4.3.7 Landslide

Hazard Profile

The following section provides the hazard profile (hazard description, location, extent, previous occurrences and losses, probability of future occurrences, and impact of climate change) and vulnerability assessment for the landslide hazard in Rockland County.

Hazard Description

According to the U.S. Geological Survey (USGS), the term landslide includes a wide range of ground movement, such as rock falls, deep failure of slopes, and shallow debris flows. Gravity acting on an over-steepened slope is the primary reason for a landslide, but there are other contributing factors that include the following (USGS n.d.):

- Erosion by rivers, glaciers, or ocean waves create over steepened slopes
- Rock and soil slopes are weakened through saturation by snowmelt or heavy rains
- Earthquakes create stresses that make weak slopes fail
- Earthquakes of magnitude 4.0 and greater have been known to trigger landslides
- Volcanic eruptions produce loose ash deposits, heavy rain, and debris flows
- Excess weight from accumulation of rain or snow, stockpiling of rock or ore, from waste piles, or from man-made structures may stress weak slopes to failure and other structures

Areas generally prone to landslide hazards include previous landslide areas, bases of steep slopes, bases of drainage channels, developed hillsides, and areas recently burned by forest and brush fires (NYS DHSES n.d.). Landslide materials may be composed of natural rock, soil, artificial fill, or a combination of these materials. These events can transpire quickly with little to no warning. Depending on the location of a landslide, they can pose significant risks to health, safety, transportation, as well as other services. Annually, landslides in the U.S. cause approximately $1 billion in damages and between 25 and 50 fatalities (USGS n.d.).

Landslides may be triggered by both natural and human-caused changes in the environment. Natural causes can include heavy rain, rapid snow melt, steepening of slopes caused by erosion, earthquakes, and changes in groundwater levels. Human activities that contribute to slope failure include altering the natural slope gradient, steepening slopes by construction, increasing soil water content, and removing vegetation cover. Warning signs for landslide activity include the following (USGS n.d.):

- 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 roadbeds
- Rapid increase in creek water levels, possibly accompanied by increased turbidity

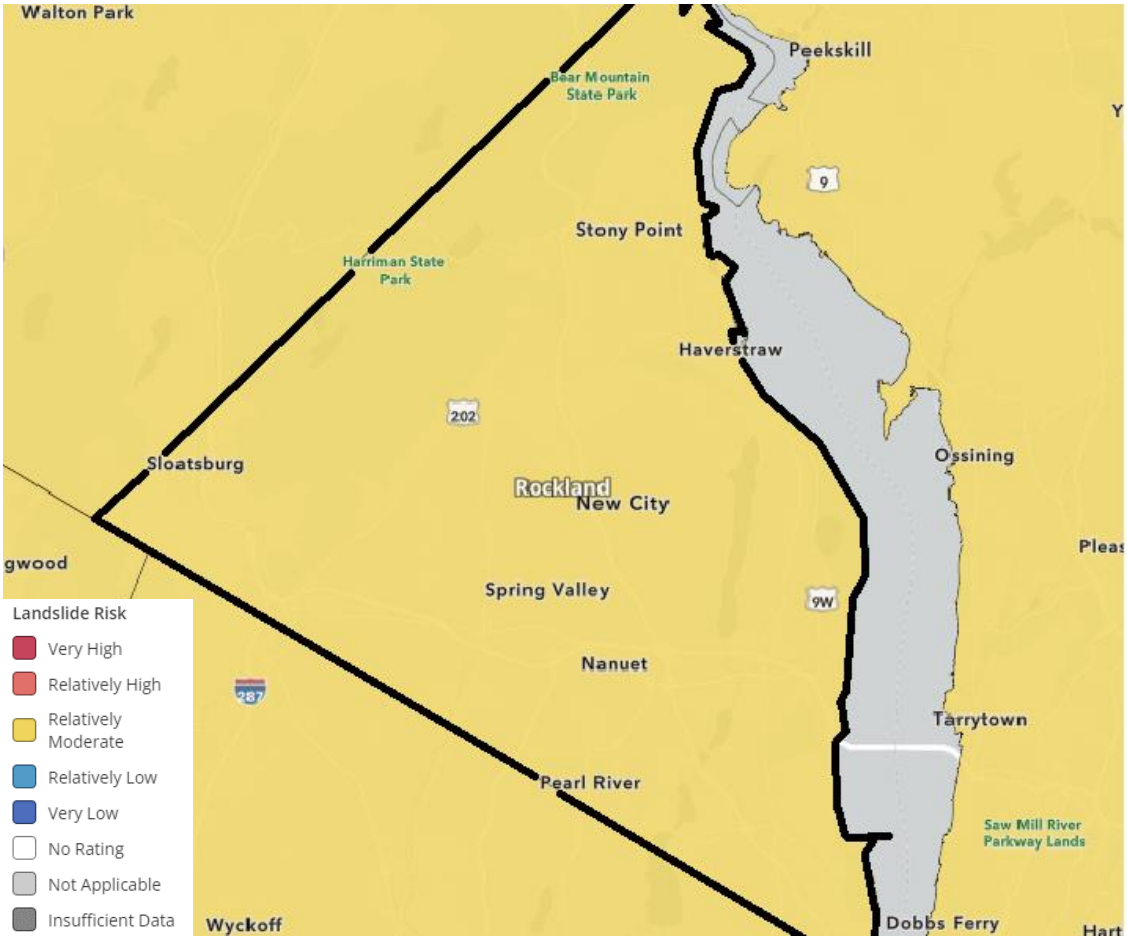
- Sudden increase in creek water levels while rain is still falling or just recently ended
- Sticking doors and windows, and visible open spaces indicating jambs and frames out of plumb
- A faint rumbling sound that increases in volume as the landslide nears
- Unusual sounds, such as trees cracking or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

