



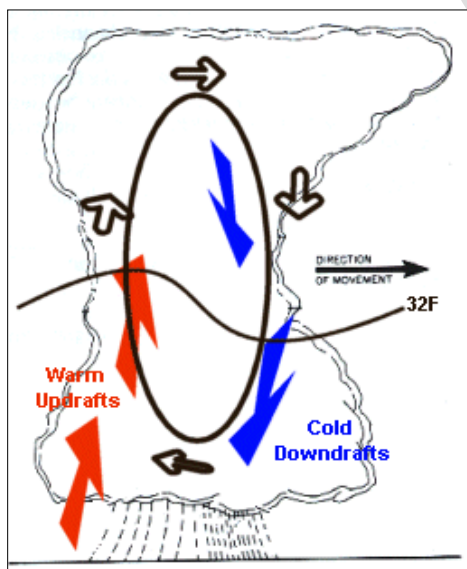
4.3.6 Hailstorm

This section describes the location and extent, range of magnitude, past occurrence, future occurrence, and vulnerability assessment for the hailstorm hazard for Fulton County.

A hailstorm is a storm accompanied by hail, which is precipitation in the form of small balls or lumps of clear ice or compact snow (Merriam Webster, 2017). Hail forms inside a thunderstorm when strong updrafts of warm air and downdrafts of cold water are present. If a water droplet is picked up by the updrafts, it can be carried well above the freezing level. Water droplets freeze when temperatures reach 32°F or colder. As the frozen droplet begins to fall, it may thaw as it moves into warmer air toward the bottom of the thunderstorm. However, the droplet may be picked up again by another updraft, carried back into the cold air, and re-frozen. The frozen droplet adds another layer of ice with each trip above and below the freezing level. The frozen droplet, with many layers of ice, falls to the ground as hail. Most hail is small and typically less than 2 inches in diameter (National Weather Service [NWS] 2009). Figure 4.3.6-1 illustrates the process that occurs in hail formulation.

The size of hailstones is a direct function of the size and severity of the storm. The higher the temperatures at the earth's surface, the greater the strength of the updrafts, and the greater the amount of time the hailstones are suspended, giving them more time to increase in size. Damage to crops and vehicles is typically the most significant impact of hailstorms.

Figure 4.3.6-1. Hail Formation



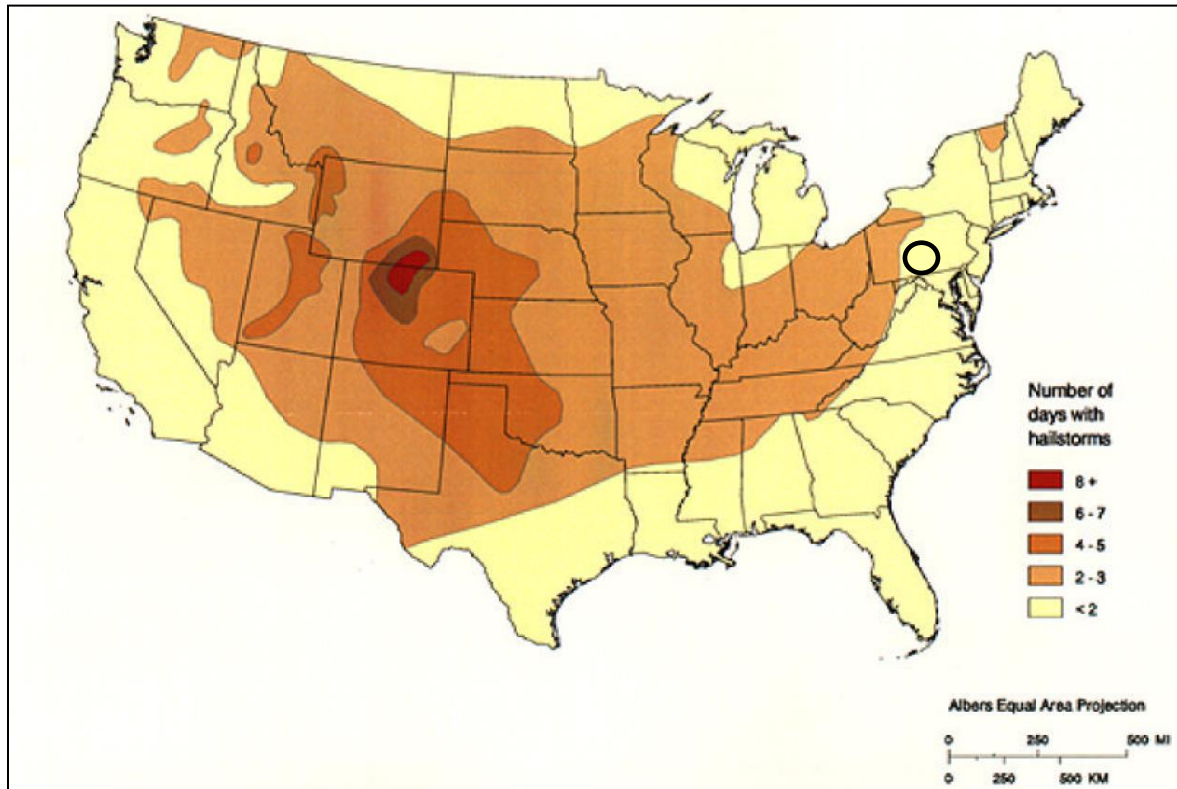
Source: National Oceanic and Atmospheric Administration (NOAA) 2012
°F degrees Fahrenheit

