8390 W County Road 400 S
Yorktown, Indiana 47396
Phone: 765-716-9535
E-mail: info@tdsweather.com
Website: www.tdsweather.com

FORENSIC WEATHER INVESTIGATION OF WINTER WEATHER CONDITIONS FROM FEBRUARY 12-17, 2021 AT ADDRESS IN BLOOMFIELD, MICHIGAN 48322

Report Date: June 4, 2021

CASE NAME:	"Company vs. Complainant"
PREPARED FOR:	Employee
COMPANY:	Company Name
DATE OF INCIDENT:	February 12-17, 2021

This written report and all of the tables, graphs, findings, data, and opinions contained in it has been prepared for use with this specific case only. Use of any of this information for any other matter, claim or case other than what is indicated above, including for use in expert disclosures in other cases, is strictly prohibited.

ASSIGNMENT:

This investigation was requested of me by Employee at Company. I was asked to perform an in-depth weather analysis and forensic weather investigation at Address in Bloomfield, Michigan 48322 in order to determine what the weather conditions were each day during the period of February 12-17, 2021, and to specifically to determine if and when winter weather conditions occurred. I was then asked to prepare a written report of the weather conditions that occurred at Address in Bloomfield, Michigan 48322 on the aforementioned dates.

Studies to determine if and when winter weather conditions occurred should only be conducted by a degreed or certified meteorologist who is an expert in the field, who has the education, training, and experience, and who employs the correct methodology and accepted practices normally relied upon by meteorologists in forensic weather investigations.

OVERVIEW OF WEATHER DATA SOURCES

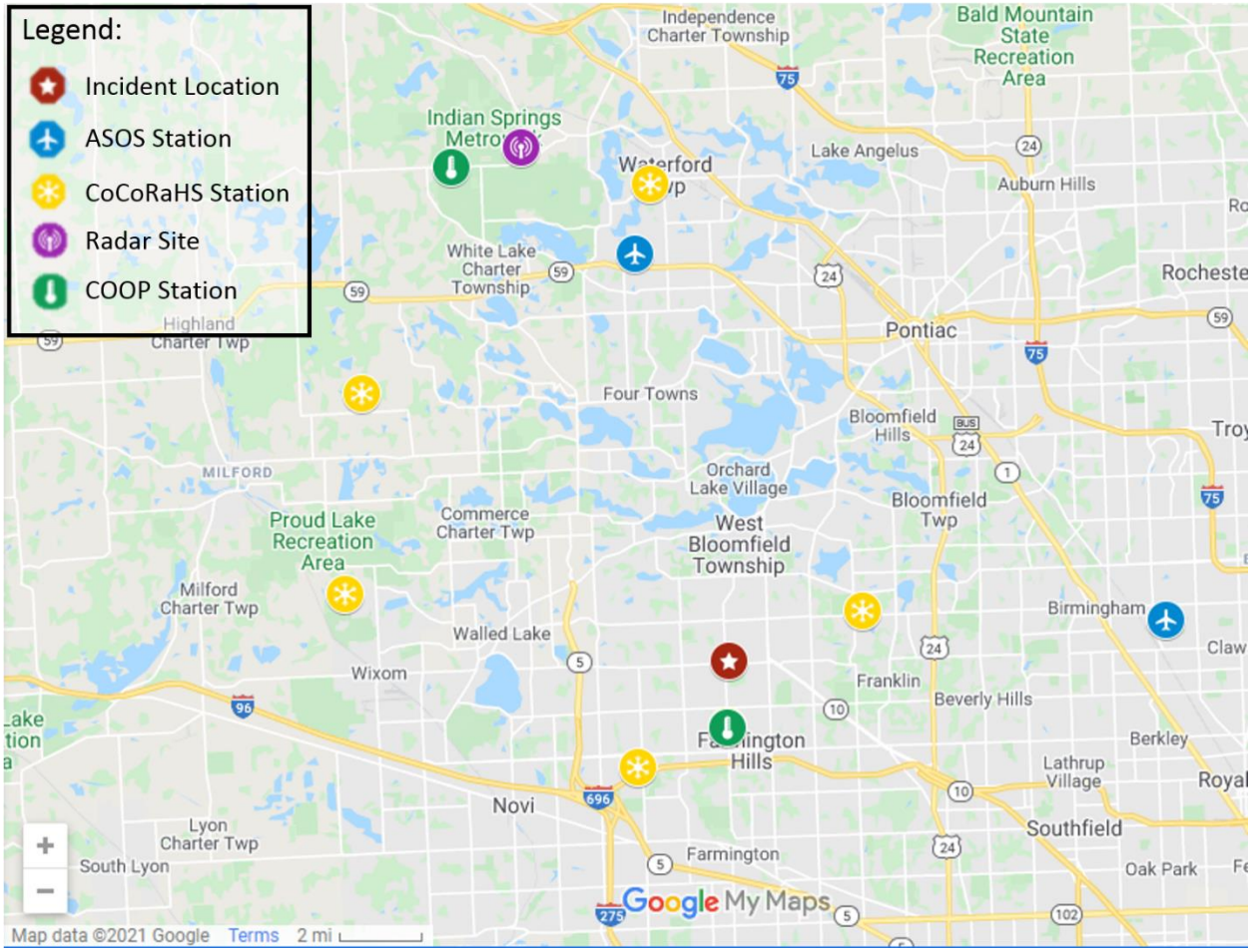
To thoroughly conduct a weather investigation, several forms of historical weather data are analyzed. For informational purposes, various weather data sources are described below, some of which may not have been utilized in this case.

