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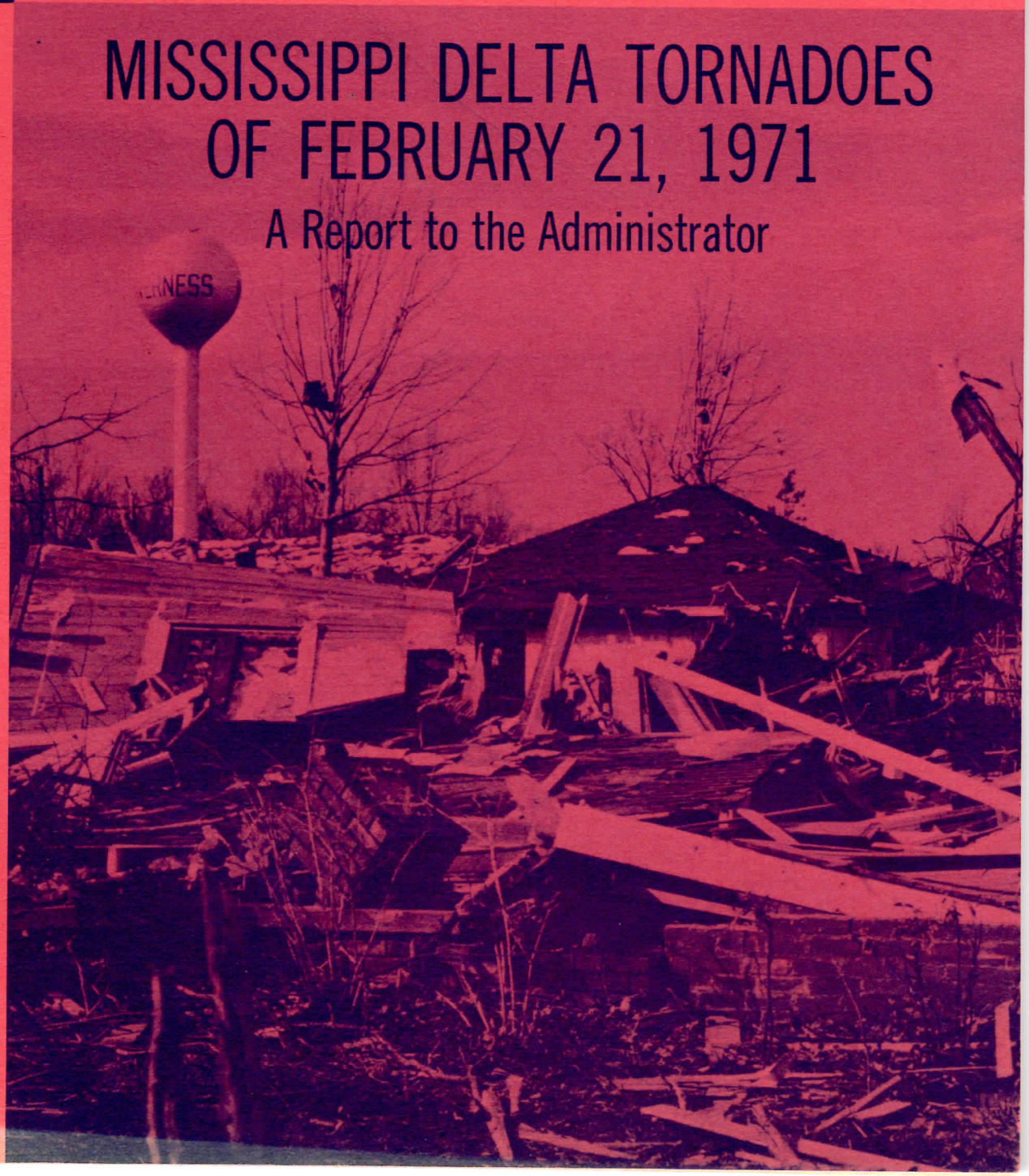
NATURAL DISASTER SURVEY REPORT 71-2

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration

MISSISSIPPI DELTA TORNADOES OF FEBRUARY 21, 1971

A Report to the Administrator



ROCKVILLE, MD.
JULY 1971

U.S. DEPARTMENT OF COMMERCE
Maurice H. Stans, Secretary

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
Robert M. White, Administrator

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FOREWORD

The morning after the disastrous tornadoes swept through northeast Louisiana, northwest Mississippi, and southwest Tennessee, a survey team was dispatched by the National Oceanic and Atmospheric Administration to the devastated areas to review the effectiveness of NOAA's tornado warning services. This report—Mississippi Delta Tornadoes of February 21, 1971—presents the findings and recommendations of the survey team.

Donald F. Moore
Assistant Administrator for Plans and Programs

PREFACE

The NOAA Natural Disaster Survey Team that investigated the Mississippi Delta tornadoes of February 21, 1971, consisted of Arthur C. Peterson, Senior Program Analyst, and Alexander F. Sadowski, Program Analyst, of the Office of Plans and Programs; Harry P. Foltz, Chief, Weather Analysis and Prediction Division, Office of Meteorological Operations, National Weather Service; George A. Baker, Office of Public Information; Carl M. Reber, User Services Representative, and Harold S. McCrabb, Service Operations Evaluation Meteorologist, of the National Weather Service Southern Region. The team arrived at Jackson, Miss., on February 22, 1971—the Southern Region members early in the afternoon, and the Washington contingent late the same day.

The survey team, in its effort to assess the effectiveness of NOAA's tornado warning system preceding and during the tornado outbreak, found the following problems to be particularly troublesome at the onset of the field survey.

- The extensiveness and the dispersion of the tornado occurrences, from eastern Texas and Arkansas eastward through Louisiana, Mississippi, and southwestern Tennessee—which made it necessary to concentrate the survey on those areas that would be most meaningful;
- The exceptionally large number of reports of sightings of tornadoes, over 50 in the Mississippi Delta area alone—which made it necessary to identify quickly those reports which related to the same tornado; and
- The large toll of lives and injuries suffered in spite of the issuance of timely warnings for nearly all areas where casualties occurred—which raised serious questions as to the effectiveness of the warnings.

The first problem was resolved by concentrating the field survey efforts in areas where casualties and destruction were greatest. This confined the study area to northeastern Louisiana, central and northern Mississippi, and extreme southwestern Tennessee. For convenience this area is referred to as the Mississippi Delta Area. The second prob-

lem—that of sorting out just how many tornadoes occurred and along what tracks they traveled—was largely resolved by conducting a visual low-level aerial survey at the first opportunity to identify the tracks of the major storms. The third problem was solved early in the survey, when it became readily apparent that—without storm cellars or basements and with relatively few ditches, culverts, or bridges to offer protection—in all too many instances there simply was no nearby place for the individual to find safety.

The survey team is indebted to many people within NOAA, officials of the States of Louisiana, Mississippi, and Tennessee, and representatives of the news media for their contributions to this report. The team is particularly indebted to the Mississippi Highway Safety Patrol for providing access to its records of severe weather reports and warnings handled through its districts throughout the State, and to the National Aeronautics and Space Administration for conducting an independent aerial survey of the storm tracks. A special word of thanks is extended to Don Munro and the staff at the National Weather Service Office at Jackson, and to Mrs. M. H. Lewis, John H. Lentz, Walter A. Schulz, Jr., and Leonard A. Waas for their assistance and contributions to the survey.

CONTENTS

EXECUTIVE SUMMARY

At 11:45 a.m. CST Sunday, February 21, 1971, the Police Department of Cleveland, Miss., reported to the Jackson, Miss., National Weather Service Office that a tornado had been spotted southwest of Cleveland. Between the time of this first sighting and the time of lifting all Tornado Watches and Warnings just before midnight, more than 50 sightings of tornadoes and funnel clouds were reported to NOAA Weather Service Offices at Shreveport, La., Jackson, Miss., and Memphis, Tenn.—the stations directly responsible for tornado warnings for the areas affected by the Mississippi Delta Tornadoes.

Three great tornadoes of this outbreak of severe storms took by far the greatest toll of lives. The first had a continuous ground path 102 miles long. The second moved along a track parallel to the first storm for a distance of 159 miles on the ground. The third great tornado moved parallel to the other two and remained on the ground for 69 miles. These three tornadoes traveled a total distance of 330 miles, at speeds on the order of 55 m.p.h., making individual swaths of one-quarter to one-half mile across. A fourth tornado had a track of about 10 miles. There were other tornadoes of brief duration, but these four were the most significant.

Many cities and towns in the path of these storms suffered major damage, and the communities of Delta City, Inverness, Cary, Pugh City, and Little Yazoo, Miss., were virtually leveled.

Preliminary Civil Defense and Red Cross statistics indicate that in the three-State area affected by the tornadoes—Louisiana, Mississippi and Tennessee—113 persons were killed, 2,003 persons were injured, and 611 homes were destroyed. Total property loss was estimated to be $19,000,000.

That the death toll was not greater can be attributed to the vigilance of the National Severe Storms Forecast Center (NSSFC) at Kansas City, prompt action by the National Weather Service Offices at Shreveport, Jackson, and Memphis, and the response of public safety authorities and radio and television stations that serve the disaster area. Findings and recommendations of the survey team follow.

Findings

1. Advance preparedness planning for alerting public safety officials and news media to the development of severe local storms and tornadoes proved very effective; Community Warning Centers were activated promptly and Watches and Warnings were broadcast without delay. Consequently, essentially all people in the affected area had some advance warning. Predetermined plans of action were carried out from the onset of the situation and sustained effectively through the time of issuing all-clears for the areas involved. Reports of tornadoes and tornado damage were quickly communicated back through the system to Weather Service Offices and others, which helped greatly in keeping abreast of the situation.
2. Advance preparedness planning was effective in achieving a public awareness of what places of shelter or protection to seek in the event of an approaching tornado. Unfortunatetly, the geography and the general character of building construction in the affected areas were such that there were few nearby places to find protection. Also, too many people waited too long to seek safety.
3. All NOAA basic data collection and communications systems performed satisfactor-

ily. There were no significant interruptions in NOAA communications services.

4. The Severe Weather Preparedness Program places special emphasis on enlisting storm spotters. Special note is taken of the fact that most actual tornado sightings were reported by Mississippi Highway Safety Patrol officers whose prompt reports made possible the issuances of timely Tornado Warnings. The Jackson WSO provides a thorough training course in storm spotting, plus a refresher course, at the Safety Patrol Academy each year.
5. Three massive tornadoes remained in contact with the ground for periods in excess of 1 hour and for distances averaging 110 miles. The survey team believes that if some real-time, remote-sensing method had been available to identify the location and movement of individual thunderstorm cells (some of which were associated with tornadoes) on a minute-by-minute basis, the warning service could have been further improved. By using a method similar to the digital weather radar individual storm-tracking technique, being developed at the National Severe Storms Laboratory (ESSA Technical Memorandum ERLTM-NSSL 46, June 1970), warnings to the public could have been more localized and specific than was possible with existing facilities. As things turned out in the Mississippi Delta disaster, 53 counties were warned and 22 of these were actually struck by tornadoes.
6. The series of tornadoes that struck Mississippi were directly associated with the same weather system that produced severe weather and tornadoes earlier in northeast Louisiana —in the warning responsibility area of the Shreveport Weather Service Office. The National Weather Service radar at Shreveport is a modified World War II surplus airborne unit that is still retained in service as a local-use radar. The staff at Shreveport did an outstanding job of maintaining this obsolete equipment at peak performance and of interpreting the radar scope returns.
7. The National Meteorological Center (at Suitland, Md.) products satisfactorily depicted the significant large-scale features of the circulation and accurately forecast movement of a squall line, accompanied by showers and thunderstorms, through Louisiana into Mississippi and Tennessee on February 21, 1971.
8. NSSFC issued Tornado Watch Bulletins well in advance of all tornado occurrences in Louisiana, Mississippi, and Tennessee. The Watch lead times were exceptionally good, ranging from 1 to 11 hours and averaging 6 hours for the areas where all the fatalities and most injuries occurred.
9. The operation of NOAA's National Weather Service was most effective in warning the public and keeping them informed of impending tornadoes because the responsible National Weather Service Offices had the tools (radar, excellent communications, and action plans) and the professional competence to act promptly and responsibly upon recognizing a developing hazardous situation. The staffs exercised skill and judgment in their warnings and statements throughout the day and evening of February 21. This was particularly true of the Jackson WSO, which bore the brunt of the task of issuing warnings and in every respect discharged its responsibilities in an outstanding manner. The average lead time of specific Warnings for areas where the most deaths, injuries, and damage occurred was about 50 minutes.
10. The NOAA Weather Wire Service for Mississippi effectively disseminated weather warnings and other weather information of immediate importance to the public. Participation of broadcasting media through direct connection to the NOAA Weather Wire Service is below that considered desirable. This is attributable, in part, to the relatively high cost of teletypewriter rentals. Participation included seven out of eight commercial VHF TV stations, but only 26 percent of the full-time AM radio stations and 9 percent of the daytime AM radio stations. Both Associated Press and United Press International are connected to the NOAA Weather Wire at Jackson. Practically all commercial radio and TV broadcast facilities in Mississippi are connected to at

least one of the news wire services over which National Weather Service Watches and Warnings are transmitted.

11. The overall task of receiving, diagnosing, and synthesizing the voluminous amount of incoming information—radar weather reports; information received via National Warning System (NAWAS) on sightings, damage, and power and communications outages; radar report and warning coordination circuit (RAWARC) information; and miscellaneous reports—and concurrently updating and disseminating Watch and Warning bulletins on proper circuits is next to impossible to achieve effectively at the fast-moving pace required, particularly when multiple storm outbreaks occur. Technologically, much of this work could be automated through the use of message compositors and automatic call-up and transmission of messages on NOAA circuits.
12. During the field investigation of the Mississippi Delta Tornadoes it was virtually impossible to determine accurately, from reports of tornado sightings, the actual number of tornadoes and the track they followed. This aspect of the field investigation was greatly facilitated by an aerial survey in advance of ground surveys, particularly determining the major tornadoes, their paths, and times. This information was then used as a basis for evaluating the timeliness and effectiveness of the tornado watches and warnings.
13. Many cities and towns in tornado-prone sections of the country use fire sirens to attract the public's attention to tornadoes. During this outbreak of tornadoes, sirens were used at Jackson and Greenwood, Miss., but apparently not at other locations. A common complaint is that in the larger cities people are accustomed to hearing sirens at all times of the day and night. In large cities, and often in smaller cities, unless persons are in some way conditioned to anticipate a siren-type warning of severe weather, they are more inclined to relate the warning signals to fires or accidents. One possibility would be to develop a siren which would be accessory to existing sirens and which would provide a distinctive beat note. Such a locally-controlled audible warning signal operated by a responsible official from a vantage point of constant watch would serve to tell the local populace emphatically that the time for waiting is over and that they must take cover immediately in order to save themselves!
14. The success of the overall warning system in saving lives was greatly diminished by the circumstances of generally old and inadequately constructed houses and other buildings, and the lack of community shelters.

Recommendations

1. NOAA's National Weather Service should continue its vigorous support and assistance in preparing community preparedness plans.
2. Each State in tornado-prone regions should assure the availability of a statewide corps of trained tornado spotters and should provide a refresher course at least annually.
3. Remote-sensing studies should be accelerated to develop an automated technique of detecting and tracking severe storms and tornadoes.
4. *The Federal Plan for Weather Radars and Remote Displays* should be reviewed to assure that those National Weather Service offices that have tornado warning responsibilities be furnished with the tools essential to fulfilling their mission.
5. NOAA's National Weather Service should continue to encourage additional news media to participate in the NOAA Weather Wire Service.
6. Aids and techniques should be developed to automate the composition and dissemination of Watch and Warning bulletins to the greatest possible extent.
7. The field investigation of all major tornadoes should include an early aerial reconnaissance survey to determine storm paths more accurately.
8. Public safety authorities should be encouraged to develop distinctive, audible, warning signals to warn of approaching tornadoes, and particularly to warn of immediate need to take cover.
9. Public authorities should be encouraged to establish a system of suitably designed community shelters, particularly in areas where the construction of basements is impractical.

Inverness, Miss.

ess, Miss.

CHAPTER 1
The Mississippi Delta Tornadoes

The Delta Country along the Mississippi River is, for the most part, a flat expanse of fertile land that stretches unbroken, except for occasional clusters of trees, from horizon to horizon. The water table, throughout most of the Delta Country, lies only a few feet below the surface. In the small communities along the east side of the river homes are built either on concrete slabs or on pilings. The lack of basements and other suitable shelters weighed heavily in accounting for the large number of fatalities and other casualties during the tornadoes of Sunday afternoon and evening, February 21, 1971.

Early Sunday morning, local radios carried news of a crippling snowstorm and several tornadoes in Texas. There were no other indications of bad weather in the offing to disturb the peaceful Sunday-morning routine in Delta Country. This calm was short-lived when at 9:55 a.m. CST the National Severe Storms Forecast Center (NSSFC) at Kansas City—where concern was growing over the intensification and rapid eastward movement of the Texas disturbance—issued a Tornado Watch for northern Mississippi. The Watch was immediately reissued over the NOAA Weather Wire Service by the Jackson, Miss., Weather Service Office (WSO). News of the Tornado Watch spread quickly through the countryside where the people have learned from bitter experience to suspect the black storm clouds that move in from the west each spring.

Apprehension mounted when—shortly before 11 a.m.—the Jackson WSO issued a Severe Thunderstorm Warning for the counties of Sunflower, Tallahatchie, Quitman, and Panola, which lie along a north-south line in northwest Mississippi.

At 11:45 a.m. the Police Department of Cleveland, Miss. (Bolivar Co. near Sunflower Co. line) reported to the Jackson WSO that a tornado had been spotted 6 miles southwest of town. The Severe Thunderstorm Watch was changed to a Tornado Warning, which documented the beginning of a day of tragedy and destruction in Mississippi Delta Country. Between the time of the first sighting and the lifting of all Watches and Warnings just before mdnight more than 50 reports of tornado and funnel cloud sightings were received.

During the outbreak of severe storms, by far the greatest toll in lost lives was taken by three major tornadoes (fig. 1). At 3:10 p.m. the first tornado of the deadly trio touched down east of Delhi, La. It moved northeastward across the river into Mississippi on a continuous path 102 miles long and lifted into the parent cloud just south of the small town of Schlater, Miss. One hour later, at 4:10 p.m., the second tornado funnel struck a few miles southwest of Cary, Miss., moved northeastward a distance of 159 miles, on a track parallel to the first tornado, and reached a point just east of the town of Abbeville, Miss. At 5:15 p.m., the third great tornado began its course due south of Bovina, Miss., followed the same northeastward direction, remained on the ground for 69 miles, and lifted south of Lexington, Miss. The three tornadoes raked individual paths that varied from one-quarter to one-half mile across, traveled a total distance of 330 miles, and moved at speeds on the order of 55 m.p.h. A fourth tornado followed a ground track for about 10 miles and skirted the edges of the towns of Parchman, Rome, and Tutwiler, Miss. There were other tornadoes of brief duration, but these four were the most significant.

In the paths of these storms scores of cities

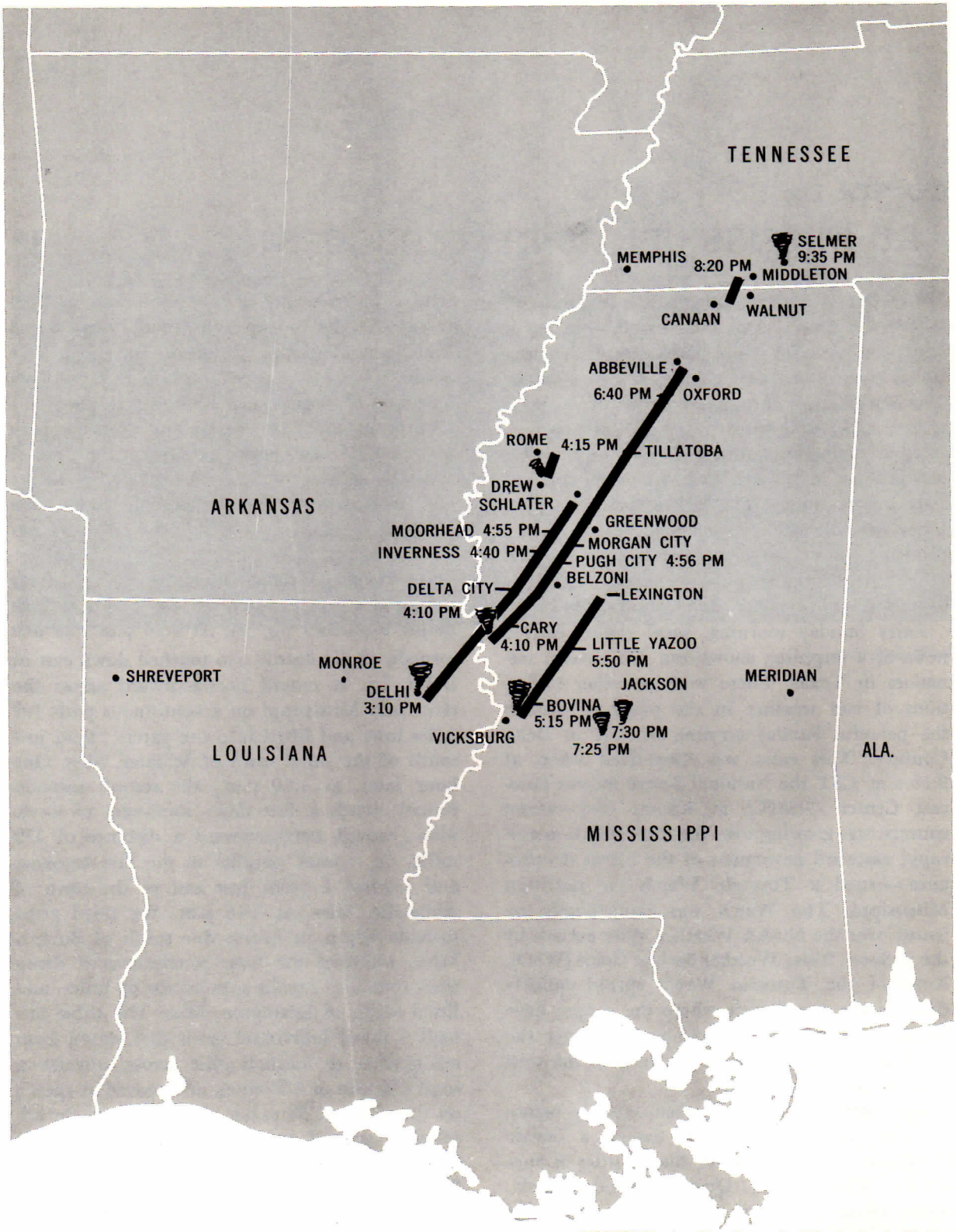


FIGURE 1. Tracks of Mississippi Delta Tornadoes, February 21, 1971.

and towns suffered major damage, and the communities of Delta City, Inverness, Cary, Pugh City, and Little Yazoo, Miss., were virtually destroyed.

