4. RISK ASSESSMENT METHODOLOGY AND TOOLS

A risk assessment is the process of evaluating the potential loss of life, personal injury, and economic and property damage that could result from identified hazards. Identifying potential hazards and vulnerable assets allows planning personnel to address and reduce hazard impacts and allows emergency management personnel to establish early response priorities. Results of the risk assessment are used in subsequent mitigation planning processes, including determining and prioritizing mitigation actions that reduce each jurisdiction's risk from each hazard. Past, present, and future conditions must be evaluated to assess risk most accurately for the county and participating jurisdictions. The process focuses on the following elements:

- **Identify Hazards of Concern**—Use all available information to determine what types of hazards may affect a jurisdiction.

- **Profile Each Hazard**—Understand each hazard in terms of:
  - Extent—The potential severity of each hazard
  - Location—Geographic area most likely to be affected by the hazard
  - Previous occurrences and losses
  - Impacts of climate change
  - Probability of future hazard events

- **Assess Risk**—Use all available information to estimate to what extent populations and assets may be adversely affected by a hazard:
  - Determine vulnerability—Estimate the total number of assets in the jurisdiction that are likely to experience a hazard event if it occurs by overlaying hazard maps with the asset inventories.
  - Estimate potential impacts—Assess the impact of hazard events on the people, property, economy, and lands of the region, including estimates of the cost of potential damage or cost that can be avoided by mitigation.
  - Evaluate future changes that may affect vulnerability and impacts—Analyze how demographic changes, projected development and climate change impacts can alter current vulnerability and potential impacts.

The Passaic County risk assessment was updated using the following best-available information:

- A new building stock inventory was generated using 2019 Microsoft building footprints, tax assessor and parcel data from the New Jersey Office of Information Technology (NJOIT); and 2024 RSMeans cost adjustment values.

- 2020 Decennial Census population data and 2018-2022 American Community Survey 5-year population estimates were utilized.

- Critical facilities were updated and reviewed by the Planning Partnership and county jurisdictions.

- Lifelines were identified in the critical facility inventory to align with FEMA's community lifeline definition.

- FEMA's Hazus program was used to estimate potential impacts from the flood, wind, and seismic hazards.

- Best-available hazard data were used, as described in this section.

4.1 ASSET INVENTORIES

Passaic County assets were identified to assess potential vulnerability and impacts associated with the hazards of concern. The HMP update assesses vulnerability and potential hazard impacts for the following types of assets: population, buildings, critical facilities, community lifelines, the environment, and new development. Each asset type is described below. To protect individual privacy and the security of critical facilities, information on properties assessed is presented in aggregate, without details about specific individual properties.

4.1.1 Population

Statistics from the 2020 Decennial Census Population estimate and 2018-2022 American Community Survey (ACS) 5-year estimate were used to estimate the vulnerability of and potential impacts on the County's population. The Hazus model, which was used to estimate sheltering and injuries as part of the hazard analysis, contains 2020 U.S. Census data.

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

Population counts at the jurisdictional level were averaged among the residential structures in the county to estimate the population at the structure level. This provides a more precise distribution of population across the county compared to only using census block or census tract boundaries.

Vulnerable populations in Passaic County included in the risk assessment are children, elderly, population below the poverty level, non-English speaking individuals, and persons with a disability.

4.1.2 Buildings

A custom-building stock inventory was developed for Passaic County. The inventory was updated using the most current parcel data from NJOIT, in addition to the 2019 Microsoft Building Footprints. Parcel attributes provided in the associated files were used to further define each structure, such as year built, number of stories, occupancy class, and square footage. Attributes were assigned to the largest building footprint per parcel. Default assumptions were applied to the remaining structures. The centroid of each building footprint was used to estimate the building location.

Structural and content replacement cost values (RCVs) were calculated for each building using the available assessor data, the building footprint, and RSMeans 2024 values. RCV is the cost of returning a destroyed asset to its pre-damaged condition using present-day cost of labor and materials. Total RCV consists of both the structural cost to replace a building and the estimated value of contents of the building. The cost analysis used the following location factors based on zip code:

- Zip codes beginning in 070-071
  - Residential location factor = 1.15
  - Non-Residential location factor = 1.14
- Zip codes beginning in 074-075
  - Residential location factor = 1.14
  - Non-Residential location factor = 1.12

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The occupancy classes available in Hazus were condensed into the categories of residential, commercial, industrial, and other (agricultural, religious, governmental, and educational) to facilitate analysis and presentation of results. Residential loss estimates addressed both multi-family and single-family dwellings.

