



## 5.4.4 Landslide

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

### 5.4.4.1 Hazard Profile

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

#### 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. Although gravity acting on an over steepened slope is the primary reason for a landslide, there are other contributing factors (USGS 2013). Among the contributing factors are: (1) erosion by rivers, glaciers, or ocean waves which create over-steepened slopes; (2) rock and soil slopes weakened through saturation by snowmelt or heavy rains; (3) earthquakes which create stresses making weak slopes fail; and (4) excess weight from rain/snow accumulation, rock/ore stockpiling, waste piles, or man-made structures. Scientists from the USGS also monitor stream flow, noting changes in sediment load in rivers and streams that may result from landslides. All of these types of landslides are considered aggregately in USGS landslide mapping.

Landslide materials may be composed of natural rock, soil, artificial fill, or a combination of these materials. They can be caused by numerous factors such as volcanic eruptions, earthquakes, fire, storms, and by human land modifications. Landslides 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 \$3.5 billion in damages and between 25 and 50 fatalities (NYS HMP 2014).

#### Location

The entire U.S. experiences landslides, with 36 states having moderate to highly severe landslide hazards. Expansion of urban and recreational developments into hillside areas exposes more people to the threat of landslides each year. According to the USGS, Warren County has areas of high potential; however, the majority of the County has low landslide potential. For a figure displaying the landslide potential of the conterminous United States, please refer to <http://pubs.usgs.gov/fs/2005/3156/2005-3156.pdf> (USGS 2005).

The potential for landslides exists across New York State and in Warren County. Scientific and historical data exists for New York State which indicates that some areas of the State have a substantial landslide risk. It is estimated that 80% of New York 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.

#### Extent

To determine the extent of a landslide hazard, the affected areas need to be identified and the probability of the landslide occurring within some time period needs to be assessed. 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 and with reliable



information. As a result, the landslide hazard is often represented by landslide incidence and/or 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% 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% of an area has been involved (State of Alabama Date Unknown).
- 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 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 landsliding (State of Alabama Date Unknown).

### **Previous Occurrences and Losses**

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Numerous sources provided historical information regarding previous occurrences and losses associated with geological hazard events throughout Warren County. According to the 2014 New York State HMP, Warren County has experienced one landslide between 1960 and 2012. Many sources were reviewed for the purpose of this HMP and loss and impact information could vary depending on the source. Therefore, the accuracy of monetary figures, if any, is based only on the available information identified during research for this HMP.

Between 1953 and 2015, FEMA issued a disaster (DR) or emergency (EM) declaration for the New York State for one geological hazard-related event, classified as severe storm, heavy rain, landslides and flooding (DR 487 in October 1975). This declaration did not include Warren County (FEMA 2015).

For this HMP, known landslide events that have impacted Warren County between 2010 and 2016 are identified below. Many sources were researched for historical information regarding landslide events in Warren County; however, limited information was found. Major land failure events that have impacted the County are summarized in Table 5.4.4-1.



**Table 5.4.4-1. Landslide Events in Warren County Between 2010 and 2016**

Dates of Event	Event Type	FEMA Declaration Number	County Declared?	Losses / Impact
April 28-29, 2011	Severe Storms, Flooding, Tornadoes, and Straight-line Winds	DR-1993	Yes	Flooding occurred along the Hudson River in Warren County, from North River southward to the Saratoga County line. Many towns reported flooding of roadways, homes, and riverside camps. Numerous roads were closed throughout the County. The river gauge at North Creek on the Hudson River crested at 13.65 feet (flood stage is 10 feet). In North Creek, a couple hundred feet of railway tracks were reported under two to five feet of water and several buildings in the train station flooded. There were washouts on 13 <sup>th</sup> Lake, Parrish and Beach Roads in the Town of Johnsbury due to the heavy rain from the thunderstorms. There was a reported mudslide in North River/North Creek (Town of Johnsbury) 13 <sup>th</sup> Lake Road. There was another reported incident at Laflure Lane and Old River Road in Chestertown (Town of Chester).
May 15, 2011	Mudslide	N/A	N/A	During a heavy rain event, a stone wall that supported State Route 9N in Hague gave way and set off a mudslide that sent guardrails, trees and debris into Lake George. The NYSDOT temporarily stabilized the area with fill to keep the road open.
April 12, 2014	Mudslide	N/A	N/A	A mudslide near Warrensburg closed a portion of Route 418, from Warrensburg to Thurman, in southeastern Adirondacks. Mud and trees covered approximately 100 feet of the roadway; however, there were no injuries as a result of this event.

