Natural Disaster Survey Report

Pike-Buchanan Flash Floods of July 15, 1979

National Weather Service, NOAA
U.S. Department of Commerce
Silver Spring, Maryland

October 1979

PREFACE

The Natural Disaster Survey Team named to investigate the Pike County, Ky., and Buchanan County, Va., flash floods of Sunday, July 15, 1979, was comprised of:

R.L. Carnahan, Team Leader and Chief, Weather & Flood Warnings Coordination Staff, NWS* Headquarters, Silver Spring, Md.

A.F. Flanders, Assistant to Associate Director, NWS (Hydrology), NWS Headquarters, Silver Spring, Md.

Lars O. Feese, Hydrologist in Charge, River Forecast Center, Harrisburg, Pa.

Ronald A. Willis, Principal Assistant, Weather Service Forecast Office, Minneapolis, Minn.

Dr. Walter J. Saucier, Consultant, Professor of Meteorology, North Carolina State University, Raleigh, North Carolina

The team gathered in Louisville, Ky., July 24, and began the survey July 25, traveling to Charleston, W. Va., into the flooded areas of Pike County and Buchanan County and terminating July 27 in Tri-Cities, Tenn. Primary areas reviewed were:

1) internal NWS operations;

2) community preparedness and individual public response; and

3) flash flood observation system and local warning aspects of the Appalachian pilot flash flood program.

Media response was not a part of the survey since no flash flood watch or warning had been issued for the event by NWS.

The event was a series of classic flash floods occurring from intense thunderstorms over a small area on the order of a 15-mile diameter circle in the steep mountainside country of Appalachia in extreme eastern Kentucky in the headwaters of the Tug Fork of the Big Sandy River.

Three deaths were reported as direct results of the flash flood and damages may reach $13 million in Pike and Buchanan Counties.

Assistance was provided by numerous individuals in the conduct of the survey but the help of the Appalachian Regional Commission (ARC) office in Pikeville, Ky., was invaluable. Mr. Keith Kelly, Director Central Appalachian Development Project, ARC, made the arrangements that permitted the team to meet with local and State officials in the two counties. Messrs. Benny Ward and Allan Reed of ARC accompanied the team into the disaster area. Mr. Robert Morrison, Regional Coordinator, Kentucky Disaster Emergency Services, was most helpful in guiding the team to the areas that received flood damage. Mr. Stanley Schneider of NOAA NESS* performed a special analysis of satellite imagery.

Cover picture of Majestic, Ky., on Poplar Creek courtesy Dave Chaffins, Pike County, Ky., Information Officer. Photographs in Figures 2.3 and 2.4 were taken by A.F. Flanders during the survey.

* U.S. Department of Commerce
NOAA - National Oceanic & Atmospheric Administration
NWS - National Weather Service
NESS - National Environmental Satellite Service

1. Summary, Findings and Recommendations

Indications from eyewitness accounts, local disaster services officials, firsthand examination of the flooded areas and data sources available to the NWS all lead to the conclusion that the storm activity that produced the flash flooding was concentrated over a very small area. Rainfall was intense and of short duration. The steep terrain contributed to the rapid runoff, causing a classic flash flood situation.

The NWS observing system is not sensitive enough to detect these small scale short-lived events. The scale of the event was so small that the usually accepted practices in the field offices failed to reveal its significance. The problem was further aggravated by its occurring on the midnight shift when staffing was at a minimum. The Louisville staff was preoccupied by an even stronger system to the west of WSFO Louisville. Neither the satellite imagery nor the radar information available to the duty forecasters was of significant intensity to warrant special attention.

Although the pilot flash flood program is in its beginning stages in both Pike and Buchanan Counties, no real-time surface reports of rainfall are currently available for monitoring. Flash flood rainfall observers were scattered through the area but none lived in the area of heaviest rainfall. When they did communicate among themselves and to their coordinators and local officials none of this information ever reached NWS channels until routine reporting time the following morning after the flood was over. Loss of life was undoubtedly kept low by the fact that most residents were either awake or awakened by the thunderstorms. As stated by one Flash Flood Coordinator "There was no way on God's Green Earth you could have warned those people." There was no great criticism of the NWS for not detecting the storm and issuing a timely warning. This event demonstrates that local initiative and individual response is vital to protect life and property from flash floods in such rugged terrain.

Finding 1

NOAA Weather Radio false tone alerts have created a loss of confidence in the system. The low power output of the repeater at Pikeville has also limited its usefulness.

<u>Recommendation 1</u>

Examine NOAA Weather Radio transmitters within range of Pike and Buchanan Counties to detect any possible source of false turn-on tone alerts at the transmitters. Advise state and local personnel of probable causes of malfunctions of receivers.

Finding 2

There was a serious lack of real-time rainfall reports available to radar operators and offices with watch/warning responsibility. Some local volunteer observation sites currently have no backup to compensate for locations that are closed at night or on weekends.

Recommendation 2

Increase recruiting activity in both Kentucky and Virginia in an effort to obtain more observers and improve observation site coverage.

Finding 3

The flash flood rainfall reporting network did not respond. Early reports of flooding and other indicators of a potentially serious situation were not passed along to the NWS. Training programs of both police and community flash flood observers, when implemented, have been beneficial to improved response.

Recommendation 3

Expand training of flash flood cooperative observers to improve understanding of mutual roles of observers and NWS forecasters and to increase the number of real-time reports.

Finding 4

Improved data sources and communications in the 12-county area are necessary for more assessment of extent and magnitude of flood events.

Recommendation 4

Continue and accelerate when possible installation of automatic reporting rain and stream gages in the area.

Finding 5

Warning responsibilities in the 12-county area should be reviewed to assure maximum coordination and optimum communications.

