



5.4.6 Landslide

This section provides a profile and vulnerability assessment of the landslide hazard for the Livingston County Hazard Mitigation Plan (HMP).

5.4.6.1 Hazard Profile

This section provides information regarding the description, extent, location, previous occurrences and losses, and the probability of future occurrences for the landslide hazard.

Description

Landslides are composed of natural rock, soil, artificial fill, or a combination and move along a downward slope. They flow rapidly, striking at avalanche speeds that can travel several miles, growing as they pick up trees, boulders, cars, and other materials (New York State Division of Homeland Security and Emergency Services [NYS DHSES] 2019).

Landslides occur when the slope or soil stability changes from stable to unstable, which may be caused by earthquakes, storms, volcanic eruptions, erosion, fire, or additional human-induced activities. Typically, the steeper the slope, the higher the risk for landslide occurrence. Slopes greater than 10 degrees are more likely to slide, as are slopes where the height from the top of the slope to its toe is greater than 40 feet. Slopes are also more likely to fail if vegetative cover is low and/or soil water content is high. However, landslides can occur with very little slope, sometimes classified as earth slumping or earth flow (NYS DHSES 2019).

Several different types of landslides include:

- *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 noticed only by presence of crooked trees and disturbed structures
- *Block Slides:* Blocks of rock that slide along a slip plane as a unit down a slope
- *Debris Avalanche:* Predominantly 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)

The amount of damage associated with landslides is small, but they are constantly reoccurring in regular maintenance and repair costs of impacted. In addition, if residential damage occurs and is deemed not able to be rehabilitated, private losses could approach \$50,000 to \$80,000 per residential structure. Certain conditions can be life threatening such as structural failure, or disruption to utilities (natural gas, propane, and electric).

Extent

Extent of a landslide hazard is determined by identifying affected areas and assessing probability of a landslide occurring within a time period. Natural variables that contribute to 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, defined as follows:

- *Landslide incidence*: Categorized by percentage of a given geographic area that has undergone landslides. High incidence means greater than 15 percent of a given area has been involved in landsliding, medium incidence means that 1.5 to 15% of an area has been involved, and low incidence means that less than 1.5 percent of an area has been involved. (Radbruch-Hall et al. 1982).
- *Landslide susceptibility*: Defined as the probable degree of response of geologic formations to natural or artificial cutting, to loading of slopes, or to unusually high precipitation. Assumedly, unusually high precipitation or changes in existing conditions can initiate landslide movement in areas where rocks and soils have been involved with landslides in the past. Landslide susceptibility depends on slope angle and geologic material underlying the slope. Landslide susceptibility applies only to areas potentially affected, and does not imply a time frame within which a landslide might occur. High, medium, and low susceptibility are delimited by the same percentages used for classifying incidence of landslides (Radbruch-Hall et al. 1982).

