

# Hazus Flood Model FEMA Standard Operating Procedure for Hazus Flood Level 2 Analysis







# **Credits**

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# **Overview**

In order to assess flood losses, vulnerability, and risk for a community, a comprehensive understanding of the flood hazard, and the built environment needs to be developed. The purpose of this Standard Operating Procedure (SOP) is to outline the geospatial processes required to estimate flood damages from an event accurately and quickly, in order to communicate those impacts to decision makers in the response, recovery, and mitigation phases of an event in a timely manner. The flood estimation methodology will be described in this SOP in the following sections defined below:

- 1. **Building Inventory**: Building Inventory for a region can be developed before an event occurs so it is available for use in damage assessment. This section defines the required attributes and outlines how to create a detailed building inventory.
- 2. **Depth Grid Production**: This explains two methods for creating a depth grid if a depth grid for desired study region is not available to download from the Map Service Center.
- 3. Analyzing Flood Losses Using FEMA's Hazus Flood Model: This section explains the difference between an aggregated analysis and a site specific approach. This section also describes how to add data to a State Database for a study region using CDMS and how to run a "General Building Stock Damage and Loss" and "User Defined Structures" analysis.
- 4. **The User Defined Facilities Flood Loss Results:** This section describes how to join the Hazus UDF results to the original UDF data set.
- 5. **The VDatum Example Appendix:** This section shows how to use the VDatum software to transform the vertical datum of data into a useable format for Hazus.

Based on the information presented in this document, it is the Hazus Programs official recommendation that users import user-defined flood hazard information when available.

# **1. Building Inventory**

Development of a detailed building inventory for use in a flooding event damage assessment can be done before an event takes place. This can be done ahead of time for communities with general high risk, or those who have a predicted forecast of high probability flood risk in the weeks/months to come. In order to create a detailed building inventory GIS dataset that can be used to estimate flooding damages on a structure by structure basis, following information for the built environment for the community is needed:

- Point structure location
- Foundation type
- First floor height
- Building value
- Contents value

- Occupancy type
- Number of stories

# 1.1. Establish Workspace and Define Data

**Depth grid/flood hazard data creation** - depth grid/flood hazard data can be created well before an event to be used to model scenario planning events, derived immediately before an event by H&H experts based on forecast predictions, or after an event using real world data. The following data is required to estimate flooding damages in a geospatial environment.

**Flooding depth grid** - consists of an Esri raster grid file, with flooding depths represented by each pixel value. Flooding extent and depth are depicted by this raster dataset.

\*Import process for user-defined depth grids now support the following file formats: GRID (as before), IMAGINE (IMG), HEC-RAS (FLT), TAGGED IMAGE FILE (TIF), and fGDB. Hazus will also automatically reproject any user-defined depth grids which are not in WGS84.

**Analyzing flood losses using FEMA's Hazus flood model software** – the methods for incorporating the site specific building information and flood hazard data are described.

# **1.2. Creating the Building Inventory**

In an ideal situation, the potential for flooding impacts to a community would be foreseen before the event takes place in order to give geospatial analysts time to prepare building inventory datasets ahead of time. At times, flood forecasts from the National Weather Service (NWS) allow for a few days or a few weeks' notice of the potential for high impacts in an area, but many times an event can happen with no notice. The development of the building inventory is possible to create in a timely manner, even in no notice events.

## **1.2.1.** Create point locations for all impacted structures

When importing a building point dataset into the Hazus flood model for site specific analysis, the depth of water at a given point is applied from the depth grid to the structure based on its physical (latitude/longitude) location. Having the building point locations as accurate as possible can greatly increase the results accuracy.

A. When parcel data are available, conduct a polygon to point conversion based on the parcel centroid. To enhance accuracy, move the point on top of structure using satellite/aerial imagery. If a depth grid or post event imagery is already available, manual movement of structure point locations only need to take place in the flooded areas, which takes much less time than manual point movement for an entire community. This step can be time consuming but greatly enhances the accuracy of the analysis. In past studies, manual movement of 3,000 to 4,000 structures has been completed in just a few hours. For the greatest accuracy, place the point on structure at the lowest elevation point using LiDAR (however, the lowest elevation point method may require too much time. The building centroid method will suffice).



Figure 1-1: Points placed based on parcel centroid. If strictly using parcel centroids, many structure locations would be much too close to the flood hazard.



Figure 1-2: Points moved over structure manually. Structure locations are much more accurate.

B. When parcels are not available, manually place a point on each structure using imagery (only place points on structures in the flooded area). Damage percentages/economic loss calculations will not be possible without parcel/assessor information. This will enable increased accuracy for structure damages counts, and depth on structure totals dependent on the flood hazard data available.

Alternatively, if building footprint data is available, a polygon to point conversion using the building footprint centroid will eliminate the need to manually adjust the placement of points derived from parcel datasets as well as eliminate the need to manually place points for a whole community in the absence of parcel data.

It is important to mention that it is only necessary to create point data for primary structures. Structures such as sheds, garages, and small out-buildings do need to be included into the dataset.

#### 1.2.2. Collect required structure attributes for Hazus Flood loss estimation

The attributes covered in this section are required to produce accurate loss estimates. In an ideal situation, these attributes from local tax assessor/parcel data would be able to obtain. Most commonly however, all of these attributes are not available. Attribute availability varies from community to community, and in place of missing values, assumptions will need to be made based on averages for an area, and RSMeans standards.

The Hazus flood model uses what are called depth damage functions to estimate the percentage of damage and thus economic impact to a structure. The depth damage function selected is a combination of occupancy type, foundation type, and number of stories. The first-floor height is then used to adjust the amount of flooding depth calculated against the structure, and the building value/contents values are used to estimate economic impacts.



Figure 1-3: FIA-based Residential Contents Damage Curves from the Hazus Flood Technical manual (Figure 5.5).

For instance, a RES1 (single family home) occupancy type experiences different damage percentages at two feet of flooding than a light industrial facility IND1. This attribute is commonly found in local assessor's information with a name such as "use," "property type" or "zoning."

Estimation can be derived using the following methods when the required Hazus flood model attributes are not available (foundation type, first floor height, occupancy type, number of stories, building values/cost, contest cost, inventory values, latitude / longitude, building/content/inventory damage function ID (Optional), and import building data into Hazus)

#### 1.2.2.1 Foundation type

The foundation type modifies the Hazus depth damage curve applied to the structure, thus altering the percentage damage applied and the economic losses reported for that structure. For instance, a building with a finished basement with -two feet of flooding (two feet below ground level) would experience much greater losses than a structure that did not have a basement. The Hazus foundation types are broken into the following categories:

 1-1. Deladit hoor heights above drade to hop of hinshed hoor (hin					
ID	Foundation Type	Pre-FIRM	Post-FIRM		
1	Pile	7 ft.	8 ft.		
2	Pier (or post and beam)	5 ft.	6 ft.		
3	Solid Wall	7 ft.	8 ft.		
4	Basement (or Garden Level)	4 ft.	4 ft1		
5	Crawlspace	3 ft.	4 ft.		
6	Fill	2 ft.	2 ft.		
7	Slab	1 ft.	1 ft1		

Table 1	L-1: Defa	ult Floor	Heights	above	Grade to	o Top of	f Finished	Floor (F	liverine
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Source Data: Expert Opinion Note: 1 is typically not allowed, but may exist

When classifying the foundation type for a selected structure, the ID number above should be used to identify the corresponding foundation type. This attribute is occasionally reported in local assessor's information, but when it isn't, it can be collected using the following methods:

A. Visual verification using oblique aerial imagery – oblique imagery gives the analyst a side viewing angle of the structure, and the ability to assess whether a building has a basement (windows shown in the basement below).



Figure 1-4: Visual verification using oblique aerial imagery. Photo courtesy of Pictometry.

B. Census block assumptions – census block based assumptions can be made using known common practices for an area by occupancy type, or using the Hazus default flood specific occupancy mapping schemes for a selected block/tract.

## 1.2.2.2 First floor height

This attribute describes the height above ground (not above sea level) of the building first floor. This can be obtained from tax assessor information (or elevation certificate where available) or approximated by using one of the following methods:

- A. Subtracting the elevation certificate by ground surface elevation from high resolution LiDAR, ensuring each are in the same vertical datum.
- B. Measuring in the field or from orthorectified oblique imagery from the front door threshold to the ground surface.
- C. Approximation based on foundation type. The Hazus flood technical manual has approximate first floor heights based on foundation type selected shown in Table 1-1 from the Hazus Flood Technical Manuals and shown above in Figure 1-4.

#### 1.2.2.3 Occupancy type

The Hazus flood model requires a specific occupancy identifier that corresponds to the following codes from the Hazus flood technical manual shown in Table 1-2.

Label	Occupancy Class	Example Descriptions
	Residential	
RES1	Single Family Dwelling	House
RES2	Mobile Home	Mobile Home
RES3	Multi Family Dwelling	Apartment/Condominium
	RES3A Duplex	
	RES3B 3-4 Units	
	RES3C 5-9 Units	
	RES3D 10-19 Units	
	RES3E 20-49 Units	
	RES3F 50+ Units	
RES4	Temporary Lodging	Hotel/Motel
RES5	Institutional Dormitory	Group Housing (military, college), Jails
RES6	Nursing Home	
	Commercial	
COM1	Retail Trade	Store
COM2	Wholesale Trade	Warehouse
COM3	Personal and Repair Services	Service Station/Shop
COM4	Processional/Technical/	Offices
	Business Services	
COM5	Banks	
COM6	Hospitals	
COM7	Medical Office/Clinic	
COM8	Entertainment & Recreation	Restaurants/Bars
COM9	Theaters	Theaters
COM10	Parking	Garages
	Industrial	
IND1	Heavy	Factory
IND2	<ul> <li>Light</li> </ul>	Factory
IND3	Food/Drugs/Chemicals	Factory
IND4	Metal/Minerals Processing	Factory
IND5	High Technology	Factory
IND6	Construction	Office
	Agriculture	
ARG1	Agriculture	
	Religion/Non-Profit	
REL1	Church/Non-Profit	
	Government	
GOV1	General Services	Office
GOV2	Emergency Response	Police/Fire Station/EOC
	Education	
EDU1	Grade Schools	
EDU2	Colleges/University	Does not include group housing

Table 1-2: Hazus Building Occupancy Classes, from Hazus Technical Manual.

Occupancy type provides Hazus with a use description code that is utilized when choosing a depth damage function. Below are a few different methods for determining the Hazus occupancy code for a buildings dataset.

A. Assessor's/parcel information – attributes are commonly found in local assessor's data with either zoning information (commercial, residential, industrial, etc.) or more detailed use type information (single family home, duplex, etc.). Once acquired, these attributes will

need to be converted to Hazus specific occupancy use codes from the Hazus Technical Manual shown in Table 1-2.

B. Visual verification using satellite/aerial/oblique imagery – when looking at a structure (or neighborhood) using one of these remote sensing assets, it is often easy to distinguish between a single-family home (RES1) and a retail store (COM1).

#### 1.2.2.4 Number of stories

This attribute is commonly found in assessor's data, but when not available can be derived using the following methods:

- A. Google Earth Pro, assessors/parcel data these sources often include number of stories, depending on the location.
- B. An assumption can be made based on specific occupancy using the following criteria from the Hazus Flood Technical Manual shown in Table 1-2.
- C. The attribute can be derived visually using oblique aerial imagery (Image below) or Google Street View.

Note: An enhancement was made to the number of stories field for RES1 structures in UDF imports to limit the number of stories handled by Hazus. Users can enter up to 255 with 255 reserved to indicate a split-level structure, however, Hazus will treat it as no higher than five stories. Users are not advised to enter a RES1 UDF with more than five stories, as these types of structures are rare for single-family dwellings.



Figure 1-5: Number of stories for a single-family dwelling. Picture courtesy of Pictometry.

#### 1.2.2.5 Building Values/Cost

This attribute is commonly found in local tax assessor/parcel data. Assessed value, fair market value, or replacement value can all be used as the building value in the dataset as long as clarification is made

when communicating the results. When tax assessor/parcel data is not available, it can be calculated by the following methods:

- A. RSMeans calculation using square footage and occupancy type eg. (Sqft x RSMeans \$ per sqft) x (CPI adjustment) x (CountyModFactor). RSMeans estimates approximate value per square foot for each Hazus occupancy type and the 2006 valuations are presented in Table 14.1, 14.2, and 14.3 of the Hazus Flood Technical Manual. Standard Hazus RSMeans values are typically adjusted from 2006 values to current values using the latest <u>Consumer Price Index calculator</u>.
- B. Hazus uses an RSMeans County Adjustment Factor for every county in the U.S., these adjustments accommodate for relative differences in the costs associated with building materials and differences in the expenses associated with contractors. A table of County modification factors is available in the Hazus State data folders (ex. syHazus.dbo.hzMeansCountyLocationFactor).
- C. The RES1 (single family residential) replacement cost model utilizes socio-economic data from the census to determine an appropriate mix of construction classes (Economy, Average, Custom and Luxury) and associated replacement cost models. The 2006 valuations are presented in Table 14.3 of the Hazus Flood Technical Manual.

## 1.2.2.6 Contents Cost

Content values are occasionally available in local tax assessor/parcel data. When content values are not available, they can be calculated using the following method.

A. RSMeans average percent value calculated from building value/occupancy type – the table below shows average content values by occupancy type. Apply the percent to the building value of each occupancy type based on the Hazus Flood Technical Manual as shown below.

NO.	IO. Label Occupancy Class		Contents Value (%)
		Residential	
1	RES1	Single Family Dwelling	50
2	RES2	Mobile Home	50
3	RES3	Multi Family Dwelling	50
4	RES4	Temporary Lodging	50
5	RES5	Institutional Dormitory	50
6	RES6	Nursing Home	50
		Commercial	
7	COM1	Retail Trade	100
8	COM2	Wholesale Trade	100
9	COM3	Personal and Repair Services	100
10	COM4	Processional/Technical/Business Services	100
11	COM5	Banks	100
12	COM6	Hospitals	150
13	COM7	Medical Office/Clinic	100
14	COM8	Entertainment & Recreation	100
15	COM9	Theaters	50
16	COM10	Parking	
		Industrial	
17	IND1	Heavy	150
18	IND2	Light	150
19	IND3	Food/Drugs/Chemicals	150
20	IND4	Metal/Minerals Processing	150
21	IND5	High Technology	150
22	IND6	Construction	100
	·	Agriculture	
23	ARG1	Agriculture	100
		Religion/Non-Profit	
24	REL1	Church/Non-Profit	100
		Government	
25	GOV1	General Services	100
26	GOV2	Emergency Response	150
		Education	
27	EDU1	Grade Schools	100
28 EDU2 Colleges/University 150			150

#### Table 1-3: Default Hazus Contents Value Percent of Structure Value. From Hazus Flood Technical Manual

#### 1.2.2.7 Inventory Values

For occupancies with inventory considerations (COM1, COM2, IND1 - IND6 and AGR1, inventory losses are estimated using USACE-based depth-damage functions, in conjunction with Hazus default inventory values determined as a percentage of annual sales per square foot (see Earthquake Loss Estimation Methodology Hazus Technical Manual, Section 15.2.3).

#### 1.2.2.8 Latitude/Longitude

Latitude and longitude of the user site(s) in decimal degrees.

#### 1.2.2.9 Building/Content/Inventory Damage Function ID (optional)

A UDF without an assigned Depth Damage Function by the user will now use Coastal DDFs for Coastal hazards using a type of depth approach similar to Hazus GBS. For structures at a depth greater than two (2) feet, a Coastal V DDF is used and for structures in two (2) feet or less of flood depth, a Coastal A DDF is used. Four (4) feet is the boundary between using Coastal A and V DDFs for Content and Inventory.

#### 1.2.2.10 Two ways to Import Building Data Into Hazus

- A. Using CDMS: Refer to section, "Importing Structural Data into the User Definer Facilities (UDF) Database using the Comprehensive Data Management System (CDMS)."
- B. Import the completed buildings data into a UDF geodatabase and directly into Hazus: The Hazus User Defined Facilities Module requires an Esri 8.2 geodatabase format. These can't be created from newer versions of ArcGIS, but one is available in the Hazus program files at the locations listed below:
  - 32 bit operating system: C:\Program Files\Hazus-MH\Data\UDS.mdb
  - 64 bit operating system: C:\Program Files (x86)\Hazus-MH\Data\UDS.mdb
  - Copy the UDS.mdb database to a folder on the local drive (it will not import from a network drive due to MS access Jet Engine Database architecture).
  - Import the buildings database into the UDS geodatabase.
  - Open the UDF table in MS Access. Choose design view to see data types.

Field	Туре	Size
CONTACT	Text	40
NAME	Text	40
ADDRESS	Text	40
CITY	Text	40
STATE	Text	2
ZIPCODE	Text	40
PHONENUMBER	Text	47
OCCUPANCY *	Text	5
YEARBUILT	Integer	2
COST *	Currency	8
BACKUPPOWER	Yes/No	1
NUMSTORIES *	Byte	1
AREA ***	Single	4
BLDGTYPE	Text	15
LATITUDE *	Double	16
LONGITUDE *	Double	16
COMMENT	Text	40
CONTENTCOST **	Currency	8
DESIGNLEVEL	Text	1
FOUNDATIONTYPE *	Text	1
FIRSTFLOORHT **	Double	8
SHELTERCAPACITY	Integer	2
BLDGDAMAGEFNID **	Text	10
CONTDAMAGEFNID **	Text	10
INVDAMAGEFNID **	Text	10
FLOODPROTECTION **	Long Integer	4

#### Table 1-4: Data types. Note: \*Required, \*\*Optional, \*\*\*required for Commercial analysis/ must not be null

It is important to match the above data types identically. If they are not, change them in the data type column on the right and save document. In addition, square footage is a useful attribute to maintain in order to update valuations and is used directly to estimate inventory exposure for certain industrial and commercial occupancies described in Section 14.2.7 of the <u>Hazus Flood Technical Manual</u>.

Once the data types are correctly identified, the UDF is ready for import into Hazus. Reference section Importing Structural Data into the User Defined Facilities (UDF) Database using the Comprehensive Data Management System (CDMS) for steps on inserting the UDF into Hazus.

# 2. Depth Grid Production

This section will demonstrate two methods to create a depth grid. This section will take roughly one hour total to complete.

A Depth Grid is GIS raster format data that represents the extent of riverine flooding or coastal storm surge inundation and the depth of water at a given location. Non-regulatory products, including depth grids, are available for download from FEMA's Map Service Center. If a non-regulatory depth grid for desired region is unavailable for download from the Map Service Center, there are two methods to create a depth grid. One method is using high water mark data and the other is using a DFIRM. This section will demonstrate how to create a depth grid using each method.

Depth Grids are commonly delivered in raster Esri GRID format, each pixel contains a value representing potential water depth. Factors that contribute to the resolution or level of detail displayed by a depth grid are twofold. These factors include resolution of the terrain data, and availability of flood surface elevation information.

Depth Grid accuracy is dependent on the resolution of the Digital Elevation Model (DEM) or terrain data used during the processing of a Depth Grid. The method used for collecting information on the elevation of the flood surface may vary. Common methods for generating flood surface information are: the use of High Water Mark (HWM) data, the use of BFE (Base Flood Elevation) cross sections, or local H&H (Hydrology and Hydraulics) models.

Determining the resolution requirements for a Depth Grid is reliant on the type of analyses that will be conducted with the processed Depth Grid. For example, when site specific (structure by structure) analyses are needed for loss estimation, higher resolution elevation datasets are more appropriate, whereas, if to gain a general idea of flood extent is the intent, a lower resolution elevation dataset would be adequate.

# 2.1. Input Data Types

**High Water Mark (HWM) Data:** High Water Marks are point data collected using high resolution Real Time Kinematic (RTK) GPS systems or other methods. HWM points represent the highest extent of riverine flood or coastal storm surge inundation. These points are used as the foundation for interpolating maximum flooding extent for the final processed Depth Grid.

**FEMA Digital Flood Insurance Rate Map (DFIRM) Base Flood Elevations or Cross Sections:** Base Flood Elevation cross sections are a product of H&H studies used in FEMA's Digital Flood Insurance Rate Maps (DFIRM). These cross sections can be used to interpolate a flood surface which is then used as an input into the depth grid production process, ending with a representation of potential flood depth.

**Terrain Data:** Terrain data can be acquired from many sources. The most common venue for obtaining elevation datasets are through the <u>USGS National Map Viewer</u>. NED data is available nationally at resolutions of 1 arc-second (about 30 meters), 1/3 arc-second (about 10 meters), and in 1/9 arc-second (about 3 meters). NED 1/9 arc-second resolution data is limited in coverage for most areas of the U.S. In addition, high resolution LiDAR (Light Detection and Ranging) terrain data (1-3 meter resolution) may be available through local municipalities within the project area.

**NOTE ON VERTICAL DATUMS:** The points used for flood surface interpolation must be converted to match the vertical datum of the terrain data. It is possible for hydrologic data or terrain data to be processed in either NAVD88 or NGVD29 vertical datum. The difference in vertical elevations between NAVD88 and NGVD29 is slight, however it must be converted to ensure data accuracy and consistency. To convert the orthometric height of a dataset, determine the appropriate vertical datum to be used and navigate to the following website developed by the National Oceanic and Atmospheric Administration (NOAA). A detailed example using the <u>Coastal Flood Loss Atlas</u> in regards to converting the vertical datum using the VDatum software is outlined in Appendix A. Given the nature of the data, the workflow process for executing this conversion process may be different. This conversion must not be overlooked prior to beginning the depth grid processing steps outlined in the next section.

# 2.2. Creating a Depth Grid Using HWM Data

When creating a Depth Grid using HMW Data keep in mind that this is a rudimentary method for flood modeling; this approach does not take into consideration discharge values, flood control measures and a variety of hydrological processes. This particular example is solely based on observed high water marks during the anticipated "peak" of the flooding event. The flood depth representation generated by the following method should only be used as best available data when hydrological/hydraulic modeling data is not available and should be used for planning purposes only, not for regulatory use. This section will take approximately 20 minutes to complete.

File structure and file names in this example are guidelines. The particular GIS workflow and file structure methods utilized may be different.