Recommendation 5

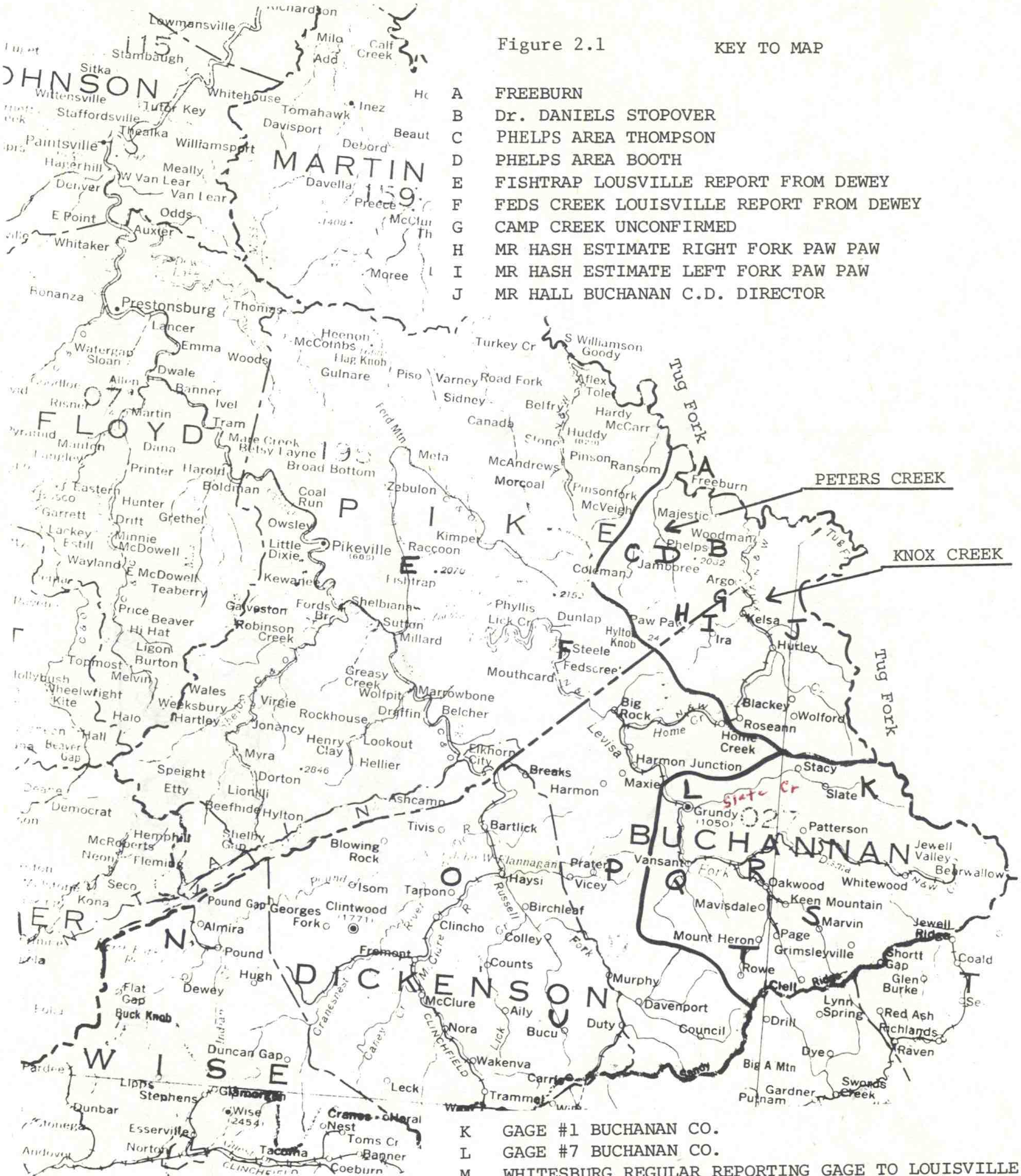
Initiate an examination of NWS warning responsibility assignments in the 12-county area with a view toward shortening communications lines and facilitating warnings operations.

2. The Flash Floods

Thunderstorm rainfall in the early morning hours of Sunday, July 15, 1979, caused extensive flooding to numerous small creeks in the headwaters of the Tug Fork of the Big Sandy River basin. A resident along one of these small creeks said "It started at 3 a.m. like pouring out of a bucket, but close to 5 a.m. it sounded like a transformer exploding and then all hell broke loose." That was the description of how the waters came down Camp Creek, one of the typical creeks in the basin. The event was over around 7 a.m. EDT.

Figure 2.1 KEY TO MAP

A FREEBURN
B Dr. DANIELS STOPOVER
C PHELPS AREA THOMPSON
D PHELPS AREA BOOTH
E FISHTRAP LOUSVILLE REPORT FROM DEWEY
F FEDS CREEK LOUISVILLE REPORT FROM DEWEY
G CAMP CREEK UNCONFIRMED
H MR HASH ESTIMATE RIGHT FORK PAW PAW
I MR HASH ESTIMATE LEFT FORK PAW PAW
J MR HALL BUCHANAN C.D. DIRECTOR



K GAGE #1 BUCHANAN CO.
L GAGE #7 BUCHANAN CO.
M WHITESBURG REGULAR REPORTING GAGE TO LOUISVILLE
N NORTH FORK REGULAR REPORTING GAGE TO LOUISVILLE
O FLANNAGAN REGULAR REPORTING GAGE TO LOUSIVILLE
P GAGE #9 BUCHANAN CO.
Q GAGE #6 BUCHANAN CO.
R GAGE #3 BUCHANAN CO.
S GAGE #5 BUCHANAN CO.
T GAGE #4 BUCHANAN CO.
U BUCU