As evening approached, isolated tornadoes continued to develop and strike on both sides of the Mississippi-Tennessee border, leaving a trail of more destruction.

Frequent comments, made to the disaster survey team members, were: "We heard the warnings—everyone knew they were coming." From the widely scattered homes of the rural countryside, people dived into drainage ditches to protect themselves, and most of them made it in time. In the towns and cities, there were no cellars and few ditches in which to hide. Many sought safety under beds, in bathtubs, or lying flat against inside walls. Some tried to outrace the funnels, some took cover under bridges, and some sought refuge in the sturdiest buildings. Also, there were "fatalists" who decided to take the chance and remain in their homes.

In the three-State disaster area, 113 persons were killed, 2,003 were injured, and 611 homes were destroyed. The total cost in property loss was estimated to be about $19,000,000.[1]

That the death toll was not considerably higher can be attributed to the vigilance of the National Severe Storms Forecast Center, prompt action by the National Weather Service Offices at Shreveport, Jackson, and Memphis, and the responsiveness of public safety authorities and radio and television stations serving the disaster area. During the Mississippi Delta outbreak, all tornadoes were within the areas and times specified in Tornado Watch Bulletins issued by NSSFC. Lead times of Tornado Watch Bulletins for counties affected by tornadoes ranged from a minimum of 1 hour to a maximum of 11 hours—an average of 6 hours.

Lead times of Tornado Warnings, issued by the responsible NWS offices, for the 22 affected counties averaged 0.9 hour; however, 5 of these counties had no Tornado Warnings and the lead time for the other 17 counties average 1.2 hours.

Knowledge of tornado safety precautions was widespread in this storm-prone area and most people reacted promptly to save themselves. The real tragedy was that in spite of known precautions and timely warnings many died needlessly, looking in vain for safety.

Times of Tornado Watches and Warnings in the communities suffering greatest loss of life are given in table 1.

Table 1.—Tornado Watch and Warning times (CST) relating to communities suffering the greatest loss of life

Community	Time of watch issuance	Time of warning issuance	Time of tornado	Deaths
*Cary, Miss. (Sharkey Co.)	1400	1520	1610	14
*Delta City, Miss. (Sharkey Co.)	1400	1520	1610	8
Gooden Lake, Miss. (10 mi WSW Belzoni) (Humphreys Co.)	1000	1520	1630	11
*Inverness, Miss. (Sunflower Co.)	1000	1615	1640	19
*Little Yazoo, Miss. (Yazoo Co.)	1400	1615	1750	9
*Pugh City, Miss. (Joe Regh Plantation) (Leflore Co.)	1000	1537	1656	22
3 mi E of Delhi, La. (Madison Parish)	1400	1520	1510	10

* The four small Mississippi communities of Delta City, Inverness, Little Yazoo, and Pugh City were virtually destroyed.

[1] The figures given are preliminary and subject to change. They were obtained from Civil Defense authorities and the American Red Cross.

CHAPTER 2
Summary of Preparedness Action

The effectiveness of actions following the receipt of a warning depends upon the preparations made beforehand. Advance preparation is almost as important as the warning itself. Planning for effective community and individual actions when a tornado strikes is a major concern of NOAA National Weather Service Offices throughout every tornado-prone area of the Nation.

Before the commencement of the tornado season, which peaks in February in the Gulf States, officials in charge of those NOAA National Weather Service Offices that are responsible for relaying Tornado Watches and issuing Tornado Warnings hold preparedness sessions with local officials to establish and to update plans for community preparedness. These meetings are attended by mayors; civil defense, law enforcement, utility, and engineering officials, superintendents of schools; hospital administrators; representatives of State government departments and local public works; radio, television, and newspaper officials; and others.

The Mississippi Delta Tornadoes of February 21, 1971, involved three States—Louisiana, Mississippi, and Tennessee—and three National Weather Service Offices—Shreveport, La., Jackson, Miss., and Memphis, Tenn. Each of these offices holds preparedness meetings and helps with the development of community preparedness plans on a continuing basis throughout its area of responsibility. Although the frequency of tornadoes in the south central States is greatest in the month of February, it is necessary to promote community preparedness planning on essentially a year-round basis because the tornado "season" in this part of the country extends from November through May.

In the February 21 storms, most of the storm-track distance and most of the casualties and damage occurred in Mississippi. For this reason the postdisaster survey was concentrated there, and dealt mostly with the community preparedness activities of the Jackson WSO.

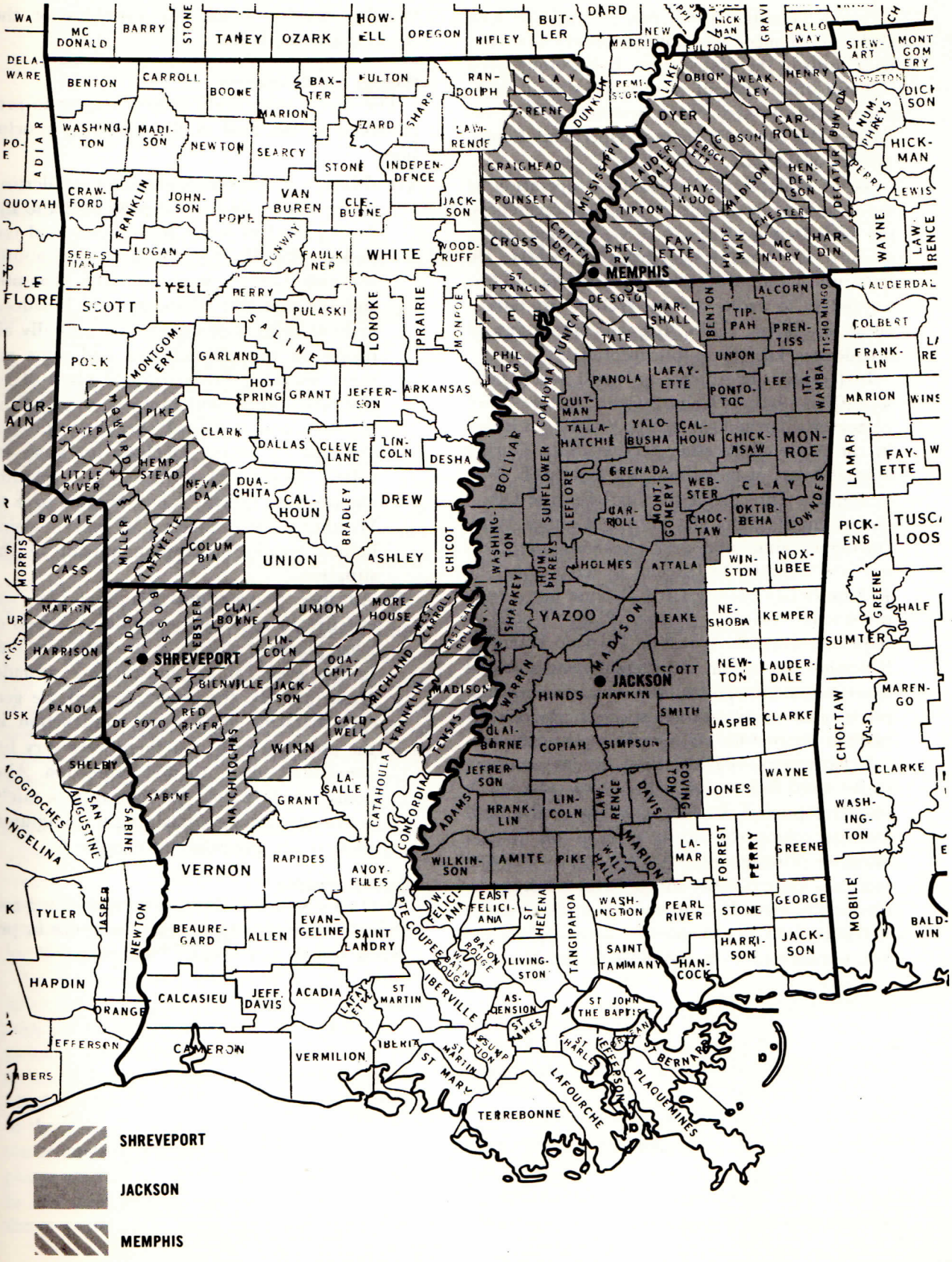
The Jackson WSO has a 57-county area of responsibility (fig. 2). The educational program is designed to encourage the organization of Community Warning Centers (where they are not already established), to assure strong cooperative storm reporting networks (see chapter 3), and to develop reporting networks where they do not exist, making full use of the best available communications facilities.

The Jackson WSO helps and encourages community preparedness planning in its area of responsibility, primarily through periodic conferences and special meetings with the news media, NOAA Weather Wire Service subscribers, and public officials. More than 40 such conferences were held throughout the State by the Jackson WSO over the years 1969 and 1970 (see appendix A).

The center of the Mississippi Office of Civil Defense in Jackson is activated whenever a Tornado Watch or Tornado Warning is issued. Civil Defense has drops on the NOAA Weather Service and on the National Warning System (NAWAS), and the Radio Amateur Civil Emergency Service (RACES) is available.

In cooperation with the State Civil Defense, which is called the Mississippi Civil Defense Council (CDC), the Jackson WSO prepares Tornado Warning Plans for individual counties. On Sunday February 21, the Mississippi CDC

FIGURE 2. Areas of warning responsibility for National Weather Service Offices.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received Tornado Watch No. 37 at 10:00 a.m. CST, and immediately notified county Civil Defense units in the Watch areas. Each county Civil Defense unit acted in accordance with its prepared plan. As each center was activated, it informed the State Emergency Operation Center (EOC) of the CDC.

As an example of Civil Defense operation at the local level in the area of tornado occurrences, the Civil Defense Director in Greenwood, Miss., manned the Emergency Operation Center. He took information directly from NAWAS and forwarded it to radio station WGRM in Greenwood by direct radio link and simultaneous broadcast to keep the public informed.

In Jackson, the center is activated by the Jackson (City)—Hinds County Civil Defense Office whenever a Tornado Watch or Warning is issued by the National Weather Service Office. During normal hours of operation, Mr. Charles E. Wilkinson, the Director of the Civil Defense Office, obtains notification via NOAA Weather Wire. During evenings and over weekends, the Jackson WSO notifies the Director by telephone. The Jackson-Hinds County Civil Defense has a comprehensive "Natural Disaster Plan." Upon receipt of a Tornado Watch or Tornado Warning, it notifies the mayor, city commissioners, school superintendents, police, fire department, hospitals, and severe weather spotters who are located at selected fire stations throughout the city.

Upon receipt of notification the mayor comes to the Civil Defense office to keep a close watch on developments. Communications in the Civil Defense offices consist of a drop on NOAA Weather Wire Service, NAWAS, and a radio that monitors continuously all government frequencies in the area. If a tornado or a severe storm is reported on any of these frequencies, but was not transmitted over NAWAS to the National Weather Service Office, the members of the center notify the WSO.

Findings and Conclusions

The survey team findings with respect to preparedness action lead to the following conclusions.

(1) Advance preparedness planning for alerting public safety officials and news media to the development of severe local storms and tornadoes proved very effective. Community Warning Centers were activated promptly and Watches and Warnings were broadcast without delay. Consequetnly, essentially all people in the affected area had some advance warning. Predetermined plans of action were carried out from the onset of the situation and sustained effectively through the time of issuing all-clears for areas involved. Reports of tornadoes and tornado damage were quickly communicated back to Weather Service Offices and others, which helped greatly in keeping abreast of the situation.

(2) Advance preparedness planning also was effective in achieving a public awareness of what places of shelter or protection to seek in the event of an approaching tornado. Unfortunately, the geography and the general character of building construction in the area was such that there were very few convenient places to find protection. Also, many people waited too long to seek safety. Recommendations pertaining to community shelters are presented in chapter 5.

Recommendation

NOAA's National Weather Service should continue its vigorous support and assistance in preparing community preparedness plans.

CHAPTER 3

Data Collection and Communications

Surface Observations

The national surface observational networks of the Federal meteorological system and the related data collection systems provide basic information for many uses, both immediate and long range. In the case of the Mississippi Delta Tornadoes these networks operated effectively without interruption of any significance throughout the storm period. The existing networks of surface observing stations (in Mississippi and adjacent States) that report weather conditions each hour throughout the 24-hour day, or more often, are shown in figure 3.

Through the SKYWARN program, which enlists the aid of Civil Defense, law enforcement, and various other State and municipal officials, as well as interested private citizens, there is a vast but unnumbered observational network of sources for reports of visual sightings. Standard practice is to request reports of severe weather to be directed to the nearest law enforcement office for relay to the National Weather Service (NWS) through the NAWAS hot-line telephone system. The Jackson WSO also maintains a special telephone that is listed "to report severe weather only," which is accessible to the public for that purpose.

In implementing SKYWARN the Jackson WSO developed excellent working arrangements with the Mississippi Highway Safety Patrol. The Jackson WSO uses NAWAS to notify the communications center at the Headquarters of the Mississippi Highway Safety Patrol (in Jackson) of the Tornado Watches and Warnings. In turn, the communication center starts a cascade of telephone calls to notify the communication centers in the nine districts shown in figure 4. While theses centers are being informed, the notification is received simultaneously over the NAWAS line by sheriff's offices, police, and Civil Defense personnel in the counties. This alert sets into action a large observing network. The most highly trained tornado spotters are the patrolmen of the Mississippi Highway Safety Patrol. More than 400 members have received training in the recognition of tornadoes and in tornado safety rules during their 3-month course at the Safety Patrol Academy. Each year they complete a refresher training course. Therefore, it is not surprising that most reports of actual tornado sightings were from patrolmen.

Upper Air Observations

Upper air observations include rawinsondes—measurements of upper level winds, pressures, temperatures, and relative humidity—and pilot balloons, which measure only upper level winds. The geographic spacing of these stations in and about Mississippi satisfy NWS network requirements (fig. 3). During the storm period, all scheduled observations were made on time, met established standards of accuracy, and were utilized in the usual manner as required by actual and expected severe weather conditions. There were no breakdowns in the communication of information.

Radar Observations

Weather radar was a primary tool in detecting and tracking the severe thunderstorm cells which spawned the tornadoes in Mississippi and adjacent portions of Louisiana and Tennessee. Locations of existing radar facilities are shown in figure 5.

Within the past two years the National Weather Service has installed and commissioned

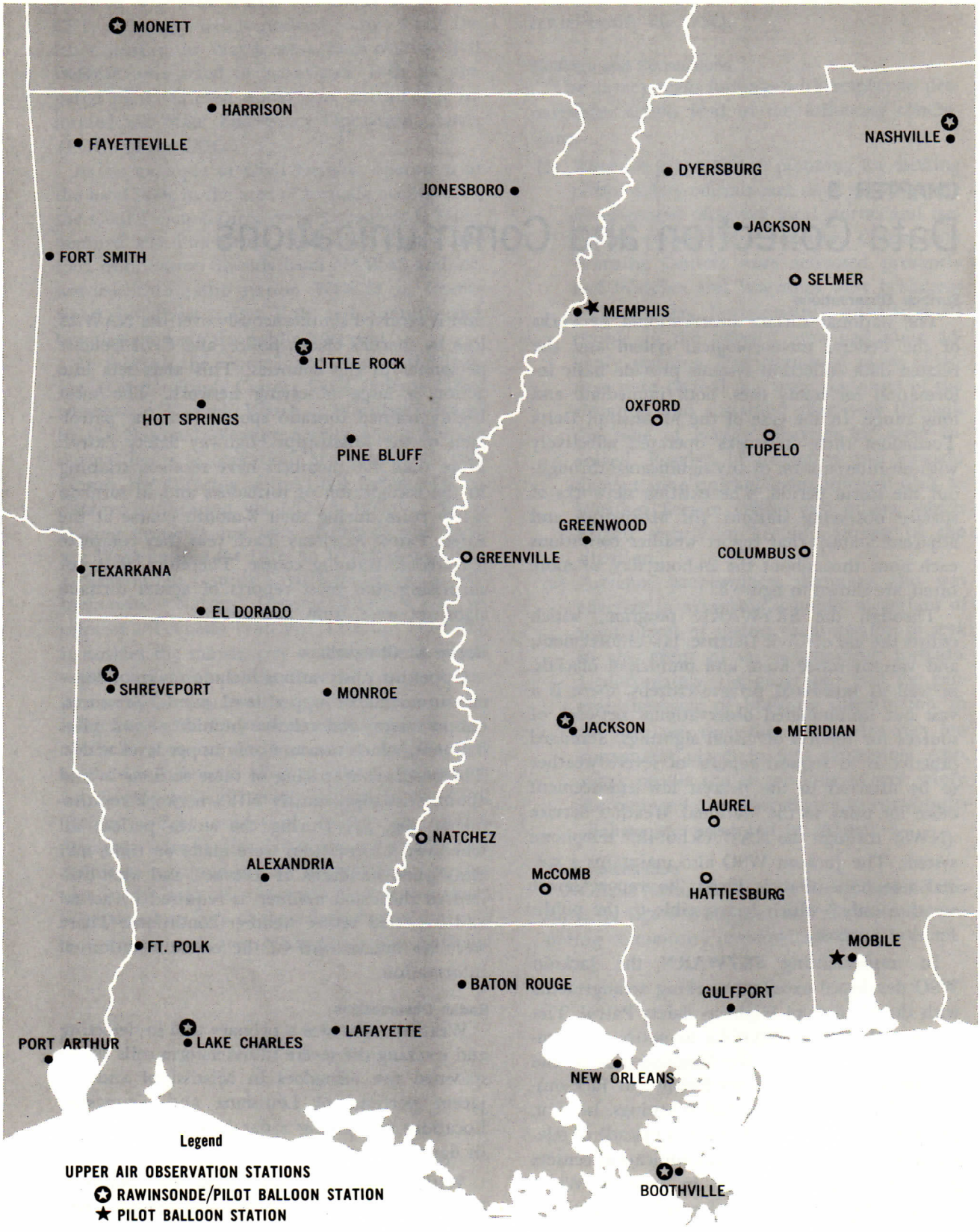

FIGURE 3. Surface and upper air weather observation networks.

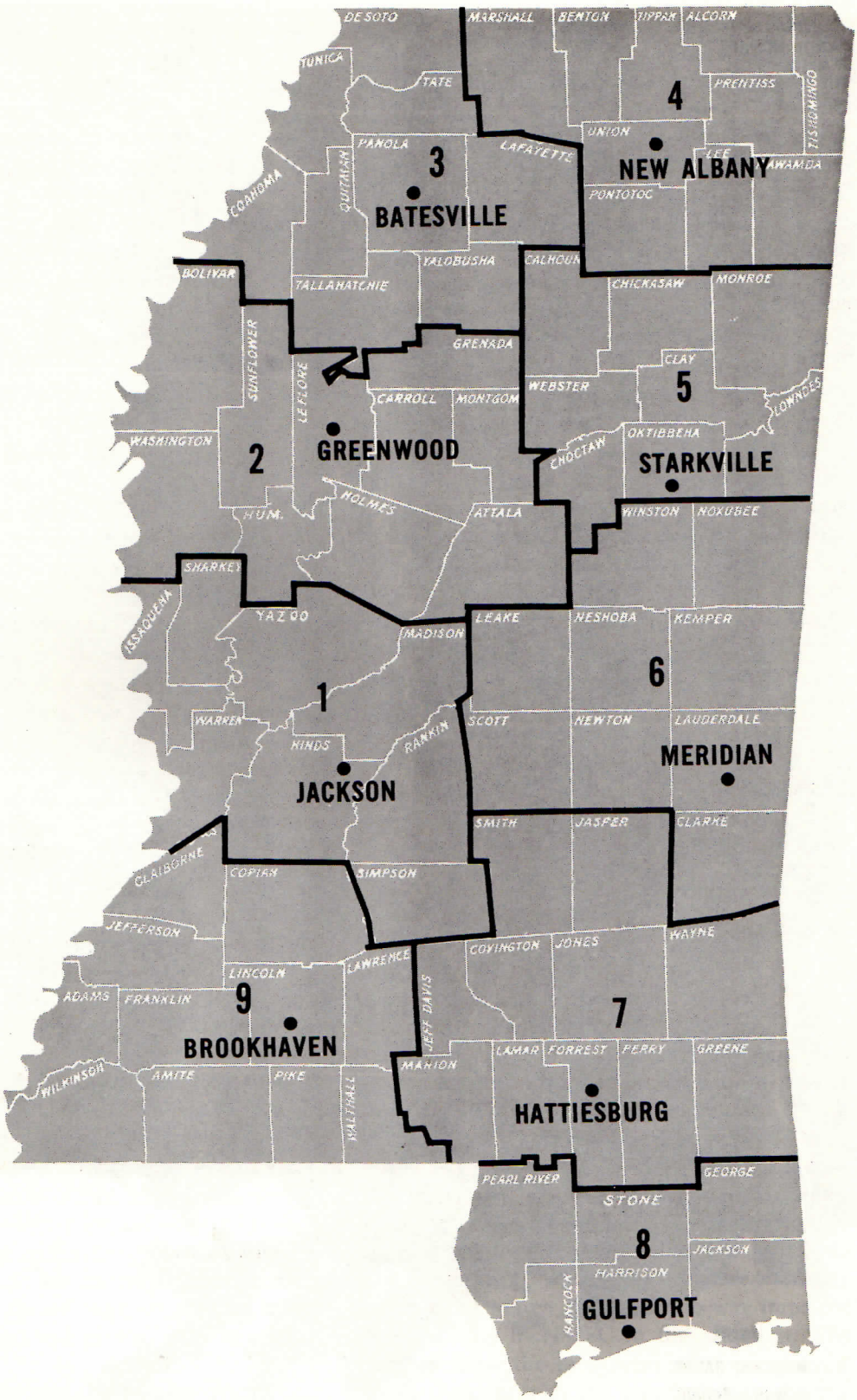

FIGURE 4. Mississippi Highway Safety Patrol Districts.

