

REGIONAL SURVEY REPORT

TANQUE VERDE FALLS FLASH FLOOD

SUMMARY

The flash flood which occurred July 26, 1981 at Tanque Verde Falls, near Tucson, Arizona resulted from a relatively small, but apparently an intense thundershower occurring in the upper reaches of the basin. The meteorological and hydrological analyses support the premise that while the storm was intense, it was not unusual for the season, but rather was typical of the many storms which occur during the Arizona monsoon season. The nature of the thundershower; i.e., its intensity, slow movement relative to the drainage area, and the configuration of the watershed, combined to produce extremely rapid and concentrated runoff, resulting in a wall of water progressing down the Tanque Verde Wash, through an area where approximately 150 people were concentrated. Because of the steepness of the canyon walls and the sudden appearance of the wall of water, people were caught totally unaware. In fact, rescue personnel from the Arizona Department of Public Safety were engaged in a rescue operation at Tanque Verde Falls and were nearly caught in the flash flood themselves. It is significant that these personnel are actively engaged in a county program to warn the public of the dangers of flash flooding in the dry washes of the Tucson Valley.

A review of the WSFO and WSO procedures indicates that forecasts and weather statements were issued in accordance with NWS procedure, and reflected weather conditions within the state of the science.

While the public, media and public safety agencies have a high level of consciousness over the dangers of flash flooding in the Tucson area. There appears to be apathy among some segments of the general public. This is reflected by the fact that there is much publicity in the Tucson area regarding the dangers of areas like Tanque Verde Falls, yet the area continues to be heavily used. It is interesting to note that a newspaper article on August 3 (one week following the tragedy at Tanque Verde Falls) reported that "crowds packed the Falls area" (see Attachment 11). A young citizen is quoted as saying: "Sure it's dangerous, but people get killed all the time. People got to have a little fun".

RECOMMENDATIONS

1. An aggressive public information program needs to be continued in the Tucson area to educate the general public. The NWS should work closely with the local county sheriffs in providing information and literature to augment their respective programs.

2. A local warning radar, WSR-74C, has been appropriated for the Tucson WSO and is planned to be in operation by June 1982. The NWS Western Region should work closely with the WSO Tucson to identify flash flood-prone areas and develop operational procedures to provide as much site specificity as possible for flash flood warnings in the future.

3. It was suggested by Pima County Sheriff's Department that their dispatch office be equipped with a NWR with warning alert capability. WSO Tucson should follow through on this suggestion and assist them in acquiring the proper radio.

4. NWS should work closely with state and county and other Federal agencies in establishing meteorological data sites in flash flood-prone areas with real-time reporting capability (perhaps event reporting systems).

5. Storms of this type amplify the need for enhanced mesoscale analyses to help identify patterns conducive for flash flooding in the Tucson area.

Survey Team: Herbert P. Benner, Chief, Meteorological Services Division, WRH; Claire Jensen, Area Manager, WSFO Phoenix, AZ; Tom Zickus, Hydrologist, WSFO Phoenix, AZ; Rob Emmett, Hydrologist, Arizona Department of Water Resources; Ron Imes, Meteorologist in Charge, WSO Tucson, AZ.

THE EVENT

On the afternoon of Sunday, June 26, 1981 at 4:50 p.m., a flash flood occurred in the Tanque Verde Falls area. Tanque Verde Falls is approximately 16 miles east-northeast of Tucson, Arizona. It is an area that is favored by local residents for picnics, hiking and swimming. It is an area also highly susceptible to flash flooding.

On Sunday afternoon, July 26, there were approximately 150 people in the Tanque Verde Falls area. During the afternoon, a swimmer was critically injured by diving into a pool of water below one of the large falls. Pima County Sheriff, Search and Rescue, Department of Public Safety Air Rescue, and Davis Monthan AFB Air Rescue were dispatched to the scene, arriving between 4:30 and 4:45 p.m. The helicopter was landed a short distance above the main falls area, while rescuers worked some 30 feet below in the waterfall pool. The stream was observed to be running normally at that time and rescuers crossed it in knee-deep water. While the rescue operation was in progress, the helicopter pilot observed water rising rapidly around his feet, and looking upstream, observed a wall of water coming down the wash. The wall of water was estimated by eyewitness accounts to be approximately 8 feet in height. In spite of the helicopter pilot's attempts to warn people downstream, the surge of water caught many unaware, causing 8 to be swept down the wash--5 were washed over the falls and killed by impact on the rocks, and 3 were drowned. About 20 people were stranded in life-threatening positions and subsequently were rescued by rescue people on the scene.

The event, as observed by eyewitnesses, began and ended over a period of a few minutes. Some estimated the crest or wall of water passing through the Tanque Verde area in a period of less than 5 minutes.

The tragedy appeared to be the result of a number of unique circumstances: 1) Nature of shower activity in upper basin, 2) physical features of the watershed, and 3) occurrence during a time of the week when numerous people happened to be in the area. It is evident from the physical features of the wash and the scarring and polishing of rocks in the area that numerous flash flood events occurred in the Tanque Verde Wash each year, although

probably very seldom of this magnitude. People interviewed said they had not seen a flash flood in the Tanque Verde Falls "anything like this before". Pima County Sheriff personnel indicated that the Tanque Verde Falls area is frequented by the people mainly on the weekend and from about 2 p.m. in the afternoon until evening. The combination of the rain event on the day of the week and time of day combined to create a tragedy. The occurrence of flash floods in dry washes in the Tucson area, resulting from moderate to heavy thunderstorms, is almost commonplace and most go unreported.

No significant property damage was reported. After the crest of water moved through the Tanque Verde Falls area, it entered a rapidly widening section of the canyon and the water was quickly attenuated to near normal flow 2 miles downstream.

It is interesting to note that this tragedy occurred in spite of the fact that rescue people were on the scene when the event occurred. While it is a matter of record that their presence probably saved the lives of many people, 8 lives were still lost. It is a vivid example of the danger of flash floods.

THE METEOROLOGY

At 12Z (5 a.m. MST), July 26, 1981, the 50 KPA chart from NMC (Attachment 1) showed a trough in the westerlies over northcentral Arizona with another trough upstream from northcentral Nevada to between Vandenberg and San Diego, California. A local re-analysis showed a weak upper low aloft over central Arizona. At the surface at 12Z (Attachment 2), the normal thermal low pressure area prevailed over the southwestern U.S. with no discernible abnormalities. A cold front had become nearly stationary from northern Texas to near the 4-Corners area.

At 00Z (5 p.m. MST) Sunday, the 50 KPA chart (Attachment 3) showed a trough in the westerlies from northeast Utah to southwest Arizona. There was still some evidence of an upper low over northwest Sonora. This upper low caused a southerly flow of moist air into southern Arizona, which is typical of the Arizona monsoon. The thermal surface low was unchanged at 00Z and there was still some evidence of a quasi-stationary front from northern Texas into the 4-Corners area.

The 3:10 a.m. state forecast for Arizona and the southeast Arizona zone forecast issued at 10:30 a.m. MST, Sunday, July 26 (Attachment 4) both indicated the possibility of heavy thunderstorms Sunday afternoon and evening. Thunderstorm development occurred in a nearly typical manner, beginning around noon. By mid-afternoon, there were widely scattered moderate thundershowers over the southeastern quarter of Arizona, with a few heavy thundershowers. These thundershowers continued into the evening hours.

This weather pattern was verified by examination of radar reports from Phoenix and Davis Monthan AFB, observational records at the WSO Tucson and Davis Monthan AFB and satellite photo (see Attachment 5). Other "lay observations" from people interviewed supported occurrences of scattered thundershower activity of a usual nature for this time of year in the Tucson area. Spotter reports of shower activity over the Rincon Mountains indicated nothing of an unusual nature.

THE HYDROLOGY

Tanque Verde Creek, located northeast of Tucson is a rocky, very steep-walled, generally east to west flowing stream basin with a drainage area of 237 square miles above the confluence with Pantano Wash, of 43 square miles above the now satellite telemetered USGS stream gage, and 39 square miles above Tanque Verde Falls (the disaster site). (See Attachment 6).

The drainage basin is composed of a series of well-developed tributaries and steep slopes which drain the Santa Catalina Mountains from the north, and the Rincon Mountains from the east and south. Elevations within the basin range from approximately 2,500 feet msl at the mouth, to approximately 3,000 feet msl at the falls, to a high point of 8,666 feet msl at Mica Mountain. Above the falls, the creek slopes at an average of 300 feet per mile as it cascades through a boulder-strewn channel.

The falls is an area comprised of a series of five waterfalls, the highest and upstreammost being about 100 feet from top to bottom. The availability of such "recreational" water, the remote atmosphere, and the easy accessibility of this area to a large metropolitan population in a desert environment combine to make it a popular weekend retreat.