#### 2.2.1. Required Geographic Datasets

- 1. Terrain Data Esri GRID format (Ex. High resolution community/county specific LiDAR, NED 10m or NED 30m)
- 2. High Water Mark (HWM) data (DFIRM BFE's can also be used in place of HWM's to represent the flood surface elevation of 100 or 500 year flood conditions)



Figure 2-1: Geoprocessing steps for Depth Grid creation

#### 2.2.2. HWM Depth Grid Example

This example below demonstrates the generation of depth grids using HWM data collected from the Souris River flooding of June 2011.

#### 2.2.2.1 Establish Workspace and Define Data

1. Open the Catalog.

Note: Intermediate datasets are created during the processing of a Depth Grid. It is important to ensure proper organization of these datasets during the Depth Grid creation process. The folders in this structure will also be used to delineate the geoprocessing environments in ArcMap.

- 2. Create a new project folder.
  - 2.1 Within the created project folder, create a new folder called "scratch." This is where all intermediate geoprocessing datasets will be stored.
  - 2.2 Within the created project folder, create a new folder called "final\_datasets"



Figure 2-2: Example of creating a new folder called "final\_datasets"

- 3. Open Arcmap.
- 4. Add terrain and HWM data for the project area in an ArcMap document. Make sure the orthometric height conversion has been completed.



Figure 2-3: Example of adding terrain and HMW data

5. Set geoprocessing environments for ArcMap Document by clicking "Geoprocessing" in the ribbon then clicking "Environments". It is important to indicate workspace environments inside of ArcMap; this will ensure that intermediate datasets are stored in the proper directories.

🛠 Environment Settings		-				
Workspace     Current Workspace     I:\Remote_Sensing\Region     Scratch Workspace     H:\Events\2012_Minot\Dat	WorthDakota Minot_LiDAR \dem \Workspace					•
Output Coordinates     Processing Extent     Extent						
Default					- 🔁	
Left	Br	Top	<b>a</b>	light		Ш
Snap Raster					_	
minot_ft					- 🖻	
<ul> <li>XY Resolution and To</li> <li>M Values</li> <li>Z Values</li> <li>Geodatabase</li> <li>Geodatabase Advance</li> <li>Fields</li> <li>Random Numbers</li> <li>Cartography</li> <li>Coverage</li> <li>Raster Analysis</li> <li>Coverage</li> </ul>	erance :d					-
			ок	Cancel	<< Hide Help	

Figure 2-4: Setting geoprocessing environments for ArcMap document

- 5.1 Set the "Current Workspace" to mirror the location of the terrain data.
- 5.2 Set the "Scratch Workspace" to mirror the location of the "scratch" folder within the project folder.
- 5.3 It is important that the "Snap Raster" setting is pointed to the terrain data loaded into the current ArcMap document. If this step is overlooked, inconsistencies will result in the final Depth Grid.

#### 2.2.2.2 Interpolate and Process HMW Data

 Interpolate HWM points using Inverse Distance Weighted (IDW) Spatial Analyst Tool. Note: BFE (Base Flood Elevation) cross sections can also be used in place of High Water Marks to represent 100 or 500-year flood conditions (where effective DFIRMs are available). To do so, convert the BFE cross sections to points using the feature vertices to point tool, then proceed with step 1.

🔨 IDW			
Input point features			*
USGS_HWMs_NAVD88			<b>_</b>
Z value field			
HWMElevFt			-
Output raster			
H:\Events\2012_Minot\Data\Mi	inot_HWM\scratch\hwm_idw		
Output cell size (optional)			
9.25925926011928E-05			6
Power (optional)			
			2
Search radius (optional)	_		
Variable	▼		
Search Radius Settings			
Muchanafasida	12		
Number of points:	12		
Maximum distance:			
Maximan distance.			
Input harrier polyling features (o	ontional)		
triput barrier poryline readeres (o	poonaly		
			-
		OK Cancel Environments	<< Hide Help

Figure 2-5: IDW

- 1.1 Input Point Feature: HWM dataset with converted orthometric height measurements (if necessary).
- 1.2 Z value field: Set this value to the Attribute field in the HWM data representing height in feet.
- 1.3 Output raster: Set output raster to the "scratch" folder previously created and name the output dataset "hwm\_idw."
- 1.4 Set the output raster cell size to that of the DEM.
- 1.5 Under environments set the processing extent to that of the bounding box of the project. If this is omitted, the interpolated surface will extent around the points, and could miss important areas near the edge.



Figure 2-6: Interpolate HWM points using the IDW Spatial Analyst Tool

2. Subtract IDW surface (hwm\_idw) with terrain data using the Minus Spatial Analyst Tool or Raster Calculator.



Figure 2-7: Subtract IDW surface with terrain data

2.1 Input raster or constant value 1: "hwm\_idw."

- 2.2 Input raster or constant value 2: "minot\_navd88" (terrain data).
- 2.3 Output Raster: Set output raster to the "scratch" folder and name the output dataset "RasMinus."
- 3. In this step, the negative values that are generated in the "RasMinus" surface during the subtraction process need to be removed; this is achieved by using the *Greater Than Equal* Spatial Analyst Tool.



Figure 2-8: Greater Than Equal Spatial Analyst Tool

- 3.1 Input raster or constant value 1: "RasMinus".
- 3.2 Input raster or constant value 2: "0." An input value of "0" is necessary at this step since we are only interested in extracting positive values.
- 3.3 Output Raster: Set output raster to "scratch" folder (ArcMap should automatically default to this folder if environments are set correctly) and name the output dataset "GreaterMin."

Note: The above step will generate a raster dataset with output values of "1" and "0." Raster value "1" represents a "true" statement, in the case of this analysis, all depths greater than Oft. Raster value "0" represents a "false" statement, meaning all other depths (in this case, all negative values).

#### 2.2.2.3 Extract the Flood Boundary

1. In order to extract a flood extent and have a shapefile to use as a mask to create a final Depth Grid, it is necessary to convert the GreaterMin raster surface created in the previous step into a polygon shapefile. To complete this, use the *Raster to Polygon* Conversion Tool.



Figure 2-9: Raster to Polygon Conversion Tool

- 1.1 Input Raster: "GreaterMin".
- 1.2 Field: "Value".
- 1.3 Output polygon features: If not automatically populated, set the output polygon to "scratch" folder and name the output shapefile "RasPoly."
- 1.4 Uncheck the box "Simplify Polygons" before processing.
- 1.5 The output polygon will contain an attribute field called "GRIDCODE." The values of "1" and "0" are populated in this field. These values are congruent with the representations described in the previous step.
- 2. Right click the "RasPoly" shapefile in the ArcMap table of contents and click "Properties."

Note: The GRIDCODE value of "0" needs to be removed from the "RasPoly" shapefile created in the previous step. Once this step is completed, the shapefile can be exported and used as a mask to create a depth grid. Use the "Definition Query" tab under the shapefile properties to extract the "1" value.

Layer Properties		8 X
General Source Sele	Query Builder	HTML Popup
Definition Query:	"FID"       "ID"         "GRIDCODE"       "         =       <>       Like       0         >       >       And       1         <       <=       Or       Setter the set of	
	OK Cancel	Apply

Figure 2-10: Query Builder

- 3. Click on the "Definition Query" tab and click "Query Builder."
  - 3.1 Enter: "GRIDCODE" = 1, click OK in the "Query Builder" window, click "OK" in "Layer Properties" window.



Figure 2-11: Using the "Definition Query" tab under the shapefile properties to extract the "1" values.

4. Right click the "RasPoly" shapefile in the ArcMap table of contents and click "Data" then "Export Data." Click "OK"

Note: Export the "RasPoly" shapefile created in the previous step (with GRIDCODE "1" extracted). This is the final flood extent polygon. This will be saved in the "final\_datasets" directory.



Figure 2-12: Exporting the "RasPoly" shapefile

5. Save in the "final\_datasets" folder created in previous steps and name the shapefile "Flood\_Extent."

## 2.2.2.4 Create the Final Depth Grid

1. Create final depth grid using Extract by Mask Spatial Analyst Tool. In the previous step, a new shapefile was created showing the maximum potential flood extent derived from the High-Water Mark data. The previously created shapefile will now be used as a mask to create the final depth grid.



Figure 2-13: Create final depth grid using Extract by Mask Spatial Analyst Tool

- 1.1 Input Raster: "RasMinus" (created in step 5).
- 1.2 Input raster or feature mask data: "Flood\_Extent" (created in previous step).
- 1.3 Output raster: Set the output to save in the "final\_datasets" folder and name the raster "final\_dg."
- 2. Symbolize the final depth grid to better illustrate differences in depth.

Layer Properties				90.00	COL.	? ×
General Source E	Extent Displa	y Symbology				
Show: Unique Values	streto	h values along	g a co <mark>lor ramp</mark>			mport
Stretched Discrete Color			Velue	1-b-l		Â
		or	35.2578	Labei High : 35.2578	Labeling	
	11		0.00012207	Low: 0.00012207		E
	Color	Ramp:			•	
		Display Bac				
		Use hillshad				
A the		rpe:				
		Apply Gan				-
						Apply

Figure 2-14 Symbolizing the final depth grid

- 2.1 Double click the "final\_dg" raster file in the ArcMap table of contents to access the layer properties.
- 2.2 Click the "Symbology" tab.
- 2.3 Select the light-blue to dark-blue color ramp.
- 2.4 If desired, click the "Display" tab and set the transparency to 40 percent.
- 2.5 Click "OK"

# 2.3. Creating a Depth Grid using DFIRM Data

The example below demonstrates the geoprocessing steps to create a depth grid using the Digital Flood Insurance Rate Map (DFRIM) and Esri ArcMap spatial analyst toolset. A depth grid based off of the city and county of Denver DFIRM for an area along the South Platte River near Evans Avenue and Interstate 25 (I-25) will be created. This section will take roughly 40 minutes to complete.

#### 2.3.1. Required Geographic Datasets

Terrain Data (DEM): Use 1 meter LiDAR collected after the 2013 Colorado floods for the exercise.

**Digital Flood Insurance Rate Map (DFIRM):** The data for this example is for the City and County of Denver (NFHL\_080046; Last Study Effective Date: 11/20/2013; Last LOMR Effective Date: 09/29/2017) and can be located on the <u>FEMA Maps Service Center website (https://msc.fema.gov/portal)</u>.

**Area of Interest (AOI):** An AOI is provided to ensure it is possible to complete this example is a reasonable timeframe.

# 2.3.2. DFIRM Depth Grid Example

The example below demonstrates the geoprocessing steps to create a depth grid using the Digital Flood Insurance Rate Map (DFRIM) and Esri ArcMap spatial analyst toolset. A depth grid based off of the city and county of Denver DFIRM for an area along the South Platte River near Evans Avenue and Interstate 25 (I-25) will be created.

## 2.3.2.1 Establish Workspace and Define Data

- 1. Download data for the city and county of Denver, Colorado.
  - 1.1 DFIRM Data
  - 1.2 DEM data
  - 1.3 AOI data
- 2. Ensure all data are projected in the Geographic Coordinate System North American Datum (GCS\_NAD83) as shown in Figure 2-15.



Figure 2-15: Data Frame Coordinate System

- 2.1 Ensure the Spatial Analyst extension is activated by navigating to "Customize," "Extensions," and check the box next to "Spatial Analyst."
- 3. Use the Clip tool to clip the "S\_FLD\_HAZ\_AR" shapefile from the DFIRM data to the "Denver\_DG\_AOI" (see Figure 2-16).

Clip	
Input Featu	res
S_FLD_HA	Z_AR 🗾 🖻
Clip Feature	s
Denver_D	G_AOI 🗾 🖻
Output Feat	ure Class
C:\	\Desktop\FEMA\HAZUS\DFIRM Depth Grid Exercise\DFIRM2\Step2B.shp
XY Tolerance	e (optional)
	Decimal degrees 👻
	1
	OK Cancel Environments Show Help >>
	OK Cancel Environments Show Help

Figure 2-16: Clip Tool



Figure 2-17: S\_FLD\_HAZ\_AR layer clipped to Denver\_DG\_AOI

- 4. Use the "Select by Attribute" tool to select the following flood zones (FLD\_ZONE) as shown in Figure 2-18.
  - 4.1 Select the AE flood zones and click "Apply."

Method :	Create a ne	w selection	
"DFIRM_ "VERSIO "FLD_AR "STUDY_ "FLD_ZO	ID" N_ID" _ID" _TYP" NE"		*
= · > : < ·	<> Like >= And <= Or () Not	'AE' 'AH' 'AO' 'X'	
	In Null FROM 26 WH	Get Unique Values Go To:	
"FLD_ZON	\E" = 'AE'		

Figure 2-18: Select the "AE" Flood Zone



Figure 2-19: AE Flood Zone selected

4.2 Right click on the shapefile in the Table of Contents and navigate to Data and then to Export Data to export the AE flood zone selection to a new shapefile.

Table Of Contents	; <b>Ф</b> Х		
🏡 🤤 🈓 🔀	<u>•</u>		
🖃 <i> Eayers</i>			
🗆 🗹 🗧 👘	Сору		
Ξ Π X	Remove		
	Open Attribute Table		
	Joins and Relates	•	
٩	Zoom To Layer		
	Zoom To Make Visible		
	Visible Scale Range	•	
	Use Symbol Levels		
	Selection	•	
🖃 🗖 S	Label Features		
	Edit Features	•	
	Convert Labels to Annotation		
🗉 🗆 S 😪	Convert Features to Graphics		
	Convert Symbology to Representation		
	Data	•	Repair Data Source
🗉 🗆 S 🔶	Save As Layer File		Export Data
	Create Layer Package		Export To CAD 나강
	Properties		Make Permanent
	HAZ_AR		View Item Description
			Review/Rematch Addresses
	L'AN		

Figure 2-20: Export selection to new shapefile

4.3 Select the radio button next to "the data frame" and click "OK" to save the shapefile In the Export Data dialog box (see Figure 2-21).

Export Da	ta	×
Export:	Selected features	•
Use the s	ame coordinate system as:	
🔘 this la	yer's source data	
• the da	ata frame	
the fe	ature dataset you export the data into applies if you export to a feature dataset in a geodatabase)	
Output fe	eature dass;	
C:\User	s\ABerkow\Desktop\FEMA\HAZUS\DFIRM Depth Grid Exerc	8
		(aaaaaad)
	OK	3

Figure 2-21: Export Data dialog box



Figure 2-22: AE Flood Zone

4.4 Select the AO flood zones and click "Apply" (see Figure 2-23).

elect by At	ttributes	×
Enter a WH	IERE clause to select records in the table window.	
Method :	Create a new selection	•
"VERSION "FLD_AR "STUDY_ "FLD_ZO "ZONE_S	N_ID" LID" _TYP" NE" SUBTY"	•
= < > > < < _%	<> Like 'AE' 'AH' 'AO' <= Or X' () Not Get Unique Values Go To:	
SELECT * F	FROM 26 WHERE:	
"FLD_ZON	NE'' = 'AO'	*
Clear	Verify Help Load Sa Apply Cl	ve

Figure 2-23: Select the "AO" Flood Zones



Figure 2-24: "AO" Flood Zones Selected



Figure 2-25: AO Flood Zone

- 4.5 Right click on the shapefile in the Table of Contents and navigate to Data and then to Export Data to export the AO flood zone selection to a new shapefile.
- 4.6 Select the radio button In the Export Data dialog box next to "the data frame" and click "OK" to save the shapefile.
- 4.7 Select the AH flood zones as shown in Figure 2-26.

Select by Attributes
Enter a WHERE clause to select records in the table window.
Method : Create a new selection
"DFIRM_ID" "VERSION_ID" "FLD_AR_ID" "STUDY_TYP" "FLD_ZONE"
$ \begin{array}{c c} = & \langle \rangle & \text{Like} & \text{`AE'} \\ \hline & \rangle & \rangle = & \text{And} & \text{`AH'} \\ \hline & \langle AO' \\ \hline & \langle < = & \text{Or} & & \\ \hline & \chi' \\ \hline & & \langle \rangle & \text{Not} \end{array} $
Is In Null Get Unique Values Go To:
SELECT * FROM 2b WHERE:
"FLD_ZONE" = 'AH'
Clear Venfy Help Load Save Apply Close

Figure 2-26: Select AH Flood Zone



Figure 2-27: AH Flood Zone Selected
- 4.8 Right click on the shapefile in the Table of Contents and navigate to Data and then to Export Data to export the AH flood zone selection to a new shapefile.
- 4.9 Select the radio button in the Export Data dialog box next to "the data frame" and click "OK" to save the shapefile.



Figure 2-28: AH Flood Zone

Use the "Select by Attribute" tool to create a new shapefile.
 5.1 Select "SFHA\_TF" = "T" and click "Apply."

Select by At	tributes			<b>×</b>
Enter a WH	IERE clause to	o select records in the	table window	
Method :	Create a ne	w selection		•
"STUDY_ "FLD_ZO "ZONE_S "SFHA_T "STATIC_	TYP" NE" UBTY" F" BFE"			*
	<> Like >= And <= Or	F T		
	() Not In Null FROM 25 WH	Get Unique Value:	Go To:	
"SFHA_TF	"" = "T"			*
Clear	Verify	Help	Load	+ Save
			Apply	Close

Figure 2-29: Select SFHA = T

- 5.2 Right click on the shapefile in the Table of Contents and navigate to Data and then to Export Data to export the "SFHA\_TF" = "T" selection to a new shapefile.
- 5.3 Select the radio button in the Export Data dialog box next to "the data frame" and click "OK" to save the shapefile.



Figure 2-30: SHFA=T Selection

5.4 Use the "Dissolve" tool to create the inundation boundary.

6. The input feature class is the results from the steps above.

input Features		_
<u>\$FHA_T</u>		✓ 2
Dutput Feature Class		
C:\Users\ABerkow\Documents\ArcGIS\Default.gd	db\SFHA_T_Dissolve	6
Dissolve_Field(s) (optional)		
FID FID		*
DFIRM_ID		
VERSION_ID		E
FLD_AR_ID		
STUDY_TYP		
FLD_ZONE		
ZONE_SUBTY		
SFHA_TF		-
I STATIC BE	m	
Select All Unselect All		Add Field
Statistics Field(s) (optional)		
		•
Field	Statistic Type	
		×

Figure 2-31: Dissolve SFHA\_T polygon



Figure 2-32: Inundation Boundary

7. Use the Clipping tool to clip "S\_XS" (cross sections) by the AE\_Flood\_Zones (Figure 2-33).

Input Features	(*
s_xs	I 🔁
Clp Features	
AE_Flood_Zones	I 🔁
Output Feature Class	
C: \Users\ABerkow\Desktop\FEMA\HAZUS\DFIRM Depth Grid Exercise\XS_Clip.shp	6
XY Tolerance (optional)	
De	cimal degrees 🔹 🔻

Figure 2-33: Clip the cross sections by the AE flood zones



Figure 2-34: Cross sections clipped by AE flood zones

- 8. Open the Feature Vertices to Points tool to convert the cross section line segments into points as shown in Figure 2-35.
  - 8.1 Change the input features to the "XS\_Clip" file created.
  - 8.2 Set the Point Type to All.

Feature Vertices To Points		
Input Features		
XS_Clip		I 🔁
Output Feature Class		_
C: \Users \ABerkow \Desktop \FEMA \HAZUS \D	FIRM Depth Grid Exercise \XS_Clip_FVtoPoint.shp	
Point Type (optional)		
ALL		•

Figure 2-35: Feature Vertices to Points tool



Figure 2-36: Feature Vertices to Points conversion

- 9. Use the Extract Values to Points tool to extract the DEM value at each feature point as shown in Figure 2-37.
  - 9.1 The input features are the points from the previous step.
  - 9.2 The input raster is the DEM.

input point features			
FVtoPoint		•	
input raster			
dem_ft		•	2
Dutput point features			
C: \Users \ABerkow \Desktop \FEMA \HAZUS \DFIRM De	pth Grid Exercise\DFIRM2\EVt	toPoint.shp	2
Interpolate values at the point locations (optional) Append all the input raster attributes to the output pathers.	point features (optional)		
<ul> <li>Interpolate values at the point locations (optional)</li> <li>Append all the input raster attributes to the output part of the ou</li></ul>	point features (optional)		
<ul> <li>Interpolate values at the point locations (optional)</li> <li>Append all the input raster attributes to the output part of the point of the poin</li></ul>	point features (optional)		

Figure 2-37: Extract Values to Points tool



Figure 2-38: DEM Values extracted to cross section end points

## 2.3.2.2 Interpolate the Water Surface

- 1. Similar to the HWM example, use the Inverse Distance Weighted (IDW) tool to interpolate a water surface (steps below shown in Figure 2-39).
  - 1.1 The input point feature is the point shapefile created during the step above.
  - 1.2 Set the "Z-value field" to "RasterValu," which stands for Raster Value.

