

4.3.4 Flood

This section provides a profile and vulnerability assessment for the flood hazard. Floods are one of the most common natural hazards in the U.S. and are the most prevalent type of natural disaster occurring in Pennsylvania. Pennsylvania has more miles of streams than any other state and leads the U.S. in flood-related losses. Over 94-percent of the State’s municipalities have been designated as flood-prone areas. Both seasonal and flash floods have been the cause of millions of dollars in annual property damages, loss of lives, and disruption of economic activities (PEMA, 2010).

The FEMA definition for flooding is “a general and temporary condition of partial or complete inundation of two or more acres of normally dry land area or of two or more properties from the overflow of inland or tidal waters or the rapid accumulation of runoff of surface waters from any source” (FEMA, Date Unknown).

Most floods fall into three categories: riverine, coastal and shallow (FEMA, 2005). Other types of floods may include ice-jam floods, alluvial fan floods, dam failure floods, and floods associated with local drainage or high groundwater (as indicated in the previous flood definition). For the purpose of this HMP and as deemed appropriate by the Steering Committee, riverine, flash, ice jam, dam failure and stormwater flooding are the main flood types of concern for the Lehigh Valley. These types of floods are further discussed below.

Riverine Floods – Riverine floods are the most common flood type and occur along a channel. Channels are defined features on the ground that carry water through and out of a watershed. They may be called rivers, creeks, streams or ditches. When a channel receives too much water, the excess water flows over its banks and inundates low-lying areas. These floods usually occur after heavy rains, heavy thunderstorms, or snowmelt, and can be slow or fast-rising, and generally develop over a period of hours to days (FEMA, Date Unknown; The Illinois Association for Floodplain and Stormwater Management, 2006).

Flash Floods – According to the National Weather Service (NWS), flash floods are a rapid and extreme flow of high water into a normally dry area, or a rapid water level rise in a stream or creek above a predetermined flood level, beginning within six hours of the causative event (e.g., intense rainfall, dam failure, ice jam) (NWS, 2009).

Flash floods can occur very quickly and with very little warning. This type of flood can be deadly because it produces rapid rises in water levels and has devastating flow velocities. Urban areas are more susceptible to flash floods because a high percentage of the surface area is impervious (LVPC, 2006).

However, the actual time threshold may vary in different parts of the country. Ongoing flooding can intensify to flash flooding in cases where intense rainfall results in a rapid surge of rising flood waters (NWS, 2005). Flash floods often have a dangerous wall of roaring water that carries rocks, mud, and other debris and can sweep away most things in its path. They usually result from intense storms dropping large amounts of rain within a brief period with little or no warning; can reach their peak in only a few minutes. They normally occur in the summer during the thunderstorm season. The most severe flooding conditions usually occur when direct rainfall is augmented by snowmelt. If the soil is saturated or frozen, stream flow may increase due to the inability of the soil to absorb additional precipitation (FEMA, Date Unknown).

Ice Jam Floods - An ice jam is an accumulation of ice that acts as a natural dam and restricts flow of a body of water. Ice jams occur when warm temperatures and heavy rains cause rapid snow melt. The

melting snow, combined with the heavy rain, causes frozen rivers to swell. The rising water breaks the ice layers into large chunks, which float downstream and often pile up near narrow passages and obstructions (bridges and dams). Ice jams may build up to a thickness great enough to raise the water level and cause flooding (NESEC, Date Unknown; U.S. Army Corps of Engineers [USACE], 2002).

There are two different types of ice jams: freeze-up and breakup. Freeze-up jams occur in the early to mid-winter when floating ice may slow or stop due to a change in water slope as it reaches an obstruction to movement. Breakup jams occur during periods of thaw, generally in late winter and early spring. The ice cover breakup is usually associated with a rapid increase in runoff and corresponding river discharge due to a heavy rainfall, snowmelt or warmer temperatures (USACE, 2002).

Dam Failure Floods – A dam is an artificial barrier that has the ability to impound water, wastewater, or any liquid-borne material for the purpose of storage or control of water (FEMA, 2010). Dams are man-made structures built across a stream or river that impound water and reduce the flow downstream (FEMA, 2003). They are built for the purpose of power production, agriculture, water supply, recreation, and flood protection. Dam failure is any malfunction or abnormality outside of the design that adversely affect a dam’s primary function of impounding water (FEMA, 2004). Dams can fail for one or a combination of the following reasons:

- Overtopping caused by floods that exceed the capacity of the dam (inadequate spillway capacity);
- Prolonged periods of rainfall and flooding;
- Deliberate acts of sabotage (terrorism);
- Structural failure of materials used in dam construction;
- Movement and/or failure of the foundation supporting the dam;
- Settlement and cracking of concrete or embankment dams;
- Piping and internal erosion of soil in embankment dams;
- Inadequate or negligent operation, maintenance and upkeep;
- Failure of upstream dams on the same waterway; or
- Earthquake (liquefaction / landslides) (FEMA, 2009).

Flooding can occur when a dam fails or breaks, producing effects similar to flash floods. Areas that are most susceptible to the effects of floods are low-lying areas that are near water or downstream from a dam (FEMA, 2006).

Flooding due to dam failure is addressed in Section 4.3.14 of this plan.

4.3.4.1 Location and Extent

Flooding in Pennsylvania is typically associated with abnormally high and intense rainfall amounts. It can also be caused by sudden snowmelt, landslides, or dam failures. In Pennsylvania, flooding usually occurs in the summer; however, flooding has occurred during the winter months as well (LVPC, 2006).

Flooding is the most significant natural hazard in the Lehigh Valley. Two major rivers, the Lehigh and Delaware, are located within the Lehigh Valley, along with the tributaries of these two rivers. The Lehigh River essentially splits the Lehigh Valley in half and it is a tributary to the Delaware River. The Delaware River flows along the eastern portion of Northampton County and eventually flows into the Atlantic Ocean. In Lehigh and Northampton Counties, all municipalities have areas prone to flooding along streams and rivers (LVPC, 2006).

Floodplains are found in lowlands, adjacent to rivers, streams, creeks, lakes, or other bodies of water that become inundated during a flood. The size of a floodplain is described by the recurrence interval of a

given flood. A floodplain is associated with a flood that has a 1-percent chance of occurring in a given year, and is smaller than the floodplain associated with a flood that has a 0.2-percent annual chance of occurring (PEMA, 2010).

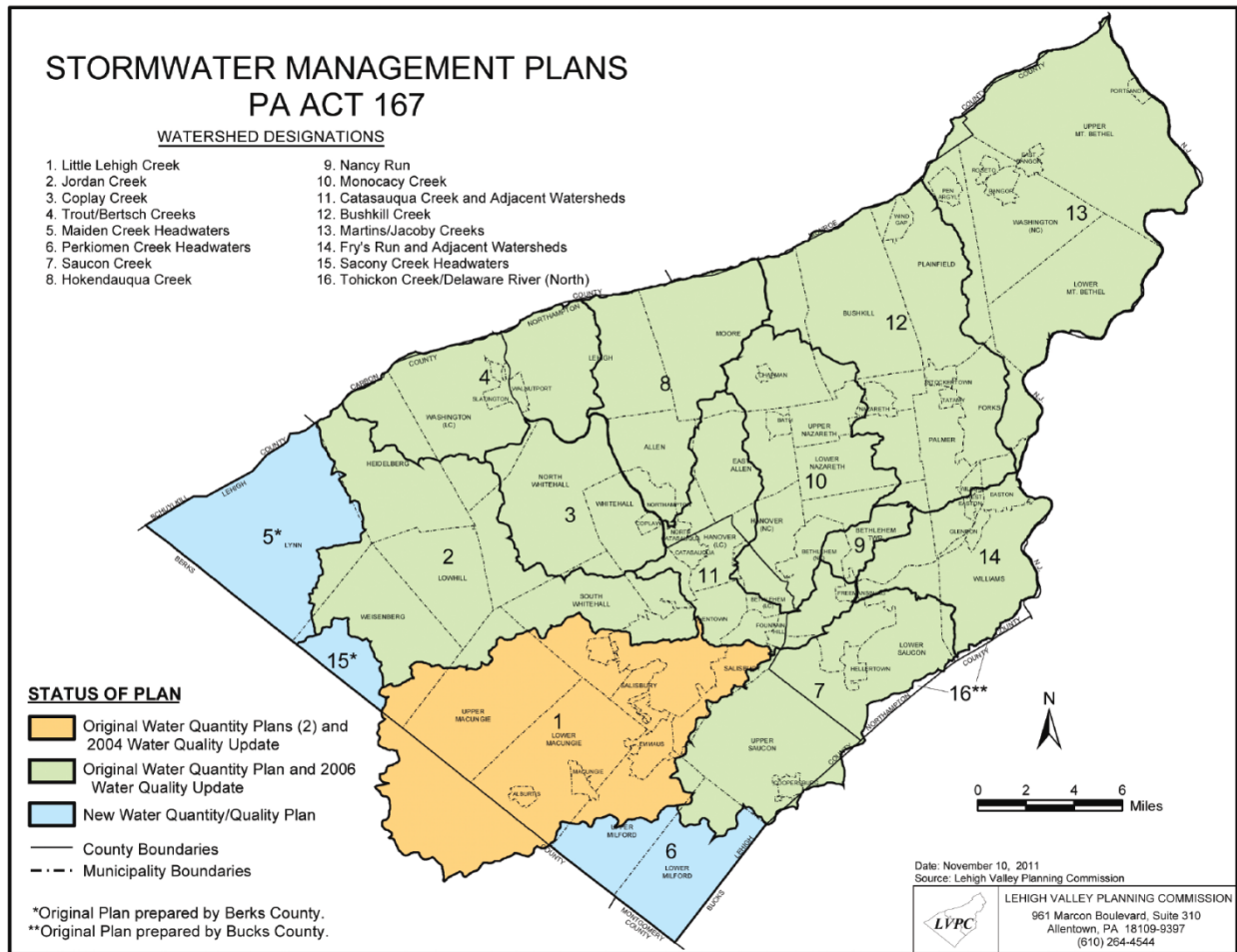
Within the Lehigh Valley, the majority of flooding problems are located within the Delaware River Basin. Both Lehigh and Northampton Counties are located within the Delaware River Basin. The Delaware River Basin is located in eastern Pennsylvania. The Basin has a total area of 13,539 square miles, with 6,466 square miles in Pennsylvania. It is the third largest watershed in the State (Allegheny College, Date Unknown).

Two major rivers flow through the region: the Lehigh River and Delaware River. In Pennsylvania, the Delaware River has a total length of 326 miles. Numerous other streams flow through the region. They include the Coplay, Jordan and Little Lehigh creeks in the west, the Saucon Creek in the south and the Monocacy, Bushkill and Martins creeks in the north, all of which drain into the Lehigh or Delaware rivers (LVPC, 2006).

The Lehigh River flows through Lehigh Gap at the northern boundary of Lehigh and Northampton Counties southbound to Allentown where it makes an abrupt turn eastward. From Allentown the Lehigh River flows eastward to its confluence with the Delaware River at Easton. Major tributary streams flowing into the Lehigh River are Jordan Creek, Little Lehigh Creek, Hokendauqua Creek, Monocacy Creek and Saucon Creek. Bushkill Creek and Martins Creek flow directly into the Delaware.

Per the 1978 Pennsylvania Stormwater Management Act 167, counties are required to prepare stormwater management plans on a watershed-by-watershed basis. Within Lehigh and Northampton Counties, the state has designated 16 Act 167 study areas, as identified on Figure 4.3.4-1. Table 4.3.4-1 summarizes the municipalities each stormwater management plan covers. Please refer to these plans for additional details on the flooding in each of these watersheds.

Figure 4.3.4-1: Stormwater Management Plans



Source: LVPC, 2011

Table 4.3.4-1: Stormwater Management Plans for the Lehigh Valley

ID	Title	Lehigh County	Northampton County
167-001	Bushkill Creek Watershed- ACT 167-Storm Water Management Plan, May 1992		Bethlehem Township Bushkill Township City of Easton Forks Township Lower Nazareth Township Moore Township Nazareth Borough Palmer Township Plainfield Township Stockertown Borough Tatamy Borough Upper Nazareth Township Wilson Borough Wind Gap Borough
167-016	Catasauqua Creek Watershed and Lehigh River Sub-Basin 4- ACT 167-Storm Water Management Plan, February 1997	City of Allentown Catasauqua Borough Fountain Hill Borough Hanover Township Salisbury Township Whitehall Township	Allen Township City of Bethlehem East Allen Township Freemansburg Borough Hanover Township Lower Saucon Township Moore Township Northampton Borough North Catasauqua Borough
167-003	Coplay Creek Watershed and Lehigh River Sub-Basin 2- ACT 167-Storm Water Management Plan, November 1994	Coplay Borough North Whitehall Township South Whitehall Township Washington Township Whitehall Township	
167-002	Delaware River Sub-Basin 2 and Lehigh River Sub-Basin 5 (Fry's Run Study Area)-ACT 167-Storm Water Management Plan, February 1999		Bethlehem Township City of Easton Glendon Borough Lower Saucon Township Palmer Township West Easton Borough Williams Township Wilson Borough
167-004	Hokendauqua Creek Watershed and Lehigh River Sub-Basin 3- ACT 167-Storm Water Management Plan, September 1997		Allen Township East Allen Township Lehigh Township Moore Township Northampton Borough North Catasauqua Borough
167-005	Jordan Creek Watershed- ACT 167-Storm Water Management Plan, May 1992	City of Allentown Heidelberg Township Lowhill Township Lynn Township North Whitehall Township South Whitehall Township Upper Macungie Township Washington Township Weisenberg Township Whitehall Township	

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ID	Title	Lehigh County	Northampton County
167-007	Little Lehigh Creek Watershed-ACT 167-Storm Water Management Plan Update, June 1999	Alburtis Borough City of Allentown Emmaus Borough Lower Macungie Township Macungie Borough Salisbury Township South Whitehall Township Upper Macungie Township Upper Milford Township Weisenberg Township	
167-008	Maiden Creek Headwaters- ACT 167-Storm Water Management Plan, April 2010	Heidelberg Township Lynn Township Weisenberg Township	
167-009	Martins/Jacoby Creeks Watershed and Delaware Sub-Basin 1 ACT 167-Storm Water Management Plan, February 1996		Bangor Borough East Bangor Borough City of Easton Forks Township Lower Mount Bethel Township Pen Argyl Borough Plainfield Township Portland Borough Roseto Borough Upper Mount Bethel Township
167-010	Monocacy Creek Act 167 Stormwater Management Plan, March 1989	Hanover Township	Bath Borough City of Bethlehem Bethlehem Township Bushkill Township Chapman Borough East Allen Township Hanover Township Lower Nazareth Township Moore Township Nazareth Borough Upper Nazareth Township
167-011	Nancy Run Watershed- ACT 167-Storm Water Management Plan, March 1989		City of Bethlehem Bethlehem Township Freemansburg Borough
167-012	Perkiomen Creek Headwaters- ACT 167-Storm Water Management Plan, ACT 167-Storm Water Management Plan, October 2009	Lower Macungie Township Lower Milford Township Upper Milford Township Upper Saucon Township	
167-013	Saony Creek Headwaters- ACT 167-Storm Water Management Plan, Stormwater Management Plan, April 2010	Weisenberg Township	
167-014	Saucon Creek Act 167 Stormwater Management Plan, April, 1991	Coopersburg Borough Lower Milford Township Salisbury Township Upper Milford Township Upper Saucon Township	City of Bethlehem Hellertown Borough Lower Saucon Township Williams Township
167-015	Trout/Bertsch Creeks and Lehigh River Sub-Basin- ACT 167-Storm Water Management Plan, April 1995	Heidelberg Township Slatington Borough Washington Township	Lehigh Township Walnutport Borough

Source: LVPC, Various Dates



Flood Protection Measures

The U.S. Army Corps of Engineers (USACE) constructed and operates four flood-control reservoirs in the Delaware River Basin. Reservoirs are located on tributaries in Wayne County, Pennsylvania. The Francis E. Walter Dam is on the Lehigh River in Carbon and Luzerne Counties, Pennsylvania, approximately 77 miles above the confluence of the Delaware River. Beltzville Reservoir is located on Pohopoco Creek, approximately four miles upstream from the confluence of the Lehigh River in Carbon County, Pennsylvania. These two reservoirs are used for low-flow augmentation and recreation, in addition to flood control. The State maintains Nockamixon State Park on Tohikon Creek for flood control, recreation and future water supply. In addition, several local flood protection projects have been constructed along the Lehigh River in the City of Bethlehem (FEMA, 2011).

