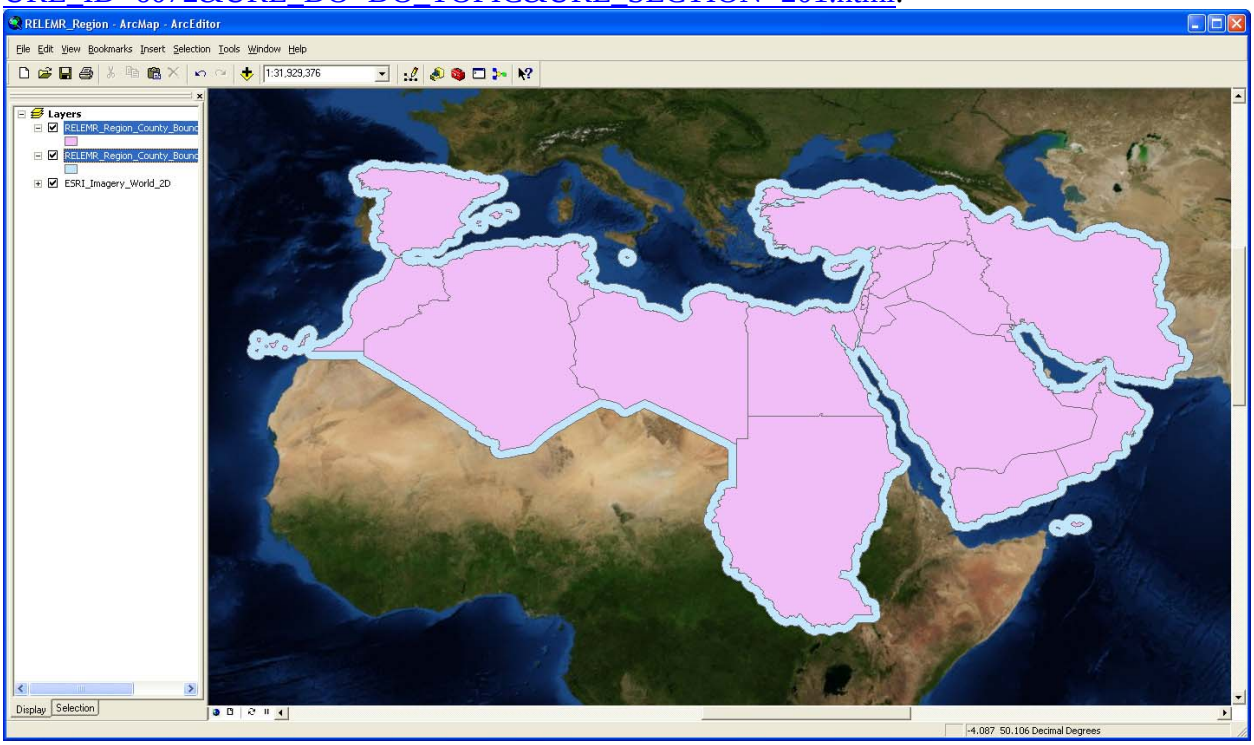
An Updated GIS-Based Methodology for Exporting the HAZUS Earthquake Model for Global Applications: HAZ EM (Extended Mediterranean) Loss Estimation

Doug Bausch, FEMA Region VIII
Douglas.Bausch@dhs.gov
Rich Hansen, FEMA Region VIII
Richard.Hansen@dhs.gov
Sean CJ McNabb, FEMA Region VIII
Sean.McNabb@dhs.gov
Jesse Rozelle, FEMA Region VIII
Jesse.Rozelle@dhs.gov

We have updated and enhanced the methodology first described by Hansen and Bausch (2006) http://www.hazus.org/HAZUSorg_DOCUMENTS/BAUSCH_EXPORTING_HAZUS_nonUS.pdf for a Sicily study region. This new application reaches across 21 Countries that participate in the joint UNESCO/USGS Reduction of Earthquake Loss in the Extended Mediterranean Region (RELEMR) http://portal.unesco.org/science/en/ev.php-URL_ID=6072&URL_DO=DO_TOPIC&URL_SECTION=201.html:



Enhancement include the development of 3 layers of resolution, including grid sizes of 100 km, 10 km, and 1 km, based on a population threshold of 100K. A new treatment for "urban" or high population density grids (1 km) where we assign the majority of non-residential building

occupancy types was developed. Additional ShakeMap scenarios covering the area of interest have been developed by the USGS and we have formatted and developed a "500 year" Probabilistic Hazard map from the Global Seismic Hazard Map http://www.seismo.ethz.ch/gshap/ to use for loss estimates

Background: The HAZUS-MH earthquake model

The HAZUS-MH earthquake model uses Geographic Information System (GIS) software and scientifically developed algorithms to calculate, map, and display earthquake loss data for communities throughout the U.S. (United States). Once the ground motions are provided or modeled by the HAZUS software, the program uses a series of mathematical formulas, calculates the violence of ground shaking, the amount of damage, the number of casualties, the number of people displaced by damaged structures, and the disruption and economic losses caused by the earthquake. These formulas describe the relationship between earthquake magnitude, violence of ground shaking, building and utility system damage, cost of repair, and indirect economic impact.

Concept: An International Application

In general we export a U.S. building stock to other areas of the world based on a user defined grid. We select a U.S. building stock that best fits the population and the built environment for the application, but the intent is that the user would replace the building stock information with their own local data. In this example we export the U.S. proxy data from the Puerto Rico building stock to the RELEMR region, which includes the Middle Eastern and Mediterranean countries of Algeria, Cyprus, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Malta, Morocco, Oman, Saudi Arabia, Spain, Sudan, Syria, Tunisia, Turkey, United Arab Emirates, West Bank (Palestinian Authority) and Yemen. This method allows the user to benefit from an existing methodology and to concentrate resources on developing good building inventory information to replace the U.S. proxy data. In addition, the required building inventory format is readily apparent since the U.S. proxy data are in a format that can be followed by the user.

This concept requires the use of the USGS (United States Geological Survey) ShakeMaps Earthquake Hazards Program http://earthquake.usgs.gov/earthquakes/shakemap/ as a source of ground motion and shaking intensity algorithms, the USGS PAGER (Prompt Assessment of Global Earthquakes for Response) http://earthquake.usgs.gov/eqcenter/pager/ as a source for ground motion data based on scenario earthquakes and LandScan 2008™ as a source for a high resolution (1km) population grid. It is possible to develop ground motion and population data from other sources, but these three provide global capabilities that are already available in a useable GIS format. In the case of ShakeMaps and PAGER, hazus.zip files are provided that includes the necessary HAZUS ground motion inputs (PGA, PGV, SA 0.3 and SA 1.0).

The LandScan 2008™ Global Population Database, 2008 is produced by the Oak Ridge National

Laboratory, http://www.ornl.gov/gist/ and requires a license agreement to utilize and has some access constraints.

For more information on PAGER and/or ShakeMaps, please contact:
Dr. David Wald, wald@usgs.gov

For more information on LandScan™, please contact:
Dr. Budhendra Bhaduri, bhaduribl@ornl.gov

Steps: 3 Basic Steps

Three basic steps are required to implement and run an analysis of losses for an international study region using HAZUS.

1) Create and Populate a User Defined Grid
2) Develop and Incorporate Ground Motion and Hazard Information
3) Run Analysis

These basic steps are described in more detail below, however, the user of these proposed methods should understand the technical methodology of the HAZUS loss estimation program (see HAZUS-MH Earthquake Technical and User Manuals; http://www.fema.gov/hazus/hz_manuals.shtm) Step 1 requires the skills of an advanced GIS person knowledgeable in working with ArcGIS Geodatabases, as well as the ArcInfo-level software license available from ESRI www.esri.com. The user of this method is required to replace U.S. proxy building stock data with that developed locally and to apply or modify the loss functions that best represent their local building stock. A number of resources can help facilitate this, including EERI's World Housing Encyclopedia http://www.world-housing.net/index.asp, but developing building stock inventories can be a significant effort. We will describe options that allow the user to import more limit portfolios of buildings that may be available through a survey of essential facilities, such as schools or hospitals, using the HAZUS Advanced Engineering Building Module (AEBM) http://www.fema.gov/hazus/dl_aebm.shtm or the HAZUS Comprehensive Data Management System (CDMS) http://www.fema.gov/plan/prevent/hazus/index.shtm#2. As noted above, a diverse set of GIS and engineering skills are required to successfully implement this method. In addition, the user community typically includes emergency managers and public policy makers. Therefore, success in utilizing HAZUS internationally, as well as in the U.S., requires a group of users. In the U.S. we have developed HAZUS User Groups across the Country to help implement the program. www.hazus.org and www.usehazus.com.

Step 1 – Create and Populate a User-Defined Grid

Step-by-Step Instructions

The following instructions are divided into numbered tasks that are then followed by the detailed steps required to complete each task. Many steps are also followed by italicized comments that provide additional helpful information.

NOTE: The following steps are associated with the creation and population of a user-defined grid for the RELEMR region to be used with FEMA's HAZUS loss estimation software. The concepts presented here are adaptable to any global study area.

Set the Working Environment

Creating and populating a user-defined grid will take many steps. During this process we will need to create numerous temporary datasets and it is important to keep these organized. To keep our datasets in order we will first set up our working environment.

NOTE: Because HAZUS-MH was developed for use within the United States and Puerto Rico, you must replace the Geodatabases in an existing State folder with your new regional data. For this exercise we will be replacing the Puerto Rico folder.

1. In the working directory of your choice, create the following folders:

   FinalData – Contains the final Geodatabases that will replace the Puerto Rico folder.

   OrigData – Contains the original Geodatabases that will be used to import attribute table structures.

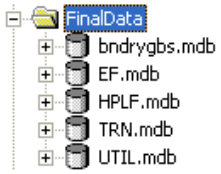
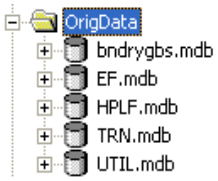
   IntData – Contains the intermediate Geodatabases that will be loaded into the FinalData folder.

   syBoundary – Contains the syBoundary.mdb Geodatabase to be edited.

   Working – Will be used as a working directory and store any intermediate datasets.

2. Copy the **syBoundary.mdb** Geodatabase from any of the **HAZUS data DVDs** into the **syBoundary** folder.

3. Copy the following Geodatabases from the original **PR1** (Puerto Rico) folder into the **FinalData** and **OrigData** folders:

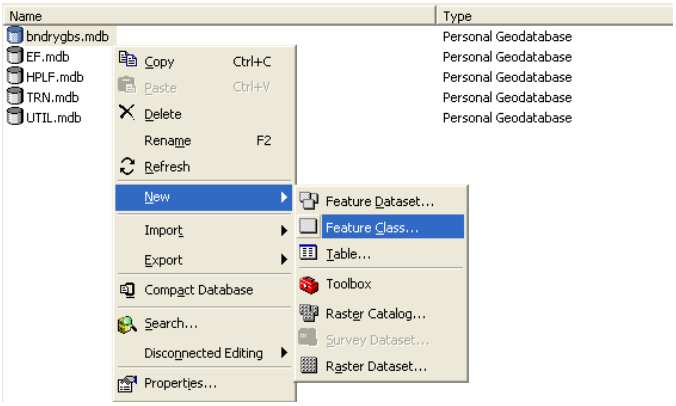
FinalData Folder	OrigData Folder
	

The original PR1 folder is located on Data DVD #4.

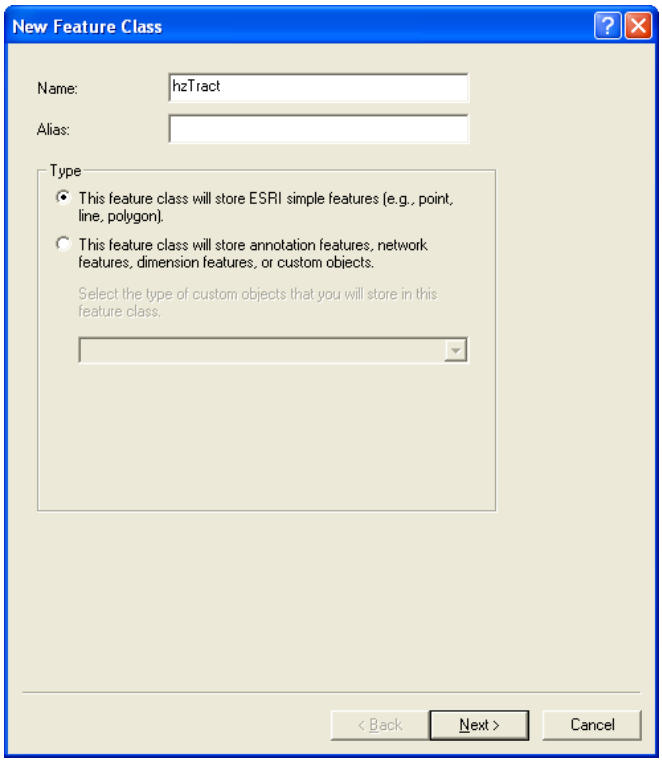
4. In ArcCatalog, delete the existing feature classes and tables in each Geodatabase in the FinalData folder.

5. Replace the deleted feature classes and tables in the FinalData folder with new empty datasets:

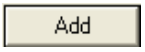
   - In ArcCatalog, Right-Click on the **bndrygbs.mdb** Geodatabase and select **New→Feature Class…**



   - In the New Feature Class Window, enter **hzTract** as the **Name** of the new feature class.



- Click **Next**.
- Leave the default settings in the Database Storage Configuration window. Click **Next**.
- In the Field Definition window click the **Import…** button. 

- Browse to the **hzTract** feature class in the **OrigData** folder and click the **Add** button. 

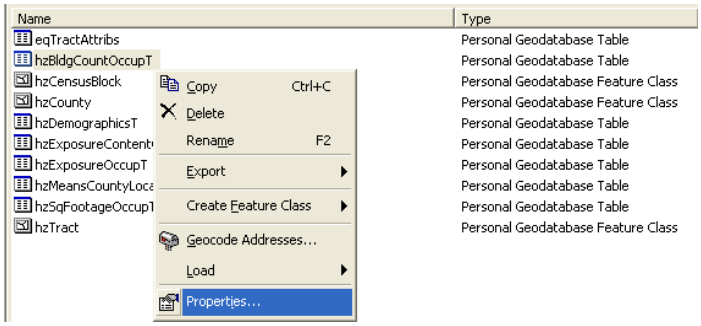
- Click on the **Shape** field and set the following **Field Properties**:
  - Geometry Type – **Polygon**
  - Spatial Reference – **GCS_North_American_1983**
- Click **Finish**.
- **Repeat** the previous steps for the following feature classes and tables in the FinalData folder. Be sure to specify Geometry Type for each new feature class as there are polygon, polyline, and point feature classes.

bndryGBS.mdb	EF.mdb	HPLF.mdb	TRN.mdb	UTIL.mdb
bndrygbs.mdb eqTractAttribs hzBldgCountOccupT hzCounty hzDemographicsT hzExposureContentOccupT hzExposureOccupT hzMeansCountyLocationFactor hzSqFootageOccupT hzTract	EF.mdb eqCareFlty eqEmergencyCtr eqFireStation eqPoliceStation eqSchool hzCareFlty hzEmergencyCtr hzFireStation hzPoliceStation hzSchool	HPLF.mdb eqDams eqHazmat eqLevees eqMilitary eqNuclearFlty hzDams hzHazmat hzLevees hzMilitary hzNuclearFlty	TRN.mdb eqAirportFlty eqBusFlty eqFerryFlty eqHighwayBridge eqHighwaySegment eqHighwayTunnel eqLightRailBridge eqLightRailFlty eqLightRailSegment eqLightRailTunnel eqPortFlty eqRailFlty eqRailwayBridge eqRailwaySegment eqRailwayTunnel eqRunway hzAirportFlty hzBusFlty hzFerryFlty hzHighwayBridge hzHighwaySegment hzHighwayTunnel hzLightRailBridge hzLightRailFlty hzLightRailSegment hzLightRailTunnel hzPortFlty hzRailFlty hzRailwayBridge hzRailwaySegment hzRailwayTunnel hzRunway	UTIL.mdb eqCommunicationFlty eqElectricPowerFlty eqNaturalGasDL eqNaturalGasFlty eqNaturalGasPl eqOilFlty eqOilPl eqPotableWaterDL eqPotableWaterFlty eqPotableWaterPl eqWasteWaterDL eqWasteWaterFlty eqWasteWaterPl hzCommunicationFlty hzElectricPowerFlty hzNaturalGasFlty hzNaturalGasPl hzOilFlty hzOilPl hzPotableWaterFlty hzPotableWaterPl hzWasteWaterFlty hzWasteWaterPl

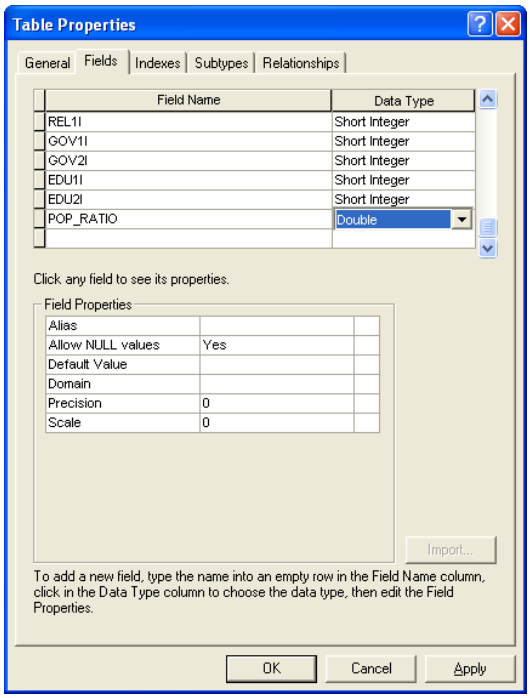
6. Copy the new set of earthquake Geodatabases from the **FinalData** folder into the **IntData** folder.

7. Add the Population Ratio field to the necessary tables in the **bndrygbs.mdb** Geodatabase in the **IntData** folder.

   - In ArcCatalog, Right-Click on the **hzBldgCountOccupT** table and select **Properties…**



- Scroll to the bottom of the Fields tab and add a new field named **POP_RATIO** as Type **Double**.



- Click **OK**.

- **Repeat** these steps to create another field called **U_POP_RATIO** as Type **Double** (This will represent the Urban Population Ratio).

- **Repeat** these steps for the **hzExposureContentOccupT**, **hzExposureOccupT**, and the **hzSqFootageOccupT** tables.

  The POP_RATIO (Population Ratio) field will be used to distribute the General Building Stock throughout the study region.

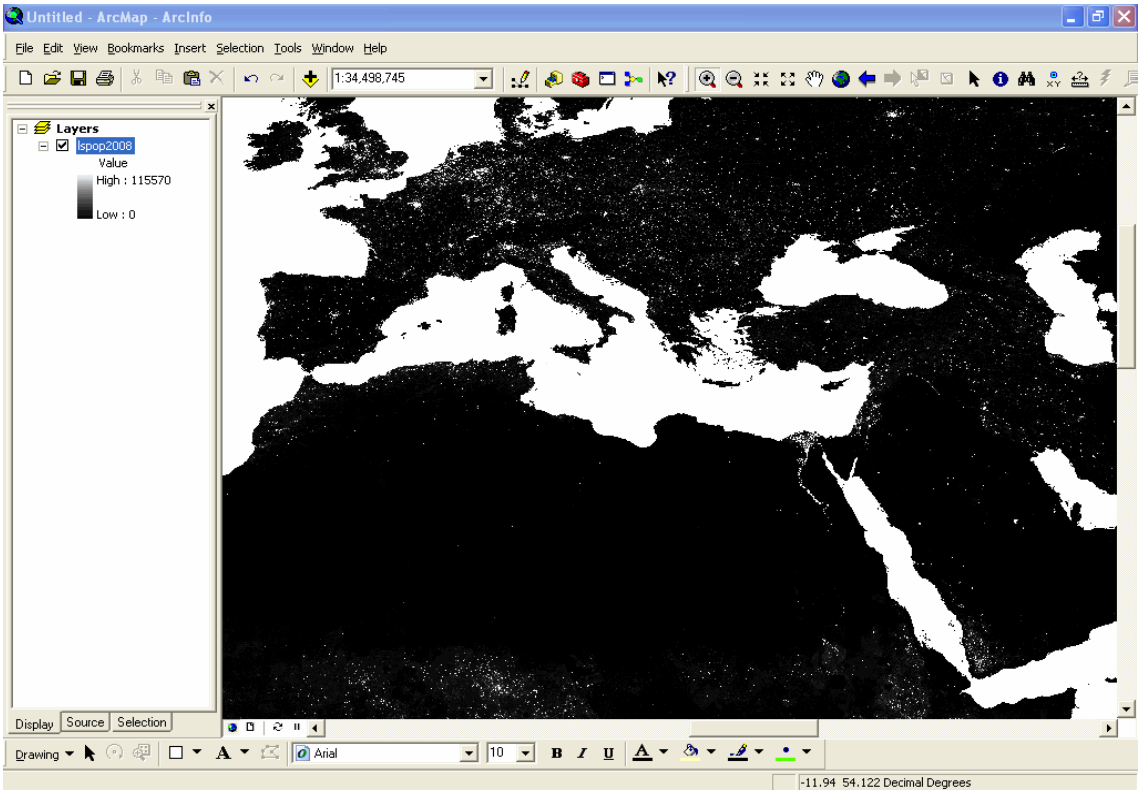
  The U_POP_RATIO (Urban Population Ratio) field will be used to distribute the General Building Stock throughout the designated urban areas within the study region.

8. Perform any necessary geographic transformations to preliminary datasets (Landscan Grid, Study Region Boundary). The HAZUS software uses the **Geographic Coordinate System North American Datum 1983**.

Develop the Landscan Grid

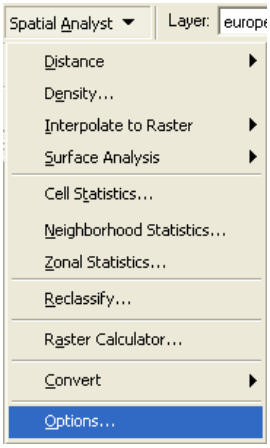
Now that you have set up the working environment you are ready to develop the polygonal grid that will be used to define your study area. The following example will create a grid for the RELEMR region using the Landscan 2008 data. This methodology is one of many that could be used to create an International study region.

1. **Open** a new ArcMap session and **Add** the **lspop2008** Landscan Grid.



2. Set the Spatial Analyst Working Environment:

   - On the Spatial Analyst drop-down menu, select **Options…**

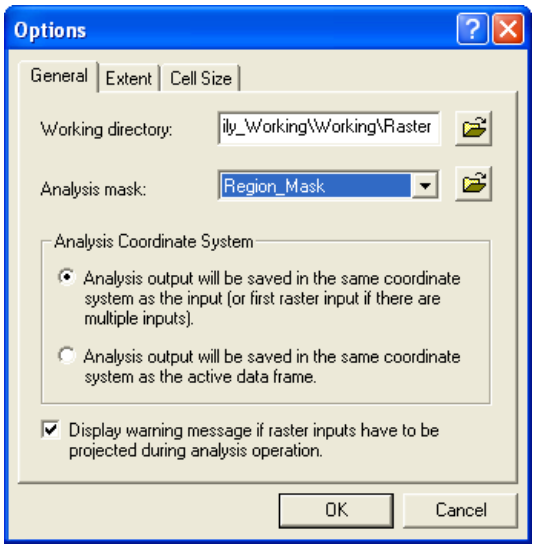


- Set the Working Directory as your **Working** folder that was created in a previous step.

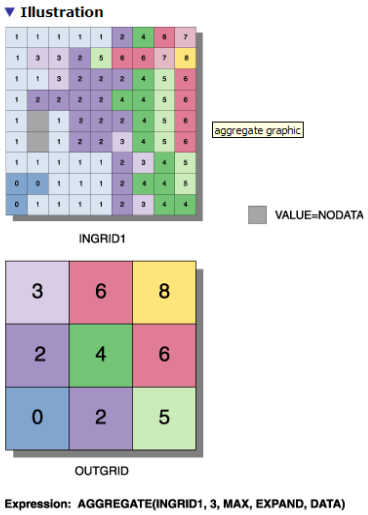
  The working directory will store any grids created with the Raster Calculator.

- (Optional) Set the **Analysis Mask** to a shapefile that represents your study region with a 100km buffer, the buffer will ensure that LandScan data will not be omitted along the boundaries of your study region.

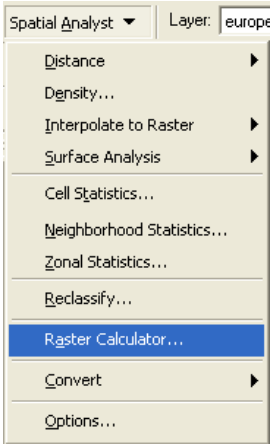
  The analysis mask will limit the extent of any newly created grids to the extent of the mask. Any polygonal or raster dataset can act as a mask and should be used to reduce file size and processing time.



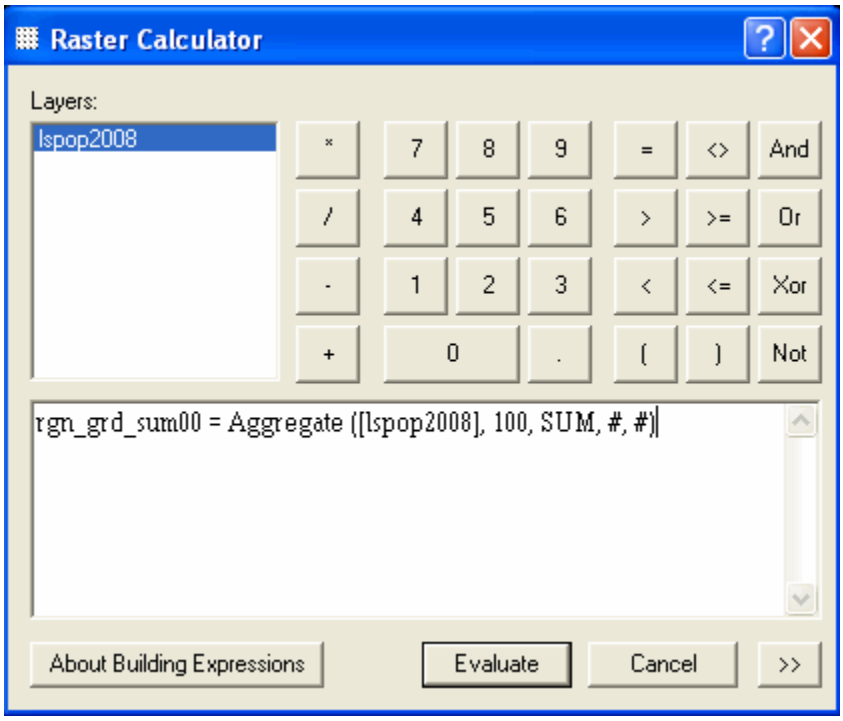
3. Aggregate three manageable grids to represent urban areas, urban/rural interface areas and rural areas. The LandScan data has a resolution of 1km grid cells and an aggregation based on a multiplier can be used to create different grid cell sizes to represent the population distribution differently throughout the study region.



- On the Spatial Analyst drop-down menu select **Raster Calculator…**



- Create the rural (100km) grid. Enter the following expression (the output will be a raster so it is important to remember to keep the name limited to 13 characters: **rgn_grd_sum00 = Aggregate ([lspop2008], 100, SUM, #, #)**.

