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OFFSITE DRAINAGE CONCEPT STUDY
Part A - Offsite Hydrology

OUTER LOOP HIGHWAY
(Buckeye Road to Northern Avenue)
Revised December 10, 1987

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OUTER LOOP HIGHWAY
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Revised December 10, 1987

Registered Professional Engineer (Civil)
CERTIFICATE NO. 15564
MARK T. GAVAN
Date Signed 1-27-88
ARIZONA, U.S.A.

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1.0 INTRODUCTION

This is the off-site hydrology report for the Outer Loop Highway between Buckeye Road and Northern Avenue. The WLB Group, Inc. was subcontracted by DeLeuw, Cather and Company, the Outer Loop Management Consultant for the Arizona Department of Transportation, to determine the off-site flows that will reach the Outer Loop and to investigate alternative conceptual drainage designs that will protect both the Outer Loop and adjacent property owners from flooding. This report summarizes the results of the off-site hydrology study along with the methods and assumptions used to create the hydrologic model. The investigation of drainage design concepts will be covered in a subsequent report.

2.0 DESCRIPTION OF DRAINAGE AREA

The total drainage area studied is 78.3 square miles and slopes primarily in a southwesterly direction at approximately 0.36%. Under existing conditions, 36.5 square miles of the area flows to the channel along the north side of the Papago Freeway, 38.0 square miles flows to the Outer Loop between the Papago Freeway and Northern Avenue, and the runoff from the remaining 3.8 square miles will be intercepted by the Outer Loop between Buckeye Road and the Papago Freeway.

The majority of the drainage basin has been developed except for agricultural land in the western and northwestern portions of the drainage area. The existing development is a mix of residential, commercial, and industrial with the majority being residential. The area is complicated by the proposed Paradise Corridor and the proposed Grand Avenue Expressway. The alternative cases discussed later in this report represent the effect of these proposed freeways on the off-site flows that will reach the Outer Loop.

has it been adopted?

The study area is further complicated by the proposed storm drains in the Glendale/Peoria ADMS. The storm drain plan for Glendale and Peoria is a 10-year system with substantial detention provided at many locations. Although a plan has been prepared for the area, it has not been accepted by the Flood Control District of Maricopa County and adequate information does not exist on the proposed detention basins. Therefore, the effects of the storm drains were not included in this hydrology report. The storm drain system will, however, be considered in the drainage concept portion of this study.

3.0 HYDROLOGY

The computer program used to compute the peak discharges and volumes of runoff is the U.S. Army Corps of Engineers HEC-1 program (Reference 1). The methodology used in the program was the SCS Dimensionless Unit Hydrograph (Reference 2). The following paragraphs describe the approach used in developing the various input parameters to the HEC-1 program.

3.1 Watershed Area

The study area was divided into subbasins based on topography, street alignments, field observations, and points of concentration at least once every mile along the Outer Loop Highway. The U.S.G.S. Quadrangle Maps were used as a base for the subbasin delineations.

3.2 Precipitation Depth, Duration, and Distribution

The average precipitation depths for the watershed were determined from the Arizona Department of Transportation design manual "Hydrologic Design for Highway Drainage" (Reference 3). The storm used in the model has a 24-hour duration; distributed by the Hypothetical storm in HEC-1 using the 5 minute, 15 minute, 1 hour, 2 hour, 3 hour, 6 hour, 12 hour, and 24 hour depth/duration data for the study area. The following is a list of the 50-year and 100-year depth/duration data.

Duration	50-year Precipitation, In.	100-year Precipitation, In.
5-min.	.63	.71
10-min.	.97	1.10
15-min.	1.23	1.40
30-min.	1.71	1.94
1-hr.	2.16	2.45
2-hr.	2.36	2.64
3-hr.	2.50	2.82
6-hr.	2.76	3.10
12-hr.	3.02	3.40
24-hr.	3.29	3.71

Reduction of these point rainfall values was applied in the program to properly account for the effect of the watershed size.

Refer to Appendix 1 for a discussion on the selection of the rainfall distribution. The 24-hour hypothetical distribution was used for this study for two reasons. First, the results using the hypothetical storm agreed very well with the results using the rainfall distribution developed by the City of Phoenix for design of their storm drainage systems. Secondly, the hypothetical distribution was used to be consistent with the off-site hydrology already completed for the Outer Loop from Northern Avenue to Bell Road.

3.3 Curve Number

The curve number is used to describe the infiltration/interception characteristics of the drainage area. Factors that affect the curve number are soil type, cover type, and land use. The soils within the study area were all in the Hydrologic Soil Group B as shown in the SCS "Soil Survey of

Maricopa County, Arizona, Central Part" (Reference 4). The curve numbers were based on existing conditions and were taken from Table 2.2 in TR-55 (Reference 5), supplemented by City of Phoenix data for land uses not covered in TR-55. The curve numbers were weighted by area to produce a representative curve number for each subwatershed. Aerial photos and City and County zoning maps were used to identify the different land uses for each area.

3.4 Time of Concentration/Lag Time

The lag time for the watershed is required input for the SCS dimensionless unit hydrograph method. The lag is calculated by multiplying the time of concentration by 0.6. The time of concentration is defined as the time it takes runoff to travel from the hydraulically most distant point in the watershed to the point of concentration.

The time of concentration was calculated using a combination of overland flow time and gutter flow time. Overland flow time was calculated using the SCS Upland Method (Reference 2) and gutter flow time was calculated using Mannings equation for streets flowing full to the top of an assumed 6" curb. The hydraulic lengths and slopes were obtained from the 7.5 minute U.S.G.S. quadrangle maps of the area.

3.5 Channel Routing

The kinematic wave method was used to route the hydrographs through the streets, channels, and storm drains. Channel routing in the streets was simulated by a triangular channel with 50:1 side slopes and Manning's N of 0.020. Channel routing in trapezoidal channels and circular concrete pipes was simulated with their corresponding shapes and N values of 0.018 and 0.012, respectively.

4.0 RESULTS

Four seperate hydrologic models were developed for this report. They include one for the Outer Loop from Buckeye Road to the Papago Freeway and three (Case A, B and C) for the reach from the Papago Freeway to Northern Avenue. The three alternative models for the Papago Freeway to Northern Avenue reach were required to study the effects of the proposed Grand Avenue Expressway and the Paradise Corridor.

The results are presented with summary printouts from the HEC-1 model with concentration points that correspond to points on the drainage area maps. The peak discharges along the Outer Loop are summarized directly on the drainage area maps.

4.1 Buckeye Road to the Papago Freeway

A separate hydrologic model was developed for the Buckeye Road to the Papago Freeway section of the Outer Loop. The contributing drainage area is approximately 3.8 square miles.

The flows were assumed to be intercepted and collected along the Outer Loop. However, if the expressway in this section is elevated over the Southern Pacific Railroad, the majority of the flow can simply flow under the Outer Loop along the north side of the Railroad as it does now under existing conditions.

RUNOFF SUMMARY

FLOW IN CUBIC FEET PER SECOND

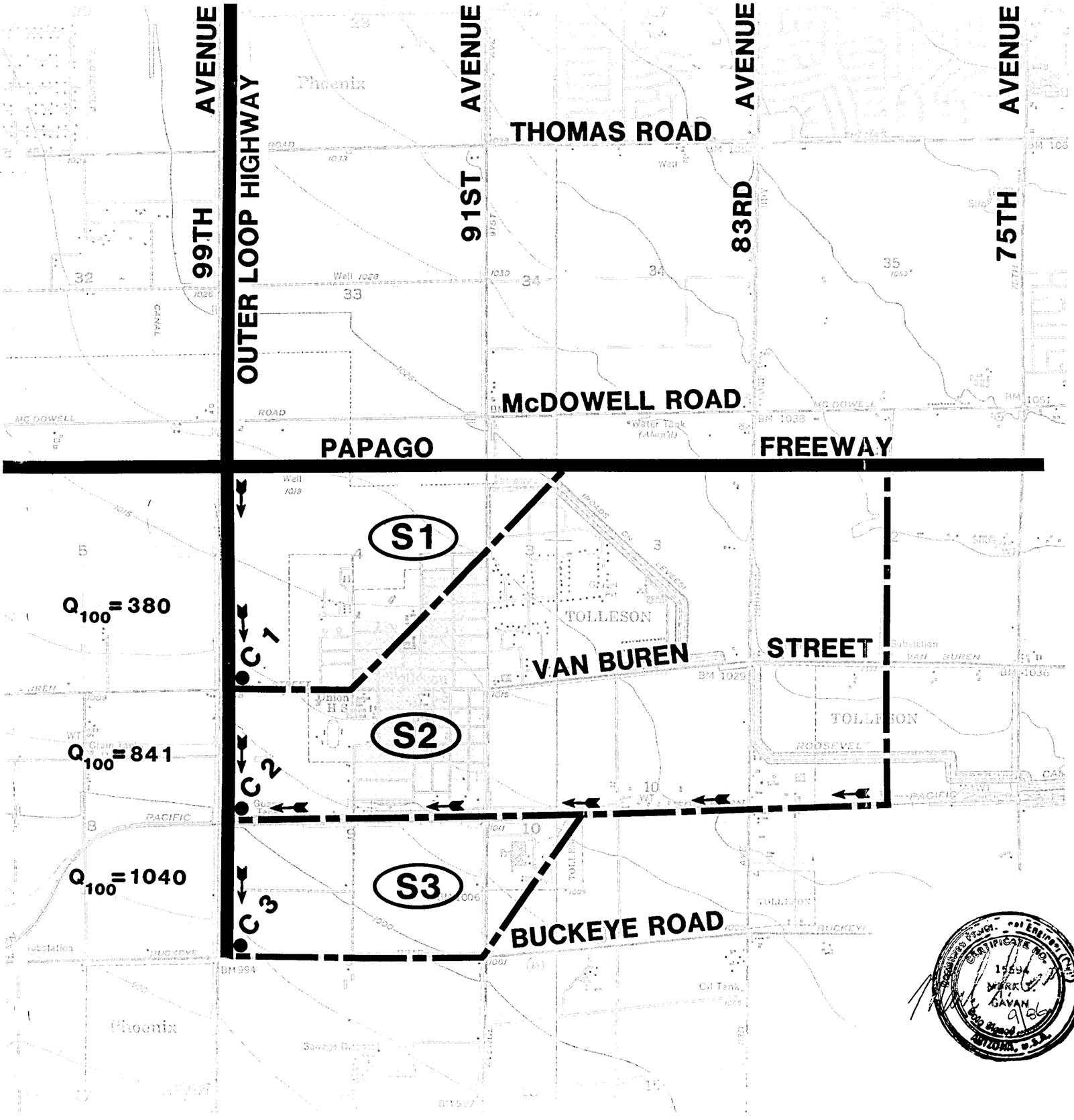
TIME IN HOURS, AREA IN SQUARE MILES

BUCKEYE ROAD TO PAPAGO FREEWAY

OPERATION	STATION	PEAK FLOW 100-YEAR	BASIN AREA	LAG TIME	CURVE NUMBER
HYDROGRAPH AT	S1	380	0.81	1.37	81
ROUTED TO	C2	379	0.81		
HYDROGRAPH AT	S2	632	2.40	2.81	82
2 COMBINED AT	C2	841	3.21		
ROUTED TO	C3	839	3.21		
HYDROGRAPH AT	S3	239	0.60	1.58	80
2 COMBINED AT	C3	1040	3.81		

THE OUTER LOOP HIGHWAY

BUCKEYE ROAD TO PAPAGO FREEWAY



OFF-SITE HYDROLOGY
100- YEAR

LEGEND

S1	SUBWATERSHED DESIGNATION
C1	CONCENTRATION POINT
	DRAINAGE AREA BOUNDARIES
	MAJOR DRAINAGE PATHS
Q_{100} =	100 - YEAR PEAK DISCHARGE
Q_{50} =	50 - YEAR PEAK DISCHARGE

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

OPERATION	STATION	PEAK FLOW 100-YEAR	BASIN AREA	LAG TIME	CURVE NUMBER
HYDROGRAPH AT	S1	380	0.81	1.37	81
ROUTED TO	C2	379	0.81		
HYDROGRAPH AT	S2	632	2.40	2.81	82
2 COMBINED AT	C2	841	3.21		
ROUTED TO	C3	839	3.21		
HYDROGRAPH AT	S3	239	0.60	1.58	80
2 COMBINED AT	C3	1040	3.81		

0 500 1000 2000 3000

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BASE MAP: USGS 7.5 MINUTE QUADRANGLES

