4.3.6 Landslide

This section provides a profile and vulnerability assessment for the landslide hazard. According to the U.S. Geological Survey (USGS), "ground failure" is the term used to describe zones of ground cracking, fissuring, and localized horizontal and vertical permanent ground displacement that may be caused by surface rupture along faults; secondary movement on shallow faults; shaking-induced compaction of natural deposits in sedimentary basins and river valleys; liquefaction of loose, sandy sediment (USGS, 2005); landslides; and land subsidence and sinkholes. For the purpose of this HMP, the ground failure hazard to which the Lehigh Valley is vulnerable includes, but is not limited to, landslides, which are further defined as follows:

A landslide is described in the Commonwealth of Pennsylvania 2010 Standard All-Hazard Mitigation Plan (PA HMP) as the downward and outward movement of slope-forming soil, rock, and vegetation reacting to the force of gravity. Materials can move up to 120 miles per hour (mph) or more, and slides can last a few seconds or a few minutes, or can be gradual, slower movements over several hours or days. There are several different types of landslides including:

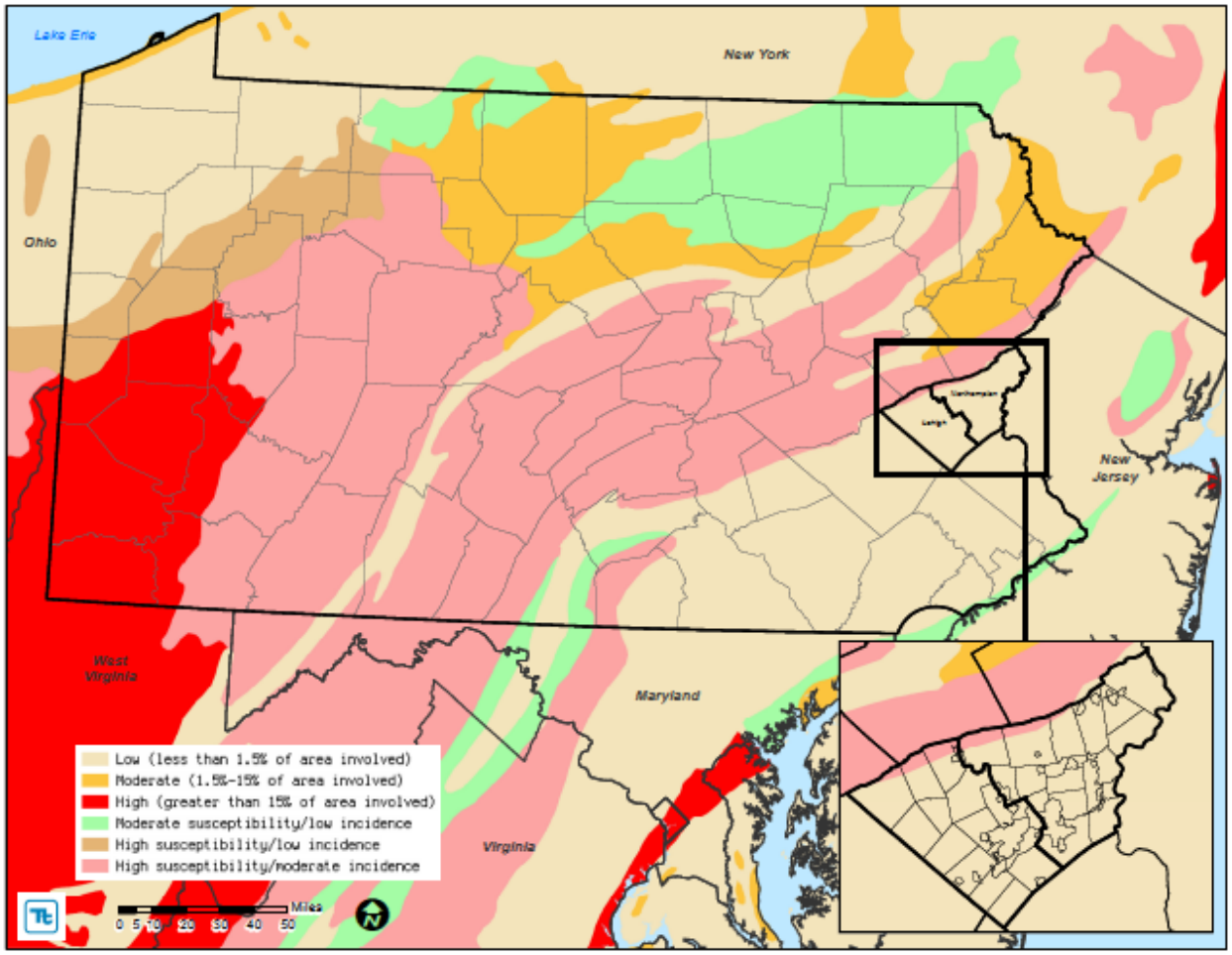
- *Rock Falls* are when a mass detaches from a steep slope or cliff and descends by free-fall, bounding, or rolling.
- *Rock Topples* are when a mass tilts or rotates forward as a unit.
- *Slides* are when a mass displaces on one or more recognizable surfaces, which may be curved or planar.
- *Flows* are when a mass moves downslope with a fluid motion. A significant amount of water may or may not be part of the mass (PEMA, 2010).

