4. Risk Assessment

4.1. Update Process Summary

A key component to reducing future loss is to first have a clear understanding of what the current risks are and what steps may be taken to lessen their threat. The development of the risk assessment is a critical first step in the entire mitigation process, as it is an organized and coordinated way of assessing potential hazards and risks. The risk assessment identifies the effects of both natural and human-caused hazards and describes each hazard in terms of its frequency, severity, and county impact. Numerous hazards were identified as part of the process.

A risk assessment evaluates threats associated with a specific hazard and is defined by probability and frequency of occurrence, magnitude, severity, exposure, and consequences. The Tioga County risk assessment provides in-depth knowledge of the hazards and vulnerabilities that affect Tioga County and its municipalities. This document uses an all-hazards approach when evaluating the hazards that affect the county and the associated risks and impacts each hazard presents.

This risk assessment provides the basic information necessary to develop effective hazard mitigation/prevention strategies. Moreover, this document provides the foundation for the Tioga County Emergency Operations Plan (EOP), local EOPs and other public and private emergency management plans.

The Tioga County risk assessment is not a static document, but rather, is a biennial review requiring periodic updates. Potential future hazards include changing technology, new facilities and infrastructure, dynamic development patterns and demographic and socioeconomic changes into or out of hazard areas. By contrast, old hazards, such as brownfields and landfills, may pose new threats as county conditions evolve.

Using the best information available and geographic information systems (GIS) technologies, the county can objectively analyze its hazards and vulnerabilities. Assessing past events is limited by the number of occurrences, scope and changing circumstances. For example, ever-changing development patterns in Pennsylvania have a dynamic impact on traffic patterns, population density and distribution, storm water runoff and other related factors. Therefore, limiting the risk assessment to past events is myopic and inadequate.

The Tioga County Local Planning Team reviewed and assessed the change in risk for all natural and human-caused hazards identified in the 2017 hazard mitigation plan. The mitigation planning team then identified hazards that were outlined within the Pennsylvania Hazard Mitigation Plan but not included in the 2017 Tioga County Hazard Mitigation Plan that could impact Tioga County. The team utilized the hazard identification and risk evaluation worksheet that was provided by the Pennsylvania Emergency Management Agency.

The Tioga County Steering Committee met with municipalities and provided guidance on how to complete the municipal hazard identification and risk evaluation worksheet. Thirty-seven municipalities in Tioga County, including Mansfield University, returned a completed worksheet. This information was combined with the county information to develop an overall list of hazards that would need to be profiled.

Once the natural and human-caused hazards were identified and profiled, the local planning team then completed a vulnerability assessment for each hazard. An inventory of vulnerable assets was completed utilizing GIS data and local planning team knowledge. The team used the most recent Tioga County assessment data to estimate loss to particular hazards. Risk factor was then assessed to each of the twenty-one hazards utilizing the hazard prioritization matrix. This assessment allows the county and its municipalities to focus on and prioritize local mitigation efforts on areas that are most likely to be damaged or require early response to a hazard event.

4.2. Hazard Identification

4.2.1. Presidential and Gubernatorial Disaster Declarations

Table X – Presidential & Gubernatorial Disaster Declaration contains a list of all Presidential and Gubernatorial disaster declarations that have affected Tioga County and it's municipalities from 1955 through 2021, according to the Pennsylvania Emergency Management Agency.

Table X - Presidential & Gubernatorial Disaster Declarations

Presidential Disaster Declarations and Gubernatorial Declarations and Proclamations		
Date	**Hazard Event**	**Action**
September, 1955	Drought	Gubernatorial Declaration
January, 1966	Heavy snow	Gubernatorial Declaration
February, 1972	Heavy snow	Gubernatorial Declaration
June, 1972	Flood (Agnes)	Presidential Disaster Declaration
February, 1974	Truckers' strike	Gubernatorial Declaration
September, 1975	Severe storms, heavy rains, flooding	Presidential Disaster Declaration
January, 1978	Heavy snow	Gubernatorial Declaration
February, 1978	Blizzard	Gubernatorial Declaration
March, 1993	Blizzard	Presidential Emergency Declaration
January, 1994	Severe winter storms	Presidential Disaster Declaration
September, 1995	Drought	Gubernatorial Declaration
January, 1996	Severe winter storms	Presidential Disaster Declaration
January, 1996	Flooding	Presidential Disaster Declaration
July, 1999	Drought	Gubernatorial Declaration
September, 1999	Hurricane Floyd	Presidential Disaster Declaration

Date	Hazard Event	Action
December, 1999	Drought	Gubernatorial Declaration
September, 2003	Hurricane Isabel/Henri	Presidential Disaster Declaration
September, 2004	Tropical Depression Ivan	Presidential Disaster Declaration
September, 2005	Hurricane Katrina	Gubernatorial Proclamation of Emergency
September, 2006	Tropical depression Ernesto	Gubernatorial Proclamation of Emergency
February, 2007	Severe winter storm	Gubernatorial Proclamation of Emergency
February, 2007	Waive the regulations regarding hours-of-service limitations for drivers of commercial vehicles	Gubernatorial Proclamation of Emergency
April, 2007	Severe storm	Gubernatorial Declaration
April, 2007	Severe winter storm	Gubernatorial Proclamation of Emergency
February, 2010	severe winter storm	Gubernatorial Proclamation of Emergency
October, 2010	Hurricane Sandy	Presidential Emergency Declaration
January, 2011	Severe winter storm	Gubernatorial Proclamation of Emergency
September, 2011	Severe storms and flooding (Lee/Irene)	Gubernatorial Proclamation of Emergency
April, 2012	Spring, winter storms	Gubernatorial Proclamation of Emergency
October, 2012	Hurricane Sandy	Gubernatorial Proclamation of Emergency
June, 2013	High winds, thunderstorms, heavy rain, tornado, flooding	Gubernatorial Proclamation of Emergency
January, 2014	Extended prolonged cold	Gubernatorial Proclamation of Emergency
January, 2014	Driver hours waived due to prolonged and continued severe winter weather	Gubernatorial Proclamation of Emergency
February, 2014	Severe winter weather	Gubernatorial Proclamation of Emergency
February, 2014	Severe winter storm	Presidential Proclamation of Emergency

Date	Hazard Event	Action
March, 2017	Severe winter storm	County and Municipal Declarations
July, 2017	Flash flooding	County and Municipal Declarations
January, 2018	Opioid crisis	Gubernatorial Proclamation of Emergency
March, 2020	COVID-19	Presidential Disaster Declaration
Source: Pennsylvania Emergency Management Agency and Federal Emergency Management Agency		

4.2.2. Summary of Hazards

The Tioga County Local Planning Team (LPT) was provided the Pennsylvania Standard List of Hazards to be considered for evaluation in the 2022 HMP Update. Following a review of the hazards considered in the 2017 HMP and the standard list of hazards, the local planning team decided that the 2022 plan should identify, profile, and analyze twenty-one profiled hazards. These twenty-one hazards include all of the hazards profiled in the 2017 plan. The list below contains the twenty-one hazards that have the potential to impact Tioga County as identified through previous risk assessments, the Tioga County Hazard Vulnerability Analysis and input from those who participated in the 2022 HMP update. Hazard profiles are included in Section 4.3 for each of these hazards.

Identified Natural Hazards

Drought

Drought is defined as a deficiency of precipitation experienced over an extended period of time, usually a season or more. Droughts increase the risk of other hazards, like wildfires, flash floods, and landslides or debris flows. This hazard is of particular concern in Pennsylvania due to the prevalence of farming and other water-dependent industries, water dependent recreation uses, and residents who depend on wells for drinking water.

Earthquake

An earthquake is the motion or trembling of the ground produced by sudden displacement of rock usually within the upper 10 to 20 miles of the Earth's crust. Earthquakes result from crustal strain, volcanism, landslides, or the collapse of underground caverns. Earthquakes can affect hundreds of thousands of square miles, cause damage to property measured in the tens of billions of dollars, result in loss of life and injury to hundreds of thousands of people and disrupt the social and economic functioning of the affected area. Most property damage and earthquake-related deaths are caused by the failure and collapse of structures due to ground shaking which is dependent upon amplitude and duration of the earthquake. (FEMA, 1997).

Extreme Temperature

Extreme heat often results in the highest number of annual deaths of all weather-related hazards. In most of the United States, extreme heat is defined as a long period (2 to 3 days) of high heat and humidity with temperatures above 90 degrees. Extremely cold air comes every winter in at least part of the country and affects millions of people across the United States. The arctic air, together with brisk winds, can lead to dangerously cold wind chill values. People exposed to extreme cold are susceptible to frostbite and hypothermia in a matter of minutes.

Flooding, Flash Flooding and Ice Jam Flooding

Flooding is the temporary condition of partial or complete inundation of normally dry land, and it is the most frequent and costly of all-natural hazards in Pennsylvania. Flash flooding is usually a result of heavy localized precipitation falling in a short time period over a given location, often along mountain streams and in urban areas where much of the ground is covered by impervious surfaces. Winter flooding can include ice jams which occur when warm temperatures and heavy rain cause snow to melt rapidly. Snow melt combined with heavy rains can cause frozen rivers to swell, which breaks the ice layer on top of a river. The ice layer often breaks into large chunks, which float downstream, piling up in narrow passages and near other obstructions such as bridges and dams.

Invasive Species

An invasive species is a species that is not indigenous to the ecosystem under consideration and whose introduction causes or is likely to cause economic, environmental, or human harm. These species can be any type of organism: plant, fish, invertebrate, mammal, bird, disease, or pathogen.

Landslide

In a landslide, masses of rock, earth or debris move down a slope. Landslides can be caused by a variety of factors, including earthquakes, storms, fire, and human modification of land. Areas that are prone to landslide hazards include previous landslide areas, areas on or at the base of slopes, areas in or at the base of drainage hollows, developed hillsides with leach field septic systems, and areas recently burned by forest or brush fires.

Pandemic, Epidemic and Infectious Diseases

A pandemic is a global outbreak of disease that occurs when a new virus emerges in the human population, spreading easily in a sustained manner, and causing serious illness. An epidemic describes a smaller scale infectious outbreak, within a region or population, that emerges at a disproportionate rate. Infectious disease outbreaks may be widely dispersed geographically, impact large numbers of the population, and could arrive in waves lasting several months at a time.

Solar Flare

According to the European Space Agency (ESA), solar flares are "a tremendous explosion on the Sun that happens when energy stored in 'twisted' magnetic fields (usually above sunspots) is suddenly released. In a matter of just a few minutes they heat material to many million degrees and produce a burst of radiation across the electromagnetic spectrum, including from radio waves to x-rays and gamma rays." Solar flares affect the ionosphere with magnetic energy disrupting satellites, communication equipment, and radio navigation.

Subsidence, Sinkhole

Subsidence is a natural geologic process that commonly occurs in areas with underlying limestone bedrock and other rock types that are soluble in water. Water passing through naturally occurring fractures dissolves these materials leaving underground voids. Eventually, overburden on top of the voids causes a collapse which can damage structures with low strain tolerances. This collapse can take place slowly over time or quickly in a single event. Karst topography describes a landscape that contains characteristic structures such as sinkholes, linear depressions, and caves. In addition to natural processes, human activity such as water, natural gas, and oil extraction can cause subsidence and sinkhole formations. (FEMA, 1997). Sinkholes can also be caused by abandoned mined land.

Tornadoes, Windstorm

A tornado is a narrow, violently rotating column of air that extends from the base of a thunderstorm to the ground. About 1,250 tornadoes hit the U.S. each year, with about sixteen hitting Pennsylvania. Damaging winds exceeding 50-60 miles per hour can occur during tornadoes, severe thunderstorms, winter storms, or coastal storms. These winds can have severe impacts on buildings, pulling off the roof covering, roof deck, or wall siding and pushing or pulling off the windows.

Wildfire

A wildfire is an unplanned fire that burns in a natural area. Wildfires can cause injuries or death and can ruin homes in their path. Wildfires can be caused by humans or lightning, and can happen anytime, though the risk increases in periods of little rain. In Pennsylvania, 98% of wildfires are caused by people.

Winter Storm

A winter storm is a storm in which the main types of precipitation are snow, sleet, or freezing rain. A winter storm can range from a moderate snowfall or ice event over a period of a few hours to blizzard conditions with wind-driven snow that lasts for several days. Most deaths from winter storms are not directly related to the storm itself, but result from traffic accidents on icy roads, medical emergencies while shoveling snow, or hypothermia from prolonged exposure to cold.

Identified Human Caused Hazards

Civil Disturbance/Criminal Activity

A civil disturbance is defined by FEMA as a civil unrest activity (such as a demonstration, riot, or strike) that disrupts a community and requires intervention to maintain public safety. Criminal activity is an act committed in violation of law that can lead to imprisonment.

Dam Failure

Dam failure is the uncontrolled release of water (and any associated wastes) from a dam. This hazard often results from a combination of natural and human causes, and can follow other hazards such as hurricanes, earthquakes, and landslides. The consequences of dam failures can include property and environmental damage and loss of life.

Emergency Services

Emergency medical services (EMS) and fire department services play a crucial role in the emergency response system, and the functionality of these emergency services directly impacts many of the other hazard profiles in this report. Both EMS and fire services face challenges from lack of funding and lower rates of volunteerism.

Environmental Hazards

Environmental hazards are hazards that pose threats to the natural environment, the built environment and public safety through the diffusion of harmful substances, materials, or products. Environmental hazards include the following:

- Hazardous material releases: at fixed facilities or as such materials are in transit and including toxic chemicals, infectious substances, biohazardous waste and any materials that are explosive, corrosive, flammable, or radioactive (PL 1990-165, § 207(e)).
- Air or Water Pollution; the release of harmful chemical and waste materials into water bodies or the atmosphere, for example (National Institute of Health Sciences, July 2009; Environmental Protection Agency, Natural Disaster PSAs, 2009).
- Superfund Facilities: hazards originating from abandoned hazardous waste sites listed on the National Priorities List (Environmental Protection Agency, National Priorities List, 2009).
- Manure Spills: involving the release of stored or transported agricultural waste, for example (Environmental Protection Agency, Environmental Impacts of…, 1998).
- Product Defect or Contamination; highly flammable or otherwise unsafe consumer products and dangerous foods (Consumer Product Safety Commission, 2003).

Opioid Epidemic

The opioid epidemic is the rapid increase in the use of prescription and non-prescription opioid drugs in the United States beginning in the late 1990s and continuing throughout the first two decades of the 2000s. Opioids are a diverse class of moderately strong painkillers, including oxycodone, hydrocodone, and a very strong painkiller, fentanyl, which is synthesized to resemble other opiates such as opium-derived morphine and heroin. The potency and availability of these substances, de-spite their high risk of addiction and overdose, have made them popular both as for-mal medical treatments and as recreation-al drugs. Due to their sedative effects on the part of the brain which regulates breathing, opioids in high doses present the potential for respiratory depression and may cause respiratory failure and death.

The Commonwealth of Pennsylvania, along with other states in the nation has enact-ed legislation to curb the prescription and distribution of these drugs to try to prevent addiction rising from abuse as a painkiller. This includes but is not limited to restrictions to prescribing to minors, quantity limits, a prescription database with entry requirements and other limits to its availability.

Terrorism/Cyber Attack

Terrorism is use of force or violence against persons or property with the intent to intimidate or coerce. Acts of terrorism include threats of terrorism; assassinations; kidnappings; hijackings; bomb scares and bombings; cyber-attacks (computer-based); and the use of chemical, biological, nuclear, and radiological weapons. Cyber-attacks have become an increasingly pressing concern. Cyber-attack refers to acts of terrorism committed using computers, networks, and the internet. The most widely cited definition comes from Denning's Testimony before the Special Oversight Panel on Terrorism: "Cyber-attack/cyber terrorism…is generally understood to mean unlawful attacks and threats of attack against computers, networks, and the information stored therein when done to intimidate or coerce a government or its people in furtherance of political or social objectives. Further, to qualify as cyberterrorism/cyber-attack, an attack should result in violence against persons or property, or at least cause enough harm to generate fear".

Transportation Accidents and Transportation of Hazardous Materials

Transportation accidents are technological hazards involving the nation's system of land, sea, and air transportation infrastructure. A flaw or breakdown in any component of this system can and often does result in a major disaster involving loss of life, injuries, property and environmental damage, and economic consequences.

The Department of Homeland Security defines a hazardous materials release as "The improper leak, spillage, discharge, or disposal of hazardous materials or substances (such as explosives, toxic chemicals, and radioactive materials) poses a significant threat to human health and safety, campus property, and the surrounding environment."

Utility Interruption

Utility interruption hazards are hazards that impair the functioning of important utilities in the energy, telecommunications and public works and information network sectors. Utility interruption hazards include the following:

- Geomagnetic Storms; including temporary disturbances of the Earth's magnetic field resulting in disruptions of communication, navigation, and satellite systems (National Research Council et al., 1986).
- Fuel or Resource Shortage; resulting from supply chain breaks or secondary to other hazard events, for example.
- Electromagnetic Pulse; originating from an explosion or fluctuating magnetic field and causing damaging current surges in electrical and electronic systems (Institute for Telecommunications Sciences, 1996).
- Information Technology Failure; due to software bugs, viruses, or improper use (Rainer Jr., et al, 1991).
- Ancillary Support Equipment; electrical generating, transmission, system-control, and distribution-system equipment for the energy industry (Hirst & Kirby, 1996).
- Public Works Failure; damage to or failure of highways, flood control systems, deep-water ports and harbors, public buildings, bridges, dams, for example (Unit-ed States Senate Committee on Environment and Public Works, 2009).
- Telecommunications System Failure; Damage to data transfer, communications, and processing equipment, for example (FEMA, 1997).
- Transmission Facility or Linear Utility Accident; liquefied natural gas leakages, explosions, facility problems, for example (United States Department of Energy, 2005).
- Major Energy, Power, Utility Failure; interruptions of generation and distribution, power outages, for example (United States Department of Energy, 2000).

4.2.3. Climate Change

Impacts of Climate Change on Identified Hazards

Humans have become the dominant species on Earth and our society and influence is globalized. Human activity such as the large-scale consumption of fossil fuels and de-forestation has caused atmospheric carbon dioxide concentrations to significantly increase and a notable diversity of species to go extinct. The result is rapid climate change unparalleled in Earth's history and an extinction event approaching the level of a mass extinction (Barnosky et al., 2011; Wake & Vredenburg, 2008). The corresponding rise of average atmospheric temperatures is intensifying many natural hazards, and further threatening biodiversity. The effects of climate change on these hazards are expected to intensify over time as temperatures continue to rise, so it is prudent to be aware of how climate change is impacting natural hazards.

The most obvious change is in regard to extreme temperature. As average atmospheric temperatures rise, extreme high temperatures become more threatening, with record high temperatures outnumbering record low temperatures 2:1 in recent years. As climate change intensifies, it is expected that the risk of extreme heat will be amplified whereas the risk of extreme cold will be attenuated. Some studies show increased insect activities during a similar rapid warming event in Earth's history. Other studies make projections that with the warming temperatures and lower annual precipitation that are expected with climate change, there will be an expansion of the suitable climate for mosquitos, potentially increasing the risk of disease.

Climate change is likely to increase the risk of droughts (Section 4.3.1). Higher average temperatures mean that more precipitation will fall as rain rather than snow, snow will melt earlier in the spring, and evaporation and transpiration will increase. Along with the prospect of decreased annual precipitation, the risk of hydrological and agricultural drought is expected to increase (Sheffield & Wood, 2008). Correspondingly this will impact wildfires. Drought is accompanied by drier soils and forests, resulting in an elongated wildfire season and more intense and long-burning wildfires (Pechony & Shindell, 2010). However, the Southwest United States is at a greater risk of this increased drought and wildfire activity than Tioga County in the Eastern United States.

While it may seem counterintuitive considering the increased risk of drought, there is also an increased risk of flooding associated with climate change (Section 4.3.3). As previously mentioned, warmer temperatures mean more precipitation will fall as rain rather than snow. Combined with the fact that warmer air holds more moisture, the result is heavier and more intense rainfalls, increasing the risk of flooding and dam and levee failures. Similarly, winter storms are expected to become more intense, if possibly less frequent (Section 4.3.9). Climate change is also expected to result in more intense hurricanes and tropical storms. With the rise of atmospheric temperatures, ocean surface temperatures are rising, resulting in warmer and more moist conditions where tropical storms develop (Stott et al., 2010). A warmer ocean stores more energy and is capable of fueling stronger storms. It is projected that the Atlantic hurricane season is elongating, and there will be more category 4 and 5 hurricanes than before (Trenberth, 2010).

Climate change is contributing to the introduction of new invasive species (Section 4.3.4). As maximum and minimum seasonal temperatures change, non-native species are able to establish themselves in previously inhospitable climates where they have a competitive advantage. This may shift the dominance of ecosystems in the favor of non-native species, contributing to species loss and the risk of extinction.

This type of sudden global change is novel to humanity. Despite the myriad of well thought out research, there is still much uncertainty surrounding the future of the Earth. All signs point to the intensification of the hazards mentioned above, especially if human society and individuals do not make swift and significant changes to reduce emissions and species losses.

4.3. Hazard Profiles

4.3.1. Drought

4.3.1.1 Location and Extent

While Pennsylvania is generally more water-rich than many U.S. states, the commonwealth may be subject to drought conditions. A drought is broadly defined as a time period of prolonged dryness that contributes to the depletion of ground and surface water. Droughts are regional climatic events, so when such an event occurs in Tioga County, impacts are not restricted to the county and are often more widespread. The spatial extent of the impacted area can range from localized areas in Pennsylvania to the entire Mid-Atlantic region.

There are three types of drought:

Meteorological Drought – A deficiency of moisture in the atmosphere compared to average conditions. Meteorological drought is defined by the duration of the deficit and degree of dryness and is often associated with below average rainfall. Depending on the severity of the drought, it may or may not have a significant impact on agriculture and the water supply.

Agricultural Drought – A drought inhibiting the growth of crops, due to a moisture deficiency in the soil. Agricultural drought is linked to meteorological and hydrologic drought.

Hydrologic Drought – A prolonged period without rainfall that has an adverse effect on streams, lakes, and groundwater levels, potentially impacting agriculture.

Leaving areas with little moisture, droughts are often one of the leading contributing factors to wildfires.

Droughts can have adverse effects on farms and other water-dependent industries. This can result in a local economic loss. Areas with extensive agriculture uses are particularly vulnerable to drought; 212,797 acres of Tioga County, or roughly 35% of the 725,760 total land acreage, are held in farms (United States Department of Agriculture [USDA], 2017 Census). Acreage for farming has increased by 4% since the 2012 USDA Census and 399 farm owners are new and beginning enterprisers.

Public safety is an issue in terms of consumable water not being available, as well as water for fire protection and emergency services.

4.3.1.2 Range of Magnitude

Over 60% of the annual precipitation of 37 inches is during the spring/summer. Average snowfall for the county has a wide range of between 42 and 60 inches. Rural farming areas of Tioga County are most at risk when a drought occurs. A drought can be a significant financial burden (especially on families as 97% of Tioga County farms are family-owned and run) and approximately 58% of the county farmland use is devoted to crop cultivation and 11% to livestock and poultry. (U.S. Census of Agriculture, 2017). Wildfires are often the most severe secondary effect associated with drought. Wildfires can devastate wooded and agriculture areas, threatening natural resources, structures near high wildfire loads, and farm production facilities. Prolonged drought conditions can have a lasting impact on the economy and can cause major ecological changes, such as increases in scrub growth, flash flooding and soil erosion.

Error! Not a valid bookmark self-reference. shows the FEMA-defined levels of drought severity along with suggested actions, requests, and goals. Drought can cause municipalities to enforce water rationing and distribution.

Table X - Drought Preparation Phases

Drought Preparation Phases *(PA DEP, 2017)*				
Phase	**General Activity**	**Actions**	**Request**	**Goal**
Drought Watch	Early stages of planning and alert for drought possibility	Increased water monitoring, awareness, and preparation for response among government agencies, public water suppliers, water users and the public	Voluntary water conservation	Reduce water use by 5%
Drought Warning	Coordinate a response to imminent drought conditions and potential water shortages	Reduce shortages - relieve stressed sources, develop new sources if needed	Continue voluntary water conservation, impose mandatory water use restrictions if needed	Reduce water use by 10-15%
Drought Emergency	Management of operations to regulate all available resources and respond to emergency	Support essential and high priority water uses and avoid unnecessary uses	Possible restrictions on all nonessential water uses	Reduce water use by 15%

<u>Local Water Rationing</u>: Although not a drought phase, local municipalities may, with the approval of the Pennsylvania Emergency Management Council, implement local water rationing to share a rapidly dwindling or severely depleted water supply in designated water supply service areas. These individual water rationing plans, authorized through provisions of 4 PA Code

Chapter 120, will require specific limits on individual water consumption to achieve significant reductions in use. Under both mandatory restrictions imposed by the commonwealth and local water rationing, procedures are provided for granting of variances to consider individual hardships and economic dislocations.

Long-term water shortages during severe drought conditions can have a significant impact on agribusiness, public utilities, and other industries reliant on water for production services. Tioga County also has a growing agritourism business that would be threatened by long-term drought.

The Commonwealth uses five parameters to assess drought conditions:

- Stream flows (compared to benchmark records);
- Precipitation (measured as the departure from normal, thirty-year average precipitation);
- Reservoir storage levels in a variety of locations such as three New York City reservoirs in the upper Delaware River Basin;
- Groundwater elevations in a number of counties (comparing to past month, past year and historic record); and
- Soil moisture via the Palmer Drought Index (See *Table X* – *Palmer Drought Severity* Index) - a soil moisture algorithm calibrated for relatively homogeneous regions which measures dryness based on recent precipitation and temperature.

Table X - Palmer Drought Severity Index

Palmer Drought Severity Index	
Severity Category	**PDSI**
Extremely wet	4.0 or more
Very wet	3.0 to 3.99
Moderately wet	2.0 to 2.99
Slightly wet	1.0 to 1.99
Incipient wet spell	0.5 to 0.99
Near normal	0.49 to -0.49
Incipient dry spell	-0.5 to -0.99
Mild drought	-1.0 to -1.99
Moderate drought	-2.0 to -2.99
Severe drought	-3.0 to -3.99
Extreme drought	-4.0 or less

Hydrologic drought events result in a reduction of stream flows, reduction of lake/reservoir storage, and a lowering of groundwater levels. These events have adverse impacts on public water supplies for human consumption, rural water supplies for livestock consumption and agricultural operations, water quality, natural soil water or irrigation water for agriculture, soil moisture, conditions conducive to wildfire events, and water for navigation and recreation.

The effects of a drought can be far-reaching in both the economic and environmental realms. Economic impacts include the reduced productivity of aquatic resources, mandatory water use restrictions, well failures, cutbacks in industrial production, agricultural losses, and limited recreational opportunities. Environmental impacts of drought include the following:

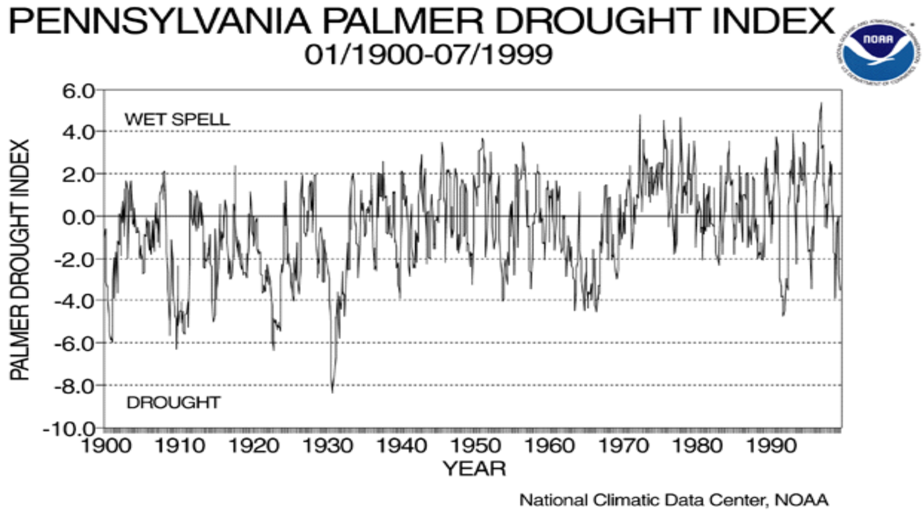
- Hydrologic effects – Lower water levels in reservoirs, lakes, and ponds; reduced stream flow; loss of wetlands; estuarine impacts; groundwater depletion and land subsidence; and effects on water quality, such as increases in salt concentration and water temperature;
- Damage to animal species – Lack of feed and drinking water; disease; loss of biodiversity, migration, or concentration; and reduction and degradation of fish and wildlife habitat;
- Damage to plant communities – Loss of biodiversity and loss of trees from urban landscapes and wooded conservation areas;
- Increased number and severity of fires;
- Reduced soil quality;
- Air quality effects – Dust and pollutants; and
- Loss of quality in landscape.

4.3.1.3 Past Occurrence

The Department of Environmental Protection (PA DEP) maintains the most comprehensive data on drought occurrences across the commonwealth. Descriptions of drought status categories (i.e., watch, warning, and emergency) are included in the "Range of Magnitude" section above. The declared drought status from 1980 to 2021 is shown in *Table X - Past Drought Events in Tioga County (PA DEP, 2020).*

The National Oceanic and Atmospheric Administration (NOAA) has archived records showing extreme droughts for the commonwealth in 1931 and a prolonged event in the 1960s; see Figure X - *Pennsylvania Palmer Drought Index 1900-1999*.

Figure x, Pennsylvania Palmer Drought Index 1900-1999



Based on the county's more recent disaster history and other drought occurrence data, the worst drought event in Tioga County occurred in the summer of 1999. Extended dry weather spurred Governor Ridge to declare a drought emergency in fifty-five counties, including Tioga. During this event, precipitation deficits for that summer averaged 5 to 7 inches; the Susquehanna River hit record low flows, streams were empty, and wells dried up. Crop damages indicated losses of over $500 million statewide, and crop losses totaled 70% to 100%. There were also additional losses from the decline of milk production due to the drought (National Climatic Data Center [NCDC], 2011). Additionally, during this event, the state asked municipal and private water suppliers to cut local water use.

Table X - Past Drought Events in Tioga County (PA DEP, 2021)

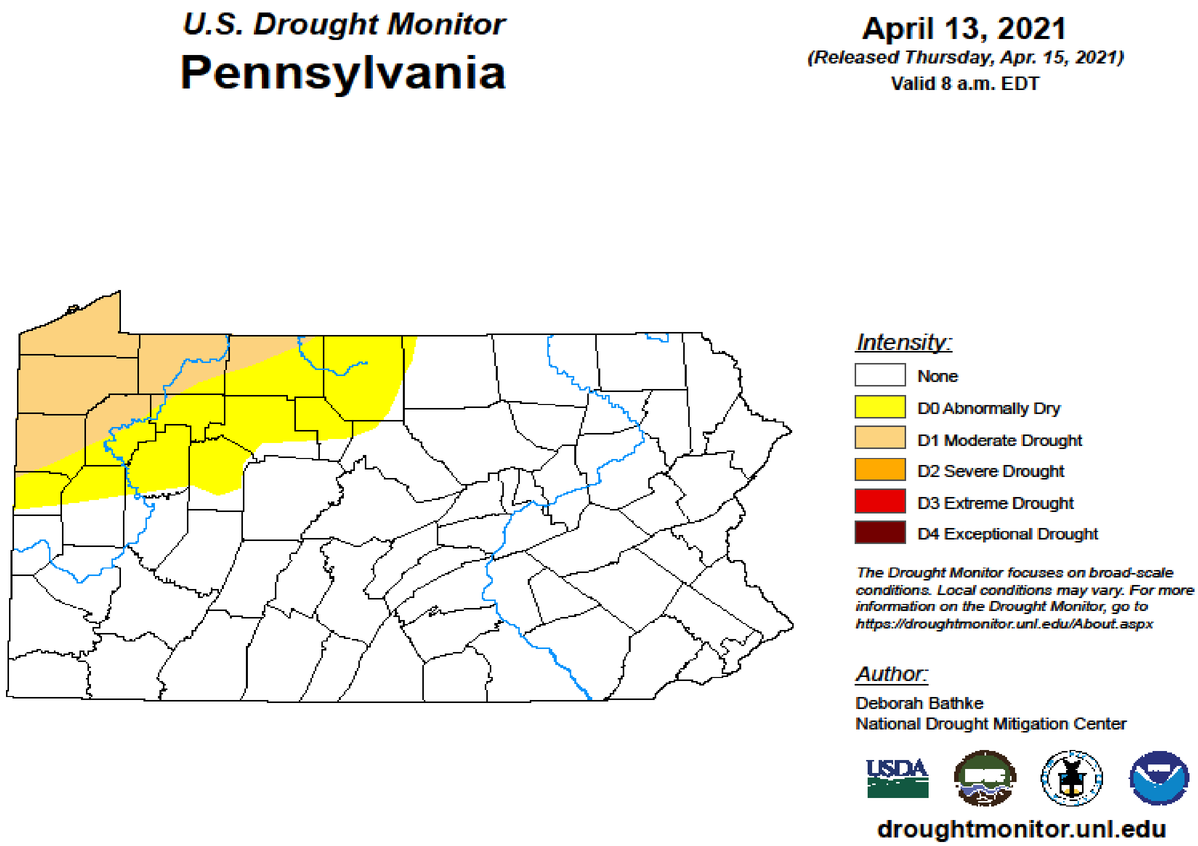
Past Drought Events in Tioga County (PA DEP, 2021)			
Start Date	**End Date**	**Drought Status**	**Event Duration**
11/18/1980	4/20/1982	Emergency	2 years 5 months 3 days
04/26/1985	12/19/1985	Watch	7 months 24 days
070/7/1988	8/24/1988	Watch	10 months 9 days
08/24/1988	12/12/1988	Warning	
12/12/1988	5/15/1989	Watch	
06/28/1991	7/24/1991	Warning	1 year 2 months 15 days
07/24/1991	4/20/1992	Emergency	
04/20/1992	6/23/1992	Warning	
06/23/1992	9/11/1992	Watch	

Start Date	End Date	Drought Status	Event Duration
09/01/1995	9/20/1995	Warning	3 months 18 days
09/20/1995	11/8/1995	Emergency**	
11/08/1995	12/18/1995	Warning	
07/17/1997	11/13/1997	Watch	3 months 28 days
12/03/1998	12/14/1998	Watch	1 year 5 months 3 days
12/14/1998	4/15/1999	Warning	
04/15/1999	6/10/1999	Watch	
6/10/1999	7/20/1999	Warning	
07/20/1999	9/30/1999	Emergency**	
09/30/1999	5/5/2000	Watch	
08/24/2001	5/13/2002	Watch	8 months 20 days
090/5/2002	11/7/2002	Watch	2 months 3 days
4/11/2006	6/30/2006	Watch	2 months 20 days
08/06/2007	9/5/2007	Watch	5 months 6 days
10/05/2007	1/11/2008	Watch	
11/07/2008	1/26/2009	Watch	2 months 20 days
9/16/2010	11/10/2010	Watch	1 month 26 days
08/05/2011	9/2/2011	Watch	29 days
04/24/2015	7/10/2015	Watch	2 months 17 days
08/10/2016	8/16/2016	Watch	3 months
08/16/2016	9/6/2016	Warning	
09/06/2016	11/9/2016	Watch	
09/10/2020	01/07/2021	Watch	3 months, 27 days
**Gubernatorial Disaster Declaration			

Pennsylvania had its warmest July on record in 2020, and 18 counties, including Tioga, entered Drought Watch status on September 10, 2020. At the writing of this plan, however, drought watches had been lifted for all commonwealth counties, but dry conditions were again creeping east across the commonwealth and had reached a small portion of the county (*Figure X, U.S Drought Monitor, Pennsylvania,* below). According to NOAA, Tioga County had its wettest

February in 2021 in 127 years, while also recording its driest year in 127 years – thus far.

Figure X – U. S. Drought Monitor, Pennsylvania



4.3.1.4 Future Occurrence

It is difficult to forecast the exact severity and frequency of future drought events and the future of climate change will lead to increased uncertainty and extremity of climate events, suggesting that it is best to be prepared for potentially adverse conditions. As Tioga County has experienced severe drought between 5% - 10% of the time between 1895 and 1995 (***Error! Reference source not found.***– a 100-year data collection), the report can be used to make a rough estimate of the future probability of drought in Tioga County, although it does not account for changes introduced by climate change. Drought conditions are expected to become more severe with climate change, as evaporation and transpiration will increase with higher temperatures (Sheffield & Wood, 2008; EPA, 2016).

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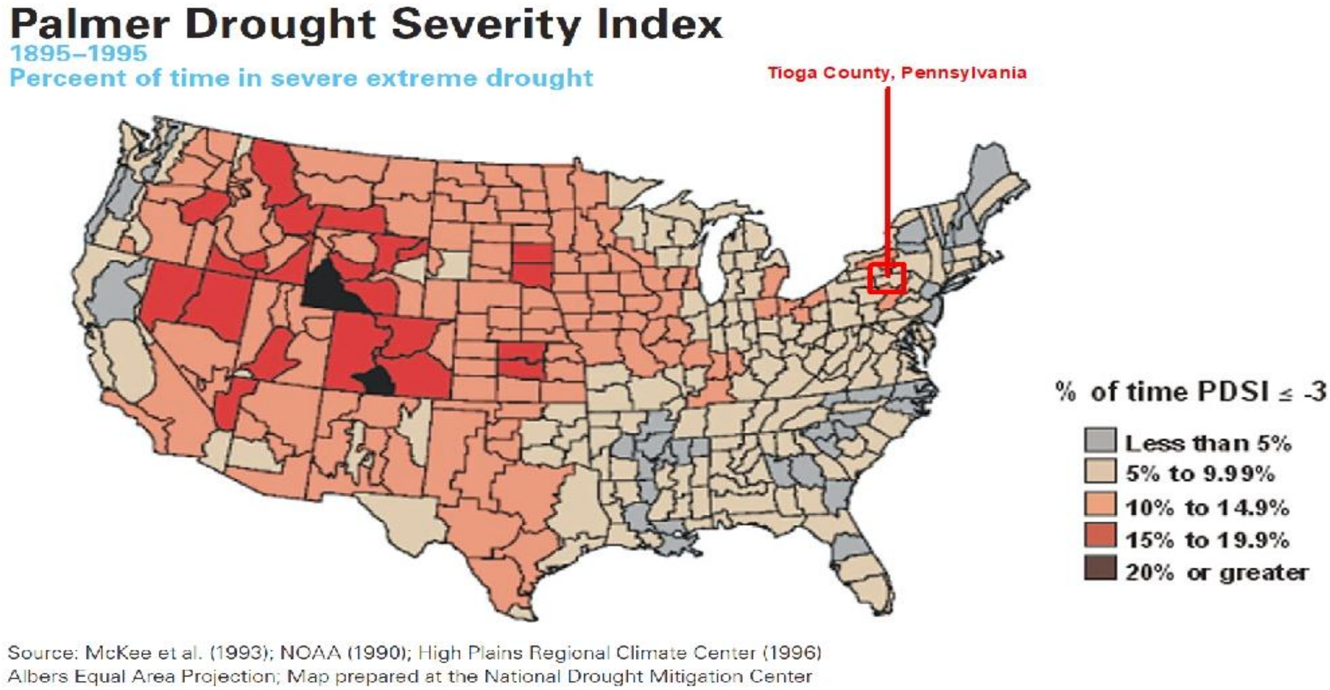
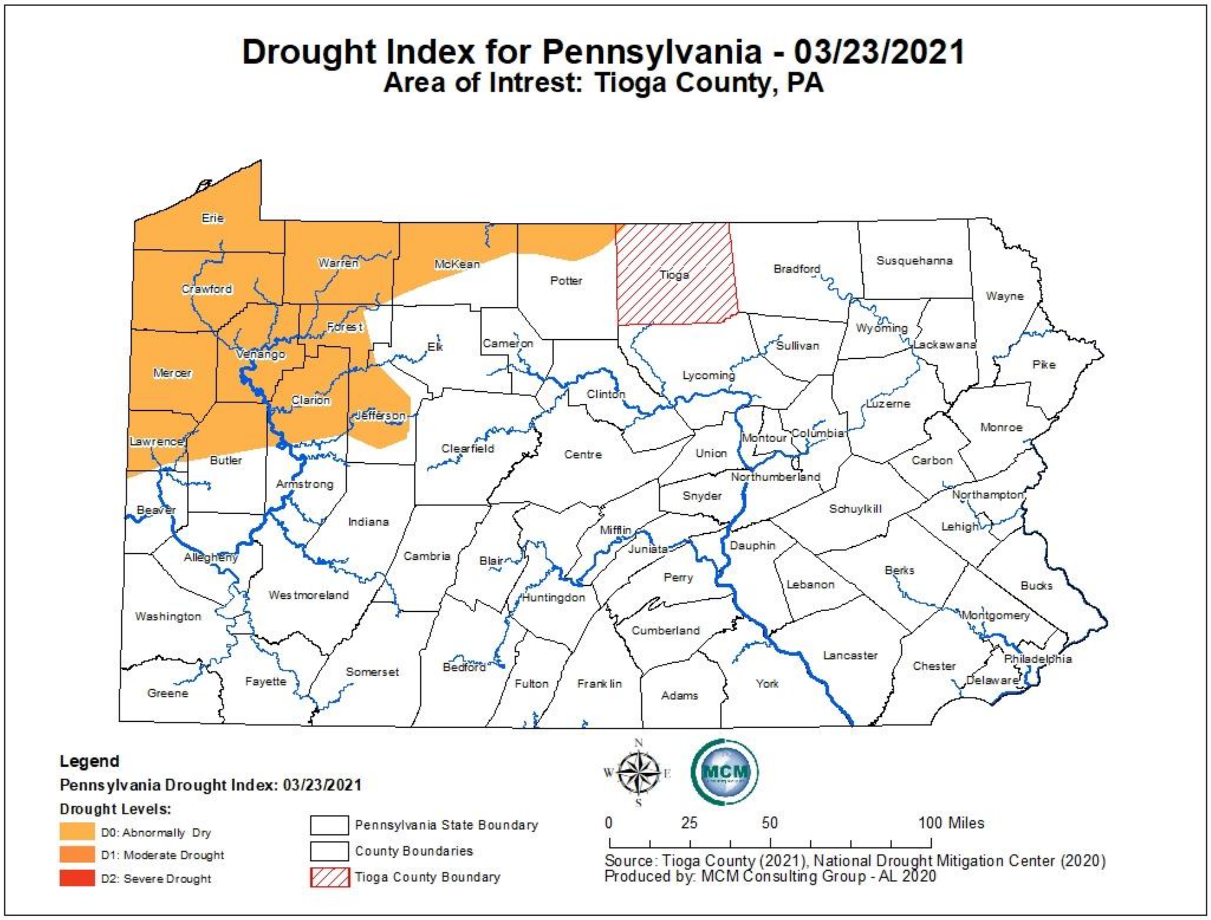


Error! Reference source not found.below shows that Tioga County is currently in normal conditions. The last of the 2020 Drought Watches was lifted in February 2021.

Figure X – Current Drought Index for Pennsylvania



The potential for a drought to occur in Tioga County is, nevertheless, high. Given the frequency of drought watches issued for Tioga County and its municipalities, the county can reasonably expect to be under a drought watch at least once per year. While some form of drought condition frequently exists in Tioga County, the impact depends on the duration of the event, severity of conditions, and area affected. The map above shows that Tioga County and most of Pennsylvania is currently in normal (non-drought) conditions.

4.3.1.5 Vulnerability Assessment

Drought vulnerability depends on the duration and area of impact. However, other factors contribute to the severity of a drought. Unseasonably high temperatures, prolonged winds, and low humidity can heighten the impact of a drought.

Extended periods of drought can lead to lowered stream levels, altering the delicate balance of riverine ecosystems. Certain tree species are susceptible to fungal infections during prolonged periods of soil moisture deficit. Fall droughts pose a particular threat because groundwater levels are typically at their lowest following the height of the summer growing season.

Wildfire is the most severe secondary effect associated with drought. Wildfires can devastate wooded and agricultural areas, threatening natural resources and farm production facilities.

Prolonged drought conditions can cause major ecological changes, such as increases in scrub growth, flash flooding, and soil erosion.

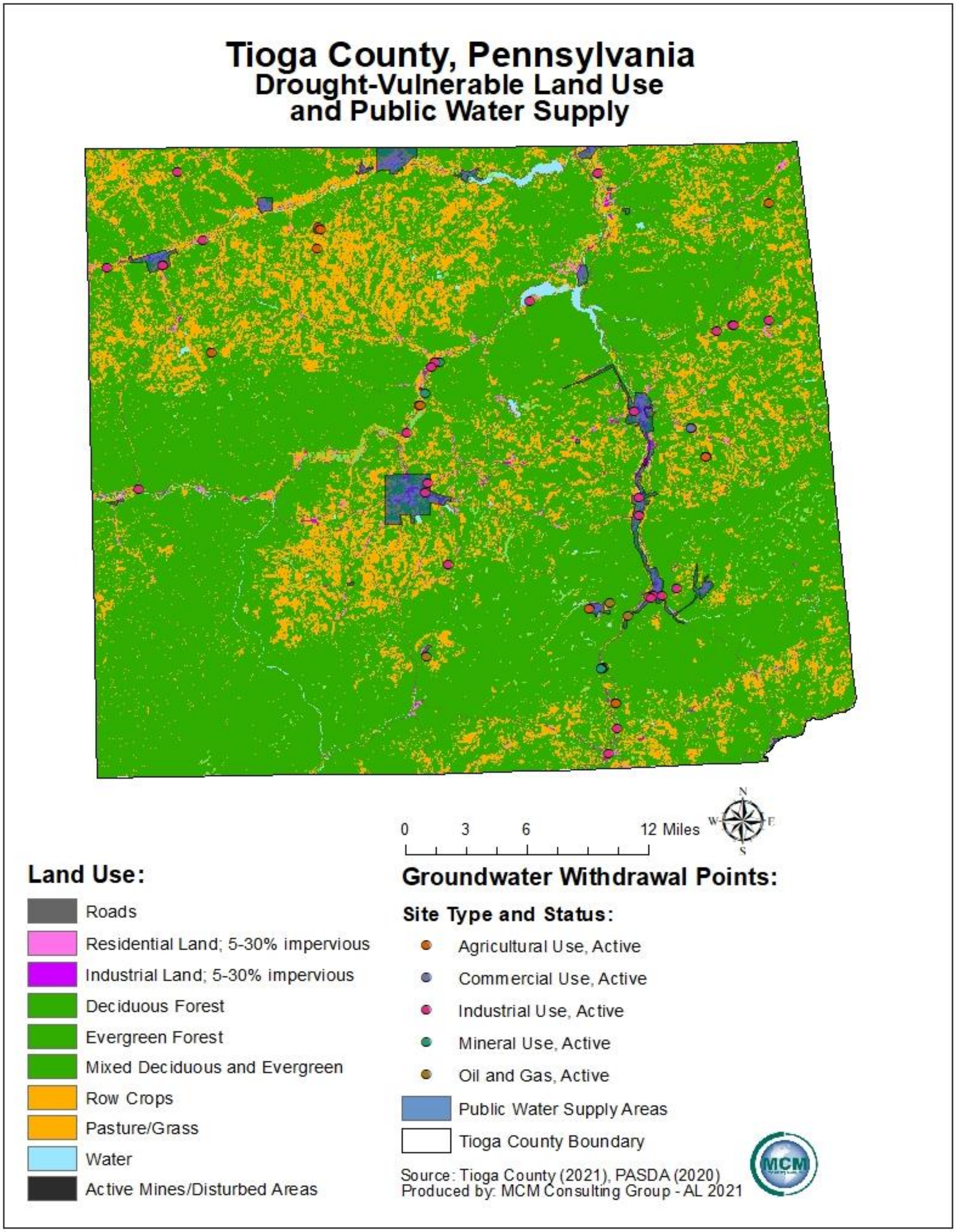
Droughts can have adverse effects on farms and other water-dependent industries. This can result in a local economic loss. The 2017 U.S. Census of Agriculture lists over 27,607 acres of prime agricultural land in Tioga County and there are multiple recreational sites across the county dependent on consistent water sources and replenishment. From a societal perspective, public safety is an issue in terms of consumable water not being available, as well as water for fire protection and emergency services.

The most significant losses resulting from drought events are typically found in the agriculture and aquaculture sectors. The 1999 Gubernatorial Proclamation was issued in large part due to significant crop damage. Preliminary estimates by the Pennsylvania Department of Agriculture indicated possible crop losses across the commonwealth in excess of $500 million. This estimate did not include a 20% decrease in dairy milk production which also resulted in million-dollar losses (NCDC, 2009).

While these were statewide impacts, they illustrate the potential for droughts to severely impair the local economy in more agricultural communities. The 2017 Census of Agriculture reports there were 1,056 farms in Tioga County, at an average size of 202 acres. Tioga County ranks 22nd of sixty-seven counties (up from the ranking of 27th reported in the 2017 hazard mitigation plan) in the commonwealth for agricultural production, totaling just over $92 million annually (USDA, 2017). Agricultural production from crops, including nursery and greenhouse crops, accounts for $26 million in commerce annually. Production from livestock, poultry, and their products accounts for $66 million annually.

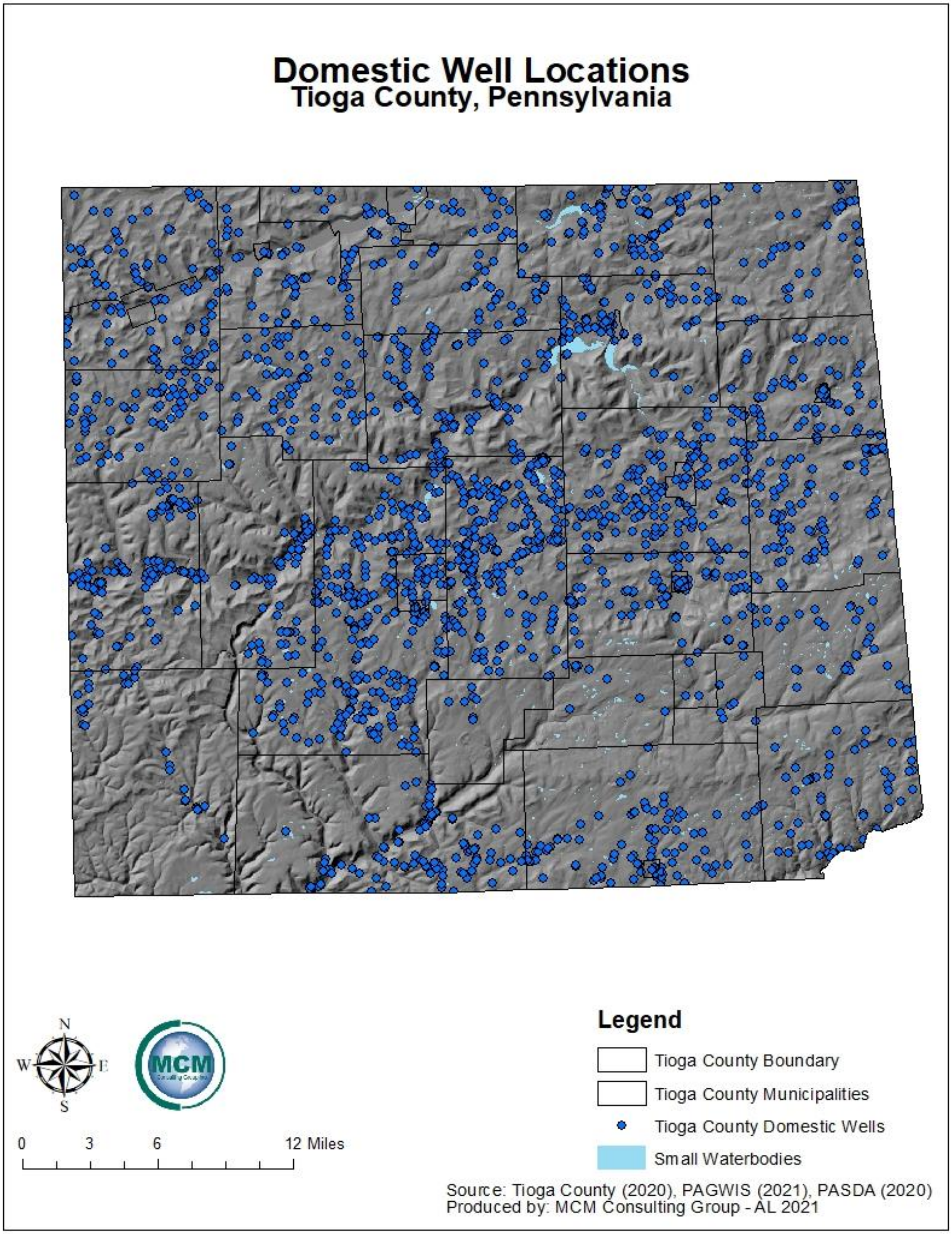
A map of properties with tillable agricultural land use, forestry, and other land in the county vulnerable to drought is shown below at *Figure X*, *Drought-Vulnerable Land Use and Public Water Supply.*

Figure X – Drought-Vulnerable Land Use and Public Water Supply



Public or municipal water supplies are also vulnerable to the effects of drought because supply sources include rivers, reservoirs, and groundwater. Public water service areas cover only some of the land area in the county, as depicted in *Figures X and X – Drought-Vulnerable Land Use and Public Water Supply* and *Domestic Well Locations - Tioga County*. The majority of the county relies on domestic wells for their fresh drinking water. Residents or water authorities that use private domestic wells are more vulnerable to droughts because their drinking water can literally dry up. There is a total of 2,412 domestic water wells in the county. It is important to note that the well data was obtained from the Pennsylvania Groundwater Information System (PaGWIS). PaGWIS relies on *voluntary submissions* of well record data by well drillers; as a result, it is not a complete database of all domestic wells in the county. This is the most complete dataset of domestic wells available.

Figure X, Domestic Well Locations – Tioga County



Through 2017, the USGS conducted many baseline water quality studies throughout Pennsylvania, but one for Tioga County had not yet been completed. In the spring of 2018, the county did submit an application for a grant to assist with completion of the study, but it was not awarded. The studies comprise a useful reference to get a general sense of the water quality and challenges associated with domestic water wells in the commonwealth.

The EPA has provided a guide published in October 2017 for water utilities to aid in drought response and recovery. The guide outlines what goes into a good drought response plan, how to manage water supply and demand during a drought, best practices for communication and partnerships with other local utilities and provides case studies to discuss examples of drought management practices (EPA, 2017). The guide may be found here:

https://www.epa.gov/sites/production/files/2017-10/documents/drought_guide_final_508compliant_october2017.pdf.

