Per Occupancy Class

		Source of Data		
Label	Occupancy Class	Census		Dun and Bradstreet
		Unit of Data	Conversion Factor	SIC Code
	Residential			
RES1	Single Family Dwelling	# of Units	variable	
RES2	Mobile Home	# of Units	1000 sq. t./unit	
RES3	Multi Family Dwelling	# of Units	1000 sq. t./unit	
RES4	Temporary Lodging			70
RES5	Institutional Dormitory	# in Group Quarters	700 sq. ft./person	
RES6	Nursing Home			8051, 8052, 8059
	Commercial			
COM1	Retail Trade			52, 53, 54, 55, 56, 57, 59
COM2	Wholesale Trade			42, 50, 51
COM3	Personal/Repair Services			72,75,76,83,88
COM4	Prof./Technical Services			40, 41, 44, 45, 46, 47, 49, 61, 62, 63, 64, 65, 67, 73, 78 (except 7832), 81, 87, 89
COM5	Banks			60
COM6	Hospital			8062, 8063, 8069
COM7	Medical Office/Clinic			80 (except 8051, 8052, 8059, 8062, 8063, 8069)
COM8	Entertainment & Rec.			48, 58, 79, (except 7911), 84
COM9	Theaters			7832, 7911
COM10	Parking			
	Industrial			
IND1	Heavy			22, 24, 26, 32, 34, 35 (except 3571, 3572), 37
IND2	Light			23, 25, 27, 30, 31, 36 (except 3671, 3672, 3674), 38, 39
IND3	Food/Drugs/Chemicals			20, 21, 28, 29
IND4	Metals/Minerals Processing.			10, 12, 13, 14, 33
IND5	High Technology			3571, 3572, 3671, 3672, 3674
IND6	Construction			15, 16, 17
	Agriculture			
AGR1	Agriculture			01, 02, 07, 08, 09
	Religion/Non/Profit			
REL1	Church/ N.P. Offices			86



Source: Earthquake Technical Manual Pg. 88

Student Manual

How to Get Specific Occupancy

Specific Occupancy Crosswalk - https://www.naics.com/naics-to-sic-crosswalk-2/

Visual 23: Exercise 9.1: Advanced Parameter Update

- Goal: Update the social and economic parameters using better data
- Time: 60 minutes

Student Manual

Exercise 9.1 Advanced Parameter Update

Goal: Determine which study region to use in the capstone and which advanced applications are most relevant for you.

Time: 60 minutes

Exercise Steps:

1. Refer to Activities Document “9.1_Exercise_AdvancedParameter".
2. Listen to instructor’s directions.
3. Ask questions if clarification is needed.
4. Work individually on the goal.
5. Ask questions to the instructor if needed.
6. Complete the assigned goal.
7. Be prepared to share your answers/results.
8. Ask any final questions.

Visual 24: Exercise 9.1: Tasks

- Task 1: Use local data to update shelter parameters
- Task 2: Use national data sources to identify economic parameters
- Task 3: Compare updated parameters with existing parameters

Student Manual

Exercise 9.1: Tasks

Refer to Activities Document “9.1_Exercise_AdvancedParameter”.

Exercise 9.1: Advanced Parameter Update

Type: Activity

Time: 60 minutes

Goals:

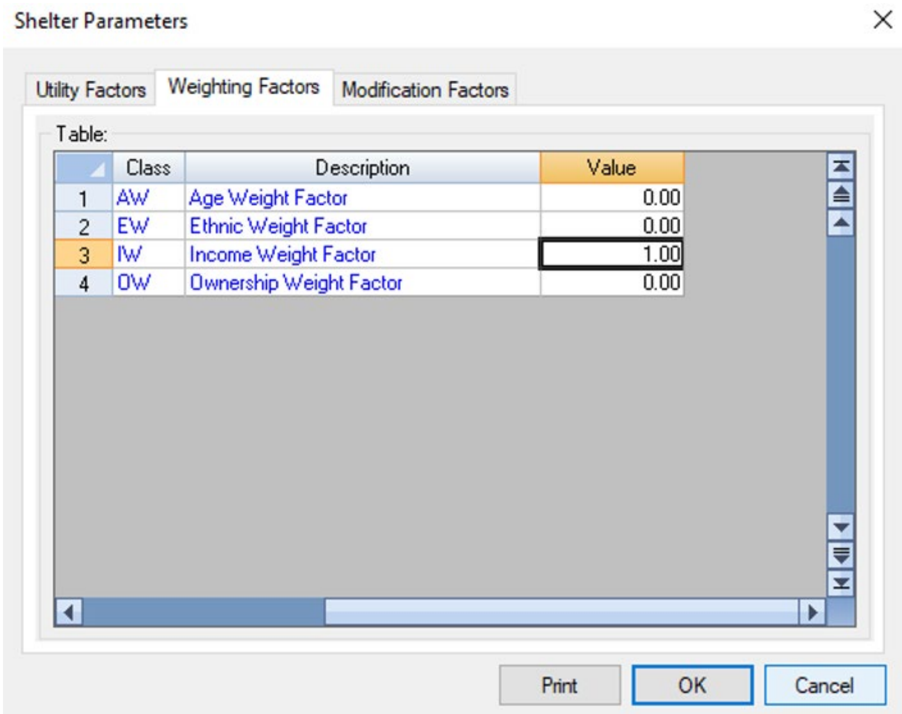
- Task 1: Use Local Data to Update Shelter Parameters
- Task 2: Use National Data Sources to Identify Economic Parameters and Update the Hazus Tables
- Task 3: Compare Results Between Baseline and Updated Parameters

Background: This activity will help you identify and implement an advanced parameter update. You'll make updates to the parameters which determine social loss and then you'll make edits to the parameters that help determine economic loss. For the capstone activity, choose which parameter update and results to discuss – social or economic. Data has been provided for Virginia Beach, Virginia but you may use your own study region for the capstone presentation.

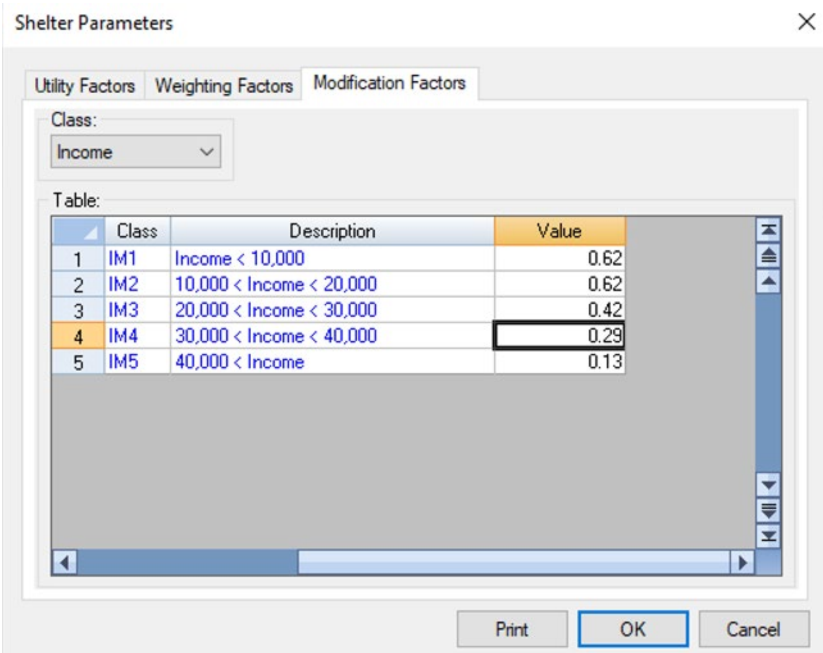
Task 1: Use Local Data to Update Shelter Parameters

1. For this task, create a study region for Virginia Beach, Virginia that is hurricane only. If you're using your own data, feel free to create your own study region with the hazard of interest to you or keep building on a region you've already used for the inventory and hazard updates.

2. Open the study region. Go to Analysis, then Parameters, and Shelter. Select the Weighting Factors tab and change the Income Weight Factor to 1.0 and make everything else 0.0.



3. Then select the Modification Factors tab. Use the dropdown menu to select Income. The poverty line in Virginia Beach is between $20,000 and $30,000 household income per year. Change the IM2 class percentage to .62, change the IM3 class percentage to 0.42, and change the IM4 class percentage to 0.29. Keep the IM1 and IM5 class percentages the same. Although the U.S. Census data has been updated in Hazus, these percentages have not been updated. This means that the number of households making less than $10k a year has decreased since 2000 which is when these percentages were established. These percentages should be updated based on local information. Unfortunately, few jurisdictions are collecting this data after a disaster. Collecting this data for future disasters could be a recommendation provided to the jurisdiction.



4. Click OK and save the edits.

5. Now, assess the shelter data. Go to Hazard, then Scenario, and click Next. Select Probabilistic and select Next. Then click Next and Finish. Go to Analysis and Run, and then select Run Analysis. Click OK when the analysis is complete.

6. Add the shelter data to the map. Virginia Beach maintains a database on available shelters for the City at [this website](https://gis.data.vbgov.com/datasets/027917e45e0847c282140356dc10a77d_0) (https://gis.data.vbgov.com/datasets/027917e45e0847c282140356dc10a77d_0). This data has already been downloaded and placed here: C:\E0177\Activity\9.1\Emergency_Shelter.shp.

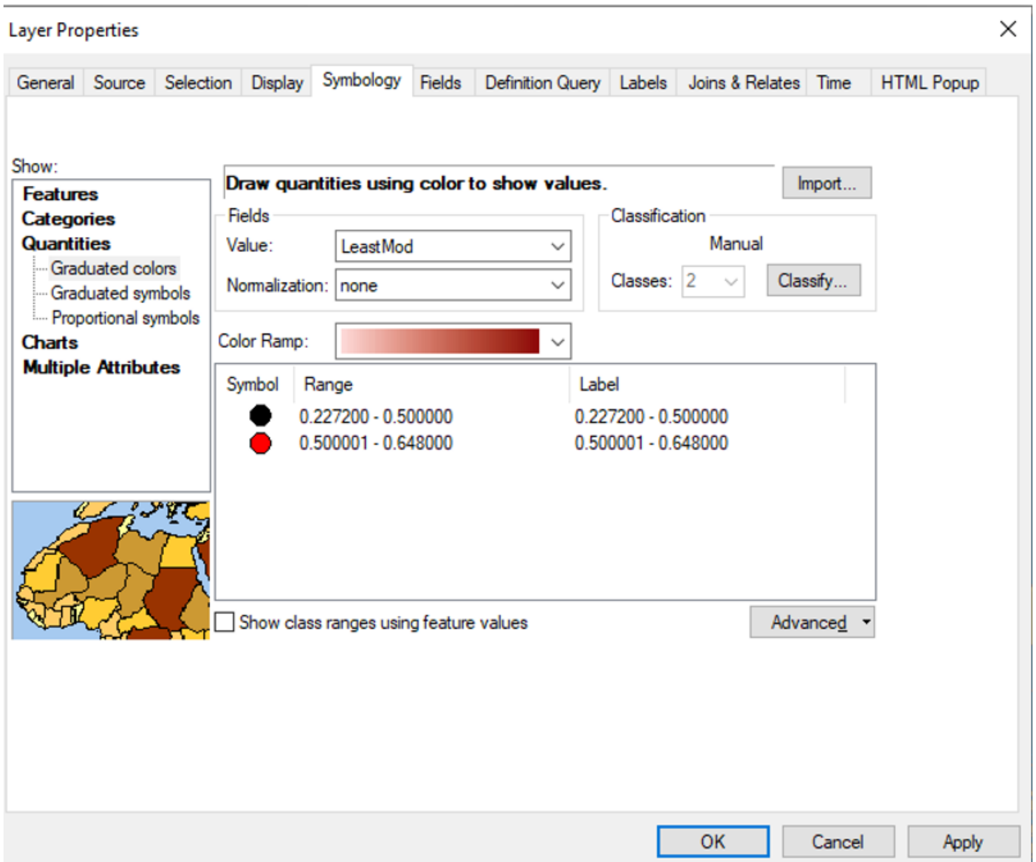
7. Go to Results and Shelter. Then select the shelter needs column and click Map. Close the menu. Open the shelter needs attribute table and use Statistics to determine the total amount of shelter needs. Next, open the attribute table for the Emergency Shelters layer and look at the capacity of the shelters. Notice there is a field called Sub_Catego which identifies each shelter as a Class 1 or Class 2 shelter. Would the capacity of all the Class 1 shelters be able to handle a 100-year event? How about a 500- or 1000-year event? Would both the Class 1 and 2 shelters be able to handle the 1000-year event?

8. The public shelters are all schools. Go to Results and Essential Facilities, then click on the Schools tab. Click on the 500 Year Event in the Return Period dropdown menu. Click the Moderate column and select Map. Close the menu.

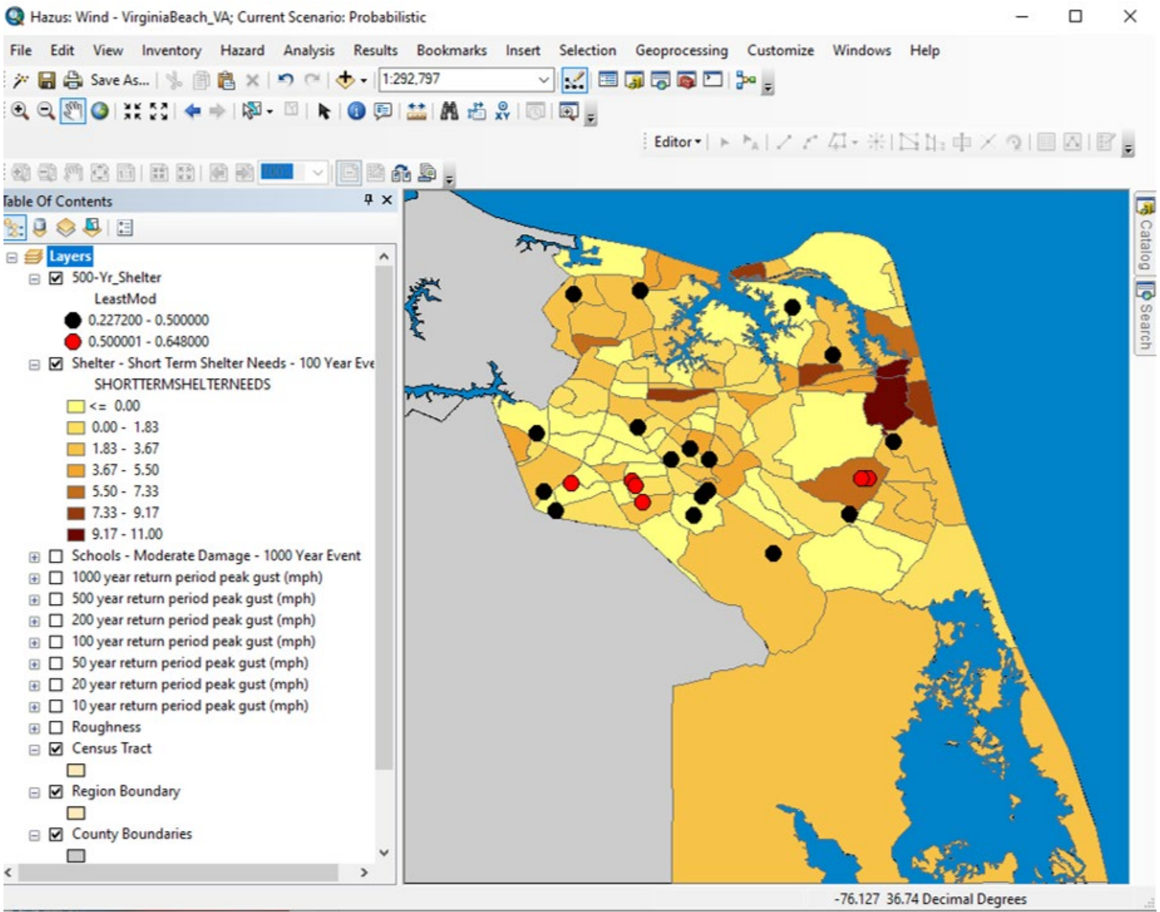
9. Export the Schools-Moderate Damage – 500 Year Event layer as: C:\E0177\Activity\9.1\500-Yr_Schools.shp and add it to the map

10. Right click on the Emergency_Shelter layer and do a spatial join with the 500-Yr_Schools layer. Select the second option – Each point will be given all the attributes of the point in the layer being joined that is closest to it. Save the new layer as: C:\E0177\Activity\9.1\500-Yr_Shelter.shp. Then click OK.

11. Open the attribute table of the 500-Yr_Shelter layer and add a Field Called LeastMod as a double data type. Use the Field Calculator to add the Moderate, Severe, and Complete fields. Close the attribute layer. Change the symbology of the 500-Yr_Shelter layer so that all at least moderate values greater than 0.5 are displayed as a different color than the ones less than 0.5. Then click OK.



12. Assume that the shelters which are likely (>50%) to sustain more than moderate damage will be unusable. Will there still be enough shelters for the community?



13. Add the floodplain the map (C:\E0177\Activity\4.1\VirginiaBeach\515531_20160229\S_FLD_HAZ_AR.shp) and select all the 100-year floodplains. Then determine whether the shelters are located in the floodplain.

Task 2: Use National Data Sources to Identify Economic Parameters and Update Hazus Tables

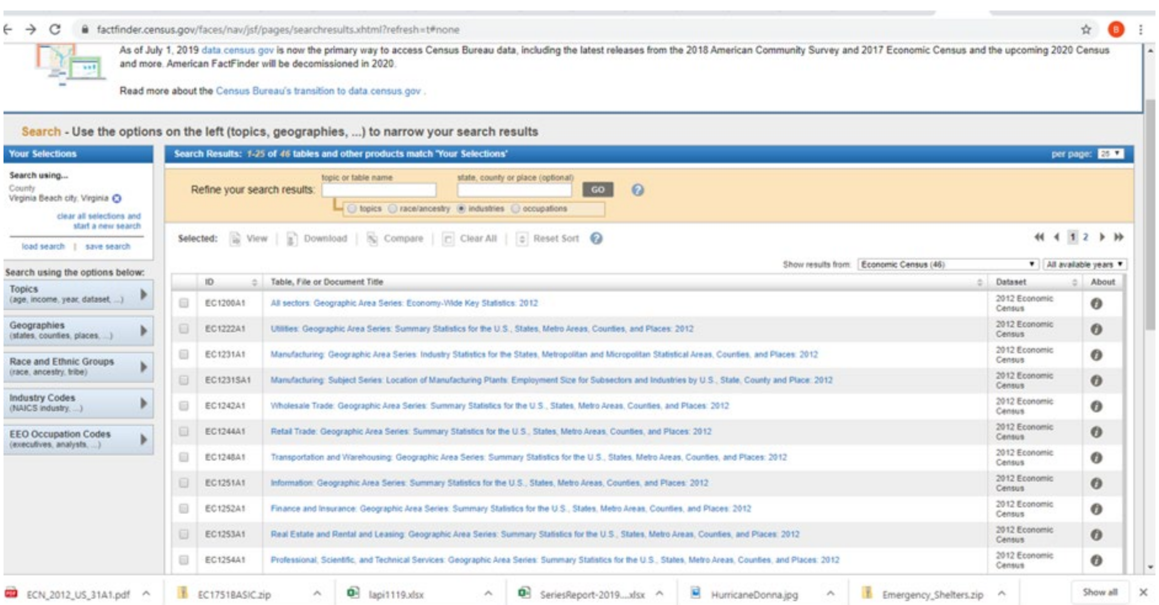
1. Open the Hazus Virginia Beach hurricane study region if it's not already open. Go to Analysis, then Parameters, and Building Economic. These are the tables which will be updated during this task – Business Inventory and Income Loss. The tables have all been copied to a spreadsheet called: C:\E0177\Activity\9.1\EconomicFactors.xlsx.

