INTRODUCTION

This analysis was done to determine the flooding conditions that will occur along the east end of Cave Buttes Dike # 2 in response to the standard project storm used to design Cave Buttes Dam (USACE, 1976). The purpose of the analysis is to determine the magnitude of flow along the east end of the dike and the ponding conditions that would occur at the intersection of the dike and Cave Creek road (Figure 1). The limits of flooding will be compared to the Flood Control District's right-of-way for this structure. This analysis is needed because the flooding along the dike in this area was not specifically considered in the original hydrology and hydraulic design work done for Cave Buttes Dam. Additionally, recent improvements to Cave Creek road will also change the limits of flooding.

AREA DESCRIPTION

Approximately 14.2 square miles of desert land drains to the intersection of Cave Buttes Dike 2 and Cave Creek road (figure 2). This drainage basin is approximately 1 mile wide and extends for over 13 miles to the northeast from the road-dike intersection. The drainage basin slopes at a relatively uniform 110 feet per mile (+ - 30 ft/mi) throughout the basin. There are no significant grade-breaks or mountainous areas within the basin.

The basin is sparsely developed, especially in the upper half of the watershed. However, because of the areas proximity to Phoenix, Scottsdale, Cave Creek and Carefree, it has a high potential for development in the future. The area has been included in area drainage master studies done for Phoenix and Scottsdale (Water Rescource Associates, Inc., 1989).

A distributary flow drainage pattern occurs throughout the drainage basin. The channels in the basin are not well defined and have a very limited capacity. Most of the channels have a capacity of less than 30 cfs. For large storms that generate significant quantities of runoff, it is not possible to predict the exact flow path of floodwaters within the basin. This is probably why FEMA has elected to use the alluvial fan method to delineate 100 year floodplains in this area ~~because of this~~.

Because of the distributary drainage pattern, the drainage basin boundaries are difficult to determine in some areas. For this study the drainage boundaries were determined based on 1990 aerial photography. Four 'split flow' locations were noted along the southern boundary of the watershed. At these locations it could not be determined whether flow would go to the west, and stay in the drainage basin, or be diverted to the south and out of the basin. These locations are marked with an 'Sp' on the watershed map. Photos of the locations are contained in the appendix. For this analysis, all flow was assumed to remain in the drainage basin. Inclusion of the split flow areas resulted in a drainage area that was about 2.8 sqaure miles larger than was delineated in a previous study by the city of Phoenix (Water Rescource Associates, Inc., 1989).

PONDING CONDITIONS AT CAVE CREEK ROAD

Cave Creek road crosses over Cave Buttes dike 2 approximately 4400 feet from the east end of the dike (figure 3). For existing conditions, water that ponds to the east of the road-dike intersection can cross the road through a 36 inch pipe at the road-dike intersection or through six, 48 inch pipes that drain an unnamed wash crossing the road approximately 900 feet north of the intersection. Cave Creek road improvements and sewer installation will raise the road by as much as 5 feet between the dike and the wash. The 48 inch pipes will be replaced by five, 8' X 12' box culverts and a 15'x 25' elliptical culvert will be installed approximately 150' north of the road-dike intersection. These improvements will change the drainage characteristics of the ponding area.

Flow into the ponding area comes from two sources: 1.) flow from small washes and overland flow that is captured by the dike and 2.) overflow from the box culverts at the unnamed wash. Because the capacity of the unnamed wash is much smaller than the flows predicted to occur, it was modelled as if it flowed directly into the ponding area before spilling through the culverts

HYDROLOGIC METHODS

Ponding along the dike was analyzed using the August, 1988 version of the U.S. Army Corps of Engineers HEC-1 computer program. The following sections describe the methods used to develop the hydrologic model for this analysis. Supporting material and a diskette containing the model can be found in the appendices to this report.

BASIN AND SUBBASIN DELINEATION

Basin and subbasin delineations were done using 1990 aerial photography and 7.5 minute USGS maps. A total of 15 subbasins were used in the model. These subbasins are shown on the watershed map. Because of the distributary flows in the basin, the number of subbasins was held to a minimum. Most of the subbasin concentration points are located at split flow sites and along Scottsdale road. Subbasins A and C correspond to subbasins used in a FEMA floodplain study for this area. The concentration points of subbasins A and C were used by FEMA as appexes of alluvial fans.

RAINFALL AND RAINFALL LOSS METHOD

The rainfall used in this analysis was developed by the U.S. Army Corps of Engineers to predict the standard project flood for the design of Cave Buttes Dam (1976). The storm developed by the Corps has a 7 hour duration with 5.5 inches of total rainfall (figure 4). From this storm the Corps predicted 3.27 inches of rainfall excess. The pattern of rainfall excess shown in figure 4 was entered directly into the HEC-1 model and no rainfall losses were calculated.

UNIT HYDROGRAPH AND HYDROGRAPH GENERATION

Runoff hydrograhps for the subbasins were generated from the rainfall excess using the unit hydrograph method. Unit hydrographs for the subbasins were

determined by using the Phoenix valley regional S-graph and the MCUHP2 computer program. This S-graph was developed from streamflow data in the Phoenix area. The S-graph and the method are described in the FCD Hydrology Manual. The subbasin parameters and assumptions used to develop unit hydrographs for the subbasins are shown in table 1.

STREAMFLOW ROUTING

Flow was routed between concentration points in the HEC-1 model using the kinematic wave routing method. Because this method results only in hydrograph translation, and no hydrograph attenuation, the peak flows predicted at concentration points in the HEC-1 model may be higher than would occur in reality. A sensitivity analysis done on the HEC-1 model showed that the predicted ponding level at the road-dike intersection is not very sensitive to changes in inflow hydrograph shape.

The channel dimensions used for kinematic wave routing are based on equations developed by Dawdy (1979) to determine stable channel geometry for flow on alluvial fans. The equations and the resultant channel dimensions are shown in table 2. In order to determine channel dimensions the flow into the channel routing reach must be determined. This was done by running the HEC-1 model up to the concentration point at the top of the routing reach and using this flow to determine channel dimensions. Channel dimensions are then entered into the model which is then rerun to determine flow at the top of the next routing reach downstream. A change in channel width will change the travel time through the reach. The drainage basin being studied consists of parralell routing reaches and is not a branched channel system. Therefore, the model is not very sensitive to travel time through the channel systems.

HYDRAULICS OF THE PONDING AREA

Outflow from the ponding area at the road-dike intersection occurs through the 15' x 25' elliptical culvert and the five 8' x 12' box culverts. Flow in excess of the combined culvert capacity occurs over Cave Creek road at the box culvert location. This is the low point of the roadway. The following assumptions were made in calculating the stage-discharge relationship for the ponding area.

1. Inlet control was assumed at all stages for the 15' x 25' box culvert. A maximum flow of 4000 cfs was allowed through this culvert. The equations used to determine flow through the culverts for submerged and unsubmerged conditions were developed by the Federal Highway Administration (1985). The equations and calculations can be found in the appendix.

2. Inlet control was assumed at all stages for the 8' x 12' box culverts. The channel downstream of the culverts is not deeply entrenched and does not have any type of bank protection or stabalization. It is believed that it will not cause a significant backwater effect at full flow conditions. Also, the design report for Cave Buttes Dam indicates that ponding behind the dam will not reach the culvert outlets. Therefore, it seemed reasonable to ignore tailwater in this analysis.

3. Discharge across Cave Creek road was calculated using a broad-crested weir equation. The roadway profile is approximately triangular in shape with the low point being at the box culverts. In calculating discharge, an average depth above the roadway (one-half the depth at the low point) was used as the as the depth of flow over the weir. The top width of water across the road was used as the width of the weir.

RESULTS

The output of the HEC-1 model is contained in the appendix. The following is a summary of the calculated results:

- peak flow into the road-dike ponding area	7500 cfs
- peak flow captured along the length of the dike	4900 cfs
- peak flow in the unnamed wash	3850 cfs
- maximum ponding elevation behind the dike	1672.0 ft.
- top of dike	1678.8 ft.
- depth of flow over Cave Creek road	0. ft.

DISCUSSION

The approximate ponding limits and the boundaries of the Flood Control District's right-of-way are shown on plate 2. Although the HEC-1 model indicates that the maximum ponding elevation is 1670.8 feet, ponding from the predicted flows would likely reach an elevation of 1672 feet, since this elevation must be reached before the ponding areas behind the box culverts and the elliptical culvert function as a single ponding area (as modelled in the HEC-1 runs). Plate 2 shows that the FCD's right-of-way does not include the entire SPF ponding area. The flooded area covers about 5.5 acres and contains about 24 acre-feet of water. This volume of water is not significant when compared to the 2470 acre-feet of total runoff. The small amount of storage volume in the ponding area does very little to attenuate the peak inflow. Most of the inflow quickly drains to the west side of Cave Creek road through the box culverts and the elliptical culvert. Because of the large combined capacity of the box culverts,the elliptical culverts and the roadway, the ponding level is not very sensitive to the predicted peak inflow. Increasing the peak inflow from 7500 cfs to 12,500 cfs will increase the flooded area by 6 acres. It should also be noted that runoff from smaller storms may also have about the same ponding limits. Likewise, if the 8.7 square miles of drainage area above Scottsdale road is excluded from the analysis, the ponding limits will not change significantly.

The ponding behind the dike causes very little additional backwater at the box culvert location where the unnamed wash crosses Cave Creek road. As a result,

the changes caused by the dike to the natural limits of flooding along the unnamed wash are insignificant and will not be considered further.

Flow that is intercepted along the length of the dike may create more of a flooding hazard than would occur if the dike was not present. The HEC-1 model predicts a peak flow of 4900 cfs along the dike. There is no channel along the dike to carry this flow efficiently to the culverts. There are also no well defined points of inflow along the dike. Therefore it is possible that a concentrated flow of 4900 cfs could backup at the point that it intercepts the dike and cause flooding north of the dike. Although a single concentrated flow was assumed to be the case in the HEC-1 model in order to calculate maximum ponding limits, it is probably not realistic. In reality, inflow along the dike is likely to occur as sheet flow and concentrated flow that intercepts the dike at multiple, unpredictable locations. For these types of flows, water ponding behind the dike, east of the ponding area shown on plate 2, is not likely to exceed the current FCD right of way.

```
*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*      BY THE COE IN FEBRUARY 1981      *
*            REVISED 02 AUG 88          *
*                                       *
*  RUN DATE  12/07/1990  TIME  12:06:01 *
*                                       *
*****************************************
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*****************************************
*                                       *
*     DODSON AND ASSOCIATES, INC.       *
*   HYDROLOGIST AND CIVIL ENGINEERS     *
*      7015 W TIDWELL SUITE 107         *
*        HOUSTON, TEXAS  77092          *
*          (713) 895-8322               *
*                                       *
*****************************************
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X     X  XXXXXXX   XXXXX          X
X     X  X        X     X        XX
X     X  X        X              X
XXXXXXX  XXXX     X       XXXXX  X
X     X  X        X              X
X     X  X        X     X        X
X     X  XXXXXXX  XXXXX          XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

HEC-1 INPUT PAGE 1

```
LINE          ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

  1           ID    HEC-1 MODEL FOR DRAINAGE AREA ABOVE CAVE BUTTES DIKE # 2
  2           ID
  3           ID    - C.O.E. 7 HOUR RAINFALL EXCESS FOR THE SPF STORM  (NO LOSSES CALCULATED)
  4           ID    - PHOENIX VALLEY S-GRAPH USED TO GENERATE RUNOFF FOR ALL SUBBASINS
  5           ID    - C.O.E. REGRESSION EQUATION USED TO DETERMINE SUBBASIN LAG
  6           ID       AVERAGE MANNING'S N OF 0.10 USED FOR Kn PARAMETER IN THE REGRESSION EQ.
  7           ID    - CHANNEL DIMENSIONS FOR ROUTINGS BASED ON DAWDY (1979) ASSUMPTIONS:
  8           ID       WIDTH = 9.5Q**0.4,  DEPTH = 0.07Q**0.4
  9           ID    - MANNING'S N OF 0.025 ASSUMED FOR ALL CHANNELS
 10           ID    - RATING CURVE FOR PONDING AREA BEHIND CAVE CREEK ROAD IS BASED ON IMPROVED
 11           ID      ROAD CONDITIONS AND NO PONDING ON THE WEST SIDE OF CAVE CREEK ROAD
 12           ID    - NO FLOW IS DIVERTED OUT OF THE WATERSHED AT THE SPLIT FLOW SITES ALONG
 13           ID      THE WATERSHED BOUNDARY
 14           ID
              *DIAGRAM
 15           IT      10                    120
```

```
16          IO       5
            *

17          KK       A
18          KM    SUB-BASIN A
19          BA    3.558
20          IN       15
21          PB    3.27
22          PI    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05
23          PI     0.1     0.1     0.1     0.1     0.1     0.1     0.4     1.0     1.7     2.7
24          PI     2.5     1.4     0.7    0.65     0.2     0.1     0.1       0       0       0
25          LU       0       0       0
26          UI    77.     77.     77.    149.    266.    317.    367.    410.    443.    486.
27          UI   541.    593.    682.    848.    981.    924.    796.    708.    645.    593.
28          UI   530.    477.    431.    386.    350.    282.    221.    143.    136.    127.
29          UI   126.     91.     77.     77.     70.     24.     24.     24.     24.     24.
30          UI    24.     24.     24.     24.     24.     24.      0.      0.      0.      0.
            *

31          KK      rA
32          KM    ROUTE FLOW FROM A TO D
33          KM    CHANNEL DIMENSIONS BASED ON PEAK Q OF 3303 CFS
34          RK    15000    0.02   0.025            TRAP     235       0
            *

35          KK       D
36          KM    SUB-BASIN D
37          BA    1.085
38          LU       0       0       0
39          UI     20.     20.     27.     70.     86.    102.    114.    127.    146.    165.
40          UI    212.    256.    236.    198.    174.    157.    136.    121.    104.     91.
41          UI     69.     48.     36.     34.     32.     20.     20.     16.      6.      6.
42          UI      6.      6.      6.      6.      6.      6.      6.      0.      0.      0.
            *
```



```
LINE        ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

43          KK      cD
44          KM    COMBINE FLOWS FROM A AND D
45          HC       2
            *

46          KK     rcD
47          KM    ROUTE FLOW FROM cD TO I
48          KM    CHANNEL DIMENSIONS BASED ON PEAK Q OF 3724 CFS
49          RK    31000   0.017   0.025            TRAP     226       0
            *

50          KK       I
51          KM    SUB-BASIN I
52          BA    1.982
53          UI     37.     37.     37.     37.    110.    134.    157.    177.    194.    211.
```

```
54          UI    225.    246.    271.    291.    333.    409.    456.    475.    409.    366.
55          UI    332.    308.    287.    259.    236.    218.    197.    180.    163.    135.
56          UI    107.     76.     66.     64.     61.     61.     40.     37.     37.     37.
57          UI     18.     11.     11.     11.     11.     11.     11.     11.     11.     11.
58          UI     11.     11.     11.      0.      0.      0.      0.      0.      0.      0.
            *

59          KK   BOXIN
60          KM   INFLOW TO BOX CULVERTS UNDER CAVE CREEK ROAD
61          KO                                    21
62          HC       2
            *

63          KK       E
64          KM   SUB-BASIN E
65          BA  0.8518
66          UI     25.     25.     49.     92.    118.    136.    153.    176.    201.    259.
67          UI    321.    288.    240.    211.    185.    160.    138.    120.     91.     62.
68          UI     45.     42.     36.     25.     25.     12.      8.      8.      8.      8.
69          UI      8.      8.      8.      0.      0.      0.      0.      0.      0.      0.
            *

70          KK      rE
71          KM   ROUTE FLOW FROM E TO J
72          RK   13000   0.019   0.025          TRAP     130       0
            *

73          KK       J
74          KM   SUB-BASIN J
75          BA  0.8284
76          UI     31.     31.     99.    137.    166.    193.    230.    295.    387.    328.
77          UI    270.    231.    192.    160.    130.     83.     54.     50.     36.     31.
78          UI     17.      9.      9.      9.      9.      9.      9.      0.      0.      0.
            *
```



```
LINE        ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

79          KK      cJ
80          KM   COMBINE FLOWS FROM J AND E
81          HC       2
            *

82          KK      rJ
83          KM    ROUTE FLOWS FROM J TO M
84          RK    1150   0.017   0.025          TRAP     169       0
            *

85          KK       M
86          KM   SUB-BASIN M
87          BA  0.4337
88          UI     17.     19.     61.     82.     98.    116.    141.    197.    205.    160.
89          UI    135.    111.     92.     74.     46.     30.     28.     18.     17.      5.
```

```
 90          UI     5.     5.     5.     5.     5.     0.     0.     0.     0.     0.
             *

 91          KK     cM
 92          KM   COMBINE FLOWS FROM rJ AND M
 93          HC      2
             *

 94          KK      B
 95          KM   SUB-BASIN B
 96          BA   1.085
 97          UI    37.    37.   102.   156.   192.   220.   258.   305.   406.   471.
 98          UI   376.   319.   276.   232.   196.   163.   115.    66.    63.    53.
 99          UI    37.    35.    11.    11.    11.    11.    11.    11.    11.     0.
             *

100          KK     rB
101          KM   ROUTE FLOWS FROM B TO C
102          RK    9500   0.038   0.025          TRAP    149      0
             *

103          KK      C
104          KM   SUB-BASIN C
105          BA   2.112
106          UI    44.    44.    44.    71.   148.   174.   207.   227.   248.   267.
107          UI   296.   328.   359.   430.   521.   576.   496.   436.   392.   360.
108          UI   331.   296.   269.   243.   219.   198.   161.   126.    84.    78.
109          UI    73.    72.    58.    44.    44.    44.    20.    13.    13.    13.
110          UI    13.    13.    13.    13.    13.    13.    13.    13.     0.     0.
             *

111          KK     cC
112          KM   COMBINE FLOWS FROM rB AND C
113          HC      2
             *
                                    HEC-1 INPUT                                PAGE  4

LINE         ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

114          KK     rC
115          KM    ROUTE FLOWS FROM cC TO F
116          RK    4500   0.016   0.025          TRAP    201      0
             *

117          KK      F
118          KM   SUB-BASIN F
119          BA  0.1156
120          UI    10.    39.    58.    93.    96.    65.    43.    19.    12.     5.
121          UI     3.     3.     0.     0.     0.     0.     0.     0.     0.     0.
             *

122          KK     cF
123          KM   COMBINE FLOWS FROM rC AND F
```

```
124          HC       2
             *

125          KK     rcF
126          KM   ROUTE FLOWS FROM cF TO H
127          RK    8750   0.017   0.025           TRAP     202       0
             *

128          KK       H
129          KM   SUB-BASIN H
130          BA  0.3102
131          UI     15.     29.     64.     83.    103.    135.    188.    149.    120.     95.
132          UI     75.     49.     27.     23.     15.      9.      5.      5.      5.      5.
             *

133          KK      cH
134          KM   COMBINE FLOWS FROM rcF AND H
135          HC       2
             *

136          KK       L
137          KM   SUB-BASIN L
138          BA   0.099
139          UI      8.     32.     48.     74.     84.     57.     39.     19.     11.      6.
140          UI      2.      2.      0.      0.      0.      0.      0.      0.      0.      0.
             *

141          KK      cL
142          KM   COMBINE FLOWS FROM cH AND L
143          HC       2
             *

144          KK     dv1
145          KM   DIVERT FLOWS
146          DT   DIV 1
147          DI       0    1000   50000
148          DQ       0       0       0
             *
```



```
LINE         ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

149          KK    rdv1
150          KM   ROUTE CONTINUING FLOWS FROM dv1 TO K
151          RK   11000   0.018   0.025           TRAP     205       0
             *

152          KK       G
153          KM   SUB-BASIN G
154          BA  0.2091
155          UI     17.     67.    101.    156.    178.    120.     82.     39.     23.     12.
156          UI      5.      5.      0.      0.      0.      0.      0.      0.      0.      0.
             *
```

```
157          KK      rG
158          KM   ROUTE FLOWS FROM G TO K
159          RK   16250   0.019   0.025           TRAP      97       0
             *

160          KK       K
161          KM   SUB-BASIN K
162          BA  0.7128
163          UI     22.     22.     47.     82.    105.    122.    137.    159.    185.    243.
164          UI    282.    230.    196.    173.    148.    128.    109.     91.     62.     39.
165          UI     37.     34.     22.     22.     12.      7.      7.      7.      7.      7.
166          UI      7.      7.      0.      0.      0.      0.      0.      0.      0.      0.
             *

167          KK      cK
168          KM   COMBINE FLOWS FROM rdv1, rG AND K
169          HC       3
             *

170          KK     dv2
171          KM   DIVERT FLOWS AT K
172          DT   DIV 2
173          DI       0    1000   50000
174          DQ       0       0       0
             *

175          KK    rdv2
176          KM   ROUTE CONTINUING FLOWS FROM dv2 TO N
177          RK    4500    0.02   0.025           TRAP     227       0
             *

178          KK       N
179          KM   SUB-BASIN N
180          BA  0.4515
181          UI     18.     20.     63.     85.    102.    121.    146.    205.    213.    167.
182          UI    141.    116.     96.     77.     48.     31.     29.     18.     18.      6.
183          UI      5.      5.      5.      5.      5.      0.      0.      0.      0.      0.
             *
```



```
LINE         ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

184          KK      cN
185          KM   COMBINE FLOWS FROM rdv2 AND N
186          HC       2
             *

187          KK     dv3
188          KM   DIVERT FLOWS AT N
189          DT   DIV 3
190          DI       0    1000   50000
191          DQ       0       0       0
```

```
*
KK    rdv3
KM   ROUTE CONTINUING FLOWS FROM dv3 TO O
RK    7000   0.014   0.025            TRAP     236       0
*

KK       O
KM   SUB-BASIN O
BA  0.3436
UI     18.     37.     77.    100.    125.    173.    212.    159.    127.     99.
UI     74.     40.     29.     20.     15.      5.      5.      5.      5.      0.
UI      0.      0.      0.      0.      0.      0.      0.      0.      0.      0.
*

KK  DIKEIN
KM   TOTAL INFLOW TO THE EAST END OF CAVE BUTTES DIKE # 2
KO                                      21
HC       3
*

KK   TOTAL
KM    TOTAL FLOW INFLOW TO PONDING AREA IF WASH IS DIVERTED TO POND
KO                                      21
HC       2
*

