Appendix G Hazus Methodology and Results Report

The Cumberland County HMP used an enhanced Hazus run to model the 1% annual-chance-flood. Enhancements to the model focused on improving three aspects of the model:

- Essential Facilities
- Demographic data
- Flood depth grids

ESSENTIAL FACILITIES

Shapefiles of essential facilities were created from MS Excel tables exported CDMS for each county using Latitude and Longitude attributes provided in the exports. Essential facility categories include: Emergency Operations Center (EOC), Fire Stations, Medical Facilities/Hospitals, Police Stations and Schools. The shapefiles were created using Esri's *Create Feature Class from XY Tool* in ArcCatalog. The Geographic Coordinate System (GCS) North American Datum 1983 was assigned.

The essential facilities exported from CDMS were individually reviewed to determine if the facility existed in reality, the location matched reality, and if the attributes were correct.

Each facility was classified as either MATCH, EDIT, KEEP, MOVED or ADD. The rules for classification are listed below:

- MATCH – County data and CDMS data are located on the same parcel and have the same name and address.
- EDIT – Attributes such as Facility Name, Address, City, Zip, and Telephone were modified to match county data.[1]
- MOVED – The CDMS data point was moved to a new location. Several scenarios instigated this classification. For example, the CDMS point was located near the county data but not within the same parcel. In this scenario, the point was moved to be within the correct parcel. Another example was the CDMS facility was in the wrong place entirely. In this scenario, the point was moved to coincide with the county data point. In both scenarios, Latitude and Longitude were recalculated in decimal degrees after the point was moved. Even if an attribute was edited, the point was classified as MOVED and a note was added to identify which attributes were updated.
- KEEP – Facility did not exist in county data, but other sources such as Municipal, County and State websites verified the facility existed at that location.
- ADD – Facility exists in County provided data and was added to the dataset for import into CDMS.

Locations of facilities were compared to data provided by each county. If the point fell within the parcel, the point was not moved. If the point did fall within the correct parcel, for example in the

[1] For School Facilities, the School District attribute was updated for all public schools. This update did not change the classification from MATCH to EDIT because none of the essential facilities exported from CDMS had School District populated.

public ROW or in the wrong location, it was moved to the parcel and/or building footprint (if available) of the facility and the latitude and longitude were recalculated in decimal degrees.

The facility name, address, city, zip code and telephone number attributes were verified. For school facilities, the School District field was updated.

State Data Sources

Schools

Pennsylvania Department of Education Educational Names & Addresses database, also known as EdNA.[2] District Offices and Administrative buildings were left out of the essential facilities, as were unlicensed preschools and universities.

Hospitals

Pennsylvania Department of 2012-2013 Hospital Reports, "1-A Utilization Data."[3]

County Data Sources

The following summary tables of which sources and attributes were used to update the essential facilities for Cumberland County.

FIELD	EOC	FIRE	MEDICAL	POLICE	SCHOOL
HazusID	UNCHANGED				
Address				Site_AddressPts.shp	
AHA_ID	n/a	n/a	default value	n/a	n/a
Area	default value				
Back-up Power (Yes or No)	UNCHANGED				
Census Tract	UNCHANGED				
City	Site_AddressPts.shp [CITY]				
Contact Person	UNCHANGED				
Facility Class	EFEO	EFFS	EFHM	EFPS	EFS1
Facility Name	Site_AddressPts.shp [BLDG NAME]		Site_PublicFacilities.shp [NAME]	Site_AddressPts.shp [BLDG NAME]	Sites_Education.shp [NAME]
Kitchen Facilities (Yes or No)	UNCHANGED				
Latitude	Calculate Geometry of Y point in GCS NAD83 IF moved from orig loc, [REVIEW]=MOVED				
Longitude	Calculate Geometry of X point in GCS NAD83 IF moved from orig loc, [REVIEW]=MOVED				
Misc. Comments	UNCHANGED				
Number of Beds	n/a	n/a	PA Dept of Health Report	n/a	n/a
Number of Stories	UNCHANGED. Parcels.shp [STORY_HEIG] null for Essential Facilities				
Number of Students	n/a	n/a	n/a	n/a	UNCHANGED
Number of Trucks	n/a	UNCHANGED	n/a	n/a	n/a
Primary Function	UNCHANGED				
Telephone Number	Site_PublicFacilities.shp [PHONE]				
Replacement Cost (thous. $)	UNCHANGED BECAUSE ALREADY POPULATED				
School District	n/a	n/a	n/a	n/a	Jurisdiction_SchoolDistrict.shp [NAME]
Shelter Capacity	UNCHANGED				
State	default value = PA				
Year Built (Between 1500 and 2100)	Mapping_Parcels.shp [YEAR_BLT]				
ZIP Code	UNCHANGED				Site_PublicFacilities.shp [ZIP]
FL Contents Damage Function	default value/unchanged				
FL Flood Building Type	default value/unchanged				