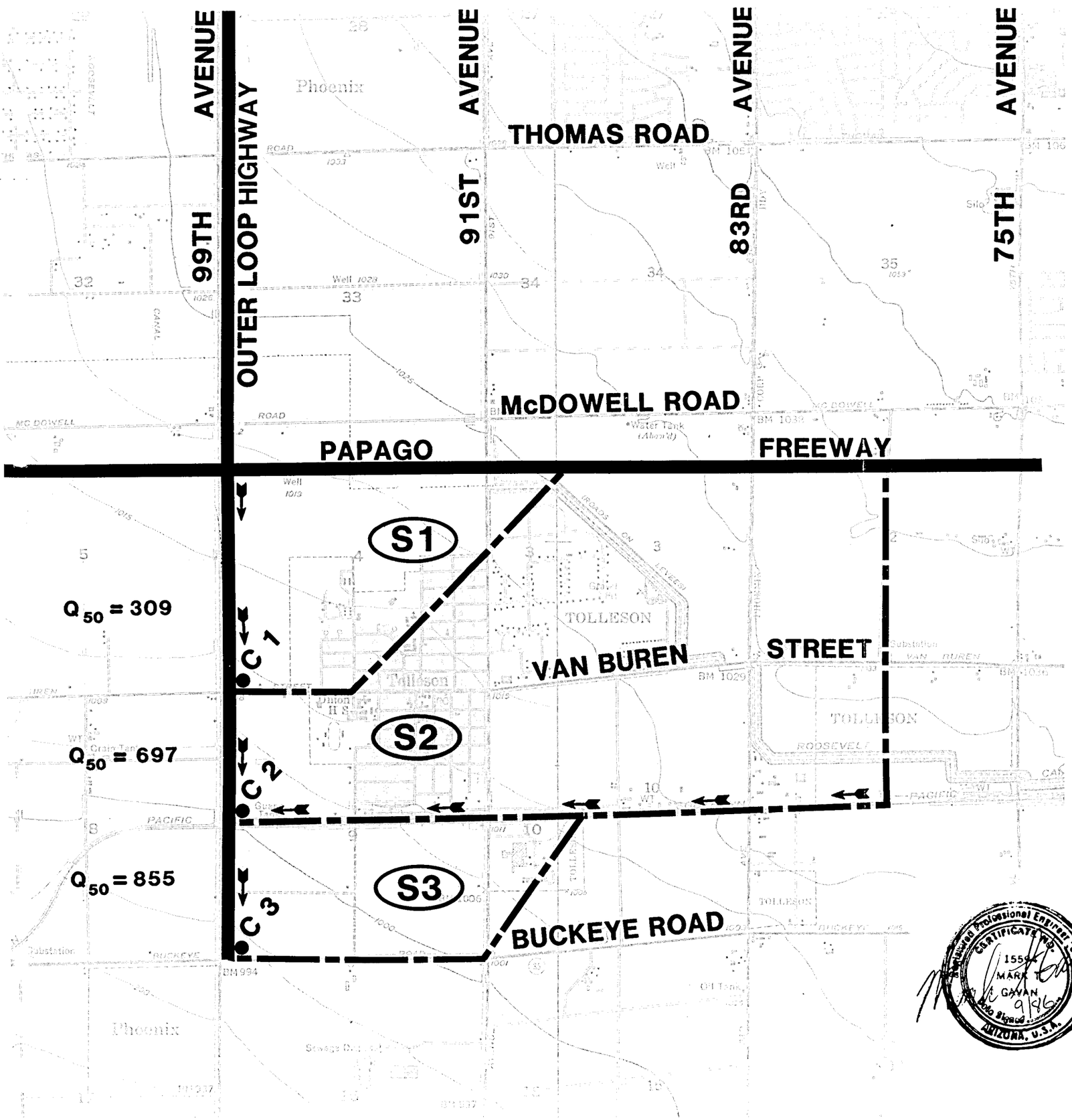
RUNOFF SUMMARY
FLOW IN CUBIC FEET PER SECOND
TIME IN HOURS, AREA IN SQUARE MILES

BUCKEYE ROAD TO PAPAGO FREEWAY

OPERATION	STATION	PEAK FLOW 50-YEAR	BASIN AREA	LAG TIME	CURVE NUMBER
HYDROGRAPH AT	S1	309	0.81	1.37	81
ROUTED TO	C2	308	0.81		
HYDROGRAPH AT	S2	517	2.40	2.81	82
2 COMBINED AT	C2	697	3.21		
ROUTED TO	C3	695	3.21		
HYDROGRAPH AT	S3	193	0.60	1.58	80
2 COMBINED AT	C3	855	3.81		

THE OUTER LOOP HIGHWAY

BUCKEYE ROAD TO PAPAGO FREEWAY



OFF-SITE HYDROLOGY

50 - YEAR

LEGEND

S1	SUBWATERSHED DESIGNATION
C1	CONCENTRATION POINT
	DRAINAGE AREA BOUNDARIES
	MAJOR DRAINAGE PATHS
Q_{100} =	100 - YEAR PEAK DISCHARGE
Q_{50} =	50 - YEAR PEAK DISCHARGE

RUNOFF SUMMARY

FLOW IN CUBIC FEET PER SECOND

TIME IN HOURS, AREA IN SQUARE MILES

OPERATION	STATION	PEAK FLOW 50-YEAR	BASIN AREA	LAG TIME	CURVE NUMBER
HYDROGRAPH AT	S1	309	0.81	1.37	81
ROUTED TO	C2	308	0.81		
HYDROGRAPH AT	S2	517	2.40	2.81	82
2 COMBINED AT	C2	697	3.21		
ROUTED TO	C3	695	3.21		
HYDROGRAPH AT	S3	193	0.60	1.58	80
2 COMBINED AT	C3	855	3.81		

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BASE MAP: USGS 7.5 MINUTE QUADRANGLES

4.2 Papago Freeway to Northern Avenue

As previously explained, the drainage area for this section is complicated by two proposed freeways, the Grand Avenue Expressway and the Paradise Corridor. A Grand Avenue Corridor Study has been prepared that includes low expressway and high expressway alternatives. In the case of the low expressway, the drainage pattern across the expressway would be essentially the same as the existing Grand Avenue. On the other hand, the high expressway alternative would collect flows on the north side of the expressway and convey them to New River and the Agua Fria River in the proposed Olive Avenue storm drain, the proposed Orangewood Avenue storm drain, and the proposed Paradise Corridor collection channel. South of the Paradise Corridor the drainage would be collected along the expressway and conveyed to the Salt River in a proposed 27th Avenue storm drain. A study for the Paradise Corridor has just recently been started and therefore there are no available drainage concepts. However, it is reasonable to assume that drainage collection facilities will have to be constructed which will probably result in a collector channel along the north side of the roadway.

To determine the effect of these proposed freeways, three hydrologic models were developed which are presented as Case A, B, and C. All three cases collect the flows along the Outer Loop in the same manner to allow a direct comparison of flows reaching the Outer Loop. That is, the flows are collected along the Outer Loop and conveyed to New River along Bethany Home Road (on the north side of the Grand Canal) and to the Agua Fria River along Thomas Road. South of the half mile point between McDowell Road and Thomas Road the flows are conveyed to the Papago Channel as they are now under existing conditions.

It should be noted that, in all three cases, it was assumed that a drainage channel will be constructed along the north side of the Grand Canal between the Outer Loop and 83rd Avenue. (Refer to Part B - Concept Designs, under separate cover.) If the channel is not constructed, some of the overland flows would be conveyed west in the Grand Canal and the remainder would flow over the Grand Canal and impact the Outer Loop to the south.

4.2.1. Case A

Case A is the existing condition for the contributing drainage area between the Papago Freeway and Northern Avenue. That is, the proposed Grand Avenue Expressway and the Paradise Corridor were not considered in the delineations of the subwatersheds.

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

CASE A

OPERATION	STATION	PEAK FLOW 100-YEAR	BASIN AREA	LAG TIME	CURVE NUMBER
HYDROGRAPH AT	A1	2731.	7.45	2.26	86
ROUTED TO	CP2	2730.	7.45		
HYDROGRAPH AT	A2	2629.	7.79	2.49	86
2 COMBINED AT	CP2	5232.	15.24		
ROUTED TO	CP3	5230.	15.24		
HYDROGRAPH AT	A3	2279.	6.70	2.47	86
2 COMBINED AT	CP3	7315.	21.94		
ROUTED TO	CP4	7314.	21.94		
HYDROGRAPH AT	A4	2405.	5.80	2.15	88
2 COMBINED AT	CP4	9383.	27.74		
ROUTED TO	CP5	9376.	27.74		
HYDROGRAPH AT	A5	1132.	3.19	1.65	79
2 COMBINED AT	CP5	10107.	30.93		
ROUTED TO	CP6	10102.	30.93		
HYDROGRAPH AT	A6	1274.	2.23	1.22	84
2 COMBINED AT	CP6	10531.	33.16		
ROUTED TO	CP7	10527.	33.16		
HYDROGRAPH AT	A7	874.	1.47	1.17	84
2 COMBINED AT	CP7	10794.	34.63		
ROUTED TO	CP8A	10788.	34.63		
ROUTED TO	CP8	10781.	34.63		
HYDROGRAPH AT	A8	710.	1.19	.83	78
2 COMBINED AT	CP8	10876.	35.82		
ROUTED TO	CP9	10871.	35.82		
HYDROGRAPH AT	A9	161.	0.20	.57	78
2 COMBINED AT	CP9	10879.	36.02		
HYDROGRAPH AT	A9C	89.	0.09	.43	78
ROUTED TO	CP9B	89.	0.09		
HYDROGRAPH AT	A9B	89.	0.09	.43	78
2 COMBINED AT	CP9B	176.	0.19		
ROUTED TO	CP9A	176.	0.19		
HYDROGRAPH AT	A9A	164.	0.19	.49	78

2 COMBINED AT	CP9A	337.	0.37		
ROUTED TO	CP9	334.	0.37		
2 COMBINED AT	CP9	10890.	36.39		
HYDROGRAPH AT	A12	1309.	3.14	1.69	83
ROUTED TO	CP13	1184.	3.14		
HYDROGRAPH AT	A11	1260.	3.30	1.69	81
ROUTED TO	CP13	1134.	3.30		
HYDROGRAPH AT	A13	1417.	4.10	2.00	82
3 COMBINED AT	CP13	3363.	10.54		
ROUTED TO	CP14	3362.	10.54		
HYDROGRAPH AT	A10	2623.	6.33	1.69	83
ROUTED TO	CP14	2377.	6.33		
HYDROGRAPH AT	A14	1536.	5.29	2.20	80
2 COMBINED AT	CP14	3705.	11.62		
2 COMBINED AT	CP14	6785.	22.16		
ROUTED TO	CP18	6769.	22.16		
HYDROGRAPH AT	A18	416.	0.70	.79	77
2 COMBINED AT	CP18	6794.	22.86		
HYDROGRAPH AT	A15	791.	1.77	1.12	77
ROUTED TO	CP16	786.	1.77		
HYDROGRAPH AT	A16	1821.	5.31	1.91	81
2 COMBINED AT	CP16	2401.	7.08		
ROUTED TO	CP17	2398.	7.08		
HYDROGRAPH AT	A17	1632.	6.28	2.78	82
2 COMBINED AT	CP17	3633.	13.36		
HYDROGRAPH AT	A17A	331.	0.50	.73	78
2 COMBINED AT	CP17	3687.	13.86		
ROUTED TO	CP19	3664.	13.86		
HYDROGRAPH AT	A19	460.	1.32	1.43	76
2 COMBINED AT	CP19	3956	15.18		