1. The Automated Surface Observing Systems (ASOS) is a joint effort of the National Weather Service (NWS), the Federal Aviation Administration (FAA), and the Department of Defense (DOD). The ASOS systems serves as the nation's primary surface weather observing network. ASOS is designed to support weather forecast activities and aviation operations and, at the same time, support the needs of the meteorological, hydrological, and climatological research communities. ASOS systems collect and report on over a dozen basic weather elements at least one time per hour, and the information is reviewed, maintained, and stored by NOAA.
2. The National Weather Service (NWS) Cooperative Observer Program (COOP) provides weather observations from over 8,700 locations across the United States. Observations are recorded by volunteers daily and regularly include information on the maximum and minimum temperatures, and precipitation types and amounts. Additional weather conditions such as soil temperature, soil moisture, and evapotranspiration may also be recorded. Examples of these observation locations include on farms, in urban and suburban areas, National Parks, seashores, and mountaintops.
3. The Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) is a unique, non-profit, community-based network of thousands volunteers working together to measure and map precipitation (rain, hail, and snow) across the United States and abroad. Volunteers record daily measurements of precipitation and electronically report them into an online database. This database of information is heavily relied upon by the National Weather Service (NWS), meteorologists, and private companies such as insurance adjusters, farmers, and utilities managers. CoCoRaHS stresses training and education of its volunteers, and aims to provide the highest-quality weather data for natural resource, education and research applications.