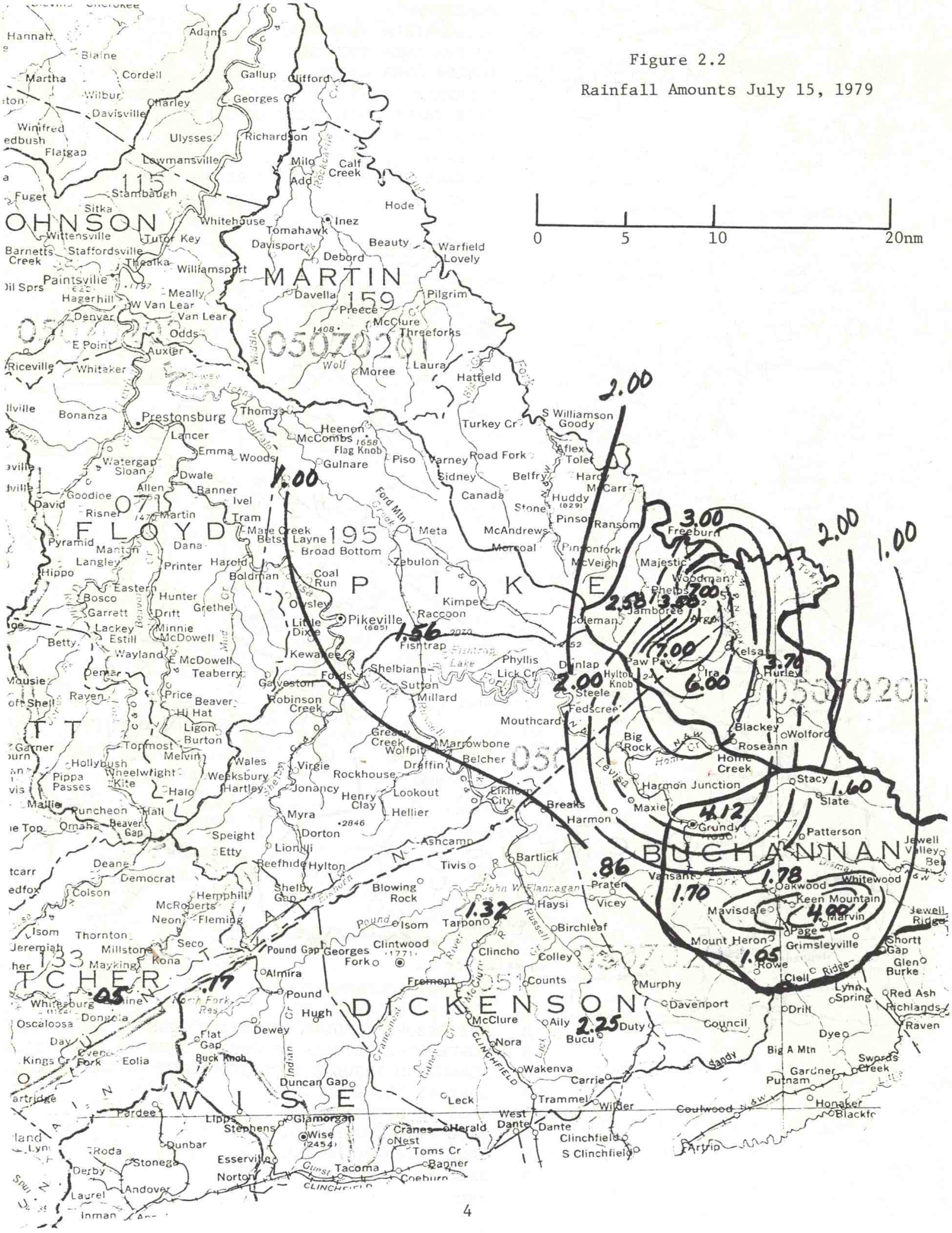


Figure 2.2

Rainfall Amounts July 15, 1979

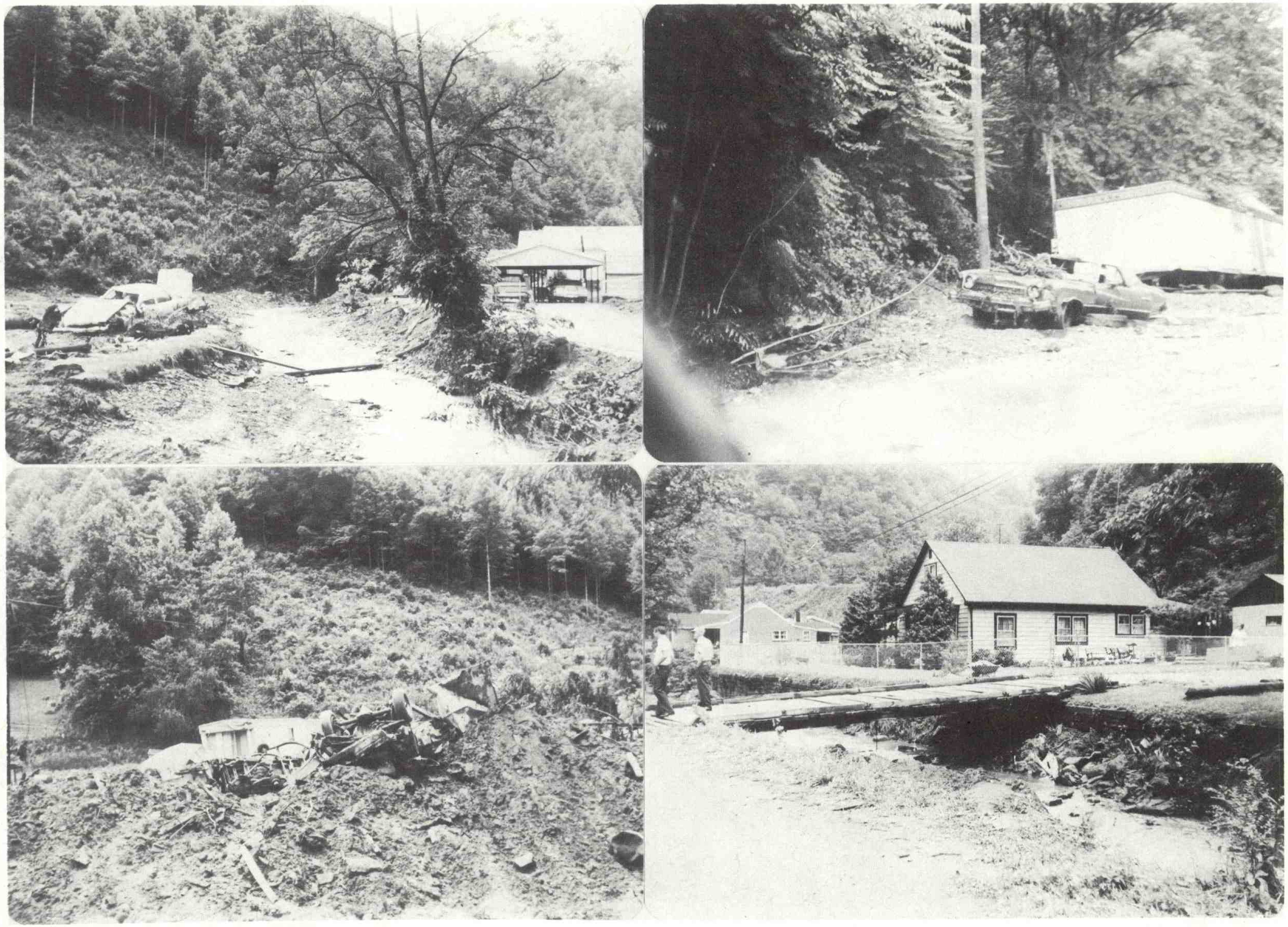


Figure 2.3

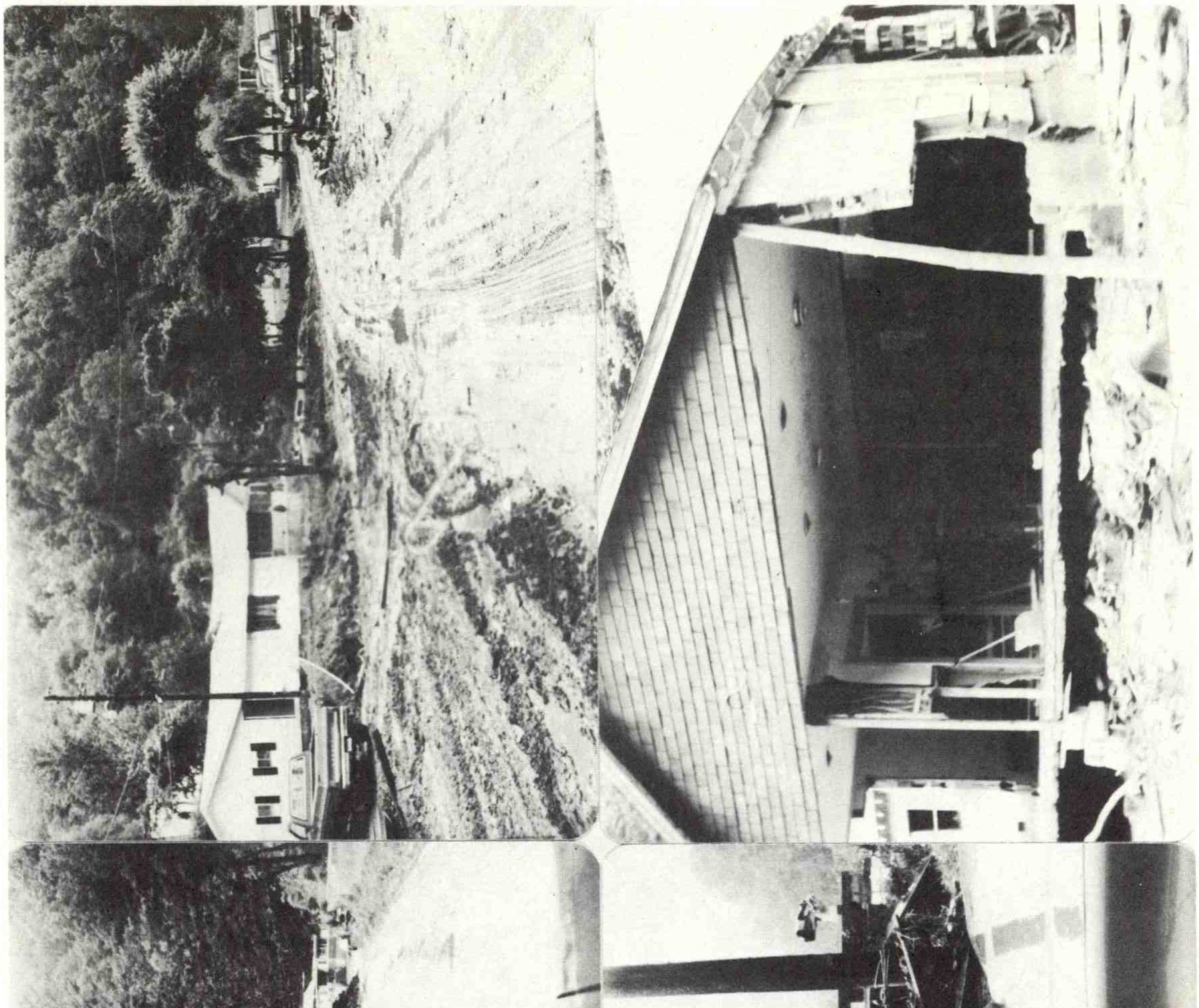


Figure 2.4

There were two confirmed deaths and a 4-year old child is missing and presumed dead from the flood.

Property damage is reported at $2.6 million in Buchanan County with disaster survey reports indicating a possible final figure of $6 to 8 million. In Pike County $2.4 million is reported with possible upper limits of $6.5 million.

Rainfall locations (figure 2.1) and amounts (figure 2.2) show the concentration of heavy rainfall in a small area with general estimates of 6 to 7 inches.

Damage survey reports indicate more than 250 homes destroyed or damaged in Pike County and about 200 homes in Buchanan County. Several hundred people were evacuated to public shelters. More than 250 private bridges of the kind in figure 2.3 (lower right) were destroyed. About 50 miles of public road and a dozen bridges were destroyed (figure 2.4).

Events during the early morning hours, as reconstructed from information furnished by the Flash Flood Coordinators in Pike County and Buchanan County:

BUCHANAN COUNTY, VA

Report of Flash Flood Coordinator - John Hash - Grundy, VA

County Civil Defense Director - Mr. Hall

Times (EDT)

3 a.m.	Mr. Hash noticed thermal buildups northwest of area.
5:30 a.m.	Mr. Hash was called by employee with information on creeks washing out.
5:35 a.m.	Mr. Hash called dispatcher at Grundy. They reported 4.2 inches of rain.
Approx. 6 a.m.	Mr. Hash called CD Director in Hurley area. He had 2.7 inches and still raining. Storm total amounted to 3.70 inches. CD Director is Mr. Hall.
7 a.m.	Mr. Hash arrived at Grundy and confirmed 4.2 inches.
	He proceeded to call gages to locate his trouble area. Called northwest area at Indian Creek Gap, Boyd gage read .70. Total for Boyd, 1.05 inches.
	He tried with no success to reach the #1 Rife-Slate gage--no response.
	By this time he felt he knew where his trouble area was and proceeded to take care of his problem areas.

Gage Reports in Flash Flood Program

Pcpn	Gage	
1.60"	1	Rife-Slate NW of Grundy
