5.4.6 EXPANSIVE SOILS

This section provides a hazard profile and vulnerability assessment of the expansive soils hazard.

Hazard Profile

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

Description

Soils and soft rock that tend to swell or shrink due to changes in moisture content are known as expansive soils. Expansive soils are often referred to as swelling clays because clay materials are most susceptible to swelling and shrinking. Changes in soil volume present a hazard primarily to structures built on expansive soils. The most extensive damage occurs to highways and streets (FEMA 1997).

In the U.S., two major groups of rocks serve as parent materials of expansive soils and more common in the western portion of the country. The first group consists of ash, glass, and rocks of volcanic origin. The aluminum silicate minerals in these volcanic materials often decompose to form expansive clay minerals, known as montmorillonite. The second group consists of sedimentary rocks containing clay minerals, for example the shales of the semiarid west-central states (FEMA 1997).

The current New York State HMP does not profile expansive soils. However, according to the 2014 NYS HMP update, expansive soils are any soil that expands when wet and shrinks when dry. Soils are tested using an accepted standard of measurement to determine swell potential. Expansive soils can exert pressures up to 14,000 pounds per foot, causing the breakdown of building foundations and structural integrity. Roadbeds may also be affected and could lead to avalanche and collapse when cutting into mountains and hillsides (NYS DHSES 2014).

Expansive soils contain minerals, such as smectite clays, that are capable of absorbing water. As these clays absorb water, they increase in volume. The more water absorbed, the more their volume increases. Expansions of 10% or more are not uncommon. This change in volume can exert enough force on a building or other structure to cause damage. When dry, expansive soils shrink and can remove support from buildings or other structures and result in damaging subsidence. Fissures in the soil can also develop. Fissures can facilitate the deep penetration of water when moist conidtiosn or runoff occurs. This produces a cycle of shrinkage and swelling that places repetitive stress on structures (NYS DHSES 2014).

Issues associated with expansive soils include:

- Foundation cracks
- Heaving and cracking on floor slabs and walls
- Jammed doors and windows
- Ruptured pipelines
- Heaving and cracking of sidewalks and roads
- Damage to the upper floors of the building (when motion in the structure is significant) (NYS DHSES 2014)

Extent

The extent to which soil expansion is present in an area or site can be measured using the Soil Expansion Potential standard (ASTM D-4829). The expansion index (EI) provides an indication of swelling potential of a compacted soil. The EI test is not used to duplicate any particular field conditions such as soil density, water content, loading, in-place soil structure, or soil water chemistry.

Table 5.4.6-1. Soil Expansion Index

Expansion Index	Potential Expansion
0-20	Very Low
21-50	Low
51-90	Medium
91-130	High
>130	Very High

Source: ASTM 2013
Note: The Uniform Building Code (UBC) mandates that special foundation design consideration be employed if the EI is 20 or greater.

Based on the expansion potential rating, mitigation may be required for building construction or repairs. The UBC mandates that special foundation design consideration be employed if the EI is 20 or greater. The New York Residential Building Code (Section R403.1.8) addresses consideration of expansive soils. Construction dangers are reduced when engineers incorporate cement or lime or other salts into expansive soils. These help to lessen the effects of expansion. Other methods of reducing expansive soil danger include replacing the top three to four feet of expansive soil with non-expansive soils or compacting existing expansive soil.

Linear extensibility is also used to determine the shrink-swell potential of soils. The shrink-swell potential is low if the soil has a linear extensibility of less than 3 percent; moderate if 3 to 6 percent; high if 6 to 9 percent; and very high if more than 9 percent; refer to Table 5.4.6-2. If linear extensibility is more than 3, shrinking and swelling can cause damage to buildings, roads, and other structures and plant roots. As noted, special design is commonly needed; however, this data does not replace a geotechnical exploration and report used to determine expansive soil potential (USDA NRCA 2020).

