



NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

October 19, 2020

Factual Report

METEOROLOGY

RRD20FR002

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A. ACCIDENT

Location: Draffin, Kentucky
Date: February 13, 2020
Time: 0654 eastern standard time
1154 Coordinated Universal Time (UTC)
Accident: CSX freight train derailment

B. METEOROLOGIST

Paul Suffern
Senior Meteorologist
Operational Factors Division (AS-30)
National Transportation Safety Board

C. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's (NTSB) Meteorologist did not travel for this investigation and gathered the weather data for this investigation from official National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) sources including the National Centers for Environmental Information (NCEI). All times are eastern standard time (EST) on February 13, 2020, and are based upon the 24-hour clock, where local time is -5 hours from UTC, and UTC=Z. Directions are referenced to true north and distances in nautical miles. Heights are above mean sea level (msl) unless otherwise noted. Visibility is in statute miles and fractions of statute miles. NWS airport and 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 37.33488° N, longitude 82.39375° W, at an approximate elevation of 750 feet (ft).

D. WEATHER 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 Weather Prediction Center, 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 00-45H¹ and in the NWS Directive System.²

1.1 Surface Analysis Chart

The Ohio Valley section of the NWS Surface Analysis Chart for 0700 EST is provided as figure 1 with the approximate location of the accident site marked within the red circle. The chart identified 3 frontal systems between Chicago, Illinois, and central North Carolina. One of the cold fronts was located directly above the accident site with the frontal boundary oriented northeast to southwest. It was associated with a surface low pressure system located in western Maryland that had a minimum pressure of 1003-hectopascals (hPa). The station models near the accident site depicted overcast skies with light rain, air temperatures in the low 50’s degrees Fahrenheit (°F), dew point temperatures near 50°F with a temperature-dew point spread of 2° or less, and a southwest to west wind under 10 knots.

¹

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

² <https://www.nws.noaa.gov/directives/>

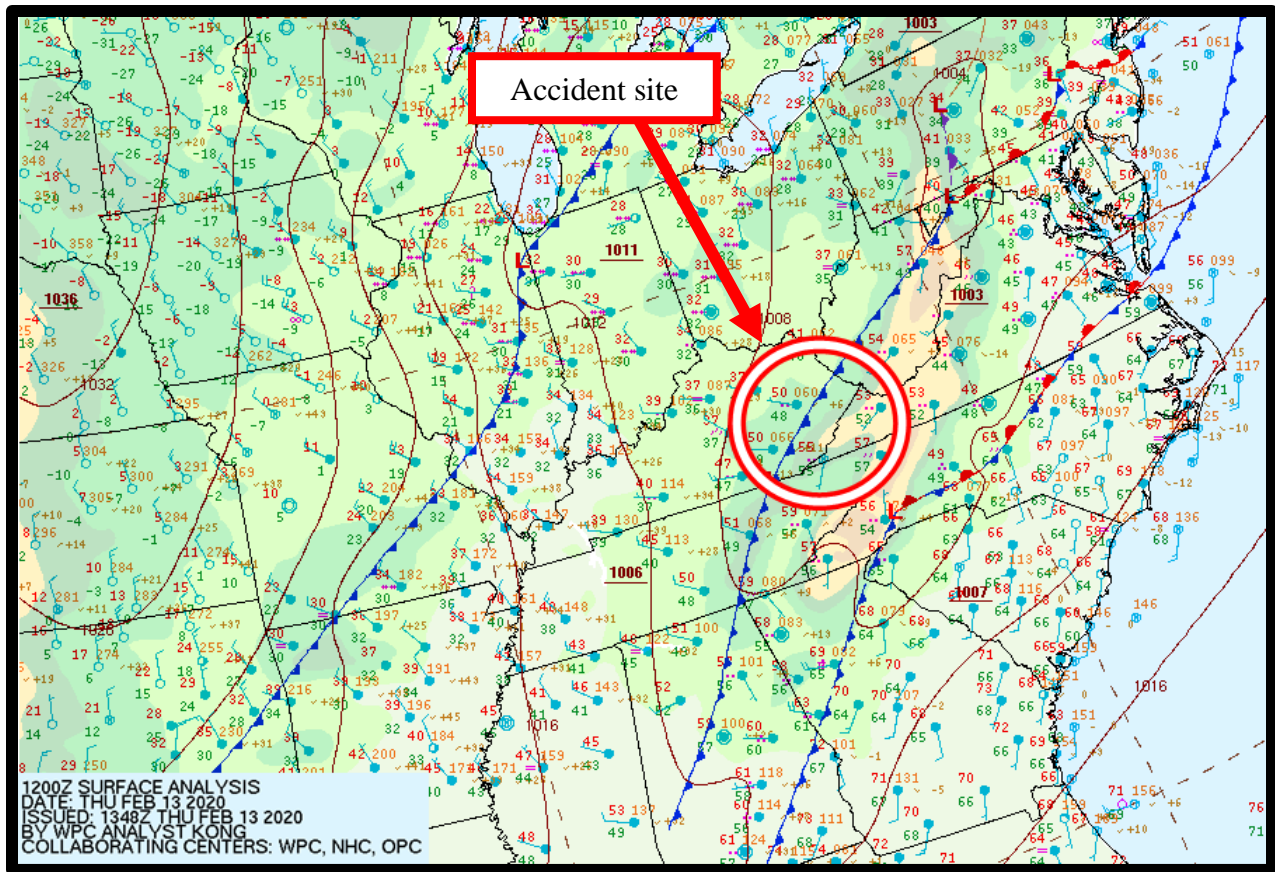


Figure 1 – NWS Surface Analysis Chart for 0700 EST

2.0 SPC Products

The Storm Prediction Center (SPC) issued the following Day 1 Convective Outlook at 1930 EST on February 12 (figure 2) with areas of general thunderstorms forecast for the accident site. SPC defines the “TSTM” area as an area that encloses where a 10% or higher probability of thunderstorms is forecast during the valid period. This thunderstorm probability is higher than the normal expected probability for the day. The SPC Day 1 Convective Outlook text follows figure 2:

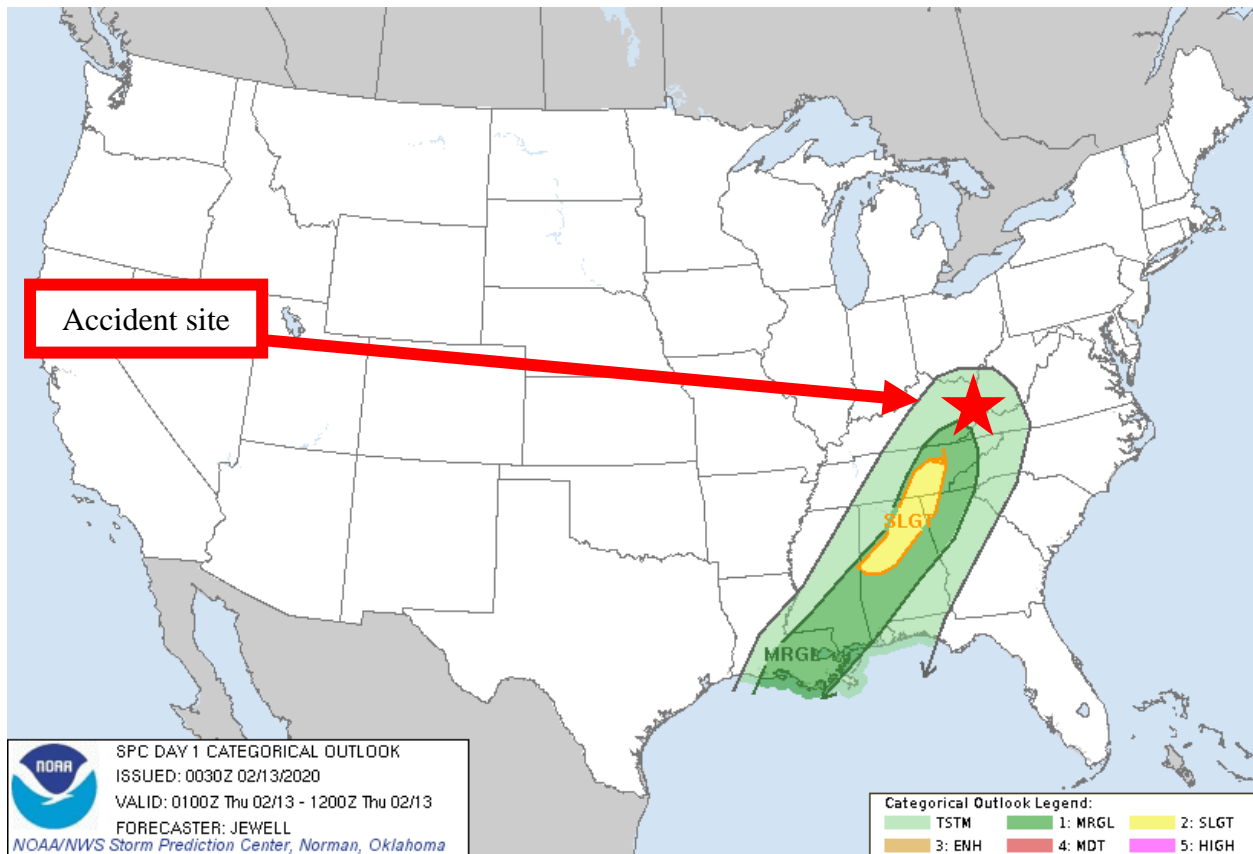


Figure 2 – SPC day 1 Convective Outlook valid at the time of the accident

SPC AC 130030

Day 1 Convective Outlook
NWS Storm Prediction Center Norman OK
0630 PM CST Wed Feb 12 2020

Valid 130100Z - 131200Z

...THERE IS A SLIGHT RISK OF SEVERE THUNDERSTORMS FROM NORTHERN ALABAMA INTO PARTS OF TENNESSEE...

...SUMMARY...

A line of storms may produce isolated severe wind gusts across parts of Alabama and into Tennessee.

...Tennessee Valley...

A line of storms continues to move rapidly east across northern AL and into eastern Middle TN. Objective analysis indicates waning instability ahead of these storms, thus a gradual weakening trend is expected. Until then, strong wind gusts will be common, with isolated severe possible. Tornado risk continues to be limited by low-level lapse rates and instability, despite strong low-level shear. For more information see MCD 121.

..Jewell.. 02/13/2020

CLICK TO GET WUUS01 PTSDY1 PRODUCT

3.0 Surface Observations

The area surrounding the accident site was documented using official Meteorological Aerodrome Reports (METARs) and Specials (SPECIs). The following observations were taken from standard code and are provided in plain language. Figure 3 is a local sectional chart with the accident site and the closest weather reporting location marked.