4. The Citizen Weather Observer Program (CWOP) is a network of privately-owned weather observation stations across the world, with over 10,000 registered members. Members transmit weather observations to the National Weather Service (NWS) through the Meteorological Assimilation Data Ingest System (MADIS), in which quality checks of data are performed before storing and distributing.
5. Weather Surveillance Radar (WSR) provide meteorologists with detailed information about precipitation type, shape, rate, and size. The radar currently used by the National Weather Service (NWS) is called the WSR-88D, which stands for Weather Surveillance Radar - 1988 Doppler. The "Doppler" portion of the name refers to the ability to detect precipitation toward or away from the radar, as well as its location. There are 155 WSR-88D Doppler radar in the United States, including the U.S. Territory of Guam and the Commonwealth of Puerto Rico, which are operated by the National Weather Service and the Department of Defense.
6. CoreLogic STRIKEnet Reports provide lightning strike information using Vaisala's National Lightning Detection Network (NLDN), the most comprehensive lightning strike archive database in North America which is over 99% accurate at verifying the presence or absence of cloud-to-ground lightning.
7. National Weather Service (NWS) offices across the United States issue weather alerts, advisories, watches, warnings, and other outlooks daily. These bulletins provide information on expected and/or observed weather phenomena.
8. The Storm Events Database from the National Centers for Environmental Information contains records of the occurrence of storms and other significant weather phenomena having sufficient intensity to cause loss of life, injuries, significant property damage, and/or disruption to commerce; rare, unusual, weather phenomena that generate media attention, such as snow flurries in South Florida or the San Diego coastal area; and other significant meteorological events, such as record maximum or minimum temperatures or precipitation that occur in connection with another event.
9. The National Weather Service (NWS) Local Storm Reports (LSR) page through the Storm Prediction Center (SPC) provides tornado, damaging wind, and hail reports from across the United States beginning January 5, 2010. The Storm Reports page is organized based on reports received from 1200 UTC to 1159 UTC the next day.
10. The Weather Prediction Center (WPC) Surface Analysis Archive provides historical continental United States (CONUS) and North American surface observation maps beginning March 29, 2006.

LOCATION ANALYSIS FOR AVAILABLE DATA SOURCES

The following image shows the incident location (Address in Bloomfield, Michigan 48322) marked in RED and plotted in "Google Maps". ASOS systems are represented in BLUE. COOP sites are represented in GREEN. CoCoRaHS sites are represented in YELLOW. WSR-88D radar sites are represented in PURPLE.



In order to perform my analysis of weather conditions that occurred at Address in Bloomfield, Michigan 48322 during the period of February 12-17, 2021, I obtained and reviewed the following records, with the distance and direction from the incident location provided:

a) Automated Surface Observing Systems (ASOS) hourly observed weather data from the Oakland County International Airport weather station KPTK (approximately xxxx miles N of the incident location).
b) Automated Surface Observing Systems (ASOS) hourly observed weather data from the Oakland County/Troy Airport weather station KVLL (approximately xxxx miles E of the incident location).
c) Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) reports from station MI-OK-35 2.1 NW Waterford, MI (approximately xxxx miles N of the incident location).
d) Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) reports from station MI-OK-47 3.1 SW Bloomfield Township, MI (approximately xxxx miles ENE of the incident location).

e) Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) reports from station MI-OK-51 2.3 WNW Farmington Hills, MI (approximately xxxx miles SW of the incident location).
f) Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) reports from station MI-OK-119 2.0 NNW Wixom, MI (approximately xxxx miles WNW of the incident location).
g) Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) reports from station MI-OK-50 5.2 SSE White Lake, MI (approximately xxxx miles NW of the incident location).
h) National Weather Service (NWS) Cooperative Observer Program (COOP) reports from station US1MIOK0094 1.4 N Farmington Hills, MI (approximately xxxx miles S of the incident location).
i) National Weather Service (NWS) Cooperative Observer Program (COOP) reports from station USC00208941 4 E White Lake, MI (approximately xxxx miles NNW of the incident location).
j) WSR-88D Doppler Radar images from the Pontiac, Michigan radar site, KDTX (approximately xxxx miles NNW of the incident location).
k) Iowa Environmental Mesonet (IEM) Archived Warnings, Watches, and Advisories issued by the National Weather Service (NWS) Weather Forecast Office (WFO) Detroit/Pontiac, Michigan.
l) Continental United States Surface Analysis images from the Weather Prediction Center (WPC).

The weather data and climatological records used for this analysis are the official records that meteorologists rely upon during the normal course of business and are stored at the National Centers for Environmental Information (NCEI), the National Oceanic and Atmospheric Administration (NOAA), NOAA's child agencies, or partner databases. The findings in this report utilize the weather records that were available at the time of data retrieval for this case. Any additional weather records and data that become available at a later date may be incorporated into this report in the future.

