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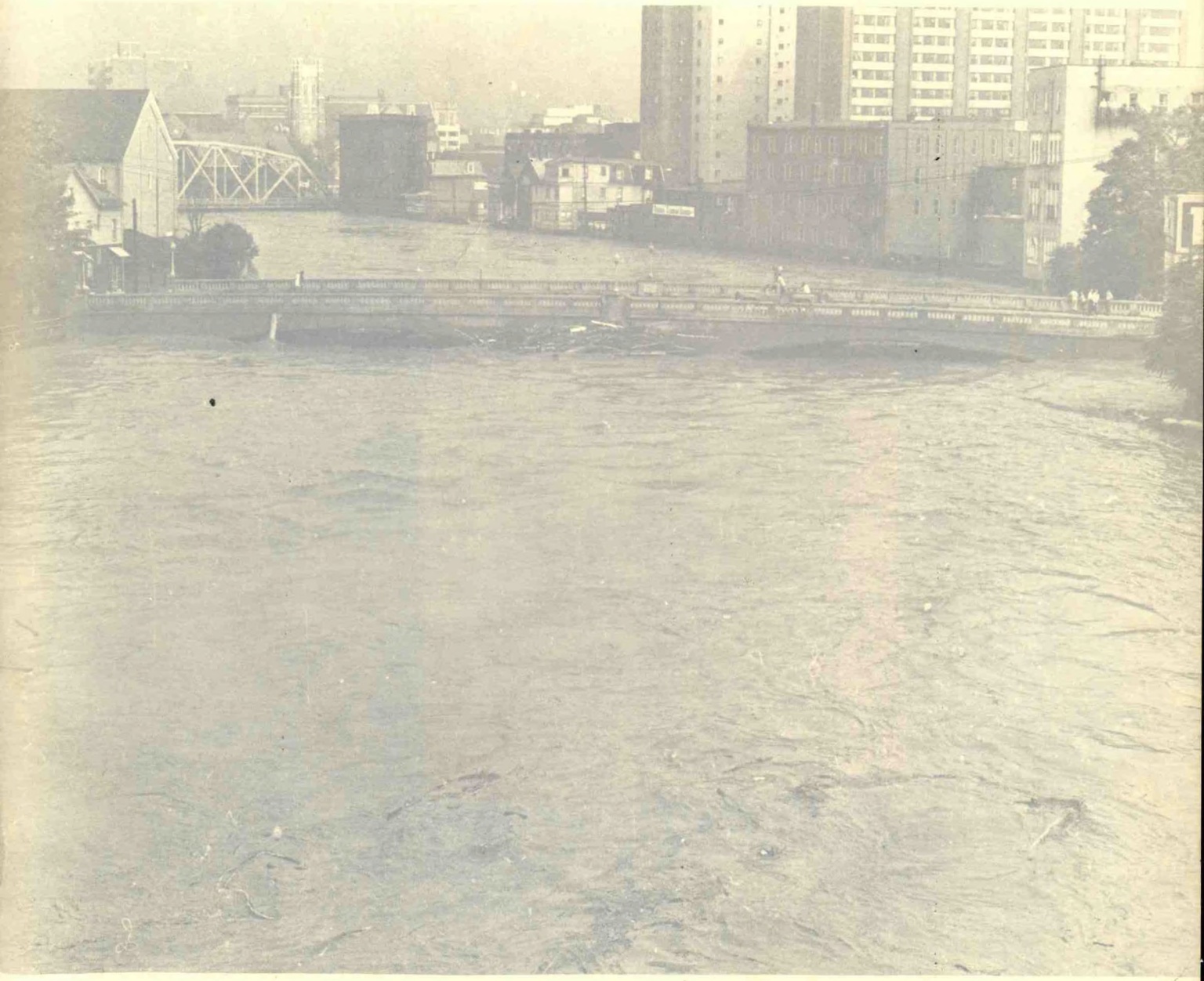
A Report to the Administrator



U. S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Rockville, Md.
October 1977

NATURAL DISASTER SURVEY REPORT 77-1

Johnstown, Pennsylvania Flash Flood of July 19-20, 1977

A REPORT TO THE ADMINISTRATOR

Rockville, Maryland
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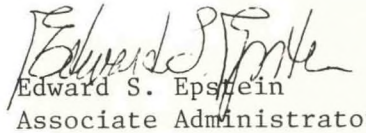
U.S. DEPARTMENT OF COMMERCE
Juanita M. Kreps

National Oceanic and Atmospheric Administration
Richard A. Frank, Administrator

FOREWORD

As soon as the flood waters at Johnstown, Pennsylvania, receded and rescue operations were underway, the survey team of the National Oceanic and Atmospheric Administration was dispatched to the Conemaugh River Basin area of southwestern Pennsylvania to review the performance of the natural hazards warning system and to make recommendations for improvement. This report describes the meteorological and hydrologic conditions causing the flood, the dissemination of warnings, and public preparedness, and presents the findings and recommendations of the team.



Edward S. Epstein
Associate Administrator for
Environmental Monitoring and
Prediction

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PREFACE

The NOAA survey team reviewed the performance of the National Weather Service and National Environmental Satellite Service related to the flash flood that struck Johnstown, Pennsylvania, and the Conemaugh River Basin the night of July 19-20, 1977. The purpose of the survey was to determine whether the observation/warning/dissemination system worked as effectively as it could and whether the Johnstown 1977 flood would have lessons and applications to broader regional and national plans and programs as well. Details of the findings and recommendations are given at the end of each chapter.

The team was composed of Dr. Edward S. Epstein, Associate Administrator for Environmental Monitoring and Prediction; Dr. Carl W. Kreitzberg, Professor of Physics and Atmospheric Sciences, Drexel University; Robert L. Sorey, Director, Meteorological and Hydrological Services; John Davies, Office of Meteorological and Hydrological Services; H. Michael Mogil, Severe Storms Meteorologist, NWS; Herbert Groper, Deputy Chief, Disaster Preparedness Staff, NWS; John Monro, Flash Flood Program Leader, NWS (did not participate in field trip); Edwin Weigel, Office of Public Affairs, NWS; Robert L. Nolan, Assistant Chief, Meteorological Services, NWS, Eastern Region; Albert S. Kachic, Regional Hydrologist, NWS, Eastern Region.

The team began its review at the Pittsburgh Weather Service Forecast Office on July 21 with most of the team starting extended field trips into the flooded areas on July 23 and 24. In addition to visits to damaged areas, interviews were held with local city, county, and Civil Defense officials and news media representatives in Indiana, Ebensburg, and Johnstown. The team was greatly assisted by staffs of the National Weather Service and the National Environmental Satellite Service in the data collection, post analysis, and evaluation phases of the survey.

The survey team wishes to thank the numerous individuals who cooperated by giving of their time and assistance. These included personnel of the National Oceanic and Atmospheric Administration and other Federal agencies, officials of Indiana and Cambria Counties, various city and Civil Defense officials, and representatives of the news media. Their help made this report possible and will contribute to improvements in the warning system. The team is particularly grateful to the Johnstown Tribune Democrat for the cover photograph of the Haynes Street Bridge in Johnstown taken at approximately 9:15 a.m., July 20.

CHAPTER 1.

THE JOHNSTOWN FLOOD

Torrential rains described by one resident as the "heaviest I have seen in my 65 years" deluged the rugged terrain of the Conemaugh River Basin in southwest Pennsylvania on the night of July 19-20, 1977. These rains caused flash flooding which killed 76 persons and brought property damage over $200 million. The city of Johnstown was hard hit as were numerous smaller communities in a seven-county area surrounding the city which had been devastated previously by the record flood of March 1936 and the South Fork Dam break in May 1889.

While several isolated or local areas in northwestern Pennsylvania were earlier subjected to short periods of heavy rain and small stream flooding during the afternoon on July 19, 1977,the loss of life and large-scale destruction were centered that night in the Conemaugh River Basin. The counties of Indiana, Cambria, Westmoreland, Bedford, and Somerset were the most severely hit. The map in Figure 1 shows the communities most affected. The terrain of this region is irregular with both deep and wide and flat valleys. The valley in which Johnstown is located is about twenty miles long and four miles wide at Johnstown, with small valleys feeding in along its entire length. Several earthen dams were washed away aggravating the severe flooding.

The Conemaugh Basin was subjected to almost continuous rain for approximately a nine-hour period from 7 p.m.* on July 19 to 4 a.m. on July 20. From preliminary data, the intensity of the rain ranged up to 1.8 inches per hour for two- to three-hour periods; however, 2.2 inches fell on a part of Johnstown in the 40-minute period from 2:50 a.m. to 3:30 a.m. on the 20th. Figure 2 shows the total storm rainfall for the area. The localized nature of the heavy rainfall is evident from the fact that no rain fell 20 miles southwest of Johnstown.

In addition to 76 deaths, the American Red Cross reports 2,696 persons were injured or suffered illness because of the flood. Five of these were hospitalized. Four hundred thirteen dwellings were destroyed, 1,363 suffered major damage, and 4,108 had minor damage. As unusually high 26% of these properties had some insurance. One hundred thirty-five mobile homes were destroyed and 77 suffered major damage. Fifty-two apartments or condominiums were destroyed, 93 had major damage, and 1,148 incurred minor damage. A total of 405 small businesses were destroyed or suffered major damage and 7,794 families suffered losses of some sort.

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* All times given are Eastern Daylight Time.

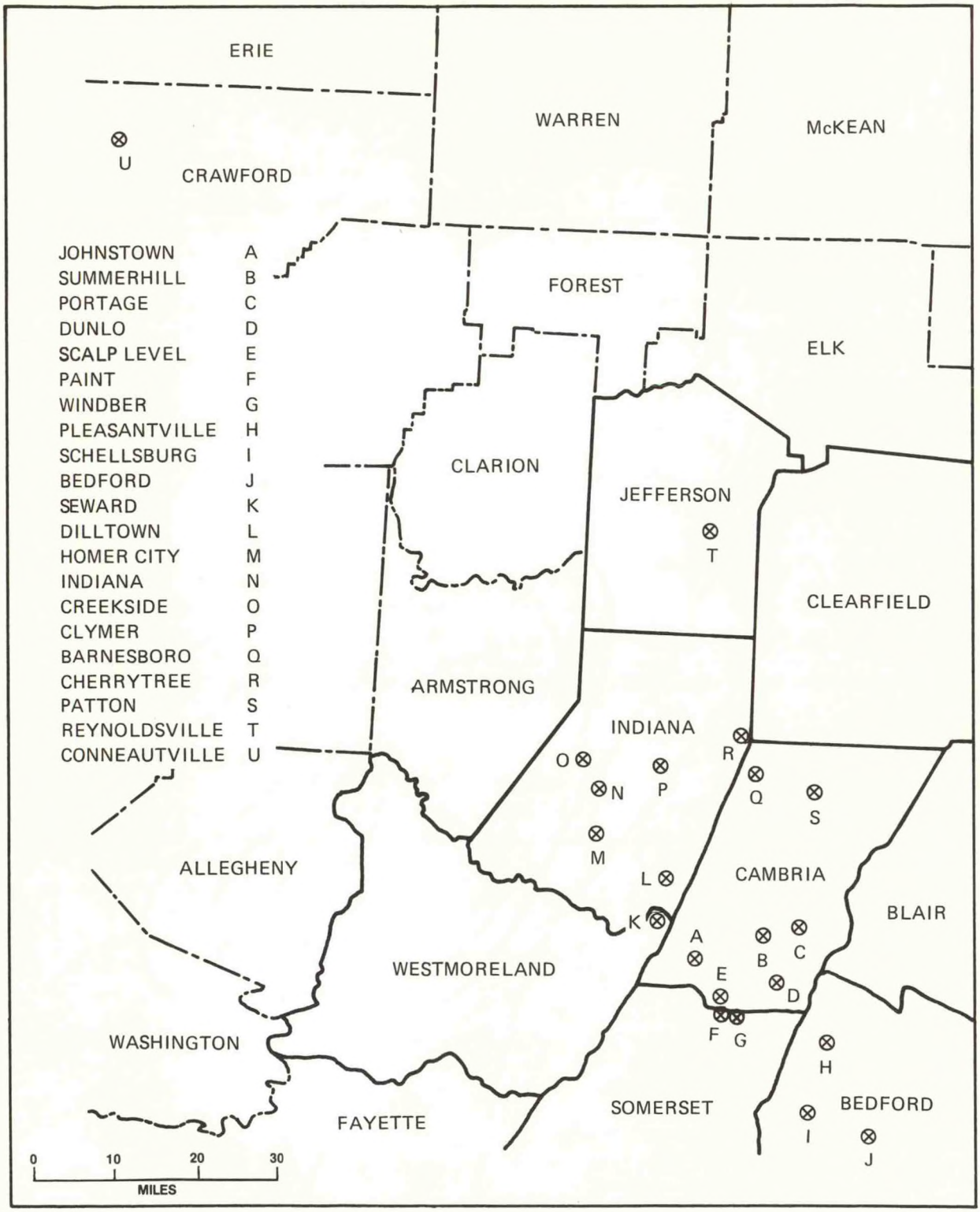


Figure 1. Communities Most Affected by Flood.

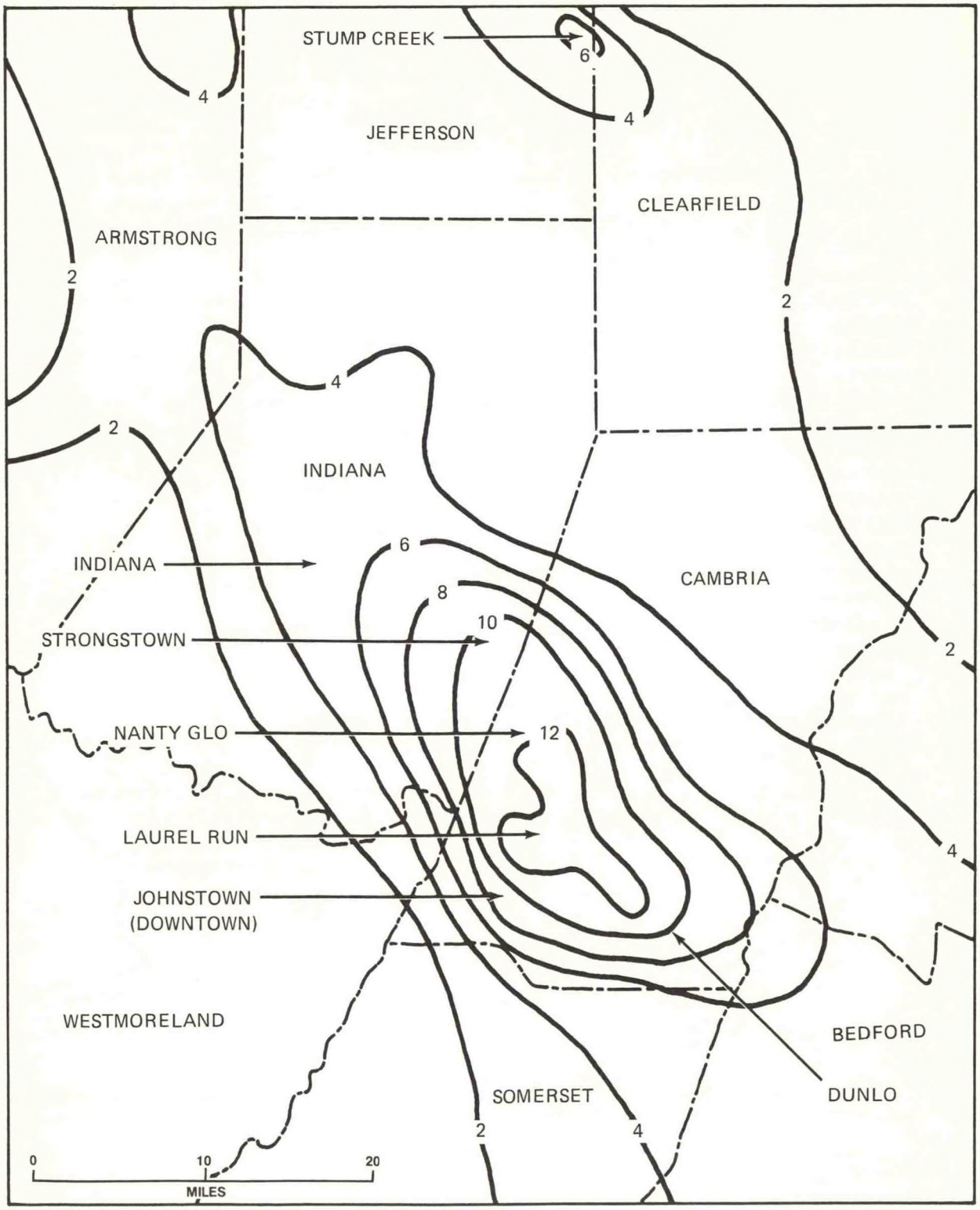


Figure 2. Total Rainfall (inches) July 19-20, 1977.

Federal Disaster Assistance Administration figures show total cost to the Federal Government of $215 million, with about 28,000 persons registering for some form of assistance. Over 5,000 are eligible for temporary housing, and 4,300 have applied for loans.

The following chronology and damage survey, while not exhaustive, gives details of events during the flood. It was gleaned from newspaper accounts and from interviews with residents of the flood area.

7:30 p.m. Indiana	"It got very dark, and the storm arrived about a half-hour later."
8:30 p.m. Indiana	Rain coming down in torrents, with furious lightning and thunder. Water was running in the streets.
About 9:00 p.m. Home	Power out.
9:00 p.m. Windber	Firemen said power first went out.
9:30 p.m. Dunlo	Telephone and power out.
11:00 p.m. Indiana	Newspaper began getting calls; firemen were being called out on electrical fires. One $100,000 home was gutted; basements were flooded. One person noted he did not turn on TV because of severity of storm. Corps of Engineer (CoE) observer measured 3.67 inches of rain since 8:00 p.m. Tried to call daytime (CoE) number and then Conemaugh Reservoir number...No answer. Phones went out about midnight or a little later.
11:00 p.m. Johnstown	Newspaper employees noticed water leaking into the ground floor of building. Leaks became worse. Some water was gushing into building. Morning editions were headed for 1:15 a.m. press start. (All but 11 members of news department left safely, as did many compositors. About 25 or 30 people were stranded in the building.)

11:30 p.m. Strongstown	Corps of Engineer observer measured 2 1/2 inches of rain since 8:15 p.m. Tried to call Conemaugh Reservoir office at 11:35...No answer. Phones went out at midnight.
11:35 p.m. Johnstown	Radio station WJAC news report noted that "Flooding is reported in many areas. Power lines are down and communities in scattered areas are without electrical service."
Before midnight. Johnstown	Water was in the streets, but streets near newspaper office were still passable.
11:59 p.m. Indiana	Power outage took radio station WDAD (AM & FM) off the air, about one hour early. Power back on in that location an hour later. (Timing of power outage is indefinite because not all the area was affected the same way. Some people had no power for 10-12 hours.) Telephone service was also affected, with much of this area unable to place calls out until next morning.
Shortly after midnight. Johnstown	First word aired over city police radio network that the city had been closed to all incoming traffic because of emergency.
12:30 a.m. Johnstown	Morrellville's power went out.
12:45 a.m. Johnstown	Water was reported overflowing foot of Prospect Viaduct at Walnut Street. Police were then helping people get out of town, according to one patrolman. He said there was enough time for the fire department to get around and spread the warning in the downtown area for people to get to higher levels.
1:00 a.m. Johnstown	City firemen lost all two-way communications. Phone lines were down.

