4.1 METHODOLOGY AND TOOLS

This section describes the methodology and tools used to support the risk assessment process.

Methodology

The risk assessment process used for this Plan is consistent with the process and steps presented in FEMA 386-2, State and Local Mitigation Planning How-to-Guide, Understanding Your Risks – Identifying Hazards and Estimating Losses (FEMA, 2001). This process identifies and profiles the hazards of concern and assesses the vulnerability of assets (population, structures, critical facilities and the economy) at risk in the community. A risk assessment provides a foundation for the community's decision makers to evaluate mitigation measures that can help reduce the impacts of a hazard when one occurs (Section 5.4 of this plan).

Step 1: The first step of the risk assessment process is to identify the hazards of concern. FEMA's current regulations only require an evaluation of natural hazards. Natural hazards are natural events that threaten lives, property, and many other assets. Often, natural hazards can be predicted, where they tend to occur repeatedly in the same geographical locations because they are related to weather patterns or physical characteristics of an area.

Step 2: The next step of the risk assessment is to prepare a profile for each hazard of concern. These profiles assist communities in evaluating and comparing the hazards that can impact their area. Each type of hazard has unique characteristics that vary from event to event. That is, the impacts associated with a specific hazard can vary depending on the magnitude and location of each event (a hazard event is a specific, uninterrupted occurrence of a particular type of hazard). Further, the probability of occurrence of a hazard in a given location impacts the priority assigned to that hazard. Finally, each hazard will impact different communities in different ways, based on geography, local development, population distribution, age of buildings, and mitigation measures already implemented.

Steps 3 and 4: To understand risk, a community must evaluate what assets it possesses and which assets are exposed or vulnerable to the identified hazards of concern. Hazard profile information combined with data regarding population, demographics, general building stock, and critical facilities at risk, located in Section 4, prepares the community to develop risk scenarios and estimate potential damages and losses for each hazard.

Tools

To address the requirements of DMA 2000 and better understand potential vulnerability and losses associated with hazards of concern, the Lehigh Valley used standardized tools, combined with local, state, and federal data and expertise to conduct the risk assessment. Our standardized tools used to support the risk assessment are described below.

Hazards U.S. – Multi-Hazard (HAZUS-MH)

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 the need to identify areas that face the highest risk and potential for loss. HAZUS was expanded into a multi-hazard methodology, HAZUS-MH with new models for estimating potential losses from wind (hurricanes) and flood (riverine and coastal) hazards. HAZUS-MH is a Geographic Information System (GIS)-based software tool that applies engineering and scientific risk calculations that 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-MH uses GIS technology to produce 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-MH uses default HAZUS-MH 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, and economic impact) depending on the hazard and available local data. HAZUS-MH's 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. The guidance Using HAZUS-MH for Risk Assessment: How-to Guide (FEMA 433) was used to support the application of HAZUS-MH for this risk assessment and plan. More information on HAZUS-MH is available at http://www.fema.gov/plan/prevent/hazus/index.shtm.

In general, probabilistic analyses were performed to develop estimates of long-term average losses (annualized losses) for the earthquake and wind hazards, as well as an expected/estimated distribution of losses (mean return period losses) for the earthquake, flood and wind hazards. The probabilistic hazard generates estimates of damage and loss for specified return periods. For annualized losses, HAZUS-MH 2.1 calculates the maximum potential annual dollar loss resulting from various return periods averaged on a "per year" basis. It is the summation of all HAZUS-supplied return periods (e.g., 10, 50, 100, 200, 500) multiplied by the return period probability (as a weighted calculation). In summary, the estimated cost of a hazard (earthquake and wind) each year is calculated.

Custom methodologies in HAZUS-MH 2.1 were used to assess potential exposure and losses associated with hazards of concern for the Lehigh Valley:

- Inventory: The default demographic data in HAZUS-MH 2.1, based on the 2000 U.S. Census, was used for analysis. However, the 2010 U.S. Census data was used to estimate hazard exposure at the municipal level.

  The default building inventory in HAZUS-MH 2.1 was updated and replaced at the Census-block level with a custom building inventory developed for the Lehigh Valley. The custom building inventory was developed using detailed structure-specific assessor data, as well as parcel and structure location information. Structural and content replacement cost values were calculated for each building utilizing available assessor data and RSMeans 2011 values. An updated critical facility inventory was also developed and incorporated into HAZUS-MH replacing the default essential facility (police, fire, schools, etc.) and utility inventories.

