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THE ROLE OF LITIGATION IN THE DISCOVERY OF A PROBABLE UNDOCUMENTED F1 TORNADO IN MUNSTER, INDIANA (27 JUNE 1995)

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1. INTRODUCTION

One of the major challenges for the operational and research severe weather communities is the validation of warnings and documenting the enhancements in their effectiveness from investments in technology and training (Rothfusz 2000). It is well known that not all large hail, damaging winds and (weak) tornado occurrences are documented, creating gaps in the record which distort both climatological and forecast verification statistics, including the Probability of Detection (POD) and False Alarm Rate (FAR) (Brooks 2004).

Forensic investigations are frequently involved with the reconstruction of severe weather events relevant to litigation. This paper reports on one such study, the outcome of which is the documentation of an apparent F1 tornado not reported in *Storm Data* or other databases. According to *Storm Data*, on the evening of 27 June 1995 (2300 UTC), thunderstorm winds (speed unspecified) damaged car windows and several buildings in Munster, IN, with a total loss of $20,000. The site is located on the Indiana–Illinois state line, 48 km and 98 degrees from the Romeoville, IL [KLOT] WSR-88D. No severe thunderstorm warnings were issued for Lake County, IN, as the parent storm passed through. Our investigation, however, was the result of insurance claims for major structural damage to a GE distribution warehouse, primarily involving a large section of the roof (Fig. 1). There was a ~100 meter wide, southwest-to-northeast swath of roof in which 2 inch river rock was scoured, roofing fabric was torn and bubbled, and skylights were damaged. A heavy air conditioning unit was hurled off the roof into an adjacent field (Figs. 2 and 3). Total damage to the structure and building contents was estimated at several million dollars. The opposing side (the plaintiffs) in the litigation argued that the loss of the warehouse roofing system was the result of poor design or installation which lead to the failure during microburst winds of no greater than 55 mph. The KLOT WSR-88D radar radial velocity display indeed indicate that straight line winds, if from the west, which swept over the building site had speeds <55 mph. The defendants, representing the insurers, were on the other hand, of the belief that a tornado accounted for the observed damage, thus absolving its policy holders of blame. This opinion was reinforced upon review of a climatology of peak wind gusts and the number of times wind gusts reaching mph or higher were recorded at first order NWS stations in the lower Great Lakes and Ohio Valley region. The study period extended from 1988 (when the warehouse roof was initially installed) though the year 2002. Figure 4 suggests that there was a strong likelihood that gusts of 70-80 mph were experienced at least once at the warehouse site during this period. In addition, wind speeds in excess of 55 mph were likely to have occurred approximately once per year (Fig. 5). Yet the only roof failure in this time frame occurred during the 27 June 1995 storm in which the opposing party maintained straight line winds were 55 mph or less.

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2. GENERAL WEATHER FOR 27 JUNE 1995

As a result of the discovery process leading to a potential trial, a considerable amount of information was collected, allowing for the creation of a rather comprehensive meteorological analysis and damage assessment. Resources included GOES and NEXRAD imagery, NLDN flash data, aviation weather reports, surface and upper air analyses, *Storm Data* and SPC summaries, local storm reports, NWS public forecasts and warnings, aerial photographs, numerous eyewitness accounts (through depositions) and damage reports from local newspapers, police, utility and fire department logs.

During the afternoon and early evening of 27 June 1995, numerous, though generally short-lived thunderstorms erupted within a 500 mb cold-core circulation drifting over Illinois and Indiana (Figs. 6 and 7). Most storms, though intense, generally did not reach severe status. No severe thunderstorm or tornado watches were issued. However, as is typical of cold-core convection in this region during late spring and early summer, the storms did produce a number of funnels and small, short lived tornadoes. There were five funnel reports and three confirmed touchdowns within ~160 km of Munster over approximately a seven hour period (Fig. 8). The only tornado warning issued was for Grundy County (IL) around 2130 UTC, for a confirmed F1. No warnings were issued for Lake County, IN, though a special marine warning for thunderstorm wind gusts to 40 mph were issued for the Illinois and Indiana coastal waters of Lake Michigan. The highest reported surface wind gust in the region was 47 mph at

Matteson, IL in southern Cook County, IL, about 17 km west of Munster.

Figure 9 is the GOES visible image taken approximately 10 minutes after the major damage occurred in Munster (star). The multi-cellular nature of the convective development on this date is clear, which was very characteristics of early-summer cold-core low pressure systems. The wind damage occurred near the leading edge of the advancing cluster of thunderstorms.

3. THE EVENTS IN MUNSTER, INDIANA. At 2322 UTC, the local Munster police call log noted a "tornado spotted heading N/E" from an address less than a kilometer from the GE warehouse. The local newspaper on 28 June 1995 headlined, "Tornado Whips Through Munster." It stated, "the tornado moved through Munster from the southwest, traveling to northeast about 6:20 pm…said Munster Police Chief Lt. Dean Patrick, 'The whole thing was over in matter of a minute or two'…No injuries were reported, but the funnel cloud damaged cars and roofs and tore down trees and power lines…power and phone outages were reported in the southeast part of Munster...a semi-trailer was overturned, and the roof and skylight were damaged at the General Electric building…the funnel cloud passed through the *Times* parking lot (note: located ~1000 m northeast of the GE warehouse), turning over a delivery truck, blowing out car windows and carrying newspaper boxes…in the Munster Business Complex roofs were stripped off, and styrofoam packing material was strewn across the road….(a man) had just opened the back door to his store to let the wind flow through when he saw a funnel cloud filled with debris…'the wind got so intense so fast'…as he saw the funnel cloud, which he described as five times higher than a telephone pole…"

The *Hammond Post-Tribune* ran a story on 29 June 1995 which headlined "Conflicting Reports Follow Heavy Winds." It was stated that "…an unidentified man saw a funnel cloud drift over the General Electric Appliance Distribution Center…and to the northeast. Around 6:20 PM CDT, an eye-witness, whose work place adjacent to the warehouse was damaged, reported '…a dark cloud along with a vortex… a 'turny' looking thing with a bunch of debris in it…" This eyewitness's report was later repeated under oath in a deposition using essentially the same language.

