

National Transportation Safety Board

Office of Aviation Safety

Washington, DC 20594



ERA22FA397

METEOROLOGY

Specialist's Factual Report

November 15, 2022

TABLE OF CONTENTS

A. ACCIDENT	3
B. METEOROLOGY SPECIALIST	3
C. DETAILS OF THE INVESTIGATION	3
D. FACTUAL INFORMATION	4
1.0 SYNOPTIC SITUATION	4
1.1 Surface Analysis Chart.....	4
1.2 Upper Air Charts	5
2.0 STORM PREDICTION CENTER CONVECTIVE OUTLOOK	9
3.0 SURFACE OBSERVATIONS	13
4.0 UPPER AIR SOUNDING	16
5.0 SATELLITE DATA.....	18
6.0 NATIONAL RADAR IMAGERY	19
7.0 WEATHER SURVEILLANCE RADAR IMAGERY.....	20
7.1 Volume Scan Strategy	20
7.2 Beam Height Calculation	21
7.3 Reflectivity.....	22
7.4 Base Reflectivity and Lightning Data	22
8.0 PILOT REPORTS	23
9.0 SIGNIFICANT METEOROLOGICAL INFORMATION	24
10.0 CENTER WEATHER SERVICE ADVISORIES	25
11.0 AIRMEN'S METEOROLOGICAL INFORMATION.....	25
12.0 GRAPHICAL FORECASTS FOR AVIATION.....	26
13.0 TERMINAL AERODROME FORECAST	26
14.0 NATIONAL WEATHER SERVICE AREA FORECAST DISCUSSION	27
15.0 WINDS AND TEMPERATURE ALOFT FORECAST.....	29
16.0 PILOT WEATHER BRIEFING	30
17.0 ASTRONOMICAL DATA	30
E. LIST OF ATTACHMENTS	31

A. ACCIDENT

Location: Arthur, Kentucky
Date: September 3, 2022
Time: 1740 central daylight time
2240 coordinated universal time (UTC)
Helicopter: Rotorcraft JetExec; Registration: N162NH

B. METEOROLOGY SPECIALIST

Specialist Paul Suffern
National Transportation Safety Board
Washington, DC

C. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's Senior Meteorologist was not on scene for this investigation and conducted the meteorology phase of the investigation remotely, collecting data from official National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) sources including the Weather Prediction Center (WPC) and the National Center for Environmental Information (NCEI). This Specialist's Factual Report contains the meteorological factors pertinent to the weather surrounding the accident time. All times are central daylight time (CDT) and are based upon the 24-hour clock, where local time is -5 hours from UTC. Directions are referenced to true north and distances are in nautical miles. Heights are above mean sea level (msl) unless otherwise noted. Visibility is in statute miles and fractions of statute miles. NWS station identifiers use the standard International Civil Aviation Organization 4-letter station identifiers versus the International Air Transport Association 3-letter identifiers, which deletes the initial country code designator "K" for U.S. airports.

The accident site was located at latitude 37.1759° N, Longitude 86.1503° W, at an approximate elevation of 510 feet (ft).

D. FACTUAL INFORMATION

1.0 Synoptic Situation

The synoptic or large-scale migratory weather systems influencing the area were documented using standard NWS charts issued by the National Center for Environmental Prediction and the WPC, located in College Park, Maryland. These are the base products used in describing synoptic weather features and in the creation of forecasts and warnings for the NWS. Reference to these charts can be found in the joint NWS and Federal Aviation Administration (FAA) Advisory Circular "Aviation Weather Services", AC 00-45H.¹

1.1 Surface Analysis Chart

The NWS Surface Analysis Chart centered over the Ohio River Valley region of the United States for 1900 CDT is provided as figure 1 with the location of the accident site within the black circle. The chart depicted a low-pressure system in Illinois with a pressure of 1018-hectopascals (hPa) and a low-pressure system in northern Mississippi with a pressure of 1014-hPa. Associated frontal boundaries to these low-pressure systems were located across the Midwest and southern United States, respectively. A trough² was located from west to east across Kentucky located just north of the accident site. A high pressure system was located in Ohio.

The closest station model near the accident site depicted heavy rain, a light southeasterly wind, an air temperature of 72° Fahrenheit (°F), with a dew point temperature of 69°F, and overcast clouds.

¹ https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1030235

² Trough - An elongated area of relatively low atmospheric pressure or heights.

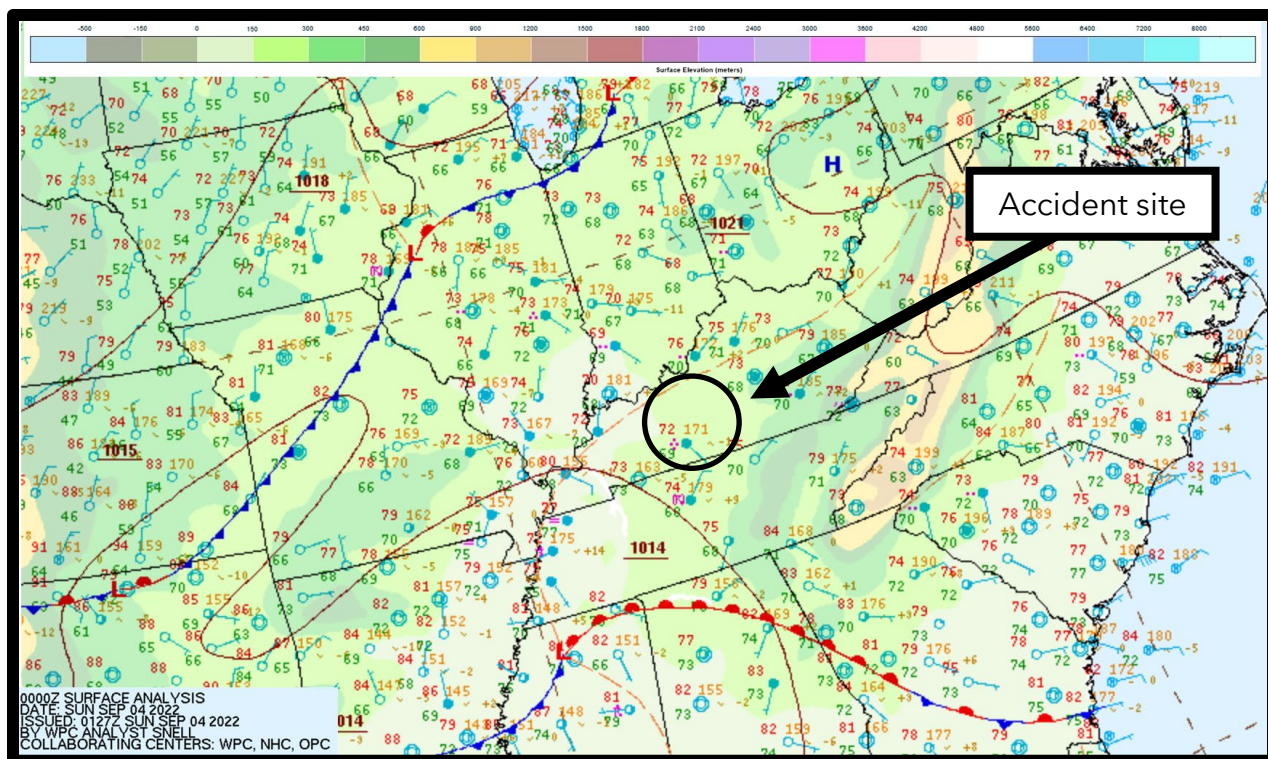


Figure 1. NWS Surface Analysis Chart for 1900 CDT.

1.2 Upper Air Charts

The NWS Storm Prediction Center (SPC) Constant Pressure Charts for 1900 CDT at 925-, 850-, 700-, and 500-hPa are presented in figures 2 through 5. A mid-level trough was located just west of the accident at 700- and 500-hPa (figures 4 and 5). Troughs and fronts can act as lifting mechanisms to help produce clouds and precipitation if sufficient moisture is present. The 925- and 850-hPa constant pressure charts depicted variable winds at or below 10 knots above the accident site at 1900 CDT. A southwest wind of 15 to 30 knots was located above the accident site by 500-hPa (figure 5).

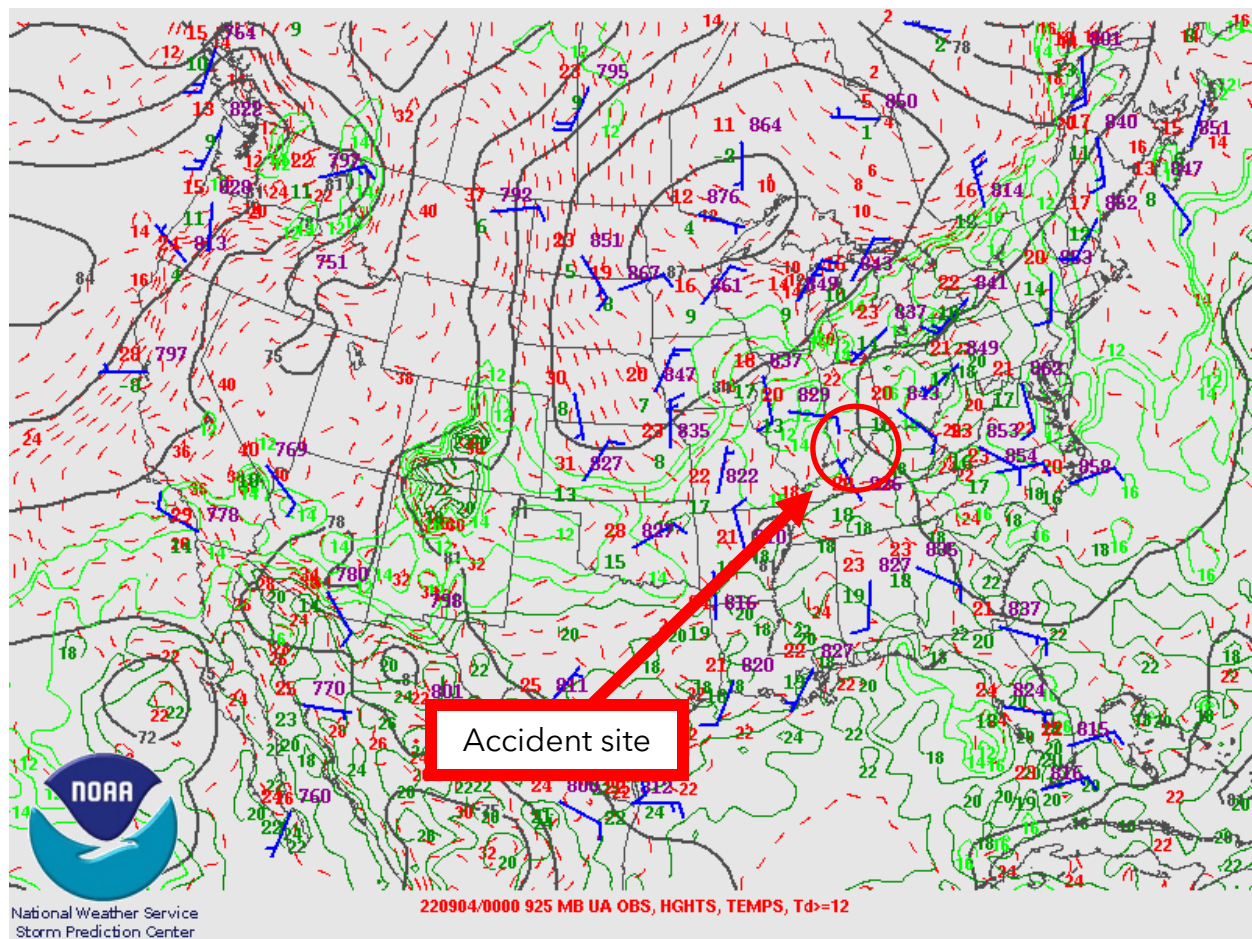


Figure 2. 925-hPa Constant Pressure Chart for 1900 CDT.