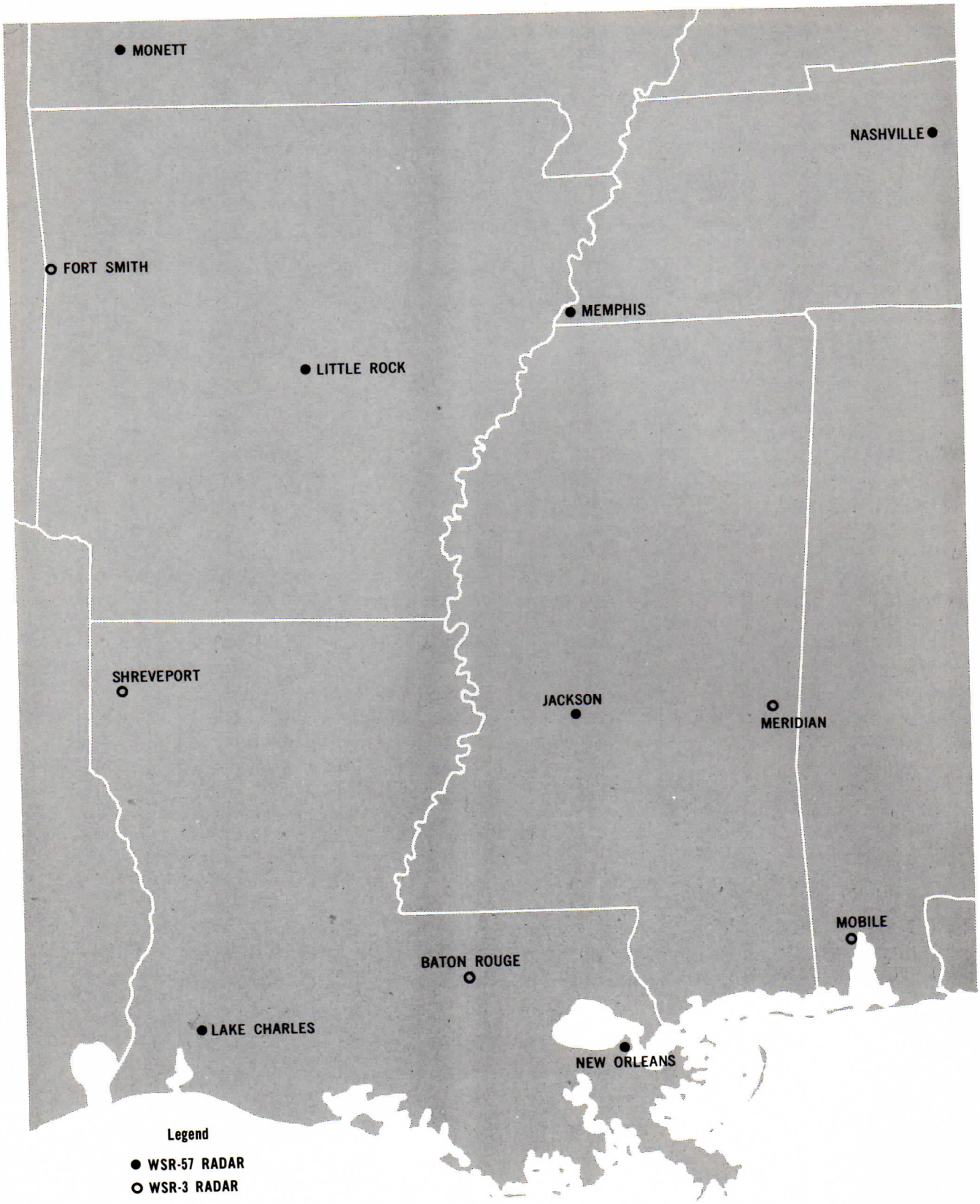

FIGURE 5. Weather radar network.

a new WSR-57M weather search radar at Jackson. This radar is the latest version of the standard radar adopted some years earlier by NWS and has been updated technically from time to time. The radar is well situated on Jackson's Allen C. Thompson Field, is free of obstructions that would hinder detection of storms in any direction, and has an independent standby electric power generating plant. This power plant can be activated and monitored from the quarters of the Jackson WSO and also can provide power to operate all other essential weather equipment at the station, including lighting, air conditioning and ventilation, and communication facilities.

The Jackson radar equipment functioned satisfactorily throughout the storm period of February 21. An electronics technician was made available full time to handle any maintenance requirement which might develop. The radar was manned by a competent staff. Members were well-trained and experienced in use of the set and their reports were frequent, timely, and complete.

During the storm period of February 21, the entire State of Mississippi and the immediate adjacent area was under continuous radar weather surveillance. The recently activated WSR-57 radar at Memphis, which formerly was operated by the Navy, supplemented the Jackson radar coverage in northern Mississippi. Excellent supplemental radar coverage also was provided by the WSR 57 radars at Centerville, Ala., and New Orleans, La. The communications facilities for these radars functioned properly and made radar reports available to the Jackson WSO, to the National Severe Storms Forecast Center (NSSFC) at Kansas City, and to other offices without delay.

At Shreveport, La., there is a type WSR-1 radar, converted from World War II surplus airborne radar equipment, which has been in service since the early 1950's. Parts for this set are no longer available commercially. Special arrangements must be made for manufacture of components unique to the set, and, in general, it is difficult and expensive to keep this radar in operational readiness.

At Meridian, Miss., there is a similar WSR-1/3 type radar, which is no longer used as a network tool.

Experience in recent years has shown repeatedly that it is most important for Weather Service Offices, which have severe local storm warning responsibility, to have a weather radar capability that enables them to maintain a close watch on storm developments in their areas of responsibility. At Weather Service Offices which are more than 75 miles from a WSR-57 or other synoptic network radar, NWS policy is to provide a modern local use radar. This policy is followed because the capability of providing necessary detail on remote displays is inversely related to the distance from the radar. At those Weather Service Offices not having, but within 75 miles of a synoptic network radar, a remote display from that radar and a hot-line for warning coordination is to be provided. Although the use of remote displays as a source of radar information for warning purposes has not been completely evaluated, limited experience seems to indicate that they will satisfy this requirement.

According to *The Federal Plan for Weather Radars and Remote Displays* (Fiscal years 1969-73), the WSR-1 radar at Shreveport, La. is to be replaced with a remote display from the FPS-77 radar at Barksdale AFB, La. If it is ascertained that the remote display is not sufficient to enable Shreveport (or any other station similarly equipped) to measure and track storm cells to the degree needed to carry out its storm warning responsibilities, then that station should be equipped with a local-use radar.

Environmental Satellite Data

Pictures were taken by NASA's Applications Technology Satellite (ATS-3) geostationary spacecraft about every 12 minutes from sunrise until late afternoon on February 21, 1971. These pictures were not received at the National Severe Storms Forecast Center (NSSFC) in Kansas City, Mo., because the satellite picture processing team that was responsible for developing new techniques for use of ATS-3 data and related communications support was not scheduled for activation until March 1. This in no way impaired the capability of NSSFC in this situation. The pictures show the movement of three separate squall lines through the area in which the tor-

nadoes occurred. The thunderstorms making up these squall lines are believed to be the storms which spawned the tornadoes.

Upon activation of the ATS-3 team and communications support at NSSFC, ATS-3 pictures will be available to NSSFC on a realtime basis. In practice the pictures are acquired by the National Environmental Satellite Service (NESS) read-out station at Wallops Island, Va. The information is sent immediately to Kansas City over a special circuit, is received there on high quality recorders, and then is given further photographic processing. The time interval between the actual ATS-3 picture and the time the picture is available for meteorological analysis at NSSFC is 40 to 45 minutes.

Communications

Basic meteorological communications at Jackson, Miss., Memphis, Tenn., and Shreveport, La., are the standard Service C, Service A, and RAWARC teletypewriter circuits, and the National Facsimile Circuit.

Teletypewriter Systems

Services A and C teletypewriter networks serve to collect and distribute hourly and special surface weather reports and upper air data in support of National Weather Service functions. The Radar Report and Warning Coordination (RAWARC) teletypewriter network is an internal NWS system that collects and distributes weather radar reports; severe local storm and hurricane watches, warnings, and bulletins issued by the NWS; and such miscellaneous information as observations from substations, spotter networks, and citizen reports of severe weather.

The NOAA Weather Wire Service (NWWS) teletypewriter system serves as the primary means for disseminating weather information to local safety officials, radio, TV, and newspapers. Transmission of warning traffic on NWWS has priority over all other teletypewriter systems. The information transmitted includes routine weather data and forecasts; severe weather watches, warnings, and statements; local radar weather reports; and spotter reports of severe weather. Figure 6 shows the offices and news media served by the NOAA Weather Wire Service in Mississippi.

Telephone Systems

The Jackson WSO telephone service consists of: One unlisted line for receiving weather reports, providing weather briefings, and communicating with news media; one unlisted line designated for receiving severe weather reports; one line with recorder for radar, travelers, and recreation weather; two lines in rotary providing recorded weather information; and an administrative line normally answered only during regular business hours.

Findings and Conclusions

The survey team findings with respect to data collection and communications lead to the following conclusions.

1. All of the NOAA basic data collection and communication systems performed satisfactorily. There were no significant interruptions in NOAA communications services.
2. The Severe Weather Preparedness Program places special emphasis on enlisting storm spotters. Special note is taken of the fact that most actual tornado sightings were reported by Mississippi Highway Safety Patrol officers, whose prompt reports made possible the issuances of timely Tornado Warnings. The Jackson WSO provides a thorough training course in storm spotting, plus a refresher course, at the Safety Patrol Academy each year.
3. Three massive tornadoes remained in contact with the ground for periods in excess of 1 hour and for distances averaging 110 miles. The survey team believes that if some real-time, remote-sensing method had been available to identify the location and movement of individual thunderstorm cells (some of which were associated with tornadoes) on a minute by minute basis, the warning service could have been further improved. By using a method similar to the digital weather radar individual storm-tracking technique, being developed at the National Severe Storms Laboratory (ESSA Technical Memorandum ERLTM-NSSL 46, June 1970), warnings to the public could have been more localized and specific than was possible with existing facilities. As things turned out in the Mississippi Delta disaster, 53 counties were warned and 22 of these were actually struck by tornadoes.
4. The tornadoes that struck Mississippi were directly associated with the same weather system that produced severe weather earlier in

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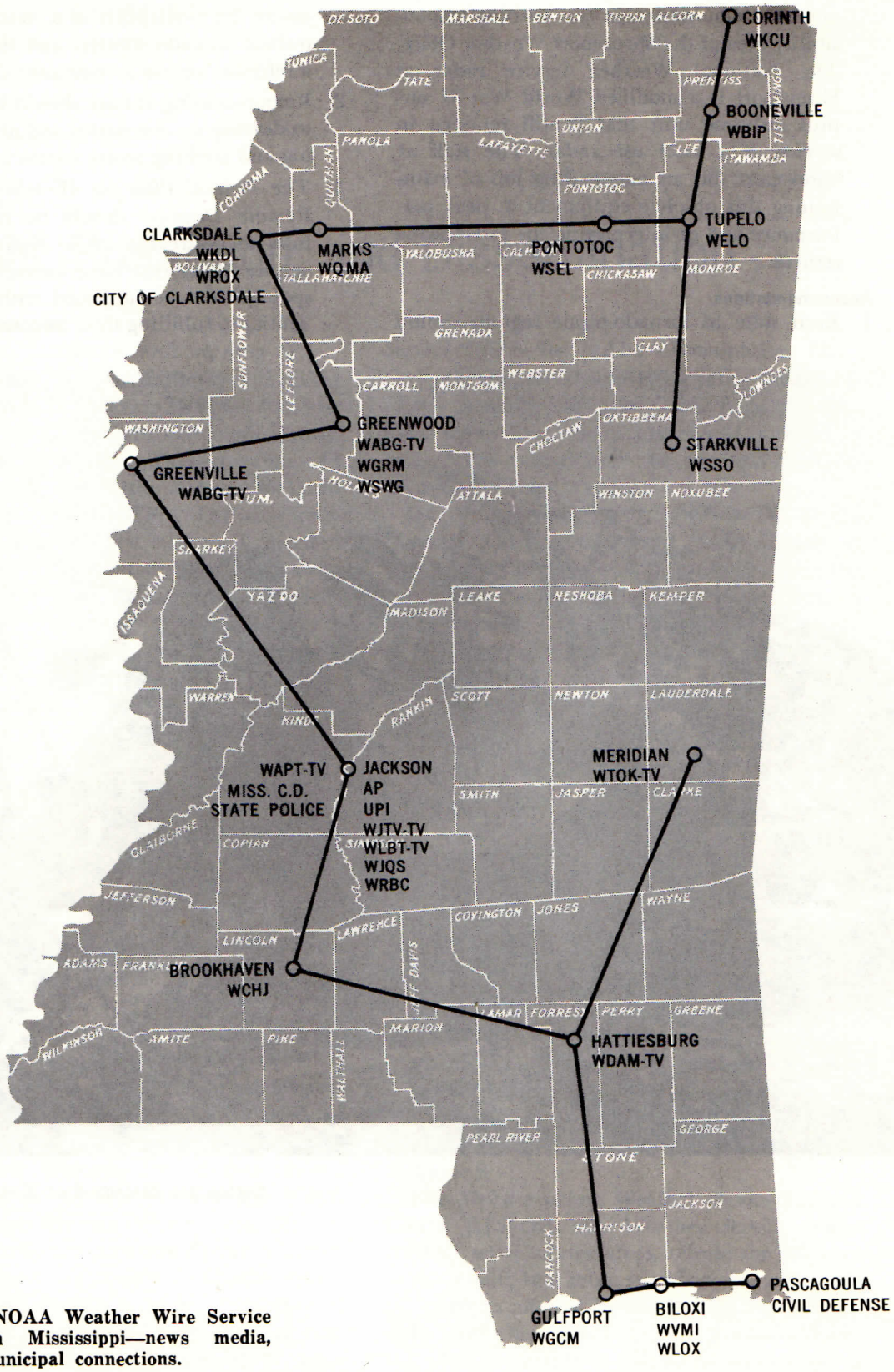

FIGURE 6. NOAA Weather Wire Service (NWWS) in Mississippi—news media, State, and municipal connections.

northeast Louisiana—in the warning responsibility area of the Shreveport Weather Office. The National Weather Service radar at Shreveport is a modified World War II surplus airborne unit that is still retained in service as a local use radar. The staff at Shreveport did an outstanding job of maintaining this obsolete equipment at peak performance and of interpreting the radar scope returns.

Recommendations

1. Each state in tornado-prone regions should assure the availability of a statewide corps of trained tornado spotters and should provide a refresher course at least annually.
2. Remote-sensing studies should be accelerated to develop an automated technique of detecting and tracking severe storms and tornadoes.
3. *The Federal Plan for Weather Radars and Remote Displays* should be reviewed carefully to assure that those National Weather Service offices that have tornado warning responsibilities be furnished with the tools essential to fulfilling their mission.

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CHAPTER 4
Analysis, Prediction, and Dissemination

Analysis and Prediction

The analysis, prediction, and warning of tornadoes is essentially a three-echelon system within the National Weather Service (NWS). The *first echelon* involves the analysis and prediction of large-scale weather patterns. These are prepared and distributed by the National Meteorological Center (NMC) at Suitland, Md. The basic guidance material from this first echelon is prepared largely through computerized operations, covers the conterminous States, and extends for periods out to 72 hours in advance. The centralized processing of data, analyses, and predictions at NMC is designed to eliminate most local requirements for charting by hand and independent meteorological analysis at NWS Offices. NMC products are transmitted to forecast centers and field offices over the National Facsimile System. The products issued for February 21, 1971, satisfactorily depicted the significant large-scale features of the circulation, including the squall line accompanied by showers and thunderstorms that moved across Louisiana into Mississippi and Tennessee during the day.

The *second echelon,* the National Severe Storms Forecast Center (NSSFC) at Kansas City, constantly analyzes atmospheric conditions over the 48 conterminous States. The Severe Local Storms (SELS) Unit of NSSFC is responsible for preparing and releasing forecasts of expected severe local storms, including tornadoes. These forecasts, called Watches, are released in two forms: (1) for public use—the Tornado Watch or Severe Thunderstorm Watch; and (2) for aviation services—the Aviation Severe Weather Watch. Watches are released immediately—whenever conditions indicate a high probability of severe weather occurrence—over national teletypewriter systems to local National Weather Service Offices for public dissemination. SELS also prepares and issues twice-daily assessments of the possibility of severe local storm development up to 24 hours in advance. It is issued to local NWS Offices over the national teletypewriter and facsimile system.

On February 21, 1971, the NSSFC Severe Weather Outlook Narrative (AC) issued at 3:00 a.m. CST stated that a few severe thunderstorms were expected during the afternoon in eastern Texas, western Louisiana, and southwestern Arkansas, and during the evening and night in Louisiana, southern Arkansas, Mississippi, and western Alabama. This outlook was depicted in the Severe Weather Outlook transmitted on the National Weather Facsimile Network at 5:01 a.m. The outlook issued at 9:00 a.m. stated that a few severe thunderstorms were expected in eastern Texas, Louisiana, south and central Arkansas, Mississippi, west and middle Tennessee, and northwest Alabama. The first Tornado Watch Bulletin for the area of the four major tornadoes was issued by NSSFC (Bulletin number 37) at 9:55 a.m., well in advance of confirmed tornado occurrences in Louisiana, Mississippi, and Tennessee. Bulletin 37 and subsequent Tornado Watch Bulletins pertaining to the area of concern, numbers 39 to 42, are plotted by counties in figure 7a-e. Watch and Warning lead times for counties struck by tornadoes are given in Table 2.

The *Third echelon,* Weather Service Forecast Offices (WSFOs) and Weather Service Offices (WSOs) serve specific areas, release the Watches to the public in a more specific form, and name the counties affected by the Watch. The responsible NWS Office issues the vital Tornado Warning when a tornado is sighted or when there is

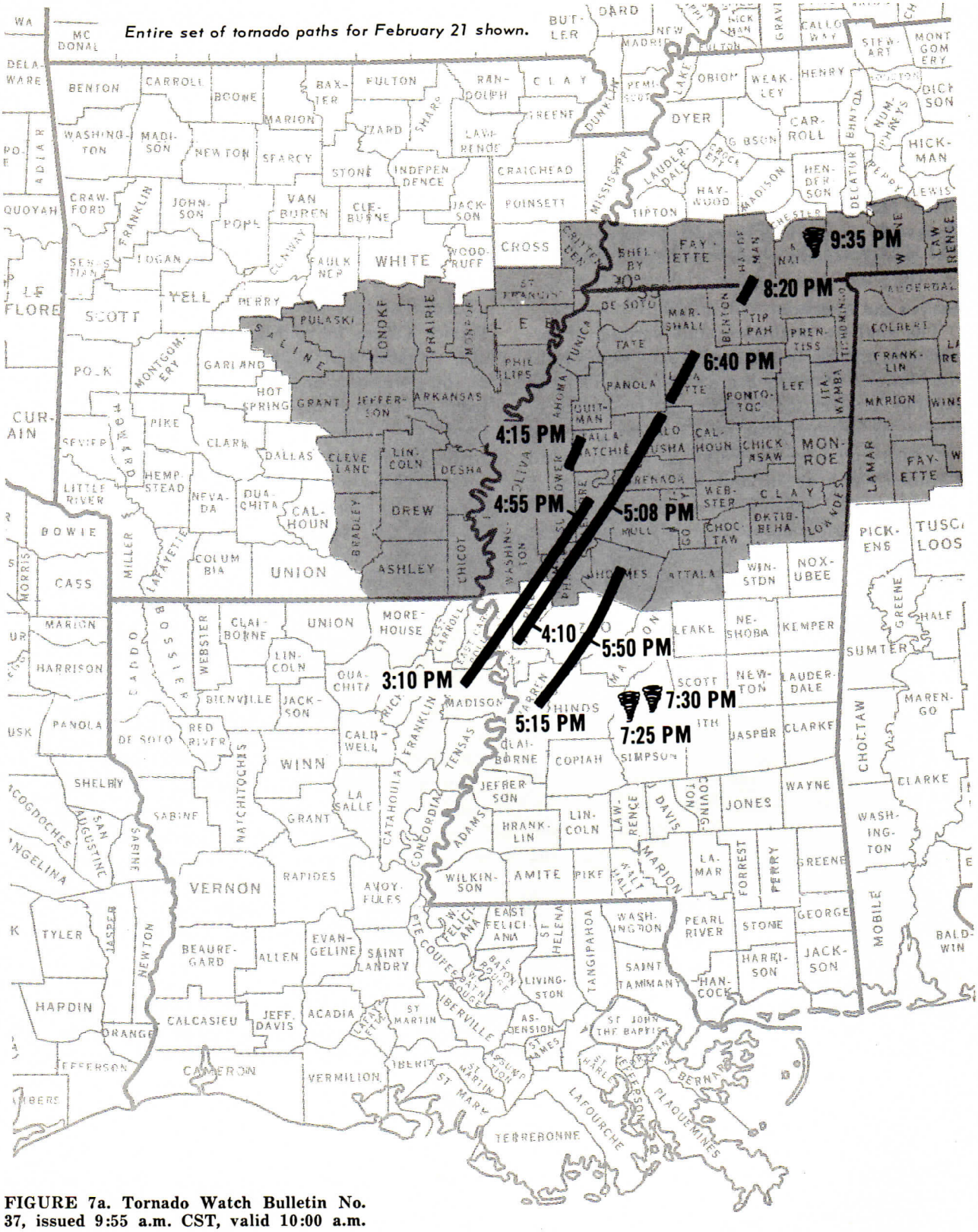


FIGURE 7a. Tornado Watch Bulletin No. 37, issued 9:55 a.m. CST, valid 10:00 a.m. to 4:00 p.m.

