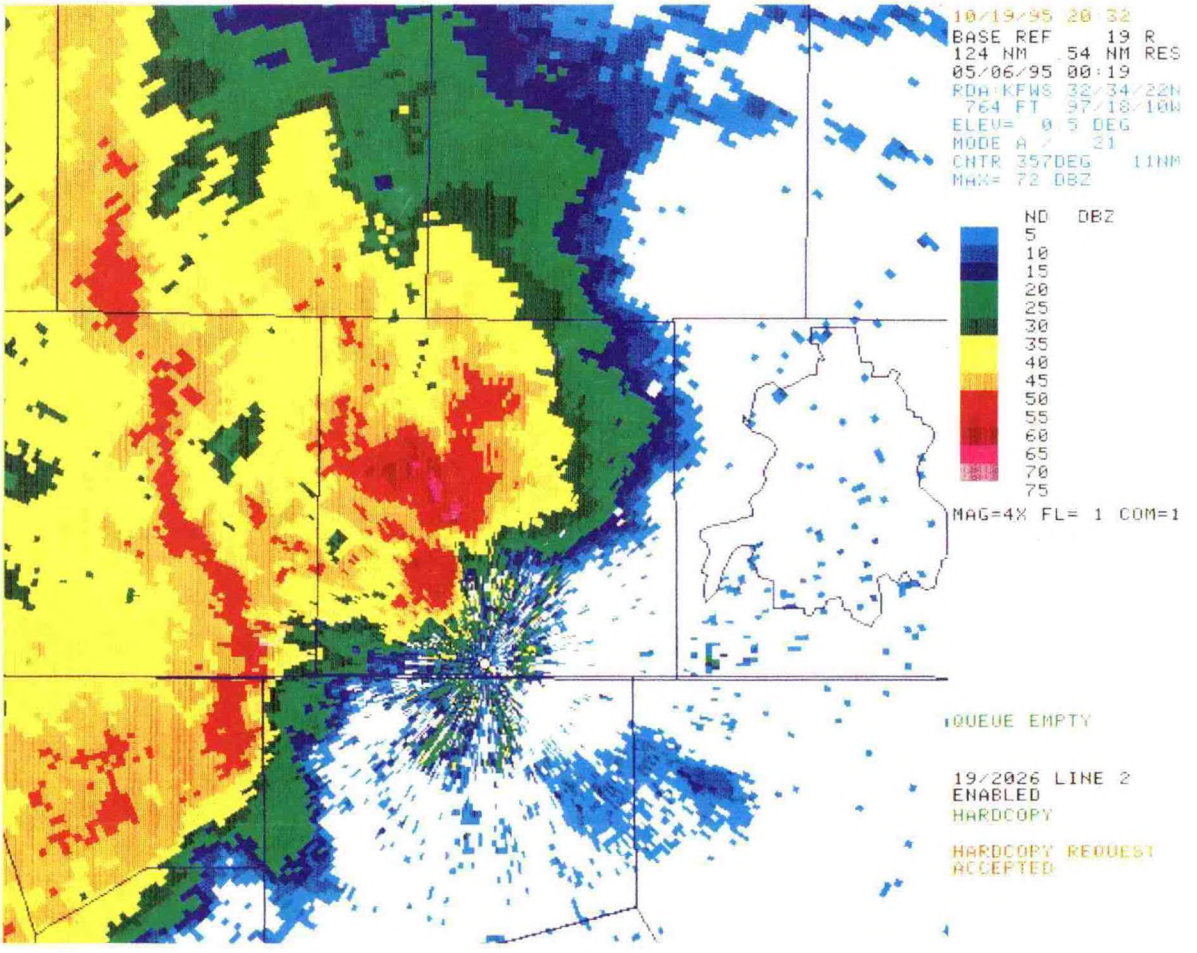
atural Disaster Survey Report

The Fort Worth-Dallas Hailstorm/Flash Flood

May 5, 1995



U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service, Southern Region
Fort Worth, Texas

November 1995

COVER: Fort Worth WSR-88D view (0.5 degree elevation reflectivity) of the supercell over Fort Worth. Softball size hail was falling at this time.

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National Weather Service
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National Weather Service, Southern Region
Harry S. Hassel, Director

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Preface

During the evening hours of May 5, 1995, a devastating hail storm and flash flood struck the heart of the Dallas-Fort Worth Metroplex. The National Weather Service's Southern Region Headquarters (SRH) appointed a Disaster Survey Team (DST) to review the operations and effectiveness of products and services of NWSFO Fort Worth before and during the event.

The DST members included the Team Leader, *Steven Cooper*, Assistant Chief of Meteorological Services, SRH; *Larry Eblen*, Warning Coordination Meteorologist, NWSFO Austin/San Antonio; *Bernard Meisner*, Techniques Development Meteorologist, Scientific Services Division, SRH; *Bill Reed*, Hydrologic Transition Manager, Hydrologic Services Division, SRH; *Gary Woodall*, Warning Coordination Meteorologist, SRH; and *Jeff Zimmerman*, Office of Hydrology, NWSH. The team first assembled Tuesday morning, May 9, at the SRH. Initial discussions focused on organizational purposes and the design of a strategy for the survey. The team developed an outline and provided assignments to all members.

During the afternoon of May 9, the DST interviewed the management team and others at both the NWSFO Fort Worth and West Gulf River Forecast Center (WGRFC). Wednesday, Larry and Bill visited local officials and media personnel in Dallas County while Gary and Jeff interviewed selected individuals in Tarrant County. The team planned to meet again Thursday, May 11. However, additional severe weather in the north Texas/southern Oklahoma area precluded this as Larry and Gary visited the Ardmore, Oklahoma area. The remainder of the team met and developed a list of preliminary findings and recommendations.

The team would like to thank all those individuals at NWSFOs Fort Worth and Norman and the WGRFC who helped in gathering data and meeting with the DST. The team also extends appreciation to local officials and media personnel for taking the time for interviews.

Executive Summary

On Friday, May 5, a typical springtime Southern Plains thunderstorm complex struck in the worst possible place (a major metropolitan area) at the worst possible time (a Friday evening).

During the late afternoon, an isolated severe thunderstorm developed ahead of a squall line approaching the Dallas-Fort Worth (DFW) Metroplex. The isolated supercell produced extremely large hail, damaging winds, and heavy rainfall as it passed over Tarrant County. The hail swath included the bank of the Trinity River where the outdoor Mayfest festival was in progress.

After a merger of the squall line and the isolated supercell, the storm complex slowed as it passed over Dallas County resulting in rainfall rates of nearly 2.25 inches per quarter hour. The survey team believes the rainfall *rates*, rather than the rainfall *amounts*, resulted in the flash flooding that occurred in Tarrant and Dallas counties.

The NEXRAD Weather Service Forecast Office (NWSFO) at Fort Worth, TX provided excellent services as this storm and others moved across the north Texas area. The office issued a severe thunderstorm warning for Tarrant County 15 minutes before the first reports of large hail were received. The NWSFO Fort Worth staff was in close contact with Emergency Management officials in Tarrant County as the storm moved across the area, and issued frequent statements updating the storm's location. As the storm tracked into Dallas County, resources at the NWSFO were redirected to address the combined severe weather and flash flood threat which the storm posed.

The May 5 storm was just the beginning of a very active severe weather week. From May 5 through May 10, 1995, tornadoes, very large hail, and extremely heavy rains buffeted residents of Texas, Oklahoma, and Louisiana.

During the early morning of Sunday, May 7, a supercell developed to the southwest of Amarillo, Texas. At 1:24 a.m., the NWSO at Amarillo issued a tornado warning for Randall County as the storm approached. The storm produced a strong (F2 on the Fujita scale) tornado at approximately 1:40 a.m. between the cities of Canyon and Amarillo. The tornado destroyed six mobile homes, a permanent home, damaged several buildings, killed one person and injured 12. The fatality occurred as a resident of the permanent home was attempting to get into a shelter. The early warnings allowed the mobile home residents to take shelter in more substantial structures. One resident specifically noted that his NWR had alerted him to the approaching storm.

On the afternoon of May 7, a supercell thunderstorm moved over northern portions of Texas and southern portions of Oklahoma. This supercell produced a strong (F3) tornado with a 44-mile long track. As the tornado moved across Montague and Love Counties, authorities reported four fatalities and 17 injuries. These casualties occurred despite warnings issued nearly 30 minutes in advance from NWSFOs Fort Worth and Norman with

follow-up statements pinpointing the storm's location. The storm then moved north-northeast into Carter County.

The tornado struck western portions of the city of Ardmore at 5:10 p.m. Ardmore is in east-central Carter County with a population of about 25,000. The tornado damaged or destroyed 28 homes and a school (which was closed) in southwestern Ardmore. As the tornado moved north, it paralleled Interstate 35 just west of the highway, and struck a Uniroyal tire plant with approximately 350 employees inside. The storm heavily damaged the Uniroyal plant and several other buildings in the area. The tornado also significantly damaged a truck stop just north of the plant. Despite the considerable damage to the west side of Ardmore and the large number of people in the storm's path, *no fatalities or injuries were reported in Ardmore*. This amazing statistic is due to many factors, including:

- The collaboration between the Ardmore Emergency Manager (EM) and the NWSFO at Norman, Oklahoma (OUN)

- The preparedness and spotter training conducted by the Warning Coordination Meteorologist (WCM) at OUN in cooperation with the Ardmore EM

- The cooperation between the Ardmore Emergency Operations Center (EOC) and the Uniroyal plant, the city's largest employer

- The emergency plan prepared by the plant's safety officers and rehearsed by the entire plant staff

- The early and accurate warnings and supplemental statements prepared by NWSFO Norman

- The application of tornado safety tips by the employees at the truck stop

From the 8th to the 10th of May, persistent thunderstorms produced torrential rainfalls and occasional severe weather over southeastern Louisiana. The rain, which totaled up to 20 inches in localized areas, resulted in widespread flooding in New Orleans and surrounding locations. At one point, the flood waters isolated the staff of the NWSFO and RFC at Slidell. The water level came within one inch of flooding the Slidell WSR-88D. Despite these operational difficulties, the NWSFO/RFC staff continued to provide vital services to the residents of southeast Louisiana and southern Mississippi.

Obviously, the staff and equipment at these offices were severely tested during these episodes of hazardous weather. The outstanding services provided by the office staffs was a testament to their dedication and professionalism; to the coordination efforts between the offices and local government and media officials; and to the public education programs led by all of the local entities.

Acronyms and Abbreviations

AM	Area Manager
ADAP	AFOS Data Analysis Program
AWIPS	Advanced Weather Interactive Processing System
CWA	County Warning Area
DAPM	Data Acquisition Program Manager
DFW	Dallas-Fort Worth
DST	Disaster Survey Team
EBS	Emergency Broadcast System
EOC	Emergency Operations Center
EMA	Emergency Management Agency
EMC	Emergency Management Coordinator
FIC	Forecaster-In-Charge
HAM	Licensed amateur radio operator
HAS	Hydrometeorological Analysis and Support
J/Kg	Joules/Kilogram
mb	Millibar
NEXRAD	Next Generation Radar
NIDS	NEXRAD Information Distribution Service
NOAA	National Oceanic and Atmospheric Administration
NSSFC	National Severe Storms Forecast Center
NSSL	National Severe Storms Laboratory
NWR	NOAA Weather Radio
NWS	National Weather Service
NWSFO	NEXRAD Weather Service Forecast Office
NWSH	National Weather Service Headquarters
NWSO	NEXRAD Weather Service Office
NWWS	NOAA Weather Wire Service
PUP	Principal User Processor (NEXRAD)
RADS	Radar Algorithm Display System
RDA	Radar Data Acquisition (NEXRAD)
RFC	River Forecast Center
RPG	Radar Product Generator (NEXRAD)
SAME	Specific-Area Message Encoder
SOO	Science and Operations Officer
SRH	Southern Region Headquarters
SWO	Severe Weather Outlook
TLETS	Texas Law Enforcement Teletype System
UTC	Coordinated Universal Time
VIL	Vertically Integrated Liquid
WCM	Warning Coordination Meteorologist
WDSS	Warning Decision Support System
WSR-57	Weather Surveillance Radar-1957
WSR-88D	Weather Surveillance Radar-1988 Doppler (NEXRAD)

Findings and Recommendations

Chapter 1

Finding: Organizers of many outdoor activities in the Dallas-Fort Worth area contact the Fort Worth NWS office for weather assistance during their events. Mayfest officials contacted neither the local office nor the EMA's office for assistance.

Finding: NWSFO Fort Worth issued a Severe Thunderstorm Warning specifically mentioning the threat of hail greater than two inches in diameter and winds in excess of 60 mph nearly 25 to 30 minutes before the storm hit the Mayfest area. However, Mayfest officials either did not receive the warning or did not take actions to mitigate the potential problem.

Finding: The DST believes the rate of rainfall (2.25 inches per quarter hour) rather than the total amount was a major factor in the large number of fatalities in Dallas. Other contributing factors included: (1) degree of urbanization, (2) failure of aging urban infrastructure, (3) the event in Dallas occurred after dark, and (4) areal coverage, although to a lesser degree.

Chapter 2

Finding: The WSR-88D provided invaluable information in the warning process. Storm Total precipitation estimates of four inches were in overall agreement with observed data.

Recommendation: Although the precipitation algorithm did well in this event, forecasters throughout the region have expressed a general lack of confidence due to the algorithm's poor performance in recent events. Additional studies should be undertaken to improve the performance of the system and provide greater confidence in the precipitation products.

Finding:	Although the DST does not believe this was a factor in this event, information from the Dallas ALERT system was not available at the Fort Worth NWS office. It could provide valuable information in future flash flood events.
Recommendation:	Efforts to access these Dallas rainfall data in real time should be accelerated.
Recommendation:	All NWS offices should review their areas for existing ALERT type data networks and the potential for accessing the data.
Finding:	The WDSS (Warning Decision Support System) demonstrates the value of being able to integrate multiple data sets on a single workstation.
Recommendation:	Consideration should be given for integrating the WDSS into AWIPS.
Recommendation:	The development and deployment of AWIPS, which will allow the forecaster to integrate many data sets onto a single workstation, should proceed as quickly as possible.

Chapter 3

Finding:	In past years, the amateur radio operators had access to monitors from the conventional network radars. Although the data from the WSR-88Ds are superior to those obtained from the other radars, there is no convenient method for providing the ARCs (Amateur Radio Coordinator) with direct WSR-88D access.
Recommendation:	Additional WSR-88D displays should be provided to the forecast staff and others involved in the warning process.

Finding: West Gulf RFC personnel remained on duty several additional hours Friday night to access the potential for river flooding associated with this event. Normal hours of operations are 16 hours per day. Twenty four hour operations began Saturday morning.

Recommendation: To integrate the HAS forecasters into the short term forecast program, they should provide additional information (guidance) related to short term flash flood potential to offices in their areas of responsibility.

Finding: The Warning Decision Support System (WDSS), being tested at NWSFO FTW, was found invaluable in severe weather operations. Utilizing the WSR-88D data, the Radar Analysis and Display System (the display component of the WDSS) was found superior to the PUP. It allowed the forecasters to interrogate the character of storms in a more timely and comprehensive manner. The hail size algorithm was especially useful.