1:00 a.m. Johnstown	The mayor set up a command center at the Meadowvale School (Hornerstown). Half an hour later water came smashing through windows. Mayor's personal cruiser and a police cruiser were washed away. Seconds before the water smashed through the school, about 100 persons there were moved from the first to the second floor. The mayor was quoted, "If someone hadn't suggested moving everybody it would have been absolute terror and tragedy."
1:00 a.m. Between Greensburg and Indiana	Associate editor of newspaper returning home to Indiana on Route 119. Lightning so vivid he could see without headlights. Sheets of water were running over the highway. Cars were stalled.
2:00 a.m. Johnstown	Mayor declared city a disaster area. Morrellville resident reported underpass at Fairfield was impassable, with water at least 10 feet deep.
During the night. Indiana	Storm seemed to last all night long; lightning was nearly continuous. One resident reported unable to sleep; never recalled rain so hard as occurred that night. Storm was bad at first, according to another witness, then seemed to let up a bit about 10:00 p.m., later resumed intensity. Was particularly bad about 1:00 a.m.
During the night. Cambria County	Communities cut off from all communications with world outside from 1:00 a.m. to 5:20 a.m.
During the night. Johnstown (Solomon Run)	"Runoff waters ran in a 'mad plunge' along Johnstown Expressway, leaving normally adequate steep banks of Solomon Run to dump debris across various points of the 4-lane highway, breaking steel guardrails like ribbon. Literally sawed off half the Widman Street exit ramp onto the Expressway. Survivor said flood hit Solomon Homes 'all of a sudden' with between 15 and 20 feet of water. Rain reportedly began about 7:00 p.m., and didn't stop until 5:00 in the morning. Accompanied by seemingly continuous lightning and thunder."

During the night. Johnstown	Emergency airways were jammed with messages, but at various times the Westmont Suburban Radio Network, the city fire network, and eventually the city police network went down. "The CB'ers held this town together. Breaker 19s flooded the airwaves during the night and early morning...as individual callers pleaded... for clear channels to issue emergency orders."
During the night. Windber	Eight-inch rain sent Paint Creek and Elton Run on devastating rampage. Flood-control project on Paint Creek in center of town was of little help; creek quickly spilled over embankments and sent torrents into the streets. The Windber REACT (Radio Emergency Associated Citizens Teams) and other CB radio members coordinated communications. (A fireman said community of Scalp Level was hit worse than Windber, which had to be pretty bad because the lower half of Windber was wiped out.)
3:00 a.m. Bedford County	Firemen and police began evacuating residents near waterways. A deputy sheriff said it had been difficult to get people to leave their homes beforehand because they felt there was no danger of a flood.
3:00 a.m. Clymer (Indiana County)	Witnesses said they heard the coming of the water runoff--like a loud roar. The runoff lasted until about 5 or 6 a.m.
3:00 a.m. Johnstown	Two staff members of newspaper decided to try to get out of city. Big mistake. Drove car onto Washington Street and were engulfed. Motor stalled. Water seeped into doors. They climbed through car window to escape. Water waist-high. Hand-in-hand they plowed through the water back to the newspaper building.
3:00 a.m. Harrisburg	WSO Harrisburg called the home of the Deputy Officer, State Civil Defense, with the 2:40 a.m. Warning message. The Duty Officer then began calling around to establish the extent of the

	crisis. Until then, word had not effectively spread outside of the disaster area on any emergency communication channel.
During the night. Seward (Westmoreland County)	According to mayor..."Rains started about 9:00 p.m. About midnight we were bailing out basements... By 4 in the morning the trailer court was gone...It was terrible...People screaming, trailers floating down the river with people hanging on to them...and there was nothing we could do."
4:00 a.m. Johnstown	Two women, fleeing Washington Street apartment on the advice of their landlady, attempting to get to Lee Hospital, were washed under water repeatedly, water ripped them from poles. Caught hold of half-submerged truck, climbed on truck roof.
	Windows in nearby building began popping, so they decided to make a break for those windows. Struggle across sidewalk from truck to windows took 20 minutes. Made way to second floor of building.
About 4:00 a.m. Tanneryville	Much of the community swept away by a "wall of water" when the Laurel Run Dam burst at about 4:00 a.m. When the dam broke it took house after house, all reportedly in about 15 minutes. At least 13 dead, many missing. Remains of houses were piled high at the bottom of Cooper Avenue near the Cramer Pike.
4:15 a.m. Strongstown (Indiana County)	Rainfall total 11 inches.
4:30 a.m. New Florence (Westmoreland County)	Fire Chief said evacuation of borough's northern section began about 4:30 and that nearly 350 families had been moved to safety by mid-morning. 27 families living in trailer court were evacuated only hours before that section was submerged.

4:30 a.m. Johnstown	Last police vehicles left the downtown area. A couple who live on the second floor of a house downtown feared for their lives at 4:30 a.m. when they saw the river rising at an alarming rate. They got in their car and drove up the "Easy Grade" (Menoher Boulevard). Were stuck there until 6 a.m.
4:30 - 5:00 a.m. Homer City (Indiana County)	Flooding began.
5:00 a.m. Cherry Tree (Indiana County)	West Branch of Susquehanna and Cushcushion Creek, which had begun rising about 12:30 a.m., crested about 5:00 a.m. with 75 percent of community under 3 to 8 feet of water. Water flowed over river dike near Route 580 bridge close to heart of town.
5:30 a.m. Johnstown	Water was six feet deep in the center of town. Water crested in the downtown area at 5:20 and began to recede at 5:30 a.m.
Daybreak. Johnstown	Waters began to subside. The first floor of the newspaper office was flooded to desktops about 5:30 a.m. At 8:45 a.m. the water had subsided several feet. ("But perhaps the strangest thing to marooned journalists was that they were sitting in the middle of the most sophisticated news-gathering agency in the area--and they knew only what they could see from the window or hear on the radio.")
7:45 a.m. Indian Gap	The first National Guard rescue helicopter took off for Johnstown, stopping enroute to Johnstown airport to make its first rescue.
8:00 - 9:00 a.m. Homer City (Indiana	Flood crest. Water marks about 6 feet high on sides of homes. Bridge on Two Lick Creek washed out about 10:00 a.m.

9:00 a.m. Johnstown	Newspaper office...there still was no communication from the paper to anywhere else--no phone service, no two-way radio. Incoming was only the area radio stations' repeated...announcements of intentions to begin broadcasting facts about the flood.
Early Wednesday Morning. Johnstown	Hundreds of persons gathered at the top of the Incline Plane in Westmont to view the waters in Johnstown. Traffic jams developed. Heavy fog obscured most of the city's business district. Suburban Radio Police headquarters in Westmont receiving steady stream of calls about damaged streets, flooded basements and destroyed bridges. A policeman reported that steep Gilbert Street in Brownstown Borough was wiped out, with up to 10 cars piled at the bottom of the hill.
Wednesday. Johnstown	Most of water had receded by 1:00 p.m.
Clymer (Indiana County)	It was noted that people on hillsides suffered almost as much damage as those in basin below. A hill on the eastern side of town is something like a funnel. Rainfall must have been so heavy that it was like a river on the hillside. A boulder the size of a conference table had been washed out of the forest. Brick streets and pavement laid down in the early 1900's were torn up.
Between Indiana and Cherry Tree, PA	Some shoulders of road were washed out as deep as four feet, attesting to power of runoff. (Department of Transportation estimated 3 million dollars damage to roads in Indiana County. A big problem with the devastation in parts of the area was that a lot of residents could not get flood insurance because they were not in a flood plain. Yet they suffered flood damage. As one person put it, "Why would you buy flood insurance if you live on the side of a hill?" Even in Johnstown, areas like Dale Boro, which isn't even near the river, were affected.)

Cambria County	Two National Guard battalions were alerted to help evacuate people stranded in homes by rising water. A Civil Defense spokesman was quoted: "Streams I never knew existed are causing problems."
Wednesday Mid-Afternoon. Seward (Westmoreland County)	Helicopters had rescued more than 30 persons who were stranded in treetops above debris-strewn rivers.
Friday Morning. Johnstown	Death toll rose tragically with discovery of 12 bodies in debris near plant of Cambria Chair, Inc., in Hornerstown section.

Deaths: Primarily in Johnstown, Tanneyville, Dunlo, Dilltown, Creekside, and Seward.

Cambria County

Over $100 million damage in Johnstown. Multimillion dollar disaster to Bethlehem Steel's Johnstown plant. There were crippled communications, fuel supply shutoffs, and muck-coated mill buildings in 13-mile stretch of Johnstown plant along the Little Conemaugh and Conemaugh Rivers.

Patton Boro appeared hardest hit of northern Cambria County communities. Chest Creek, Little Chest Creek, and feeder streams overflowed, causing extensive damage.

Other Communities--Summerhill $2.5 million damage, 20 homes badly damaged. Portage- $1.5 million damage, 50-75 families were evacuated. A bridge in Marsteller was washed out. The 80-billion-gallon lake at Prince Gallitzin State Park was filled to capacity. Campers at the Crooked Run Campground were forced to evacuate.

Indiana County

Storm caused flooding in virtually every community along Black Lick Creek, including Clymer, Homer City, Dilltown, Robindale, and Robinson. A large steel bridge carrying Route 56 over Two Lick Creek at Homer City was swept away Wednesday morning. Pumps at the Western Pennsylvania Water Company were drowned out and sent away for repair.

Cherrytree--Damage to this borough was in tens of thousands of dollars. Officials said it was worse than during Agnes in June 1972.

Bedford County

Damage estimated at more than $5 million, with hardest hit areas being Pleasantville and East and West St. Clair Townships. Crop damage estimated at about $300,000 with 700 farms affected. Farm property damage estimated at more than $1 million. Most damage in the county was caused when small tributaries feeding into the Juniata River overflowed their banks. Many summer homes, cottages, and campsites were destroyed. Waterways in northwest and north-central parts of the counties were most affected. The Bedford Shopping Plaza suffered a great deal of damage.

Somerset County

Windber--Preliminary damage estimate of $20 million. Two persons known drowned. Several new and used car lots were vacant; forty-five new and used cars had been washed away. Hundred of other cars were damaged or destroyed on streets of town. Officials estimated that 100 families in Windber, Paint Borough and Paint Townships and the surrounding area lost their homes in the flood.

Westmoreland County

Seward and New Florence ravaged. Bridges, roads, trailers, homes, and power lines washed away. Seward hardest hit with dead and missing. Hoover Trailer Court along U.S. 56 devastated. One 12-year resident of the trailer court spent 8 hours in a tree with family and neighbors before being rescued by helicopter. Pennsylvania Electric Generating Station was flooded. All roads and highways leading to Seward closed by water and debris. In New Florence, water in places 15 feet deep covered a six-block section of the community. A steel-structured bridge spanning the Conemaugh was snapped by floodwaters.

CHAPTER 2.

THE FLASH FLOOD WARNING SYSTEM

General Description

The systems designed to protect our citizens against flash floods--which, like tornadoes and severe thunderstorms, are short-fused and generally localized hazards -- relies on elements of the National Oceanic and Atmospheric Administration (NOAA), the awareness and readiness of local officials and the public, and the cooperation and availability of mass media channels. The system has two basic facets. As presented below, one facet consists of the National Weather Service (NWS) efforts to produce and disseminate watches and warnings to which the public and local officials can respond. The other facet depends upon developing local flash flood warning systems by which local communities can detect and respond to immediate threats without any external forecasts or warnings.

Wherever possible, NWS attempts to issue timely watches and warnings of flash floods. In those situations where excessive rainfall appears likely, in terms of the ability of the ground to absorb the water or for the stream to handle it, flash flood "watches" are issued hours or even minutes in advance. These watches serve to alert local officials and the public, as well as NWS personnel in our smaller warning offices, that flash flooding is possible. But our capability to predict heavy or extreme rainfall amounts over small areas is limited, so this "watch" phase has not been very successful for summertime flash floods. Only slightly more successful, but still not adequate, is our capability to perform the close monitoring needed to determine when existing rainfall accumulations and stream conditions pose an immediate flash flood threat to an area. This monitoring relies on telemetered river and rain gauges, direct measuring networks (which are not usually dense enough to cover most small drainage basins), estimates from remote sensors (radar and satellite), and reports from volunteer observers. In some cases effective flash flood "warnings" have been provided.

The local flash flood warning system is dependent on more direct local interest and cooperation. In this approach, NWS hydrologists, meteorologists, and disaster preparedness specialists tailor local forecast procedures based on rainfall and stream data, and, in some instances, on automatic local flash flood alarms, to give timely warnings to a threatened area. This approach requires a large degree of local cooperation and interest; it is often necessary to Weather Service personnel to spend considerable time working with communities to generate that interest.

It should be noted that whether or not a local warning system exists in a particular community, the Weather Service still is responsible for

disseminating appropriate statements and warnings. However, if the community and the local population are unprepared to receive or respond to messages from NWS, no amount of investment in equipment or new techniques will avert future tragedies. When community programs exist the feedback to NWS to allow for downstream warning has been of high caliber and successful.

NOAA Elements Supporting the Flash Flood Warning Program in Western Pennsylvania

Several NOAA elements have responsibility to provide input to the flash flood warning program in western Pennsylvania. The responsibilities of these NWS and National Environmental Satellite Service (NESS) units include the following:

1. Weather Service Forecast Office (WSFO) Pittsburgh, located at the Federal Building in downtown Pittsburgh, issues and disseminates zone forecasts, flash flood watches and warnings, and appropriate statements. This office also serves as the hydrologic service office for western Pennsylvania. It functions with three duty shifts: day (8 a.m. to 4 p.m.), swing (4 p.m. to 12 p.m.), and midnight (12 p.m. to 8 a.m.).

2. The National Meteorological Center (NMC), located at Camp Springs, Maryland, provides guidance consisting of large-scale analyses and prognoses, large-scale quantitative precipitation forecasts, and probabilistic forecasts of thunderstorms and severe weather.

3. Weather Service Meteorological Observatory (WSMO), Pittsburgh, located at a separate site west of the city, provides upper air observations and radar support consisting of routine and special observations and summaries, radarscope remote presentations (WBRR) and commentaries to the WSFO, Manually Digitized Radar (MDR) values, and the Digitized Radar Experiment system (D/RADEX) determination of precipitation echo intensities and accumulated precipitation estimates. When the radar operator sees indications of severe weather or extremely heavy rain, he is supposed to call the appropriate warning office. WSFO Pittsburgh is one of 13 warning offices under the umbrella of this radar.

4. River Forecast Center (RFC) Cincinnati provides guidance of rainfall needed to produce flash flooding. It also issues Headwater Statements which specify the amount of rain required to produce half-flood and twice-flood discharge at selected locations.

5. NESS Satellite Field Service Station (SFSS) Washington, D.C., transmits satellite imagery (visible and infrared) and regularly scheduled (usually every six hours) satellite interpretation messages. In addition, this unit initiates telephone calls to WSFOs when the SFSS meteorologists consider observed cloud elements, patterns, or motion to be significant or threatening.

Overall management of the NWS units mentioned here lies in the NWS Eastern Region and NWS Headquarters. Management of the SFSS resides in NESS Headquarters.

CHAPTER 3.

DATA ACQUISITION

Meteorological data and information from numerous sources were made available to WSFO Pittsburgh and other NOAA elements involved in the forecast and warning program. These data reach concerned offices through several communications channels, including teletype, facsimile, telephone, and computer terminals linked by telephone lines. With the exception of intermittent problems with telephone lines to three Automatic Hydrologic Observing Stations (AHOS) gauges during the afternoon and evening and telephone outage in the flood area beginning late in the evening of July 19, communications channels were operative prior to and during the flood. The remainder of this chapter discusses the data sources as they existed the night of the flood.

Surface Observations

Four types of surface observations were available in western Pennsylvania: (1) aviation observations; (2) reports from cooperative or paid observers in the hydrologic and public service networks; (3) reports from automated observing equipment; and (4) reports from the public, spotter networks, and law enforcement agencies. The effectiveness of this reporting system on July 19-20 was as follows:

Aviation Observations--Aviation observations were taken by NWS, Federal Aviation Administration (FAA), or airline personnel at the stations shown in Figure 3. Most of these stations take 24-hour observations and report precipitation each 6 hours. One significant exception is the FAA-staffed station at Johnstown (JST) which closes between the hours of 11:30 p.m. and 6:30 a.m. EDT. This station does not report precipitation. None of the other reporting points were in the area of heavy rain.

