DICK PEARSON

ADDENDUM NO. 3 TO:
PRELIMINARY HYDRAULIC ANALYSIS OF THE SALT RIVER FOR THE EAST PAPAGO FREEWAY AND RED MOUNTAIN INTERCHANGE

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PRELIMINARY HYDRAULIC ANALYSIS OF THE SALT RIVER FOR THE EAST PAPAGO FREEWAY AND RED MOUNTAIN INTERCHANGE

Submitted to:

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PREFACE

The results presented in this report are based on state-of-the-art techniques for river mechanics and scour analysis. However, the state-of-the-art of river mechanics is such that flow depths on the order of those which exist within the Salt River cannot realistically be predicted more accurately than plus or minus 10%. In addition, the state-of-the-art for scour analysis is such that predictions may vary by as much as 50% to 100%. The results obtained depend on the data base used, assumptions made, engineering computer models utilized, engineering judgement exercised, etc. Some of the assumptions made in conjunction with this study effort include: 1) hydrology (flood peaks) for the Salt River is correct; 2) the 1986 topographic mapping is sufficient to accurately depict topographic conditions; 3) sediment sampling adequately represents the existing sediment distributions in the stream bed; and 4) one-dimensional hydraulic modeling is appropriate to apply to the study reach. Consequently, the results obtained by different investigators could vary widely. Because the results presented within this report are considered to be conservative, based on the assumptions made, they can be used to give a relative measure of the maximum impacts associated with the proposed project. However, the results are only preliminary and not to be used for final design.

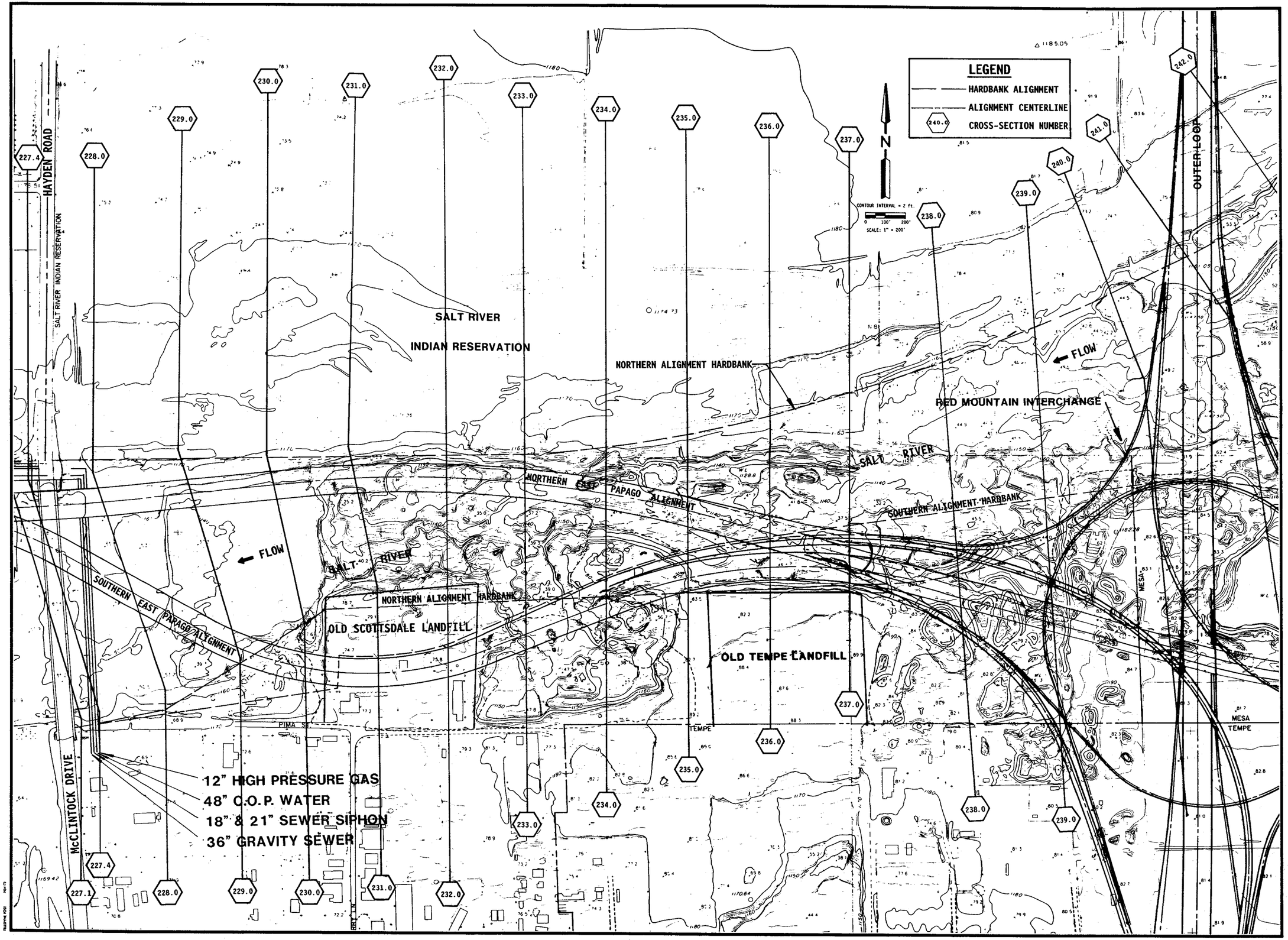
I. INTRODUCTION

This addendum to the report titled "Preliminary Hydraulic Analysis of the Salt River for the East Papago and Red Mountain Interchange," (1), dated September 1989, presents the results of a preliminary hydraulic analysis for an alternate alignment of Section 6 of the East Papago Freeway. The initial report summarized the preliminary hydraulic and sediment-transport analyses for a proposed alignment which would cross the existing Hayden Road Bridge on a southeasterly skew, and then generally follow the southern bank of the Salt River on fill. This initial alignment for Section 6 of the East Papago, has been referred to as the southern alignment.

"Addendum No. 1 to: Preliminary Hydraulic Analysis of the Salt River for the East Papago Freeway and Red Mountain Interchange," (2), dated November 22, 1989, presents the results of the preliminary hydraulic analysis for an alternate northern alignment for Section 6 of the East Papago Freeway which would be entirely on structure east of Hayden Road. This alternate alignment would cross the existing Hayden Road Bridge at an approximate right angle, then follow the north bank of the river to a point north of the Old Tempe Landfill, where the alignment would turn southeasterly and cross the Salt River in order to tie into the Red Mountain Interchange. Concept conditions presented in Addendum No. 1 utilized a south hardbank for protection of the Old Scottsdale Landfill and the Old Tempe Landfill. In this addendum, the northern alignment concept conditions presented in Addendum No. 1 are referred to as Alternative 1.

