4.11 Severe Summer Weather

4.11.1 Description

Severe summer weather events may include severe thunderstorms and thunderstorm winds, hail, and lightning. High winds, tornadoes, and flooding may also be related to severe summer storms and, due to the potential threat of these events, they are each discussed in separate risk assessments. While tropical storms and hurricanes are also forms of severe storms, Clinton County does not have any record of such events affecting the County; therefore, the County has not deemed tropical storms and hurricanes to be a threat and these specific types of weather will not be addressed further.

According to the National Weather Service (NWS), a severe thunderstorm is a thunderstorm that produces a tornado, winds of at least 58 MPH, and/or hail at least one inch in diameter. A Severe Thunderstorm Watch is issued by the NWS if conditions are favorable for the development of severe thunderstorms. A watch is usually in place for four to eight hours, during which time people should be prepared to move to a safe place if threatening weather approaches.

A Severe Thunderstorm Warning is issued if either the WSR-88D radar indicates a severe thunderstorm or if a spotter reports a storm producing hail or winds meeting the criteria outlined in the description above. The WSR-88D radar is an advanced Weather Surveillance Doppler Radar utilized by the NWS to generate a radar image. The NWS recommends that people in the affected area seek safe shelter immediately, as severe thunderstorms have the potential to produce tornadoes with little-to-no advance warning. Lightning frequency is not a criterion for issuing a severe thunderstorm warning. The warnings are usually issued for one hour and can be issued without a Severe Thunderstorm Watch already in effect. The National Weather Service Forecast Office in Wilmington is responsible for issuing Severe Thunderstorm Watches and Warnings for Clinton County.

Lightning is caused by a rapid discharge of electrical energy that has built up in the atmosphere between clouds, the air, or the ground. Lightning strikes can be either direct or indirect. A direct strike is when lightning strikes a building or a specific zone, which can result in fusion points melting holes of varying sizes at the point of impact of materials with high resistivity. An indirect lightning strike is when lightning causes power surges that disrupt electrical equipment.

Severe summer storms can also create strong winds – often called “straight-line” winds – to differentiate thunderstorm winds from tornadic winds. These winds, which have the potential to cause damage, are caused by an outflow generated by a thunderstorm downdraft. Severe wind events are discussed in more detail in **Section 4.12.**

Hail is a type of frozen precipitation that occurs when thunderstorm updrafts carry raindrops upward into extremely cold atmospheric zones where they freeze before falling to the ground. The resulting hailstones can fall at speeds greater than 100 MPH and range in size from smaller than 0.50 inches (the size of a pea) to 4.5 inches (the size of a softball) (Source: National Weather Service).

4.11.2 Location

Severe summer storms are a countywide hazard and all of Clinton County is susceptible to severe weather.

4.11.3 Extent

Severe summer storm events have the potential to create large-scale damage in Clinton County. Specifically, lightning is responsible for approximately 50 deaths annually across the United States, as well as hundreds of injuries (Source: NOAA). Winds associated with severe summer storms have the potential to cause damage by bringing down tree limbs and generating widespread power outages. Additionally, hail can result in property damage.

Severe summer storms can lead to flooding, downed trees and power lines, and other dangerous conditions.

4.11.4 History

According to the National Centers for Environmental Information (NCEI), there have been 152 thunderstorm wind events, 16 heavy rain events, 61 hail events, and two lightning events recorded in Clinton County from February 1956 to June 2020. These events resulted in $3.545 million in property damage and $0 in crop damage. These events were not responsible for any deaths or injuries. These events are summarized in **Table 4.11.1**, below:

Table 4.11.1: Thunderstorm-Related Events in Clinton County since 1956

Severe Storm Event Type	Number of Events	Injuries	Deaths	Property Damages	Crop Damages
Thunderstorm Wind	152	1	0	$3,114,000	$0
Heavy Rain	16	0	0	$0	$0
Hail	61	0	0	$281,000	$0
Lightning	2	0	0	$150,000	$0
Total	**231**	**1**	**0**	**$3,545,000**	**$0**

Clinton County has not been associated with any thunderstorm-related disaster declarations since the previous hazard mitigation plan. The events that resulted in the largest amounts of property damage, as well as the sole injury due to summer storms in the County's history, are described below.