Recommendation: Information on the WDSS needs to be made available to the groups looking at the open system porting of the RPG and to AWIPS.

Chapter 5

Finding: The NWSFO staff provided timely, informative warnings with all interviewees complimentary of products and services and with their relationship with the Fort Worth NWS office.

Finding: While staffing levels are adequate for infrequent, short duration weather events, prolonged events lasting for hours, or multiple events over weeks and months strains staffing resources.

Recommendation: During the transition into the modernized NWS, additional staffing should be provided to allow maximum utilization of the new technologies.

Chapter 1

Description and Impact of the Event

During the evening of Friday, May 5, 1995, a supercell thunderstorm and squall line moved across Tarrant and Dallas Counties, Texas. The storm produced torrential rainfall in a very short time, softball size hail, and wind gusts to 70 miles an hour as it moved across the area. Major impacts from the storm were felt west of downtown Fort Worth, where an outdoor festival was in progress; in central Fort Worth, where the hail was a major destructive force; and in north central Dallas, where intense rainfall produced flash flood conditions. The storm left more than $900 million in insured losses with hundreds of injuries (Appendix A). Authorities can directly relate nineteen fatalities to the storm including sixteen flash flood victims (Appendix B).

1.1 Overview of Tarrant and Dallas Counties

Tarrant and Dallas Counties compose the heart of the Dallas/Fort Worth Metroplex. They are both heavily populated, with a combined population of nearly 3.1 million. Dallas/Fort Worth is a major commercial center with many companies having industrial complexes and/or headquarters facilities in the area.

Located in north central Texas, Tarrant and Dallas Counties are near the climatological maximum of large hail occurrences that extend through the southern and central Great Plains. Severe weather is not an uncommon occurrence in the counties. On May 4, 1989, a derecho tracked across the Metroplex, producing winds to 100 miles an hour and very heavy rainfall. Four people were killed when flood waters trapped them in their vehicles, and widespread damage was reported in the counties. On April 28, 1992, a supercell caused more than $600 million in damage across the area. Hail up to softball size and wind gusts of 80-100 miles an hour were reported.

On April 25, 1994, a supercell tracked across southern Tarrant and Dallas Counties. The hail, again up to softball size, caused nearly $200 million in damage. The storm also produced a violent tornado that struck De Soto and Lancaster, in southern Dallas County (see the Southern Region Disaster Survey of September 1994). On April 29, 1995, a storm pounded the Dallas/Fort Worth Airport with baseball size hail, damaging more than 70 aircraft and causing major disruptions to the airline industry.

1.2 Impact in Tarrant County

The supercell thunderstorm that affected Tarrant and Dallas Counties on May 5 developed to the west of the DFW area in Palo Pinto County. The storm intensified steadily as it moved into Parker County by 6:00 p.m. (Figure 1.2.1). The supercell had developed at the south end of a short line of storms. Farther west, a longer line of storms extended from near Graham to near Breckenridge to near Brownwood.

Thunderstorms in this line were also severe, producing damaging wind gusts and golfball size hail.

The supercell continued to intensify as it moved across Parker County. Very strong radar reflectivities (up to 77 dBZ at one time) and high Vertically Integrated Liquid (VIL) values were detected in the storm, suggesting the presence of large hail. Spotters reported hen egg to baseball size hail in central and eastern Parker County, with hail covering the ground to a depth of 2 feet in some locations. Damage was reported to many cars and buildings between 6:30 and 7:00 p.m. Behind the supercell, the large squall line continued moving east, reaching a line from Jacksboro to east of Mineral Wells to near Stephenville by 6:45 p.m. (Figure 1.2.2).

The core of the supercell, containing the heaviest rain and largest hail, moved into Tarrant County just after 7:00 p.m. The supercell continued east, and moved over Fort Worth about ten minutes later. As the storm tracked across Fort Worth, amateur radio spotters logged more than 80 reports of large hail, including many reports of baseball to softball size hail (Appendix C). The hail damaged thousands of vehicles and hundreds of buildings, including most of the buildings in downtown Fort Worth.

At the time the storm struck, several thousand people were attending an outdoor festival, entitled Mayfest, in west-central Fort Worth. Mayfest is an annual event, held on the west bank of the Trinity River, where the river winds through the west side of Fort Worth. The festival site is a low-lying, open area with few permanent structures and limited parking. Mayfest attendees had to park at remote lots, and were transported to the festival via busses.

As the supercell moved into eastern Parker County, NWSFO Fort Worth issued a severe thunderstorm warning at 6:45 p.m. for Tarrant County. The severe thunderstorm warning specifically mentioned 2.5 inch hail and winds greater than 60 mph. The impact of the storm was felt at the Mayfest celebration around 7:10 p.m., as large hail--up to 4 inches in diameter--began falling. Interviews with NWS personnel, local emergency management officials, local media, and Mayfest organizers indicated Mayfest organizers had made no arrangements (other than equipping the ranking police officer with a NWR) for weather-related coordination and support with either the local NWSFO, emergency management operations, or any of the local media outlets. There also may be some confusion whether they received the 6:45 p.m. severe thunderstorm warning at Mayfest. As a result, no information regarding thunderstorm activity was relayed to the Mayfest attendees until 7:00 p.m. An announcement closing the festival was not made until shortly after that, barely five minutes before the large hail started falling.

In the aftermath of the event, an impromptu triage facility was set up at Mayfest, and upwards of 400 people were treated. Amazingly, there were no fatalities, although approximately 60 people required hospitalization.

Meanwhile, shortly before 7:00 p.m., a portion of the squall line began accelerating eastward. This resulted in a bow echo configuration in the squall line over southern Parker County, with over

50-knot velocities indicated just behind the bow. By 7:15 p.m., the leading edge of the bow echo was about 12 miles southwest of the supercell's core (Figure 1.2.3).

The supercell continued moving to the east, dropping baseball to softball size hail on eastern Fort Worth between 7:30 p.m. and 7:45 p.m. Wind gusts to 70 mph were reported in southeast Fort Worth, near the storm's rear-flank downdraft (RFD). Quarter-size hail was reported in northeastern Tarrant County.

At this time, the NWSFO received reports of high water in western Fort Worth. The WSR-88D indicated a swath of two to two and a half inches of rain (one-hour precipitation) across western and northern Fort Worth (Figure 1.2.4), and a Flash Flood Warning was issued. The bow echo continued east across southern Tarrant County. Winds above 64 knots were detected in the area just behind the bow shortly before 8:00 p.m., and strong cyclonic shear was evident on the north side of the bow at the same time. At 7:50 p.m., building damage was reported in southern Fort Worth associated with the bow echo. The bow echo's strongest reflectivity was just a few miles southwest of the supercell by 8:00 p.m., and it is likely that some interaction was occurring at this time. Also at this time, the first reports of flooding were received from amateur radio spotters in southwestern Fort Worth.

The supercell and squall line merged just after 8:00 p.m. over eastern Tarrant County (Figure 1.2.5). The area near the merger changed into a large comma-head configuration within two volume scans of the merger. Reflectivity values decreased somewhat, but remained more than 60 dBZ. Two-inch diameter hail and 70 mph winds were reported east of DFW Airport as the storm crossed into Dallas County (Figure 1.2.6).

1.3 Impact in Dallas County

The primary impact in Dallas County was severe flash flooding by an extremely high intensity, short duration rainfall event. After the merger of the supercell and the squall line, the northern end of the line of thunderstorms - the area of the comma head configuration - slowed markedly as it moved through Dallas County. Rainfall rates in this area approached 2.25 inches in 15 minutes (Appendix D). The rainfall rates, more than the rainfall amounts, caused flash flooding in this highly urbanized area.

As the storm system approached Dallas County, its history had suggested a continuation of the threat of large hail, damaging wind, and perhaps even tornadoes. The SKYWARN network for Dallas County was activated at 7:30 p.m.; the leading edge of the storm system moved into the county around 7:45 p.m. Reports were received almost immediately of a wall cloud increasing in size. At 7:55 p.m., a tornado warning was issued for the county and sirens were sounded. A tremendous number of calls to the Dallas 911 system began almost immediately, causing delays in responding to the calls. A backlog in answering 911 lines continued through the remainder of the event.

Just before 8:20 p.m., the NWSFO received conflicting reports regarding the storm's intensity trend. The WSR-88D

indicated a decrease in storm rotation. However, spotters reported that the storm's wall cloud became better defined. It was at 8:20 p.m. that Dallas emergency operations began to place barricades along flooded streets and to clear debris from streets.

The Dallas EMC received the first reports of heavy rain at 8:25 p.m. At 8:31 p.m., another report of a 2.00 inch accumulation just east of Dallas-Fort Worth Airport was received. The first report of rainfall more than 4 inches was received at 8:45 p.m. with street flooding also indicated. Between 8:45 p.m. and 8:50 p.m., several more reports of rainfall near 2 inches were received from the western and central parts of Dallas.

Although the NWSFO staff did not have reports of flooding when the decision was made to issue a Flash Flood Warning, the NWSFO completed and transmitted a Warning for Dallas County at 8:58 p.m. While composing the Warning, several reports received between 8:54 p.m. and 9:00 p.m. indicated flash flooding associated with rainfall more than 3 inches. At 8:57 p.m., the NWSFO received the first report of a car stranded in high water. At 9:03 p.m., they received the first report of flooding in a home. The 8:58 p.m. (01:58 UTC) One Hour Precipitation data from the Doppler Weather Radar (Figure 1.3.1) was received around 9:03 p.m. and indicated nearly three inches of rainfall during the past one hour.

The meteorological situation remained complicated, as golfball-size hail was reported at 9:07 p.m. with damaging wind in northeast Dallas. Doppler Weather Radar at this time indicated upper level rotation in the system just east of Dallas. Rotation continued to be reported in this storm system until it exited the county. At 9:14 p.m., a second Tornado Warning was issued for Dallas County. At 9:16 p.m., the windows of a building in east Dallas were reported knocked out by hail. At 9:18 p.m., the roof of the Haggar plant (in north Dallas) collapsed due to the extreme weight of water on its roof, killing two people. At 9:30 p.m., the Tornado Warning for Dallas County was replaced with a Severe Thunderstorm Warning.

At its peak, this widespread event required the efforts of more than 1200 employees of the city of Dallas. They rescued hundreds of motorists from cars stalled in high water. More than 350 vehicles had to be towed because of weather-related damage.

Chapter 2

Summary of Forecast and Warning Services

The atmospheric conditions that combined to produce the Tarrant-Dallas County event could not be considered "classical" for flash flood occurrence. Neither did the synoptic environment closely resemble those of a classic strong wind event. In spite of this, some features conducive to the formation of severe weather were recognized in the analysis of data from the evening of May 4 and throughout the day of May 5. The staffs of NWSFO Fort Worth and NSSFC in Kansas City addressed these features in their severe weather outlooks.

Once the thunderstorm complex developed, extensive use was made of WSR-88D data and storm spotter reports. Forecasters at NWSFO Fort Worth also had available to them, for beta testing, the Warning Decision Support System (WDSS) developed by the National Severe Storms Laboratory. The WDSS combines radar, lightning and gridded meteorological data to help forecasters in identifying the cells within the cylinder of radar coverage that are most likely to produce severe weather. The WDSS incorporates experimental radar algorithms and time history displays not available on the WSR-88D Principal User Processor (PUP). The NWSFO Fort Worth forecasters found the WDSS to be very useful in this event.

Synoptic-Scale Evolution and Forecast Services

On the morning of May 5, a stationary front was oriented east-west over central Texas with a dry line in extreme West Texas. A region of low surface pressure was developing in the Great Basin, while an area of high pressure was over the central Plains. In the middle to upper troposphere, a deep low lay over the West Coast with a ridge axis over the Great Plains. Low level winds were from the east over much of Texas and Oklahoma, while winds aloft were from the south to southwest.

The severe weather outlook issued by the National Severe Storms Forecast Center on the morning of May 5 indicated a slight risk of severe weather for the NWSFO Fort Worth county warning area. A North Texas Severe Weather Outlook (NTSWO) was issued at 1:15 p.m. The NTSWO is routinely issued by NWSFO Fort Worth whenever a portion of their forecast area is included in a severe weather outlook. Although not specifically mentioned for the metro area, the NTSWO noted that the main threat for severe weather would be from large hail and damaging winds.

The weather components conducive to severe weather mentioned in the NTSWO included the east-west oriented warm front over the northern part of the state and a series of upper level disturbances expected to traverse the area throughout the day (Figure 2.1).

The 1200 UTC upper air sounding (Figure 2.2) from Fort Worth indicated strong instability, with a Lifted Index of -5 and a

Convective Available Potential Energy (CAPE) of 1371 J/kg. Although the sounding was unstable, there was a capping inversion in the low levels. Winds in the sounding were moderately strong. A southerly low-level jet extended from 1000 to 2000 m MSL (mean sea level) with winds greater than 40 knots. Winds in the mid to upper levels were from the southwest with speeds of 47 knots at 500 mb and 75 knots at 300 mb. Maximum updraft strength estimated from the sounding was 52 m/sec, which would be capable of supporting the development of large hail.

The 1200 UTC model runs did not indicate a significant potential for severe weather over the metroplex. The 12-hour forecast from both the Eta and NGM models suggested that the dry line would remain in west Texas. The Eta model accurately forecast the CAPE to be approximately 1200 J/Kg. The strong low level flow and 850 mb moisture ridge were predicted to remain in west Texas. Weak to moderate southerly flow in the lower troposphere was predicted over the state. Weak cyclonic flow was forecast at 500 mb with synoptic scale lift over west and central Texas. At 200 mb there were substantial differences between the Eta and NGM forecasts. The Eta model forecast indicated that North Texas would be under the right rear quadrant of a jet streak (Figure 2.3), an area favorable for convection; the NGM forecast indicated a jet streak over west Texas (Figure 2.4).

As an upper level disturbance passed over West Texas shortly before noon, a line of thunderstorms developed along the dry line near the Texas-New Mexico border. This squall line moved rapidly to the east while the dry line remained in West Texas. Surface winds in north and west Texas were from the east ahead of the squall line, and remained from the east after passage of the line. Dew points decreased only slightly after the passage.

Storm Scale Evolution and Warning Services

As the squall line moved eastward, the squall line took the shape of a classic bow echo, usually associated with damaging winds. Cells formed in the outflow ahead of the bow echo but were quickly overtaken by it. By 4:00 p.m. the squall line entered the NWSFO Fort Worth CWA. Severe thunderstorm warnings were successively issued for Haskell, Stephens, Eastland, Parker, Comanche and Erath counties.

At 5:34 p.m., the WSR-88D showed a thunderstorm approaching the Palo Pinto/ Parker County line ahead of the squall line (Figure 2.5). As the supercell moved toward the northeast across Parker and Tarrant counties, it intercepted the low level flow of warm moist air ahead of the squall line. At 5:48 p.m., a severe thunderstorm warning was issued for Parker County, highlighting the possibility of one and one-half inch hail and winds in excess of 60 mph.