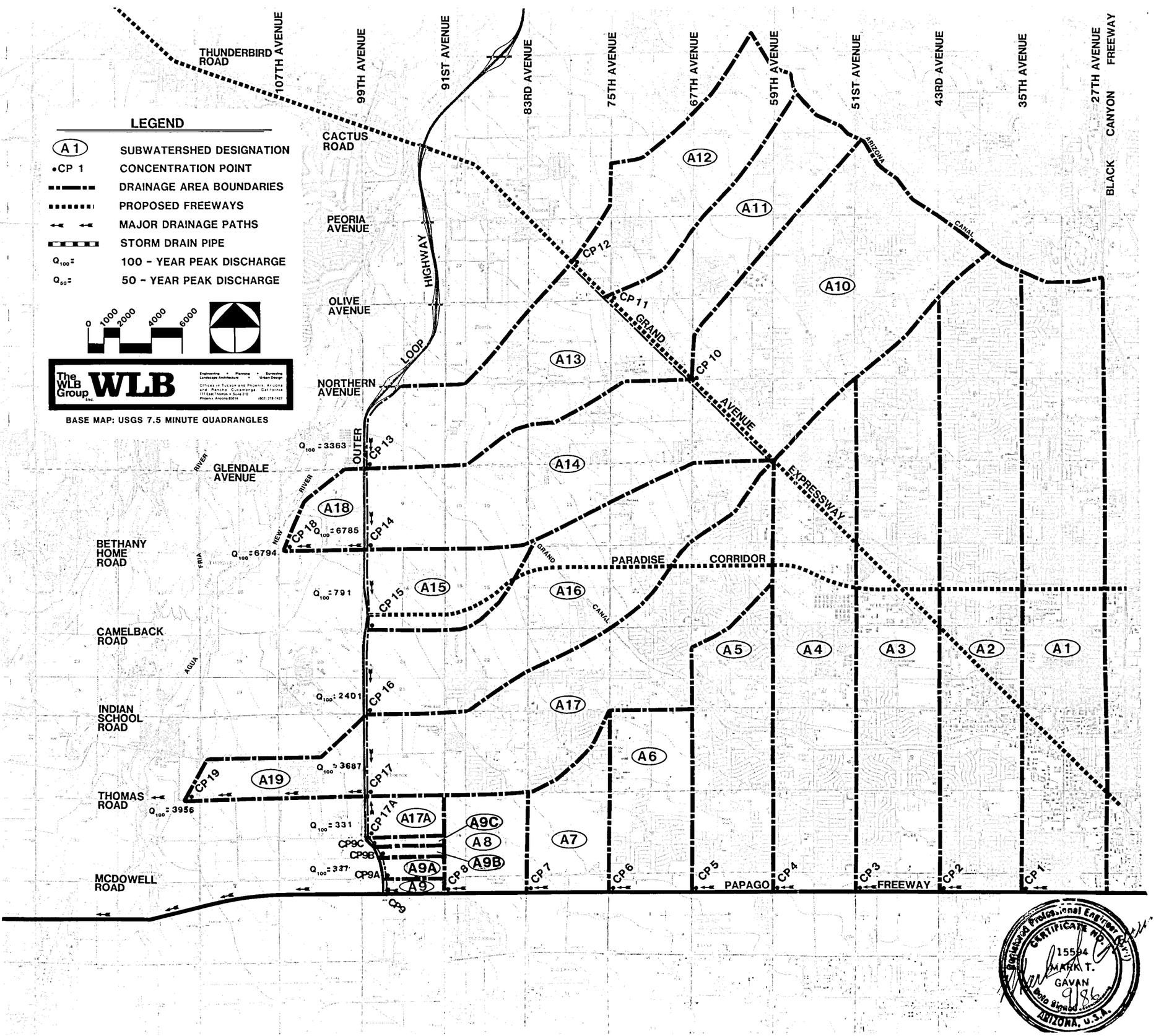
THE OUTER LOOP HIGHWAY

PAPAGO FREEWAY TO NORTHERN AVENUE

OFF-SITE HYDROLOGY
100 - YEAR STORM

CASE (A)

EXISTING FLOW PATTERN WITHOUT THE EFFECTS FROM THE PROPOSED PARADISE CORRIDOR AND GRAND AVENUE EXPRESSWAY.



RUNOFF SUMMARY

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

OPERATION	STATION	PEAK FLOW 100-YEAR	BASIN AREA	LAG TIME	CURVE NUMBER
HYDROGRAPH AT	A1	2731.	7.45	2.26	86
ROUTED TO	CP2	2730.	7.45		
HYDROGRAPH AT	A2	2629.	7.79	2.49	86
2 COMBINED AT	CP2	5232.	15.24		
ROUTED TO	CP3	5230.	15.24		
HYDROGRAPH AT	A3	2279.	6.70	2.47	86
2 COMBINED AT	CP3	7315.	21.94		
ROUTED TO	CP4	7314.	21.94		
HYDROGRAPH AT	A4	2405.	5.80	2.15	88
2 COMBINED AT	CP4	9383.	27.74		
ROUTED TO	CP5	9376.	27.74		
HYDROGRAPH AT	A5	1132.	3.19	1.65	79
2 COMBINED AT	CP5	10107.	30.93		
ROUTED TO	CP6	10102.	30.93		
HYDROGRAPH AT	A6	1274.	2.23	1.22	84
2 COMBINED AT	CP6	10531.	33.16		
ROUTED TO	CP7	10527.	33.16		
HYDROGRAPH AT	A7	874.	1.47	1.17	84
2 COMBINED AT	CP7	10794.	34.63		
ROUTED TO	CP8A	10788.	34.63		
ROUTED TO	CP8	10781.	34.63		
HYDROGRAPH AT	A8	710.	1.19	.83	78
2 COMBINED AT	CP8	10876.	35.82		
ROUTED TO	CP9	10871.	35.82		
HYDROGRAPH AT	A9	161.	0.20	.57	78
2 COMBINED AT	CP9	10879.	36.02		
HYDROGRAPH AT	A9C	89.	0.09	.43	78
ROUTED TO	CP9B	89.	0.09		
HYDROGRAPH AT	A9B	89.	0.09	.43	78
2 COMBINED AT	CP9B	176.	0.19		
ROUTED TO	CP9A	176.	0.19		
HYDROGRAPH AT	A9A	164.	0.19	.49	78
2 COMBINED AT	CP9A	337.	0.37		
ROUTED TO	CP9	334.	0.37		
2 COMBINED AT	CP9	10890.	36.39		
HYDROGRAPH AT	A12	1309.	3.14	1.69	83
ROUTED TO	CP13	1184.	3.14		
HYDROGRAPH AT	A11	1260.	3.30	1.69	81
ROUTED TO	CP13	1134.	3.30		
HYDROGRAPH AT	A13	1417.	4.10	2.00	82
3 COMBINED AT	CP13	3363.	10.54		
ROUTED TO	CP14	3362.	10.54		
HYDROGRAPH AT	A10	2623.	6.33	1.69	83
ROUTED TO	CP14	2377.	6.33		
HYDROGRAPH AT	A14	1536.	5.29	2.20	80
2 COMBINED AT	CP14	3705.	11.62		
2 COMBINED AT	CP14	6785.	22.16		
ROUTED TO	CP18	6769.	22.16		
HYDROGRAPH AT	A18	416.	0.70	.79	77
2 COMBINED AT	CP18	6794.	22.86		
HYDROGRAPH AT	A15	791.	1.77	1.12	77
ROUTED TO	CP16	786.	1.77		
HYDROGRAPH AT	A16	1821.	5.31	1.91	81
2 COMBINED AT	CP16	2401.	7.08		
ROUTED TO	CP17	2398.	7.08		
HYDROGRAPH AT	A17	1632.	6.28	2.78	82
2 COMBINED AT	CP17	3633.	13.36		
HYDROGRAPH AT	A17A	331.	0.50	.73	78
2 COMBINED AT	CP17	3687.	13.86		
ROUTED TO	CP19	3664.	13.86		
HYDROGRAPH AT	A19	460.	1.32	1.43	76
2 COMBINED AT	CP19	3956	15.18		

Registered Professional Engineer (Civil)
CERTIFICATE NO. 15594
MARK T. GAVAN
Date Signed 9/86
ARIZONA, U.S.A.

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

CASE A

OPERATION	STATION	PEAK FLOW 50-YEAR	BASIN AREA	LAG TIME	CURVE NUMBER
HYDROGRAPH AT	A1	2281.	7.45	2.26	86
ROUTED TO	CP2	2279.	7.45		
HYDROGRAPH AT	A2	2195.	7.79	2.49	86
2 COMBINED AT	CP2	4367.	15.24		
ROUTED TO	CP3	4364.	15.24		
HYDROGRAPH AT	A3	1903.	6.70	2.47	86
2 COMBINED AT	CP3	6103.	21.94		
ROUTED TO	CP4	6102.	21.94		
HYDROGRAPH AT	A4	2029.	5.80	2.15	88
2 COMBINED AT	CP4	7841.	27.74		
ROUTED TO	CP5	7839.	27.74		
HYDROGRAPH AT	A5	910.	3.19	1.65	79
2 COMBINED AT	CP5	8418.	30.93		
ROUTED TO	CP6	8411.	30.93		
HYDROGRAPH AT	A6	1054.	2.23	1.22	84
2 COMBINED AT	CP6	8763.	33.16		
ROUTED TO	CP7	8754.	33.16		
HYDROGRAPH AT	A7	722.	1.47	1.17	84
2 COMBINED AT	CP7	8973.	34.63		
ROUTED TO	CP8A	8964.	34.63		
ROUTED TO	CP8	8963.	34.63		
HYDROGRAPH AT	A8	566.	1.19	.83	78
2 COMBINED AT	CP8	9032.	35.82		
ROUTED TO	CP9	9028.	35.82		
HYDROGRAPH AT	A9	128.	0.20	.57	78
2 COMBINED AT	CP9	9034.	36.02		
HYDROGRAPH AT	A9C	71.	0.09	.43	78
ROUTED TO	CP9B	71.	0.09		
HYDROGRAPH AT	A9B	71.	0.09	.43	78
2 COMBINED AT	CP9B	140.	0.19		
ROUTED TO	CP9A	140.	0.19		

HYDROGRAPH AT	A9A	131.	0.19	.49	78
2 COMBINED AT	CP9A	268.	0.37		
ROUTED TO	CP9	265.	0.37		
2 COMBINED AT	CP9	9044.	36.39		
HYDROGRAPH AT	A12	1077.	3.14	1.69	83
ROUTED TO	CP13	957.	3.14		
HYDROGRAPH AT	A11	1025.	3.30	1.69	81
ROUTED TO	CP13	906.	3.30		
HYDROGRAPH AT	A13	1158.	4.10	2.00	82
3 COMBINED AT	CP13	2677.	10.54		
ROUTED TO	CP14	2676.	10.54		
HYDROGRAPH AT	A10	2158.	6.33	1.69	83
ROUTED TO	CP14	1929.	6.33		
HYDROGRAPH AT	A14	1242.	5.29	2.20	80
2 COMBINED AT	CP14	2970.	11.62		
2 COMBINED AT	CP14	5413.	22.16		
ROUTED TO	CP18	5400.	22.16		
HYDROGRAPH AT	A18	328.	0.70	.79	77
2 COMBINED AT	CP18	5420.	22.86		
HYDROGRAPH AT	A15	628.	1.77	1.12	77
ROUTED TO	CP16	623.	1.77		
HYDROGRAPH AT	A16	1480.	5.31	1.91	81
2 COMBINED AT	CP16	1943.	7.08		
ROUTED TO	CP17	1942.	7.08		
HYDROGRAPH AT	A17	1335.	6.28	2.78	82
2 COMBINED AT	CP17	2958.	13.36		
HYDROGRAPH AT	A17A	264.	0.50	.73	78
2 COMBINED AT	CP17	3001.	13.86		
ROUTED TO	CP19	2976.	13.86		
HYDROGRAPH AT	A19	363.	1.32	1.93	76
2 COMBINED AT	CP19	3200.	15.18		