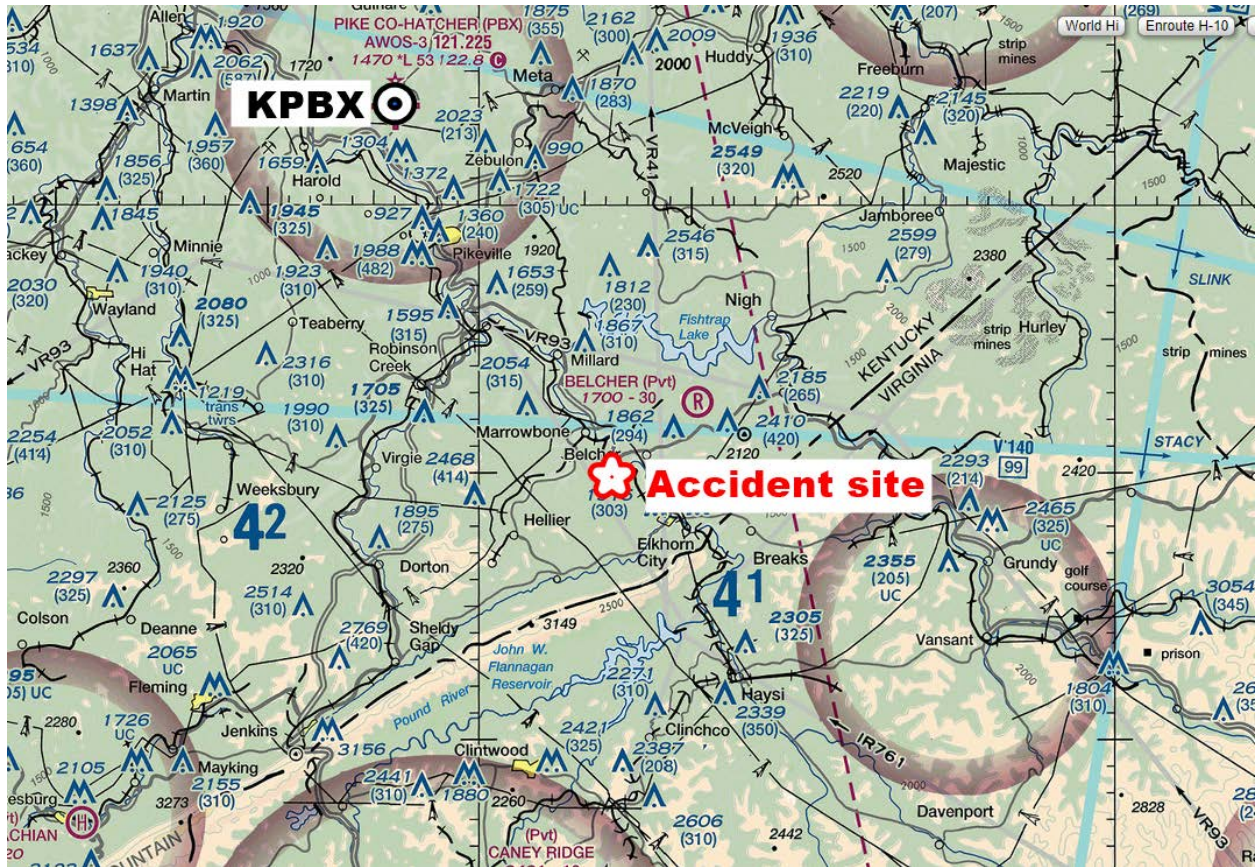


Figure 3 – Sectional map of the accident area with the location of the accident site and surface observation site

Pike County Airport-Hatcher Field (KPBX) was the closest official observation point to the accident site. KPBX had an Automated Weather Observing System (AWOS³) whose reports were not supplemented. The KPBX AWOS⁴ did not contain precipitation accumulation information. KPBX was located 16 miles northwest of the accident site, at an elevation of 1,470 ft, and had a 7° westerly magnetic variation⁵ (figure 3). The following observations were taken and disseminated during the times surrounding the accident:⁶

[0455 EST] METAR KPBX 130955Z AUTO 0000KT 3/4SM -RA BKN002 BKN026 OVC080 13/13 A2969 RMK AO2 T01250125=

[0515 EST] METAR KPBX 131015Z AUTO 18005KT 10SM -RA SCT024 BKN050 OVC080 13/13 A2969 RMK AO2 T01270127=

[0535 EST] METAR KPBX 131035Z AUTO 19004KT 10SM -RA SCT024 BKN070 OVC080 13/13 A2969 RMK AO2 T01270127=

[0555 EST] METAR KPBX 131055Z AUTO 20004KT 10SM -RA SCT015 BKN080 OVC095 13/13 A2970 RMK AO2 T01270127=

[0615 EST] METAR KPBX 131115Z AUTO 18005KT 4SM RA SCT060 BKN075 OVC095 13/13 A2969 RMK AO2 T01260126=

[0635 EST] METAR KPBX 131135Z AUTO 21004KT 10SM RA OVC075 13/13 A2971 RMK AO2 T01270127=

ACCIDENT TIME 0654 EST

[0655 EST] METAR KPBX 131155Z AUTO 20004KT 10SM -RA OVC075 13/13 A2971 RMK AO2 T01260126 10138 20125=

[0715 EST] METAR KPBX 131215Z AUTO 18006KT 10SM DZ SCT075 BKN080 OVC110 12/12 A2969 RMK AO2 T01240124=

[0735 EST] METAR KPBX 131235Z AUTO 17008KT 10SM -DZ SCT017 SCT060 OVC110 12/12 A2967 RMK AO2 T01230123=

³ AWOS – Automated Weather Observing System is equipped with meteorological instruments to observe and report temperature, dewpoint, wind speed and direction, visibility, cloud coverage and ceiling up to 12,000 feet, and altimeter setting.

⁴ https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_150_5220-16E.pdf

⁵ Magnetic variation – The angle (at a particular location) between magnetic north and true north. Latest measurement taken from <https://skyvector.com/>

⁶ The bold sections in this NWS product and the rest of the products in this report are intended to highlight the sections 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.

[0755 EST] METAR KPBX 131255Z AUTO 19005KT 10SM DZ SCT021 BKN070 OVC110
13/13 A2966 RMK AO2 T01250125=

KPBX weather at 0635 EST, automated, wind from 210° at 4 knots (5 miles per hour, mph), 10 miles visibility or greater, moderate rain (see section 7.3), an overcast ceiling⁷ at 7,500 ft above ground level (agl), temperature of 13°Celsius (55°F), dew point temperature of 13°C (55°F), and an altimeter setting of 29.71 inches of mercury (inHg). Remarks: automated station with a precipitation discriminator, temperature 12.7°C, dew point temperature 12.7°C.

KPBX weather at 0655 EST, automated, wind from 200° at 4 knots (5 mph), 10 miles visibility or greater, light rain, an overcast ceiling at 7,500 ft agl, temperature of 13°C (55°F), dew point temperature of 13°C (55°F), and an altimeter setting of 29.71 inHg. Remarks: automated station with a precipitation discriminator, temperature 12.6°C, dew point temperature 12.6°C, 6-hourly maximum temperature 13.8°C, 6-hourly minimum temperature 12.5°C.

The observations from KPBX surrounding the accident time indicated surface visibilities as low as 4 miles in moderate rain. The wind remained from the south to southwest at 6 mph around the accident time.

4.0 Upper Air Data

A High-Resolution Rapid Refresh (HRRR)⁸ model sounding was created for the accident site for 0700 EST with a station elevation of 1,010 ft.⁹ The 0700 EST HRRR sounding was plotted on a standard Skew-T Log P diagram¹⁰ with the derived stability parameters included in figure 4 with data from the surface to 700-hPa (or approximately 10,000 ft msl). These data were analyzed using the RAOB¹¹ software package. The sounding depicted the lifted condensation level (LCL)¹² at 1,387 ft agl (2,397 ft msl) and the convective condensation level (CCL)¹³ at 4,378 ft agl (5,388 ft msl). The sounding had a greater than 80% relative humidity from the surface through 3,000 ft msl. The freezing level was located at 10,186 ft msl. The precipitable water value was 1.12 inches in the 0700 EST HRRR sounding, which was 0.23 inches above the maximum daily value (and 0.01 inches above the max moving average line) of precipitable water observed in any recorded

⁷ Ceiling - After U.S. weather observing practice, the height ascribed to the lowest layer of clouds or obscuring phenomena when it is reported as broken, overcast, or obscuration and not classified "thin" or "partial." <http://glossary.ametsoc.org/wiki/Ceiling>

⁸ 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.

⁹ HRRR sounding was created using NOAA Air Resource Laboratory: <https://ready.arl.noaa.gov/READYamet.php>

¹⁰ 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.

¹¹ RAOB – (The complete Rawinsonde Observation program) is an interactive sounding analysis program developed by Environmental Research Services, Matamoras, Pennsylvania.

¹² LCL - The height at which a parcel of moist air becomes saturated when it is lifted dry adiabatically.

¹³ 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.

0700 EST sounding from Wilmington, Ohio¹⁴ (KILN) for February 12 (period of record from 1947 through 2019).¹⁵

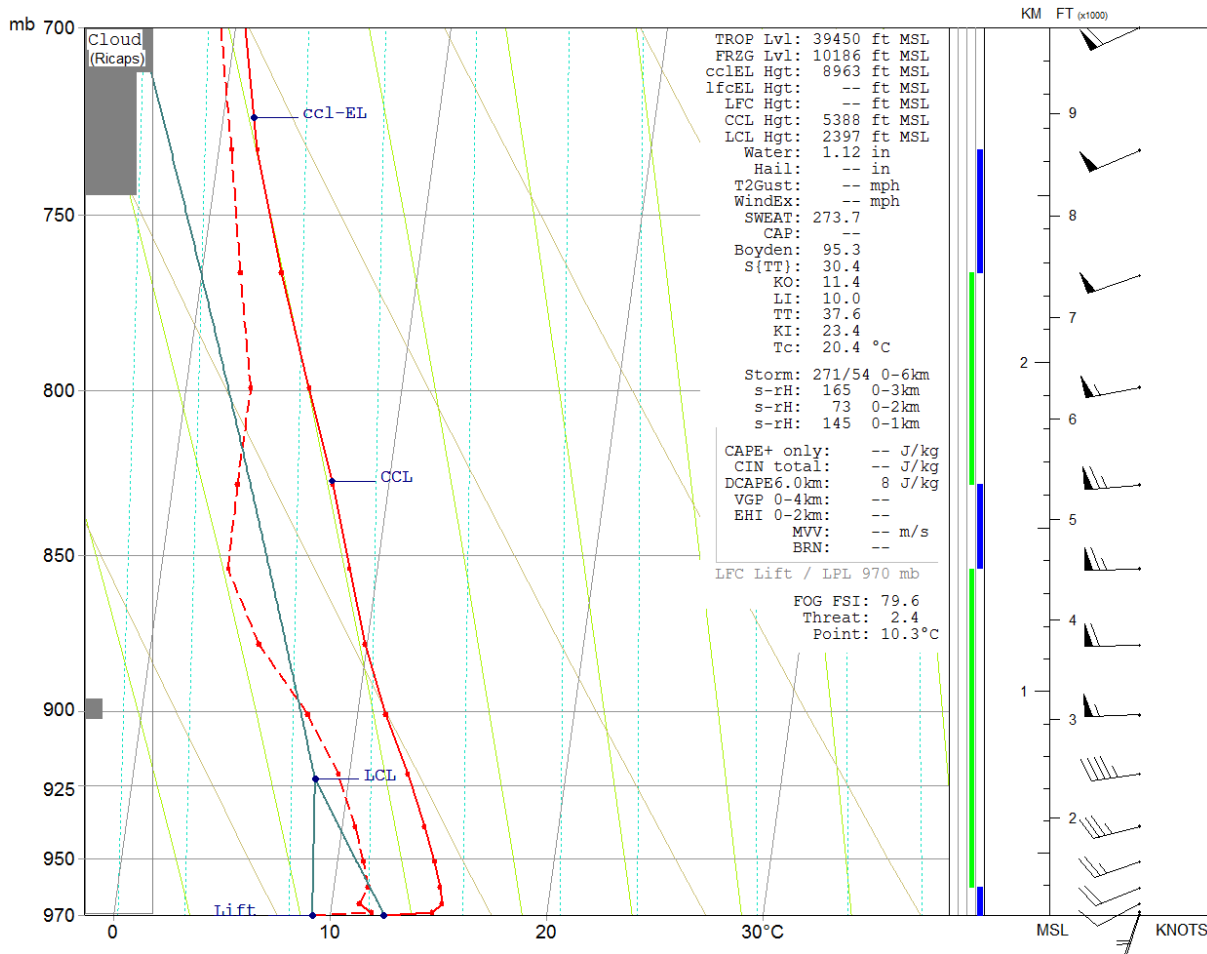


Figure 4 – 0700 EST HRRR sounding

The 0700 EST HRRR sounding for the accident site indicated a mostly conditionally unstable environment from the surface through 10,000 ft, with a Lifted Index¹⁶ of 10. RAOB identified the possibility of clouds from 8,000 ft msl through 10,000 ft msl.

