District
lease Return
2801 W. Durango
AZ 85

FINAL HYDROLOGIC AND HYDRAULIC REPORT

FOR

CAVE CREEK/CAREFREE

FLOOD DELINEATION STUDY

Prepared for

FLOOD CONTROL DISTRICT
OF
MARICOPA COUNTY

By

CH2M HILL

Project RDD27815.H3/(FCD 88-53)

March 1990

FINAL HYDROLOGIC AND HYDRAULIC REPORT

FOR

CAVE CREEK/CAREFREE

FLOOD DELINEATION STUDY

Prepared for

FLOOD CONTROL DISTRICT
OF
MARICOPA COUNTY

By

CH2M HILL

Project RDD27815.H3/(FCD 88-53)

March 1990

DRAFT

FINAL HYDROLOGIC AND HYDRAULIC REPORT

FOR

CAVE CREEK/CAREFREE

FLOOD DELINEATION STUDY

Prepared for

**FLOOD CONTROL DISTRICT
OF
MARICOPA COUNTY**

By

CH2M HILL

Project RDD27815.H3/(FCD 88-53)

March 1990

CONTENTS

FIGURES

TABLES

EXHIBITS

LIST OF APPENDIXES

1.0 INTRODUCTION

1.1 PURPOSE OF STUDY

This Flood Delineation Study includes revised and updated information on the existence and severity of flood hazards in the geographic area of Maricopa County, Arizona. The study area includes the cities Cave Creek and Carefree and unincorporated areas of Maricopa County, hereinafter referred to collectively as Maricopa County. This information will be used to update existing floodplain regulations as part of the regular phase of the National Flood Insurance Program (NIP). The information will also be used by local and regional planners to further promote sound land use and floodplain development.

1.2 AUTHORITY AND ACKNOWLEDGEMENTS

The hydraulic analyses for this study were performed by CH2M HILL for the Flood Control District of Maricopa County (FCDMC) under Contract Number 88-53. This work was completed in March 1990. Discharges for the study reaches were derived from a hydrologic analysis initially prepared by FCDMC and updated by the study contractor. Topographic mapping was prepared by Aerial Mapping Company, Inc., from aerial photography flown on August 2, 1989.

Portions of this Flood Insurance Study are based on previous flood insurance studies for the Cave Creek/Carefree area. The previous study was performed by Harris-Toups Associates (HTA) under Contract Number H-4008. This work was completed in February 1978.

1.3 COORDINATION

FCDMC selected the areas and approximate studies. FCDMC also provided a HEC-1 watershed model of the study area, along with guidelines and criteria for modifying the model.

On July 14, 1989, representatives of CH2M HILL and FCDMC held an initial coordination meeting to discuss scheduling methods, assumptions, and the format of deliverable items. In addition, the Flood Control District and study contractor staff met throughout the study to discuss preliminary results of the hydrologic and hydraulic modeling. FCDMC staff also assisted in the field reconnaissance of the study area.

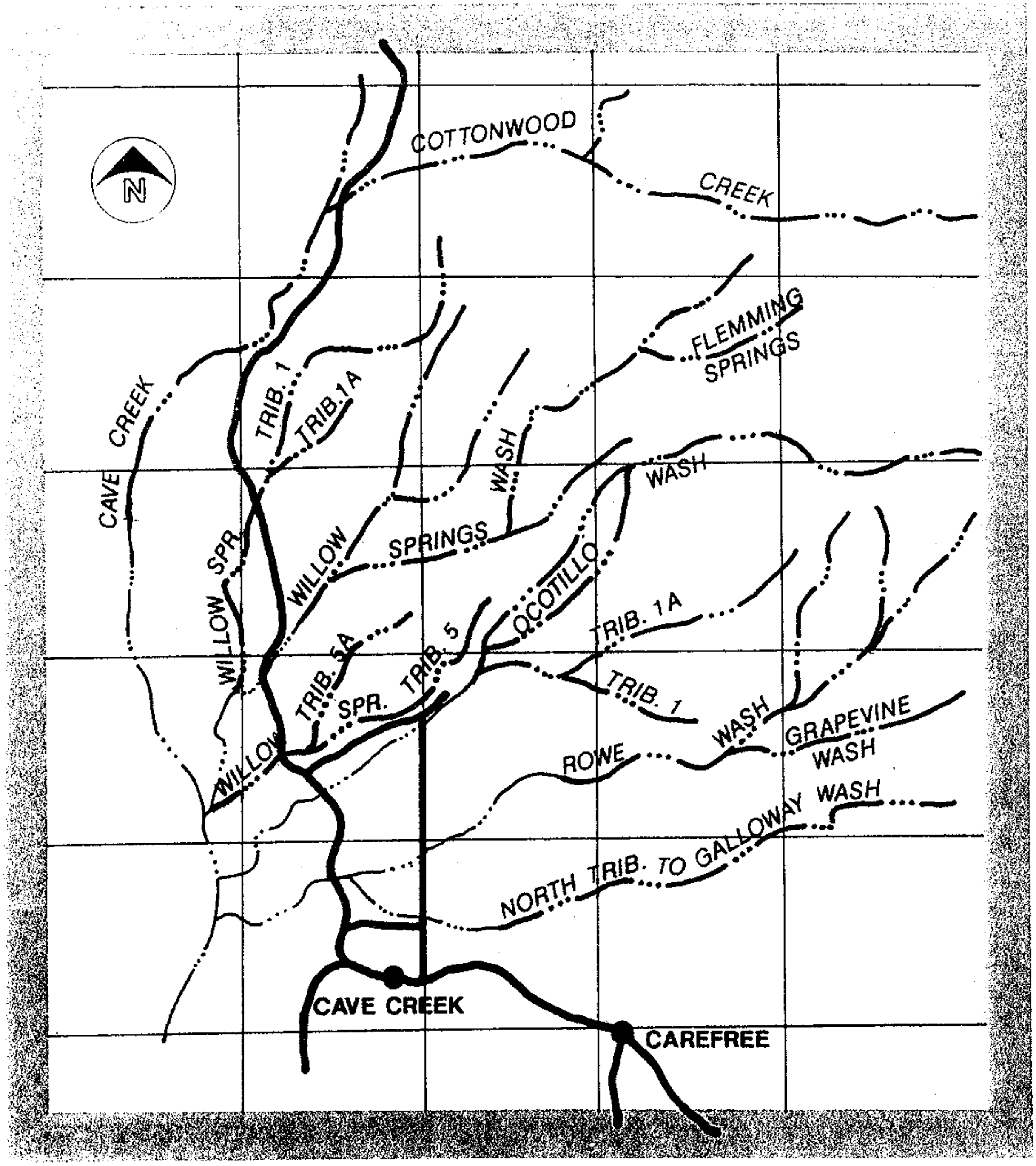
page 2 missing

2.0 AREA STUDIED

2.1 SCOPE OF STUDY

This Flood Insurance Study covers the portions of Cave Creek and its major tributaries north of Cave Creek Road. The study area is shown on the vicinity map (Figure 1). The flooding sources studied by detailed methods, shown in Table 1 were selected with priority given to known flood hazard areas and developed areas or areas of proposed construction.

Portions of streams studied by approximate methods are listed in Table 2. Approximate analyses were used to study those areas having minimal potential flood hazard. Figure 1A is the Work Map Index Sheet showing the location of all study reaches.



DETAILED STUDY STREAM REACHES

APPROXIMATE STUDY STREAM REACHES

NOT IN CONTRACT

STUDY AREA

NOT TO SCALE

CAVE CREEK / CAREFREE
FLOODPLAIN DELINEATION STUDY

RDD 27815.H3

CH2M HILL

FIGURE 2
WATERSHED DELINEATION MAP
MARICOPA COUNTY
FLOOD CONTROL DISTRICT
CAVE CREEK / CAREFREE
FLOOD INSURANCE STUDY

MARCH 1990

LA027815.H1

Table 1

STUDIED BY DETAILED METHODS

Flooding Source	Limits of Study
Cave Creek	From River Mile 35.49 near Morning Star Road to the Tonto National Forest Boundary (River Mile 38.79).
Cottonwood Creek	From confluence with Cave Creek to River Mile 4.52.
Cottonwood Creek Tributary 1	From confluence with Cottonwood Creek to the Tonto National Forest Boundary (River Mile 0.70).
Cottonwood Creek Tributary 2	From confluence with Cottonwood Creek Tributary 1 to the Tonto National Forest Boundary (River Mile 0.22).
Flemming Springs Wash	From confluence with Willow Springs Wash to its headwater River Mile 0.76.
North Tributary of Galloway Wash[1]	From confluence with Grapevine Wash near School House Road to the Pima Road alignment (River Mile 3.26).
Grapevine Wash	From confluence of Rowe Wash to the Pima Road alignment boundary (River Mile 1.43).

