



## 5.4.7 Mine Subsidence

This section provides a hazard profile and vulnerability assessment of the mine subsidence hazard.

### 5.4.7.1 Hazard Profile

This section presents the mine subsidence hazard description, extent, location, previous occurrences and losses, and probability of future occurrences.

#### Hazard Description

"Mine Subsidence" means lateral or vertical ground movement caused by a failure initiated at the mine level, of manmade underground mines, including, but not limited to salt mines, coal mines, clay mines, limestone mines, and fluor spar mines that directly damages residences or commercial buildings. "Mine Subsidence" does not include lateral or vertical ground movement caused by earthquake, landslide, volcanic eruption, soil conditions, soil erosion, soil freezing and thawing, improperly compacted soil, construction defects, roots of trees and shrubs or collapse of storm and sewer drains and rapid transit tunnels.

Sinkhole subsidence occurs in areas generally where there is less than 50 feet of overburden, or vertical distance between ground surface and the mineral seam. This is commonly associated with abandoned mining activities because current mining regulations ensure that there is sufficient overburden to reduce the likelihood of subsidence. Sinkholes occur from the collapse of the mine roof into a mine opening, resulting in caving of the overlying strata and an abrupt depression in the ground surface (i.e. when the roof of an underground mine collapses, it causes the ground above to sink or subside). This type of subsidence is typically localized, affecting a small area on the overlying surface. However, structures and surface features affected by subsidence can experience extensive and costly damages. Subsidence troughs can occur over active or abandoned mines. Trough subsidence induced by room-and-pillar mining occurs when the overburden sags downward due to the failure of the remnant pillars or by punching of the pillars into a soft mine floor or roof (PA DEP 2018)

This section provides a profile and vulnerability assessment of subsidence related to mining activities. Subsidence is defined as the movement of the ground surface as a result of readjustments of the overburden due to collapse or failure of underground mine workings. Areas underlain by coal or other minerals (e.g., salt) may become susceptible to subsidence. Mine subsidence features usually take the form of either sinkholes or troughs. (PA DEP 2018)

#### Extent

Damages from mine subsidence are generally classified as cosmetic, functional, or structural. Cosmetic damage refers to slight problems where only the physical appearance of a structure is affected. Functional damage refers to when the structure's use has been impacted. More significant damages that impact structural integrity is classified as structural damage. This includes situations where entire foundations need replacement due to severe cracking of supporting walls and footings (PA DEP 2018)