Input point features   EVtoPoint   Z value field   RASTERVALU   Output raster   C:\Users\ABerkow\Documents\ArcGIS\Default.gdb\tdw   Output cell size (optional)   9.56050427896287E-05   Power (optional)   Search radius (optional)   Variable   Search Radius Settings   Number of points:   12   Maximum distance:   Input barrier polyline features (optional)	
EVtoPoint         Z value field         RASTERVALU         Output raster         C: \Users\ABerkow\Documents\ArcGIS\Default.gdb\Idw         Output cell size (optional)         9.56050427896287E-05         Power (optional)         Search radius (optional)         Variable         Search Radius Settings         Number of points:       12         Maximum distance:         Input barrier polyline features (optional)	
Z value field RASTERVALU Output raster C:\Users\ABerkow\Documents\ArcGIS\Default.gdb\Idw Output cell size (optional) 9.56050427896287E-05 Power (optional) Variable Search radius (optional) Variable Search Radius Settings Number of points: 12 Maximum distance: Input barrier polyline features (optional)	<b>_</b>
RASTERVALU Output raster C:\Users\ABerkow\Documents\ArcGIS\Default.gdb\Idw Output cell size (optional) 9.56050427896287E-05 Power (optional) Search radius (optional) Variable Search Radius Settings Number of points: 12 Maximum distance: Input barrier polyline features (optional)	
Output raster C: \Users\ABerkow\Documents\ArcGIS\Default.gdb\Idw Output cell size (optional) 9.56050427896287E-05 Power (optional) Variable Search radius (optional) Variable Search Radius Settings Number of points: 12 Maximum distance: Input barrier polyline features (optional)	-
C: \Users\ABerkow\Documents\ArcGIS\Default.gdb \Idw Output cell size (optional) 9.56050427896287E-05 Power (optional) Search radius (optional) Variable Search Radius Settings Number of points: 12 Maximum distance: Input barrier polyline features (optional)	_
Output cell size (optional) 9.56050427896287E-05 Power (optional) Search radius (optional) Variable Search Radius Settings Number of points: 12 Maximum distance: Input barrier polyline features (optional)	<b>6</b>
9.56050427896287E-05 Power (optional) Search radius (optional) Variable  Search Radius Settings Number of points:  12 Maximum distance: Input barrier polyline features (optional)	
Power (optional) Search radius (optional) Variable  Search Radius Settings Number of points:  12 Maximum distance: Input barrier polyline features (optional)	
Search radius (optional)          Variable         Search Radius Settings         Number of points:         12         Maximum distance:         Input barrier polyline features (optional)	
Search radius (optional)          Variable         Search Radius Settings         Number of points:         12         Maximum distance:         Input barrier polyline features (optional)	2
Variable           Search Radius Settings           Number of points:           Maximum distance:           Input barrier polyline features (optional)	
Search Radius Settings Number of points: 12 Maximum distance: Input barrier polyline features (optional)	
Number of points:     12       Maximum distance:     12       Input barrier polyline features (optional)	
Maximum distance: Input barrier polyline features (optional)	
Input barrier polyline features (optional)	
Input barrier polyline features (optional)	
1	
OK Cancel Environm	ents Show Help >>

Figure 2-39: IDW tool

- 1.3 Navigate to Processing Extent within Environments.
- 1.4 Set the Processing Extent to the "Denver\_DG\_AOI.shp" and the Snap Raster to the DEM.
- 1.5 Navigate to Raster Analysis within Environments.
- 1.6 Set the output cell size equal to the DEM.
- 1.7 Click "OK" to close the Environments window.
- 1.8 Click "OK" to run the IDW tool window.



Figure 2-40: Interpolated water surface

## 2.3.2.3 Create the Zone Depth Grid

There are three types of Zone Depth Grids that can be developed 1) AE Flood Zone Depth Grid two (2), 2) AH Flood Zone Depth Grid and 3) AO Flood Zone Depth Grid. This section describes the steps for developing the Zone Depth Grid.

## 2.3.2.3.1 AE Flood Zone Depth Grid

1. Use the Raster Calculator or Minus Spatial Analyst tool to subtract the DEM from the interpolated water surface from the previous step (WSE – DEM = DG) as shown in Figure 2-41.

lap Algebra expression	
Layers and variables	Conditional —
<ul> <li>✓ idw</li> <li>✓ dem ft</li> </ul>	7 8 9 / == != & Con Pick
0 <b>*</b>	4 5 6 * > >=   SetNull
	1 2 3 - < <= ^ Math
"idw" - "dem_ft" Dutput raster	
C: \Users \ABerkow \Desktop \FEN	1A \HAZUS \DFIRM Depth Grid Exercise \DFIRM2 \rastercalc

Figure 2-41: Raster Calculator

- 1.1 Navigate to Processing Extent within Environments.
- 1.2 Set the Snap Raster to the DEM.
- 1.3 Navigate to Raster Analysis Within Environments.
- 1.4 Set the output cell size equal to the DEM.
- 1.5 Re-read the data considerations at the beginning of the exercise if any geoprocessing errors arise.



Figure 2-42: Raster Calculator results

2. Use the Raster Calculator tool to remove the negative values from the raster output generated from the previous step as shown in Figure 2-43.

Layers and variables rastercalc dem ft	Conditional Con 7 8 9 / == != & Con Pick SetNull
V dem_st	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$
"rastercalc" >= 0	
output raster	
C:\Users\ABerkow\Desktop\FEI	MA HAZUS IDFIRM Depth Grid Exercise IDFIRM2 (raster_remneg )

Figure 2-43: Raster Calculator tool

- 2.1 Navigate to Processing Extent within Environments.
- 2.2 Set the Snap Raster to the DEM.
- 2.3 Navigate to Raster Analysis within Environments.
- 2.4 Set the output cell size equal to the DEM.



Figure 2-44: Raster Calculator results

- 2.5 Use the Raster to Polygon tool to convert the raster from the previous step to a vector dataset as shown in Figure 2-45.
- 2.6 Set the input raster as the file from the previous step.
  - a. The raster output from the previous step is a "True/False" raster: "1" represents a true statement, and "0" represents a false statement.
  - b. The "1" or "True" values need to be extracted to derive a flood extent.
- 2.7 Uncheck the box next to Simplify Polygons.



Figure 2-45: Raster to Polygon tool

2.8 Click "OK" to create the polygon conversion.



Figure 2-46: Raster to Polygon results

2.9 Use the Select by Attributes tool to select the "1" or "true" values from the output vector polygon from the previous step.

lethod :	Create a new	w selection			
"FID" "ID" "GRIDCO	DE"				
= (	<ul> <li>Like</li> <li>And</li> <li>Or</li> </ul>	0 1			
_% [  s	() Not In Null	Get Unique	e Values	Go To:	
ELECT * F	ROM step5e \ E'' = 1	WHERE:			2
					-

Figure 2-47: Select by Attributes tool



Figure 2-48: Gridcode = 1 Selection

- 2.10 Right click on the "Step4C" shapefile in the Table of Contents and navigate to Data then to Export Data to export the "1" selection to a new shapefile.
- 2.11 Select the radio button in the Export Data dialog box next to "the data frame" and click "OK" to save the shapefile.



Figure 2-49: Gridcode = 1 Shapefile

- 3. Optional: Use the Dissolve tool to dissolve the flood polygon from the previous step.
  - 3.1 The Dissolve Field and the Statistics Field remain unchanged.

Tonacoact	🔟 🖆
Output Feature Class	
C:\Users\ABerkow\Desktop\FEMA\HAZUS\DFIRM Depth Grid Exercise	e\DFIRM2\grid1_dissolve.shp
Dissolve_Field(s) (optional)	
FID FID	
Id	
gridcode	
	Add Field
Select All Unselect All	

Figure 2-50: Dissolve tool

3.2 Click "OK" to dissolve the layer.



Figure 2-51: Dissolve result

4. Use the Clip tool to clip the dissolved flood polygon boundary by the AE flood zone shapefile created in the previous steps.

Clip		
Input Features		
grid1_dissolve		I 🔁
Clip Features		
AE_Selection		I 🔁
Output Feature Class		
C: \Users \ABerkow \Desktop \FEMA \+	AZUS\DFIRM Depth Grid Exercise\DFIRM2\c	dissolve_clip.shp 🔂
XY Tolerance (optional)		
		Decimal degrees 🔹

Figure 2-52: Clip tool



Figure 2-53: Clip result

5. Use the Extract by Mask spatial analyst tool to create a flood depth grid using the flood boundary polygon created in the previous step.

Extract by Mask	
Input raster	-
rastercalc	I 🔁
Input raster or feature mask data	
dissolve_clip	I 🔁
Output raster	
C: \Users \ABerkow \Desktop \FEMA \HAZUS \DepthGrid \extractmask	
OK Cancel Environments	. Show Help >>

Figure 2-54: Extract by Mask

- 5.1 Navigate to Processing Extent within Environments.
- 5.2 Set the Snap Raster to the DEM.
- 5.3 Navigate to Raster Analysis within Environments.
- 5.4 Set the output cell size equal to the DEM.



Figure 2-55: Extract by Mask result

6. Use the Erase tool and the output vector polygon from the step above to create a feature class of areas not inundated in the previous steps.

s Erase			) <b>x</b>
Input Features		_	*
AE_Selection			
Erase Features			
dissolve_clip		E	
Output Feature Class			
C: \Users \ABerkow \Desktop \FEMA \	HAZUS\DFIRM Depth Grid Exercise\DFIRM2\AE_bound	ary_erase.sht 📔	5
XY Tolerance (optional)			
	Decim	al degrees 🔹 🔻	
			Ŧ
	OK Cancel Environment	s Show Help	

Figure 2-56: Erase tool



Figure 2-57: Erase result

7. Use the Extract by Mask spatial analyst tool and the flood boundary polygon created in the previous step to create a flood depth grid.

Extract by Mask		
Input raster		
dem_ft		
Input raster or feature mask data	#	
AE_boundary_erase		I 🖆
Output raster		<u></u>
C:\Users\ABerkow\Desktop\FEM	A\HAZUS\DFIRM Depth Grid Exercise\DFIRM2\extra	ict4I 🛃
	OK Cancel Environr	ments Show Help >>

Figure 2-58: Extract by Mask tool

- 7.1 Navigate to Processing Extent within Environments.
- 7.2 Set the Snap Raster to the DEM.
- 7.3 Navigate to Raster Analysis within Environments.

7.4 Set the output cell size equal to the DEM.



Figure 2-59: Extract by Mask result

8. Use the Raster Calculator to set the raster equal to 0.1.

♦ Step4J									Conditional —	
5m2	r	-							Con	E
step5e			<u> </u>	9			!=	a	Pick	
step50		4	5	6	*	>	>=	1	SetNull	
extract4I	= (	Ti		T	$\equiv$				Math ———	
rastercalc				<u> </u>			_		Abs	
🔷 dem_ft	+	0						1 1	Evo	
"extract4I"=0, 1 utput raster C: \Users\ABerkow\De	:sktop\FEM	A\HA2	ZUS\De	pthGri	id\Ste	04J		~	Eve 10	•
"extract4I"=0.1 utput raster C: \Users\ABerkow\De	:sktop \FEM	'A\HAZ	ZUS\De	pthGri	id\Ste	p4]		~	Even 10	•
"extract4I"=0.1 utput raster C: \Users\ABerkow\De	esktop \FEM	IA \HAZ	ZUS\De	pthGri	id\Ste	 p4]		~		•
"extract4I"=0.1 utput raster C: \Users \ABerkow \De	esktop \FEM	IA \HAZ	ZUS\De	pthGri	id\Step	p4J		~	Even 10	•
"extract4I"=0.1 utput raster C: \Users\ABerkow\De	esktop VFEM	IA \HAZ	ZUS\De	pthGri	id\Step	043		~	Even10	•
"extract4I"=0.1 utput raster C: \Users\ABerkow\De	esktop \FEM	IA \HAZ	ZUS\Pe	pthGri	id\Step	p4J		~		-

Figure 2-60: Raster Calculator tool



Figure 2-61: Raster equal to 0.1 feet

9. Use the Mosaic to New Raster tool to create the final AE Flood Zone Depth Grid using the two depth grids created in the previous steps.

Input Rasters			
		🖃 🖻	
extractmask			1
<ul> <li>◆Step4J</li> </ul>			1
		×	
		<b></b>	]
			ע ר
Output Location			3
C: \Users \ABerkow \Desktop \FE	МА		
Raster Dataset Name with Exte	nsion		
AEMosaic			
Spatial Reference for Raster (op	itional)		
Pixel Type (optional)			
8_BIT_UNSIGNED			
Cellsize (optional)			
Number of Bands			
		1	

Figure 2-62: Mosaic to New Raster tool

- 9.1 Change the Number of Bands to 1.
- 9.2 Navigate to Processing Extent within Environments.
- 9.3 Set the Snap Raster to the DEM.
- 9.4 Navigate to Raster Analysis within Environments.
- 9.5 Set the output cell size equal to the DEM.
- 9.6 Click "OK" to close the Environments tab.
- 9.7 Click "OK" to create the mosaic.



Figure 2-63: AE Mosaic Raster

## 2.3.2.3.2 AH Flood Zone Depth Grid

The AH Flood Zone has a constant water surface elevation, known as a static Base Flood Elevation (BFE). Recent revisions to the DFRIM database can cause errors to occur. There is no static BFE associated with the S\_FLD\_HAZ\_AR shapefile used in steps below in this case specifically. Please refer to the FIRM (use the FIRM Panel shapefile for reference) to determine the Static BFE, which is 5,256 feet in this example, if an error occurs. It is not necessary to interpolate a water surface because the water surface elevation is predetermined at a static level for AH field zones.

- 1. Use the Extract by Mask tool and the AH Flood Zone boundary created to create the water surface.
  - 1.1 Set the input raster to the DEM.
  - 1.2 Navigate to Processing Extent within Environments.
  - 1.3 Set the Snap Raster to the DEM.
  - 1.4 Navigate to Raster Analysis within Environments.
  - 1.5 Set the output cell size equal to the DEM.
  - 1.6 Click "OK" to close the Environments tab.
  - 1.7 Click "OK" to initiate the Extract by Mask tool.

Input raster		
dem_ft		<u>→</u> 🔁
Input raster or feature mask data	 	
AH_Selection		I 🖻
Output raster		

Figure 2-64: Extract by Mask tool



Figure 2-65: Extract by Mask result

- Open the Raster Calculator tool and enter the following expression: "([Raster File from Step5-B] \* 0)
   + [Static BFE in Feet])" to finish the creating the depth grid.
  - 2.1 The static BFE is 5,256 feet. This information can be found in the "S\_FLD\_HAZ\_AR" attribute table.

♦ idw + 0 . + ( ) ~ Exp + 0 . +	Raster Calculator Map Algebra expression Layers and variables Step5B AEMosaic extract4I extract4I raster_remneg rastercalc		Conditional — Abs
C:\Users\ABerkow\Desktop\FEMA\HAZUS\DFIRM Depth Grid Exercise\DFIRM2\step5C	idw (("Step5B"*0)+5256) Output raster C:\Users\ABerkow\Desktop	+ 0 , + ( ) ~	

Figure 2-66: Raster Calculator tool

- 2.2 Navigate to Processing Extent within Environments.
- 2.3 Set the Snap Raster to the DEM.
- 2.4 Navigate to Raster Analysis within Environments.
- 2.5 Set the output cell size equal to the DEM.
- 2.6 Click "OK" to close the Environments tab.
- 2.7 Click "OK" to implement the Raster Calculator.



Figure 2-67: Raster Calculator Result

3. Use the Raster Calculator or Minus spatial analyst tool and the interpolated water surface from the previous step to subtract the DEM from this surface (WSE – DEM = DG).

1ap Algebra expression		
Step 5B AEMosaic extract4I extract4I restractmask restracter remneg	7     8     9     /     ==     1     1     Conditional     4       4     5     6     *     >>=     1     Pick       SetNull	•
♦ rastercalc ♦ idw ♦ dem_ft	I     I <td>•</td>	•
"step5C" - "dem_ft"		
"step5C" - "dem_ft" Dutput raster		-
"step5C" - "dem_ft" Dutput raster C:\Users\ABerkow\Desktop	>\FEMA\HAZUS\DFIRM Depth Grid Exercise\DFIRM2\step5d	3
"step5C" - "dem_ft" Dutput raster C: \Users\ABerkow\Desktop	o\FEMA\HAZUS\DFIRM Depth Grid Exercise\DFIRM2\step5d	3
"step5C" - "dem_ft" Dutput raster C: \Users\ABerkow\Desktop	▷\FEMA\HAZUS\DFIRM Depth Grid Exercise\DFIRM2\step5d	3
"step5C" - "dem_ft" Dutput raster C: \Users \ABerkow \Desktop	o\FEMA\HAZUS\DFIRM Depth Grid Exercise\DFIRM2\step5d	3
"step5C" - "dem_ft" Dutput raster C: \Users\ABerkow\Desktop	o\FEMA\HAZUS\DFIRM Depth Grid Exercise\DFIRM2\step5d	

Figure 2-68: Raster Calculator tool

- 3.1 Navigate to Processing Extent within Environments.
- 3.2 Set the Snap Raster to the DEM.
- 3.3 Navigate to Raster Analysis within Environments.
- 3.4 Set the output cell size equal to the DEM.
- 3.5 Click OK to close the Environments tab.
- 3.6 Click "OK" to subtract the DEM from the interpolated water surface.
- 3.7 Re-read the data considerations at the beginning of the exercise and ensure the data conforms to these considerations if any geoprocessing errors arise.



Figure 2-69: Raster Calculator result

4. Use the Raster Calculator tool to remove the negative values from the raster output from the previous step.

Ap Algebra expression     Layers and variables <ul> <li>step5d</li> <li>step5d</li> <li>step5B</li> <li>AEMosaic</li> <li>extract4I</li> <li>extractmask</li> <li>raster_remneg</li> </ul> <ul> <li>a</li> <li>a</li> <li>a</li> <li>a</li> <li>a</li> </ul> <ul> <li>step5d" &gt;= 0</li> </ul> <ul> <li>Conditional</li> <li>Con</li> <li>Pick</li> <li>SetNull</li> <li>Math</li> <li>Abs</li> <li>Exp</li> <li>Even 10</li> </ul> <ul> <li>Step5d" &gt;= 0</li> </ul> <ul> <li>Output raster</li> <li>C: Users \ABerkow \Desktop \FEMA \HAZUS \DFIRM Depth Grid Exercise \DFIRM2 \step5e</li> </ul>	Algebra expression     Layers and variables <ul> <li>step5d</li> <li>step5d</li> <li>step5d</li> <li>AEMosaic</li> <li>extractHi</li> <li>extractMask</li> <li>raster_remneg</li> </ul> Table 56     Step5d*>=0     Output raster   C:\Users\ABerkow\Desktop\FEMA\HAZUS\DFIRM Depth Grid Exercise\DFIRM2\step5e				
Layers and variables   Image: step5d   Image: step5d <th>Layers and variables    step5d     step5C     Step5B     AEMosaic    extractMask     extractmask     o     taster_remneg              Step5d* &gt;= 0     Conditional       Conditional       Conditional    Conditional    Conditional    Conditional    Conditional    Conditional    Conditional    Conditional    Conditional   Conditional    Conditional    Conditional   Conditional    Conditional    Conditional   Conditional    Conditional    Conditional    Conditional    Conditional   Conditional    Conditional   Conditional    Conditional   Conditional    Conditional    Conditional   Conditional    Conditional    Conditional   Conditional    Conditional   Conditional   Conditional    Conditional   Conditional    Conditional   Conditional    Conditional   Conditional    Conditional   Conditional    Conditional   Conditional   Conditional   Conditional    Conditional   Conditional   Conditional    Conditional   Conditional   Conditional    Conditional   Conditional    Conditional   Conditional    Conditional   Conditional   Conditional   Conditional   Conditional   Conditional   Conditional   Con</th> <th>1ap Algebra expression</th> <th></th> <th></th> <th></th>	Layers and variables    step5d     step5C     Step5B     AEMosaic    extractMask     extractmask     o     taster_remneg              Step5d* >= 0     Conditional       Conditional       Conditional    Conditional    Conditional    Conditional    Conditional    Conditional    Conditional    Conditional    Conditional   Conditional    Conditional    Conditional   Conditional    Conditional    Conditional   Conditional    Conditional    Conditional    Conditional    Conditional   Conditional    Conditional   Conditional    Conditional   Conditional    Conditional    Conditional   Conditional    Conditional    Conditional   Conditional    Conditional   Conditional   Conditional    Conditional   Conditional    Conditional   Conditional    Conditional   Conditional    Conditional   Conditional    Conditional   Conditional   Conditional   Conditional    Conditional   Conditional   Conditional    Conditional   Conditional   Conditional    Conditional   Conditional    Conditional   Conditional    Conditional   Conditional   Conditional   Conditional   Conditional   Conditional   Conditional   Con	1ap Algebra expression			
raster_remneg * v · + v / * v · + v / * v · + v / * v · + v / * v · + v ·	<pre>   raster_remneg</pre>	Layers and variables step5d step5C Step5B AEMosaic extract4I extract4I extractmask	7     8     9     /     ==     1:       4     5     6     *     >       1     2     3     -     <	Cond Con Pick SetNull (= ^ Abs Exp	itional — A
Output raster C: \Users\ABerkow\Desktop\FEMA\HAZUS\DFIRM Depth Grid Exercise\DFIRM2\step5e	Output raster C: \Users\ABerkow\Desktop\FEMA\HAZUS\DFIRM Depth Grid Exercise\DFIRM2\step5e	<pre>raster_remneg * "step5d" &gt;= 0</pre>	0.+()	) ~ Exp Even10	*
		Dutput raster C: \Users \ABerkow \Desktop \FEMA \HA	ZUS\DFIRM Depth Grid Exercise\DFIf	RM2\\$tep5e	
		Dutput raster C: \Users \ABerkow \Desktop \FEMA \HA	ZUS \DFIRM Depth Grid Exercise \DFIf	RM2\step5e	

Figure 2-70: Raster Calculator tool

- 4.1 Navigate to Processing Extent within Environments.
- 4.2 Set the Snap Raster to the DEM.
- 4.3 Navigate to Raster Analysis within Environments.
- 4.4 Set the output cell size equal to the DEM.
- 4.5 Click "OK" to close the Environments tab.
- 4.6 Click "OK" to remove the negative values.



Figure 2-71: Raster Calculator result

- 5. Use the Raster to Polygon conversion tool to convert this raster into a vector dataset.
  - 5.1 Set the file from the previous step as the Input raster.
  - 5.2 The raster output from the previous step is a "True/False" raster where "1" represents a true statement, and "0" represents a false statement.
  - 5.3 Uncheck the box next to "Simplify Polygons."
  - 5.4 Click "OK" to initiate the conversion.

Raster to Polygon		
Input raster		
step5e		I 🔁
Field (optional)		
VALUE		3. <del></del>
Output polygon features		
C:\Users\ABerkow\Desktop\FEMA	\HAZUS\DFIRM Depth Grid Exercise\DFIRM2\Step5F.shp	<b>2</b>
	OK Cancel Environments	Chow Hole >>

Figure 2-72: Raster to Polygon tool



Figure 2-73: Raster to Polygon result

- 6. The "1" or "True" values from the previous step needs to be extracted to derive a flood extent.
- 7. Use the Select by Attributes tool to export the "1" values from the "Gridcode" field in the attribute table.
  - 7.1 Click "Apply" to select.

