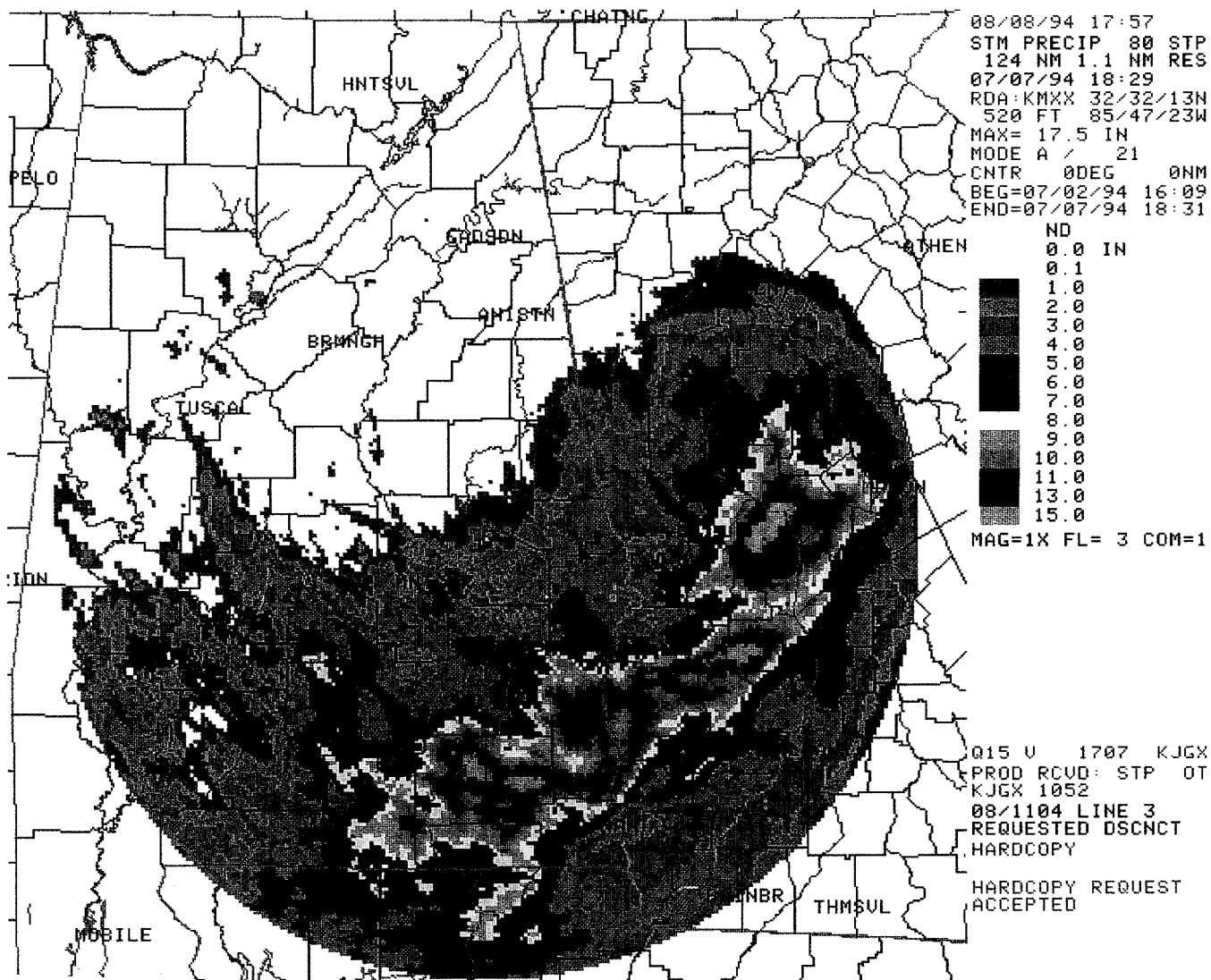


Alberto

Natural Disaster Survey Report

Tropical Storm Alberto Heavy Rains and Flooding Georgia, Alabama, Florida July 1994



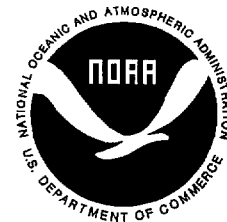
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Natural Disaster Survey Report

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PREFACE

A decaying tropical system, previously known as Tropical Storm Alberto, produced torrential rainfall which resulted in some of the worst flooding ever observed across portions of the States of Georgia, Alabama, and Florida during July 1994. The rainfall led to exceptional flooding across central and western Georgia, eastern Alabama, and the Florida Panhandle. Five river basins were particularly hard hit: (1) the Flint River Basin in western Georgia, (2) the Ocmulgee River Basin in central Georgia, (3) the Chattahoochee River Basin along the Georgia-Alabama state line, (4) the Choctawhatchee River Basin in Alabama, and (5) the Apalachicola River Basin in Florida. The flooding claimed 33 lives and caused damages estimated at close to \$750 million. A National Oceanic and Atmospheric Administration (NOAA) disaster survey team assembled for its first meeting in Peachtree City, Georgia, on the morning of July 18, 1994. All aspects of weather and flood warning systems--from data acquisition to user response--were surveyed to determine NOAA's effectiveness and to recommend improvements if deficiencies were found. This report gives the results and findings of the survey team.

The survey team consisted of the following individuals:

Dr. William H. Hooke, Team Leader, Program Director for Weather Research, Office of Atmospheric Research, Silver Spring, Maryland

Christine Alex, Meteorologist, Office of Meteorology, National Weather Service Headquarters, Silver Spring, Maryland

Aris Georgakakos, Professor of Engineering, Georgia Institute of Technology, Atlanta, Georgia (independent consultant)

Anton Haffer, Meteorologist in Charge/Area Manager, NEXRAD National Weather Service Forecast Office, Phoenix, Arizona

Edwin May, Deputy Regional Hydrologist, Hydrologic Services Division, Southern Region Headquarters, National Weather Service, Fort Worth, Texas

Debra Van Demark, Technical Leader, Hydrologist, Office of Hydrology, National Weather Service Headquarters, Silver Spring, Maryland

Background and overview information on the hydrologic situation, which appears in Chapter 1, was contributed by Scott Kroczyński of the Hydrologic Information Center, Office of Hydrology, Silver Spring, Maryland. Graphics support was provided by Paul Hrebanach of the Office of Hydrology. Descriptions of the meteorological conditions and forecasts, which are presented in Chapter 2, were contributed by Bruce Terry of the Meteorological Operations Division, National Meteorological Center, Camp Springs, Maryland, and Edward Rappaport of the National Hurricane Center, Coral Gables, Florida. Debra Anderson, Program Assistant in the Office of Hydrology, edited and formatted this report into a camera-ready document for publication.

The team was divided into two groups during parts of the survey so that the wide geographic area of impact could be covered efficiently. One group, composed of Alex, Georgakakos, and May, traveled through Georgia and the eastern portion of the Florida Panhandle. The other group, composed of Haffer, Hooke, and Van Demark, concentrated on Alabama and the western portion of the Florida Panhandle. During the week, the two teams coordinated their progress by meetings and telephone calls. The survey team conducted its field work on Monday, July 18, through Friday, July 22. The entire survey team met in Atlanta, Georgia, on Saturday, July 23.

The consensus of the survey team was that overall NOAA provided good, high-quality services throughout this event. The report discusses successful features of NOAA's services program, as well as recommendations for areas needing improvement.



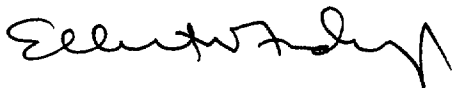
William H. Hooke
Team Leader

FOREWORD

The National Weather Service (NWS), one of the line offices of the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA), has broad Federal responsibility to provide public forecasts and warnings of weather and river conditions for the protection of life and property and in support of the Nation's commerce. NOAA conducts a survey of major natural disasters to thoroughly assess the performance of its warning system in all aspects, from data collection and assimilation through creation and dissemination of products and, ultimately, effective user response. This report of the disaster survey team's findings regarding the disastrous floods of the southeastern United States in 1994 identifies opportunities to improve the NWS's weather and flood warning system, not only in the affected region but throughout the Nation.

The survey team was sent to the region affected by major flooding in July 1994. The team visited NWS offices that provide flood warning service to the affected region. They interviewed numerous officials and representatives of the print and broadcast media.

I would like to express the special gratitude of the NWS to the numerous Federal, state, and local officials and media representatives in Alabama, Georgia, and Florida who helped the survey team. Having provided admirable service to the public through this disastrous flood event, you also aided the survey team in evaluating the NWS's warning services.



Elbert W. Friday, Jr.
Assistant Administrator
for Weather Services

EXECUTIVE SUMMARY

Tropical Storm Alberto originated in Senegal on June 18, 1994, as a tropical wave. The system became Tropical Depression One on June 30 at approximately 0600 Universal Coordinated Time (UTC). On July 2 at about 0000 UTC, the depression strengthened in the Gulf of Mexico near the Yucatan Peninsula to become Tropical Storm Alberto. When the center made landfall near Destin, Florida, at 1500 UTC on July 3, Alberto was at its peak intensity, 993 millibars and 55-knot winds. Winds then quickly subsided, and Alberto's central pressure rose rapidly.

After landfall, the motion of the storm slowed and precipitation increased. The storm moved slowly through Alabama into Georgia, stalling just south of Atlanta. Over the next few days it reversed its course and then looped back on its previous course before ultimately dissipating. During that period it dumped copious amounts of rain across the area. Amounts as high as 21.1 inches in 24 hours were observed at Americus, Georgia. The Weather Surveillance Radar-1988 Doppler (WSR-88D) provided the forecasters with a very good representation of the areal extent of the precipitation although it underestimated precipitation amounts somewhat. This rainfall produced record and near-record flooding along the Flint, Ocmulgee, Chattahoochee, Choctawhatchee, and Apalachicola Rivers. Overall, flash flooding and flooding caused by the rainfall from Alberto took 33 lives, destroyed thousands of homes (including some entire communities), forced approximately 50,000 people to be evacuated, and caused property damage (including lost crops) estimated as high as \$750 million.

Based on the current technologies available to the National Weather Service (NWS) offices in the area affected by Alberto, the offices in general performed their forecast and warning functions in an exemplary manner. The NWS received high praise for its products and services from all affected parties (emergency managers, the media, and the general public). Throughout Georgia, Alabama, and Florida, the disaster survey team found a remarkably universal degree of high regard.

The lack of negative comments may be attributed in part to the fact that external perceptions and expectations of NWS's present and future capabilities were quite limited relative to what the NWS believes it can and should be able to do as a result of the modernization now underway. Initial uncertainties regarding Alberto's landfall, the failure to predict that the storm would stall over Georgia instead of moving to the northeast, the Bainbridge forecast discrepancy, and the relatively short lead-time of some flash flood warnings are all examples of where users of NWS forecasts and products should, in the future, be able to expect a more accurate and timely service.

Many of the deaths in this event can be attributed to individual lack of judgment: refusal to evacuate despite the request of emergency managers and other authorities, attempts to either drive around barricades or on inundated roads, and other actions obviously inappropriate in the face of the hazard. Approximately two-thirds of the deaths were related to vehicular incidents. They also represent a small fraction (less than 0.1 percent) of the total number of people evacuated. Nevertheless, the high loss of life is troubling and clearly leaves room for improvement. A few people were seemingly unaware of the impacts of their weather-related decisions. Some complacency was evident early in the event. A factor which may have contributed to this complacency is the fact that recent floods in the Southeast have not been nearly as severe as this one. Therefore, most residents did not have previous experience in dealing with such a dangerous flood event.

Although general external impressions of NWS performance were favorable, the disaster survey team's closer examination revealed a number of causes for concern and opportunities for improvement (a summary of all the findings and recommendations of the disaster survey team is located in Appendix A):

- Perhaps as much as any single factor, the inability of NWS centralized model guidance to predict the reversal of the storm motion and precipitation amounts significantly limits the utility of NWS products and services. *The NWS should work with the Office of Atmospheric Research and other Federal agencies, as well as the academic research community, to improve such predictions.*
- The forecast for the Flint River at Bainbridge received considerable media and public attention when the river crested well below the forecasted level. *The forecast at Bainbridge needs to be investigated and appropriate changes made to the forecast scheme.*
- There is some indication that a number of problems occurred during the event that were related to the public's perception of the interfaces between responsibilities. Examples of these interfaces include the following: between the National Hurricane Center and National Meteorological Center's Meteorological Operations Division as the storm made landfall; between Weather Service Forecast Offices; between Weather Service Forecast Offices and Weather Service Offices; between Weather Service Forecast Offices and the River Forecast Center; and between the NWS and the media, emergency managers, and the general public. *Interfaces are inevitable. Modernization in the NWS will cause a shift in a number of them. The NWS should develop an inventory of particularly important interfaces and ensure that the treatment of these receive special attention and priority.*

- Transition to the modernized NWS and its associated staffing configurations pose special challenges. Throughout the affected region, offices had to deal with added stress in their handling of the event by conflicts between scheduled training and urgent operations, by recent introduction of the new technologies (particularly the WSR-88D), and by vacancies. *The NWS should reexamine its approach to staffing and training during the transition with an eye to the special vulnerabilities represented by extreme events and make necessary adjustments. In addition, the NWS should continue working with management at the Department of Commerce, the National Oceanic and Atmospheric Administration (NOAA), and the Office of Management and Budget, and with the Congress, to ensure that this is the last such wrenching modernization the NWS undertakes. In the future, modernization must be a continuing process, not a disruptive event.*

- Preparedness is a special issue. As warnings and forecasts of particular events improve, opportunities for saving lives and property will depend increasingly on preparedness. In the modernized NWS, it will be challenging for a smaller number of offices to work with communities and other affected parties spread over large geographical areas to build the needed relationships and coordination on an ongoing basis. *The NWS should identify resources for improving the capabilities of Weather Service Forecast Offices and future Weather Forecast Offices to build community preparedness with special focus on taking advantage of the "information highway."*

- New demands on NOAA for information are created by increasing and changing societal vulnerability to weather, growing awareness of this vulnerability, and technological advances, especially in computing and communications. *NOAA should continue to shift emphasis from particular events to ongoing processes of preparedness. It should create national capabilities that parallel the Federal Emergency Management Agency's capabilities for special emergency response and disaster relief operations. NOAA should also give more emphasis to the development of all-hazard telecommunications capability for NOAA Weather Radio.*

ACRONYMS AND ABBREVIATIONS

AFB	Air Force Base
AFOS	Automation of Field Operations and Services
AVN	AViationN (model), global spectral model that forecasts out to 72 hours
AWIPS	Advanced Weather Interactive Processing System
CAC	Climate Analysis Center
cfs	cubic feet per second
CLIPER	CLImate and PERsistence hurricane tracking model
COE	U.S. Army Corps of Engineers
CWA	County Warning Area
DNR	Department of Natural Resources
EDT	eastern daylight time
EMA	Emergency Management Agency
EOC	Emergency Operations Center
Eta	Eta model, Western Hemisphere (northern portion) out to 48 hours
FEMA	Federal Emergency Management Agency
FFA	Flash Flood Watch
FFW	Flash Flood Warning
FLS	Flood Statement
FLW	Flood Warning
FS	Flood Stage
GOES	Geostationary Operational Environmental Satellite
HAS	Hydrometeorological Analysis and Support
HDRAIN	hourly digital rainfall product (WSR-88D Stage I Precipitation Processing)
HSA	Hydrologic Service Area
IFP	Interactive Forecast Program
LARC	Limited Automatic Remote Collector
mb	millibar
MIC	Meteorologist in Charge
mph	miles per hour
NAWAS	National Attack Warning System
NCCF	NOAA Central Computer Facility
NCDC	National Climatic Data Center
NEXRAD	Next Generation Weather Radar
NHC	National Hurricane Center
NHC90	statistical dynamic model that uses output from the AVN as predictors
NMC	National Meteorological Center
NOAA	National Oceanic and Atmospheric Administration
NWR	NOAA Weather Radio
NWS	National Weather Service

NWSFO	NEXRAD Weather Service Forecast Office
NWSRFS	National Weather Service River Forecast System
NWWS	NOAA Weather Wire Service
OAR	Office of Atmospheric Research
prog	prognostication chart
PUP	Principle User Processors (WSR-88D)
QPF	Quantitative Precipitation Forecast
RAFS	Regional Analysis and Forecast System
RFC	River Forecast Center
RJE	remote job entry
RVS	River Statement
SERFC	Southeast River Forecast Center
SH	Service Hydrologists
SID	site identification
UGC	Universal Generic Code
USGS	U.S. Geological Survey
UTC	Universal Coordinated Time
WCM	Warning Coordination Meteorologist
WFB	Weather Forecast Branch
WFO	Weather Forecast Office
WSFO	Weather Service Forecast Office
WSO	Weather Service Office
WSR-88D	Weather Surveillance Radar-1988 Doppler

CHAPTER 1

BACKGROUND AND OVERVIEW OF THE EVENT

1.1 INTRODUCTION

A decaying tropical system, previously known as Tropical Storm Alberto, produced torrential rainfall which resulted in some of the worst flooding ever observed across portions of the States of Georgia, Alabama, and Florida during July 1994. Alberto, the 1994 Atlantic Hurricane Season's¹ first named tropical system, came ashore near the Florida Panhandle town of Destin at about 1500 Universal Coordinated Time (UTC) on July 3. The winds associated with the tropical storm caused only minor damage and no casualties, as maximum sustained winds of around 65 mph (55 knots) were briefly observed at the time of landfall. The highest storm surge was estimated at 5 feet near the point of landfall (Destin, Florida). No reports of tornadoes were confirmed in association with Alberto or its remnants.

As the tropical storm's winds rapidly diminished, attention was quickly and appropriately turned to the threat of heavy rainfall associated with the deep tropical moisture being transported by the remnants of Alberto. Indeed, over the course of the 4 days following landfall, the forward motion of the remnants of Alberto slowed and halted, only to loop back over the same area already traversed before finally dissipating. It was this meandering motion which resulted in record-breaking rainfall, including a storm total of over 27 inches at Americus, Georgia, more than 21 inches of which fell in a 24-hour period. The torrential rainfall led to exceptional flooding across central and western Georgia, southeastern Alabama, and the Florida Panhandle. Five river basins were particularly hard hit (see Figure 1-1): (1) the Flint River Basin in western Georgia, (2) the Ocmulgee River Basin in central Georgia, (3) the Chattahoochee River Basin along the Georgia-Alabama state line, (4) the Choctawhatchee River Basin in Alabama, and (5) the Apalachicola River Basin in Florida.

1.2 IMPACT OF THE FLOODING

Figure 1-2 shows the counties that were Presidentially declared disaster areas. Most of the declared counties were concentrated along the five rivers (and their tributaries) mentioned in the section above. A total of 78 counties were declared Federal disaster areas, including 55 in Georgia, 10 in Alabama, and 13 in Florida.

¹Hurricane Season is defined as the period each year from June 1 through November 30.

The flooding took a significant toll on human life, as a total of 33 persons perished². Of that total, 31 deaths occurred in Georgia, while the other 2 occurred in Alabama. Many of the fatalities, as is typical with flood events, occurred as a result of flash flooding³; and most occurred in vehicles. In addition, approximately 50,000 people were forced from their homes due to the flooding. More than 18,000 dwellings were damaged or destroyed by the floods, and nearly 12,000 people applied for emergency housing. In Macon, Georgia, the fresh water supply to nearly 160,000 people was disrupted when the water treatment plant, located along the banks of the Ocmulgee River, was flooded. Some residences were without fresh water for as long as 19 days. In addition, thousands of people and pieces of equipment were engaged in various flood-fighting efforts throughout the three-state area impacted by the flooding. Dozens of Federal, state, and local government agencies, private organizations, as well as various volunteer groups, were heavily involved in the massive mobilization of resources. Federal agency participation included, but was not limited to, the Federal Emergency Management Agency (FEMA), U.S. Army, U.S. Army Corps of Engineers, U.S. Department of Transportation, U.S. Department of Housing and Urban Development, and Small Business Administration.

With respect to property damages, the estimates are nearly \$750 million⁴ across the States of Georgia, Alabama, and Florida as a result of this flood event. In addition to the more than 18,000 dwellings damaged or destroyed, hundreds of bridges and well over 1,000 roads sustained damages. Also, 218 dams (most of them small dams located in Georgia) were damaged by the flooding, many of which failed altogether. Agricultural losses accounted for approximately \$100 million. In the States of Georgia, Alabama, and Florida combined, more than 900,000 acres of crops were affected by the flooding. Georgia and Alabama suffered the greatest crop losses with more than 400,000 acres in each state impacted. In all three states, peanuts and cotton were the commodities most severely affected. Livestock losses were also significant, especially to poultry, with as many as 250,000 chickens reportedly lost to the flooding.

1.3 HYDROMETEOROLOGICAL ANALYSIS

While Tropical Storm Alberto will not likely be remembered for its wind nor its storm surge, it most certainly will be remembered, especially amongst Georgians, for its rainfall and flooding. The following sections describe, in some detail, the tropical weather system that

²This total includes 26 fatalities directly related to the flooding and 7 fatalities indirectly related. Fatalities directly related to flooding would include individuals who perished when their vehicles were swept away by floodwaters. Indirect fatalities might include individuals who perished when their vehicles became involved in accidents attributed to rain-slickened roadways.

³Flash flooding is characterized by rapid development as a result of intense precipitation. Flash floods are generally of short duration, usually on the order of several hours. Typically, small streams and urban areas are affected by flash flooding. Flash floods are often violent and very forceful and are one of the leading causes of weather-related fatalities. When flash flooding persists over prolonged periods of time due to continued rainfall, the cumulative effect can lead to significant flooding of larger river systems, as occurred in Georgia in July 1994. In this sense, widespread flash flooding can be thought of as the preliminary phase to major river flooding.

⁴Some independent damage estimates range as high as \$1 billion.

was Alberto, from its origin as a tropical wave over western Africa to its dissipation as a tropical depression over central Alabama.

1.3.1 STORM GENESIS AND LANDFALL

The tropical weather system which would eventually become Alberto was first detected as a tropical wave over western Africa on Saturday, June 18. Moving on a westerly course, the wave traversed the tropical Atlantic Ocean uneventfully until it neared the Virgin Islands when some increase in thunderstorm activity occurred. However, thunderstorm activity diminished 2 days later when the wave neared the Bahamas.

The wave continued moving westward and, on June 29, moved across Cuba where thunderstorm activity rapidly increased; and a very weak circulation became evident. With the system located in the vicinity of the western tip of Cuba, a National Oceanic and Atmospheric Administration (NOAA) reconnaissance aircraft was sent to investigate the disturbed weather area. Based on the information obtained from that flight, NOAA's National Hurricane Center proclaimed the system the 1994 Atlantic Hurricane Season's first tropical depression on June 30 (see Figure 1-3 for Alberto's track). Still moving westward, the poorly organized depression cleared Cuba then took a turn to the northwest into the Gulf of Mexico where it became better organized. Reconnaissance aircraft data indicated that the depression then strengthened to a tropical storm⁵ at approximately 0000 UTC, July 2, at which time the system was named Tropical Storm Alberto.

Alberto then began to track northward towards the Florida Panhandle as it continued to gradually intensify. Peak intensity was reached just prior to landfall when Alberto's sustained winds were 60-65 mph (55 knots), and the central pressure of the storm was near 993 millibars (mb). Alberto's center made landfall near the town of Destin, Florida, at 1500 UTC on Sunday, July 3, approximately 39 hours after becoming a tropical storm. On Sunday evening (0000 UTC July 4), just a few hours after landfall, the storm was downgraded to a tropical depression. For the next 2 days after landfall, the remnants of Alberto moved north-northeastward at a progressively slower forward speed, eventually coming to a halt near Atlanta, Georgia, on July 5. The remnants of Alberto then began to backtrack, moving westward into east-central and then central Alabama. The system dissipated during the evening hours of Thursday, July 7, over central Alabama.

1.3.2 DESCRIPTION OF THE ANTECEDENT CONDITIONS AND HEAVY PRECIPITATION

With respect to the antecedent conditions prior to Alberto's arrival, much of the spring of 1994 was quite dry throughout the Southeast. In fact, many southeastern residents were

⁵A tropical storm is defined as a tropical low pressure system which has sustained wind speeds of 39 mph (34 knots) or greater. When a tropical low-pressure system achieves tropical storm strength, it is given a name, such as "Alberto." A tropical storm is stronger than a tropical depression but weaker than a hurricane, which has sustained wind speeds of at least 74 mph (65 knots).

undoubtedly concerned about recurring drought conditions, similar to those which occurred during the summer of 1993. However, June 1994 brought much wetter conditions over most of the Southeast. In fact, the rainfall in June resulted in some localized flash flooding and even some limited, mostly minor river flooding across portions of the Southeast. At the beginning of June, moderate-to-extreme drought conditions existed across a considerable portion of the Southeast, especially over Georgia and South Carolina. But due to the wet June, by the time of Alberto's arrival in early July, hydrologic conditions across much of the Southeast had returned to near normal, or just slightly drier than normal. Thus, the wet June certainly was a factor in the evolution of the July flood.

There is little question as to the cause of the torrential rainfall associated with Alberto and its remnants. While heavy precipitation accompanies nearly every tropical system, excessive rainfall was produced by the remnants of Alberto due to two main factors: (1) the slow, forward motion of the system and (2) the meandering, looping (retrogressive) nature of the system's track. These characteristics contributed to rainfall accumulations that, in several places, exceeded 20 inches. Noteworthy was Americus, Georgia, which received a storm total of 27.61 inches (July 3-9), including a 24-hour total of 21.1 inches (July 5-6). While such amounts are certainly not unprecedented, they are nonetheless rare, even with decaying tropical systems.

Figure 1-4 shows the National Weather Service (NWS) Climate Analysis Center's storm total isohyetal analysis. The heaviest rains (16 inches or greater) fell in a relatively narrow band across southwestern Georgia and southeastern Alabama. Some of the worst flash and urban flooding occurred in this excessive rainfall area, as evidenced by the 15 fatalities that occurred in the vicinity of Americus, Georgia. In contrast, a far larger area was inundated with 8 or more inches of rainfall. It was this heavy precipitation that fell over a fairly large area that generated tremendous runoff and resulted in the widespread river flooding.