Landslides may be triggered by both natural and human-caused changes in the environment, including heavy rain, rapid snow melt, steepening of slopes due to construction or erosion, earthquakes, and changes in groundwater levels. Areas that are generally prone to landslide hazards include previous landslide areas, the bases of steep slopes, the bases of drainage channels, developed hillsides, and areas recently burned by forest and brush fires (Delano and Wilshusen, 2001). Human activities that contribute to slope failure include altering the natural slope gradient, increasing soil water content, and removing vegetation cover.

4.3.6.1 Location and Extent

According to the PA HMP, landslides have occurred in many parts of Pennsylvania but are most abundant and troublesome in much of the western and north central portions of the state and adjacent states. Rockfalls and other slope failures can occur in areas of the Lehigh Valley with moderate to steep slopes. Areas experiencing erosion, decline in vegetation cover, and earthquakes are also susceptible to landslides. Figure 4.3.6-1 shows areas of low, moderate, and high landslide susceptibility as determined by the USGS.

Figure 4.3.6-1. U.S Geological Survey. Landslide Incidence and Susceptibility



Source: Godt, 2011 (Geology WMS Layer from the National Atlas of the United States)

4.3.6.2 Range of Magnitude

Landslides cause damage to transportation routes, utilities, and buildings. They can also create travel delays and other side effects. Fortunately, deaths and injuries due to landslides are rare in Pennsylvania, and most landslides in the State are moderate to slow moving, damaging things rather than people. Almost all of the known deaths due to landslides have occurred when rockfalls or other slides along highways have involved vehicles. Storm-induced debris flows are the only other type of landslide likely to cause death and injuries. As residential and recreational development increases on and near steep mountain slopes, the hazards from these events will also increase.

Both the State HMP and the Pennsylvania Geological Survey indicate that the landslide susceptibility in the Lehigh Valley is low. The Lehigh Valley's worst-case scenario is for a landslide to hit the Lehigh Gap, or any busy roadway in this area including the intersection of Routes 145, 248 and 873. This scenario is based on a rough overlay of steep slopes and major roadways and/or urban/populated areas throughout the Valley. This specific area is based on the topographic and land use conditions for this area. A landslide into the Lehigh River from the adjacent slopes could divert or entirely block water flows resulting in flood effects upstream. Also, depending on the time of day and the number of vehicles on the road at that time, a slide over one of the riverside roadways in either Lehigh Gap or Slatington Borough could potentially trigger a severe traffic accident, resulting in multiple fatalities.

4.3.6.3 Past Occurrence

Outside of impacts to important transportation routes, landslide history is not documented as completely (if at all) as other hazards, primarily because landslides are not always seen, and therefore historical landslide occurrences in the Lehigh Valley are not well known. PEMA records list one mud slide incident in Hanover Township (L), when heavy rainfall in March, 2007, created a mudslide and hazardous road conditions. Dauphin Drive in Hanover Township (L) was temporarily closed, and no injuries were reported. While there have been no incidents of major landslide recorded in the Lehigh Valley, geological conditions coupled with human-caused changes in slope vegetation in some areas and changing weather patterns create the need to examine the potential for this particular type of ground failure to occur in the future.

