DICK PERRETTI

ADDENDUM NO. 2 TO:
PRELIMINARY HYDRAULIC ANALYSIS OF THE SALT RIVER FOR THE EAST PAPAGO FREEWAY AND RED MOUNTAIN INTERCHANGE

sla

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

Submitted to:

Daniel, Mann, Johnson, & Mendenhall
300 West Clarendon Avenue, Suite 400
Phoenix, Arizona 85013-3499

Submitted by:

Simons, Li & Associates, Inc.
4600 South Mill Avenue, Suite 280
Tempe, Arizona 85282

December 7, 1989

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PREFACE

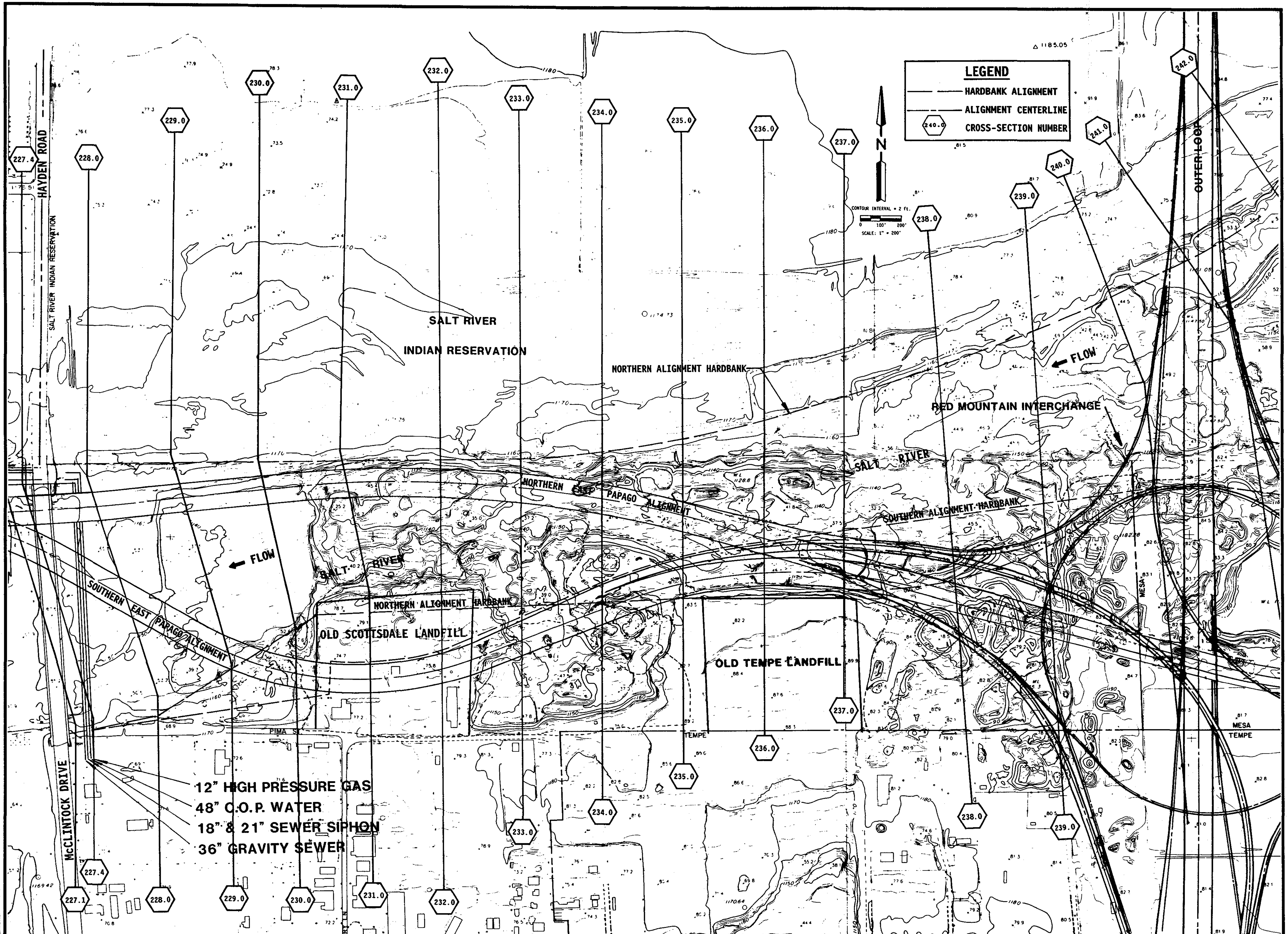
The results presented in this report are based on state-of-the-art techniques for river mechanics and scour analysis. However, the state-of-the-art of river mechanics is such that flow depths on the order of those which exist within the Salt River cannot realistically be predicted more accurately than 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," 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 analysis 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. In this addendum, the alignment analyzed in the initial report will be termed the southern alignment.

