NATURAL DISASTER SURVEY REPORT
TO THE ADMINISTRATOR
OF THE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

THE OHIO-PENNSYLVANIA TORNADOES
OF MAY 31, 1985

OCTOBER 1985
SILVER SPRING, MARYLAND

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Members of the team visited Ohio and Pennsylvania between June 3 and June 10, 1985. The field portion of the survey included trips into and over the damage area. The team interviewed state, county, and local officials, media representatives, disaster service personnel, NOAA employees, and victims of the disaster. Communities such as Newton Falls, Niles, Youngstown, and Cleveland in Ohio, and Atlantic, Wheatland, Sharon, Hermitage, Albion, Jamestown, Beaver Falls, Erie, and Pittsburgh in Pennsylvania were visited.

The survey team wishes to thank the numerous individuals who cooperated in giving their time and assistance. These included personnel of NOAA, state officials, city and county officials, members of the news media and disaster service personnel. Their help made this report possible and will contribute to improvement in the warning system.

The team also wishes to express its appreciation to Ms. Linda Kremkau, Program Support Assistant, who was an integral part of the team and spent many hours compiling, typing, and editing this report.

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EXECUTIVE SUMMARY

Forty-one tornadoes and numerous damaging thunderstorms ravaged Ohio, Pennsylvania, New York, and Canada during the late afternoon and evening of May 31, 1985. Eighty-eight people perished -- seventy-six of them in the United States -- and over 1,000 were injured. Property damage totaled $450 million for the U.S. The outbreak was the worst since April 3-4, 1974, and surpassed the March 28, 1984, outbreak in the Carolinas which claimed 59 lives.

Historically, the outbreak was unprecedented in the affected area. Pennsylvania experienced the most tornadoes ever in one day and the 65 fatalities nearly equalled the total number of deaths (69) recorded since 1916. Perhaps the lesson to be learned from the 1985 outbreak is that under the proper atmospheric conditions, major tornadoes can occur irrespective of the location or terrain.

The National Weather Service's National Severe Storms Forecast Center at Kansas City, Missouri, has national responsibility for issuing tornado and severe thunderstorm watches and severe weather outlooks. The severe weather watches and outlooks on May 31 were accurate and timely and enabled the National Weather Service to alert the populace to the threat of severe weather. The survey team was, in general, impressed with the professionalism, dedication and motivation of staffs at Kansas City and the numerous Weather Service Offices and Weather Service Forecast Offices involved in the outbreak.

The use of trained amateur radio storm spotters has once again proven to be a valuable resource to the National Weather Service. In offices where a strong spotter program exists, timely and accurate warnings are commonplace. The National Weather Service must continue to recruit, train, and maintain these networks and, when practical, provide office space for spotters to ensure their participation during weather emergencies.

The dissemination of warnings is another key factor in the warning system. Warnings must be distributed by multiple communication systems to ensure the public receives this life-saving information. The National Oceanic and Atmospheric Administration (NOAA) Weather Radio was a vital means of communications because of reliance by the broadcasters to tape and replay the warnings. The increased cost of the NOAA Weather Weather Wire teletypewriter circuit has pushed broadcasters to the weather radio system. In addition, the Emergency Broadcast System, state law enforcement communication systems, and state emergency management agency communication systems all play important roles in the distribution of weather information. The Weather Service should continually explore ways to quickly and efficiently provide warning information to these types of systems.

The final step in the warning process is community awareness. The survey team found the excellent awareness program in Ohio contributed to saving many lives. An extremely violent tornado, powerful enough to move empty 75,000 pound oil tanks in Niles, Ohio, moved across Trumbull County, Ohio. Tragically, nine people died in Trumbull County, but the death toll could have been much higher had it not been for the local warning system in Newton Falls and that many people along the tornado track knew how to protect themselves.

All times in this report are Eastern Daylight Times.

The following are specific findings and recommendations.

FINDINGS AND RECOMMENDATIONS

Finding 1:

The NWS overall response to the May 31, 1985, tornado outbreak was determined to be very good. If the rarity of such a broadscale outbreak is factored into the evaluation, the response of the agency could be rated as excellent. National Center and WSFO issuances set the stage for an expected severe weather event many hours preceding the outbreak. A very accurate tornado watch bracketed the area affected by the 28 tornadoes and was issued prior to the occurrence of the first tornado report in the 4-hour outbreak. Field offices responsible for local warnings had severe thunderstorm warnings in effect prior to tornado activity in almost all cases and tornado warnings in effect as soon as evidence of formation was available.

Finding 2:

Community awareness varied across the three-state area affected by the tornado outbreak. The team observed a generally high level of awareness in the state of Ohio, apparently related to the intensive outreach program directed by the Area Manager at WSFO Cleveland. There was also evidence that awareness programs conducted in schools contributed to correct actions taken by many individuals affected by the tornadoes. After analyzing the spectrum of awareness activities across the affected area, the survey team determined that the following factors were key in explaining differences noted:

a. Resources available to respective offices.

b. Aggressiveness of Area Manager and priority set for program.

c. Climatological frequency of event.

Recommendation:

The awareness activities and general preparedness of Newton Falls, Ohio, and Mahoning County, Ohio, were notable and should be considered models for the Nation.

Finding 3:

A devastating tornado moved through Trumbull County between 6:40 p.m. and 7:05 p.m. A tornado watch was in effect and a timely severe thunderstorm warning based on radar was issued for Trumbull County at 6:30 p.m. At 6:40 p.m., a verbal tornado warning was placed over the Emergency Broadcast System (EBS) by Youngstown. It warned of a possible tornado approaching the Niles-Warren area. However, with the exception of the verbal warning, the severe thunderstorm warning was never upgraded to a written tornado warning and transmitted on the NOAA Weather Wire or NOAA Weather Radio. Two factors contributed to this. First, Youngstown failed to notify Cleveland of the verbal tornado warning. Cleveland would have likely upgraded the severe thunderstorm warning to a tornado warning since they had taken over responsibility for Youngstown's warning area at 5:40 p.m. because of an AFOS communications line failure. Second, the decision not to activate the spotter network at Youngstown deprived the staff of critical spotter reports indicating a tornado had occurred in Newton Falls. That knowledge may have prompted the Youngstown office to urge Cleveland into upgrading the Severe Thunderstorm Warning to a Tornado Warning.

Recommendation:

NWS must ensure that any verbal warnings be followed up by written warnings. If the primary office is unable to issue a warning, they must make every effort to contact their backup office if they have received critical severe weather information that impacts either issuing a warning or upgrading or cancelling a warning. The National Weather Service should investigate the feasibility of placing instructions in its Weather Service Operations Manual to make it mandatory for offices to activate their SKYWARN network (providing a network is in place) when a tornado watch is put in effect and it appears warnings will be necessary.

Finding 4:

The survey team was very impressed with the potential of utilizing amateur radio volunteers to augment the communications support during an outbreak like the one that occurred on May 31, 1985. It was also noted that not all opportunities for utilizing this resource were exploited in areas where the additional information could have made a difference in terms of timeliness and accessibility after other system failures had occurred.

Recommendation:

National Weather Service offices should continue to recruit and train spotters not only for tornadoes and severe thunderstorms, but for floods, flash flood, winter storms, etc. The team also recommends WSFO Pittsburgh consider providing space in the office to bring in a SKYWARN coordinator during severe weather events.

Finding 5:

Although the Automation of Field Operations and Services (AFOS) system performed well on a national and regional level, there were two separate findings primarily at the local level that the survey team felt warranted further investigation.

a. WSFO Cleveland was operating AFOS in degraded mode (partial system failure) because of failures within the hardware or software systems. This degraded status had existed for days prior to the event. Resources had been devoted to the problem locally without success. The survey team felt that the emergency response procedures to address such a chronic problem should have been initiated in accordance with instructions in the Weather Service Operations Manual (WSOM) Chapter H-50 after a reasonable period of time.

b. WSO Youngstown experienced progressively worse problems with the integrity of the AFOS communications line between Youngstown and Cleveland on the evening of the severe weather event. On close examination, the problem appeared to be more related to very high noise levels on the telephone line than power fluctuations. This determination was made based on review of the system log (Cleveland and Youngstown), interviews with staff, and other similar reports from other agencies in the area. This problem eventually became so severe that the AFOS synchronous communications system was non-functional.

Recommendation:

a. All Regional Headquarters should review their policy in initiating emergency procedures in accordance with WSOM Chapter H-50.

b. NWS should review nature of communications failure at Youngstown to determine both areal extent, relationship to severe weather, and procedures for real-time correction.

Finding 6:

NOAA Weather Radio played a major role in relaying warning information either directly to the public or indirectly via media facilities. A significant number of radio and television stations, both in Ohio and Pennsylvania, used weather radio as their prime link to the NWS for receipt of warning information. Many individuals reported receiving timely warnings directly from the weather radio. No failures of NWR in any of the three affected states were reported.

Recommendation:

All levels of the NWS structure continue to emphasize the importance of NOAA Weather Radio and strive to maintain a high quality system. In addition, the Weather Service should make every effort to make the public and media aware of this lifesaving system.

Finding 7:

The NOAA Weather Wire Service worked well in Pennsylvania and Ohio, but a significant communication failure of this system occurred in New York apparently along one of the major trunk lines linking offices in the state. Even though the system worked well in Pennsylvania, the survey team noted that there were very few NWWS customers in Pennsylvania. The main reason given was cost of the service.

Recommendation:

NWS management should review the vulnerability of the weather wire in light of increasing costs to the user and explore ways of economically providing this information.

Finding 8:

The Emergency Broadcast System was deemed a potentially powerful tool for dissemination of critical warnings in the affected area. However, the team noted two critical deficiencies.

a Time required to manually relay critical warnings from the Pittsburgh Weather Service Forecast Office to EBS when many warnings were being issued within a short period of time.

b. Many of the EBS stations beyond the primary station did not participate indicating a need for stronger coordination of stations and the NWS in the area affected.

Recommendation:

Weather Service management explore ways to automate or speed up the delivery of warnings to primary EBS stations. Second, all NWS offices should contact their primary Emergency Broadcast System stations at least once a year and try to establish a yearly drill to test the EBS.

Finding 9:

The potential for utilizing state and wire service distribution circuits for relay of critical warnings was very evident. The LEADS state network in Ohio was invaluable for relay of information to emergency management personnel. The same was true for the CLEAN and PEMA circuits in Pennsylvania and the UPI/AP wire services, however, automatic relay from the NWS to these systems and the ability to automatically flag critical data at the user end are essential for timely issuances.

Recommendation:

National Weather Service management should investigate automating procedures for relay of critical weather information. Using the LEADS system in Ohio as an excellent model for the rapid movement of Weather Service watches and warnings, Weather Service management should investigate and work toward automating procedures for relay of critical weather information on a nationwide basis.

Finding 10:

The concept of multiple dissemination of critical warnings played a major role in getting information to the public. The survey team reaffirmed the fact that no single communication system was effective or readily available because of the varied activities individuals might be involved in at the time of emergency. Warning delivery by a multitude of means increased effectiveness of the overall warning system.

Recommendation:

NWS continue to stress the importance of multiple dissemination of warnings to state and local officials and the broadcast media.

Finding 11:

Relations between the NWS and the media in general were observed to be excellent. This was particularly true in Ohio overall and in the counties served by WSO Erie. The survey team felt that this positive relationship played a key role in the way the warning system worked during the tornado outbreak.

Recommendation:

The NWS should continue its efforts to foster solid media relationships. A series of workshops should be conducted by NOAA Office of Public Affairs for the benefit of National Weather Service meteorologists in charge and officials in charge.

CHAPTER 1

THE OHIO-PENNSYLVANIA TORNADOES OF MAY 31, 1985

1. INTRODUCTION

At 5:05 p.m., a state policeman at Pennside in Erie County, Pennsylvania, at the Ohio border, spotted a funnel cloud heading for Albion. Moments later an Albion fire department volunteer saw the tornado coming into Albion and raced to the radio room to broadcast a message of impending destruction. Scores of residents heard the message and credited the broadcast with saving their lives. The volunteer's home was destroyed.

A dedicated Weather Service employee at Erie remained on duty even though he knew the Albion tornado passed close to his home. He found out later his home and family were fine.

So began the onslaught of killer tornadoes that in just 4 hours and 20 minutes in Ohio, Pennsylvania, and New York would instantly kill or fatally injure 75 persons, injure at least 1,023 more, destroy about 1,350 homes, and leave at least 500 more homes heavily damaged. An additional 12 people were killed in Canada, and one woman was killed in Wisconsin earlier in the day by the same storm system, bringing the total death toll to 88. Damage in the U.S. was estimated to be approximately $450 million. Further statistics of the outbreak's toll are given in table 1. The outbreak ranks as one of the worst in United States history and the deadliest since the April 3, 1974, "super outbreak," which affected an area from the Mississippi River to the Appalachian Mountains.