Method :	Create a ne	w selection		
"FID" "Id" "gridcode				
= •	<> Like >= And	0 1		
	() Not			
ls	In Null	Get Unique Values	Go To:	
SELECT * F "gridcode"	FROM Step5F = 1	WHERE:		
	] [ +++			-

Figure 2-74: Select by Attribute tool



Figure 2-75: Gridcode = 1 selection

- 7.2 Right click on the Step5F shapefile in the Table of Contents and navigate to Data then to Export Data to export the "1" selection to a new shapefile.
- 7.3 Select the radio button in the Export Data dialog box next to "the data frame" and click "OK" to save the shapefile.



Figure 2-76: Gridcode = 1 shapefile

- 8. Optional: Use the Dissolve tool to dissolve the flood polygon.
  - 8.1 The Dissolve Field and Statistics Field remains unchanged.

Step5G   Output Feature Class   C: \Users \ABerkow \Desktop \FEMA \HAZUS \DFIRM Depth Grid Exercise \DFIRM2 \Step5H.shp   Dissolve_Field(s) (optional)   FID   Id   gridcode     Select All   Unselect All   Statistics Field(s) (optional)	Input Features				
Output Feature Class         C: \Users\ABerkow\Desktop\FEMA\HAZUS\DFIRM Depth Grid Exercise\DFIRM2\Step5H.shp         Dissolve_Field(s) (optional)         Id         gridcode         Select All       Unselect All         Add Field	Step5G			-	B
C: \Users \ABerkow \Desktop \FEMA \HAZUS \DFIRM Depth Grid Exercise \DFIRM2 \Step 5H.shp Dissolve_Field(s) (optional) I d gridcode Select All Unselect All Add Field Statistics Field(s) (optional)	Output Feature Class				=
Dissolve_Field(s) (optional)  I d gridcode  Select All Unselect All Add Field  Statistics Field(s) (optional)	C: Users \ABerkow \Desktop \F	EMA\HAZUS\DFIRM Depth Grid Exerci	ise\DFIRM2\Step5H.shp		B
FID         Id         gridcode         Select All         Unselect All         Add Field         Statistics Field(s) (optional)	Dissolve_Field(s) (optional)				-
	Id gridcode				
	Select All Unsele Statistics Field(s) (optional) Field	t All	ic Туре	Add Field	•
	Select All Unsele Statistics Field(s) (optional) Field	t All	ic Type	Add Field	
	Select All Unsele Statistics Field(s) (optional) Field	t All	ic Type	Add Field	- + ×
	Select All Unsele Statistics Field(s) (optional) Field	t All	ic Type	Add Field	<ul> <li>▼</li> <li>★</li> <li>★</li> <li>★</li> <li>★</li> </ul>

Figure 2-77: Dissolve tool



Figure 2-78: Dissolve result

9. Use the Clip tool to clip the dissolved flood polygon boundary by the AH flood zone shapefile created in the previous steps.

Спр		
Input Features		
Step5H		💽 🔁
Clip Features		
AH_Selection		2
Output Feature Class		
C:\Users\ABerkow\Desktop\FEMA\HA	ZUS\DFIRM Depth Grid Exercise\DFIRM2\Step5I.shp	
XY Tolerance (optional)		
	Decimal de	egrees 🔻

Figure 2-79: Clip tool



Figure 2-80: Clip result

- 10. Use the Extract by Mask spatial analyst tool to create a flood depth grid using the flood boundary polygon created in the previous step.
  - 10.1 Navigate to Processing Extent within Environments.
  - 10.2 Set the Snap Raster to the DEM.
  - 10.3 Navigate to Raster Analysis within Environments.
  - 10.4 Set the output cell size equal to the DEM.

Input raster				
step5d			<u> </u>	3
Input raster or feature mask dat	ta			_
step5I			E	3
Output raster				_
C: \Users \ABerkow \Desktop \FE	MA HAZUS DepthG	Grid\Step5J	E	3

Figure 2-81: Extract by Mask tool



Figure 2-82: Extract by Mask result

11. Use the Erase tool and the output vector polygon from the step above to create a feature of the areas not inundated in the previous steps.

Erase	-	
Input Features		
AH_Selection	-	] 🔁
Erase Features		_
Step5I		] 🔁
Output Feature Class		
C:\Users\ABerkow\Desktop\FEMA\	HAZUS\DFIRM Depth Grid Exercise\DFIRM2\AH_boundary_erase.sh	1 🔁
XY Tolerance (optional)		
	Decimal degrees	-

Figure 2-83: Erase tool



Figure 2-84: Erase results

12. Use the Extract by Mask spatial analyst tool and the flood boundary polygon created in the previous step to create the 0.1 ft flood depth grid.

Extract by Mask					
Input raster					
dem_ft				•	2
Input raster or feature mask data					_
AH_boundary_erase				-	
Output raster					_
C:\Users\ABerkow\Desktop\FEMA\HAZUS\DFIR	M Depth Grid E	Exercise \DFIR	M2\step5L		2

Figure 2-85: Extract by Mask tool
- 12.1 Navigate to the Processing Extent within Environments.
- 12.2 Set the Snap Raster to the DEM.
- 12.3 Navigate to Raster Analysis within Environments.
- 12.4 Set the output cell size equal to the DEM.
- 12.5 Click "OK" to close the environments tab.
- 12.6 Click "OK" to extract the new flood depth grid.



Figure 2-86: Extract by Mask results

13. Use the Raster Calculator to set the raster equal to 0.1 feet.

♦ Step43	*							Conditional —	
					$\square$		$\square$	Con	H
♦ step5e		7 8	][9]		==	!=	&	Pick	
step5d		4 5	6	*	>	>=		SetNull	
StepsL	-			$\square$	$\square$		$\square$	Math	
	-	1 2	3	. •••	<	<=	<u></u>	Abs	
✓ dem ft		0		+	$\left[ \right]$		~	Exp	

Figure 2-87: Raster Calculator tool



Figure 2-88: Raster equal to 0.1 feet

14. Use the Mosaic to New Raster tool to create the final AH Flood Zone Depth Grid using the two (2) depth grids created in the previous steps.

Input Rasters		
		<b>_</b>
Asten5i		
Step 5M		
		×
Engenne zower wernen.		
Output Location		
C:\Users\ABerkow\Downlo	ads	
Raster Dataset Name with	xtension	
AHMosaic		
Spatial Reference for Raste	r (optional)	
Pixel Type (optional)		
8_BIT_UNSIGNED		
Cellsize (optional)		

Figure 2-89: Mosaic to New Raster tool

- 14.1 Change the Number of Bands to 1.
- 14.2 Navigate to Processing Extent within Environments.
- 14.3 Set the Snap Raster to the DEM.
- 14.4 Navigate to Raster Analysis within Environments.
- 14.5 Set the output cell size equal to the DEM.
- 14.6 Click "OK" to close the Environments tab.
- 14.7 Click "OK" to create the mosaic.



Figure 2-90: AH Mosaic Raster

15. There is only one AH Flood Zone in this exercise. There are multiple AH zones with different depths in many cases. A depth grid should be created for each separately when there are many cases.

#### 2.3.2.3.3 AO Flood Zone Depth Grid

The AO Flood Zone has a constant water depth, generally below 3 feet in foot increments. Each AO can be unique, and the process is much simpler to create a depth grid for this zone of the same water depth. The water surface elevation is not necessary with AO Zones; therefore, it is not necessary to interpolate a water surface. The water depth in the AO zone can be found in the S\_FLD\_HAZ\_AR attribute table.

1. Use the "Extract by Mask" tool and the AO Flood Zone boundary created to create the water surface.

Extract by Mask		
nput raster		
dem_ft	•	2
nput raster or feature mask data		_
AO_Selection	-	2
Dutput raster		
C:\Users\ABerkow\Desktop\FEMA\HAZUS\DFIRM Depth Grid Exercise\DFIRM2\Step6B		2
OK Cancel Environments	Show He	elp >>

Figure 2-91: Extract by Mask tool

- 1.1 Navigate to Processing Extent within Environments.
- 1.2 Set the Snap Raster to the DEM.
- 1.3 Navigate to Raster Analysis within Environments.
- 1.4 Set the output cell size equal to the DEM.
- 1.5 Click "OK" to close the Environments tab.
- 1.6 Click "OK" to extract the water surface.



Figure 2-92: Results from Extract by Mask tool

 Open the Raster Calculator tool and enter the following expression: ([Raster from Step 6-B \* 0) + [Constant Water Depth]) to finish creating the depth grid. "Constant Water Depth" is two (2), but this value could also be one (1) in this example.

🔨 Raster Calculator		
Map Algebra expression		*
Layers and variables ▲ ♦ Step68 ♦ AHMosaic ♦ step5L ♦ Step5J ♦ step5d ♦ step5C ▼	$\begin{array}{c} 7 & 8 & 9 & 7 & = 1 \\ \hline 7 & 8 & 9 & 7 & = 1 \\ 4 & 5 & 6 & * & > > = 1 \\ 1 & 2 & 3 & - < < = ^{A} \\ 0 & . & + ( ) & \sim \end{array}$	Conditional A Co
(("Step6B"*0)+2) Output raster C: \Users\ABerkow\Desktop\FEMA\HA	ZUS\DFIRM Depth Grid Exercise\DFIRM2\Step6C	
	OK Cancel Environmen	ts Show Help >>

Figure 2-93: Raster Calculator

- 2.1 Navigate to Processing Extent within Environments.
- 2.2 Set the Snap Raster to the DEM.
- 2.3 Navigate to Raster Analysis within Environments.
- 2.4 Set the output cell size equal to the DEM.
- 2.5 Click "OK" to close the Environments tab.
- 2.6 Click "OK" to extract the water surface.



Figure 2-94: Raster water depth

3. There is only one AO Flood Zone in this exercise. There are multiple AO zones with different depths in many cases. A depth grid should be created for each separately.

#### 2.3.2.4 Create the Final Depth Grid

- 1. Use the "Mosaic to New Raster" tool to create the final DFIRM Depth Grid.
  - 1.1 Add the raster surfaces created in steps above.

Input Rasters	
	<b>_</b>
Sten6C	×
- Supec	
	1
Output Location	
C: \Users\ABerkow\Desktop\FEMA\HAZUS\DFIRM Depth Grid Exercise\DFIRM2	
Raster Dataset Name with Extension	
Final_DG	
Spatial Reference for Raster (optional)	
	· · · · · · · · · · · · · · · · · · ·
Pixel Type (ontional)	
8 BIT UNSIGNED	•
Cellsize (optional)	
2007 - D.D.	
Number of Bands	
	1
Mosaic Operator (optional)	
LACT	•
LAST	
Mosaic Colormap Mode (optional)	
Mosaic Colormap Mode (optional)	

Figure 2-95: Mosaic to New Raster tool

- 1.2 Change the Number of Bands to 1.
- 1.3 Navigate to Processing Extent within Environments.
- 1.4 Set the Snap Raster to the DEM.
- 1.5 Navigate to Raster Analysis within Environments.
- 1.6 Set the output cell size equal to the DEM.
- 1.7 Click "OK" to close the Environments tab.
- 1.8 Click "OK" to create the mosaic.



Figure 2-96: Final Depth Grid

# 3. Analyzing Flood Losses Using FEMA's Hazus Flood Model

Once the building inventory and flood depth grid are created, a site specific (structure by structure) flood analysis can be run through the Hazus flood model. Hazus can be used at an aggregated (census block) level or a site specific level. An aggregated approach uses an area weighting scheme to estimate losses on the built environment, assuming a uniform distribution of structures across the census block. Aggregated flood analyses can be appropriate for understanding regional flood risk as the nature of the analysis will over estimate losses in some areas, while underestimating in others. However, when smaller geographic areas need to be assessed or more accurate results are needed, the site specific approach, in all cases, should be favored over the aggregated loss estimation analyses. The site specific flood loss approach is much more accurate, estimating damages structure by structure instead of across an entire census block.



Figure 3-1: Displays one census block in Fargo, ND.

Hazus uses an area weighted approach to calculate the percentage of flooded area at each one-foot depth interval. The total losses sustained for this census block using the area weighted approach is \$3,325,000.



Figure 3-2: Illustrates the site specific analysis approach.

The buildings in yellow are inundated by the depth grid; the buildings in orange are not. Only eight structures would have actually been inundated due to the real 2009 event which is apparent in the site specific analysis, with losses totaling \$442,437 as opposed to over \$3.3M using the area weighted approach. The initial building valuations for this block based on local assessor's data are \$82,636,800 and \$41,980,000 based on Hazus building valuations; therefore, the overestimation based on the area weighted approach is more than an order of magnitude.

## 3.1. Importing Structural Data into the User Defined Facilities (UDF) Database using the Comprehensive Data Management System (CDMS)

This section will cover how to use CDMS to import UDF for a study region. This section will take roughly 45 minutes to complete. Users can use an old Access geodatabase (.mdb), a shapefile (.shp), or an old excel file (.xls).

To improve the fidelity of analysis, Hazus state geodatabase default data can be updated and enhanced with the Comprehensive Data Management System (CDMS) when known changes have occurred, such as accessor data for particular buildings after floods or when essential facilities like fire stations or Emergency Operation Centers (EOCs) have closed or opened. The example below shows how to add a User Defined Facilities (UDF) geodatabase with CDMS in Arapahoe County, Colorado. Once a database has been updated in CDMS, every newly created study region will have these UDFs; the old study regions will not show the newly updated data.

In recent versions of Hazus, users can import UDF points with a minimum of occupancy type, and CMDS will apply Hazus default attributes for the remaining fields.

#### 3.1.1. File Preparation

Place the Excel file with updated data (in this example, ArapahoeTest.xls) in the Hazus Data folder on the hard drive of the computer where the analysis is being conducted (in this example, the C:\HazusData\Regions\ folder).

Download the Colorado State data from the <u>FEMA Maps Service Center (MSC) Resources webpage</u> (<u>https://msc.fema.gov/portal/resources/hazus</u>), move the file to the C:\HazusData\Inventory\ folder and then unzip (double click the CO file and it will extract itself to the correct location) the folder onto the hard drive of the computer on which the analysis is being conducted (in this example, C:\HazusData\Inventory).

#### **3.1.2.** Specify State in CDMS

Specify the state where UDF information is being added.

1. Open "CDMS."



Figure 3-3: CDMS main page.

2. Click "Tools" in the menu options in the upper left-hand corner of the CDMS window and then click "Specify Hazus-MH Data Location" from the dropdown menu as shown in Figure 3-4.



Figure 3-4: Selecting "Specify Hazus-MH Data Location" from dropdown menu

3. The CDMS Statewide DB Configuration window will open.

/B Configuration	
Statewide Database	
Specify the Statewide DB folder that you want	to connect to:
Even le Maren de la	Browse
Example: \\server\sna	ret
	111
	Statewide Database Specify the Statewide DB folder that you want Example: \\server\sha

Figure 3-5: CDMS Statewide DB Configuration window.

4. Click "Browse" and then select the respective state from the HazusData folder in the browse window that opens (in this example, the State data for Colorado is selected).

Browse For Folder	$\times$
Select Folder	
OS (C:)	<u>^ </u>
> Apps	
> 🔄 b5d496c031af9191c300d68f019a	
> dell	_
> Drivers	
✓ 📙 HazusData	
HazardInput	
Inventory	
> AL	
CO	
> FL	
> 📙 Flood_Demo	~
Make New Folder OK Cancel	

Figure 3-6: Selecting the State from the Browse window.

5. Click "OK." This will change the Current State in the CDMS to Colorado, as shown below in the red box in Figure 3-7.

🤱 Comprehensive Data Management System (C	CDMS)						— C	x c
File Tools 🕜 Help								
<b>FEMA</b>	Compre	Welcom hensive	ne to the H Data Man	lazus-MH agement \$	System			
Please select one of the following:	CDMS	Repository	(Not yet transfe	erred into Statewide L	_ayers)			
Import into CDMS Repository from File			Category	Layer	Records	Upload Date	Uploaded E	y .
Import into CDMS Repository from Hazus-MH Study Region								
Building-Specific Data								
Query/Export Statewide Datasets						Transfer to S	tatowida Data	aat
Update Study Region with Hazus-MH Data						Tunaici to a	late wide bata	301
	Statewi	de Layer N	lodification I	(Or rep	nly last 10 updates are displayed ort on the right)	below. To view all reco	rds run the	
		State	Category	Layer	Records	Upload Date	Uploaded	Ву
Current State Colorado								
Exit CDMS								

Figure 3-7: Current State in CDMS has changed.

#### 3.1.3. Select Data for Import

Select the data to import into CDMS and tell CDMS what kind of data it is.

- 1. Click the "Import into CDMS Repository from File" button highlighted in the yellow box in Figure 3-7.
- 2. Then click "Browse" under "Select a file for Import".
- 3. Select the Excel file from the location on the computer's hard drive. In this example, the file "ArapahoeTest.xls" is located in the C:\HazusData\Regions\ folder (see Figure 3-8). In the dropdown menu in the bottom right, the user must select "Microsoft Excel file (\*.xls) to see the file.

🤱 Open File							×
← → ~ ↑ → T	his PC → OS (C:) → H	HazusData > Regions			✓ <sup>™</sup> Se	earch Regions	Q
Organize 🔻 New fol	der					≣== ▼ □□	0
Documents	Name		Date modified	Туре	Size		^
FL_Exercises	ArapahoeTest.	xls	5/21/2018 11:39 AM	Microsoft Excel 97	72 KB		
Notebooks	Hurr_Andrew		5/21/2018 9:21 AM	File folder			
Shared with Ever	SC_Hurr		5/18/2018 6:22 PM	File folder			
This DC	FL_Exercises		5/18/2018 4:17 PM	File folder			
This PC	El_Paso_2013		5/18/2018 10:11 AM	File folder			
3D Objects	Salt_Lake_City	FL	5/16/2018 12:55 PM	File folder			
E. Desktop	MecklenburgF	-L	5/15/2018 11:23 AM	File folder			ile.
Documents	LA_uni		5/8/2018 3:45 PM	File folder			
🖶 Downloads	info		5/8/2018 3:34 PM	File folder			
Music	New_Activity_	25	5/7/2018 12:02 PM	File folder			
Pictures	Raster.gdb		5/7/2018 10:53 AM	File folder			
Videos	New File Geod	latabase.gdb	5/7/2018 10:22 AM	File folder			
Videos	E_QuickLook		5/3/2018 4:17 PM	File folder			
<b>A</b> OS (C:)	Flood_Model_	Test	5/3/2018 3:44 PM	File folder			
Seagate Backup	SLC_UDF_Data	1	5/3/2018 12:06 PM	File folder			
- *	EnQuickLook		5/2/2018 3-51 PM	File folder			~
File	name: ArapahoeTest.x	ds			~ N	Aicrosoft Excel File (*.xls)	~
					N N E	/licrosoft Access/Geodataba /licrosoft Excel File (*.xls) SRI Shape File (*.shp)	se File (*.mdb)

Figure 3-8: Selecting updated Excel file to import.

4. Uncheck the Earthquake box and select "User Defined Facilities" from the Select Hazus-MH Inventory Category and Select Hazus-MH Inventory Dataset (Layer) dropdown menus.

🤰 Comprehensive Data Management Systen	n (CDMS) – $\Box$ X
File Tools 🔞 Help	
<b>FEMA</b>	Welcome to the Hazus-MH Comprehensive Data Management System
Please select one of the following:	Import into CDMS Repository
Import into CDMS Repository from File	Point O Line For Tsunami select both Earthquake and Flood Select a file for Import:
Import into CDMS Repository from Hazus-MH Study Region	C:\HazusData\Regions\ArapahoeTest.xls  Specify hazards importing data for. Earthquake Flood Hurricane Wind  Fields corresponding to the hazards selected will be displayed in the Field Matching options if available.
Building-Specific Data	If importing an excel document, please make sure the first row contains field names If importing a mdb file, please make sure file names have four (4) or more characters
Query/Export Statewide Datasets	Select Hazus-MH Inventory Category: User Defined Facilities
Current State Colorado	Select Hazus-MH Inventory Dataset (Layer): User Defined Facilities
🕘 Exit CDMS	Continue Continue

Figure 3-9: Options to select before the file is imported into CDMS.

5. Click "Continue," and the CDMS window should refresh.

🤰 Comprehensive Data Management Systen	n (CDMS) —		×
File Tools 🔞 Help			
<b>FEMA</b>	Welcome to the Hazus-MH Comprehensive Data Management System		
Please select one of the following:	Import into CDMS Repository		
Import into CDMS Repository from File	Input File Name: ArapahoeTest.xls Data Category: User Defined Facilities		
Import into CDMS Repository from Hazus-MH Study Region	Dataset Name: User Defined Facilities Data Import Type: Site Specific		
Building-Specific Data	Salact Import Table:		
Query/Export Statewide Datasets	Arapahoe_UDF_FL   ** The HAZUS-ID is the field t Hazus-MH to uniquely ident	tilized by	
	Select HAZUS-ID Field ** (if available):     analysis tasks. This field munique and must have the f       Select     ✓	tion and ust be prmat ric)	
	Additionally when transferin           Select Latitude (Y) Field:         Select Longitude (X) Field:           Select Latitude (Y) Field:         Select Longitude (X) Field:	g data, th source d n the alues	e ata
Current State	Select  V Select Contained in this field must required format (XX00000)	meet the or have	
Colorado	Please verify that data provided is in Geographic Coordinate System NAD 83.  Records not found in the st. database will be added and HAZUS-ID if an empty value which does not meet the re- format was provided.	atewide given a : or a valu quired	Je
- Exit CDMS	Continue 🐑 🟠	CDMS Ho	me

Figure 3-10: Options after the Excel file has been imported into CDMS.