Table 5.4.6-2. Linear Extensibility Ratings

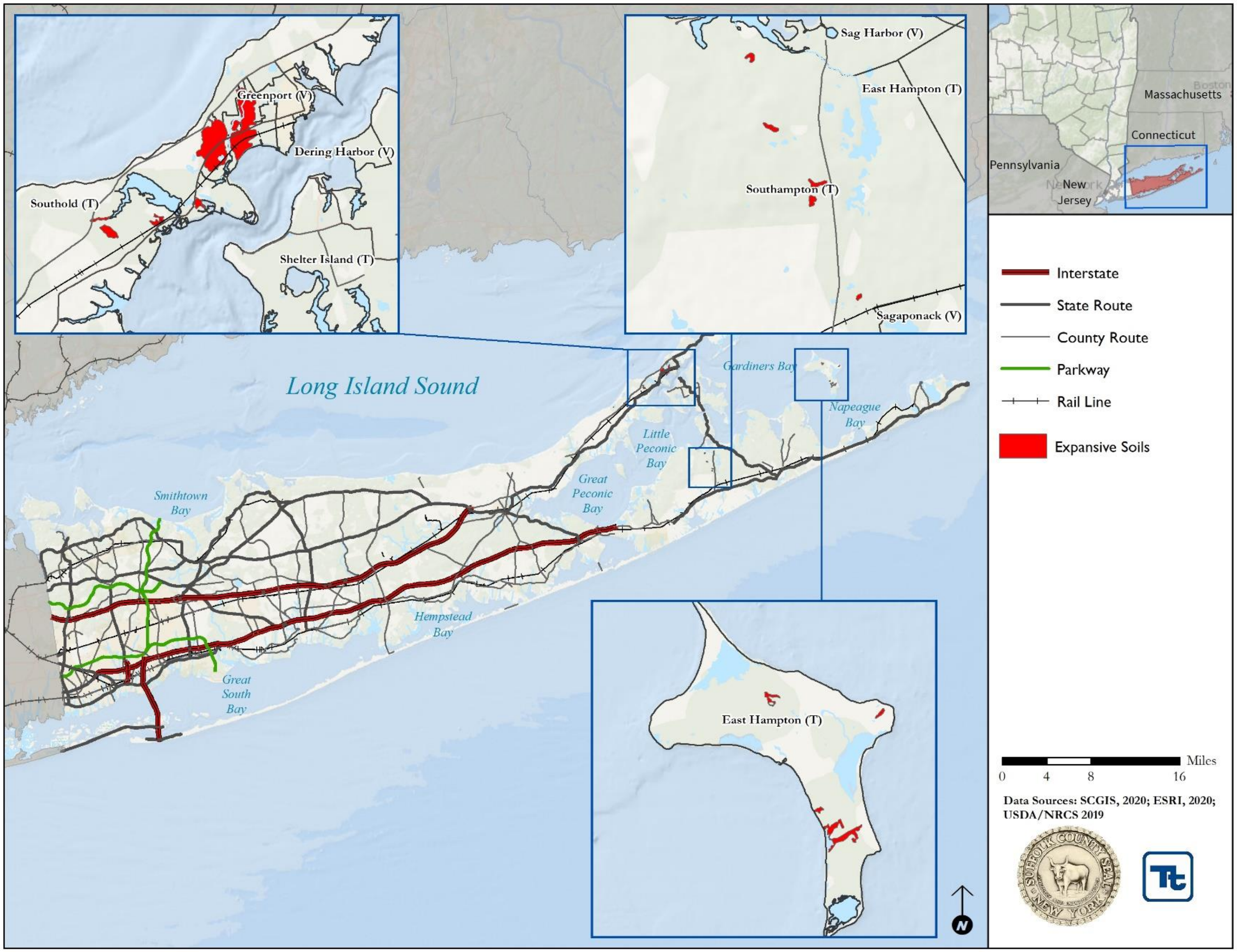
Percent Linear Extensibility	Shrink-Swell Potential
0-3	Low
3-6	Moderate
6-9	High
9-13	Very High

Source: USDA NRCA 2020

Location

A custom soil report was run for Suffolk County using USDA Natural Resources Conservation Area soils data. Canadice silt loam soils are the only soil unit in Suffolk County with linear extensibility potential with a highest rating of 4.3% which is moderate shrink-swell potential. Figure 5.4.6-1 illustrates the location of the linear extensibility potential in Suffolk County with the only area in the moderate category located in the Town of Southold, Village of Greenport, Town of Southampton and Town of East Hampton.