2. Open the spreadsheet and click on the Business Inventory tab. The spreadsheet will allow work to be done and finalized before editing the tables in Hazus. It will also allow the work to be saved and used in future study regions.

	Occupancy	Business Inventory	% of annual sales		Occupancy	Annual Sales	$/sqft
2	AGR1	8			AGR1	156	
3	COM1	13			COM1	56	
4	COM2	10			COM2	81	
5	IND1	5			IND1	750	
6	IND2	4			IND2	238	
7	IND3	5			IND3	733	
8	IND4	3			IND4	690	
9	IND5	4			IND5	459	
10	IND6	2			IND6	808	

Business Inventory | Wages and Capital Related Ir ...

3. To update the business inventory values, U.S. Economic Census data will be used. Go to the American FactFinder site here: https://factfinder.census.gov/faces/nav/jsf/pages/searchresults.xhtml?refresh=t. In the state, county, or place search add: Virginia Beach city, Virginia. Then click Go. A menu comes up asking to clarify the Geography Type, select the County geography. Once the table comes up, use the dropdown menu next to Show results from: to select Economic Census. Then select GO. Click on the fifth option: Wholesale Trade: Geographic Area Series: Summary Statistics: 2012.



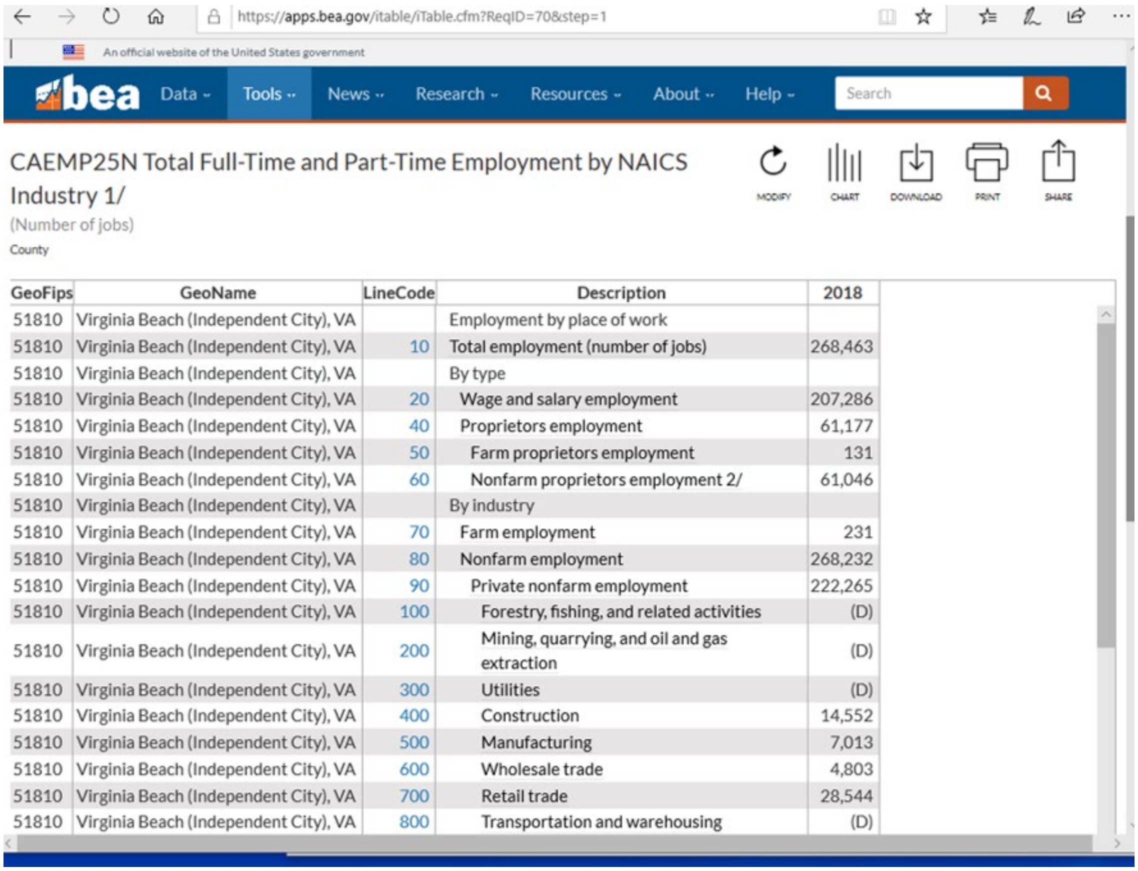
4. Scroll down to Merchant wholesalers. Calculate the average of inventories between beginning and end of year: (84636+93301)/2 = 88969. Then divide that inventory average value by the total sales: 88969/1557453 = 5.7%. Replace the COM2 value with 5.7%.

5. Scroll down to Apparel for COM1. Calculate the average inventory values and divide by total sales. Replace the COM1 value with 7.5%. Scroll down to Farm Supplies for AGR1. Calculate the average inventory values and divide by total sales. Replace the AGR1 value with 2.3%. Scroll up to Chemical and Allied Products for IND3. Do the calculation and replace the IND3 value with 8.3%. Leave the other values with the current defaults.

6. Go to the EconomicFactors spreadsheet and copy the cells from A1 to C10. Then go back into Hazus to the Business Inventory tab in the Buildings Economic Data parameters menu, select the Business Inventory dropdown, and click on the top left part of the table so all the cells are selected. Then press CTRL+V to paste the value into Hazus. Click OK and save the edits.

7. Next, identify the wages for the City. Go to the U.S. Bureau of Economic Analysis here: https://bea.gov/tools/. Click on Interactive Data and then Regional Data – GDP and Personal Income in the bottom right. Click Begin using the data…

8. Scroll down to Personal Income and Employment by County and Metropolitan Area and click on it. Select Total Full-Time and Part-Time Employment by Industry (CAEMP25), then NAICS and click Next Step. Click County and Next Step. Then Virginia and Next Step. Scroll down to Virginia Beach (Independent City), VA next to Area and select All statistics in table next to Statistic and click Next Step. For Time Period, select 2018 and click Next Step. The table should now come up.


https://apps.bea.gov/itable/iTable.cfm?ReqID=70&step=1

An official website of the United States government

bea Data Tools News Research Resources About Help Search

CAEMP25N Total Full-Time and Part-Time Employment by NAICS Industry 1/

MODIFY CHART DOWNLOAD PRINT SHARE

(Number of jobs)

County

GeoFips	GeoName	LineCode	Description	2018
51810	Virginia Beach (Independent City), VA		Employment by place of work	
51810	Virginia Beach (Independent City), VA	10	Total employment (number of jobs)	268,463
51810	Virginia Beach (Independent City), VA		By type	
51810	Virginia Beach (Independent City), VA	20	Wage and salary employment	207,286
51810	Virginia Beach (Independent City), VA	40	Proprietors employment	61,177
51810	Virginia Beach (Independent City), VA	50	Farm proprietors employment	131
51810	Virginia Beach (Independent City), VA	60	Nonfarm proprietors employment 2/	61,046
51810	Virginia Beach (Independent City), VA		By industry	
51810	Virginia Beach (Independent City), VA	70	Farm employment	231
51810	Virginia Beach (Independent City), VA	80	Nonfarm employment	268,232
51810	Virginia Beach (Independent City), VA	90	Private nonfarm employment	222,265
51810	Virginia Beach (Independent City), VA	100	Forestry, fishing, and related activities	(D)
51810	Virginia Beach (Independent City), VA	200	Mining, quarrying, and oil and gas extraction	(D)
51810	Virginia Beach (Independent City), VA	300	Utilities	(D)
51810	Virginia Beach (Independent City), VA	400	Construction	14,552
51810	Virginia Beach (Independent City), VA	500	Manufacturing	7,013
51810	Virginia Beach (Independent City), VA	600	Wholesale trade	4,803
51810	Virginia Beach (Independent City), VA	700	Retail trade	28,544
51810	Virginia Beach (Independent City), VA	800	Transportation and warehousing	(D)

9. Download the number of employees into a spreadsheet, then copy the values into the EconomicFactors.xlsx spreadsheet in the Wages and Capital Related Income tab. Match up the employment type to the Hazus specific occupancy. Farm employment would by AGR1, Retail Trade is COM1, Wholesale Trade is COM2, etc. All of the specific occupancies that have values for income, wages, and employment should be matched to the employment values. Some specific occupancies may be matched to multiple categories (COM4) while some categories may be matched to multiple specific occupancies (Manufacturing). If there are no values for employees, don’t match it up – there is no data.

	G	H	I	J	K	L	M
7	1.222	COM5			By industry		
8	3.968	COM6		AGR1	Farm employment	231	
9	1.045	COM7		[redacted]	Nonfarm employment	268232	
10	2.09	COM8		[redacted]	Private nonfarm employment	222265	
11	1.318	COM9		[redacted]	Forestry, fishing, and related activities		
12	1.255	COM10		[redacted]	Mining, quarrying, and oil and gas extraction		
13	4.05	IND1		[redacted]	Utilities		
14	6.156	IND2		IND6	Construction	14552	
15	0.837	IND3		IND1-5	Manufacturing	7013	
16	0.961	IND4		COM2	Wholesale trade	4803	
17	2.119	IND5		COM1	Retail trade	28544	
18	2.119	IND6		[redacted]	Transportation and warehousing		
19	2.825	AGR1		COM4	Information	4145	
20	2.241	REL1		COM5	Finance and insurance	15013	
21	4.236	GOV1		COM4	Real estate and rental and leasing	18833	
22	2.099	GOV2		COM4	Professional, scientific, and technical services	19736	
23	2.09	EDU1		COM4	Management of companies and enterprises	3367	
24	0	EDU2		COM3	Administrative and support and waste management and remediation services	16455	
25	0	RES4		EDU1/EDU2	Educational services	5910	
26	0	RES6		COM6/COM7	Health care and social assistance	26354	
27	0			COM8/COM9	Arts, entertainment, and recreation	6152	
28	0			RES4/RES6,	Accommodation and food services	27576	
29	0			REL1	Other services (except government and government enterprises)	15139	
30	0			GOV1/GOV2	Government and government enterprises	45967	
31	0				Federal civilian	6386	

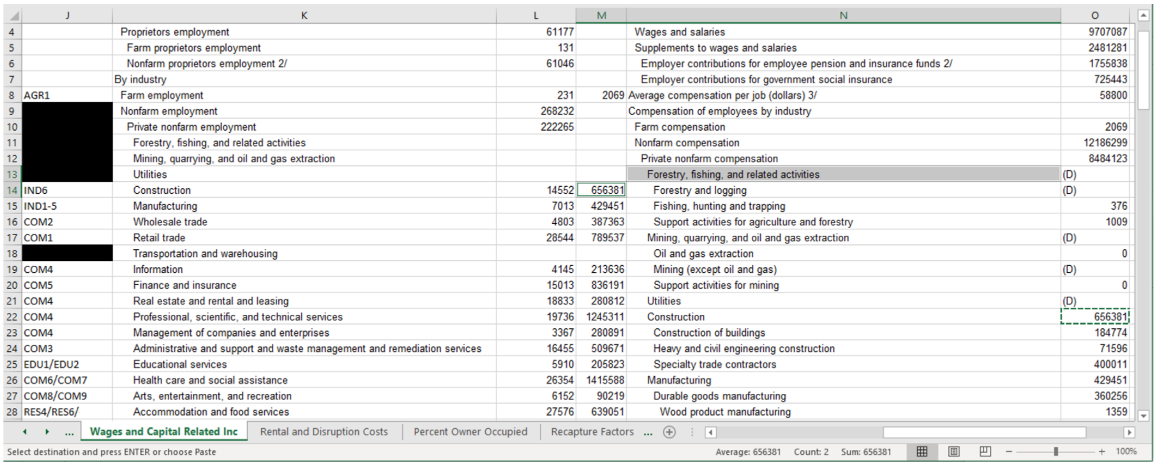
Wages and Capital Related Inc | Rental and Disruption Costs

Ready 100%

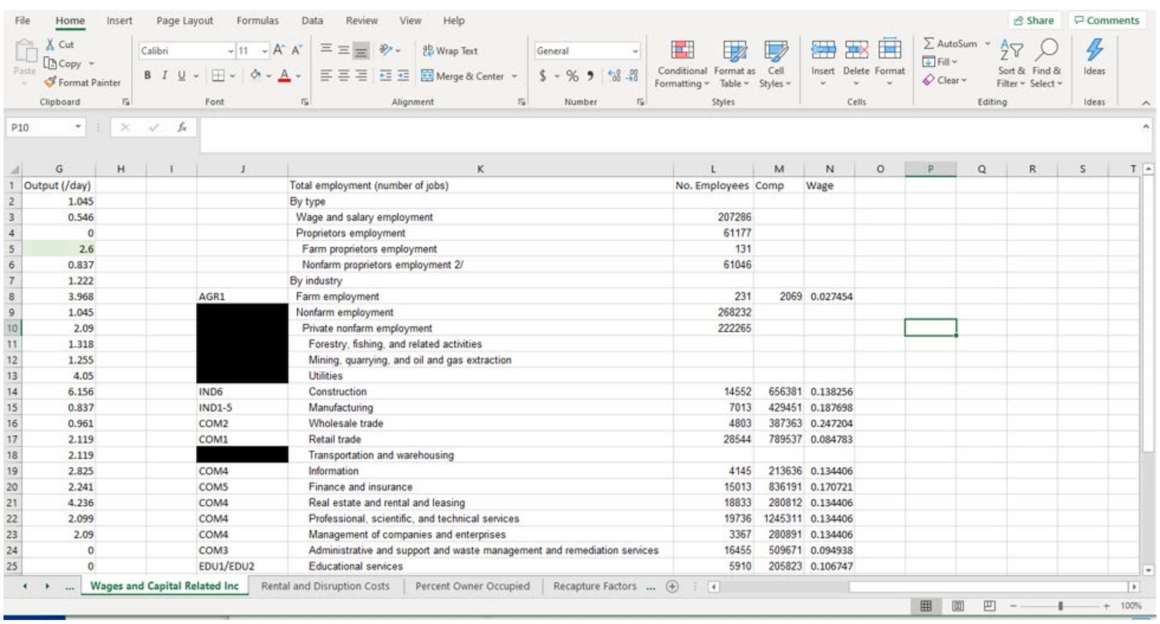
10. Go back to the U.S. Bureau of Economic Analysis here: https://bea.gov/tools/. Click on Interactive Data and then Regional Data – GDP and Personal Income in the bottom right. Click Begin using the data…

11. Scroll down to Personal Income and Employment by County and Metropolitan Area and click on it. Select Compensation of Employees by Industry (CAINC6), then NAICS and click Next Step. Click County and Next Step. Then Virginia and Next Step. Scroll down to Virginia Beach (Independent City), VA next to Area and select All statistics in table next to Statistic and click Next Step. For Time Period, select 2018 and click Next Step. The table should now come up.

12. Download the compensation of employees into a spreadsheet, then copy and paste the values into the EconomicFactors.xlsx spreadsheet in the Wages and Capital Related Income tab. Match up the description with the previous table which was copied. For example, farm compensation would go next to farm employment. Do this for all the matching categories that have a specific occupancy next to them. Dividing the wages by the total compensation shows that they make up about 80% of the total compensation.

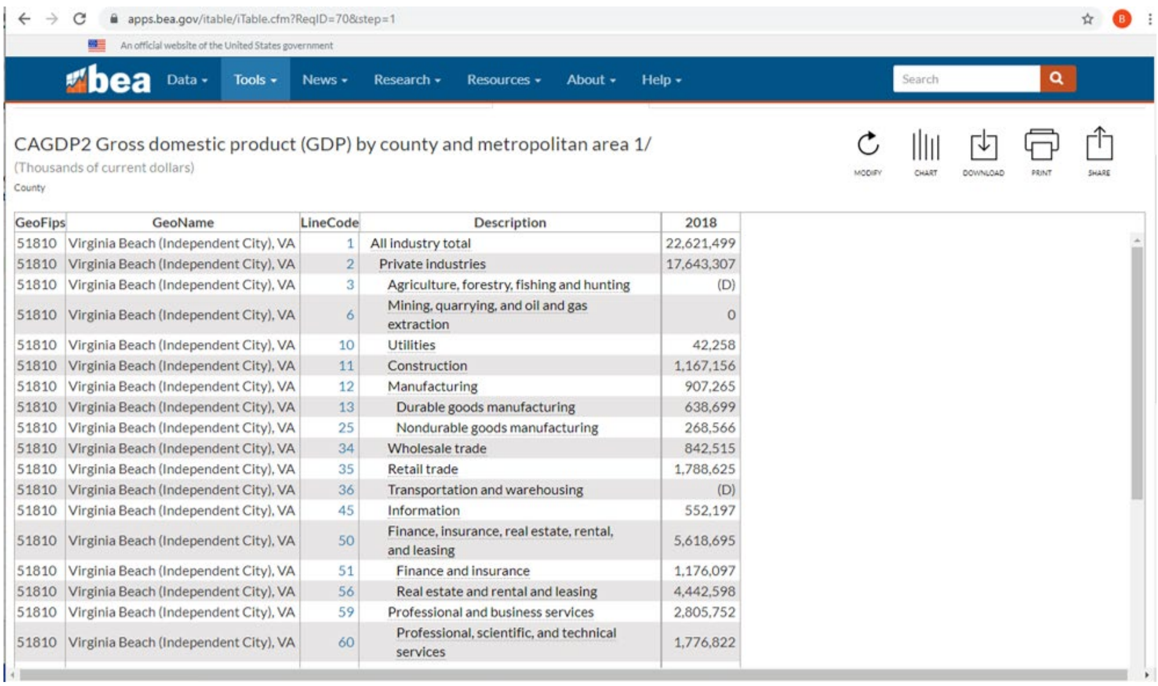


13. Delete all columns to the right of compensation (in example above, columns N and O). Create a new column N called Wage and make it equal to M/L*0.8/261. Divide by 261 because that's how many workdays are in a year and the units should be $/day. Since COM4 is made up of multiple rows, calculate by adding together all the M values associated with COM4 and dividing by the L values associated with COM4. Then multiple by 0.8 and divide by 261. COM4 becomes: 0.134.



14. Now, identify the worker output data. Go back to the U.S. Bureau of Economic Analysis (https://bea.gov/tools/). Click on Interactive Data and then Regional Data – GDP and Personal Income in the bottom right. Click Begin using the data…

15. Scroll down to Gross Domestic Product (GDP) by County and Metropolitan Area and click on it. Select GDP in current dollars (CAGDP2). Click County and Next Step. Then Virginia and Next Step. Scroll down to Virginia Beach (Independent City), VA next to Area and select All statistics in table next to Statistic and click Next Step. For Time Period, select 2018 and click Next Step. The table should now come up.



CAGDP2 Gross domestic product (GDP) by county and metropolitan area 1/

(Thousands of current dollars)

County

GeoFips	GeoName	LineCode	Description	2018
51810	Virginia Beach (Independent City), VA	1	All industry total	22,621,499
51810	Virginia Beach (Independent City), VA	2	Private industries	17,643,307
51810	Virginia Beach (Independent City), VA	3	Agriculture, forestry, fishing and hunting	(D)
51810	Virginia Beach (Independent City), VA	6	Mining, quarrying, and oil and gas extraction	0
51810	Virginia Beach (Independent City), VA	10	Utilities	42,258
51810	Virginia Beach (Independent City), VA	11	Construction	1,167,156
51810	Virginia Beach (Independent City), VA	12	Manufacturing	907,265
51810	Virginia Beach (Independent City), VA	13	Durable goods manufacturing	638,699
51810	Virginia Beach (Independent City), VA	25	Nondurable goods manufacturing	268,566
51810	Virginia Beach (Independent City), VA	34	Wholesale trade	842,515
51810	Virginia Beach (Independent City), VA	35	Retail trade	1,788,625
51810	Virginia Beach (Independent City), VA	36	Transportation and warehousing	(D)
51810	Virginia Beach (Independent City), VA	45	Information	552,197
51810	Virginia Beach (Independent City), VA	50	Finance, insurance, real estate, rental, and leasing	5,618,695
51810	Virginia Beach (Independent City), VA	51	Finance and insurance	1,176,097
51810	Virginia Beach (Independent City), VA	56	Real estate and rental and leasing	4,442,598
51810	Virginia Beach (Independent City), VA	59	Professional and business services	2,805,752
51810	Virginia Beach (Independent City), VA	60	Professional, scientific, and technical services	1,776,822

16. Download the GDP values into a spreadsheet, then copy and paste the values into the EconomicFactors.xlsx spreadsheet in the Wages and Capital Related Income tab. Add a new column called GDP in the O column and a new column called Output in the P column. Match up the description of the new data with the previous table. For example, retail trade GDP would go next to retail trade employees, compensation, and wages. Do this for all the matching categories that have a specific occupancy next to them.