The 0700 EST HRRR sounding wind profile indicated a surface wind from 197° at 4 knots (5 mph) with the wind veering¹⁷ to the west by 2,000 ft msl. Wind speeds increased to 35 knots (40 mph) by 2,000 ft msl and wind speeds as high as 65 knots (75 mph) were indicated by 4,500 ft msl.

¹⁴ KILN was located 142 miles northwest of the accident site is the closest upper air sounding location west of the Appalachian Mountains to the accident site. KRNK (Blacksburg, Virginia) was located 96 miles east of the accident site had maximum daily precipitable water value of 0.98 inches.

¹⁵ <https://www.spc.noaa.gov/exper/soundingclimo/>

¹⁶ Lifted Index (LI) is a measure of stability used in meteorology. <https://www.weather.gov/lmk/indices>

¹⁷ A clockwise turning of the wind with height in the northern hemisphere.

5.0 Satellite Data

Data from the Geostationary Operational Environmental Satellite number 16 (GOES-16) data was 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 (bands 2 and 13) imagery at wavelengths of 0.64 microns (μm) and 10.3 μm were retrieved for the period. Satellite imagery surrounding the time of the accident, from 0500 EST through 1000 EST at approximately 5-minute intervals were reviewed, and the closest images to the time of the accident are documented here. Due to the time of the accident, which was before sunrise, the visible imagery did not provide helpful data at the accident time.

Figure 5 presents the GOES-16 infrared imagery from 0650 EST at 4X magnification and with a temperature enhancement curve applied with the accident site highlighted with a red square. Inspection of the infrared imagery indicated abundant cloud cover over the accident site at the accident time with the lowest brightness temperatures (blue and green colors, higher clouds) located over the accident site. Based on the brightness temperatures above the accident site (233 Kelvin) and the vertical temperature profile provided by the 0700 EST HRRR sounding, the approximate cloud-top heights over the accident site were 31,000 ft at 0650 EST. It should be noted these figures have not been corrected for any parallax error.

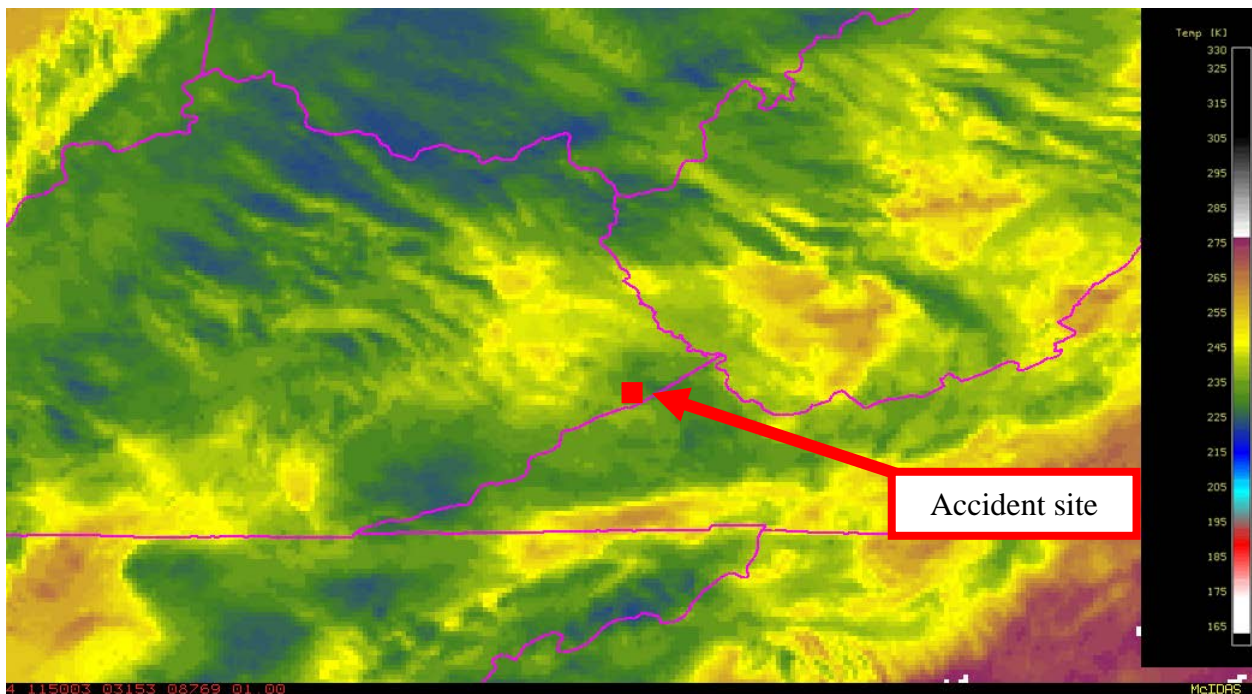


Figure 5 – GOES-16 infrared image at 0650 EST

6.0 Regional Radar Imagery Information

A regional view of the NWS National Composite Radar Mosaic is included as figure 6 for 0655 EST with the approximate location of the accident site marked with the red circle. The image depicted 30 to 50 decibel (dBZ¹⁸) echoes above the accident site.

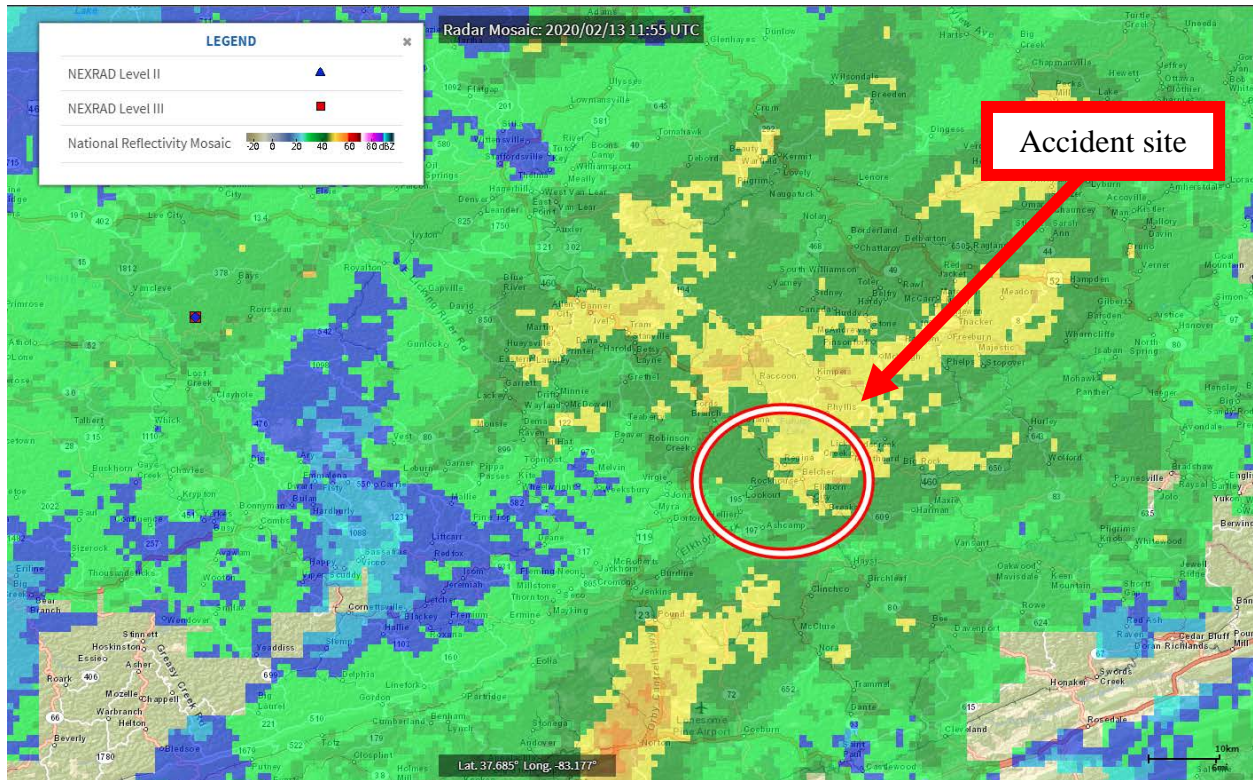


Figure 6 – Regional Composite Reflectivity image for 0655 EST

7.0 Radar Imagery Information

The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)¹⁹ to the accident site was Jackson, Kentucky, (KJKL) and was located 46 miles west-northwest of the accident site. Level II and III 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.

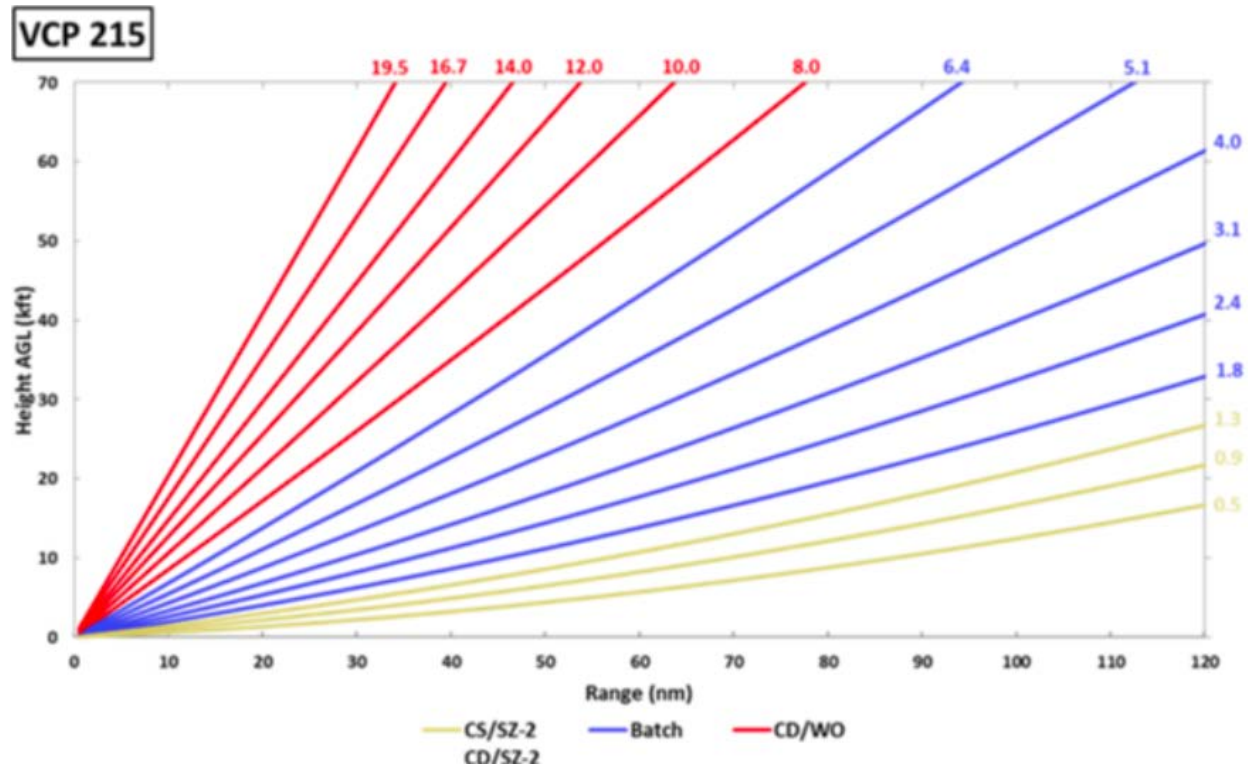
7.1 Volume Scan Strategy

The WSR-88D is a computer-controlled radar system, which automatically creates a complete series of specific scans in a specific sequence known as a volume scan. Individual elevation scans are immediately available. Products that require data from multiple elevation scans are not available until the end of the five to ten-minute volume scan.