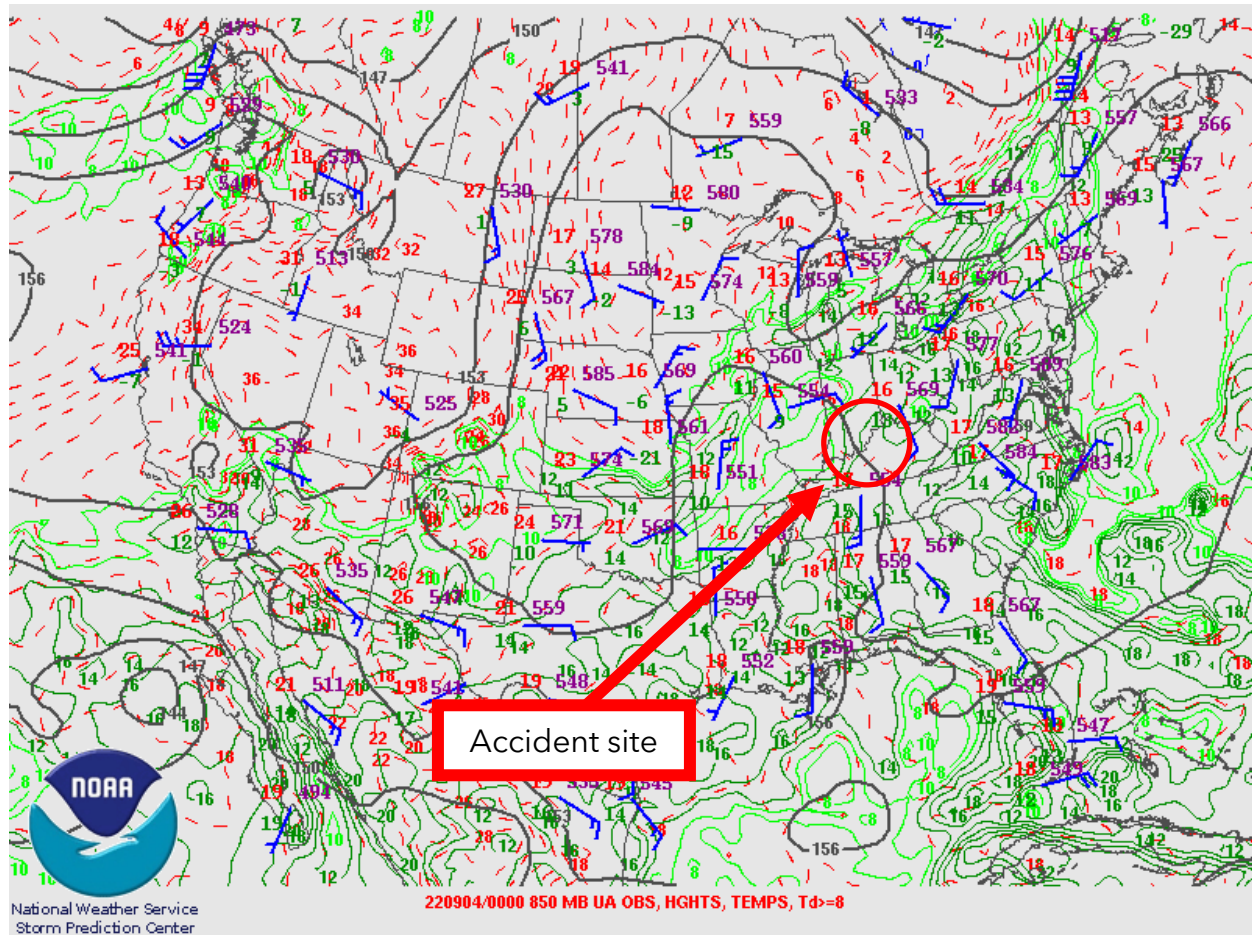


Figure 3. 850-hPa Constant Pressure Chart for 1900 CDT.

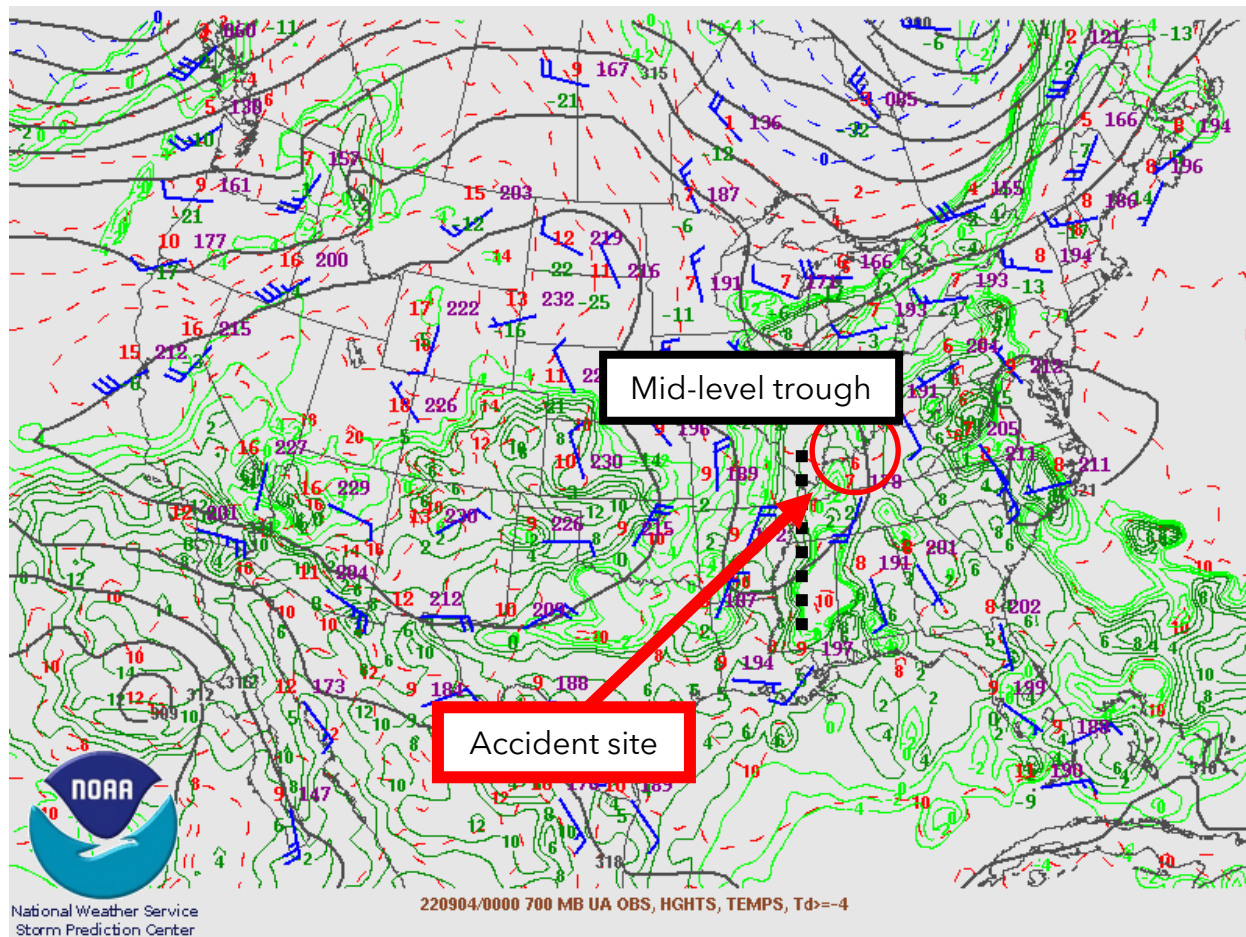


Figure 4. 700-hPa Constant Pressure Chart for 1900 CDT.