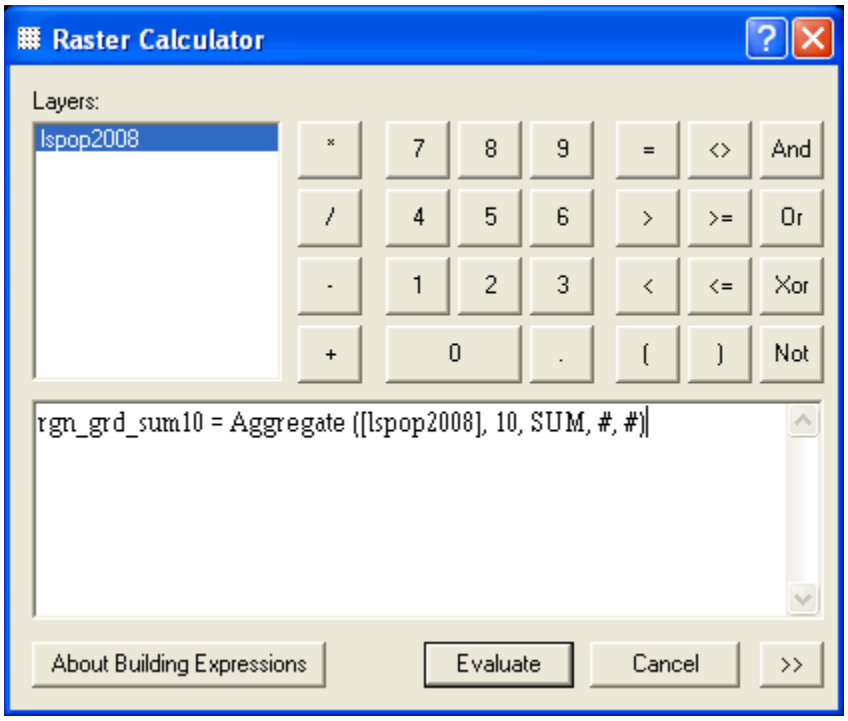


- Click **Evaluate**.

  This will create a new grid in the specified working directory called rgn_grd_sum00 that is one hundred times the size of the original and represents the sum of the input cells.

- On the Spatial Analyst drop-down menu select **Raster Calculator…**

- Create the urban/rural interface (10km) grid. Enter the following expression: **rgn_grd_sum10 = Aggregate ([lspop2008], 10, SUM, #, #)**.

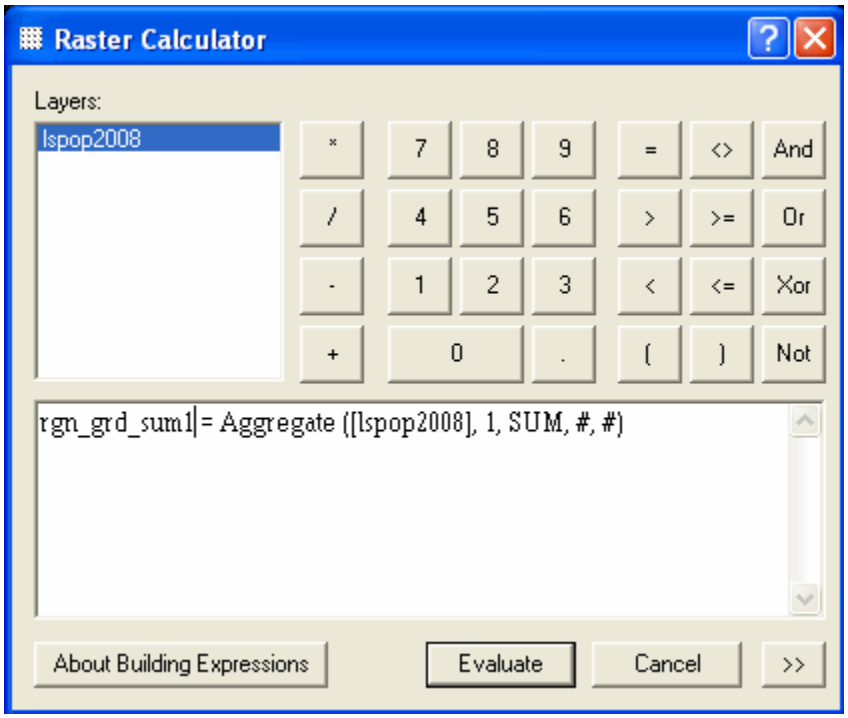


- Click **Evaluate**.

  This will create a new grid in the specified working directory called rgn_grd_sum10 that is 10 times the size of the original and represents the sum of the input cells.

- On the Spatial Analyst drop-down menu select **Raster Calculator…**

- Create the urban (1km) grid. Enter the following expression: **rgn_grd_sum10 = Aggregate ([lspop2008], 1, SUM, #, #)**.

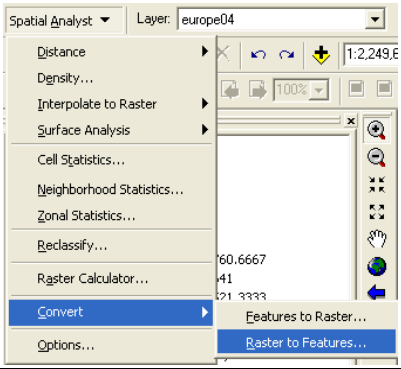


- Click **Evaluate**.

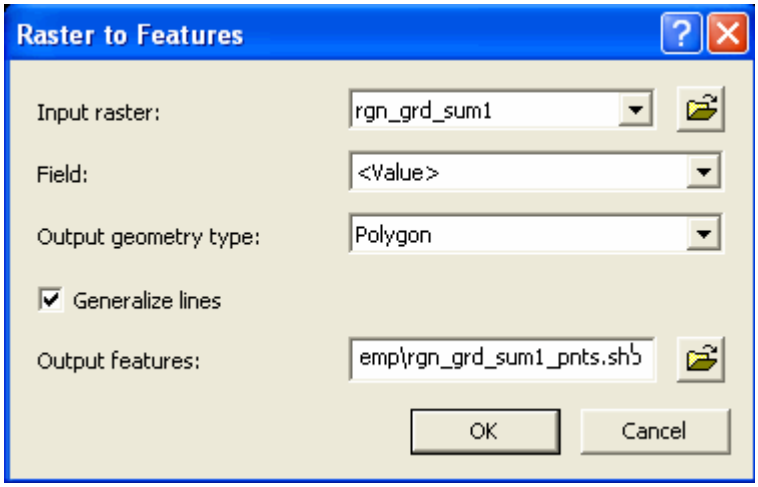
  This will create a new grid in the specified working directory called rgn_grd_sum1 that is 1 times the size of the original and represents the sum of the input cells

4. Convert the aggregated grids to features.

   - On the Spatial Analyst drop-down menu select **Convert →Raster to Features…**



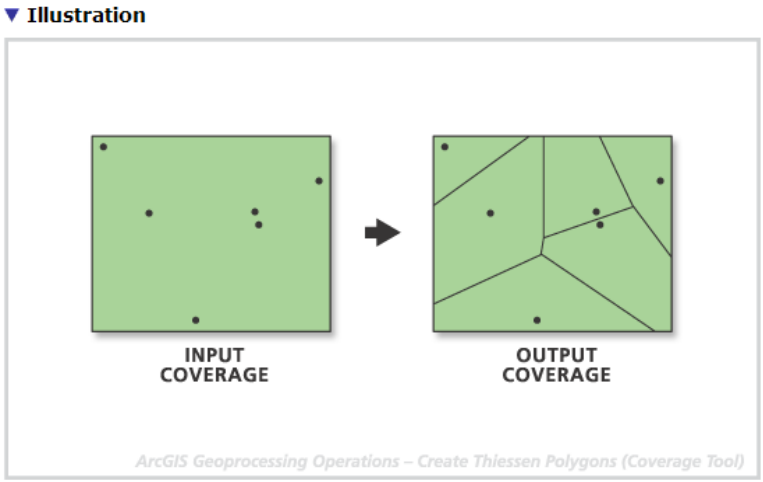
- Set the Input raster to **rgn_grd_sum1**.
- Set the Output geometry type to **Point**.
- Set the **Output features** to **rgn_grd_sum1_pnts** in the working directory.



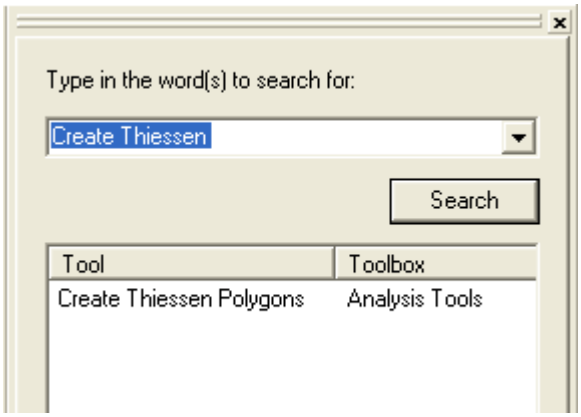
- **Repeat** steps 1 – 4 for **rgn_grd_sum10** saving the feature dataset as **rgn_grd_sum10_pnts**.
- **Repeat** steps 1 – 4 for **rgn_grd_sum00** saving the feature dataset as **rgn_grd_sum00_pnts**.

5. Create Thiessen Polygons.

   You must have an ArcInfo License to create Create Thiessen Polygons in ArcMap.

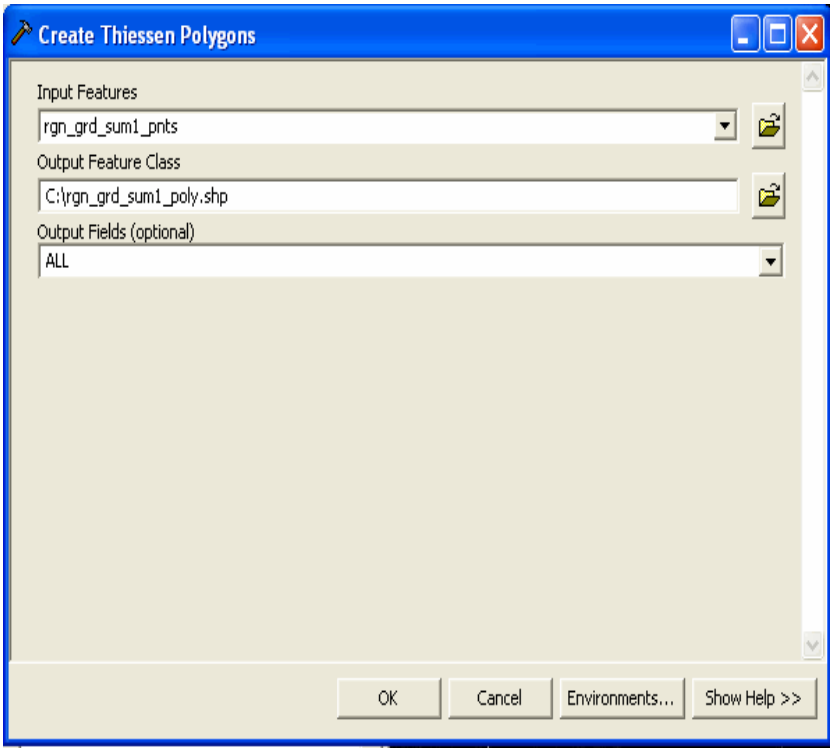


- Open ArcToolbox, click the Search tab and type "Create Thiessen" in the search box.



- Open the "Create Thiessen Polygons" tool.

Be sure that "ALL" is selected in the Output Fields (optional) dialog.

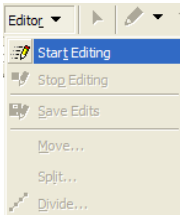


- **Repeat** steps 1 – 3 for **rgn_grd_sum10_pnts** and save the output dataset as **rgn_grd_sum10_poly**.
- **Repeat** steps 1 – 3 for **rgn_grd_sum00_pnts** and save the output dataset as **rgn_grd_sum00_poly**.
- You should now have three polygonal grids (1km, 10km and 100km) that can be combined to make your regional grid dataset.

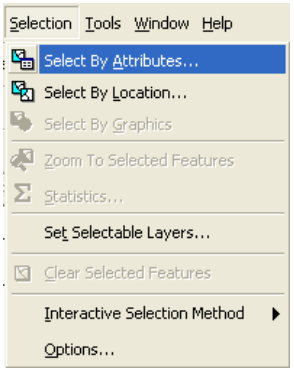
Depending on the size of the study region a shapefile size limit can be reached when converting the 1km grid to a point and polygon shapefile. If this happens it is best to split the study region up into multiple regions for processing the 1km grid. These separate 1km point and polygon files can be merged together later in the process when they are combined with the 10km and 100km grid point and polygon files.

6. Combine urban (1km), urban/rural interface (10km) grids and rural (100km) grids.

- Start an Editing Session in ArcMap by selecting **Start Editing** from the Editor Toolbar drop-down menu. The data location of the files that will be edited may need to be selected in the dialog box.

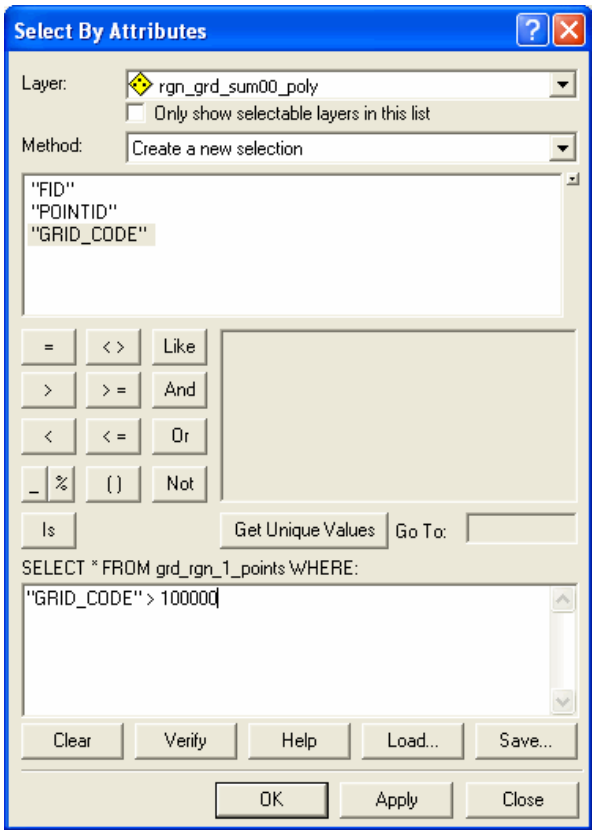


- From the Selection drop-down menu select **Select By Attributes…**

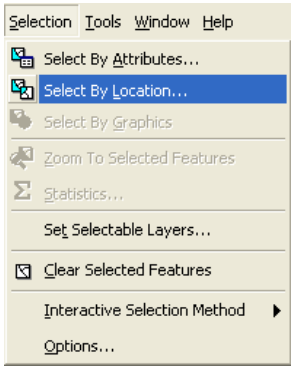


- Set the Layer to **rgn_grd_sum00_poly**.
- Set the Method to "Create a New Selection".
- Set the Population threshold. Enter **"GRID_CODE" > 100000** into the Query Text Box.

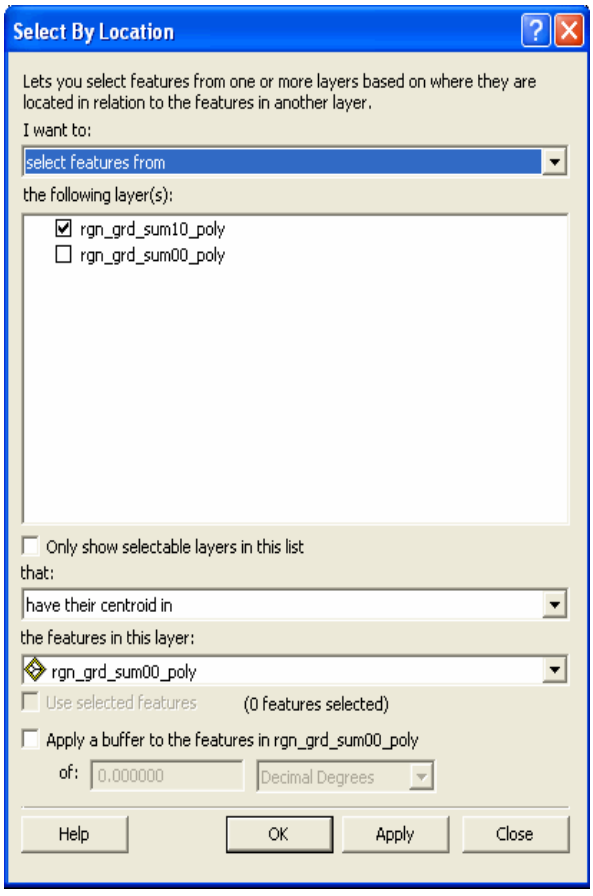
  The population threshold will determine where to use the finer resolution grids. This is a variable number and can be modified to match the needs of your study area. The lower the threshold the higher number of grid cells.



- Click **Apply**.
- Open the attribute table of the selected shapefile: **rgn_grd_sum00_poly**.
- **Delete** the selected grid cells.
- From the Selection drop-down menu select **Select By Location…**



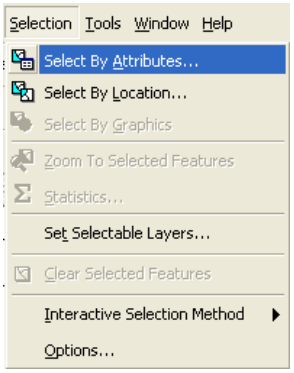
- Create the following query: I want to: **select features from** the following layer(s): **rgn_grd_sum10_poly** that: **have their centroid in** the features in this layer: **rgn_grd_sum00_poly**.



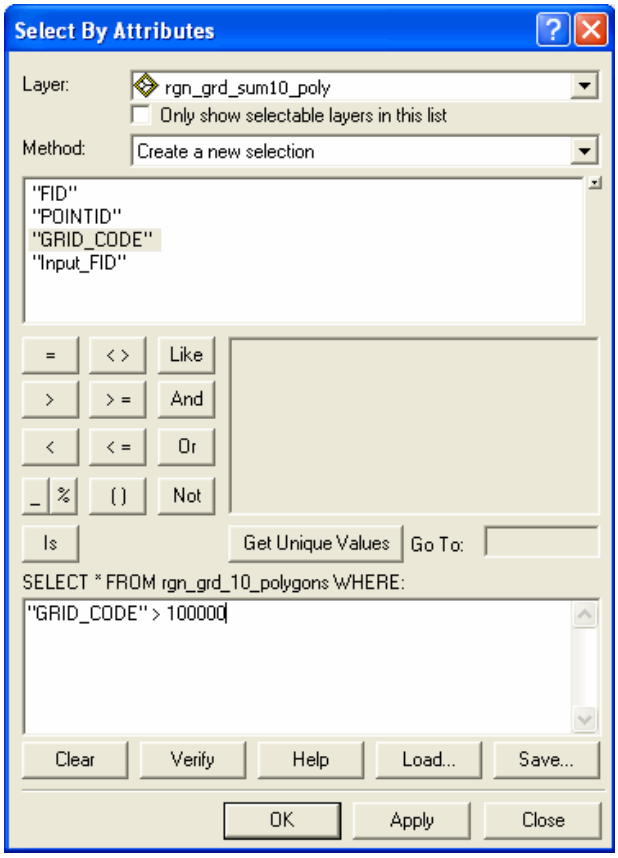
- Click **Apply**.

- Open the attribute table of the selected shapefile: **rgn_grd_sum10_poly**.

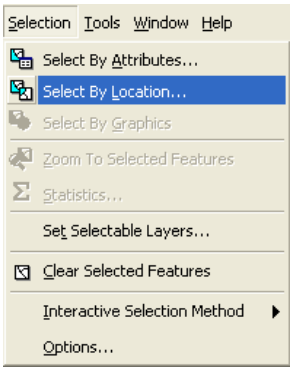
- **Delete** the selected grid cells.
- From the Selection drop-down menu select **Select By Attributes…**



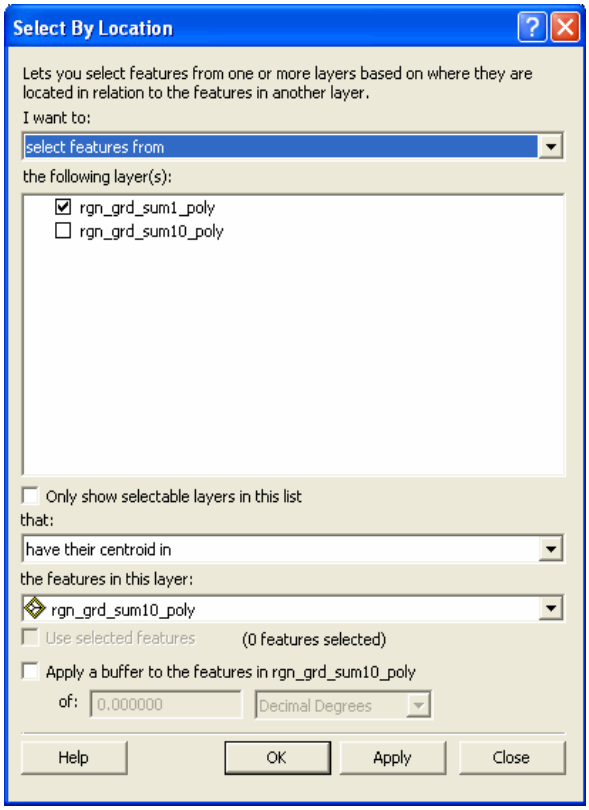
- Set the Layer to **rgn_grd_sum10_poly**.
- Set the Method to "Create a New Selection".
- Set the Population threshold. Enter **"GRID_CODE" > 100000** into the Query Text Box.



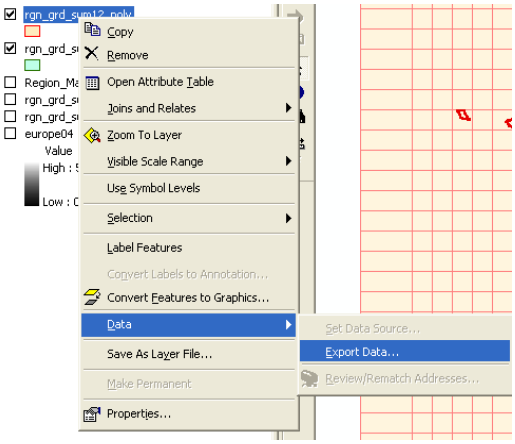
- Click **Apply**.
- Open the attribute table of the selected shapefile: **rgn_grd_sum10_poly**.
- **Delete** the selected grid cells.
- From the Selection drop-down menu select **Select By Location…**



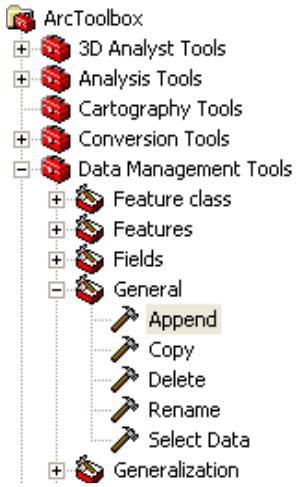
- Create the following query: I want to: **select features from** the following layer(s): **rgn_grd_sum1_poly** that: **have their centroid in** the features in this layer: **rgn_grd_sum10_poly**.



- Click **Apply**.
- Open the attribute table of the selected shapefile: **rgn_grd_sum1_poly**.
- **Delete** the selected grid cells
- **Stop** the Editing session and **Save** your edits.
- Right-click **rgn_grd_sum00_poly** and select **Data→Export data…**

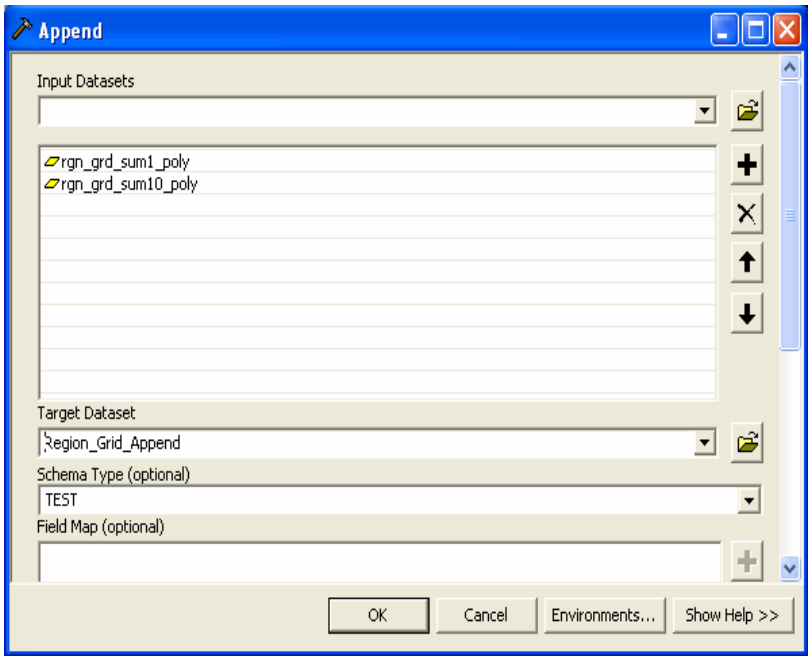


- Save the exported dataset as **Region_Grid_Append** in your working directory.
- Open the ArcToolbox Window.
- Double-click the **Append** Tool under **Data Management Tools→General** to open the Append Tool Window.



- Select **rgn_grd_sum1_poly** and **rgn_grd_sum10_poly** as your **Input Features**.

- Select **Region_Grid_Append** as your **Output Features**.



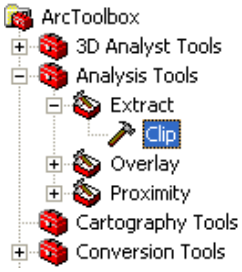
- Click **OK**.

- You should now have one combined polygonal grid that can be clipped to finalize the regional grid dataset.

7. Clip the Grid dataset by your regional boundary.

- Open the ArcToolbox Window by pressing the ArcToolbox button. 

- Double-Click the **Clip** tool under **Analysis Tools→Extract** to open the Clip Tool Window.

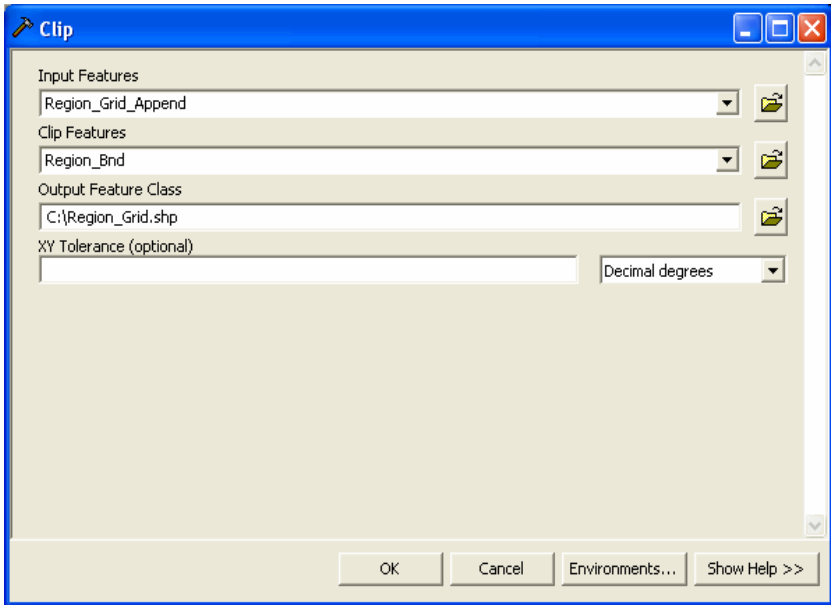


- Select **Region_Grid_Append** as your **Input Features**.