Location

Variables that contribute to the overall extent of potential landslide activity 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 an area's landslide incidence and/or susceptibility.

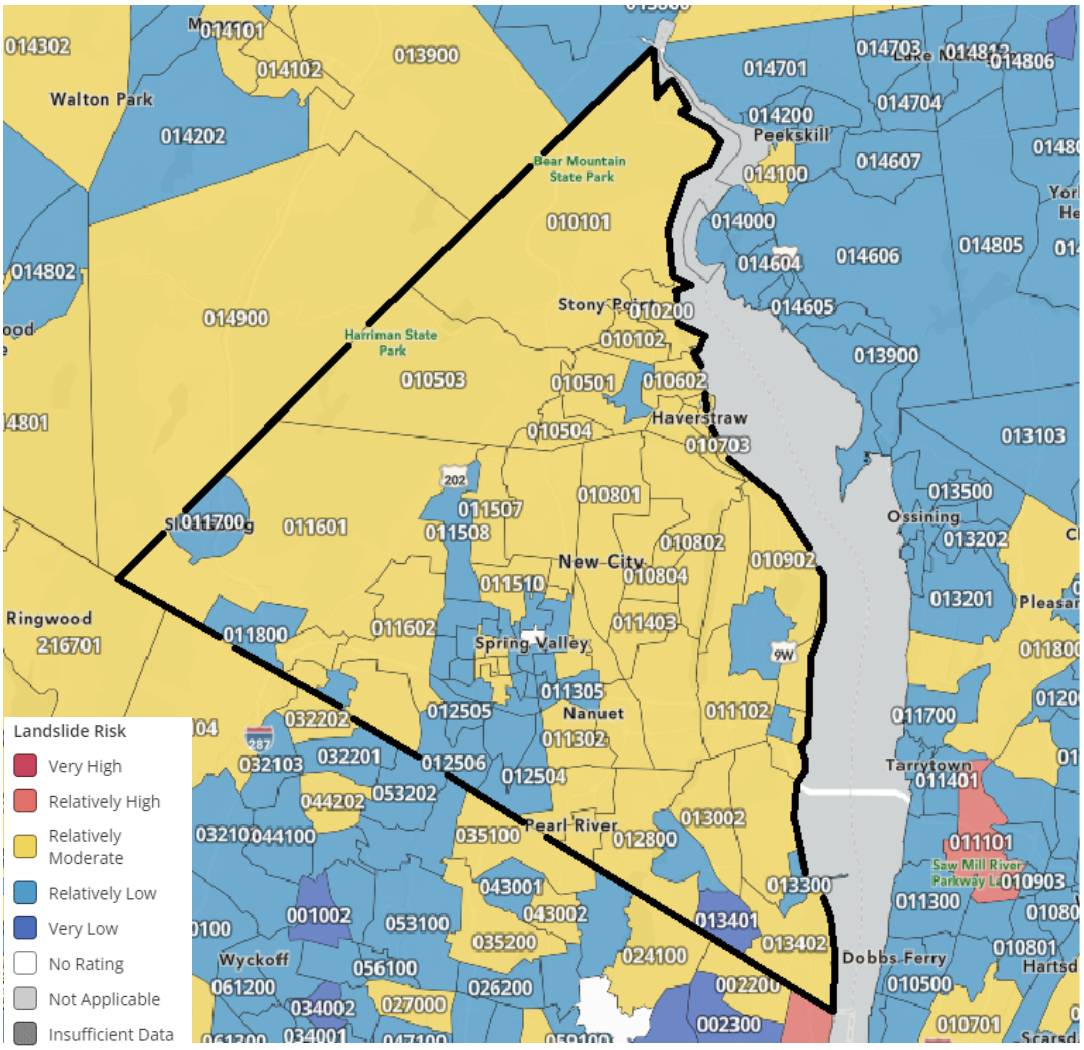
Figure 4.3.7-1 and Figure 4.3.7-2 show the Wildfire Risk Index for Rockland County on the county and census tract scales, respectively. This index helps to understand the susceptibility of the County to landslides. According to the National Risk Index, on the county scale, the County has a relatively moderate risk to landslides; on the census tract scale, portions of the County ranges from a very low risk to a relatively moderate risk, with the area of Spring Valley having no rating (FEMA 2019).