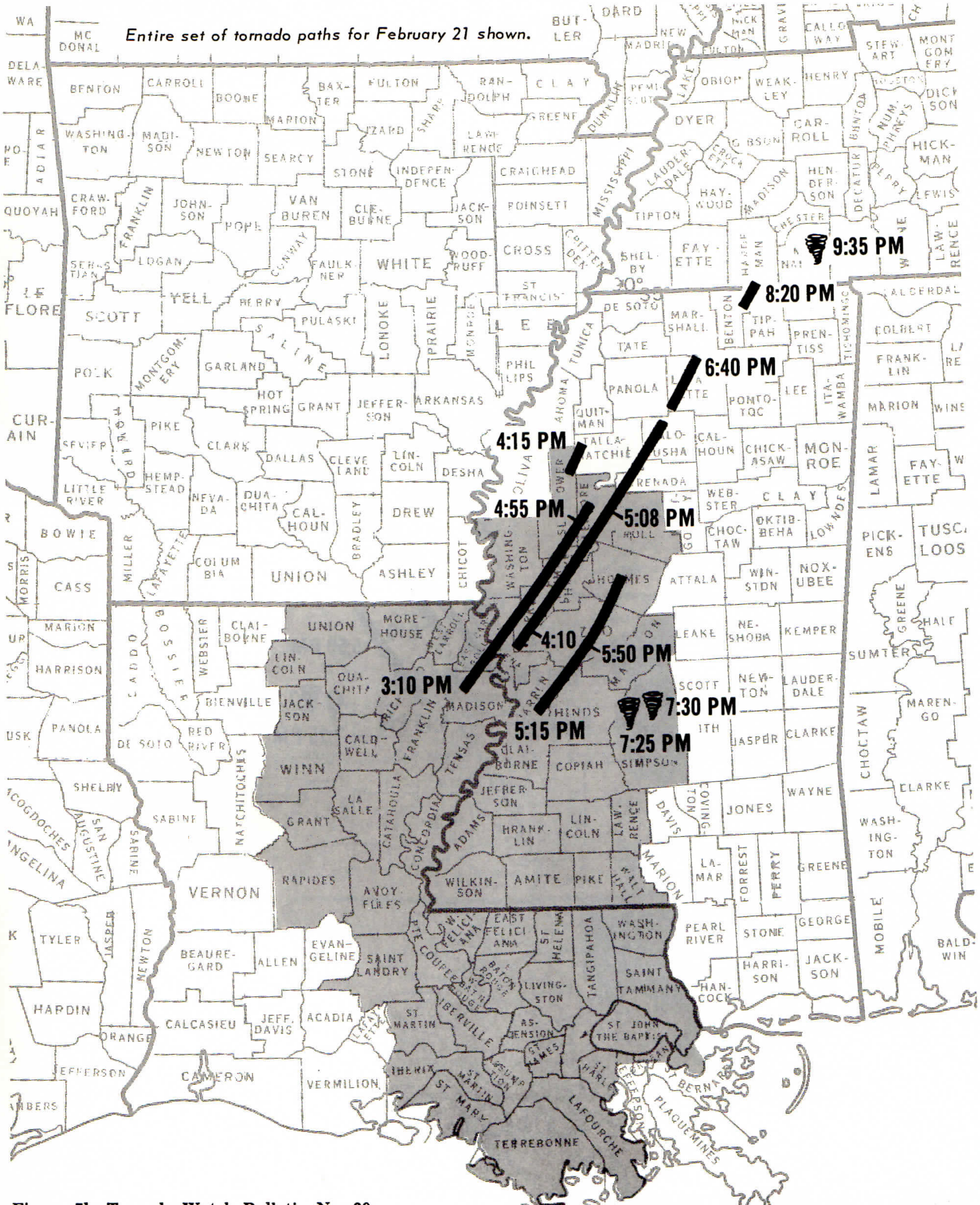


Figure 7b. Tornado Watch Bulletin No. 39, issued 2:00 p.m. CST, valid 2:00 p.m. to 8:00 p.m.

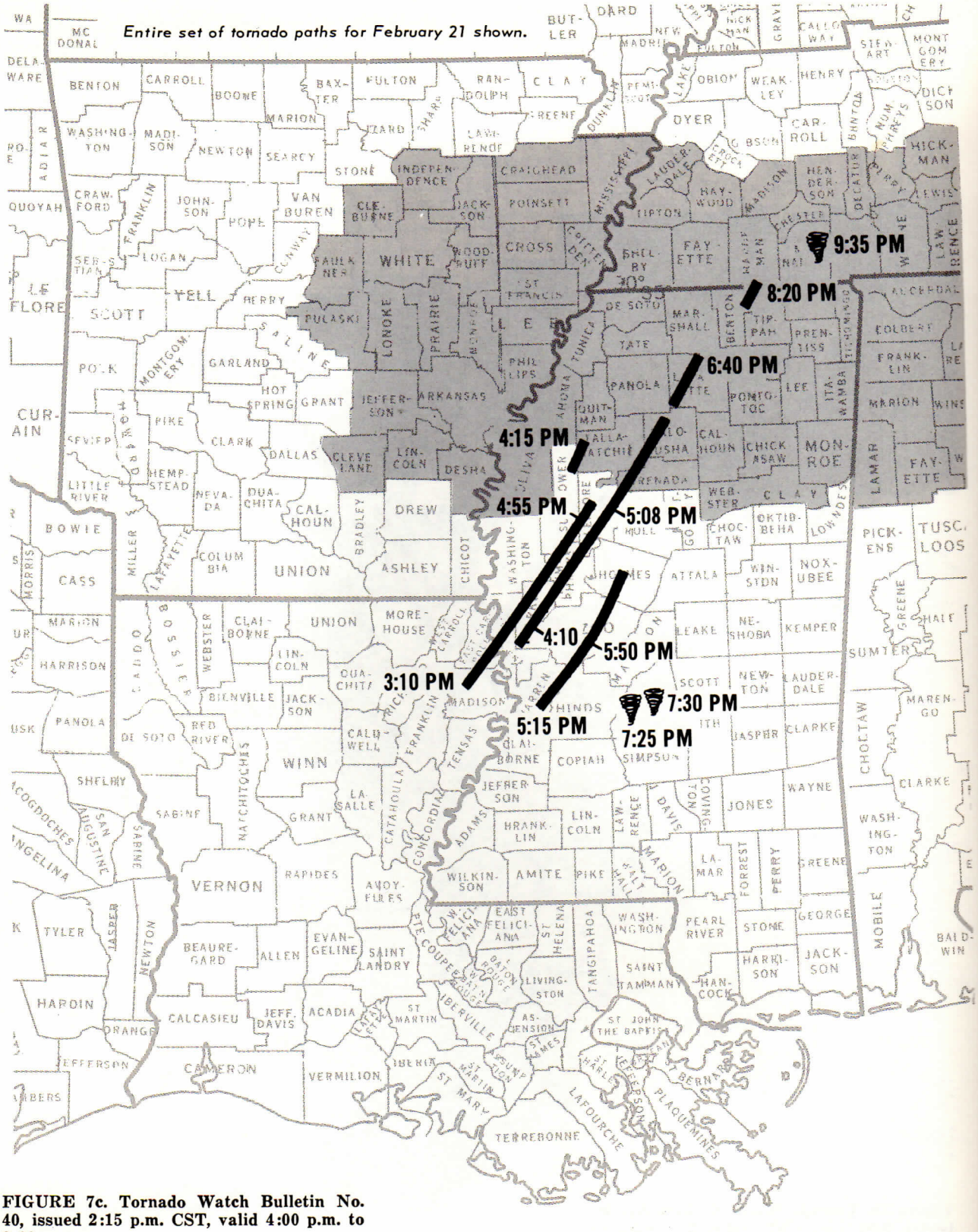


FIGURE 7c. Tornado Watch Bulletin No. 40, issued 2:15 p.m. CST, valid 4:00 p.m. to 8:00 p.m.

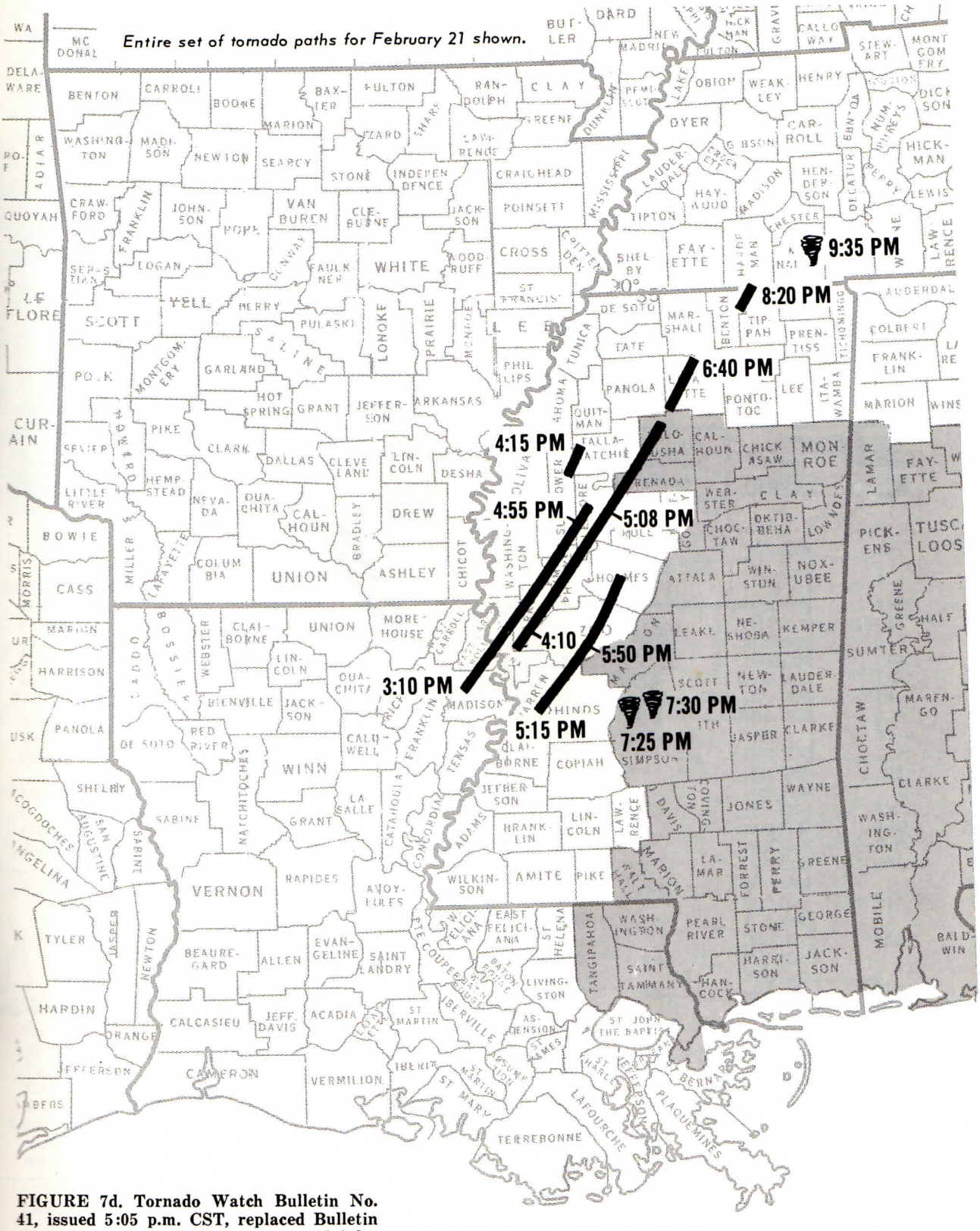


FIGURE 7d. Tornado Watch Bulletin No. 41, issued 5:05 p.m. CST, replaced Bulletin 39 at 6:00 p.m., valid 6:00 p.m. to midnight.

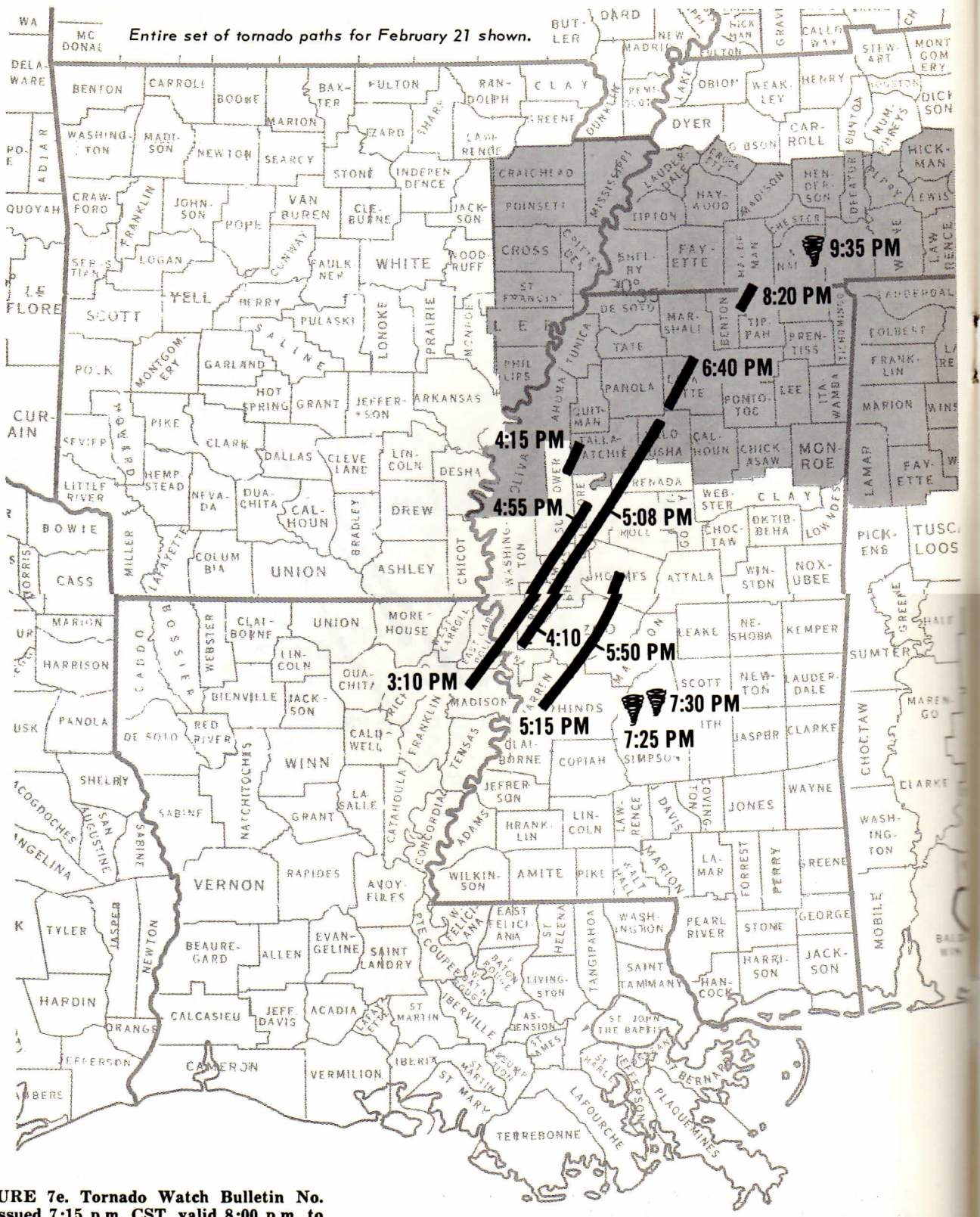
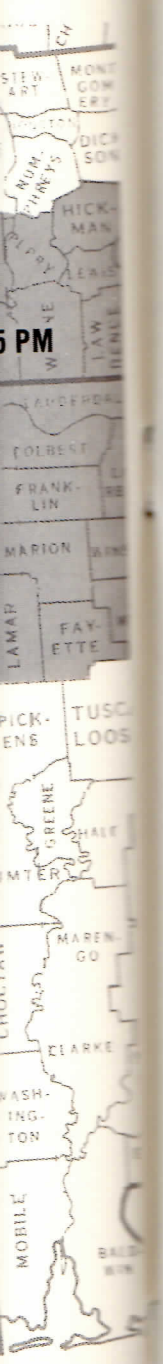


FIGURE 7e. Tornado Watch Bulletin No. 42, issued 7:15 p.m. CST, valid 8:00 p.m. to 2:00 a.m.



an indication of probable tornado activity on radar. Local National Weather Service Offices use the basic guidance from NMC, the Watch Bulletins from NSSFC, and realtime data from weather radar, surface reporting stations, and spotters. These offices constitute the focal point of the program, and office personnel must maintain continuous surveillance over assigned geographic areas of responsibility, often tens of thousands of square miles. Success or failure of the entire program depends on how well the small staffs at Weather Service Offices do their jobs of interpreting the guidance from NMC and NSSFC, monitoring conditions in their geographic area of warning responsibility, and issuing Warnings. A chronological listing of significant events, actions taken, and messages issued by National Weather Service Offices in the region of the Mississippi Delta tornadoes is given in appendix B.

The Shreveport WSO, because of persistent thunderstorms during the night of February 20-21, began issuing hourly severe weather statements early Sunday morning and called additional personnel to the station. The storm-warning area for which Shreveport is responsible is shown in figure 2. Upon receipt of Tornado Watch Bulletin number 37 at 9:55 a.m. CST,

Table 2.—Tornado Watch and Warning lead times for counties struck by Mississippi Delta tornadoes of February 21, 1971

County or Parish struck by tornado	Tornado occurrence		Tornado Watch		Tornado Warning	
	Time CST [1]	Track [2]	Effective period CST	Minimum lead time (hours)	Effective period CST	Lead time [3] (hr:min)
Louisiana						
East Carroll	1523-1543	1	1400-2000	1½	None	0
Madison	1508-1523	1	1400-2000	1	1520-1600	0
Mississippi						
Benton	2105		1000-2330	11	1930	1:35
Grenada	1733-1743	2	1000-2400	7½	1537-2000	1:56
Hinds	1712-1715	3	1400-1800	3¼	1723-2000	0
Holmes	1806-1816	3	1000-1800	8	1700-2000	1:06
Humphreys	1627-1632	1	1000-1800	6½	1520-1830	1:07
	1635-1655	2	1000-1800	6½	1520-1830	1:15
Issaquena	1543-1600	1	1400-1800	1¾	1520-1830	0:23
Lafayette	1823-1853	2	1000-2300	8½	1930	0
Leflore	1656-1710	1	1000-1800	7	1537-1830	1:19
	1655-1733	2	1000-1800	7	1537-1830	1:18
Marshall	After 1840		1000-2330	9	1435-1530	
					1655-1800	1:45
Pontotoc	2050		1000-2330	11	2005-2130	0:45
Sharkey	1600-1615	1	1400-1800	2	1520-1830	0:40
	1606-1635	2	1400-1800	2	1520-1830	0:46
Sunflower	1632-1653	1	1000-1800	6½	1155-1300	
					1615-1830	0:17
	1625-1650	2	1000-1800	6½	1155-1300	
					1615-1830	0:10
	1610-1615	4	1000-1800	6	1155-1300	
					1615-1830	0
Tallachatchie	1743-1753	2	1000-2330	7¾	1155-1300	
					1537-1830	2:06
Tippah	2105		1000-2330	11	1930-2130	1:35
Warren	1706-1728	3	1400-1800	3	1615-1730	0:51
Washington	1615-1627	1	1000-1800	6	1530-1830	0:45
Yalobusha	1758-1823	2	1000-2400	8	1537-1830	2:21
Yazoo	1728-1806	3	1400-2400	3½	1615-2000	1:13
Tennessee						
Hardeman	2020		1000-0200	10	None	0
McNairy	2135		1000-0200	11½	2155-2330	0

[1] From time tornado touched down or entered county to time of lifting off ground or leaving county.

[2] Tornado track number as indicated on figure 11.

[3] Time elapsed from beginning of tornado warning to time when tornado touched down or entered county.

Shreveport released it immediately to the public. It affected only a small portion of extreme northeastern Louisiana. The issuance of Tornado Watch Bulletin number 38, at 11:05 a.m. for portions of northwestern Louisiana imposed a second area over which Shreveport was required to maintain vigilance for possible tornadoes. This second area was upwind from, and at the western edge of, the Shreveport WSO area of responsibility, whereas the first Watch area was at the eastern extremity and downwind from the main area of Shreveport WSO responsibility. As a consequence, the Shreveport staff had to devote greater attention to the new tornado threat in the west. Nevertheless, as activity developed in northeastern Louisiana, the Shreveport WSO issued a Severe Thunderstorm Warning at 1:30 p.m. for six parishes, including specifically named Madison Parish where the first long tornado track began. About 3:05 p.m. an intense echo appeared on the radar scope at Shreveport. WSO used the NAWAS line to call the Louisiana State Police at Monroe and requested a check on the storm in the Delhi area. About 7 minutes later, the State Police called back on NAWAS to report that a tornado occurred at 3:10 p.m., 3 miles east of Delhi, and just then was north, or northwest, of Tallulah. At 3:20 p.m., a Tornado Warning was issued for downwind areas in Madison Parish.

It is noted that the Shreveport staff's ability to recognize the strong radar echo—associated with severe weather at a distance of about 130 miles (Shreveport to Delhi)—with an obsolete radar unit attests to the skill of the Shreveport personnel in applying local-use radar, as well as to their proficiency in maintaining an obsolete unit in a condition of peak performance.