Never before had a tornado outbreak of this magnitude struck this particular region. Twenty-eight tornadoes developed in the United States -- 17 in Pennsylvania, 10 in eastern Ohio, and 1 in southwestern New York (3 tornadoes crossed from Ohio to Pennsylvania and one crossed from Pennsylvania to New York). Thirteen more tornadoes were reported in Canada.

Seven of the U.S. tornadoes were classified as violent, capable of completely leveling homes, with wind speeds estimated in excess of 207 mph. Tracks of the tornadoes are shown on figure 1, and a list of tornado characteristics is given in table 2.

Tornadoes are classified as weak, strong, or violent and are related to a scale from F0 to F5 developed by Dr. Theodore Fujita[1] and Mr. Allen Pearson. F0 and F1 tornadoes are classified as weak with wind speeds ranging from 40 to 112 mph. F2 and F3 tornadoes are categorized as strong tornadoes with wind speeds of 113-206 mph. F4 and F5 tornadoes are classified as violent and contain wind speeds from 207 to 318 mph.

In actuality, but certainly unknown to virtually everyone in the United States at the time, the tornado outbreak had begun 2 hours earlier about 200 miles to the north in Ontario, Canada. Eight tornadoes had already occurred there -- two were dead in Grand Valley, and the community of Barrie was about to be hit where eight more would die.

Prior to 3:30 p.m., EDT, in the Great Lakes region of the United States, there was, however, no imminent cause for alarm as skies were free of thunderstorms, and the most significant weather feature was a broad area of blowing dust generated by strong surface winds behind a cold front and driven by an unusually intense late spring low-pressure system centered over Lake Superior and moving eastward. The surface winds were being accentuated by persistently increasing wind speeds aloft, providing the energy for the occasional channeling of gusts to the surface. One such gust caused a covered walkway to collapse in Lansing, Michigan, killing a 77-year-old woman at about 11 a.m. Two men in Wisconsin were also injured when hit by a flying plank that wind had ripped from

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1. Fujita, T. T., 1981: Tornadoes and downbursts in the context of generalized planetary scales. Journal of Atmospheric Science, Vol. 38, pp. 1511-1534.

TABLE 2

LIST OF TORNADOES -- MAY 31, 1985 OUTBREAK

Number	Tornado Name	F-Scale	Length km	Width km	Times EDT	Deaths
1	Rush Cove	2	4	30	3:00-	0
	BARRIE FAMILY					
2	Hopeville	3	17	200	4:10-	0
3	Corbetton	3	25(35)	200	4:17-	0
4	Borden	2	9(18)	150	4:50-	0
5	Essa	1	1	75	4:57-	0
6	Barrie	4	9	250	5:00-	8
	GRAND VALLEY FAMILY					
7	Grand Valley	4	86(102)	300	4:15-	4
8	Wagner Lake	1	5	100	5:40-	0
9	Reaboro	1	9	100	6:05-	0
	ALMA FAMILY					
10	Alma	3	17(33)	150	4:15-	0
11	Ida	2	9	200	6:15-	0
12	Rice Lake	3	7(14)	200	6:20-	0
13	Minto	1	1	13	6:35-	0
	ALBION FAMILY					
14	Albion PA-OH	4	23	400	4:59-	12
15	Corry PA-NY	4	45	600	5:25-	0
16	Busti NY	3	21	500	6:25-	0
17	Dorset OH-PA	2	16	150	5:28-	0
	SAEGERTOWN FAMILY					
18	Linesville PA	2	6	200	5:10-	1
19	Saegertown PA	3	29(37)	600	5:25-	0
20	Centerville PA	3	17	800	6:12-	2
21	Thompson Run PA	1	8	200	6:30-	0
	ATLANTIC FAMILY					
22	Mesopotamia OH	3	24	300	5:05-	0
23	Kinsman OH	2	5	150	5:20-	0
24	Atlantic PA	4	90	600	5:20-	16
25	Tionesta PA	4	48	850	6:35-	7
26	Lamont PA	2	33	400	6:50-	0
	KANE FAMILY					
27	Tidioute PA	3	21	800	7:25-	0
28	Kane PA	4	42	900	8:00-	4

TABLE 2 (Con't)

	MOSHANNON FAMILY					
29	Moshannon St. Frst.	4	105(115)	1000	7:35-	0
30	Watsontown PA	3	34	600	9:15-	6
31	Hollenback Twp. PA	1	16	400	10:45-	0
	WHEATLAND FAMILY					
32	Wheatland PA-OH	5	66	450	6:40-	17*
33	Big Bend PA	2	10	130	7:54-	0
34	Emlenton PA	0	8	30	7:56	0
	BEAVER FALLS FAMILY					
35	Middleton OH	2	24	40	7:35-	0
36	Beaver Falls PA	3	63	300	8:10-	9
37	Penn Run PA	0	10	25	9:53-	0
	UTICA FAMILY					
38	Utica OH	3	45	80	7:15-	1
39	Cooperdale OH	1	18	70	7:50-	0
40	London OH	1	1	40	7:06-	0
41	West Union OH	1	1	20	9:05-	0

NOTES: * indicates 9 in OH and 8 in PA. The convention 9(18) in the path length column indicates a track continuous for 9 km and partly aloft for 9 more, for a total path length of 18 km.

The tornado statistics were prepared by G. Forbes based upon aerial and ground surveys, interviews, and newspaper accounts, as part of his tasks for the National Weather Service Disaster Survey Team and the National Research Council Survey Team.

Aerial and ground surveys in the United States were performed by:

Dr. Greg Forbes, Associate Professor, Penn State Univ.
National Weather Service
Mr. Duane Stiegler, University of Chicago

Aerial and ground surveys in Ontario were performed by:

Ontario Weather Centre, Atmospheric Environment Service
Mr. Brian Smith, University of Chicago

the top of some bleachers at an athletic field. There were numerous reports of sporadic tree damage in southern Wisconsin, northern Illinois, northern Indiana, and southern Michigan.

1.1 A Historical Perspective

The tornado outbreak was unprecedented in the history of the regions affected. For example, the 65 fatalities in Pennsylvania nearly equalled the total number of fatalities statewide for the entire period from 1916-1984 (69 killed). Forty-five of those occurred on one day, June 23, 1944, when four long-track tornadoes moved southeastward across eastern Ohio, southwestern Pennsylvania, and West Virginia. Thus, May 31, 1985, was the deadliest tornado day in Pennsylvania history. Further, for Pennsylvania and Ohio combined, there had been only 16 tornado deaths (14 in Ohio) during the month of May in the period 1916-1984. During that 69-year period, Pennsylvania and Ohio averaged 0.6 and 1.5 tornadoes, respectively, for the entire month of May. Pennsylvania had never previously had a month with more than 10 tornadoes and never more than 5 in May.

In many respects, the tornadoes took optimum paths, avoiding most but not all of the population centers of the region. Figure 1 shows the locations of the fatalities along the tornado paths. No community suffered more than 10 fatalities (Albion); fatal injuries occurred in 29 locations (separated by at least 1 mile).

The tornadoes were generally quite visible, and photographs of at least 10 of the 28 United States tornadoes have appeared in newspapers. Only 4 of the 41 touchdowns occurred after dark although several others took place during twilight hours. The distribution of locations of fatal injuries, given in table 3 does not appear to be especially anomalous. Likewise, the age distribution of the fatalities, table 4, does not appear to be unusual.

TABLE 3

LOCATIONS OF FATAL INJURIES*

House	39
Modular home	2
Mobile home	23
Farm building	1
Business establishment	7
Industrial building	1
Camper trailer	2
Automobile	6
Outdoors	7
TOTAL	88

* Includes deaths in Canada.

TABLE 4

AGES OF PERSONS FATALLY INJURED*

Less than 6	4
6 - 10	4
11 - 15	4
16 - 20	3
21 - 25	5
26 - 30	6
31 - 35	2
36 - 40	6
41 - 45	4
46 - 50	4
51 - 55	1
56 - 60	2
61 - 65	5
66 - 70	15
71 - 75	6
76 - 80	8
81 - 85	5
Over 85	2
Unknown age	2
TOTAL	88

* Includes deaths in Canada.

Interviews and newspaper accounts did not reveal any glaring lack of individual safety awareness (although in some instances, community preparedness could have been improved). As is usually the case, it is difficult to determine what precautions were taken by those killed. Of the 15 instances where such information was available, 9 appeared to have taken (or had been in the process of taking) proper shelter. In six instances, ill-advised actions in the face of a known hazard may have contributed to the loss of life.

A companion study of the actions taken by survivors of the tornadoes has not been completed, but there were a great many reports of proper actions taken. There were also a few instances where it was evident that following the recommended action of taking shelter in the basement could have proved fatal. On the other hand, there is considerable evidence that inadequate anchoring of houses to foundations contributed to the problem. Many houses were moved off their foundations while largely intact, and there were many cases of persons being blown away with their home.

The main factor associated with the unprecendented number of fatalities appears to be related to the unusually high number of intense tornadoes. Since 1940, the affected region had only experienced 12 violent tornadoes, all of which were apparently F4. Thus, the Wheatland tornado, which was rated F5 in the Niles-Wheatland portion, appears to be the strongest tornado ever to occur in the region. There were 7 violent tornadoes in the Pennsylvania-Ohio-New York region, more than on any other occasion (depending on how the region is selected, there were 3-5 violent tornadoes on June 23, 1944). What is especially unusual is that four of the violent tornadoes occurred not in Pennsylvania's "tornado alleys" -- along Lake Erie and in the southwestern and southeastern corners of the Commonwealth -- but in the hilly or mountainous regions not generally associated with tornado activity: the Corry, Tionesta, Kane, and Moshannon tornadoes. The tornado frequency in these areas is only 10-20 percent of that in the "alleys."

In his well known compilation Tornadoes of the United States, Snowden D. Flora stated that the 1944 outbreak had "effectively exploded the theory that such storms do not cause damage in a mountainous country." Perhaps the lesson to be learned from the 1985 outbreak is that under the proper atmospheric conditions, a major tornado outbreak can occur irrespective of the location or terrain. In conclusion, given the rarity of the event on a national basis and even more so on a regional basis, it is impressive that the death toll wasn't worse.

1.2 Tornadoes and Damage

Figure 8 illustrates the many forms taken by the various tornadoes in this outbreak. By comparing the tornado appearances to the widths listed in table 2, a correlation between width of damage and width of funnel is readily discerned. Table 5 lists some interesting aspects of the tornadoes and their paths.

Figure 9 illustrates some of the damage produced by the tornadoes. A comprehensive account of the damage is not practical in this report, but photos accompanying this report document the major destruction and character of the damage.

Perhaps the long term impact of the tornadoes can be appreciated when put in a broader context. For Albion, the tornado meant another hurdle for the survival of the small community. Its major employer had moved out 2 years earlier, and officials estimated that only half of the high school graduates remain in Albion. Given an aging community and a tornadic stimulus for many of

TABLE 5

MISCELLANEOUS STATISTICS

First tornado touchdown: Rush Cove, Ontario, 3 PM
Last tornado liftoff: Hollenback Township PA, 11 PM
Duration of outbreak: 8 hours
Total path length of 41 tornadoes: 1124 km

Number of violent tornadoes (F4, F5): 9
Number of strong tornadoes (F2, F3): 21
Number of weak tornadoes (F0, F1): 11

Strongest tornado: Wheatland OH-PA, F5
Longest tornado: Moshannon State Forest, 105 km
Widest tornado: Moshannon State Forest, up to 3.5 km

Number of tornadic thunderstorms: 15
Number of tornado families: 11
Longest tornado family: Moshannon Family, 231 km
(155 on ground)

Number of killer thunderstorms: 10
Number of killer tornadoes: 12
Deadliest tornado: Wheatland PA-OH, 17; hit Newton Falls, OH
Niles, OH, Farrell-Sharon, PA, Wheatland, PA
small communities of Bailey's Corners, OH, and Greenfield, PA

those to move to warmer climates plus destruction which eliminated about one-third of the property tax base, the tornado may very well have precipitated for Albion a community disaster of long-term proportion.

Wheatland's situation was a little better although this community and others in the area had already been hard hit by the decline in the steel industry, and unemployment was running high; most people indicated they would rebuild. The mayor estimated that 95 percent of Wheatland's industry and businesses had been affected by the tornado and that 84 percent of the tax base had been potentially eliminated.

In Atlantic, the township secretary indicated that the township could not afford to give back rebates on already collected 1985 property taxes, even though many of the properties involved were now gone. The Amish people in the area, however, showed little inclination to leave their homey community and had much of it rebuilt on their own before Federal and state disaster assistance funds became available.