	J	K	L	M	N	O	P	Q	R	S	T
1		Total employment (number of jobs)	No. Employees	Comp	Wage	GDP	Output	All industry total	22621499		
11	[redacted]	Forestry, fishing, and related activities						Retail trade	1788625		
12		Mining, quarrying, and oil and gas extraction						Transportation and warehousing	(D)		
13		Utilities						Information	552197		
14	IND6	Construction	14552	656381	0.138256	1167156		Finance, insurance, real estate, ren	5618695		
15	IND1-5	Manufacturing	7013	429451	0.187698	907265		Finance and insurance	1176097		
16	COM2	Wholesale trade	4803	387363	0.247204	842515		Real estate and rental and leasing	4442598		
17	COM1	Retail trade	28544	789537	0.084783	1788625		Professional and business services	2805752		
18	[redacted]	Transportation and warehousing						Professional, scientific, and techn	1776822		
19	COM4	Information	4145	213636	0.134406	552197		Management of companies and er	298435		
20	COM5	Finance and insurance	15013	836191	0.170721	1176097		Administrative and support and wa	730495		
21	COM4	Real estate and rental and leasing	18833	280812	0.134406	4442598		Educational services, health care, a	2121365		
22	COM4	Professional, scientific, and technical services	19736	1245311	0.134406	1776822		Educational services	361153		
23	COM4	Management of companies and enterprises	3367	280891	0.134406	298435		Health care and social assistance	1760212		
24	COM3	Administrative and support and waste management and remediation services	16455	509671	0.094938	730495		Arts, entertainment, recreation, acc	1151605		
25	EDU1/EDU2	Educational services	5910	205823	0.106747	361153		Arts, entertainment, and recreatio	137094		
26	COM6/COM7	Health care and social assistance	26354	1415588	0.164642	1760212		Accommodation and food services	1014512		
27	COM8/COM9	Arts, entertainment, and recreation	6152	90219	0.04495	137094		Other services (except government	508769		
28	RES4/RES6/	Accommodation and food services	27576	639051	0.071032	1014512		Government and government enterpris	4978192		
29	REL1	Other services (except government and government enterprises)	15139	379753	0.076887	508769		Addenda:			
30	GOV1/GOV2	Government and government enterprises	45967	3702176	0.246865	4978192		Natural resources and mining	(D)		
31		Federal civilian	6386					Trade	2631140		

17. In the Output column, create the following equation: O/L/261. For COM4 add up all four O values corresponding to COM4 and divide that value by the four L values and divide by 261.

=O14/L14/261

J	K	L	M	N	O	P	Q
	Total employment (number of jobs)	No. Employees	Comp	Wage	GDP	Output	
[redacted]	Forestry, fishing, and related activities						
	Mining, quarrying, and oil and gas extraction						
	Utilities						
IND6	Construction	14552	656381	0.138256	1167156	0.3073022	
IND1-5	Manufacturing	7013	429451	0.187698	907265	0.4956668	
COM2	Wholesale trade	4803	387363	0.247204	842515	0.6720855	
COM1	Retail trade	28544	789537	0.084783	1788625	0.2400844	
[redacted]	Transportation and warehousing						
COM4	Information	4145	213636	0.134406	552197	0.5878414	
COM5	Finance and insurance	15013	836191	0.170721	1176097	0.3001478	
COM4	Real estate and rental and leasing	18833	280812	0.134406	4442598	0.5878414	
COM4	Professional, scientific, and technical services	19736	1245311	0.134406	1776822	0.5878414	
COM4	Management of companies and enterprises	3367	280891	0.134406	298435	0.5878414	
COM3	Administrative and support and waste management and remediation services	16455	509671	0.094938	730495	0.17009	
EDU1/EDU2	Educational services	5910	205823	0.106747	361153	0.2341333	
COM6/COM7	Health care and social assistance	26354	1415588	0.164642	1760212	0.2559045	
COM8/COM9	Arts, entertainment, and recreation	6152	90219	0.04495	137094	0.0853811	
RES4/RES6/COM8	Accommodation and food services	27576	639051	0.071032	1014512	0.1409566	
REL1	Other services (except government and government enterprises)	15139	379753	0.076887	508769	0.1287606	
GOV1/GOV2	Government and government enterprises	45967	3702176	0.246865	4978192	0.4149397	
	Federal civilian	6386					
	Military	17231					
	State and local	22350					
	State government	1994					

18. Delete columns Q and R. Now, calculate how many employees per square foot. Add a new column to Q called SqFt and add a new column to R called Employee.

19. Go to Hazus, then Inventory, then General Building Stock, and Square Footage. Click on the RES1 column and select Map and then OK. Open the attribute table for the new layer. Use the

Statistics tool to summarize the square footage for the occupancies where there are values in the spreadsheet. Remember that the values in Hazus are in thousands of square feet. Add the square footage totals to the spreadsheet. Some of the values will need to be added together. For example, manufacturing requires adding IND1-IND5.

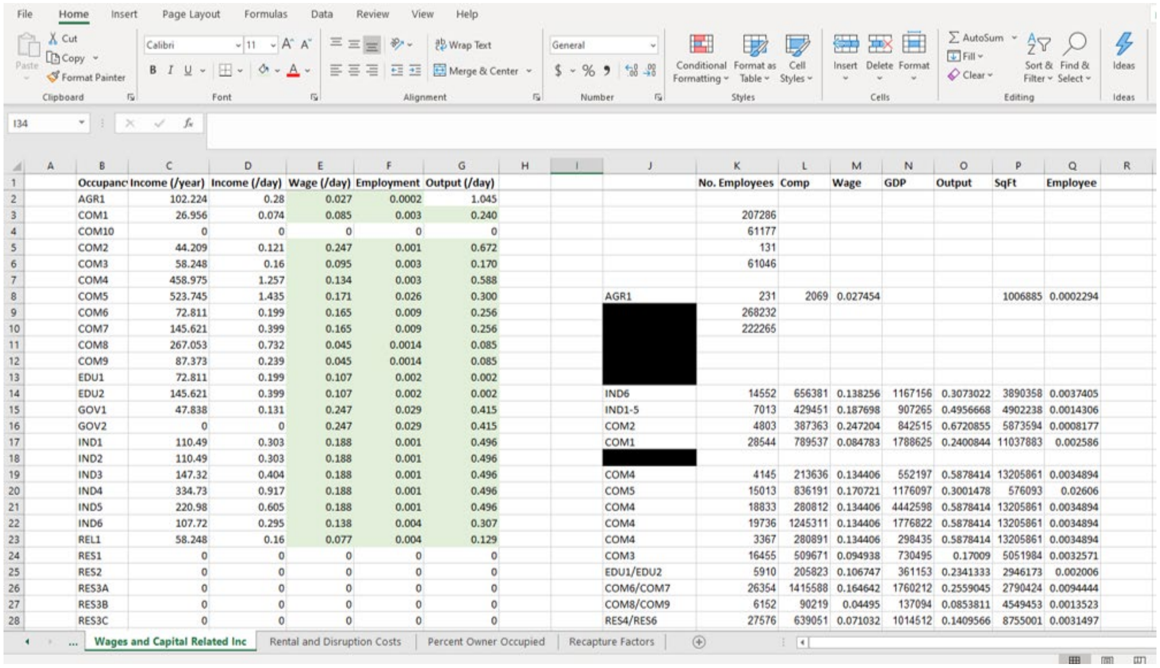
20. Under Employee, create a calculation of L/Q. For COM4, the total number of employees (all four values for COM4) will need to be divided by square footage of COM4.

R14 =L14/Q14

	J	K	L	M	N	O	P	Q	R
1		Total employment (number of jobs)	No. Employees	Comp	Wage	GDP	Output	SqFt	Employee
8	AGR1	Farm employment	231	2069	0.027454			1006885	0.0002294
9	[redacted]	Nonfarm employment	268232						
10		Private nonfarm employment	222265						
11		Forestry, fishing, and related activities							
12		Mining, quarrying, and oil and gas extraction							
13		Utilities							
14	IND6	Construction	14552	656381	0.138256	1167156	0.3073022	3890358	0.0037405
15	IND1-5	Manufacturing	7013	429451	0.187698	907265	0.4956668	4902238	0.0014306
16	COM2	Wholesale trade	4803	387363	0.247204	842515	0.6720855	5873594	0.0008177
17	COM1	Retail trade	28544	789537	0.084783	1788625	0.2400844	11037883	0.002586
18	[redacted]	Transportation and warehousing							
19	COM4	Information	4145	213636	0.134406	552197	0.5878414	13205861	0.0034894
20	COM5	Finance and insurance	15013	836191	0.170721	1176097	0.3001478	576093	0.02606
21	COM4	Real estate and rental and leasing	18833	280812	0.134406	4442598	0.5878414	13205861	0.0034894
22	COM4	Professional, scientific, and technical services	19736	1245311	0.134406	1776822	0.5878414	13205861	0.0034894
23	COM4	Management of companies and enterprises	3367	280891	0.134406	298435	0.5878414	13205861	0.0034894
24	COM3	Administrative and support and waste management and remediation services	16455	509671	0.094938	730495	0.17009	5051984	0.0032571
25	EDU1/EDU2	Educational services	5910	205823	0.106747	361153	0.2341333	2946173	0.002006
26	COM6/COM7	Health care and social assistance	26354	1415588	0.164642	1760212	0.2559045	2790424	0.0094444
27	COM8/COM9	Arts, entertainment, and recreation	6152	90219	0.04495	137094	0.0853811	4549453	0.0013523
28	RES4/RES6/COM8	Accommodation and food services	27576	639051	0.071032	1014512	0.1409566	8755001	0.0031497
29	REL1	Other services (except government and government enterprises)	15139	379753	0.076887	508769	0.1287606	3877487	0.0039043
30	GOV1/GOV2	Government and government enterprises	45967	3702176	0.246865	4978192	0.4149397	1564355	0.029384
31		Federal civilian	6386						

Wages and Capital Related Inc | Rental and Disruption Costs | Percent Owner Occupi...

21. Replace the original table which was taken from Hazus with the new values. Values in column Q replace column F values, values in column O replace column G values, values in column M replace column E values. If there aren't any new values (e.g. AGR1 output), keep the Hazus defaults. Make sure to paste as values so the equations don't get copied.



	B	C	D	E	F	G	J	K	L	M	N	O	P	Q
1	Occupanc	Income (/year)	Income (/day)	Wage (/day)	Employment	Output (/day)		No. Employees	Comp	Wage	GDP	Output	SqFt	Employee
2	AGR1	102.224	0.28	0.027	0.0002	1.045								
3	COM1	26.956	0.074	0.085	0.003	0.240		207286						
4	COM10	0	0	0	0	0		61177						
5	COM2	44.209	0.121	0.247	0.001	0.672		131						
6	COM3	58.248	0.16	0.095	0.003	0.170		61046						
7	COM4	458.975	1.257	0.134	0.003	0.588								
8	COM5	523.745	1.435	0.171	0.026	0.300	AGR1	231	2069	0.027454			1006885	0.0002294
9	COM6	72.811	0.199	0.165	0.009	0.256	[redacted]	268232						
10	COM7	145.621	0.399	0.165	0.009	0.256		222265						
11	COM8	267.053	0.732	0.045	0.0014	0.085								
12	COM9	87.373	0.239	0.045	0.0014	0.085								
13	EDU1	72.811	0.199	0.107	0.002	0.002								
14	EDU2	145.621	0.399	0.107	0.002	0.002	IND6	14552	656381	0.138256	1167156	0.3073022	3890358	0.0037405
15	GOV1	47.838	0.131	0.247	0.029	0.415	IND1-5	7013	429451	0.187698	907265	0.4956668	4902238	0.0014306
16	GOV2	0	0	0.247	0.029	0.415	COM2	4803	387363	0.247204	842515	0.6720855	5873594	0.0008177
17	IND1	110.49	0.303	0.188	0.001	0.496	COM1	28544	789537	0.084783	1788625	0.2400844	11037883	0.002586
18	IND2	110.49	0.303	0.188	0.001	0.496	[redacted]							
19	IND3	147.32	0.404	0.188	0.001	0.496	COM4	4145	213636	0.134406	552197	0.5878414	13205861	0.0034894
20	IND4	334.73	0.917	0.188	0.001	0.496	COM5	15013	836191	0.170721	1176097	0.3001478	576093	0.02606
21	IND5	220.98	0.605	0.188	0.001	0.496	COM4	18833	280812	0.134406	4442598	0.5878414	13205861	0.0034894
22	IND6	107.72	0.295	0.138	0.004	0.307	COM4	19736	1245311	0.134406	1776822	0.5878414	13205861	0.0034894
23	REL1	58.248	0.16	0.077	0.004	0.129	COM4	3367	280891	0.134406	298435	0.5878414	13205861	0.0034894
24	RES1	0	0	0	0	0	COM3	16455	509671	0.094938	730495	0.17009	5051984	0.0032571
25	RES2	0	0	0	0	0	EDU1/EDU2	5910	205823	0.106747	361153	0.2341333	2946173	0.002006
26	RES3A	0	0	0	0	0	COM6/COM7	26354	1415588	0.164642	1760212	0.2559045	2790424	0.0094444
27	RES3B	0	0	0	0	0	COM8/COM9	6152	90219	0.04495	137094	0.0853811	4549453	0.0013523
28	RES3C	0	0	0	0	0	RES4/RES6	27576	639051	0.071032	1014512	0.1409566	8755001	0.0031497

22. Copy the cells from G34 to A1. Open Hazus and go to Analysis, Parameters, and Building Economic. Click on the Income Loss tab and select the Wages and Capital Relate Income dropdown option. Click on the top left cell so the whole table is highlighted and paste the new values into the table. Then click OK and save the edits.

23. Now, edit the rental costs. Go to the Zillow Research Data website (https://www.zillow.com/research/data/). There is up to date, local residential data for Hazus here. Scroll down to Rentals. In the first dropdown box, select Median Rent List Price ($ Per Square Foot), Single Family Residence. Under Geography, choose County and then click the Download button. Open the spreadsheet and find Virginia Beach (use the Find tool) and scroll to the far right to see that the latest average is 1.0 (accessed on 10/2019). That is $1/sqft/month which is one of the values required by Hazus. Go back to the EconomicFactors spreadsheet and create a new column header for F and call it New Rental (/month). Then replace the value under column C next to RES1 (current value 0.83) to 1.00. Set column D to equal column C divided by 30 to get the daily rate.

24. Go back to the website and download the following datasets:

- Median Rent List Price ($ Per Square Foot), Duplex/Triplex to update RES3A and RES3B.
- Median Rent List Price ($ Per Square Foot), MultiFamily 5+ units to update RES3C, RES3D, RES3E, and RES3F.

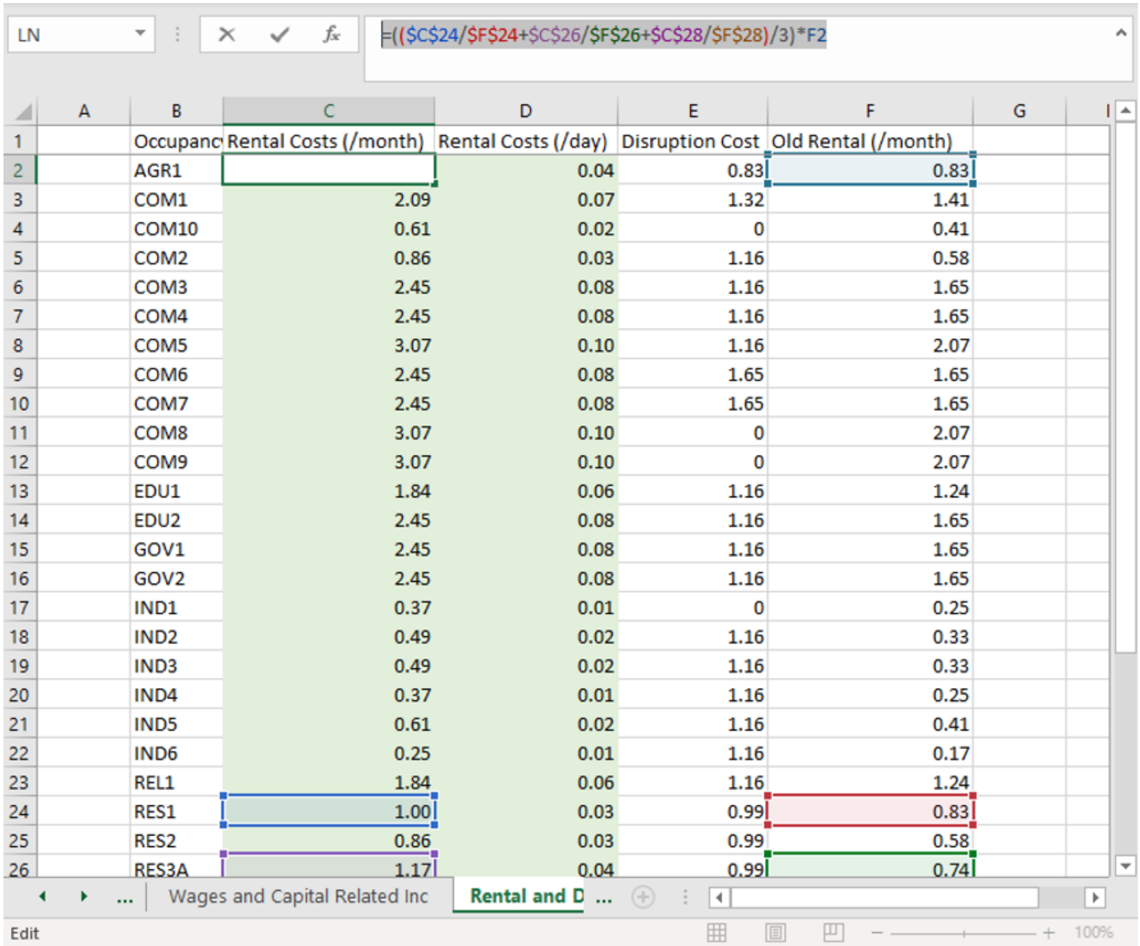
25. Update the values in the EconomicFactors spreadsheet with the Zillow data.

D24 =C24/30

	A	B	C	D	E	F	G
1		Occupanc	Rental Costs (/month)	Rental Costs (/day)	Disruption Cost	Old Rental (/month)	
11		COM8	2.07	0.07	0	2.07	
12		COM9	2.07	0.07	0	2.07	
13		EDU1	1.24	0.04	1.16	1.24	
14		EDU2	1.65	0.06	1.16	1.65	
15		GOV1	1.65	0.06	1.16	1.65	
16		GOV2	1.65	0.06	1.16	1.65	
17		IND1	0.25	0.01	0	0.25	
18		IND2	0.33	0.01	1.16	0.33	
19		IND3	0.33	0.01	1.16	0.33	
20		IND4	0.25	0.01	1.16	0.25	
21		IND5	0.41	0.01	1.16	0.41	
22		IND6	0.17	0.01	1.16	0.17	
23		REL1	1.24	0.04	1.16	1.24	
24		RES1	1.00	0.03	0.99	0.83	
25		RES2	0.58	0.02	0.99	0.58	
26		RES3A	1.17	0.04	0.99	0.74	
27		RES3B	1.17	0.04	0.99	0.74	
28		RES3C	1.23	0.04	0.99	0.74	
29		RES3D	1.23	0.04	0.99	0.74	
30		RES3E	1.23	0.04	0.99	0.74	
31		RES3F	1.23	0.04	0.99	0.74	
32		RES4	2.48	0.08	0.99	2.48	
33		RES5	0.5	0.02	0.99	0.5	
34		RES6	0.91	0.03	0.99	0.91	
35							

Wages and Capital Related Inc | Rental and D ...