¹⁸ 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.

¹⁹ 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.

The WSR-88D operates in several different scanning modes, identified as Mode A and Mode B. Mode A is the precipitation scan and has three common scanning strategies. The most common is where the radar makes 15 elevation scans from 0.5° to 19.5° every six minutes. This particular scanning strategy is documented as volume coverage pattern 215 (VCP-215). Mode B is the clear-air mode, where the radar makes 5 elevation scans during a ten-minute period. During the period surrounding the accident, the KJKL WSR-88D radar was operating in the precipitation mode VCP-215. The following chart 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.



VCP-215 Precipitation Mode Scan Strategy²⁰

²⁰ 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)

7.2 Beam Height Calculation

Assuming standard refraction²¹ of the WSR-88D radar beam with the antenna elevation at 1,461 ft (KJKL), and considering a beamwidth²² 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.

ANTENNA ELEVATION	BEAM CENTER	BEAM BASE	BEAM TOP
KJKL 0.5°	5,430 ft	3,160 ft	7,700 ft

Based on the radar height calculations, the elevation scan listed in the above table depicted the conditions between 3,160 ft and 7,700 ft msl over the accident site and these scans “saw” the closest altitudes to the ground.

7.3 Reflectivity

Reflectivity is the measure of the efficiency of a target in intercepting and returning radio energy. With hydrometeors²³ 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 00-24C²⁴, “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 but less than 50 dBZ, inclusive. Finally, any dBZ values above 50 dBZ shall be described as “extreme.” From the NWS, precipitation conditions at the surface can be inferred from VIP Levels described in the chart below:

²¹ Standard Refraction in the atmosphere is when the temperature and humidity distributions are approximately average, and values set at the standard atmosphere.

²² Beamwidth - the angular separation between the half power points on the antenna radiation pattern, where the gain is one half the maximum value.

²³ 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.

²⁴

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

- VIP 1 (Level 1, 18-30 dBZ) - Light precipitation
- VIP 2 (Level 2, 30-38 dBZ) - Light to moderate rain
- VIP 3 (Level 3, 38-44 dBZ) - Moderate to heavy rain
- VIP 4 (Level 4, 44-50 dBZ) - Heavy rain
- VIP 5 (Level 5, 50-57 dBZ) - Very heavy rain; hail possible
- VIP 6 (Level 6, >57 dBZ) - Very heavy rain and hail; large hail possible

7.4 Base Reflectivity and Lightning Data

Figure 7 presents the KJKL WSR-88D base reflectivity images for the 0.5° elevation scans initiated at 0651:29 EST, with a resolution of 0.5° X 250 m. Reflectivity values between 20 and 35 dBZ or light to moderate rain intensity echoes (section 7.3) were located above the accident site at the time of the accident (figure 7). The reflectivity bands were moving from west to east with time (attachment 1). The KJKL WSR-88D digital storm total precipitation data between 1930 EST February 11 and 0657 EST on February 13 indicated 0.56 inches of precipitation fell on the accident site (figure 8).

There were no lightning strikes near the accident site at the accident time.²⁵

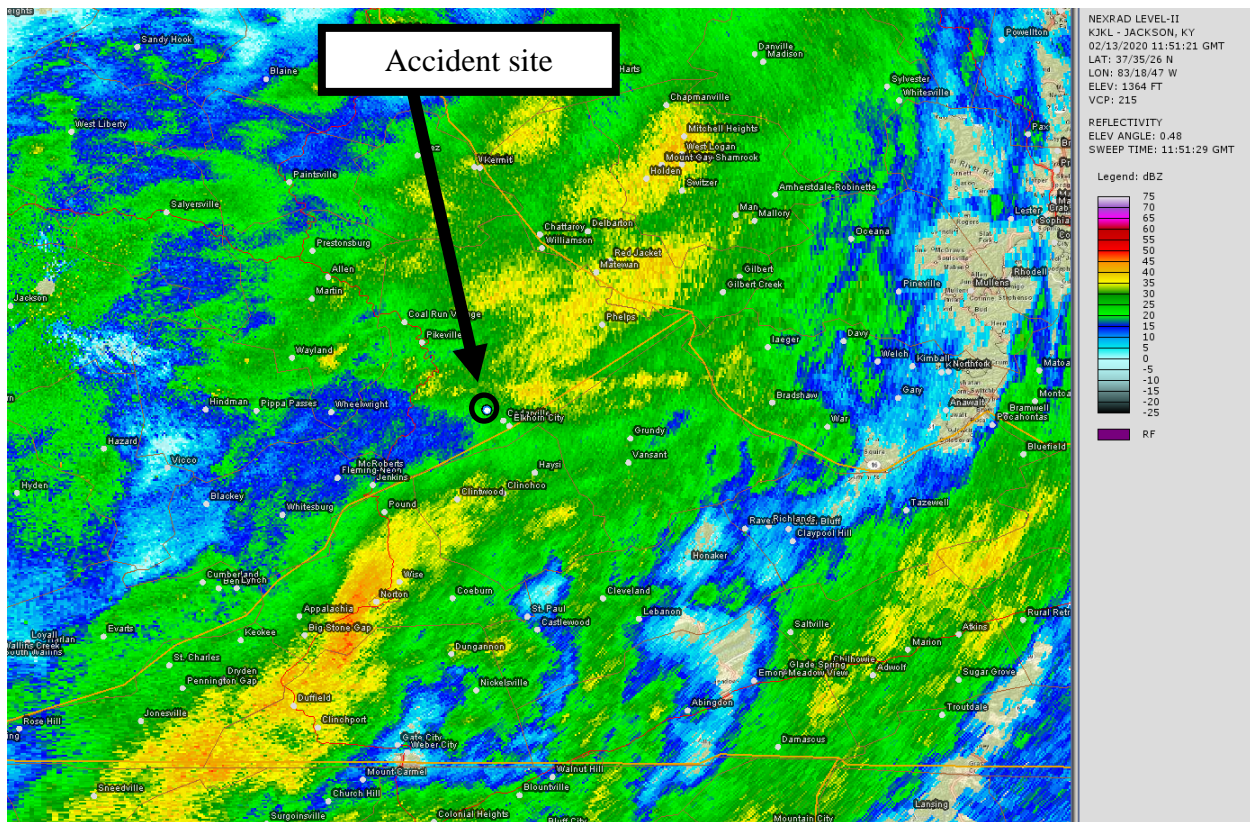


Figure 7 – KJKL WSR-88D reflectivity for the 0.5° elevation scan initiated at 0651:29 EST with the accident site marked with black circle

²⁵ A review of data from the Earth Networks Total Lightning Network was performed.

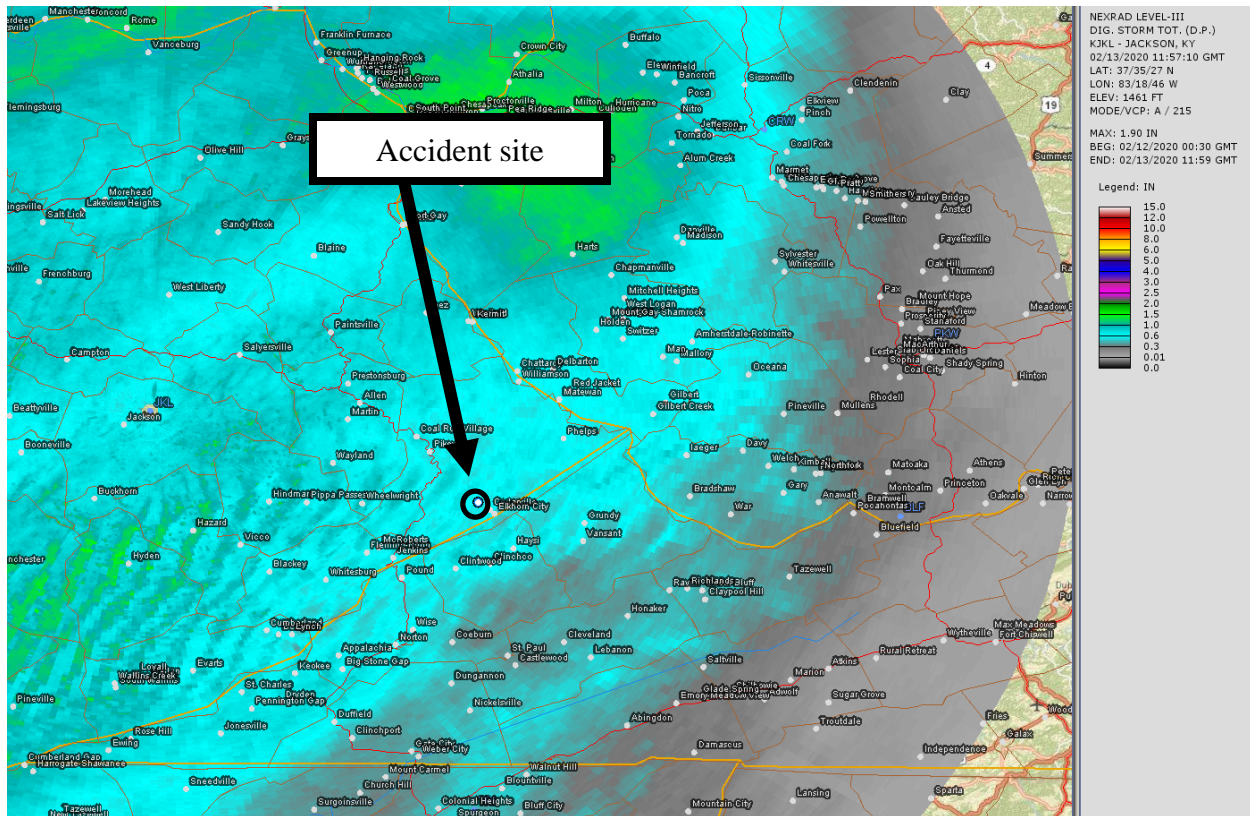


Figure 8 – KJKL WSR-88D digital storm total precipitation for the 0.5° elevation scan initiated at 0651:29 EST with the accident site marked with black circle

8.0 NWS Area Forecast Discussion

The NWS office in Jackson, Kentucky, (JKL) issued the following Area Forecast Discussion (AFD) at 0510 EST (closest AFD to the accident time). The AFD indicated continued rainfall during the morning and continuing a flood watch across the region (including accident site) through 0700 EST:

FXUS63 KJKL 131010
AFDJKL

AREA FORECAST DISCUSSION
National Weather Service Jackson KY
510 AM EST Thu Feb 13 2020

.SHORT TERM...(Today through Friday)
Issued at 510 AM EST THU FEB 13 2020

09z sfc analysis shows low pressure and its frontal wave moving past eastern Kentucky to the northeast. This is still bringing a stream of moisture and showers into this part of the state, though the heaviest rains have moved on off to the east. Yet, some rainfall rates approaching a half an inch remain possible from the healthier showers. This will fall on saturated grounds ending up mostly as runoff and for that reason we will keep the

Flood Watch going through 7 am. Winds have responded to the passing boundary, as well, with values generally around 10 mph along with occasional gusts to 20 mph - from the northwest over our western locations but still southerly on the system's warm side. Temperatures (and dewpoints) likewise vary across the boundary from the upper 30s northwest to the mid 50s for JKL and points south and east.