[2] http://www.edna.ed.state.pa.us/Screens/wfSearchEntity.aspx
[3] http://www.portal.state.pa.us/portal/server.pt?open=18&objID=1401353&mode=2

FIELD	EOC	FIRE	MEDICAL	POLICE	SCHOOL
FL Flood Pre/Post FIRM Design Level	default value/unchanged				
FL Flood Structure Foundation Type	default value/unchanged				
FL Height of the First Occupied Floor	default value/unchanged				
FL Protection In terms of return period	default value/unchanged				
FL Structure Damage Function Id	default value/unchanged				

The facilities were then imported into CDMS for incorporation into the model.

DEMOGRAPHIC DATA

Hazus's default databases by default use the 2000 Census data. However, Cumberland County's population is changing, as are the racial and economic characteristics of the County. Using up-to-date Census information allows the model to have more realistic results for how many people will be impacted by hazard events. The demographics updated include population, households, group quarters, male population by age, female population by age, and population by race at both the Census tract and block level. However, income, housing tenure by housing type, housing vacancy by housing tape, age of structures, average cash rent, median home value, and educational enrollment were not updated at the Census tract level only because this data is not available at the Census block level geography. This demographic data matches the values used in the 2013 Standard State All-Hazard Mitigation Plan.

DEPTH GRIDS

Depth grids were created for Cumberland County per guidance provided by FEMA Region III using the effective DFIRM database special flood hazard area polygons and the cross sections and PaMAP LiDAR data digital elevation models.

Existing Digital Elevation Models (DEM) were downloaded from PASDA. The extent of blocks downloaded was determined by selecting all blocks that intersected Special Flood Hazard Areas in that county. The DEMs are tiled in 10,000' by 10,000' blocks. [4]

COUNTY	NUMBER OF BLOCKS	PROJECTION	DATUM	UNITS
Cumberland	131	Pennsylvania State Plane South	NAD83	Feet

NHFL data was downloaded from the FEMA MSC for the Cumberland County to create the depth grids. The DEM tiles were mosaicked into one seamless raster for each county using ArcToolbox tools *Create Raster Dataset* and *Mosaic*. The spatial reference used for Cumberland was Pennsylvania State Plane South. The pixel type was 32 bit float, and the cell size was 3.2 feet.

Hazus only accepts depth grid rasters in UTM with horizontal units in meters, therefore the source DEM needed to be projected from State Plane to UTM. The mosaicked DEM rasters

[4] ftp://pamap.pasda.psu.edu/pamap_lidar/cycle1/DEM/

were projected from State Plane (feet) to UTM Zone 18N (meters) using the *Project Raster* tool in ArcToolbox. The resampling technique was nearest, and the output cell size was 0.97536 meters.

TINs were created for Cumberland County to represent the water surface during a 100 year flood event, per data provided in the NFHL county-wide data. Features where the attribute SFHA = T were selected from *S_FLD_HAZ_AR.shp*. Those selected features were dissolved into one polygon per county; this polygon represented the extent of the flooded area. Base flood elevation lines (*S_BFE.shp*) were used as well. The *Create TIN* tool in ArcToolbox was used. The floodplain polygon was input with the height field set to NULL and the SF_type as hardclip. *S_BFE.shp* was input with the height field set to ELEV and SF_type as hard_line. Constrained Delaunay was checked and in the Environments settings, the Processing Extent Snap Raster was set to the projected DEM.

The TIN created for Cumberland was then converted to a raster format. The output data type was FLOAT, the interpolation method used was linear, the sampling distance was CELLSIZE 0.97536 meters, and in the Environments settings, the Processing Extent Snap Raster was set to the projected DEM. The output raster represented the water surface elevation in a grid format that could be used to determine the depth of flooding compared to the ground elevation DEM.

Using Raster Calculator and the Conditional operation, the depth grid was calculated from the water surface elevation grid and the ground elevation grid (projected DEM) using the following expression. Note “water” and “ground” are generic placeholders; specific raster file names must be used.

