5.4.6 Landslide

This section provides a profile, and vulnerability assessment for the landslide hazard.

5.4.6.1 Hazard Profile

This section provides profile information of the hazard, including: description, extent, location, previous occurrences and losses, and the probability of future occurrences.

Description

A landslide is the process that results in the downward and outward movement of slope-forming materials (NYS Geological Survey, Date Unknown). Landslide materials can consist of natural rock, soil, artificial fill, or any combination of these materials (NYS DHSES 2014). The materials move by falling, toppling, sliding, spreading, or flowing (NYS Geological Survey, Date Unknown).

Landslides are caused by one or more of the following factors: change in slope of the terrain, increased load on the land, shocks and vibrations, change in water content, groundwater movement, frost action, weathering of rocks, and removing or changing the type of vegetation covering slopes. Landslide hazard areas exist where the land has characteristics that contribute to the risk of the downhill movement of material, such as the following:

- A slope greater than 33 percent
- A history of landslide activity or movement during the last 10,000 years
- Stream or wave activity that has caused erosion, undercut a bank, or cut into a bank to cause the surrounding land to be unstable
- The presence or potential for snow avalanches
- The presence of an alluvial fan, indicating vulnerability to the flow of debris or sediments
- The presence of impermeable soils, such as silt or clay, which are mixed with granular soils such as sand and gravel.

Landslides may be triggered by both natural and human-caused changes in the environment, including heavy rain, rapid snow melt, steepening of slopes caused by 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 (NYS DHSES 2014). Human activities that contribute to slope failure include altering the natural slope gradient, increasing soil water content, and removing vegetation cover. Warning signs for landslide activity include:

- Springs, seeps, or saturated ground in areas that have not typically been wet before
- New cracks or unusual bulges in the ground, street pavement, or sidewalk
- Soil moving away from foundations
- Ancillary structures, such as decks and patios, tilting and moving relative to the main house
- Tilting or cracking of concrete floors and foundations
- Broken water lines and other underground utilities
- Leaning telephone poles, trees, retaining walls, or fences
- Offset fence lines
- Sunken or down-dropped road beds
- Rapid increase in creek water levels, possibly accompanied by increased turbidity

- Sudden increase in creek water levels while rain is still failing or just recently ended
- Sticking doors and windows, and visible open spaces indicating jambs and frames out of plumb
- A faint rumbling sound that increases in volume as the landslide nears
- Unusual sounds, such as trees cracking or boulders knocking together (USGS 2013).

There are several different types of landslides including:

- *Rock Falls:* blocks of rock that fall away from a bedrock unit without a rotational component
- *Rock Topples:* blocks of rock that fall away from a bedrock unit with a rotational component
- *Rotational Slump:* blocks of fine grained sediment that rotate and move down slope
- *Transitional Slide:* sediments that move along a flat surface without a rotational component
- *Earth Flows:* fine-grained sediments that flow downhill and typically form a fan structure
- *Creep:* a slow moving landslide often only noticed through crooked trees and disturbed structures
- *Block Slides:* blocks of rock that slide along a slip plane as a unit down a slope
- *Debris Avalanche:* predominately gravel, cobble, boulder, and sediment portions, and trees that move quickly down slope
- *Debris Flows:* coarse sediments that flow downhill and spread out over relatively flat areas (NYS DHSES 2014)

Extent

The extent of a landslide hazard is determined by identifying the affected areas and assessing the probability of a landslide occurring within a time period. Natural variables that contribute to the overall extent of potential landslide activity in any particular area include soil properties, topographic position and slope, and historical incidence. Predicting a landslide is difficult, even under ideal conditions. As a result, the landslide hazard is often represented by landslide incidence and susceptibility, as defined below.

- Landslide incidence is the number of landslides that have occurred in a given geographic area. High incidence means greater than 15 percent of a given area has been involved in landsliding; medium incidence means that 1.5 to 15 percent of an area has been involved; and low incidence means that less than 1.5 percent of an area has been involved. (Radbruch-Hall, Dorothy H., et. al. 1982).
- Landslide susceptibility is defined as the probable degree of response of geologic formations to natural or artificial cutting, to loading of slopes, or to unusually high precipitation. It can be assumed that unusually high precipitation or changes in existing conditions can initiate landslide movement in areas where rocks and soils have experienced landslides in the past. Landslide susceptibility depends on slope angle and the geologic material underlying the slope. Landslide susceptibility only identifies areas potentially affected and does not imply a time frame when a landslide might occur. High, medium, and low susceptibility are delimited by the same percentages used for classifying the incidence of landsliding (Radbruch-Hall, Dorothy H., et. al. 1982).