METHODOLOGY:

Thermodynamic Solutions LLC uses several reliable sources of observed weather information in order to conduct an accurate weather analysis. In order to accurately determine the weather conditions that were observed on the day in question at the incident location, a detailed search was conducted to find the nearest official weather observation sites provided by the National Centers for Environmental Information (NCEI), the National Weather Service (NWS), and their partners. A location analysis was performed using the online program "Google Maps" by plotting nearby weather observation sites. While not all of the weather data provided by these observation sites can be independently verified by the NCEI, the majority of this data is housed and maintained on National Oceanic and Atmospheric Administration (NOAA) websites and databases, and are the records that meteorologists rely upon during the normal course of business to conduct weather investigations. The distances and directions between the incident location and various weather observation sites were then calculated. Reports were then gathered from the weather observation sites and were analyzed, including the extrapolation of the data from many weather stations, in

order to determine the weather and ground conditions that existed at the incident location during the given period of February 12-17, 2021.

In order to formulate an opinion on the daily maximum and minimum temperatures that occurred at the incident location during the given period of February 12-17, 2021, we reviewed the meteorological data recorded at the following weather stations:

- Automated Surface Observing Systems (ASOS) hourly observed weather data from the Oakland County International Airport weather station KPTK (approximately xxxx miles N of the incident location).
- Automated Surface Observing Systems (ASOS) hourly observed weather data from the Oakland County/Troy Airport weather station KVLL (approximately xxxx miles E of the incident location).
- National Weather Service (NWS) Cooperative Observer Program (COOP) reports from station US1MIOK0094 1.4 N Farmington Hills, MI (approximately xxxx miles S of the incident location).
- National Weather Service (NWS) Cooperative Observer Program (COOP) reports from station USC00208941 4 E White Lake, MI (approximately xxxx miles NNW of the incident location).

It is important to note that while extrapolating between the weather stations utilized in this investigation, we considered the distances and directions of each weather station from the incident location.

Data analysis was also conducted in order to determine if and when melting and refreezing processes occurred at the incident location during the given period. It should be noted that direct sunshine and the resultant incoming solar radiation sometimes causes melting to occur even when the air temperature is below freezing. Therefore, if/when the air temperature remained below freezing for the entire calendar day, we reviewed the surface observations to determine if the reported sky cover was conducive for any melting and refreezing processes to occur.

In addition to the temperature analysis, we reviewed reports from the following weather stations to analyze and extrapolate the following information: liquid-equivalent precipitation (in inches) that fell within each 24-hour period, the amount of new snow/sleet (in inches) that fell during each 24-hour period), the amount of freezing rain/ice (in inches) that accumulated during each 24-hour period, and the snow depth (in inches) that was present on the ground at 7:00am EST each morning.

- Automated Surface Observing Systems (ASOS) hourly observed weather data from the Oakland County International Airport weather station KPTK (approximately xxxx miles N of the incident location).
- Automated Surface Observing Systems (ASOS) hourly observed weather data from the Oakland County/Troy Airport weather station KVLL (approximately xxxx miles E of the incident location).
- National Weather Service (NWS) Cooperative Observer Program (COOP) reports from station US1MIOK0094 1.4 N Farmington Hills, MI (approximately xxxx miles S of the incident location).

- National Weather Service (NWS) Cooperative Observer Program (COOP) reports from station USC00208941 4 E White Lake, MI (approximately xxxx miles NNW of the incident location).
- Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) reports from station MI-OK-35 2.1 NW Waterford, MI (approximately xxxx miles N of the incident location).
- Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) reports from station MI-OK-47 3.1 SW Bloomfield Township, MI (approximately xxxx miles ENE of the incident location).
- Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) reports from station MI-OK-51 2.3 WNW Farmington Hills, MI (approximately xxxx miles SW of the incident location).
- Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) reports from station MI-OK-119 2.0 NNW Wixom, MI (approximately xxxx miles WNW of the incident location).
- Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) reports from station MI-OK-50 5.2 SSE White Lake, MI (approximately xxxx miles NW of the incident location).