Findings by USGS personnel indicate a series of three events over a period of 6 days. The first event occurred Saturday morning, July 25, and the river peaked about 7 a.m., nearly 34 hours prior to the disaster. The river flow preceding the initial event was measured at approximately 100 cfs. According to estimates and measurements, the river level at the falls increased from 100 cfs to the 11,000 cfs peak and returned back to about 100 cfs in a few minutes.

River flow amounts were very high from the north side tributaries beginning about 3 miles above the falls, and considerably less from the southern tributaries such as Joaquin Canyon.

Although erosion increased in an upstream direction, the relatively low amount of this erosion and the hydrologically unaffected vegetation throughout this area indicated a flow of extremely short duration. There also were signs of backwatering at many of the tributary-creek confluences.

At a point, 3 miles upstream from the falls (drainage area 23 square miles), the estimated peak flow from apparent high-water marks was approximately 6,000 cfs. In between the falls and the point 3 miles upstream is a drainage area of 16 square miles, which contains two very large, nearly vertical walled and inaccessible tributaries.

In the area of the falls, where the canyon's winding and narrowing obscures all view of upstream and the remainder of the drainage basin, the high water mark was approximately 8 feet above the streambed. Here, the peak flow was estimated to be about 11,000 cfs.

The stream gage indicated a peak value of approximately 6.0 feet with a flow of nearly 5,000 cfs. Because the slope decreases dramatically and the channel widens over the nearly 2 miles from the falls to the gage site, such attenuation is feasible.

No accounts of this event were reported or noted for some time after the disaster. No one was in this remote canyon at the time and, consequently, no one died.

The disaster occurred the next afternoon, Sunday, July 26, just after 5 p.m. The peak was estimated at about 15% of the peak the morning before (probably under 2,000 cfs). The volume was just enough to fill the canyon, the river again peaked in less than 15 minutes, there was a large number of people in the canyon, and 8 died.

Searches upstream provided no indication of debris, debris dams, or any significant movement of the river bottom boulders during either event. Eyewitness accounts of no visible rainfall activity in the area, and rainfall measurements of 0.00 inches in the surrounding basins were also noted during the second and disastrous event.

Except for the volume of the storm and runoff events, the scenario was the same for both the first two, and perhaps even all three events. However, the result of this second, relatively minor but ill-timed event was considerably more devastating.

Four days after the disaster, Thursday night, July 30, the same canyon was hit again by heavy rains. We, on the disaster survey team, had left the canyon that same morning, and the last of the bodies had been removed that afternoon. A peak flow about 8 times that which had caused the disaster and 1 to 3 times that which occurred 35 hours prior to the disaster, was recorded in the canyon at 11:30 p.m. Again, no one was in the canyon and no one died.

Three floods were recorded over that 6-day period. The killer flood was the smallest, while the two others, 6 to 8 times larger, did no damage. The killer flood occurred when canyon activity was high. The other two floods, which could have been much more devastating, went almost unnoticed because the canyon is usually empty during the times at which they occurred.

The following is a summary of events at the downstream gage. Peak flows at the falls could be double those recorded at this gage site.

<u>Event</u>	<u>Peak Date/Time</u>	<u>Approx. Peak (cfs)</u>	<u>Deaths</u>
1	Sat 25th/7:00 a.m.	5,000	0
2	Sun 26th/5:45 p.m.	860	8
3	Thu 30th/11:30 p.m.	6,700	0

Because the original, and even the third, events had not been observed, the surveys had been conducted several days after the first two events, and these two events had coincided so dramatically, it was not until the rains stopped several days after the third event that the streamflow records were obtained and a separation of events was found and made.

CONCLUSION

Rainfall of a relatively short duration and probably moderate intensity moved into the upper tributary areas just prior to the disaster. The cell was either stationary or moved slowly in a downstream direction causing the tributaries to peak in downstream sequence, each about the time the main-stream was peaking at the confluence. The rain was not observed near the falls because it did not rain in that immediate area, and the cell was concealed by the sinuous portion of the canyon.

Because of the terrain and topography, the water quickly began to build a "wall" as it progressed downstream to cause the disaster. The wall's rather quick appearance and disappearance further verified the lack of a large volume of runoff and, therefore, the lack of a large amount or a lengthy period of rain.

ACTIONS BY WSFO PHOENIX

The WSFO Phoenix has zone forecast responsibility for the State of Arizona. Based on the meteorology described above, zone forecasts issued, including FP3 (Attachment 4), advertised the probability of thunderstorm activity, heavy at times, in southeast Arizona. A review of these forecasts issued indicates they were well-worded and covered the meteorological situation very well. The FP3s were quite detailed and effectively described the lead forecaster's thinking on the meteorology of the day.

WSFO Phoenix is equipped with a WSR-74C weather radar with local warning responsibility. The radar was operated on the date by a meteorologist intern. At approximately 1 p.m. MST, the lead forecaster was informed by the radar observer that he had observed a radar echo south of Tucson, it was a rather large diameter cell which had been growing and reached VIP-4 level intensity. At approximately 1:30 p.m., the lead forecaster was informed that the large cell south of Tucson had gone to a VIP-2 level--there was no indication of any strong cells anywhere else, although a few new cells south of Tucson appeared.

At approximately 2:15 p.m., the radar observer called WSO Tucson and advised of convective activity to the south and southeast of Tucson. Tucson informed the radar operator that he planned to issue a special weather statement to cover the developing thunderstorm activity and to advise the public to take precautions when these thundershowers occur. The radar operator (met intern) discussed this action with the lead forecaster at Phoenix, who concurred in that action and considered it adequate to cover the situation. A radar overlay prepared at WSFO Phoenix at 2250Z (Attachment 7) shows an echo (VIP-3) southwest of Redington (vicinity of Tanque Verde Wash drainage) that could have been responsible for rainfall in the basin. The echo was not of sufficient intensity to warrant special attention and was not brought to the attention of Tucson. Radar echoes of VIP-4 or 5 level are commonplace during this time of year. No significant radar echoes, i.e., those which would give rise to the issuance of a warning, were observed in the Tucson area. According to the radar log, the radar RHI strobe malfunctioned and required cleaning of the slip ring contacts. Only limited use of the radar was possible during the period from 1415 MST to 1545 MST. No reports of significant weather were received at the WSFO during the afternoon or evening from the Tucson area.

CONCLUSIONS

Zone forecasts were issued in a timely and well-worded manner and adequately covered the thunderstorm activity in the Tucson area. Lead forecaster used radar and satellite information effectively.

The radar was operated in a satisfactory manner, in spite of an equipment malfunction 1415-1545 MST. Prompt action was taken by the lead forecaster to restore the radar to full operation. The RHI strobe problem did not preclude at least limited use of the radar during that time.

Actions taken by the radar observer and the lead forecaster are commensurate with the weather situation. The radar information was used effectively to support the Tucson office. Issuance of a warning was not indicated from the meteorological information available.

ACTION BY WSO TUCSON

The WSO Tucson is located at the airport in the southwest portion of the city of Tucson. The WSO operates 24 hours per day, providing full weather service functions, including surface and upper air observations and has county warning responsibility for Pima, Cochise and Santa Cruz Counties (Tanque Verde Falls lies within Pima County). The office is staffed by a Meteorologist in Charge and 7 Weather Service Specialists. On July 26, 1981, two Weather Service Specialists were on duty.

The Tucson WSO issued a forecast for the greater Tucson area at 10:00 a.m. MST:

"Variable cloudiness with widely scattered afternoon and early nighttime showers or thunderstorms today and Monday. Some locally heavy showers with gusty winds and possible flooding of washes and other flood-prone areas can be expected. Continued humid with afternoon high about 98° today and 101° Monday. The low Monday morning near 73°. Probabilities of measurable precipitation in the Tucson Valley 20% this afternoon, 30% tonight and 20% Monday." (See Attachment 8)

This forecast was distributed over the NWWS, telephone recording, and NWR. Through these communications systems, forecasts are made available to radio, television and newspaper media, and, hence, the general public.

Observed weather conditions at the Tucson airport on the morning of July 26 showed scattered to broken middle and high clouds with cumulus forming over the mountains to the south and southeast. By 10:00, cumulus were reported building over the mountains northwest, southeast and southwest, and by 11:00 a.m., cumulus were noted building over the mountain areas in all directions with towering cumulus developing to the southeast and southwest. A approximately 2:00 p.m. MST, the Weather Service Specialists observed the towering cumulus developing to the southeast of Tucson and began considering the need for the issuance of a special weather statement to cover the developing thunderstorm activity. Upon returning to the office at approximately 2:15 p.m. MST, the Weather Service Specialists received a

telephone call from the radar observer at the WSFO Phoenix office. The radar observer informed Tucson that radar showed developing thunderstorm activity to the south and southeast of Tucson, moving in a northerly direction. With this added impetus, the Weather Service Specialist issued a special weather statement at 2:40 p.m.