Another *Post-Tribune* article stated that the Lake County Emergency Management Agency had been unable to find anyone who could confirm that a tornado did indeed touch down. A spokesperson for the NWS Chicago WSO was quoted as stating "the system spawned a number of funnel clouds in Illinois but that none of them touched down."

The Lansing, IL Airport AWOS station (KIGQ) is located 1000 m due west of the north end of the warehouse (the portion damaged). At 2301 UTC, it reported a ceiling of 2200 feet broken and ¼ to ½ mile visibility (presumably in rain), winds from 100 degrees at 5 kts, and temperature of 22.8 C and dewpoint of 21.7 C. For the next report at 2321 UTC, the ceiling had lowered to 1500 feet broken, visibility was 2 miles, with temperature and dewpoint both 21.1 C, winds 260 degrees at 20 kts (with no gusts). The altimeter had jumped 0.04 inches between observations, strongly indicating the passage of an outflow boundary. At this point electric power in the area failed. Very heavy rain and small hail occurred at the warehouse site immediately after the damaging winds.

4. DETAILED ANALYSIS. A detailed analysis of the damage, and its relationship to the parent thunderstorm, was conducted. It was our conclusion that while indeed a weak microburst, with wind gusts 40-55 mph from the west, had swept over the warehouse, the resulting damage was from a small tornado forming along the leading edge of the outflow. It is suspected this was a "gustnado" or non-supercell tornado (Lee and Wilhelmson 1997).

The KLOT base radial velocity display at 2319 UTC suggested outbound winds (assumed to be essentially westerly from the AWOS report) of 25-35 kts (29-40 mph) were passing over the warehouse. The base reflectivity at the same time showed the storm core with a 58 dBZ reflectivity approaching the warehouse. (At this range, the 0.5 degree beam height would be only 0.58 km above the radar). The mesocyclone detection algorithm located a 3D correlated shear just west of the warehouse at 2313 UTC. As shown in Figs. 10 and 11, this feature moved east-northeast, passing just to the north of the warehouse at the approximate time of the damage (2319 UTC). It was located on the southern flank of the band of heaviest rainfall totaling 1.50 to 1.75 inches (not shown) and cloud-to-ground lightning activity (Fig. 11). The 3-D correlated shear feature persisted for another 30 minutes while the cell moved northeastwards. The 3-D shear feature was shallow (1.9 to 4.6 km) with radial and azimuthal diameters of 1.3 and 4.5 km respectively at 2319 UTC. While the eyewitness description of the event suggests a vortex developing upward from the ground in classic gustnado fashion, there is some radar support for a weak circulation aloft which could have abetted the vortex development.

The eyewitness and damage reports were compiled, located and arranged in a time line. The following are the more salient reports listed in spatial order from the southwest to the northeast:

(1) GE warehouse building:

- 100 meter-wide swath of roof damaged
- 2 inch diameter river rock thrown off roof both to the east AND the west
- large boxes sucked out the *west*-facing doors of the warehouse
- large HVAC unit (~500 lbs?) torn from roof mooring and hurled ~100 m to northeast

- empty trailers in east side parking lot blown into fences (in the west-wind wake region of the large north-south oriented building)

(2) Empty, parked tractor trailer tipped over on road

(3) Munster Times building (east side only):
- picnic table blown across parking lot
- small tree uprooted and tossed
- panel truck tipped over and rotated
- whirling debris seen by employees
- plexiglass debris from GE building found

(4) Whirling debris cloud reported on ground

(5) Munster Business Complex:
- south and east door blown in
- roof damage
- roof damage to second building
- packing material hurled across street

(6) Damage to cars, windows blown out

(7) Damage to cars

The above are plotted on an aerial photograph (Fig. 12). It is clear that the damage, while sporadic, lies in a narrow curvilinear swath less than 100 meters wide and which extends sporadically for slightly more than 2 km. The damage swath could be considered as spiraling inwards towards the weak circulation center identified by radar. The damage characteristics are typical of FO and F1 intensity. An independent engineering report estimated a 105 mph wind would have been required to remove the warehouse roof HVAC unit from its moorings. Schmidlin et al. (2002) note that only 4% of vehicles involved in F1 and F2 tornadoes are actually tipped over. Though the newspaper delivery truck, an empty panel van with a high center of gravity, would probably be more prone to tipping than most vehicles, but this simply can not be explained by 55 mph straight-line winds. The damage track appears to have moved northeastwards along an eastward-propagating gust front. Had this been classic straight-line wind damage, the orientation would be expected to have been oriented much more east-west.

Knupp (2000) suggests that, in part, due to the lack of comprehensive damage surveys for all severe storms, the number of weak tornadoes (F0-F1) may be significantly underestimated by a factor of 2-3 or more. Knupp proposed that the aspect ratio of the damage pattern be used as a strong constraint in differentiating the classification of damage between straight-line downburst and tornadic winds. For tornadic-scale vortices, the length/width ratio of the damage pattern should be of an order of 10 or higher. Microburst winds would tend to exhibit a small aspect ratio and divergent wind/damage patterns.