The Jackson WSO began receiving indications of severe weather in its area of warning responsibility (fig. 2) early Sunday morning. At 12:30 a.m. CST, there were reports of a funnel cloud and strong gusty winds west of Jackson. Radar was already showing a few very strong echoes with tops above 50,000 feet and individual cells moving from the southwest at 45 knots. Before the day was over there were frequent and widespread radar indications of echo tops penetrating well above 40,000 feet and individual cell movements of up to 60 knots. At 1:00 a.m. a Severe Thunderstorm Warning was issued for 11 counties in west-central Mississippi. Much of this area was raked later by vicious tornadoes. After this warning, at least hourly severe weather statements and radar summaries were issued and the WSO received reports of strong winds and some hail from the area. At 4:00 a.m., thundershowers were indicated in the State forecast for Mississippi, and at 5:00 a.m. thundershowers were indicated in all Mississippi Zone Forecasts. At 9:55 a.m. Tornado Watch number 37 was issued for most of the northern half of Mississippi as shown in figure 7a. At 10:50 a.m., a severe thunderstorm warning was issued for Sunflower, Tallahatchie, Quitman, and Panola Counties based on a severe thunderstorm indicated by radar at 10:45 a.m. just west of Cleveland. The Mississippi Zone Forecasts issued at 11:00 a.m. headlined the Tornado Watch for those areas the Watch affected. At 11:55 a.m., a Tornado Warning was issued for northern Sunflower, Tallahatchie, and Quitman Counties. This tornado warning was based on a tornado reported 5 miles northeast of Cleveland and a hook echo observed on radar at about 12 miles south of Clarksdale. A chronology of events and releases by Weather Service Offices is given in appendix B.

The Jackson WSO called in an extra man to work from 6:00 a.m. to 2:00 p.m. to handle the anticipated heavy workload, and an extra radar man at 11:00 a.m. Several other persons were called Sunday afternoon to provide extra help for most shifts. The Meteorologist-in-Charge and Principal Assistant arrived at the office late Sunday afternoon.

The Memphis WSFO began increased activity with the receipt of Tornado Watch Bulletin number 37 at about 10:00 a.m. CST. In addition to transmitting the information over teletypewriter network (NWWS) and over telephones (commercial and NAWAS), the Memphis WSFO radioed the information to the American Red Cross. Frequent releases were made throughout the afternoon and evening, disseminating watches, warnings, severe weather bulletins, statements, and radar summaries. Reports of storms were received within 10 to 15 minutes of occurrence

Homes destroyed at Pugh City, Miss. (NASA Earth Resources Laboratory) ▶

via Tennessee Highway Patrol in accordance with the West Tennessee Severe Weather Plan. Extra personnel were called on duty as early as 8:30 a.m. to help with the increased workload and to assure the issuance of effective warnings.

In summary, between 11:55 a.m. and 9:30 p.m., 16 tornado warnings—one by Shreveport WSO, eleven by Jackson WSO, and four by the Memphis Weather Service Forecast Office (WSFO)—were issued. Lead times of Tornado Warnings for the counties struck by tornadoes are given in table 2. Many counties received three and a few as many as four Tornado Warnings. The later Warnings usually extended the valid times.

Determining Storm Tracks

The accounts in preceding sections of this report indicate many reports of severe storm activity were received from the established surface and radar reporting systems and from SKYWARN observers. One could easily assume that the responsible NWS offices were kept currently informed on the number of tornadoes, their location, and how they were moving. Valuable as these reports were to the NWS offices, considerable difficulty was experienced by forecasters in analyzing with confidence just what was happening from place to place and from time to time.

Figure 8 shows a plot of all severe storm reports received at Jackson WSO during the day of February 21, 1971. Figure 9 shows the weather echoes as observed by radar at the Jackson WSO at 4:20 p.m. and at 5:32 p.m. Figure 10 shows a plot of radar weather hook echoes reported by the Jackson Radar Weather Unit on February 21. Together, these figures illustrate the problem facing NWS offices in presenting a coherent picture of what is happening at any time and in extrapolating future events. It was virtually impossible for NWS personnel to fit together in

Inverness, Miss.

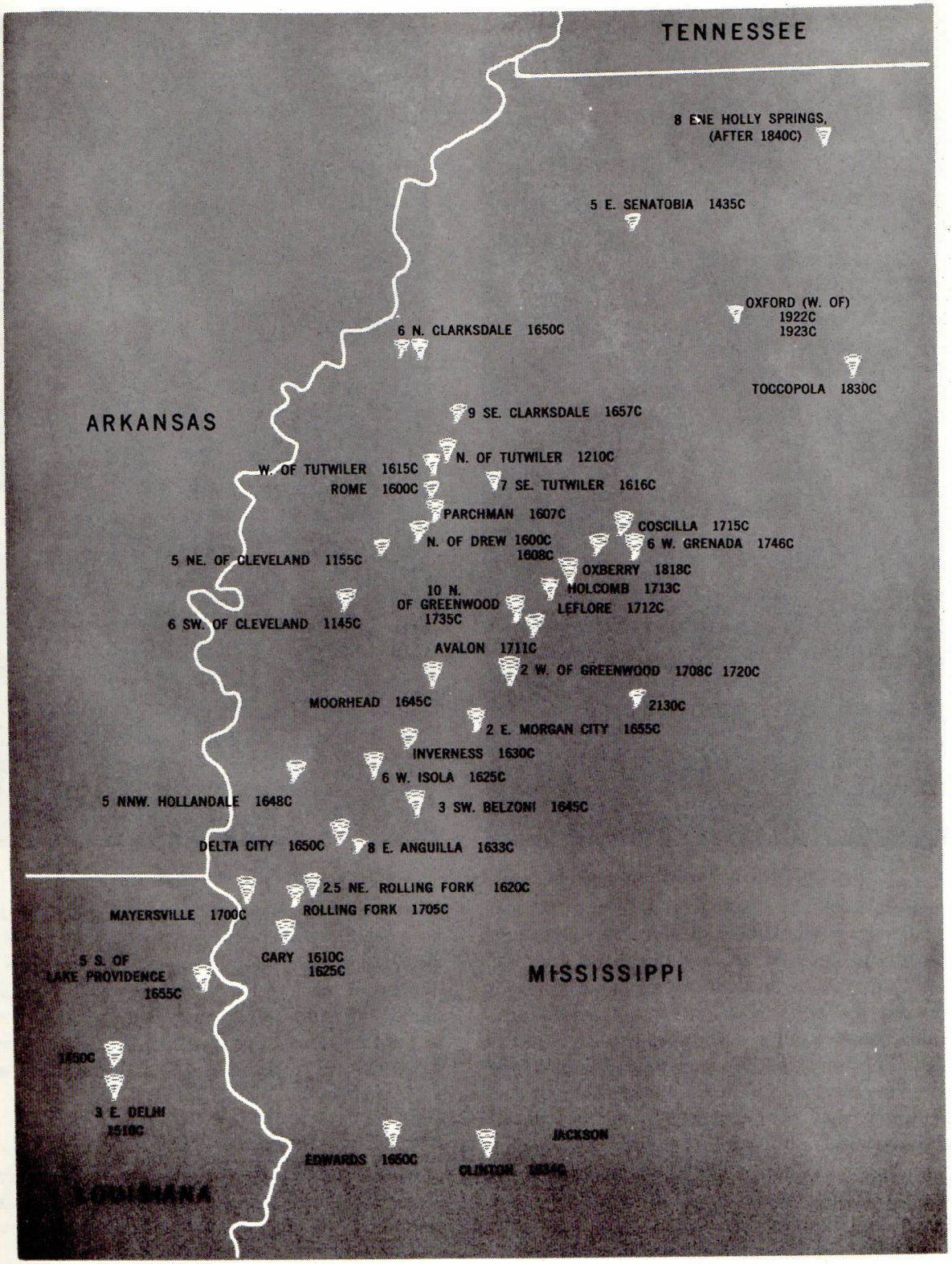


FIGURE 8. Tornado reports received at Jackson WSO on February 21, 1971. (Central Standard Time)

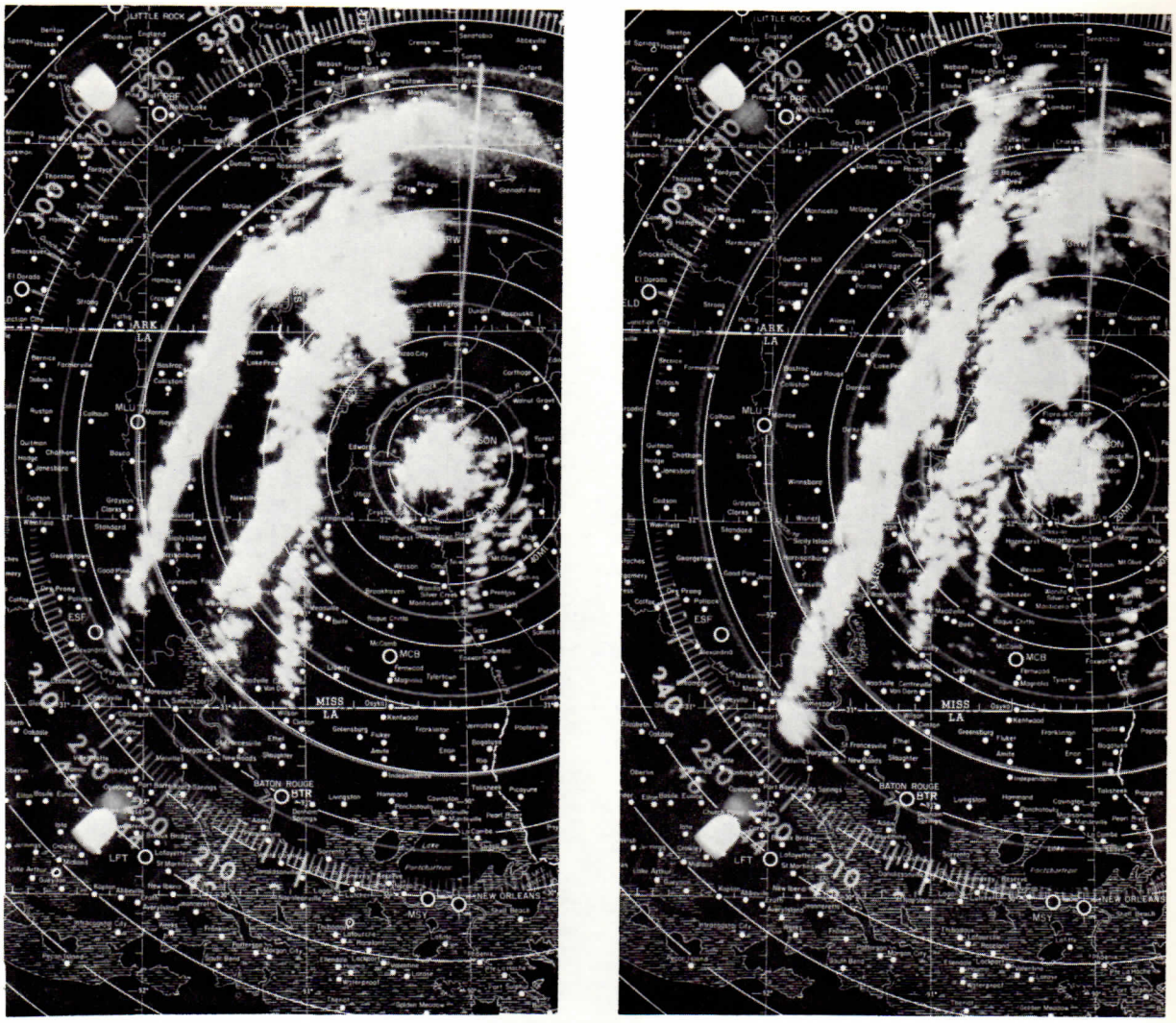


FIGURE 9. Radar scope pictures at Jackson WSO. (a) 4:20 p.m.; (b) 5:32 p.m.

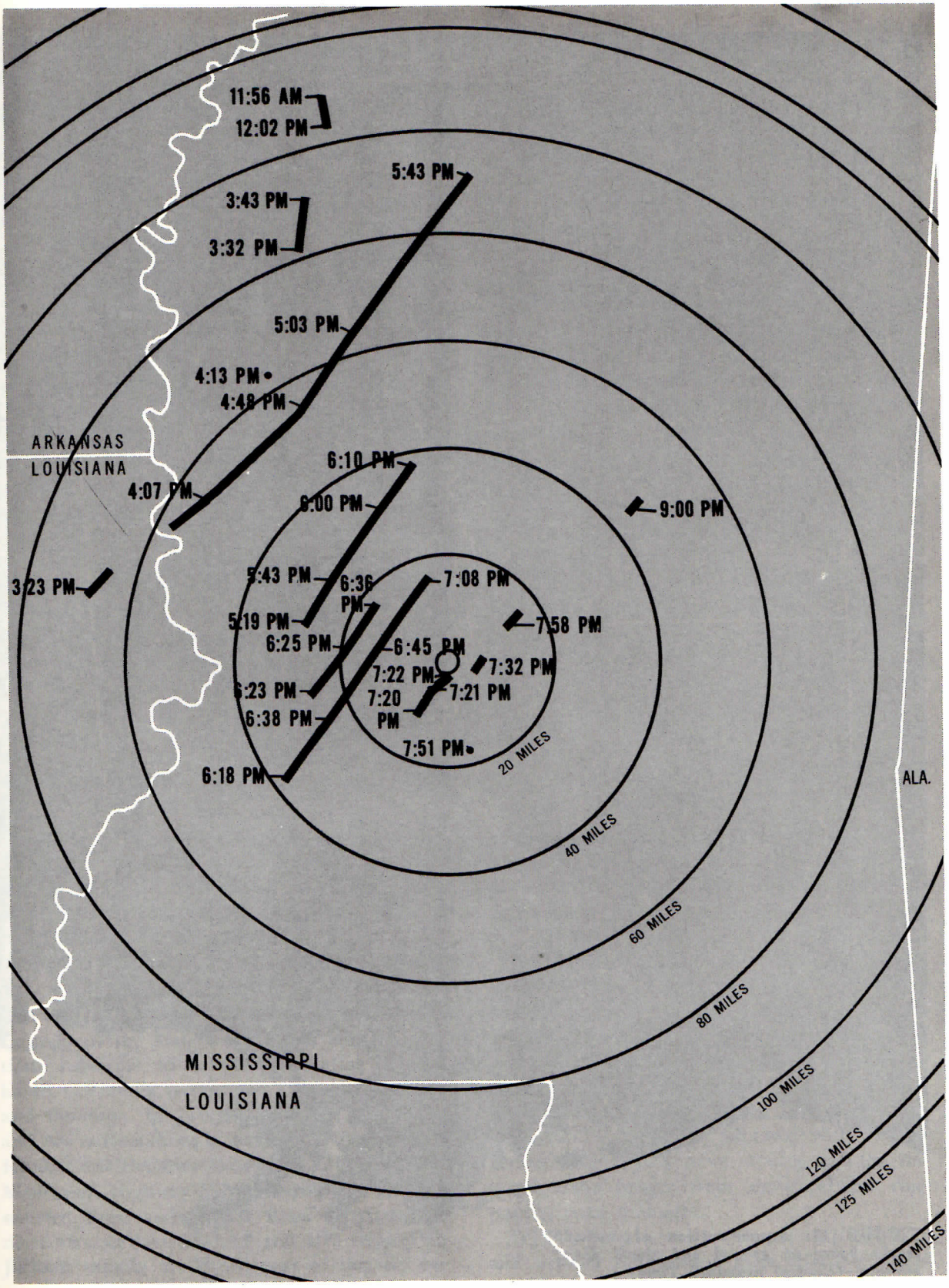
logical order the sequences of events as they were taking place. Part of the difficulty results from the method of collecting information, which must pass through several hands before it reaches the NWS office. Times of communications become confused with times of occurrences and times of occurrences are best estimates and not very precise. Often the same occurrence is reported from two different sources that specify different times. This reporting difficulty, together with rapid movement of the storm, creates the impression that more storms are occurring than is actually the case.

Even during the post-tornado investigation, the survey team encountered considerable difficulty in fitting the individual reports into a coherent picture. Consequently, the survey team decided to make an aerial survey of the damage paths in order to resolve many apparent discrepancies in reports of tornado locations and times. The four major tornado tracks confirmed by the aerial survey are shown in figure 11. Both aerial and ground surveys of the storm tracks are discussed in appendix C.

Disseminating Watches and Warnings

Radio and TV listening habits of the general public are usually much less routine on Sunday, and broadcast stations and wire services operate

FIGURE 10. Radar hook echoes reported by Jackson weather radar unit on February 21, 1971. (Central Standard Time)


11:56 AM
12:02 PM
5:43 PM
3:43 PM
3:32 PM
5:03 PM
4:13 PM
4:48 PM
ARKANSAS
LOUISIANA
4:07 PM
6:10 PM
6:00 PM
9:00 PM
3:23 PM
5:43 PM
6:36 PM
7:08 PM
5:19 PM
7:58 PM
6:25 PM
6:45 PM
7:22 PM
7:32 PM
6:23 PM
7:21 PM
7:20 PM
6:38 PM
7:51 PM
6:18 PM
20 MILES
40 MILES
60 MILES
80 MILES
100 MILES
120 MILES
125 MILES
140 MILES
ALA.
MISSISSIPPI
LOUISIANA

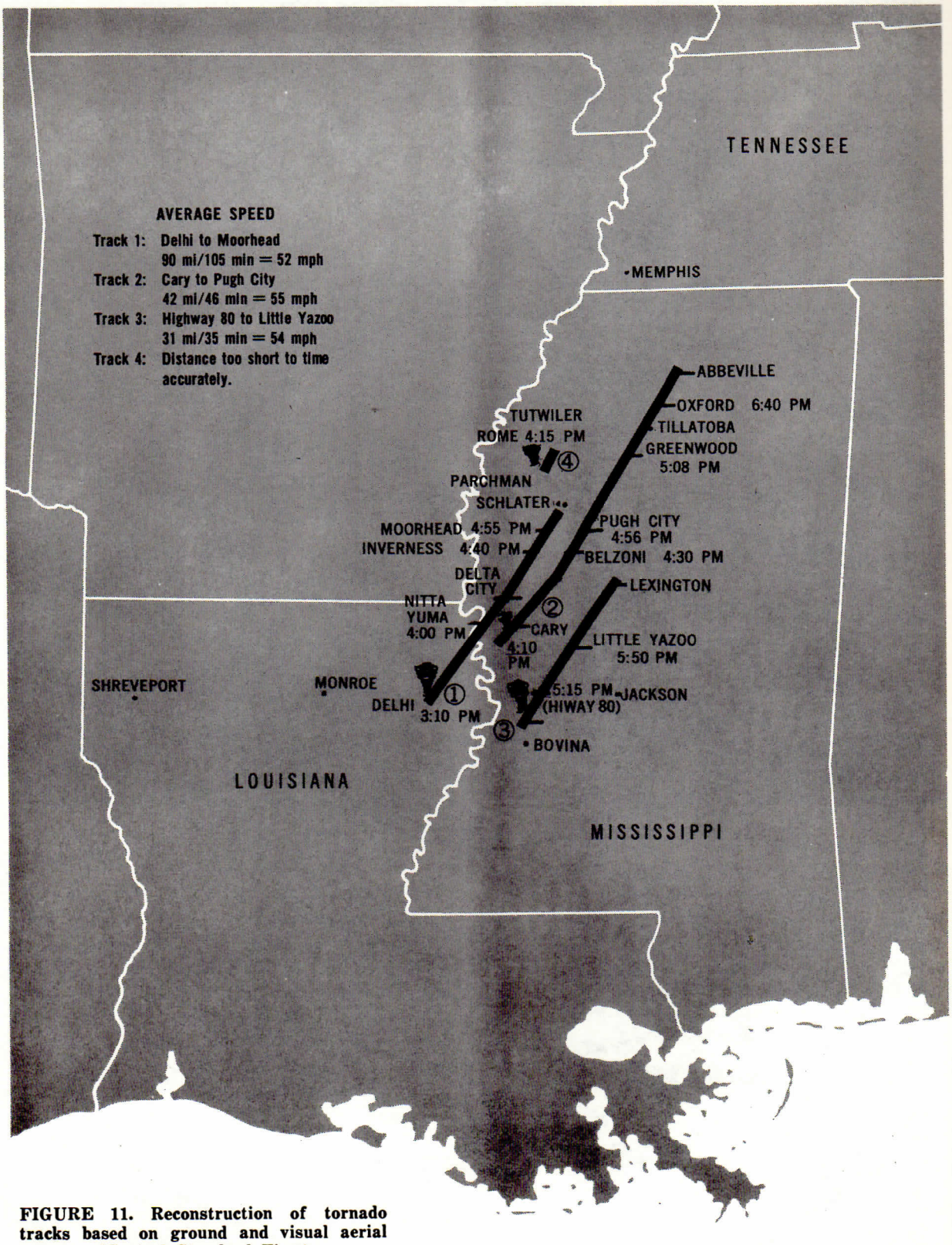


FIGURE 11. Reconstruction of tornado tracks based on ground and visual aerial surveys. (Central Standard Time)

with only skeleton crews. Even with these handicaps the dissemination of the Tornado Watch and Warning messages achieved almost total saturation of the Mississippi Delta communities that were subjected to the tornado outbreaks of February 21, 1971.

The NOAA Weather Wire Service (NWWS) is a land-line teletypewriter system configured on an intrastate basis. The NWWS network in Mississippi is shown in figure 6. NWWS is the "output" arm of the communications systems. All copy is in plain language suitable for direct broadcast to the public. The National Weather Service pays the cost of the long-line connection to any city where a daily newspaper, commercial radio station, or commercial television station desires to connect. The subscriber is responsible for leasing directly from the local telephone company the necessary teletypewriter machine and for supplying paper. There is no charge by the National Weather Service and no contractual agreement. All NOAA Weather Wire Service circuits operate at 75 words per minute and use conventional, commercial types of equipment. A special "overlay" circuit interconnects adjacent States to facilitate rapid dissemination of weather information to the public.

The National Warning System (NAWAS) communications system of the Civil Defense also serves a fundamental function in the dissemination of Watches and Warnings as well as the exchange of vital information. Each State Civil Defense has its own NAWAS circuit contained within the State. The NAWAS networks for Louisiana, Mississippi and western Tennessee are shown in figure 12.