Figure 4.3.7-1. National Risk Index, Landslide Risk Index Score Using the County Scale



Source: *FEMA 2019*
Note: *Rockland is outlined in a boldened black border.*

Figure 4.3.7-2. National Risk Index, Landslide Index Score Using the Census Tract Scale



Source: *FEMA 2019*

Note: *Rockland is outlined in a boldened black border.*

Landslide incidence is the number of landslides that have occurred in a geographic area (DOROTHY H. RADBRUCH-HALL 1982). Refer to Table 4.3.7-1 for the degrees of landslide incidence.

Table 4.3.7-1. Degrees of Landslide Incidence and Susceptibility

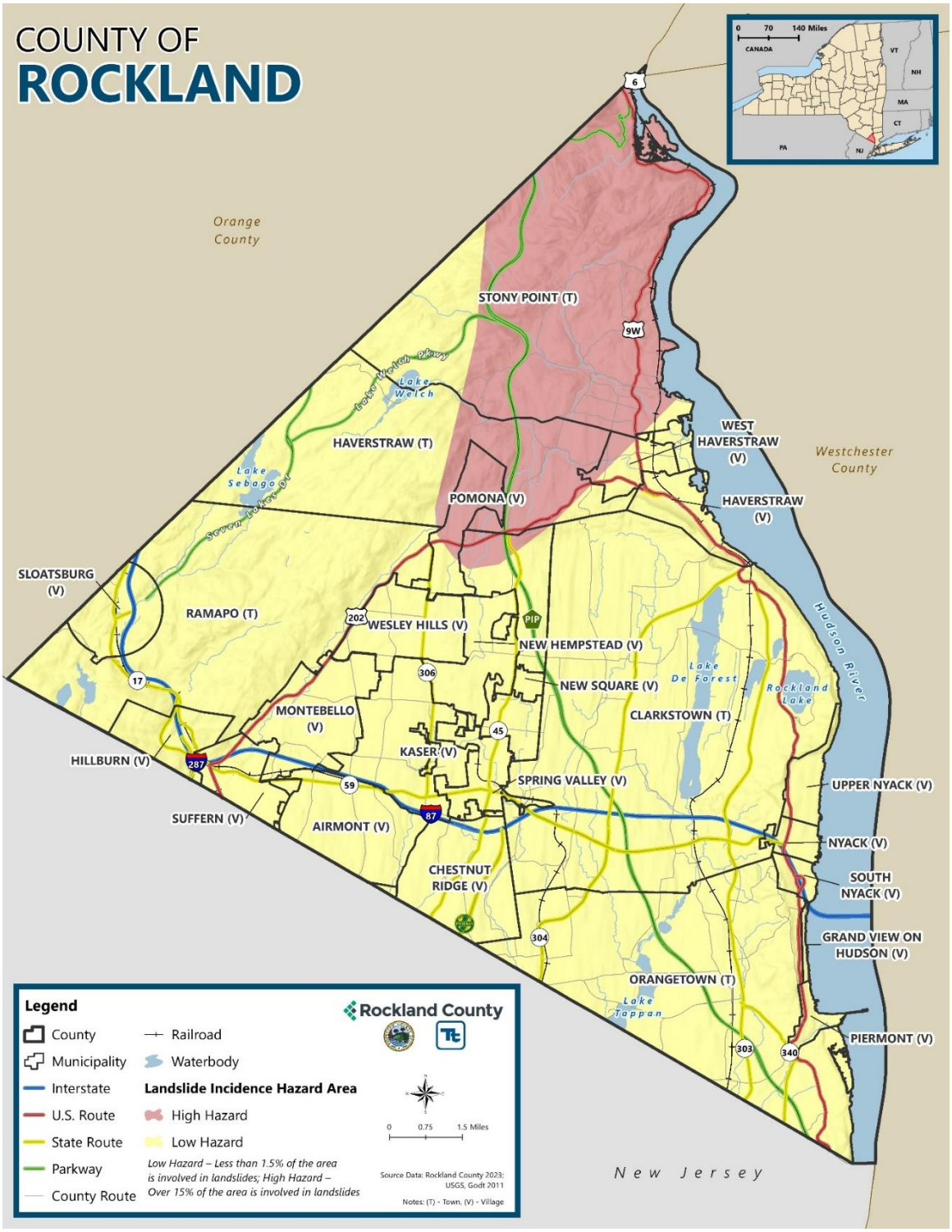
Degree of Incidence	Degree of Susceptibility	Total Area of Landslide(%)
High Incidence	High Susceptibility	15%
Medium Incidence	Medium Susceptibility	1.5% to 15%
Low Incidence	Low Susceptibility	< 1.5%

Source: *Dorothy H. Rudbruch-Hall, 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. Unusually high precipitation or changes in existing conditions can initiate landslide movement in areas where rocks and soils have experienced numerous 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 land sliding (refer to Table 4.3.7-1). Refer to Figure 4.3.7-3 below for the landslide susceptibility of Rockland County.