4.3.6.4 Future Occurrence

Mismanaged, intense development in steeply sloped areas could increase the frequency of landslides in the Lehigh Valley. Building and road construction are contributing development factors to landslides, as they can often undermine or steepen otherwise stable soil.

Any events that do occur would take place in steeply sloped areas that do not feature extensive land development or many structures. Increased deforestation and soil disturbances caused by development on sloped areas further increases these risks. As timbering and development of sloped land continues the risk of significant landslides increases.

Based on available historical data, the future occurrence of landslides can be considered *unlikely* as defined by the Risk Factor Methodology probability criteria (refer to Section 4.4).

4.3.6.5 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable in the identified hazard area. The following section discusses the potential impact of the landslide hazard on the Lehigh Valley including:

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

4.3.6.5.1 Overview of Vulnerability

Vulnerability to ground failure hazards is a function of location, soil type, geology, type of human activity, use, and frequency of events. The effects of landslides on people and structures can be lessened by total avoidance of hazard areas or by restricting, prohibiting, or imposing conditions on hazard-zone activity. Local governments can reduce landslide effects through land use policies and regulations. Individuals can reduce their exposure to hazards by educating themselves on past hazard history of the site and by making inquiries to planning and engineering departments of local governments (National Atlas, 2007).

Table 4.3.6-1 below summarizes the area of each municipality in the approximate high susceptibility/moderate incidence landslide hazard area.

Table 4.3.6-1. Area Located in the Approximate High Susceptibility/Moderate Incidence Landslide Hazard Area

Municipality	Total Area (sq. mi.)	Area Exposed			
		High Susceptibility/ Moderate Incidence (sq. mi.)	Percent of Total	Low Susceptibility (sq. mi.)	Percent of Total
Lehigh County					
Alburtis Borough	0.71	0	0	0.71	100
Allentown, City of	18.02	0	0	18.02	100
Bethlehem, City of	4.4	0	0	4.4	100
Catasauqua Borough	1.3	0	0	1.3	100
Coopersburg Borough	0.94	0	0	0.94	100
Coplay Borough	0.63	0	0	0.63	100
Emmaus Borough	2.9	0	0	2.9	100
Fountain Hill Borough	0.76	0	0	0.76	100
Hanover Township	4.3	0	0	4.3	100
Heidelberg Township	24.7	6.5	26.3	18.2	73.7
Lower Macungie Township	22.5	0	0	22.5	100
Lower Milford Township	19.7	0	0	19.7	100
Lowhill Township	14.1	0	0	14.1	100
Lynn Township	41.7	4.5	10.8	37.2	89.2
Macungie Borough	0.99	0	0	0.99	100
North Whitehall Township	28.5	0	0	28.5	100
Salisbury Township	11.3	0	0	11.3	100
Slatington Borough	1.4	0.4	28.6	1	71.4
South Whitehall Township	17.2	0	0	17.2	100
Upper Macungie Township	26.2	0	0	26.2	100
Upper Milford Township	18.0	0	0	18	100
Upper Saucon Township	24.7	0	0	24.7	100
Washington Township	23.7	9.1	38.4	14.6	61.6
Weisenberg Township	26.8	0	0	26.8	100
Whitehall Township	12.8	0	0	12.8	100
Lehigh County (est. total)	***348.3***	***20.5***	***5.9***	***327.8***	***94.1***
Northampton County					
Allen Township	11.3	0	0	11.3	100
Bangor Borough	1.5	0	0	1.5	100
Bath Borough	0.9	0	0	0.9	100
Bethlehem Township	14.7	0	0	14.7	100
Bethlehem, City of	15.0	0	0	15	100
Bushkill Township	25.7	1.9	7.4	23.8	92.6
Chapman Borough	0.4	0	0	0.4	100
East Allen Township	14.6	0	0	14.6	100
East Bangor Borough	0.9	0	0	0.9	100
Easton, City of	4.4	0	0	4.4	100
Forks Township	12.3	0	0	12.3	100
Freemansburg Borough	0.8	0	0	0.8	100
Glendon Borough	0.8	0	0	0.8	100