Cooperative and Paid Observers-- Many of the observations used in the NWS hydrologic and public service programs are provided by cooperative and paid observers, some of whom are paid by and report to other organizations. Figure 4 shows the network of river/rainfall observing stations in the affected area of western Pennsylvania. Unfortunately, the Corps of Engineers (CoE) observers in Indiana and Cambria counties report only once daily to the Corps of Engineers in Pittsburgh and do not routinely report heavy rains during interim periods. However, they can report such events if they so desire. On this occasion attempts were made between 11:00 and 11:35 p.m. by CoE cooperative observers at Strongstown and Indiana to call special reports of heavy rainfall to their CoE reporting office which, unfortunately, was not manned at that time. The officer in charge of the CoE Pittsburgh district office has advised the survey team that they will be glad to provide their cooperative observers with the telephone number of WSFO Pittsburgh for use as backup in

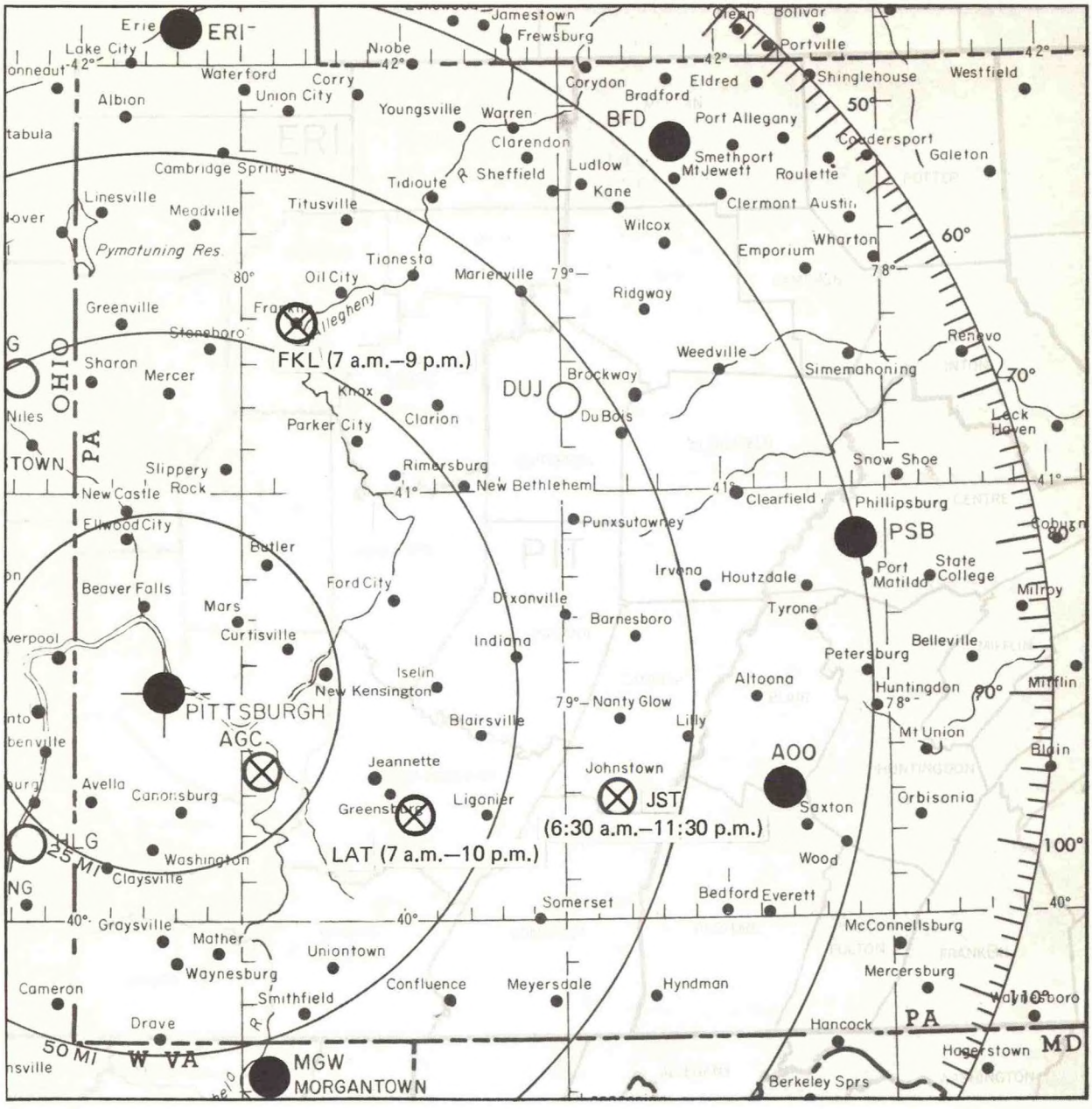


Figure 3. NWS, FAA, and Supplementary Aviation Weather Reporting Stations (unless indicated, hours are 24 hours).

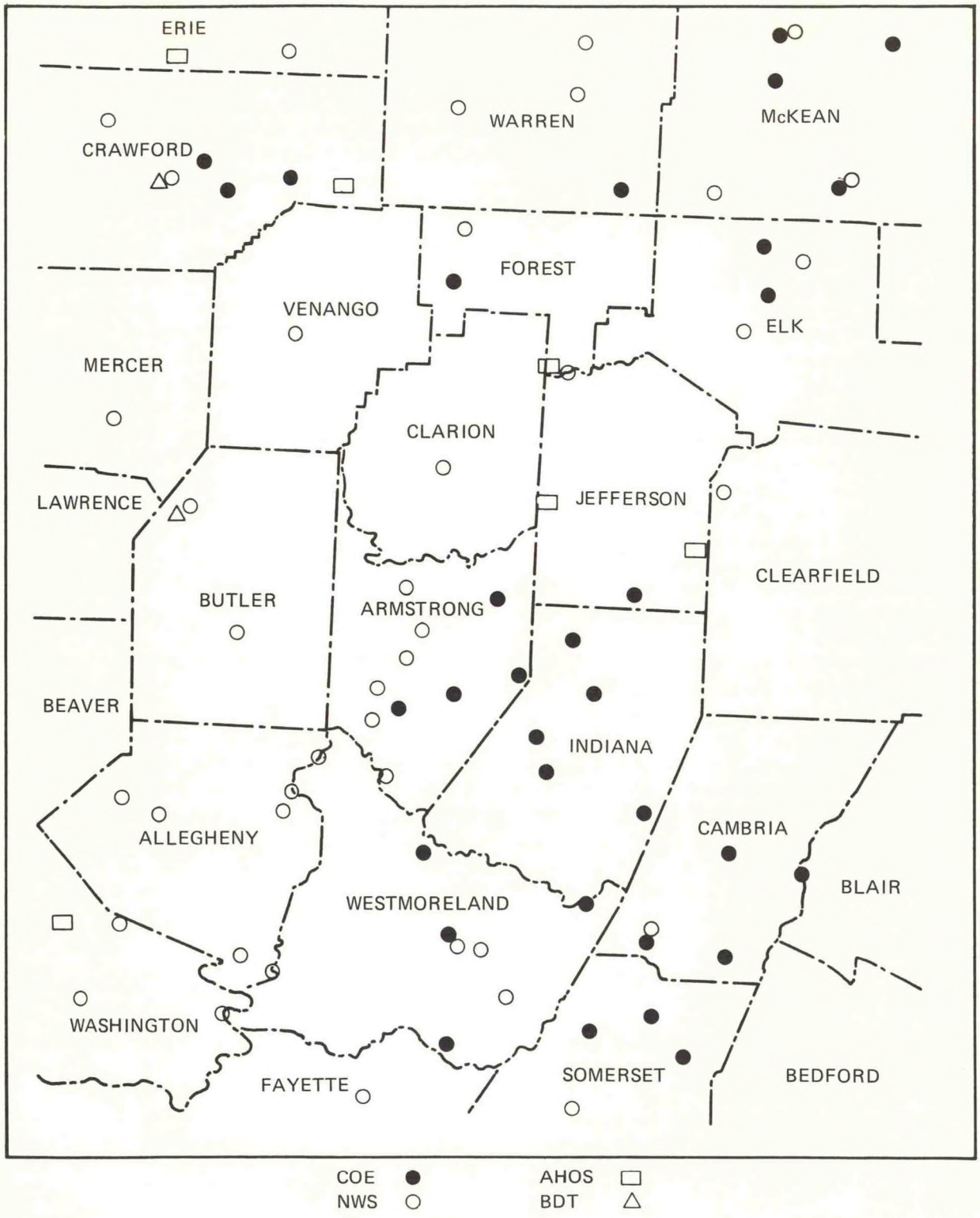


Figure 4. River/Rainfall Observing Stations.

reporting special weather events if they are unable to call the CoE reporting office. There were two NWS cooperative substations in Johnstown, but neither of these have been established to report rainfall to WSFO Pittsburgh. One is a public service station located atop the newspaper building,and the other, atop the public safety building, has a recording rain gauge, the chart from which is periodically changed and mailed to NWS Eastern Region Headquarters.

Reports From Automated Data Sources --Figure 4 also shows the location of the Automatic Hydrologic Observing Stations (AHOS) and Binary Digital Transmitter (BDT) stations available in western Pennsylvania. An examination of the daily data log for the AHOS stations indicates relatively little outage of this equipment over the previous three months. However, attempts by the swing shift to interrogate the AHOS rain gauge at Stump Creek in eastern Jefferson County on the evening of July 19 were unsuccessful. The routine collection of AHOS data made later through the Automatic Data Acquisition System (ADAS) at 2:00 a.m. on July 20 indicated the accumulated rainfall at Stump Creek to be 6 inches. It has been the experience of the staff members at WSFO Pittsburgh that the AHOS equipment, which is all of the telephone relay type, works reasonably well and is adequately maintained by the electronic technicians, but that telephone outage is frequent during periods of wet or stormy weather when it is needed the most.

Reports From Public, Spotter Networks, Local and State Officials-- A few reports from the spotter networks were available to the swing shift on July 19. However, the midnight shift did not receive any spotter reports or any information from the National Warning System (NAWAS). At 1:30 a.m. on July 20, a law enforcement agency in Indiana County called the WSFO to indicate that the situation was "pretty bad" in that county and asking how long the rain would continue. After 2:00 a.m., one radio station in Pittsburgh and one radio station in Johnstown called the WSFO but provided little in the way of detailed information. One caller described cars washing down the street in Johnstown. The 1:30 a.m. call was considered by the forecaster to be the first indication he had that the situation was serious.

Upper Air Reports

WSMO Pittsburgh is a rawinsonde station in the national network. Observations are made routinely at 8:00 a.m. and 8:00 p.m. with release time up to one hour early authorized in order to get the data into the National Meteorological Center for use in numerical forecast models. The 8:00 p.m. observation on July 19 was actually begun at 7:00 p.m. The WSFO Pittsburgh plots and uses this sounding routinely.

Weather Radar

The weather radar equipment at WSMO Pittsburgh and the facsimile repeater (WBRR) at the WSFO were fully operational during the period. All scheduled radar products from WSMO Pittsburgh were provided the WSFO. The radar operators on duty through the night of July 19-20 were trained, well-qualified, and experienced. However, the conclusion must be made that an additional radar operator on duty, coupled with routine coordination between the radar unit and the WSFO, would have resulted in better radar information and its use.

The intensity of the radar returns required "special" observations (i.e., observations on the hour as well as near the half-hour) from 4:00 p.m. until 1:30 a.m. This required closer surveillance and more tracings of the radar scope, leaving less time for the coding of observations and the writing of narrative summaries. These products suffered as a result. Lines of heavier activity embedded in the area of radar echoes were not coded, nor did the single movement given for the coded area adequately portray the information that thunderstorms continued to develop to the northwest and move over the Conemaugh Basin. This picture was also not apparent in the narrative summaries provided the mass media over the NOAA Weather Wire. These were not well-written and required changes by the WSFO before being placed on the NOAA Weather Radio. There is no indication that any feedback of these deficiences was given to the WSMO. Other indicators of the workload in the radar unit that night were a delay of 45 minutes in changing a radar archive tape and the failure to update the annotation on the WBRR each hour, as called for by station instructions.

The station duty manual at the WSMO makes calling in extra help mandatory during severe thunderstorm situations; no such instructions prevail for flash flood situations (or when special observations are reqired). The Meteorologist-in-Charge of the WSMO remained on extra duty from late afternoon through early evening of the 19th when some hail was reported with thunderstorm activity, but he departed at 7:00 p.m.

The team found no provisions for routine briefings of the radar operators by the WSFO at the beginning of each shift, and there is no indication that the radar operator on the midnight shift the night of the flood was aware that the forecasters expected the thunderstorm activity to decrease. Such a briefing would certainly have provided the radar operator a basis to note that things were not going as expected and possibly prompt a call back to the WSFO much earlier than the call made at 2:30 a.m., the first of the midnight shift.

The remote radar (WBRR) displays available to the WSFO were usable, although this display is subject to some fading of the first image following a change in annotation. The forecasters who worked the night of the flood advised that they do not rely on the annotated remarks on the WBRR; rather, they use the coded observations to obtain maximum echo tops and other details. There was no indication that the midnight shift forecasters made any tracings of the WBRR display to obtain an indication of the persistence of the precipitation echoes over the flood area. There is also no indication that any notice or use was made of MDR totals until the radar operator called at 2:30 a.m. to report a 4-hour MDR total of 20 for the grid area in which Johnstown is located. (An MDR total is an indicator of combined radar return intensity and area coverage which gives an estimate of rainfall accumulation.) No specific instructions are in effect which require calls for certain MDR totals, although a technical report available to the radar operators and forecasters does provide some guidance. In actuality, the Johnstown grid box had a 4-hour MDR total of 20 as early as 12:30 a.m., and again at 1:30 a.m. A mapping of 4-hour MDR totals was available over the request/reply teletypewriter circuit, but was not requested by the midnight forecaster.

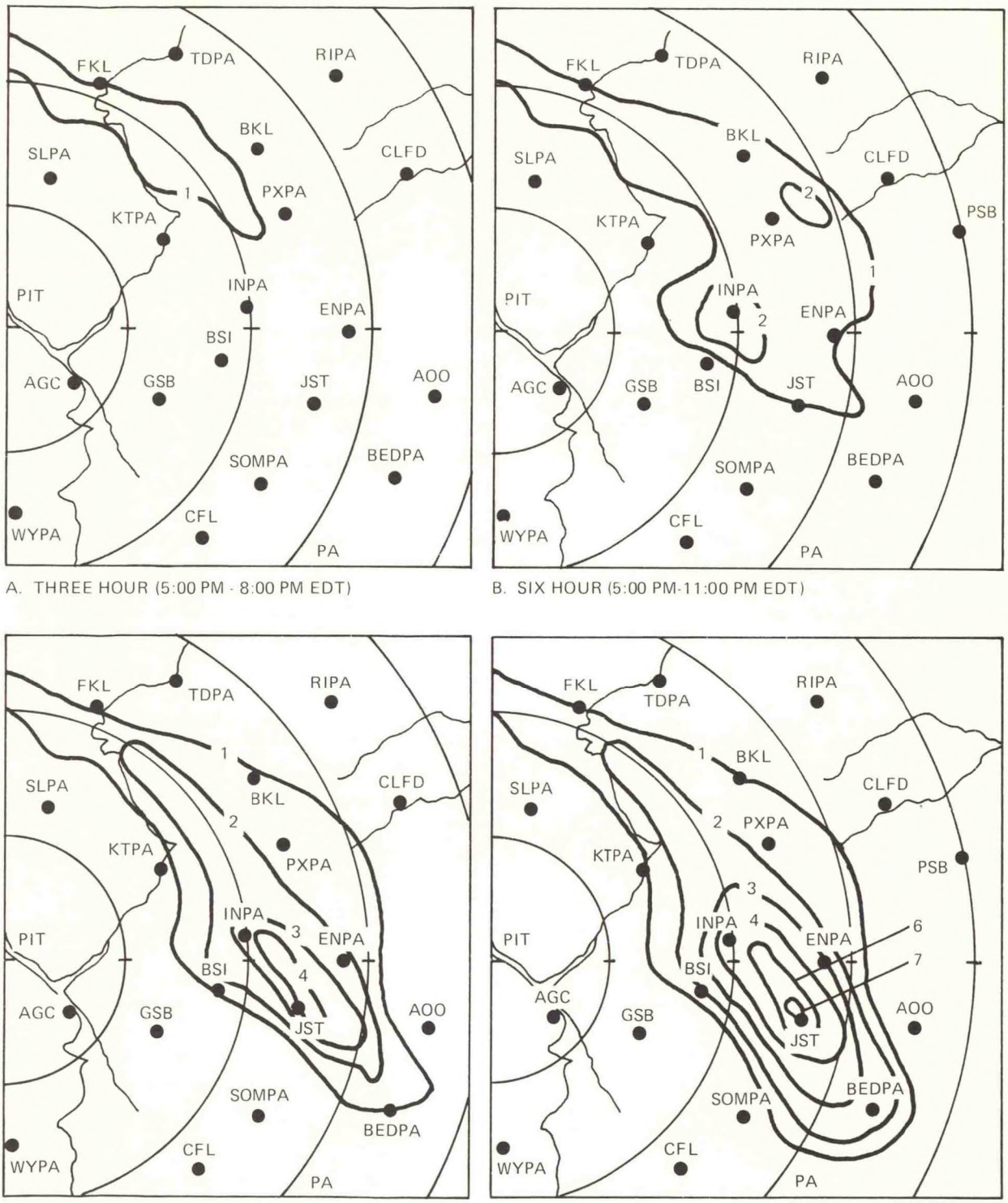
It is probable that WSFO Pittsburgh places less emphasis on MDR totals because this station has more sophisticated radar information available in the D/RADEX (Digitized Radar Experiment) system. This system, which is still evolving, provides digitized radar information in various forms for operational use. This D/RADEX information, which is presented on a much finer grid than the MDR, was monitored closely by the shift which went off duty at midnight. However, little or no use of available D/RADEX information was made between midnight and 1:30 a.m. The forecaster attempted, on two occasions between 1:30 and 2:30 a.m., to obtain a late accumulated rainfall grid as estimated by D/RADEX, but was unable to do so because the single telephone line to the D/RADEX equipment was busy. The scheduled three-hour rainfall accumulation up to 2:00 a.m. was not received until after the flash flood warning was issued at 2:40 a.m.

An investigation into the reasons for the busy signals shows that D/RADEX observations are started at 12, 24, 36, and 48 minutes past each hour, with an observation taken on the hour at three-hourly intervals, beginning at 8:00 a.m. The first and third observations take about 4 minutes; the second and fourth take about a minute. One telephone line is available for transmitting this information to the Cincinnati RFC and the Pittsburgh WSFO. In addition, other offices, such as RFC Harrisburg and WSFO Charleston, can call to receive D/RADEX information. Several months ago, it appeared that calls to the D/RADEX while archiving was occurring were interfering with this function. Therefore, instructions were issued to the forecasters at WSFO Pittsburgh to avoid calling during these periods, with recommended call times at 04, 15, 27, 40, and 50 past each hour. NWS Headquarters has purchased additional lines for access to this equipment, and these are scheduled for installation by January 1978.

Another digitized product provided by D/RADEX is an estimate of the rainfall averaged over the 15-square-mile grid box. The rainfall area depicted on this printout was found to be consistent with the area of reported rainfall, but the estimated areal rainfall accumulation appears to be about half of the observed maximum point amount in the area of heaviest rainfall. Figure 5 depicts the cumulative rainfall for various periods from 5:00 p.m. on the 19th to 5:00 a.m. on the 20th. For the 6-hour period from 5:00 p.m. to 11:00 p.m. on the 19th over 4 inches of rain had fallen in those areas indicated by the 2-inch area average isohyet. The depiction in Figure 5 for the period 5:00 p.m. on the 19th to 5:00 a.m. on the 20th indicates 7 inches of rain in the Johnstown area when in actuality 12 inches had accumulated. The conversion of radar reflectivity to precipitation estimates is based on empirically derived relationships.

Satellite Data

On the day and evening of the flood, all scheduled satellite data were received at WSFO Pittsburgh and SFSS Washington. There was some problem noted with the gridding accuracy of the images received at the SFSS. The imagery received at WSFO Pittsburgh was of good quality,although the lines indicating state boundaries could be improved. There were no GOES-1 images during the critical period from 12:50 a.m. to 3:20 a.m. on July 20 due to routine scheduled preventive maintenance of the Wallops GOES antenna. NESS has a standard procedure that when criticial weather conditions exist, the SFSS meteorologist can make arrangements to forego this maintenance. This procedure does take about two hours advance notice and was not initiated. During this period GOES-2 imagery was available at SFSS Washington. However, the portion of the imagery covering western Pennsylvania is nearly unusable due to the angle of picture scanning over western Pennsylvania. A post-analysis of the satellite data by SFSS Washington indicated "from 8:00 p.m. on July 19 to 4:00 a.m. July 20 the associated thunderstorms cluster with many imbedded cells, passed over the Johnstown area with continued strong intensity." The persistence of this activity and its significance were not realized by the SFSS meteorologist. The meteorologist who prepared the 2:00 a.m. satellite interpretation message compared his latest available image (12:30 a.m.) with the 8:30 p.m. EDT image and noted that in the past 4 hours the area of -70°C cloud top had "decreased significantly." He then indicated in his satellite interpretation message that activity had decreased in western Pennsylvania. There is no evidence that this information, available over teletypewriter, was seen or used by the midnight shift forecaster at WSFO Pittsburgh. There is also no evidence that this forecaster used the satellite information available prior to the scheduled maintenance shutdown at 12:50 a.m. to note persistence of the thunderstorm cluster in western Pennsylvania. No calls were made during the swing or midshifts between SFSS Washington and WSFO Pittsburgh.