Figure 4.3.7-3. Landslide Susceptibility of Rockland County

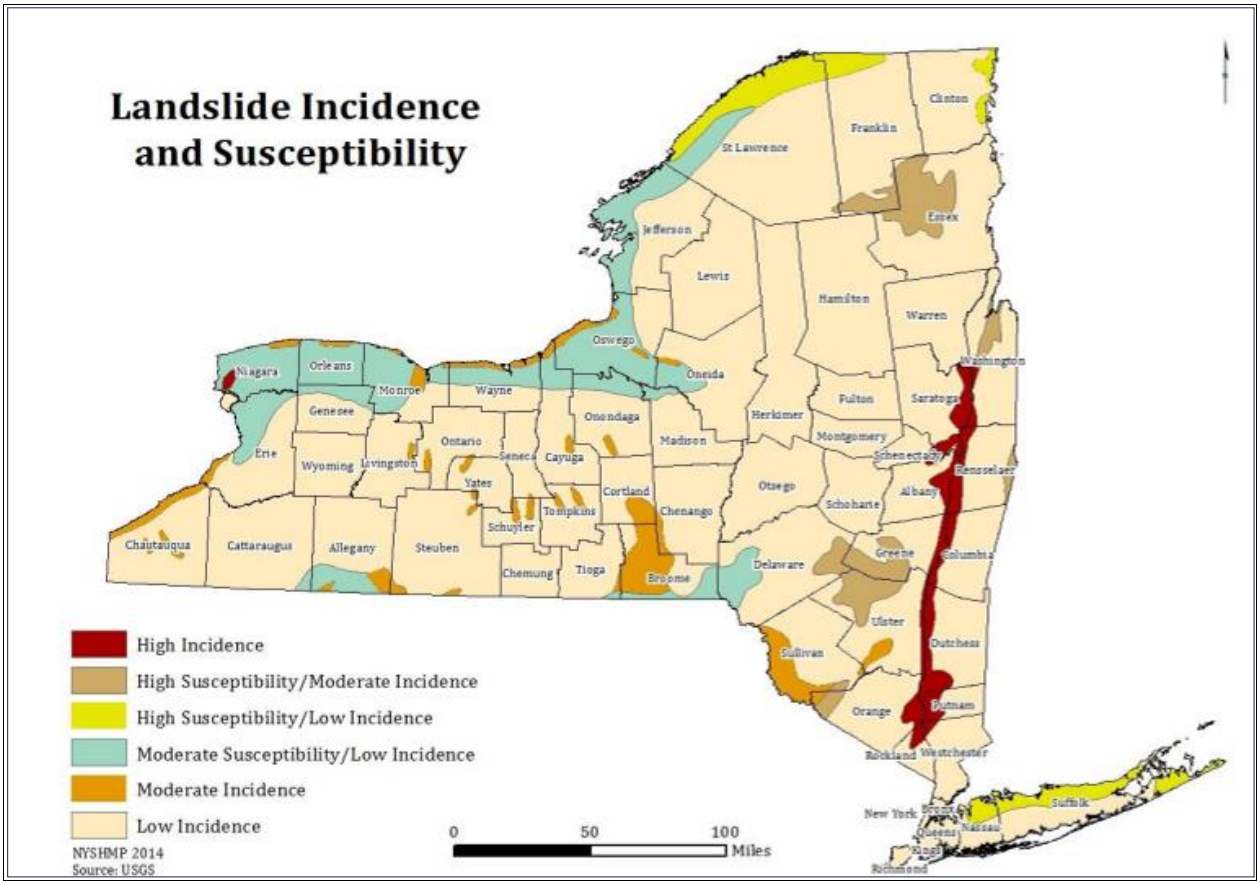


Extent

The potential for landslides exists across the entire State and the entire northeast region of the US. Scientific and historical data for the State of New York indicates that some areas of the State have a substantial landslide risk. It is estimated that 80% of the State has a low susceptibility to the landslide hazard. In general, the highest potential for landslides can be found along major rivers and lake valleys that were formerly occupied by glacial lakes resulting in glacial lake deposits and usually associated with steeper slopes (for example, the Hudson and Mohawk River Valleys). Some natural variables, such as soil properties, topographic position and slope, and historical incidence, all contribute to determining the overall risk of landslide activity in any particular area (NYS 2019).

As illustrated in Figure 4.3.7-4, the northern section of Rockland County has a high incidence of landslide events. This area has steep slopes, resulting in bed rock topples and soil slides (also known as debris slides). The remainder of the County has a low landslide incidence, but landslides are a concern for some jurisdictions. In the Town of Ramapo, there are areas of steep slopes along Route 202. In the Town of Stony Point, there are steeply sloped areas along Route 9W heading north (Rockland County 2011). The Village of Upper Nyack and sections of the Town of Orangetown (formerly the incorporated Village of South Nyack) have identified concerns about landslides due to development on steeply sloped areas (Rockland County 2018).

Figure 4.3.7-4. Landslide Susceptibility in New York State



Source: NYS DHSES 2014

Note: According to this figure, the northern portion of the county is located within the high incidence area for landslide susceptibility while the remainder of the county has a low incidence.