In November 1989, Simons, Li & Associates, Inc. (SLA), prepared "Addendum No. 1 to: Preliminary Hydraulic Analysis of the Salt River for the East Papago Freeway and Red Mountain Interchange." Addendum No. 1 evaluated 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 in Addendum No. 1 included a channel with bank protection along the south bank of the Salt River between Hayden Road and the Outer Loop Highway crossing, and no bank protection along the north bank. In this addendum, the above described alternative will be termed Alternative 1.

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 addendum. However, the reach of river from the existing Hayden Road Bridge through the Outer Loop crossing was assumed to be leveed on both the north and south banks. Therefore, the proposed alignment presented in this addendum evaluates the northern structural alignment under channelized conditions, and will be termed Alternative 2. Figure 1 shows the general location of the alignments analyzed to date.



sla SIMONS, LI & ASSOCIATES, INC.
NEWPORT BEACH, CA., FORT COLLINS, CO.,
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 2

2.1 General

The procedures and data base used for the analysis of the proposed northern alignment were the same as those used for the analysis of the proposed southern alignment, and are described in the initial report (1). For concept conditions of Alternative 2 (proposed northern alignment with bank protection), 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 impacts resulting from the project. This is the same approach as was used in the initial report and the first addendum, 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. This approach provides a conservative estimate of baseline water-surface elevations.

The baseline condition used for this study is identical to that used in the first addendum (2), which includes an adjustment made to cross-section 234.00. It was determined that cross-section 234.00 in the initial analysis contained an obstruction which was unique to the location of the cross-section, and that produced irregular results. Therefore, the baseline condition presented in this addendum incorporates an adjustment to cross-section 234.00.

2.2 Concept Analysis - Alternative 2

Concept conditions for Alternative 2 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) leveed embankments on both the north and south sides of the Salt River, which establishes channelized conditions; and (3) the best estimate of the Outer Loop bridge configuration. The effects of gravel pits were removed from the concept conditions for Alternative 2, 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 Alternative 1 presented in the first addendum (2).

In addition to removing the effects of gravel pits, concept conditions for Alternative 2 include bank protection along the south bank of the river identical to that described in the first addendum. 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. Concept conditions for Alternative 2 also include bank protection along the north bank from the east side of the existing Hayden Road Bridge abutment through the Outer Loop Highway crossing of the Salt River. The alignment of the north bank generally follows the southern edge of the Salt River Project's power transmission easement on the north bank of the Salt River.