CHAPTER 2

METEOROLOGY

2. METEOROLOGICAL CONDITIONS

The large-scale meteorological setting early May 31, 1985, was characterized by an intense late spring storm system moving across the Great Lakes. At the surface (figure 2) a very intense cyclone over the northern Great Lakes was promoting a strong low-level southwesterly flow over Ohio, Pennsylvania, Michigan, New York, and Ontario. As a warm front swept northward, skies that had been cloudy and rainy over the central and northern portions of Pennsylvania began to clear. Temperatures and dew points began to rise as the warmer air mass moved in. Temperatures in the warm air mass reached about 27°C (80°F) and dew points ranged from about 19°C to 22°C (66-71°F), whereas the temperatures in the cloudy region to the east were about 22°C (70°F) and the dew points near 18°C (65°F). The tornadic thunderstorms formed in the warm, unstable air mass although several of them subsequently invaded the less thermodynamically-favorable regions to the east.

The strong cyclone also provided the large-scale counterclockwise circulation in which the embedded thunderstorms would form. Just as the skater spins faster when arms are drawn in, the air turning slowly about the large-scale cyclone is made to rotate faster as it is concentrated within the inflow to a thunderstorm. The first response is for the thunderstorm to begin to rotate and later for tornadoes to form. This entire process of interaction between meteorological phenomena of different scales is quite complicated, and research efforts are continuing to learn how tornadoes actually form.

Another favorable parameter for severe weather is a jet stream approaching the region (figure 3). The jet stream at 30,000 feet was strong for this time of year, having velocities of up to about 145 mph.

A third ingredient is the flow of warm and moist air into the region, coupled by heating by the sun. The transport of warmth and moisture from the south and southwest was being accomplished because of the intense large-scale cyclone. Sunshine was abundantly available over Ohio and southwestern Pennsylvania by mid afternoon, but the rest of the region had a cloudy, cool day with only a brief period of sun by late afternoon (see figure 4).

The atmosphere was already unstable (there were devastating hailstorms in southern Ontario on May 30 and flash flood-producing rains in West Virginia during the night of May 30-31) and became more unstable on May 31 through cooling aloft. Imagine a boiling pot of soup being heated from below in which "bubbles" can be seen rising to the top of the pot. Because the pot has been heated at the bottom and not at the top, the liquid at the bottom begins to rise in the form of bubbles or "thermals." The thunderstorm is in many ways the atmosphere's analogy of a bubbling pot of soup. In the same manner as the pot of soup, air warmed in contact with the ground develops lower density and rises because it has become less dense than the air above it. The usual way for the atmosphere to become warmed at low levels is by warm air being transported northward by low-level winds and through heating by the sun. While this kind of warming certainly did occur on May 31, the atmosphere was made more unstable because the air aloft was becoming cooler caused by a disturbance racing rapidly east-northeastward at a speed faster than that of the surface front (figure 5). During the period from about 3:30 to 4:30 p.m. when thunderstorms developed, (1) the lower atmosphere had been warmed by the sun, (2) this air was flowing northward toward areas where it was cooler aloft, and (3) the upper-air disturbance was making the air still more cooler aloft.

The nature of the destabilization can be seen from table 6. Between 8 a.m. and 8 p.m. on May 31, the temperatures at Pittsburgh increased by about 3°C (6°F) at 850 mb (about 5,000 feet) while the temperatures decreased by about 4°C (8°F) at 500 mb. However, this information was not available until approximately 4 hours after severe weather began to develop.

For tornadoes to occur, the air must somehow develop intense rotation. Besides the concentration of the large-scale circulation by thunderstorm inflow, another means for thunderstorms to develop the needed rotation is by taking advantage of the atmosphere's change of winds with height -- "vertical wind shear." As the jet stream approached, the winds near the 18,000 foot level increased in speed by about 45 mph. With weaker winds near the surface, the atmosphere had a tendency to roll over about a horizontal axis (like a person running on a log floating in a lake). As some of these "rolls" of air are drawn into the thunderstorm (figure 6), the portions entering the thunderstorm first are drawn upwards, tilting the roll. In this manner, some of the rolling motion is converted to a counterclockwise spin about a semi-vertical axis. Thus, the existence of large vertical wind shear in the lower portions of the atmosphere stimulates rotation in the thunderstorm which ultimately may lead to tornado formation.

Development of rotation was evidenced on May 31 by the appearance of many "hook echoes" precipitation patterns seen by radar that had a counter-clockwise spiral in a hook shape resulting from the development of the rotation in the thunderstorms. An example is shown in figure 7a. Depending upon the vigor and length of time of the thunderstorm rotation, the probability of the thunderstorm developing a tornado is 60-90 percent.

TABLE 6

EVOLUTION OF THE ATMOSPHERE AT PITTSBURGH ON MAY 31, 1985

PARAMETER	8 AM	8 PM
850 mb temperature	14 C	17 C
700 mb temperature	5 C	7 C
500 mb temperature	-9 C	-13 C

The appearance of hook echoes in a number of cases enabled NWS to issue tornado warnings before they had received reports of public sightings of funnel clouds. A hook echo is a comma-shaped appendage located at the rear quadrant of the radar echo and is an indication the thunderstorm may contain a tornado. However, the detection of bona fide hook echoes is highly dependent on optimum adjustment of the radar. The normal method of viewing the radar, as shown in figure 7b, is for the condensed moisture intensity to be made more visible through contouring of the echo. This is especially useful for location of regions of intense rain and possible large hail, but diffuses the appearance of the hook echo. The NWS is planning to deploy by the early 1990's a more sophisticated type of radar, Doppler radar, which can detect not just the shape of the precipitation pattern but also the velocity pattern in the thunderstorm. With this ability to more easily detect developing rotation, the capabilities for improved lead times on tornado warnings should improve.

The magnitude of the tornado outbreak was aggravated because three lines of tornadic thunderstorms formed, each oriented northeast-southwest, were 50 miles apart. The lines can be seen in figure 4c. The Kane, Wheatland, Beaver Falls, and Utica tornado families (table 2) and the Dorset, London, and West Union tornadoes formed on the second (western) line; the Canadian tornadoes formed on a third (more western but earlier) line; and the remainder formed from four tornadic thunderstorms on the eastern line (including the deadly Albion, Saegertown, Atlantic, and Moshannon tornado families). Thirteen tornadoes formed on the second line from seven tornadic thunderstorms. Thirteen tornadoes also formed on the westernmost Canadian line from four tornadic thunderstorms (including the deadly Barrie and Grand Valley families).

CHAPTER 3

NATIONAL WEATHER SERVICE OPERATIONS

3. OVERVIEW OF THE TORNADO AND SEVERE LOCAL STORMS WARNING PROGRAM

The basic forecast program begins at the National Meteorological Center (NMC) at Camp Springs, Maryland. NMC computer-processes meteorological observations and produces maps of observed and forecast weather systems. NMC also computes and transmits automated statistical thunderstorm and severe thunderstorm guidance forecasts, and several forecast and observed stability indices to the National Severe Storms Forecast Center (NSSFC) in Kansas City, Missouri, and to NWS field offices.

NSSFC is responsible for issuing severe weather outlooks and tornado and severe thunderstorm watches. A Satellite Field Service Station (SFSS) is a part of the Kansas City Center.

Meteorologists at NSSFC monitor potential severe weather conditions over the contiguous United States, using surface observations from hundreds of locations, radar information, satellite imagery, detailed meteorological upper air profiles and analyses, and special computer-derived fields (not only from NMC, but also locally developed and produced at NSSFC). A Centralized Storm Information System (CSIS) at Kansas City, an interactive computer system, allows forecasters to overlay various meteorological features and helps provide a three-dimensional look at the atmosphere. From this arsenal of weather information, the forecasters determine the area(s) in which severe local storms are most likely to occur.

NSSFC routinely issues severe weather outlooks at 4 a.m., 11 a.m., and 3:30 p.m. daily. These outlooks contain information about both severe and nonsevere thunderstorms for periods up to 27 hours in advance for all areas of the Nation and are distributed to all NWS offices, Federal Aviation Administration facilities, and the media. The outlooks are updated as necessary.

Tornado watches are messages from the Kansas City severe storm center alerting areas potentially threatened by tornadoes. They specify the area covered by the watch and establish a period of a few hours during which tornado probabilities are expected to be dangerously high. Watches are sent by Automation of Field Operations and Services (AFOS) to Weather Service offices where they are broadcast on NOAA Weather Radio (NWR) and by NOAA Weather Wire Service (NWWS) to commercial radio and television stations for dissemination to the general public in and near endangered areas. The watches also alert law enforcement and emergency service officials, volunteer storm spotters, and other cooperating personnel. Some of these people "fan out" the watch information to others.

Tornado watches are not tornado warnings. They tell people that tornadoes are possible in a specified area for a specified period of time. Until a tornado warning is issued, persons in watch areas are advised to watch for threatening weather and listen for later statements and possible warnings.

The 52 Weather Service Forecast Office's (WSFO) are the backbone of the field forecasting operation. These offices have forecast responsibility for states or large portions of states. WSFO's redefine the Kansas City's NSSFC watch areas usually into county and major metropolitan areas.

The 52 WSFO's and the more than 200 local Weather Service Office's (WSO) have important county warning responsibilities. In the contiguous United States, all counties are assigned to specific field offices for warning purposes. County warning areas are assigned on the basis of radar coverage, availability of methods for communicating with the public and public safety officials, station staffing, and other factors. In addition to issuing tornado and severe thunderstorm warnings, these offices issue weather statements to keep people in their areas informed, especially when severe weather is anticipated.

Tornado Warnings are issued when a tornado or funnel cloud has actually been sighted or radar indicates a tornado-bearing storm. In many cases, warnings are made possible through the cooperation of SKYWARN Volunteers (trained storm spotters) and other public-spirited persons who notify the nearest NWS office or community warning center when they see a tornado or funnel cloud or experience large hail or high winds. Warnings usually indicate the location of the tornado at the time of detection, the area through which it is expected to move, and the time (usually within an hour or less) when the tornado is expected to move through the area warned. When a tornado warning is issued, persons in the path of the storm should seek shelter immediately.

Severe Thunderstorm Warnings are issued when winds are reported or expected to be 58 mph or greater and/or hail is 3/4 inches or larger in diameter. These warnings normally describe the position of the storm and its projected path and are issued for one hour or less.

Volunteer Spotter Network (SKYWARN)

The Weather Service relies on 90,000 trained spotters around the Nation to provide visual sighting of severe weather and continuous suspicious radar echoes. These spotters (frequently referred to as SKYWARN) report tornadoes, hail, severe thunderstorms, flash floods, dust storms, and winter weather conditions to about 250 weather offices. One third of the spotters are Amateur Radio Operators (hams). Many NWS offices have facilities for hams to operate radio networks during severe weather episodes or when a watch is put into effect. Spotter information coupled with radar, satellite, and other observations has enabled the NWS to issue more timely and accurate warnings.

3.1 National Severe Storms Forecast Center

Forecasters at the Kansas City severe storms forecast center were concerned about a threat of severe thunderstorms from the Great Lakes and Upper Ohio Valley into New England early on May 31. A deep low pressure system moving across the upper Great Lakes was expected to draw moisture-laden air northward which would fuel development of intense thunderstorms later in the day. The 4 a.m. severe weather outlook called for a moderate risk of severe thunderstorms from the Great Lakes to New England and included Ohio, Pennsylvania, and New York. It mentioned a significant severe weather episode was expected.

During the morning, warm unstable air continued pushing into the Great Lakes region. The presence of a strong jet stream in the upper levels of the atmosphere would enhance the thunderstorms rapidly once they began. Once again at 11 a.m., an outlook was issued which continued a moderate risk of severe thunderstorms for Ohio, Pennsylvania, and western and central New York. This outlook significantly reduced the size of the moderate risk area and effectively delineated the actual outbreak area.

Around 2 p.m., thunderstorms began developing in Ontario, Canada, and the Kansas City forecasters were closely monitoring the thunderstorm activity for indication of the storm building southward toward the U.S. The WSFO's at Cleveland, Buffalo, Albany, Philadelphia, and Pittsburgh talked to the Kansas City forecasters throughout the afternoon concerning the possibility of severe weather for their areas. Forecasters at the National Center emphasized the most likely area for development was eastern Ohio, western Pennsylvania, and western New York.

Another severe weather outlook was due at 3:30 p.m. The meteorological parameters indicated the strongest thunderstorm activity would likely remain over Canada. Satellite pictures revealed practically clear skies over the upper Ohio Valley with thunderstorms continuing to intensify over Ontario.

The forecaster felt the potential for severe weather still existed, but because there had been no southward extension of the Canadian storms and an apparent lack of any thunderstorm activity as a cold front approached Ohio, the severe weather outlook for Ohio, Pennsylvania, and New York was downgraded at 3:30 p.m. to a slight risk.

At 3:50 p.m., however, thunderstorms began to develop near Cleveland. The Kansas City forecaster conferred with Buffalo and Cleveland to coordinate the issuance of a severe weather watch. The forecaster determined that the potential for very intense thunderstorms was high, and at 4:25 p.m., Kansas City issued Tornado Watch No. 212 to become effective at 5 p.m.

The watch bounded eastern Ohio, western Pennsylvania, western New York, and portions of the Great Lakes and West Virginia (figure ___) until 11 p.m. This watch included all of the major tornado activity that occurred later in northeast Ohio, western Pennsylvania, and southwest New York. As the system progressed eastward during the evening, Kansas City issued an additional tornado watch and two severe thunderstorm watches.

