Report on

FLOODING IN EASTERN MARICOPA COUNTY

JULY 17-18, 1984

prepared by

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Table of Contents

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Introduction

General Statement

On July 17-18, 1984 areas in East Central Maricopa County, Arizona were subjected to localized flooding as a result of runoff from an intense rainstorm over that area. At the time of these occurrences, two government sponsored projects were under construction in that area: 1) the Central Arizona Project (CAP) aqueduct, Bureau of Reclamation, and 2) the Signal Butte Floodway, Soil Conservation Service project sponsored by the Flood Control District of Maricopa County (FCDMC). The purpose of this study is to determine the effects, if any, that these construction projects had on the flooding.

It is not the intention of this report to identify which, if any, private or public entities caused flooding to occur. Nor is it the intention of this report to identify which, if any, property owners have justifiable claims as a result of flooding. An investigation of that nature is beyond the scope of this report, which is an overview of the rainfall and subsequent flooding events.

The conclusions are generally applicable to the area discussed, but may or may not be appropriate for a specific site within that area.

Purpose of Study

This investigation was undertaken with the intention of addressing the following details:

A. Whether the return period (i.e., the average interval of time within which a given event will be equalled or exceeded) of the precipitation event which occurred in East Mesa on July 17-18, 1984 exceeded the design rainfall event (i.e., the return period used for planning purposes).

B. The effect, if any, of the Signal Butte Floodway construction on down slope flooding.

C. The effect, if any, of the CAP aqueduct construction on down slope flooding.

Scope of the Study

In order to accomplish the above objectives, the following tasks were performed:

A. Gathered precipitation data from Flood Control District recording

rain gauges and from volunteer precipitation observers in the study area.

B. Obtained radar weather traces from the National Weather service for the period of interest.

C. Physically inspected the study area to determine which areas were heavily impacted by the runoff and the extent of flooding in those areas.

D. Interviewed residents of the area in order to establish the timing and extent of the flooding.

E. Physically inspected both the Signal Butte Floodway and the CAP aqueduct to determine areas of inflow to and outflow from these structures as well as storage volume utilized.

F. Viewed an aerial video-tape of the CAP aqueduct which was recorded the morning after the precipitation event.

G. Reviewed pertinent hydraulic reports:

1) East Side Stormwater Drainage Study for the City of Mesa, prepared by Yost and Gardner Engineers, May 1981.

2) Solicitation/Specifications, Salt-Gila Aqueduct Reach 1B, Central Arizona Project, Bureau of Reclamation.

H. Developed three HEC-1 models of the study area:

1) Recreating the historical event of July 17-18, 1984.

2) Creating the hypothetical event which might have occurred if the Signal Butte Floodway had been fully operational.

3) Creating the hypothetical event which might have occurred if neither the Signal Butte Floodway nor the CAP aqueduct were in place.

Watershed Characteristics

Description of Area

The study area is located in east-central Maricopa County, bounded on the north by the Usery Mountains, on the south by Baseline Road, on the east by Meridian Road (Maricopa-Pinal County line) and on the west by Sossaman Road. The topography can be characterized as an alluvial fan with steep and rugged terrain in the northeast and generally sloping to the southwest. The drainage pattern is typical of alluvial fans with numerous small washes none of which

consistently acts as a main collector channel. Soils are shallow and allow for only small infiltration losses. In the natural condition much of the runoff occurs in the form of sheet flow.

The CAP aqueduct crosses the area with a generally northwest-southeast alignment. Signal Butte Floodway has two main sections: 1) the concrete-lined section has a northeast-southwest alignment and terminates on the northside of the CAP aqueduct between Ellsworth Road and Hawes Road, and 2) the unlined section which was under construction during the period of interest lies north of Brown Road and has an eastward alignment. This second section extends eastward to Signal Butte Road.

Apache Trail (US 60-80-89), which divides the area into north and south sections, is lined on either side by numerous commercial developments. Residential developments exist off of Apache Trail to both the north and south.

Precipitation

Summer precipitation typically consists of local storms over small areas and of brief (up to 3 hours) duration, which include sporadic showers and cloudbursts, due usually to insolation heating of tropical maritime air that frequently invades the region from the Gulf of Mexico or the Gulf of California and the Pacific Ocean.

The one-hour 100-year point precipitation event used for subdivision and development drainage review in this area has a total depth of approximately 2.60 inches.

Discussion of Analysis

Method of Analysis

The runoff which resulted from the storm of July 17-18, 1984 and that which might have occurred in the hypothetical situations previously described in the scope of this study, was determined through the use of the Hydrologic Engineering Center (HEC-1) flood hydrograph package (COE, 1981). The HEC-1 model simulates the surface runoff response of a basin to precipitation by representing the basin as an interconnected system of hydrologic and hydraulic components.