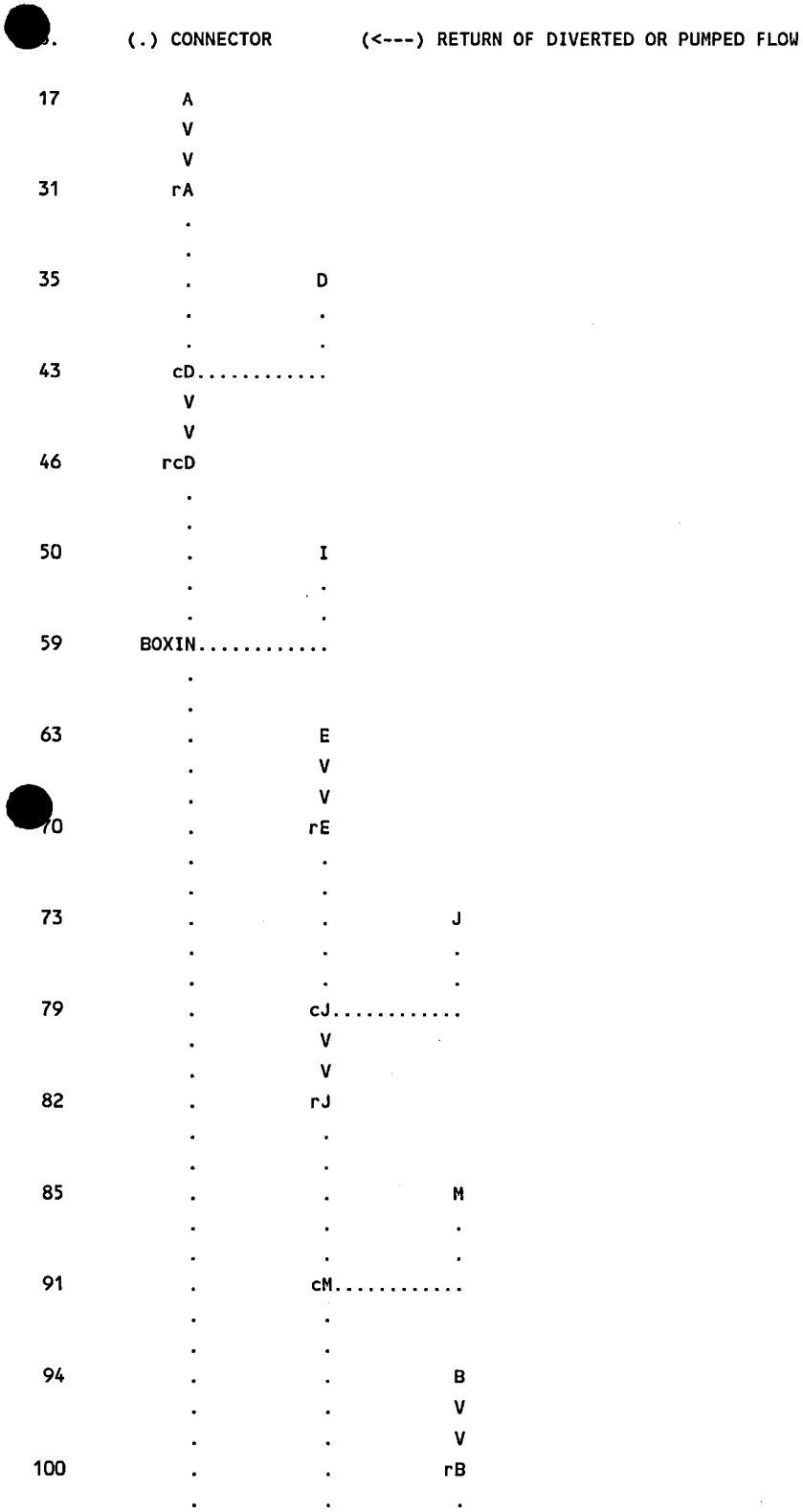
KK   BASIN
KM   PONDING AREA AT THE INTERSECTION OF CAVE CREEK ROAD AND CAVE BUTTES
KM   DIKE # 2.  RATING CURVE BASED ON IMPROVED ROAD CONDITIONS.
KO                                      21
RS       1    STOR       0
SV       0    0.37    0.74    1.32    2.32    3.86    5.94    8.60    11.9    16.0
SV    24.1    32.4    39.4    49.9    62.5    77.5    95.6     117
SQ       0     217     600    1180    1890    2720    3650    4683    5800    6990
SQ    8800    9900   10750   12500   15300   19300   24200   28600
SE    1660  1662.4  1663.4  1664.4  1665.4  1666.4  1667.4  1668.4  1669.4  1670.4
SE  1672.0  1673.2    1674    1675    1676    1677    1678  1678.8
*
ZZ
```

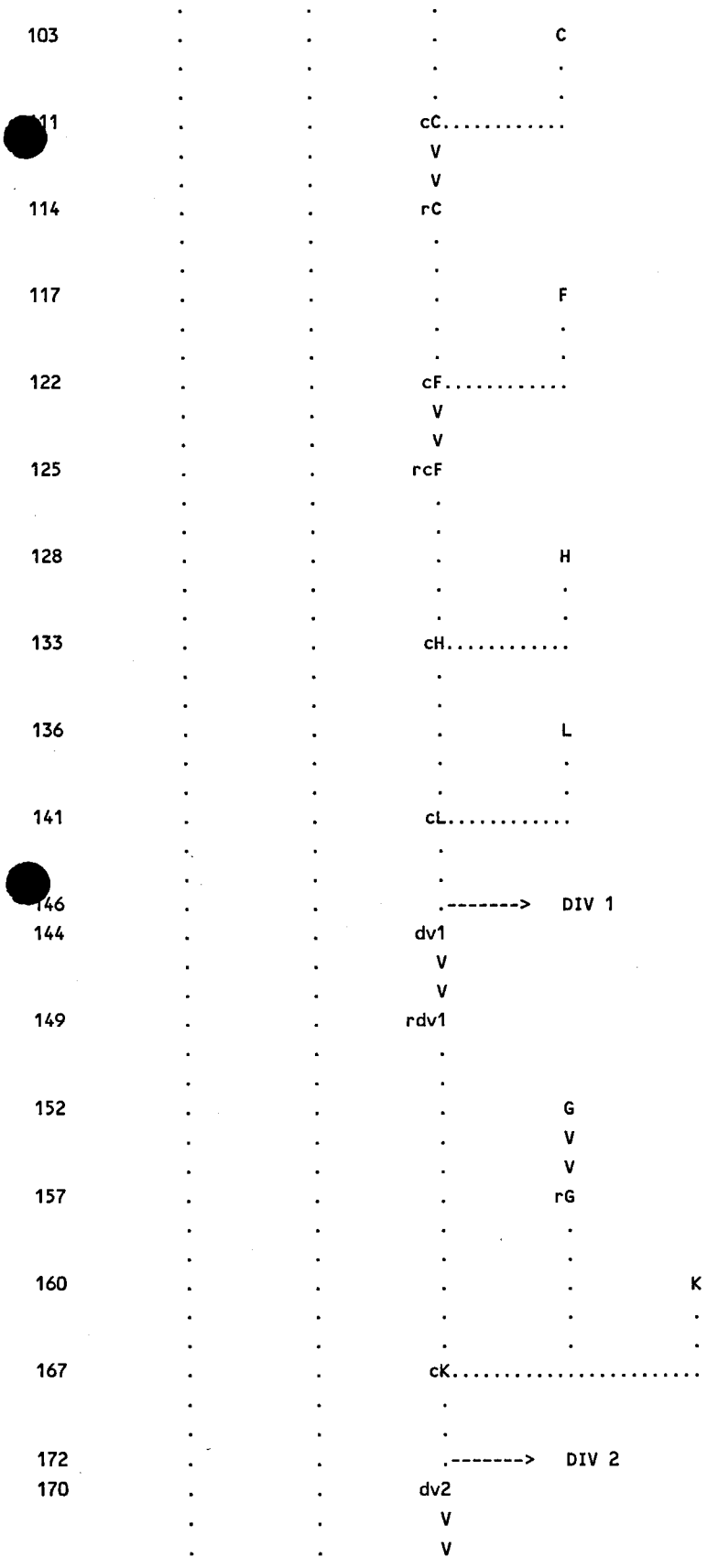
SCHEMATIC DIAGRAM OF STREAM NETWORK

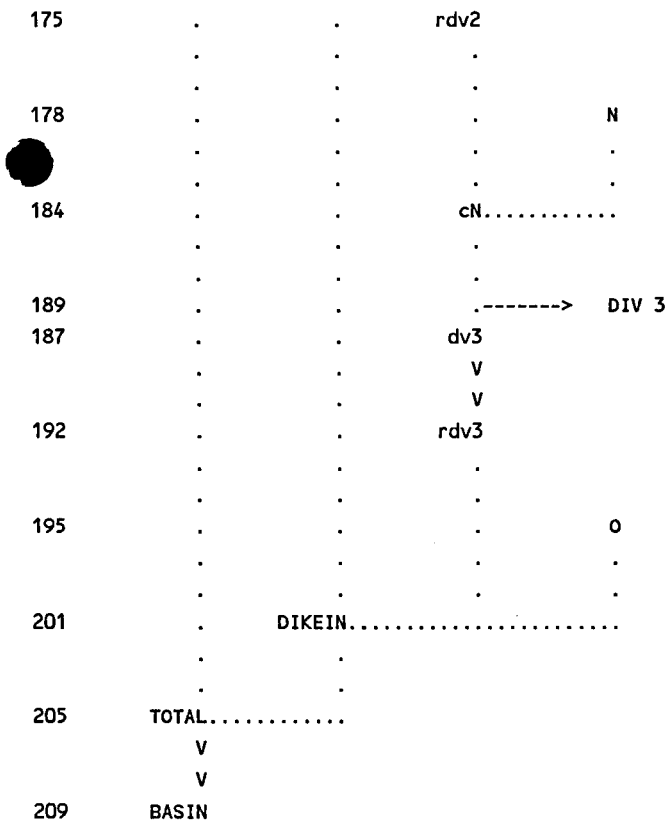
INPUT LINE

(V) ROUTING (---->) DIVERSION OR PUMP FLOW

(.) CONNECTOR (<---) RETURN OF DIVERTED OR PUMPED FLOW




103
C
111
cC
114
rC
117
F
122
cF
125
rcF
128
H
133
cH
136
L
141
cL
146
DIV 1
144
dv1
149
rdv1
152
G
V
V
157
rG
160
K
167
cK
172
DIV 2
170
dv2



(***) RUNOFF ALSO COMPUTED AT THIS LOCATION

```
*****************************************
 ***************************************
*                                       *
*  FLOOD HYDROGRAPH PACKAGE  (HEC-1)    *
*      BY THE COE IN FEBRUARY 1981      *
*           REVISED 02 AUG 88           *
*                                       *
*  RUN DATE  12/07/1990  TIME  12:06:01 *
*                                       *
*****************************************
```


```
*                                       *
*     DODSON AND ASSOCIATES, INC.       *
*   HYDROLOGIST AND CIVIL ENGINEERS     *
*      7015 W TIDWELL SUITE 107         *
*         HOUSTON, TEXAS  77092         *
*           (713) 895-8322              *
*                                       *
*****************************************
```


HEC-1 MODEL FOR DRAINAGE AREA ABOVE CAVE BUTTES DIKE # 2

- C.O.E. 7 HOUR RAINFALL EXCESS FOR THE SPF STORM (NO LOSSES CALCULATED)
- PHOENIX VALLEY S-GRAPH USED TO GENERATE RUNOFF FOR ALL SUBBASINS
- C.O.E. REGRESSION EQUATION USED TO DETERMINE SUBBASIN LAG
  AVERAGE MANNING'S N OF 0.10 USED FOR Kn PARAMETER IN THE REGRESSION EQ.
- CHANNEL DIMENSIONS FOR ROUTINGS BASED ON DAWDY (1979) ASSUMPTIONS:
  WIDTH = 9.5Q**0.4, DEPTH = 0.07Q**0.4
- MANNING'S N OF 0.025 ASSUMED FOR ALL CHANNELS
- RATING CURVE FOR PONDING AREA BEHIND CAVE CREEK ROAD IS BASED ON IMPROVED ROAD CONDITIONS AND NO PONDING ON THE WEST SIDE OF CAVE CREEK ROAD
- NO FLOW IS DIVERTED OUT OF THE WATERSHED AT THE SPLIT FLOW SITES ALONG THE WATERSHED BOUNDARY

```
 16 IO          OUTPUT CONTROL VARIABLES
                     IPRNT          5  PRINT CONTROL
                     IPLOT          0  PLOT CONTROL
                     QSCAL          0.  HYDROGRAPH PLOT SCALE

    IT          HYDROGRAPH TIME DATA
                      NMIN         10  MINUTES IN COMPUTATION INTERVAL
                     IDATE      1    0  STARTING DATE
                     ITIME         0000  STARTING TIME
                        NQ         120  NUMBER OF HYDROGRAPH ORDINATES
                    NDDATE      1    0  ENDING DATE
                    NDTIME         1950  ENDING TIME
                     ICENT           19  CENTURY MARK

                  COMPUTATION INTERVAL      .17 HOURS
                      TOTAL TIME BASE   19.83 HOURS

        ENGLISH UNITS
             DRAINAGE AREA         SQUARE MILES
             PRECIPITATION DEPTH   INCHES
             LENGTH, ELEVATION     FEET
             FLOW                  CUBIC FEET PER SECOND
```

```
            STORAGE VOLUME        ACRE-FEET
            SURFACE AREA          ACRES
            TEMPERATURE           DEGREES FAHRENHEIT


       *** FLOGRD - MAXIMUM NUMBER OF DX INTERVALS REACHED. MDX= 51
        THIS MAY AFFECT ACCURACY OF KW  SOLUTION. TO REDUCE ERRORS SHORTEN CHANNEL ELEMENT = 3


       *** FLOGRD - MAXIMUM NUMBER OF DX INTERVALS REACHED. MDX= 51
        THIS MAY AFFECT ACCURACY OF KW  SOLUTION. TO REDUCE ERRORS SHORTEN CHANNEL ELEMENT = 3


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***


          **************
          *            *
 59 KK    *     BOXIN  *
          *            *
          **************

 61 KO          OUTPUT CONTROL VARIABLES
                     IPRNT          5  PRINT CONTROL
                     IPLOT          0  PLOT CONTROL
                     QSCAL         0.  HYDROGRAPH PLOT SCALE
                     IPNCH          0  PUNCH COMPUTED HYDROGRAPH
                      IOUT         21  SAVE HYDROGRAPH ON THIS UNIT
                     ISAV1          1  FIRST ORDINATE PUNCHED OR SAVED
                     ISAV2        120  LAST ORDINATE PUNCHED OR SAVED
                    TIMINT       .167  TIME INTERVAL IN HOURS


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***


          **************
          *            *
201 KK    *    DIKEIN  *
          *            *
          **************

203 KO          OUTPUT CONTROL VARIABLES
                     IPRNT          5  PRINT CONTROL
                     IPLOT          0  PLOT CONTROL
                     QSCAL         0.  HYDROGRAPH PLOT SCALE
                     IPNCH          0  PUNCH COMPUTED HYDROGRAPH
                      IOUT         21  SAVE HYDROGRAPH ON THIS UNIT
                     ISAV1          1  FIRST ORDINATE PUNCHED OR SAVED
                     ISAV2        120  LAST ORDINATE PUNCHED OR SAVED
                    TIMINT       .167  TIME INTERVAL IN HOURS
```

*** ***

```
          **************
          *            *
205 KK    *     TOTAL  *
          *            *
          **************

207 KO          OUTPUT CONTROL VARIABLES
                     IPRNT           5  PRINT CONTROL
                     IPLOT           0  PLOT CONTROL
                     QSCAL          0.  HYDROGRAPH PLOT SCALE
                     IPNCH           0  PUNCH COMPUTED HYDROGRAPH
                      IOUT          21  SAVE HYDROGRAPH ON THIS UNIT
                     ISAV1           1  FIRST ORDINATE PUNCHED OR SAVED
                     ISAV2         120  LAST ORDINATE PUNCHED OR SAVED
                    TIMINT        .167  TIME INTERVAL IN HOURS
```

*** ***

```
          **************
          *            *
209 KK    *     BASIN  *
          *            *
          **************