The models are in pretty good agreement aloft through the short term portion of the forecast. They all depict a positively tilted, full-latitude trough basically running from the Great Lakes southwest into the Southern Plains at the start of the period slowly sliding east in time. The lead shortwave of this larger trough scoots through eastern Kentucky today pushing the sfc system ahead of it. Given the broad and deep southwest flow over our area the moisture will likely be slow to completely clear out until the main trough crosses the region around midday Friday. Given the limited model spread through 00z Saturday have favored a blended solution as offered up by the NBM - with a strong lean on the near term HRRR details and later tonight the more climatic norms for cold air advection in a low QPF/departing sfc low environment.

Sensible weather will feature a wind down to the steadier rains this morning as the winds completely switch to the west and somewhat drier air moves in at the sfc. These winds also bring in colder air through the column meaning that there will be some potential for snow flakes mixing in with the lingering showers from northwest to southeast this afternoon followed by flurries at night. Temperatures are likely to slowly drop through the day and tonight as the cooler air mass works into the area. As such, we will have one of the colder nights on tap since the third week of January. Chilly conditions extend into the day Friday with much of it spent below freezing and only a few spots topping out in the mid 30s for highs, despite returning sunshine and a slackening of the wind.

Again preferred to derive the MaxTs from the hourly values of the NBM today due to the non-diurnal curve. Through tonight the CONSShort was favored for PoPs with some enhancement added over our terrain areas tonight due to the lingering boundary layer moisture and upslope winds.

.LONG TERM...(Friday night through Wednesday)
Issued at 349 AM EST THU FEB 13 2020

Still looking at a dry period heading into the extended. A strong area of high pressure will be moving overhead and just north of the state Friday night. With a colder airmass in place, and strong subsidence, temps are expected to bottom out in the upper teens to around 20 degrees. By Saturday, however, the high pressure system will be exiting east of the state, and return flow will take hold. With loss of CAA aloft, temps will be able to rebound quite nicely, with highs in the 40s.

Meanwhile, a disturbance is forecast to develop across the Upper

Midwest and points northward through the Upper Great Lakes and into Canada during the day Saturday. As this system shifts eastward Saturday night into Sunday, a weak cold front may pass through Kentucky. However, both the GFS and ECMWF continue to keep associated precip north of the state, and JKL dry. This dry forecast has been consistent for several days now. We will then quickly be overcome by another area of high pressure by Sunday evening/night. Despite the models going dry, the NBM continues to forecast scattered pops beginning Saturday night and persisting through Sunday night. Coordinated with surrounding offices once more, and removed pops during this time based on the consistent dry model agreement.

As this second area of high pressure quickly exits east of the state by Monday morning, another period of return flow will boost temps into the mid and upper 50s for the day, with some locations possibly hitting 60. It will also allow for an influx of moisture into the state in the form of increasing clouds. Models are still having some disagreements about an approaching system from the west, but compared to yesterday, they are in better agreement about timing of precip as it makes its way into the state. This area of low pressure is forecast to shift from the Central Plains to The Mississippi River Valley...with the GFS showing it over the Upper Mississippi Valley, and the ECWMF shunting it farther south across the Middle Mississippi Valley. As this system progresses northeastward, both have a cold front and associated precip pushing eastward across the state. Despite their differences on placement, both are in fairly good agreement that pops will enter the CWA starting around 6Z Tuesday, quickly overspreading the region by Tuesday morning. This is a later onset than was forecast 24 hours ago, when pops were expected as early as early afternoon Monday and models were not in as good of alignment. However, NBM was still placing pops throughout the day Monday, so coordinated with neighboring offices to push back the start time based on the latest GFS and ECMWF.

Model timing and placement of the low pressure system track actually start to fall back in line again by 12Z Wednesday as the system continues eastward. The cold front should be exiting the state, and associated precip should be coming to an end as a large area of high pressure takes hold from the NW throughout the remainder of the day. This high pressure system should remain in place across the region to finish out the extended period. Given that all pops should be out of the CWA by Wednesday morning (perhaps late morning based on the ECMWF), and such a strong area of dry air is taking hold, still not sure why the NBM continues to hold on to pops throughout the remainder of the extended. Once again, coordinated with neighboring offices, and dropped pops after Wednesday morning, keeping dry weather in place through the end of the forecast period. The only caveat is that the incoming dry airmass will also be a colder one. So depending on how quickly the cold air advects in vs. how quickly the moisture from the departing system moves out, there may be enough cold air to transition some rain to a mix of rain and snow showers. Uncertainty is still somewhat low at this point given the inconsistencies between the NBM and models, but whatever snow does fall should be light. While highs on Tuesday are forecast in the upper 50s to low 60s, highs for Wednesday and Thursday should only

be in the upper 30s to mid 40s.

&&

.AVIATION...(For the 06Z TAFS through 06Z Thursday night)
ISSUED AT 115 AM EST THU FEB 13 2020

Aside from a brief period of VFR and MVFR at some sites through 08z, poor aviation conditions are expected through the rest of the night and into Thursday - mostly IFR and below. Rain will be falling much of the time, with a band of heavier showers developing over our western locations and sliding east before the end of the night. This, in conjunction with the low CIGs, will also provide for lower visibilities at times. A period of low level wind shear is also forecast for a time early this morning. The rain clears out west to east by midday Thursday with some marginal improvements in the low CIGs while VIS becomes unrestricted. In general, southwest winds of around 10 kts with some occasional gusts to 15 or so kts will switch more westerly through the night and continue that way during the day Thursday.

&&

.JKL WATCHES/WARNINGS/ADVISORIES...
Flash Flood Watch until 7 AM EST this morning for KYZ044-050>052-058>060-068-069-079-080-083>088-104-106>120.

&&

\$\$

9.0 Local Storm Reports

The JKL NWS office issued the following two local storm reports (LSR) at 2227 and 2340 EST on February 12 with mudslides reported. The mudslide near Eversole, Kentucky was located 60 miles west-northwest of the accident site and the mudslide near Yeadon, Kentucky was located 50 miles west-northwest of the accident site:

NWUS53 KJKL 130327
LSRJKL

PRELIMINARY LOCAL STORM REPORT
NATIONAL WEATHER SERVICE JACKSON KY
1027 PM EST WED FEB 12 2020

..TIME... ..EVENT... ..CITY LOCATION... ..LAT.LON...
..DATE... ..MAG.... ..COUNTY LOCATION..ST.. ..SOURCE....
..REMARKS..

1013 PM HEAVY RAIN 2 SSE YEADON 37.53N 83.44W
02/12/2020 U0.00 INCH BREATHITT KY PUBLIC

REPORT VIA SOCIAL MEDIA INDICATING THAT
BELCHER FORK RD. IS IMPASSABLE DUE TO A
MUDSLIDE.

&&

\$\$

NWUS53 KJKL 130440
LSRJKL

PRELIMINARY LOCAL STORM REPORT
NATIONAL WEATHER SERVICE JACKSON KY
1140 PM EST WED FEB 12 2020

..TIME... ..EVENT... ..CITY LOCATION... ..LAT.LON...
..DATE... ..MAG.... ..COUNTY LOCATION..ST.. ..SOURCE....
..REMARKS..

1235 PM HEAVY RAIN 1 NE EVERSOLE 37.46N 83.63W
02/12/2020 U0.00 INCH OWSLEY KY PUBLIC

REPORT VIA SOCIAL MEDIA INDICATES KY-2024
CLOSED BETWEEN MM 9-10 DUE TO A MUDSLIDE
INVOLVING POWER LINES. THIS IS ON THE BEAR
BRANCH SECTION, NEAR THE KY 30 INTERSECTION.

&&

\$\$

10.0 NWS Public Forecast and Hazardous Weather Outlook

The NWS JKL office issued a Zone Forecast Product (ZFP) at 0350 EST, which was valid at the accident time for the accident site, which included a flash flood watch valid through 0700 EST. The ZFP indicated rain showers were expected with areas of fog and a southwest to west wind around 10 mph:

KYZ120-140000-
Pike-
Including the cities of Coal Run, Elkhorn City, Pikeville,
and South Williamson
350 AM EST Thu Feb 13 2020

...FLASH FLOOD WATCH IN EFFECT UNTIL 7 AM EST THIS MORNING...

.EARLY THIS MORNING...Showers. Areas of fog. Southwest winds around 10 mph. Chance of rain near 100 percent.

.TODAY...Areas of fog early. Rain showers in the morning, then a chance of rain showers and flurries in the afternoon. Highs in the mid 50s. West winds around 10 mph. Chance of rain near 100 percent.

.TONIGHT...Cooler, cloudy. Sprinkles possible in the evening. A chance of flurries through the night. Lows in the lower 20s. Northwest winds around 10 mph.

.FRIDAY...Cooler. Mostly sunny. Flurries possible early. Highs in the lower 30s. Light winds.
.FRIDAY NIGHT...Mostly clear. Lows in the upper teens. Light winds.
.SATURDAY...Mostly sunny. Highs in the upper 40s. Light winds.
.SATURDAY NIGHT...Mostly cloudy. Lows in the mid 30s.
.SUNDAY...Mostly cloudy. Highs in the lower 50s.
.SUNDAY NIGHT...Mostly cloudy. Lows in the upper 30s.
.WASHINGTONS BIRTHDAY...Partly sunny. Highs in the upper 50s.
.MONDAY NIGHT...Mostly cloudy with rain likely. Near steady temperatures in the lower 50s. Chance of rain 60 percent.
.TUESDAY...Rain. Highs in the lower 60s. Chance of rain 80 percent.
.TUESDAY NIGHT...Cloudy with rain likely. Lows in the upper 30s. Chance of rain 70 percent.
.WEDNESDAY...Mostly cloudy with a 50 percent chance of rain. Highs in the mid 40s.