Summary

The overall performance of the National Severe Storms Forecast Center was excellent. The Kansas City center was well aware of the possibility of significant tornado activity as early as 4 a.m. on May 31.

Severe weather outlooks highlighted the threat of severe thunderstorms and tornadoes in Ohio, Pennsylvania, and New York for later in the day. At 4:25 p.m., a timely and accurate tornado watch was issued which eventually included almost all of the major tornadic activity in the outbreak. One more tornado watch and two severe thunderstorm watches were issued later in the evening which included portions of Ohio, Pennsylvania, New York, and Kentucky.

3.2 Satellite

A Satellite Field Service Station (SFSS) at the Kansas City center provides support to the forecasters. On May 31, the Rapid Interval Scan Operations (RISOP) was utilized. RISOP is designed to provide imagery from a NOAA Geostationary Satellite located 22,000 miles above the earth at a faster rate than normal. The RISOP schedule provides one image every fifteen minutes which is twice the frequency of the normal mode of operation. RISOP is used by the Center to closely monitor severe weather development and help forecasters decide where and when watches should be placed in effect.

The Rapid Scan data were only available at NSSFC during the outbreak. One of the major advantages of Rapid Scan is near real-time data compared to data which is almost 30 minutes old under normal circumstances. WSFO's at Cleveland and Pittsburgh received visual or infrared images every 30 minutes but did not have access to Rapid Scan data. The lack of Rapid Scan data at NWS field offices had no impact on the issuance of warnings since satellite data are not used to pinpoint severe weather warnings for individual counties.

3.3 Pennsylvania

3.3.1 Pre-event Actions by the Pittsburgh Weather Service Forecast Office.

Weather conditions prior to the May 31 outbreak of severe weather in western Pennsylvania were a harbinger of coming events. No doubt, the early morning weather that day itself served to heighten public awareness of a weather threat.

Actions by the Pittsburgh forecast office enhanced this awareness. As early as 1:55 a.m., Pittsburgh issued a severe thunderstorm warning for several counties in western Pennsylvania and wind damage did occur in the area warned. This warning was followed by the issuance of a flash flood watch for southwestern Pennsylvania at 2:30 a.m. The text of the watch mentioned "thunderstorms heavy at times." At 5:10 a.m. and at 7:45 a.m., flash flood statements, besides giving a picture of where heavy rain was occurring, called attention to "Severe thunderstorms with hail and damaging winds are expected later today in Pennsylvania."

The zone forecasts issued at 4 a.m. highlighted "thunderstorms redeveloping this afternoon" and "becoming severe tonight." The 11 a.m. update and the 3:30 p.m. zone forecast stated "thunderstorms...some may be severe."

The weather picture presented to the public was well defined before the severe weather outbreak began. However, by mid-afternoon no one, neither weather forecaster nor weather user, could have been totally prepared for the unprecedented event that was to follow.

At 5 p.m., the Pittsburgh forecaster updated the zone forecasts to include the tornado watch that had been issued by Kansas City for the northwest half of western Pennsylvania. By this time, the Pittsburgh staff knew severe weather was occurring near the Pennsylvania border in Ashtabula County, Ohio.

Before the Pittsburgh staff had issued their first severe weather warning that Friday evening, they were beginning to realize the magnitude of this severe weather outbreak. They had benefited from watching the Erie weather office issue more than a half dozen warnings between 4:30 and 6:30 p.m. And they realized the weather was edging southward toward their county warning area. Also at about 5:25 p.m., Pittsburgh received a call from the Youngstown weather office informing them of the tornado that had struck Albion around 5:13 p.m.

During this time, the staff was augmented. An extra forecaster was there to help issue and disseminate warnings, the NOAA Weather Radio staff person was there to handle all broadcasting, and an additional staff member was assigned to the radar (there were two radar operators on duty) to ensure constant surveillance. A SKYWARN coordinator at the office could have provided the staff with more timely reports and acted as a filter for incoming calls from hams.

Pittsburgh's Warning and Event Chronology

Pittsburgh issued their first warning that evening at 6:40 p.m. (most warnings noted in this report have valid times of 45-60 minutes) for Clarion County. Pittsburgh's radar indicated a severe thunderstorm in western Clarion County. Radar data and the survey team's tornado tracks suggest that Pittsburgh was seeing some echo debris associated with the tornado that was affecting Tionesta in Forest County (just north of Clarion County) at the time this warning was issued. Golf ball-size hail was reported in Clarion County around 7:15 p.m.

At around 6:45 p.m., the Youngstown office called WSFO Pittsburgh via the Federal Emergency Management Ageny's (FEMA) National Warning System (NAWAS) hot line and asked Pittsburgh to issue a warning for Mercer and Lawrence Counties in Pennsylvania. Youngstown's communications and dissemination systems had failed because of weather related power and telephcne outages. Pittsburgh issued a severe thunderstorm warning for Mercer and Lawrence Counties at 6:50 p.m. which included a statement that tornadoes were a possibility. Neither Youngstown nor Pittsburgh knew that at the time this severe thunderstorm warning was issued, a devastating tornado was approaching Niles, Ohio. Niles is located just 12 miles west of the Mercer County line.

At around 7:10 p.m., Pittsburgh received a telephone call from the Cleveland forecast office asking them to take over warning responsibility for Mercer and Lawrence Counties and notifying them of a possible tornado at Niles. Pittsburgh immediately issued a tornado warning at 7:15 p.m. for Mercer County. Investigations by the survey team suggest that the Sharon/Wheatland area of Mercer County was hit about 7:05 p.m. by the continuation of the Niles tornado. At 7:20 p.m., Youngstown phoned Pittsburgh and reported the Sharon Steel plant in Sharon, Mercer County, had been demolished by a tornado although this report turned out to be incorrect. Also in Wheatland, Mercer County, two Cyclops Corporation steel-making facilities were destroyed. Several people were killed.

For the Wheatland/Sharon tornado, the Pittsburgh staff reacted quickly to the request from Cleveland office to take over warning responsibility for Mercer County. The severe thunderstorm warning that was issued for Mercer County at 6:50 p.m. was timely and contained a reference to the possibility of tornadic activity. At 6:50 p.m., there were no spotter reports at Pittsburgh relating the Newton Falls/Niles tornado, and there was no distinct tornado signature appearing on Pittsburgh's radar.

At 8 p.m., the Pittsburgh office issued a severe thunderstorm warning for Lawrence and Beaver Counties. This warning was based on radar indicating a severe thunderstorm in eastern Columbiana County, Ohio. This county borders Lawrence and Beaver Counties. At 8:15 p.m., the Pittsburgh office received a call from a spotter which stated that a tornado was on the ground one-half mile north of Beaver Falls.

At about this same time, the Pittsburgh radar indicated a possible tornado in central Clarion County. Consequently, Pittsburgh issued a tornado warning for Clarion and Jefferson County at 8:20 p.m. where no warning was in effect. The time it took for issuance of this warning delayed the tornado warning based on the Beaver Falls sightings.

At 8:25 p.m., Pittsburgh issued a tornado warning for Beaver and Butler Counties based on the above spotter reports. The weak tornado that occurred in Clarion County was short-lived and had already occurred around 8 p.m. The Beaver Falls tornado was much stronger. It moved through the Big Beaver Shopping Plaza at 8:20 p.m. and into Zelienople in Butler County at 8:30 p.m. Residents there had a few minutes warning. The tornado continued eastward striking Saxonburg around 8:50 p.m. before lifting a few miles east of there. Several fatalities occurred in Beaver and Butler Counties.

The spotter network in Pittsburgh's county warning area was primarily organized to assist the office with its flash flood problems although the hams received training in severe weather reporting. During the tornado event, the office received calls from spotters by telephone. Around 9 p.m., an amateur radio operator came to the station on his own volition, but by that time, most of the severe weather events were over. A highly trained ham brought into the office when the watch was issued would have enhanced the staff capability. Hams provide two valuable functions. First, there is immediate communication from spotters in the field. This avoids use of the telephone system to report severe weather and the inherent risks of busy signals. Second, the ham can filter extraneous reports and pass on the most critical information to the forecaster.

Between 8:50 and 10 p.m., Pittsburgh issued two additional tornado warnings and four severe thunderstorm warnings. No fatalities or severe injuries occurred after 8:50 p.m., but there were numerous reports of hail and high winds in the warned areas. The final warning was issued at 10 p.m., and a severe weather statement at 11:30 p.m. related that all warnings and watches had expired in western Pennsylvania.

Summary

Overall, the Pittsburgh staff did a fine job during this tornado event, especially considering the rarity of this phenomenon. A high percentage of warnings issued verified and many initial warnings were timely. The office was staffed in a way that optimized warning decision making and warning dissemination.

The upgrading of a severe thunderstorm warning to a tornado warning for Mercer County was delayed by late reports and lack of spotter information. The upgrading to a tornado warning for Beaver County was delayed by the issuance of a tornado warning for Clarion County. Since no warning at all was in effect for Clarion County, Pittsburgh reacted properly by warning Clarion first before upgrading the severe thunderstorm warning for Beaver County to a tornado warning.

A spotter network was available but a stronger effort should be made to bring a ham radio operator into the office during severe weather events.

The Pittsburgh staff, through no fault of their own, was burdened by having to make numerous telephone calls to the Emergency Broadcast Stations. The Emergency Broadcast System's plan called for dissemination of warnings by telephone, and the Pittsburgh staff had no other means to provide this information to the primary broadcast stations. The time spent hampered the attentiveness to the weather situation by one staff member because of the demand to make these calls. (See section 4 for details.)

Finally, all equipment including AFOS, NOAA Weather Radio, NOAA Weather Wire Service, radar, computer system, and telephones functioned properly throughout the event.

3.3.2 Pre-event Actions by the Erie Weather Service Office. By early on Friday, May 31, the Erie staff was well aware of the severe weather threat for later that day. The Kansas City Center and the Pittsburgh forecast office had conveyed this message very clearly, and Erie's morning local forecasts mentioned the possibility of severe thunderstorms later in the day.

By afternoon after Kansas City had lowered the risk of severe weather in western Pennsylvania from moderate to slight, the mention of severe thunderstorms was removed from the local forecast.

Around 2:45 p.m., the Erie staff began observing on their local warning radar intense thunderstorms developing north of Lake Erie in Canada. They subsequently called the Canadian Weather Service in Toronto to brief them on the developing thunderstorms. For the next hour, they waited for thunderstorms to develop further south but none did.

The man on the evening shift arrived a little before 4 p.m., and the official in charge (OIC) was preparing to leave for the day. However, thunderstorms began to develop rapidly in eastern Ohio and began to move toward Erie's warning area. Therefore, the OIC and the man on day shift stayed over. Just before the first warning was issued, western Pennsylvania was included in a tornado watch. At about the same time, a SKYWARN amateur radio operator arrived on station. The information he provided later that evening proved to be valuable in the issuance of a warning for Erie and Crawford Counties.

Erie's Warning and Event Chronology

The first warning in Pennsylvania was issued by the Erie office at 4:30 p.m. for Erie and Crawford Counties and for adjacent Lake Erie. This warning was triggered by Erie's radar showing a severe thunderstorm over Ashtabula County, Ohio, that was moving northeastward. This same severe thunderstorm produced a tornado which was sighted by a state trooper near Pennside at 5:05 p.m. At 5:13 p.m., the Erie office issued a tornado warning for Erie County. At the time this tornado warning was issued, the tornado was ravaging the town of Albion, killing 10 and injuring 200. Also, just before the severe thunderstorm warning was upgraded to a tornado warning, a weaker tornado had struck Linesville at 5:10 p.m.

At 5:30 p.m., Erie issued a tornado warning for Crawford County based on a report of a tornado on the ground northeast of Youngstown, Ohio. While this tornado warning was in effect, a weak tornado moved across the Ohio/ Pennsylvania line near Pennline around 5:40 p.m.

Also at 5:30 p.m., Erie's radar showed three distinct "hook" echoes (see figure ___). As a result, the 5:30 p.m. tornado warning for Crawford County was updated at 5:45 p.m. and Erie County was added. The southern most tornado had touched down near Jamestown at 5:20 p.m. and devastated the small community of Atlantic around 5:30 p.m. This tornado moved eastward from Atlantic, stayed on the ground continuously for over 50 miles, and lasted over an hour.

The second or middle tornado first touched down in Crawford County around 5:25 p.m. near Saegertown, moved east-northeast in Crawford County, and lasted approximately a half-hour. The third or northern most tornado touched down at 5:30 p.m. near Beaver Dam, moved east-northeast, and crossed the Pennsylvania/New York border near Corry around 5:55 p.m. Fortunately, this powerful tornado moved through a relatively unpopulated area and no one was killed. A fourth tornado struck Centerville in eastern Crawford County at 6:15 p.m. while this tornado warning was in effect.