Location

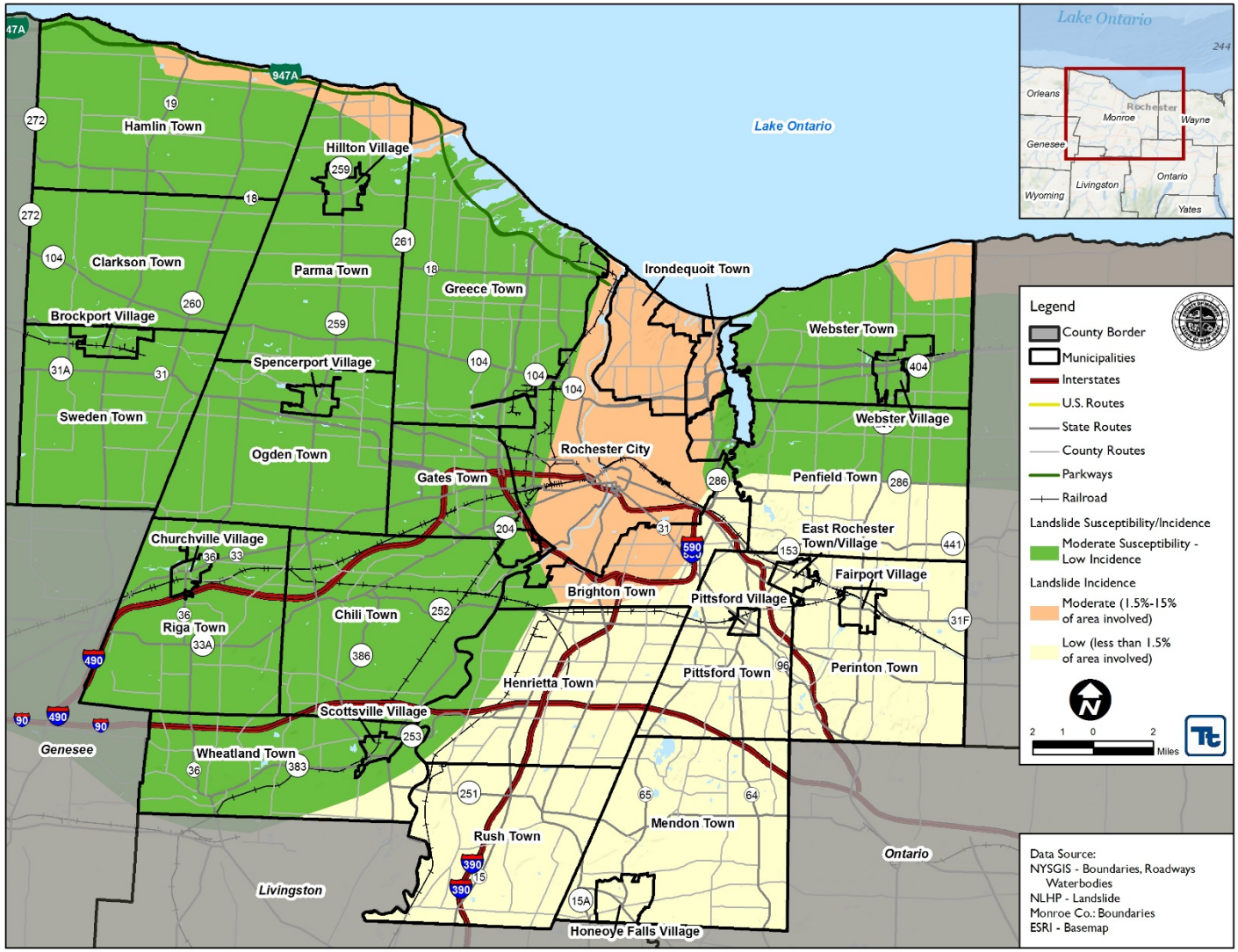
Landslides have occurred in several areas of Monroe County, often as a result of flooding and erosion along the Lake Ontario shoreline and bluffs. Landslides have also occurred in some of the large open gravel pits. Natural variables such as soil properties, topographic position and slope contribute to determining the overall risk of the landslide hazard in a given area. Specific areas of the county which have historically been most susceptible include:

- The high angle slope areas surrounding Irondequoit Bay and the south shore of Lake Ontario, including the houses and businesses and other nearby structures
- Specific areas within Monroe County parks
- Open mine pits.

The underlying cause of a landslide is another significant variable influencing the occurrence of an event. These causes, or triggers, can be natural or human-induced sources. The three most common landslide triggers are water saturation of the ground; loading, or increased weight at the top or high end of the slope; and taking away soil or removing mass from the bottom (NYS DHSES 2014).

According to the NYS DHSES, 316,093 persons in Monroe County live in a moderate susceptibility/low incidence landslide area; 263,031 live in a moderate incidence area; and 163,647 live in a low incidence area (NYS DHSES 2014). Figure 5.4.6-1 shows the landslide incidence and susceptibility in Monroe County based on terrain slopes and soil type throughout the county (Monroe County 2015).