\$\$

A Hazardous Weather Outlook (HWO) was issued by the NWS JKL office at 0400 EST and valid at the accident time. The HWO warned of a period of heavier showers across the region with isolated low lying flooding and high running rivers:

FLUS43 KJKL 130900
HWOJKL

Hazardous Weather Outlook
National Weather Service Jackson KY
400 AM EST Thu Feb 13 2020

KYZ044-050>052-058>060-068-069-079-080-083>088-104-106>120-141200-
Fleming-Montgomery-Bath-Rowan-Estill-Powell-Menifee-Rockcastle-
Jackson-Pulaski-Laurel-Wayne-McCreary-Whitley-Knox-Bell-Harlan-
Elliott-Morgan-Johnson-Wolfe-Magoffin-Floyd-Lee-Breathitt-Knott-
Owsley-Perry-Clay-Leslie-Letcher-Martin-Pike-
Including the cities of Flemingsburg, Camargo, Jeffersonville,
Mount Sterling, Owingsville, Morehead, Irvine, Ravenna,
Clay City, Stanton, Frenchburg, Brodhead, Mount Vernon, McKee,
Annville, Burnside, Somerset, London, Monticello, Stearns,
Whitley City, Corbin, Williamsburg, Barbourville, Middlesboro,
Pineville, Cumberland, Harlan, Sandy Hook, West Liberty,
Paintsville, Campton, Salyersville, Prestonsburg, Wheelwright,
Beattyville, Jackson, Hindman, Pippa Passes, Booneville, Hazard,
Manchester, Hyden, Jenkins, Whitesburg, Inez, Coal Run,
Elkhorn City, Pikeville, and South Williamson
400 AM EST Thu Feb 13 2020

...FLASH FLOOD WATCH IN EFFECT UNTIL 7 AM EST THIS MORNING...

This hazardous weather outlook is for portions of eastern Kentucky.

.DAY ONE...Today and Tonight.

A period of heavier showers moving through the area early this

morning will pose a threat for isolated low lying flooding.

Rivers will continue to run high in many locations.

.DAYS TWO THROUGH SEVEN...Friday through Wednesday.

Rivers will continue to run high or be in flood for many locations through the rest of the week.

.SPOTTER INFORMATION STATEMENT...

Spotters are encouraged to report instances of excessive rains and flooding through the rest of the week.

\$\$

11.0 Local Climate Information

The closest local climate site²⁶ to the accident site was JKL. JKL reported the below information for February 12 and February 13. The data indicated that at JKL 0.71 inches of precipitation fell on February 12 with 5.38 inches of precipitation since the beginning of February which was 3.79 inches higher than normal. In addition, there had been 8.75 inches of precipitation at JKL since January 1 which was 3.55 inches above normal. On February 13, an additional 0.72 inches of precipitation fell, with 6.10 inches of precipitation since the beginning of February, and 9.47 inches since January, which were 4.38 and 4.14 inches above normal, respectively:

These data are preliminary and have not undergone final quality control by the National Climatic Data Center (NCDC). Therefore, these data are subject to revision. Final and certified climate data can be accessed at the NCDC - <http://www.ncdc.noaa.gov>.
Climatological Report (Daily)

411
CDUS43 KJKL 130533
CLIJKL

CLIMATE REPORT
NATIONAL WEATHER SERVICE JACKSON KY
1233 AM EST THU FEB 13 2020

.....

...THE JACKSON KY CLIMATE SUMMARY FOR FEBRUARY 12 2020...

CLIMATE NORMAL PERIOD 1981 TO 2010
CLIMATE RECORD PERIOD 1981 TO 2020

²⁶ Local Climatological Data (LCD): Local Climatological Data (LCD) are summaries of climatological conditions from airport and other prominent weather stations managed by NWS, FAA, and DOD. The product includes hourly observations and associated remarks, and a record of hourly precipitation for the entire month.
[https://data.nodc.noaa.gov/cgi-bin/iso?id=gov.noaa.ncdc:C00684#:~:text=Local%20Climatological%20Data%20\(LCD\)%20are,precipitation%20for%20the%20entire%20month](https://data.nodc.noaa.gov/cgi-bin/iso?id=gov.noaa.ncdc:C00684#:~:text=Local%20Climatological%20Data%20(LCD)%20are,precipitation%20for%20the%20entire%20month).

WEATHER ITEM OBSERVED TIME RECORD YEAR NORMAL DEPARTURE LAST
 VALUE (LST) VALUE VALUE FROM YEAR
 NORMAL

.....
 TEMPERATURE (F)

YESTERDAY
 MAXIMUM 56 1159 PM 72 2017 47 9 60
 MINIMUM 37 729 AM -4 1981 29 8 33
 AVERAGE 47 38 9 47

PRECIPITATION (IN)

YESTERDAY 0.71 0.74 1999 0.13 0.58 0.73
 MONTH TO DATE 5.38 1.59 3.79 3.06
 SINCE DEC 1 15.05 9.38 5.67 14.79
 SINCE JAN 1 8.75 5.20 3.55 7.32

SNOWFALL (IN)

YESTERDAY 0.0 12.0 1985 0.3 -0.3 0.0
 MONTH TO DATE 2.0 3.4 -1.4 T
 SINCE DEC 1 3.8 15.4 -11.6 3.5
 SINCE JUL 1 5.0 16.0 -11.0 5.2
 SNOW DEPTH 0

DEGREE DAYS

HEATING
 YESTERDAY 18 27 -9 18
 MONTH TO DATE 217 337 -120 214
 SINCE DEC 1 1587 2103 -516 1841
 SINCE JUL 1 2421 2903 -482 2790

COOLING

YESTERDAY 0 0 0 0
 MONTH TO DATE 0 0 0 0
 SINCE DEC 1 0 1 -1 0
 SINCE JAN 1 0 0 0 0

.....
 WIND (MPH)

HIGHEST WIND SPEED 20 HIGHEST WIND DIRECTION W (290)
 HIGHEST GUST SPEED 34 HIGHEST GUST DIRECTION NW (310)
 AVERAGE WIND SPEED 3.7

SKY COVER

POSSIBLE SUNSHINE MM
 AVERAGE SKY COVER 0.7

WEATHER CONDITIONS

THE FOLLOWING WEATHER WAS RECORDED YESTERDAY.

RAIN
 LIGHT RAIN
 FOG
 FOG W/VISIBILITY <= 1/4 MILE

RELATIVE HUMIDITY (PERCENT)

HIGHEST 96 700 PM
 LOWEST 85 1200 AM

AVERAGE 91

THE JACKSON KY CLIMATE NORMALS FOR TODAY

	NORMAL	RECORD	YEAR
MAXIMUM TEMPERATURE (F)	47	72	1990
MINIMUM TEMPERATURE (F)	29	7	1988

SUNRISE AND SUNSET

FEBRUARY 13 2020.....	SUNRISE	725 AM EST	SUNSET	610 PM EST
FEBRUARY 14 2020.....	SUNRISE	724 AM EST	SUNSET	611 PM EST

- INDICATES NEGATIVE NUMBERS.
- R INDICATES RECORD WAS SET OR TIED.
- MM INDICATES DATA IS MISSING.
- T INDICATES TRACE AMOUNT.

The U.S. Naval Observatory (USNO) data is currently unavailable. The links provided are from other US Government sources. When USNO data is returned to service, the links will be updated.

These data are preliminary and have not undergone final quality control by the National Climatic Data Center (NCDC). Therefore, these data are subject to revision. Final and certified climate data can be accessed at the NCDC - <http://www.ncdc.noaa.gov>.
Climatological Report (Daily)

773
CDUS43 KJKL 140648
CLIJKL

CLIMATE REPORT
NATIONAL WEATHER SERVICE JACKSON KY
147 AM EST FRI FEB 14 2020

...THE JACKSON KY CLIMATE SUMMARY FOR FEBRUARY 13 2020...

CLIMATE NORMAL PERIOD 1981 TO 2010
CLIMATE RECORD PERIOD 1981 TO 2020

WEATHER ITEM	OBSERVED TIME	RECORD YEAR	NORMAL DEPARTURE LAST
VALUE (LST)	VALUE	VALUE FROM	YEAR
NORMAL			

TEMPERATURE (F)			
YESTERDAY			
MAXIMUM	59 224 AM	72 1990	47 12 45
MINIMUM	32 1159 PM	7 1988	29 3 29
AVERAGE	46	38 8	37

PRECIPITATION (IN)			
YESTERDAY	0.72	1.26 1989	0.13 0.59 0.00
MONTH TO DATE	6.10	1.72 4.38	3.06

SINCE DEC 1 15.77 9.51 6.26 14.79
SINCE JAN 1 9.47 5.33 4.14 7.32

SNOWFALL (IN)

YESTERDAY T 2.6 2014 0.3 -0.3 0.0
MONTH TO DATE 2.0 3.7 -1.7 T
SINCE DEC 1 3.8 15.7 -11.9 3.5
SINCE JUL 1 5.0 16.3 -11.3 5.2
SNOW DEPTH 0

DEGREE DAYS

HEATING

YESTERDAY 19 27 -8 28
MONTH TO DATE 236 364 -128 242
SINCE DEC 1 1606 2130 -524 1869
SINCE JUL 1 2440 2930 -490 2818

COOLING

YESTERDAY 0 0 0 0
MONTH TO DATE 0 0 0 0
SINCE DEC 1 0 1 -1 0
SINCE JAN 1 0 0 0 0

WIND (MPH)

HIGHEST WIND SPEED 20 HIGHEST WIND DIRECTION W (290)
HIGHEST GUST SPEED 30 HIGHEST GUST DIRECTION NW (300)
AVERAGE WIND SPEED 7.5

SKY COVER

POSSIBLE SUNSHINE MM
AVERAGE SKY COVER 1.0

WEATHER CONDITIONS

THE FOLLOWING WEATHER WAS RECORDED YESTERDAY.
HEAVY RAIN
RAIN
LIGHT RAIN
FOG

RELATIVE HUMIDITY (PERCENT)

HIGHEST 93 1200 AM
LOWEST 75 1100 PM
AVERAGE 84

THE JACKSON KY CLIMATE NORMALS FOR TODAY

NORMAL RECORD YEAR

MAXIMUM TEMPERATURE (F) 47 71 1990
MINIMUM TEMPERATURE (F) 30 9 2015

SUNRISE AND SUNSET

FEBRUARY 14 2020.....SUNRISE 724 AM EST SUNSET 611 PM EST
FEBRUARY 15 2020.....SUNRISE 723 AM EST SUNSET 612 PM EST

- INDICATES NEGATIVE NUMBERS.
R INDICATES RECORD WAS SET OR TIED.
MM INDICATES DATA IS MISSING.
T INDICATES TRACE AMOUNT.

The U.S. Naval Observatory (USNO) data is currently unavailable. The links provided are from other US Government sources. When USNO data is returned to service, the links will be updated.

For more information on the climate information from JKL for the whole month of February 2020 please see attachment 2.

12.0 Climate Precipitation and Temperature Imagery for Kentucky

Precipitation and temperature information for Kentucky and the accident site were reviewed using the Midwestern Regional Climate Center (MRCC)²⁷ application tools environment for the times surrounding and leading up the accident time. The MRCC climate data indicated that in the 7 days leading up to the accident time, between 500% and 750% of normal precipitation had fallen (figure 9). During the month of February between 300% and 400% of normal precipitation had fallen on the accident site (figure 10). Finally, in the 30 days and 60 days leading up to the accident time, between 175% and 200% of normal precipitation had fallen on the accident site area (figures 11 and 12). In the 30 days leading up to the accident time the average temperature²⁸ for the accident site had been between 6° to 8°F above normal. For more temperature information and precipitation amounts for the accident site from MRCC please see attachment 3.