March 14, 2019

Thunderstorms developed through the afternoon hours ahead of an approaching cold front. Some of the storms produced damaging winds and large hail. According to the Clinton County EMA, 92 poles were knocked down as a result. 35 of these poles were power transmission poles resulting in an eight-hour countywide power outage on March 16, 2020. All parts of the County were impacted except for Blanchester. This set of storms was responsible for $165,000 in property damage, no crop damage, and no injuries or deaths.

April 9, 1999

This line of storms was also responsible for tornadoes in other parts of the County. Three homes and a business were destroyed by the storm and 20 other properties were damaged. This storm was responsible for $1.0 million in property damages and no crop damage, injuries, or deaths.

June 19, 1994

This line of severe storms was responsible for the one injury reported due to this hazard type. A local resident was injured in a traffic accident during the storm from falling debris striking the car.

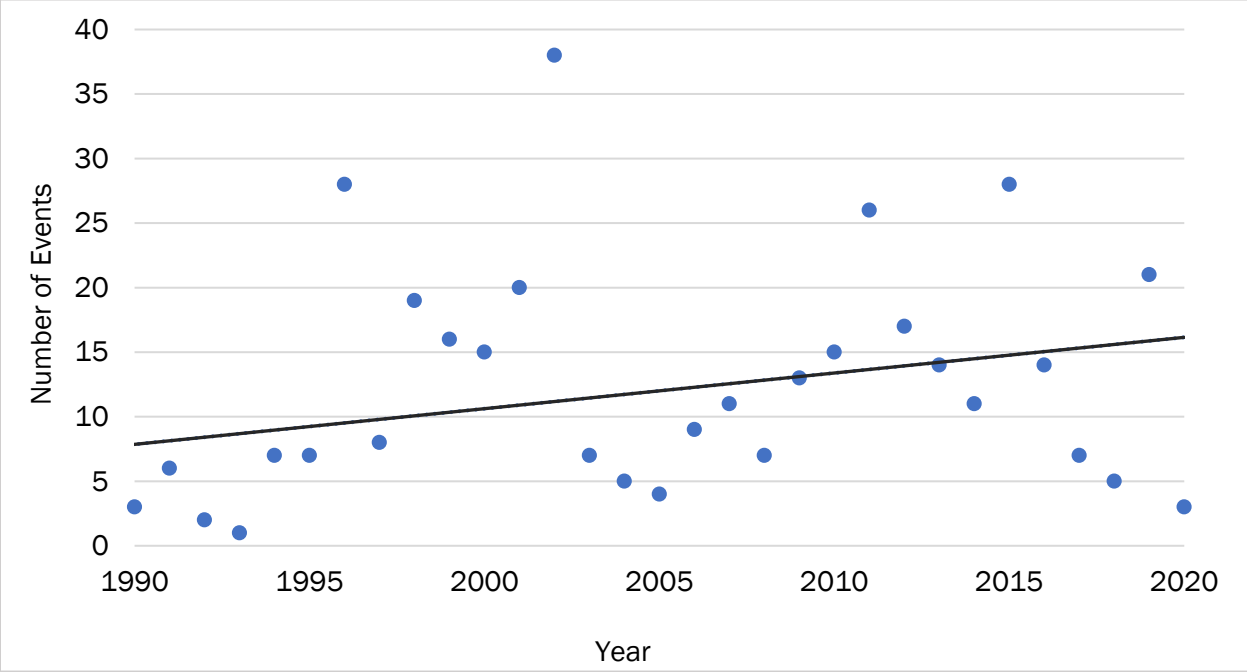
Numerous trees were downed, including some on homes and vehicles. A metal storage shed was blown from its foundation and found suspended in a tree. This storm was responsible for $50,000 in property damage and no crop damage.

April 14, 1994
This severe storm event was responsible for $500,000 in property damage, but no crop damage, injuries, or deaths. Reports indicate that trees were downed and there was minor roof and porch damage in several locations including the Village of Clarksville and City of Wilmington. A vacant mobile home was blown over in Vernon Township. A tractor-semitrailer was blown off US-68 just south of I-71 near the City of Wilmington.