Figure 5.4.6-1. Expansive Soils in Suffolk County



Previous Occurrences and Losses

There have been no federally-declared disasters for expansive soils 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 instances of expansive soils causing damage but have not been reported (NYS DHSES 2013).

Probability of Future Occurrences

In Section 5.3, the identified hazards of concern for Suffolk 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 expansive soils in Suffolk County is considered 'occasional'.

Although no reported incidences have occurred within the County, it is anticipated that Suffolk County may experience indirect impacts from expansive soils that may affect the general building stock, local economy and may induce secondary hazards such ignite fires and cause utility failure.

Climate Change Impacts

ClimAID: the Integrated Assessment for Effective Climate Change in New York State (ClimAID) was undertaken to provide decision-makers with information on the State's vulnerability to climate change and to facilitate the development of adaptation strategies informed by both local experience and scientific knowledge (New York State Energy Research and Development Authority [NYSERDA] 2011).

Each region in New York State, as defined by ClimAID, has attributes that will be affected by climate change. Suffolk County is part of Region 4, New York City and Long Island. Some of the issues in this region, affected by climate change, include: the area contains the highest population density in the State; sea level rise and storm surge increase coastal flooding, erosion, and wetland loss; challenges for water supply and wastewater treatment; increase in heat-related deaths; illnesses related to air quality increase; and higher summer energy demand stresses the energy system (NYSERDA 2011).

In Region 4, it is estimated that temperatures will increase by 4.1ºF to 5.7ºF by the 2050s and 5.3ºF to 8.8ºF by the 2080s (baseline of 54.6 ºF, mid-range projection). Precipitation totals will increase between 4 and 11% by the 2050s and 5 to 13% by the 2080s (baseline of 49.7 inches, mid-range projection) (NYSERDA 2014). The heaviest 1% of daily rainfalls have increased by approximately 70% between 1958 and 2011 in the Northeast (Horton et al. 2015). Average annual precipitation is projected to increase in the region by four to 11-percent by the 2050s and five to 13-percent by the 2080s (New York City Panel on Climate Change [NPCC] 2015).

Table 5.4.6-3. Projected Seasonal Precipitation Change in Region 4, 2050s (% change)

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

Source: NYSERDA 2011

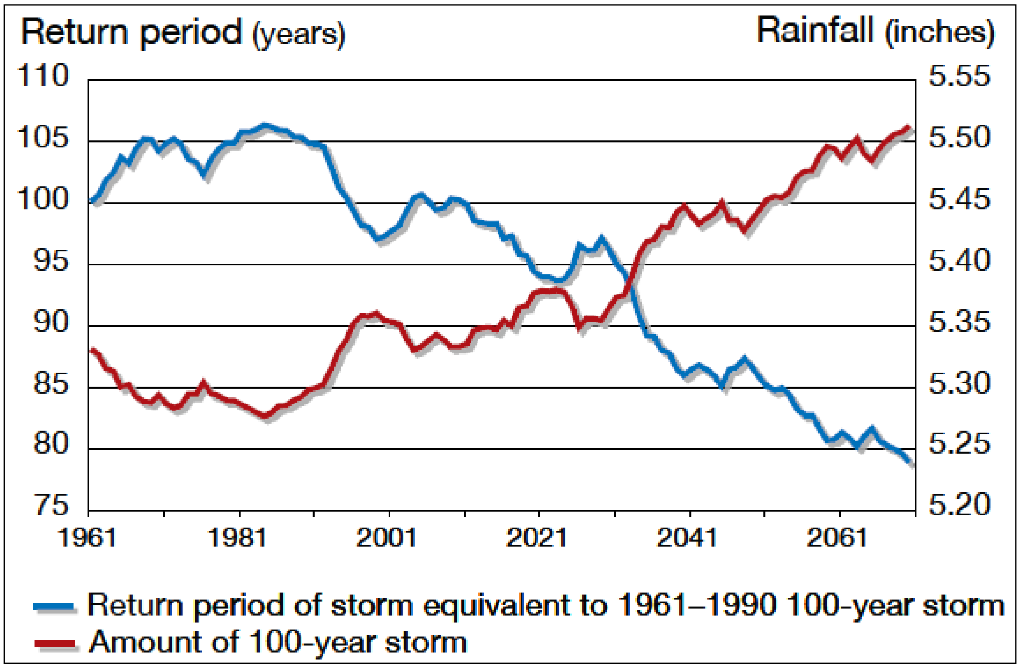
The projected increase in precipitation is expected to fall in heavy downpours and less in light rains. The increase in heavy downpours has the potential to affect drinking water; heighten the risk of riverine flooding; flood key rail lines, roadways and transportation hugs; and increase delays and hazards related to extreme weather events (NYSERDA 2011).