Figure 5.4.6-1. Landslide Incidence and Susceptibility in Monroe County



Source: Monroe County, 2015

Previous Occurrences and Losses

Landslides have occurred in several areas within Monroe County, however, none have caused personal injury. High water levels on Lake Ontario caused severe erosion in 1993, 1997, and 1998, and contributed to landslides. Cliffs along the shoreline in the Town of Webster, and along the Irondequoit Bay were eroded. In 1998, severe erosion exposed a sanitary sewage transmission main near Sea Breeze, in the Town of Irondequoit, prompting emergency measures for repair and a call for immediate protective relief from the International Joint Commission that regulates lake levels (NYS DHSES 2014). On April 2, 1997, a house on the west side of Irondequoit Bay slid off its foundation into the bay; however, the cause was unknown. In January, 1998, a basement wall on the uphill side of a home in Webster collapsed from the pressure of saturated soils and downhill drainage. On August 31, 2004, excessive rain saturated a hillside in the Town of Irondequoit and caused brush and dirt to slide 40 feet toward bayside houses known as German Village (more than ten were affected). According to the NYS HMP and other sources reviewed, there have been no landslide events in the county since at least 2010 (NYS DHSES 2014).

Between 1954 and 2014, FEMA issued one disaster declaration (DR) for landslides in New York State. 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 declaration; Monroe County was not included in this declaration (DR-487).

For this 2015 HMP Update, known landslide events that have impacted Monroe County between 1993 and 2015 are identified in Table 5.4.6-1. However, Table 5.4.6-1 may not include a complete record of all landslide events that have occurred within the county.

Table 5.4.6-1. Landslide Events between 1993 and 2015

Dates of Event	Event Type	FEMA Declaration Number	Location / County Designated?	Losses / Impacts
1993, 1997, 1998	Shoreline Erosion	N/A	No	High water levels on Lake Ontario exacerbated erosion along its shoreline. When the lake level reached 246.3 feet, erosion escalated. In these years, erosion swallowed land mass, trees and other vegetation, and artificial fill that property owners utilized as bank stabilization, some of which was placed through a U.S. Army Corps of Engineers "Advanced Measures Program" in the 1970s. Natural features have also been adversely affected by landslide. In Monroe County, cliffs along the shoreline in the Town of Webster, and along the Irondequoit Bay have been eroded. In 1998, severe erosion exposed a sanitary sewage transmission main near Sea Breeze, in the Town of Irondequoit, prompting emergency measures for repair and a call for immediate protective relief from the International Joint Commission that regulates lake levels.
April 2, 1997	House slid off Foundation/Water Main Break	N/A	No	A house on the west side of Irondequoit Bay, in the Town of Irondequoit, slid off its foundation into the bay. It is unknown whether a water service break at the house site caused the slide, or if the slide ruptured the water service. No one was home at the time of this event and no other properties were damaged (Greg Merrick, Irondequoit Fire Marshal, telephone interview, 8-12-03)
January, 1998	Saturated Soils	N/A	No	In the Town of Webster, a basement wall on the uphill side of the house collapsed from the pressure of saturated soils and downhill drainage.
August 31, 2004	Washout/ Landslide	N/A	No	Town of Irondequoit Supervisor, David Schantz called OEM to report a major wash-out on the slope above "German Village," off Point Pleasant Road on the Westside of Irondequoit Bay. Five private homes were jeopardized. Town Officials, geo-technical Engineers, and utilities were involved. OEM briefed SEMO. "...Excessive rain saturated the hillside. That deluge caused brush and dirt to slide 40 feet toward about a dozen bayside houses known as German Village" (Democrat & Chronicle, 7.29.06).
July 28, 2006	Landslide	N/A	No	An Irondequoit resident awoke, "...To find her lawn and walkway covered with water and debris, runoff from a neighboring hillside. "Water was gushing like a small river, and the sump pump is running constantly'" (Democrat & Chronicle, 7.29.06).
August 10, 2009	Erosion, Unstable Banks	N/A	No	"County Executive, Maggie Brooks, today announced the County was forced to cordon off a section of Ellison Park from public use as a result of dangerous conditions created by unstable banks along Irondequoit Creek. Significant stretches of Irondequoit Creek within both Powder Mills and Ellison Parks have been greatly impacted by storm water flow and other forms of erosion, seriously compromising the structural integrity of its banks" (Monroe County News Release, 8.10.09).

Sources: Monroe County, 2015
FEMA Federal Emergency Management Agency
N/A Not applicable

Probability of Future Occurrences

As indicated in the NYS HMP, and given the history of landslides in New York State, it is certain that future landslides will occur, but the severity of these landslides cannot be determined. Therefore, the probability of future landslides in New York State is considered high; however, since documentation on landslides in Monroe County is sparse, it is difficult to predict the extent of future landslides in the county.