Subbasins

In order to facilitate the modeling of this system, the study area was divided into either 10 or 18 subbasins, depending on which condition was being modeled. The presence of the Signal Butte and CAP structures (Situations 1, 2) resulted in different sub-drainages being created than existed prior to their introduction to the area (Situation 3).

Precipitation Pattern Analysis

The Flood Control District of Maricopa County maintains a network of telemetered and recording rain gauges throughout Maricopa County. Additionally, Flood Control District supports a network of unofficial volunteer precipitation observers through the provision of "wedge" rain gauges. Based on this data and aided by radar weather traces of the July 17-18 storm, a series of isohyets for total storm rainfall were drawn (Figure 1). An isohyet is a line connecting points which received an equal amount of precipitation. The isohyets provided a means of determining the average precipitation for individual subbasins for input to the model.

Data provided by the recording rain gauges indicated the storm began at approximately 10:30 p.m. with highly intense rainfall until 11:30 p.m. and rainfall ceasing at approximately 1:00 a.m. A mass curve (Figure 2) was drawn from the data to provide a temporal distribution of the rainfall for model input.

Model Calibration

Physical inspection of the study area as well as interviews with local residents provided some information about high water marks, direction of water movement and time of peak flow. Based on this information and hydrologic

judgment, the parameters of the model were adjusted so that the model output reflected the runoff resulting from the storm of interest. With the parameters set to these calibrated values, the area was delineated to reflect the drainage patterns for the two hypothetical situations. The model was then run again to simulate the runoff from those conditions.

The first area used for model calibration was the unlined section of Signal Butte Floodway. Soil Conservation Service (SCS) survey data provided elevation versus capacity information for that structure as well as the elevation of the high water mark above the floodway. This information allowed us to determine 1) the volume of water captured by the floodway (75 Acre-feet), 2) the peak discharge over the southside of that structure (1160 cfs), and 3) a reasonable estimate of precipitation losses to infiltration for a natural desert environment (SCS curve number of 75).

High water marks on the concrete abutments on the University Drive Bridge indicated that the flow over the bridge was approximately 21 inches deep. Assuming a flow velocity of 5-6 fps (based upon consideration of the hydraulic parameters), the peak flow at this point would have been 700 cfs. This value, combined with SCS survey data on high water marks in the CAP aqueduct and its bordering collection channel in this area provided us with a second calibration point.

SCS survey data of the CAP aqueduct in the vicinity of Broadway Road provided another point to be used for calibration. At this site water flowed out of

the aqueduct through an overchute excavation. The survey data provided information on the geometry of the outflow site as well as the high water elevation in the aqueduct (1560.74' above MSL). Residents .75 mile downslope of this point believe that the peak flow occurred at approximately 2:00 a.m.

The final points used for model calibration were the drainage channel on the northside of Desert Sands Mobile Home Park and the Sossaman Road drainage channel north of Baseline Road. The capacity of the former was exceeded resulting in flooding of homes in the mobile home park. Inasmuch as the flow probably altered the channel characteristics, it is not possible to determine what its capacity was at the time of the flooding. However, a survey made after the channel was repaired indicates that its maximum capacity is 1100 cfs.

Flow in the Sossaman Road drainage channel below its juncture with the above mentioned drainage channel slightly exceeded its capacity of 1950 cfs.

Results

Return Period of Storm of July 17-18, 1984

Three of the rain gauges located in the study area recorded total rainfall depths in excess of 2.60 inches; two of these were greater than or equal to 3.75 inches. This indicates that in parts of the study area this storm had a return period greater than the 100-year point precipitation values used for subdivision and development drainage review.

Actual Conditions July 17-18, 1984

A pictorial summary of the runoff resulting from the storm of July 17-18 is provided in Figure 3.

The lined section of Signal Butte Floodway was separated from the unlined section by an earthen plug at their juncture. The apparent purpose of this plug was to aid in "tie-in" work at the juncture of the lined and unlined sections. As a result, runoff from the drainage above the unlined section first filled and then overtopped that section of the floodway. Approximately 75 acre-feet of runoff were stored in the unlined section of the Signal Butte Floodway.

The subdivision north of University Drive in the vicinity of 96th Street and the CAP aqueduct was subjected to flooding from the direct runoff from the

drainage above it to the Signal Butte structure as well as from the runoff which was not captured by that structure. This was also the area of greatest total rainfall (3.75 inches). Peak inflow to the area was approximately 800 cfs.

Initially runoff was conveyed around and through the site in developed drainage patterns. The runoff was then captured by a collection channel on the northside of the aqueduct which directed the flow northwest to the vicinity of Ellsworth Road. In this area an excavation for the placement of an overchute allowed the water to enter the aqueduct. A partial earthen plug below University Drive prevented most of this flow from advancing beyond that point.