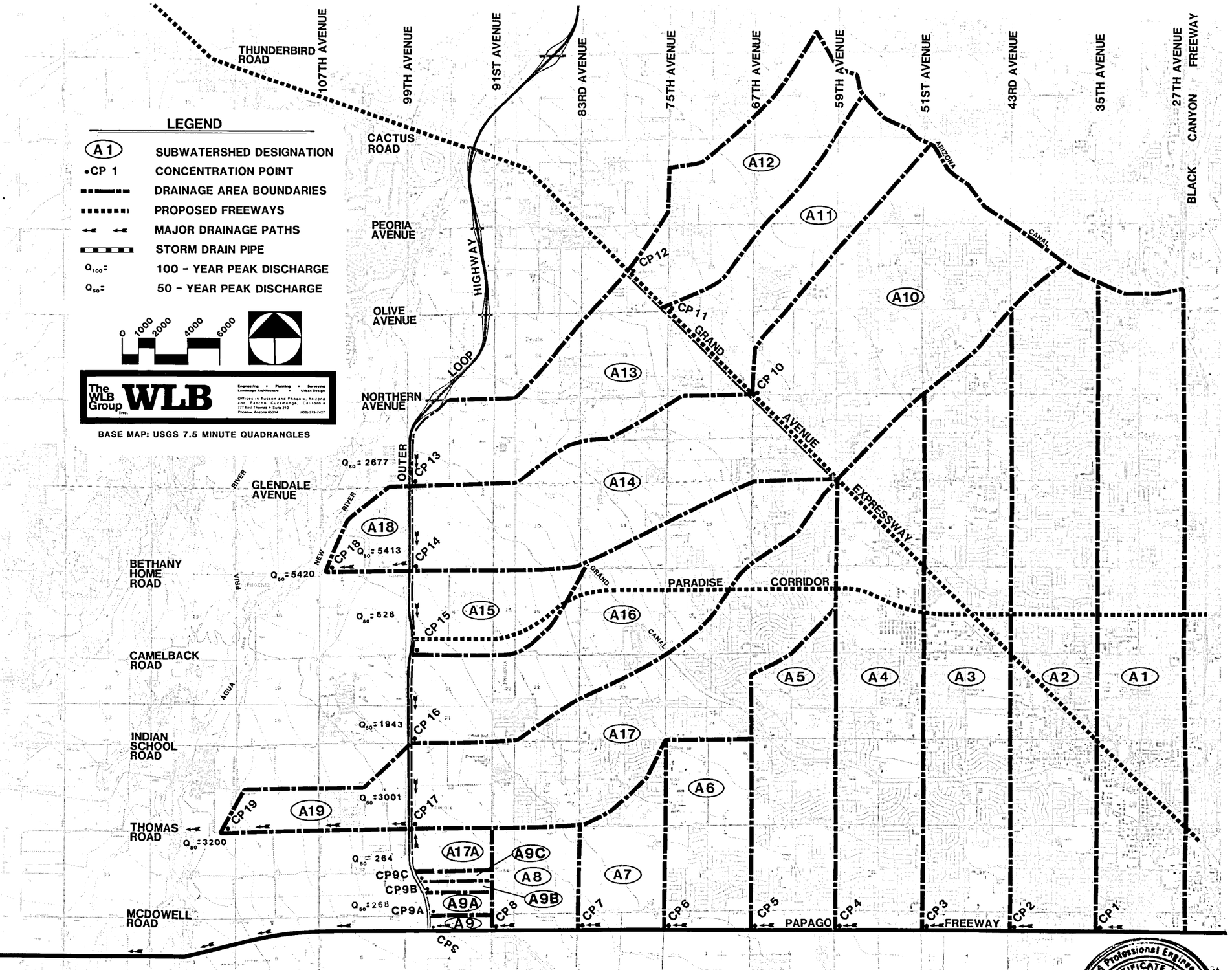
THE OUTER LOOP HIGHWAY

PAPAGO FREEWAY TO NORTHERN AVENUE

OFF-SITE HYDROLOGY
50 - YEAR STORM

CASE (A)

EXISTING FLOW PATTERN WITHOUT THE EFFECTS FROM THE PROPOSED PARADISE CORRIDOR AND GRAND AVENUE EXPRESSWAY.



RUNOFF SUMMARY

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

OPERATION	STATION	PEAK FLOW 50-YEAR	BASIN AREA	LAG TIME	CURVE NUMBER
HYDROGRAPH AT	A1	2281.	7.45	2.26	86
ROUTED TO	CP2	2279.	7.45		
HYDROGRAPH AT	A2	2195.	7.79	2.49	86
2 COMBINED AT	CP2	4367.	15.24		
ROUTED TO	CP3	4364.	15.24		
HYDROGRAPH AT	A3	1903.	6.70	2.47	86
2 COMBINED AT	CP3	6103.	21.94		
ROUTED TO	CP4	6102.	21.94		
HYDROGRAPH AT	A4	2029.	5.80	2.15	88
2 COMBINED AT	CP4	7841.	27.74		
ROUTED TO	CP5	7839.	27.74		
HYDROGRAPH AT	A5	910.	3.19	1.65	79
2 COMBINED AT	CP5	8418.	30.93		
ROUTED TO	CP6	8411.	30.93		
HYDROGRAPH AT	A6	1054.	2.23	1.22	84
2 COMBINED AT	CP6	8763.	33.16		
ROUTED TO	CP7	8754.	33.16		
HYDROGRAPH AT	A7	722.	1.47	1.17	84
2 COMBINED AT	CP7	8973.	34.63		
ROUTED TO	CP8A	8964.	34.63		
ROUTED TO	CP8	8963.	34.63		
HYDROGRAPH AT	A8	566.	1.19	.83	78
2 COMBINED AT	CP8	9032.	35.82		
ROUTED TO	CP9	9028.	35.82		
HYDROGRAPH AT	A9	128.	0.20	.57	78
2 COMBINED AT	CP9	9034.	36.02		
HYDROGRAPH AT	A9C	71.	0.09	.43	78
ROUTED TO	CP9B	71.	0.09		
HYDROGRAPH AT	A9B	71.	0.09	.43	78
2 COMBINED AT	CP9B	140.	0.19		
ROUTED TO	CP9A	140.	0.19		
HYDROGRAPH AT	A9A	131.	0.19	.49	78
2 COMBINED AT	CP9A	268.	0.37		
ROUTED TO	CP9	265.	0.37		
2 COMBINED AT	CP9	9044.	36.39		
HYDROGRAPH AT	A12	1077.	3.14	1.69	83
ROUTED TO	CP13	957.	3.14		
HYDROGRAPH AT	A11	1025.	3.30	1.69	81
ROUTED TO	CP13	906.	3.30		
HYDROGRAPH AT	A13	1158.	4.10	2.00	82
3 COMBINED AT	CP13	2677.	10.54		
ROUTED TO	CP14	2676.	10.54		
HYDROGRAPH AT	A10	2158.	6.33	1.69	83
ROUTED TO	CP14	1929.	6.33		
HYDROGRAPH AT	A14	1242.	5.29	2.20	80
2 COMBINED AT	CP14	2970.	11.62		
2 COMBINED AT	CP14	5413.	22.16		
ROUTED TO	CP18	5400.	22.16		
HYDROGRAPH AT	A18	328.	0.70	.79	77
2 COMBINED AT	CP18	5420.	22.86		
HYDROGRAPH AT	A15	628.	1.77	1.12	77
ROUTED TO	CP16	623.	1.77		
HYDROGRAPH AT	A16	1480.	5.31	1.91	81
2 COMBINED AT	CP16	1943.	7.08		
ROUTED TO	CP17	1942.	7.08		
HYDROGRAPH AT	A17	1335.	6.28	2.78	82
2 COMBINED AT	CP17	2958.	13.36		
HYDROGRAPH AT	A17A	264.	0.50	.73	78
2 COMBINED AT	CP17	3001.	13.86		
ROUTED TO	CP19	2976.	13.86		
HYDROGRAPH AT	A19	363.	1.32	1.93	76
2 COMBINED AT	CP19	3200.	15.18		

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Date Signed 9/86
ARIZONA, U.S.A.

4.2.2 Case B

Case B assumes that there will be a collector channel along the north side of the Paradise Corridor which will convey flows to the Outer Loop. This model also assumes that the Grand Avenue Expressway will be constructed as a low level facility which will not significantly alter the existing drainage patterns.

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

CASE B

OPERATION	STATION	PEAK FLOW 100-YEAR	BASIN AREA	LAG TIME	CURVE NUMBER
HYDROGRAPH AT	B1	1865.	3.82	1.62	86
ROUTED TO	CP2	1862.	3.82		
HYDROGRAPH AT	B2	2133.	3.94	1.50	87
2 COMBINED AT	CP2	3949.	7.76		
ROUTED TO	CP3	3941.	7.76		
HYDROGRAPH AT	B3	1715.	3.45	1.56	86
2 COMBINED AT	CP3	5595.	11.30		
ROUTED TO	CP4	5591.	11.30		
HYDROGRAPH AT	B4	2016.	4.00	1.56	86
2 COMBINED AT	CP4	7444.	15.30		
ROUTED TO	CP5	7426.	15.30		
HYDROGRAPH AT	B5	1132.	3.19	1.65	79
2 COMBINED AT	CP5	8433.	18.49		
ROUTED TO	CP6	8431.	18.49		
HYDROGRAPH AT	B6	1274.	2.23	1.22	84
2 COMBINED AT	CP6	9320.	20.72		
ROUTED TO	CP7	9320.	20.72		
HYDROGRAPH AT	B7	874.	1.47	1.17	84
2 COMBINED AT	CP7	9869.	22.19		
ROUTED TO	CP8A	9862.	22.19		
ROUTED TO	CP8	9846.	22.19		
HYDROGRAPH AT	B8	710.	1.19	.83	78
2 COMBINED AT	CP8	10065.	23.38		
ROUTED TO	CP9	10053.	23.38		
HYDROGRAPH AT	B9	161.	0.20	.57	78
2 COMBINED AT	CP9	10070.	23.58		
HYDROGRAPH AT	B9C	89.	0.09	.43	78
ROUTED TO	CP9B	89.	0.09		
HYDROGRAPH AT	B9B	89.	0.09	.43	78
2 COMBINED AT	CP9B	176.	0.19		
ROUTED TO	CP9A	176.	0.19		
HYDROGRAPH AT	B9A	164.	0.19	.49	78

2 COMBINED AT	CP9A	337.	0.37		
ROUTED TO	CP9	334.	0.37		
2 COMBINED AT	CP9	10095.	23.95		
HYDROGRAPH AT	B20	909.	1.51	.77	77
ROUTED TO	CP21	887.	1.51		
HYDROGRAPH AT	B21	1242.	3.61	1.91	81
2 COMBINED AT	CP21	1651.	5.12		
ROUTED TO	CP22	1650.	5.12		
HYDROGRAPH AT	B22	1433.	5.57	2.96	83
2 COMBINED AT	CP22	2685.	10.69		
HYDROGRAPH AT	B22A	331.	0.50	.73	78
2 COMBINED AT	CP22	2733.	11.19		
ROUTED TO	CP25	2715.	11.19		
HYDROGRAPH AT	B25	460.	1.32	1.43	76
2 COMBINED AT	CP25	2988.	12.51		
HYDROGRAPH AT	B10	1730.	3.63	1.59	85
ROUTED TO	CP11	1727.	3.63		
HYDROGRAPH AT	B11	1834.	3.85	1.59	85
2 COMBINED AT	CP11	3537.	7.48		
ROUTED TO	CP12	3528.	7.48		
HYDROGRAPH AT	B12	1530.	3.16	1.64	86
2 COMBINED AT	CP12	5017.	10.64		
ROUTED TO	CP13	5017.	10.64		
HYDROGRAPH AT	B13	1326.	1.80	1.24	91
2 COMBINED AT	CP13	6014.	12.44		
ROUTED TO	CP14	6006.	12.44		
HYDROGRAPH AT	B14	591.	0.71	.85	86
2 COMBINED AT	CP14	6227.	13.15		
ROUTED TO	CP23	6221.	13.15		
HYDROGRAPH AT	B23	949.	1.96	1.35	82
2 COMBINED AT	CP23	7034.	15.11		
ROUTED TO	CP19	7017.	15.11		
HYDROGRAPH AT	B15	2623.	6.33	1.69	83
ROUTED TO	CP19	2377.	6.33		
HYDROGRAPH AT	B19	1536.	5.29	2.20	80
2 COMBINED AT	CP19	3705.	11.62		
2 COMBINED AT	CP19	8570.	26.73		
HYDROGRAPH AT	B17	1309.	3.14	1.69	83
ROUTED TO	CP18	1184.	3.14		
HYDROGRAPH AT	B16	1260.	3.30	1.69	83
ROUTED TO	CP18	1134.	3.30		
HYDROGRAPH AT	B18	1417.	4.10	2.00	82

3 COMBINED AT	CP18	3363.	10.54		
ROUTED TO	CP19	3362.	10.54		
2 COMBINED AT	CP19	10868.	37.27		
ROUTED TO	CP24	10866.	37.27		
HYDROGRAPH AT	B24	416.	0.70	.79	77
2 COMBINED AT	CP24	10899.	37.97		