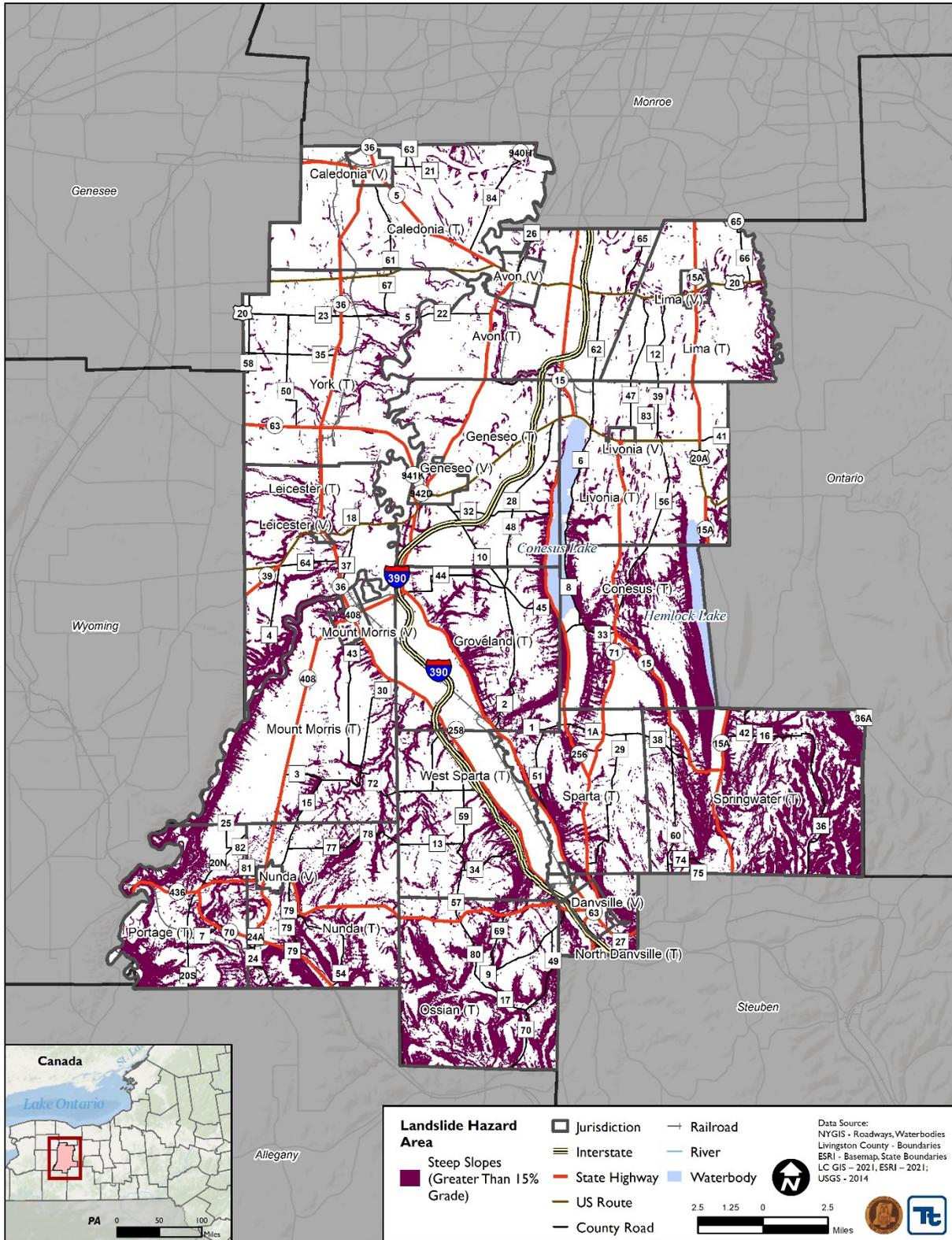
Location

The potential for landslides exists throughout New York State, including Livingston County. Generally, the highest potential for landslides is located along major rivers and lake valleys that were previously glacial lakes resulting in glacial lake deposits (glacial lake clays) and areas associated with steeper slopes.

Landslides in Livingston County occur after heavy rains when steep banks wash down into the roadways. Landslides have occurred in several areas within Livingston County. A bank slid into the Honeoye Creek just South of Routes 5 and 20 in Lima. On July 10, 1935, three landslides buried the DL&W railroad tracks in the Village of Dansville between Dansville and Perkinsville. In 1972, two landslides occurred in Stony Brook State Park in the Town of Dansville, causing \$20,000 in damages. For this 2022 Plan update, landslide events that occurred in the county between 2015 and 2021 were researched. According to the NYS HMP, there have been no landslide events in the county during this time frame. Figure 5.4.6-1 shows areas in Livingston County where slopes are greater than 15-percent grade.



Figure 5.4.6-1. Landslide Susceptibility in Livingston County - Areas with Slopes Greater Than 15-Percent Grade





Previous Occurrences and Losses

Descriptive data on historic events are limited. The NYS HMP contained no records of any events from 1996–2017 (NYS DHSES 2019). Between 1954 and 2021, the Federal Emergency Management Agency (FEMA) issued one disaster declaration (DR) for landslides in NYS (DR-487), but Livingston County was not included in the DR. Annualized loss is negligible for landslide damage.

Probability of Future Occurrences

Based on historical records and input from the Planning Partnership, probability of occurrence of landslides in Livingston County is considered “rare” (1 to 10-percent annual probability of a hazard event occurring).

Climate Change Impacts

Projecting future climate change within a specific region is challenging. Shorter-term projections are more closely tied to existing trends, rendering longer-term projections even more challenging. The further into the future a prediction extends, the more it is subject to change.