212 KO          OUTPUT CONTROL VARIABLES
                     IPRNT           5  PRINT CONTROL
                     IPLOT           0  PLOT CONTROL
                     QSCAL          0.  HYDROGRAPH PLOT SCALE
                     IPNCH           0  PUNCH COMPUTED HYDROGRAPH
                      IOUT          21  SAVE HYDROGRAPH ON THIS UNIT
                     ISAV1           1  FIRST ORDINATE PUNCHED OR SAVED
                     ISAV2         120  LAST ORDINATE PUNCHED OR SAVED
                    TIMINT        .167  TIME INTERVAL IN HOURS
```

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	A	2328.	7.50	1170.	378.	378.	3.56		
ROUTED TO	rA	2310.	7.67	1169.	378.	378.	3.56		
HYDROGRAPH AT	D	575.	7.00	250.	79.	79.	1.09		
2 COMBINED AT	cD	2754.	7.67	1410.	457.	457.	4.64		
ROUTED TO	rcD	2745.	8.17	1406.	454.	454.	4.64		
HYDROGRAPH AT	I	1167.	7.83	639.	211.	211.	1.98		
2 COMBINED AT	BOXIN	3852.	8.17	1989.	665.	665.	6.63		
HYDROGRAPH AT	E	697.	6.83	286.	90.	90.	.85		
ROUTED TO	rE	694.	7.17	286.	90.	90.	.85		
HYDROGRAPH AT	J	780.	6.50	281.	88.	88.	.83		
2 COMBINED AT	cJ	1343.	6.83	562.	178.	178.	1.68		
ROUTED TO	rJ	1343.	6.83	563.	179.	179.	1.68		
HYDROGRAPH AT	M	427.	6.33	148.	46.	46.	.43		
2 COMBINED AT	cM	1727.	6.67	708.	225.	225.	2.11		
HYDROGRAPH AT	B	973.	6.50	367.	115.	115.	1.09		
ROUTED TO	rB	973.	6.67	367.	115.	115.	1.09		
HYDROGRAPH AT	C	1343.	7.50	692.	225.	225.	2.11		
2 COMBINED AT	cC	2066.	7.17	1056.	340.	340.	3.20		
ROUTED TO	rC	2061.	7.33	1056.	340.	340.	3.20		
HYDROGRAPH AT	F	159.	5.67	40.	12.	12.	.12		
2 COMBINED AT	cF	2070.	7.33	1091.	352.	352.	3.31		
ROUTED TO	rcF	2069.	7.50	1091.	352.	352.	3.31		
HYDROGRAPH AT	H	340.	6.17	106.	33.	33.	.31		

2 COMBINED AT	cH	2164.	7.17	1187.	385.	385.	3.62		
HYDROGRAPH AT	L	135.	5.67	34.	10.	10.	.10		
2 COMBINED AT	cL	2175.	7.17	1217.	395.	395.	3.72		
DIVERSION TO	DIV 1	0.	7.17	0.	0.	0.	3.72		
HYDROGRAPH AT	dv1	2175.	7.17	1217.	395.	395.	3.72		
ROUTED TO	rdv1	2172.	7.33	1217.	395.	395.	3.72		
HYDROGRAPH AT	G	284.	5.67	72.	22.	22.	.21		
ROUTED TO	rG	283.	6.17	72.	22.	22.	.21		
HYDROGRAPH AT	K	597.	6.67	240.	76.	76.	.71		
3 COMBINED AT	cK	2792.	7.00	1515.	492.	492.	4.64		
DIVERSION TO	DIV 2	0.	7.00	0.	0.	0.	4.64		
HYDROGRAPH AT	dv2	2792.	7.00	1515.	492.	492.	4.64		
ROUTED TO	rdv2	2790.	7.17	1514.	492.	492.	4.64		
HYDROGRAPH AT	N	444.	6.33	154.	48.	48.	.45		
2 COMBINED AT	cN	3089.	7.00	1654.	540.	540.	5.10		
DIVERSION TO	DIV 3	0.	7.00	0.	0.	0.	5.10		
HYDROGRAPH AT	dv3	3089.	7.00	1654.	540.	540.	5.10		
ROUTED TO	rdv3	3081.	7.17	1654.	539.	539.	5.10		
HYDROGRAPH AT	O	386.	6.00	118.	36.	36.	.34		
3 COMBINED AT	DIKEIN	4930.	6.83	2441.	800.	800.	7.55		
2 COMBINED AT	TOTAL	7478.	7.50	4393.	1465.	1465.	14.18		
ROUTED TO	BASIN	7470.	7.50	4393.	1465.	1465.	14.18	1670.82	7.50

SUMMARY OF KINEMATIC WAVE ROUTING
(FLOW IS DIRECT RUNOFF WITHOUT BASE FLOW)

ISTAQ	ELEMENT	DT	PEAK	TIME TO PEAK	VOLUME	INTERPOLATED TO COMPUTATION INTERVAL DT	PEAK	TIME TO PEAK	VOLUME
		(MIN)	(CFS)	(MIN)	(IN)	(MIN)	(CFS)	(MIN)	(IN)
rA	3	.33	2327.19	466.44	3.27	10.00	2310.28	460.00	3.26
CONTINUITY SUMMARY (AC-FT) - INFLOW= 620.129 EXCESS= .000 OUTFLOW= 619.678 BASIN STORAGE= .384 PERCENT ERROR= .011									
rcD	3	.67	2753.47	492.39	3.01	10.00	2744.71	490.00	3.01
CONTINUITY SUMMARY (AC-FT) - INFLOW= 749.725 EXCESS= .000 OUTFLOW= 744.350 BASIN STORAGE= 5.048 PERCENT ERROR= .044									
rE	3	.49	697.25	428.36	3.26	10.00	693.92	430.00	3.26
CONTINUITY SUMMARY (AC-FT) - INFLOW= 148.231 EXCESS= .000 OUTFLOW= 148.109 BASIN STORAGE= .098 PERCENT ERROR= .016									
rJ	3	.37	1342.72	410.91	3.26	10.00	1342.71	410.00	3.27
CONTINUITY SUMMARY (AC-FT) - INFLOW= 292.564 EXCESS= .000 OUTFLOW= 292.518 BASIN STORAGE= .018 PERCENT ERROR= .009									
rB	3	.43	972.85	400.20	3.26	10.00	972.74	400.00	3.27
CONTINUITY SUMMARY (AC-FT) - INFLOW= 188.813 EXCESS= .000 OUTFLOW= 188.766 BASIN STORAGE= .029 PERCENT ERROR= .010									
rC	3	.33	2065.67	435.06	3.27	10.00	2061.15	440.00	3.27
CONTINUITY SUMMARY (AC-FT) - INFLOW= 557.062 EXCESS= .000 OUTFLOW= 556.942 BASIN STORAGE= .067 PERCENT ERROR= .010									
rcF	3	.33	2069.56	449.70	3.26	10.00	2068.84	450.00	3.27
CONTINUITY SUMMARY (AC-FT) - INFLOW= 576.794 EXCESS= .000 OUTFLOW= 576.407 BASIN STORAGE= .302 PERCENT ERROR= .015									
rdv1	3	.32	2174.92	441.90	3.26	10.00	2171.72	440.00	3.26
CONTINUITY SUMMARY (AC-FT) - INFLOW= 648.073 EXCESS= .000 OUTFLOW= 647.072 BASIN STORAGE= .880 PERCENT ERROR= .019									
rG	3	.73	283.90	369.54	3.24	10.00	283.25	370.00	3.24
CONTINUITY SUMMARY (AC-FT) - INFLOW= 36.258 EXCESS= .000 OUTFLOW= 36.166 BASIN STORAGE= .078 PERCENT ERROR= .040									

rdv2	3	.38	2792.00	424.22	3.26	10.00	2790.43	430.00	3.26

CONTINUITY SUMMARY (AC-FT) - INFLOW= 807.160 EXCESS= .000 OUTFLOW= 806.494 BASIN STORAGE= .532 PERCENT ERROR= .017

rdv3	3	.37	3088.55	427.19	3.25	10.00	3080.94	430.00	3.25

CONTINUITY SUMMARY (AC-FT) - INFLOW= 884.745 EXCESS= .000 OUTFLOW= 883.293 BASIN STORAGE= 1.261 PERCENT ERROR= .022

*** NORMAL END OF HEC-1 ***

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

PROJECT Cave Buttes Dike #2 PAGE ____ OF ____

DETAIL Subbasin Parameters COMPUTED TWH DATE 11/19/90

For Basin Lag Calculations CHECKED BY ____ DATE ____

Subbasin	Area (sq. mi.)	L (miles)	Lca (miles)	K_n *	S (ft./mi)	Lag ** (hours/min)
A	3.558	5.44	2.72	0.1	143	2.60 / 156
B	1.085	2.74	1.6	0.1	142	1.64 / 98
C	2.112	6.53	2.3	0.1	123	2.69 / 162
D	0.7473	3.70	1.85	0.1	103	2.07 / 124
E	0.8518	3.22	1.61	0.1	96	1.85 / 113
F	0.1156	0.85	0.43	0.1	84	0.705 / 42
G	0.2091	0.95	0.47	0.1	110	0.723 / 43
H	0.3102	1.66	0.83	0.1	90	1.15 / 69
I	1.982	5.88	2.92	0.1	90	3.01 / 180
	0.8284	2.46	1.23	0.1	100	1.52 / 91
K	0.7128	3.08	1.54	0.1	99	1.81 / 109
L	0.099	0.90	0.45	0.1	100	0.71 / 43
M	0.1337	2.18	1.09	0.1	92	1.41 / 85
N	0.4515	2.22	1.11	0.1	97	1.42 / 85
O	0.3436	1.52	0.76	0.1	79	1.11 / 66

* K_n was estimated from Table 3-1 (TR-55) for sheet flow.

** $Lag = 24 K_n \left[\frac{L \cdot Lca}{S^{1/2}} \right]^{0.38}$

Phoenix Valley Egraph was used for all subbasins.

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

PROJECT Cave Buttes Dike # 2 PAGE 1 OF 1

DETAIL Volume Calculation COMPUTED TWH DATE

for Ponding Area CHECKED BY DATE

Elevation	Area (acres)	ΔA (acres)	ΔH (Ft.)	Wedge Volume (ac-ft)	Total Volume (ac-ft.)
1660	0				0
		0.31	2.4	0.37	
1662.4	0.31				0.37
		0.12	1.0	0.06	
1663.4	0.43				0.74
		0.30	1.0	0.15	
1664.4	0.73				1.32
		0.54	1.0	0.27	
1665.4	1.27				2.32
		0.54	1.0	0.27	
1666.4	1.81				3.86
		0.54	1.0	0.27	
1667.4	2.35				5.94
		0.62	1.0	0.31	
1668.4	2.97				8.60
		0.75	1.0	0.37	
1669.4	3.72				11.94
		0.75	1.0	0.37	
1670.4	4.47				16.03
		1.20	1.6	0.96	
1672.0	5.67				24.14
		2.33	1.2	1.40	
1673.2	8.00				32.35
		1.58	0.8	0.63	
1674.0	9.58				39.38
		1.95	1.0	0.98	
1675.0	11.53				49.94
		1.95	1.0	0.98	
1676.0	13.48				62.45
		3.11	1.0	1.55	
1677.0	16.59				77.48
		3.10	1.0	1.55	
1678.0	19.69				95.62
		2.48	1.0	1.24	116.5
1678.8	22.17				

$$\text{Total Volume}_n = \text{wedge}_n + \text{Total Volume}_{n-1} + (\Delta H_n)(\text{Area}_{n-1})$$

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

PROJECT Cave Buttes Dike # 2 PAGE 1 OF 1

DETAIL Rating Curve for Cave Creek Road @ Box Culverts COMPUTED TWH DATE 11/26/90

CHECKED BY _____ DATE _____

Roadway is assumed to act as a broad-crested weir

$Q = 3.09 L H^{3/2}$

Elevation	L**	H*	Q
1673.2	0	0	0
1674.0	335	0.4	262
1675.0	500	0.9	1320
1676.0	690	1.4	3530
1677.0	860	1.9	6960
1678.0	980	2.4	11300
1678.8	1050	2.8	15200

* L = width of the weir. : assumed to be the width of flow at the waterline

** H = Head : assumed to be the average depth of flow across the road.

APPENDIX A
DESIGN METHODS AND EQUATIONS

A. Introduction.

This appendix contains explanations of the equations and methods used to develop the design charts of this publication, where those equations and methods are not fully described in the main text. The following topics are discussed: the design equations for the unsubmerged and submerged inlet control nomographs, the dimensionless design curves for culvert shapes and sizes without nomographs, and the dimensionless critical depth charts for long span culverts and corrugated metal box culverts.

B. Inlet Control Nomograph Equations.

The design equations used to develop the inlet control nomographs are based on the research conducted by the National Bureau of Standards (NBS) under the sponsorship of the Bureau of Public Roads (now the Federal Highway Administration). Seven progress reports were produced as a result of this research. Of these, the first and fourth through seventh reports dealt with the hydraulics of pipe and box culvert entrances, with and without tapered inlets. (4,7 to 10) These reports were one source of the equation coefficients and exponents, along with other references and unpublished FHWA notes on the development of the nomographs. (56,57)

The two basic conditions of inlet control depend upon whether the inlet end of the culvert is or is not submerged by the upstream headwater. If the inlet is not submerged, the inlet performs as a weir. If the inlet is submerged, the inlet performs as an orifice. Equations are available for each of the above conditions.

Between the unsubmerged and the submerged conditions, there is a transition zone for which the NBS research provided only limited information. The transition zone is defined empirically by drawing a curve between and tangent to the curves defined by the unsubmerged and submerged equations. In most cases, the transition zone is short and the curve is easily constructed.

Table 8 contains the unsubmerged and submerged inlet control design equations. Note that there are two forms of the unsubmerged equation. Form (1) is based on the specific head at critical depth, adjusted with two correction factors. Form (2) is an exponential equation similar to a weir equation. Form (1) is preferable from a theoretical standpoint, but form (2) is easier to apply and is the only documented form of equation for some of the inlet control nomographs. Either form of unsubmerged inlet control equation will produce adequate results.

The constants for the equations in table 8 are given in table 9. Table 9 is arranged in the same order as the design nomographs in appendix D, and provides the unsubmerged and submerged equation coefficients for each shape, material, and edge configuration. For the unsubmerged equations, the form of the equation is also noted.

Table 8
Inlet control design equations.

UNSUBMERGED [1]

$$\text{Form (1)} \quad \frac{HW_i}{D} = \frac{H_c}{D} + K\left[\frac{Q}{AD^{0.5}}\right]^M - 0.5S \text{ [2]} \qquad (26)$$

$$\text{Form (2)} \quad \frac{HW_i}{D} = K\left[\frac{Q}{AD^{0.5}}\right]^M \qquad (27)$$

SUBMERGED [3]

$$\frac{HW_i}{D} = c\left[\frac{Q}{AD^{0.5}}\right]^2 + Y - 0.5S \text{ [2]} \qquad (28)$$

Definitions

HW_i	Headwater depth above inlet control section invert, ft
D	Interior height of culvert barrel, ft
H_c	Specific head at critical depth ($d_c + V_c^2/2g$), ft
Q	Discharge, ft^3/s
A	Full cross sectional area of culvert barrel, ft^2
S	Culvert barrel slope, ft/ft
K,M,c,Y	Constants from table 9

NOTES:
[1] Equations (26) and (27) (unsubmerged) apply up to about $Q/AD^{0.5} = 3.5$.
[2] For mitered inlets use +0.7S instead of -0.5S as the slope correction factor.
[3] Equation (28) (submerged) applies above about $Q/AD^{0.5} = 4.0$.

Table 9

Constants for inlet control design equations.

CHART NO.	SHAPE AND MATERIAL	NOMOGRAPH SCALE	INLET EDGE DES: ON	UNSUBMERGED EQUATION FORM	K	M	SUBMERGED c	Y	References
1	Circular	1	Square edge w/headwall	1	0.0098	2.0	0.0398	0.67	(56) (57)
	Concrete	2	Groove end w/headwall		.0078	2.0	.0292	.74	(56) (57)
		3	Groove end projecting		.0045	2.0	.0317	.69	(56) (57)
2	Circular	1	Headwall	1	.0078	2.0	.0379	.69	(56) (57)
	CNP	2	Mitered to slope		.0210	1.33	.0463	.75	(57)
		3	Projecting		.0340	1.50	.0553	.54	(57)
3	Circular	A	Beveled ring, 45° bevels	1	.0018	2.50	.0300	.74	(57)
		B	Beveled ring, 33.7° bevels*		.0018	2.50	.0243	.83	(57)
8	Rectangular	1	30° to 75° wingwall flares		.026	1.0	.0385	.81	(56)
	Box	2	90° and 15° wingwall flares	1	.061	0.75	.0400	.80	(56)
		3	0° wingwall flares		.061	0.75	.0423	.82	(8)
9	Rectangular	1	45° wingwall flare d=.043D	2	.510	.667	.0309	.80	(8)
	Box	2	18° to 33.7° wingwall flare d=.083D		.486	.667	.0249	.83	(8)
10	Rectangular	1	90° headwall w/3/4" chamfers	2	.515	.667	.0375	.79	(8)
	Box	2	90° headwall w/45° bevels		.495	.667	.0314	.82	(8)
		3	90° headwall w/33.7° bevels		.486	.667	.0252	.865	(8)
11	Rectangular	1	3/4" chamfers; 45° skewed headwall	2	.522	.667	.0402	.73	(8)
	Box	2	3/4" chamfers; 30° skewed headwall		.533	.667	.0425	.705	(8)
		3	3/4" chamfers; 15° skewed headwall		.545	.667	.04505	.68	(8)
		4	45° bevels; 10°-45° skewed headwall		.498	.667	.0327	.75	(8)
12	Rectangular	1	45° non-offset wingwall flares	2	.497	.667	.0339	.803	(8)
	Box	2	18.4° non-offset wingwall flares		.493	.667	.0361	.806	(8)
	3/4" chamfers	3	18.4° non-offset wingwall flares 30° skewed barrel		.495	.667	.0386	.71	(8)
13	Rectangular	1	45° wingwall flares - offset	2	.497	.667	.0302	.835	(8)
	Box	2	33.7° wingwall flares - offset		.495	.667	.0252	.881	(8)
	Top Bevels	3	18.4° wingwall flares - offset		.493	.667	.0227	.887	(8)
16-19	C M Boxes	1	90° headwall	1	.0083	2.0	.0379	.69	(57)
		2	Thick wall projecting		.0145	1.75	.0419	.64	(57)
		3	Thin wall projecting		.0340	1.5	.0496	.57	(57)

8'X12' Box Culvert

Table 9 (continued)

Constants for inlet control design equations.

CHART NO.	SHAPE AND MATERIAL	NOMOGRAPH SCALE	INLET EDGE DESCRIPTION	UNSUBMERGED EQUATION FORM	K	M	SUBMERGED c	Y	Reference
29	Horizontal	1	Square edge with headwall	1	0.0100	2.0	.0398	.67	(57)
	Ellipse	2	Groove end with headwall		.0018	2.5	.0292	.74	(57)
	Concrete	3	Groove end projecting		.0045	2.0	.0317	.69	(57)
30	Vertical	1	Square edge with headwall	1	.0100	2.0	.0398	.67	(57)
	Ellipse	2	Groove end with headwall		.0018	2.5	.0292	.74	(57)
	Concrete	3	Groove end projecting		.0095	2.0	.0317	.69	(57)
34	Pipe Arch	1	90° headwall	1	.0083	2.0	.0496	.57	(57)
	18" Corner	2	Mitered to slope		.0300	1.0	.0463	.75	(57)
	Radius CM	3	Projecting		.0340	1.5	.0496	.53	(57)
35	Pipe Arch	1	Projecting	1	.0296	1.5	.0487	.55	(56)
	18" Corner	2	No Bevels		.0087	2.0	.0361	.66	(56)
	Radius CM	3	33.7° Bevels		.0030	2.0	.0264	.75	(56)
36	Pipe Arch	1	Projecting	1	.0296	1.5	.0487	.55	(56)
	31" Corner		No Bevels		.0087	2.0	.0361	.66	(56)
	Radius CM		33.7° Bevels		.0030	2.0	.0264	.75	(56)
40-42	Arch CM	1	90° headwall	1	.0083	2.0	.0379	.69	(57)
		2	Mitered to slope		.0300	2.0	.0463	.75	(57)
		3	Thin wall projecting		.0340	1.5	.0496	.57	(57)
54	Circular	1	Smooth tapered inlet throat	2	.534	.555	.0196	.89	(3)
		2	Rough tapered inlet throat		.519	.64	.0289	.90	(3)
55	Elliptical	1	Tapered inlet-beveled edges	2	.536	.622	.0368	.83	(3)
	Inlet Face	2	Tapered inlet-square edges		.5035	.719	.0478	.80	(3)
		3	Tapered inlet-thin edge projecting		.547	.80	.0598	.75	(3)
56	Rectangular	1	Tapered inlet throat	2	.475	.667	.0179	.97	(3)
57	Rectangular	1	Side tapered-less favorable edges	2	.56	.667	.0466	.85	(3)
	Concrete	2	Side tapered-more favorable edges		.56	.667	.0378	.87	(3)
58	Rectangular	1	Slope tapered-less favorable edges	2	.50	.667	.0466	.65	(3)
	Concrete		Slope tapered-more favorable edges		.50	.667	.0378	.71	(3)

15'x25' elliptical culvert

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

PROJECT Cave Buttes Dike #2 PAGE 1 OF 1

DETAIL Stage - discharge for COMPUTED TWH DATE 11/26/90

8'x12' box culverts CHECKED BY _____ DATE _____

Unsubmerged condition

$$HW_i = KD\left[\frac{Q}{AD^{1/2}}\right]^M$$

K = 0.495 M = 0.667

D = 8 ft. A = 96.0 ft²

$$HW_i = 0.09426\, Q^{0.667} \Rightarrow Q = \left[\frac{HW_i}{0.09426}\right]^{3/2}$$

HW_i	Q	Q x 5
1	34.5	172
2	97.73	489
3	179.54	898
4	276.4	1382
5	386.3	1931
6	507.8	2540
7	639.9	3200
8	781.8	3910