Table 1 (Con't.)
STUDIED BY DETAILED METHODS

Flooding Source	Limits of Study
Ocotillo Wash	From River Mile 2.03 near Lone Mountain Road to River Mile 4.61.
Ocotillo Wash Tributary 1	From confluence with Ocotillo Wash to its head waterseat River Mile 1.10
Ocotillo Wash Tributary 1A	From confluence with Ocotillo Wash Tributary 1 to River Mile 0.71.
Ocotillo Wash Tributary 2	From confluence with Ocotillo Wash to River Mile 1.07.
Ocotillo Wash Tributary 3	From confluence with Ocotillo Wash to its headwater at River Mile 1.10.
Ocotillo Wash Tributary 4	From confluence with Ocotillo Wash to its headwater at River Mile 1.25.
Rowe Wash	From River Mile 1.52 near Echo Canyon Road to confluence with Rowe Wash Tributary 2.

Table 1 (Con't.)

STUDIED BY DETAILED METHODS

Flooding Source	Limits of Study
Willow Springs Wash	From River Mile 1.78 to River Mile 4.60.
Willow Springs Wash Tributary 1	From confluence with Willow Springs Wash to confluence with Willow Springs Wash Tributary 1A.
Willow Springs Wash Tributary 1A	From confluence with Willow Springs Wash Tributary 1 to River Mile 0.97.
Willow Springs Wash Tributary 2	From confluence with Willow Springs Wash to River Mile 1.61.
Willow Springs Wash Tributary 2A	From confluence with Willow Springs Wash Tributary 2 to River Mile 1.00.
Willow Springs Wash Tributary 4	From confluence with Willow Springs Wash near Sierra Vista Road to River Mile 1.09.
Willow Springs Tributary 5	From confluence with Willow Springs Wash to its headwater at River Mile 2.04.
Willow Springs Tributary 5A	From confluence with Willow Springs Wash Tributary 5 to its headwater at River Mile 0.60.

Table 2
STUDIED BY APPROXIMATE METHODS

Flooding Source	Limits of Study
Ocotillo Wash	From River Mile 4.61 to its headwaters at River Mile 5.61.
Rowe Wash	From confluence with Rowe Wash Tributary 2 to its headwater at River Mile 4.53.
Rowe Wash Tributary 1	From confluence with Rowe Wash to its headwater at River Mile 0.85.
Rowe Wash Tributary 2	From confluence with Rowe Wash to its headwater at River Mile 0.53.
Willow Springs Wash	From River Mile 4.60 to its headwater at River Mile 5.31.
Willow Springs Tributary 3	From confluence with Willow Springs Wash to River Mile 3.59.

2.2 COMMUNITY DESCRIPTION

The study area is located in north central Maricopa County, and it is roughly bounded on the south by the towns of Cave Creek and Carefree, and on the east, west, and north by Tonto National Forest. The streams vary in character from steep, well incised channels to wide, braided, distributary flow systems. Except for portions of Cave Creek, all of the washes studied are ephemeral, flowing only in direct response to rainfall events. Portions of Cave Creek flow continuously for portions of the year.

Vegetation in the area is primarily desert brush in the lower elevations and mountain brush in the upper elevations. Surface cover densities range from approximately 20 to 50 percent. The climate is warm, semi-arid Sonoran desert with average daily maximum temperatures of 64 degrees Fahrenheit in January and 102 degrees Fahrenheit in July. Elevations ranges from 5,204 feet on Hunbolt Mtn. to 2,000 feet at Cave Creek flood crossing of Cave Creek.

The mean annual precipitation at Carefree is approximately 11 inches. Rainfall in the area results from two distinctly different meteorological events. High intensity, short- duration thunderstorms typically occur in the late summer months, resulting in high rates of runoff from small areas. Rainfall from frontal and Pacific storm movements typically occurs in the winter and spring months. These storms have longer duration and lower intensity and cover larger watershed areas (Reference 12).

2.2.1 Study Streams

Cave Creek and its tributaries drain the mountainous areas of east central Maricopa County flowing southwesterly to the confluence with the Arizona Canal Diversion Channel. Cave Creek flows are regulated by Cave Creek Dam located just north of Phoenix. This study area extends from Cave Creek River Mile 35.49 approximately 3.3 miles to the Tonto National Forest boundary.

Cottonwood Creek is the uppermost tributary to Cave Creek within the study area, along with two small tributaries. The Cottonwood system includes a total of 4.9 river miles and flows westerly within well defined channels to Cave Creek.

The **Willow Springs** drainage system includes Willow Springs[1] and Tributaries 1, 1A,2, 2-A, 3A, 4 and Fleming Springs. This drainage system includes a total of approximately 14.7 river miles. The channels are generally well incised, steep mountainous streams.

Ocotillo Wash and its Tributaries 1, 1-A, 2, 3, and 4, extend from the previous study limits easterly to the headwaters of the basin. A total of approximately 10.1 river miles were mapped. The lower portion of Ocotillo Wash is a wide, poorly defined, braided stream system. The tributaries are generally well-defined streams draining small watersheds.

The wash shown on USGS quadrangle maps as **Grapevine Wash** is included in this study extending from its confluence with Rowe Wash, easterly, approximately 1.4 miles. **Rowe Wash** and Rowe Wash tributaries 1 and 2 study reaches begin at the study limit of the previous Flood Insurance Study. These streams extend easterly, to the Pima Road extension, totaling approximately 4.3 river miles. The Rowe system is generally well incised and steep.

The **North Tributary of Galloway Wash** study reach extends from the confluence with Galloway Wash approximately 2.9 miles northeasterly to the Pima Road extension. The previous Flood Insurance Study included a study stream referred to as Grapevine Wash, which was tributary to the current study reach of the North Tributary of Galloway. USGS quadrangle mapping and local anecdotal information, indicates this small tributary, which originates at Grapevine Spring, was misnamed and should be referred to as Unnamed Tributary to Galloway.

2.3 PRINCIPAL FLOOD PROBLEMS

The principal flood hazards in this study area result from two distinctly different geomorphic channel types. The first is inundation and erosion of wide, flat floodplain areas adjacent to braided alluvial channels. Flow paths for these streams are dynamic and unpredictable. The principal hazard associated with the narrow, more well incised channels results from the erosive impacts of high velocity flows.

Recent significant flood events on Cave Creek and its tributaries were recorded on August 21, 1921; October 23, 1959; October 30, 1959; March 2, 1978; February 21, 1980; and October 1, 1981. In the most recent flood, 2.4 inches of rain fell in the

[1] In the hydrologic and hydraulic analyses, Willow Springs was referred to as Tributary 3.

Carefree area during a 2-day period. Floodwater in excess of 4 feet overtopped Schoolhouse Road at Galloway Wash. Several minor injuries were reported.

2.4 FLOOD PROTECTION MEASURES

No significant flood control levees or other flood control measures have been constructed within the areas being studied. The Cave Creek Dam, located approximately 8 miles downstream of the study area, and built in 1923, provides protection from a 25-year flood to parts of Phoenix. (Reference 18)

3.0 ENGINEERING METHODS

3.1 HYDROLOGIC ANALYSES

The 1978 Flood Insurance Study for the Cave Creek area was developed using the SCS TR20 program. FCDMC staff subsequently developed a HEC-1 model simulating the Cave Creek/Bloody Basin area. The portion of that model covering the contributing watersheds to the study area was provided for use in this study by FCDMC. This rainfall-runoff model was revised to incorporate necessary sub-basins for this study. Lag times, loss rates, and channel reach travel times were revised to incorporate methods and parameters selected by FCDMC.

Following preliminary reviews by the Arizona Department of Water Resources, FCDMC incorporated final revisions to the model. The following sections describe the modeling procedures and parameters. Detailed data are shown in Appendix A.

3.1.1 Rainfall

The watersheds (Figure 2) contributing runoff to Cave Creek cover approximately 110 square miles at the downstream limit of the study area. It was assumed that this watershed would develop the greatest runoff in response to a widely distributed, frontal rainfall event. The 24-hour duration storm was selected as a design storm for Cave Creek. The basins contributing storm runoff to the study tributaries range in size from approximately 0.5 square miles to 10 square miles. These basins develop a more extreme runoff response from short duration, high intensity rainfall events. A 2-hour storm duration was therefore chosen as a design storm for the tributaries to Cave Creek. Separate models were developed representing each of these storm durations.

Following FCDMC specifications, the SCS Type II rainfall distribution was selected for use in this study. This hypothetical rainfall depth versus time distribution was developed by the Soil Conservation Service (SCS) for use in the western U.S. (Reference 14). Rainfall depths were derived from the National Oceanographic and Atmospheric Agency Precipitation-Frequency Atlas. (References 2 and 11)

To account for the higher average precipitation depths that occur in the higher elevations of the Cave Creek watershed, the basins were divided at approximately the Cave Creek-Cottonwood Wash confluence. The sub-basins upstream and downstream of this point are referred to as Upper Cave Creek and Lower Cave

Creek, respectively. Separate precipitation/frequency relationships were estimated for each. An areal reduction factor of .85 was applied to the 24-hour Cave Creek model. This reduction factor was based on the NOAA publication Hydro 40. (Reference 10) No areal reduction was applied to the 2-hour tributary watershed model.

3.1.2 Loss Rates

Following FCDMC criteria, watershed losses were estimated in the HEC-1 model using the initial and uniform loss rate procedure. Loss rates parameters were estimated by FCDMC as a function of soil type, vegetation type, and cover density using Tables 3-1 and 3-2 below. Soil types were identified from the SCS Soil Survey of the Aguila-Carefree area (Reference 15) and were weighted by area.