Surface weather observations from the following weather stations were analyzed to help determine what type of precipitation were reported and when they occurred, as well as observed sky conditions:

- Automated Surface Observing Systems (ASOS) hourly observed weather data from the Oakland County International Airport weather station KPTK (approximately xxxx miles N of the incident location).
- Automated Surface Observing Systems (ASOS) hourly observed weather data from the Oakland County/Troy Airport weather station KVLL (approximately xxxx miles E of the incident location).

METEOROLOGICAL ANALYSIS

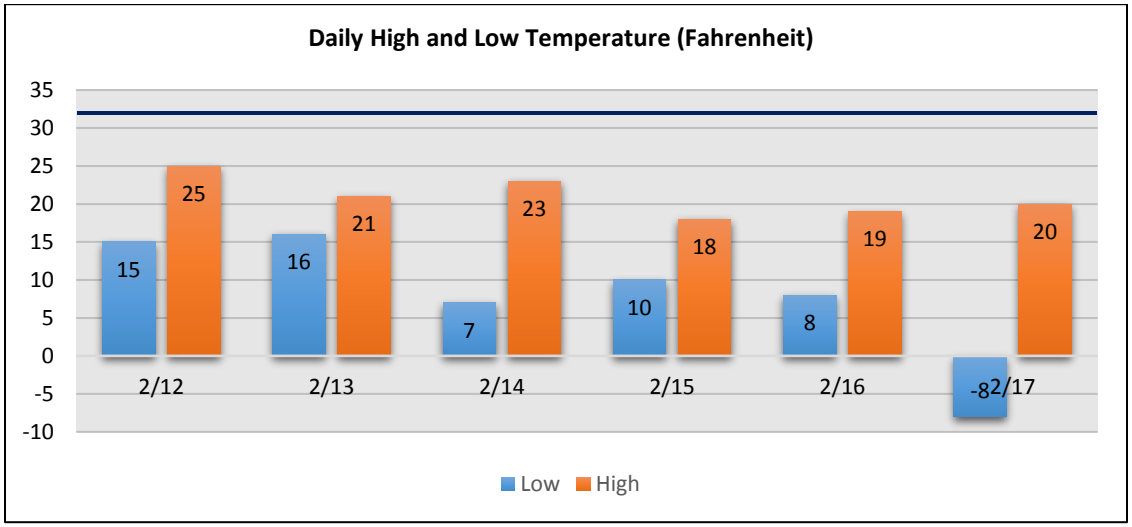
The following tables and charts provide a detailed summary of the daily weather and ground conditions for each day during the period of February 12-17, 2021. The summary includes the date, maximum temperature for the 24-hour period (in Fahrenheit), minimum temperature for the 24-hour period (in Fahrenheit), liquid-equivalent precipitation/rain total for the 24-hour period (in inches), the amount of snow and sleet that fell during the 24-hour period (in inches), the snow depth that was present on the ground at 7:00am EST (in inches), the amount of freezing rain/ice that accumulated during the 24-hour period (in inches), and the observed sky conditions.

The liquid-equivalent precipitation/rain measurement is the total amount of melted snow/ice and/or the amount of rain that fell. It is important to note that any snow and/or ice measurements, including snow depth, are taken in exposed, untreated, and undisturbed areas away from any objects that may act to distort the true measurement. A “Trace” amount of liquid precipitation/rain is reported when the amount is less than 0.01” or is not measureable. A “Trace” amount of snow/sleet is reported when the amount is less than 0.1” or is not measureable. A “Trace” amount of snow/ice depth is reported when the amount is less than 0.5”.