The NSSFC issued a Severe Thunderstorm Watch for a large part of North Central Texas at 5:53 p.m. This watch replaced one that had earlier been issued for portions of central Texas. The watch noted the potential for large hail and damaging winds. Reports of large hail were received from Parker County by 6:17 p.m.

At 6:45 p.m., a Severe Thunderstorm Warning was issued for Tarrant County. The warning noted that hail as large as 2.5 inches and winds in excess of 60 mph were to be expected. At 7:06 p.m., a tornado warning was issued for Tarrant County based on the WSR-88D data (Figures 2.6 & 2.7).

The supercell produced an unconfirmed tornado in Parker County and extremely large hail and damaging winds as it passed over Tarrant County. The hail swath included the bank of the Trinity River where the outdoor Mayfest festival was in progress.

The 0000 UTC Fort Worth upper air sounding was released shortly before the squall line passed over the radiosonde site with the isolated supercell just south of the site. The sounding therefore should not be considered representative of the pre-storm environment. Winds then were 30 and 40 knots from the south at all levels up to 400 mb.

After the squall line overtook the isolated supercell over eastern Tarrant County, the storm complex slowed as it passed over Dallas County after dark, resulting in rainfall rates in excess of two inches per quarter hour (Figure 2.8). Doppler Weather Radar indicated a circulation moving along and just to the north of the I-30 corridor between the cities of Arlington and Dallas. As a result, a tornado warning was issued for Dallas County at 7:52 p.m.

Rain began falling in Dallas County shortly before 8:00 p.m. By 8:15 p.m., 0.75 inches of rain was recorded by the City's network[1] in the extreme western part of Dallas County. Measured rainfall rates increased to more than one inch per quarter hour as the storm approached the city center. Rainfalls in excess of two inches per quarter hour were measured north and south of the city center by 9:00 p.m (Figure 2.9). One gage located at Inwood and University Boulevard recorded 2.24 inches from 8:45 to 9:00 p.m.

At 8:40 p.m., the emergency rooms in the basements of Parkland and Baylor Hospitals in Dallas County were reported closed due to high water at the entrances and water in the buildings. A flash flood warning was issued for Dallas and Ellis counties at 8:58 p.m., based in part on Doppler radar estimates. At 9:09 p.m., a tornado warning was issued for eastern Dallas County.

Heavy rains continued to fall as the storm complex passed over Dallas. At 9:30 p.m., several rain gauges in northeast Dallas reported rates of approximately two inches per quarter hour (again refer to Figure 2.9). By 10:00 p.m., the rain had nearly ceased over Dallas, with storm total precipitation--as measured by the rain gauge network--varying from 0.79-4.73 inches, with most gauges reporting totals in the two to four inch range (Appendix D). WSR-88D storm total precipitation estimates (Figure 2.10) indicated three to four inch rainfalls over the area.

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[1]*Between 1991 and 1992, the City of Dallas installed a $2.4 million computerized early warning system that includes a network of 42 automated rain gauges (see Appendix E for gage locations). These gauges can be interrogated as frequently as every five minutes. However, as noted earlier, these data were not available to NWSFO FTW during the event.*

Between 9:00 and 11:00 p.m., severe thunderstorm warnings were issued for Kaufman, Navarro, Hamilton, Van Zandt, Smith, Rains, Wood, Cherokee and Upshur counties as the northern part of the storm system continued to progress to the extreme eastern portion of the NWSFO FTW CWA.

Additional severe thunderstorms in the southern portion of the CWA, associated with the storm complex, resulted in the issuance of severe thunderstorm and flash flood warnings for Mills, Hamilton, Bosque, Coryell, Limestone, McLennan and Hill counties between 8:30 and 11:00 p.m.

Chapter 3

Severe Weather Operations

3.1 NEXRAD Weather Service Forecast Office

3.1.1 Staffing

To increase the efficiency of NWSFO Fort Worth's severe weather operations, the NWSFO staff developed and implemented a Severe Weather Operational Staffing Configuration Guide. See the De Soto/ Lancaster Disaster Survey of September 1994 for a copy of the plan in its entirety. The following is a review of the staffing for May 5-6, 1995.

Warning Coordinator

Michael Foster until 8:45 p.m.
Jim Stefkovich 8:45 p.m. - 1:00 a.m.
Gifford "Skip" Ely after 1:00 a.m.

The *Warning Coordinators (WC)* served as overall supervisors of the office's severe weather operations. They had the final input regarding warning decisions and ensured that all hazardous weather functions were completed.

Assistant Warning Coordinator

Brian Curran 6:00 p.m. - 1:00 a.m.

The *Assistant Warning Coordinator (AWC)* assisted the *Warning Coordinator* by typing hazardous weather products, monitoring expiration times of various warnings, and ensuring that severe weather log sheets were updated. The *AWC* helped ensure that hazardous weather information reached the media, public, and others in a timely manner.

Information Officer

Jim Stefkovich 7:00 p.m. - 8:45 p.m.
Michael Mach and Jesse Moore 8:45 p.m. - 10:00 p.m.
Roland Nunez 10:00 p.m.-1:00 a.m.

Assistant Information Officer

Kurt Hondl (NSSL Staff)
Douglas Cain
Larry Maifeld
Skip Ely 9:30 p.m. - 1:00 a.m.

The *Information Officer (IO)* and assistants served as the primary coordination points for all incoming and outgoing contacts regarding hazardous weather. The *IO* team provided briefings to Emergency Managers, requested activation of spotter groups, and passed radar updates to the amateur radio operators stationed at the NWSFO. Significant information was forwarded to the *Warning Coordinator* or the *AWC*.

WSR-88D Interpreter

Wendell Hohmann - Dyess
Michael Mach - Fort Worth Spinks
Skip Ely - Granger
Ed Calianese - RADS (Radar Algorithm Display System)

A meteorologist was assigned to each Principal User Processor (PUP) to maintain a continuous weather watch. Significant information was passed on to the *Warning Coordinator* or the *AWC*.

In 1995, NWSFO Fort Worth was a test site for the NSSL WDSS (Warning Decision Support System). The WDSS consists of a number of radar algorithms running on a Sun workstation. The algorithms evaluate maximum hail size, the presence of a mesocyclone, TVS, VIL values, and other parameters to identify the storm(s) with the highest severe weather potential. The software then ranks the storms based on these severe weather parameters. The RADS is the display component of the WDSS and allows the user to view and analyze the information by color coding parameters, zooming on individual cells for closer interrogation, etc. These evaluations are updated after each volume scan.

In addition to the evaluation algorithms, WDSS also provides users with a time series of many parameters, such as mesocyclone base and height, VIL value, echo top, and maximum reflectivity. Early feedback from the NWSFO forecasters suggests that this is a valuable system that was of great assistance during the 1995 severe weather season. It was especially useful during those times when many potentially severe storms were present, allowing the staff members to focus their attention and resources on storms with the highest likelihood of producing severe weather.

NOAA Weather Radio/Public Service

Douglas Cain
Larry Maifeld

NOAA Weather Radio (NWR) has long been recognized as an important tool for disseminating hazardous weather information to the public. The *NWR/Public Service* team maintained NWR programming by incorporating the latest warnings and statements into the broadcast cycle. *NWR* operators also activated SAME, the Specific Area Message Encoder, as pertinent products were broadcast.

Public Forecaster

Brian Curran 4:00 p.m. - 6:00 p.m.
Jesse Moore 6:00 p.m. - 8:00 p.m. and 9:30 p.m. - midnight
Michael Mach 8:00 p.m. - 9:30 p.m.

The *Public Forecaster* maintained the integrity of the public forecast products, including the zone and state forecasts. The *Public Forecaster* also coordinated severe weather watches with the Lead Forecaster (for those cases when the *Public Forecaster* was a journeyman), NSSFC, and adjacent offices.

Aviation Forecaster

Jesse Moore

The *Aviation Forecaster* maintained a weather watch to ensure the integrity of the terminal and route forecasts provided by NWSFO Fort Worth.

Amateur Radio Coordinators

Larry Dowdy, N5RES
Dennis Davis, N5JIL
Lawrence Priddy, K5LP

The NWSFO staff called amateur radio operators into the NWSFO Fort Worth at the onset of hazardous weather in north Texas. The *Amateur Radio Coordinators (ARC)* maintained contact with amateur radio spotters in Tarrant and nearby counties. The coordinators provided a flow of information from the NWSFO in the form of WSR-88D radar updates, and to the NWSFO by receiving visual observations and other reports.

3.1.2 WSR-88D

NWSFO Fort Worth is one of a few offices to have access to data from three WSR-88Ds. The RDAs for these systems are at Spinks Airport in Fort Worth, near Granger, Texas (in Williamson County), and near Moran, Texas (the "Dyess AFB" radar, in Shackelford County). When thunderstorms broke out, the *Warning Coordinator* assigned a meteorologist to each PUP, with the meteorologists maintaining a continuous weather watch during the event.

While staffing all three PUPs during severe weather operations presents a considerable workload problem, the staff at the NWSFO has noted that interpreting data from all PUPs is essential to a successful operation. The storm-scale changes that occurred, especially around the time of the squall line/supercell merger, made continuous radar observations essential.

3.1.3 Amateur Radio Operators

Members of the Tarrant County RACES (Radio Amateur Civil Emergency Services) organization volunteer to work at NWSFO Fort Worth during periods of hazardous weather. On May 5, RACES members arrived at approximately 5:00 p.m. to begin the task of organizing the spotters and serving as a liaison to other county spotter groups.

Due to its large CWA, NWSFO FTW has seven amateur radio base stations located adjacent to the forecast operations area. The large number of base stations allows the *ARCs* to communicate with several county spotter groups concurrently. This configuration also allows the amateur radio coordinators to receive and relay information to and from the Warning Coordinator as quickly as possible.

In past years, the amateur radio operators had access to drops from the Longview and Stephenville network radars, and the 5-cm Doppler radar from KXAS-TV. While the data from the WSR-88Ds is superior to those obtained from the other radars, there is no convenient method for providing the *ARCs* with direct WSR-88D access. This necessitated additional coordination and dialogue between the *ARCs* and the *Warning Coordinator*.

3.1.4 Dissemination

NWSFO Fort Worth has four NOAA Weather Radio consoles that provide programming for six transmitters. One console serves the Fort Worth and Dallas transmitters, one programs the Paris and Sherman transmitters, one is connected to the Tyler transmitter, and one serves the Waco area.

The number of consoles and transmitters at NWSFO FTW makes programming and updating NWR a laborious task. Nevertheless, the NWSFO staff was able to keep NWR up to date. In addition, the Fort Worth/Dallas console has the Specific Area Message Encoder (SAME), which was activated as needed for events in the Dallas/ Fort Worth area.

SRWARN was the primary software used for warning and statement generation. Several personal computers in the NWSFO are loaded with the SRWARN software, allowing the generation of many products

concurrently. SRWARN performed smoothly during the event.

The NWSFO has a dedicated phone line to the Dallas EOC, while conventional phone service and amateur radio are used for communication with the Fort Worth EOC. Staff at the NWSFO was in near-continuous contact with emergency management personnel from Fort Worth, Dallas, and other surrounding communities who were also being impacted by hazardous weather.

3.2 West Gulf River Forecast Center (WGRFC)

There are two consecutive Hydrometeorological Analysis and Support (HAS) shifts daily, providing scheduled coverage from 6:00 a.m. to 10:00 p.m. Two of the primary tasks assigned these shifts are 1) Stage III Precipitation Processing, and 2) Hydrometeorological Discussions. A third task in the future will be the coordination of Quantitative Precipitation Forecast (QPF) efforts as related to the RFC's operations.

3.2.1 Staffing

Forecaster In Charge

Mike Schultz 8:00 a.m. - 4:30 p.m.

HAS

Jack Kaitala 6:00 a.m. - 2:00 p.m.
Chris Bovitz 2:00 p.m. - Midnight

3.2.2 Stage III Precipitation Processing

Stage III precipitation processing of WSR-88D data occurs at the RFCs. Stage III is the step in WSR-88D precipitation processing where the Hydrometeorological Forecaster quality controls the data, modifies it when necessary, and mosaics the data from all WSR-88D radars providing coverage within the RFC's area of responsibility. This process provides the best precipitation information for input into the RFC's models. However, because of the steps and the data requirements of this process, the Stage III product is not useful for issuing warnings in most flash flood situations, since the Stage III product is not available in near real time.

3.2.3 Hydrometeorological Discussions

The RFC staff routinely prepares a Hydrometeorological Discussion as part of the morning HAS shift duties. The discussion covers the RFC area of responsibility and includes from that perspective: 1) a meteorological discussion, 2) precipitation over the past 24 hours, 3) QPF from NMC, 4) flood potential and hydrologic discussion, and 5) an outlook.

Chapter 4

Preparedness Activities

The NEXRAD Weather Service Forecast Office (NWSFO) in Fort Worth takes an aggressive approach to its preparedness programs, including storm spotter training, weather preparedness and warning coordination for 57 counties throughout north Texas. A strong emphasis is placed on both organizational and individual training and education in severe storm identification and safety guidelines. This emphasis encourages emergency operations plans, aiding the public with proper protective measures, storm reporting networks, and effective warning dissemination.

Between January 1994 and April 1995 alone, nearly 2400 persons were trained at numerous NWSFO SKYWARN presentations in the Dallas/Fort Worth Metroplex. These frequent and highly attended SKYWARN presentations have been regularly provided by Fort Worth office since 1971.

In addition, since the late 1970s, each spring severe weather season is preceded by a statewide Severe Weather Awareness Week, usually held in March. During this week, people are encouraged to become familiar with severe weather safety rules. NWSFO Fort Worth mails out approximately 800 information packages to the media, law enforcement, emergency managers, and school districts across north Texas. These packages provide information on severe weather and severe weather safety, and are intended to reach the public through mass media outlets such as newspapers and commercial broadcast stations.

The NWSFO works closely with all Emergency Management Agencies (EMA) within the 57 counties of their CWA and has an excellent working relationship with both the Tarrant and Dallas County EMAs.

A listing of preparedness activities for Tarrant and Dallas Counties from January 1994 through March 1995 is included in Appendix F of this report.

Chapter 5

User Interviews

The DST interviewed various customers in both Tarrant and Dallas Counties. The following are summaries of those discussions.

Tarrant County

Fort Worth Emergency Manager
Jim Marx
Emergency Management Officer
Ted Jones
Technological Services Officer
James Scarberry
EMO Volunteer
John Ruth

Mr. Marx said that at the time of the event Friday evening, only two people were staffing the emergency operations center (EOC). Those people were busy answering telephones and trying to bring up the county spotter network. The network, consisting of Tarrant County RACES members, is typically activated by the EOC based on input from NWS. Mr. Marx called the NWSFO around 6:00 p.m. to see if they wanted the network activated. One of the problems in getting the network activated on this evening was that some key players, including many network controllers, were out of town.

The EOC staff expressed some concern about the way RACES is activated. They said it takes them about one hour to fully activate their network. Therefore, they need at least 1-1.5 hour lead time. They also said they were not concerned if network was activated, but no significant weather occurred.