4.11.5 Probability
According to the NCEI, there have been 231 severe summer storm events reported in Clinton County from February 1956 to June 2020 with total losses reaching more than $3.545 million in property damage and $0 in crop damage. This amounts to between three and four severe storm events annually with average annual damages of $55,390.

Furthermore, **Figure 4.11.2** below shows the trend in number of thunderstorm events per year since 1990. The trend line has a slightly positive slope, which indicates that the number of severe summer storms has increased over the last 30 years. Years prior to 1990 are excluded from the probability calculation due to missing and/or unreliable data reporting.

Figure 4.11.2: Severe Summer Storm Probability



4.11.6 Vulnerability Assessment
Infrastructure Impact
Above-ground infrastructure is at risk for storm damage by wind and falling debris. For infrastructure, high winds and hail are the most damaging part of a severe storm. Thunderstorm winds can strip

bark from trees and detach limbs. If large branches fall, they can damage buildings and supporting above-ground infrastructure. In the most severe storms with high winds, large trees can be uprooted and have the potential to fall on buildings including houses, which can cause harm or death.
Utilities are at risk for damage by severe summer storms as well. Electrical lines are spread throughout the County connecting homes, businesses, and other facilities. Severe storms are likely to down tree limbs and generate other debris that can affect above-ground electrical lines causing power outages. Downed power lines that are still live are extremely hazardous and can cause death by electrocution.

Population Impact
According to the American Community Survey's 2018 population estimates, the population of Clinton County is approximately 41,896. Summer storms are random in nature and affect the entire area of the County. Everyone within the County should be prepared during a storm event. Populations residing in mobile home parks are particularly vulnerable and should seek out shelters.

Property Damage
As described above, these events have caused an average of $55,390 in property damages annually. Due to the non-site-specific nature of this hazard, **Table 4.11.2** lists all structures within Clinton County as having potential impacts from severe storms.

Loss of Life
Although no loss of life was reported due to the 231 severe summer storm events on record with the NCEI, there is always potential for injuries and fatalities during severe weather.

Economic Losses
Severe storms usually cause minor damage to structures, such as blowing shingles off roofs and downed branches breaking windows or falling onto buildings and above-ground infrastructure. More severe damage may also result. Of the 231 severe summer storm events since 1956, 43 events resulted in property damage of $10,000 or more. The costliest storm in the County's history was a thunderstorm wind event on April 9, 1999 which caused $1.0 million in property damage.

Table 4.11.2: Structure Vulnerability from Severe Storms

Structure Type	Number of Properties Exposed	Value of Vulnerable Structures		
		Land	Building	Total
Residential	17,871	$110,107,680	$406,567,870	$516,675,550
Non-Residential	8,935	$561,925,770	$325,785,670	$887,711,440
Critical Facilities	102	$7,359,920	$56,094,270	$63,454,190
Total	26,806	$672,033,450	$732,353,540	$1,404,386,990

**Note: Critical Facilities are non-residential structures and their value is incorporated into the non-residential totals as well. Calculated totals are determined by summing the residential and non-residential values.*

4.11.7 Land Use and Development Trends
Severe storms can occur anywhere. Any development that has occurred since the previous plan and any future development has the potential to be impacted by severe storms.

4.12 Severe Wind and Tornadoes

4.12.1 Description

FEMA defines a tornado as "a violently rotating column of air extending from a thunderstorm to the ground." Tornadoes can generate wind speeds of greater than 250 MPH. Tornado paths can be as large as one mile wide and 50 miles long. Nationally, there is an average of 800 tornadoes reported annually across all 50 states.

In general, the midsection of the United States experiences a higher rate of tornadoes than other parts of the country because of the recurrent collision of moist, warm air moving north from the Gulf of Mexico with colder fronts moving east from the Rocky Mountains. Supercells, which form from rotating thunderstorms, are the most destructive variety of tornado.