Submerged Condition

$$HW_i = D\left[c\left(\frac{Q}{AD^{1/2}}\right)^2 + Y - 0.55\right]$$

C = 0.0252 A = 96.0 ft²

Y = 0.881 D = 8.0 ft.

$$HW_i = 8\left[0.0252\,\frac{Q^2}{(96)^2(8)} + 0.881 - 0.5(0.0143)\right] \Rightarrow HW_i = A\cdot Q^2 + 7.047 \;\therefore\; A = 2.739\times10^{-6}$$

$$Q = \left[\frac{HW_i - 6.991}{A}\right]^{1/2}$$

HW_i	Q	Q_5
9.6	976.8	4880
10.8	1180	5900
11.6	1298	6490
12.6	1432	7160
13.6	1555	7770
14.6	1668	8340
15.6	1774	8870
16.6	1875	9370

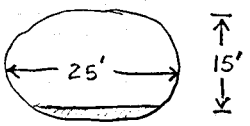
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

PROJECT Cave Buttes Dike #2 PAGE 1 OF 1

DETAIL Stage - Discharge Eq. COMPUTED TWH DATE 12/7/90

for 15'x25' Elliptical Culvert CHECKED BY _____ DATE _____

Calculations for the horse crossing culvert at the road-dike intersection



Inlet control is assumed at all stages for the culvert. The fill material will wash out for large flows and is therefore ignored.

Invert elevation = 1660.5 X-sectional Area = 294.5 ft^2

barrel slope = 0.0183 ft/ft

from Table 9 : K = 0.356 , M = 0.622

$$HW_i = KD\left[\frac{Q}{AD^{1/2}}\right]^M \Rightarrow HW_i = (0.356)(15)\left[\frac{Q}{(294.5)(15)^{1/2}}\right]^{0.622}$$

$$\Rightarrow HW_i = 0.067\,Q^{0.622} \Rightarrow Q = \left[\frac{HW_i}{0.067}\right]^{1.608}$$ (unsubmerged condition)

elev.	HW_i	Q
1660	0	0
1662.4	1.9	217
1663.4	2.9	428
1664.4	3.9	689
1665.4	4.9	994
1666.4	5.9	1340
1667.4	6.9	1724
1668.4	7.9	2143
1669.4	8.9	2596
1670.4	9.9	3080
1672.0	11.5	3920
1674.0	13.5	4000 ★
1675.0	14.5	4000
1676.0	15.5	4000
1677.0	16.5	4000
1678.0	17.5	4000
1678.8	18.3	4000

Submerged condition

$$HW_i = D\left[C\left(\frac{Q}{AD^{1/2}}\right)^2 + Y - 0.75\right]$$ mitered inlet

C = 0.0368 , Y = 0.83

$$\Rightarrow HW_i = (4.243\times10^{-7})\,Q^2 + 12.313$$

$$\Rightarrow Q = \left[\frac{HW_i - 12.26}{4.243\times10^{-7}}\right]^{1/2}$$

★ see notes on Table 8

Maximum flow of 4000 cfs assumed for this analysis

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY

PROJECT Cave Buttes Dike # 2 PAGE 1 OF 1

DETAIL Rating Curve for Pending COMPUTED TWH DATE 11/22

Area East of Cave Creek Road CHECKED BY _____ DATE _____

Elevation	Area (acres)	Volume (ac-Ft.)	Q_{Box} (CFS)	Q_{Road} (CFS)	$Q_{ellipse}$ (CFS)	Q_{Total} (CFS)	Comments
1660	0	0	0	0	0	0	
1662.4	0.31	0.37	0	0	217	217	Invert of box culvert
1663.4	0.43	0.74	172.	0	428	600	
1664.4	0.73	1.32	489.	0	689	1180	
1665.4	1.27	2.32	898.	0	994	1890	
1666.4	1.81	3.86	1380	0	1340	2720	
1667.4	2.35	5.94	1930	0	1724	3650	
1668.4	2.97	8.60	2540	0	2143	4683	
1669.4	3.72	11.9	3200	0	2596	5800	
1670.4	4.47	16.0	3910	0	3080	6990	Top of box culvert
1672.0	5.67	24.1	4880	0	3920	8800	
1673.2	8.00	32.4	5900	0	4000	9900	Invert of roadway
1674.0	9.58	39.4	6490	262	4000	10,750	
1675.0	11.53	49.9	7160	1320	4000	12,500	
1676.0	13.48	62.5	7770	3530	4000	15,300	
1677.0	16.59	77.5	8340	6960	4000	19,300	
1678.0	19.69	95.6	8870	11300	4000	24,200	
1678.8	22.17	117.	9370	15200	4000	28,600	Low point of Cave Buttes Dike # 2

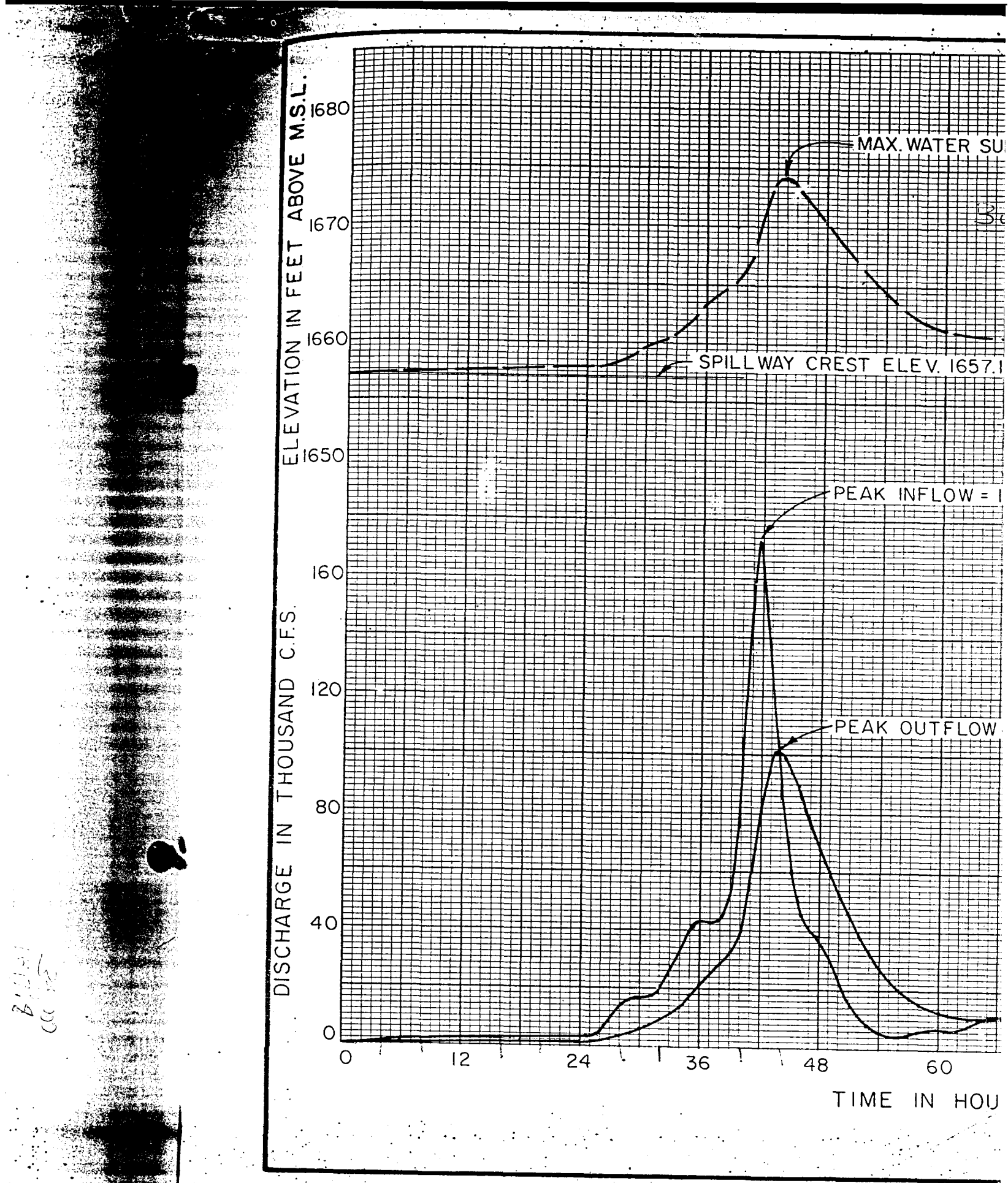
MESSAGE DISPLAY

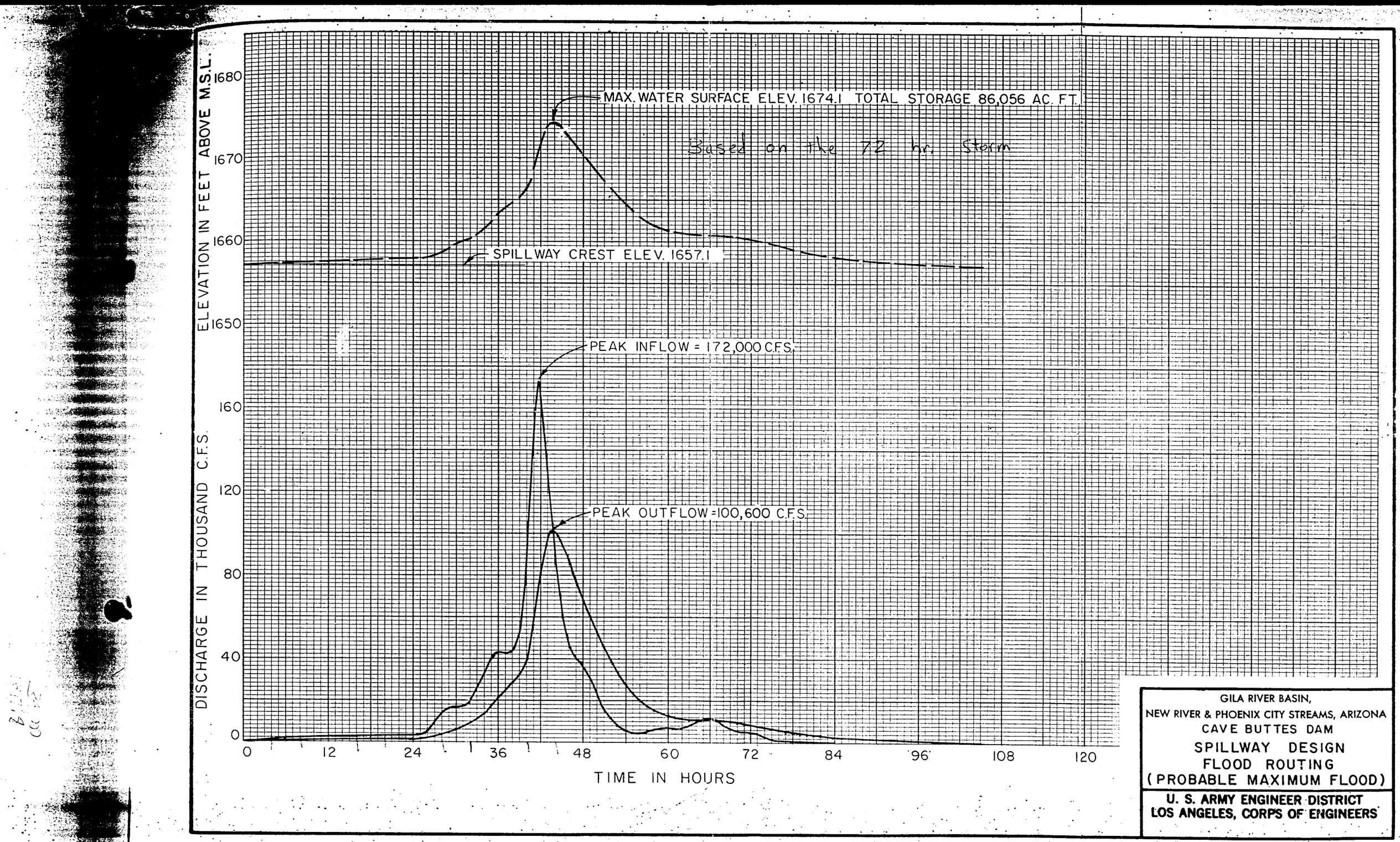
T DHK
TMD
CC RWC
CC JJT

From: Dave Johnson
Postmark: 1 November 1990 4:31 PM Delivered: 1 November 1990 4:31 PM
Status: Previously read
Subject: Cave Buttes Dike #2 east of Cave Creek Road

Message:
I want an analysis made of the contributing runoff to Cave Buttes Dike #2 east of Cave Creek Road from Cave Creek Road upstream. The SPF flow must be routed to and along the Dike to Cave Creek Road and then routed through and over the Road. The peak flows will then be used to delineate the flooding limits (ponding or conveyance) to existing District R/W.
In addition, we need to establish the conditions along Dike #2 during the PMF contributing to Dike #2 East of Cave Creek Road. I anticipate that those flows will all be diverted into the Cave Buttes Reservoir without overtopping of the Dike, however we need the documentation reflecting the PMF condition. The issue of whether the combination Cave Creek Road/Dike #2 east of Cave Creek Road "structure" falls under ADWR Dam Safety jurisdiction will need to be resolved, but the development of such data is still necessary.
If you have questions concerning data for the Road or topo, talk to n Rodriquez.

-------========X========-------

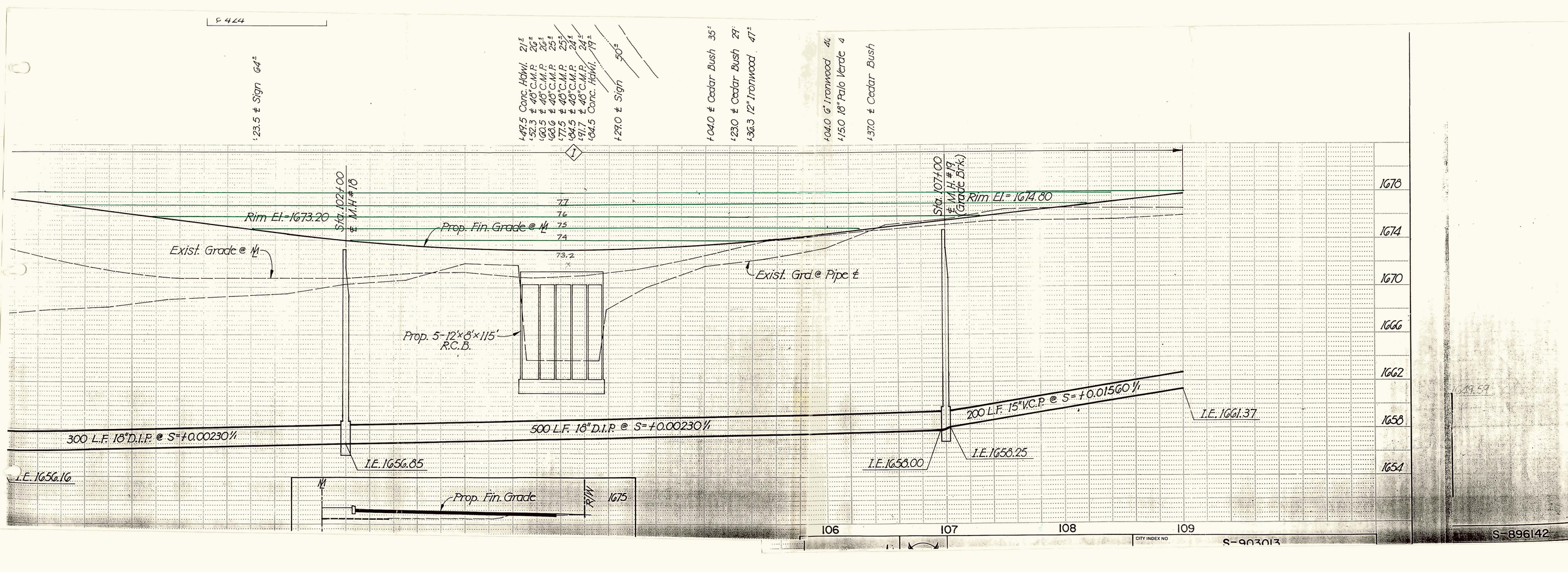

ELEVATION IN FEET ABOVE M.S.L.
1680
1670
1660
1650
MAX. WATER SU
SPILLWAY CREST ELEV. 1657.
PEAK INFLOW =
DISCHARGE IN THOUSAND C.F.S.
160
120
80
40
0
PEAK OUTFLOW
0
12
24
36
48
60
TIME IN HOU



GILA RIVER BASIN,
NEW RIVER & PHOENIX CITY STREAMS, ARIZONA
CAVE BUTTES DAM
SPILLWAY DESIGN
FLOOD ROUTING
(PROBABLE MAXIMUM FLOOD)

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS

APPENDIX I FIGURE 6


123.5 ℄ Sign @ 4°
149.5 Conc. Hdwl. 21"
152.3 ℄ 48" C.M.P. 26°
160.5 ℄ 48" C.M.P. 26°
168.6 ℄ 48" C.M.P. 25°
177.5 ℄ 48" C.M.P. 24°
184.5 ℄ 48" C.M.P. 24°
191.7 ℄ 48" C.M.P. 24°
194.5 Conc. Hdwl. 19°
229.0 ℄ Sign 50°
204.0 ℄ Cedar Bush 35°
230 ℄ Cedar Bush 29°
236.3 12" Ironwood 47°
204.0 6" Ironwood 46
215.0 18" Palo Verde 4
237.0 ℄ Cedar Bush
Sta. 102+00
℄ M.H. #18
Rim El.=1673.20
Prop. Fin. Grade @ ℄
Exist. Grade @ ℄
Prop. 5-12'x8'x115' R.C.B.
Sta. 107+00
℄ M.H. #19 (Grade Brk.)
Rim El.=1674.80
Exist. Grd. @ Pipe ℄
300 L.F. 18" D.I.P. @ S=+0.00230 ft/ft
500 L.F. 18" D.I.P. @ S=+0.00230 ft/ft
200 L.F. 15" V.C.P. @ S=+0.01560 ft/ft
I.E. 1656.85
I.E. 1656.16
I.E. 1658.00
I.E. 1658.25
I.E. 1661.37
Prop. Fin. Grade
R/W
1675
1678
1674
1670
1666
1662
1658
1654
106
107
108
109
CITY INDEX NO
S-903013
S-896142

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

CAVE CREEK QUADRANGLE
ARIZONA—MARICOPA CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WILDCAT HILL QUADRANGLE
ARIZONA—MARICOPA CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)

CAVE CREEK RECREATION AREA

BLACK MOUNTAIN YAVAPAI

TONTO NATIONAL FOREST

A B C D E F G H I J K L M N O

Mapped, edited, and published by the Geological Survey

Control by USGS and NOS/NOAA

Topography by photogrammetric methods from aerial photographs taken 1962. Field checked 1965

Polyconic projection. 10,000-foot grid ticks based on Arizona coordinate system, central zone
1000-meter Universal Transverse Mercator grid ticks, zone 12, shown in blue. 1927 North American Datum
To place on the predicted North American Datum 1983 move the projection lines 1 meter south and 65 meters east as shown by dashed corner ticks

Where omitted, land lines have not been established

Fine red dashed lines indicate selected fence lines

There may be private inholdings within the boundaries of the National or State reservations shown on this map

UTM GRID AND 1981 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

SCALE 1:24 000

CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U.S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

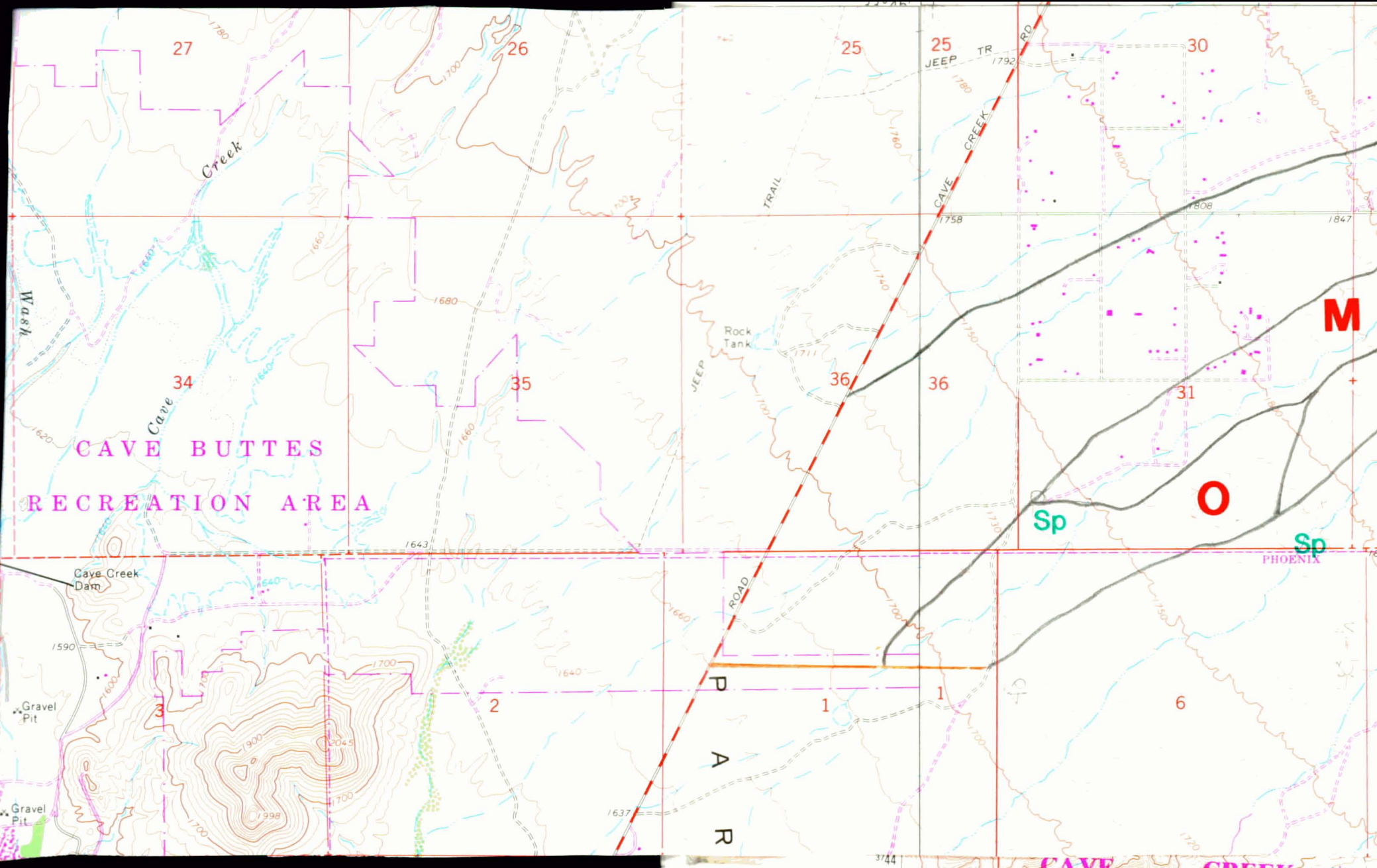
ARIZONA
QUADRANGLE LOCATION

ROAD CLASSIFICATION
Medium-duty — Light-duty
Unimproved dirt - - - -

Revisions shown in purple and woodland compiled from aerial photographs taken 1978 and other sources. This information not field checked. Map edited 1981

WILDCAT HILL, ARIZ.
N3345—W11145/7.5

1965
PHOTOREVISED 1981
DMA 3651 IV SE-SERIES V898


27
26
25
25
30
36
36
31
34
35
Creek
Wash
Cave
CAVE BUTTES
RECREATION AREA
JEEP TR
TRAIL
CAVE CREEK RD
CAVE CREEK
Rock Tank
JEEP
ROAD
Cave Creek Dam
Gravel Pit
Gravel Pit
PHOENIX
M
O
Sp
Sp
1758
1792
1808
1847
1711
1643
1637
1998
2045
3744

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

CAVE CREEK QUADRANGLE
ARIZONA—MARICOPA CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WILDCAT HILL QUADRANGLE
ARIZONA—MARICOPA CO.
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Topography by photogrammetric methods from aerial photographs taken 1962. Field checked 1965

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SCALE 1:24 000

CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

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Light-duty
Unimproved dirt

ARIZONA
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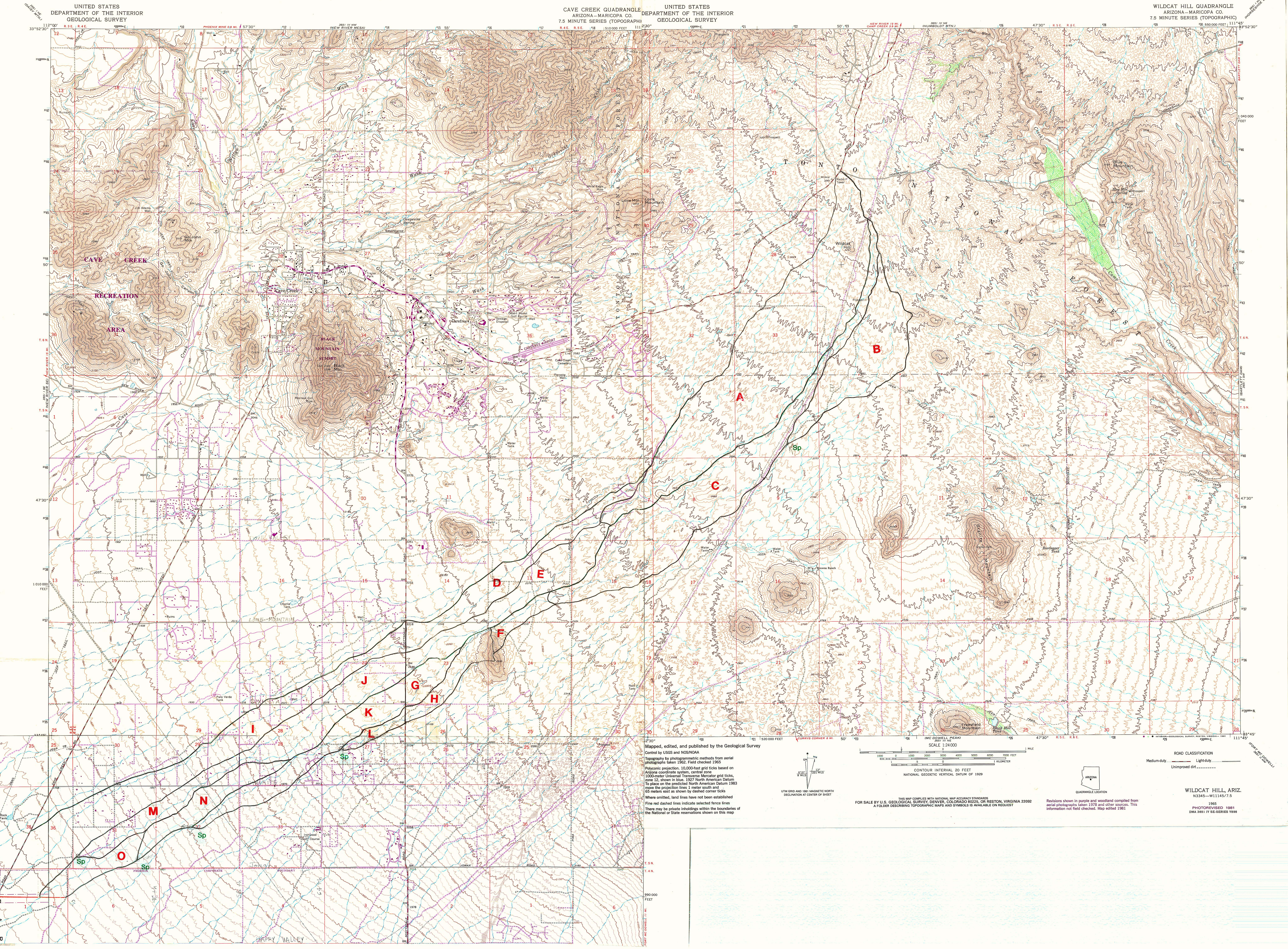
N3345—W11145/7.5

1965
PHOTOREVISED 1981
DMA 3651 IV SE-SERIES V898

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1982


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CAVE CREEK QUADRANGLE
ARIZONA—MARICOPA CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
WILDCAT HILL QUADRANGLE
ARIZONA—MARICOPA CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
CAVE CREEK RECREATION AREA
BLACK MOUNTAIN SUMMIT
TONTO NATIONAL FOREST
Wildcat Hill
Fraesfield Mountain
Black Hill Tank
HAPPY VALLEY
A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
Sp
Mapped, edited, and published by the Geological Survey
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Polyconic projection. 10,000-foot grid ticks based on Arizona coordinate system, central zone
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UTM GRID AND 1981 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
SCALE 1:24 000
CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929
THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS
FOR SALE BY U.S. GEOLOGICAL SURVEY, DENVER, COLORADO 80225, OR RESTON, VIRGINIA 22092
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Revisions shown in purple and woodland compiled from aerial photographs taken 1978 and other sources. This information not field checked. Map edited 1981
ROAD CLASSIFICATION
Medium-duty
Light-duty
Unimproved dirt
WILDCAT HILL, ARIZ.
N3345—W11145/7.5
1965
PHOTOREVISED 1981
DMA 3651 IV SE-SERIES V898

Ponding Limits

FCD Right of Way Boundary

CAVE CREEK ROAD

CAVE CREEK

N 990 000
E 475 750

MATCH TO SHEET No. 4

See Map No. 2-Y

MAP MANUSCRIPT NO. 2-X
(With Contour Lines in area east of Cave Creek Road)

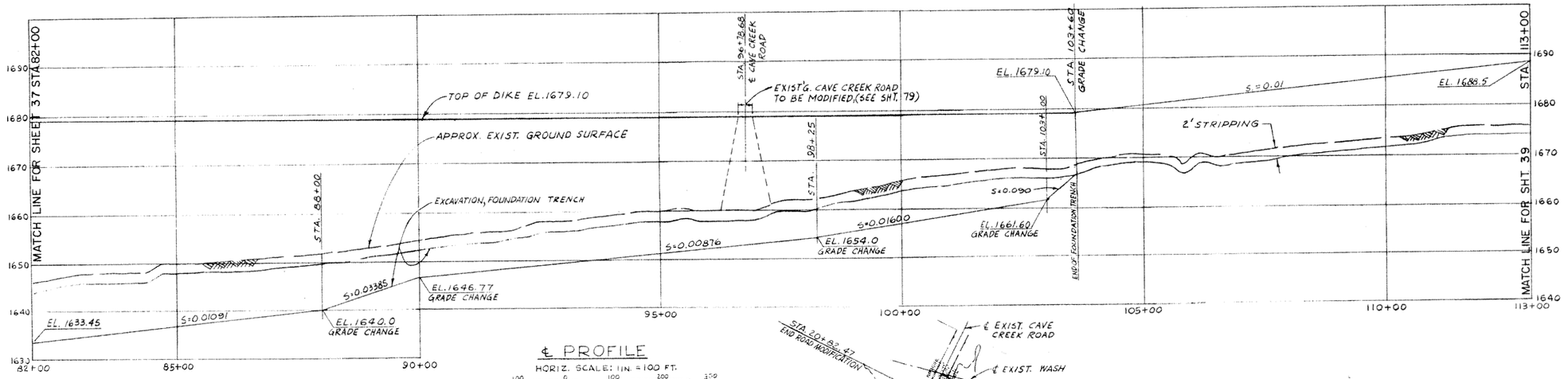
CAVE BUTTES

SCALE 1"=200' CONTOUR INTERVAL 4' FLOWN BY PICTORIAL CRAFTS
DATE FLOWN 7-31-69 FLIGHT ALTITUDE 6200' A.S.L. COMPILED BY PAFFORD & ASSOCIATES
DATUM MSL FLIGHT LINE NO. H-1
PHOTO NO. GROUND CONTROL BY FITTZER, PAFFORD & ASSOCIATES

Original

U.S. ARMY ENGINEER DISTRICT

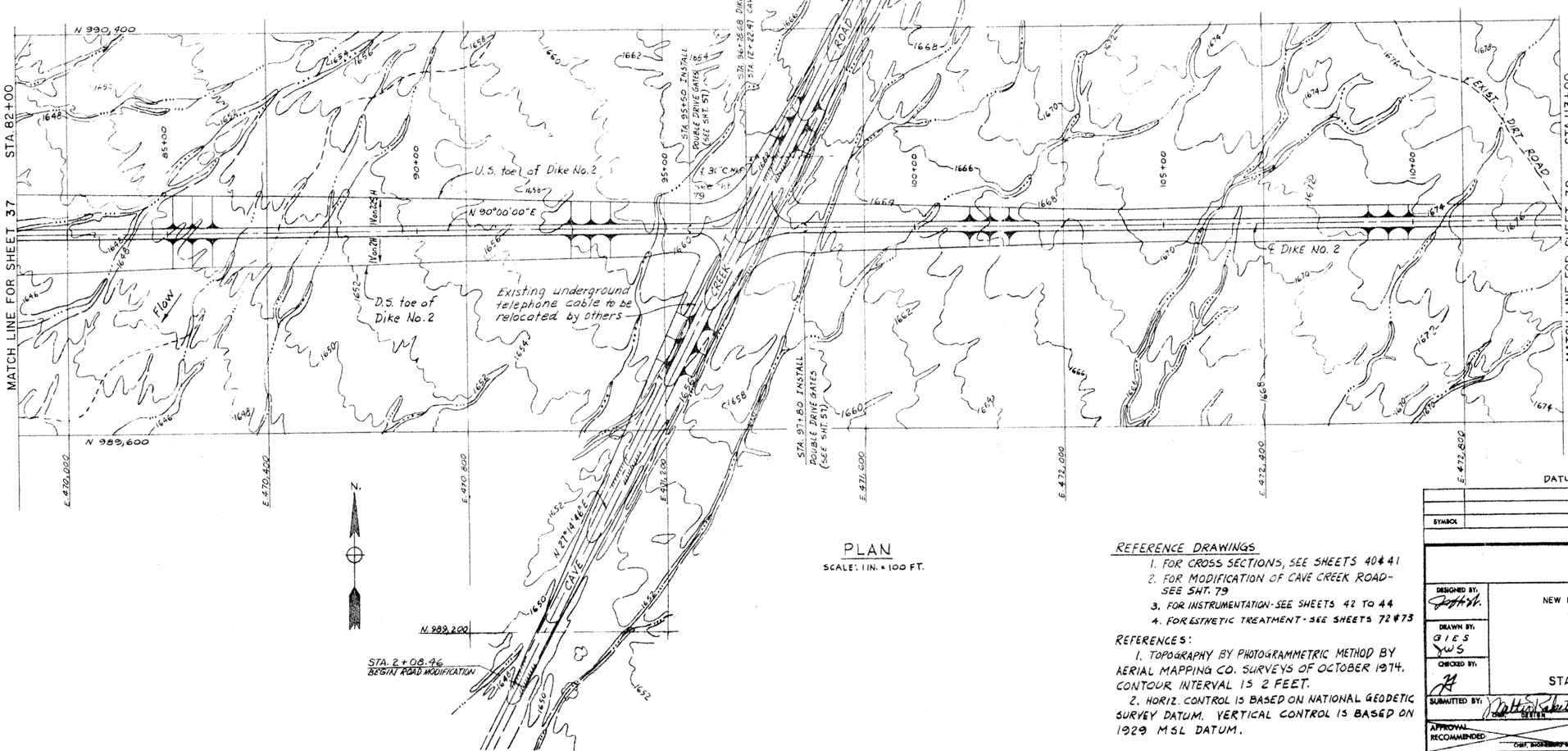
CORPS OF ENGINEERS



℄ PROFILE

HORIZ. SCALE: 1 IN. = 100 FT.

VERT. SCALE: 1 IN. = 10 FT.



PLAN

SCALE: 1 IN. = 100 FT.

28 SEP 1977

DATUM IS MEAN SEA LEVEL

REFERENCE DRAWINGS

1. FOR CROSS SECTIONS, SEE SHEETS 40 & 41
2. FOR MODIFICATION OF CAVE CREEK ROAD - SEE SHT. 79
3. FOR INSTRUMENTATION - SEE SHEETS 42 TO 44
4. FOR ESTHETIC TREATMENT - SEE SHEETS 72 & 73

REFERENCES:

1. TOPOGRAPHY BY PHOTOGRAMMETRIC METHOD BY AERIAL MAPPING CO. SURVEYS OF OCTOBER 1974. CONTOUR INTERVAL IS 2 FEET.
2. HORIZ. CONTROL IS BASED ON NATIONAL GEODETIC SURVEY DATUM. VERTICAL CONTROL IS BASED ON 1929 MSL DATUM.

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

DESIGNED BY:

DRAWN BY: GIES YWS

CHECKED BY:

SUBMITTED BY: CHIEF, DESIGN BRANCH

APPROVED: COL/LTC, CE DISTRICT ENGINEER

APPROVAL RECOMMENDED: CHIEF, ENGINEERING DIVISION

GILA RIVER BASIN
NEW RIVER AND PHOENIX CITY STREAMS, ARIZONA

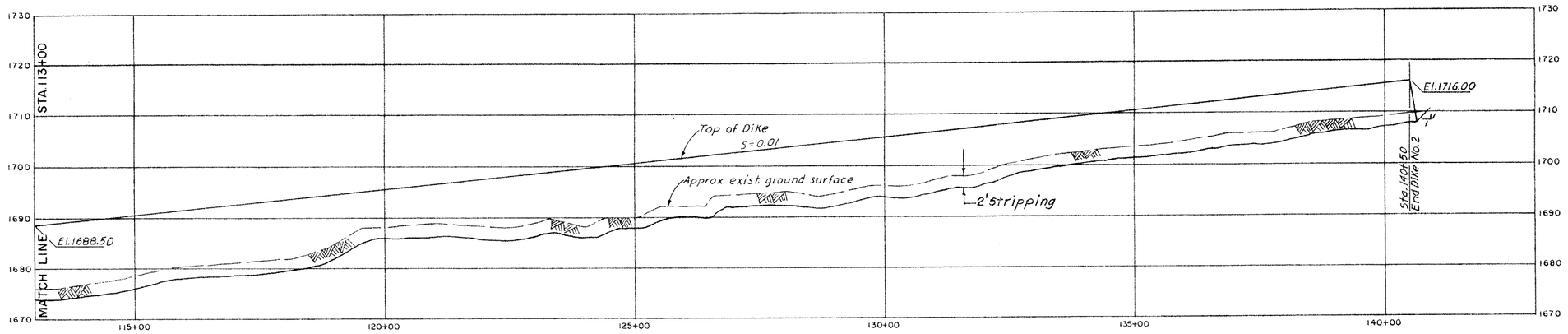
CAVE BUTTES DAM
DIKE NO. 2
PLAN AND PROFILE
STA. 82+00 TO STA. 113+00

SPEC. NO. DACW09-77-B-0031

DISTRICT FILE NO. 244/38

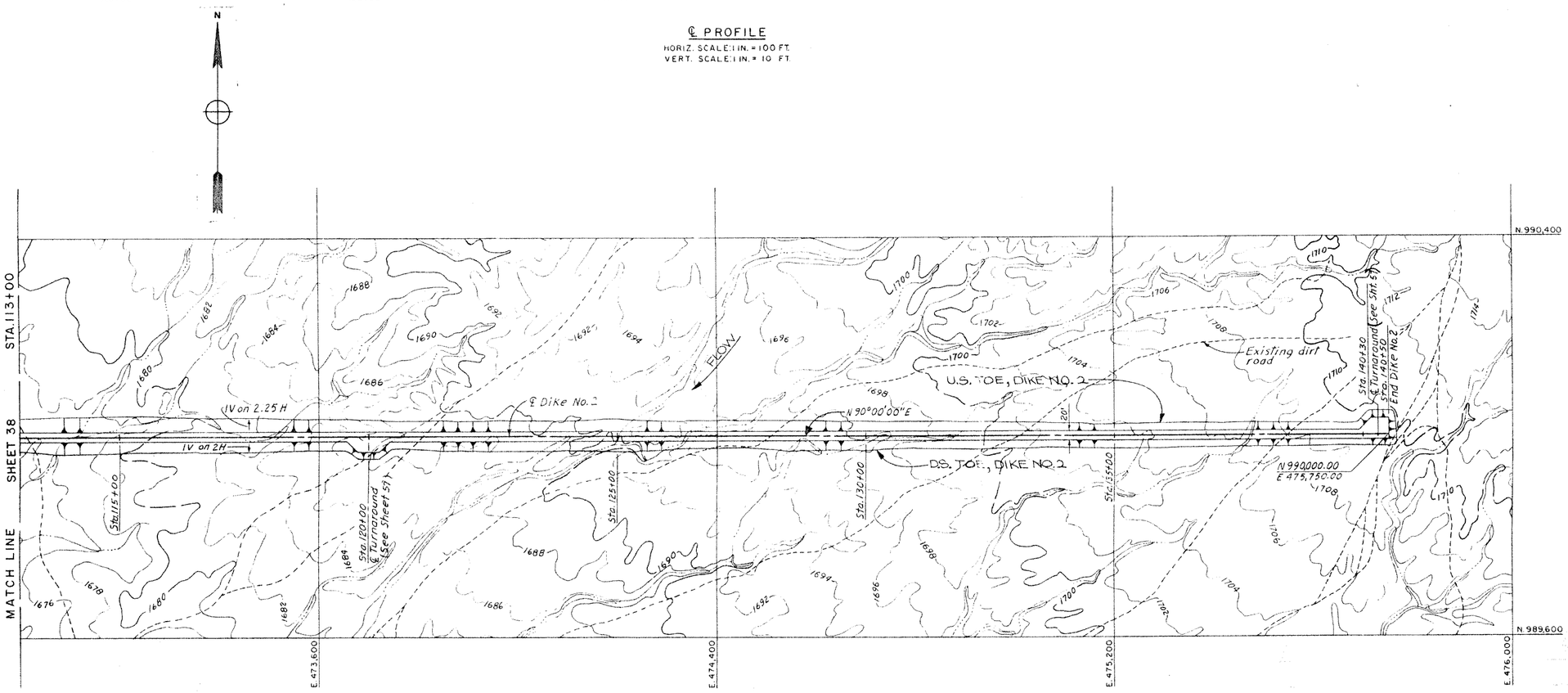
SHEET 38 OF 79 SHEETS

11/71 DIETZGEN-POST CLEARPRINT 5488-36



℄ PROFILE

HORIZ. SCALE: 1 IN. = 100 FT.
VERT. SCALE: 1 IN. = 10 FT.



PLAN

SCALE: 1 IN. = 100 FT.

28 SEP 1977

REFERENCE DRAWINGS:

1. FOR CROSS SECTIONS, SEE SHEET 41
2. FOR INSTRUMENTATION, SEE SHEETS 42 TO 44.
3. FOR ESTHETIC TREATMENT, SEE SHEETS 72 AND 73.

HORIZ. SCALE: 1 IN. = 100 FT.
100 0 100 200 300

VERT. SCALE: 1 IN. = 10 FT.
10 0 10 20 30

REFERENCE:

1. TOPOGRAPHY BY PHOTOGRAMMETRIC METHOD BY AERIAL MAPPING CO. SURVEYS OF OCTOBER 1974. CONTOUR INTERVAL IS 2 FEET.
2. HORIZONTAL CONTROL IS BASED ON NATIONAL GEODETIC SURVEY DATUM. VERTICAL CONTROL IS BASED ON 1929 M.S.L. DATUM.

DATUM IS MEAN SEA LEVEL

SYMBOL	DESCRIPTIONS	DATE	APPROVAL
	REVISIONS		

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES
CORPS OF ENGINEERS

GILA RIVER BASIN
NEW RIVER AND PHOENIX CITY STREAMS, ARIZONA

CAVE BUTTES DAM
DIKE NO. 2
PLAN AND PROFILE
STA. 113+00 TO STA. 140+50

DESIGNED BY: J.H.S.
DRAWN BY: E.W.W.
CHECKED BY:
SUBMITTED BY: CHIEF, DESIGN BRANCH
APPROVED: COLONEL, CE, DISTRICT ENGINEER
APPROVAL RECOMMENDED: CHIEF, ENGINEERING DIVISION
SPEC. NO. DACW09-77-B-0021
DISTRICT FILE NO. 244/39

SHEET 39 OF 79 SHEETS

MESSAGE DISPLAY

[redacted] DHK
[redacted] TMD
CC RWC
CC JJT

From: Dave Johnson
Postmark: 1 November 1990 4:31 PM Delivered: 1 November 1990 4:31 PM
Status: Previously read
Subject: Cave Buttes Dike #2 east of Cave Creek Road

Message:
I want an analysis made of the contributing runoff to Cave Buttes Dike #2 east of Cave Creek Road from Cave Creek Road upstream. The SPF flow must be routed to and along the Dike to Cave Creek Road and then routed through and over the Road. The peak flows will then be used to delineate the flooding limits (ponding or conveyance) to existing District R/W.
In addition, we need to establish the conditions along Dike #2 during the PMF contributing to Dike #2 East of Cave Creek Road. I anticipate that those flows will all be diverted into the Cave Buttes Reservoir without overtopping of the Dike, however we need the documentation reflecting the PMF condition. The issue of whether the combination Cave Creek Road/Dike #2 east of Cave Creek Road "structure" falls under ADWR Dam Safety jurisdiction will need to be resolved, but the development of such data is still necessary.
If you have questions concerning data for the Road or topo, talk to [redacted]n Rodriquez.

-------========X========-------

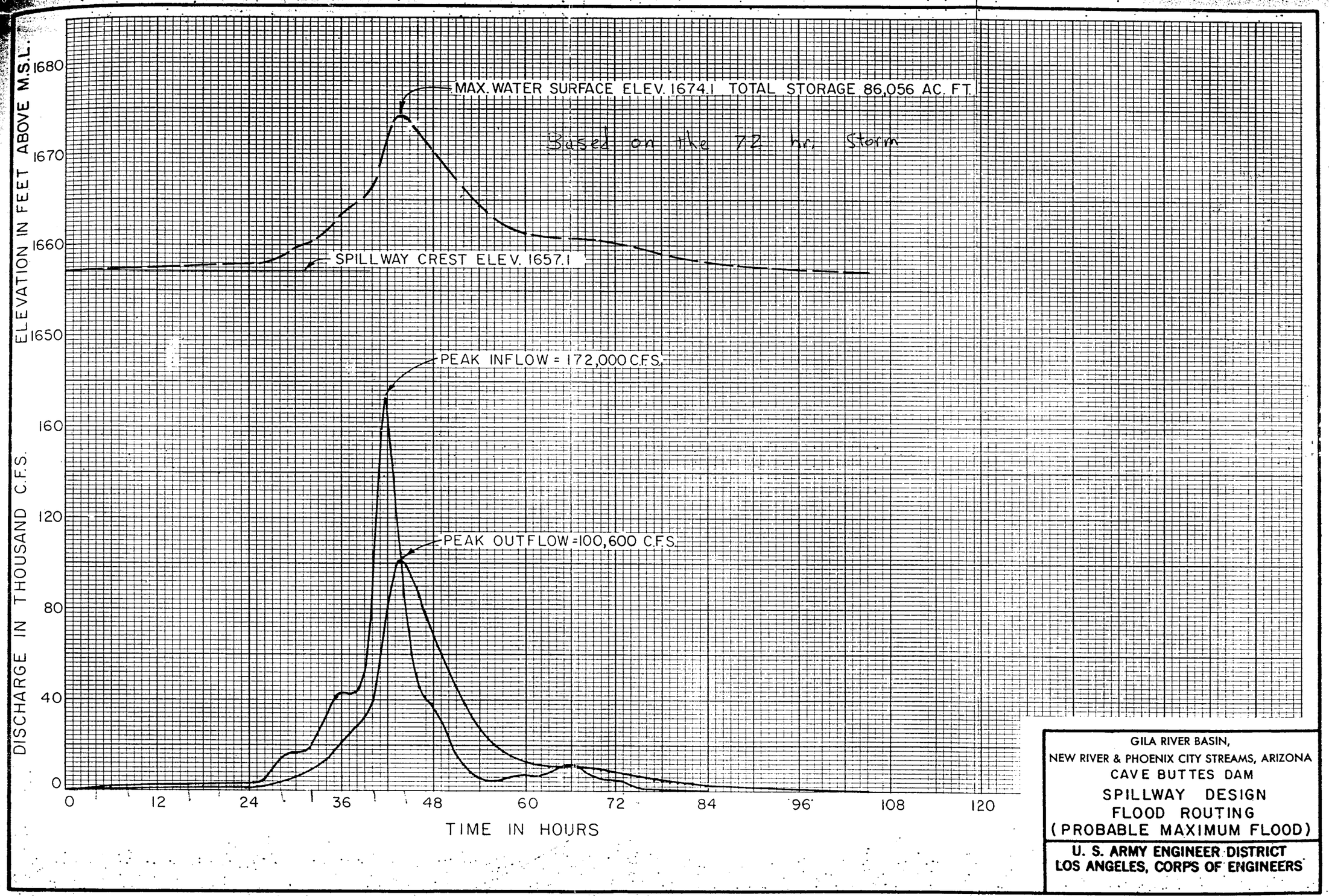
MESSAGE DISPLAY

TO DHK
TMD
CC RWC
CC JJT

From: Dave Johnson
Postmark: 1 November 1990 4:31 PM Delivered: 1 November 1990 4:31 PM
Status: Previously read
Subject: Cave Buttes Dike #2 east of Cave Creek Road

Message:
I want an analysis made of the contributing runoff to Cave Buttes Dike #2 east of Cave Creek Road from Cave Creek Road upstream. The SPF flow must be routed to and along the Dike to Cave Creek Road and then routed through and over the Road. The peak flows will then be used to delineate the flooding limits (ponding or conveyance) to existing District R/W.
In addition, we need to establish the conditions along Dike #2 during the PMF contributing to Dike #2 East of Cave Creek Road. I anticipate that those flows will all be diverted into the Cave Buttes Reservoir without overtopping of the Dike, however we need the documentation reflecting the PMF condition. The issue of whether the combination Cave Creek Road/Dike #2 east of Cave Creek Road "structure" falls under ADWR Dam Safety jurisdiction will need to be resolved, but the development of such data is still necessary.
If you have questions concerning data for the Road or topo, talk to n Rodriquez.

-------========X========-------



GILA RIVER BASIN,
NEW RIVER & PHOENIX CITY STREAMS, ARIZONA
CAVE BUTTES DAM
SPILLWAY DESIGN
FLOOD ROUTING
(PROBABLE MAXIMUM FLOOD)

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS

APPENDIX I FIGURE 6

TOTAL DRAINAGE AREA_____195 SQUARE MILES
TOTAL INCIDENT RAINFALL_____5.50 INCHES
TOTAL EXCESS RAINFALL_____3.27 INCHES
RUNOFF VOLUME_____34,000 ACRE-FEET

RAINFALL IN INCHES PER HOUR (AVERAGE RATE OVER AREA)

0
1
2
3
4

HYETOGRAPH

RAINFALL LOSS

RAINFALL EXCESS

PEAK FLOW 87,000 CFS

FLOOD HYDROGRAPH

UNIT HYDROGRAPH

UNIT HYDROGRAPH DISCHARGE IN THOUSAND C.F.S.

0
5
10

0
3
6
9
12
15

TIME IN HOURS

FLOOD HYDROGRAPH DISCHARGE IN THOUSAND CFS.

20
40
60
80
100

GILA RIVER BASIN,
NEW RIVER & PHOENIX CITY STREAMS, ARIZONA
STANDARD PROJECT
FLOOD HYDROGRAPH
CAVE BUTTES DAMSITE

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY DESIGN MEMO NO. 2

PLATE 33