	2	No observer
1.78"	3	Janey SE of Grundy towards Richlands
1.05"	4	Boyd Indian Creek Gap
4.00"	5	Marvin SE East on 460 from Grundy
1.70"	6	Short near Deel on Route 460
4.20"	7	Grundy
3.70"	8	Pounding Mill Hall
.86"	9	Prater Airport

None of these gages drain into the Knox Creek or Peter Creek drainage.

Mr. Hash's estimates are: Right Fork of Paw Paw 7"; Left Fork of Paw Paw 6" by bucket measurement.

PIKE COUNTY, KENTUCKY

Report of Flash Flood Coordinator - Joyce Hale, Pikeville, Ky.

Pcpn	
2.58"	Phelps area - Thompson, 2 miles out of Phelps area towards Pineville. This gage was not read immediately.
3.50"	Phelps area - Booth, South edge of Phelps - gage was read immediately.
unknown	Solid Waste Treatment Plant - Wolford, gage was cracked and possibly had been emptied. When Benny Ward, ARC, arrived there was 2.31 inches in gage. Probably not connected to this particular storm. Gage is located 4 miles from Phelps towards Pineville on right fork of Peter Creek.
6.50"	Stopover - Dr. Daniels, 7 inches was reported, however 6.50" was reported on Form E-16 sent to Louisville WSFO. It is confirmed the gage is located on the side of a telephone pole. Station is located one mile south of Stopover on Turkey Creek.
13:00" unconfirmed	Camp Creek area - Thursday, July 16 still unable to confirm this report. Benny Ward, ARC, was in the area and unable to find the gage. The lady with the baby who was awake at 5 a.m. when storm started and at 5:45 a.m. observed water out of the creek. NOTE: Highway patrol investigated with follow-up by ARC determined initial report of 13.00" was in error, somehow confused with report from stopover.
7" to 9"	Estimated in swimming pool along right fork Peter Creek between 3 - 6 a.m.

3. The Flash Flood Warning System

The systems designed to protect our citizens against flash floods --which, like tornadoes and severe thunderstorms, are short-fused and generally localized hazards -- rely on elements of the National Oceanic and Atmospheric Administration (NOAA), National Weather Service (NWS), 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. 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.