Table 3-1
SURFACE RETENTION LOSS FOR VARIOUS LAND SURFACES IN MARICOPA COUNTY

Land-Use and/or Surface Cover (1)	Surface Retention Loss IA, (inches) (2)
Natural	
Desert and rangeland, flat slope	0.35
Hillslopes, Sonoran Desert	0.15
Mountain, with vegetated surface	0.25
Developed (residential and commercial)	
Lawn and turf	0.20
Desert landscape	0.10
Pavement	0.05
Agricultural	
Tilled fields and irrigated pasture	0.50

Table 3.2
INITIAL LOSS PLUS UNIFORM LOSS RATE
PARAMETER VALUES FOR BARE GROUND
ACCORDING TO HYDROLOGIC SOIL GROUP

Hydrologic Soil Group	Uniform Loss Rate CNSTL	Initial Loss, (inches) IL[1] Dry	Normal	Saturated
A	0.4	0.6	0.5	0
B	0.25	0.5	0.3	0
C	0.15	0.5	0.3	0
D	0.05	0.4	0.2	0

[1]Selection of IL:

Dry	=	Nonirrigated lands such as desert and rangeland
Normal	=	Irrigated lawn, turf, and permanent pasture
Saturated	=	Irrigated agricultural land

Table 3-1 gives initial abstraction as a function of land type. Table 3-2 was used to estimate bare ground initial and uniform loss rates for various hydrologic soil types. Both factors were adjusted for vegetative cover density (Figure 4).

3.1.3 Routing Parameters

The SCS Dimensionless Unit Hydrograph (Reference 14) was used for this study. Lag times developed by FCD staff in the original version of this model were reviewed and modified using the CH2M HILL "TC" Program (Reference 7). This model uses a velocity method to estimate the travel times for overland flow, collector channels, and main channel flow. Program parameters for each section are channel roughness, slope, side slope, bottom width, basin area, flow rate entering the main channel from upstream, and excess rainfall rate. The last parameter is dependent on time of concentration (tc). The user iteratively adjusts rainfall rate until the calculated tc matches the assumed tc. Flow rates vary along the main and collector channels. The user may specify whether computations will consider average flow velocity or wave velocity.

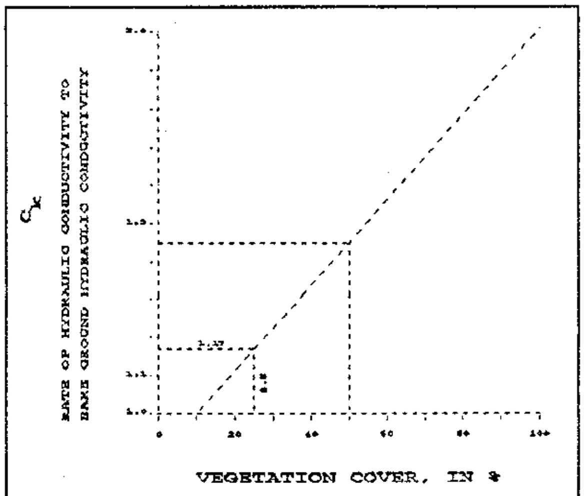


Figure 4

Channel geometrics were estimated from USGS 7.5 minute quadrangle mapping and field reconnaissance. Overland flow roughness factors of 1.0 were assumed. In the collector and main channels, roughness factors ranged from 0.04 to 0.065.

These calculations were reviewed by the Flood Control District and the Arizona Department of Water Resources (ADWR) and were further revised by FCDMC staff. The final HEC-1 model reflects the Flood Control District's revisions, which generally decreased estimates of velocity, increasing the resultant lag.

Channel routings were performed using the Muskingham method. A Muskingham K factor of 0.2 was used. The Muskingham "X" coefficient was derived from the travel time for each routing reach. The travel times were derived from the main channel velocities which resulted from the lag time computations. Channel transmission losses were not simulated in the routing model because of the lack of reliable available data for calibration.

The watershed modeling was performed using the 1988 revision to the HEC-1 model. Watersheds delineated from USGS 7.5 minute quadrangle mapping included the following:

- Cooks Mesa
- Rover Peak
- Daisy Mountain
- New River Mesa
- Humboldt Mountain
- New River Southeast
- Cave Creek

- Wildcat HILL

3.1.4 Results

Computations referred to in the previous discussion are contained in Appendix A. HEC-1 input and output listings are located in Appendix B. Table 4 summarizes the 10-, 50-, 100-, and 500-year discharges for each stream at various locations by river mile and concentration point. Where the current study extends previous mapping, the 100-year discharge from the previous study is shown. The estimated peak discharges for the tributary basins appear to be reasonably consistent with earlier studies and are appropriate peak discharges for this flood delineation study.

The estimates of peak discharges for Cave Creek which resulted from this study were higher than the previous study estimates. At the confluence of Cave Creek and Cottonwood Creek the previous and current study 100-year peak discharge were 23,500 cfs and 28,338 cfs respectively. At the confluence with Andora Hills Wash the estimates 100-year peak discharges were 35,000 cfs and now is 40,643 cfs. The differance is attributable to the difference in level of detail and methodology between the HTA TR-20 model and the FCDMC model updated for this project. the HTA model used five sub-basins for the watershed above the Town of Cave Creek and used very general SCS curve number assumptions. The current model was much more detailed and used procedures currently recommended by MCFCD.

Table 4
Summary of Peak Discharges

Sheet 1 of 3

Location	Conc. Point	Drainage Area (sq.mi.)	Peak Discharges (Cubic feet per second) 10-Year	50-Year	100-Year	500-Year
CAVE CREEK						
HTA study limits - Cave Creek	CP 27	75.86	16890	24831	28338	34901
RM 35.77 - above minor trib.	CP 26	75.13	16888	24817	28319	34868
RM 36.40 - above minor trib.	CP 25	73.94	16870	24778	28271	34802
RM 36.78 - above minor trib.	CP 24	71.70	16966	24890	28381	34909
RM 37.37 - above minor trib.	R10	60.21	16605	24234	~~27588~~ 27580	33851
Above confl. w/Cottonwood Creek	CP 10	60.21	16613	24246	27603	33871
COTTONWOOD CREEK						
Above confl. w/Cave Creek	CP B	10.06	5952	9253	10956	14038
Above confl. w/Cottonwood Cr. Trib. 1	CP 11A	9.62	5905	9202	10925	14016
RM 1.85 - above minor trib.	CP 12A	8.31	5127	7963	9424	12075
RM 2.71 - above minor trib.	CP 14A	1.64	746	1154	1366	1747
COTTONWOOD CREEK TRIBUTARY 1						
Above confl. w/Cottonwood Creek	CP 11A	0.82	764	1187	1410	1804
Above confl. w/Cottonwood Cr. Trib. 2[a]		0.74	688	1068	1269	1624
COTTONWOOD CREEK TRIBUTARY 2						
Above confl. w/Cottonwood Cr. Trib. 1[b]		0.08	76	119	141	180
NORTH TRIBUTARY OF GALLOWAY WASH						
HTA study limits-HTA "Grapevine Wash"	CP 59	5.60	4265	6389	7470	9393
RM 1.89 - above minor trib.	I-1	4.98	3751	5632	6593	8303
GRAPEVINE WASH						
Above confl. w/Rowe Wash	CP 52A	3.80	2865	4266	5004	6316
OCOTILLO WASH						
HTA study limits - Ocotillo Wash	CP-35	2.54	2274	3445	4047	5109
Above confl. w/Ocotillo Wash Trib. 1	35A	1.78	1652	2499	2922	3667
RM 3.29	SW G1	0.61	1029	1494	1714	2099
OCOTILLO WASH TRIBUTARY 1						
Above confl. w/Ocotillo Wash	CP 36	0.76	802	1201	1397	1743
Above confl. w/Ocotillo Wash Trib. 1A	G2B	0.15	126	190	223	283
OCOTILLO WASH TRIBUTARY 1A						
Above confl. w/Ocotillo Wash Trib. 1	G2A	061	693	1030	1206	1517
OCOTILLO WASH TRIBUTARY 2						
Above confl. w/Ocotillo Wash[c]		0.19	145	222	260	330
OCOTILLO WASH TRIBUTARY 3						
Above confl. w/Ocotillo Wash[d]		0.21	164	252	296	375
OCOTILLO WASH TRIBUTARY 4						
Above confl. w/Ocotillo Wash[e]		0.06	46	71	83	105