```
*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*      BY THE COE IN FEBRUARY 1981      *
*           REVISED 02 AUG 88           *
*                                       *
*  RUN DATE  11/08/1990  TIME  14:29:14 *
*                                       *
*****************************************
```


```
*****************************************
*                                       *
*     DODSON AND ASSOCIATES, INC.       *
*   HYDROLOGIST AND CIVIL ENGINEERS     *
*      7015 W TIDWELL SUITE 107         *
*        HOUSTON, TEXAS  77092          *
*           (713) 895-8322              *
*                                       *
*****************************************
```


```
X     X  XXXXXXX   XXXXX           X
X     X  X        X     X         XX
X     X  X        X               X
XXXXXXX  XXXX     X         XXXXX  X
X     X  X        X               X
X     X  X        X     X         X
X     X  XXXXXXX   XXXXX          XXX
```

THIS PROGRAM REPLACES ALL PREVIOUS VERSIONS OF HEC-1 KNOWN AS HEC1 (JAN 73), HEC1GS, HEC1DB, AND HEC1KW.

THE DEFINITIONS OF VARIABLES -RTIMP- AND -RTIOR- HAVE CHANGED FROM THOSE USED WITH THE 1973-STYLE INPUT STRUCTURE.
THE DEFINITION OF -AMSKK- ON RM-CARD WAS CHANGED WITH REVISIONS DATED 28 SEP 81. THIS IS THE FORTRAN77 VERSION
NEW OPTIONS: DAMBREAK OUTFLOW SUBMERGENCE , SINGLE EVENT DAMAGE CALCULATION, DSS:WRITE STAGE FREQUENCY,
DSS:READ TIME SERIES AT DESIRED CALCULATION INTERVAL LOSS RATE:GREEN AND AMPT INFILTRATION
KINEMATIC WAVE: NEW FINITE DIFFERENCE ALGORITHM

```
LINE      ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

    1     ID        BASE MODEL DEVELOPED FROM:
    2     ID        GENERAL DRAINAGE PLAN FOR PARADISE VALLEY FAN TERRACE
    3     ID        CITY OF PHOENIX AREAS C & D
    4     ID
    5     ID        REVISED FOR PMP STORM OF 7.55 INCHES AND A UNIFORM LOSS RATE OF
    6     ID        0.143 INCHES/HOUR.   T.W. HIEB  7-11-90
    7     ID
    8     IT       5 10JAN89       0     240
    9     IO       3       0
          *DIAGRAM
   10     IN      60               0
          *

   11     KK    1430     SUB
   12     KM         RUNOFF FROM SUB 1430
   13     BA  1.4319
          *   FOR THIS MODEL, RAINFALL EXCESS IS ENTERED DIRECTLY AND NO RAINFALL LOSS
          *   IS CALCULATED.  THE 6 HOUR RAINFALL EXCESS USED TO DESIGN CAVE BUTTES DAM
          *   IS USED.
   14     PB    6.69
   15     PC   0.307   0.657   4.057   1.057   0.357   0.257
   16     LU       0       0    1.19
   17     UK     240   .0555     .20     100
   18     RK   25800   .0271    .045             TRAP      30       3
          *

   19     KK    1440     SUB
   20     KM         RUNOFF FROM SUB 1440
   21     BA  1.8882
   22     LU       0       0
   23     UK     240   .0555     .20     100
   24     RK   24800   .0258    .045             TRAP      30       3
          *

   25     KK    1441      CP
   26     KM         COMBINE SUB 1430 AND SUB 1440
   27     HC       2
          *

   28     KK    1450     SUB
   29     KM         RUNOFF FROM SUB 1450 AND ROUTE CP 1441
   30     BA   .7662
   31     LU       0       0    1.04
   32     UK     200   .0200     .20     100
   33     RK   18200   .0189    .045             TRAP      30       3     YES
          *

   34     KK    3470     SUB
   35     KM         RUNOFF FROM SUB 3470 & ROUTE SUB 1450
   36     BA   .8085
   37     LU       0       0    4.30
   38     UK     224   .0212     .15     100
   39     RK   15500   .0191    .045             TRAP      30      20     YES
          *
```

+222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222+

```
$   $   $   $   $$$$     $$$    $$$$$
$   $   $   $   $   $   $   $   $
$   $    $ $    $   $   $  $$   $$$$
$$$$$     $     $   $   $ $ $       $
$   $     $     $   $   $$  $       $
$   $     $     $   $   $   $   $   $
$   $     $     $$$$     $$$     $$$
```

DEST=HYD05 USER=OP QUEUE=LPT DEVICE=@LPB
SEQ=7850 QPRI=127 CPL=132 LPP=66 COPIES=1 PAGES=65535
QUEUED BY A SUPERUSER, /DELETE, /FOLDLONGLINES

CREATED: 08-NOV-90 14:29:00
ENQUEUED: 08-NOV-90 14:29:26
PRINTING: 08-NOV-90 14:29:56

PATH=:NET:MVNET:HYD05_MVNET37

```
$   $   $   $   $$$$     $$$    $$$$$           $   $   $   $   $   $   $$$$$   $$$$$   $$$$$   $$$$$
$   $   $   $   $   $   $   $   $               $$ $$   $   $   $$  $   $         $         $         $
$   $    $ $    $   $   $  $$   $$$$            $ $ $   $   $   $ $ $   $         $        $         $
$$$$$     $     $   $   $ $ $       $           $ $ $   $   $   $  $$   $$$$      $      $$$        $
$   $     $     $   $   $$  $       $           $   $   $   $   $   $   $         $         $      $
$   $     $     $   $   $   $   $   $           $   $    $ $    $   $   $         $     $   $      $
$   $     $     $$$$     $$$     $$$    $$$$$   $   $     $     $   $   $$$$$     $      $$$       $
```

+222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222222+

AOS/VS II RELEASE 2.00.00.50

AOS/VS II RELEASE 2.00.00.00
AOS/VS II XLPT-32 REVISION 2.00.00.00