- Select **Region_Bnd (or whatever dataset defines your study area)** as your **Clip Features**.

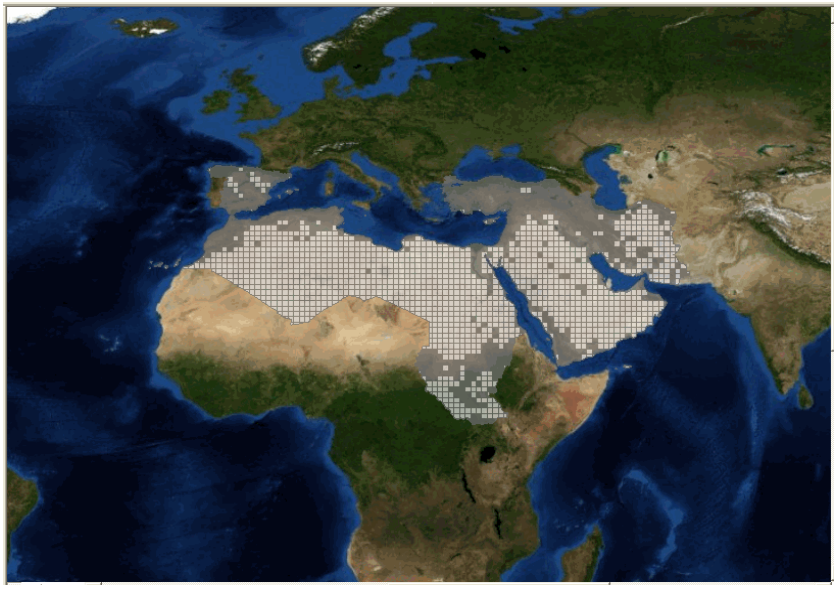
- Navigate to your working directory and set the **Output Feature Class** to **Region_Grid**.

  This will create a new feature dataset named Region_Grid which will represent census tracts in the HAZUS bndrygbs.mdb geodatabase.

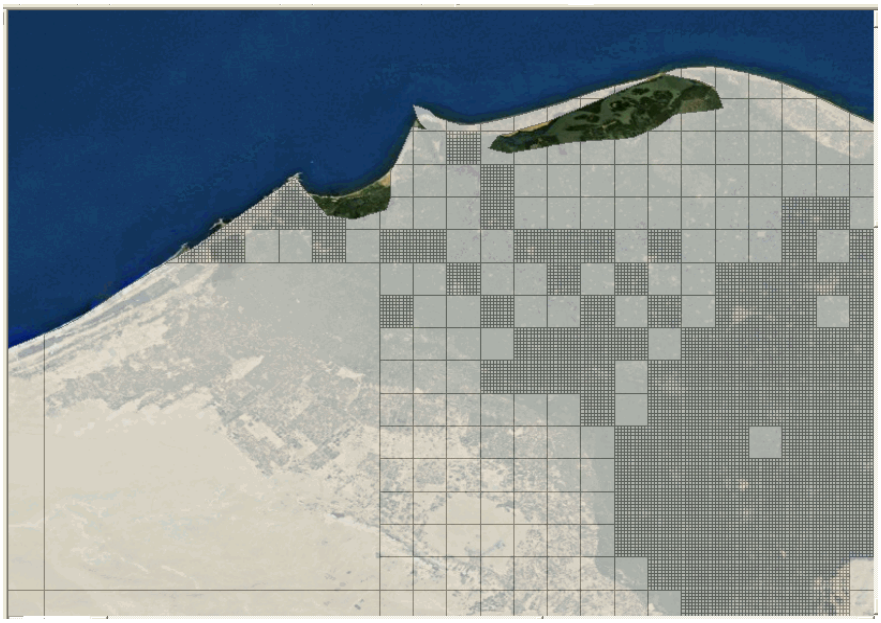


- Click **OK**.

- You should now have your regional grid dataset.



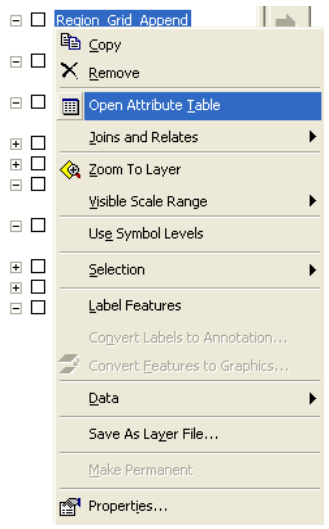
RELEMR Region



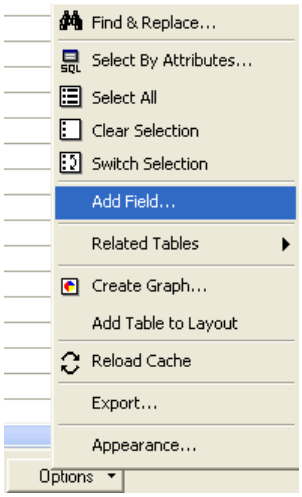
RELEMR Region – Zoomed into an area of Egypt to show the 1km, 10km and100km grids side-by-side.

8. Calculate the Population Ratio.

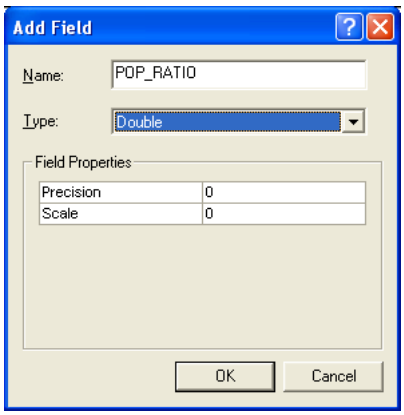
   - Right-Click Region_Grid and select **Open Attribute Table**.



   - In the Attribute Table, Click the **Options** button and select **Add Field**.



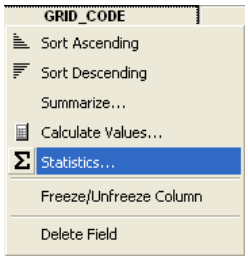
- Enter **POP_RATIO** into the **Name** field.
- Set **Type** as **Double**.



- Click **OK**.

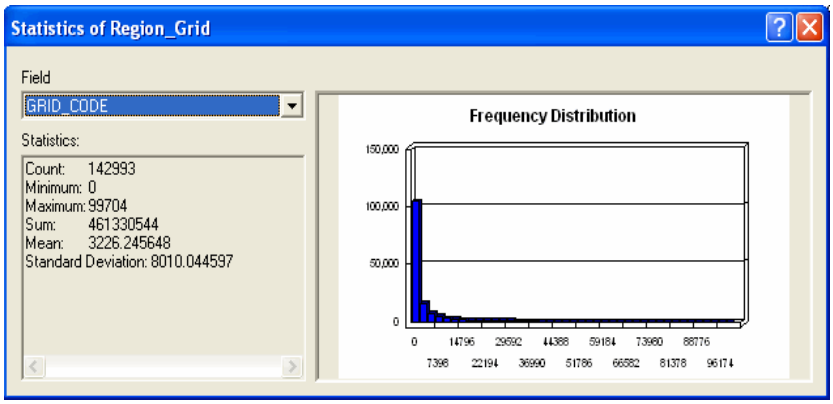
A new field is created in the Region_Grid attribute table.

- In the Attribute Table, Right-Click on the **GRID_CODE** field name and select **Statistics**.

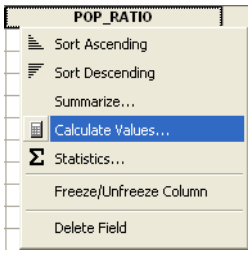


- Write down the **Sum: 461330544**

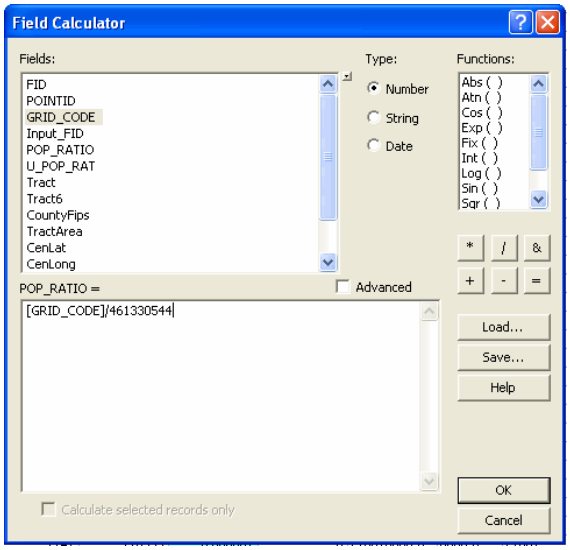
  The sum of 461,330,544 represents the total population for our study area. You will use this number to calculate the Population Ratio.



- Right-Click on the **POP_RATIO** field name select **Calculate Values…**



- Enter the following expression: **[GRID_CODE]/461330544** in the Field Calculator.



- Click **OK**.

POP_RATIO
0.000032
0.000022
0
0.000019
0
0.000004
0.000051

- Repeat steps for **U_POP_RATIO** (Urban Population Ratio).
- Select out the urban (1km) grids from your Region_Grid shapefile.
- Calculate the urban population from the selected tracts in the same way that the population for the region was calculated.
- Distribute the urban population through the selected urban (1km) grids in the same way that the population was distributed throughout the region.

The U_POP_RATIO should only be distributed to the urban (1km) tracts and the POP_RATIO should be distributed to all tracts in the region. The POP_RATIO (Population Ratio) and U_POP_RATIO (Urban Population Ratio) fields will be used to distribute the General Building Stock throughout the study region.

9. Calculate the Census Tract ID and County Identifier.

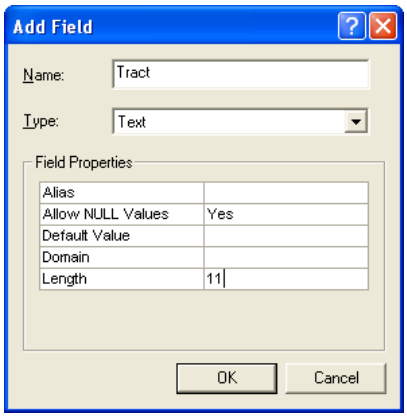
   HAZUS uses Federal Information Processing Standards (FIPS) Codes as unique identifiers for each Census Tract. This is an eleven digit number of which the first two digits identify the State, the next three digits identify the County, and the final six digits identify the Census Tract.

   Because you will be replacing the data for Puerto Rico you will use the Puerto Rico State identifier (72) and an existing County identifier (001) to represent the first five digits of the Census Tract ID. The remaining six digits will be calculated using a simple numbering expression.

   It is important to note that because HAZUS is designed for use within the U.S. and Puerto Rico you must maintain an existing State and County identifier in order for HAZUS to work. To go even further, you must maintain the State and County identifiers of the State data you will be replacing.

   - In the Region_Grid Attribute Table, Click the **Options** button and select **Add Field**.
   - Enter **Tract** into the **Name** field.

- Set **Type** as **Text**.
- Set **Length** as **11**.

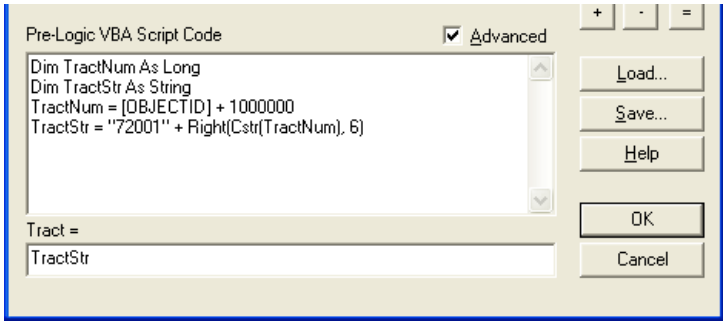


- Click **OK**.
- Right-Click on the **Tract** field name select **Calculate Values…**
- Check the **Advanced** checkbox and enter the following Expression into the Pre-Logic VBA Script Code text box:

  Dim TractNum As Long
  Dim TractStr As String
  TractNum = [OBJECTID] + 1000000
  TractStr = "72001" + Right(Cstr(TractNum), 6)

  The number "72001" is the State and County identifier for Adjuntas County in Puerto Rico. Please see the notes above for a discussion on the use of this number.

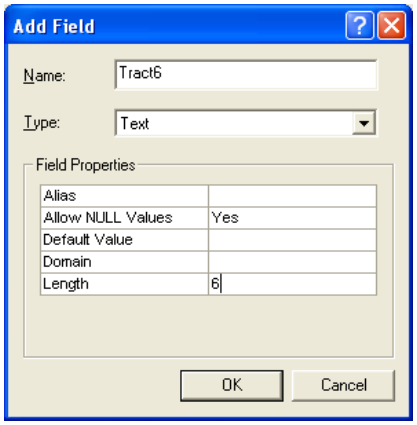
- Enter **TractStr** into the lower text box.



- Click **OK**.

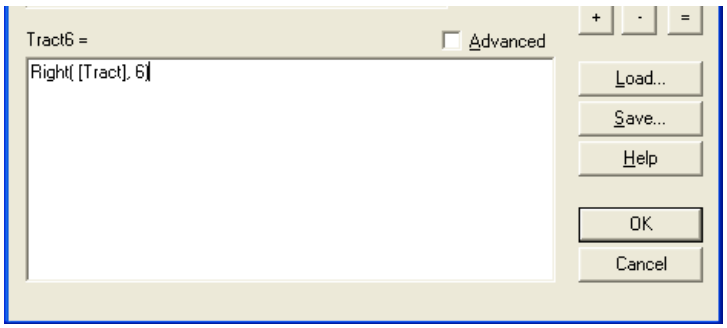
Tract*
72001000001
72001000002
72001000003
72001000004
72001000005
72001000006

- In the Region_Grid Attribute Table, Click the **Options** button and select **Add Field**.
- Enter **Tract6** into the **Name** field.
- Set **Type** as **Text**.
- Set **Length** as **6**.



- Click **OK**.
- Right-Click on the **Tract6** field name select **Calculate Values…**
- Enter the expression **Right([Tract], 6)** in the Field Calculator.

  Tract6 represents the last six digits of the Census Tract ID.



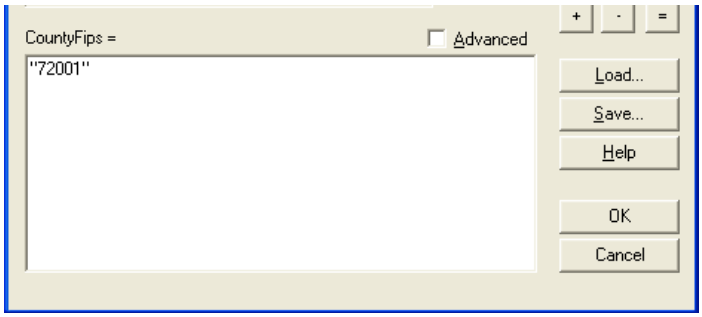
- Click **OK**.

Tract6
000001
000002
000003
000004
000005
000006

- In the Region_Grid Attribute Table, Click the **Options** button and select **Add Field**.
- Enter **CountyFips** into the **Name** field.
- Set **Type** as **Text**.
- Set **Length** as **5**.

- Click **OK**.
- Right-Click on the **CountyFips** field name select **Calculate Values…**
- Enter the expression **"72001"** in the Field Calculator.

  The number "72001" is the State and County identifier for Adjuntas County in Puerto Rico. Please see the notes above for a discussion on the use of this number.



- Click **OK**.

CountyFips
72001
72001
72001
72001
72001
72001

10. Calculate the Area, Latitude, and Longitude.

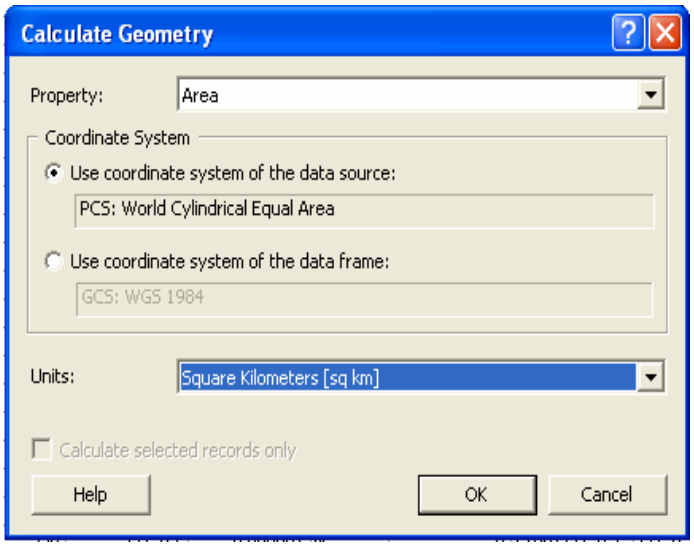
    - In the Region_Grid Attribute Table, Add the following three fields:

Name:	Type:
TractArea	**Float**
CenLat	**Double**
CenLongit	**Double**

    - Calculate the **TractArea** field.

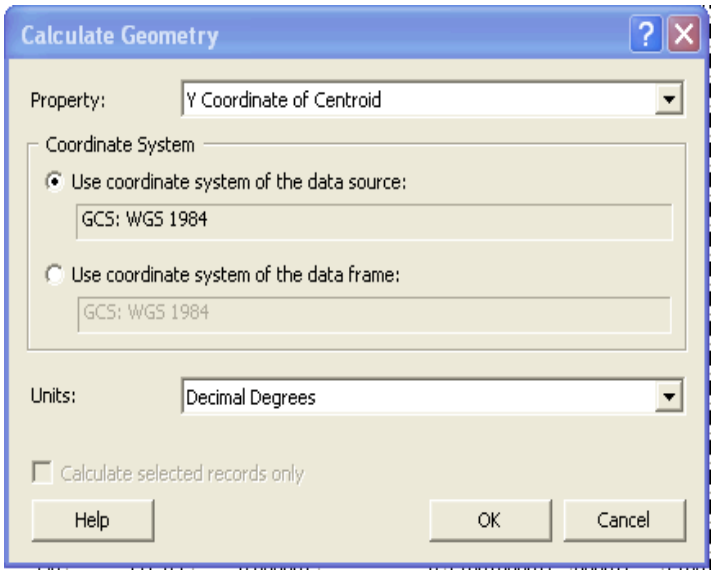
    - Open the Attribute Table of the Region_Grid shapefile, right-click the **TractArea** column and select "Calculate Geometry".

    - Select **Area** in the "Property:" field and **Square Kilometers** in the "Units:" field.



Because HAZUS uses GCS NAD83 a projected coordinate system, the feature class must also be in a projected coordinate system to make an accurate area calculation. If Area in the "Property:" field appears as "Area – Disabled" it means that the Region_Grid shapefile is not in a projected coordinate sytem and needs to be re-projected. This can be done through the Project tool in ArcToolbox.

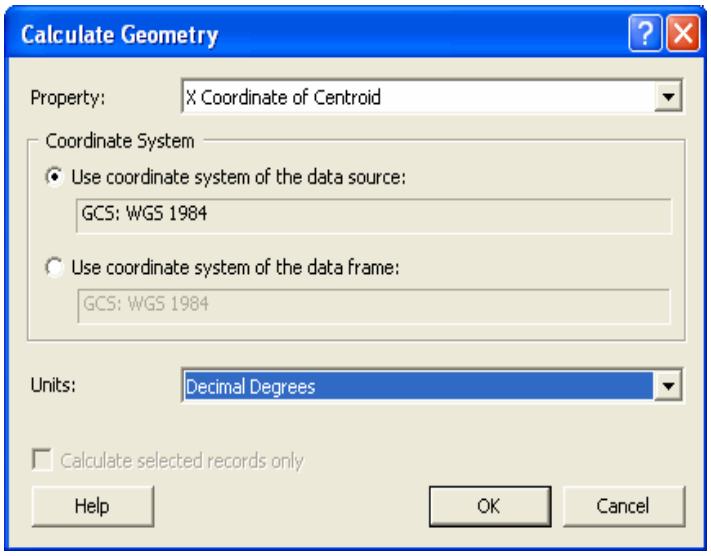
- Calculate the **CenLat** field.
- Open the Attribute Table of the Region_Grid shapefile, right-click the **CenLat** column and select "Calculate Geometry".
- Select **Y Coordinate of Centroid** in the "Property:" field and **Decimal Degrees** in the "Units:" field



- Calculate the **CenLongit** field.

- Open the Attribute Table of the Region_Grid shapefile, right-click the **CenLongit** column and select "Calculate Geometry".

- Select **X Coordinate of Centroid** in the "Property:" field and **Decimal Degrees** in the "Units:" field



TractArea	CenLat	CenLongit
3.05815	38.804540	15.223618
5.6935	38.708050	13.179209
0.075133	38.709134	13.200977
1.62109	38.788769	15.195019
8.0521	38.788175	15.216953
2.59057	38.695957	13.171031

11. Calculate remaining Census Tract fields.

- In the Region_Grid Attribute Table, Add the following two fields:

Name:	Type:
NumAggrBocks	**Long Integer**
BldgSchemesId	**Text (length 5)**

- Calculate the **NumAggrBocks** field to equal **1**.

  The NumAggrBocks field contains the number of census blocks in each census tract. Because the earthquake only operates at the census tract level this number is irrelevant; however, the field does not allow for null values.

- Calculate the **BldgSchemesId** field to equal "**PR2**".

  The BldgSchemesId field identifies the default Building Scheme for Puerto Rico. This value was taken from the original Puerto Rico Tract feature class and will be applied to the RELEMR region. After completing your study region you will be able to alter these building schemes to better reflect local conditions. If you are using any State other than Puerto Rico as your surrogate you will need to alter this value accordingly.

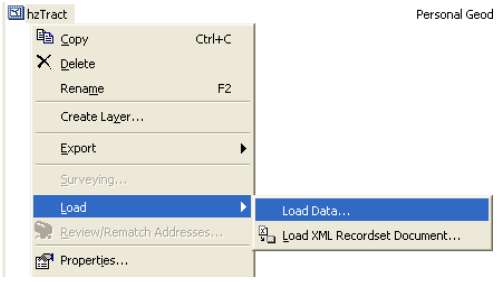
NumAggrBocks	BldgSchemesId
1	PR2
1	PR2
1	PR2
1	PR2
1	PR2
1	PR2

Populate the Geodatabases

This next section will take you through the steps of populating the Intermediate Geodatabases and loading the Final Data. We will use the population ratio to distribute the General Building Stock throughout the study area. This methodology is one of many that could be used for distributing the GBS.

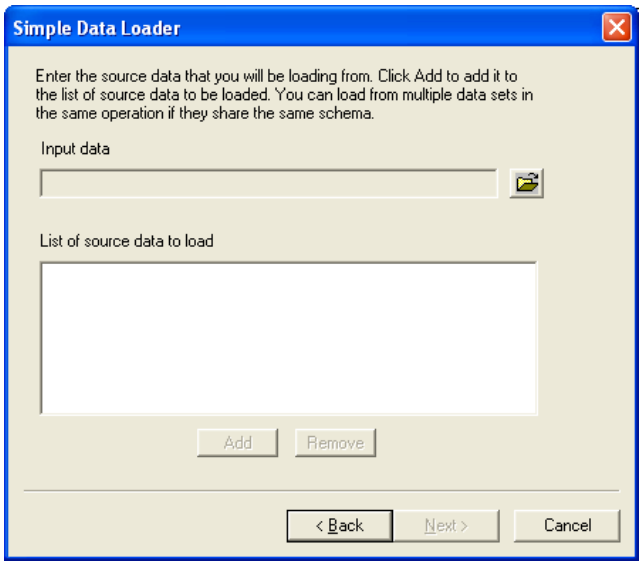
1. Load the data into the Intermediate Geodatabases in the **IntData** folder.

   - In ArcCatalog, Right-Click on **hzTract** in the IntData folder and select **Load→Load Data…**



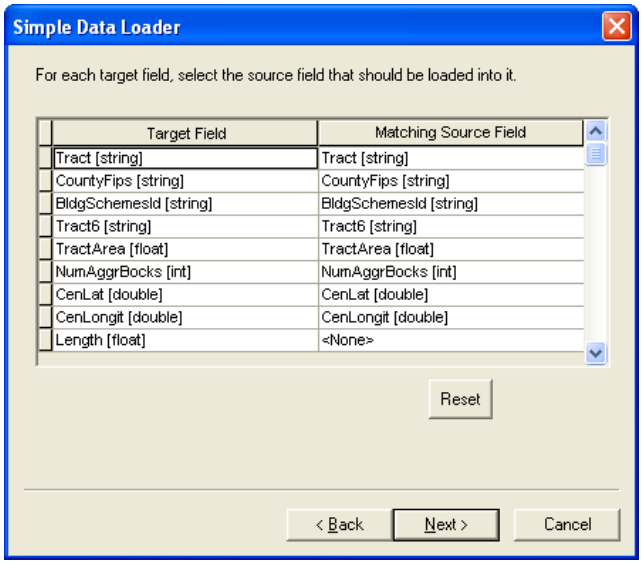
   - Click **Next** in the first screen of the **Simple Data Loader**.

   - Navigate to the **Region_Grid** feature class in your Working folder and Click the **Add** button.



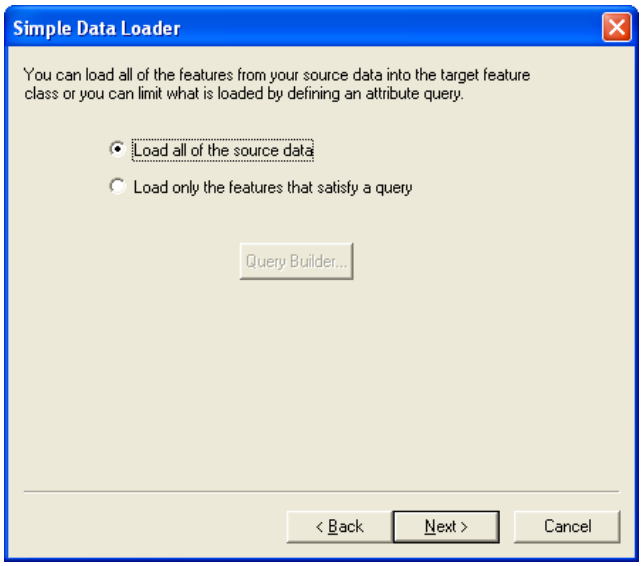
- Click **Next** twice to get to the Field Matching Window.
- Set each **Matching Source** field to match the **Target** field.

  Each field will automatically find its counterpart if there is an identical match. There should be a match for every Target Field except Length.



- Click **Next**.
- Make sure the "**Load all of the source data**" radio button is selected and Click **Next**.

There is a limit to the number of records you can load with the Simple Data Loader. When loading tens of thousands of records you may need to load the data in two or more batches. This can be done with the "Load only the features that satisfy a query" radio button.