Mr. Marx also indicated that he felt the response of the NWS was a little late because no warnings came across the television until after 7:00 p.m. At the time of the event, the EOC did not have the NOAA Weather Wire Service. They do have NOAA weather radio, but on that evening it was apparently in another room and unavailable to the people who were answering the phone and trying to establish the spotter network. One of the televisions in the EOC was turned on to the local cable channel that broadcasts a feed of a local weather radar. Based on Mr. Marx's observations of the local radar feed, and without any NWS warning (at least as far as he was concerned), he sounded the Fort Worth siren system at 7:03 p.m. The siren was sounded again at 7:13 p.m. in response to the tornado warning issued by NWSFO FTW at 7:06 p.m.

Marx indicated that the Fort Worth EOC had no contact with the Mayfest organizers. A minimal amount of weather support for the Mayfest activities was coordinated with the KXAS-TV weather department.

Director, Fort Worth City Parks and Recreation
Richard Zavala

Mr. Zavala stated that plans for large outdoor events include a police officer who monitors the NOAA Weather Radio.

Mr. Zavala contacted the officer in charge at Mayfest around 7:00 p.m. The officer in charge informed Mr. Zavala that a "thunderstorm watch" was in effect. At that time, a message was broadcast over the public address system at Mayfest advising attendees to use this information at their own discretion.

Bernard Meisner from the Disaster Survey Team informed Mr. Zavala that the local Amateur radio group had expressed interest in assisting the Parks and Recreation Department with weather support with next year's Mayfest. Additionally, Mr. Meisner provided Mr. Zavala NWSFO Fort Worth's Warning Coordination Meteorologist's telephone number for any assistance he may need.

KRLD Radio
Frieda Ross-Finley

Ms. Ross-Finley felt that the products and services provided by NWSFO Fort Worth were "excellent" regarding their timeliness and accuracy. KRLD subscribes to the NOAA Weather Wire Service as their primary means of receiving hard-copy information. KRLD also has a satellite link to KXAS-TV, with which they can receive radar information or speak with one of the on-air meteorologists.

KRLD provided frequent weather updates during the late afternoon and early evening. After the storm moved across Fort Worth, they interrupted regular programming and provided continuous weather coverage from 7:50 p.m. to 10:30 p.m. During this time, they received frequent updates from the NWS and KXAS, and took phone calls from listeners. Ms. Ross-Finley noted that none of the listeners who called in to KRLD were critical of the NWS or its services.

KXAS-TV Channel 5
David Finfrock

Mr. Finfrock felt that overall NWS services were good, although the NWSFO seemed a little slow to react when the supercell storm was over Parker County. From Benbrook (southwest Tarrant County) eastward, though, he felt that NWS services were quite good.

On the 5:00 p.m. newscast, he mentioned that he thought thunderstorm activity would pass to the north and west of the Dallas-Fort Worth Metroplex. By the time of the 6:00 newscast, however, it was evident that the storms would indeed move through the area. Mr. Frinfrock reflected this updated information in his weathercast, as he indicated a potential for severe weather in the area.

He indicated that the Mayfest communications staff called and talked to someone at the station (not him). He did not recall the exact time of the call, and did not have an entry of the call in any of the station records. He estimated the time of the call at around 7:05 p.m. To his knowledge, this was the only contact the station had with the Mayfest officials.

Based on the spotter reports received, the newscast focused on the large hail event in Tarrant County. As the storm moved into Dallas County, spotter reports of large hail quickly decreased. Mr. Finfrock stated that, as the storm moved into Dallas County, he noticed it slowing and mentioned this on the air, and specifically mentioned the potential for heavy rain/flash flooding (this is in line with what NWSFO FTW was thinking). He

placed the timing of this around 9:00 p.m. He mentioned that since the giant hail was such an immediate threat, the newscast focused on this versus flash flood potential.

When asked about how they disseminate warnings, he stated that KXAS insists on meteorologists with professional degrees. The station has three, and they all make their own forecasts. They receive the NOAA Weather Wire Service and they subscribe to Kavouris for NIDS and other weather products. When they receive a severe thunderstorm warning, they look at the situation and use their judgement concerning whether to pass that warning on to the public. Depending on the situation, this could result in a delay between the time the NWSFO issues a warning and when KXAS broadcasts that warning.

KTVT Channel 11
Bob Goosmann

Mr. Goosmann felt satisfied with the services provided by the NWS. He was on the air from about 7:25 to 9:00 p.m. At 9:00 p.m. the broadcast of the Texas Rangers baseball began. Because Channel 11 is the flagship station of the regional Rangers baseball network, the station does not permit him to crawl severe weather warnings across the screen. Station officials do not want the crawls to be seen in other parts of the country. However, if the event is significant enough, he can get the on-air announcers to mention the event during a game.

From 7:30 to 8:00 p.m., KTVT was in near-constant contact with the NWSFO. They have NOAA Weather Radio but did not have NOAA Weather Wire Service at the time. Their NIDS and other weather products are provided through Kavouris. He indicated that they received the severe thunderstorm warning for Tarrant County between 6:45-6:50 p.m. Since he had just been on the air, he did not go back on, but the warning was displayed on the screen. He went on the air for the 7:06 p.m. tornado warning, and then again at 7:25 p.m. showing the large hail at the station (KTVT is located about 5 miles east of downtown Fort Worth).

Channel 11 had no contact with the Mayfest organizers. As with KXAS, he felt that the large hail event was the primary story. Many of the station's resources were directed to cover the story in Fort Worth, so only limited resources were available to cover the flooding in Dallas. Mr. Goosmann noted that it was difficult to grasp the impact of the flooding, since the flooding reports were generally not as definitive as the spotter reports of large hail. KTVT's satellite uplink was out of service between 7:45 and 8:00 p.m., which aggravated the difficulties in documenting the merger of the supercell and squall line.

Dallas County

Dallas City/County Emergency Coordinator
Bill Gross

In Mr. Gross's opinion, the dissemination of flood warnings by NWSFO FTW was both timely and accurate. His spotter information is supplemented with a Flood Alert System that can be set to update rainfall information every five minutes. He receives warnings via Amateur Radio communications in his Emergency

Operations Center and through NOAA Weather Radio.

Mr. Gross felt that several unfortunate factors combined to confuse the public and make his job much more difficult. Above all else, the magnitude of this event, in which more than 3 inches of rain fell in less than 30 minutes across a large part of central Dallas County, severely taxed both communications and response. Many of the creeks and drainage routes in the East Central part of Dallas are very flashy, reacting quickly to runoff and producing sustained flash flooding. Street and highway traffic early on a Friday evening in the Dallas area is quite heavy, and many of the motorists were likely on their way home or out for the evening, unaware of the threat of heavy rain and flooding. Finally, unlike the late afternoon daylight setting of the Tarrant County severe event, the flash flooding in Dallas took place at night, severely restricting visibility and limiting the ability to make good judgments.

Mr. Gross expressed deep appreciation for the work done by NWSFO FTW. He explained that he understands the high demand for information that occurs during such a severe weather event. He tries to limit his requests for data to the minimum required during such events, but has always received prompt and useful answers to his requests.

TV Channel 4
Mike Berger

Mr. Berger was also highly complimentary of the staff at NWSFO FTW. He receives weather data via NOAA Weather Wire, but, as a member of RACES, can also obtain warnings and watches via Amateur Radio.

His overall feeling about the event was that the staff did a "very good job." One aspect of the messages issued by FTW that was very helpful was the mention of specific cities in the path of this storm system. Mr. Berger's weather system immediately generates a crawl across the bottom of the television screen upon receipt of a warning. Following the crawl, a graphic map of the counties under warnings and watches remains displayed. As severe weather impacts the nine county area around Dallas County, he will often go on the air "live" to describe weather threats.

He also felt that the timing of the event during the dark hours and during a Friday evening were two major factors to the large number of deaths in Dallas County that evening. He expressed concern that is it so very difficult to convince people not to cross into flooded low areas. He suggested that increased emphasis should be placed on flash flooding by the radio media.

WFAA TV Channel 8
Troy Dungan

Mr. Dungan has remained very pleased with the level of service provided by NWSFO FTW. He stated that he felt the "warnings were timely" and that statements were received in a very frequent manner. He receives weather data from NOAA Weather Wire and through RACES Amateur Radio communications. He reviews warnings and statements very quickly and transmits them as crawls across the screen. As with Mike Berger, Mr. Dungan is prepared to break into television programming "live"

to highlight threatening weather, especially when tornadoes are threatening.

Mr. Dungan has a computer program that ingests data on storm movement and intensity from a privately constructed Doppler radar at Corsicana (just south of Dallas) and provides a listing of cities in the path of the storm. He also felt that frequent (but brief) severe weather statements as issued by NWSFO FTW were extremely helpful in pinpointing severe weather threats that night.

He believes that the extreme rainfall rates approaching 2.25 inches per quarter hour were a major reason for the large number of deaths. Much of the flooding that night centered around the Dallas Fair Park, a rather flat and poorly drained area. A concert was taking place and crowds were heavy during the flash flooding event. The extreme rainfall also caused flooding where it has not generally occurred before. That might also explain the poor reaction by the Dallas public.

Liaison Officer, Region 1
Texas Division of Emergency Management
Ronald H. Staggs

As do many of the television and radio broadcasters, Mr. Staggs receives information on watches and warnings through Amateur Radio communications. He also has access to the Texas Law Enforcement Telecommunications System (TLETS). He was very pleased with the operations of the NWSFO FTW during the event. He is aware of the intense work load at the office during severe weather events, and restricts calls to a "need-to-know." He was very satisfied with their watches and warnings and describes them as a "top notch bunch of people" and notes that they have produced a very professional and well-trained group of severe weather spotters in the Dallas area.

Appendix A

Damage/Injuries

Tarrant County

Breakdown between hail and flood damage not available. However, most of the damage was from the large hail driven by 70 mph winds. (From Ft. Worth Emergency Management)

Injuries - 110 requiring transport to hospitals, 60 from the Mayfest festival. Additionally, 400 people were treated at a temporary triage near the activities

Damage -

Businesses
231 - significant

Homes
3 destroyed
48 serious
4523 slight/moderate damage

Mobile Homes
2 damaged - not habitable
7 damaged - habitable

Multi-Family Dwellings
2 (2 units) destroyed
59 seriously damaged
1361 slight/moderate damage

Dallas County

Injuries - Data unavailable.

Damage -

Homes
4 destroyed
29 damaged - not habitable
23 damaged - habitable

Multi-Family Dwellings
65 damaged - not habitable
94 damaged - habitable

Insured losses for May 5 in Texas are estimated at $900 million. Most of this concentrated in the Tarrant/Dallas County areas.

Appendix B

May 5-6 Fatalities

Flash Flood Fatalities - Direct

Tarrant County

Male 21 approximate time of death - unknown
Drove into water from South Mary's Creek in western Tarrant County.

Dallas County

Female 53 approximate time of death - 2130 CDT

Male 52 approximate time of death - 2120 CDT

Female 10 approximate time of death - 2120 CDT

Male 2 approximate time of death - 2130 CDT

Female 25 approximate time of death - 2130 CDT

Female 64 approximate time of death - 2130 CDT
Swept away in Turtle Creek (3800 block of McFarlin Boulevard). North central Dallas.

Female 38 approximate time of death - 2145 CDT
Drowned in high water at a railroad underpass (Skillman Street, north of Woodcrest Lane). Northeast Dallas.

Male 41 approximate time of death - unknown
Pickup was submerged after he pulled another car from rising water.

Male 69 approximate time of death - unknown
South Industrial Blvd. near R.L. Thornton Freeway in central Dallas.

Male 40 approximate time of death - 2115 CDT
Apparently slipped on the sidewalk outside his home and drowned (900 Holcomb Road). East Dallas.

Female 38 approximate time of death - 2200 CDT
Drove into high water on her way to work (5406 Lawnview Ave.) in northeast Dallas.

Female 68 approximate time of death - 2130 CDT
Swept away after getting out of car after hitting a curb (6464 E. Mockingbird Ln.) in northeast Dallas.

Male 34 approximate time of death - unknown

Male 33 approximate time of death - 2230 CDT

Male ?? approximate time of death - 2230 CDT
Victim lived in the area. He had already rescued 3 people from approximately 10 feet of water (over street). He went back to assist another vehicle with 3 occupants. However, at this time a manhole cover popped open creating a whirlpool. Two of the three occupants and this victim were pulled into the drainage system. Their bodies were recovered several days later in the Trinity River. Ervay Street - Dallas.

Other Fatalities - Direct

Dallas County

Male 15 approximate time of death - 2015 CDT
Struck by lightning in Victoria Park in Irving, northwest Dallas County. (Northgate Dr. between Story and Beltline.)

Female 60 approximate time of death - unknown
Roof collapsed from water at Haggar plant located at 6113 Lemmon Ave. in north Dallas

Female 26 approximate time of death - unknown
Roof collapsed from water at Haggar plant located at 6113 Lemmon Ave. in north Dallas.

Other Fatalities -Indirect

Dallas County

Female 78 0400 CDT on 5/6/95
Smoke Inhalation caused by a house fire caused lightning strike. (1300 West Saner Ave. in central Dallas.)

Appendix C

Severe Weather Report for Tarrant and Dallas Counties

The following are excerpts from the Preliminary Local Storm Report issued by NWSFO Fort Worth. Reports from other locations have been excluded. Note: Since this was a preliminary Storm Report, numbers provided may not coincide with others contained within this DSR.

ZCZC FTWLSRFTW
TTAA00 KFTW 060611

PRELIMINARY LOCAL STORM REPORT
NATIONAL WEATHER SERVICE FORT WORTH TX
110 AM CDT SAT MAY 06 1995

...PRELIMINARY STORM REPORTS FROM FRIDAY MAY 5TH...