Through the 2020s, average annual temperature is expected to increase in Region 1 by 1.8°F in the region of NYS where Livingston County is located. By the 2050s, this increase will be 3.6 °F, and by 2100, it will be 4.5 °F (New York State Energy Research and Development Authority [NYSERDA] 2014). Future climate change may impact storm patterns, increasing probability of more frequent, intense storms with varying duration. Global temperature increase could affect the snowpack and its ability to hold and store water. Warming temperatures also could increase occurrence and duration of droughts, which could increase probability of wildfire and likely reduce the vegetation that helps support steep slopes. All these factors could increase the probability of landslide occurrence.

5.4.6.2 Vulnerability Assessment

To evaluate the landslide hazard in Livingston County, slopes above 15-percent were selected using the 2014 USGS 1-meter Digital Elevation Model (DEM). The following text summarizes the potential impact of landslides on the County. Refer to Section 5.1 (Methodology and Tools) for additional details on the methodology used to assess the landslide hazard risk.

Impact on Life, Health, and Safety

Generally, a landslide event would be an isolated incidence and impact the populations within the immediate area of the incident. Specifically, the population located downslope of the landslide hazard areas are particularly vulnerable to this hazard. In addition to causing damages to residential buildings and displacing residents, landslide events can block off or damage major roadways and inhibit travel for emergency responders or populations trying to evacuate the area.

Table 5.4.6-1 summarizes the population located in the landslide-susceptible hazard area, or areas where slopes have degree angles greater than 15-percent. The Town of Livonia has the greatest number of persons located in the landslide-susceptible hazard area with 547 people, or 8.8-percent of its total population. The Town of Geneseo has the greatest percentage of its population located in the landslide-susceptible hazard area (18.8-percent of its total population).



Table 5.4.6-1. Total Number of Persons Located in the Landslide Hazard Area

Jurisdiction	Total Population (American Community Survey 2015-2019)	Estimated Population Located in the Landslide Hazard Areas	
		Number of Persons Located in the Steep Slopes (Greater Than 15% Grade) Hazard Area	Percent of Total
Avon (T)	3,637	108	3.0%
Avon (V)	3,260	9	0.3%
Caledonia (T)	2,060	12	0.6%
Caledonia (V)	2,078	0	0.0%
Conesus (T)	2,325	342	14.7%
Dansville (V)	4,586	118	2.6%
Geneseo (T)	2,540	479	18.8%
Geneseo (V)	8,095	21	0.3%
Groveland (T)	3,241	403	12.4%
Leicester (T)	1,798	47	2.6%
Leicester (V)	518	0	0.0%
Lima (T)	1,833	42	2.3%
Lima (V)	2,278	26	1.2%
Livonia (T)	6,231	547	8.8%
Livonia (V)	1,353	29	2.2%
Mount Morris (T)	1,340	45	3.4%
Mount Morris (V)	2,931	72	2.5%
North Dansville (T)	696	71	10.2%
Nunda (T)	1,716	110	6.4%
Nunda (V)	1,211	0	0.0%
Ossian (T)	701	104	14.8%
Portage (T)	837	58	7.0%
Sparta (T)	1,591	126	7.9%
Springwater (T)	2,233	233	10.4%
West Sparta (T)	1,229	116	9.4%
York (T)	3,273	32	1.0%
Livingston County (Total)	63,591	3,150	5.0%

Source: American Community Survey 2019; USGS 2014

Notes: T – Town; V – Village; % - Percent

Research has also shown that some populations, while they may not have more hazard exposure, may experience exacerbated impacts and prolonged recovery if/when impacted. For example, persons over the age of 65 and people below the poverty level are most vulnerable to geologic hazards because of the potential limited access to mobilization or medical resources if a landslide or subsidence event occurs. According to the 2019 ACS 5-Year Population Estimate, there are 10,929 persons over 65 years old and 7,572 persons living below the poverty level out of the total 63,591 persons that live in Livingston County.

Impact on General Building Stock

In general, the built environment is vulnerable to the landslide hazard if built on slopes that are greater than 15-percent. Landslide hazard areas may destabilize the foundation of structures resulting in monetary losses to businesses and residents. There are 1,894 buildings with a replacement cost value of approximately \$728 million built on lands with slopes greater than 15-percent.