"Addendum No. 2 to: Preliminary Hydraulic Analysis of the Salt River for the East Papago Freeway and Red Mountain Interchange," (3), dated December 7, 1989, presents the results for a northern structural alignment for Section 6 of the East Papago Freeway with channel bank protection on both the north and south banks. The reach of river from the existing Hayden Road Bridge through the Outer Loop Highway crossing was assumed to be leveed to contain the design flow between the north and south banks. In this addendum, the concept conditions for the channelized northern structural alignment presented in Addendum No. 2 are referred to as Alternative 2.

The proposed alignment presented in this addendum evaluates the same northern structural alignment for Section 6 of the East Papago Freeway as that presented in the first and second addendums. The north and south banks between the existing Hayden Road Bridge through the Outer Loop Highway crossing are identical to those presented in Addendum No. 2, with one exception. The north hardbank is assumed to provide bank protection to an elevation of 1170.0 feet, the approximate existing top of bank elevation for this reach of the Salt River. The reconfigured north bank, presented in this addendum, will be referred to as Alternative 3. Figure 1 shows the general location of the northern alignment for Section 6 of the East Papago Freeway analyzed to date.



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TUCSON, AZ., PHOENIX, AZ.

EAST PAPAGO FREEWAY - SECTION 6
ALTERNATE ALIGNMENTS

Project No.	AZ-DMJM-03
Date:	11/7/89
Design:	
Drawn:	JRM
Check:	
Revisions:	

FIGURE 1

II. HYDRAULIC ANALYSIS FOR ALTERNATIVE 3

2.1 General

The procedures and data base used for the hydraulic analysis of Alternative 3 were the same as those described in the initial report (1). For concept conditions of Alternative 3 (proposed northern alignment with leveed south bank and north bank protection to elevation 1170.0 ft.), bridge routines were not used to analyze the East Papago crossing of the Salt River. Instead, the same procedure was used as that described in the first addendum (2). Piers from the East Papago structure were modeled as obstructions in the flow field, thus removing the pier area from the effective flow area of the channel. This modeling procedure was used due to the alignment of the structure with respect to the flow.

A baseline condition, with the effects of gravel pits removed, was used to analyze project impacts. This is the same approach as was used in the initial report and both previous addendums, and was done to provide an estimate of water-surface elevations that would result if the gravel pits were filled in with water and/or sediment during flood events. Baseline conditions presented in this addendum are identical to baseline conditions in the first and second addendums (2,3). A consistent baseline condition permits relative comparison among the three alternatives.

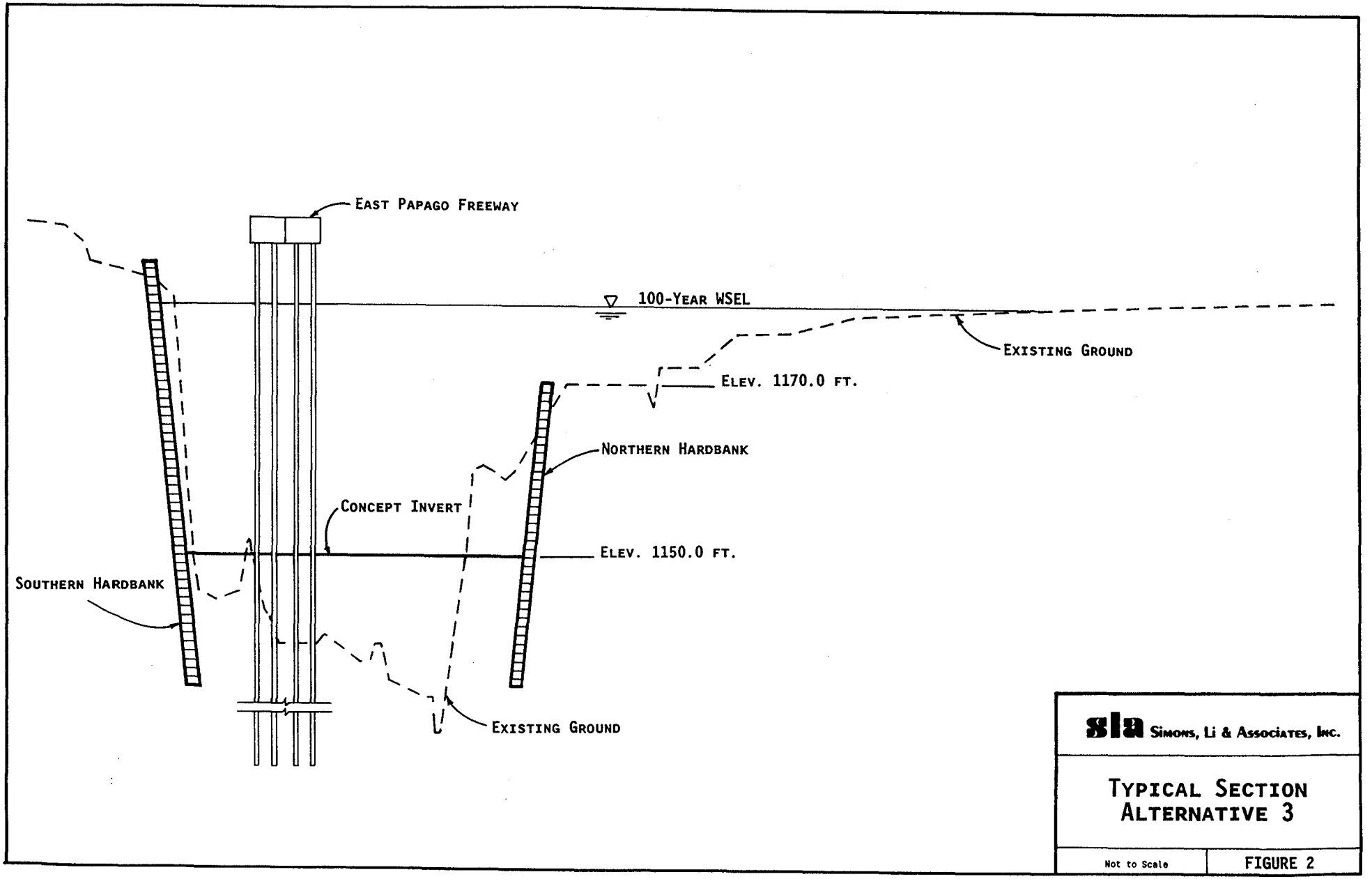
2.2 Concept Analysis - Alternative 3

Concept conditions for Alternative 3 are a consequence of the best estimate of conditions resulting from: (1) the northern alignment of the East Papago Freeway, which is entirely on structure; (2) a leveed embankment on the south side of the Salt River, which does not permit flow in the south overbank; (3) a protected north bank to an elevation of 1170.0 ft.; and (4) the best estimate of the Outer Loop bridge configuration. The effects of gravel pits were removed from the concept conditions for Alternative 3, as in the baseline conditions, in order to provide a conservative estimate of impacts resulting from the project, and to permit comparison with the concept conditions of previous addendums.

