4.2 METHODOLOGY AND TOOLS

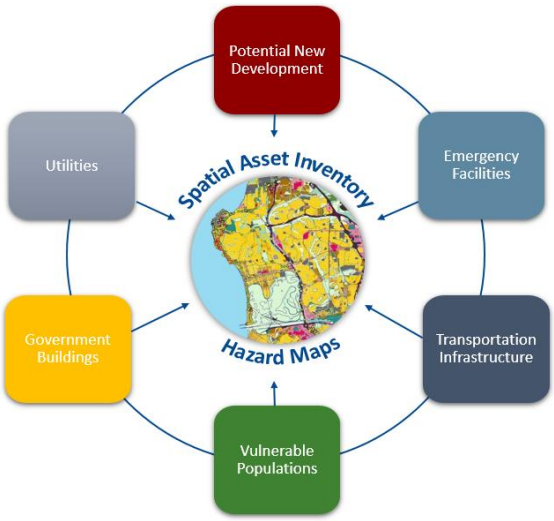
2021 HMP Changes

The risk assessment was updated using best available information.

- The 2014-2018 American Community Survey (ACS) 5-year Population Estimates were utilized.
- Countywide 2020 parcels, 2018 MOD-IV data, and 2020 RSMeans values were used to develop a structure-level building inventory and estimate replacement cost value for each building.
- The 2016 HMP critical facility inventory was reviewed and updated by the Planning Partnership.
- Community lifelines were identified in the critical facility inventory to align with FEMA's lifeline definition.
- Hazus v4.2 was used to estimate potential impacts to the flood, seismic and wind hazards.

4.2.1 ASSET INVENTORIES

Sussex County assets were identified to assess potential exposure and loss associated with the hazards of concern. For the HMP update, Sussex County assessed exposure and vulnerability of the following types of assets: population, buildings and critical facilities/infrastructure, new development, and the environment. Some assets may be more vulnerable because of their physical characteristics or socioeconomic uses. To protect individual privacy and the security of critical facilities and community lifelines, information on properties assessed is presented in aggregate, without details about specific individual properties.



The risk assessment included the collection and use of an expanded and enhanced asset inventory to estimate hazard exposure and vulnerability

Population

Total population statistics from the 2014-2018 ACS 5-year estimate were used to estimate the exposure and potential impacts to the County's population in place of the 2010 U.S. Census block estimates. Borough, town, and township populations were extracted directly from the ACS. Population counts at the jurisdictional level were averaged among the residential structures in the County to estimate the population at the structure level. This estimate is a more precise distribution of population across the County compared to using the Census block or Census tract boundaries. Limitations of these analyses are recognized, and thus the results are used only to provide a general estimate for planning purposes.

FEMA's Hazus program was used to model estimate potential losses to flood, seismic and wind hazards; as discussed further later in this section. Hazus still contains 2010 U.S. Census data and was used to estimate sheltering and injuries as part of the hazard analysis.

As discussed in Section 3 (County Profile), research has shown that some populations are at greater risk from hazard events because of decreased resources or physical abilities. Vulnerable populations in Sussex County included in the risk assessment are children, elderly, population below the poverty level, non-English speaking individuals, and persons institutionalized with a disability.

Buildings

A custom general building stock was created countywide. To develop the building inventory, updated building footprints provided by Sussex County and parcels from the 2018 MOD-IV tax assessor data obtained from the New Jersey Geographic Information Network Open Data portal were used. Attributes provided in the associated files were used to further define each structure, such as year built, number of stories, basement type, occupancy class, and square footage. The centroid of each building footprint was used to estimate the building location. Structural and content replacement cost values (RCV) were calculated for each building using the available assessor data, the building footprint, and RSMeans 2020 values. The analysis used a location factor of 1.14 and 0.96 for non-residential and residential occupancy classes, respectively. These location factors were associated with the zip-code options for Sussex County. Replacement cost value is the current cost of returning an asset to its pre-damaged condition using present-day cost of labor and materials. Total replacement cost value consists of both the structural cost to replace a building and the estimate value of contents of a building. The occupancy classes available in Hazus were condensed into the categories of residential, commercial, industrial, agricultural, religious, governmental, and educational to facilitate analysis and presentation of results. Residential loss estimates addressed both multi-family and single-family dwellings.