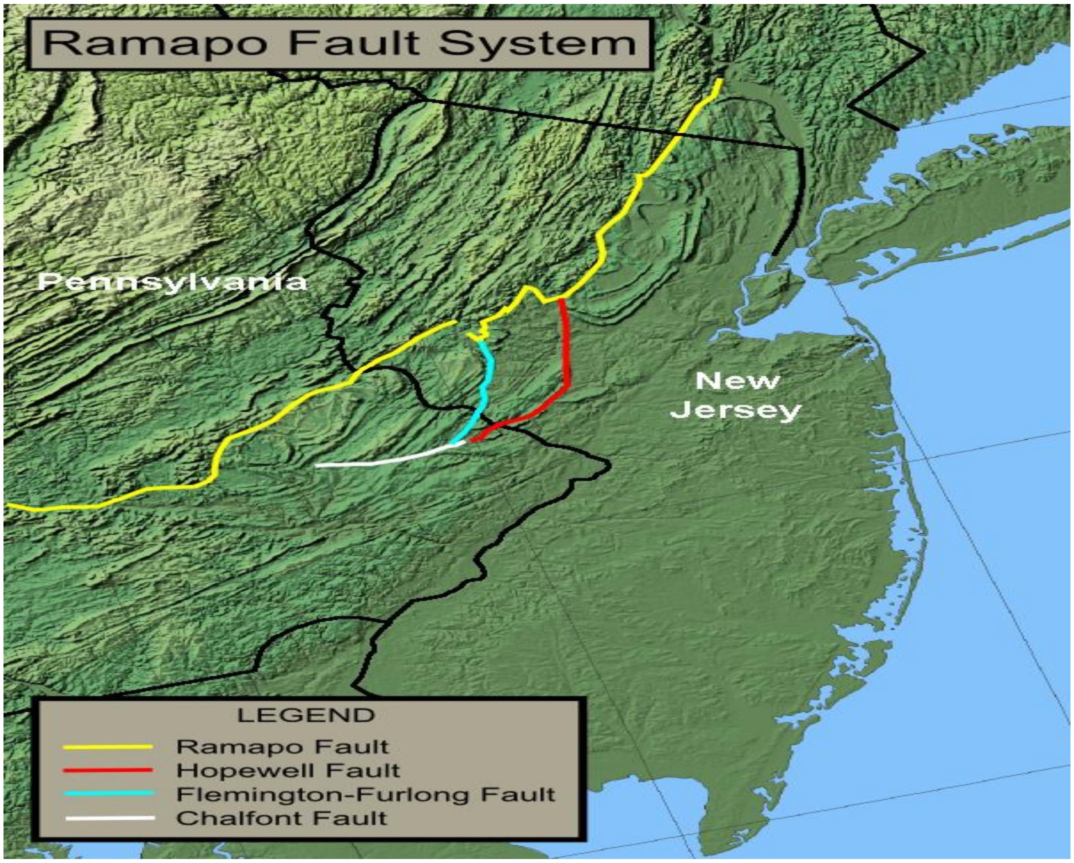
4.3.2. Earthquake

4.3.2.1 Location and Extent

An earthquake is sudden movement of the earth's surface caused by the release of stress accumulated within or along the edge off the earth's tectonic plates, a volcanic eruption, or by a human induced explosion (DCNR, 2007). Earthquake events in Pennsylvania, including Tioga County, are usually mild events, impacting areas no greater than sixty-two miles in diameter from the epicenter. A majority of earthquakes occur along boundaries between tectonic plates, and some earthquakes occur at faults on the interior of plates. Today, Eastern North America, including Tioga County, Pennsylvania, is far from the nearest plate boundary. That plate boundary is the Mid-Atlantic Ridge and is approximately 2,000 miles to the east. The Ramapo Fault System runs through New York, New Jersey, and eastern Pennsylvania (See *. Their locations in Tioga County* are plotted on a map later in this profile.

). This fault system is associated with some small earthquakes, and it is thought unlikely to produce large earthquakes.

Figure X, Ramapo Fault System



When the supercontinent of Pangaea broke apart about 200 million years ago, the Atlantic Ocean began to form. Since then, many faults have developed. Locating all of the faults would be an idealistic approach to identifying the region's earthquake hazard; however, many of the fault lines in this region have no seismicity associated with them. The best way to determine earthquake history for Tioga County is to conduct a probabilistic earthquake-hazard analysis with the earthquakes that have already happened in and around the county. ***Error! Reference source not found.*** shows that Tioga County is in a low hazard zone (3-6%) for earthquake activity according to the USGS (2014), suggesting a low probability of earthquake occurrence. However, the map shown as Figure X, *Earthquake Epicenters Within 200 Miles of Tioga County*, shows one earthquake epicenter inside the county boundary.

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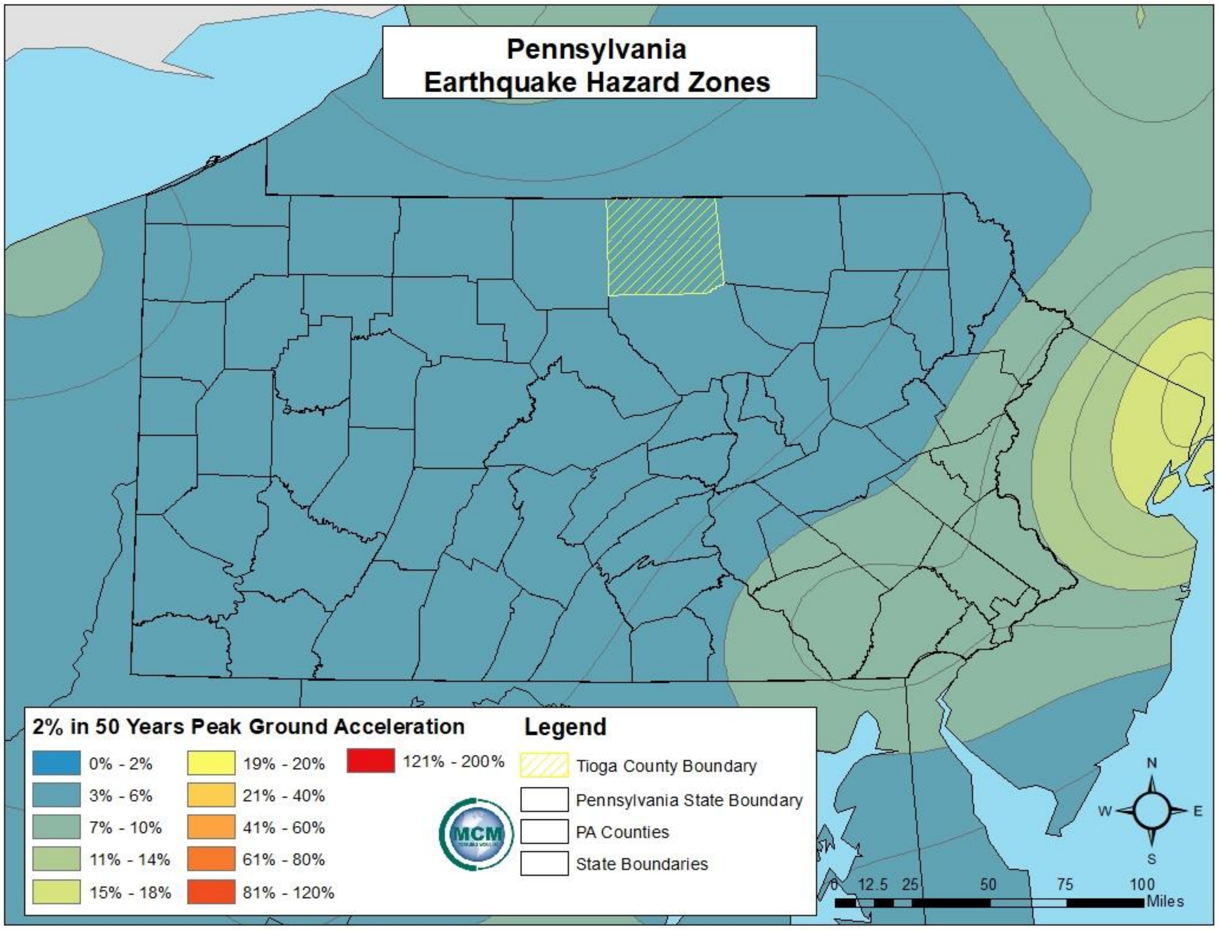
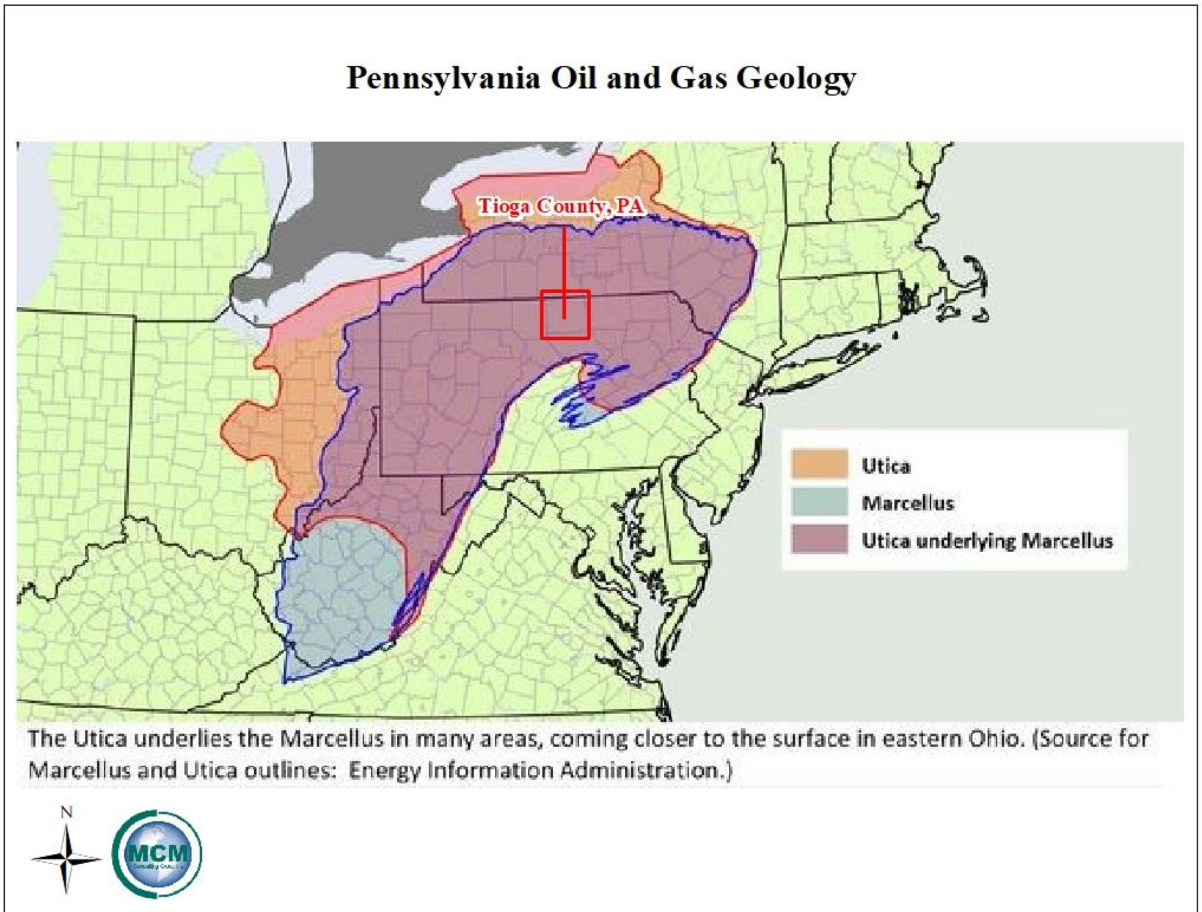


Natural gas extraction of the Marcellus/Utica Shale formation (see *Figure X, Pennsylvania Oil and Gas Geology*) has occurred in many regions of the commonwealth, including Tioga County. Hydraulic fracturing, or fracking, is used to extract the gas, and the process is thought to lead to an increase in seismic activity (Meyer, 2016).

Figure X, Pennsylvania Oil and Gas Geology



However, fracking does not appear to be linked to the increased rate of magnitude three and larger earthquakes (USGS 2014). In recent years, permits for extraction of the natural gas and oil in the commonwealth are issued for unconventional wells and have been issued by the Pennsylvania Department of Environmental Protection. Their locations in Tioga County are plotted on a map later in this profile.

4.3.2.2 Range of Magnitude

Earthquakes result in the propagation of seismic waves, which are detected using seismographs. These seismograph results are measured using the Richter Scale, an open-ended logarithmic scale that describes the energy release of an earthquake. *Table X* - *Richter Scale* summarizes Richter Scale magnitudes as they relate to the spatial extent of impacted areas. The Modified Mercalli Intensity Scale (
Table X - *Modified Mercalli Intensity* Scale) is an alternative measure of earthquake intensity that is scaled by the impacts of the earthquake event. Earthquakes have many secondary impacts, including disrupting critical facilities, transportation routes, public water supplies and other utilities.

Table X - Richter Scale

Richter Scale	
Richter Magnitude	**Earthquake Effects**
Less than 3.5	Not generally felt but recorded.
3.5-5.4	Often felt, but rarely causes damage.
Under 6.0	At most, slight damage to well-designed buildings; can cause major damage to poorly constructed buildings over small regions.
6.1-6.9	Can be destructive in areas where people live up to about 100 kilometers across.
7.0-7.9	Major earthquake; can cause serious damage over large areas.
8.0 or greater	Great earthquake; can cause serious damage in areas several hundred kilometers across.

Table X - Modified Mercalli Intensity Scale

Modified Mercalli Intensity Scale			
Scale	**Intensity**	**Earthquake Effects**	**Richter Scale Magnitude**
I	**Instrumental**	Detected only on seismographs.	<4.2
II	**Feeble**	Some people feel it.	
III	**Slight**	Felt by people resting, like a truck rumbling by.	
IV	**Moderate**	Felt by people walking.	
V	**Slightly Strong**	Sleepers awake; church bells ring.	<4.8
VI	**Strong**	Trees sway; suspended objects swing; objects fall off shelves.	<5.4
VII	**Very Strong**	Mild alarm, walls crack, plaster falls.	<6.1
VIII	**Destructive**	Moving cars uncontrollable, masonry fractures, poorly constructed buildings damaged.	<6.9
IX	**Ruinous**	Some houses collapse, ground cracks, pipes break open.	

Scale	Intensity	Earthquake Effects	Richter Scale Magnitude
X	**Disastrous**	Ground cracks profusely, many buildings destroyed, liquefaction and landslides widespread.	<7.3
XI	**Very Disastrous**	Most buildings and bridges collapse, roads, railways, pipes, and cables destroyed, general triggering of other hazards.	<8.1
XII	**Catastrophic**	Total destruction, trees fall, ground rises and falls in waves.	>8.1

4.3.2.3 Past Occurrence

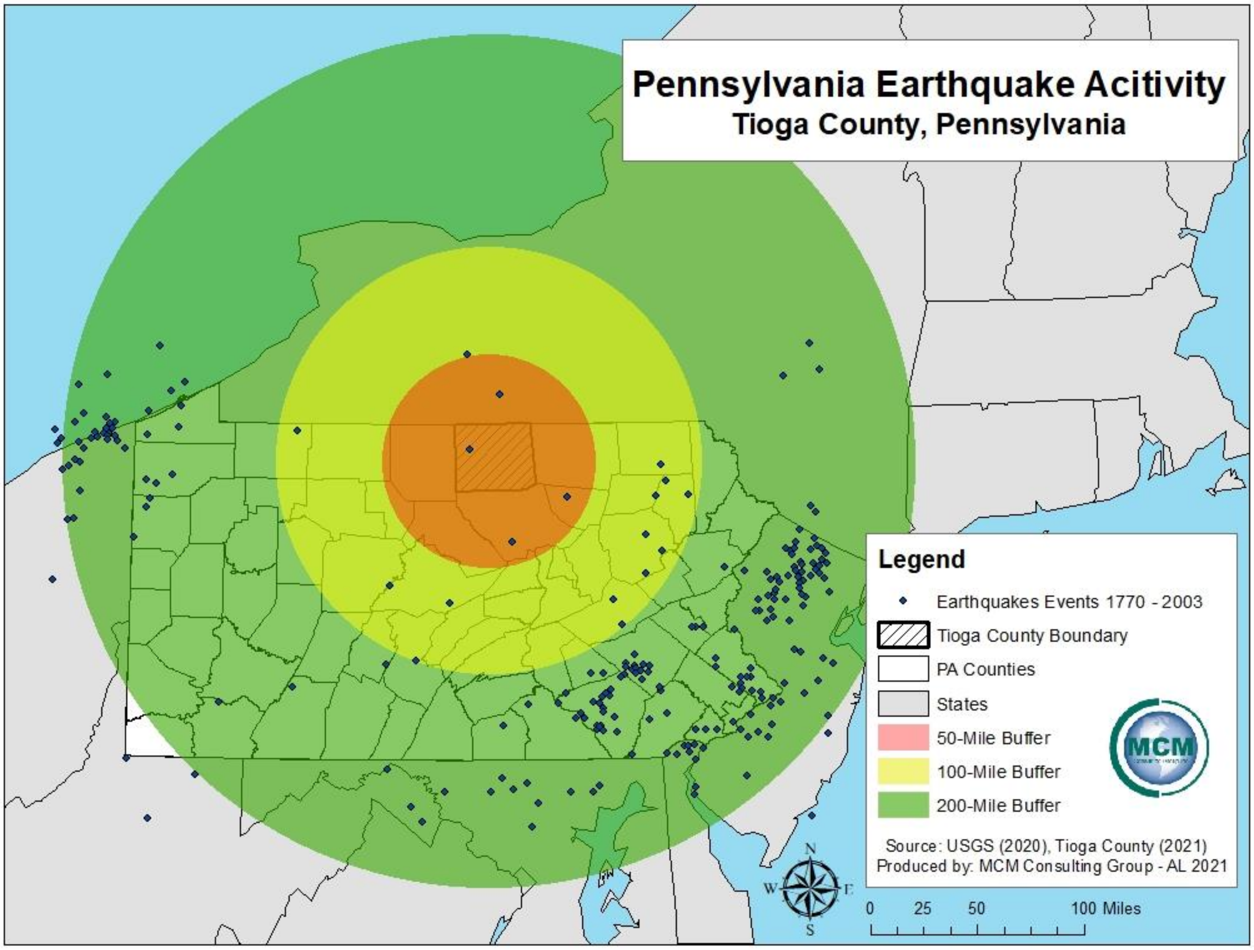
The USGS reports a 1.4 magnitude earthquake originated four miles east of Wellsboro on August 22, 2016. This earthquake caused no damage and went largely unnoticed by residents. All earthquake events that occurred within 200 miles of Tioga County between 1770 and 2003 can be seen in *Figure X, Pennsylvania Earthquake Activity*. Both *Figure X, Pennsylvania Earthquake Activity*, and the one at the following hyper-link show earthquake epicenters within close enough proximity to the county to produce some effects in the county:

http://elibrary.dcnr.pa.gov/GetDocument?docId=1751247&DocName=Map69_EQCatalog-Epicenter_Pa

In July 2019, a 2.2 earthquake occurred just west of Reading, Pennsylvania. Parts of the county experienced some of the shock waves from these minor earthquakes and others that have occurred around the region. The strongest recorded earthquake in Pennsylvania history (5.2) occurred on September 25, 1998, in northwestern Pennsylvania and is known as the Pymatuning Earthquake for its epicenter near Pymatuning Lake. The effects of the earthquake were felt across the commonwealth and were blamed for many wells in the epicentral region drying up, while new springs and old wells began to flow. A three-month date range revealed 120 dry household-supply wells on the ridge of Jamestown and Greenville, Pennsylvania. Declines of up to 100 feet were observed on a ridge where at least eighty of the wells resided. The degree of the damage varied. Some of the wells lost all power or could barely hold their yields and some of the water in wells turned black or began to smell of sulfur.

The most likely cause of the wells drying was because of the increase in hydraulic conductivity or "fracking" of shale rock under this area caused by the earthquake. The quake affected the existing faults and created new faults in the shale. This created more permeability for the water to leak down from the hilltops on the ridge down to the valleys following the contours of the Meadville shale.

Figure X - Pennsylvania Earthquake Activity (Epicenters Within 200 Miles of Tioga County)



4.3.2.4 Future Occurrence

Earthquake activity and intensities are difficult to predict, but a probabilistic analysis of prior earthquakes can assist in gauging the likelihood of future occurrences. ***Error! Reference source not found.*** shows that Tioga County is in a low hazard zone (3-6%) for earthquake activity according to the USGS (2014), suggesting a low probability of earthquake occurrence. However, according to the USGS, there has been a recent trend increasing the frequency of magnitude three and larger earthquakes in the central and eastern U.S. (*Table X - Recent Earthquake Trends in Northeastern United States*). This uptick in seismicity is considered to be due to hydraulic fracturing activities, and specifically occurs as a result of wastewater from the fracking process being injected into the earth (Meyer, 2016). Recent studies have moved towards being able to predict such induced seismicity by looking at uplift after injections, but more work needs to be done to confirm uplift as a reliable indicator of induced seismicity (Shirzei et al., 2016). It is important to note that seismicity can occur even after wells become inactive and injection rates decline (Shirzaei et al., 2016). *Figure X, Tioga County Unconventional Well Locations*, shows the current possible earthquake risk due to fracking activity.

Figure X, Tioga County Unconventional Well Locations

Isostatic Rebound is a hypothesis for earthquake occurrence that has been kicked around for a lot of years, according to Charles Scharnberger, a retired professor of geology at Millersville University, who monitors the seismic station there. Scharnberger said Pennsylvania earthquakes are more of a mystery but could have something to do with the westward shift of the North American tectonic plate. Though the plates meet in California, where most of the seismic activity occurs, that movement still causes stress, squeezing and pressure along the entire length of the plate, reverberating as far back as the East Coast. A 3.4 earthquake like the one in Mifflintown, Juniata County in 2019 is in the medium range for Pennsylvania and may occur every couple of years. According to the USGS, this was the strongest earthquake felt or originating in Pennsylvania that year. It was followed by a 1.3 aftershock.

The chances of a devastating earthquake are low, but do exist, according to Scharnberger, His calculations on the probability of a severe earthquake based on the historic record indicate it is about a one in 200 chance in any given year.

Table X - Recent Earthquake Trends in Northeastern United States

Earthquake Trends in Northeastern U.S. *(USGS, 2020)*	
Year	**Number of Magnitude 3+ Earthquakes**
2015	0
2016	3
2017	4
2018	0
2019	5
2020	3

4.3.2.5 Vulnerability Assessment

According to the U.S. Geological Society Earthquake Hazards Program, an earthquake hazard is anything associated with an earthquake that may affect a resident's normal activities. For Tioga County, this could include surface faulting, ground shaking, landslides, liquefaction, fracking, dried up or rejuvenated water wells, tectonic deformation, and seiches (sloshing of a closed body of water from earthquake shaking).

Earthquakes usually occur without warning and can impact areas a great distance from their point of origin (epicenter). Ground shaking is the greatest risk to building damage within Tioga County. Risk to public safety and loss of life from an earthquake is dependent upon the severity and proximity of the event. Injury or death to those inside buildings, or people walking below building ornamentation and chimneys is a higher risk to Tioga County's general public during an earthquake. Infrastructure is more at risk on the east coast than the west coast because its buildings are older.

4.3.3 Extreme Temperatures

4.3.3.1 Location and Extent

Pennsylvania and more specifically, Tioga County, can experience many different temperature extremes. High temperatures occur about ten days per year at any location in Pennsylvania, however, southern parts of the state, experiences more than twice this number. Freezing temperatures occur on an average of 100 or more days per year with longest freeze-free period at near sea level and northwest Pennsylvania (adjacent to Lake Erie). Extreme temperatures can be devastating – extreme heat can cause sunburn, heat cramps, heat exhaustion, heat stroke, and dehydration, while extreme cold can cause hypothermia and frostbite. Both can potentially cause long-lasting disabilities. January is typically the coldest month for Tioga County, with average temperatures of 14°F. *Figure X - Average Minimum Temperature Trends for Pennsylvania* shows the average minimum temperatures in Pennsylvania with Tioga County identified. July has typically been the warmest month for Tioga County, with an average temperature of 80°F. *Figure X - Average Maximum Temperature Trends for Pennsylvania* shows the average maximum temperatures in Pennsylvania with Tioga County identified. Temperatures can vary across Tioga County due to elevation changes in topography.

Figure X - Average Minimum Temperature Trends for Pennsylvania

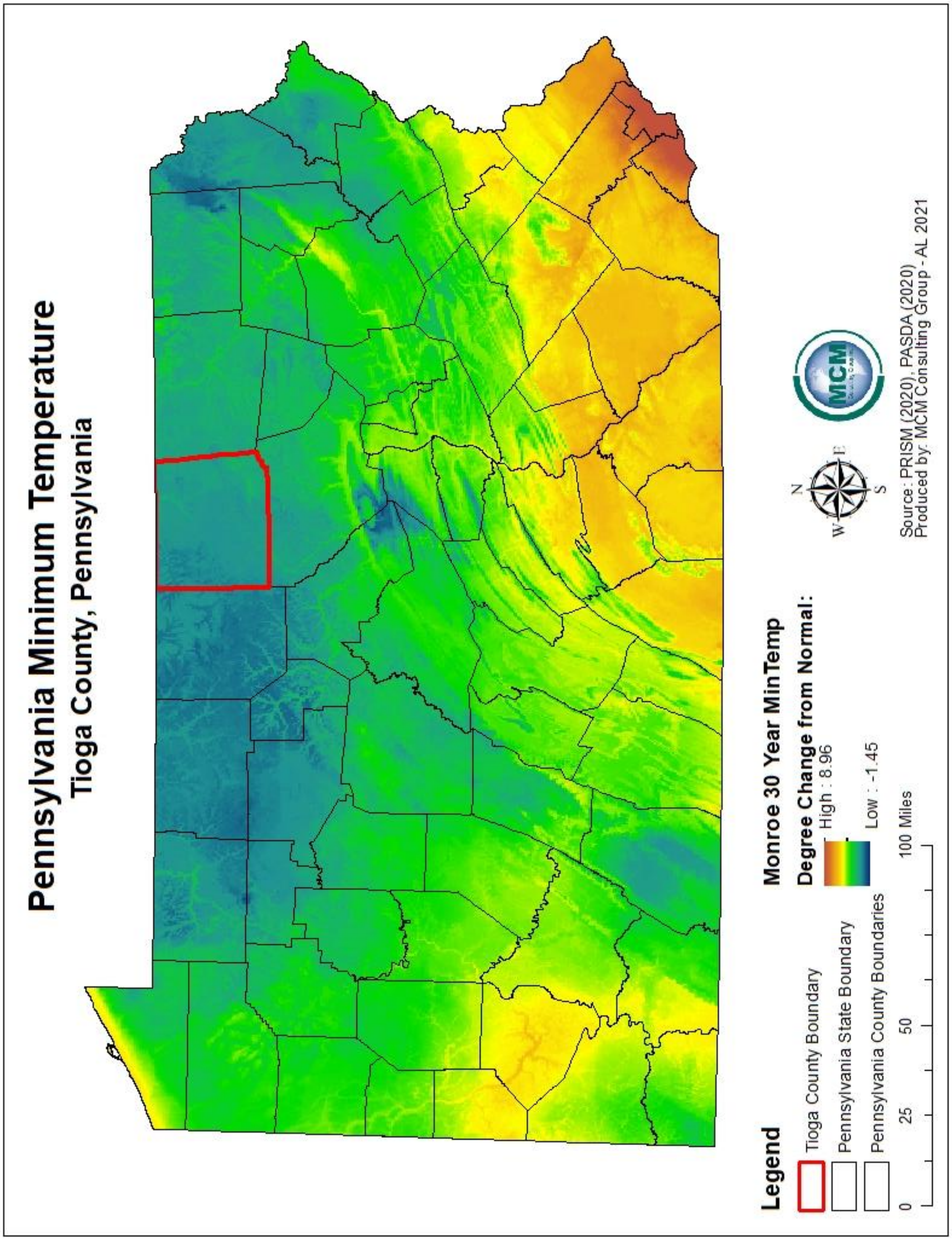
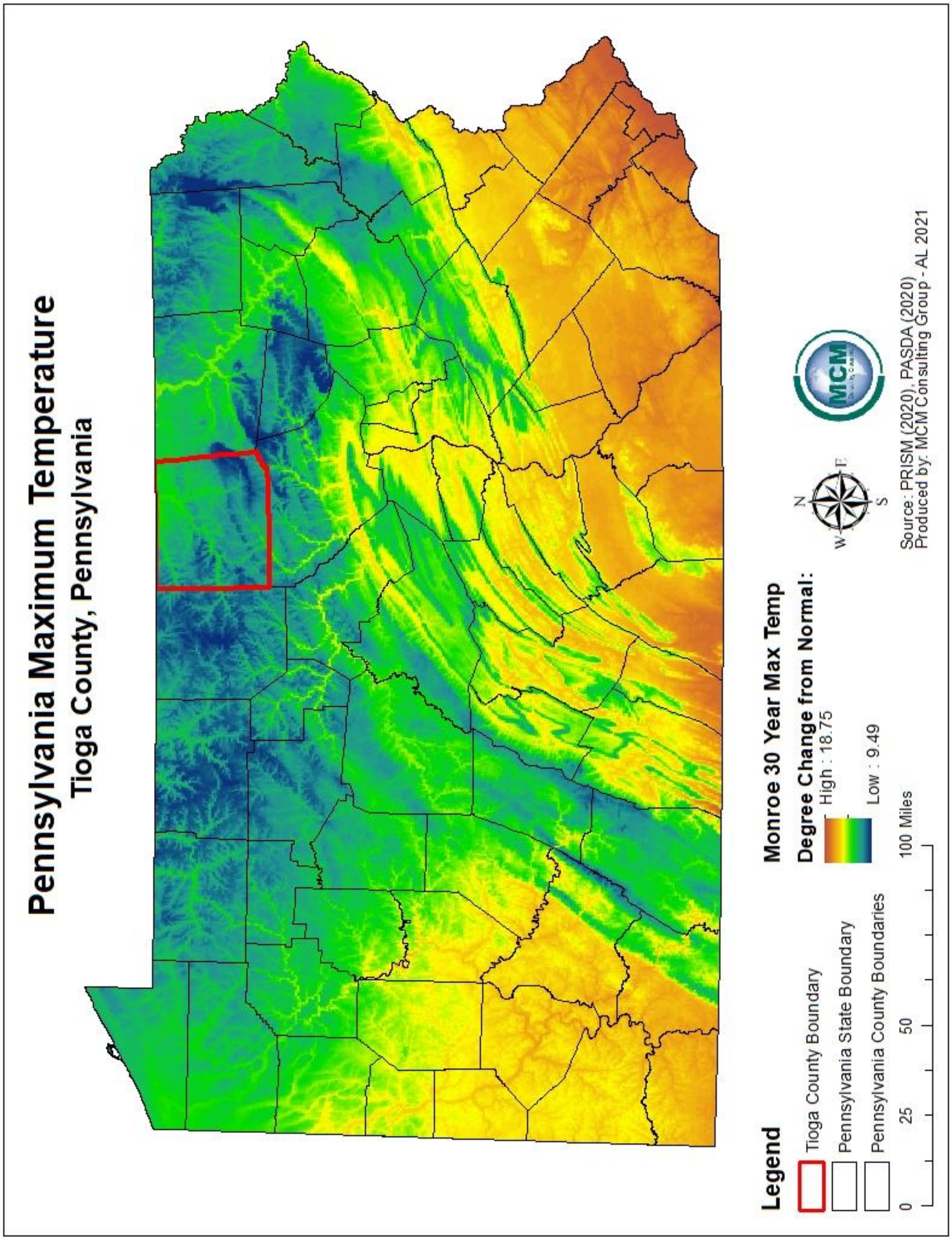


Figure X - Average Maximum Temperature Trends for Pennsylvania



4.3.3.2 Range of Magnitude

When extreme temperature events occur, they typically impact the entirety of Tioga County, including the surrounding region. Extreme heat is described as temperatures that hover at least 10ºF above the average high temperature for a region during the summer months. Extreme heat is responsible for more deaths in Pennsylvania than all other natural disasters combined. Temperature advisories, watches, and warnings are issued by the National Weather Service relating impacts to the range of temperatures typically experienced in Pennsylvania. Heat advisories are issued when the heat index temperature is expected to be equal to 100°F, but less than 105°F. Excessive heat warnings are issued when heat indices will attain or exceed 105°F and are issued within twelve hours of the onset. Excessive heat watches are issued when there is a possibility that excessive heat warning criteria may be experienced within twenty-four to seventy-two hours, but their occurrence and timing are still uncertain. A potential worst-case extreme temperature scenario would be if widespread areas of the Commonwealth experienced 90°F or higher temperatures for an extended number of days. The heat could overwhelm the power grid and cause widespread blackouts, cutting off vital HVAC services for residents. It could create crisis management issues for senior citizens on fixed incomes and the homeless population. The heat index is a measurement that takes int account both the temperature and relative humidity and is calculated as shown in *Figure X - National Weather Service's Heat Index Matrix*.

Figure X - National Weather Service's Heat Index Matrix

Temperature (°F)

Relative Humidity (%)	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
40	80	81	83	85	88	91	94	97	101	105	109	114	119	124	130	136
45	80	82	84	87	89	93	96	100	104	109	114	119	124	130	137	
50	81	83	85	88	91	95	99	103	108	113	118	124	131	137		
55	81	84	86	89	93	97	101	106	112	117	124	130	137			
60	82	84	88	91	95	100	105	110	116	123	129	137				
65	82	85	89	93	98	103	108	114	121	128	136					
70	83	86	90	95	100	105	112	119	126	134						
75	84	88	92	97	103	109	116	124	132							
80	84	89	94	100	106	113	121	129								
85	85	90	96	102	110	117	126	135								
90	86	91	98	105	113	122	131									
95	86	93	100	108	117	127										
100	87	95	103	112	121	132										

Likelihood of Heat Disorders with Prolonged Exposure or Strenuous Activity

Caution | Extreme Caution | Danger | Extreme Danger

Source: (NOAA NWS, 2018)

Extreme cold temperatures drop well below typical temperatures and are often associated with winter storm events. Wind can make the apparent temperature drop further, and exposure to such extreme cold temperatures can cause hypothermia, frost bite and death. Wind chill warnings are issued when wind chills drop to -25°F or lower. While this threshold applies to the entire state, the threshold for advisories varies based on regions. Wind chill advisories are issued in the south and western sections of Pennsylvania, when wind chill values drop to -10°F to -24°F. Wind chill advisories are issued in the southern-central to northern sections of the Commonwealth when wind chills drop to -15°F to -24°F. The National Weather Service created a wind chill chart which shows the time frostbite takes to set in depending on temperature and wind speed as shown in *Figure X - National Weather Service's Wind Chill Matrix*.

Figure X - National Weather Service's Wind Chill Matrix

Wind Chill Chart

Wind (mph) \ Temperature (°F) Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes, 10 minutes, 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

Source: (NOAA NWS, 2001)

4.3.3.3 Past Occurrence

Tioga County has had more past occurrences of extreme cold incidents than extreme heat due to the geographic location of the county. *Table X - Past Extreme Temperature Occurrences for Tioga County* shows the past occurrence events associated with extreme temperature that have occurred in Tioga County. The data in the table was reported from early 2000s to the year 2019. Due to the source used, no events have been documented before 2004 and after 2019, however, events most likely have occurred without being documented. Additionally, the source had no extreme heat temperature events listed, but these events have probably occurred. There was a total of nineteen extreme cold events that were experienced in Tioga County. There were no reports of death of injury related to the occurrences. However, numerous sources have provided information in regard to past occurrences and losses associated with extreme temperature in Tioga County and the Commonwealth as a whole. Due to the number of sources available with information, number of events and losses could vary slightly in number.

Data from the National Climatic Data Center reports that there have been eighty-five extreme temperature episodes in Pennsylvania from 2000 to present, resulting in a total of ninety-four deaths and 103 injuries. Out of the eighty-five events, fifty of them were extreme cold related with four deaths. The other thirty-five events were extreme heat related with ninety deaths and 103 injuries across the state. Specifically, with Tioga County, majority of the extreme cold temperature events that occur hit a wind chill of around -25°F to -30°F. The most recent event for Tioga County happened during January 30th, 2019 had a widespread wind chills of -25°F to -35°F from the northern mountains southward into the Laurel Highlands.

Table X - Past Extreme Temperature Occurrences for Tioga County

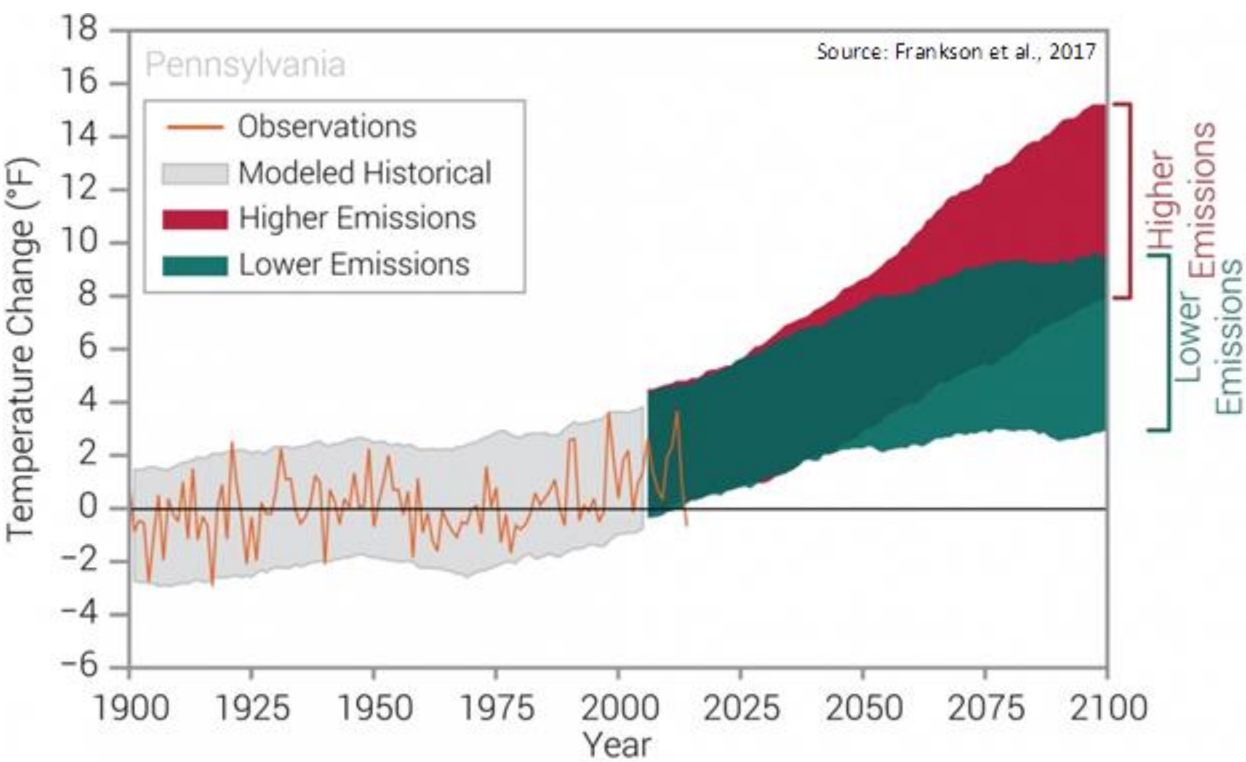
Past Extreme Temperature Occurrences for Tioga County (NOAA, 2020)		
Location	**Date**	**Type**
Tioga County	12/20/2004	Extreme Cold
Tioga County	01/26/2007	Extreme Cold
Tioga County	02/03/2007	Extreme Cold
Tioga County	02/16/2007	Extreme Cold
Tioga County	03/06/2007	Extreme Cold
Tioga County	02/10/2008	Extreme Cold
Tioga County	12/21/2008	Extreme Cold
Tioga County	01/15/2009	Extreme Cold
Tioga County	03/02/2009	Extreme Cold
Tioga County	01/06/2014	Extreme Cold
Tioga County	01/28/2014	Extreme Cold
Tioga County	02/12/2015	Extreme Cold
Tioga County	02/15/2015	Extreme Cold
Tioga County	02/19/2015	Extreme Cold
Tioga County	02/23/2015	Extreme Cold
Tioga County	02/13/2016	Extreme Cold
Tioga County	01/05/2018	Extreme Cold
Tioga County	01/20/2019	Extreme Cold
Tioga County	01/30/2019	Extreme Cold

4.3.3.4 Future Occurrence

Extreme temperatures will continue to impact Tioga County in the future. Anthropogenic climate change is causing extreme climatic events to occur more frequently, suggesting that extreme temperatures are becoming a more threatening hazard as the impacts of climate change intensify.

The annual average temperature has increased by 1.2˚F across the continental United States from 1986 to present compared to the time period 1901 to 1960 and temperatures are expected to continue to rise. ***Error! Reference source not found.*** *for Pennsylvania* shows these projected changes in temperature for Pennsylvania based on climate models considering the possibilities of increased and decreased levels of greenhouse gas emissions. In recent years, record high temperatures have outnumbered record low temperatures 2:1 so it is expected that the risk of extreme heat will be amplified whereas the risk of extreme cold will be attenuated. The Northeastern United States is expected to experience twenty to thirty more days with temperatures above 90˚F, and twenty to thirty fewer days below freezing by approximately 2050. While there may be fewer extreme cold events, those that do occur are expected to reach record-setting low temperatures more often. Historically, Tioga County has had more extreme cold events than extreme heat events due to the geographic location of the county; however, this balance is expected to shift somewhat in the coming years to include a greater proportion of extreme heat events.

Figure X - Observed and Projected Temperature Change for Pennsylvania



Source: (Frankson et al., 2017)

4.3.3.5 Vulnerability Assessment

Extreme temperatures are usually a regional hazard when they occur. The very old (22.6% of sixty-five years or older individuals in Tioga) and the very young (5.2% of five years of younger in Tioga) are most vulnerable to extreme temperatures due to risk factors, mobility challenges, and disabilities. Extreme temperatures can increase the demand for utility services, often resulting in an increased cost to consumers. The increased expense can make it difficult for the consumer to afford the service. The increased demand for services may cause a decrease in availability of these services or failure of the system. A decrease or failure of the utility system during extreme temperature events puts a large population at great risk. Extreme temperature events can also drastically increase the volume of emergency calls, potentially overwhelming the public safety answering point. Extreme heat events can also contribute to drought conditions, which in turn increase the risk of wildfires.

4.3.4 Flood, Flash Flood, and Ice Jam

4.3.4.1 Location and Extent

Flooding is the temporary condition of partial or complete inundation on normally dry land and it is the most frequent and costly of all hazards in Pennsylvania. Flooding events are generally the result of excessive precipitation. General flooding is typically experienced when precipitation occurs over a given river basin for an extended period. Flash flooding is usually a result of heavy localized precipitation falling in a short time period over a given location, often in mountain streams and mountainous regions, and in urban areas where much of the ground is covered in impervious surfaces. Flash floods are relatively common in Tioga County and the severity of said flood events is dependent upon a combination of creek, stream, and river basin topography and physiography, hydrology, precipitation, and weather patterns. Present soil conditions, the degree of vegetative clearing, and the presence of impervious cover must also be considered when determining the severity of a flood or flood event.

Winter flooding can include ice jams which occur when warm temperatures and heavy rain cause snow to melt rapidly. Snow melt combined with heavy rains can cause frozen rivers to swell, which breaks the ice layer on top of a river. The ice later often breaks into large chunks, which float downstream, piling up in narrow passages and near other obstructions such as bridges and dams. All forms of flooding can damage infrastructure.

Floodplains are lowlands adjacent to rivers, streams, and creeks that are subject to recurring floods. The size of the floodplain is described by the recurrence interval of a given flood. Flood recurrence intervals are explained in more detail in Section 4.3.4.4. However, in assessing the potential spatial extent of flooding, it is important to know that a floodplain associated with a flood that has a 10% chance of occurring in a given year is smaller than the floodplain associated with a flood that has a 0.2% annual chance of occurring.

The National Flood Insurance Program (NFIP) publishes digital flood insurance rate maps (DFIRMs). These maps identify the 1% annual chance of flood area. Special flood hazard area (SFHA) and base flood elevations (BFE) are developed from the 1% annual chance flood event. As seen in *Figure X – Flooding and Floodplain Diagram*. Structures located within the SFHA have a 26% chance of flooding in a thirty-year period. The SFHA serves as the primary regulatory boundary used by FEMA, the Commonwealth of Pennsylvania, and the Tioga County local governments. Federal floodplain management regulations and mandatory flood insurance purchase requirements apply to the following high-risk special flood hazard areas in *Table X – Flood Hazard High Risk Zones*. Appendix D of this hazard mitigation plan includes a flooding vulnerability map for each municipality in Tioga County with vulnerable structures and functional needs facilities identified using the most current DFIRM data for Tioga County.

A large portion of Tioga County's municipalities are flood prone and Tioga County is located largely in the Tioga River and Pine Creek watersheds. Flood problems exist mostly in Charleston, Clymer, Middlebury, Liberty, Putnam, and Richmond townships. Flooding has also occurred in multiple boroughs, including Elkland, Mansfield, Lawrenceville, and Wellsboro boroughs. Flooding has occurred among the Tioga River and its tributaries in Tioga County.

Past flooding events have been primarily caused by heavy rains which cause small creeks and streams to overflow their banks, often leading to road closures. Flooding poses a threat to functional needs facilities, agricultural areas, and those who reside or conduct business in the floodplain. The most significant hazard exists for facilities in the floodplain that process, use and/or store hazardous materials. A flood could potentially release and transport hazardous materials throughout the area. Most flood damage to property and structures located in the floodplain is caused by water exposure to the interior, high velocity water and debris flow.

Figure X – Flooding and Floodplain Diagram

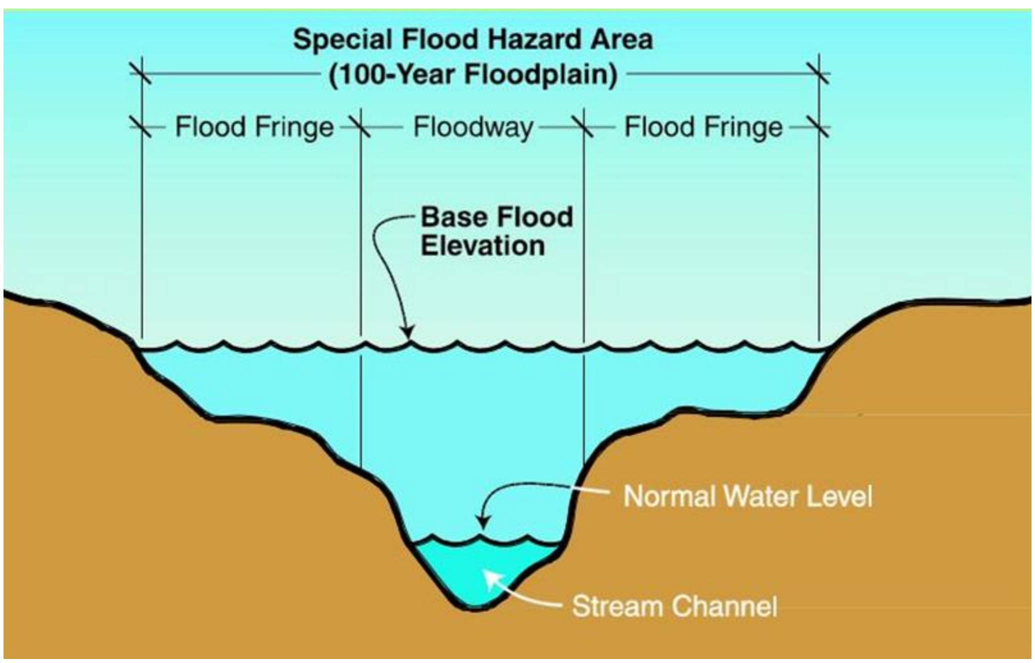


Table X – Flood Hazard High Risk Zones

Flood Hazard High Risk Zones *(FEMA, 2017)*	
Zone	**Description**
A	Areas subject to inundation by the 1% annual chance flood event. Because detailed hydraulic analysis has not been performed, no base flood elevations or flood depths are shown.
AE	Areas subject to inundation by the 1% annual chance flood event determined by detailed methods. BFEs are shown within these zones.
AH	Areas subject to inundation by the 1% annual chance shallow flooding (usually areas of ponding) where average depths are 1-3 feet. BFEs derived from detailed hydraulic analysis are shown in this zone.
AO	Areas subject to inundation by the 1% annual chance shallow flooding (usually sheet flow on sloping terrain) where average depths are 1-3 feet. Average flood depths derived from detailed hydraulic analysis are shown within this zone.
AR	Areas that result from the decertification of a previously accredited flood protection system that is determined to be in the process of being restored to provide base flood protection.

4.3.4.2 Range of Magnitude

The Tioga River Basin and the Cowanesque River Basin have caused significant flooding in Tioga County, specifically on the following rivers and their tributaries:

- Cowanesque River
- Tioga River
  - Mill Creek
  - Crooked Creek
  - Norris Brook
  - Crooked Creek
- Pine Creek

Several factors determine the severity if floods, including rainfall intensity and duration, topography, ground cover and the rate of snowmelt. Water runoff is greater in areas with steep slopes and little to np vegetative ground cover. The mountainous terrain of Tioga County can cause more severe floods as runoff reaches receiving water bodies more rapidly over steep terrain. This is of particular concern for areas along the Pennsylvania Grand Canyon in Tioga County.

Urbanization typically results in the replacement of vegetative ground cover with impermeable surfaces like asphalt and concrete, increasing the volume of surface runoff and stormwater, particularly in areas with poorly planned stormwater drainage systems. A large amount of rainfall over a short time span can cause flash flood events. Additionally, small amounts of rain can cause floods in locations where the soil is still frozen, saturated from a previous wet period, or if the area is largely covered in impermeable surfaces such as parking lots, paved roadways, and other developed areas. The county occasionally experiences intense rainfall from a tropical storm in late summer and early fall, which can potentially cause flooding as well.

Severe flooding can cause injuries and deaths and can have long-term impacts on the health and safety of the citizens. Severe flooding can also result in significant property damage, potentially disrupting the regular function of functional needs facilities and have long-term negative impacts on local economies. Industrial, commercial, and public infrastructure facilities can become inundated with flood waters, threatening the continuity of government and business. The functional needs population must be identified and located in flooding situations, as they are often home bound. Mobile homes are especially vulnerable to high water levels. Flooding can have significant environmental impacts when the flood water release and/or transport hazardous materials.

Flash floods can occur very quickly and with little warning. Flash floods can also be deadly because of the rapid rises in water levels and devastating flow velocities. The more developed areas in the county can be easily susceptible to flash floods because of the significant presence of impervious surfaces, such as streets, sidewalks, parking lots, and driveways.

Severe flooding also comes with secondary effects that could have long lasting impacts on the population, economy, and infrastructure within Tioga County. Power failures are the most common secondary effect associated with flooding. Coupled with a shortage of critical services and supplies, and power failures could cause a public health emergency. Critical infrastructure, such as sewage and water treatment facilities, can fail, causing sewage overflows and the contaminating of groundwater and drinking water. Flooding also has the potential to trigger other hazards, such as landslides, hazardous material spills, and dam failures.

The maximum threat of flooding for Tioga County is estimated by looking at the potential loss data and repetitive loss data, both analyzed in the risk assessment section of the hazard mitigation plan. In these cases, the severity and frequency of damage can result in permanent population displacement, and businesses may close if they are unable to recover from the disaster.

Estimation of potential loss is completed through FEMA's HAZUS software, A level two HAZUS scenario was performed for the entirety of Tioga County and there were no failed reaches within the scenario. The FEMA reports generated by the software at the end of the scenario were utilized to estimate the amount of damage and loss from a flood. The total building loss for a 100-year flood based on a HAZUS level two scenario is displayed in *Table X – HAZUS Building Economic Loss Figures*. The total business interruption values occurring from a proposed 100-year flood based on FEMA HAZUS data is illustrated in *Table X – HAZUS*

Business Interruption Economic Loss Figures. *Figure X – Loss by Occupancy Type* illustrates the breakdown of economic losses by either residential, commercial, industrial, or other use type.

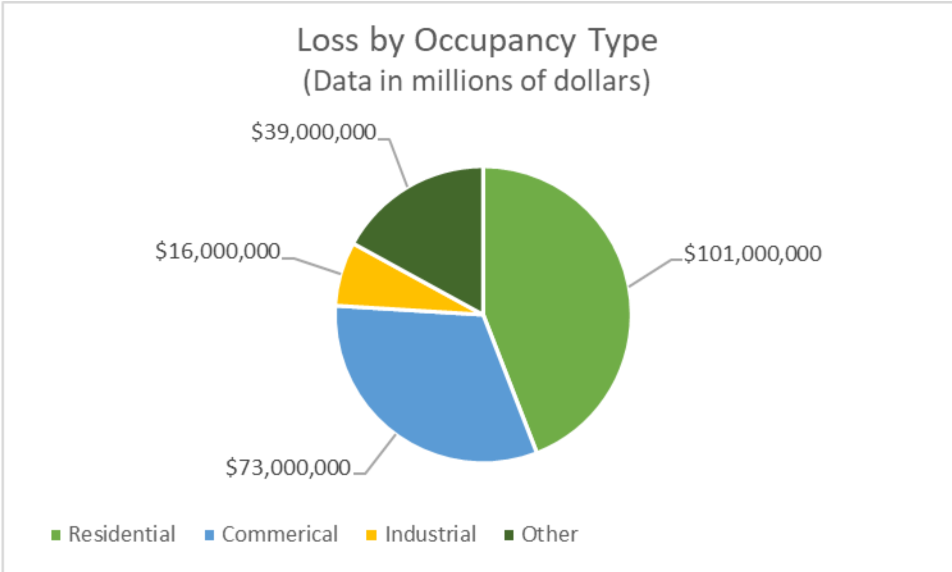
Table X – HAZUS Building Loss Figures

HAZUS Building Economic Loss Figures (HAZUS 2021)					
	Residential	**Commercial**	**Industrial**	**Other**	**Total**
Building:	$50,840,000.00	$6,360,000.00	$3,770,000.00	$1,740,000.00	$62,710,000.00
Content:	$23,110,000.00	$19,400,000.00	$9,830,000.00	$9,310,000.00	$61,650,000.00
Inventory:	$0.00	$520,000.00	$1,350,000.00	$120,000.00	$1,990,000.00
Subtotal:	**$73,950,000.00**	**$26,270,000.00**	**$14,960,000.00**	**$11,170,000.00**	**$126,350,000.00**

Table X – HAZUS Business Interruption Economic Loss Figures

HAZUS Business Interruption Economic Loss Figures (HAZUS 2021)					
	Residential	**Commercial**	**Industrial**	**Other**	**Total**
Income:	$1,320,000.00	$18,420,000.00	$210,000.00	$4,210,000.00	$24,160,000.00
Relocation:	$16,240,000.00	$5,070,000.00	$340,000.00	$1,580,000.00	$23,240,000.00
Rental Income:	$6,500,000.00	$3,280,000.00	$60,000.00	$190,000.00	$10,040,000.00
Wage:	$3,130,000.00	$19,880,000.00	$340,000.00	$22,220,000.00	$45,570,000.00
Subtotal:	**$27,190,000.00**	**$46,660,000.00**	**$950,000.00**	**$28,200,000.00**	**$103,000,000.00**

Figure X – Loss by Occupancy Type



Source: HAZUS Scenario for Tioga County (2021)

Although floods can cause deaths, injuries, and damage to property, they are naturally occurring events that benefit riparian systems which have not been disrupted by human actions. Such benefits include groundwater recharge and the introduction of nutrient rich sediments which improves soil fertility. However, human development often disrupts natural riparian buffers by changing land use and land cover, and the introduction of chemical or biological contaminants that often accompany human presence can contaminate habitats after flood events.