1.3.3 DESCRIPTION OF THE FLOODING

Figure 1-5 is a composite figure combining portions of Figures 1-1 through 1-4. This figure shows the inland track of Alberto and its remnants, the area enveloped by the 8-inch rainfall isohyet, the major rivers affected by flooding, and the counties that were Presidentially declared disaster areas.

As is typical with flood events of this magnitude, widespread major river flooding evolves from flooding which first manifests itself in the form of urban, small stream, and flash flooding. Such was the case with this flood. The first reports of flooding included flooded roads, underpasses, culverts, and the like. Since the heaviest rains were generally close to the path of the center of Alberto, the pattern of flooding essentially followed the path of the storm center. Thus, flooding first broke out across portions of the Florida Panhandle and southeast Alabama, then across southwestern portions of Georgia. Flooding later broke out across much of the remainder of western and central Georgia. As rainfall persisted and soils became saturated, small streams and rivers began to overflow; and small dams were

threatened by the tremendous inflow into the reservoirs behind them. Some small, unregulated earthen dams began to fail, and reports of road and bridge washouts became common.

Within a day after landfall, the forward motion of Alberto slowed. The rains continued, and some of the larger rivers began to approach flood stage at various locations. Late on July 5, with the center of Alberto coming to a halt near Atlanta, portions of numerous large rivers exceeded flood stage; and river flooding became more widespread and significant. By the morning of July 6, some locations had observed record flooding; and the first crests began to appear along some of the smaller rivers and at some upstream locations along the larger rivers. Alberto's movement became erratic--the system was now moving westward, looping back over a portion of its previous track. Additional rainfall caused a progression in flooding from urban and small stream flooding to river flooding. By July 7, as Alberto's center drifted into central Alabama, rainfall finally diminished, both in intensity and in areal coverage. Tremendous volumes of water were now moving down major river systems in portions of Georgia, Alabama, and Florida: the Flint, Ocmulgee, Chattahoochee, Choctawhatchee, and the Apalachicola Rivers. River flooding peaked, both in terms of coverage and severity, during the period July 6-15; but flooding would continue along portions of some rivers until close to the end of July.

By far, the worst flooding occurred along Georgia's Flint and Ocmulgee Rivers and their tributaries. Some of the hardest hit cities along these rivers include Albany, Macon, and Montezuma. Across the entire three-state area impacted by the flooding, 17 NWS river forecast locations set new record flood stages, some breaking the old record by 5-7 feet. In all, 47 NWS river forecast locations exceeded flood stage. Crests of 5-15 feet above flood stage were common, while portions of some rivers observed crests that exceeded flood stage by more than 20 feet. The NWS offices involved in the flood event across the three-state area issued 657 watches, warnings, and statements related to the event; and the Southeast River Forecast Center (SERFC) issued 238 NWS internal river forecasts.

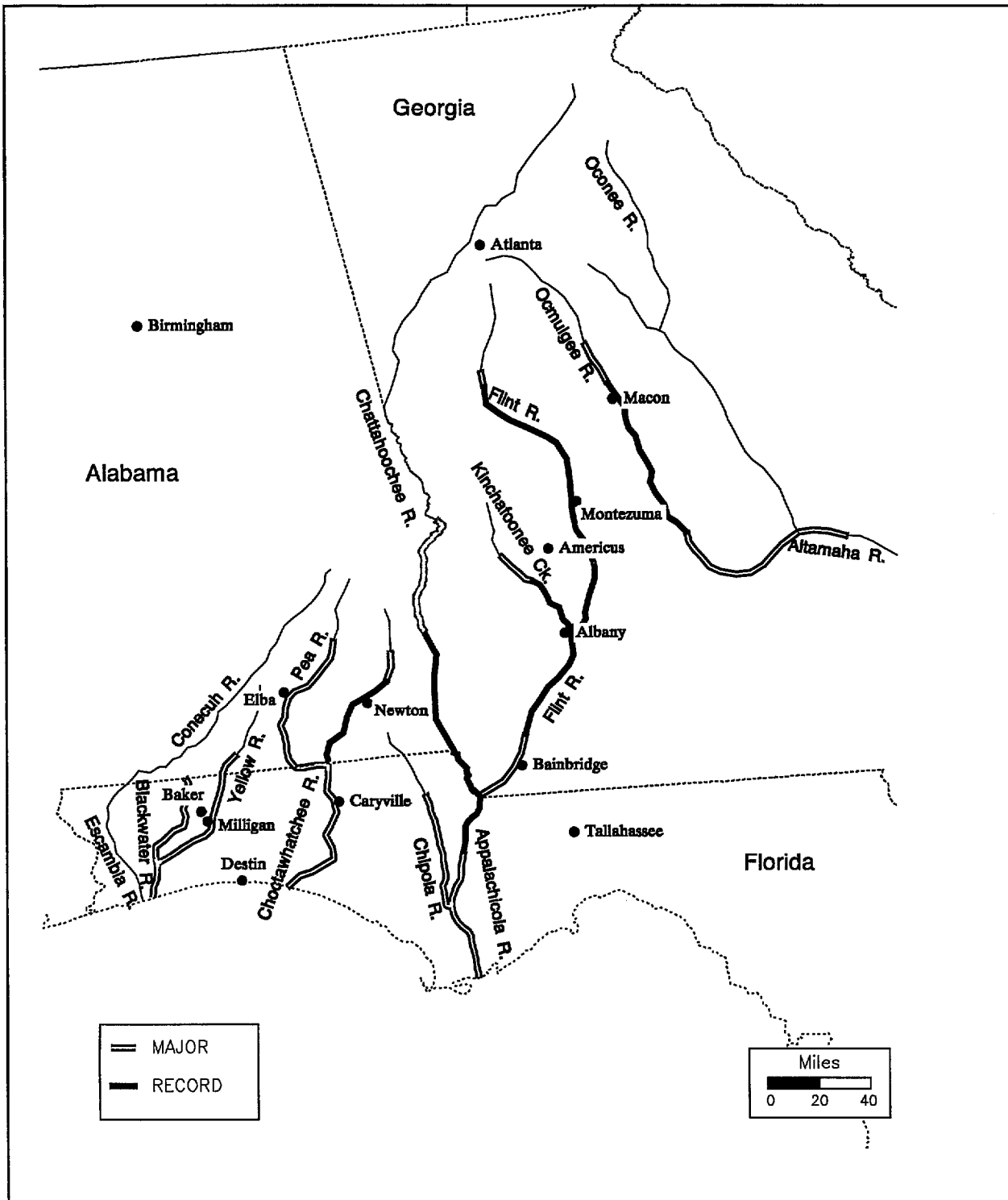


Figure 1-1. Major river basins impacted by flooding in July 1994 as a result of Alberto: Flint, Ocmulgee, Chattahoochee, Choctawhatchee, and Apalachicola River Basins.

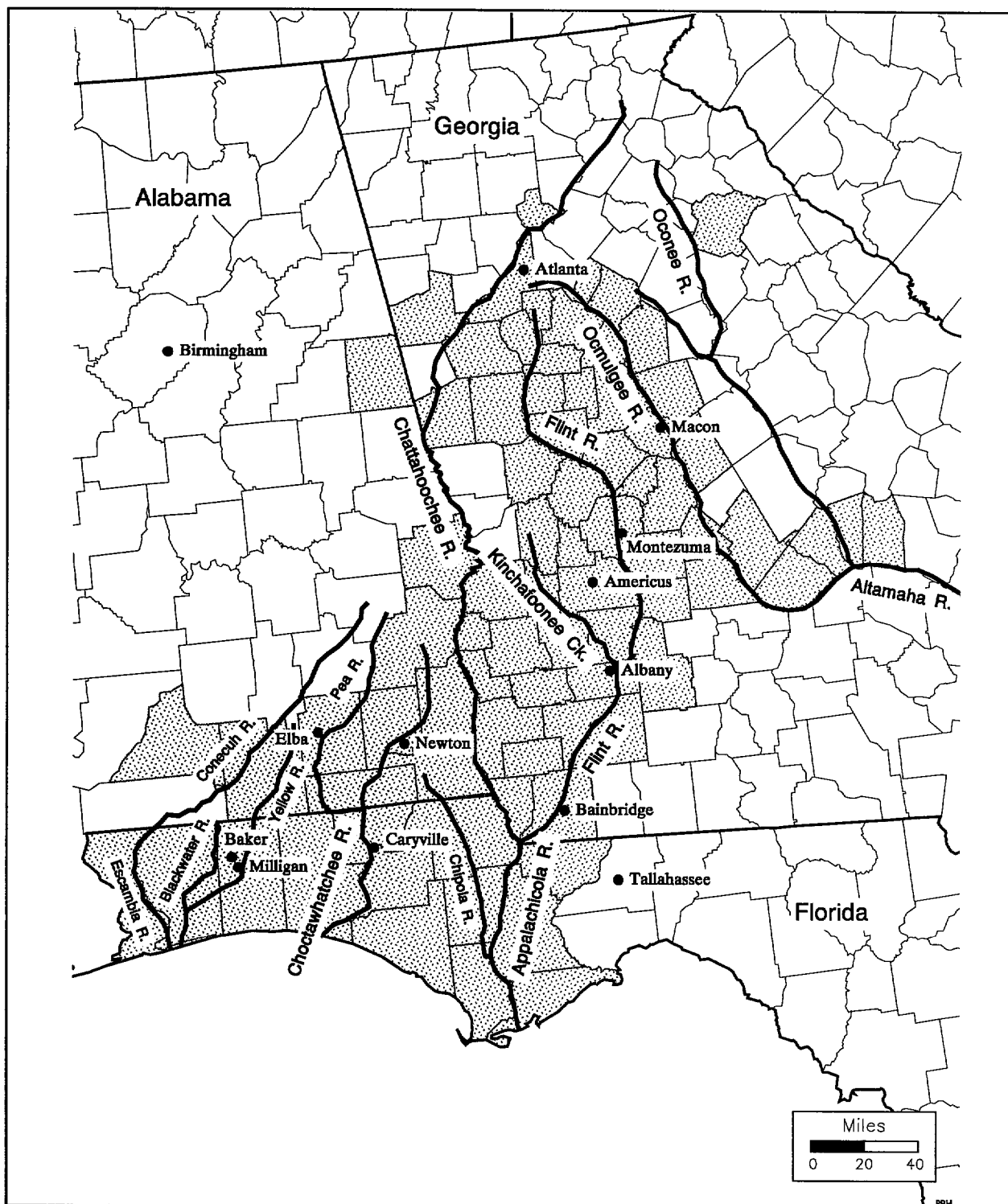


Figure 1-2. A total of 78 counties were declared Federal disaster areas: 55 in Georgia, 10 in Alabama, and 13 in Florida.

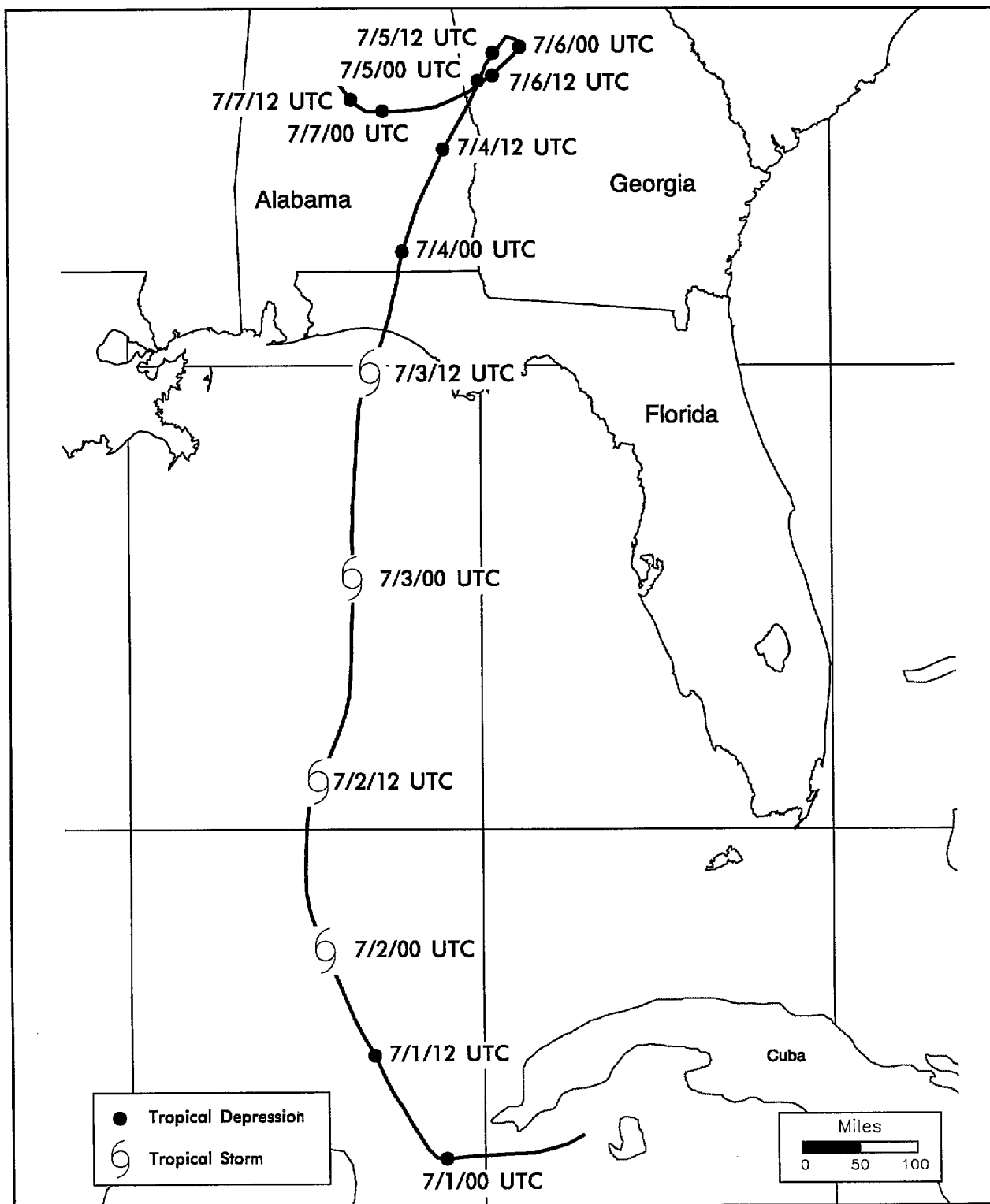


Figure 1-3. *Alberto's track, July 1994.*

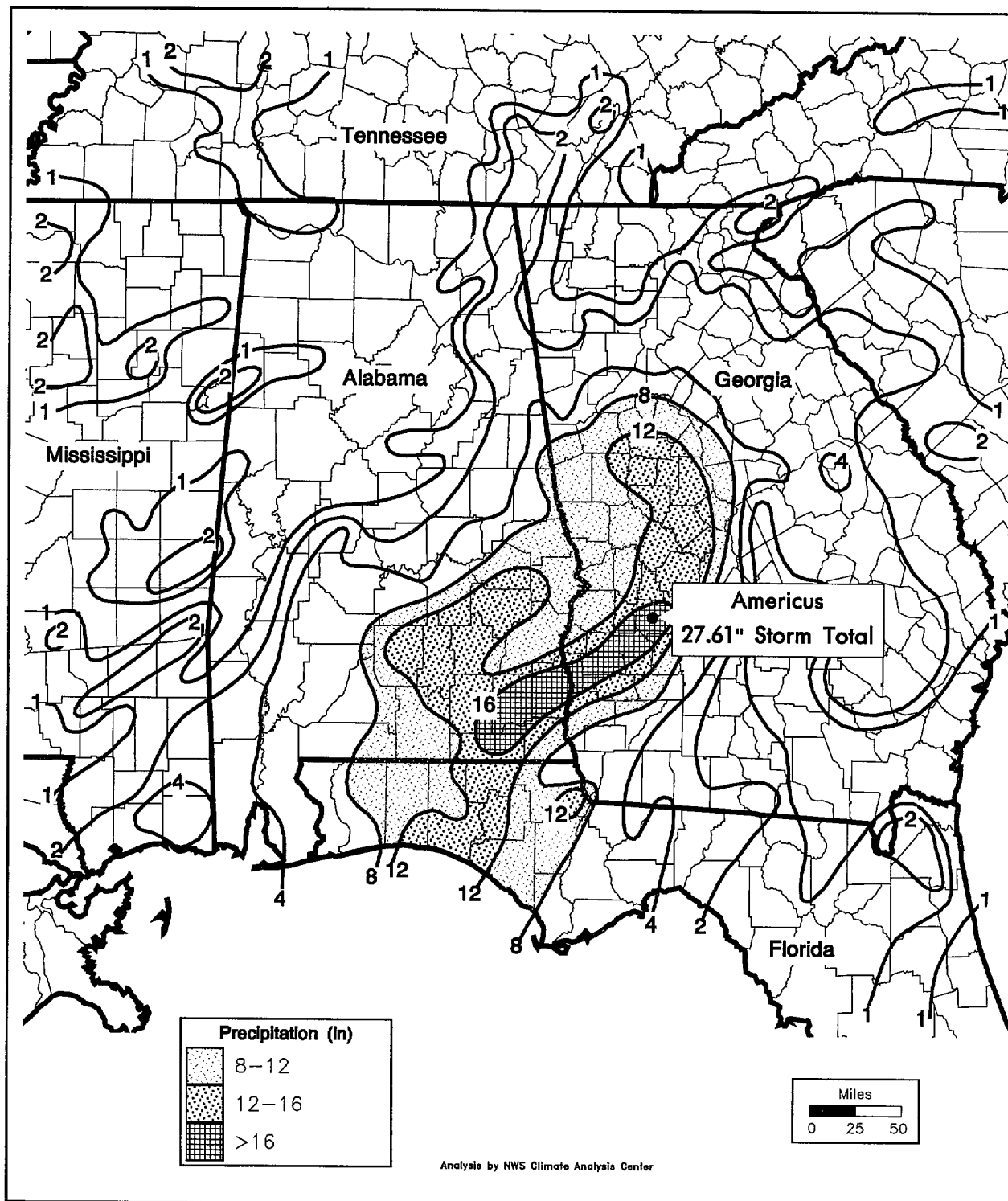


Figure 1-4. Storm total precipitation during the period July 3-9, 1994 (Americus, GA: 27.61" storm total).

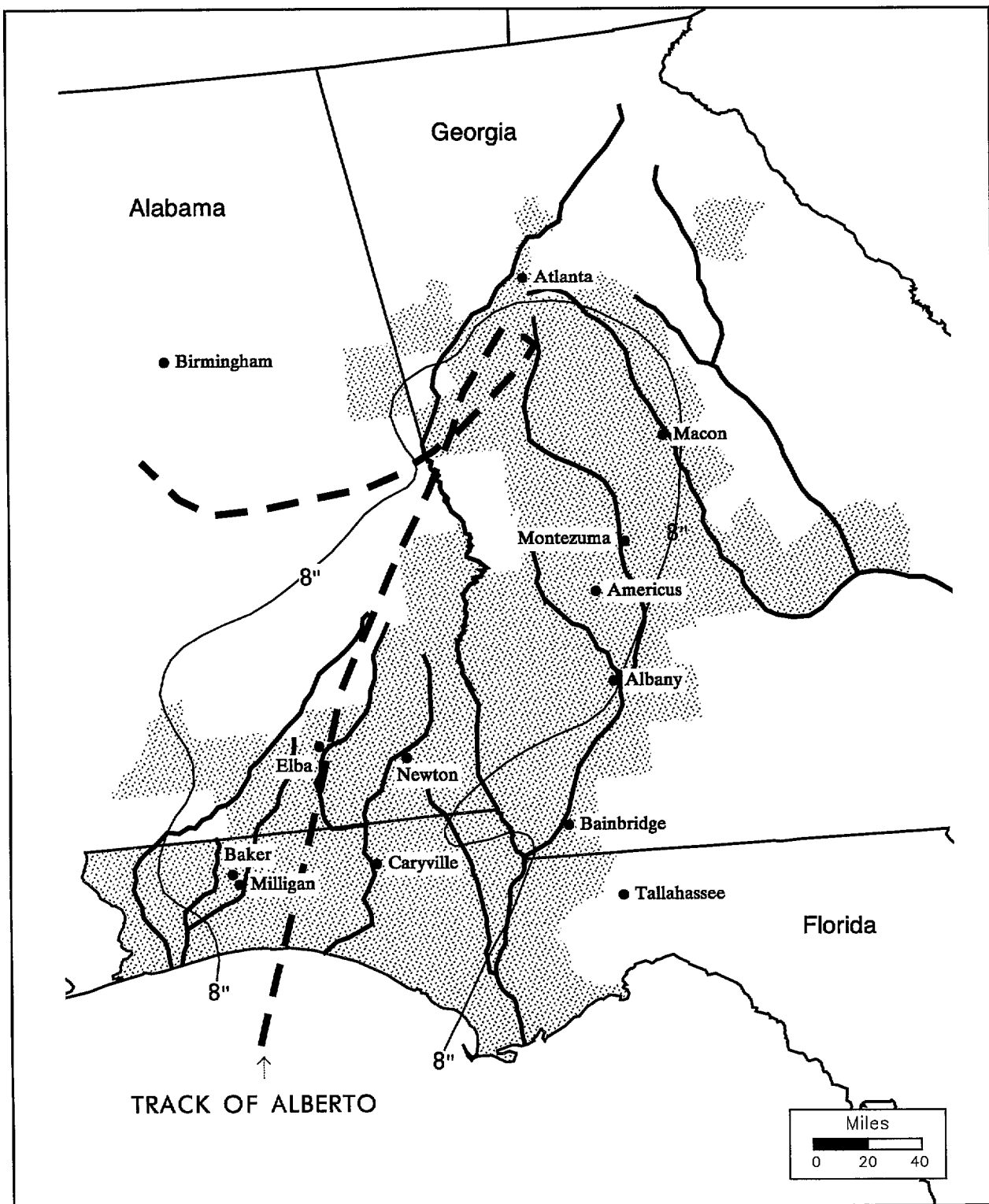


Figure 1-5. Composite showing Alberto's inland track (dashed line), the 8-inch isohyet, the 78 counties declared Federal disaster areas (shaded), and the five major river systems.

CHAPTER 2

OVERVIEW OF NWS PERFORMANCE

2.1 STORM PREDICTION

The National Meteorological Center (NMC) provides weather analyses and forecast guidance for use by field offices. Two divisions within NMC, the National Hurricane Center (NHC) and the Weather Forecast Branch (WFB) of the Meteorological Operations Division, share responsibility for tracking and forecasting tropical systems. The NHC has primary responsibility for forecasts until, in coordination with the WFB, it is decided that the WFB assumes the responsibility. WFB is also responsible for issuing the Quantitative Precipitation Forecast (QPF) guidance for the contiguous United States.

2.1.1 SUMMARY OF STORM TRACK AND FORECASTS

Alberto began as a tropical depression just west of Cuba at approximately 0600 UTC on Thursday, June 30, and was upgraded to a tropical storm at 0000 UTC on July 2. At that time, steering winds throughout the atmosphere indicated Alberto would track towards the Gulf Coast of the United States, but exactly where it would make landfall was uncertain. Forecasts issued from the NHC at this time took Alberto into Louisiana very early Monday, July 4, while forecasts from the WFB took Alberto very near Mobile Bay, Alabama, on Sunday afternoon, July 3. As synoptic forcing became clearer, the forecasts from the NHC and WFB converged. By the morning of July 2, landfall was predicted by the NHC and the WFB to be in southern Alabama and the western Florida Panhandle, respectively, around midday Sunday, July 3. Forecasts issued later in the afternoon of July 2 were almost identical, with Alberto forecast to make landfall in the western Florida Panhandle around noon on Sunday, July 3. Subsequent forecasts remained extremely similar and, as it turns out, quite accurate, since Alberto did come ashore in the western Florida Panhandle at 1500 UTC July 3 as a very strong tropical storm.

The storm, which produced near-hurricane-force winds as it moved inland, began to quickly weaken later on Sunday. The emphasis at this point shifted to the potential for very heavy rains, since Alberto had plenty of tropical moisture associated with it and would likely be a slow-moving storm after landfall.

The NHC issued its first advisory on the tropical depression at 2100 UTC on June 30. Near 0000 UTC on July 2, based on reconnaissance data, the depression was upgraded to Tropical Storm Alberto. A tropical storm watch was issued at 0900 UTC on July 2 for the northern Gulf of Mexico coastal areas from Sabine Pass, Texas, to Pensacola, Florida. Later that morning (1500 UTC), a tropical storm warning was issued for the north Gulf of Mexico coastal areas from Gulfport, Mississippi, to Cedar Key, Florida. At that same time, the tropical storm watch

was discontinued west of Gulfport. Alberto continued to strengthen, and the advisory issued at 2100 UTC on July 2 mentioned that, based on the trend at that time, Alberto could be close to hurricane strength by the time of forecasted landfall. Based on a reconnaissance flight, the tropical storm warning was upgraded to a hurricane warning at 0000 UTC on July 3, covering the same portion of the Gulf of Mexico coast (from Gulfport, Mississippi, to Cedar Key, Florida). In the advisory issued at 0300 UTC on July 3, landfall was estimated to be over northwest Florida during the morning daylight hours. A tropical storm *watch* was not issued for the eventual landfall location of Destin, Florida. However, a tropical storm *warning* including Destin was issued with a lead-time of 24 hours; and a hurricane warning was issued with 15 hours lead-time. Upon landfall (around 1500 UTC on July 3), the hurricane warning was discontinued. However, a tropical storm warning continued in effect from Cedar Key, Florida, to Mobile, Alabama. All tropical storm warnings were discontinued at 2100 UTC on July 3 and, at the same time, Alberto was downgraded to a tropical depression.

NHC issued its last advisory on Alberto at 2100 UTC on July 3. At that time, forecast responsibility for the remains of Alberto were assumed by the WFB, which issued its first advisory (storm summary) at 2300 UTC July 3.