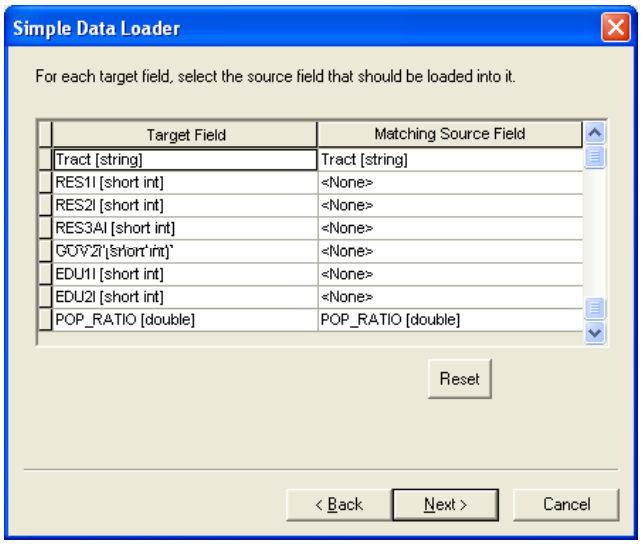


- Review the Summary window and Click **Finish**.

- The process for loading data into feature classes and tables is the same. **Repeat** these steps by loading the Region_Grid feature class into the following tables:

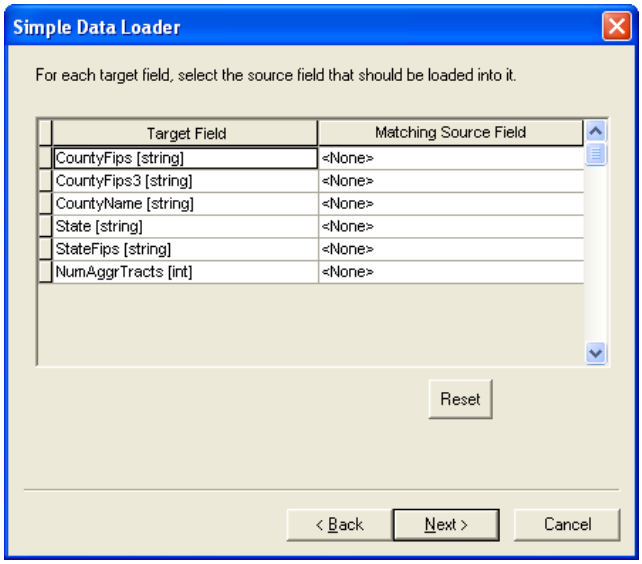
  hzBldgCountOccupT
  hzExposureContentOccupT
  hzExposureOccupT
  hzSqFootageOccupT
  hzDemographicsT

  The only matching fields should be **Tract** and **POP_RATIO**. The rest of the fields will be calculated in the following steps.



- Load the **Region_Bnd (or whatever dataset defines your study area)** dataset into the **hzCounty** feature class.

  You may not have any matching fields; however, the geographic feature will still be loaded. We will calculate any remaining fields in the following step.



2. Calculate any remaining fields in the **hzCounty** feature class.

   - In ArcMap, add the **hzCounty** feature class from the FinalData folder.
   - Open the Attribute Table.
   - Calculate the following values for each field:

CountyFips = "72001" *State + County Identifier*
CountyFips3 = "001" *County Identifier*
CountyName = "Sicily" *Name of Study Area*
State = "PR" *State Abbreviation for Puerto Rico*
StateFips = "72" *State Identifier*
NumAggrTract = 679 *Total # of Census Tracts*

CountyFips	CountyFips3	CountyName	State	StateFips	NumAggrTracts
72001	001	Sicily	PR	72	679

3. Calculate the General Building Stock and Demographics distribution.

   - (Optional) Create a summary table containing total values for each of the HAZUS GBS attribute tables. This will provide a quick reference when calculating the General Building Stock distribution and Demographics distribution.

General Building Stock Totals by Occupancy				
Occupancy	hzBldgCountOccupT	hzExposureOccupT	hzExposureContent	hzSqFootageOccupT
RES1I	1022374	111670824	55845945	1635083.97
RES2I	4602	184469	95071	5972.07
RES3AI	13528	2787205	1401364	48191.79
RES3BI	7672	1865429	940337	29673.86
RES3CI	3391	3916231	1962727	36245.81
RES3DI	1842	2770523	1387808	28577.17
RES3EI	160	1235579	619254	13197.69
RES3FI	420	3258578	1630950	35700.17
RES4I	17	290182	145103	3224.90
RES5I	801	2231679	1116156	21839.70
RES6I	10	35394	17707	393.40
COM1I	267	1989179	1989179	32330.93
COM2I	1133	1860408	1860408	34942.30
COM3I	546	419320	419320	5616.57
COM4I	260	1973705	1973705	23191.11
COM5I	488	264789	264789	1999.70
COM6I	51	381602	572411	3068.60
COM7I	473	391781	587733	3509.29
COM8I	999	592851	592851	5031.01
COM9I	12	14453	14453	164.20
COM10I	0	0	0	0.00
IND1I	308	598589	897916	9428.70
IND2I	548	894148	1341265	16793.69
IND3I	325	1523691	2285571	14825.00
IND4I	14	76981	115482	748.99
IND5I	8	41792	62691	406.60
IND6I	189	341771	341771	6419.19
AGR1I	107	184621	184621	3467.51
REL1I	140	243019	243019	2477.03
GOV1I	383	329978	329978	4249.09
GOV2I	14	17076	25616	145.90
EDU1I	13	246271	246271	3085.75
EDU2I	45	243149	364735	2465.40

   - To accommodate the large difference between the population of Puerto Rico and The RELEMR Region a multiplier was used to correct for the population differences, the multiplier was applied to all General Building Stock and Demographic data in the RELEMR study region. The multiplier was applied to the Puerto Rico data and logged in a table similar to the one pictured above. The values established with the multiplier were then distributed as described below.

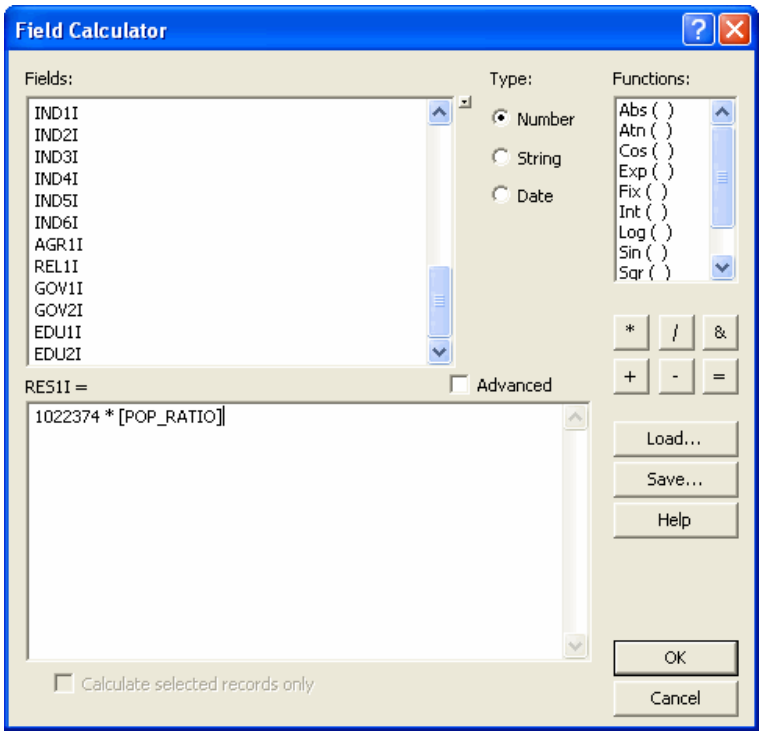
- Distribution of General Building Stock and Demographics data through the use of the POP_RATIO and U_POP_RATIO.

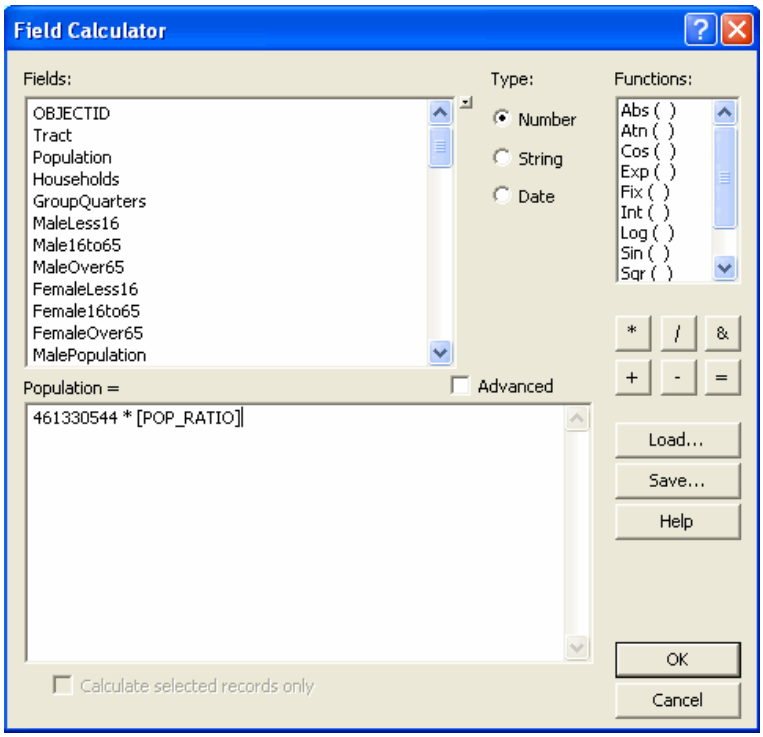
  1. POP_RATIO is applied to all Residential Building Types through the use of the field calculator, for example: RES1 = 1022374 * [POP_RATIO]. See example below.

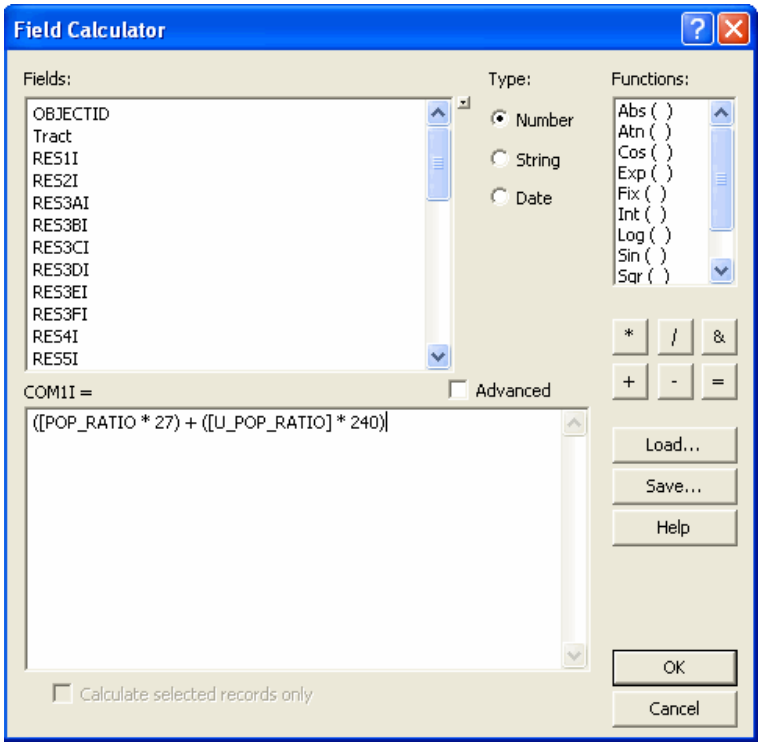
  2. POP_RATIO is applied to all Demographic Data through the use of the field calculator, for example: Population = 461330544 * [POP_RATIO]. See example below.

  3. POP_RATIO and U_POP_RATIO are applied to all Commercial, Industrial, Religious, Agricultural and Educational Building Types through the use of the field calculator, for example:
     COM1 = (27 * [POP_RATIO]) + (240 * [U_POP_RATIO]). See example below.

In this example the total number of COM1locations would be 267, we took 10% of that number (27) and distributed those locations throughout the entire region though the use of the POP_RATIO which is applied to all grids in the study region. The remaining 90% (240) COM1 locations were distributed throughout the urban areas through the use of the U_POP_RATIO which is applied to only the urban grids in the area.




Field Calculator
Fields:
OBJECTID
Tract
Population
Households
GroupQuarters
MaleLess16
Male16to65
MaleOver65
FemaleLess16
Female16to65
FemaleOver65
MalePopulation
Type:
Number
String
Date
Functions:
Abs ( )
Atn ( )
Cos ( )
Exp ( )
Fix ( )
Int ( )
Log ( )
Sin ( )
Sqr ( )
* / &
+ - =
Population =
Advanced
461330544 * [POP_RATIO]
Load...
Save...
Help
OK
Cancel
Calculate selected records only


Field Calculator
Fields:
OBJECTID
Tract
RES1I
RES2I
RES3AI
RES3BI
RES3CI
RES3DI
RES3EI
RES3FI
RES4I
RES5I
Type:
Number
String
Date
Functions:
Abs ( )
Atn ( )
Cos ( )
Exp ( )
Fix ( )
Int ( )
Log ( )
Sin ( )
Sqr ( )
* / &
+ - =
COM1I =
Advanced
([POP_RATIO * 27) + ([U_POP_RATIO] * 240)
Load...
Save...
Help
OK
Cancel
Calculate selected records only

- In ArcMap, add the **hzBldgCountOccupT, hzExposureContentOccupT**, **hzExposureOccupT**, **hzSqFootageOccupT** and **hzDemographicsT** tables.

- Open the attribute table of **hzBldgCountOccupT**.

- Right-Click the field name **RES1I** and select **Calculate Values.**

- Apply the methodology outlined above to properly distribute General Building Stock and Demographics Data throughout the region using POP_RATIO and U_POP_RATIO.

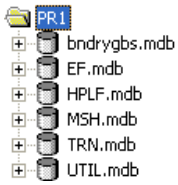
- Repeat these steps for the **hzExposureContentOccupT**, **hzExposureOccupT**, **hzSqFootageOccupT** and **hzDemographicsT** tables.

4. Load the data into the Final Geodatabases in the FinalData folder:

   - In ArcCatalog, use the Simple Data Loader to load data from the Intermediate Geodatabases in the IntData folder to the Final Geodatabases in the FinalData folder. Do this for the following feature classes and tables:

     hzTract
     hzCounty
     hzBldgCountOccupT
     hzExposureContentOccupT
     hzExposureOccupT
     hzSqFootageOccupT
     hzDemographicsT

5. Copy the Geodatabases in the **FinalData** folder to the **PR1** data aggregation folder. The five newly created Geodatabases should replace five of the existing Geodatabases. Your final PR1 folder should look like this:.



6. Edit the **syBoundary.mdb** Geodatabase.

   Numerous fields in the syBoundary.mdb Geodatabase contain indexes. These indexes may need to be removed in order to delete features in ArcMap.

   - In ArcMap, add the **syState**, **syCounty**, and **syTract** feature classes from the syBoundary folder.

- Start an Editing Session and delete all features for Puerto Rico in each feature class. Use the following queries for each dataset to select the appropriate features:

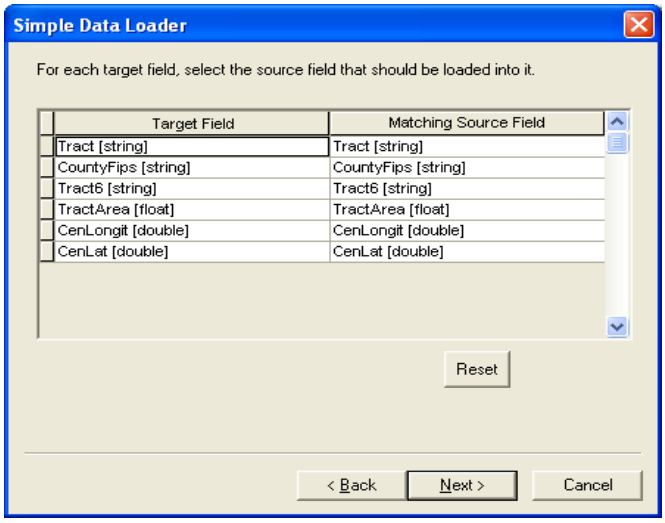
  syState – SELECT * FROM syState WHERE **StateFips = '72'**
  syCounty – SELECT * FROM syCounty WHERE **CountyFips LIKE '72*'**
  syTract – SELECT * FROM syTract WHERE **Tract LIKE '72*'**

- Stop the Editing Session and Save your edits.

7. Load data into the **syBoundary.mdb** Geodatabase.

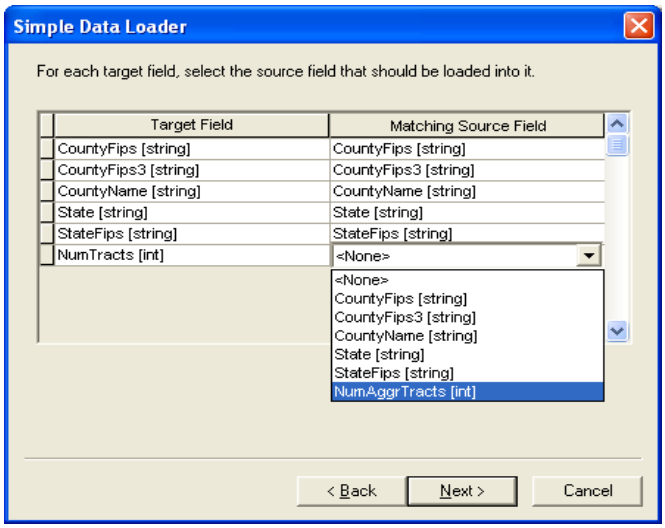
   - In ArcCatalog, use the Simple Data Loader to load the **hzTract** feature class from the FinalData folder into the **syTract** feature class in the syBoundary folder.

     All Target fields and Matching Source fields should automatically match.



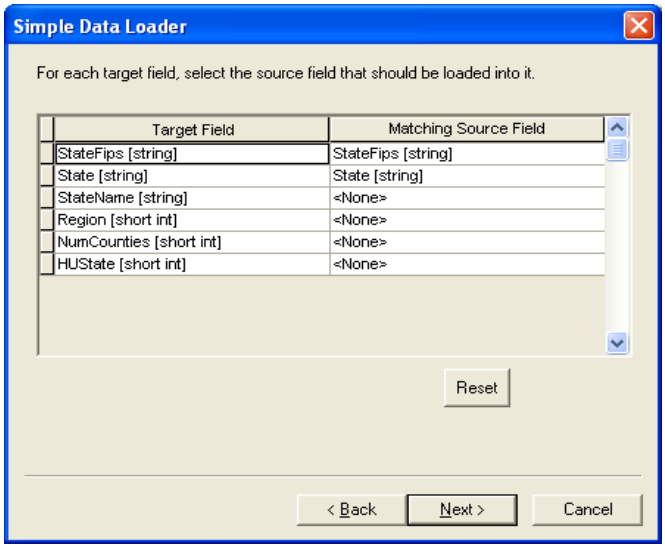
   - Load the **hzCounty** feature class from the FinalData folder into the **syCounty** feature class in the syBoundary folder.

     *All Target fields and Match Source fields should automatically match except **NumTracts**. You should manually select the Matching Source field as **NumAggrTracts**.*



- Load the **hzCounty** feature class from the FinalData folder into the **syState** feature class in the syBoundary folder.

  You will not have matching fields for StateName, Region, NumCounties, and HUState. We will calculate these remaining fields in the following step.



8. Calculate any remaining fields in the **syState** feature class.

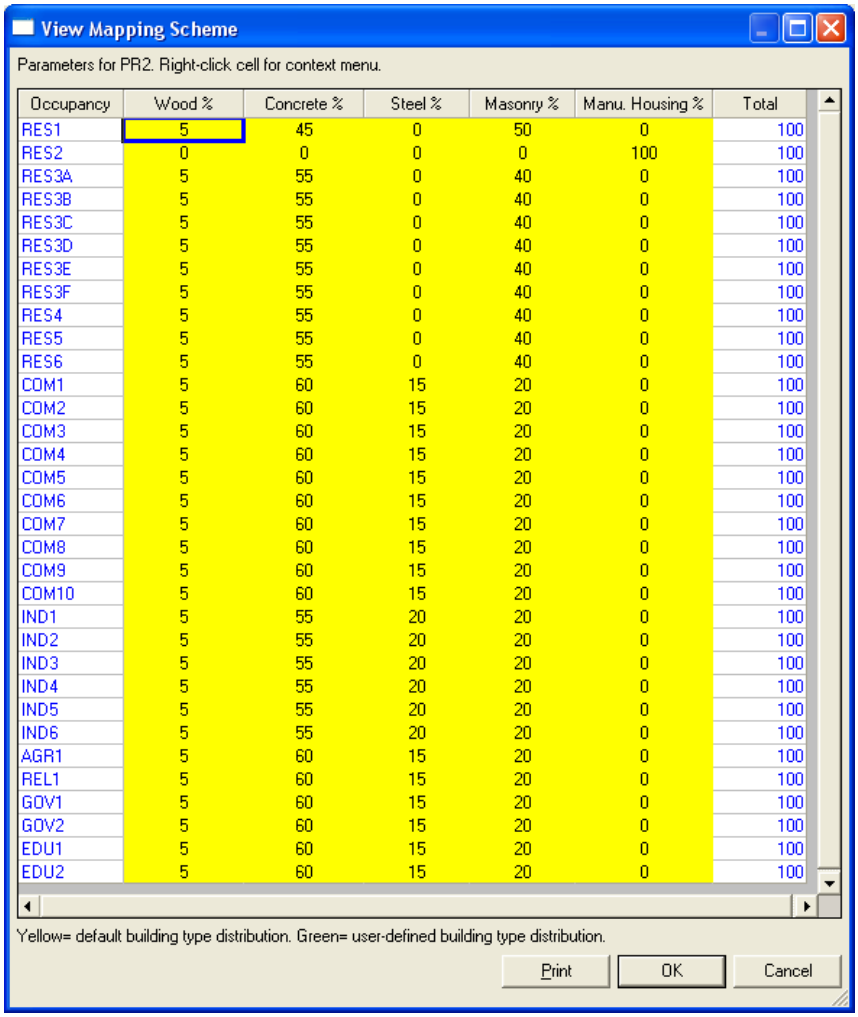
   - In ArcMap, add the **syState** feature class from the syBoundary folder.
   - Open the Attribute Table.
   - Calculate the following values for each field:

StateName = "RELEMR"	*Broad Name of Study Area*
Region = 0	*Identifies PR as an Eastern State*
NumCounties = 1	*Total # of Counties*
HUState = 0	*Identifies Ineligibility for the Hurricane Model*

9. Copy the new syBoundary.mdb Geodatabase in the syBoundary folder to the HAZUS data aggregation folder and replace the existing Geodatabase.

10. (Optional) Replace any indices for large feature classes (e.g. syTract, hzTract, hzBldgCountOccupT. Although this step is not required, it may improve processing time while building your study region.

NOTE: As discussed these steps provide users outside the United States with a sophisticated earthquake loss estimation tool. One of the critical next steps will be to adjust the U.S. building type information to better represent the building stock of the local Country. We start with the Puerto Rico building types as the best proxy mainly because a relatively low percentage is assigned to the wood frame categories so prevalent elsewhere in the U.S:



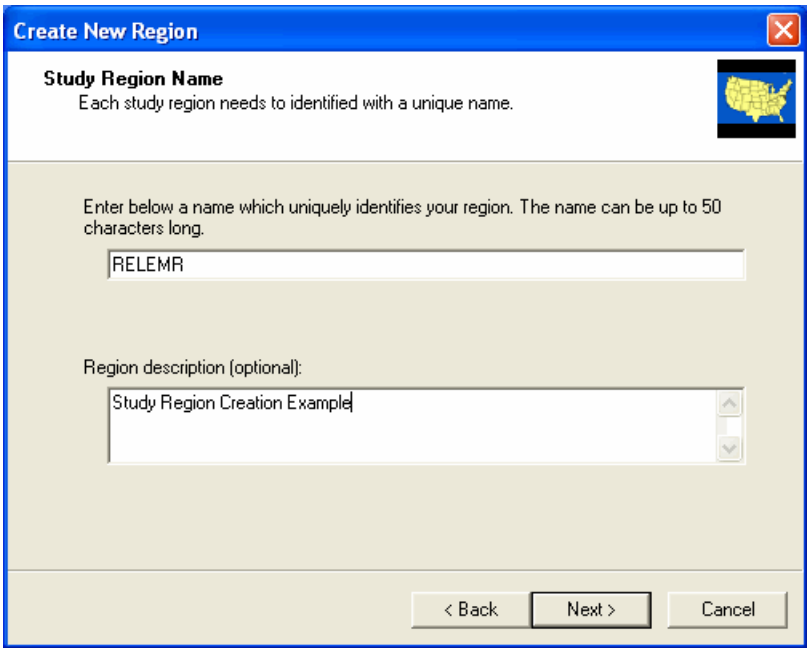
Occupancy	Wood %	Concrete %	Steel %	Masonry %	Manu. Housing %	Total
RES1	5	45	0	50	0	100
RES2	0	0	0	0	100	100
RES3A	5	55	0	40	0	100
RES3B	5	55	0	40	0	100
RES3C	5	55	0	40	0	100
RES3D	5	55	0	40	0	100
RES3E	5	55	0	40	0	100
RES3F	5	55	0	40	0	100
RES4	5	55	0	40	0	100
RES5	5	55	0	40	0	100
RES6	5	55	0	40	0	100
COM1	5	60	15	20	0	100
COM2	5	60	15	20	0	100
COM3	5	60	15	20	0	100
COM4	5	60	15	20	0	100
COM5	5	60	15	20	0	100
COM6	5	60	15	20	0	100
COM7	5	60	15	20	0	100
COM8	5	60	15	20	0	100
COM9	5	60	15	20	0	100
COM10	5	60	15	20	0	100
IND1	5	55	20	20	0	100
IND2	5	55	20	20	0	100
IND3	5	55	20	20	0	100
IND4	5	55	20	20	0	100
IND5	5	55	20	20	0	100
IND6	5	55	20	20	0	100
AGR1	5	60	15	20	0	100
REL1	5	60	15	20	0	100
GOV1	5	60	15	20	0	100
GOV2	5	60	15	20	0	100
EDU1	5	60	15	20	0	100
EDU2	5	60	15	20	0	100

Build the Study Region

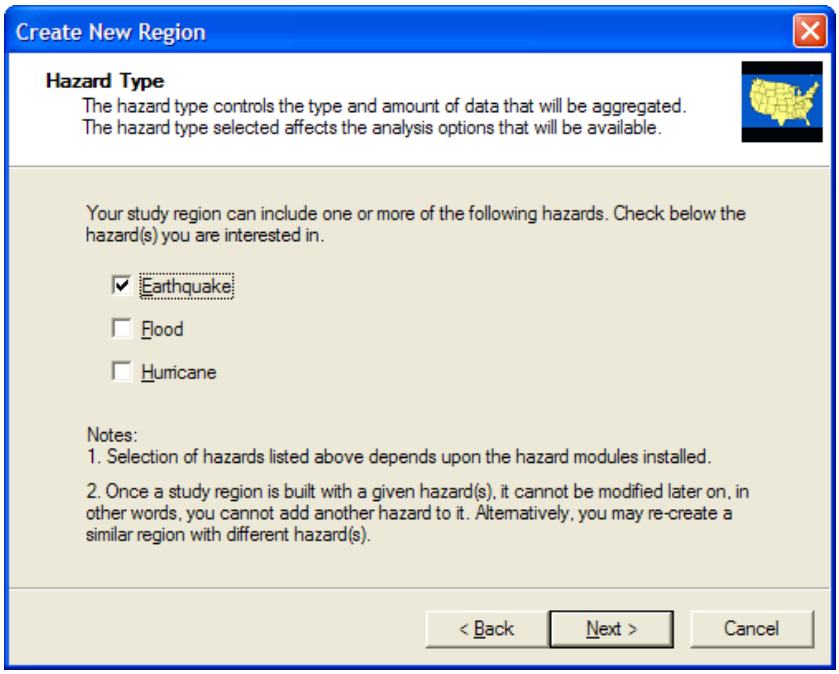
This section involves the creation of a study region in Sicily, Italy for which you will model the impact of a user-defined scenario and simulation in this course.