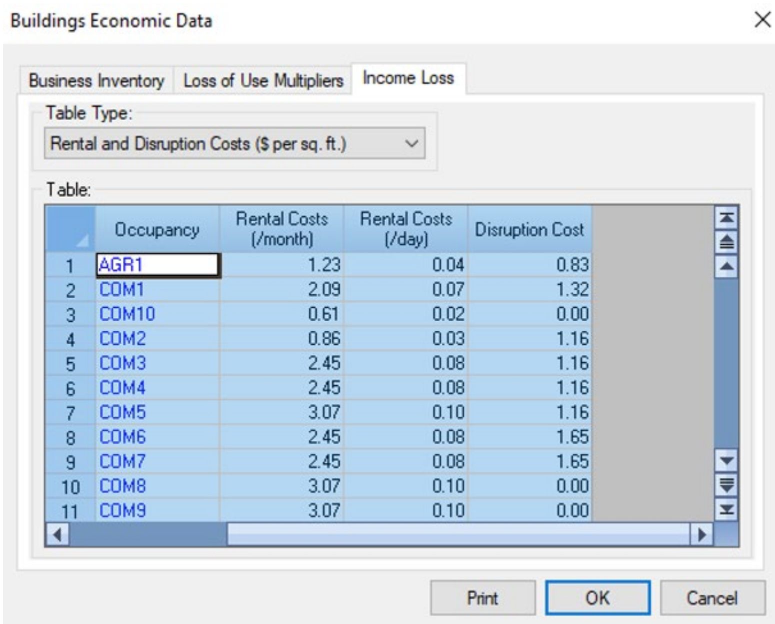
26. Assume that the other rental costs change by the same proportion as the residential values. Take the average increase of the three new values and multiple that increase by the other rental costs. So, the cell C2 will be equal to: =(($C$24/$F$24+$C$26/$F$26+$C$28/$F$28)/3)*F2. Copy this equation for the values that were not updated earlier. Then update the column D values by dividing column C by 30.



LN =(($C$24/$F$24+$C$26/$F$26+$C$28/$F$28)/3)*F2

	A	B	C	D	E	F	G
1		Occupanc	Rental Costs (/month)	Rental Costs (/day)	Disruption Cost	Old Rental (/month)	
2		AGR1		0.04	0.83	0.83	
3		COM1	2.09	0.07	1.32	1.41	
4		COM10	0.61	0.02	0	0.41	
5		COM2	0.86	0.03	1.16	0.58	
6		COM3	2.45	0.08	1.16	1.65	
7		COM4	2.45	0.08	1.16	1.65	
8		COM5	3.07	0.10	1.16	2.07	
9		COM6	2.45	0.08	1.65	1.65	
10		COM7	2.45	0.08	1.65	1.65	
11		COM8	3.07	0.10	0	2.07	
12		COM9	3.07	0.10	0	2.07	
13		EDU1	1.84	0.06	1.16	1.24	
14		EDU2	2.45	0.08	1.16	1.65	
15		GOV1	2.45	0.08	1.16	1.65	
16		GOV2	2.45	0.08	1.16	1.65	
17		IND1	0.37	0.01	0	0.25	
18		IND2	0.49	0.02	1.16	0.33	
19		IND3	0.49	0.02	1.16	0.33	
20		IND4	0.37	0.01	1.16	0.25	
21		IND5	0.61	0.02	1.16	0.41	
22		IND6	0.25	0.01	1.16	0.17	
23		REL1	1.84	0.06	1.16	1.24	
24		RES1	1.00	0.03	0.99	0.83	
25		RES2	0.86	0.03	0.99	0.58	
26		RES3A	1.17	0.04	0.99	0.74	

27. Copy the cells from E34 to A1 then go back into Hazus to Analysis, Parameters, and Building Economic. Then click on the Income Loss tab, make sure the dropdown is displaying Rental and Disruption Costs ($ per sq.ft.) and click the upper left box in the table to highlight the whole table. Then press CTRL+V and paste the values into the table. Click OK and save the edits.



	Occupancy	Rental Costs (/month)	Rental Costs (/day)	Disruption Cost
1	AGR1	1.23	0.04	0.83
2	COM1	2.09	0.07	1.32
3	COM10	0.61	0.02	0.00
4	COM2	0.86	0.03	1.16
5	COM3	2.45	0.08	1.16
6	COM4	2.45	0.08	1.16
7	COM5	3.07	0.10	1.16
8	COM6	2.45	0.08	1.65
9	COM7	2.45	0.08	1.65
10	COM8	3.07	0.10	0.00
11	COM9	3.07	0.10	0.00

28. Select Analysis and Run. When the combined analysis warning comes up, click OK. Select General Building Stock and OK. Click OK when the analysis is finished. There should now be results for general building stock.

Task 3: Compare Results Between Baseline and Updated Parameters

1. Run a probabilistic analysis with the new economic parameter values. Export some of the global summary reports and results. Pay close attention to the business interruption losses that are now being generated.

2. Now create a new study region for the same region and run a probabilistic analysis without updating the economic parameters. Compare the summary reports and other outputs. How has updating the parameters changed the results?

Visual 25: Lesson 9: Review

1. List three social impact outputs for Hazus.
2. What are the four components of business interruption loss?
3. Identify four sources which can be used to update Hazus economic parameters.

Visual 26: Questions?

Lesson 10: Hazus Results and Outputs

Visual 1: Lesson 10: Hazus Results and Outputs

Visual 2: Lesson 10: Goal and Objectives

Goal: Understand the meaning behind the Hazus results, how to better communicate those results, and creating advanced products.

After completing this lesson you will be able to:

- Understand how loss is calculated
- Identify uncertainties in the Hazus analysis
- Define the validation process
- List advanced communications practices
- Create advanced products with your hazard of concern

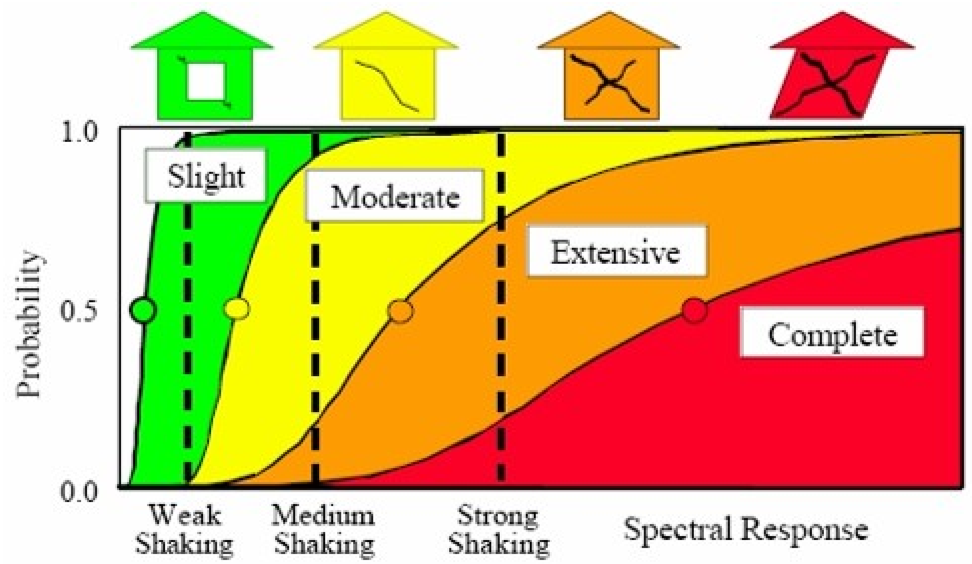
Visual 3: Results Overview

Hazus Capabilities	Earthquake Ground Shaking Ground Failure	Flood Frequency |Depth Riverine |Coastal Surge	Hurricane Wind Surge	Tsunami Depth |Momentum Flux Runup |Velocity
Direct Damage				
General Building Stock	X	X	X	X
Essential Facilities	X	X	X	
Transportation Systems	X	X		
Utility Systems	X	X		
User-Defined Facilities	X	X	X	X
Induced Damage				
Fire Following	X			
Debris Generation	X	X	X	
Direct Losses				
Cost of Repair	X	X	X	X
Income Loss	X	X	X	X
Agricultural		X		

Hazus Capabilities	Earthquake Ground Shaking Ground Failure	Flood Frequency |Depth Riverine |Coastal Surge	Hurricane Wind Surge	Tsunami Depth |Momentum Flux Runup |Velocity
Casualties	X			X
Shelter and/or Evacuation Needs	X	X	X	X
Average Annualized Loss (AAL)	X	X	X	

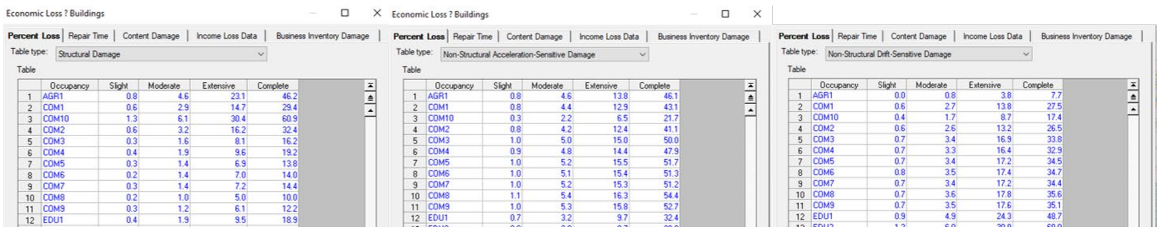
Visual 4: Advanced Results Interpretation

- The earthquake, tsunami and hurricane models calculate damage state probabilities
- Each of the four damage states are based on the ground shaking (EQ), windspeeds (HU), or momentum flux (TS)



Visual 5: Advanced Results Interpretation

- Earthquake and tsunami loss is calculated using damage state and economic loss table values
- Tables are provided for structural, non-structural (acceleration sensitive) and non-structural (drift sensitive)



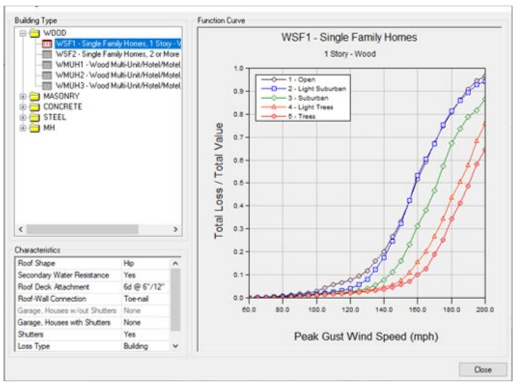
	Occupancy	Slight	Moderate	Extensive	Complete
1	AGR1	0.8	4.6	23.1	46.2
2	COM1	0.6	2.9	14.7	29.4
3	COM10	1.3	6.1	30.4	60.9
4	COM2	0.6	3.2	16.2	32.4
5	COM3	0.3	1.6	8.1	16.2
6	COM4	0.4	1.9	9.6	19.2
7	COM5	0.3	1.4	6.9	13.8
8	COM6	0.2	1.4	7.0	14.0
9	COM7	0.3	1.4	7.2	14.4
10	COM8	0.2	1.0	5.0	10.0
11	COM9	0.3	1.2	6.1	12.2
12	EDU1	0.4	1.9	9.5	18.9

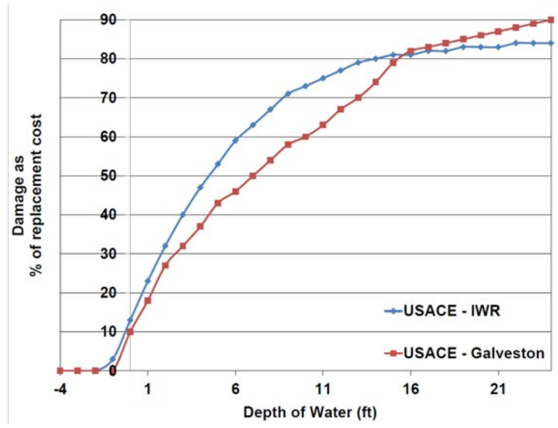
	Occupancy	Slight	Moderate	Extensive	Complete
1	AGR1	0.8	4.6	13.8	46.1
2	COM1	0.8	4.4	12.9	43.1
3	COM10	0.3	2.2	6.5	21.7
4	COM2	0.8	4.2	12.4	41.1
5	COM3	1.0	5.0	15.0	50.0
6	COM4	0.9	4.8	14.4	47.9
7	COM5	1.0	5.2	15.5	51.7
8	COM6	1.0	5.1	15.4	51.3
9	COM7	1.0	5.2	15.3	51.2
10	COM8	1.1	5.4	16.3	54.4
11	COM9	1.0	5.3	15.8	52.7
12	EDU1	0.7	3.2	9.7	32.4

	Occupancy	Slight	Moderate	Extensive	Complete
1	AGR1	0.0	0.8	3.8	7.7
2	COM1	0.6	2.7	13.8	27.5
3	COM10	0.4	1.7	8.7	17.4
4	COM2	0.6	2.6	13.2	26.5
5	COM3	0.7	3.4	16.9	33.8
6	COM4	0.7	3.3	16.4	32.9
7	COM5	0.7	3.4	17.2	34.5
8	COM6	0.8	3.5	17.4	34.7
9	COM7	0.7	3.4	17.2	34.4
10	COM8	0.7	3.6	17.8	35.6
11	COM9	0.7	3.5	17.6	35.1
12	EDU1	0.9	4.9	24.3	48.7

Visual 6: Advanced Results Interpretation

- Hurricane uses a loss function and flood uses a depth damage function for loss
- Flood Loss = Damage x Replacement Cost





Visual 7: Sources of Uncertainty

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

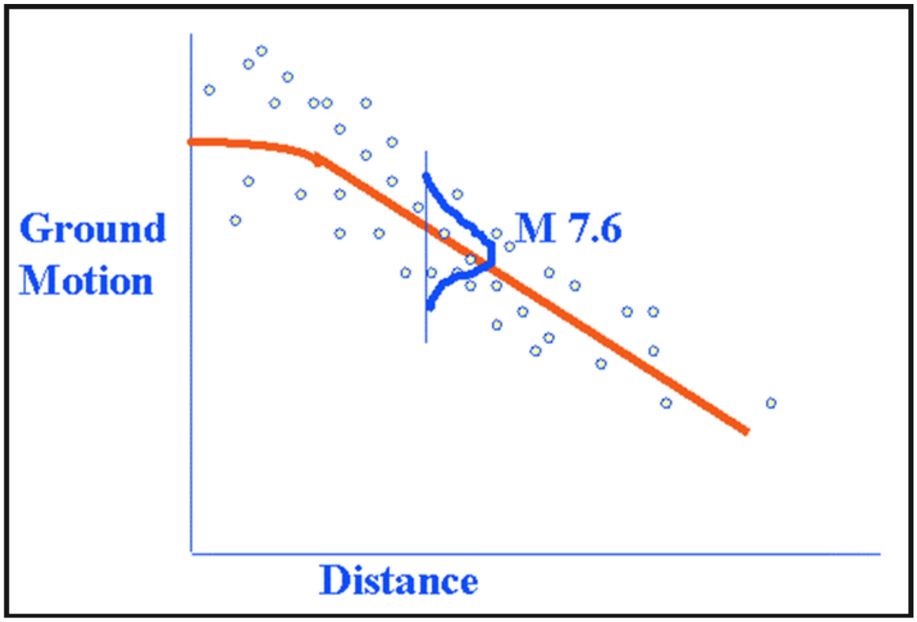
Visual 8: Sources of Uncertainty (Cont'd.)

Modelling assumptions

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

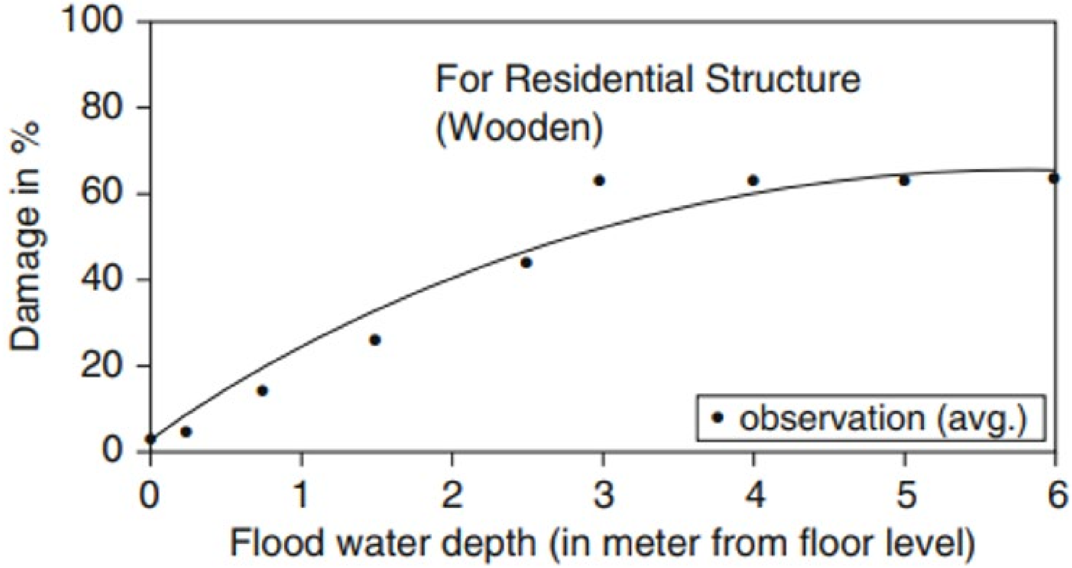
Empirical approach

- Ground motion computation
- Damage models



Simplified example of an attenuation function

Visual 9: Sources of Uncertainty (Cont'd.)



Visual 10: Sources of Uncertainty

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

Interpretation

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

Incidental errors

- Assigning wrong projection system for GIS data

Visual 11: Treatment of Uncertainties

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

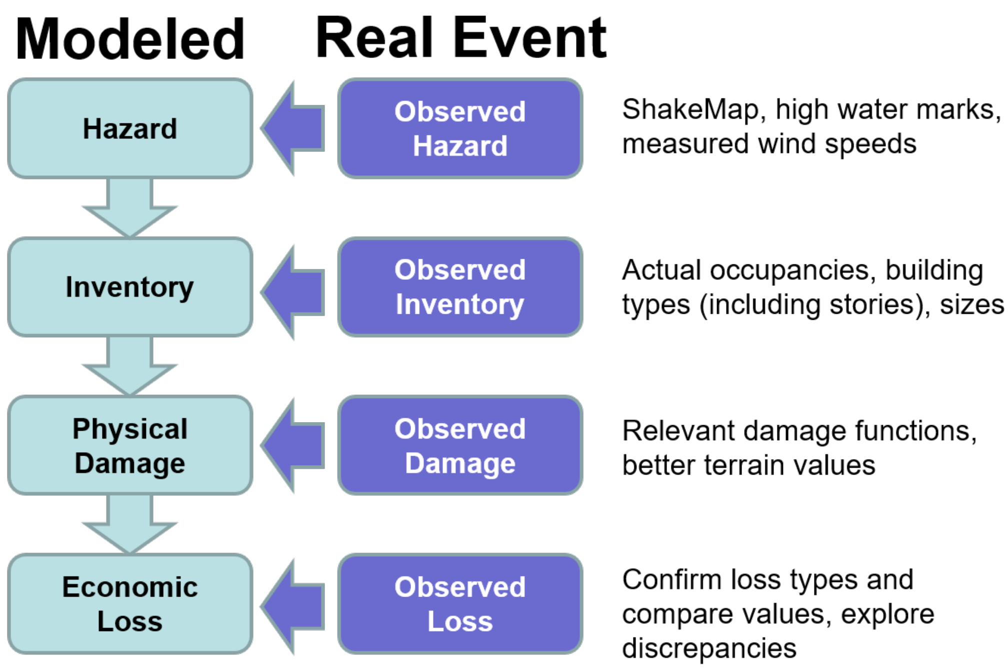
Variability of models is best evaluated by conducting multiple sensitivity analyses.