At 6 p.m., Erie issued a tornado warning for Venango and Warren Counties after Erie's radar showed the radar echoes associated with the Atlantic, Saegertown, and Corry tornadoes were approaching from the west. A weak tornado produced some tree damage at Thompson Run in Warren County around 6:35 p.m. while this warning was in effect.

At 6:20 p.m., the Erie weather office issued a tornado warning for Erie and Crawford Counties based on radar showing new tornadoes west of Albion and Conneautville. The survey team did not find tornado damage associated with these radar signatures. This warning message mentioned "another tornado south of Spartansburg moving into Warren County and one north of Oil City moving into northern Forest County."

Warren County was covered by the tornado warning issued at 6 p.m. Forest County was not included in a tornado warning until 6:35 p.m. because at 6:20 p.m., the tornado was at least 12 miles from the Forest County line. This warning was indeed necessary because a tornado struck Tionesta in Forest County at 6:40 p.m. Around this time, a tornado was near Marienville in Forest County. It continued to track east-northeastward through Lamont in Elk County and then northeastward to near Mount Jewett in McKean County. This tornado was rather weak, and there was no warning in effect for either Elk or McKean Counties since radar showed no severe weather echoes and no spotter reports were available from the area.

At 7:05 p.m., Erie issued a severe thunderstorm warning for Erie, Crawford, and Warren Counties. This warning was based on a line of thunderstorms extending from near Corry in Erie County to near Meadville in Crawford County. While this severe thunderstorm warning was in effect, a tornado struck Tidioute in Warren County around 7:40 p.m. There were other damage reports from each of these counties while this warning was in effect.

The Erie office issued a severe thunderstorm warning at 7:45 p.m. for Warren, Forest, and Venango Counties. This warning was based on a line of thunderstorms extending from southwest New York State through Warren and Titusville, Pennsylvania, to Youngstown, Ohio. The survey team did not have time to verify whether or not this line of thunderstorms caused damage in the above warned counties.

At around 8 p.m., a tornado touched down near the Warren County/ McKean County line about 10 miles west of Kane in McKean County. This powerful tornado moved into Kane at approximately 8:17 p.m. This tornado continued eastward and ended around 8:40 p.m. about 5 miles southeast of Mt. Jewett in McKean County. There was no warning issued for this storm.

At 8:35 p.m., Erie issued a severe thunderstorm warning for McKean, Forest, Elk, and Cameron Counties. This warning was based on radar data. At about the time this warning was issued, a powerful tornado was moving eastward through the Moshannon Forest near the borders of Elk, Cameron, and Clearfield Counties.

At 9:30 p.m., the Erie weather office issued a severe thunderstorm warning for Warren, McKean, Potter, Cameron, Forest, and Elk Counties. Radar continued to indicate severe thunderstorms in and near these counties. It is unknown whether or not damage occurred in these counties during the time the warning was in effect.

At 10:35 p.m., the Erie office issued its final warning for that night for Potter County. This warning was based on Erie's radar showing heavy thunderstorms in southern Potter County. At 10:45 p.m., State Police in Potter County experienced heavy thunderstorms with golf ball-size hail and high winds which knocked down trees and caused power failures.

Summary

WSO Erie has trained a force of about 100 severe storm spotters. However, most of these were concentrated in Erie, Crawford, and Warren Counties. There were very few, if any, trained spotters in the other six counties within Erie's area of warning responsibility. One must realize though that severe weather, and particularly tornadoes, rarely occur in Pennsylvania. Therefore, the training of 100 spotters in three counties was quite an accomplishment by the official in charge. On May 31, the mobilization of this spotter force was hampered by the fact that when the first tornado watch was issued around 4:30 p.m. that afternoon, most spotters were on their way home from work. Also, the event developed so quickly after the watch was issued that there was no time for spotters to organize. As a result, there were valuable but limited spotter reports received during the event.

The performance of the Erie staff during the event was very good. All but a few warnings verified. The only significant event that occurred without any warning was the tornado that struck Kane in McKean County at 8:17 p.m. Mountainous terrain between this storm and Erie's radar which interfered with the radar echoes and the lack of spotters were storm detection factors.

In a few cases, severe thunderstorm warnings were not upgraded to tornado warnings. For example, when the tornado warning was issued at 5:30 p.m. for Crawford County, a tornado had already struck Atlantic, another tornado had hit Saegerton, and another tornado had touched down near Beaver Dam in Erie County which was not placed under a tornado warning until 5:45 p.m. All of these were major tornadoes with exceptionally long tracks. However, Erie had no knowledge these tornadoes were in existence since the spotters were on their way home from work, and distinct tornado signatures or "hook echoes" did not appear on Erie's radar until 5:30 p.m.

All equipment, including AFOS, NOAA Weather Radio, NOAA Weather Wire Service, radar, computer systems, and the telephones functioned properly. The dissemination of information to the Pennsylvania counties bordering New York State were degraded by a NOAA Weather Wire failure in New York State. This failure interrupted the flow of information to the media in Buffalo, New York, who broadcast the warnings to counties in northwest Pennsylvania.

Considering these facts, the Erie staff did remarkably well in issuing accurate and timely warnings throughout the evening.

3.3.3 Pre-event Actions by the Williamsport Weather Service Office. During the morning hours of Friday, May 31, the staff at Williamsport was well aware of the possibility of severe weather that evening, and had noted the messages from the National Severe Storms Forecast Center which mentioned "a moderate risk of severe thunderstorms" for western and central Pennsylvania.

The Williamsport local forecast included the possibility of severe weather for that night. However, during the afternoon, the personnel at Kansas City and at the Philadelphia forecast office agreed there was a decreased chance of severe weather during the evening. An administrative message from Philadelphia at 2:05 p.m. gave Williamsport the option of deleting severe thunderstorms from the forecast. Since neither the Buffalo nor Pittsburgh radars showed any echoes at that time, Williamsport elected at 2:15 p.m. to update the local forecast and remove the mention of severe thunderstorms for that night.

The Williamsport staff noticed, however, that Pittsburgh continued to mention the possibility of severe weather for western Pennsylvania. Hence, Williamsport compromised on the issuance of their 4 p.m. local forecast and stated that there was a "chance of heavy thunderstorms" tonight.

Around 4:25 p.m., the staff noted that a tornado watch was issued by Kansas City for northwestern Pennsylvania effective 5 p.m. to 11 p.m. This watch did not include any counties in their area of responsibility, but it did serve to heighten their awareness of the situation. Also, the Pittsburgh and Buffalo radars were beginning to indicate severe thunderstorms over Ohio and Ontario, Canada, and during the evening Williamsport became aware that a serious tornado outbreak was occurring in western Pennsylvania. They noted the Erie office had three tornadoes on the ground in its area of responsibility at the same time. The man on duty later made the statement, "Warnings were coming over the circuit every few minutes -- more than I have ever seen in the 4 years I have been at Williamsport."

At around 7:20 p.m., the Kansas City Center issued a severe thunderstorm watch for north-central Pennsylvania. Williamsport's counties were in the watch area so the local forecast and NOAA Weather Radio were updated. The Harrisburg radar was now clearly showing thunderstorms about to move into central Pennsylvania. The person on duty anticipating the issuance of warnings tried to get additional help. At first, he was unsuccessful, but at 7:50 p.m. he contacted another staff member and this man reached the office before 8 p.m.

At 8:10 p.m., Kansas City issued a tornado watch for much of central and eastern Pennsylvania. Some of Williamsport's counties were within the watch area. Consequently, the local forecast and the NOAA Weather Radio were updated again. Severe weather statements were issued at 8:30 p.m. and at 8:45 p.m. The statements discussed the severe thunderstorm watch, the tornado watch, and the weather appearing on radar.

WSO's Williamsport Warning Actions

The first warning by Williamsport was issued at 8:55 p.m. for Lycoming County. This warning was based on echoes detected by the Binghamton, New York, radar. The Binghamton radar operator stated that the thunderstorm moving eastward from the Clinton County/Lycoming County line contained hail and had met severe thunderstorm criteria. At 9 p.m., the Harrisburg radar operator advised this thunderstorm had a top of 62,000 feet. It is most unusual for thunderstorms to reach above 50,000 feet in Pennsylvania. At 9:25 p.m., the Emergency Management Agency (EMA) of Lycoming County stated that golf ball-size hail had fallen at Jersey Shore in Lycoming County.

At 9:31 p.m., the radar operator at Binghamton called Williamsport and stated that a severe thunderstorm was moving toward Union County. Union County is within Harrisburg's warning area so Williamsport coordinated with Harrisburg, and it was decided that Williamsport should issue the warning. Therefore, at 9:40 p.m., a severe thunderstorm warning was issued for Union County.

With reference to the above two severe thunderstorm warnings issued by WSO Williamsport, the survey team found later that a tornado moved through southern Lycoming County from around 9:20 p.m. to 9:40 p.m. and then moved through Union County near the White Deer and Allenwood communities before crossing the Susquehanna River and striking Watsontown in Northumberland County around 9:55 p.m.

At 10 p.m., Williamsport issued a severe thunderstorm warning for Sullivan County. This warning was prompted by information received by the Binghamton radar operator.

At 10:05 p.m., the Pennsylvania State Police reported a possible tornado in southern Lycoming County. At 10:10 p.m., Williamsport issued a tornado warning for Northumberland County based on this report and the track of the strongest radar echo.

At this point, Williamsport felt they needed more help. The official in charge was called, and he immediately proceeded to the station.

At 10:30 p.m., Williamsport issued its final warning for the night. A severe thunderstorm warning was placed in effect for Tioga and Bradford Counties. This warning was based on an Emergency Management Agency's report of golf ball-size hail in Blossburg, Tioga County, at 10:20 p.m. Hail and/or wind damage occurred in both counties following this warning.

Summary

The Williamsport staff handled the severe weather occurring in their warning area very well. Of the five warnings Williamsport issued (two for Harrisburg), at least four verified. All severe thunderstorm warnings contained the remark "Tornadoes are also possible in these areas." In addition to the warnings, the staff managed to issue timely and informative weather statements. All warnings and messages were quickly relayed by NOAA Weather Radio.

There were a few operational problems during the time Williamsport was issuing warnings that night. The Remote Terminal to AFOS (RTA) failed several times because of power interruptions, but outages were short-lived. The RTA is the office's means of entering data to AFOS and the NOAA Weather Wire System (NWWS) teletype circuit.

Two of the warnings were not relayed from the Remote Terminal to AFOS and to the NWWS. The Remote Terminal is wired to AFOS at WSO Scranton/Wilkes-Barre. The warning message should have been echoed back to Williamsport from Scranton/Wilkes-Barre, but the AFOS failure at Scranton prevented the return of the warning. Because the office was extremely busy, they did not realize the warnings failed to echo back, and as a result, these two warnings did not get on the NOAA Weather Wire. However, they were disseminated over NOAA Weather Radio.

WSO Williamsport suffered from the same lack of ground-truth information as did other offices in Pennsylvania. There were no reports from spotters. A few important bits of information were received from the county Emergency Management Agency and the Pennsylvania State Police. Finally, before the event ended, a fire chief from nearby Montoursville arrived at the office with a walkie-talkie. This helped bridge the communication gap. Having amateur radio operations at the office could have helped considerably.

3.4 Ohio

3.4.1 Pre-event Actions by the Cleveland Weather Service Forecast Office.

WSFO Cleveland recognized the threat of severe weather for Ohio early in the day. Zone forecasts issued at 3:32 a.m. included a flash flood watch and the possibility of severe weather for northeast Ohio for later in the day. The 5:56 a.m. Ohio Weather Story (a summary of past, present, and expected weather issued 4 times a day) also highlighted the possibility of severe storms for the afternoon and evening. The zone forecasts and Ohio Weather Story issued between 10:30 and 11:30 a.m. again emphasized the threat of severe weather for northeast Ohio. Forecasters were anticipating severe weather and early in the afternoon were surprised that thunderstorms had not yet developed. Several calls were made to Kansas City to discuss the possibility of severe weather developing.

WSFO Cleveland has a very active ham radio network. In fact, the coordinator for the network came into the office around 8:30 a.m., after hearing the early morning forecast and was there for the remainder of the day.

During severe weather episodes, Cleveland augments the staff so they can efficiently prepare warnings and other necessary products. One person is assigned to handle the NOAA Weather Radio, a second is dedicated to the radar, a third handles voice dissemination (phone calls, etc.), and a fourth acts to coordinate the warning function. The SKYWARN coordinator sits next to the severe weather coordinator so there is no delay of incoming spotter reports. When the first thunderstorms began developing in Ohio shortly after 4 p.m., the severe weather staffing was activated.

The AFOS system was operating in degraded mode throughout the day and had been in that configuration for several days. Electronic technicians were trying to find the problem. Degraded mode means that AFOS operates at a slower speed and about one-half of the graphic products are not available to the forecasters. It did not prevent forecasters from issuing warnings, forecasts, or other critical statements. However, the transmission of one warning was delayed because of an AFOS crash.