4.3.4.3 Past Occurrence

Tioga County has experienced numerous flooding, flash flooding, and ice jam events in the past. The flooding and flash flooding were caused by a variety of heavy storms, tropical storms, and other issues. A summary of flood event history for Tioga County from January 1996 to April 2021 is found in *Table X – Past Flood and Flash Flood Events*. Details of each event can be found in NOAA's National Center for Environmental Information (NCEI) database. Additional data was also acquired by examining Tioga County's Knowledge Center information from 2013 to 2021. *Figure X – Mutton Lane Creek Flooding September 2018* displays a flooding event that took place along Mutton Lane Creek as a result of Tropical Storm Florence. *Figure X – Heffner Hollow Flooding September 2018* also displays a flooding event as a result of Tropical Storm Florence.

Figure X – Mutton Lane Creek Flooding September 2018

Image provided by the Tioga County Conservation District

Figure X – Heffner Hollow Flooding September 2018

Image provided by the Tioga County Conservation District

Table X – Past Flood and Flash Flood Events

Past Flood and Flash Flood Events (NCEI NOAA)			
Event Location	**Event Date**	**Event Type**	**Property Damage Estimate**
Tioga County (entire county)	01/19/1996	Flood	$0*
Tioga County (entire county)	01/19/1996	Flash Flood	$0*
Clymer Township	04/30/1996	Flash Flood	$0*
Middlebury Township	05/11/1996	Flash Flood	$0*
Wellsboro Borough	11/08/1996	Flash Flood	$2,500,000*
Tioga County (Southeast)	12/01/1996	Flash Flood	$0*
Tioga Borough	06/23/1998	Flash Flood	$0*
Deerfield Township	06/13/2000	Flash Flood	$0*
Tioga County (Northeast)	06/25/2000	Flash Flood	$0*
Wellsboro Borough	08/09/2003	Flash Flood	$50,000.00*
Tioga County (entire county)	11/19/2003	Flood	$0*
Wellsboro Borough	11/19/2003	Flash Flood	$0*
Tioga County (entire county)	12/11/2003	Flood	$0*
Elkland Borough	07/17/2004	Flash Flood	$0*
Tioga County (entire county)	07/27/2004	Flood	$0*
Wellsboro Borough	08/30/2004	Flash Flood	$0*
Tioga County (entire county)	09/08/2004	Flood	$0*
Tioga County (entire county)	09/17/2004	Flood	$0*
Tioga County (entire county)	01/14/2005	Flood	$0*
Tioga County (entire county)	04/02/2005	Flood	$0*
Tioga County (entire county)	06/27/2006	Flash Flood	$0*
Elkland Borough	07/21/2006	Flash Flood	$0*
Clymer Township	03/15/2007	Flood	$0*
Blossburg Borough	08/30/2007	Flash Flood	$0*
Westfield Borough	04/28/2011	Flash Flood	$0*

Event Location	Event Date	Event Type	Property Damage Estimate
Lawrenceville Township	05/19/2011	Flash Flood	$0*
Clymer Township	05/19/2011	Flash Flood	$0*
Lawrence Township	09/07/2011	Flood	$450,000.00*
Morris Township	09/06/2012	Flash Flood	$0*
Tioga Borough	08/31/2013	Flood	$0*
Middlebury Township	03/12/2014	Flood	$0*
Deerfield Township	05/16/2014	Flood	$0*
Richmond Township	06/25/2014	Flood	$0*
Mansfield Borough	06/25/2014	Flood	$0*
Liberty Township	02/24/2016	Flood	$0*
Stokesdale Township	07/23/2017	Flash Flood	$0*
Charleston Township	07/23/2017	Flash Flood	$0*
Putnam Township	08/13/2018	Flood	$0*
Roseville Borough	09/17/2018	Flood	$0*
Nelson Township	09/17/2018	Flood	$0*
Westfield Borough	09/17/2018	Flood	$0*
Middlebury Township	09/17/2018	Flood	$0*
Tioga County (entire county)	09/21/2018	Flood	$0*
		Total:	**$3,000,000.00***
*Property Damage Values are estimated and are not exact figures. Data from NCEI and Knowledge Center			

The National Flood Insurance Program (NFIP) identifies properties that frequently experience flooding. Repetitive loss properties are structures insured under the NFIP which have had at least two paid flood losses of more than $1,000 over any ten-year period since 1978. The hazard mitigation assistance (HMA) definition of a repetitive loss property is a structure covered by a contract for flood insurance made available under the NFIP that has incurred flood-related damage on two occasions, in which the cost of repair, on average, equaled or exceeded 25% of the market value of the structure at the time of each such flood event; and at the time of the second incidence of flood-related damage, the contract for flood insurance contains increased cost of compliance coverage. *Table X – Repetitive Loss Properties* illustrates the communities that have repetitive loss properties, the total building payments, the contents payments, and the number of losses and properties. There and eighteen repetitive loss properties in Tioga County.

A property is considered a severe repetitive loss property either when there are at least four losses each exceeding $5,000 or when there are two or more losses where the building payments exceed the property value. *Table X – Severe Repetitive Loss Properties* illustrates the communities within Tioga County that have severe repetitive loss properties, the total building payments, the contents payments, and the number of losses and properties. The data used in the table is based on data from PEMA.

Most municipalities in Tioga County participate in the NFIP. Information on each participating municipality can be found in *Table X – Municipal NFIP Policies & Vulnerability*.

Table X – Repetitive Loss Properties

Repetitive Loss Properties (PEMA)						
Community Name	**Community Number**	**Cumulative Building Payment**	**Cumulative Contents Payment**	**Sum of Total Paid**	**Losses**	**Properties**
Blossburg Borough	420817	$24,969.04	$0	$24,969.04	5	2
Gaines Township	421005	$51,561.99	$7,924.30	$59,486.29	5	2
Knoxville Borough	420819	$14,776.24	$1,800.00	$16,576.24	2	1
Middlebury Township	421179	$65,956.88	$27,933.75	$93,890.63	4	2
Osceola Township	421182	$32,192.52	$1,877.18	$34,069.70	3	2
Putnam Township	420824	$16,644.51	$0	$16,644.51	2	1
Richmond Township	420825	$18,014.13	$1,039.82	$19,053.95	3	2
Shippen Township	422100	$295,906.09	$97,107.72	$393,013.81	14	4
Union Township	421184	$49,260.97	$0	$49,260.97	3	2
	Total:	**$569,282.37**	**$137,682.77**	**$707,965.14**	**41**	**18**

Table X – Severe Repetitive Loss Properties

Severe Repetitive Loss Properties (PEMA)						
Community Name	**Community Number**	**Cumulative Building Payments**	**Cumulative Contents Payments**	**Sum of Total Paid**	**Losses**	**Properties**
Shippen Township	422100	$123,358.90	$38,522.96	$161,881.86	5	N/A

Table X – Municipal NFIP Policies & Vulnerability

Municipal NFIP Policies (PEMA 2020)					
Community Name	**Community Number**	**Contract Count**	**Policy Count**	**Total Coverage**	**Premium and Policy Fee**
Bloss Township	422094	1	1	$77,000.00	$843.00
Blossburg Borough	420817	45	45	$4,904,300.00	$66,778.00
Brookfield Township	421171	2	2	$525,000.00	$1,001.00
Charleston Township	421172	4	4	$426,000.00	$1,670.00
Chatham Township	421173	3	3	$606,000.00	$1,311.00
Clymer Township	421174	1	1	$280,00.00	$418.00
Covington Township	421175	12	12	$1,638,000.00	$12,067.00
Deerfield Township	421176	5	5	$1,050,000.00	$2,706.00
Delmar Township	421177	8	8	$930,400.00	$5,854.00
Elk Township	421154	1	1	$350,000.00	$446.00
Elkland Borough	420818	15	15	$2,365,500.00	$11,611.00
Gaines Township	421005	2	2	$247,200.00	$2,929.00
Knoxville Borough	420819	2	2	$378,000.00	$698.00
Lawrence Township	421006	7	7	$1,125,600.00	$4,954.00
Lawrenceville Borough	420821	1	1	$70,000.00	$234.00
Liberty Borough	420822	2	2	$127,000.00	$1,273.00
Mansfield Borough	420823	4	4	$861,400.00	$4,185.00
Middlebury Township	421179	16	16	$3,133,200.00	$13,359.00
Osceola Township	421182	9	9	$825,400.00	$4,929.00
Putnam Township	420824	19	19	$1,521,000.00	$18,490.00
Richmond Township	420825	17	17	$4,064,900.00	$15,234.00
Roseville Borough	420826	3	3	$424,000.00	$2,897.00
Shippen Township	422100	6	6	$791,500.00	$3,429.00
Sullivan Township	421183	6	6	$520,000.00	$2,875.00
Tioga Borough	420827	3	3	$1,455,000.00	$3,779.00
Union Township	421184	7	7	$409,000.00	$5,048.00
Wellsboro Borough	420829	13	13	$4,329,900.00	$9,870.00

Community Name	Community Number	Contract Count	Policy Count	Total Coverage	Premium and Policy Fee
Westfield Township	421185	16	16	$1,453,500.00	$12,158.00
Westfield Borough	422093	20	20	$4,348,000.00	$38,084.00
	Total:	**252**	**252**	**$39,236,800.00**	**$249,100.00**

4.3.4.4 Future Occurrence

Flooding is a frequent problem throughout the Commonwealth of Pennsylvania. Tioga County will certainly be impacted by flooding events in the future, as Tioga County experiences some degree of flooding annually. The threat of flooding is compounded in the late winter and early spring months, as melting snow can overflow streams, creeks, and tributaries, increasing the amount of groundwater, clogging stormwater culverts and bridge openings. The NFIP recognizes the 1% annual chance flood, also known as the base flood of one-hundred-year flood, as the standard for identifying properties subject to federal flood insurance purchase requirements. A 1% annual chance flood is a flood which has a 1% chance of occurring in a given year or is likely once every one-hundred years. The digital insurance maps (DFIRMs) are used to identify areas subject to the 1% annual chance of flooding.

A property's vulnerability to a flood is dependent upon its location in the floodplain. Properties along the banks of a waterway are the most vulnerable. The property within the floodplain is broken into sections depending on its distance from the waterway. The ten-year flood zone that has a 10% chance of being flooded every year. However, this label does not mean that this area cannot flood more than once every ten years. This label simply designates the probability of a flood of this magnitude every year. Further away from this area is the fifty-year floodplain. This area includes all of the ten-year floodplain plus additional property. The probability of a flood of this magnitude occurring during a one-year period is 2%. A summary of flood probability is shown in Table X – Flood Probability Summary.

Table X – Flood Probability Summary

Flood Probability Summary *(FEMA)*	
Flood Recurrence Intervals	**Annual Chance of Occurrence**
10-year	10.00%
50-year	2.00%
100-year	1.00%
500-year	0.20%

4.3.4.5 Vulnerability Assessment

River and Stream Flooding:

Tioga County is vulnerable to stream and river flooding events. Flooding puts the entire population at some level of risk, whether through flooding of homes, businesses, places of employment, roadways, sewer, and water infrastructure. Flooding can cause significant power outages and poor road conditions that can lead to heightened transportation accident risk.

Functional needs facilities and critical infrastructure are the most vulnerable buildings and services when river and stream flooding is considered. Functional needs facilities are facilities that if damaged would present and immediate threat to life, public health, and safety. Facilities that use and store hazardous materials pose a potential threat to the environment during flooding events if flooding causes a leak, inundation, or equipment failure. Appendix D of this hazard mitigation plan includes a flooding vulnerability map for each municipality in Tioga County, with vulnerable structures and functional needs facilities that are located within the special flood hazard area.

While the regulatory one-hundred-year floodplain is defined by the NFIP and FEMA as a useful tool to estimate flooding vulnerability, it is important to note that it is not always completely accurate.

Flash Flooding:

Flash flooding is a common occurrence in Tioga County and can occur anywhere in the county. A large portion of flash flooding occurs in populated areas that have increased impervious ground cover. During the risk assessment process, numerous resources were utilized to determine flash flooding locations in Tioga County. Municipalities were asked to identify locations within the municipality that were prone to frequent flash flooding. The National Climatic Data Center was also queried to determine flash flood vulnerable areas. This data is reflected in *Table X – Past Flood and Flash Flood Events* above.

Locations that are identified as vulnerable to flash flooding in Tioga County are as follows:

- Wellsboro Borough
- Elkland Borough
-
- Westfield Borough
- Middlebury Township

The most costly flood in recent history was a flash flood where the Tioga river and Canoe Camp Creek overflowed the night of September 7, 2011, incurring an estimated $449,652 in damages to public facilities and buildings.

Although the above locations were identified as vulnerable areas in Tioga County, they are not the only locations that are vulnerable to flash flooding. The Tioga County Hazard Mitigation Team will continue to work with municipalities to identify vulnerable flash flooding locations and identify vulnerable functional needs populations and critical facilities.

Ice Jam Flooding:

Ice jam flooding has affected Tioga County in the past. Areas along the Pine Creek and the Tioga River are the most vulnerable. The affected areas would see an increase in erosion to riverbanks and loss of vulnerable land.

There are recorded instances of ice jam flooding along the Locey Creek impacting the Middlebury area along Route 287 in the past.

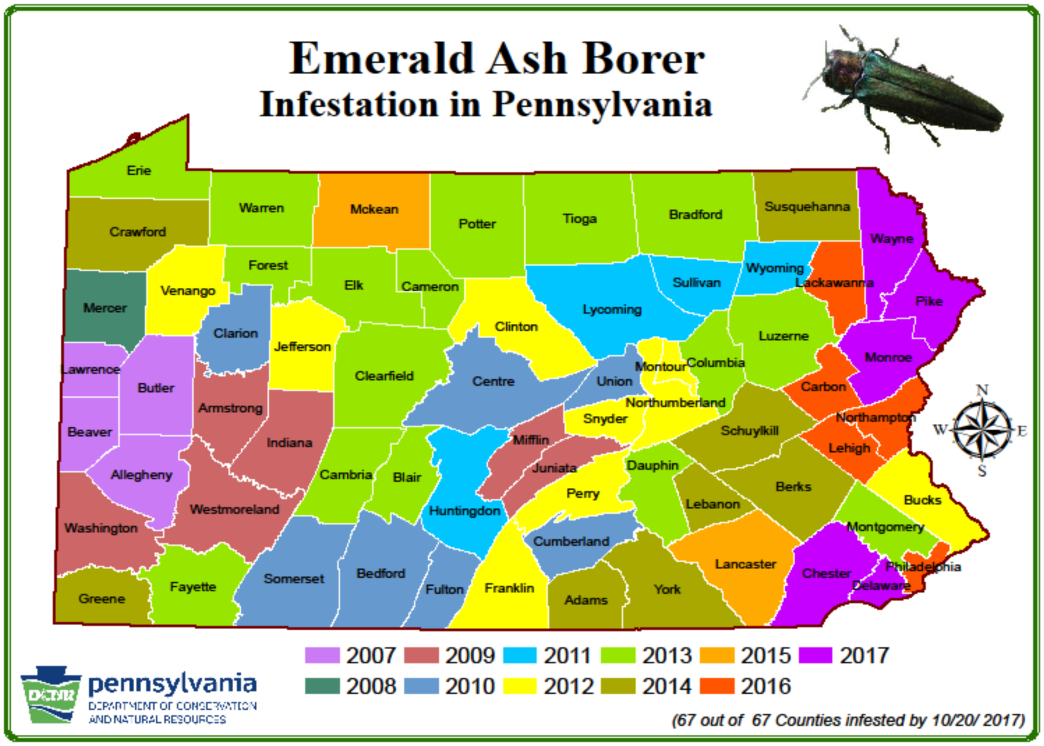
The Tioga County Hazard Mitigation Team will continue to work with the municipalities to identify ice jam flooding locations and identify vulnerable functional needs population and facilities.

4.3.5. Invasive Species

4.3.5.1 Location and Extent

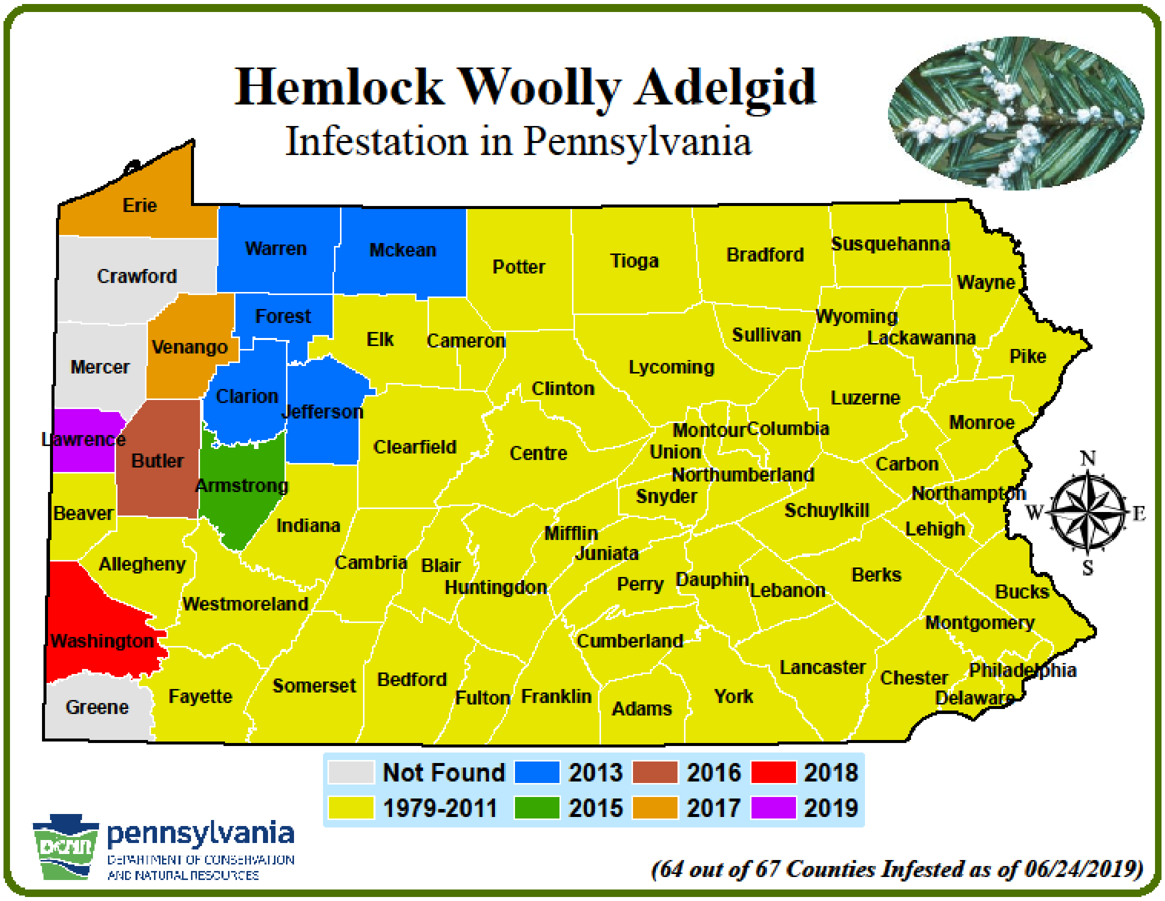
The magnitude of invasive species threats ranges from nuisance to widespread killer. Some invasive species are not considered agricultural pests, and do not harm humans or cause significant ecological problems. For example, Brown Marmorated Stink Bugs are not considered to be an agricultural pest and do not harm humans. Other invasive species can have many negative impacts and cause significant changes in the composition of ecosystems. For example, the Emerald Ash Borer creates a 99% mortality rate for any ash tree it infects. The aggressive nature of many invasive species can cause significant reductions in biodiversity by crowding out native species. This can affect the health of individual host organisms as well as the overall well-being of the affected ecosystem. An example of a worst-case scenario for invasive species is the success of the Emerald Ash Borer in Tioga County and the surrounding region. The Emerald Ash Borer has already become established in Tioga County (see *Figure X - Emerald Ash Borer Infestation in Pennsylvania*) and the surrounding region, and there is a high mortality rate for trees associated with this pest.

Figure X - Emerald Ash Borer Infestation in Pennsylvania



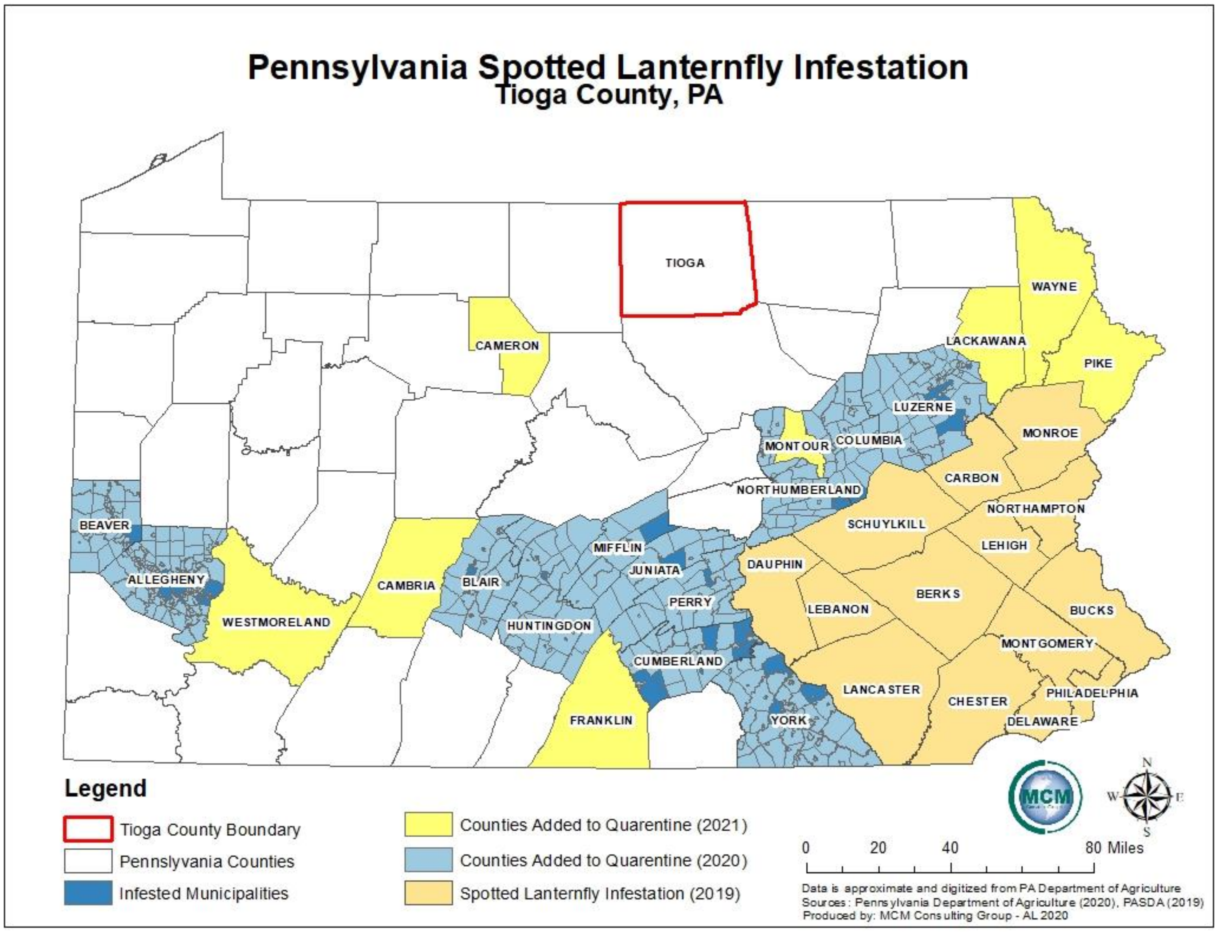
Another example of a negative invasive pest is the hemlock woolly adelgid. Hemlock woolly adelgid is a fluid-feeding insect that feeds on hemlock trees throughout eastern North America, including Pennsylvania. The egg sacs of these insects look like the tips of cotton swabs clinging to the undersides of hemlock branches. Hemlock woolly adelgid was introduced from Asia into the Pacific Northwest in 1924. It was most likely introduced into the northeastern United States in the 1950s and it was first discovered in Pennsylvania in 1967. This insect has been damaging hemlock ever since and it is spreading. To date, sixty-four counties in Pennsylvania, including Tioga County, have been infested with this insect. See *Figure X - Hemlock Woolly Adelgid Infestation in Pennsylvania*. Eastern hemlock (Pennsylvania's state tree) and Carolina hemlocks (found further south in the Smoky Mountain sections of the Appalachians) are more susceptible to hemlock woolly adelgid damage than Asian and western hemlock trees due to feeding tolerance and predators that protect the latter species. Hemlock woolly adelgid sucks fluid from the base of hemlock needles. It may also inject toxins into the tree as it feeds, accelerating needle drop and branch dieback. Although some trees die within four years, trees often persist in a weakened state for many years. Hemlocks that have been affected by hemlock woolly adelgid often have a grayish-green appearance (hemlocks naturally have a shiny, dark green color).

Figure X - Hemlock Woolly Adelgid Infestation in Pennsylvania



A final example of an invasive species is the Spotted Lanternfly. The Spotted Lanternfly is a harmful invasive pest with a healthy appetite for our plants and can negatively impact the quality of life and enjoyment of the outdoors. According to the Penn State Extension, the Spotted Lanternfly is a significant threat to Pennsylvania agriculture, landscapes, and natural ecosystems, including grape, tree-fruit, hardwood, and nursery industries, which collectively are worth nearly $18 billion to the state's economy, outdoor recreation, and biodiversity. The Spotted Lanternfly has not been identified to be in Tioga County but could make its appearance into the county in the near future. *Figure X – Pennsylvania Spotted Lanternfly Infestation* illustrates the counties in Pennsylvania that are in the quarantine zone for this pest.

Figure X – Pennsylvania Spotted Lanternfly Infestation



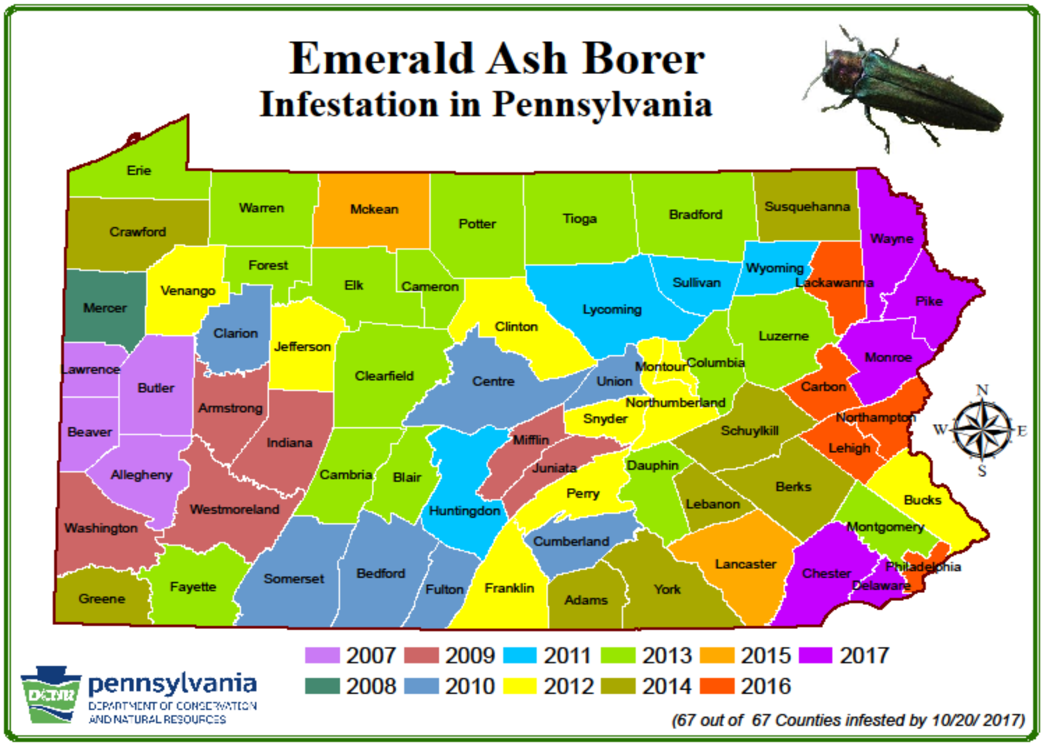
The magnitude of an invasive species threat is generally amplified when the ecosystem or host species is already stressed, such as in times of drought. The already weakened state of the native ecosystem causes it to succumb to an infestation more easily. A worst-case example could be the Hemlock Woolly Adelgid causing reduced biodiversity, increased wildfire potential, and thermal harm to small stream cold water fisheries and habitats.

4.3.5.2 Range of Magnitude

The magnitude of invasive species threats ranges from nuisance to widespread killer. Some invasive species are not considered agricultural pests, and do not harm humans or cause significant ecological problems. For example, Brown Marmorated Stink Bugs are not considered to be an agricultural pest and do not harm humans. Other invasive species can have many negative impacts and cause significant changes in the composition of ecosystems. For example, the Emerald Ash Borer creates a 99% mortality rate for any ash tree it infects. The aggressive nature of many invasive species can cause significant reductions in biodiversity by crowding out native species. This can affect the health of individual host organisms as well as the overall well-being of the affected ecosystem. An example of a worst-case scenario for invasive species is the success of the Emerald Ash Borer in Tioga County and the surrounding region. The Emerald Ash

Borer has already become established in Tioga County (see *Figure X - Emerald Ash Borer Infestation in Pennsylvania*) and the surrounding region, and there is a high mortality rate for trees associated with this pest.

Figure X - Emerald Ash Borer Infestation in Pennsylvania



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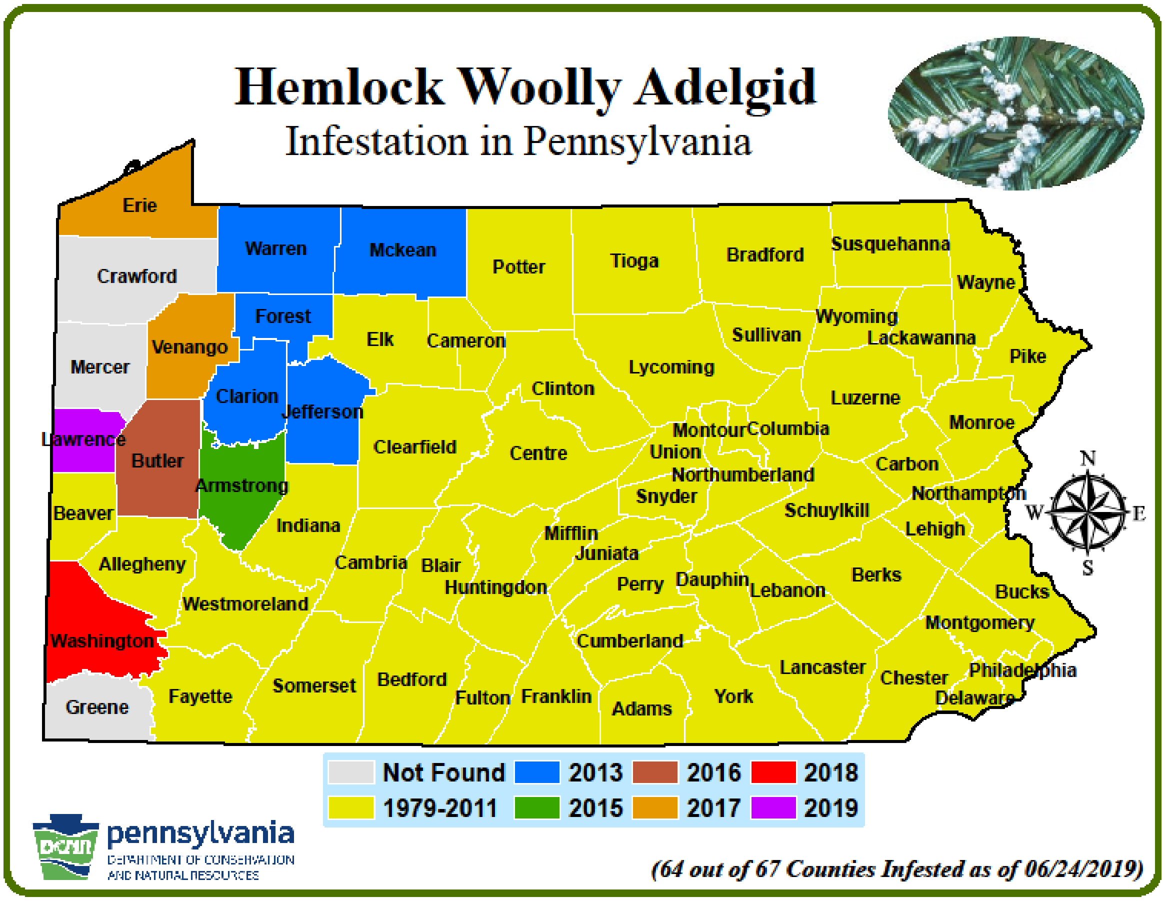

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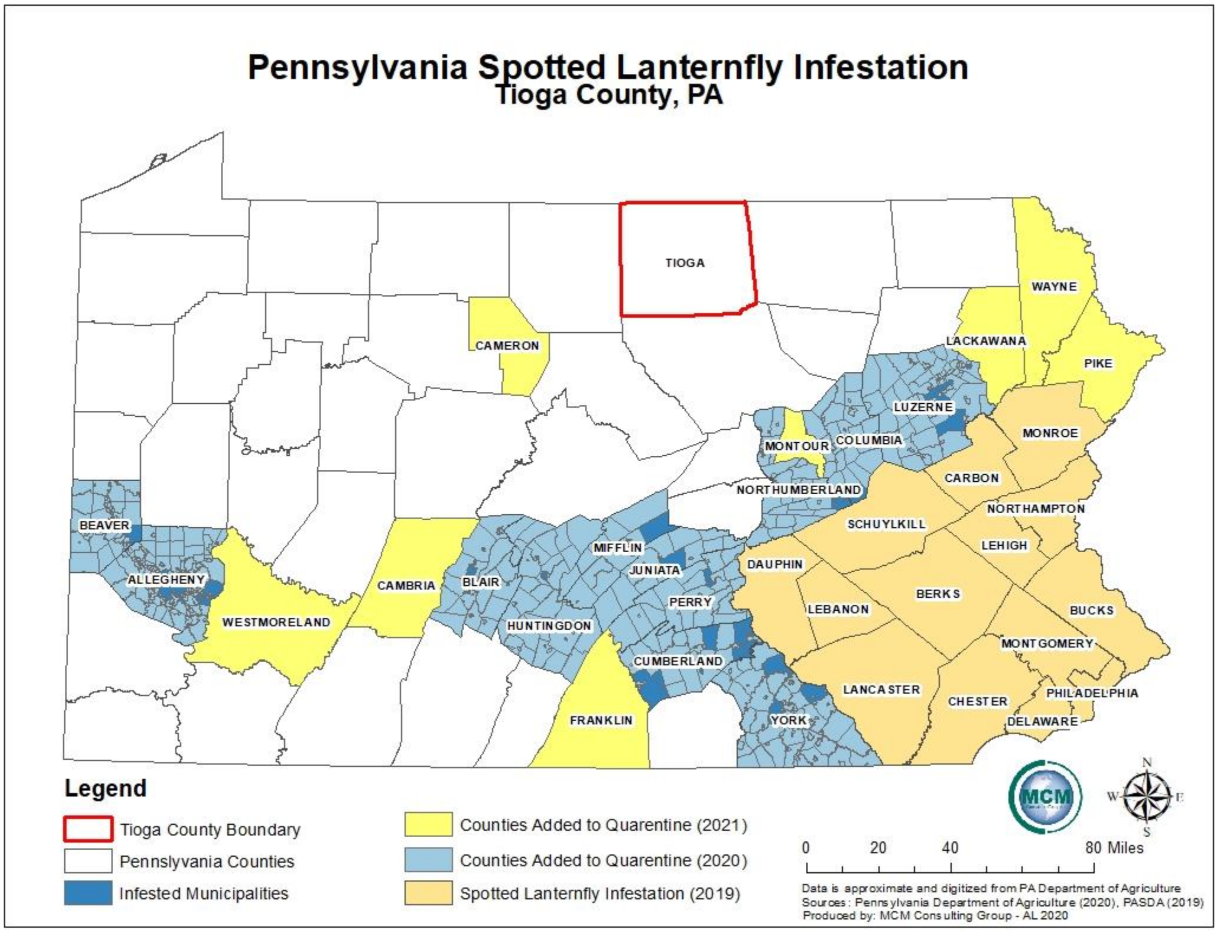
Figure X – Pennsylvania Spotted Lanternfly Infestation



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4.3.5.3 Past Occurrence

Invasive species have been entering Pennsylvania since the arrival of European settlers, but not all occurrences required government action. Tioga County is known for its great number of geographic features. There are five main state game lands within Tioga County which include State Game Lands (SGL) 037, 208, 268, 313 and 335. SGL 037 has 13,138 acres and is located in uplands near Tioga and Hammond Lakes. SGL 208 is found near the confluence of Pine Creek and Long Run with 8,834 acres. SGL 268 has 3,049 acres and located on the East Branch of Stony Fork. SGL 313 offers 409 acres of waterfowl habitat. Lastly, SGL 335 has 1,169 acres near the headwaters of Tioga River. Additionally, there are three Pennsylvania state parks in Tioga County which include Hills Creek State Park, Colton Point State Park, and Leonard Harrison State Park. Along with vast amounts of forest available in the county, there are a great number of waterways available in the county such as Tioga River, Cowanesque River, Cowanesque Lake, Tioga-Hammond Lakes, and Hills Creek Lake. Therefore, Tioga County has great amounts of forest and lakes available for species to potentially invade. Due to the vast area of forests and waterways, there are both many invasive terrestrial and aquatic species that have been widespread in Tioga County that are common problems throughout the Commonwealth. Some of the most popular problematic species in Tioga include:

- Multiflora Rose
- Japanese Knotweed
- Common Carp
- Eurasian Watermilfoil
- Common Crown-Vetch
- Zebra Mussel

Since the past, many of the extreme problematic species have been around for many years. However, the most recent problematic species are the Emerald Ash Borer and Hemlock Wooly Adelgid. In 2007, both the Emerald Ash Borer and Hemlock Wooly Adelgid were both newly spotted species that caused extreme damage. *Table X - Prevalent Invasive Species* lists problematic non-native species that are established in Tioga County. While all species listed here are not native to Tioga County, those species highlighted in red are considered to pose a severe ecological threat than some of the others (Rank 1), species highlighted in yellow are considered to pose a significant ecological threat but not considered to spread as easily and aggressively (Rank 2), and species highlighted in green are considered to pose a lesser ecological threat (Rank 3).

Table X - Prevalent Invasive Species

Prevalent Invasive Species (EDDMaps, 2021; iMapInvasives, 2021; PA DCNR, 2019)		
Scientific Name	**Common Name**	**Type**
Corbicula fluminea	Asiatic Clam	Animal
Lonicera spp	Bush Honeysuckle	Plant
Cirsium vulgare	Bull Thistle	Plant
Cirsium arvense	Canada Thistle	Plant
Cyprinus carpio	Common Carp	Animal
Phragmites australis ssp. australis	Common Reed	Plant
Tanacetum vulgare	Common Tansy	Plant
Agrilus planipennis	Emerald Ash Borer	Insect
Myriophyllum spicatum	Eurasian Watermilfoil	Plant
Alliaria petiolata	Garlic Mustard	Plant
Fallopia sachalinensis	Giant Knotweed	Plant
Frangula alnus	Glossy Buckthorn	Plant
Lymantria dispar	Gypsy Moth	Insect
Adelges tsugae	Hemlock Woolly Adelgid	Insect

Scientific Name	Common Name	Type
Berberis thunbergii	Japanese Barberry	Plant
Lonicera japonica	Japanese Honeysuckle	Plant
Polygonum cuspidatum	Japanese Knotweed	Plant
Microstegium vimineum	Japanese Stiltgrass	Plant
Persicaria perfoliata	Mile-A-Minute Vine	Plant
Lonicera morrowii	Morrow's Honeysuckle	Plant
Rosa multiflora	Multiflora Rose	Plant
Celastrus orbiculata	Oriental Bittersweet	Plant
Lythrum salicaria	Purple Loosestrife	Plant
Ailanthus altissima	Tree-of-Heaven	Plant
Dreissena polymorpha	Zebra Mussel	Animal
Elaeagnus umbellata	Autumn Olive	Plant
Cryptococcus fagisuga	Beech Bark Disease	Disease
Tussilago farfara	Colt's-foot	Plant
Potamogeton crispus L.	Curly-leaved Pondweed	Plant
Popillia japonica	Japanese Beetle	Insect
Poa pratensis	Kentucky Bluegrass	Plant
Phalaris arundinacea	Reed Canary Grass	Plant
Centaurea stoebe ssp. micranthos	Spotted Knapweed	Plant
Anthoxanthum odoratum	Sweet Vernal Grass	Plant
Myosotis scorpioides	True Forget-me-not	Plant
Cronartium ribicola	White Pine Blister Rust	Disease
Halyomorpha halys	Brown Marmorated Stink Bug	Insect
Ophiognomonia clavigignenti-juglandacearum	Butternut Canker	Disease
Hypericum perforatum	Common St. John's-wort	Plant
Holcus lanatus	Common Velvetgrass	Plant
Achillea millefolium	Common Yarrow	Plant
Discula destructiva	Dogwood Anthracnose	Disease
Euphorbia esula	Leafy Spurge	Plant
Harmonia axyridis	Multicolored Asian Lady Beetle	Insect
Hieracium aurantiacum	Orange Hawkweed	Plant
Rorippa nasturtium-aquaticum	Watercress	Plant

4.3.5.4 Future Occurrence

According to the Pennsylvania Invasive Species Council (PISC), the probability of future occurrence for invasive species threats is growing due to the increasing volume of transported goods, increasing efficiency and speed of transportation, and expanding international trade agreements. Expanded global trade has created opportunities for many organisms to be transported to and establish themselves in new counties and regions. In 2017, Pennsylvania alone imported over $83 billion in goods from abroad, including agricultural, forestry, and fishery goods that commonly carry unknow pests. Climate change is contributing to the introduction of new invasive species. As maximum and minimum seasonal temperatures change, pests can establish themselves in previously inhospitable climates. This also gives introduced species an earlier start and increases the magnitude of their growth, possibly shifting the dominance of ecosystems in the favor of non-native species. In order to combat the increase in future occurrences, the PISC released the Invasive Species Management Plan in April 2010 and updated the plan in 2017. The plan outlines the Commonwealth's goals for managing the spread of nonnative invasive species and creates a framework for responding to threats through research, action, public outreach, and communication. More information can be found here: https://www.agriculture.pa.gov/Plants_Land_Water/PlantIndustry/GISC/Pages/default.aspx.

There are several invasive species that are found near Tioga County but have not yet been detected inside the county (see *Table X – Future Vulnerable Species*). Especially in cases like this, control efforts, heightened awareness, and public outreach and education can help prevent an invasive species from becoming established in the future. Once a species is established, it is more difficult to eradicate it from an ecosystem meaning prevention is very important. The species that are labeled in red are listed as a Rank 1 species, which indicates a severe ecological threat to the environment. Therefore, European Water Chestnut, Goatsrue, Japanese Hops, Oriental Lady's-thumb, and Spotted Lanternfly are all widespread and highly problematic in nearby counties but have not been reported in Tioga County (as shown highlighted in red in *Table X – Future Vulnerable Species*). The development of appropriate plans will assist the county in reducing the possibility of a future encounter with any of these species. It would be beneficial to the forests of Tioga County to work toward keeping these species out of the area.

Table X – Future Vulnerable Species

Future Vulnerable Species (EDDMaps, 2021; PA DCNR, 2019; iMapInvasives, 2021)		
Scientific Name	**Common Name**	**Type**
Lithobates catesbeianus	American Bullfrog	Animal
Brassica nigra	Black Mustard	Plant
Otiorhynchus sulcatus	Black Vine Weevil	Insect
Bromus tectorum L.	Cheatgrass	Plant
Solanum dulcamara	Climbing Nightshade	Plant
Trapa natans	European Water Chestnut	Plant
Convolvulus arvensis	Field Bindweed	Plant
Galega officinalis	Goatsrue	Plant
Humulus japonicus	Japanese Hop	Plant
Pristiphora erichsonii	Larch Sawfly	Insect
Artemisia vulgaris	Mugwort	Plant
Carduus nutans	Musk Thistle	Plant

Scientific Name	Common Name	Type
Polygonum caespitosum	Oriental Lady's-thumb	Plant
Ligustrum spp.	Privet	Plant
Trachemys scripta elegans	Red-eared Slider	Amphibian
Lycroma delicatula	Spotted Lanternfly (Lycorma)	Insect
Salix alba	White Willow	Plant

4.3.5.5 Vulnerability Assessment

Tioga County's vulnerability to invasion depends on the species in question. Human activity and mobility are ever increasing, and combined with the prospects of climate change, invasive species are becoming increasingly threatening. Invasive species can have adverse economic effects by impacting agriculture and logging activities. Natural forest ecosystems provide clean water, recreational opportunities, habitat for native wildlife, and places to enjoy the tranquility and transcendence of nature. The balance of forest ecosystems and forest health are vulnerable to invasive species threats. While there is significant acreage of wetlands, waterways, state parks, and game lands in Tioga County where forest managers can impact invasive species, private lands can provide refuge for invasive species if landowners are unaware of or apathetic towards the threat.

Since there are large swatches of public land in Tioga County, there is a risk of future damage from invasive species that are present in the area. With 26,599 SGL acres in Tioga County (which takes up about 3.7% of the county), there is vulnerability to various land sites and waterways. If an invasive species were to invade the popular terrestrial areas or waterways in Tioga, great devastation would occur. The invasion from an invasive species could cause damage to the scenic and natural resources needed in the county. Additionally, tourism for the county is vulnerable to the invasive species as well and would be affected if the parks were destroyed. Therefore, a great amount of land and native wildlife within Tioga County are at risk with the presence of invasive species.

An interesting facet of the invasive species problem in Pennsylvania is that deer do not eat many invasive plants, giving invasive species a competitive advantage over the native species that deer prefer. As such, the management of deer populations in Tioga County has a significant impact on the vulnerability of an ecosystem to invasive species, where overpopulation of deer favors invasive species.

The Governor's Invasive Species Council of Pennsylvania (PISC) has identified over 100 species threats that are or could potentially become significant in Pennsylvania. Of these threats, county and municipal leaders believe that the most significant are invasive forest pests like the Emerald Ash Borer, Hemlock Woolly Adelgid, and plants like the Tree-of-Heaven which all been identified red in *Table X - Prevalent Invasive Species* for priority species in Tioga County.

Due to the past experiences with invasive plants in the county, there are five primary components which help with managing invasive plants to lower vulnerability:

Prioritize: Public use areas such as state parks and other healthy forest ecosystems should be prioritized over developed and private areas. Locations with lower densities of invasive plants are often easier to control and should be given quick attention. Locations where humans are disturbing the landscape opens up niche space, and often times the aggressive invasive species move in faster than native species. Such locations include areas around road work, ditch/culvert work, logging activities, stream improvement/stabilization and bridge work. Some species pose a higher risk than others - invasive species are easiest to control before they become widespread and established in an area, and for that reason, species that are less widespread should be prioritized for management.

Locate: Detailed locations should be recorded for invasive plants so sites can be easily relocated, treated, and monitored.

Delineate: The scale and extent of the infestation should be recorded and mapped so that the progress of the infestation can be monitored.

Control: Methods of control depend on the specific infestation, but the most common approaches are mechanical (cutting and hand-pulling) and chemical (herbicide treatments).

Monitor: Identified sites should be monitored and revisited as often as several times in a growing season (depending on the location/species). Monitoring can allow for early detection of spreading infestations. Most importantly, it prevents a relapse towards full-blown infestation.

It is best to act before a species can become established in the county, so forest management such as park rangers should be aware of invasive species found nearby Tioga County but not yet present in the county (priority species in *Table X – Future Vulnerable Species*). Public outreach and education are important for these species to improve identification and prevention of invasion. Without action, due to the instances and extent of the current infestations, it is reasonable to project that the county’s vulnerability will increase.

4.3.6. Landslides

4.3.6.1 Location and Extent

The large regions of Pennsylvania have a variety of different topography, with each area having a different susceptibility to landslides. Landslide are described as downward and outward movement of slope-forming soils, rock, and vegetation reactive to the force of gravity. Rockfalls, rockslides, rock topples, block glides, debris flows, mud flows, and mudslides are all forms of landslides. Natural causes of landslides include heavy rain, rapid snow melt, erosion, earthquake, and changes in groundwater level. Landslides occur most frequently in areas with moderate to steep slopes and high precipitation, and most often slope failures happen during or after periods of sustained or above average precipitation or snow melt events. Human activity can increase the likelihood of landslides by reducing vegetation cover, altering the natural slope gradient, or increasing the soil water content. Areas where this type of human activity is common are areas that were excavated along highways and other roadways.

Most landslides are slow moving and more often cause property damage rather than causing human injury. These landslides are due to geologic properties of the area that make it easily prone to erosion.

4.3.6.2 Range of Magnitude

Landslides can cause damage to utilities as well as transportation routes, resulting in road closure or travel delays. Fortunately, deaths and injuries due to landslides are rare in Pennsylvania and Tioga County. Most reported deaths due to landslides have occurred when rockfalls or other slides along highways have involved vehicles. Storm-induced debris flows can also sometimes cause death and injury. As residential and recreational development increases on and near steep mountain slopes. The hazard from these rapid events will also increase. Most Pennsylvania landslides are moderate to slow moving and damage property rather than people.

The Pennsylvania Department of Transportation (PennDOT) and large municipalities incur substantial costs due to landslide damage and to extra construction costs for new roads in landslide-prone areas. A 1991 estimate showed an average of $10 million per year is spent on landslide repair contracts across the Commonwealth and a similar amount is spent on mitigation costs for grading projects. A number of highway sites in Pennsylvania are in need of permanent repair at estimated costs of $300,000.00 to $2 million each (DCNR, 2010). Areas that are susceptible to landslides are geologically prone to giving way after significant precipitation events.

4.3.6.3 Past Occurrence

No comprehensive list of landslide incidents in Tioga County is available, as there is no formal reporting system in place. PennDOT and municipal maintenance departments are responsible for slides that inhibit the flow of traffic or damage to roads and bridges, but they generally only repair the road itself and right-of-way areas. The county has a record of one incident that occurred in the early 1970's during the construction of Route 15 in Tioga Township and another that took place in Heffner Hollow in September of 2018 (see *Figure X – Heffner Hollow Landslide* below). In addition, as a result of flooding that took place in April 2011, there was another incident that required repair to Route 15, section 144. Due to anecdotal evidence, there have been minor landslides in the past decade that did not result in deaths or serious damages around the county.

Figure X – Heffner Hollow Landslide

Image provided by the Tioga County Conservation District

Figure X – Canoe Camp Creek Streambank Stabilization, depicted below, shows progress being made on streambanks at Canoe Camp Creek to prevent landslides and other hazards that may result due to embankment failure.

Figure X - Canoe Camp Creek Streambank Stabilization

Image provided by the Tioga County Conservation District

4.3.6.4 Future Occurrence

The entirety of Tioga County falls within a region defined by Pennsylvania Department of Conservation of Natural Resources (DCNR) as having high susceptibility in steep areas along stream beds, valleys, and bluffs. A large portion of the county sits along valleys, in bluffs, or along stream beds. Most of the major transportation corridors through and around Tioga County occur in areas where all three vulnerabilities are present. Road cuts are the most common development that puts an area at an increased probability of a landslide or erosion event. The Pennsylvania Department of Environmental Protection has an Erosion and Sediment (E & S) program that sets requirements for which development projects of a certain scale are intended to mitigate erosion, which are similar practices to prevent causing landslides.

4.3.6.5 Vulnerability Assessment

Landslides are often precipitated by other natural causes such as earthquake or floods, and a serious landslide can cause millions of dollars in damage. Continued enforcement of floodplain management and proper road and building construction helps to mitigate the threat of landslides. Floodplain management is important where mining has occurred within the proximity to watercourse and associated flat-lying areas. Surface water may permeate into areas that still have open fractures and the build-up of surface water in fractures could lead to unexpected flood events.

A comprehensive database of land highly prone to erosion and landslides is difficult to come by. Construction projects in Tioga County should be wary of erosion and the potential for landslides. There are several general factors that can be indicators of a landslide prone area. These include:

- On or close to steep hills.
- Areas of steep road cuts or excavations.
- Steep areas where surface run-off is channeled.
- Fan shaped areas of sediment ad rock accumulations.
- Evidence of past sliding such as tilted utility lines, tilted trees, cracks in the ground and irregularly surface ground.

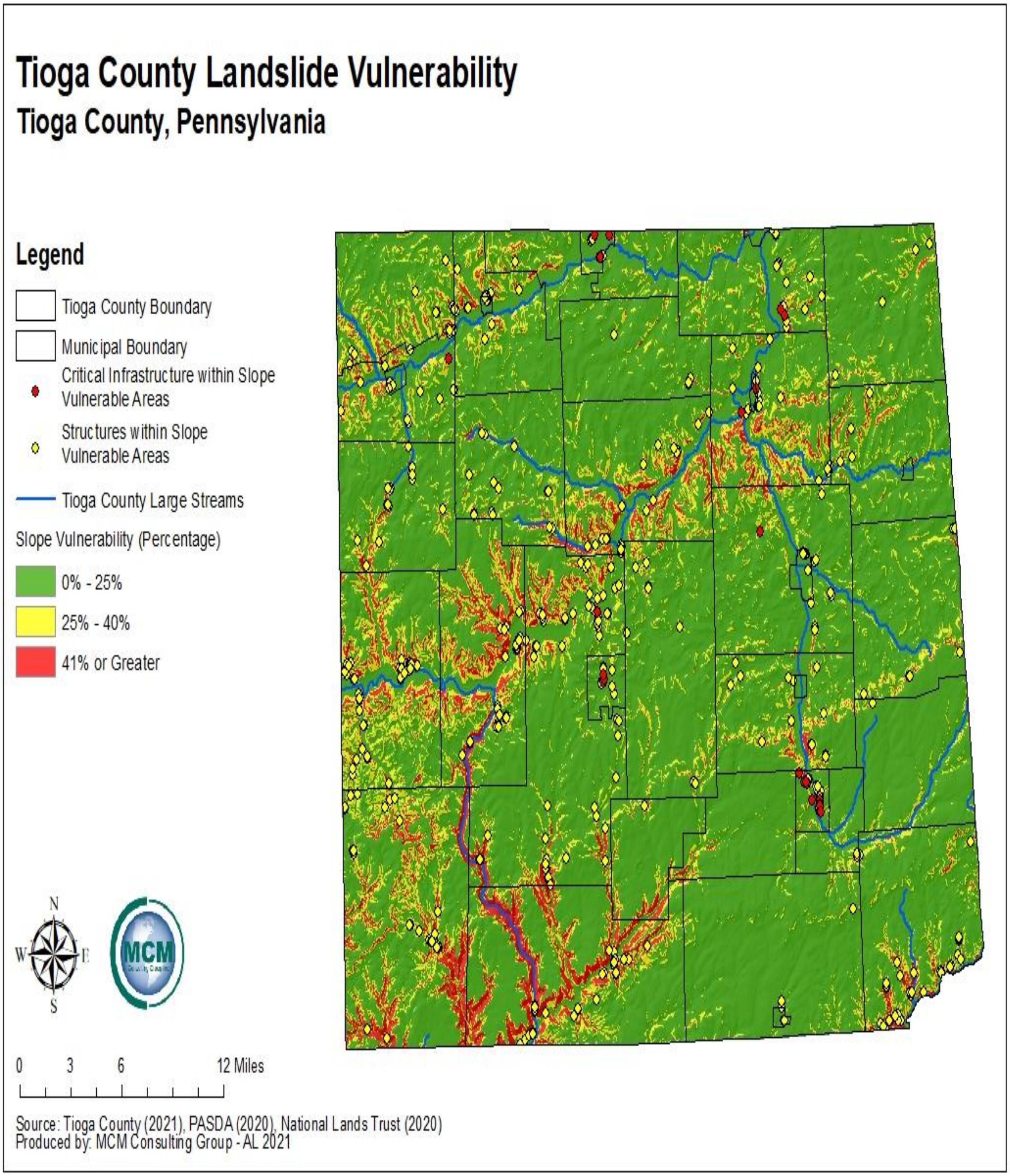
Tioga County has approximately 583 structures that are at risk to landslide vulnerability. These structures are within an area that has a high percentage of slope, which given specific sets of weather patterns, could result in a landslide. There are 1,248 critical infrastructure or functional needs facilities that fall within high percentage slope areas for Tioga County. *Figure X – Landslide Vulnerable Structures* shows structure within Tioga County that are within a high slope area where the slope percentage is severe. *Table X – Structure Vulnerability Data* illustrates the number of site structures per municipality, the number of structures in high slope areas, and the number of critical infrastructure sites in the high slope area.