"Radar has indicated thunderstorms are developing to the south of Tucson. Tops are reported at 30,000 feet and moving northeast at about 12 mph. Residents in eastern Pima, Cochise and Santa Cruz Counties are advised to observe the normal routine precautions when these thunderstorms occur. Since the ground is already saturated, flooding can easily occur. Other statements will be issued as deemed necessary". (See Attachment 8)

This special weather statement was relayed to the public over NWWS, NWR, NAWAS and local telephone recording. This is standard distribution procedure for this action. Light thunderstorm activity was reported at the Tucson airport at 2:45 p.m. moving from the south. By 4:00 p.m., cumulonimbus clouds were reported in all directions.

In the opinion of the observer, thunderstorm activity observed was commensurate with weather conditions forecast; i.e., no unusual activity was noted. Observations made at the Tucson airport were similar to those recorded by Davis Monthan AFB, although at 1656 MST, Davis Monthan reported thunderstorm activity 14 miles north of the base, which would place it in the vicinity of Tanque Verde Falls watershed. Rainfall amount records at Tucson on July 26 was .01 inches at the U.S. weather station. Observational records for WSO Tucson and Davis Monthan AFB are included as Attachment 9 and 10.

Throughout the remainder of that afternoon and night, no reports of flash flooding or copious amounts of rain were reported to the Tucson WSO. It was not until the next morning that word was received of the Tanque Verde flash flood.

CONCLUSIONS

In the experience of the Weather Service Specialists and from other observers in the area (spotter networks, sheriffs department, rescue workers, etc.), thunderstorm activity observed during the afternoon of July 26 was typical of activity associated with summer monsoon season in Arizona. Well developed thunderstorms are commonplace, particularly in the mountain areas near Tucson. Many of these thunderstorms produce heavy localized precipitation and do cause local flash flooding.

Forecasts issued by the WSO Tucson covered thunderstorm activity and the probability of flash flooding in vulnerable areas well in advance of the event. A special weather statement issued by the Weather Service Specialist at 2:40 p.m. was timely and very well worded to cover possible flash flooding in the vicinity of thunderstorm activity. The issuance of that statement reflects most favorably on the judgment of the Weather Service Specialist.

Forecasts and weather statements were disseminated in accordance with the station policy and procedures and the Weather Service Operations Manual. The effective use of radar coverage by the Local Warning Radar at Phoenix was apparent and may have been the convincing factor resulting in the issuance of the weather statement.

While the forecasts and weather statement were not site-specific, it is concluded by the survey team that due to the monsoon-type weather regime and the numerous high potential flash flood-prone areas in and around the mountains in the Tucson area, it is not possible to be site-specific. A local warning radar located at Tucson would greatly enhance their ability to be more site-specific regarding location of local severe storms.

Note: A local warning radar has been approved and is in the procurement state for the WSO Tucson, and is expected to be in operation by June 1982.

COMMUNITY PREPAREDNESS

Community preparedness for heavy thunderstorms and flash flood events is a high priority program in Arizona. Through the efforts of the WSFO Phoenix, the Governor of Arizona proclaimed a flash flood awareness week, June 28-July 4. The WSO Tucson participated in all activities during the week. These activities included taped messages regarding flash floods on the NWR; i.e., what flash floods are and where information could be obtained. Several interviews were given in the media, including radio, television and newspapers, highlighting flash flood precautions and safety rules. The WSO Tucson and WSFO Phoenix had good response from the public in requesting more information on flash floods; i.e., many cards and letters were received asking for more information. These were all answered.

The Tucson office routinely runs a promotional tape on flash floods over NWR. This tape runs twice a week for a total of approximately 4 hours. The staff at Tucson is actively engaged in bringing flash flood awareness to the public through school talks (10 during the month of May), radio and TV interviews, and so on.

Tucson has one of the most highly developed spotter networks in the region. More than 300 spotters have been enlisted for the network. This spring, 2 REACT groups, Tucson REACT and Pima County REACT, have volunteered their services to this program. The MIC Tucson has personally addressed both of these groups.

Mr. Chuck McHugh, Coordinator of the Pima County Search and Rescue, told the survey team of his active involvement in warning the public of the dangers of entering flash flood-prone areas during the monsoon season. He has an active program of speaking to schools and civic groups.

It was noted that most roads crossing dry washes in and around the Tucson area have signs warning of the danger of flash floods. The Sheriff's Department routinely barricades dry washes where roads cross when flash flooding is forecast.

PUBLIC RESPONSE

While the Tanque Verde Falls area is located on USFS lands, responsibility for public safety generally lies with the Pima County Department of Public Safety, of which the Sheriff's Department is a part. However, since Tanque Verde Falls is on USFS land, Pima County Sheriff does not have authority to keep people out. The USFS has said it would be impossible to close the area and warning signs wouldn't do any good.

Interviews with the Sheriff's Department personnel reflect a very high level of consciousness over the threat of flash flooding. It is a problem that the Sheriff's Department deals with frequently during the monsoon season. When thunderstorms occur in the Tucson Valley, they expect to be called out to effect rescues from flooded dry washes as a matter of routine. They indicated that, in spite of their attempts to barricade dry washes (areas with high probability of flash flooding), some local residents disregard the barricades and drive around them. They point out that they do not have enough people to be everywhere at once, and they must rely on the public to keep themselves informed of the hazards of flash flooding and where those flash flood-prone areas are.

The Sheriff's Department indicated that they did not take any special action based on the forecast issued on July 26 nor the statement issued at 2:40 p.m. on that date. In fact, they indicated that they would take little action, if any, on a flash flood warning unless that warning were to be site-specific, in which case they would probably watch the area or "take a look". In the case of the Tanque Verde Falls location, it would have taken a Sheriff's vehicle 30 minutes, Code 3, to reach the area had a warning been issued for that specific area. In this particular incident, it is estimated that the lag time between the shower and the wall of water at Tanque Verde Falls was on the order of 30 minutes or less.

The Sheriff's Department had no criticism of our service. It was discussed, however, that perhaps they should get NWRs in their dispatch offices, with the "warning alarm" feature.

U. S. FOREST SERVICE

The Acting District Ranger of the Santa Catalina Ranger District, in whose area the Tanque Verde Falls are located, expressed a high level of concern over the disaster. However, the area is too large to fence or to post warnings that would be effective. Their policy is to rely on people understanding the danger of going into that area during the flash flood season. If specifically requested, they would go into the area and attempt to warn people in the event of a site specific flash flood warning.

RADIO AND TELEVISION

The radio and TV media have a high level of consciousness in warning the public of flash floods. When flash flood warnings are issued, crawlers appear across the bottom of the TV screen, showing the content of the warning issued. Weather statements have a lower priority and will be used if time permits, but this is generally in conjunction with a scheduled news and

weather broadcast. There is no indication that the weather statement on July 26 was given priority dissemination by the TV media. A check with several of the AM/FM radio stations in the area revealed that weather statements and warnings are given immediate dissemination, and on July 26, the weather statement issued at 2:40 was broadcast to the public. Both AM/FM and NWR are readily received in the Tanque Verde Falls area.

CONCLUSIONS

Considerable effort has been made by the NWS, state and county public safety organizations and by the media to make the general public in the Tucson area conscious of the threats of flash floods. A number of the people interviewed expressed the feeling that almost everyone knows of the threat of flash floods in the Tucson area, but no one thinks it will happen to them.

Forecasts and weather statements and their dissemination were commensurate with the meteorological information. Had a warning been issued for possible flash flooding in the Tucson area, it is doubtful that any special action would have been taken by the Pima County Sheriff to warn people in the Tanque Verde Falls area since there are many similar areas equally vulnerable.

The need for "site specific" watches, warnings and statements is clearly indicated: however, the paucity of meteorological observations in the Tanque Verde watershed, as well as many other areas, makes site-specific forecasts and warnings extremely difficult, if not impossible.

ATTACHMENT

SURVEY

The survey was conducted on July 29-31, 1981. The team conducted interviews and reviewed data and information in the Tucson and Tanque Verde Falls area on July 29-30. July 31 was spent at the WSFO Phoenix.