1. Create a New Study Region

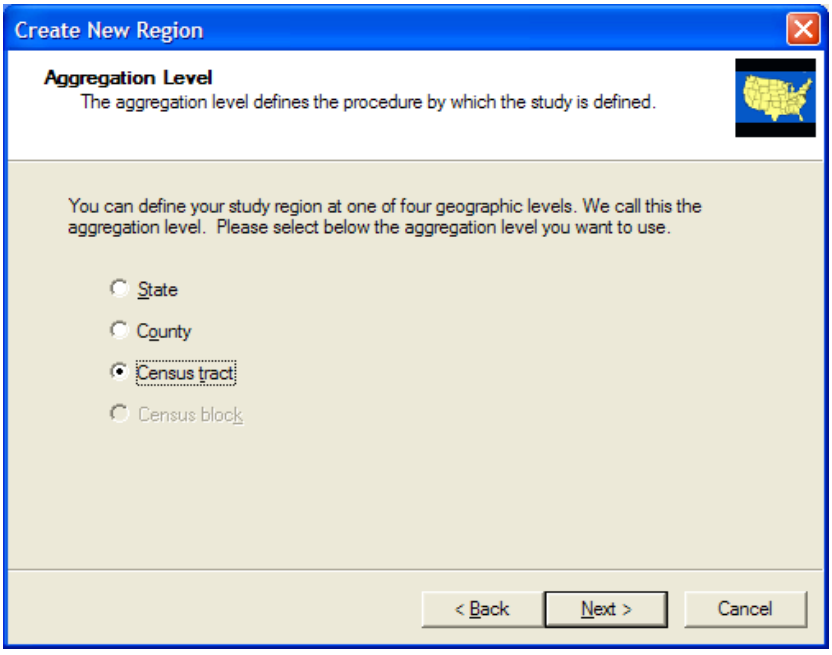
   - Start HAZUS-MH and choose **Create a New Region**.
   - Click **Next** to open the Create New Region window.
   - Enter **RELEMR** for the study region name.



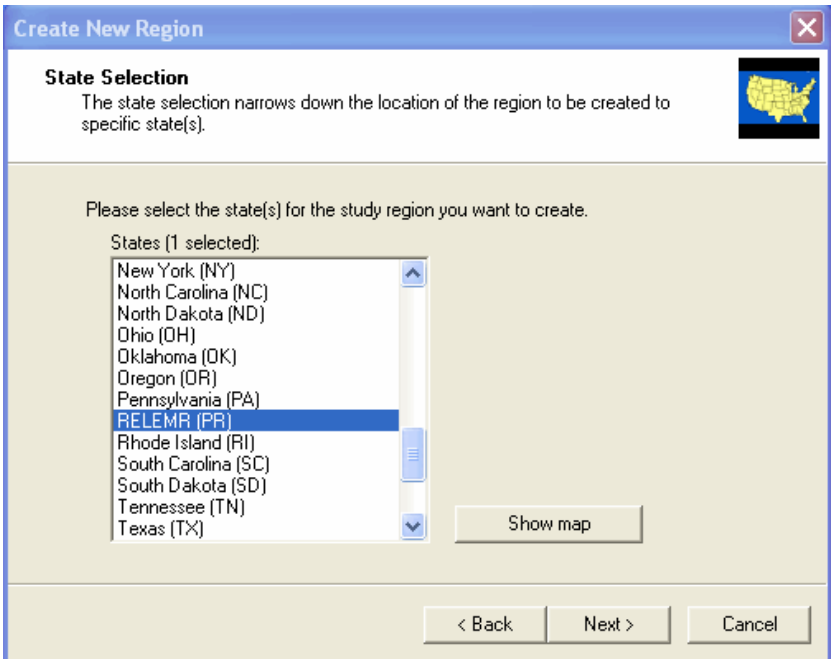
   - Click **Next** to move to the Hazard Type window.
   - Verify that ONLY the **Earthquake** option is checked,



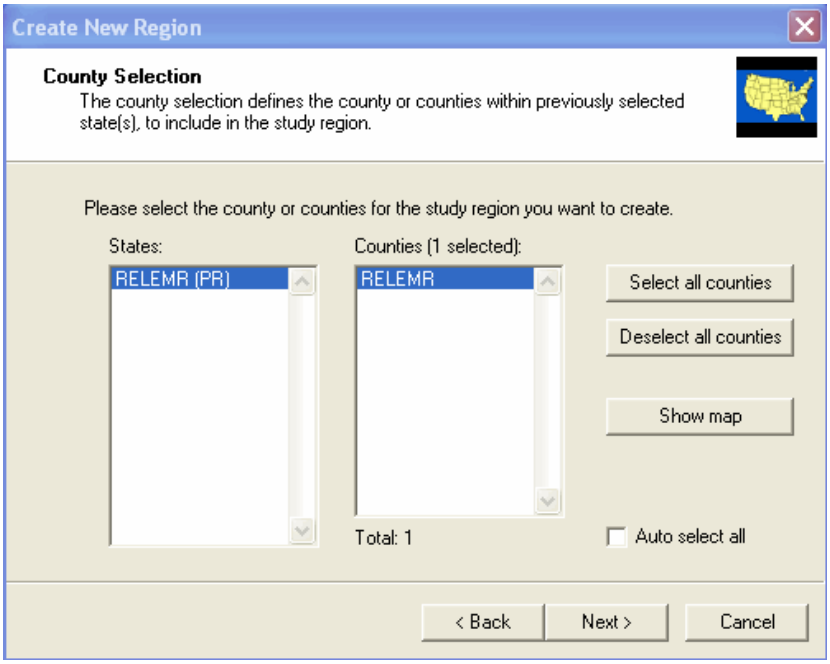
- Click **Next** to move to the Aggregation Level window.
- Choose **Census Tract** as the aggregation level.



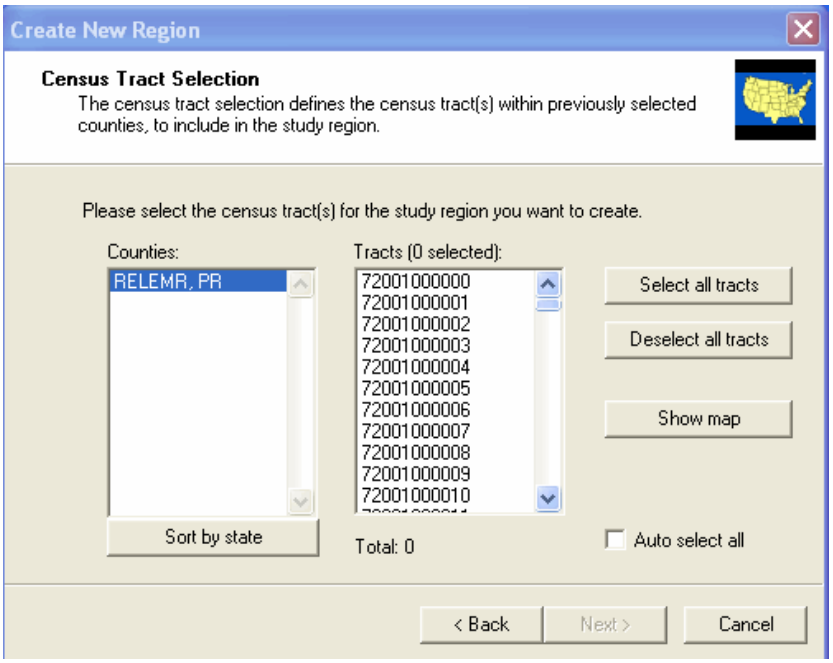
- Click the **Next** button to move to the State Selection window.
- Choose **RELEMR (PR)** for the state to include in your study region.



- Click the **Next** button to move to the County Selection window.
- Choose **RELEMR** for the county to include in your study region.



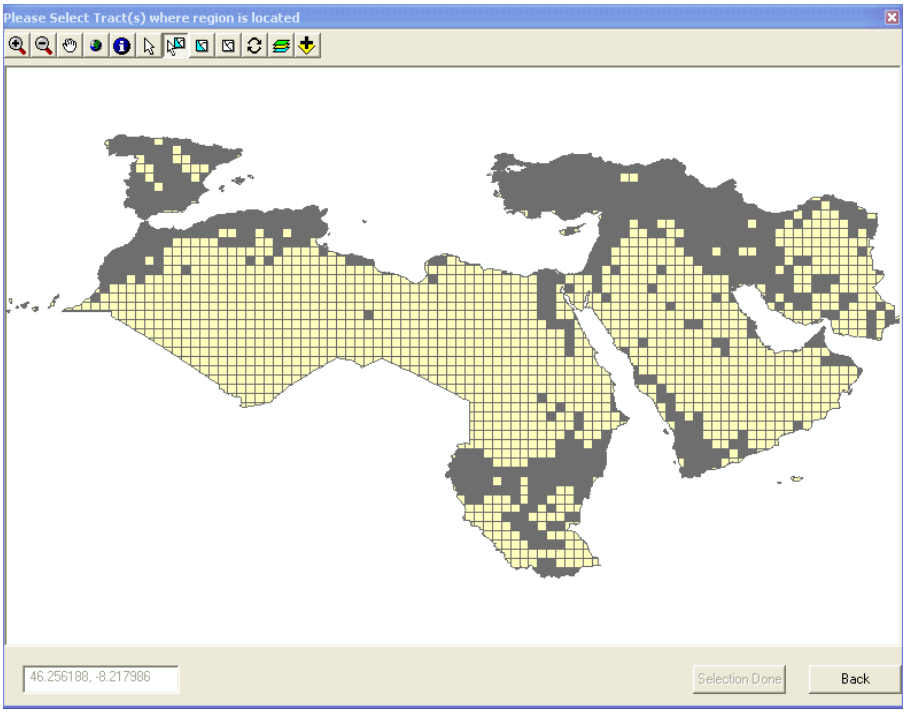
- Click the **Next** button to move to the Census Tract Selection window.



There are two ways to select Counties or Tracts. The first is by selecting the County Names (as we did above) or the Tract numbers. The second is by selecting the Counties or Tracts from the Map View. We will use the second method in the following step.

- Click the **Show Map** button to move to the Map Selection window.

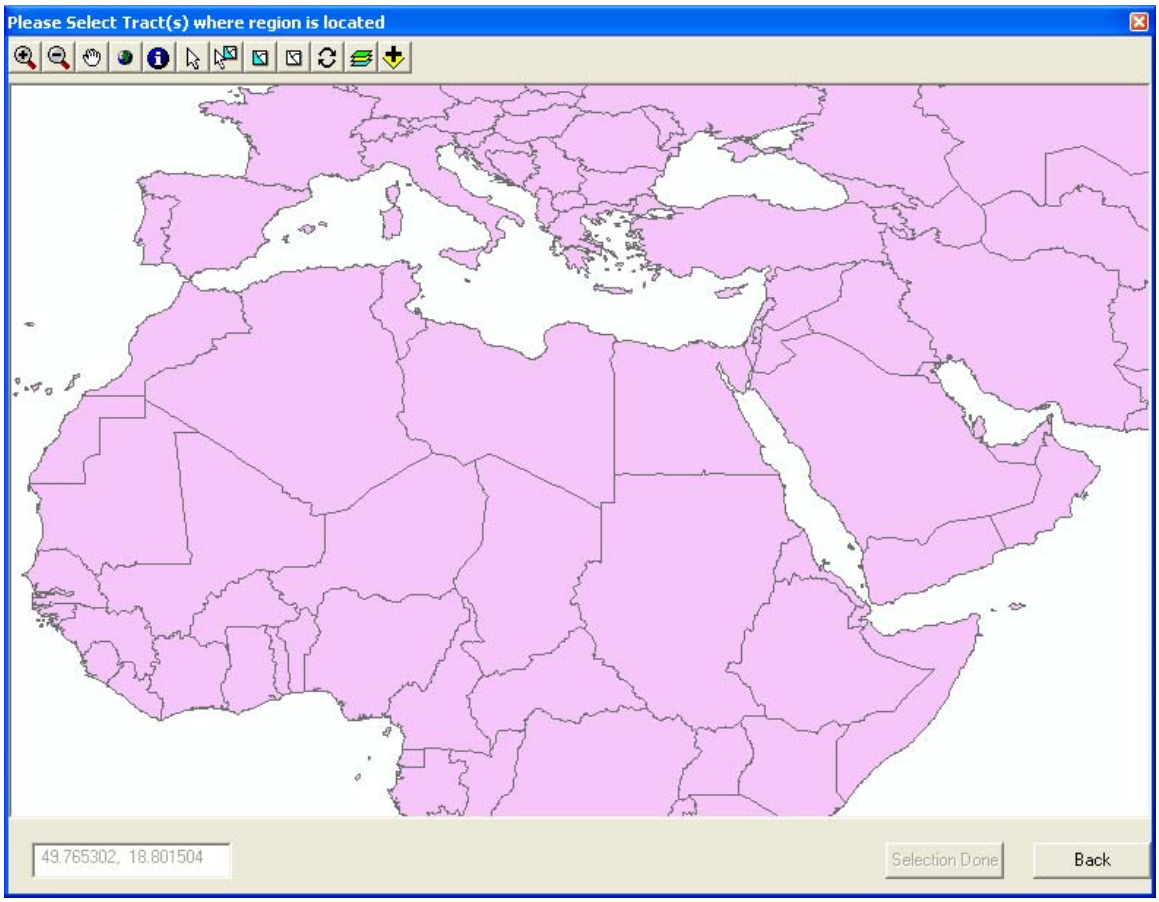
***IMPORTANT NOTE:** Because of the large number (140K) of grid cells in the RELEMR Region the Map View will take about **5 minutes** to display in window on a typical machine*



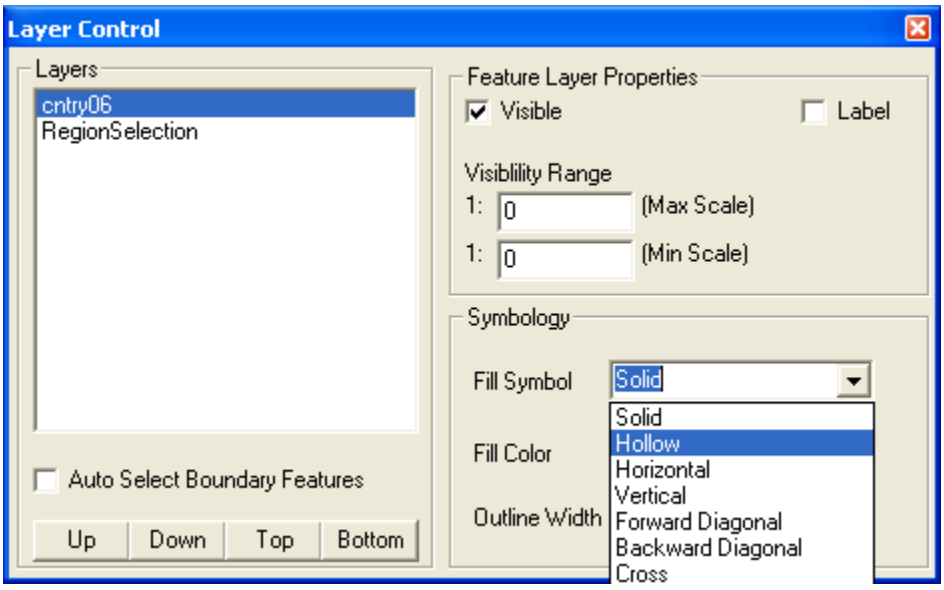
- Use the **Select Features** button to select tracts of interest.

  The Map View provides simple tools such as pan, zoom, info and add data to enable you to navigate through and select the data. Data can be added to the dialog box to make selections easier, data such as county boundaries, administrative boundaries or jurisdiction boundaries can be added.

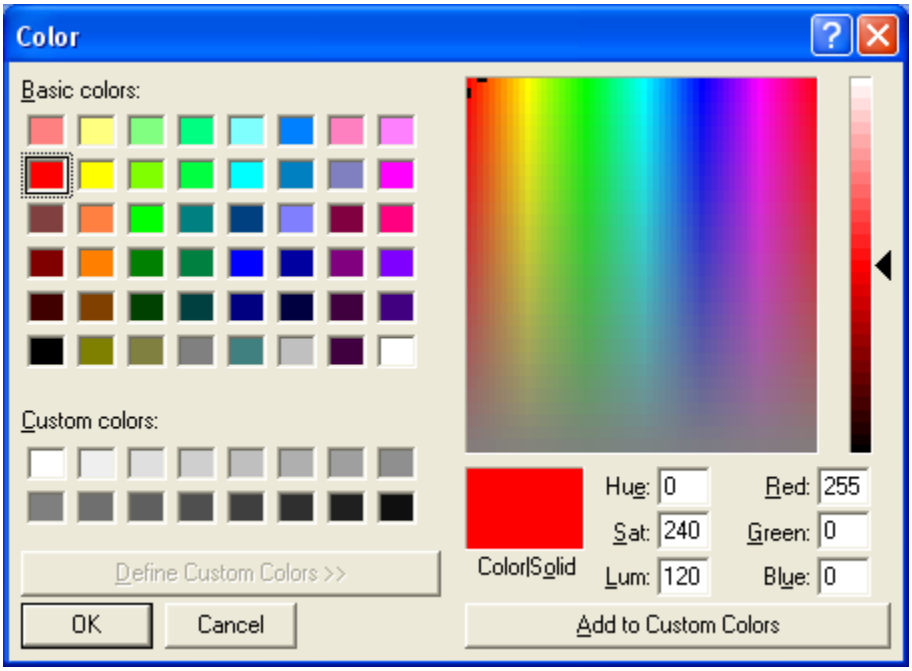
- For this example, we will use the **Add Data** button  to add a Country boundaries layer for guidance in selecting a study region incorporating Amman, Jordan. Navigate to the folder containing a Country boundary file. For this example, it is at \\RELEMR\WorldData\data\cntry06.



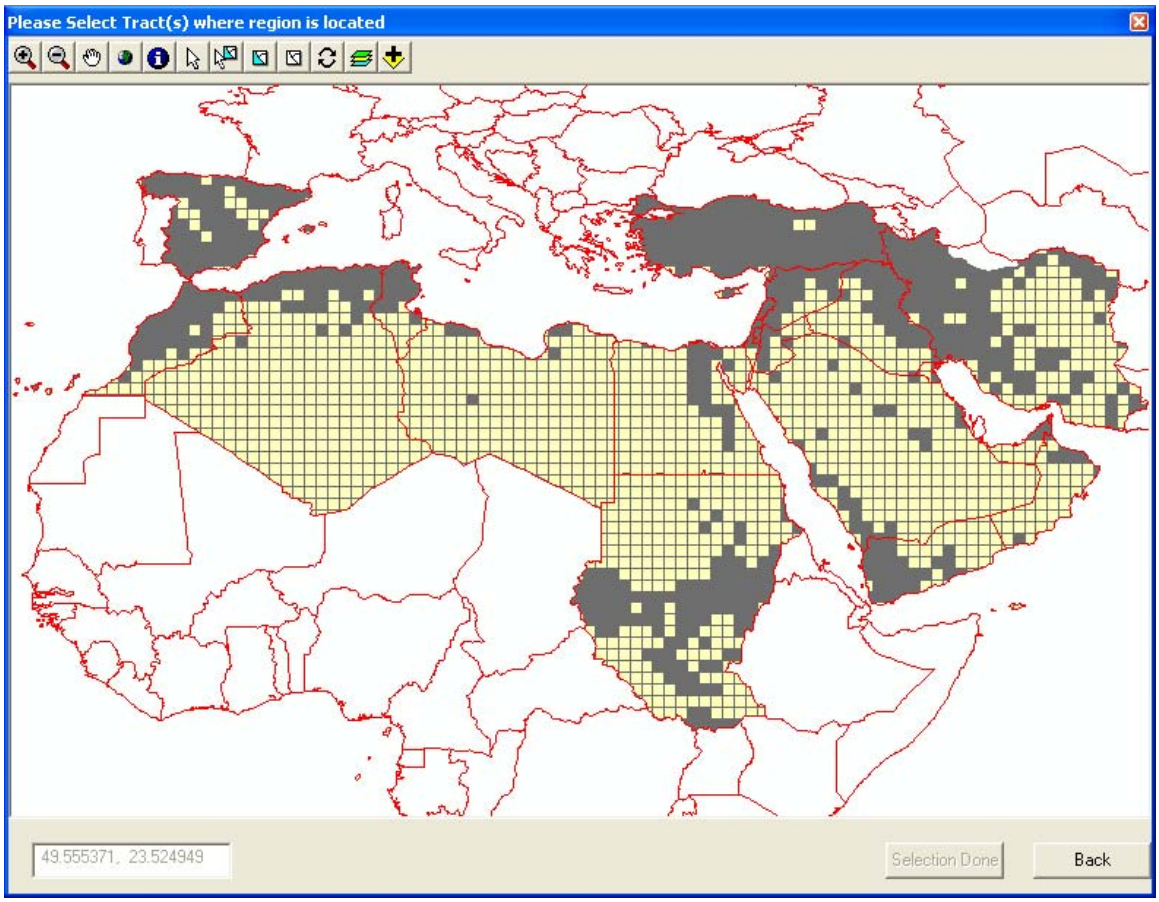
- To set the Country boundaries layer so that fill does not display, click on the **Layer Control** tool 



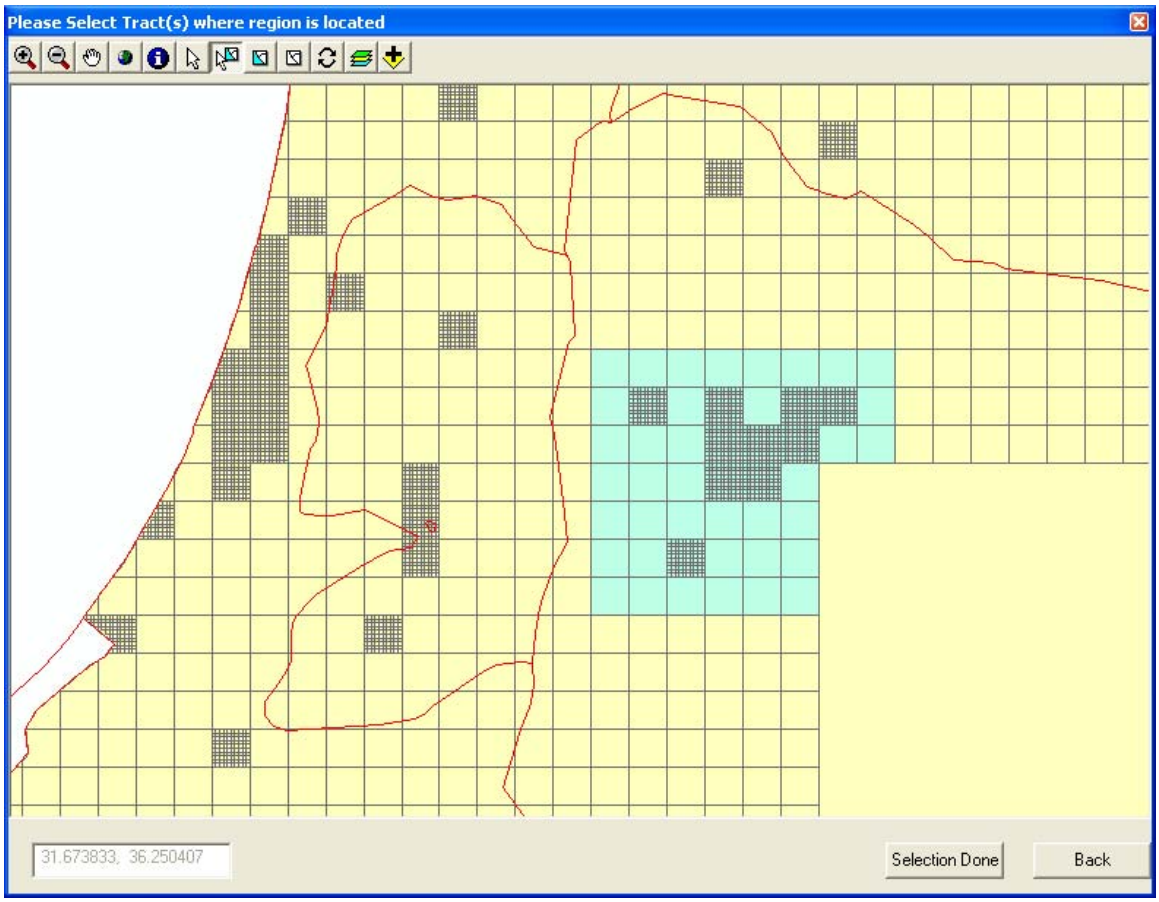
- Change the **Fill Symbol** to **Hollow** as shown above.



- It also helps to change the **Outline Color** to something brighter as shown above.



- Use **Zoom Tool**  to zoom into your area of interest.

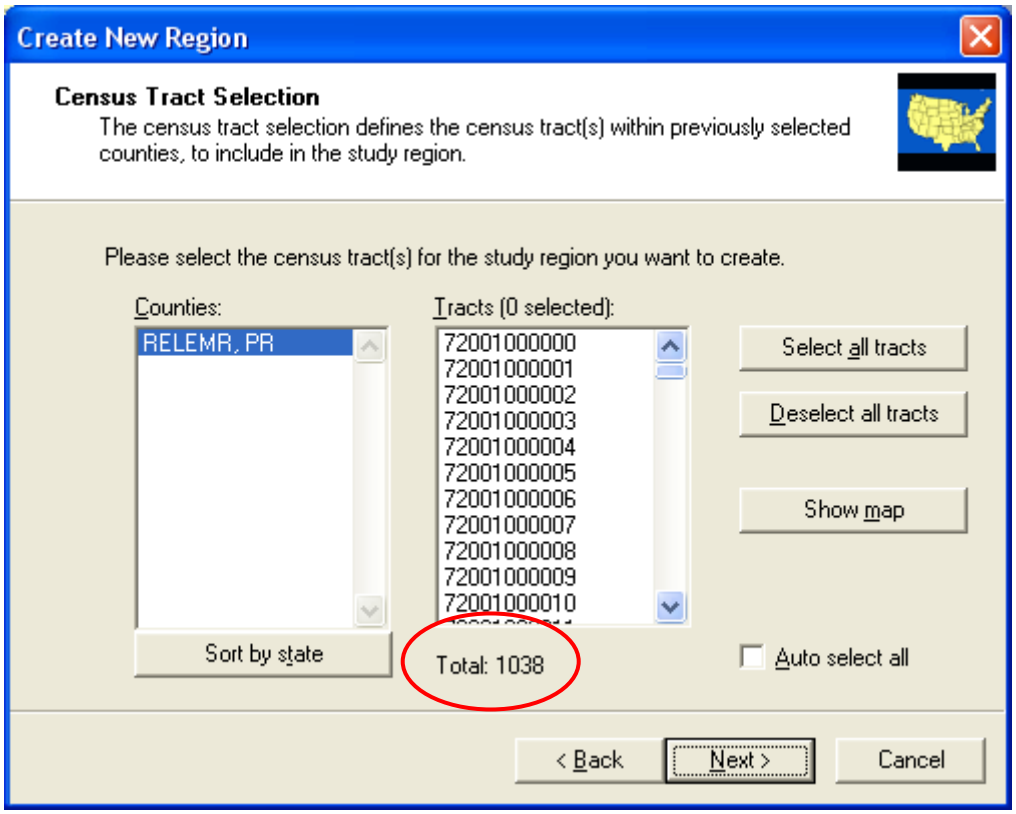


- Use **Select Key**  to select the grid cells you wish to analyze.