At some time the inflow to this area greatly exceeded the outflow into the collection channel and severe ponding, as deep as 3-4 feet, occurred in the area of University Drive and 96th Street. Highwater marks on the University Drive bridge indicate that in excess of 700 cfs flowed over the bridge in a westerly direction. This flow then continued as sheetflow and as channel flow in the existing drainage patterns in a southwesterly direction.

Another earthen plug was located in the CAP aqueduct in the vicinity of Signal Butte Road. Between University Drive and this point, runoff entered the aqueduct at a number of sites where excavations had been made for the placement of overchute pipes. However, because inflow to the area exceeded

the rate of flow into the aqueduct, ponding on the upstream side of the aqueduct in the vicinity of Wood Avenue occurred.

In excess of 120 acre-feet of water was stored in the aqueduct until the water surface elevation exceeded the elevation of an overchute excavation on the downslope side of the aqueduct in the vicinity of Broadway Road.

Runoff exiting the aqueduct at this point caused erosion of the aqueduct embankment which in turn allowed the previously stored water to exit. Failure of the embankment at this section was gradual.

Broadway Road and its bordering blader ditches captured some of the flow to their capacity (approximately 750 cfs) with the remainder flowing in a generally southwesterly direction as streetflow, sheetflow and channel flow in existing drainage ways. This flow eventually entered a drainage channel with an east-west alignment located between Baseline Road and Southern Avenue. This channel bounds Desert Sands Mobile Home Park on the north.

The flow west along Broadway Road was augmented by the runoff from above Apache Trail, including that flow which had passed over the University Drive bridge. At Hawes Road, most of this flow was directed south, with flow in excess of 1500 cfs continuing west along Broadway Road.

The flow along Hawes Road was again split by a control structure at Southern Avenue with approximately one-half of the flow continuing along Hawes Road and

the remainder directed in a westerly direction to empty into the Sossaman Road drainage channel.

The flow which remained along Hawes Road then entered the same drainage channel which was to receive the runoff which had exited the CAP aqueduct in the vicinity of Broadway Road.

The peak discharge of these combined flows was approximately 1800 cfs. This exceeded the capacity of that drainage channel and caused some flooding in the Desert Sands Mobile Home Park. This flow was ultimately captured by the Sossaman Road drainage channel.

Effect of Signal Butte Floodway Construction

A pictorial summary of the runoff described in the following discussion is provided in Figure 4.

The area most directly impacted by the construction of the Signal Butte Floodway was that area immediately below it which received the overflow from that structure; specifically, the Desert Vista Estates subdivision located in the vicinity of 96th Street and University Drive. A comparison of peak flows through this area for actual conditions (see above section), and those which might have occurred had the structure not been in place, provide a measure of its effect. The peak flow under actual existing conditions was approximately 800 cfs; under this hypothetical condition the flow would have been 1200 cfs,

or an increase in peak discharge of 50%. Stated differently, the Signal Butte Floodway, even in its partially constructed form, significantly reduced the flows.

On the other hand, had this floodway been fully operational at the time of the storm, the peak flow into this area would have been less than 550 cfs or a reduction in peak flow of nearly 30%. Additionally, the flow over the University Drive bridge would have been reduced from 700 cfs to only 90 cfs, thereby alleviating, if not eliminating, the flooding on the west side of that bridge and further south.

Effects of CAP Aqueduct Construction

A pictorial summary of the runoff described in the following discussion is provided in Figure 5.

In order to assess the effect of the CAP aqueduct construction on the flooding, a model simulating the absence of this structure was created.

There are basically three geographical areas of concern here, all of which were subjected to flooding: 1) the areas above the CAP aqueduct where ponding occurred, 2) the area below the aqueduct overflow point in the vicinity of Broadway Road, and 3) Desert Sands Mobile Home Park.

Under existing conditions the CAP aqueduct received the runoff from a large area upslope from it. This water collected in drainage channels on the upslope side of the aqueduct before entering it at overchute excavation sites. Due to the limited flow into the aqueduct, ponding occurred in several locations, notably the 96th Street and Cisco Road, Apache Trial and Crismon Road, and 101st Street and Wood Avenue areas.

After entering the aqueduct this water was stored until the water surface elevation exceeded the elevation of an overchute excavation site on the downslope side. This stored volume of water then exited the aqueduct at this point. The effect of the aqueduct, then, was to funnel a large volume of runoff to a single outlet. The peak flow through the area in the vicinity of 96th Street and Pueblo Avenue under these conditions was approximately 1800 cfs. Without this funneling effect, the peak flow at that point would have been approximately 750 cfs.