Persons interviewed:

Ray Echols, Weather Service Specialist, WSO Tucson

Richard Griggs, Weather Service Specialist, WSO Tucson

Sgt. Campbell, Weather Detachment, Davis-Monthan AFB, Tucson, Arizona

Lt. Jim Rose, Pima County Sheriff's Department, Department of Public Safety,
Tucson, Arizona

Charles McHugh, S&R Coordinator, Pima County Sheriff's Department, Department
of Public Safety

Pete Karp, Acting District Ranger, Santa Catalina Ranger District, USFS

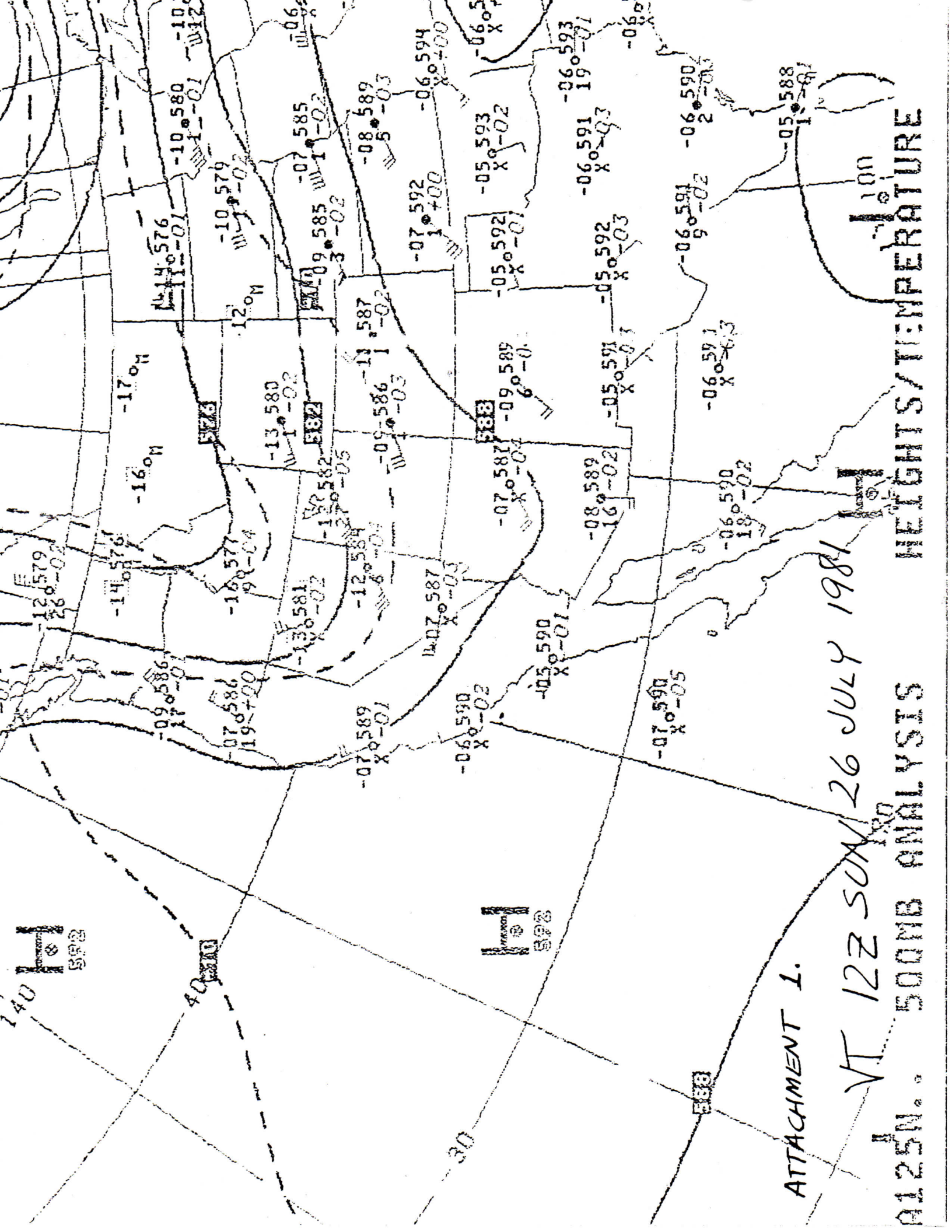
Wayne Crowthers, Volunteer Spotter (247) Redington, Arizona

Mr. Williams, National Park Service Ranger

Mike Bevers, USFS

John R. Pedley, National Park Service (visitor in the area)

Win Hjalmarson, Supervisor Hydrologist, USGS Subdistrict Office, Tucson, Arizona

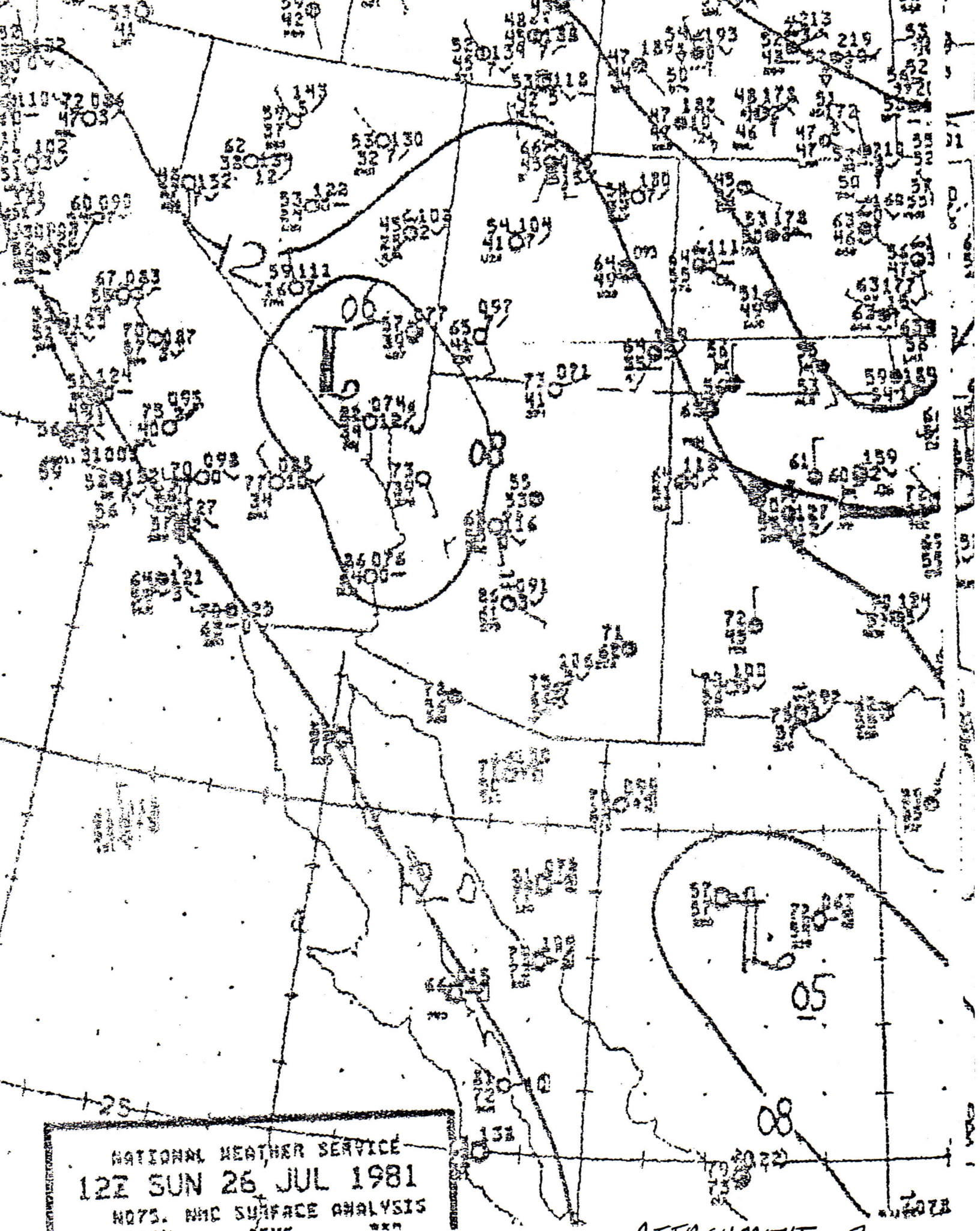


ATTACHMENT 1.