Municipality	Total Area (sq. mi.)	Area Exposed			
		High Susceptibility/ Moderate Incidence (sq. mi.)	Percent of Total	Low Susceptibility (sq. mi.)	Percent of Total
Hanover Township	6.6	0	0	6.6	100
Hellertown Borough	1.3	0	0	1.3	100
Lehigh Township	29.8	11.1	37.2	18.7	62.8
Lower Mt. Bethel Township	24.6	0	0	24.6	100
Lower Nazareth Township	13.6	0	0	13.6	100
Lower Saucon Township	24.5	0	0	24.5	100
Moore Township	37.7	8.52	22.6	29.18	77.4
Nazareth Borough	1.7	0	0	1.7	100
North Catasauqua Borough	0.8	0	0	0.8	100
Northampton Borough	2.6	0	0	2.6	100
Palmer Township	10.4	0	0	10.4	100
Pen Argyl Borough	1.4	0	0	1.4	100
Plainfield Township	24.5	0	0	24.5	100
Portland Borough	0.6	0	0	0.6	100
Roseto Borough	0.6	0	0	0.6	100
Stockertown Borough	1.0	0	0	1	100
Tatamy Borough	0.6	0	0	0.6	100
Upper Mt. Bethel Township	44.0	0.0006	<1	43.9994	99.9
Upper Nazareth Township	7.5	0	0	7.5	100
Walnutport Borough	0.8	0	0	0.8	100
Washington Township	18.0	0	0	18	100
West Easton Borough	0.3	0	0	0.3	100
Williams Township	18.6	0	0	18.6	100
Wilson Borough	1.2	0	0	1.2	100
Wind Gap Borough	1.4	0	0	1.4	100
Northampton County (est. total)	***377.2***	***21.5***	***5.7***	***355.9***	***94.3***

Source: Godt, 2011 (Geology WMS Layer from the National Atlas of the United States)
Notes: est. = Estimated; sq. mi. = Square miles

4.3.6.5.2 Data and Methodology

Unlike the flood, wind and earthquake hazards, there are no standard loss estimation models or methodologies for the landslide hazard. In an attempt to estimate the Lehigh Valley's vulnerability, the Geology - Landslide Incidence and Susceptibility GIS layer from National Atlas was used to coarsely define the general landslide susceptible area (herein "approximate hazard area") (Figure 4.3.6-1). The limitations of this analysis are recognized and are only used to provide a general estimate. Over time additional data will be collected to allow better analysis for this hazard. Available information and a preliminary assessment are provided below.

According to Radbruch-Hall et.al., the Landslide Incidence and Susceptibility GIS layer from National Atlas '….was prepared by evaluating formations or groups of formations shown on the geologic map of the United States (King and Beikman, 1974) and classifying them as having high, medium, or low landslide incidence (number of landslides) and being of high, medium, or low susceptibility to landsliding. Thus, those map units or parts of units with more than 15 percent of their area involved in

landsliding were classified as having high incidence; those with 1.5 to 15 percent of their area involved in landsliding, as having medium incidence; and those with less than 1.5 percent of their area involved, as having low incidence. This classification scheme was modified where particular lithofacies are known to have variable landslide incidence or susceptibility. In continental glaciated areas, additional data were used to identify surficial deposits that are susceptible to slope movement. Susceptibility to landsliding was defined as the probable degree of response of the areal rocks and soils to natural or artificial cutting or loading of slopes or to anomalously high precipitation. High, medium, and low susceptibility are delimited by the same percentages used in classifying the incidence of landsliding. For example, it was estimated that a rock or soil unit characterized by high landslide susceptibility would respond to widespread artificial cutting by some movement in 15 percent or more of the affected area. We did not evaluate the effect of earthquakes on slope stability, although many catastrophic landslides have been generated by ground shaking during earthquakes. Areas susceptible to ground failure under static conditions would probably also be susceptible to failure during earthquakes' (Radbruch-Hall, 1982).