- Use different attenuation functions
- Use different damage functions
- Use different parameters (Lesson 9)
- Use different hazard data – soils, terrain, etc

Visual 12: Treatment of Uncertainties (Cont'd.)

- Understand the dependency of modules and parameters
- Enhance inventory data
- Replace predicted hazard with observed hazard – ShakeMap, flood inundation, wind speeds

Visual 13: Uncertainty – Validation Study



Visual 14: Outputs

- Any mapped layer can be exported as a shapefile or geodatabase feature class
- Output file types: feature class, table, database, shapefile, raster
- Geodatabases: store multiple feature classes
- Shapefiles must be zipped before you can send it
- HPRs: include SQL tables and hazard datasets
  - If you do not have Hazus you can still view HPRs in ArcMap
  - Change HPR to zip file and connect to SQL

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Outputs

Packaging Data

- Output file types: feature class, table, database, shapefile, raster
- Geodatabases: store multiple feature classes
- Shapefiles must be zipped before you can send it
- HPRs: include SQL tables and hazard datasets
  - If you do not have Hazus you can still view HPRs in ArcMap
  - Change HPR to zip file and connect to SQL

Visual 15: Enhanced Results – Building Tags

- Converting damage from Hazus analysis into a building tag as defined by ATC-20
- Using FEMA's SOP for Hazus Earthquake Data Preparation and Scenario Analysis (2019)
- Estimating inspection needs

Visual 16: Enhanced Results – Building Tags

- Map damage state by count
- Categorize:
    - Green Tag – Sum of slight and moderate damage states
    - Yellow Tag – Sum of extensive damage state
    - Red Tag – Sum of complete damage state

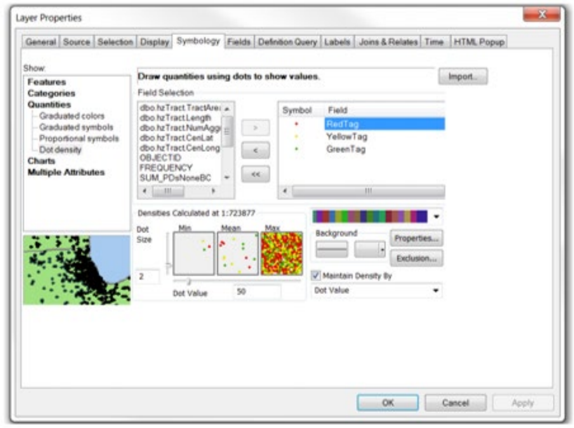
Visual 17: Enhanced Results – Building Tags

- Change symbology to dot density
- Determine how many inspectors are needed assuming the following number of inspectors are required per day:

10 for red tagged

5 for yellow tagged

10 for green tagged



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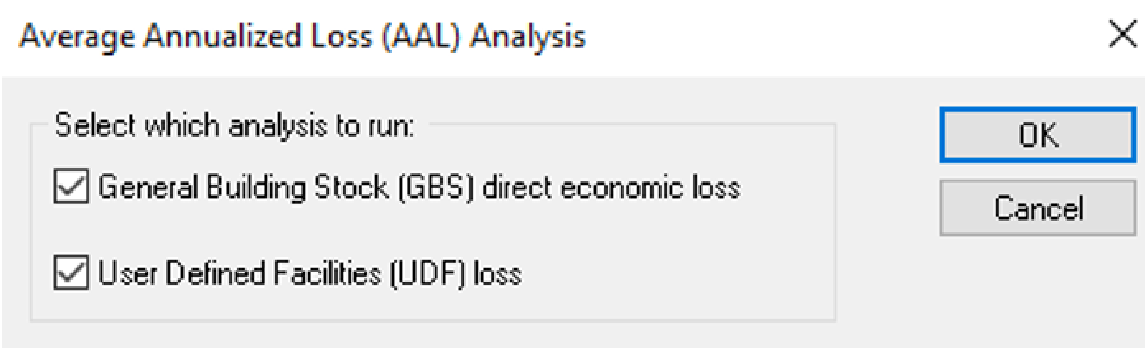
Enhanced Results – Building Tags

[Standard Operating Procedure](https://www.fema.gov/media-library-data/1560288412257-a04f79331bc4d9dec3bf49420769e7bb/SOPfortheCreationofHazusEarthquakeScenarioPriorityMaps.pdf) (https://www.fema.gov/media-library-data/1560288412257-a04f79331bc4d9dec3bf49420769e7bb/SOPfortheCreationofHazusEarthquakeScenarioPriorityMaps.pdf)

Visual 18: Enhanced Results – AAL Analysis

- Using the flood model to calculate AAL for UDF
- Calculating annualized earthquake loss using AEBM

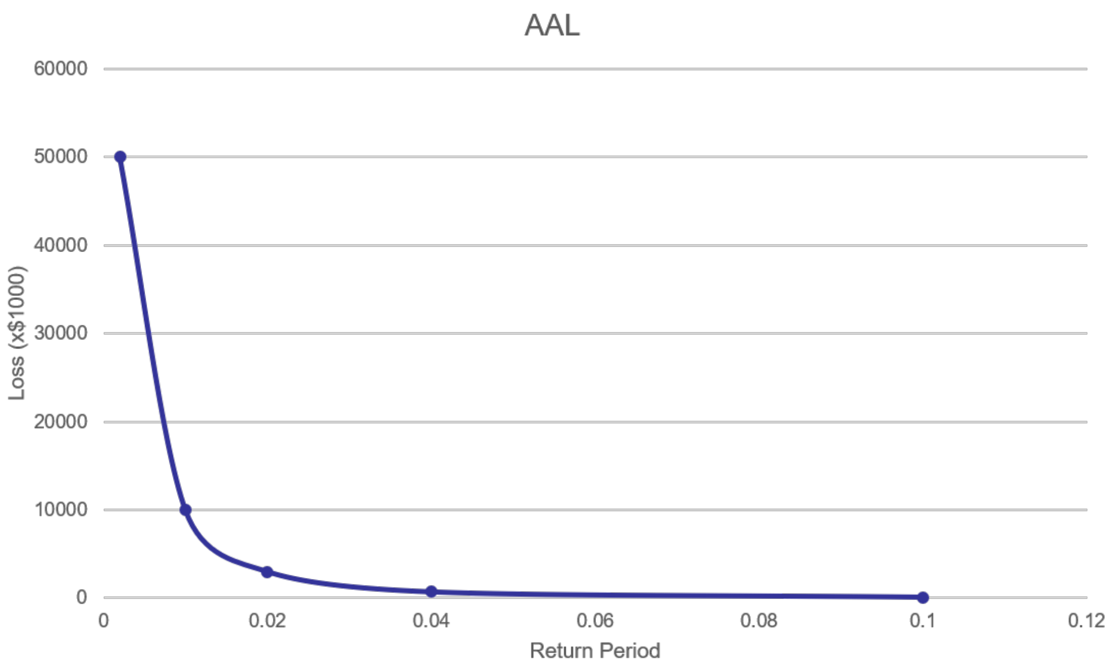


Visual 19: Enhanced Results – AAL Analysis

- Using Hazus to calculate UDF loss at site level for flood
- Running the flood, hurricane, or earthquake loss outside of Hazus and incorporating business interruption for commercial and industrial buildings in an Excel tool
- Using AEBM losses to determine AAL in an Excel tool

Visual 20: Enhanced Results – AAL Analysis

- Flood AAL = (f10-f25)*((L10+L25)/2) + (f25-f50)*((L25+L50)/2) + (f50-f100)*((L50+L100)/2) + (f100-f500)*((L100+L500)/2) + f500*L500
- Flood AAL = 0.030L10 + 0.040L25 + 0.015L50 + 0.009L100 + 0.006L500



Visual 21: Enhanced Results – Mitigation

What can Hazus do?

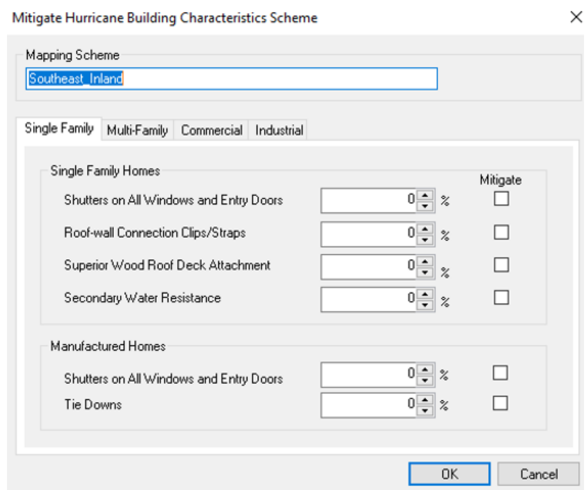
- Compute benefits as part of cost-effectiveness studies
- Identify sources of vulnerability in the infrastructure
- Model effects of future land use & development trends
- Assess preparedness levels
- Evaluate and prioritize different mitigation alternatives

Several mitigation actions clearly supported:

- Building code regulations and enforcement
- Land use regulations and planning
- Building upgrades - strengthening, retrofitting, remodeling, elevating, and/or hardening of targeted buildings
- Buyouts

Visual 22: Enhanced Results - Mitigation

- Calculating losses avoided
- Implementing mitigation actions in Hazus
- Evaluating other considerations



Visual 23: Enhanced Results – Benefit Cost Analysis

- Run analysis - AAL
- Implement mitigation in model and rerun AAL to get loss avoidance
- Calculate total benefits using annual economic benefits, project lifespan, and discount rate
- Determine cost of mitigation – upfront costs and maintenance
- Calculate benefit cost ratio
- Assess other multi-criteria considerations

Visual 24: Enhanced Results - Communication

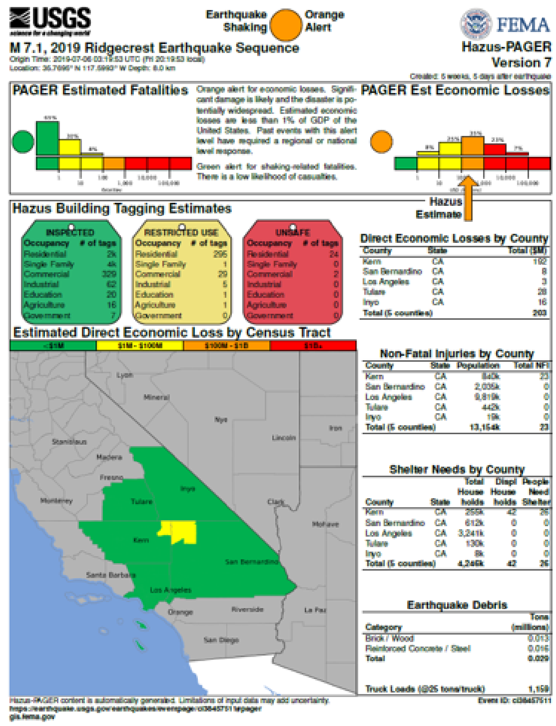
- Knowing your audience
- Using Hazus results in a familiar format
- Normalizing results
- Exploring different ways to express results

Visual 25: Communicating Results - Audience

- Describe results in non-technical language that is easily understood by the intended audience
- Format will depend on the use of the results and the intended audience (tables, maps, talking points, etc.)
- The users of the results should be involved from the beginning in determining the types and formats of the results that best suit their needs

Visual 26: Communicating Results - Narrative

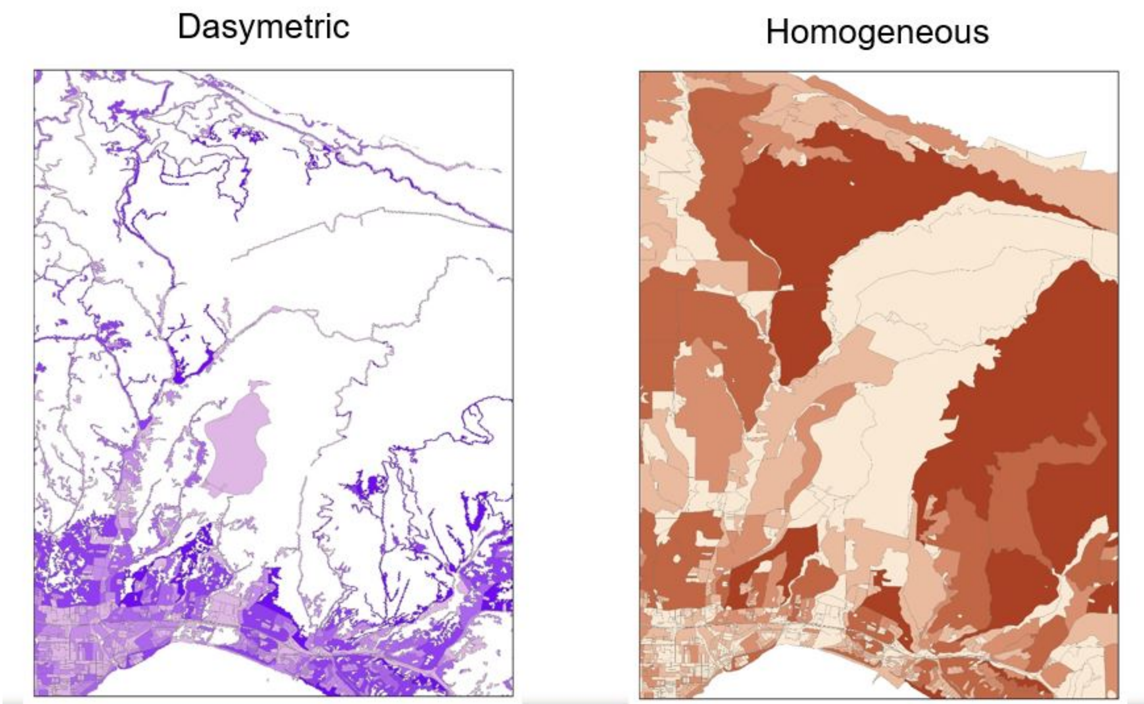
- Hazus 2PAGER generated by USGS and FEMA to quickly communicate earthquake risk
- Combination of maps and tables



Visual 27: Communicating Results - Blocks

- Flood census block results are provided using dasymetric block geometries these can be very small and difficult to see.
- Homogeneous census blocks are provided in the SQL database and can be used to display data (hzCensusBlock_TIGER).
- Advanced application will transfer results from dasymetric to homogeneous census blocks.

Visual 28: Communicating Results - Blocks



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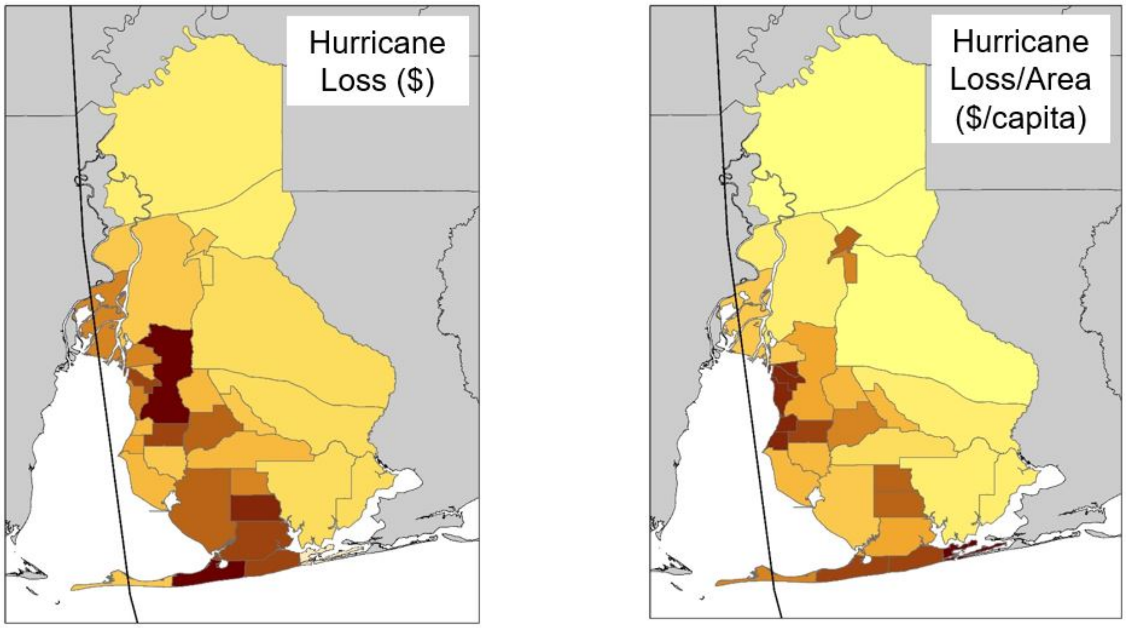
Communicating Results - Blocks

This map shows Humboldt County, California which has several rural areas. The white areas on the left are unpopulated.

Visual 29: Communicating Results - Normalizing



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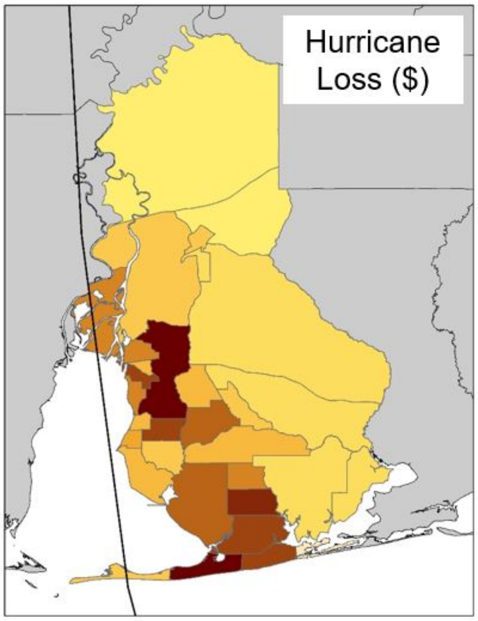
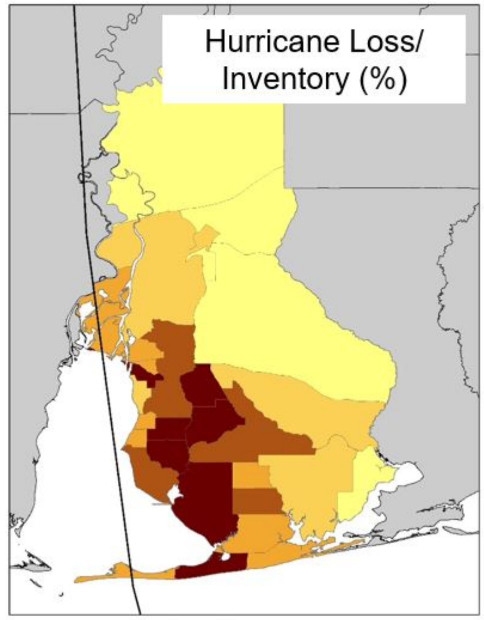
Communicating Results - Normalizing

These two maps show a probabilistic 500-year hurricane moving through Baldwin County, Alabama. The map on the left shows the loss value in dollars, while the middle shows the loss value divided by the census tract population.

Visual 30: Communicating Results - Normalizing





Student Manual

Communicating Results - Normalizing

These two maps show a probabilistic 500-year hurricane moving through Baldwin County, Alabama. The map on the left shows the loss value in dollars, while the map on the right shows the loss divided by the inventory which is the loss ratio (%).