[a]Discharge is CP "11A" * 0.90

[b]Discharge is CP "11A" * 0.10

[c]Discharge is Subshed "G3" * 0.22

[d]Discharge is Subshed "G3" * 0.25

[e]Discharge is Subshed "G3" * 0.07

Table 4
Summary of Peak Discharges

Location	Conc. Point	Drainage Area (sq.mi.)	Peak Discharges (Cubic feet per second) 10-Year	50-Year	100-Year	500-Year
ROWE WASH						
HTA study limits - Rowe Wash	CP 51	4.63	3033	4531	5307	6687
Above confl. w/Grapevine Wash	CP 50	0.74	1225	1782	2048	2512
Above confl. w/Rowe Wash Trib. 1	CP 50A	0.49	790	1158	1334	1639
Rm 4.05	CP HIF	0.12	217	305	352	433
ROWE WASH TRIBUTARY 1						
Above confl. w/Rowe Wash	SW HIC	0.25	435	624	714	872
ROWE WASH TRIBUTARY 2						
Above confl. w/Rowe Wash Trib. 1	SW HIE	0.13	237	345	397	486
WILLOW SPRINGS WASH						
HTA study limits - Willow Springs Wash	CP 19	2.76	2652	4004	4682	5877
Above confl. w/Willow Spr. Wa. Trib. 2	CP 17	1.64	1835	2746	3193	3978
Above confl. w/Willow Spr. Wa. Trib. 4	CP 17A	1.41	1698	2528	2932	3640
RM 3.81 - below CP 16	CP 16	0.88	1189	1755	2027	2502
RM 4.31 - above confl. w/minor trib.	CP D2	0.32	420	626	724	897
RM 4.95 - above confl. w/minor trib.[f]		0.16	210	313	362	449
WILLOW SPRINGS WASH TRIBUTARY 1						
Above confl. w/Willow Springs Wash	CP 31B	1.65	817	1227	1439	1823
RM 0.98 - above confl. w/minor trib.[g]		1.31	604	908	1065	1385
Above confl. w/Willow Spr. Wa. Trib. 1A	CP F1B	0.56	358	537	629	784
RM 2.82[h]		0.25	158	246	292	374
WILLOW SPRINGS WASH TRIBUTARY 1A						
Above confl. w/Willow Spr. Wa. Trib. 1	FIA	0.27	192	290	341	431
WILLOW SPRINGS WASH TRIBUTARY 2						
Above confl. w/Willow Springs Wash	CP 18	0.72	856	1275	1492	1866
Above confl. w/Willow Spr. Wa. Trib. 2A	CP F2B	0.43	511	762	891	1114
RM 1.31 - above confl. w/minor trib.[i]		0.22	256	381	446	557
WILLOW SPRINGS WASH TRIBUTARY 2A						
Above confl. w/Willow Spr. Wa. Trib. 2	F2A	0.29	345	514	601	752
RM 0.52 - above confl. w/minor trib.[j]		0.19	231	344	403	504
WILLOW SPRINGS WASH TRIBUTARY 3						
Above confl. w/Willow Springs Wash[k]		0.08	Approx.	Metho	165	

[f] Discharge is Subshed "D2" * 0.50

[g] Discharge is Subshed "F1B" + "F1" * 0.10

[h] Discharge is Subshed "F1B" * 0.45

[i] Discharge is Subshed "F2B" * 0.50

[j] Discharge is Subshed "F2A" * 0.67

[k] Discharge is Subshed "F2C" * 0.15

Table 4
Summary of Peak Discharges

Location	Conc. Point	Drainage Area (sq.mi.)	Peak Discharges (Cubic feet per second) 10-Year	50-Year	100-Year	500-Year
WILLOW SPRINGS WASH TRIBUTARY 4						
Above confl. w/Willow Springs Wash	F2D	0.23	180	271	318	402
RM 0.52[l]		0.16	124	186	219	277
RM 0.98[m]		0.10	75	113	133	168
WILLOW SPRINGS WASH TRIBUTARY 5						
Above confl. w/Willow Springs Wash	F3	0.89	352	536	631	804
Above confl. w/Willow Spr. Wa. Trib. 5A[n]		0.42	236	359	423	539
WILLOW SPRINGS WASH TRIBUTARY 5A						
Above confl. w/Willow Spr. Wa. Trib. 5[o]		0.20	81	123	145	185
FLEMMING SPRINGS WASH	SW D1					
Above confl. w/Willow Spr. Wash	CP 16	0.32	768	1129	1302	1606

[l]Discharge is Subshed "F2D" * 0.69

[m]Discharge is Subshed "F2D" * 0.42

[n]Discharge is Subshed "F3" * 0.47

[o]Discharge is Subshed "F3" * 0.23

3.2 HYDRAULIC ANALYSES

3.2.1 Procedures

For areas studied by detailed methods, water surface elevations for floods of the selected recurrence intervals were computed using the COE HEC-2 Water Surface Profile computer program (Reference 21).

The cross-section data for each of the streams were derived from 1"=200' scale topographic mapping with 4-foot contour intervals prepared for this project. The cross-section data were digitized directly from the stereographic model. Topographic mapping was prepared by Aerial Mapping Company, Inc., from stereo photography dated August 1989. Ground control surveys and check profiles were provided by Greiner Engineering. Elevation reference marks were placed during field surveys at locations noted in Table 5. All elevations in reference to the National Geodetic Vertical Datum of 1929 (NGVD) Study.

Table 5

ELEVATION REFERENCE MARKS

REM No.	Elevation	Description
1	2043.08	Brass cap in concrete slab N78°E, 934' to the approximate northeast corner of Section 29 T6N R4E
2	2149.19	Brass cap in rock wall N74°W, 852' to the approximate northeast corner of Section 20 T6N R4E
3	2214.93	Brass cap in headwall S13°E, 507' to the approximate northeast corner of Section 17 T6N R4E
4	2345.75	Brass cap in concrete slab N20°E, 225' to the approximate northeast corner of Section 4 T6N R4E
5	2547.25	Brass cap in stone S55°W, 27' to the approximate northeast corner of Section 9 T6N R4E
6	2250.00	Brass cap in headwall S73°W, 616' to the approximate northeast corner of Section 21 T6N R4E
7	2167.08	Brass cap in headwall S10°E, 682' to the approximate northeast corner of Section 33 T6N R4E
8	2406.61	Brass cap in headwall N85°W, 1708' to the approximate northeast corner of Section 27 T6N R4E
9	2516.45	Brass cap in stone N20°E, 52' to the approximate northeast corner of Section 15 T6N R4E
10	2937.19	Brass cap in concrete N86°E, 1500' to the approximate northeast corner of Section 11 T6N R4E
11	2762.78	Brass cap in stone N22°E, 4100' to the approximate northeast corner of Section 11 T6N R4E
12	2761.42	Brass cap in stone N68°, 45' to the approximate northeast corner of Section 23 T6N R4E
13	2443.70	Brass cap in headwall N04°W, 277' to the approximate northeast corner of Section 35 T6N R4E
14	2635.91	Brass cap in curb N35°E, 625' to the approximate northeast corner of Section 25 T6N R4E

Cross sections were located at close intervals above and below bridges to enable the significant backwater effects of these structures to be computed. Locations of selected cross sections used in the hydraulic analyses are shown on the flood profiles, Exhibit 1. For stream segments studied by detailed methods, selected cross-section locations are also shown on the work maps, Exhibit 2. Hydraulic roughness coefficients (Mannings "n") were selected on the basis of field inspection and engineering judgment. Table 6 gives the range of Mannings "n" values for each flooding source studied by detailed methods. Photographic documentation and modeling details are shown in Appendix A.