In addition to removing the effects of gravel pits, concept conditions for Alternative 3 include bank protection along the south bank of the river identical to that described in the first two addendums. The bank protection along the south bank was located adjacent to the Old Scottsdale Landfill and the Old Tempe Landfill in an effort to minimize disturbance to the sites, and yet maximize conveyance in the Salt River channel. Alignment of the bank protection on the north bank is identical to that described in the second addendum, and generally follows the southern edge of the Salt River Project's power transmission easement on the north bank of the Salt River. However, concept conditions for Alternative 3 utilize bank protection along the north bank line to an elevation of 1170.0 feet, the approximate existing top of bank of the main channel for this reach of the Salt River. This protection of the north bank will extend between the Hayden Road and the Outer Loop Highway crossing, and will permit flow in the north overbank similar to baseline conditions for large magnitude flood events. Figure 2 presents a typical channel section which illustrates concept conditions for Alternative 3.

Concept conditions for the proposed northern alignment of the East Papago Freeway assumed a structure consisting of 135-foot spans with 7-foot diameter columns, 2 columns per structure. Each column of the East Papago structure will be exposed to the flow. The effective length of the mainline of the Outer Loop crossing under concept conditions is approximately 1900 feet. Overbank flow north of the main channel is permitted through the Outer Loop structures. Concept conditions for the Outer Loop crossing of the Salt River were analyzed using 130-foot spans with 6-foot diameter columns, 3 columns per structure. As a result of the small angle to which the structures are skewed to the flow, it was assumed that the piers for the Outer Loop crossing would essentially be aligned with the flow.

Water-surface profiles for Alternative 3 were computed for the 100-year peak discharge for two concept conditions. The first case did not consider debris buildup on the piers. The second case considered debris buildup, and assumed that the effective pier diameter would be double the actual pier diameter. The hydraulic results are presented in Table 1 for the case without debris buildup, and in Table 2 for the case with debris buildup. The case with debris buildup provides a more conservative estimate of water-surface elevations.



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TYPICAL SECTION ALTERNATIVE 3

Not to Scale | FIGURE 2

TABLE 1. Hydraulic Information -- Baseline and Concept Conditions for Alternative 3, 100-Year Event without Debris Buildup

		----- BASELINE CONDITION -----				----- CONCEPT CONDITION -----				
PROJECT STATION (ft)	CROSS-SECTION NUMBER	CALCULATED WATER SURFACE ELEV. (ft)	HYDRAULIC DEPTH (ft)	CHANNEL VELOCITY (fps)	TOPWIDTH (ft)	CALCULATED WATER SURFACE ELEV. (ft)	HYDRAULIC DEPTH (ft)	CHANNEL VELOCITY (fps)	TOPWIDTH (ft)	PHYSICAL FEATURE
36263	225.00	1170.5	17.6	10.6	2180	1170.7	17.8	11.2	1231	
36660	226.00	1171.3	17.6	10.7	2252	1171.4	17.8	11.7	1289	
37027	227.10	1171.8	17.1	11.0	1571	1173.1	21.3	8.7	1800	Hayden Road Bridge
37116	227.40	1171.8	14.2	13.2	1496	1173.8	22.1	8.4	1884	
37436	228.00	1173.8	18.7	10.5	2426	1174.5	22.2	7.2	2359	
37836	229.00	1174.9	22.7	7.7	2430	1174.6	19.4	8.9	2219	
38236	230.00	1175.0	22.6	8.7	2655	1174.9	17.2	10.1	2480	
38635	231.00	1175.0	21.3	12.8	2059	1175.4	16.7	11.2	2319	Old Scottsdale
39042	232.00	1175.4	22.8	13.0	2093	1176.3	18.2	10.5	2504	Landfill
39444	233.00	1177.3	15.4	9.1	2311	1177.1	20.2	10.3	2166	
39840	234.00	1177.7	24.6	8.4	1987	1177.8	21.6	9.8	1874	
40246	235.00	1177.7	22.3	10.8	1603	1178.3	22.2	9.5	1774	
40647	236.00	1178.6	24.6	9.1	1875	1178.9	24.4	9.0	2015	Old Tempe Landfill
41043	237.00	1179.1	24.6	8.6	1472	1179.3	24.3	8.9	1420	
41553	238.00	1179.6	25.2	7.8	1456	1180.1	28.7	7.4	1495	
42018	239.00	1179.8	16.5	8.9	1438	1180.3	28.4	7.7	1457	
42568	240.00	1180.4	25.0	8.0	1461	1181.1	20.8	5.6	1883	Outer Loop Highway
43073	241.00	1181.0	22.9	6.8	1826	1181.3	21.0	5.6	1884	
43588	242.00	1181.5	25.0	5.1	2324	1181.6	24.3	5.4	2064	
44058	243.00	1181.7	25.7	4.0	2482	1181.9	25.5	4.2	2182	
44528	244.00	1181.8	19.2	4.5	2532	1181.9	19.3	4.7	2438	
45078	245.00	1181.9	16.1	4.8	2868	1182.1	16.3	4.9	2730	
45693	246.00	1182.2	16.9	4.2	3146	1182.4	17.0	4.1	3147	Evergreen Road
46197	247.00	1182.2	13.6	6.9	2354	1182.4	13.7	6.7	2386	
46736	248.00	1183.0	17.0	4.1	3177	1183.1	17.2	4.0	3177	
47237	249.00	1183.1	19.5	4.4	2579	1183.2	19.9	4.3	2577	
47757	250.00	1183.2	17.7	5.1	2450	1183.3	17.8	5.0	2452	
48364	251.00	1183.2	13.0	9.1	1861	1183.3	13.2	9.0	1862	
48862	252.00	1183.9	15.1	9.4	1558	1184.0	15.2	9.3	1559	Dobson Road
49506	253.00	1185.3	11.8	8.8	2121	1185.4	11.9	8.7	2121	
49980	254.00	1185.5	9.5	15.0	1545	1185.6	9.5	14.9	1547	
50487	255.00	1189.7	12.8	11.1	1541	1189.7	12.8	11.1	1541	
50957	256.00	1191.5	18.4	7.5	1586	1191.5	18.4	7.5	1586	
51491	257.00	1191.5	13.2	11.2	1496	1191.5	13.2	11.2	1496	
51910	258.00	1192.6	17.3	11.0	1162	1192.6	17.2	11.0	1162	
52496	259.00	1194.3	15.5	9.1	1565	1194.3	15.5	9.1	1565	
53001	260.00	1195.3	17.8	8.0	1662	1195.3	17.8	8.0	1662	
53445	261.00	1195.9	20.9	6.9	2069	1195.9	20.9	6.9	2069	
53954	262.00	1195.9	17.2	11.7	1820	1195.9	17.2	11.7	1820	
54478	263.00	1196.9	13.1	11.7	2145	1196.9	13.1	11.8	2144	
55034	264.00	1198.2	12.2	12.2	1871	1198.2	12.2	12.2	1871	
55471	265.00	1199.6	13.4	11.0	2008	1199.6	13.3	11.0	2008	Alma School Road