5. SUMMARY AND CONCLUISONS. A reconstruction of the damage path indicates it was confined to 100 m width and extended for about 2.0 km. Thus, it would appear to fit easily within the criteria proposed by Knupp (2000) to distinguish straight-line microbursts from small tornadic vortex winds. The sporadic nature of the damage suggested one or more suction vortices. The damage path, which ran almost parallel to the advancing gust front, curved inwards towards the cyclonic circulation (3-D correlated shear) of the parent storm. Aside from damaging a large swath of the warehouse roof, impacts included large (>2 inch) river rock being hurled off the roof in *both* east and west directions, overturned trailers and delivery trucks, debris carried more than a half mile, heavy VAC equipment being uplifted and removed from roofs, damage to other roofs and small trees being uprooted and tossed. We believe the evidence compiled is consistent with a short-lived F1 tornado.

Given the extent of litigation endemic in the U.S. today, can we suggest that there may be other tornado, large hail or damaging wind investigations which have uncovered incidents which would further enhance the severe weather climatological database? A mechanism to update the "official" records and climatological databases as a result of forensic and insurance claims investigations is desired.

6. ACKNOWLEDGEMENTS

This work has been supported in part by the National Science Foundation (ATM-0221512) and the support of the law firms of Bullaro & Carton, and Kopka, Pinkus & Solan, and especially Robert Kopka, Esq. We appreciate the input and suggestions received from Joe Schaeffer, Mike Magsig, Gregg Stumpf, Jason Levitt and Tom Nelson.

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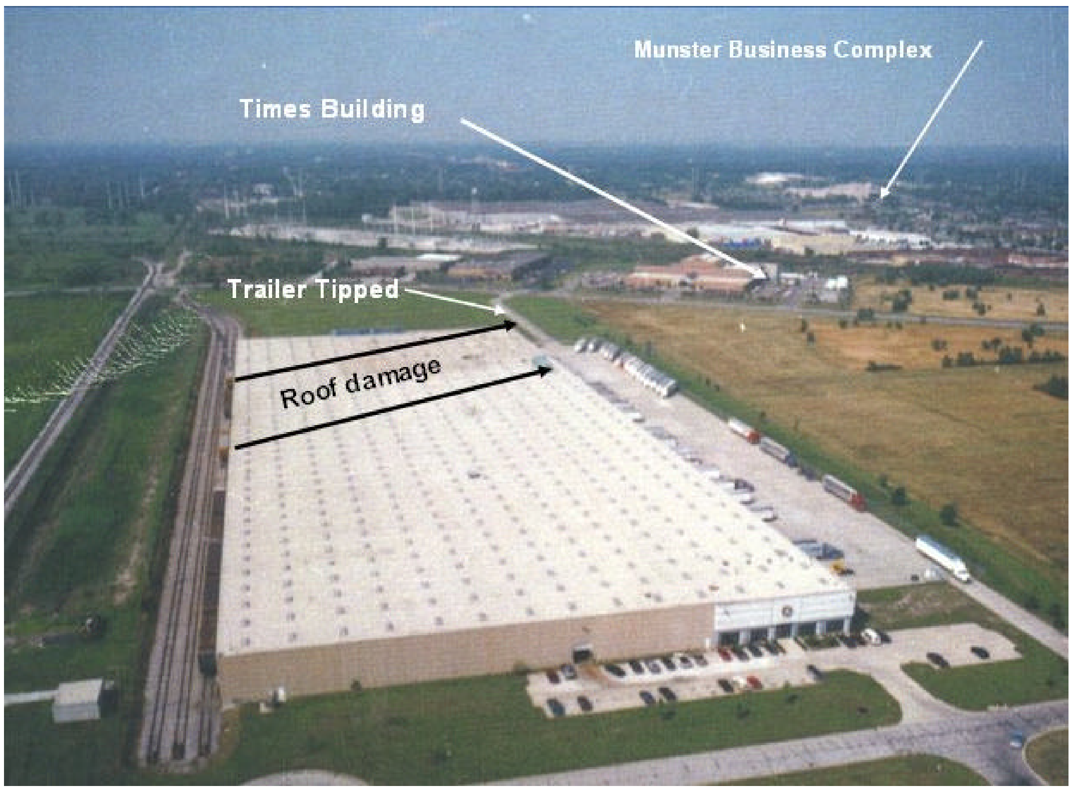

Figure 1. Aerial photograph (looking north) of a GE warehouse in Munster, IN, that sustained wind damage to the north end of the roof during the thunderstorm of 27 June 1995. Other building complexes also sustaining damage are indicated.

Figure 2 (left) Ballooned roofing fabric, scoured 2 inch diameter river rock and damaged skylights covered a large section of the north portion of the GE warehouse roof. Figure 3 (right) Large HVAC unit ripped from this mooring and tossed into the field northeast of the warehouse.