2.1.2 EVALUATION OF NMC NUMERICAL GUIDANCE AND STORM TRACK FORECASTS

The various NMC numeric models are briefly described below:

AVN -	Aviation Model, global spectral model that forecasts out to 72 hours
CLIPER -	CLImate and PERsistence no-skill model
Eta -	Eta Model, Western Hemisphere (northern portion) out to 48 hours with more resolution in the vertical than the RAFS model
NHC90 -	Statistical dynamic model that uses output from the AVN as predictors
RAFS -	Regional Analysis and Forecast System, Western Hemisphere (northern portion) out to 48 hours

Most track model guidance (and the NHC official forecasts based, in part, on that guidance) had a large left bias prior to about 1200 UTC or 1800 UTC on July 2 (Figure 2-1). The rightward swing of the official forecast tracks eventually required an eastward shift of the watch/warning area along the north coast of the Gulf of Mexico.

The performance of the NHC90 model was the best overall (including the depression stage of the storm), with errors comparable to the long-term average NHC official forecast errors. Another hurricane model, CLIPER, which has no dynamical input, also forecast the track fairly well. The Aviation (AVN) model track scheme produced by far the worst storm track forecasts. The NHC and model guidance intensity forecasts were quite good. Most NHC wind speed forecasts were no larger than 10 knots for all forecast periods.

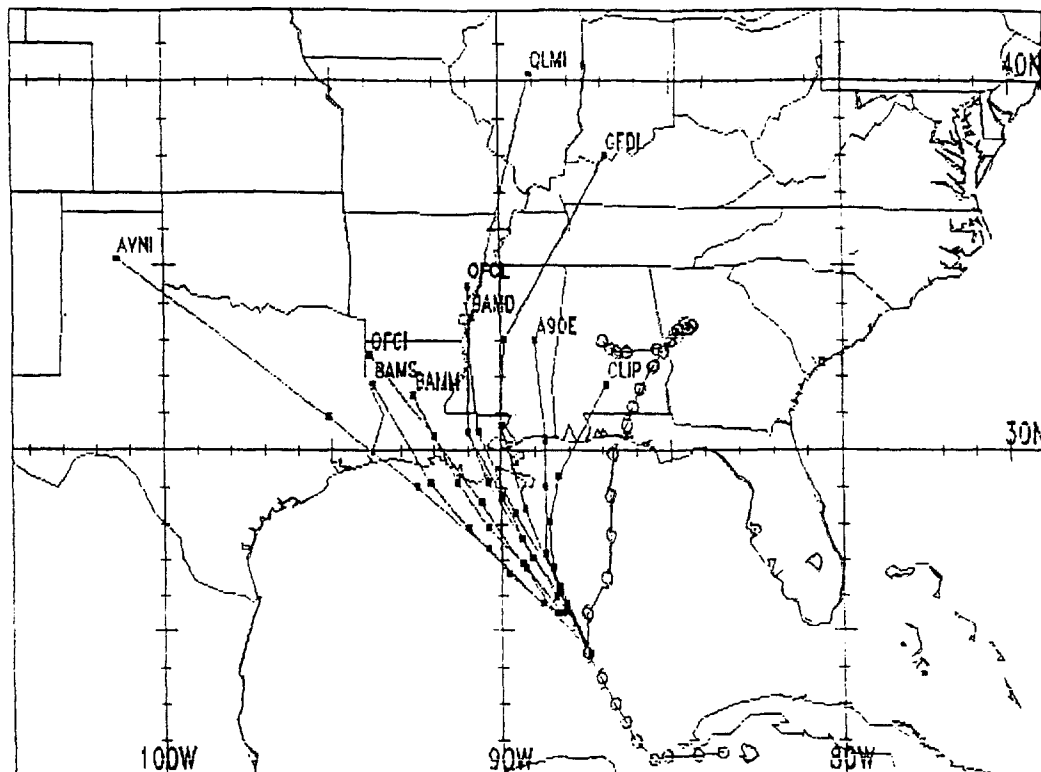


Figure 2-1. NHC track guidance showing projected storm track with model names indicated at the end of the trajectory and actual storm track depicted by the line with open circles.

Since the synoptic pattern had little or no forcing and weak steering currents, the NMC models generally did not perform well with regard to the track of the storm, especially after the storm made landfall. In addition to difficulty in forecasting storm track, current numerical models do not typically perform well forecasting precipitation amounts associated with tropical systems. Beginning Tuesday, July 5, the models began to diverge with respect to the forecast track of the remnants of Alberto. The Eta model consistently produced the preferred (and best, as it turned out) forecast of storm movement and QPFs throughout the event.

The model forecasts were good for the first two days of the event, Sunday, July 3, and Monday, July 4. However, after this time, only the Eta model performed well. Although the Eta model at times had a tendency to take the remains of Alberto a little too far north, it offered the most reliable numerical model guidance. From Tuesday, July 5, through Thursday, July 7, the RAFS model was incorrectly trying to shear the remnants of Alberto out to the northeast, while the AVN model would continually dissipate the system beyond its 24-hour forecast. Thus, much of the manual guidance issued by the WFB was based on the Eta model.

FINDING 2-1: As is generally the case with a synoptic pattern with little or no forcing and weak steering currents, the NMC and NHC models in general did not perform well with regard to the track of the remnants of Tropical Storm Alberto.

RECOMMENDATION 2-1: The NWS should continue to strive for improvements in tracking tropical systems once they make landfall. It is especially important that improvements be made in the forecasts at the surface and not just in the mid and upper levels of the atmosphere. Interactions with the research community within NOAA (such as the Office of Atmospheric Research) and other Federal agencies, as well as the academic research community, are especially encouraged.

2.1.3 SUMMARY OF QUANTITATIVE PRECIPITATION FORECASTS

Forecast discussions issued by the forecasters in the WFB between July 4 and July 7 highlighted the strong possibility for flooding and extremely heavy rain. A discussion issued very early Monday morning, July 4, highlighted a "Very dangerous Flash Flood and Flood situation for much of Georgia today into tonight as the remnants of Alberto drift slowly north." This same discussion mentioned isolated rains of greater than 5 inches between Monday morning and Tuesday morning. On Tuesday afternoon, July 5, an excessive rainfall discussion was issued which indicated that 5-8 inches of rain was a good possibility Tuesday night over a large portion of northern and central Georgia into eastern Alabama. On Wednesday, July 6, an excessive rainfall discussion began with "A dangerous and almost unbelievable situation remains over Georgia and is expected to spread into eastern Alabama, with additional rainfall amounts of 5 to 8 inches possible across southwestern Georgia into southeastern Alabama."

Manual QPFs issued by the WFB were better than the QPFs generated by the models. QPF graphic forecasts for July 4, 5, 6, and 7 are included as Figures 2-2, 2-3, 2-4, and 2-5,

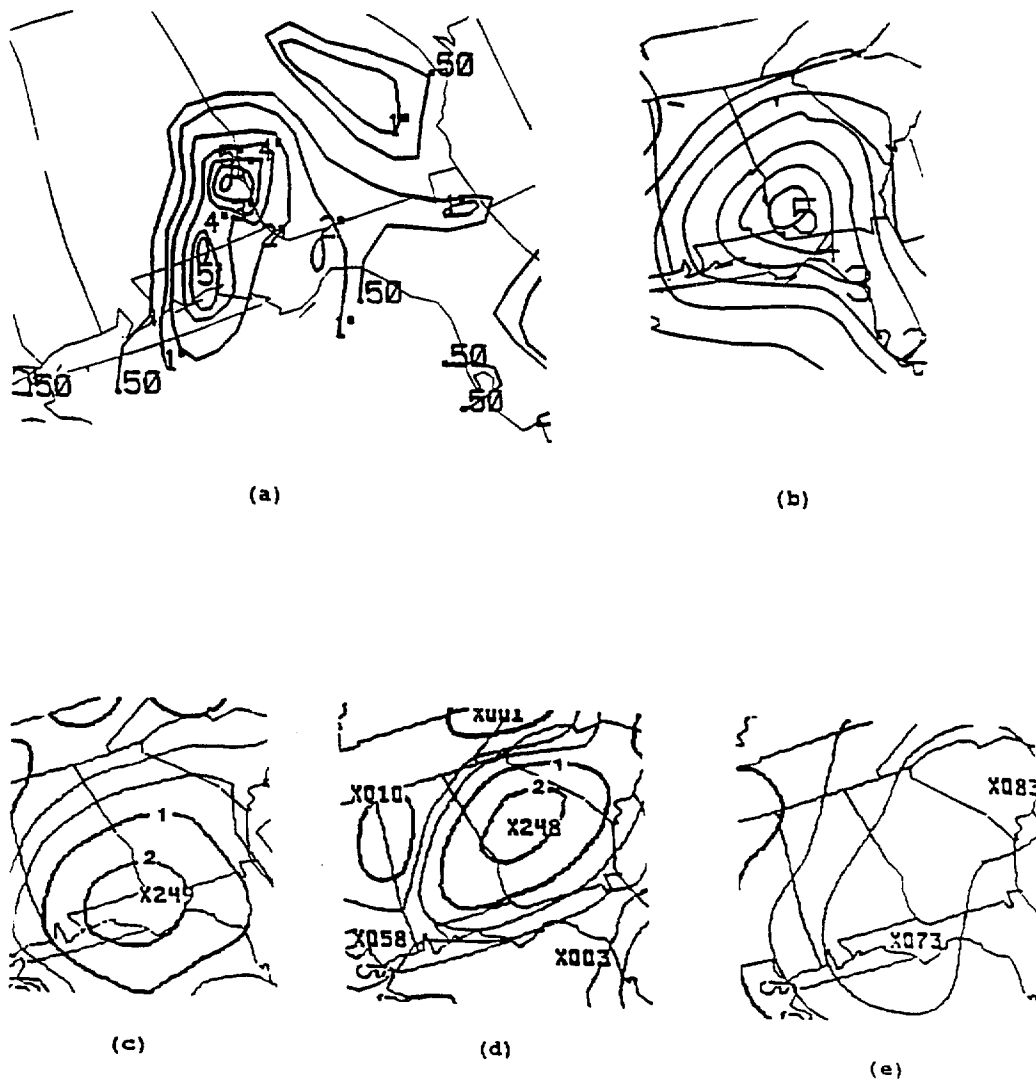
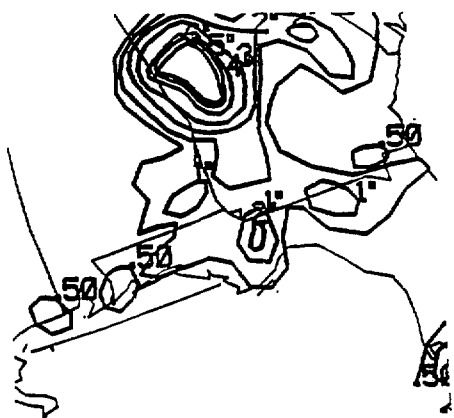
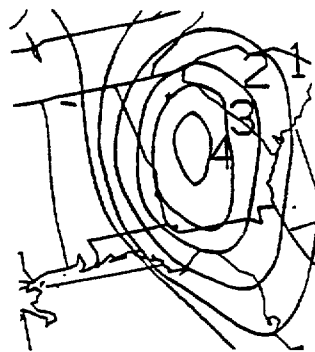


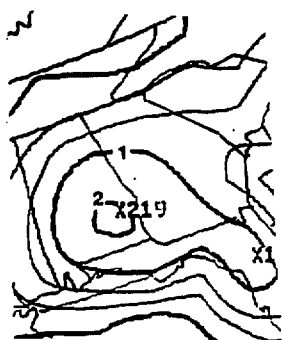
Figure 2-2. QPF graphics for 24 hours ending 1200 UTC July 4, 1994: (a) observed, (b) manual forecast, (c) ETA forecast, (d) RAFS forecast, and (e) AVN forecast.



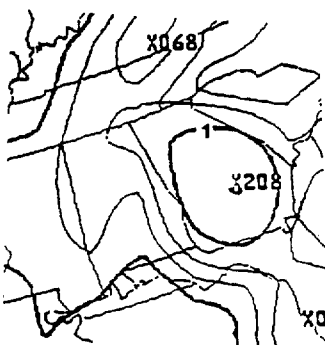
(a)



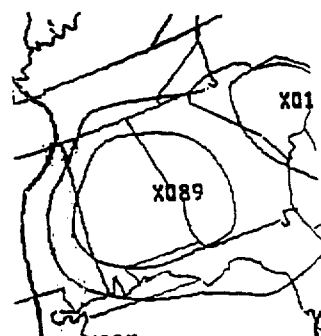
(b)



(c)



(d)



(e)

Figure 2-3. QPF graphics for 24 hours ending 1200 UTC July 5, 1994: (a) observed, (b) manual forecast, (c) ETA forecast, (d) RAFS forecast, and (e) AVN forecast.

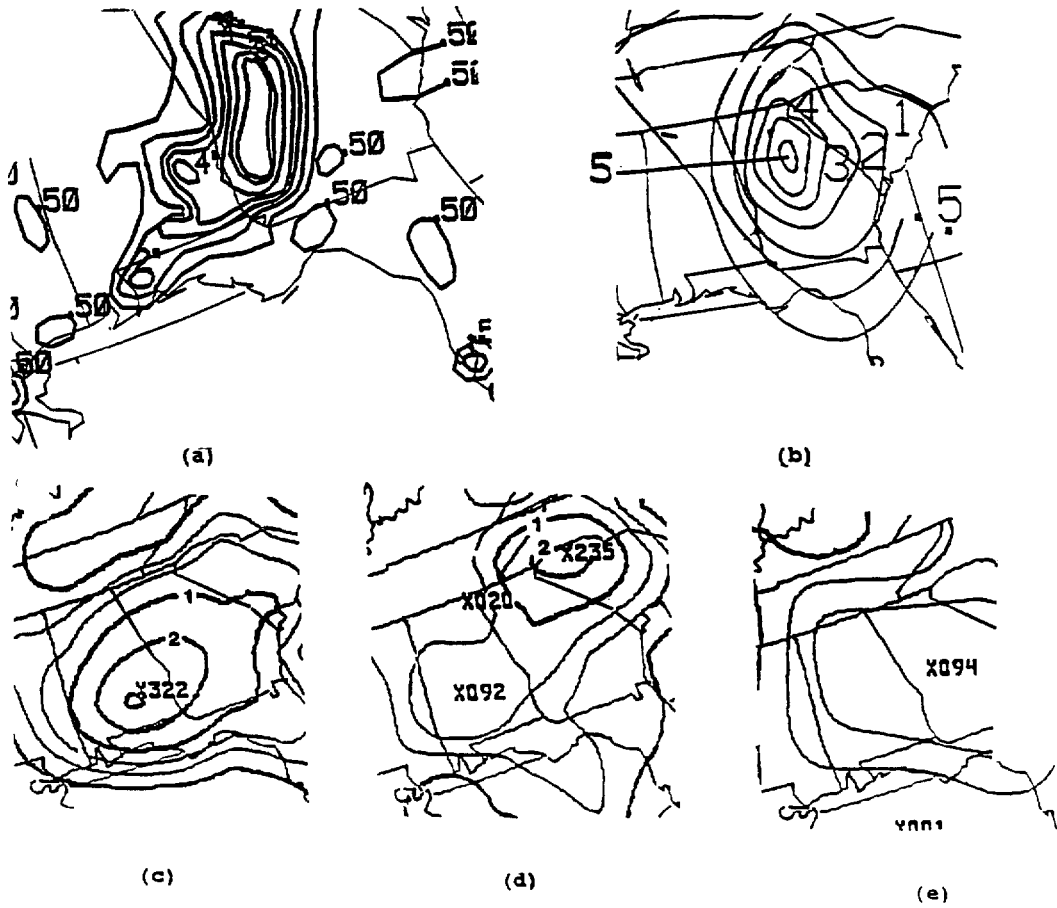
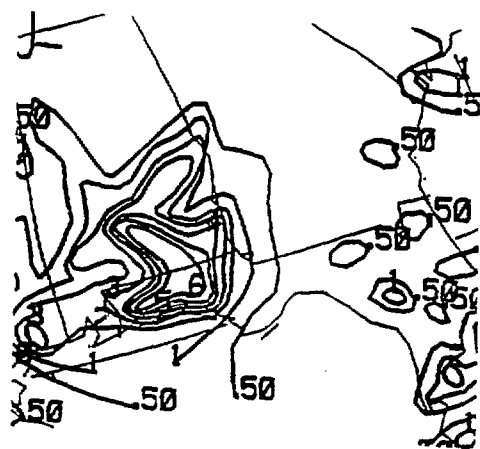
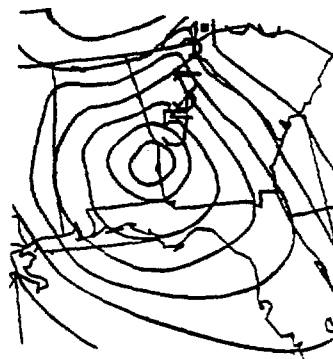


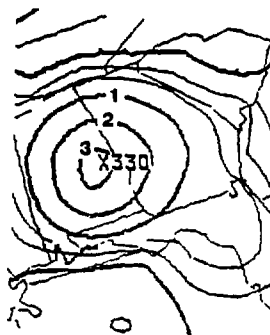
Figure 2-4. QPF graphics for 24 hours ending 1200 UTC July 6, 1994: (a) observed, (b) manual forecast, (c) ETA forecast, (d) RAFS forecast, and (e) AVN forecast.



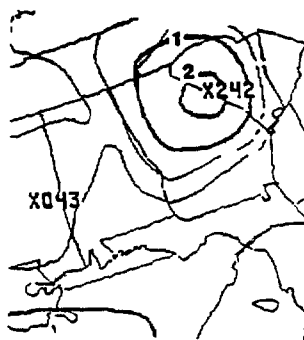
(a)



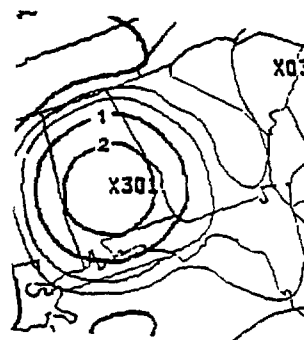
(b)



(c)



(d)



(e)

Figure 2-5. QPF graphics for 24 hours ending 1200 UTC July 7, 1994: (a) observed, (b) manual forecast, (c) ETA forecast, (d) RAFS forecast, and (e) AVN forecast.

respectively. For the most part, all of the manual 24-hour QPFs were typically not quite heavy enough and were generally displaced a little too far north and east from the heaviest rain occurrence. Clearly, the manual 24-hour QPFs issued about 1000 UTC each day did not completely capture the magnitude of the event. However, quotes from many of the excessive rainfall discussions and storm summaries that were issued definitely showed that WFB forecasters were very aware of the dangers of this decaying storm.

2.1.4 DAY-BY-DAY COMPARISON OF NUMERICAL GUIDANCE AND MANUALLY ISSUED FORECASTS

Between 1200 UTC July 3 and 1200 UTC July 4, as Alberto was making landfall, the heaviest rains occurred over portions of the western Florida Panhandle and southeastern Alabama, just to the east of the storm track. The 24-hour manual QPF issued early Monday morning, July 4, and valid at 1200 UTC Tuesday, July 5, had greater than 5-inch rains occurring over southwestern Georgia and extreme southeastern Alabama. Model QPFs for the same time period were not nearly as good. The Eta model indicated just over 2 inches of rain for parts of the Florida Panhandle and southern Alabama and Georgia. The RAFS indicated slightly more than 2-inch rains in central Georgia, and the AVN model forecasted only 0.75 inch of rain for the Florida Panhandle.

Alberto drifted slowly north-northeastward from near Montgomery, Alabama, on Monday morning, July 4, to just southwest of Atlanta, Georgia, by Tuesday morning, July 5. Extremely heavy rains of locally greater than 10 inches occurred near the path of the storm, across parts of west-central Georgia. QPFs issued by the WFB indicated up to 5 inches of rain over central Georgia. As was the case the previous day, model QPFs were grossly underforecast compared to the manual forecasts; and they were generally in the wrong location. The Eta model forecast a little over 2 inches of rain for southeastern Alabama; the RAFS had 2 inches for southeastern Georgia; and the AVN forecast had only a paltry 0.9 inch for east-central Alabama. Despite poor QPFs, the models did a respectable job of forecasting where the storm would be for this 24-hour period, at least as interpreted from their 500-mb prognostication chart (prog). This added some confidence to the manually prepared QPF issued by the WFB forecaster.

The period between Tuesday, July 5, and Wednesday, July 6, was a great challenge for the WFB forecasters. The models had been doing a fair job in forecasting the position of the storm in their 500-mb progs, but they started to diverge on the track of the remnants of Alberto. Only the Eta model performed well with its 500-mb forecast during this period. It essentially kept the well-defined, mid-level remains of Alberto nearly stationary in the vicinity of the Alabama/Georgia border, which turned out to be a very good prediction. The RAFS, on the other hand, tried to shear the remains out to the northeast into the central and southern Appalachians, while the AVN model consistently dissipated the system with time. WFB meteorologists correctly accepted the Eta forecast as early as Monday afternoon. The discussion issued at 2:30 p.m. EDT noted that "the RAFS forecast seems too quick considering the lack of upper level winds, and the Eta appears to have the best handle on the situation with a well-organized vorticity field/upper low meandering ever so slowly northeastward."

By following the Eta solution, the 24-hour QPF issued by the WFB on Tuesday morning and ending at 1200 UTC Wednesday, July 6, hit central Georgia the hardest, with up to 5 inches of rain forecast. Subsequent shorter-range forecasts issued later Tuesday afternoon and verified Wednesday morning increased the rainfall potential. The excessive rainfall discussion issued at 2:50 p.m. EDT Tuesday, July 5, mentioned a "good possibility of 5-8 inch rains" by Wednesday morning for a large part of central and northern Georgia and eastern Alabama. The observed 24-hour precipitation ending at 1200 UTC Wednesday, July 6, showed the manual forecast was underforecast and a little too far north. Several stations in central and southwest Georgia received in excess of 10 inches of rain during this period.

QPFs produced by the models were generally less accurate than the manual forecasts for the verifying period from Tuesday through Wednesday morning, especially the RAFS and AVN. The Eta model was the best of the models, forecasting a little more than 3 inches of rain for southern Alabama.

By Tuesday night, July 5, it became increasingly apparent from upper air data that Alberto likely would be blocked from moving any farther north. The upper-level analyses from 0000 UTC Wednesday, July 6, indicated that a ridge was building north of the system from the Tennessee Valley eastward through the central Appalachians. This building ridge would essentially put a halt to any further northward progression. In addition, on Tuesday evening, satellite pictures showed Alberto had stopped moving north and could even be drifting very slowly southwestward.

Unfortunately, the numerical models couldn't agree again on where the system was going. The Eta model kept the system stationary in northern Georgia. The RAFS again sheared the system out too quickly into the Appalachians, and the AVN "lost" the feature after about 24 hours. Knowing that the Eta model had been superior in handling this storm throughout the event, and seeing what was developing synoptically, WFB forecasters again adopted the Eta solution. The excessive rainfall discussion issued very early Wednesday morning, July 6, correctly noted that "The actual center has been forced a little southward during the past 24 hours by ridging to the north and by far the Eta model has been superior in handling this system. Believe the system could continue moving slowly southward for a while longer before becoming stationary later today. Additional rains of 5 to 8 inches are possible over southwestern Georgia and southeastern Alabama."

The 24-hour manual QPF issued around 1000 UTC Wednesday morning, July 6, valid 1200 UTC on Thursday, July 7, had more than 5 inches of rain occurring over a large part of southeastern Alabama and a smaller portion of southwestern Georgia and more than 3 inches of rain for much of southwestern Georgia, the southern half of Alabama, and most of the Florida Panhandle. These amounts turned out to be underforecasted and displaced a little too far north and east. The observed rains, ending at 1200 UTC Thursday, July 7, showed maximum amounts greater than 10 inches over the Florida Panhandle, with much of the Panhandle and southeastern Alabama receiving more than 5 inches.

Model QPF guidance showed essentially the same trends as previous days, although the AVN got closer for the 24-hour period ending on July 7. The Eta again gave the best QPF guidance with a forecast of greater than 3-inch rains for east-central Alabama. The RAFS was much too far north and east with its maximum rain, having forecast a 2.5-inch maximum near the Georgia/South Carolina border. Somehow, even though the AVN continually tried to dissipate the feature, it still forecast a 3-inch rainfall maximum over central Alabama. This in itself is significant, though, since AVN rarely forecasts rains in excess of 2-3 inches in a 24-hour period.

By late Thursday, July 7, any circulation associated with Alberto was becoming increasingly hard to find and, by very early Friday, July 8, the system had dissipated completely. Between 1200 UTC Thursday, July 7, and 1200 UTC Friday, July 8, only isolated greater than 3-inch rains occurred, mostly in central and southwest Alabama.

FINDING 2-2: The QPF guidance generated by the NMC models was poor (as is common for convective situations during the warm season) and therefore of limited help to the forecasters. The national QPF guidance frequently underestimated excessive rainfall amounts and sometimes did not accurately highlight the area of maximum rainfall.

RECOMMENDATION 2-2: The NWS should continue to strive for improvements in QPFs for tropical and convective systems.

2.2 PRECIPITATION

This section focuses on the acquisition and use of precipitation data. A description of the heavy precipitation that accompanied Alberto and the storm total isohyetal analysis (Figure 1-4) is contained in section 1.3.2. Section 2.1.3 discusses the NMC-issued QPF (NWS field offices did not issue QPFs).

2.2.1 NEXRAD WSR-88D

Figure 2-6 shows that Weather Surveillance Radar-1988 Doppler (WSR-88D) umbrellas provide almost complete coverage of the SERFC area of responsibility, which includes all the areas affected by Alberto. Some of the WSR-88Ds in the SERFC area were recent acquisitions, with acceptance of the radars at NEXRAD Weather Service Forecast Office (NWSFO) Atlanta just days before Alberto and at Warner Robbins Air Force Base (AFB) in January 1994. The NWS staff at NWSFO Atlanta and NWSFO Birmingham and at SERFC were adequately trained in the use of the WSR-88D prior to installation of the equipment.