- 6. Select the user defined facilities table of data for the import table. This data must be in WGS-84. From the "Select Import Table" drop-down menu, the only option is "Arapahoe \_UDF\_FL" because that is the only worksheet in the Excel file (see Figure 3-10). There would be more than one option in the drop-down menu if there were more sheets.
- 7. Select "No HAZUS ID" from the "Select HAZUS\_ID Field" drop-down menu (see Figure 3-11). The user will most frequently use the "No HAZUS ID option" unless the user has exported a Hazus dataset using the "Query/Export Statewide datasets" and only edited the information. When exporting from CDMS, all the Hazus fields are maintained and the data can be edited. The field names should not be changed. The Hazus ID field is what connects all the tables together, for example, the fire stations table is connected to a unique flood hazard table and a separate earthquake hazard table, which are all connected to the study region tables. Select "Latitude" from the "Select Latitude (Y) field" drop down menu and select "Longitude" from the "Select Longitude (X) field" drop down menu.

🤱 Comprehensive Data Management System	n (CDMS) — 🗆	×
File Tools 🔞 Help		
FEMA	Welcome to the Hazus-MH Comprehensive Data Management System	
Please select one of the following:	Import into CDMS Repository	
Import into CDMS Repository from File	Input File Name: ArapahoeTest.xIs Data Category: User Defined Facilities	
Import into CDMS Repository from Hazus-MH Study Region	Dataset Name: User Defined Facilities Data Import Type: Site Specific	
Building-Specific Data		
Query/Export Statewide Datasets	Arapahoe_UDF_FL   ** The HAZUS-ID is the field utilized by Hazus-MH to uniquely identify invent	y tory
	Select HAZUS-ID Field ** (if available):     data for performing aggregation and analysis tasks. This field must be unique and must have the format XX000000. (2 alpha 6 numeric)	
	Additionally when transfering data, the HAZUS-ID is used to match source or records to existing records in the statewide database. The values	he Jata
Current State	Languide contained in this field must meet the required format (XX000000) or have	
Colorado	Please verify that data provided is in Geographic Coordinate System NAD 83. Records not found in the statewide database will be added and given a HAZUS-ID if an empty value or a value which does not meet the required format was provided.	lue
- Exit CDMS	🗲 Back Continue 💇 🖾 CDMS H	ome

Figure 3-11: Selecting options in dropdown menus.

Note: Earlier versions of Hazus used the Geographical Coordinate System 1984 (GCS-1983) as its projection, Hazus 4.2 uses World Geodetic System 1984 (WGS-1984) as its new projection. In this example, the user is importing an Excel file, so the data does not have a projection associated with it. The user must know this information before importing it. Hazus will assume the Latitude and Longitude coordinates are already in WGS-1984. If the user chooses to import an incorrectly projected Access geodatabase (mdb) as the imported table and clicks "Continue," CDMS will inform the user that the table is not in the correct projection. To correct this, the user can project the geodatabase using ArcMap and place the projected data into the same MDB file by using the Feature Class to Feature Class tool. Many Access MDB files have multiple different tables, the user can open the table on the computer to explore the data and figure out which table would be best to import into Hazus through CDMS.

8. Click "Continue," and the CDMS window should refresh to display the Data Field Matching window.



Figure 3-12: Data Field Matching window.

#### 3.1.4. Matching Fields in the Datasets

Hazus does not automatically match all columns; the user must map the database columns to the respective Hazus fields.

- 1. In the "Source (from) Fields (click to select)" menu, select "BUPower."
- 2. In the "Destination (to) Fields (click to select)" menu, select "Back-up Power.
- 3. Click the "Add Match" button to confirm the column mapping.

🤱 Comprehensive Data Management System	(CDMS)								-		×
File Tools 🞯 Help											
<b>FEMA</b>	We Comprehen	elcome sive [	e to th Data M	ne Hazı Manage	us-N emer	1H nt System					
Please select one of the following:	Import into CDMS	Reposito	ory - Data	a Field Mat	ching						
Import into CDMS Repository from	Define Source(from	) and Des	tination (	to) Field Ma	tches -						
File	Source (from) Field	s			De	stination (to) Fie	ds (click to select)				
Import into CDMS Pepasitony from	(Click to select) BidoDamage	<b>^</b>	Field N	ame	Field	Туре	Field Length	Defa	ult Val	lue	^
Hazus-MH Study Region	BldgType		Back-up	Power	Yes/No	D					
	ContDamage		Content	t Replac	Mone	y		0			-
Building-Specific Data	ContentCos		Sholton	lumber Canacity	text	1	4				-
	DesignLeve	~	Census	Tract	text	1	1				-
Query/Export Statewide Datasets			BldgDa	mageFnId	Numb	er 1	0				~
Current State Colorado	Default building ar	d content re	LEGEND: Fie placement Match	Earthqua elds marked in costs will be p	ake GREEN rovided I	Flood Fi are required. A deb based on RS Means	Hurricane Wind elds marked in RED ar fault value will be prov s tables and building ar	e require ided if th ea wher	ed fields re field is a not pro	from the is not mat ovided by	user. Iched. User.
Input File Name: ArapahoeTest.mdb	Source	Destina	tion	Field Type	;	Field Length	Default Value	^			
Data Import Type: Site Specific	Address	Address		Text		40				Load	
Data Category: User Defined Facilities	Area	Area (So	q feet)	real		40		- 1			
Dataset Name: User Defined Facilities	City	City		text		40		-11		Save	
	Contact	Contact	nt	text		40		- 1			
	Cost	Building	Repl	Currency		-10	0	_	X	Remove	
	Name	Name		text		40					
	NumStories	Num Sto	ries	int		40	1	~	1		
- Exit CDMS					K	Back	Continue	2	<b>∆</b> ⊂	CDMS Ho	me

Figure 3-13: Matching fields in the datasets.

4. After adding the match, it will be listed with the other Field Matches at the bottom of the window.

🤱 Comprehensive Data Management System	(CDMS)									- 0	×
File Tools 🕜 Help											
<b>FEMA</b>	We Comprehen	elcom sive [	e to th Data M	ne Hazi Nanage	us-N emer	IH nt Syster	n				
Please select one of the following:	Import into CDMS I	Reposito	ory - Data	Field Mat	ching						
Import into CDMS Repository from	Define Source(from)	and Des	tination (	to) Field Ma	tches						
File	Source (from) Field	Source (from) Fields			De	stination (to) Fie	elds (click to	select)			
Import into CDMS Popository from	(Click to select) BidoDamage		Field N	ame	Field	Туре	Field Leng	yth	Defa	ult Value	^
Hazus-MH Study Region	BldgType		Content	Replac	Mone	у			0		_
	ContDamage ContentCos		PhoneN	lumber	text		14				_
Building-Specific Data	County DesignLeve		Shelter	Capacity	int		44				_
	FirstFloor	~	BldgDa	mageEnId	Numh	er	10				
Query/Export Statewide Datasets			ContDa	mageFnId	Numb	er	10				~
Current State Colorado	Default building an	d content re	LEGEND: Fie eplacement of Match	Earthqua elds marked in costs will be p	GREEN rovided I	Flood Flood are required. A de based on RS Mear	Hurrica Fields marked efault value wi ns tables and t	ane Wind in RED are r ill be provide building area	require ed if th a when	d fields from e field is not not provide	the user. matched. d by user.
	Field Matches										
Input File Name: ArapahoeTest.mdb	Source	Destina	tion	Field Type	•	Field Length	Defau	ılt Value	^		
Data Import Type: Site Specific	Name	Name		text		40			_	🔓 Loa	d
Data Category: User Defined Facilities	NumStories	NumSto	ries	int		40 5	1		-		
Dataset Name: User Defined Facilities	State	State	псу	text		2				🚽 Sav	e
	YearBuilt	Year Bu	ilt (Bet	Number		2			-		
	ZipCode	Zipeede		tout		10				X Rem	ove
	BUPower	Back-up	Powe	Yes/No							
									~		
- Exit CDMS					K	Back	Conti	inue 💟			Home

Figure 3-14: New match shown in Field Matches window.

5. Use the same process to add the following column mappings:

SOURCE (EROM) EIFLDS	DESTINATION (TO) FIELDS
SOONEE (I NOM) I IEEDS	DESTINATION (TO) TIEEDS
BLDGDAMAGE	BldgDamageFnld
CONTDAMAGE	ContDamageFnId
CONTENTCOS	Content Replacement Value
FIRSTFLOOR	First Floor Height
FLOODPROTE	FloodProtection
FOUNDATION	Flood Foundation Type
INVDAMAGEF	InvDamageFnld
PHONE	PhoneNumber
SHELTERCAP	ShelterCapacity

#### \_ . . . . . . . .

Note: In general, the user will have to map some of the fields. CDMS automatically matches fields with similar names but will not recognize all of them. After field mapping is complete, if the user has multiple files that they wish to import with the same field names, the user can create an FMP file, which can be

uploaded and used to match fields more quickly. To do this, after manually matching fields, the user would click the "Save" button. CDMS will bring up a file explorer window to save the FMP file. The user can name and place the file on their computer. When importing a new file through CDMS with the same field names, the user can click the "Load" button and browse and select the FMP file. When loaded, the FMP file will match the source and destination fields automatically.

- 🤰 Comprehensive Data Management System (CDMS) × File Tools 🕜 Help Welcome to the Hazus-MH FEMA Comprehensive Data Management System Please select one of the following: Import into CDMS Repository - Data Field Matching Define Source(from) and Destination (to) Field Matches Import into CDMS Repository from Source (from) Fields File Destination (to) Fields (click to select) (click to select) **Field Type Field Name** Field Length **Default Value** Import into CDMS Repository from BldgType Census Tract County text Hazus-MH Study Region DesignLeve OBJECTID\_1 **Building-Specific Data** ParcellD Query/Export Statewide Datasets LEGEND: Earthquake Flood Hurricane Wind Fields marked in RED are required fields from the user **Current State** Fields marked in GREEN are required. A default value w rill be provided if the field is not ma Default building and content replacen ent costs will be provided based on RS Means tables and building area when not provided by user Colorado + Add Match Field Matches Destination Field Length **Default Value** Source Field Type Input File Name: ArapahoeTest xls BUPower Back-up Powe... Yes/No Data Import Type: Site Specific 👍 Load BldgDamageF 10 BldgDamage Number Data Category: User Defined Facilities ContDamage ContDamageF Number 10 Dataset Name: User Defined Facilities 📕 Save ContentCos Content Repla... Money 0 FirstFloor First Floor Hei float 4 1 FloodProtection FloodProte int X Remove Flood Founda... 1 7 Foundation text InvDamageF InvDamageEnId Number 10 Exit CDMS Back CDMS Home Continue
- 6. After the source and destination columns are mapped, click "Continue."

Figure 3-15: Data Field Matching window after source and destination columns have been mapped.

Note: In this example, the UDF data only has values for the Flood field categories. The UDF database will populate the Earthquake values too, but they will be set to default values. There are available defaults for many Hazus fields. If the imported UDF dataset does not have values, they will be set to Hazus' predefined defaults, if they exist, which can be seen in the default value columns. The only required fields for a UDF import are Area (sq ft) and Occupancy.

7. CDMS will bring up a "Categorize Fields" window. Because CDMS doesn't always recognize the values or codes in the imported database, some values that are not numeric in nature, like "Area" or "Cost," may need to be specified. Click "OK."



Figure 3-16: Example of fields that are not numeric values and will need to be specified.

8. Verify that the value and description align, and then click "Continue" to confirm that "0" means "No" in the database.

	Management	System	(CDMS)	
ategory Value Ma	tching: Back-	up Pow	er (Yes or No)	
Source (click to s	elect)	Destin	ation (click to sele	ct)
Field Valu	e	Value	)	Description
		0		No
	- Marine	1		Yes
	- Add I	Match		
Matching Resu	÷ Add I	Match		
Matching Resu Source	Add I	Match ion	Description	Load
Matching Resu Source 0	Add I → Add I Destinat 0	Match ion	Description No	Load
Matching Resu Source 0	s → Add I  Its   Destinat  0	ion	Description No	Load
Matching Resu Source 0	Destinat 0	ion	Description No	Load Save X Remove
Matching Resu Source 0	Destinat 0	ion	Description No	Load Save Remove

Figure 3-17: Example of specifying value for Back-up Power.

9. Click "Continue" to confirm that "4" means "Basement/Yard" and "7" means "Slab on Grade." If the automatic matching is incorrect, the user can select the incorrect match and click the "Remove" button. This will remove the match from the "Matching Results" table and place the numbers back in the source and destination tables above. The user can then select the source field value and destination and click the "Add Match" button. This is similar to mapping table fields, but instead, the user is matching column values to their Hazus attributes.

gory Value Ma	atching : Flo	od Founda	ation Type			
urce (click to s	elect)	Destin	ation (click to se	elect)		1
Field Value		Valu	e	Des	cription	^
		1		Pile	ŝ.	
		2		Pier		
		3		Soli	d Wall	
		4		Bas	ement/Yard	
		5		Crav	wl Space	
Weiteren and State	TRANSPORT TO	6		Fill		
		7		Slat	on Grade	~
atching Resu	⇒ Ac	ld Match				2
Source	Destir	nation	Description	e	<b>A</b>	2
4	4		Basement/Y	ard	Load	
7	7		Slab on Gra	de		
					Save	2207
					X Remove	

Figure 3-18: Example of specifying value for Flood Foundation Type.

- 10. CDMS will then take a moment to process the selections for matching the imported columns and codes to the Hazus-expected format.
- 11. Click "OK."



Figure 3-19: CDMS import success message.

#### 3.1.5. Merging New Data with State Database

 View and edit the incoming information in the "CDMS Repository." This is a "holding tank" for data before importing it into a State Inventory folder. When satisfied that the data is correct, click "Transfer to Statewide Dataset."

🤰 Comprehensive Data Management System (	CDMS)						- 🗆	$\times$
File Tools 🛞 Help								
<b>FEMA</b>	N Comprehe	Velco ensive	me to the H Data Mana	azus-MH agement Sys	stem			
Please select one of the following:	CDMS Re	eposito	ry (Not yet transfe	rred into Statewide Layers	3)			
			Category	Layer	Records	Upload Date	Uploaded By	
Import into CDMS Repository from File	√iew/ Edit	Remove	User Defined Facilities	User Defined Facilities	100	3/20/2018	FACTOR\mglass	
Import into CDMS Repository from Hazus-MH Study Region								
Building-Specific Data								
Query/Export Statewide Datasets						Transforte	Statawida Datasat	
Update Study Region with Hazus-MH Data						Transfer to	statewide balaset	
	Statewide	e Layer	Modification H	(Only las report on	t 10 updates are display the right)	yed below. To view all rec	cords run the	
	St	ate	Category	Layer	Records	Upload Date	Uploaded By	
Current State Colorado								
🖑 Exit CDMS								

Figure 3-20: Example of CDMS Repository window.

2. A window with two transfer options will open: "Append/Update Data" or "Replace Data." Select "Append/Update Data" and Click "Submit." Append/Update means all the new data is going to be added and then any existing duplicated information is going to be updated based on the Hazus-ID value. The replace data option tells CDMS that wherever it finds a new record in a census tract, it is going to delete anything that is currently in the state database in that tract and replace it solely with the imported data (for that type of inventory). In this case, all previous UDFs would be left and new UDFs would be added or appended if the Hazus-ID was the same.

Comprehensive Da	ta Management System (CDMS)
	Statewide Data Transfer Options:
	Please select one of the options below:  Append / Update Data (all new data will be added and existing/duplicate information will be updated based on Hazus ID
4	<ul> <li>Replace Data         <ul> <li>(all existing data in the Statewide datasets with matching census tracts will be deleted and replaced with the current data being transferred.)</li> <li>* It is highly recommended to package the statewide dataset before selecting this option by going to Tools Menu.</li> </ul> </li> </ul>
	Submit Cancel

Figure 3-21: Statewide Data Transfer Options window.

3. Click "Yes" to confirm the transfer of UDF data to the State Database.



Figure 3-22: Pop-up window to confirm transfer to Statewide Datasets.

4. The UDF data transfer will appear in the "Statewide Layer Modification History."

🤰 Comprehensive Data Management System (C	DMS)						- 0	×
File Tools 🕜 Help								
<b>FEMA</b>	Compre	Welcome hensive D	to the Haz ata Manage	us-MH ement Syste	em			
Please select one of the following:	CDMS	Repository	(Not yet transferred in	to Statewide Layers)				
		Cat	egory Lay	er R	tecords	Upload Date	Uploaded By	
Import into CDMS Repository from File								
Import into CDMS Repository from Hazus-MH Study Region								
Building-Specific Data								
Query/Export Statewide Datasets								
Update Study Region with Hazus-MH Data						Transfer to Sta	atewide Datase	t
	Statewi	de Layer Mo	dification Histo	(Only last 10 report on the	updates are displayed right)	pelow. To view all record	ls run the	
		State	Category	Layer	Records	Upload Date	Uploaded By	_
	Remove	CO	User Defined Facilities	User Defined Facilities	100	3/20/2018	FACTOR\mgla	s
Current State								
Colorado								
🕛 Exit CDMS								

Figure 3-23: Example of UDF data transfer updating the modification history.

- 5. Clicking "Remove" in the "Statewide Layer Modification History" window will not remove the data from the State database but will only clear the user's "Modification History." Before the user can go to any new State database in CDMS in tools, the user must clear their "Modification History."
- 6. To delete added data or any data in a State database, click "Query/Export Statewide Datasets," find the data and delete or export it.

### 3.2. Build a Study Region

Build a Hazus flood study region for the tracts that intersect the user's depth grid.
 1.1 Aggregate at the census tract level.

Create New Region			×
Aggregation Level The aggregation level defines the procedure by which the study is defi	ined.		
You can define your study region at one of the geographic levels. We c aggregation level. Please select below the aggregation level you want f	all this the to use.		
C State			
C County			
Census tract			
C Census block			
C Community (NFIP)			
C Watershed			
	< Back	Next >	Cancel

Figure 3-24: Create new region and aggregate at the census tract level.

- 1.2 When the census tract ID screen appears, choose "show map."
- 2. Bring in the "flood\_extent" shapefile by clicking the "Add Data" (Top Left) button.



Figure 3-25: Add flood\_extent shapefile to map.

- 3. Use the "Select by Added Data" located on the bottom right of the window to select all the tracts that intersect the flood extent.
- 4. Choose "next" on the remaining screens and aggregate the study region.

## 3.3. Create a New Study Region

The updated UDF data will be inside a Hazus study region. To use the updated State data, a new study region must be created as old study regions will not be updated.

1. Open Hazus and select "Create a new region" from the start up window. Click "OK."



Figure 3-26: Creating a new region in Hazus.

- 2. Click "Next" on the "Create New Region" start page.
- 3. Insert a name and an optional description and click "Next.

Create New Region	×
Study Region Name Each study region needs to be identified with a unique name.	
Enter below a name which uniquely identifies your region. The name can be up to 18 characters long.	
Arapahoe_UDFs	
Pagian description (antional):	
Added UDFs to Arapahoe County in Colorado	
· · · · · · · · · · · · · · · · · · ·	
< Back	Next > Cancel

Figure 3-27: Insert name and description for new region study.

4. Check the appropriate hazard types for the new study region and click "Next." In this example, check the "Flood" box.

Create New Region	×
Hazard Type The hazard type controls the type and amount of data that will be aggregated. The hazard type selected affects the analysis options that will be available.	
Your study region can include one or more of the following hazards. Check below the hazard(s) you are interested in.  Earthquake  For Flood	
Tsunami	
Notes: 1. Selection of hazards listed above depends upon the hazard modules installed.	
<ol><li>Once a study region is built with a given hazard(s), it cannot be modified later on, in other words, you cannot add another hazard to it. Alternatively, you may re-create a similar region with different hazard(s).</li></ol>	
<ol> <li>If you are creating a Near Source only Tsunami region, please also check Earthquake checkbox.</li> </ol>	
< Back Next >	Cancel

Figure 3-28: Selecting hazard for new study region.

5. Select the appropriate aggregation level for the new study region and click "Next." In this example, select "County."

Create New Region	×
Aggregation Level The aggregation level defines the procedure by which the study is defined.	
You can define your study region at one of the geographic levels. We call this the aggregation level. Please select below the aggregation level you want to use.	
C State	
County	
C Census tract	
C Census block	
C Community (NFIP)	
C Watershed	
< Back Next >	Cancel

Figure 3-29: Selecting aggregation level for new study region.

6. Select the state or states for the new study region and click "Next." In this example, select "Colorado."

Create New Region			×
State Selection The state selection narrows down the l	ocation of the region to be crea	ated to specific state(s).	
Please select the state(s) for the study States (1 selected): Alabama (AL) Alaska (AK) American Samoa (TS Only) (AS) Arizona (AZ) Arkansas (AR) California (CA) Colorado (CO) Connecticut (C1) Delaware (DE) District of Columbia (DC) Florida (FL) Georgia (GA) Guam (TS Only) (GU)	region you want to create.		
		< Back Next >	Cancel

Figure 3-30: Selecting states for new study region.

7. Since county was selected in the aggregation level, select the appropriate county or counties and select "Next." In this example, select "Arapahoe."

Create New Region County Selection The county selection def region. Please select the county	ines the	county or counties t	within previou gion you wan	usly selected state(s), to include in the study
States: Colorado (CO)	^	Counties (1 select Adams Alamosa Arapahoe Archuleta Baca Bent Boulder Broomfield Chaffee Cheyenne Clear Creek	ted):	Select all counties Deselect all counties Show map
	*	Total: 1		Auto select all     Auto select all     Cancel

Figure 3-31: Selecting counties for the new study region.

8. Click "Finish."

## 3.4. Opening a Study Region

1. Select "Open a region" and click "OK."



Figure 3-32: Opening a region in Hazus.

2. Select the UDF study region created in Section 1.6 and click "Next." In this example, the new study region is "Arapahoe\_UDFs."

Open Region		×
Select Region The study region selectio	n sets the region that will be opened.	
Select the study region you to so far.	want to open from the list of study regions you h	ave created
Activity 15 Activity 15 Activity 18 Activity 19 Activity 20 Activity 20 Activity 21 Activity 22 Activity 23 Activity 25		Created            3/20/2018 1;            3/20/2018 1;            3/20/2018 1;            3/20/2018 1;            3/20/2018 1;            3/20/2018 1;            3/20/2018 3;            3/20/2018 3;            3/20/2018 3;            3/20/2018 3;            3/20/2018 3;            3/20/2018 3;            3/20/2018 3;            3/20/2018 3;            3/20/2018 4;
Arapahoe_UDFs	Added UDFs to Arapahoe County in Color	>
	< Back Next >	Cancel

Figure 3-33: Selecting a new study region.