Previous Occurrences

FEMA Major Disaster and Emergency Declarations

Between 1954 and 2023, New York State was included in one landslide major disaster (DR) declaration on October 2, 1975 (DR-487-NY). The event was classified as a severe storm, heavy rain, landslide, and flooding. Generally, these declarations cover a wide region of the State, but not all counties are included in every declaration. NYS HMP and other sources indicate that Rockland County was declared as a disaster or emergency area as part of this landslide declaration (FEMA 2023). For declarations that occurred between 2017 and 2023, specific information regarding any landslide events was not identified. Detailed information about the declared disasters since 1954 is provided in Section 3 (County Profile).

USDA Declarations

The Secretary of Agriculture from the U.S. Department of Agriculture (USDA) is authorized to designate counties as disaster areas to make emergency loans to producers suffering losses in those counties and in counties that are contiguous to a designated county. Between 2018 and 2023, Rockland County was not included in any landslide-related agricultural disaster declarations.

Previous Events

There are not many recorded events of landslide events occurring in Rockland County. However, this does not mean that landslide events have not and do not occur regularly in the area. There is insufficient data and reporting capabilities for landslide-related hazards at this time.

Probability of Future Occurrences

For the 2024 HMP update, best available data was used to collect hazard event details. These details were used to calculate the probability of future occurrence of hazard events in the County. Information from NOAA-NCEI, the 2019 State of New York HMP, the 2018 Rockland County HMP, and FEMA were used to identify the number of events that occurred between 1954 and 2023. Table 4.3.7-2 provides the calculated probability of future landslide events in Rockland County.

Table 4.3.7-2. Probability of Future Landslide Events in Rockland County

Hazard Type	Number of Occurrences Between 1954 and 2023	Percent Chance of Occurring in Any Given Year
Landslides	0	0 percent

Sources: *NOAA-NCEI 2024, FEMA 2024, State of New York 2019*
Notes: *Disaster occurrences include federally declared disasters since the 1950 Federal Disaster Relief Act, and selected landslide events since 1968. Due to limitations in data, not all landslide events occurring between 1954 and 1996 are accounted for in the tally of occurrences. As a result, the number of hazard occurrences is underestimated.*

In Section 4.4, the identified hazards of concern for Rockland County were ranted. 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 Partnership, the probability of occurrence for landslide in the County is considered ‘rare.’

Future landslides certainly will occur in the State of New York, but severity of these landslides cannot be determined. Additionally, because documentation on landslides in Rockland County is sparse, predicting the extent of future landslides in the County is difficult.

According to the New York State Geological Survey (NYSGS) Landslide Inventory Study to estimate probability of future landslides (based on documented historical occurrences), NYS 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.

Climate Change Projections

Climate change may impact storm patterns, increasing the probability of more frequent, intense storms with varying duration. Refer to Table 4.3.7-3 for ClimAID Region 2 seasonal precipitation percent changes. Increase in global temperature could also affect the snowpack and its ability to hold and store water. Thus, resulting in an increase in the occurrence and duration of droughts, which would increase the probability of wildfire, leading to the reduction in vegetation growth that helps to support steep slopes. All these factors would increase the probability for landslide occurrences.

The West Hudson River Valley, encompassing Rockland County, is expected to experience average temperatures increases 3.1°F to 6.9°F by the 2050s and 4.0°F to 10.7°F by the 2080s (baseline of 50.0°F). Precipitation totals will increase between 1 percent and 14 percent by the 2050s and 2 percent to 18 percent by the 2080s (baseline of 46.0 inches). Table 4.3.7-3 displays the projected seasonal precipitation change for the Catskill Mountains and West Hudson River Valley ClimAID Region (NYSERDA 2014).

Table 4.3.7-3. Projected Seasonal Precipitation Percent Change in Region 2 from Present to 2050s

Winter	Spring	Summer	Fall
0 to +15	0 to +10	-5 to +10	-5 to +10

Source: NYSERDA 2014

Vulnerability Assessment

To assess Rockland County's risk to the landslide hazard, an exposure analysis was conducted for the County's assets (population, building stock, critical facilities, historic assets, and new development) using the USGS's Landslide Incidence and Susceptibility data, which approximates areas that are vulnerable to this hazard. For the purposes of this plan, the Vulnerability Assessment define high landslide incidence hazard area as areas with over 15 percent of the area is involved in landsliding.

Impact on Life, Health, and Safety

Generally, a landslide event is an isolated incidence and impacts the populations within the immediate area of the incident. Specifically, the population located downslope of high landslide incidence hazard areas are particularly vulnerable. 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 4.3.7-4 summarizes the estimated population exposed to the landslide hazard by municipality. Based on the analysis, an estimated 32,842 residents, or 9.8 percent of the County's population, are in the landslide hazard area. Overall, the Town of Stony Point has the greatest number of individuals located in high landslide incidence hazard area (14,761 persons).