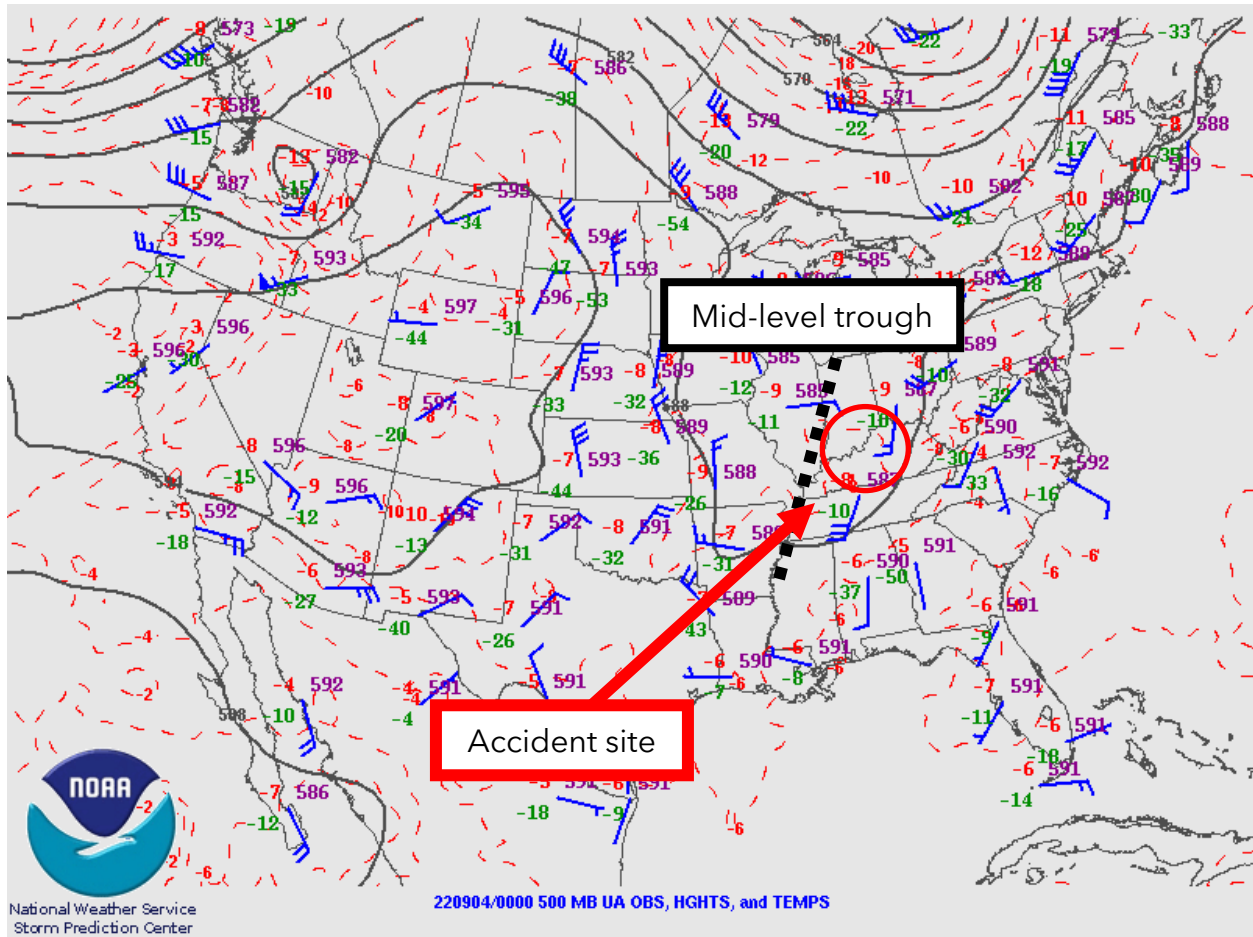


Figure 5. 500-hPa Constant Pressure Chart for 1900 CDT.

2.0 Storm Prediction Center Convective Outlook

The SPC issued a Day 1 Convective Outlook at 1500 CDT (figure 6) with areas of general thunderstorms forecast for the accident site. SPC defines the “TSTM” area as an area where a 10% or higher probability of thunderstorms is forecast during the valid period. The accident site was located on the border of the SPC marginal risk³ for severe thunderstorms. In addition, the accident site was located right next to an area where SPC forecasted a 5 percent chance of damaging thunderstorm winds or wind gusts 50 knots or greater within 25 miles of a point (figure 7). The SPC text bulletin that was associated with the Convective Outlook text follows figure 7.

³ SPC risk definitions: [SPC Products \(noaa.gov\)](https://www.spc.noaa.gov/products/convective-outlook/convout.shtml)

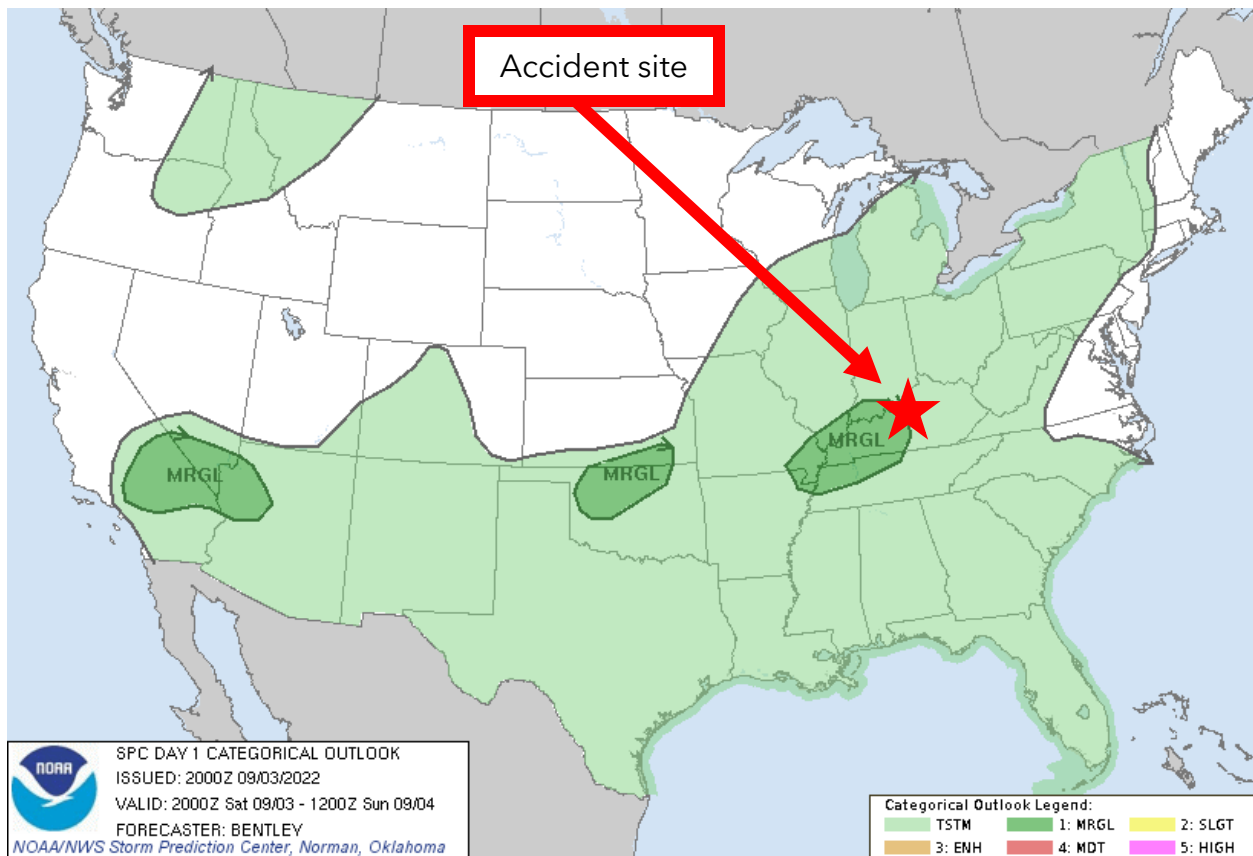


Figure 6. SPC day 1 Convective Outlook valid at the time of the accident.

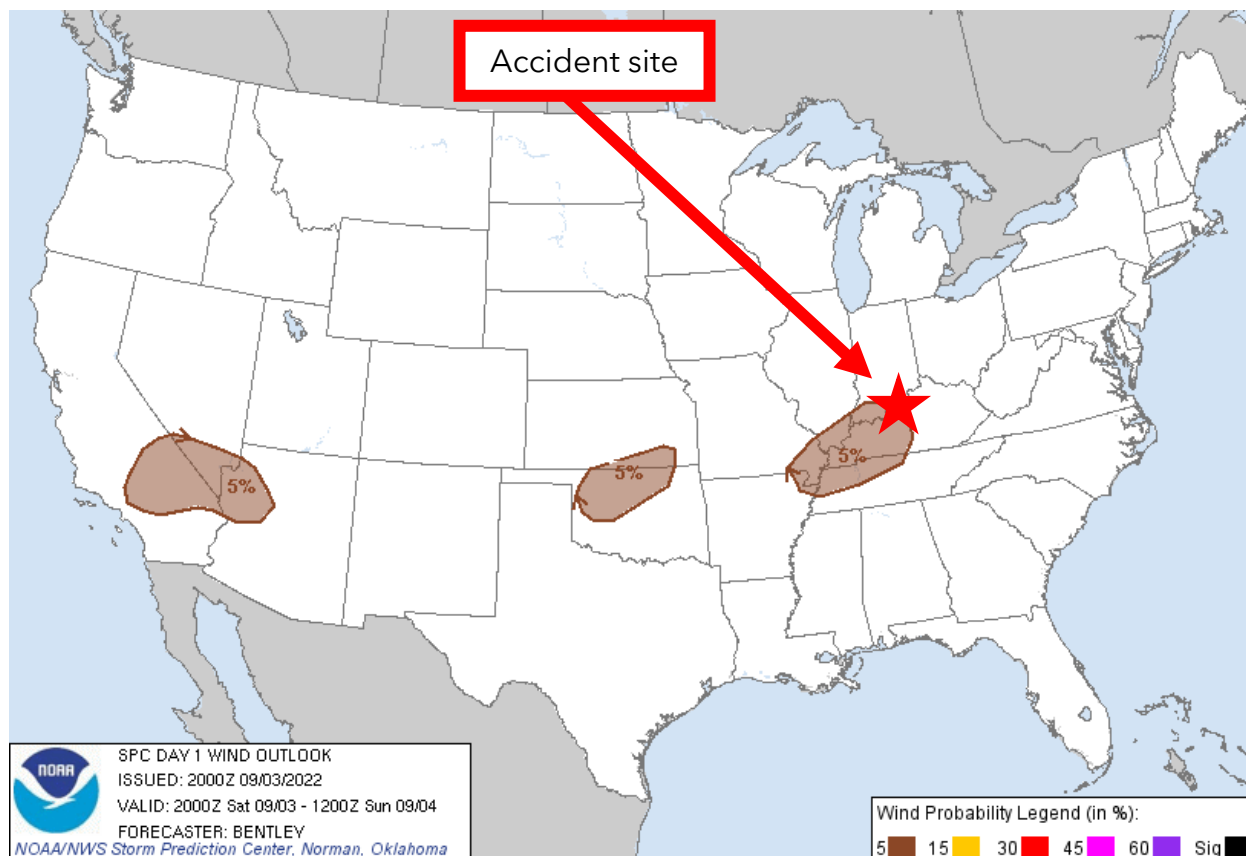


Figure 7. SPC day 1 Convective Outlook valid at the time of the accident.

SPC AC 032000

Day 1 Convective Outlook
 NWS Storm Prediction Center Norman OK
 0300 PM CDT Sat Sep 03 2022

Valid 032000Z - 041200Z

...THERE IS A MARGINAL RISK OF SEVERE THUNDERSTORMS OVER PORTIONS OF THE DESERT SOUTHWEST...SOUTHERN GREAT PLAINS...AND THE MID-SOUTH....

...SUMMARY...

Isolated severe thunderstorms are possible across a portion of the Desert Southwest, the southern Great Plains, and the Mid-Mississippi and Lower Ohio River Valleys, mainly during the late afternoon and early evening.

Storms have started to develop, with some stronger cores within the Marginal outlook area across the Lower Ohio Valley/Mid-South region. Instability continues to increase and additional storms are expected to develop within this Marginal risk area. For additional details, see MCD 1760.

One isolated storm has developed in west-central Oklahoma. The

cumulus field in this region, ahead of a weak front, suggests additional storms may develop in the next 1 to 2 hours. Moderate instability, may prove sufficient for a few strong to severe wind gusts with any stronger updraft/downdraft pairs.

A 84 mph wind gust was measured below a collapsing storm core near Wolfforth, TX. Radar presentation suggests this was likely a small scale microburst which caused this wind gust. Additional storms are forming within this environment which may suggest additional strong wind gusts are possible, but the KLBB WSR-88D shows outflow boundaries have already extended far beyond the ongoing thunderstorms which casts doubt on the development of additional strong updrafts in this region.