Hint: *Hold the shift key to highlight areas for selection or de selection.*

NOTE: When using the free version of SQL Express that ships with HAZUS, try to keep the area of analysis to **fewer than 4,000 grids**. Otherwise the 4GB SQL limitation may be exceeded and some of the analyses results will be excluded.

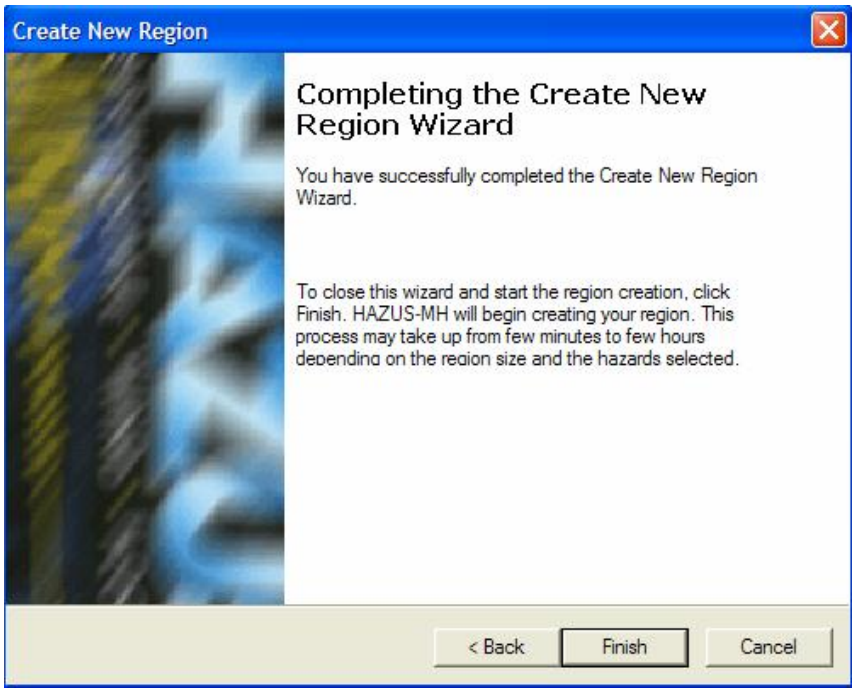
- Click on **Selection Done** button



- After selecting it will take a few minutes to process and return back to the Census Tract Selection window.

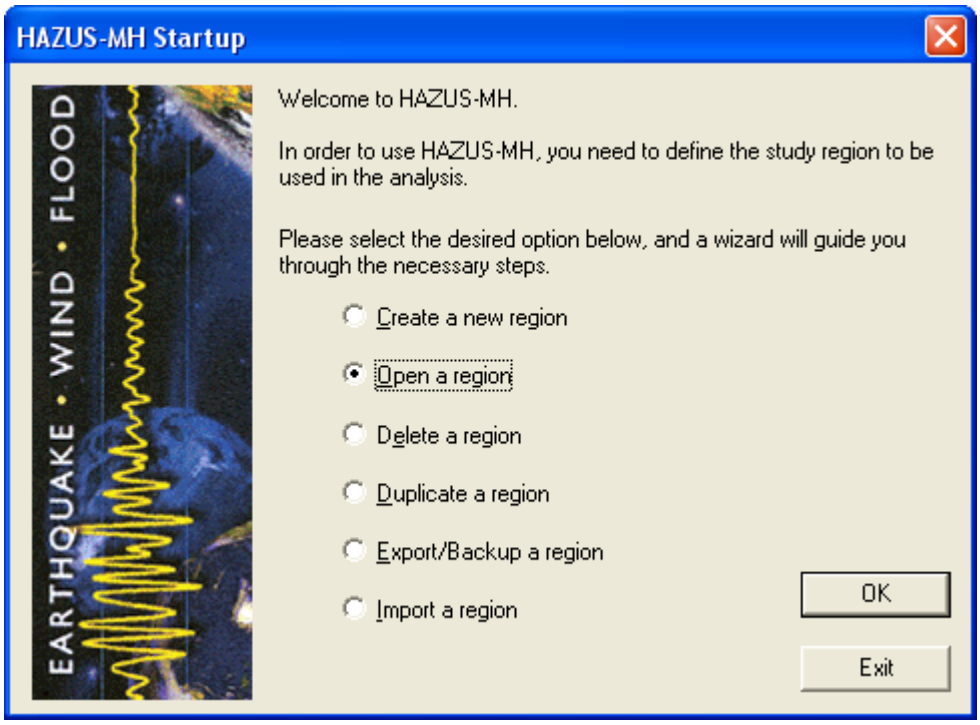
NOTE: At this point it is a good idea to confirm that the **Total** number of tracts (grids) selected is **less than 4,000** depending on the user's license restrictions with SQL Server.

- Click the **Next** button to move to the final screen of the Study Region Creation wizard.



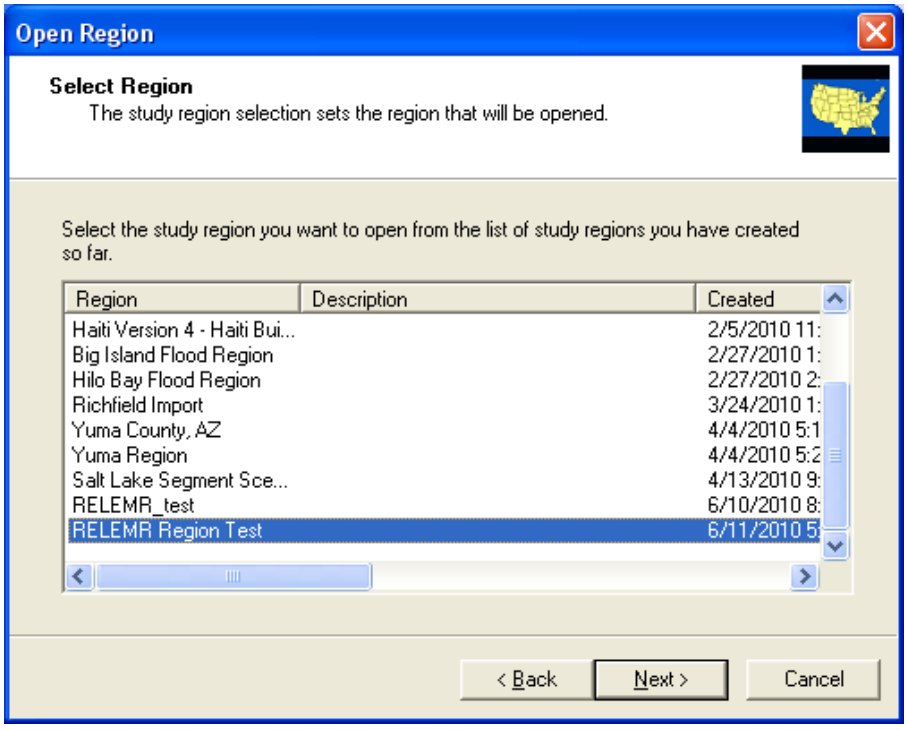
- Click **Finish** to complete the new region creation process.

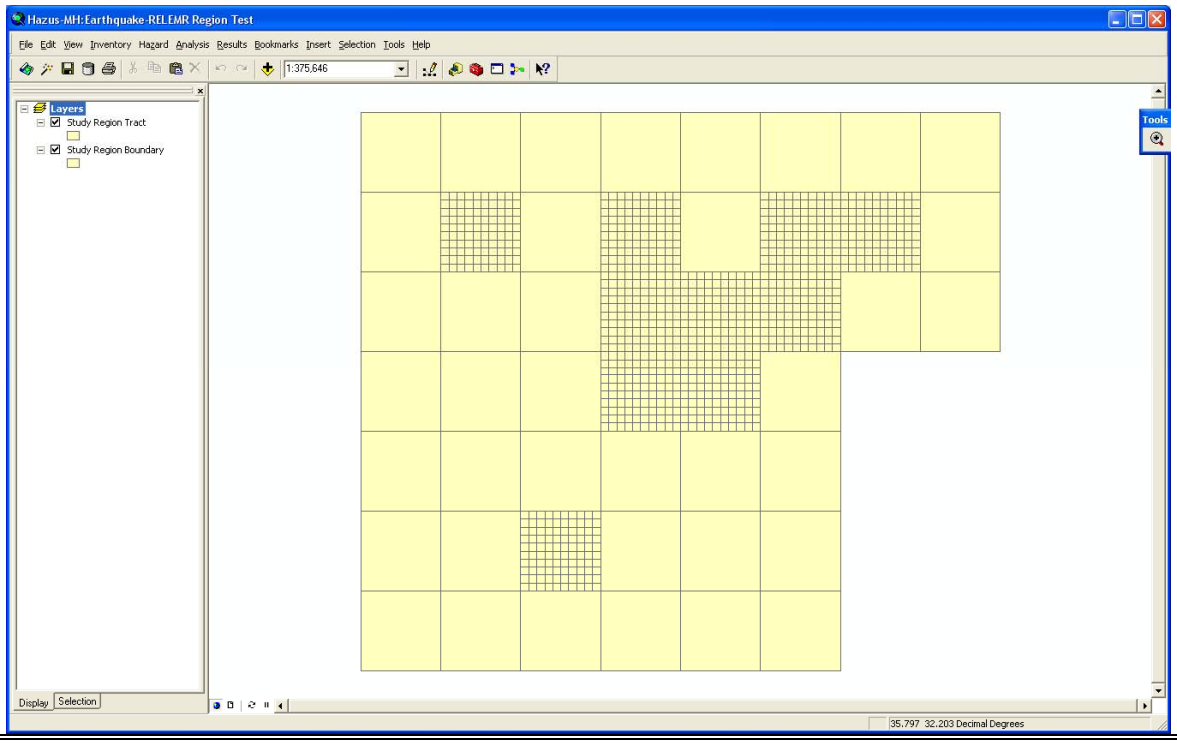
  When the region creation has completed, the HAZUS-MH startup screen will appear.



2. Open the study region

   - Open the **RELEMR** region.



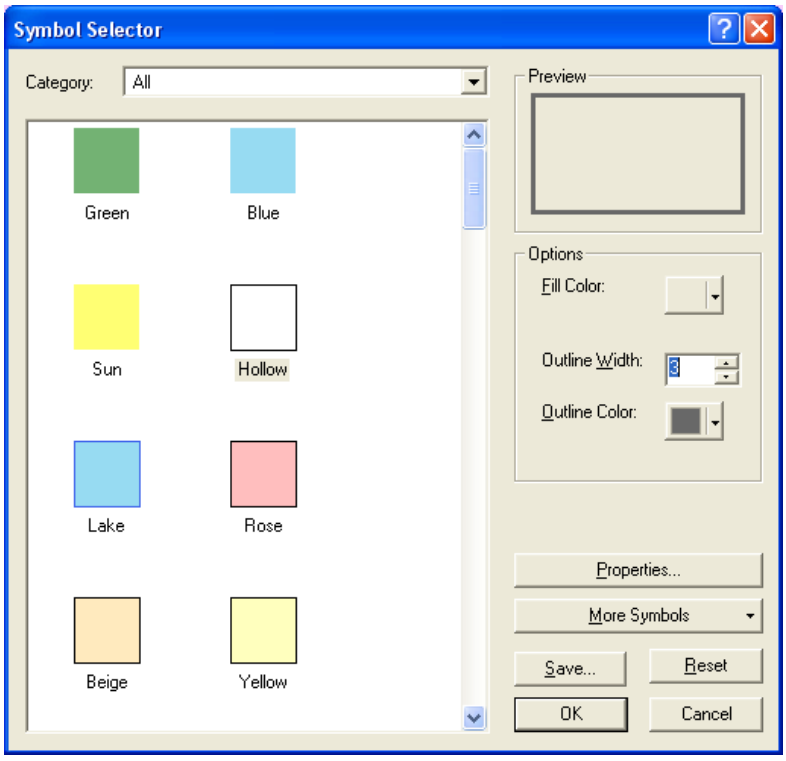


Adding Base Map Layers

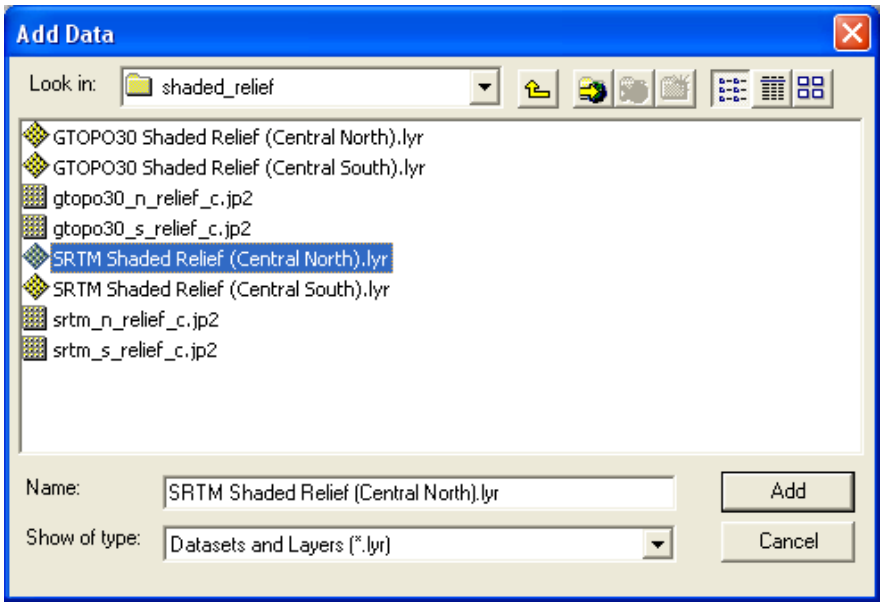
- **While not required for an earthquake loss estimation analysis, the view can benefit from base layers added to the ArcMap Table of Contents**

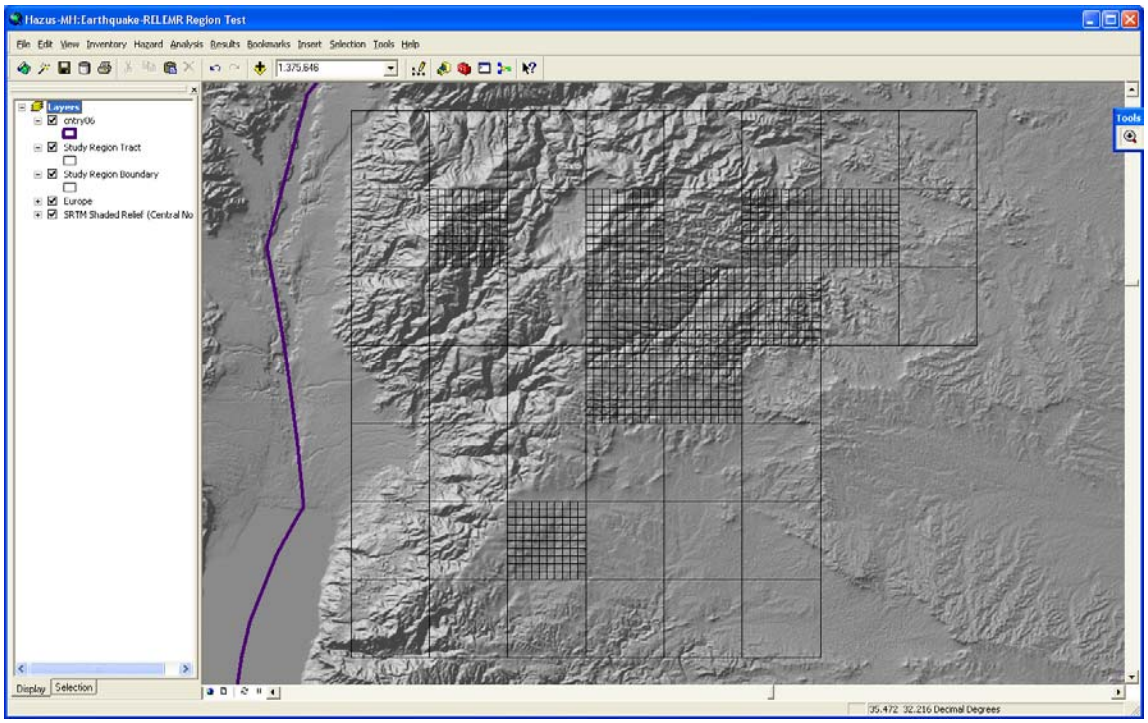
- For this example, we will use the **Add Data** button  to add a Country boundaries layer from \\RELEMR\WorldData\data\cntry06

- Double click on the symbol beneath the Country layer in the Table of Contents to change the symbology to hollow and increase the line width:



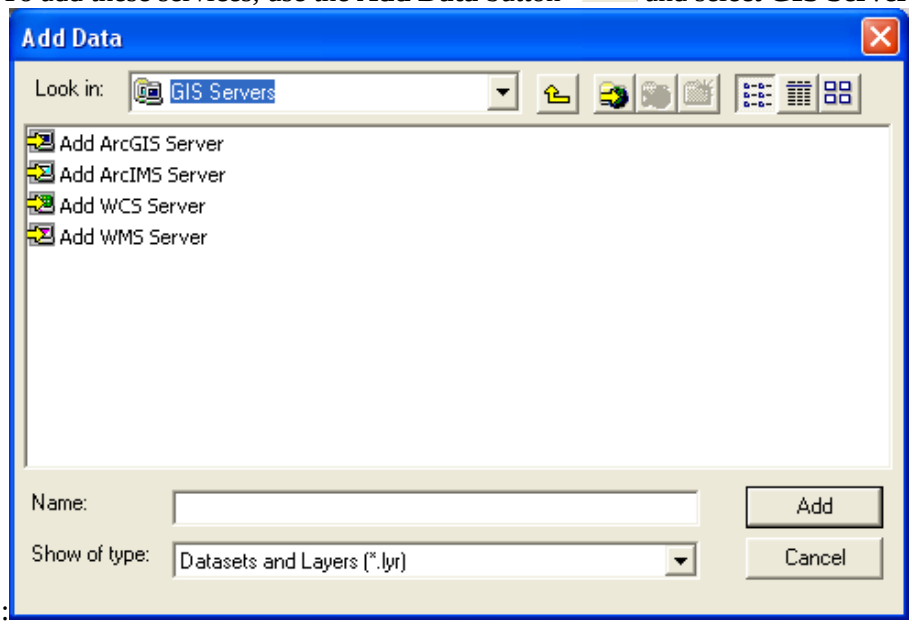
- We will use the **Add Data** button  to add a hillshade located here \\RELEMR\WorldData\shaded_relief\SRTM Shaded Relief (Central North).lyr that will illustrate the important role topographic relief will play later when we utilize ground motion maps.





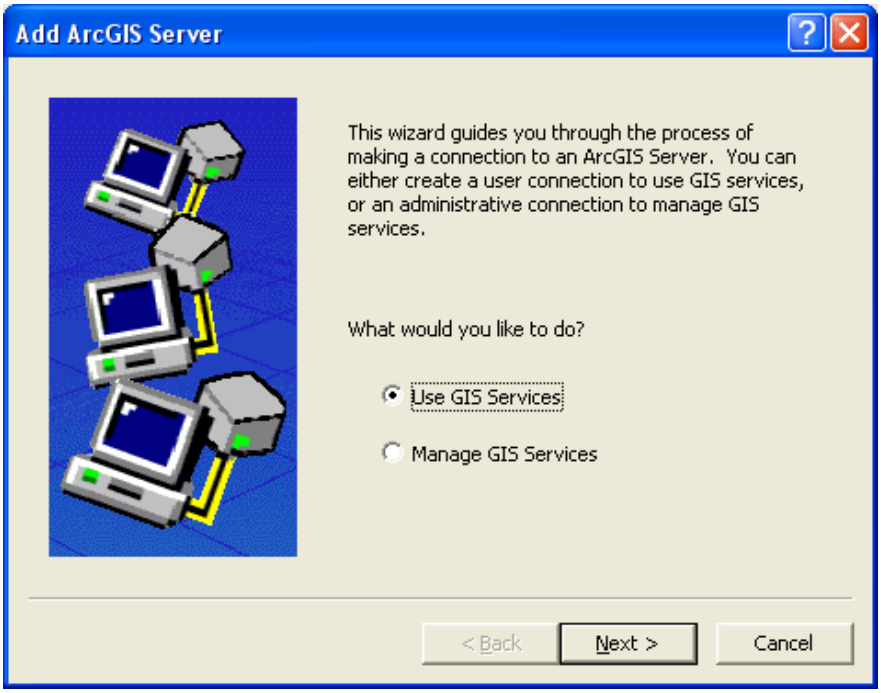
- Another extremely useful way to add base data is to use **ArcGIS Online Services**, such as those available from ESRI **.**

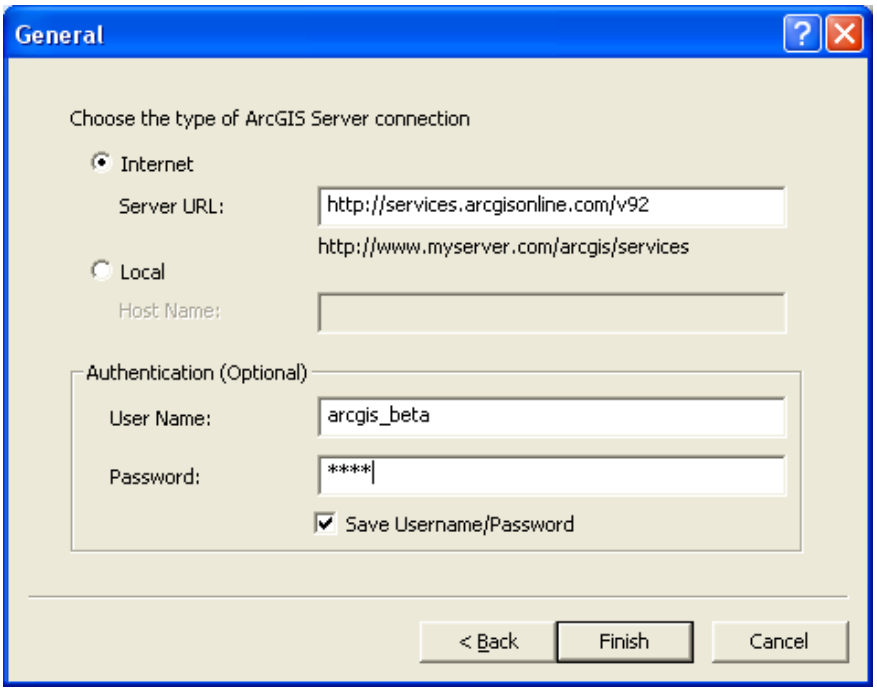
- To add these services, use the **Add Data** button  and select **GIS Server**



:

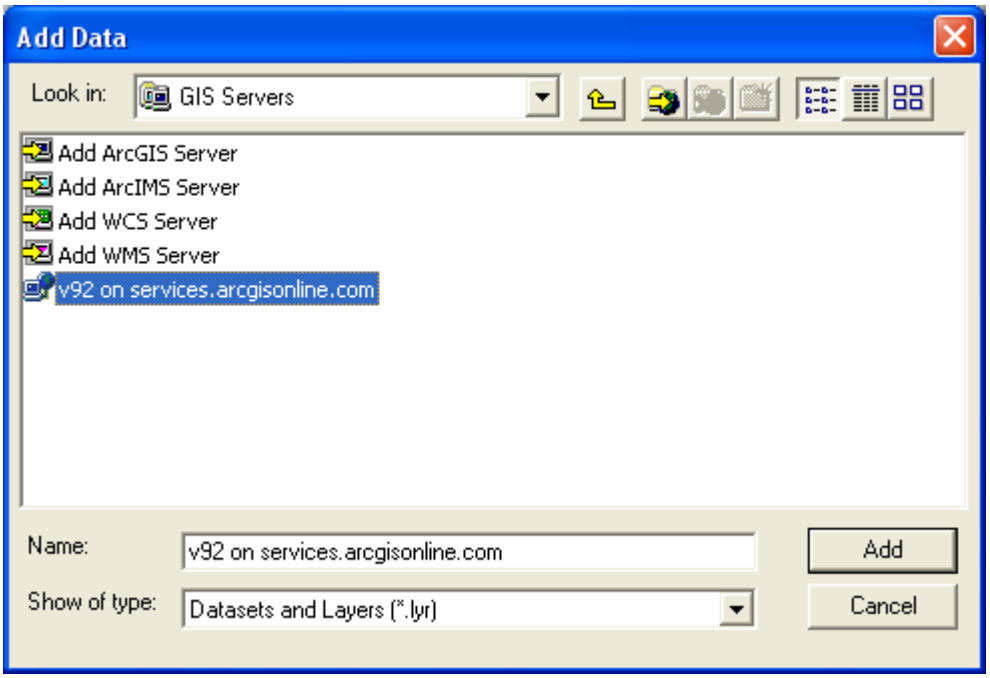
- Select **Add ArcGIS Server** and select the radio button for **Use GIS Services:**



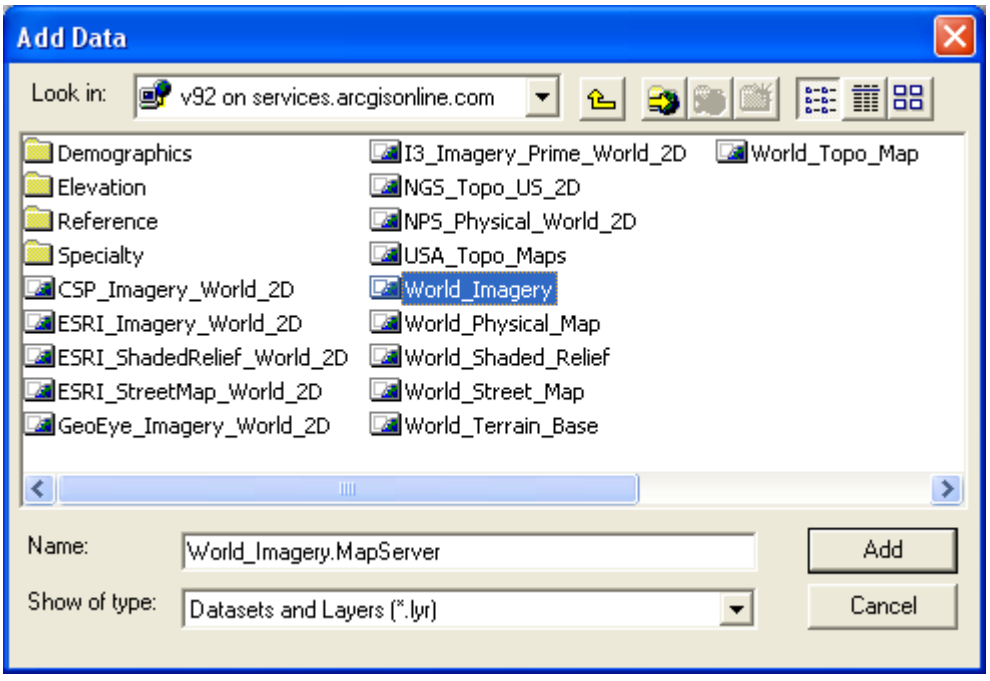


- This service is provided streaming over the internet using: **http://services.arcgisonline.com/v92**