In northeast Louisiana, at Monroe, radio station KNOE (AM and FM) and TV station KNOE (Channel 8) subscribe to the Louisiana NWWS. In Mississippi there are 15 locations throughout the State where radio and TV stations subscribe to NWWS, including Brookhaven, Greenville, Greenwood, Clarksdale, Marks, and Pontotoc. In Jackson there are three TV and two radio stations in addition to the Jackson-Hinds Civil Defense, Mississippi Civil Defense, Mississippi Highway Safety Patrol, and the Associated Press and United Press International news wire services. The AP and UPI services at Jackson usually are closed part of the day on Sunday, on holidays, and at night. The Jackson WSO has a standing arrangement to notify AP in New Orleans, and UPI in Atlanta, when AP and UPI offices are closed in Jackson to make sure they know about Watches and Warnings for Mississippi and to alert them for possible opening of their Jackson offices. The Jackson WSO also calls the Jackson AP and UPI offices when they are open to make sure they have received any Watches and Warnings on the Mississippi NWWS.

The Associated Press office in Jackson had no one on duty until 2:30 p.m. CST on February 21, but news origination was handled through the New Orleans headquarters until the office in Jackson was staffed. Copies of AP releases were not available in Jackson, but interviews with radio station personnel indicated that the coverage was timely and thorough, and the AP line was split whenever weather bulletins were received from the Jackson or New Orleans Weather Service Offices.

The United Press International office in Jackson was open Sunday morning and reports from the Jackson WSO and NWWS were taped, beginning with a Tornado Watch at 10:33 a.m., and repeated at 10:43 a.m. Subsequent information on the storms was re-taped from NWWS and cleared on the UPI wire throughout the day, with bulletins on the ¼-hour split.

Radio and television coverage of the emergency weather situation in Jackson was exemplary, despite some Sunday staffing problems. Station WJDX (the Emergency Broadcast System monitoring station for the area) gave constant coverage on both AM and FM from 10:00 a.m. CST until 1:30 a.m. Monday, February 22. WJDX-FM coverage reaches all but extreme northern counties in the State. Safety rules were broadcast, and amplified to meet local conditions in the Delta area. Commercial programming was cancelled almost entirely during the day. The station reported that its AM signal was subject to heavy static from lightning interference.

WLBT-TV, which is affiliated with WJDX Radio, used WJDX news reports, and the station's radar images were shown almost constantly, until midnight.

WJTV, Jackson, was on the air with bulletins and weather information from 2:00 p.m. until

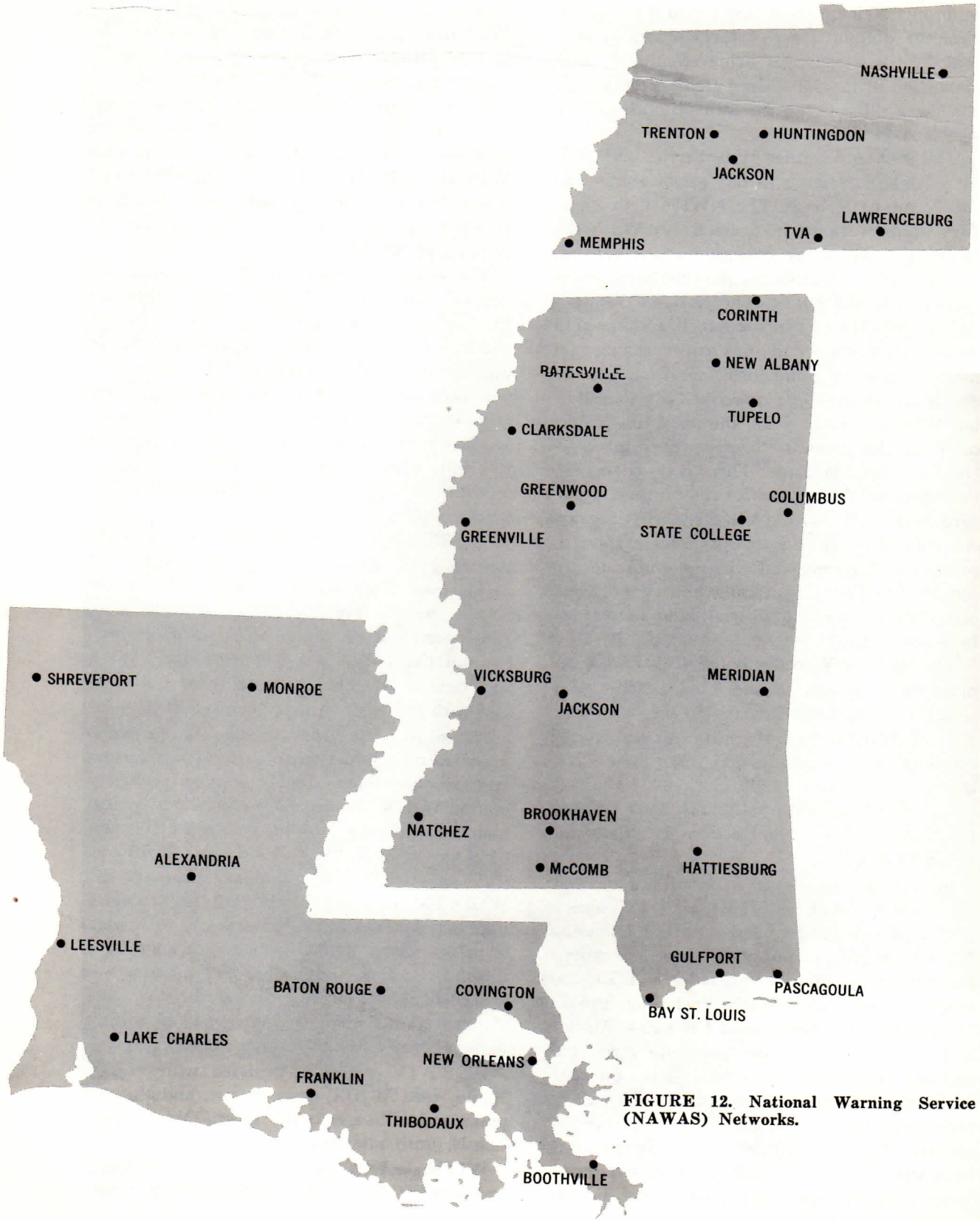


FIGURE 12. National Warning Service (NAWAS) Networks.

10:30 p.m., and the sister station, WSLI-Radio, gave similar coverage with bulletins at least every quarter hour during the same period. WJTV subscribes to NWWS and shares the wire service with WSLI. Other Jaskson radio stations that subscribe to NWWS are WJQS and WRBC.

The Jackson WSO used NAWAS to contact police and highway facilities throughout the State.

Radio stations and TV outlets are sparsely scattered throughout the small communities of the Mississippi Delta area. In Yazoo City, approximately 45 miles north of Jackson, Station WAZF does not subscribe to NWWS, but relied on AP wire reports to give warnings.

The Jackson WSO used the standard severe weather forms and made three copies of all Warnings and other bulletins. These were transmitted about the same time on the Mississippi NWWS, on NAWAS, and over the Emergency Broadcast System (EBS) of Radio Station WJDX in Jackson. Warnings and severe storm reports also were transmitted on RAWARC together with some severe weather statements. There is a microphone in the Jackson WSO to Radio Station WJDX on which all Warnings were broadcast. The announcer, when keyed by the Jackson WSO, taped the message and broadcast them over FM, which other stations monitor. On February 21 all Warnings and most indications of radar hook echoes were broadcast to WJDX. Jackson personnel made approximately 65 direct radio broadcasts for dissemination by radio stations on EBS that day. Radio Station WJDX is on the NWWS circuit and receives hard copy of all weather information for Mississippi.

The Mississippi Highway Safety Patrol broadcast Watches, Warnings, and other bulletins to their 10 field offices in Mississippi.

The timely functioning of the dissemination system on February 21 is indicated by the following sequence of events. At 5:05 p.m. CST, Jackson WSO observed a hook echo on radar and issued a Severe Weather Statement and radar report that a tornado was indicated by radar 20 miles southwest of Greenwood, Miss., and was moving northeast at 40 to 45 mph. The sirens were sounded at Greenwood at 5:15 p.m. Between about 5:08 p.m. and 5:25 p.m., the tornado passed about 2 miles west of Greenwood, causing considerable damage.

In Jackson the sirens were sounded at 6:25 p.m. on instructions from the mayor, who was at the Hinds-Jackson Civil Defense Office. In Hinds County, which contains the City of Jackson, there was a Tornado Warning from 5:23 p.m. to 8:00 p.m., an extension of the first Warning being issued at 6:25 p.m. The sirens, which consisted of a steady blast for 3 to 5 minutes, were sounded when 2 or 3 funnels were sighted, one over the Robinson Street Baptist Church by personnel of the sheriff's office. The Civil Defense had been in personal contact with the Jackson WSO and sounded the sirens on their own initiative. Seventeen fire station spotters also report to the Hinds County-Jackson Civil Defense Office. The February 21 sounding of the siren for tornadoes was the second in Jackson in 1971 and the third sounding since the system was inaugurated.

At 7:29 p.m. the Jackson WSO, located in the airport terminal building at Thompson Field, notified the people at the airport of imminent tornado danger and recommended they go into the basement. Nearly everyone but the WSO personnel took shelter for about 10 minutes. This action was based on hook echoes observed on the Jackson WSR-57 radar, one about 11 miles south and another about 4 miles south-southwest of the airport, moving northward. It is believed that minor damage to buildings and timber in areas near these hook echoes was caused by brief touchdowns of two tornadoes. Rankin County, in which Thompson Field is located, was under a tornado warning from 6:25 p.m. until 8:00 p.m.

NOAA weather service wire, NAWAS, telephones, and all other communication equipment stayed in operation at the Jackson WSO with the exception of the NWWS Overlay Circuit, which was out for a few minutes sometime between 6:30 p.m. and 8:05 p.m. This failure did not affect the operation of the Severe Weather Program at Jackson.

Findings and Conclusions

Findings with respect to analysis and prediction of severe weather and dissemination of statements, Watches, and Warnings lead the survey team to the following conclusions.

1. The National Meteorological Center (at Suitland, Md.) products satisfactorily depicted the significant large-scale features of the circulation and accurately forecast movement of a squall line, accompanied by showers and thunderstorms, through Louisiana into Mississippi and Tennessee on February 21, 1971.
2. NSSFC issued Tornado Watch Bulletins well in advance of all tornado occurrences in Louisiana, Mississippi, and Tennessee. The Watch lead times were exceptionally good, ranging from 1 to 11 hours and averaging 6 hours for areas where all the fatalities and most injuries occurred.
3. The operation of the National Weather Service was most effective in warning the public and keeping them informed of impending tornadoes, because the responsible National Weather Service Offices had the tools (radar, excellent communications, and action plans) and the professional competence to act promptly and responsibly upon recognizing a developing hazardous situation. The staffs exercised skill and judgment in their warnings and statements throughout the day and evening of February 21. This was particularly true of the Jackson WSO, which bore the brunt of the task of issuing warnings and in every respect discharged its responsibilities in an outstanding manner. The average lead time of the specific Warnings for areas where the most deaths, injuries, and damage occured was about 50 minutes.

Ground view of Inverness, Miss.

Aerial view of destruction at Inverness, Miss. (NASA Earth Resources Laboratory) ▶

4. The NOAA Weather Wire Service for Mississippi effectively disseminated weather warnings and other weather information of immediate importance to the public. Participation of broadcasting media through direct connection to the NOAA Weather Wire Service is below that considered desirable. This is attributed, in part, to the relatively high cost of teletypewriter rentals. Participation included seven out of eight commercial VHF TV stations, but only 26 percent of the full-time AM radio stations and 9 percent of the daytime AM radio stations. Both Associated Press and United Press International are connected to the NOAA Weather Wire at Jackson. Practically all commercial radio and TV broadcast facilities in Mississippi are connected to at least one of the news wire services over which National Weather Service Watches and Warnings are transmitted.

5. The overall task of receiving, diagnosing, and synthesizing the voluminous amount of incoming information—radar weather reports; information received via National Warning System (NAWAS) on sightings, damage, and power and communications outages; radar report and warning coordination circuit (RAWARC) information; and miscellaneous reports—and concurrently updating and disseminated Watch and Warning bulletins on proper circuits is next to impossible to achieve effectively at the fast pace required, particularly when multiple storm outbreaks occur. Technologically, much of this work could be automated through the use of message compositors and automatic call-up and transmission of messages on NOAA circuits.

6. During the field investigation of the Mississippi Delta Tornadoes it was virtually impossible to determine accurately, from reports of tornado sightings, the actual number of tornadoes and the tracks they followed. This aspect of the field investigation was greatly facilitated by an aerial survey in advance of the ground surveys, particularly determining the major tornadoes, their paths, and times. This information was then used as a basis for evaluating the timeliness and effectiveness of the tornado watches and warnings.

Recommendations

1. NOAA's National Weather Service should continue to encourage additional news media to participate in the NOAA Weather Wire Service.
2. Aids and techniques should be developed to automate the composition and dissemination of Watch and Warning bulletins to the greatest possible extent.
3. The field investigation of all major tornado disasters should include an early aerial reconnaissance survey to determine storm paths more accurately.

CHAPTER 5
User Response and Service Benefits

The U.S. Weather Bureau (now the National Weather Service) began the tornado warning service in 1952. Since then much emphasis has been placed upon the preparation and distribution of educational material to increase public awareness about the warning service, tornado safety rules, and individual and community preparedness. Special efforts have been made to inform both urban and rural populations in tornado-prone regions.

User Response

Survey team members interviewed numerous people in the disaster area to learn if they were aware of the Tornado Watches and Warnings, understood the implications of the bulletins, and were informed as to safety precautions. Most people were aware of the bulletins, which, for the most part, they heard by radio. With few exceptions, the interviewed individuals knew the different implications of Watches and Warnings—that in a Watch situation they were to maintain normal activities, but watch for threatening weather and listen to radio and television for further severe weather announcements. They also knew that when a Warning is received, persons close to the storm should take cover immediately, and persons farther away from the storm should be prepared to take cover if threatening conditions are sighted.

The actions taken by persons during the tornado outbreaks indicate that, although they were familiar with safety precautions, there was little they could do to find adequate nearby shelter. Houses did not have basements. Ditches were sometimes a long distance from houses, and some ditches were filled with water. For many, the best options were to seek shelter in open ditches, culverts, and under road overpasses. Others did not have these options. Mayor Roy Gerrard of Carey, Miss., tried to evacuate people to a school house several miles away, but could not persuade any of them to leave their homes—17 were lost. Many stayed at home and did not seek cover until the tornado was actually sighted by a member of the household. Many took shelter inside houses that offered little protection when the tornado struck.

The safety actions that were taken by residents of the disaster area saved many lives, but it is clear that people must be better informed about the implications of Tornado Watch and Warning Bulletins and public officials and action groups must intensify their efforts to assure that tornado safety precautions include adequate provision of shelters in all areas. In the Mississippi Delta area, suitably designed above-ground shelters are needed in all communities, and in rural areas, if tornado safety precaution measures are to be effective.

Evaluation of Service Benefits

The effectiveness of the tornado warning service can be measured, in part by comparing the number of tornadoes and tornado deaths in the years before 1953 (before the formal tornado and severe local storm warning service) and in the years since 1953. The comparison for the States Louisiana and Mississippi (fig. 13) shows a marked increase in the annual number of tornadoes and a significant decrease in the number of tornado deaths after 1952. The marked increase in tornadoes was not the result of any marked climatological change, but can be attributed to increased public participation in reporting tornadoes—increased participation largely brought about by the Weather Service's education program. The same response seems to correlate with the reduction in number of tornado deaths.

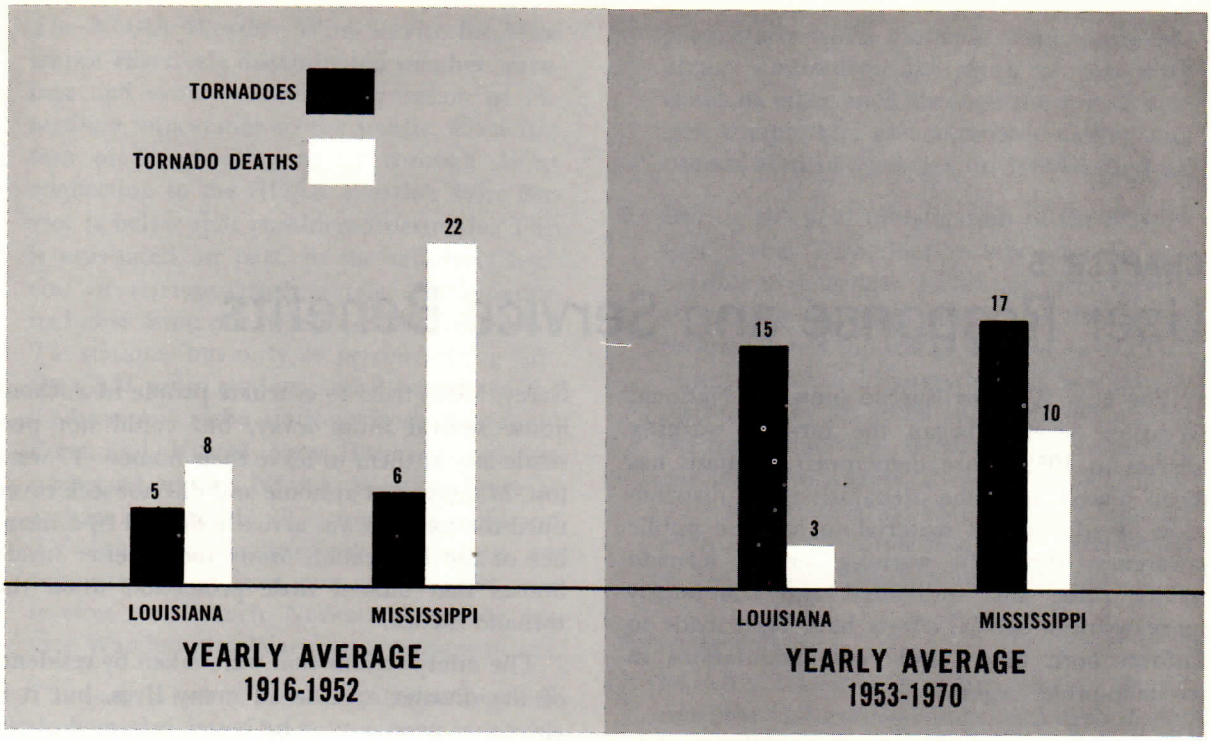


FIGURE 13. Comparison of number of tornadoes and tornado deaths (yearly average) before and after establishment of tornado warning service in Louisiana and Mississippi.

The effectiveness of NOAA's tornado warning service during the Mississippi Delta Tornadoes of February 21, 1971, can be inferred by making a comparison with a similar but "unwarned" tornado event. The Tri-State Tornado (Missouri, Illinois, and Indiana) of March 18, 1925, was used in making this comparison. The 1925 tornado killed 689 persons, injured 1,980 others, and traveled at a speed of 60 mph along an almost continuous path 219 miles long and varying from one-half to 1 mile wide. Using an average width of three-fourths of a mile, it is estimated that the total devastated area was 164 square miles.

The four major Mississippi Delta Tornadoes of February 21, 1971, killed 113 persons, injured 2,003 others, traveled at a speed between 50 and 55 mph along a combined path 340 miles long that varied in width from one-fourth to more than one-half mile. Using an average width of three-eighth of a mile, it is estimated that the total devastated area was 128 square miles.

If one assumes comparable population densities in the geographic areas of the 1925 Tri-State Tornado and the 1971 Mississippi Delta Tornadoes, the following statistical comparison can be made:

	Tri-State Tornado 1925	Mississippi Delta Tornadoes 1971
Devastated area	164 sq. mi.	128 sq. mi.
Fatalities	689	113
Fatalities per square mile of devastated area	4+ (4.2)	1− (.88)
Warning	no	yes

An initial estimate, from these statistics, suggests that as many as 510 fatalities would have occurred during the Mississippi Delta Tornadoes if there had been no tornado warning service. However, the mean population density of the 11 counties affected by the 1925 Tri-State Tornado was 41 persons per square mile, whereas the mean population density of the 20 counties affected by the 1971 Mississippi Delta Tornadoes was 37 persons per square mile. Applying this ratio, 37/41, of population densities per square mile to the initial estimate of 510 possible fatalities, gives an adjusted estimate of 460 potential fatalities had there been no warning service.

Since the actual number of lives lost was 113, it is estimated that approximately 350 lives were saved as a result of effective warnings and community preparedness.

Findings and Conclusions

Findings with respect to user response and service benefits lead the survey team to the following conclusions:

1. Many cities and towns in tornado-prone sections of the country use fire sirens to attract the public's attention to possible tornadoes. During this outbreak of tornadoes, sirens were used at Jackson and Greenwood, Miss., but apparently not at other locations. A common complaint is that in the larger cities people are accustomed to hearing sirens at all times of the day and night. In large cities, and often in smaller cities, unless persons are in some way conditioned to anticipate a siren-type warning of severe weather, they are more inclined to relate the warning signals to fires or accidents. One possibility would be to develop a siren which would be accessory to existing sirens and which would provide a distinctive beat note. Such a locally-controlled audible warning signal operated by a responsible official from a vantage point of constant watch would serve to tell the local populace emphatically that the time for waiting is over and that they must take cover immediately in order to save themselves!
2. The success of the overall warning system in saving lives was greatly diminished by the circumstances of generally old and inadequately constructed houses and other buildings, and the lack of community shelters.

Recommendations

1. Public safety authorities should be encouraged to develop distinctive, audible, warning signals to warn of approaching tornadoes, and particularly to warn of immediate need to take cover.
2. Public authorities should be encouraged to establish a system of suitably designed community shelters, particularly in areas where the construction of basements is impractical.

Felled pecan trees north of Belzoni, Miss.
(NASA Earth Resources Laboratory)

APPENDIX A

Preparedness Actions — Jackson WSO

The Jackson WSO provided leadership or otherwise played a significant role in the following actions over the past two years in the Jackson area of warning responsibility to heighten community advance preparedness for severe weather events.

Tornado Preparedness Actions 1969

January 2—Severe weather literature describing tornado preparedness was distributed to local radio and TV stations through Jackson-Hinds Civil Defense.

March 2—Lauderdale County conducted tornado preparedness operation test.

April—Director of Lee County Civil Defense notified Jackson WSO that schools, factories, and hospitals were briefed on emergency preparedness rules for severe weather and tornado events.

June 11—Tornado preparedness planning program given at Mississippi Civil Defense Directors Meeting at Biloxi, Miss. Meteorologists-in-Charge at Mobile, Meridan, and Jackson were on the program.