The concept condition 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 and ramps of the Outer Loop crossing under concept conditions is approximately 1100 feet. A decrease in effective length of the Outer Loop crossing relative to the initial report and Addendum No. 1 are a result of the concept channelized conditions 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 2 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. Figure 2 provides plots of the water-surface profiles for the 100-year event. Computed differences between concept conditions for Alternative 2, with debris

TABLE 1. Hydraulic Information -- Baseline and Concept Conditions for Alternative 2, 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	21.4	8.8	1138	Hayden Road Bridge
37116	227.40	1171.8	14.2	13.2	1496	1173.5	21.7	8.7	1141	
37436	228.00	1173.8	18.7	10.5	2426	1174.2	23.2	7.5	1232	
37836	229.00	1174.9	22.7	7.7	2430	1174.2	23.4	9.5	970	
38236	230.00	1175.0	22.6	8.7	2655	1174.5	24.3	11.1	796	
38635	231.00	1175.0	21.3	12.8	2059	1175.0	25.0	12.4	696	Old Scottsdale
39042	232.00	1175.4	22.8	13.0	2093	1176.0	26.0	11.8	704	Landfill
39444	233.00	1177.3	15.4	9.1	2311	1176.9	26.8	11.5	700	
39840	234.00	1177.7	24.6	8.4	1987	1177.8	27.4	10.9	722	
40246	235.00	1177.7	22.3	10.8	1603	1178.4	26.9	10.6	752	
40647	236.00	1178.6	24.6	9.1	1875	1179.3	26.4	9.6	846	Old Tempe Landfill
41043	237.00	1179.1	24.6	8.6	1472	1179.9	25.6	9.1	927	
41553	238.00	1179.6	25.2	7.8	1456	1180.7	30.2	7.7	930	
42018	239.00	1179.8	16.5	8.9	1438	1180.9	28.9	7.8	970	
42568	240.00	1180.4	25.0	8.0	1461	1181.5	29.3	6.5	1160	Outer Loop Highway
43073	241.00	1181.0	22.9	6.8	1826	1182.0	29.8	5.4	1360	
43588	242.00	1181.5	25.0	5.1	2324	1182.2	24.9	5.3	1715	
44058	243.00	1181.7	25.7	4.0	2482	1182.5	26.1	4.1	2183	
44528	244.00	1181.8	19.2	4.5	2532	1182.5	20.0	4.5	2439	
45078	245.00	1181.9	16.1	4.8	2868	1182.7	16.9	4.8	2732	
45693	246.00	1182.2	16.9	4.2	3146	1183.0	17.6	4.0	3151	Evergreen Road
46197	247.00	1182.2	13.6	6.9	2354	1183.0	14.1	6.5	2412	
46736	248.00	1183.0	17.0	4.1	3177	1183.6	17.7	3.9	3185	
47237	249.00	1183.1	19.5	4.4	2579	1183.7	20.4	4.2	2582	
47757	250.00	1183.2	17.7	5.1	2450	1183.8	18.2	4.9	2461	
48364	251.00	1183.2	13.0	9.1	1861	1183.8	13.7	8.7	1865	
48862	252.00	1183.9	15.1	9.4	1558	1184.4	15.5	9.1	1561	Dobson Road
49506	253.00	1185.3	11.8	8.8	2121	1185.7	12.1	8.5	2123	
49980	254.00	1185.5	9.5	15.0	1545	1185.8	9.7	14.6	1557	
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	11.7	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	13.4	11.0	2008	Alma School Road