TABLE 2. Hydraulic Information -- Baseline and Concept Conditions for Alternative 3, 100-Year Event with Debris Buildup

		----- BASELINE CONDITION -----				----- CONCEPT CONDITION -----				
PROJECT STATION (ft)	CROSS-SECTION NUMBER	CALCULATED WATER SURFACE ELEV. (ft)	HYDRAULIC DEPTH (ft)	CHANNEL VELOCITY (fps)	TOPWIDTH (ft)	CALCULATED WATER SURFACE ELEV. (ft)	HYDRAULIC DEPTH (ft)	CHANNEL VELOCITY (fps)	TOPWIDTH (ft)	PHYSICAL FEATURE
36263	225.00	1170.5	17.6	10.6	2180	1170.7	17.8	11.2	1231	
36660	226.00	1171.3	17.6	10.7	2252	1171.4	17.8	11.9	1261	
37027	227.10	1171.8	17.1	11.0	1571	1173.2	21.4	8.7	1813	Hayden Road Bridge
37116	227.40	1171.8	14.2	13.2	1496	1173.9	22.2	8.4	1895	
37436	228.00	1173.8	18.7	10.5	2426	1174.6	21.7	7.3	2345	
37836	229.00	1174.9	22.7	7.7	2430	1174.7	18.9	9.1	2200	
38236	230.00	1175.0	22.6	8.7	2655	1175.0	16.7	10.4	2453	
38635	231.00	1175.0	21.3	12.8	2059	1175.5	16.2	11.5	2328	Old Scottsdale
39042	232.00	1175.4	22.8	13.0	2093	1176.5	17.7	10.7	2481	Landfill
39444	233.00	1177.3	15.4	9.1	2311	1177.3	19.6	10.5	2254	
39840	234.00	1177.7	24.6	8.4	1987	1178.1	21.1	9.9	1923	
40246	235.00	1177.7	22.3	10.8	1603	1178.6	21.7	9.7	1941	
40647	236.00	1178.6	24.6	9.1	1875	1179.3	23.8	9.2	2194	Old Tempe Landfill
41043	237.00	1179.1	24.6	8.6	1472	1179.7	23.8	9.0	1396	
41553	238.00	1179.6	25.2	7.8	1456	1180.6	29.2	7.3	1496	
42018	239.00	1179.8	16.5	8.9	1438	1180.7	28.8	7.6	1461	
42568	240.00	1180.4	25.0	8.0	1461	1181.5	21.2	5.5	1885	Outer Loop Highway
43073	241.00	1181.0	22.9	6.8	1826	1181.7	21.3	5.5	1885	
43588	242.00	1181.5	25.0	5.1	2324	1181.9	24.7	5.3	2065	
44058	243.00	1181.7	25.7	4.0	2482	1182.2	25.8	4.2	2183	
44528	244.00	1181.8	19.2	4.5	2532	1182.3	19.7	4.6	2439	
45078	245.00	1181.9	16.1	4.8	2868	1182.4	16.7	4.8	2731	
45693	246.00	1182.2	16.9	4.2	3146	1182.8	17.4	4.0	3150	Evergreen Road
46197	247.00	1182.2	13.6	6.9	2354	1182.8	13.9	6.6	2401	
46736	248.00	1183.0	17.0	4.1	3177	1183.4	17.5	4.0	3182	
47237	249.00	1183.1	19.5	4.4	2579	1183.5	20.2	4.2	2580	
47757	250.00	1183.2	17.7	5.1	2450	1183.6	18.0	5.0	2457	
48364	251.00	1183.2	13.0	9.1	1861	1183.6	13.5	8.8	1863	
48862	252.00	1183.9	15.1	9.4	1558	1184.2	15.4	9.2	1560	Dobson Road
49506	253.00	1185.3	11.8	8.8	2121	1185.6	12.0	8.6	2122	
49980	254.00	1185.5	9.5	15.0	1545	1185.7	9.6	14.7	1549	
50487	255.00	1189.7	12.8	11.1	1541	1189.7	12.8	11.1	1541	
50957	256.00	1191.5	18.4	7.5	1586	1191.5	18.4	7.5	1586	
51491	257.00	1191.5	13.2	11.2	1496	1191.5	13.2	11.2	1496	
51910	258.00	1192.6	17.3	11.0	1162	1192.6	17.3	11.0	1162	
52496	259.00	1194.3	15.5	9.1	1565	1194.3	15.5	9.1	1565	
53001	260.00	1195.3	17.8	8.0	1662	1195.3	17.8	8.0	1662	
53445	261.00	1195.9	20.9	6.9	2069	1195.9	20.9	6.9	2069	
53954	262.00	1195.9	17.2	11.7	1820	1195.9	17.2	11.7	1820	
54478	263.00	1196.9	13.1	11.7	2145	1196.9	13.1	11.7	2145	
55034	264.00	1198.2	12.2	12.2	1871	1198.2	12.2	12.2	1871	
55471	265.00	1199.6	13.4	11.0	2008	1199.6	13.4	11.0	2008	Alma School Road

Figure 3 presents plots of computed water-surface profiles of baseline and concept conditions for Alternative 3 for the 100-year event with debris buildup. Table 3 presents computed differences in water-surface elevations, average velocities, and topwidths between concept conditions for Alternative 3 and baseline conditions.