Con((“water”-“ground”),(“water”-“ground”))

The output raster had negative and zero values in areas where the ground elevation was greater than the interpolated water surface elevation, therefore those values were reclassified to be excluded as NODATA using the following expression where “depth” represents the output raster from the previous step, note that exact file names must be used.

SetNull("depth"<0,"depth")

The resulting raster is the final depth grid that was imported into Hazus.

The following pages show the Hazus Global Summary Report associated with this analysis.

Hazus-MH: Flood Event Report

Region Name: Cumberland County HMP

Flood Scenario: Cumberland_100year

Print Date: Friday, September 12, 2014

Disclaimer:

Totals only reflect data for those census tracts/blocks included in the user's study region.

The estimates of social and economic impacts contained in this report were produced using Hazus loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social

Table of Contents

General Description of the Region

Hazus is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS). The primary purpose of Hazus is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

The flood loss estimates provided in this report were based on a region that included 1 county(ies) from the following state(s):

- Pennsylvania

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 550 square miles and contains 4,922 census blocks. The region contains over 68 thousand households and has a total population of 172,605 people (2000 Census Bureau data). The distribution of population by State and County for the study region is provided in Appendix B.

There are an estimated 83,822 buildings in the region with a total building replacement value (excluding contents) of 18,003 million dollars (2006 dollars). Approximately 91.32% of the buildings (and 68.18% of the building value) are associated with residential housing.

Building Inventory

General Building Stock

Hazus estimates that there are 83,822 buildings in the region which have an aggregate total replacement value of 18,003 million (2006 dollars). Table 1 and Table 2 present the relative distribution of the value with respect to the general occupancies by Study Region and Scenario respectively. Appendix B provides a general distribution of the building value by State and County.

Table 1
Building Exposure by Occupancy Type for the Study Region

Occupancy	Exposure ($1000)	Percent of Total
Residential	12,273,420	68.2%
Commercial	2,980,604	16.6%
Industrial	857,547	4.8%
Agricultural	72,284	0.4%
Religion	357,255	2.0%
Government	193,268	1.1%
Education	1,268,306	7.0%
Total	**18,002,684**	**100.00%**

Table 2
Building Exposure by Occupancy Type for the Scenario

Occupancy	Exposure ($1000)	Percent of Total
Residential	2,466,004	67.3%
Commercial	588,368	16.0%
Industrial	336,873	9.2%
Agricultural	19,142	0.5%
Religion	86,378	2.4%
Government	75,879	2.1%
Education	93,713	2.6%
Total	**3,666,357**	**100.00%**

Essential Facility Inventory

For essential facilities, there are 5 hospitals in the region with a total bed capacity of 699 beds.
There are 107 schools, 38 fire stations, 19 police stations and 1 emergency operation center.

Flood Scenario Parameters

Hazus used the following set of information to define the flood parameters for the flood loss estimate provided in this report.

Study Region Name:	Cumberland County HMP
Scenario Name:	Cumberland_100year
Return Period Analyzed:	100
Analysis Options Analyzed:	No What-Ifs

Building Damage

General Building Stock Damage

Hazus estimates that about 749 buildings will be at least moderately damaged. This is over 75% of the total number of buildings in the scenario. There are an estimated 433 buildings that will be completely destroyed. The definition of the 'damage states' is provided in Volume 1: Chapter 5.3 of the Hazus Flood Technical Manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 summarizes the expected damage by general building type.

Table 3: Expected Building Damage by Occupancy

	1-10		11-20		21-30		31-40		41-50		Substantially	
Occupancy	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
Agriculture	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Commercial	0	0.00	1	33.33	0	0.00	0	0.00	2	66.67	0	0.00
Education	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Government	0	0.00	2	100.00	0	0.00	0	0.00	0	0.00	0	0.00
Industrial	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Religion	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
Residential	0	0.00	5	0.67	20	2.69	118	15.86	168	22.58	433	58.20
Total	**0**		**8**		**20**		**118**		**170**		**433**	

Table 4: Expected Building Damage by Building Type

Building Type	1-10		11-20		21-30		31-40		41-50		Substantially	
	Count	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**	**Count**	**(%)**
Concrete	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00
ManufHousing	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	59	100.00
Masonry	0	0.00	0	0.00	4	2.06	31	15.98	47	24.23	112	57.73
Steel	0	0.00	3	75.00	0	0.00	0	0.00	1	25.00	0	0.00
Wood	0	0.00	5	1.02	16	3.25	87	17.68	122	24.80	262	53.25

Essential Facility Damage

Before the flood analyzed in this scenario, the region had 699 hospital beds available for use. On the day of the scenario flood event, the model estimates that 699 hospital beds are available in the region.