The three stages of NEXRAD precipitation processing are described below to provide some background information. Stage I Precipitation Processing is performed within the WSR-88D itself and is designed to incorporate up to 50 ground-based precipitation gages to adjust the WSR-88D precipitation estimates (see Figure 2-7 for rain gage locations under the various WSR-88D umbrellas). Subsequent steps in WSR-88D precipitation processing require interactive

WSR-88D Coverage as of July 1994

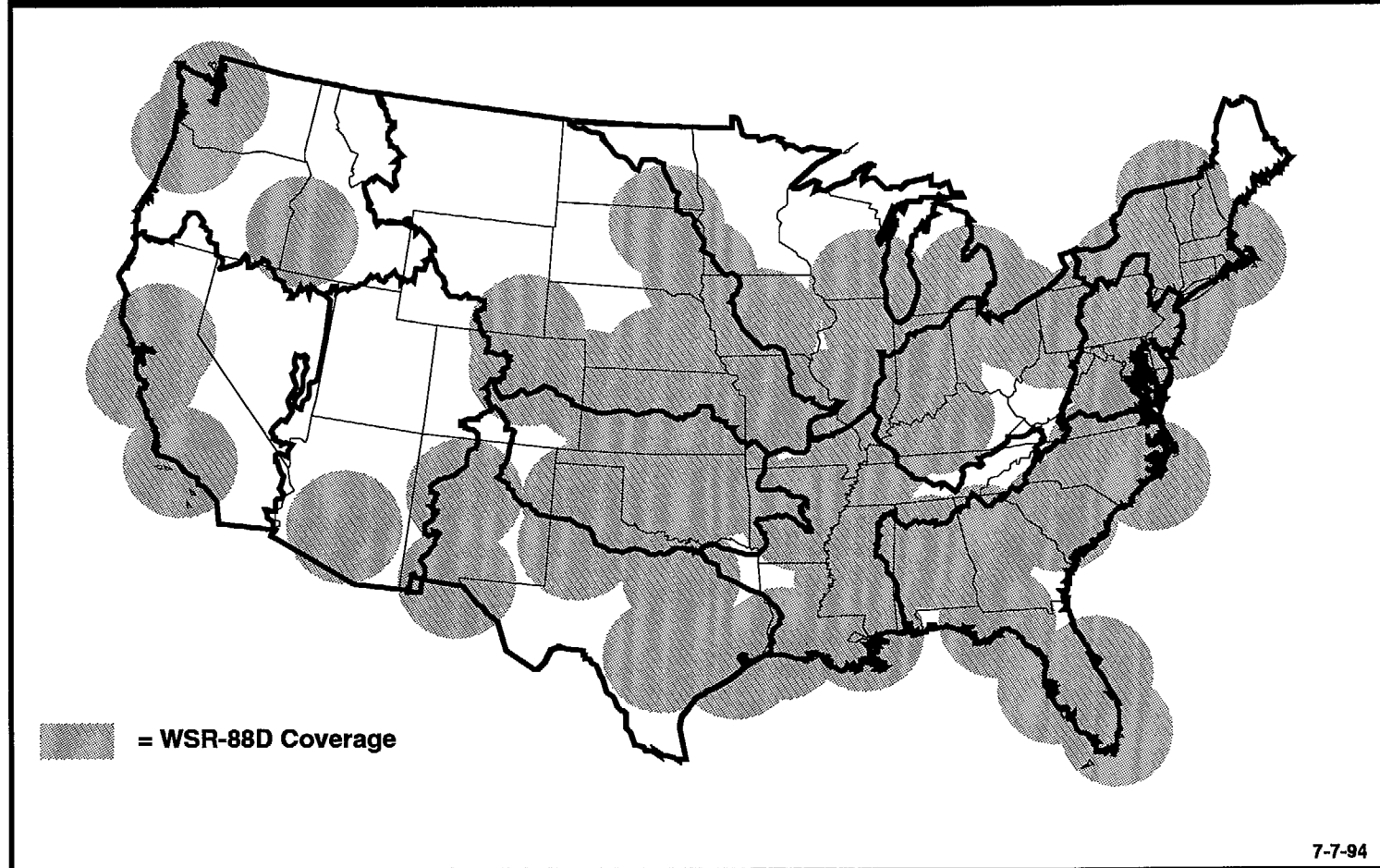


Figure 2-6. *Approximate area covered by WSR-88Ds during Tropical Storm Alberto (does not consider terrain effects).*

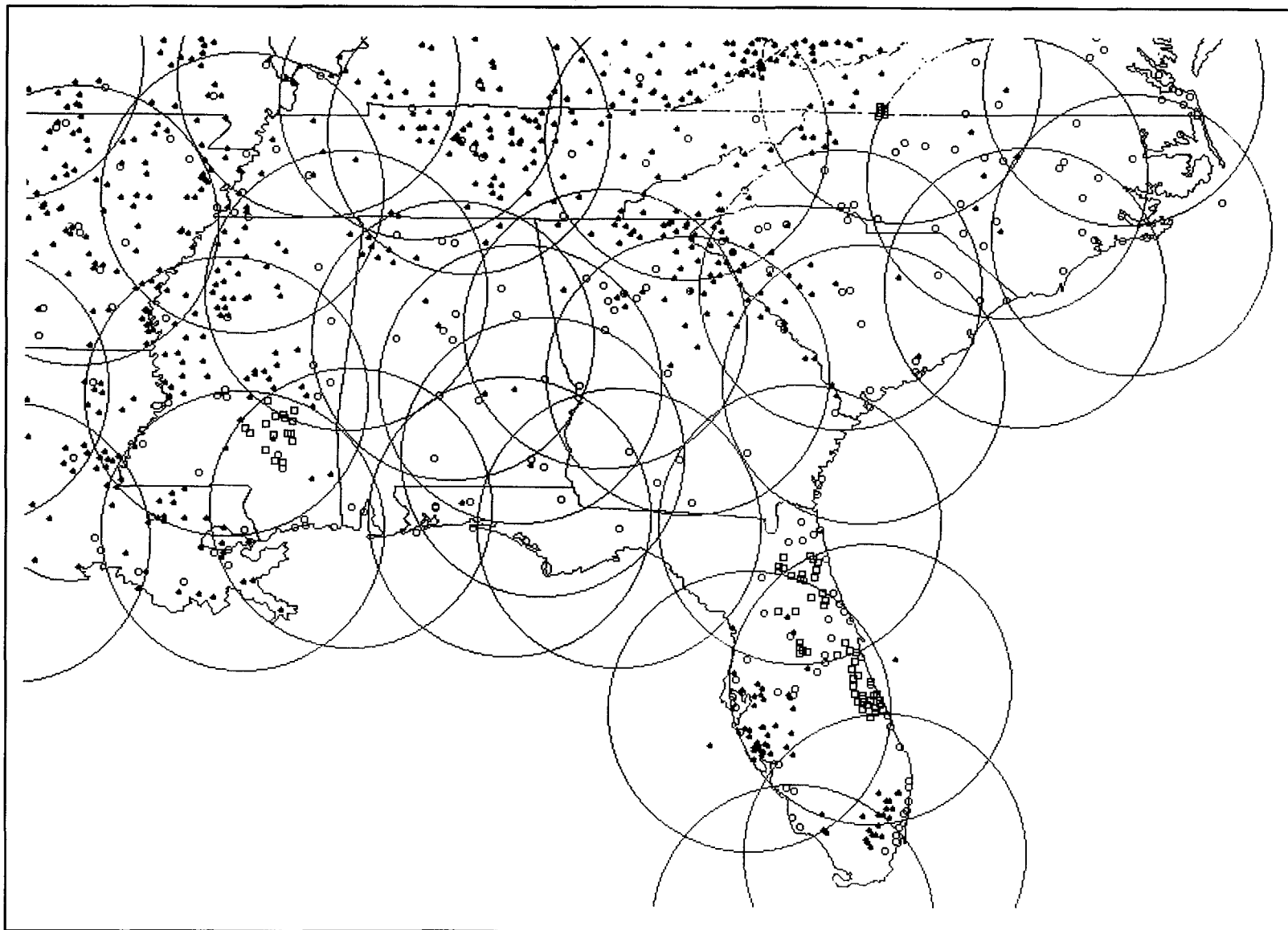


Figure 2-7. *Rain gage locations under various WSR-88D umbrellas.*

computer systems at NWS offices; these systems were not available at the offices affected by Alberto. In Stage II, the hourly digital precipitation data from Stage I are combined with Geostationary Operational Environmental Satellite (GOES) infrared satellite data and rain gage data to perform additional quality analysis and screen out anomalous data. Stage III Precipitation Processing involves interactive analysis and assimilation of gridded precipitation estimates from all WSR-88Ds covering a River Forecast Center (RFC) area of responsibility. The resulting hourly precipitation product is used as gridded input to the RFC's hydrologic modeling system. In the summer of 1994, the WSR-88D Stages II and III Precipitation Processing were being run on pre-AWIPS workstations at the Arkansas-Red Basin RFC and the North Central RFC for their areas of responsibility. The gridded precipitation products are then input to the NWS River Forecasting System (NWSRFS) Interactive Forecast Program (IFP), which is also run on the workstations.

The consensus of NWS field personnel, cooperating agencies, and the media was that the WSR-88Ds did a fine job of representing the areal coverage of the precipitation. WSR-88D images appeared on television and in the newspapers. A WSR-88D storm total precipitation color graphic is shown on the cover of this report. While the representation of the areal coverage was good, the WSR-88D underestimated the amount of precipitation associated with the Alberto warm tropical event.

FINDING 2-3: The WSR-88D Stage I Precipitation Processing, which runs in the Radar Products Generator, does not currently use rain gage data to provide potentially better quantitative estimates of the precipitation.

RECOMMENDATION 2-3: Rain gage data must be included in the WSR-88D Stage I Precipitation Processing as soon as possible, so that the radar-rainfall can be adjusted to avoid underestimation of rainfall associated with warm tropical events.

FINDING 2-4: The number of automated rain gages under the umbrellas of many of the WSR-88Ds in the area affected by Alberto was inadequate to effectively incorporate rain gage data into the Stage I Precipitation Processing.

RECOMMENDATION 2-4: The rain gage data network must be expanded and the reporting characteristics of existing sites modified to provide more timely data to produce a higher quality WSR-88D precipitation estimate.

Because the only usable information available from the WSR-88D was visual, it was only used to "flavor" SERFC forecasts. The SERFC staff looked for downstream/upstream rainfall concentrations in the WSR-88D images to manually adjust timing and distribution of the precipitation. The hourly digital rainfall (HDRAIN) products from Stage I Precipitation Processing could not be used due to lack of workstations to process data and incorporate them into hydrologic models at the SERFC.

FINDING 2-5: Even though the SERFC area of responsibility has almost complete WSR-88D coverage, the SERFC was not able to quantitatively use the WSR-88D information in its forecasts. The capability to process WSR-88D digital precipitation estimates would have added value to the hydrologic forecasts.

RECOMMENDATION 2-5: Pre-AWIPS workstations must be deployed immediately to the SERFC and other RFCs so the Stages II and III Precipitation Processing can be performed and utilized in the forecasts.

The WSR-88D has known hardware and software problems that make it unreliable for archiving. Although the Atlanta NWSFO did not detect a problem with their WSR-88D Levels 3 and 4 archiving (base and derived products) during Alberto, they encountered an unrecoverable error in trying to retrieve the archived data after the event. There has only been limited success in getting archived products from the Warner Robbins (near Macon, Georgia) WSR-88D, which was the closest WSR-88D to the area of heavy precipitation.

FINDING 2-6: The Atlanta WSR-88D was not able to retrieve data from the archive for a precipitation event that set historical records.

RECOMMENDATION 2-6: The potential for losing data, for all time, that could be used for storm analysis, training, and calibration of hydrometeorologic models and calibration of the WSR-88D dictates a requirement that there be a prompt resolution of the problems with the archive media.

There were also problems acquiring data from associated Principle User Processors (PUP). Associated PUPs provide access to WSR-88Ds that are not located at the NWS office and are usually not owned by the NWS. The NWSFO at Birmingham, Alabama, noted a problem with the number of products that can be sent from associated PUPs (e.g., Maxwell AFB) when there is widespread precipitation. They had to reduce the number of Maxwell AFB products from 36 to 20 to get the subset of products in a timely manner.

FINDING 2-7: The WSR-88D was unable to provide all the products in the time required when there was a large-scale precipitation event.

RECOMMENDATION 2-7: Develop methods to increase the number of products that can be obtained by associated PUPs, especially for offices with warning responsibilities.

2.2.2 LOCALLY ACQUIRED DATA

The SERFC reported a good flow of observed data from the NWS offices in its area. The storm precipitation totals are included in Figure 1-4. The Atlanta NWSFO experienced difficulty in getting data from cooperative observers because of the evacuation of some of the observers. The Atlanta NWSFO used the sheriffs' departments to get more reports. The cooperative observer

from Plains, Georgia, was unable to call in his observation due to repeatedly busy phones at NWSFO Atlanta. All spotters and cooperative observers share one phone line which is not dedicated to those functions. The Meteorologist in Charge (MIC) at Atlanta said additional phone lines would have been helpful. NWSFO Birmingham had some problems getting people to the gages to take observations and also with backup observers adding the height above mean sea level to their gage readings. The NWSFO Birmingham frequently called their cooperative observers to obtain data. Both the Atlanta and Birmingham NWSFOs called the Limited Automatic Remote Collector (LARC) gages themselves and routinely got 6-hour data (or more frequently, as needed).

FINDING 2-8: A limitation in the number of phone lines caused problems for at least one office and a cooperative observer from a critical area who was not able to provide data to the NWS because of busy phone lines.

RECOMMENDATION 2-8: Ensure that data are not lost due to inadequate phone lines into NWS offices and have adequate automated collection systems to acquire data so that the capacity of voice lines is not a constraint.

2.2.3 CENTRAL DATA SYSTEMS AND RFC PROCESSING

The SERFC gets centrally decoded data and makes its model runs on the NOAA Central Computer Facility (NCCF) via a Remote Job Entry (RJE) system. There were no problems with the central data systems, and model run performance on the NCCF was good. When the dedicated RJE communications were down for 3-4 hours, the dial backup feature did not work because the dial backup phone line was not reattached to the RJE system after the office moved in April 19, 1994. The SERFC staff later successfully tested the dial backup by sharing the fax line.

FINDING 2-9: The RJE dial backup did not function because the dedicated phone line had not been connected to the system. The RJE dial backup had not been tested since the office moved.

RECOMMENDATION 2-9: RFC staffs must routinely test the RJE dial backup.

The RFCs running on the NCCF have the ability to declare a Critical Flood Situation which allows them to use the crisis job priority, increases the priority of the central data acquisition systems, and may limit the preventative maintenance that is done on the NCCF.

FINDING 2-10: The SERFC did not declare a Critical Flood Situation during the Alberto event, because job processing times were adequate.

RECOMMENDATION 2-10: The declaration of a Critical Flood Situation and use of the crisis job priority are powerful tools that should be utilized by the RFCs during any critical flood event.

2.2.4 DATA EXCHANGE WITH COOPERATING AGENCIES

The U.S. Army Corps of Engineers reported receiving good information via the RFC HYDROMET system but wanted access to the WSR-88D data. They had ports allocated on most WSR-88D systems for their use but at the time did not have their PUP emulator systems in place to interface with these ports.

2.3 FLOOD FORECASTING SERVICE

The flooding in this event occurred on rivers in Georgia, Alabama, and Florida. The SERFC, located in Peachtree City, Georgia, has river forecast responsibility for all rivers affected by the event. Hydrologic Service Area (HSA) responsibility was shared by three offices:

NWSFO Atlanta has HSA responsibility for the rivers in Georgia, including the Chattahoochee River along the Georgia-Alabama border.

NWSFO Birmingham has HSA responsibility for rivers in Alabama and the Florida Panhandle west of the Apalachicola River.

NWSO Melbourne has HSA responsibility for rivers in Florida, excluding the rivers in the Florida Panhandle west of the Apalachicola River but including the Apalachicola River.

HSAs are defined for the issuance of longer-fused Flood Warnings and Statements, while the County Warning Area (CWA) determine responsibility for the shorter-fused Flash Flood Watches and Warnings. Figure 2-8 contains a map with the HSA boundaries and Figure 2-9 contains the CWA boundaries. CWA responsibility in the flooded area was shared by NWSFO Atlanta, WSO Columbus, WSO Macon, NWSFO Birmingham, WSO Montgomery, NWSO Tallahassee, and WSO Pensacola.

2.3.1 FLASH FLOODING

All the offices with CWA responsibility were involved in issuing Flash Flood Warnings and Statements for their areas. RFC flash flood guidance and NMC QPF were used to create the Flash Flood Watch and Warning products. The local offices did not refine the NMC QPF. Table 2-1 below shows the number of public products related to Alberto that were issued by each office.

The early part of this event was marked by major flash flooding, particularly in west-central Georgia and southeast Alabama. Although several counties suffered major flash flooding, the loss of life in Sumter County, Georgia, was extremely high compared to surrounding areas. Sumter County received the heaviest 24-hour rainfall during the storm with 21.10 inches falling at Americus in the period ending 7 a.m. July 6. The resultant flash flooding and flooding claimed 15 lives in this county.



Figure 2-8. Boundaries of hydrologic service areas of responsibility (the Melbourne office had HSA responsibility rather than Miami as shown on map).



Figure 2-9. *Boundaries of county warning areas.*

Table 2-1. Products related to Alberto issued by the NWSFO, NWSO, and WSO offices

OFFICE	SPS	FFA	FFW	FFS	FLW	FLS	RVS
Georgia Offices:							
Atlanta (ATL)	3	13	16	18	18	95	
Columbus (CSG)	41		11	15			
Macon (MCN)	10		20	27			
Alabama Offices:							
Birmingham (BGM)	27	15	4	11	18	54	23
Montgomery (MGM)	20		13	11			
Florida Offices:							
Melbourne (MLB)					2	9	
Pensacola (PNS)	90		4	1			
Tallahassee (TLH)	43		1	23			
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Totals	234	28	69	104	31	167	23

LEGEND: SPS - Special Weather Statement
FFA - Flash Flood Watch
FFW - Flash Flood Warning
FFS - Flash Flood Statement
FLW - Flood Warning
FLS - Flood Statement
RVS - River Statement

Flash flooding in Sumter County was aggravated by the overtopping and failure of many small, unregulated earthen dams. According to the Georgia Department of Natural Resources (DNR), Safe Dams Program, a total of 218 dams failed in Georgia during this event, of which 35 were in Sumter County. Unregulated earthen dams are defined by Georgia DNR as small rural stock ponds and do not fall under the state dam inspection program. These dams often fail when an extreme rainfall event causes the outflow for the dam to exceed the spillway capacity of the dam.

Floodwaters swept many vehicles off roadways (two-thirds of the flood deaths here occurred in vehicles) as motorists attempted to cross flooded roads and bridges while floodwaters were rising rapidly. A number of homes were also flooded--and in a few cases swept away--by rapidly rising flood waters, which resulted in two of the deaths.

NWSFO Atlanta had that area of Georgia which includes Sumter County under a Flash Flood Watch (FFA) continuously beginning 4 p.m. July 3 through July 7. WSO Columbus, which has CWA responsibility for Sumter County, issued the first Flash Flood Warning (FFW) for Sumter County at 2:19 a.m. EDT on July 6. Flash flooding claimed its first victim in Sumter County around midnight, and the majority of the deaths in this county occurred between midnight and dawn on July 6.

Additional major flash flooding occurred in numerous counties stretching from central Georgia westward and southward into southeastern Alabama. Considerable property and road damage resulted due to this flooding, but the loss of life was restricted to vehicle-related incidents. Sumter County is out of range of WSO Macon's NOAA Weather Radio (NWR), which is 68 miles away (the tone alert range is 40 miles). All the Sumter County patrol cars are equipped to monitor NWR, but it blocks out other radio communications so is not used much. There is a similar situation in Bainbridge, Georgia. The Emergency Operation Center has NWR but doesn't use it nor rely on it. Additionally, emergency operation centers should have the National Attack Warning System (NAWAS), which is a telephone communication link. But, again, not every county in Georgia has this system. The Georgia Emergency Management Agency rebroadcasts NWS forecasts on radio and faxes hard copies of NWS watches/warnings to its six field offices across the State. Sumter County has no means of direct contact (other than phone) or automated dissemination from NWS. It does not receive NOAA Weather Wire Service (NWWS) or NAWAS and is out of range of NWR from WSO Macon. The same situation applies in Calhoun County, Alabama. Florida now has NAWAS in each county, however, it is in the Sheriff's office or connected to a 911 dispatch but not necessarily located in an emergency management agency/emergency operation center. Word does not always get through to emergency management agencies.

FINDING 2-11: The Sheriff/Emergency Management Agency Director for Sumter County, Georgia, receives weather watches and warnings from the public broadcast media. The county does not receive the NAWAS transmissions and is on the outside fringe of NWR reception (Americus is 68 miles from the nearest NWR transmitter). The NWR tone alert does not work reliably in the county because of this distance.

RECOMMENDATION 2-11: NWS should work with FEMA to ensure that every county emergency management agency/emergency operation center in Alabama, Florida, and Georgia has a communication link to NAWAS. Additionally, the Gore Initiative should be implemented as soon as possible to expand the NWR network of transmitters to reach 95 percent of the population.

FINDING 2-12: The Sheriff of Sumter County, Georgia, as with many other emergency management officials in the impacted area, expressed a high degree of frustration in making residents aware of the danger from the floodwaters and of the need to evacuate. Some of the deaths that occurred were people who had been warned (more than once) to evacuate but failed to act until it was no longer safe to do so. No flash flood/flood anywhere near the magnitude of this event had ever occurred in this area; and residents were, for the large part, unable to realize the dangers they faced until it was too late.

RECOMMENDATION 2-12: More emphasis should be placed on public awareness and preparedness training for flood and flash flood events. The continued high number of vehicle-related deaths during floods and flash floods

indicates the need to educate the public of the risks involved with vehicles in flood situations. The "Hidden Danger" video currently being developed by the NWS should be used to inform the public of the dangers of low-water crossings.

FINDING 2-13: The Sheriff of Sumter County, Georgia, had high praise for NWS products and service during this event and did not think there was anything the NWS could have done to reduce the loss of life during this event. He did think it is a mistake for the NWS and the media to emphasize tropical storms only up until landfall; and then, in some cases, the public perceives that there is no danger because of a relatively weak wind-producing storm.

RECOMMENDATION 2-13: The NWS should work with the media to educate the public on the fact that heavy rains and widespread flooding from tropical storms and hurricanes may have as much, and in some cases even more, detrimental impact as winds at landfall.

FINDING 2-14: The disaster survey team found that the Flash Flood Warnings issued in this event were generally accurate and timely. However, many lacked a strong enough indication of the life-threatening nature of the flash flooding.

RECOMMENDATION 2-14: NWS offices should strive to better recognize truly extreme rainfall events and, in those events, use the strongest possible wording in the warnings and statements issued to make the public more cognizant of the life-threatening nature of the event.

2.3.2 RIVER FLOODING

The area affected by flooding from the rains of Alberto stretched from central Georgia southwest into southeastern Alabama and southward into the Florida Panhandle. The river basins with the most severe flooding included the Ocmulgee and Flint Basins in Georgia, the Chattahoochee Basin along the Georgia-Alabama border, the Choctawhatchee Basin in Alabama, and the Apalachicola Basin in Florida.

Appendix B includes the USGS listing of the crest values, previous record crests, and return interval of the crests for this event. Appendix C also includes selected hydrographs. Table 2-2 summarizes the number of locations by basin that equaled or exceeded the 100-year recurrence interval and the number of locations that exceeded the previous record crest.

The SERFC issued 238 river forecasts for locations in the impacted area during this event. On July 3, 24-hour operations began and continued through July 9 at 9 p.m. with the brief exception from midnight July 4 to 6 a.m. on July 5. The SERFC Hydrometeorological Analysis and Support (HAS) unit had not yet become operational and contained only one of the three positions. As was Southern Region policy at the time, the SERFC did not use QPF in the preparation of river forecasts since the majority of the WSFOs in their forecast area did not

Table 2-2. River basins that reached new floods of record and equaled/exceeded the 100-year recurrence of floods

Basin	number of locations >=100 yr recurrence	number of locations with new record flood
Ocmulgee (GA)	3	5
Chattahoochee (GA)	0	0
Flint (GA)	18	20
Alabama*	0	4
Apalachicola (GA)	0	1
Choctawhatchee (FL)	2	0
Totals	23	30

* includes all affected basins in Alabama

routinely supply QPFs. Interestingly, an analysis of the forecasts indicates the lack of any clear trend in the river forecasts issued. Some forecasts were very close to the observed crests several days in advance; some forecasts were lower than the observed crest; and a few forecasts were above the observed crests. Appendix D includes a chronological listing, by forecast point, of the forecasts issued by SERFC during this event.

The destruction and human misery wrought by the floodwaters were enormous. A brief summary of some of the major flood impacts is listed below.

Ocmulgee River - Macon, Georgia, was swamped by a record crest of 35.4 feet on July 7 (previous record was 28.00 feet on 11/29/48). The floodwaters overtopped and breached levees at Macon and flooded the water treatment plant. Freshwater was not restored for nearly 3 weeks. Two major Interstate Highways (I-75 and I-16) were closed for approximately 36 hours due to the floodwaters and required traffic detours of more than 100 miles. Several hundred homes were evacuated in Macon, most of which eventually flooded.

Flint River - Some of the most spectacular flooding occurred along the Flint River. The crest, generally 20-25 feet above flood stage and 4-6 feet above the previous record crest (January 1925), wreaked havoc as it moved downstream and caused immense damage as well as the evacuation of tens of thousands of people. Blackshear Dam, upstream of Albany, was overwhelmed; and the high pool level forced the evacuation of residents in about 1,400 homes around the lake (almost all of which were ultimately inundated) before the dam was overtopped and breached. Albany suffered major flood damage after nearly one-third of its 76,000 residents were evacuated. Further downstream, at Newton, nearly the entire town was flooded to depths of 15-20 feet. After exceeding previous record flood levels as far downstream as Newton, the Flint River at Bainbridge crested about 4 feet below record levels (although the measured discharge of 108,000 cfs exceeded the previous record discharge of 101,000 cfs). Section 2.3.3 of this report further analyzes the Bainbridge forecast problem.

Chattahoochee River - This river is somewhat more controlled by impoundment structures than the other rivers impacted by Alberto, but the volume of water still caused considerable flooding along the lower half the river. At Columbia Tailwater, a record crest more than 2 feet higher than the previous record, and over 12 feet above flood stage, was observed.