Using documented historical occurrences from the New York State Geological Survey (NYSGS) Landslide Inventory Study to estimate the probability of future landslides, New York State can expect on average approximately two major landslides each year, a greater number of smaller but still significant slides, slumps, or flows each year, and at least one landslide causing a fatality once every 12 years.

Monroe County can expect at least one small slide, slump, or flow at least once every 25 years. The frequency of damaging landslides within Monroe County can be classified, relative to other higher risk areas, as low. However, the fact that high landslide susceptibility exists and landslides have occurred in the past suggests that the certain parts of the county's infrastructure, as well as people, are at risk from damaging landslide hazards in in the county.

In Section 5.3, the identified hazards of concern for Monroe County were ranked using various parameters. The probability of occurrence, or likelihood of the event, is one parameter used for hazard rankings. Based on historical records and input from the Planning Committee, the probability of occurrence for landslides in Monroe County is considered 'Frequent' (hazard event likely to occur within 25 years) in Table 5.3-3.

Climate Change Impacts

Providing projections of future climate change for a specific region is challenging. Shorter-term projections are more closely tied to existing trends making longer-term projections even more challenging. The further out a prediction reaches, the more it is subject to change.

Temperatures in the northeastern parts of the United States have increased 1.5 degrees Fahrenheit (°F) on average since 1900. Most of this warming has occurred since 1970. Future climate change may impact storm patterns, increasing the probability of more frequent, intense storms with varying duration. Increase in global temperature could affect the snowpack and its ability to hold and store water. Warming temperatures also could increase the occurrence and duration of droughts, which could increase the probability of wildfire, reducing the vegetation that helps to support steep slopes. All of these factors could increase the probability for landslide occurrences.

Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed or vulnerable in the identified hazard area. For this analysis, the hazard area is defined as the moderate susceptibility/low incidence and moderate incidence landslide zones. This potential impacts of the landslide hazard on Monroe County include the following:

- Overview of vulnerability
- Data and methodology used for the evaluation
- Impact to: (1) life, health, and safety of county residents, (2) general building stock, (3) critical facilities, (4) economy, and (5) future growth and development
- Effect of climate change on vulnerability
- Change of vulnerability from the 2011 Monroe County Hazard Mitigation Plan
- Further data collections that will assist understanding of this hazard over time

Overview of Vulnerability

Vulnerability to the landslide hazard 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 hazard effects by educating themselves on site history, and by obtaining data from planning and engineering departments of local governments (USGS 2004).

Data and Methodology

In an attempt to estimate Monroe County's vulnerability to landslides, the Geology - Landslide Incidence and Susceptibility geographic information systems (GIS) layer from National Atlas was used to coarsely define the general landslide susceptible area. The Geology - Landslide Incidence and Susceptibility GIS layer was overlaid upon the Monroe County 2010 Census municipality population data, updated building inventory, and Monroe County's critical facility inventory to estimate exposure.

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. 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 cutting by some movement in 15 percent or more of the affected area. The effect of earthquakes on slope stability was not evaluated, although many catastrophic landslides have been generated by ground shaking during earthquakes. Areas susceptible to landslides under static conditions would probably also be susceptible to failure during earthquakes" (Radbruch-Hall 1982).

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.

Impact on Life, Health, and Safety

Table 5.4.6-2 summarizes the area within each hazard ranked area, specific to Monroe County municipalities. 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 having their center (centroid) within the boundary of the landslide incidence hazard areas were used to calculate the estimated population considered exposed to this hazard. In total, 263,040 (35.3%) of the County's population is exposed to the moderate incidence hazard area, and 316,423 (42.5%) of the county's population is exposed to the moderate susceptibility/low incidence hazard area.

Table 5.4.6-2. Estimated Population Exposed to Landslides in Monroe County

Municipality	Total Population (U.S. Census 2010)	Landslide Incidence		Landslide Susceptibility/Incidence	
		Moderate	% of Total	Moderate/Low	% of Total
Brighton (T)	36,609	20,874	57.0%	907	2.5%
Brockport (V)	8,366	0	0.0%	8,366	100.0%
Chili (T)	28,625	0	0.0%	28,625	100.0%
Churchville (V)	1,961	0	0.0%	1,961	100.0%
Clarkson (T)	6,588	0	0.0%	6,588	100.0%
East Rochester (V/T)	6,587	0	0.0%	0	0.0%
Fairport (V)	5,353	0	0.0%	0	0.0%
Gates (T)	28,400	0	0.0%	28,400	100.0%
Greece (T)	96,095	518	0.5%	94,642	98.5%
Hamlin (T)	9,045	700	7.7%	8,345	92.3%
Henrietta (T)	42,581	0	0.0%	11,788	27.7%
Hilton (V)	5,886	0	0.0%	5,886	100.0%
Honeoye Falls (V)	2,674	0	0.0%	0	0.0%
Irondequoit (T)	51,692	48,304	93.4%	3,096	6.0%
Mendon (T)	6,478	0	0.0%	0	0.0%
Ogden (T)	16,255	0	0.0%	16,255	100.0%
Parma (T)	9,747	1,189	12.2%	8,558	87.8%
Penfield (T)	36,242	0	0.0%	14,811	40.9%
Perinton (T)	41,109	0	0.0%	0	0.0%
Pittsford (T)	28,050	0	0.0%	0	0.0%
Pittsford (V)	1,355	0	0.0%	0	0.0%
Riga (T)	3,629	0	0.0%	3,629	100.0%
Rochester (C)	210,565	188,597	89.6%	20,614	9.8%
Rush (T)	3,478	0	0.0%	0	0.0%
Scottsville (V)	2,001	0	0.0%	2,001	100.0%
Spencerport (V)	3,601	0	0.0%	3,601	100.0%