However, this is not to say that flooding would not have occurred under pre-construction conditions. Rather, different areas which were not inundated under actual conditions would have been subjected to flooding. For example, under actual conditions Broadway Road and the bordering blader ditches did not flow much in excess of their capacity, if at all, west of Ellsworth Road. Had the aqueduct not been in place, the capacity would have been exceeded by approximately 1100 cfs near Ellsworth Road and by 800 cfs near 88th Street. This would have resulted in flooding of the areas south of Broadway Road between Ellsworth Road and Hawes Road.

Under actual conditions, the drainage channel on the north side of Desert Sands Mobile Home Park experienced a peak flow of 1800 cfs, which exceeded its capacity. As a result, some mobile homes in this area experienced some flooding. Model output indicates that this channel would have received a peak flow of 3000 cfs under pre-construction conditions.

Conclusions

A. The one-hour 100-year point precipitation used for subdivision and development drainage review in this area has a total depth of approximately 2.60 inches. Three rain gauges in the east Mesa area recorded total rainfall in excess of this value following the July 17-18 storm. This indicates that the storm in question had a return period greater than that used for subdivision and development drainage review.

B. The construction of the Signal Butte Floodway did not contribute to the flooding which resulted from this storm. Though not operational in its design context at the time of the storm, this structure captured nearly 75 acre feet of runoff which otherwise would have impacted downslope locations.

The peak flow into the area immediately below the floodway (96th Street and University Drive) was approximately 800 cfs under the existing conditons. As modeled for the pre-construction scenario, flow into this same area was 1200 cfs, or an increase in peak discharge of 50%. On the otherhand, as modeled for the scenario where Signal Butte Floodway was operational, the peak inflow to this area was approximately 500 cfs.

Ponding of water in this area was not a consequence of too much water entering the area due to a failure of the floodway to convey runoff to another site. Rather, the ponding was due to inadequate conveyance of the water in the collection channels on the northside of the CAP aqueduct.

C. The construction of the CAP aqueduct resulted in ponding of runoff water in a number of sites on the northside of that structure as well as a re-direction of a large volume of runoff.

Collection channels on the northside of the CAP aqueduct are designed with relatively flat slopes so as to distribute runoff among a number of overchutes. Because the overchutes were not operational at the time of the storm, the collection channels were not able to drain as designed. This resulted in water being ponded in a number of areas.

Although flow into the aqueduct was not adequate to prevent ponding on the northside of that structure, inflow did take place. Effectively the CAP aqueduct acted as a reservoir, storing runoff from a large drainage area upslope from it. This continued until the water surface elevation exceeded the elevation of an overchute excavation on the downslope side of the aqueduct in the vicinity of Broadway Road and Crismon Road. A large portion of this stored water then exited the aqueduct at a single point. This re-direction of flow from the natural and developed drainages to a single outlet

resulted in flooding immediately below the outflow point (e.g., Pueblo Avenue and 96th Street). Peak outflow through this site was approximately 2500 cfs. This can be compared with the flow of 750 cfs which the computer model indicates would have impacted this area in the pre-construction condition.

Desert Sands Mobile Home subdivision experienced flooding when the capacity of the drainage channel on its north side was exceeded. There is some question about the condition of this channel on the evening of the flooding. However, even under ideal conditions the capacity of the channel would have only been about 1000 cfs. The actual inflow was about 1800 cfs or almost twice the channel's maximum capacity. The computer model of preconstruction conditions indicates that the peak flow would have been nearly 3000 cfs had the Signal Butte Floodway and the CAP Aqueduct not captured a portion of the runoff. Flooding in this subdivision occurred because the drainage facilities around Desert Sands simply were not designed or constructed to control runoff from a storm of this magnitude.

References

East Side Stormwater Drainage Study for the City of Mesa, Yost and Gardner Engineers, May 1981.

HEC-1 Flood Hydrograph Package, Users Manual, US Army Corps of Engineers, September 1981.

Solicitation/Specifications Salt-Gila Aqueduct Reach 1-B, Central Arizona Project, Bureau of Reclamation.