Some storms have developed along a front from northern Illinois into central Michigan. These storms should remain mostly sub-severe and expect any severe threat to be brief and isolated.

..Bentley.. 09/03/2022

.PREV DISCUSSION... /ISSUED 1129 AM CDT Sat Sep 03 2022/

...Interior Southern CA to northwest AZ...

Isolated thunderstorm development is anticipated over interior southern CA and northwest AZ along the northern edge of a deep moisture plume. Although the stronger midlevel flow will reside farther south near the international border, slightly stronger mid-level easterly flow averaging 25 kts and steep low-level lapse rates will result in an environment conducive for isolated strong/severe wind gusts.

...Northern/west-central OK to far southern KS...

Increasing frontal convergence and minimal CINH will contribute to isolated thunderstorm development by early evening along a slow-moving surface front. RAP/NAM forecast soundings depict a deep/well-mixed atmosphere and 1000-1500 J/kg MLCAPE by late afternoon. Within this environment, an isolated stronger storm will be capable of producing strong/potentially severe gusts.

...Mid-MS/Lower OH River Valleys...

An increase in thunderstorm coverage is expected this afternoon/early evening east of a weak midlevel trough. Despite poor lapse rates, a very moist environment and modestly enhanced mid-level flow (20-25 kts) may yield a few storms capable of wet microbursts, especially where breaks in cloud cover result in locally greater buoyancy. Storms should diminish in intensity as the evening progresses.

CLICK TO GET WUUS01 PTSDY1 PRODUCT

NOTE: THE NEXT DAY 1 OUTLOOK IS SCHEDULED BY 0100Z

3.0 Surface Observations

The area surrounding the accident site was documented using official Aviation Routine Weather Reports (METARs) and Special Reports (SPECIs). The following observations were taken from standard code and are provided in plain language. Figure 8 is a local sectional aeronautical chart with the accident site and the closest weather reporting location marked. The chart depicted the magnetic variation⁴ as 4.5° west over the area.

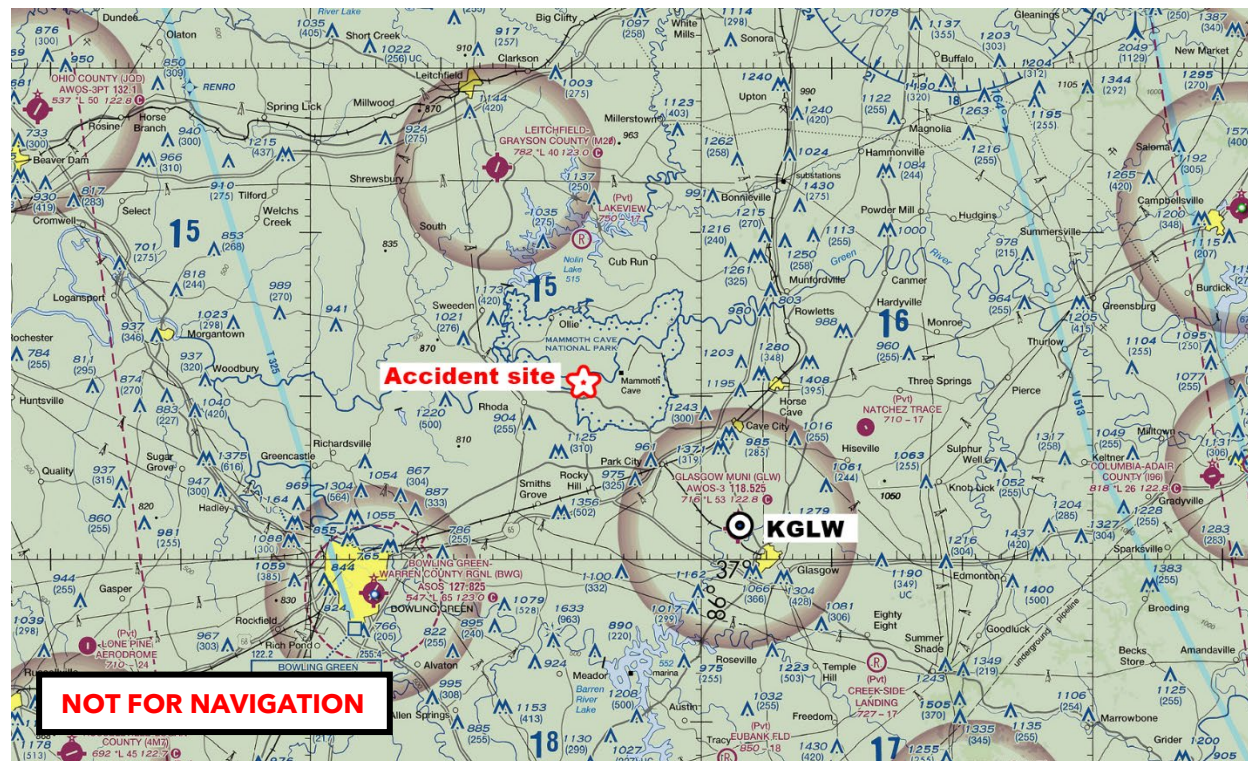


Figure 8. FAA sectional aeronautical chart of the accident area with the location of the accident site and surface observation site.

⁴ Magnetic variation - The angle (at a particular location) between magnetic north and true north. Latest measurement taken from <https://skyvector.com/>

The accident helicopter's destination was Glasgow Municipal Airport (KGLW) and KGLW also had the closest official weather station to the accident site (figure 8). KGLW had an Automated Weather Observing System (AWOS⁵) whose non-augmented reports were sent longline⁶. The KGLW AWOS was located 13 miles southeast of the accident site, at an elevation of 716 ft, and issued the following observations surrounding the period of the accident:⁷

[1615 CDT] METAR KGLW 032115Z AUTO 17005KT 10SM VCTS
SCT039 SCT044 BKN050 28/22 A3006 RMK AO2 LTG DSNT S THRU N
T02760221

[1635 CDT] METAR KGLW 032135Z AUTO 24003KT 7SM -TSRA SCT035
BKN049 OVC090 25/23 A3007 RMK AO2 LTG DSNT SE THRU NW
P0001 T02470230

[1655 CDT] METAR KGLW 032155Z AUTO 22007KT 7SM VCTSRA
BKN080 BKN090 OVC110 24/23 A3007 RMK AO2 LTG DSNT SE SW
AND NW P0003 T02360225

[1710 CDT] METAR KGLW 032210Z AUTO 24006KT 1 1/2SM TSRA
BKN070 OVC090 23/23 A3008 RMK AO2 LTG DSNT SW THRU NW
P0003 T02320225

⁵ AWOS - Automated Weather Observing System is equipped with meteorological instruments to typically observe and report temperature, dewpoint, wind speed and direction, visibility, cloud coverage and ceiling up to 12,000 feet, and altimeter setting. AWOS are maintained by the FAA. Certain AWOS may have different reporting or observational equipment.

⁶ "Longline" refers to the dissemination of weather observations with the intent that they are available in near-real time to national databases and accessible to the general global public from a large number of vendors. This does not include public accessibility to observations from a reporting station's Very High Frequency (VHF; line-of-site) or telephone broadcast, where applicable. Longline dissemination of weather observations is the primary vehicle through which the weather observations are distributed.

⁷ The bold sections in this NWS product and the rest of the products in this report are intended to highlight the text that directly reference the weather conditions that affected the accident location around the accident time. The local times in this section next to the METARs are provided for quick reference between UTC and local times around the accident time.

**[1735 CDT] METAR KGLW 032235Z AUTO 28006KT 7SM RA
OVC090 22/22 A3008 RMK AO2 LTG DSNT N S AND NW P0009
T02240220**

ACCIDENT TIME 1740 CDT

**[1755 CDT] METAR KGLW 032255Z AUTO 28005KT 5SM +VCTSRA
SCT075 OVC090 22/22 A3009 RMK AO2 LTG DSNT ALQS P0015
T02190218**

[1815 CDT] METAR KGLW 032315Z AUTO 00000KT 4SM RA SCT075
OVC090 22/21 A3009 RMK AO2 LTG DSNT N S AND W P0005
T02150213

The bold type observations decoded in plain language were as follows:

KGLW weather at 1735 CDT, automated, wind from 280° at 6 knots, visibility 7 miles, moderate rain, overcast ceiling at 9,000 ft above ground level (agl), temperature of 22° Celsius (C), dew point temperature 22°C, and an altimeter setting of 30.08 inches of mercury (inHg). Remarks, automated station with a precipitation discriminator, lightning distant⁸ north, south, and northwest, 0.09 inches of precipitation since 1655 CDT, temperature 22.4°C, dew point temperature 22.0°C.

KGLW weather at 1755 CDT, automated, wind from 280° at 5 knots, visibility 5 miles, vicinity⁹ thunderstorm and heavy rain, scattered clouds at 7,500 ft agl, overcast ceiling at 9,000 ft agl, temperature of 22°C, dew point temperature 22°C, and an altimeter setting of 30.09 inHg. Remarks, automated station with a precipitation discriminator, lightning distant all quadrants, 0.15 inches of precipitation since 1655 CDT, temperature 21.9°C, dew point temperature 21.8°C.

The observations from KGLW surrounding the accident time indicated VFR to IFR¹⁰ conditions with moderate to heavy rain and thunderstorms.

⁸ Distant indicated that the lightning was beyond 10 miles but less than 30 miles from the center of the airport (or airport location point, [ALP]).

⁹ In the vicinity of the airport is defined as a weather phenomenon within 5-10 statute miles of the airfield.

¹⁰ As defined by the NWS and the FAA Aeronautical Information Manual (AIM) section 7-1-7 defines the following general flight categories:

- Low Instrument Flight Rules (LIFR*) - ceiling below 500 ft above ground level (agl) and/or visibility less than 1 statute mile.
- Instrument Flight Rules (IFR) - ceiling between 500 to below 1,000 feet agl and/or visibility 1 to less than 3 miles.
- Marginal Visual Flight Rules (MVFR**) - ceiling from 1,000 to 3,000 ft agl and/or visibility 3 to 5 miles.
- Visual Flight Rules (VFR) - ceiling greater 3,000 ft agl and visibility greater than 5 miles.

4.0 Upper Air Sounding

A High-Resolution Rapid Refresh (HRRR)¹¹ model sounding was created for the approximate accident site coordinates for 1800 CDT.¹² The HRRR sounding was plotted on a standard Skew-T Log P diagram¹³ from the surface to 600-hPa (or approximately 14,000 ft) using the RAOB¹⁴ software package and is included as figure 9. The sounding depicted an elevation of 682 ft over the grid point with a near surface temperature of 22.2°C and a dew point temperature of 21.2°C, with a relative humidity of 94%. The sounding depicted the lifted condensation level (LCL)¹⁵ at 426 ft agl, the convective condensation level (CCL)¹⁶ at 3,084 ft agl, and the level of free convection (LFC)¹⁷ at 3,510 ft agl. The freezing level was located at 15,204 ft. The precipitable water value at 2.21 inches.