VT 12Z SURF 26 JULY 1981

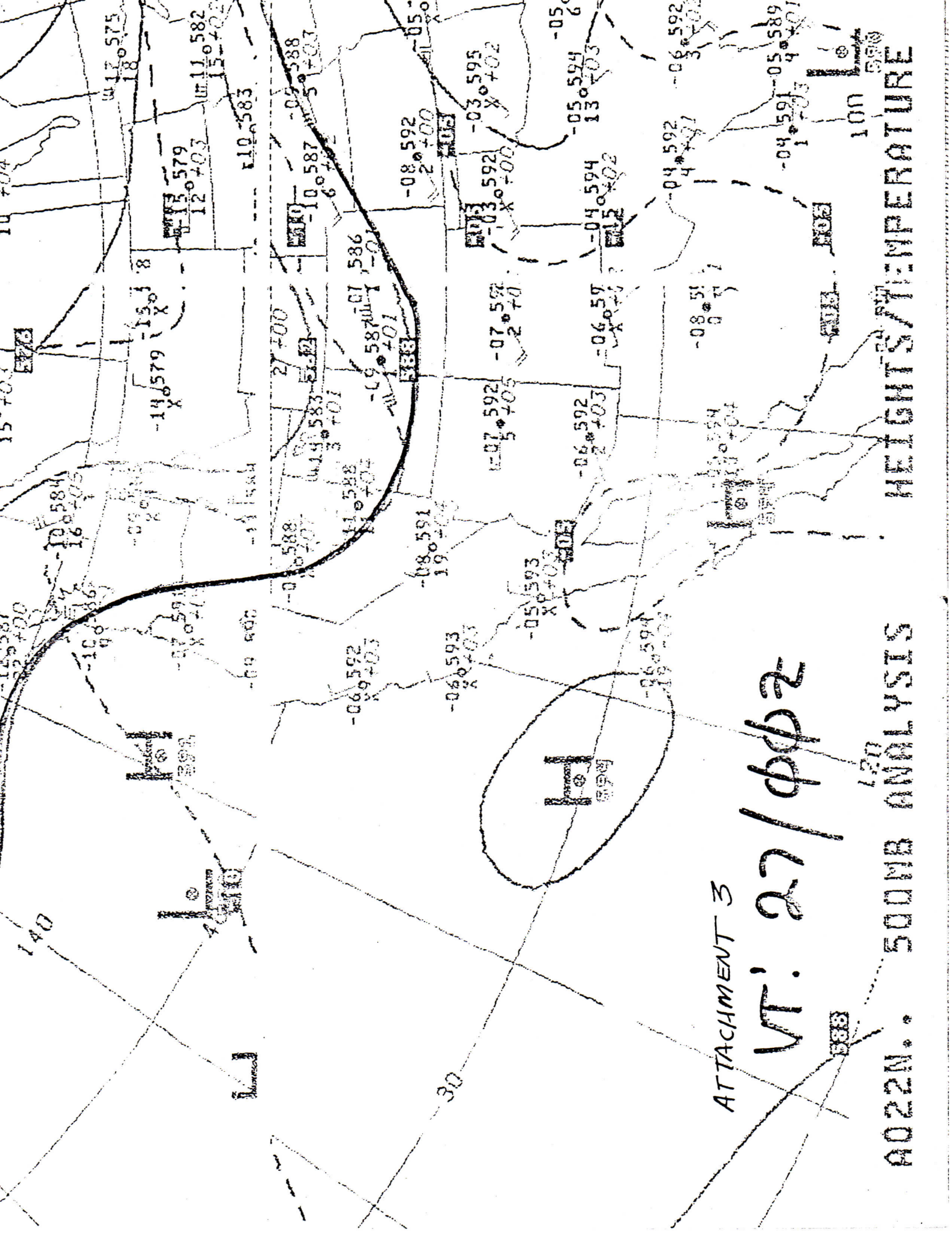
A125N. 500MB ANALYSIS

HEIGHTS/TEMPERATURE



NATIONAL WEATHER SERVICE
12Z SUN 26 JUL 1981
NO75. NHC SURFACE ANALYSIS

ATTACHMENT 2.



ATTACHMENT 3

VT: 27/φφ2

A022N. 500MB ANALYSIS

HEIGHTS/TEMPERATURE

ATTACHMENT A

QSWZLAJSFPAZ
WOUS00 KPHX 261000
QYYX SSE SSU
PHX FPI 261010
FPUS1 KPHX 261010
ISSUED 310 AM MST SUNDAY

AZ50
ARIZONA

MOSTLY SUNNY TODAY WITH WIDELY SCATTERED AFTERNOON AND EVENING THUNDERSHOWERS MAINLY CENTRAL MOUNTAINS AND SOUTHEAST. POSSIBLE HEAVY THUNDERSTORMS WITH STRONG GUSTY WINDS. MOSTLY SUNNY MONDAY BUT WITH ONLY A FEW AFTERNOON AND EVENING THUNDERSHOWERS CENTRAL MOUNTAINS AND SOUTHEAST. WARMER DAYS AND A LITTLE LESS HUMID MONDAY. HIGHS TODAY MID 70S TO MID 80S MOUNTAINS TO 105 TO 112 SOUTHWEST DESERTS. HIGHS MONDAY UPPER 70S AND 80S MOUNTAINS TO 108 TO 115 SOUTHWEST. OVERNIGHT LOWS MID 40S TO MID 50S MOUNTAINS TO THE 70S AND LOW 80S SOUTHWEST.

BEHM

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PHX FP3 261558
FPUS3 KPHX 261558

AFTER SEEING 12Z RAOBS AND YUMA PIBAL...NOT SO SURE ELYS ARE LOSING OUT TO WLYS. RATHER IT SEEMS THE STANDOFF CONTINUES...WITH THE SE HALF OF AZ IN ELYS...OF IN RETURN FLOW ARND THE SUBTROP HI...AND THE NW HALF IN THE DRY WLYS. STREAMLINE ANAL AT BOTH 700 AND 500 MB SHOWS AN INVERTED TROF ALG 115W...A COL NR THE CA...BAJA BORDER AND A WLY TROF NWD FROM THERE. SATLT PIX STILL SHOW A CLD PTRN ASOCID W THE INVERTED TROF FROM 25/123 ACRS NRN BAJA AND LINED UP WITH CLDS ASOCID WITH THE WLY TROF XINDG INTO CO. STILL THINK THERES GOOD CHC THE INVERTED TROF WL SPLIT OFF AND DRIFT INTO THE WLYS AND OF THE SIG SHRT WV NOW MOVG INTO THE WRN TROF. IN ANY CASE THE AMS NOW OVR CNTRL AND SE AZ IS WET AND UNSTBL. WE NO LONGER HAVE THE LOW LVL COOL ADV FROM THE STRONG GULF SURGE WE HAD YDA...OR FROM THE OUTWASH FROM THE LARGE TSTM CLUSTER IN SE AZ. SO THERE SHOULD BE BETTER SFC HEATING AND CONV THIS AFTN. FCST LOOKS OK WITH MENTION FEW HVY TSTMS. NOT SURE ABT DRYING TMRW BUT WL NOT CHG ATTM. FL6312 INW121 PHX01-TUS232 YUM000. TENHARKEL

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FPUS5 KPHX 261730
NATIONAL WEATHER SERVICE PHOENIX AZ
1030 AM MST SUN JUL 26 1991

AZ06
SOUTHEAST ARIZONA
VARIABLE CLOUDINESS TODAY AND MONDAY. SCATTERED AFTERNOON AND EVENING THUNDERSHOWERS. POSSIBLE HEAVY THUNDERSTORMS THIS EVENING WITH STRONG WINDS AND HAIL. WARMER DAYS. HIGH TODAY IN THE 90S...MONDAY 90 TO 105. OVERNIGHT LOWS IN THE 60S AND LOW 70S.

TENHARKEL

ZCZC

ATTACHMENT 4 (CONT)

PHX FP3 262158

FPUS3 KPHX 262158

SE AZ WET AND UNSTBL WHILE NW HALF IS DRY. DRY LINE SEEMS TO BE HOLDING IN ABT SAME PLACE...SUGGESTING THE SHRT WV THAT IS MOVG THRU GT BASIN IS BNGG TO WKN AS PROGED. BOTH SP AND LFM NOW RZBUILD HTS IN SWRN US NEXT 48 HR...WITH SP BLDG THEM A LTL FASTER. THAT SHOULD ENSURE THERE WL BE NO FRTHR LOSS OF MSTR. BUT AS PRES RISES ALF THERE SHOULD BE SOME SUBSDC AND STBLSG...SO THERE SHOULD BE FEWER TSTMS ON MONDAY AFTN THAN TDA. UNCRTN JUST WHEN MSTR WL BEGIN TO INCR AGN. PTRN SHOWN ON 48 HR SP AND LFM WOULD NOT LEAD TO ANY RAPID INFLUX OF MSTR XCPT PSBLY IN SE QRTR. BOTH PROGS AT 48 HRS SHOW 500 MB HI SE US AND OVR SRN CA CST WITH COL IN NM. THAT PUTS INVERTED TROF POS NR 105W...WHICH IS USUALLY WET PTRN FOR SE AZ AND DRY FOR N AND W. NEXT BIG SURGE OF MSTR MAY WAIT UNTIL THE REMINANTS OF THE TROP DEP IN LWR RIO GRANDE VLY ARE BROUGHT ACROSS NRN MEXICO...WHICH MAY TAKE 2 OR 3 DAYS. FCST WL CONFINE TSTMS TO AREA E OF INW..PHX LINE FOR MON AND TUE. FLG11- INW211 PHX1-1 TUS212 YUM000.
TENHARKEL