In Lehigh County, levees provide several communities with some degree of protection against flooding. Levees are located in the Cities of Allentown and Bethlehem and in the Township of Salisbury. Two USACE dams currently operate in Lehigh County. The Francis E. Walter Dam and Beltzville Lake are designed for low-flow augmentation, recreation and flood control. They reduce flood stages on the Lehigh River; thereby, decreasing the backwater effect on the Little Lehigh Creek. In addition to the two flood control dams, several local flood protection projects have been constructed along the Lehigh River. In the City of Allentown, there is a 750-foot low levee along the right bank of the River, a concrete floodwall extends 204 feet upstream of the Old Hamilton Street bridge, a short levee spanning 69 feet between the abutment of the Old and New Hamilton Street bridges, a levee extending 1,125 feet connecting with Kline's Island Levee, and a training dike approximately 1,300 feet long that was constructed around a sharp bend to reduce backwater stages in the Little Lehigh Creek. A straightened and deepened main channel, extending 8,280 feet, is another local flood control project within the City. In Salisbury Township, a dike was built along the south side of the Lehigh River to protect the floodplain in the loop of the River (FEMA, 2004).

FEMA Regulatory Flood Zones

According to FEMA, flood hazard areas are defined as areas that are shown to be inundated by a flood of a given magnitude on a map. These areas are determined using statistical analyses of records of riverflow, storm tides, and rainfall; information obtained through consultation with the community; floodplain topographic surveys; and hydrologic and hydraulic analyses. Flood hazard areas are delineated on FEMA's Flood Insurance Rate Maps (FIRM), which are official maps of a community on which the Federal Insurance and Mitigation Administration has delineated both the Special Flood Hazard Areas (SFHA) and the risk premium zones applicable to the community. These maps identify the SFHAs; the location of a specific property in relation to the SFHA; the base (1% or 100-year) flood elevation (BFE) at a specific site; the magnitude of flood a flood hazard in a specific area; the undeveloped coastal barriers where flood insurance is not available and locates regulatory floodways and floodplain boundaries (100-year and 500-year floodplain boundaries) (FEMA, 2003; FEMA, 2004; FEMA, 2006; FEMA, 2008).

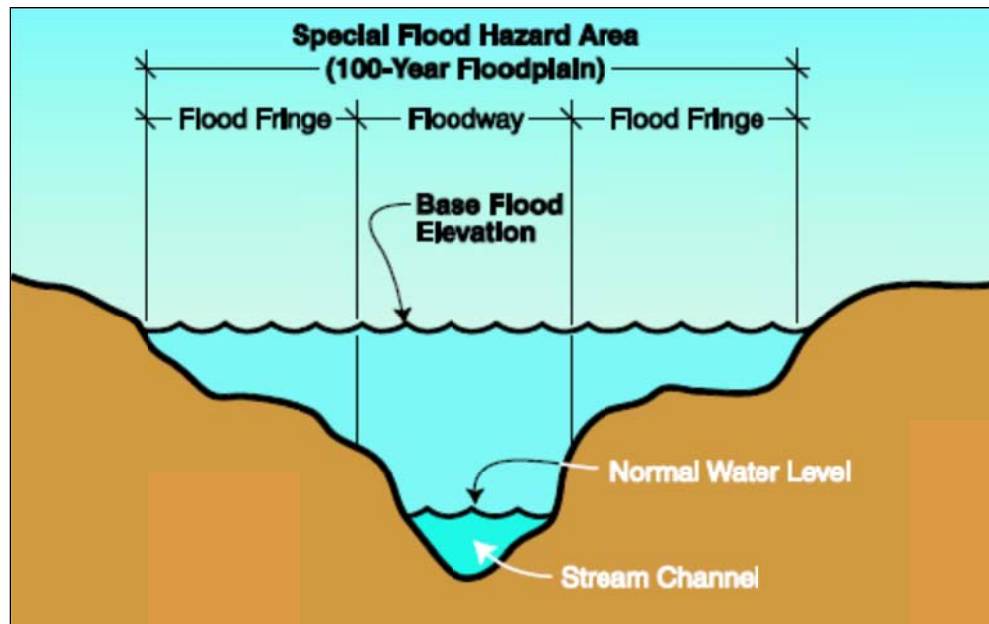
The land area covered by the floodwaters of the base flood is the SFHA on a FIRM. It is the area where the National Flood Insurance Programs (NFIP) floodplain management regulations must be enforced and the area where the mandatory purchase of flood insurance applies. The SFHA includes Zones A, AO, AH, A1-30, AE, A99, AR, AR/A1-30, AR/AE, AR/AO, AR/AH, AR/A, VO, V1-30, VE, and V (FEMA, 2007). This regulatory boundary is a convenient tool for assessing vulnerability and risk in flood-prone communities since many communities have maps showing the extent of the base flood and likely depths that will be experienced.

The base flood is often referred to as the "100-year" flood designation. As defined by NFIP, the BFE on a FIRM is the elevation of a base flood event, or a flood which has a one-percent chance of occurring in any given year. The BFE describes the exact elevation of the water that will result from a given discharge

level, which is one of the most important factors used in estimating the potential damage to occur in a given area. A structure located within a 100-year floodplain has a 26-percent chance of suffering flood damage during the term of a 30-year mortgage. The 100-year flood is a regulatory standard used by federal agencies and most states, to administer floodplain management programs. The 100-year flood is used by the NFIP as the basis for insurance requirements nationwide. FIRMs also depict 500-year flood designations, which is a boundary of the flood that has a 0.2-percent chance of being equaled or exceeded in any given year (FEMA, 2003; FEMA, 2006).

Figure 4.3.4-2 depicts the special flood hazard area, the base flood elevation, the flood fringe, and the floodway areas of a floodplain.

Figure 4.3.4-2: Floodplain Illustration

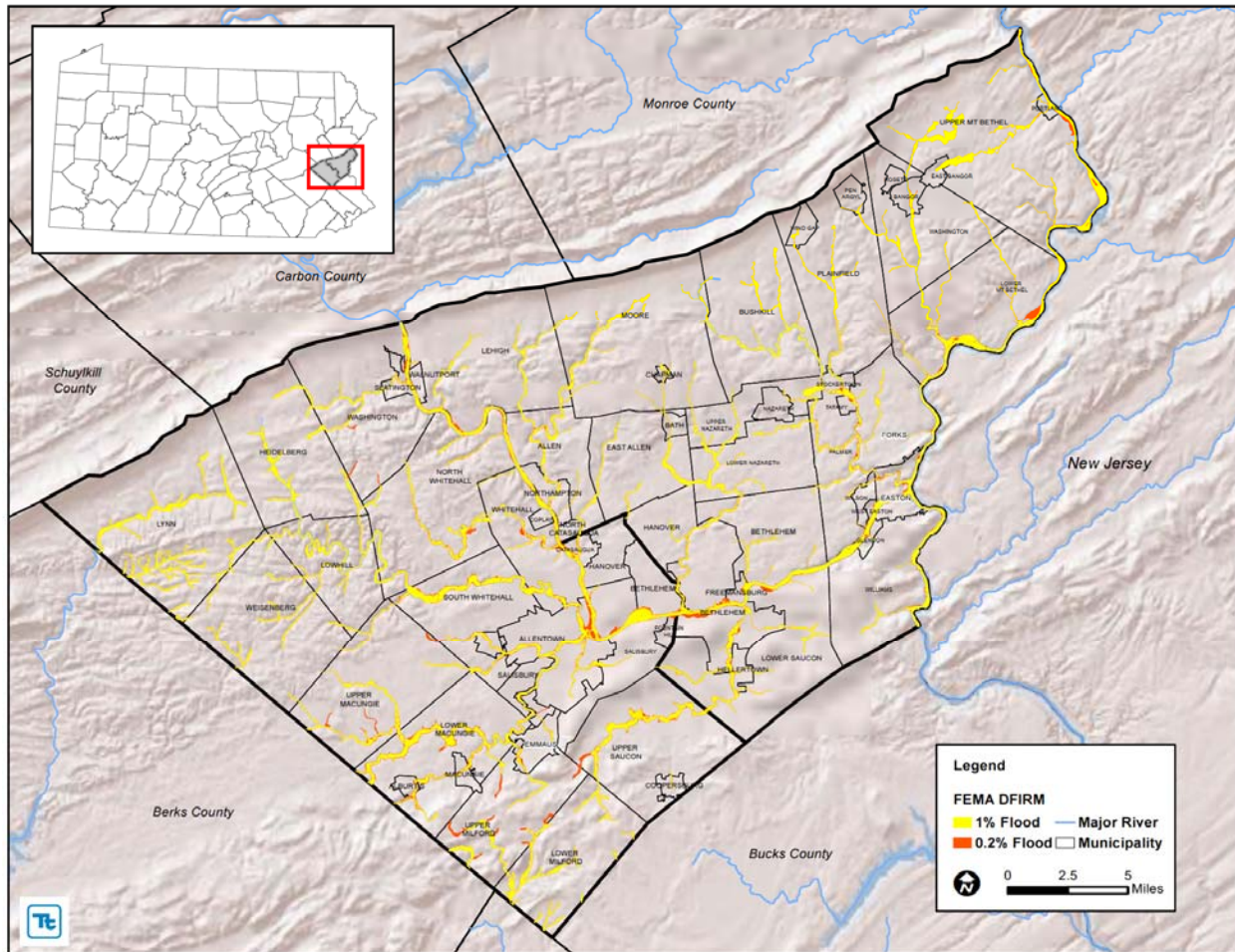


Source: PEMA, 2010

The Special Flood Hazard Area (SFHA) serves as the primary regulatory boundary used by FEMA and Pennsylvania. Digitized FIRMs (DFIRMs), FIRMs and other flood hazard information can be used to identify the expected spatial extent of flooding from a one-percent and 0.2-percent annual change event.

At the time this plan was written, the 2004 Lehigh County DFIRMs and the Northampton County preliminary DFIRMs are considered best available and used for the risk analysis. Figure 4.3.4-3 illustrates the NFIP flood zones in Lehigh Valley. Individual municipal maps showing the NFIP flood zones may be found in the municipal annexes in Volume II of this plan.

Figure 4.3.4-3. NFIP Floodplains in the Lehigh Valley



Source: FEMA, 2004; FEMA 2011

Note: Please note the Northampton County preliminary DFIRMs were used to generate this figure and are not considered regulatory at the time this plan was written.

FEMA DFIRMs were overlaid upon Lehigh Valley to summarize the flood mapping and hazard areas in Northampton and Lehigh Counties. Refer to Table 4.3.4-2 below.

Table 4.3.4-2. Area Located in the 1% and 0.2% FEMA DFIRM Flood Boundaries

Municipality	Total Area (sq. mi.)	1% Flood Hazard Area		0.2% Flood Hazard Area	
		Area Exposed (sq. mi.)	% of Total	Area Exposed (sq. mi.)	% of Total
Lehigh County					
Alburtis Borough	0.71	0.044	6.2	0.075	10.6
Allentown, City of	18.02	1.77	9.8	2.36	13.1
Bethlehem, City of	4.4	0.00012	0	0.000119	0.0
Catasauqua Borough	1.3	0.18	13.8	0.26	20.0
Coopersburg Borough	0.94	0.021	2.2	0.02	2.1
Coplay Borough	0.63	0.025	4	0.027	4.3

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Municipality	Total Area (sq. mi.)	1% Flood Hazard Area		0.2% Flood Hazard Area	
		Area Exposed (sq. mi.)	% of Total	Area Exposed (sq. mi.)	% of Total
Emmaus Borough	2.9	0.12	4.1	0.17	5.9
Fountain Hill Borough	0.76	0.02	2.6	0.045	5.9
Hanover Township	4.3	0.093	2.2	0.11	2.6
Heidelberg Township	24.7	1.06	4.3	1.06	4.3
Lower Macungie Township	22.5	1.9	8.4	2.46	10.9
Lower Milford Township	19.7	1.25	6.3	1.25	6.3
Lowhill Township	14.1	1	7.1	1	7.1
Lynn Township	41.7	2.58	6.2	2.58	6.2
Macungie Borough	0.99	0.04	4	0.069	7.0
North Whitehall Township	28.5	1.5	5.3	1.78	6.2
Salisbury Township	11.3	0.55	4.9	0.59	5.2
Slatington Borough	1.4	0.15	10.7	0.21	15.0
South Whitehall Township	17.2	1.38	8	1.64	9.5
Upper Macungie Township	26.2	0.94	3.6	1.16	4.4
Upper Milford Township	18.0	0.81	4.5	1.26	7.0
Upper Saucon Township	24.7	1.13	4.6	1.41	5.7
Washington Township	23.7	0.59	2.5	0.69	2.9
Weisenberg Township	26.8	0.85	3.2	0.85	3.2
Whitehall Township	12.8	0.91	7.1	1.18	9.2
Lehigh County (est. total)	348.3	18.9	5.4	22.3	6.4
Northampton County					
Allen Township	11.3	0.8	7.1	0.85	7.5
Bangor Borough	1.5	0.12	8.0	0.15	10.0
Bath Borough	0.9	0.02	2.2	0.023	2.6
Bethlehem Township	14.7	0.66	4.5	0.69	4.7
Bethlehem, City of	15.0	1.00	6.7	1.39	9.3
Bushkill Township	25.7	0.99	3.9	0.99	3.9
Chapman Borough	0.4	0.06	15.0	0.06	15.0
East Allen Township	14.6	0.54	3.7	0.54	3.7
East Bangor Borough	0.9	0.10	11.1	0.10	11.1
Easton, City of	4.4	0.96	21.8	1.12	25.5
Forks Township	12.3	0.57	4.6	0.65	5.3
Freemansburg Borough	0.8	0.14	17.5	0.19	23.8
Glendon Borough	0.8	0.14	17.5	0.17	21.3
Hanover Township	6.6	0.16	2.4	0.17	2.6
Hellertown Borough	1.3	0.13	10.0	0.16	12.3
Lehigh Township	29.8	1.1	3.7	1.21	4.1
Lower Mt. Bethel Township	24.6	1.9	7.7	2.16	8.8
Lower Nazareth Township	13.6	0.74	5.4	0.74	5.4
Lower Saucon Township	24.5	0.84	3.4	0.97	4.0

Municipality	Total Area (sq. mi.)	1% Flood Hazard Area		0.2% Flood Hazard Area	
		Area Exposed (sq. mi.)	% of Total	Area Exposed (sq. mi.)	% of Total
Moore Township	37.7	0.90	2.4	0.91	2.4
Nazareth Borough	1.7	0.0099	0.6	0.0099	0.6
North Catasauqua Borough	0.8	0.067	8.4	0.082	10.3
Northampton Borough	2.6	0.35	13.5	0.40	15.4
Palmer Township	10.4	0.54	5.2	0.66	6.3
Pen Argyl Borough	1.4	0.030	2.1	0.030	2.1
Plainfield Township	24.5	0.65	2.7	0.67	2.7
Portland Borough	0.6	0.12	20.0	0.14	23.3
Roseto Borough	0.6	0.00028	0.0	0.00028	0.0
Stockertown Borough	1.0	0.14	14.0	0.17	17.0
Tatamy Borough	0.6	0.050	8.3	0.082	13.7
Upper Mt. Bethel Township	44.0	2.89	6.6	3.13	7.1
Upper Nazareth Township	7.5	0.52	6.9	0.52	6.9
Walnutport Borough	0.8	0.09	11.3	0.11	13.8
Washington Township	18.0	0.61	3.4	0.61	3.4
West Easton Borough	0.3	0.083	27.7	0.095	31.7
Williams Township	18.6	0.87	4.7	0.95	5.1
Wilson Borough	1.2	0.045	3.8	0.052	4.3
Wind Gap Borough	1.4	0.054	3.9	0.056	4.0
Northampton County (est. total)	377.2	19.00	5.0	21.01	5.6

Source: FEMA, 2004; FEMA 2011

Notes: This analysis was conducted using the DFIRMs available for Lehigh Valley (2004 for Lehigh County and preliminary 2011 for Northampton County). est. = Estimated. sq. mi. = Square miles. % = Percent.