* By definition, IFR is a ceiling less than 1,000 ft agl and/or visibility less than 3 miles while LIFR is a sub-category of IFR.

**By definition, VFR is a ceiling greater than or equal to 3,000 ft agl and visibility greater than 5 miles while MVFR is a sub-category of VFR.

¹¹ The HRRR is a NOAA real-time three-kilometer resolution, hourly-updated, cloud-resolving, convection-allowing atmospheric model, initialized by three-kilometer grids with three-kilometer radar assimilation. Radar data is assimilated in the HRRR every 15 minutes over a one-hour period.

¹² HRRR sounding was created using NOAA Air Resource Laboratory:
<https://ready.arl.noaa.gov/READYamet.php>

¹³ Skew T log P diagram – is a standard meteorological plot using temperature and the logarithmic of pressure as coordinates, used to display winds, temperature, dew point, and various indices used to define the vertical structure of the atmosphere.

¹⁴ RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Esonde Research Services, The Villages, Florida.

¹⁵ LCL - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

¹⁶ CCL - The level in the atmosphere to which an air parcel, if heated from below, will rise dry adiabatically, without becoming colder than its environment just before the parcel becomes saturated.

¹⁷ LFC - The level at which a parcel of saturated air becomes warmer than the surrounding air and begins to rise freely. This occurs most readily in a conditionally unstable atmosphere.

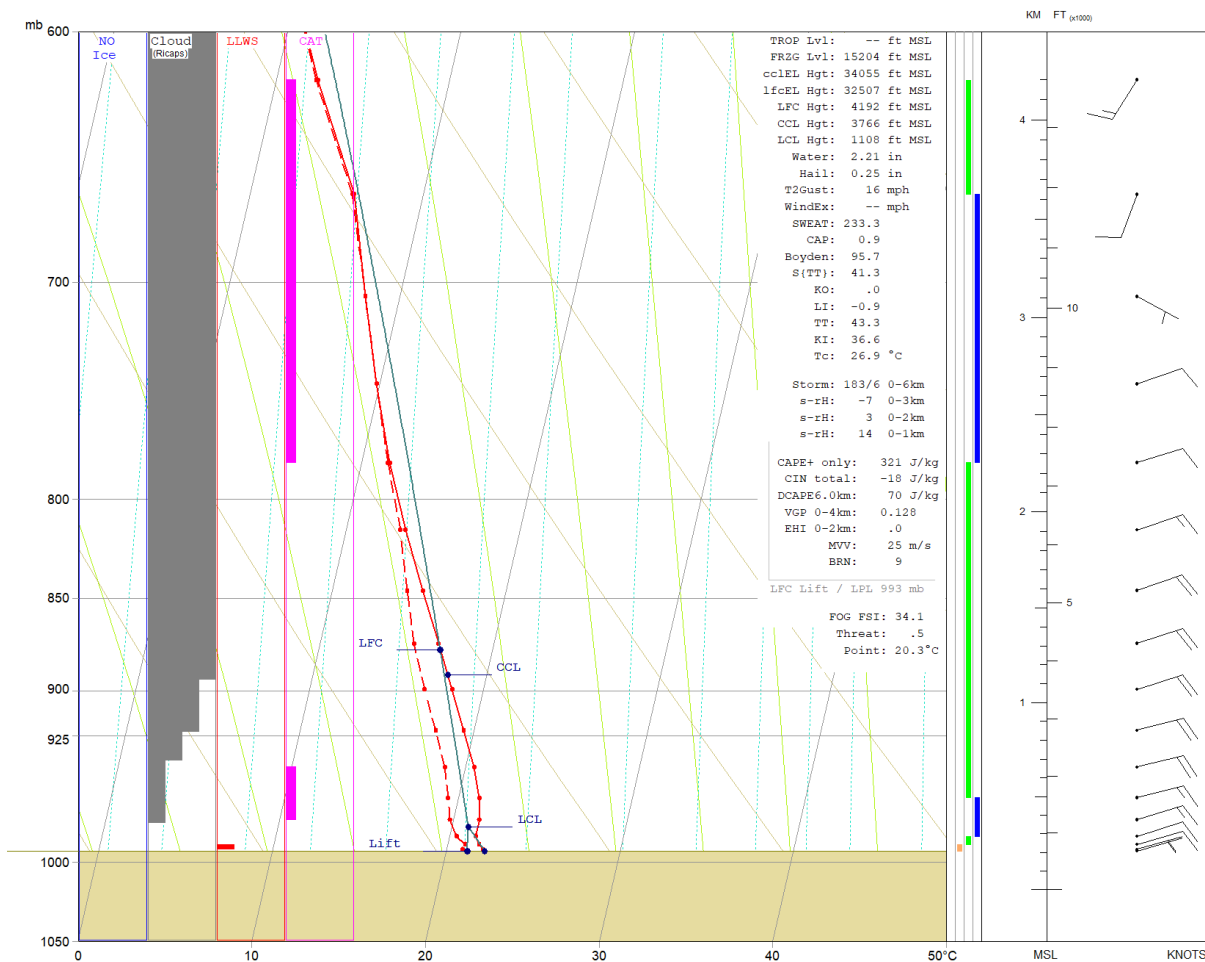


Figure 9. 1800 CDT HRRR sounding.

The 1800 CDT HRRR sounding indicated an unstable atmosphere based on the Lifted Index of -0.9 and the Convective Available Potential Energy (CAPE)¹⁸ of 321 Joules/kilogram (J/kg), with the maximum vertical velocity (MVV) for this atmosphere was calculated as 25 meters/second (about 4,921 ft per minute).¹⁹ Outside of rain shower or thunderstorm activity, RAOB indicated cloud cover from 500 ft agl through 14,000 ft msl with no icing below 14,000 ft.

The 1800 CDT HRRR sounding wind profile indicated a near surface wind from 074° at 6 knots with the wind veering to the southwest by 10,000 ft. The wind speed increased to 20 knots by 4,000 ft. RAOB indicated the possibility of very light low-level wind shear (LLWS) near the surface and two areas of very light clear air turbulence (CAT) were indicated by RAOB above 1,500 ft.

¹⁸ Convective Available Potential Energy (CAPE) - CAPE is a measure of the amount of energy available for convection and is directly related to the maximum potential vertical speed within an updraft.

¹⁹ MVV is not usually considered a realistic estimate for maximum vertical velocity in a storm. Anecdotes suggest considering a value of MVV/2, however it is not well understood when or where such a half-value should be applied.

5.0 Satellite Data

Geostationary Operational Environmental Satellite number 16 (GOES-16) visible and infrared data were obtained from an archive at the Space Science Engineering Center at the University of Wisconsin-Madison in Madison, Wisconsin, and processed using the Man-computer Interactive Data Access System software. Visible and infrared imagery (GOES-16 bands 2 and 13) at wavelengths of 0.64 microns (μm) and 10.3 μm , respectively, were retrieved for the period from 1400 CDT through 2000 CDT and reviewed, and the closest images to the time of the accident were documented.

Figure 10 presents the GOES-16 visible imagery from 1741 CDT at 2X magnification with the accident site highlighted with a red square and cloud cover indicated above the accident site. Figure 11 presents the GOES-16 infrared imagery from 1741 CDT at 6X magnification with the accident site highlighted with a red square. The lower cloud top temperatures (green and blue colors; higher cloud tops) were located above and surrounding the accident site at the accident time. The cloud cover had a radiative cloud top temperature of 229 Kelvin above the accident site and would have been near 36,000 ft based on the vertical temperature profile provided by the 1800 CDT HRRR sounding (heights above 14,000 ft not shown). It should be noted these figures have not been corrected for any parallax error.

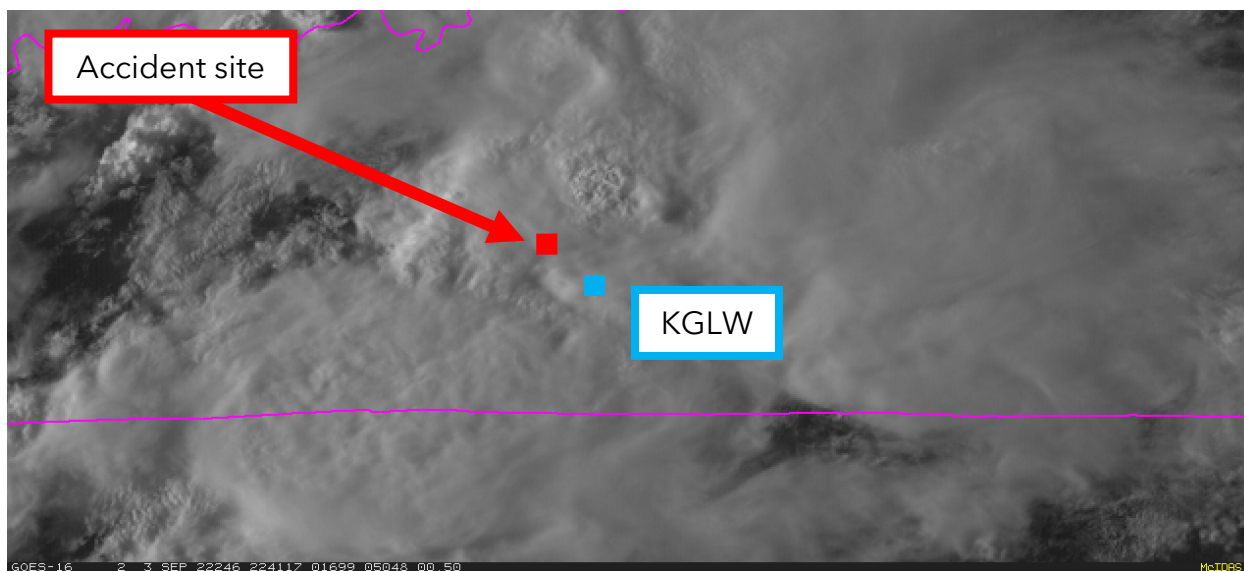


Figure 10. GOES-16 visible image at 1741 CDT.