Table X – Structure Vulnerability Data

Structure Vulnerability Data (Tioga County, 2021)			
Municipality	**Number of Structures within Municipality**	**Number of Structures within Slope Vulnerable Area**	**Number of Critical Infrastructure within Slope Vulnerable Area**
Bloss Township	423	0	0
Blossburg Borough	1184	24	10
Brookfield Township	674	10	0
Charleston Township	3342	16	0
Chatham Township	1072	17	0
Clymer Township	951	18	0
Covington Township	1475	18	0
Deerfield Township	877	11	0
Delmar Township	3633	70	1
Duncan Township	321	1	0
Elk Township	329	42	0
Elkland Borough	1298	9	3
Farmington Township	1034	6	0
Gaines Township	1512	58	0
Hamilton Township	607	2	0
Jackson Township	2135	4	0
Knoxville Borough	536	9	0

Municipality	Number of Structures within Municipality	Number of Structures within Slope Vulnerable Area	Number of Critical Infrastructure within Slope Vulnerable Area
Lawrence Township	1658	20	2
Lawrenceville Borough	427	0	0
Liberty Borough	221	4	0
Liberty Township	1456	4	0
Mansfield Borough	1225	6	0
Middlebury Township	1536	24	0
Morris Township	1299	34	0
Nelson Township	628	2	0
Osceola Township	750	1	0
Putnam Township	394	0	0
Richmond Township	2655	13	1
Roseville Borough	172	0	0
Rutland Township	903	4	0
Shippen Township	901	43	0
Sullivan Township	1722	8	0
Tioga Borough	450	0	0
Tioga Township	1141	25	2
Union Township	1405	47	0
Ward Township	778	1	0
Wellsboro Borough	2486	13	3
Westfield Borough	920	3	0
Westfield Township	1378	16	1

Figure X – Landslide Vulnerable Structures



4.3.7. Pandemic and Infectious Disease

4.3.7.1 Location and Extent

Pandemic & Epidemic

An epidemic occurs when an infectious disease spreads more quickly than experts expect. It is characterized by very widespread growth or extent that spreads quickly and affects many individuals at the same time. When an epidemic occurs, it typically impacts a larger area than an outbreak would. The rise and decline in epidemic prevalence of an infectious disease is dependent on the transfer of an effective dose of the infectious agent from an infected individual to a susceptible one. After an epidemic has subsided, the affected host population contains a small proportion of susceptible individuals that reintroduction of the infection will not result in a new epidemic. Therefore, the host population develops an immunity to the epidemic disease, which is termed as herd immunity.

A pandemic is a disease outbreak that spreads across countries or continents, which affects the population of an extensive area. Extensive regions that could potentially be affected are several counties, countries or even continents at a time. When a pandemic is present, the event usually affects more people and takes more lives than an epidemic typically would. Pandemics are further described as an extensive epidemic. Generally, pandemic diseases cause sudden illness in all age groups on a global scale. Pandemics are continuous events in third-world countries but do not affect the United States as frequently. A pandemic is measured and defined by the spreading of a disease rather than the fatalities associated with it. There are various characteristics of a pandemic outbreak, such as large, rapid scale spread, overload of healthcare systems, inadequate medical supplies, disruption of economy/society, and medical supply shortages. While a pandemic may be characterized as a type of epidemic, an epidemic is not a type of pandemic. Pandemics travel more effectively than epidemics.

Each year, different strains of influenza are labeled as potential pandemic threats. Pandemics happen when novel (new) viruses emerge and can infect people easily and spread efficiently and are sustained from person to person. In the event of a pandemic taking place in the eastern United States, the entirety of Tioga County would likely be impacted. Strains of influenza, or the flu, are highly contagious as they commonly attack the respiratory tract in humans. Influenza pandemic planning began in response to the H5N1 (avian) flu outbreak in Asia, Africa, Europe, the Pacific, and the Near East in the late 1990s and early 2000s. Avian flu did not reach pandemic proportions in the United States, but the country began planning for flu outbreaks.

The 2009 H1N1 flu virus resulted in seventy-eight deaths in Pennsylvania by the time the pandemic ended. Studies after the 2009 H1N1 influenza pandemic showed that the strain disproportionately impacted people younger than twenty-four years old. Schools have potential to become outbreak centers due to their large young adult populations, high levels of close social contact, and permeable boundaries. During a pandemic or disease outbreak, the population affected may exceed the seasonal norm of 1/3 of the student population. Because universities and schools can be sites of transmission, they may cause a virus to spread among the surrounding community as well.

On March 11, 2020, the World Health Organization (WHO) characterized the outbreak of a coronavirus disease as a pandemic. The virus was named “SARS-CoV-2” and the disease it causes is named “coronavirus disease 2019” (COVID-19). The virus mostly attacks the respiratory tract in humans but can cause further medical issues if the patient was previously considered high risk or immunocompromised. Both the upper respiratory tract, such as sinuses, nose, and throat) and lower respiratory tract, such as windpipe and lungs, are initially infected as a result of the disease. Lungs are typically the first targeted organ in the body for COVID-19. Other organs that could possible be infected by COVID-19 are the heart, brain, liver and gastrointestinal. Coronaviruses are common in humans and many different species of animals including camels, cattle, cats, and bats. The disease is believed to have started in Wuhan Province, China in late 2019 and spread around the globe. The original source of viral transmission to humans remains unclear, as does whether the virus became pathogenic before or after the spillover event. The intermediate animal that passed the virus from bats to people has not been identified, however researchers believe it to be a wild species that is sold as food in the wet markets within Wuhan at the Huanan Seafood Market. The overall origin of the virus remains uncertain during the writing of this plan. However, as the WHO digs into the origin of the COVID-19 pandemic, more clues and evidence leading to the origination of the virus is becoming clearer due to the high research and science technology available in today’s medical fields. Public health officials say it is critical to determine the identification of the origin of the pandemic to take steps to avert future outbreaks and pandemics. Future prevention may take many years for completion. Currently, researchers of the WHO believe it to be a zoonotic disease with origination from an animal reservoir rather than bioterrorism or laboratory accidental.

Infectious Disease

Infectious diseases are illnesses caused by pathogenic organisms such bacteria, viruses, fungi, or parasites. There are various types of bacterial organisms that live on and within the human system but are considered harmless due the normal flora present. Organisms become harmful and cause disease when under certain conditions. The causes of infectious diseases vary. The sources of infectious disease occur from contaminated food or waterways, infected animals/livestock, infection from biological vectors such as mosquitoes, etc. Infectious diseases include influenza, rabies, Middle East Respiratory Syndrome (MERS), West Nile virus, Lyme Disease, Zika virus, and Ebola virus.

West Nile virus is contracted through a mosquito bite and is aided by warm temperatures and wet climates conducive to mosquito breeding, with most cases occurring between April and October. West Nile virus is a vector-borne disease. This means an animal, usually an insect or a tick, transmits parasitic microorganisms to people and animals, and therefore, the diseases they cause. The disease causes headaches, high fever, neck stiffness, disorientation, tremors, convulsions, muscle weakness, paralysis, and death in its most serious form.

Lyme Disease, spread by the bite of infected blacklegged ticks, is a bacterial disease with symptoms including fever, headaches, and characteristic skin rash. Untreated, Lyme Disease can spread to joints, the heart, and the nervous system (CDC, 2016). To prevent the disease, it is recommended to use insect repellent, remove ticks promptly, apply pesticides, and reduce tick habitat.

The Zika virus is another infectious disease that is spread by mosquito bites and it is related to West Nile virus. Zika virus can also be spread through sexual intercourse, blood transfusion, or passed from mother to child in the womb. The virus was first identified in 1947, but largely came to the attention of the United States in 2015 when there was an outbreak of Zika in Brazil. The direct illness caused by Zika can include fever, red eyes, joint pain, headache, and a rash, or sometimes no symptoms at all. Zika is problematic for pregnant mothers as the virus can result in microcephaly or cause other problems for brain development. For adults, the virus can be linked to increased incidence of Guillain-Barré syndrome.

Pandemic and infectious disease events cover a wide geographical area and can affect large populations, potentially including the entire population of the Commonwealth. The exact size and extent of an infected population is dependent upon how easily the illness is spread, the mode of transmission, and the amount of contact between infected and uninfected individuals. The transmission rates of pandemic illnesses are often higher in denser areas where there are large concentrations of people. The transmission rate of infectious disease will depend on the mode of transmission of a given illness. Pandemic events can also occur after other natural disasters, particularly floods, when there is the potential for bacteria to grow and contaminate.

4.3.7.2 Range of Magnitude

Pandemic & Epidemic

Public health emergencies typically occur on a regional basis. The magnitude of pandemic or infectious disease threat in the Commonwealth will range significantly depending on the aggressiveness of the virus in question, factors within the community that are impacted (medical care access, population density, etc.), and the ease of transmission. For example, the West Nile virus has less than 80% of cases that are clinically asymptomatic. Therefore, approximately 20% of the cases result in mild infection, as known as West Nile fever. However, there is a small percentage of cases that will result in severe neurological disease and even death.

Pandemic influenza has a higher transmission rate from person-to-person compared to the West Nile virus disease. However, advances in medical technologies have greatly reduced the number of deaths caused by the influenza over time. In the early 1900s, flu pandemics could cause tens of millions of deaths, while the 2009 Novel H1N1, known as swine flu, caused fewer than 20,000 deaths world-wide, and many people infected with swine flu in 2009 recovered without needing medical treatment. However, the modern flu viruses are still quite dangerous. About 70% of those who were hospitalized during the 2009 H1N1 flu virus in the United States belonged to a high-risk group. However, with the COVID-19 pandemic, the transmission rates are much higher than any previous outbreaks related to other members of the coronavirus family such as SARS-CoV and MERS-CoV. In the past 100 years, the globe did not face a microbial pandemic similar in scale to the COVID-19 pandemic. As of the writing of this plan, the worldwide transmission of COVID-19 from human to human is spreading rapidly. The current data includes 134 million COVID-19 cases with more than 2.9 million patient deaths; however, it is difficult to make a projection of the final outcomes with the COVID-19 pandemic. Of the six global outbreaks of viral infections, three were caused by coronaviruses (SARS, MERS, and COVID-19), of which COVID-19 is characterized by the most efficient and aggressive transmission.

High risk populations for diseases/illnesses include children, the elderly, pregnant women, and patients with reduced immune system capability. The advancements of medical technology help with previous and current pandemics. The wireless thermometer gun has become increasingly popular and beneficial to the COVID-19 pandemic by giving opportunity to measure individual's body temperatures without being in close contact. Additionally, the wireless thermometer gun assists with pinpointing individuals that may be COVID infected if the individual has a fever, which helps reduce spread of the disease. This important medical equipment is being used as checkpoints during the pandemic at various public destinations such as hospitals, nursing home facilities, airports, etc. Other advances in medical technology instruments for COVID-19 include vaccination advancements (such as the new mRNA vaccines which have been seen with the Pfizer, Moderna, and Johnson & Johnson vaccines), virus DNA sequencing, and molecular testing techniques for COVID-19 diagnosis.

With the advancements made during pandemics, such as the COVID-19 pandemic, the global effects of various outbreaks have drastically declined over the past century. While there are limited secondary hazards related to public health emergencies, an outbreak can cause a variety of general secondary effects. Civil disorder is the most likely secondary hazard to result from a public health emergency. Further potential secondary effects could include: a shortage of medical supplies and personnel; hoarding of household paper and cleaning supplies; school, business, and government closings; government restrictions on travel; low attendance at places of employment; and, slowed productivity.

The seasonal flu is still present throughout the country during a pandemic. A pandemic illness is not identical to a seasonal flu, as explained in *Table X – Pandemic and Seasonal Flu Differences*. The seasonal flu is less of a concern than what a pandemic potentially is. Predictability and regularity are factors into the reasoning behind less of a concern when dealing with seasonal flu. However, a pandemic is considered to be more severe than seasonal flu due to lack of these factors.

Table X – Pandemic and Seasonal Flu Differences

Pandemic and Seasonal Flu Differences		
	Seasonal Flu	**Pandemic**
What is it?	Influenza (flu) is a contagious respiratory illness caused by flu A and B viruses that infect the human respiratory tract.	A flu pandemic is a global outbreak of a new flu A virus in people that is very different from current and recently circulating seasonal flu A viruses.
Occurrence?	Epidemics of seasonal flu happen every year. Fall and winter is the most common time for flu in the United States.	Flu pandemics happen rarely. Five have happened within the last 100 years.
Transmission ?	Flu viruses are thought to spread mainly from person to person through droplets made when someone with flu coughs, sneezes, or talks near a person (within 6 feet).	Pandemic flu viruses spread in the same way as seasonal flu, but a pandemic virus is likely to infect more people because fewer people have immunity to the pandemic flu virus.
Vaccination?	Seasonal flu vaccines are made each year to vaccinate people against the seasonal flu. Typically, only one dose is needed.	Although the U.S. government maintains a limited stockpile of pre-pandemic flu vaccines, this inventory may not be widely available in the early stages of a pandemic. Two doses of pandemic flu vaccine are likely to will be needed.
High Risk Group?	Young children, people sixty-five years and older, pregnant women, and the immunocompromised are more likely to have serious flu complications.	In some past pandemics, healthy and young adults, along with the immunocompromised and elderly were at high risk for developing severe flu complications.
Source: (CDC, 2009)		

The World Health Organization (WHO) developed an alert system to help inform the world about the seriousness of a pandemic. The alert system has six phases, with Phase 1 being the lowest risk and Phase 6 being the greatest risk of pandemic. The phases were developed in 1999, but then revised in 2005 and 2009 to provide a global framework and aid countries in pandemic preparedness and response planning. The time after the first pandemic wave has been elaborated into post peak and post pandemic periods. These phases are listed below in *Table X - Pandemic Influenza Phases*.

Table X - Pandemic Influenza Phases

Pandemic Influenza Phases	
Phase	**Characteristics**
Phase 1	No animal influenza virus circulating among animals has been reported to cause infection in humans.
Phase 2	An animal influenza virus circulating in domesticated or wild animals is known to have caused infection in humans and is therefore considered a specific potential pandemic threat.
Phase 3	An animal or human-animal influenza reassortant virus has caused sporadic cases or small clusters of disease in people but has not resulted in human-to-human transmission sufficient to sustain community-level outbreaks.
Phase 4	Human-to-human transmission (H2H) of an animal or human-animal influenza virus able to sustain community-level outbreaks has been verified.
Phase 5	The same identified virus has caused sustained community level outbreaks in two or more countries in one WHO region.
Phase 6	The pandemic phase is characterized by community level outbreaks in at least one other country in a different WHO region in addition to the criteria defined in Phase 5. Designation of this phase will indicate that a global pandemic is under way.
Post-Peak Period	Levels of pandemic influenza in most countries with adequate surveillance have dropped below peak levels.
Possible New Wave	Level of pandemic influenza activity in most countries with adequate surveillance rising again.
Post-Pandemic Period	Levels of influence activity have returned to the levels seen for seasonal influenza in most countries with adequate surveillance.
Source: (WHO, 2009)	

4.3.7.3 Past Occurrence

Pandemic & Epidemic

Several pandemic influenza outbreaks have occurred over the past 100 years that not only affected Tioga County but the United States as a whole. *Table X - Past Pandemic Events in the*

United States illustrates the various past pandemic events that have occurred since the late 1800's. The worst recorded pandemic was the Spanish Flu, due to the amount of infection spread that was present in the world. The two most recent pandemics that have occurred in Tioga County and the United States are the swine flu/Novel H1N1 and COVID-19 pandemics, with COVID-19 having the highest transmission rates yet.

Spanish Flu

Prior to the COVID-19 world-wide pandemic, the 1918 influenza (Spanish Flu) pandemic was classified as the "Mother of all Pandemics". An estimated 1/3 of the world's population was infected and had clinically apparent illnesses during the 1918 - 1919 influenza pandemic. Pennsylvania was one of the most affected states in the country. The Spanish Flu claimed 500,000 lives in the United States, which included Tioga County. There is a lack of sources to provide with exact deaths experienced in Tioga from the Spanish Flu, however, a total of 60,000 deaths occurred in Pennsylvania from the Spanish Flu. Philadelphia itself lost about 12,000 lives and had about 47,000 reported cases in just over four weeks. In the first six months, there were about 16,000 deaths and half a million cases of the Spanish Flu in Philadelphia. Although Philadelphia had a great number of deaths, the 60,000 deaths would also include Tioga County's deaths, but the exact number is uncertain. The factors of high populations, crowded places, and unhygienic conditions is what caused higher deaths and cases across Pennsylvania. Therefore, Tioga County was drastically affected by the Spanish Flu Pandemic.

Swine Flu/H1N1

Tioga County was impacted by the H1N1 virus during 2009. The Pennsylvania Department of Health set up clinics throughout the county to administer vaccines. There is a lack of sources when determining the exact cases and deaths from swine flu in Tioga County. However, Pennsylvania as a total had 10,940 cases and 78 deaths from this pandemic. Within the total cases and deaths of Pennsylvania, Tioga County's numbers were included although exact numbers are uncertain.

COVID-19

This is an on-going pandemic at the time of the writing of this plan, so credible websites are used to provide the most up-to-date statistics. As of April 2021, Pennsylvania has an estimated 1,064,092 total cases and 25,380 deaths related to the COVID-19 pandemic occurred in the United States. The first cases in Pennsylvania were reported on March 6, 2020 in Delaware and Wayne counties. The first confirmed case of COVID-19 in Tioga County was on March 31st, 2020. As of April 2021, Tioga County alone has recorded 2,707 cases with 2,316 confirmed cases, 391 probable cases, and 9,046 negatives. Tioga County has a daily new case rate of 25.0% per 100,000, an infection rate of 0.97%, a positive test rate of 11.0%, and a vaccinated rate of 17.9%. A total of 101 deaths related to the COVID-19 pandemic have occurred in Tioga County. All municipalities in Tioga County indicated an increase in the pandemic section of the risk assessment valuations. The biggest peak of known cases for Tioga County was on December

13th, 2020, with the highest of cases in the county of fifty new cases a week. Over the winter of 2020-2021, much of Pennsylvania was experiencing a dangerous number of daily cases. The cases and deaths in Tioga County are still increasing. Therefore, exact numbers of deaths and cases are constantly changing. Pennsylvania is currently in vaccination Phase 1B, Tier 1, which include education workers. The Phase 1A included long-term care facility residents, health care personnel, individuals of ages 65 or older, and the high-risk individuals. Currently, between the three approved vaccines of Pfizer, Moderna, and Johnson & Johnson (newly approved vaccine) a total of 6,055,844 total vaccinations have been administered in Pennsylvania alone. During the writing of this plan, Tioga County specifically, a total of 2,275 individuals have been partially vaccinated which indicates that the person has received at least one COVID-19 vaccine but has not yet received the necessary number of vaccines at the recommended time intervals to be fully covered. At present, all COVID vaccines under EUA require two dosages. Therefore, the individual partially covered has only received one dose in the two-dose series. Meanwhile 5,035 individuals in Tioga County are fully vaccinated which indicates that the person has received the necessary number of COVID vaccines at the recommended time in intervals. Therefore, per 100,000 residents in Tioga County, 5,604.7 are vaccinated. To see more updated information, follow here: https://www.health.pa.gov/topics/disease/coronavirus/Pages/Cases.aspx.

Table X - Past Pandemic Events in the United States

Past Pandemic Events in the United States	
Year(s)	**Common Name**
1889	Russian Flu
1918	Spanish Flu/H1N1
1957	Asian Flu/H2N2
1968	Hong Kong Flu/H3N2
2009	Swine flu/Novel H1NI
2020	COVID-19
Sources: (WHO & CDC, 2020)	

Infectious Disease

Not only has Tioga County experienced past pandemic events, but the county has also experienced past infectious disease events. The two major infectious disease events experienced across Tioga County and Pennsylvania as a whole are the West Nile Virus and Lyme Disease. Due to large rural and wooded areas within the county, these infectious diseases thrive in Tioga County. Both diseases are transmitted by the biological vector of an insect which is found throughout the county.

West Nile Virus

West Nile virus reached the United States in 1999 and a year later was detected in Pennsylvania when mosquito pools, dead birds, and/or horses in nineteen counties tested positive for the virus. Tioga is one of the counties in which the virus is found. A comprehensive network has been developed in Pennsylvania that includes trapping mosquitoes, collecting dead birds, and monitoring horses, people and, in past years, sentinel chickens. Although West Nile Virus positive cases are limited in Tioga County, 2018 had the most positive cases in Tioga County since 2015. *Table X - West Nile Virus Control Program in Tioga County Since 2015* outlines the West Nile Virus within Tioga County from 2015 to 2020.

Table X - West Nile Virus Control Program in Tioga County Since 2015

West Nile Virus Control Program in Tioga County Since 2015				
Year	**Total Positives**	**Human Positives**	**Mosquito Positives**	**Bird Positives**
2020	0	0	0	0
2019	0	0	0	0
2018	2	1	1	0
2017	0	0	0	0
2016	0	0	0	0
2015	0	0	0	0
Source: (PA Department of Environmental Protection, 2020)				

Lyme Disease

Lyme Disease has been present in the United States and Tioga County for many years. More wooded areas, such as Tioga County, have higher cases due to ticks being the main biological vector. Lyme disease is found in all sixty-seven counties within Pennsylvania. Tioga County has an overall approximated 3,300 confirmed cases of Lyme disease according to the CDC. Tioga County experienced the highest number of positive cases in 2017 at eighty-five cases, compared to the lowest number of cases in 2013 at seventeen cases. However, it is possible that numbers have risen dramatically due to lack of testing in previous years. Lyme disease case counts are alarming and consistently rising over the past several years. Although, it should be noted that information represented for each county "may vary with respect to the resources they have to devote to investigation of Lyme cases". It should also be noted that these figures represent a rough estimate of the Lyme disease burden in Tioga County. *Table X - Lyme Disease Data for Tioga County* outlines the Lyme Disease within Tioga County since 2013 to 2018. Data after 2018 was not available in this report.

Table X - Lyme Disease Data for Tioga County

Lyme Disease Data for Tioga County	
Year	**Total Positives**
2018	61
2017	85
2016	57
2015	40
2014	24
2013	17
Source: (PA Department of Environmental Protection, 2018)	

4.3.7.4 Future Occurrence

Pandemic & Epidemic

The probability of a widespread pandemic public health emergency is every ten years or less with varying degrees of severity. Minor outbreaks of less serious communicable disease, such as influenza, occur much more frequently. Tioga County is expected to undergo pandemic influenza outbreaks every 11 - 41 years according to historical data. Exact timing of pandemic influenza outbreaks is unpredictable, and complete avoidance of the events is nearly impossible. Therefore, future occurrences of pandemics and infectious disease are unclear. Future pandemics may also emerge from other diseases, especially invasive pathogens for which Tioga County and Pennsylvania as a whole lack natural immunity. With the current pandemic of COVID-19, the future is still unknown in regard to the disease due to the novelty of the virus. Recently, the three approved COVID-19 vaccines of Pfizer, Moderna, and Johnson & Johnson vaccines have been offered to millions of Americans across the country, including Tioga County. The approval of the vaccines gives hope for the future of the current COVID-19 pandemic.

Infectious Disease

Pandemic future occurrences have several unknown circumstances; however, future infectious disease occurrences are likely to occur in the future. Infectious diseases such as West Nile Virus, Influenza, and Lyme Disease have been present in Tioga County for many years and are expected to continue in the future of Tioga County.

West Nile Virus

The best defense against West Nile virus in the future is to remove mosquito breeding locations – stagnant water sources. Another defensive measure to prevent future insect bites is wearing shoes, socks, long pants, and a long-sleeved shirt when outdoors for long periods of time, or when mosquitoes are most active. Also, mosquito repellent can be used whenever people are outside.

Influenza

It is estimated that 5% - 25% of Pennsylvanians get the flu each year, and 120 - 2,000 die from complications of influenza. The CDC recommends that everyone six months and older get a flu vaccine every season to prevent future cases from rising. People who are at a high risk of serious flu illness should take flu antiviral drugs as soon as they get sick.

Lyme Disease

Lyme disease is best combated using insect repellent, removing ticks promptly, applying pesticides, and reducing tick habitat to decrease the number of future cases from occurring. Once a person realizes they have been bitten by a tick, they should seek medical attention, as undetected Lyme Disease can seriously damage a body's musculoskeletal and nervous systems or result in death.

4.3.7.5 Vulnerability Assessment

The vulnerability for Tioga County associated with the COVID-19 disease and pandemic is considered to be low vulnerability. When looking at specific vulnerability with COVID-19, the vulnerability for crowded living and working areas is medium, older age and health issues is medium, population density is medium, health system challenges are medium, unemployment and short income is low, and minorities/non-English speakers is very low. However, it is extremely difficult to predict a pandemic or an epidemic. The severity of the next pandemic cannot be predicted, but modeling studies suggest the impact of a pandemic on the United States could be substantial. In the absence of any control measures (vaccination or drugs), it is estimated that a "medium-level" pandemic could cause 89,000 - 207,000 deaths, 314,000-734,000 hospitalizations, 18 to 42 million outpatient visits, and another 20 - 47 million sick people in the United States. Between 15% - 35% of the U.S. population could be affected by a pandemic, and the economic impact could range between $71.3 - $166.5 billion. This data for the current COVID-19 pandemic has fluctuated widely but, at the time of the writing of this plan, was on pace for greater than a "medium level" pandemic. The COVID-19 pandemic has severely affected populations over the age of sixty-five, especially those in nursing homes – disproportionately; it has also severely affected different races disproportionately, e.g., non-Hispanic American Indian and Black people. The CDC reports that long-standing systemic health and social inequities have put some members of racial and ethnic minority groups at increased risk of getting COVID-19 or experiencing severe illness, regardless of age.

Elderly individuals, children and immune deficient individuals are most vulnerable to disease. Nursing facilities, personal care facilities, daycares, schools, and hospitals are considered more vulnerable since there are normally groups of these functional-needs population present at the facilities. The spread of disease has increased due to the vulnerability and density of these populations. Congregate living facilities, including correctional institutions and dormitories would also be at an increased risk due to the difficulties in adhering to the social distancing required to help stop the spread of a pandemic. During the COVID-19 pandemic, nursing homes and personal care homes in Pennsylvania suffered staggering numbers of cases and deaths and several county jails and state correctional institutions reported wide community spread. Specifically, in Tioga County, nursing and personal care homes facilitates were critically affected by COVID-19. A total of six facilities in the county have had COVID-19 cases, three of which are long-term care facilities. With this number of infected facilities, about 201 cases were reported among the elderly residents and 103 cases were reported among the employees within these facilities. A total of fifty-nine deaths occurred in these vulnerable individuals of elderly and facility employees. The three major long-term care facilities in Tioga County are Broad Acres Health and Rehabilitation Center with eight-three resident cases, twenty resident deaths, and fifty-two employee cases, Green Home Inc. with eighty-five resident cases, thirty-five resident deaths, and forty-seven employee cases, and Carleton Healthcare and Rehabilitation Center with no available data of reported cases or deaths.

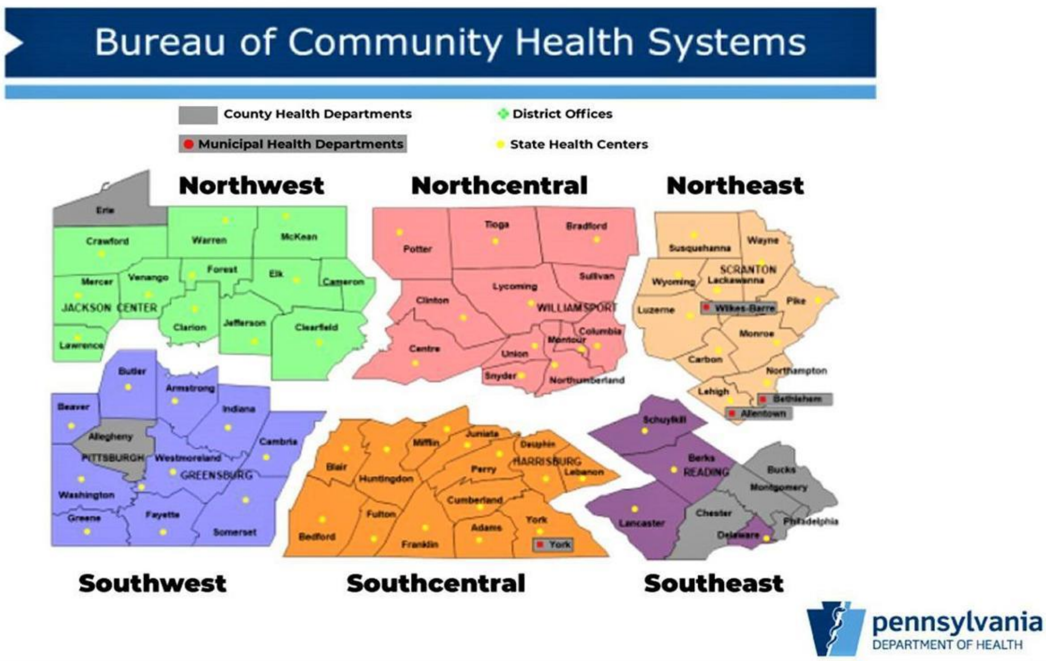
Health-care workers and those working in direct-care situations (such as correctional institutions or those who cannot social distance due to their jobs) are more likely to be exposed to a pandemic disease. Those that work outdoors for extended periods of time in warm months may be more vulnerable to West Nile, Lyme Disease or the Zika virus.

The number of hospitals and beds present in a county can affect the vulnerability impact on the county as well. The number of hospitals within the county and number of beds within the hospital determines the amount of care vulnerable and sick patients will receive in times of need. The vulnerable individuals will need access to hospitals and medical procedures as well. If sick and vulnerable patients are higher in number than beds available, the vulnerability rates within the county will rise. Within Tioga County, the top two major hospitals within the county contain numerous beds along with various medical and emergency centers. UPMC Wellsboro has 403 beds, and Laurel Health Medical Center- Wellsboro 124 beds. It is important to plan preparedness activities that will permit a prompt and effective public health response.

During a public health emergency, the PA DOH may open emergency medicine centers called points of dispensing (PODs) to ensure that medicine, supplies, vaccines, and information reach Pennsylvania residents during a public health emergency. An open POD is where the general public goes to receive free emergency medicine and supplies from public health officials, while a closed POD provides free emergency medicine and supplies to a specific community, like a university, including faculty, staff, and students. Dispensing of medications/vaccines is a core function of the Strategic National Stockpile’s Mass Dispensing of Medical Countermeasures Plan.

PODs are coordinated with county emergency managers by the PA DOH with the six regional healthcare districts (see *Figure X - Pennsylvania Department of Health Districts)*. Tioga County is in the northcentral district. At the time of the writing of this plan, POD planning for mass vaccinations against COVID-19 is occurring and hundreds of locations are offering the vaccinations of Pfizer, Moderna, and Johnson & Johnson vaccines.

Figure X – Pennsylvania Department of Health Districts



Source: (PA DOH, 2019)

4.3.8. Solar Flares

4.3.8.1 Location and Extent

Solar flares are concentrated releases of magnetic energy that emanate from sunspots and can last for minutes or hours. Solar flares can cause coronal mass ejections from the outer solar atmosphere which are large clouds of plasma and magnetic field which induce geomagnetic currents when they reach the surface of Earth. A combination of these events can be referred to as solar storms, solar weather, or space weather. Solar weather only impacts Earth when it occurs on the side of the sun that is actively facing Earth. A severe solar storm can have a geographically wide-ranging impact that can last for days or weeks (NASA, 2016).

4.3.8.2 Range of Magnitude

Minor solar flares have no negative impacts on Earth thanks to the protection afforded by Earth's magnetic field and atmosphere, but cause beautiful visual displays known as the Northern Lights or Aurora Borealis. However, severe solar storms can cause an electromagnetic pulse (EMP) that is able to break through Earth's magnetic field and send current to Earth's surface, inducing geomagnetic currents. Geomagnetically induced currents (GICs) impact the electrical grid and can cause transformers to burn and fail, potentially knocking out wide swatches of electricity infrastructure resulting in blackouts (Phillips, 2009). Electricity blackouts have many secondary effects, including limited water distribution capabilities, losing perishable foods and medicines, heating, and air conditioning as well as communication services. A solar EMP would also contribute to corrosion of oil and gas pipelines, disrupt high-frequency signals from global positioning system (GPS) satellites, and require aircrafts to avoid polar-routes to avoid communication malfunctions (Baker et al., 2008). Industries that are most impacted by severe space weather are: electric power, spacecraft, aviation, and other industries relying on GPS.

4.3.8.3 Past Occurrence

From August 28 to September 4 of 1859, two severe solar storms resulted in widespread auroral displays in North and South America, Europe, Asia, Australia, and as far south as Hawaii and Cuba (Baker et al., 2008). The event is known as the Carrington Event, and resulted in the widespread disruption of telegraph lines, even setting fire to some telegraph offices (Phillips, 2014). The Carrington Event is estimated to be one of the strongest recorded geomagnetic storm events.

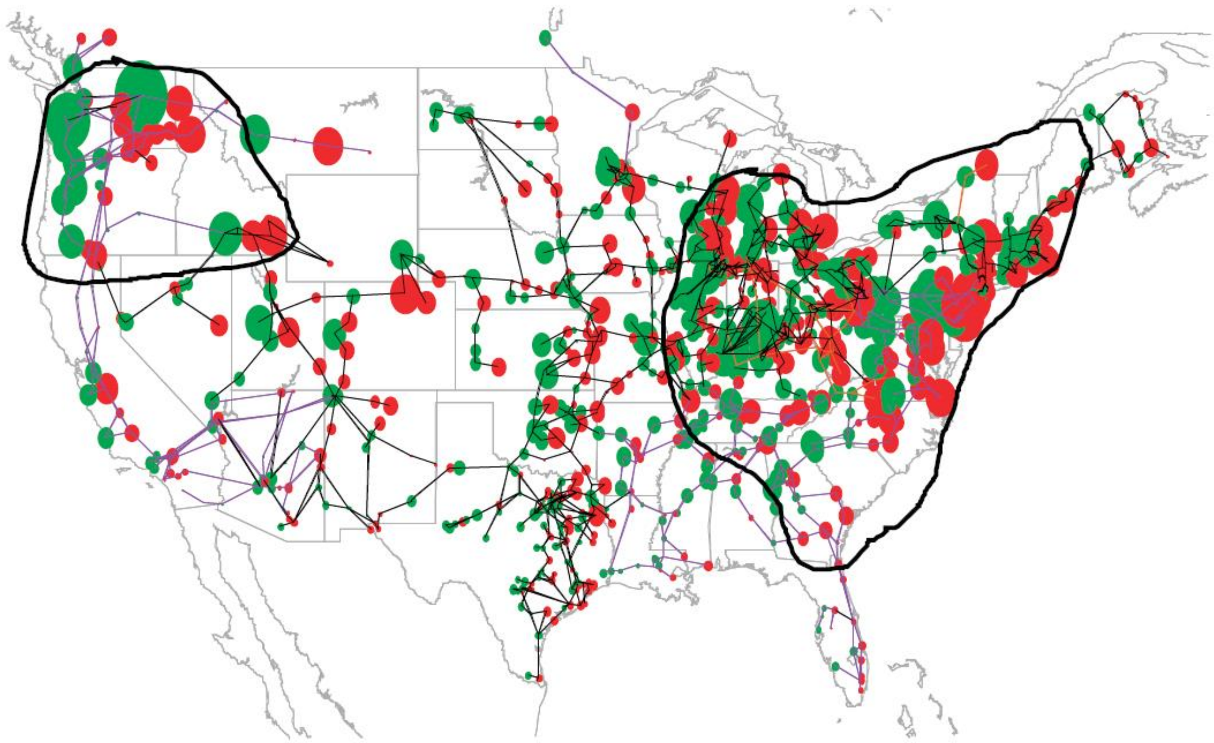
In March of 1989, a severe geomagnetic storm caused a widespread blackout (occurring within 90 seconds) in northeastern Canada's Hydro-Quebec power grid, resulting in over 6 million people being without electricity for 9 hours (Baker et al., 2008). On May 14 of 1921, a geomagnetic storm produced ground currents that are estimated to be half as strong as the Carrington event, but ten times stronger than the Hydro-Quebec event.

In July of 2012, a powerful solar storm produced an intense coronal mass ejection, estimated to be possibly stronger than the Carrington Event (Baker et al., 2013). Fortunately, due to the position of the event and the location of Earth in its orbit, the event missed Earth by as little as a week (Phillips, 2014). The STEREO-A spacecraft was, however, in the line of fire, and was able to record valuable data on the event (Baker et al., 2013).

4.3.8.4 Future Occurrence

Space weather is getting more attention as an infrastructure risk, due in part to a March 2020 report by the U.S. Geological Survey (USGS). Geomagnetic storms are caused by the dynamic action of the Sun and solar wind on the space environment surrounding the Earth. Magnetic disturbance during such a storm generates electric fields in the Earth's crust and mantle. These electric fields can interfere with the operation of grounded electric power-grid systems. Geomagnetic storms occur only occasionally, but when sufficiently energetic they can produce blackouts (USGS). It is estimated that the probability of occurrence in the next ten years of an extreme space weather event at the scale of the Carrington Event is 12% (Riley, 2012). If a solar storm on the scale of the 1921 event impacted our modern electricity infrastructure, it could permanently damage an estimated 350 transformers, and cause blackouts for 130 million people (*Figure xx – Potential Electricity Grid Failure*) (Baker et al., 2008).

Figure xx – Potential Electricity Grid Failure (Baker et al., 2008)



Scenario showing effects of a 4800 nT/min geomagnetic field disturbance at 50° geomagnetic latitude scenario. The regions outlined are susceptible to system collapse due to the effects of the GIC disturbance; the impacts would be of unprecedented scale and involve populations in excess of 130 million. SOURCE: J. Kappenman, Metatech Corp., "The Future: Solutions or Vulnerabilities?," presentation to the space weather workshop, May 23, 2008.

4.3.8.5 Vulnerability Assessment

The National Oceanic and Atmospheric Administration (NOAA) monitors solar activity from the Space Weather Prediction Center (SWPC) and is able to alert power grid operators of the impending geomagnetic storm so they may make efforts to protect the grid from GICs (Baker et al., 2008). Events such as the 1989 Hydro-Quebec blackout have illuminated the hazard that solar storms pose to electricity infrastructure, however modern power grids are more vulnerable than ever. Power grids have become increasingly interconnected, which improves efficiency in many ways, but makes them more vulnerable to wide-ranging rolling failures as seen in *Figure xx - Potential Electricity Grid Failure* (Baker et al., 2008).

Geomagnetic storms can cause permanent damage to transformers that could result in much longer restoration times than experienced in the 1989 Hydro-Quebec outage. Transformer damage occurs when GICs cause excessive internal heating resulting in melting and burning of many large-amperage copper windings and leads. Such damage cannot be repaired, and the damaged transformer must be replaced. Transformers are extremely large and heavy apparatuses, and replacement can be a long process, suggesting that efforts should be taken to protect resident transformers from GICs. A workshop held by the Committee on the Societal and Economic

Impacts of Severe Space Weather Events offered solutions to mitigating negative impacts of GICs, suggesting that supplemental transformer neutral ground resistors should be installed because they are relatively inexpensive, have low engineering trade-offs, and can produce 60% - 70% reduction of GIC levels during severe solar storms (Baker et al., 2008).

The sun goes through cycles of high and low activity that repeat approximately every 11 years. Solar minimum refers to the several Earth years when the number of sunspots is lowest; solar maximum occurs in the years when sunspots are most numerous. During solar maximum, activity on the sun and the possibility of space weather effects on the Earth's environment is higher.

Based on the number of sunspots that formed, scientists considered the last solar cycle, No. 24, "weak". No current observations or data show any impending catastrophic solar event, but some scientists believe the latest data of the upcoming solar maximum point to a stronger cycle. The solar cycle forecast was made public at the annual Space Weather Workshop in April 2021, hosted by NOAA's Space Weather Prediction Center. A solar physicist with Space Systems Research Corporation and co-chair of the panel issuing predictions, said Cycle No. 25 should begin between mid-2019 and late 2020 and that it should reach its maximum between 2023 and 2026, when between 95 and 130 sunspots are projected. Average is between 140 and 220 sunspots.

At present, with scientists' limited understanding of the patterns, the historical record suggests that such powerful Earth-sun events occur at least once a century (*Phys.org*).

And, as this profile was being drafted, NASA's STEREO-A and ESA/NASA's SOHO spacecraft detected a coronal mass ejection, or CME, leaving the Sun on April 17, 2021, at 12:36 p.m. This CME did not impact Earth but did move toward and reach Mars two days after NASA's *Ingenuity Mars* helicopter became the **first aircraft in history** to make a powered, controlled flight on another planet. NASA tracks such solar eruptions because they can trigger particle and radiation events that pose a risk to astronauts and sensitive spacecraft electronics. As astronauts venture beyond Earth's protective magnetic field to the Moon and Mars, NASA's Moon to Mars Space Weather Office at NASA Goddard Space Flight Center in Greenbelt, Maryland, in collaboration with the Community Coordinated Modeling Center, tracks solar activity to give advanced warning to spacecraft and crewed missions.

The CME caused no issues for concern and the *Ingenuity* team did not need to take any steps to protect the helicopter. However, NASA will continue to include space weather updates as a factor when making decisions around our technology – and one day, astronauts – on Mars.

The April 2021 CME demonstrates that as society's reliance on technological systems grows, so does vulnerability to space weather. The ultimate goal in studying space weather is an ability to foretell events and conditions on the Sun and in near-Earth space that will produce potentially harmful societal and economic effects, and to do this adequately far in advance and with sufficient accuracy to allow preventive or mitigating actions to be taken. The Department of

Homeland Security (DHS) has a Solar Storm Mitigation effort, which "aims to provide owners and operators of the electricity grid with advanced and actionable information about anticipated GCI current levels in the event of a solar storm" (US GAO, 2017). According to the DHS, when provided with accurate solar storm warnings, utility operators can "make operational decisions to mitigate the impacts from solar storms. This can range from canceling maintenance work to temporarily shutting down vulnerable grid components and preventing permanent damage" (DHS, 2015).

4.3.9. Subsidence and Sinkhole

4.3.9.1 Location and Extent

Subsidence is the sinking movement of the earth's surface; the result of this movement is commonly referred to as a sinkhole. There are two common causes of subsidence in Pennsylvania: 1) dissolution of carbonate rock such as limestone or dolomite and 2) mining activity. In the first case, water passing through naturally occurring fractures and bedding planes dissolves bedrock leaving voids below the surface. Eventually, overburden on top of those voids collapses, leaving surface depressions resulting in what is known as karst topography. This bedrock geology is found mostly in the south-central and eastern portions of Pennsylvania, and it is not a main component in the bedrock of Tioga County. Subsidence in the county is primarily a result of mining activity.

Areas which are underlain by coal or other minerals which are extracted through deep mining techniques may become susceptible to subsidence. This can be exacerbated by poor engineering practices at the time of withdrawal or progressive degradation in geological stability. Areas of Pennsylvania that have underlying mines are subject to subsidence and constitute a potential threat to the people living and working in those regions and areas. *Figure X – Abandoned Mined sites in Tioga County* illustrates the abandoned mine sites throughout the county and their locations in municipalities. *Figure X – Pennsylvania Sinkhole Risk* shows a smaller scale overview of Pennsylvania's subsidence risk.

4.3.9.2 Range of Magnitude

No two subsidence areas or sinkholes are exactly alike. Variations in size and shape, time period under which they occur (i.e. gradually or abruptly), and the proximity to development ultimately determines the magnitude of damage incurred. Events could result in minor elevation changes or deep, gaping holes in the surface. Subsidence and sinkhole 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. Isolated incidents of subsidence throughout the coal regions over the past years have affected houses, garages, and trees that have been swallowed up by subsidence holes. Lengths of local streets and highways, and countless building foundations have been damaged.

The worst care scenario in Tioga County would result from the long-term subsidence or sinkhole formations that were not recognized, and mitigation measures that were not implemented. In this case fractures or complete collapse of building foundations and roadways may result. If mitigation measures are not taken, the cost to fill in and stabilize sinkholes can be significant although sinkholes are limited in extent.

4.3.9.3 Past Occurrence

The PA DCNR provides an online Sinkhole Inventory Database, which lists a total of 2,665 identified sinkholes in Pennsylvania as of 2009. However, none of these listed sinkholes are in Tioga County or the surrounding counties (DCNR, 2009). This is the most comprehensive list of incidents available, but the fact that no sinkholes are identified does not necessarily mean there are no sinkholes or historical subsidence hazards in a given county or area. Tioga County does not have any sinkhole events listed in their previous hazard vulnerability assessment or other plans. In addition, there is no anecdotal evidence of significant sinkholes occurring.

4.3.9.4 Future Occurrence

Based on the amount of abandoned mined sites in Tioga County, the annual occurrence of subsidence and sinkhole events in the county where mining occurs is considered likely.

4.3.9.5 Vulnerability Assessment

Most of the mining that has occurred in Tioga County was strip mining, leaving these abandoned mine sites susceptible to subsidence events. The southern portion of Tioga County is subject to surface and subsurface sinkhole occurrence because of these mining practices. This is illustrated in *Figure X – Abandoned Mined Areas in Tioga County*. The frequency of subsidence incidences occurring in the county is expected to remain low. However, considering past mining activity that occurred in the county, subsidence cannot be ruled out as a potential hazard.

Figure X – Abandoned Mined Areas in Tioga County

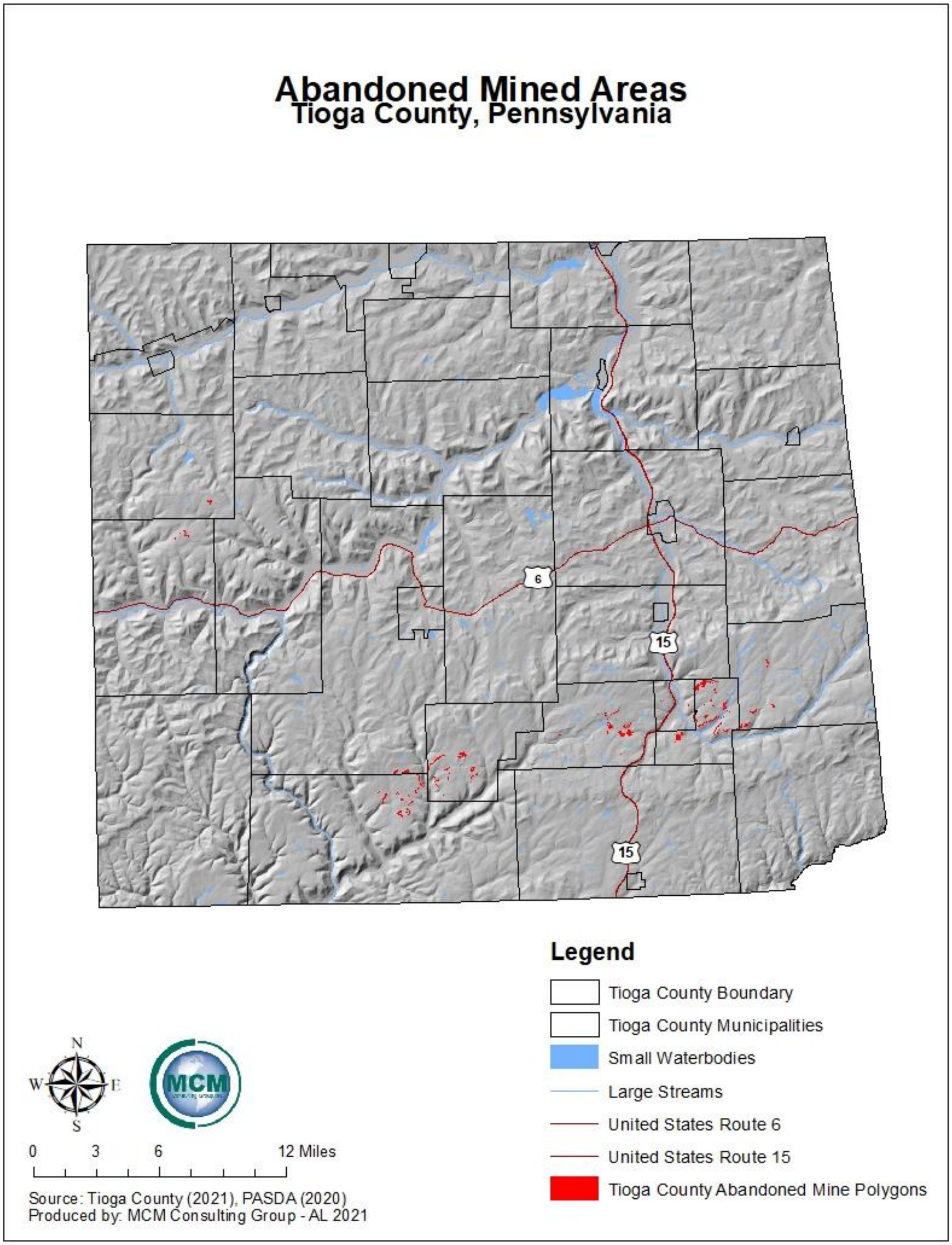
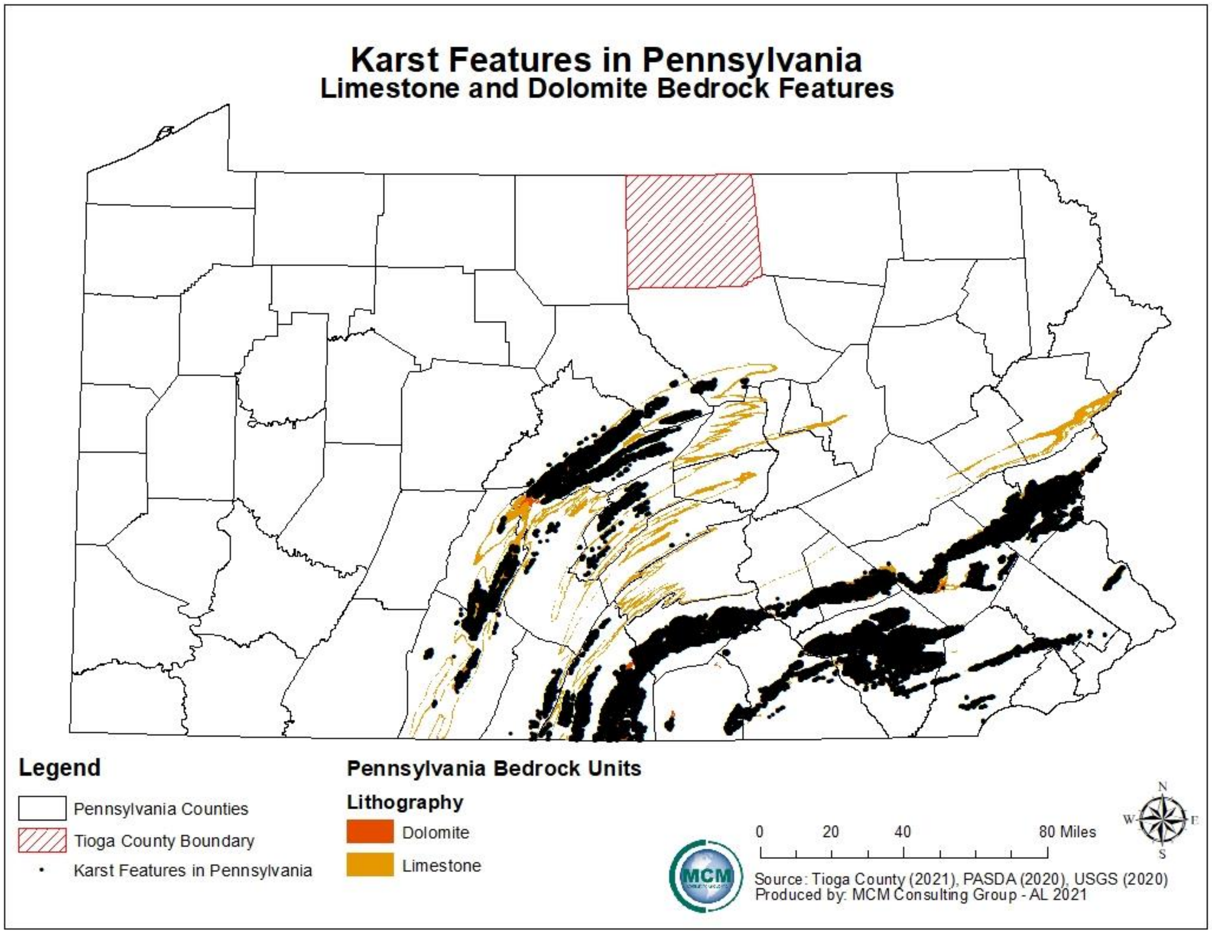


Figure X - Pennsylvania Sinkhole Risk



4.3.10. Tornado/Windstorm

4.3.10.1 Location and Extent

Tornadoes and windstorms can occur throughout Tioga County, though incidents are usually localized. Severe thunderstorms may result in conditions favorable for the formation of numerous or long-living tornadoes. Tornadoes are nature's most violent storm and can cause fatalities and devastation to neighborhoods within the county. Tornadoes can occur at any time during the day or night but are most frequent during late afternoon into early evening, the warmest hours of the day, and most likely during the spring and early summer months of March through June. Tornado movement is characterized in two ways: direction/speed of spinning winds and forward movement of the tornado, also known as the storm track. The rotational wind speeds can range from 100 to more than 250 mph. The speed of forward motion can range from 0 mph to 50 mph. On estimate, the maximum velocity of tornadoes is about 300 mph. Forward motion of the tornado path can be a few to several hundred miles in length. Widths of tornados vary from less than 100 feet to more than a mile wide. The National Centers for Environmental Information (NCEI) reports that, "the maximum winds in tornadoes are often confined to extremely small areas and vary tremendously over short distances", which explains why one house may be completely demolished by a tornado and a neighboring house could be untouched. Some tornadoes never touch the ground and are short lived, while others may touch the ground several times.

There are two main types of tornadoes: supercell and non-supercell. Supercell tornadoes are the most common and often the most dangerous type of tornado. A rotating updraft is key to the development of a supercell and eventually a tornado. Once the updraft is rotating and being fed by warm air flowing in, the tornado is formed. The other type of tornado is categorized as non-supercell, which is not as commonly found. One type of non-supercell tornado is the "Quasi-Linear Convective Systems" (QLCS). The QLCS tornadoes typically arise during the late night or early morning hours. These types of tornadoes are weaker and more short-lived compared to super cell thunderstorms. However, the QLCS are more difficult to detect effectively. Another type of non-supercell tornado is a landspout. These tornadoes are narrow and rope-like funnels that form when the thunderstorm cloud is still growing with no rotating updraft which causes the spinning motion to appear near the ground more. Waterspouts are similar non-supercell tornadoes to the landspout but not likely to be found within Tioga County.