PHX FP1 262210

FPUS1 KPHX 262210

ISSUED 310 PM MST SUNDAY

AZ50

ARIZONA

MOSTLY FAIR NORTHWEST HALF AND PARTLY CLOUDY WITH WIDELY SCATTERED THUNDERSHOWERS SOUTHEAST HALF TONIGHT MONDAY AND TUESDAY. A FEW HEAVY THUNDERSTORMS THIS EVENING...AND IN THE SOUTHEAST CORNER MONDAY AND TUESDAY EVENINGS. SOMEWHAT WARMER DAYS. HIGHS MONDAY AND TUESDAY 80S MOUNTAINS TO NEAR 110 SOUTHWEST DESERTS. OVERNIGHT LOWS NEAR 50 MOUNTAINS TO NEAR 80 DESERTS."
TENHARKEL

ZCZC PHXZFPZ

WOUS00 KPHX 262300

ZBYZWZ SSE SSU

ZCZC

PHX FP5 262230

FPUS5 KPHX 262230

NATIONAL WEATHER SERVICE PHOENIX AZ

430 PM MST SUN JUL 26 1981

AZ06

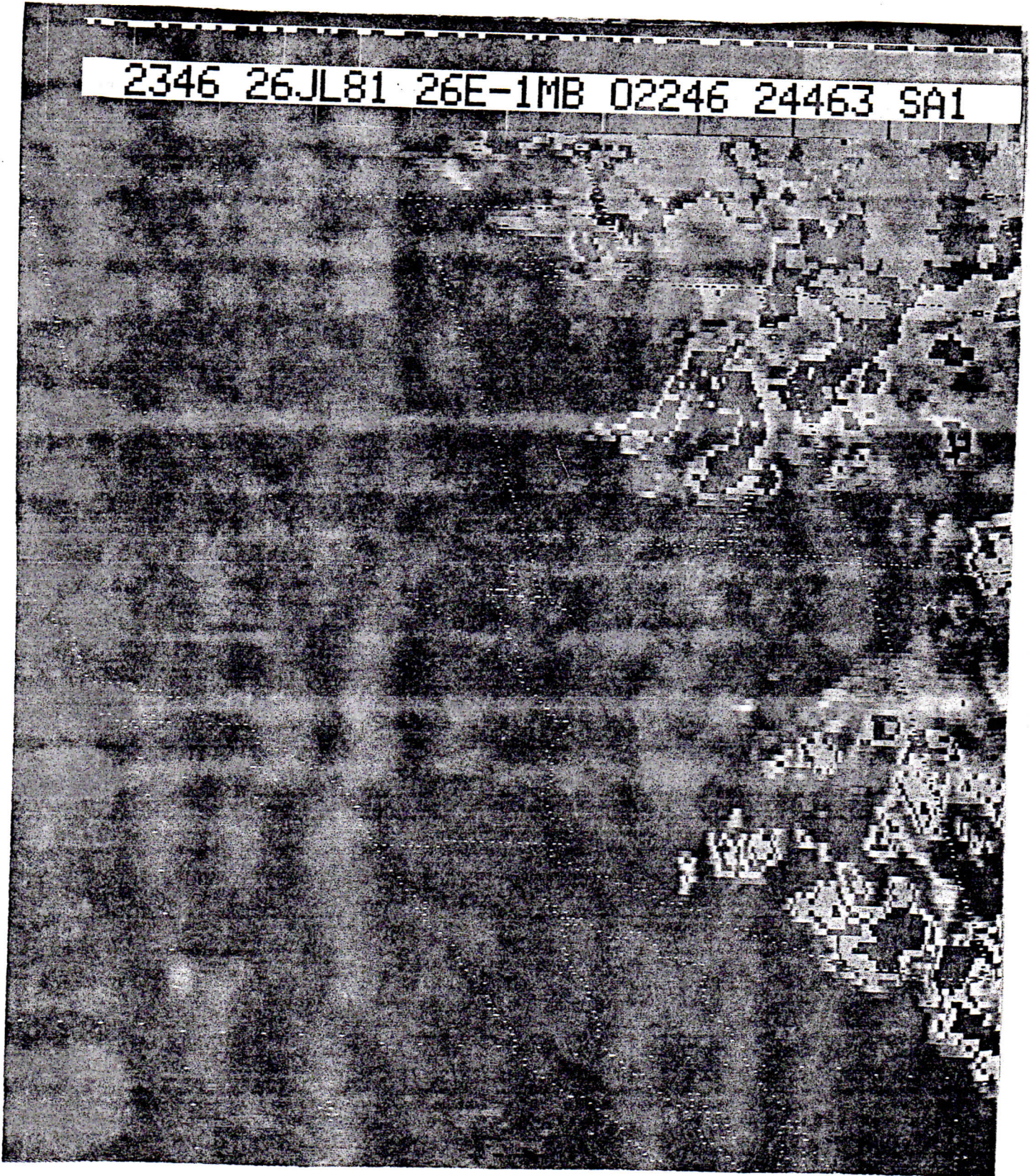
SOUTHEAST ARIZONA

SCATTERED THUNDERSHOWERS...MAINLY IN THE LATE AFTERNOONS AND EVENINGS ...TONIGHT MONDAY AND TUESDAY. A FEW HEAVY THUNDERSTORMS WITH HAIL AND STRONG WINDS...ESPECIALLY THIS EVENING. PARTLY CLOUDY WARM AND HUMID AT OTHER TIMES. HIGHS MONDAY IN THE 90S AND TUESDAY 90 TO 105. LOW BOTH NIGHTS UPPER 60S AND 70S."
TENHARKEL