4.3.6.5.3 Impact on Life, Health and Safety

To estimate the population located within the landslide hazard areas, the approximate hazard area boundaries were overlaid upon the 2010 Census population data (U.S. Census, 2010). The Census blocks with their center (centroid) within the boundary of the high susceptibility/moderate incidence landslide hazard area were used to calculate the estimated population considered exposed to this hazard. Table 4.3.6-2 summarizes the population exposed to this hazard by municipality (U.S. Census 2010).

Table 4.3.6-2. Population Located in the High Susceptibility/Moderate Incidence Landslide Hazard Area

Municipality	Total Pop.	Population Exposed			
		High Susceptibility/ Moderate Incidence	Percent of Total	Low Susceptibility	Percent of Total
Lehigh County					
Alburtis Borough	2,361	0	0.0	2,361	100
Allentown, City of	118,032	0	0.0	118,032	100
Bethlehem, City of	19,343	0	0.0	19,343	100
Catasauqua Borough	6,436	0	0.0	6,436	100
Coopersburg Borough	2,386	0	0.0	2,386	100
Coplay Borough	3,192	0	0.0	3,192	100
Emmaus Borough	11,211	0	0.0	11,211	100
Fountain Hill Borough	4,597	0	0.0	4,597	100
Hanover Township	1,571	0	0.0	1,571	100
Heidelberg Township	3,416	311	9.1	3,105	90.9
Lower Macungie Township	30,633	0	0.0	30,633	100
Lower Milford Township	3,775	0	0.0	3,775	100
Lowhill Township	2,173	0	0.0	2,173	100
Lynn Township	4,229	360	8.5	3,869	91.5
Macungie Borough	3,074	0	0.0	3,074	100
North Whitehall Township	15,703	0	0.0	15,703	100
Salisbury Township	13,505	0	0.0	13,505	100
Slatington Borough	4,232	636	15.0	3,596	85.0
South Whitehall Township	19,180	0	0.0	19,180	100
Upper Macungie Township	20,063	0	0.0	20,063	100

Municipality	Total Pop.	Population Exposed			
		High Susceptibility/ Moderate Incidence	Percent of Total	Low Susceptibility	Percent of Total
Upper Milford Township	7,292	0	0.0	7,292	100
Upper Saucon Township	14,808	0	0.0	14,808	100
Washington Township	6,624	1,248	18.8	5,376	81.2
Weisenberg Township	4,923	0	0.0	4,923	100
Whitehall Township	26,738	0	0.0	26,738	100
Lehigh County	**349,497**	**2,555**	**0.7**	**346,942**	**99.3**
Northampton County					
Allen Township	4,269	0	0.0	4,269	100
Bangor Borough	5,273	0	0.0	5,273	100
Bath Borough	2,693	0	0.0	2,693	100
Bethlehem Township	23,730	0	0.0	23,730	100
Bethlehem, City of	55,639	0	0.0	55,639	100
Bushkill Township	8,178	361	4.4	7,817	95.6
Chapman Borough	199	0	0.0	199	100
East Allen Township	4,903	0	0.0	4,903	100
East Bangor Borough	1,172	0	0.0	1,172	100
Easton, City of	26,800	0	0.0	26,800	100
Forks Township	14,721	0	0.0	14,721	100
Freemansburg Borough	2,636	0	0.0	2,636	100
Glendon Borough	440	0	0.0	440	100
Hanover Township	10,866	0	0.0	10,866	100
Hellertown Borough	5,898	0	0.0	5,898	100
Lehigh Township	10,526	3,583	34.0	6,943	66.0
Lower Mt. Bethel Township	3,101	0	0.0	3,101	100
Lower Nazareth Township	5,674	0	0.0	5,674	100
Lower Saucon Township	10,772	0	0.0	10,772	100
Moore Township	9,198	731	7.9	8,467	92.1
Nazareth Borough	5,746	0	0.0	5,746	100
North Catasauqua Borough	2,849	0	0.0	2,849	100
Northampton Borough	9,926	0	0.0	9,926	100
Palmer Township	20,691	0	0.0	20,691	100
Pen Argyl Borough	3,595	0	0.0	3,595	100
Plainfield Township	6,138	0	0.0	6,138	100
Portland Borough	519	0	0.0	519	100
Roseto Borough	1,567	0	0.0	1,567	100
Stockertown Borough	927	0	0.0	927	100
Tatamy Borough	1,203	0	0.0	1,203	100
Upper Mt. Bethel Township	6,706	0	0.0	6,706	100
Upper Nazareth Township	6,231	0	0.0	6,231	100
Walnutport Borough	2,070	0	0.0	2,070	100
Washington Township	5,122	0	0.0	5,122	100
West Easton Borough	1,257	0	0.0	1,257	100
Williams Township	5,884	0	0.0	5,884	100
Wilson Borough	7,896	0	0.0	7,896	100