- ***User Name**: arcgis_beta and **Password**: beta*



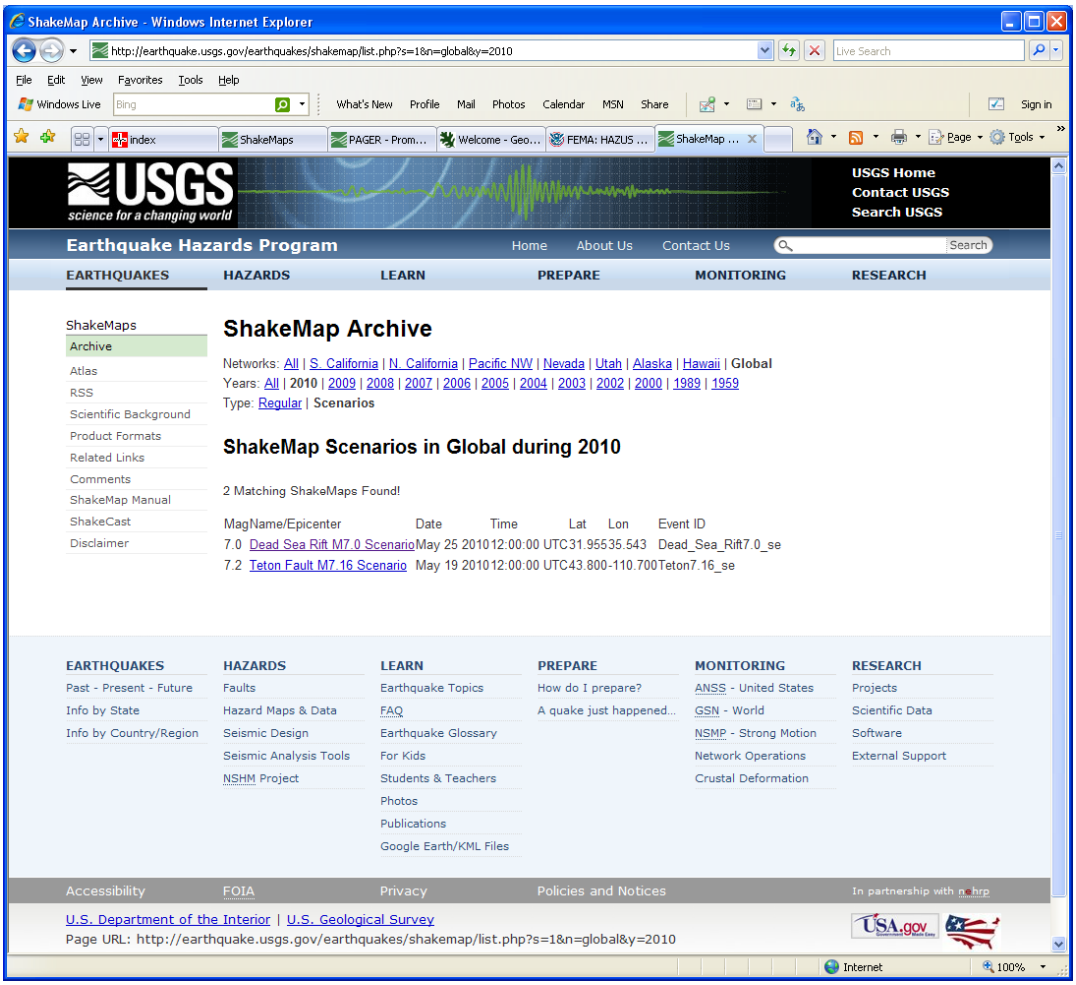
- Select the new **ArcGIS Server** and add **World Imagery** and/or other layers to your base map:

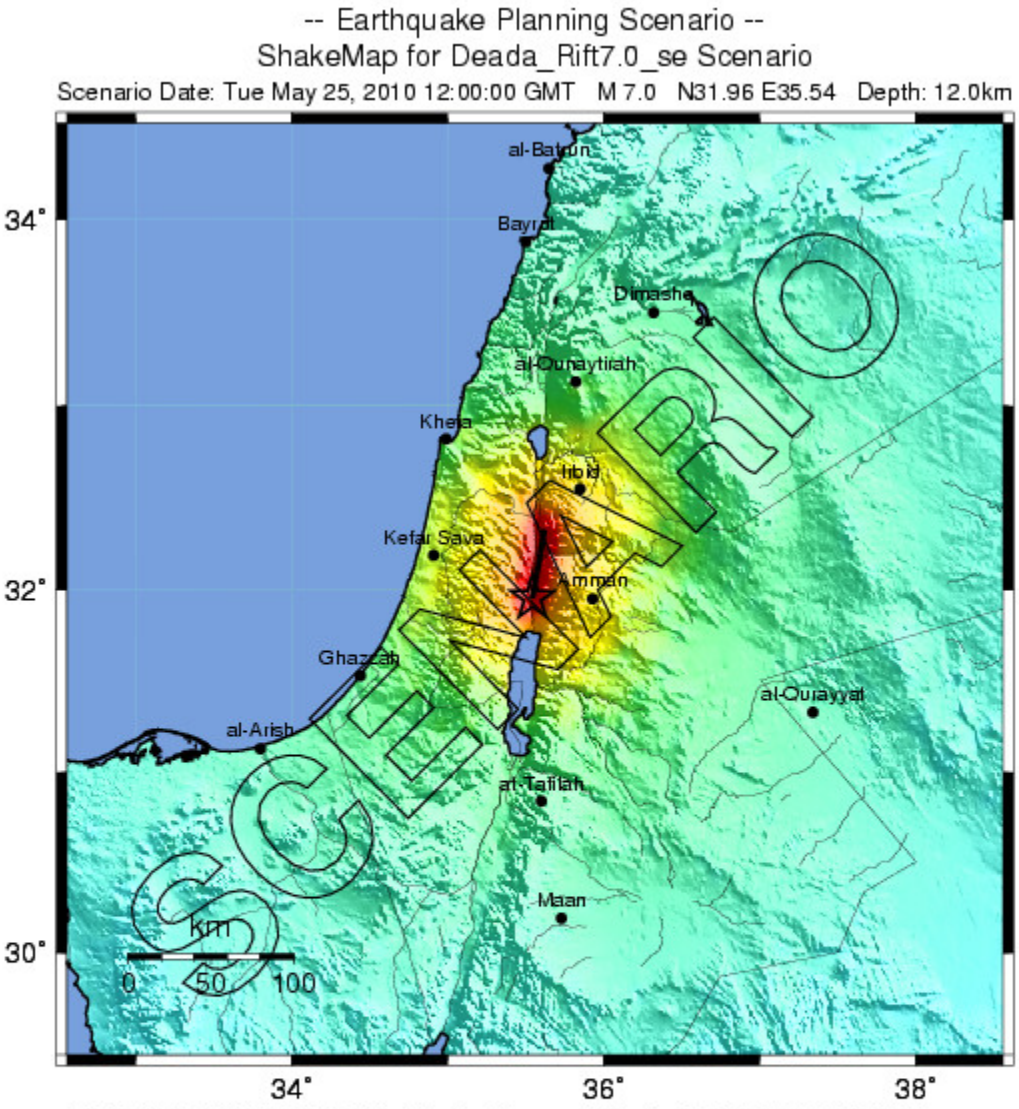


Step 2 – Developing and Incorporating Ground Motions and Hazard Information

In the U.S., there are many options available for a HAZUS earthquake model user to define a scenario or utilize ground motions from a real event. These options include selecting from a database of historical earthquakes, from a set of fault sources used in the development of the USGS National Hazard Map, selecting a probabilistic or annualized loss ground motions based on USGS probabilistic mapping, and inputting user defined ground motions from a network of ground motion monitoring instruments such as ShakeMap www.shakemap.org or developed by users outside the HAZUS program. The user supplied ground motions are required to be in a geodatabase format and include layers of ground motion: peak ground acceleration, peak ground velocity (in/sec), and spectral accelerations at 0.3 and 1.0 seconds to represent short and long period ground motions, respectively.

For this application, we recently created an M 7.0 Dead Sea scenario that is both credible and will impact our Amman area study region
http://earthquake.usgs.gov/earthquakes/shakemap/list.php?s=1&n=global&y=2010





PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	*8.1-16*	*16-31*	*31-60*	*60-116*	*>116*
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

The ground motions above are based on modeling a M 7.0 rupture along the Dead Sea rift and are further constrained by using soil amplification parameters based on topography as described by Wald and others: http://earthquake.usgs.gov/hazards/apps/vs30/.

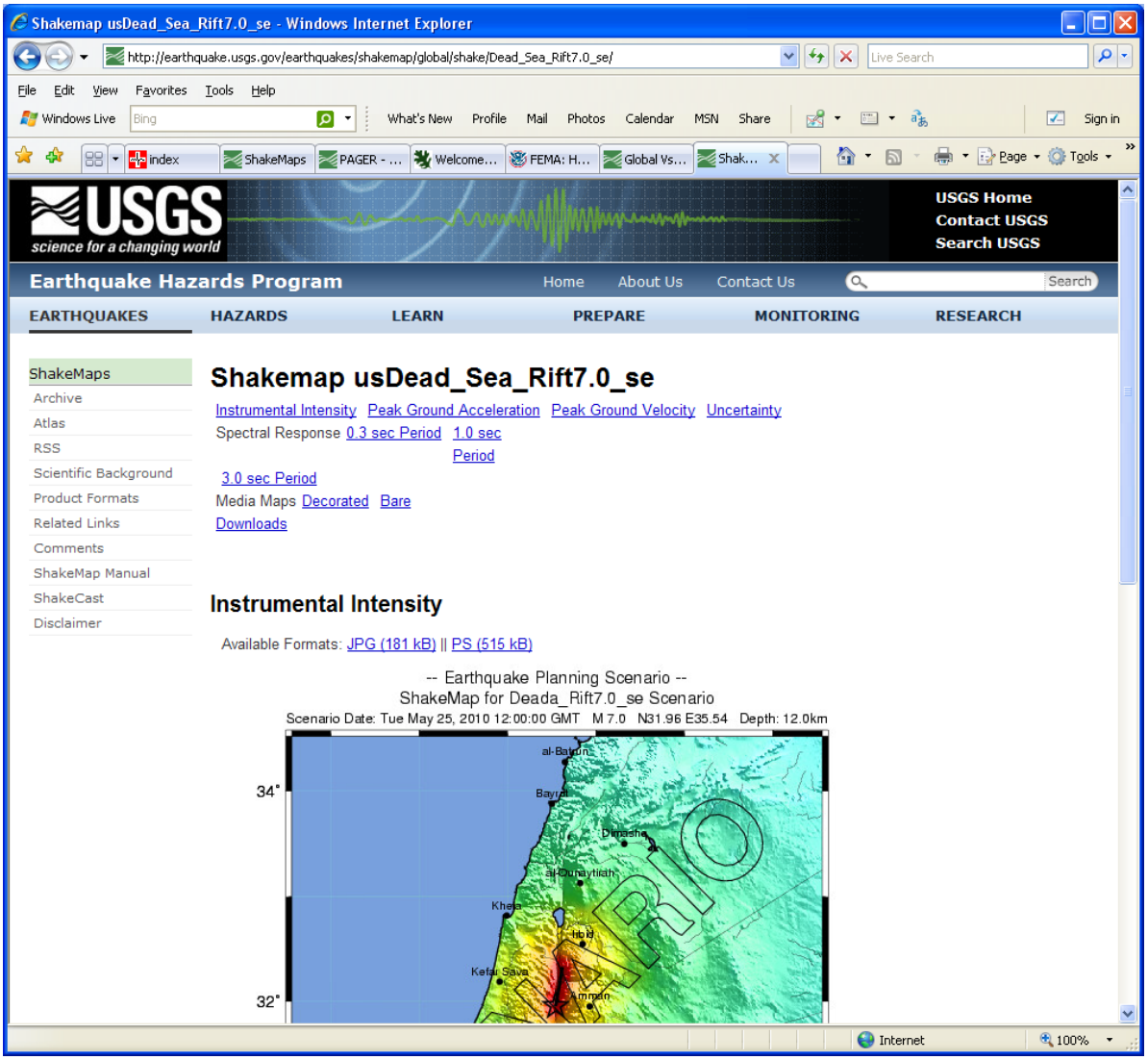
Step-by-Step Instructions

The following instructions are divided into numbered tasks that are then followed by the detailed steps required to complete each task. Many steps are also followed by italicized comments that provide additional helpful information. Be sure to ask your instructor for clarification or assistance whenever you are unclear about a step in the exercise.

NOTE: Completion of the exercise requires internet access.

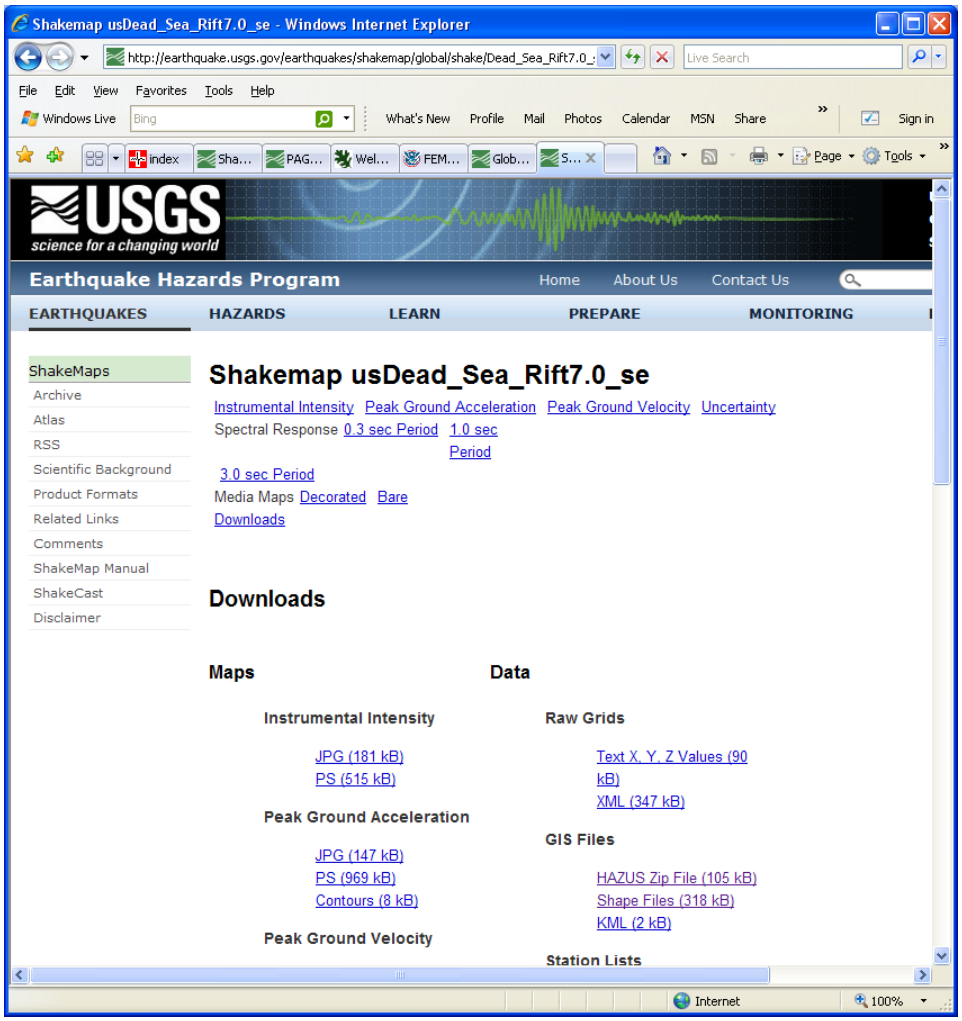
1. Select the "**Downloads**" section of the ShakeMap scenario. http://earthquake.usgs.gov/earthquakes/shakemap/global/shake/Dead_Sea_Rift7.0_se/#download

   Ask your instructor if you need assistance with this task.

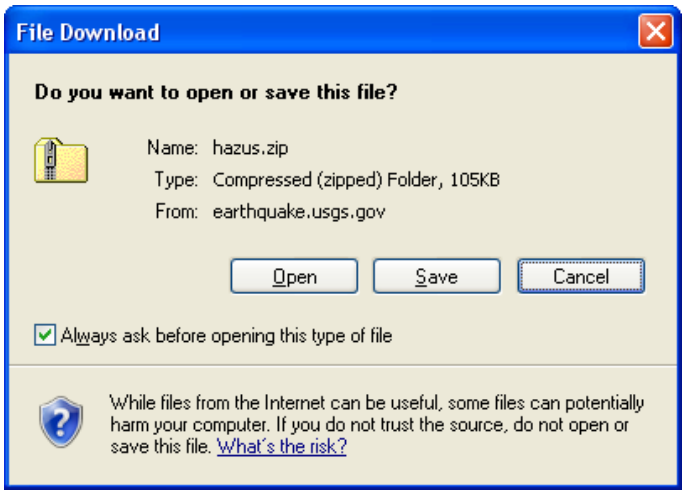


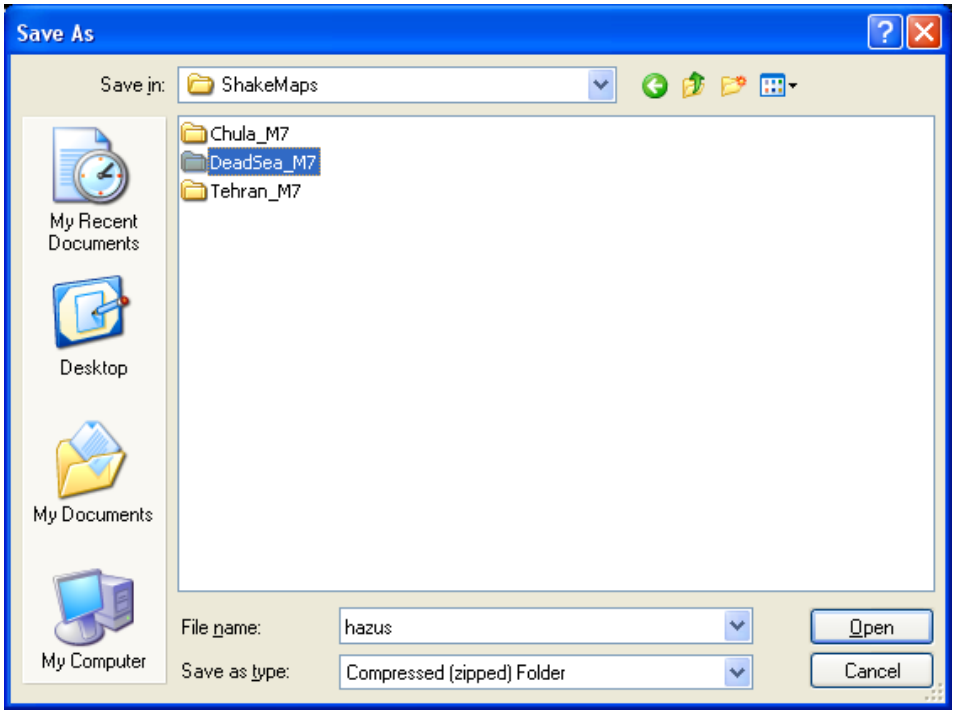
2. Scroll down to the "GIS Files" and select the **HAZUS Zip File – hazus.zip**.

   Also note the .kml file format that works with the free GoogleEarth viewer. First download and install GoogleEarth www.googleearth.com then simply double click on the .kml file and "fly into" Jordan while overlaying the semi-transparent event intensity map. Note that you can also sign up for the automatic service and have these delivered and opened automatically on your desktop http://earthquake.usgs.gov/eqcenter/shakemap/rss_info.php



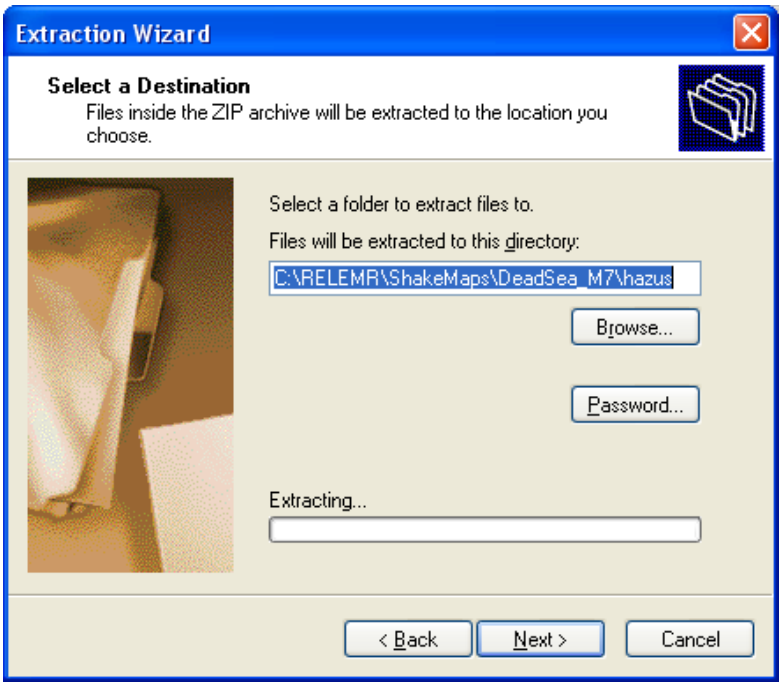
3. **Save** into a data folder:



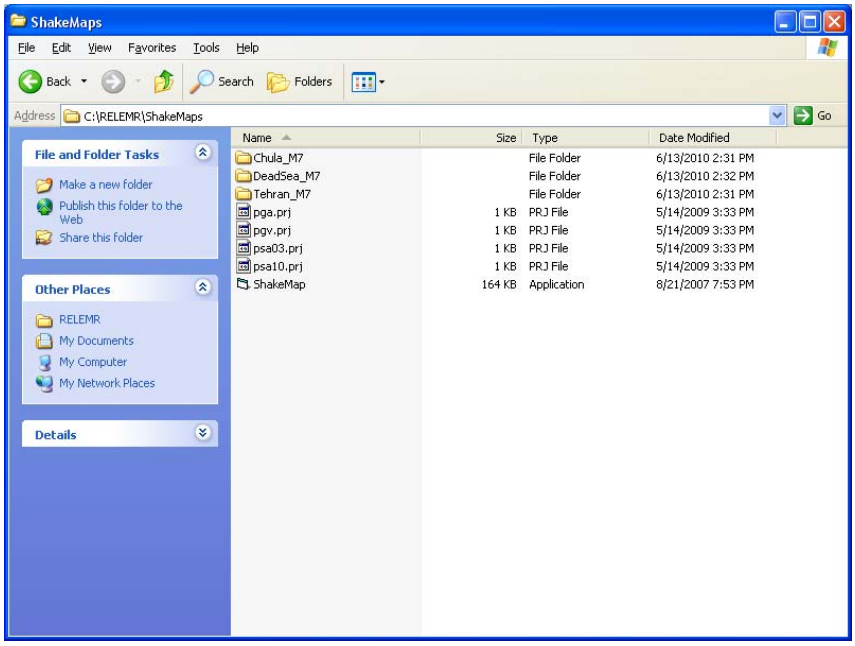


4. **UnZip** and **Extract** the .shp files to a data folder.

Note these include ground motion layers for the four inputs required by HAZUS (PGA, PGV, SA 0.3 and SA 1.0). However, they are in the older ESRI shape file format and need to be converted to a geodatabase as outlined in the following steps to work with the new 9.x version of the software.

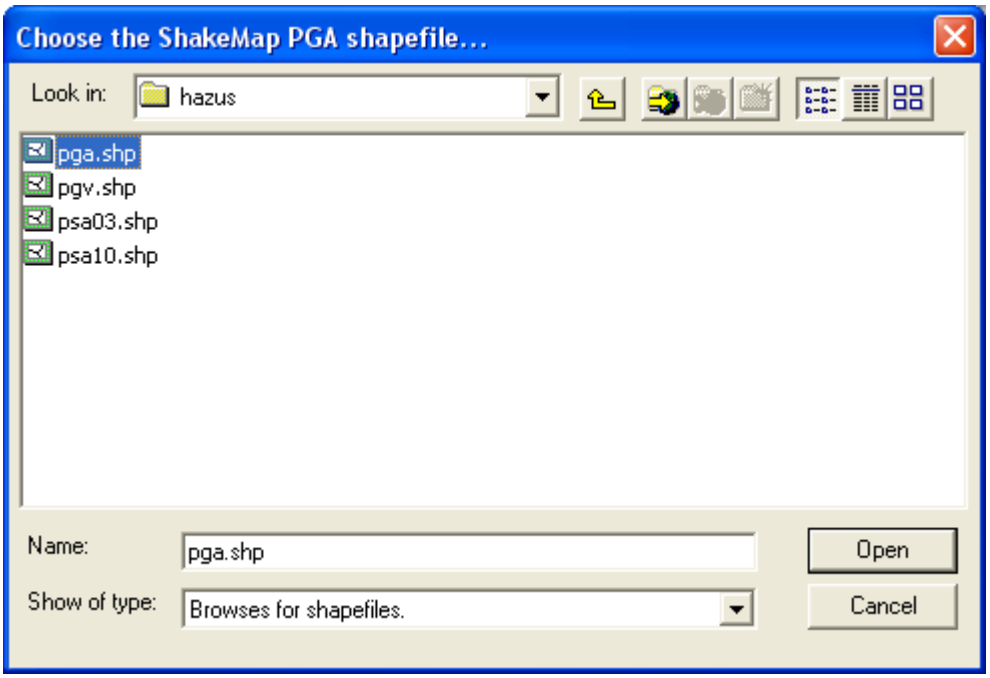


5. To use these ground motion files in HAZUS the user needs to define the projection of these files. We have already created the four necessary **projection files (.prj)** that can be directly copied to the folder containing the ground motion .shp files. This will automatically provide the correct NAD '83 Geographic projection required by HAZUS when the **ShakeMap.exe** utility creates the geodatabase in the next step.