Windstorms may be caused by thunderstorms, hurricanes, and tornadoes, but the most frequent cause of windstorms in Pennsylvania is thunderstorms. Windstorms are defined as sustained wind speeds of 40 mph or greater, lasting for at least one hour, or winds of 58 mph or greater lasting for any duration. There are a wide variety of windstorm events that can take place in Tioga County: Straight-line wind, downdraft, macroburst, microburst, downburst, gust front, and derecho. Straight-line winds are the most common wind event. Straight-line winds are different than tornadic winds. A downdraft is a small-scale column of air that rapidly sinks toward the ground. A macroburst is the outward burst of strong winds that are near or at the surface with horizontal dimensions greater than 2 1/2 miles. Microburst winds may begin over a smaller area and then spread out to an even wider area, sometimes producing damage similar to a tornado. On the other hand, microbursts are smaller outward bursts of strong winds near or at the surface. Microbursts are less than 2 1/2 miles in horizontal dimension and are typically short-lived winds that last a maximum of ten minutes, with windspeeds reaching up to 100 mph. Microburst events can be wet or dry. Wet microbursts are typically associated with heavy precipitation at the surface. Dry microbursts do not have precipitation associated with them and are found in the western portion of the United States. Tioga County is more likely to experience a wet microburst instead of a dry microburst event. A downburst is typically used to describe the macro and microbursts. A gust front is the leading edge of rain-cooled air that clashes with warmer thunderstorm inflow. The gust fronts are characterized by wind shift, temperature drop, and gusty winds out ahead of a thunderstorm. Derecho is a long-lived windstorm that is associated with a band of rapidly moving showers or thunderstorms. A typical derecho contains various downbursts and microbursts. If the wind damage is more than 240 miles and includes wind gusts of at least 58 mph, the event would then be classified as a derecho.

4.3.10.2 Range and Magnitude

Each year, tornadoes account for $1.1 billion in damages and cause over eighty deaths nationally. The number of tornado reports has increased by 14% since 1950. While the extent of tornado damage is usually localized, the vortex of extreme wind associated with a tornado can result in some of the most destructive forces on Earth. The damage caused by a tornado is a result of the high-wind velocity and windblown debris, also accompanied by lightning or large hail. The most violent tornadoes have rotating winds of 250 mph or more and are capable of causing extreme destruction and turning normally harmless objects into deadly projectiles.

The destruction caused by tornadoes may range from light to severe depending on the path of travel. Damages and deaths can be especially significant when tornadoes move through populated, developed areas. The destruction caused by tornadoes ranges from light to inconceivable depending on the intensity, size, and duration of the storm. Typically, tornadoes cause the greatest damages to structures of light weight construction such as mobile homes. Further discussion about the vulnerability of mobile homes can be found in section 4.3.X.5. The Enhanced Fujita Scale, also known as the "EF-Scale", measures tornado strength and associated damages. The EF-Scale is an update to the earlier Fujita Scale, also known as the "F-Scale", that was published in 1971. These scales classify U.S. tornadoes into six intensity categories based upon the estimated maximum winds occurring within the wind vortex (*Table X - Enhanced Fujita Scale*). Although F Scale has been used for many years, this scale has limitations associated with it. Limitations of the F-Scale include lack of damage indicators (DI), no account of construction quality and variability, and no definitive correlation between damage and wind speeds. The limitation is what led to a more accurate scaling method of the EF- Scale. The EF-Scale became effective on February 1st, 2007. Since its implementation by the National Weather Service in 2007, the EF-Scale has become the definitive metric for estimating wind speeds within tornadoes based upon damage to buildings and structures. Previously recorded tornadoes are reported with the older F-Scale values, but *Table X - Enhanced Fujita Scale* shows F-Scale categories with corresponding EF-Scale wind speeds.

Figure X - Pennsylvania Wind Zones identifies wind speed zones across the state. The figure identifies wind speeds that could occur across the state to be used as the basis for design and evaluation of the structural integrity of shelters and critical facilities. The majority of Pennsylvania falls within Zone III, meaning that design wind speeds for shelters and critical facilities should be able to withstand a three-second gust of up to 200 mph, regardless of whether the gust is the result of a tornado, hurricane, tropical storm, or windstorm incident. The western portion of the state falls within the Zone IV which indicates shelters can withstand up to 250 mph winds, while the eastern side falls within the Zone II where shelters can withstand up to only 160 mph. *Table X - Wind Zones and Counties Affected in Pennsylvania* identifies which county is located in specific wind zones throughout Pennsylvania. As shown on Figure X and Table X, Tioga County is situated in Wind Zone III.

Figure X – Pennsylvania Wind Zones

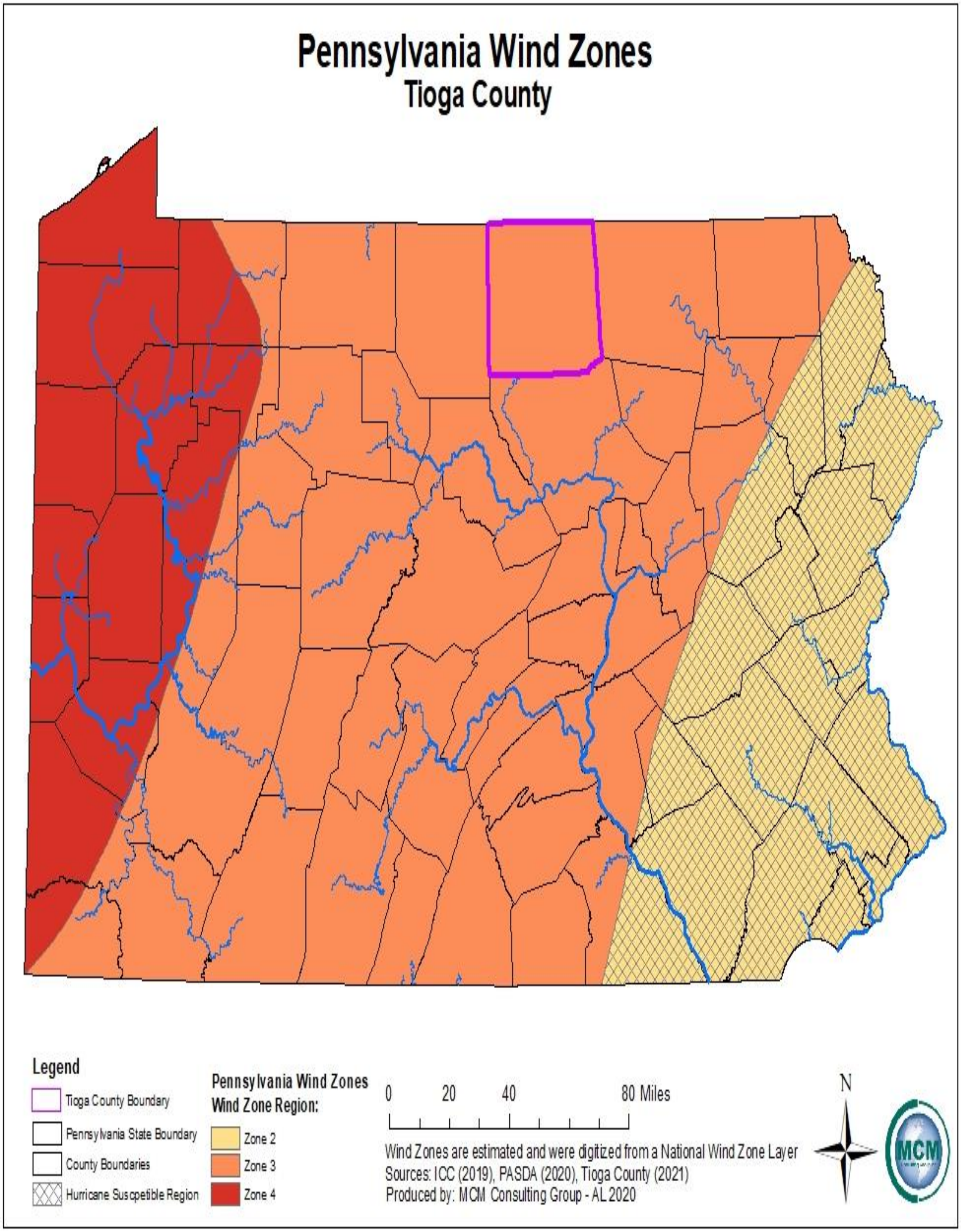


Table X - Wind Zones and Counties Affected in Pennsylvania

Wind Zones and Counties Affected in Pennsylvania (NOAA, 2019)	
Wind Zones with Speed	**Counties Affected**
Zone I (130 mph)	N/A
Zone II (160 mph)	Berks, Bucks, Carbon, Chester, Delaware, Lackawanna, Lancaster, Lebanon, Lehigh, Luzerne, Monroe, Montgomery, Northampton, Philadelphia, Pike, Schuylkill, Wayne, York
Zone III (200 mph)	Adams, Armstrong, Bedford, Blair, Bradford, Cambria, Cameron, Centre, Clearfield, Clinton, Columbia, Cumberland, Dauphin, Elk, Fayette, Franklin, Fulton, Greene, Huntingdon, Indiana, Juniata, Jefferson, Lycoming, McKean, Mifflin, Montour, Northumberland, Perry, Potter, Snyder, Somerset, Sullivan, Susquehanna, **Tioga**, Union, Westmoreland,
Zone IV (250 mph)	Allegheny, Beaver, Butler, Clarion, Crawford, Erie, Forest, Lawrence, Mercer, Venango, Warren, Washington

Since Tioga County falls within Zone III, shelters and critical facilities should be designed to withstand up to 200 mph winds, regardless of whether the gust is the result of a tornado, coastal storm, or windstorm event. Additionally, these structures should be able to withstand the wind speeds experienced in an EF3 tornado event. While it is difficult to pinpoint the exact locations at the greatest risk of a tornado, the southeast, southwest, and northwest sectors of the Commonwealth are more prone to tornadoes. Tornadoes can have varying secondary effects. The most common is power failure. The severe wind can dismantle power sources and cause significant structural damage. Hazardous material spills can occur if a tornado comes near a holding tank, or the spill stems from a traffic accident caused by high winds. Since tornado incidents are typically localized, environmental impacts are rarely widespread. However, where these incidents occur, severe damage to plant species is likely. This includes loss of trees and an increased threat of wildfire in areas where dead trees are not removed.

Tornadoes/windstorms of all types have caused the following problems within Tioga County:

- Power failures lasting four hours or longer.
- Loss of communications networks lasting four hours or more.
- Residents requiring evacuation or provision of supplies or temporary shelter.
- Severe crop loss or damage
- Trees down or snapped off high above the ground/tree debris-fire fuel.
- Toppled high profile vehicles, including those containing hazardous materials.

Table X - Enhanced Fujita Scale

Enhanced Fujita Scale (NWS, 2007)			
EF-Scale Number	**Wind Speed (MPH)**	**F-Scale Number**	**Description of Potential Damage**
EF0	65–85	F0-F1	**Minor damage**: Peels surface off some roofs; some damage to gutters or siding; branches broken off trees; shallow-rooted trees pushed over. Confirmed tornadoes with no reported damage (i.e., those that remain in open fields) are always rated EF0.
EF1	86-110	F1	**Moderate damage**: Roofs severely stripped; mobile homes overturned or badly damaged; loss of exterior doors; windows and other glass broken.
EF2	111–135	F1-F2	**Considerable damage**: Roofs torn off well-constructed houses; foundations of frame homes shifted; mobile homes completely destroyed; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
EF3	136–165	F2-F3	**Severe damage**: Entire stories of well-constructed houses destroyed; severe damage to large buildings such as shopping malls; trains overturned; trees debarked; heavy cars lifted off the ground and thrown; structures with weak foundations blown away some distance.
EF4	166–200	F3	**Devastating damage**: Well-constructed houses and whole frame houses completely leveled; cars thrown and small projectiles generated.
EF5	>200	F3-F6	**Extreme damage**: Strong frame houses leveled off foundations and swept away; automobile-sized projectiles fly through the air in excess of 100 m (300 ft.); steel reinforced concrete structure badly damaged; high-rise buildings have significant structural deformation.

4.3.10.3 Past Occurrence

Tioga County has experienced seven tornado events since 1970 and twelve wind incidents since 1999 (see *Table X – Tioga County Tornado History and Table X – Tioga County High Wind History*). Numerous sources provide information in regard to past occurrences and losses associated with tornadoes/windstorms in Tioga County and the Commonwealth as a whole. Due to the number of sources available with information, specific number of events and losses could vary slightly in number. Tornado data was only available from 1970 until 2019 while windstorm data was only available from 1999 until 2019 even though more past or recent events could have possibly occurred. Historically, the county has experienced both severe windstorms and tornadoes.

The most recent tornado impact on Tioga County occurred on May 29th, 2019, in the afternoon when an EF0 was reported within the county. The EF0 tornado touched down near Whiteville in Tioga County and produced maximum winds of around 75 mph along a path that was about one mile long and a maximum path width of about fifty yards. There was significant damage to trees, a barn, and a trampoline that were observed along North Elk Run Road (Route 660). The most damaging tornado event to affect Tioga County was an F2 on May 2nd, 1983, which reported to have caused about $2.5 million in damages. This tornado started in Deerfield Township and ended its path in Nelson Township. The length of the tornado was about 9.8 miles and had a width of about thirty yards wide. Along the path, nine barns, ten buildings, one house, one mobile home, and one camper were completely demolished. All or part of the roof was off on five different buildings. There was minor damage to four houses, one barn, and one building. Two mobile homes were completely moved off their foundation. One pickup truck was thrown and severely damaged while another was damaged by a falling tree. Many trees were uprooted or broken off. There were four cattle that were lost on one farm. Farther northeast at Lawrenceville, witnesses saw and heard the funnel cloud pass overhead, but the only damage in this area was to some treetops. North of the tornado track, golf ball size hail was reported at Osceola. A total of five out of the seven tornado events in Tioga County documented property damage.

The most recent wind incident in Tioga County occurred on February 24th, 2019, when a 52-mph wind event was reported. This wind event resulted in west-northwest winds that developed across central Pennsylvania. Gusts over 60 mph were observed across portions of central Pennsylvania, as were scattered power outages and downed trees. The wind gusts were near 60 mph that were observed across Tioga County from February 24th to the 25th of 2019. The most damaging wind incident to affect Tioga County was on December 12th, 2000, which is reported to have caused $13,900.00 in damages. This event was the only high wind event reported to have property damage.

See *Tables X – Tioga County Tornado History*, *Table X- Tioga County High Wind History*, and *Figure X - Past Tornado Occurrences in Tioga County* below for reference to the past tornado and wind occurrence events and data within the county.

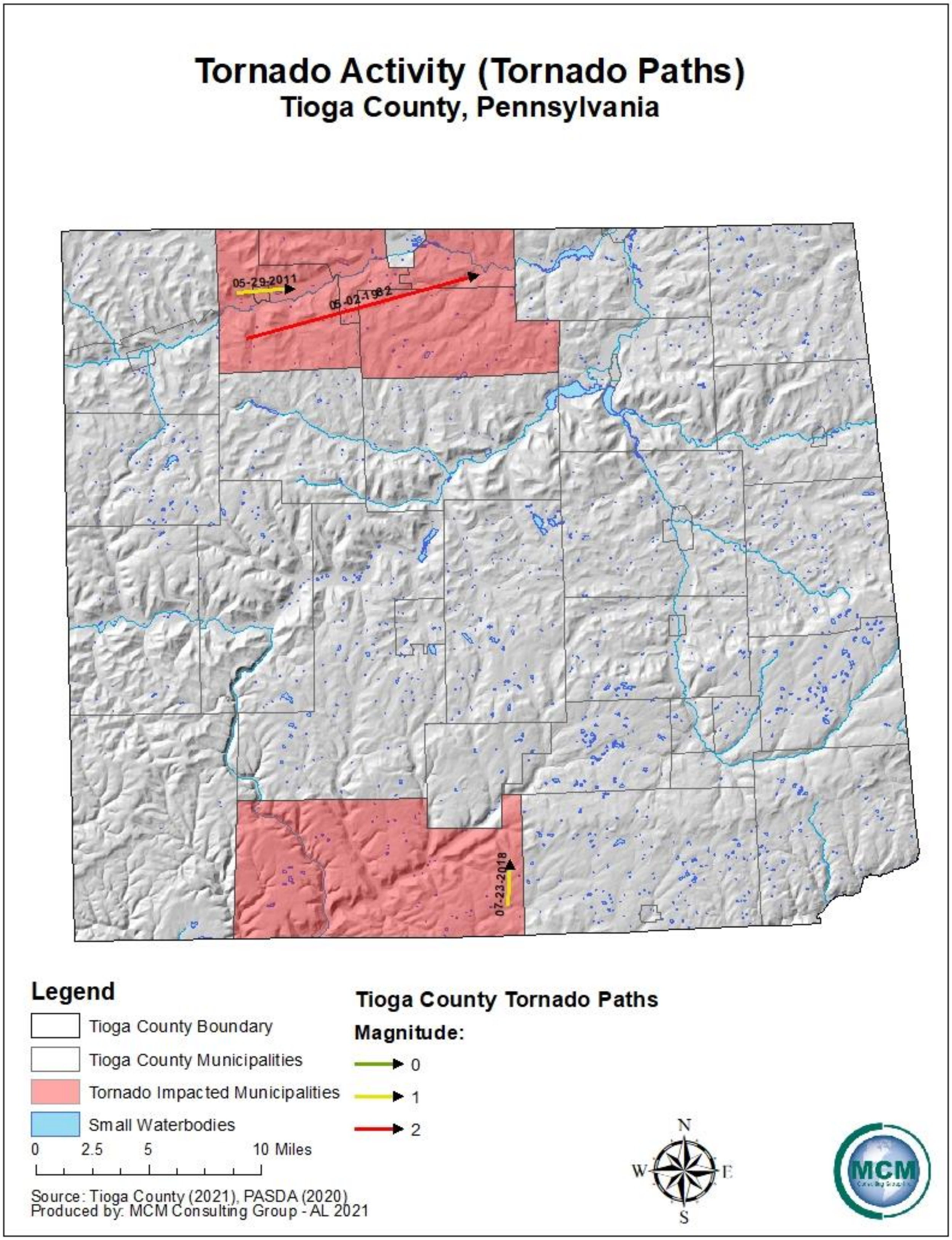
Table X – Tioga County Tornado History

Tioga County Tornado History (NOAA NCEI, 2020)					
Location	**Date**	**Magnitude (F/EF Scale)**	**Deaths**	**Injuries**	**Property Damage**
Tioga County	08/30/1970	F1	0	0	$25,000.00
Tioga County	05/02/1983	F2	0	0	$2,500,000.00
Tioga County	07/08/1997	F1	0	0	$0.00
Tioga County	06/06/2005	F0	0	0	$0.00
Knoxville	05/30/2011	EF1	0	0	$25,000.00
Nauvoo	07/23/2018	EF1	0	0	$10,000.00
Whiteville	05/29/2019	EF0	0	0	$25,000.00
Totals	**-**	**-**	**0**	**0**	**$2,585,000.00**

Table X – Tioga County High Wind History

Tioga County High Wind History (NOAA NCEI, 2020)				
Location	**Date**	**Mag. (knots)**	**Injuries**	**Property Damage**
Tioga County	09/29/1999	60 kts.	0	$0.00
Tioga County	01/04/2000	50 kts.	0	$0.00
Tioga County	01/10/2000	50kts	0	$0.00
Tioga County	12/12/2000		0	$13,900.00
Tioga County	02/01/2002	63 kts.	0	$0.00
Tioga County	03/09/2002	50 kts.	0	$0.00
Tioga County	11/13/2003	60 kts.	0	$0.00
Tioga County	12/01/2006	45 kts.	0	$0.00
Tioga County	09/14/2008	50 kts.	0	$0.00
Tioga County	10/29/2012	50 kts.	0	$0.00
Tioga County	04/04/2018	52 kts.	0	$0.00
Tioga County	02/24/2019	52 kts.	0	$0.00
Total	**-**	**-**	**0**	**$13,900.00**

Figure X – Past Tornado Occurrences in Tioga County



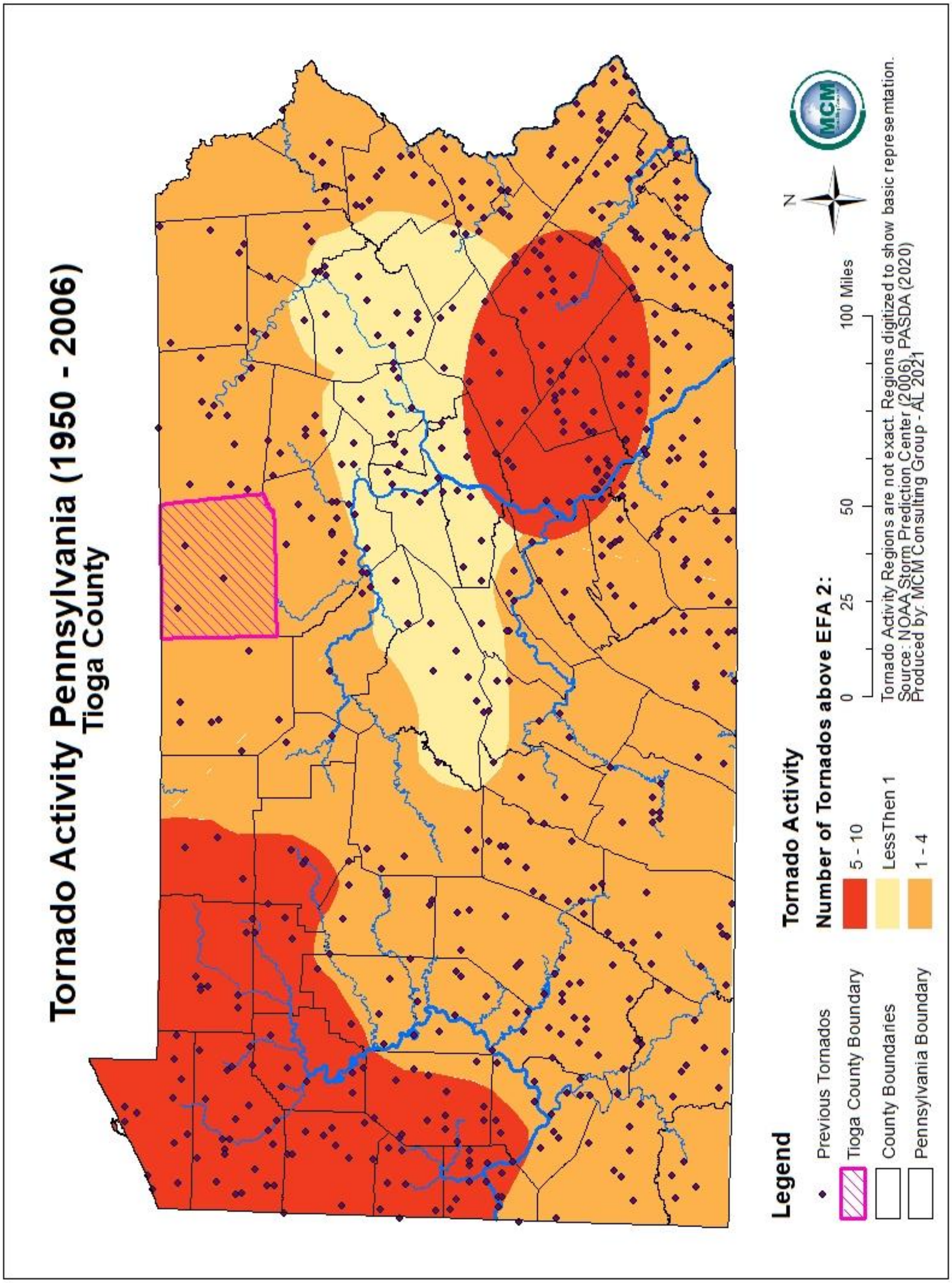
4.3.10.4 Future Occurrence

The future probability of a disastrous tornado hitting Tioga County is ranked as possible. According to the National Weather Service, the Commonwealth of Pennsylvania has an annual average of ten tornadoes with two related deaths. While the chance of a tornado occurring in Tioga County is small, the damage that results when the tornado arrives could be devastating. An EF-5 tornado with a 0.019% annual probability of occurring can carry wind velocities of 200 mph, resulting in a force of more than 100 pounds per square foot of surface area. This is a "wind load" that exceeds the design limits of most buildings. As the county's population continues to grow and as residential and commercial construction continues, the number of people and properties will be greatly affected by tornadoes and windstorms as they increase accordingly.

Based on historic patterns, tornadoes are unlikely to remain on the ground for long distances, especially in areas of the county with hilly terrain, such as Tioga County. However, the high historical number of windstorms with winds at or over 50 knots indicates that the annual chance of a windstorm in the county is higher. The number of days when tornadoes occur in the United States has decreased; however, there has been an increase in tornado activity on those days. The tornado season has also been lengthening, with the season starting earlier than it has historically. Pennsylvania had, for example, a record number of tornadoes in April and May 2019 compared to any other April or May on record. Climate change is causing temperatures and air moisture to increase, and it is thought that these changes could result in an increase in frequency and intensity of tornadoes and severe windstorms; however, there is somewhat low confidence in these conclusions and there is still much uncertainty. Therefore, the number of future tornado/windstorm events could potentially increase due to many factors.

Based on historical incidents, there are three zones in Pennsylvania that can either experience less than one, one to four, and five to ten of EF2 or above tornadoes per 3,700 square miles. Communities in Tioga County, as shown in the Figure X - Tornado Activity in Tioga County below, are expected to have one to four tornadoes annually. The approximation of one to four tornadoes annually assists with determining the rate of future tornado occurrences within Tioga County. Future tornadoes will be similar to those that affected the county in past events. Windstorm events occur on a more frequent basis compared to tornadoes. Therefore, unlike tornadoes, this hazardous event has a highly likely probability for future events to occur within the county.

Figure X - Tornado Activity in Tioga County



4.3.10.5 Vulnerability Assessment

Tornadoes can occur at any time of the year, though they are more likely during peak months, which are during the summer for the northern part of the United States, such as Pennsylvania. While the frequency of windstorms and minor tornadoes is expected to remain relatively constant, vulnerability increases in more densely developed areas. Factors that impact the amount of damage caused by a tornado are the strength of the tornado, the time of day and the area of impact. Usually, such distinct funnel clouds are localized phenomena impacting a small area. However, the high winds of tornadoes make them one of the most destructive natural hazards. There can be many secondary impacts of tornadoes and windstorms, including transportation accidents, hazardous material spills, flooding, and power outages. A proper warning system is vital for the public to be informed of what to do and where to go.

Dangers that accompany thunderstorms associated with tornadoes which increase the vulnerability of Tioga County:

- Flash floods – with 146 deaths annually nationwide
- Lightning – 75 to 100 deaths annually nationwide
- Damaging straight-line winds – reaching 140 mph wind speed
- Large hail – can reach the size of a grapefruit and causes several $100 million in damages annually to property and crops.

Since high-wind incidents may affect the entire county, it is important to identify specific critical facilities and assets that are most vulnerable to the hazard. Critical facilities are highly vulnerable to high windstorms and tornado events. While many severe storms can cause exterior damage to structures, tornadoes can also completely destroy structures, along with their surrounding infrastructure and abruptly halting operations. Tornadoes are often accompanied by severe storms which can be threatening to critical facilities within the county. Many secondary effects from these disasters can jeopardize the operation of these critical facilities as well. Critical facilities are particularly vulnerable to power outages which can leave facilities functionless, potentially crippling infrastructure supporting the population of the county. A storm potentially has the ability to destroy structures, citizens, and their possessions that are often left at the will of the storm. The elderly, disabled, special needs, and non-English speaking residents are at risk when faced with tornadoes. Without assistance to evacuate or difficulty understanding public information, they may be unable to prepare themselves or their homes and other possessions to safely endure the storm.

The economy of Tioga County is highly vulnerable to tornadoes. While there may be limited impact on the financial and commercial systems of the economy, these storms, and the resulting damage can disrupt business long-term. The local economy is vulnerable due to possibility of being crippled by tornadoes and windstorms and their secondary effects when buildings and supporting infrastructure are destroyed in the storm. Power outages can create work stoppages while transportation accidents and road closures can limit the transportation of goods and services. Additionally, flooding cannot be discounted as it can destroy the physical structures, merchandise, and equipment essential for business operation. Tioga's environment is also vulnerable to tornado events. Most notably, hazardous materials spills can pollute ground water systems and vegetation. In the case of hazardous material spills caused by the event, the local environment can also be negatively impacted which requires extensive clean-up and mitigation efforts.

While the frequency of windstorms and minor tornadoes is expected to remain relatively constant, vulnerability increases in more densely developed areas. Since high wind events may affect the entire county, it is important to identify specific critical facilities and assets that are most vulnerable to this hazard. Due to their lightweight and often unanchored design, commercial trailers and mobile homes are also extremely vulnerable to high winds/tornadoes and will generally sustain the most damage. These structures represent a reasonable percentage of the occupied structures within the county. A majority of the mobile homes are found in Lawrence Township and Richmond Township, which makes these two municipalities more vulnerable to tornado events than others. Locations and numbers of mobile home parcels in Tioga County can be found in Table X – Vulnerable Mobile Home Parcels in Tioga County. While clearly an estimate, this enables the county to take a preliminary look at which jurisdictions are more vulnerable to mobile home damage.

Table X – Vulnerable Mobile Home Parcels in Tioga County

Vulnerable Mobile Home Parcels in Tioga County (Tioga County GIS, 2021)	
Municipality	**Number of Mobile Homes Parcels**
Delmar Township	38
Lawrence Township	145
Middlebury Township	22
Putnam Township	28
Richmond Township	53
Total	**286**

4.3.11. Wildfire

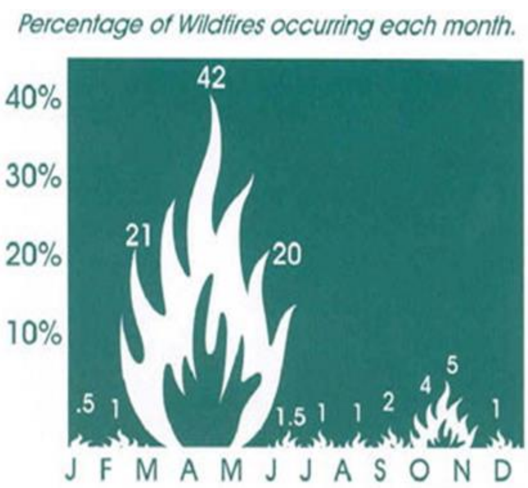
4.3.11.1 Location and Extent

Most wildfires are caused by human carelessness, negligence, and ignorance. However, some are precipitated by lightning strikes and in rare instance, spontaneous combustion. Lightning-caused wildfires in Pennsylvania are also relatively rare. The Pennsylvania Department of Conservation and Natural Resources (PA DCNR) reports that 98% of wildfires are caused by people.

Wildfires can take place in less developed or completely undeveloped areas, spreading rapidly through vegetative fuels. This type of fire occurs any time of the year, but mostly during the spring and fall months. The greatest potential for wildfires is in the spring months of March, April, and May, and the autumn months of October and November; 83% of all Pennsylvania wildfires occur in these two time periods. In the spring, bare trees allow sunlight to reach the forest floor, drying fallen leaves and other ground debris. In the fall, dried leaves are also fuel for fires. *Figure X – Seasonal Wildfire Percentage* shows the wildfire percentage occurrence during each month occurring in Pennsylvania. Any small fire, if not quickly detected and suppressed, can get out of control. Wildfires in Pennsylvania can occur in open fields, grass, dense brush, and forests.

The majority of Tioga County's land cover is forest and the potential geographic extent of wildfires in the county is quite large. Under dry conditions or droughts, wildfires have the potential to burn forests as wells as croplands.

Figure X – Seasonal Wildfire Percentage



Tioga County is part of the Tioga State Forest District, PA DCNR District 16, and covers 161,890 acres in Bradford and Tioga counties.

4.3.11.2 Range of Magnitude

Wildfire events can range from small fires that can be managed by local firefighters to large fires impacting many acres of land. Large events may require evacuation from one or more communities and necessitate regional or national firefighting support. The impact of a severe wildfire can be devastating. A wildfire has the potential to kill people, livestock, fish, and wildlife. Wildfires can destroy property, valuable timber, forage, and recreational, and scenic values. A worst-case scenario for wildfires occurred in Tioga County in 2008 when a wildfire destroyed 3,200 acres of land in Tioga and Lycoming counties. Most of the fire was in Tioga County, near Cedar Run, before it spread into Lycoming County.

In addition to the risk wildfires pose to the general public and property owners, the safety of firefighters is also a concern. Although loss of life among firefighters does not occur often in Pennsylvania, it is always a risk. More common firefighting injuries include falls, sprains, abrasions, or heat-related injuries such as dehydration. Response to wildfires also exposes emergency responders to the risk of motor vehicle accidents and can place them in remote areas away from the communities that they are chartered to protect.

Significant potential environmental impacts from wildfires include severe erosion, silting of stream beds and reservoirs, and flooding due to ground-cover loss following a fire event. Wildfire can also have a positive environmental impact in that they burn dead trees, leaves, and grasses to allow more open spaces for new vegetation to grow and receive sunlight. Another positive effect of wildfires is the growth of new shoots on trees and shrubs and its release of high heat which can open pinecones creating new seed pods.

The United States Forest Services utilizes the Forest Fire Assessment System to classify the dangers of a wildfire. *Table X – Wildland Fire Assessment System* identifies each threat classification and provides a description of the level.

Table X – Wildland Fire Assessment System

Wildland Fire Assessment System *(U.S. Forest Service)*	
Rank	**Description**
Low (L)	Fuels do not ignite readily from small firebrands although a more intense heat source, such as lightning, may start fires in duff or punky wood. Fires in open cured grasslands may burn freely a few hours after rain, but woods fires spread slowly by creeping or smoldering and burn in irregular fingers. There is little danger of spotting.
Moderate (M)	Fires can start from most accidental causes, but with the exception of lightning fires in some areas, the number of starts is generally low. Fires in open cured grasslands will burn briskly and spread rapidly on windy days. Timber fires spread slowly to moderately fast. The average fire is of moderate intensity, although heavy concentrations of fuel, especially draped fuel, may burn hot. Short-distance spotting may occur but is not persistent. Fires are not likely to become serious and control is relatively easy.
High (H)	All fine dead fuels ignite readily, and fires start easily from most causes. Unattended brush and campfires are likely to escape. Fires spread rapidly and short-distance spotting is common. High intensity burning may develop on slopes or in concentrations of fine fuels. Fires may become serious and their control difficult unless they are attacked successfully while small.
Very High (VH)	Fires start easily from all causes and, immediately after ignition, spread rapidly and increase quickly in intensity. Spot fires are a constant danger. Fires burning in light fuels may quickly develop high intensity characteristics such as long-distance spotting and fire whirlwinds when they burn into heavier fuels.
Extreme (E)	Fires start quickly, spread furiously, and burn intensely. All fires are potentially serious. Development into high intensity burning will usually be faster and occur from smaller fires than in the very high fire danger class. Direct attack is rarely possible and may be dangerous except immediately after ignition. Fires that develop headway in heavy slash or in conifer stands may be unmanageable while the extreme burning condition lasts.

4.3.11.3 Past Occurrence

Between 2000 and 2020, there were a total of 398 wildfire events reported to the PA DCNR Bureau of Forestry for District 16. This list of events comes directly from PA DCNR and is up to date with information from 2020. The largest number of wildfire events for any year was recorded in 2008 when there was a total of twenty-seven wildfire events which burned a total of 4,087.2 acres. In 2011, as illustrated below in *Table X – List of Wildfire Events for District 16*, there were no wildfire events or occurrences in District 16.

Table X – List of Wildfire Events for District 16

Number of Wildfire Events for District 16 (PA DCNR, 2021)		
Year	**Number of Wildfire Events**	**Number of Acres in Wildfire Events**
2000	9	114.5
2001	13	101.5
2002	12	90.4
2003	8	35.6
2004	1	5.0
2005	16	142.5
2006	12	104.7
2007	19	38.9
2008	27	4,087.2
2009	16	894.6
2010	8	6.9
2011	0	0.0
2012	9	45.2
2013	7	7.6
2014	14	23.6
2015	23	135.7
2016	52	175.0
2017	39	66.0
2018	31	40.0
2019	23	33.5
2020	59	29.9
Total:	**398**	**6,178.3**

In recent years, the number of prescribed burns in Pennsylvania has been increasing. This corresponds to an embrace of the need for fire in many natural ecosystems and management strategies for reducing vulnerability to wildfire; it also improves hunting opportunities in the

Commonwealth of Pennsylvania. In July of 2020 there were numerous prescribed burns in state owned game lands.

Wildfire occurrence per municipality in Tioga County for 2016:

PA DCNR Forest Fire Specialist Supervisor Brian L. Plume provided the following information regarding wildfires in Tioga County for 2016. Listed below are all of the municipalities in Tioga County with the associated number of wildfires in each municipality.

- Bloss Township, Deerfield Township, Duncan Township, Elkland Borough, Knoxville Borough, Lawrenceville Borough, Nelson Township, Osceola Township, Putnam Township, Roseville Borough and Westfield Borough all experienced no wildfires in 2016.
- Blossburg Borough, Liberty Borough, Mansfield Borough, Shippen Township, Tioga Borough, Union Township, Ward Township, and Wellsboro Borough all experienced one wildfire in 2016.
- Chatham Township, Covington Township, Elk Township, Hamilton Township, Morris Township, Sullivan Township, Tioga Township, and Westfield Township each experienced two wildfires events 2016.
- Farmington Township, Gaines Township, Lawrence Township, and Middlebury Township all experienced three wildfires each in 2016.
- Brookfield Township, Clymer Township, Delmar Township, Richmond Township, and Rutland Township all experienced four wildfire events in 2016.
- Jackson Township experienced six wildfire events in 2016.
- Charleston Township and Liberty Township experienced seven wildfires each in 2016.

Table X – Wildfire Acreage Loss lists the number of wildfires and the acres burnt on a case-by-case basis in 2016. The data also lists the cause of the fires listed for each event:

Table X – 2016 Wildfire Acreage Loss

Wildfire Acreage Loss		
Cause	**Number of Wildfires**	**Acres Burnt**
Debris burning	28	164.52
False alarm	14	-
No report	11	-
Powerlines	8	1.71
Equipment	5	6.1
Miscellaneous	4	1.79
Campfire	3	0.45
Fireworks	1	0.01
Lightning	1	0.01
Smoker	1	0.25

4.3.11.4 Future Occurrence

Between 2003 and 2007, 18,132 acres of state forest have burned in Pennsylvania and at least 218 acres of land have burned in Tioga County. Previous events indicate that wildfire events will continue to occur yearly. Weather conditions like drought can increase the likelihood of wildfires occurring. Any fire, without the quick response of fire fighters, forestry personnel, or visitors to the forest, has the potential to become a wildfire.

The probability of a wildfire occurring in Tioga County is highly likely in any given year. However, the likelihood of one of those fires attaining significant size and intensity is unpredictable and highly dependent on environmental conditions and firefighting response.

Climate change is expected to bring an elongated wildfire season and more intense and long-burning fires (Pechony & Shindell, 2010). Unfortunately, in some regions of the United States, this is not a hypothetical, but a very real concern. Northern California has experienced unprecedented devastating wildfires in 2017, 2018, 2019, and 2020. The fires that have occurred in California are thought to be burning faster and hotter due to worsening drought conditions caused by increased climate change (Cvijanovic et al., 2017). Wildfire conditions in Pennsylvania are not nearly as severe as in Northern California, but the intensification is a signal that the changes brought on by climate change are not to be ignored. In Pennsylvania, higher air temperatures and earlier warming in the spring are expected to continue, resulting in more wildfire prone conditions in the summer and fall (Shortle et al., 2015).

4.3.11.5 Vulnerability Assessment

The size and impact of a wildfire depends on its location, climatic conditions, and the response of firefighters. If the right conditions exist, these factors may often mitigate the effects of wildfires; however, during a drought, wildfires can be devastating.

Firefighters and other first responders can encounter life-threatening situations due to forest fires and wildfires. Traffic accidents during a response and the impacts of fighting the fire once on scene are examples of first responder vulnerabilities.

The Wildland Urban Interface (WUI) was nationally mapped by a United States Department of Agriculture Forest Service effort in 2015 that used data from 1990-2010 to develop a robust dataset that related housing density and vegetative density. The dataset provides a way to identify locations where larger numbers of humans are living in or near natural areas that could be at risk in the event of a wildfire. The WUI defines two types of communities – interface and intermix. Intermix refers to areas where housing and wildland vegetation intermingle, and interface refers to areas where housing is in the vicinity of a large area of dense wildland vegetation. The WUI was the fastest-growing land use type in the United States between 1990 and 2010. Factors behind the growth include population shifts, expansion of cities into the wildlands, and the expansion of new vegetation growth. The primary cause has been the migration of people, not vegetation growth.

Pennsylvania is among the states with the largest WUI and the most housing units in a WUI designated area. Pennsylvanians desire the proximity of natural beauty in their daily lives, and the growth of the WUI housing noted above illustrates this. *Figure X – Wildland Urban Interface* shows the extent of Tioga County and the critical infrastructure facilities, functional needs facilities, and fire stations. A wildfire hazard is defined by conditions that affect wildfire ignition and/or behavior such as fuel, topography, and local weather. The many addressable structures in the Wildland Urban Interface and intermix sones are broken up by assessed parcel use codes.

There are seventeen fire departments that serve Tioga County, a list of which can be seen in *Table X* of the Emergency Services profile. Each fire department conducts its own schedule of in-house training sessions for its members.

The response of firefighters is integral to the containment of wildfires in the county. The likelihood that some fire stations and services will close is of concern to the safety of communities in the county. *Figure X – Fire Station Locations* illustrates the position of fire stations and the location of state game lands, state forests, and natural areas within Tioga County. Many communities have already experienced the unfortunate fact that services have failed in the past. It is recommended that each municipality asses their own vulnerabilities by maintaining and building a relationship with their local providers to make the determination and begin to plan accordingly for if a local service were to shut down its operation. The statistics, response times, and call times associated with all units dispatched are easily obtainable from the local 911 center.

These departments must be supported to create and or discover new ways to not only recruit but also, retain volunteers. If left unattended, the issues will continue to devolve and worsen, and the lack of response will grow, leaving the community more vulnerable to loss of life and loss of property to the threats of wildfires.

At the time of this writing, it is possible the continuing COVID-19 pandemic will impact the availability of firefighters and their response times. Many fire departments have created and begun to enforce new regulations regarding response to emergencies in the pandemic.

It is recommended that the entire community and county be educated on the perpetual need associated with providing these services. In addition, continued efforts to inform the state legislature could prove to be paramount in assuring these services remain in operation into the future. At the time of this writing, a flurry of bills had been introduced to both the House of Representatives and the Senate as the result of a two-year study initiated by Senate Resolutions (SR 6).

Figure X – Wildland Urban Interface

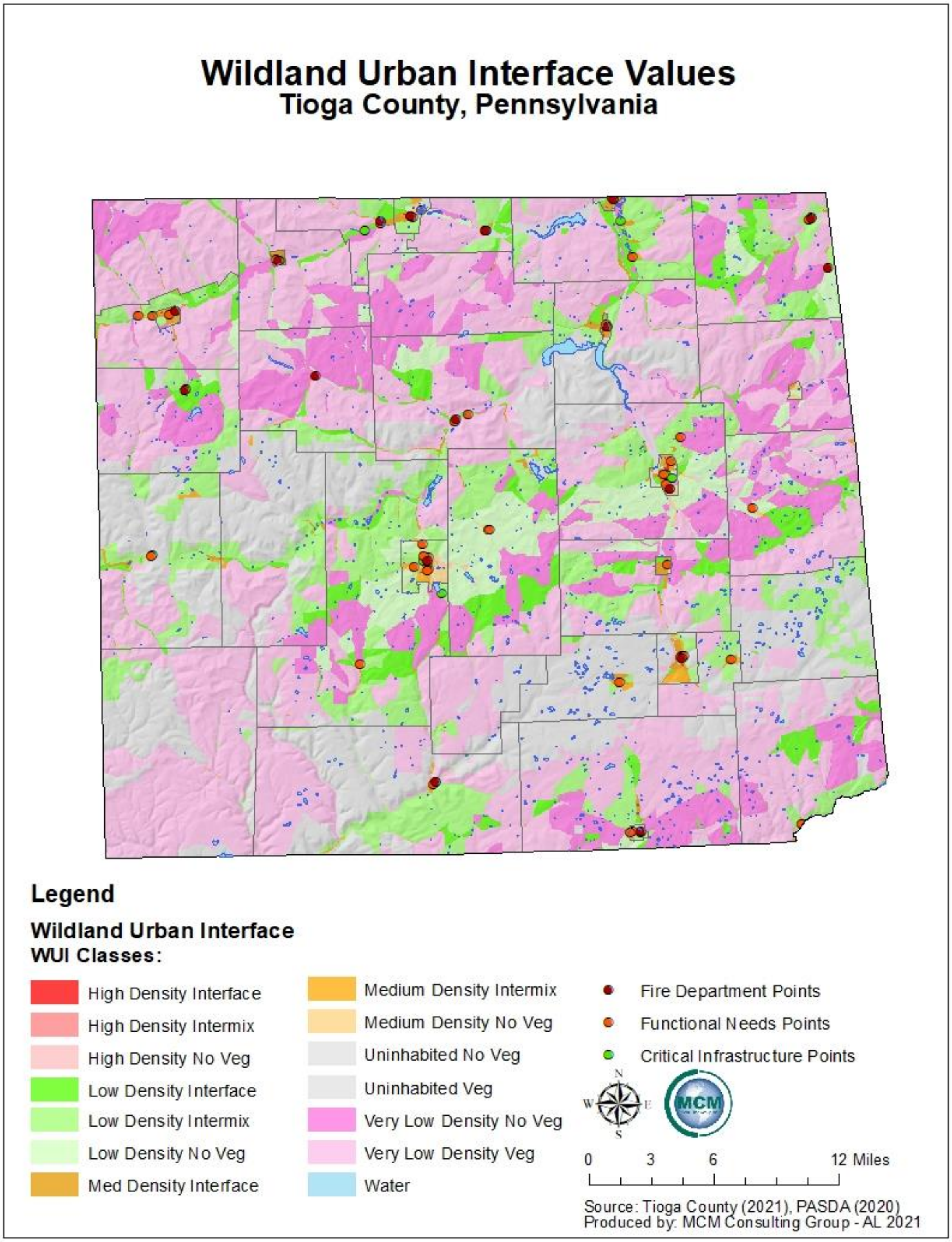
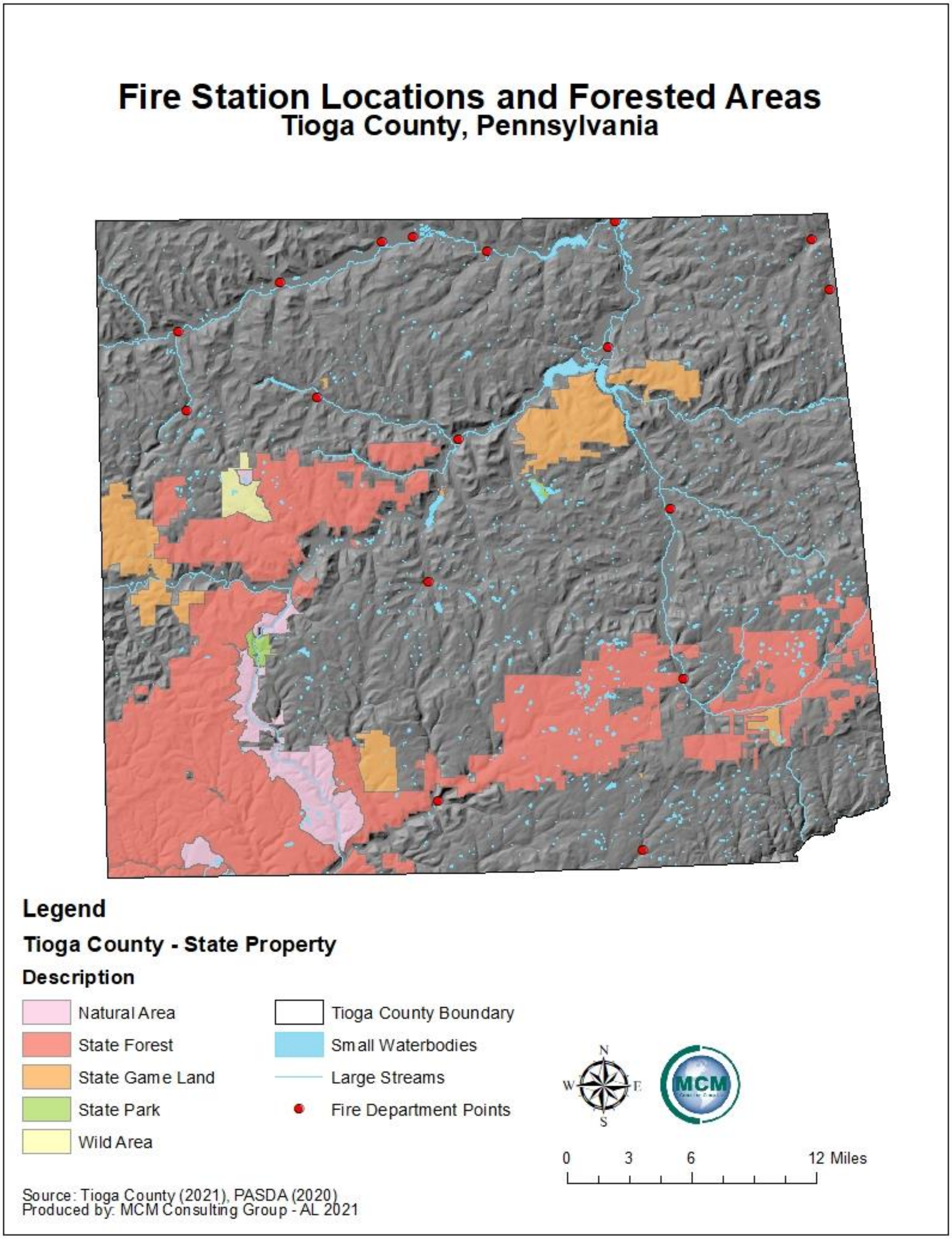


Figure X – Fire Station Locations



4.3.12. Winter Storm

4.3.12.1 Location and Extent

There is an average of thirty-five winter weather events that impact Pennsylvania each year. Such winter storms are regional events, so each county in Pennsylvania share these hazards; however, the northern tier, western counties and mountainous regions generally experience storms more frequently and with a greater severity due to lake effects and geographic influence. The extent of a severe winter storm can be classified by meteorological measurements and by evaluating the societal impacts. Severe winter storms most frequently occur in Tioga County during the winter months (November through March) and can be caused by lake-effect conditions, warm air masses associated with the Gulf Stream, etc. Within Tioga County, there are slight variations in the average amount of snowfall that is received throughout different parts of the county because of terrain differences. Generally, the average annual snowfall in the county increases from southeast to northwest.

On occasion, Tioga County can be affected by a Nor'easter, depending on its track. A Nor'easter is a storm characterized by a central low-pressure area that deepens dramatically as it moves northward along the U.S. East Coast. The name came from the strong northeast winds that precede and accompany the storm as it passes over New England. Nor'easters are notorious for producing heavy snow in the Central and Northeastern Mountains, but typically make lighter snow (or even no snow) for counties in the west. Nor'easters will ordinarily produce a heavy, wet snow. There is usually a fairly consistent distinction between rain, mixed precipitation, and snow which moves along with the storm and generally parallel to the track of the surface low. The boundary typically pivots with the storm as the track changes direction. The mixed precipitation and rainfall are generated when warmer marine air is pulled into the storm. The heaviest snow in a Nor'easter falls to the north and west of the track of the surface low (NWS).

4.3.12.2 Range of Magnitude

Winter storms consist of cold temperatures, heavy snow or ice, and sometimes strong winds. Descriptions of types of winter storms can be found in *Table X - Winter Weather Events*. Tioga County generally experiences one or more significant winter storms each year. The storms come in the form of snow, freezing rain, and sub-zero temperatures lasting for several days. Winter storms have caused power failures, loss of communications networks, road closings, disruption of EMS and fire response capabilities and losses of water supplies throughout the county. Power outages, sometimes caused by large amounts of snow or ice weighing on and breaking power lines, can result in a loss of heat for residential customers, potentially posing a threat to human life.

Table X - Winter Weather Events

Winter Weather Events (NWS, 2009)	
Weather Event	**Classification/Description**
Heavy Snowstorm	Accumulations of 4 inches or more in a six-hour period, or 6 inches or more in a twelve-hour period.
Sleet Storm	Significant accumulations of solid pellets which form from the freezing of raindrops or partially melted snowflakes causing slippery surfaces posing hazards to pedestrians and motorists.
Ice Storm	Significant accumulations of rain or drizzle freezing on objects (trees, power lines, roadways, etc.) as it strikes them, causing slippery surfaces and damage from the sheer weight of ice accumulation.
Blizzard	Wind velocity of 35 miles per hour or more, temperatures below freezing, considerable blowing snow with visibility frequently below one-quarter mile prevailing over an extended period of time.
Severe Blizzard	Wind velocity of 45 miles per hour, temperatures of 10°F or lower, a high density of blowing snow with visibility frequently measured in feet prevailing over an extended period time.

NOAA's National Centers for Environmental Information (NCEI) has produced the Regional Snowfall Index (RSI) for significant snowstorms that impact the eastern two thirds of the United States. The RSI ranks snowstorm impacts on a scale from one to five, similar to the Fujita scale for tornadoes or the Saffir-Simpson scale for hurricanes. However, RSI differs from these others because population is included. The RSI is based on spatial extent of the storm, the amount of snowfall, and the combination of these elements with population. Including population information ties the index to societal impacts. The RSI is an evolution of the Northeast Snowfall Impact Scale (NESIS), which NCEI, then NCDC, produced. *Table X – NOAA's RSI Scale* shows the RSI categories one through five with their related description. The United States, as a whole, is divided up into six easternmost climate regions which include, Northern Rockies, Upper Midwest, Northeast, Ohio Valley, South, and Southeast. Tioga County, along with the Commonwealth, are located within the Northeast portion of the six.

Table X – NOAA's RSI Scale

NOAA's RSI Scale (NOAA & NCDC, 2011)		
Category	**RSI Value**	**Description**
1	1-3	Notable
2	3-6	Significant
3	6-10	Major
4	10-18	Crippling
5	18.0+	Extreme

Long cold spells can cause rivers and lakes to freeze over. A subsequent thaw and rise in the water level break the ice into large chunks and can result in ice jams when the ice begins to flow. The ice jams can act as dams and result in flooding. Environmental impacts often include damage to shrubbery and trees due to heavy snow loading, ice build-up, and high winds which can break limbs or even bring down large trees. While gradual melting of snow and ice provides excellent groundwater recharge, high temperatures following a heavy snowfall can cause rapid surface water runoff and severe flooding. *Table X – Monthly Snowfall Average* illustrates the snowfall average for each month experienced in Tioga County.