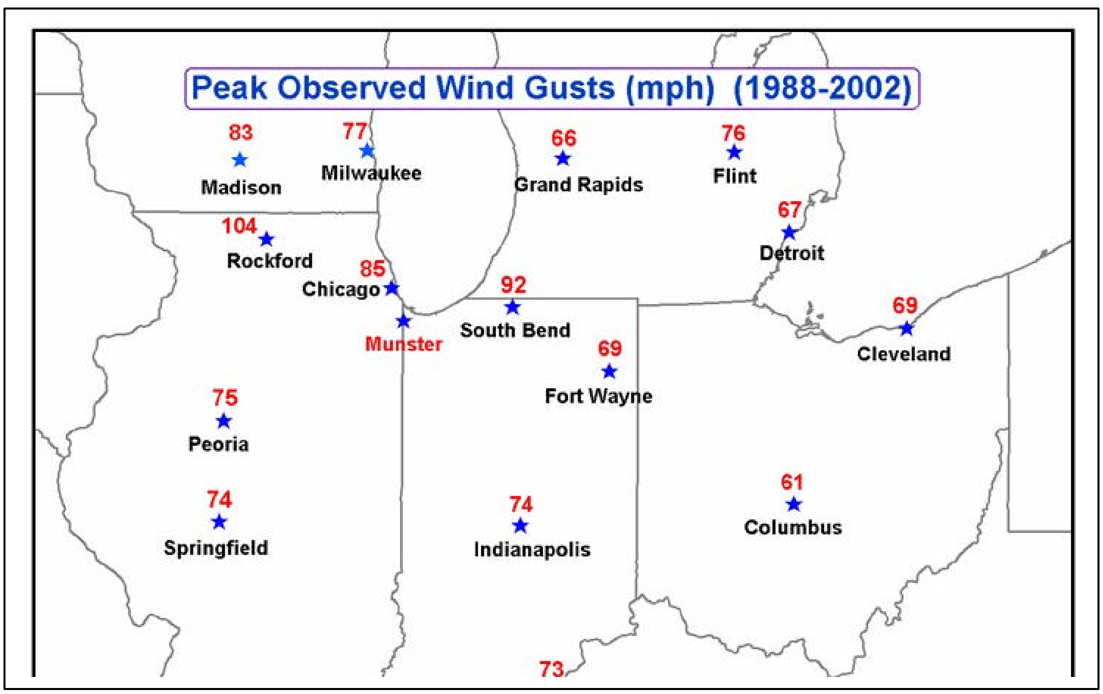

Figure 4. Peak observed wind gusts (mph) at NWS first order stations in the lower Great Lakes and Ohio Valley from 1988 through 2002. The location of the site under investigation (Munster, IN) is also shown.

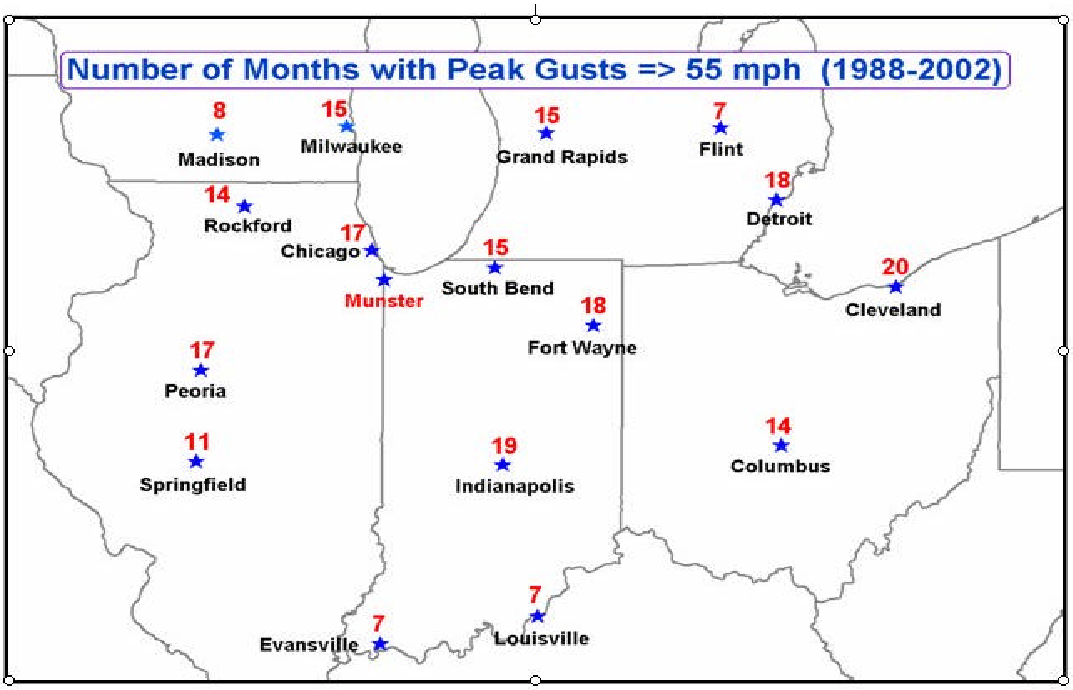

Figure 5. The number of months in which peak wind gusts of 55 mph or higher were reported at NWS first order stations in the lower Great Lakes and Ohio Valley from 1988 through 2002. The location of the site under investigation (Munster, IN) is also shown.