Tornado Warnings are issued by the Wilmington NWS Forecast Office when a tornado is indicated by the WSR-88D radar or sighted in person by spotters. The WSR-88D radar is an advanced Weather Surveillance Doppler Radar utilized by the NWS to generate a radar image. Once a warning has been issued, people in the warning area should seek shelter immediately. Warnings will include the location of the tornado, as well as what communities will be in its path. A tornado warning can be issued without a tornado watch, and they are typically issued for 30 minutes at a time. If the thunderstorm responsible for the formation of the tornado is also producing large volumes of rain, the tornado warning may be combined with a Flash Flood Warning. The NWS Office will follow up any Tornado Warnings with Severe Weather Statements to provide up-to-date information on the tornado and inform the public when the warning is no longer in effect (Source: NWS).

This section also takes severe wind events, as they can be as destructive as some tornadoes. The NWS can issue various types of wind advisories and warnings. A **wind advisory** is issued when sustained winds of 31 to 39 MPH are reached for an hour or more and/or if there are wind gusts of 46 to 57 MPH for any duration. A **High Wind Watch** indicates that sustained, strong winds are possible and outdoor items should be secured. People should modify plans so they are not caught outside. Additionally, a **High Wind Warning** indicates that sustained, strong winds (40 MPH or greater) with even stronger gusts (greater than 58 MPH) are happening. People should seek shelter, and those driving should keep both hands on the wheel and slow down. An **extreme wind warning** is issued for surface winds of 115 MPH or greater associated with non-convective, downslope, derecho (not associated with a tornado), or sustained hurricane winds that are expected to occur within one hour.

4.12.2 Location

Tornadoes can occur anywhere in Clinton County. All areas and jurisdictions should be considered at risk for a tornado.

4.12.3 Extent

Tornadoes are measured by damage scale for their winds with greater damage equating greater wind speed. The original Fujita Tornado Damage Scale (F-scale) was developed in 1971 without much consideration to a structure's integrity or condition as it relates to the wind speed required to damage it. The Enhanced Fujita-scale (EF-Scale) took effect on February 1, 2007. This scale starts with the original F-scale's F0-F5 ratings and classifies tornado damage across 28 different types of damage indicators. These indicators mostly involve building/structure type and are assessed at eight damage levels from 1-8. Therefore, construction types and their relative strengths and weaknesses are incorporated into the EF classification given to a particular tornado. The most intense damage

within the tornado path will generally determine the EF scale given the tornado. **Table 4.12.1** lists the classifications under the EF- and F-scale. It should be noted that the wind speeds listed in this table are estimates based on damage rather than measurements.

There are no plans by the National Oceanic Atmospheric Administration (NOAA) or the National Weather Service to re-evaluate the historical tornado data using the enhanced scale. Therefore, this Plan and subsequent plans will reference both scales until a complete switchover is deemed necessary.