Increasing air temperatures intensify the water cycle by increasing evaporation and precipitation. This can cause an increase in rain totals during events with longer dry periods in between those events. These changes can have a variety of effects on the State's water resources (NYSERDA 2011).

Over the past 50 years, heavy downpours have increased and this trend is projected to continue. This can cause an increase in localized flash flooding in urban areas and hilly regions (NYSERDA 2011).

Figure 5.4.6-2 displays the project rainfall and frequency of extreme storms in New York State. The amount of rain fall in a 100-year event is projected to increase, while the number of years between such storms (return period) is projected to decrease. Rainstorms will become more severe and more frequent (NYSERDA 2011).

Figure 5.4.6-2. Projected Rainfall and Frequency of Extreme Storms



Source: NYSERDA 2011

Total precipitation amounts have slightly increased in the Northeast U.S., by approximately 3.3 inches over the last 100 years. There has also been an increase in the number of two-inch rainfall events over a 48-hour period since the 1950s (a 67-percent increase). The number and intensity of extreme precipitation events are increasing in New York State as well. More rain heightens the danger of localized flash flooding, streambank erosion and storm damage (Cornell University College of Agriculture and Life Sciences 2011).

Increased heavy precipitation events are expected in New York State due to climate change. As previously stated, as expansive soils absorb more water, they increase in volume, creating the potential to exert enough force on a building or other structure to cause damage. Temperatures are expected to increase throughout New York State. Increasing temperatures can increase the rate at which soils dry. When expansive soils are dry, they shrink and can remove support from buildings or other structures, resulting in damaging subsidence.

Vulnerability Assessment

To understand risk, a community must evaluate what assets are exposed and vulnerable in the identified hazard area. An exposure analysis was conducted in GIS for the expansive soils hazard area utilizing Canadice silt loam soils. Refer to Section 5.2 (Methodology and Tools) for additional details on the methodology used to assess expansive soil hazard area risk.

Impact on Life, Health and Safety

Based on previous occurrences and severity, impacts to life, health and safety are minimal for expansive soils. As indicated by earlier sections, Canadice soil is the sole expansive soil type in the County that has a low to moderate linear extensibility rating (approximately 3-percent). The shrink and swelling properties of this soil type is minimal compared to other expansive soils that are not present in the County.

According to the 2018 ACS annual estimate, Suffolk County had a population of 1,488,179 people. The two jurisdictions with populations at risk of events caused by expansive soils have a population of 51,008 and 20,202 total persons (i.e., Town of Southampton and Town of Southold, respectively). Please note that even though the Town of East Hampton and the Village of Greenport have expansive soils within their jurisdictional boundaries, they do not have any residential structures, thus population, exposed to the expansive soils hazard area. Table 5.4.6-4 shows that an estimated 7 residents and 92 residents live on the expansive soils hazard area in the Town of Southampton and Town of Southold, respectively.