Critical Facilities and Lifelines

*A **lifeline** provides indispensable service that enables the continuous operation of critical business and government functions, and is critical to human health and safety, or economic security (FEMA).*

The 2016 HMP critical facility inventory was updated using GIS data provided by Sussex County GIS & Mapping Services. The dataset, which includes essential facilities, utilities, transportation features and user-defined facilities as outlined in Section 3, was enhanced with attributes provided within the spatial layers. The inventory was then reviewed by the Planning Partnership allowing for County and municipal input. The update involved a review for accuracy, additions or deletions of new/moved critical assets, identification of backup power for each asset (if known) and the addition of community lifelines in accordance with FEMA's definition; refer to Appendix E (Risk Assessment Supplement). To protect individual privacy and the security of assets, information is presented in aggregate, without details about specific individual properties or facilities.

New Development

In addition to summarizing the current vulnerability, Sussex County examined new development that can affect the planning area's vulnerability to hazards. New development that occurred within the last five years and development that is projected to occur in the next five years were identified by the County and participating municipalities using Survey123; a cloud-based ESRI ArcGIS online platform. Identifying these changes and integrating them into the risk assessment ensures their vulnerability, if any, is considered when developing the mitigation strategy to reduce future risk. An exposure analysis was conducted and the results shared with the plan participants (one tool in the Mitigation Toolbox discussed in Section 6 – Mitigation Strategy). The new development and exposure analysis results are presented in Section 9 (Jurisdictional Annexes), as a table in each annex.

4.2.2 METHODOLOGY

To address the requirements of the DMA 2000 and better understand potential vulnerability and losses associated with hazards of concern, Sussex County used standardized tools, combined with local, state, and federal data and expertise to conduct the risk assessment. Three levels of analysis were used depending on the data available for each hazard as described below. Table 4.2-1 summarizes the type of analysis conducted by hazard of concern.

1. **Historic Occurrences and Qualitative Analysis**—This analysis includes an examination of historic impacts to understand potential impacts of future events of similar size. In addition, potential impacts and losses are discussed qualitatively using best available data and professional judgement.

2. **Exposure Assessment**—This analysis involves overlaying available spatial hazard layers, or hazards with defined extent and locations, with assets in GIS to determine which assets are located in the impact area of the hazard. The analysis highlights which assets might be affected by the hazard. If the center of each asset is located in the hazard area, it is deemed exposed and potentially vulnerable to the hazard.

3. **Loss estimation**—The FEMA Hazus modeling software was used to estimate potential losses for the following hazards: flood, earthquake, and hurricane. In addition, an examination of historic impacts and an exposure assessment was conducted for these spatially-delineated hazards.

Table 4.2-1 Summary of Risk Assessment Analyses

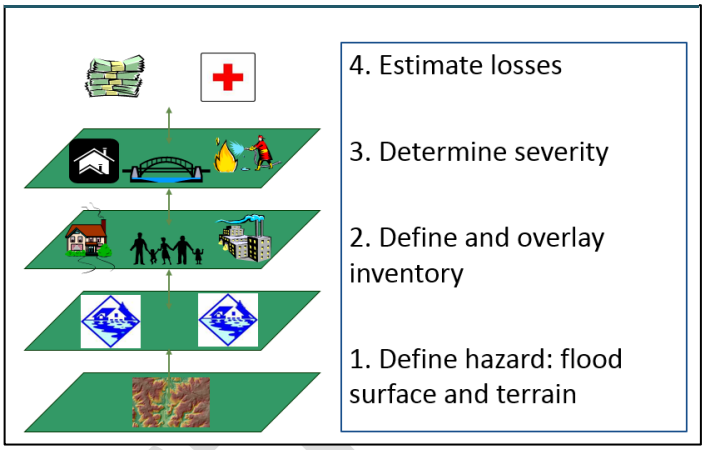
Hazard	Data Analyzed			
	Population	General Building Stock	Critical Facilities	New Development
Dam Failure	Q	Q	Q	Q
Disease Outbreak	Q	Q	Q	Q
Drought	Q	Q	Q	Q
Earthquake	H	H	H	Q
Flood	E, H	E, H	E, H	E
Geological	E	E	E	E
Hazardous Material Release	E	E	E	E
Hurricane and Tropical Storms	H	H	H	Q
Infestation and Invasive Species	Q	Q	Q	Q
Nor'Easter	Q	Q	Q	Q
Severe Weather	Q	Q	Q	Q
Severe Winter Weather	Q	Q	Q	Q
Wildfire	E	E	E	E

Notes: E = Exposure analysis; H = Hazus analysis; Q = Qualitative analysis

Hazards U.S. – Multi-Hazard (Hazus)