Visual 31: Communicating Results

- Provide results as rounded numbers – not exact numbers
- Provide results as ranges (consider bracketing)
- Include a disclaimer
- Use different symbology – charts, proportional symbols, dot density, transparency, etc.

Visual 32: Exercise 10.1: Enhanced Results and Applications

- Goal: Select one of the advanced products to create and present to the class
- Time: 60 minutes

Student Manual

Exercise 10.1 Enhanced Results and Applications

Goal: Select one of the advanced products to create and present to the class

Time: 60 minutes

Exercise Steps:

1. Refer to Activities Document “10.1_Exercise_EnhancedResults".
2. Listen to instructor’s directions.
3. Ask questions if clarification is needed.
4. Work individually on the goal.
5. Ask questions to the instructor if needed.
6. Complete the assigned goal.
7. Be prepared to share your answers/results.
8. Ask any final questions.

Visual 33: Exercise 10.1: Tasks

- Task 1: Create at least one advanced product
- Task 2: Develop maps and tables for your selected audience

Student Manual

Exercise 10.1: Tasks

Refer to Activities Document "10.1_Exercise_EnhancedResults".

Exercise 10.1: Enhanced Results and Applications

Type: Activity

Time: 90 minutes for all results applications

Goals:

- Identify and create an advanced product
  - Application 1: How do I map predicted building tags for an event?
  - Application 2: How do I use Hazus to assess another hazard?
  - Application 3: How do I conduct an average annual loss (AAL) analysis for my community?
  - Application 4: How do I use Hazus to model mitigation?
- Develop a focused one-page narrative for your target audience

Background: This activity will help you identify and implement an advanced product and develop material for your target audience. You can choose any of the hazards for these products. Also, feel free to integrate any of the inventory and parameter updates finished earlier in the class. In the first task, the four advanced applications will be provided to you and you'll select the one (or more) that would be most beneficial to your community. If you finish the first application and still have time, feel free to work through another application. Approximate times have been provided for each application so just be aware of the time allotted for each activity. Data has been provided for Santa Cruz, California and Virginia Beach, Virginia but you may use your own study region for the capstone presentation.

Before you Begin: Identify an Appropriate Advanced Hazard Product

There are four advanced results applications and resulting products to select from in this activity. Select the one that is most beneficial to your community:

Application 1: How do I map predicted building tags for an event?

This process involves running a deterministic analysis and using the Hazus output to determine whether a building is most likely to be assigned a green, yellow, or red tag. This process can be completed for any of the hazards. Follow Application 1 to implement this application.

- Data Required: None
- Time Required: 20-30 Minutes
- Difficulty Level: Easy

Application 2: How do I use Hazus to assess another hazard?

This process will walk you through completing an exposure analysis for landslides resulting from flood using the Hazus inventory. Follow Application 2 to implement this application.

- Data Required: Hazard map
- Time Required: 20-30 Minutes
- Difficulty Level: Easy - Moderate

Application 3: How do I conduct an average annual loss (AAL) analysis for my community?

This process will walk you through conducting an AAL using general building stock and site level data (when available). This process is for earthquake, hurricane, and flood hazards. Additional directions will be provided for site specific AAL analysis. Additionally, Application 4 may be completed at the same time. This will better explain how the AAL can support mitigation. Follow Application 3 to implement this application.

- Data Required: Flood (depth grids for five different return periods), UDF for flood site level analysis, and AEBM for earthquake site level analysis.
- Time Required: 45-60 Minutes
- Difficulty Level: Easy (GBS) – Hard (Site-Level)

Application 4: How do I use Hazus to model mitigation?

This process will take you through integrating common mitigation practices into Hazus for all four hazards. This process may be conducted with Application 3. If you want to do that, start with 3 and finish with 4. Follow Application 4 to implement this application.

- Data Required: None
- Time Required: 20-30 Minutes
- Difficulty Level: Moderate

Once you have chosen an Application, navigate to that section and begin the activity.

Application 1: How do I map predicted building tags for an event?

Task 1: Identify and create an advanced product

For this process, you'll need a hazard event. This could be a hurricane, flood, earthquake, or tsunami but it should be a deterministic event. You may use this process for a hazard event as it unfolds or to plan for a future event.

1. Run the deterministic analysis in Hazus and make sure there are results. Map the damage state probabilities according to the directions below.

- **Hurricane:** Go to Results, General Building Stock, Building Damage Counts, by Occupancy. When the menu comes up, select All Occupancies and select the Minor column and click Map. Then Close.
- **Flood:** Go to Results, General Building Stock, and by Count. When the menu comes up, select the Total tab, and total of pre- and post-firm structures. Then click the total buildings column and select Map then Close.
- **Earthquake:** Go to Results, General Building Stock, Damage by Count, click on the Total tab, click on Slight and Map. Then Close. Do the same process but click Moderate, then Extensive, and Complete. There should be four layers mapped at the end of this process.
- **Tsunami:** Go to Results, General Building Stock, Damage by Count, click on the By General Occupancy tab, select Total next to table type, then click on Moderate and Map. Then Close.

2. Export the layer(s) and format the fields.

- **Hurricane:** Right click the new layer and export data as: C:\E0177\Activity\10.1\Tags.shp. Add the layer to the map. Open the attribute table and add three new fields called: Green_Tag, Yellow_Tag, and Red_Tag with a data type of short integer. Use the Field Calculator to make the Green_Tag equal to the Minor+Moderate fields, make the Yellow_Tag field equal to the Severe field, and make the Red_Tag field equal to the Complete field. Close the attribute table.

- **Flood:** Right click the new layer and export data as: C:\E0177\Activity\10.1\Tags.shp. Add the layer to the map. Open the attribute table and add three new fields called: Green_Tag, Yellow_Tag, and Red_Tag with a data type of short integer. Use the Field Calculator to make the Green_Tag equal to the PctDmg1to1+PctDmg11to fields, make the Yellow_Tag field equal to the PctDmg21to+PctDmg31+PctDmg41+PctDmg51+ PctDmg61+PctDmg71+PctDmg81 fields, and make the Red_Tag field equal to the PctDmg91to field. Close the attribute table.
- **Earthquake:** Right click the first new layer and export data as: C:\E0177\Activity\10.1\Tags1.shp. Then export the other three as: Tags2.shp, Tags3.shp, and Tags4.shp. Add the layers to the map and remove the Hazus-generated damage state layers. Right click on the Tags layer and Join it to Tags2 using the Census Tract field, then join it to Tags3 and Tags4. Export the joined layer as Tags.shp. Open the attribute table of Tags.shp and add three new fields called: Green_Tag, Yellow_Tag, and Red_Tag with a data type of short integer. Use the Field Calculator to make the Green_Tag equal to the PDsSlightB + PDsModerat fields, make the Yellow_Tag field equal to the PDsExtensi field, and make the Red_Tag field equal to the PDsComplet field. Close the attribute table.
- **Tsunami:** Right click the new layer and export data as: C:\E0177\Activity\10.1\Tags.shp. Add the layer to the map. Open the attribute table and add three new fields called: Green_Tag, Yellow_Tag, and Red_Tag with a data type of short integer. Use the Field Calculator to make the Green_Tag equal to the Moderate field, make the Yellow_Tag field equal to the Extensive field, and make the Red_Tag field equal to the Complete field. Close the attribute table.

3. Symbolize the data. For all hazards, right click on the layer and select properties at the bottom. Select the Symbology tab. Click Quantities on the left and Dot density. In the Field Selection, select Green_Tag, Yellow_Tag, and Red_Tag. Click on the Green_Tag symbol and make it green, make the other two colors match their tag color. Click OK to go back to the map. If the dots are too small or the dot to structure value too small or big, come back to this screen to edit those values.

4. Calculate how many inspectors are required if the community has 30 days to do inspections. Each inspector can complete 10 red- and green-tagged buildings per day while only 5 yellow-tagged buildings can be inspected.

Task 2: Develop a focused one-page narrative for your target audience

For this task, the object is to create a one-pager containing map(s), table(s), text, images, and whatever other media should be included to get your point across to your audience. Think about how the USGS and FEMA created the Hazus 2PAGER for a specific target audience. Your audience is going to determine how you present your information, the mapping, the data, and the message.

Here are a few things to consider:

- Normalize your data. Take the results and divide those results by the amount of inventory or population or area. This will give your audience a better sense for the loss results. This can be accomplished by joining layers to each other. The results may be joined to the inventory using the Census Tract or Census Block ID. Make sure your normalizing by the correct value. If you're showing building and content results make sure you divide by both building and contents and not just building.
- Show the results using the Homogenous data (TIGER Census Blocks). The CensusBlock_TIGER data is provided at the State and study region level. If it is difficult to see the dasymetric Census Blocks at the County level, transfer the results to the TIGER data. Add hzCensusBlock_TIGER from the statewide inventory database to the map and join it to your results, and then export as a separate layer.
- Round off your results. Hazus provides a very high level of precision when creating results and this level of precision is not needed when creating your maps.
- Understand your units of measure. When you export results, remember the units and add that data into the title of the layer if it's not already there.

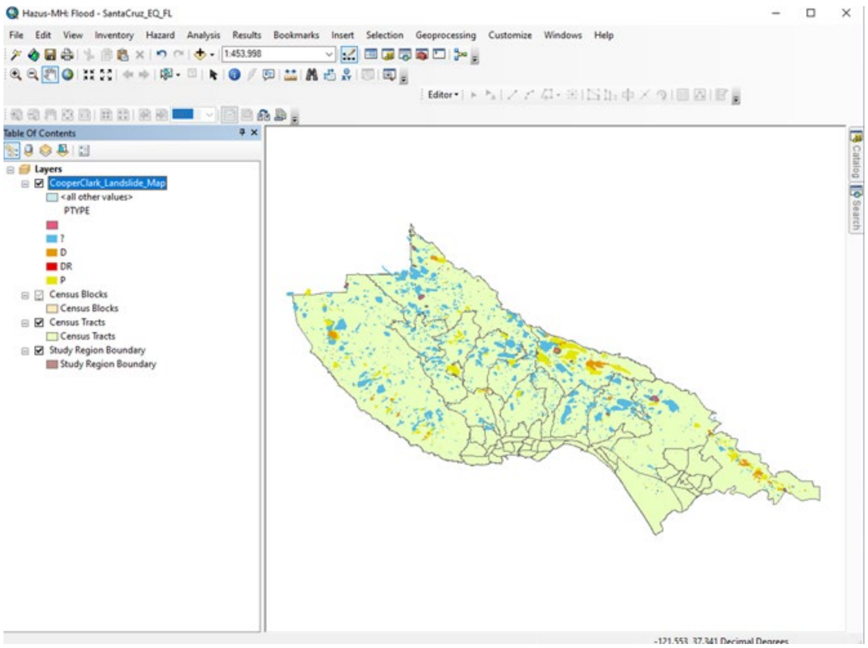
Application 2: How do I use Hazus to assess another hazard?

Task 1: Identify and create an advanced product

For this process, you'll need a hazard map. The example provided below involves using a local landslide map to identify landslide exposure resulting from flooding. However, any hazard map may be used. Hazards which cover the entire area should not be used since the exposure would be 100% of the community.

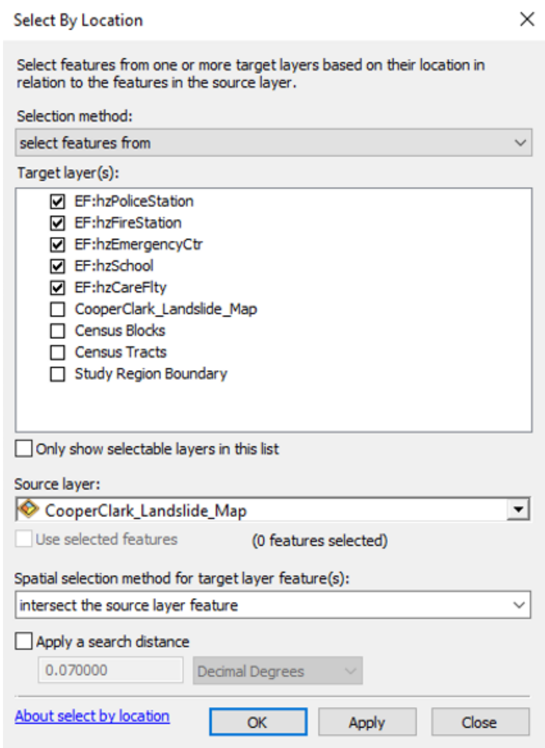
1. Create a flood study region for the analysis. Since the flood general building stock inventory is aggregated at the Census Block level and not the Census Tract level, it will have a better resolution. For the example, Santa Cruz, California will be created.

2. Open the study region and add the following data: C:\E0177\Activity\10.1\CooperClark_Landslide_Map.shp. This hazard map was downloaded from the Santa Cruz GIS website: http://www.co.santa-cruz.ca.us/default.aspx?tabid=93 and metadata: https://gis.santacruzcounty.us/arcserver/rest/services/opendata/MapServer/138. There is a field in the data called Ptype and the metadata defines the values (as does the last field). D is definite landslide deposit, DR is definite rapid landslide deposit, P is probable landslide deposit, ? is questionable landslide deposit, and a blank is unattributed landslide deposit.



Santa Cruz flood study region with landslide data

3. Map the essential facilities. Then run a Selection by Location. For Selection method, use select features from; for target layer(s), select EF:hzPoliceStation, EF:hzFireStation, EF:hzEmergencyCtr, EF:hzSchool, and EF:hzCareFlty. Under source layer, select CooperClark_Landslide_Map and under Spatial selection method, select Intersect the source layer feature. Click OK.



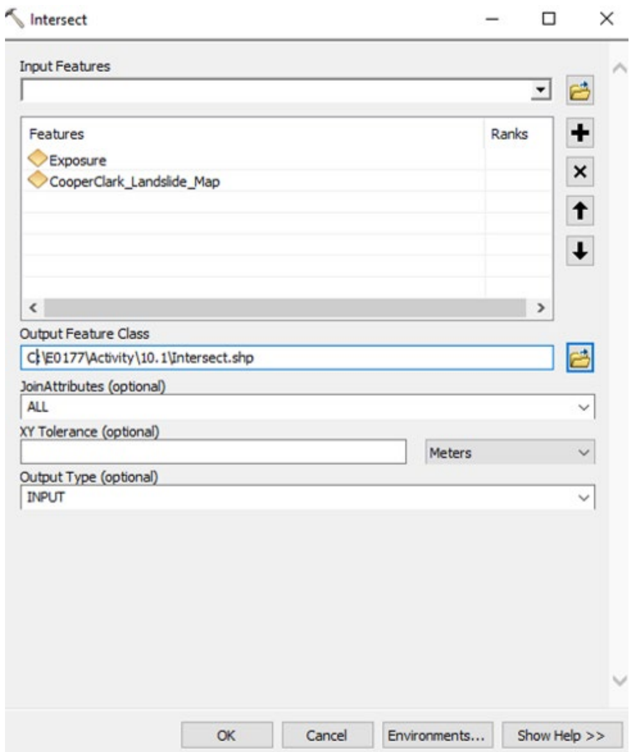
Identifying the essential facilities in the landslide zone

4. The query brings back that two schools fall within the landslide zone: Scotts Valley High and Tara Redwood School. They both fall within the questionable landslide deposit area. Remove the essential facility layers. Now complete the same process with the utilities. Do any utilities reside in the landslide zones? For Santa Cruz, there are none.

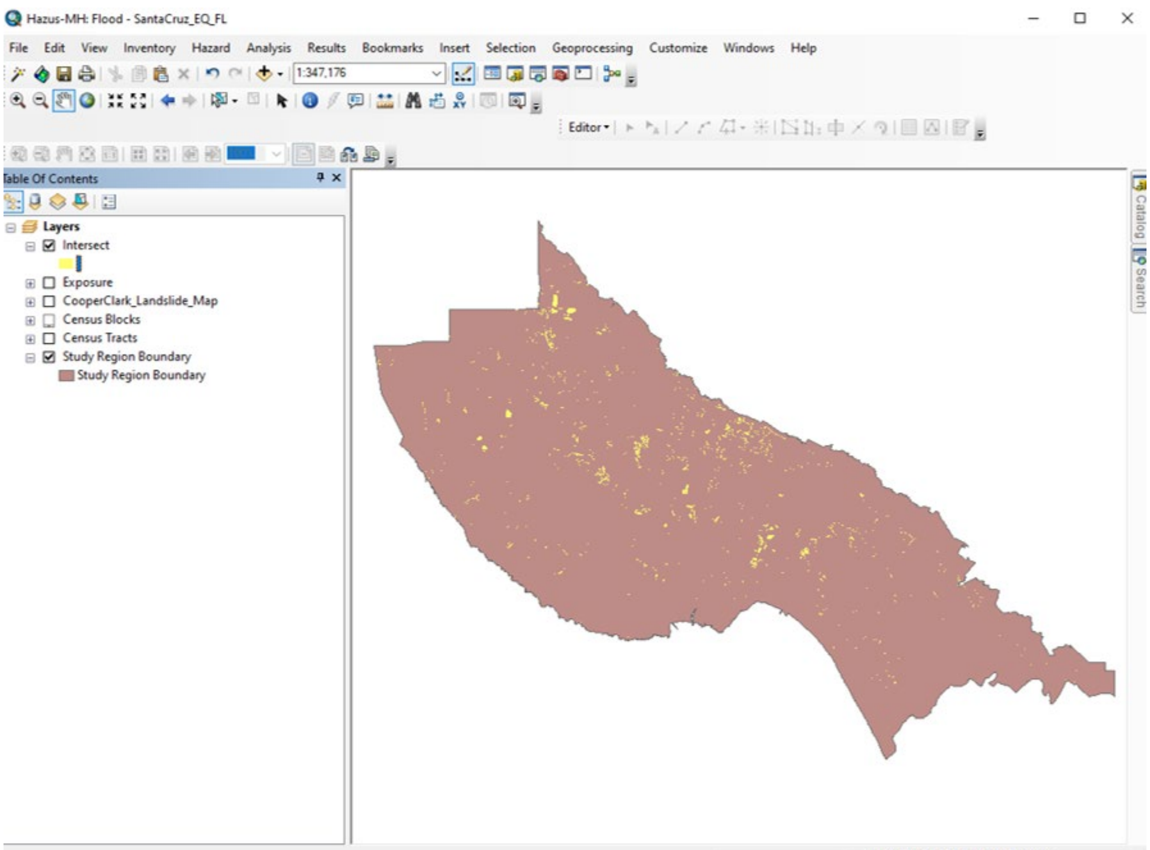
5. Assess the general building stock. Go to Inventory, then General Building Stock and Dollar Exposure. For the Occupancy tab, select General Occupancy Type, and under Building use Total. Map the total exposure column. Close the menu. Export the total exposure layer as: C:\E0177\Activity\10.1\Exposure.shp. Add it to the map and remove the Hazus generated layer.

6. Right click in the map and select Data Frame Properties. Then click Coordinate System and change the coordinate system to: WGS_1984_UTM_Zone_10N. Then click OK. Open the Exposure layer's attribute table. Right click on the BlockArea field and use Calculate Geometry to determine the area in square feet US. Go to ArcToolbox, then Analysis Tools, Overlay, and double click Intersect. For the Input Features, select Exposure and CooperClark_Landslide_Map and for the Output Feature Class, select: C:\E0177\Activity\10.1\Intersect.shp. Then click OK.

Note: Santa Cruz provides building footprints on their County GIS website. For a better analysis, use the building footprints to create dasymetric Census Block data as described in the Lesson 4 activity.