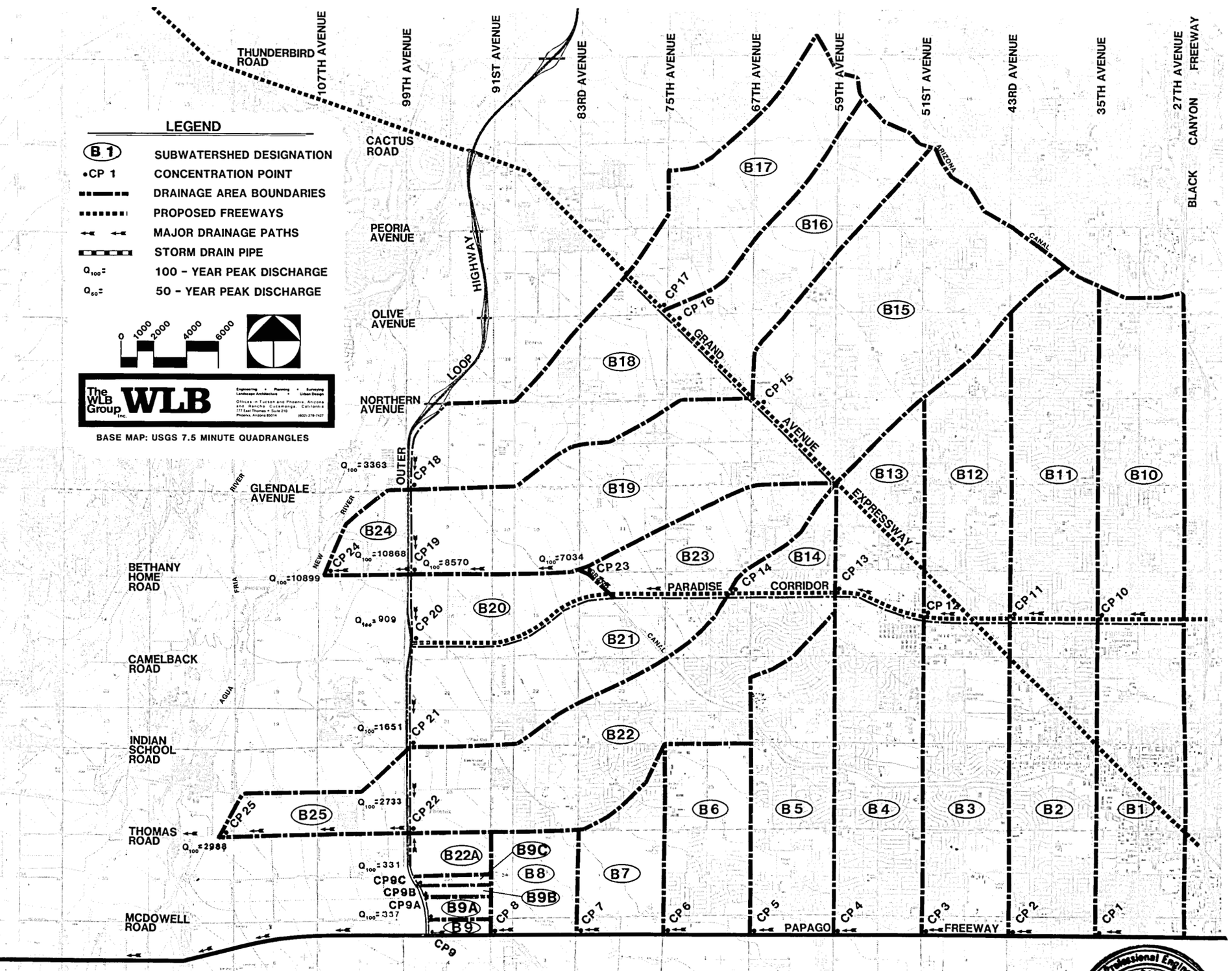
THE OUTER LOOP HIGHWAY

PAPAGO FREEWAY TO NORTHERN AVENUE

OFF-SITE HYDROLOGY
100 - YEAR STORM

CASE (B)

INTERCEPTOR CHANNEL ALONG THE NORTH SIDE OF THE PARADISE CORRIDOR AND THE GRAND AVENUE EXPRESSWAY AS A LOW LEVEL FACILITY.



RUNOFF SUMMARY

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

OPERATION	STATION	PEAK FLOW 100-YEAR	BASIN AREA	LAG TIME	CURVE NUMBER
HYDROGRAPH AT	B1	1865.	3.82	1.62	86
ROUTED TO	CP2	1862.	3.82		
HYDROGRAPH AT	B2	2133.	3.94	1.50	87
2 COMBINED AT	CP2	3949.	7.76		
ROUTED TO	CP3	3941.	7.76		
HYDROGRAPH AT	B3	1715.	3.45	1.56	86
2 COMBINED AT	CP3	5595.	11.30		
ROUTED TO	CP4	5591.	11.30		
HYDROGRAPH AT	B4	2016.	4.00	1.56	86
2 COMBINED AT	CP4	7444.	15.30		
ROUTED TO	CP5	7426.	15.30		
HYDROGRAPH AT	B5	1132.	3.19	1.65	79
2 COMBINED AT	CP5	8433.	18.49		
ROUTED TO	CP6	8431.	18.49		
HYDROGRAPH AT	B6	1274.	2.23	1.22	84
2 COMBINED AT	CP6	9320.	20.72		
ROUTED TO	CP7	9320.	20.72		
HYDROGRAPH AT	B7	874.	1.47	1.17	84
2 COMBINED AT	CP7	9869.	22.19		
ROUTED TO	CP8A	9862.	22.19		
ROUTED TO	CP8	9846.	22.19		
HYDROGRAPH AT	B8	710.	1.19	.83	78
2 COMBINED AT	CP8	10065.	23.38		
ROUTED TO	CP9	10053.	23.38		
HYDROGRAPH AT	B9	161.	0.20	.57	78
2 COMBINED AT	CP9	10070.	23.58		
HYDROGRAPH AT	B9C	89.	0.09	.43	78
ROUTED TO	CP9B	89.	0.09		
HYDROGRAPH AT	B9B	89.	0.09	.43	78
2 COMBINED AT	CP9B	176.	0.19		
ROUTED TO	CP9A	176.	0.19		
HYDROGRAPH AT	B9A	164.	0.19	.49	78
2 COMBINED AT	CP9A	337.	0.37		
ROUTED TO	CP9	334.	0.37		
2 COMBINED AT	CP9	10095.	23.95		
HYDROGRAPH AT	B20	909.	1.51	.77	77
ROUTED TO	CP21	887.	1.51		
HYDROGRAPH AT	B21	1242.	3.61	1.91	81
2 COMBINED AT	CP21	1651.	5.12		
ROUTED TO	CP22	1650.	5.12		
HYDROGRAPH AT	B22	1433.	5.57	2.96	83
2 COMBINED AT	CP22	2685.	10.69		
HYDROGRAPH AT	B22A	331.	0.50	.73	78
2 COMBINED AT	CP22	2733.	11.19		
ROUTED TO	CP25	2715.	11.19		
HYDROGRAPH AT	B25	460.	1.32	1.43	76
2 COMBINED AT	CP25	2988.	12.51		
HYDROGRAPH AT	B10	1730.	3.63	1.59	85
ROUTED TO	CP11	1727.	3.63		
HYDROGRAPH AT	B11	1834.	3.85	1.59	85
2 COMBINED AT	CP11	3537.	7.48		
ROUTED TO	CP12	3528.	7.48		
HYDROGRAPH AT	B12	1530.	3.16	1.64	86
2 COMBINED AT	CP12	5017.	10.64		
ROUTED TO	CP13	5017.	10.64		
HYDROGRAPH AT	B13	1326.	1.80	1.24	91
2 COMBINED AT	CP13	6014.	12.44		
ROUTED TO	CP14	6006.	12.44		
HYDROGRAPH AT	B14	591.	0.71	.85	86
2 COMBINED AT	CP14	6227.	13.15		
ROUTED TO	CP23	6221.	13.15		
HYDROGRAPH AT	B23	949.	1.96	1.35	82
2 COMBINED AT	CP23	7034.	15.11		
ROUTED TO	CP19	7017.	15.11		
HYDROGRAPH AT	B15	2623.	6.33	1.69	83
ROUTED TO	CP19	2377.	6.33		
HYDROGRAPH AT	B19	1536.	5.29	2.20	80
2 COMBINED AT	CP19	3705.	11.62		
2 COMBINED AT	CP19	8570.	26.73		
HYDROGRAPH AT	B17	1309.	3.14	1.69	83
ROUTED TO	CP18	1184.	3.14		
HYDROGRAPH AT	B16	1260.	3.30	1.69	83
ROUTED TO	CP18	1134.	3.30		
HYDROGRAPH AT	B18	1417.	4.10	2.00	82
3 COMBINED AT	CP18	3363.	10.54		
ROUTED TO	CP19	3362.	10.54		
2 COMBINED AT	CP19	10868.	37.27		
ROUTED TO	CP24	10866.	37.27		
HYDROGRAPH AT	B24	416.	0.70	.79	77
2 COMBINED AT	CP24	10899.	37.97		

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9/86
ARIZONA, U.S.A.

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

CASE B

OPERATION	STATION	PEAK FLOW 50-YEAR	BASIN AREA	LAG TIME	CURVE NUMBER
HYDROGRAPH AT	B1	1559.	3.82	1.62	86
ROUTED TO	CP2	1554.	3.82		
HYDROGRAPH AT	B2	1790.	3.94	1.50	87
2 COMBINED AT	CP2	3303.	7.76		
ROUTED TO	CP3	3296.	7.76		
HYDROGRAPH AT	B3	1425.	3.54	1.56	86
2 COMBINED AT	CP3	4667.	11.30		
ROUTED TO	CP4	4666.	11.30		
HYDROGRAPH AT	B4	1684.	4.00	1.56	86
2 COMBINED AT	CP4	6215.	15.30		
ROUTED TO	CP5	6205.	15.30		
HYDROGRAPH AT	B5	910.	3.19	1.65	79
2 COMBINED AT	CP5	7010.	18.49		
ROUTED TO	CP6	6994.	18.49		
HYDROGRAPH AT	B6	1054.	2.23	1.22	84
2 COMBINED AT	CP6	7736.	20.72		
ROUTED TO	CP7	7719.	20.72		
HYDROGRAPH AT	B7	722.	1.47	1.17	84
2 COMBINED AT	CP7	8178.	22.19		
ROUTED TO	CP8A	8157.	22.19		
ROUTED TO	CP8	8150.	22.19		
HYDROGRAPH AT	B8	566.	1.19	.83	78
2 COMBINED AT	CP8	8312.	23.38		
ROUTED TO	CP9	8311.	23.38		
HYDROGRAPH AT	B9	128.	0.20	.57	78
2 COMBINED AT	CP9	8325.	23.58		
HYDROGRAPH AT	B9C	71.	0.09	.43	78
ROUTED TO	CP9B	71.	0.09		
HYDROGRAPH AT	B9B	71.	0.09	.43	78
2 COMBINED AT	CP9B	140.	0.19		
ROUTED TO	CP9A	140.	0.19		
HYDROGRAPH AT	B9A	131.	0.19	.49	78

2 COMBINED AT	CP9A	268.	0.37		
ROUTED TO	CP9	265.	0.37		
2 COMBINED AT	CP9	8344.	23.95		
HYDROGRAPH AT	B20	719.	1.51	.77	77
ROUTED TO	CP21	700.	1.51		
HYDROGRAPH AT	B21	1010.	3.61	1.91	81
2 COMBINED AT	CP21	1337.	5.12		
ROUTED TO	CP22	1337.	5.12		
HYDROGRAPH AT	B22	1179.	5.57	2.96	83
2 COMBINED AT	CP22	2193.	10.69		
HYDROGRAPH AT	B22A	264.	0.50	.73	78
2 COMBINED AT	CP22	2232.	11.19		
ROUTED TO	CP25	2208.	11.19		
HYDROGRAPH AT	B25	363.	1.32	1.43	76
2 COMBINED AT	CP25	2423.	12.51		
HYDROGRAPH AT	B10	1438.	3.63	1.59	85
ROUTED TO	CP11	1433.	3.63		
HYDROGRAPH AT	B11	1524.	3.85	1.59	85
2 COMBINED AT	CP11	2938.	7.48		
ROUTED TO	CP12	2930.	7.48		
HYDROGRAPH AT	B12	1279.	3.16	1.64	86
2 COMBINED AT	CP12	4168.	10.64		
ROUTED TO	CP13	4167.	10.64		
HYDROGRAPH AT	B13	1134.	1.80	1.24	91
2 COMBINED AT	CP13	5039.	12.44		
ROUTED TO	CP14	5032.	12.44		
HYDROGRAPH AT	B14	493.	0.71	.85	86
2 COMBINED AT	CP14	5213.	13.15		
ROUTED TO	CP23	5207.	13.15		
HYDROGRAPH AT	B23	775.	1.96	1.35	82
2 COMBINED AT	CP23	5847.	15.11		
ROUTED TO	CP19	5836.	15.11		
HYDROGRAPH AT	B15	2158.	6.33	1.69	83
ROUTED TO	CP19	1929.	6.33		
HYDROGRAPH AT	B19	1242.	5.29	2.20	80
2 COMBINED AT	CP19	2970.	11.62		
2 COMBINED AT	CP19	6940.	26.73		
HYDROGRAPH AT	B17	1077.	3.14	1.69	83
ROUTED TO	CP18	957.	3.14		
HYDROGRAPH AT	B16	1025.	3.30	1.69	81
ROUTED TO	CP18	906.	3.30		
HYDROGRAPH AT	B18	1158.	4.10	2.00	82

3 COMBINED AT	CP18	2677.	10.54		
ROUTED TO	CP19	2676.	10.54		
2 COMBINED AT	CP19	8711.	37.27		
ROUTED TO	CP24	8703.	37.27		
HYDROGRAPH AT	B24	328.	0.70	.79	77
2 COMBINED AT	CP24	8731.	37.97		