In 1997, FEMA developed a standardized model for estimating losses caused by earthquakes, known as Hazards U.S. or Hazus. Hazus was developed in response to the need for more effective national-, state-, and community-level planning and for identification of areas that face the highest risk and potential for loss. Hazus was expanded into a multi-hazard methodology, Hazus, with new models for estimating potential losses from wind (severe storms) and flood (riverine) hazards. Hazus is a Geographic Information System (GIS)-based software tool that applies engineering and scientific risk calculations, which have been developed by hazard and information technology experts, to provide defensible damage and loss estimates. These methodologies are accepted by FEMA and provide a consistent framework for assessing risk across a variety of hazards. The GIS framework also supports the evaluation of hazards and assessment of inventory and loss estimates for these hazards.

Hazus – How it works



Hazus uses GIS technology to produce damage reports, detailed maps and analytical reports that estimate a community's direct physical damage to building stock, critical facilities, transportation systems, and utility systems. To generate this information, Hazus uses default Hazus provided data for inventory, vulnerability, and hazards. This default data can be supplemented with local data to provide a more refined analysis. Damage reports can include induced damage (inundation, fire, threats posed by hazardous materials and debris) and direct economic and social losses (casualties, shelter requirements, economic impact) depending on the hazard and available local data. Hazus' open data architecture can be used to manage community GIS data in a central location. The use of this software also promotes consistency of data output now and in the future and standardization of data collection and storage. More information on Hazus is available at http://www.fema.gov/hazus.

In general, probabilistic analyses were performed to develop expected and estimated distribution of losses (mean return period losses) for the flood, seismic and wind hazards. The probabilistic model generates estimated damages and losses for specified return periods (e.g., 100- and 500-year). Table 4.2-2 displays the various levels of analyses that can be conducted using the Hazus software.

Table 4.2-2. Summary of Hazus Analysis Levels

Hazus Analysis Levels	
Level 1	Hazus provided hazard and inventory data with minimal outside data collection or mapping.
Level 2	Analysis involves augmenting the Hazus provided hazard and inventory data with more recent or detailed data for the study region, referred to as *local data*.
Level 3	Analysis involves adjusting the built-in loss estimation models used for the hazard loss analyses and is typically done in conjunction with the use of local data.

Dam Failure

A qualitative analysis was conducted for the dam failure hazard. The dam classifications and their status were obtained from NJDEP. For security reasons, these asset locations and downstream inundation due to a failure are not displayed on maps or discussed in this plan.

Disease Outbreak

A qualitative analysis was conducted using data from the County's COVID-19 resource website and research from the Centers for Disease Control and Prevention to review the County's risk to illnesses, including the most recent COVID-19 outbreak.

Drought

A qualitative analysis was conducted for the drought hazard. The United States Department of Agriculture (USDA) Census of Agriculture 2017 was used to estimate economic impacts. Information regarding the number of farms and farmland area was extracted from the report and summarized in the vulnerability assessment. Additional resources from the 2019 NJ HMP, NJDEP and the National Drought Mitigation Center (NDMC) were used to assess the potential impacts to the population from a drought event.

Earthquake

A probabilistic assessment was conducted for Sussex County for the 100- and 500-year mean return period (MRPs) events through a Level 2 analysis in Hazus to analyze the earthquake hazard and provide a range of loss estimates. The probabilistic method uses information from historic earthquakes and inferred faults, locations and magnitudes, and computes the probable ground shaking levels that may be experienced during a recurrence period by Census tract.

As noted in the Hazus Earthquake User Manual, "*Although the software offers users the opportunity to prepare comprehensive loss estimates, it should be recognized that uncertainties are inherent in any estimation methodology, even with state-of-the-art techniques. Any region or city studied will have an enormous variety of buildings and facilities of different sizes, shapes, and structural systems that have been constructed over a range of years under diverse seismic design codes. There are a variety of components that contribute to transportation and utility system damage estimations. These components can have differing seismic resistance."* However, Hazus' potential loss estimates are acceptable for the purposes of this HMP.

Groundwater was set at a depth of five (5) feet (default setting). The default assumption is a magnitude 7.0 earthquake for all return periods. In 2012, the NJDOT published a map of zip-codes in New Jersey and their associated soil classification. The soil classification system ranges from A to E, where A represents hard rock that reduces ground motions from an earthquake and E represents soft soils that amplify and magnify ground shaking and increase building damage and losses. These are referred to as National Earthquake Hazard Reductions Program (NEHRP) soils. The NJDOT map indicates Sussex County contains Class C and D soils. An associated soil layer with Class C and D soils was imported into Hazus to inform the seismic model.