Results from the hydraulic analysis for concept conditions of Alternative 3 show a maximum increase in water-surface elevation of 2.1 feet, which occurs at the upstream face of the Hayden Road bridge. This increase is due to the East Papago freeway encroachment on the Salt River downstream of Hayden Road, and the assumed configuration of the East Papago freeway crossing. Upstream of the existing Hayden Road Bridge, the maximum water-surface elevation increase of 1.2 feet occurs at the Old Scottsdale Landfill (cross-section 232.0). Backwater from the hydraulic constriction at the Old Tempe Landfill generates a maximum increase in water-surface elevation of 1.1 feet at the downstream side of the Outer Loop Highway crossing (cross-section 240.0). Upstream of the Outer Loop crossing, the increase in water-surface elevation above baseline gradually decreases from 0.5 feet to baseline conditions around Dobson Road.

The maximum increase in average velocity over baseline conditions is 1.7 feet per second downstream of the Old Scottsdale Landfill at cross-section 230.00. The maximum decrease in average velocity is 4.8 feet per second at the upstream face of the existing Hayden Road bridge. Additionally, Table 3 reflects the change in topwidth associated with increased water-surface elevations resulting from leveed conditions on the south bank.

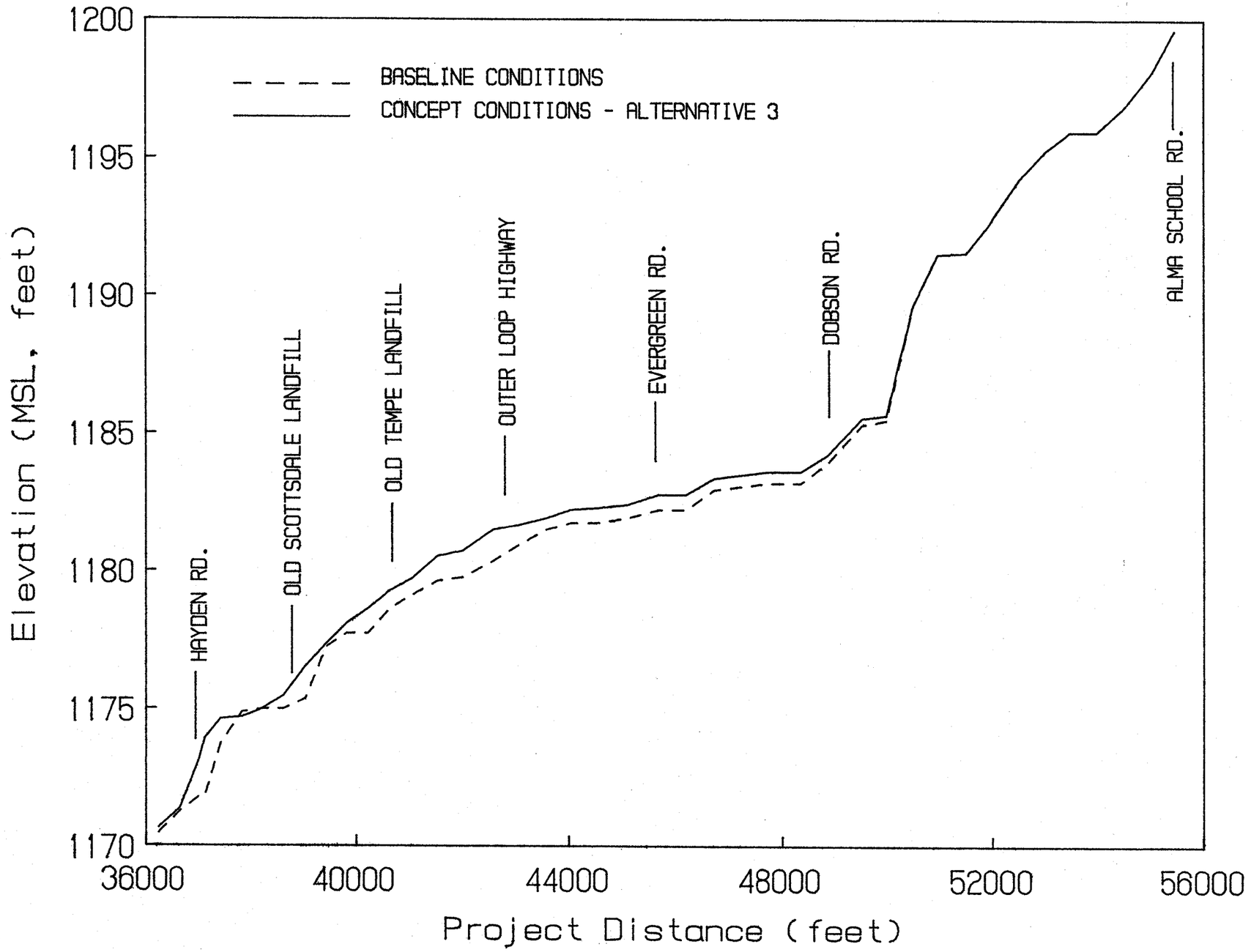

Figure 3. Water-Surface Profiles of Baseline and Concept Conditions for Alternative 3, 100-Year Event with Debris Buildup

TABLE 3. Water-Surface Elevations, Average Velocity, and Topwidth Comparisons -- Concept Conditions for Alternative 3 Minus Baseline Conditions, 100-Year Event with Debris Buildup

PROJECT STATION (feet)	CROSS-SECTION NUMBER	WATER SURFACE ELEVATION (feet)	CHANNEL VELOCITY (ft/sec)	TOPWIDTH (ft)	PHYSICAL FEATURE
36263	225.0	0.2	0.6	-949	
36660	226.0	0.2	1.2	-991	
37027	227.1	1.4	-2.3	242	Hayden Road Bridge
37116	227.4	2.1	-4.8	399	
37436	228.0	0.9	-3.2	-80	
37836	229.0	-0.2	1.4	-230	
38236	230.0	-0.0	1.7	-202	
38635	231.0	0.5	-1.3	270	Old Scottsdale Landfill
39042	232.0	1.2	-2.3	388	
39444	233.0	0.1	1.3	-56	
39840	234.0	0.3	1.5	-64	
40246	235.0	0.9	-1.1	338	
40647	236.0	0.7	0.0	320	Old Tempe Landfill
41043	237.0	0.6	0.4	-76	
41553	238.0	0.9	-0.5	41	
42018	239.0	1.0	-1.3	23	
42568	240.0	1.1	-2.5	424	Outer Loop Highway
43073	241.0	0.7	-1.3	59	
43588	242.0	0.5	0.3	-259	
44058	243.0	0.5	0.2	-299	
44528	244.0	0.5	0.0	-94	
45078	245.0	0.5	0.1	-137	
45693	246.0	0.5	-0.1	4	Evergreen Road
46197	247.0	0.5	-0.3	47	
46736	248.0	0.4	-0.1	6	
47237	249.0	0.4	-0.2	1	
47757	250.0	0.4	-0.1	8	
48364	251.0	0.4	-0.3	3	
48862	252.0	0.3	-0.2	2	Dobson Road
49506	253.0	0.2	-0.2	2	
49980	254.0	0.2	-0.3	4	
50487	255.0	0.0	0.0	0	
50957	256.0	0.0	0.0	0	
51491	257.0	0.0	0.0	0	
51910	258.0	0.0	0.0	0	
52496	259.0	0.0	0.0	0	
53001	260.0	0.0	0.0	0	
53445	261.0	0.0	0.0	0	
53954	262.0	0.0	0.0	0	
54478	263.0	0.0	0.0	0	
55034	264.0	0.0	0.0	0	
55471	265.0	0.0	0.0	0	Alma School Road