The Town of Livonia has the greatest number of buildings built on landscapes with slopes greater than 15-percent; 302 buildings (7.8-percent of its total building stock) with an estimated replacement cost of \$95.9 million. Table 5.4.6-2 summarizes the number of buildings and the total replacement cost of these buildings built on landslide susceptible areas by municipality.



Table 5.4.6-2. Total Number of Buildings and Replacement Cost Value Located in the Landslide Hazard Area

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Located in the Landslide Hazard Area			
			Number of Buildings Located in the Steep Slope (Greater Than 15% Grade) Hazard Area	Percent of Total	Total Replacement Cost Value of Buildings Located in the Steep Slope (Greater Than 15% Grade) Hazard Area	Percent of Total
Avon (T)	2,149	\$1,324,846,766	56	2.6%	\$26,375,092	2.0%
Avon (V)	1,245	\$1,365,771,007	5	0.4%	\$2,359,980	0.2%
Caledonia (T)	1,362	\$792,755,652	7	0.5%	\$3,409,162	0.4%
Caledonia (V)	979	\$735,609,120	0	0.0%	\$0	0.0%
Conesus (T)	1,774	\$625,005,723	274	15.4%	\$96,910,622	15.5%
Dansville (V)	1,950	\$1,341,807,175	48	2.5%	\$19,239,494	1.4%
Geneseo (T)	1,753	\$1,161,720,041	243	13.9%	\$79,051,230	6.8%
Geneseo (V)	1,329	\$1,570,704,963	9	0.7%	\$45,556,721	2.9%
Groveland (T)	1,330	\$1,203,662,583	125	9.4%	\$48,815,372	4.1%
Leicester (T)	1,214	\$715,987,145	40	3.3%	\$13,451,412	1.9%
Leicester (V)	240	\$142,879,953	0	0.0%	\$0	0.0%
Lima (T)	1,436	\$859,636,929	30	2.1%	\$13,158,641	1.5%
Lima (V)	777	\$452,768,112	13	1.7%	\$15,757,688	3.5%
Livonia (T)	3,888	\$1,866,897,181	302	7.8%	\$95,877,306	5.1%
Livonia (V)	569	\$371,319,429	13	2.3%	\$4,689,840	1.3%
Mount Morris (T)	1,115	\$646,574,328	33	3.0%	\$12,477,394	1.9%
Mount Morris (V)	1,337	\$785,505,655	30	2.2%	\$9,276,300	1.2%
North Dansville (T)	607	\$497,159,183	58	9.6%	\$18,911,168	3.8%
Nunda (T)	1,354	\$544,934,442	85	6.3%	\$27,369,853	5.0%
Nunda (V)	641	\$392,488,596	0	0.0%	\$0	0.0%
Ossian (T)	817	\$488,703,931	95	11.6%	\$36,625,158	7.5%
Portage (T)	620	\$338,465,763	37	6.0%	\$9,367,278	2.8%
Sparta (T)	1,151	\$449,674,840	96	8.3%	\$33,130,058	7.4%
Springwater (T)	1,822	\$702,256,303	181	9.9%	\$50,350,293	7.2%
West Sparta (T)	1,010	\$423,213,015	90	8.9%	\$53,299,506	12.6%
York (T)	2,183	\$1,677,949,006	24	1.1%	\$12,980,680	0.8%
Livingston County (Total)	34,652	\$21,478,296,842	1,894	5.5%	\$728,440,249	3.4%

Source: Livingston County 2021; RS Means 2021; USGS 2014

Notes: T – Town; V – Village; % - Percent

Impact on Critical Facilities and Lifelines

To estimate potential risk, the critical facility and lifeline inventory was overlaid upon the landslide hazard area. There are 44 critical facilities built on landscapes with slopes greater than 15-percent. All of the critical facilities located on these areas of steep slopes are considered lifelines for the cCounty. Refer to Table 5.4.6-3 which summarizes the number of critical facilities and lifelines exposed to the landslide hazard area by municipality. Overall, bridges and polling sites are the most common critical facility types located on landscapes with slopes greater than 15-percent grade. The critical facilities located on slopes greater than 15-percent grade are also categorized by the FEMA lifeline categories, refer to Table 5.4.6-4. Out of the lifelines in the county, transportation lifelines have the greatest number of facilities in the landslide hazard area. Appendix E summarizes the distribution of critical facilities by facility type located on landscapes with greater than 15-percent grade slopes.