4.3.5.1 Location and Extent

Hail causes nearly \$2 billion in crop and property damages, on average, each year in the United States. Hail occurs most frequently in states within the southern and central plains; however, hail damage is possible throughout the entire United States because hail may accompany a thunderstorm (Federal Alliance for Safe Homes 2013). As indicated on Figure 4.3.6-2, Fulton County undergoes fewer than two hailstorms per year, on average.



Figure 4.3.6-2. Annual Frequency of Hailstorms in the U.S.



Source: Federal Emergency Management Agency (FEMA) 1997

Note: The black oval indicates the approximate location of Fulton County.

Hailstorms may be a part of a severe thunderstorm or other severe weather patterns. The National Oceanic and Atmospheric Administration’s (NOAA) National Severe Storms Laboratory (NSSL) started a project to estimate the likelihood of severe weather hazards in the United States. “Severe thunderstorms” were defined as having one or more of the following characteristics: associated tornados, gusts at least 58 miles per hour (mph), or hail at least 0.75 inches in diameter.

4.3.5.2 Range of Magnitude

Hail can vary in size from less than 1 inch to several inches in diameter and can cause significant damage to crops and property. Damage depends on the size, duration, and intensity of hail precipitation. Individuals who do not seek shelter could face serious injury. Automobiles and aircraft are particularly susceptible to damage. Effects of other hazards associated with thunderstorms (strong winds, intense precipitation, and lightning) often occur concurrently because hail precipitation usually occurs during thunderstorms.

Fulton County has experienced hail ranging in size from 0.75 to 2.75 inches in diameter. No deaths or injuries due to hail have been recorded in the County. The largest recorded hail in Fulton County occurred on May 26, 2002, when thunderstorms produced baseball-sized hail near Buck Valley. The most damaging hailstorm in Fulton County occurred on May 26, 2011. Hail fell across the county, causing over \$100,000 in damage.

Based on reports from the National Centers for Environmental Information (NCEI) and Fulton County residents, the worst-case scenario for a hailstorm would be a storm that dropped baseball-sized hail (the largest observed in the County) throughout the County. This hail would cause widespread damage to property and crops.



Hail can be produced during many different types of storms. Typically, hail occurs with thunderstorms. The size of hail is estimated by comparing it with a known object. During most hailstorms, hail is produced in a variety of sizes, and only the very largest hailstones pose serious risk to people who are exposed. Table 4.3.6-1 shows the various sizes of hail as compared to real-world objects.