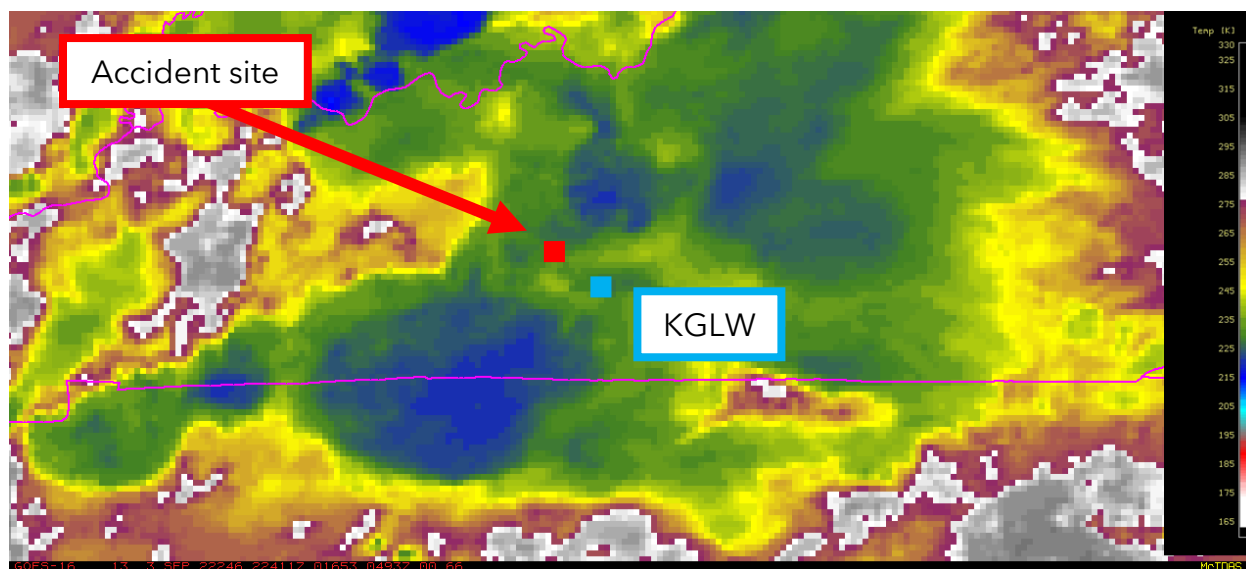


Figure 11. GOES-16 infrared image at 1741 CDT.

6.0 National Radar Imagery

A regional view of the NWS National Reflectivity Mosaic is included as figure 12 for 1740 CDT with the approximate location of the accident site marked by a black circle. The image depicted 25 to 45 dBZ²⁰ echoes above the accident site.

²⁰ dBZ - A non-dimensional "unit" of radar reflectivity which represents a logarithmic power ratio (in decibels or dB) with respect to radar reflectivity factor, Z.

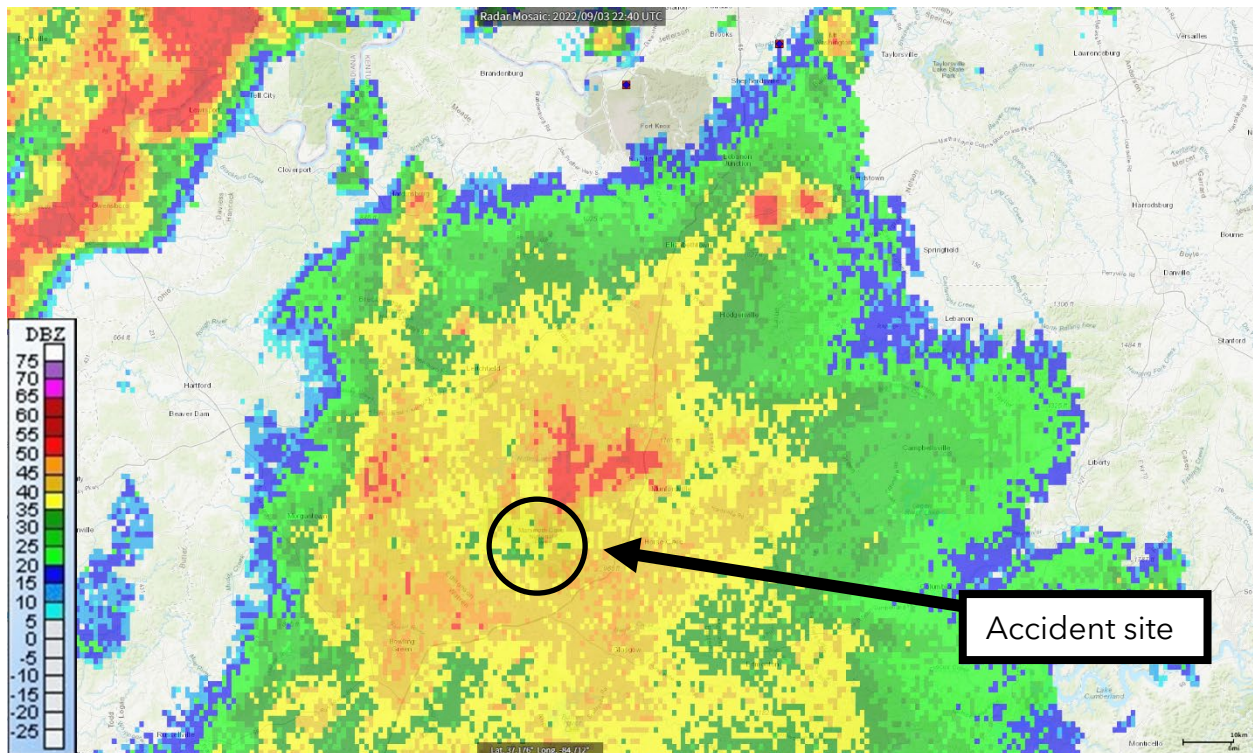


Figure 12. National Reflectivity Mosaic for 1740 CDT.

7.0 Weather Surveillance Radar Imagery

The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)²¹ to the accident site was Fort Knox, Kentucky, WSR-88D, (KLVX) located 49 miles north-northeast of the accident site. The Level II archive radar data were obtained from the NCEI utilizing the NEXRAD Data Inventory Search and displayed using the NOAA's Weather and Climate Toolkit software.

7.1 Volume Scan Strategy

During the period surrounding the accident, the KLVX WSR-88D radar was operating in the precipitation mode VCP-212 (figure 13). The following figure provides an indication of the different elevation angles in this VCP, and the approximate height and width of the radar beam with distance from the radar site.

²¹ The WSR-88D is an S-band 10-centimeter wavelength radar with a power output of 750,000 watts, and with a 28-foot parabolic antenna that concentrates the energy between a 0.87° and 0.96° beam width. The radar produces three basic types of products: base reflectivity, base radial velocity, and base spectral width.

VCP 212

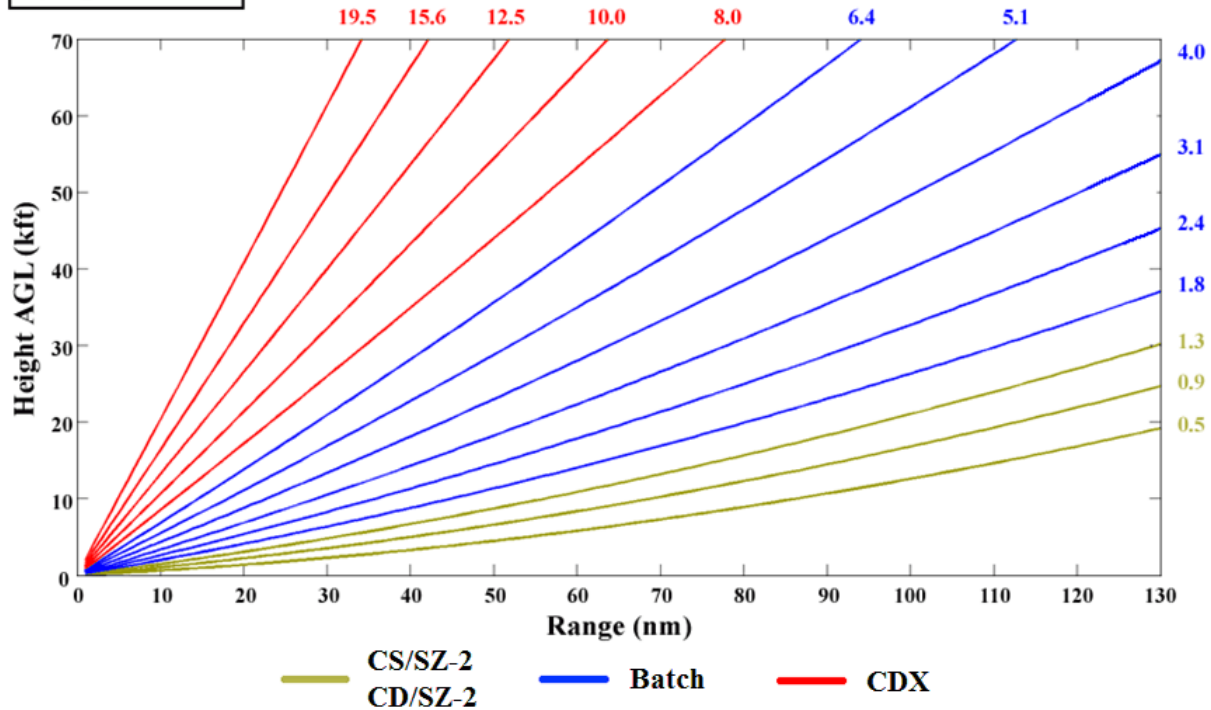


Figure 13. VCP-212 Precipitation Mode Scan Strategy²².

7.2 Beam Height Calculation

Assuming standard refraction²³ of the KLVX WSR-88D radar beam with the antenna elevation at 833 ft, and considering a beamwidth²⁴ of 0.95°, the following table shows the approximate heights for the radar beam center, top and base for antenna elevations over the accident site. These heights have been rounded to the nearest 10 ft.

²² Contiguous Surveillance (CS)--The low Pulse Repetition Frequency (PRF) scan of the split cut. Gives a high R_{max} value to determine proper target location and intensity, but a low V_{max} value limits the velocities that can be measured.

Contiguous Doppler (CD)--The high PRF scan of the split cut. Gives a low R_{max} value causing more range folded (multiple trip) echoes, but a high V_{max} value to get higher, more accurate velocity values. Batch Mode - Uses alternating low and high PRFs on each radial for one full rotation at each elevation angle. The two resulting data sets (low PRF and high PRF) are combined to resolve range ambiguity. Used in the middle elevation angles.

W - With range unfolding (W)

WO - Without range unfolding (WO)

²³ Standard Refraction in the atmosphere is when the temperature and humidity distributions are approximately average, and values set at the standard atmosphere.

²⁴ Beamwidth - the angular separation between the half power points on the antenna radiation pattern, where the gain is one half the maximum value.

ANTENNA ELEVATION	BEAM CENTER	BEAM BASE	BEAM TOP
KLVX 0.5°	5,170 ft	2,750 ft	7,590 ft

Based on the radar height calculations, the elevation scans reviewed from KLVX listed in the above table depicted the conditions between 2,750 ft and 7,590 ft over the accident site and this elevation scan “saw” the closest weather radar information to the ground.