Table 5.4.6-4. Estimated Population in the Expansive Soils Hazard Area

Jurisdiction	Total Population	Population in Expansive Soils Hazard Area	
		Number	% of Total
Southampton (T)	51,008	7	0.0%
Southold (T)	20,202	92	0.5%
Suffolk County	**1,488,179**	**99**	**0.0%**

Source: American Community Survey 2018; USDA/NRCS 2019

Impact on General Building Stock

Because of differences in building construction, residential structures and one-story commercial structures are more susceptible to damage by expansive soils compared to multi-story buildings. Multi-story buildings are heavier and can generally counter the swelling pressures. The exception is when multi-story buildings are built on wet clay, and may experience damage by shrinkage of the clay if moisture levels are substantially reduced (be evapotranspiration or by evaporation from under heated buildings) (FEMA 1997).

FEMA's Coastal Construction Manual recommends that any development along the coast should follow the 2012 IBC requirements (FEMA n.d.). The 2012 IBC requires that geotechnical investigations are conducted if expansive soils are likely to be present. Subsurface testing includes boring, creating test pits, soil sampling, and laboratory tests. If an expansive soil is present, it is recommended that development does not occur. Table 5.4.6-5 summarizes the estimated number of buildings currently built on expansive soil hazard areas. Three jurisdictions have buildings at risk of impacts; The Village of Greenport's total exposure is a total replacement cost value of approximately $6.9 million (0.5-percent of total replacement cost value), the Town of Southampton's exposure is a total replacement cost value of approximately $10.6 million (less than 1-percent of the total replacement cost value), and the Town of Southold's exposure is a total replacement cost value of approximately $110.8 million (0.6-percent of the total replacement cost value). Please note that even though the Town of East Hampton has expansive soils within its jurisdictional boundary, the Town does not have any buildings exposed to the expansive soils hazard area.

Table 5.4.6-5. Estimated Building Exposure to the Expansive Soils Hazard Areas

Jurisdiction	Total # Buildings	Total Replacement Cost Value (RCV)	Total (All Occupancies)			
			# Buildings	Percent (%) Total	RCV	Percent (%) Total
Greenport (V)	982	$1,316,147,268	6	0.6%	$6,902,415	0.5%
Southampton (T)	33,290	$69,558,169,929	4	0.0%	$10,647,600	0.0%
Southold (T)	15,123	$17,842,698,534	74	0.5%	$110,830,502	0.6%
Suffolk County	**533,279**	**$861,988,782,069**	**84**	**0.0%**	**$128,380,518**	**0.0%**

Source: Suffolk County GIS 2020; RS Means 2019; Microsoft, 2018, Open Street Map, 2019; USDA/NRCS 2019
Notes: RCV = Total replacement cost value (structure and contents)

Impact on Critical Facilities

Less than 1-percent of the critical facilities in Suffolk County are considered exposed to the expansive soils hazard area. Of the 10,486 critical facilities in the County, seven are located on expansive soils. Six of these critical facilities are classified as community lifelines with the majority located in the Town of Southold. Table 5.4.6-6 summarizes the number of critical facilities by type per jurisdiction in Suffolk County located on expansive soil hazard areas. Table 5.4.6-7 summarizes the number of critical facilities exposed to the expansive soil hazard area by FEMA's lifeline categories.

Table 5.4.6-6. Critical Facilities Located on Expansive Soils

Jurisdiction	Total Critical Facilities Located in Jurisdiction	Total Lifelines Located in Jurisdiction	Number of Critical Facilities and Lifeline Facilities Exposed to Expansive Soils Hazard Area			
			Critical Facilities	Percent (%) of Total Critical Facilities	Lifelines	Percent (%) of Total Lifelines
Greenport (V)	31	20	2	6.5%	2	10.0%
Southold (T)	269	230	4	1.5%	4	1.7%
Suffolk County Total	**10,220**	**8,117**	**6**	**0.1%**	**6**	**0.1%**

Source: Suffolk County GIS 2020; USDA/NRCS 2019
Notes: CF = Critical Facility; T = Town; V = Village