Table 4.3.6-1. Hail Size

Size	Inches in Diameter	Updraft Speed (MPH)
BB	<0.25	< 24
Pea	0.25	24
Marble	0.50	35
Dime	0.70	38
Penny	0.75	40
Nickel	0.88	46
Quarter	1.0	49
Half-dollar	1.25	54
Walnut	1.5	60
Golf Ball	1.75	64
Hen Egg	2.0	69
Tennis Ball	2.5	77
Baseball	2.75	81
Tea Cup	3.0	84
Grapefruit	4.0	98
Softball	4.5	103

Source: NWS n.d.

4.3.5.3 Past Occurrence

Hailstorms occur as a routine part of severe weather in Fulton County. The potential for hailstorms exists throughout the County, with a few minor incidents occurring each year. While the future occurrence of hailstorms in the County can be considered likely, Fulton County has a low potential for significant hail events based on previous records.

The Commonwealth of Pennsylvania 2018 All-Hazard Mitigation Plan (PA HMP) states that approximately 96 percent of hailstorm events throughout the Commonwealth have occurred during the months of April, May, June, July, August, and September. Moreover, approximately 87 percent of historical hailstorm events have occurred during the afternoon (noon to 5:00 p.m.) or evening (5:00 p.m. to 9:00 p.m.) hours. Both of these two preceding statements are consistent with historical hailstorm reports from Fulton County.

According to the U.S. Department of Agriculture (USDA) Risk Management Agency, hailstorm events within Fulton County between 1948 and 2017 have resulted in \$56,541.90 in crop insurance claims. Over 90% of the amount of crop loss dollars are due to hail events from only three years: 2008, 2011, and 2013. In 2013, the County experienced \$43,399 in loss claims; in 2008, the County claimed \$6,456; in 2011, the County claimed \$5,351 in losses (USDA 2019).

The NOAA-NCEI (formerly NCDC) Storm Events database includes hail reported during storm incidents in Fulton County from 1950 to March 31, 2019, as shown in Table 4.3.6-2. The database indicates that 14 separate reports were issued throughout the County from 1950 to 2017. Some reports specified different times of day or different localities regarding the same storm. According to these reports, Fulton County has undergone hail ranging in size from 0.75 inches to 2.75 inches in diameter, with no reported deaths or injuries and only one event contributing to property damages. This information differs from USDA records, as shown below.



Table 4.3.6-2. History of Hailstorms in Fulton County, 1988 to 2019

Date	Location	Diameter (in)	Deaths	Injuries	Property Damage (\$)	Crop Damage (\$)
5/16/1988	Fulton County	1	0	0	0	0
7/10/1995	Town Hill	1	0	0	0	0
6/4/1996	Big Cove Tannery	0.75	0	0	0	0
7/30/1996	Gracey	1.75	0	0	0	0
7/14/2000	Big Cove Tannery	1.75	0	0	2,000	0
5/26/2002	Buck Vly	2.75	0	0	0	0
5/26/2002	Needmore	1.5	0	0	0	0
6/13/2007	Akersville	0.75	0	0	0	0
5/26/2011	Dickeys Mtn	2	0	0	0	0
6/29/2012	Sideling Hill	1.75	0	0	0	0
6/29/2012	Sideling Hill	1	0	0	0	0
6/24/2013	Cito	1.75	0	0	0	0
6/24/2013	Webster Mill	1.75	0	0	0	0
8/7/2013	Burnt Cabins Strip	1	0	0	0	0

Source: NCEI 2019

Notes:

Events occurring on the same date in the same municipality were recorded as separate events based on hail diameter.

Personal narratives from County residents and local officials report that the worst-case scenario in the County occurred on May 26, 2011. While this event is noted in the NCEI database, the database does not list some of the property damage reported by residents; this damage led to a minimum of \$100,000 worth of repairs. Thompson Township, in particular, was severely impacted. County residents stated that they had never witnessed anything like this before and reported hailstones as large as softballs. The images below demonstrate the size of the hailstones and the severe impact of the storm on residents.