4.1.3 Critical Facilities and Community Lifelines

A critical facility inventory, which includes essential facilities, utilities, transportation features and user-defined facilities, was created by the Planning Partnership and county jurisdictions. The development involved a review for accuracy, additions, or deletions of new or moved critical assets, identification of backup power for each asset (if known) and whether the critical facility is considered a lifeline in accordance with FEMA's definition.

> 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).

4.1.4 Environment and Land Cover

Draft national data for 2020 from the New Jersey Department of Environmental Protection (NJDEP) was used to assess land cover in the county. Non-urban areas were categorized as agricultural, barren land, forest, rangeland, water, or wetlands. The built land use areas were defined as urban and include developed open space along with low, medium, and high intensity development.

4.1.5 New Development

New development in the planning area was defined as development that occurred over the last 5 years and development that is expected to occur over the next 5 years. Each jurisdiction was asked to provide a list by address of major development that has taken place within these timeframes. The location of new development projects was submitted via ArcGIS Survey123.

A geographic information system (GIS) analysis was conducted to determine hazard exposure of these development sites. Projects built on multiple parcels were assessed as one unit. If one parcel identified within the project boundary intersected a spatial hazard layer, the entire project was considered "exposed" to the hazard area of concern. The hazard vulnerability analysis results are presented as a table in each annex in Volume II.

4.2 METHODOLOGY

Passaic County used standardized tools, combined with local, state, and federal data and expertise to assess potential vulnerability and losses associated with hazards of concern. Three levels of analysis were used, depending upon the data available for each hazard:

- **Qualitative Review**—This analysis includes an examination of historical impacts to understand potential impacts of future events of similar size. Potential impacts and losses are discussed qualitatively using best-available data and professional judgment.
- **Vulnerability Analysis**—This analysis involves overlaying available spatial hazard layers, for hazards with defined locations, on asset mapping in GIS to determine which assets are located in the hazard area.

- **Loss Estimation**—The FEMA Hazus modeling software was used to estimate potential losses for the following hazards: flood, earthquake, and hurricane.

Table 4-1 summarizes the type of analysis conducted by hazard of concern.

Table 4-1. Summary of Risk Assessment Analyses

Hazard	Population	General Building Stock	Critical Facilities	New Development
Dam Failure	Q	Q	Q	Q
Drought	Q	Q	Q	Q
Extreme Temperature	Q	Q	Q	Q
Flood	V, L	V, L	V, L	V
Geological Hazards	V, L	V, L	V, L	V
Severe Weather	L	L	L	L
Severe Winter Weather	Q	Q	Q	Q
Wildfire	V	V	V	V

Notes: V = Vulnerability analysis; L = Loss estimation; Q = Qualitative analysis

4.2.1 Hazus

Hazus is a GIS-based software tool developed by FEMA that uses engineering and scientific risk calculations to estimate damage and loss. Its use is accepted by FEMA and provides a consistent framework for assessing risk across a variety of hazards. Hazus uses GIS technology to produce detailed maps and analytical reports that estimate direct physical damage to building stock, critical facilities, transportation systems and utility systems. To generate this information, Hazus uses default data for inventory, vulnerability, and hazards; this default data can be supplemented with local data to provide a more refined analysis. Table 4-2 lists the levels of analysis that can be conducted using the Hazus software depending on the hazard and inventory data provided.

Table 4-2. Summary of Hazus Analysis Levels

Level 1	Hazus provides hazard and inventory data with minimal outside data collection or mapping.
Level 2	Hazus-provided hazard and inventory data are augmented with more recent or detailed data for the study region, referred to as "local data"
Level 3	The built-in Hazus loss estimation models are adjusted for the hazard loss analyses, usually in conjunction with the use of local data.

Hazus damage reports can include induced damage (inundation, fire, threats posed by hazardous materials and debris) and direct economic and social losses (casualties, shelter requirements, and 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.

For this HMP, losses were estimated in Hazus using depth grids for the flood analysis and probabilistic (mean return period) analyses for hurricane wind and seismic hazards. The probabilistic model generates estimated damage and losses for specified return periods (e.g., 100- and 500-year).

4.2.2 Hazard-Specific Methodologies

Dam Failure

To assess the vulnerability of the county to dam failure and its associated impacts, a qualitative assessment was conducted.