Municipality	Total Pop.	Population Exposed			
		High Susceptibility/ Moderate Incidence	Percent of Total	Low Susceptibility	Percent of Total
Wind Gap Borough	2,720	0	0.0	2,720	100
Northampton County (est. total)	***297,735***	***4,675***	***1.6***	***293,060***	***98.4***

Source: U.S. Census 2010; Godt, 2011 (Geology WMS Layer from the National Atlas of the United States)
Note: Pop. = population

4.3.6.5.4 Impact on General Building Stock

In general, the built environment located in the high susceptibility zones and the population, structures and infrastructure located downslope are vulnerable to this hazard. In an attempt to estimate the general building stock vulnerable to this hazard, the associated building replacement values (buildings and contents) were determined for the identified Census blocks within the approximate hazard area. In summary, less than one percent of the general building stock is vulnerable. Table 4.3.6-3 lists the replacement value (structure and contents) of general building stock exposed to this hazard.

Table 4.3.6-3. General Building Stock Located in the High Susceptibility/Moderate Incidence Landslide Hazard Area

Municipality	Total GBS	GBS Exposed (Structure and Contents)			
		High Susceptibility/ Moderate Incidence	Percent of Total	Low Susceptibility	Percent of Total
Lehigh County					
Alburtis Borough	$280,994,000	$0	0.0	$280,994,000	100
Allentown, City of	$20,982,347,000	$0	0.0	$20,982,347,000	100
Bethlehem, City of	$4,769,721,000	$0	0.0	$4,769,721,000	100
Catasauqua Borough	$934,748,000	$0	0.0	$934,748,000	100
Coopersburg Borough	$421,475,000	$0	0.0	$421,475,000	100
Coplay Borough	$406,752,000	$0	0.0	$406,752,000	100
Emmaus Borough	$2,088,277,000	$0	0.0	$2,088,277,000	100
Fountain Hill Borough	$1,101,911,000	$0	0.0	$1,101,911,000	100
Hanover Township	$2,254,652,000	$0	0.0	$2,254,652,000	100
Heidelberg Township	$550,037,000	$34,753,000	6.3	$515,284,000	93.7
Lower Macungie Township	$5,924,050,000	$0	0.0	$5,924,050,000	100
Lower Milford Township	$534,598,000	$0	0.0	$534,598,000	100
Lowhill Township	$371,530,000	$0	0.0	$371,530,000	100
Lynn Township	$612,033,000	$21,778,000	3.6	$590,255,000	96.4
Macungie Borough	$533,007,000	$0	0.0	$533,007,000	100
North Whitehall Township	$2,850,746,000	$0	0.0	$2,850,746,000	100
Salisbury Township	$3,606,044,000	$0	0.0	$3,606,044,000	100
Slatington Borough	$715,470,000	$177,154,000	24.8	$538,316,000	75.2
South Whitehall Township	$4,885,829,000	$0	0.0	$4,885,829,000	100