Sources: NOAA-NCDC 2015; FEMA 2015; NASA 2015  
 FEMA Federal Emergency management Agency  
 NCDC National Climatic Data Center  
 NOAA National Oceanic and Atmospheric Administration  
 NYSDOT New York State Department of Transportation



### Probability of Future Events

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Based upon risk factors for and past occurrences, it is likely that landslides will occur in Warren County in the future. Landslide probabilities are largely a function of surface geology, but are also influenced by both weather and human activities. Based on recent occurrences, the County can expect to experience 0.4 landslides each year. It is estimated that the County will continue to experience direct and indirect impacts of geological hazards and its impacts on occasion, with the secondary effects causing potential disruption or damage to communities.

In Section 5.3, the identified hazards of concern for Warren County were ranked. 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 the County is considered ‘frequent’ (likely to occur within 25 years, as presented in Table 5.3-3).

### Climate Change Impacts

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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 would increase the probability of wildfire, reducing the vegetation that helps to support steep slopes. All of these factors would increase the probability for landslide occurrences.



### 5.4.4.2 Vulnerability Assessment

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To understand risk, a community must evaluate what assets are exposed or vulnerable in the identified hazard area. For landslides, the known vulnerable areas as identified by New York State and others have been identified as the hazard area. The following text evaluates and estimates the potential impact of landslides on Warren County including:

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

#### Overview of Vulnerability

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Vulnerability to ground failure hazards is a function of location, soil type, geology, type of human activity, use, and frequency of events. The effects of ground failure 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 ground failure effects by educating themselves on past hazard history of the site and by making inquiries to planning and engineering departments of local governments (National Atlas, 2007).

#### Data and Methodology

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The 2014 New York State Hazard Mitigation Plan (NYS HMP) was used to assess the County's vulnerability to landslides. To determine the vulnerability within the State, each county jurisdiction accumulated points based on the value of each variable indicator; the higher the indication for landslide exposure the more points assigned, resulting in a final rating score. The results of the State's landslide vulnerability assessment present a collective review of counties most threatened by and vulnerable to the landslide hazard using readily available information. Based on this, Warren County received a rating score of 5 (out of 15). Figure 5.4.4-1 presents the landslide incidence and susceptibility in New York State. According to this figure, Warren County has an overall low incidence, with a very small area of high incidence in the southeast corner of the County.

#### Impact on Life, Health and Safety

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In order to determine the population risk of landslide incidence, the 2014 NYS HMP used data provided by the USGS. Populations located within landslide susceptibility zones were used to determine the number of people at risk of landslides. According to this data, 250 people in Warren County live within a high incidence zone, while the remaining population, 65,457, living within a low incidence zone.