III. LOCAL SCOUR

Local scour, due to the presence of structures and debris in the flow field, was computed for the 100-year design flood under concept conditions for Alternative 3. Concept conditions for Alternative 3 assume that sand and gravel mining operations would not be permitted to extensively impact channel invert stability west of the Outer Loop Highway crossing. Local-scour computations at all locations were based on several pier-scour equations reported in the literature, and the most conservative result was adopted. Due to the close proximity of pier columns relative to the direction of the flow, pier scour and its resulting zone of influence was considered in the preliminary analyses for the East Papago crossing.

The zone of influence for local scour is the distance that the local scour extends from the face of the pier. This zone of influence can be approximately determined by assuming that the bottom of the scour hole extends horizontally one pier diameter away from the face of the pier in a radial direction, and then slopes upward to the bed of the channel on a 1.75 to 1 (horizontal to vertical) side-slope, which is approximately equal to the natural angle of repose of the streambed sediments. For example, the zone of influence for a 7-foot diameter pier with 24.7 feet of local scour would be 50.2 feet (7 feet plus 1.75 times 24.7 feet).

Local scour can be deeper if scour holes overlap. The mechanisms of this phenomenon are not well understood, but a conservative estimate of local scour can be obtained by considering the local-scour components to be additive at a given location. Consequently, if the predicted local scour for an individual 7-foot diameter pier column is 24.7 feet, the total (additive) local scour for 7-foot columns spaced on 40-foot centers would be 38.5 feet due to the overlapping of the scour holes. During the passage of the design flood, this 38.5 foot deep scour hole could migrate against the face of either pier. In addition, the zone of influence of this increased local scour, due to the overlapping of the scour holes, would expand to approximately 74.5 feet (7 feet plus 1.75 times 38.5 feet). This example demonstrates the need to carefully evaluate the size and location of piers in relation to each other when considering local scour.

A conservative approach for computing local scour under concept conditions was taken, since nothing in the literature addresses the determination of local scour at piers subject to such unique flow conditions. It is possible that a more precise estimate of local scour for these conditions could be developed with the aid of a physical model, should a more definitive estimate of local scour be desired.

IV. TOTAL SCOUR

As was stated in the initial report, the total-scour depth at any given point along the reach of the Salt River under investigation is the sum of the general scour; bedform-trough depths; local scour; and long-term degradation. A summary of total-scour depths that can be expected under concept conditions for Alternative 3 are presented in Table 4. The scour depths included in Table 4 were based on the assumption that mining operations would not be allowed under channelized conditions.

Pier scour included in Table 4 is for an East Papago structure with 135-foot spans and 7-foot diameter columns with 7 feet of additional pier width included for debris buildup. Pier-scour calculations at the Outer Loop crossing were performed assuming 130-foot spans and 6-foot diameter columns, with 6-feet of additional pier width included for debris buildup. Local-scour depths included in Table 4 are believed to be conservative. The depths included in the table account for the overlap of scour holes, and assume that no bedrock is encountered within the scour zone.

As stated previously, it was assumed that, under concept conditions, sand and gravel mining operations within a channelized section of the Salt River would not be permitted. As addressed in the initial report (1), particles with a minimum diameter of 110 mm are necessary to provide armoring for hydraulic conditions during a 100-year event. Assuming the fill material used to construct the concept channelized invert contained material at least ten percent coarser than the particle diameter necessary to form an armor layer, the long-term channel response would be governed by the armoring process. Using twice the diameter of the particle size necessary for armoring to constitute the thickness of the armor layer (4), a sufficient quantity of material is available within the top 6.5 feet of the concept channel invert to form an armor layer which will prevent further degradation beyond a depth of 6.5 feet during the 100-year design flood. Because this 6.5 feet of degradation occurs during the 100-year flood, and all floods of lesser magnitude would produce armoring depths less than 6.5 feet; it is felt that 6.5 feet of degradation is justified, under the preceding assumptions, as representative of the long-term channel response for concept conditions along the subject reach of the Salt River.

TABLE 4. Summary of Total-Scour Depths at Piers for Alternative 3

Project Station (ft)	Cross-Section Number	General Scour (ft)	Bed-Form Scour (ft)	Pier[1] Scour (ft)	Long-term[2] Degradation (ft)	Safety Factor (ft)	Total Scour at Piers (ft)	Minimum[3] Predicted Invert Elevation (ft)	Physical Feature
36660	226.0	1.9	2.0	39.0	6.5	3.1	52.5	1095.5	
37027	227.1	1.6	2.0	39.0	6.5	3.0	52.1	1097.9	Hayden Road Bridge
37116	227.4	0.0	2.0	39.0	6.5	2.6	50.1	1100.0	
37436	228.0	0.0	2.0	39.0	6.5	2.6	50.1	1100.0	
37836	229.0	3.0	2.0	39.0	6.5	3.4	54.0	1096.1	
38236	230.0	3.0	2.0	39.0	6.5	3.4	54.0	1096.1	
38635	231.0	3.0	2.0	39.0	6.5	3.4	54.0	1096.1	Old Scottsdale
39042	232.0	3.0	2.0	39.0	6.5	3.4	54.0	1096.1	Landfill
39444	233.0	3.0	2.0	39.0	6.5	3.4	54.0	1096.1	
39840	234.0	3.0	2.0	39.0	6.5	3.4	54.0	1096.1	
40246	235.0	3.0	2.0	39.0	6.5	3.4	54.0	1096.1	
40647	236.0	3.0	2.0	39.0	6.5	3.4	54.0	1096.1	Old Tempe Landfill
41043	237.0	3.0	2.0	39.0	6.5	3.4	54.0	1096.1	
41553	238.0	0.6	2.0	39.0	6.5	2.7	50.8	1099.2	
42018	239.0	0.5	2.0	23.0	6.5	9.6	41.6	1108.4	
42568	240.0	0.2	2.0	23.0	6.5	9.5	41.2	1110.2	Outer Loop Highway
43073	241.0	0.2	2.0	23.0	6.5	9.5	41.2	1110.3	
43588	242.0	0.5	2.0	23.0	6.5	9.6	41.6	1110.4	

NOTES:
1 Includes consideration for debris buildup.
2 Assumes armoring is the controlling process.
3 Based upon ADOT 1986 topographic mapping.