TABLE 2. Hydraulic Information -- Baseline and Concept Conditions for Alternative 2, 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	21.5	8.8	1139	Hayden Road Bridge
37116	227.40	1171.8	14.2	13.2	1496	1173.6	21.8	8.6	1141	
37436	228.00	1173.8	18.7	10.5	2426	1174.3	23.3	7.7	1204	
37836	229.00	1174.9	22.7	7.7	2430	1174.3	23.4	9.7	942	
38236	230.00	1175.0	22.6	8.7	2655	1174.5	24.4	11.5	768	
38635	231.00	1175.0	21.3	12.8	2059	1175.1	25.1	12.8	668	Old Scottsdale
39042	232.00	1175.4	22.8	13.0	2093	1176.3	26.2	12.1	676	Landfill
39444	233.00	1177.3	15.4	9.1	2311	1177.2	27.0	11.8	672	
39840	234.00	1177.7	24.6	8.4	1987	1178.2	27.7	11.2	694	
40246	235.00	1177.7	22.3	10.8	1603	1178.8	27.2	10.9	725	
40647	236.00	1178.6	24.6	9.1	1875	1179.7	26.8	9.8	819	Old Tempe Landfill
41043	237.00	1179.1	24.6	8.6	1472	1180.4	26.0	9.2	899	
41553	238.00	1179.6	25.2	7.8	1456	1181.3	30.8	7.5	930	
42018	239.00	1179.8	16.5	8.9	1438	1181.5	29.5	7.7	970	
42568	240.00	1180.4	25.0	8.0	1461	1182.1	29.9	6.4	1161	Outer Loop Highway
43073	241.00	1181.0	22.9	6.8	1826	1182.5	30.3	5.3	1361	
43588	242.00	1181.5	25.0	5.1	2324	1182.7	25.4	5.2	1715	
44058	243.00	1181.7	25.7	4.0	2482	1183.0	26.5	4.0	2184	
44528	244.00	1181.8	19.2	4.5	2532	1183.0	20.4	4.4	2440	
45078	245.00	1181.9	16.1	4.8	2868	1183.2	17.4	4.6	2733	
45693	246.00	1182.2	16.9	4.2	3146	1183.5	18.1	3.9	3155	Evergreen Road
46197	247.00	1182.2	13.6	6.9	2354	1183.5	14.5	6.3	2434	
46736	248.00	1183.0	17.0	4.1	3177	1184.0	18.1	3.8	3189	
47237	249.00	1183.1	19.5	4.4	2579	1184.1	20.8	4.1	2586	
47757	250.00	1183.2	17.7	5.1	2450	1184.2	18.6	4.8	2469	
48364	251.00	1183.2	13.0	9.1	1861	1184.2	14.0	8.4	1867	
48862	252.00	1183.9	15.1	9.4	1558	1184.7	15.8	8.9	1564	Dobson Road
49506	253.00	1185.3	11.8	8.8	2121	1185.9	12.4	8.4	2125	
49980	254.00	1185.5	9.5	15.0	1545	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