July—Mississippi Highway Safety Patrol held classes at the Law Enforcement Academy for all members of the Patrol, Game and Fish Commission personnel, and various officers from local sheriff's offices and city police departments. Classes included instruction as Tornado Spotters. 500 Spotters Handbooks and Reporting Procedures were distributed.

Tornado Preparedness Planning Conferences 1969

November 14—
Bureau of Public Roads, Jackson Office

November 19—
Police Training Academy, Jackson

November 25—
At Philadelphia, Miss.

December 4—
At Greenwood, Miss.

Civil Defense Conferences and Training Exercises During 1970

	Date	Place	Number in attendance
1.	January 27	Tupelo	80
2.	March 10	Ashland	26
3.	April 3	Jackson State Civil Defense	15
4.	April 28	Tupelo	90
5.	June 17-19	Jackson City Police Department	60
6.	July 15	Gulfport	150
7.	July 26	Oxford	45
8.	August 11	Natchez	100
* 9.	October 22	Jackson, Mayor's Office	30
*10.	November 9	Jackson Emergency Operations Center	30
*11.	November 10	Jackson Emergency Operations Center	42
*12.	November 18	Jackson Emergency Operations Center	50
*13.	November 19	Jackson Emergency Operations Center	60
14.	December 8	Meadville	35
15.	December 10	Corinth	46

* BIG HUMMER—Tornado Preparedness Exercise.

Natural Disaster Preparedness Contacts 1970

January 30: Columbia—met with Chairman of Emergency Disaster Commission.

February 2: Laurel—talked to 60 people on severe local storm and flood preparedness.

February 11: Hattiesburg—met with Forest County Civil Defense Director.

April 16: Met in Jackson with two Civil Defense instructors from University of Mississippi.

April 21: Corinth and Ripley—contacted city officials and personnel from Highway Patrol and Civil Defense.

April 22: Talked to 60 members of the Mississippi Valley Gas Company Field Office on tornado and severe storm warning system.

April 30: Met with United Press International about preparing information.

May 1: Gloster—met with 21 members of Homochitto Ranger Office for tornado spotters training.

June 11-14: Biloxi—met with Mississippi Broadcasters Association.

June 22: Met with station WJDX and Director for Jackson-Hinds Civil Defense to improve local warning and spotter network.

June 29: Met with 20 members of Jackson Power Squadron to discuss dissemination of Lake Warnings.

July 7: Met with Emergency Broadcast Service station and Laurel Civil Defense personnel to improve Warnings for Laurel area.

July 10: Contacted Jackson-Hinds Civil Defense regarding Warnings for local areas.

July 14: Laurel—talked to business leaders of Laurel about dissemination of severe weather information.

July 17: Jackson—Talked to Optimist Club on improved severe weather Warnings.

July 29: Oxford—Instructed at training session on local preparedness. Tornado information provided to University of Mississippi.

August 31: Instructed at American Telephone and Telegraph Company personnel training session for tornado spotters.

September 10: Met with radio and television technicians concerning reporting network.

October 14: Met with Jackson-Hinds and National Civil Defense representatives to prepare for Model Training Exercise.

Communications and Warning Plans Prepared and Distributed, 1969-1970.

1. Tornado Warning Plans for Lauderdale County Tornado Preparedness Committee—distributed June 11, 1969 at Biloxi Meeting
2. Key Warning point lists by Mississippi Civil Defense Council for nine State Districts (June 1970)
3. Vicksburg - Warren County Civil Defense Council Tornado Preparedness Planning Annex
4. Benton County Warning Annex C
5. Bolivar County Communications and Warning Annex
6. DeSoto County Warning Annex
7. Forest County Warning Annex
8. Franklin County Civil Defense Annex B and C
9. George County Operation Plan
10. Biloxi Annex C
11. Holmes County Communications and Warning Annex
12. Jackson County Warning Annex
13. Pascagoula Warning Annex
14. Carthage City Warning Annex
15. Tupelo and Lee County Warning Annex
16. Leflore County Warning Diagram
17. Columbus and Lowndes County Warning Annex
18. Canton – Madison County Warning Annex
19. City of Philadelphia Warning Annex
20. Perry County Civil Defense Warning Plan
21. Pontotoc County Warning Plan
22. Booneville – Prentiss County Warning Annex
23. Morton Communications and Warning Plan
24. Sunflower County Annex
25. City of Charleston Communications Warning
26. Tishomingo Warning Plan
27. Vicksburg and Warren County Communications and Warning Annex
28. Washington County Warning Annex
29. Wayne County Warning

APPENDIX B

Chronology of Warnings, Statements, and Actions Taken*

February 21, 1971

1. 7:50 a.m. CST**—Severe Local Storm (SELS) Unit of the National Severe Storms Forecast Center (NSSFC) issued Public Tornado Watch Bulletin Number 36 valid until noon for northeast Texas, portions of northern Louisiana, and portions of southern Arkansas. National Weather Service Office (WSO) at Shreveport, La., immediately disseminated the Watch with areal outline.
2. 9:45 a.m.—National Weather Service (WSO) at Jackson, Miss., and National Weather Service Forecast Office (WSFO) at Memphis, Tenn., issued statements of radar weather on NOAA Weather Wire Service (NWWS).
3. 9:55 a.m.—NSSFC issued Public Tornado Watch Bulletin Number 37 for southeast Arkansas, northern Mississippi, a small portion of extreme northeastern Louisiana, southern portion of western Tennessee, a small portion of southwestern middle Tennessee, and portions of northwestern Alabama. Shreveport WSO, Jackson WSO, and Memphis WSFO immediately disseminated the Watch with appropriate areal outlines.
4. 10:40 a.m.—Shreveport WSO transmitted over NWWS a Severe Thunderstorm Warning Bulletin for Bowie and Cass Counties, Tex., and Little River and Miller Counties, Ark.
5. 10:45 a.m.—Jackson WSO transmitted a Severe Weather Statement and Radar Summary, which included a Tornado Watch, simultaneously over NWWS, National Warning Service (NAWAS), and microphone to Radio Station WJDX of the Emergency Broadcast System. (EBS).
6. 10:50 a.m.—Jackson WSO transmitted a Severe Thunderstorm Warning Bulletin simultaneously over NWWS, NAWAS, and Radio Station WJDX with immediate broadcast requested for Sunflower, Tallahatchie, Quitman, and Panola Counties. Radar observation indicated a severe thunderstorm just west of Cleveland, Miss.
7. 11:00 a.m.—Memphis WSFO issued a Severe Weather Statement over EBS at 11:02; over NAWAS at 11:03; and over NWWS at 11:06 a.m. and Radar Warning and Coordination Circuit (RAWARC) at 11:16 a.m. The Civil Defense Director was notified at 11:12 a.m.
8. 11:05 a.m.—Jackson WSO issued an Aviation Local Wind Warning.
9. 11:05 a.m.—NSSFC issued Public Tornado Watch Bulletin Number 38 for portions of southwestern Oklahoma, portions of western Arkansas, portions of northeastern Texas and portions of northwestern Louisiana. Shreveport WSO, Jackson WSO and Memphis WSFO immediately disseminated the Watch.
10. 11:17 a.m.—Memphis WSFO and Jackson WSO conferred on issuing warnings for counties within the responsibility of each office in the event of a severe thunderstorm or tornado.
11. 11:25 a.m.—Memphis WSFO issued a Severe Thunderstorm Warning for Benton

* State names are omitted with county or parish and community place names when these geographic identities are located within the same State as the WSO, WSFO, or State organizational unit mentioned in, or initiating, the action.

** Central Standard Time is used throughout appendix B.

and Marshall Counties, Miss. and Fayette and Hardeman Counties, Tenn. Informed Jackson WSO. Transmitted Warning over EBS at 11:26 a.m., over NAWAS at 11:28 a.m., over NWWS at 11:30 a.m., over American Red Cross Radio at 11:31 a.m., and over RAWARC at 11:34 a.m.

12. 11:40 a.m.—Memphis WSFO requested Sheriff Dispatcher to contact Mississippi Highway Safety Patrol about weather conditions 5 to 10 miles south of Arkabutla Lake at which locality radar observations indicated strong echo return with top to 43,000 feet.
13. 11:40 a.m.—Jackson WSO transmitted a Mississippi Weather Summary simultaneously over NWWS, NAWAS, and Radio Station WJDX of EBS.
14. 11:45 a.m.—Shreveport WSO issued a Severe Weather Statement for Shreveport.
15. 11:45 a.m.—Jackson WSO transmitted Severe Weather Statement and Radar Summary simultaneously over NWWS, NAWAS, and Radio Station WJDX of EBS.
16. 11:45 a.m.—Memphis WSFO on the basis of radar indications issued a Severe Thunderstorm Warning Bulletin for De Soto County, Miss., and Shelby County, Tenn., over EBS and NAWAS at 11:45 a.m. Emergency Action Notification Signal (EANS) was requested.
17. 11:45 a.m.—Cleveland, Miss., Police Department reported sighting a tornado 6 miles southwest of Cleveland—via Substation of Mississippi Highway Safety Patrol in Greenwood, which relayed report over NAWAS to Jackson WSO.
18. 11:50 a.m.—Shreveport WSO released Severe Weather Bulletin clearing Bowie and Cass Counties, Tex., and Little River and Miller Counties, Ark.
19. 11:55 a.m.—Jackson WSO issued a Tornado Warning Bulletin valid until 1:00 p.m., for northern Sunflower, Tallahatchie, and Quitman Counties. The Warning was based on a tornado reported (by public) 5 miles northeast of Cleveland and a hook echo shown on radar about 12 miles south of Clarksdale. EANS requested.
20. 12:10 p.m.—Jackson WSO received report of funnel just north of Tutwiler, about 12:10 p.m.
21. 12:15 p.m.—Memphis WSFO issued a Severe Thunderstorm Warning for Panola, Marshall, Benton, and DeSoto Counties in northern Mississippi; over EBS at 12:22, NAWAS at 12:24, NWWS and American Red Cross Radio at 12:25 and RAWARC at 12:28 p.m.
22. 12:22 p.m.—Memphis radio station reported a funnel at Drew, Miss.
23. 12:31 p.m.—Memphis WSFO requested Sheriff Dispatcher to ask Mississippi Highway Safety Patrol to check on thunderstorm in Crenshaw and Panola Counties, Miss.
24. 12:35 p.m.—Memphis WSFO issued a Severe Thunderstorm Warning Bulletin, valid until 1:30 p.m., for Tate and Tunica Counties, Miss., based on radar indications. EANS requested.
25. 12:35 p.m.—Shreveport WSO issued a Severe Thunderstorm Warning, valid until 1:30 p.m., for Winn, Webster, Ouchita, and Richland Parishes, based on radar indications.
26. 12:45 p.m.—Jackson WSO transmitted a Severe Weather Statement and Radar Summary over NWWS, NAWAS, and Radio Station WJDX.
27. 12:55 p.m.—Shreveport WSO transmitted a Severe Weather Statement.
28. 1:00 p.m.—Jackson WSO transmitted a Severe Weather Bulletin simultaneously over NWWS, NAWAS, and Radio Station WJDX clearing northern Sunflower, Tallahatchie, and Quitman Counties. The hook echo indicated by radar 5 miles northeast of Cleveland at 11:55 a.m. had passed out of the area.
29. 1:00 p.m.—Memphis WSFO issued a Severe Thunderstorm Warning, valid until 3:00 p.m., for Crittendon and Mississippi Counties, Ark., and Tipton and Lauderdale Counties in western Tennessee, based on radar indications. Warning was transmitted over EBS at 1:06 p.m., NAWAS and NWWS at 1:08 p.m., and American Red Cross Radio at 1:09 p.m. and RAWARC

at 1:15 p.m. Civil Defense was briefed at 1:10 p.m.

30. 1:30 p.m.—Memphis WSFO issued a Severe Weather Bulletin clearing all but Crittendon and Mississippi Counties, Ark., and Tipton and Lauderdale Counties in western Tennessee. It was transmitted over EBS and NWWS at 1:35, NAWAS at 1:37, American Red Cross Radio at 1:38, and RAWARC at 1:40 p.m.
31. 1:30 p.m.—Shreveport WSO transmitted a Severe Thunderstorm Warning, valid until 2:30 p.m., over NWWS for parishes in northeastern Louisiana. EANS requested.
32. 1:45 p.m.—Shreveport WSO transmitted a Severe Weather Statement over NWWS.
33. 1:45 p.m.—Jackson WSO transmitted a Severe Weather Statement and Radar Summary simultaneously over NWWS, NAWAS, and Radio Station WJDX of EBS.
34. 2:00 p.m.—Memphis WSFO transmitted a Severe Weather Statement over EBS, NAWAS, American Red Cross Radio, NWWS, and RAWARC.
35. 2:00 p.m.—NSSFC issued Public Tornado Watch Bulletin Number 39, valid until 8:00 p.m., for portions of eastern Louisiana, portions of western Mississippi, and portions of southeastern Arkansas. Shreveport WSO, Jackson WSO, and Memphis WSFO immediately disseminated the Watch with appropriate areal outline.
36. 2:15 p.m.—NSSFC issued Public Tornado

Trailer camp west of Belzoni, Miss. (NASA Earth Resources Laboratory)

Watch Bulletin Number 40, valid from 4:00 to 8:00 p.m., for portions of eastern Arkansas, northern Mississippi, portions of northern Alabama, and portions of western and middle Tennessee. This Bulletin replaced Tornado Watch Number 37 which would not be in effect after 4:00 p.m. Jackson WSO and Memphis WSFO immediately disseminated the Watch with appropriate areal outlines.

37. 2:25 p.m.—Shreveport WSO released a Severe Weather Bulletin clearing part of northern Texas and Bossier, Caddo, and De Soto Counties in northwest Louisiana.
38. 2:30 p.m.—Memphis WSFO received a report from Shelby County Sheriff Dispatcher, relayed from Mississippi Highway Safety Patrol, of a funnel cloud 5 miles east of Senatobia in Tate County, Miss.
39. 2:35 p.m.—Memphis WSFO issued a Tornado Warning for Tate and Marshall Counties, Miss.
40. 2:35 p.m.—Shreveport WSO issued a Severe Thunderstorm Warning for 13 parishes in central and northeastern Louisiana, including Madison and East Carroll, based on radar indications.
41. 2:45 p.m.—Shreveport WSO issued a Severe Weather Bulletin summarizing reports of severe weather and announced that Tornado Watch Bulletin Number 37 was replaced by Tornado Watch Bulletin Number 40.
42. 2:45 p.m.—Jackson WSO issued a Severe Weather Statement and Radar Summary.
43. 2:45 p.m.—Memphis WSFO issued a Severe Weather Statement and Radar Summary.
44. 3:00 p.m.—Memphis WSFO issued a Severe Weather Bulletin cancelling the Severe Thunderstorm Warning for Crittendon and Mississippi Counties, Ark., and Tipton and Lauderdale Counties in western Tennessee.
45. 3:17 p.m.—Shreveport WSO observed intense echo on radar and used NAWAS to request Louisiana State Police Troop F at Monroe to check Delhi area for storm. In 7 minutes State Police reported over NAWAS that a tornado had occurred 3 miles east of Delhi at 3:10 p.m. and now was just north and northwest of Tallulah.
46. 3:20 p.m.—Shreveport WSO issued a Tornado Warning, valid until 4:30 p.m., for Madison Parish.
47. 3:20 p.m.—Jackson WSO issued a Tornado Warning for Sharkey, Issaquena, Washington, and Humphreys Counties, which were in the projected path of the Delhi tornado.
48. 3:30 p.m.—Memphis WSFO released a Severe Weather Bulletin cancelling Tornado Warning for Tate and Marshall Counties in northern Mississippi.
49. 3:30 p.m.—Jackson WSO received a report from the public of heavy hail 3 miles northwest of Indianola in Sunflower County.
50. 3:37 p.m.—Jackson WSO issued a Tornado Warning, valid until 4:30 p.m., based on a radar hook echo southwest of Ruleville (6 miles south of Drew), for Leflore, Tallahatchie, Grenada, and Yalobusha Counties. EANS requested.
51. 3:45 p.m.—Jackson WSO and Memphis WSFO issued Severe Weather Statements and Radar Summaries.
52. 3:55 p.m.—Shreveport WSO issued a Severe Thunderstorm Warning based on radar indications for Richland, East Carroll, and West Carroll Parishes and requested EANS.
53. 3:55 p.m.—Jackson WSO received a report from the public that a funnel 4 miles west of Rolling Fork at 3:55 p.m. was moving northeastward. The radar showed a hook echo 5 miles south-southwest of Rolling Fork.
54. 3:55 p.m.—Memphis WSFO asked city sheriff to contact Mississippi Highway Safety Patrol and request a check on tornado at Rome, Miss. Jackson WSO notified.
55. 4:00 p.m.—Shreveport WSO released a Severe Weather Bulletin cancelling the Severe Thunderstorm Warning for Caldwell, Franklin, Madison, Morehouse, Ouchita, Union, Tensas, Jackson, Lincoln, and Winn Parishes.
56. 4:00 p.m.—Jackson WSO received a report from the Mississippi Highway Safety Patrol, that a funnel just northeast of Drew at 4:00 p.m. was moving northeastward.
57. 4:08 p.m.—Jackson WSO received a report

from Mississippi Highway Safety Patrol, that a tornado just north of Drew was moving toward Tutwiler.

58. 4:10 p.m.—Shreveport WSO received a report from State Police at Monroe, La., that four to seven houses were blown away and some deaths were caused by the tornado at Delhi at 3:10 p.m. Shreveport transmitted this information on RAWARC.
59. 4:10 p.m.—Mississippi Civil Defense Council in Jackson received a report from the Mississippi Highway Safety Patrol of a tornado at Rome and notified the Civil Defense at Cleveland.
60. 4:13 p.m.—Jackson WSO received a report of a funnel 12 miles southwest of Clarksdale.
61. 4:15 p.m.—Jackson WSO issued a Tornado Warning for Warren, Yazoo, Sharkey, Washington, Humphreyes, Leflore, Tallahatchie, Grenada, and Yalobusha Counties. valid until 5:30 p.m.
62. 4:15 p.m.—Jackson WSO received a report of a tornado west of Tutwiler.
63. 4:16 p.m.—Jackson WSO received a report of a tornado north of Webb.
64. 4:17 p.m.—Mississippi Civil Defense Council in Jackson received a report from Mississippi Highway Safety Patrol that a tornado destroyed a gin and some tenement houses at Rome in Sunflower County.
65. 4:17 p.m.—Memphis WSFO received a report from Mississippi Highway Safety Patrol of a funnel in the vicinity of Greenwood, Miss.
66. 4:23 p.m.—Mississippi Civil Defense Council in Jackson received a report from the Mississippi Highway Safety Patrol that a tornado touched down at Cary in Sharkey County and overturned some vehicles.
67. 4:25 p.m.—Jackson WSO received a report that a tornado was 6 miles west of Isola at 4:25 p.m. and moving northeast toward Greenwood.
68. 4:25 p.m.—Jackson WSO received a report of a tornado at Fitler.
69. 4:25 p.m.—Jackson WSO received a report that a tornado was sighted 2½ miles northeast of Rolling Fork at 4:20 p.m. This tornado was observed on radar as a hook echo 5 miles southwest of Rolling Park at 4:07 p.m. The hook echo was tracked to 10 miles southwest of Belzoni at 4:48 p.m.
70. 4:20 p.m.—Jackson WSO notified SELS over RAWARC that there were several tornadoes in the Delta.
71. 4:30 p.m.—Jackson WSO tried to call radio station at Belzoni but the line was busy; called Police Department at Belzoni and advised them to go to radio station and issue warnings. Also, at 4:30 p.m., received report of tornado at Cary.
72. 4:33 p.m.—Jackson WSO received a report of a tornado 8 miles east of Anguilla.
73. 4:40 p.m.—Jackson WSO received report from cooperative observer at Sunflower that debris was falling out of the air 2 miles west of Sunflower at 4:40 p.m., accompanied by hail, heavy rain, and strong wind. Visibility was limited to a few yards and the observer could not see a tornado.
74. 4:45 p.m.—Jackson WSO and Memphis WSFO released Severe Weather Statements and Radar Summaries.
75. 4:45 p.m.—Jackson WSO received a report from Mississippi Highway Safety Patrol that a patrolman spotted a tornado moving northeast 3 miles southwest of Belzoni. There was a hook echo on radar 6 miles southwest of Belzoni.
76. 4:55 p.m.—Memphis WSFO issued a Tornado Warning valid until 6:00 p.m. for Tate, De Soto and Marshall Counties, Miss., and the eastern half of Shelby and Fayette Counties, Tenn., based on a tornado reported 3 miles southwest of Tutwiler, Miss. EANS requested.
77. 4:55 p.m.—Memphis WSFO released a Severe Storm Report on tornadoes at Rome and near Tutwiler, Miss.
78. 4:55 p.m.—Shreveport issued a Severe Thunderstorm warning, valid until 6:30 p.m., for East Carroll, Madison, Franklin, and Tensas Parishes, based on radar indications.
79. 4:57 p.m.—Jackson WSO received a report from Mississippi Highway Safety Patrol of two tornadoes 6 miles north of Clarksdale, sighted at 4:50 p.m.
80. 5:00 p.m.—Jackson WSO issued a Tornado

Warning that extended until 6:30 p.m. the Tornado Warning for Issaquena, Sharkey, Yazoo, Washington, Humphreys, Holmes, Sunflower, Leflore, Carroll, Tallahatchie, Grenada, and Yalobusha Counties.