```
LINE          ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

  40          KK    3480     SUB
  41          KM         RUNOFF FROM SUB 3480 & ROUTE SUB 3470
  42          BA   .2590
  43          LU      0        0    2.54
  44          UK    100   .0213     .10     100
  45          RK   5400   .0167     .045            TRAP      35       30      YES
              *

  46          KK    3490     SUB
  47          KM         RUNOFF FROM SUB 3490 & ROUTE SUB 3480
  48          KO                                        21
  49          BA   .7196
  50          LU      0        0    3.86
  51          UK    100   .0213     .10     100
  52          RK  10100   .0140     .045            TRAP      50       40      YES
              *

  53          KK    1470     SUB
  54          KM         RUNOFF FROM SUB 1470
  55          BA   .2977
  56          LU      0        0
  57          UK    200   .0500     .20     100
  58          RK  15000   .0293     .045            TRAP      20        3
              *

  59          KK    1475     SUB
  60          KM         RUNOFF FROM SUB 1475 AND ROUTE SUB 1470
  61          BA  1.6895
  62          LU      0        0
  63          UK    285   .0419     .20     100
  64          RK  17600   .0188     .045            TRAP      25        3      YES
              *

  65          KK    1480     SUB
  66          KM         RUNOFF FROM SUB 1480 AND ROUTE SUB 1475
  67          BA  1.0015
  68          LU      0        0    1.07
  69          UK    300   .0167     .20     100
  70          RK   7500   .0213     .045            TRAP      25        3      YES
              *

  71          KK    1481     DIV
  72          KM         DIVERT FLOW FROM SUB 1480 TO SUB 3510
  73          DT    1482
  74          DI       0    8000
  75          DQ       0    4000
              *

  76          KK    3510     SUB
  77          KM         RUNOFF FROM SUB 3510 & ROUTE DIV 1481
  78          BA  1.4047
  79          LU      0        0    3.86
  80          UK    224   .0212     .15     100
  81          RK  21800   .0188     .045            TRAP      30       30      YES
              *
```

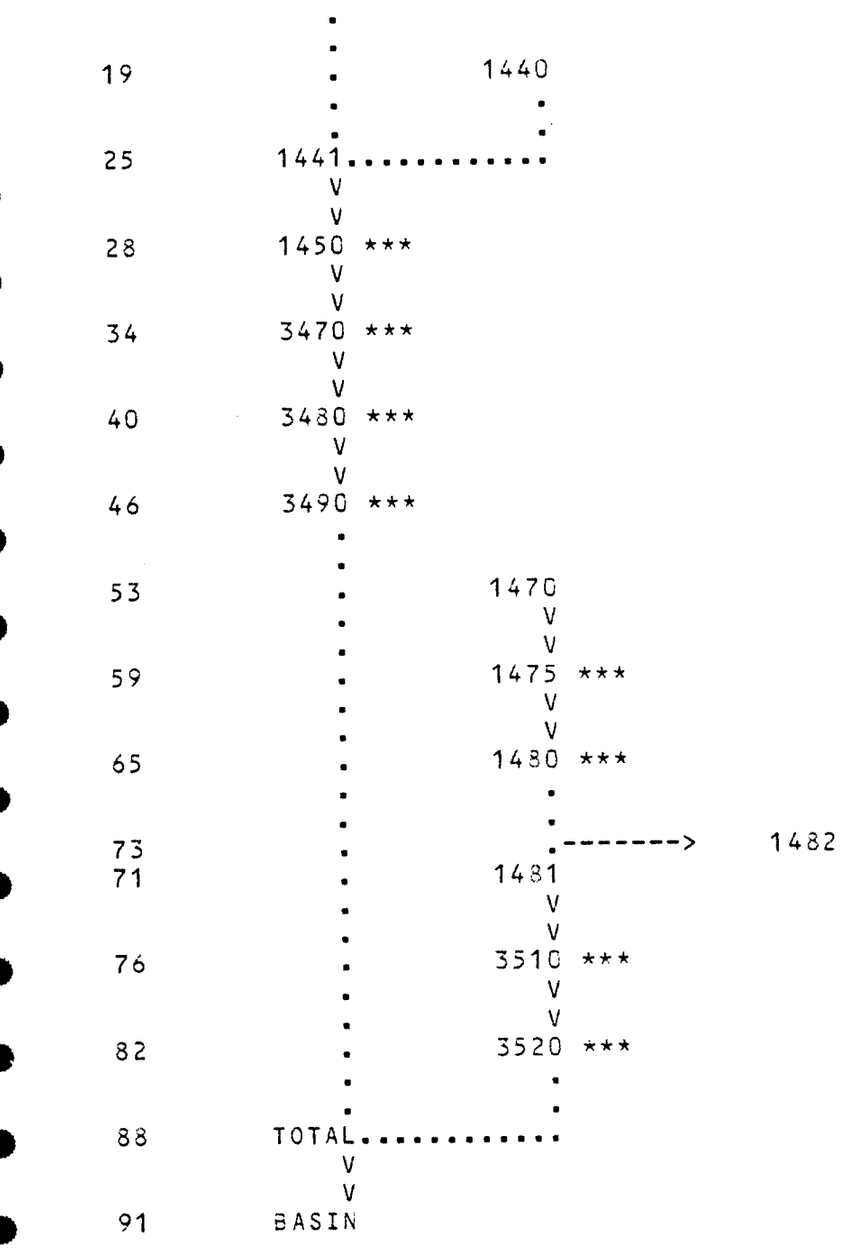
```
LINE          ID.....1.....2.....3.....4.....5.....6.....7.....8.....9.....10

  82          KK    3520     SUB
  83          KM         RUNOFF FROM SUB 3520 & ROUTE SUB 3510
  84          BA  1.1113
  85          LU       0        0    1.88
  86          UK     100    .0213     .10     100
  87          RK   15400    .0146     .045            TRAP      30      30     YES
              *
  88          KK   TOTAL
  89          KM   COMBINE FLOWS FROM 3490 AND 3520 ABOVE THE ROAD
  90          HC        2
              *
  91          KK   BASIN
  92          KM   PONDING AREA AT THE INTERSECTION OF CAVE CREEK ROAD AND CAVE BUTTES
  93          KM   DIKE # 2
  94          RS        1    STOR        0
  95          SV        0    1.88     15.1     64.7     80.8     99.3    120.6    144.6    171.7    201.9
  96          SQ        0       0        0        0      671     3784    10440    21430    37450    59000
  97          SE     1660    1664     1668     1673     1674     1675     1676     1677     1678     1679
              *
  98          ZZ
```

SCHEMATIC DIAGRAM OF STREAM NETWORK

(V) ROUTING (---->) DIVERSION OR PUMP FLOW

(.) CONNECTOR (<----) RETURN OF DIVERTED OR PUMPED FLOW



(***) RUNOFF ALSO COMPUTED AT THIS LOCATION

```
*****************************************
*                                       *
*   FLOOD HYDROGRAPH PACKAGE  (HEC-1)   *
*      BY THE COE IN FEBRUARY 1981      *
*            REVISED C2 AUG 88          *
*                                       *
*  RUN DATE  11/08/1990  TIME  14:29:14 *
*                                       *
*****************************************
```


```
*****************************************
*                                       *
*     DODSON AND ASSOCIATES, INC.       *
*   HYDROLOGIST AND CIVIL ENGINEERS     *
*      7015 W TIDWELL SUITE 107         *
*        HOUSTON, TEXAS  77092          *
*           (713) 895-8322              *
*                                       *
*****************************************
```


BASE MODEL DEVELOPED FROM:
GENERAL DRAINAGE PLAN FOR PARADISE VALLEY FAN TERRACE
CITY OF PHOENIX AREAS C & D

REVISED FOR PMP STORM OF 7.55 INCHES AND A UNIFORM LOSS RATE OF
0.143 INCHES/HOUR. T.W. HIEB 7-11-90

```
  9 IO          OUTPUT CONTROL VARIABLES
                     IPRNT          3  PRINT CONTROL
                     IPLOT          0  PLOT CONTROL
                     QSCAL         0.  HYDROGRAPH PLOT SCALE

    IT          HYDROGRAPH TIME DATA
                     NMIN           5  MINUTES IN COMPUTATION INTERVAL
                     IDATE      10JAN89  STARTING DATE
                     ITIME         0000  STARTING TIME
                       NQ           240  NUMBER OF HYDROGRAPH ORDINATES
                     NDDATE     10JAN89  ENDING DATE
                     NDTIME         1955  ENDING TIME
                     ICENT            19  CENTURY MARK

                  COMPUTATION INTERVAL      .08 HOURS
                      TOTAL TIME BASE    19.92 HOURS

        ENGLISH UNITS
             DRAINAGE AREA          SQUARE MILES
             PRECIPITATION DEPTH    INCHES
             LENGTH, ELEVATION      FEET
             FLOW                   CUBIC FEET PER SECOND
             STORAGE VOLUME         ACRE-FEET
             SURFACE AREA           ACRES
             TEMPERATURE            DEGREES FAHRENHEIT


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***


            ***************
            *             *
 11 KK      *      1430   *          SUB
            *             *
            ***************
                          RUNOFF FROM SUB 1430

 10 IN          TIME DATA FOR INPUT TIME SERIES
                     JXMIN          60  TIME INTERVAL IN MINUTES
                     JXDATE     10JAN89  STARTING DATE
```

```
                JXTIME           0  STARTING TIME

            SUBBASIN RUNOFF DATA

13 BA         SUBBASIN CHARACTERISTICS
                TAREA        1.43  SUBBASIN AREA

              PRECIPITATION DATA

14 PB           STORM        6.69  BASIN TOTAL PRECIPITATION

15 PI         INCREMENTAL PRECIPITATION PATTERN
                .03       .03       .03       .03       .03       .03       .03       .03       .03       .03
                .03       .03       .28       .28       .28       .28       .28       .28       .28       .28
                .28       .28       .28       .28

16 LU         UNIFORM LOSS RATE
                STRTL         .00  INITIAL LOSS
                CNSTL         .00  UNIFORM LOSS RATE
                RTIMP        1.19  PERCENT IMPERVIOUS AREA

              KINEMATIC WAVE
17 UK           OVERLAND-FLOW ELEMENT NO. 1
                    L         240.  OVERLAND FLOW LENGTH
                    S        .0555  SLOPE
                    N         .200  ROUGHNESS COEFFICIENT
                   PA        100.0  PERCENT OF SUBBASIN
                 DXMIN            5  MINIMUM NUMBER OF DX INTERVALS
18 RK           MAIN CHANNEL
                    L       25800.  CHANNEL LENGTH
                    S        .0271  SLOPE
                    N         .045  CHANNEL ROUGHNESS COEFFICIENT
                   CA         1.43  CONTRIBUTING AREA
                SHAPE         TRAP  CHANNEL SHAPE
                   WD        30.00  BOTTOM WIDTH OR DIAMETER
                    Z         3.00  SIDE SLOPE
                DXMIN            2  MINIMUM NUMBER OF DX INTERVALS
               RUPSTQ           NO  ROUTE UPSTREAM HYDROGRAPH

                                                ***
                          COMPUTED KINEMATIC PARAMETERS
                               VARIABLE TIME STEP
                            (DT SHOWN IS A MINIMUM)
                ELEMENT    ALPHA        M          DT          DX        PEAK    TIME TO PEAK    VOLUME    MAXIMUM CELERITY
                                                   (MIN)       (FT)      (CFS)         (MIN)      (IN)         (FPS)

                      1     1.76     1.67        1.24       48.00    5602.70        119.16      6.68          .65
                      3      .81     1.51        4.10     6450.00    5589.75        107.76      6.65        26.22

CONTINUITY SUMMARY (AC-FT) - INFLOW=      .000  EXCESS=  510.870 OUTFLOW=  507.967 BASIN STORAGE=      .078 PERCENT ERROR=      .553

                                  INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

                      3      .81     1.51        5.00                 5587.47        110.00      6.66

          ***         ***          ***          ***          ***

                             HYDROGRAPH AT STATION     1430
```

```
   TOTAL RAINFALL =     6.69, TOTAL LOSS =      .00, TOTAL EXCESS =    6.69

  PEAK FLOW      TIME                                    MAXIMUM AVERAGE FLOW
    (CFS)        (HR)                         6-HR           24-HR          72-HR        19.92-HR
    5587.        1.83              (CFS)      1023.           309.           309.            309.
                                 (INCHES)     6.640          6.659          6.659           6.659
                                  (AC-FT)      507.           509.           509.            509.

                                   CUMULATIVE AREA =      1.43 SQ MI


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

               **************
               *            *
   19 KK       *     1440   *           SUB
               *            *
               **************
                                       RUNOFF FROM SUB 1440

                  SUBBASIN RUNOFF DATA

   21 BA            SUBBASIN CHARACTERISTICS
                          TAREA          1.89  SUBBASIN AREA

                    PRECIPITATION DATA

   14 PB                  STORM          6.69  BASIN TOTAL PRECIPITATION

   15 PI              INCREMENTAL PRECIPITATION PATTERN
                          .03       .03       .03       .03       .03       .03       .03       .03       .03       .03
                          .03       .03       .28       .28       .28       .28       .28       .28       .28       .28
                          .28       .28       .28       .28

   22 LU            UNIFORM LOSS RATE
                          STRTL           .00  INITIAL LOSS
                          CNSTL           .00  UNIFORM LOSS RATE
                          RTIMP           .00  PERCENT IMPERVIOUS AREA

                    KINEMATIC WAVE
   23 UK              OVERLAND-FLOW ELEMENT NO. 1
                              L          240.  OVERLAND FLOW LENGTH
                              S         .0555  SLOPE
                              N          .200  ROUGHNESS COEFFICIENT
                             PA         100.0  PERCENT OF SUBBASIN
                          DXMIN             5  MINIMUM NUMBER OF DX INTERVALS
   24 RK              MAIN CHANNEL
                              L        24800.  CHANNEL LENGTH
                              S         .0258  SLOPE
                              N          .045  CHANNEL ROUGHNESS COEFFICIENT
                             CA          1.89  CONTRIBUTING AREA
                          SHAPE          TRAP  CHANNEL SHAPE
                             WD         30.00  BOTTOM WIDTH OR DIAMETER
                              Z          3.00  SIDE SLOPE
                          DXMIN             2  MINIMUM NUMBER OF DX INTERVALS
                         RUPSTQ            NO  ROUTE UPSTREAM HYDROGRAPH

                                                                  ***
                                            COMPUTED KINEMATIC PARAMETERS
                                                 VARIABLE TIME STEP
```

(DT SHOWN IS A MINIMUM)

ELEMENT	ALPHA	M	DT (MIN)	DX (FT)	PEAK (CFS)	TIME TO PEAK (MIN)	VOLUME (IN)	MAXIMUM CELERITY (FPS)
1	1.76	1.67	1.24	43.00	7388.10	119.16	6.68	.65
3	.79	1.51	4.76	8266.67	7381.70	108.93	6.66	28.93

CONTINUITY SUMMARY (AC-FT) - INFLOW= .000 EXCESS= 673.668 OUTFLOW= 670.996 BASIN STORAGE= .071 PERCENT ERROR= .386

INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

ELEMENT	ALPHA	M	DT	DX	PEAK	TIME TO PEAK	VOLUME
3	.79	1.51	5.00		7380.80	110.00	6.67

*** *** *** *** ***

HYDROGRAPH AT STATION 1440

TOTAL RAINFALL = 6.69, TOTAL LOSS = .00, TOTAL EXCESS = 6.69

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	19.92-HR
7381.	1.83	(CFS)	1351.	408.	408.	408.
		(INCHES)	6.651	6.667	6.667	6.667
		(AC-FT)	670.	671.	671.	671.

CUMULATIVE AREA = 1.89 SQ MI

*** ***

```
             **************
             *            *
 25 KK       *    1441    *           CP
             *            *
             **************
                         COMBINE SUB 1430 AND SUB 1440

 27 HC           HYDROGRAPH COMBINATION
                     ICOMP          2  NUMBER OF HYDROGRAPHS TO COMBINE
```

***

*** *** *** *** ***

HYDROGRAPH AT STATION 1441

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	19.92-HR
12968.	1.83	(CFS)	2373.	717.	717.	717.
		(INCHES)	6.646	6.663	6.663	6.663
		(AC-FT)	1177.	1180.	1180.	1180.

CUMULATIVE AREA = 3.32 SQ MI

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          **************
          *            *
28 KK     *      1450  *          SUB
          *            *
          **************
                              RUNOFF FROM SUB 1450 AND ROUTE CP 1441

                SUBBASIN RUNOFF DATA

30 BA             SUBBASIN CHARACTERISTICS
                        TAREA          .77  SUBBASIN AREA

                  PRECIPITATION DATA

14 PB                   STORM         6.69  BASIN TOTAL PRECIPITATION

15 PI               INCREMENTAL PRECIPITATION PATTERN
                      .03       .03       .03       .03       .03       .03       .03       .03       .03       .03
                      .03       .03       .28       .28       .28       .28       .28       .28       .28       .28
                      .28       .28       .28       .28

31 LU             UNIFORM LOSS RATE
                        STRTL          .00  INITIAL LOSS
                        CNSTL          .00  UNIFORM LOSS RATE
                        RTIMP         1.04  PERCENT IMPERVIOUS AREA

                  KINEMATIC WAVE

32 UK             OVERLAND-FLOW ELEMENT NO. 1
                          L           200.  OVERLAND FLOW LENGTH
                          S          .0200  SLOPE
                          N           .200  ROUGHNESS COEFFICIENT
                         PA          100.0  PERCENT OF SUBBASIN
                       DXMIN              5  MINIMUM NUMBER OF DX INTERVALS
33 RK             MAIN CHANNEL
                          L         18200.  CHANNEL LENGTH
                          S          .0189  SLOPE
                          N           .045  CHANNEL ROUGHNESS COEFFICIENT
                         CA            .77  CONTRIBUTING AREA
                      SHAPE           TRAP  CHANNEL SHAPE
                         WD          30.00  BOTTOM WIDTH OR DIAMETER
                          Z           3.00  SIDE SLOPE
                       DXMIN              2  MINIMUM NUMBER OF DX INTERVALS
                      RUPSTQ            YES  ROUTE UPSTREAM HYDROGRAPH

                                        ***
                          COMPUTED KINEMATIC PARAMETERS
                               VARIABLE TIME STEP
                            (DT SHOWN IS A MINIMUM)
```

ELEMENT	ALPHA	M	DT (MIN)	DX (FT)	PEAK (CFS)	TIME TO PEAK (MIN)	VOLUME (IN)	MAXIMUM CELERITY (FPS)
1	1.05	1.67	1.51	40.00	2997.97	119.22	6.68	.44
3	.68	1.51	3.21	6066.67	15961.02	118.73	6.65	31.48

CONTINUITY SUMMARY (AC-FT) - INFLOW= 1179.849 EXCESS= 273.363 OUTFLOW= 1448.276 BASIN STORAGE= .190 PERCENT ERROR= .327

INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

	3	.68	1.51	5.00	15953.21	115.00	6.65
***	***	***	***	***			

HYDROGRAPH AT STATION 1450

TOTAL RAINFALL = 6.69, TOTAL LOSS = .00, TOTAL EXCESS = 6.69

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	19.92-HR
15953.	1.92	(CFS)	2910.	830.	880.	880.
		(INCHES)	6.622	6.647	6.647	6.647
		(AC-FT)	1443.	1449.	1449.	1449.