Table X – Monthly Snowfall Average

Monthly Snowfall Average (NOAA, 2020)	
Month	**Tioga County**
January	12.2”
February	9.8”
March	10.6”
April	2.2”
May	0.1”
June	0.0”
July	0.0”
August	0.0”
September	0.0”
October	0.3”
November	3.4”
December	10.2”
Annual	48.8”

4.3.12.3 Past Occurrences

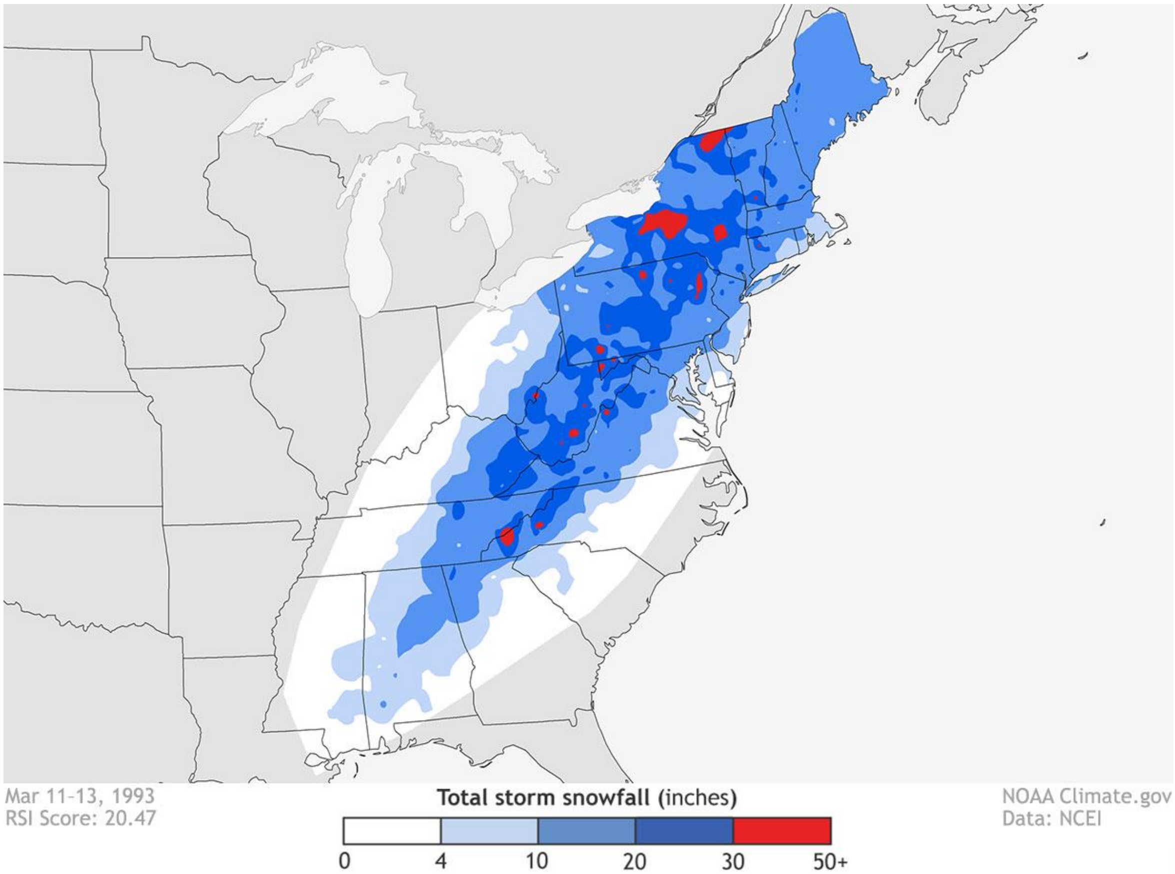
Due to a great number of various sources in regard to winter events in Tioga County, loss and impact information for these events may vary depending on the source. Tioga County and the Commonwealth of Pennsylvania have a long history of severe winter weather events. The sources used demonstrated significant events that have affected Tioga County since 1997 through 2019. With the sources used, other past events most likely occurred before the year 1997 date and after the year 2019, however, this information was not recorded in the sources. The National Climatic Data Center data on past occurrence for winter weather events is the only comprehensive list of data available for the county.

According to NOAA-NCEI, Tioga County underwent thirty-two winter storm events, thirty heavy snow events, and eleven ice storm events from 1997 to 2019. There was no available data for sleet events in Tioga County. No direct deaths or injuries were reported for the following winter weather events in Tioga County, but detailed reports of each event can be found on

NOAA's Storm Events Database at www.ncdc.noaa.gov/stormevents. Tioga County has been susceptible to an array of past winter weather events. In the past, this type of weather has had the ability to close businesses, close schools, and block/damage roadways throughout the county. The main transportation routes in the county (Interstates I-99, U.S. Route 6 and 15, State Routes 14, 49, 249, 287, 328, 349, 362, 414, 549, and 660) are normally opened immediately for emergency traffic, but secondary roads can remain impassable for long periods of time. The history of major winter storms and other related events in Tioga County since 1997 is outlined in the tables of ***Error! Reference source not found.*** (data available up to 2019), ***Error! Reference source not found.*** (data unavailable after 2014), and ***Error! Reference source not found.*** (data unavailable after 2008).

A severe winter event in the county's history and the Commonwealth as a whole was in the winter of 1994 when the state was hit by a series of protracted winter storms. The severity and nature of these storms combined with accompanying record-breaking frigid temperatures posed a major threat to the lives, safety and well-being of Commonwealth residents and caused major disruptions to the activities of schools, businesses, hospitals, and nursing homes. One of these devastating winter storms occurred in early January 1994 with record snowfall depths in many areas of the commonwealth, strong winds and freezing rains. Numerous storm-related power outages were reported and as many as 600,000 residents were without electricity, in some cases for several days at a time. A ravaging ice storm followed which closed major arterial roads and downed many trees and power lines. Utility crews from a five-state area were called to assist in power restoration repairs. Serious and sporadic power supply outages continued through mid-January in many locations due to record cold temperatures. The entire Pennsylvania-New Jersey-Maryland grid and its partners in the District of Columbia, New York and Virginia experienced fifteen to thirty minute rolling blackouts, threatening the lives of people and the safety of the facilities in which they resided. Power and fuel shortages affecting Pennsylvania and the East Coast power grid system required the Governor to recommend power conservation measures be taken by all commercial, residential, and industrial power consumers. The record cold conditions (with temperatures as low as -31˚F) resulted in numerous water-main breaks and interruptions of service to thousands of municipal and city water customers throughout the Commonwealth. The extreme cold in conjunction with accumulations of frozen precipitation resulted in acute shortages of road salt. Trucks were dispatched to haul salt from New York to expedite deliveries to Pennsylvania Department of Transportation storage sites. For Tioga County specifically, exact snowfall totals during that storm were not available, but the county noted this was one of the worst storms ever experienced. The year prior to the 1994 event, the country's so-called "Storm of the Century" clobbered the east coast. See *Figure X - Storm of the Century Total Storm Snowfall*.

Figure X - Storm of the Century Total Storm Snowfall.



Source: (NOAA, 1993)

On March 12–14, 1993, a massive storm system bore down on nearly half of the U.S. population. Causing approximately $5.5 billion in damages ($9.9 billion in year 2020 dollars), America's "Storm of the Century", as it would become known, swept from the Deep South all the way up the East Coast. With a central pressure usually found in category three hurricanes, the storm spawned tornadoes and left coastal flooding, crippling snow, and bone-chilling cold in its wake. Of the more than 250 weather and climate events with damages exceeding $1 billion since 1980.

However, more recently, winter storms are still continuously affecting Tioga County. The most recent winter storm event (based on ***Error! Reference source not found.*** and sources) was the December 1st, 2019 event. This winter storm event lasted over a span of two days. This particular winter storm event produced heavy snow and ice across the county. The storm total snow accumulation from this event in Tioga County was from eight to thirteen inches. Another recent winter storm event that occurred in Tioga County is from March 13th, 2017. This particular winter storm event was named Winter Storm Ezekiel which was an event that slammed the East Coast. In Tioga County, Lawrenceville recorded the highest snow accumulations with 13 inches total. Elkland and Mansfield both recorded snow accumulations of 11 inches while Middlebury

Township, Wellsboro, Cowanesque, and Blossburg posted between 7 - 9 inches. This storm in general produced seven to 15 inches of snow across Tioga County.

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Tioga County Winter Storm History (NOAA NCEI, 2020)					
Location	**Date**	**Event**	**Location**	**Date**	**Event**
Tioga County	02/13/1997	Winter Storm	Tioga County	01/10/2009	Winter Storm
Tioga County	01/02/1999	Winter Storm	Tioga County	01/27/2009	Winter Storm
Tioga County	01/08/1999	Winter Storm	Tioga County	10/15/2009	Winter Storm
Tioga County	01/14/1999	Winter Storm	Tioga County	02/25/2010	Winter Storm
Tioga County	02/18/2000	Winter Storm	Tioga County	02/01/2011	Winter Storm
Tioga County	12/13/2000	Winter Storm	Tioga County	03/23/2011	Winter Storm
Tioga County	03/24/2002	Winter Storm	Tioga County	16/26/2012	Winter Storm
Tioga County	01/05/2005	Winter Storm	Tioga County	02/04/2014	Winter Storm
Tioga County	01/22/2005	Winter Storm	Tioga County	02/01/2015	Winter Storm
Tioga County	02/21/2005	Winter Storm	Tioga County	01/23/2017	Winter Storm
Tioga County	03/23/2005	Winter Storm	Tioga County	02/09/2017	Winter Storm
Tioga County	12/16/2005	Winter Storm	Tioga County	03/13/2017	Winter Storm
Tioga County	12/13/2007	Winter Storm	Tioga County	02/07/2018	Winter Storm
Tioga County	02/01/2008	Winter Storm	Tioga County	11/15/2018	Winter Storm
Tioga County	12/11/2008	Winter Storm	Tioga County	01/19/2019	Winter Storm
Tioga County	12/19/2008	Winter Storm	Tioga County	12/01/2019	Winter Storm

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Tioga County Heavy Snow History (NOAA NCEI, 2020)					
Location	**Date**	**Event**	**Location**	**Date**	**Event**
Tioga County	01/02/1996	Heavy Snow	Tioga County	01/02/2003	Heavy Snow
Tioga County	03/07/1996	Heavy Snow	Tioga County	02/16/2003	Heavy Snow
Tioga County	11/14/1997	Heavy Snow	Tioga County	03/30/2003	Heavy Snow
Tioga County	12/10/1997	Heavy Snow	Tioga County	12/14/2003	Heavy Snow
Tioga County	12/29/1997	Heavy Snow	Tioga County	02/03/2004	Heavy Snow
Tioga County	02/23/2998	Heavy Snow	Tioga County	03/16/2004	Heavy Snow
Tioga County	03/14/1998	Heavy Snow	Tioga County	10/25/2005	Heavy Snow
Tioga County	03/21/1998	Heavy Snow	Tioga County	02/13/2007	Heavy Snow
Tioga County	03/04/1999	Heavy Snow	Tioga County	03/16/2007	Heavy Snow
Tioga County	03/04/2001	Heavy Snow	Tioga County	04/15/2007	Heavy Snow
Tioga County	03/21/2001	Heavy Snow	Tioga County	02/20/2011	Heavy Snow
Tioga County	01/06/2002	Heavy Snow	Tioga County	03/06/2011	Heavy Snow
Tioga County	01/19/2002	Heavy Snow	Tioga County	04/22/2012	Heavy Snow
Tioga County	12/05/2002	Heavy Snow	Tioga County	12/14/2013	Heavy Snow
Tioga County	12/21/2002	Heavy Snow	Tioga County	01/02/2014	Heavy Snow

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Tioga County Ice Storm History (NOAA NCEI, 2020)		
Location	**Date**	**Event**
Tioga County	03/14/1997	Ice Storm
Tioga County	01/15/2998	Ice Storm
Tioga County	01/22/1998	Ice Storm
Tioga County	02/13/2000	Ice Storm

Location	Date	Event
Tioga County	01/31/2002	Ice Storm
Tioga County	12/10/2002	Ice Storm
Tioga County	12/13/2002	Ice Storm
Tioga County	12/02/2007	Ice Storm
Tioga County	12/09/2007	Ice Storm
Tioga County	03/04/2008	Ice Storm
Tioga County	12/23/2008	Ice Storm

4.3.12.4 Future Occurrence

There is a high probability of winter weather and winter storms occurring in Tioga County, with expected annual events across most of the Commonwealth. An analysis of the past occurrences indicates that this trend will continue annually in the future. Meanwhile, climate change is expected to bring changes to the future of winter storms impacting Pennsylvania. Climate scientists believe that extreme winter storms are expected to occur more frequently. There were about twice as many extreme snow events in the United States in the latter half of the 20th century as occurred in the first half. This uptick is caused, in part, by higher-than-normal ocean surface temperatures that result in an increased source of moisture for storms that develop over the Atlantic Ocean. Conditions for severe winter storms are particularly heightened in the eastern United States due to changes in atmospheric circulation patterns caused by higher temperatures and melting Arctic sea ice. Winters in 2000 and 2001 were mild in Pennsylvania and led to spring-like thunderstorms during the winter months rather than snowstorms. Such thunderstorms can be followed by cold fronts and winter storms resulting in temperature drops of 50˚F in a few short hours. Even though average temperatures are expected to be higher overall and there are expected to be fewer extreme cold days, those that do occur are expected to reach record-setting low temperatures more frequently. Winter storms are a regular, annual occurrence in Tioga County and should be considered highly likely.

4.3.12.5 Vulnerability Assessment

Winter storms are a concern based on frequency of winter storm effects on Tioga County. Based on the information available, all communities in Tioga County are essentially equally vulnerable to the direct impacts of winter storms. Residents of the more rural areas of the county may be more susceptible to the vulnerability of delayed emergency medical assistance. Icy and snow-covered roads often result in increases in traffic incidents. Residents of the mountainous and more rural areas of the county may be more susceptible during severe storms, especially when emergency medical assistance is required due to the location's potential for isolation. The economic impacts from snow removal, road and infrastructure repair and other secondary effects can create a strain on the budgets and material resources of local municipalities.

Because of the frequency of winter storms, strategies have been developed to respond these events. Snow removal and utility repair equipment is present to respond to typical events. The use of auxiliary heat and electricity supplies such as wood burning stoves, kerosene heaters and gasoline power generators reduces the vulnerability of humans to extreme cold temperatures commonly associated with winter storms but can increase their vulnerability to other hazards. People residing in structures lacking adequate equipment to protect against cold temperatures or significant snow and ice are more vulnerable to winter storm events. Even for communities that are prepared to respond to winter storms, severe events involving snow accumulations that exceed six or more inches in a twelve-hour period can cause a large number of traffic accidents, interrupt power supply and communications, and cause the failure of inadequately designed and/or maintained roof systems.

Even for communities that are prepared to respond to winter storms, severe events involving snow accumulations that exceed six or more inches in a twelve-hour period can cause a large number of traffic accidents, strand motorists due to snow drifts, interrupt power supply and communications, and cause the failure of inadequately designed and/or maintained roof systems. Similar to the vulnerability assessment discussion for tornados and severe wind, vulnerability to the effects of winter storms on buildings is dependent on the age of the building, construction material used and condition of the structure.

Winter storm events often cause vulnerability in environmental impacts as well. Environmental impacts often include damage to shrubbery and trees due to heavy snow loading, ice build-up and/or high winds which can break limbs of even bring down large trees. An example of indirect effect to the environment is the treatment of roadway surfaces with salt, chemicals, and other de-icing materials which can impair adjacent surface and ground waters. However, winter storms have a positive environmental impact as well; gradual melting of snow and ice provides excellent groundwater recharge. However, abrupt high temperatures following a heavy snowfall can cause rapid surface water runoff and severe flooding to occur in the county.

4.3.13. Civil Disturbance and Criminal Activity

4.3.13.1 Location and Extent

Civil disturbance refers to mass acts of disobedience where participants can become hostile to authority and there is a threat to maintaining public safety and order. Such disturbances can often be forms of protest in the face of socio-political problems. Riots have not been frequent occurrences throughout the history of the Commonwealth, however when they occur, they can cause significant property damage, injury and even loss of life. The scale and scope of civil disturbance events varies widely. Government facilities, local landmarks, prisons, and universities are common sites where crowds and mobs may gather.
Criminal activity refers to all criminality, including enemy attack, disinformation, sabotage, physical or information break of security, workplace or school violence, harassment, discrimination, and other crimes. Criminal activity is a very broad hazard category and similar to

civil disturbance, the scale and scope of incidents or events vary widely.

4.3.13.2 Range of Magnitude

Civil disturbances can take the form of small gatherings or large groups blocking or impeding access to a building or disrupting normal activities by generating noise and intimidating people. They can range from a peaceful sit-in to a full-scale riot, in which a mob burns or otherwise destroys property and terrorizes individuals. Even in its more passive forms, a group that blocks roadways, sidewalks, or buildings interferes with public order. There are two types of large gatherings typically associated with civil disturbances: a crowd and a mob. A crowd may be defined as a casual, temporary collection of people without a strong, cohesive relationship. Crowds can be classified into four categories:

- **Casual Crowd**: A casual crowd is merely a group of people who happen to be in the same place at the same time. Violent conduct does not occur.
- **Cohesive Crowd**: A cohesive crowd consists of members who are involved in some type of unified behavior. Members of this group are involved in some type of common activity, such as worshipping, dancing, or watching a sporting event. Although they may have intense internal discipline, they require substantial provocation to arouse to action.
- **Expressive Crowd**: An expressive crowd is one held together by a common commitment or purpose. Although they may not be formally organized, they are assembled as an expression of common sentiment or frustration. Members wish to be seen as a formidable influence. One of the best examples of this type is a group assembled to protest.
- **Aggressive Crowd**: An aggressive crowd is comprised of individuals who have assembled for a specific purpose. This crowd often has leaders who attempt to arouse the members or motivate them to action. Members are noisy and threatening and will taunt authorities. They may be more impulsive and emotional and require only minimal stimulation to arouse violence. Examples of this type of crowd could include demonstrators and strikers, though not all demonstrators and strikers are aggressive.

A mob can be defined as a large disorderly crowd or throng. Mobs are usually emotional, loud, tumultuous, violent and lawless. Similar to crowds, mobs have different levels of commitment and can be classified into four categories:

- **Aggressive Mob**: An aggressive mob is one that attacks, riots, and terrorizes. The object of violence may be a person, property, or both. An aggressive mob is distinguished from an aggressive crowd only by lawless activity. Examples of aggressive mobs are the inmate mobs in prisons and jails, mobs that act out their frustrations after political defeat, or violent mobs at political protests or rallies.
- **Escape Mob**: An escape mob is attempting to flee from something such as a fire, bomb, flood, or other catastrophe. Members of escape mobs are generally difficult to control and can be characterized by unreasonable terror.

- **Acquisitive Mob**: An acquisitive mob is one motivated by a desire to acquire something. Riots caused by other factors often turn into looting sprees. This mob exploits a lack of control by authorities in safeguarding property.
- **Expressive Mob**: An expressive mob is one that expresses fervor or revelry following some sporting event, religious activity, or celebration. Members experience a release of pent-up emotions in highly charged situations.

In the event of a significant civil disturbance or criminal activity incident, local government operations and the delivery of services in the community may experience short-term disruptions. The greatest secondary effect is the impact on the economic and financial conditions of the affected community, particularly in relation to the property, facilities, and infrastructure damaged as a result of the disturbance. More serious acts of vandalism may result in limited power failure or hazardous material spills, leading to a possible public health emergency. Altered traffic patterns may increase the probability of a transportation accident.

Tioga County's greatest likelihood for civil disturbance is in the borough of Wellsboro, the county seat. Citizens, property, and infrastructure could be affected if a large-scale disorder were to take place. Typically, government facilities, landmarks, prisons, and universities are common sites where crowds or mobs may gather. Tioga County is home to two colleges/universities within its borders: Mansfield University and the Pennsylvania College of Technology – North Campus, located in the Wellsboro School District Administration Building. Additionally, other universities such as the main campus of the Pennsylvania College of Technology and Lycoming College in Williamsport and three across the border in New York State are all located within an hour of Tioga County.

4.3.13.3 Past Occurrences

The county has not experienced any significant civil disturbance events.

Following the death of George Floyd in Minneapolis, Minnesota in May 2020 at the hands of law enforcement, civil unrest erupted across the nation. A peaceful demonstration of support for *Black Lives Matter* (BLM) on Wellsboro's Main Street became less civilized on a Friday evening in July 2020: while approximately 25 local protesters silently held signs highlighting racial inequality, other local residents hurled insults and racial epithets (as well as words of support). The evening ended with Wellsboro police handcuffing and removing a man who had refused their instructions. As BLM demonstrators walked on the boulevards, a second crowd gathered in small groups along Main Street.

Figure X - Counter-Protest on Main Street

The crowd waved confederate flags and shouted comments. A small group of counter-protesters, holding signs reading “All Lives Matter” and similar sentiments, paraded silently on the sidewalks of Main Street in Wellsboro (see *Figure X – Counter-Protest on Main Street* above). (Westfield Free Press-Courier).

Other peaceful *Black Lives Matter (BLM)* marches and demonstrations took place in the county throughout the summer of 2020.

4.3.13.4 Future Occurrence

While unlikely, civil disturbances may occur in Tioga County, and it is difficult to accurately predict the probability of future occurrence for civil disturbance events over the long-term. However, *Table X - Civil Disturbance Events Reported to PEMA 2012-2018*, depicts the range of potential civil disturbances in Pennsylvania and gives the county some background for consideration of future occurrences.

Table X - Civil Disturbance Events Reported to PEMA 2012-2018 (Knowledge Center)

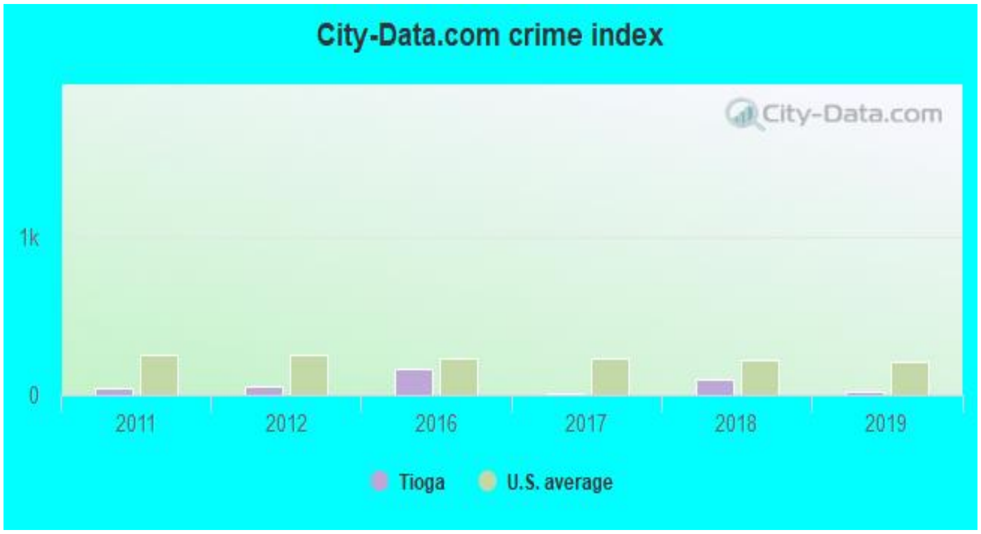
Civil Disturbance Events Reported to PEMA 2012-2018)							
Event Type	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Demonstration	1	3	9	3	3	3	3
Juvenile Detention Center	0	0	0	0	0	0	1

Event Type	2012	2013	2014	2015	2016	2017	2018
Prison Disturbance	0	2	0	0	0	1	0
Detainee Escape	2	4	3	4	0	2	1
Protest	4	24	49	35	64	78	13
Large Crowd Gathering	0	1	0	4	2	3	2
Riot	0	0	0	1	0	0	0
School Threat	1	2	0	2	0	2	0
Assault	2	8	2	2	3	4	0
Gun/Bomb Incident	3	15	3	7	2	3	0
Civil Disturbance Totals	***13***	***59***	***66***	***58***	***74***	***96***	***20***

According to the Pennsylvania State Hazard Mitigation Plan, from 2012 to 2017, the commonwealth experienced an average of 74 civil disturbance events each year. While that number is relatively low and the occurrences in Tioga County are rare, the local planning team (LPT) decided civil disturbance should be regarded as a moderate-risk hazard due to the current political trends and frictions across the country.

Similar to civil disturbance, it is extremely difficult to predict when criminal activity may take place in Tioga County and throughout the Commonwealth of Pennsylvania. According to the City-Data.com crime index, the 2019 crime rate in Tioga County was 10.9 times lower than the U.S. average. (See *Figure X, City-Data.com crime index*.) In the last five years, Tioga County has seen decreasing violent crime but a rise of property crime. Read more at: https://www.city-data.com/crime/crime-Tioga-Pennsylvania.html.

Figure X - City-Data.com crime index



Overall, the local planning team has designated criminal activity as a moderate-risk hazard, according to the risk factor score found on page 180.

4.3.13.5 Vulnerability Assessment

All municipalities in Tioga County can be vulnerable to civil disturbance and criminal activity; however, the anticipated impact from such events is minimal. These events may be sparked for varying reasons and the seriousness of the event may well be exacerbated by how authorities handle the crowd. At the writing of this plan, the political temperature of the country as a whole continued to run high, making this hazard vulnerability one for consistent monitoring by public safety officials.

4.3.14. Dam Failure

4.3.14.1 Location and Extent

A dam restricts the flow of water or underground streams and often creates reservoirs for water storage. The reservoirs created by these barriers not only suppress floods but also provide water for activities such as irrigation, human consumption, industrial use aquaculture, and navigability.

Dam failures occur usually as a secondary effect of massive rainfall and flooding, causing too much water to enter the spillway system. This type of failure occurs with little to no warning. Spring thaws, severe thunderstorms, and heavy rainfall are also contributing factors to dam failure. Depending on the size of the body of water where the dam is constructed, additional water may come from distant upstream locations. Water contributions may also come from dam failures in adjoining counties that are along the same riverine or water features.

Poor engineering or poor maintenance may also cause dam failures. The Pennsylvania Department of Environmental Protection (PA DEP) and the United States Army Corps of Engineers (USACE) award permits for dams and also share inspection responsibilities. Inspection results are characterized as either safe or unsafe.

The National Inventory of Dams (NID) is a registry that captures information about structures that are greater than or equal to 25 feet in height or that impound 50-acre-feet or more of water (an acre-foot is equal to 325,851 gallons of water); it includes structures above 6 feet in height where failure would potentially cause damage downstream. The dams are classified in terms of hazard potential as “High”, “Significant”, or “Low”, with high-hazard dams requiring emergency action plans (EAPs). There are twenty-one high and low hazard dams located in Tioga County that are both publicly and privately owned and are registered with the USACE in the NID. There are fifteen dams within the county that are high hazard and require an emergency action plan and there are six dams that are low hazard and do not require an emergency action plan. *Table X – High Hazard Dam Class and Category* lists the class and category of the dams located in Tioga County. Dam classes are based on potential life and economic loss in the event of a failure.

Table X – High Hazard Dam Class and Category

High Hazard Dam Class and Category (PA DEP)	
Class:	**Description:**
A	Equal to or greater than 50,000-acre feet of impoundment and is equal or greater than 100 feet in height.
B	Less than 50,000 and greater than 1,000-acre feet of impoundment storage and is less than 100 and greater than 40 feet in height.
C	Equal to or less than 1,000-acre feet of impoundment storage and equal to or less than 40 feet in height.
Category:	**Description:**
1	Substantial potential loss – numerous homes or small businesses or a large business or school.
2	Few potential losses – a smaller number of homes or small businesses.
3	No expected losses – no permanent structures for human habitation or employment with significant damages to public or private property.
4	No expected losses – no permanent structures for human habitation or employment with minimal damage to public or private property.

Table X – Tioga County Dams is an inventory of dams in Tioga County provided by the Pennsylvania DEP Bureau of Waterways Engineering and Wetlands and is broken down by classification, then municipality. *Table X – High Hazard Dams Municipal Summary* summarizes the high-hazard dams in Tioga County by municipality. The municipalities not listed do not have high-hazard dams.

Table X – High Hazard Dams Municipal Summary

High Hazard Dams – Municipal Summary (PA DEP)	
Municipality	**Number of High Hazard Dams**
Charleston Township	3
Clymer Township	2
Delmar Township	3
Hamilton Township	1
Jackson Township	2
Lawrence Township	1
Liberty Township	1
Middlebury Township	1
Richmond Township	2
Tioga Township	3
Wellsboro Borough	1
Westfield Township	1
Total:	**21**

Table X – Tioga County Dams

Tioga County Dams (DEP & NID)							
Class	**Name**	**Owner Type**	**Owner**	**Primary Purpose**	**River / Stream**	**Municipality**	**Hazard**
A-1	Cowanesque Dam	Federal	CENAB	Flood Control	Cowanesque River	Lawrence Township	H
	Tioga Dam	Federal	CENAB	Flood Control	Tioga River	Tioga Township	H
	Tioga Dam – Mansfield Levee	Federal	CENAB	Flood Control	Crooked Creek	Tioga Township	H
	Hammond Dam	Federal	CENAB	Flood Control	Charleston Creek	Tioga Township	H
B-1	Hamilton Lake (PA-602) Dam	Local Government	Borough of Wellsboro	Flood Control	Charleston Creek	Charleston Township	H
	Beechwood Lake (PA-454) Dam	State	PA Fish and Boat Commission	Flood Control	East Beech Woods Creek	Clymer Township	H
	Lake Nessmuk (PA-601) Dam	State	PA Fish and Boat Commission	Flood Control	Morris Branch Marsh Creek	Delmar Township	H
C-1	Kelsey Creek (PA-600) Dam	Local Government	Tioga County Commissioners	Flood Control	Kelsey Creek	Wellsboro Borough	H
	Eberle (PA-456) Dam	Local Government	Tioga County Commissioners	Flood Control	Closes Creek	Westfield Township	H
	Griffin (PA-455) Dam	Local Government	Tioga County Commissioners	Flood Control	West Beech Woods Run	Clymer Township	H
C-2	Morris Run No 3 Dam	Local Government	Hamilton Township Municipal Authority	Water Supply	Morris Run	Hamilton Township	H
C*	Hills Creek Dam	State	DCNR	Recreation	Hills Creek	Charleston Township	H
	Lewis Pond	Private	Don Lewis	Recreation	-	Charleston Township	L
	Mackiewicz	Private	Charles Mackiewicz	Fish and Wildlife Pond	Blockhouse	Liberty Township	L
	Brown	Private	Russell Brown	Recreation	Tributary – Elkhorn Creek	Middlebury Township	H

	Name	Owner Type	Owner	Primary Purpose	River / Stream	Municipality	Hazard
	Browns Lake Dam	Private	Arlington Brown	Recreation	Watershed West Branch Stony Fork	Delmar Township	L
	Borg	Private	Herbert Borg	Fish and Wildlife Pond	Tributary Elk Creek	Richmond Township	H
	Brechbill Dam	Private	Ivan Brechbill	Fish and Wildlife Pond	Tributary Stony Fork	Delmar Township	L
	Hammond Lakes	Private	Tony Dreslim	Fish and Wildlife Pond	Hammond Creek	Jackson Township	L
	Collum Pond	Private	Wilton Collum	Stock or Small-Fish Pond	Harts Creek	Jackson Township	H
	Taylor Run Dam	Local Government	Municipal Authority of Mansfield	Other	Tributary Lambs Creek	Richmond Township	L
*undesignated category							

The PA DEP defines a high-hazard dam as “Any dam so located as to endanger populated areas downstream by its failure”. High-hazard dams receive two inspections each year – once by a professional engineer on behalf of the owner and once by a PA DEP inspector (DEP 2008).

4.3.14.2 Range of Magnitude

The municipalities where these dams are located, and the communities downstream, are at the greatest risk for a dam failure. Flooding is the most common secondary effect of dam failure. If the dam failure is severe, a large amount of water will enter the downstream body of water and overflow the stream banks for miles. Environmental vulnerability is dependent on the contents of the water and the path it takes.

A catastrophic failure is characterized by the sudden, rapid, and uncontrolled release of water from a dammed impoundment. Seepages in earthen dams usually develop gradually, and if detected early, downstream residents have anywhere from a few hours to a few days to evacuate. Overtopping of a dam normally gives sufficient lead time for evacuation. Failures of concrete or masonry dams tend to occur suddenly, sending a wall of water and debris down a valley or inundation area quickly.

4.3.14.3 Past Occurrence

There are no recorded dam failures in Tioga County. Smaller incidences in the county have occurred but have not had significant impacts in the county. The most destructive dam failure is

US history took place in Johnstown, Pennsylvania (Cambria County) in 1889, claiming 2,209 lives. Another significant dam failure took place in Austin, Pennsylvania (Potter County) in 1911, claiming 78 lives.

4.3.14.4 Future Occurrence

Although dam failures can occur at any time, given the right circumstances, the likelihood of a dam failure in Tioga County is considered to be unlikely.

The presence of structural integrity and inspection programs significantly reduces the potential for major dam failure events to occur. The PA DEP inventories and regulates all the dams that meet or exceed the following criteria (PA DEP, 2008):

- Impound water from a drainage area of greater than 100 acres
- Have a maximum water depth greater than 15 feet
- Have a maximum storage capacity of 50 acre-feet or greater

The construction, operation, maintenance, and abandonment of dams is reviewed and monitored by the PA DEP Division of Dam Safety. Dams are evaluated based on categories such as slope stability, undermining seepage, and spillway adequacy.

4.3.14.5 Vulnerability Assessment

Property and populations located downstream from any dams or levees are vulnerable to dam failures. The Pennsylvania Code (§105.91 Classification of dams and reservoirs) classifies both dams by size and the amount of loss of life and economic loss expected in a failure event. Although the size of a dam may result in varying impacts, the hazard potential classification of category one dams is a more important reference indicator, since that will indicate the level of potential substantial loss of life and excessive economic loss.

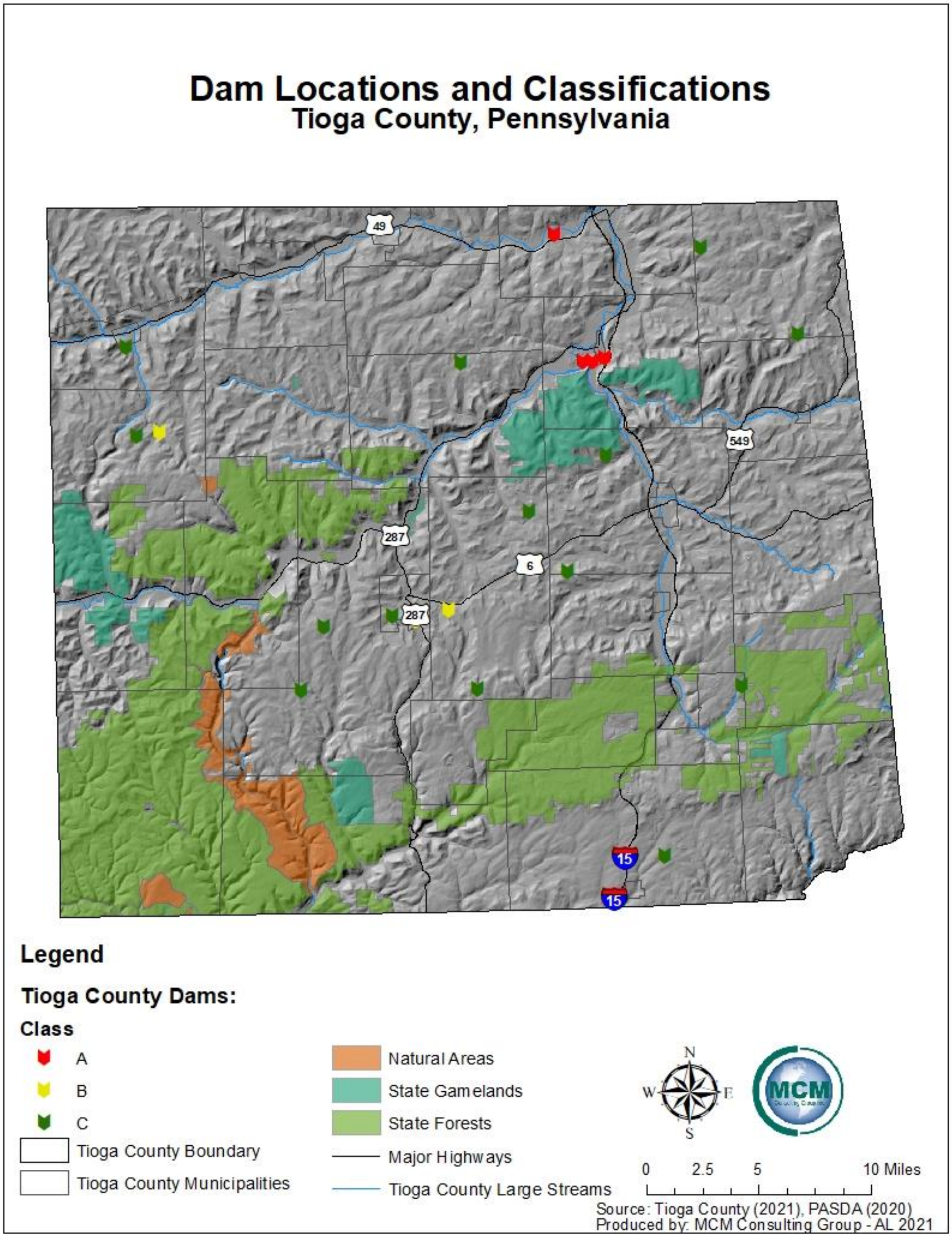
Most dam failures are usually gradual, low volume releases that are unexpected, and do not cause loss of life or damage to the environment. There is always the possibility that a dam could fail, however the probability is unlikely in Tioga County. The Pennsylvania 2013 Standard State All-Hazard Mitigation Plan identified an estimated 11,850 people in Tioga County who are vulnerable to dam failure. *Figure X – Dam Locations and Classifications* shows the locations of dams within Tioga County by class.

Emergency action plans are developed by owners of high hazard dams. These plans are then disseminated to first responders and other planning partners. Vulnerable populations are those residents and businesses located downstream from a high hazard dam within the inundation area. The emergency action plan identifies a call list to notify downstream at-risk population. Emergency action plan exercises are held every five to seven years.

Dam failures can cause significant environmental effects, as the resulting flood from a dam failure is likely to disperse debris and hazardous materials downstream that can damage local ecosystems. Debris carried downstream can block roads, cause traffic accidents, disrupt traffic patterns, and delay the delivery of essential services along major traffic corridors. Debris flow can also cause landslides along steep slopes and embankments. The economic and financial impact from damage and recovery ranges from minimal to severe, depending on the magnitude of damage and scale of failure.

Of the fifteen high hazard dams that are located within Tioga County, the Cowanesque Dam has the largest drainage area with a total drainage area of 298 acres. The dams that were constructed most recently are the Cowanesque Dam and the Borg Private Dam, which were constructed in 1980 and 1984 respectively. The dam that is the oldest in the county is the Morris Run Number Three Dam which was completed in 1920. The dam with the highest height in the county is the Taylor Run Dam with a height of 151 feet. The largest owner of dams in Tioga County is the Tioga County Commissioners who own three dams within the county. A majority of the dams in Tioga County are owned by small municipalities, different state agencies, local individuals, or corporations. The county dams are also distributed evenly throughout the county and the municipalities, with an even mix of high and low hazard dams.

Figure X – Dam Locations and Classifications



4.3.15. Disorientation

4.3.15.1 Location and Extent

An urban fire involves a structure or property within an urban or developed area. Structural and urban fires within Tioga County have had a detrimental impact on life, property, and the local economy over the past decade. The age of many residential structures within the region combined with changes in building construction and materials has increased the threat of fire loss that is occurring on a regular basis.

As defined by the National Fire Protection Agency (NFPA) in the *NFPA 901: Standard Classifications for Incident Reporting and Fire Protection Data*, a structure fire is defined as "any fire inside, on, under, or touching a structure". This definition includes any mobile residential structure such as a mobile or modular home but does not include roadworthy vehicles such as recreation vehicles (*NFPA 2011*). Significant urban fires are limited to densely populated areas of the county that contain large and/or multiple buildings. Urban fires may start in a single structure but spread to nearby buildings, or throughout a large building if adequate fire control measures are not in place.

An explosion is defined as a violent expansion in which energy is transmitted outward as a shock wave. Significant explosions are most common in densely populated areas and at industrial facilities that utilize combustible hazardous materials. Explosions can also occur in conjunction with automobile, boat, and rail accidents. All such explosions can turn into fires, spreading to nearby structures.

The presence of meth-labs can be the cause of severe fires and/or explosions due to the volatile chemicals involved in this illegal practice. Another hazardous condition with the potential for fires and explosions is Marcellus Shale natural gas sites, during drilling, flaring, or production.

4.3.15.2 Range of Magnitude

The severity of urban fires is measured according to the losses associated with the incident. The impact to the local economy is minimal with the loss of a residential structure, but effects of the loss of a large manufacturing facility that employs many people can be extensive. Likewise, the impact to the local environment from a single residential fire is minimal, while the impact from an industrial or commercial fire can take years to measure. Finally, the loss of life caused by urban fires appears to be opposite of the previous two impacts. The loss of life is more likely to be associated with a residential fire than an industrial or commercial building fire. Building compositions combined with the time of day of the incident are risk factors that can increase the chance for the loss of life during a residential-type fire.

The effects of a major (industrial) explosion include minor to serious property damage, loss of life, environmental damage, and residential or industrial displacement. Severe explosions result in extensive damage to residential, commercial, and/or public property. Lives may be lost, and people are often displaced. Additionally, major explosions may result in hazardous materials mitigation issues. Explosion severity has two classifications: supersonic and subsonic. Supersonic explosions are created by high explosives and known as detonations and travel via shock waves. Subsonic explosions are created by low explosives through a slower combustion process known as deflagration.

The urban fires within Tioga County are usually small and generally affect residential structures These fires are limited in duration. While the average fire is small, the threat from a large or even catastrophic fire is always present. Many operations within larger industrial and commercial sties within Tioga County are prone to and have experienced small fires that if improperly contained can (and do) lead to catastrophic fire losses. Combined with the presence of volatile materials, threats of fires and explosions are ever changing and increasing within the region. Vacant buildings (both residential and commercial) pose a particular threat concerning urban fires.

A worst-case scenario for fire would be a large urban fire destroying residential and industrial building, which would potentially cause additional environmental hazard effects. A worst-case scenario for explosions would be a massive explosion causing numerous fatalities in a facility as well as the surrounding area and leading to a secondary urban fire.

4.3.15.3 Past Occurrence

Table 59 – Reported Structural Fires 1999-2015 shows an annual fire report for Tioga County from 1999 to October 13, 2015. These fires were reported to the Pennsylvania Emergency Management Agency (PEMA) through the Pennsylvania Emergency Incident Response System (PEIRS). This table also shows the number of brush fires and fatalities. The worst year on record in Tioga County for fire hazards was 2000, when eleven people lost their lives due to fires. Between 2003 and 2007 was the worst five-year period for structure fires with an average of 1,339 fires a year within Tioga County.

Table 1 - Reported Structural Fires 1999-2015

Tioga County Reported Structural Fires 1999-2015			
Year	**Structure Fires**	**Brush Fires**	**Fatalities**
1999	952	575	6
2000	841	380	11
2001	751	307	2
2002	601	360	2
2003	1,275	488	1
2004	1,315	226	5
2005	1,224	524	2
2006	1,324	647	0
2007	1,557	372	0
2008	796	289	0

Year	Structure Fires	Brush Fires	Fatalities
2009	594	361	2
2010	472	251	0
2011	48	2	2
2012	74	6	1
2013	71	2	0
2014	72	5	1
2015	78	3	0
Total	12,046	4,798	35

Source: Pennsylvania Emergency Incident Response System (PEIRS) reports for 1999 to 2010; Knowledge Center 2011 to October 12, 2015. Note: One fire event in 2013 was listed as both a structure fire and brush fire. This event was recorded under both categories; however, the total number of reported fires in 2013 is 72.

Table 60 – Reported Structural Fires 2015-2020 (Corvena 2021) outlines structural fires, from residential to commercial, and identifies those with reported entrapments or fatalities. It should be noted that 2015 is listed in the two separate tables outlining fires in Tioga County, and that the table below has all structure fires for that year identified. In 2015 one residential structure fire resulted in the death of two individuals; while the most recent fire fatality occurred on August 25, 2020 in Industry Borough where one person died because of the fire.

Table 2 - Reported Structural Fires 2015-2020 (Corvena 2021)

Tioga County Reported Structural Fires 2015-2020 (Corvena 2021)									
Year	Structural Fires						Commercial		Total
	Residential	with entrapment	with fatalities	Barn	Multiple structures	Functional Needs Facilities (to include schools)	Commercial/ Industrial (to include churches and apartment buildings)	with fatalities	
2015	57	3	1	2	4	0	16	0	83
2016	28	4	0	0	0	5	14	0	51
2017	26	0	0	0	0	1	5	0	32
2018	29	0	0	1	0	1	11	0	42
2019	21	0	0	1	0	1	14	0	37
2020	34	0	1	1	0	1	13	0	50

Several explosions have occurred in Tioga County. These incidents were primarily industrial in nature and resulted in one or more of the following: extensive use of resources, loss of jobs, or impact to the community.

- In 1984, an explosion at the Valvoline Plant in Freedom caused multiple fatalities. In addition, heavy smoke conditions caused road closures and forced evacuations of surrounding buildings.
- In July 2010, an explosion at the Horsehead Corporation, a zinc smelting plant in Monaca, killed two people (Chemical Safety Board [CSB] 2015).
- In February 2011, an explosion at a Marcellus Shale natural gas well site in Independence Township led to minimal environmental damage, however; there was a large fire and injuries to three employees (WTAE 2011).
- In July 2014, a home in South Tioga exploded and resulted in the death of two residents. The explosion was heard from several miles away. Investigators identified both a basement stove and outside propane tank as possible causes for the explosion (Pittsburgh CBS Local News 2014).

Between January 2015 and December 2020 there were only seven incidents that either had an explosion or had the potential for explosions. These incidents were identified on Corvena and are:

- January 18, 2017, a military ordinance was found.
- January 22, 2017, a mobile meth lab was found in Hopewell Township.
- February 12, 2017, a meth lab was discovered inside a residence in Franklin Township.
- August 30, 2017, while police were assisting with a medical emergency, they discovered a mini meth lab in the apartment.
- September 10, 2018, there was a gas line explosion and fire in Center Township.
- December 13, 2018, Tioga County Detectives received a bomb threat at the courthouse, via an email.
- November 18, 2020, there was a structural fire with explosion reported in Big Tioga Borough. This is also listed in the structural fires table above.

4.3.15.4 Future Occurrence

Structure fires are hard to predict, however there are some initiatives that if utilized can prevent fires from becoming a devastating event. NFPA fire sprinkler initiative, 2019, reports that the U.S. experiences on average more than 255,000 home fires annually. These fires cause more than 2,500 civilian fire deaths and nearly 11,600 civilian fire injuries. Nearly 80% of fire deaths occur at home. First issued in 1975, *NFPA 13D, Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes* proposed home fire sprinklers as a solution. In 2006, *NFPA 5000, Building Construction and Safety Code®,* included a building code requirement for sprinklers in one- and two-family dwellings. There is a myth that the fire problem is only in older homes; the fact is, new homes have larger open spaces, unprotected, lightweight construction materials; and furniture stuffed with combustible materials, all factors that lead to homes burning hotter and faster. Fire sprinklers are green and:

- Reduce water use to fight a fire by 90% compared to a fire hose.
- Reduce greenhouse gases by 98%.
- Reduce fire damage by up to 97%.

Section 13,7.1.8 of the *Fire Code* contains criterial for the general installation of smoke alarms, including requirements for the interconnection of smoke alarms in new construction. NFPA has two source documents regarding smoke alarms, *NFPA 101 (The Life Safety Code)* regulates where smoke alarms are required, and *NFPA 72 (The National Fire Alarm and Signaling Code)* regulates how smoke alarms are installed.

By using smoke alarms and having a home fire sprinkler system can reduce the devastating effects of fires, in loss of life and financial losses. However, with the decline in the number of volunteer firefighters within the commonwealth, any structure fire may have an extended period prior to more defined mitigation efforts (by fire departments) being applied. With increased limitations to manpower, single alarm fires of the past are now being handled as multiple-alarm events. This means that fire departments are calling for assistance from neighboring fire companies more often to meet the necessary requirements of properly fighting (mitigating) fires and explosions.

4.3.15.5 Vulnerability Assessment

The potential for fire and or explosions exists county-wide. Human error can play an important role in creating the potential for a major urban fire or explosion. The vulnerability of the citizens and property of Tioga County to fire and related incidents depends on many factors. On the negative side, homes and businesses within the county have their risk of loss increased each year they go without fire safety updates.

In Pennsylvania, the most vulnerable population groups to fires are those 65 years of age and over, and the low-income earners.

4.3.16. Emergency Services

4.3.16.1 Location and Extent

Fire, emergency medical services (EMS), local emergency management coordinators (LEMC), and law enforcement service agencies are defined per municipality in Tioga County. In addition to the local services, the county hosts numerous special teams. Regional and state-wide services are also available.

Most areas are served by volunteers instead of career personnel, which adds to response time due to volunteer availability. Volunteers provide emergency services above and beyond their regular means of financial support and time constraints. Agencies struggle with the availability of personnel depending on the time of day and skills/resources needed. The number of responders in general has decreased due to funding issues and retention of personnel.

Additionally, the time and expense of training required for emergency service personnel (volunteers and paid) is another factor in decreasing numbers of volunteers. The initial training for fire, EMS, and law enforcement can take several months to complete. For those in emergency medical services, there is a regular schedule of continued education to maintain certification. In the fire service, after the initial training, there are specialty courses offered, which are recommended, but not required. For law enforcement, skills such as firearms proficiency must be maintained, and updates to new laws and regulations continues throughout the officer's career.

4.3.16.2 Range of Magnitude

Finances, changing political climates, leadership, or a significant high-profile event can all trigger a system to be declared as "success" or "failure". In some cases, a combination of these factors can create a perfect storm. Unfortunately, many "failed" systems are measured by recent events, no matter how successful they may have been in the past. Although financial problems are often blamed on poor leadership, they have many root causes. Labor rates, benefits, poor productivity, operational design, insurance reimbursements, and market regulation all have a significant direct impact on the financial viability of an organization.

Two fundamental topics are the financial and economic variables that drive emergency service systems. These systems typically generate revenue through tax subsidies, memberships, direct sales, diversification into other lines of business, grants, or fundraising. They spend most of these revenues on direct and indirect labor, and benefits. The remaining dollars go into infrastructure, fuel, medical supplies, insurances, fleet maintenance, dispatch, and other essential items. The remaining amount is used for recapitalization or fund balance development. Replacing and properly equipping an emergency response vehicle can cost up to or over $1 million.

4.3.16.3 Past Occurrence

There are no official records kept on shortages to emergency services. However, there has been a decrease in the number of new volunteers in the fire service. Most agencies are private organizations that lack local funding and exist based on tax dollars, fund raising, and donations received from their community. The time demand for fund raising adds to the demands on the availability of volunteers. Past practices are not sustaining the needed funds or manpower.

Without financial support from the communities, services may not be able to remain in operation to serve the same communities they have served for decades. Recruitment and personnel retention are keys to success.

4.3.16.4 Future Occurrence

Volunteerism is a significant component of the fire services in Tioga County. Most, if not all, members of the various community fire departments in the county are volunteers. A common problem with volunteerism in the fire services and emergency medical services is recruitment and retention of volunteers to keep both departments staffed. A decline in volunteerism has been seen within these services. With fewer volunteers to perform the tasks associated with fire and rescue operations, it is imperative for services to facilitate fundraising. Operational needs are impacted if there are fewer volunteers to raise funds. Without fundraising and community support these fire departments and volunteer EMS agencies will experience broader challenges. Municipalities can help offset some of the financial burdens to their local fire company by imposing a fire tax on its citizens.

Volunteerism and overall emergency services are low due to volunteers facing many challenges. Most volunteers must address their own needs by providing for family and, in many cases, are part of a two-income family. Limitations with time is another challenge many volunteers face due to the number of hours required to become certified as a first responder. Training is essential to provide for the general knowledge and safety of volunteers. With the limitation of time, many people find it personally challenging to dedicate time to a volunteer position. Volunteers are becoming less reliable, with many current volunteers getting older and becoming unable to perform at the same levels they once were.

Initially, fire departments were started to handle fires. Fire departments now preform many tasks other than fighting fire. Over time when other emergencies occurred, communities called upon the volunteer fire departments to handle various hazards such as vehicle accidents, commercial accidents, flooded basements, wire/trees down, trench rescue, hazardous material spills, traffic control, and sometime event standbys to support other agencies or events.

4.3.16.5 Vulnerability Assessment

The likelihood that EMS agencies and fire services will fail is a concern for all Tioga County communities. Law enforcement agencies also have been experiencing personnel shortages. The perception of law enforcement in society changes as events occur. A negative perception of law enforcement can discourage individuals from pursuing a career in law enforcement. Becoming a law enforcement officer requires a commitment of time and finances for training at local, state, or federal levels. The selection of law enforcement officers includes not only physical and mental aptitudes, but also a comprehensive physiological screening.

If any current public service agency fails to provide enough personnel to perform their required duties, then those duties must be provided for by another service agency that may be many miles away. This can put people and property in danger due to the increased response time. Many communities in Pennsylvania have already experienced the closure of services.

It is recommended that each municipality assess their own vulnerabilities by maintaining and building relationships with their local providers to begin to plan accordingly for if a local service were to shut down its operation. The statistics, response times, and all times associated with units dispatched are easily obtainable from the county 911 center. Consolidation of services is not a new concept for addressing the closure of services. Municipalities must weigh all the pros and cons for consolidation of emergency services with neighboring communities. In addition, continued support, and efforts to inform legislature could all prove to be paramount in assuring these services remain in operation into the future. At the time of the writing of this plan, a number of bills had been introduced in both the House of Representatives and the Senate as a result of a two-year study initiated by Senate Resolution 6 (SR6). The final report can be found here: http://pehsc.org/wp-content/uploads/2014/05/SR-6-REPORT-FINAL.pdf.

Emergency response agencies that currently provide services within Tioga County are identified in the following tables, *Table X – Tioga County Fire Departments* identifies the municipalities served. All fire departments in Tioga County are volunteer. *Table X – Tioga County EMS Agencies* identifies each emergency medical service agency and the municipalities served. *Table X – Tioga County Law Enforcement Agencies* identifies each police department to include the Pennsylvania State Police (PSP) and the municipalities served. *Figure X – Emergency Services Facilities* shows the geographical layout of the first responder services within Tioga County.