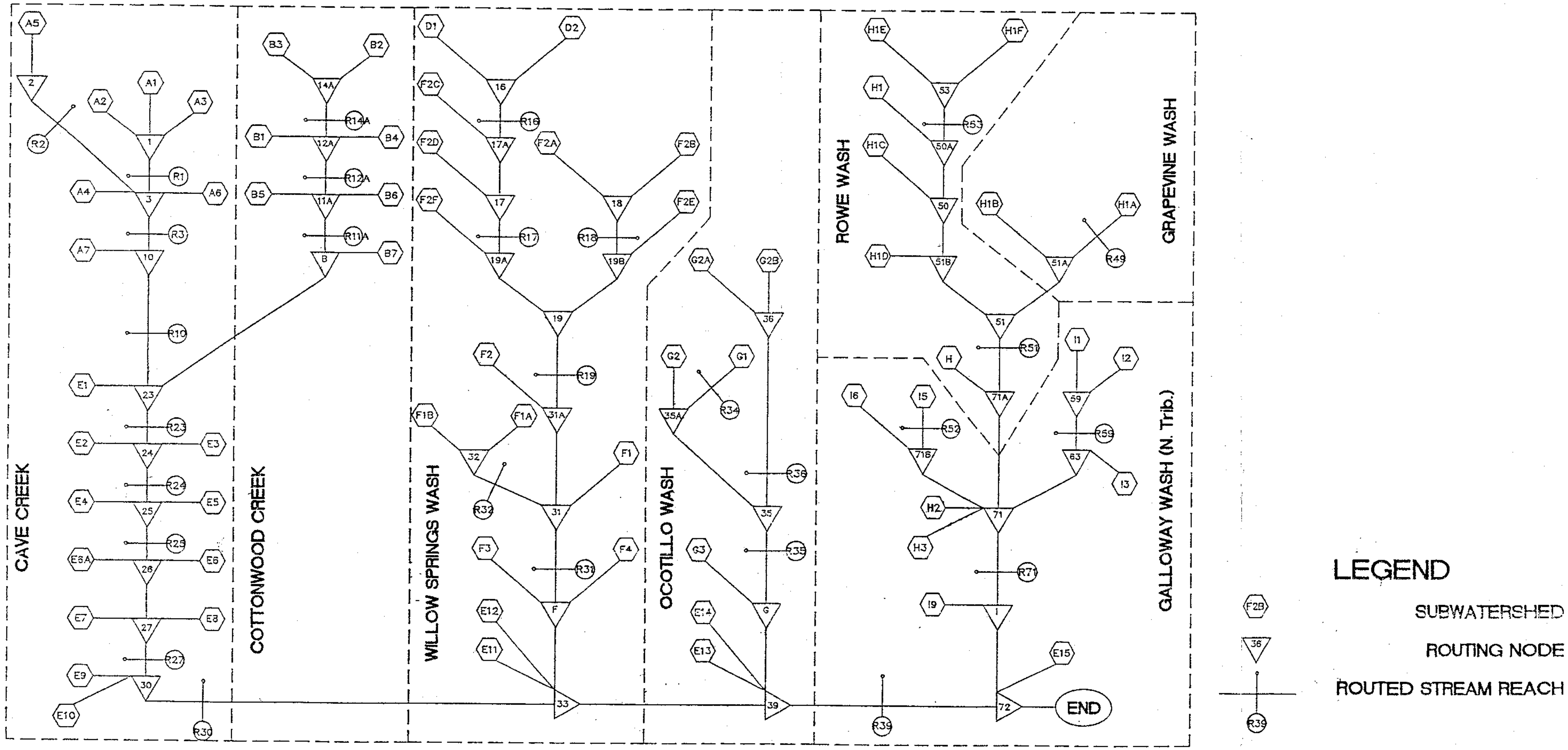


FIGURE 5

DSGN	D. STOUGH
DR	D. STOUGH
CHK	S. WALKER
APVD	

NO.	DATE	REVISION	BY	APVD

CAVE CREEK - FIS
ROUTING SCHEMATIC

SHEET	FIGURE 4
DWG NO.	MCROUTE.DWG
DATE	MAR. 1990
PROJ NO.	RD027815 H3

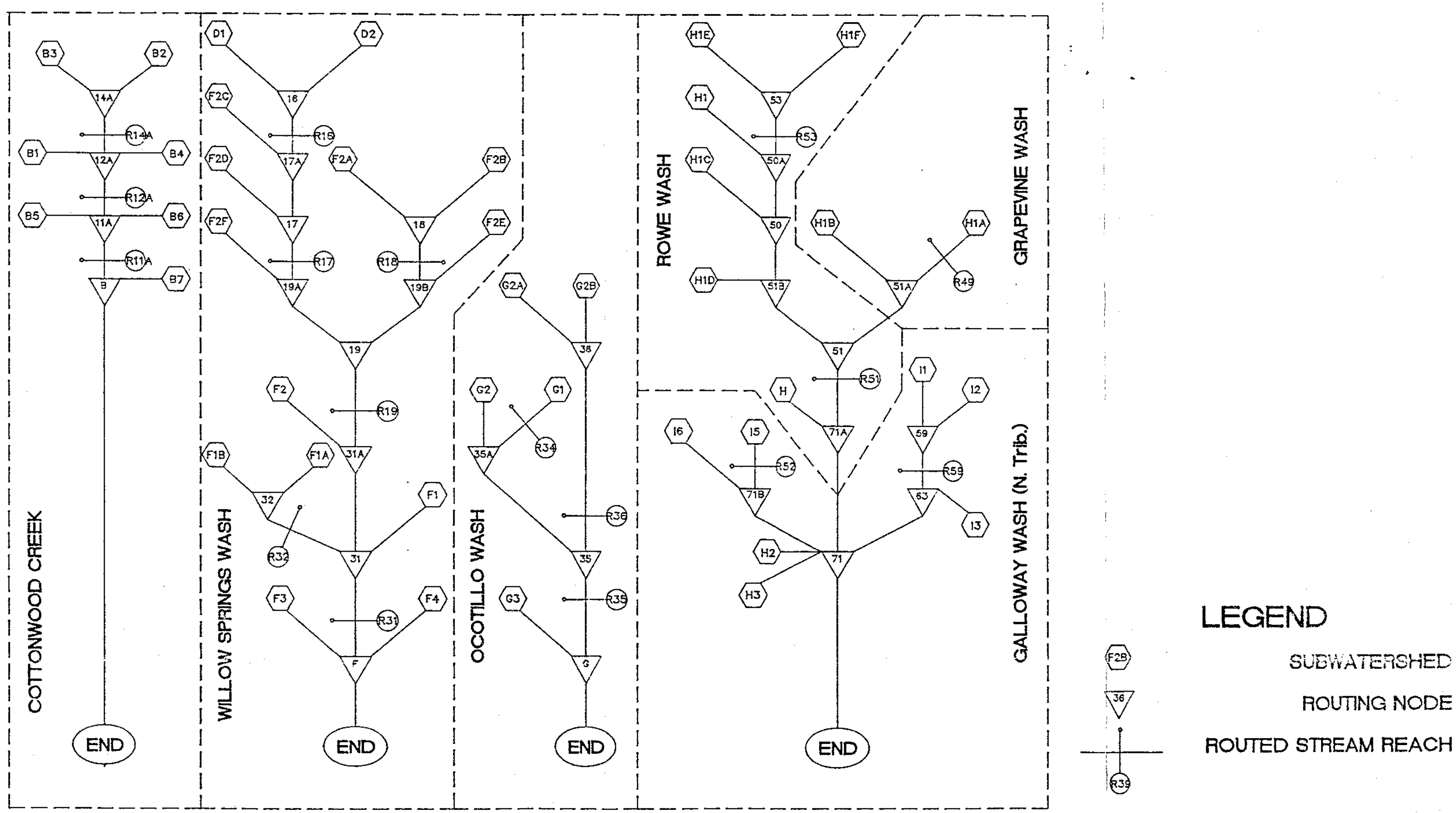


FIGURE 5A

DSGN D. STOUGH	NO. DATE REVISION BY APVD	CAVE CREEK TRIBUTARIES ROUTING SCHEMATIC
DR MCROUTE D. STOUGH		SHEET FIGURE 5A
CHK S. WALKER		DWG NO. MCROUTE.DWG
APVD		DATE MAR. 1990
		PROJ NO. RDD27815.H3

Table 6
RANGE OF HYDRAULIC ROUGHNESS COEFFICIENTS (Manning's "n")

Flooding Source	Channel	Overbanks
Cave Creek	0.035-0.065	0.055-0.065
Cottonwood Creek	0.030-0.060	0.050-0.080
Cottonwood Creek Tributary 1	0.045-0.050	0.060-0.070
Cottonwood Creek Tributary 2	0.050	0.060-0.070
North Tributary of Galloway Wash	0.025-0.041	0.045
Grapevine Wash	0.040-0.046	0.050
Ocotillo Wash	0.03-0.055	0.035-0.060
Ocotillo Wash Tributary 1	0.035-0.040	0.045
Ocotillo Wash Tributary 1A	0.032-0.035	0.040-0.045
Ocotillo Wash Tributary 2	0.035-0.045	0.040-0.050
Ocotillo Wash Tributary 3	0.045-0.055	0.055
Ocotillo Wash Tributary 4	0.025-0.045	0.045-0.050
Rowe Wash	0.035-0.048	0.048-0.055
Rowe Wash Tributary 1	0.045	0.045-0.055
Rowe Wash Tributary 2	0.045	0.050-0.055
Willow Springs Wash	0.025-0.060	0.045-0.080
Willow Springs Wash Tributary 1	0.030-0.040	0.035-0.055
Willow Springs Wash Tributary 1A	0.028-0.050	0.040-0.060
Willow Springs Wash Tributary 2	0.030-0.055	0.045-0.060

Table 6 (Con't.)
RANGE OF HYDRAULIC ROUGHNESS COEFFICIENTS (Manning's "n")

Flooding Source	Channel	Overbanks
Willow Springs Wash Tributary 2A	0.040-0.050	0.050-0.055
Willow Springs Wash Tributary 3A	0.060	0.080
Willow Springs Wash Tributary 4	0.040-0.050	0.050
Willow Springs Wash Tributary 5	0.035-0.050	0.045-0.06
Willow Springs Wash Tributary 5A	0.040	0.045-0.050
Flemming Springs Wash	0.038-0.060	0.055-0.060
Cave Creek	0.035-0.065	0.055-0.065
Cottonwood Creek	0.030-0.060	0.050-0.080
Cottonwood Creek Tributary 1	0.045-0.050	0.060-0.070
Cottonwood Creek Tributary 2	0.050	0.060-0.070
North Tributary of Galloway Wash	0.025-0.041	0.045
Grapevine Wash	0.040-0.046	0.050
Ocotillo Wash	0.03-0.055	0.035-0.060
Ocotillo Wash Tributary 1	0.035-0.040	0.045
Ocotillo Wash Tributary 1A	0.032-0.035	0.040-0.045
Ocotillo Wash Tributary 2	0.035-0.045	0.040-0.050
Ocotillo Wash Tributary 3	0.045-0.055	0.055
Ocotillo Wash Tributary 4	0.025-0.045	0.045-0.050
Rowe Wash	0.035-0.048	0.048-0.055

Table 6 (Con't.)
RANGE OF HYDRAULIC ROUGHNESS COEFFICIENTS (Manning's "n")

Flooding Source	Channel	Overbanks
Rowe Wash Tributary 1	0.045	0.045-0.055
Rowe Wash Tributary 2	0.045	0.050-0.055
Willow Springs Wash	0.025-0.060	0.045-0.080
Willow Springs Wash Tributary 1	0.030-0.040	0.035-0.055
Willow Springs Wash Tributary 1A	0.028-0.050	0.040-0.060
Willow Springs Wash Tributary 2	0.030-0.055	0.045-0.060
Willow Springs Wash Tributary 2A	0.040-0.050	0.050-0.055
Willow Springs Wash Tributary 3A	0.060	0.080
Willow Springs Wash Tributary 4	0.040-0.050	0.050
Willow Springs Wash Tributary 5	0.035-0.050	0.045-0.06
Willow Springs Wash Tributary 5A	0.040	0.045-0.050
Flemming Springs Wash	0.038-0.060	0.055-0.060

Starting water surface elevations for those study reaches that are extensions of previously studied streams were taken from the 1988 FIS profiles. The starting water surface elevations for all other streams were developed by using the slope area method. Backwater influences from major tributaries are reflected in the final profiles.