²⁷ Source Midwestern Regional Climate Center: <https://mrcc.illinois.edu/CLIMATE/welcome.jsp>

²⁸ The high and low temperature combined above or below the mean daily average.

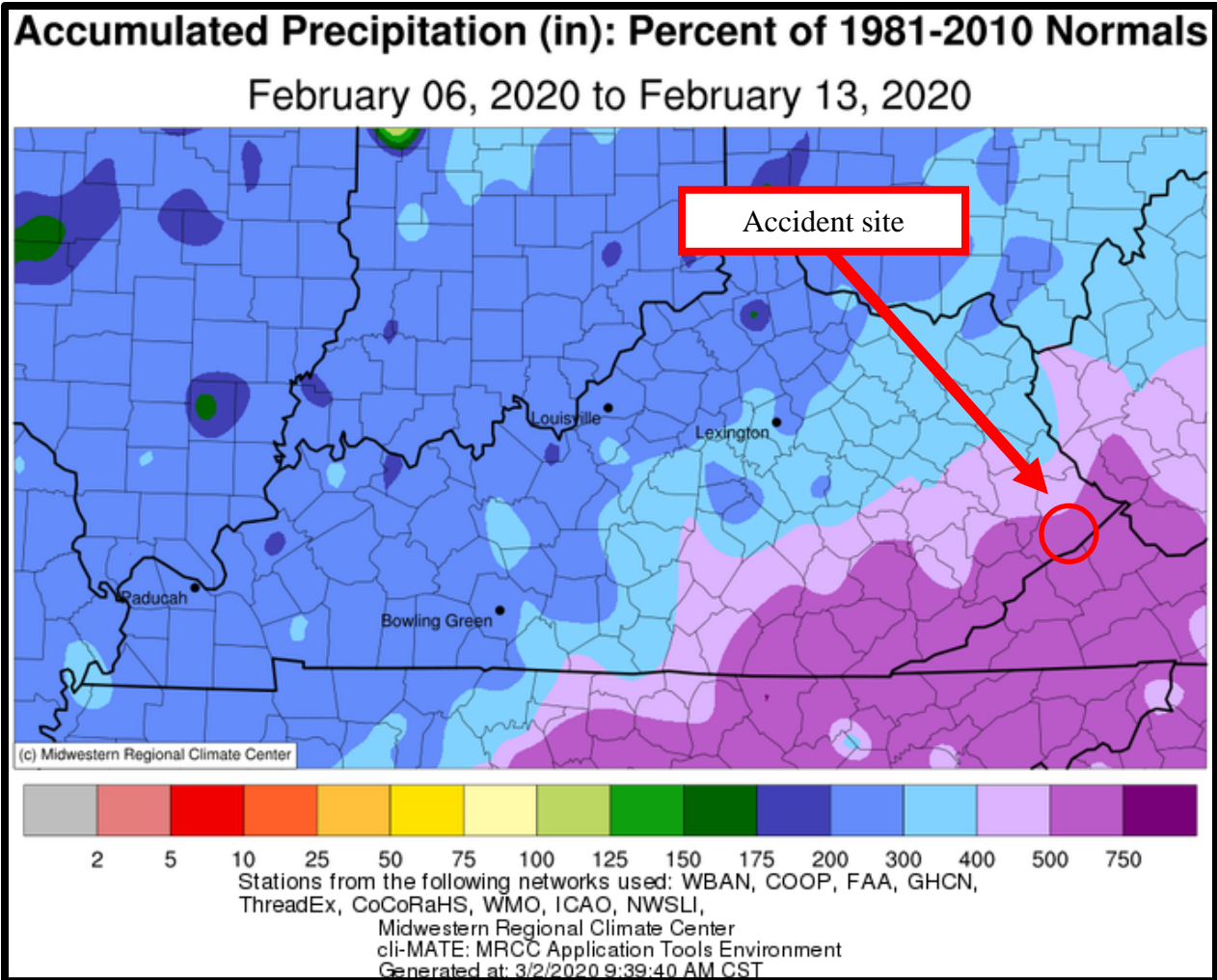


Figure 9 – Accumulated precipitation percent of 1981-2010 climate normal from February 6 to February 13

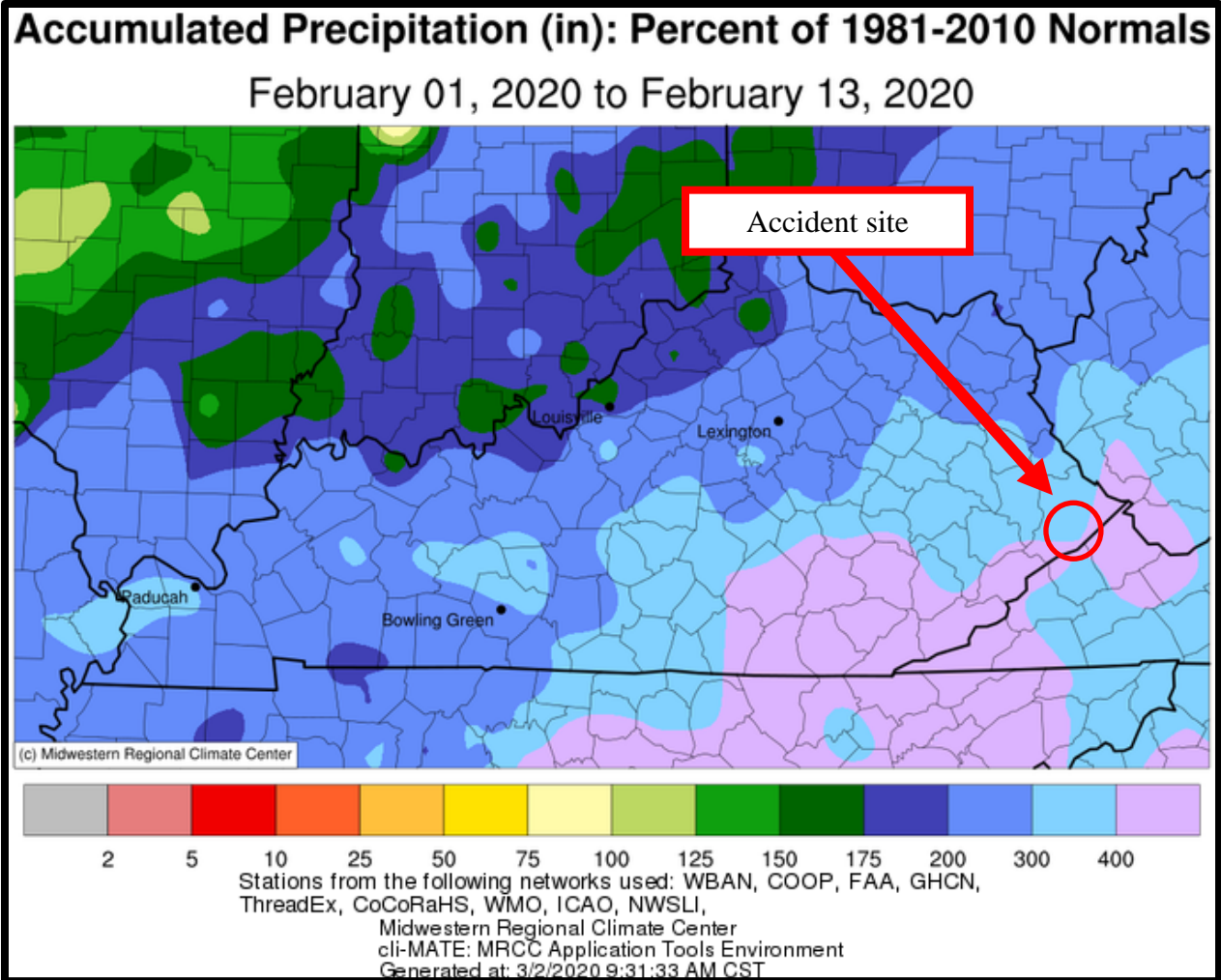


Figure 10 – Accumulated precipitation percent of 1981-2010 climate normal from February 1 to February 13

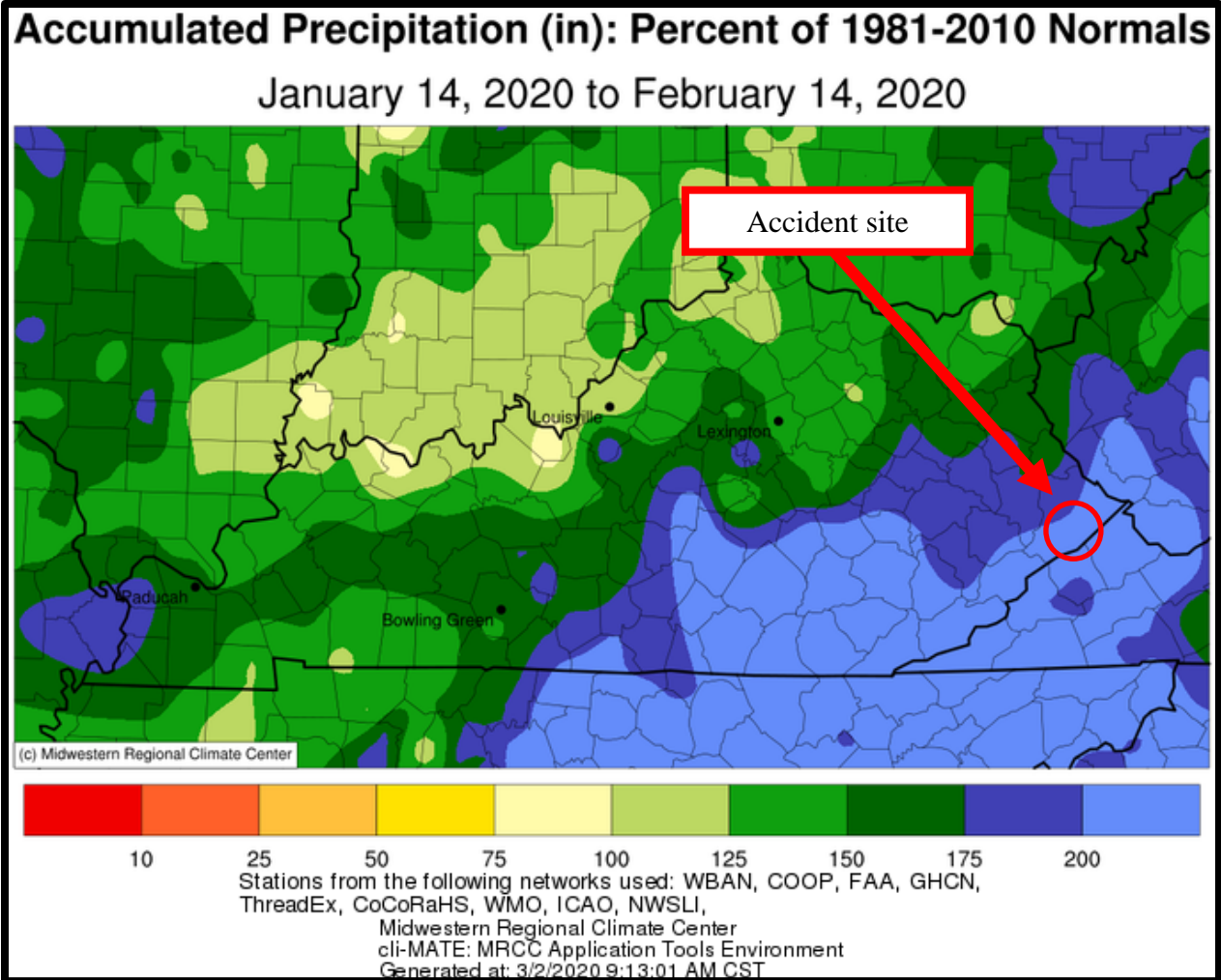


Figure 11 – Accumulated precipitation percent of 1981-2010 climate normal from January 14 to February 14