CUMULATIVE AREA = 4.09 SQ MI

*** ***

34 KK

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**************
*            *
*      3470  *
*            *
**************
```

SUB

RUNOFF FROM SUB 3470 & ROUTE SUB 1450

SUBBASIN RUNOFF DATA

36 BA SUBBASIN CHARACTERISTICS

TAREA	.81	SUBBASIN AREA

PRECIPITATION DATA

14 PB

STORM	6.69	BASIN TOTAL PRECIPITATION

15 PI INCREMENTAL PRECIPITATION PATTERN

.03	.03	.03	.03	.03	.03	.03	.03	.03	.03
.03	.03	.28	.28	.28	.28	.28	.28	.28	.28
.28	.28	.28	.28						

37 LU UNIFORM LOSS RATE

STRTL	.00	INITIAL LOSS
CNSTL	.00	UNIFORM LOSS RATE
RTIMP	4.30	PERCENT IMPERVIOUS AREA

KINEMATIC WAVE

38 UK OVERLAND-FLOW ELEMENT NO. 1

L	224.	OVERLAND FLOW LENGTH
S	.0212	SLOPE
N	.150	ROUGHNESS COEFFICIENT
PA	100.0	PERCENT OF SUBBASIN
DXMIN	5	MINIMUM NUMBER OF DX INTERVALS

39 RK MAIN CHANNEL

L	15500.	CHANNEL LENGTH
S	.0191	SLOPE
N	.045	CHANNEL ROUGHNESS COEFFICIENT
CA	.81	CONTRIBUTING AREA

SHAPE	TRAP	CHANNEL SHAPE
WD	30.00	BOTTOM WIDTH OR DIAMETER
Z	20.00	SIDE SLOPE
DXMIN	2	MINIMUM NUMBER OF DX INTERVALS
RUPSTQ	YES	ROUTE UPSTREAM HYDROGRAPH

***

COMPUTED KINEMATIC PARAMETERS
VARIABLE TIME STEP
(DT SHOWN IS A MINIMUM)

ELEMENT	ALPHA	M	DT (MIN)	DX (FT)	PEAK (CFS)	TIME TO PEAK (MIN)	VOLUME (IN)	MAXIMUM CELERITY (FPS)
1	1.45	1.67	1.33	44.80	3163.48	118.97	6.68	.56
3	.81	1.37	2.97	3100.00	19023.19	121.15	6.64	17.39

CONTINUITY SUMMARY (AC-FT) - INFLOW= 1448.715 EXCESS= 288.455 OUTFLOW= 1732.443 BASIN STORAGE= .274 PERCENT ERROR= .256

INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

3	.81	1.37	5.00		19008.09	120.00	6.64
***	***	***	***		***		

HYDROGRAPH AT STATION 3470

TOTAL RAINFALL = 6.69, TOTAL LOSS = .00, TOTAL EXCESS = 6.69

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	19.92-HR
19008.	2.00	(CFS)	3472.	1052.	1052.	1052.
		(INCHES)	6.595	6.635	6.635	6.635
		(AC-FT)	1722.	1732.	1732.	1732.

CUMULATIVE AREA = 4.89 SQ MI

*** ***

40 KK

****
* *
* 3480 * SUB
* *
****

RUNOFF FROM SUB 3480 & ROUTE SUB 3470

SUBBASIN RUNOFF DATA

42 BA SUBBASIN CHARACTERISTICS
TAREA .26 SUBBASIN AREA

PRECIPITATION DATA

14 PB STORM 6.69 BASIN TOTAL PRECIPITATION

15 PI INCREMENTAL PRECIPITATION PATTERN

	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03
	.C3	.03	.28	.28	.28	.28	.28	.28	.28	.28
	.28	.28	.28	.28						

43 LU UNIFORM LOSS RATE

STRTL	.00	INITIAL LOSS
CNSTL	.00	UNIFORM LOSS RATE
RTIMP	2.54	PERCENT IMPERVIOUS AREA

KINEMATIC WAVE

44 UK OVERLAND-FLOW ELEMENT NO. 1

L	100.	OVERLAND FLOW LENGTH
S	.0213	SLOPE
N	.100	ROUGHNESS COEFFICIENT
PA	100.0	PERCENT OF SUBBASIN
DXMIN	5	MINIMUM NUMBER OF DX INTERVALS

45 RK MAIN CHANNEL

L	5400.	CHANNEL LENGTH
S	.0167	SLOPE
N	.045	CHANNEL ROUGHNESS COEFFICIENT
CA	.26	CONTRIBUTING AREA
SHAPE	TRAP	CHANNEL SHAPE
WD	35.00	BOTTOM WIDTH OR DIAMETER
Z	30.00	SIDE SLOPE
DXMIN	2	MINIMUM NUMBER OF DX INTERVALS
RUPSTQ	YES	ROUTE UPSTREAM HYDROGRAPH

***

COMPUTED KINEMATIC PARAMETERS
VARIABLE TIME STEP
(DT SHOWN IS A MINIMUM)

ELEMENT	ALPHA	M	DT (MIN)	DX (FT)	PEAK (CFS)	TIME TO PEAK (MIN)	VOLUME (IN)	MAXIMUM CELERITY (FPS)
1	2.17	1.67	.64	20.00	1013.41	99.77	6.68	.52
3	.70	1.36	2.03	1800.00	19834.85	122.05	6.63	14.79

CONTINUITY SUMMARY (AC-FT) - INFLOW= 1732.158 EXCESS= 92.405 OUTFLOW= 1822.194 BASIN STORAGE= .103 PERCENT ERROR= .124

INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

3	.70	1.36	5.00	19828.05	120.00	6.63
***	***	***	***	***		

HYDROGRAPH AT STATION 3480

TOTAL RAINFALL = 6.69, TOTAL LOSS = .00, TOTAL EXCESS = 6.69

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	19.92-HR
19828.	2.00	(CFS)	3651.	1108.	1108.	1108.
		(INCHES)	6.586	6.634	6.634	6.634
		(AC-FT)	1810.	1823.	1823.	1823.

CUMULATIVE AREA = 5.15 SQ MI

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          **************
          *            *
46 KK     *      3490  *          SUB
          *            *
          **************
                              RUNOFF FROM SUB 3490 & ROUTE SUB 3480

48 KO          OUTPUT CONTROL VARIABLES
                     IPRNT           3  PRINT CONTROL
                     IPLOT           0  PLOT CONTROL
                     QSCAL          0.  HYDROGRAPH PLOT SCALE
                     IPNCH           0  PUNCH COMPUTED HYDROGRAPH
                      IOUT          21  SAVE HYDROGRAPH ON THIS UNIT
                     ISAV1           1  FIRST ORDINATE PUNCHED OR SAVED
                     ISAV2         240  LAST ORDINATE PUNCHED OR SAVED
                    TIMINT        .083  TIME INTERVAL IN HOURS


               SUBBASIN RUNOFF DATA

49 BA            SUBBASIN CHARACTERISTICS
                     TAREA         .72  SUBBASIN AREA

                 PRECIPITATION DATA

14 PB                STORM        6.69  BASIN TOTAL PRECIPITATION

15 PI              INCREMENTAL PRECIPITATION PATTERN
                    .03       .03       .03       .03       .03       .03       .03       .03       .03       .03
                    .03       .03       .28       .28       .28       .28       .28       .28       .28       .28
                    .28       .28       .28       .28

50 LU          UNIFORM LOSS RATE
                     STRTL         .00  INITIAL LOSS
                     CNSTL         .00  UNIFORM LOSS RATE
                     RTIMP        3.86  PERCENT IMPERVIOUS AREA

               KINEMATIC WAVE
51 UK            OVERLAND-FLOW ELEMENT NO. 1
                         L        100.  OVERLAND FLOW LENGTH
                         S       .0213  SLOPE
                         N        .100  ROUGHNESS COEFFICIENT
                        PA       100.0  PERCENT OF SUBBASIN
                     DXMIN           5  MINIMUM NUMBER OF DX INTERVALS
52 RK            MAIN CHANNEL
                         L      10100.  CHANNEL LENGTH
                         S       .0140  SLOPE
                         N        .045  CHANNEL ROUGHNESS COEFFICIENT
                        CA         .72  CONTRIBUTING AREA
                     SHAPE        TRAP  CHANNEL SHAPE
                        WD       50.00  BOTTOM WIDTH OR DIAMETER
                         Z       40.00  SIDE SLOPE
                     DXMIN           2  MINIMUM NUMBER OF DX INTERVALS
                    RUPSTQ         YES  ROUTE UPSTREAM HYDROGRAPH

                                                ***
                                  COMPUTED KINEMATIC PARAMETERS
                                       VARIABLE TIME STEP
                                    (DT SHOWN IS A MINIMUM)
```

ELEMENT	ALPHA	M	DT (MIN)	DX (FT)	PEAK (CFS)	TIME TO PEAK (MIN)	VOLUME (IN)	MAXIMUM CELERITY (FPS)
1	2.17	1.67	.64	20.00	2815.63	99.77	6.68	.52
3	.57	1.37	3.22	2525.00	21310.39	125.78	6.63	13.09

CONTINUITY SUMMARY (AC-FT) - INFLOW= 1823.352 EXCESS= 256.737 OUTFLOW= 2075.480 BASIN STORAGE= .318 PERCENT ERROR= .206

INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

3	.57	1.37	5.00	21149.26	125.00	6.63
***	***	***	***	***		

HYDROGRAPH AT STATION 3490

TOTAL RAINFALL = 6.69, TOTAL LOSS = .00, TOTAL EXCESS = 6.69

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	19.92-HR
21149.	2.08	(CFS)	4145.	1261.	1261.	1261.
		(INCHES)	6.562	6.627	6.627	6.627
		(AC-FT)	2056.	2076.	2076.	2076.

CUMULATIVE AREA = 5.87 SQ MI

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          **************
          *            *
53 KK     *      1470  *          SUB
          *            *
          **************
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RUNOFF FROM SUB 1470

SUBBASIN RUNOFF DATA

55 BA SUBBASIN CHARACTERISTICS
TAREA .30 SUBBASIN AREA

PRECIPITATION DATA

14 PB STORM 6.69 BASIN TOTAL PRECIPITATION

15 PI INCREMENTAL PRECIPITATION PATTERN

.03	.03	.03	.03	.03	.03	.03	.03	.03	.03
.03	.03	.28	.28	.28	.28	.28	.28	.28	.28
.28	.28	.28	.28						

56 LU UNIFORM LOSS RATE
STRTL .00 INITIAL LOSS
CNSTL .00 UNIFORM LOSS RATE
RTIMP .00 PERCENT IMPERVIOUS AREA

KINEMATIC WAVE

57 UK OVERLAND-FLOW ELEMENT NO. 1

L	200.	OVERLAND FLOW LENGTH
S	.0500	SLOPE
N	.200	ROUGHNESS COEFFICIENT
PA	100.0	PERCENT OF SUBBASIN
DXMIN	5	MINIMUM NUMBER OF DX INTERVALS

58 RK MAIN CHANNEL

L	15000.	CHANNEL LENGTH
S	.0293	SLOPE
N	.045	CHANNEL ROUGHNESS COEFFICIENT
CA	.30	CONTRIBUTING AREA
SHAPE	TRAP	CHANNEL SHAPE
WD	20.00	BOTTOM WIDTH OR DIAMETER
Z	3.00	SIDE SLOPE
DXMIN	2	MINIMUM NUMBER OF DX INTERVALS
RUPSTQ	NO	ROUTE UPSTREAM HYDROGRAPH

***

COMPUTED KINEMATIC PARAMETERS
VARIABLE TIME STEP
(DT SHOWN IS A MINIMUM)

ELEMENT	ALPHA	M	DT (MIN)	DX (FT)	PEAK (CFS)	TIME TO PEAK (MIN)	VOLUME (IN)	MAXIMUM CELERITY (FPS)
1	1.67	1.67	1.15	40.00	1164.83	115.21	6.68	.58
3	1.10	1.48	4.99	5000.00	1164.09	109.57	6.67	16.71

CONTINUITY SUMMARY (AC-FT) - INFLOW= .000 EXCESS= 106.213 OUTFLOW= 105.903 BASIN STORAGE= .008 PERCENT ERROR= .284

INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

3	1.10	1.48	5.00	1164.02	110.00	6.68

*** *** *** *** ***

HYDROGRAPH AT STATION 1470

TOTAL RAINFALL = 6.69, TOTAL LOSS = .00, TOTAL EXCESS = 6.69

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	19.92-HR
1164.	1.83	(CFS)	213.	64.	64.	64.
		(INCHES)	6.665	6.678	6.678	6.678
		(AC-FT)	106.	106.	106.	106.

CUMULATIVE AREA = .30 SQ MI

*** ***

59 KK

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**************
*            *
*     1475   *
*            *
**************
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SUB

RUNOFF FROM SUB 1475 AND ROUTE SUB 1470

SUBBASIN RUNOFF DATA

61 BA SUBBASIN CHARACTERISTICS

TAREA	1.69	SUBBASIN AREA

PRECIPITATION DATA

14 PB

STORM	6.69	BASIN TOTAL PRECIPITATION

15 PI INCREMENTAL PRECIPITATION PATTERN

.03	.03	.03	.03	.03	.03	.03	.03	.03	.03
.03	.03	.28	.28	.28	.28	.28	.28	.28	.28
.28	.28	.28	.28						

62 LU UNIFORM LOSS RATE

STRTL	.00	INITIAL LOSS
CNSTL	.00	UNIFORM LOSS RATE
RTIMP	.00	PERCENT IMPERVIOUS AREA

KINEMATIC WAVE

63 UK OVERLAND-FLOW ELEMENT NO. 1

L	285.	OVERLAND FLOW LENGTH
S	.0419	SLOPE
N	.200	ROUGHNESS COEFFICIENT
PA	100.0	PERCENT OF SUBBASIN
DXMIN	5	MINIMUM NUMBER OF DX INTERVALS

64 RK MAIN CHANNEL

L	17600.	CHANNEL LENGTH
S	.0188	SLOPE
N	.045	CHANNEL ROUGHNESS COEFFICIENT
CA	1.69	CONTRIBUTING AREA
SHAPE	TRAP	CHANNEL SHAPE
WD	25.00	BOTTOM WIDTH OR DIAMETER
Z	3.00	SIDE SLOPE
DXMIN	2	MINIMUM NUMBER OF DX INTERVALS
RUPSTQ	YES	ROUTE UPSTREAM HYDROGRAPH

***

COMPUTED KINEMATIC PARAMETERS
VARIABLE TIME STEP
(DT SHOWN IS A MINIMUM)

ELEMENT	ALPHA	M	DT (MIN)	DX (FT)	PEAK (CFS)	TIME TO PEAK (MIN)	VOLUME (IN)	MAXIMUM CELERITY (FPS)
1	1.52	1.67	1.49	57.00	6610.64	115.46	6.68	.64
3	.76	1.50	3.72	5866.67	7768.99	118.38	6.67	26.27

CONTINUITY SUMMARY (AC-FT) - INFLOW= 106.032 EXCESS= 602.776 OUTFLOW= 706.535 BASIN STORAGE= .070 PERCENT ERROR= .311

INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

3	.76	1.50	5.00	7763.54	115.00	6.66

*** *** *** *** ***

HYDROGRAPH AT STATION 1475

TOTAL RAINFALL = 6.69, TOTAL LOSS = .00, TOTAL EXCESS = 6.69

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PEAK FLOW     TIME                              MAXIMUM AVERAGE FLOW
  (CFS)       (HR)                     6-HR        24-HR       72-HR       19.92-HR
   7764.      1.92          (CFS)      1420.        429.        429.          429.
                          (INCHES)     6.646       6.662       6.662         6.662
                           (AC-FT)      704.        706.        706.          706.

                          CUMULATIVE AREA =     1.99 SQ MI


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

             **************
             *            *
 65 KK       *    1480    *        SUB
             *            *
             **************
                              RUNOFF FROM SUB 1480 AND ROUTE SUB 1475

                SUBBASIN RUNOFF DATA

 67 BA            SUBBASIN CHARACTERISTICS
                       TAREA        1.00  SUBBASIN AREA

                  PRECIPITATION DATA

 14 PB                 STORM        6.69  BASIN TOTAL PRECIPITATION

 15 PI               INCREMENTAL PRECIPITATION PATTERN
                       .03        .03        .03        .03        .03        .03        .03        .03        .03        .03
                       .03        .03        .28        .28        .28        .28        .28        .28        .28        .28
                       .28        .28        .28        .28

 68 LU            UNIFORM LOSS RATE
                       STRTL         .00  INITIAL LOSS
                       CNSTL         .00  UNIFORM LOSS RATE
                       RTIMP        1.07  PERCENT IMPERVIOUS AREA

                  KINEMATIC WAVE
 69 UK               OVERLAND-FLOW ELEMENT NO. 1
                           L        300.  OVERLAND FLOW LENGTH
                           S       .0167  SLOPE
                           N        .200  ROUGHNESS COEFFICIENT
                          PA       100.0  PERCENT OF SUBBASIN
                       DXMIN           5  MINIMUM NUMBER OF DX INTERVALS
 70 RK               MAIN CHANNEL
                           L       7500.  CHANNEL LENGTH
                           S       .0213  SLOPE
                           N        .045  CHANNEL ROUGHNESS COEFFICIENT
                          CA        1.00  CONTRIBUTING AREA
                       SHAPE        TRAP  CHANNEL SHAPE
                          WD       25.00  BOTTOM WIDTH OR DIAMETER
                           Z        3.00  SIDE SLOPE
                       DXMIN           2  MINIMUM NUMBER OF DX INTERVALS
                      RUPSTQ         YES  ROUTE UPSTREAM HYDROGRAPH

                                                       ***
                                    COMPUTED KINEMATIC PARAMETERS
                                         VARIABLE TIME STEP
                                       (DT SHOWN IS A MINIMUM)
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ELEMENT	ALPHA	M	DT (MIN)	DX (FT)	PEAK (CFS)	TIME TO PEAK (MIN)	VOLUME (IN)	MAXIMUM CELERITY (FPS)
1	.96	1.67	2.03	60.00	3918.60	119.62	6.68	.49
3	.81	1.50	1.39	2500.00	11680.74	117.80	6.67	29.97

CONTINUITY SUMMARY (AC-FT) - INFLOW= 706.035 EXCESS= 357.313 OUTFLOW= 1062.334 BASIN STORAGE= .050 PERCENT ERROR= .091

INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

3	.81	1.50	5.00		11672.37	115.00	6.66

*** *** *** *** ***

HYDROGRAPH AT STATION 1480

TOTAL RAINFALL = 6.69, TOTAL LOSS = .00, TOTAL EXCESS = 6.69

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	19.92-HR
11672.	1.92	(CFS)	2135.	645.	645.	645.
		(INCHES)	6.643	6.661	6.661	6.661
		(AC-FT)	1059.	1062.	1062.	1062.

CUMULATIVE AREA = 2.99 SQ MI

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              **************
              *            *
  71 KK       *     1481   *          DIV
              *            *
              **************
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DIVERT FLOW FROM SUB 1480 TO SUB 3510

DT DIVERSION
ISTAD 1482 DIVERSION HYDROGRAPH IDENTIFICATION

DI INFLOW .00 8000.00

DQ DIVERTED FLOW .00 4000.00

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DIVERSION HYDROGRAPH 1482

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	19.92-HR
5836.	1.92	(CFS)	1068.	323.	323.	323.
		(INCHES)	3.322	3.330	3.330	3.330
		(AC-FT)	529.	531.	531.	531.

CUMULATIVE AREA = 2.99 SQ MI

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     ***              ***              ***              ***              ***

                         HYDROGRAPH AT STATION     1481

 PEAK FLOW      TIME                              MAXIMUM AVERAGE FLOW
   (CFS)        (HR)                       6-HR        24-HR        72-HR       19.92-HR
   5836.        1.92            (CFS)      1068.        323.         323.          323.
                             (INCHES)      3.322        3.330        3.330         3.330
                              (AC-FT)       529.         531.         531.          531.

                        CUMULATIVE AREA =      2.99 SQ MI


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

              **************
              *            *
  76 KK       *    3510    *          SUB
              *            *
              **************
                                RUNOFF FROM SUB 3510 & ROUTE DIV 1481

                SUBBASIN RUNOFF DATA

  78 BA           SUBBASIN CHARACTERISTICS
                        TAREA         1.40  SUBBASIN AREA

                  PRECIPITATION DATA

  14 PB                 STORM         6.69  BASIN TOTAL PRECIPITATION

  15 PI             INCREMENTAL PRECIPITATION PATTERN
                        .03       .03       .03       .03       .03       .03       .03       .03       .03       .03
                        .03       .03       .28       .28       .28       .28       .28       .28       .28       .28
                        .28       .28       .28       .28

  79 LU           UNIFORM LOSS RATE
                        STRTL          .00  INITIAL LOSS
                        CNSTL          .00  UNIFORM LOSS RATE
                        RTIMP         3.86  PERCENT IMPERVIOUS AREA

                  KINEMATIC WAVE
  80 UK             OVERLAND-FLOW ELEMENT NO. 1
                            L         224.  OVERLAND FLOW LENGTH
                            S        .0212  SLOPE
                            N         .150  ROUGHNESS COEFFICIENT
                           PA        100.0  PERCENT OF SUBBASIN
                        DXMIN            5  MINIMUM NUMBER OF DX INTERVALS
  81 RK             MAIN CHANNEL
                            L       21800.  CHANNEL LENGTH
                            S        .0188  SLOPE
                            N         .045  CHANNEL ROUGHNESS COEFFICIENT
                           CA         1.40  CONTRIBUTING AREA
                        SHAPE         TRAP  CHANNEL SHAPE
                           WD        30.00  BOTTOM WIDTH OR DIAMETER
                            Z        30.00  SIDE SLOPE
                        DXMIN            2  MINIMUM NUMBER OF DX INTERVALS
                       RUPSTQ          YES  ROUTE UPSTREAM HYDROGRAPH
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COMPUTED KINEMATIC PARAMETERS
VARIABLE TIME STEP
(DT SHOWN IS A MINIMUM)

ELEMENT	ALPHA	M	DT (MIN)	DX (FT)	PEAK (CFS)	TIME TO PEAK (MIN)	VOLUME (IN)	MAXIMUM CELERITY (FPS)
1	1.45	1.67	1.33	44.80	5496.28	118.97	6.68	.56
3	.77	1.36	3.90	3114.29	11056.04	119.85	4.40	13.30

CONTINUITY SUMMARY (AC-FT) - INFLOW= 530.839 EXCESS= 501.166 OUTFLOW= 1030.306 BASIN STORAGE= .205 PERCENT ERROR= .145

INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

3	.77	1.36	5.00		11053.67	120.00	4.40

*** *** *** *** ***

HYDROGRAPH AT STATION 3510

TOTAL RAINFALL = 6.69, TOTAL LOSS = .00, TOTAL EXCESS = 6.69

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	19.92-HR
11054.	2.00	(CFS)	2065.	626.	626.	626.
		(INCHES)	4.370	4.395	4.395	4.395
		(AC-FT)	1024.	1030.	1030.	1030.

CUMULATIVE AREA = 4.39 SQ MI

*** ***

```
        **************
        *            *
82 KK   *     3520   *        SUB
        *            *
        **************
```

RUNOFF FROM SUB 3520 & ROUTE SUB 3510

SUBBASIN RUNOFF DATA

84 BA SUBBASIN CHARACTERISTICS
TAREA 1.11 SUBBASIN AREA

PRECIPITATION DATA

14 PB STORM 6.69 BASIN TOTAL PRECIPITATION

15 PI INCREMENTAL PRECIPITATION PATTERN

.03	.03	.03	.03	.03	.03	.03	.03	.03	.03
.03	.03	.28	.28	.28	.28	.28	.28	.28	.28
.28	.28	.28	.28						

85 LU UNIFORM LOSS RATE

```
                    STRTL          .00  INITIAL LOSS
                    CNSTL          .00  UNIFORM LOSS RATE
                    RTIMP         1.38  PERCENT IMPERVIOUS AREA

              KINEMATIC WAVE
   86 UK        OVERLAND-FLOW ELEMENT NO. 1
                        L         100.  OVERLAND FLOW LENGTH
                        S        .0213  SLOPE
                        N         .100  ROUGHNESS COEFFICIENT
                       PA        100.0  PERCENT OF SUBBASIN
                    DXMIN            5  MINIMUM NUMBER OF DX INTERVALS
   87 RK        MAIN CHANNEL
                        L       15400.  CHANNEL LENGTH
                        S        .0146  SLOPE
                        N         .045  CHANNEL ROUGHNESS COEFFICIENT
                       CA         1.11  CONTRIBUTING AREA
                    SHAPE         TRAP  CHANNEL SHAPE
                       WD        30.00  BOTTOM WIDTH OR DIAMETER
                        Z        30.00  SIDE SLOPE
                    DXMIN            2  MINIMUM NUMBER OF DX INTERVALS
                   RUPSTQ          YES  ROUTE UPSTREAM HYDROGRAPH

                                               ***
                              COMPUTED KINEMATIC PARAMETERS
                                   VARIABLE TIME STEP
                                 (DT SHOWN IS A MINIMUM)
```

ELEMENT	ALPHA	M	DT (MIN)	DX (FT)	PEAK (CFS)	TIME TO PEAK (MIN)	VOLUME (IN)	MAXIMUM CELERITY (FPS)
1	2.17	1.67	.64	20.00	4348.27	99.77	6.68	.52
3	.68	1.36	4.10	3080.00	13096.15	129.22	4.86	12.51

```
CONTINUITY SUMMARY (AC-FT) - INFLOW= 1029.911  EXCESS=  396.487 OUTFLOW= 1425.276 BASIN STORAGE=     .280 PERCENT ERROR=     .059
```

INTERPOLATED TO SPECIFIED COMPUTATION INTERVAL

ELEMENT	ALPHA	M	DT (MIN)	DX (FT)	PEAK (CFS)	TIME TO PEAK (MIN)	VOLUME (IN)	MAXIMUM CELERITY (FPS)
3	.68	1.36	5.00		13074.83	130.00	4.86	

```
      ***                ***                ***                ***                ***

                     HYDROGRAPH AT STATION       3520

    TOTAL RAINFALL =      6.69, TOTAL LOSS =       .00, TOTAL EXCESS =      6.69
```

PEAK FLOW (CFS)	TIME (HR)		6-HR	24-HR	72-HR	19.92-HR
			MAXIMUM AVERAGE FLOW			
13075.	2.17	(CFS)	2848.	866.	866.	866.
		(INCHES)	4.811	4.857	4.857	4.857
		(AC-FT)	1412.	1426.	1426.	1426.

```
                     CUMULATIVE AREA =     5.50 SQ MI


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

          **************
```

```
          *             *
88 KK     *     TOTAL   *
          *             *
          ***************
                        COMBINE FLOWS FROM 3490 AND 3520 ABOVE THE ROAD

90 HC           HYDROGRAPH COMBINATION
                      ICOMP           2  NUMBER OF HYDROGRAPHS TO COMBINE
                                                                    ***

     ***              ***              ***              ***              ***

                         HYDROGRAPH AT STATION    TOTAL

PEAK FLOW      TIME                                MAXIMUM AVERAGE FLOW
  (CFS)        (HR)                    6-HR         24-HR        72-HR      19.92-HR
  34072.       2.17          (CFS)     6993.        2128.        2128.        2128.
                          (INCHES)     5.715        5.771        5.771        5.771
                            (AC-FT)    3468.        3502.        3502.        3502.

                         CUMULATIVE AREA =   11.38 SQ MI


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

          ***************
          *             *
91 KK     *     BASIN   *
          *             *
          ***************
                        PONDING AREA AT THE INTERSECTION OF CAVE CREEK ROAD AND CAVE BUTTES
                        DIKE # 2

              HYDROGRAPH ROUTING DATA

94 RS           STORAGE ROUTING
                      NSTPS           1  NUMBER OF SUBREACHES
                       ITYP        STOR  TYPE OF INITIAL CONDITION
                     RSVRIC         .00  INITIAL CONDITION
                          X         .00 WORKING R AND D COEFFICIENT

95 SV             STORAGE          .0       1.9      15.1      64.7      80.8      99.3     120.6     144.6     171.7     201.9

96 SQ             DISCHARGE        0.       0.       0.        0.        671.      3784.    10440.    21430.    37450.    59000.

97 SE             ELEVATION     1660.00  1664.00  1668.00   1673.00   1674.00   1675.00  1676.00   1677.00   1678.00   1679.00

                                                                    ***

*** WARNING *** MODIFIED PULS ROUTING MAY BE NUMERICALLY UNSTABLE FOR OUTFLOWS BETWEEN     3784. TO    59000.
                THE ROUTED HYDROGRAPH SHOULD BE EXAMINED FOR OSCILLATIONS OR OUTFLOWS GREATER THAN PEAK INFLOWS.
                THIS CAN BE CORRECTED BY DECREASING THE TIME INTERVAL OR INCREASING STORAGE (USE A LONGER REACH.)

     ***              ***              ***              ***              ***

                         HYDROGRAPH AT STATION    BASIN
```

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	19.92-HR
34125.	2.17	(CFS)	6880.	2088.	2088.	2088.
		(INCHES)	5.622	5.664	5.664	5.664
		(AC-FT)	3411.	3437.	3437.	3437.