While the FIRMs provide a creditable source to document extent and location of the flood hazard, there are limitations to the accuracy of the data reflected on these maps. As such, it is noted that FIRMs are based upon the existing hydrology conditions at the time of the maps preparation. FIRMs are not set up to account for the possible changes in hydrology that can occur over time.

Flood Insurance Study

In addition to FIRM and DFIRMs, FEMA also provides Flood Insurance Studies (FIS) for entire counties and individual jurisdictions. These studies aid in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. They are narrative reports of countywide flood hazards, including descriptions of the flood areas studied and the engineered methods used, principal flood problems, flood protection measures and graphic profiles of the flood sources (FEMA, Date Unknown). A countywide FIS for Lehigh and Northampton Counties has been completed although the FIS for Northampton County is a preliminary document. The principal flood problems within each of the Counties, as stated in their FISs, are further discussed below.

Lehigh County

Flooding in Lehigh County occurs during all seasons. Flood conditions may be aggravated by the rapid melting of an existing snow pack or by reduction in infiltration losses due to frozen ground. Flooding in

the County typically occurs along the Lehigh River (FEMA, 2004). The FIS noted the following areas of concern for flooding.

- **Catasauqua Borough** – Within the Borough, CONRAIL lies between the Lehigh River and Canal and Catasauqua Creek. At this point, both the canal and railroad cross the Creek. At this location, the Borough has experienced flooding. Flooding has also occurred in the vicinity of Race Street over Catasauqua Creek (FEMA, 2004).
- **Salisbury Township** – Trout Creek No. 1 is subject to wide variation in flow with flood flows being caused by the rapid runoff from surrounding mountain slopes. In this area, flood-related damage has been limited to occasional residential damage (FEMA, 2004).
- **South Whitehall Township** – Jordan Creek flows across the Township within a narrow channel with well-defined banks and wide floodplain areas. Numerous floods have occurred along the Creek. Cedar Creek and Little Cedar Creek have also had flood occurrences in the past. Some of the flooding is caused by the inadequate capacity of drainage culverts and bridges to carry the flood flows (FEMA, 2004).

Northampton County

Flooding in Northampton County occurs during all seasons. Flood conditions may be aggravated by the rapid melting of an existing snow pack or by reduction in infiltration losses due to frozen ground. Flooding in the County typically occurs in the Delaware River Basin (FEMA, 2011). No specific areas of concern or flood locations were noted in the FIS.

Ice Jam Hazard Areas

Ice jams are common in the Northeast U.S. and the State of Pennsylvania is not an exception. The Ice Jam Database, maintained by the Ice Engineering Group at the USACE Cold Regions Research and Engineering Laboratory (CRREL), currently consists of over 18,000 records from across the U.S. According to the USACE-CRREL, the Lehigh Valley experienced 17 historic ice jam events between 1780 and 2012 (Ice Engineering Research Group, Date Unknown). Historical events are further mentioned in the “Past Occurrence” section of this hazard profile.

4.3.4.2 Range of Magnitude

Both localized and widespread floods are considered hazards when people and property are affected. Injuries and deaths can occur when people are swept away by flood currents or bacteria and disease are spread by moving or stagnant floodwaters. Most property damage results from inundation by sediment-filled water. A large amount of rainfall over a short period of time can result in flash floods. Small amounts of rain can cause flooding in areas where there is frozen soil or saturated soils from a previous event or if the rain is concentrated in areas of impervious surfaces (PEMA, 2010).

Several factors determine the severity of floods, including intensity and duration, topography, ground cover and rate of snowmelt. Water runoff is greater in areas with steep slopes and little or no vegetative ground cover. Many areas in Pennsylvania have relatively steep slopes which promotes quick surface water runoff. Most storms track from west to east; however, some originate in the Great Lakes or the Atlantic Ocean (PEMA, 2010).

Rainfall in Pennsylvania is about average for the eastern U.S. When classified, the amount of precipitation can be divided into six categories. The six categories are as follows:

- Very light rain – precipitation rate of <0.01 inches per hour
- Light rain – precipitation rate between 0.01 inches and 0.04 inches per hour

- Moderate rain – precipitation rate between 0.04 inches and 0.16 inches per hour
- Heavy rain – precipitation rate between 0.16 inches and 0.63 inches per hour
- Very heavy rain – precipitation rate between 0.63 inches and two inches per hour
- Extreme rain – precipitation rate greater than two inches per hour (PEMA, 2010)

The severity of a flood depends not only on the amount of water that accumulates in a period of time, but also on the land's ability to manage this water. One element is the size of rivers and streams in an area; but an equally important factor is the land's absorbency. When it rains, soil acts as a sponge. When the land is saturated or frozen, infiltration into the ground slows and any more water that accumulates must flow as runoff (Harris, 2001).

Riverine and Flash Floods

In the case of riverine or flash flooding, once a river reaches flood stage, the flood extent or severity categories used by the NWS include minor flooding, moderate flooding, and major flooding. Each category has a definition based on property damage and public threat:

- Minor Flooding - minimal or no property damage, but possibly some public threat or inconvenience.
- Moderate Flooding - some inundation of structures and roads near streams. Some evacuations of people and/or transfer of property to higher elevations are necessary.
- Major Flooding - extensive inundation of structures and roads. Significant evacuations of people and/or transfer of property to higher elevations (NWS, 2008).

4.3.4.3 Past Occurrence

Many sources provided historical information regarding previous occurrences and losses associated with flooding events throughout the State of Pennsylvania and the Lehigh Valley. With so many sources reviewed for the purpose of this HMP, loss and impact information for many events could vary depending on the source. Therefore, the accuracy of monetary figures discussed is based only on the available information identified during research for this HMP.

According to NOAA's NCDC storm events database, the Lehigh Valley experienced 129 flood events between April 30, 1950 and November 30, 2011. Total property damages, as a result of these flood events, were estimated at \$156.97 million. Total crop damages, as a result of these flood events, were estimated at \$2 million. This total also includes damages to other counties. According to the Hazard Research Lab at the University of South Carolina's Spatial Hazard Events and Losses Database for the U.S. (SHELDUS), between 1960 and 2010, 50 flood events occurred within the Lehigh Valley. The database indicated that flood events and losses specifically associated with Lehigh and Northampton Counties and its municipalities totaled over \$105.8 million in property damage and over \$13.5 million in crop damage. However, these numbers may vary due to the database identifying the location of the hazard event in various forms or throughout multiple counties or regions.

Between 1954 and 2012, the State of Pennsylvania experienced 32 FEMA-declared flood-related disasters (DR) or emergencies (EM) classified as one or a combination of the following disaster types: severe storms, mudslides, flash flooding, tropical storm, tropical depression, high winds, and rains. Generally, these disasters cover a wide region of the State; therefore, they may have impacted many counties. However, not all counties were included in the disaster declarations. Of those events, PEMA and other sources indicate that Lehigh and Northampton Counties have been declared as a disaster area as a result of five flood events (FEMA, 2011).

Based on all sources researched, known flooding events that have affected the Lehigh Valley and its municipalities are identified in Table 4.3.4-3. With flood documentation for the State of Pennsylvania being so extensive, not all sources have been identified or researched. Therefore, Table 4.3.4-3 may not include all events that have occurred throughout the Lehigh Valley.

Table 4.3.4-3. Flooding Events between 1950 and 2012 in the Lehigh Valley

Dates of Event	Event Type	FEMA Declaration Number	Counties Designated?	Losses / Impacts	Source(s)
August 19-20, 1955	Floods, Rains (Hurricane Diane)	DR-40	Yes	This flood was a result of two tropical storms (Connie and Diane) passing over the Delaware Basin within one week of each other. Tropical Storm Diane brought heavy rainfall that resulted in high surface runoff and severe flooding in Lehigh Valley. The elevation of the estimated 100-year flood at the Walnutport gaging station on the Lehigh River is 364.5 feet. The elevation of a high water mark experienced during the 1955 flood at Walnutport was 367.95 feet.	FEMA, PEMA
August 1967	Flash Flood	N/A	N/A	Northampton County	PEMA
January 1969	Flood	N/A	N/A	Lehigh County	PEMA
June 21-23, 1972	Flood (Tropical Storm Agnes)	DR-340	Yes	Tropical Storm Agnes brought heavy rain to the Lehigh Valley. Rainfall totals were around four inches. Roads were closed and people were evacuated. The central portion of the State was the hardest hit. Lehigh Valley had over \$14 M in property damage and \$1.4 M in crop damages.	FEMA, PEMA, SHELDUS
July 17, 1973	Severe Storms and Flooding	DR-400	Northampton	No reference and/or no damage reported	FEMA, PEMA
September 23-26, 1975	Flood (Tropical Storm Eloise)	DR-485	No	Over \$1.5 M in property damage.	FEMA, PEMA
September 1987	Flood	N/A	N/A	Lehigh and Northampton	PEMA
September 1989	Flood	N/A	N/A	Lehigh and Northampton	PEMA
January 19-21, 1996	Flooding	DR-1093	Yes	The combination of snowmelt, unseasonably warm temperatures and additional two inches or rain, caused flash flooding of almost every small stream and significant roadway flooding in the area. Major flooding also occurred along the larger streams and rivers in Pennsylvania. In Lehigh County, firefighters in the City of Allentown responded to 123 calls for flooded basements, the most in 22 years. Adams Island in Allentown was evacuated due to Lehigh River flooding. In South Whitehall Township, the heavy rain caused a snow slide that damaged two homes and caused one injury. The	FEMA, PEMA, NOAA-NCDC

Dates of Event	Event Type	FEMA Declaration Number	Counties Designated?	Losses / Impacts	Source(s)
				<p>Lehigh River at Walnutport crested 4.3 feet above flood stage. In the City of Bethlehem, the river 0.9 feet above flood stage.</p> <p>Northampton County experienced both small stream and large river flooding. Route 611 was closed due to flooding, river debris and erosion. Most of the significant flooding occurred along the Lehigh and Delaware Rivers. In the Township of Upper Mount Bethel, 12 homes were damaged and hundreds of people were evacuated. In the Township of Forks, 50 homes were damaged and about 50 people were evacuated. In the City of Easton, flooding was severe at the confluence of the Delaware and Lehigh Rivers. Evacuations were ordered. All downtown streets and parks were flooded. In the Township of Williams, 13 homes suffered flood damage.</p> <p>Lehigh Valley had approximately \$42.3 M in property damages.</p>	
September 16, 1999	Flooding (Hurricane Floyd)	DR-1294	No	Hurricane Floyd struck the eastern portion of Pennsylvania, bringing heavy rain and damaging winds. The hurricane caused widespread flash flooding as storm totals averaged around six to eight inches. All counties were included in the Pennsylvania Governor's Proclamation	FEMA, PEMA
August 11, 2001	Flash Flood	N/A	N/A	Slow moving thunderstorms with heavy downpours caused flash flooding in the Townships of Salisbury and Upper Saucon. Businesses along Main Street flooded. Rainfall totals were between six and eight inches. Lehigh County had approximately \$10 M in property damage.	NOAA-NCDC
September 15, 2003	Flood (Remnants of Tropical Storm Henri)	N/A	N/A	<p>In Lehigh County, the heaviest rain fell across the Townships of Upper and Lower Milford and the Boroughs of Slatington and Washington. Rainfall totals in Lehigh County ranged between two and six inches.</p> <p>Heavy rain fell across portions of Northampton County, with the heaviest rain in the Township of Lower Saucon and the Borough of Hellertown. Rainfall totals ranged between two and four inches.</p>	LV HMP
September 18-19, 2004	Tropical Depression Ivan	DR-1557	Yes	Remnants of Tropical Storm Ivan caused widespread heavy rain. Storm totals averaged around five inches and caused widespread poor drainage, creek and river flooding throughout Lehigh Valley. In Lehigh County, the hardest hit municipalities in the County included the City of Allentown and the Townships of Lower Macungie and Macungie. It was estimated that 85	FEMA, PEMA, NOAA-NCDC, NWS, LV HMP

Dates of Event	Event Type	FEMA Declaration Number	Counties Designated?	Losses / Impacts	Source(s)
				<p>homes, 31 businesses and 5 public buildings and structures were damaged. Damage along the Nancy Run, Monocacy, Bushkill, Saucon and Schoeneck Creeks was the result of flash flooding, and damage along Jacoby Creek resulted when an old earthen dam at Lake POCO failed and caused increased damage in the Borough of Portland, which was already flooded by the Delaware River. The Little Lehigh Creek within the Lehigh Parkway crested at 4.49 feet above flood stage. The Little Lehigh Creek at 10th Street in Allentown crested at 2.05 feet above flood stage.</p> <p>In Northampton County, nearly every town reported flood damages. Approximately 865 homes, businesses and structures were damaged, including several roads and bridges. The Lehigh River at Walnutport crested at 4.32 feet above flood stage. The Lehigh River in Bethlehem crested at 2.79 feet above flood stage. In Glendon the Lehigh River crested at 0.82 feet above flood stage. The Monocacy Creek at Bethlehem crested at 5.17 feet above flood stage. The Delaware River at Easton crested at 11.45 feet above flood stage.</p> <p>Total damages for the Counties were approximately \$6 M.</p>	
April 2-3, 2005	Severe Storms and Flooding	DR-1587	Northampton	<p>Heavy rain fell across Lehigh and Northampton Counties. In Lehigh County, the heavy rain caused poor drainage flooding and flooding along the Lehigh River. Storm totals ranged between three and four inches in the area. In the City of Allentown, flooding closed two roads. In the City of Bethlehem, the Industrial Quarter along the Monocacy Creek was flooding.</p> <p>In Northampton County, the municipalities along the Delaware River experienced the worst damage. Downtown areas of the City of Easton, Portland the Townships of Upper and Lower Mount Bethel were the hardest hit. Approximately 500 people were evacuated. About 700 homes and businesses were damaged, 32 homes were destroyed and 160 suffered major damage. Two small bridges were destroyed and 16 others were damaged. About 100 roads were damaged. Four sewage pumping stations in the City of Easton were heavily damaged. In Portland, the downtown area was seriously flooded as the Jacoby Creek also flooded. Water reached up to seven feet in some stores. In Upper Mount Bethel, 200 people were evacuated. In Forks Township, 23 homes suffered major</p>	FEMA, PEMA, NOAA-NCDC, NWS, LV HMP