For flooding sources studied by detailed methods, water surface elevations were estimated for 10-, 50-, 100- and 500-year frequency storm events using HEC-2. For flooding sources studied by approximate methods, the HEC-2 program was generally utilized; however, only 100-year profiles were completed. Flood limits for the approximate study of Willow Springs Tributary 3A were estimated using Manning's equation for normal depth.

Although this study was limited to the use of fixed bed modeling for the hydraulic analyses, during occurrence of a large flood, substantial changes in the river geometry are expected to occur. When the bottom slope is non-uniform and/or structures such as bridges cause local variations in velocity, resultant changes in water surface elevations can be expected.

3.2.3 Structures

Three bridge crossing structures occur in the study area. They are located on Ocotillo Tributary 3 and 4 and Willow Springs Tributary 5. Each of these crossings consists of a low-flow culvert and a dip section weir overflow. Several low water dip crossings have been constructed by homeowners in the area. These typically consist of a small culvert (i.e., 12 inches), with minimal cover and no reinforcement, headwalls, or scour protection. These crossings were assumed to fail or have no influence on large events; therefore, they were not modeled. No clogging factor was applied to the culverts. Culvert calculations for the large culverts were modeled using normal computation procedures from references 24. The resulting water surface elevation was the impact using a X-5 card at the upstream culvert section.

3.2.4 Unusual Modeling Conditions

Portions of Rowe, Galloway, Ocotillo, and Grapevine Washes have wide, braided channels which are subject to high velocities, and significant erosion during major flood events. Within the braided areas, flow path may be unpredictable during any flood event, because of channel migration. Per discussions with FCDMC and FEMA, the channel bank stations for these reaches were established at the outer limits of the braided area to restrict floodway encroachment into the area subject to braiding. (See correspondence, Section 7.)

During large flow events, flow splits may occur around "islands" on Ocotillo and Grapevine Washes. Both channels are both steep. Flow is anticipated to be at or below critical depth and the downstream water surface at the confluence does not influence the magnitude of the flow diversion. For these areas, the HEC-2 split flow option was used to estimate discharge in each channel. The breakover was assumed to be approximated by a weir along the area subject to diversion. For the final HEC-2 runs, the entire peak discharge was assumed to occur in the major channel. However, only that discharge that was estimated to be diverted was assumed to occur in the minor channel. Floodplains and floodways were delineated in the major channel by detailed methods. The 100-year flood limit only was estimated for the minor channel.

3.2.5 Floodway Methods

Floodways were modeled using Encroachment Method 6. This method was selected due to the high velocities and incidence of critical and supercritical flow in the study reaches. Preliminary runs were made using a target rise in energy grade line of 1.0 feet. This target was varied at subsequent runs on a section-by-section basis to optimize the rise in energy grade line and water surface elevation. The floodway was finalized by using a Method 1 encroachment at each cross section.

3.3 RESULTS

Due to the generally steep slopes and narrow channels in the study area, most discharges modeled were contained within channels. In most cases, the 100-year and 500-year flood limits are nearly coincident, and floodway encroachments were limited. Where the study reach extends a previous FIS study stream, good agreement of profiles and floodway width was obtained.

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

4.1 FLOODPLAIN BOUNDARIES

Floodplain boundaries were delineated on topographic maps at a scale of 1 to 2400 (1" = 200'), with a contour interval of 4 feet. The boundaries of the 100-year and 500-year floods were delineated using the elevations determined at each cross section and interpolated elevations between cross sections. In cases where the 100-year and 500-year flood boundaries are close together or coincident, only the 100-year boundary has been shown. Since the cross-section data were digitized directly from the stereo models, the accuracy of the GR card data is greater than that of the topographic mapping. Flood limits were located on the work maps from the HEC-2 STRST and EMST data. As a result, small discrepancies between the computed elevations and the intersections of the flood limits with contour lines resulted.

4.2 FLOODWAYS

The floodways presented in this study were computed by using Method 6 and Method 1 in the HEC-2 model with a maximum allowable rise in the water surface or energy grade line not exceeding 1.0 feet at any location. The principle of equal overbank conveyance reduction was utilized for the target of 1 foot of rise allowed. After the initial runs, the target was varied to smooth out the floodway and assure that a 1.0 feet allowable rise criterion was adhered to. Encroachments using method 1 were used in the final runs and were needed to provide minor corrections to the computed floodway.

On those stream reaches having wide, braided channels with unpredictable flow paths, floodways were established by using Method 1, or by setting the left and right channel bank stations approximately equal to the outer limits of braiding.

For those channel reaches located in steep, narrow, well incised channels where 100-year floodplain widths were small (approximately 50 feet or less), floodways were established equal to the 100-year floodplains. In cases where the floodway and 100-year floodplain boundaries are either close or coincident, only the floodway boundary has been shown.

5.0 INSURANCE APPLICATION

For flood insurance rating purposes, flood insurance zone designations are assigned to a community on the basis of results of the engineering analysis. These zones are as follows:

Zone A

Zone A is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the Flood Insurance Study by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no base flood elevations or depths are shown within this zone.

Zone AE

Zone AE is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the Flood Insurance Study by detailed methods. In most instances, whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AH

Zone AH is the flood insurance rate zone that corresponds to the areas of 100-year shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AO

Zone AO is the flood insurance rate zone that corresponds to the areas of 100-year shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. Average whole-foot depths derived from the detailed hydraulic analyses are shown within this zone.

Zone X

Zone X is the flood insurance rate zone that corresponds to areas outside the 500-year floodplain, areas within the 500-year floodplain, areas of 100-

year flooding where average depths are less than 1 foot, areas of 100-year flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 100-year flood by levees. No base flood elevations or depths are shown within this zone.

Zone D

Zone D is the flood insurance rate zone that corresponds to unstudied areas where flood hazards are undetermined, but possible.

6.0 REFERENCES

1. Arizona Department Transportation, Hydrologic Design for Highway Drainage in Arizona. December 1968

2. Arizona Department of Transportation, ADOT-R5-15-(121), Methods for Estimating the Magnitude and Frequency of Floods in Arizona. R.H. Roeske, 1978.

3. Chow, Ven Te. Open-Channel Hydraulics. New York, McGraw-HILL Book Company, 1959.

4. Federal Emergency Management Agency, Flood Insurance Rate Maps, Maricopa County, Arizona, and Incorporated Areas. April 15, 1988

5. Federal Emergency Management Agency, Flood Insurance Study, Maricopa County, Arizona, and Incorporated Areas. August 12, 1988.

6. Federal Emergency Management Agency, Guidelines and Specifications for Study Contractors.

7. Gonwa, Williams. CH2M HILL, TC - A Program to Estimate Time of Concentration. October, 1989.

8. Harris-Toups Associates, Topographic Maps, Scale 1:4,800, Contour Interval 4 feet. 1976.

9. Hoggin, Daniel H. Computer Assisted Floodplain Hydrology and Hydraulics. 1989.

10. National Oceanographic and Atmospheric Administration. Hourly Precipitation Data for Arizona. July 1987

11. National Oceanographics and Atmospheric Administration. Precipitation-Frequency Atlas of the Western United States, Atlas 2, Volume III. 1973.

12. Sellers, W.D. Arizona Climate the First Hundred Years, University of Arizona. 1985.

13. U.S. Dept. of the Army Corps of Engineers. HEC-1 Flood Hydrograph Package User's Manual. March 1987.

14. USDA Soil Conservation Service. National Engineering Handbook, Section 4, Hydrology. 1969.

15. USDA Soil Conservation Service. Soil Survey of Aguila-Carefree Area. April 1986.

16. USD Soil Conversation Service. TR-20 Project Formulation Hydrology. May 1982.

17. U.S. Department of Agriculture, Soil Conservation Service. Technical Release No. 55. Urban Hydrology for Small Watersheds. January 1975.

18. U.S. Department of the Army Corps of Engineers. Flood Hazard and Information-Cave Creek Arizona Canal to 19th Avenue. October 1971.

19. U.S. Department of the Army, Corps of Engineers, Los Angeles District. Flood Plain Information, Maricopa County, Arizona, Volume II, Cave Creek. November 1964.