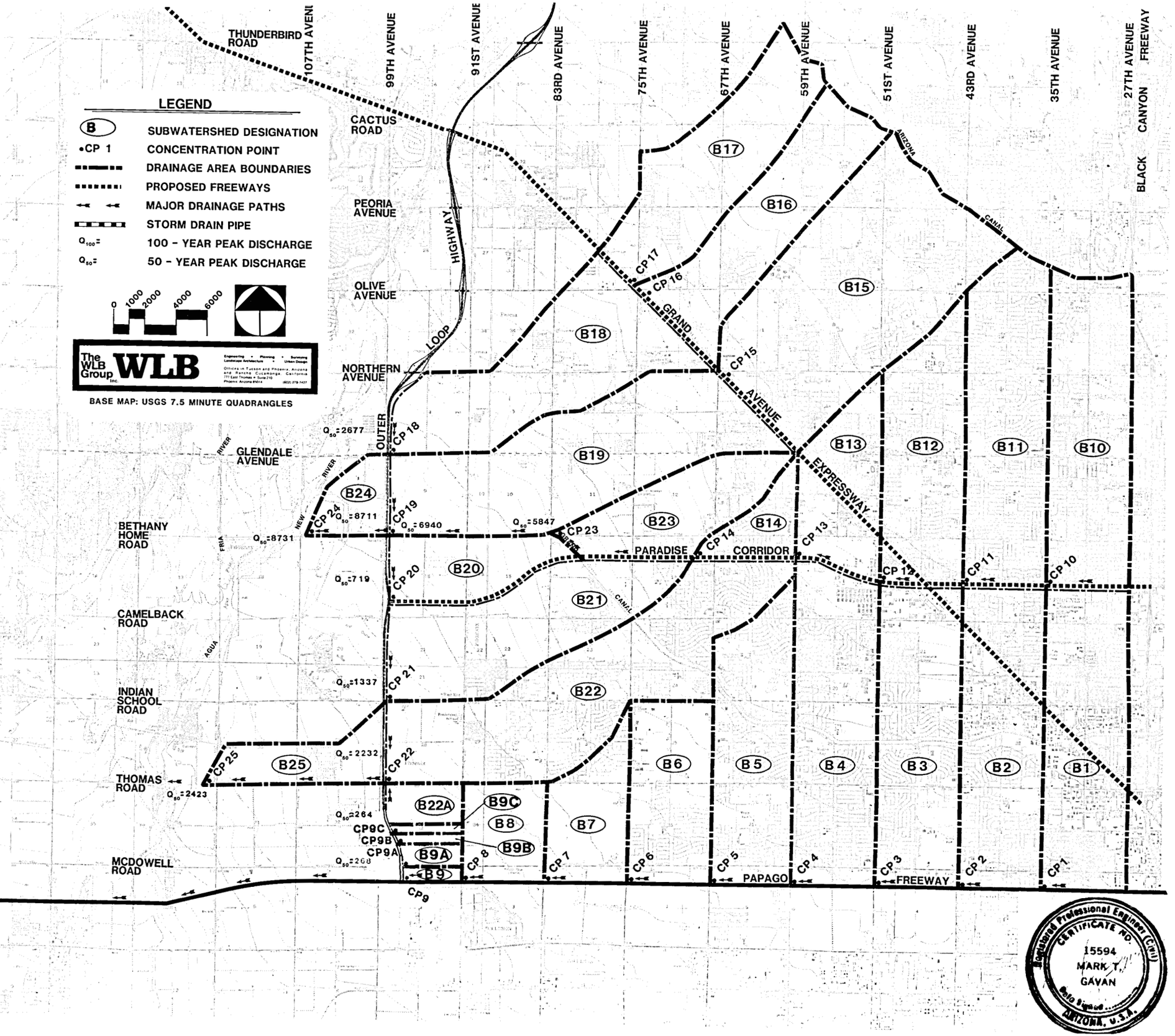
THE OUTER LOOP HIGHWAY

PAPAGO FREEWAY TO NORTHERN AVENUE

OFF-SITE HYDROLOGY
50 - YEAR STORM

CASE (B)

INTERCEPTOR CHANNEL ALONG THE NORTH SIDE OF THE PARADISE CORRIDOR AND THE GRAND AVENUE EXPRESSWAY AS A LOW LEVEL FACILITY.



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

OPERATION	STATION	PEAK FLOW 50-YEAR	BASIN AREA	LAG TIME	CURVE NUMBER
HYDROGRAPH AT	B1	1559.	3.82	1.62	86
ROUTED TO	CP2	1554.	3.82		
HYDROGRAPH AT	B2	1790.	3.94	1.50	87
2 COMBINED AT	CP2	3303.	7.76		
ROUTED TO	CP3	3296.	7.76		
HYDROGRAPH AT	B3	1425.	3.54	1.56	86
2 COMBINED AT	CP3	4667.	11.30		
ROUTED TO	CP4	4666.	11.30		
HYDROGRAPH AT	B4	1684.	4.00	1.56	86
2 COMBINED AT	CP4	6215.	15.30		
ROUTED TO	CP5	6205.	15.30		
HYDROGRAPH AT	B5	910.	3.19	1.65	79
2 COMBINED AT	CP5	7010.	18.49		
ROUTED TO	CP6	6994.	18.49		
HYDROGRAPH AT	B6	1054.	2.23	1.22	84
2 COMBINED AT	CP6	7736.	20.72		
ROUTED TO	CP7	7719.	20.72		
HYDROGRAPH AT	B7	722.	1.47	1.17	84
2 COMBINED AT	CP7	8178.	22.19		
ROUTED TO	CP8A	8157.	22.19		
ROUTED TO	CP8	8150.	22.19		
HYDROGRAPH AT	B8	566.	1.19	.83	78
2 COMBINED AT	CP8	8312.	23.38		
ROUTED TO	CP9	8311.	23.38		
HYDROGRAPH AT	B9	123.	0.20	.57	78
2 COMBINED AT	CP9	8325.	23.58		
HYDROGRAPH AT	B9C	71.	0.09	.43	78
ROUTED TO	CP9B	71.	0.09		
HYDROGRAPH AT	B9B	71.	0.09	.43	78
2 COMBINED AT	CP9B	140.	0.18		
ROUTED TO	CP9A	140.	0.19		
HYDROGRAPH AT	B9A	131.	0.19	.49	78
2 COMBINED AT	CP9A	268.	0.37		
ROUTED TO	CP9	265.	0.37		
2 COMBINED AT	CP9	8544.	23.95		
HYDROGRAPH AT	B20	719.	1.51	.77	77
ROUTED TO	CP21	700.	1.51		
HYDROGRAPH AT	B21	1010.	3.61	1.91	81
2 COMBINED AT	CP21	1337.	5.12		
ROUTED TO	CP22	1337.	5.12		
HYDROGRAPH AT	B22	1179.	5.57	2.96	83
2 COMBINED AT	CP22	2193.	10.69		
HYDROGRAPH AT	B22A	264.	0.50	.73	78
2 COMBINED AT	CP22	2232.	11.19		
ROUTED TO	CP25	2208.	11.19		
HYDROGRAPH AT	B25	363.	1.32	1.43	76
2 COMBINED AT	CP25	2423.	12.51		
HYDROGRAPH AT	B10	1438.	3.63	1.59	85
ROUTED TO	CP11	1433.	3.63		
HYDROGRAPH AT	B11	1524.	3.85	1.59	85
2 COMBINED AT	CP11	2938.	7.48		
ROUTED TO	CP12	2930.	7.48		
HYDROGRAPH AT	B12	1279.	3.16	1.64	86
2 COMBINED AT	CP12	4168.	10.64		
ROUTED TO	CP13	4167.	10.64		
HYDROGRAPH AT	B13	1134.	1.80	1.24	91
2 COMBINED AT	CP13	5039.	12.44		
ROUTED TO	CP14	5032.	12.44		
HYDROGRAPH AT	B14	493.	0.71	.85	86
2 COMBINED AT	CP14	5213.	13.15		
ROUTED TO	CP23	5207.	13.15		
HYDROGRAPH AT	B23	775.	1.96	1.35	82
2 COMBINED AT	CP23	5847.	15.11		
ROUTED TO	CP19	5836.	15.11		
HYDROGRAPH AT	B15	2158.	6.33	1.69	83
ROUTED TO	CP19	1929.	6.33		
HYDROGRAPH AT	B19	1242.	5.29	2.20	80
2 COMBINED AT	CP19	2970.	11.62		
2 COMBINED AT	CP19	6940.	26.73		
HYDROGRAPH AT	B17	1077.	3.14	1.69	83
ROUTED TO	CP18	957.	3.14		
HYDROGRAPH AT	B16	1025.	3.30	1.69	81
ROUTED TO	CP18	906.	3.30		
HYDROGRAPH AT	B18	1158.	4.10	2.00	82
3 COMBINED AT	CP18	2677.	10.54		
ROUTED TO	CP19	2676.	10.54		
2 COMBINED AT	CP19	8711.	37.27		
ROUTED TO	CP24	8703.	37.27		
HYDROGRAPH AT	B24	328.	0.70	.79	77
2 COMBINED AT	CP24	8731.	37.97		

Registered Professional Engineer (Civil)
CERTIFICATE NO.
15594
MARK T. GAVAN
Date Signed
ARIZONA, U.S.A.

4.2.3 Case C

Case C assumes that the Grand Avenue Expressway will be constructed as a high level facility and the Paradise Corridor will have a channel along its north side. As described earlier, the high level Grand Avenue Expressway will collect stormwater flows and convey them to New River, the Agua Fria River, and the Salt River. The result is a reduction in the contributing drainage area to the Outer Loop with a corresponding reduction in peak discharge.

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

CASE C

OPERATION	STATION	PEAK FLOW 100-YEAR	BASIN AREA	LAG TIME	CURVE NUMBER

OPERATION	STATION	PEAK FLOW 50-YEAR	BASIN AREA	LAG TIME	CURVE NUMBER
HYDROGRAPH AT	C1	1820.	1.71	.70	89
ROUTED TO	CP2	1799.	1.71		
HYDROGRAPH AT	C2	2178.	2.66	.90	87
2 COMBINED AT	CP2	3907.	4.37		
ROUTED TO	CP3	3884.	4.37		
HYDROGRAPH AT	C3	2041.	3.58	1.41	87
2 COMBINED AT	CP3	5449.	7.95		
ROUTED TO	CP4	5427.	7.95		
HYDROGRAPH AT	C4	2016.	4.00	1.56	86
2 COMBINED AT	CP4	7004.	11.95		
ROUTED TO	CP5	7003.	11.95		
HYDROGRAPH AT	C5	1132.	3.19	1.65	79
2 COMBINED AT	CP5	7844.	15.14		
ROUTED TO	CP6	7821.	15.14		
HYDROGRAPH AT	C6	1274.	2.23	1.22	84
2 COMBINED AT	CP6	8974.	17.37		
ROUTED TO	CP7	8963.	17.37		
HYDROGRAPH AT	C7	874.	1.47	1.17	84
2 COMBINED AT	CP7	9713.	18.84		
ROUTED TO	CP8A	9692.	18.84		
ROUTED TO	CP8	9663.	18.84		
HYDROGRAPH AT	C8	710.	1.19	.83	78
2 COMBINED AT	CP8	10058.	20.03		
ROUTED TO	CP9	10045.	20.03		
HYDROGRAPH AT	C9	161.	0.20	.57	78
2 COMBINED AT	CP9	10076.	20.23		
HYDROGRAPH AT	C9C	89.	0.09	.43	78
ROUTED TO	CP9B	89.	0.09		