Dates of Event	Event Type	FEMA Declaration Number	Counties Designated?	Losses / Impacts	Source(s)
				<p>damage as the Bushkill Creek also flooded. In Williams Township, about 70 homes were heavily damaged. The heavy rain also caused the Monocacy Creek to flood in downtown Bethlehem. The Delaware River at Easton crested at an estimated 36.5 feet on April 4th. The Monocacy Creek in Bethlehem crested at 0.94 feet above flood stage. The Lehigh River in Walnutport crested at 2.49 feet above flood stage. The Lehigh River at Glendon crested at 1.81 feet above flood stage. The Lehigh River at Bethlehem was briefly above its 16-foot flood stage at 16.06 feet.</p> <p>Rainfall totals for Lehigh Valley ranged from 3.5 inches in Germansville (Lehigh) to 4.3 inches in the Township of Forks (Northampton).</p>	
October 8, 2005	Flash Flood	N/A	N/A	<p>The remnants of Tropical Storm Tammy produced heavy rain across the Lehigh Valley. Storm totals averaged around 10 inches, causing widespread poor drainage flooding and flooding along the smaller creeks. The worst flooding was reported along the Little Lehigh Creek in Lehigh County and the Bushkill Creek in the Townships of Palmer and Fork in Northampton County. In the City of Allentown, the Little Lehigh Creek divided the City in half. Three County roads were closed due to flooding. Many of the municipalities within Lehigh County experienced flooding along the creeks and roadways. The County had approximately \$100 K in property damage.</p>	NOAA-NCDC
June 27-30, 2006	Severe Storms, Flooding and Mudslides	DR-1649	Northampton	<p>Several days of heavy rain throughout the Delaware River Basin caused flash flooding of smaller streams and along the Lehigh River. Storm totals in Lehigh County ranged between five and nine inches. In Eastern Pennsylvania, over 5,000 homes, apartments and businesses were damaged. In Lehigh County, about 300 homes and businesses were affected by the flooding. In the City of Allentown, residents from Adam's Island were evacuated. Homes were danged in the Townships of Catasauqua, Coopersburg, Emmaus, Heidelberg, Lynn Slatington, South Whitehall, and Upper Saucon. The County had approximately \$1 M in property damage and \$1 M in crop damage. In Northampton County, approximately 400 homes and businesses were affected by the flooding. Eleven homes were destroyed in the Townships of Upper Mount Bethel, Lower Mount Bethel, and Williams and in the Borough of West Easton. The worst damage was in the City of Easton and the Townships</p>	FEMA, PEMA, NOAA-NCDC

Dates of Event	Event Type	FEMA Declaration Number	Counties Designated?	Losses / Impacts	Source(s)
				of Portland, Upper and Lower Mount Bethel. More than 20 bridges and roads were closed. The County had approximately \$10 M in property damages and \$1 M in crop damages.	
July 4, 2007	Flash Flooding	N/A	N/A	Heavy rain caused roadway flooding and small stream flooding in southern portions of Northampton County. The City of Bethlehem and the Township of Lower Saucon were hit the hardest. In the City of Bethlehem, flooding along the Monocacy Creek inundated historic buildings. Total damages in the County were approximately \$500 K.	NOAA-NCDC
August 12-13, 2009	Storms and Flooding	N/A	N/A	Showers and thunderstorms produced heavy rain which resulted in flooding. In Lehigh County, heavy rain caused roadway flooding and flooding of smaller streams in the northern portion of the County and near the Townships of Whitehall, North Whitehall, and Heidelberg. Rainfall totals in the County were approximately six inches.	PEMA, NOAA-NCDC
July 10, 2010	Flash Flood	N/A	N/A	Heavy rain caused flash flooding along Monocacy Creek. The Creek flooded four structures near the intersection of Main and West Church Streets. There was about five feet of water in these structures. The County had approximately \$200 K in property damage.	NOAA-NCDC
March 10-12, 2011	Flood	N/A	N/A	Heavy rain fell across eastern Pennsylvania, bringing between 1.5 to 5 inches of rain. This caused widespread river, stream and poor drainage flooding. The Delaware, Lehigh and Schuylkill Rivers experienced flooding. The worst flooding was seen in Northampton and Bucks County. In Northampton County, flooding caused considerable damage along the towpaths of both the Lehigh and Delaware River canals. Many people were evacuated; roads were closed. The County had approximately \$1.8 M in property damage.	NOAA-NCDC
August 13-14, 2011	Flash Flood	N/A	N/A	A series of thunderstorms brought heavy rain to the Lehigh Valley. This rain caused flash flooding and flooding of streams and creeks. In Northampton County, flash flooding along the Monocacy Creek caused evacuations in the City of Bethlehem. The County had approximately \$100 K in property damage.	NOAA-NCDC
August 27-28, 2011	Flood (Hurricane Irene)	DR-4025	Yes	Hurricane Irene produced heavy rains, flooding, tropical storm force wind gusts and moderate tidal flooding along the Delaware River. Approximately 700,000 people were without power in eastern Pennsylvania. The Little Lehigh Creek at Little Lehigh Park near the City of Allentown had moderate flooding. Preliminary damages in the State were around \$6 M.	FEMA, NOAA-NCDC
September 5-8,	Flood	DR-4030	Northampton	Remnants of Tropical Storm Lee produced several days of	FEMA, NOAA-

Dates of Event	Event Type	FEMA Declaration Number	Counties Designated?	Losses / Impacts	Source(s)
2011	(Tropical Storm Lee)			<p>heavy rain across eastern Pennsylvania. Rainfall totals ranged from four to nine inches, with six to 12 in Berks County. The heavy rain caused widespread poor drainage flooding, as well as moderate flooding along the Delaware and Schuylkill River Basins, with minor to moderate flooding along the Lehigh River Basin. The Upper Schuylkill, Lehigh, and Delaware River Basins crests were the highest since June 2006. Some of the smaller streams in southeastern Pennsylvania reached major flooding levels. Total damages for the State were estimated at \$500 M.</p> <p>In eastern Pennsylvania, there were 22 homes and businesses that were destroyed, 201 that suffered major damage, 672 that had minor damage, and 1,217 that were affected.</p> <p>In the Lehigh Valley, the heavy rain caused poor drainage flooding and flash flooding of smaller streams in the Townships of Lower Milford and Upper Saucon. The Lehigh River at Walnutport was briefly above flood stage. The Little Lehigh at Little Lehigh Park in Allentown was above its six foot flood stage. Rainfall totals in the Lehigh Valley ranged from 6.02 inches in Schnecksville to 7.07 inches at the Lehigh Valley Airport.</p>	NCDC

Note (1): Monetary figures within this table were U.S. Dollar (USD) figures calculated during or within the approximate time of the event. If such an event would occur in the present day, monetary losses would be considerably higher in USDs as a result of increased U.S. Inflation Rates.

DR	Federal Disaster Declaration	N/A	Not applicable
EM	Federal Emergency Declaration	NCDC	National Climate Data Center
FEMA	Federal Emergency Management Agency	NOAA	National Oceanic Atmospheric Administration
HMP	Hazard Mitigation Plan	NWS	National Weather Service
K	Thousand (\$)	PEMA	Pennsylvania Emergency Management Agency
LV	Lehigh Valley	SHELDUS	Spatial Hazard Events and Losses Database for the U.S
M	Million (\$)		

Figure 4.3.4-1: Historic Ice Jams in the Lehigh Valley

As of the date of this Plan, the figure for ice jams in the Lehigh Valley is unavailable.

Source: CRREL Ddatabase

Based on review of the CRREL database, Table 4.3.4-4 lists the ice jam events that have occurred in the Lehigh Valley between 1780 and 2012. Information regarding losses associated with these reported ice jams was limited.

Table 4.3.4-4. Ice Jam Events in the Lehigh Valley between 1780 and 2012

Municipality	River	Jam Date	Water Year	Gage Number
Salisbury Township	Big Piney Run	2/27/1936	1936	3078500
Salisbury Township	Big Piney Run	1/3/1939	1939	3078500
Salisbury Township	Big Piney Run	3/9/1942	1942	3078500
Salisbury Township	Big Piney Run	1/28/1944	1944	3078500
Salisbury Township	Big Piney Run	2/22/1944	1944	3078500
Salisbury Township	Big Piney Run	2/22/1944	1944	3078500
Salisbury Township	Big Piney Run	3/14/1947	1947	3078500
Salisbury Township	Big Piney Run	2/14/1948	1948	3078500
City of Allentown	Jordan Creek	2/20/1948	1948	1452000
Salisbury Township	Big Piney Run	12/22/1951	1952	3078500
Salisbury Township	Big Piney Run	12/22/1951	1952	3078500
Salisbury Township	Big Piney Run	1/21/1959	1959	3078500
Salisbury Township	Big Piney Run	3/28/1960	1960	3078500
Salisbury Township	Big Piney Run	2/19/1961	1961	3078500
Salisbury Township	Big Piney Run	2/7/1965	1965	3078500
Salisbury Township	Big Piney Run	2/11/1966	1966	3078500
Bushkill Township	Delaware River	2/5/1970	1970	?

Source: CRREL, 2012

Note: Although many events were reported for Lehigh Valley, information pertaining to every event was not easily ascertainable; therefore this table may not represent all ice jams in the Counties.

National Flood Insurance Program

According to FEMA's 2002 *National Flood Insurance Program (NFIP): Program Description*, the U.S. Congress established the NFIP with the passage of the National Flood Insurance Act of 1968. The NFIP is a Federal program enabling property owners in participating communities to purchase insurance as a protection against flood losses in exchange for State and community floodplain management regulations that reduce future flood damages. The NFIP collects and stores a vast quantity of information on insured structures, including the number and location of flood insurance policies number of claims per insured property, dollar value of each claim and aggregate value of claims, repetitive flood loss properties, etc.

NFIP data presents a strong indication of the location of flood events among other indicators (NYSDFPC, 2008).

Participation in the NFIP is based on an agreement between communities and the Federal Government. If a community adopts and enforces a floodplain management ordinance to reduce future flood risk to new construction and substantial improvements in floodplains, the Federal Government will make flood insurance available within the community as a financial protection against flood losses. This insurance is designed to provide an insurance alternative to disaster assistance to reduce the escalating costs of repairing damage to buildings and their contents caused by floods (FEMA, 2002).

There are three components to the NFIP: flood insurance, floodplain management and flood hazard mapping. Nearly 20,000 communities across the U.S. and its territories participate in the NFIP by adopting and enforcing floodplain management ordinances to reduce future flood damage. In exchange, the NFIP makes federally backed flood insurance available to homeowners, renters, and business owners in these communities. Community participation in the NFIP is voluntary. Flood insurance is designed to provide an alternative to disaster assistance to reduce the escalating costs of repairing damage to buildings and their contents caused by floods. Flood damage is reduced by nearly \$1 billion each year through communities implementing sound floodplain management requirements and property owners purchasing flood insurance. Additionally, buildings constructed in compliance with NFIP building standards suffer approximately 80-percent less damages annually than those not built in compliance (FEMA, 2008).

4.3.4.4 Future Occurrence

Given the history of flood events that have impacted the Lehigh Valley, it is apparent that future flooding of varying degrees will occur. The fact that the elements required for flooding exist and that major flooding has occurred throughout the Counties in the past suggests that many people and properties are at risk from the flood hazard in the future.

As defined by FEMA, geographic areas within the 100-year floodplain in the Lehigh Valley are estimated to have a one-percent chance of flooding in any given year. A structure located within a 100-year floodplain has a 26-percent chance of suffering flood damage during the term of a 30-year mortgage. Geographic areas in the Lehigh Valley located within the 500-year flood boundary are estimated to have a 0.2-percent chance of being flooded in any given year (FEMA, 2003; FEMA, 2006). As noted, Figure 4.3.4-2 illustrates the FEMA DFIRM 100-year and 500-year flood zones for Lehigh Valley.

In Section 4.4, the identified hazards of concern for the Lehigh Valley were ranked for relative risk. The probability of occurrence, or likelihood of the event, is one parameter used for ranking hazards. Based on historical records, NFIP data and information, and reference to the Pennsylvania State Hazard Mitigation Plan, the probability of occurrence for flood events in the Lehigh Valley is considered ‘highly likely’ (100% annual probability).

It is estimated that the Lehigh Valley will continue to experience flooding annually. Some of the flooding events may induce secondary hazards such as: water quality and supply concerns, infrastructure damage, deterioration and failure, utility failures, power outages, transportation delays/accidents/inconveniences, and public health and safety concerns.

4.3.4.5 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable in the identified hazard area. For the flood hazard, areas identified as hazard areas include the 1% and 0.2% flood zones. The following text evaluates and estimates the potential impact of flooding in the Lehigh Valley including:

- Overview of vulnerability
- Data and methodology used for the evaluation
- Impact on: (1) life, health and safety of residents, (2) general building stock, (3) critical facilities and infrastructure, (4) economy, (5) environment and (6) future growth and development
- Effect of climate change on vulnerability
- Further data collections that will assist understanding of this hazard over time

4.3.4.5.1 Overview of Vulnerability

All types of flooding can cause widespread damage throughout rural and urban areas, including but not limited to: water-related damage to the interior and exterior of buildings; destruction of electrical and other expensive and difficult-to-replace equipment; injury and loss of life; proliferation of disease vectors; disruption of utilities, including water, sewer, electricity, communications networks and facilities; loss of agricultural crops and livestock; placement of stress on emergency response and healthcare facilities and personnel; loss of productivity; and displacement of persons from homes and places of employment (Foster, Date Unknown).

The flood hazard is a major concern for the Lehigh Valley. To assess vulnerability, potential losses were calculated for the Lehigh Valley for riverine flooding for 1% (100-year) and 0.2% (500-year) annual chance flood events. The flood hazard exposure and loss estimate analysis is presented below.

4.3.4.5.2 Data and Methodology

The 1% and 0.2% chance flood events were examined to evaluate the Lehigh Valley's risk and vulnerability to the 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 default building inventory in HAZUS-MH was updated and replaced at the Census-block level with a custom building inventory developed for both Counties. The updated building inventory was built using detailed structure-specific assessor data, as well as parcel and structure location information. 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 Lehigh County FEMA 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 Lehigh and Northampton Counties. 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.

4.3.4.5.3 Impact on Life, Health and Safety

The impact of flooding on life, health and safety is dependent upon several factors including the severity of the event and whether or not adequate warning time is provided to residents. Exposure represents the population living in or near floodplain areas that could be impacted should a flood event occur. Additionally, exposure should not be limited to only those who reside in a defined hazard zone, but everyone who may be affected by the effects of a hazard event (e.g., people are at risk while traveling in flooded areas, or their access to emergency services is compromised during an event). The degree of that impact will vary and is not strictly measurable.

To estimate the population exposed to the 1% and 0.2% flood events, the FEMA DFIRM floodplain boundaries (Lehigh County 2004 DFIRMs and Northampton County 2011 preliminary DFIRMs) were used to estimate the number of structures within the floodplains, which were then factored by the average number of persons per household in the Lehigh Valley. While this assumes that all structures in the floodplain are residential and single-household, it provides a reasonable estimate of population directly exposed to the flood risk. According to this methodology, Table 4.3.4-5 lists the estimated population located within the 1% and 0.2% flood zones by municipality for both Lehigh and Northampton Counties.