Except for when scour holes overlap, a safety factor equal to 30 percent of the sum of the above scour components is included to account for the non-uniform flow distribution that is typical of alluvial channels. It is felt that the conservative approach of simply adding depths for overlapping scour holes already incorporates an adequate safety factor for local scour at those locations where scour overlap occurs.

It should be noted that the minimum predicted invert elevations presented in Table 4 are intended for use in the design of bridge foundations. Toe-down depths for bank-protection systems should be designed considering the zone of influence of local scour at bridge piers. Since the location of the channel banks has not yet been determined, use of the long-term predicted invert elevation given in Table 4 for bank protection toe-down depths may produce an overly conservative design with regard to this component of bank protection design.

V. COMPARISON OF ALTERNATIVES

Addendum No. 1 to the initial report (2) presented a preliminary hydraulic analysis of Alternative 1, comprised of a south bank levee and the northern structural alignment east of Hayden Road. Addendum No. 2 presented the results of a preliminary hydraulic analysis for conditions similar to Addendum No. 1, but included a north bank levee which provided channel capacity to convey the design discharge. This addendum presents preliminary hydraulic results, using the same channel and freeway alignment as Addendum No. 2. However, protection along the north bank is limited to the top of the existing bank (approximate elevation of 1170.0 feet).

Table 5 presents hydraulic results of concept conditions for the proposed channel configurations which utilize bank protection along the north bank of the Salt River (Alternative 2 and Alternative 3). The results presented in Table 5 include consideration for debris buildup. Table 6 is a relative comparison between concept conditions of Alternative 2 and Alternative 3 for computed water-surface elevations, average velocities, and topwidths for the 100-year event, with debris buildup.

A comparison of water-surface elevations for the proposed alternatives show that Alternative 3 will result in lower water-surface elevations upstream of the Old Scottsdale Landfill. Above the Outer Loop crossing of the Salt River, the decrease in water-surface elevation, when compared to Alternative 2, is as much as 0.8 feet. Between Hayden Road and the Outer Loop crossing, Alternative 3 provides lower average velocities and greater topwidths than Alternative 2. The increased topwidth is the result of the decrease in height of the north hardbank, which permits overbank flow along the north bank. Concept conditions for Alternative 3 provide stability to the north bank while minimizing the resultant increase in water-surface elevations over baseline conditions.

TABLE 5. Hydraulic Information -- Concept Conditions for Alternative 2 and Alternative 3, 100-Year Event with Debris Buildup

		ALTERNATIVE 3				ALTERNATIVE 2				
PROJECT STATION (ft)	CROSS-SECTION NUMBER	CALCULATED WATER SURFACE ELEV. (ft)	HYDRAULIC DEPTH (ft)	CHANNEL VELOCITY (fps)	TOPWIDTH (ft)	CALCULATED WATER SURFACE ELEV. (ft)	HYDRAULIC DEPTH (ft)	CHANNEL VELOCITY (fps)	TOPWIDTH (ft)	PHYSICAL FEATURE
36263	225.00	1170.7	17.8	11.2	1231	1170.7	17.8	11.2	1231	
36660	226.00	1171.4	17.8	11.9	1261	1171.4	17.8	11.9	1261	
37027	227.10	1173.2	21.4	8.7	1813	1173.2	21.5	8.8	1139	Hayden Road Bridge
37116	227.40	1173.9	22.2	8.4	1895	1173.6	21.8	8.6	1141	
37436	228.00	1174.6	21.7	7.3	2345	1174.3	23.3	7.7	1204	
37836	229.00	1174.7	18.9	9.1	2200	1174.3	23.4	9.7	942	
38236	230.00	1175.0	16.7	10.4	2453	1174.5	24.4	11.5	768	
38635	231.00	1175.5	16.2	11.5	2328	1175.1	25.1	12.8	668	Old Scottsdale
39042	232.00	1176.5	17.7	10.7	2481	1176.3	26.2	12.1	676	Landfill
39444	233.00	1177.3	19.6	10.5	2254	1177.2	27.0	11.8	672	
39840	234.00	1178.1	21.1	9.9	1923	1178.2	27.7	11.2	694	
40246	235.00	1178.6	21.7	9.7	1941	1178.8	27.2	10.9	725	
40647	236.00	1179.3	23.8	9.2	2194	1179.7	26.8	9.8	819	Old Tempe Landfill
41043	237.00	1179.7	23.8	9.0	1396	1180.4	26.0	9.2	899	
41553	238.00	1180.6	29.2	7.3	1496	1181.3	30.8	7.5	930	
42018	239.00	1180.7	28.8	7.6	1461	1181.5	29.5	7.7	970	
42568	240.00	1181.5	21.2	5.5	1885	1182.1	29.9	6.4	1161	Outer Loop Highway
43073	241.00	1181.7	21.3	5.5	1885	1182.5	30.3	5.3	1361	
43588	242.00	1181.9	24.7	5.3	2065	1182.7	25.4	5.2	1715	
44058	243.00	1182.2	25.8	4.2	2183	1183.0	26.5	4.0	2184	
44528	244.00	1182.3	19.7	4.6	2439	1183.0	20.4	4.4	2440	
45078	245.00	1182.4	16.7	4.8	2731	1183.2	17.4	4.6	2733	
45693	246.00	1182.8	17.4	4.0	3150	1183.5	18.1	3.9	3155	Evergreen Road
46197	247.00	1182.8	13.9	6.6	2401	1183.5	14.5	6.3	2434	
46736	248.00	1183.4	17.5	4.0	3182	1184.0	18.1	3.8	3189	
47237	249.00	1183.5	20.2	4.2	2580	1184.1	20.8	4.1	2586	
47757	250.00	1183.6	18.0	5.0	2457	1184.2	18.6	4.8	2469	
48364	251.00	1183.6	13.5	8.8	1863	1184.2	14.0	8.4	1867	
48862	252.00	1184.2	15.4	9.2	1560	1184.7	15.8	8.9	1564	Dobson Road
49506	253.00	1185.6	12.0	8.6	2122	1185.9	12.4	8.4	2125	
49980	254.00	1185.7	9.6	14.7	1549	1186.0	9.8	14.3	1577	
50487	255.00	1189.7	12.8	11.1	1541	1189.7	12.8	11.1	1541	
50957	256.00	1191.5	18.4	7.5	1586	1191.5	18.4	7.5	1586	
51491	257.00	1191.5	13.2	11.2	1496	1191.5	13.2	11.2	1496	
51910	258.00	1192.6	17.3	11.0	1162	1192.6	17.3	11.0	1162	
52496	259.00	1194.3	15.5	9.1	1565	1194.3	15.5	9.1	1565	
53001	260.00	1195.3	17.8	8.0	1662	1195.3	17.8	8.0	1662	
53445	261.00	1195.9	20.9	6.9	2069	1195.9	20.9	6.9	2069	
53954	262.00	1195.9	17.2	11.7	1820	1195.9	17.2	11.7	1820	
54478	263.00	1196.9	13.1	11.7	2145	1196.9	13.1	11.7	2145	
55034	264.00	1198.2	12.2	12.2	1871	1198.2	12.2	12.2	1871	
55471	265.00	1199.6	13.4	11.0	2008	1199.6	13.4	11.0	2008	Alma School Road