At Cleveland, the AFOS slowdown had no effect on the issuance of warnings because the office uses a Radio Shack TRS-80 microcomputer to prepare warning messages. A lot of the warning messages are preformatted with the forecaster selecting the counties included in the warning. The system is fast and efficient for placing warnings on the NOAA Weather Wire. All other systems, including NOAA Weather Radio, Local Warning Radar, on-station emergency broadcast equipment, and satellite imagery, performed perfectly during the episode.

One other pre-event activity was very important -- preparing public response to the severe weather. If the National Weather Service issued perfect warnings for each event, no matter how good those warnings were, people must know how to respond to those warnings. Because of the excellent awareness efforts of the Weather Service offices in Ohio, many people knew how to protect themselves from a tornado.

Time and time again, the survey team found people who took protective action and it saved their lives. The team even found a number of incidences where children told their parents what to do after learning the safety rules in school. Considering that the strongest of all possible tornadoes moved across the populated central portion of Trumbull County, and only nine fatalities were recorded is evidence of a successful awareness program in Ohio. The efforts of the National Weather Service, news media, local and state officials, and the school systems all contributed to the high level of awareness in Ohio. (For details of the Ohio awareness program, see chapter 5.)

Cleveland's Warning and Event Chronology

The first warning was issued by Cleveland at 4:10 p.m for Ashtabula County based on radar indicating a severe thunderstorm. The Severe Thunderstorm Warning was valid until 5:15 p.m. The warning verified with 3/4-inch hail and winds over 60 mph near Austinburg at 4:40 p.m. At 4:25 p.m., Cleveland disseminated the Tornado Watch which covered all the northeast Ohio counties.

At 5:21 p.m., Cleveland issued a Tornado Warning for Ashtabula County based on radar and a report from the public. The warning was valid until 6 p.m. However, the warning was not disseminated over the NOAA Weather teletypewriter circuit because a brief failure of AFOS (about 1 minute) occurred just before 5:25 p.m. This original warning, however, was disseminated over the NOAA Weather Radio system and the EBS system shortly after 5:20 p.m. At 5:30 p.m., the office discovered the warning had not gone out on the teletype and tried again to issue the warning, but an old March 28 warning went out instead over the NOAA Weather Wire. Cleveland then issued a corrected warning which was disseminated at 5:43 p.m. The weak tornado occurred in Ashtabula county at 5:30 p.m.

A 5:28 p.m., Cleveland issued a severe thunderstorm warning for Lake and Geauga Counties valid until 6:15 p.m. Both counties experienced hail golf ball-size hail during the warning period.

At 5:40 p.m., Cleveland took over responsibility for three of Youngstown's counties because of a failure of the AFOS telephone communications line. (See WSO Youngstown section.)

A Severe Thunderstorm Warning was issued at 6 p.m., for Medina County Ohio, and a Severe Thunderstorm Warning was issued for Geuaga at 6:15 p.m. Both warnings were based on radar indications of severe storms and both were in effect for 45 minutes. Hail and high winds were associated with these storms.

Cleveland issued a Severe Thunderstorm Warning for Trumbull County at 6:30 p.m. based on a very strong radar echo near Hudson. (See WSO Youngstown sections for details.) At 6:45 p.m., Cleveland also issued a Severe Thunderstorm Warning for Mahoning County which was based on radar showing a strong thunderstorm in Portage County moving east at 40 mph.

At 7:30 p.m., a Severe Thunderstorm Warning was issued for Mahoning and Columbiana Counties. The warning was based on radar and was effective until 8:15 p.m. At 7:40 p.m., the warning was upgraded to a Tornado Warning for Columbiana County based on radar indications of a tornadic storm. A weak tornado occurred in Columbiana County between
7:35 and 7:55 p.m.

Two additional warnings based on radar were issued for Columbiana County later in the evening. One was a tornado warning and the other was a severe thunderstorm warning. No tornado occurred, but there were reports of hail and high winds.

The tornado watch expired at 11 p.m., and by then all severe weather activity had ceased in Ohio.

Summary

Cleveland issued timely and accurate warnings throughout the severe weather episode. One warning was not disseminated over the NOAA Weather Wire until after a weak tornado occurred in Ashtabula County because of a brief AFOS failure. However, the warning was disseminated over NOAA Weather Radio and the Emergency Broadcast System well before the tornado occurred. Cleveland was attuned to the possibility of severe weather and highlighted its threat in forecasts and the Ohio Weather Story throughout the day. A ham radio operator came on duty at 8:30 a.m. and was there until the severe weather event ended. Finally, the excellent awareness efforts by the Cleveland staff over the last several years contributed significantly to saving lives.

3.4.2 Pre-Event Actions by the Youngstown Weather Service Office. WSO Youngstown was aware of the threat of severe weather on May 31. Early morning forecasts called for the possibility of severe thunderstorms later in the day, and Cleveland's Ohio Weather Story highlighted the threat in both the early morning and late morning issuances. Youngstown was sensitive to the possibility of severe weather since the day shift worker contacted the evening shift person to see if he could come in early if severe weather developed during the afternoon.

No thunderstorms developed before 4 p.m. so the evening shift worker did not report for duty until 3:45 p.m. The day worker was just about to leave for home when thunderstorms began to form west of Youngstown's warning area. Because of the threat of severe weather he decided he should stay and help.

Youngstown's Warning and Event Chronology

The Meteorologist in Charge at Cleveland called Youngstown at 4:40 p.m. and advised them to issue a severe thunderstorm warning for Trumbull County. Cleveland radar indicated a severe thunderstorm was moving toward Trumbull County. Youngstown issued the warning at 4:45 p.m. valid until 5:45 p.m.

At 5:15 p.m., the radar operator at WSO Canton-Akron called Youngstown on an internal hot line and advised a possible hook echo was located over the northern part of Trumbull County near the community of Mesopotamia. Since the radar operator advised the echo was only a possible hook and a severe thunderstorm warning was in effect, Youngstown decided it was not necessary to upgrade the the Severe Thunderstorm Warning to a Tornado Warning.

Shortly before 5 p.m., the local SKYWARN Coordinator called into the office after hearing the warning which was issued at 4:45 p.m. Youngstown has a trained active group of 30 to 40 ham radio operators who are available during a severe weather situation. The SKYWARN Coordinator was advised that by the time he got into the office to set up the network the storm in northern Trumbull County would be gone. Because no other storms appeared to be threatening Youngstown's warning area, the two people on duty felt the spotters would not be needed.

The decision not to bring in the SKYWARN Coordinator with a tornado watch still in effect most likely hindered the office later in the evening and prevented them from receiving any spotter reports.

At 5:24 p.m., Youngstown began to have problems with their AFOS system. The AFOS communications line connecting Youngstown and Cleveland became very unreliable and required many restarts to maintain the communications link. At 5:40 p.m., the AFOS communications line to Cleveland completely failed which meant Youngstown was not able to issue any warnings or statements via AFOS. The survey team found that other users of systems that had telephone line connections experienced similar problems.

By a pre-arranged agreement, Cleveland took over Youngstown warning responsibility for Trumbull, Mahoning, and Columbiana Counties in Ohio, and Pittsburgh took over responsibility for Mercer and Lawrence Counties in Pennsylvania. (Takeover by Pittsburgh occurred at 7:10 p.m.)

Around 6:15 p.m., Youngstown began to have problems with the phone system. Incoming calls were not ringing the commercial phone, and the hotline to Canton-Akron became intermittently noisy. At 6:30 p.m., Cleveland issued a Severe Thunderstorm Warning for Trumbull County which was in effect until 7:30 p.m.

As the clock approached 6:38 p.m., Youngstown received a report that a possible tornado was approaching the Niles-Warren area. Because of the communication problems and the frantic efforts to get AFOS working again, it was not clear where the tornado report originated. However, the report prompted one of the staff to relay a message to the primary Emergency Broadcast Station in Youngstown, reporting that a possible tornado was approaching the Niles-Warren area.

The log at the primary EBS station showed the warning was rebroadcast to the secondary stations at 6:39 p.m. At 6:40 p.m., a tornado struck Newton Falls, Ohio, in extreme western Trumbull County.

The survey team visited the primary stations and three commercial broadcast stations. Based on this, the team concluded the EBS system was activated several times during the evening, but the activation times were inconsistent with the issuances of watches and warnings via other means, and on at least two occasions where the EBS system was activated, no message came over the system. Based on this, the team concluded that very few of the secondary stations received and rebroadcast the tornado warning issued at 6:39 p.m.

The Youngstown office failed to notify Cleveland of the statement placed over the EBS system. As a result, Cleveland had no knowledge a possible tornado was headed for the Niles-Warren area and thus had no reason to upgrade the Severe Thunderstorm Warning to a Tornado Warning.

The Canton-Akron weather office called Youngstown at 6:50 p.m. and said a possible hook was approaching the Niles-Warren area. A Severe Thunderstorm Warning was still in effect, and there was still no positive confirmation a tornado was on the ground. Canton-Akron again called Youngstown at 6:55 p.m. and advised there was an apparent hook over the Niles-Warren area. About the same time according to ham radio logs in the Cleveland and Canton-Akron offices that damage had occurred at Newton Falls and hams speculated about a tornado there. Around 7 p.m., ham radio reports confirmed a tornado touched down at Newton Falls. Since no hams were in the Youngstown office, the staff had no knowledge of these reports and, thus, could not relay information to the Cleveland office who at that time was responsible for the warnings in Trumbull County.

The tornado hit Niles at 7:02 p.m. About this time Canton-Akron discussed with Cleveland the possibility of upgrading the Severe Thunderstorm Warning to a Tornado Warning, but since the storm was less than 12 miles from the Pennsylvania border, it was decided by the time a Tornado Warning was issued the storm would be moving into Pennsylvania. Cleveland contacted Pittsburgh notifying them a possible tornado was heading into Mercer County. At 7:03 p.m., all power failed at Youngstown, and they had no communications.

Summary

The tornadoes in Youngstown's area of responsibility were preceded by both a Tornado Watch and Severe Thunderstorm Warnings. A complex set of circumstances contributed to the Severe Thunderstorm Warning issued at 6:30 p.m. not being upgraded to a Tornado Warning. The failure of their AFOS communications line forced Youngstown to turn over their warning responsibility to Cleveland. Shortly thereafter, telephone and hot line communications began to experience intermittent failures depriving Youngstown of significant information concerning the progress of the storm.

The decision not to bring in the SKYWARN Coordinator and establish the ham radio network took away an opportunity for backup communications and deprived the staff of vital reports which could have complemented radar information received from Canton-Akron. The staff performed properly and immediately by placing a Tornado Warning on the EBS system at 6:38 p.m. but did not pass the information on to Cleveland who, in turn, could have issued a written Tornado Warning.

3.4.3 Canton-Akron and Columbus Weather Offices. Severe Weather also occurred in the warning areas of Columbus and Canton-Akron. The survey team could not thoroughly review the performance of the warning system in those areas because of the time needed to study the devastating tornadoes that struck the northeast section of Ohio and Pennsylvania.

Both offices issued several tornado and severe thunderstorm warnings during the evening. One significant tornado touched down in Licking County (Columbus's warning area) around 7:20 p.m. and lasted until 7:45 p.m. A tornado warning was issued at 7:32 p.m., based on a spotter report. Prior to the spotter report, there was no radar indication of a severe storm or tornado.

The Canton-Akron office provided excellent support to both Youngstown and Cleveland during the severe weather episode. In addition to issuing warnings for their counties, they frequently contacted the other two offices concerning significant radar echoes in Youngstown's warning area.

3.5 New York

3.5.1 Buffalo Weather Office. One significant tornado occurred in Chautauqua County, New York, which falls under Buffalo's warning umbrella. The tornado passed through Busti, New York, and was on the ground from 6:25 p.m. to 6:45 p.m. Several persons were injured, but there were no fatalities. The survey team as explained earlier had to concentrate its efforts in Ohio and Pennsylvania; hence, could not thoroughly review performance of the New York warning system.

Chautauqua was under the same tornado watch that affected Ohio and Pennsylvania, and the watch was disseminated in New York shortly after 4:25 p.m. A tornado warning was issued by Buffalo at 5:20 p.m. valid until 6:30 p.m. In addition to routine dissemination, the office called the

Sheriff's department in Chautauqua County who, in turn, broadcast the warning over county radio frequencies. The warning was based on radar and reports to Buffalo about tornadoes downstream in Ohio and Pennsylvania. At 5:55 p.m., the tornado warning was extended for Chautauqua until 7 p.m. Seven other counties were warned during the evening and there were numerous reports of hail and high winds. One problem developed around 7 p.m. when the NOAA Weather Wire failed. One of the Buffalo TV stations has a listening audience in Pennsylvania, and the failure of the New York NOAA Weather Wire resulted in Pennsylvania warnings not being received and broadcast by this New York station into their listening area in Pennsylvania after 7 p.m.