Municipality	Total Population (U.S. Census 2010)	Landslide Incidence		Landslide Susceptibility/Incidence	
		Moderate	% of Total	Moderate/Low	% of Total
Sweden (T)	5,957	0	0.0%	5,957	100.0%
Webster (T)	37,242	2,858	7.7%	34,351	92.2%
Webster (V)	5,399	0	0.0%	5,399	100.0%
Wheatland (T)	2,774	0	0.0%	2,643	95.3%
Monroe County (Total)	**744,344**	**263,040**	**35.3%**	**316,423**	**42.5%**

Source: Godt, 2001; U.S. Census 2010
Notes:
C City
T Town
V Village

Impact on General Building Stock

In general, the building environment located in the high susceptibility zones and the population, structures, and infrastructure located downslope are vulnerable to this hazard. The Census blocks having their center (centroid) within the boundary of the landslide incidence hazard areas were used to calculate the estimated building stock exposed to this hazard. Table 5.4.6-3 and Table 5.4.6-4 list the results of the general building stock exposed to this hazard.

Table 5.4.6-3. Estimated General Building Stock Replacement Cost Value in the Landslide Hazard Area

Municipality	Total GBS RCV	Landslide Incidence		Landslide Susceptibility/Incidence	
		Moderate	% of Total	Moderate/Low	% of Total
Brighton (T)	$18,462,216,409	$11,979,635,395	64.9%	$330,763,729	1.8%
Brockport (V)	$2,035,910,815	$0	0.0%	$2,035,910,815	100.0%
Chili (T)	$8,342,622,610	$151,969,763	1.8%	$8,190,652,847	98.2%
Churchville (V)	$920,696,714	$0	0.0%	$920,696,714	100.0%
Clarkson (T)	$1,812,049,577	$0	0.0%	$1,812,049,577	100.0%
East Rochester (V/T)	$2,846,820,718	$0	0.0%	$0	0.0%
Fairport (V)	$2,449,020,743	$0	0.0%	$0	0.0%
Gates (T)	$9,547,208,635	$19,110,263	<1%	$9,528,098,371	99.8%
Greece (T)	$25,595,860,286	$207,658,040	<1%	$25,098,220,358	98.1%
Hamlin (T)	$1,737,395,194	$195,106,192	11.2%	$1,537,612,479	88.5%
Henrietta (T)	$13,259,007,785	$0	0.0%	$2,678,974,995	20.2%
Hilton (V)	$1,664,654,730	$0	0.0%	$1,664,654,730	100.0%
Honeoye Falls (V)	$1,119,568,668	$0	0.0%	$0	0.0%
Irondequoit (T)	$16,075,218,322	$15,028,488,943	93.5%	$1,010,519,158	6.3%
Mendon (T)	$2,996,719,632	$0	0.0%	$0	0.0%
Ogden (T)	$4,469,332,464	$0	0.0%	$4,469,332,464	100.0%
Parma (T)	$2,595,035,929	$303,063,890	11.7%	$2,286,402,423	88.1%
Penfield (T)	$14,501,168,927	$0	0.0%	$6,067,163,605	41.8%
Perinton (T)	$17,896,609,894	$0	0.0%	$0	0.0%

Table 5.4.6-3. Estimated General Building Stock Replacement Cost Value in the Landslide Hazard Area