Drought

All of Passaic County is at risk from the impacts of drought events. A qualitative analysis was conducted to assess the county's vulnerability to this hazard of concern and its associated impacts.

Extreme Temperatures

All of Passaic County is at risk from the impacts of extreme temperature events. A qualitative analysis was conducted to assess the county's vulnerability to this hazard of concern and its associated impacts.

Flood

The 1 percent and 0.2 percent annual chance flood events were examined to evaluate the county's risk from the flood hazard. The following data were used to evaluate vulnerability and determine potential future losses for this plan update:

- The Passaic County FEMA Effective Digital Flood Insurance Rate Map (DFIRM) dated April 17, 2020, with a latest LOMR of May 15, 2024, was used for the vulnerability analysis
- The flood depth grid from the 2020 hazard mitigation plan was used for loss estimation using Hazus. The previously developed flood depth grid was generated using the April 17, 2020, effective DFIRM flood data and a 10-foot resolution digital elevation model downloaded from the New Jersey Geographic Information Network (NJGIN) web portal.

To estimate vulnerability to the 1 percent and 0.2 percent annual chance flood events, the DFIRM flood boundaries were overlaid on the maps of updated assets (population, building stock, critical facilities, and new development). Assets that have a centroid within the flood boundaries were totaled to estimate the numbers and values vulnerable to the riverine flood hazard.

A Level 2 Hazus (v6.1) riverine flood analysis was performed to estimate flood losses for the 1 percent annual chance flood event. The critical facility and building inventories were formatted to be compatible with Hazus, and the Hazus riverine flood model was run to estimate losses. Inventoried buildings were imported as user-defined facilities to estimate potential losses at the structural level. Hazus estimated the following potential losses based on the depth grids generated and the default Hazus damage functions in the flood model:

- Impacts on the population (default 2020 U.S. Census data)
- Potential damage to the general building stock
- Amounts of flood-generated debris

Additionally, SLOSH (Sea, Lake, and Overland Surges from Hurricanes) Categories 1 through 4 were analyzed to evaluate the county's risk from storm surge. SLOSH data from NOAA (2022) was overlaid on the maps of updated assets (population, building stock, critical facilities, and new development). Assets that have a centroid within the SLOSH boundaries were totaled to estimate the numbers and values vulnerable to the SLOSH hazard.

Geological Hazards

To estimate the County's risk to the geologic hazard, the following hazard datasets were analyzed:

- NEHRP D&E Soils—Sourced from NJGWS (2015)
- Carbonate Rock—Sourced from NJDEP (2023)
- Landslide Classes A and B—Sourced from NJGWS (2015)
- Liquefaction Class 4—sourced from NJGWS (2015)

To determine what assets are vulnerable to the geologic hazard, these datasets were overlaid on the maps of updated assets (population, building stock, critical facilities, and new development). Assets that have a centroid within the hazard area boundaries were totaled to estimate the numbers and values vulnerable to the geological hazards.

The risk assessment evaluated the 500-year and 2,500-year mean return period (MRP) earthquake events through a Level 2 analysis in Hazus to estimate losses from the earthquake hazard. The probabilistic method uses information from historic earthquakes and inferred faults, locations and magnitudes to compute the probable ground shaking levels during a seismic event by census tract.

Groundwater was set at a depth of 5 feet (default setting). The default assumption for all return periods is a magnitude 7.0 earthquake. A density analysis was used to extract the percent of building structures that fall within each census tract and jurisdiction. The percentage was multiplied against the results calculated for each tract and summed to provide results for each municipality.

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, boilers, etc.

Severe Weather

A Hazus analysis was performed to analyze wind damage for the 100- and 500-year MRP hurricane wind 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 in or near Passaic County. Hazus contains data on historical hurricane events and wind speeds. It also includes surface roughness and vegetation (tree coverage) maps for the area, which 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. Because 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 to provide results for each jurisdiction.

Severe Winter Weather

All of Passaic County is at risk from the impacts of severe winter weather. A qualitative analysis was conducted to assess the county's vulnerability to this hazard of concern and its associated impacts.

Wildfire

Wildfire risk data, sourced from the New Jersey Forest Fire Service (NJFFS 2009) was referenced to delineate extreme, very high and high wildfire hazard areas. To determine what assets are exposed to wildfire, the NJFFS GIS data were overlaid on maps of updated assets (population, building stock, critical facilities, and new development). Assets with their centroid located in the hazard area were totaled to estimate the numbers and values vulnerable to the wildfire hazard.