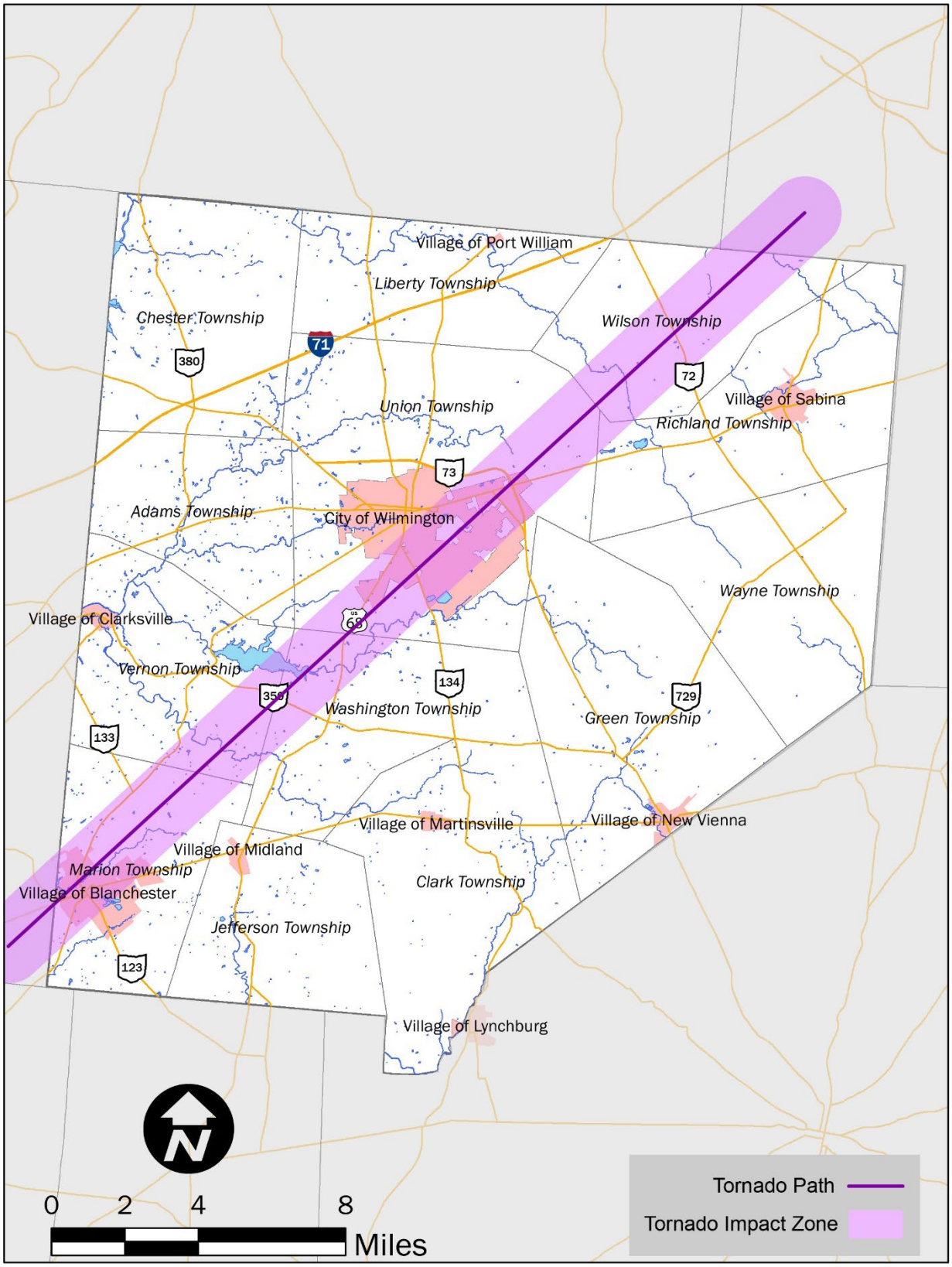
Figure 4.12.1, simulates an extremely destructive, worst-case scenario EF5 tornado and its impacts on Clinton County assets and infrastructure. The worst-case scenario is simulated by running the EF5 tornado on a straight path through the most populated areas of the County. This theoretical scenario is performed to determine maximum potential damage within the County. The damages associated with this theoretical scenario are used to identify the County's potential vulnerability to tornadoes (**Table 4.12.2**).

Table 4.12.1 Fujita and Enhanced Fujita Scale Classifications

Fujita Scale 3-Second Wind Gust (MPH)		Damage Levels	Enhanced Fujita Scale 3-Second Wind Gust (MPH)	
F0	45-78	**Light Damage**: Tree branches down.	**EF-0**	65-85
F1	79-117	**Moderate damage**: Roof damage.	**EF-1**	86-110
F2	118-161	**Considerable damage**: Houses damaged.	**EF-2**	111-135
F3	162-209	**Severe damage**: Buildings damaged.	**EF-3**	136-165
F4	210-261	**Devastating damage**: Structures leveled.	**EF-4**	166-200
F5	262-317	**Incredible damage**: Whole towns destroyed.	**EF-5**	Over 200

Source: SOHMP

Figure 4.12.1: Worst-Case Tornado Scenario



4.12.4 History

There have been 36 severe wind or tornado events in Clinton County between April 1961 and June 2020 resulting in a total of $13.417 million in property damage and $16,000 in crop damage. These events were responsible for two deaths and 19 injuries. Ten of these events occurred in the last ten years. Annualized damages average to approximately $227,407 in property damages and $271 in crop damages. Events with the highest recorded property damages, injuries, and fatalities are described below. Additionally, one event resulted in a Disaster Declaration. This is also described below.