Municipality	Total GBS RCV	Landslide Incidence		Landslide Susceptibility/Incidence	
		Moderate	% of Total	Moderate/Low	% of Total
Pittsford (T)	$12,295,191,719	$0	0.0%	$0	0.0%
Pittsford (V)	$2,204,429,074	$0	0.0%	$0	0.0%
Riga (T)	$1,283,085,436	$0	0.0%	$1,283,085,436	100.0%
Rochester (C)	$94,424,953,585	$86,972,405,520	92.1%	$6,998,174,662	7.4%
Rush (T)	$1,453,693,815	$0	0.0%	$0	0.0%
Scottsville (V)	$706,870,704	$0	0.0%	$706,870,704	100.0%
Spencerport (V)	$1,862,825,476	$0	0.0%	$1,862,825,476	100.0%
Sweden (T)	$1,771,453,297	$0	0.0%	$1,771,453,297	100.0%
Webster (T)	$11,420,618,527	$823,938,896	7.2%	$10,545,474,483	92.3%
Webster (V)	$1,799,326,797	$0	0.0%	$1,799,326,797	100.0%
Wheatland (T)	$1,061,455,206	$0	0.0%	$1,006,500,585	94.8%
Monroe County (Total)	**$278,611,021,689**	**$115,681,376,902**	**41.5%**	**$93,604,763,705**	**33.6%**

Source: *Godt 2001; Monroe County*
Notes: *GBS General Building Stock;*
RCV Replacement Cost Value.
C City
T Town
V Village

Table 5.4.6-4. Number of Buildings located in the Landslide Hazard Area

Municipality	Total GBS RCV	Landslide Incidence		Landslide Susceptibility/Incidence	
		Moderate	% of Total	Moderate/Low	% of Total
Brighton (T)	10,545	5,223	49.5%	210	2.0%
Brockport (V)	1,604	0	0.0%	1,604	100.0%
Chili (T)	9,774	9	<1%	9,765	99.9%
Churchville (V)	807	0	0.0%	807	100.0%
Clarkson (T)	2,040	0	0.0%	2,040	100.0%
East Rochester (V/T)	2,495	0	0.0%	0	0.0%
Fairport (V)	2,056	0	0.0%	0	0.0%
Gates (T)	10,550	3	<1%	10,547	99.9%
Greece (T)	32,375	303	<1%	31,590	97.6%
Hamlin (T)	2,808	365	13.0%	2,431	86.6%
Henrietta (T)	12,657	0	0.0%	2,107	16.6%
Hilton (V)	1,884	0	0.0%	1,884	100.0%
Honeoye Falls (V)	922	0	0.0%	0	0.0%
Irondequoit (T)	19,765	18,173	91.9%	1,441	7.3%
Mendon (T)	2,366	0	0.0%	0	0.0%

Table 5.4.6-4. Number of Buildings located in the Landslide Hazard Area

Municipality	Total GBS RCV	Landslide Incidence		Landslide Susceptibility/Incidence	
		Moderate	% of Total	Moderate/Low	% of Total
Ogden (T)	5,331	0	0.0%	5,331	100.0%
Parma (T)	3,743	556	14.9%	3,178	84.9%
Penfield (T)	13,077	0	0.0%	5,548	42.4%
Perinton (T)	14,901	0	0.0%	0	0.0%
Pittsford (T)	9,159	0	0.0%	0	0.0%
Pittsford (V)	656	0	0.0%	0	0.0%
Riga (T)	1,271	0	0.0%	1,271	100.0%
Rochester (C)	58,996	51,319	87.0%	7,343	12.4%
Rush (T)	1,433	0	0.0%	0	0.0%
Scottsville (V)	747	0	0.0%	747	100.0%
Spencerport (V)	1,253	0	0.0%	1,253	100.0%
Sweden (T)	1,986	0	0.0%	1,986	100.0%
Webster (T)	13,477	909	6.7%	12,520	92.9%
Webster (V)	1,305	0	0.0%	1,305	100.0%
Wheatland (T)	991	0	0.0%	935	94.3%
Monroe County (Total)	**240,974**	**76,860**	**31.9%**	**105,843**	**43.9%**

Source: *Godt 2001; Monroe County*
Notes: *GBS* *General Building Stock;*
C *City*
T *Town*
V *Village*

Impact on Critical Facilities

To estimate exposure, the approximate landslide hazard areas were overlaid upon the essential and municipal facilities. Table 5.4.6-5 and Table 5.4.6-6 lists the essential facilities (e.g., police, fire, emergency operations centers [EOC], hospitals, and schools) that are located in the landslide susceptibility/ incidence hazard areas.

Table 5.4.6-5. Number of Critical Facilities Located in the Landslide Hazard Area