7.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors²⁵ it is a function of the drop size distribution, number of particles per unit volume, physical state (ice or water), shape, and aspect. Reflectivity is normally displayed in dBZ and is a general measure of echo intensity. FAA Advisory Circular AC 00-24C²⁶, “Thunderstorms,” dated February 19, 2013, also defines the echo intensity levels and weather radar echo intensity terminology associated with those levels. For dBZ values less than 30 the weather radar echo intensity terminology should be “light.” For dBZ values between 30 and 40, the terminology should be “moderate.” “Heavy” terminology is used for dBZ values greater than 40 dBZ to 50 dBZ, inclusive. Finally, any dBZ values above 50 dBZ shall be described as “extreme.”

7.4 Base Reflectivity and Lightning Data

Figure 14 presents the KLVX WSR-88D base reflectivity images for the 0.5° elevation scan initiated at 1739:55 CDT, with a resolution of 0.5° X 250 m. The image depicted reflectivity values between 20 and 35 dBZ above the accident site with the precipitation moving from southwest to northeast (attachment 1).

²⁵ Hydrometeors are any product of condensation or sublimation of atmospheric water vapor, whether formed in the free atmosphere or at the earth’s surface; also, any water particles blown by the wind from the earth’s surface. Hydrometeors are classified as; (a) Liquid or solid water particles suspended in the air: cloud, water droplets, mist, or fog. (b) Liquid precipitation: drizzle and rain. (c) Freezing precipitation: freezing drizzle and freezing rain. (d) Solid (frozen) precipitation: ice pellets, hail, snow, snow pellets, and ice crystals. (e) Falling particles that evaporate before reaching the ground: virga. (f) Liquid or solid water particles lifted by the wind from the earth’s surface: drifting snow, blowing snow, blowing spray. (g) Liquid or solid deposits on exposed objects: dew, frost, rime, and glazed ice.

²⁶

https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1020774

There were 318 lightning flashes²⁷ reported within 50 miles of the accident site within 20 minutes prior to or following the accident time.²⁸

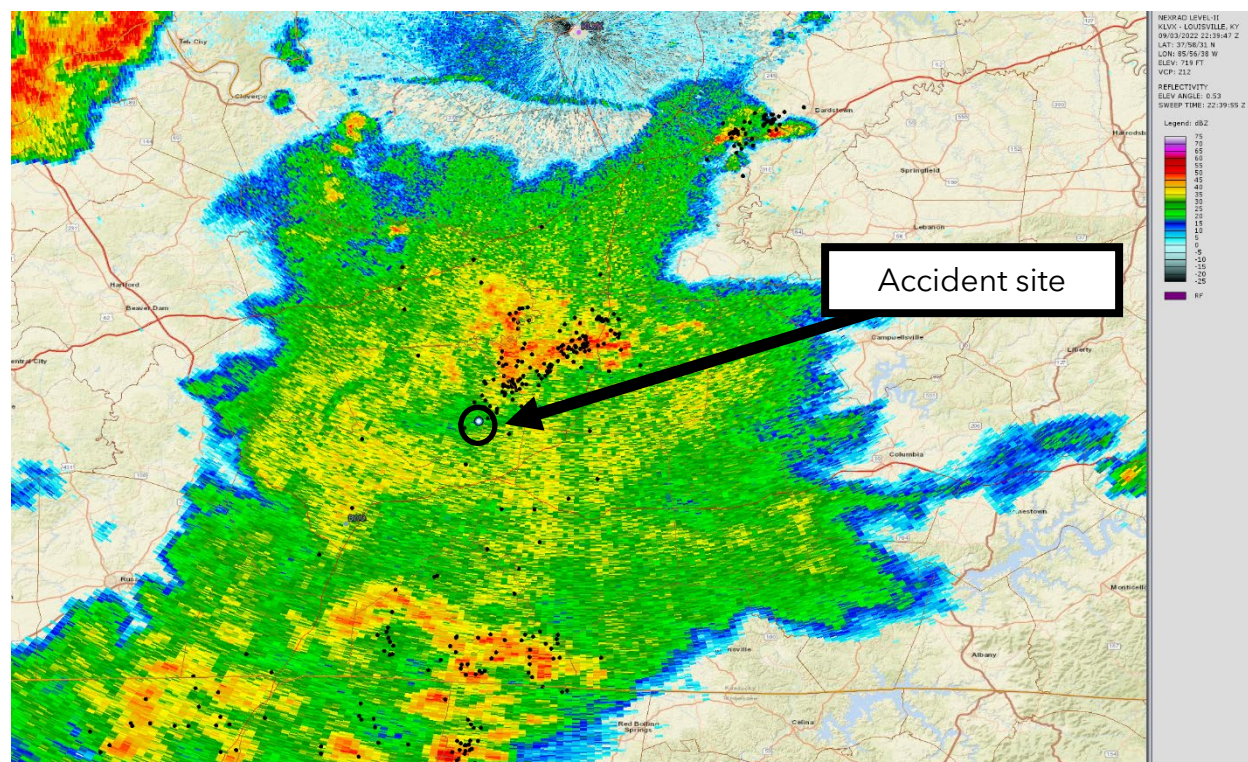


Figure 14. KLVX WSR-88D reflectivity for the 0.5° elevation scan initiated at 1739:55 CDT with the accident site marked with the black circle.

8.0 Pilot Reports

The longline-disseminated pilot reports²⁹ (PIREPs) distributed into the national airspace system (NAS) were reviewed for about two hours on either side of the accident time and the PIREPs issued into the NAS within 50 miles of the accident site for below 19,000 ft are shown here:

SDF UUA /OV IIU/TM 2326/FL110/TP PA27/TB 1500-2000FT PER MINUTE UPDRAFT=

SDF UA /OV FTK/TM 0017/FL030/TP E75S/WX RA/TB LGT=

²⁷ Lightning Flash – This is one contiguous conducting channel and all the current strokes/pulses that flow through it. There are two types of flashes: ground flashes and cloud flashes.

²⁸ A review of Earth Networks Total Lightning network and GOES-16 Geostationary Lightning Mapper was done.

²⁹ Only pilot reports with the World Meteorological Organization headers UBKY**, UBTN**, and UBIN** were considered. These do not include pilot reports only broadcast via radio.

9.0 Significant Meteorological Information

There was a convective Significant Meteorological Information (SIGMET) advisory valid for the accident site at the accident time. SIGMET 09E (figure 15), which was issued at 1655 CDT, warned of an area of thunderstorms with cloud tops above FL450³⁰ with the convective SIGMET box moving from 210° at 15 knots. In addition, a convective SIGMET was issued at 1555 CDT that was valid for the accident area (SIGMET 51C):

WSUS31 KPCI 032155
SIGE
-MKCE WST 032155
CONVECTIVE SIGMET 09E
VALID UNTIL 2355Z
TN KY AL MS
FROM 10SSW IIU-50SW LOZ-30E VUZ-40W IGB-70NE DYR-10SSW IIU
AREA TS MOV FROM 21015KT. TOPS ABV FL450.

WSUS32 KPCI 032055
SIGC
-MKCC WST 032055
CONVECTIVE SIGMET 51C
VALID UNTIL 2255Z
TN KY IN AL IL MS
FROM 10W PXV-40WSW IIU-50SW LOZ-50WSW GQO-50NNW IGB-10W PXV
AREA SEV TS MOV FROM 21015KT. TOPS ABV FL450.
HAIL TO 1 IN...WIND GUSTS TO 50KT POSS.

³⁰ Flight Level - A Flight Level (FL) is a standard nominal altitude of an aircraft, in hundreds of ft. This altitude is calculated from the International standard pressure datum of 1013.25 hPa (29.92 inHg), the standard sea-level pressure, and therefore is not necessarily the same as the aircraft's true altitude either above mean sea level or above ground level.

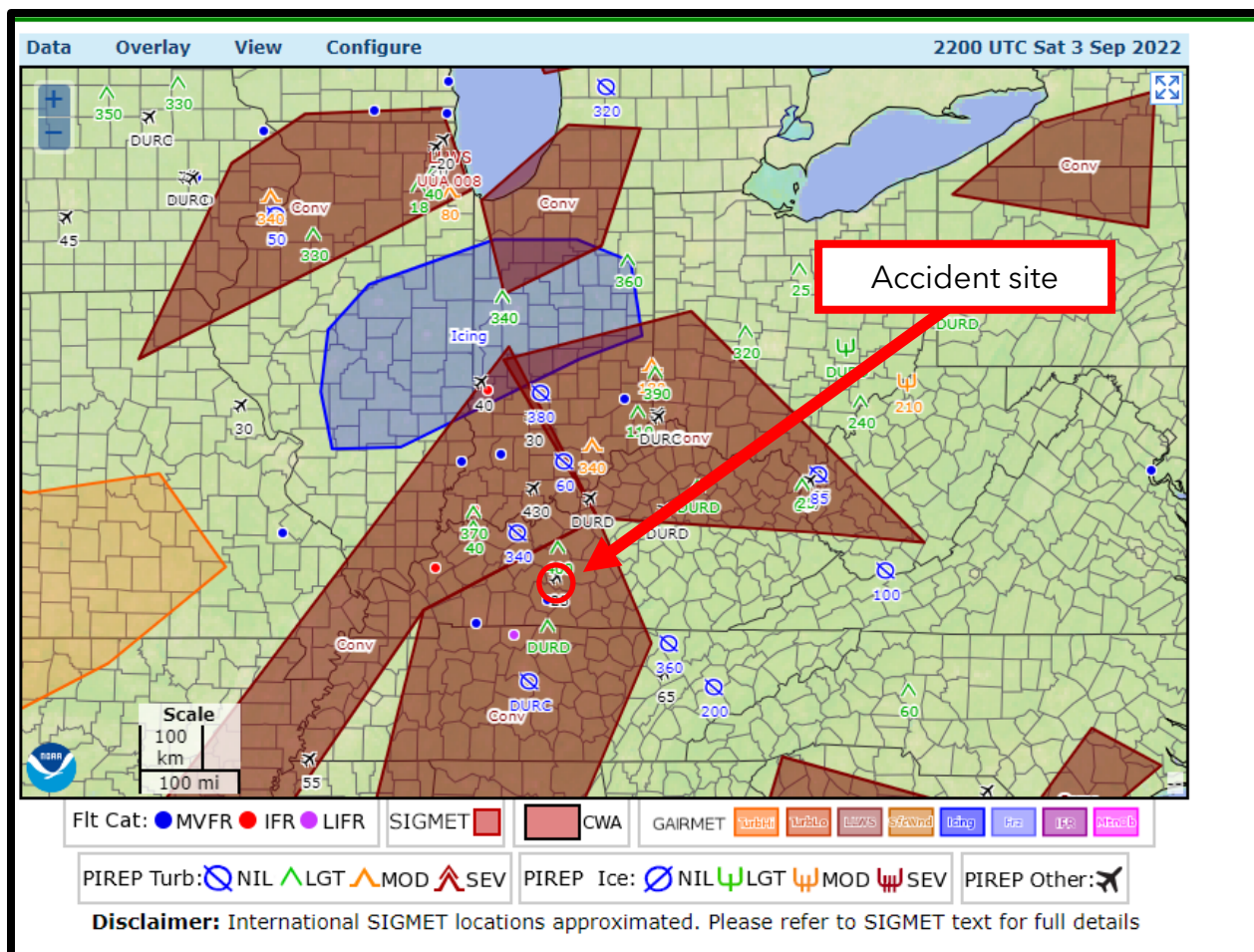


Figure 15. Aviation Weather Center graphic valid at 1700 CDT with valid convective SIGMETs, AIRMETs, and PIREPs with the accident location marked.