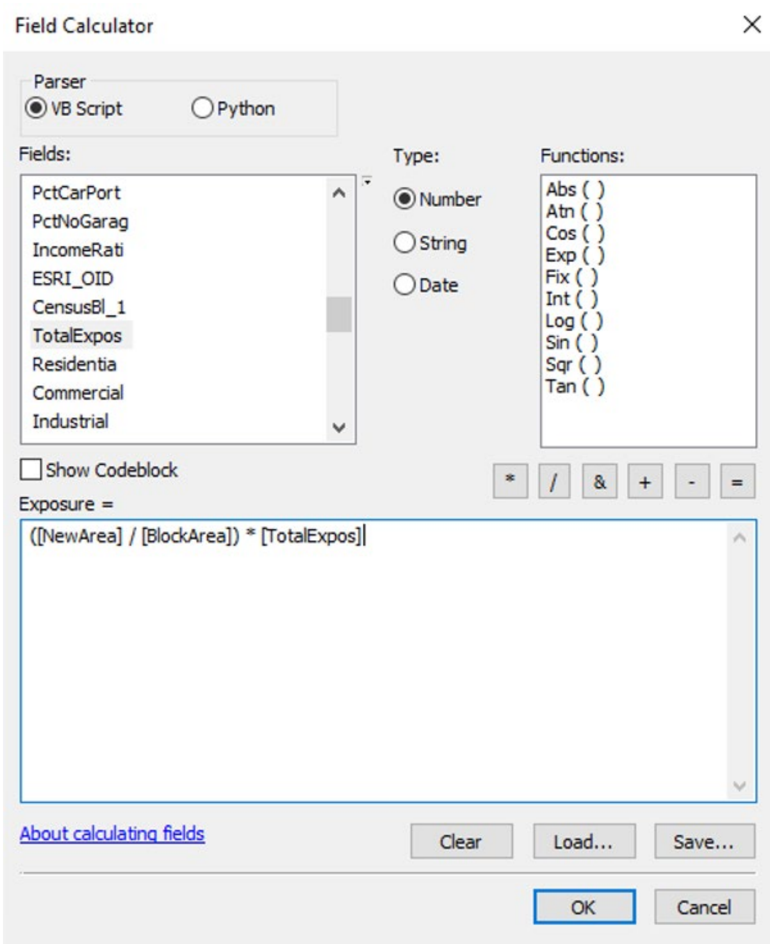


Intersecting the exposure with the landslide data



Exposure which falls in the landslide hazard areas

7. Open the attribute layer of the new Intersect layer and create a new field called NewArea as a Double data type. Use the Calculate Geometry tool to determine the new area in square feet US. Then create a new field called Exposure with a Double data type. Use the Field Calculator tool to make Exposure = ([NewArea] / [BlockArea]) * [TotalExpos]. A similar calculation can be done for each general occupancy. Landslide Residential = ([NewArea] / [BlockArea]) * [Residentia], etc.



Using the Field Calculator tool to calculate exposure which falls in the landslide hazard areas

8. Go to ArcToolbox, then Data Management Tools, Generalization, and double click Dissolve. For the Input Features, select Intersect; for the Output Feature Class, select C:\E0177\Activity\10.1\LandslideExp.shp; for Dissolve_Field(s) select CensusBloc; and for the Statistics Field(s) select Exposure with a Statistic Type of Sum.

9. Change the symbology to a color scale. Compare the new exposed inventory with the total inventory and notice that 3-4% of the inventory for the County is exposed to landslide. Additional analysis could be conducted to determine how much inventory is exposed to Definite Deposits and Definite Rapid Deposits. To do that just go back to the intersect layer and run a select by attributes query on the DR and D values. Then dissolve just those selected.

Task 2: Develop a focused one-page narrative for your target audience

For this task, the object is to create a one-pager containing map(s), table(s), text, images, and whatever other media should be included to get your point across to your audience. Think about how the USGS and FEMA created the Hazus 2PAGER for a specific target audience. Your audience is going to determine how you present your information, the mapping, the data, and the message.

Here are a few things to consider:

- Normalize your data. Take the results and divide those results by the amount of inventory or population or area. This will give your audience a better sense for the loss results. This can be accomplished by joining layers to each other. The results may be joined to the inventory using the Census Tract or Census Block ID. Make sure your normalizing by the correct value. If you're showing building and content results make sure you divide by both building and contents and not just building.
- Show the results using the Homogenous data (TIGER Census Blocks). The CensusBlock_TIGER data is provided at the State and study region level. If it is difficult to see the dasymetric Census Blocks at the County level, transfer the results to the TIGER data. Add hzCensusBlock_TIGER from the statewide inventory database to the map and join it to your results, and then export as a separate layer.
- Round off your results. Hazus provides a very high level of precision when creating results and this level of precision is not needed when creating your maps.
- Understand your units of measure. When you export results, remember the units and add that data into the title of the layer if it's not already there.

Application 3: How do I conduct an average annual loss (AAL) analysis for my community?

Task 1: Identify and create an advanced product

This process involves running the full suite of return periods and calculating the AAL from those losses. Both general building stock and site-level analysis will be identified. Specifically, there will be a sub-process for:

1. Hurricane general building stock AAL analysis (this one may be carried into Application 4)
2. Flood general building stock AAL analysis
3. Earthquake general building stock analysis
4. Flood UDF AAL analysis (this one may be carried into Application 4)
5. Earthquake AEBM AAL analysis (this one may be carried into Application 4)

Sub-Process 1: Hurricane general building stock AAL analysis

1. Create a Virginia Beach, Virginia hurricane study region or create a hurricane study region of your choosing.

2. Run a probabilistic analysis. Go to Hazard, Scenario, Next, click Probabilistic and Next, then Next again and Finish. Go to Analysis and Run. Then click Run Analysis. This should take about 5 minutes to complete. Feel free to take a break at this time. Click OK when the Analysis Completed message comes up.

3. Go to Results, General Building Stock, and Building Economic Loss by Occupancy. There is a Return Period drop down menu with the seven return periods and the annualized option. Select Annualized, then click on the Total column and Map. Then close the menu.

4. Open the attribute table and see the values for total, building, content, inventory, relocation, income, rental, and wage. The values are in thousands of dollars.

Sub-Process 2: Flood general building stock AAL analysis

1. Create a Virginia Beach, Virginia flood study region or create a flood study region of your choosing. Keep in mind that the AAL analysis can take hours to run if you select the entire study region. The example below is a subset of the Virginia Beach, Virginia region.

2. Run a probabilistic analysis. Go to Hazard and Flood Hazard Type, then select Coastal only. For your own study region, feel free to select riverine or coastal or both. Click OK.

3. Go to Hazard and User Data. Then click on the Depth Grid tab. To make things fast, a set of depth grids covering one Virginia Beach neighborhood has been created ahead of time. If you don't have depth grids for all five return periods, you would need to generate them in Hazus which could take several hours. Click Browse and select each of the five depth grids found here: C:\E0177\Activity\10.1\10year_clip.img, then Set Parameters and assign a return period to each grid. Click Ok.

4. Go to Hazard, then Scenario and New. Call the new scenario AAL and click OK. Select Add to selection and select all the grids. Click Select All, then Select, then Save selection, and OK.

5. Go to Hazard, Coastal, and Delineate Floodplain. In the top dropdown menu for Analysis type, select Full Suite of Return Periods and OK. Click Yes when the warning message comes up. Then click OK when the processing is complete.

6. Go to Analysis and Run. Select General Building Stock Damage and Loss, then click OK.

7. After the processing is complete, click OK. Go to Analysis and Average Annualized Loss. Unselect User defined Facilities (UDF) loss and click OK.

8. Go to Results; View Current Scenario Results By; under Available Results, select Annual; and OK. Go to Results, General Building Stock, Economic Loss, and By Full Replacement. Select the Total tab on top. In the Pre- and Post-Firm dropdown, select Total. Then click the TotalLoss column and select Map and then Close.

9. Open the attribute table and see the values for total, building, content, inventory, relocation, income, rental, and wage. The values are in thousands of dollars.

Sub-Process 3: Earthquake general building stock AAL analysis

1. Create a Santa Cruz, California earthquake study region or create an earthquake study region of your choosing.

2. Run a probabilistic analysis. Go to Hazard, Scenario, Next, click Define a new scenario, Next, Probabilistic Hazard, Next, Annualized loss, Next, and name it AAL, then select Next and Finish. Go to Analysis and Run. Then select Buildings direct economic loss and OK.

3. Go to Results, General Building Stock, Building Economic Loss and Direct Economic Loss. Click on the Total tab, then scroll to the far right column, click Total Loss (thous. $), and Map. Then close the menu.

4. Open the attribute table and see the values for total. To get the building, content, inventory, relocation, income, rental, and wage losses each column will need to be mapped. The values are in thousands of dollars.

Sub-Process 4: Flood UDF AAL analysis

1. For this analysis, you will need UDF data. If you've already added UDF inventory to your state study region, you can skip to step 2. If you haven't, UDF data has been provided here: C:\E0177\Activity\10.1\Site_Level.gdb\UDF_VA_Beach_Neighborhood. Open ArcCatalog and browse to VA.dbo.hzUserDefinedFlty and right click on it. Select Load Data. Click Next when the Simple Data Loader menu comes up. Then browse to the UDF feature class here: C:\E0177\Activity\4.1\VirginiaBeach\ Site_Level.gdb\UDF_VA_Beach_Neighborhood. Then click Add. Then click Next. The next menu will show a box with the Target Fields on the left and Source Field on the right. Since the name and data type all match, everything should match up correctly. Click Next. Select Load all of the source data. Then select Next and Finish. Next, update the glUserDefinedFlty table. Right click on the table and follow the directions above on how to import the data.

2. Create a Virginia Beach, Virginia flood study region or create a flood study region of your choosing. Keep in mind that the AAL analysis can take hours to run if you select the entire study region. The example below is a subset of the Virginia Beach, Virginia region. Open the UDF in the inventory menu to make sure the UDF data is populated for the one neighborhood.

3. Run a probabilistic analysis. Go to Hazard and Flood Hazard Type, then select Coastal only. For your own study region, feel free to select riverine or coastal or both. Click OK.

4. Go to Hazard and User Data. Then click on the Depth Grid tab. To make things fast, a set of depth grids covering one Virginia Beach neighborhood has been created ahead of time. If you don't have depth grids for all five return periods, you would need to generate them in Hazus which could take several hours. Click Browse and select each of the five depth grids found here: C:\E0177\Activity\10.1\10year_clip.img, then Set Parameters and assign a return period to each grid. Click Ok.

5. Go to Hazard, then Scenario and New. Call the new scenario AAL and click OK. Select Add to selection and select all the grids. Click Select All, then Select, then Save selection, and OK.

6. Go to Hazard, Coastal, and Delineate Floodplain. In the top dropdown menu for Analysis type, select Full Suite of Return Periods and OK. Click Yes when the warning message comes up. Then click OK when the processing is complete.

7. Go to Analysis and Run. Select User Defined Structures, then click OK.

8. After the processing is complete, click OK. Go to Analysis and Average Annualized Loss. Unselect General Building Stock (GBS) direct economic loss and click OK.

9. Go to Results; View Current Scenario Results By; under Available Results, select Annual; and OK. Go to Results and User defined Facilities. Click the BldgLossUSD column and select Map and then Close.

10. Open the attribute table and see the values for building, content, and inventory. There are no values for relocation, income, rental, and wage. This is a limitation in the current methodology. The values provided are in thousands of dollars.

11. Right click on the UDF results layer and export as: C:\E0177\Activity\10.1\Flood_UDF_AAL.shp. Add it to the map and remove the UDF results layer that Hazus added.

12. Map the UDF results for each return period and export them out as: Flood_UDF_10yr.shp, Flood_UDF_25yr.shp, etc. Then add the five depth grids to the map.

13. Add the water depths to each of the UDF result layers except the AAL layer. In ArcToolbox, go to Spatial Analyst Tools, then Extraction, and then Extract Value from Points. For Input point features, use Flood_UDF_10yr; for input raster, use 10year_clip; for Output point features, use: C:\E0177\Activity\6.1\Flood_UDF_10yr_Wtr.shp. Then click OK. Add the depths to the other four return period UDFs using their corresponding depth grids.

14. Add the square footage values to the UDF Result layers. Go to inventory and map the UDF inventory. Export the Hazus generated inventory layer as: C:\E0177\Activity\6.1\UDF_Inventory.shp and add it to the map. Remove the Hazus-generated UDF Inventory layer. Right click on the Flood_UDF_10yr_Wtr layer and create a join to the UDF inventory using the UserDefine field and the UserDefine field. Keep all records. Add a field to the Flood_UDF_10yr_Wtr layer called SqFt and make it a Double data type. Used the Field Calculator tool to make the SqFt field equal to the [UDF_Inventory.Area] field. Close the attribute table and remove the join. Repeat this process for the other four UDF results layers.

15. Minimize Hazus and open the AAL UDF tool located here: E:\E0177\Activity\10.1\Flood_AAL_UDF_Tool. xlsx. Find the tab called 10yr. Minimize the tool and open Flood_UDF_10yr_Wtr.dbf in Excel. In the dbf file, copy V29 through A1. Go back into the AAL UDF tool and paste the values at the A1 cell in the 10yr tab. Complete this process for the four other return periods. Then open the Flood_UDF_AAL.dbf. Copy the area S550 to A1 and paste it into the A1 cell in the AAL tab of the UDF AAL tool. Columns T-Y will auto-populate with the business interruption and total values.

16. Save the AAL UDF tool and close it. If you want to bring the data back into ArcMap, join the UDF inventory to the tab desired using the UserDefinedID (called UserDefine) column in the spreadsheet.

Sub-Process 5: Earthquake AEBM AAL analysis

1. For this analysis, you will need AEBM data. If you've already added AEBM inventory to your state study region, you can skip to step 2. If you haven't, AEBM data has been provided here: C:\E0177\Activity\10.1\AEBM_Santa_Cruz.shp. Open CDMS and add the AEBM data to Santa Cruz, California. If you need information on how to do this, please review Activity 7 Application 3.

2. Create a Santa Cruz, California earthquake study region or create an earthquake study region of your choosing. Keep in mind that the AAL analysis can take several minutes to run if you select the entire study region. The example below is a subset of the Santa Cruz, California region. Open the AEBM in the inventory menu to make sure the AEBM data is populated for the one neighborhood.

3. Run a probabilistic analysis. Go to Hazard, Scenario, Next, click Define a new scenario, Next, Probabilistic Hazard, Next, 2500-year with 8.0 magnitude, Next, and name it 2500-year, then select Next and Finish. Go to Analysis and Run. Then select Advanced Engineering Bldg Mode, click OK, and then Yes.

4. Go to Results, Advanced Engineering Building Module (AEBM). Select the Total Economic Loss column and Map. Then close the menu. Export the layer as AEBM_2500yr.shp.

5. Run additional probabilistic analysis and export the AEBM files after completion:

- 2000-year at mag 7.6
- 1500-year at mag 7.3

- 1000-year at mag 7.1
- 50-year at mag 6.9
- 500-year at mag 6.7
- 250-year at mag 6.5
- 100-year at mag 6.3

6. Open the AEBM_AAL.xlsx file and then open the AEBM_100yr.dbf file in Excel and copy cells A1 to CB735. Then copy those cells to the 100yr tab at cell A1. Do the same thing for the other return period dbf files.

7. View the AAL tab, the AAL calculations are completed starting at V2 through AG2. This tab can be added to ArcMap by joining the eqAEBMID to the inventory or by mapping the latitude and longitude fields.

Task 2: Develop a focused one-page narrative for your target audience

For this task, the object is to create a one-pager containing map(s), table(s), text, images, and whatever other media should be included to get your point across to your audience. Think about how the USGS and FEMA created the Hazus 2PAGER for a specific target audience. Your audience is going to determine how you present your information, the mapping, the data, and the message.

Here are a few things to consider:

- Normalize your data. Take the results and divide those results by the amount of inventory or population or area. This will give your audience a better sense for the loss results. This can be accomplished by joining layers to each other. The results may be joined to the inventory using the Census Tract or Census Block ID. Make sure your normalizing by the correct value. If you're showing building and content results make sure you divide by both building and contents and not just building.
- Show the results using the Homogenous data (TIGER Census Blocks). The CensusBlock_TIGER data is provided at the State and study region level. If it is difficult to see the dasymetric Census Blocks at the County level, transfer the results to the TIGER data. Add hzCensusBlock_TIGER from the statewide inventory database to the map and join it to your results, and then export as a separate layer.
- Round off your results. Hazus provides a very high level of precision when creating results and this level of precision is not needed when creating your maps.
- Understand your units of measure. When you export results, remember the units and add that data into the title of the layer if it's not already there.

Application 4: How do I use Hazus to model mitigation?

Task 1: Identify and create an advanced product

This process involves modeling mitigation in Hazus and using the software to determine loss avoidance. Additional analysis will be completed to determine if mitigation is cost effective. There are examples for each hazard below.

Sub-Process 1: Hurricane mitigation

1. Create a new hurricane study region in Virginia Beach, Virginia. Open the region. If you completed Application 3, go straight to Step 5.

2. Run a probabilistic analysis. Go to Hazard, Scenario, Next, click Probabilistic and Next, then Next again and Finish. Go to Analysis and Run. Then click Run Analysis. This should take about 5 minutes to complete. Feel free to take a break at this time. Click OK when the Analysis Completed message comes up.

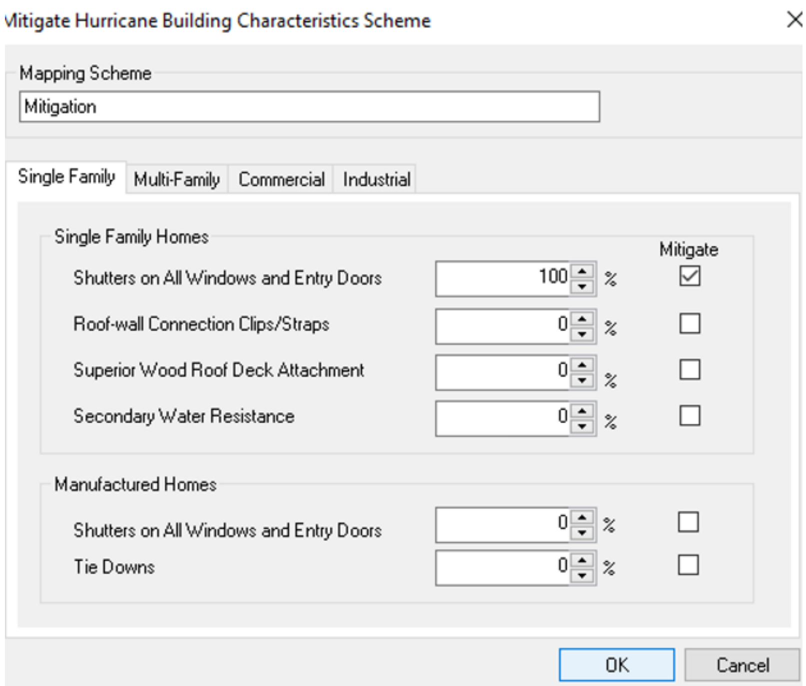
3. Go to Results, General Building Stock, and Building Economic Loss by Occupancy. There is a Return Period drop down menu with the seven return periods and the annualized option. Select Annualized, then click on the Total column and Map. Then close the menu.

4. Open the attribute table and see the values for total, building, content, inventory, relocation, income, rental, and wage. The values are in thousands of dollars.