Whenever possible, NWS attempts to issue timely watches and warnings of flash floods. In those situations where flooding appears likely, in terms of expected precipitation and the ability of the ground to absorb it or for the stream to handle it, flash flood "watches" are issued in advance. These watches serve to alert local officials and the public, as well as NWS personnel in smaller warning offices, that flash flooding is possible. But NWS capability to predict heavy or extreme rainfall amounts over small areas is limited. This "watch" phase has therefore not been very successful for summertime flash floods. Only slightly more successful, but still not adequate, is NWS 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 gages, direct measuring networks (which are not usually dense enough to cover very small drainage basins), estimates from remote sensors (radar and satellite), and reports from volunteer observers.

The local flash flood warning system is dependent on more direct local initiative and cooperation. In this approach, NWS hydrologists, meteorologists, and warnings coordination specialists prepare 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 for NWS 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 NWS is still 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. Where active community programs exist, the feedback to NWS to allow for downstream warning has been of high caliber and successful.

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

1. Weather Service Forecast Office (WSFO) Louisville, Ky., has weather forecast and flash flood watch responsibility for Kentucky and county flash flood warning responsibility that includes Pike County. WSFO Louisville is also responsible for hydrologic services in all of Kentucky. Louisville has a local warning radar about 170 nm from Pike County.

2. Weather Service Forecast Office (WSFO) Washington, D. C. has weather forecast responsibility for Virginia, Maryland, and Delaware and flash flood watch responsibility that includes Buchanan County.

3. Weather Service Office (WSO) Tri-Cities, Tenn., has local weather and county warning responsibility that includes Buchanan County. Tri-Cities operates a network radar about 75 nm from the flooded area.

4. 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.

5. 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.

6. NESS Satellite Field Service Station (SFSS), Kansas City, Mo., 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, Central, and Southern Regions and NWS Headquarters. Management of the SFSS resides in NESS Headquarters.

4. Meteorological Conditions

All regularly scheduled facsimile analyses and guidance charts originating from the National Meteorological Center (NMC) were available to forecasters at WSFOs Louisville and Washington, D.C. prior to the flood event.

The surface analysis for Saturday evening, July 14, showed a cold front extending from Ontario, Canada, southwestward through central Michigan, central Illinois, and into eastern Missouri. Prognostic charts indicated this front would move slowly southward during the next 12 hours, but remain north of Kentucky. Thunderstorms were indicated over the area. The front did move slowly southeastward through Sunday morning, July 15, and by 8 a.m. EDT was approaching the northern tip of Kentucky. A small high pressure ridge extended into extreme southeastern Kentucky from a high pressure center in the Gulf of Mexico, and remained nearly stationary from Saturday evening through Sunday morning. Analyses and prog charts at the 850 mb and 700 mb levels during the same period reflected the persistence of the Gulf of Mexico high pressure center and ridge at these levels. A weakening north-south short wave trough was evident at both levels moving over the top of the ridge and was located in western Kentucky by 1200 GMT Sunday. Wind flow was from the northwest at both levels with an average speed of about 15 knots.

At the 500 mb level, wind flow was from the north-northwest at 15 to 25 knots circulating around a weak high pressure center over western Missouri. The short wave trough was hardly evident at this level. The Barotropic, Baroclinic, and Limited Fine Mesh (LFM) model vorticity charts available on Saturday evening valid for Sunday morning indicated little vorticity advection of any kind over the flood area. Numerical values of vorticity were low. Cooling of about two degrees Celsius took place at the 500 mb level during Saturday night over the flood area, but the ridge continued to dominate.

At the 300 mb level Saturday evening, a weak ridge was situated north to south from central Kentucky southward to the Gulf of Mexico. This ridge drifted eastward but remained west of the flood area through Sunday morning. Winds were generally less than 10 knots from the northwest.

Atmospheric moisture is analyzed and forecast on several different charts available from NMC. The LFM 700 mb relative humidity analysis available Saturday evening placed most of the eastern quarter of the U.S. in an area of 70 to 90 percent relative humidity, including eastern Kentucky. By Sunday morning this moisture area was forecast to shift eastward, but with the westernmost edge cutting the eastern tip of Kentucky. The average relative humidity from the surface to 500 mb was above 60 percent over the eastern third of the U.S. on Saturday evening with the flood area experiencing about 70 percent from late Saturday through Sunday morning. Precipitable water was moderately high and changed little through the same period with an average value of about 1.70 inches. The lifted index was calculated to be minus 4 both Saturday and Sunday afternoon with a value of minus 1 Sunday morning. The K index averaged about 31. These indices were quite common over much of the southeastern third of the U.S. and indicate no extremes in atmospheric instability.

The LFM precipitation prog chart available early Saturday evening indicated no precipitation over the flood area Sunday morning. However, precipitation was indicated for much of central Kentucky and western

West Virginia. The man-made Quantitative Precipitation Forecast Chart from NMC indicated precipitation up to 0.25 inch over the flood area during the period. The Excessive Precipitation Forecast Chart did not indicate excessive rainfall over or near the flood area. The Hydrologic Flash Flood Guidance received from the Cincinnati River Forecast Center indicated a precipitation amount of 2.9 inches was needed in a three-hour time period to cause flooding in the area.

Neither WSFO Louisville nor WSFO Washington, D.C. issued a Flash Flood Watch prior to the flood event, although the evening forecasts did indicate the possibility of thunderstorms over the area. An analysis of the information available to the forecasters prior to the flood event indicated that a Flash Flood Watch would probably not have to be issued.

Surface and upper air analyses and prog charts contained little information to indicate that heavy rains should be concentrated over the flood area. Considerable moisture had been advected into the south central portions of the U.S. prior to the flood by a weakening low pressure center which was the remains of Hurricane Bob. However, equally moist air was evident over much of the southeastern part of the U.S. as well, and no one particular area could be singled out as suspect for heavy rains.

The flood producing thunderstorms did not form near the surface front, but rather formed just northwest of the flood area itself, which was well south of the front. Since the air was relatively unstable prior to the thunderstorm activity, the effect of the 500 mb cooling coupled with the presence of the weak 850 mb and 700 mb trough moving into the area resulted inadditional destabilization in the general area. This destabilization along with available moisture very likely accounted for the heavier precipitation that occurred over the flood area. However, these features looked very insignificant on the analyses charts available Saturday evening, July 14. There was no indication on the prog charts to cause the forecaster to suspect significant precipitation in the flood area. This was backed up by the fact that neither the NMC Quantitative Precipitation Forecast Chart nor the Excessive Precipitation Forecast Chart indicated significant precipitation for the flood area.

Satellite photographs and radar observations provide shorter time range tools which may be utilized for issuance of Flash Flood Watches and especially Flash Flood Warnings. Satellite photographs proved of limited value in this situation, leaving radar observations as the probable best tool. A post-storm analysis is described in Section 6.