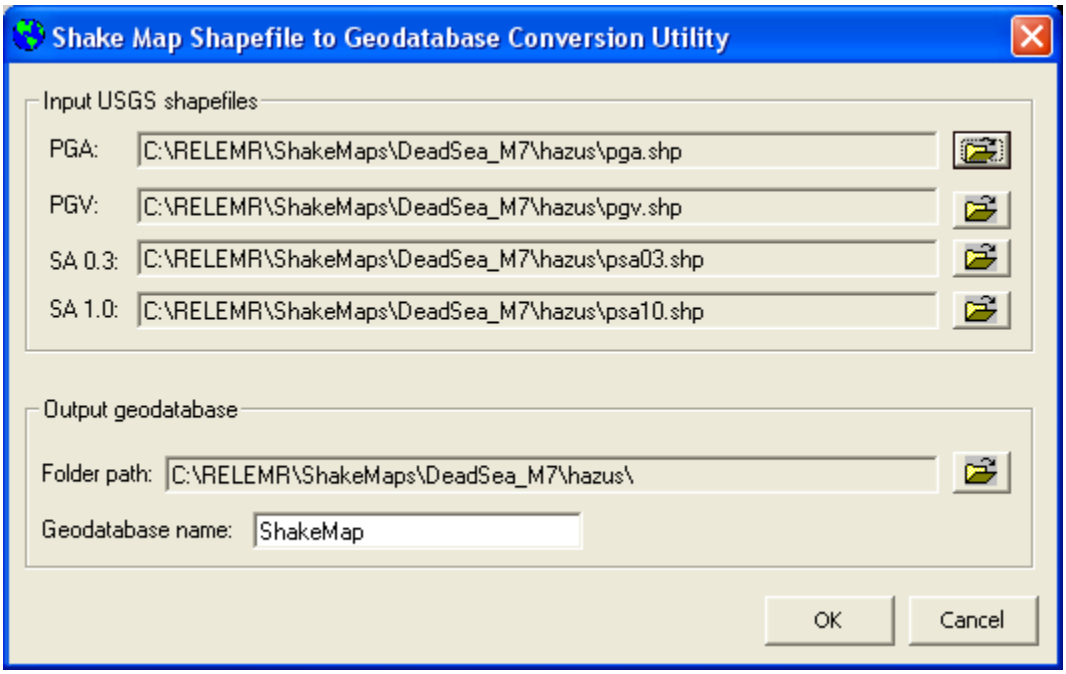
6. To convert the ShakeMap shape files to the correct geodatabase format, double click on the **ShakeMap.exe** utility.

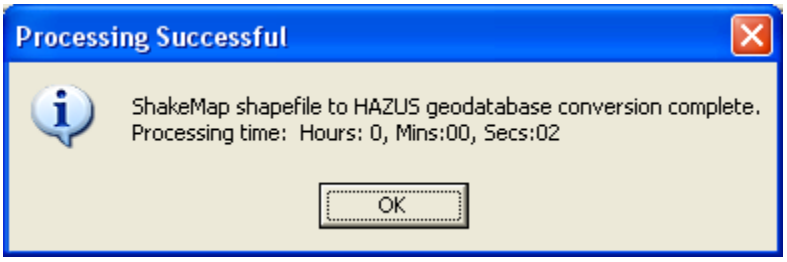
Note that this utility is provided free with the HAZUS-MH program and is located in the ShakeMap Utility folder on the Setup DVD. These do not automatically move to the local machine during a typical program installation, therefore, the user will have to manually copy the file or run it from the Setup DVD. More detailed instructions on using this utility are provided in the ShakeMap Instructions.doc.



7. Select the folder icon to browse to and upload the 4 shape files as shown.

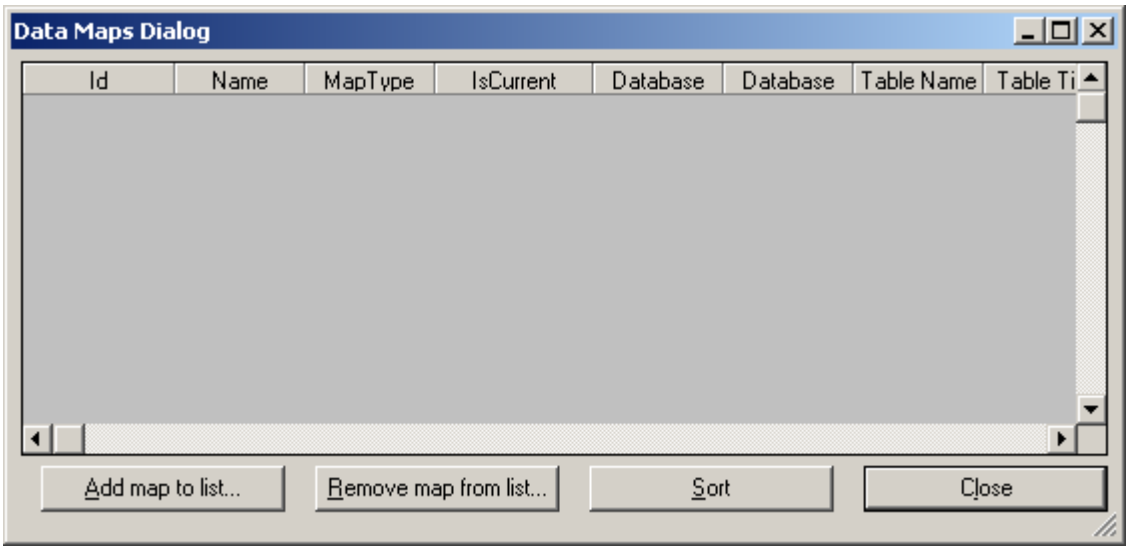
Be extra careful not to enter a file on the wrong line, for example if pgv.shp is loaded in pga.shp the loss calculation results will be erroneous. Note that it will automatically create and name the geodatabase we need to utilize for the loss estimation. An error may occur at this utility looks for a specific filename that includes "_data", however, the global ShakeMap product may be named slightly differently. Please see solution below.



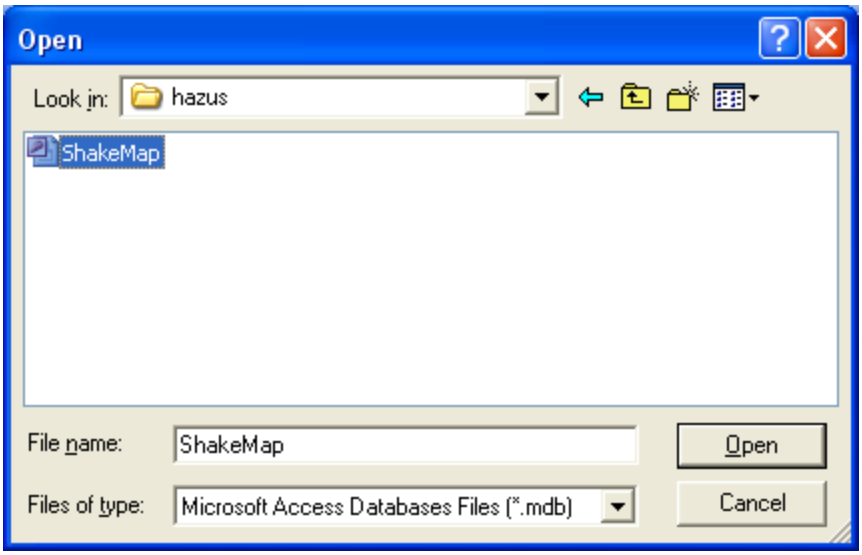


Note: There are two processes that will now need to be completed in the HAZUS program. These include pointing the program to the ShakeMap geodatabase and then selecting the ShakeMap scenario as the user-supplied earthquake scenario.

8. Open your HAZUS study region and from the **Hazard** menu choose **DataMaps** to open the Data Maps Dialog:

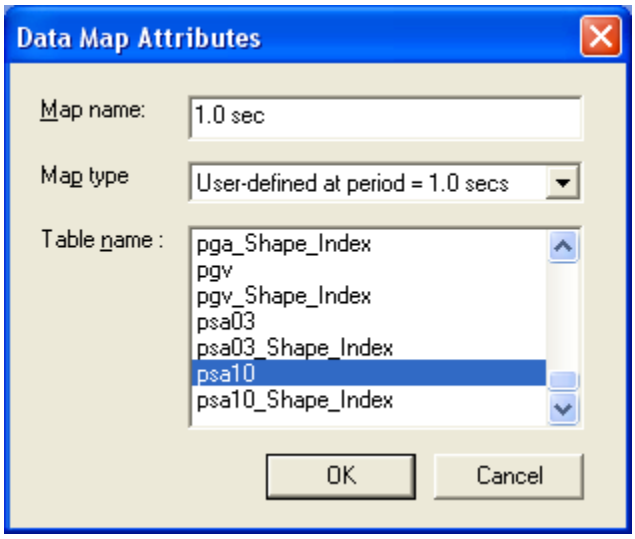


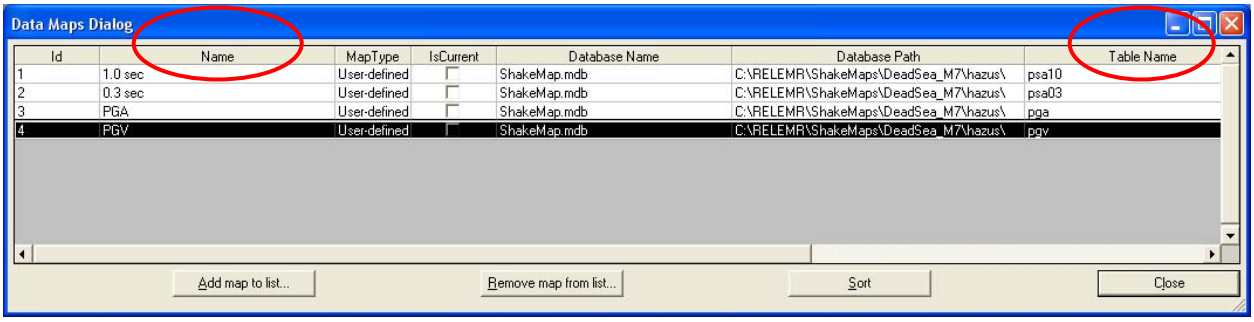
- Select the **Add map to list…** button on the bottom left corner. Browse to and open the **ShakeMap.mdb** geodatabase that we created above. In this case it is located at \\RELEMR\ShakeMaps\DeadSea_M7\hazus\



- The program needs to be pointed to each of the 4 data tables to define the ground motions used by HAZUS. The Data Map Attributes dialog will automatically open when the **ShakeMap.mdb** file is opened. The **Map name** *(typed by the user)***, Map type** *(selected using the combo box and scroll arrows)* and **Table name** *(scroll toward bottom of list and do not select the Shape_Index files)* need to be defined as shown below. This process needs to be completed until all four map table names are defined.

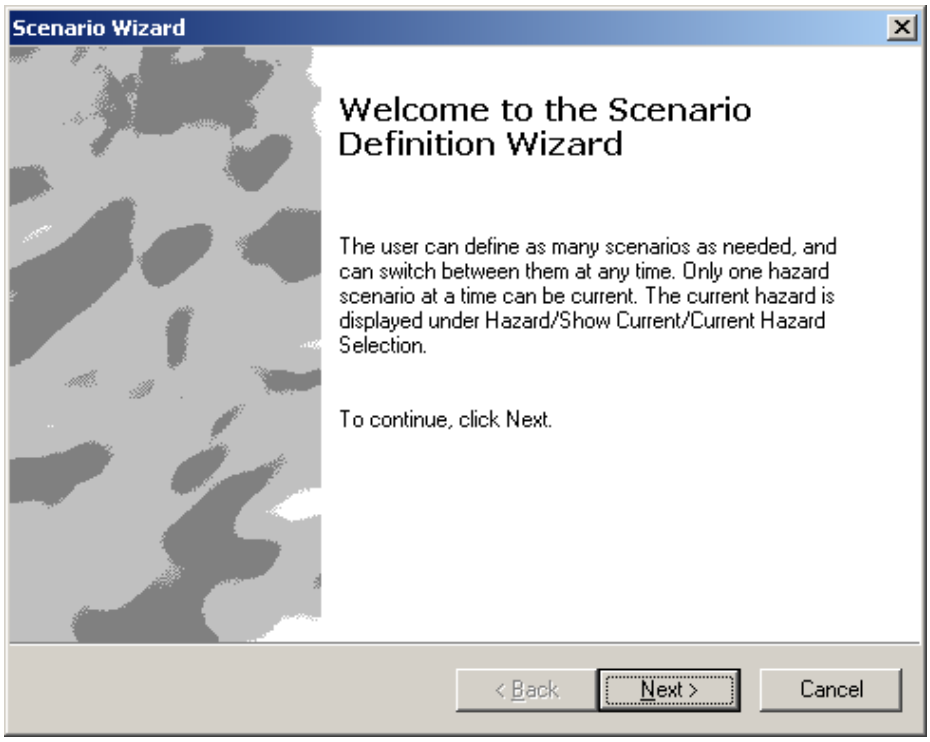
Note: This dialog is also the interface for adding hazard maps such as landslide, liquefaction, tsunami and dam inundation if available for your study region.



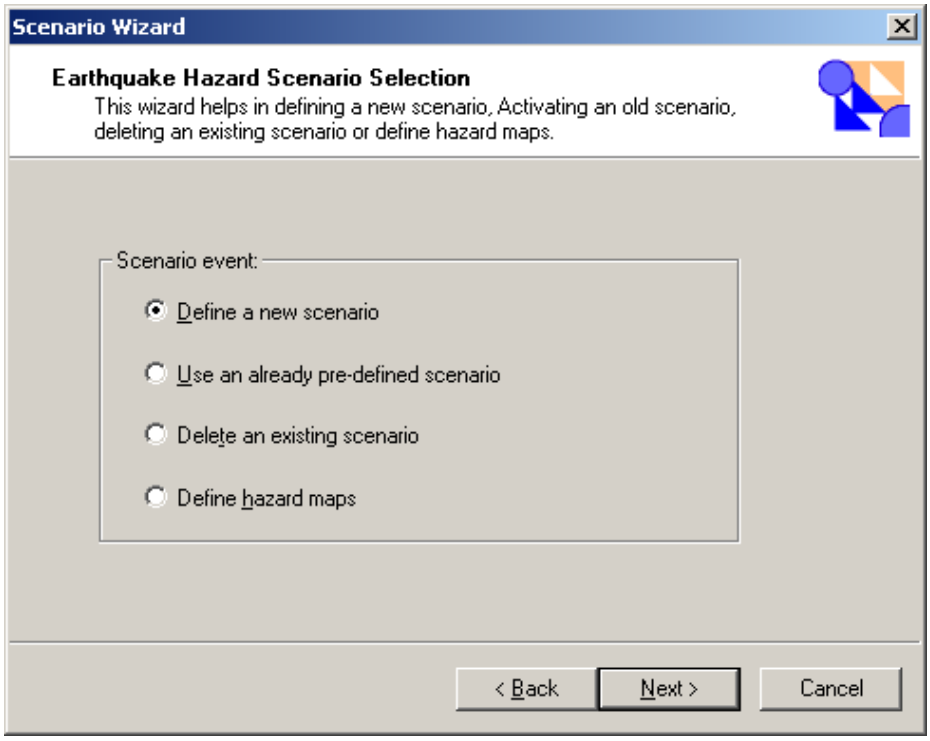


9. Review the Data Maps Dialog box to confirm no layers were entered into the wrong ground motion types. Make certain the **Table Names** and the user entered **Name** fields match for each ground motion type.

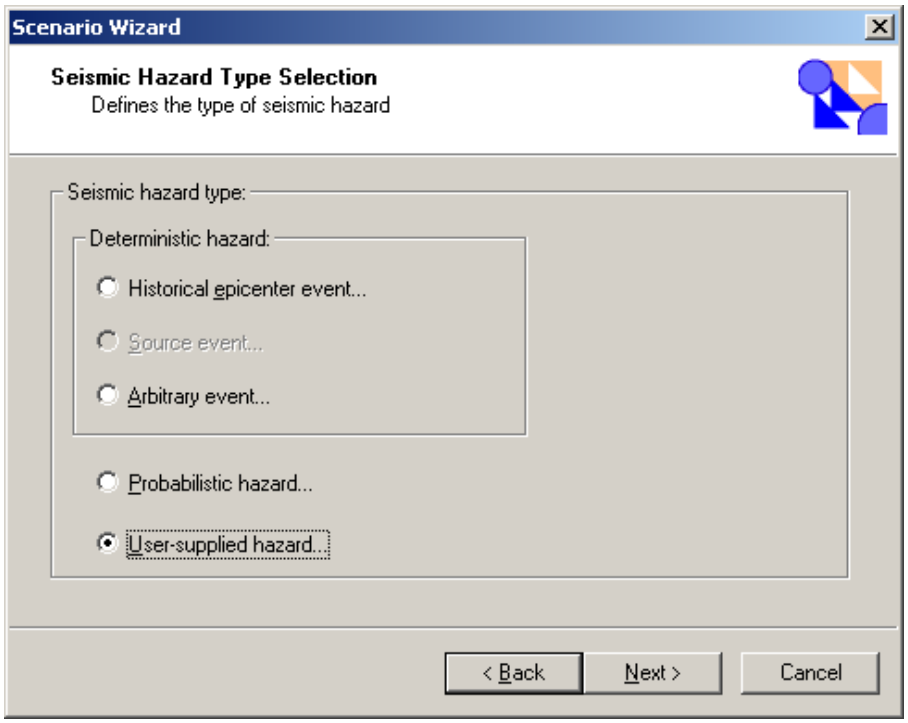
10. From the **Hazard** menu choose **Scenario** to define the earthquake scenario for this analysis:



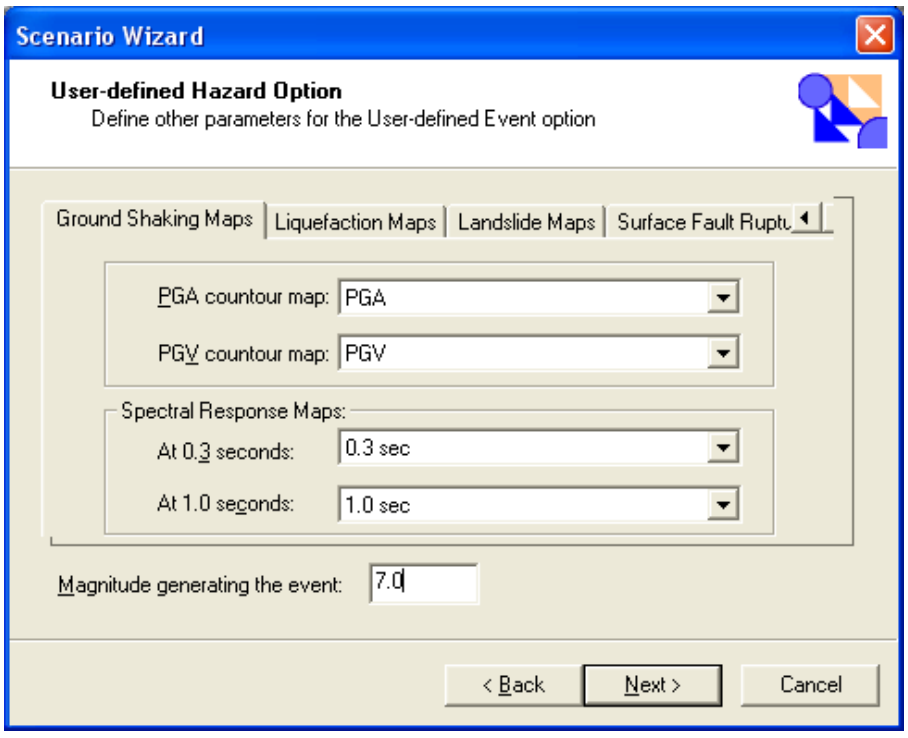
- Select the **Next** button.



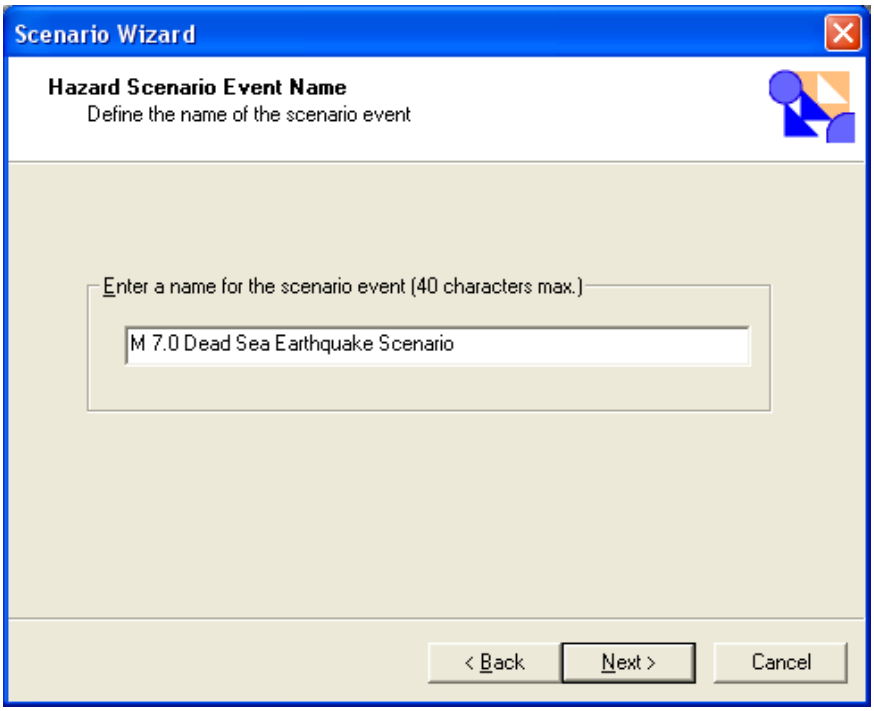
- Use the radio button to **Define a new scenario**.



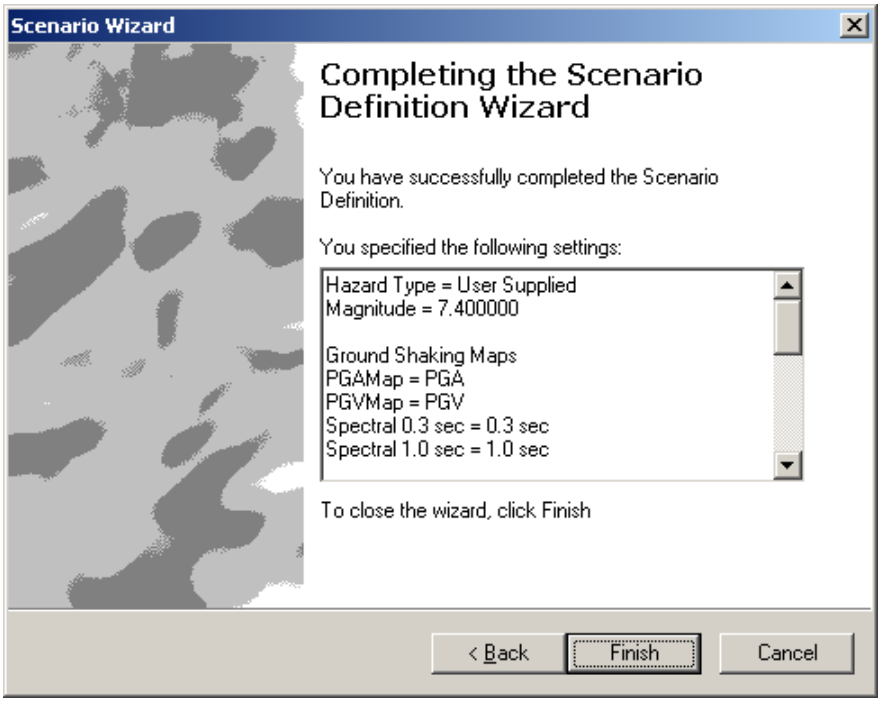
- For Seismic Hazard Type select the **User-supplied hazard…**



- Point each combo box to the ground motion tables we named earlier in the exercise and indicate the magnitude generating the event.

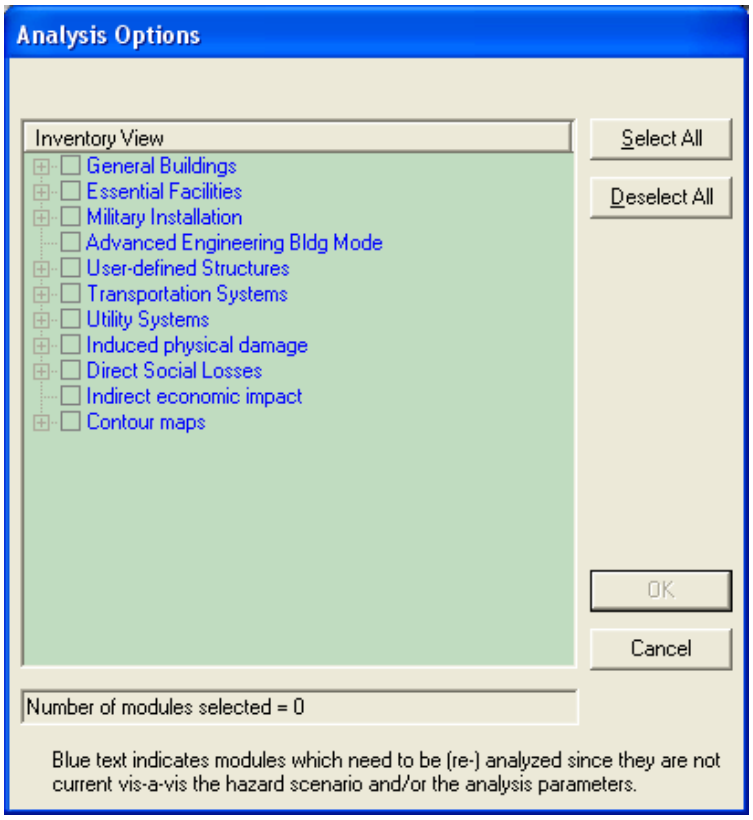


- Clearly name the event being careful not to make typographical errors as each results page will include the event name then press **Next**.

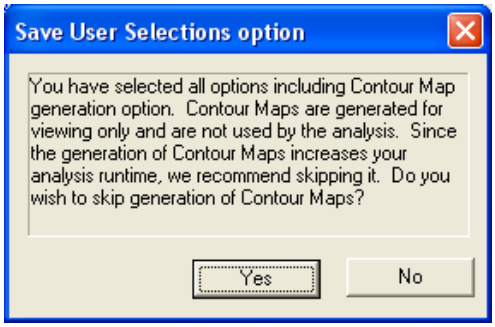


Step 3 – Run Analysis

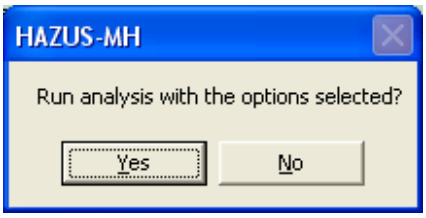
Under the **Analysis** drop down menu-select **Run** and the **Analysis Options** screen will pop up:

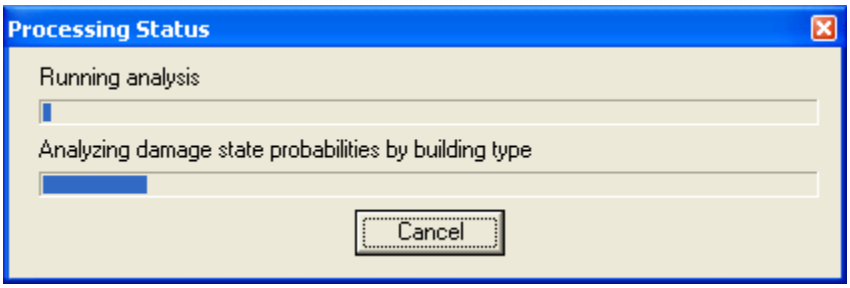


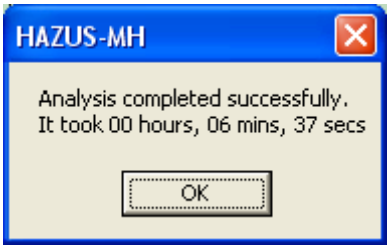
- Choose the **Select All** button and answer **Yes** to skipping the creation of ground motion contour maps since you are providing these:



- Then select **Okay** and **Yes** to running the analysis:







- For this scenario the analysis completed in 6 minutes and 37 seconds.
- A broad range of results including tables, thematic maps and reports are now available under the **Results** drop down menu.