Damage estimates are calculated for losses to buildings (structural and non-structural) and contents; structural losses include load carrying components of the structure, and non-structural losses include those to architectural, mechanical, and electrical components of the structure, such as nonbearing walls, veneer and finishes, HVAC systems, boils, etc. Although damages are estimated at the Census tract level, results were presented at the municipal level. Since there are multiple Census tracts that contain more than one jurisdiction, an area analysis was used to extract the percent of each tract that falls within individual jurisdictions. The percentage was multiplied against the results calculated for each tract and summed for each jurisdiction. For example, two municipalities are located within one census tract. The total replacement cost value of Municipality A is 90% of the total census tract replacement cost value, while Municipality B is 10% of the total value. Therefore, 90% of the losses for the census tract will be applied to Municipality A, and 10% will be applied to Municipality B.

Flood

The 1- and 0.2-percent annual chance flood events were examined to evaluate Sussex County's risk to the flood hazard. These flood events are generally those considered by planners and evaluated under federal programs such as the NFIP.

The following data was used to evaluate exposure and determine potential future losses:

- The effective Sussex County FEMA Digital Flood Insurance Rate Maps (DFIRMs) dated September 2011.
- The 1-percent annual chance flood depth grid generated for the 2016 Sussex County HMP which was generated using a DEM from the NJ Office of Information Technology and the base flood and cross-section elevations for the detailed study areas. The depth grid was integrated into the Hazus riverine flood model used to estimate potential losses for the 1-percent annual chance flood event.

To estimate exposure to the 1-percent- and 0.2-percent annual chance flood events, the asset inventories (population, building stock, critical facilities, and new development) were overlaid on the 2011 DFIRM. Asset centroids that intersected the flood boundaries were totaled to estimate the building replacement cost value and population located in the FEMA delineated floodplain.

A Level 2 Hazus riverine flood analysis was performed to estimate potential future loss. Both the critical facility and building inventories were formatted to be compatible with Hazus and its Comprehensive Data Management System (CDMS) and integrated into Hazus. The Hazus riverine flood model was run to estimate potential losses in Sussex County for the 1-percent annual chance flood event. A user-defined analysis was also performed for the building stock. Buildings located in the floodplain were imported as user-defined facilities to estimate potential losses at the structural level. Hazus calculated the estimated potential losses to the population (default 2010 U.S. Census data across dasymetric blocks), potential damages to the general building stock, and potential damages to critical facility inventories based on the depth grids generated and the default Hazus damage functions in the flood model.

Geological

An exposure assessment was conducted using steep slope and carbonate layers to determine the County's risk to the geologic hazard. Steep slopes are an indication of where slides may occur and carbonate soils may be prone to subsidence. Based on the Highlands NJ Council's Steep Slope Protection Area classifications, steep slopes are considered to be greater than 15-percent. A steep slope layer was created using NJ DEP contour lines layer. The surface slope was calculated between the contour lines and slopes greater than 15-percent were selected. To determine what assets are exposed to steep slopes and carbonate rock, the County's assets were overlaid with these hazard areas. Assets with their centroid located in the hazard area(s) were totaled to estimate the number (or count) and replacement cost values exposed to a hazard event.

Resources from the New Jersey Geological and Water Survey and 2014 US Geological Survey (USGS) were also referenced to assess potential impacts to the County.

Hazardous Material Release

An exposure analysis was conducted for the County's assets (population, building stock, critical facilities, and new development) using a radius around potential HazMat incident sites as follows: exposure within one mile of 2019 NJDOT railways, exposure within one mile of 2020 EPA Superfund and TRI Sites, and within 50-miles of the Indian Point Energy Center in New York State. Assets with their centroid located in the hazard area were totaled to estimate the totals and values potentially vulnerable if a hazardous materials release should occur.

Hurricane/Severe Storm

A Hazus analysis was performed to analyze the potential future wind losses associated with the 100- and 500-year MRP events. The probabilistic Hazus hurricane model activates a database of thousands of potential storms that have tracks and intensities reflecting the full spectrum of Atlantic hurricanes observed since 1886 and identifies those with tracks associated with Sussex County. Hazus contains data on historic hurricane events and wind speeds. It also includes surface roughness and vegetation (tree coverage) maps for the area. Surface roughness and vegetation data support the modeling of wind force across various types of land surfaces. Default demographic and updated building and critical facility inventories in Hazus were used for the analysis. Although damages are estimated at the census tract level, results were presented at the municipal level. Since there are multiple census tracts that contain more than one jurisdiction, a density analysis was used to extract the percent of building structures that fall within each tract and jurisdiction. The percentage was multiplied against the results calculated for each tract and summed for each jurisdiction.