Table X – Tioga County Fire Departments

Tioga County Fire Departments	
Station Name	**Department Number**
Morris Fire Department	15
Wellsboro Fire Department	1
Liberty Fire Department	9
Mansfield Fire Department	2
Tioga Fire Department	7
Millerton Fire Department	12
Lawrenceville Fire Department	8
Daggett Fire Department	13
Blossburg Fire Department	4
Middlebury Fire Department	11
Chatham Fire Department	17
Westfield Fire Department	0
Clymer Fire Department	16
Osceola Fire Department	14
Knoxville Fire Department	6
Elkland Fire Department	3
Nelson Fire Department	18

Table X – Tioga County EMS Agencies

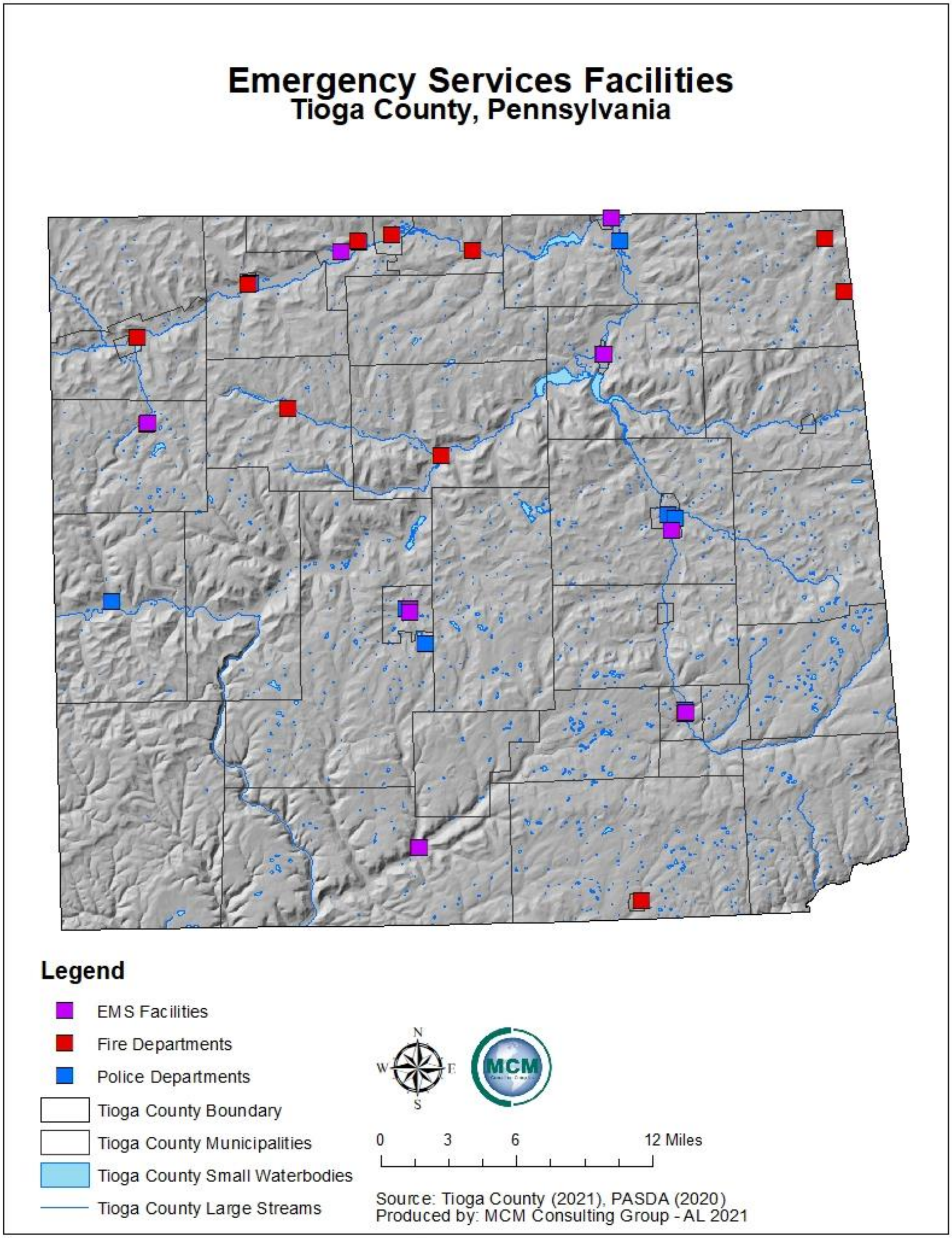
Tioga County EMS Agencies	
Station Name	**Radio ID**
Wellsboro Fireman's Ambulance	1
Mansfield Ambulance	2
Blossburg Ambulance	4
Tioga Ambulance	7
Lawrenceville Ambulance	8
Morris Ambulance	15
Clymer Ambulance	16
Valley Community Ambulance	25

Station Name	Radio ID
Soldiers & Sailors Hospital	Medic 1

Table X – Tioga County Law Enforcement Agencies

Tioga County Police Departments	
Station Name	**Department Number**
Blossburg Police Dept	1
Elkland Police Dept	2
Knoxville Police Dept	3
Lawrenceville Police Dept	4
Mansfield Police Dept	6
Tioga Police Dept	8
Wellsboro Police Dept	9
Westfield Police Dept	11
Gaines Police Dept	23
Lawrence Twp Police Dept	26
Nelson Twp Police Dept	30
Osceola Twp Police Dept	31
Department of Forestry	-
Mansfield University Police Dept	-
Tioga County Sheriff	-
Tioga County Probation	-

Figure X – Emergency Services Facilities



4.3.17 Environmental Hazards

4.3.17.1 Location and Extent

Environmental hazards in Tioga County mostly consists of hazardous materials releases at fixed facilities, Marcellus Shale gas well incidents, or due to transportation accidents. Activities associated with Marcellus gas well sites can cause fire and pollute streams and drinking water.

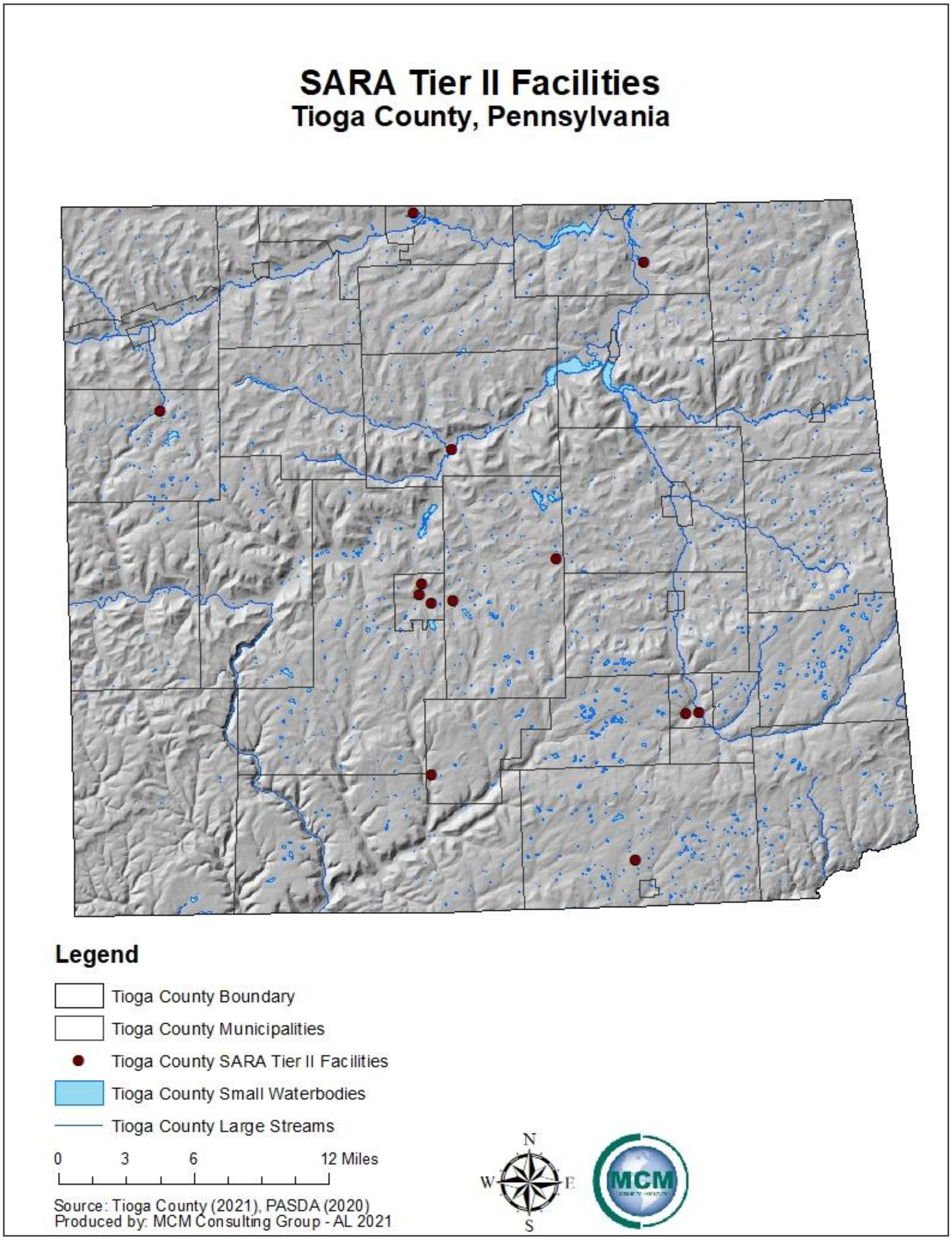
Hazardous materials fall into the following categories: flammable and combustible materials, compressed gases, explosive and blasting agents, radioactive materials, oxidizing materials, poisons, and corrosive liquids. Most hazardous materials incidents are generally unintentional and are associated with transportation accidents or accidents at fixed facilities. However, hazardous materials can be released as a criminal or terrorist act. Regardless of how a release happens, the result can be injury or death, and contamination to the air, water, and/or soil.

Facilities that use, manufacture, or store hazardous materials in Pennsylvania must comply with both Title III of the federal Superfund Amendments and Reauthorization Act (SARA), also known as the Emergency Planning and Community Right-to-Know Act (EPCRA), and the reporting requirements under the Hazardous Materials Emergency Planning and Response Act (1990-165) as amended for the commonwealth. Communities are kept abreast of the presence and release of chemicals at individual facilities with the community right-to know reporting requirements. The EPCRA was designed to ensure that state and local communities are prepared to respond to potential chemical accidents through local emergency planning committees (LEPCs). LEPCs are charged with developing emergency response plans for SARA Title III facilities; these plans cover the location and extent of hazardous materials; establish evacuation plans, response procedures, and methods to reduce the magnitude of a materials release; and establish methods and schedules for training and exercises.

There are thirteen facilities classified as using or storing extremely hazardous substances as defined by the EPA under SARA Title III in Tioga County. These facilities routes are shown in *Figure X - SARA Tier II Facilities*.

Transportation of hazardous materials along highways poses the greatest risk of release to Tioga County. Releases from rail transport are also a concern. The most traveled routes in the county are: U.S. Route 6, U.S. Route 15, PA Route 14, PA Route 49, PA Route 249, PA Route 287, PA Route 328, PA Route 349, PA Route 362, PA Route 414, PA Route 549, and PA Route 660. These major roads pass through the more populous areas of Tioga County. Similarly, rail lines pass through cities, borough and along major waterways where larger numbers of people could be vulnerable should a hazardous materials accident occur.

Figure X – SARA Tier II Facilities



Natural gas extraction from the Marcellus Shale formation exists at a depth of 5,000 to 8,000 feet and is located underneath the entire county. Activities associated with Marcellus Shale gas drilling can cause fires and pollute steams or drinking water. An additional hazard from oil and gas well drilling is stray methane gas in the subsurface, which can migrate into wells and homes. If the methane gas meets an ignition source it will ignite. Transportation of Marcellus Shale gas along pipelines, poses no greater threat to the environment or people as does any other natural gas pipeline. Pipelines are being constructed to connect each compressor station together as a gathering point, while major pipelines are being constructed to transfer the natural gas out of the county.

Marcellus Shale drilling has decreased within Tioga County. In 2008, there were fifteen shale wells drilled in the county; the next year, there were 123, and the year after that, there were 276. The year 2010 was the peak with the number of new wells dropping quickly to just thirty-three in 2013 and seventeen in 2016. Since then, the number of shale wells drilled has been very low in the county.

4.3.17.2 Range of Magnitude

Whether its accidental or intentional, there are several potentially exacerbating circumstances that will affect the severity or impact of a hazardous materials release. Some of these conditions, or characteristics that can enhance or magnify the effects of a hazardous materials release, include the following:

- Weather conditions: Affect how the hazard occurs and develops.
- Micro-meteorological effects of buildings and terrain: Alters dispersion of hazardous materials.
- Non-compliance with applicable codes (e.g., building or fire codes) and maintenance failures (e.g., fire protection and containment features): Can substantially increase the damage to the facility itself and to surrounding buildings.

There is also concern of hazardous materials releases during a flood event, should the flood compromise the production or storage of chemicals. This type of situation could swiftly move toxic chemicals throughout a water supply and across great distances.

The severity of any given hazardous materials incident is dependent not only on the circumstances described above, but also with the type of materials released and the distance and related response time for emergency response teams. Areas within close proximity to a release are generally at a greater risk, yet depending on the agent, a release can travel great distances or remain present in the environment for a long period of time resulting in extensive impacts on people and the environment.

Any type of drilling can cause stray methane gas in the subsurface; under certain conditions, to migrate to private water supply wells and ultimately into a building. This migration, if left unmitigated, can build up to explosive concentrations. A proper well vent allows methane to vent to the atmosphere rather than build up to explosive levels. The risk of an explosion from stray methane varies from location to location based on site-specific conditions.

Natural gas well fires occur when natural gas is ignited at the well site. Often, these fires erupt during drilling when a spark from machinery or equipment ignites the gas. The initial explosion and resulting flames have the potential to seriously injure or kill individuals in the immediate area. These fires are often difficult to extinguish due the intensity of the flame and the abundant fuel source. The potential impacts of oil and natural gas wells range in magnitude and extent to water, land, and air.

4.3.17.3 Past Occurrence

The majority of incidents in the past have involved natural gas problems along the highways or leaks from a fixed source. Most of these are the result of leaks that have limited impact on people and the environment. Yearly the number of hazardous materials being produced, stored, and transported continues to increase. Table X- Hazardous Materials Released in Tioga County lists the various past occurrence material releases and spills in Tioga County from the year 2014 to current.

Table X – Hazardous Materials Released in Tioga County

Hazardous Materials Released in Tioga County		
Date	**Municipality**	**Event**
04/03/2014	Tioga, Wellsboro Borough	NRC # 1079018 Tioga Co
11/04/2014	Tioga, Bloss Township	Compressor Station Gas Flaring
11/11/2014	Tioga, Bloss Township	Gas Compressor Maintenance-Tioga Co
12/11/2014	Tioga, Liberty Township	Gas Well Flaring-Tioga Co
12/17/2014	Tioga, Bloss Township	Natural Gas Blow Down
12/17/2014	Tioga, Sullivan Township	Gas Well Compressor Blowoff
01/19/2015	Tioga, Liberty Township	Gas Well Flaring Operations
02/10/2015	Tioga, Bloss Township	Compressor Station Annual Test
03/05/2015	Tioga, Liberty Township	Gas Venting
03/05/2015	Tioga, Richmond Township	Gas Venting
04/30/2015	Tioga, Sullivan Township	Gas Blow Down
05/18/2015	Tioga, Elk Township	Gas Blow Down - Tioga County
07/02/2015	Tioga, Brookfield Township	Gas Leak at Well Site
08/04/2015	Tioga, Gaines Township	Gas Well Flaring - Tioga Co
09/16/2015	Tioga, Gaines Township	Gas Well Blowdown-Tioga Co
12/18/2015	Tioga, Mansfield Borough	NRC #1136164 Tioga
02/03/2016	Tioga, Wellsboro Borough	NRC #1139673-Oil Spill-Tioga Co
02/24/2016	Tioga, Clymer Township	Gas Blow Down - Tioga County

Date	Municipality	Event
04/13/2016	Tioga, Nelson Township	Hazmat-Mineral Oil Spill
07/03/2016	Tioga, Covington Township	Gas Well Leak
08/25/2016	Tioga, Elk Township	Gas Blow Downs
10/01/2016	Tioga, Delmar Township	Gas Well Flaring
10/18/2016	Tioga, Hamilton Township	NRC #1161836 - Unknown Spill
07/11/2017	Tioga, Chatham Township	Well Blow Downs
07/18/2017	Tioga, Chatham Township	Natural Gas Blow Down - Tioga County
09/03/2017	Tioga, Liberty Township	Diesel Fuel Spill
11/12/2017	Tioga, Duncan Township	Hazardous Materials Release
12/28/2017	Tioga, Lawrence Township	Hazmat
05/05/2018	Tioga, Covington Township	Natural Gas Leak
09/25/2018	Tioga, Richmond Township	Natural Gas Blow Down- Tioga County
09/25/2018	Tioga, Sullivan Township	Natural Gas Blow Down
09/25/2018	Tioga, Covington Township	Natural Gas Blow Down- Tioga County
01/24/2019	Tioga, Osceola Township	Diesel Fuel Spill
03/11/2019	Tioga, Union Township	NRC #1240101 - Sheen on a Small Stream
04/22/2019	Tioga, Sullivan Township	Gas Well Venting
01/26/2020	Tioga, Delmar Township	Fracking Water Spill
04/21/2020	Tioga County	Natural Gas Pipeline Blow Down
05/17/2020	Tioga, Richmond Township	Gas Pipeline Blow Down
08/24/2020	Tioga, Ward Township	Natural Gas Flaring
09/02/2020	Tioga, Ward Township	Natural Gas Blow Down
03/23/2021	Tioga, Covington Township	Natural Gas Blow Down

Tioga County utilizes the reporting tool Corvena™ to track events related to environmental or hazardous material events. Reports to 911 of hazardous materials spills, to include Marcellus Shale drilling and pipeline emergencies, are tracked on Corvena™.

4.3.17.4 Future Occurrence

Future occurrence of an environmental hazard occurring in Tioga County is likely, however it is difficult to predict. Traffic accidents involving hazardous materials can be caused by many different facets, such as weather conditions or drivers' errors. As natural gas drilling and pipeline activities continue to grow in Tioga County, the inherent dangers persist. Pennsylvania is second only to the state of Texas. The natural gas production has increased dramatically in Pennsylvania since 2008. This has resulted in an increase to energy security, due to less dependence on fossil fuels from other parts of the world.

The Marcellus shale has been the predominant shale play in Pennsylvania, however, there is interest in the exploration and production of the Utica shale and Point Pleasant shale plays that are located well below the Marcellus shale play. The term "shale play" is used by the oil and gas exploration and development industry to identify areas of shale basins that appear to be suitable for shale gas development. There are more than a dozen geologic formations below the state's land surface that contain rich deposits of natural gas. As technology progresses, and oil and gas drilling companies are able to extract the natural gas from the multiple natural gas shales, the potential for environmental hazards due to this process exists.

4.3.17.5 Vulnerability Assessment

There are many miles of roadways within Tioga County, including interstate future I-99, of which most are owned and maintained by PennDOT. Interstate future I-99 is a major route that traverses the Commonwealth of Pennsylvania and crosses into New York. Various materials and substances, to include hazardous materials are transported over the interstate highway and other highways through the county. The railway network also is vulnerable to hazardous materials incidents.

Jurisdictions where one or more TRI (EPA's Toxic Release Inventory) fixed facilities are in operation should be considered vulnerable to a release of hazardous material(s). These releases could be the result of severe weather conditions, power outages, acts of criminal activities or terrorism, and/or human error.

All communities in Tioga County are vulnerable, on some level, to environmental hazards resulting from oil and gas well activity; to include drilling, pipeline construction, and distribution. Tioga County has previously taken steps to protect residents and reduce the county's overall vulnerability to oil/gas well drilling emergencies, with the development of procedures for handling emergencies at Marcellus well sites. Individual gas well drilling operators should have an Emergency Response Plan for their wells in place, however, the county's plan can substitute in an emergency. The Well Control Emergency Plan defines a well control emergency as uncontrolled flow of oil, gas, condensate, brine, sand, gravel, rock, and/or steam from a wellbore. The emergency plan lists procedures on how to deal with a blowout or control incident with or without fire, environmental release, injury on a rig, or other miscellaneous incidents.

4.3.18. Opioid Epidemic

4.3.18.1 Location and Extent

Pennsylvania and the United States at large have been experiencing an epidemic of opioid drug abuse. Opioid addiction occurs when an individual becomes physically dependent on opioids. Opioids are a class of drug that interact with receptors on nerve cells in the body and the brain. The use of opioids is a broad term that includes opiates, which are drugs naturally extracted from certain types of poppy plants, and narcotics. Opioids can also be synthetically made to emulate opium. Both prescribed (e.g. fentanyl) and illicit (e.g. heroin) opioid drugs are highly addictive and typically result in increasing numbers of overdose deaths. Overdose deaths from opioids occur when a large dose slows breathing, which can be more likely when opioids are combined with alcohol and antianxiety drugs. While generally prescribed with good intention, opioids can be over-prescribed, resulting in addiction.

According to the Drug Enforcement Administration (DEA), opioids come in various forms such as tablets, capsules, skin patches, powder, chunks in various colors from white to brown/black, liquid form for oral use or injection, syrups, suppositories, and lollipops. The Centers for Disease Control and Prevention (CDC) define the following as the three most common types of opioids:

- **Prescription Opioids:** Opioid medication prescribed by doctors for pain treatment. These can be synthetic, oxycodone (OxyContin), hydrocodone (Vicodin), or natural (morphine).
- **Fentanyl:** A powerful synthetic opioid that is 50 to 100 times more powerful than morphine and used for treating severe pain. Illegally made and distributed fentanyl is becoming more prevalent.
- **Heroin:** An illegal natural opioid processed from morphine which is becoming more commonly used in the United States.

While other addictive substances such as methamphetamines and alcohol can be problematic for the health of individuals in Tioga County, this profile focuses on opioid drugs and the opioid epidemic. The opioid crisis was declared to be a public health emergency on October 26, 2017. While the declaration provides validation for the scope and severity of the problem, it was not accompanied by any release of funding for mitigating actions. On January 10, 2018, Governor Tom Wolf declared the opioid epidemic to be a statewide public health disaster emergency for Pennsylvania. The declaration is intended to enhance response and increase access to treatment.

4.3.18.2 Range of Magnitude

Opioid addiction can lead to overdose, which can be fatal. Opioid addiction can affect others beyond the users themselves. The most dangerous side effect of an opioid overdose is depressed breathing. The lack of oxygen to the brain causes permanent brain damage, leading to organ failure, and eventually death. Opioid addiction can also be passed from mother to child in the womb. This condition, known as neonatal abstinence syndrome, has increased five-fold. According to the National Institute on Drug Abuse (NIDA). This results in an estimated 22,000 babies in the United States born with this condition. First responders such as paramedics, police officers, and firefighters are also affected by the opioid addiction crisis. First responders face exposure due to an increase of responses, particularly to synthetic fentanyl, consuming time and resources. Two or three milligrams of fentanyl can cause an induced respiratory depression, arrest, and possibly death to occur.

According to the Centers for Disease Control and Prevention (CDC), more than 192 Americans die every day from an opioid overdose. In 2014, 2,732 overdose deaths were reported across

Pennsylvania. This number increased to 3,264 reported overdose deaths in 2015, an increase of 19.5%. Reported overdose deaths increased again in 2016 to 4,627, an increase of 41.7% from 2015, then again to a total of 5,388 deaths in 2017. From 2015 to 2017, the increase in reported drug related deaths in Pennsylvania increased 65%. This increased the need for the gubernatorial disaster declaration in Pennsylvania on January 10, 2018. Heroin and fentanyl are the two drugs most often found in overdose deaths, and they are considered to be highly available and nearly ubiquitous in Pennsylvania.

4.3.18.3 Past Occurrence

In 2020, there was an estimated total of 81,000 drug-related overdose deaths in the United States. This number is the highest number of overdose deaths ever recorded in a 12-month period, according to the recent provisional data from the Centers for Disease Control and Prevention. Opioid deaths in Tioga County have been fairly infrequent. In 2015, Tioga County had an average of 7.16 overdose deaths per 100,000 people, with three recorded overdose deaths occurring in the county. This is down from 2014, where the county had an average of 9.55 overdose deaths per 100,000 people with four recorded deaths. This is below the statewide average of overdose deaths.

In 2020, the most commonly used opioids in Tioga County were cannabis and cocaine, as seen in *Table X – Drugs Present in 2020 Pennsylvania Overdose Deaths*. For the calendar year 2020 and the calendar 2021, there were no recorded deaths to the state of Pennsylvania. This is illustrated in *Figure X – Opioid Deaths in Pennsylvania 2019* and *Figure X – Opioids Deaths in Pennsylvania in 2020*.

Table X – Drugs Present in 2020 Pennsylvania Overdose Deaths

Drugs Present in 2020 PA Overdose Deaths (DEA, 2020)	
Drug Category	**Percent Reported Among 2020 Decedents**
Cannabis	25%
Cocaine	20%
Heroin	15%
Fentanyl	14%
Methamphetamine	10%
Prescription Opioids	5.5%
Cathinones	5.5%
Benzodiazepines	5%

4.3.18.4 Future Occurrence

According to recent research, in states where medical marijuana has been permitted, overdose deaths from opioids have decreased about 25%, and the effect was even stronger five to six years after medical marijuana was allowed (Bachhuber et al., 2014). In those states where medical marijuana is permitted, each physician prescribed an average of 1826 fewer doses of pain medication each year (Bradford & Bradford, 2016), suggesting that medical marijuana could help prevent patients from being exposed to addicting opioids and substances (Miller, 2016).

Rather than reduce pain, in some cases high doses of opioid painkillers can actually increase pain due to a phenomenon known as opioid-induced hyperalgesia (OIH), however, it is difficult to know how much of an influence OIH has on the opioid epidemic. Some researchers think that OIH could be increasing patients' pain and in turn, increasing their dosages and dependence on opioid drugs, suggesting that patients should work with lower dosages of opioids (Servick, 2016).

In the event of an opioid overdose, death can sometimes be prevented with the use of the drug naloxone. Emergency medical responders have access to the treatment, and as of 2015, naloxone is available without a prescription in Pennsylvania.

While Tioga County is below the statewide average for opioid overdose deaths, the problem is still present in the county and can still be devastating. The CDC offers a list of suggested actions and precautions that can be taken to prevent opioid overdose deaths in the future:

- Improve opioid prescribing to reduce exposure to opioids, prevent abuse, and stop addiction.
- Expand access to evidence-based substance abuse treatment, such as medication-assisted treatment, for people already struggling with opioid addiction.
- Expand access and use of naloxone, a safe antidote to reverse opioid overdoses.
- Promote the use of state prescription drug monitoring programs, which give health care providers information to improve patient safety and prevent abuse.
- Implement and strengthen state strategies that help prevent high-risk prescribing and prevent opioid overdose.
- Improve detection of the trends of illegal opioid use by working with state and local public health agencies, medical examiners and coroners, and law enforcement.

4.3.18.5 Vulnerability Assessment

Opioid overdoses have resulted in many tragic deaths in Pennsylvania and many people have been affected by the epidemic through either a family member, a close friend, or a member of their community. Opioid addiction is a direct detriment to the personal well-being of addicts, a burden to their families and communities, and a strain to the emergency response system that cares for overdose victims.

While opioid addiction is often viewed as a criminal problem, an additional way to view the epidemic can be to view opioid addiction as a chronic disease. This paradigm shift moves away from faulting the abuser and incentivizing quick cures, to viewing the abuser as a patient and working towards long-term management of the disease. In general, it is important to consider alternative approaches to pain treatment in order to avoid beginning a dependence on highly addictive prescribed opioids.

Fentanyl and related substances are hazardous materials which cause the environment and the people around the substance to be vulnerable. Contact with fentanyl can impact first responders and others that are related to the opioid user. Depending on the potency of the drug, it can take as little as the equivalent of few grams of table salt to cause health complications. There have been several reports nationally of first responders accidentally overdosing on fentanyl or carfentanyl through brief skin contact or the drug becoming airborne. It is best for first responders to err on the side of caution to avoid any potential exposure. The American College of Medical Technology (ACMT) and the American Academy of Clinical Toxicology (AACT) suggest that nitrile gloves provide sufficient protection for handling fentanyl, and for "exceptional circumstances where the drug particles or droplets are suspended in the air, an N95 respirator provides sufficient protection". Other environmental structures such as streams, rivers, and lakes have been known to contain traces of opioids and other drugs within them. These traces come from human urine, feces, or medications that have been discarded in the bathroom. The Environmental Protection Agency (EPA) suggests that while the risks of pharmaceuticals found in wastewater, ambient water, and drinking water are low, further research is needed. State facilities are not at risk to the opioid crisis, but there are some occupation-specific risks that may make some employees more vulnerable. State employees working in direct patient care are vulnerable to fentanyl exposure. However, the physical plant and facilities of Tioga County are not likely to experience losses from the opioid addiction crisis. Absenteeism associated with an opioid addiction in state facilities located in high-risk areas could lead to economic loss through lost productivity and increased medical costs.

The COVID-19 pandemic and the associated quarantine periods cause vulnerability in past, present, and future opioid users. In 2020 and 2021, the vulnerability associated with the opioid epidemic is at the highest it has ever been. The pandemic is the perfect form for anyone who is struggling with substance due to the loss of a job, limited social interactions, increased depression/anxiety, and financial struggles. These factors from the pandemic can push a person who was getting their addiction under control back toward substance use. In other cases, the pandemic might be the trigger that actually makes someone consider initiating drug use, which could end up becoming an addiction. Additionally, the pandemic took away the attention that was being focused on the opioid crisis.

Figure X – Opioid Deaths in Pennsylvania 2019

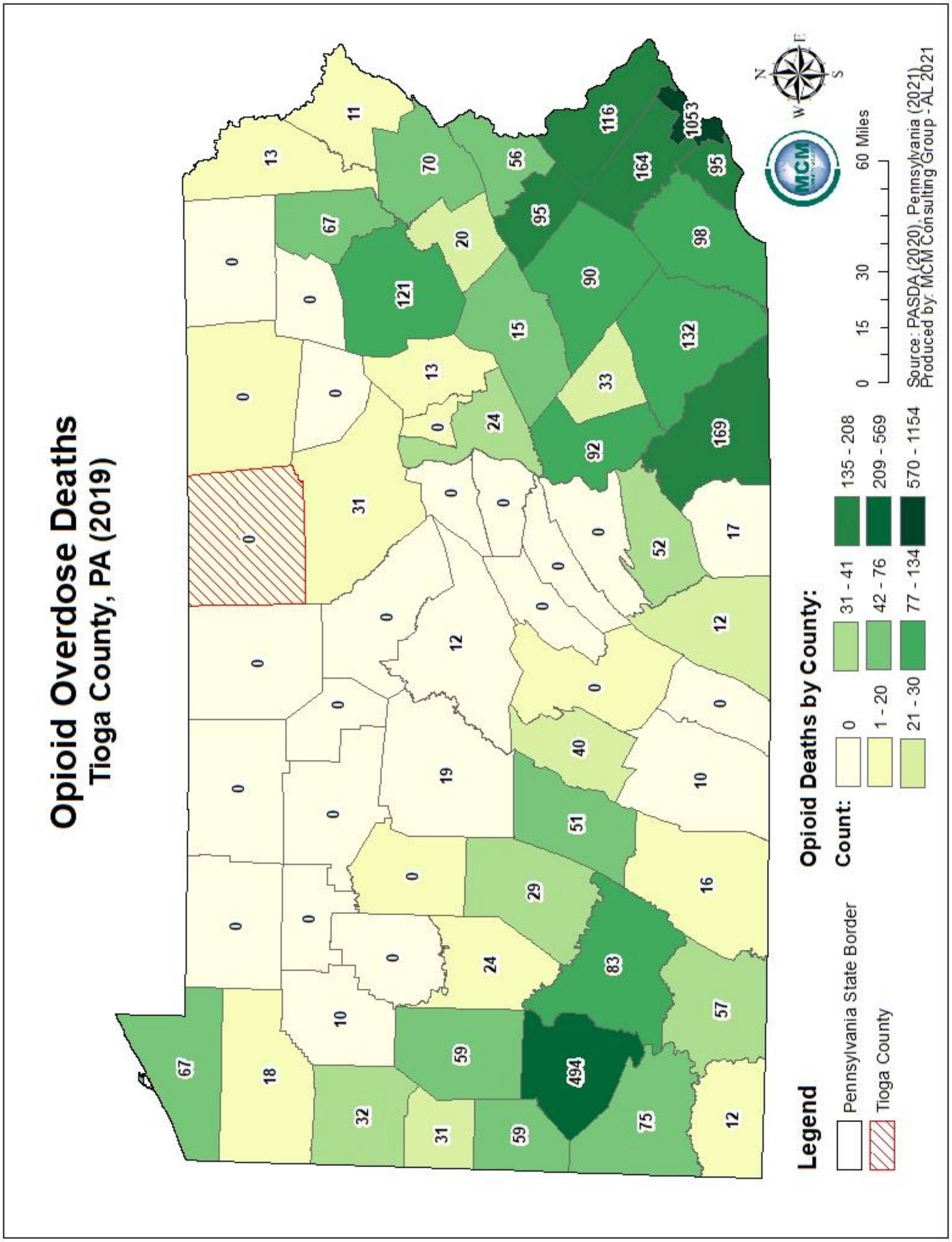
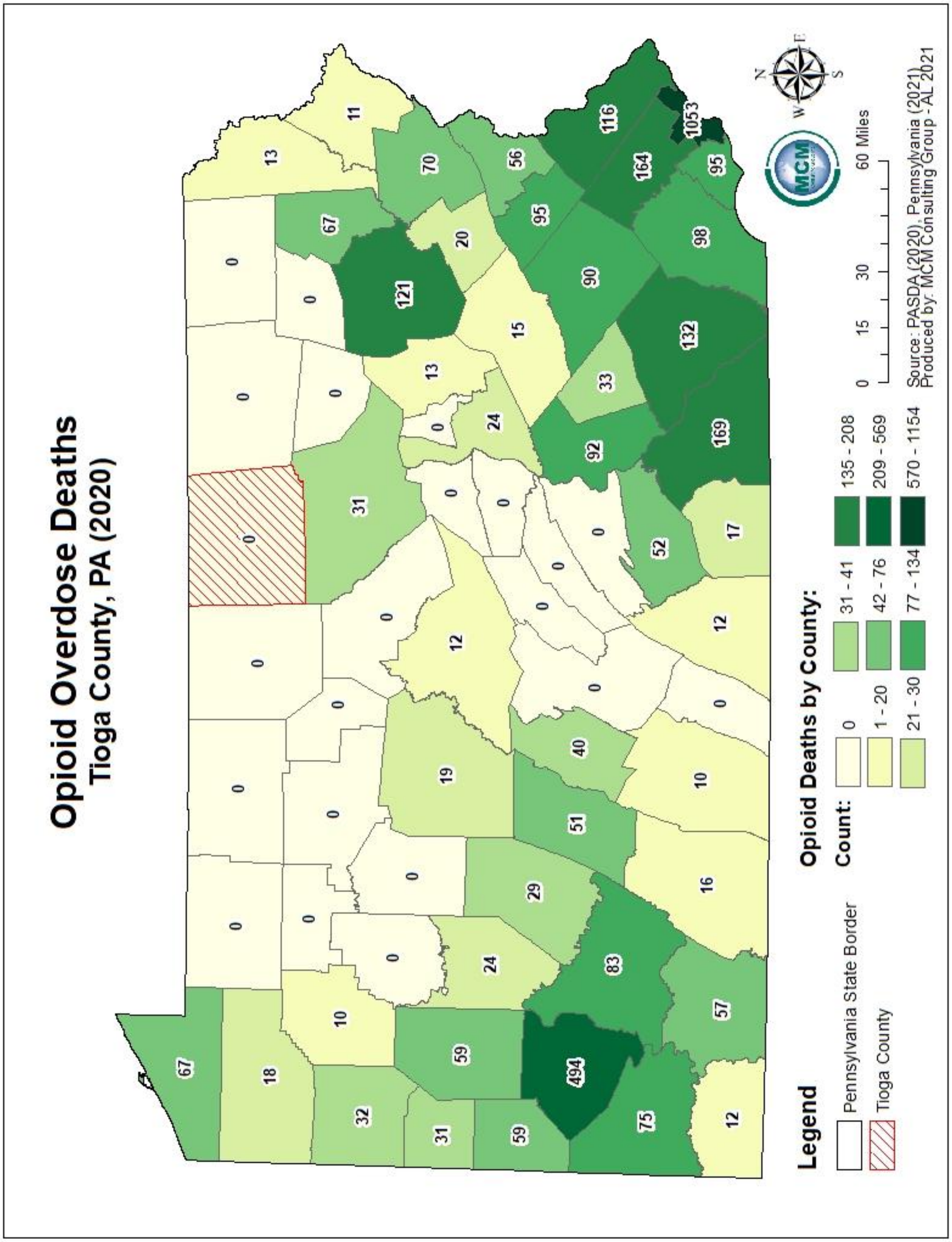


Figure X – Opioid Overdose Deaths in Pennsylvania 2020



4.3.19. Terrorism and Cyber Attack

4.3.19.1 Location and Extent

Following several serious international and domestic terrorist incidents during the 1990s and early 2000s, citizens across the United States paid increased attention to the potential for deliberate, harmful actions of individuals or groups. The term "terrorism" refers to intentional, criminal, malicious acts. The functional definition of terrorism can be interpreted in many ways. Officially, terrorism is defined in the Code of Federal Regulations as "…the unlawful use of force and violence against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof, in furtherance of political or social objectives." (28 CFR §0.85).

Cyber-terrorism is the unlawful use of force and violence over technological methods to cause harm to financial security, identity information, personal information, and attacking personal computers, mobile phones, gaming systems, and other Bluetooth or wirelessly connected devices. Cyber-terrorism can be just as damaging to infrastructure as conventional terrorism, due to the large amount of business that is carried out over the internet, through wirelessly connected devices, or from employees of companies working remotely.

The Federal Bureau of Investigations (FBI) further characterizes terrorism as either domestic or international, depending on the origin, base, and objectives of the terrorist organization. Often, the origin of the terrorist or person causing the hazard is far less relevant to mitigation planning than the hazard itself and the consequences. However, it is important to consider that the prevalence of homegrown violent extremists (HVE's) has increased in recent years, with individuals able to become radicalized on the internet. In a speech on August 29, 2018 addressed to the 11th annual Utah National Security and Anti-Terrorism Conference, FBI Director Christopher Wray describes HVE's as "the primary terrorist threat to the homeland here today, without question."

Critical facilities are either in the public or private sector and provide essential products and/or services to the general public. Critical facilities are often necessary to preserve the welfare and quality of life in the county, or fulfill important public safety, emergency response, and/or disaster recovery functions. Critical facilities identified in the county are hospitals and health care facilities, schools, childcare centers, fire stations, police departments, municipal buildings, and hazardous waste facilities. In addition to critical facilities, the county contains at risk populations that should be factored into a vulnerability assessment. These populations include not only the residents and workforce in the county, but also the tourists that visit the area on a daily basis, those that are traveling through the county on any major highway and marginalized groups such as LGBTQ persons and racial minorities.

Potential targets include:

- Commercial facilities

- Family planning clinics/organizations associated with controversial issues
- Education facilities
- Events attracting large amounts of people
- Places of worship
- Industrial facilities, especially those utilizing large quantities of hazardous materials
- Transportation infrastructure
- Historical Sites
- Government facilities

4.3.19.2 Range of Magnitude

Terrorism may include use of Weapons of Mass Destruction (WMD) (including biological, chemical, explosive, nuclear, and radiological weapons) which include arson, incendiary, explosive, armed attacks, industrial sabotage, intentional release of hazardous materials, and cyber-terrorism. Within these general categories, there are many variations. There is a wide variety of agents and ways for them to be disseminated, particularly in the case of biological and chemical weapons.

Terrorist methods can take many forms including:

- Active assailant
- Agri-terrorism
- Arson/incendiary attack
- Armed attack
- Assassination
- Biological agent
- Chemical agent
- Cyber-terrorism
- Conventional bomb or bomb threat
- Hijackings
- Release of hazardous materials
- Kidnapping
- Nuclear bomb
- Radiological agent

Active assailant incidents and threats can disrupt the learning atmosphere in schools, interfere with worship services, cause traffic to be re-routed, and use taxpayer assets including deploying police, EMS and/or fire units. Tioga County has five school districts (public schools K through 12^{th} grade) that include Canton Area School District, Galeton Area School District, Northern Tioga School District, Southern Tioga School District, and Wellsboro Area School District, several private schools, and Mansfield University.

The areas along major transportation routes can be susceptible to forms of public transit terrorist attacks. More populated areas of the county, including the county seat of Wellsboro, can be susceptible to chemical, biological, radiological, nuclear, or explosive (CBRNE) events due to the concentration and density of residential communities and government activity and buildings. Secondary effects from CBRNE incidents can be damaging as well. Mass evacuations could result in congestion of roadways and possibly result in breakdown of civil order, further exacerbating the situation. Government operations may be disrupted due to the need to displace or operate under reduced capacity. Radiation fallout, hazardous chemical introduction into the groundwater or biologic/germ agents can cause long-term environmental damage.

Cyber terrorism is becoming increasingly prevalent. Cyber terrorism can be defined as activities intended to damage or disrupt vital computer systems. These acts can range from taking control of a host website to using networked resources to directly cause destruction and harm. Protection of databases and infrastructure are the main goals for a safe cyber environment. Cyber terrorists can be difficult to identify because the internet provides a meeting place for individuals from various parts of the world. Individuals or groups planning a cyber-attack are not organized in a traditional manner, as they are able to effectively communicate over long distances without delay. The largest threat to institutions from cyber terrorism comes from any processes that are networked or controlled via computers.

Ransomware continues to be the leading threat, with Maze ransomware accounting for nearly half of all known cases in 2020. Cybercriminals have increasingly begun to steal proprietary – and sometimes embarrassing – data before encrypting it. The cybercriminal will then threaten to publicly release the stolen files if the victims do not provide financial transactions.

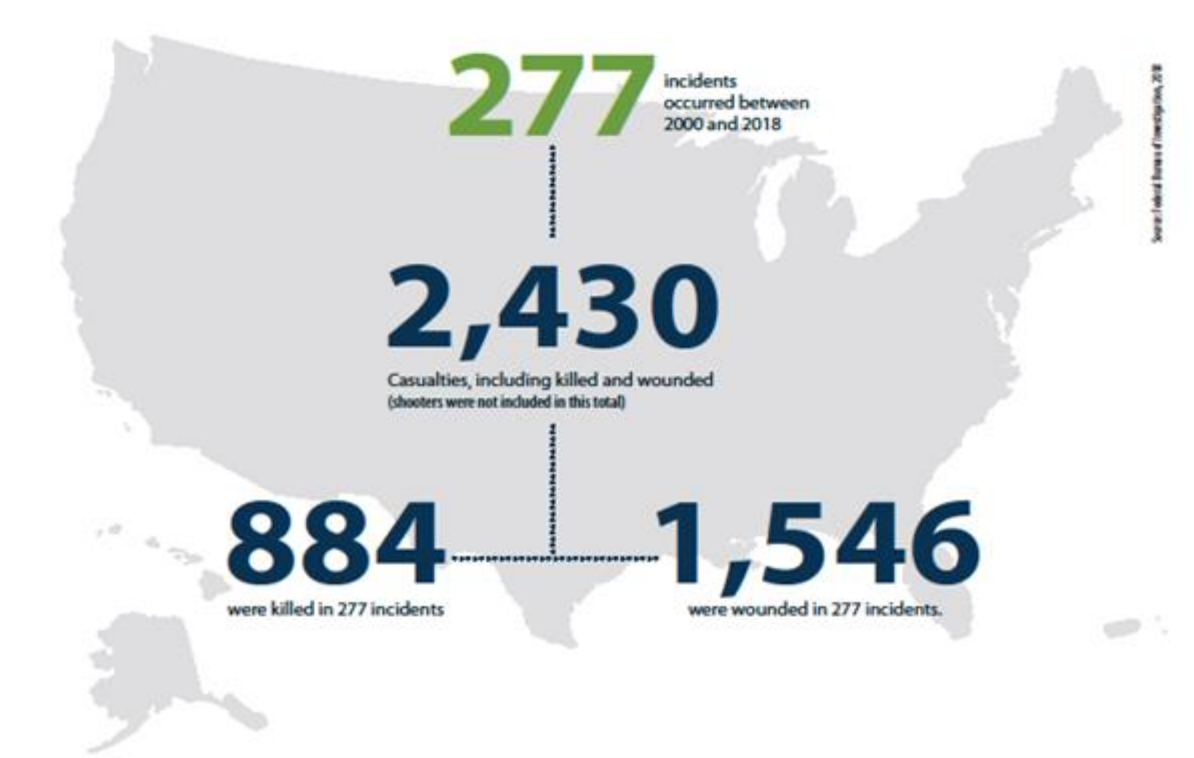
4.3.19.3 Past Occurrence

There have been no physical terrorist attacks in Tioga County, to date.

An active assailant (shooter), as defined by the U.S. Department of Homeland Security, is an individual actively engaged in killing or attempting to kill people in a confined area, in most cases, active assailants use firearms and there is not necessarily a pattern or method to their selection of victims. Throughout the year in 2020, there were a total of twenty-eight mass shooting incidents in the United States according to the FBI. Often these shooters are homegrown violent extremists (HVE's). Two significant events have occurred in Pennsylvania in recent history: one occurred on October 27, 2018, where eleven people were killed by a gunman in the Pittsburgh neighborhood of Squirrel Hill; the gunman was a homegrown violent extremist and attacked the congregation of the Tree of Life Synagogue in a shooting that targeted the Jewish population and was fueled by the gunman's anti-Semitic, anti-immigrant, and anti-refugee sentiments. Another event occurred in January of 2019, where a gunman killed two people and permanently injured one inside P.J. Harrigan's bar in State College and later killed a homeowner and himself.

There have also been a number of active shooter events in the United States in recent years and they include those that occurred at Virginia Tech (April 2007), Sandy Hook Elementary School (December 2012), San Bernardino, California (December 2015), an Aurora, Colorado movie theater (July 2012) and a church in Charleston, South Carolina (June 2015). A 2014 study by the FBI concluded that there has been a significant recent increase in frequency of active shooter incidents, and that the vast majority (150 of 154 shooters between 2000 and 2013) were male (FBI, 2014). Of these 160 incidents, 45.6% took place in commercial environments, 24.3% took place in an educational environment, and the remaining 30.1% took place at other locations such as open spaces, military and other government properties, residential locations, houses of worship, and health care facilities (FBI, 2019). The annual report on the study may be found here: https://www.justice.gov/usao-mdpa/page/file/1272096/download. *Figure X – Active Shooter Incidents 2000 – 2018* illustrates a numerical breakdown of shooting events for those eighteen years.

Figure X – Active Shooter Incidents 2000 – 2018 (FBI, 2019)



Significant international terrorism incidents in the United States include the World Trade Center bombing in 1993, the bombing of the Murrow Building in Oklahoma City in 1995, and the September 11^{th}, 2001 attacks on the World Trade Center and the Pentagon. One of the aircrafts hijacked in the September 11^{th} attacks crash landed in Somerset County, Pennsylvania before it reached its intended target. While fatalities and destruction at the intended target were avoided, all passengers on the flight perished.

While the largest scale terrorist incidents have often had international stimuli, many other incidents are caused by home grown actors who may have become radicalized through hate groups either in real life or via the internet, and who may struggle with mental health issues. Hate groups such as the Ku Klux Klan (KKK), Aryan Nation, and more recently, the Alt-Right, Antifa, Proud Boys, plus conspiracy theorist believers/promoters such as QAnon, have been part of domestic terrorism in different forms. Supporters of former President Donald Trump from one or more of these groups stormed the United States Capitol on January 6, 2021 to disrupt the certification of the 2020 presidential election, resulting in five deaths and evacuation of Congress.

Terrorist/cyber-attack activity in Tioga County as of April 2021 can be found in *Table X – Terrorist/Cyber Attack Activity History*; however, these incidents are not all inclusive of the history of terrorism or cyber-attacks, nor are they necessarily real terrorism as defined by the FBI. Entries vary due to recorder's selection of category and description.

Table X – Terrorist/Cyber Attack Activity History

Terrorist/Cyber Attack Activity History			
Date	**Title**	**Severity**	**Total Incidents**
April 2021	Policy Violations: 23 Unusual Network Activity: 1	Informational: 24	24
March 2021	Policy Violation: 31 Unusual Network Activity: 0	Informational: 31	31
February 2021	Policy Violations: 16 Unusual Network Activity: 1	Informational: 17	17
January 2021	Policy Violations: 26 Unusual Network Activity: 4	Informational: 29 Warning: 1	30
December 2020	Policy Violations: 28 Unusual Network Activity: 1	Informational: 29	29

4.3.19.4 Future Occurrence

The likelihood of Tioga County being a primary target for a major international terrorist attack is small and unlikely. More likely terrorist activity in Tioga County includes bomb threats or other incidents at schools. Tioga County has five school districts consisting of eighteen public schools. Several private schools and Mansfield University are also located in Tioga County.

4.3.19.5 Vulnerability Assessment

Tioga County should stay prepared for terrorism type incidents. The existence of industrial commerce, interstate highways and freight railroad activity create soft targets that could be used to interfere with the focus of day-to-day life that the county experiences. It is important to note that the use and exposure to biological agents can remain unknown for several days until the infected person(s), livestock, or crops begin to experience symptoms or show damages. Often such agents are contagious, and the infected person(s) must be quarantined, livestock culled, and/or crops destroyed.

Although previous events have not resulted in what are considered significant terrorist attacks, the severity of a future incident cannot be predicted with a total level of certainty. One of the major concerns with agroterrorism is that acts can be carried out with minimal planning, effort, or expense.

In a 2020 Cyberthreats Report by Acronis, a cyber protection company, there is an in-depth review of the current threat landscape and projections for the coming year. Based on the protection and security challenges that were amplified by the shift to remote work during the COVID-19 pandemic, Arconis warns 2021 will bring aggressive cybercrime activities as criminals pivot their attacks from data encryption to data exfiltration.

The major points illustrated in the report are as follows:

- Attacks against remote workers will increase due to the movement of workers to less secure working areas.
- Ransomware will look for new victims and will become more automated.
- Legacy IT and technical solutions will struggle to keep pace with ransomware and cybercrime attacks.

According to a study carried out on the data sourced from the Federal Bureau of Investigation, Pennsylvania is ranked second worst among states when it comes to handling cyber-attacks. The study made by Information Network Associates – an international security consulting company – says an increase of 25% was witnessed in cyber-attacks between 2016 and 2017. This illustrates the amount of preparation that must occur in the commonwealth so that it can better respond to potential cybercrime attacks.

The probability of terrorist activity is more difficult to quantify than some other hazards. Instead of considering the likelihood of occurrence, vulnerability is assessed in terms of specific assets.

By identifying potentially at-risk terrorist targets in communities, planning efforts can be put in place to reduce the risk of attack. Planning should work towards identifying potentially at-risk critical infrastructure and functional needs facilities in the community, prioritizing those assets and locations, and identifying their vulnerabilities relative to known potential threats.

All communities in Tioga County are vulnerable on some level, directly or indirectly, to a terrorist attack. However, communities with schools and government infrastructure like the county seat, should be considered more likely to attract terrorist activity.

4.3.20. Transportation Accidents and Transportation of Hazardous Materials

4.3.20.1 Location and Extent

There are approximately 2,200 miles of developed roads in Tioga County; with state and US highways contributing about 840 miles. Significant transportation routes such as US Route 6 and US Route 15, as well as state routes 14, 249, 287, and 660 course through the county. *Figure xx – Major Transportation Routes* shows the major transportation systems in Tioga County.

The Wellsboro & Corning Railroad (WCOR) is a short-line railroad and is the only active rail rote in Tioga County. The rail line commences in Wellsboro and runs generally north northeast, paralleling PA Route 287 and terminates in Corning, New York. The WCOR has a total of forty-two owned or leased miles, with twenty-nine of those in Tioga County. Commodities transported on this line consist of agricultural products, chemicals, plastics, minerals, and stone. In Corning, New York, the line connects with Norfolk Southern's southern tier line.

Wellsboro Johnston Airport is the only public use airport in Tioga County. Private airports in Tioga County are: Baker Airport, H and H Airport/ Hughes Airport, Hi Line Lodge Airport, Malco Airport, and Sharrett's Airport. There is also Sabinsville-Consolidated Heliport. The locations of these airports and heliport are identified in *Figure xx – Airports and Vulnerability Zones*.

There are eleven pipeline companies that transport hazardous materials in and through Tioga County. These companies and the product transported are:

- Dominion Energy, which transports natural gas and propane.
- DTE, which transports natural gas.
- Energy Transfer, which transports natural gas.
- Enterprise Products, which transports ethane and propane.
- EQT Production Company, which transports natural gas.
- Howard Energy Partners Northeast Gathering, which transports natural gas.
- National Fuel Gas Midstream Company, LLC, which transports natural gas.
- Stagecoach Gas Services, LLC, which transports natural gas.
- Tennessee Gas Pipeline Company, LLC, which transports natural gas.
- UGI Energy Services, which transports natural gas and propane.
- UGI Utilities, Inc., which transports natural gas and hydrogen sulfide.

4.3.20.2 Range of Magnitude

Transportation accidents can result in death or serious injury and extensive property loss or damage. Inclement weather and higher traffic volumes and speeds increase the risk for automobile accidents.

Railroad accidents occur with less frequency than highway accidents. However, when these types of incidents occur, they often cause extensive property damage and have the potential to cause serious injury or death.

Aviation incidents most often occur near landing or take-off sites; the two-mile radius around each airport in Tioga County are considered high-risk areas.

Hazardous materials are transported along highways, railways, airways, and pipelines in Tioga County. In 2017 a commodity flow study was conducted in Tioga County. Of the 4,618 trucks observed during the study at the five observation locations, 107 were identified as placarded. Of these placarded loads Class 3 (Flammable Liquids) were observed the most, making up 62%. Class 2 (Flammable Gases), Class 9 (Miscellaneous), and Class 8 (Corrosive) each represented 10% (for a total of 30%) of the placards seen. The remaining 8% of placarded trucks was a combination of Class 4 (Flammable Solids), Class 5 (Oxidizing), and Class 6 (Toxic substances and Infectious substances). Neither Class 1 (Explosives), nor Class 7 (Radioactive) placards were observed during the survey. It should not be assumed that explosives or radioactive commodities are not present in Tioga County, just because these loads weren't observed during the commodity flow study timeframe.

4.3.20.3 Past Occurrence

The most serious transportation concerns in Tioga County involve US Route 6 and US Route 15. *Table X – Transportation Incidents* depicts accidents that were reported to Tioga County 9-1-1 as they were entered into the Tioga County Knowledge Center™ database between January 2013 and April 2021.

There are several airplane incidents that have occurred in Tioga County, the most destructive of which occurred in 1967, when a commercial aircraft crashed on Barney Hill in Blossburg, killing all thirty people aboard the plane, and four people on the ground. Other recorded incidents include:

- In 2006 a small plan made an emergency landing in a field near an airport in Knoxville Borough (no reported injuries).
- In 2008 an ultralight aircraft crashed in Knoxville Borough (one reported injury).
- In 2017 an ultralight aircraft crashed in Clymer Township (one reported injury).