5. Export the AAL economic loss as: C:\E0177\Activity\10.1\HU_AAL_Premitigation.shp.

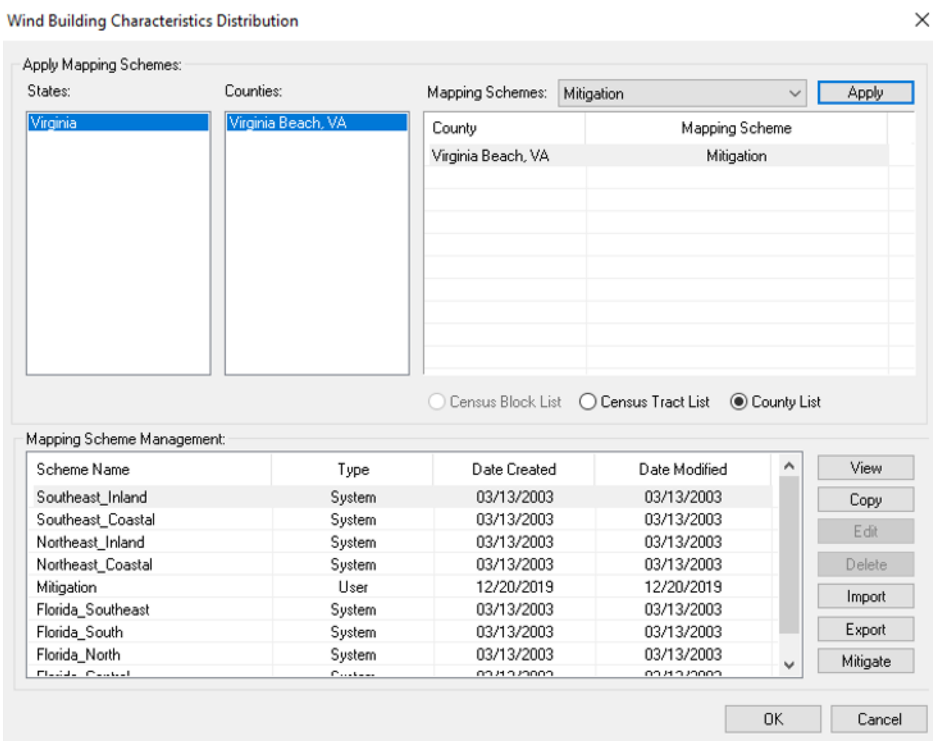
6. Identify and implement mitigation in Hazus. Go to Inventory, then General Building Stock, and Wind Building Characteristics. Under Mapping Scheme Management, select Northeast_Coastal and on the right and click View. Take a look at the single-family home characteristics. Click on the plus sign next to wood and masonry and look at the single-family home entries. There could be several updates – shuttering is only at 2%, there is no secondary water resistance, 60-61% have hurricane straps, and roof deck attachment could have larger nails and smaller spacing. Click Cancel. Some of these mitigation recommendations are more cost effective during construction or when the roof needs to be replaced.

7. Select Northeast_Coastal and on the right and click Copy. Name the new scheme mitigation and click OK. Then click on mitigation and select Mitigate on the right. Under the Single Family tab, enter 100% next to Shutters on All Windows and Entry Doors. Shuttering can be done after construction. Click on the Mitigate button on the right and then click OK at the bottom.



Modeling single family homes with shutters

8. Now assign the new mapping scheme to the entire study region. Under Counties at the top, click on Virginia Beach, VA then on the right side, click the County List button. Highlight the County and apply the mitigation scheme to it. Then click OK.



Assigning the new mapping scheme to the county

9. Run a probabilistic analysis. Go to Analysis and Run. Then click Run Analysis. This should take about 5 minutes to complete. Feel free to take a break at this time. Click OK when the Analysis Completed message comes up.

10. Go to Results, General Building Stock, and Building Economic Loss by Occupancy. There is a Return Period drop down menu with the seven return periods and the annualized option. Select Annualized, then click on the Total column and Map. Then close the menu.

11. Open the attribute table and see the values for total, building, content, inventory, relocation, income, rental, and wage. The values are in thousands of dollars. Export the AAL economic loss as: C:\E0177\Activity\10.1\HU_AAL_Postmitigation.shp.

12. Now determine if the mitigation is cost effective. Identify how many single-family homes are in the study region. Go to Inventory, then General Building Stock, and Building Count. Select By Occupancy and Number of Buildings By Specific Occupancy. Click on RES1, then Map and OK. Open the attribute table and count how many RES1 homes are located in the study region: 135,978. So, pre-mitigation numbers were 2% of 135,978 = 2,720 which means 133,258 homes were mitigated with shutters. Let’s assume it costs an average of $3,374 to add hurricane shutters to one home.

13. Calculate losses avoided. Join the pre- and post-mitigation layers together, add a LossAvoid column that has a double data type, and find the different between the two total loss values. This number is the losses avoided. Adding all the records together results in a benefit of $8,541,516. The cost to implement the mitigation will be assessed looking at the lifespan of the project and discount rate (7% for federal projects). The equation for Total Benefits = Annual Net Benefits x

(1 – (1 + r)-Lifespan)/r where r is the discount rate and lifespan is in years. This equation is also used to calculate present worth of annual maintenance costs. The discount rate reflects the time value of money. Benefits and costs are worth more if they are experienced sooner. All future benefits and costs, including nonmonetized benefits and costs, should be discounted. The higher the discount rate, the lower the present value of future cash flows. For typical investments, with costs concentrated in early periods and benefits following in later periods, raising the discount rate tends to reduce the net present value.

14. Determine cost effectiveness. Using a discount rate of 7% and a lifespan of 50 years, the total benefits = $8,541,516*(1-(1+.07)-50)/.07 = $8,541,516*(1-(.0339))/.07 = $117,885,123. The costs will be $3,374 x 133,258 = $449,612,492. The benefit cost ratio is 117885123/449612492 = 0.26. Since it is less than 1, it is not very cost effective.

15. Model other hurricane mitigation: hurricane straps can be installed for an entire house for $300 during construction. Secondary water resistance and larger/more nails also cost a fraction of the cost of shutters.

Sub-Process 2: Flood mitigation

1. This process requires that Application 3, Sub-process 4 be completed and AAL results have been calculated at the site level for UDF. Due to the nature of flooding, it is best to do a flood mitigation analysis at the site level. Review the results of the UDF AAL to identify a few structures which may need to be mitigated. There are a few options to consider:

- Buyout the property
- Elevate the property
- Dry flood-proofing
- Wet flood-proofing
- Others require changing the floodplain itself

2. Dry flood-proofing techniques are designed to prevent floodwater from entering a building. Measures include the protection of doors and other openings with permanent or removable flood shields by sealing walls with waterproof coatings, impermeable membranes or supplemental layers of masonry or concrete. Wet flood-proofing measures allow floodwater to enter a building but limit the damage to the structure and its contents. This minimizes the risk that the walls of the house will collapse due to hydrostatic pressure from rising floodwaters on the outside. Measures include building utility installations and high-value areas above flood levels, raising electrical sockets, fitting tiled floors so that the building can quickly be returned to use after the flood, and sealing walls with water-resistant building materials. Consider the costs associated with each mitigation. These are based on size of the building, foundation type, and local costs (contractors, permits, etc.). Figures are found in this publication (https://www.mdpi.com/2073-4441/10/11/1646/pdf).

- Elevating residential building (+2’): $33,239 – $82,498 • Elevating residential building (+4’): $35,464 – $87,535 • Elevating residential building (+6’): $37,319 – $91,732
- Buyout: Pre-flood market value (use Zillow or similar service)
- Dry flood-proofing (+2’): $8,290 – $13,690 (lifespan 20-30 years)
- Dry flood-proofing (+6’): $12,576 – $21,126 (lifespan 20-30 years)
- Wet flood-proofing (+2’): $2,151 – $4,869 (lifespan 20-30 years)
- Wet flood-proofing (+6’): $8,531 – $19,307 (lifespan 20-30 years)

3. Open Flood_AAL_UDF_Tool.xlsx and go to the AAL tab. Scroll over to the Total Loss column. These values are in dollars. The cost to implement the mitigation will be assessed looking at the lifespan of the project and discount rate (7% for federal projects). The equation for Total Benefits = Annual Net Benefits x (1 – (1 + r)-Lifespan)/r where r is the discount rate and lifespan is in years. This equation is also used to calculate present worth of annual maintenance costs. The discount rate reflects the time value of money. Benefits and costs are worth more if they are experienced sooner. All future benefits and costs, including nonmonetized benefits and costs, should be discounted. The higher the discount rate, the lower the present value of future cash flows. For typical investments, with costs concentrated in early periods and benefits following in later periods, raising the discount rate tends to reduce the net present value.

4. Determine cost effectiveness. For some of the flood mitigation, it's easy to determine losses avoided since the mitigation should reduce the loss to zero. Using a discount rate of 7% and a lifespan of 50 years for elevating the building, the total benefits need to equal about $40k, the cost of elevating the structure. So, working backwards: $40,000 = Annual Benefits*(1-(1+.07)-50)/.07 => Annual Benefits = $40,000/13.8 = $2,899. Scroll through the spreadsheet to identify any buildings that have sustained $3k or more in loss. Make sure to consider single-family homes and not larger apartments. Outbuildings/sheds can usually be moved so don't identify them either. One single family home which fits the criteria is UserDefineID: 241241.

5. Do the same exercise, but look at wet flood-proofing. $3,000 = Annual Benefits*(1-(1+.07)-25)/.07 => Annual Benefits = $3,000/11.65 = $258. When applying for grant money to mitigate, it's not enough just to show a break-even value. The benefit must be several times bigger than the cost. Buildings which sustained $1000 of AAL and have under 2' of floodwaters, would have a Benefit Cost Ratio of about 4. Again, look for residential buildings which may not be cost effective for elevation but could be very cost effective for flood-proofing. The single-family home with the UseDefineID of 241856 fits this criteria.

6. Identify and implement mitigation in Hazus. Go to Inventory and then User Defined Facilities. Scroll down until 241241 comes up. Double click in the FirstFloorHt column and type 7 which was selected after looking at the depth of flooding for the 500-year event (6.3'). Next, find 241856 and under FloodProtection, type 500. This building will be flood-proofed up to the 500-year event. Then click Close and save the edits. Running the AAL again, should results in no damage to those two buildings. Return to Process C if you've forgotten how to run an AAL. The address_point data found in Activity 4 also has appraised value which matches up well with Zillow for this community. This would give you information about the cost of a buyout. The other consideration for buyouts is what to do with the land once the City owns it.

Sub-Process 3: Earthquake mitigation

1. This process requires that Application 3, Sub-Process 5 be completed and AEBM AAL results have been calculated at the site level for AEBM. Open the study region and open the AEBM results in the AEBM_AAL tool.

2. Calculating the losses avoided will be a little different in earthquake than what was done in the flood model. Much of the flood mitigation resulted in zero loss after the event. For earthquake, there is probably going to be some loss after mitigation. This means that the AAL analysis will definitely need to be run twice, pre- and post-mitigation.

3. Calculating the cost to do a seismic retrofit which could include bolting the structure to the foundation; anchoring to the foundation; bracing the wall between the foundation and

floor/exterior walls; anchoring furniture, bookshelves, cabinets, and water heater tanks; installing reinforcing film on large, untampered windows; and rebuilding chimneys with a metal-wood chimney. More detailed techniques for seismic rehabilitation may be found in FEMA 547: https://www.fema.gov/media-library-data/20130726-1554-20490-7382/fema547.pdf. For the purpose of this exercise, make the following assumptions:

- RES1: $4k-$7k – assume $3.50/sqft for single family home
- RES3A: $4k-$10k
- RES3B: $7k-$15k
- RES3C: $20k-$40k
- RES3D: $45k-$80k
- RES3E: $82k-$120k
- RES3F: $250k-$350k

4. Open the Hazus study region that contains the AEBM inventory. Scroll through the ProfileNames and stop when you see low-code or pre-code buildings. For example, the profile: RES1RM1LLC0 is a RES1, Reinforced Masonry Low-Story, low-code building. To make it a high code building, change the LC to HC. Change the buildings with the IDs: CA000244 and CA000088 from LC to HC. Then save the AEBM table.

5. Copy the AEBM_AAL tool and call the copy AEBM_AAL_Mitigate. Rerun the AAL analysis for each return period and populate the new spreadsheet. Take the difference between the mitigated AAL and the unmitigated AAL. For CA000088, the difference is 7.881 which is $7,881 while CA000244 has a difference of $375.

6. These numbers are the losses avoided. The cost to implement the mitigation will be assessed looking at the lifespan of the project and discount rate (7% for federal projects). The equation for Total Benefits = Annual Net Benefits x (1 – (1 + r)-Lifespan)/r where r is the discount rate and lifespan is in years. This equation is also used to calculate present worth of annual maintenance costs. The discount rate reflects the time value of money. Benefits and costs are worth more if they are experienced sooner. All future benefits and costs, including nonmonetized benefits and costs, should be discounted. The higher the discount rate, the lower the present value of future cash flows. For typical investments, with costs concentrated in early periods and benefits following in later periods, raising the discount rate tends to reduce the net present value.

7. Determine cost effectiveness. Using a discount rate of 7% and a lifespan of 50 years, the total benefit (CA000088) = $7,881*(1-(1+.07)-50)/.07 = $7,881*(1-(.0339))/.07 = $108,764. The costs to upgrade a RES3C will be about $40,000. The benefit cost ratio is 108764/40000 = 2.72. Since it is greater than 1, it is cost effective. For CA000244: the total benefit = $375*(1-(1+.07)-50)/.07 = $375*(1-(.0339))/.07 = $5,175. $5,175 is also the cost to implement the retrofit but it isn't as cost effective as the retrofit for CA000088.

Sub-Process 4: Tsunami mitigation

1. Open the tsunami study region which was used in Activity 8.1. Make sure the general building stock results are populated.

2. Open ArcCatalog and create a connection to the SQL data for the study region you're using. Browse down to dbo.ts.NsiGbs and move this table to the map interface in Hazus. Open the table and notice that the tsunami model actually does the GBS modeling at the site level. There is a field for FirstFloorHt so the building could be elevated to account for mitigation.

3. The mitigation identified in the flood and earthquake models (Application 4, Sub-Process 2 and Application 4, Sub-Process 3) can also be used for the tsunami model since the fields are the same. It is probably easier to model the mitigation using UDFs. A UDF file could be generated with the dbo.ts.NsiGbs table since there is a latitude and longitude point. Follow the flood process to investigate that kind of mitigation and earthquake to investigate additional mitigation.

4. Another option for assessing mitigation in tsunami would be to review the casualty results and see how the casualties change for different levels of community preparedness. A benefit doesn't always have to be an economic benefit and these provide information on the social benefits of preparation.

Task 2: Develop a focused one-page narrative for your target audience

For this task, the object is to create a one-pager containing map(s), table(s), text, images, and whatever other media should be included to get your point across to your audience. Think about how the USGS and FEMA created the Hazus 2PAGER for a specific target audience. Your audience is going to determine how you present your information, the mapping, the data, and the message.

Here are a few things to consider:

- Normalize your data. Take the results and divide those results by the amount of inventory or population or area. This will give your audience a better sense for the loss results. This can be accomplished by joining layers to each other. The results may be joined to the inventory using the Census Tract or Census Block ID. Make sure your normalizing by the correct value. If you're showing building and content results make sure you divide by both building and contents and not just building.
- Show the results using the Homogenous data (TIGER Census Blocks). The CensusBlock_TIGER data is provided at the State and study region level. If it is difficult to see the dasymetric Census Blocks at the County level, transfer the results to the TIGER data. Add hzCensusBlock_TIGER from the statewide inventory database to the map and join it to your results, and then export as a separate layer.
- Round off your results. Hazus provides a very high level of precision when creating results and this level of precision is not needed when creating your maps.
- Understand your units of measure. When you export results, remember the units and add that data into the title of the layer if it's not already there.

Visual 34: Lesson 10: Review

1. How are earthquake and tsunami losses determined?
2. List four sources of uncertainty.
3. Green tag includes which damage states?
4. List three ways Hazus may be used to model mitigation.

Visual 35: Questions?

Capstone Exercise

Visual 1: Capstone Exercise

HAZUS®

EARTHQUAKE • WIND • FLOOD • TSUNAMI

Visual 2: Capstone Exercise Preparation

- You are to complete a Hazus risk assessment using advanced applications for the inventory, hazard, parameter, and results model components.
    - Select community and hazard(s) for your analysis
    - Select 4 advanced applications to integrate into your analysis
    - Complete the processes for integrating the 4 advanced applications into your analysis
- You will present your analysis scenario and your results while the remaining participants assume the role of the leadership team.
    - Present and explain the advanced applications and the scenario you've chosen to analyze
    - Present and explain the results of your analysis

Visual 3: Capstone Exercise Explanation

Presentation Guidelines:

- Should be prepared using PowerPoint and include at least one slide each showing an inventory, hazard, parameter, and results advanced application.
- Include maps, tables, or other media you deem appropriate and helpful for conveying your message.
- Information should be primarily derived from Hazus, but may be supplemented by other sources.
- 10 minutes in length; allowing 5 minutes for questions.

Community Stakeholder Guidelines:

- Class and instructor will assume the role of risk-mitigation community stakeholders.
- Community stakeholder may ask questions related to the presentation.

Visual 4: Capstone Exercise Preparation

- Time allowed to work on presentations
- Break as needed

Visual 5: Questions?

Lesson 11: Course Wrap-Up

Visual 1: Lesson 11: Wrap-Up

Visual 2: Lesson 11: Goal and Objectives

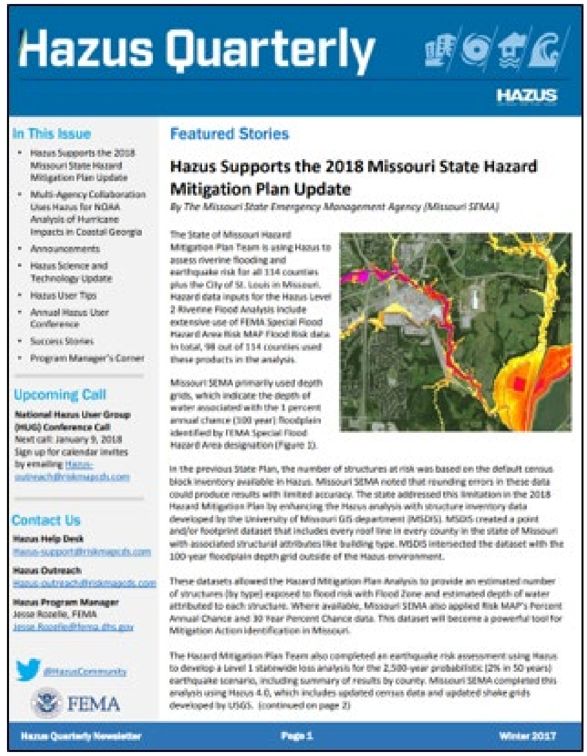
Goal: To review the major themes of the course and discuss opportunities for learning more about Hazus.

After completing this lesson you will be able to:

- Identify additional resources available to explore to enhance your Hazus experience.

Visual 3: Hazus Community Participation

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



Hazus Quarterly

HAZUS

In This Issue

- 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
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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)

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Visual 4: Getting Help

Hazus Help Desk - email

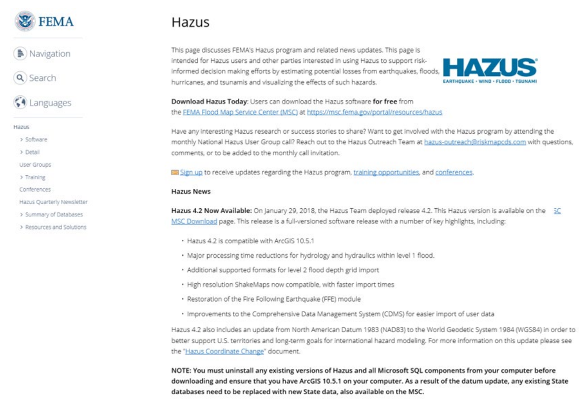
hazus-support@riskmapcds.com

Consult the User Manuals and Technical Manuals

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

Visual 5: FEMA Hazus Website

Primary FEMA resource for updated Hazus information:
FEMA Hazus Website:
https://www.fema.gov/hazus



Visual 6: Additional Resources

Hazus YouTube Videos – http://bit.ly/HAZUS

- 21 short (3-7 min) tutorials on all parts of Hazus.

Hazus GitHub - https://github.com/nhrap-hazus

- Site of published Hazus Open Source tools, such as Hazus FAST.

- Hazus Training Data and Student Guides - Site TBD

New Natural Hazards Risk Assessment Program website - https://www.fema.gov/nhrap

- Document Container of methods and research applications - https://www.fema.gov/media-library/assets/documents/180915

Visual 7: So in closing...

What is Hazus and why should you use it?

Visual 8: Questions?