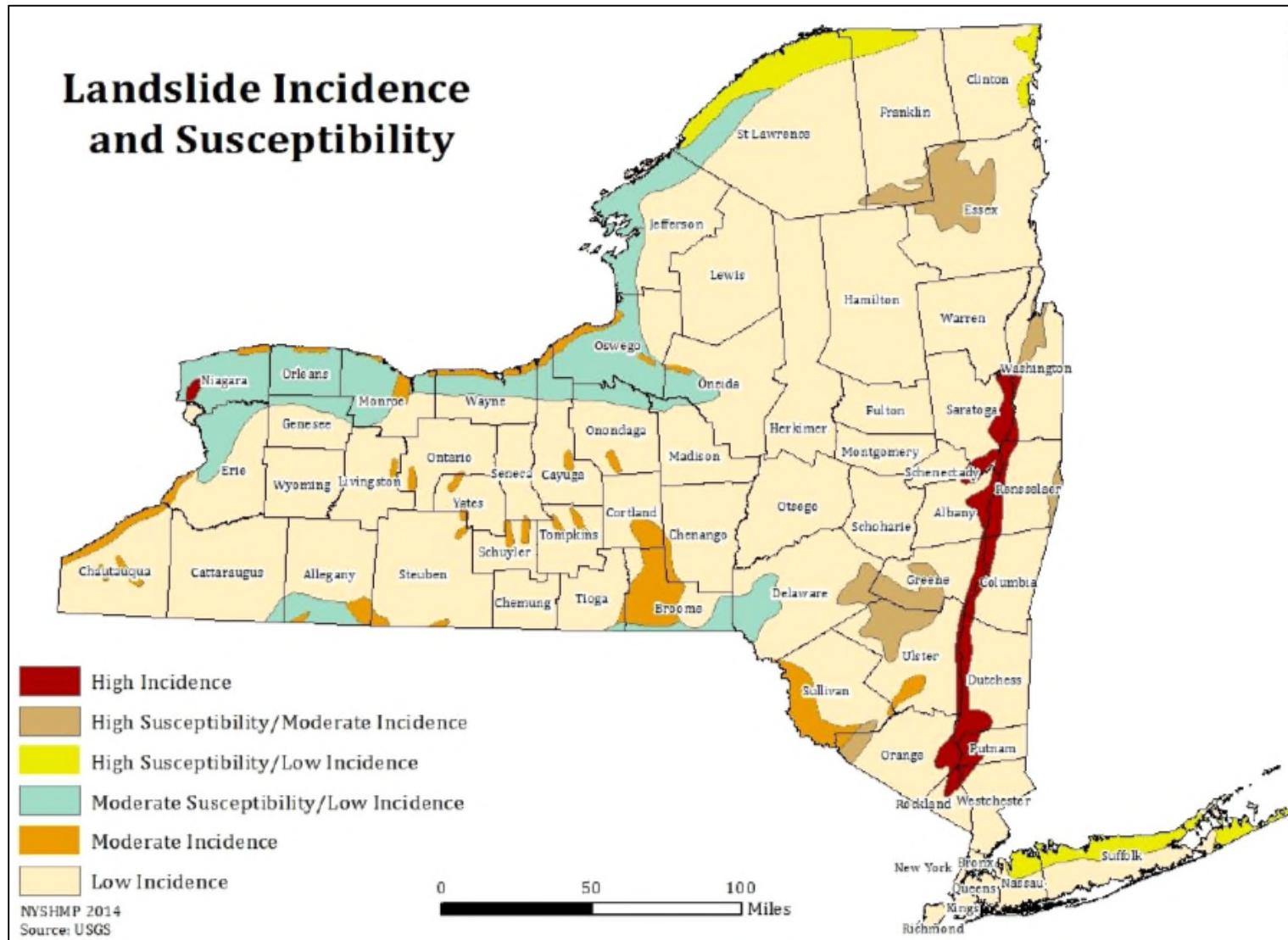
#### Impact on General Building Stock and Critical Facilities

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Losses incurred from landslides within Warren County have been associated with roads. The impact of closed roadways may be increased if the road is critical for hospitals and other emergency facilities.



Figure 5.4.4-1. Landslide Incidence and Susceptibility in New York State



Source: NYS HMP 2014





### Impact on the Economy

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Landslide impacts 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, land failure threatens transportation corridors, fuel and energy conduits and communication lines (USGS 2003). Estimated potential damages to general building stock can be quantified as discussed above. For the purposes of this analysis, general building stock damages are discussed further.

### Future Growth and Development

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As discussed in Section 4 and Volume II, Section 9, areas targeted for future growth and development have been identified across the County. It is anticipated that new development within the high landslide incidence areas identified by USGS will be exposed to landslide risks.

### Effect of Climate Change on Vulnerability

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Providing projections of future climate change for a specific region is challenging. Some scientists feel that melting glaciers could induce tectonic activity. As ice melts and water runs off, tremendous amounts of weight are shifted on the Earth's crust. As newly freed crust returns to its original, pre-glacier shape, it could cause seismic plates to slip and stimulate volcanic activity according to research into prehistoric earthquakes and volcanic activity. National Aeronautics and Space Administration (NASA) and USGS scientists found that retreating glaciers in southern Alaska might be opening the way for future earthquakes.

Secondary impacts of earthquakes could be magnified by future climate change. Soils saturated by repetitive storms could experience liquefaction during seismic activity because of the increased saturation. Dams storing increased volumes of water from changes in the hydrograph could fail during seismic events. There are currently no models available to estimate these impacts.

### Additional Data and Next Steps

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Obtaining historic damages to buildings and infrastructure incurred due to ground failure 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 included using the Natural Resource Conservation Services (NRCS) Digital Soil Survey soil units and their associated properties including the American of State Highway Transportation Officials (AASHTO) rating, liquid limit, hydrologic group, percentage of silt and clay, erosion potential and slope derived from high resolution digital elevation models. Further, research on rainfall thresholds for forecasting landslide potential may also be an option for Warren County.