4.3 RATING PROBABILITY OF OCCURRENCE

Based on records of previous hazard events and consideration of potential future changes that could affect the frequency of future events, the risk assessment for each hazard assigns a rating for the probability of occurrence of that hazard in the future. These ratings were assigned as follows:

- Unlikely—not likely to occur or less than 1% annual chance of occurring
- Rare—between 1 and 10% annual chance of occurring
- Occasional—between 10 and 100% annual chance of occurring
- Frequent—100% chance occurring; occurs multiple times a year

4.4 DATA SOURCE SUMMARY

Table 4-3 summarizes the data sources used for the risk assessment for this plan.

4.5 LIMITATIONS

Uncertainties inherent in loss estimation methodologies arise from the following:

- Incomplete scientific knowledge concerning natural hazards and their effects on the built environment
- Approximations and simplifications necessary to conduct a study
- Incomplete or dated inventory, demographic, or economic parameter data
- The unique nature, geographic extent, and severity of each hazard
- Mitigation measures already employed by the participating jurisdictions
- The amount of advance notice residents have to prepare for a specific hazard event
- Uncertainty of climate change projections

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

Potential economic loss is based on the present value of the general building stock using best-available data. The county acknowledges significant impacts may 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, and 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.

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Table 4-3. Risk Assessment Data Documentation

Data	Source	Date	Format
Population	U.S. Census 2010, 2020, American Community Survey 5-Year Estimates 2022	2010, 2020, 2022	CSV Format
Building Inventory	NJOIT, Microsoft 2019, RSMeans 2024	n.d., 2019, 2024	Digital (GIS) Format
Critical Facilities	Passaic County 2020 HMP, Passaic County 2024, NJGIN 2017, 2021, 2022, HIFLD 2017, 2018, 2022, 2023, Passaic County Dept. of Planning & Economic Development 2024	2020, 2024, 2017, 2021, 2022, 2017, 2018, 2022, 2023, 2024	Digital (GIS) Format
Land Use	NJDEP, DOIT, BGIS 2020	2020	Digital (GIS) Format
Digital Elevation Model	NJGIN (10ft RES)	n.d.	Digital (GIS) Format
Flood	FEMA 2020 Effective DFIRM, latest LOMR 5/15/24	2020, 2024	Digital (GIS) Format
NEHRP Soils	NJGWS 2015	2015	Digital (GIS) Format
Liquefaction	NJGWS 2015	2015	Digital (GIS) Format
Carbonate Rock	NJDEP 2023	2023	Digital (GIS) Format
Landslide Areas	NJGWS 2015	2015	Digital (GIS) Format
SLOSH	NOAA 2022	2022	Digital (GIS) Format
Wildfire	NJFFS 2009	2009	Digital (GIS) Format
New Development	Passaic County Planning Partnership 2024	2024	Digital (GIS) Format

Notes: BGIS = Bureau of GIS; DOIT = Department of Information Technology; FEMA = Federal Emergency Management Agency; HIFLD = Homeland Infrastructure Foundation-Level Data; NJDEP = New Jersey Department of Protection; NJGIN = New Jersey Geographic Information Network; NJGWS = New Jersey Geological and Water Survey; NJOIT = New Jersey Office of Information Technology; NOAA = National Oceanic and Atmospheric Administration

4.6 CONSIDERATIONS FOR MITIGATION AND NEXT STEPS

The following should be considered to enhance the risk assessment for the next plan update:

- All hazards
  - Create an updated user-defined general building stock dataset using up-to-date parcels, footprints, and RSMeans values.
  - Utilize updated and current demographic data.
  - Integrate evacuation route data that is currently being developed.
- Dam failure
  - Leverage current dam failure inundation data to perform a quantitative assessment
- 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
  - Update the general building stock inventory 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).
- Conduct a repetitive loss area analysis.
- 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 vulnerability analysis and generate a more detailed flood depth grid that can be integrated into the current Hazus version.

- Geological hazards
  - Leverage updated data for NEHRP soils, liquefaction, landslide and carbonate rock hazards
- Severe weather
  - Update the general building stock inventory to include attributes regarding protection against strong winds, such as hurricane straps, to enhance loss estimates.
- Severe winter weather
  - If available for the region, obtain average snowfall distributions to determine if various areas in the county have historically received higher snowfalls and might 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, fire detection equipment, or distance to fuels as another measure of vulnerability