Municipality	Facility Types																			
	Agriculture	Air	Alcohol/Drug Rehabilitation	Bridge	Bus	Chemical	Commercial	Communication	Correctional Facility	Court	Dam	Defense Industrial	DPW	DMV	EOC	Fire Station	Golf Course	Government Building	Homeless Shelter	Industrial
Brighton (T)	0	0	2	0	0	0	0	0	1	1	0	0	1	0	0	3	0	0	0	0
Brockport (V)	2	0	0	0	0	0	0	1	0	1	0	0	1	0	0	3	0	0	0	0
Chili (T)	1	0	0	0	0	0	0	1	0	1	7	0	1	0	0	5	3	2	0	0
Churchville (V)	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	1	0	0	0	0
Clarkson (T)	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	3	0	0	0
East Rochester (V/T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fairport (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gates (T)	0	0	0	0	0	0	1	0	0	1	1	0	1	0	0	3	1	0	0	0
Greece (T)	1	0	5	0	0	0	1	5	0	1	5	0	1	1	0	11	4	0	0	2
Hamlin (T)	1	0	0	0	0	0	0	1	0	1	2	0	1	0	0	3	1	0	0	0
Henrietta (T)	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	1	0	0	0
Hilton (V)	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	1	0	0	0	0
Honeoye Falls (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Irondequoit (T)	0	0	3	1	0	0	0	3	0	1	2	0	1	1	0	7	0	1	1	0
Mendon (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ogden (T)	2	0	0	0	0	0	0	1	0	1	2	0	1	0	0	1	3	0	0	0
Parma (T)	1	0	0	0	0	0	0	1	0	1	4	0	0	0	0	1	2	0	0	0
Penfield (T)	1	0	0	0	0	0	0	0	0	0	2	0	1	0	0	2	0	0	0	0
Perinton (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pittsford (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pittsford (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Riga (T)	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	2	0	0	0

Table 5.4.6-5. Number of Critical Facilities Located in the Landslide Hazard Area

Municipality	Facility Types																			
	Agriculture	Air	Alcohol/Drug Rehabilitation	Bridge	Bus	Chemical	Commercial	Communication	Correctional Facility	Court	Dam	Defense Industrial	DPW	DMV	EOC	Fire Station	Golf Course	Government Building	Homeless Shelter	Industrial
Rochester (C)	2	1	24	6	2	1	2	18	1	1	8	1	1	1	1	19	2	15	14	2
Rush (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scottsville (V)	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	1	0	0	0	0
Spencerport (V)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
Sweden (T)	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	1	0	0	0
Webster (T)	0	0	0	0	0	0	0	3	0	1	2	0	1	0	0	3	1	1	0	0
Webster (V)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0	0
Wheatland (T)	0	0	0	0	0	0	0	0	0	0	7	0	1	0	0	1	0	0	0	1
Monroe County (Total)	**11**	**1**	**34**	**7**	**2**	**1**	**4**	**38**	**2**	**14**	**45**	**1**	**21**	**3**	**1**	**71**	**24**	**19**	**15**	**5**

Source: *Monroe County, Godt 2001*
Notes: *C City*
T Town
V Village

Table 5.4.6-6. Number of Critical Facilities Located in the Landslide Hazard Area Continued

Municipality	Facility Types																			
	Information Technology	Library	Major Employer	Manufacturing	Military	Natural Gas	Police Station	Post Office	Potable Treatment Facility	Potable Pump	Oil	Rail	Recreation Center	Religious Center	School	Senior	Shelter	Town Halls	Wastewater Pump	Wastewater Treatment Facility
Brighton (T)	0	1	2	0	0	0	1	1	1	0	0	0	0	14	12	1	3	1	2	0

Table 5.4.6-6. Number of Critical Facilities Located in the Landslide Hazard Area Continued

Municipality	Facility Types																			
	Information Technology	Library	Major Employer	Manufacturing	Military	Natural Gas	Police Station	Post Office	Potable Treatment Facility	Potable Pump	Oil	Rail	Recreation Center	Religious Center	School	Senior	Shelter	Town Halls	Wastewater Pump	Wastewater Treatment Facility
Brockport (V)	0	0	0	0	0	0	2	1	0	0	0	0	1	6	6	1	2	2	0	0
Chili (T)	0	1	0	0	1	0	1	1	3	4	0	0	0	16	8	2	1	1	13	0
Churchville (V)	0	1	0	0	0	0	0	1	1	0	0	0	0	4	1	0	1	1	1	0
Clarkson (T)	0	1	0	0	0	0	0	1	0	0	0	0	0	5	1	0		1	0	0
East Rochester (V/T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fairport (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gates (T)	0	1	1	0	0	0	1	1	2	1	2	0	0	18	7	1	3	1	9	0
Greece (T)	1	2	2	0	2	1	3	3	3	3	0	0	0	36	29	4	6	1	8	1
Hamlin (T)	0	1	0	0	0	0	0	1	1	0	0	0	0	8	1	1	2	1	0	0
Henrietta (T)	0	0	1	0	0	0	0	0	0	0	0	0	0	1	13	0	0	0	1	0
Hilton (V)	0	1	0	0	0	0	0	1	1	0	0	0	0	6	5	1	2	0	0	0
Honeoye Falls (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Irondequoit (T)	1	2	0	0	1	0	1	1	0	1	0	0	1	32	27	1	8	1	2	0
Mendon (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ogden (T)	0	1	0	0	0	0	2	1	2	1	0	0	0	9	7	1	3	1	6	0
Parma (T)	0	0	0	0	0	0	0	0	0	1	0	0	0	7	0	0	0	1	0	0
Penfield (T)	0	0	0	0	0	0	0	0	0	3	0	0	0	9	4	0	0	1	0	0
Perinton (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pittsford (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pittsford (V)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Riga (T)	0	0	0	0	0	0	1	0	2	1	0	0	0	1	4	1	1	1	2	0
Rochester (C)	1	11	15	1	0	1	12	10	3	3	3	1	3	310	106	10	11	2	15	1
Rush (T)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 5.4.6-6. Number of Critical Facilities Located in the Landslide Hazard Area Continued