Source: Fulton County 2011

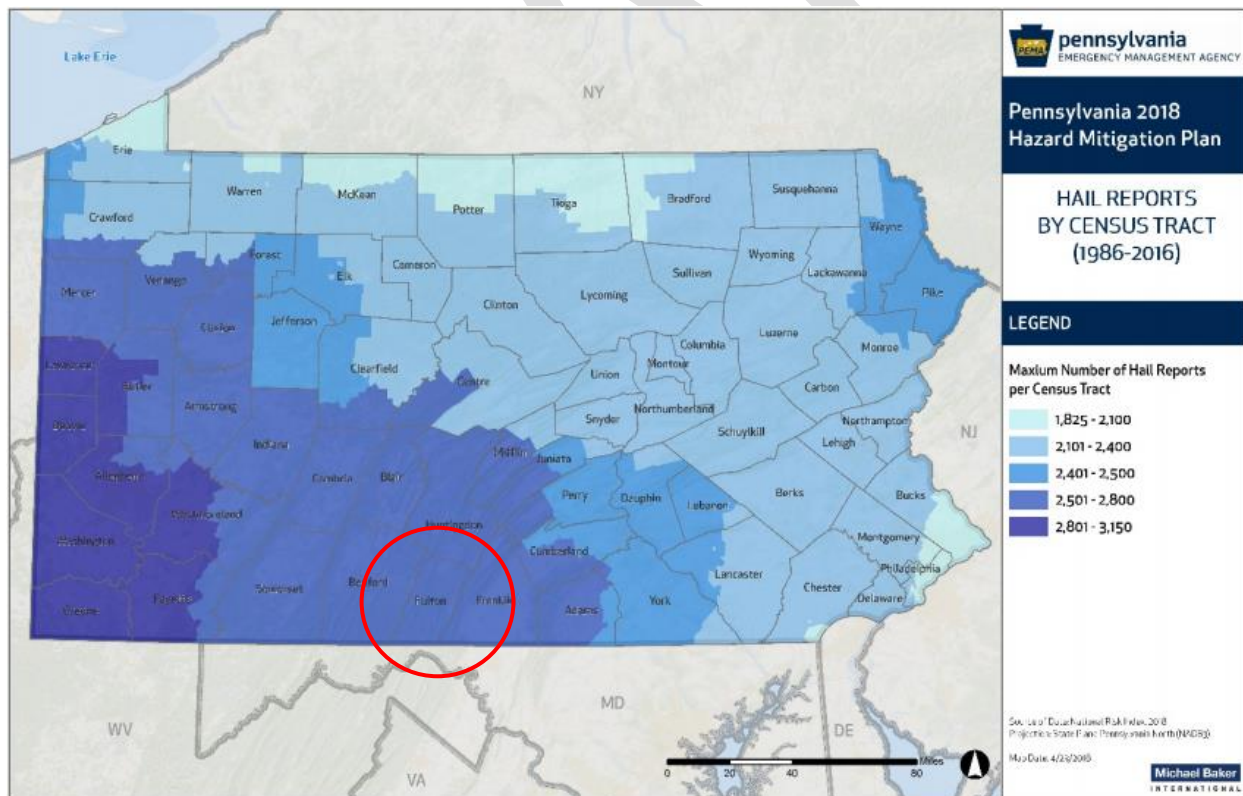


Source: Fulton County, 2011

4.3.5.4 Future Occurrence

It is not possible to predict the formation of a hailstorm with more than a few days' lead time. The past occurrences described above, however, indicate that hailstorm events in Fulton County probably will occur every year throughout the months of May through September. Encompassing events between 1986 and 2016, Figure 4.3.6-3 below shows the maximum number of hail reports per Census Tract across Pennsylvania.

Figure 4.3.6-3. Hail Reports by Census Tract in Pennsylvania



Source: PEMA 2018

Note: The red oval indicates the location of Fulton County.



Future occurrences of hailstorms can be considered *likely* as defined by the Risk Factor Methodology probability criteria (further discussed in Section 4.4).