A. THREE HOUR (5:00 PM - 8:00 PM EDT)

B. SIX HOUR (5:00 PM-11:00 PM EDT)

C. NINE HOUR (5:00 PM-2:00 AM EDT)

D. TWELVE HOUR (5:00 PM-5:00 AM EDT)

Figure 5. Estimated areal average rainfall accumulation from D/RADEX for indicated times on July 19-20, 1977. (JST is Johnstown)

FINDINGS AND RECOMMENDATIONS

Finding 1: In this flood, as in the Big Thompson flash flood, required rainfall information was not available to the NWS warning office. In some cases, observers in the area had such information but prior arrangements had not been made to obtain the reports. NWS rain gauges were located at two 24-hour-per-day locations in Johnstown, the police station, and a newspaper. This information was known at WSFO Pittsburgh. However, they were established for hydrological records and local service use and were not available for operational rainfall reporting.

Recommendation: NWS should arrange for sufficient rainfall reports to carry out its flash flood warning responsibility. Necessary steps should be taken to obtain when needed all rainfall reports from:

- Gauges reporting through GOES;
- Gauges operated by other Federal, State, and local agencies; and
- Gauges operated by NWS cooperative observers.

To assure their availability, the system to obtain them should be tested on a regular basis. Also, NWS should work closely with other government agencies to increase the rain gauge/GOES network and to insure access to hourly amounts in real time.

Finding 2: Telephone communications again proved sporadic and highly unreliable in this situation for transmitting reports of heavy rainfall and flooding.

Recommendation: NWS should make a concerted effort to encourage the organization of local amateur radio, CB, and public service groups to mobilize for reporting significant weather and river information. In addition, these groups can act as emergency backup for relay of warnings.

Finding 3: SKYWARN observers are trained in observing severe weather and routinely do not report rainfall, even if they have such equipment. Valuable descriptions of heavy rain or flooding conditions were voluntarily called to WSFO Pittsburgh by SKYWARN observers the night of the flood.

Recommendation: NWS should encourage these motivated, weather-conscious SKYWARN observers to report heavy rains, flooding, and other hazardous events as well as severe thunderstorms and tornadoes. Where possible SKYWARN observers should be furnished rain gauges, training, and reporting procedures.

Finding 4: The radar operators at WSMO Pittsburgh, working alone, were unable to adequately carry out all assigned duties because of excessive workload.

Recommendation: NWS should establish a procedure for adequate manning of network radar stations for heavy rain and flash flood situations analogous to that used in the severe thunderstorm warning program.

Finding 5: No procedures had been established for routine coordination between the Pittsburgh WSFO and the WSMO at shift-change time or during the rapidly developing flash flood producing weather conditions.

Recommendation: NWS should take steps to insure routine coordination between all elements of the warning team. Emphasis should be given to the urgent need for frequent or even continuous coordination in heavy rainfall conditions and severe thunderstorm or tornado situations.

Finding 6: Radar observations from WSMO Pittsburgh and satellite information supplied by the Washington Satellite Field Service Station did not give sufficient attention to important small details. For example, the radar observations did not indicate the reorientation of the rainfall area/line or movement of intense thunderstorm cells. There was little telephone coordination between the WSFO and the WSMO in Pittsburgh. The satellite interpretation messages received at Pittsburgh around 2:00 a.m. indicated that thunderstorms in western Pennsylvania were decreasing. A more detailed and thorough analysis of the imagery indicated the contrary. WSFO Pittsburgh was never advised that the most intense convective activity was remaining nearly stationary over southwestern Pennsylvania.

Recommendation: Radar operators and satellite meteorologists must be instructed to pay more attention to small details and to relay this information to forecast offices more frequently, particularly during events that may cause major local forecast problems. It is better to err on the side of frequent rather than infrequent communication.

Finding 7: The D/RADEX output gave good areal definition of significant precipitation and reasonable estimates of rainfall accumulations, as averaged over the 15-square-mile grid boxes. However, it did not adequately indicate the peak rainfall amounts. (Another finding relative to D/RADEX is given in Chapter 4.)

Recommendation: Steps should be taken to provide, as another D/RADEX product, estimates of peak rainfall within each grid box.

Finding 8: The WBRR provided usable radar information to the WSFO only when used in conjunction with coded radar observations and satellite imagery.

Recommendation: NWS should investigate improved means of remoting and depicting weather radar imagery to the warning office to insure forecaster awareness of echo persistence and movement, e.g., the use of time lapse animation as is done with satellite pictures at SFSS.

CHAPTER 4.

METEOROLOGICAL CONDITIONS AND FORECASTS

Since the mid-1940's meteorologists have come to recognize that important atmospheric processes occur over a wide spectrum of interacting scales. The conditions contributing to the Johnstown, Pennsylvania, flash flood were no exception--large or synoptic scale conditions were favorable for convective activity, but data from radars, satellites, and surface observations indicated that small or mesoscale features, several hundred kilometers or less in size, were significant factors in triggering and localizing the very heavy rainfall. Unfortunately, there are substantial gaps in our knowledge and understanding of mesoscale meteorology and there are significant limitations in our ability to observe and forecast these phenomena.

Synoptic Scale Features

A nearly stationary upper atmospheric high-pressure ridge, oriented east-west at around 35°N latitude, had persisted across the United States for several days prior to the flood. A relatively weak upper level low-pressure center had moved from western Wisconsin at 8:00 p.m. on July 17 to northwest Ohio at 8:00 a.m. on July 19. Although moisture values associated with this low-pressure center at customarily analyzed levels were not abnormally high, relative humidities from the surface to the 500mb (50 kPa) level, about 6 kilometers above sea level, were generally above 70%. Precipitable water values (another measure of atmospheric moisture) associated with the disturbance were generally from 50% to 100% above climatological values. The air mass immediately in advance of the upper level low was very unstable.

Winds at the 6-kilometer level over western Pennsylvania were generally from the west during the 2-day period preceding the flood, but shifted to the northwest during the late afternoon on July 19. Wind speeds exceeded 30 knots at Pittsburgh at 8:00 p.m. on July 17 and 8:00 a.m. on July 19, but were 20 knots or less otherwise. Winds at the 1.5-kilometer level were generally less than 20 knots, too. However, a 35-knot wind, much stronger than nearby winds, was reported at Detroit at 8:00 a.m. on July 19 and at Pittsburgh at 8:00 p.m. on July 19. This implied a small zone of low-level convergence ahead of the upper level low. The combination of these factors would be favorable for thunderstorm formation.

A weak upper level low had moved northwestward from the northern Gulf of Mexico into Mississippi on the 19th. This low spread moisture northward into the lower Mississippi Valley and parts of the Ohio Valley. Based on satellite imagery it does not appear that moisture from this weather system moved into eastern Ohio and western Pennsylvania.

At the surface a high-pressure ridge extended from the western Atlantic into the southeast U.S. and the central Mississippi Valley. Generally south and southwest winds, and surface temperatures and dewpoints near or slightly above normal values, were observed over a large area from New England and the middle Atlantic States into the central U.S. There were no surface fronts affecting the area.

Figure 6 shows the NMC surface analysis at 8:00 a.m. and 8:00 p.m. on July 19.

Figure 7 shows the 500mb (50 kPa) analysis for the same times.

These synoptic features--well above normal moisture, an unstable air mass, and low-level convergence all favored thunderstorm activity in western Pennsylvania. The relatively light upper level winds, and the slow movement of the upper level low, all indicated that individual thunderstorms would move slowly enough for some locally heavy rainfall. Despite these clues, which, even in conjunction, are not uncommon, there was no basis to predict the 12 inches of rain that fell near Johnstown causing the disastrous flash flood.

Guidance Received at WSFO Pittsburgh

The National Meteorological Center (NMC), a largely computerized facility, provides a variety of analyses and prediction products covering the Northern Hemisphere with emphasis on the United States and surrounding waters. Subjective forecasts showing frontal positions, cloudiness, and precipitation areas and amounts are also prepared. This basic guidance material, covering periods out to 48 hours in the future, is distributed over facsimile and teletypewriter networks.

The guidance products available to WSFO Pittsburgh by early afternoon on July 19 indicated that there would be relatively little change in the wind flow pattern at upper levels. Weak upward vertical motion with mean relative humidities just above 50% were shown for Pennsylvania. The Limited Area Fine Mesh (LFM) model guidance based on 8:00 p.m. July 18 and 8:00 a.m. July 19 data indicated no precipitation for Pennsylvania during the 12-hour period beginning 8:00 p.m. on July 19. The weak upper level low was forecast to continue moving slowly southeast; little change was forecast in the surface pressure pattern.

Although the numerical guidance indicated no precipitation for Pennsylvania, forecasters at the NMC Quantitative Precipitation Branch (QPB) were aware that rainfall amounts of an inch or more had been associated with the upper level low during the previous two days. Thus, in their early morning forecast on July 19, they indicated that rainfall amounts from one quarter to one inch were possible over eastern and central Pennsylvania. Later updates moved the one-half inch to one inch area further westward. NMC Basic Weather Branch subjective rainfall area forecasts indicated minimum thunderstorm activity for Pennsylvania until the 1:30 p.m. July 19 update that indicated widespread thunderstorm activity was expected over much of Pennsylvania around 8:00 p.m.

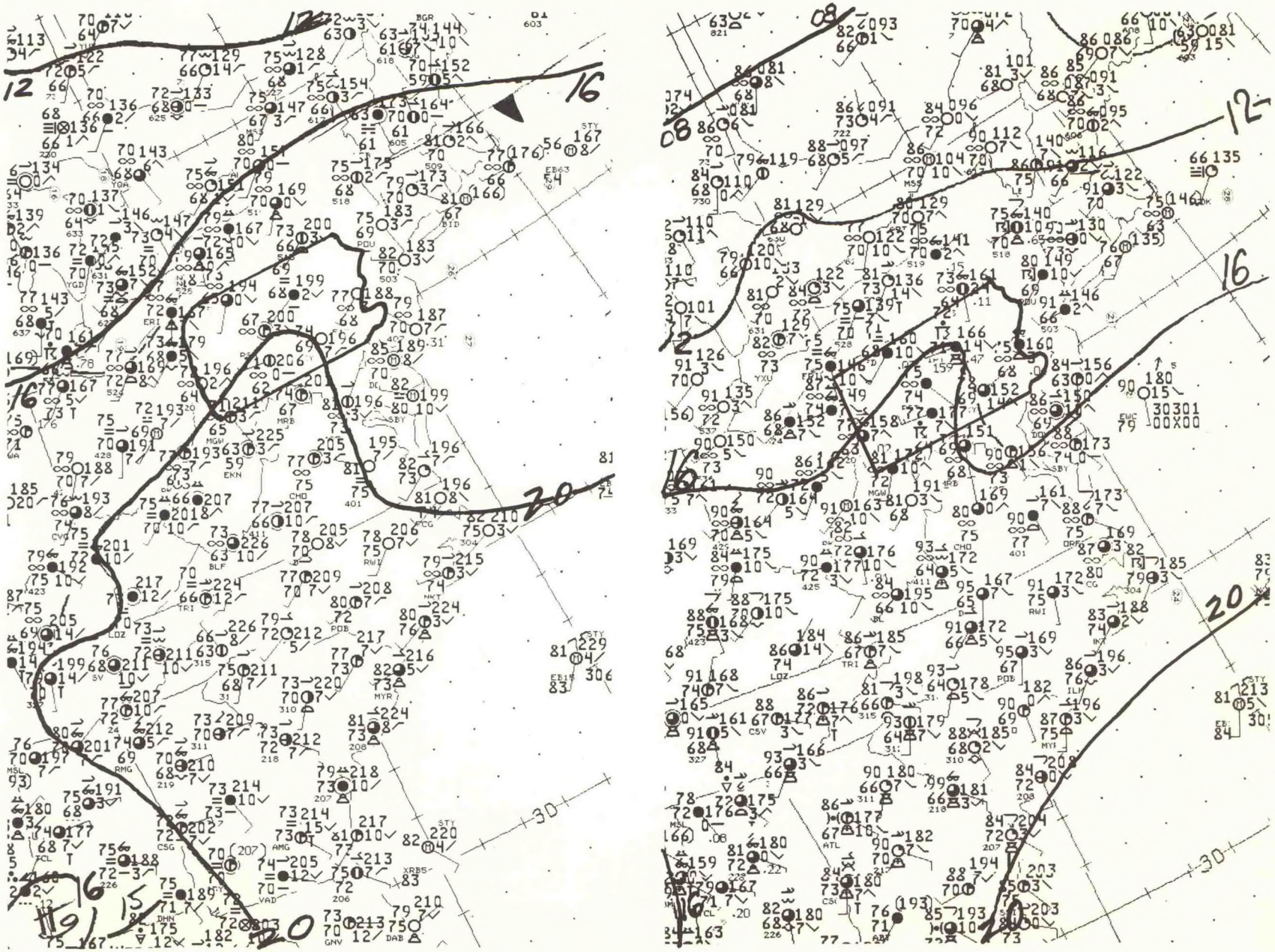


Figure 6. NMC Surface Analyses for 8:00 a.m. and 8:00 p.m., July 19, 1977.

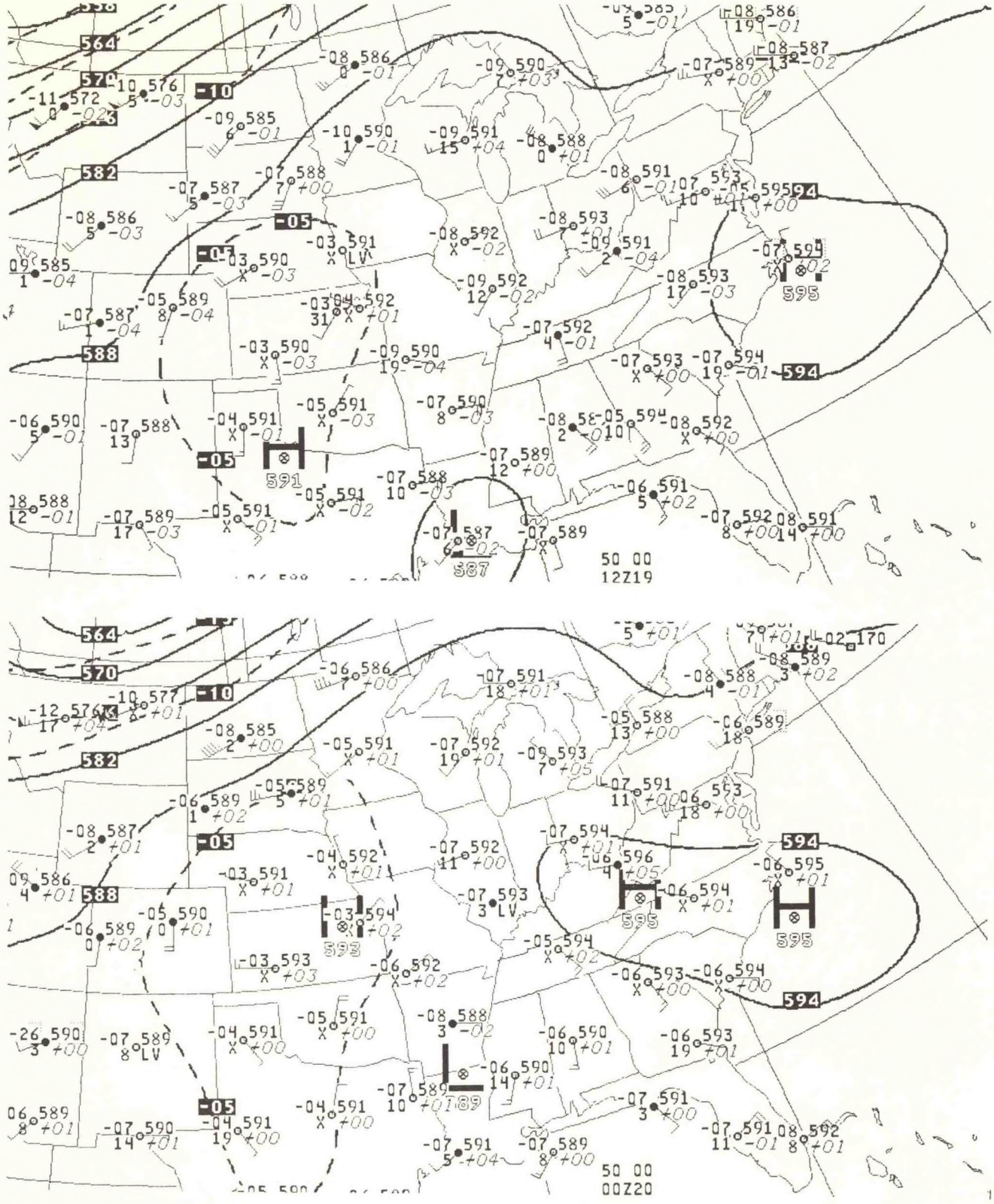


Figure 7. 500 mb (50 kPa) charts for July 19, 1977.
8:00 a.m. (above), 8:00 p.m. (below)

While NMC has the responsibility for issuing quantitative precipitation forecasts, it should be noted that prediction of extremely heavy rains from thunderstorms is beyond the current state of the art.

Statistical precipitation guidance for the 12-hour period beginning 8:00 p.m. on July 19 based on 8:00 a.m. observations on July 19, and available at WSFO Pittsburgh by early afternoon, showed lower probabilities for measurable rainfall for the western Pennsylvania area than earlier guidance did. Thunderstorm guidance forecasts from NMC for the 4-hour periods centered at 9:00 p.m. and midnight (and available at 6:00 p.m. and 9:00 p.m. respectively) showed a relative maximum for southwestern Pennsylvania, but the values were barely above the threshold value for thunderstorms.

The National Severe Storm Forecast Center (NSSFC) in Kansas City uses all available surface, upper air, radar,and satellite data to provide 24-hour surveillance of the development of severe thunderstorms within the contiguous 48 States. Severe weather outlooks are issued on a scheduled basis at 4:30 a.m., 11:00 a.m., and 3:30 p.m. Watches are issued as required to advise of areas of greatest potential for severe thunderstorm or tornado development. These products are distributed mainly over the Radar Report and Warning Coordination (RAWARC) Circuit to WSFOs and WSOs. A graphic version of the severe weather outlook is transmitted via the National Facsimile Network (NAFAX). NSSFC does not issue guidance on the potential for very heavy rainfall associated with severe thunderstorms. Predictions of this type are beyond the current state of the art,and research and development will be necessary before they could be provided.

NSSFC first indicated that severe thunderstorms were possible for eastern Pennsylvania at 3:30 p.m. on July 19.