TENHARKEL

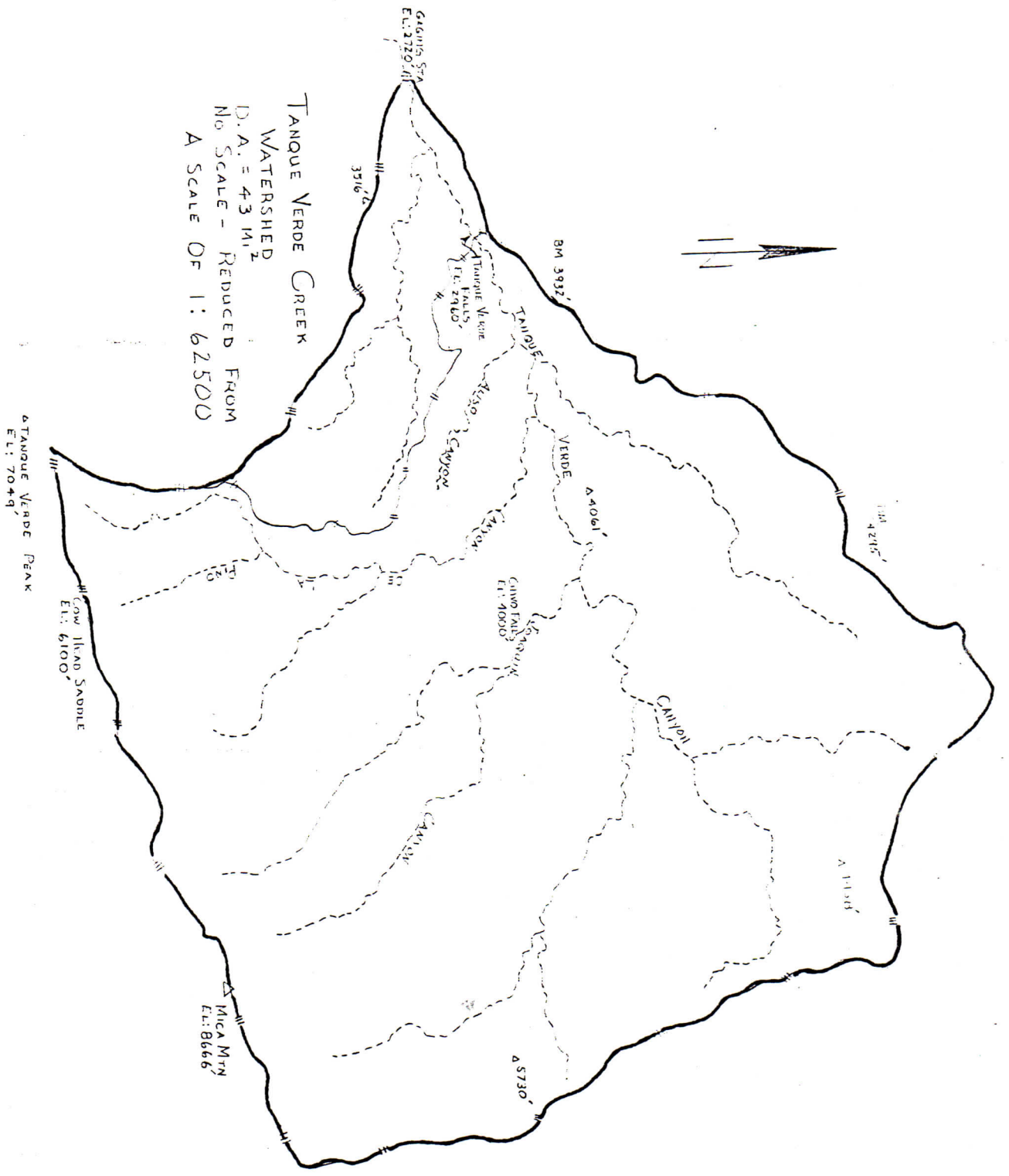
ATTACHMENT 5

2346 26JL81 26E-1MB 02246 24463 SA1



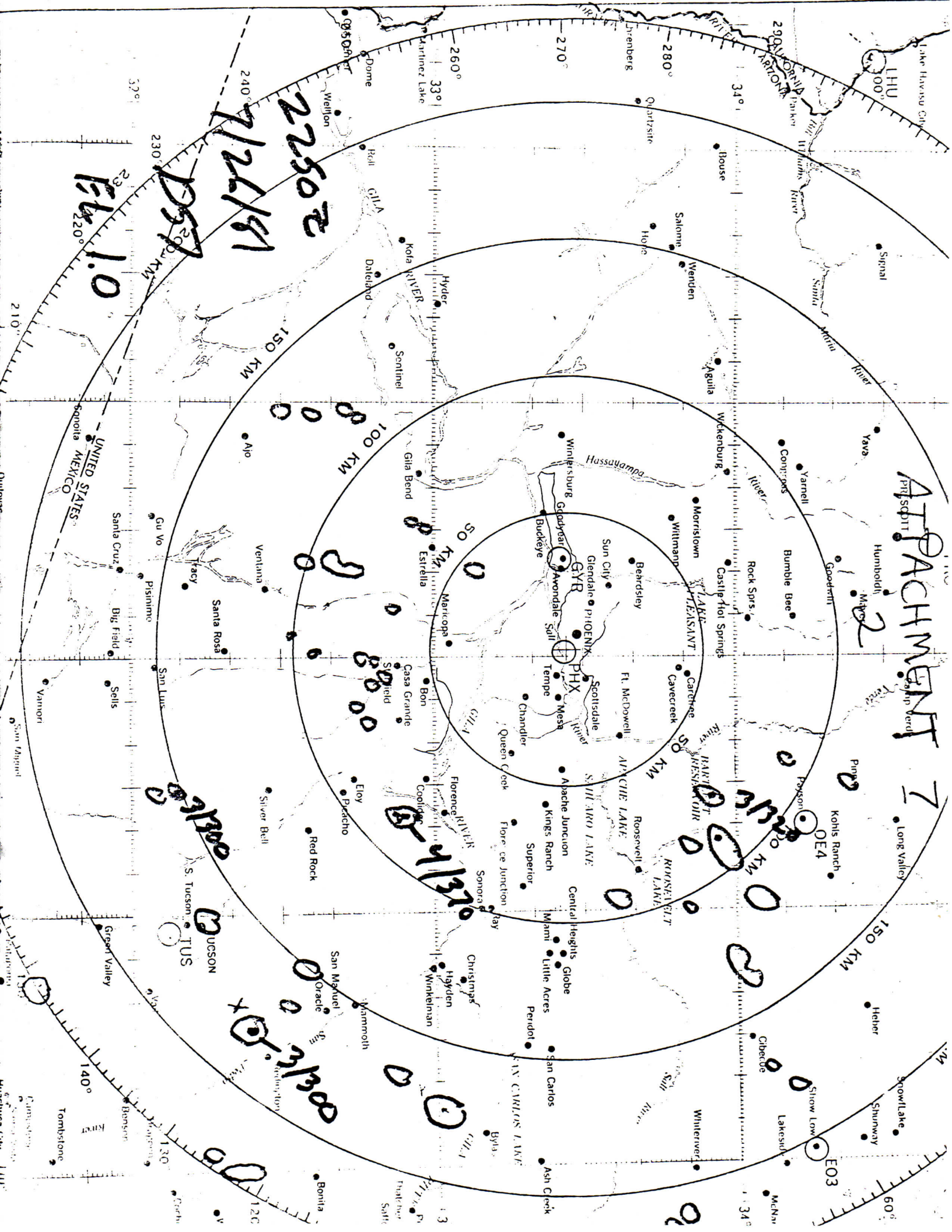


TANQUE VERDE CREEK
 WATERSHED
 D. A. = 43 MI.²
 No SCALE - REDUCED FROM
 A SCALE OF 1 : 62500



ATTACHMENT 6

ATTACHMENT 2



2250Z
7/26/81

PSA
FL 1.0

2

PHOENIX
TUS

EO3

ATTACHMENT

8

ZCZC PHXLFT US
WOU503 KTUS 261700

ZCZC
FGUS1 KTUS 261700

TJAZ
FORECAST FOR THE GREATER TUCSON AREA
NATIONAL WEATHER SERVICE TUCSON ARIZONA
10 AM MST SUN JULY 26 1981

VARIABLE CLOUDINESS WITH WIDELY SCATTERED AFTERNOON AND EARLY NIGHTTIME SHOWERS OR THUNDERSHOWERS TODAY AND MONDAY. SOME LOCALLY HEAVY SHOWERS WITH GUSTY WINDS AND POSSIBLE FLOODING OF WASHES AND OTHER FLOOD PRONE AREAS CAN BE EXPECTED. CONTINUED HUMID WITH THE AFTERNOON HIGH ABOUT 98 DEGREES TODAY AND 101 MONDAY. THE LOW MONDAY MORNING NEAR 73 DEGREES.

PROBABILITIES OF MEASURABLE PRECIPITATION IN THE TUCSON VALLEY 20 PERCENT THIS AFTERNOON...30 PERCENT TONIGHT AND 20 PERCENT MONDAY.

KOCH

NNNN

PHXSPSTUS
WOU500 KTUS 262200
SPECIAL WEATHER STATEMENT
NATIONAL WEATHER SERVICE TUCSON, AZ
02:24 PM MST JUL 26 1981

RWRE2 RWJS 072140
TJAZ
SPECIAL WEATHER STATEMENT
NATIONAL WEATHER SERVICE..TUCSON AZ
240PM MST SUN JULY 26 1981

RADAR HAS INDICATED THUNDERSTORMS ARE DEVELOPING TO THE SOUTH OF TUCSON. TOPS ARE REPORTED AT 30000 FT. AND MOVING NORTHEAST ABOUT 12 MPH. RESIDENTS IN EASTERN PIMA ..COCHISE AND SANTA CRUZ COUNTIES ARE ADVISED TO OBSERVE THE NORMAL ROUTINE PRECAUTIONS WHEN THESE THUNDERSTORMS OCCUR. SINCE THE GROUND IS ALREADY SATURATED FLOODING CAN EASILY OCCUR. OTHER STATEMENTS WILL BE ISSUED AS DEEMED NECESSARY. S3
ECHOLS

RAL METEOROLOGICAL FORM 1-10 SURFACE WEATHER OBSERVATIONS (MILITARY USE)