4.3.5.5 Vulnerability Assessment

To understand risk, a community must evaluate the assets that are exposed or vulnerable within the identified hazard area. Regarding hail events, the entire County has been identified as the hazard area. Therefore, all assets in Fulton County (population, structures, critical facilities, and lifelines), as described in the County Profile (Section 2), are vulnerable. This section evaluates and estimates the potential impact of hailstorm events on the County in the following sections:

- Impacts on: (1) life, health, and safety of residents; (2) general building stock; (3) critical facilities; (4) economy; and (5) future growth and development
- Effect of climate change on vulnerability
- Collection of further data that will assist in understanding this hazard

The entire County, including all critical infrastructure, is vulnerable to the effects of hail, as the storm cells that produce this hazard can develop over any part of the region. The area of damage caused by these storms is relatively small because a single storm does not cause widespread devastation but may cause damage within a focused area.

Hail can cause serious damage to automobiles, aircraft, skylights, livestock, and crops. Areas of the County with large amounts of farmland and high agricultural yields are more likely to be affected by hailstorm hazards.

Impact on Life, Health, and Safety

The entire population of the County is considered exposed to the hail hazard. People outdoors (for example, pursuing recreational activities and farming) are considered most vulnerable to the hazard because they ordinarily would receive little to no warning, and shelter may not be available to them. Moving to a lower-risk location decreases a person's vulnerability.

Impact on General Building Stock, Critical Facilities, and the Economy

Hailstorms primarily affect agricultural products. The facilities most vulnerable to hailstorm threats are food- and agriculture-related producers and manufacturers. These facilities are present within both urban and rural areas and would be directly or indirectly affected by a hailstorm event.

As discussed earlier in the Past Occurrence subsection, Fulton County has experienced some historical hailstorm property damage and significant crop damage (\$2,000 in property damage claims from only one event [per NCEI records] and \$56,541.90 in USDA crop damage claims [per USDA records, which differ from the NCEI records]). However, given the unpredictability of hailstorms, significant property and crop damage is possible during any hailstorm event. Jurisdictional loss estimation is based on lost agricultural revenues throughout the County. The USDA Census of Agriculture enumerates farmland acreage by county as well as the annual market value of all agricultural products sold by county, from the year 2017. If a hailstorm would eliminate the entire agricultural yield in Fulton County, total losses on the County's 100,465 acres of farmland could reach nearly \$76 million.

Future Growth and Development

Areas targeted for potential future growth and development within the next 5 to 10 years have been identified across Fulton County and are further discussed in Section 2.4 of this HMP. New developments and new residents are expected to be exposed to the hailstorm hazard in the future.



Effect of Climate Change on Vulnerability

The definition of “climate” is not restricted to average temperature and precipitation, but also includes type, frequency, and intensity of weather events. On both global and local scales, climate change could alter the prevalence and severity of extremes such as hailstorms. While predicting changes of storm events under a changing climate is difficult, understanding vulnerabilities to potential changes is a critical part of estimating effects of future climate change on human health, society, and the environment (U.S. Environmental Protection Agency [EPA] 2006).

As directed by the Climate Change Act (Act 70 of 2008), Pennsylvania’s Department of Environmental Protection (PA DEP) initiated a study of potential impacts of global climate change on the Commonwealth. The June 2009 Pennsylvania Climate Impact Assessment’s main findings indicate the likelihood that Pennsylvania will undergo increased temperatures in the 21st century. An increase in variability of temperature and precipitation may well lead to increased frequency and severity of hailstorm events. Future improvements in modeling smaller-scale climatic processes such as thunderstorms and associated hailstorms can be expected and will lead to improved understanding of the ways in which the changing climate will alter storms, such as hailstorm events, in Pennsylvania (Shortle et al. 2009).

Additional Data and Next Steps

The assessment above identifies vulnerable populations and potential structural and economic losses associated with this hazard of concern. Collection of additional information and actual loss data specific to the plan participants will further enhance Fulton County’s vulnerability assessment.