The following table is a summary of the observed maximum and minimum 24-hour temperatures, ice accumulation, and sky cover at the incident location:

Date	Maximum Air Temperature	Minimum Air Temperature	Ice Accumulation	Sky Cover
2/12/21	25	15	0.00	OVC
2/13/21	21	16	0.02	BKN-OVC
2/14/21	23	7	Trace	BKN-OVC
2/15/21	18	10	0.00	SCT-OVC
2/16/21	19	0	Trace	BKN-OVC → CLR
2/17/21	20	-8	0.00	CLR-SCT → OVC

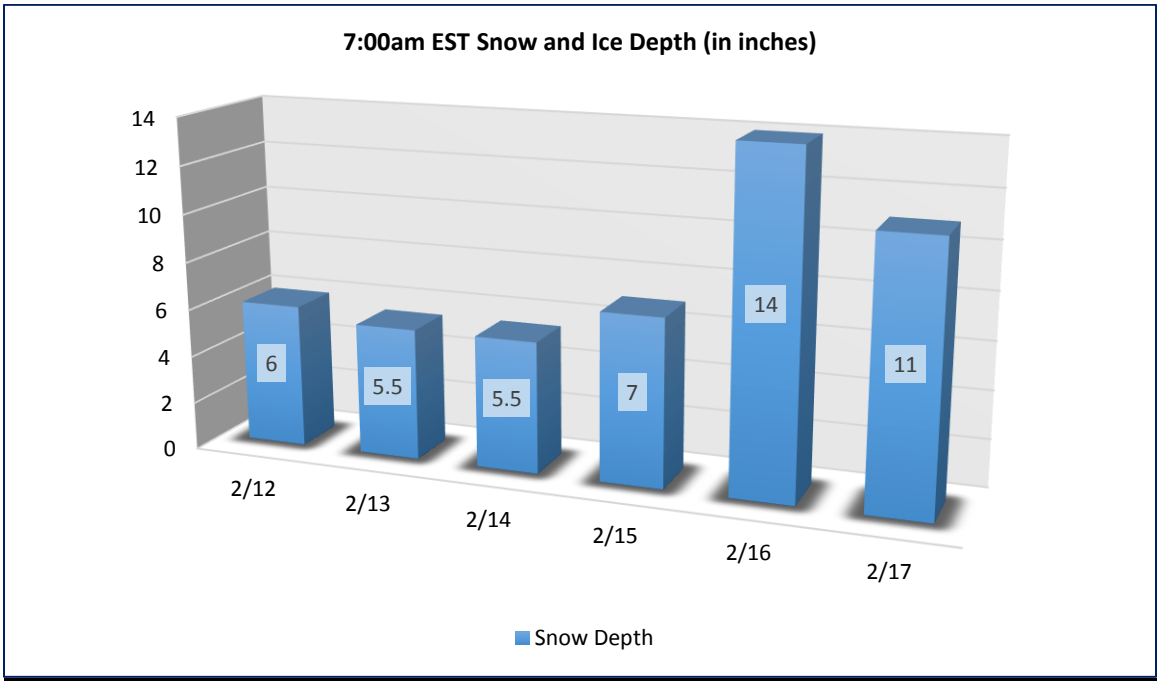
DAILY TEMPERATURE



The following table is a summary of the observed snowfall, snow/ice depth, and liquid equivalent precipitation/rain at the incident location. It should be noted that the snowfall amounts and depth are representative of measurements on exposed, untreated, and undisturbed surfaces.

Date	Snow/Sleet	Snow/Ice Depth	Liquid Equivalent Precip./Rain
2/12/21	1.5	6.0	0.06
2/13/21	0.8	5.5	0.03
2/14/21	1.8	5.5	0.14
2/15/21	8.0	7.0	0.65
2/16/21	0.0	14.0	0.00
2/17/21	0.0	11.0	0.00

DAILY SNOW AND ICE DEPTH



FEBRUARY 12 SUMMARY

A mid-level wave of energy moved through southwestern Michigan through the late evening hours of February 11, 2021 and persisted into the early morning hours of February 12, 2021. This resulted in light snow showers at the incident location between 10:53pm EST on February 11, 2021 and 2:00am EST on February 12, 2021. The 7:00am EST snow depth was 6.0". Light snow showers began again at 7:50am EST and lasted through the entirety of the day before ending at 11:45pm EST. Through the course of this 24-hour period, new snowfall accumulations of 1.5" occurred at the incident location.