Municipality	Total GBS	GBS Exposed (Structure and Contents)			
		High Susceptibility/ Moderate Incidence	Percent of Total	Low Susceptibility	Percent of Total
Upper Macungie Township	$10,206,499,000	$0	0.0	$10,206,499,000	100
Upper Milford Township	$1,178,767,000	$0	0.0	$1,178,767,000	100
Upper Saucon Township	$3,171,479,000	$0	0.0	$3,171,479,000	100
Washington Township	$893,760,000	$226,895,000	25.4	$666,865,000	74.6
Weisenberg Township	$1,189,552,000	$0	0.0	$1,189,552,000	100
Whitehall Township	$5,424,311,000	$0	0.0	$5,424,311,000	100
Lehigh County (est. total)	***$75,888,589,000***	***$460,580,000***	***0.6***	***$75,428,009,000***	***99.4***
Northampton County					
Allen Township	$712,840,000	$0	0.0	$712,840,000	100
Bangor Borough	$926,661,000	$0	0.0	$926,661,000	100
Bath Borough	$471,748,000	$0	0.0	$471,748,000	100
Bethlehem Township	$5,752,889,000	$0	0.0	$5,752,889,000	100
Bethlehem, City of	$9,934,952,000	$0	0.0	$9,934,952,000	100
Bushkill Township	$1,289,529,000	$20,129,000	1.6	$1,269,400,000	98.4
Chapman Borough	$32,434,000	$0	0.0	$32,434,000	100
East Allen Township	$1,104,833,000	$0	0.0	$1,104,833,000	100
East Bangor Borough	$118,151,000	$0	0.0	$118,151,000	100
Easton, City of	$4,848,037,000	$0	0.0	$4,848,037,000	100
Forks Township	$3,177,595,000	$0	0.0	$3,177,595,000	100
Freemansburg Borough	$361,483,000	$0	0.0	$361,483,000	100
Glendon Borough	$89,841,000	$0	0.0	$89,841,000	100
Hanover Township	$3,484,970,000	$0	0.0	$3,484,970,000	100
Hellertown Borough	$888,848,000	$0	0.0	$888,848,000	100
Lehigh Township	$1,487,389,000	$405,674,000	27.3	$1,081,715,000	72.7
Lower Mt. Bethel Township	$502,664,000	$0	0.0	$502,664,000	100
Lower Nazareth Township	$2,194,429,000	$0	0.0	$2,194,429,000	100
Lower Saucon Township	$1,968,200,000	$0	0.0	$1,968,200,000	100
Moore Township	$1,223,870,000	$100,078,000	8.2	$1,123,792,000	91.8
Nazareth Borough	$1,312,606,000	$0	0.0	$1,312,606,000	100
North Catasauqua Borough	$386,289,000	$0	0.0	$386,289,000	100
Northampton Borough	$1,843,226,000	$0	0.0	$1,843,226,000	100
Palmer Township	$4,169,701,000	$0	0.0	$4,169,701,000	100
Pen Argyl Borough	$651,065,000	$0	0.0	$651,065,000	100
Plainfield Township	$1,086,698,000	$0	0.0	$1,086,698,000	100
Portland Borough	$162,069,000	$0	0.0	$162,069,000	100
Roseto Borough	$276,318,000	$0	0.0	$276,318,000	100
Stockertown Borough	$298,470,000	$0	0.0	$298,470,000	100
Tatamy Borough	$216,261,000	$0	0.0	$216,261,000	100
Upper Mt. Bethel Township	$1,311,378,000	$0	0.0	$1,311,378,000	100
Upper Nazareth Township	$1,071,480,000	$0	0.0	$1,071,480,000	100
Walnutport Borough	$506,739,000	$0	0.0	$506,739,000	100
Washington Township	$875,751,000	$0	0.0	$875,751,000	100

Municipality	Total GBS	GBS Exposed (Structure and Contents)			
		High Susceptibility/ Moderate Incidence	Percent of Total	Low Susceptibility	Percent of Total
West Easton Borough	$267,628,000	$0	0.0	$267,628,000	100
Williams Township	$1,200,406,000	$0	0.0	$1,200,406,000	100
Wilson Borough	$1,731,473,000	$0	0.0	$1,731,473,000	100
Wind Gap Borough	$532,380,000	$0	0.0	$532,380,000	100
Northampton County (est. total)	***$58,471,301,000***	***$525,881,000***	***0.9***	***$57,945,420,000***	***99.1***

Source: Godt, 2011 (Geology WMS Layer from the National Atlas of the United States)
Note: est. = Estimated; GBS = General Building Stock

4.3.6.5.5 Impact on Critical Facilities

The approximate landslide hazard area was used to identify the essential facilities located within the identified high susceptibility/moderate incidence zone. Table 4.3.6-4 lists these essential (i.e., police, fire, EOCs and hospitals) as identified by the Lehigh Valley plan participants.