Table 5.4.6-7. Number of Lifelines Located on Expansive Soils

Lifeline Categories	Total Lifelines in the County	Expansive Soils Exposure
Communication	126	0
Energy	397	3
Food, Water, Shelter	1,458	1
Health and Medical	1,081	1
Safety and Security	1,956	0
Transportation	3,099	1
Total	**8,117**	**6**

Source: Suffolk County GIS 2020; FEMA 2020; USDA/NRCS 2019

Critical facilities will experience similar impacts from expansive soils as highlighted in the general building stock section. Smaller structures built on expansive soils may be more susceptible to damages caused by the shrinking and swelling properties of expansive soils. Furthermore, roadways built on expansive soils 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 expansive soils could create a disruption to critical services. There are 0.83 miles of major evacuation routes exposed to the expansive soil hazard area out of a total of 614.7 miles of evacuation routes in the County. Majority of the roadway is within the Village of Greenport.

Impact on the Economy

Expansive soils 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, expansive soils may also cause damage to highways and roads. Damages result from differential vertical movement that occurs as clay moisture content adjusts to the changed environment. 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

As discussed in earlier sections, expansive soils shrink and swell based on available water content. Absorbing available water could reduce water availability for surrounding ecosystems. Shrinking soils from a lack of water could create cracks in the ground, impacted rooted plants. The instability of this soil type may not be the most ideal habitat for species in the County.

Cascading Impacts to Other Hazards

There are no known cascading impacts expansive soils cause to other hazards of concern for the County.

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. Any areas of growth in the three jurisdictions where expansive soils exist (i.e., Village of Greenport, Town of Southampton, Town of Southold) could be potentially impacted by this hazard.

Projected Development

As discussed in Section 4, areas targeted for future growth and development have been identified across Suffolk County. The County areas targeted for potential future growth and development in the next five (5) years have been identified across the County at the municipal level. There are approximately 49 new development projects identified for the County (refer to Figure 5.4.6-3). There are no new development projects exposed to the expansive soil hazard areas. Refer to the jurisdictional annexes in Volume II of this HMP for more information about the planned new development.

New development projects within the County will be advised to follow the 2012 IBC requirements (FEMA n.d.). The 2012 IBC requires that geotechnical investigations are conducted if expansive soils are likely to be present. Subsurface testing includes boring, creating test pits, soil sampling, and laboratory tests. If an expansive soil is present, it is recommended that development does not occur.

Projected Changes in Population

According to the Suffolk County Department of Economic Development and Planning's February 2017 Annual Report update, the population of the County is growing. The report indicates that slow population growth is expected to continue in the future (Suffolk County 2017). The Village of Greenport and Town of Southampton have proposed expansions for a life-care community and several housing units, retail space, and professional services, respectively. More housing units in the jurisdictions most vulnerable to expansive soil impacts suggests that a greater number of persons will be at risk of being exposed to expansive soil hazard areas.

Climate Change

As discussed above, most studies project that the State of New York will see an increase in average annual temperatures. Additionally, the State is projected to experience more frequent droughts which may affect the availability of water supplies, primarily placing an increased stress on the population and their available potable water. A decrease in water supply, or increase in water supply demand, may increase the County's vulnerability to expansive soil impacts. Critical water-related service sectors may need to adjust management practices and actively manage resources to accommodate for future changes.

Vulnerability Change Since the 2014 HMP

When examining the change in the County's vulnerability to expansive soils impacts from the 2014 HMP to this update, it is important to look at each entity that is exposed and vulnerable. Updated population data was referenced to determine the number of persons at risk of expansive soil impacts compared to 2010 census data used in the 2014 HMP (i.e., ACS 2018 5-Year Estimates). Furthermore, updated building stock and critical facility inventory data was supplied by the County to assess the change in impacted structures. The most significant change is that a quantitative analysis was complete for the County using soils data from USGS/NRCS.

Figure 5.4.6-3. New Development and Expansive Soils in Suffolk County