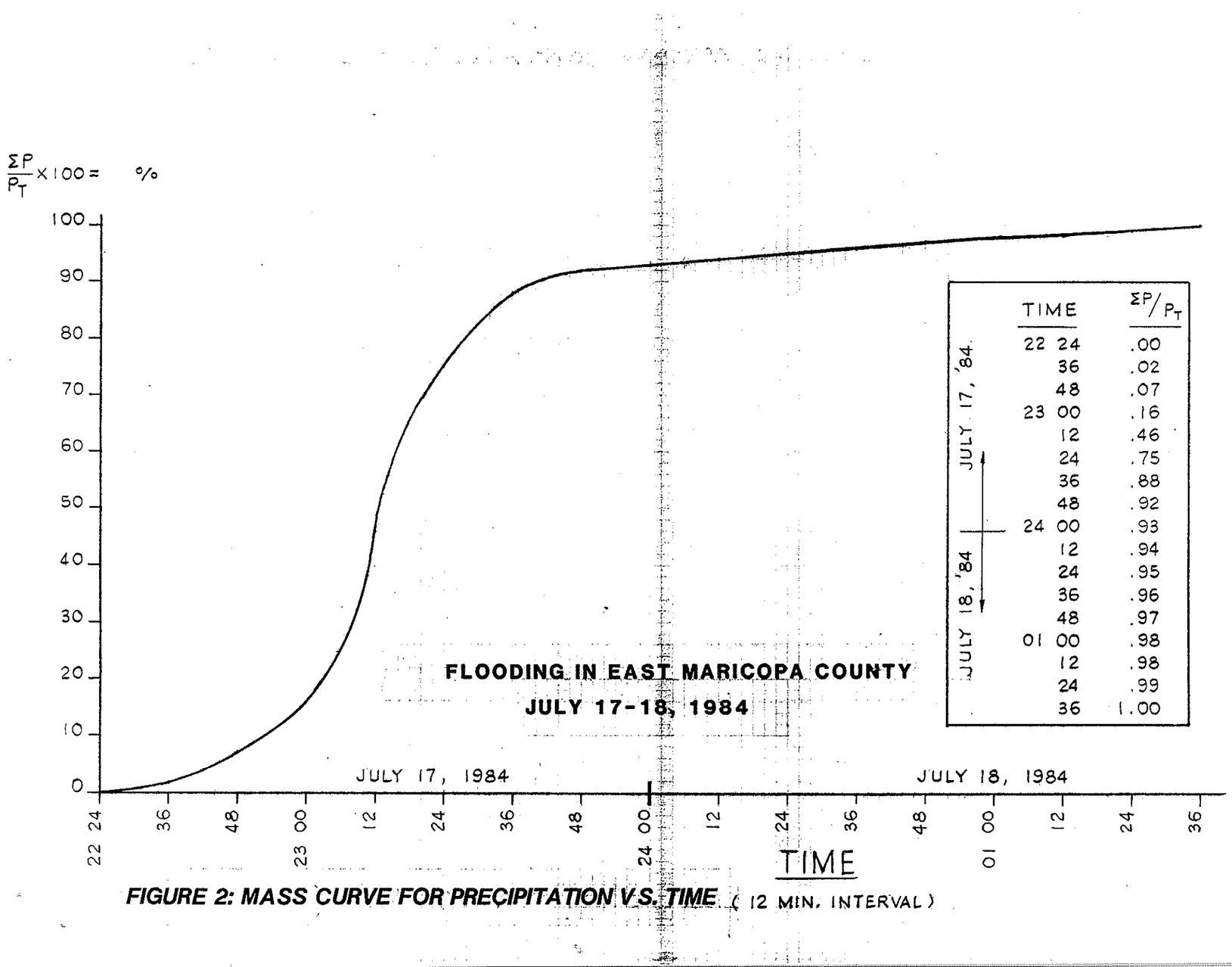

FIGURE 2: MASS CURVE FOR PRECIPITATION V.S. TIME (12 MIN. INTERVAL)