10.0 Center Weather Service Advisories

The Memphis (ZME) Air Route Traffic Control Center (ARTCC) Center Weather Service Unit (CWSU) was responsible for the accident region. There was no Center Weather Advisory (CWA) valid from ZME CWSU at the accident time.

11.0 Airmen's Meteorological Information

There were no text Airmen's Meteorological Information (AIRMET) advisories valid for the accident site at the accident time.

12.0 Graphical Forecasts for Aviation

The Graphical Forecasts for Aviation (GFA) products issued before the accident flight and valid at 1900 CDT are shown in attachment 2. The GFA surface forecast applicable to the accident site that was valid before the accident flight's departure for times surrounding the accident time indicated VFR surface visibilities, numerous (between 60 to 100 percent chance) thunderstorms, and a light and variable surface wind. The GFA cloud forecast applicable to the accident site that was valid before departure for times surrounding the accident time indicated, outside of thunderstorm activity, scattered cloud coverage with bases at 3,500 to 8,000 ft and cirrus clouds above. There were no Graphical AIRMETs³¹ (G-AIRMET) valid for the accident site at 1600 or 1900 CDT. All weather information presented in GFAs, with the exception of G-AIRMETs, are computer-generated with no human input. For more information, please see attachment 2.

13.0 Terminal Aerodrome Forecast

The closest Terminal Aerodrome Forecast³² (TAF) to the accident site was from Bowling Green-Warren County Regional Airport (KBWG) located 18 miles southwest of the accident site. The KBWG amended TAF was issued 1535 CDT and was valid for a 21-hour period beginning at 1600 CDT. The 1535 CDT TAF for KBWG was as follows:

FTUS43 KLMK 032035 AAA
TAFBWG
TAF AMD
KBWG 032035Z 0321/0418 **15005KT P6SM VCTS BKN050CB**
TEMPO 0321/0323 2SM TSRA BKN035CB
FM032300 15005KT P6SM -SHRA BKN070=

³¹ **Graphical AIRMETs (G-AIRMETs)**, found on the Aviation Weather Center webpage at <http://aviationweather.gov>, are graphical forecasts of en-route weather hazards valid at discrete times no more than 3 hours apart for a period of up to 12 hours into the future (for example, 00, 03, 06, 09, and 12 hours). G-AIRMETs are snap shots at discrete time intervals as defined above. The text AIRMET is the result of the production of the G-AIRMET but provided in a time smear for a 6hr valid period.

³² According to NWS Instruction 10-813: "An NWS TAF consists of the expected meteorological conditions significant to aviation at an airport for a specified time period. For the U.S., this is the area within five (5) statute miles (SM) of the center of an airport's runway complex."
www.nws.noaa.gov/directives/sym/pd01008013curr.pdf

Between 1600 CDT and 1800 CDT, the forecast expected a wind from 150° at 5 knots, greater than 6 miles visibility, thunderstorms in the vicinity, and a broken ceiling of cumulonimbus clouds at 5,000 ft agl. Temporary conditions³³ were forecast between 1600 and 1800 CDT with 2 miles visibility, thunderstorms and moderate rain, and a broken ceiling of cumulonimbus clouds at 3,500 ft agl.

14.0 National Weather Service Area Forecast Discussion

The NWS weather forecast office in Louisville, Kentucky, (WFO LMK) was responsible for the public forecast in the region of the accident site. WFO LMK issued the following Area Forecast Discussion (AFD) at 1350 CDT, and it was the AFD with an aviation section that was issued closest to the accident time:

FXUS63 KLMK 031850
AFDLMK

Area Forecast Discussion
National Weather Service Louisville KY
250 PM EDT Sat Sep 3 2022

.Short Term...(This evening through Sunday)
Issued at 236 PM EDT Sat Sep 3 2022

Scattered storms have begun to blossom from northwest Alabama to western and southern Indiana as we destabilize this afternoon ahead of an upper trough to our west. While a few storms may produce locally gusty winds over the next few hours, locally heavy rains will be the main threat. While the storms are moving to the NNE, they are also tending to backbuild as they align with the deep low-mid level flow. With deep warm cloud depths and precipitable water values just shy of two inches, and training of cells (as has already been witnessed in Washington County, Indiana), local flooding issues may arise late this afternoon into the early evening hours.

The convection is developing ahead of a long and slowly deepening upper trough reaching from the upper Great Lakes to the western Gulf coast. This trough will stay put during the short term with deep moisture continuing to stream into the region. As a result, widespread shower and scattered thunderstorm chances will continue through tonight and into Sunday. Shear and instability may be weaker tomorrow than today, keeping severe chances low, but once again locally heavy rain will be the main threat. Locations that receive torrential downpours this afternoon may be particularly vulnerable with any heavier storms Sunday.

³³ The TEMPO group is used for any conditions in wind, visibility, weather, or sky condition which are expected to last for generally less than an hour at a time (occasional), and are expected to occur during less than half the time period.

With the clouds and high humidity, diurnal temperature ranges will be small. Lows tonight will be in the upper 60s with highs tomorrow around 80.

&&

.Long Term...(Sunday night through Saturday)
Issued at 245 PM EDT Sat Sep 3 2022

Sunday Night - Wednesday...

The upper disturbance will continue to sit nearly stationary over the mid Mississippi River Valley through mid week. This feature will be situated between strong upper ridging over the western half of the CONUS, and another area of upper ridging off the Atlantic Coast. Our region will remain situated in the deep southerly flow between the trough axis just to our west and the ridge to our east, and given the strength of the two bookending upper ridges don't see much change to the pattern through mid week. The end result will be periods of slow moving showers and storms in a moist and meagerly unstable atmosphere. In fact, very little instability looks to survive past Sunday so will mainly be carrying shower chances with an outside shot at a few rumbles of thunder. The moist column will be a bigger concern by this time with PWAT values in the 1.7" - 2.0" range. Rainfall totals may also be adding up by this time, so the longer this pattern persists, the better chance for a few flooding concerns. Confidence is highest in the southern and eastern portions of the CWA seeing the most rainfall (between 1" - 3", locally higher) between Saturday and Wednesday.

Will keep high pops in the likely to categorical range on Monday, peaking with max diurnal heating. Thereafter, will call for scattered to numerous showers each day through mid week. Temperatures look to run in the upper 70s and low 80s through mid week, a little more on the higher side of that range by then. These values will be a little below normal for this time of year, which is to be expected given the increased cloud cover and precipitation chances.

Wednesday Night - Saturday...

Confidence is lower going into the late week portion of the forecast. By this time, the upper disturbance will start to be displaced southward along the lower Mississippi River Valley, however deep southerly flow may remain over our region between the elongated trough axis and upper ridging to our east. This will continue to draw a deeper moisture component over our area from the Gulf, but the lack of notable triggering features may leave only diurnal heating as the main driver. Therefore, do have lower overall pops during this time. Will also have to watch a northern stream shortwave moving through the flow. If it makes it far enough south, it could enhance the moisture plume over our area and squeeze out more of a shower and storm threat late week. Something to watch.

Highs by this time should continue to be in the lower 80s for most locations.

&&

**.Aviation...(18Z TAF Issuance)
Issued at 122 PM EDT Sat Sep 3 2022**

With a stagnant pattern in place, the weather will be similar through the TAF period. The airports will be situated just east of a slowly deepening upper trough with deep, moist SSW flow resulting in widespread clouds (mostly VFR). Showers and thunderstorms should become more widespread this afternoon as we destabilize, with showers continuing tonight into tomorrow. There is some indication that MVFR ceilings over southern Indiana tomorrow morning may drift into HNB's airspace.

The most detrimental flying conditions in this TAF period will be in torrential downpours and locally gusty winds associated with scattered storms this afternoon and evening.

&&

.LMK WATCHES/WARNINGS/ADVISORIES...

IN...None.

KY...None.

&&

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15.0 Winds and Temperature Aloft Forecast

The NWS 1459 CDT Winds and Temperature Aloft forecast valid for the closest points to the accident site is included below:

FBUS31 KWNO 031959

FD1US1

DATA BASED ON 031800Z

VALID 040000Z FOR USE 2000-0300Z. TEMPS NEG ABV 24000

FT 3000 6000 9000 12000 18000 24000 30000 34000 39000

BNA 1807 1913+15 2215+10 2118+05 2223-07 2420-18 233133 243443 243553

EVV 0712 9900+15 2308+09 2319+04 2334-07 2326-19 211435 212844 223752

LOU 1416 1106+14 9900+09 2005+04 2329-07 2430-18 242634 233344 234253

The closest forecast points to the accident site were Nashville, Tennessee (BNA), Evansville, Indiana (EVV), and Louisville, Kentucky (LOU). This forecast, which was issued at 1459 CDT, was for use between 1500 CDT and 2200 CDT.

16.0 Pilot Weather Briefing

Title 14 CFR 91.103 states that “Each pilot in command shall, before beginning a flight, become familiar with all available information concerning that flight.” FAA AC 91-92 “Pilot’s Guide to a Preflight Planning” (dated March 15, 2021) provided pilot guidance on preflight self-briefings, including planning, weather interpretation, and risk identification/mitigation skills. The AC further stated in part:

Pilots adopting these guidelines will be better prepared to interpret and utilize real-time weather information before departure and en route, in the cockpit, via technology like Automatic Dependent Surveillance-Broadcast (ADS-B) and via third-party providers.³⁴

A search of archived information indicated that the accident pilot did not request weather information from Leidos Flight Service or via ForeFlight. The accident pilot did update route strings and viewed airport information via ForeFlight as late as 1326 CDT on the day of the accident (attachment 3). It is unknown what, if any, additional weather information the accident pilot viewed before or during the accident flight.

17.0 Astronomical Data

The astronomical data obtained for the accident site on September 3, 2022, indicated the following:

SUN

Begin civil twilight	0550 CDT
Sunrise	0617 CDT
Sun transit	1244 CDT
Accident time	1740 CDT ³⁵
Sunset	1911 CDT
End civil twilight	1937 CDT

At the time of the accident the Sun was located at an altitude of 17.14° and azimuth of 266.18°.

³⁴ https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_91-92.pdf. The AC also listed multiple online FAA resources for aviation flight planning services for adverse weather.

³⁵ Inserted accident time for reference and context.

E. LIST OF ATTACHMENTS

Attachment 1 - KLVX base reflectivity animation between 1719 and 1756 CDT

Attachment 2 - GFA information valid at the accident time

Attachment 3 - ForeFlight information

Submitted by:

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