Table 4.3.4-5. Estimated Lehigh Valley Population Vulnerable to the 1% Flood Hazard

Municipality	Population in SFHA	Percent Population	Population in 0.2% Flood Boundary	Percent Population
Lehigh County				
Alburtis Borough	5	0.2	86	3.7
Allentown, City of	798	0.7	1267	1.1
Bethlehem, City of	58	0.3	173	0.9
Catasauqua Borough	183	2.8	378	5.9
Coopersburg Borough	5	0.2	5	0.2
Coplay Borough	0	0.0	0	0.0
Emmaus Borough	107	1.0	137	1.2
Fountain Hill Borough	0	0.0	3	0.1
Hanover Township	0	0.0	3	0.2
Heidelberg Township	142	4.2	145	4.2
Lower Macungie Township	500	1.6	1161	3.8
Lower Milford Township	104	2.8	104	2.8
Lowhill Township	25	1.2	25	1.2
Lynn Township	196	4.6	196	4.6
Macungie Borough	10	0.3	23	0.7
North Whitehall Township	137	0.9	155	1.0
Salisbury Township	102	0.8	124	0.9

SECTION 4.3.4: RISK ASSESSMENT – FLOOD

Municipality	Population in SFHA	Percent Population	Population in 0.2% Flood Boundary	Percent Population
Slatington Borough	15	0.4	66	1.6
South Whitehall Township	193	1.0	414	2.2
Upper Macungie Township	165	0.8	297	1.5
Upper Milford Township	168	2.3	229	3.1
Upper Saucon Township	56	0.4	91	0.6
Washington Township	89	1.3	94	1.4
Weisenberg Township	64	1.3	64	1.3
Whitehall Township	216	0.8	584	2.2
Lehigh County (est. total)	3338	1.0	5824	1.7
Northampton County				
Allen Township	61	1.4	71	1.7
Bangor Borough	457	8.7	599	11.4
Bath Borough	23	0.8	23	0.8
Bethlehem Township	254	1.1	272	1.1
Bethlehem, City of	208	0.4	411	0.7
Bushkill Township	61	0.7	61	0.7
Chapman Borough	5	2.6	5	2.6
East Allen Township	74	1.5	74	1.5
East Bangor Borough	0	0.0	0	0.0
Easton, City of	340	1.3	665	2.5
Forks Township	147	1.0	178	1.2
Freemansburg Borough	193	7.3	277	10.5
Glendon Borough	5	1.2	13	2.9
Hanover Township	18	0.2	20	0.2
Hellertown Borough	79	1.3	104	1.8
Lehigh Township	119	1.1	165	1.6
Lower Mt. Bethel Township	429	13.8	538	17.4
Lower Nazareth Township	94	1.7	94	1.7
Lower Saucon Township	150	1.4	198	1.8
Moore Township	124	1.4	127	1.4
Nazareth Borough	18	0.3	18	0.3
North Catasauqua Borough	0	0.0	0	0.0
Northampton Borough	394	4.0	554	5.6
Palmer Township	198	1.0	226	1.1

Municipality	Population in SFHA	Percent Population	Population in 0.2% Flood Boundary	Percent Population
Pen Argyl Borough	0	0.0	0	0.0
Plainfield Township	66	1.1	66	1.1
Portland Borough	69	13.2	81	15.7
Roseto Borough	0	0.0	0	0.0
Stockertown Borough	10	1.1	13	1.4
Tatamy Borough	10	0.8	23	1.9
Upper Mt. Bethel Township	401	6.0	554	8.3
Upper Nazareth Township	30	0.5	30	0.5
Walnutport Borough	36	1.7	46	2.2
Washington Township	147	2.9	147	2.9
West Easton Borough	36	2.8	53	4.2
Williams Township	178	3.0	259	4.4
Wilson Borough	8	0.1	8	0.1
Wind Gap Borough	23	0.8	23	0.8
Northampton County (est. total)	4465	1.5	5997	2.0

Source: Census, 2010; FEMA, 2004; FEMA, 2011

Notes: est. = Estimated; SFHA = Special Flood Hazard Area (1% chance flood)

Of the population exposed, the most vulnerable include the economically disadvantaged and the population over the age of 65. Economically disadvantaged populations are more vulnerable because they are likely to evaluate their risk and make decisions to evacuate based on the net economic impact to their family. The population over the age of 65 is also more vulnerable because they are more likely to seek or need medical attention which may not be available due to isolation during a flood event and they may have more difficulty evacuating.

Using 2000 U.S. Census data, HAZUS-MH 2.1 estimates the potential sheltering needs as a result of a 1% flood event. For the 1% flood event, HAZUS-MH 2.1 estimates 7,281 people will be displaced and 4,033 people will seek short-term sheltering, representing 2.3% and 1.3% of the Lehigh County population, respectively. For the 1% flood event in Northampton County, HAZUS-MH 2.1 estimates 7,100 people will be displaced and 3,677 people will seek short-term sheltering, representing 2.7% and 1.4% of the County population, respectively. These statistics, by municipality, are presented in Table 4.3.4-6.

The total number of injuries and casualties resulting from flooding is generally limited based on advance weather forecasting, blockades and warnings. Therefore, injuries and deaths generally are not anticipated if proper warning and precautions are in place. Ongoing mitigation efforts should help to avoid the most likely cause of injury, which results from persons trying to cross flooded roadways or channels during a flood.

Table 4.3.4-6: Estimated Lehigh Valley Population Displaced or Seeking Short-Term Shelter from the 1% Chance Flood Event

Municipality	Displaced Persons	Percent Displaced	Persons Seeking Short-Term Sheltering	Percent Seeking Shelter
Lehigh County				
Alburtis Borough	35	1.6	9	0.4
Allentown, City of	1,751	1.6	1,236	1.2
Bethlehem, City of	259	1.4	233	1.2
Catasauqua Borough	328	5.0	195	3.0
Coopersburg Borough	64	2.5	9	0.3
Coplay Borough	15	0.4	4	0.1
Emmaus Borough	200	1.8	49	0.4
Fountain Hill Borough	4	0.1	0	0.0
Hanover Township	7	0.4	0	0.0
Heidelberg Township	124	3.8	8	0.2
Lower Macungie Township	929	4.8	548	2.8
Lower Milford Township	191	5.3	32	0.9
Lowhill Township	71	3.7	5	0.3
Lynn Township	298	7.7	46	1.2
Macungie Borough	73	2.4	65	2.1
North Whitehall Township	284	1.9	56	0.4
Salisbury Township	214	1.6	88	0.7
Slatington Borough	105	2.4	46	1.0
South Whitehall Township	529	2.9	377	2.1
Upper Macungie Township	234	1.7	82	0.6
Upper Milford Township	277	4.0	87	1.2
Upper Saucon Township	174	1.5	47	0.4
Washington Township	113	1.7	16	0.2
Weisenberg Township	25	0.6	0	0.0
Whitehall Township	977	3.9	795	3.2
Lehigh County (est. total)	7,281	2.3	4,033	1.3
Northampton County				
Allen Township	120	4.5	21	0.8
Bangor Borough	619	11.6	493	9.3
Bath Borough	160	6.0	114	4.3
Bethlehem Township	459	2.2	285	1.3
Bethlehem, City of	455	0.9	274	0.5
Bushkill Township	181	2.6	22	0.3
Chapman Borough	10	4.7	1	0.5
East Allen Township	149	3.0	30	0.6
East Bangor Borough	19	1.9	3	0.3
Easton, City of	477	1.8	262	1.0
Forks Township	158	1.9	53	0.6

Municipality	Displaced Persons	Percent Displaced	Persons Seeking Short-Term Sheltering	Percent Seeking Shelter
Freemansburg Borough	232	12.5	80	4.3
Glendon Borough	3	0.8	0	0.0
Hanover Township	237	2.5	191	2.0
Hellertown Borough	155	2.8	96	1.7
Lehigh Township	214	2.2	21	0.2
Lower Mt. Bethel Township	259	8.0	62	1.9
Lower Nazareth Township	284	5.4	149	2.8
Lower Saucon Township	316	3.2	117	1.2
Moore Township	282	3.2	122	1.4
Nazareth Borough	18	0.3	1	0.0
North Catasauqua Borough	31	1.1	4	0.1
Northampton Borough	534	5.7	380	4.1
Palmer Township	411	2.4	229	1.4
Pen Argyl Borough	9	0.3	1	0.0
Plainfield Township	71	1.2	4	0.1
Portland Borough	79	13.6	50	8.6
Roseto Borough	1	0.1	0	0.0
Stockertown Borough	73	10.6	47	6.8
Tatamy Borough	54	5.8	49	5.3
Upper Mt. Bethel Township	363	6.0	137	2.3
Upper Nazareth Township	179	3.9	105	2.3
Walnutport Borough	28	1.4	10	0.5
Washington Township	147	3.6	43	1.1
West Easton Borough	77	6.6	61	5.2
Williams Township	116	2.6	54	1.2
Wilson Borough	1	0.0	0	0.0
Wind Gap Borough	119	4.2	106	3.7
Northampton County (est. total)	7,100	2.7	3,677	1.4

Source: HAZUS-MH 2.1

Note: The percent of the population displaced and seeking shelter was calculated using the 2000 U.S. Census data for the Lehigh Valley. est. = Estimated

4.3.4.5.4 Impact on General Building Stock

After considering the population exposed and vulnerable to the flood hazard, the built environment was evaluated. Exposure in the flood zone includes those buildings located in the flood zone. Potential damage is the modeled loss that could occur to the exposed inventory, including structural and content value.

The total land area located in the 1% and 0.2% flood zones was calculated for each municipality, as presented in Table 4.3.4-7 below. To provide a general estimate of number of structures, parcels, and structural/content replacement value exposure, the FEMA DFIRM flood boundaries (1% and 0.2% flood zones) were overlaid upon Lehigh and Northampton Counties' parcel and the updated building stock inventory point shapefiles. The parcels that intersect the 1% and/or 0.2% flood zones were totaled for

each municipality. The total number of buildings with their centroid located in the 1% and 0.2% flood boundaries was also determined and their estimated building stock replacement value (structure and contents) is listed for each municipality in Table 4.3.4-8.

The depth grid developed for the 1% flood event for Lehigh and Northampton Counties was integrated into the HAZUS-MH riverine flood model. The model was then run to estimate the potential general building stock losses for the 1% flood event. The potential estimated losses are summarized by municipality in Table 4.3.4-8.

Table 4.3.4-7. Estimated Number of Parcels Located in the 1% and 0.2% FEMA DFIRM Flood Boundaries

Municipality	Total Number of Parcels	1% Flood Hazard Area		0.2% Flood Hazard Area	
		Number of Parcels	% of Total	Number of Parcels	% of Total
Lehigh County					
Alburtis Borough	922	22	2.4	45	4.9
Allentown, City of	33,998	714	2.1	984	2.9
Bethlehem, City of	6,208	2	0.0	2	0.0
Catasauqua Borough	2,379	165	6.9	241	10.1
Coopersburg Borough	890	61	6.9	61	6.9
Coplay Borough	1,375	4	0.3	5	0.4
Emmaus Borough	4,213	117	2.8	143	3.4
Fountain Hill Borough	1,626	0	0.0	1	0.1
Hanover Township	593	15	2.5	18	3.0
Heidelberg Township	1,708	223	13.1	224	13.1
Lower Macungie Township	10,426	644	6.2	889	8.5
Lower Milford Township	1,764	241	13.7	242	13.7
Lowhill Township	1,070	171	16.0	171	16.0
Lynn Township	2,401	402	16.7	402	16.7
Macungie Borough	874	10	1.1	19	2.2
North Whitehall Township	6,121	338	5.5	356	5.8
Salisbury Township	5,679	151	2.7	167	2.9
Slatington Borough	1,631	63	3.9	101	6.2
South Whitehall Township	7,929	275	3.5	357	4.5
Upper Macungie Township	7,207	311	4.3	425	5.9
Upper Milford Township	3,358	248	7.4	336	10.0
Upper Saucon Township	5,856	126	2.2	166	2.8
Washington Township	3,202	224	7.0	247	7.7
Weisenberg Township	2,408	214	8.9	214	8.9
Whitehall Township	9,080	329	3.6	527	5.8

SECTION 4.3.4: RISK ASSESSMENT – FLOOD

Municipality	Total Number of Parcels	1% Flood Hazard Area		0.2% Flood Hazard Area	
		Number of Parcels	% of Total	Number of Parcels	% of Total
Lehigh County (est. total)	122,980	5,070	4.1	6,343	5.2
Northampton County					
Allen Township	2,411	140	5.8	142	5.9
Bangor Borough	2,039	321	15.7	386	18.9
Bath Borough	1,013	94	9.3	94	9.3
Bethlehem Township	9,409	374	4.0	388	4.1
Bethlehem, City of	16,915	432	2.6	600	3.5
Bushkill Township	3,678	216	5.9	216	5.9
Chapman Borough	111	20	18.0	20	18.0
East Allen Township	1,984	180	9.1	180	9.1
East Bangor Borough	455	5	1.1	5	1.1
Easton, City of	8,503	396	4.7	581	6.8
Forks Township	6,699	349	5.2	407	6.1
Freemansburg Borough	1,041	135	13.0	176	16.9
Glendon Borough	209	16	7.7	19	9.1
Hanover Township	4,450	66	1.5	68	1.5
Hellertown Borough	2,420	85	3.5	106	4.4
Lehigh Township	4,844	299	6.2	300	6.2
Lower Mt. Bethel Township	1,762	483	27.4	514	29.2
Lower Nazareth Township	2,612	256	9.8	256	9.8
Lower Saucon Township	5,078	263	5.2	301	5.9
Moore Township	4,139	285	6.9	288	7.0
Nazareth Borough	2,019	29	1.4	29	1.4
North Catasauqua Borough	1,148	11	1.0	23	2.0
Northampton Borough	4,028	330	8.2	419	10.4
Palmer Township	8,924	313	3.5	353	4.0
Pen Argyl Borough	1,436	7	0.5	7	0.5
Plainfield Township	2,998	177	5.9	181	6.0



SECTION 4.3.4: RISK ASSESSMENT – FLOOD

Municipality	Total Number of Parcels	1% Flood Hazard Area		0.2% Flood Hazard Area	
		Number of Parcels	% of Total	Number of Parcels	% of Total
Portland Borough	283	69	24.4	74	26.1
Roseto Borough	757	4	0.5	4	0.5
Stockertown Borough	384	62	16.1	66	17.2
Tatamy Borough	447	20	4.5	34	7.6
Upper Mt. Bethel Township	3,590	596	16.6	638	17.8
Upper Nazareth Township	2,316	105	4.5	105	4.5
Walnutport Borough	922	24	2.6	37	4.0
Washington Township	2,530	232	9.2	232	9.2
West Easton Borough	544	33	6.1	43	7.9
Williams Township	3,148	257	8.2	288	9.1
Wilson Borough	2,923	17	0.6	18	0.6
Wind Gap Borough	1,004	32	3.2	33	3.3
Northampton County (est. total)	119,227	6,733	5.6	7,631	6.4

Source: FEMA, 2004; FEMA 2011

Notes: This analysis was conducted using the DFIRMs available for the Lehigh Valley (2004 for Lehigh County and preliminary 2011 for Northampton County).
est. = Estimated.