20. U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center. HEC-1 Flood Hydrograph Package. Davis, California, September 1981.

21. U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center. HEC-2 Water-Surface Profiles, Generalized Computer Program, Davis, California. November 1976.

22. U.S. Department of the Army Corps of Engineers, Floodway Determination Using Computer Program HEC-2. January 1988.

23. U. S. Water Resources Council. Bulletin 17A, Hydrology Committee. Guidelines for Determining Floodflow Frequency. June 1977.

24. U.S. Department of Army Corps of Engineers, Hydraulic Engineering Circular ???? 5.

7.0 PROJECT CORRESPONDENCE

CH2M HILL Engineers Planners Economists Scientists

* * * P U B L I C   N O T I C E * * *

The Flood Control District of Maricopa County has contracted with the engineering firm CH2M HILL to perform a floodplain delineation study of several washes in the Cave Creek/Carefree area. The purpose of this study is to map those areas that are potentially subject to inundation during a "100-year flood" event. The resulting maps will be available to the public in about 12 to 18 months.

The first step in this project will be surveying and aerial mapping of the area. Greiner Inc. and Aerial Mapping Company Inc. will be conducting these surveys in your area between July 10, and September 1, 1989. These surveys should not result in any damage to property. All gates will be left as they are found.

The Flood Control District and CH2M HILL appreciate your help in assuring the accuracy of this project by allowing access to the surveyors and by providing to CH2M HILL any information you may have regarding past major flooding events. If you have any questions regarding this study, please contact Steve Walker at CH2M HILL, 966-8188 or Jan Farmer at the Flood Control District of Maricopa County, 262-1501.

CH2M HILL Phoenix Office, 1620 West Fountainhead Parkway, Suite 550, P.O. Box 28440 Tempe, Arizona 85285-8440 602.966.8188

M E M O R A N D U M

TO: Jan Farmer/MCFCD

COPIES: Steve Mitchell/BOI

FROM: Steve Walker/PHX
Todd Hunziker/PHX

DATE: August 25, 1989

RE: Cave Creek/ Carefree Flood Elevation Study
Data and Information Search

PROJECT: LAO27815.A1

A search for information and data pertaining to surface water hydrology in the Cave Creek/ Carefree area has been completed. The purpose of this memo is to document the search by identifying agencies and individuals who were contacted, and to discuss the information obtained from them.

The goal of the information search was to gather and review hydrologic and hydraulic data on Cave Creek and its tributaries, in the project area, in order to check and calibrate flood models. Information of interest includes:

- previous flood hazard or surface hydrology maps and reports for the study area
- existing topographic mapping
- An existing Maricopa County FCD hydrologic model (HEC-1)
- Rain gage and stream flow data
- National Oceanic and Atmospheric Administration (NOAA) precipitation maps
- As-built plans for bridges and other hydraulic structures that might affect flood limits

- Newspaper articles and personal accounts of significant floods in the study area.

- Soils data and runoff characteristics

DATA COLLECTION

Following is a list of agencies that were contacted, and information that was collected:

Maricopa County Flood Control District (MCFCD)
3335 W. Durango St.
Phoenix, AZ
262-1501
Contacts: Jan Farmer, Steve Waters, Amir Motamed

The Flood Control District provided existing hydrology (HEC-1) output on Cave Creek for review and recommendations, locations of existing MCFCD rain gages, recording rain gage data, and two previous Cave Creek flood studies.

The existing HEC-1 model includes Cave Creek and its tributaries north of a Unites States Geological Survey (USGS) stream gage at Township 5 North, Range 3 East, Section 12. The model contains 82 subbasins covering 15.75 square miles of drainage area. CH2M HILL has reviewed the hydrologic model. A discussion of observations and recommendations is presented in "Data Review and Conclusions", below.

MCFCD maintains recording rain gages which provide hourly rainfall data in the project area. Recording gages include:

- Grapevine, T5N R4E Sec 24 (July 1989)

- Carefree Ranch, T5N R5E Sec 16 (July 1985)

- Humbolt Mountain, T7N R5E Sec 6 (July 1981)

- Bloody Basin, T8N R5E Sec 8 (November 1981)

- Cook's Mesa, T8N R4E Sec 4

MCFCD provided hourly rainfall data from the Humbolt Mountain, Bloody Basin, and Cook's Mesa stations for two storms which occurred on February 3-4 and March 3-4, 1983. Data from the February and March storms is of particular interest because it corresponds with stream gage hydrographs which were obtained from the USGS (discussed below). Data is not available from the Grapevine and Carefree stations, because they were installed after the two storms.

MCFCD also maintains rain gages in the project area which are not automated (observer gages). The gages are located in Grapevine Wash northeast of Lone Mountain. Data from observer gages was not obtained because stream gage data is not available on Grapevine Wash, and the data is considered unreliable for model calibration.

MCFCD provided two existing flood hazard reports on Cave Creek:
Flood Hazard Information, Cave Creek, Arizona Canal to 19th Avenue, Phoenix Arizona Corps of Engineers, U.S. Army Los Angeles District, October 1971

Flood Plain Information Study for Maricopa County, Arizona, Volume II, Cave Creek Report U.S. Army Engineer District, Los Angeles Corps of Engineers, November 1964

The flood hazard reports were reviewed for pertinent information.

United States Geological Survey (USGS)
Water Resources Division
3739 N. 16th St.
Phoenix, AZ
241-5410
Contact: Robert Wallace

The U.S. Geological Survey provided stream gage data at two stations on Cave Creek near Cave Creek Dam (T5N R3E Sec 12) and Cottonwood Wash (T6N R4E Sec 4). Data includes annual peak flows from the station at Cave Creek Dam and daily peak flows from the Cottonwood Wash station since the gages were installed (1957 and 1980, respectively). Stream gage data can be used in conjunction with precipitation records to calibrate the HEC-1 model.

CH2M HILL reviewed the stream gage data. The highest flows recorded since the installation of the Cottonwood Wash gage occurred on February 3-4 and March 3-4, 1983. CH2M HILL obtained pen hydrographs (raw data) from the Cottonwood Wash gage for these two events. Pen hydrographs were not available from the Cave Creek gage, but a peak discharge for the March 1983 storm is known.

National Oceanic and Atmospheric Administration
Arizona State University
Lab of Climatology
Tempe, AZ
965-6265
Contact: Pat

CH2M HILL obtained NOAA rain gage data for the two storms from Arizona State University. NOAA data is available from the Cave Creek station, the Carefree station at the Carefree airport, and from a station located at Cave Creek Dam. The data consists of total daily (24-hour) precipitation.

Foothills Library
Cave Creek and Schoolhouse Road
Cave Creek, AZ
488-2286
Contacts: Myra Howe and Barbara Joy

The Foothills Library archives newspaper articles of notable local issues and events. Library staff assisted CH2M HILL in researching and obtaining copies of newspaper articles regarding major floods in Cave Creek. The articles provided dates of storm events, interviews of local residents, and locations of flooding and damage. According to the articles, recent flooding occurred in Cave Creek on March 1-2, 1978, December 17-20, 1978,
February 13-19, 1980, and October 2-3, 1981.

Other Information

Other information obtained or utilized by CH2M HILL for this study includes:

- Soil Survey of Aguila-Carefree Area, Parts of Maricopa and Pinal Counties, Arizona, United States Department of Agriculture, Soil Conservation Service, April 1986

  The soil survey was obtained to investigate vegetation and runoff characteristics of soils in the Cave Creek watershed. If necessary, this information will be used to refine the HEC-1 model.

- Hydrologic Design for Highway Drainage in Arizona, Arizona Highway Department, Bridge Division, December 1, 1968

- Rainfall Frequency Maps For Arizona, National Oceanic and Atmospheric Administration

  NOAA isopluvial maps form the basis of hydrologic computations. Isopluvials indicate maximum precipitation depths which can be expected for a given storm duration.

- Engineering Field Manual, United States Department of Agriculture, Soil Conservation Service, July 1984

- Flood Insurance Rate Maps, Maricopa County, Arizona and Incorporated Areas, Federal Emergency Management Agency (FEMA), April 15, 1988

  CH2M HILL obtained existing FEMA maps from previous hydrologic studies on Cave Creek. FEMA maps will be used to match flood limits from previous studies with the limits determined in this study.

Below is a list of other organizations that were contacted by telephone in an effort to gather information or data relevant to this study. Each organization was informed of the project scope and location. None provided written data or information, but their contribution to the data search is acknowledged.

Arizona Department of Water Resources
542-1541
Contact: Jim Morris

Army Corps of Engineers Los Angeles District
(213) 894-5375
Contact: John Peterson

Foothills Sentinel (newspaper)
488-3436
Contact: Betty Daniels

Town of Carefree
488-3686
Contact: Diane Redgill

Cave Creek/ Carefree Museum
488-3183
Contact: Ileanne Scruggs

U.S. Forest Service
Cave Creek Ranger Dist.
488-3441

DATA REVIEW

CH2M HILL has reviewed the information provided by the Flood Control District a other sources. Several inconsistencies were noted in the HEC-1 model. Each of th inconsistencies are listed below, with recommendations for refining and calibrating th model.