Apalachicola River - The Flint and Chattahoochee Rivers join at Lake Seminole, which is formed by Woodruff Dam. Outflow from Woodruff Dam flows down the Apalachicola River. The excessive inflow into Lake Seminole forced high discharges from Woodruff Dam (the peak discharge was 224,486 cfs on July 10th) and caused record flooding at Blountstown.

Choctawhatchee River - Major flooding occurred along this river in Alabama and Florida as a crest 15-20 feet above flood stage moved down the basin. This crest was about 4 feet below the record crests. Considerable damage resulted at Newton and Geneva, Alabama, and Caryville, Florida. Additional major damage occurred in Dale County, Alabama, and Holmes County, Florida.

FINDING 2-15: The disaster survey team found a high degree of satisfaction from emergency managers, the media, and the public with the river forecast services they received during this event. In particular, the impact statements and relationship to recent and historical flood levels were judged valuable information.

RECOMMENDATION 2-15: NWS HSA offices should make every effort to include up-to-date and informative impact statements in all Flood Warnings and Flood Statements.

FINDING 2-16: There were several suggestions from emergency managers and the media that the public river forecasts be updated more frequently. The normal procedure presently is to issue the Flood Statements once per day in late morning or early afternoon. In particular, an early morning update was suggested to provide current information so the public can make more informed decisions on commute, daily activities, or evacuation activities.

RECOMMENDATION 2-16: NWS offices should make every attempt to update Flood Warnings and Flood Statements more than once per day.

FINDING 2-17: Several users suggested that changes in crest forecast values be highlighted at the beginning of Flood Statements. An analysis by the disaster survey team of the Flood Statements issued during this event where the crest forecast was revised from the previous forecast showed that they, in general, did not call attention to the fact that a crest forecast had been revised.

RECOMMENDATION 2-17: Any significant change in the crest forecast from a previous crest forecast should be highlighted at the beginning of the Flood Warning or Flood Statement.

2.3.3 THE BAINBRIDGE FORECAST

Forecasts were generally accurate and highly regarded with the notable exception of Bainbridge, Georgia, where the Flint River was forecast to reach a level some 8 feet higher than its eventual crest. This persistent overforecast was the subject of considerable negative attention by the media and the public and has resulted in some loss of forecast credibility for the NWS.

The SERFC crest forecast for Bainbridge was raised during the first days of the event (prior to July 7) due to additional heavy rainfall. Table 2-3 shows the crest forecast issued by SERFC for Bainbridge July 7-13.

Table 2-3. *Bainbridge crest forecast issued by SERFC July 7-13*

<u>Issue Date</u>	<u>Forecast Crest/Date</u>
7/7/94	near 45 feet/July 13
7/8/94	near 45 feet/July 13
7/9/94	near 45 feet/July 13
7/10/94	near 45 feet/July 13
7/11/94	44-45 feet/July 14
7/12/94	43-44 feet/July 14
7/13/94	37-38 feet/July 14

The Flint River crested at Bainbridge July 14 at a stage of 37.20 feet. A discharge measurement taken by the USGS shortly before the crest (while the stage was 37.18 feet) indicated a flow of approximately 108,000 cfs. By comparison, the record flood of January 1925 reached a level of 40.9 feet (from high water marks) with a flow of approximately 101,000 cfs.

Based on the forecast provided by the NWS, and seeing the record crests that were occurring upstream, Bainbridge city officials determined the area that would be affected by the 45 foot forecast crest and proceeded with their evacuation plans and flood protective measures. In the end, only about half the evacuated area was flooded, causing much less damage than anticipated. As a result, the credibility of the NWS river forecast for Bainbridge was indeed damaged and needs to be restored.

There may be a variety of factors which led to the Bainbridge forecast error. It will not be a part of this report to completely analyze the hydrology relating to the Bainbridge forecast. Factors that may need further investigation include:

1. The lower portion of the Flint River Basin lies in a large Karst area. Karst areas are irregular limestone regions with sinkholes and underground caverns and streams. Such areas can have a significant and complex effect on modeling the hydrology of a basin.
2. The possible hydrologic effects of Big Slough Creek when Flint River stages exceed 32 feet needs to be investigated. Big Slough Creek joins the Flint River a few miles upstream of Bainbridge.
3. The stage-discharge relationship for Bainbridge used during this flood event was a graphical or mathematical extension above 70,000 cfs based on high water marks from the 1925 flood. The rating that resulted from measurements made during the 1994 flood is significantly different and has already been implemented in the SERFC forecast model.

FINDING 2-18: The forecast for the Flint River at Bainbridge received considerable media and public attention when the river crested well below the forecasted level.

RECOMMENDATION 2-18: The SERFC must investigate the causes for the Bainbridge forecast error and make the appropriate changes to the hydrologic forecast model as soon as possible. When the appropriate modifications to the hydrologic model are completed, NWS personnel (RFC and/or NWSFO) should make the necessary effort to brief the Bainbridge public officials (and media) on their findings.

2.4 PREPAREDNESS

The primary mission of the NWS is to save lives and reduce losses to property due to the weather. Generally stated, this is accomplished by the NWS in two equally important phases. The first is the generation of hydrometeorological forecasts and warnings; the second is internal and external preparedness activities.

The offices and individuals contacted by the disaster survey team are contained in Appendix E. The survey team found that the NWS's internal state of preparedness prior to and during the event was, for the most part, adequate. However, the survey team found external awareness of the NWS's hydrologic services to range from a high level to a relatively low level. For example, awareness ranged from knowing the NWS contact by name to confusion over who provides river forecasts and warnings. The variance seemed to be directly related to frequency of personal contact by NWS personnel with all levels of the emergency management community.

Overall, the survey team judged NWS preparedness activities to be acceptable. The fact that 33 people lost their lives caused much concern. The survey team felt that this high figure could perhaps have been lower had NWS preparedness activities been more frequent and comprehensive in two broad areas: (1) the number of personal visits to the user community by the Warning Coordination Meteorologists (WCM) and Service Hydrologists (SH); and,

(2) greater emphasis in routine preparedness activities on the dangers posed to passengers in vehicles in flood situations and posed by heavy rains and flooding, including floods caused by decaying tropical cyclones.

The two deaths in Alabama involved (1) a man who, in the early hours of Wednesday, July 6, drove his vehicle around a barricade and then slid into the swollen Choctawhatchee River and (2) a 13-year-old boy playing in a storm drain, was subsequently swept away by the floodwater on July 5, and later died from his injuries. Table 2-4 contains a chronicle of the 31 deaths in Georgia from *The Atlanta Constitution* newspaper article dated July 31, 1994.

Table 2-4. Georgia flood-related deaths from Tropical Storm Alberto

July 5, 1994

John F. Peavy, male, age 54, truck hydroplaned and hit a wrecker.

Richard Rodgers, male, age 20, car crashed.

Jack S. Shriver, male, age 40, trying to tie down a small bridge in Line Creek.

Teresa Beyahf, female, age 31, car hit a washed-out road.

Gloria Dixon, female, age 16, current pulled her under in a ditch after she rescued dog.

Monty Folsom, male, age 35, truck caught in whirlpool that formed in a flooded parking lot and was pulled through an 8-foot culvert.

Lisa Sheppard, female, age 25, passenger in truck with Folsom.

William Miller, male, age 62, car was swept into the Towaliga River.

July 6, 1994

Eugene Marner, male, age 40, truck and trailer swept away by wall of water.

Kent Marner, male, age 12, passenger in truck and trailer swept away by wall of water.

Roger Cornelius, male, age 40, passenger in truck and trailer swept away by wall of water.

Josephine S. Anderson, female, age 70, car went into a creek.

Walter Davenport Stapleton, III, male, age 17, died stringing telephone lines on Lake Corinth when his boat overturned (upstream dam break caused log to ram boat; current pulled him over the dam).

Oscar Brown, male, age 84, mobile home crushed by water.

Idell Jackson, female, age 67, home crushed by water.

Gloria Tatum, female, age 28, car washed off bridge into flooded creek.

Tomeko Y. Woodham, female, age 20, car went into a creek.

Chad Jones, male, age 18, trying to rescue animals by using an inner tube on the Towaliga River.

Douglas K. Bassett, male, age 32, trying to cross a train trestle over the Towaliga River.

Hilton Howard, male, age 42, car went into a creek.

Freddie Hawkins, male, age 35, bridge washed out and truck was swept away.

Kedrick Hawkins, male, age 16, passenger in truck that was swept away when bridge washed out.

Kourtney Hawkins, male, age 8, passenger in truck that was swept away when bridge washed out.

Kathy R. Hurley, female, age 28, car was swept into a creek.

John Hurley, male, age 2, car was swept into a creek.

July 7, 1994

William Wallace, male, age 41, died searching for his mother (she was later found in a shelter).

July 8, 1994

Kason Mallory, female, age 4, passenger in father's car which plunged into the Flint in Albany.

Shabazz Mallory, male, age 2, passenger in father's car which plunged into the Flint in Albany.

July 10, 1994

Ishkabah T. Linkhorn, male, age 28, swept away by the Flint.

July 13, 1994

Pearlie Mae Brantley, female, age 59, drowned when Flint River floodwaters filled her home.

July 14, 1994

Maureen Johnson, female, age 71, car plunged into a creek in Terrell County.

The survey team felt expectation levels of the NWS by the public and emergency management community were based on its past capabilities. Hence, relative to the NWS's capabilities during its transition and modernized phases, the level of expectations by the users was perhaps low. This poses a significant challenge to the NWS: Improving the public's awareness level of the impacts of both short-term and longer-term hydrometeorological events must be put on at least the same level as improvement of the NWS's scientific capabilities in the generation of forecasts and warnings.

FINDING 2-19: Some communities, and perhaps emergency managers, were not as prepared for the disastrous floods as they could have been if there were greater personal contact and education on floods by NWS WCMs and SHs.

RECOMMENDATION 2-19: NWS policy should require periodic (annual if possible) personal visits by the WCMs and/or SHs to emergency management and other action agencies from the state to the local level. These contacts should include a review of the flood threat to the local community (emphasizing the threat to vehicular passengers) and a review of the hydrologic services that the NWS provides. This educational process should specify what products are available, how they can be used, and where they can most efficiently be obtained.

Several individuals interviewed by the survey team remarked that there may have been an overemphasis on the landfall of Tropical Storm Alberto and not enough attention focused on the potential for heavy rain and flooding associated with the storm. This is probably more of a media and public perception problem than a forecast problem. For example, the Meteorological Operations Division of NMC highlighted a "very dangerous flash flood and flood situation for much of Georgia today [July 4] into tonight as the remnants of Alberto drift slowly north."

FINDING 2-20: The public's perceived threat from Alberto appeared to lessen once it made landfall.

RECOMMENDATION 2-20: The NWS and NOAA should take maximum advantage of the recommendations from the 1995 Interdepartmental Hurricane and the NOAA Hurricane Conferences, which focused on the inland effects of tropical cyclones, in order to enhance the public's perception of the dangers associated with landfalling tropical cyclones. In addition, the WCMs in all areas which might be affected by the aftermath of decaying tropical cyclones should reenforce the potential for severe flooding from such storms with the user community.

There is room for improvement in better identification of flood-prone areas. Traditionally non-NOAA agencies identified flood-prone areas, most often as part of a flood insurance study. If potential flood inundation maps were widely available and used, the NWS and emergency management personnel could coordinate more easily with local communities to communicate the potential impact a disastrous flood could have on their community.

FINDING 2-21: The disaster team believes another possible contributing factor to the high death count could be that the public was not adequately educated regarding the locations of flood-prone areas (particularly roads), safe evacuation routes, and the potential impact of their actions.

RECOMMENDATION 2-21: If funding permits, the NWS, in conjunction with FEMA and appropriate state and local agencies, should embark upon a campaign to educate the public as to their local flood-prone areas. This should include a widely distributed array of visual representations of flood-prone areas depicting roads and bridges as well as portions of communities that may be potentially inundated by floods. Additionally, the NWS should plan to issue graphical flood forecasts as well as the traditional text products.

2.5 DISSEMINATION

An area that the NWS clearly needs to improve is its national-level response to disasters. FEMA has improved the timeliness and magnitude of its disaster response. During a disaster, FEMA is able to quickly establish a television communications link to the affected communities as well as to key Federal officials in Washington, D.C., and other areas across the Nation. The NWS must be prepared to participate in or establish similar radio and satellite communication links and be a part of the information superhighway.

The media showed tremendous interest in broadcasting from the NHC before and during landfall of Alberto. The NHC Director (or representative) was prominently featured on the broadcasts, which heightened the sense of urgency. Once the storm was inland, however, there was much less attention by the media and no single spokesperson from the NWS focusing attention on continued potential from weather hazards.

FINDING 2-22: The disaster team felt it was inappropriate for a single NWS office to be expected to respond to an event that covered multiple offices and to FEMA's national-level press and Federal coordination briefings. In addition, there was an imbalance in the media contacts and interest with NHC prior to landfall and WFB once the tropical cyclone had made landfall.

RECOMMENDATION 2-22: The NWS should establish a national media unit to provide beginning-to-end coverage of storm events that have national impact or interest. This unit would provide a consistent posture in front of the national media, which could emphasize the dangers associated with each phase of the storm. The unit would be headed by a public affairs specialist and supported by an *ad hoc* team of meteorologists and hydrologists, as appropriate for the event. Teleconferencing should be utilized to maximize participation of personnel from a variety of NWS offices.

CHAPTER 3

ISSUES HIGHLIGHTED BY THE EVENT

3.1 TRANSITION/STAFFING/MODERNIZATION VULNERABILITIES

This event pointed to several aspects of the NWS modernization of its weather services where the survey team felt the NWS was vulnerable, risking degradation of these services. These fall into three general areas: (1) the transition to a modernized state, (2) staffing--both during transition and after, and (3) several aspects of the NWS modernization and associated restructuring.

3.1.1 TRANSITION

Two aspects of the transition to a modernized state clearly pose potential pitfalls for the NWS. First and foremost is the amount of off-site training that is required during the transition. Second is the increased length of the transition period resulting from budgetary constraints and the inability of the NWS and its contractors to deliver significantly improved technology to its field offices according to earlier projections.

The substantial requirement to train its work force often leaves field offices with staffing situations that threaten their ability to efficiently perform their prime mission. Such was the case in both NWSFOs and the RFC that were part of this survey. In each case, key personnel were away from the office attending in-residence training courses for all or a portion of the event. This, coupled with the fact the remaining staff at these offices included a notable number of new, inexperienced people, posed a high potential for unacceptable service due to staff overload during the disaster. This threat was averted in this event because of the extreme dedication and extra effort of the personnel at the offices involved during the disaster. Nevertheless, the risk is very real while the NWS undergoes a protracted transition period.

FINDING 3-1: Key members of the staffs of both NWSFOs and the RFC were attending training away from their home offices during this event.

RECOMMENDATION 3-1: Especially during transition, when we have extensive training requirements which are not a luxury, we must have adequate staff to cover operations.

In addition to staffing concerns, the survey team found several potentially vulnerable aspects of hardware configurations being implemented during the extended NWS transition period. While the five WSR-88Ds accepted by the Government in this area were operational throughout the event, use of the data from the radars was notably constrained. For instance, the SERFC had

no way to directly input the WSR-88D precipitation estimates into its hydrologic models. Additionally, none of the spin-down WSOs with county warning responsibility had any access to WSR-88D data (other than what was verbally communicated secondhand or via text products). Due to staffing limitations, one NWSFO and the SERFC chose not to dedicate someone to monitor the WSR-88D throughout the event. Rather, they chose to make note of the WSR-88D data on an *ad hoc* basis. These factors alone could have (but did not in this case) severely limited the ability of the field offices to determine the magnitude of the event at the earliest possible time.

FINDING 3-2: One NWSFO and the RFC affected by Alberto did not have sufficient human resources, and the other NWSFO did not have sufficient communications resources, to fully utilize data from the WSR-88Ds in the area. None of the WSOs with warning responsibilities had any access to WSR-88D data. In addition, the RFC was unable to process the precipitation data from the WSR-88Ds so they could be input to the hydrologic models.

RECOMMENDATION 3-2: The NWS must recognize that during the transition it is not able to fully utilize the WSR-88D and should continue to take steps to accelerate other portions of the modernization and make maximum use of technology components which are mature enough to warrant deployment.

There is another area where the NWS seems to be very vulnerable during transition and into modernization: the amount of time available for the WCMs to coordinate with their present and future emergency management (and other action agency) officials. Due to operational shift workload requirements that result from staff shortages (because of training requirements), WCMs often do not have adequate time available to coordinate with their users. The survey team found this to be the case during its study.

FINDING 3-3: The operational shift and training requirements, coupled with a large geographic area of responsibility, limited the opportunity for the WCMs to interact with local users. Consequently, the WCMs did not thoroughly coordinate with all the users in their CWA.

RECOMMENDATION 3-3: The NWS needs to develop an efficient strategy to maximize the efficiency of the collective efforts of the WCMs and other staff members. A WCM team approach should be considered whereby other WFO (and occasionally RFC) staff members are designated as liaisons with the state and local agencies involved in such activities as emergency management, water resources, and public safety.

One aspect of current NWS operations, which becomes a greater problem during transition, is the flow of information from NWS field offices in one state to emergency managers in an adjoining state. Some local emergency managers with adequate funding and personnel resources subscribe to NWWS and receive hard copies of NWS products. However, due to the large

number of products issued over NWWS by the NWS offices outside of their home states, they generally chose to receive only those products issued by NWS offices in their own states. For example, even though products were issued, the survey team found that the Houston County, Alabama, emergency managers lacked river forecast and warning information because they chose not to receive flood products issued by WSO Columbus (Georgia) and NWSFO Atlanta (Georgia) even though the products covered Houston County. Universal Generic Codes (UGC) enable users to be more selective in the products they receive. Flash Flood Warnings currently use the UGC codes, but River Statements (RVS), Flood Statements (FLS), and Flood Warnings (FLW) do not. UGC will be included in RVS, FLS, and FLW once they are produced by the AWIPS River Product Formatter.

FINDING 3-4: At least one member of the emergency management community chose not to be burdened with the numerous products sent via NWWS for a neighboring state. As a result, critical forecasts and warnings for that county were not received. NWWS users want to efficiently receive weather information that pertains only to their jurisdictions.

RECOMMENDATION 3-4: Users need the ability on NWWS to parse only those hydrologic products that apply to their areas of responsibility, e.g., a given county. The NWS should require the use of generic codes on all NWS public hydrologic products until AWIPS is implemented, and the WCMs should work with the users to insure that all necessary products are being received.

3.1.2 STAFFING

Attempts were made to supplement field office staffs during the disaster with personnel from other field offices. At the SERFC, an additional hydrologist was brought in from the West Gulf RFC. At WSO Pensacola (Florida), the previous MIC, who had transferred to WSO Mobile (Alabama), was called back to help out. While this approach may seem laudable, its practicality as a mainstay of staffing plans is questionable. To provide an effective supplement, personnel sent to offices during an emergency must be capable of providing specific hydrometeorological expertise for the geographic area of concern. The nature of the science of hydrology and, to a limited extent, the science of meteorology requires knowledge of the area. Without such knowledge, personnel sent during emergencies often are little help to the receiving office. In fact, time spent getting these individuals to a point where they can contribute to ongoing operations reduces the time available to the on-site staff to perform their jobs. As a result of this dilemma, field offices are often reluctant to accept off-site assistance. In addition, there seems to be an unspoken philosophy that accepting such assistance is a reflection on the competence of the office in question. The net result is that field offices tend to "make do" with the staff available during disasters. This often leads to field office staffs becoming overwhelmed in times of crises. There was some evidence that this occurred during the disaster caused by Alberto.

FINDING 3-5: The NWS offices affected by Alberto were stressed to provide enough human resources during the disaster to continuously utilize all information the WSR-88Ds had to offer. It would have been virtually impossible for these offices to have provided the critical services they did if they were staffed with any less employees.

RECOMMENDATION 3-5: The NWS should reassess its core-level staffing requirements (going from five lead forecasters and five journeyman forecasters down to four lead forecasters and four journeyman forecasters), especially for offices with multiple WSR-88Ds.

3.1.3 MODERNIZATION

An area of vulnerability was the amount of time that Service Hydrologists (SH) have to develop, transfer, and maintain a high level of hydrologic expertise at current and future NWS offices. The survey team found that there are situations where the SHs were unable to adequately address some of the following duties: (1) hydrologic training of on-site and off-site personnel, (2) frequent and regular coordination visits to all county-level management in their present and future CWAs, (3) station information (i.e., E-19) data collection activities, (4) personal professional development (hydrologic and meteorological), and (5) frequent and regular visits to the RFC to keep current on RFC operations.

The size of the present and future hydrologic service areas and hydrologic program training and development responsibilities of each SH are so extensive that the SHs may not be able to fully address important hydrologic program management functions and services.

FINDING 3-6: The SH workload at the offices surveyed was quite extensive and typical of any WFO. Despite the good effort put forth by the SHs, it was apparent that timely completion of important hydrology-related duties could not always be accomplished. This will be compounded in the future for SHs who support multiple hydrologic service areas.

RECOMMENDATION 3-6: The NWS should reassess its staffing philosophy for field offices; each WFO should have a resident SH.

FINDING 3-7: Staffing levels at the NWSFOs surveyed by the team, coupled with operational workloads and off-station training requirements, made it virtually impossible for a sufficient number of hydrologic training shifts to be made available for each forecaster to become totally competent in the station hydrology program.

RECOMMENDATION 3-7: The NWS should reexamine WFO staffing levels and procedures for developing adequate on-station hydrologic training to avoid difficulties during critical hydrologic events. This should include an adequate

number of nonoperational shifts for each meteorologist to be trained to handle hydrologic crises at all times. In addition, MICs should adhere to the guidance that SHs work no more than 20 percent of their time on forecast shifts.

The consolidation of WSFOs and WSOs into the future WFOs (currently 300+ offices down to 115+ offices) poses significant problems for the present-day and future WCMs. These problems include (1) the number of counties in their areas of responsibility, (2) the geographic size of the CWA, (3) the number of responsible county and local officials, (4) the geographic distance between them and the WFOs, and (5) that the CWA may include multiple states.

FINDING 3-8: The personal contacts between the local EMA officials and WSO staffs contributed to their satisfaction with the NWS services. When these offices spin down, the responsibility switches to a single WCM.

RECOMMENDATION 3-8: A WCM team approach should be considered with other WFO staff members (e.g., the SH) interacting with the customers.

3.2 EMERGING CHALLENGES

3.2.1 EXPANDING THE USE OF IMPROVED COMMUNICATION TECHNOLOGY

New demands for information are placed on the NWS due to increasing and changing societal vulnerability to weather, growing awareness of this vulnerability, and technological advances, especially in computing and communications. These demands, and the changes brought about by the ongoing NWS restructuring, continue to impact and influence both the current operations and planning for future operations of the NWS.

In this event, as is typical in current NWS operations, at least a portion of the dissemination of forecasts and services was conducted over the telephone, one-on-one with users/customers. The primary methods of dissemination continue to be the NWWS and the NWR. Many customers place a high value on the personalized service provided by phone contact, and it contributes greatly to the perception of high-quality services provided by the NWS. One challenge of the modernized NWS will be to continue, and to increase, the level of service and customer satisfaction with that service while decreasing the number of individual contacts required.

FINDING 3-9: One-on-one phone contacts between the NWS and all types of users are frequently associated with the user's satisfaction with the service provided by the NWS. However, the number of individual phone calls which can and should be made is limited. An additional drawback for the users who rely on phone contacts is that they have to verbally repeat, dictate, or retype (or some combination) the information in order for it to be shared.

RECOMMENDATION 3-9: The NWS must be more sophisticated in its use of communication and dissemination technologies. For example, the NWS should take advantage of aspects of the Information Superhighway (e.g., Internet) to coordinate with the public and other Federal, state, and local agencies as much as possible. Through increased electronic dissemination of NWS products, the NWS staff's time is more effectively used by allowing direct communication with many more users/agencies. Additionally, users/agencies getting information directly from the NWS can then further distribute it automatically without having to repeat, dictate, or retype the information.

Another approach is to integrate into routine NWS field operations a range of communications tools (e.g., satellite broadcast, packet radio, teleconferencing) in order to match the ever-increasing technical capabilities of the NWS' many customers.

3.2.2 IMPROVED COORDINATION BETWEEN NWS AND FEMA

Upon arrival in the disaster area, FEMA quickly established elaborate satellite television communications to continually broadcast important information to its personnel in the field, as well as FEMA officials in Washington, D.C. Included in the string of information were updates on current weather and flooding information.

FINDING 3-10: Agencies, like FEMA, have made and continue to make great advances in their abilities to effectively communicate with their users; however, the NWS is not fully utilizing the recent advances in information technologies.

RECOMMENDATION 3-10: NWS should create national capabilities that parallel the capabilities of FEMA for special emergency response and disaster relief operations. This should be coordinated by the regional or national NWS offices, as appropriate for the magnitude of the event. For example, the NWS should institutionalize the capability to provide support for satellite feeds coordinated by FEMA which are then made available to other Federal and state government agencies and locally on cable television.

A possible mechanism for such support would be one (or more) centrally located national media center(s) that would have access to equipment (e.g., a communications uplink; large-screen video monitors capable of depicting NEXRAD, AFOS, AWIPS data and products; etc.). In addition, personnel would be available to be rapidly deployed to NWS offices involved in major meteorological and/or hydrological events.

The NWS should also give more emphasis to development of all-hazard telecommunications capability for NWR. A FEMA representative was concerned about NWS' capability/staffing implications to handle FEMA information on "all-hazards" NWR. The essence of this issue is whether NWS has sufficient ability/staffing to support "all-hazards" operation of NWR since post-disaster information provided by FEMA is very high-volume traffic.

FINDING 3-11: The limited ability of the NWS to interact with FEMA raised the concern that the NWS may not be able to synchronize with FEMA and effectively operate an "all hazards" NWR.

RECOMMENDATION 3-11: The NWS must be careful not to commit to operating an "all-hazards" NWR without considering issues, such as staffing and length of the NWR program cycle.

APPENDIX A

SUMMARY OF FINDINGS AND RECOMMENDATIONS

CHAPTER 1: BACKGROUND AND OVERVIEW OF THE EVENT

No findings and recommendations in this chapter.