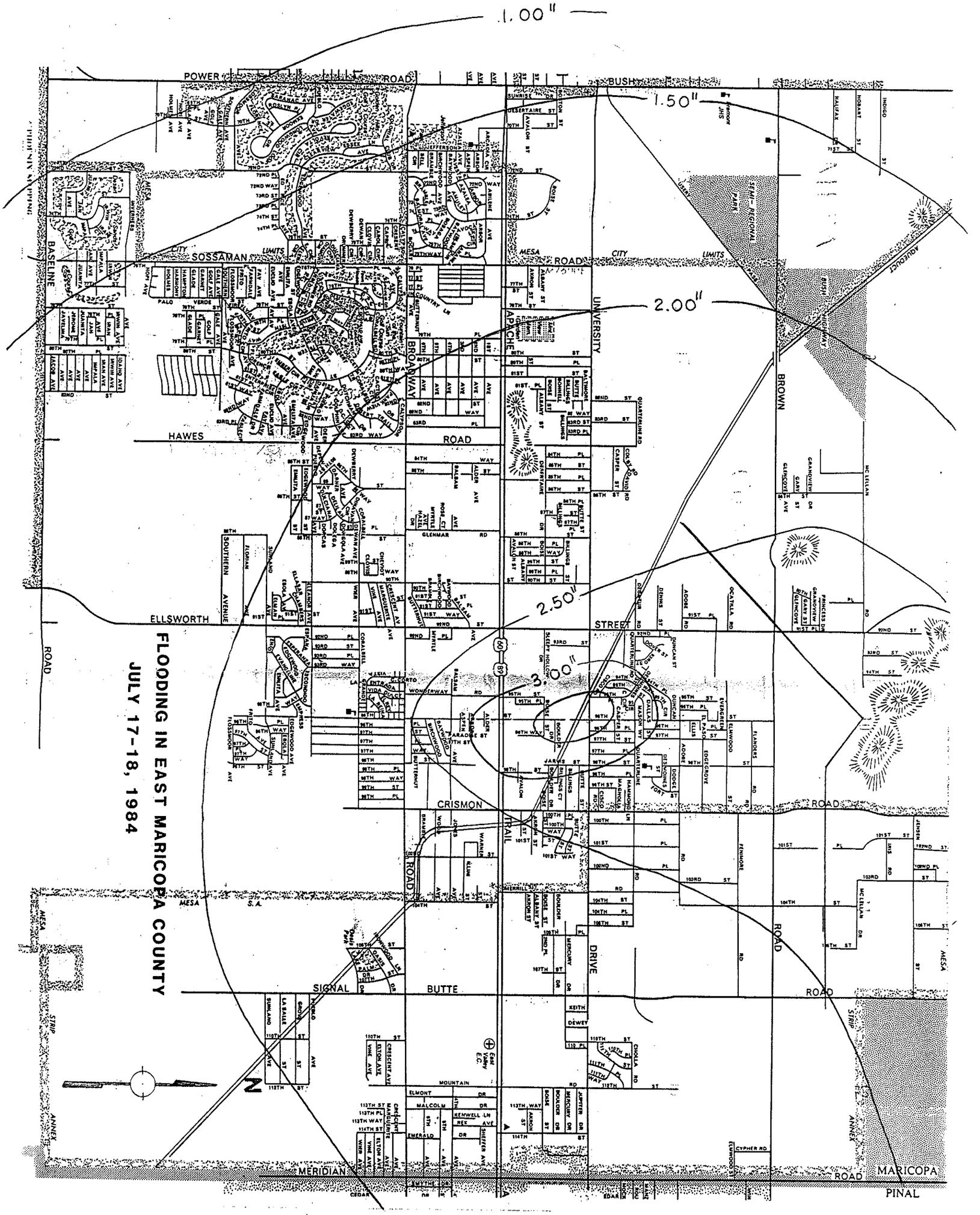

FIGURE 1: ISOHYETS FOR STORM OF JULY 17-18, 1984

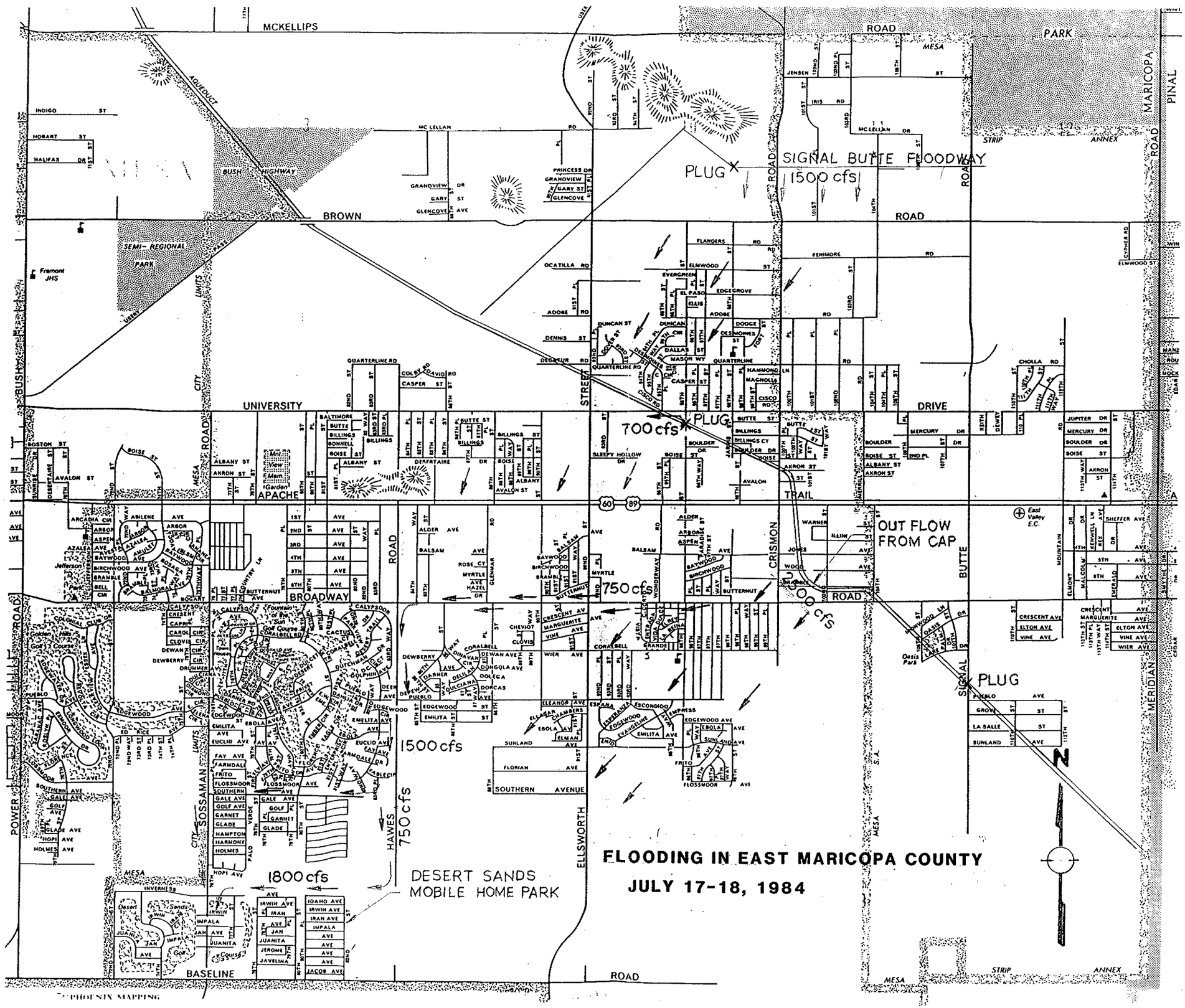