- Total storm precipitation. The existing HEC-1 model applies a 24-hou 100 year storm of 4.81-inches to the entire Cave Creek watershed. According to NOAA precipitation atlases, the 4.80-inch rainfall is adequate for lower elevations of the watershed, but higher elevations receive more rain. Our computations indicate that 5.00 inches is appr priate for higher elevations.

  An appropriate refinement to the hydrology model would include high total precipitation to subbasins above the Cave Creek confluence with Cottonwood Creek.

- Curve Numbers. Curve numbers were computed for each subbasin u soil survey reports. The curve numbers are based on hydrologic char teristics of the soil, vegetation type, and vegetation density in each subbasin. Computed curve numbers ranged between 88 and 93, wher curve number in the existing HEC-1 model ranged between 79 and 8

  Use of the higher curve numbers in the HEC-1 model seems approp The use of higher curve numbers may substantially increase runoff ra

- Lag Times. Lag times were computed for each subbasin using the S curve number method, Kirpich equations, and Pima County methods.

The computed lag times varied, both higher and lower than times used i the current HEC-1 model. Some refinements may be necessary.

- Muskinghorn "K" parameters: In some routings the Muskinghorn "K" is greater than the terms of concentration for the basin.

- Rainfall (mass) Distribution Curve. An examination of subbasins and la times within the study area indicates that it may also be appropriate to modify the mass distribution curve. Two modifications are recommende 1) Divide precipitation increments into 15-minute intervals. 30-minute increments are used in the existing HEC-1 model, and may be too long for the smallest basins. 2) Use a modified type II distribution curve wi a higher rainfall intensity during the middle of the storm. This modific tion will result in higher runoff rates in large subbasins (e.g. North Tributary of the Galloway Wash) by simulating a 1-hour storm within a 24-hour storm.

In addition to the changes listed above, calibration of the HEC-1 model should be considered with rainfall and stream gage data obtained by CH2M Hill. The Februa and March 1983 storms were small compared to a 100-year event, but calibration m yield a more accurate model.

July 14, 1989

^F1^

Subject: Announcement of Intent to Perform Flood Elevation Study

Dear ^F2^:

The Flood Control District of Maricopa County (FCDMC) has contracted CH2M HILL to perform floodplain delineations for the following streams as shown on the attached map:

CAVE CREEK	-	From the limits of the existing study to the Tonto National Forest boundary.
WILLOW SPRINGS	-	From the limits of the existing study to the Willow Springs Head Waters within the Continental Mountains.
WILLOW SPRINGS TRIBUTARIES		
OCOTILLO WASH	-	From the limits of the existing study to the Tonto National Forest boundary.
OCOTILLO WASH TRIBUTARIES		
ROWE WASH	-	From the limits of the existing study to the Tonto National Forest boundary.
ROWE WASH TRIBUTARIES		

GRAPEVINE WASH - From the limits of the existing study to the Tonto National Forest boundary.

COTTON WOOD CREEK - From the confluence with Cave Creek River to the Tonto National Forest boundary.

NORTH TRIBUTARIES
OF GALLAWAY WASH

These studies will examine and evaluate the flood hazard areas in the community to determine the flood elevation for those areas. These elevations will then be used to determine the flood insurance rates used by the Federal Emergency Management Agency.

This announcement is intended to inform all interested persons and communities of the commencement of this study so that they may have an opportunity to bring any relevant technical information to the attention of FCDMC/FEMA, so that they could be considered during the course of this study. Your comments should be addressed to Jan Farmer, Hydrologist at the Flood Control District of Maricopa County, or Steve Walker at CH2M HILL.

Sincerely,

CH2M HILL

Steven R. Walker, P.E.
Project Manager

Attachment

cc: Jan Farmer/Flood Control District of Maricopa County

Engineers
Planners
Economists
Scientists

July 28, 1989

LA027815.A1

Mr. Bob Wallace
U.S. Geological Survey
3738 N. 16th Street
Suite E
Phoenix, Arizona 85016-5915

Dear Mr. Wallace:

This letter is a follow-up to our telephone conservation last Friday, and a request for data from the Geological Survey.

CH2M HILL is currently involved in a Flood Insurance Study for Maricopa County in the Cave Creek/Carefree area. The study includes Cave Creek and many of its tributaries north of the Town of Cave Creek.

It is my understanding that the Geological Survey maintains two stream flow gages on Cave Creek. The gages are located as follows:

1. T6N, R4E, SEC 4 (Station 09512280)
2. T5N, R3E, SEC 12 (Station 09512300)

Please mail us any available data from these stations including rainfall data, if it is available.

Feel free to call me if you have any questions. Thank you for your cooperation.

Sincerely,

CH2M HILL

Todd J. Hunziker, P.E.
Civil Engineer

cc: Steve Walker/PHX

CH2M HILL Phoenix Office, 1620 West Fountainhead Parkway, Suite 550, P.O. Box 28440 Tempe, Arizona 85285-8440 602.966.8188

United States
Department of
Agriculture

Soil
Conservation
Service

201 E. Indianola Ave.
Suite 200
Phoenix, AZ 85012

— RECEIVED —
AUG - 1 1989
CH2M HILL/PHOENIX

July 26, 1989

Steven R. Walker, P.E.
Project Manager
CH2M Hill
P.O. Box 28440
Tempe, Arizona 85285-8440

Dear Mr. Walker:

Referencing your letter to Ralph Arrington dated July 17, 1989, concerning intent to perform flood elevation studies on selected streams in the Cave Creek-Carefree area, the Soil Conservation Service has no relevant technical information on the listed streams, except for possibly soil survey information. Should you have need of the soil survey data, please let us know.

Sincerely,

BARTON E. AMBROSE
Assistant State Conservationist (P)

MEMORANDUM

CH2M HILL

TO: Ms. Jan Farmer
Flood Control District of Maricopa County

COPIES: Neal Dixon/RDD
Bob Charley/PHX
Todd Hunziker/PHX

FROM: Steven R. Walker, P.E. SRW

DATE: December 4, 1989

SUBJECT: Cave Creek/Carefree Flood Insurance Study

PROJECT: LAO27815.A0

On Wednesday, November 29, I spoke to Ray Lenaberg regarding your request that the channel bank stations be increased to include all the braided portions of Galloway and Rowe Washes to limit potential floodway fringe development. Mr. Lenonberg told me that if these braided areas are subject to erosion, high velocity or other flood related hazards, he foresees no objection from FEMA in defining the entire braided area as floodway. He indicated that the Flood Control District should be prepared to defend these floodway definitions, however. He also reminded me that floodways can be appealed and redefined at any time should bank stabilization or other channel improvements make redefinition appropriate. Based on this conversation, I would suggest that we define the channel bank station so as to include the entire potentially braided area as channel. We will proceed under this assumption unless otherwise directed by you.

FLOOD CONTROL DISTRICT
of
Maricopa County

3335 West Durango Street • Phoenix, Arizona 85009
Telephone (602) 262-1501

D. E. Sagramoso, P.E., Chief Engineer and General Manager

DEC 11 1989

Mr. Ray Lenaburg
Federal Emergency Management Agency
Presidio of San Francisco
Building 105
San Francisco, CA 94129

Re: Cave Creek/Carefree
Flood Insurance Study

Dear Mr. Lenaburg:

Thank you for endorsing our request to define the channel bank stations to include all braided areas subject to high velocities and erosion, within the channel, for those washes currently being studied within the Cave Creek/Carefree area, by our Engineer, CH2M Hill.

We would appreciate a letter of your concurrence regarding our approach in defining braided streams for mapping purposes. Mapping these washes in the method described will provide prudent floodplain management to the community.

If you have any questions regarding this matter please call me at 602-262-1501.

Sincerely,

Jan Farmer
Hydrologist

Enclosure

Copy to: Steve Walker, CH2M Hill

Federal Emergency Management Agency
Region IX Building 105
Presidio of San Francisco, California 94129

JAN 19 1990

Ms. Jan Farmer
Hydrologist
Maricopa County Flood Control District
3335 West Durango Street
Phoenix, Arizona 85009

Dear Ms. Farmer:

This is in response to your letter of December 11, 1989 and discussions with Raymond T. Lenaburg of my staff concerning the appropriateness of designating braided stream areas as floodway for mapping purposes.

Just as the Maricopa County Flood Control District (MCFCD), the Federal Emergency Management Agency is very concerned with the problems encountered on alluvial streams.

As outlined in the COE publication "Floodway Concept Application in Unique Situations", braided streams commonly fail to meet ideal floodway criteria. Usually braided channels are a result of deposition beyond a stream carrying capacity in addition to steep valley slopes which produces wide shallow channels with islands in between. As a result, any floodway which is developed for a braided stream area should consider the total future size of the channel in addition to a detailed quantitative geomorphic and engineering analysis.

As a result of the complex physical processes that occur on alluvial streams, we see no problem in the MCFCD designating the braided stream areas as within the regulatory floodway.

If you have any questions or need further information in regards to this matter, please contact Raymond T. Lenaburg at 415/923-7181.

Sincerely,

Nicholas B. Nikas
Division Chief
Natural and Technological Hazards

cc: Jim Morris, ADWR