Table 5.4.6-3. Number of Critical Facilities and Lifelines Located in the Landslide Hazard Area

Jurisdiction	Total Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Located in the Steep Slope (Greater Than 15% Grade) Hazard Area			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Avon (T)	51	46	2	3.9%	2	4.3%
Avon (V)	36	27	0	0.0%	0	0.0%
Caledonia (T)	19	16	4	21.1%	4	25.0%
Caledonia (V)	28	25	0	0.0%	0	0.0%
Conesus (T)	26	26	2	7.7%	2	7.7%
Dansville (V)	46	37	1	2.2%	1	2.7%
Geneseo (T)	48	45	2	4.2%	2	4.4%
Geneseo (V)	46	39	2	4.3%	2	5.1%
Groveland (T)	63	59	1	1.6%	1	1.7%
Leicester (T)	26	26	3	11.5%	3	11.5%
Leicester (V)	13	13	0	0.0%	0	0.0%
Lima (T)	16	14	0	0.0%	0	0.0%
Lima (V)	21	19	2	9.5%	2	10.5%
Livonia (T)	70	65	4	5.7%	4	6.2%
Livonia (V)	16	12	1	6.3%	1	8.3%
Mount Morris (T)	30	29	2	6.7%	2	6.9%
Mount Morris (V)	28	24	0	0.0%	0	0.0%
North Dansville (T)	35	31	3	8.6%	3	9.7%
Nunda (T)	25	25	1	4.0%	1	4.0%
Nunda (V)	23	20	0	0.0%	0	0.0%
Ossian (T)	20	20	2	10.0%	2	10.0%
Portage (T)	23	22	3	13.0%	3	13.6%
Sparta (T)	18	18	0	0.0%	0	0.0%
Springwater (T)	27	26	2	7.4%	2	7.7%
West Sparta (T)	25	25	2	8.0%	2	8.0%
York (T)	58	54	5	8.6%	5	9.3%
Livingston County (Total)	837	763	44	5.3%	44	5.8%

Source: Livingston County Planning Partners 2021; HIFLD 2020; USGS 2014

Notes: T – Town; V – Village; % - Percent

Table 5.4.6-4. Number of Lifelines Categorized by FEMA Lifeline Category Located in the Landslide Hazard Area

FEMA Lifeline Category	Number of Lifelines	Number of Lifelines Located in the Steep Slope (Greater Than 15% Grade) Hazard Area
Communications	72	10
Energy	18	1
Food, Water, Shelter	100	8
Hazardous Materials	50	0
Health and Medical	36	0
Safety and Security	269	12
Transportation	218	13
Livingston County (Total)	763	44

Source: Livingston County Planning Partners 2021; HIFLD 2020; USGS 2014; FEMA 2021



In addition to critical facilities, a significant amount of infrastructure can be exposed to mass movements of geological material:

- *Roads*—Access to major roads is crucial to life-safety after a disaster event and to response and recovery operations. Landslides can block egress and ingress on roads, causing isolation for neighborhoods, traffic problems, and delays for public and private transportation. This can result in economic losses for businesses.
- *Bridges*—Landslides can significantly impact road bridges. Mass movements can knock out bridge abutments or significantly weaken the soil supporting them, making them hazardous for use.
- *Power Lines*—Power lines are generally elevated above steep slopes; but the towers supporting them can be subject to landslides. A landslide could trigger failure of the soil underneath a tower, causing it to collapse and ripping down the lines. Power and communication failures due to landslides can create problems for vulnerable populations and businesses.
- *Rail Lines* – Similar to roads, rail lines are important for response and recovery operations after a disaster. Landslides can block travel along the rail lines, which would become especially troublesome, because it would not be as easy to detour a rail line as it is on a local road or highway. Many residents rely on public transport to get to work around the county and into Philadelphia and New York City, and a landslide event could prevent travel to and from work.

Several other types of infrastructure may also be exposed to the geologic hazards, including water and sewer infrastructure. At this time, all critical facilities, infrastructure, and transportation corridors located within the hazard areas are considered vulnerable until more information becomes available.