Table 4.3.4-8. Estimated Building Exposure and Potential Losses to the 1% and 0.2% Flood Events

Municipality	Total Number of Buildings	Total RV	1% Event						0.2% Event			
			Exposed				Estimated Potential Loss		Exposed			
			Number of Buildings	% of Total	RV	% of Total	RV	% of Total	Number of Buildings	% of Total	RV	% of Total
Lehigh County												
Alburtis Borough	884	\$280,994,000	2	0.2	\$447,803	0.1	\$0 *	0.0*	34	3.8	\$8,894,616	3.2
Allentown, City of	33,947	\$20,982,347,000	314	0.9	\$459,623,347	2.2	\$87,951,767	0.4	499	1.5	\$815,926,964	3.9
Bethlehem, City of	6,437	\$4,769,721,000	23	0.4	\$16,497,498	0.3	\$3,823,292	0.1	68	1.1	\$40,715,000	0.9
Catasauqua Borough	2,258	\$934,748,000	72	3.2	\$64,751,762	6.9	\$13,572,704	1.5	149	6.6	\$94,462,469	10.1
Coopersburg Borough	867	\$421,475,000	2	0.2	\$543,570	0.1	\$9,956	0.0	2	0.2	\$543,570	0.1
Coplay Borough	1,316	\$406,752,000	0	0	\$0	0	\$0	0.0	0	0	\$0	0
Emmaus Borough	4,166	\$2,088,277,000	42	1	\$22,204,207	1.1	\$1,298,745	0.1	54	1.3	\$27,932,348	1.3
Fountain Hill Borough	1,554	\$1,101,911,000	0	0	\$0	0	\$0	0.0	1	0.1	\$42,929,696	3.9
Hanover Township	616	\$2,254,652,000	0	0	\$0	0	\$0	0.0	1	0.2	\$270,043	0
Heidelberg Township	1,261	\$550,037,000	56	4.4	\$21,668,702	3.9	\$472,220	0.1	57	4.5	\$21,940,023	4
Lower Macungie Township	11,371	\$5,924,050,000	197	1.7	\$98,878,159	1.7	\$12,059,304	0.2	457	4	\$237,785,998	4
Lower Milford Township	1,433	\$534,598,000	41	2.9	\$15,193,448	2.8	\$801,315	0.1	41	2.9	\$15,193,448	2.8
Lowhill Township	864	\$371,530,000	10	1.2	\$3,995,586	1.1	\$640,899	0.2	10	1.2	\$3,995,586	1.1
Lynn Township	1,670	\$612,033,000	77	4.6	\$28,251,857	4.6	\$5,626,176	0.9	77	4.6	\$28,251,857	4.6
Macungie Borough	1,809	\$533,007,000	4	0.2	\$5,252,628	1	\$55,203	0.0	9	0.5	\$11,553,563	2.2
North Whitehall Township	5,485	\$2,850,746,000	54	1	\$37,602,959	1.3	\$1,872,214	0.1	61	1.1	\$39,218,883	1.4
Salisbury Township	5,299	\$3,606,044,000	40	0.8	\$115,464,662	3.2	\$14,244,095	0.4	49	0.9	\$163,967,438	4.5
Slatington Borough	1,484	\$715,470,000	6	0.4	\$2,631,933	0.4	\$486,482	0.1	26	1.8	\$12,432,388	1.7
South Whitehall Township	7,891	\$4,885,829,000	76	1	\$32,881,268	0.7	\$1,153,788	0.02	163	2.1	\$66,423,903	1.4
Upper Macungie Township	6,903	\$10,206,499,000	65	0.9	\$34,502,731	0.3	\$1,175,439	0.01	117	1.7	\$52,076,836	0.5
Upper Milford Township	3,010	\$1,178,767,000	66	2.2	\$33,941,755	2.9	\$1,629,335	0.1	90	3	\$44,870,707	3.8
Upper Saucon Township	5,301	\$3,171,479,000	22	0.4	\$119,843,915	3.8	\$845,309	0.0	36	0.7	\$125,154,286	3.9

SECTION 4.3.4: RISK ASSESSMENT – FLOOD

Municipality	Total Number of Buildings	Total RV	1% Event						0.2% Event			
			Exposed				Estimated Potential Loss		Exposed			
			Number of Buildings	% of Total	RV	% of Total	RV	% of Total	Number of Buildings	% of Total	RV	% of Total
Washington Township	2,516	\$893,760,000	35	1.4	\$13,078,422	1.5	\$487,129	0.1	37	1.5	\$13,859,185	1.6
Weisenberg Township	1,878	\$1,189,552,000	25	1.3	\$6,450,939	0.5	\$297,330	0.02	25	1.3	\$6,450,939	0.5
Whitehall Township	8,974	\$5,424,311,000	85	0.9	\$55,257,330	1	\$3,547,116	0.1	230	2.6	\$214,334,925	4
Lehigh County (est. total)	119,194	\$75,888,589,000	1,314	1.10	\$1,188,964,481	1.57	\$152,049,818	0.20	2,293	1.92	\$2,089,184,671	2.75
Northampton County												
Allen Township	2,043	\$712,840,000	24	1.2	\$41,046,480	5.7	\$10,313,020	1.4	28	1.4	\$42,501,553	5.9
Bangor Borough	1,849	\$926,661,000	180	9.7	\$240,768,217	25.9	\$83,770,170	9.0	236	12.8	\$297,389,629	32
Bath Borough	939	\$471,748,000	9	1	\$8,352,303	1.8	\$244,958	0.1	9	1	\$8,352,303	1.8
Bethlehem Township	8,683	\$5,752,889,000	100	1.2	\$70,803,684	1.2	\$13,134,031	0.2	107	1.2	\$82,662,097	1.4
Bethlehem, City of	15,889	\$9,934,952,000	82	0.5	\$226,971,075	2.3	\$30,527,071	0.3	162	1	\$616,001,097	6.2
Bushkill Township	3,001	\$1,289,529,000	24	0.8	\$9,073,207	0.7	\$2,519,746	0.2	24	0.8	\$9,073,207	0.7
Chapman Borough	86	\$32,434,000	2	2.3	\$609,672	1.9	\$0	0.0	2	2.3	\$609,672	1.9
East Allen Township	1,730	\$1,104,833,000	29	1.7	\$14,773,261	1.3	\$1,085,392	0.1	29	1.7	\$14,773,261	1.3
East Bangor Borough	375	\$118,151,000	0	0	\$0	0	\$0	0.0	0	0	\$0	0
Easton, City of	7,643	\$4,848,037,000	134	1.8	\$347,201,853	7.2	\$111,092,616	2.3	262	3.4	\$598,150,980	12.3
Forks Township	5,661	\$3,177,595,000	58	1	\$25,067,233	0.8	\$7,168,387	0.2	70	1.2	\$28,307,911	0.9
Freemansburg Borough	931	\$361,483,000	76	8.2	\$35,689,588	9.9	\$7,737,003	2.1	109	11.7	\$64,272,950	17.8
Glendon Borough	167	\$89,841,000	2	1.2	\$7,579,362	8.3	\$0 *	0.0*	5	3	\$11,134,727	12.2
Hanover Township	4,288	\$3,484,970,000	7	0.2	\$8,898,211	0.3	\$1,348,806	0.04	8	0.2	\$9,304,871	0.3
Hellertown Borough	2,314	\$888,848,000	31	1.3	\$29,582,113	3.3	\$2,774,447	0.3	41	1.8	\$40,360,406	4.5
Lehigh Township	3,863	\$1,487,389,000	47	1.2	\$23,437,269	1.6	\$2,764,042	0.2	65	1.7	\$30,844,951	2.1
Lower Mt. Bethel Township	1,237	\$502,664,000	169	13.7	\$65,573,683	12.8	\$19,317,630	3.8	212	17.1	\$85,022,698	16.6
Lower Nazareth Township	2,274	\$2,194,429,000	37	1.6	\$20,809,242	0.9	\$1,153,330	0.1	37	1.6	\$20,809,242	0.9
Lower Saucon Township	4,331	\$1,968,200,000	59	1.4	\$42,011,502	2.1	\$9,223,565	0.5	78	1.8	\$52,369,178	2.6



SECTION 4.3.4: RISK ASSESSMENT – FLOOD

Municipality	Total Number of Buildings	Total RV	1% Event						0.2% Event			
			Exposed				Estimated Potential Loss		Exposed			
			Number of Buildings	% of Total	RV	% of Total	RV	% of Total	Number of Buildings	% of Total	RV	% of Total
Moore Township	3,289	\$1,223,870,000	49	1.5	\$20,188,049	1.6	\$3,567,907	0.3	50	1.5	\$20,599,178	1.7
Nazareth Borough	1,876	\$1,312,606,000	7	0.4	\$2,583,924	0.2	\$89,607	0.007	7	0.4	\$2,583,924	0.2
North Catasauqua Borough	1,089	\$386,289,000	0	0	\$0	0	\$0	0.0	0	0	\$0	0
Northampton Borough	3,757	\$1,843,226,000	155	4.1	\$68,488,687	3.7	\$12,791,593	0.7	218	5.8	\$118,078,813	6.4
Palmer Township	8,073	\$4,169,701,000	78	1	\$54,256,641	1.3	\$9,310,796	0.2	89	1.1	\$89,388,973	2.1
Pen Argyl Borough	1,306	\$651,065,000	0	0	\$0	0	\$0	0.0	0	0	\$0	0
Plainfield Township	2,412	\$1,086,698,000	26	1.1	\$11,914,046	1.1	\$1,401,605	0.1	26	1.1	\$11,914,046	1.1
Portland Borough	222	\$162,069,000	27	12.2	\$41,162,613	25.4	\$13,702,107	8.5	32	14.4	\$48,090,975	29.7
Roseto Borough	612	\$276,318,000	0	0	\$0	0	\$0	0.0	0	0	\$0	0
Stockertown Borough	335	\$298,470,000	4	1.2	\$4,601,284	1.5	\$17,592	0.0	5	1.5	\$4,691,374	1.6
Tatamy Borough	417	\$216,261,000	4	1	\$58,261,178	26.9	\$6,405,961	3.0	9	2.2	\$73,217,968	33.9
Upper Mt. Bethel Township	2,542	\$1,311,378,000	158	6.2	\$56,932,675	4.3	\$16,922,758	1.3	218	8.6	\$71,425,841	5.4
Upper Nazareth Township	1,973	\$1,071,480,000	12	0.6	\$8,707,011	0.8	\$185,290	0.0	12	0.6	\$8,707,011	0.8
Walnutport Borough	825	\$506,739,000	14	1.7	\$2,379,216	0.5	\$505,590	0.1	18	2.2	\$3,115,770	0.6
Washington Township	1,927	\$875,751,000	58	3	\$28,625,717	3.2	\$6,133,702	0.7	58	3	\$28,625,717	3.2
West Easton Borough	475	\$267,628,000	14	2.9	\$70,706,197	26.4	\$17,350,937	6.5	21	4.4	\$75,387,427	28.1
Williams Township	2,629	\$1,200,406,000	70	2.7	\$46,419,802	3.8	\$21,516,886	1.8	102	3.9	\$57,626,700	4.8
Wilson Borough	2,803	\$1,731,473,000	3	0.1	\$6,946,734	0.4	\$13,200	0.0	3	0.1	\$6,946,734	0.4
Wind Gap Borough	869	\$532,380,000	9	1	\$11,808,483	2.2	\$103,354	0.0	9	1	\$11,808,483	2.2
Northampton County (est. total)	104,735	\$58,471,301,000	1,758	1.7	\$1,712,230,210	2.9	\$414,193,098	0.7	2,361	2.3	\$2,644,149,665	4.5

Source: Lehigh County GIS; Northampton County GIS; HAZUS-MH 2.1

Notes: This analysis was conducted using the DFIRMs available for the Lehigh Valley (2004 for Lehigh County and preliminary 2011 for Northampton County) and the point shapefiles generated for the HAZUS-MH general building stock update using the structure, parcel and assessor’s data available from both Counties. est. = Estimated.

Values represent replacement values (RV) for building structure and contents.

* Although buildings are located within the special flood hazard boundary, HAZUS did not estimate potential damages. This may be because even though these structures are located within the boundary of the flood depth grid, the depth of flooding does not amount to any damages to the structure or contents according to the depth damage function used in HAZUS.



In addition to total building stock modeling, individual data available on flood policies, claims, Repetitive Loss (RL) and Severe Repetitive Loss (SRL) properties were analyzed. FEMA Region 3 provided a list of residential properties with NFIP policies, past claims and multiple claims (including RL\SRL). According to the metadata provided: “The NFIP Repetitive Loss File contains losses reported from individuals who have flood insurance through the Federal Government. A property is considered a repetitive loss property when there are two or more losses reported which were paid more than \$1,000 for each loss. The two losses must be within 10 years of each other & be as least 10 days apart. Only losses from (*sic* since) 1/1/1978 that are closed are considered.”

SRL properties were then examined in the Lehigh Valley. According to section 1361A of the National Flood Insurance Act, as amended (NFIA), 42 U.S.C. 4102a, an SRL property is defined as a residential property that is covered under an NFIP flood insurance policy and:

- Has at least four NFIP claim payments (including building and contents) over \$5,000 each, and the cumulative amount of such claims payments exceeds \$20,000; or
- For which at least two separate claims payments (building payments only) have been made with the cumulative amount of the building portion of such claims exceeding the market value of the building.
- For both of the above, at least two of the referenced claims must have occurred within any 10-year period, and must be greater than 10 days apart.

Table 4.3.4-9 and Figure 4.3.4-5 summarize the NFIP policies, claims and repetitive loss data and statistics for the Lehigh Valley. According to FEMA, there 50 RL and 11 SRL properties in Lehigh County; and 185 RL and 35 SRL properties in Northampton County. Of the 11 SRL properties in Lehigh County, three (3) are classified as residential structures and eight (8) are non-residential structures (data from column ‘occ01’). Of the 35 SRL properties in Northampton County, 27 are classified as residential, two (2) are classified as two-to-four family, five (5) are classified as non-residential and one (1) is classified as ‘other’ (data from column ‘occ01’) (FEMA Region 2, 2011). This information is current as of February 29, 2012.

The location of the properties with policies, claims and repetitive and severe repetitive flooding were geocoded by FEMA with the understanding that there are varying tolerances between how closely the longitude and latitude coordinates correspond to the location of the property address, or that the indication of some locations are more accurate than others.

Table 4.3.4-9. NFIP Policies, Claims and Repetitive Loss Statistics

Municipality	# Policies (1)	# Claims (Losses) (1)	Total Loss Payments (2)	# Rep. Loss Prop. (1)	# Severe Rep. Loss Prop. (1)	# Policies in 100-year Boundary (3)	# Policies in 500-Boundary (3)	# Policies Outside the 500-year Flood Hazard (3)
Lehigh County								
Alburtis Borough	1	1	\$0	0	0	0	0	1
Allentown, City of	171	387	\$3,675,590	15	6	107	120	51
Bethlehem, City of	94	171	\$2,780,150	12	4	0	0	94
Catasauqua Borough	34	11	\$204,371	2	1	27	29	5
Coopersburg Borough	3	5	\$16,414	0	0	2	2	1
Coplay Borough	2	0	\$0	0	0	0	0	2
Emmaus Borough	25	11	\$65,317	0	0	11	11	14
Fountain Hill Borough	1	1	\$3,161	0	0	0	0	1
Hanover Township	0	0	\$0	0	0	0	0	0
Heidelberg Township	20	7	\$18,032	1	0	13	13	7
Lower Macungie Township	157	123	\$1,713,140	12	0	94	110	47
Lower Milford Township	7	2	\$0	0	0	3	3	4
Lowhill Township	6	2	\$17,108	0	0	2	2	4
Lynn Township	27	1	\$6,862	0	0	14	14	13
Macungie Borough	13	42	\$300,452	3	0	2	4	9
North Whitehall Township	28	11	\$85,149	0	0	5	6	22
Salisbury Township	13	6	\$15,872	0	0	4	4	9
Slatington Borough	2	3	\$7,525	0	0	0	0	2
South Whitehall Township	63	55	\$346,928	1	0	33	45	18
Upper Macungie Township	34	12	\$34,248	0	0	5	12	22
Upper Milford Township	30	12	\$192,595	2	0	19	21	9
Upper Saucon Township	28	16	\$76,845	0	0	5	8	20
Washington Township	10	1	\$23,080	0	0	4	4	6
Weisenberg Township	10	0	\$0	0	0	8	8	2