CHAPTER 2: OVERVIEW OF NWS PERFORMANCE

FINDING 2-1: As is generally the case with a synoptic pattern with little or no forcing and weak steering currents, the National Meteorological Center and National Hurricane Center models in general did not perform well with regard to the track of the remnants of Tropical Storm Alberto.

RECOMMENDATION 2-1: The National Weather Service (NWS) should continue to strive for improvements in tracking tropical systems once they make landfall. It is especially important that improvements be made in the forecasts at the surface and not just in the mid and upper levels of the atmosphere. Interactions with the research community within National Oceanic and Atmospheric Administration (NOAA) (such as the Office of Atmospheric Research) and other Federal agencies, as well as the academic research community, are especially encouraged.

FINDING 2-2: The quantitative precipitation forecast (QPF) guidance generated by the National Meteorological Center models was poor (as is common for convective situations during the warm season) and therefore of limited help to the forecasters. The national QPF guidance frequently underestimated excessive rainfall amounts and sometimes did not accurately highlight the area of maximum rainfall.

RECOMMENDATION 2-2: The NWS should continue to strive for improvements in QPFs for tropical and convective systems.

FINDING 2-3: The Weather Surveillance Radar-1988 Doppler (WSR-88D) Stage I Precipitation Processing, which runs in the Radar Products Generator, does not currently use rain gage data to provide potentially better quantitative estimates of the precipitation.

RECOMMENDATION 2-3: Rain gage data must be included in the WSR-88D Stage I Precipitation Processing as soon as possible, so that the radar-rainfall can be adjusted to avoid underestimation of rainfall associated with warm tropical events.

FINDING 2-4: The number of automated rain gages under the umbrellas of many of the WSR-88Ds in the area affected by Alberto was inadequate to effectively incorporate rain gage data into the Stage I Precipitation Processing.

RECOMMENDATION 2-4: The rain gage data network must be expanded and the reporting characteristics of existing sites modified to provide more timely data to produce a higher quality WSR-88D precipitation estimate.

FINDING 2-5: Even though the Southeast River Forecast Center (SERFC) area of responsibility has almost complete WSR-88D coverage, the SERFC was not able to quantitatively use the WSR-88D information in its forecasts. The capability to process WSR-88D digital precipitation estimates would have added value to the hydrologic forecasts.

RECOMMENDATION 2-5: Pre-AWIPS workstations must be deployed immediately to the SERFC and other River Forecast Centers (RFC) so the Stages II and III Precipitation Processing can be performed and utilized in the forecasts.

FINDING 2-6: The Atlanta WSR-88D was not able to retrieve data from the archive for a precipitation event that set historical records.

RECOMMENDATION 2-6: The potential for losing data, for all time, that could be used for storm analysis, training, and calibration of hydrometeorologic models and calibration of the WSR-88D dictates a requirement that there be a prompt resolution of the problems with the archive media.

FINDING 2-7: The WSR-88D was unable to provide all the products in the time required when there was a large-scale precipitation event.

RECOMMENDATION 2-7: Develop methods to increase the number of products that can be obtained by associated principle user processors, especially for offices with warning responsibilities.

FINDING 2-8: A limitation in the number of phone lines caused problems for at least one office and a cooperative observer from a critical area who was not able to provide data to the NWS because of busy phone lines.

RECOMMENDATION 2-8: Ensure that data are not lost due to inadequate phone lines into NWS offices and have adequate automated collection systems to acquire data so that the capacity of voice lines is not a constraint.

FINDING 2-9: The remote job entry (RJE) dial backup did not function because the dedicated phone line had not been connected to the system. The RJE dial backup had not been tested since the office moved.

RECOMMENDATION 2-9: RFC staffs must routinely test the RJE dial backup.

FINDING 2-10: The SERFC did not declare a Critical Flood Situation during the Alberto event, because job processing times were adequate.

RECOMMENDATION 2-10: The declaration of a Critical Flood Situation and use of the crisis job priority are powerful tools that should be utilized by the RFCs during any critical flood event.

FINDING 2-11: The Sheriff/Emergency Management Agency (EMA) Director for Sumter County, Georgia, receives weather watches and warnings from the public broadcast media. The county does not receive the National Attack Warning System (NAWAS) transmissions and is on the outside fringe of NOAA Weather Radio (NWR) reception (Americus is 68 miles from the nearest NWR transmitter). The NWR tone alert does not work reliably in the county because of this distance.

RECOMMENDATION 2-11: NWS should work with Federal Emergency Management Agency (FEMA) to ensure that every county emergency management agency/emergency operation center in Alabama, Florida, and Georgia has a communication link to NAWAS. Additionally, the Gore Initiative should be implemented as soon as possible to expand the NWR network of transmitters to reach 95 percent of the population.

FINDING 2-12: The Sheriff of Sumter County, Georgia, as with many other emergency management officials in the impacted area, expressed a high degree of frustration in making residents aware of the danger from the floodwaters and of the need to evacuate. Some of the deaths that occurred were people who had been warned (more than once) to evacuate but failed to act until it was no longer safe to do so. No flash flood/flood anywhere near the magnitude of this event had ever occurred in this area; and residents were, for the large part, unable to realize the dangers they faced until it was too late.

RECOMMENDATION 2-12: More emphasis should be placed on public awareness and preparedness training for flood and flash flood events. The continued high number of vehicle-related deaths during floods and flash floods indicates the need to educate the public of the risks involved with vehicles in flood situations. The "Hidden Danger" video currently being developed by the NWS should be used to inform the public of the dangers of low-water crossings.

FINDING 2-13: The Sheriff of Sumter County, Georgia, had high praise for NWS products and service during this event and did not think there was anything the NWS could have done to reduce the loss of life during this event. He did think it is a mistake for the NWS and the media to emphasize tropical storms only up until landfall; and then, in some cases, the public perceives that there is no danger because of a relatively weak wind-producing storm.

RECOMMENDATION 2-13: The NWS should work with the media to educate the public on the fact that heavy rains and widespread flooding from tropical storms and hurricanes may have as much, and in some cases even more, detrimental impact as winds at landfall.

FINDING 2-14: The disaster survey team found that the Flash Flood Warnings issued in this event were generally accurate and timely. However, many lacked a strong enough indication of the life-threatening nature of the flash flooding.

RECOMMENDATION 2-14: NWS offices should strive to better recognize truly extreme rainfall events and, in those events, use the strongest possible wording in the warnings and statements issued to make the public more cognizant of the life-threatening nature of the event.

FINDING 2-15: The disaster survey team found a high degree of satisfaction from emergency managers, the media, and the public with the river forecast services they received during this event. In particular, the impact statements and relationship to recent and historical flood levels were judged valuable information.

RECOMMENDATION 2-15: NWS Hydrologic Service Area offices should make every effort to include up-to-date and informative impact statements in all Flood Warnings and Flood Statements.

FINDING 2-16: There were several suggestions from emergency managers and the media that the public river forecasts be updated more frequently. The normal procedure presently is to issue the Flood Statements once per day in late morning or early afternoon. In particular, an early morning update was suggested to provide current information so the public can make more informed decisions on commute, daily activities, or evacuation activities.

RECOMMENDATION 2-16: NWS offices should make every attempt to update Flood Warnings and Flood Statements more than once per day.

FINDING 2-17: Several users suggested that changes in crest forecast values be highlighted at the beginning of Flood Statements. An analysis by the disaster survey team of the Flood Statements issued during this event where the crest forecast was revised from the previous

forecast showed that they, in general, did not call attention to the fact that a crest forecast had been revised.

RECOMMENDATION 2-17: Any significant change in the crest forecast from a previous crest forecast should be highlighted at the beginning of the Flood Warning or Flood Statement.

FINDING 2-18: The forecast for the Flint River at Bainbridge received considerable media and public attention when the river crested well below the forecasted level.

RECOMMENDATION 2-18: The SERFC must investigate the causes for the Bainbridge forecast error and make the appropriate changes to the hydrologic forecast model as soon as possible. When the appropriate modifications to the hydrologic model are completed, NWS personnel, RFC and/or NEXRAD Weather Service Forecast Office (NWSFO), should make the necessary effort to brief the Bainbridge public officials (and media) on their findings.

FINDING 2-19: Some communities, and perhaps emergency managers, were not as prepared for the disastrous floods as they could have been if there were greater personal contact and education on floods by NWS Warning Coordination Meteorologists (WCM) and Service Hydrologists (SH).

RECOMMENDATION 2-19: NWS policy should require periodic (annual if possible) personal visits by the WCMs and/or SHs to emergency management and other action agencies from the state to the local level. These contacts should include a review of the flood threat to the local community (emphasizing the threat to vehicular passengers) and a review of the hydrologic services that the NWS provides. This educational process should specify what products are available, how they can be used, and where they can most efficiently be obtained.

FINDING 2-20: The public's perceived threat from Alberto appeared to lessen once it made landfall.

RECOMMENDATION 2-20: The NWS and NOAA should take maximum advantage of the recommendations from the 1995 Interdepartmental Hurricane and the NOAA Hurricane Conferences, which focused on the inland effects of tropical cyclones, in order to enhance the public's perception of the dangers associated with landfalling tropical cyclones. In addition, the WCMs in all areas which might be affected by the aftermath of decaying tropical cyclones should reenforce the potential for severe flooding from such storms with the user community.

FINDING 2-21: The disaster team believes another possible contributing factor to the high death count could be that the public was not adequately educated regarding the locations of

flood-prone areas (particularly roads), safe evacuation routes, and the potential impact of their actions.

RECOMMENDATION 2-21: If funding permits, the NWS, in conjunction with FEMA and appropriate state and local agencies, should embark upon a campaign to educate the public as to their local flood-prone areas. This should include a widely distributed array of visual representations of flood-prone areas depicting roads and bridges as well as portions of communities that may be potentially inundated by floods. Additionally, the NWS should plan to issue graphical flood forecasts as well as the traditional text products.

FINDING 2-22: The disaster team felt it was inappropriate for a single NWS office to be expected to respond to an event that covered multiple offices and to FEMA's national-level press and Federal coordination briefings. In addition, there was an imbalance in the media contacts and interest with the National Hurricane Center prior to landfall and Weather Forecast Branch once the tropical cyclone had made landfall.

RECOMMENDATION 2-22: The NWS should establish a national media unit to provide beginning-to-end coverage of storm events that have national impact or interest. This unit would provide a consistent posture in front of the national media, which could emphasize the dangers associated with each phase of the storm. The unit would be headed by a public affairs specialist and supported by an *ad hoc* team of meteorologists and hydrologists, as appropriate for the event. Teleconferencing should be utilized to maximize participation of personnel from a variety of NWS offices.

CHAPTER 3: ISSUES HIGHLIGHTED BY THE EVENT

FINDING 3-1: Key members of the staffs of both NWSFOs and the RFC were attending training away from their home offices during this event.

RECOMMENDATION 3-1: Especially during transition, when we have extensive training requirements which are not a luxury, we must have adequate staff to cover operations.

FINDING 3-2: One NWSFO and the RFC affected by Alberto did not have sufficient human resources, and the other NWSFO did not have sufficient communications resources, to fully utilize data from the WSR-88Ds in the area. None of the Weather Service Offices (WSO) with warning responsibilities had any access to WSR-88D data. In addition, the RFC was unable to process the precipitation data from the WSR-88Ds so they could be input to the hydrologic models.

RECOMMENDATION 3-2: The NWS must recognize that during the transition it is not able to fully utilize the WSR-88D and should continue to take steps to accelerate other portions of

the modernization and make maximum use of technology components which are mature enough to warrant deployment.

FINDING 3-3: The operational shift and training requirements, coupled with a large geographic area of responsibility, limited the opportunity for the WCMs to interact with local users. Consequently, the WCMs did not thoroughly coordinate with all the users in their County Warning Area.

RECOMMENDATION 3-3: The NWS needs to develop an efficient strategy to maximize the efficiency of the collective efforts of the WCMs and other staff members. A WCM team approach should be considered whereby other Weather Forecast Office (WFO) and occasionally RFC staff members are designated as liaisons with the state and local agencies involved in such activities as emergency management, water resources, and public safety.

FINDING 3-4: At least one member of the emergency management community chose not to be burdened with the numerous products sent via NOAA Weather Wire Service (NWWS) for a neighboring state. As a result, critical forecasts and warnings for that county were not received. NWWS users want to efficiently receive weather information that pertains only to their jurisdictions.

RECOMMENDATION 3-4: Users need the ability on NWWS to parse only those hydrologic products that apply to their areas of responsibility, e.g., a given county. The NWS should require the use of generic codes on all NWS public hydrologic products until AWIPS is implemented, and the WCMs should work with the users to insure that all necessary products are being received.

FINDING 3-5: The NWS offices affected by Alberto were stressed to provide enough human resources during the disaster to continuously utilize all information the WSR-88Ds had to offer. It would have been virtually impossible for these offices to have provided the critical services they did if they were staffed with any less employees.

RECOMMENDATION 3-5: The NWS should reassess its core-level staffing requirements (going from five lead forecasters and five journeyman forecasters down to four lead forecasters and four journeyman forecasters), especially for offices with multiple WSR-88Ds.

FINDING 3-6: The SH workload at the offices surveyed was quite extensive and typical of any WFO. Despite the good effort put forth by the SHs, it was apparent that timely completion of important hydrology-related duties could not always be accomplished. This will be compounded in the future for SHs who support multiple hydrologic service areas.

RECOMMENDATION 3-6: The NWS should reassess its staffing philosophy for field offices; each WFO should have a resident SH.

FINDING 3-7: Staffing levels at the NWSFOs surveyed by the team, coupled with operational workloads and off-station training requirements, made it virtually impossible for a sufficient number of hydrologic training shifts to be made available for each forecaster to become totally competent in the station hydrology program.

RECOMMENDATION 3-7: The NWS should reexamine WFO staffing levels and procedures for developing adequate on-station hydrologic training to avoid difficulties during critical hydrologic events. This should include an adequate number of nonoperational shifts for each meteorologist to be trained to handle hydrologic crises at all times. In addition, Meteorologists in Charge should adhere to the guidance that SHs work no more than 20 percent of their time on forecast shifts.

FINDING 3-8: The personal contacts between the local EMA officials and WSO staffs contributed to their satisfaction with the NWS services. When these offices spin down, the responsibility switches to a single WCM.

RECOMMENDATION 3-8: A WCM team approach should be considered with other WFO staff members (e.g., the SH) interacting with the customers.

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Another approach is to integrate into routine NWS field operations a range of communications tools (e.g., satellite broadcast, packet radio, teleconferencing) in order to match the ever-increasing technical capabilities of the NWS' many customers.

FINDING 3-10: Agencies, like FEMA, have made and continue to make great advances in their abilities to effectively communicate with their users; however, the NWS is not fully utilizing the recent advances in information technologies.

RECOMMENDATION 3-10: NWS should create national capabilities that parallel the capabilities of FEMA for special emergency response and disaster relief operations. This should be coordinated by the regional or national NWS offices, as appropriate for the magnitude of the event. For example, the NWS should institutionalize the capability to provide support for satellite feeds coordinated by FEMA which are then made available to other Federal and state government agencies and locally on cable television.

FINDING 3-11: The limited ability of the NWS to interact with FEMA raised the concern that the NWS may not be able to synchronize with FEMA and effectively operate an "all hazards" NWR.

RECOMMENDATION 3-11: The NWS must be careful not to commit to operating an "all-hazards" NWR without considering issues, such as staffing and length of the NWR program cycle.

APPENDIX B

U.S. GEOLOGICAL SURVEY PEAK FLOWS

The following chart, from U.S. Geological Survey data, shows a summary of the peak stages and discharges during floods from July 4 to July 16, 1994, in Georgia, Florida, and Alabama.

[mi², square miles; ft, feet above an arbitrary datum; ft³/s, cubic feet per second; *, new peak of record; a, approximately; d, discharge may have been affected by dam break; --, not determined or not applicable; <, less than; >, greater than; number in () is the ratio of the peak discharge to the 100-year flood discharge. Source: Recurrence intervals calculated from U.S. Geological Survey data through 1990 water year. Other data from U.S. Geological Survey reports or data bases]

USGS station number	Stream and place of determination	Drain- age area (mi ²)	Period of record	Maximum prior to July 1994				Maximum in July 1994		
				Year	Stage (ft)	Discharge (ft ³ /s)	Day	Stage (ft)	Discharge (ft ³ /s)	Discharge recurrence interval (years)
OCMULGEE RIVER BASIN										
02204500	South River near McDonough, Ga	456	1940-82, 94	1946	24.70	34,500	6	28.70	*41,000	>100 (1.1)
02207500	Yellow River near Covington, Ga	378	1936, 45-65, 76-94	1936	29.90	30,000	6	13.46	4,530	<2
02210500	Ocmulgee River near Jackson, Ga	1,420	1912, 20, 40- 65, 76-82, 88-94	1919	26.80	69,000	6	26.87	69,000	Regulated
02212500	Ocmulgee River at Juliette, Ga	1,960	1886, 1916-21, 49, 75-88, 90, 94	1948	33.10	78,000	6	41.45	*100,000	>100 (1.2)
02213000	Ocmulgee River at Macon, Ga	2,240	1887, 1893- 1994	1948	29.90 (1990)	83,500	6	35.4	*107,000	>100 (1.2)
02213500	Tobesofkee Creek near Macon, Ga	182	1929, 38-94	1929	25.40	12,700	6	39.52	*54,200	>100 (3.5)
02213700	Ocmulgee River near Warner Robbins, Ga	2,690	1973-94	1990	15.85	81,000	7	21.75	*105,000	>100 (1.2)
02214820	Mossy Creek near Perry, Ga	92.9	1979-94	1981	8.27	788	6	19.86	*24,000	>100 (4.7)
02215000	Ocmulgee River at Hawkinsville, Ga	3,800	1877, 1909-80, 83-94	1925	36.50	79,000	9	40.91	*100,000	>100 (1.2)
02215100	Tusawhatchee Creek near Hawkinsville, Ga	163	1984-94	1991	14.13	4,740	7	15.17	*5,960	25
02215260	Ocmulgee River at Abbeville, Ga	4,460	1902-65, 88-94	1925	19.40	88,000	11	23.10	*100,000	>100 (1.2)
02215320	Ocmulgee River near Jacksonville, Ga	4,890	1948, 69-72, 75-77, 94	1948	17.29	70,000	13	19.79	*96,000	100
02215500	Ocmulgee River at Lumber City, Ga	5,180	1909-94	1925	26.30	98,400	15	24.59	92,900	85

[mi², square miles; ft, feet above an arbitrary datum; ft³/s, cubic feet per second; *, new peak of record; a, approximately; d, discharge may have been affected by dam break; --, not determined or not applicable; <, less than; >, greater than; number in () is the ratio of the peak discharge to the 100-year flood discharge. Source: Recurrence intervals calculated from U.S. Geological Survey data through 1990 water year. Other data from U.S. Geological Survey reports or data bases]

B-3

USGS station number	Stream and place of determination	Drain- age area (mi ²)	Period of record	Maximum prior to July 1994			Maximum in July 1994			Discharge recurrence interval (years)
				Year	Stage (ft)	Discharge (ft ³ /s)	Day	Stage (ft)	Discharge (ft ³ /s)	
CHATTAHOOCHEE RIVER BASIN										
02337500	Snake Creek near Whitesburg, Ga	35.5	1955-94	1961	14.40	7,690	4	3.83	455	<2
02338660	New River near Corinth, Ga	127	1979-94	1990	17.17	10,000	6	11.29	3,470	3
02341500	Chattahoochee River at Columbus, Ga	4,670	1841, 86, 1913, 16, 1920-94	1929	55.20	198,000	7	31.24	69,000	Regulated
02342500	Uchee Creek near Fort Mitchell, Al	322	1947-94	1964	26.45	55,100	8	23.35	25,600	25
02342933	South Fork Cowikee Creek near Batesville, Al	112	1964-94	1990	43.40	28,200	4	31.17	13,200	30
02343244	Cemochechobee Creek near Coleman, Ga	15.3	1984-94	1984	7.46	965	4	11.84	*5,160	>100 (2.7)
02343267	Temple Creek near Blakely, Ga	2.78	1978-94	1978	2.59	110	6	6.13	*746	>100 (1.2)
02343300	Abbie Creek near Haleburg, Al	146	1958-94	1970	23.84	7,590	6	37.00	*35,000	>100 (3.5)
02343801	Chattahoochee River at Andrews Lock & Dam, Ga	8,210	1975-94	1990	123.29	195,000	7	123.98	*202,000	Regulated
FLINT RIVER BASIN										
02344300	Camp Creek near Fayetteville, Ga	17.2	1961-73, 94	1961	9.90	2,800	5	13.89	*6,300	>100 (1.6)
02344350	Flint River near Lovejoy, Ga	130	1986-94	1990	17.76	8,090	5	23.60	*19,000	>100 (1.2)
02344500	Flint River near Griffin, Ga	272	1929, 37-94	1929	17.90	15,300	6	24.22	*31,500	>100 (1.9)
02344700	Line Creek near Senoia, Ga	101	1965-94	1977	14.88	9,580	5	20.1	*28,400	>100 (2.4)
02346180	Flint River near Thomaston, Ga	1,220	1900-29, 39- 50, 1952-56, 61, 64-94	1929	--	62,000	6	21.83	55,000	100
02346195	Lazer Creek near Talbotton, Ga	81.3	1981-94	1990	24.10	36,100	6	16.17	19,600	>100 (1.7)

[mi², square miles; ft, feet above an arbitrary datum; ft³/s, cubic feet per second; *, new peak of record; a, approximately; d, discharge may have been affected by dam break; --, not determined or not applicable; <, less than; >, greater than; number in () is the ratio of the peak discharge to the 100-year flood discharge. Source: Recurrence intervals calculated from U.S. Geological Survey data through 1990 water year. Other data from U.S. Geological Survey reports or data bases]

USGS station number	Stream and place of determination	Drain- age area (mi ²)	Period of record	Maximum prior to July 1994			Maximum in July 1994			Discharge recurrence interval (years)
				Year	Stage (ft)	Discharge (ft ³ /s)	Day	Stage (ft)	Discharge (ft ³ /s)	
FLINT RIVER BASIN--Continued										
02346500	Potato Creek near Thomaston, Ga	186	1938-73, 90, 94	1990	9.19	12,300	6	12.0	*28,000	>100 (1.9)
02347500	Flint River near Culloden, Ga	1,850	1913-31, 37-94	1929	38.40	92,000	6	45.73	*100,000	>100 (1.2)
02349030	Cedar Creek near Rupert, Ga	41.1	1979-94	1979	4.72	580	6	7.50	*2,400	>100 (1.1)
02349350	Buck Creek near Ellaville, Ga	146	1929-94	1990	9.67	3,730	6	11.31	*7,800	>100 (1.1)
02349500	Flint River at Montezuma, Ga	2,900	1897, 1905-94	1897	26.00	97,000	8	34.11	*136,000	>100 (1.4)
02349900	Turkey Creek near Byromville, Ga	45.0	1951-94	1981	13.82	4,820	6	14.29	*5,820	>100 (1.2)
02350512	Flint River at Oakfield, Ga	3,880	1967-75, 88-94	1990	27.37	50,200	10	40.1	*112,000	>100 (1.4)
02350520	Little Abrama Creek near Doles, Ga	3.77	1965-75, 94	1967	5.99	652	6	7.06	*840	>100 (1.1)
02350600	Kinchafoonee Creek near Preston, Ga	197	1943, 48-78, 87-94	1990	12.16	14,500	6	11.66	12,400	100
02350685	Choctahatchee Creek trib near Plains, Ga	0.32	1977-94	1982	2.42	73	6	9.25	*625	>100 (3.1)
02350900	Kinchafoonee Creek near Dawson, Ga	527	1943, 48-66, 73, 85-94	1943	23.00	15,000	7	26.56	*29,500	>100 (1.7)
02351500	Muckalee Creek near Americus, Ga	140	1948, 1963-83, 94	1948	12.50	9,000	6	19.50	d *33,500	>100 (4.0)
02351890	Muckalee Creek near Leesburg, Ga	362	1943, 48, 80-94	1943	--	18,000	6	29.1	d *64,400	>100 (5.0)
02352500	Flint River at Albany, Ga	5,310	1893-1994	1925	37.80	92,000	11	43.0	*120,000	>100 (1.3)
02353000	Flint River at Newton, Ga	5,740	1925, 29, 38-94	1925	41.30	94,000	13	45.25	*100,000	>100 (1.2)
02353500	Ichawaynochaway Creek at Milford, Ga	620	1906-07, 16, 25, 40-94	1916	17.20	15,500	7	23.20	*53,000	>100 (3.0)
02356000	Flint River at Bainbridge, Ga	7,570	1897, 1905-94	1925		101,000	14	37.20	*108,000	>100 (1.1)
02357000	Spring Creek near Iron City, Ga	485	1938-78, 83-94	1975	19.43	17,700	8	19.95	12,900	25

[mi², square miles; ft, feet above an arbitrary datum; ft³/s, cubic feet per second; *, new peak of record; a, approximately; d, discharge may have been affected by dam break; --, not determined or not applicable; <, less than; >, greater than; number in () is the ratio of the peak discharge to the 100-year flood discharge. Source: Recurrence intervals calculated from U.S. Geological Survey data through 1990 water year. Other data from U.S. Geological Survey reports or data bases]