Table 4.3.7-4. Estimated Population Located in the High Landslide Incidence Hazard Area

Jurisdiction	Total Population	Estimated Population in High Landslide Incidence Hazard Area	
		Number of Persons	Percent of Total
Airmont, Village of	9,964	0	0.0%
Chestnut Ridge, Village of	10,211	0	0.0%
Clarkstown, Town of	81,385	0	0.0%
Grand View on Hudson, Village of	241	0	0.0%
Haverstraw, Town of	14,028	12,936	92.2%
Haverstraw, Village of	12,292	0	0.0%
Hillburn, Village of	1,110	0	0.0%
Kaser, Village of	5,433	0	0.0%
Montebello, Village of	4,665	0	0.0%
New Hempstead, Village of	5,440	0	0.0%
New Square, Village of	9,433	0	0.0%
Nyack, Village of	7,303	0	0.0%
Orangetown, Town of	36,127	0	0.0%
Piermont, Village of	2,525	0	0.0%
Pomona, Village of	3,306	2,157	65.2%
Ramapo, Town of	48,846	608	1.2%
Sloatsburg, Village of	3,043	0	0.0%
South Nyack, Village of	2,803	0	0.0%
Spring Valley, Village of	32,953	0	0.0%
Stony Point, Town of	14,876	14,761	99.2%
Suffern, Village of	11,376	0	0.0%
Upper Nyack, Village of	2,355	0	0.0%
Wesley Hills, Village of	6,105	0	0.0%
West Haverstraw, Village of	10,665	2,380	22.3%
Rockland County (Total)	**336,485**	**32,842**	**9.8%**

Source: U.S. Census Bureau, American Community Survey 5-Year Estimates 2017-2021; USGS, Godt 2011
Notes: Values are rounded down.

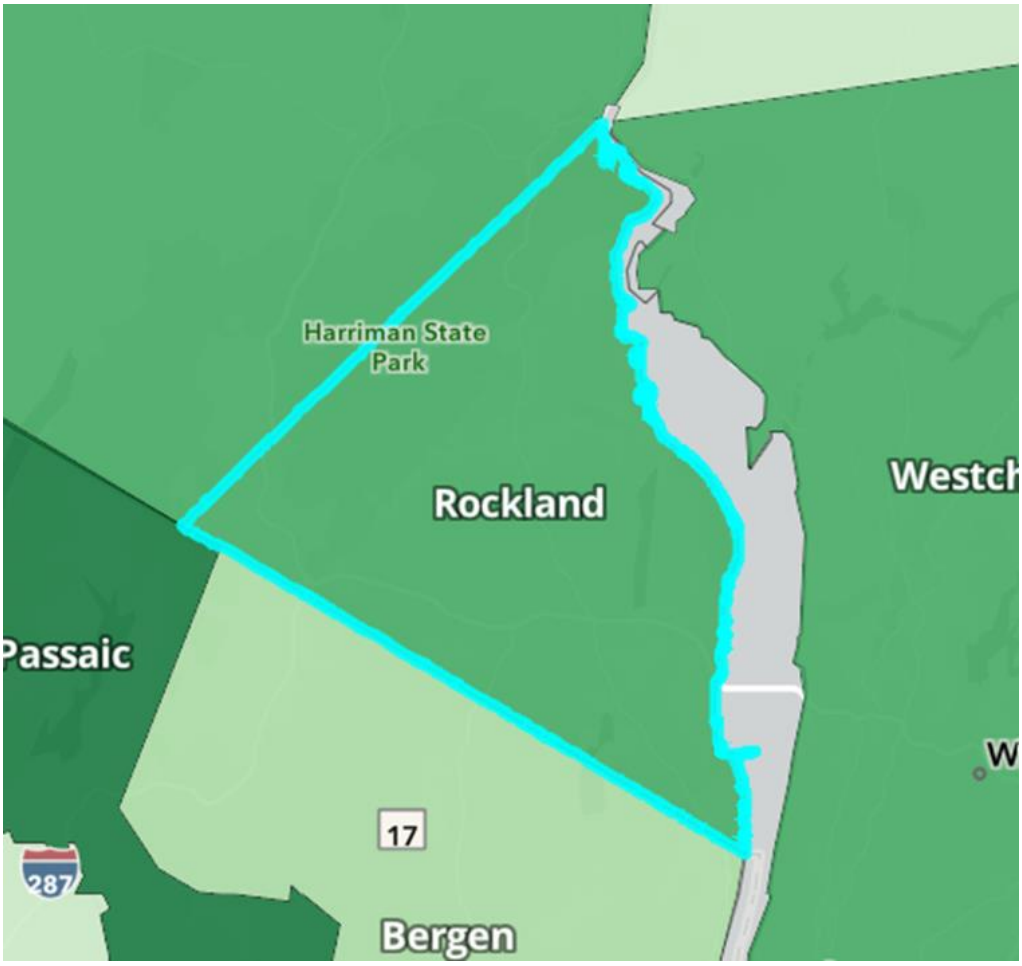
Socially Vulnerable Population

According to the 2017 to 2021 American Community Survey, there are 49,451 total persons living below the poverty level, 52,060 persons over the age of 65 years, 27,605 persons under the age of five years, 26,990 non-English speakers, 29,008 persons with a disability, 49,451 living in poverty, and 109,704 living below the Asset Limited, Income Constrained, Employed (ALICE) threshold in Rockland County.