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 exert direct and indirect effects on society. Direct costs include actual damage sustained by buildings, property, and infrastructure and estimated costs to repair or replace damaged buildings. Indirect costs include clean-up costs, business interruption, loss of tax revenues, reduced property values, and loss of productivity. The 2019 NYS HMP shows that Livingston County has experienced zero economic damages from landslide events between 1996 and 2017 (NYS HMP 2019). Historic losses discussed earlier in this section also show that Livingston County has not experienced any economic losses from landslides. Therefore, the impact landslides have on the economy for Livingston County is minimal.

Impact on the Environment

A landslide event will alter the landscape and can have great impacts on the changes it creates to the natural topography. In addition to changes in topography, vegetation and wildlife habitats may be damaged or destroyed, and soil and sediment runoff will accumulate downslope potentially blocking waterways and roadways and impacting quality of streams and other water bodies. Additional environmental impacts include loss of forest productivity.

Furthermore, soil and sediment runoff can accumulate downslope potentially blocking waterways and roadways and impacting quality of streams and other water bodies. Mudflows that erode into downstream waterways can threaten the life of freshwater species (USGS 2021). The impacts of eroded landscape can travel for miles downstream into adjacent waterways and create issues for surrounding watersheds.

Figure 5.4.6-1 shows landslide susceptibility (i.e., where slope degrees are greater than 15 percent) in Livingston County. Approximately 13.2-percent of Livingston County is susceptible to landslide events where slopes are greater than 15-percent grade (approximately 54,000 acres).



Cascading Impacts on Other Hazards

Landslide events can have cascading impacts on utility failure in Livingston County. As discussed in earlier sections, landslides may disrupt the functionality of utilities if the debris falls, topples, or spreads over the utilities providing services to the county. For example, electric utilities may become disconnected if power lines are broken from displaced geologic material. Water utilities may become breached with excess debris and/or contaminates carried by landslide events. More information about utility interruptions can be found in Section 5.4.12 Utility Failure.

Future Changes that May Impact Vulnerability

Understanding future changes that impact vulnerability in the county can assist in planning for future development and ensuring that appropriate mitigation, planning, and preparedness measures are in place. The County considered the following factors to examine potential conditions that may affect hazard vulnerability:

- Potential or projected development
- Projected changes in population
- Other identified conditions as relevant and appropriate, including the impacts of climate change

Projected Development

As discussed in Section 4, areas targeted for future growth and development have been identified across the County. Any areas of growth located in the landslide-susceptible hazard areas could be potentially impacted by the geologic ground movement caused by landslides. It is recommended that the County and jurisdictional partners implement design strategies that mitigate against the risk of landslides. The maps in the jurisdictional annexes in Section 9 show new development locations throughout the county and their proximity to the landslide-susceptible hazard areas (i.e., where slope degrees are greater than 15 percent).

Projected Changes in Population

According to the 2019 American Community Survey 5-year population estimates, the population of the county has decreased by approximately 3-percent since 2010. While less people will reside in the County, those that remain may move into areas that are susceptible to landslide events. Section 4, County Profile, provides additional discussion on population trends.

Climate Change

A direct impact of climate change on landslides is difficult to determine. However as discussed earlier, multiple secondary effects of climate change have the potential to increase the likelihood of landslides. Warming temperatures resulting in wildfires would reduce vegetative cover along steep slopes and destabilize the soils due to destruction of the root system; increased intensity of rainfall events would increase saturation of soils on steep slopes. Under these future conditions, the County’s assets located on or at the base of these steep slopes will have an increased risk to landslides. Roadways and other transportation infrastructure located in these areas will also be at an increased risk of closure, which would impact the County’s risk as described above.

Change of Vulnerability Since 2014 HMP

For this HMP, the 2014 1-meter Digital Elevation Model (DEM) from USGS was used to determine areas within Livingston County that have slope degrees greater than 15 percent. Population statistics have also been updated using the 5-Year 2014-2019 American Community Survey Population Estimates. The general building stock was updated using RSMeans 2021 building valuations that estimated replacement cost value for each building in the inventory. 2021 building footprint and tax assessor data from Livingston County was used to update the



general building stock attributes. 2021 critical facility inventory data provided by the Livingston County Planning Partners and the Homeland Infrastructure Foundation-Level Data (HIFLD) were used to assess the number of critical facilities and lifelines at risk to the landslide hazard.

Overall, this vulnerability assessment uses a more accurate and updated building inventory than that used in the 2015 HMP. This information provides more accurate exposure and potential loss estimates for Livingston County.