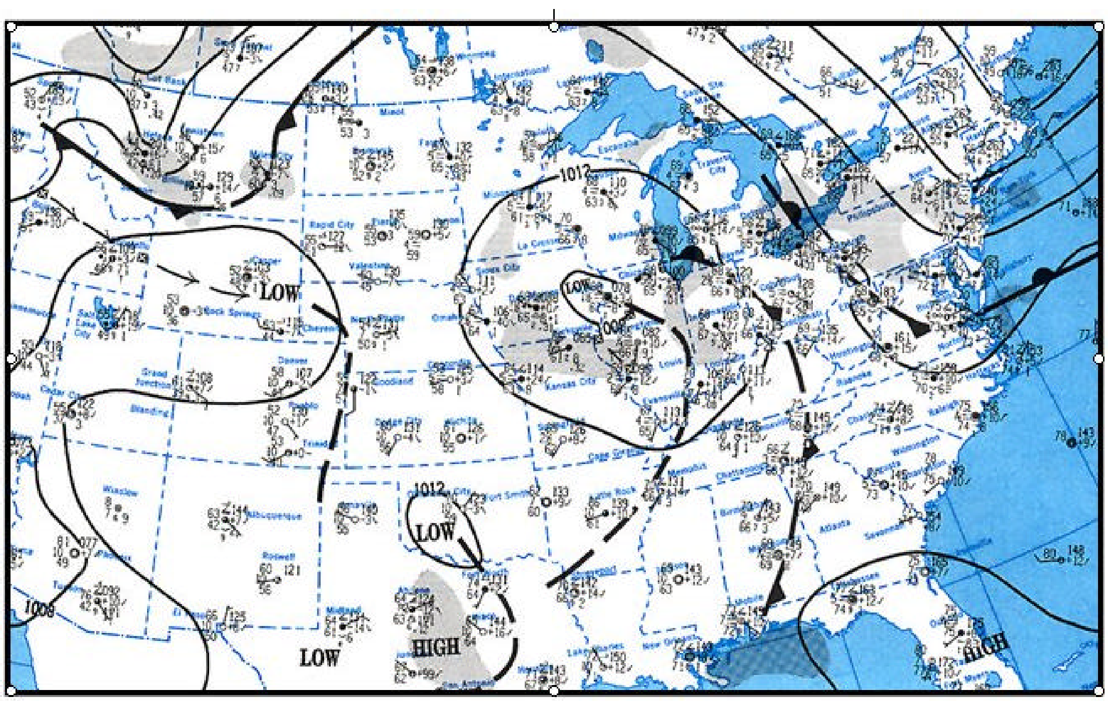

Figure 6. Surface analysis at 1200 UTC on 27 June 1995 showing a quasi-stationary occluded low pressure system over the Midwest, a reflection of a cold core cut off low at 500 mb.

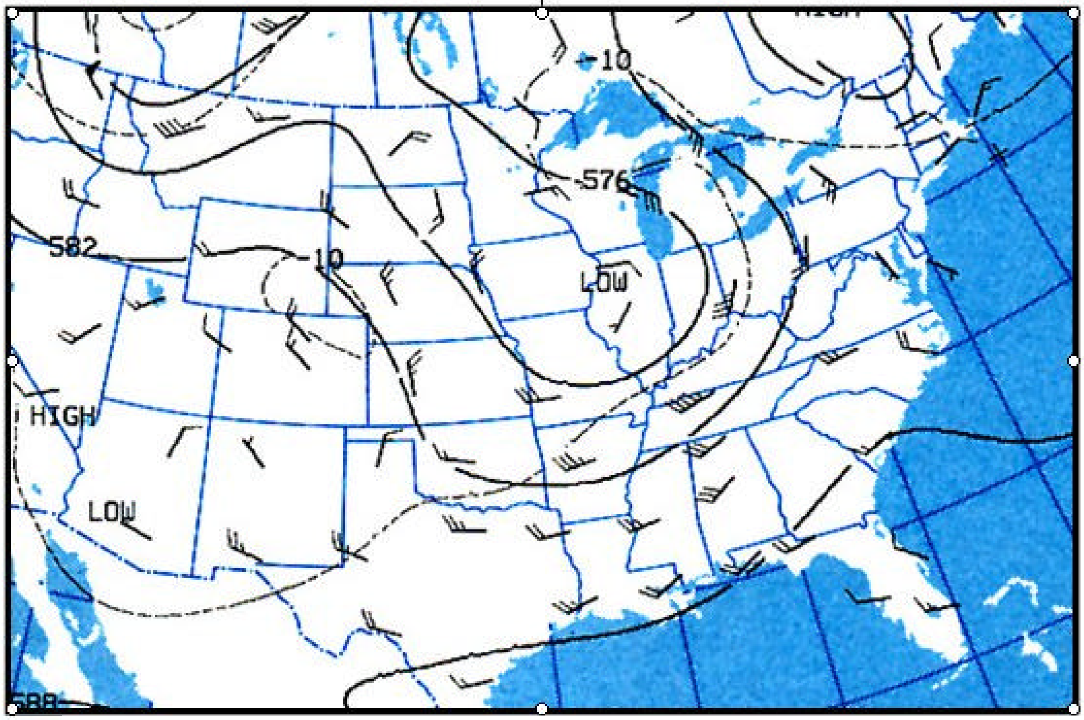

Figure 7. 500 mb chart, 1200 UTC, 27 June 1995. Note cut-off low over Ohio Valley.