PEAK STORAGE (AC-FT)	TIME (HR)	MAXIMUM AVERAGE STORAGE 6-HR	24-HR	72-HR	19.92-HR
166.	2.17	98.	72.	72.	72.

PEAK STAGE (FEET)	TIME (HR)	MAXIMUM AVERAGE STAGE 6-HR	24-HR	72-HR	19.92-HR
1677.79	2.17	1674.81	1673.05	1673.05	1673.05

CUMULATIVE AREA = 11.38 SQ MI

RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW	TIME OF PEAK	AVERAGE FLOW FOR MAXIMUM PERIOD 6-HOUR	24-HOUR	72-HOUR	BASIN AREA	MAXIMUM STAGE	TIME OF MAX STAGE
HYDROGRAPH AT	1430	5587.	1.83	1023.	309.	309.	1.43		
HYDROGRAPH AT	1440	7381.	1.83	1351.	408.	408.	1.89		
2 COMBINED AT	1441	12968.	1.83	2373.	717.	717.	3.32		
HYDROGRAPH AT	1450	15953.	1.92	2910.	880.	880.	4.09		
HYDROGRAPH AT	3470	19008.	2.00	3472.	1052.	1052.	4.89		
HYDROGRAPH AT	3480	19828.	2.00	3651.	1108.	1108.	5.15		
HYDROGRAPH AT	3490	21149.	2.08	4145.	1261.	1261.	5.87		
HYDROGRAPH AT	1470	1164.	1.83	213.	64.	64.	.30		
HYDROGRAPH AT	1475	7764.	1.92	1420.	429.	429.	1.99		
HYDROGRAPH AT	1480	11672.	1.92	2135.	645.	645.	2.99		
DIVERSION TO	1482	5836.	1.92	1068.	323.	323.	2.99		
HYDROGRAPH AT	1481	5836.	1.92	1068.	323.	323.	2.99		
HYDROGRAPH AT	3510	11054.	2.00	2065.	626.	626.	4.39		
HYDROGRAPH AT	3520	13075.	2.17	2848.	866.	866.	5.50		
2 COMBINED AT	TOTAL	34072.	2.17	6993.	2128.	2128.	11.38		
ROUTED TO	BASIN	34125.	2.17	6880.	2088.	2088.	11.38	1677.79	2.17

SUMMARY OF KINEMATIC WAVE ROUTING
(FLOW IS DIRECT RUNOFF WITHOUT BASE FLOW)

ISTAQ	ELEMENT	DT	PEAK	TIME TO PEAK	VOLUME	INTERPOLATED TO COMPUTATION INTERVAL DT	PEAK	TIME TO PEAK	VOLUME
		(MIN)	(CFS)	(MIN)	(IN)	(MIN)	(CFS)	(MIN)	(IN)
1430	3	4.10	5589.75	107.76	6.65	5.00	5587.47	110.00	6.66
CONTINUITY SUMMARY (AC-FT) - INFLOW= .000 EXCESS= 510.870 OUTFLOW= 507.967 BASIN STORAGE= .078 PERCENT ERROR= .553									
1440	3	4.76	7381.70	108.93	6.66	5.00	7380.80	110.00	6.67
CONTINUITY SUMMARY (AC-FT) - INFLOW= .000 EXCESS= 673.668 OUTFLOW= 670.996 BASIN STORAGE= .071 PERCENT ERROR= .386									
1450	3	3.21	15961.02	118.73	6.65	5.00	15953.21	115.00	6.65
CONTINUITY SUMMARY (AC-FT) - INFLOW= 1179.849 EXCESS= 273.363 OUTFLOW= 1448.276 BASIN STORAGE= .190 PERCENT ERROR= .327									
3470	3	2.97	19023.19	121.15	6.64	5.00	19008.09	120.00	6.64
CONTINUITY SUMMARY (AC-FT) - INFLOW= 1448.715 EXCESS= 288.455 OUTFLOW= 1732.443 BASIN STORAGE= .274 PERCENT ERROR= .256									
3480	3	2.03	19834.85	122.05	6.63	5.00	19828.05	120.00	6.63
CONTINUITY SUMMARY (AC-FT) - INFLOW= 1732.158 EXCESS= 92.405 OUTFLOW= 1822.194 BASIN STORAGE= .103 PERCENT ERROR= .124									
3490	3	3.22	21310.39	125.78	6.63	5.00	21149.26	125.00	6.63
CONTINUITY SUMMARY (AC-FT) - INFLOW= 1823.352 EXCESS= 256.737 OUTFLOW= 2075.480 BASIN STORAGE= .318 PERCENT ERROR= .206									
1470	3	4.99	1164.09	109.57	6.67	5.00	1164.02	110.00	6.68
CONTINUITY SUMMARY (AC-FT) - INFLOW= .000 EXCESS= 106.213 OUTFLOW= 105.903 BASIN STORAGE= .008 PERCENT ERROR= .284									
1475	3	3.72	7768.99	118.38	6.67	5.00	7763.54	115.00	6.66
CONTINUITY SUMMARY (AC-FT) - INFLOW= 106.032 EXCESS= 602.776 OUTFLOW= 706.535 BASIN STORAGE= .070 PERCENT ERROR= .311									
1480	3	1.39	11680.74	117.80	6.67	5.00	11672.37	115.00	6.66
CONTINUITY SUMMARY (AC-FT) - INFLOW= 706.035 EXCESS= 357.313 OUTFLOW= 1062.334 BASIN STORAGE= .050 PERCENT ERROR= .091									
3510	3	3.90	11056.04	119.85	4.40	5.00	11053.67	120.00	4.40
CONTINUITY SUMMARY (AC-FT) - INFLOW= 530.639 EXCESS= 501.166 OUTFLOW= 1030.306 BASIN STORAGE= .205 PERCENT ERROR= .145									
3520	3	4.10	13096.15	129.22	4.86	5.00	13074.83	130.00	4.86
CONTINUITY SUMMARY (AC-FT) - INFLOW= 1029.911 EXCESS= 396.487 OUTFLOW= 1425.276 BASIN STORAGE= .280 PERCENT ERROR= .059									

*** NORMAL END OF HEC-1 ***

Analysis of Ponding at Cave Buttes Dike Number 2 and Cave Creek Road

INTRODUCTION

Cave Buttes Dike Number 2 intersects Cave Creek road approximately one quarter mile south of Jomax road (figure 1). The dike extends 4400 feet east of this intersection. As originally designed, the dike was intended to divert flows eastward into the Cave Buttes Dam reservoir. Proposed improvements to Cave Creek road will raise the roadway and thereby increase the ponding behind the dike-road intersection. The following summarizes an analysis done to determine if raising Cave Creek road will cause the dike to overtop under conditions of probable maximum precipitation.

METHODS

Inflow to the ponding area was analyzed using the Corps of Engineers HEC-1 computer program and hydrologic input parameters developed by Water Rescource Associates (1989). A worst-case scenario, consisting of the following assumptions, was analyzed.

1. Probable maximum precipitation of 7.55 inches.
2. Total blockage of a 36" drainage pipe that runs under Cave Creek road and is located approximately 100 feet north of the dike.
3. Total blockage of 5 - 12'x8'x115' RCB culverts under Cave Creek road that are located approximately 900 feet north of the dike.

Under these assumptions, the drainage area above the road-dike ponding site was determined to be 11.38 square miles. The drainage area is generally less than a mile wide and extends for over 13 miles to the northeast of the ponding area. The subbasin delineation was not changed from that used by Water Rescource Associates. The delineation contains one split flow situation in which 50 % of the flow ocuuring from 3.0 square miles of the drainage area is diverted out of the drainage area. From inspection of aerial photography for this area, this seems to be a reasonable assumption.

The probable maximum precipitation used was a 6 hour storm developed by the Corps of Engineers (1976) for the design of Cave Buttes Dam (see figure 2). Although this storm was developed for the entire 195 square mile drainage area above Cave Buttes Dam, it was considered appropriate for this analysis because of the shape of the contributing drainage area and the severity of the other assumptions used in the analysis.

The constant rainfall loss rate of 0.143 inches per hour used by the Corps (figure 2) was also used in this analysis. This resulted in 6.69 inches of runoff from the drainage area. This loss rate is lower than what is generally used in this area and therefore it produced approximately 1.5 inches more runoff than the curve number method used by Water Rescource Associates. The Corps loss rate was used because it was the most conservative assumption.

The assumption of complete blockage of the culverts under Cave Creek road, although unlikely, is a possibility which may occur during construction, or if the culverts area not properly maintained, or if large quantities of sediment and debris are contained in the first portion of the storm runoff.

PONDING CONDITIONS:

For the situation described above, runoff will pond in a roughly triangular area behind the dike-road intersection. The maximum water depth that can be contained at the intersection is approximately 20 feet, which occurs at an elevation of 1679 feet. This corresponds to a maximum storage volume of 235 acre feet. Discharge from this ponding area will occur across Cave Creek road through a depressed area of the improved roadway. The depressed roadway is approximately 1300 feet wide, with the low point (1673') occuring at the site of the 5 - 8'x12'x115' box culverts. For modelling purposes, the roadway in the depressed area was assumed to behave as a broad-crested weir.

RESULTS:

The results of the HEC-1 modelling indicate that the dike will not overtop even under the severe conditions assumed for this analysis. The maximum water surface elevation indicated for the ponding site (1677.8') is more than 1 foot lower than the top of the dike (1679'). The HEC-1 output of results is attached to this report.

DISCUSSION:

As a further indication of the conservative nature of this analysis, it should be noted that the Water Rescources model used in the analysis uses kinematic wave hydrograph generation and routing. This type of modelling generally produces a very rapid runoff response and correspondingly high peak flows. The peak flow predicted from the 11.38 square miles in this study was over 34,000 cfs, even with the split flow diversion described above. Because of the severe assumptions used for the analysis, it is the authors opinion that it is very unlikely that the dike will ever fail due to overtopping.

REFERENCES USED:

Landiscor Aerial Photography, Feb., 22, 1990.

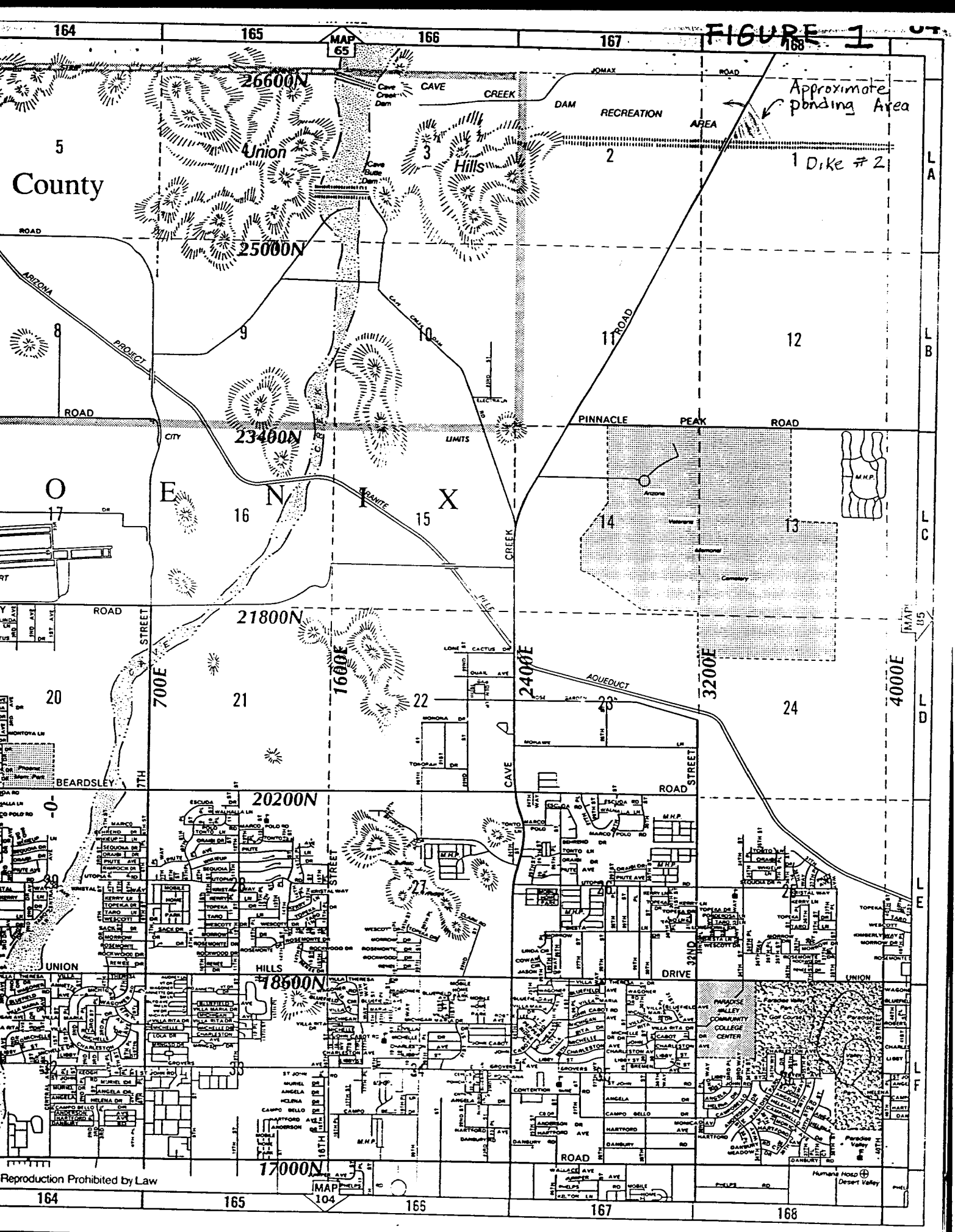
SEA Consulting Engineers. 1990. design plans for Cave Creek road sanitary sewer. City of Phoenix index number S896142.

United States Army Corps of Engineers. 1976. Cave Buttes Dam Deesign Memorandum No. 3, General Design Memorandum Phase II, Project Design Phase I.

United States Geological Survey 7.5 minute quadrangles: Cave Creek (Photorevised 1981), Curry Corner (photorevised 1982), Wildcat Hill (photorevised 1981).

Water Rescource Associates. 1989. Concept Drainage Study, Paradise Valley Fan Terrace, Part of Peripheral areas C and D.

FIGURE 1


MAP 65
MAP 104
164
165
166
167
168
26600N
25000N
23400N
21800N
20200N
18600N
17000N
Union Hills
Cave Creek Dam
CAVE CREEK
DAM
RECREATION AREA
Approximate ponding Area
Dike #2
JOMAX ROAD
ARIZONA PROJECT CANAL
CAVE CREEK ROAD
PINNACLE PEAK ROAD
CITY LIMITS
GRANITE REEF AQUEDUCT
BEARDSLEY CANAL
7TH STREET
16TH STREET
32ND DRIVE
700E
1600E
2400E
3200E
4000E
LA
LB
LC
LD
LE
LF
Arizona Memorial Cemetery
MHP
Paradise Valley Community College Center
Humana Hosp Desert Valley
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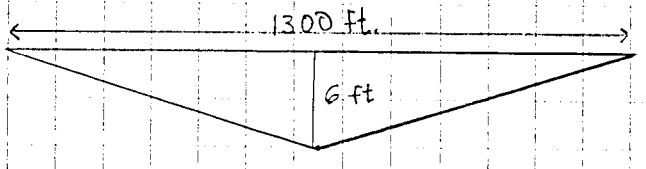
Weir flow for Cave Buttes Dike # 2 TWH 7/11/90

Approximate weir shape caused by the low area of Cave Creek Road.

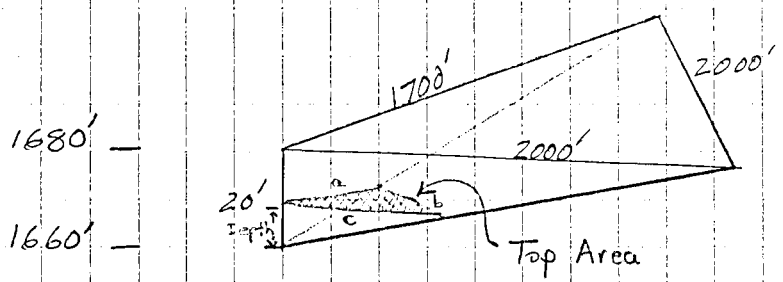


Using the formula for a broad crested weir $Q = 3.09LH^{3/2}$ and 1 ft. intervals. The top length will be used for the length (L) in the weir equation

depth (H)	Length (L)	Discharge (Q)	Elevation
0	0	0	1673
1	217	671	1674
2	433	3784	1675
3	650	10,440	1676
4	867	21,430	1677
5	1084	37,450	1678
6	1300	59,000	1679

Storage Volume Behind Cave Buttes Dike # 2 TWH 11/7/90

Approximate Dimensions of Ponding Area at Cave Creek Road and Dike #2



not to scale

Volume = $\frac{1}{3}$ (Top Area)(Depth) [volume of a pyramid]

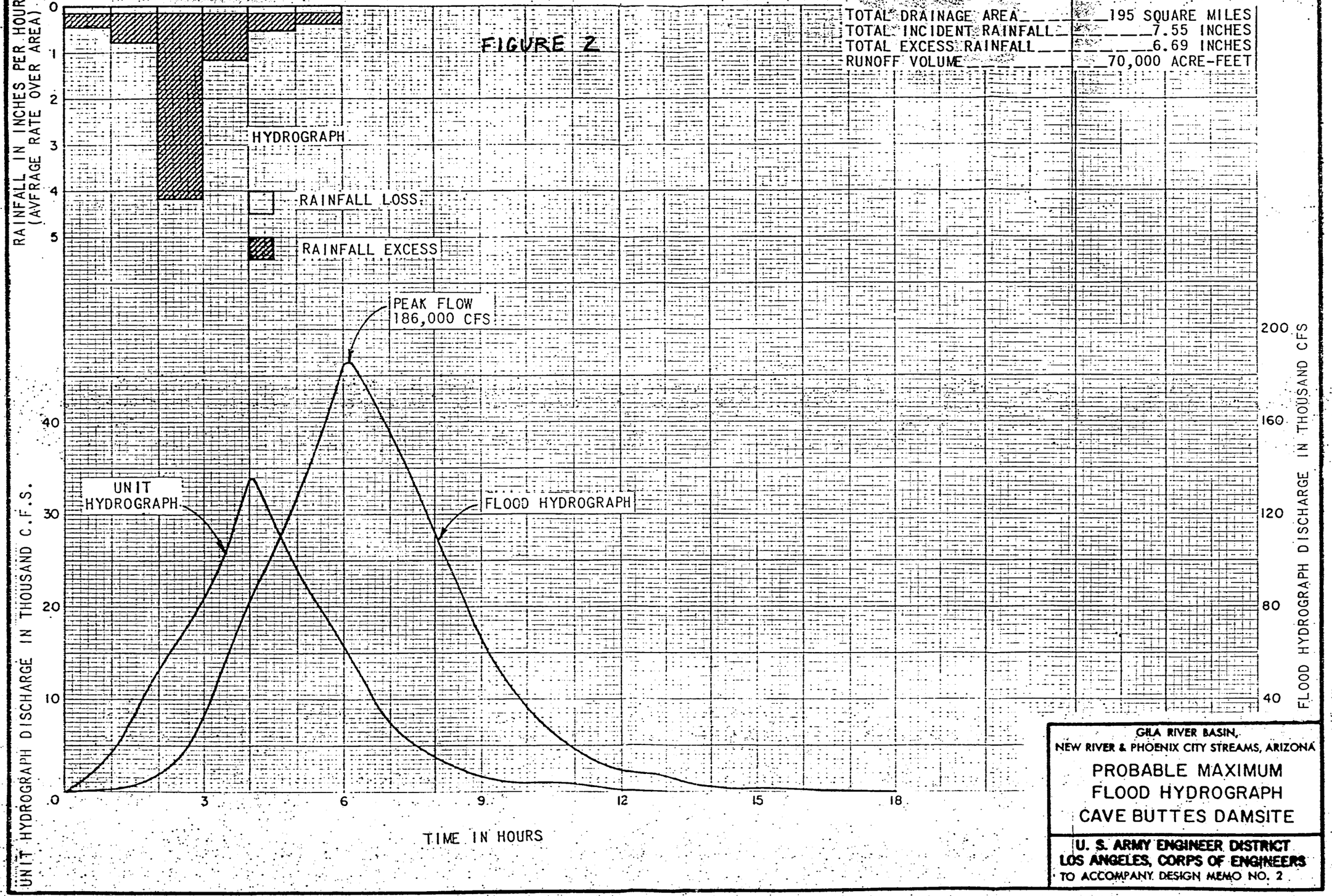
Top Area = $\sqrt{s(s-a)(s-b)(s-c)}$ [area of a triangle with side lengths a, b, c]

a, b, and c can be found using similar triangles

Elevation	Depth	a	b	c	Top Area (Acres)	Volume (acre-feet)	Discharge ft³/s
1660	0					0	0
1664	4	340	400	400	1.41	1.88	0
1668	8	680	800	800	5.65	15.1	0
1673	13	1105	1300	1300	14.9	64.7	0
1674	14	1190	1400	1400	17.3	80.8	671
1675	15	1275	1500	1500	19.9	99.3	3784
1676	16	1360	1600	1600	22.6	120.6	10,440
1677	17	1445	1700	1700	25.5	144.6	21,430
1678	18	1530	1800	1800	28.6	171.7	37,450
1679	19	1615	1900	1900	31.9	201.9	59,000
1680	20	1700	2000	2000	35.3	235.5	overtopped

FIGURE 2

TOTAL DRAINAGE AREA	195 SQUARE MILES
TOTAL INCIDENT RAINFALL	7.55 INCHES
TOTAL EXCESS RAINFALL	6.69 INCHES
RUNOFF VOLUME	70,000 ACRE-FEET



GILA RIVER BASIN,
NEW RIVER & PHOENIX CITY STREAMS, ARIZONA

PROBABLE MAXIMUM
FLOOD HYDROGRAPH
CAVE BUTTES DAMSITE

U. S. ARMY ENGINEER DISTRICT
LOS ANGELES, CORPS OF ENGINEERS
TO ACCOMPANY DESIGN MEMO NO. 2

PLATE 38