FIGURE 3: OVERVIEW OF RUNOFF RESULTING FROM STORM OF JULY 17-18, 1984

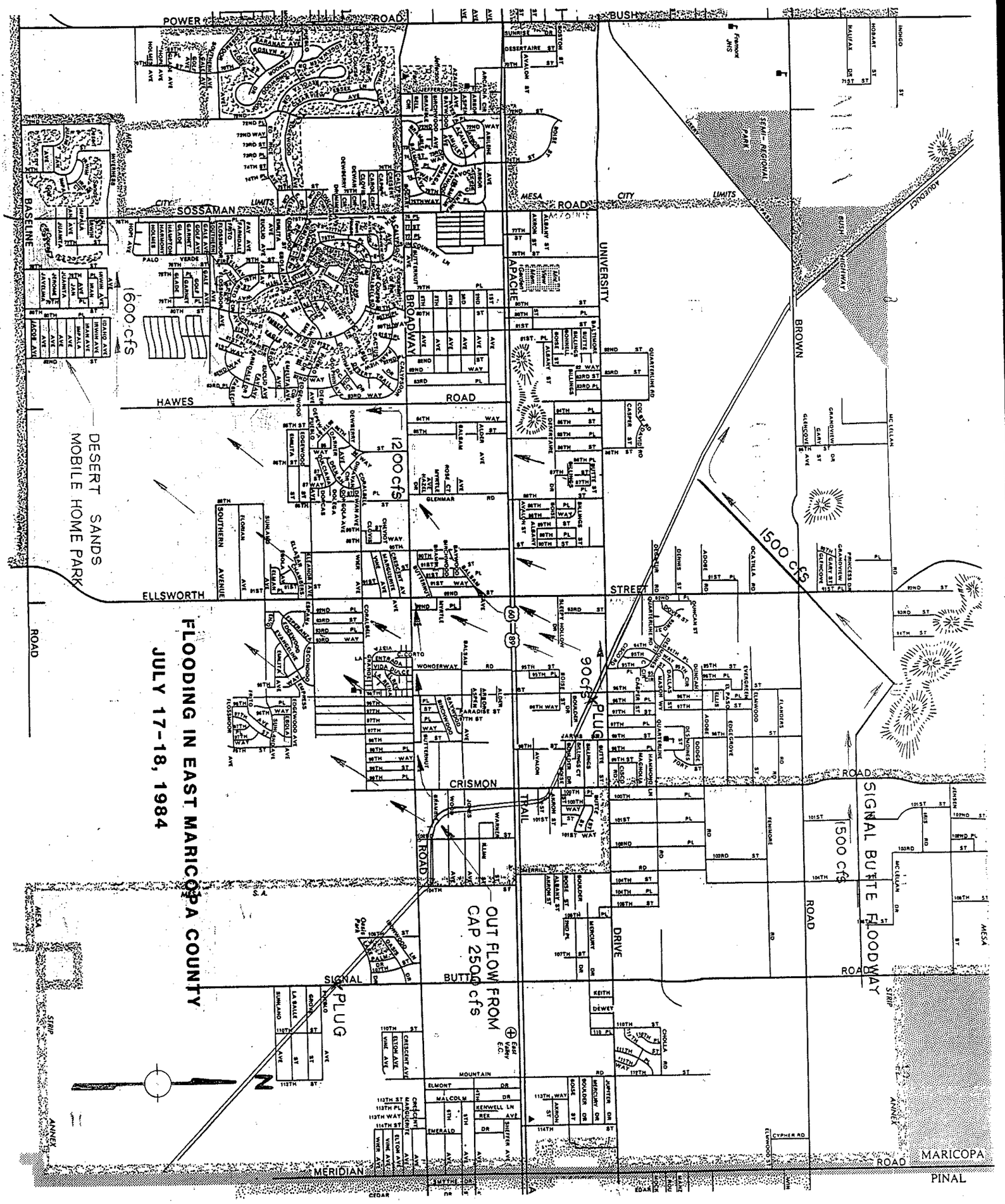

FIGURE 4: OVERVIEW OF RUNOFF RESULTING FROM