TIME(CDT) .....CITY LOCATION..... ....COUNTY LOCATION....	STATE	...EVENT/REMARKS...
0700 PM TARRANT COUNTY 05/05/95 TARRANT	TX	4.00 INCH HAIL TARRANT COUNTY RACES LOGGED OVER 80 REPORTS OF LARGE HAIL OVER THE SOUTHEASTERN TWO-THIRDS OF TARRANT COUNTY BETWEEN 700 PM AND 750 PM. NUMEROUS BASEBALL TO SOFTBALL HAIL REPORTS WERE LOGGED. MANY INSTANCES OF SIGNIFICANT DAMAGE TO CARS...HOMES..AND BUSINESSES WERE RECEIVED. IN ADDITION..SEVERAL REPORTS OF WINDS IN EXCESS OF 70 MPH WERE RECEIVED.
0703 PM WHITE SETTLEMENT 05/05/95 TARRANT	TX	2.00 INCH HAIL
0705 PM BENBROOK 05/05/95 TARRANT	TX	2.75 INCH HAIL
0708 PM FORT WORTH 05/05/95 TARRANT	TX	1.00 INCH HAIL REPORTED AT NAS CARSWELL

0711 PM WHITE SETTLEMENT 05/05/95 TARRANT	TX	2.00 INCH HAIL
0720 PM FORT WORTH 05/05/95 TARRANT	TX	2.75 INCH HAIL JUST WEST OF DOWNTOWN FORT WORTH
0720 PM FORT WORTH 05/05/95 TARRANT	TX	2.75 INCH HAIL AT HWY 80 AND CHERRY LANE IN SW FORT WORTH.
0730 PM FORT WORTH 05/05/95 TARRANT	TX	4.00 INCH HAIL *** 90 INJ *** HAIL TO SOFTBALL SIZE FELL IN AND NEAR DOWNTOWN FORT WORTH. 60-70 INJURIES OCCURRED AT MAYFEST EVENT AT TRINITY PARK JUST WEST OF DOWNTOWN FORT WORTH. MOST OF INJURIES WERE CUTS AND BRUISES... SOME BROKEN BONES WERE ALSO REPORTED BY LOCAL MEDIA. NUMEROUS REPORTS OF MAJOR DAMAGE TO BUILDINGS IN DOWNTOWN FORT WORTH. FORT WORTH CITY HALL SUFFERED CONSIDERABLE DAMAGE. GLASS ATRIUM AT HARRIS METHODIST HOSPITAL WAS SEVERELY DAMAGED. REPORTS RELAYED FROM TARRANT COUNTY RACES AND KRLD.
0735 PM FORT WORTH 05/05/95 TARRANT	TX	4.00 INCH HAIL SOFTBALL HAIL ON SOUTHEAST SIDE OF FORT WORTH AT KXAS
0735 PM FORT WORTH 05/05/95 TARRANT	TX	75 MPH WIND SOUTHEAST SIDE OF FORT WORTH AT KXAS
0735 PM FORT WORTH 05/05/95 TARRANT	TX	2.75 INCH HAIL BASEBALL HAIL ON EAST SIDE OF FORT WORTH
0735 PM FORT WORTH 05/05/95 TARRANT	TX	2.75 INCH HAIL BASEBALL HAIL ON SOUTHEAST SIDE OF FORT WORTH
0735 PM FORT WORTH 05/05/95 TARRANT	TX	1.00 INCH HAIL AT NWSFO FTW ON NORTH SIDE OF FORT WORTH

0750 PM FORT WORTH TX WIND DAMAGE
05/05/95 TARRANT WALL BLOWN IN AT GE WAREHOUSE IN SOUTH FORT WORTH

0746 PM NORTH RICHLAND HILLS TX 0.75 INCH HAIL
05/05/95 TARRANT

0750 PM BEDFORD TX 1.00 INCH HAIL
05/05/95 TARRANT

0820 PM LAS COLINAS TX 2.00 INCH HAIL
05/05/95 DALLAS

0832 PM 5 EAST OF DFW TX 70 MPH WIND
05/05/95 DALLAS

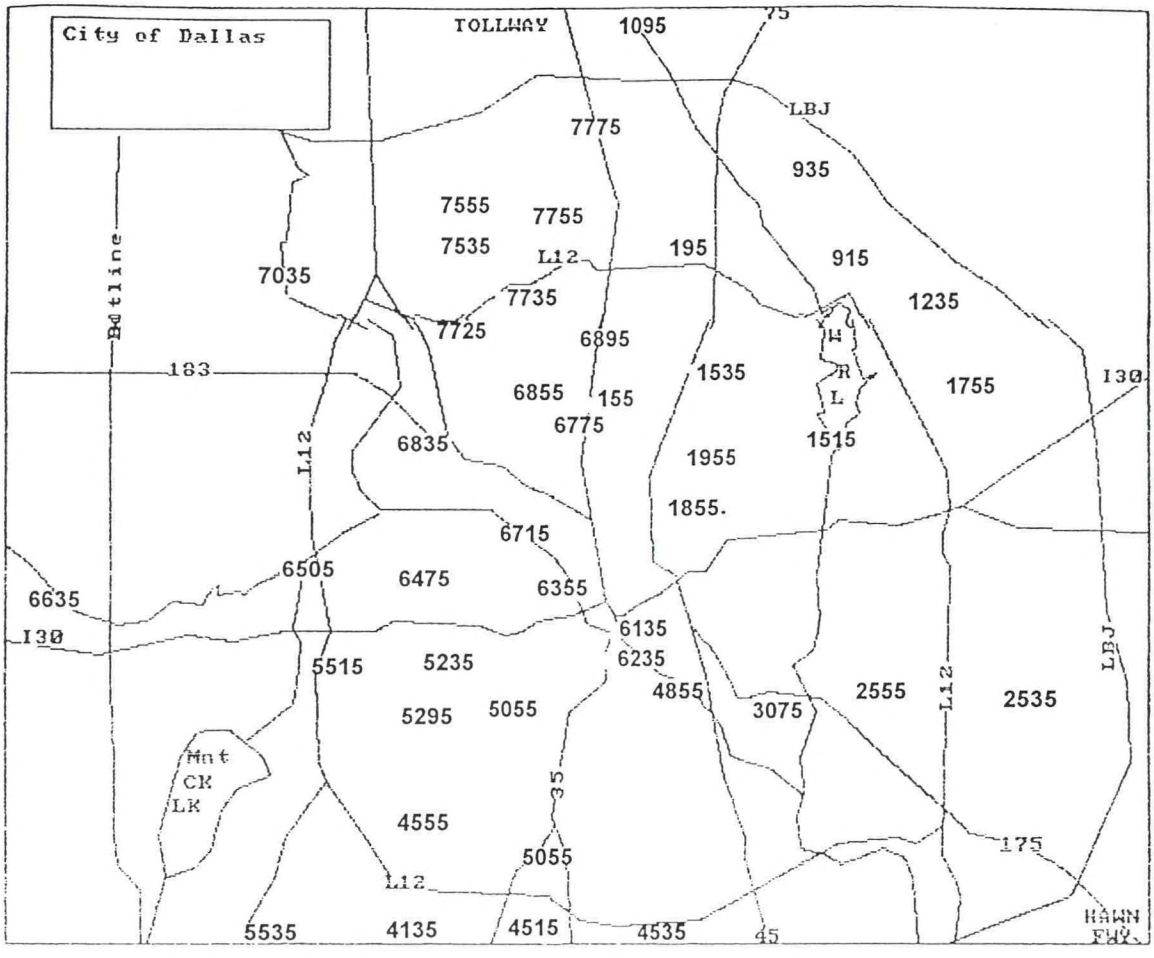
0840 PM DALLAS TX FLOODING
05/05/95 DALLAS PARKLAND AND BAYLOR EMERGENCY ROOMS CLOSED DUE TO HIGH WATER CLOSING ENTRANCES. PUMPING WATER FROM BUILDING AT THIS TIME.

0900 PM DALLAS TX WIND DAMAGE
05/05/95 DALLAS *** 2 DEAD, 12 INJ *** ROOF AT HAGGAR PLANT NEAR LOVE FIELD COLLAPSED DUE TO HIGH WINDS.

Appendix D

Station ID	Sensor Name	8:15	8:30	8:45	9:00	9:15	9:30	9:45	10:00	Total at 10:00 PM	Radar 9:57 PM
					Fifteen	Minute	Rainfalls				
3075	SMAX Municipal@Budd	0.00	0.00	0.04	1.84	0.64	0.60	0.20	0.00	3.32	2.0 - 2.5
2555	Elam Creek@Lake June	0.00	0.00	0.00	0.63	0.91	0.34	0.17	0.00	2.05	1.5 - 2.0
2535	Lake June@St August	0.00	0.00	0.00	0.24	0.28	0.64	0.12	0.04	1.32	2.0 - 2.5
4535	5 Mile Creek @ Lancaster	0.00	0.00	0.08	0.96	0.00	0.28	0.00	0.00	1.32	1.5 - 2.0
4855	Sargent @ Morrell	0.00	0.00	0.16	2.12	0.32	0.31	0.20	0.00	3.11	2.0 - 2.5
6135	Upper Able Sump	0.00	0.00	0.47	1.22	0.00	0.00	0.00	0.00	1.69	2.5 - 3.0
4135	Woody @ Westmoreland	0.00	0.24	0.78	0.24	0.23	0.08	0.04	0.00	1.61	1.5 - 2.0
4155	Woody Br @ Polk Street	0.00	0.12	0.67	0.00	0.00	0.00	0.00	0.00	0.79	1.0 - 1.5
4515	5 Mile Creek @ Polk Street	0.00	0.08	0.67	0.75	0.00	0.00	0.43	0.04	1.97	1.5 - 2.0
4555	5 Mile Creek @ Westmoreland	0.00	0.00	0.20	0.19	0.01	0.00	0.98	0.28	1.66	2.0 - 2.5
5055	Cedar Creek @ Clarendon	0.00	0.04	0.79	0.27	0.01	0.30	0.01	0.00	1.42	2.0 - 2.5
5235	Coombs Creek @ Hampton	0.00	0.16	0.82	0.09	0.42	0.01	0.23	0.01	1.74	2.0 - 2.5
5295	Donald School	0.00	0.43	0.79	1.49	0.12	0.00	0.16	0.08	3.07	2.0 - 2.5
5515	Jefferson @ Ira	0.00	0.55	0.95	0.86	0.01	0.00	0.20	0.00	2.57	2.0 - 2.5
5535	Camp Wisdom @ Sarah	0.04	0.75	0.47	0.12	0.00	0.31	0.04	0.00	1.73	1.0 - 1.5
6235	Corinth St Int @ LW	0.00	0.00	0.35	1.70	0.39	0.28	0.07	0.01	2.80	2.0 - 2.5
6355	Sylvan @ Union Pacific RR	0.00	0.04	0.90	1.70	0.31	0.12	0.08	0.00	3.15	2.0 - 2.5
6475	Singleton @ Shadrack	0.00	0.51	0.99	1.25	0.25	0.00	0.28	0.03	3.31	1.5 - 2.0
6505	Eagle Flood Control Gate	0.04	1.18	0.87	1.14	0.00	0.00	0.20	0.00	3.43	1.5 - 2.0
6635	West Fork @ Beltline	0.75	1.18	0.59	0.63	0.16	0.08	0.04	0.00	3.43	2.0 - 2.5
6715	2255 Irving Blvd	0.00	0.04	1.02	1.58	0.43	0.28	0.03	0.01	3.39	2.0 - 2.5
6775	Cedar Springs @ Kings	0.00	0.04	0.55	1.18	1.02	0.63	0.20	0.00	3.62	2.5 - 3.0
6835	Mockingbird @ CRI&P	0.04	0.16	0.98	1.70	0.00	0.47	0.08	0.00	3.43	1.5 - 2.0
6855	Knights Branch @ Denton	0.00	0.00	0.75	1.69	0.91	0.43	0.28	0.00	4.06	2.5 - 3.0
6895	Inwood @ University Blvd	0.00	0.04	0.24	2.24	0.99	0.94	0.24	0.04	4.73	3.0 - 4.0
7035	Elm Fort @ Cal Cross	0.12	0.00	0.67	0.98	0.16	0.08	0.08	0.00	2.09	2.5 - 3.0
7535	Joes Creek @ Walnut Hill	0.00	0.08	0.08	0.90	0.01	0.70	0.21	0.00	1.98	2.5 - 3.0
7555	Townsend @ Royal Park	0.04	0.04	0.08	0.98	0.00	0.79	0.08	0.04	2.05	2.5 - 3.0
7725	Bachaan Dam	0.04	0.04	0.08	1.46	0.23	0.12	0.12	0.00	2.09	2.0 - 2.5
7735	Bachaan Branch @ Midway	0.04	0.04	0.04	1.36	0.72	0.40	0.28	0.00	2.88	2.5 - 3.0
7755	Bachaan Branch @ Walnut Hill	0.04	0.00	0.08	1.14	0.95	0.92	0.06	0.00	3.19	3.0 - 4.0
7775	Bachaan Branch @ Forest	0.00	0.08	0.04	0.63	0.67	0.75	0.27	0.01	2.45	2.5 - 3.0
195	NW Hwy @ Edgemere	0.00	0.04	0.00	0.67	1.02	1.15	0.03	0.01	2.92	2.5 - 3.0
1095	Preston Rd @ Olive	0.00	0.04	0.20	0.00	0.51	0.99	0.27	0.01	2.02	2.5 - 3.0
915	McCree @ W. Rock Trail	0.00	0.00	0.00	0.39	0.91	1.65	0.16	0.00	3.11	2.5 - 3.0
935	Jackson Branch @ Skilman	0.00	0.00	0.00	0.04	0.00	0.16	0.78	0.01	0.99	2.5 - 3.0
1235	Dixon Branch below NW Hwy	0.00	0.00	0.00	0.16	0.59	1.97	0.31	0.08	3.11	3.0 - 4.0
1515	White Rock Lake Dam	0.00	0.00	0.00	0.98	0.48	0.43	0.20	0.04	2.13	2.5 - 3.0
1755	Harry Stone Park	0.00	0.00	0.00	0.00	1.06	1.97	0.43	0.04	3.50	2.5 - 3.0
155	Turtle Creek @ Wilwood	0.00	0.00	0.16	0.98	0.75	1.02	0.32	0.00	3.23	2.5 - 3.0
1535	Jackson School	0.00	0.00	0.04	1.26	0.63	2.13	0.31	0.08	4.45	2.5 - 3.0
1855	Exall Park	0.00	0.00	0.20	1.10	0.47	1.03	0.03	0.01	2.84	2.5 - 3.0
1955	Garrett Park	0.00	0.00	0.04	2.13	0.63	1.46	0.27	0.01	4.54	2.5 - 3.0

Appendix E


City of Dallas
TOLLWAY
1095
75
LBJ
7775
935
7555
7755
7535
L12
195
915
7035
7735
1235
Beltline
7725
6895
183
1535
1755
130
6855
155
6775
1515
6835
1955
1855.
6715
6505
6475
6355
6635
6135
130
6235
5515
5235
4855
2555
2535
3075
5295
5055
Mnt
CK
LK
35
4555
175
5055
L12
5535
4135
4515
4535
45
HAWN
FWY

Appendix F

Preparedness Activities In Tarrant and Dallas Counties (1994-1995)

March 20, 1995
Arlington

350 people attended a safety/awareness program at The Ballpark in Arlington.

March 20, 1995
Los Colinas, GTE Headquarters

Spotter training was provided to 45 individuals.

February 25, 1995
Garland

Spotter training was provided to 350 spotters.

January 28, 1995
Fort Worth

A spotter training session was provided to spotters, HAMs, Law Enforcement, and the public. 200 people attended.

June 13, 1994
Crowley

Spotter training was provided for 35 people from south Tarrant County, Emergency Managers, Law Enforcement, and the public. A total of 35 individuals attended.

June 12, 1994
Arlington

350 HAM radio operators received spotter training.

April 6, 1994
Hurst

15 individuals from the Hurst Fire Department participated in this spotter training session.

March 22, 1994
Arlington

Fire Department officials, Police, and Emergency Managers attended this spotter training session. Total attendance - 25.

March 19, 1994
Irving

450 people attended spotter training event including area RACES, City of Dallas Emergency Management, Texas Severe Storms Association, and radio station KRLD.