HYDROGRAPH AT	C9B	89.	0.09	.43	78
2 COMBINED AT	CP9B	176.	0.19		
ROUTED TO	CP9A	176.	0.19		
HYDROGRAPH AT	CP9A	164.	0.19	.49	78
2 COMBINED AT	CP9A	337.	0.37		
ROUTED TO	CP9	334.	0.37		
2 COMBINED AT	CP9	10120.	20.60		
HYDROGRAPH AT	C10	1730.	3.63	1.59	85
ROUTED TO	CP11	1727.	3.63		
HYDROGRAPH AT	C11	1834.	3.85	1.59	85
2 COMBINED AT	CP11	3537.	7.48		
ROUTED TO	CP12	3530.	7.48		
HYDROGRAPH AT	C12	1368.	2.94	1.64	85
HYDROGRAPH AT	C13	772.	1.03	1.12	89
ROUTED TO	CP12	770.	1.03		
3 COMBINED AT	CP12	5432.	11.45		
ROUTED TO	CP14	5423.	11.45		
HYDROGRAPH AT	C14	1658.	0.99	.46	95
2 COMBINED AT	CP14	5564.	12.44		
ROUTED TO	CP15	5550.	12.44		
HYDROGRAPH AT	C15	591.	0.71	.85	86
2 COMBINED AT	CP15	5776.	13.15		
ROUTED TO	CP21	5763.	13.15		
HYDROGRAPH AT	C21	949.	1.96	1.35	82
2 COMBINED AT	CP21	6571.	15.11		
ROUTED TO	CP17	6558.	15.11		
HYDROGRAPH AT	C17	1427.	4.69	2.20	81
2 COMBINED AT	CP17	7711.	19.80		
HYDROGRAPH AT	C16	1702.	4.70	1.89	82
ROUTED TO	CP17	1702	4.70		
2 COMBINED AT	CP17	9172	24.50		
ROUTED TO	CP22	9156	24.50		
HYDROGRAPH AT	C22	416.	0.70	.79	77
2 COMBINED AT	CP22	9260.	25.20		
HYDROGRAPH AT	C18	909.	1.51	.77	77
ROUTED TO	CP19	887.	1.51		
HYDROGRAPH AT	C19	1242.	3.61	1.91	81
2 COMBINED AT	CP19	1651.	5.12		
ROUTED TO	CP20	1650.	5.12		
HYDROGRAPH AT	C20	1433.	5.57	2.96	83
2 COMBINED AT	CP20	2685.	10.69		
HYDROGRAPH AT	C20A	331.	0.50	.73	78

2 COMBINED AT	CP20	2733.	11.19		
ROUTED TO	CP23	2715.	11.19		
HYDROGRAPH AT	C23	460.	1.32	1.43	76
2 COMBINED AT	CP23	2988.	12.51		

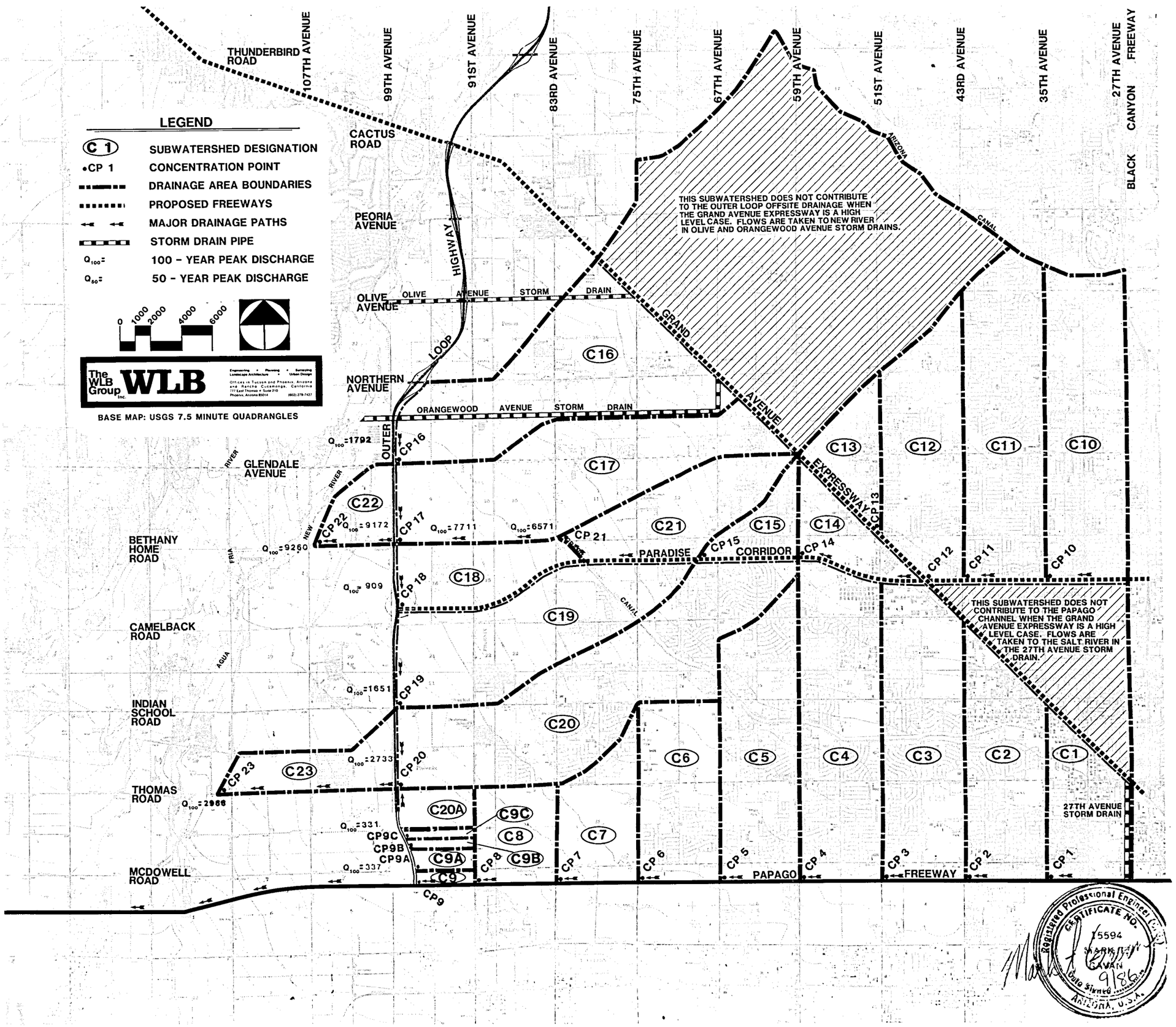
THE OUTER LOOP HIGHWAY

PAPAGO FREEWAY TO NORTHERN AVENUE

OFF-SITE HYDROLOGY
100 - YEAR STORM

CASE (C)

INTERCEPTOR CHANNEL ALONG THE NORTH SIDE OF THE PARADISE CORRIDOR AND THE GRAND AVENUE EXPRESSWAY AS A HIGH LEVEL FACILITY.



RUNOFF SUMMARY

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

CASE C

OPERATION	STATION	PEAK FLOW 100-YEAR	BASIN AREA	LAG TIME	CURVE NUMBER
HYDROGRAPH AT	C1	1820.	1.71	.70	89
ROUTED TO	CP2	1799.	1.71		
HYDROGRAPH AT	C2	2178.	2.66	.90	87
2 COMBINED AT	CP2	3907.	4.37		
ROUTED TO	CP3	3884.	4.37		
HYDROGRAPH AT	C3	2041.	3.58	1.41	87
2 COMBINED AT	CP3	5449.	7.95		
ROUTED TO	CP4	5427.	7.95		
HYDROGRAPH AT	C4	2016.	4.00	1.56	86
2 COMBINED AT	CP4	7004.	11.95		
ROUTED TO	CP5	7003.	11.95		
HYDROGRAPH AT	C5	1132.	3.19	1.65	79
2 COMBINED AT	CP5	7844.	15.14		
ROUTED TO	CP6	7821.	15.14		
HYDROGRAPH AT	C6	1274.	2.23	1.22	84
2 COMBINED AT	CP6	8974.	17.37		
ROUTED TO	CP7	8963.	17.37		
HYDROGRAPH AT	C7	874.	1.47	1.17	84
2 COMBINED AT	CP7	9713.	18.84		
ROUTED TO	CP8A	9692.	18.84		
ROUTED TO	CP8	9663.	18.84		
HYDROGRAPH AT	C8	710.	1.19	.83	78
2 COMBINED AT	CP8	10058.	20.03		
ROUTED TO	CP9	10045.	20.03		
HYDROGRAPH AT	C9	161.	0.20	.57	78
2 COMBINED AT	CP9	10076.	20.23		
HYDROGRAPH AT	C9C	89.	0.09	.43	78
ROUTED TO	CP9B	89.	0.09		
HYDROGRAPH AT	C9B	89.	0.09	.43	78
2 COMBINED AT	CP9B	176.	0.19		
ROUTED TO	CP9A	176.	0.19		
HYDROGRAPH AT	CP9A	164.	0.19	.43	78
2 COMBINED AT	CP9A	337.	0.37		
ROUTED TO	CP9	334.	0.37		
2 COMBINED AT	CP9	10120.	20.60		
HYDROGRAPH AT	C10	1730.	3.63	1.59	85
ROUTED TO	CP11	1727.	3.63		
HYDROGRAPH AT	C11	1834.	3.85	1.59	85
2 COMBINED AT	CP11	3537.	7.48		
ROUTED TO	CP12	3530.	7.48		
HYDROGRAPH AT	C12	1368.	2.94	1.64	85
HYDROGRAPH AT	C13	772.	1.03	1.12	89
ROUTED TO	CP12	770.	1.03		
3 COMBINED AT	CP12	5432.	11.45		
ROUTED TO	CP14	5423.	11.45		
HYDROGRAPH AT	C14	1658.	0.99	.46	95
2 COMBINED AT	CP14	5564.	12.44		
ROUTED TO	CP15	5550.	12.44		
HYDROGRAPH AT	C15	591.	0.71	.85	86
2 COMBINED AT	CP15	5776.	13.15		
ROUTED TO	CP21	5763.	13.15		
HYDROGRAPH AT	C21	949.	1.96	1.35	82
2 COMBINED AT	CP21	6571.	15.11		
ROUTED TO	CP17	6558.	15.11		
HYDROGRAPH AT	C17	1427.	4.69	2.20	81
2 COMBINED AT	CP17	7711.	19.80		
HYDROGRAPH AT	C16	1702.	4.70	1.89	82
ROUTED TO	CP17	1702	4.70		
2 COMBINED AT	CP17	9172	24.50		
ROUTED TO	CP22	9156	24.50		
HYDROGRAPH AT	C22	416.	0.70	.79	77
2 COMBINED AT	CP22	9260.	25.20		
HYDROGRAPH AT	C18	909.	1.51	.77	77
ROUTED TO	CP19	887.	1.51		
HYDROGRAPH AT	C19	1242.	3.61	1.91	81
2 COMBINED AT	CP19	1651.	5.12		
ROUTED TO	CP20	1650.	5.12		
HYDROGRAPH AT	C20	1433.	5.57	2.96	83
2 COMBINED AT	CP20	2685.	10.69		
HYDROGRAPH AT	C20A	331.	0.50	.73	78
2 COMBINED AT	CP20	2733.	11.19		
ROUTED TO	CP23	2715.	11.19		
HYDROGRAPH AT	C23	460.	1.32	1.43	76
2 COMBINED AT	CP23	2988.	12.51		

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

CASE C

OPERATION	STATION	PEAK FLOW 50-YEAR	BASIN AREA	LAG TIME	CURVE NUMBER
HYDROGRAPH AT	C1	1539.	1.71	.70	89
ROUTED TO	CP2	1522.	1.71		
HYDROGRAPH AT	C2	1825.	2.66	.90	87
2 COMBINED AT	CP2	3283.	4.37		
ROUTED TO	CP3	3275.	4.37		
HYDROGRAPH AT	C3	1713.	3.58	1.41	87
2 COMBINED AT	CP3	4591.	7.95		
ROUTED TO	CP4	4572.	7.95		
HYDROGRAPH AT	C4	1684.	4.00	1.56	86
2 COMBINED AT	CP4	5895.	11.95		
ROUTED TO	CP5	5895.	11.95		
HYDROGRAPH AT	C5	910.	3.19	1.65	79
2 COMBINED AT	CP5	6566.	15.14		
ROUTED TO	CP6	6549.	15.14		
HYDROGRAPH AT	C6	1054.	2.23	1.22	84
2 COMBINED AT	CP6	7484	17.37		
ROUTED TO	CP7	7483	17.37		
HYDROGRAPH AT	C7	722.	1.47	1.17	84
2 COMBINED AT	CP7	8104.	18.84		
ROUTED TO	CP8A	8069.	18.84		
ROUTED TO	CP8	8069	18.84		
HYDROGRAPH AT	C8	566.	1.19	.83	78
2 COMBINED AT	CP8	8353.	20.03		
ROUTED TO	CP9	8353.	20.03		
HYDROGRAPH AT	C9	128.	0.20	.57	78
2 COMBINED AT	CP9	8378	20.23		
HYDROGRAPH AT	C9C	71.	0.09	.43	78
ROUTED TO	CP9B	71.	0.09		
HYDROGRAPH AT	C9B	71.	0.09	.43	78
2 COMBINED AT	CP9B	140.	0.19		
ROUTED TO	CP9A	140.	0.19		