River Forecast Centers (RFCs) supply WSFOs with river stage forecasts, headwater statements, and flash flood guidance specifying those threshold rainfall amounts which will produce minor flooding. This latter guidance covers zones or parts of States and in some cases contains information for a specific drainage basin. The RFC in Cincinnati provided Pittsburgh with flash flood guidance values for western Pennsylvania zones at around 2:30 p.m. on July 19. This guidance indicated that 2.0 inches of rainfall would be needed to produce flash flooding in northwestern Pennsylvania and 3.9 inches in the region to the east and southeast of Pittsburgh.

In summary, the synoptic situation as depicted by observed data and analyses, and forecast guidance available to WSFO Pittsburgh only pointed to a chance of thunderstorm activity in western Pennsylvania. However, if thunderstorms did occur some heavy rainfall would be possible. The information available did not provide a basis for specific forecasts of localized intense thunderstorms or a catastrophic flash flood.

Mesoscale Considerations

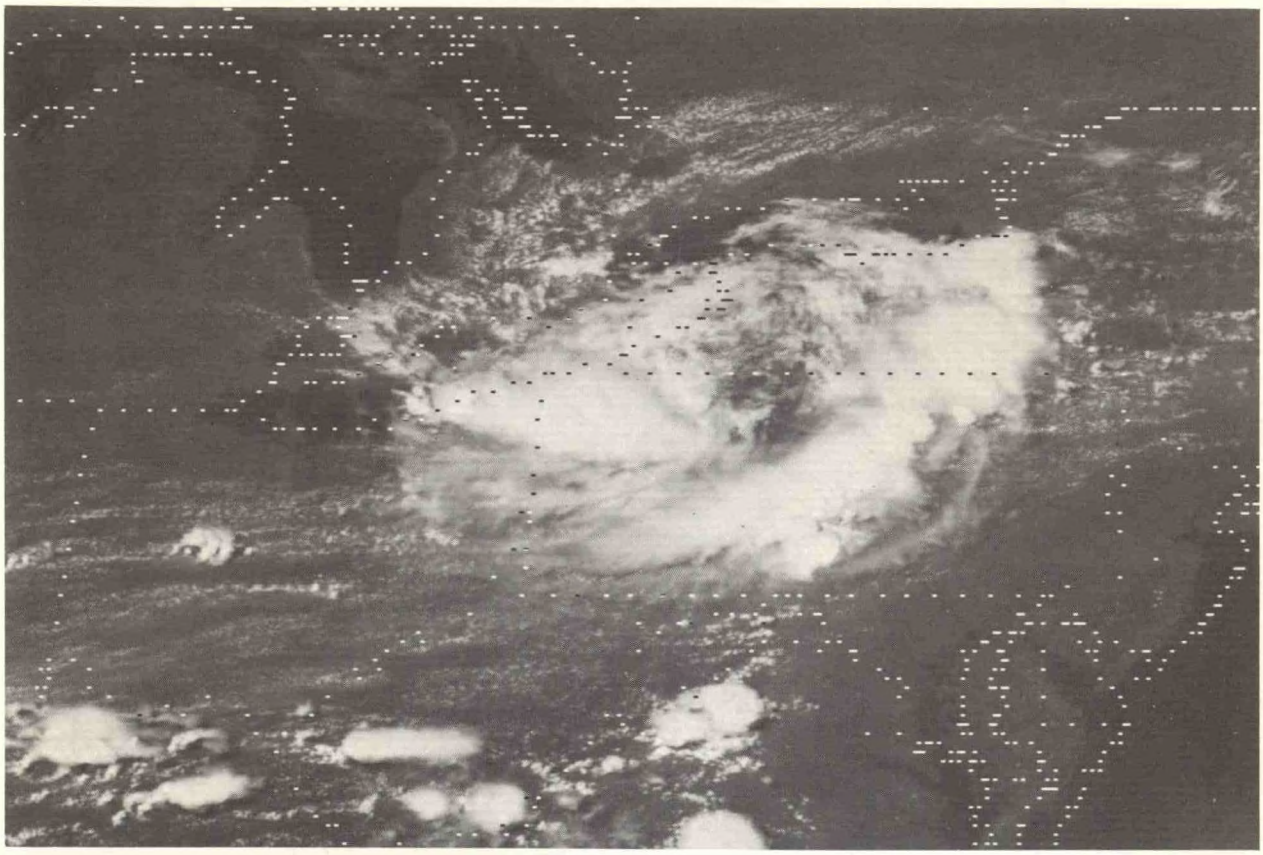
During the early morning hours of the 19th thunderstorms developed in extreme southeast Michigan. These thunderstorms moved east southeastward during the day across northwest Pennsylvania and into eastern Pennsylvania. A few of the thunderstorms that lagged in northwest Pennsylvania were responsible for the heavy rains that fell in Crawford County during the afternoon of the 19th. However, most of the concern at NMC, NSSFC, the Washington SFSS, and Pennsylvania and southern New York weather offices was focused on the thunderstorm activity moving through eastern Pennsylvania and southern New York State. These thunderstorms had strong winds associated with them. Figure 8 is a composite of the satellite imagery and radarscope photography and tracing at 3:30 p.m. on the 19th, depicting the well-organized line of thunderstorms and the area of thunderstorms that had remained in northwest Pennsylvania. The line of thunderstorms in eastern Pennsylvania weakened rapidly after 8:00 p.m. on the 19th.

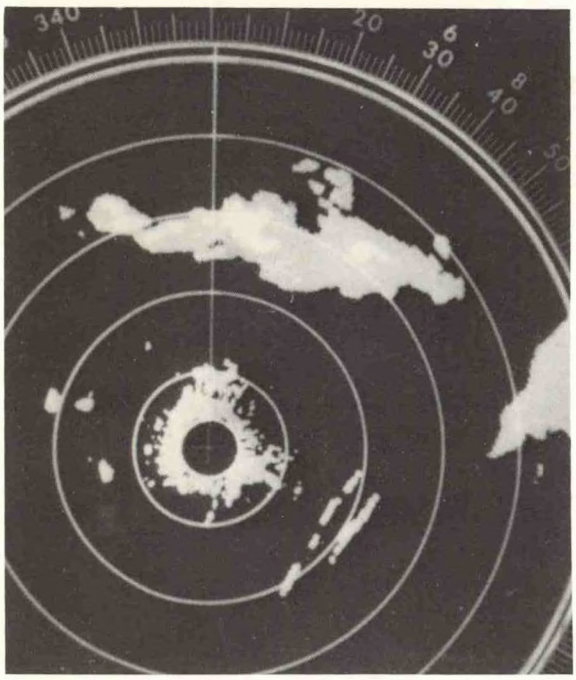
At about 4:30 p.m. an isolated heavy thunderstorm developed to the west of Pittsburgh. This storm formed along an east-west cumulus line that extended from eastern Indiana to near Johnstown, Pennsylvania. The cumulus line and thunderstorms were clearly visible on the GOES imagery available at Pittsburgh.(See Figures 8, 9, and 10.)

This thunderstorm moved eastward at 35 to 40 knots and dropped one-half to one inch of rain as it moved through Johnstown shortly before 8:00 p.m. The same storm also brought 40 mph winds to the Pittsburgh and Johnstown areas. Small hail was reported with the storm near Pittsburgh. As this isolated thunderstorm moved rapidly to the east, the thunderstorm activity in northwestern Pennsylvania began to intensify and move southeast. The leading edge of this thunderstorm area had the most intense storms and resembled a line. The northwest portion of the area showed little overall movement. From 8:30 to 9:30 p.m. on the 19th, the orientation of the rainfall area began changing from west-east to northwest-southeast. Thunderstorms were now beginning to move from northwest to southeast along the line that became quasi-stationary.(See Figures 11, 12, 13, and 14.)

The thunderstorm area in western Pennsylvania also created its own rain-cooled air mass. Thus, very warm and humid low-level air moving toward the western edge of the rain-cooled air mass (recall strong 1.5-km level west wind at Pittsburgh at 8:00 p.m. on July 19) was forced to rise.

The stage was set for thunderstorms to continue to develop just to the northwest of the Johnstown area and move toward the southeast. Terrain factors probably contributed to the preferential thunderstorm development as well.





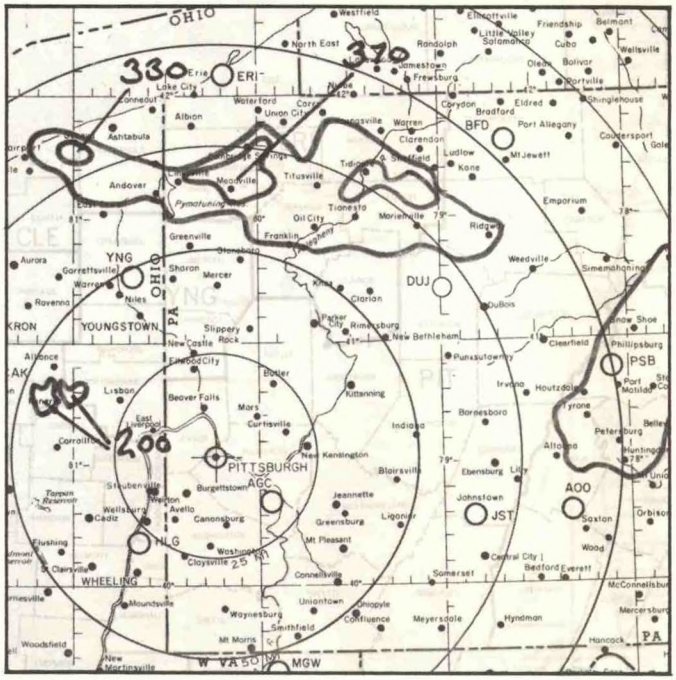


Figure 8. 3:30 p.m., July 19, 1977
GOES-1 Satellite Visual Imagery,
Radar Scope Photograph, and Tracing.
(Figures in tracing are echo tops in hundreds of feet)

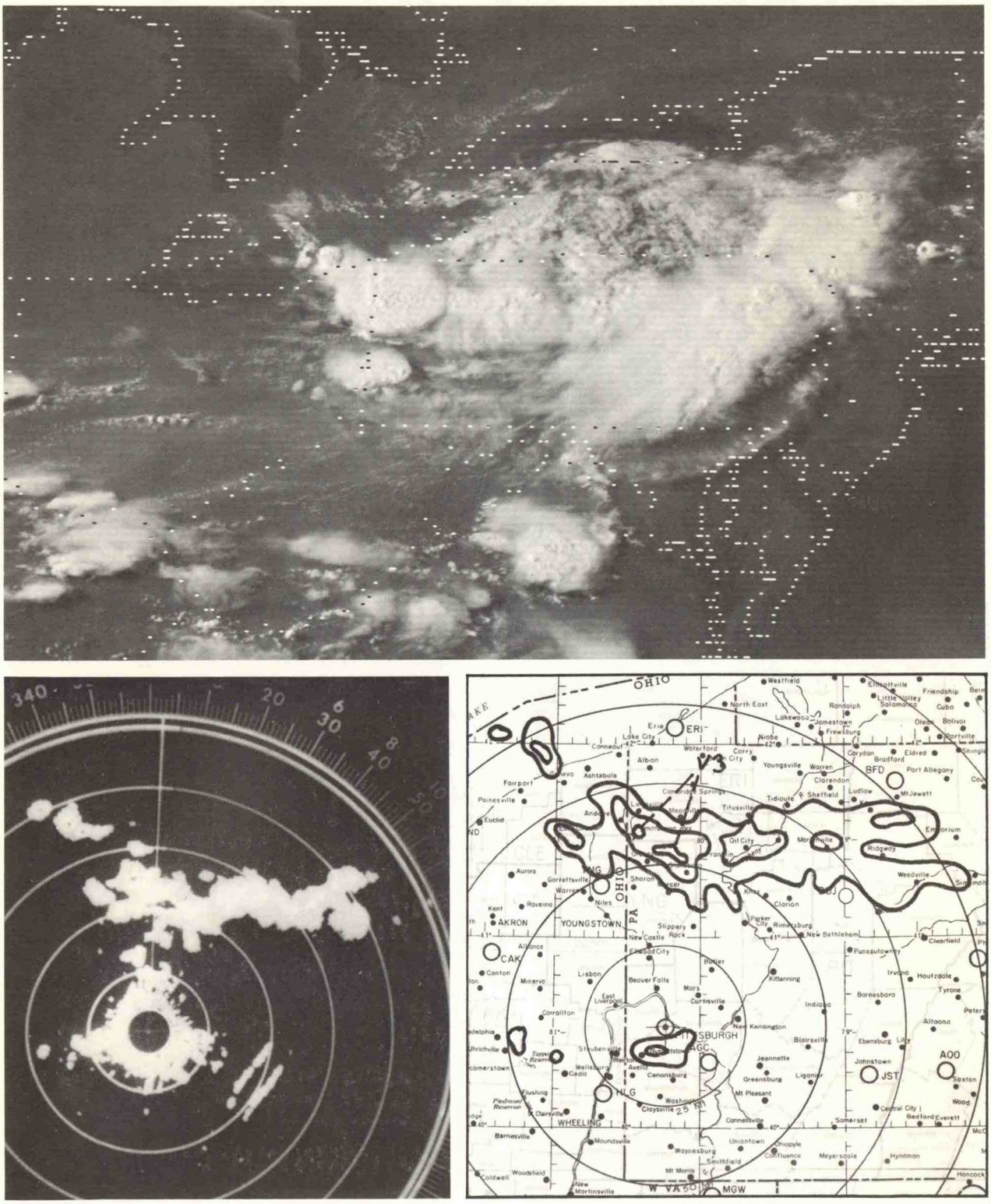


Figure 9. 5:30 p.m., July 19, 1977
GOES-1 Satellite Visual Imagery,
Radar Scope Photograph, and Tracing.
("V numbers" on tracing depict strongest echo intensity)

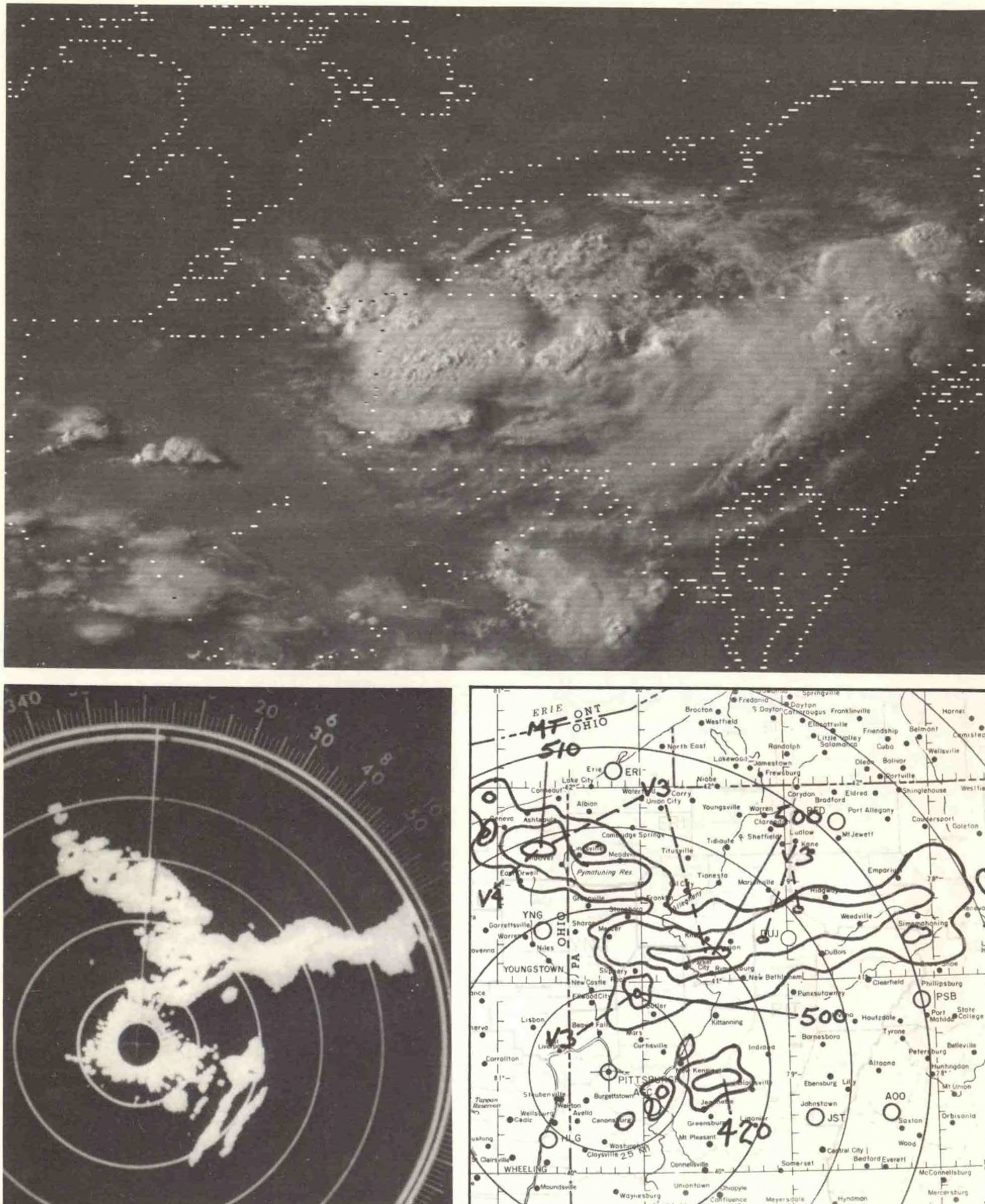
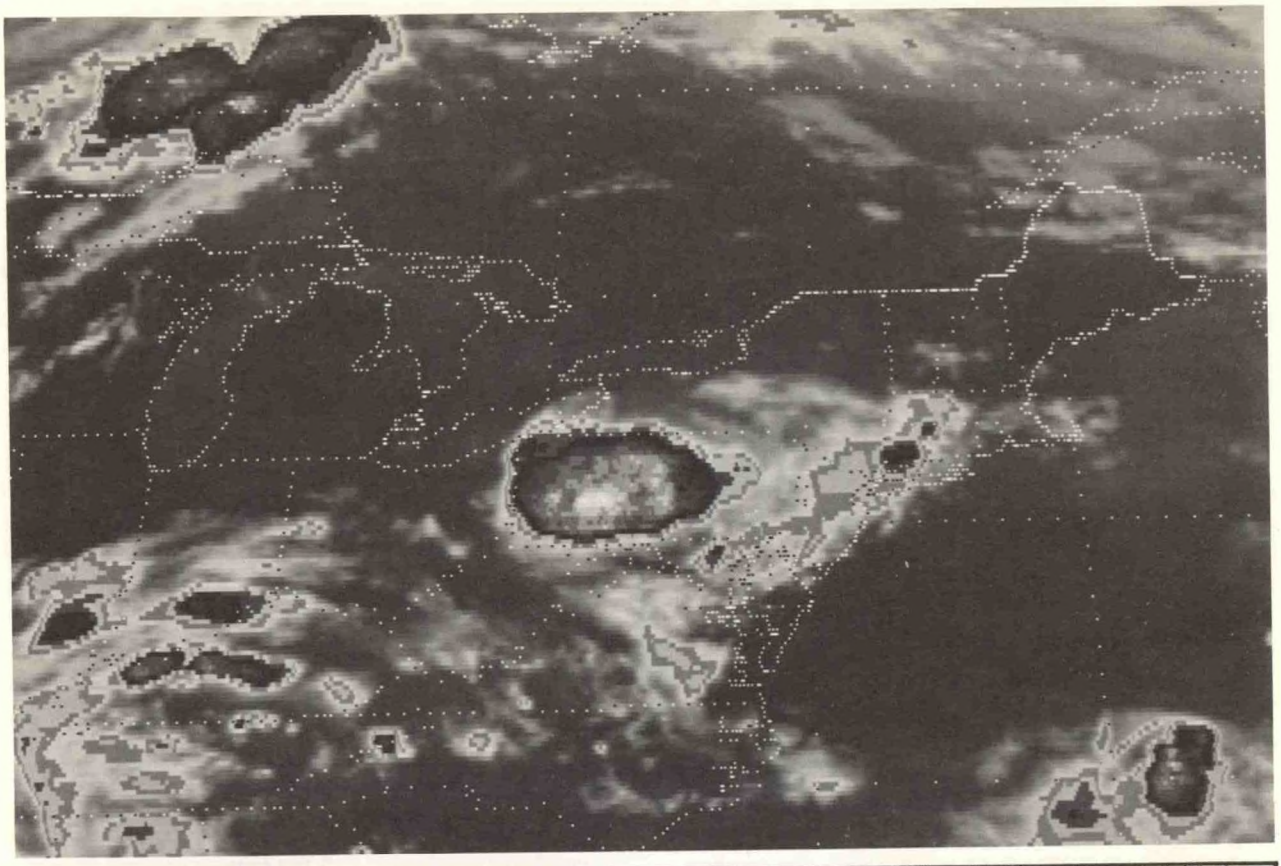


Figure 10. 6:30 p.m., July 19, 1977
GOES-1 Satellite Visual Imagery,
Radar Scope Photograph, and Tracing.