Gridded infrared satellite photographs (resolution 5 nautical miles) were available at half-hour intervals at WSFO Louisville and Charleston prior to and through the precipitation period. Satellite photos beginning at 0600 GMT (2 a.m. EDT) Sunday, July 15, indicated two large areas of showers and thunderstorms approaching northwestern and northern Kentucky. Neither of these areas crossed over the flood area, but did occupy the attention of the forecasters through Saturday evening and into Sunday morning. At this same time a tiny dot appeared over eastern Kentucky, which was the activity that would ultimately grow into the thunderstorms that caused the heavy rains between 0700 GMT and 1000 GMT (3 a.m. EDT and 6 a.m. EDT). The satellite grid was not aligned correctly on the 0630 GMT and 0700 GMT photos, thus placing the developing storm area over eastern Tennessee on these two photos. Neither the Great Lakes nor the Gulf of Mexico was easily identifiable to help the forecaster correctly hand grid the photos. By 0730 GMT the grid was once again correct and remained so for the remainder of Sunday morning.

The cloud area over eastern Kentucky at 0600 GMT grew and intensified slowly through 0930 GMT after which time dissipation began. The second gray level was in predominance through 0830 GMT reaching approximately 60 miles by 100 miles in extent. A small black level area was evident at 0900 GMT and increased slightly by 0930 GMT before dissipating by 1000 GMT. The whole area was moving slowly toward the southeast over extreme eastern Kentucky and western Virginia.

Radar information was available from the WSR-57 network radar at the Tri-Cities airport near Bristol, Tennessee (TRI) and the WSR-74 local warning radar at Charleston, West Virginia (CRW). The Tri-City Weather Service Office is located about 60 miles south of the flood area and the Charleston Forecast Office about 60 miles to the northeast. Hourly overlays were available from TRI with observations taken about 30 minutes past each hour. There is no requirement to prepare overlays at CRW, but several were available during the early hours of the morning on Sunday, July 15. Neither radar is monitored continuously as station duties require the radar meteorologist to perform other assignments in addition to radar.

Precipitation appeared to move into the flood area first about 0600 GMT with echoes moving over the area until about 1100 GMT at which time all activity had moved to the east. Overlays indicated that as many as four individual thunderstorm cells may have moved over the flood area during this time period. Cell movement was from the northwest at an average of 17 knots. Video Integrator and Processor (VIP) levels of the strongest cells as observed at TRI were level 3 with maximum tops between 31,000 and 39,000 feet MSL. Charleston radar indicated an occasional VIP level 4 and similar maximum tops except for a top of 45,000 MSL at 0900Z corresponding to a VIP level 4 over the flood area at that time.

This corresponds closely to the time of maximum intensity indicated by satellite photos. Level 3 VIP corresponds to an estimated precipitation amount category of 1.1 to 2.2 inches per hour, while the VIP level 4 category is 2.2 to 4.5 inches per hour. Some attenuation may have taken place due to the ground clutter in the hill and mountain area north of TRI. Also, the VIP 4 levels at CRW could have occurred at a time when the TRI radar was not being monitored.

Manually Digitized Radar (MDR) values are transmitted by the TRI office and were available to the forecasters at neighboring NWS offices. However, with no value greater than 3 entered in the MDR grid square during any one hour, flood producing rain was not suspected. The TRI office does not issue narrative radar statements at night due to lack of personnel, and personnel on duty early Sunday morning did not think the precipitation was of such significance as to warrant an information call to WSFO Louisville, which has Flash Flood Warning responsibility for Pike County, Kentucky. (The TRI office has Flash Flood Warning responsibility for Buchanan County, Virginia.) The Charleston WSFO did make two calls to the Huntington WSO during the early morning hours to discuss the precipitation event.

Probably the most significant information to be gleaned from the hourly radar overlays from TRI is the likelihood that several cells moved over or very close to the flood area in a period of three to four hours. If the strongest thunderstorms moved through late in this period, which seems to be the case, the heavy precipitation would have fallen on saturated ground and would have fed into already rising creeks and streams. Real-time detection of this pattern would require constant monitoring of the radar scope, which can be done effectively only with radar data processing equipment, such as is planned for installation in the 1982-85 time frame. Monitoring of the radar echoes can be increased by calling in extra help on overtime, if conditions warrant.

At Bristol, during the night of the flood, normal staffing was maintained. No scheduled radar observations were missed. Weather conditions did not warrant calling in extra staff to assist in continuous monitoring of the radar scope. Even if extra help had been available, it is doubtful that the flooding situation would have been indicated by the radar using manual techniques.

In summary, analyses and prog charts were of little help in aiding the forecasters to predict the occurrence of such locally heavy rain in advance. Satellite photos did indicate a slowly expanding area of precipitation over the flood area. However, the size and intensity of the area looked rather insignificant, especially compared to the other areas of precipitation in the same general area for which the forecasters were responsible. Radar could have been of some value in detecting heavier precipitation over the flood area, but the identification of any train of cells that may have moved over the area would have required the services of a full-time radar observer, which were not available at either TRI or at CRW the night of the flood. Weather stations utilizing radar data from TRI should be made aware that reported VIP levels may be too low in the mountain areas surrounding that station to the north. Telephone coordination between radar stations, and between radar and nonradar stations, should be stressed.

5. Hydrologic Conditions

In the headwaters of the Tug Fork, flooding was confined to two principal creeks, Peters Creek and Knox Creek. The Tug Fork forms the state boundary between Kentucky and West Virginia. These creeks are fed by numerous small creeks such as Camp Creek, Hurricane Creek and Poplar Creek, most with drainage areas of less than 10 sq miles. They all sustained serious flooding.

Across the divide in the Levisa Fork Basin, flooding occurred on smaller creeks, principally Slate Creek to the east of Grundy and the small creeks that drain into Slate Creek. Grundy has a flash flood alarm which was not activated as Levisa Fork rose less than half bankfull.

Hydrological guidance available to the forecast offices with Flash Flood Warning responsibility includes: Daily Flash Flood Guidance, Limited Area Fine Mesh Prog (LFM), Quantitative Precipitation Forecast (QPF), and Excessive Precipitation Forecast Chart.

The LFM, QPF, and Excessive Precipitation Chart showed no indication of excessive precipitation over the flooded area. The Flash Flood Guidance indicated that it would take 3.2 inches of rain in three hours to cause flash flooding in Zone 8, which includes Pike County, Kentucky; 2.6 inches were required in Virginia Zone 10, which includes Buchanan, Virginia.

On the Tug Fork at Williamson, West Virginia, the river crested at 20.5 ft., flood stage is 27 ft.

There are no formal river forecast points in the flood area. All these creeks are small ungaged watersheds with warning services limited to community flash flood warning programs.

6. Observing Systems

Interpretation and use of available radar and satellite information by the duty forecasters was discussed in the earlier sections. This section concerns a post-analysis to ascertain what additional information might be derived from these sources in an attempt to better understand the weather system that caused the flash flooding and perhaps provide insight to earlier detection.