- 3. Click "Finish." This will open an ArcMap document of the region.
- 4. Select "Inventory" in the top ribbon.
- 5. Click "User Defined Facilities" from the "Inventory" dropdown menu.



Figure 3-34: Inventory dropdown menu.

- 6. The UDFs added in CDMS will open and can now be used in Hazus analyses.
- 7. Click on the "Cost" column and click the "Map" button to display the UDF data in the study region.

## 3.5. Importing Depth Grid

The procedure outlined below will guide the user on how to import a user defined Depth Grid into the Hazus flood model.

1. Inside the study region, click "Hazard -> User Data." The "User Data" menu will now be visible. Click the "Depth Grid" tab.

User Data			
DEM	FIT	Depth Grid	HEC-RAS
Select depth gric	ls		
			Browse Remove Set Parameters
			OK Cancel

Figure 3-35: User Data dialog box.

2. Inside the "Depth Grid" tab, click "Browse" and navigate to the depth grid representing the desired flood hazard. It is important that the depth grid is in "Esri Grid" format. Once the depth grid is imported, it will be visible in the "Select depth grids" menu. Click "Set Parameters."

U	er Data	
	DEM FIT Depth Grid HEC-RAS	
	Select depth grids	
i.	Riverine	
L	C:\Austen\SLC\Final\dg_final3	
L	Remove	
L	Set	
L	Parameters	
L		
L		
L		
L		
	OK Cancel	

Figure 3-36: Browse to add depth grid.
3. Inside the "Set Parameters" menu, indicate the vertical units of the depth grid under the "Units" dropdown. The "Return Period" textbox is optional, however, adding a return period here will help identify results when multiple scenarios have been created in the Hazus study region. Click "OK" in the "Set Parameters" menu. Click "OK" in the "User Data" menu. Hazus will now start processing the user defined depth grid.

User Data				
DEM	FIT	Depth Grid	HEC-RAS	
Select depth grid:	s Depth grid parameters Uni Return perio (optiona	ts: Feet Id: 0K	▼ Cancel	wvse move Set ameters
			ОК	Cancel

Figure 3-37: Set Parameters for the depth grid.

Now that User Defined Facilities and depth grid have been imported, proceed with defining a new scenario, Delineating Floodplain, and running the User Defined Structures analysis within the Hazus study region.

### 3.6. Dasymetric General Building Stock Processing

This section will take roughly five (5) minutes per 1,000 records for importing and ten (10) minutes per 1,000 records for analysis. The above estimates are based on the minimum required Hazus setup. Results are subject to changes depending on user CPU, memory allocation, etc.

1. Create a new study region.

Note: The selected region will use the "Dasymetric" data by default as shown in Figure 3-38.

Create New Region			×
Study Region Name Each study region needs to be identified with a unique name.		-	K
Enter below a name which uniquely identifies your region. The name of characters long.	can be up to 18		
Arapahoe			
People description (optional):			
Dasymetric	^		
	~		
	< Back	Next > Cancel	

Figure 3-38: Create new study region.

2. Select "Flood" then select "Next."

Create New Region	×
Hazard Type The hazard type controls the type and amount of data that will be aggregated. The hazard type affects the analysis options that will be available.	selected
Your study region can include one or more of the following hazards. Check below the hazard(s) you are interested in.	
☐ Earthquake	
I Flood	
☐ Hurricane	
Tsunami	
Notes: 1. Selection of hazards listed above depends upon the hazard modules installed.	
<ol><li>Once a study region is built with a given hazard(s), it cannot be modified later on, in other words, you cannot add another hazard to it. Alternatively, you may re-create a similar region with different hazard(s).</li></ol>	
<ol><li>If you are creating a Near Source only Tsunami region, please also check Earthquake checkbox.</li></ol>	
< Back Next	> Cancel

Figure 3-39: Select Flood as the hazard type.

3. Select preferred County.

Create New Region County Selection The county selection defi region.	ines the	county or counties v	vithin previou	usly selected state(s), to include in the study	×
Please select the county States: Colorado (CO)	or cour	ties for the study reg Counties (1 select Adams	ed):	t to create. Select all counties	
		Alamosa Archuleta Baca Bent Boulder Broomfield Chaffee Cheyenne Clear Creek	~	Deselect all counties Show map	
	~	Total: 1		Auto select all	

Figure 3-40: Select the county of interest.

	ID ID	Name	Address	City	State	Zipl
1	US000001	]	7696 S MONA CIR E	Centennial	CO	80112
2	US00002		7694 S MONA CIR E	Centennial	CO	80112
3	US000003		7552 S MONA WAY	Centennial	CO	80112
4	US000004		7700 S MONA CIR E	Centennial	CO	80112
5	US00005		7698 S MONA CIR E	Centennial	CO	80112
6	US00006		7702 S MONA CIR E	Centennial	CO	80112
7	US00007		7664 S OLIVE CIR	Centennial	CO	80112
8	US00008		7725 E KETTLE PL	Centennial	CO	80112
9	US000009		7779 E MINERAL DF	Centennial	CO	80112
10	US000010		7708 E LONG PL -2	Centennial	CO	80112
11	US000011		7704 E KETTLE CT	Centennial	CO	80112
12	US000012		7703 E KETTLE CT	Centennial	CO	80112
13	US000013		9828 E MAPLEW001	Englewood	CO	80111
14	US000014		9858 E MAPLEW001	Englewood	CO	80111
15	US000015		9719 E PINEWOOD /	Englewood	CO	80111
16	US000016		9801 E PINEW00D /	Englewood	CO	80111
17	US000017		9899 E FAIR LN -562	Englewood	CO	80111
18	US000018		9864 E MAPLEW00	Englewood	CO	80111
19	US000019		9862 E MAPLEW00	Englewood	CO	80111
20	US000020		6073 S EMPORIA CT	Englewood	CO	80111
21	US000021		9862 E PINEWOOD /	Englewood	CO	80111
22	US000022		9988 E MAPLEW00	Englewood	CO	80111
23	US000023		10155 E FAIR CIR -5	Englewood	CO	80111
24	US000024		6244 S ELMIRA CIR	Englewood	CO	80111
25	US000025		9729 E PINEWOOD /	Englewood	CO	80111
26	US000026		10040 E MAPLEW00	Englewood	CO	80111
27	US000027		9866 E MAPLEW001	Enalewood	CO	80111

4. Open "Study Region," Go to "Inventory->User Defined Facilities" and Import the point data.

Figure 3-41: Import user defined facilities.

- 5. Go to "Hazard->User Data" in the ribbon, then in the "Choose a Riverine depth grid..." window, select "quickdepth."
- 6. Set the depth grid parameters in the "Set Parameters" window and click "OK," then "OK" again to process.
- 7. Go to "Hazard->Scenario->New" in the ribbon. Under the "Create New Scenario" window, name the scenario.
- 8. Select "Depth Grid" on the map, click "Save selection," and click "OK."

File	New Connector	Analysi
7 6	INew Scenario	🕁 -
•	Select map features to be included in the scenario. Asingle scenario may	
Table C	contain more than one object type.	Ţ
%: U	Map layer type	
• 🗲	<ul> <li>River reaches</li> </ul>	
	<ul> <li>Coastal shorelines</li> </ul>	CO1\Us
	○ FIT analysis areas	
	User-defined depth grids	
	Map layer selection	
	Add to selection +	
	Remove from selection -	
	Clearselection	
	Save selection	
	OK Cancel	

Figure 3-42: Select the depth grid.

9. Go to "Hazard->Riverine" and Click "Delineate Floodplain."

File Edit View Inventory	Hazard Analysis Results Bo	okmarks Insert Selection Geoprocessing Cus
i 🎢 🌰 🖶 😂 i % 🛞 🛍 🦻	Flood Hazard Type	
i 🔍 🔍 💇 🥝 i 💥 😒 i 🖛 i	User Data	M 🛍 🕺 💿 💽 🚽
Table Of Contents	Develop Stream Network	
🗽 📮 🐟 📮 📴	Scenario	•
🗉 🎒 Layers	Riverine	Hydrology
DGRiv	Coastal	<ul> <li>Delineate Floodplain</li> </ul>
🖂 🖂 UserData	Quick Analysis	Level Delineate Floodplain
Depth Grid		Veloc Delineate Floodolain
UDS:hzUserDefinedFlty	·	Flow
UDS:hzUserDefinedF	lty	
Census Blocks		
Census Blocks		
- FR Communities		

Figure 3-43: Delineate Floodplain.

10. Click "OK" to "Hydraulic Analysis."

	Riverine Hydra	aulic Analysis			×
1	Analysis type:	Single Return Per	riod	~	Fill Down
ł	Output cell size:	20		~	
	Riverine depth grid	ds			
1	DG ID P	eriod(s) to Analyze	Available Periods	Path	^
9	1 10	)0	100	DG00_qi	
E					~
				ОК	Cancel

Figure 3-44: Run Hydraulic Analysis.

- 11. Click "Yes" to process.
- 12. Go to "Analysis," click "Run."

File Edit View Inventory Hazard	Analysis	Results	Bookmarks	Insert	Selection (
🖓 🏈 🖬 🖨 % 🗿 🖀 🗙 🔊 q	Dam	age Funct	ions	•	🖂 🧊 🐻 🛛
🔍 🔍 🖑 🎱 💥 🖓 🔶 🕬 -	Rest	pration Fu	nctions	•	0
Table Of Contents	Para	meters		•	
S: 📮 🐟 🖳 🗄	Floo	d Warning	J	1	
E SLayers	Aver	age Annu	alized Loss	3	L
🖃 🧊 C:\HazusData\Regions\Arapaho	Com	bined Wir	nd and Flood		L
🖃 🖶 SelectedData	Quic	k Analysis			
	Run				
😑 둼 Hydrology			Run		
□ I BoundaryPolygon			Calculate	Loss	
🖃 🔚 C:\HazusData\Regions\Arapahoe	eCO1\scena		1		



- 13. In the "Analysis Options" window, check "General Building Stock Damage and Loss," "User Defined Structures" and Click "OK."
- 14. Go to "Results->View Current Scenario Results."

lysis	Results	Bookmarks	; Insert	Selection	Geoprocessing
• • [	Vie	w Current Sc	enario Res	ults By	5 🖸 🐎
R	Flo	od Hazard V	iew Curre	nt Scenario	Results By
Ψ×	Ge	neral Build	Select Reti	urn Period to	Report on
	Co	mbined W			
	Ess	ential Faciliti	es		1
scen	Use	er Defined Fa	cilities		
	Ad	vanced Build	ing Analys	is	
	Tra	nsportation S	Systems		
	Uti	lity Systems			L
	Ag	ricultural Pro	ducts		
scena	Veł	nicles			
	De	bris			
	Ca	sualties			•
	She	elter			
	Ind	lirect Econon	nic Loss		
	Qu	ick Analysis I	Report		
Userl	Sur	mmary Repo	rts		

Figure 3-46: View Current Scenario Results.

- 15. In the "View Results by" window, select the "Available Results" and Click "OK."
- 16. Go to "General Building Stock->Economic Loss," Select "By Full Replacement."



Figure 3-47: View General Building Stock results.

17. View "Results by Census block."

18. Go to "General Building Stock," select "User Defined Facilities."



Figure 3-48: View User Defined Facilities results.

19. View "User Defined Facilities Loss" results for respective scenario.

# 4. User Defined Facilities Flood Loss Results

Once Hazus has completed the User Defined Facilities analysis, the results generated by the analysis will be placed in separate database tables within the unique Hazus database structure. Consequently, UDF results generated by Hazus will not contain attributes native to the original UDF dataset imported into Hazus. Changing the Hazus results back to the original imported UDF dataset is often necessary for visualization purposes but not always needed. The process of joining the Hazus UDF results to the original UDF data set is summarized below.

### 4.1. Viewing and Mapping Results

 Inside the Hazus study region, Click "Results" --> View "Current Scenario Results By..." Under "Available Results" select either the default (only one scenario within the study region has been defined) or another set of results. The names given to the "Available Results" reflects the optional input return period text box described in the previous section.

View Results by	J
Scenario Name:	
SLC_test	
Scenario Description:	
	-
Available Results:	
100 -	·
What-If Options:	

Figure 4-1: View results by window

 Inside the Hazus study region, Click "Results" --> "User Defined Facilities." Click the "UserDefinedFltyID" field to highlight the column and then click "Map." Hazus will now map the User Defined Facilities results.

nesults for Scenario: SI	_C_test				Return period: 1
	UserDefinedFltvld	FacilityName	OccupancyClass	ControllingHazard	BidaDmaPct
1	US000210	1	RES1	R	41.59
2	US000213		RES1	R	47.12
3	US000219		RES1	R	29.92
4	US000496		COM2	R	1.67
5	US000558		IND2	R	0.31
6	US000559		COM2	R	1.67
7	US000667		IND2	R	0.95
8	US000668		COM4	R	8.38
9	US000669		COM4	R	8.38
10	US000673		COM4	R	2.70
11	US000691		IND2	R	2.78
12	US000692		IND2	R	0.36
13	US000693		COM4	R	1.63
14	US000694		COM2	R	0.78
15	US000695		COM2	R	0.78
16	US000696		RES1	R	2.40
17	US000697		RES1	R	2.40
18	US000698		RES1	R	2.40
19	US000702		COM3	R	0.00
20	US000704		COM2	R	0.00
21	US000705		COM2	R	0.00
22	US000706		COM2	R	0.00
	UC000707		COMP	In .	0.00

Figure 4-2: User defined facilities loss window

3. Open the attribute table of the UDF results layer by right-clicking the "UserDefinedFlty" layer in the Hazus/ArcMap table of contents and clicking "Open Attribute Table." Scroll to the right, to the end of the table, to find individual building flood loss values.

Note: Listed below are the five main Hazus result output attributes in the "UserDefinedFlty" table.

- **BldgDmgPct** Percent building damage to individual structure.
- **BldgLossUSD** Building loss in US Dollars.
- **ContDmgPct** Percent content damage to individual structure.
- ContentLossUSD Building Content loss in US Dollars.
- InventoryLossUSD Total loss (Building + Content losses).

BldgDmgPct	BldgLossUSD	ContDmgPct	ContentLossUSD	InventoryLossUSD
41.59082	78068.048681	60	56311.5	0
47.122069	41137.566237	41.944335	18308.702228	0
29.915525	36437.408605	23.09863	14067.181163	0
1.66992	4326.635186	7.341792	18621.941483	22852.625557
0.310547	29125.047895	0	0	0
1.66992	4326.635186	7.341792	18621.941483	22852.625557
0.953125	14768.185781	0	0	0
8.376464	50491.565935	13.335936	80386.221661	0
8.376464	50491.565935	13.335936	80386.221661	0
2.703125	16122.329531	3.25	19384.0725	0
2.781248	27322.034728	2.003904	29528.507353	3062.155773
0.356445	2662.975644	0	0	0
1.63086	2675.637842	1.63086	2675.63842	0
0.78369	622.837628	5.037594	4003.627832	5047.512883
0.78369	622.837628	5.037594	4003.627832	5047.512883
2.400882	27921.225281	1.746096	10153.172829	0
2.400882	27921.225281	1.746096	10153.172829	0
2.400882	27921.225281	1.746096	10153.172829	0
0	0	0.4	1325.672	0
0	0	0.3	1661.206	2213.608
0	0	0.3	1661.206	2213.608
0	0	0.3	1661.206	2213.608
0	0	0.3	1661.206	2213.608
0	0	0.3	1661.206	2213.608
0	0	0.3	1661.206	2213.608
0	0	0.3	1661.206	2213.608
0	0	0.3	1661.206	2213.608
0.753418	3300.7996	0	0	0

Table 4-1: Five main Hazus Result Output Attributes

Notice that many attributes native to the original User Defined Facilities building inventory dataset do not exist in the resulting output table. Depending on the users desired end result, often times attributes contained in the original dataset are needed for visualization purposes. The following section will demonstrate the process involved with joining the Hazus UDF results back to the original input UDF dataset.

## 4.2. Joining Hazus UDF Results to Source Data

 Using the "ArcCatalog" tab inside Hazus/ArcMap, Double click "Add Database Connection" located under the "Database Connections" folder. In the "Database Connection" dialog, select "SQL Server" for database platform, "Localhost\HAZUSPLUSSRVR" for instance, and "Database Authentication" for authentication type. To get the user name and password, open the "settings.xml" file in the "<<LocalInstall>>\Program Files (x86)\Hazus-MH" directory with a text editor and search for UserID and Password tags. Select the Hazus study region from the drop-down menu and click "OK."



Figure 4-3: Catalog and database link properties

Database Connection	ł	×
Database Platform:	SQL Server	~
Instance:	localhost\HAZUSPLUSS	RVR
Authentication Type:	Database authenticatio	n ~
	User name:	hazuspuser
	Password:	•••••
	Save user name and	d password
Database:	Arapahoe	~
About Database Connections		OK Cancel

Figure 4-4: Database connection properties

 Under the "ArcCatalog" tab in Hazus/ArcMap, expand the newly created database connection in order to display the Hazus data tables. Find "dbo.absv\_FRUserDefinedFlty" and "dbo.hzUserDefinedFlty" from the list of tables and add the tables to Hazus/ArcMap.

- 3. Notice that both tables added to the Hazus/ArcMap instance have a field titled "UserDefinedFltyId." Perform a tabular join in ArcMap to join the tables using the "UserDefinedFltyId" field. Also notice, contained in the "dbo.hzUserDefinedFlty" table is the "Comment" field, created in the development of the original UDF feature class.
- 4. Once the combination in the previous step has been performed, export the newly joined table.
- 5. After the export in the previous step has been completed, join the exported table to the original UDF feature class using the "UserDefinedFltyId" Field. The Hazus UDF analysis results are now contained in the original UDF feature class.

## 4.3. Installing and Using the Hazus Export Tool

This section will guide the user in the installation and use of the Hazus Export tool to export Hazus results. The steps outlined assume the user has completed a scenario and has the scenario open in a Hazus session and is ready to install the tool and export the results.

The Hazus Export tool is composed of a Python script and an ArcToolbox (.tbx) file that, once installed, will be located in the Hazus program files directory (\Hazus-MH\BIN\Tools) on the computer's hard drive (in this example, the toolbox file and Python script are located in C:\Program Files (x86)\Hazus-MH\BIN\Tools).

 Install the Hazus Export Tool. In the Hazus interface, open ArcCatalog by clicking the ArcToolbox icon or selecting "Geoprocessing" from the toolbar options and then "ArcToolbox" from the drop-down menu.



Figure 4-5: Open the ArcToolbox from within ArcMap.

2. In the ArcCatalog window, right click on "ArcToolbox" and select "Add Toolbox."



Figure 4-6: In the ArcCatalog window, right click on "ArcToolbox" and select "Add Toolbox."

- Navigate to the Hazus-MH folder where the tool is located (in this example, C:\Program Files (x86)\Hazus-MH\BIN\Tools), select "Hazus\_Export.tbx," and click "Open." The tool is now installed and ready to use.
- 4. To use the Hazus Export tool, a folder named "ExportResults" will be needed in the HazusData directory (in this example, the HazusData directory is located on the C:\ drive, under C:\HazusData). Create this folder using Windows File Explorer if it does not already exist.
- 5. In ArcCatalog, expand the "Hazus\_Export" toolbox and double-click the "Hazus\_Export" script to start the tool.



Figure 4-7: Start the Hazus Export tool.

- 6. In the Hazus\_Export dialog, click the folder button next to the "Export Folder" textbox to open the file browsing window. Select the "ExportResults" file created in step 1 above (in this example, C:\HazusData\ExportResults folder). In the Hazus Study Region Name textbox, type the Hazus activity name exactly as it appears in the title bar of the Hazus application. In this example, our activity name is "Activity6\_results." Click "OK" to continue.
- 7. This will create a geodatabase file with the activity name inside the "ExportResults" folder (in this example, C:\HazusData\ExportResults\Activity6\_results).
- 8. Browse the layers of the created geodatabase (in this example, Activity6\_results.gdb) in ArcMap. The feature layers are stored in seven feature datasets:
  - AEBM\_UDF (Advanced Engineering Building Module User-Defined Facilities)
  - Essential\_Facilities
  - General\_Building\_Stock
  - High\_Potential\_Loss\_Facilities
  - Study\_Region\_Base\_Data
  - Transportation
  - Utilties



Figure 4-8: Browse the exported results in the geodatabase using ArcCatalog.

#### 4.4. Export Results to a Geodatabase

- Please refer to the section "Installing and Using the Hazus Export Tool" to export the analysis results to a geodatabase. The remainder of this section assumes all results are residing in a subfolder in C:\HazusData\ExportResults.
- Open the Hazus application and the region for the desired results to view. Browse to the geodatabase in ArcCatalog where the results are exported. In this example, this is C:\HazusData\ExportResults.

### 4.5. Export Geodatabase Layer to Shapefile

1. Add the "GBSFullRepDirectEconLoss" layer to the map window.

Note: This layer includes all Census Blocks left-joined to the analysis results. The Census blocks with modeled damage is all that is needed. Select "Selection >> Select by Attributes" to do this. Scroll through the fields and add the one ending "\_TotalLoss" so the text box below the WHERE clause looks as follows (greater than 0):



Figure 4-9: Add GBSFullRepDirectEconLoss layer to map window.

Layer:		GBSFu Only sho	IIRepDirectEcor	nLoss ers in this list	
Method:	Cre	eate a ne	ew selection		~
fullecon_ fullecon_ fullecon_ fullecon_	Full2_0 Full2_1 Full2_E Full2_0	CensusB FotalLoss BuildingL Contents	lock s oss Loss		* *
-	<>	Like	NULL		^
>	> =	And	0		
<	< =	Or	2		
_ %	()	Not	6		~
ls	In	Null	Get Unique Va	alues Go To:	
ELECT	FROM	GBSFul	RepDirectEconL	oss WHERE:	
ullecon_F	ull2_T	otalLoss	>0		^
Clear		Verify	Help	Load	Save
Clear		Verify	Help	Load	Save

Figure 4-10: Add "\_Total Loss" below "WHERE" clause.