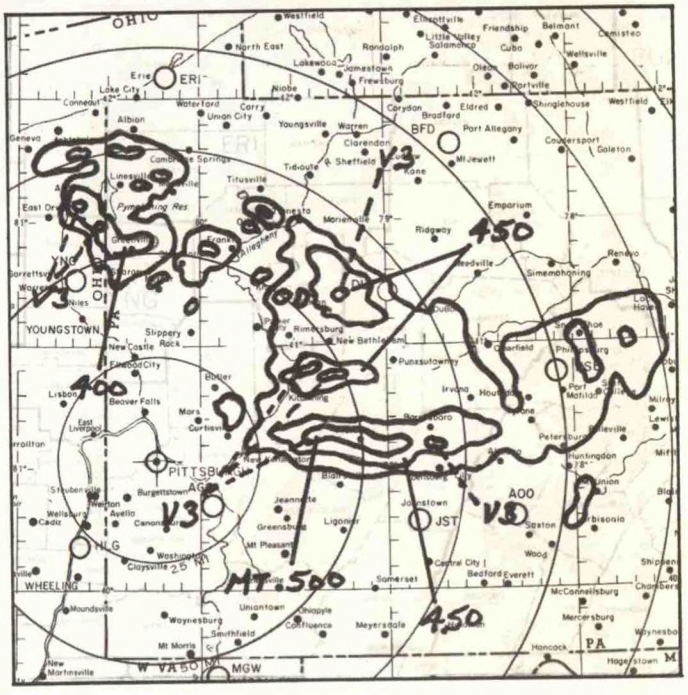
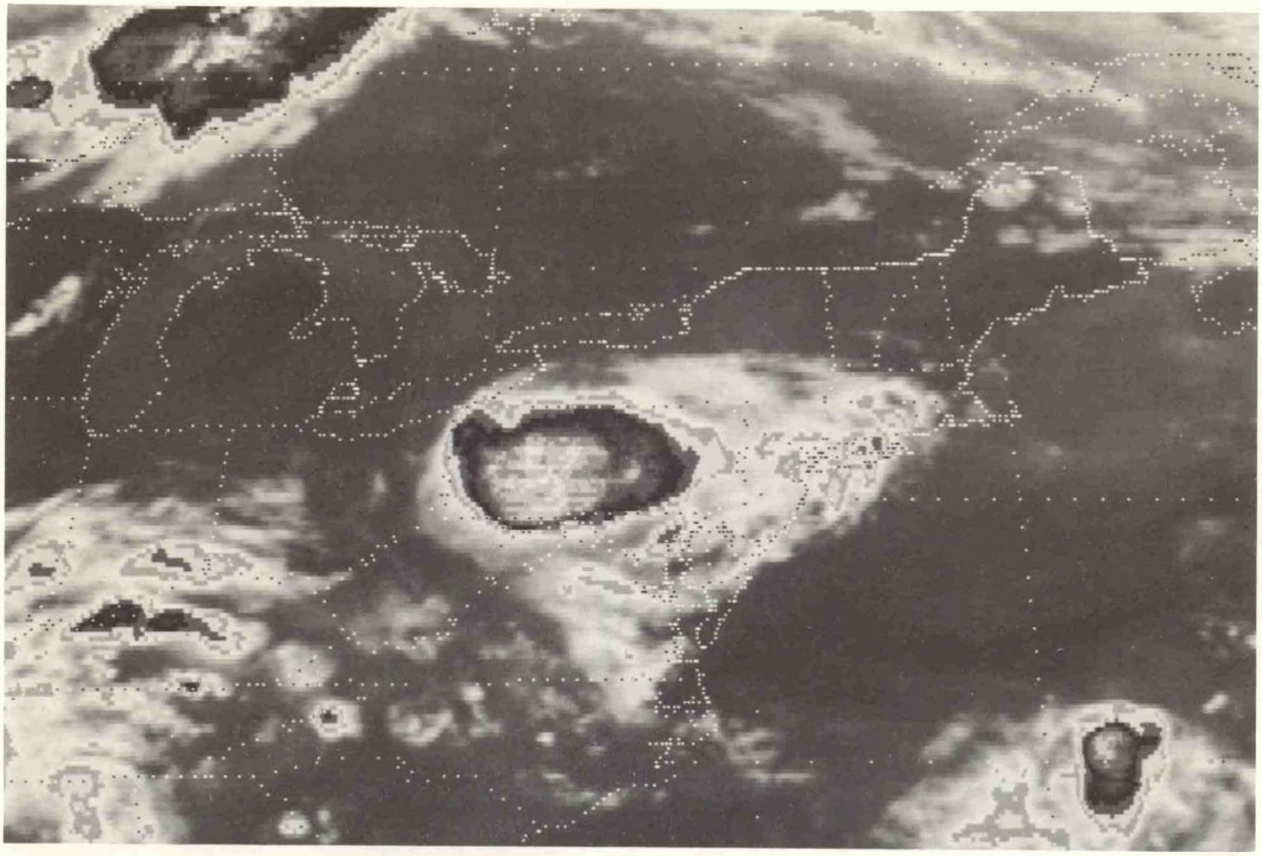


Figure 11. 8:30 p.m., July 19, 1977
GOES-1 Satellite Visual Imagery
Radar Scope Photograph, and Tracing.



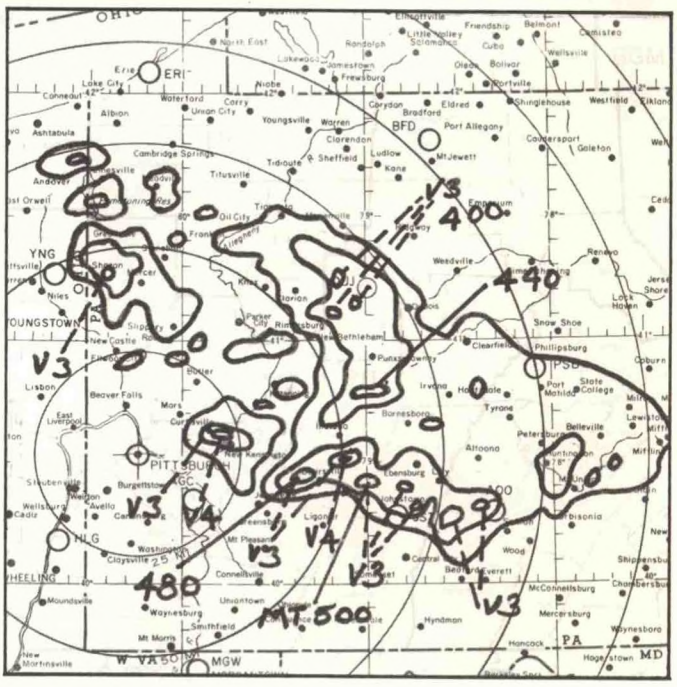


Figure 12. 10:30 p.m., July 19, 1977
GOES-1 Satellite Infrared Imagery,
Radar Scope Photograph, and Tracing.

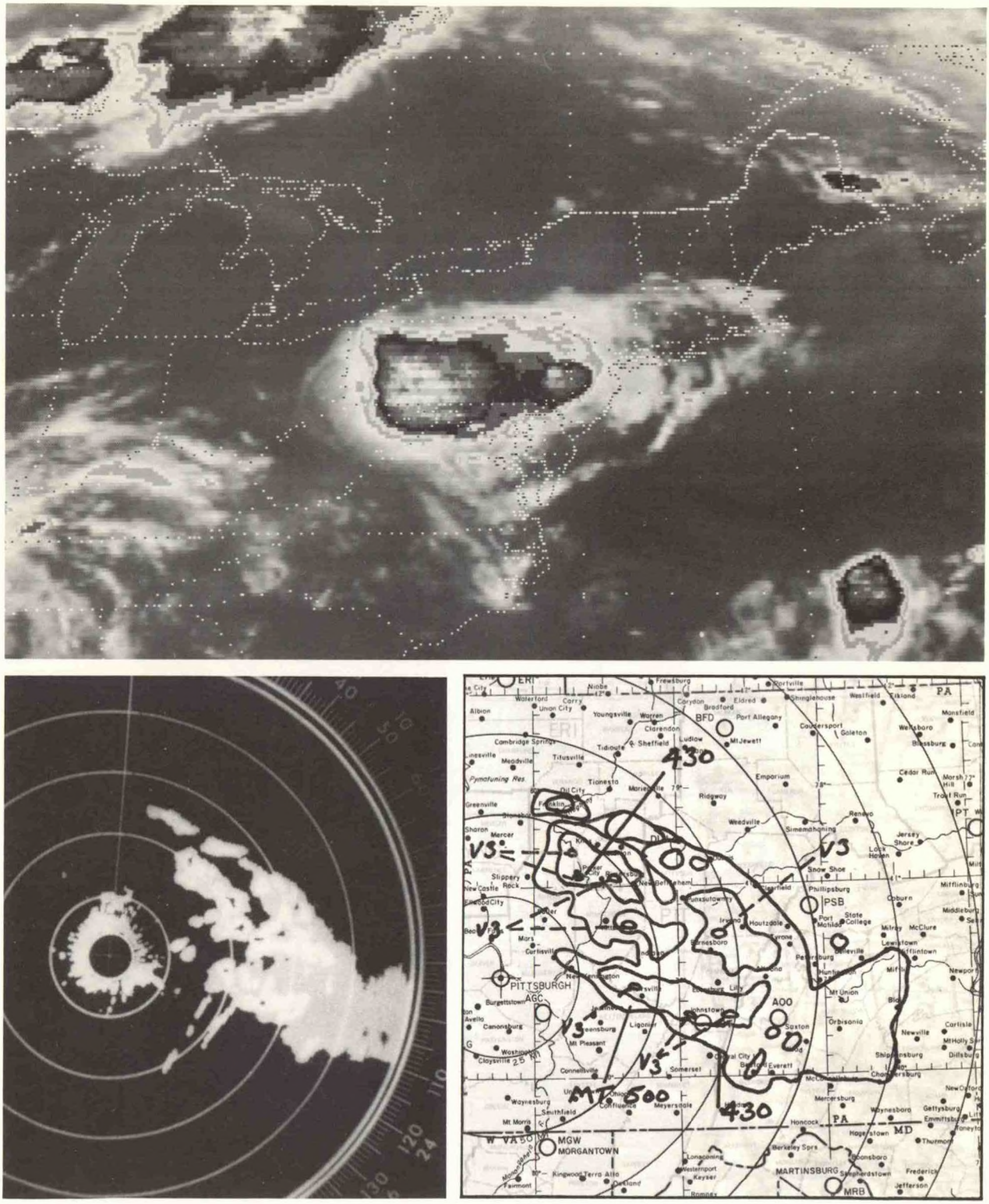


Figure 13. 11:30 p.m., July 19, 1977
GOES-1 Satellite Infrared Imagery,
Radar Scope Photograph, and Tracing.

Figure 14. 12:30 a.m., July 20, 1977
GOES-1 Satellite Infrared Imagery,
Radar Scope Photograph, and Tracing.

As seen in Figures 15 and 16, the thunderstorm activity began moving out of south Pennsylvania around 4:00 a.m. on July 20.

WSFO Pittsburgh Procedures, Forecasts, and Warnings

The detailed procedures for handling this flash flood situation varied somewhat with each forecaster on duty during the swing and mid shifts, but the general operation is described below:

1. They noted that the flash flood guidance issued by RFC Cincinnati at 2:20 p.m. indicated that a total accumulation of 3.9 inches of rainfall in 3 hours or less would be needed to produce flood problems in the regions east and southeast of Pittsburgh and the precipitation forecast from NMC did not indicate that this amount of rainfall would occur over western Pennsylvania. Their evaluation of the weather situation as depicted by available weather charts, radar, and satellite imagery led them to conclude that there was not a sufficient probability (interpreted by most forecasters as 30% or more) to issue a flash flood watch in advance of actual reports of rainfall approaching the 3.9 inches given the RFC guidance.

2. Their resulting procedure was to attempt to monitor stream conditions and amounts of rainfall occurring and accumulating over western Pennsylvania. Up until 11:30 p.m. concerted efforts were made to obtain rainfall amounts from the Automatic Hydrologic Observing Station and collecting reports from the few observers who called in and reported rainfall amounts and local flooding conditions. Also, they monitored the rainfall amount estimates depicted on D/RADEX printouts and interpreted them to be consistently below the amounts needed to warrant a flash flood warning for the area. They expected the thunderstorm intensity to decrease, as it had the previous evening. The temporary decrease in intensity noted on the 10:30 p.m. coded radar observation strengthened this expectation. This, along with their study of the limited rainfall data, the WBRR remote weather radar display, and the satellite imagery led the swing shift to decide not to issue a flash flood warning.

3. One factor in this decision was the expressed reluctance by all forecasters to issue flash flood warnings without verification of flooding or rainfall data approaching or exceeding flash flood guidance values. The forecasters also expressed a very conservative attitude to issuing flash flood watches and were definitely swayed by criticism from the press and public for apparently overforecasting in the past. This attitude is in direct conflict with instructions from the Eastern Region. It is the Region's stated policy to have the least possible number of significant flash floods"missed" even though this could increase false alarms and that flash flood watches may be issued even with limited possibility (less than 30%).

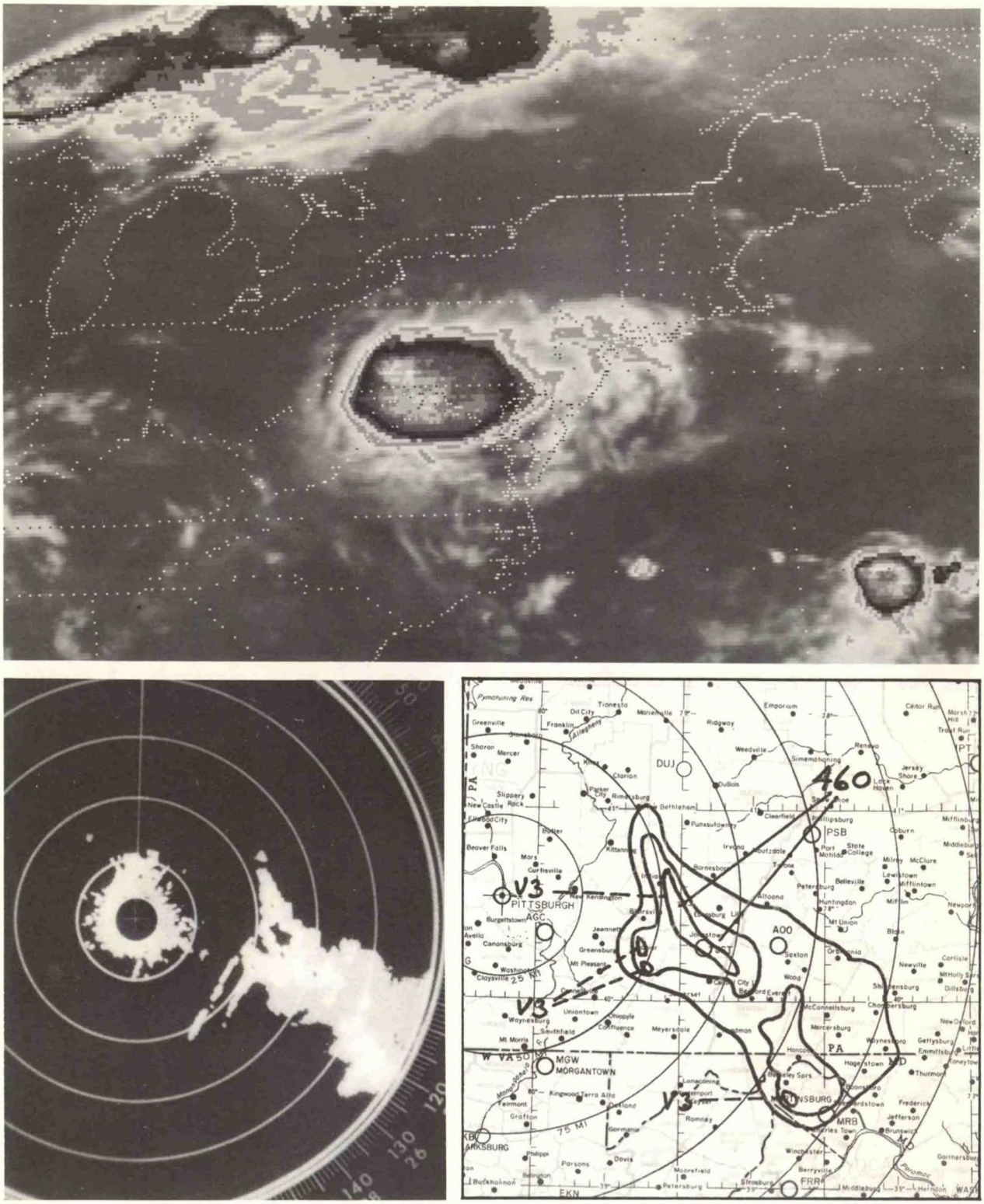


Figure 15. 3:30 a.m., July 20, 1977
GOES-1 Satellite Infrared Imagery,
Radar Scope Photograph, and Tracing.