March 12, 1994
Los Colinas

45 spotters attended this advanced spotter training session.

February 26, 1994
Garland

300 spotters, RACES, Emergency Managers, Fire Department Officials, and the public attended a basic spotter training session.

January 29, 1994
Fort Worth

Emergency Managers, spotters, and Fire Department officials attended this spotter training session. 200 individuals attended this presentation.

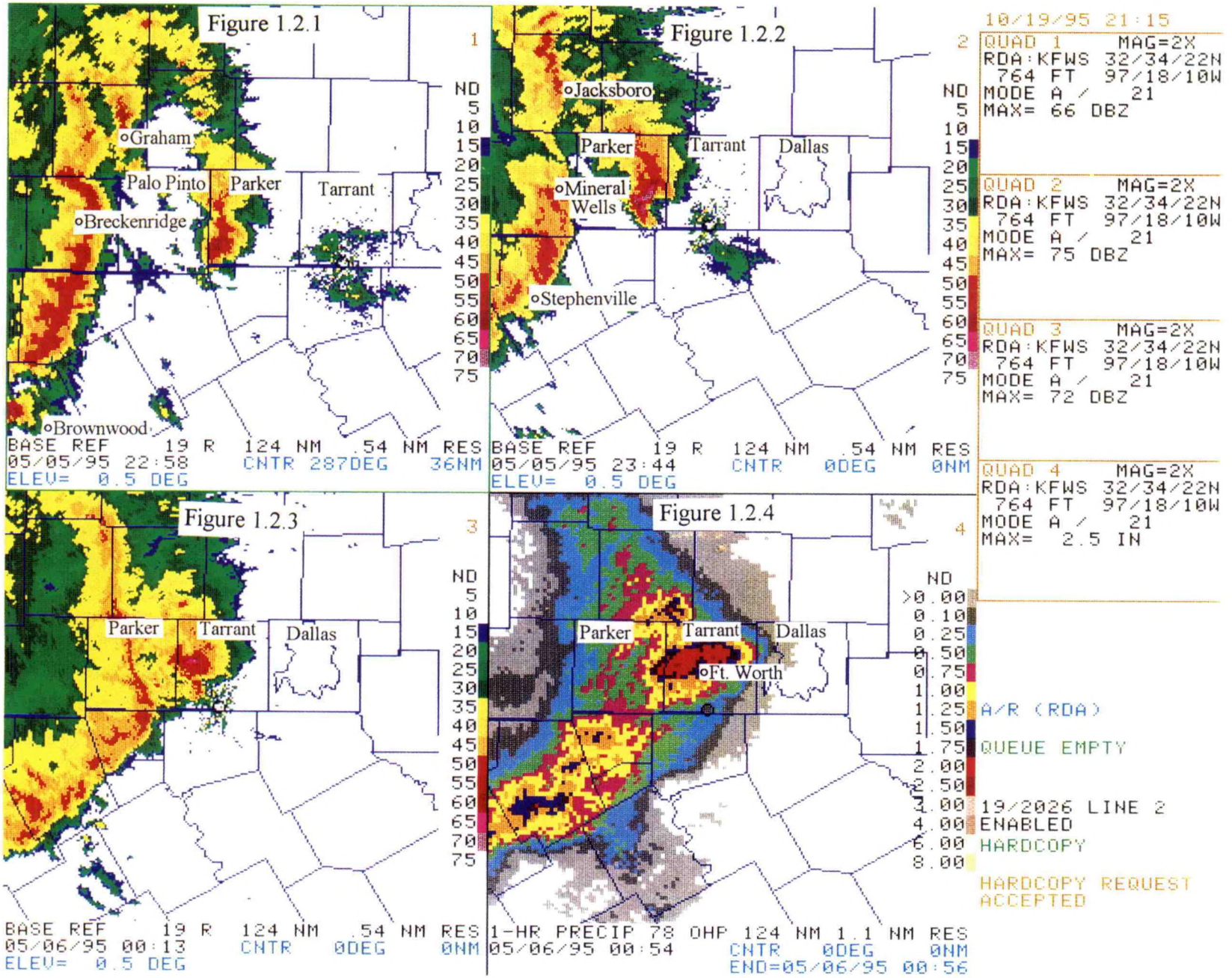
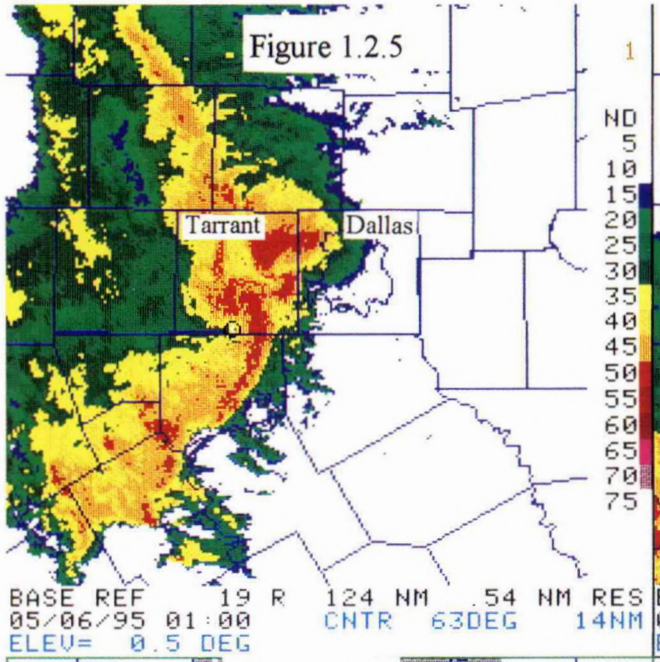
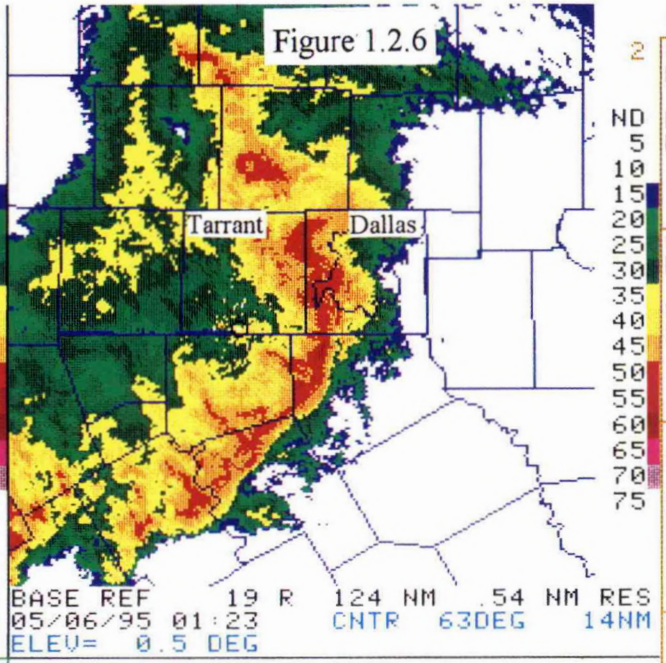
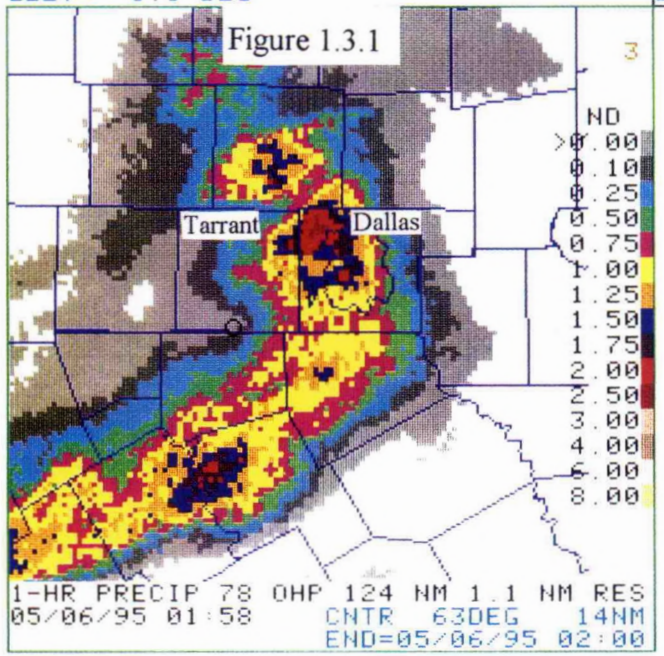


Figure 1.2.1
Graham
Palo Pinto
Parker
Tarrant
Breckenridge
Brownwood
1
ND
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
BASE REF 19 R 124 NM .54 NM RES
05/05/95 22:58 CNTR 287DEG 36NM
ELEV= 0.5 DEG
Figure 1.2.2
Jacksboro
Parker
Tarrant
Dallas
Mineral Wells
Stephenville
2
ND
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
BASE REF 19 R 124 NM .54 NM RES
05/05/95 23:44 CNTR 0DEG 0NM
ELEV= 0.5 DEG
10/19/95 21:15
QUAD 1 MAG=2X
RDA:KFWS 32/34/22N
764 FT 97/18/10W
MODE A / 21
MAX= 66 DBZ
QUAD 2 MAG=2X
RDA:KFWS 32/34/22N
764 FT 97/18/10W
MODE A / 21
MAX= 75 DBZ
QUAD 3 MAG=2X
RDA:KFWS 32/34/22N
764 FT 97/18/10W
MODE A / 21
MAX= 72 DBZ
QUAD 4 MAG=2X
RDA:KFWS 32/34/22N
764 FT 97/18/10W
MODE A / 21
MAX= 2.5 IN
Figure 1.2.3
Parker
Tarrant
Dallas
3
ND
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
BASE REF 19 R 124 NM .54 NM RES
05/06/95 00:13 CNTR 0DEG 0NM
ELEV= 0.5 DEG
Figure 1.2.4
Parker
Tarrant
Dallas
Ft. Worth
4
ND
>0.00
0.10
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
2.50
3.00
4.00
6.00
8.00
1-HR PRECIP 78 OHP 124 NM 1.1 NM RES
05/06/95 00:54 CNTR 0DEG 0NM
END=05/06/95 00:56
A/R (RDA)
QUEUE EMPTY
19/2026 LINE 2
ENABLED
HARDCOPY
HARDCOPY REQUEST
ACCEPTED







10/19/95 21:26

QUAD 1 MAG=2X
RDA:KFWS 32/34/22N
764 FT 97/18/10W
MODE A / 21
MAX= 61 DBZ

QUAD 2 MAG=2X
RDA:KFWS 32/34/22N
764 FT 97/18/10W
MODE A / 21
MAX= 64 DBZ

QUAD 3 MAG=2X
RDA:KFWS 32/34/22N
764 FT 97/18/10W
MODE A / 21
MAX= 2.8 IN

A/R (RDA)