B-5

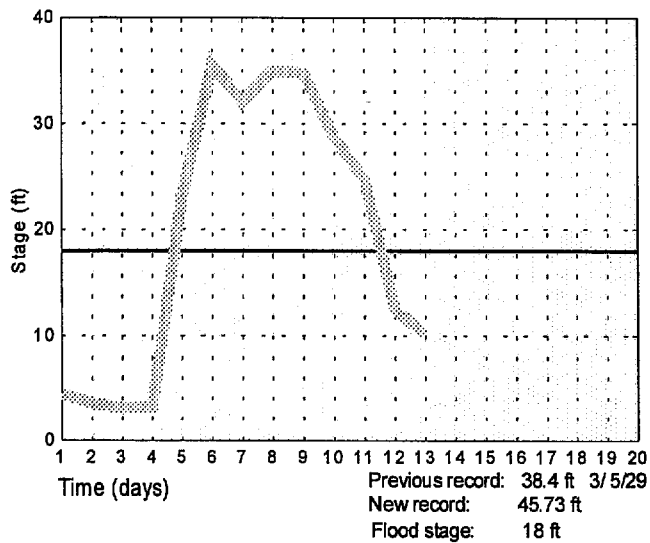
USGS station number	Stream and place of determination	Drain- age area (mi ²)	Period of record	Maximum prior to July 1994			Maximum in July 1994			Discharge recurrence interval (years)
				Year	Stage (ft)	Discharge (ft ³ /s)	Day	Stage (ft)	Discharge (ft ³ /s)	
APALACHICOLA RIVER BASIN										
02358700	Apalachicola River near Blountstown, Fl	17,600	1920-94	1978	28.6 (1929)	172,000	10	27.39	225,000	50
02359000	Cipola River near Altha, Fl	781	1921-94	1926	33.35	25,000	12	29.60	14,200	30
02359170	Apalachicola River at Sumatra, Fl	19,200	1977-94	1990	13.82	179,000	13	15.05	221,000	55
CHOCTAWHATCHEE RIVER BASIN										
02360500	East Fork Choctawhatchee River near Maryland City, Al	291	1953-63, 66- 70, 90, 94	1990	28.18	35,000	6	29.30	*43,000	>100 (2.1)
02360275	Judy Creek near Ozark, Al	102	1951-77, 90, 94	1990	22.29	25,000	6	19.02	13,000	40
02361000	Choctawhatchee River at Newton, Al	686	1922-27, 35-94	1990	40.30	87,500	7	37.78	58,000	>100 (1.4)
02362240	Little Double Bridges Creek near Enterprise, Al	21.4	1986-94	1990	13.90	7,950	6	16.45	*14,200	>100 (2.5)
02365500	Choctawhatchee River at Caryville, Fl	3,499	1929-94	1929	27.10	206,000	9	23.85	164,000	>100 (1.3)
02366500	Choctawhatchee River near Bruce, Fl	4,384	1931-82, 85-94	1929	29.20	220,000	11	26.76	165,000	>100 (1.5)
YELLOW RIVER BASIN										
02368000	Yellow River at Milligan, Fl	624	1938-94	1990	19.00	51,500	8	17.55	40,200	40
02369000	Shoal River near Crestview, Fl	474	1938-94	1975	15.58	25,200	8	14.82	22,600	25
ESCAMBIA RIVER BASIN										
02371000	Conecuh River near Troy, Al	257	1944-68, 90, 94	1990	19.41	33,000	7	15.58	17,700	10
02371500	Conecuh River at Brantley, Al	500	1938-94	1990	24.44	25,700	7	22.37	17,000	10
02421000	Catoma Creek near Montgomery, Al	190	1949, 53-94	1990	29.78	49,100	8	26.07	22,800	10

APPENDIX C

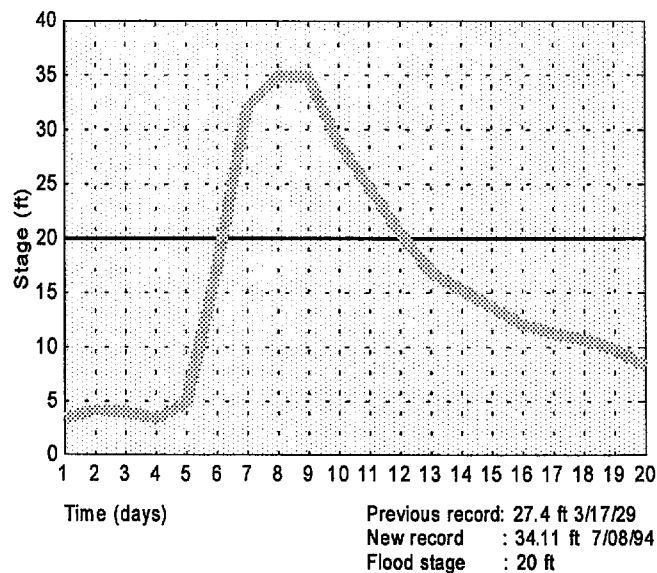
HYDROGRAPHS OF OBSERVED RIVER STAGE FOR SELECT FORECAST POINTS

This appendix contains hydrographs (plot of river stage versus time) for selected forecast points affected by Tropical Storm Alberto. The hydrographs include only the stages reported at 7 a.m.; consequently, they may not include the peak if it occurred outside the 7 a.m. window. In addition to the observed river stages, the figures that follow contain (1) the name of the forecast point, (2) a horizontal line at the flood stage level and text stating the flood stage, (3) the date and river stage of the previous record, and (4) the date and river stage of the peak during the Alberto event.

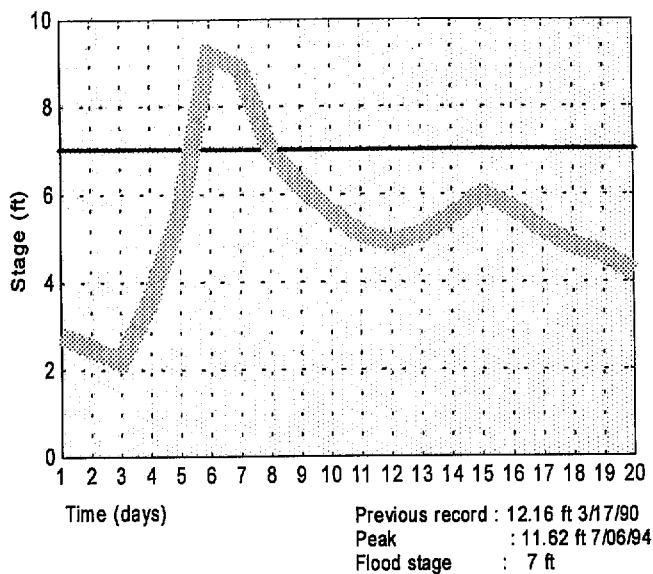
**Flint River at Culloden
July 1994**



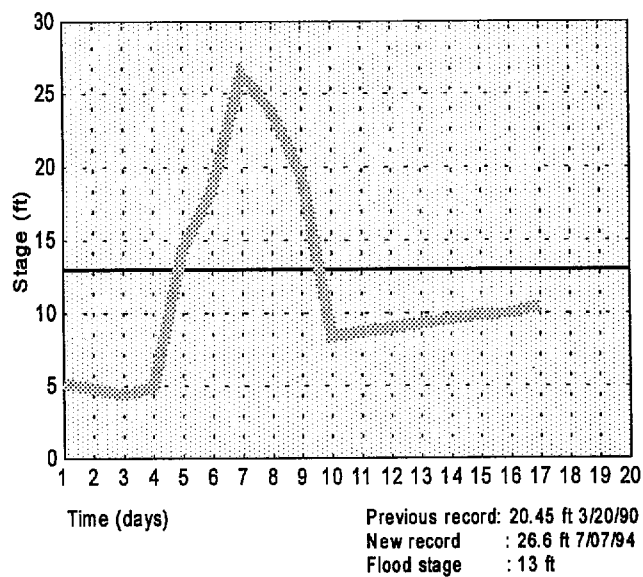
**Flint River at Montezuma
July 1994**



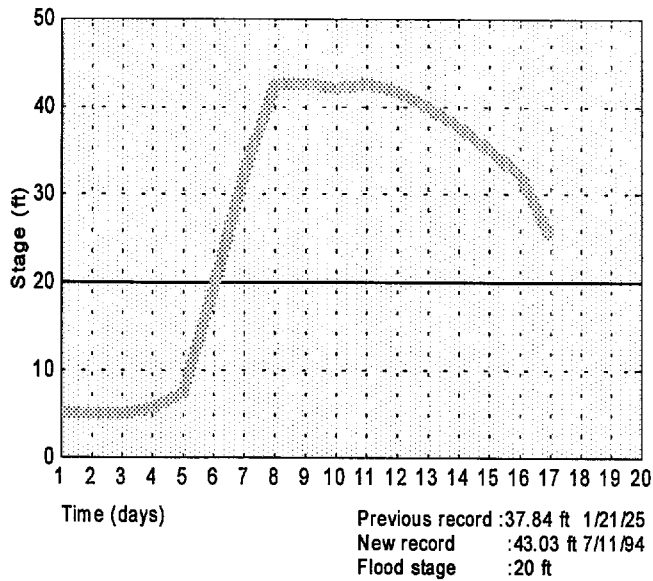
**Kinchafoonee River at Preston
July 1994**



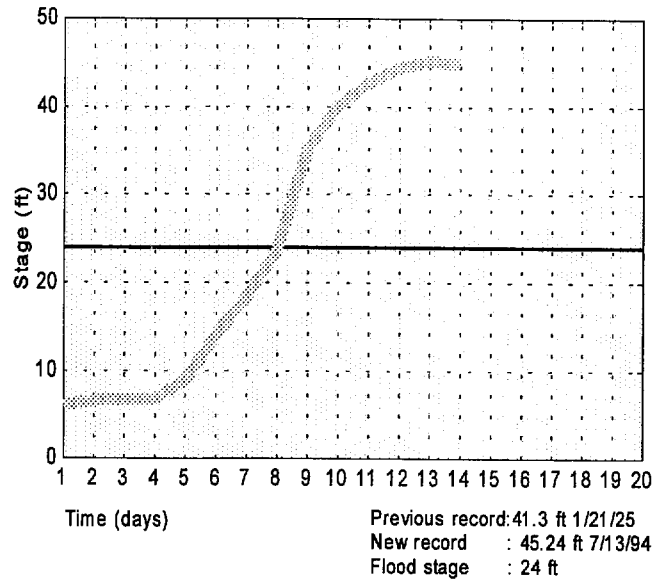
**Kinchafoonee River at Dawson
July 1994**



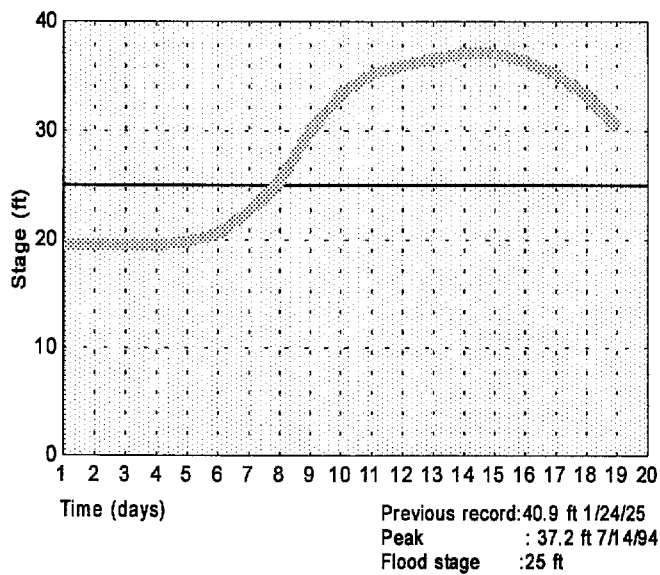
**Flint River at Albany
July 1994**



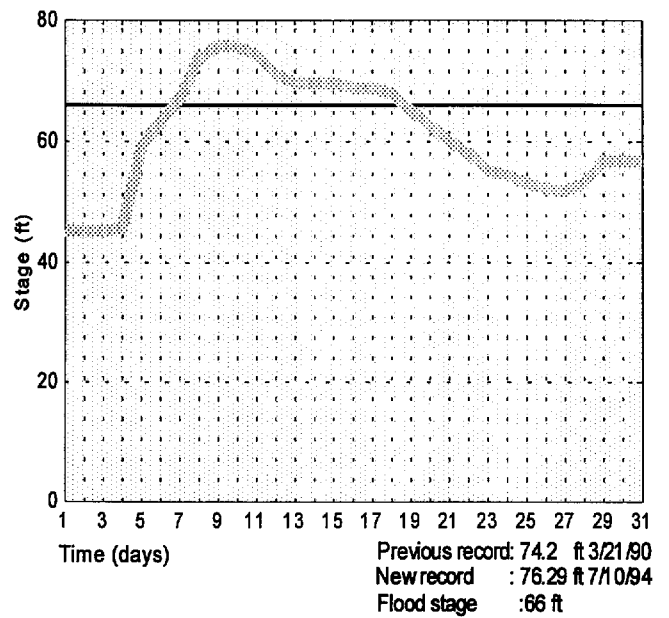
**Flint River at Newton
July 1994**



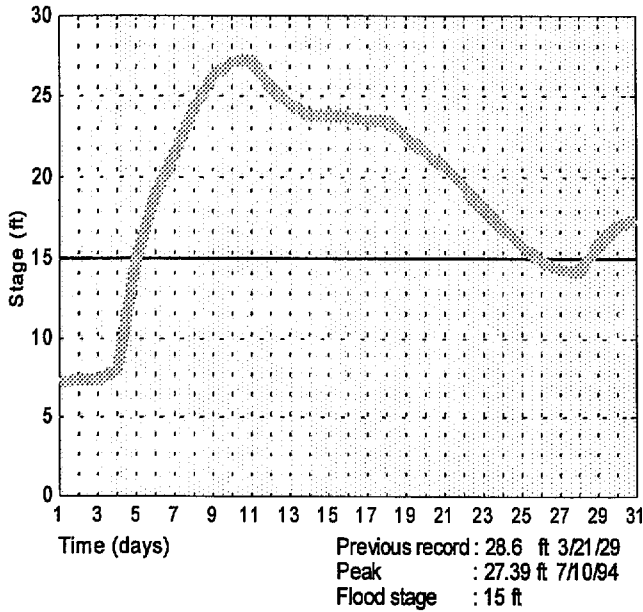
**Flint River at Bainbridge
July 1994**



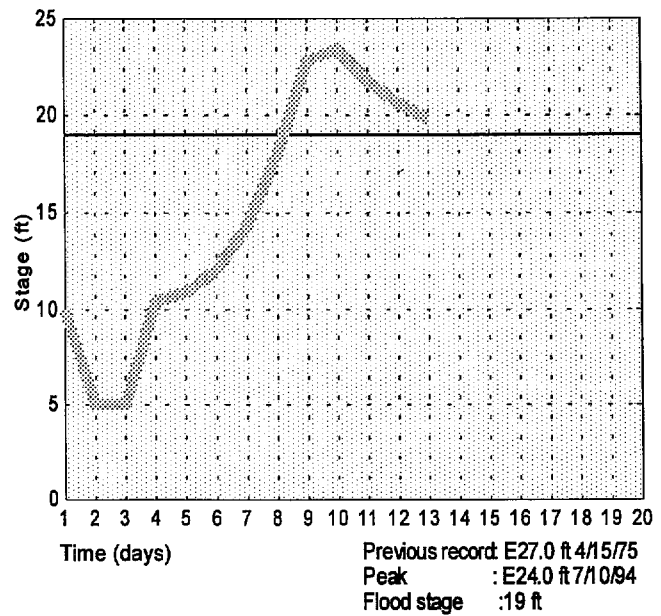
**Apalachicola River at Woodruff TW
July 1994**



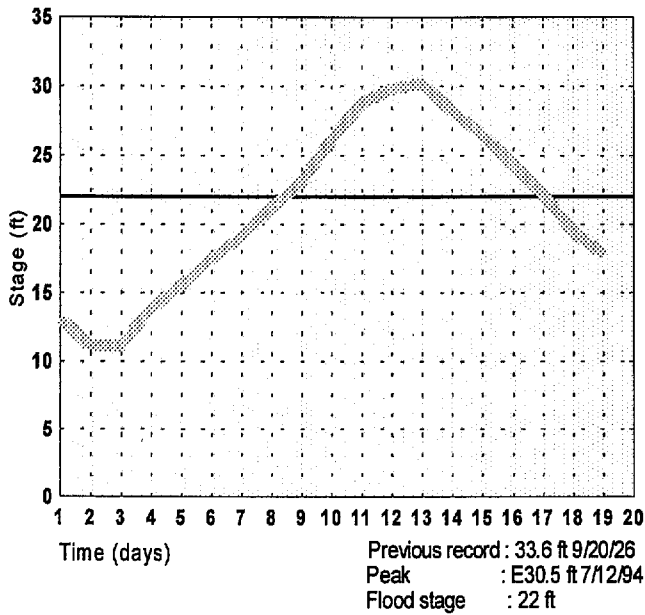
**Apalachicola River at Blountstown
July 1994**



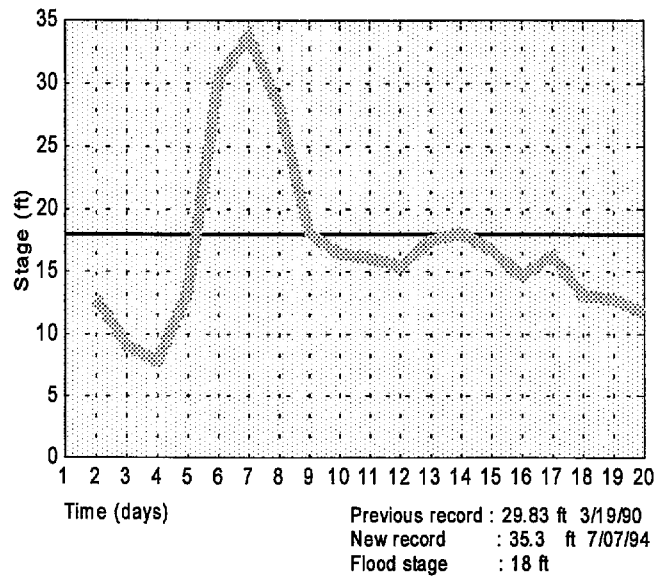
**Chipola River at Marianna
July 1994**



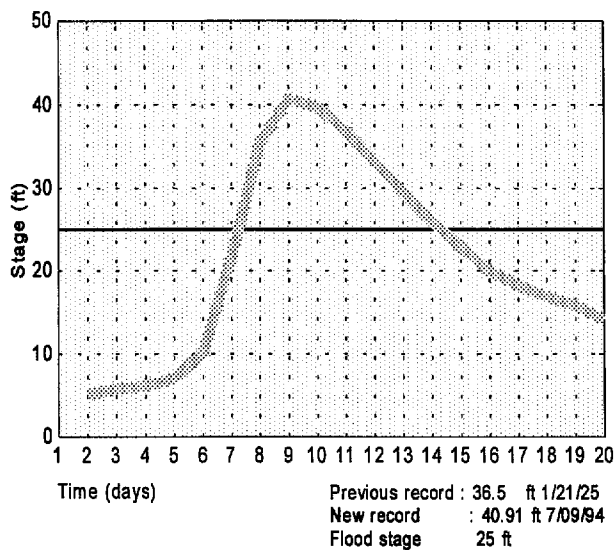
**Chipola River at Altha
July 1994**



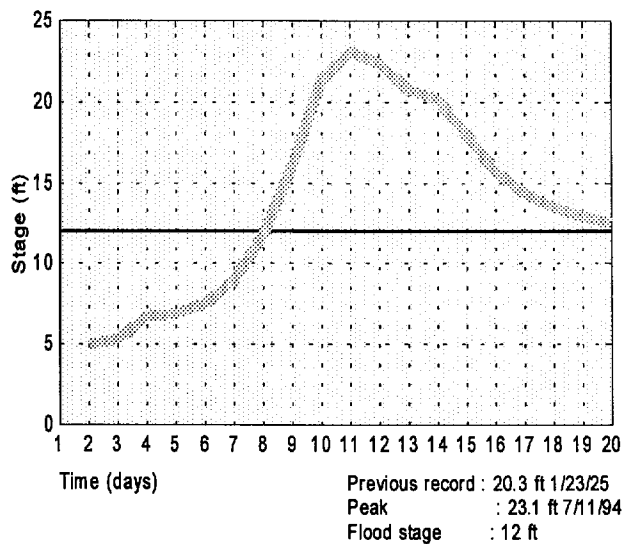
**Ocmulgee River at Macon
July 1994**



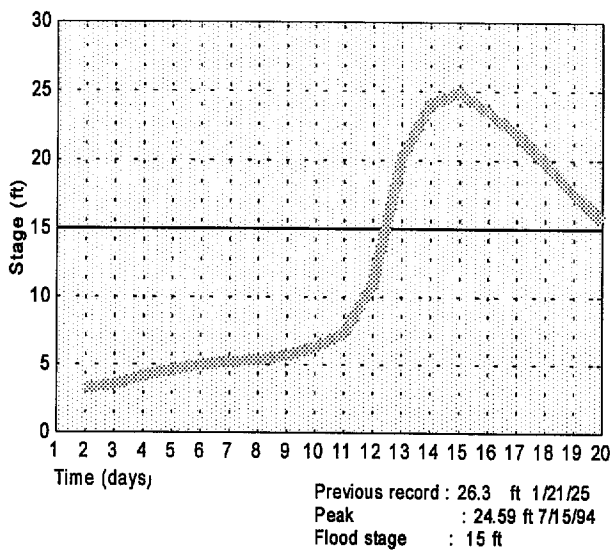
**Ocmulgee River at Hawkinsville
July 1994**



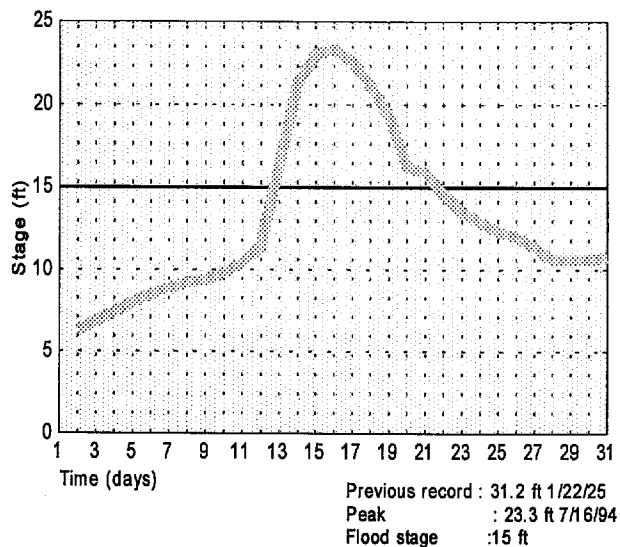
**Ocmulgee River at Abbeville
July 1994**



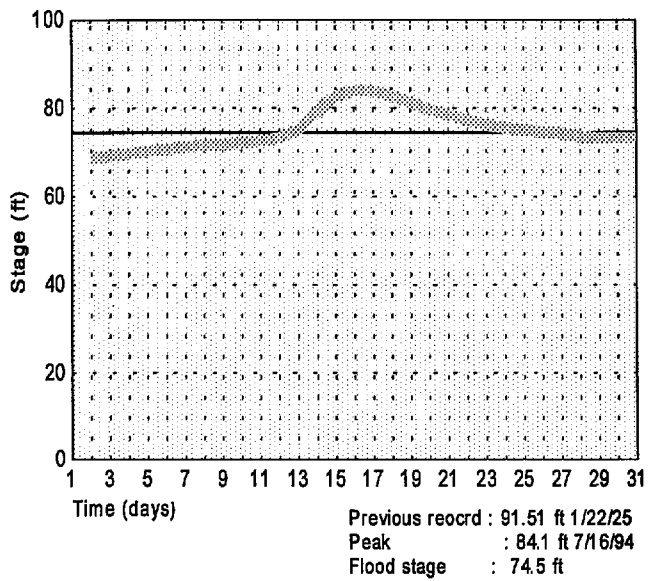
**Ocmulgee River at Lumber City
July 1994**



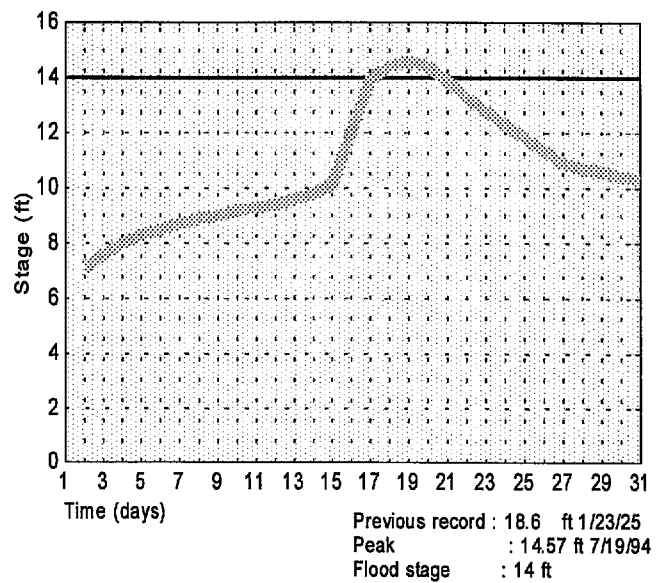
**Altamaha River at Charlotte
July 1994**



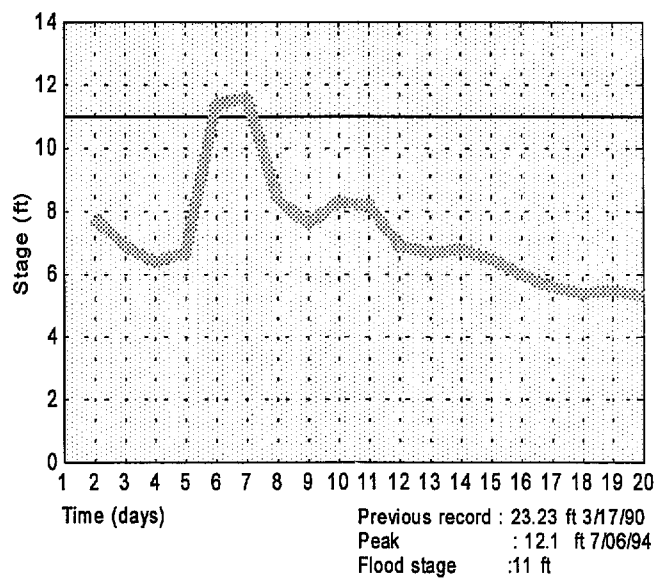
**Altamaha River at Baxley
July 1994**



**Altamaha River at Doctortown
July 1994**



**Oconee River at Penfield
July 1994**



APPENDIX D

FORECASTS ISSUED BY SOUTHEAST RIVER FORECAST CENTER BY FORECAST POINTS

Table D-1 shows selected forecast points on the major rivers/creeks throughout the southeastern United States that were affected by heavy precipitation from Tropical Storm Alberto. The table identifies (1) the river or creek; (2) the location of the forecast point; (3) the site identifier; (4) the flood stage, in feet; (5) the date/time and stage of the forecast crest; (6) the issue date/time of the forecast; and (7) the date/time and stage of the observed crest. Those sites that had a flood of record are noted with an "*" in the observed crest.