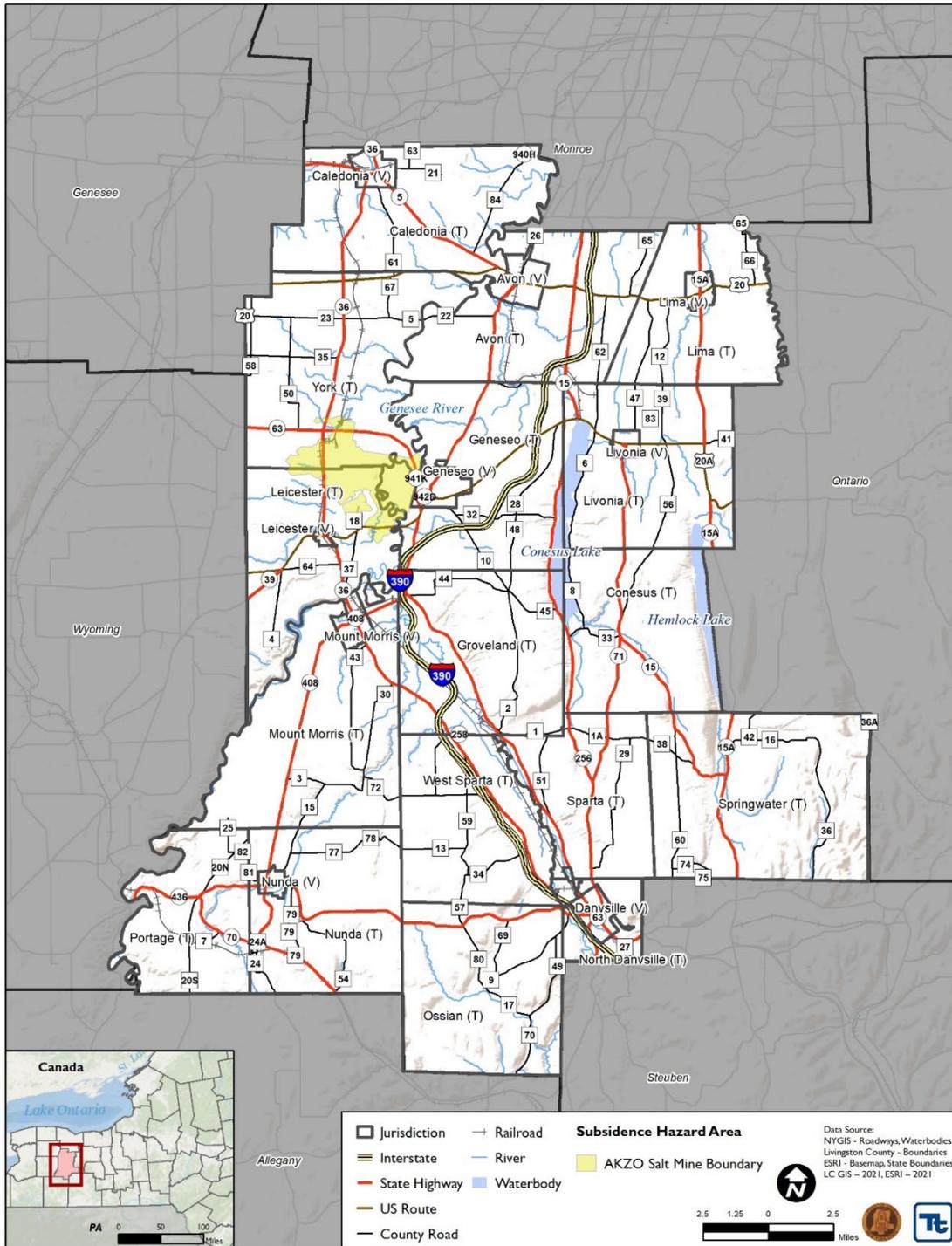
No two subsidence areas are exactly alike. Variations in size and shape, time period under which they occur (i.e. gradually or abruptly), and their proximity to development ultimately determines the magnitude of damage incurred. Events could result in minor elevation changes or deep, gaping holes in the ground surface. Subsidence events can cause severe damage in urban environments, although gradual events can be addressed before significant damage occurs. Primarily, problems related to subsidence include the disruption of utility services and damages to private and public property including buildings, roads, and underground infrastructure.



Location

The area of concern for this hazard in Livingston County is limited to the area above the Retsof Salt Mine. The mine is located in teh Town of Leicester, though the mine extends underground into the Towns of Geneseo and York, as shown in Figure 5.4.7-1.

Figure 5.4.7-1. Mine subsidence in Livingston County





### Previous Occurrences and Losses

There have been no federally declared disasters for mine subsidence in New York State. According to the New York State Geological Survey (NYSGS), historical records, including scientific study data for land subsidence in the state, is either sparse, not readily available, or does not exist in summary form. There may have been incidents of mine subsidence causing damage, but these incidents have not been reported (NYS DHSES 2013).

Four mine collapse incidents were recorded between 1905 and 2005, all of which occurred over the Retsof mine (Livingston County 2007). The most major collapse occurred on March 12, 1994. Following this collapse, the subsidence of the area above the mine forced the closure of NYS Route 20A. The collapse cost \$200 million for construction of a new mine, geological work, and reparations to landowners (Livingston County 2007). No injuries or fatalities were reported during this collapse. However, there were two fatalities and one person injured in an incident in 1990, when a large slab fell from the roof of the mine.

### Probability of Future Occurrences

Based on there having been four mine collapse incidents since 1993, and that the subsidence experienced in the county in that time has been due to mine collapse incidents, there is an estimated probability of the mine subsidence hazard impacting the county in the future of approximately 10 percent.

In Section 5.3, the identified hazards of concern for Livingston County were ranked. The probability of occurrence, or likelihood of the event, is one parameter used for ranking hazards. Based on historical records and input from the Planning Committee, the probability of occurrence for mine subsidence, in that it is caused by the collapse of the underlying Retsof Mine, is considered “occasional” (between 10 and 100-percent annual probability of a hazard event occurring, as presented in Table 5.3-1) for the areas over the mine, but “unlikely” (a hazard event is not likely to occur or is unlikely to occur with less than a 1-percent annual chance probability) for the county as a whole.

### Climate Change Impacts

A direct impact of climate change on mine subsidence is difficult to determine. Multiple secondary effects of climate change have the potential to increase the likelihood of subsidence events. Warming temperatures resulting in wildfires would reduce vegetative cover along the Retsof Salt Mine and destabilize the soils due to destruction of the root system. Changes in precipitation may alter the soil structure in the salt mine project area, making soils more susceptible to ground failure. Under these future conditions, the county’s assets located on or around the Retsof Salt Mine will have an increased risk to mine subsidence. 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.