QUEUE EMPTY

19/2026 LINE 2
ENABLED
HARDCOPY

HARDCOPY REQUEST
ACCEPTED

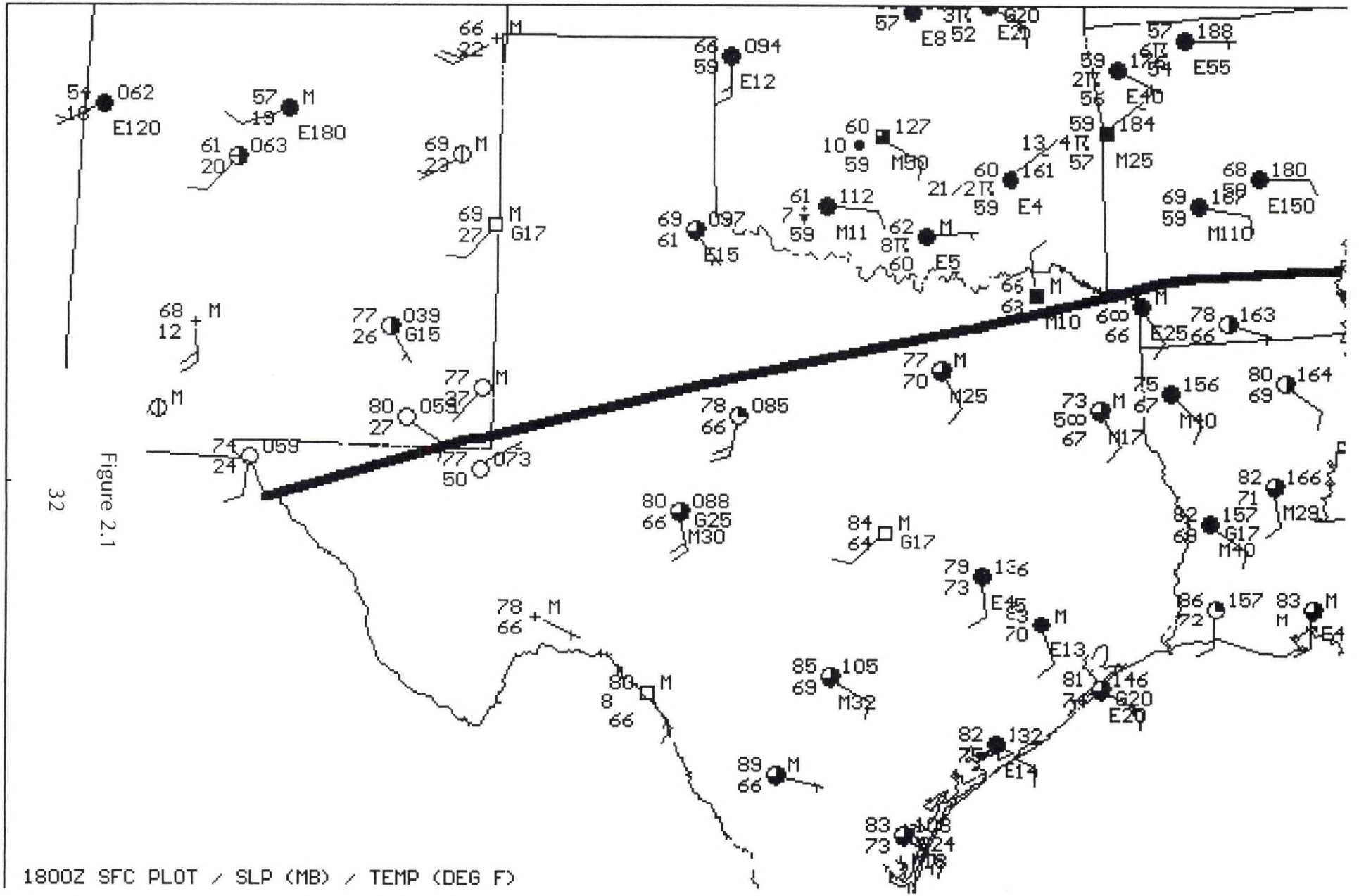


Figure 2.1

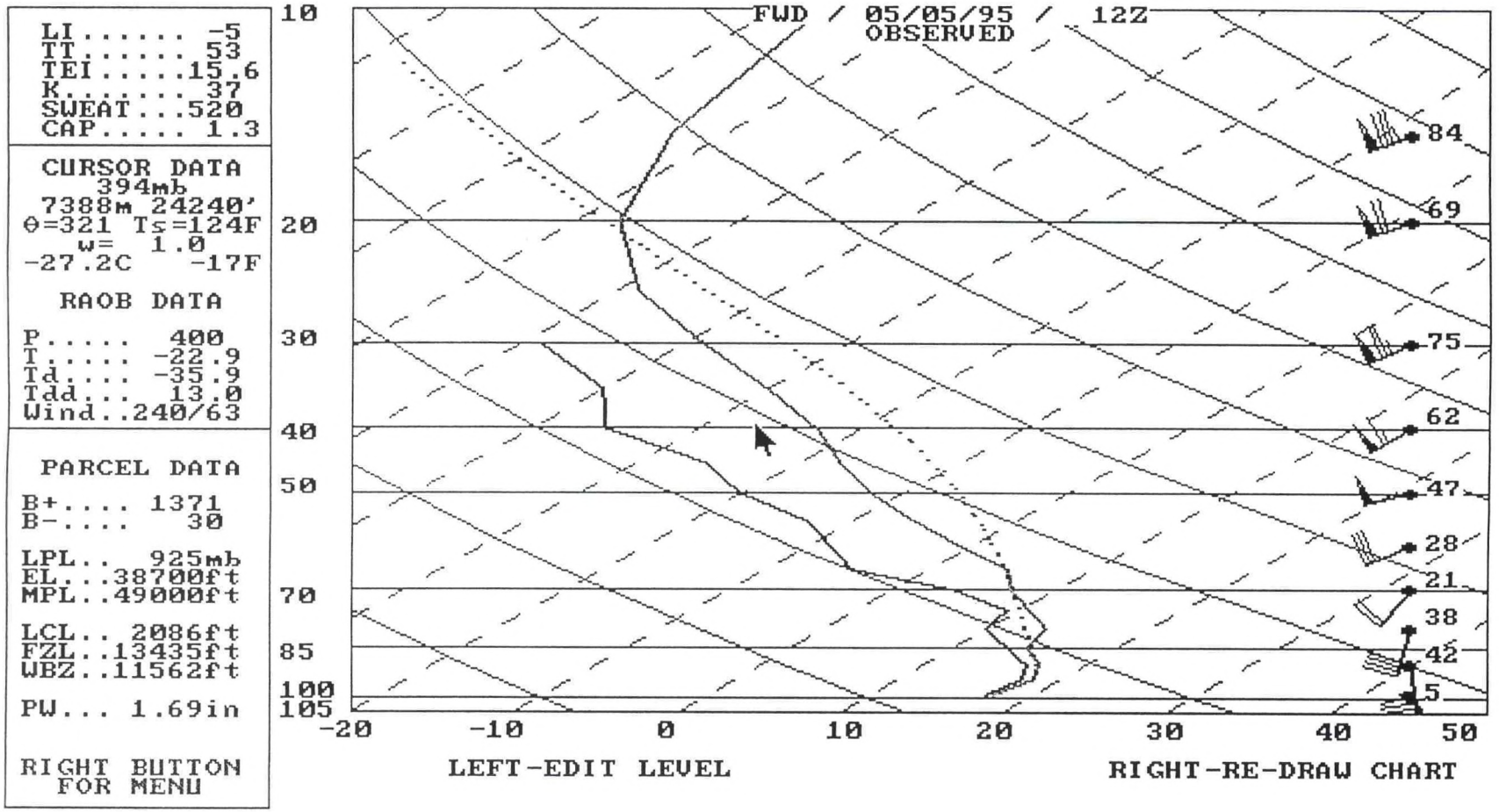

LI..... -5
TT..... 53
TEI.....15.6
K..... 37
SWEAT...520
CAP..... 1.3
CURSOR DATA
394mb
7388m 24240'
θ=321 Tε=124F
w= 1.0
-27.2C -17F
RAOB DATA
P..... 400
T..... -22.9
Td..... -35.9
Tdd... 13.0
Wind..240/63
PARCEL DATA
B+.... 1371
B-.... 30
LPL.. 925mb
EL...38700ft
MPL..49000ft
LCL.. 2086ft
FZL..13435ft
WBZ..11562ft
PW... 1.69in
RIGHT BUTTON
FOR MENU
FWD / 05/05/95 / 12Z
OBSERVED
10
20
30
40
50
70
85
100
105
84
69
75
62
47
28
21
38
42
5
-20
-10
0
10
20
30
40
50
LEFT-EDIT LEVEL
RIGHT-RE-DRAW CHART

Figure 2.2

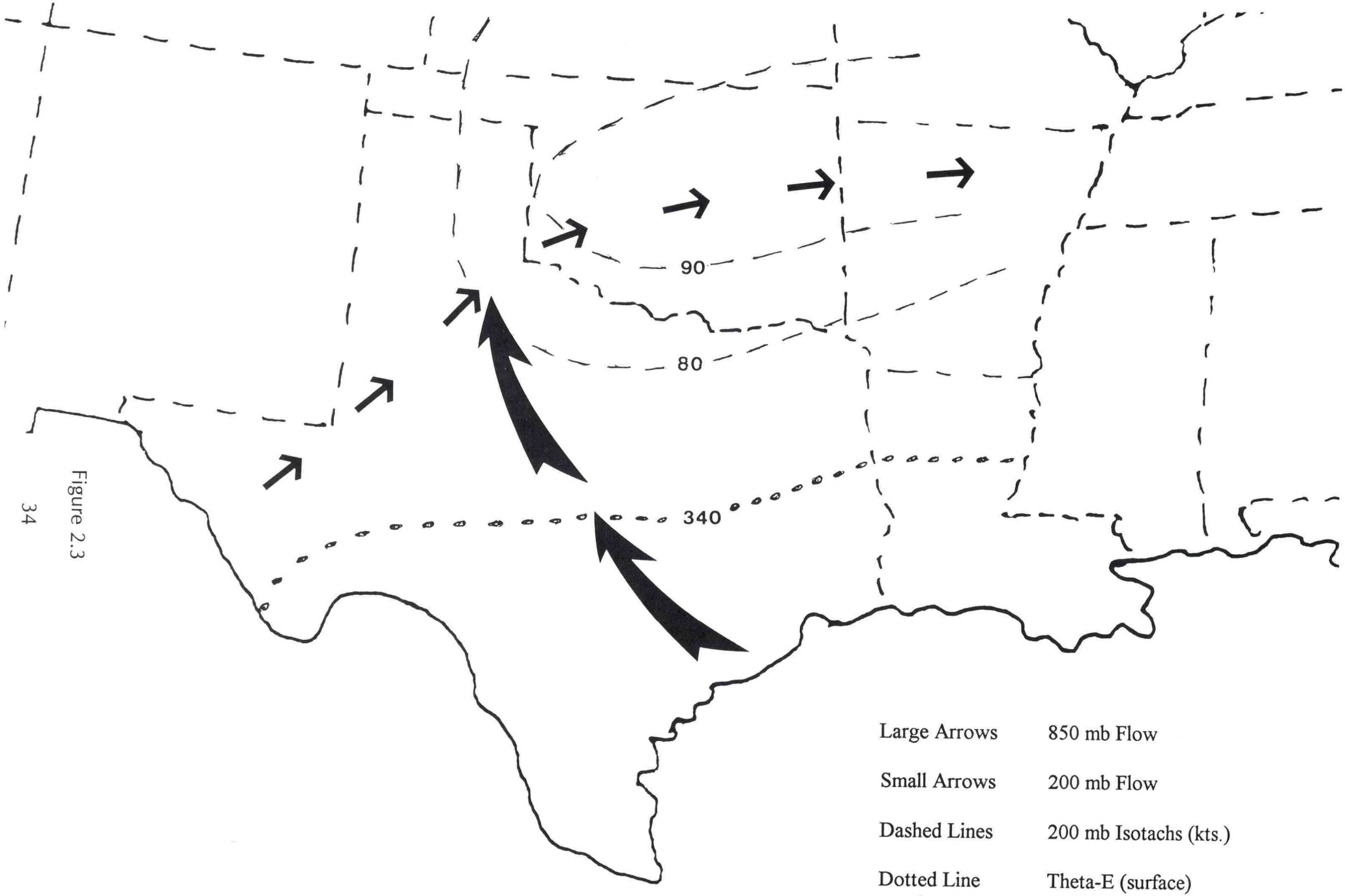

90
80
340
Large Arrows 850 mb Flow
Small Arrows 200 mb Flow
Dashed Lines 200 mb Isotachs (kts.)
Dotted Line Theta-E (surface)

Figure 2.3

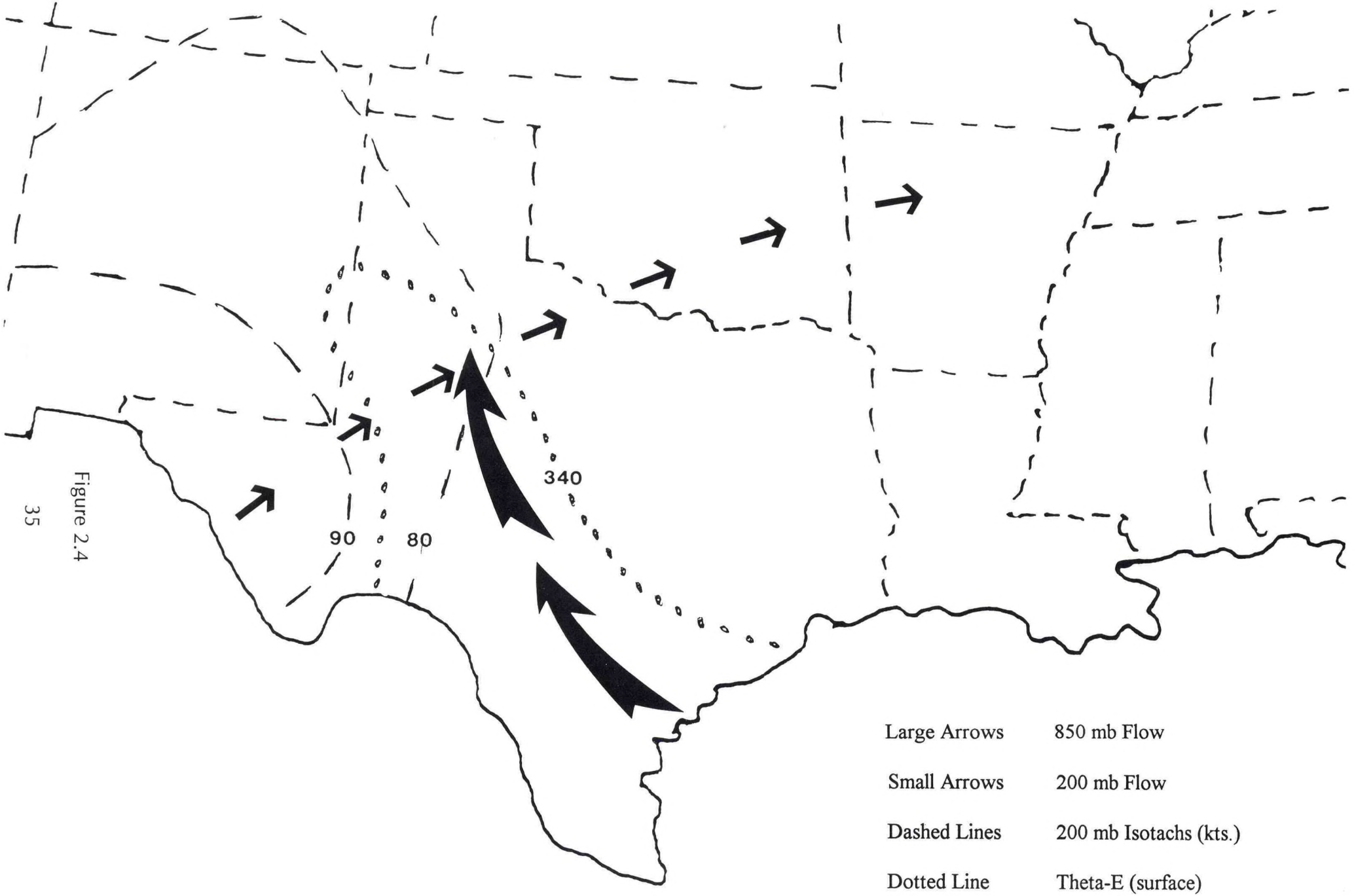

340
90
80
Large Arrows 850 mb Flow
Small Arrows 200 mb Flow
Dashed Lines 200 mb Isotachs (kts.)
Dotted Line Theta-E (surface)