Disaster Declaration FEMA-1805-DR on October 14, 2008 | Windstorms on September 14, 2008

On October 14, 2008, Governor Ted Strickland requested a major disaster declaration due to a severe windstorm associated with Tropical Depression Ike on September 14, 2008. The Governor requested a Declaration for public assistance for 33 counties and Hazard Mitigation for all counties. During the period of October 6-10, 2008, joint Federal, State, and local Preliminary Damage Assessments (PDAs) were conducted in the requested counties and are summarized below. PDAs estimate damage immediately after an event and are considered, along with several other factors, in determining whether a disaster is of such severity and magnitude that effective response is beyond the capabilities of the State and the affected local governments, and that Federal assistance is necessary.

On October 24, 2008, President Bush declared that a major disaster exists in the State of Ohio. This declaration made Public Assistance requested by the Governor available to State and eligible local governments and certain private nonprofit organizations on a cost-sharing basis for emergency work and the repair or replacement of facilities damaged by the severe windstorm associated with Tropical Depression Ike in Ashland, Brown, Butler, Carroll, Champaign, Clark, Clermont, Clinton, Coshocton, Delaware, Fairfield, Franklin, Greene, Guernsey, Hamilton, Harrison, Highland, Hocking, Holmes, Knox, Licking, Madison, Miami, Montgomery, Morrow, Perry, Pickaway, Preble, Shelby, Summit, Tuscarawas, Union, and Warren Counties. This declaration also made Hazard Mitigation Grant Program assistance requested by the Governor available for hazard mitigation measures statewide.

In total, the County reported $5.1 million in property damages associated with this event. Clinton County had a per capita impact of $10.76, which is more than twice the statewide per capita impact of $4.75. (Source: FEMA)

Tornado on September 14, 1990

An F2 tornado caused $2.5 million in property damage, as well as two injuries. The tornado was approximately 200 yards wide and tracked 22.5 miles. Two mobile homes were destroyed, as well as seven barns and outbuildings. (Source: NCEI)

Tornado on March 10, 1986

An F2 tornado caused ten injuries and $2.5 million in property damage on March 10, 1986. The tornado was measured to be 50 yards wide and tracked 8.8 miles across the County. The tornado touched down in western Wilmington and tracked northeast, traveling through the northern part of the City. Two permanent homes were destroyed, and six permanent homes were badly damaged. Five business buildings were also seriously damaged. In one trailer park, 30 mobile homes were overturned. The tornado was 73 yards wide and tracked for 6 miles.

Tornado on April 23, 1968

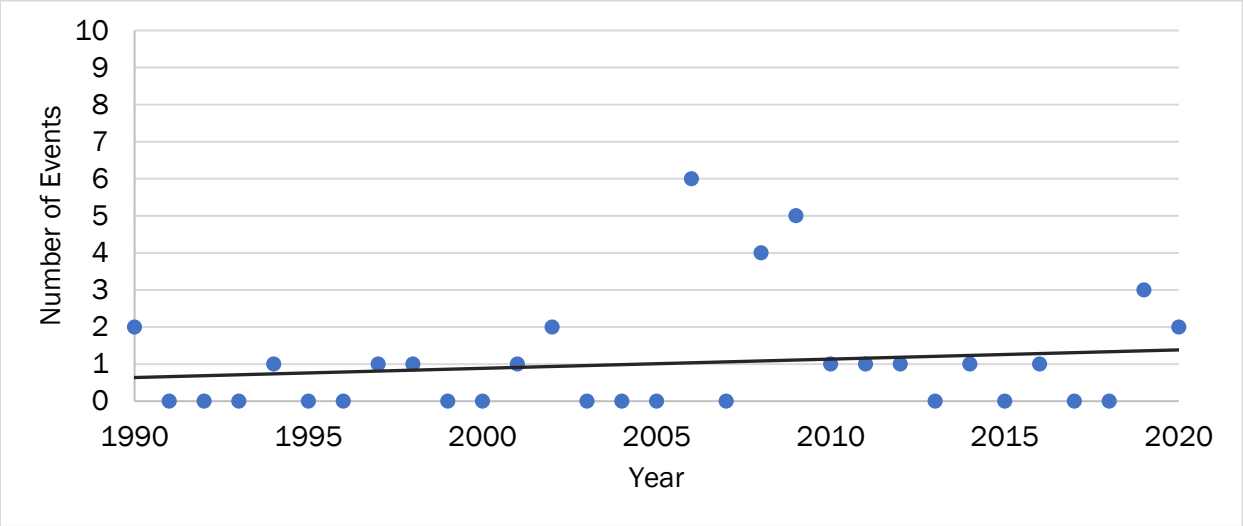
An F4 tornado caused two injuries and $2.5 million in property damage on April 23, 1968. The tornado was measured to be 33 yards wide and tracked 6.1 miles across the County.