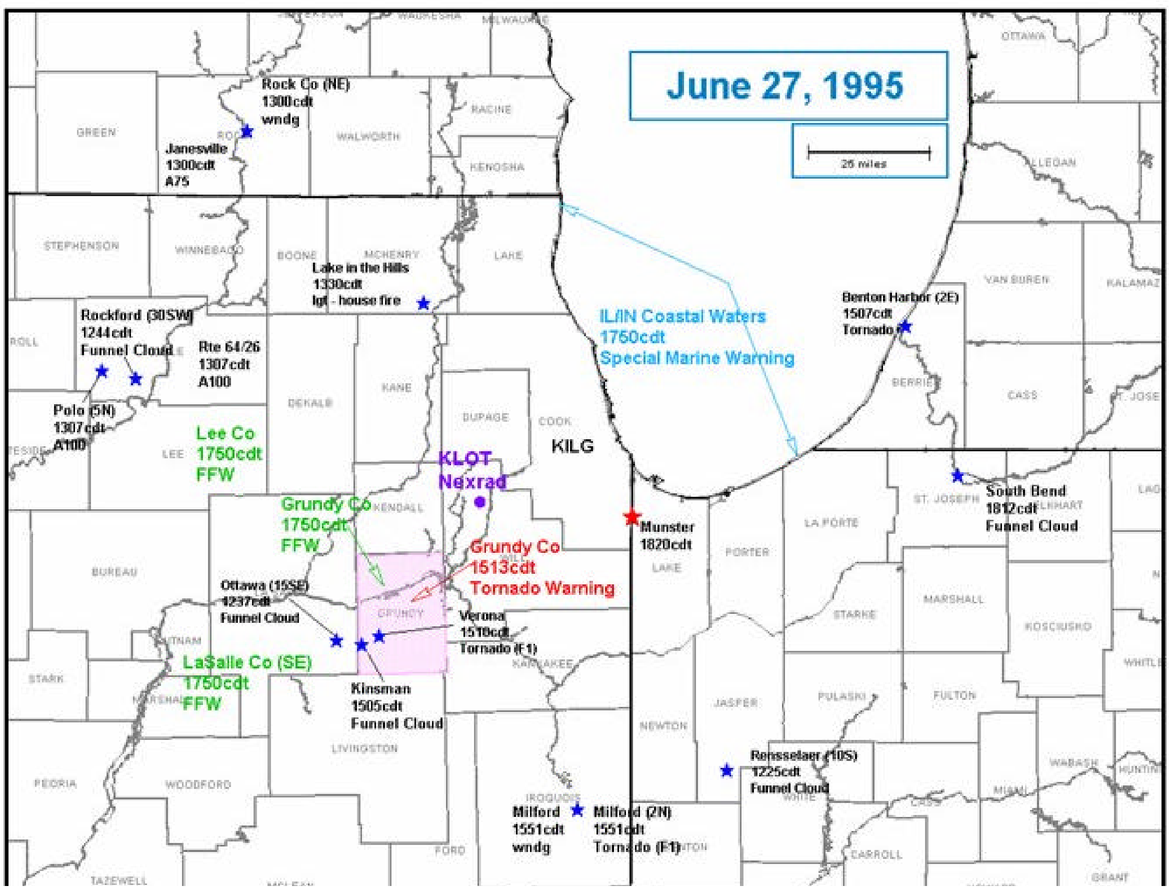

Figure 8. Severe weather reports for portions of Illinois, Indiana, Wisconsin and Michigan, 27 June 1995.

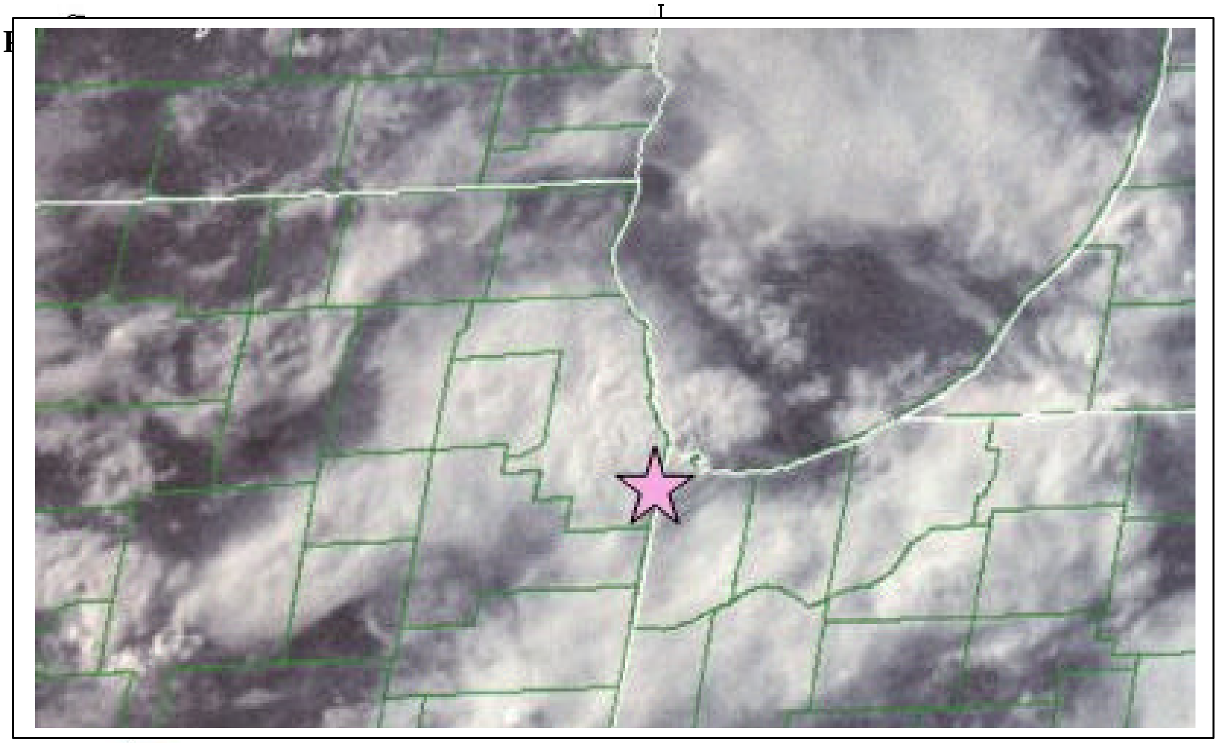

Figure 9. GOES visible imagery, 2330 UTC, 27 June 1995. Star marks the location of the suspected F1 tornado 11 minutes before.