Figure 2.4

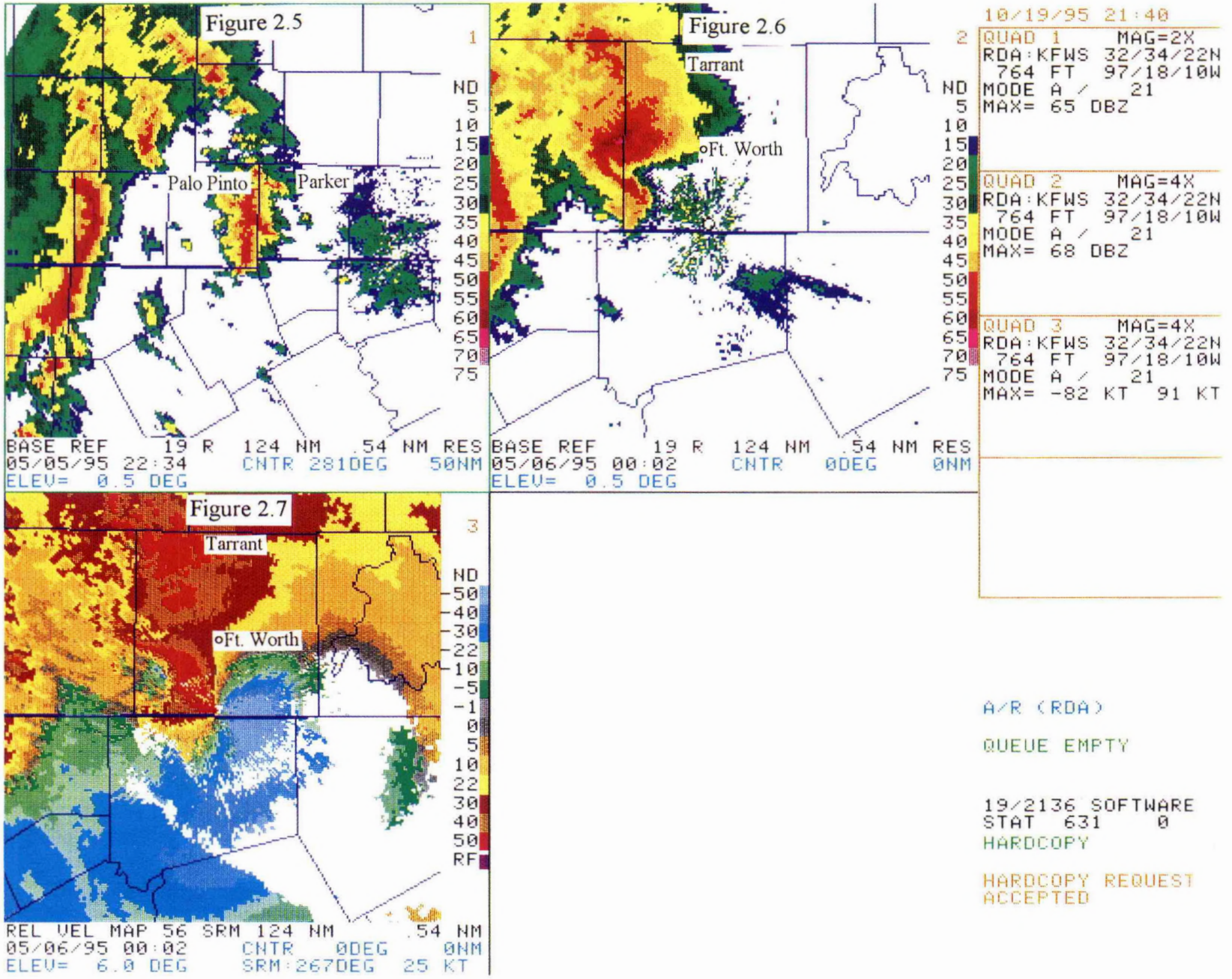


Figure 2.5
Palo Pinto
Parker
1
ND
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
BASE REF 19 R 124 NM .54 NM RES
05/05/95 22:34 CNTR 281DEG 50NM
ELEV= 0.5 DEG
Figure 2.6
Tarrant
°Ft. Worth
2
ND
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
BASE REF 19 R 124 NM .54 NM RES
05/06/95 00:02 CNTR 0DEG 0NM
ELEV= 0.5 DEG
10/19/95 21:40
QUAD 1 MAG=2X
RDA:KFWS 32/34/22N
764 FT 97/18/10W
MODE A / 21
MAX= 65 DBZ
QUAD 2 MAG=4X
RDA:KFWS 32/34/22N
764 FT 97/18/10W
MODE A / 21
MAX= 68 DBZ
QUAD 3 MAG=4X
RDA:KFWS 32/34/22N
764 FT 97/18/10W
MODE A / 21
MAX= -82 KT 91 KT
Figure 2.7
Tarrant
°Ft. Worth
3
ND
-50
-40
-30
-22
-10
-5
-1
0
5
10
22
30
40
50
RF
REL VEL MAP 56 SRM 124 NM .54 NM
05/06/95 00:02 CNTR 0DEG 0NM
ELEV= 6.0 DEG SRM:267DEG 25 KT
A/R (RDA)
QUEUE EMPTY
19/2136 SOFTWARE
STAT 631 0
HARDCOPY
HARDCOPY REQUEST
ACCEPTED

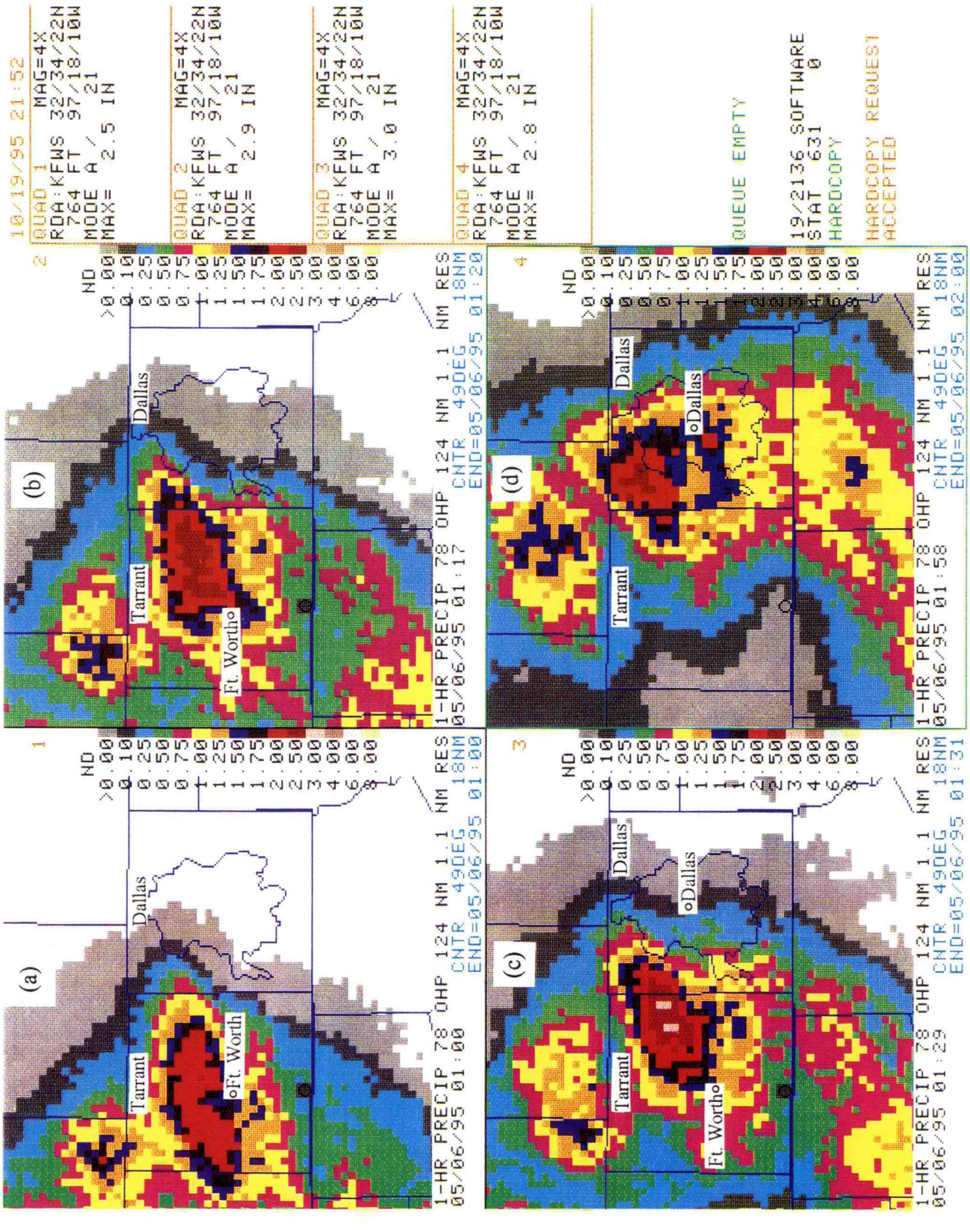
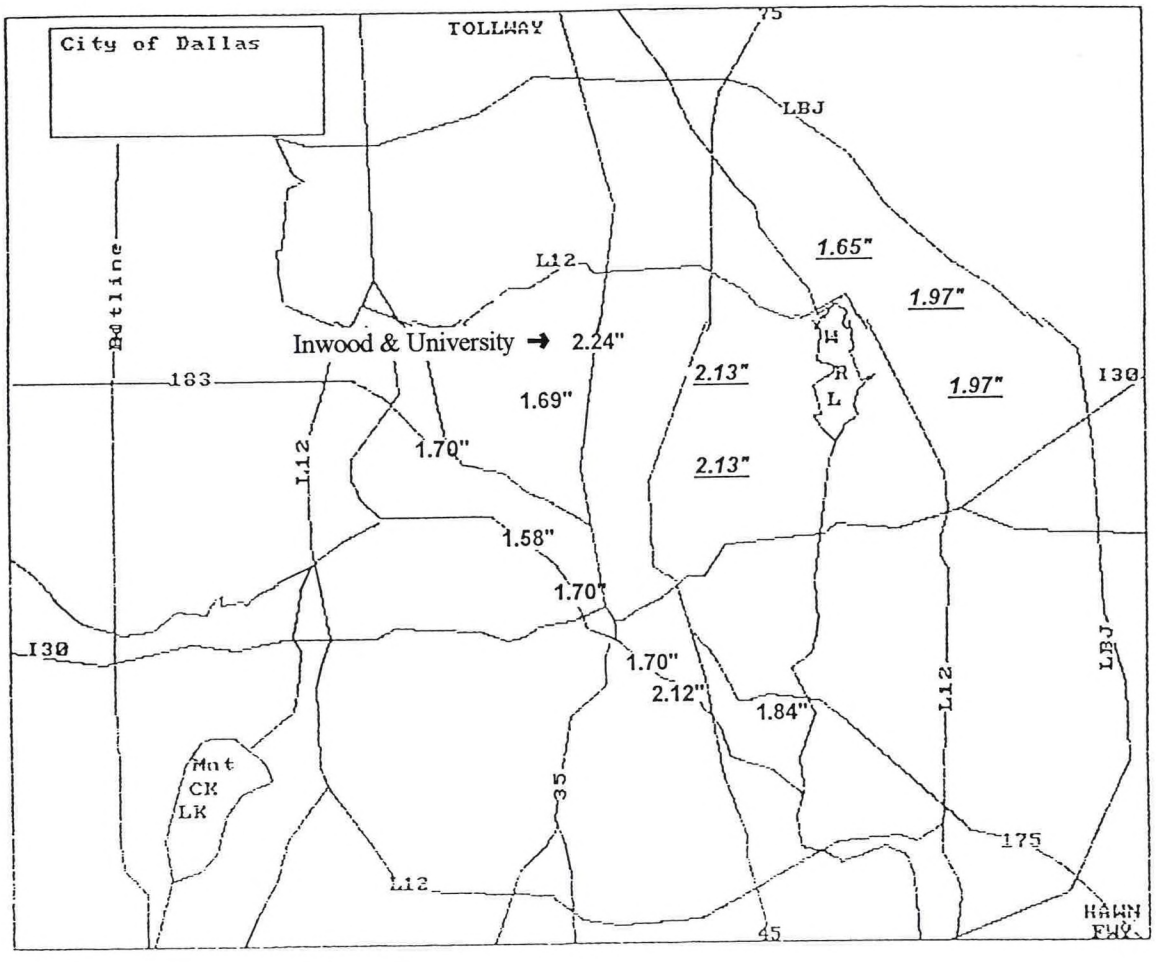

(a)
Tarrant
Dallas
Ft. Worth
(b)
Tarrant
Dallas
Ft. Worth
(c)
Tarrant
Dallas
Dallas
Ft. Worth
(d)
Tarrant
Dallas
Dallas

Figure 2.8



Not Underlined 8:45-9:00 p.m. CDT

Underlined 9:15-9:30 p.m. CDT

Figure 2.9

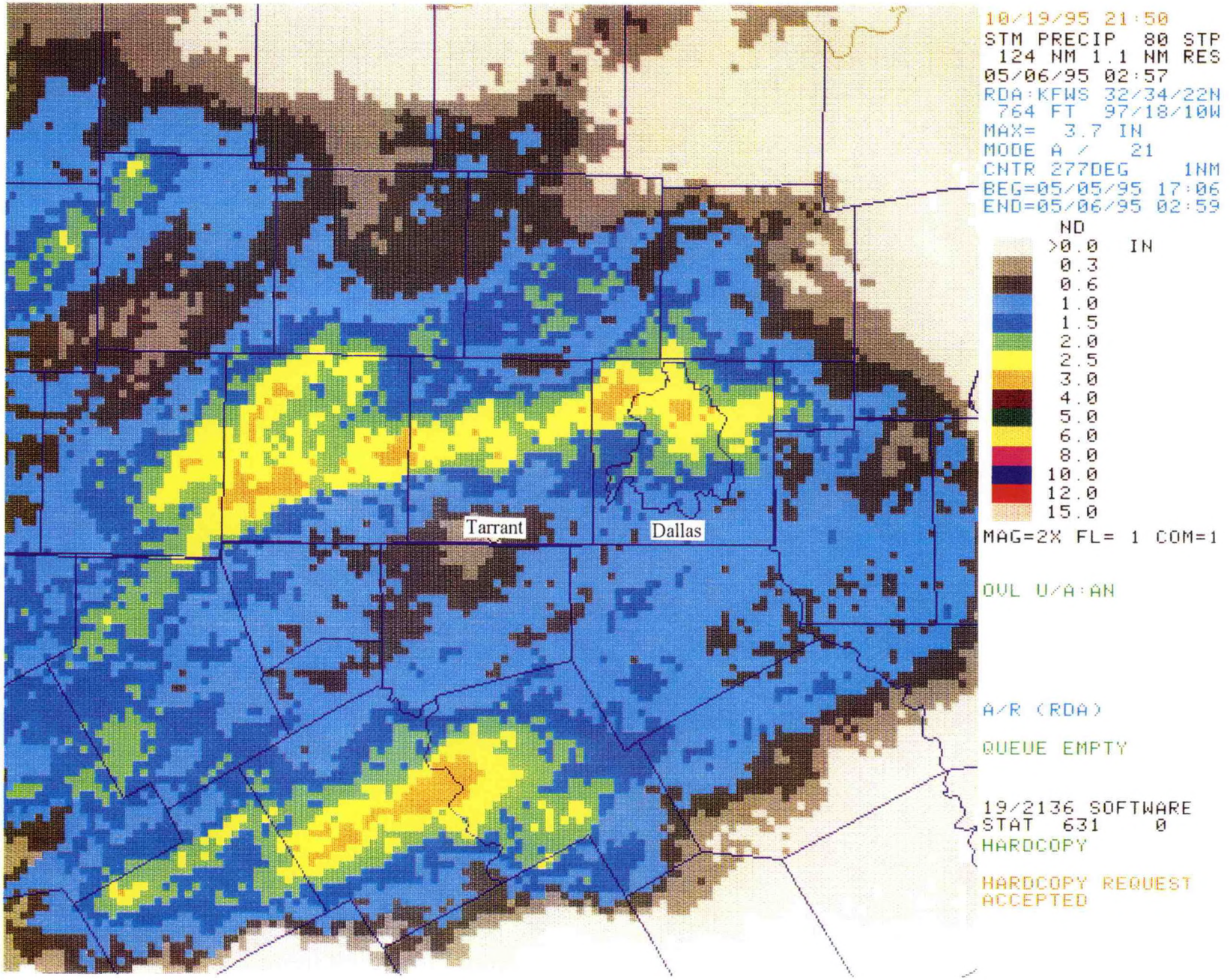

10/19/95 21:50
STM PRECIP 80 STP
124 NM 1.1 NM RES
05/06/95 02:57
RDA:KFWS 32/34/22N
764 FT 97/18/10W
MAX= 3.7 IN
MODE A / 21
CNTR 277DEG 1NM
BEG=05/05/95 17:06
END=05/06/95 02:59
ND
>0.0 IN
0.3
0.6
1.0
1.5
2.0
2.5
3.0
4.0
5.0
6.0
8.0
10.0
12.0
15.0
MAG=2X FL= 1 COM=1
OVL U/A:AN
A/R (RDA)
QUEUE EMPTY
19/2136 SOFTWARE
STAT 631 0
HARDCOPY
HARDCOPY REQUEST
ACCEPTED
Tarrant
Dallas

Figure 2.10