SECTION 4.3.4: RISK ASSESSMENT – FLOOD

Municipality	# Policies (1)	# Claims (Losses) (1)	Total Loss Payments (2)	# Rep. Loss Prop. (1)	# Severe Rep. Loss Prop. (1)	# Policies in 100-year Boundary (3)	# Policies in 500-Boundary (3)	# Policies Outside the 500-year Flood Hazard (3)
Whitehall Township	56	51	\$213,272	2	0	25	30	26
Lehigh County	835	931	\$9,796,111	50	11	383	446	389
Northampton County								
Allen Township	10	3	\$18,209	1	0	1	2	8
Bangor Borough	71	53	\$1,446,296	8	1	55	58	13
Bath Borough	8	6	\$50,861	0	0	0	0	8
Bethlehem Township	63	40	\$2,022,525	5	0	12	12	51
Bethlehem, City of*	0	0	\$1,783,018	0	0	0	0	0
Bushkill Township	15	13	\$170,522	0	0	4	4	11
Chapman Borough	2	0	\$0	0	0	1	1	1
East Allen Township	8	8	\$54,947	0	0	1	1	7
East Bangor Borough	0	0	\$0	0	0	0	0	0
Easton, City of	110	273	\$11,262,520	37	4	79	87	23
Forks Township	86	166	\$5,578,611	37	9	54	67	19
Freemansburg Borough	35	45	\$285,453	3	0	28	31	4
Glendon Borough	0	0	\$0	0	0	0	0	0
Hanover Township	8	2	\$33,455	3	1	0	0	8
Hellertown Borough	29	16	\$252,655	2	0	7	10	19
Lehigh Township	21	7	\$12,453	0	0	2	2	19
Lower Mt. Bethel Township	103	219	\$6,768,867	38	7	62	66	37
Lower Nazareth Township	15	7	\$71,178	1	0	1	1	14
Lower Saucon Township	34	25	\$354,179	2	1	5	5	29
Moore Township	19	14	\$90,856	1	0	8	8	11
Nazareth Borough	7	4	\$18,664	0	0	1	1	6
North Catasauqua Borough	0	0	\$0	0	0	0	0	0
Northampton Borough	97	28	\$372,699	3	1	82	83	14



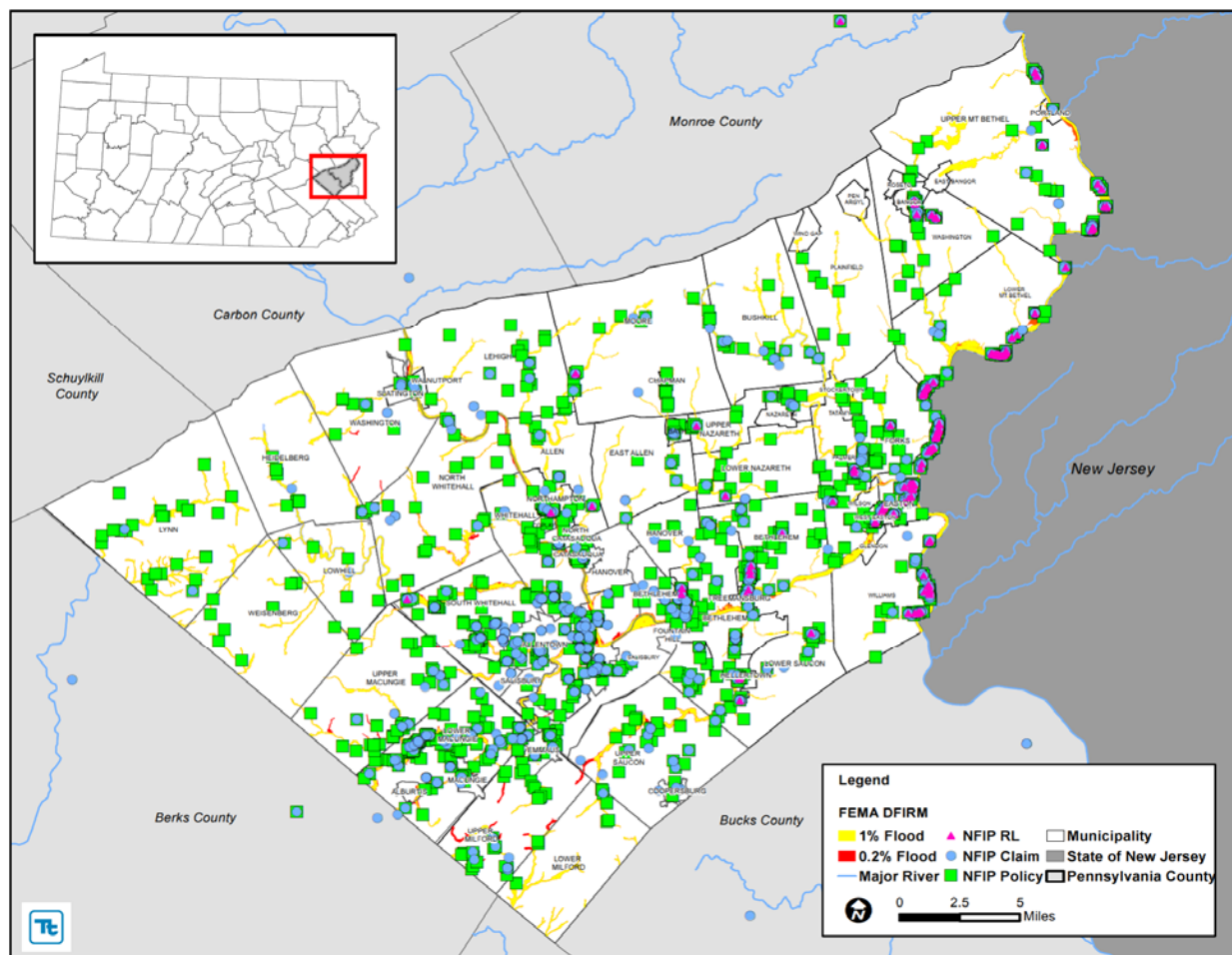
SECTION 4.3.4: RISK ASSESSMENT – FLOOD

Municipality	# Policies (1)	# Claims (Losses) (1)	Total Loss Payments (2)	# Rep. Loss Prop. (1)	# Severe Rep. Loss Prop. (1)	# Policies in 100-year Boundary (3)	# Policies in 500-Boundary (3)	# Policies Outside the 500-year Flood Hazard (3)
Palmer Township	41	24	\$1,607,949	1	0	2	2	39
Pen Argyl Borough	0	0	\$0	0	0	0	0	0
Plainfield Township	6	0	\$0	0	0	1	1	5
Portland Borough	7	15	\$2,424,858	0	0	9	9	-2
Roseto Borough	0	0	\$0	0	0	0	0	0
Stockertown Borough	4	2	\$100,772	0	0	1	1	3
Tatamy Borough	3	0	\$0	0	0	0	2	1
Upper Mt. Bethel Township	89	136	\$3,845,690	17	6	60	65	24
Upper Nazareth Township	11	3	\$53,507	1	0	1	1	10
Walnutport Borough	4	3	\$829	0	0	2	2	2
Washington Township	25	3	\$7,760	0	0	13	13	12
West Easton Borough	6	18	\$206,233	2	0	17	17	-
Williams Township	56	128	\$4,286,487	23	5	35	39	17
Wilson Borough	2	0	\$0	0	0	0	0	2
Wind Gap Borough	0	0	\$0	0	0	0	0	0
Northampton County	995	1,261	\$41,399,035	185	35	546	594	401

Source: FEMA Region 3, 2012

- (1) Policies, claims, repetitive loss and severe repetitive loss statistics provided by FEMA Region 3, in April 2012 using the “Comm_Name”. These statistics are current as of February 29, 2012. Please note the total number of repetitive loss properties includes the severe repetitive loss properties.
- (2) Total building and content losses from the claims file provided by FEMA Region 3 (current as of February 29, 2012).
- (3) The policies inside and outside of the flood zones is based on the latitude and longitude provided by FEMA Region 3 in the policy file.
* The number of policies and claims appears low for the City of Bethlehem when using the ‘Comm_Name’ column in the spreadsheets provided by FEMA. If based on location, regardless of the community name provided, there are 69 policies, 91 claims, 3 repetitive loss properties which are also severe repetitive loss properties and \$1,783,018 in total loss payments (claims) within the City limits.

Figure 4.3.4-5. NFIP Policies, Claims, Repetitive Loss and Severe Repetitive Loss Properties in the Lehigh Valley



Source: FEMA Region 3, 2012

4.3.4.5.5 Impact on Critical Facilities

In addition to considering general building stock at risk, the risk of flood to critical facilities, utilities and user-defined facilities was evaluated. HAZUS-MH was used to estimate the flood loss potential to critical facilities exposed to the flood risk. Using depth/damage function curves, HAZUS estimates the percent of damage to the building and contents of critical facilities. Table 4.3.4-10 lists the critical facilities and utilities located in the FEMA preliminary DFIRM flood zones and the percent damage HAZUS-MH 2.1 estimates to the facility as a result of the 1% event.

In cases where short-term functionality is impacted by a hazard, other facilities of neighboring municipalities may need to increase support response functions during a disaster event. Mitigation planning should consider means to reduce impact to critical facilities and ensure sufficient emergency and school services remain when a significant event occurs.

Table 4.3.4-10. Critical Facilities Located in the DFIRM 1% and 0.2% Flood Boundaries and Estimated Potential Damage from the 1% Flood Event

Name	Municipality	Type	Exposure		Potential Loss from 1% Flood Event		
			1% Event	0.2% Event	Structure Damage	Content Damages	Days to 100-Percent Functional
Lehigh County							
CITY OF ALLENTOWN	Allentown (C)	User Defined (Gov)	X	X	5.7	37.0	NA
LEHIGH COUNTY HUMANE SOC	Allentown (C)	User Defined (Gov)	X	X	5.7	37.0	NA
CITY OF ALLENTOWN	Allentown (C)	User Defined (Gov)	X	X	2.0	11.7	NA
CITY OF ALLENTOWN	Allentown (C)	User Defined (Gov)	X	X	0.0	0.0	NA
CITY OF ALLENTOWN	Allentown (C)	User Defined (Gov)	X	X	0.0	0.0	NA
SALISBURY HOUSE OF NORTHEAST PA INC	Allentown (C)	User Defined (Res)	X	X	27.6	35.9	NA
COMMONWEALTH OF PA	Allentown (C)	User Defined (Gov)	X	X	37.1	100.0	NA
COMMONWEALTH OF PA	Allentown (C)	User Defined (Gov)	X	X	36.0	100.0	NA
COMMONWEALTH OF PA	Allentown (C)	User Defined (Gov)	X	X	47.4	100.0	NA
COMMONWEALTH OF PA	Allentown (C)	User Defined (Gov)	X	X	55.0	100.0	NA
COMMONWEALTH OF PA	Allentown (C)	User Defined (Gov)	X	X	47.8	100.0	NA
OCASIO RAYMOND S & BERTHA L	Allentown (C)	User Defined (Edu)	X	X	0.0	0.0	NA
U G I CORP-LEHIGH DIV	Allentown (C)	Electric Power	X	X	-	-	-
PENNA POWER & LIGHT CO	Allentown (C)	Electric Power		X	-	-	-
Union Terrace Elementary School	Allentown (C)	School		X	-	-	-
Borough of Catasauqua	Catasauqua (B)	User Defined		X	-	-	-
PENNA POWER & LIGHT CO	Catasauqua (B)	Electric Power		X	-	-	-
CITIZENS FIRE CO	Emmaus (B)	Fire	X	X	0.0	0.0	0.0
BORO OF EMMAUS	Emmaus (B)	User Defined (Gov)	X	X	11.1	68.3	11.1
GOLDSTEIN LEE A ET AL	Emmaus (B)	Communication	X	X	-	-	-
HANOVER TOWNSHIP	Hanover (T)	User Defined (Gov)	X	X	14.9	98.7	14.9

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Name	Municipality	Type	Exposure		Potential Loss from 1% Flood Event		
			1% Event	0.2% Event	Structure Damage	Content Damages	Days to 100-Percent Functional
HEIDELBERG TWP	Heidelberg (T)	User Defined (Gov)	X	X	-	-	-
RITTER DEAN L & MARYBETH A	Heidelberg (T)	User Defined (Res)	X	X	-	-	-
LOWER MACUNGIE TWP	Lower Macungie (T)	User Defined (Gov)	X	X	14.1	90.6	14.1
LOWER MACUNGIE TWP	Lower Macungie (T)	User Defined (Gov)	X	X	22.0	100.0	22.0
LOWER MACUNGIE TWP	Lower Macungie (T)	User Defined (Gov)	X	X	15.1	100.0	15.1
LOWER MACUNGIE TWP	Lower Macungie (T)	User Defined (Gov)	X	X	19.9	100.0	19.9
LOWER MACUNGIE TWP	Lower Macungie (T)	User Defined (Gov)	X	X	18.5	100.0	18.5
LOWER MACUNGIE TWP	Lower Macungie (T)	User Defined (Gov)	X	X	26.2	100.0	26.2
LOWER MACUNGIE TWP	Lower Macungie (T)	User Defined (Gov)	X	X	9.7	64.2	9.7
LOWER MACUNGIE TWP	Lower Macungie (T)	User Defined (Gov)	X	X	14.7	97.2	14.7
CONTEL OF PENNSYLVANIA INC	Lower Macungie (T)	Electric Power	X	X	-	-	-
LOWER MILFORD TWP FIRE CO #1	Lower Milford (T)	Fire	X	X	1.1	1.2	1.1
Lynn Township Sewer Auth	Lynn (T)	WWTF	X	X	-	-	-
NORTHAMPTON BORO MUN AUTH	North Whitehall (T)	Electric Power	X	X	-	-	-
COUNTY OF LEHIGH	Salisbury (T)	User Defined (Gov)	X	X	-	-	-
BORO OF SLATINGTON	Slatington (B)	User Defined (Gov)	X	X	9.8	19.1	9.8
Slatington Airport	Slatington (B)	Airport		X	-	-	-
PFG Gas Inc	Slatington (B)	Electric		X	-	-	-
DATZYK MONTESSORI SCHOOL	South Whitehall (T)	School	X	X	-	-	-
City of Allentown (owner)	South Whitehall (T)	User Defined (Gov)		X	-	-	-
TREXLERTOWN GOOD WILL FIRE CO #1	Upper Macungie (T)	Fire	X	X	1.8	2.0	1.8
COMMONWEALTH OF PA	Upper Macungie (T)	User Defined (Gov)	X	X	0.0	0.0	0.0
PENNA POWER & LIGHT CO	Upper Macungie (T)	Electric Power	X	X	-	-	-
City of Allentown (owner)	Upper Macungie (T)	User Defined (Gov)		X	-	-	-



SECTION 4.3.4: RISK ASSESSMENT – FLOOD

Name	Municipality	Type	Exposure		Potential Loss from 1% Flood Event		
			1% Event	0.2% Event	Structure Damage	Content Damages	Days to 100-Percent Functional
WASHINGTON TWP	Washington (T)	User Defined (Gov)	X	X	-	-	-
WHITEHALL TWP	Whitehall (T)	User Defined (Gov)	X	X	-	-	-
Coplay-Whitehall Sewer Authority	Whitehall (T)	WWTF		X	-	-	-

Name	Municipality	Type	Exposure		Potential Loss from 1% Flood Event		
			1% Event	0.2% Event	Structure Damage	Content Damages	Days to 100-Percent Functional
Northampton County							
District Court 03-3-03	Bangor (B)	User Defined	X	X	0.0	0.0	NA
Learning Locomotion	Bangor (B)	User Defined	X	X	21.8	24.5	NA
Bangor Public Library	Bangor (B)	User Defined	X	X	17.5	100.0	NA
BANGOR PD	Bangor (B)	Police	X	X	17.8	83.2	630
PPL Martins Creek Stream Electric Station	Bangor (B)	Electric		X	-	-	-
Gaffrey Funeral Home	Bangor (B)	User Defined		X	-	-	-
United States Post Office	Bangor (B)	User Defined		X	-	-	-
Bath Sewer Plant	Bath (B)	WWTF	X	X	-	-	-
USGS Lehigh River Gauge at Bethlehem, PA	Bethlehem (C)	User Defined	X	X	-	-	-
Morning Call	Bethlehem (C)	User Defined	X	X	-	-	-
Historic Bethlehem Partnership	Bethlehem (C)	User Defined		X	-	-	-
Fritch, Inc.	Bethlehem (C)	Natural Gas	X	X	-	-	-
Golden Eagle Courier Systems, Inc.	Bethlehem (C)	Bus	X		-	-	-
Moravian College-South	Bethlehem (C)	School	X	X	8.5	49.0	480
St Lukes Union Station	Bethlehem (C)	Medical		X	-	-	-
Bio Med Sciences Inc	Bethlehem (C)	Medical		X	-	-	-