The maximum air temperature for the day was 25 degrees Fahrenheit and the minimum air temperature for the day was 15 degrees Fahrenheit. No melting occurred due to air temperatures remaining below freezing during the 24-hour period, as well as overcast skies overhead during the daytime hours limiting solar radiation.

Winds were from the north at 5-13mph.

FEBRUARY 13 SUMMARY

Broadening synoptic lift, an approaching and strengthening mid-level jet, and polar low pressure system supported additional light snow showers at the incident location from 4:30am to 9:55pm EST on February 13, 2021. The 7:00am EST snow depth was 5.5". During this 24-hour period, new snowfall accumulations of 0.8" occurred at the incident location. Additionally, 0.02" of ice accumulation was reported between 11:41 and 11:53pm EST.

The maximum air temperature for the day was 21 degrees Fahrenheit and the minimum air temperature for the day was 16 degrees Fahrenheit. No melting occurred due to air temperatures remaining below freezing during the 24-hour period, as well as broken to overcast skies overhead during the daytime hours limiting solar radiation.

Winds were from the northeast at 4-12mph.

FEBURARY 14 SUMMARY

Areas of fog were observed through the early morning hours of February 14, 2021, with patchy areas of dense fog leading to isolated reports of freezing fog and resulting slippery conditions. A trace of ice accumulation was reported at 4:53am EST. A mid-level wave of energy and weak frontal boundary provided support for additional light snow showers between 7:35 and 8:50am EST. The 7:00am EST snow depth was 5.5".

The maximum air temperature for the day was 23 degrees Fahrenheit and the minimum air temperature for the day was 7 degrees Fahrenheit. No melting occurred due to air temperatures remaining below freezing during the 24-hour period, as well as broken to overcast skies overhead during the daytime hours limiting solar radiation.

Winds were from the northwest at 5-15mph and gusted to 18mph.

At 3:57pm EST on February 14, 2021, the National Weather Service in Detroit/Pontiac, Michigan issued a "Winter Weather Advisory" that was in effect from 12:00am February 15, 2021 to 12:00pm February 16, 2021.

FEBRUARY 15 SUMMARY

Light snow showers from the aforementioned mid-level wave of energy and weak frontal boundary resulted in additional light snow showers between 12:45am and 11:35am EST, along with a brief period of light snow between 12:53pm and 1:20pm EST. During the 24-hour period of 7:00am EST on February 14, 2021 and 7:00am EST on February 15, 2021, new snowfall accumulations of 1.8" were observed at the incident location. The 7:00am EST snow depth on February 15, 2021 was 7.0".

A second, much more robust low level circulation, associated high levels of moisture, strong ascent, and mid-level convective instability brought a prolonged period of moderate snow showers, blowing snow, and areas of freezing fog to the incident location between 5:53pm EST February 15, 2021 and 1:55am EST February 16, 2021.

The maximum air temperature for the day was 18 degrees Fahrenheit and the minimum air temperature for the day was 10 degrees Fahrenheit. No melting occurred due to air temperatures remaining well below freezing during the 24-hour period, as well as scattered clouds to overcast skies overhead during the daytime hours limiting solar radiation.

Winds were from the northwest during the morning hours, then shifted out of the north-northeast through the afternoon at 5-21mph, gusting to 25mph.

At 10:10am EST on February 15, 2021, the National Weather Service in Detroit/Pontiac, Michigan issued a "Winter Storm Warning" that was in effect from 6:00pm EST on February 15, 2021 to 12:00pm EST on February 16, 2021.