- 1.1 Click "OK" and only records with losses will be selected.
- 1.2 Right-click on the layer and select "Data >> Export Data."

dayers		Lange Proto
<ul> <li>GBSFullRenDr</li> <li>Boundary X</li> </ul>	Copy Remove	
	Open Attribute Table Joins and Relates	
absv_FRG Totall ○ 0.00 t	Zoom To Layer Zoom To Make Visible Visible Scale Range	
221.00 547.00	Use Symbol Levels Selection	
□ 2299.0 □ RPD500_r Value	Label Features Edit Features	
Low : ( Sa	Convert Labels to Annotation Convert Features to Graphics Convert Symbology to Representation	
ChosenR	Data	Repair Data Source
🗉 🗌 Reaches 🔶	Save As Layer File Create Layer Package	Export Data
🖃 🗌 RegionDE 🚁	Properties	Make Permanent Save this laver's data as a shanefil
High : 2547.	78	View Item Description or geodatabase feature class

Figure 4-11: Export Data.

 Ensure "Selected features" is selected in the drop-down in the next dialog and browse to the C:\HazusData\ExportResults folder, choosing Shapefile as "Save as type:" and specifying "TotalLosses.shp" as the name of the file.



Figure 4-12: Saving file as "TotalLosses.shp."

2.1 Click "OK" and the shapefile will be created.

Note: any number of shapefiles may be exported to a chosen folder using the "Feature Class to Shapefile (Conversion)" tool in ArcCatalog.

Note: It is possible to bring in the exported data to verify it contains only the Census blocks with total losses > 0.

### 4.6. Displaying in Online GIS Viewer

This section will guide the user in displaying the Hazus analysis results in an online GIS Web Viewer, ArcGIS Online. The steps generally include setting up an ArcGIS Public account (if not already done), selecting layers for inclusion in the map, uploading the layers, styling the map and sharing it with others. Additionally, this section includes steps for sharing a map package file containing the map document and layers directly from ArcGIS to ArcGIS Online.

- 1. Create an ArcGIS Public account on the ArcGIS website.
- 2. Use femadata.com to request a user account for the FEMA GeoPlatform.

This will help create a basic map with the content of the analysis results as well as a base layer (e.g., satellite imagery, streets, terrain).

#### 4.6.1 Compress the Shapefile

1. Navigate to the location of the exported shapefile in Windows Explorer.

 Select all of the "TotalLosses" files making up the shapefile (The file extension will likely be cpg, dbf, prj, sbn, sbx, shp, shp.xml and shx). Right-click and select "Send to >> Compressed (zipped) folder." Accept the file name, "TotalLosses.zip."

Clipboard	Organize	New	Open	Select	
🖌 📙 > This PC > OS	(C:) > HazusData > ExportResults				~ Č
ents 刘	Name	Date modified	Туре	Size	
2 - 2 - <sup>2</sup>	Activity6_results.gdb	4/16/2018 3:09 PM	File folder		
b_results	Activity29_Import.gdb	4/16/2018 3:51 PM	File folder		
~	TotalLosses.cpg	4/16/2018 3:50 PM	CPG File	1 KB	
portSteps	TotalLosses.dbf	4/16/2018 3:50 PM	DBF File	24 KB	
nlineGISViewer	TotalLosses.prj	4/16/2018 3:50 PM	PRJ File	1 KB	
	TotalLosses.sbn	4/16/2018 3:50 PM	SBN File	1 KB	
	TotalLosses.sbx	4/16/2018 3:50 PM	SBX File	1 KB	
	TotalLosses.shp	4/16/2018 3:50 PM	SHP File	128 KB	
	TotalLosses.shp.xml	4/16/2018 3:50 PM	XML Document	1 KB	
- FACTOR	TotalLosses.shx	4/16/2018 3:50 PM	SHX File	1 KB	
		7-Zip		>	
ete		CRC SHA		>	
cts		📓 Edit with Note	pad++		
		🚼 Scan with Wir	dows Defender		
ents		🖻 Share			
ads		🙀 WinMerge			
	8 Bluetooth device	Send to		>	
	Compressed (zipped) folder	Cut			
	Desktop (create shortcut)	Conv			
	Documents				
ems selected 152 KB	Fax recipient	Create shortco	ıt		
	Mail recipient	Delete			
	TeamViewer	Rename			
	My Passport (D:)	Properties			

Figure 4-13: Send all "TotalLosses" to compressed folder.

#### 4.6.2 Navigate to ArcGIS Online

- 1. Open a browser and navigate to <u>ArcGIS Online</u>.
- 2. Sign in with user credentials by clicking "Sign In" in the upper right-hand corner of the page.
- 3. Click the header "Content" and then click the newly created map package ("Arapahoe" in this example).
- 4. There are four options on the right-hand side of the page:
  - 4.1 "Open in ArcGIS Desktop" and "Download" both of these options will download the .mpk file (i.e., to the Downloads folder). Double-clicking on this file will open the package in ArcGIS and display all of the layers.
  - 4.2 "Update" this option enables a user to manually update a map package by uploading another .mpk file.
  - 4.3 "Share" change the sharing settings (visible to everyone or made available to select ArcGIS Online groups).
- 5. Click "Open in ArcGIS Desktop" and double-click the downloaded file to open and view the map package in ArcMap. Verify that the map and data are what was exported from the region.

Note: without an ArcGIS Online for Organizations subscription, it is not possible to publish directly to ArcGIS Online and have the layers/data viewable through a browser. Explore an ArcGIS Online for Organizations subscription or purchasing ArcGIS Server if this functionality is required.

### 4.6.3 Upload the Shapefile to ArcGIS.com and Create a Map

1. Select "Add" and choose "Add Layer from File" on the map page.



Figure 4-14: Uploading the Shapefile to ArcGIS.com and creating map.

2. Click the "Choose File" button in the next window and navigate to the "TotalLosses.zip" file created earlier (C:\HazusData\ExportResults\TotalLosses.zip). Specify "Keep original features" to keep the features with all of the shapepoints (this will not generalize the features' geometry).

Add Layer from File	)
Locate the file you want to import.	
<ul> <li>Shapefile (ZIP archive containing all shapefile files)</li> <li>CSV or TXT files with optional address, place or coordinate locations (comma, semi-colon or tab delimited)</li> <li>GPX (GPS Exchange Format)</li> <li>GeoJSON (open standard format for simple geographical features)</li> </ul>	
File: Choose File TotalLosses.zip	
<ul> <li>Generalize features for web display</li> <li>Keep original features</li> </ul>	
IMPORT LAYER CANCEL	

Figure 4-15: Keeping original features.

3. Click the "Import Layer" button.

Note: A limitation of ArcMap needs to be discussed here; ArcMap is not able to display long field names (more than 10 characters). As a result, the exported field names are renamed fullecon\_1, fullecon\_2, etc. In this example, we know that the TotalLoss field corresponds to fullecon\_4, but in specific cases, renaming the fields before exporting the shapefile could be done. Go to the <u>ArcGIS</u> renaming shapefile website for more information.

Note: It is possible to specify the style of map to display at this point. There are numerous ways to display single layer, but use "Counts and Amounts (Color)" for the purposes of this exercise.



Figure 4-16: Creating map.

- 4. Click "Done" and the map is created.
  - 4.1 There are several options to experiment with, including addition of other layers, changing the basemap, adding bookmarks, etc. These are beyond the scope of this document. Please reference ArcGIS.com help for information on how to customize this map further.
  - 4.2 The map must be saved before sharing it with others.
- 5. Click "Save" on the toolbar, then give the map an appropriate title, tags and summary and click "Save Map."

Title:	Flood Model Results	
Tags:	Hazus x FloodModel x	
	Add tag(s)	
Summary:	Charlotte Flood Model Exercise Results	
Save in folder:	Laboratory	

Figure 4-17: Saving map.

#### 4.6.4 Sharing the Map

The map has now been saved and can be shared with others via URL or as a Map Package.

#### 4.6.4.1 Sharing the Map via URL

- 1. Click "Share" on the map toolbar and check the box next to "Everyone (public)" to allow anyone with the link to view the map.
- 2. Copy the url and paste in an email to allow recipients to view the content.

Note: The recipient must have a public ArcGIS.com account to view the content. There is an additional method for sharing GIS data created by Hazus with others via ArcGIS Online. This involves the creation of a portable map package (.mpk) file that includes the map document and data referenced by the layers it contains. This map package file is uploaded directly to ArcGIS Online, where it can be downloaded by others and referenced in ArcMap.

#### 4.6.4.2 Sharing as a Map Package

1. Select "File," then "Share As" then "Map Package" to bring up the Map Package dialog.



Figure 4-18: Share as Map Package.

 Select the "Map Package" tab, make sure the "Upload package to my ArcGIS Online Account" option is selected and name it appropriately. In this example, we will name the map package, "Arapahoe." Make sure that the option "Include Enterprise Geodatabase data instead of referencing the data" is unchecked. This option would attempt to reference the data published by the user's organization rather than the locally referenced data.

ap Package		
	🖌 Analyze 🛛 🙀 Share	0
Map Package	Map Package	
Additional Files	Upload package to my ArcGIS Online account	
Sharing	Arapahoe	
	Save package to file C:\HazusData\Regions\Arapahoe\hazusFl.mpk	
	Include Enterprise Geodatabase data instead of referencing the data	
	About creating a map package	

Figure 4-19: Screenshot of Map Package Dialog (Specify Details).

3. Click the "Item Description" tab and populate the required text boxes: "Summary," "Tags" and "Description." Populate the other text boxes on this tab as desired (i.e., Access and Use Constraints and credits).

	🖌 Analyze 🛛 🙀 Share 🤇
Map Package	Item Description
tem Description	Summary (required):
Additional Files Sharing	Export of Hazus data to ArcGIS Online (Arapahoe County, CO)
	Tags (required):
	Hazus
	Choose Your Tags
	Description:
	This is a map of Hazus data in Arapahoe County, CO.
	Access and Use Constraints:
	N/a
	Credits:
	FEMA - Hazus

Figure 4-20: Screen Capture of Map Package Item Description.

4. Click the "Sharing" tab. There is the option to choose to make this map package visible to everyone (Public) or share this with certain groups. Check the box next to "Everyone (public)."

Note: Explore <u>ArcGIS Online support on groups</u> to learn more about how to restrict the visibility of shared map packages.

- 5. Click the "Analyze" option (with the green check) in the upper right corner of the Map Package dialog to check for any issues that might prevent a successful package publish. If there are no issues discovered, click the "Share" button. This may prompt the user to save the map document before creating the map package; click "Yes" to confirm.
- 6. Click "OK" to confirm the successful map package creation.

#### 4.6.5 Open a Region

- 1. Open a region in Hazus. In this example, we are going to use the base flood scenario with user defined facilities in Arapahoe County, CO.
- 2. Sign in to ArcGIS Online by selecting the "File" menu and "Sign In."



Figure 4-21: Sign in to ArcGIS Online from ArcMap.

3. Enter the user specific ArcGIS Online credentials (username and password) and click "Sign In."

# 5. Appendix A: VDatum Example

Hazus requires data to be in NAVD 1988 vertical datum, thus NGVD 1929 data must be converted. The section below details how this can be done. It will take roughly two (2) hours (one (1) hour of data processing).

In this example, the user will be converting a shapefile of elevations in Corvallis, Oregon, from NGVD 1929 to NAVD 1988 in VDatum and confirming the change in ArcMap. For a short explanation of the difference between vertical datums and why conversions are necessary, watch these videos from the National Oceanic and Atmospheric Administration (NOAA):

- NOAA's VDatum: Transforming Heights between Vertical Datums
- What are Geodetic Datums?

VDatum is able to transform many different types of horizontal and vertical datums with a choice of units (meters, international feet, or U.S. feet), as well as a selection of particular geoid models, including Light Detection and Ranging (LiDAR) data, American Standard Code for Information Interchange (ASCII)

files, rasters, GeoTIFF files, and points with Latitude and Longitude or Easting and Northing units. Not all the features of VDatum will be explored in this example. For more information, go to <u>NOAA's VDATUM</u> <u>website</u>.

This example assumes the user is familiar with the ArcGIS software.

### 5.1 Update Java software

VDatum can be run directly through a command prompt window, but for users who are unfamiliar with programming and the VDatum software, the VDatum Graphic User Interface (GUI) is utilized in this example, which necessitates a current version of Java on the computer used for the analysis.

- 1. Go to the Java download website.
- 2. Click the "Free Java Download" button on the webpage.
- 3. Read the disclaimer and click the "Agree and Start Free Download" button to start the download.
- 4. When the execute file (.exe) is downloaded, click "Run" to start the installation process.
- 5. Click "Yes" to allow the app to make changes to the device.
- 6. Click "Install" on the Java window to start the installation process.

### 5.2 Download the Elevation Dataset

This example will use Elevation points from Corvallis, Oregon, because it has clearly documented metadata. Any dataset in which the source's horizontal and vertical projections, as well as the units of those projections, are known can be converted.

- 1. Go to the Corvallis, Oregon, data download webpage.
- 2. Scroll down to the "Elevation" dataset.



Figure 5-1: Screenshot of Elevation dataset on the Corvallis, Oregon, website.

3. Click "Point\_NGVD29" to read the metadata, the horizontal and vertical projections are of most interest.



- 4. Click the "Shapefile" icon to start downloading the dataset.
- 5. When the computer prompt appears, click "Save" (see Figure 5-3).

From: ftp.ci.corvallis.or.us	Open	Save	<b>^</b>	Cancel	×
•					

Figure 5-3: Example of computer prompt to save the Point\_NGVD29 file to the computer

- 6. Open "File Explorer" and go to the "Downloads" folder.
- 7. Unzip the compressed "Elevation" file by right-clicking the file and then selecting "Extract All..." Keep the default information for the file extraction destination. In this example, the folder will remain in the "Downloads" folder as C:\Downloads\Elevation. The user can place the folder anywhere on their computer as long as they note the location for future reference.

🔢 Elevation	3/2/2018.9:04.AM Compressed (zinn	879,347 KB
	Open	
	Open in new window	
	Extract All	

Figure 5-4: Drop down menu after right-clicking the file. Select "Extract All..."

### 5.3 Download VDatum

VDatum is a free software distributed by NOAA, previously called VERTCON. VDatum only works for the United States and U.S. territories.

1. Go to the <u>VDATUM user agreement webpage</u>.



Figure 5-5: Screenshot of VDatum webpage

- 2. Read the VDatum Terms of Use.
- 3. Click the "Agree and Start Free Download" button near the bottom of the webpage.
- 4. If need be, install prerequisites "GEOTIFF(GDAL)," if the user wishes to convert a GeoTIFF. In this example the GeoTIFF download is not required because the user will be converting an Esri shapefile.

- 5. Click the "vdatum\_all\_20180306.zip" file (or the most current version of the data) to begin the download.
- 6. Unzip the file using "Extract All..."

▶ > This PC > Downloads						
Name	Date modified	Туре				
📕 vdatum_all_20180306	4/24/2018 11:41 A	File folder				

Figure 5-6: Unzip the VDatum file in File Explorer.

7. Move the newly unzipped folder "vdatum\_all\_20180306" to "Program Files" on the computer's hard drive (in this example, C:\Program Files).

← → • ↑ <mark>↓</mark> >	$\leftarrow \rightarrow \checkmark \uparrow$ 🚺 > This PC > Downloads								
> 📙 HazusData		^ Name	Date modified	Туре	Size				
> 📙 Intel		vdatum_all_20180306	4/24/2018 11:41 A	File folder					
> 📜 PerfLogs		vdatum_v3.8	3/26/2018 1:58 PM	File folder					
🗸 📜 Program Files		27z1801-x64.exe	3/27/2018 9:29 AM	Application	1,382 KB				
> 📙 7-Zip	$\rightarrow$ Move	to Program Files 2147_SLC_UDF_Data_for_Hazus_Training_20180413.zip	4/17/2018 1:07 PM	Compressed (zipp	351,883 KB				

Figure 5-7: Moving the VDatum file to the Program Files folder

- 8. Open the "vdatum\_all\_20180306" folder in C:\Program Files.
- 9. Open "vdatum" folder.
- 10. Double-click the "vdatum" batch file. This will open a command prompt window and a NOAA GUI.

F	igure 5-8: VDatum batch file		
🦫 vdatum.bat	4/24/2018 11:41 A	Windows Batch File	2 KB

11. Leave the command prompt window open to execute the GUI (see Figure 5-9).

C:\Windows\system32\cmd.exe			_	
* the United States of America. The program is di 😒	NOAA's Vertical Datu	um Transformation - v3.8		- 🗆 X
* the warranties of merchantability, fitness for * event shall the U.S. Government, the Department	Horizontal Informat	tion		Tarnat
* any of their employees, contractors, subcontrac * damages or other liability resulting from any u	Reference Frame:	MAD83(2011/2007/COR\$96/HARN) - Nor	rth 🔻 🥘 N/	AD83(2011/2007/COR\$96/HARN) - North 💌
* * The Vertical Datum Transformation software and	Coor. System:	Geographic (Longitude, Latitude)	Geogra	aphic (Longitude, Latitude) 💌
* public domain and may be used without restricti * that in any subsequent use of this work, NOAA/N	Unit:			
* acknowledgement. *	Zone:			
* *******	<ul> <li>Vertical Information</li> </ul>	ation Source		Target
<ul> <li>* Although many of the vertical datum transformat</li> <li>* America Vertical Datum of 1988 (NAVD 88) and me</li> </ul>	Reference Frame:	🛞 NAVD 88	🔻 🥘 N/	AVD 88
* mean sea level and the other tidal datums, are * the present National Tidal Datum Epoch (NTDE 19	Unit:	meter (m)	▼ meter	(m) 💌
* on data from older tidal epochs. NOS is in the * in VDatum to conform to the latest NTDE. In the		Height     Sounding	Hei	ght O Sounding
* used when applying these transformations. *		GEOID model:		DID model:
<pre>* For more information, please visit: http://vdat *</pre>	Point Conversion	ASCII File Conversion File Conversion	1	
***************************************		Input	Out	put
NOAA's Vertical Datum Transformation - v3.8	Longitude:	Convert Longitude:		File Report to DMS
GUI: dstHorzDatum is: gov.noaa.vdatum.referencing	Latitude:	Reset Latitude:		Vertical Uncertainty
	Height:	DMS Height:		

Figure 5-9: Example of command prompt window and VDatum GUI

Note: If Java is up to date and the GUI does not execute, all the files may not have transferred to the new folder location. In the "Downloads" folder, open the unzipped folder "vdatum\_all\_20180306," click on the "vdatum" folder, and then click on the "vdatum" batch file. If the GUI executes, continue the instructions from this folder location.

### 5.4 Input Dataset into VDatum and Convert the Vertical Datum

Using the VDatum software downloaded for Corvallis, Oregon, convert the Elevation file downloaded in the previous step from NGVD 1929 to NAVD 1988.

1. In the VDatum GUI, click the "File Conversion" tab.

NOAA's Vertical Datu	um Transformation - v3.8				_	
Horizontal Informat	tion					
	Sour	rce			Target	North
Reference Frame:	W NAD83(2011/2007/CC	DK 596/HAKN) - NOTIN	-	MAD83(2011/200	//CORS96/HARN)	- North 🔻
Coor. System:	Geographic (Longitude, L	atitude)	•	Geographic (Longitud	e, Latitude)	-
Unit:			-			-
Zone:			-			•
• 🗹 Vertical Informa	ation					
	Sour	rce			Target	
Reference Frame:	(S) NAVD 88		-	SAVD 88		•
Unit:	meter (m)		-	meter (m)		-
	Height	Sounding		Height	Sounding	
	GEOID model:		-	GEOID model:		•
Point Conversion	ASCII File Conversion	File Conversion				
File type:	ASPRS LiDAR Data Excha	nge LAS/LAZ 1.0, 1.1, 1	.2 aı	nd 1.4 👻 🛛 LAS	Classification:	ALL 🔺
Use VDatum's	Source Georeferencing S	etup (above)				
O Use Source Fi	le(s) Built.in Georeferencir	na Setup			<u> </u>	2
File normation		ig ootap				3
File name(s):						5
Save as:						. –
	Excluding NODATA point	ts (points with coors. =	-999	9999)	Conve	ert

Figure 5-10: File Conversion tab in VDatum

- 2. Click the "File type" drop-down menu and select the appropriate file type indicated by the user's source data file (in this example, select "Esri Shapefile Vector Format").
- 3. Select the "Use Source File(s) Built-in Georeferencing Setup" radio button.

Point Conversion	ASCII File Conversion File Conversion
File type:	ESRI Shapefile Vector Format
🔾 Use VDatum	's Source Georeferencing Setup (above)
Use Source	File(s) Built-in Georeferencing Setup
File name(s):	
Save as:	
	Excluding NODATA points (points with coors. = -999999)

Figure 5-11: Selecting the georeferencing setup

Note: The "Coor. System" of the Source and the Zone is already defined by the source file inside the metadata. This information can only be changed by selecting the "Use VDatum's Source Georeferencing Setup (above)" radio button if the user knows that the information is incorrectly referenced.

- 4. Click the "..." (Browse) button next to "File name(s):" to select the file to import.
- 5. Locate the Corvallis, Oregon, Elevation dataset in the "Downloads" folder on the computer (or the folder where the Elevation dataset is located) and select the file the user wishes to convert to a different datum, (in this example, "Elevation\_Point\_NGVD29.shp").