SECTION 4.3.4: RISK ASSESSMENT – FLOOD

Name	Municipality	Type	Exposure		Potential Loss from 1% Flood Event		
			1% Event	0.2% Event	Structure Damage	Content Damages	Days to 100-Percent Functional
Orasure Technologies Inc.	Bethlehem (C)	Medical		X	-	-	-
Movarian College-South	Bethlehem (C)	School		X	-	-	-
EATMA EAST ALLEN GARDENS WATER SYS	East Allen (T)	Potable Water	X	X	-	-	-
E BANGOR MUNI AUTH WATER SYS	East Bangor (B)	Potable Water	X	X	-	-	-
Quality Inn	Easton (C)	User Defined	X	X	43.7	56.8	NA
Easton (Lehigh River) Boat Access Ramp	Easton (C)	User Defined	X	X	10.4	29.9	NA
United States Post Office	Easton (C)	User Defined	X	X	0.0	0.0	NA
Easton (Delaware River) Boat Access Ramp	Easton (C)	User Defined	X	X	47.1	100.0	NA
Easton - Phillipsburg Toll Bridge	Easton (C)	User Defined	X	X	0.0	0.0	NA
PA WATER RECUE	Easton (C)	Fire	X	X	22.7	97.0	630
USGS Lehigh River Gage at Easton PA	Easton (C)	User Defined	X	X	-	-	-
Carish Rico	Easton (C)	WWTF		X	-	-	-
Bachmann Publick House	Easton (C)	User Defined		X	-	-	-
Lou Reda Productions	Easton (C)	User Defined		X	-	-	-
Easton Irregular	Easton (C)	User Defined		X	-	-	-
DAR Parsons Taylor House	Easton (C)	User Defined		X	-	-	-
First Presbyterian Church	Easton (C)	User Defined		X	-	-	-
St. John's Evangelical Lutheran Church	Easton (C)	User Defined		X	-	-	-
First Presbyterian Church	Easton (C)	Shelter		X	-	-	-
Binney & Smith	Forks (T)	User Defined	X	X	15.9	76.7	NA
USGS Lehigh River Gage at Glendon PA	Glendon (B)	User Defined	X	X	-	-	-
WESTGATE WATER SYS	Hanover (T)	Potable Water	X	X	-	-	-
WESTGATE WATER SYS	Hanover (T)	Potable Water	X	X	-	-	-
VILLAGE VIEW WATER SYS	Hanover (T)	Potable Water	X	X	-	-	-



SECTION 4.3.4: RISK ASSESSMENT – FLOOD

Name	Municipality	Type	Exposure		Potential Loss from 1% Flood Event		
			1% Event	0.2% Event	Structure Damage	Content Damages	Days to 100-Percent Functional
Yeagers Pharmacy	Hellertown (B)	Medical		X	-	-	-
HELLERTOWN PD	Hellertown (B)	Police		X	-	-	-
TREICHLERS WATER SYS	Lehigh (T)	Potable Water	X	X	-	-	-
LEHIGH TWP MUN AUTH	Lehigh (T)	WWTF		X	-	-	-
Sandt's Eddy Boat Access Ramp	Lower Mt Bethel (T)	User Defined	X	X	7.5	24.0	NA
PPL Public Boat Access Ramp	Lower Mt Bethel (T)	User Defined	X	X	8.0	25.0	NA
Rivers Edge	Lower Mt Bethel (T)	User Defined	X		-	-	-
James Palmeri Funeral Home	Lower Mt Bethel (T)	User Defined		X	-	-	-
SE-WY-CO FIRE	Lower Saucon (T)	Fire	X	X	2.0	2.3	480
Whisper Hollow North	Moore (T)	Mobile Home	X		-	-	-
Herd Manufactured Homes	Moore (T)	Potable Water		X	-	-	-
Duck Duck Goose	Northampton (B)	User Defined		X	0.0	0.0	NA
Northampton Borough	Northampton (B)	User Defined	X	X	0.0	0.0	NA
Unknown name (Senior)	Northampton (B)	User Defined	X	X	9.5	6.4	NA
Saint John the Baptist Elementary School	Northampton (B)	School	X	X	8.0	45.5	480
NORTHAMPTON REGIONAL EMS	Northampton (B)	Fire	X	X	10.1	22.5	480
Sacred Heart Outpatient Lab Services	Northampton (B)	Medical		X	0.0	0.0	360
Northampton Boro PD	Northampton (B)	Police		X	-	-	-
Little People Country Club	Palmer (T)	User Defined	X	X	25.6	35.2	NA
Palmer Township Muni Water System	Palmer (T)	Potable Water	X	X	-	-	-
United States Post Office	Portland (B)	User Defined		X	0.0	0.0	NA
PORTLAND & VICINITY AMBULANCE CORPS	Portland (B)	Fire		X	0.0	0.0	480
USGS Bushkill Creek Gauge Route 33	Tatamy (B)	User Defined	X	X	-	-	-
USGS Bushkill Creek Gauge SR2017 brdg	Tatamy (B)	User Defined	X	X	-	-	-



Name	Municipality	Type	Exposure		Potential Loss from 1% Flood Event		
			1% Event	0.2% Event	Structure Damage	Content Damages	Days to 100-Percent Functional
Doe Hollow Boat Access Ramp	Upper Mt Bethel (T)	User Defined	X	X	91.0	100.0	NA
Portland - Columbia Pedestrian Bridge	Upper Mt Bethel (T)	User Defined	X	X	91.0	100.0	NA
Bethany Home	Upper Mt Bethel (T)	Senior		X	-	-	-
KELLOW'S	Upper Nazareth (T)	Mobile Home	X		-	-	-
USGS Lehigh River Gauge at Walnutport, PA	Walnutport (B)	User Defined	X	X	-	-	-
Interstate 78 Toll Bridge	Williams (T)	User Defined	X	X	-	-	-

Source: FEMA, 2004; FEMA, 2011; HAZUS-MH 2.1

Notes:

X = indicates the facility location as provided by the Lehigh Valley plan participants is located in the DFIRM flood zone.

NA = HAZUS-MH 2.1 does not estimate the days to 100-percent functional for user-defined facilities.

- = There is no damage estimate either because the 0.2% annual chance flood event potential loss estimates were not run in HAZUS or HAZUS did not calculate potential loss estimates for some facilities located in the DFIRM flood hazard zone. This may be because even though these facilities are located within the boundary of the flood depth grid generated by HAZUS, the depth of flooding does not amount to any damages to the structure or contents according to the depth damage function used in HAZUS.

B = Borough; C = City; T = Township; % = Percent

4.3.4.5.6 Impact on the Economy

For impact on economy, estimated losses from a flood event are considered. Losses include, but are not limited to, general building stock damages, agricultural losses, business interruption, impacts to tourism and loss of tax base within the Lehigh Valley. Damages to general building stock can be quantified using HAZUS-MH as discussed above. Other economic components such as loss of facility use, functional downtime and social economic factors are less measurable with a high degree of certainty. For the purposes of this analysis, general building stock damages are discussed further.

Flooding can cause extensive damage to public utilities and disruptions to the delivery of services. Loss of power and communications may occur; and drinking water and wastewater treatment facilities may be temporarily out of operation. Flooded streets and road blocks make it difficult for emergency vehicles to respond to calls for service. Floodwaters can washout sections of roadway and bridges (Foster, Date Unknown).

Direct building losses are the estimated costs to repair or replace the damage caused to the building. The potential damage estimated to the general building stock inventory associated with the 1% flood is approximately \$1.4 billion. This estimated building damage represents approximately one-percent of the Lehigh Valley's overall total general building stock inventory exposed to this hazard. These dollar value losses to the Lehigh Valley's total building inventory replacement value, in addition to damages to roadways and infrastructure, would greatly impact both Counties' tax base and the local economy.

When a flood occurs, the agricultural industry is at risk in terms of economic impact and damage (i.e., damaged crop, financial loss to the farmer). For Lehigh County, the market value of all agricultural products sold was \$72 million with 73% in crop sales. In 2007, according to the Census of Agriculture, the market value of all agricultural products sold from Northampton County was greater than \$31.7 million with 70% in crop sales (USDA, 2007).

Specific agricultural loss information (monetary losses per agricultural product) was not available at the time this plan was drafted. However, given professional knowledge and historic loss information available, 40-percent and 60-percent loss estimates for crops as a result of major flood events is considered conservative estimates of potential losses for this hazard. These losses would be devastating to the local agricultural economy.

HAZUS-MH estimates the amount of debris generated from the flood events as a result of the 1% annual chance flood event. The model breaks down debris into three categories: 1) finishes (dry wall, insulation, etc.); 2) structural (wood, brick, etc.) and 3) foundations (concrete slab and block, rebar, etc.). The distinction is made because of the different types of equipment needed to handle the debris. Table 4.3.4-11 summarizes the debris HAZUS-MH 2.1 estimates for each municipality in the Lehigh Valley.

Table 4.3.4-11. Estimated Debris Generated from the 1% Flood Event

Municipality	Total (tons)	Finish (tons)	Structure (tons)	Foundation (tons)
Lehigh County				
Alburtis Borough	4	4	0	0
Allentown, City of	10,668	2,990	4,258	3,420
Bethlehem, City of	874	163	402	309
Catasauqua Borough	2,116	625	837	653
Coopersburg Borough	33	33	0	0

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Municipality	Total (tons)	Finish (tons)	Structure (tons)	Foundation (tons)
Coplay Borough	76	40	22	14
Emmaus Borough	192	126	38	28
Fountain Hill Borough	2,660	79	1,482	1,099
Hanover Township	30	11	11	8
Heidelberg Township	101	84	10	7
Lower Macungie Township	3,522	1,452	1,200	871
Lower Milford Township	490	223	152	115
Lowhill Township	883	231	371	281
Lynn Township	1,041	407	377	257
Macungie Borough	31	31	0	0
North Whitehall Township	940	388	317	234
Salisbury Township	1,001	285	384	332
Slatington Borough	765	251	296	217
South Whitehall Township	1,326	739	327	260
Upper Macungie Township	2,218	812	816	591
Upper Milford Township	930	532	227	171
Upper Saucon Township	686	646	24	16
Washington Township	397	201	114	82
Weisenberg Township	26	23	2	1
Whitehall Township	4,617	1,271	1,853	1,493
Lehigh County (est. total)	35,628	11,648	13,521	10,458
Municipality	Total (tons)	Finish (tons)	Structure (tons)	Foundation (tons)
Northampton County				
Allen Township	656	315	200	141
Bangor Borough	1,801	1,106	406	289
Bath Borough	40	40	0	0
Bethlehem Township	1,379	708	383	289
Bethlehem, City of	2,926	794	1,299	833
Bushkill Township	176	156	11	10
Chapman Borough	2	2	0	0
East Allen Township	70	66	2	2
East Bangor Borough	24	19	2	3
Easton, City of	15,277	1,871	7,912	5,495
Forks Township	563	202	198	163
Freemansburg Borough	2,728	631	1,204	894
Glendon Borough	2	2	0	0
Hanover Township	115	115	0	0
Hellertown Borough	99	99	0	0
Lehigh Township	343	165	97	81
Lower Mt. Bethel Township	1,945	496	842	607
Lower Nazareth Township	197	178	11	8

Municipality	Total (tons)	Finish (tons)	Structure (tons)	Foundation (tons)
Lower Saucon Township	723	504	126	92
Moore Township	73	64	4	4
Nazareth Borough	18	18	0	0
North Catasauqua Borough	221	87	81	53
Northampton Borough	1,816	807	602	407
Palmer Township	623	404	130	89
Pen Argyl Borough	5	5	0	0
Plainfield Township	59	50	5	4
Portland Borough	472	180	165	127
Roseto Borough	3	1	1	1
Stockertown Borough	97	75	13	9
Tatamy Borough	133	127	4	2
Upper Mt. Bethel Township	3,197	844	1,376	977
Upper Nazareth Township	383	161	125	97
Walnutport Borough	241	58	94	89
Washington Township	412	270	80	62
West Easton Borough	759	259	283	216
Williams Township	2,042	341	961	740
Wilson Borough	32	10	12	10
Wind Gap Borough	49	49	0	0
Northampton County (est. total)	39,700	11,277	16,628	11,795

Source: HAZUS-MH 2.1

Note: est. = Estimated

4.3.4.5.7 Impact on the Environment

Floods are naturally occurring events that benefit riparian systems which have not been disrupted by human actions. Such benefits include groundwater recharge and the introduction of nutrient rich sediment improving soil fertility. However, the destruction of riparian buffers, changes to land-use and land-cover throughout a watershed, and introduction of chemical or biological contaminants which often accompany human presence cause environmental harm when floods occur. Hazardous material facilities are potential sources of contamination during flood events. Other environmental impacts of flooding include: waterborne diseases, heavy siltation, erosion of stream banks and riverbeds, destruction of aquatic habitat, damage to water and sewer infrastructure located in floodplains, increased acid mine drainage, damage or loss of crops and drowning of both humans and animals.

4.3.4.5.8 Future Growth and Development

Areas targeted for potential future growth and development in the next five (5) years have been identified across the Lehigh Valley at the municipal level. Refer to the jurisdictional annexes in Volume II of this Plan. Table B.1 in each jurisdictional annex lists the location of the potential new development and its exposure (if any) to known flood hazard zones. Any areas of growth could be potentially impacted by the flood hazard if located within the identified hazard areas.

4.3.4.5.9 Effect of Climate Change on Vulnerability

Climate is defined not simply as average temperature and precipitation but also by the type, frequency and intensity of weather events. Both globally and at the local scale, climate change has the potential to alter the prevalence and severity of extremes such as flood events. While predicting changes of flood events under a changing climate is difficult, understanding vulnerabilities to potential changes is a critical part of estimating future climate change impacts on human health, society and the environment (U.S. Environmental Protection Agency [EPA], 2006).

Pennsylvania's Department of Environmental Protection was directed by the Climate Change Act (Act 70 of 2008) to initiate a study of the potential impacts of global climate change on the Commonwealth. The June 2009 Pennsylvania Climate Impact Assessment's main findings indicate it is very likely that Pennsylvania will experience increased temperatures in the 21st century. An increase in the variability of temperature and precipitation may lead to increased frequency and/or severity of storm events. Summer floods and general stream flow variability are projected to increase due to increased variability in precipitation. Even with the anticipated increase in winter precipitation as rain rather than snow, increased winter temperatures and a reduced snowpack may decrease rain-on-snow events and thus major flooding events in Pennsylvania. This conclusion however remains speculative until further studies can validate. Future improvements in modeling smaller scale climatic processes can be expected and will lead to improved understanding of how the changing climate will alter temperature, precipitation, storms and flood events in Pennsylvania (Shortle et. al, 2009).

4.3.4.5.10 Additional Data and Next Steps

A HAZUS-MH flood analysis was conducted for the Lehigh Valley using the most current and best available data including updated building and critical facility inventories, DFIRMs, FIS, 2008 3.2-foot LiDAR DEM and default model demographic data. For future plan updates, more accurate exposure and loss estimates can be produced by replacing the national default demographic inventory with 2010 U.S. Census data. The updated building inventory can be analyzed at the structure, not Census block level, for individualized building results. In addition, a 0.2% depth grid may be generated similar to the 1% depth grid to estimate potential losses for the Lehigh Valley for this event. As Assessor databases continue to be updated, the general building inventory should also be maintained. In the future, FEMA's Risk Mapping, Assessment, and Planning (Risk MAP) will be providing the flood depth and analysis grids as part of the DFIRM deliverable. These depth grids can be incorporated into HAZUS and used to calculate the potential losses to the Lehigh Valley inventory. The utilization of the Risk MAP depth grids and the updated general building stock inventory on a structural level will provide even more accurate flood loss estimates.