SITUATION 2 (SIGNAL BUTTE FLOODWAY OPERATIONAL)

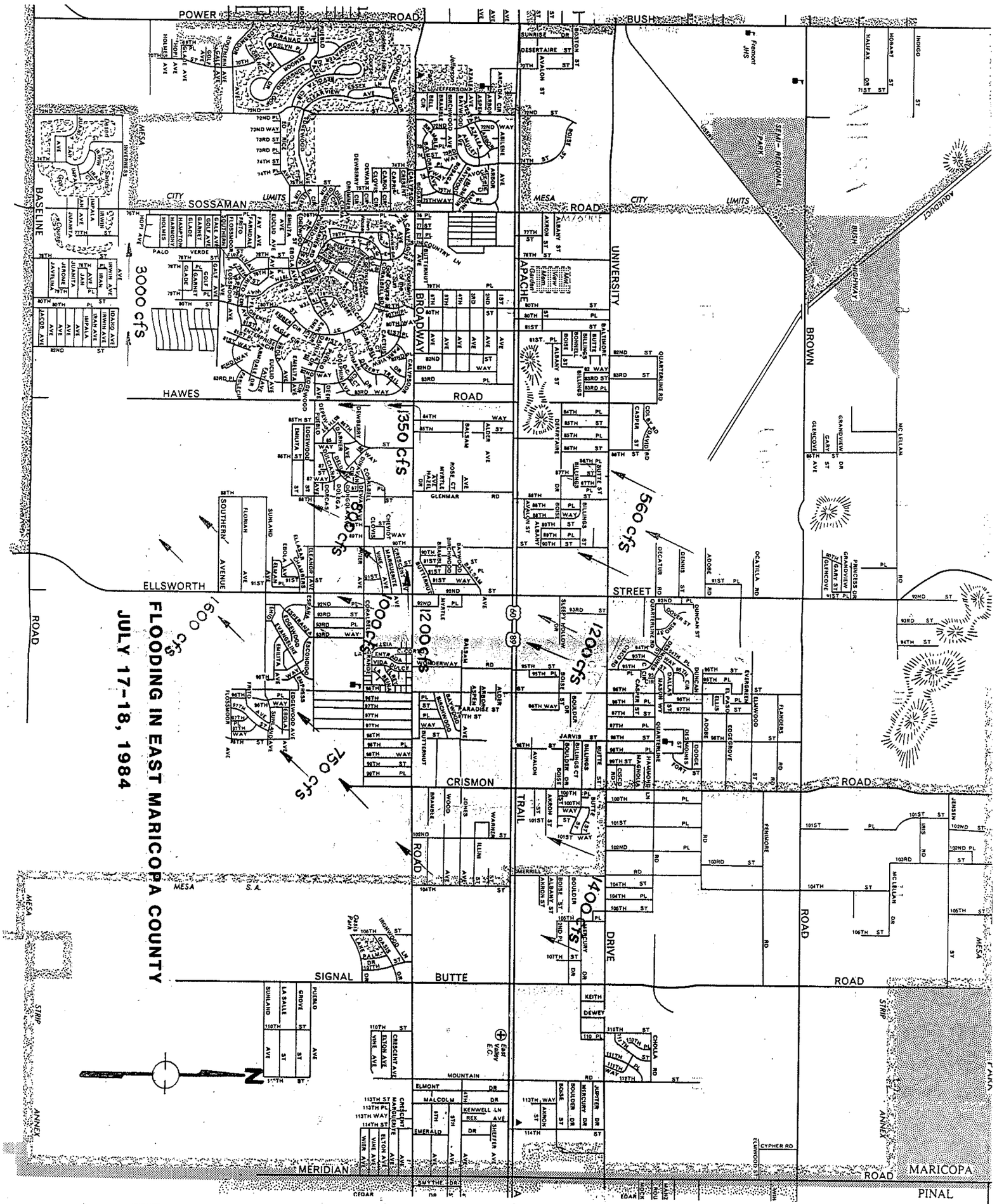

FIGURE 5: OVERVIEW OF RUNOFF RESULTING FROM SITUATION 3