CHAPTER 4

DISSEMINATION

4. EMERGENCY BROADCAST SYSTEM (EBS)

Nearly 10 years ago, the Federal Communications Commission (FCC) authorized expanded activation of the EBS to include alerting the public to possible or impending "short-fuse" natural and man-made disasters. The EBS relies upon existing facilities and personnel of the communications industry on a voluntary, organized basis to operate an Emergency Broadcasting Network.

Broadcasters in each state helped develop local plans. The concept of each plan includes relaying official government warning messages from a central program control station-1 (CPCS-1) to other stations in an established monitoring area. At the discretion of station management, these stations then rebroadcast the warning messages. All such plans had been developed and were in place in Ohio, Pennsylvania, and New York before the May 31, 1985, tornado outbreak.

The survey team has concluded that the EBS is a very valuable method of relaying weather warnings. However, the actual implementation of the EBS needs strengthening. Since participation by individual stations is voluntary, there must be added incentives or controls developed to encourage station participation. A survey by the Federal Communications Commission found that only five of nine CPCS-1 stations in the affected area activated the Emergency Broadcast System. In addition, only 17 of 52 radio stations in communities directly affected by the tornadoes broadcast the warning messages using the Emergency Broadcast System. Also, the EBS should be tested on a regular basis. For example, in the Youngstown area during this tornado event, several radio stations cited technical difficulties in receiving and recording weather warnings from the CPCS-1. In one location, a station engineer reported interference from a nearby cluster of TV antenna towers. Frequent drills would help ensure system reliability.

The transfer of National Weather Service warnings by CPCS-1 to participating relay stations is often too slow. It is imperative that weather warnings and, in particular, tornado warnings be relayed and rebroadcast without a minute's delay.

In the western Pennsylvania area affected by the May 31 tornadoes, the Weather Service used direct telephone calls to CPCS-1 stations to activate the EBS. A post storm evaluation by the Pittsburgh office showed that passing warnings to the CPCS-1 by telephone was entirely inadequate.

This evaluation concluded that the warnings issued by their office during the evening of May 31 were heard on EBS radio stations an average of 20 minutes after issuance! Tornado warnings that are 20 minutes old are often useless. Much of this time was spent trying to contact the CPCS-1 station, waiting for hookup of the recording, recording the warning, and confirming the recording. Time is also consumed in relaying the warning from the CPCS-1 to monitoring stations.

The Pittsburgh weather office conservatively estimated each EBS telephone call required 5 minutes on the average to complete. There were 16 EBS calls made by Pittsburgh during the 4-hour warning period that evening which means that 80 minutes or about 35 percent of one staff member's time was spent relaying warnings to the broadcasters. In a fast-breaking, life-threatening, family-type tornado outbreak, these 80 minutes could have been more effectively used in obtaining and evaluating information and helping with the warning decision process and warning dissemination.

For maximum efficiency, the telephone relay of warnings from the NWS to the EBS must be reduced or eliminated. The warning transfer must be automated. Activation of the Emergency Broadcast System via NWR or NOAA Weather Wire Service or some other automated system should be explored.

4.1 NOAA Weather Radio (NWR)

The NWR provides continuous around-the-clock broadcasts of the latest weather directly from NWS offices. On days when severe weather is likely, these offices usually broadcast weather safety messages. On May 31, Weather Service Offices in Ohio and Pennsylvania broadcast severe weather safety rules via the NOAA Weather Radio well before the tornadoes struck.

During severe weather, weather radio operators interrupt routine broadcasts to substitute special warning messages. Weather radio broadcasts can also activate specially designed warning receivers. Such receivers either sound an alarm that prompts listeners to turn their sets up to an audible volume or receivers can be automatically turned on so that the warning message can be heard. Warning alarm receivers are especially valuable for schools, hospitals, public safety agencies, and news media offices.

With regard to this major tornado outbreak, the survey team found that nearly all radio and TV stations broadcasting in the affected area used NOAA Weather Radio to receive weather information from the National Weather Service. In many instances, the broadcast media was totally dependent on NOAA Weather Radio as their warning source. This was found to be particularly true in the hard hit areas covered by the Youngstown and Erie media.

Evidence gathered by the survey team points to outstanding performances by the various weather offices programming NWR transmitters in the affected area. As warnings were issued, they were usually aired quickly, and all warnings were preceded by the sounding of the warning alarm signal. There was no loss of power at the weather radio transmitter sites as is often the case during a severe weather outbreak, but this was due only to good fortune because standby power was not available at the these sites.

One limitation of the NOAA Weather Radio system is the area covered by a radio signal. There are nine weather radio transmitter sites in Ohio, nine in New York, and ten in Pennsylvania. One can assume that each transmitter has a listening radius of about 40 miles. However, differences in terrain features, forestation, transmitter height and orientation, transmission power, etc., shrink or expand or distort each listening area in a unique way. Despite a large number of transmitter sites compared to some other states, weather radio coverage in Ohio, New York, and Pennsylvania has significant gaps. Unfortunately, the Newton Falls/Niles/Wheatland tornado (F5, killed 24, injured 200) cut a path across one of these gaps between the Akron, Erie, and Pittsburgh transmitters.

After interviewing Weather Service employees, Disaster Service Agency officials, the media, and other users, this survey team concludes without reservation that in the area most affected by the May 31 tornadoes, the most effective method of disseminating warnings to the public was NOAA Weather Radio. The warning may have been received directly from the Weather Service Office by the public, but was more apt to have been relayed from the weather radio transmitter to the broadcast media and then to the public. Since the weather radio in most instances was either directly or indirectly responsible for bringing warnings to the public's attention in this severe weather outbreak, every consideration should be given to making the public more aware of this lifesaving system.

4.2 Pennsylvania Emergency Management Agency (PEMA) Teletypewriter Circuit

PEMA at Harrisburg has a teletype circuit designed to deliver all Weather Service watches, warnings, and other selected products to the offices of the 67 County Emergency Management Office Directors.

There are several problems with the PEMA circuit. In 1984, PEMA installed a new system that is not compatible with AFOS. An automated computer program was installed to store Weather Service products. When NWS AFOS is polled by the PEMA program, the stored Weather Service product is then transmitted.

The meteorologist in charge at Harrisburg estimates this equipment has been inoperative approximately 50 percent of the time in normal weather; during severe weather occurrences, he estimates down time is even higher. The longest periods of system outage occur during weekends and at night when PEMA Headquarters is not staffed. During the severe weather of Friday evening, May 31, the Weather Service leg of the PEMA Circuit went dead at 6:37 p.m. and remained inoperative until 9 minutes after midnight. The Harrisburg Weather Service Office is responsible for restarting the PEMA computer.

The PEMA Circuit was effective in delivering the Tornado Watch at 4:45 p.m. to all but one county office, Tioga County. There is the problem, however, that many of the printers are not carefully monitored 24 hours a day. Furthermore, no alarm bells or alert tones sound for tornado watches or warnings.

The PEMA Circuit has a message confirmation process that lists "undeliverables" after 10 minutes of trying, but there is no break capability for weather warnings. With these characteristics, the circuit frequently repeats the same transmission over and over and will not stop for emergency traffic. This scenario does not allow for rapid distribution of time dependent warning information.

4.2.1 Telephone Relay of Warnings to PEMA. By prior arrangements made several years ago, the Harrisburg office calls the PEMA staff duty officer for the following issuances.

1. Flash Flood Watch -- All Zones of PA.
2. Flash Flood Warning -- All Counties of PA.
3. Tornado Watch -- Any areas of PA within Watch Area.
4. Tornado Warning -- All Counties of PA.
5. Winter Storm Warning -- All Zones of PA.

These calls are to be made to the staff duty officer from 4 p.m. to 8 a.m. each night, Monday through Friday, and all day during weekends and holidays.

PEMA headquarters is staffed Monday through Friday from 8 a.m. to 4 p.m. A staff duty officer is assigned by PEMA for the remainder of the time to be available at home. The duty officer is reached by the Harrisburg office during these periods by dialing the PEMA phone number. The phone call is then transferred to the assigned staff duty officer's home.

On the evening of May 31, the Harrisburg office contacted the PEMA duty officer at his home at 5:50 p.m. to advise him a Tornado Watch was issued. The office continued to call the officer at home with information concerning watches and warnings. Shortly after 8 p.m., the duty officer was relieved of duty at home when an Emergency Operation Center was activated at PEMA Headquarters.

4.3 Commonwealth Law Enforcement Agency Network (CLEAN)

Pennsylvania State Police operate a communications system known as the Commonwealth Law Enforcement Agency Network, referred to as CLEAN. The network has over 300 terminals throughout the state in municipalities, boroughs, Pennsylvania State Police Troop Headquarters, and Emergency Operational Centers.

WSO Harrisburg manually enters into this system, all warnings issued for any county in Pennsylvania. The CLEAN system has been reliable, but typing in the successive warnings issued on May 31 put an added burden on Harrisburg Weather Office that just couldn't be handled without omissions. For example, the Weather Service Office at Erie reported the Millcreek Township Police Department in Erie County received none of the warnings issued by WSO Erie via the CLEAN System.

4.4 Law Enforcement Automated Data System (LEADS)

The Ohio Law Enforcement Automated Data System (LEADS) has established an interface with the National Weather Service to provide automated weather warnings to the law enforcement community in Ohio. This interface became operational April 23, 1985, after over a year of planning and work in a coordinated effort by the Ohio Highway Patrol and WSFO Cleveland. The LEADS is maintained on a Sperry Univac 1100-83 computer.

There are currently 924 terminals connected to the LEADS, either directly or through regional interfaces, covering 86 of the 88 counties of Ohio. By using the header in the message from the NWS, weather messages are routed only to the counties affected. A message that affects the entire state is routed to all terminals in the state of Ohio.

The LEADS is currently utilizing nine Weather Service products. These are: Flash Flood Watches, Flash Flood Warnings, Flood Warnings, Flood Statements, Severe Thunderstorm Warnings, Tornado Warnings, Severe Weather Statements, Special Weather Statements, and Severe Storm Watches prepared by NSSFC, Kansas City, Missouri. These are identified by the header contained on the message. The software at LEADS monitors the line and only rebroadcasts these nine types of messages. A tenth message, the Zone Forecast Product, is being received in the LEADS control center to help ensure the operation of the interface and as a possible addition to the network product line in the future. The NWS line that the LEADS monitors is the same line that the media is connected to for their weather information.

The agencies who are part of the LEADS network now receive severe weather information instantaneously as the National Weather Service distributes it. There is no human intervention from the time the NWS transmits the weather information to the time the agencies on the LEADS receive this information. Of the numerous product lines the Weather Service offers, only the ones deemed of interest to the law enforcement community are forwarded to them as controlled by software. An agency only receives weather statements that directly affect the area the agency covers.

The warnings, watches, and special statements related to the severe weather of May 31 were promptly communicated via LEADS. State troopers reported they were satisfied with the way LEADS worked. There were no problems. In an interview with the Disaster Survey Team, representatives of the Ashtabula County, Ohio Emergency Management Agency, stated they first became aware of the Tornado Watch at about 4:55 p.m. when one of them heard it broadcast on the Sheriff's frequency in his car. The Sheriff's office had received the watch via LEADS.

4.5 AP and UPI Wire Services

4.5.1 Associated Press (AP). The AP has a high speed, 1200 baud service, and a slow speed 56 baud service. Of about 5,700 national subscribers to AP services, 700 subscribe to the high speed circuit.

AP computers automatically receive all Weather Service watches and warnings. High speed subscribers receive warnings as issued with no loss in time. The whole process is automated. For slow speed subscribers, there is a loss in time because switching is necessary by AP to get the messages out. Apparently, AP has no flagging feature for weather warnings, so they have to be alert or be called to minimize the loss of time before the warnings are manually switched to slow speed subscribers. On May 31, the AP office in Pittsburgh was called at least seven times by Pittsburgh Weather Service Office concerning watches and warnings.

AP personnel in Ohio and Pennsylvania were satisfied with the NWS performance on May 31, but some problems were identified. The AP editor for Pennsylvania told the survey team that at one point there was a backup of information going to the high speed subscribers with time loss of less than 3 minutes.

The AP representative on duty on May 31 at the AP office in Cleveland said: "Things probably went as well as things could go." Problems he identified included multiple transmissions of messages, erroneous information concerning number of fatalities, and the omission of end of text code on NWS messages broken by warnings. The latter problem results in warnings appearing as a continuation of the previous broken message and makes it difficult for AP to recognize the warning message.

4.5.2 United Press International (UPI). UPI relies on an NMC computer interface (Gateway) to get weather information into their computer system. The local UPI operator then scans the headlines and looks for key-words to identify what is coming in for rerouting to subscribers. Warnings are not flagged. Some, if not all, UPI offices also have the NOAA Weather Wire. In correspondence to the survey team, the UPI State Editor for Pennsylvania stated: "We often are busy with breaking news and don't get the chance to monitor it (NWWS) properly." He said it would be helpful if NWS stations in Pennsylvania called UPI, when possible, to alert them about severe weather conditions. On May 31, UPI was called at least seven times by WSFO Pittsburgh. UPI in Ohio would like to be called for the first warning issued from each office.