TABLE 6. Water-Surface Elevation, Average Velocity, and Topwidth Comparisons -- Concept Conditions for Alternative 3 Minus Alternative 2, 100-Year Event with Debris Buildup

PROJECT STATION (feet)	CROSS-SECTION NUMBER	WATER SURFACE ELEVATION (feet)	CHANNEL VELOCITY (ft/sec)	TOPWIDTH (ft)	PHYSICAL FEATURE
36263	225.00	0.0	0.0	0	
36660	226.00	0.0	0.0	0	
37027	227.10	0.1	-0.1	674	Hayden Road Bridge
37116	227.40	0.4	-0.3	753	
37436	228.00	0.4	-0.4	1142	
37836	229.00	0.4	-0.7	1258	
38236	230.00	0.4	-1.1	1686	
38635	231.00	0.4	-1.4	1661	Old Scottsdale Landfill
39042	232.00	0.3	-1.5	1805	
39444	233.00	0.1	-1.4	1583	
39840	234.00	-0.1	-1.2	1230	
40246	235.00	-0.2	-1.2	1216	
40647	236.00	-0.5	-0.6	1376	Old Tempe Landfill
41043	237.00	-0.7	-0.2	497	
41553	238.00	-0.7	-0.2	566	
42018	239.00	-0.7	-0.1	491	
42568	240.00	-0.6	-0.8	724	Outer Loop Highway
43073	241.00	-0.8	0.1	524	
43588	242.00	-0.8	0.1	350	
44058	243.00	-0.8	0.1	-1	
44528	244.00	-0.8	0.2	-1	
45078	245.00	-0.8	0.2	-2	
45693	246.00	-0.7	0.2	-5	Evergreen Road
46197	247.00	-0.7	0.3	-33	
46736	248.00	-0.6	0.1	-6	
47237	249.00	-0.6	0.1	-6	
47757	250.00	-0.6	0.2	-11	
48364	251.00	-0.6	0.4	-4	
48862	252.00	-0.5	0.3	-3	Dobson Road
49506	253.00	-0.4	0.3	-2	
49980	254.00	-0.3	0.5	-28	
50487	255.00	0.0	0.0	0	
50957	256.00	0.0	0.0	0	
51491	257.00	0.0	0.0	0	
51910	258.00	0.0	0.0	0	
52496	259.00	0.0	0.0	0	
53001	260.00	0.0	0.0	0	
53445	261.00	0.0	0.0	0	
53954	262.00	0.0	0.0	0	
54478	263.00	0.0	0.0	0	
55034	264.00	0.0	0.0	0	
55471	265.00	0.0	0.0	0	Alma School Road

VI. SUMMARY

This addendum has presented the preliminary results of a hydraulic and local-scour analysis for a northern alignment of Section 6 of the East Papago Freeway. Concept channel modifications include a leveed south bank identical to that used in the first and second addendums. Alternative 3 concept conditions include bank protection to the top of the existing north main channel bank (approximately 1170.0 feet) from Hayden Road through the Outer Loop crossing of the Salt River.

The results presented as concept conditions are for the best estimate of conditions resulting from the proposed northern alignment, which is entirely on structure from Hayden Road to the Red Mountain Interchange. Concept conditions for the proposed northern alignment were analyzed both with and without debris buildup on the piers. Preliminary estimates of local scour at bridge piers have been performed, based on initial bridge configurations. In addition, scour depths for piers, based upon preliminary total-scour estimates, and a comparison of alternatives have been provided as part of this addendum.

From a hydrologic, hydraulic, and erosion standpoint; the advantages/ disadvantages of Alternative 2 (proposed northern alignment with both north and south bank levees) and of Alternative 3 (proposed northern alignment with south bank levee and bank protection to the top of the existing north bank) are as follows:

ALTERNATIVE 2

Advantages	Disadvantages
Shorter Outer Loop structure	Higher water-surface elevations.
Potential for reclaimed land from the 100-year floodplain.	Higher average velocities.

ALTERNATIVE 3

Advantages	Disadvantages
Lower water-surface elevations.	Flood flow inundation of the north overbank.
Lower average velocities.	Longer Outer Loop structure.

In summary, the results presented in this addendum show that the proposed northern alignment, under the concept conditions of Alternative 3, will increase water-surface elevations above baseline conditions. However, the concept conditions of Alternative 3 have presented reduced upstream impacts in comparison with Alternative 2. Increases on the order of 1.0 feet occur upstream of the Hayden Road Bridge, near the Old Scottsdale Landfill, and downstream from the Outer Loop Highway crossing. However, upstream of the Outer Loop crossing, the increase in water-surface elevation remains below 0.5 feet and gradually diminishes to baseline conditions around Dobson Road.

VII. REFERENCES

1. Simons, Li & Associates, Inc., "Preliminary Hydraulic Analysis of the Salt River for the East Papago Freeway and Red Mountain Interchange." Submitted to Daniel, Mann, Johnson, & Mendenhall. September 1989.

2. Simons, Li & Associates, Inc., "Addendum No. 1 to: Preliminary Hydraulic Analysis of the Salt River for the East Papago Freeway and Red Mountain Interchange." Submitted to Daniel, Mann, Johnson, & Mendenhall. November 22, 1989.

3. Simons, Li & Associates, Inc., "Addendum No. 2 to: Preliminary Hydraulic Analysis of the Salt River for the East Papago Freeway and Red Mountain Interchange." Submitted to Daniel, Mann, Johnson, & Mendenhall. November 1989.

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