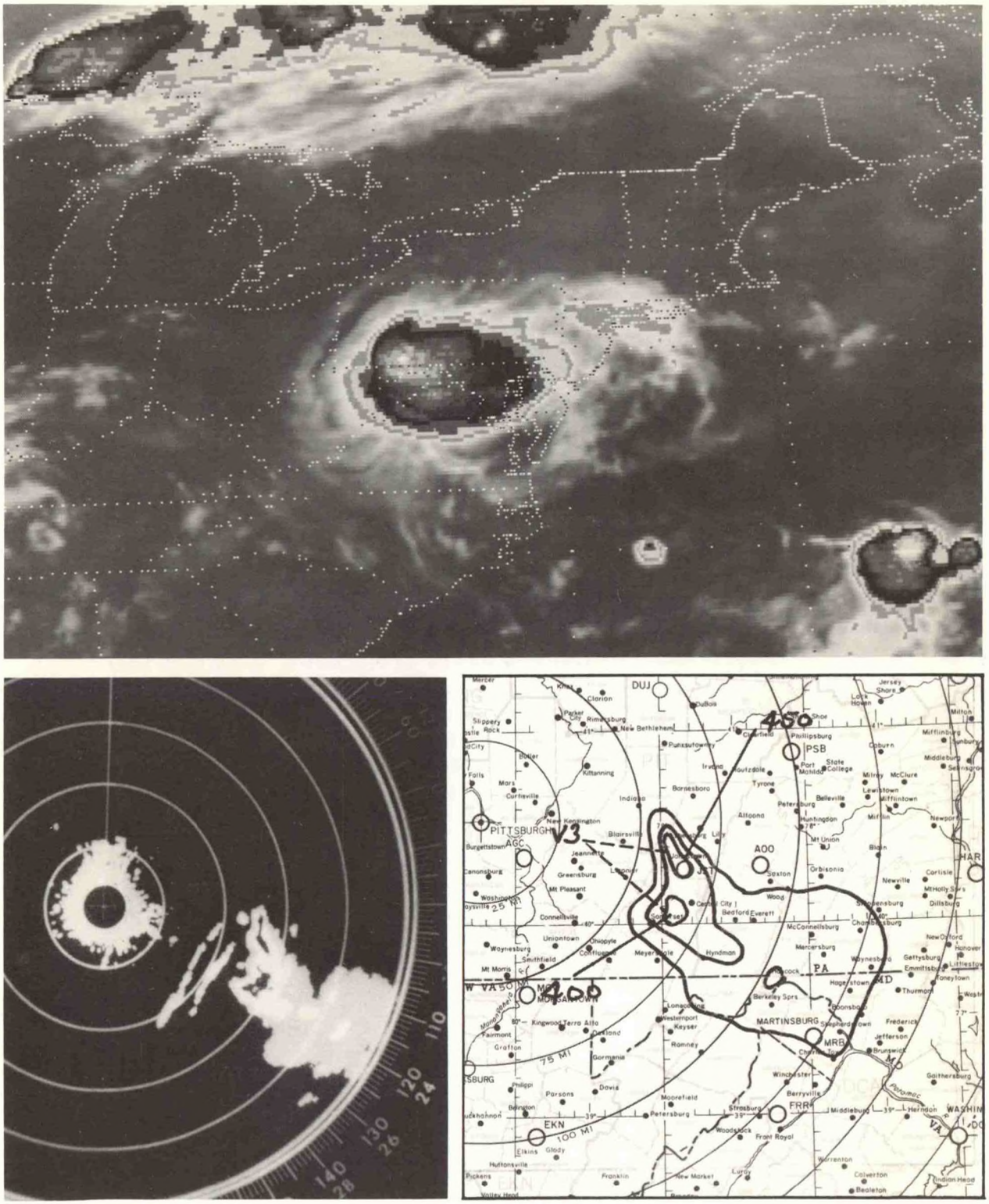


Figure 16. 4:30 a.m., July 20, 1977
GOES-1 Satellite Infrared Imagery,
Radar Scope Photograph, and Tracing.

4. Zone forecasts issued by WSFO Pittsburgh at 4:00 a.m., 10:00 a.m., and 4:00 p.m. on July 19 for the Johnstown area only indicated 30% chance of thundershowers Tuesday afternoon and evening. The 10:00 p.m. zone forecasts indicated showers would be ending overnight (40% chance of measurable precipitation). There was no mention of possible abnormally heavy rainfall in any of these forecasts.

5. At 4:00 p.m. on July 19 WSFO Pittsburgh issued a flash flood warning valid until 8:00 p.m. for northern Crawford County (northwest Pennsylvania). This warning was based on reports of heavy rainfall and flooding and was terminated at 8:30 p.m. Several weather statements concerning this area were issued between 6:00 p.m. and 11:40 p.m. on the 19th. The first weather statement, not a warning, for the Johnstown area was issued at 7:30 p.m. based on radar observations and reports of brief heavy rain and minor urban flooding. Another statement issued at 11:40 p.m. discussed minor flooding to the north of the disaster area.

6. The midnight shift issued no information until the flash flood warning for Johnstown at 2:40 a.m. The meteorologist on duty made little use of the radar data (MDR values, D/RADEX printouts and WBRR pictures) prior to 2:00 a.m. Additional help was not requested when isolated reports of flooding were received. When he received a report of cars washing down the street at Johnstown, he did not attempt to call Johnstown police for a situation report. By then the communications may have been out, a fact that may have triggered action on his part.

7. The 4:00 a.m. zone forecast made no mention of flooding in progress. While the hardest hit sections were becoming more and more isolated from communication after midnight, prompt warnings and complete statements may have assisted in alerting officials in the surrounding areas to the disaster in progress that necessitated their assistance.

8. The statements and warnings issued are as follows:

BULLETIN ACTIVATE EBS
FLASH FLOOD WARNING

NATIONAL WEATHER SERVICE PITTSBURGH PA
4PM EDT TUE JULY 19 1977

A FLASH FLOOD WARNING IS IN EFFECT UNTIL 8 PM THIS EVENING FOR NORTHERN CRAWFORD COUNTY IN PENNSYLVANIA.

HEAVY RAINS HAVE FALLEN ACROSS THIS AREA SINCE LATE THIS MORNING. THE FOLLOWING CREEKS ARE NEAR BANKFUL OR ALREADY OVERFLOWING... CONNEAUT TEE...CONNEAUT CREEK...SADLER CREEK...
AND THE CUSSEWAGO CREEK.

THERE WILL BE RISES ON THE FRENCH CREEK THROUGH THIS EVENING AS THE SMALLER CREEKS EMPTY INTO IT.

CRAWFORD COUNTY CIVIL DEFENSE REPORTED AT THREE FIFTY PM THAT THREE AND THREE FOURTHS INCHES OF RAIN FELL AT CONNEAUTVILLE... WITH ONE AND A FOURTH INCHES AT MEADVILLE AND HYDETOWN PA.

ROUTE NINETEEN IN SAEGERTOWN HAS BEEN CLOSED DUE TO HIGH WATER.

ROUTES EIGHTEEN AND ONE NINETY EIGHT NEAR CONNEAUTVILLE ARE ALSO CLOSED.

FURTHER STATEMENTS WILL BE ISSUED.

BULLETIN
FLASH FLOOD STATEMENT

NATIONAL WEATHER SERVICE PITTSBURGH PA
610PM TUE JUL 19 1977

...HEAVY RAINS ARE MOVING SLOWLY SOUTHWARD...

SLOW MOVING THUNDERSTORMS ARE DUMPING ONE TO TWO INCH RAINS OVER NORTHWESTERN PENNSYLVANIA. A FLASH FLOOD WARNING CONTINUES UNTIL 8PM FOR NORTHERN CRAWFORD COUNTY...JUST SOUTH OF ERIE PA.

THE RAINS IN CRAWFORD COUNTY HAVE LET UP A LITTLE BIT...BUT STREAMS WILL STILL BE RISING FOR SEVERAL HOURS AFTER THE RAINS SUBSIDE. PERSONS IN THE WARNING AREA SHOULD WATCH SMALL STREAMS AND BE READY FOR QUICK ACTION IF THEY OVERFLOW.

THESE RAINS WILL BE MOVING INTO THE FOLLOWING COUNTIES BY 730PM...BUTLER...VENANGO...MERCER...CLARION...AND ARMSTRONG. WHILE RAIN IS NOT COMING DOWN HARD ENOUGH FOR FLOODING IN THESE OTHER COUNTIES...TEMPORARY FLOODING OF UNDERPASSES...LOW LYING PLACES IN ROADS...AND SEWERS MAY OCCUR...AND EVEN A FEW SMALL STREAMS MAY GO OVER THEIR BANKS FOR A SHORT TIME.

IN A THUNDERSTORM THAT PASSED SOUTHWESTERN PENNSYLVANIA...SMALL HAIL FELL AT BURGETTSTOWN AND CORAOPOLIS PA.

PITTSBURG AIRPORT HAD A WIND GUST TO THIRTY EIGHT MPH.

MORE STATEMENTS WILL BE ISSUED.

FLASH FLOOD STATEMENT

NATIONAL WEATHER SERVICE PITTSBURGH PA
730PM EDT TUE JUL 19 1977

AT 730 RADAR SHOWED A LINE OF MODERATE TO HEAVY THUNDERSHOWERS IN THE PENNSYLVANIA COUNTIES OF MERCER...VENANGO...CLARION... ARMSTRONG...JEFFERSON...INDIANA...CLEARFIELD...AND CAMBRIA.

NO SEVERE WEATHER HAS YET BEEN REPORTED...BUT BRIEF HEAVY RAIN AND MINOR URBAN FLOODING HAS OCCURRED. RAINFALLS HAVE BEEN ONE TO ONE AND A HALF INCHES.

THE LINE OF THUNDERSHOWERS CONTINUES TO MOVE SLOWLY SOUTHEAST. IF YOU LIVE IN THESE COUNTIES OR JUST SOUTH OF THEM...BE ON THE LOOKOUT FOR HEAVY RAIN...GUSTY WINDS...AND SMALL HAIL.

A STATEMENT ON THE FLASH FLOOD WARNING FOR CRAWFORD COUNTY WILL BE ISSUED BEFORE EIGHT THIRTY TONIGHT.

TERMINATION OF FLASH FLOOD WARNING

NATIONAL WEATHER SERVICE PITTSBURGH PA
830PM EDT TUE JULY 19 1977

THE FLASH FLOOD WARNING FOR NORTHERN CRAWFORD COUNTY HAS ENDED.

THE FRENCH CREEK AT MEADVILLE WILL RISE OVERNIGHT. A PRELIMINARY CREST OF NINE FEET IS EXPECTED AROUND NOON WEDNESDAY...WELL BELOW THE FLOOD STAGE OF THIRTEEN FEET.

THE RAIN IS ABOUT OVER...BUT SOME CREEKS WILL BE RISING SLOWLY FOR SEVERAL MORE HOURS. IF YOU LIVE IN THE CUSSEWAGO CREEK DRAINAGE AREA NORTHWEST OF MEADVILLE...REMAIN ON THE ALERT FOR RISES IN THE CREEK UNTIL MIDNIGHT.

HEAVY RAINS EARLIER TODAY DUMPED ONE TO FOUR INCHES THROUGHOUT CRAWFORD COUNTY...CAUSING CREEKS AND SMALLER STREAMS TO OVERLOW RAPIDLY AROUND CONNEAUTVILLE AND SAEGERTOWN WHERE STATE ROUTES ONE NINETY EIGHT... EIGHTEEN...AND NINETEEN WERE CLOSED.

AT SEVEN FIFTY PM...CRAWFORD COUNTY CIVIL DEFENSE REPORTED THE CONNEAUTVILLE AREA HAD THE MOST DAMAGE. SOME BUILDINGS AND A BRIDGE WERE DAMAGED...AND THERE IS STILL SOME WATER IN TOWN.

ELSEWHERE...TWO INCHES OF RAIN FELL BETWEEN FIVE AND EIGHT PM AT PINEY DAM NEAR CLARION PA.

THIS IS THE FINAL STATEMENT.

SPECIAL WEATHER STATEMENT

NATIONAL WEATHER SERVICE PITTSBURGH PA
1140PM EDT TUE JUL 19 1977

...MUD SLIDES AND BASEMENT FLOODING IN JEFFERSON COUNTY PA...

AT ELEVEN TEN PM A SKYWARN OBSERVER REPORTED THAT HEAVY RAIN TONIGHT IN JEFFERSON COUNTY HAS CAUSED PARTS OF SANDY LICK CREEK TO OVERFLOW ITS BANK ON ROUTE NINE FIFTY BETWEEN FALLS CREEK AND REYNOLDSVILLE PA.

THERE WERE A FEW MUD SLIDES. SOME SMALL STREAMS IN THE AREA ARE WELL OVER THEIR BANKS. THERE WAS SOME BASEMENT FLOODING IN THE REYNOLDSVILLE AREA.

AS OF ELEVEN THIRTY THERE WAS STILL LIGHT RAIN OVER THE AREA. RESIDENTS SHOULD WATCH FOR FURTHER RISES OVER THE NEXT SEVERAL HOURS.

BULLETIN ACTIVATE EBS
FLASH FLOOD WARNING

NATIONAL WEATHER SERVICE PITTSBURGH PA
240AM EDT WED JULY 20 1977*

A FLASH FLOOD WARNING IS IN EFFECT UNTIL 4 AM EDT THIS MORNING JULY 20 1977 FOR PERSONS IN INDIANA AND CAMBRIA COUNTIES OF PENNSYLVANIA.

HEAVY RAIN AND SOME FLOODING HAS BEEN REPORTED IN THIS AREA. RADAR SHOWS HEAVY RAINFALL CONTINUING THRU THE AREA FOR THE NEXT HOUR OR SO.

PERSON SHOULD MOVE TO HIGHER GROUND IMMEDIATELY IF NEAR FLOODED STREAMS.

DO NOT ATTEMPT TO DRIVE ON FLOODED HIGHWAYS.

LISTEN FOR LATER STATEMENTS.

*This 2:40 a.m. warning was transmitted first on NAWAS at 2:35.

FINDING AND RECOMMENDATIONS

Finding 1: Numerical model guidance and subjective QPF guidance received at WSFO Pittsburgh and the zone forecasts they issued gave no indication of the abnormally heavy rainfalls that occurred in Pennsylvania on July 19 and 20. Additional guidance material, and techniques that allow forecasters at local offices to derive objective estimates of rainfall potential from synoptic scale and mesoscale data, are needed. This will require a substantial research effort.

Recommendation: NOAA should immediately initiate with the highest priority a coordinated R&D program to develop an improved capability for forecasting rainfall amounts associated with convective activity. Improved operational guidance products should be issued as soon as they can be developed.

Finding 2: The journeyman forecaster on the swing shift at WSFO Pittsburgh was concentrating on flash flooding,and his efforts were largely devoted to obtaining precipitation observations to the north of this disaster area, due to lack of AHOS sites further south, lack of recognition of possible bias of D/RADEX precipitation estimates, and the expectation of thunderstorm dissipation. The priority given to severe weather, compared to flash floods, in directives and studies using radar data probably detracts from the use of radar data for flash floods by many observers and forecasters throughout the Nation.

Although radar coding did not indicate reorientation of the thunderstorm area, this should have been evident to the forecaster on the WBRR records he had available. Satellite imagery also showed continued development of thunderstorm activity prior to midnight, although this was not explicitly pointed out to the forecaster by SFSS.

Recommendation: NWS should develop improved radar and other operating directives that emphasize flash flood producing rainfall situations. Training should be emphasized in the recognition of radar and satellite patterns favorable for heavy rainfall and in the limitations of forecast guidance and remote-sensing precipitation estimates. Development of meteorological training will depend upon model improvements and on the recognition of synoptic and mesoscale features favorable for heavy rainfall. However, preliminary training can utilize what has been learned about the meteorology of recent flash flood disasters, and from several on-going NWS and NESS local studies.

Finding 3: Investigation of this and other recent major flash flood disasters clearly indicate that most field forecasters have difficulty with forecasting rare events. Duty forecasters do not have the formal training or experience necessary to monitor and forecast the mesoscale phenomena causing the amounts or rates of rainfall that cause flash

floods, nor do they have the time to carry out their routine duties, to monitor severe weather events, and to perform the analysis required. However, the duty forecaster, to perform his warning functions must be involved. A procedure is needed to redirect the efforts of the warning office and perhaps bring in added staff when warranted, but especially to determine when warranted.

Recommendation: NWS should model the flash flood warning program more closely after the hurricane and tornado warning program. A unit should be established or made part of a central office such as the National Severe Storms Forecast Center to issue heavy rainfall guidance for general areas. Field offices would still have responsibility for issuing flash flood watches and warnings for their specific areas of responsibility. Such a National unit could develop the required skills, adequately train personnel,and apply existing data sources and derived forecast products.

CHAPTER 5.

WARNING DISSEMINATION AND COMMUNITY PREPAREDNESS

Warning Dissemination

Numerous channels are involved in getting warning information to the public and local officials in western Pennsylvania. From the warning office, in this case WSFO Pittsburgh, warnings are sent directly over the National Warning System (NAWAS), NOAA Weather Radio (NWR), NOAA Weather Wire Service (NWWS), and telephone. From these channels, warnings are sent over the wire services, radio and television broadcasts, and facilities of the State or local law enforcement agencies. The following sections describe in more detail the effectiveness of these channels the night of the flood.

National Warning System (NAWAS). This telephone hotline system, operated nationally by the Defense Civil Preparedness Agency (DCPA), has in the past proven quite effective in disseminating warning information to local officials and supplying feedback of storm reports to the NWS warning offices. In western Pennsylvania, this channel's effectiveness, particularly for feedback, is limited by lack of local drops. NAWAS locations are at State police barracks at Punxsutawney, Butler, Greensburg, Washington, and Hollidaysburg. There are no drops in Cambria, Indiana, Somerset, Bedford, or Clearfield counties. There is no evidence that the warnings issued on NAWAS reached the flooding area.

WSFO Pittsburgh requested feedback about hail, high winds, or flooding when sending the 4:00 p.m., July 19, flash flood warning over NAWAS. A similar request accompanied the 2:40 a.m. flash flood warning, issued first over NAWAS at 2:35 a.m. on the 20th. Shortly after 7:00 p.m., a report of moderate rains from Parker in Clarion County came in on NAWAS. No further feedback was received on this channel the remainder of the night.

NOAA Weather Radio (NWR). The NOAA Weather Radio transmission from WSFO Pittsburgh reaches into the western portions of Westmoreland County but does not cover the area hard-hit by the flood. This station became inoperative about 9:00 p.m. on July 19. The electronic technician at WSMO Pittsburgh was immediately notified, and the station returned to the air by 11:00 p.m. Warnings and statements issued by WSFO Pittsburgh were broadcast over NWR while the station was operating. Additional NWR installations scheduled for the summer of 1978 will provide coverage for the Johnstown area and the other counties affected by the flood.