Table 4.3.6-4. Essential Critical Facilities in the High Susceptibility/Moderate Incidence Landslide Hazard Area

Name	Municipality	Type
Lehigh County		
Commonwealth of PA	Heidelberg Township	User Defined
Slatington Elementary School	Slatington Borough	School
Northern Lehigh High School	Slatington Borough	School
Northern Lehigh Middle School	Slatington Borough	School
Northampton County		
Blue Ridge Veterinary Clinic	Lehigh Township	User Defined
Lehigh Township	Lehigh Township	User Defined
Personal Care Home	Lehigh Township	User Defined
Liza's House Personal Care Home	Lehigh Township	User Defined
United States Post Office	Lehigh Township	User Defined
PA DOT - Stockpile Danielsville	Lehigh Township	User Defined
LEHIGH TWP PD	Lehigh Township	Police
Pond View Manor Personal Care Home	Lehigh Township	User Defined

Source: Godt, 2011 (Geology WMS Layer from the National Atlas of the United States)

4.3.6.5.6 Impact on the Economy

Landslide's impact on the economy and estimated dollar losses are difficult to measure. As stated earlier, landslides can impose direct and indirect impacts on society. Direct costs include the actual damage sustained by buildings, property and infrastructure. Indirect costs, such as clean-up costs, business interruption, loss of tax revenues, reduced property values, and loss of productivity are difficult to measure. Additionally, ground failure threatens transportation corridors, fuel and energy conduits and communication lines (USGS, 2003). Estimated potential damages to general building stock can be

quantified as discussed above. For the purposes of this analysis, general building stock damages are discussed further.

Direct building losses are the estimated costs to repair or replace the damage caused to the building. The estimated replacement value of general building stock located in landslide susceptible areas is nearly $1 billion. This estimate represents less than one-percent of the total building stock value inventory in the Lehigh Valley. These dollar value losses to the region's total building inventory replacement value would impact the local tax base and economy.

4.3.6.5.7 Future Growth and Development

Areas targeted for potential future growth and development in the next five (5) to ten (10) years have been identified across the Lehigh Valley at the municipal level. Refer to the jurisdictional annexes in Volume II of this HMP. Table B.1 in each jurisdictional annex lists the location of the potential new development and its exposure (if any) to known hazard zones. It is anticipated that new development within the identified high susceptibility/moderate incidence landslide hazard area will be exposed to such risks.

4.3.6.5.8 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 severe storms, including those which may bring intense and/or prolonged precipitation (U.S. Environmental Protection Agency [EPA], 2006). An increase in rainfall intensity and duration will saturate the soil and potentially erode the local landscape and impact slope stability. This may lead to an increase of landslide events in the Lehigh Valley.

While predicting changes in these types of 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 (EPA, 2006). The potential effects of climate change on the Lehigh Valley's vulnerability to landslide events shall need to be considered as a greater understanding of regional climate change impacts develop.

4.3.6.5.9 Additional Data and Next Steps

More detailed landslide susceptibility zones can be generated so that communities can more specifically identify high hazard areas. A pilot study was conducted for Schenectady County, New York as described in the 2011 Draft New York State Hazard Mitigation Plan to develop higher resolution landslide susceptibility zones. The methodology included using the Natural Resource Conservation Services (NRCS) Digital Soil Survey soil units and their associated properties including the American of State Highway Transportation Officials (AASHTO) rating, liquid limit, hydrologic group, percentage of silt and clay, erosion potential and slope derived from high resolution digital elevation models. Obtaining historic damages to buildings and infrastructure incurred due to landslides will also help with loss estimates and future modeling efforts, given a margin of uncertainty. Further, research on rainfall thresholds for forecasting landslide potential may also be an option for the Lehigh Valley.