## 5.4.7.2 Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed and vulnerable in the identified hazard area. The analysis used the Retsof Salt Mine boundary to document the historic subsidence hazard area to estimate future risk to the county’s assets. Refer to Section 5.1 (Methodology and Tools) for additional details on the methodology used to assess the salt mine subsidence hazard area.

### Impact on Life, Health and Safety

Generally, a subsidence event is an isolated incidence and impacts the populations within the immediate area. In addition to causing damages to residential buildings and displacing residents, subsidence events can block off or damage major roadways and inhibit travel for emergency responders or populations trying to evacuate the area.



According to the 2019 ACS annual estimate, Livingston County has a population of 63,591 people. The Town of York has the greatest population at risk of events caused by mine subsidence (653 people) and the greatest percentage of population located in the mine subsidence hazard area (i.e., 19.9-percent of the total population). Additionally, Table 5.4.7-5. shows that an estimated 18 residents and 103 residents live on the mine subsidence hazard area in the Town of Geneseo and Town of Leicester, respectively.

**Table 5.4.7-1. Total Number of Persons Located in the Retsof Salt Mine Subsidence Hazard Area**

Jurisdiction	Total Population (American Community Survey 2015-2019)	Estimated Population Located in the Subsidence Hazard Area	
		Number of Persons Located in the Salt Mine Subsidence Hazard Area	Percent of Total
Avon (T)	3,637	0	0.0%
Avon (V)	3,260	0	0.0%
Caledonia (T)	2,060	0	0.0%
Caledonia (V)	2,078	0	0.0%
Conesus (T)	2,325	0	0.0%
Dansville (V)	4,586	0	0.0%
Geneseo (T)	2,540	18	0.7%
Geneseo (V)	8,095	0	0.0%
Groveland (T)	3,241	0	0.0%
Leicester (T)	1,798	103	5.7%
Leicester (V)	518	0	0.0%
Lima (T)	1,833	0	0.0%
Lima (V)	2,278	0	0.0%
Livonia (T)	6,231	0	0.0%
Livonia (V)	1,353	0	0.0%
Mount Morris (T)	1,340	0	0.0%
Mount Morris (V)	2,931	0	0.0%
North Dansville (T)	696	0	0.0%
Nunda (T)	1,716	0	0.0%
Nunda (V)	1,211	0	0.0%
Ossian (T)	701	0	0.0%
Portage (T)	837	0	0.0%
Sparta (T)	1,591	0	0.0%
Springwater (T)	2,233	0	0.0%
West Sparta (T)	1,229	0	0.0%
York (T)	3,273	653	19.9%
<b>Livingston County (Total)</b>	<b>63,591</b>	<b>774</b>	<b>1.2%</b>

Source: American Community Survey 2019; Livingston County 2021

Notes: T - Town; V - Village; % - percent

### Impact on General Building Stock

Structures built near or on salt mining locations, such as the Retsof Salt Mine in Livingston County, will inevitably experience an increase in mine subsidence risk. Historically, USGS has identified that salt mines will increase surface and underground impacts of subsidence, especially for poorly managed operations which result in ground failure (USGS 1983). Overall, there are 493 buildings located in the Retsof Salt Mine project area at risk to subsidence impacts. This is equivalent to approximately \$384.5 million of replacement cost value. Refer to Table 5.4.7-6 which summarizes the number of structures within the mine subsidence hazard area by jurisdiction.