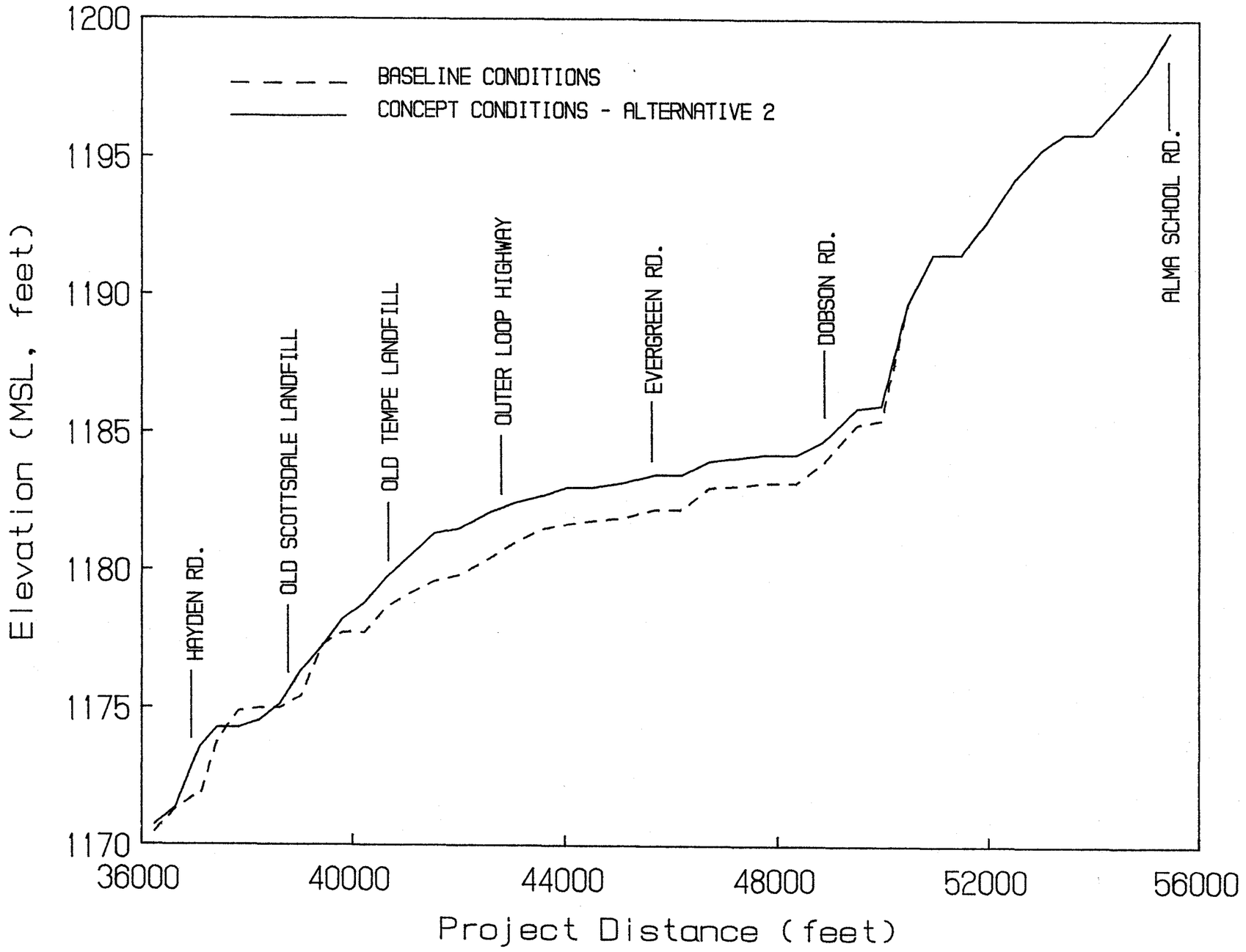


Figure 2. Water-surface Profiles of Baseline and Concept Conditions for Alternative 2, 100-Year Event with Debris Buildup

buildup, and baseline conditions for water-surface elevations, average velocities, and channel topwidths are presented in Table 3 for the 100-year event.

Results from the hydraulic analysis for concept conditions of Alternative 2 show a maximum increase in water-surface elevation of 1.8 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. A hydraulic constriction upstream, created by the proposed leveed north and south banks through the Old Scottsdale Landfill and the Old Tempe Landfill, results in a 1.7 foot increase in water-surface elevation (cross-sections 238.00 to 240.00). Upstream of the Outer Loop Highway crossing, the increase in water-surface elevation is 1.3 feet and continues to be 1.0 foot, or greater, to Dobson Road. This increase in water-surface elevation is due largely to the reduction in channel width associated with concept conditions.

The maximum increase in average velocity is 2.8 feet per second, which occurs downstream of the Old Scottsdale Landfill at cross-section 230.00. The maximum decrease in channel velocity is 4.5 feet per second, which occurs at the upstream face of the existing Hayden Road bridge. In general, the average channel velocity decreases from upstream of the Old Tempe Landfill through approximately Dobson Road. Table 3 also reflects a significant decrease in the average channel topwidth as a result of the concept channelization.