Economically disadvantaged populations, including those living below the poverty and ALICE thresholds, are more vulnerable to landslides because they are likely to evaluate their risk and make decisions to evacuate based on net economic impacts on their families. The population over age 65 and those living with a disability is also more vulnerable because they are more likely to seek or need medical attention that may not be available due to isolation during a landslide event, and they may have more difficulty evacuating. Similarly, those under five may be more vulnerable because they are dependent on others for essential needs and mobility. Individuals that are

not proficient in English may be unable to interpret emergency warning messages to evacuate or providing resources to protect or mitigate damage to themselves and/or their property.

Figure 4.3.7-5. FEMA Social Vulnerability Index for Natural Hazards



Source: FEMA n.d.

As shown in Table 4.3.7-4, there are 32,842 persons located in high landslide incidence hazard area. Table 4.3.7-5 presents the estimated socially vulnerable populations located in high landslide incidence hazard area. Of the 32,842 persons located in high landslide incidence hazard area, there are 5,702 persons over the age of 65 years, 2,055 persons under the age of five years, 1,641 non-English speakers, 3,180 persons with a disability, 2,542 living in poverty, and 10,567 living below ALICE.

Table 4.3.7-5. Estimated Vulnerable Persons Located Within the High Landslide Incidence Hazard Area

Jurisdiction	Estimated Vulnerable Persons Located Within the High Landslide Incidence Hazard Area											
	Over 65	Percent of Total	Under 5	Percent of Total	Non-English Speaking	Percent of Total	Disability	Percent of Total	Poverty Level	Percent of Total	Living Below ALICE	Percent of Total
Airmont, Village of	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Chestnut Ridge, Village of	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Clarkstown, Town of	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Grand View on Hudson, Village of	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Haverstraw, Town of	2,326	92.2%	1,007	92.1%	918	92.2%	1,132	92.2%	1,303	92.1%	4,632	92.2%
Haverstraw, Village of	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Hillburn, Village of	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Kaser, Village of	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Montebello, Village of	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
New Hempstead, Village of	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
New Square, Village of	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Nyack, Village of	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Orangetown, Town of	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Piermont, Village of	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Pomona, Village of	399	65.1%	160	65.0%	75	64.7%	191	65.2%	72	64.9%	339	65.2%
Ramapo, Town of	58	1.2%	89	1.2%	15	1.2%	30	1.2%	201	1.2%	235	1.2%
Sloatsburg, Village of	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
South Nyack, Village of	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Spring Valley, Village of	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Stony Point, Town of	2,632	99.2%	589	99.2%	262	98.9%	1,606	99.2%	661	99.1%	4,359	99.2%
Suffern, Village of	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Upper Nyack, Village of	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Wesley Hills, Village of	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
West Haverstraw, Village of	287	22.3%	210	22.2%	371	22.3%	221	22.3%	305	22.3%	1,002	22.3%
Rockland County (Total)	**5,702**	**11.0%**	**2,055**	**7.4%**	**1,641**	**6.1%**	**3,180**	**11.0%**	**2,542**	**5.1%**	**10,567**	**9.6%**

Source: U.S. Census Bureau, American Community Survey 5-year estimates 2017-2021; ALICE 2021; USGS, Godt 2011
Notes: Values are rounded down.

Impact on General Building Stock

The potential damage is the modeled loss that could occur to the exposed inventory measured by the structural and content replacement cost value. There are an estimated 14,996 buildings in high landslide incidence hazard area, representing approximately 20.8 percent of the County's total general building stock inventory replacement cost value. The Town of Stony Point has the greatest number of its buildings located in high landslide incidence hazard area (8,680 buildings or 98.4 percent of its total building stock). Refer to Table 4.3.7-6 for the estimated exposure of high landslide incidence hazard area by jurisdiction.

Table 4.3.7-6. Estimated Buildings Located in the High Landslide Incidence Hazard Area