Infestations and Invasive Species

A qualitative assessment was conducted to analyze infestation and invasive species on the County. Resources from the USDA Forest Service, New Jersey Department of Agriculture, and NJDEP were referenced to assess the potential impacts to the County's assets.

Nor'Easter

A qualitative assessment was conducted for the Nor'Easter hazard. The Hazus model's wind speeds and associated losses may be used as a reference for Nor'Easter wind impacts. Research from the National Weather Service, National Climatic Data Center, and Office of the New Jersey State Climatologist were used to assess the nature of Nor'Easters and their impact on the County.

Severe Storm

A qualitative assessment was performed to analyze the impacts of severe storm events. Data and studies from the Storm Prediction Center, FEMA, and National Weather Service were analyzed in order to measure the vulnerability of the County to thunderstorms, lightning, hailstorms, windstorms, tornadoes, and extreme temperatures.

Severe Winter Storm

All of Sussex County is exposed and vulnerable to the winter storm hazard. In general, structural impacts include damage to roofs and building frames, rather than building content. Current modeling tools are not available to estimate specific losses for this hazard. A percentage of the custom-building stock structural replacement cost value was utilized to estimate damages that could result from winter storm conditions (i.e., 1-percent, 5-percent, and 10-percent of total replacement cost value). Given professional knowledge and currently available information, the potential losses for this hazard are considered to be overestimated; hence, providing a conservative estimate for losses associated with winter storm events.

Wildfire

The NJFFS uses Wildfire Fuel Hazard data to assign wildfire fuel hazard rankings across the State. This data, developed in 2009, is based upon NJDEP's 2002 Land Use/Land Cover datasets and NJDEP's 2002 10-meter Digital Elevation Grid datasets. For the wildfire hazard, the NJFFS Wildfire Fuel Hazard "extreme', 'very high' and 'high' areas are identified as the wildfire hazard area. The defined hazard area was overlaid upon the asset data (population, building stock, critical facilities and potential new development) to estimate the exposure to each hazard.

Asset data (population, building stock, critical facilities, and new development) were used to support an evaluation of assets exposed and potential impacts and losses associated with this hazard. To determine what assets are exposed to wildfire, the County's assets were overlaid with the hazard area. Assets with their centroid located in the hazard area were totaled to estimate the totals and values exposed to a wildfire event.

Considerations for Mitigation and Next Steps

- All Hazards
  - Create an updated user-defined general building stock dataset using up-to-date parcels, footprints, and RS Means values.
  - Utilize updated and current demographic data. If 2020 U.S. Census demographic data is available at the U.S. Census block level during the next plan update, use the census block estimates and residential structures for a more precise distribution of population, or the current American Community Survey 5-Year Estimate populations counts at the Census tract level.
- Dam Failure
  - Utilize dam failure inundation areas to estimate potential losses.
- Disease Outbreak
  - As more information has been collected about COVID-19, future assessments should consider adding in an evaluation of how the County responded to the pandemic, identify critical facilities with vulnerabilities/limitations to respond effectively, and major transit routes connecting the community to facilities that help treat or vaccinate patients impacted by the pandemic.
- Earthquake
  - Gather more detailed NEHRP soil data to perform an earthquake exposure analysis
  - Identify unreinforced masonry in critical facilities and privately-owned buildings (i.e., residences) by accessing local knowledge, tax assessor information, and/or pictometry/orthophotos. These buildings may not withstand earthquakes of certain magnitudes and plans to provide emergency response/recovery efforts at these properties can be developed.
- Extreme Temperature
  - Track extreme temperature data for injuries, deaths, shelter needs, pipe freezing, agricultural losses, and other impacts to determine distributions of most at risk areas.
- Flood
  - The general building stock inventory can be updated to include attributes regarding first floor elevation and foundation type (basement, slab on grade, etc.) to enhance loss estimates.
  - Conduct a Hazus loss analysis for more frequent flood events (e.g., 10 and 50-year flood events).
  - Continue to expand and update urban flood areas to further inform mitigation.
  - As more current FEMA floodplain data become available (i.e., DFIRMs), update the exposure analysis and generate a more detailed flood depth grid that can be integrated into the current Hazus version.
- Geological Hazards
  - A pilot study conducted in Schenectady County, NY (Landslide Susceptibility – A Pilot Study of Schenectady County, NY) provided a detailed methodology for delineating high-risk landslide areas. This study looked at a variety of environmental characteristics including slope and soil conditions to determine areas at risk to landslide. To coincide with the methodology of that study, the generated slopes were categorized into five classes: 0%-2%; 3%-7%; 8%-15%; 16%-25%; Greater than 25%. Should the County determine the need for a more detailed assessment of risk, it could determine steep slope by other percent categorizations. Additional