6.1 Radar Film Analysis

Examination of the 16 mm film from the Tri-Cities WSR-57 radar added little additional information. Frames were available every five (5) minutes for several hours prior to and through the period of flood-producing rains. A real disadvantage was the fact that VIP levels were not available on the film. The precipitation areas were visible with minor white shade variation in the strongest cells, but these were difficult to pick out from the general precipitation area. The film did indicate that several cells passed over or very near to the flood area. Four cells appeared to move over the area at approximately 0750

GMT, 0820 GMT, 0840 GMT and 0918 GMT. The latter cell seemed to linger over the area until nearly 1000 GMT. This corresponds closely with the time the strongest cells were observed on satellite as well as the time a VIP level four (4) with tops to 45,000 feet was observed on the Charleston radar. VIP level three (3) with tops from 35,000 to 39,000 feet was observed at the TRI radar station according to information taken from radar overlays at 0835 GMT and 0935 GMT. The presence of an extraordinarily strong cell or group of cells could not be determined from the film. VIP was inoperative on the remote scope.

Antenna elevation angles were set generally at about one-half degree, which is normal for routine radar search operation. Further elevation of the antenna was not necessary to observe the echoes in the flood area.

6.2 Satellite Imagery Analysis

NOAA's operational east coast satellite during this event was SMS-2. Images from NOAA geostationary satellites are made available to National Weather Service WSFOs from a series of Satellite Field Service Stations (SFSS). The NESS SFSS at Kansas City provides image support through the GOES Central Data Distribution System to 23 WSFOs in the central third of the United States, including WSFO Louisville. The SFSS at Washington, D.C. similarly serves 14 WSFOs including WSFO Washington, D.C. and WSFO Charleston.

Both visible and infrared (IR) imagery are transmitted during daylight hours; only the infrared images are available at night.

The meteorologists on duty at each NESS SFSS prepare Satellite Interpretation Messages (SIMS) every six hours for transmission over the RAWARC teletype circuit. The messages are routinely released at about 0600Z and 1200Z. The 0500Z SIM from the Washington, D.C. SFSS was released about an hour <u>before</u> convective cells began building over the Virginia-West Virginia-Kentucky border area. It stated, "High clouds over western West Virginia southward to western North Carolina is moisture from thunderstorms which dissipated Saturday AM." The 1200Z SIM from Washington, D.C. was released 3 hours after the most intense phase of the storm and stated "Loops show vorticity max in southwestern Virginia near Tri-Cities moving slowly southeastward. Mid/hi level overcast, scattered thunderstorms near and ahead of vorticity max are drifting southeastward into southwest Virginia, western North Carolina and northern South Carolina." A check of telephone logs at the Kansas City and Washington, D.C. SFSSs revealed no telephone calls either outgoing or incoming on July 15 from Louisville, Charleston or Washington, D.C.

The SFSSs can also request Quantitative Precipitation Estimates (QPE) from the NESS Synoptic Analysis Branch (SAB) in Camp Springs, Maryland, for relay to the WSFOs. The technique gives half-hourly or hourly rainfall estimates for county areas using specially enhanced GOES thermal IR imagery together with high resolution visible images, if available. The factors considered include cloud top temperature, rate of anvil growth, position of the cumulonimbus under the anvil, duration of the storm as well as the effect of merging cells, merging convective cloud lines and overshooting tops.

Due to the small size of the cloud cells over the impacted area and their relatively warm tops, no real-time precipitation estimates were generated. Instead, a check of SAB logs showed that on July 15, QPE were done for Kansas (twice), Iowa, Colorado and New Mexico. Convective systems over these states showed up on the imagery as larger and deeper than those over the Virginia-West Virginia-Kentucky border area.

Rod Scofield of NESS prepared retrospective QPE from the satellite imagery on file and arrived at the following precip totals for July 15, 1979, in the affected area:

	Pike County	Buchanan County
0500-1030Z	5.42 in	3.85 in

Satellite imagery did show a small convective cell beginning to build over Pike County, Virginia, at 0530Z. This activity developed as follows:

0600Z - Cell over Pike County has doubled in size over past half-hour but is still quite small. Cloud top temperatures are in the -41° to -52° range. Grid is 1° lat. too far WSW (250°).

0630Z - Convective system has increased in size by about a third in past half-hour and now covers part of Buchanan County as well as Pike. Grid 1° lat. too far NNW (340°). Convective system in Ohio warming.

0700Z - Convective system has increased slightly in size. There has been a merger of cells over Pike and Buchanan Counties. Grid about 1° lat. too far NW (320°).

0730Z - (Figure 6.1) Convective system has more than doubled in size in past half-hour as shown by IR and now covers Lawrence, Johnson, Martin and Floyd Counties in Kentucky as well as Pike. Tops still in the -41° to -52°C range. Grid OK. Notice large, intense convective systems over western Ohio and in the Nebraska-Kansas-Iowa-Missouri region.

0800Z - Convective system increasing in size. New cells forming in West Virginia over Mingo and Logan Counties. Grid OK.