  The occupancy classes available in HAZUS-MH 2.1 were condensed into the following categories (residential, commercial, industrial, agricultural, religious, government, and educational) to facilitate the analysis and the presentation of results. Residential loss estimates address both multi-family and single-family dwellings.

  The critical facility inventory (essential facilities, utilities, transportation features and user-defined facilities) was updated for the earthquake, flood and wind hazard models. This comprehensive inventory was developed by gathering input from numerous sources including Lehigh County GIS, Northampton County GIS, Northampton County's 911 database, participating municipalities and input from the Steering Committee.

The 'user-defined facilities' category includes all assets that the Lehigh Valley plan participants deemed critical to include in the inventory and that do not fit within a pre-defined HAZUS-MH facility category. These facilities include shelters, senior care facilities and municipal-owned buildings.

- Earthquake: HAZUS-MH 2.1 was used to evaluate the Lehigh Valley's risk to the seismic hazard. A probabilistic assessment was performed to analyze the earthquake hazard losses (annualized losses and 100-, 500- and 2,500-year mean return period [MRP] losses). 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.

  The National Earthquake Hazard Reduction Program (NEHRP) developed five soil classifications that impact the severity of an earthquake. 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. NEHRP soil classifications were not available for the Lehigh Valley at the time of this analysis. Soils were classified as NEHRP soil type D across the Lehigh Valley as a conservative approach to this risk assessment. Groundwater was set as at a depth of five-feet (default setting). Damages and loss due to liquefaction, landslide or surface fault rupture were not included in this analysis.

  Default demographic and the updated general building stock and critical facility inventory data in HAZUS-MH 2.1 were used for the earthquake analysis.

- Flood: The 1% and 0.2% chance flood events were examined to evaluate the Lehigh Valley's risk and vulnerability to the riverine flood hazard. These flood events are generally those considered by planners and evaluated under federal programs such as the NFIP.

  A Level 2 HAZUS-MH riverine flood analysis was performed. The Lehigh County FEMA Digital Flood Insurance Rate Maps (DFIRMs) dated July 2004 and the Northampton County preliminary DFIRMs dated 2011 were used to evaluate exposure and determine potential future losses. Please note the Northampton County 2011 DFIRMs, although considered preliminary are the best available data and used for this plan.

  A 10-foot depth grid was developed for the 1% flood event for the Lehigh Valley. Using Geographic Information System (GIS) tools and the best available data including the DFIRM database for both Counties and the 2008 3.2-foot Light Detection and Ranging (LiDAR) Bare Earth Digital Elevation Model (DEM) available from Pennsylvania Spatial Data Access – the Pennsylvania Geospatial Data Clearinghouse, a flood depth grid was generated and integrated into the HAZUS-MH riverine flood model.

  To estimate exposure to the 1% and 0.2% flood events, the DFIRM flood boundaries, updated building and facility inventories and 2010 U.S. Census population data were used. The HAZUS-MH 2.1 riverine flood model was run to estimate potential losses for the Lehigh Valley for the 1% flood event. HAZUS-MH 2.1 calculated the estimated potential losses to the population (default 2000 U.S. Census data) and potential damages to the updated general building stock and critical facility inventories based on the depth grid generated and the default HAZUS damage functions in the flood model.

- Hurricane/Wind: A HAZUS-MH 2.1 probabilistic analysis was performed to analyze the wind hazard losses for the Lehigh Valley. The probabilistic hurricane hazard 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 the Planning Area. HAZUS-MH 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. Annualized losses and the 100- and 500-year MRPs were examined for the wind/severe storm hazard. Default demographic and updated building and critical facility inventories in HAZUS-MH 2.1 were used for the analysis.

- Other Hazards: GIS tools including HAZUS-MH were used to evaluate other hazards (i.e., wildfire, landslide, etc.), as feasible. For many of the hazards evaluated in this risk assessment, historic data are not adequate to model future losses at this time. However, HAZUS-MH can map hazard areas and calculate exposures if geographic information on the locations of the hazards and inventory data are available. For some of the other hazards of concern, areas and inventory susceptible to specific hazards were mapped and exposure was evaluated to help guide mitigation efforts discussed in Section 5.4. For other hazards, a qualitative analysis was conducted using the best available data and professional judgment.

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 affects 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 and 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, the Lehigh Valley will collect additional data to assist in developing refined estimates of vulnerabilities to natural and non-natural hazards.