environmental and soil characteristics used in the Schenectady County plan can be collected and used to follow the methodology used to further delineate the County's most at risk areas.

- Hurricane
  - General building stock inventory can be updated to include attributes regarding protections against strong winds, such as hurricane straps, to enhance loss estimates.
- Severe Winter Storm
  - If available for the region, obtain average snowfall distributions to determine if various areas in the County have historically received higher snowfalls and may continue to be more susceptible to higher snowfalls and snow loads on the building stock and critical facilities and infrastructure.
- Wildfire
  - General building stock inventory can be updated to include attributes such as roofing material or fire detection equipment.

4.2.3 DATA SOURCE SUMMARY

Table 4.2-3 summarizes the data sources used for the risk assessment for this plan.

Table 4.2-3. Risk Assessment Data Documentation

Data	Source	Date	Format
Population data	U.S. Census Bureau; American Community Survey 5-Year Estimates	2010; 2014-2018	Digital (GIS) format
Building Inventory	Sussex Parcel Data, MOD-IV, Tetra Tech	2020; 2018	Digital (GIS) format
Critical facilities	Sussex Planning Partnership and County Jurisdictions	2020	Digital (GIS) format
Digitized Effective FIRM maps	FEMA	2011	Digital (GIS) format
Digital Elevation Model	NJOIT	2014	Digital (GIS) format
Road and Rail Network	NJDOT	2017; 2019	Digital (GIS) format
Carbonate Hazard Area	USGS	2014	Digital (GIS) format
EPA Superfund and TRI Sites	US EPA	2020	Digital (GIS) format
New Development Data	Sussex County Planning Partnership	2020	Digital (GIS) Format
Wildfire Fuel Hazard	NJDEP/NJFFS	2009	Digital (GIS) format
NEHRP soils by zip-code	NJDOT	2012	Image
Depth Grid	New Jersey State HMP	2014	Digital (GIS) format
Contour Lines	USGS/NJ DEP	1999	USGS Line Graphs converted by NJ DEP to Digital (GIS) format

DEP *Department of Environmental Protection*
DFIRM *Digital Flood Insurance Rate Map*
EPA *Environmental Protection Agency*
FEMA *Federal Emergency Management Agency*
FIRM *Flood Insurance Rate Map*
GIS *Geographic Information System*
NJDEP *New Jersey Department of Environmental Protection*
NJDOT *New Jersey Department of Transportation*
NJFFS *New Jersey Forest Fire Service*
NJOIT *New Jersey Office of Information Technology*
USDA *United States Department of Agriculture*
USGS *United States Geological Survey*

Limitations

For this risk assessment, the loss estimates, exposure assessments, and hazard-specific vulnerability evaluations rely on the best-available data and methodologies. Uncertainties are inherent in any loss estimation methodology and arise in part from incomplete scientific knowledge concerning natural hazards and their effects on the built environment. Uncertainties also result from the following:

1) Approximations and simplifications necessary to conduct such a study.
2) Incomplete or dated inventory, demographic, or economic parameter data.
3) The unique nature, geographic extent, and severity of each hazard.
4) Mitigation measures already employed by the participating municipalities.
5) The amount of advance notice residents have to prepare for a specific hazard event.

These factors can result in a range of uncertainty in loss estimates, possibly by a factor of two or more; therefore, potential exposure and loss estimates are approximate. These results do not predict precise results and should be used to understand relative risk. Over the long term to assist in estimating potential losses, Sussex County will collect additional data and update and refine existing inventories.

Potential economic loss is based on the present value of the general building stock using best-available data. The county acknowledges significant impacts can occur to critical facilities and infrastructure as a result of these hazard events, causing great economic loss. However, monetized damage estimates to critical facilities and infrastructure, as well as economic impacts were not quantified and require more detailed loss analyses. In addition, economic impacts to industry, such as tourism and the real-estate market, were not analyzed.