HYDROGRAPH AT	C9A	131.	0.19	.49	78
2 COMBINED AT	CP9A	268.	0.37		
ROUTED TO	CP9	265.	0.37		
2 COMBINED AT	CP9	8414.	20.60		
HYDROGRAPH AT	C10	1438.	3.63	1.59	85
ROUTED TO	CP11	1433.	3.63		
HYDROGRAPH AT	C11	1524.	3.85	1.59	85
2 COMBINED AT	CP11	2938.	7.48		
ROUTED TO	CP12	2929.	7.48		
HYDROGRAPH AT	C12	1137.	2.94	1.64	85
HYDROGRAPH AT	C13	654.	1.03	1.12	89
ROUTED TO	CP12	652.	1.03		
3 COMBINED AT	CP12	4519.	11.45		
ROUTED TO	CP14	4505.	11.45		
HYDROGRAPH AT	C14	1440.	0.99	.46	95
2 COMBINED AT	CP14	4626.	12.44		
ROUTED TO	CP15	4620.	12.44		
HYDROGRAPH AT	C15	493.	0.71	.85	86
2 COMBINED AT	CP15	4797.	13.15		
ROUTED TO	CP21	4793.	13.15		
HYDROGRAPH AT	C21	775.	1.96	1.35	82
2 COMBINED AT	CP21	5436.	15.11		
ROUTED TO	CP17	5429.	15.11		
HYDROGRAPH AT	C17	1160.	4.69	2.20	81
2 COMBINED AT	CP17	6378.	19.80		
HYDROGRAPH AT	C16	1392.	4.70	1.89	82
ROUTED TO	CP17	1389.	4.70		
2 COMBINED AT	CP17	7567.	24.50		
ROUTED TO	CP22	7558.	24.50		
HYDROGRAPH AT	C22	328.	0.70	.79	77
2 COMBINED AT	CP22	7631.	25.20		
HYDROGRAPH AT	C18	719.	1.51	.77	77
ROUTED TO	CP19	700.	1.51		
HYDROGRAPH AT	C19	1010.	3.61	1.91	81
2 COMBINED AT	CP19	1337.	5.12		
ROUTED TO	CP20	1337.	5.12		
HYDROGRAPH AT	C20	1179.	5.57	2.96	83
2 COMBINED AT	CP20	2193.	10.69		
HYDROGRAPH AT	C20A	264.	0.50	.73	78
2 COMBINED AT	CP20	2232.	11.19		
ROUTED TO	CP23	2208.	11.19		
HYDROGRAPH AT	C23	363.	1.32	1.43	76
2 COMBINED AT	CP23	2423.	12.51		

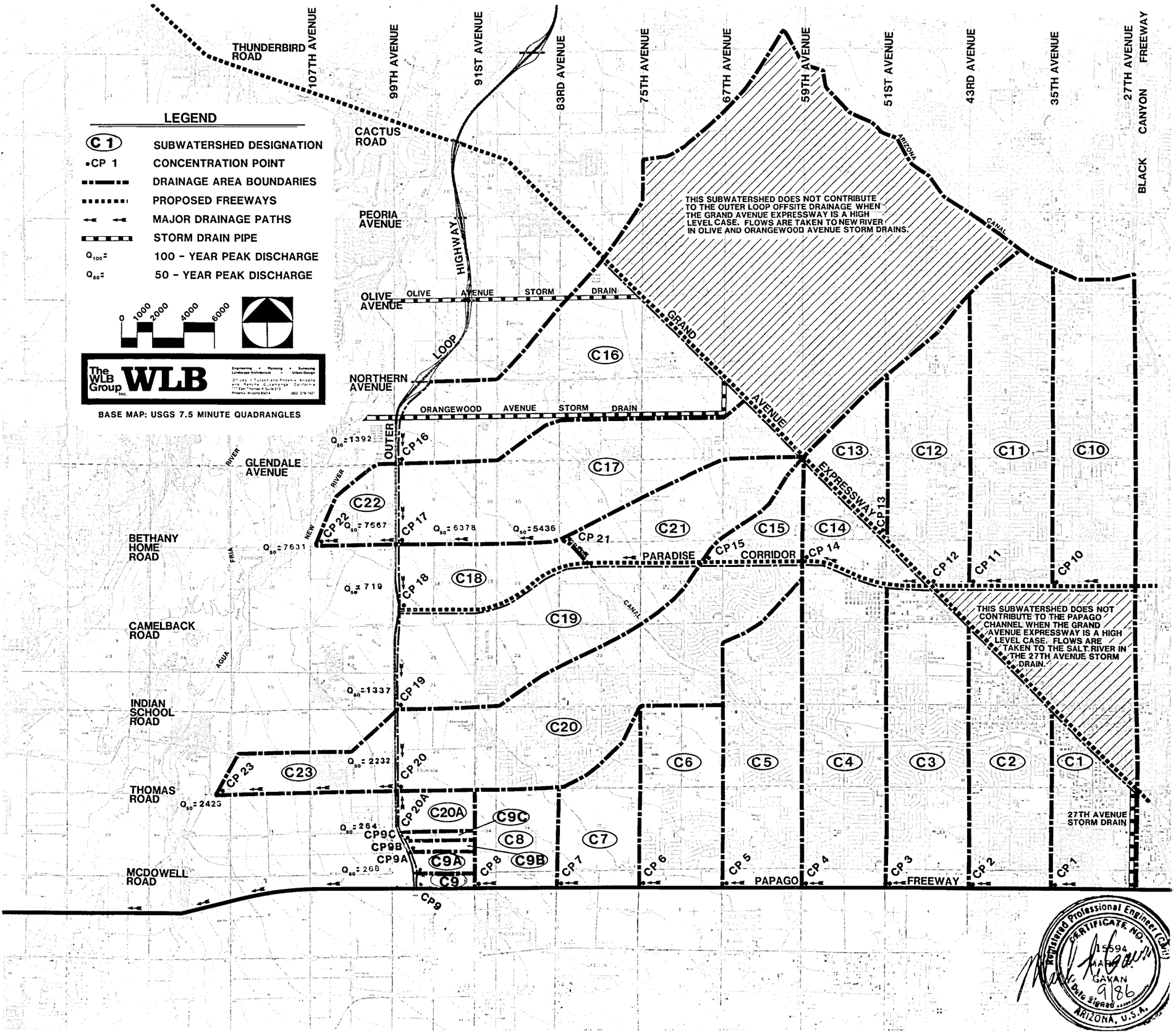
THE OUTER LOOP HIGHWAY

PAPAGO FREEWAY TO NORTHERN AVENUE

OFF-SITE HYDROLOGY
50 - YEAR STORM

CASE (C)

INTERCEPTOR CHANNEL ALONG THE NORTH SIDE OF THE PARADISE CORRIDOR AND THE GRAND AVENUE EXPRESSWAY AS A HIGH LEVEL FACILITY.



RUNOFF SUMMARY

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

CASE C

OPERATION	STATION	PEAK FLOW 50-YEAR	BASIN AREA	LAG TIME	CURVE NUMBER
HYDROGRAPH AT	C1	1539.	1.71	.70	89
ROUTED TO	CP2	1522.	1.71		
HYDROGRAPH AT	C2	1825.	2.66	.50	87
2 COMBINED AT	CP2	3283.	4.37		
ROUTED TO	CP3	3275.	4.37		
HYDROGRAPH AT	C3	1713.	3.58	1.41	87
2 COMBINED AT	CP3	4591.	7.95		
ROUTED TO	CP4	4572.	7.95		
HYDROGRAPH AT	C4	1684.	4.00	1.56	86
2 COMBINED AT	CP4	5895.	11.95		
ROUTED TO	CP5	5895.	11.95		
HYDROGRAPH AT	C5	910.	3.19	1.65	79
2 COMBINED AT	CP5	6566.	15.14		
ROUTED TO	CP6	6549.	15.14		
HYDROGRAPH AT	C6	1054.	2.23	1.22	84
2 COMBINED AT	CP6	7484	17.37		
ROUTED TO	CP7	7483	17.37		
HYDROGRAPH AT	C7	722.	1.47	1.17	84
2 COMBINED AT	CP7	8104.	18.84		
ROUTED TO	CP8A	8069.	18.84		
ROUTED TO	CP8	8069	18.84		
HYDROGRAPH AT	C8	566.	1.19	.83	78
2 COMBINED AT	CP8	8353.	20.03		
ROUTED TO	CP9	8353.	20.03		
HYDROGRAPH AT	C9	128.	0.20	.57	78
2 COMBINED AT	CP9	8378	20.23		
HYDROGRAPH AT	C9C	71.	0.09	.43	78
ROUTED TO	CP9B	71.	0.09		
HYDROGRAPH AT	C9B	71.	0.09	.43	78
2 COMBINED AT	CP9B	140.	0.19		
ROUTED TO	CP9A	140.	0.19		
HYDROGRAPH AT	C9A	131.	0.19	.49	78
2 COMBINED AT	CP9A	268.	0.37		
ROUTED TO	CP9	265.	0.37		
2 COMBINED AT	CP9	8414.	20.60		
HYDROGRAPH AT	C10	1438.	3.63	1.59	85
ROUTED TO	CP11	1433.	3.63		
HYDROGRAPH AT	C11	1524.	3.85	1.59	85
2 COMBINED AT	CP11	2938.	7.48		
ROUTED TO	CP12	2929.	7.48		
HYDROGRAPH AT	C12	1137.	2.94	1.64	85
HYDROGRAPH AT	C13	654.	1.03	1.12	89
ROUTED TO	CP12	652.	1.03		
3 COMBINED AT	CP12	4519.	11.45		
ROUTED TO	CP14	4505.	11.45		
HYDROGRAPH AT	C14	1440.	0.99	.46	95
2 COMBINED AT	CP14	4626.	12.44		
ROUTED TO	CP15	4620.	12.44		
HYDROGRAPH AT	C15	493.	0.71	.85	86
2 COMBINED AT	CP15	4797.	13.15		
ROUTED TO	CP21	4793.	13.15		
HYDROGRAPH AT	C21	775.	1.96	1.35	82
2 COMBINED AT	CP21	5436.	15.11		
ROUTED TO	CP17	5429.	15.11		
HYDROGRAPH AT	C17	1160.	4.69	2.20	81
2 COMBINED AT	CP17	6378.	19.80		
HYDROGRAPH AT	C16	1392.	4.70	1.89	82
ROUTED TO	CP17	1389.	4.70		
2 COMBINED AT	CP17	7567.	24.50		
ROUTED TO	CP22	7558.	24.50		
HYDROGRAPH AT	C22	328.	0.70	.79	77
2 COMBINED AT	CP22	7631.	25.20		
HYDROGRAPH AT	C18	719.	1.51	.77	77
ROUTED TO	CP19	700.	1.51		
HYDROGRAPH AT	C19	1010.	3.61	1.91	81
2 COMBINED AT	CP19	1337.	5.12		
ROUTED TO	CP20	1337.	5.12		
HYDROGRAPH AT	C20	1179.	5.57	2.96	83
2 COMBINED AT	CP20	2193.	10.69		
HYDROGRAPH AT	C20A	264.	0.50	.73	78
2 COMBINED AT	CP20	2232.	11.19		
ROUTED TO	CP23	2208.	11.19		
HYDROGRAPH AT	C23	363.	1.32	1.43	76
2 COMBINED AT	CP23	2423.	12.51		

5.0 REFERENCES

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4. Soil Conservation Service, Soil Survey of Maricopa County, Arizona, Central Part, September 1977.

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APPENDIX

APPENDIX 1

Comparison of Rainfall Distributions

As explained in section 3.2, the hypothetical storm calculated by HEC-1 with given depth-duration data was used in this study. However, a comparison was made between the HEC-1 hypothetical storm, the Soil Conservation Service Type II distribution, the Soil Conservation Service Type II A distribution, and the City of Phoenix design rainfall distribution which was developed with local rainfall data.

The comparison was made using the 100-year storm on the 3.8 square mile drainage area that drains to the Outer Loop between Buckeye Road and the Papago Freeway. The following table is a summary of the results.

Comparison of Rainfall Distributions
(24-hour Storm)

Rainfall Distribution	100-year Peak Discharge (CFS)
City of Phoenix Design Storm	1036
Hypothetical Storm	1033
SCS Type IIA	876
SCS Type II	843

The comparison shows that the City of Phoenix Design Storm has a discharge almost identical to the hypothetical storm and the SCS Type II and Type IIA flows are about 15-19% less. The hypothetical storm was chosen for two reasons: 1) it gives results that agree reasonably well with the City of Phoenix distribution and 2) to stay consistent with what was used previously for the Outer Loop from Northern Avenue to Bell Road.

The SCS Type II distribution was developed for the interior part of the United States: Type I and IA were developed for the coastal areas along the west coast. Historically, the SCS Type II has been used by the SCS and others for Arizona. However, researchers in New Mexico developed the Type IIA for areas in New Mexico which have more intense storms than the Type II distribution. Consequently, some hydrologists in Arizona use the Type IIA for the southern deserts and use Type II for the northern part of the state.