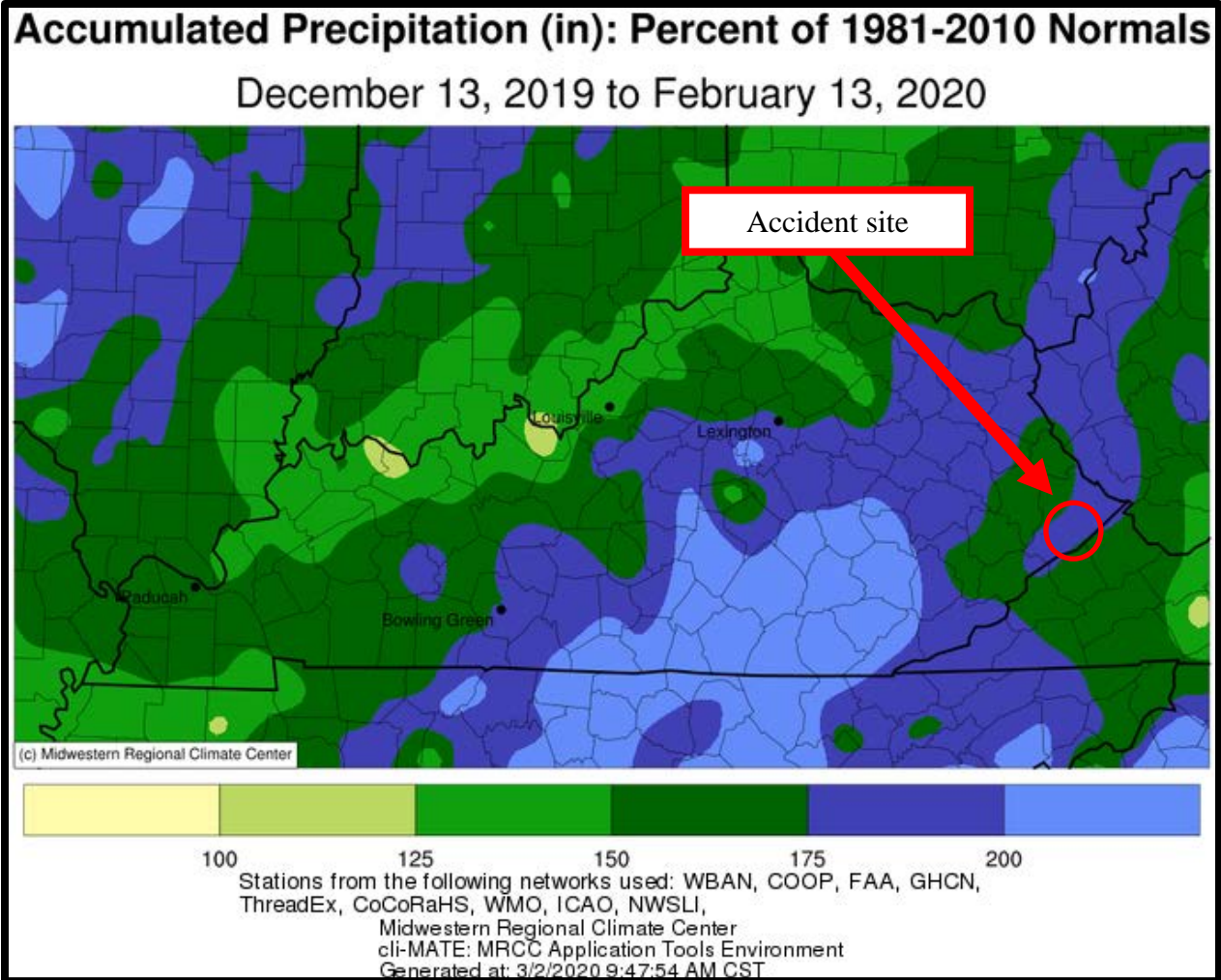


Figure 12 – Accumulated precipitation percent of 1981-2010 climate normal from December 13, 2019 to February 13, 2020

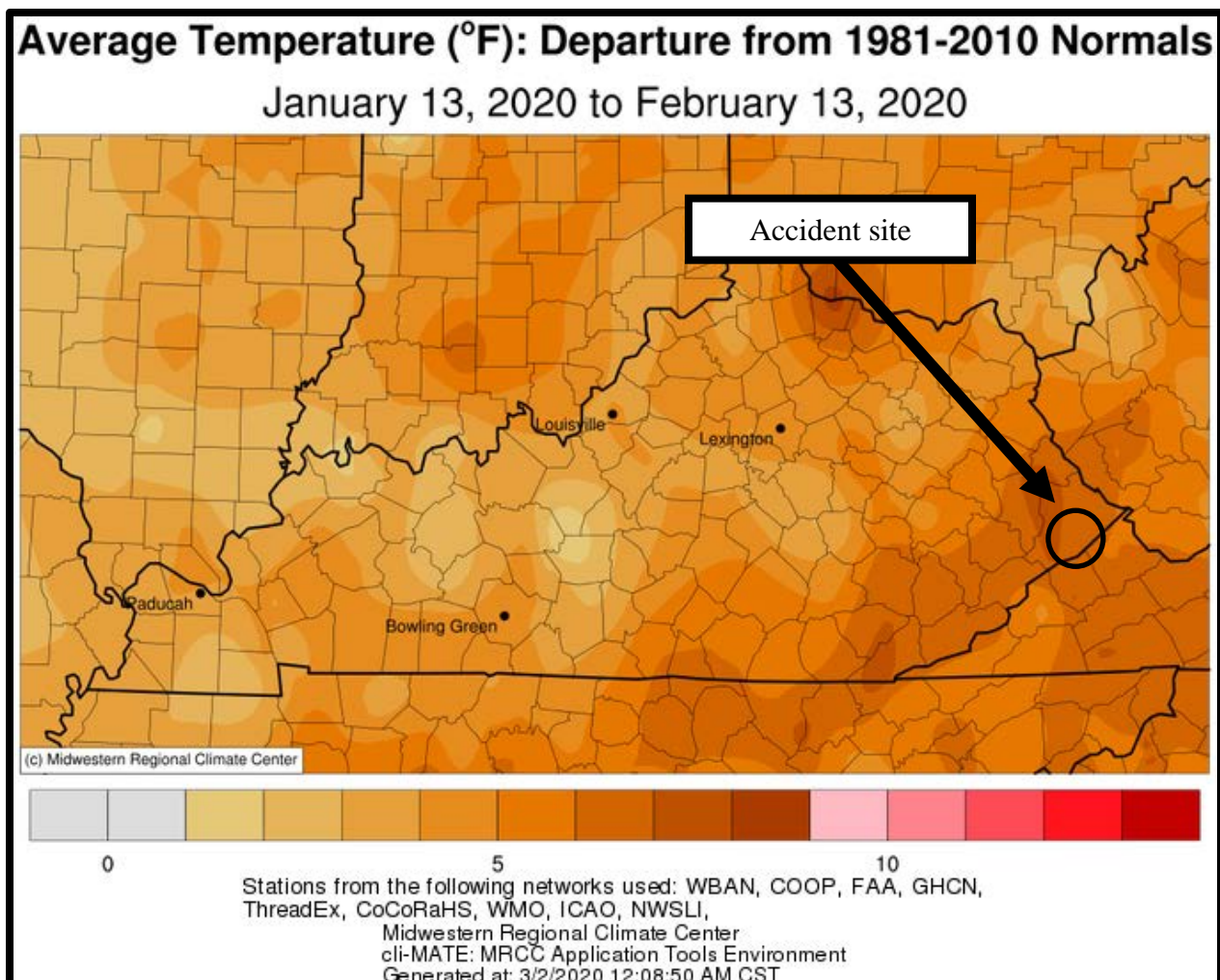


Figure 13 – Average temperature departure from 1981-2010 climate normal from January 13, 2020 to February 13, 2020

13.0 Crew Weather Information

Interviews were conducted of the accident company personnel and that information can be found in the docket for this investigation.

14.0 Company Weather Policy and Alerts

The weather alert criteria and weather notification procedures for the accident company were obtained and details are provided in attachments 4, 5, and 6. One of the weather alert criteria was called the SkyGuard Flash Flood Warning criterion. This SkyGuard Flash Flood Warning criterion threshold was reached when 3 inches of rain was expected in 3 hours or less, and if met would prompt AccuWeather (CSX’s weather provider) to send a flash flood warning message to the CSX dispatcher who was overseeing the affected track region. The CSX dispatcher would forward the warning to the affected train crew who would then take appropriate action. In addition, CSX had provided AccuWeather areas throughout CSX’s track network which they believed were prone to

flash flooding. In these flash flood prone areas, lesser amounts of rain could trigger a flash flood warning (attachment 4).

The accident company provided the guidelines and training for dispatchers with regards to weather warning criteria that, when met, would prompt the dispatcher to take action. More information can be found in attachments 7 to 10.

15.0 Static versus Dynamic Weather Alerting

The carrier's weather alert criteria described in Section 14.0 was a type of *static* criteria (i.e., the weather criteria did not change regardless of preexisting weather conditions over the affected region).²⁹ Other industries have used a *dynamic* criteria (i.e., considers antecedent conditions) approach for weather alerts. In these *dynamic* criteria examples not only were weather variables monitored, but terrain influences, landslides, and differing time scales were examined (and included Dashboard monitoring formats).³⁰

16.0 Astronomical Data

The astronomical data obtained for the accident site on February 13, 2020, indicated the following:

SUN

Accident time	0654 EST³¹
Begin civil twilight	0655 EST
Sunrise	0721 EST
Sun transit	1244 EST
Sunset	1807 EST
End civil twilight	1833 EST

MOON

Moonrise	2327 EST on February 12, 2020
Moon transit	0422 EST
Accident time	0654 EST³²
Moonset	1019 EST

The phase of the Moon was Waning Gibbous with 76% of the Moon's visible disk illuminated.

²⁹ Weather alert criteria could change if the accident carrier had asked their weather provider for a different criteria set, but this would still be static criteria and not adaptive to take into account antecedent weather conditions.

³⁰ <https://ncsu.maps.arcgis.com/apps/MapJournal/index.html?appid=068f11c4850d42e785a2e34bdfd88158>
<https://community.esri.com/thread/232232-flood-gauge-monitoring-dashboards>

³¹ Inserted accident time for reference and context.

³² Inserted accident time for reference and context.

E. LIST OF ATTACHMENTS

Attachment 1 – Animation of KJKL WSR-88D base reflectivity images for the 0.5° elevation scans between 0634 and 0705 EST

Attachment 2 – JKL February 2020 monthly climate summary

Attachment 3 – MRCC precipitation information and imagery for the accident site

Attachment 4 – CSX weather alert criteria

Attachment 5 – CSX weather alert criteria and thresholds

Attachment 6 – Weather alert criteria and thresholds

Attachment 7 – CSX weather and dispatch information

Attachment 8 – CSX dispatch information

Attachment 9 – CSX training information

Attachment 10 – CSX weather guidance

Submitted by:

Paul Suffern
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