Table 5: Expected Damage to Essential Facilities

		# Facilities		
Classification	Total	At Least Moderate	At Least Substantial	Loss of Use
Fire Stations	38	0	0	0
Hospitals	5	0	0	0
Police Stations	19	0	0	0
Schools	107	1	0	1

If this report displays all zeros or is blank, two possibilities can explain this.

(1) None of your facilities were flooded. This can be checked by mapping the inventory data on the depth grid.

(2) The analysis was not run. This can be tested by checking the run box on the Analysis Menu and seeing if a message box asks you to replace the existing results.

Induced Flood Damage

Debris Generation

Hazus estimates the amount of debris that will be generated by the flood. The model breaks debris into three general categories: 1) Finishes (dry wall, insulation, etc.), 2) Structural (wood, brick, etc.) and 3) Foundations (concrete slab, concrete block, rebar, etc.). This distinction is made because of the different types of material handling equipment required to handle the debris.

Analysis has not been performed for this Scenario.

Social Impact

Shelter Requirements

Hazus estimates the number of households that are expected to be displaced from their homes due to the flood and the associated potential evacuation. Hazus also estimates those displaced people that will require accommodations in temporary public shelters. The model estimates 1,865 households will be displaced due to the flood. Displacement includes households evacuated from within or very near to the inundated area. Of these, 3,635 people (out of a total population of 172,605) will seek temporary shelter in public shelters.

Economic Loss

The total economic loss estimated for the flood is 350.36 million dollars, which represents 9.56 % of the total replacement value of the scenario buildings.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the flood. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the flood.

The total building-related losses were 348.97 million dollars. 0% of the estimated losses were related to the business interruption of the region. The residential occupancies made up 58.25% of the total loss. Table 6 below provides a summary of the losses associated with the building damage.

Table 6: Building-Related Economic Loss Estimates

(Millions of dollars)

Category	Area	Residential	Commercial	Industrial	Others	Total
Building Loss						
	Building	129.87	23.68	7.33	6.38	167.26
	Content	74.02	62.63	13.89	27.11	177.65
	Inventory	0.00	1.42	2.39	0.25	4.07
	Subtotal	**203.89**	**87.73**	**23.61**	**33.75**	**348.97**
Business Interruption						
	Income	0.02	0.21	0.00	0.05	0.28
	Relocation	0.11	0.04	0.00	0.03	0.17
	Rental Income	0.03	0.02	0.00	0.00	0.05
	Wage	0.05	0.31	0.00	0.54	0.89
	Subtotal	**0.19**	**0.58**	**0.00**	**0.61**	**1.39**
ALL	**Total**	**204.08**	**88.31**	**23.61**	**34.36**	**350.36**

Appendix A: County Listing for the Region

Pennsylvania

- Cumberland

Appendix B: Regional Population and Building Value Data

		Building Value (thousands of dollars)		
	Population	Residential	Non-Residential	Total
Pennsylvania				
Cumberland	172,605	12,273,420	5,729,264	18,002,684
Total	**172,605**	**12,273,420**	**5,729,264**	**18,002,684**
Total Study Region	**172,605**	**12,273,420**	**5,729,264**	**18,002,684**

Direct Economic Losses for Buildings

September 12, 2014

All values are in thousands of dollars

	Capital Stock Losses				Income Losses				
	Building Loss	Contents Loss	Inventory Loss	Building Loss Ratio %	Relocation Loss	Capital Related Loss	Wages Losses	Rental Income Loss	Total Loss
Pennsylvania									
Cumberland	167,260	177,645	4,065	4.60	168	276	894	49	350,357
Total	**167,260**	**177,645**	**4,065**	**4.60**	**168**	**276**	**894**	**49**	**350,357**
Scenario Total	**167,260**	**177,645**	**4,065**	**4.60**	**168**	**276**	**894**	**49**	**350,357**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Study Region: Cumberland County HMP

Scenario: Cumberland_100year

Return Period: 100

Shelter Summary Report

September 12, 2014

	# of Displaced People	# of People Needing Short Term Shelter
Pennsylvania		
Cumberland	5,594	3,635
Total	**5,594**	**3,635**
Scenario Total	**5,594**	**3,635**

Totals only reflect data for those census tracts/blocks included in the user's study region and will reflect the entire county/state only if all of the census blocks for that county/state were selected at the time of study region creation.

Study Region: Cumberland County HMP
Scenario: Cumberland_100year
Return Period: 100