Horizontal Informat	ion —							
			Source			Targe	et	
Reference Frame:	(®) I	NAD83(2011/2	007/COR\$96/HARN) -	North 🔻	() NAD83	2011/2007/COF	RS96/HARN)	- North 🔻
Coor. System:	Geog	raphic (Longit	tude, Latitude)	-	Geographic	(Longitude, Lat	titude)	
Unit:				-				-
Zone:		실 Open file(s	)				×	-
Vertical Informa	ation	Look <u>i</u> n:	Elevation		-	a ĉ c		
Reference Frame:		Elevation	Breakline_NGVD29.	shp				-
Unit:	me	Elevation	_Contour_NAVD88.sl	hp				-
	•	Elevation	_Contour_NGVD29.sl	hp				
		Elevation	_Point_NGVD29.shp					
Point Conversion	ľ							
File type:	ESR							
Use VDatum's	Sou	File <u>N</u> ame:	Elevation_Point_NC	GVD29.shp				
Ise Source Fil	e(s)	Files of <u>Type</u> :	ESRI Shapefile (*.s	hp)			-	
File name(s):	0(0)					Open	Cancel	
Save as:								1
	Excl		A points (points with	000 = -99	9999)		Conv	ert
	LACI	adding no DATI	a pointo (pointo mui	000101 -000	00001		00111	

Figure 5-12: Selecting the Elevation file to import into VDatum

6. Click "Open" to select the file to import.

Note: After selecting the file to import, the "Save as" field will automatically populate with a new "result" folder in which the converted shapefile will be placed (in this example, C:\Downloads\Elevation\result).

Note: The Horizontal Information for the Reference Frame of the Source column will also automatically populate; however, the Vertical and Target Information does not change automatically.

Horizontal Inform	ation			_				
Reference Frame	: 🔘 NAD83(2011/2007/CC	rce DR\$96/HARN) - North	•	I NAD83(2011/2007	arget //COR\$96/HARN) - North	-		
Coor. System:	Projected State Plane Co	ordinates (Easting,	•	Projected State Plane	Coordinates (Easting,	-		
Unit:	foot (International) (ft)		•	meter (m)		-		
Zone:	3601	OR N - 3601	-	3601	OR N - 3601	-		
Vertical Inform	nation							
Deference Frame		rce	_		arget	_		
Reference Frame	; NAVD 88			NAVD 66				
Unit:	meter (m)		•	meter (m)		•		
	Height	Sounding		Height	Sounding			
	GEOID model:		-	GEOID model:		-		
Point Conversio	n ASCII File Conversion	File Conversion						
File type:	ESRI Shapefile Vector For	mat		-				
O Use VDatum	's Source Georeferencing S	etup (above)						
Use Source I	File(s) Built-in Georeferencir	ng Setup						
File name(s):	C:\Users\mglass.FACTOR	\Downloads\Elevation\E	leva	tion Point NGVD29.shp				
Save as:	C:\Users\mglass.FACTOR	\Downloads\Elevation\re	esult					
		a (pointa with coola,	-333	5557	CONVENT			

Figure 5-13: Fields automatically populate after selection of file to import.

7. In the Horizontal Information, change target units to the desired units of measurement (in this example, from "meter (m)" to "foot (International) (ft)") in the drop-down menu (see Figure 5-14).

۲	NOAA's Vertical Datu	– 🗆 X							
	Horizontal Information								
		Source	Target						
	Reference Frame:	🥘 NAD83(2011/2007/COR\$96/HARN) - North 🔻	NAD83(2011/2007/COR\$96/HARN) - North						
	Coor. System:	Projected State Plane Coordinates (Easting, 💌	Projected State Plane Coordinates (Easting, 💌						
	Unit:	foot (International) (ft)	meter (m)						
	Zone:	3601 OR N - 3601 👻	meter (m) foot (International) (ft)						
	• 🗹 Vertical Information	ation	foot (U.S. Survey) (US_ft)						

Figure 5-14: Changing Horizontal Information unit measurements for Target

8. In the Vertical Information, change the Source Reference frame to the source's file type and units of measurement (in this example, "NGVD 1929" and "foot (International) (ft)," respectively) using the correlating drop-down menus. Change the target units to the desired unit of measurement, (in this example, "foot (International) (ft)").

٢	NOAA's Vertical Datu	um Transformation - v3.8	– 🗆 X					
[	Horizontal Informat	tion						
	Reference Frame:	W NAD83(2011/2007/CORS96/HARN) - North V	₩ NAD83(2011/2007/CORS96/HARN) - NOTIN ▼					
	Coor. System:	Projected State Plane Coordinates (Easting, 💌	Projected State Plane Coordinates (Easting, 💌					
	Unit:	foot (International) (ft)	foot (International) (ft)					
	Zone:	3601 OR N - 3601 👻	3601 <b>OR N - 3601</b>					
	🗸 🗹 Vertical Informa	ation						
	Defense Francis	Source	Target					
	Reference Frame:	<b>NGVD 1929</b>	S NAVD 88					
	Unit:	foot (International) (ft)	foot (International) (ft) 💌					
		Height O Sounding	Height      Sounding					
		GEOID model:	GEOID model:					
	Point Conversion	ASCII File Conversion File Conversion						
	File type:	ESRI Shapefile Vector Format	<b>v</b>					
	O Use VDatum's	Source Georeferencing Setup (above)						
	Use Source Fi	le(s) Built-in Georeferencing Setup						
	File name(s):	C:\Users\mglass.FACTOR\Downloads\Elevation\Eleva	ation_Point_NGVD29.shp					
	Save as:	Save as: C:\Users\mglass.FACTOR\Downloads\Elevation\result						
	C	Excluding NODATA points (points with coors. = -999999)						

Figure 5-15: Vertical Information changed.

- 9. If the GEOID model boxes are NOT checked, then the VDatum program will use the most up-to-date GEOID model. Leave these boxes unchecked.
- 10. Click the "Convert" button at the bottom of the window. A new window showing the progress of the transformation should appear.

NOAA's Vertical Datum Transformation		_		×
From	Size	Progress	Status	
C:\Users\mglass.FACTOR\Downloads\Elevation\Elevation_Point_N	33840940	0%	Processing.	
<u>×</u>				
Cancel	Clear			

Figure 5-16: Example of progress window that appears when converting the file

Note: Depending on the size of the file, it may take up to several hours to convert, this example will take approximately one (1) hour.

11. Once the conversion is complete, the new shapefile can be found in the folder from the previous step (in this example, "C:\Downloads\Elevation\result") inside the original data folder.

Name	Date modified	Туре	Size
	4/25/2018 12:21 PM	File folder	
Elevation_Breakline_NGVD29.dbf	4/24/2018 1:04 PM	DBF File	80,210 KB
Elevation_Breakline_NGVD29.prj	4/24/2018 1:04 PM	PRJ File	1 KB
Elevation_Breakline_NGVD29.sbn	4/24/2018 1:04 PM	SBN File	2,654 KB
Elevation_Breakline_NGVD29.sbx	4/24/2018 1:04 PM	SBX File	85 KB

Figure 5-17: New "result" folder located in the original data folder

12. Because the names of the original file and the converted file will be identical, rename the new shapefiles with "NAVD88" instead of "NGVD29" (in this example, "Elevation\_Point\_NAVD88")

Elevation > result						
Name	Date modified	Туре	Size			
Elevation_Point_NAVD88.dbf	4/24/2018 1:04 PM	DBF File	217,815 KB			
Elevation_Point_NAVD88.prj	4/25/2018 11:16 AM	PRJ File	1 KB			
Elevation_Point_NAVD88.shp	4/25/2018 12:21 PM	SHP File	33,048 KB			
Elevation_Point_NAVD88.shp.log	4/25/2018 12:21 PM	Text Document	2 KB			
Elevation_Point_NAVD88.shx	4/24/2018 1:04 PM	SHX File	6,009 KB			

Figure 5-18: Renaming the new shapefiles

# 5.5 Confirm Change in Height Points

When the vertical datum was converted, the height of each point in the shapefile will have changed. This step will show how the Z-value of points changed, while their elevations stayed the same. Confirming this change does not have to be executed every time VDatum is used.

- 1. Open "ArcMap."
- Add both the source and the new converted shapefiles (in this example, "Elevation\_Point\_NGVD29.shp" and "Elevation\_Point\_NAVD88.shp") to a new Map document.


Figure 5-19: Adding both shapefiles as layers in new Map document

3. Open the "Add XY Coordinates" tool found under System Toolboxes, Data Management Tools, and then Features (see Figure 5-20).



Figure 5-20: Where to find the "Add XY Coordinates" tool.

4. Insert each one of those two files separately as the Input Features and click "OK" each time. This will add four columns to each one of the shapefiles (Point\_X, Point\_Y, Point\_Z, and Point\_M).



Figure 5-21: Example of the Add XY Coordinates tool.

5. Open both attribute tables by right-clicking the "Elevation point" files and selecting "Open Attribute Table." to compare the Z-values.

🖃 <i> E</i> ayers	
🖃 🚞 C:\Users\mgla	ass.FACTOR\Documents
Eleva	Сору
C:\Users X	Remove
🖃 🗹 Eleva 🔲	Open Attribute Table
•	Joins and Polator
	Zoom To Open Attribute Table
5	Zoom To Open this layer's attribute table.
	Visible Sca layer name OR CTRL + T.
	Use Symbol Levels
	Selection
	Label Features
	Edit Features
	Convert Labels to Annotation
<b>\$</b>	Convert Features to Graphics
	Convert Symbology to Representation
	Data 🕨
<b></b>	Save As Layer File
	Create Layer Package
·	Properties

Figure 5-22: Opening the attribute tables.

Note: The X and Y coordinates are given in terms of Easting and Northing.

Tab	Table									
°	🔁 -   🖶 -   🖫 🔂 💷 🗶									
Elev	Elevation_Point_NGVD29									
h	FID	Shape	TYPE	ELEVATION	DATE PUBLI	DATA DATE	POINT X	POINT Y	POINT Z	POINT M
ГÌ	0	Point ZM		756.914662	<null></null>	<null></null>	7460600	346000	756.9146	<null></null>
Гſ	1	Point ZM		764.094914	<null></null>	<null></null>	7460600	346040	764.0949	<null></null>
	2	Point ZM		768.586763	<null></null>	<null></null>	7460600	346120	768.5867	<null></null>
	3	Point ZM		775.624658	<null></null>	<null></null>	7460600	346160	775.6246	<null></null>
	4	Point ZM		761.768159	<null></null>	<null></null>	7460640	346000	761.7681	<null></null>
	5	Point ZM		765.224415	<null></null>	<null></null>	7460640	346040	765.2244	<null></null>
	6	Point ZM		772.666702	<null></null>	<null></null>	7460640	346120	772.6667	<null></null>
	7	D-1-1 711		770 000405		.810.	7400040	040400	770 0000	.810.
"	1	1	P PI		out of 709110 S	elected)				
FL	Elevation Deint NG/D201 Elevation Daint NA/D22									
LIC	vatio	n_Point_N(	SVD29	Elevation_Poin	t_NAVD88					
(LIC	vatio	n_Point_N	GVD29	Elevation_Poin	t_NAVD88					
Tab	vatio	n_Point_N	5VD29	Elevation_Poin	t_NAVD88					
Tak	vatio ole ↓↓ ↓ ↓	n_Point_NO	SVD29	Elevation_Poin	t_NAVD88					
Tak	vation ole   +   E	n_Point_NO	SVD29	Elevation_Poin	t_NAVD88					
Tab Elev	vation le   +   E vation	n_Point_NO	SVD29	Elevation_Poin	t_NAVD88					
Tab Eler	vation	n_Point_NO ■ -   Pu _Point_NA _ Shape	VD29 VD88 TYPE	Elevation_Poin	t_NAVD88	DATA_DATE	POINT_X	POINT_Y	POINT_Z	POINT_M
Tak Elev	vation le vation FID 0	Point_NO	VD29 VD88 TYPE	Elevation_Poin	DATE_PUBLI <null></null>	DATA_DATE	POINT_X 7460600	POINT_Y 346000	POINT_Z 760.241551	POINT_M 0
Tab Elev	vation le vation FID 0 1	Point_NA	VD29 VD88 TYPE	Elevation_Poin ELEVATION 756.914662 764.094914	DATE_PUBLI <null> <null></null></null>	DATA_DATE <null> <null></null></null>	POINT_X 7460600 7460600	POINT_Y 346000 346040	POINT_Z 760.241551 767.42199	POINT_M 0 0
Tak Elev	vation   +   E vation FID 0 1 2	n_Point_NA ■ ▼   ■ Point_NA Shape Point ZM Point ZM Point ZM	VD29	Elevation_Poin ELEVATION 756.914662 764.094914 768.586763	DATE_PUBLI <null> <null></null></null>	DATA_DATE <null> <null> <null></null></null></null>	POINT_X 7460600 7460600 7460600	POINT_Y 346000 346040 346120	POINT_Z 760.241551 767.42199 771.914067	POINT_M 0 0
Tab Elev	vation vation FID 0 1 2 3	Point_NA Point_NA Point_ZM Point ZM Point ZM Point ZM Point ZM	VD29	Elevation_Poin ELEVATION 756.914662 764.094914 768.586763 775.624658	DATE_PUBLI <null> <null> <null> <null></null></null></null></null>	DATA_DATE <null> <null <n<="" <null="" td=""><td>POINT_X 7460600 7460600 7460600 7460600</td><td>POINT_Y 346000 346040 346120 346160</td><td>POINT_Z 760.241551 767.42199 771.914067 778.952106</td><td>POINT_M 0 0 0</td></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null>	POINT_X 7460600 7460600 7460600 7460600	POINT_Y 346000 346040 346120 346160	POINT_Z 760.241551 767.42199 771.914067 778.952106	POINT_M 0 0 0
Elev	vation vation FID 0 1 2 3 4	Point_NA Point_NA Shape Point ZM Point ZM Point ZM Point ZM Point ZM	VD29	Elevation_Poin 756.914662 764.094914 768.586763 775.624658 761.768159	DATE_PUBLI <null> <null> <null> <null> <null></null></null></null></null></null>	DATA_DATE <null> <null> <null> <null></null></null></null></null>	POINT_X 7460600 7460600 7460600 7460600 7460600 7460640	POINT_Y 346000 346040 346120 346160 346000	POINT_Z 760.241551 767.42199 771.914067 778.952106 765.095103	POINT_M 0 0 0 0 0
	vation vation FID 0 1 2 3 4 5	Point_NA Point_NA Point ZM Point ZM Point ZM Point ZM Point ZM Point ZM	VD29	Elevation_Poin 756.914662 764.094914 768.586763 775.624658 761.768159 765.224415	DATE_PUBLI <null> <null> <null> <null> <null> <null></null></null></null></null></null></null>	DATA_DATE <nul> <nul> <nul> <nul> <nul></nul></nul></nul></nul></nul>	POINT_X 7460600 7460600 7460600 7460600 7460640 7460640	POINT_Y 346000 346040 346120 346160 346000 346040	POINT_Z 760.241551 767.42199 771.914067 778.952106 765.095103 768.551542	POINT_M 0 0 0 0 0 0 0
Elev	vation vation FID 0 1 2 3 4 5 6	Point_NA Point_NA Point ZM Point ZM Point ZM Point ZM Point ZM Point ZM Point ZM Point ZM	VD88 TYPE	ELEVATION 756.914662 764.094914 768.586763 775.624658 761.768159 765.224415 772.666702	DATE_PUBLI <null> <null> <null> <null> <null> <null> <null> <null></null></null></null></null></null></null></null></null>	DATA_DATE <null> <null> <null> <null> <null> <null></null></null></null></null></null></null>	POINT_X 7460600 7460600 7460600 7460600 7460640 7460640 7460640	POINT_Y 346000 346040 346120 346160 346000 346040 346120	POINT_Z 760.241551 767.42199 771.914067 778.952106 765.095103 768.551542 775.99412	POINT_M 0 0 0 0 0 0 0 0 0 0 0
Tab	vation vation FID 0 1 2 3 4 5 6 7	Point_NA Point_NA Point_ZM Point ZM Point ZM Point ZM Point ZM Point ZM Point ZM Point ZM Point ZM Point ZM	VD88 VD88 VD88	Elevation_Poin 756.914662 764.094914 768.586763 775.624658 761.768159 765.224415 772.666702	DATE_PUBLI <null> <null> <null> <null> <null> <null> <null> <null> <null></null></null></null></null></null></null></null></null></null>	DATA_DATE <nul> <nul> <nul> <nul> <nul> <nul> <nul></nul></nul></nul></nul></nul></nul></nul>	POINT_X 7460600 7460600 7460600 7460640 7460640 7460640 7460640	POINT_Y 346000 346040 346120 346100 346000 346040 346120 246420	POINT_Z 760.241551 767.42199 771.914067 778.952106 765.095103 768.551542 775.99412	POINT_M 0 0 0 0 0 0 0 0 0
Tab	vation FID 0 1 2 3 4 5 6 7	Point_NA Point_NA Point ZM Point ZM	VD88 TYPE	Elevation_Poin 756.914662 764.094914 768.586763 775.624658 761.768159 765.224415 772.666702 772.666702	DATE_PUBLI <null> <null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null>	DATA_DATE <nul> <nul></nul></nul></nul></nul></nul></nul></nul></nul></nul></nul></nul>	POINT_X 7460600 7460600 7460600 7460640 7460640 7460640 7460640	POINT_Y 346000 346040 346120 346160 346000 346040 346120 246400	POINT_Z 760.241551 767.42199 771.914067 778.952106 765.095103 768.551542 775.99412	POINT_M 0 0 0 0 0 0 0 0 0
	vation FID 0 1 2 3 4 5 6 7 vation	Point_NA Point_NA Point ZM Point ZM	SVD29         VD29           VD88         TYPE           SVD29         SVD29	ELEVATION 756.914662 764.094914 768.586763 775.624658 761.768159 765.224415 772.666702 772.666702	DATE_PUBLI <null> <null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null></null>	DATA_DATE <nul> <nul></nul></nul></nul></nul></nul></nul></nul></nul></nul></nul></nul></nul></nul>	POINT_X 7460600 7460600 7460600 7460640 7460640 7460640 7460640	POINT_Y 346000 346040 346120 346160 346000 346040 346040 346120	POINT_Z 760.241551 767.42199 771.914067 778.952106 765.095103 768.551542 775.99412	POINT_M 0 0 0 0 0 0 0 0

Figure 5-23: Comparing the Z-Point values in the NGVD29 and NAVD88 files.

## 5.6 Confirm conversion is Accurate Using VDatum

In the previous step, all the points of a shapefile were converted. Using the information from the attribute tables in ArcMap, the user can confirm that the points were converted properly using the VDatum point conversion method. This step does not have to be executed every time VDatum is used.

- 1. Move back to the VDatum GUI window.
- 2. Select the "Point Conversion" tab.

Point Conversion ASCII File Conversion Fi	File Conversion
Input	Output
Easting: Convert	Easting: Eas
Northing: Reset	Northing: Vertical Uncertainty
Height: DMS	Height:

Figure 5-24: Selecting the Point Conversion tab in VDatum

3. From the first row of the NGVD 1929 attribute table in ArcMap, as shown in Figure 5-25, enter the value of "Point\_X" into the Easting box, the value for "Point\_Y" into the Northing box, and the value for "Point\_Z" into the Height box.

Elevation_Point_NGVD29											
Γ	FID	Shape	TYPE	ELEVATION	DATE_PUBLI	DATA_DATE	POINT_X	POINT_Y	POINT_Z	POINT_M	
Þ	0	Point ZM		756.914662	<null></null>	<null></null>	7460600	346000	756.9146	<null></null>	

Figure 5-25: First row of the NGVD29 attribute table

- Ensure that the Horizontal Reference frame is in "NAD83(2011/2007/CORS96/HARN)-North...," the "Coor. System" is the "Projected State Plane Coordinates (Easting,...," the Unit is in "foot (International) (ft)," and the zone is "OR N – 3601;" this is from the source file metadata.
- 5. Under Vertical Information, the Source Reference Frame should be the source's file type and the Units should be the units used in the source file (in this example, "NGVD 1929" and "foot (International) (ft)," respectively). The target Reference Frame should be the converted file type and the desired units of measurement (in this example ("NAVD 88" and "foot (International) (ft)," respectively).

۲	NOAA's Vertical Date	um Transformation - v3.8 —	×
[	Horizontal Information	tion	
	Reference Frame:	Source Target           NAD83(2011/2007/CORS96/HARN) - North         Image: Constraint of the second se	
	Coor. System:	Projected State Plane Coordinates (Easting, 💌 Projected State Plane Coordinates (Easting, 💌	
	Unit:	foot (International) (ft)	
	Zone:	3601         OR N - 3601         3601         OR N - 3601	
[	Vertical Inform	ation	
		Source Target	
	Reference Frame:	▼         ▼           ▼         ▼	
	Unit:	foot (International) (ft)	
		Height O Sounding Height O Sounding	
		GEOID model: GEOID12B GEOID model: GEOID12B	
	Point Conversion	ASCII File Conversion File Conversion	
		Input Output	
	Easting: 7460	600 Convert Easting: File Report to DMS	
	Northing: 3460	00 Reset Northing:	
	Height: 756.9	D146 DMS Height:	

Figure 5-26: Final data points for point conversion

- 6. Leave the GEOID model boxes unchecked so that the most up-to-date GEOID model in VDatum is used.
- 7. Click "Convert" and the gray Output boxes will be populated.

	Input			Output	
Easting:	7460600	Convert	Easting:	7460600.0000	File Report to DMS
Northing:	346000	Reset	Northing:	346000.0000	Vertical Uncertainty
Height:	756.9146	DMS	Height:	760.242	18.7883cm
Zone: 360	1 Vertical_Area: C:\Us	ers\mglass.FACT	OR\Downloa	ds\vdatum_all_20180	306\vdatum\core\vcn

Figure 5-27: Point conversion in Output boxes.

The Northing and Easting Input and Output values should stay the same, while the Output Height value should have been converted. The Output Height in VDatum should match the "Point\_Z" value of the identical point in the "Elevation\_Point\_NAVD88" ArcMap attribute table. In this example, the Output Height in VDatum is 760.242, and the Point\_Z value from the ArcMap attribute table is 760.241551. The accuracy of the conversion has been confirmed.

El	Elevation_Point_NAVD88									
Г	FID	Shape	TYPE	ELEVATION	DATE_PUBLI	DATA_DATE	POINT_X	POINT_Y	POINT_Z	POINT_M
Þ	0	Point ZM		756.914662	<null></null>	<null></null>	7460600	346000	760.241551	0

Figure 5-28: Point\_Z from the NAVD88 ArcMap attribute table