Tornado on April 25, 1961
An F2 tornado caused two fatalities, four injuries, and $250,000 in property damage on April 25, 1961. The tornado was measured to be 50 yards wide and tracked 8.8 miles across the County.

4.12.5 Probability
There have been 36 severe wind or tornado events in Clinton County between April 1961 and June 2020 resulting in a total of $13.417 million in property damage and $16,000 in crop damage. As such, tornadoes are likely to occur within Clinton County and result in an average of $227,678 in property and crop damages annually. In the last ten years, there have been ten tornado or severe wind events.

The annual rate for tornadoes and severe wind events in Clinton County is 0.61 events per year, which amounts to approximately one event every one to two years. However, when conditions are right, there may be multiple tornadoes in one year. This rate is displayed in **Figure 4.12.2** below, which shows the number of tornado or severe wind events each year since 1990. The slope is slightly positive, which means the frequency of severe wind and tornado events has increased since 1990.

Figure 4.12.2: Probability of Severe Wind or Tornado Events in Clinton County



4.12.6 Vulnerability Assessment
Infrastructure Impact
Above-ground infrastructure can be damaged by severe winds and tornadoes. Debris caught in the high winds as well as fallen trees can also cause damage to buildings and infrastructure including road closure (**Figure 4.12.3**). Above ground utility infrastructure can be damaged or destroyed, which can cause service outages.

Population Impact
Tornadoes are random in nature and have the potential to occur anywhere in the County. Everyone within the County should be prepared for a tornado and severe wind events. Residents in mobile home parks are particularly vulnerable and should have a plan in place.

Property Damage

Tornadoes can cause significant damage to buildings and properties. There have been 36 tornadoes in Clinton County which have caused more than $13.4 million in property and crop damage. Annually, this amounts to $227,678 in damages. **Table 4.12.2** details the structural vulnerability from the worst-case scenario tornado for Clinton County, which is demonstrated in **Figure 4.12.1**.

Loss of Life

At least two lives have been lost as a result of a tornado in Clinton County. There is potential for loss of life during any tornado event.

Figure 4.12.3: A fallen tree blocks road outside Wilmington during a Tornado

Economic Losses

Tornadoes and severe winds can cause major damage to structures and roads. Higher severity tornadoes have the potential to destroy structures. Debris also has the potential to cause damage to structures by breaking windows, damaging walls, or falling directly onto buildings and above-ground infrastructure.

Damages to utilities and roadways may also cause economic damage due to business closures, destruction of goods that require electricity, and halting economic activity. The following table projects the vulnerability to structures in Clinton County based on the worst-case scenario tornado depicted in **Figure 4.12.1**. This modeling is completed only to demonstrate potential damages associated with a EF-5 tornado that tracks through the most populated areas of the County.

Table 4.12.2: Structure Vulnerability from Tornadoes

Structure Type	Number of Properties Exposed	Value of Vulnerable Structures		
		Land	Building	Total
Residential	3,183	$16,248,790	$58,535,050	$74,783,840
Non-Residential	1,683	$98,058,860	$121,132,340	$219,191,200
Critical Facilities	19	$4,534,400	$21,011,560	$25,545,960
Total	**4,866**	**$114,307,650**	**$179,667,390**	**$293,975,040**

**Note: Critical Facilities are non-residential structures and their value is incorporated into the non-residential totals as well. Calculated totals are determined by summing the residential and non-residential values.*

4.12.7 Land Use and Development Trends

Tornadoes can occur anywhere. Any development that has occurred since that previous plan and any future development has the potential to be impacted by tornadoes.