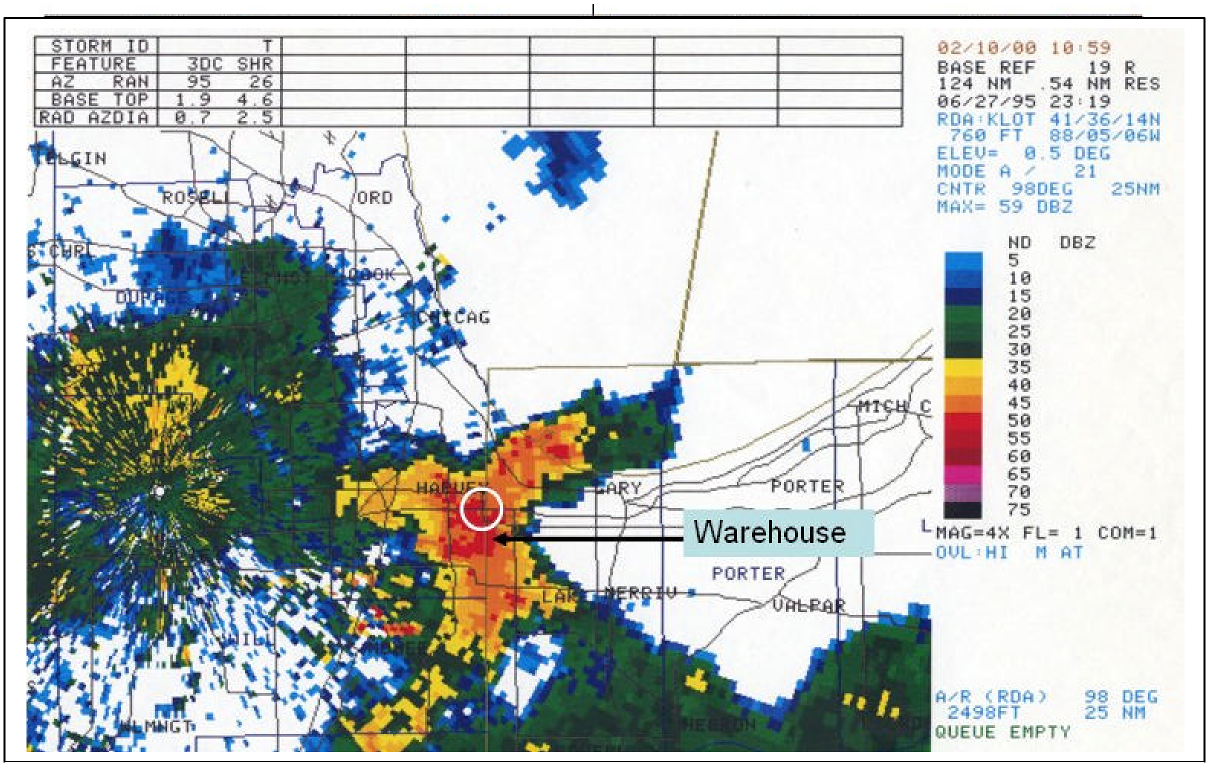

Figure 10. Romeoville, IL (KLOT) NEXRAD base reflectivity at 2319 UTC, 27 June 1995, within a few minutes of the expected tornado at the indicated location (warehouse). The 3-D correlated shear symbol is also highlighted in white. This circulation feature persisted for at least 30 more minutes.