**Table 5.4.7-2. Total Number of Buildings and Replacement Cost Value Located in the Mine Subsidence Hazard Area**

Jurisdiction	Total Number of Buildings	Total Replacement Cost Value (RCV)	Estimated Building Stock Located in the Mine Subsidence Hazard Area			
			Number of Buildings Located in the Salt Mine Subsidence Hazard Area	Percent of Total	Total Replacement Cost Value of Buildings Located in the Salt Mine Subsidence Hazard Area	Percent of Total
Avon (T)	2,149	\$1,324,846,766	0	0.0%	\$0	0.0%
Avon (V)	1,245	\$1,365,771,007	0	0.0%	\$0	0.0%
Caledonia (T)	1,362	\$792,755,652	0	0.0%	\$0	0.0%
Caledonia (V)	979	\$735,609,120	0	0.0%	\$0	0.0%
Conesus (T)	1,774	\$625,005,723	0	0.0%	\$0	0.0%
Dansville (V)	1,950	\$1,341,807,175	0	0.0%	\$0	0.0%
Geneseo (T)	1,753	\$1,161,720,041	34	1.9%	\$52,219,306	4.5%
Geneseo (V)	1,329	\$1,570,704,963	0	0.0%	\$0	0.0%
Groveland (T)	1,330	\$1,203,662,583	0	0.0%	\$0	0.0%
Leicester (T)	1,214	\$715,987,145	87	7.2%	\$73,465,467	10.3%
Leicester (V)	240	\$142,879,953	0	0.0%	\$0	0.0%
Lima (T)	1,436	\$859,636,929	0	0.0%	\$0	0.0%
Lima (V)	777	\$452,768,112	0	0.0%	\$0	0.0%
Livonia (T)	3,888	\$1,866,897,181	0	0.0%	\$0	0.0%
Livonia (V)	569	\$371,319,429	0	0.0%	\$0	0.0%
Mount Morris (T)	1,115	\$646,574,328	0	0.0%	\$0	0.0%
Mount Morris (V)	1,337	\$785,505,655	0	0.0%	\$0	0.0%
North Dansville (T)	607	\$497,159,183	0	0.0%	\$0	0.0%
Nunda (T)	1,354	\$544,934,442	0	0.0%	\$0	0.0%
Nunda (V)	641	\$392,488,596	0	0.0%	\$0	0.0%
Ossian (T)	817	\$488,703,931	0	0.0%	\$0	0.0%
Portage (T)	620	\$338,465,763	0	0.0%	\$0	0.0%
Sparta (T)	1,151	\$449,674,840	0	0.0%	\$0	0.0%
Springwater (T)	1,822	\$702,256,303	0	0.0%	\$0	0.0%
West Sparta (T)	1,010	\$423,213,015	0	0.0%	\$0	0.0%
York (T)	2,183	\$1,677,949,006	372	17.0%	\$258,803,835	15.4%
<b>Livingston County (Total)</b>	<b>34,652</b>	<b>\$21,478,296,842</b>	<b>493</b>	<b>1.4%</b>	<b>\$384,488,608</b>	<b>1.8%</b>

Source: Livingston County 2021; RS Means 2021

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

### Impact on Critical Facilities and Lifelines

Approximately two percent of the critical facilities in Livingston County are located in the mine subsidence hazard area. All 17 facilities located in the mine subsidence hazard area are considered lifelines for the county.





The majority of lifelines located in the mine subsidence hazard area provide safety and security services to the county. Table 5.4.7-7 and Table 5.4.7-8 summarize the number of critical facilities and lifelines per jurisdiction and the total number of lifelines categorized by FEMA lifeline category located in the salt mine subsidence hazard area, respectively. Appendix F summarizes the distribution of critical facilities by critical facility type and jurisdiction located in the mine subsidence hazard area.

**Table 5.4.7-3. Number of Critical Facilities and Lifelines Located in the Mine Subsidence Hazard Area**

Jurisdiction	Total Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Located in the Salt Mine Subsidence Hazard Area			
			Critical Facilities	Percent of Total Critical Facilities	Lifelines	Percent of Total Lifelines
Avon (T)	51	46	0	0.0%	0	0.0%
Avon (V)	36	27	0	0.0%	0	0.0%
Caledonia (T)	19	16	0	0.0%	0	0.0%
Caledonia (V)	28	25	0	0.0%	0	0.0%
Conesus (T)	26	26	0	0.0%	0	0.0%
Dansville (V)	46	37	0	0.0%	0	0.0%
Geneseo (T)	48	45	5	10.4%	5	11.1%
Geneseo (V)	46	39	0	0.0%	0	0.0%
Groveland (T)	63	59	0	0.0%	0	0.0%
Leicester (T)	26	26	1	3.8%	1	3.8%
Leicester (V)	13	13	0	0.0%	0	0.0%
Lima (T)	16	14	0	0.0%	0	0.0%
Lima (V)	21	19	0	0.0%	0	0.0%
Livonia (T)	70	65	0	0.0%	0	0.0%
Livonia (V)	16	12	0	0.0%	0	0.0%
Mount Morris (T)	30	29	0	0.0%	0	0.0%
Mount Morris (V)	28	24	0	0.0%	0	0.0%
North Dansville (T)	35	31	0	0.0%	0	0.0%
Nunda (T)	25	25	0	0.0%	0	0.0%
Nunda (V)	23	20	0	0.0%	0	0.0%
Ossian (T)	20	20	0	0.0%	0	0.0%
Portage (T)	23	22	0	0.0%	0	0.0%
Sparta (T)	18	18	0	0.0%	0	0.0%
Springwater (T)	27	26	0	0.0%	0	0.0%
West Sparta (T)	25	25	0	0.0%	0	0.0%
York (T)	58	54	11	19.0%	11	20.4%
<b>Livingston County (Total)</b>	<b>837</b>	<b>763</b>	<b>17</b>	<b>2.0%</b>	<b>17</b>	<b>2.2%</b>