Municipality	Facility Types																			
	Information Technology	Library	Major Employer	Manufacturing	Military	Natural Gas	Police Station	Post Office	Potable Treatment Facility	Potable Pump	Oil	Rail	Recreation Center	Religious Center	School	Senior	Shelter	Town Halls	Wastewater Pump	Wastewater Treatment Facility
Scottsville (V)	2	1	0	0	0	0	0	1	0	0	0	0	0	3	1	1	0	1	0	0
Spencerport (V)	0	0	0	0	0	0	0	1	1	0	0	0	0	3	1	1	0	1	1	1
Sweden (T)	0	0	0	0	0	0	0	0	1	1	0	0	0	4	4	1	1	0	0	0
Webster (T)	0	1	0	0	0	0	1	0	4	0	0	0	0	13	13	1	4	1	2	2
Webster (V)	0	0	1	0	0	0	0	1	1	0	0	0	0	5	2	0	1	0	0	0
Wheatland (T)	0	1	0	0	0	0	0	1	2	0	0	0	0	4	1	0	1	0	1	2
Monroe County (Total)	**5**	**26**	**22**	**1**	**4**	**2**	**25**	**27**	**28**	**19**	**5**	**1**	**5**	**514**	**253**	**28**	**50**	**19**	**63**	**7**

Source: *Monroe County, Godt 2001*
Notes: *C City*
T Town
V Village

Impact on the Economy

The impact of a landslide 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, landslides threaten transportation corridors, fuel and energy conduits, and communication lines (USGS 2003). Estimated potential damage to general building stock can be quantified as discussed above. For the purposes of this analysis, damage to general building stock is discussed below.

Direct building losses are the estimated costs to repair or replace the damage caused to the building. There are zero buildings located in the high incidence and high/moderate susceptibility/incidence landslide hazard areas. A total risk exposure of approximately $116 billion or 41.5-percent of Monroe County's total inventory is estimated for the buildings located in the landslide moderate incidence area. A total risk exposure of approximately $94 billion or 33.6 percent of Monroe County's total inventory is estimated for the buildings located in the landslide moderate susceptibility/low incidence area. Losses to Monroe County's total building inventory would impact Monroe County's tax base and the local economy.

Interstates 90, 390, 490, and 530 and the Lake Ontario State Parkway traverse the moderate incidence and moderate/susceptibility/low incidence hazard areas. Many of the county's state highways are also located within the hazard area. Refer to Figure 5.4.6-1, to see the location of major roadways in the county in relation to the hazard area.

Future Growth and Development

As discussed in Section 4 and in Volume II, Section 9, areas targeted for future growth and development have been identified across Monroe County. It is anticipated that new development within the identified hazard area will be exposed to such risks. See the jurisdictional annexes of this HMP for anticipated new development areas relative to the landslide hazard risk areas.

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 that may bring intense and prolonged precipitation (U.S. Environmental Protection Agency [EPA] 2013). 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 Monroe County.

While predicting changes in events under a varying 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 2013). The potential effects of climate change on the Monroe County's vulnerability to landslide events shall need to be considered as a greater understanding of regional climate change impacts develop.

Change of Vulnerability

The 2011 HMP did not quantitatively examine Monroe County's potential vulnerability to landslides; however, it did provide a description of past landslide events and the county's overall vulnerability. The HMP also provided municipal data on excavations and utility work that could potential cause a landslide event. For this

HMP Update, the risk for the county's population, building stock, and critical facilities was assessed, and , overall, the county's landslide vulnerability has remained unchanged.

Additional Data and Next Steps

Obtaining historic records on damage to buildings and infrastructure incurred caused by landslides will help with loss estimates and future modeling efforts, given a margin of uncertainty. 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 New York State Hazard Mitigation Plan) to develop higher resolution landslide susceptibility zones. The methodology used the Natural Resource Conservation Services (NRCS) Digital Soil Survey soil units and their associated properties, including the American Association of State Highway and Transportation Officials (AASHTO) rating, liquid limit, hydrologic group, percentage of silt and clay, erosion potential and slope derived from high resolution digital elevation models. Further, research on rainfall thresholds for forecasting landslide potential may also be an option for Monroe County.