The UPI State Editor for Ohio on duty the evening of May 31 told the survey team he saw no deficiencies in the NWS operations. Information was put out by UPI in Ohio as quickly as possible, but it was coming in very fast.

Some of the NWS warnings on May 31 either did not get to the UPI Pittsburgh computer or, if they did, were lost. Follow-up calls from Pittsburgh alerted the wire service of unissued warnings. Shortly after May 31, a Venango County radio station complained to WSFO Pittsburgh that they did not get the warnings from UPI. Another UPI subscriber in Pennsylvania complained to the Erie office recently about not getting warnings from UPI related to an outbreak of minor tornadoes that occurred on June 22 when warnings were also issued.

4.6 Local Media

Two days after the disastrous 1985 tornadoes in an interview with the New Castle News, the Lawrence County, Pennsylvania, Emergency Management Director touched on the importance of local media during weather emergencies. Saying she hoped the experience would serve as a lesson to area residents, she remarked: "If the weather conditions look serious, we cannot stress enough to turn on the radio because bulletins are being issued."

Radio is the prime communications medium for emergencies. But, year in and year out, Ohio and Pennsylvania newspapers -- daily and weekly -- help raise public consciousness of tornadoes by publicizing preparedness messages from state and Federal agencies and the disaster services. And in the days immediately following the May 31 disaster, they also served as crucial clearing houses for every kind of information -- in important detail -- needed by people pulling their homes and communities back together.

It has been demonstrated repeatedly, however, in weather emergencies like this that people look to the broadcast media because of their immediacy. This was brought out some years ago in a University of Wisconsin study of public weather awareness which showed that people rely on broadcast media for 90 percent of their weather information.

Last May, broadcast of National Weather Service bulletins spelled the difference between life and death for many people who took cover from the storm after hearing a warning or seeing it on TV.

The survey team concentrated on the Erie, Pennsylvania, and Youngstown, Ohio, areas where they met with nearly 30 key broadcast personnel whose stations blanketed the most hard-hit counties in the two states.

As they traveled from station to station, the team heard over and over again comments like "people never thought killer tornadoes would happen here" -- "we could do more on public education" -- "maybe now people won't complain when weather warnings interrupt their favorite programs."

Broadcasters serving the storm-hit counties of the two states tried their best to keep people informed minute-to-minute from the earliest reports of severe weather. Station logs freely shared with the team attest to this. And they, too, felt the battering of the storm -- phone lines down, electrical surges, antenna damaged, and power failures.

They earned the appreciation of listeners and viewers for speeding urgent weather advisories via the air waves. Radio and TV stations were busy around the clock gathering and relaying storm bulletins and advisories. One radio station stayed on the air continuously for 27 hours broadcasting storm information almost exclusively.

The vast majority of broadcast weather advisories originated with the National Weather Service, but a significant portion, including some initial tornado warnings and sightings, originated with commercial weather services, Ham operators, and station-owned radar.

The value of a warning tone to accompany the silent "crawl" message across the bottom of TV screens was discussed as were pre-taped warning messages for both radio and TV. A number of engineers were found to be Ham operators and in several instances fellow amateurs called in the first sightings and damage reports.

All outlets were aware and involved in the Emergency Broadcast Service although doubt was expressed about the follow-through of individual stations because airing of emergency messages through the EBS network is discretionary with management.

A number of broadcast executives commented that the disaster occurred at a time of day when the lowest number of people are watching TV. One manager said that when the Weather Service tornado watch was changed to a warning, his viewing audience was 22,000 homes out of a potential 284,000 in a 10-county area.

The answer to community awareness, many of them suggested, may lie in promotion of NOAA Weather Radio, with the media taking the lead. The weather radio, they revealed, is a prime element in their coverage of the subject. Such an effort, one program director suggested, should be aimed especially at trailer park residents, retail shops, schools, even manufacturing firms.

There was a general readiness to work with NOAA in expanding community awareness through "show and tell" presentations on TV, interviews, video cassette programs, spot announcements, and organizing of citizens through local fire, police, and emergency forces.

Broadcasters are interested in any help or guidance they can get to speed their processing and airing of important weather bulletins. At a time of Federal personnel cutbacks, however, they may be counting on some personal services that can no longer be provided by NWS. Their attitude throughout, however, was "Whatever it takes to get the job done, let's examine it."

Admittedly, they want to speed up processing of weather bulletins. It takes TV stations about 5 minutes to produce and air a "crawl" message, for example -- too slow for tornado effectiveness. They expressed interest in investigating advantages of the NWS Weather Wire Service or any other method short of the telephone for keeping on top of severe weather, including possible direct wires to local weather offices.

CHAPTER 5

COMMUNITY AWARENESS

5. WESTERN PENNSYLVANIA

Efforts for community awareness and education in western Pennsylvania are, at best, minimal. The officials in cnarge and their staffs at Erie, Pennsylvania, and Youngstown, Ohio (Youngstown has warning responsibility for Mercer and Lawrence Counties in Pennsylvania), conduct tours, speak to groups, and meet with county/local officials as time permits but primarily in their respective metropolitan areas. The meteorologist in charge and Weather Service Forecast Office flash flood meteorologist (focal point) acts as liaison with Emergency Management and county officials through visits and training sessions as the opportunity arises. The WSFO warning preparedness focal point makes numerous mailings to schools, media, law enforcement, etc., on weather preparedness during the course of a year.

During the May 31 episode, it was evident to the meteorologist in charge at Pittsburgh from both reports and incoming phone calls during the evening that many residents in Pittsburgh's area of warning responsibility did not know what to do or did the wrong thing. It will require greater effort and, therefore, more staff time at Pittsburgh and Erie to properly reach a significant percentage of the population in <u>all</u> western Pennsylvania counties.

Many people were not aware of watches and/or warnings that were issued because they did not have a tone-alerted NOAA Weather Radio. Many radio or TV stations did not promptly broadcast the information. In many cases, people who did hear a warning, heard it via a fire department broadcast on a scanner. Scanners are radios that monitor the various emergency frequencies such as police, fire, and ambulance. A surprisingly large percentage of the population in western Pennsylvania own these scanners.

In addition to improving the media dissemination of watches and warnings, there is a need to improve the communications of critical weather information to need-to-know people, such as the local fire departments. For example, the chief of the Cranesville, Pennsylvania, fire department said he had no idea there would be severe weather. He did not receive watches or warnings.

There is also a need to work with communities in developing procedures to alert the general public about severe weather. For example, many communities have fire sirens that can be sounded from a central location.

5.1 Ohio

The severe weather preparedness program in Ohio has evolved into ongoing activities designed to heighten public awareness of severe weather and to educate people how best to protect themselves from severe storms. In fact, a state law requires tornado drills in schools and the teaching of severe weather safety rules. Another part of the program is organized, continuous on-station preparedness at Ohio Weather Service offices. By organizing both of these areas and making use of the Warnings Preparedness Meteorologist (WPM), a specialized public awareness position, they have been able to lighten the workload of the field offices as far as routine public relations and on-station preparedness is concerned. This has allowed office managers to devote more time concentrating on problem areas.

The public preparedness program in Ohio is one of the most extensive in the country. Since 1979, the state has had tornado and winter safety week campaigns. These programs were developed in cooperation with the National Weather Service and now include several state, local, and county government agencies as well as private corporations. Both of these campaigns take a large part of the public liaison work off the shoulders of the field offices. The Winter Safety Week is a media blitz with informational safety and preparedness packets and prepared releases. The program is conducted in early December and receives good media coverage.

The tornado campaign touches all bases with distribution of preparedness information through the printed and electronic media. This campaign also extends to preparedness activities and coordination by local government and safety officials. Dissemination and communication systems are tested and preparedness plans receive an annual review. A statewide tornado drill is conducted annually, and there is total media saturation with safety information. This media saturation has led to most Ohio residents learning safety rules without even realizing the educational process going on. The Ohio tornado campaign has been a model for National Federal Emergency Management Agency (FEMA) preparedness information.

Preparedness and coordination between the NWS and state, county, and local government agencies is also accomplished in Ohio by the warnings and preparedness meteorologist participating in several recurring statewide programs. The Cleveland WPM routinely (6 to 8 times a year) instructs police and sheriff dispatchers in severe weather preparedness through the Ohio Peace Officers Training Academy. This has been an excellent way to generate storm reports and to help local communities develop severe weather plans of action. This same type of instruction has taken place at the Ohio Fire Training Academy, and annually, the WPM gives a preparedness presentation at an Ohio Disaster Service Agency quarterly local directors meeting. In addition, National Weather Service personnel have worked closely with the Ohio Cable Television Association through their annual conventions to promote the importance of relaying weather information to their subscribers. This contact has pointed out some important dissemination problems that have been addressed at the national level. Each year, the Dayton, Cincinnati, and Columbus offices participate in the Hamvention. This participation is aimed at publicizing SKYWARN. Full warning dissemination and local preparedness is also ensured by a strong local visitation program by all Ohio NWS offices. Ohio Weather Service supervisors have placed a strong emphasis on the importance of this activity.

The Ohio preparedness program also includes an excellent SKYWARN network. Every Ohio NWS office has developed a SKYWARN network of amateur radio operators and these networks have been coordinated to ensure relay of storm information across the state. These networks have been developed and maintained by frequent visits and presentations to cooperating groups by all Ohio NWS offices. Each Ohio NWS office has a host amateur radio club that has installed antennae and one or more ham radios in their office. During severe weather, amateur radio volunteers come into the offices to collect and seek information pertinent to the severe weather events. SKYWARN has proven to be the backbone of Ohio's severe weather warning program. As SKYWARN has been expanded, the Ohio severe weather warning program has improved. The spotter reports have also increased as a direct result of training at the state run safety force training academies.

To sharpen on-station preparedness, the Cleveland office has provided station preparedness drills to all Ohio weather offices to augment locally prepared drills. These drills have ensured that all Ohio NWS employees are aware of preparedness objectives and expectations. They also have developed an organized, quick storm survey and reporting systems throughout the state. This program is run by the Cleveland office with input from all the local offices. The emphasis placed on rapid storm and warning investigation has led to improved severe weather warning performance and more accurate storm reports.

An aggressive statewide severe weather verification program also has improved the state's warning program. Through quick and thorough reviews of severe weather events with the personnel involved, they have been able to learn and grow in their handling of severe weather in the state. The Cleveland office has conducted a thorough quality control program on severe weather products, from statements to warnings, for several years. This emphasis and feedback has resulted in quality products complete with proper coding.

The Cleveland forecast office has taken an active role in coordinating the preparedness program throughout the state. This has ensured a smooth and ever-growing program not bogged down by local nuances and has ensured a uniformity within the political jurisdiction of the state. This in itself eliminates problems. They also have been able to provide assistance to the local offices in problem areas and to provide support when needed.

5.2 Newton Falls, Ohio -- A Prepared Community

Newton Falls, Ohio, is a pleasant community of 5,000 people located in extreme western Trumbull County, 40 miles southeast of Cleveland. The city was built up around the steel industry and has suffered economically in recent years because of the decline of the industry throughout northeast Ohio.

Newton Falls has been emphasizing disaster awareness for several years, and on May 31 the awareness program saved lives. Two gentlemen played a major role in the awareness activities. They were both officers of the Newton Falls Public Safety Reserve (a volunteer organization). Over the years, the two conducted seminars to teach people about severe weather and saw to it that articles appeared in the local newspaper to promote severe weather awareness, safety rules, and explain the use of the siren system. In addition, they were perched on the roof of the fire station any time a severe weather watch was in effect to act as spotters for the community. Both men participated in several spotter training programs conducted by the National Weather Service.

Late in the afternoon on May 31, a tornado watch went into effect. One of the Safety Reserve volunteers climbed to the roof of the fire station to assume his spotter position. However, before he climbed to the roof, he went next door to the American Legion Hall and told over 100 bingo players that if the siren sounded, they should take cover under the tables and chairs.

At approximately 6:38 p.m., the volunteer spotter saw a tornado just west of Newton Falls heading right for the downtown area. He radioed below to the police station to sound the siren. The siren wailed for about 60-90 seconds before the tornado silenced the blast. The spotter just barely made it to safety in the building's basement. The sirens sent the people in the Amercian Legion Hall scrambling for safety under the tables and chairs.

At 6:40 p.m., an F3 tornado, packing winds of up to 200 mph, slammed into the center of Newton Falls. The tornado heavily damaged or destroyed many buildings, including the American Legion Hall and a school adjacent to the fire station. The tornado also hit a large water tower just southwest of the fire station and was strong enough to slightly twist the tower. Numerous homes to the west and east of the downtown area were destroyed or heavily damaged with the strongest damage occurring in the downtown area and to the east of the town.

The survey team found many people in the community heard the siren and knew what to do. Considering the severity of the tornado and its impact on the community, it shows having a preparedness plan and promoting education of the citizens saves lives!