NOAA Weather Wire Service (NWWS). This teletypewriter channel, which provides hard copy of all warning information, is available to anyone who wishes to pay for the teletypewriter equipment rental and line charges. Unfortunately, few radio and television stations in western Pennsylvania subscribe to this service. Broadcasters interviewed indicated that the high cost of these charges (latest cost estimated are between $75 and $100 per month) severely restrict its use in western Pennsylvania. In other parts of the country some stations make the wide assortment of weather information and the instant availability of warnings on NWWS pay off in increased revenues from program sponsors. In WSFO Pittsburgh's country warning area, subscribers are located only in Pittsburgh and in Wheeling, West Virginia. Other radio and television stations in the area who need hard copy of such warnings rely on the wire services (AP, UPI), which relay this information as they receive it on NWWS. When WSFO Pittsburgh issues a warning on NWWS, a call is placed to both AP and UPI to make sure it is received. The relay of warning information over the wire services does cause delay in dissemination. In the case of short-period warnings, as for tornadoes or flash floods, this delay can be crucial. This will be discussed further in the section on mass media dissemination.

Telephone. As noted earlier in this report, telephone service in parts of the flooded area ended prior to midnight. However, a call from Johnstown at 2:30 a.m. to WSFO Pittsburgh indicates service was at least partial in that area at that time. This call provided the forecaster with some information on which he based his 2:40 a.m. flash flood warning.

The dissemination checklists used by WSFO Pittsburgh require telephone calls to several individuals. It took 18 minutes to complete dissemination of the 4:00 p.m. warning, and more than 30 minutes to disseminate the 2:40 a.m. flash flood warning. These dissemination times are too long for flash flood warnings.

Mass Media Dissemination. While daytime and evening coverage by radio and television is very good over the area hit by the flood, only a few stations were scheduled to be on the air after 1:00 a.m. Figure 17 shows the location of radio stations in the area. When the flash flood warning was issued at 2:40 a.m. on NWWS, there was still one 24-hour station on the air in Johnstown.

The other 24-hour station reportedly had been knocked out by a power outage or lightning. The remaining station receives its weather warnings over a wire service, with this source reportedly being checked once each hour at that time of the night. The 2:40 a.m. warning was not seen by either of the two persons in the station before the basement room, which contains the teletypewriter, was flooded. Power in the basement was turned off sometime between 3:00 and 4:00 a.m. About 4:00 a.m. water was beginning to rise in the first floor broadcast studio and the station was forced off the air. The two people in the station escaped the building by breaking a window about 5:00 a.m. and succeeded in reaching a tree near the building, where they waited three hours for rescue.

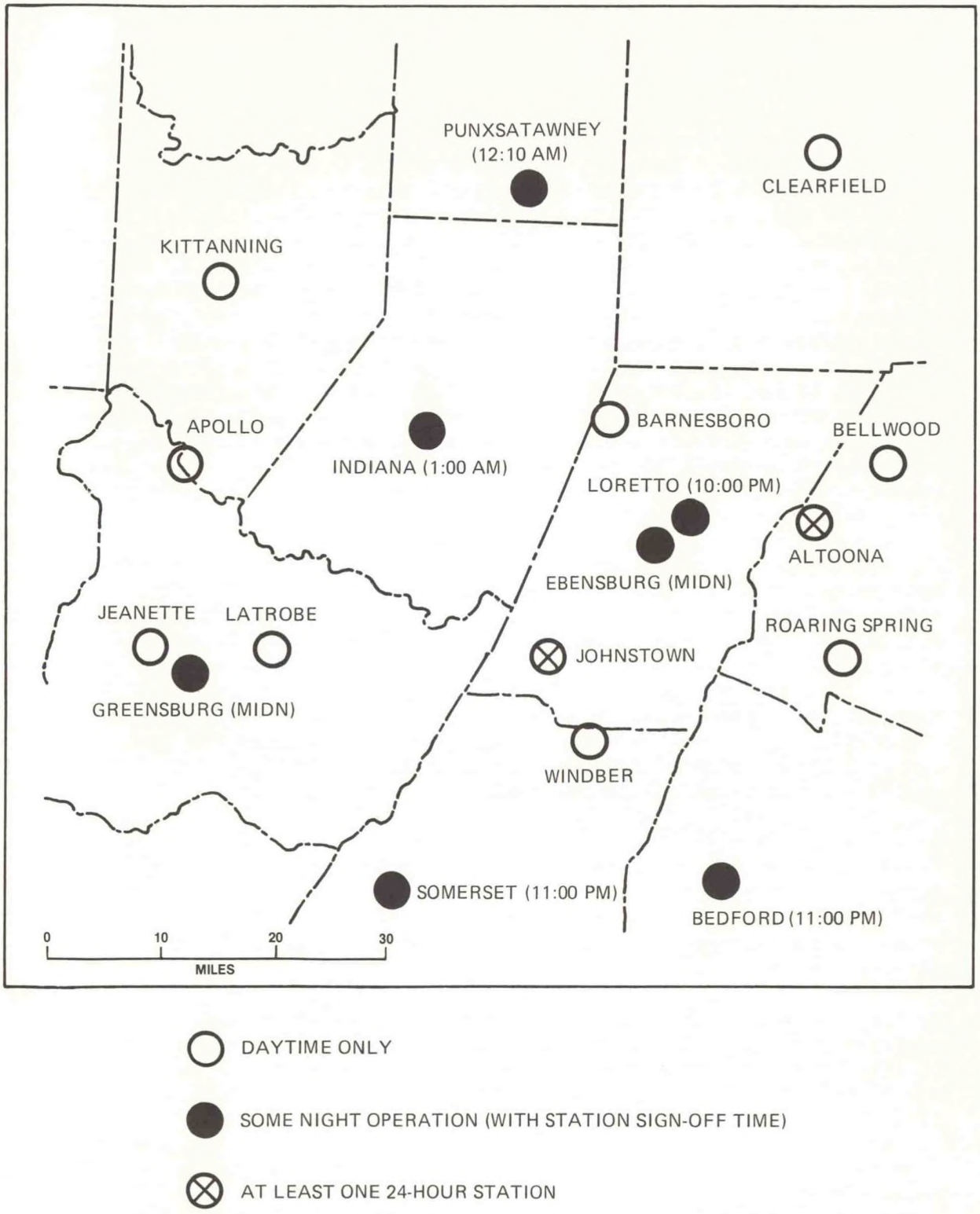


Figure 17. Location of Radio Stations in Flooding Area.

To speed the distribution of warnings, broadcasters in many areas voluntarily take part in the Emergency Broadcast System (EBS). Recently, an agreement between the Federal Communications Commission, the Defense Civil Preparedness Agency, and the National Weather Service revitalized the Nation's Emergency Broadcast System and authorized its use for short-fuse weather warnings. A key element in this effort is the holding of State seminars and workshops to develop specific written plans and procedures for use of EBS. Such plans and procedures have not yet been written for Pennsylvania, although EBS key stations do exist in the State with procedures generally set up for national and not for State and local emergencies. Seminars have been held in 26 States, and eight States have completed their written plans. By the end of this year, twelve other States, including Pennsylvania, are scheduled for the EBS seminars and workshops.

A request to use the EBS was included in the written warnings issued over NWWS at 4:00 p.m. and at 2:40 a.m. There is no indication that EBS was activated. The EBS key stations in Johnstown and in Altoona were not on the air when the 2:40 a.m. warning was issued. The forecaster did call the EBS key station in Pittsburgh and read the warning directly over the air shortly after 3:00 a.m.

The EBS station in Johnstown is WJAC. WJAC has a television station and both AM and FM radio stations. The television and FM radio stations reportedly left the air at 12:30 a.m. WJAC-TV uses a private meteorological service for its evening weather forecast. However, they do incorporate, on occasion, NWS issuances into their news segment of the program, not the routine weather segment. The forecast given to the announcer by the private meteorologist at 5:00 p.m. on July 19 was for a series of thundershowers north of Johnstown which were not expected to reach the city. A second routine call from the private meteorologist at 10:00 p.m. called for thunderstorms in the area.

In the meantime, WJAC-TV had received, over the UPI wires, the flash flood statement issued by WSFO Pittsburgh at 7:30 p.m. They carried this statement on the news segment of their program at about 11:35 p.m. (Ordinarily the news program would have started at 11:00 p.m., but its beginning was delayed until 11:30 p.m. because of the telecast of the all-star baseball game).

As for the Pittsburgh WSFO special weather statement issued at 11:40 p.m., mentioning mud slides and basement flooding in Jefferson County about 60 miles north of Johnstown, it appears that no mention was made on the air of this situation. It also appears that the Johnstown Mayor's declaration of a flood emergency in his city shortly before midnight did not go out over the air on WJAC-TV before the station lost power and was shut down at 12:30 a.m. WJAC radio, although under the same management and housed in the same building as the television station, uses a different source for weather information--namely, the Associated Press Radio Wire. The radio announcer who worked until 11:00 p.m. called the station about midnight to report that there was a lot of water in the town and that

underpasses were blocked. The announcer on duty informed him that the city has been closed to all traffic. The team was later told the first word of any warning situation reached WJAC Radio at 1:40 a.m., too late to be broadcast. Content of this warning from the Mayor of Johnstown included advice to get to high ground. At 2:15 a.m. word was received that the Mayor had declared the city a disaster area.

Law Enforcement Communications. Pennsylvania has authorized the NWS to use the Commonwealth Law Enforcement Assistance Network (CLEAN) to distribute short-period warnings across the State. CLEAN is a high-speed computer-driven teletypewriter communications system that reaches into all law enforcement and State police offices in the State through a control point at Harrisburg. WSO Harrisburg is responsible for telephoning warnings for any point in the State to this control point. The warnings issued by WSFO Pittsburgh were sent over this system on July 19-20. The flash flood warning issued at 2:40 a.m. was transmitted over the CLEAN circuit about 3:00 a.m.

In the Johnstown area, some police and fire radio communications were disabled by power outage about 1:30 a.m.

Private Citizen Communications. It should be noted that numerous newspaper accounts mentioned the effective use of CB radio to make emergency calls during the flood after commercial power and telephone channels has failed.

Dissemination by WSFO Pittsburgh. The WSFO uses dissemination checklists for the various watches and warnings released. The forecaster who issued the 2:40 a.m. warning inadvertently used a flash flood watch checklist rather than a flash flood warning list. The primary difference between the two lists lies in the inclusion of the EBS stations on the warning list and not on the watch checklist. In this instance, the forecaster realized that the Pittsburgh EBS station was one of the few on the air and called this station after he had completed the calls on the list he used. There were some calls he made which are not required by the warning checklist, and he made all the dissemination calls by himself. This lengthened the time required for disseminating this warning. The warning was not called to the central area Civil Defense headquarters as required by the checklist, since the forecaster did not realize that Cambria County is in that Civil Defense area. These events point up the need for more frequent drills in warning preparation and dissemination.

An examination of the Station Duty Manual at the WSFO shows that the list of radio and television stations in the WSFO's county warning area is not up to date. This list was made up in 1970. Some deletions have been made and some new stations added, but this list was not current. Of cricital importance was the fact that two radio stations in Johnstown

are 24-hour stations. One of these stations was listed, but without the hours of operation; the other station was not listed. Furthermore, no listing is given for nearby stations in the WSO Harrisburg County responsibility area. A station in Altoona (not the EBS station) is on the air around the clock and would have been a prime candidate for calling with a warning at 2:40 a.m.

Community Preparedness

Participation in community disaster preparedness by WSFO Pittsburgh has been limited because of a lack of a disaster preparedness meteorologist and shortage of travel funds. An exception is the volunteer SKYWARN observer network, consisting of 78 observers, established in western Pennsylvania. Reports of heavy rain or flooding were received at the WSFO after 11:00 p.m. on July 19 from SKYWARN observers at Reynoldsville, north of the heavily flooded area, and Hooverville, south of the area. These SKYWARN observers have been trained to report severe weather, i.e., severe thunderstorms, tornadoes, large hail, and are generally not furnished rain gauges nor requested to report rainfall amounts. Rainfall information was the critical need the night of July 19-20.

Personnel from WSFO Pittsburgh visited counties in the flood area during 1976 to promote the Emergency Broadcast System and to locate sites for NOAA Weather Radio. NWS Personnel have not visited the area to discuss flash flooding in over two years. However, in February 1977, western Pennsylvania was alerted to spring flood potential from ice jams and snow melt and the WSFO and Corps of Engineers had a flood preparedness meeting in Pittsburgh in which over 200 people from many communities participated. Also, on May 9 of this year, the MIC at WSFO Pittsburgh sent a letter to school superintendents, radio and TV station managers, and all County Civil Defense officials in the Pittsburgh warning area to promote local preparedness efforts against severe thunderstorms, flash floods, and tornadoes. In part, this letter advised, "Flash floods can also occur anyplace near small streams and valleys of Western Pennsylvania and the West Virginia Northern Panhandle. The floods in and near Wheeling in September 1975 give a good example of the damage that can result when slow moving thunderstorms give excessive rainfall in a small area." The WSFO planned to follow up this letter with personal visits, but a shortage of personnel, including the MIC's absence following a heart attack, made it necessary to forego these visits. The letter requested recipients to call the WSFO if they needed more copies of safety brochures or had any questions. The response was limited: four schools, two newspapers, and none from radio, TV, or Civil Defense.

Of the counties listed in the disaster declaration, only Westmoreland County officials have requested assistance from the NWS to set up a countywide flash flood plan. Meetings were held in early 1972 to begin work on this plan. River and rainfall networks were installed, observers trained, but not enough river data have yet been collected to develop forecast procedures. This responsibility lies with personnel from the

River Forecast Center in Cincinnati. It should be noted that the plan calls for the observing network to be activated by a flash flood watch; i.e., it is not self-activating. No heavy rains fell over the network in Westmoreland County.

The flood protection projects completed after the 1936 Johnstown flood have proved very effective for over thirty years. Residents and officials of the Little Conemaugh River Basin believed they were flood free. The Westmoreland County Tribune Review on July 21 captioned a flood picture: "They said it couldn't happen again." The Johnstown Tribune Democrat editorialized on July 20 that "All of us believed the city [to be] flood free."

Interviews with Civil Defense officials in Indiana and Cambria Counties clearly show that planning necessary to cope with a major flash flood had not been completed. Local flash flood warning systems have not been established. Identification of flood plain areas that require evacuation has either not been made or requires updating. Critically needed emergency communications were not available during the night and in many areas were not functioning until over 12 hours after the flood had ended.

Planning for flash floods needs the combined efforts of NWS, local officials, and the public. In western Pennsylvania, the completion of this planning is most urgent. Other than the preliminary attempts in Westmoreland County, there are no local flash flood warning systems in western Pennsylvania. This disaster clearly demonstrated the need for NWS to assist communities in establishing local volunteer observer networks, in installing simple rain gauges, river gauges, and flash flood alarms and in developing easy-to-use local floodstage prediction procedures. Such local flash flood warning systems permit communities to relate a watch or warning to their immediate problem or to react if a watch or warning is not possible.

FINDINGS AND RECOMMENDATIONS

Finding 1: Dissemination of the 2:40 a.m. flash flood warning was very limited, due to scarcity of media outlets, lack of NWWS subscribers, and power or telephone outages in the flooding area. However, available channels (NAWAS, radio stations still on the air) were not utilized to the fullest possible extent.

Recommendation: The NWS should:

(a) Encourage more use of NWWS by radio and television stations in western Pennsylvania.

(b) Expeditiously proceed with the EBS seminars and workshops scheduled for Pennsylvania.

(c) Insure that station duty manuals in all NWS warning offices include current listings of radio and television stations, their phone numbers, and hours of operation.

(d) Encourage a re-evaluation of the location of NAWAS drops in Pennsylvania and request the establishment of procedures for acknowledgment of warnings and use of this channel for reporting significant weather and flood conditions. These two-way communication channels throughout the nation should be used to get information on flash flooding out of the flood area, to NWS and State officials, as well as into the flood area.

(e) Encourage local ham radio or CB operators to organize into an effective natural disaster emergency communications system.

Finding 2: The forecasters working the midnight shift at WSFO Pittsburgh were not adequately trained in the dissemination of flash flood warnings.

Recommendation: More frequent and comprehensive drills in issuing various types of warnings are definitely recommended for WSFO Pittsburgh. Furthermore, NWS should establish performance standards to insure that station personnel in warning offices maintain proficiency in warning procedures.

Finding 3: Preparedness activity for flash floods was not adequate to cope with this event. There is no preparedness specialist on the staff at WSFO Pittsburgh and staff shortage due to illness and training assignments curtailed this year's county visitation efforts. A professional hydrologist on the staff at WSFO Pittsburgh has not been utilized in the flash flood preparedness effort. Furthermore, action by the NWS to complete a local flash flood warning system for Westmoreland County has lagged. Elsewhere in the heavily flooded area, there was little or no local interest in establishing these vital local flash flood warning systems.

Recommendation: NOAA should continue with its efforts to complete staffing the Disaster Preparedness program. This will include a preparedness specialist at WSFO Pittsburgh. In the meantime, NWS should insure that all personnel, including hydrologists, in WSFOs play an active role in the flash flood program. If illness and training assignments are adversely affecting what should be routine county visitation efforts, Regional Headquarters and NWS Headquarters should take action to detail personnel from other offices to assist in these necessary tasks. The local flash flood warning system for Westmoreland County should be completed as soon as possible, and action taken to encourage the establishment of such warning systems in other flash flood prone areas.

FINAL PERSPECTIVE

The basic conclusion reached by the survey team was that on the disastrous night of July 19-20, 1977, neither the National Weather Service component of the Flash Flood Warning System nor that part of it involving local communities and Civil Defense did much good for anyone in the Johnstown, Pennsylvania, area.

As far as the NWS programs were concerned, most of the equipment performed about as one expects it to perform, meaning there were minor but no major failures. By the same token, most of the personnel did approximately what they were supposed to do. This means there were some departures from procedures outlined in directives, but none that were so overtly deficient that disciplinary action is warranted. It also means that most of the personnel did not rise to the opportunity to provide superior performances in the presence of a relatively unique weather event.

It is hoped that this report with its findings and recommendations will strengthen the Flash Flood Warning Program in western Pennsylvania and provide lessons and applications to other local communities and broader regional and national plans and programs as well.

GLOSSARY OF ABBREVIATIONS

AHOS	Automatic Hydrologic Observing Station
D/RADEX	Digitized Radar Experiment
EBS	Emergency Broadcast System
IR	Infrared
MDR	Manually Digitized Radar
MIC	Meteorologist-in-Charge
NAFAX	National Facsimile Network
NAWAS	National Warning System
NESS	National Environmental Satellite Service
NMC	National Meteorological Center
NSSFC	National Severe Storms Forecast Center
NWR	NOAA Weather Radio
NWS	National Weather Service
NWWS	NOAA Weather Wire Service
QPF	Quantitative Precipitation Forecast
RAWARC	Radar Reports and Warning Coordination System
RFC	River Forecast Center
SFSS	Satellite Field Services Station
WBRR	Weather Bureau Radar Remote
WSFO	Weather Service Forecast Office
WSMO	Weather Service Meteorological Observatory
WSO	Weather Service Office