32°06'N 110°31'W

705 (ELEVATION FT)
 TIME COMPRESSOR
 07
 10 26
 26
 26

TIME (GMT)	SKY CONDITION	PVIS (MILES)	WEATHER AND OBSTR TO VISION	SEA LEVEL PRESS (mb)	TEMP (°F)	DWPT (°F)	DWPT - PACH (°F)	WIND - SPEED (knots)	ALTS (INCH)	REMARKS AND SUPPLEMENTARY CODED DATA
0756	120 SCT	20		107	77	66	14	04	999	
0857	120 SCT E250 BKN	20		101	78	65	12	04	999	
0957	120 SCT E250 BKN	20		102	78	64	14	04	997	
1056	80 SCT E120 BKN	20		102	77	66	13	05	997	
1159	80 SCT 120 SCT E250 BKN	25		107	76	65	13	03	999	
1257	80 SCT 120 BKN 250 BKN	40		112	76	67	12	04	001	
1355	80 SCT 120 SCT E250 BKN	35		118	77	67	15	03	002	
1445	80 SCT 120 SCT E250 BKN	35	RW-				19	04	003	
1455	80 SCT 120 SCT E250 BKN	35	RW-	121	79	67	17	05	003	114 1478
1515	80 SCT 120 SCT E250 BKN	35					18	04	004	
1555	80 SCT 120 SCT 250 SCT	35		123	82	68	20	05	004	
1655	60 SCT 80 SCT 120 SCT 250 SCT	35		124	84	68	23	04	004	MOT CU SANDW / 10200 1271
1755	60 SCT 120 SCT 250 SCT	35		123	86	65	21	07	004	
1855	60 SCT 120 SCT 250 SCT	35		119	84	63	32	01	003	TCU SANDW MOT CU ALQDS
1955	60 SCT 120 SCT 250 SCT	35		111	91	61	31	02	001	TCU SANDW MOT CU ALQDS
2055	60 SCT 120 SCT 250 SCT	35		099	94	62	60	00	998	CB 43NE-46SE-14S-19SW-45W MOVMT S / 819 1963
2125	60 SCT 120 SCT 250 SCT	35	T				36	02	994	T 95SE CB ALQDS MOVG NNE OCUL LT
2155	60 SCT 120 SCT E250 BKN	35	T	096	93	61	27	04	996	T 55SE CB ALQDS MOVG NNE FOT LTG RWL SE-SW
2213	60 SCT E120 BKN 250 BKN	30	TRW-				18	07	996	T 04HD CB ALQDS MOVG NE OCUL LTG RWL
2240										
2255	60 SCT E120 BKN 250 BKN	30	TRW-	097	82	68	19	05	996	T 04HD CB ALQDS MOVG NE OCUL LTG RWL
2310	60 SCT E120 BKN 250 BKN	35	T				19	03	994	T 04HD CB ALQDS MOVG N OCUL LTG RWL
2350	60 SCT E120 BKN 250 BKN	35	T	095	83	69	17	04	995	T 04HD CB ALQDS MOVG N OCUL LTG RWL
0020	60 SCT E120 BKN 250 BKN	35					15	04	994	T 04HD CB ALQDS MOVG N AND SE RWL N AND SE / 50801 1963
0050	60 SCT 120 SCT E250 BKN	35		090	85	69	13	04	994	T 04HD CB ALQDS MOVG N AND SE RWL
0155	60 SCT 120 SCT E250 BKN	35		092	86	65	12	01	995	T 04HD CB ALQDS MOVG N AND SE RWL
0255	60 SCT 120 SCT E250 BKN	25		093	82	73	00	03	995	T 04HD CB ALQDS MOVG N AND SE RWL
0355	120 SCT 250-BKN	20		099	82	72	12	02	997	T 04HD CB ALQDS MOVG N AND SE RWL
0455	120 SCT 250 SCT	20		105	82	69	12	04	999	T 04HD CB ALQDS MOVG N AND SE RWL
0555	120 SCT 250 SCT	20		108	80	70	13	04	000	T 04HD CB ALQDS MOVG N AND SE RWL
0657	1250-507	20		106	79	67	16	04	000	T 04HD CB ALQDS MOVG N AND SE RWL

ATTACHMENT 9

SURFACE WEATHER OBSERVATIONS

DATE

26 JUL 1981

TO CONVERT LST TO GMT
ADD 7 HRS SUBTRACT...

TIME	SEA AND CEILING	VISIBILITY		WEATHER AND OBSTRUCTIONS TO VISION	SEA LEVEL PRESS.	TEMP.	DEW POINT	WIND		ALTIMETER SETTING	REMARKS AND SUPPLEMENTAL CODED DATA
		STAT.	SEA.					DIR.	SPED.		
053	120 SCT 250 - SCT	30			10377	65	12	105	996		78387
051	M 90 BKN	30			10277	66	14	107	996		502 1500
053	90 SCT	30			10276	66	17	105	996		
055	90 SCT	30			10276	66	22	104	996		
057	E 90 BKN	30			10625	66	21	103	997		305 1400 74 2017 PMT 03109
073	74 62103 84031	106	84	64900	19305	69350					30187 42740
077	E 90 BKN	50			11075	66	12	104	999		
079	E 90 BKN 250 BKN	50			11874	67	20	105	1001		
085	E 90 BKN 120 BKN 250 BKN	50			12176	68	18	104	1002		ACCS S / 212 1481
085	250 - SCT	50			12480	67	23	104	1003		CU AUR MTS S ACCCS S
091	250 - SCT	50			12355	67	25	108	1003		CU BLDG OVR MTS W SE SW ACCCS SE
091	250 - BKN	50			12288	66	27	108	1003		CU BLDG OVR MTS ACCS SE TCU S / 103 1381 173
097	77 52708 84031	122	31	12981	19103	69265					42730
105	250 - SCT	50			11190	64	32	106	1001		CU BLDG OVR MTS ACCS TCU SE - SW
121	20 SCT 250 - SCT	50			11091	61	35	105	1002		TCU BLK PZNS
127	20 SCT 250 - SCT	50			09992	61	35	108	997		CB S AND SW / 1903 708
142	E 70 BKN 120 BKN 250 BKN	50		T	09194	61	34	104	995		TB 45 SE HORIZ ONT LTCCG
170	E 70 BKN 120 BKN 250 OVC	20		TRN -	09180	67	18	110	994		T OVRN HORIZ ONT LTCCG RBRO CB ALGDS
182	E 120 BKN 250 OVC	50					17	109	993		T E 21 DSPTD CB/RW SW - S MOVG N BLDG
185	E 120 BKN 250 BKN	50			09682	66	13	110	994		T E 21 DSPTD CB W AND N - S MOVG N FEW RWK LOS 01 1963 95 PMT 75147
187	72 74 71310 84299	096	28	14763	19608	69238					20001 49573 D
187	E 120 BKN 250 BKN	50			09184	66	14	107	993		CB/RW W ADDL DSPT S
184	120 SCT E 250 OVC	30			09684	68	21	103	994		CB NW - NE BNOVC
184	120 SCT 250 - BKN	50			04583	67	20	105	994		TCU SW / 500 1263
181	120 SCT 250 - BKN	30			09682	64	15	105	995		
181	250 - BKN	30			10681	71	15	105	998		FEW AC
184	250 - BKN	30			10580	71	14	106	998		112 1003 95
187	72 74 6406 84022	105	27	00903	22112	69250					20001 44573 D
181	250 - SCT	30			10478	72	14	106	993		DSPTD LTG NE

Despite tragedy, crowd packs falls

Twenty-year-old Jeff Gary dived head first into the Tanque Verde falls. When he emerged, thrashing in the water, he yelled, "Flash flood!" at the top of his lungs.

Then he collapsed with laughter as five panicked swimmers nearby scrambled to the shore, terrified that a wave might sweep down over the falls as one did last week. That one killed eight people and trapped 26 more in the boiling current.

Despite the terror of the July 26 flood, the falls were again choked with people yesterday afternoon. A crowd of about 100 swimmers and picnickers — including Gary and two friends — visited the scenic area near Redington Pass, heedless of warnings from sheriff's deputies that the falls are unsafe during the desert's rainy season.

"We thought about it, sure, but we weren't really worried (that another flood would strike)," Gary said. "The water was running better than I've ever seen it, so there wasn't much chance of anything backing up upstream. Anything that would collect to hold back the water was probably washed away last week."

"Really, what are the chances of a flash flood happening two weeks in a row?" added Gary's friend, Mark Kovach.

Kovach, who went to the falls to celebrate his 20th birthday, said he spent the afternoon plunging head-first over the smaller falls, and jumping down the 40-foot drop, known as the "elevator shaft," just behind the edge of the main falls.

Those main falls, which are about 100 feet high, were the site at which eight

swimmers were swept to their death when the flood hit last week. Officials said later that they were not drowned but, rather, were battered to death by the violent current.

"My mom got real worried when I told her I was going to Redington," Kovach said.

"She kept saying, 'Be careful, be careful,'" he added, lapsing into a falsetto.

"I just told my mom I was going to Sabino," said Gary.

Sheriff's deputies assigned to patrol the East Side just shook their heads when asked about the crowd at Tanque Verde Falls.

"There are people there all the time, and there's nothing we can do about it."

said Sgt. Anthony Callan. "It's Forest Service land, and we don't have any authority to keep anyone out."

"It's like telling people not to stand in the middle of the street," he went on. "You assume that after a while, they'll learn. But they never do."

The Forest Service has said that it would be impossible to close the area, and that warning signs probably wouldn't do any good.

Indeed, one swimmer claimed yesterday that "you could have five walls of water and people would still go swimming here."

"Sure it's dangerous, but people get killed there all the time," the young man said. "People got to have a little fun."

Don Schellie/2
Classified/6

TUCSON AND ARIZONA

Monday, August 3, 1981 •

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ATTACHMENT 11