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Buildings Located in the High Landslide Incidence Hazard Area			
			Number of Buildings	Percent of Total	Total Replacement Cost Value of Buildings	Percent of Total
Airmont, Village of	4,324	$2,712,726,498	0	0.0%	$0	0.0%
Chestnut Ridge, Village of	3,996	$2,590,102,202	0	0.0%	$0	0.0%
Clarkstown, Town of	34,094	$22,578,694,610	0	0.0%	$0	0.0%
Grand View on Hudson, Village of	219	$123,746,894	0	0.0%	$0	0.0%
Haverstraw, Town of	5,157	$14,687,792,118	4,495	87.2%	$14,113,465,466	96.1%
Haverstraw, Village of	2,232	$1,373,775,543	0	0.0%	$0	0.0%
Hillburn, Village of	499	$340,797,550	0	0.0%	$0	0.0%
Kaser, Village of	197	$434,976,786	0	0.0%	$0	0.0%
Montebello, Village of	2,002	$1,957,771,278	0	0.0%	$0	0.0%
New Hempstead, Village of	2,074	$1,416,579,766	0	0.0%	$0	0.0%
New Square, Village of	455	$640,979,013	0	0.0%	$0	0.0%
Nyack, Village of	1,830	$1,930,474,072	0	0.0%	$0	0.0%
Orangetown, Town of	18,439	$19,240,363,073	0	0.0%	$0	0.0%
Piermont, Village of	841	$520,681,014	0	0.0%	$0	0.0%
Pomona, Village of	1,437	$947,429,629	942	65.6%	$580,444,466	61.3%
Ramapo, Town of	9,783	$7,401,302,608	178	1.8%	$213,477,407	2.9%
Sloatsburg, Village of	1,776	$780,218,848	0	0.0%	$0	0.0%
South Nyack, Village of	1,009	$628,994,780	0	0.0%	$0	0.0%
Spring Valley, Village of	3,468	$2,977,580,954	0	0.0%	$0	0.0%
Stony Point, Town of	8,819	$4,492,546,145	8,680	98.4%	$4,203,793,357	93.6%
Suffern, Village of	3,110	$2,011,976,760	0	0.0%	$0	0.0%
Upper Nyack, Village of	1,121	$714,087,836	0	0.0%	$0	0.0%
Wesley Hills, Village of	2,432	$1,597,464,375	0	0.0%	$0	0.0%
West Haverstraw, Village of	3,171	$1,575,031,545	701	22.1%	$400,473,726	25.4%
Rockland County (Total)	**112,485**	**$93,676,093,896**	**14,996**	**13.3%**	**$19,511,654,422**	**20.8%**

Source: Rockland County, NYS Office of Information Technology Services Geospatial Services and NYS Department of Taxation and Finance's Office of Real Property Tax Services (ORPTS) 2022; Center for International Earth Science Information Network, New York State Energy Research and Development Authority 2022; U.S. Army Corps of Engineers, National Structure Inventory 2022; RS Means 2022; USGS, Godt 2011

Impact on Critical Facilities and Community Lifelines

Landslides have the potential to cause significant physical damage to critical facilities and community lifelines that may interrupt key services and resources in the region.

Landslides can cause significant damage to buildings and the supply chains that provide health and medical, public safety and security, and food, water, and shelter services. If these facilities and lifelines are not functional during or after an emergency, the County may experience cascading impacts, like additional injuries or health issues or prolonged economic impacts, if a significant number of displaced individuals cannot access temporary or transitional housing.

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 and bridge, causing isolation for neighborhoods, traffic problems, and delays for public and private transportation. This can result in economic losses for businesses. Mass movements can knock out bridge abutments or significantly weaken the soil supporting them, making them hazardous for use. 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 New York City, and a landslide event could prevent travel to and from work.

Additionally, 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. For example, for individuals that rely on medical equipment, a prolonged power outage can present serious health risks or complications. Similarly, water systems can become dammed or contaminated by landslide materials.

Table 4.3.7-7 summarizes the number of community lifelines exposed to high landslide incidence hazard area. Of the 128 community lifelines located in high landslide incidence hazard area, Water Systems has the majority of facilities (51). Refer to Section 3 (County Profile) for more information about the critical facilities and lifelines in Rockland County.

Table 4.3.7-7. Estimated Critical Facilities Located in the High Landslide Incidence Hazard Area

FEMA Lifeline Category	Number of Lifelines	Estimated Critical Facilities Located in the High Landslide Incidence Hazard Area
Communications	154	12
Energy	0	0
Food, Water, Shelter	71	5
Hazardous Material	56	3
Health and Medical	195	15
Safety and Security	349	42
Transportation	8	0
Water Systems	148	51
Rockland County (Total)	**981**	**128**

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.

Impact on the Environment

A landslide event alters the landscape. In addition to changes in topography, vegetation and wildlife habitats may be damaged or destroyed. 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 2020). The impacts of eroded landscape can travel for miles downstream into adjacent waterways and create issues for surrounding watersheds.

Future Changes That May Impact Vulnerability

Understanding future changes that affect vulnerability can assist in planning for future development and ensure establishment of appropriate mitigation, planning, and preparedness measures. 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

Potential or Projected Development

As discussed in Section 3 (County Profile), areas targeted for future growth and development have been identified across the County. Any areas of growth located in areas with moderate landslide incidence or susceptibility could be potentially impacted by the landslide hazard. Please refer to the specific areas of development indicated in tabular form and/or on the hazard maps included in the jurisdictional annexes in Volume II, Section 9 of this plan.

Projected Changes in Population

Rockland County has experienced an increase in its population since 2010. According to the U.S. Census Bureau, the County's population increased by approximately 8.5 percent between 2010 and 2020 (County of Rockland 2021). Cornell University’s Program on Applied Demographics projects Rockland County will have a population of 356,758 by 2030 and 372,432 by 2040 (Cornell University 2018).

Other Identified Conditions

The County is expected to see an increase in average annual temperatures and precipitation due to climate change. Increased severe storm and heavy rainfall events may elevate the likelihood of a landslide occurring in steep sloped areas because precipitation may fall faster or in larger quantities than the soil can absorb in a given timeframe. However, these changes depend on to what degree steep sloped areas are developed and other climate trends, such as seasonal precipitation and drought, which affect vegetation growth.

Change of Vulnerability Since 2018 HMP

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.