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

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

**Table 5.4.7-4. Number of Lifelines Categorized by FEMA Lifeline Category Located in the Mine Subsidence Hazard Area**

FEMA Lifeline Category	Number of Lifelines	Number of Lifelines Located in the Salt Mine Subsidence Hazard Area
Communications	72	1
Energy	18	2
Food, Water, Shelter	100	0
Hazardous Materials	50	3
Health and Medical	36	0
Safety and Security	269	6
Transportation	218	5
<b>Livingston County (Total)</b>	<b>763</b>	<b>17</b>

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





Critical facilities will experience similar impacts from mine subsidence as highlighted in the general building stock section. Smaller structures built on mine subsidence may be more susceptible to damages caused by the shrinking and swelling properties of mine subsidence. Furthermore, roadways built on mine subsidence that are major transportation routes leading to critical facilities or connect essential services to the community could also be affected. Roadways that become damaged from mine subsidence could create a disruption to critical services.

### Impact on the Economy

Mine subsidence may impact the economy where structures and roadways are damaged. Businesses built on the hazard area may need to shut down for repairs or move to a new, potentially less profitable, location if the building does not meet the 2012 IBC code (FEMA n.d.). As discussed earlier, mine subsidence may also cause damage to highways and roads. For pavement, differential movement of 0.4 inches with a horizontal distance of 20 feet can pose an engineering problem for fast travel (FEMA 1997). Infrastructure damage is costly and can impact the local and regional economy.

### Impact on the Environment

The impacts of mine subsidence on the environment is not well known and has not been extensively described. Mine subsidence could lead to cracks in the ground, impacting rooted plants. Salt mining subsidence could also impact the chemistry of groundwater supplies. Furthermore, the instability of salt mine soil may not be the most ideal habitat for species in the County.

### Cascading Impacts to Other Hazards

Mine subsidence can cause utility failure. Underground connections to utilities within or near the mining project area could be at risk to disconnection if the foundation of the utility sinks during a mine subsidence event, impacting the integrity of the utility's structural support. Furthermore, utilities may become disconnected if power lines are torn away from their supply during subsidence events. Additionally, mine subsidence may trigger landslide events in areas of steep slope. Refer to Section 5.4.12 Utility Failure and Section 5.4.6 Landslide for more information about these hazards of concern.

### Future Changes That May Impact Vulnerability

Understanding future changes that effect vulnerability in the County 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

### 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 mine subsidence hazard area could be potentially impacted by the geologic ground movement caused by historical or current salt mining activities. It is recommended that the county and jurisdictional partners implement design strategies that mitigate against the risk of future mine subsidence events around the Retsof Salt Mine. The maps in the jurisdictional annexes in Section 9 show new development locations throughout the county and their proximity to the Retsof Salt Mine.



### Projected Changes in Population

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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 closer to the Retsof Salt Mine project area. Section 4, County Profile, provides additional discussion on population trends.

### Climate Change

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The impact of climate change on the likelihood of mine subsidence occurring in the county was described above. The impact of climate change on the county’s vulnerability to mine subsidence events will be primarily affected to the potential for change in probability of mine subsidence, as opposed to mine subsidence events becoming more severe due to climate change.

### Vulnerability Change Since the 2015 HMP

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The mine subsidence hazard was not included in the 2015 HMP, though it was examined in the 2007 version of the HMP. For this HMP, the Retsof Salt Mine boundary was provided by Livingston County to assess the county’s risk to salt mine subsidence. Population statistics have also been updated using the 5-Year 2014-2019 American Community Survey Population Estimates. The general building stock was updated using RSMMeans 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 mine subsidence hazard.

Overall, this vulnerability assessment uses a more accurate and updated building inventory than that used in the 2007 HMP, which was the last version of the HMP to examine the mine subsidence hazard. This information provides more accurate exposure and potential loss estimates for Livingston County.