81. 5:03 p.m.—Shreveport WSO transmitted over RAWARC a report, from State Police at Monroe, La., that a tornado was 5 miles south of Lake Providence at 4:55 p.m.
82. 5:05 p.m.—Jackson WSO observed a hook echo on radar and issued a Severe Weather Statement and Radar Report that a tornado (indicated by radar) was 20 miles southwest of Greenwood and moving northeast at 40 to 45 m.p.h.
83. 5:05 p.m.—Mississippi Civil Defense Council at Jackson received a report of a funnel 18 miles southwest of Greenwood.
84. 5:05 p.m.—NSSFC issued Public Tornado Watch Bulletin Number 41 for portions of eastern and central Mississippi, a portion of western and portions of central Alabama, a portion of southeastern Louisiana, and a small portion of extreme northwestern Florida, valid from 6:00 p.m. until midnight. Jackson WSO, Shreveport WSO, and Memphis WSFO immediately disseminated the Watch with appropriate areal outlines.
85. 5:10 p.m.—Jackson WSO received reports of damage southeast of Clarksdale, and destruction at Inverness.
86. 5:19 p.m.—Jackson WSO observed a radar hook echo 8 miles north of Edwards and transmitted the information over RAWARC.
87. 5:23 p.m.—Jackson WSO, on the basis of radar hook echo, issued a Tornado Warning, valid until 6:30 p.m., for Hinds and Madison Counties.
88. 5:25 p.m.—Jackson WSO received a report that a tornado passed just west of Greenwood at 5:25 p.m. Sirens had been sounded at 5:15 p.m.
89. 5:25 p.m.—Shreveport WSO released a Severe Weather Bulletin clearing Tornado Watch for Caldwell, Ouachita, Union, Jackson, Lincoln, and Winn Parishes.
90. 5:30 p.m.—Memphis WSFO issued a Severe Weather Statement that radar hook echoes indicated possible tornadoes near Hernando, Miss., and stated that Tornado Warnings were in effect for De Soto and Marshall Counties, Miss., and Shelby and Fayette Counties, Tenn.
91. 5:31 p.m.—Mississippi Highway Safety Patrol spotted a funnel at Willow Run Gin south of Greenwood.
92. 5:35 p.m.—Shreveport WSO reported over RAWARC that there were tornado fatalities at Delhi.
93. 5:35 p.m.—Jackson WSO received report from Mississippi Highway Safety Patrol at Greenwood that a tornado was sighted 8 to 10 miles northeast of Greenwood at 5:35 moving northeast toward Grenada. (The tornado was 6 miles west of Grenada at 5:46 p.m., at which time radar showed a hook echo at that location.)
94. 5:37 p.m.—Jackson WSO received a report of a tornado 8 miles north of Edwards. Radar showed a hook echo at that location moving along the Big Black River.
95. 5:40 p.m.—Jackson WSO received: (1) a report that a tornado struck Goodenlake Community 7 miles south of Belzoni at 5:00 p.m. causing four fatalities in the "blown away community;" and (2) a report of a funnel 9 miles northwest of Holcomb at 5:34 p.m.
96. 5:45 p.m.—Jackson WSO and Memphis WSFO released Severe Weather Statements and Radar Summaries.
97. 5:45 p.m.—Memphis WSFO issued a Severe Weather Statement of a storm in the vicinity of Hernando, Miss.
98. 5:50 p.m.—Jackson WSO issued a Tornado Warning for Yazoo and Holmes Counties, valid until 7:00 p.m., based on a radar hook echo 10 miles west of Flora and moving northeastward in the general direction of Lexington.
99. 5:52 p.m.—Memphis WSFO observed a hook echo on radar 7 miles south-southeast of Memphis Airport and notified the tower at 5:53 p.m.
100. 5:53 p.m.—Memphis WSFO issued a Tornado Warning for Shelby, Tipton, and Lauderdale Counties in western Tennessee, valid until 7:00 p.m.

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101. 5:55 p.m.—Jackson WSO received a report of a tornado 1 mile west of Flora.
102. 5:58 p.m.—Jackson WSO received a report of two funnels east of Indianola, moving from Inverness towards Itta Bena.
103. 6:00 p.m.—Jackson WSO reported (over RAWARC) a radar hook echo 6 miles southeast of Yazoo City.
104. 6:05 p.m.—Memphis WSFO issued a Severe Weather Statement on an intense storm near the airport.
105. 6:10 p.m.—Memphis WSFO received a report from the public, forwarded through police, that there was a funnel over Frayser, Tenn. (Millington Road 3890). American Red Cross personnel reported a roaring noise over Parkway Village 6 miles east of the airport. Radar showed a hook echo 3 miles northeast of the airport at 6:12 p.m.
106. 6:10 p.m.—Jackson WSO transmitted over RAWARC a special radar report of a hook echo 11 miles southwest of Lexington.
107. 6:15 p.m.—Jackson WSO received a report from the public of a tornado 20 miles south of Natchez at 6:13 p.m.
108. 6:22 p.m.—Jackson WSO received a report of a tornado near Parktown Apartments in southwest Jackson.
109. 6:25 p.m.—Jackson WSO received a report of a funnel over Jackson. Immediately, a Tornado Warning was issued for Adams, Jefferson, Claiborne, Copiah, Hinds, Rankin, Madison, Yazoo, Holmes, Leake, Choctaw, Montgomery, Carroll, Grenada, Webster, Calhoun, and Chickasaw Counties, valid until 8:00 p.m. Jackson WSO also transmitted a special radar report over RAWARC of a hook echo 8 miles north-northwest of Raymond.
110. 6:30 p.m.—Jackson WSO issued a cancellation of the Tornado Warning for Issaquena, Sharkey, Washington, Humphreys, Sunflower, Leflore, Tallahatchie and Yalobusha Counties because storm activity had moved eastward.
111. 6:30 p.m.—Sheveport WSO issued a Severe Thunderstorm Warning, valid until 7:30 p.m., for Madison and Tensas Parishes, EANS requested.
112. 6:30 p.m.—Shreveport WSO issued a Severe Weather Statement cancelling the Severe Thunderstorm Warning for East Carroll and Franklin Parishes.
113. 6:38 p.m.—Jackson WSO issued over RAWARC a special radar report of a hook echo 3 miles east-northeast of Utica.
114. 6:40 p.m.—Memphis WSFO issued a Severe Weather Statement.
115. 6:43 p.m.—Jackson WSO received a report of two funnels west of Jackson. Civil Defense sounded sirens.
116. 6:45 p.m. Jackson WSO and Memphis WSFO released Severe Weather Statements and Radar Sumaries.
117. 6:54 p.m.—Jackson WSO received a report of a funnel 3 miles south of Clinton.
118. 6:55 p.m.—Jackson WSO received a report of a tornado just south of Clinton.
119. 7:05 p.m.—Memphis WSFO issued a Severe Weather Bulletin cancelling the Warning for Shelby, Tipton, and Lauderdale Counties in West Tennessee.
120. 7:08 p.m.—Jackson WSO transmitted a Weather Statement and radar report that a hook echo indicated a tornado 8 miles west-southwest of Canton. Also, Jackson WSO received a report that a funnel was sighted in southwestern Jackson.
121. 7:12 p.m.—Jackson WSO was informed of a loud roar over Florence.
122. 7:15 p.m.—NSSFC issued Public Tornado Watch Number 42 for portions of west and middle Tennessee, a portion of northwest Alabama, northern Mississippi, and a portion of northeastern Arkansas, valid from 8:00 p.m. until 2:00 a.m. Sunday night. Jackson WSO and Memphis WFSO immediately disseminated the Watch with appropriate areal outlines.
123. 7:20 p.m.—Shreveport WSO issued a Severe Weather Bulletin cancelling Severe Thunderstorm Warnings for East Carroll, West Carroll, Franklin, Madison, Morehouse, Richland, and Tensas Parishes. Thunderstorms had moved out of the area.
124. 7:20 p.m.—Jackson WSO observed a hook echo on radar 3 miles west-southwest of Florence and issued a Severe Weather Statement and Radar Report.
125. 7:22 p.m.—Jackson WSO received a report

Destruction at Little Yazoo, Miss. (NASA Earth Resources Laboratory)

of a tornado 1½ miles west of Oxford.

126. 7:29 p.m.—Jackson WSO observed a radar hook echo 4 miles south-southwest of Thompson Airport, Jackson, and issued a special report over RAWARC.
127. 7:30 p.m.—Jackson WSO issued a Tornado Warning for Lafayette, Union, Benton and Tippah Counties, based on a tornado sighted in West Oxford at 7:23 p.m. by City Police. EANS requested.
128. 7:32 p.m.—Jackson WSO observed a hook echo on radar 5 miles southwest of Thompson Airport and issued a special radar report over RAWARC.
129. 7:35 p.m.—Jackson WSO received a report of a funnel at McLaurin Shopping Center east of Jackson.
130. 7:42 p.m.—Jackson WSO received a report that a tornado destroyed 14 house trailers at Oxford.
131. 7:45 p.m.—Jackson WSO and Memphis WSFO issued Severe Weather Statements and Radar Summaries.
132. 7:51 p.m.—Jackson WSO observed a radar

hook echo midway between D'Lo and Florence and issued a special radar report over RAWARC.

133. 8:00 p.m.—Jackson WSO released a Severe Weather Bulletin cancelling the Warning for Adams, Jefferson, Claiborne, Copiah, Hinds, Madison, Yazoo, Holmes, Montgomery, Carroll, Grenada, Lafayette and Benton Counties. Tornado activity had moved out of the area.
134. 8:05 p.m.—Jackson WSO issued a Tornado Warning, valid until 9:30 p.m., based on radar and reports from the public, for Simpson, Webster, Oktibbeha, Clay, Chickasaw, Pontotoc, Lee, Union, Prentiss, Tippah, and Alcorn Counties.
135. 8:08 p.m.—Memphis WSFO issued a Severe Thunderstorm Warning, valid until 9:30 p.m., based on radar indications for Hardeman, Madison, and Chester Counties.
136. 8:20 p.m.—Jackson WSO received a report of a funnel 2 miles south of Brandon.
137. 8:30 p.m.—Jackson WSO received a report of hail at Mathiston.
138. 8:40 p.m.—Jackson WSO received a report of a funnel 1 mile south of Carthage.
139. 8:45 p.m.—Jackson WSO and Memphis WSFO issued Severe Weather Statements and Radar Summaries.
140. 8:50 p.m.—Jackson WSO received a report from the Mississippi Highway Safety Patrol that a tornado destroyed a schoolhouse in Hurricane Community, Pontotoc County, sometime between 8:30 and 8:50 p.m.
141. 8:55 p.m.—Jackson WSO received a report from the public of a funnel cloud and loud roar ½ mile south of Magee at 8:50 p.m.
142. 9:05 p.m.—Jackson WSO received reports of a tornado at the Benton-Tippah County line on Highway 72 and a tornado between Holly Springs and Ashland at 8:40 p.m.
143. 9:30 p.m.—Jackson WSO received a report that a funnel between Starkville and Ackerman, at 9:30 p.m., was moving northeastward.
144. 9:30 p.m.—Jackson WSO issued a Tornado Warning, valid until 11:00 p.m., for Alcorn, Prentiss, Tishomingo, Lee, Itawamba, Chickasaw, Munroe, Clay, Oktibbeha, and Lowndes Counties.
145. 9:30 p.m.—Jackson WSO released a Severe Weather Bulletin cancelling Tornado Warning for Simpson, Smith, Rankin, Scott, Leake, Attala, Choctaw, Webster, Pontotoc, Union, and Tippah Counties, because severe storm activity had moved eastward out of the area.
146. 9:35 p.m.—Memphis WSFO released a Severe Weather Bulletin cancelling Severe Thunderstorm Warning for Hardeman, Chester, and Madison Counties.
147. 9:37 p.m.—Memphis WSFO received a report of a possible tornado in vicinity of Salisburg and Grand Junction.
148. 9:40 p.m.—Memphis WSFO received a report from Tennessee Highway Patrol that power was off in Salisburg.
149. 9:45 p.m.—Jackson WSO and Memphis WSFO released Severe Weather Statements and Radar Summaries.
150. 9:48 p.m.—Memphis WSFO received a report from Tennessee Highway Patrol of a tornado at Selmer at 9:45 p.m.
151. 9:55 p.m.—Memphis WSFO issued a Tornado Warning, valid until 11:30 p.m., for McNairy, Chester, and Henderson Counties. EANS requested.
152. 10:25 p.m.—Memphis WSFO released a Severe Weather Bulletin clearing all counties in west Tennessee and north Mississippi in its area of responsibility.
153. 10:30 p.m.—Jackson WSO released a Severe Weather Bulletin cancelling the Tornado Watch for the western counties.
154. 10:45 p.m.—Jackson WSO and Memphis WSFO released Severe Weather Statements and Radar Summaries.
155. 10:55 p.m.—NSSFC issued Public Tornado Watch Number 43 for portions of middle Tennessee, portions of eastern Tennessee, and a large part of Alabama, valid from 11:30 p.m. Sunday night to 5:00 a.m. early Monday morning. Nashville WSO immediately disseminated the Watch with areal outline.
156. 11:00 p.m.—Jackson WSO released a Severe Weather Bulletin cancelling the Tornado

Warning for Alcorn, Prentiss, Tishomingo, Lee, Itawambia, Chickasaw, Munroe Clay, Oktibbeha, and Lowndes Counties. Tornado activity had moved eastward out of the area.

157. 11:07 p.m.—Memphis WSFO notified Jackson WSO, Tennessee Highway Patrol, and Carroll County Highway Patrol, of strong thunderstorm in south portion of Decatur County, western Tennessee.
158. 11:10 p.m.—Memphis WSFO issued a Severe Thunderstorm Warning, valid until 11:30 p.m., for Decatur County.
159. 11:45 p.m.—Memphis WSFO issued a Severe Weather Bulletin cancelling the Severe Thunderstorm Warning for Decatur County western Tennessee.
160. 11:45 p.m.—Memphis WSFO and Jackson WSO released Radar Summaries.
161. 11:55 p.m.—Jackson WSO released a Severe Weather Bulletin cancelling all Watches and Warnings in Mississippi. The thunderstorms had moved out of Mississippi.

February 22, 1971

162. 12:15 a.m.—Memphis WSFO issued a post-storm report.

Cary, Miss.

APPENDIX C

Determination of Tracks of Principal Tornadoes

At the very beginning of its task, the survey team encountered a great deal of difficulty in fitting individual reports of tornado sightings and radar observations of significant weather echoes into a coherent picture. Consequently, the survey team decided to make an aerial survey of the damage paths in order to resolve the many apparent discrepancies in reports of tornado locations and times.

On Tuesday morning, February 23, 1971, two members of the survey team (A. C. Peterson and Carl M. Reber) and the Jackson radar operator on duty on February 21 (Walter A. Schulz, Jr.) made an aerial survey in a rented Piper Cherokee Six. The pilot (Floyd Boone) was a native of the area and his detailed knowledge of landmarks and other significant features of the State helped greatly in aerial orientation as the survey flight progressed.

The procedure was to fly to intercept a damage path, then fly along it in one direction until all signs of the tornado passage were lost, then fly in the other direction to complete the survey of that damage path. The two members of the survey team each plotted track positions independently on a standard Sectional Aeronautical Chart (scale: 8 miles to the inch). The duty radar operator took notes and related track positions to radar indications of severe weather and hook-shaped radar echoes noted on February 21.

A postflight comparison of the independently plotted damage tracks showed very close agreement. Deviations in most instances were less than 1 mile. These tracks were refined further by ground surveys at selected locations the following day.

By flying at an altitude of 1,000 feet above ground or lower, it was possible to define three major tornado paths having lengths of 159, 102, and 69 miles, and a fourth path having a length of some 7 to 10 miles (figure 11 of report).

On the basis of public reports of sightings of tornadoes and funnel clouds, as well as radar indications, it is almost certain there were other tornadoes which touched the ground in areas outside the described paths. However, in the absence of damage reports or reports of injuries, the survey team concluded that such other tornadoes as occurred were of short duration and possibly of lesser intensity. Further evidence on additional tornadoes may come to light later on the basis of high-resolution aerial photography performed by NASA. The survey team concluded that all the storm deaths reported for the February 21 tornadoes in northeast Louisiana and Mississippi, and the vast majority of property damage reported, were attributable to the four individual tornadoes whose tracks were plotted during the aerial survey.

Aerial observation of the storm tracks suggested that the damage paths ranged in width from about ¼ to ½ mile. The individual tornado paths were readily recognizable from the air as evidenced by destroyed farmsteads and damaged and downed trees and power lines. Some tracks were ill-defined where tornadoes crossed large cultivated areas, but the team nearly always found sufficient indications of various types to establish continuity of the paths.

Once the paths of the principal tornadoes were determined, the team conducted ground surveys to establish additional facts about the

width of tornado tracks and the extent and nature of damage. The team also tried to determine whether, in fact, each track constituted the effects of a single tornado occurrence. To accomplish this it was necessary to establish times of occurrence of tornadoes at a number of points along each track. These times were determined by interviews with survivors, the times at which electric clocks stopped, and other indications. Discrepancies in exact times were many, and all reports had to be considered and weighed in relation to other reports to establish the most likely time of occurrence. Even so, some voids exist that cannot be reconstructed with accuracy.

During the ground surveys, track width measurements were made at a number of points, using the automobile odometer. Widths were defined as the limits of visible substantial damage, such as damaged buildings or stripped trees. Most of the measurements indicated that the damage paths of the three principal tornado tracks ranged from 3/8 to 1/2 statute mile in width. The fourth tornado track, Drew-Rome-Tutwiler, was not ground surveyed.

Description of Individual Tornado Paths

Path 1—Delhi, La., to southwest of Schlater, Miss.—Public reports indicate that this tornado existed as a funnel aloft some distance south-southwest of Delhi—perhaps as much as 10 miles—before making ground contact some 3 miles east of the town of Delhi and just south of U.S. Highway 80. From this point the tornado moved to the northeast, struck a farmstead (where 10 were killed in a family of 12), crossed the Mississippi River, and continued on beyond Moorhead, Miss. It is believed this tornado remained in continuous ground contact from Delhi to beyond Moorhead, where some breaks in ground contact occurred before it lifted at a point about 5 miles southwest of Schlater. The average speed between Delhi and Moorhead was approximately 52 m.p.h. and the total ground contact time was 2 hours.

Extensive damage was done at Nitta Yuma, Delta City, Inverness, and Moorehead. The city of Inverness was 80 to 90 percent destroyed and 19 persons were reported killed. Many farmsteads throughout the length of the tornado path suffered substantial damage or were totally destroyed. A valuable stand of mature, large pecan trees was severely damaged about 8 miles south-southwest of Lake Providence, La.

Path 2—Cary to near Abbeville, Miss.—This tornado struck 1/2 mile south of the town of Cary at 1610 CST but there is evidence from aerial surveys that its point of first ground contact occurred some 6 to 8 miles southwest of Cary. It then moved northeast (about 30° True), passed a few miles northwest of Belzoni, and a few miles farther north straddled or paralleled State Highway 7 for about 13 miles. Farm houses and outbuildings were heavily damaged and most were a total loss. The tornado swept through a plantation area at Pugh City, ripped the frame houses of low-income families to splinters, rolled and mangled implements and machinery, killed 22 persons, and injured many more. The death toll probably would have been higher at Pugh City had not some 30 persons taken last minute refuge under a concrete bridge on State Highway 7, where they huddled against the south abutment.

The storm passed about 3 miles west of Greenwood, continued on through wooded and thinly populated countryside, and passed about 4 miles west of Oxford, where it destroyed a number of mobile homes as it swept through two separate mobile home parks. All evidence of tornado ground contact was lost at a point a few miles northeast of the village of Abbeville.

The tornado appeared to remain in ground contact along most of the track except for occasional skips along a 15- to 20-mile segment beginning in the vicinity of Enid Reservoir to about 10 miles southwest of Oxford.

The point of first ground contact was established as 6 miles southwest of Cary; the total track was 159 statute miles; average forward speed between Cary and Pugh City was 55 m.p.h., and total duration was just under 3 hours.

Tornado and damage reports at points northeast of Oxford (Holly Springs, Miss., and Selmer, Tenn.) and east of Oxford (Toccopola, Miss.) could not be related directly to this storm path, but are believed to be associated with storms that could have developed from the same thunderstorm system.

Path 3—Bovina to near Lexington, Miss.—

Aerial and ground surveys indicate this tornado first touched down at a point 4 miles south of the village of Bovina, at State Highway 27, continued on a northeasterly course, mostly through cultivated or timbered country, damaged a number of farmsteads, and passed directly through the unincorporated village of Little Yazoo. Destruction of this cross-roads area, which was almost total, included several small businesses, homes, and a church, and resulted in the loss of 9 lives. The survey team traveled along a road that was perpendicular to the storm's track and measured the width of the damage path at ⅗ mile. This tornado first touched ground at 1706 CST. Its total path was 69 miles and its average forward speed between Highway 80 and Little Yazoo was 54 m.p.h.

Path 4—South of Parchman to near Tutwiler, Miss.—The aerial survey indicated that this tornado track was only about 7 to 10 miles in length and that it skirted the edges of the towns of Parchman, Rome, and Tutwiler. Damage to farm buildings and houses in its path ranged from light to complete destruction. The damage path appears to have been on the order of ¼ mile wide. The forward speed was not determined because of the short path and uncertainty of reported time of occurrence.

General Tornado Characteristics

The three major tornadoes (paths 1, 2, and 3) were of the long-lived, massive, wide type, each appearing as a rapidly approaching huge black cloud, swirling and rotating, and accompanied by flying debris and much lightning and followed by heavy rain. In describing sounds made by the tornadoes, most observers selected the phrase "sounded like a freight train." In the process of interviewing survivors who saw the storm approaching, the survivor was shown a sketch depicting characteristic tornado shapes and was asked to select the illustrated shape that best described the appearance of the storm (fig. C1). Each selected shape B. Several observers reported seeing more than one tornado. One reported seeing a big tornado flanked by a smaller tornado on each side, dancing up and down. It is the opinion of the survey team that the three principal tornadoes had very similar characteristics.

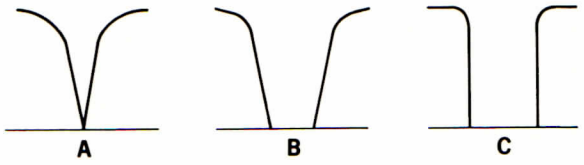

FIGURE C1. Appearance of tornado funnel cloud.

Examination of ground damage showed that in some areas there was less damage evident near the center of the path than at the sides, but this was not a general characteristic. One could conclude, perhaps, that at some places there were two funnels moving along parallel paths. Patterns of scattered debris and directions in which trees fell tended more to substantiate the occurrence of a single large vortex, the destructive force of which varied from place to place.