At 6:10pm EST on February 15, 2021, the National Weather Service in Detroit/Pontiac, Michigan issued an official update that the "Winter Storm Warning" was now in effect and would remain in effect through 12:00pm February 16, 2021.

FEBURARY 16 SUMMARY

Haze, mist, and freezing fog were present between 2:00am and 5:40am EST before light snow showers returned through 12:30pm before the event came to an end. During the period of between 7:00am EST February 15, 2021 and 12:30pm EST February 16, 2021, new snowfall accumulations of 8.0" were observed at the incident location. A trace of ice accumulation was also observed. The 7:00am EST snow depth on February 16, 2021 was 14.0".

The maximum air temperature for the day was 19 degrees Fahrenheit and the minimum air temperature for the day was 0 degrees Fahrenheit. No melting occurred due to air temperatures remaining well below freezing during the 24-hour period, as well as broken to overcast skies overhead during the first half of the day, then clearing through the afternoon and evening hours.

Winds were from the northwest at 10-20mph, gusting to 28mph. This caused blowing and drifting snowfall to persist through the early evening hours, even after the "Winter Storm Warning" expired.

At 11:39am EST on February 16, 2021, the National Weather Service in Detroit/Pontiac, Michigan issued an official update that the "Winter Storm Warning" would be allowed to expire at 12:00pm EST.

FEBRURARY 17 SUMMARY

Dry conditions were observed on February 17, 2021, with clear skies to scattered clouds overhead as high pressure built in at the surface. The 7:00am EST snow depth was 11.0". Clouds increased through the late evening and into the overnight hours.

The maximum air temperature for the day was 20 degrees Fahrenheit and the minimum air temperature for the day was -8 degrees Fahrenheit. Some melting would have been possible during the daytime hours due to incoming solar radiation and reduced cloud cover, even though air temperatures remained well below freezing.

Winds were calm through the morning hours, then increased to 3-8mph out of the east-southeast through the afternoon and evening.

CONCLUSIONS

In conclusion, it is my professional opinion that:

- The snow depth prior to the incident period beginning February 12, 2021 was near 6.0".

- Several periods of light snowfall were observed between the late evening hours of February 12, 2021 and the early afternoon hours of February 15, 2021, with occasional lulls in precipitation, resulting in total new snowfall accumulations of 4.1".
- 0.02" of ice accumulation was reported between 11:41 and 11:53pm EST on February 13, 2021.
- Patchy areas of dense fog were observed during the early morning hours of February 14, 2021, leading to isolated reports of freezing fog and resulting slippery conditions.
- A trace of ice accumulation was reported at 4:53am EST on February 14, 2021.
- The snow depth at the incident location increased to 7.0" by 7:00am EST February 15, 2021.
- A winter storm brought an additional 8.0" of new snowfall to the incident location between 5:53pm EST on February 15, 2021 and 12:30pm EST on February 16, 2021.
- Blowing and drifting snowfall was observed the night of February 15, 2021 and through the evening hours of February 16, 2021.
- The snow depth at the incident location increased to 14.0" by 7:00am EST February 16, 2021.
- A trace of ice accumulation was observed during the early morning hours of February 16, 2021.
- No precipitation was observed on February 17, 2021, with clear skies to scattered clouds overhead. Some melting could have occurred through the daytime hours due to incoming solar radiation and a lack of cloud cover. If some melting occurred, it would have re-frozen as the sun set.
- The snow depth at the incident location decreased to 11.0" by 7:00am EST February 17, 2021.
- The decreased snow depth by 7:00am EST February 17, 2021 could have been caused by a combination of normal compaction and settling, as well as some melting during the daytime hours of February 16, 2021.

CERTIFICATION

I certify that the above information contained in this report is true and accurate to the best of my ability and that all of my opinions, findings, estimations, and extrapolations expressed in this report were made with accuracy as a professional meteorologist within a reasonable degree of meteorological certainty.

X

Name
Professional Meteorologist