Figure 6.1

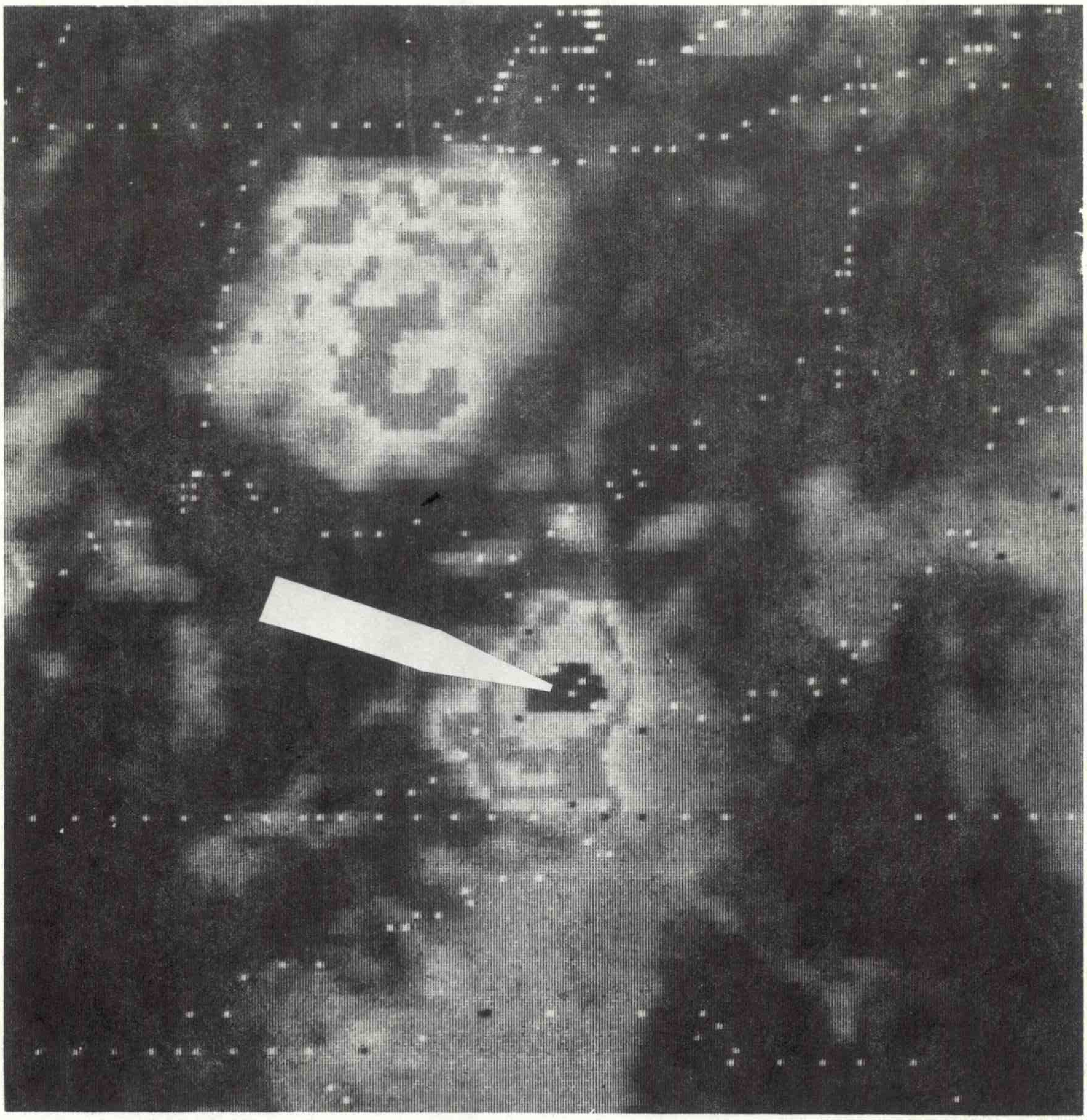


Figure 6.2

0830Z - Cells over Mingo and Logan Counties have merged in the past half-hour. Overall system growing. Grid OK.

0900Z - System still growing. Cell over Mingo County has merged with the main larger system in Kentucky and now covers parts of 10 counties along the Virginia-West Virginia-Kentucky border. Most intense part of system is directly over Pike County where tops have dropped into the -52° to -58°C range.

0930Z - (Figure 6.2) System still intensifying as shown by blown-up IR. Dark gray patch (coldest cloud tops) now covers parts of Buchanan and Mingo Counties as well as Pike.

1000Z - System still expanding but coldest tops have been lost indicating slackening in rainfall intensity.

1030Z - System no longer growing.

1100Z - System weakening over the Virginia-West Virginia-Kentucky border.

In summary the small cell that eventually increased in intensity and size to produce the flash flood was noticeable in the post analysis at 0530Z (0130 EDT). It continued to develop with cell mergers evident at 0700Z (0300 EDT). From accounts of residents in the area, some of the heaviest rainfall began about this time lasting up to two hours before ending. This timing coincides with the apparent maximum intensity observed by satellite between 0900Z and 0930Z (0500 to 0530 EDT).

7. Response

These creeks are all small ungaged watersheds with no formal river and flood forecast service provided. Local community flash flood warning systems are being implemented in the 12-county Appalachian flash flood pilot project and are the only services available to the residents. Such systems have been started in Pike County and Buchanan County.

The NWS operates a NOAA Weather Radio at Hazard, Ky., with a low-powered repeater at Pikeville. The flash flood coordinators, police and others have receivers which are their primary means for alert when the NWS issues a Flash Flood Watch or Warning. However, complaints were noted from a number of people that their receivers are subject to false "turn-on" alerts. Some no longer monitor the radio because of this problem. The NOAA Weather Radio is vital as most radio stations go off the air at night, some as early as 9 p.m.

False "turn-on" alerts can generally be attributed to the fact that many of the earlier and more inexpensive radio receivers pick up extraneous tone pulses because their response selectivity is poor. These receivers usually do not have suitable tone decoders to screen out tone frequencies other than those being transmitted by the NWS at 1050 Hz. Some receivers have been known to be triggered by signals ranging from 700-1800 cycles.

Since the radio receivers are for the most part privately owned, any modification to improve the tone signal discriminating capability has to be done by the owners. It is usually less expensive to replace the older receivers by those presently being marketed than to make the necessary modifications.

Although the alert tone can inadvertently be switched on by the operator at the NWR Broadcasting Console, this is not a very common occurrence.

There is no general warning system in the area such as fire alarm or civil defense siren to warn residents. The hills are confining and roads winding and no warning system except one designed for each of the small creek basins, known locally as "hollows" - can be truly effective.

The local flash flood rainfall reporting network did not function. Very few of the observers lived in the disaster area and those who did, failed to call in their reports. Some called their reports in at 7 a.m. One raingage is at a location that isn't open on weekends. Some gages are questionably located--such as on telephone poles.

Even though there was no NWS watch or warning issued prior to the event people responded fairly well within their areas. Neighbors telephoned neighbors as long as the telephones were in operation advising each other the creeks were rising, overflowing or that a washout had occurred. This information was passed to the civil defense directors. None of the information apparently left the area -- at least the NWS never was advised until routine data collection time around 7 a.m. -- well after the rain had ended.

8. Significance for Pilot Flash Flood Program

Since the event, NOAA representatives have met with local and state officials to consider means for improving the effectiveness of the local warning systems as a part of the pilot flash flood program. Of course, much of the instrumentation is yet to be placed. Many of the observers have yet to be recruited.

Beyond these rather easily surmountable problems, there remains the fact that those observers already recruited and equipped did not report until after the storm was past. Apparently the observers did not feel a report was necessary. Additional training is planned for all observers and coordinators, and it is anticipated that once the system is complete, participation will be increased.

Even though, in this case, no information was relayed to NWS until after the fact, it is notable that there was little loss of life. This may be fortuitous, or it may mean that the neighbor-to-neighbor warnings were effective in saving lives. It is clear that the lead time for possible warnings is indeed very short for events of this kind in Appalachia. The terrain may demand more flash flood alarms and automated response devices. Communications are very difficult in the area and more work needs to be done on NOAA Weather Radio coverage.

The appropriateness of the issuance of a delayed warning has been questioned. It was justified in the minds of the forecasters on the chance that the threat was not yet ended. It may be that a delayed warning causes confusion. Failure to issue a warning while a threat still exists is probably a worse error. On balance, it would seem that a warning should be issued so long as the forecaster recognizes some continuing threat.

The widely dispersed warning responsibility for the counties affected by this event leads one to questions whether a better arrangement might not be found. In order to maximize the probability of success for the pilot program in the area, it would seem desirable to review the assignment of warning responsibilities to assure maximum coordination and optimum communications. Ideally, the communication lines to the responsible office(s) should be short and highly dependable Reassignment of warning responsibilities could be achieved within a relatively short period of time and might have a beneficial effect on the success of the pilot project in the months immediately ahead.