Tables D-2 through D-22 represent the selected forecast(s) issued by the Southeast River Forecast Center for each forecast point that was shown in Table D-1. The columns show (1) the date of the forecast; (2) the latest observed stage at the forecast point, in feet, at the time of the forecast; (3) the forecast, in feet, and river tendency; and (4) the time the forecast was issued.

Note:

cfs	=	cubic feet per second
Cr	=	crest
EDT	=	eastern daylight time
FS	=	flood stage
ft	=	feet
SID	=	site identification
TW	=	tall water of a dam

Table D-1. Forecasts issued and observed crests at forecast points

River/Creek	Station	SID	FS	Forecast Crest	Issue Date	Observed Crest
Chattahoochee	WF George TW	FOGG1	134	Cr 146 ft on 7th	11:05 am 7/06/94	149.9 ft 7/06/94
Chattahoochee	Columbia TW	COLA1	113	Cr 119-120 ft on 7th	11:05 am 7/06/94	123.98 ft* 7/7/94
Flint	Culloden	CLUG1	18	Cr 39 ft on 6th	10:35 am 7/05/94	45.73 ft* 7/06/94
Flint	Montezuma	MNTG1	20	Cr 36 ft on 8th	12:45 pm 7/07/94	34.11 ft* 7/08/94
Kinchafoonee	Preston	PRSG1	7	Cr 10 ft on 6th	11:05 am 7/06/94	11.66 ft 7/06/94
Kinchafoonee	Dawson	DSNG1	13	Cr 30 ft on 9th	12:45 pm 7/07/94	26.56 ft* 7/07/94
Flint	Albany	ABNG1	20	Cr 45-46 ft on 10th pm	11:25 am 7/10/94	43.0 ft* 7/11/94
Flint	Newton	NEWG1	24	Cr 45-46 ft on 12th pm	11:15 am 7/12/94	45.25 ft* 7/13/94
Flint	Bainbridge	BGEG1	25	Cr 37-38 ft on 14th	11:45 am 7/13/94	37.20 ft* 7/14/94
Apalachicola	Woodruff TW	WDRF1	66	Cr 77-78 ft on 9th pm	11:55 am 7/09/94	76.29 ft* 7/10/94
Apalachicola	Blountstown	BLOF1	15	Cr 27.5-28 ft on 10th pm	11:55 am 7/09/94	27.39 ft 7/10/94
Chipola	Marianna	MALF1	19	Cr 25 ft on 9th pm	11:55 am 7/09/94	24.0 ft 7/10/94
Chipola	Altha	ALTF1	22	Cr 30-31 ft on 12th pm	12:05 pm 7/11/94	29.60 ft 7/12/94

River/Creek	Station	SID	FS	Forecast Crest	Issue Date	Observed Crest
Ocmulgee	Macon	MACG1	18	Cr 35 ft on 7th	5:00 pm 7/06/94	35.4 ft* 7/07/94
Ocmulgee	Hawkinsville	HAWG1	25	Cr 43-44 ft on 10th	12:25 pm 7/09/94	40.91 ft* 7/09/94
Ocmulgee	Abbeville	ABBG1	12	Cr 23 ft on 11th	11:25 am 7/10/94	23.1 ft* 7/11/94
Ocmulgee	Lumber City	LBRG1	15	Cr 26 ft on 15th	11:15 am 7/12/94	24.59 ft 7/15/94
Altamaha	Charlotte	CHRG1	15	Cr 24 ft on 16th	11:15 am 7/12/94	23.3 ft 7/16/94
Altamaha	Baxley	BAXG1	74.5	Cr 84-85 ft on 17th	11:45 am 7/13/94	84.1 ft 7/16/94
Altamaha	Doctortown	DCTG1	14	Cr 14-15 ft on 18th	11:45 am 7/13/94	14.57 ft 7/19/94
Oconee	Penfield	PNFG1	11	Cr 13 ft on 7th	11:05 am 7/13/94	12.10 ft 7/06/94

* Indicates flood of record level

Table D-2. *Chattahoochee River at WF George L&D TW FOGG1, Flood Stage 134 ft*

Date	Latest Report (ft)	Forecast (ft)	Issue Time (EDT)
07/06/94	133.74	Crest near 146 7th	11:05 am
07/07/94	149.08	Falling	12:45 pm
07/08/94	146.03	Falling	12:15 pm
07/09/94	137.6	Fall below FS 10th	12:25 pm
07/10/94	116.98	Below FS and falling	11:25 am

Crest: 149.9 ft, 10 pm 7/06/94

Peak discharge: 123,000 cfs for few hours on 7/06/94

Previous Flood of Record: E158.5 ft, 3/17/29

Table D-3. Chattahoochee River at Columbia L&D TW COLA1, Flood Stage 113 ft

Date	Latest Report (ft)	Forecast (ft)	Issue Time (EDT)
07/04/94	93.0	Crest near 103 this afternoon	1:00 pm
07/05/94	108.3	110-111 tonight	10:35 am
07/06/94	110.0	Crest 119-120 on 7th	11:05 am
07/07/94		At crest near 120 today	12:45 pm
07/08/94		Fall below FS tonight	12:15 pm
07/9/94		Below FS, Fall below 92 12th	12:25 pm
07/10/94		92-93 next few days	11:25 am
07/11/94	92.0	92-93 next few days	11:55 am
07/12/94	92.0	Falling below 92 today	11:15 am
07/13/94	86.2	Below 92 and falling	11:45 am

Crest: 123.98 ft, about noon 7/7/94

New record level

Previous Flood of Record: 123.29 ft, 3/19/90

Table D-4. *Flint River near Culloden CLUG1, Flood Stage 18 ft*

Date	Latest Report (ft)	Forecast (ft)	Issue Time (EDT)
07/05/94	23.1	Crest near 39 6th	10:35 am
07/05/94	35.57	Crest near 42 8th	3:30 pm
07/06/94		Crest near 39 today	11:05 am
07/07/94		Crested and falling	12:45 pm
07/08/94		Falling below FS 12th	12:15 pm

Crest: 45.73 ft, early am 7/06/94, high water mark

New record level

Previous Flood of Record: 38.4 ft, 3/15/29

Table D-5. *Flint River at Montezuma MNTG1, Flood Stage 20 ft*

Date	Latest Report (ft)	Forecast (ft)	Issue Time (EDT)
07/05/94	4.6	Crest near 27 8th	10:35 am
07/05/94	7.13	Crest near 30 8th	3:30 pm
07/06/94	18.4	Crest near 30 8th	11:05 am
07/07/94	30.2	Crest near 33 8th	4:45 am
07/07/94	E34.0	Crest near 36 8th	12:45 pm
07/08/94	E35.0	Crest near 36 today	12:15 pm
07/09/94		Crested...falling below FS 14th	12:25 pm

Crest: E35 ft, about noon 7/08/94

New record level

Previous Flood of Record: 27.4 ft, 3/17/29

USGS Measurements: 34.1 ft = 134,000 cfs, 3 pm 7/07/94

Table D-6. *Kinchafoonee Creek at Preston PRSG1, Flood Stage 7 ft*

Date	Latest Report (ft)	Forecast (ft)	Issue Time (EDT)
07/04/94	3.6	Crest near 7 6th	10:15 am
07/05/94	5.6	Crest near 7 6th	10:35 am
07/05/94	6.7	Crest near 8 6th	3:30 pm
07/06/94	9.4	Crest near 10 today	11:05 am
07/06/94	10.65	Falling...below FS on 10th	10:10 pm
07/07/94	8.93	Falling below FS on 8th	12:45 pm
07/08/94	7.08	Falling below FS today	12:15 pm

Crest: 11.66 ft, 5 am 7/06/94

Previous Flood of Record: 12.16 ft, 3/17/90

Table D-7. Kinchafoonee Creek near Dawson DSNGL, Flood Stage 13 ft

Date	Latest Report (ft)	Forecast (ft)	Issue Time (EDT)
07/04/94	4.9	Crest near 13 8th	10:15 am
07/04/94	9.6	Crest near 14 6th	9:45 pm
07/05/94	14.4	Crest 18-19 8th	10:35 am
07/05/94	16.5	Crest 20-21 7th	3:00 pm
07/06/94	18.5	Crest 20-21 7th	11:05 am
07/06/94	23.9	Crest near 25 10th	10:10 pm
07/07/94	26.42	Crest near 30 9th	12:45 pm
07/08/94	23.88	Falling below FS 11th	12:15 pm

Crest: 26.56 ft, 2 am 7/7/94

New record level

Previous Flood of Record: 20.4 ft, 3/20/90

Table D-8. Flint River at Albany ABNG1, Flood Stage 20 ft

Date	Latest Report (ft)	Forecast (ft)	Issue Time (EDT)
07/05/94	7.5	Crest 30-31 11th	10:35 am
07/05/94	11.0	Crest 36-37 11th	3:30 pm
07/06/94	19.8	Crest near 40 9th	11:05 am
07/07/94	32.69	Crest near 44 10th	12:45 pm
07/07/94	E41.00	Crest near 45 9th	09:45 pm
07/08/94	E41.95	Crest 45-46 9th pm	12:15 pm
07/09/94	E41.45	Crest 45-46 tonight	12:25 pm
07/10/94	E42.09	Crest 45-46 tonight	11:25 am
07/11/94	E42.65	Remain 42-43 next few days then slow fall	11:55 am
07/12/94	E41.77	40 38 35 31 28	11:15 am

Crest: 43 am 7/11/94

New record level

Previous Flood of Record: 37.80 1/21/25

USGS Measurements: 42.34 ft = 119,000 cfs, about noon 7/10/94

Crest discharge 120,000 to 125,000 cfs

Table D-9. Flint River at Newton NEWG1, Flood Stage 24 ft

Date	Latest Report (ft)	Forecast (ft)	Issue Time (EDT)
07/05/94	8.88	Crest 31-32 13th	10:35 am
07/05/94		Crest near 38 12th	3:30 pm
07/06/94	14.7	Crest near 41 12th	11:05 am
07/07/94	18.41	Crest near 45 11th	12:45 pm
07/08/94	24.48	Crest near 45 11th	12:15 pm
07/09/94	35.23	Crest near 45 11th	12:25 pm
07/10/94	40.20	Crest near 46 12th	11:25 am
07/11/94	42.69	Crest 45-46 12th	11:55 am
07/12/94	44.44	Crest 45-46 tonight	11:15 am
07/13/94	45.24	Near crest...fall below FS 18th	11:45 am
07/14/94	44.82	Crested...fall below FS 18th	11:50 am

Crest: 45.25 ft, 6:00 am 07/13/94

New record level

Previous Flood of Record: 41.3 ft, 1/21/25

USGS Measurements: 41.24 ft = 86,000 cfs 7/12/94;

43.5 ft = 94,400 cfs 7/12/94

Table D-10. Flint River at Bainbridge BGEG1, Flood Stage 25 ft

Date	Latest Report (ft)	Forecast (ft)	Issue Time (EDT)
07/05/94	19.77	Crest 28-29 14th	10:35 am
07/05/94		Crest near 34 14th	3:30 pm
07/06/94	20.55	Crest near 40 13th	11:05 am
07/07/94	22.65	Crest near 45 13th	12:45 pm
07/08/94	25.3	Crest near 45 13th	12:15 pm
07/09/94	30.05	Crest near 45 13th	12:25 pm
07/10/94	33.4	Crest near 45 13th	11:25 am
07/11/94	35.25	Crest 44-45 14th	11:55 am
07/12/94	36.00	Crest 43-44 14th	11:15 am
07/13/94	36.65	Crest 37-38 14th	11:45 am
07/14/94	37.10	Crest 37-38 this evening	11:50 am
07/14/94	37.15	Near crest	12:40 pm
07/15/94	37.10	Crested yesterday...near 37 today...fall below FS 22nd	11:40 am
07/16/94	36.44	Fall below FS 22nd	10:50 am

Crest: 37.3 ft 11:00 am 07/14/94, High Water Mark

New record level

Previous Flood of Record: 40.9 ft, 1/24/25

USGS Measurements: 36.23 ft = 101,000 cfs, 4:00 pm 7/12/94

37.18 ft = 108,000 cfs, 12:05 pm 7/14/94

Table D-11. *Apalachicola River at Woodruff Dam TW WDRF1, Flood Stage 66 ft*

Date	Latest Report (ft)	Forecast (ft)	Issue Time (EDT)
07/05/94	59.3	62 66 65 63 60	10:50 am
07/06/94	63.2	68 73 72 68 64 Cr 73 8th	10:50 am
07/07/94	67.16	73 72 68 64 60 Cr 73 8th	12:40 pm
07/08/94	73.47	75 74 72 68 65 Cr 75-76 tonight	12:45 pm
07/09/94	75.77	76 75 75 74 72 Cr 77-78 tonight	11:55 am
07/10/94	75.66	75 75 73 71 69 Crested...falling	11:55 am
07/11/94	74.40	74 73 71 69 67	12:05 pm

Crest: 76.29 ft, 4 am 7/10/94

New record level

Peak discharge 225,000 cfs

Previous Flood of Record: 74.2 ft, 3/21/90

Table D-12. *Apalachicola River near Blountstown BLOF1, Flood Stage 15 ft*

Date	Latest Report (ft)	Forecast (ft)	Issue Time (EDT)
07/04/94	8.0	Crest near 19 7th	10:10 am
07/05/94	15.06	Crest near 22 7th	10:50 am
07/06/94	18.9	Crest near 24 9th	10:50 am
07/07/94	21.42	Crest near 24 9th	12:40 pm
07/08/94	23.88	Crest around 27 9th	12:45 pm
07/09/94	26.16	Crest 27.5-28 10th	11:55 am
07/10/94	27.01	Crest 27.5-28 tonight	11:55 am
07/11/94	27.25	Crested..began slow fall	12:05 pm
07/12/94	25.6	24.5 24 23.5 23 22.5	11:45 am

Crest: 27.39 ft, pm 07/10/94

Previous Flood of Record: 28.6 ft, 3/21/29

Table D-13. *Chipola River near Marianna MALF1, Flood Stage 19 ft*

Date	Latest Report (ft)	Forecast (ft)	Issue Time (EDT)
07/04/94	10.4	Crest near 16 7th	10:10 am
07/05/94	10.9	Crest near 16 7th	10:50 am
07/06/94	12.1	Crest near 16 7th	10:50 am
07/06/94		Crest near 30 8th	5:30 pm
07/07/94	14.0	Crest near 30 8th	12:40 pm
07/08/94	18.0	Crest 24-25 9th pm	12:45 pm
07/09/94	22.8	Crest near 25 tonight	11:55 am
07/10/94	23.4	24-25 next few days	11:55 am
07/11/94		Slow fall	12:05 pm

Crest: near 24 ft, 07/10/94

Previous Flood of Record: E27.0 ft, 4/15/75

Table D-14. *Chipola River near Altha, ALTF1, Flood Stage 22 ft*

Date	Latest Report (ft)	Forecast (ft)	Issue Time (EDT)
07/04/94	13.9	Crest near 19 7th	10:10 am
07/05/94	15.4	Crest near 19 7th	10:50 am
07/06/94	17.5	Crest near 20 7th	10:50 am
07/06/94		Crest near 30 9th	5:30 pm
07/07/94	19.1	Crest near 30 9th	12:40 pm
07/08/94	21.2	Crest 26-27 11th	12:45 am
07/09/94	23.13	Crest 26-27 11th	11:55 am
07/10/94	26.2	Crest 29-30 11th (backwater effects)	11:55 am
07/11/94	28.85	Crest 30-31 12th	12:05 pm
07/12/94	29.75	Crest 30-31 tonight	11:45 am
07/13/94	30.2	Crested...began slow fall	11:35 am

Crest: 29.60 ft, pm 7/12/94

Previous Flood of Record: 33.35 ft, 9/20/26

Table D-15. Ocmulgee River at Macon MACG1, Flood Stage 18 ft

Date	Latest Report (ft)	Forecast (ft)	Issue Time (EDT)
07/05/94	11.5	Crest near 19 8th	10:35 am
07/05/94	13.3	Crest near 22.5 8th	11:00 am
07/05/94	21.0	Crest near 25 8th	3:30 pm
07/06/94	26.7	Crest near 29 8th	2:00 am
07/06/94	29.68	Crest near 31 6th pm	6:53 am
07/06/94	31.1	Crest near 32.5 7th	11:05 am
07/06/94	33.8	Crest near 35 7th	5:00 pm
07/07/94		Crest near 35 today	14:45 pm
07/08/94		Crested...falling	12:15 pm

Crest: 35.4 ft, early 07/07/94

New record level

Previous Flood of Record: 29.90 ft, 3/19/90

Table D-16. Ocmulgee River at Hawkinsville HAWG1, Flood Stage 25 ft

Date	Latest Report (ft)	Forecast (ft)	Issue Time (EDT)
07/05/94	7.1	Crest near 17 12th	10:35 am
07/05/94		Crest near 28 11th	3:30 pm
07/06/94	10.1	Crest near 37 11th	11:05 am
07/07/94	21.4	Crest near 37 11th	12:45 pm
07/08/94	31.0	Crest near 41 11th	12:30 am
07/08/94	35.43	Crest 41-42 11th	12:15 pm
07/09/94	40.73	Crest 43-44 10th	12:25 pm
07/10/94	39.76	Crested...now falling	11:25 am

Crest: 40.91 ft, 1 to 2 pm 7/09/94, High water mark

New record level

Previous Flood of Record: 36.5 ft, 1/21/25

USGS Measurement: 39.8 ft = 87,900 cfs, 7/10/94

Table D-17. *Ocmulgee River at Abbeville ABBG1, Flood Stage 12 ft*

Date	Latest Report (ft)	Forecast (ft)	Issue Time (EDT)
07/05/94	6.9	Crest 12-13 14th	10:35 am
07/05/94		Crest near 17 14th	3:30 pm
07/06/94		Crest near 20 13th	11:05 am
07/07/94	8.9	Crest near 20 13th	12:45 pm
07/08/94	11.8	Crest near 22-23 13th	12:15 pm
07/09/94	16.2	Crest near 23 12th	12:25 pm
07/10/94	21.3	Crest near 23 11th	11:25 am
07/11/94	23.1	Near crest...begin falling this afternoon	11:55 am
07/12/94	22.4	Crested...now falling	11:15 am

Crest: E23.1 ft, am 07/11/94

New record level

Previous Flood of Record: 19.40 ft, 01/23/25

Table D-18. Ocmulgee at Lumber City LBRG1, Flood Stage 15 ft

Date	Latest Report (ft)	Forecast (ft)	Issue Time (EDT)
07/06/94	5.0	Crest near 25 16th	11:05 am
07/07/94	5.17	Crest near 25 16th	12:45 pm
07/08/94	5.37	Crest 27-28 16th	12:15 pm
07/09/94	5.73	Crest 27-28 15th	12:25 pm
07/10/94	6.32	Crest 27-28 15th	11:25 am
07/11/94	7.31	Crest 26-27 15th	11:55 am
07/12/94	10.93	Crest near 26 15th	11:15 am
07/13/94	19.96	Crest near 26 15th	11:45 am
07/14/94	24.04	Crest near 26 15th early	11:50 am
07/15/94	24.51	Near crest 25-26...begin falling today	11:40 am
07/15/94	24.43	Crested...began slow fall	1:10 pm
07/16/94	23.47	Fall below FS 21st	10:50 am

Crest: E24.59 ft, 2:38 am 07/15/94

Previous Flood of Record: 26.3 ft, 1/21/25

USGS Measurements: 22.63 ft = 77,300 cfs, 6:30 pm 7/13/94

24.20 ft = 85,900 cfs, 11 am 7/14/94

Table D-19. *Altamaha River at Charlotte CHRG1, Flood Stage 15 ft*

Date	Latest Report (ft)	Forecast (ft)	Issue Time (EDT)
07/07/94	8.9	Crest near 24 17th	12:45 pm
07/08/94	9.2	Crest 24-25 17th	12:15 pm
07/09/94	9.4	Crest 24-25 16th	12:25 pm
07/10/94	9.8	Crest 24-25 16th	11:25 am
07/11/94	10.4	Crest 24-25 16th	11:55 am
07/12/94	11.4	Crest near 24 16th	11:15 am
07/13/94	16.3	Crest near 24 16th	11:45 am
07/14/94	21.3	Crest near 24 16th	11:50 am
07/15/94	23.0	Crest near 24 16th	11:40 am
07/16/94	23.3	Near crest...begin falling this evening	10:50 am
07/17/94	22.6	Crested yesterday...fall below FS 21st	11:10 am

Crest: 23.3 ft, am 07/16/94

Previous Flood of Record: 31.2 ft, 1/22/25

Table D-20. *Altamaha River near Baxley BAXG1, Flood Stage 74.5 ft*

Date	Latest Report (ft)	Forecast (ft)	Issue Time (EDT)
07/06/94	70.8	71 72 72 74.5 75	11:05 am
07/07/94	71.29	Crest near 81 16th	12:45 pm
07/08/94	71.64	Crest near 81 17th	12:15 pm
07/09/94	71.90	Crest near 83 17th	12:25 pm
07/10/94	72.18	Crest near 83 17th	11:25 am
07/11/94	72.57	Crest near 83 17th	11:55 am
07/12/94	73.21	Crest near 83 17th	11:15 am
07/13/94	75.10	Crest 84-85 17th	11:45 am
07/14/94	80.16	Crest 84-85 17th	11:50 am
07/15/94	82.82	Crest 84-85 16th pm	11:40 am
07/16/94	83.97	Crest 84-85 this evening	10:50 am
07/17/94	83.88	Crested...began falling	11:10 am

Crest: 84.10 ft, 8 pm 07/16/94

Previous Flood of Record: 84.2 ft, 3/12/71

USGS Measurement: 84.03 ft = 103,000 cfs about noon 7/16/94

Table D-21. *Altamaha River at Doctortown DCTG1, Flood Stage 14 ft*

Date	Latest Report (ft)	Forecast (ft)	Issue Time (EDT)
07/08/94	8.89	Crest near 14 18th	12:15 pm
07/09/94	9.05	Crest near 14 18th	12:25 pm
07/10/94	9.15	Crest near 14 18th	11:25 am
07/11/94	9.3	Crest near 14 18th	11:55 am
07/12/94	9.4	Crest near 14 18th	11:15 am
07/13/94	9.65	Crest 14-15 18th	11:45 am
07/14/94	9.78	Crest 14-15 18th	11:50 am
07/15/94	10.06	Crest 14-15 18th	11:40 am
07/16/94	11.91	Crest 14-15 18th	10:50 am
07/17/94	13.84	Crest 14-15 18th	11:10 am
07/18/94	14.44	Crest 14.5-15 this evening	11:05 am
07/19/94	14.56	Crested early this morning...now falling	11:10 am

Crest: 14.57 ft, 2:30 am 7/19/94

Previous Flood of Record: 18.6 ft, 1/23/25

Table D-22. *Oconee River near Penfield PNFG1, Flood Stage 11 ft*

Date	Latest Report (ft)	Forecast (ft)	Issue Time (EDT)
07/06/94	11.5	Crest near 13 7th	11:05 am
07/07/94	11.65	Falling below FS today	12:45 pm
07/08/94	8.45	Below FS and falling	12:15 pm

Crest: 12.10, 8:45 pm 07/06/94

Previous Flood of Record: 23.23, 3/17/90

APPENDIX E

DISASTER SURVEY TEAM CONTACTS

CONTACTS BY BOTH TEAM 1 AND TEAM 2:

U.S. Army Corps of Engineers:

Bob Watson, Chief, Water Management,
South Atlantic Division

Randy Miller, Chief, Hydraulics and
Hydrology, Savannah District

Ed Burkett, Chief, Water Management,
Mobile District

Federal Emergency Management
Agency:

Phil Cogan, Disaster Field Office

Georgia Emergency Management
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Ken Davis

National Weather Service Offices:

Southeast River Forecast Center:

David Helms, Hydrologist in Charge

WSFO Atlanta (GA):

Carlos Garza, Meteorologist in Charge;
Barry Gooden, Warning Coordination
Meteorologist

WSFO Melbourne (FL)(via phone):

Bart Hagemeyer, Meteorologist in Charge
Len Mazarowski, Service Hydrologist

TEAM 1 CONTACTS:

WSO Columbus (GA):

James Helms, Meteorologist in Charge

WSO Macon (GA):

Gary Davey, Acting Officer in Charge;
Jim Boone

Macon (GA):

Gene Field, Deputy Director, Emergency
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Americus (GA):

Randy Howard, Sumter County Sheriff and
Emergency Management Agency Director

Lake Blackshear Dam (GA):

Gene Ford, Power Commission;
Kelly Richardson, Chief Operator

Albany (GA):

Jim Bramble, Emergency Operations
Center/Emergency Management Agency for
Albany and Dougherty County

Newton (GA):

Jack Henderson, City Councilman

Bainbridge (GA):

Jerri Slemmins, 911 Director;
Captain Tracy Horne, Emergency Medical
Technicians Training Officer;
Sam Griffin, publisher;
Frank Taylor, Jr., reporter;
Dr. Oscar Jackson, DDS

WSO Tallahassee (FL):

Paul Duval, Meteorologist in Charge

TEAM 2 CONTACTS:

National Weather Service Offices:

WSFO Birmingham (AL):

Gary Petti, Meteorologist in Charge;
Brian Peters, Warning and Coordination
Meteorologist; and Roger McNeil, Service
Hydrologist

WSO Montgomery (AL):

Wade Hilton, Officer in Charge

WSO Pensacola (FL):

Frank Rieser, Acting Officer in Charge;
Dan Rice

National Hurricane Center (FL):

Bob Sheets

National Meteorological Center:

NMC3x1 Robert G. Derouin, Meteorological
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Emergency Management Agencies (EMA):

Alabama State Emergency Operations Center and FEMA:

Eddy Hamby, Dave Poundstone, and
J.C. Davenport, Disaster Field Office,
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Houston County (AL) EMA:

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Columbia (AL):

James Greene, Mayor

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Ken May

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