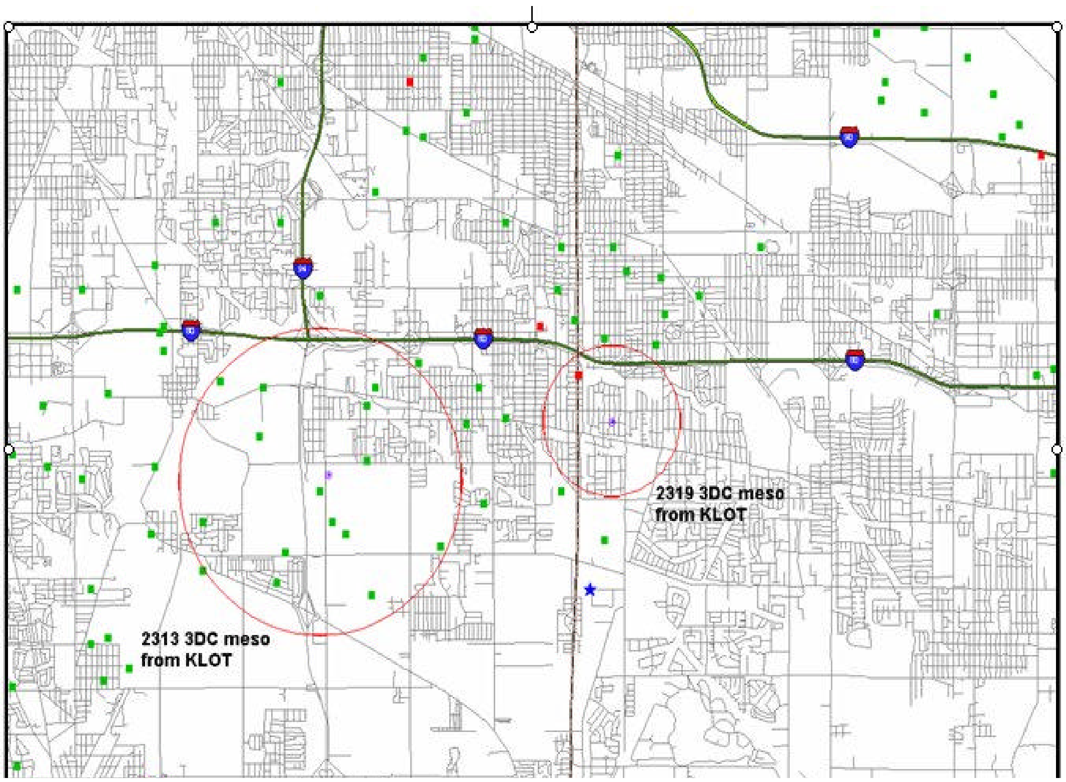

Figure 11. Location of 3-D Correlated Shear at 2313 and 2319 UCT, with the warehouse located indicated by a blue star. The green dots represent NLDN cloud-to-ground lightning flashes.

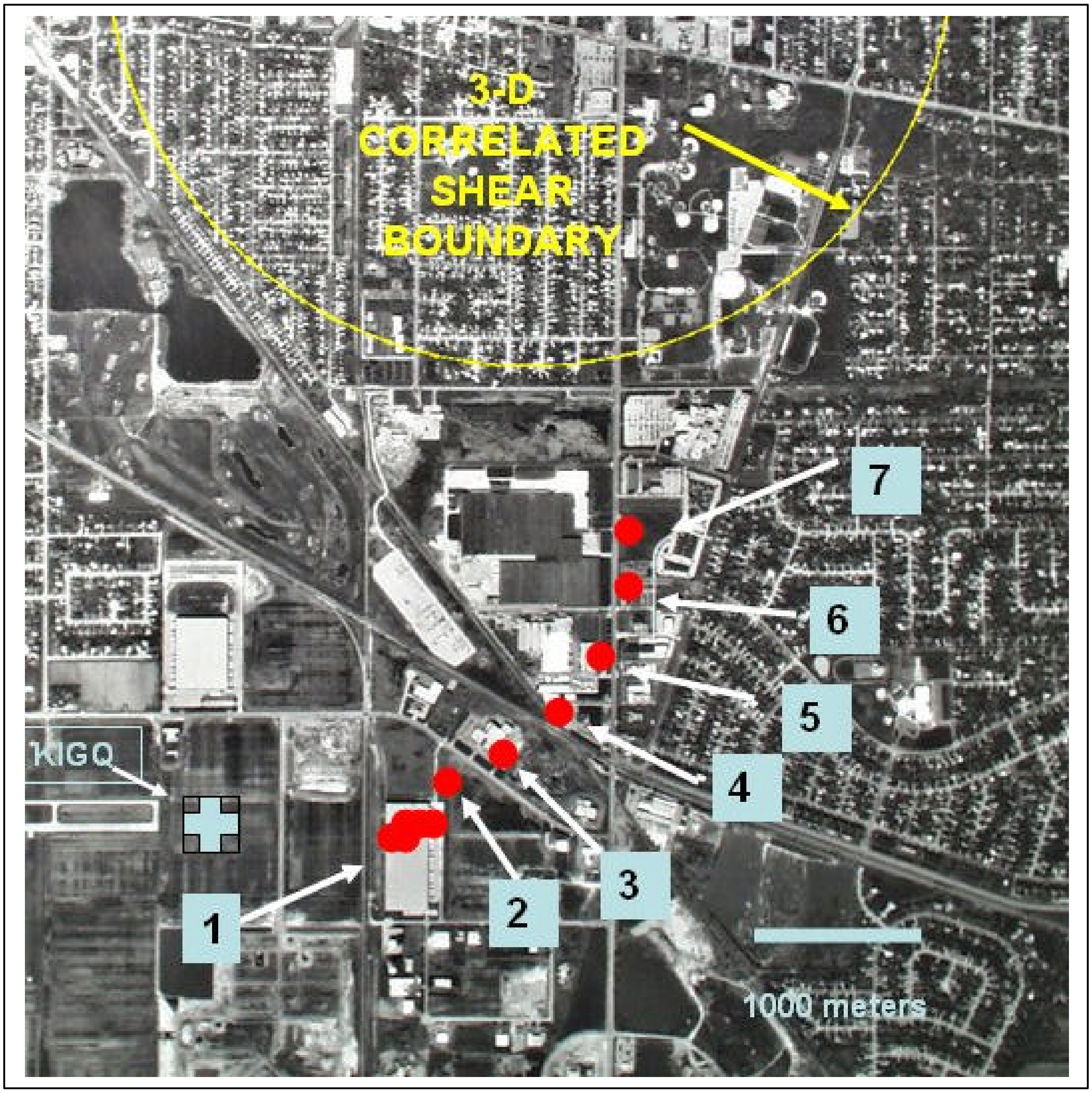

Figure 12. Damage locations (red) with identification numbers as listed in text. The damage path is discontinuous, and measures approximately 100 meters wide by slightly over 2 km long. The southern portion of the 3-D Correlated Shear feature detected by the KLOT radar is indicated in yellow. The Lansing, IL AWOS sensor location (KIGQ) is located west of the warehouse.