Table X – Transportation Incidents

Transportation Accidents and Transportation of Hazardous Materials Incidents in Tioga County		
Date	**Location**	**Description**
09/04/2013	Gaines Township	Public worker accident
12/29/2013	Delmar Township	Two-vehicle accident with road closure
06/14/2014	Middlebury Township	Road closure
07/05/2014	Tioga County	Vehicle accident with injury
08/01/2014	Shippen Township	Motor vehicle accident
01/13/2015	Deerfield Township	Tractor-trailer roll over with road closure
03/06/2015	Delmar Township	Fatal vehicle accident
05/21/2015	Liberty Township	PennDOT vehicle accident
06/06/2015	Osceola Township	Road closure
07/16/2015	Union Township	Motor vehicle accident
08/01/2015	Tioga County	Accident with road closure
09/01/2015	Delmar Township	Construction worker injury
09/17/2015	Morris Township	Head-on collision with road closure
01/06/2016	Richmond Township	Road closure
01/23/2016	Liberty Township	Road closure
01/23/2016	Tioga County	Road closure on US Route 15
02/05/2016	Tioga County	US Route 6 road closure
02/16/2016	Blossburg Borough	Tractor trailer accident involving hazmat
06/25/2016	Tioga Township	Road closure
08/03/2016	Bloss Township	Road closure
11/22/2016	Tioga County	Vehicle accident involving an ambulance
12/06/2016	Covington Township	Road closure
12/21/2016	Tioga County	Fatal vehicle accident
02/12/2017	Richmond Township	Road closure
03/07/2017	Wellsboro Borough	Road hazard
05/05/2017	Liberty Township	Road closure
05/15/2017	Tioga County	Road closure
06/03/2017	Nelson Township	Multiple vehicle accident
06/03/2017	Liberty Township	Vehicle accident
07/17/2017	Tioga Township	Road Closure
07/17/2017	Tioga Township	Vehicle accident
07/30/2017	Clymer Township	Ultra-light accident
08/08/2017	Deerfield Township	Road closure
08/23/2017	Liberty Township	Road closure
09/03/2017	Liberty Township	Diesel fuel spill

Date	Location	Description
10/16/2017	Charleston Township	Vehicle accident
11/04/2017	Bloss Township	Road closure
12/28/2017	Delmar Township	Vehicle accident
12/28/2017	Lawrence Township	High pressure line blowing gas
01/11/2018	Morris Township	Road closure
05/05/2018	Covington Township	Natural gas leak
05/09/2018	Tioga Township	Truck fire with SR 15 closed
05/28/2018	Gaines Township	Road closure
07/04/2018	Tioga Township	Vehicle fire with a road closure
08/27/2018	Morris Township	Road closure
09/26/2018	Tioga Township	Road closure
11/08/2018	Lawrenceville Borough	Road closure
11/09/2018	Gaines Township	Vehicle accident with a road closure
11/14/2018	Deerfield Township	Multi-vehicle accident with entrapment
01/11/2019	Charleston Township	Vehicle accident with a road closure
01/14/2019	Delmar Township	Road closure
01/15/2019	Elkland Borough	Road closure
01/19/2019	Charleston Township	Vehicle accident
01/24/2019	Osceola Township	Diesel fuel spill
01/29/2019	Westfield Township	Road closure
02/12/2019	Richmond Township	Vehicle accident with a road closure
02/28/2019	Jackson Township	Road closure
03/15/2019	Middlebury Township	Road closure
03/30/2019	Chatham Township	Road closure
04/22/2019	Liberty Township	Road closure
05/26/2019	Lawrence Township	Road closure
06/18/2019	Mansfield Borough	Road closure
07/14/2019	Chatham Township	Motorcycle accident
07/19/2019	Westfield Borough	Road closure
07/21/2019	Lawrenceville Borough	Vehicle accident with a road closure
08/09/2019	Richmond Township	Road closure
08/18/2019	Tioga County	Road closure
09/09/2019	Charleston Township	Vehicle accident with a road closure
10/05/2019	Rutland Township	Road closure
10/06/2019	Jackson Township	Road closure
10/27/2019	Covington Township	Road closure
10/31/2019	Tioga County	Road closure
11/03/019	Morris Township	Road closure

Date	Location	Description
11/14/2019	Clymer Township	Road closure
12/02/2019	Tioga Township	Road closure
12/07/2019	Charleston Township	Vehicle accident with a road closure
12/13/2019	Morris Township	Road closure
12/23/2019	Knoxville Borough	Road closure
01/05/2020	Middlebury Township	Road closure
01/25/2020	Delmar Township	Vehicle accident with a road closure
02/07/2020	Liberty Township	Multiple tractor trailers jackknifed with road closure
03/18/2020	Delmar Township	Road closure
03/20/2020	Delmar Township	Road closure
04/21/2020	Tioga County	Natural gas pipeline blow-down
04/21/2020	Morris Township	Road closure
05/01/2020	Richmond Township	Vehicle accident
05/17/2020	Richmond Township	Gas pipeline blow-down
06/14/2020	Wellsboro Borough	Pedestrian accident
06/15/2020	Liberty Township	Tractor trailer accident with fire
07/19/2020	Shippen Township	Road closure
07/29/2020	Tioga Township	Road closure due to utilities down
08/16/2020	Westfield Borough	Road closure due to utilities down
09/07/2020	Middlebury Township	Road closure
09/25/2020	Deerfield Township	Road closure
10/16/2020	Charleston Township	Vehicle fire
11/10/2020	Tioga Township	Vehicle fire
11/15/2020	Delmar Township	Road closure
11/22/2020	Osceola Township	Fatal vehicle accident with a road closure
12/25/2020	Wellsboro Borough	Road closure
02/03/2021	Liberty Township	Road closure
04/07/2021	Nelson Township	Vehicle accident with a road closure

Table X – PennDOT Crash Report for Tioga County shows crash statistics recorded by the Pennsylvania Department of Transportation between 2009 and 2019. *(NOTE: reports for years 2020 and 2021 were not available at the time of this report.)*

Table X – PennDOT Crash Report for Tioga County

PennDOT Crash Report for Tioga County								
Year	Train/Vehicle Accidents		Total vehicle accidents for Pennsylvania	Vehicle accidents for Tioga County				Pedestrian deaths
	Total	Deaths		Total	Fatal Accidents	Injury Crashes	Total Deaths	
2009	0	0	121,242	427	6	201	7	0

Year	Train/Vehicle Accidents		Total vehicle accidents for Pennsylvania	Vehicle accidents for Tioga County				Pedestrian deaths
	Total	Deaths		Total	Fatal Accidents	Injury Crashes	Total Deaths	
2010	0	0	121,312	552	13	250	13	0
2011	0	0	125,395	610	10	275	12	0
2012	0	0	124,092	511	8	214	10	0
2013	0	0	124,149	483	11	228	11	0
2014	1	0	121,317	407	10	189	10	0
2015	0	0	127,127	370	5	165	5	0
2016	0	0	129,395	427	12	165	13	0
2017	0	0	128,188	429	11	159	11	0
2018	0	0	128,420	455	4	171	5	1
2019	0	0	125,267	406	8	132	8	0

4.3.20.4 Future Occurrence

Automobile accidents occur frequently, and typically occur more frequently than a rail or aviation accident. US Route 6 and 15 as well as State Routes 14, 249, 287, and 660 are the most traveled roadways in Tioga County and are also the most traveled by heavy freight vehicles which can often carry hazardous materials.

Transportation accidents are impossible to predict accurately; however, areas prone to these hazards can be located, quantified through analysis of historical records, and plotted on countywide and municipal base maps.

Transportation of hazardous materials using all modes of transport will continue to increase as industry and manufacturing progress continues.

4.3.20.5 Vulnerability Assessment

The vulnerability for accidents; highway, railway, or aviation, are directly related to the population and traffic density within the county. The vulnerability increases if there are hazardous materials involved. Hazards associated with causing transportation accidents can be natural hazards that affect the environment such as winter storms or heavy rains causing slippery roadways or mud slides; to windstorms or tornadoes that cause high-profile vehicles or train cars to be toppled over.

Loss of roadway use, and public transportation services would affect commuters, employment, delivery of critical municipal and emergency services, and day-to-day operations within the county.

Studying traffic and potential transportation accident patterns could provide information on vulnerability of specific road segments and nearby populations. Increased understanding of the types of hazardous materials transported through the county will also support mitigation efforts. Maintaining a record of these frequently transported materials can facilitate development of preparatory measures for response to a release. *Figure xx – Major Highway Vulnerability* identifies a ¼-mile buffer along all highways and railroads within Tioga County.

Conducting commodity flow studies on a regular basis will assist Tioga County in knowing the greatest hazardous materials dangers. The commodity flow study should identify the container type and hazard class to assist emergency services when conducting training and pre-planning for hazardous materials involved in a transportation accident.

Figure xx – Major Transportation Routes

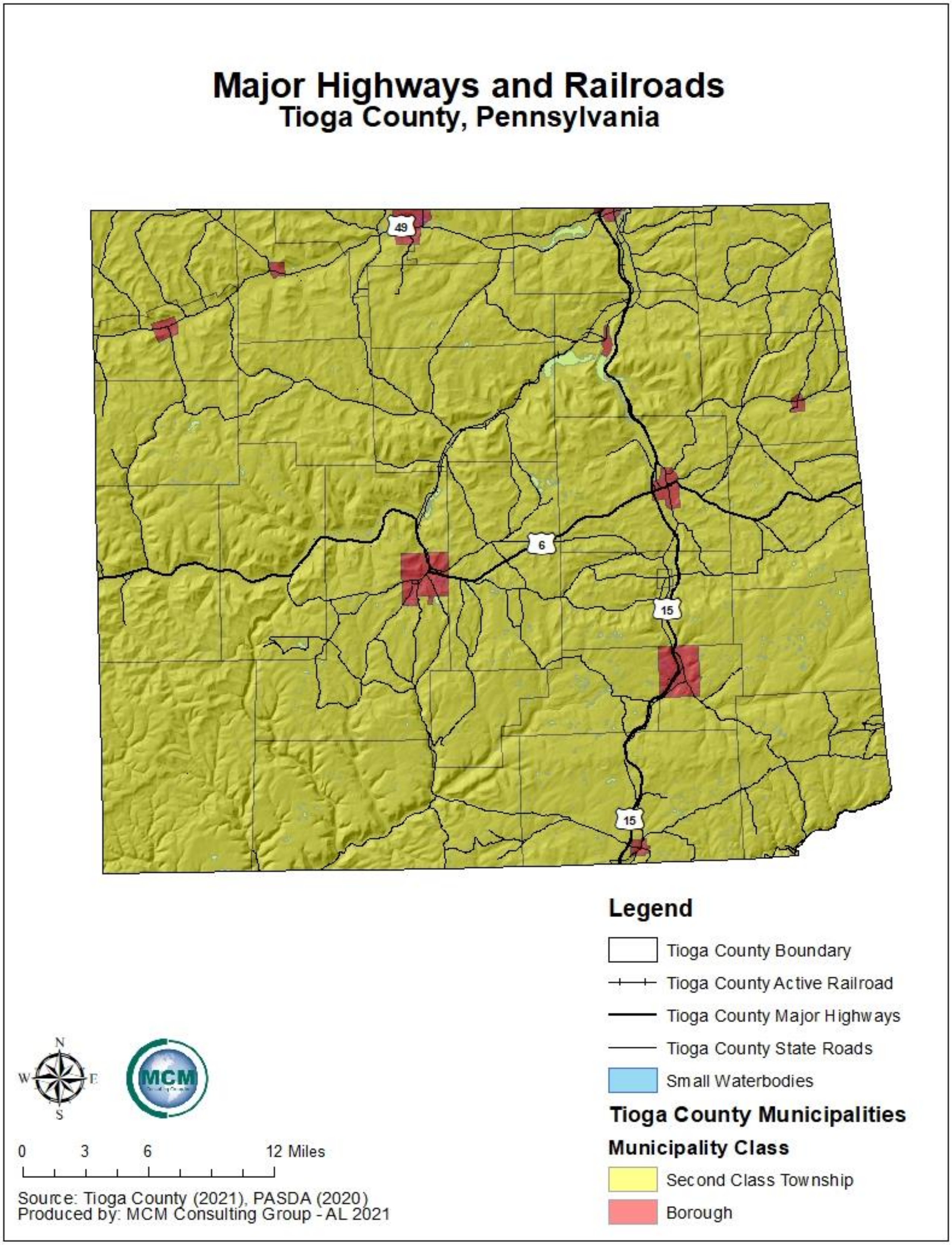


Figure xx – Airports and Vulnerability Zones

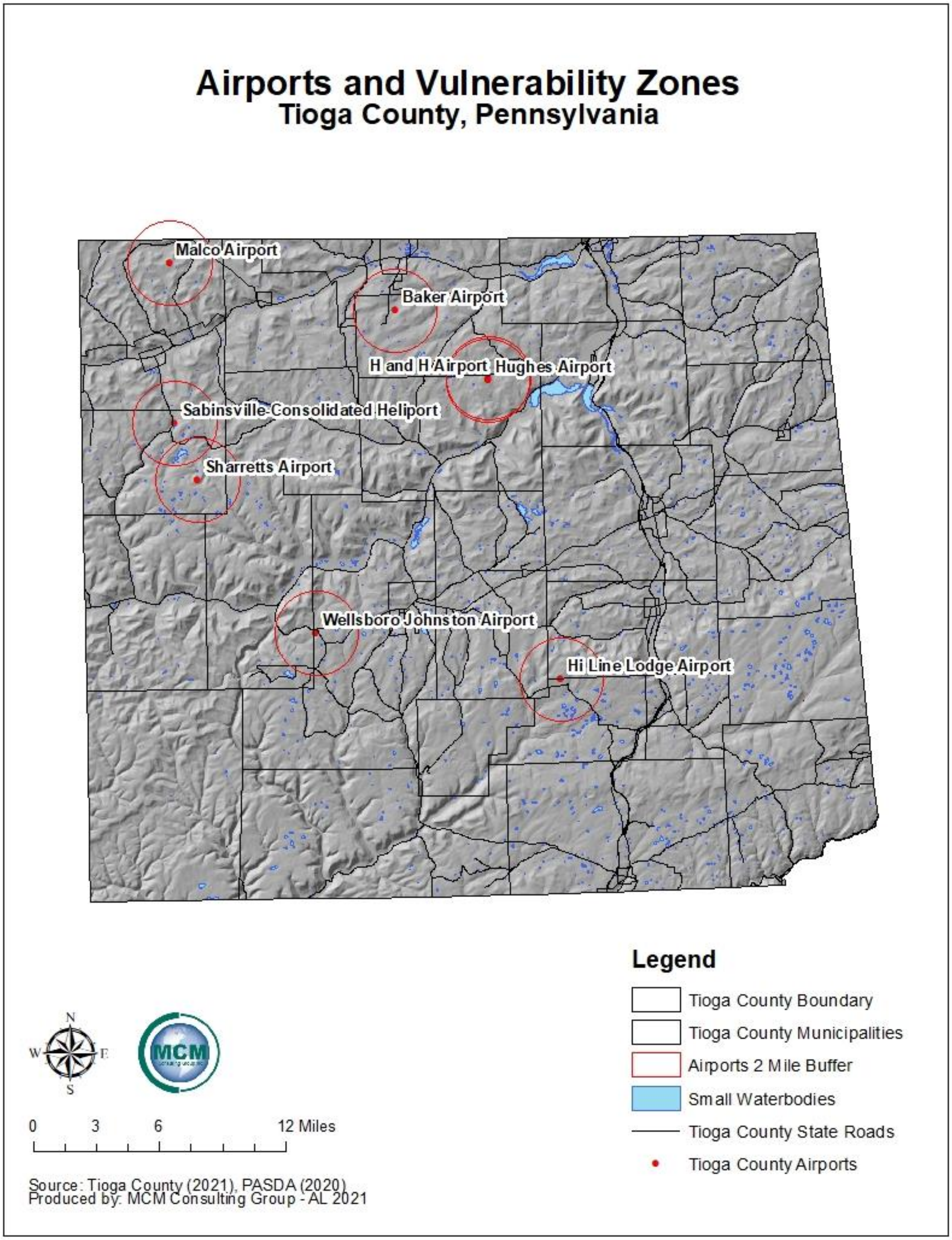
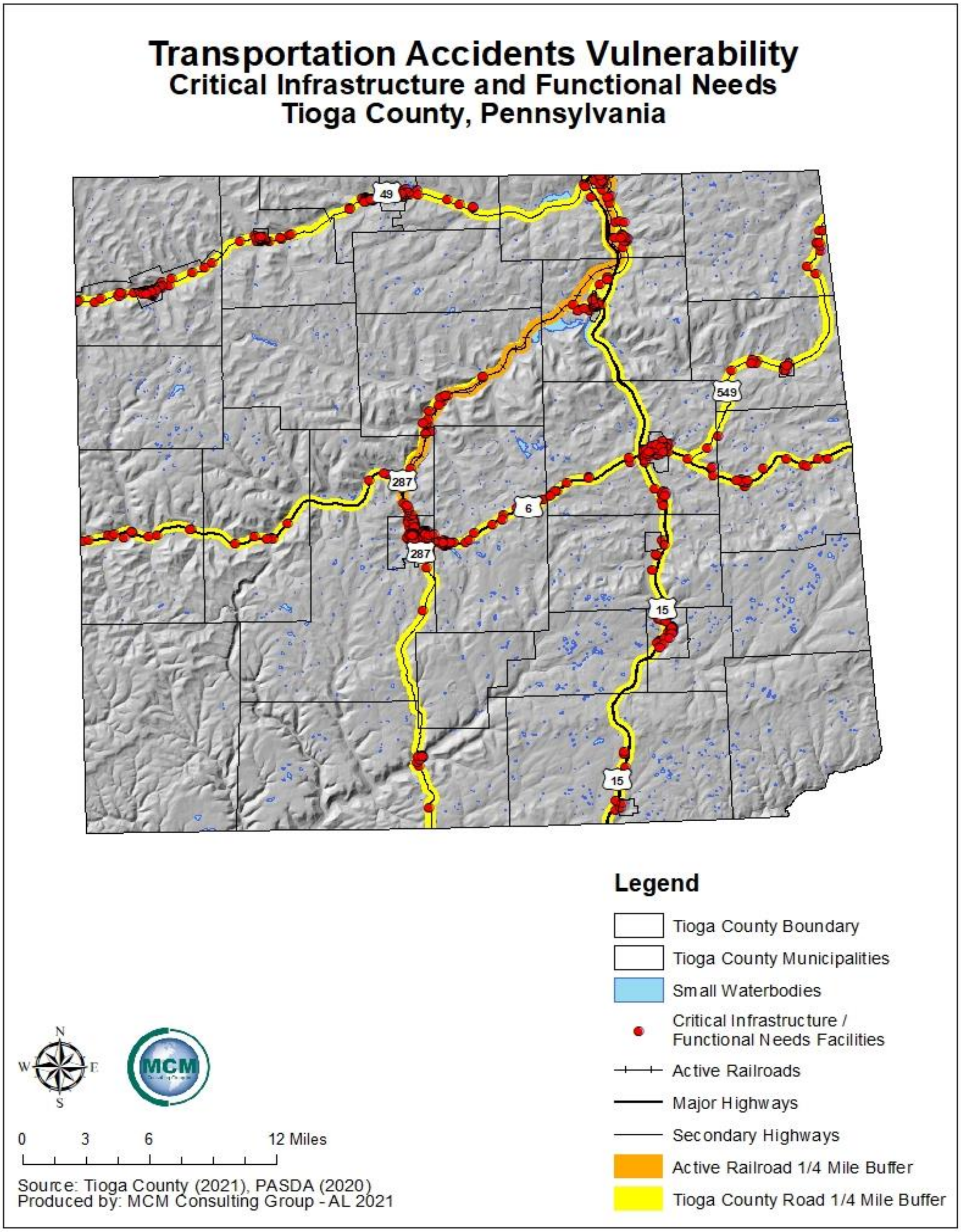


Figure xx – Major Highway Vulnerability



4.3.21. Utility Interruption

4.3.21.1 Location and Extent

Utility interruptions can occur from an internal system failure, or as a secondary impact of another hazard, such as a windstorm or a traffic accident. Examples of other hazards include severe thunderstorms or winter storms that bring down power lines and cause widespread disruptions in electric service. Strong heat waves may result in rolling blackouts where power may not be available for an extended period of time. Space weather, specifically solar flares, pose an uncommon threat, especially in the northeastern seaboard and north central United States.

The age of utility infrastructure can also play an important role in interruptions, causing longer periods of outages in a larger area. Natural gas, water, telecommunications, and electric capabilities can all experience disruptions. Worker strikes at power generation facilities have also been known to cause minor power failures. Some other causes of minor power outages include falling tree limbs, vehicle accidents, or small animals that destroy wiring. Outages can also be caused by blown transformers or tripped circuit breakers. Major power outages are typically on a regional scale.

Utility providers in Tioga County are shown in *Table X – Tioga County Utility Providers*.

Table X – Tioga County Utility Providers

Tioga County Utility Providers	
Utility Provided	**Name of Utility Provider**
Electricity	Penelec Wellsboro Electric Company Tri-County Rural Electric Coop
Telephone/9-1-1/Wireless	Frontier Communications North Penn Telephone Blue Ridge AT&T Indigo Wireless Spring T-Mobile Verizon
Natural gas	Tennessee Gas Pipeline Company
Water	Blossburg Water Company Lawrenceville Borough Water Department

4.3.21.2 Range of Magnitude

Utility interruptions do not typically lead to large-scale problems by themselves. Typically, human casualties are not a direct result from outages. Because many utility interruptions occur during storms or other severe weather events, they can have severe secondary consequences. Typical secondary effects from a power outage could include a delay in emergency response services due to poor communication, or a lack of potable water for drinking.

Electricity

Interruptions or power failures could have the following impacts:

- Public safety concerns;
- Food spoilage;
- Loss of heating or air conditioning;
- Basement flooding – due to sump pump failure;
- Loss of indoor lighting;
- Loss of internet service;
- Flashing traffic signals;
- Stopped elevators; and
- Interrupted retail sales.

Of all these, the loss of heating or air conditioning poses the greatest risk to the elderly and very young populations during times of extreme temperatures. Prolonged power outages also pose a risk to residents that rely on home-based medical equipment such as home-supply oxygen units.

Fuel

From natural gas to other products transported and delivered by way of pipelines to business and residences, interruptions pose loss of heating and manufacturing capabilities.

Telecommunications

Interruptions to telecommunications systems include impacts to 9-1-1 capabilities, telephone, and internet service. The greatest risk to the loss of this capability would be in reporting an emergency to a public safety answering point (PSAP). Extensive loss of telephone and internet service can be detrimental to government, business, and to residents. With much of the country now dependent on wireless networks, signals can be interrupted, and data can be captured – posing a range of security issues and concerns.

4.3.21.3 Past Occurrence

Minor utility interruptions occur annually in Tioga County, most often in conjunction with winter and/or windstorms. Tioga County utilizes a database system called *CORVENA* (formerly *Knowledge Center*™) to track incidents. *Table X – Utility Interruptions in Tioga County* shows interruptions to electric, natural gas, telecommunications, and water service from *CORVENA* entries.

Table X – Utility Interruptions in Tioga County

Utility Interruptions in Tioga County		
Date	**Event**	**Municipality**
08/09/2014	9-1-1 phone outage	Delmar Township
09/03/2014	Phone outage	Liberty Borough
09/27/2014	Phone outage	Lawrence Township
04/14/2015	Compressor stations – ESD testing	Bloss Township
08/06/2015	Phone outage	Lawrence Township
08/27/2015	Gas pipeline blowdown	Clymer Township
10/24/2015	9-1-1 phone outage	Lawrenceville Borough
11/19/2015	9-1-1 phone outage	Lawrenceville area
12/06/2015	Gas pipeline blowdown	Charleston Township
05/08/2016	9-1-1 phone outage	Tioga County
05/21/2016	Phone outage	Lawrenceville Borough
10/22/2016	Widespread power outage	Tioga County
12/26/2016	Widespread power outage	Tioga County
01/16/2017	Potable water outage	Tioga County
02/24/2017	9-1-1 lines down	Tioga County
08/26/2017	9-1-1 system outage	Chatham Township
09/01/2017	Phone outage	Lawrenceville Borough
11/12/2017	Phone outage	Wellsboro Borough
11/16/2017	Phone outage	Delmar Township
01/02/2018	Hospital water pipe break	Tioga County
01/12/2018	Ansonia power outage	Tioga County
02/02/2018	Phone outage	Delmar Township
04/13/2018	Frontier phone outage	Lawrenceville Borough
07/04/2018	Phone outage	Chatham Township
07/17/2018	Phone outage	Lawrenceville Borough
07/19/2018	Phone outage	Chatham Township
08/05/2018	9-1-1 phone outage	Lawrenceville Borough
08/18/2018	Phone outage	Chatham Township
08/18/2018	Phone outage	Lawrence Township
09/03/2018	Phone outage	Lawrence Township
09/06/2018	Phone outage	Delmar Township
09/12/2018	Phone outage	Lawrenceville Borough
10/09/2018	Phone outage	Lawrence Township
10/30/2018	Phone outage	Chatham Township
11/20/2018	Phone outage	Mansfield Borough
02/05/2019	Phone outage	Wellsboro Borough

Date	Event	Municipality
03/14/2019	UPMC S+S	Wellsboro Borough
03/14/2019	Phone outage	Delmar Township
03/17/2019	Phone outage	Lawrenceville Borough
03/22/2019	Phone outage	Delmar Township
04/03/2019	Phone outage	Lawrenceville Borough
04/03/2019	Phone outage	Middlebury Township
04/09/2019	Power outage	Blossburg Borough
06/04/2019	Phone outage	Morris Township
06/27/2019	Phone outage	Lawrence Township
06/29/2019	Phone outage	Delmar Township
07/07/2019	Phone outage	Lawrence Township
07/13/2019	Phone outage	Richmond Township
07/14/2019	Phone outage	Lawrence Township
07/17/2019	Phone outage	Middlebury Township
07/19/2019	Phone outage	Delmar Township
07/19/2019	Phone outage	Mansfield Borough
07/21/2019	Phone outage	Tioga County
08/07/2019	Phone outage	Lawrence Township
08/07/2019	Phone outage	Lawrenceville Borough
08/09/2019	Phone outage	Charleston Township
08/19/2019	Phone outage	Lawrence Township
08/21/2019	Phone outage	Shippen Township
09/05/2019	Phone outage	Tioga County
09/15/2019	Road closure – utility emergency	Middlebury Township
09/17/2019	Phone outage	Lawrenceville Borough
09/21/2019	Phone outage	Delmar Township
10/03/2019	Power outage	Putnam Township
10/09/2019	Phone outage	Delmar Township
10/11/2019	Phone outage	Mansfield Borough
10/16/2019	Phone outage	Mansfield Borough
10/22/2019	Phone outage	Richmond Township
10/28/2019	Phone outage	Wellsboro Borough
11/01/2019	Phone outage	Middlebury Township
12/02/2019	Phone outage	Wellsboro Borough
12/04/2019	Phone outage	Delmar Township
12/06/2019	Phone outage	Wellsboro Borough
02/06/2020	Phone outage	Westfield Township
04/13/2020	Phone outage	Wellsboro Borough

Date	Event	Municipality
05/04/2020	Phone outage	Wellsboro Borough
05/17/2020	Phone outage	Delmar Township
06/12/2020	Phone outage	Wellsboro Borough
08/23/2020	Phone outage	Tioga County
10/15/2020	Phone outage	Charleston Township
10/16/2020	Water shortage	Gaines Township
11/16/2020	Phone outage	Putnam Township
03/26/2021	Phone outage	Delmar Township
04/03/2021	Phone outage	Tioga County

The Pennsylvania Public Utility Commission tracks the reliability of electric distribution companies (EDC) and outages. *Table X –2018 Winter Storms Riley and Quinn Power Outages by EDC* compares the customers affected by power outage in Pennsylvania during these storms and compares them to statistics from Nika 2014 and Sandy 2012. Some of the EDCs were not impacted by Winter Storm Quinn. PPL customers experienced power outages for a duration of eight days with Winter Storms Quinn and Riley, whereas during Sandy in 2012 the duration was nine days, and just over three days for Nika in 2014.

Table X – 2018 Winter Storms Riley and Quinn Power Outages by EDC

2018 Winter Storms Riley and Quinn Power Outages			
EDC	**Customers affected by storms Riley and Quinn 2018 (Percentage of total customers)**	**Customers affected by Nika 2014 (Percentage of total customers)**	**Customers affected by Sandy 2012 (Percentage of total customers)**
Met-Ed	272,928 (49.22%)	144,000 (26.00%)	298,300 (54.00%)
PECO	794,969 (46.76%)	723,681 (42.00%)	845,703 (54.20%)
Penelec	90,856 (15.61%)	N/A	96,847 (16.40%)
PCLP	2,101 (47.44%)	N/A	4,487 (100.00%)
PPL	261,341 (18.67%)	92,283 (7.00%)	523,936 (37.50%)
Total	1,422,195	959,964	1,769,273

Source Winter Storm Riley and Quinn Report 2019

4.3.21.4 Future Occurrence

Utility interruptions are difficult to predict, even though minor interruptions may occur several times a year to all utilities. Even so, utility interruptions occur more frequently as a secondary factor to severe weather events or transportation accidents.

Space weather is getting more attention as an infrastructure risk, due in part to a March 2020 report by the U.S. Geological Survey (USGS). The report notes that geomagnetic storms caused by the dynamic action of the Sun and solar wind on the space environment surrounding the Earth can generate electric fields in the Earth's crust and mantle. These electric fields can interfere with the operation of grounded electric power-grid systems. Geomagnetic storms occur only occasionally, but when sufficiently energetic they can produce blackouts (USGS).

As utility infrastructure ages, interruption events could occur more frequently. Utility providers can reduce Tioga County's vulnerability to power outages by implementing improvement plans.

4.3.21.5 Vulnerability Assessment

Resources such as electricity, communications, gas, and water supply are critical to ensure the health, safety, and general welfare of the citizenry. See *Figure X - Tioga County Utility Lines* for the locations of utilities throughout the county.

Power outages can cause even greater detriment to at-risk and vulnerable populations, such as the elderly or those with functional and access needs. All critical infrastructure is vulnerable to the effects of a power outage. The probability of a large-scale, extended utility failure is low; however, small-scale failures lasting short periods of time occur annually.

Long-term care facilities, senior centers, hospitals, and emergency medical facilities are all vulnerable to utility interruptions. Often back-up power generators are used at these facilities to off-set electrical needs during extremes of hot or cold temperatures. However, these back-up power generators must be maintained, and fuel supplies must be secured in advance of the utility interruption to ensure a seamless transition from the everyday power source to the emergency generator. When officials consider maintenance and supplies for a facility, tong-term use of back-up generators should be planned.

The *Acronis Cyberthreats Report 2020* contains an in-depth review of the current internet and wireless threat landscape and projections for the coming year. Based on the protection and security challenges that were amplified by the shift to remote work during the COVID-19 pandemic, Acronis warns 2021 will bring aggressive cyber-crime activities as criminals pivot their attacks from data encryption to data exfiltration.

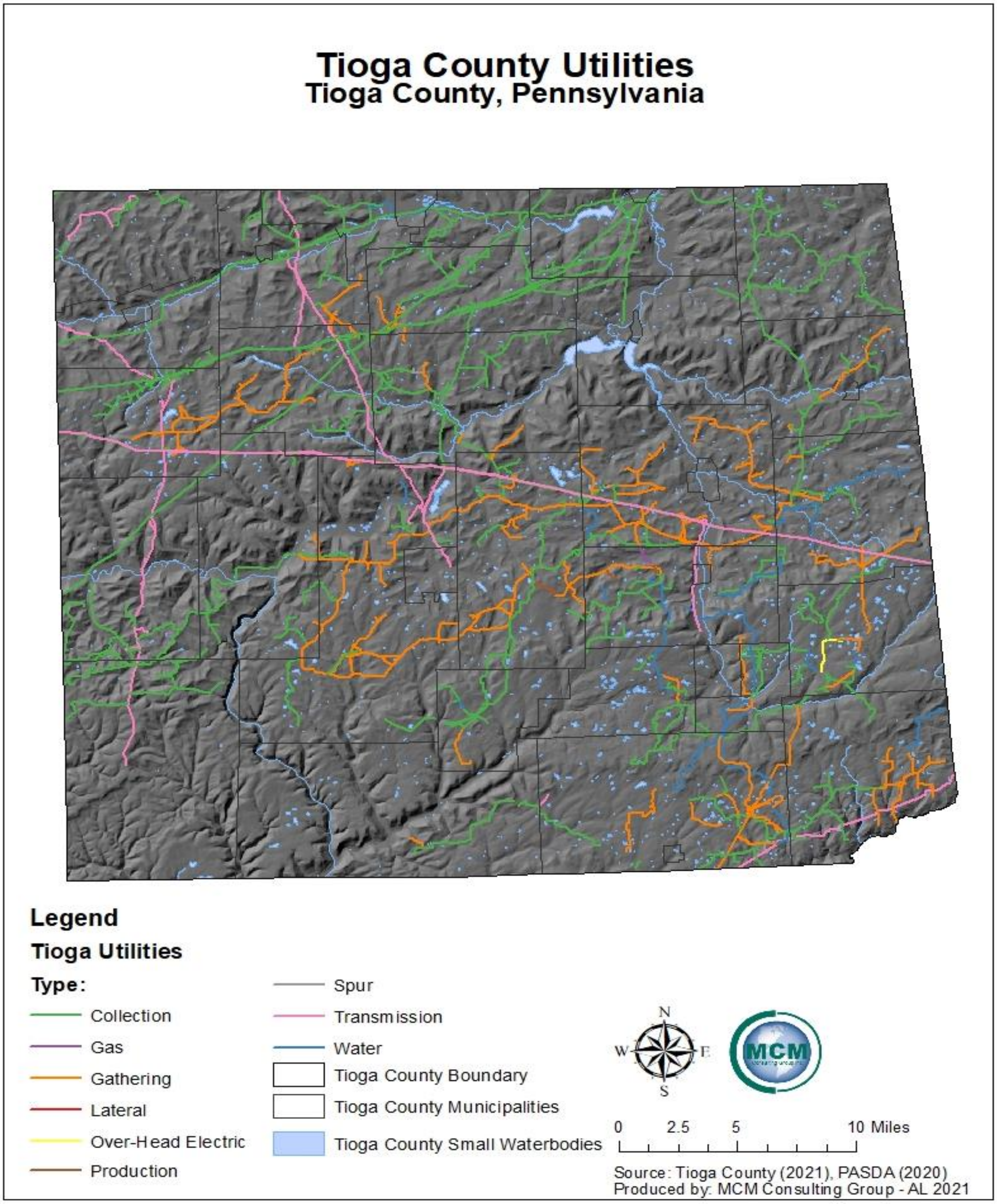
The major points illustrated in the report are as follows:

- Attacks against remote workers will increase due to the movement of workers to less secure working areas.
- Ransomware will look for new victims and will become more automated.
- Legacy IT and technical solutions will struggle to keep pace with ransomware and cyber-crime attacks.

According to a study carried out on the data sourced from the Federal Bureau of Investigation, Pennsylvania is ranked second worst among states when it comes to handling cyber-attacks. The study made by Information Network Associates – an international security consulting company – says an increase of 25% was witnessed in cyber-attacks between 2016 and 2017. This illustrates the amount of preparation that must occur in the commonwealth so that it can better respond to potential cybercrime attacks.

Tioga County currently has both 3G and 4G wireless network capability, and the tower sites and networks are at risk for temporary interruptions from weather and cyber threats; the risk is considered low, however, and any issues would be reported to multiple organizations for investigation, restoration and/or assistance.

Figure X - Tioga County Utility Lines



4.4. Hazard Vulnerability Summary

4.4.1. Methodology

Ranking hazards helps communities set goals and priorities for mitigation based on their vulnerabilities. A risk factor (RF) is a tool used to measure the degree of risk for identified hazards in a particular planning area. The RF can also assist local community officials in ranking and prioritizing hazards that pose the most significant threat to a planning area based on a variety of factors deemed important by the planning team and other stakeholders involved in the hazard mitigation planning process. The RF system relies mainly on historical data, local knowledge, general consensus from the planning team and information collected through development of the hazard profiles included in Section 4.3. The RF approach produces numerical values that allow identified hazards to be ranked against one another; the higher the RF value, the greater the hazard risk.

RF values were obtained by assigning varying degrees of risk to five categories for each of the hazards profiled in the HMP update. Those categories include *probability*, *impact*, *spatial extent*, *warning time and duration*. Each degree of risk was assigned a value ranging from one to four. The weighting factor agreed upon by the planning team is shown in *Table X – Risk Factor Approach Summary*. To calculate the RF value for a given hazard, the assigned risk value for each category was multiplied by the weighting factor. The sum of all five categories equals the final RF value, as demonstrated in the following example equation:

Risk Factor Value =
[(Probability x .30) + (Impact x .30) +(Spatial Extent x .20) + (Warning Time x .10) + (Duration x .10)]

Table X – Risk Factor Approach Summary summarizes each of the five categories used for calculating a RF for each hazard. According to the weighting scheme applied, the highest possible RF value is 4.0.

Table X - Risk Factor Approach Summary

Summary of Risk Factor Approach Used to Rank Hazard Risk.				
RISK ASSESSMENT CATEGORY	**DEGREE OF RISK**			**WEIGHT VALUE**
	LEVEL	**CRITERIA**	**INDEX**	
PROBABILITY *What is the likelihood of a hazard event occurring in a given year?*	**UNLIKELY**	LESS THAN 1% ANNUAL PROBABILITY	1	30%
	POSSIBLE	BETWEEN 1 & 10% ANNUAL PROBABILITY	2	
	LIKELY	BETWEEN 10 &100% ANNUAL PROBABILITY	3	
	HIGHLY LIKELY	100% ANNUAL PROBABILTY	4	
IMPACT *In terms of injuries, damage, or death, would you anticipate impacts to be minor, limited, critical, or catastrophic when a significant hazard event occurs?*	**MINOR**	VERY FEW INJURIES, IF ANY. ONLY MINOR PROPERTY DAMAGE & MINIMAL DISRUPTION ON QUALITY OF LIFE. TEMPORARY SHUTDOWN OF CRITICAL FACILITIES.	1	30%
	LIMITED	MINOR INJURIES ONLY. MORE THAN 10% OF PROPERTY IN AFFECTED AREA DAMAGED OR DESTROYED. COMPLETE SHUTDOWN OF CRITICAL FACILITIES FOR MORE THAN ONE DAY.	2	
	CRITICAL	MULTIPLE DEATHS/INJURIES POSSIBLE. MORE THAN 25% OF PROPERTY IN AFFECTED AREA DAMAGED OR DESTROYED. COMPLETE SHUTDOWN OF CRITICAL FACILITIES FOR MORE THAN ONE WEEK.	3	
	CATASTROPHIC	HIGH NUMBER OF DEATHS/INJURIES POSSIBLE. MORE THAN 50% OF PROPERTY IN AFFECTED AREA DAMAGED OR DESTROYED. COMPLETE SHUTDOWN OF CRITICAL FACILITIES FOR 30 DAYS OR MORE.	4	
SPATIAL EXTENT *How large of an area could be impacted by a hazard event? Are impacts localized or regional?*	**NEGLIGIBLE**	LESS THAN 1% OF AREA AFFECTED	1	20%
	SMALL	BETWEEN 1 & 10% OF AREA AFFECTED	2	
	MODERATE	BETWEEN 10 & 50% OF AREA AFFECTED	3	
	LARGE	BETWEEN 50 & 100% OF AREA AFFECTED	4	
WARNING TIME *Is there usually some lead time associated with the hazard event? Have warning measures been implemented?*	**MORE THAN 24 HRS**	SELF-DEFINED *(NOTE: Levels of warning time and criteria that define them may be adjusted based on hazard addressed.)*	1	10%
	12 TO 24 HRS	SELF-DEFINED	2	
	6 TO 12 HRS	SELF-DEFINED	3	
	LESS THAN 6 HRS	SELF-DEFINED	4	
DURATION *How long does the hazard event usually last?*	**LESS THAN 6 HRS**	SELF-DEFINED *(NOTE: Levels of warning time and criteria that define them may be adjusted based on hazard addressed.)*	1	10%
	LESS THAN 24 HRS	SELF-DEFINED	2	
	LESS THAN 1 WEEK	SELF-DEFINED	3	
	MORE THAN 1 WEEK	SELF-DEFINED	4	

4.4.2 Ranking Results

Using the methodology described in Section 4.4.1, *Table X – Risk Factor Assessment* lists the risk factor calculated for each of twenty potential hazards identified in the 2022 HMP. Hazards identified as *high* risk have risk factors greater than 2.5. Risk factors ranging from 2.0 to 2.4 were deemed *moderate* risk hazards. Hazards with risk factors 1.9 and less are considered *low* risk.

Table 3 - Risk Factor Assessment

Tioga County Hazard Ranking Based on RF Methodology.							
HAZARD RISK	HAZARD NATURAL(N) OR HUMAN-CAUSED(H)	RISK ASSESSMENT CATEGORY					RISK FACTOR (RF)
		PROBABILITY	ECONOMIC IMPACT	SPATIAL EXTENT	WARNING TIME	DURATION	
HIGH	Utility Interruption (H)	4	3	4	4	3	**3.6**
	Cyber Attack (H)	4	3	3	4	4	**3.5**
	Pandemic, Epidemic and Infectious Disease (N)	3	4	4	1	4	**3.4**
	Invasive Species (N)	4	3	4	1	4	**3.4**
	Emergency Services (H)	4	3	4	1	4	**3.4**
	Opioid Epidemic (H)	4	3	4	1	4	**3.4**
	Winter Storm (N)	4	3	4	1	3	**3.3**
	Wildfire (N)	4	3	2	4	3	**3.2**
	Drought (N)	3	3	4	1	4	**3.1**
	Flood (100 Year) (N)	3	3	3	2	3	**2.9**
	Dam Failure (N)	1	4	3	3	4	**2.8**
	Extreme Temperatures (N)	3	2	4	2	3	**2.8**
	Flash Flooding (N)	4	2	2	4	2	**2.8**
	Windstorm (N)	3	2	3	4	2	**2.7**
	Landslide (N)	3	2	2	4	4	**2.7**
	Environmental Hazards (H)	3	2	2	4	4	**2.7**
	Terrorism (H)	2	2	3	4	4	**2.6**
MODERATE	Disorientation (H)	4	1	1	4	2	2.3
	Transportation Accidents/Hazmat (H)	4	1	1	4	2	2.3

Tioga County Hazard Ranking Based on RF Methodology.							
HAZARD RISK	HAZARD NATURAL(N) OR HUMAN-CAUSED(H)	RISK ASSESSMENT CATEGORY					RISK FACTOR (RF)
		PROBABILITY	ECONOMIC IMPACT	SPATIAL EXTENT	WARNING TIME	DURATION	
	Civil Disturbance/Criminal Activity (H)	2	2	2	4	3	2.3
	Ice Jam Flooding (N)	2	2	2	4	3	2.3
	Solar Flare (N)	1	2	4	3	2	2.2
	Tornado (N)	2	2	2	4	1	2.1
LOW	Earthquake (N)	1	1	3	4	1	1.7
	Subsidence and Sinkhole (N)	1	1	1	4	4	1.6

Based on these results, there are eighteen high risk hazards, six moderate risk hazards and two low risk hazards in Tioga County. Mitigation actions were developed for all high, moderate, and low risk hazards (see sections 6.4). The threat posed to life and property for moderate and high-risk hazards is considered significant enough to warrant the need for establishing hazard-specific mitigation actions. Mitigation actions related to future public outreach and emergency service activities are identified to address low risk hazard events.

A risk assessment result for the entire county does not mean that each municipality is at the same amount of risk to each hazard. *Table X – Countywide Risk Factor* shows the different municipalities in Tioga County and whether their risk is greater than (>), less than (<), or equal to (=) the risk factor assigned to the county as a whole. This table was developed by the consultant based on the findings in the hazard profiles located in sections 4.3.1 through 4.3.19.

Table X - Countywide Risk Factor by Hazard

Calculated Countywide Risk Factor by Hazard and Comparative Jurisdictional Risk

IDENTIFIED HAZARD AND CORRESPONDING COUNTYWIDE RISK FACTOR

JURISDICTION	Utility Interruption (H)	Cyber Attack (H)	Pandemic, Epidemic, and Infectious Disease (N)	Invasive Species (N)	Emergency Services (H)	Opioid Epidemic (H)	Winter Storm (N)	Wildfire (N)	Drought (N)	Flood (100 Year) (N)
	3.6	***3.5***	***3.4***	***3.4***	***3.4***	***3.4***	***3.3***	***3.2***	***3.1***	***2.9***
Bloss Township										
Blossburg Borough										
Brookfield Township										
Charleston Township										
Chatham Township										
Clymer Township										
Covington Township										
Deerfield Township										
Delmar Township										
Duncan Township										
Elk Township										
Elkland Borough										
Farmington Township										
Gaines Township										
Hamilton Township										
Jackson Township	=	=	=	>	=	=	=	=	=	>
Knoxville Borough	=	=	=	=	=	=	=	=	=	=
Lawrence Township										
Lawrenceville Borough	>	=	=	=	=	=	=	=	=	=
Liberty Borough										
Liberty Township										
Mansfield Borough	=	>	=	=	>	=	>	<	=	=

Calculated Countywide Risk Factor by Hazard and Comparative Jurisdictional Risk

IDENTIFIED HAZARD AND CORRESPONDING COUNTYWIDE RISK FACTOR

JURISDICTION	Utility Interruption (H)	Cyber Attack (H)	Pandemic, Epidemic, and Infectious Disease (N)	Invasive Species (N)	Emergency Services (H)	Opioid Epidemic (H)	Winter Storm (N)	Wildfire (N)	Drought (N)	Flood (100 Year) (N)
	3.6	***3.5***	***3.4***	***3.4***	***3.4***	***3.4***	***3.3***	***3.2***	***3.1***	***2.9***
Middlebury Township										
Morris Township	=	=	=	=	=	=	=	=	=	=
Nelson Township	>	>	>	>	>	=	=	>	=	=
Osceola Township										
Putnam Township	=	=	=	=	=	=	=	=	=	=
Richmond Township	=	<	=	=	=	=	=	=	=	>
Roseville Borough	=	=	=	=	=	=	=	=	=	=
Rutland Township										
Shippen Township										
Sullivan Township	=	=	=	=	=	=	=	=	=	=
Tioga Borough										
Tioga Township	=	=	=	=	=	=	=	=	=	=
Union Township	=	<	=	=	=	=	=	=	=	>
Ward Township	=	=	=	=	=	=	=	=	=	=
Wellsboro Borough	=	=	=	=	=	=	=	=	=	=
Westfield Borough	=	=	=	=	=	=	=	=	=	=
Westfield Township										
Mansfield University										

Calculated Countywide Risk Factor by Hazard and Comparative Jurisdictional Risk										
IDENTIFIED HAZARD AND CORRESPONDING COUNTYWIDE RISK FACTOR										
JURISDICTION	Dam Failure (N)	Extreme Temperatures (N)	Flash Flooding (N)	Windstorm (N)	Landslide (N)	Environmental Hazards (H)	Terrorism (H)	Disorientation (H)	Transportation Accidents/Hazmat (H)	Civil Disturbance/Criminal Activity (H)
	2.8	***2.8***	***2.8***	***2.7***	***2.7***	***2.7***	***2.6***	***2.3***	***2.3***	***2.3***
Bloss Township										
Blossburg Borough										
Brookfield Township										
Charleston Township										
Chatham Township										
Clymer Township										
Covington Township										
Deerfield Township										
Delmar Township										
Duncan Township										
Elk Township										
Elkland Borough										
Farmington Township										
Gaines Township										
Hamilton Township										
Jackson Township	=	>	>	=	=	=	=	=	=	=
Knoxville Borough	=	=	=	=	=	=	=	=	=	=
Lawrence Township										
Lawrenceville Borough	=	=	=	=	=	=	=	=	=	=
Liberty Borough										
Liberty Township										
Mansfield Borough	=	=	>	=	<	=	>	=	>	=
Middlebury Township										

Calculated Countywide Risk Factor by Hazard and Comparative Jurisdictional Risk										
IDENTIFIED HAZARD AND CORRESPONDING COUNTYWIDE RISK FACTOR										
JURISDICTION	Dam Failure (N)	Extreme Temperatures (N)	Flash Flooding (N)	Windstorm (N)	Landslide (N)	Environmental Hazards (H)	Terrorism (H)	Disorientation (H)	Transportation Accidents/Hazmat (H)	Civil Disturbance/Criminal Activity (H)
	2.8	***2.8***	***2.8***	***2.7***	***2.7***	***2.7***	***2.6***	***2.3***	***2.3***	***2.3***
Morris Township	=	=	=	=	=	=	=	=	=	=
Nelson Township	=	>	>	>	>	=	=	=	=	=
Osceola Township										
Putnam Township	=	=	=	=	=	=	=	=	=	=
Richmond Township	>	=	>	=	=	=	=	=	=	=
Roseville Borough	=	=	=	=	=	=	=	=	=	=
Rutland Township										
Shippen Township										
Sullivan Township	<	=	=	=	=	=	<	=	=	=
Tioga Borough										
Tioga Township	=	=	>	=	=	=	<	=	=	=
Union Township	<	=	=	>	=	=	<	=	=	=
Ward Township	=	=	=	=	=	=	=	=	=	<
Wellsboro Borough	=	=	=	=	=	=	=	=	=	=
Westfield Borough	=	=	=	=	=	=	=	=	=	=
Westfield Township										
Mansfield University										

Calculated Countywide Risk Factor by Hazard and Comparative Jurisdictional Risk										
IDENTIFIED HAZARD AND CORRESPONDING COUNTYWIDE RISK FACTOR										
JURISDICTION	Ice Jam Flooding (N)	Solar Flare (N)	Tornado (N)	Earthquake (N)	Subsidence and Sinkhole (N)					
	2.3	***2.2***	***2.1***	***1.7***	***1.6***					
Bloss Township										
Blossburg Borough										
Brookfield Township										
Charleston Township										
Chatham Township										
Clymer Township										
Covington Township										
Deerfield Township										
Delmar Township										
Duncan Township										
Elk Township										
Elkland Borough										
Farmington Township										
Gaines Township										
Hamilton Township										
Jackson Township	=	=	=	=	=					
Knoxville Borough	=	=	=	=	=					
Lawrence Township										
Lawrenceville Borough	=	=	=	=	=					
Liberty Borough										
Liberty Township										
Mansfield Borough	=	=	>	=	>					
Middlebury Township										

Calculated Countywide Risk Factor by Hazard and Comparative Jurisdictional Risk										
IDENTIFIED HAZARD AND CORRESPONDING COUNTYWIDE RISK FACTOR										
JURISDICTION	Ice Jam Flooding (N)	Solar Flare (N)	Tornado (N)	Earthquake (N)	Subsidence and Sinkhole (N)					
	2.3	***2.2***	***2.1***	***1.7***	***1.6***					
Morris Township	=	=	=	=	=					
Nelson Township	=	=	=	=	>					
Osceola Township										
Putnam Township	=	=	=	=	=					
Richmond Township	=	=	=	=	=					
Roseville Borough	=	=	=	=	=					
Rutland Township										
Shippen Township										
Sullivan Township	=	=	=	=	=					
Tioga Borough										
Tioga Township										
Union Township	<	=	>	=	=					
Ward Township	=	=	>	=	=					
Wellsboro Borough	=	=	=	=	=					
Westfield Borough										
Westfield Township	=	=	=	=	=					
Mansfield University										

4.4.3. Potential Loss Estimates

Based on various kinds of available data, potential loss estimates were established for flooding. Estimates provided in this section are based on HAZUS-MH, version MR4, geospatial analysis, and previous events. Estimates are considered *potential* in that they generally represent losses that could occur in a countywide hazard scenario. In events that are localized, losses may be lower, while regional events could yield higher losses.

Potential loss estimates have four basic components, including:

Replacement Value: Current cost of returning an asset to its pre-damaged condition, using present-day cost of labor and materials.

Content Loss: Value of building's contents, typically measured as a percentage of the building replacement value.

Functional Loss: The value of a building's use or function that would be lost if it were damaged or closed.

Displacement Cost: The dollar amount required for relocation of the function (business or service) to another structure following a hazard event.

Flooding Loss Estimation:

Flooding is a high-risk natural hazard in Tioga County. The estimation of potential loss in this assessment focuses on the monetary damage that could result from flooding. The potential property loss was determined for each municipality and for the entire county. The quantity of commercial and residential structures in each Tioga County municipality is outlined in section 4.3.3 of the flooding hazard profile.

MCM Consulting Group, Inc. conducted a countywide flood study using the Hazards U.S. Multi-Hazard (HAZUS-MH) software that is provided by the Federal Emergency Management Agency. This software is a standardized loss estimation software deriving economic loss, building damage, content damage and other economic impacts that can be used in local flood mitigation planning activities.

Using HAZUS-MH, total building-related losses from a 1%-annual-chance flood in Tioga County are estimated to equal $126.35 million with $73.95 million of that coming from residential homes. Total economic loss, including replacement value, content loss, functional loss, and displacement cost, from a countywide 1%-annual-chance flood are estimated to equal $229.35 million.

4.4.4. Future Development and Vulnerability

The 2019 estimated population for Tioga County is 40,591 which is 809 less than the 2010 census. There was an overall decrease of 1.7% in population based on the estimate. Six municipalities have seen population increases while the remaining had decreases in the period between 2010 and the 2019 estimate as identified in *Table X – Population Change in Tioga County from 2010-2019*.

Table X - 2010-2019 Population Change

Population Change in Tioga County from 2010-2019				
Municipality	**2010 Census**	**2015 Estimates**	**2019 Estimates**	**Percent of Change 2010-2019 Estimate**
Bloss Township	351	344	338	-4.2%
Blossburg Township	1,538	1,513	1,482	-3.6%

Population Change in Tioga County from 2010-2019				
Municipality	**2010 Census**	**2015 Estimates**	**2019 Estimates**	**Percent of Change 2010-2019 Estimate**
Brookfield Township	421	413	404	-4%
Charleston Township	3,360	3,483	3,433	+2.1%
Chatham Township	588	596	584	-0.7%
Clymer Township	581	573	561	-3.4%
Covington Township	1,022	1,033	1,016	-0.6%
Deerfield Township	662	658	650	-1.8%
Delmar Township	2,856	2,852	2,797	-2.1%
Duncan Township	208	214	221	+6.3%
Elk Township	49	48	47	-0.41%
Elkland Borough	1,821	1,779	1,739	-4.6%
Farmington Township	637	663	661	+3.8%
Gains Township	542	545	536	-1.1%
Hamilton Township	499	495	485	-2%
Jackson Township	1,887	1,878	1,867	-1%
Knoxville Borough	629	617	599	-4.8%
Lawrence Township	1,718	1,686	1,644	-4.3%
Lawrenceville Borough	581	617	612	+5.3%
Liberty Borough	249	239	234	-6%
Liberty Township	1,042	1,037	1,024	-1.7%
Mansfield Borough	3,625	3,215	2,917	-2%
Middlebury Township	1,285	1,300	1,281	-0.3%
Morris Township	606	596	582	-4%
Nelson Township	571	566	560	-2%
Osceola Township	659	643	630	-4.4%
Putnam Township	425	424	419	-1.4%
Richmond Township	2,396	2,325	2,285	-4.6%
Roseville Borough	189	190	184	-2.6%
Rutland Township	805	827	809	+0.5%
Shippen Township	527	522	515	-2.3%
Sullivan Township	1,453	1,464	1,450	-0.2%
Tioga Borough	666	661	647	-2.9%
Tioga Township	991	972	961	-3%
Union Township	1,000	1,007	993	-0.7%
Ward Township	166	176	174	+4.8%
Wellsboro Borough	3,263	3,278	3,227	-1.1%
Westfield Borough	1,064	1,057	1,036	-2.6%
Westfield Township	1,047	1,013	987	-5.7%

Population Change in Tioga County from 2010-2019				
Municipality	**2010 Census**	**2015 Estimates**	**2019 Estimates**	**Percent of Change 2010-2019 Estimate**
TOTAL	**41981**	**41519**	**40591**	**-1.7%**