TABLE 3. Water-Surface Elevations, Average Velocity, and Topwidth Comparisons -- Concept Conditions for Alternative 2 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	225.00	0.2	0.6	-949	
36660	226.00	0.2	1.2	-991	
37027	227.10	1.4	-2.2	-432	Hayden Road Bridge
37116	227.40	1.8	-4.5	-355	
37436	228.00	0.5	-2.8	-1222	
37836	229.00	-0.6	2.1	-1488	
38236	230.00	-0.5	2.8	-1887	
38635	231.00	0.1	0.0	-1391	Old Scottsdale Landfill
39042	232.00	0.9	-0.9	-1417	
39444	233.00	-0.0	2.7	-1639	
39840	234.00	0.5	2.7	-1293	
40246	235.00	1.1	0.2	-878	
40647	236.00	1.1	0.7	-1056	Old Tempe Landfill
41043	237.00	1.3	0.7	-573	
41553	238.00	1.7	-0.3	-526	
42018	239.00	1.7	-1.2	-468	
42568	240.00	1.7	-1.6	-300	Outer Loop Highway
43073	241.00	1.6	-1.5	-465	
43588	242.00	1.2	0.2	-609	
44058	243.00	1.3	0.1	-298	
44528	244.00	1.3	-0.1	-92	
45078	245.00	1.2	-0.1	-135	
45693	246.00	1.2	-0.3	9	Evergreen Road
46197	247.00	1.2	-0.6	80	
46736	248.00	1.1	-0.3	12	
47237	249.00	1.0	-0.3	7	
47757	250.00	1.0	-0.3	19	
48364	251.00	1.0	-0.7	6	
48862	252.00	0.8	-0.5	6	Dobson Road
49506	253.00	0.6	-0.4	4	
49980	254.00	0.5	-0.8	32	
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

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 2. Concept conditions for the channelized northern alignment assume that sand and gravel mining operations would not be permitted within the channel. 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 26 feet of local scour would be 52.5 feet (7 feet plus 1.75 times 26 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 26 feet, the total (additive) local scour for 7-foot columns spaced on 40-foot centers would be 41.1 feet due to the overlapping of the scour holes. During the passage of the design flood, this 41.1 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 79 feet (7 feet plus 1.75 times 41.1 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 computed for concept conditions of Alternative 2 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 potential 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 fully 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 at least ten percent material 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 (3), 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 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 2

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	41.0	6.5	3.1	54.5	1093.5	
37027	227.1	1.6	2.0	41.0	6.5	3.0	54.1	1095.9	Hayden Road Bridge
37116	227.4	0.0	2.0	41.0	6.5	2.6	52.1	1098.0	
37436	228.0	0.0	2.0	41.0	6.5	2.6	52.1	1098.0	
37836	229.0	3.0	2.0	41.0	6.5	3.5	56.0	1094.1	
38236	230.0	3.0	2.0	41.0	6.5	3.5	56.0	1094.1	
38635	231.0	3.0	2.0	41.0	6.5	3.5	56.0	1094.1	Old Scottsdale
39042	232.0	3.0	2.0	41.0	6.5	3.5	56.0	1094.1	Landfill
39444	233.0	3.0	2.0	41.0	6.5	3.5	56.0	1094.0	
39840	234.0	3.0	2.0	41.0	6.5	3.5	56.0	1094.0	
40246	235.0	3.0	2.0	41.0	6.5	3.5	56.0	1094.0	
40647	236.0	3.0	2.0	41.0	6.5	3.5	56.0	1094.0	Old Tempe Landfill
41043	237.0	3.0	2.0	41.0	6.5	3.5	56.0	1094.1	
41553	238.0	0.6	2.0	41.0	6.5	2.7	52.8	1097.2	
42018	239.0	0.5	2.0	24.0	6.5	9.9	42.9	1107.1	
42568	240.0	0.2	2.0	24.0	6.5	9.8	42.5	1108.9	Outer Loop Highway
43073	241.0	0.2	2.0	24.0	6.5	9.8	42.5	1109.0	
43588	242.0	0.5	2.0	24.0	6.5	9.9	42.9	1109.1	

NOTES:
1 Includes consideration for debris buildup.
2 Represents armoring as 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 these locations.

It should be noted that the long-term 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 provide an overly conservative design.

V. COMPARISON OF ALTERNATIVES

Addendum No. 1 to the initial report (2) presented a preliminary hydraulic analysis of Alternative 1, comprised of a structural alternative east of Hayden Road. This addendum (Addendum No. 2) has presented the results of a preliminary hydraulic analysis for the same proposed northern structural alignment, but with bank protection provided on both the south bank and the north bank.

Table 5 presents the hydraulic results of concept conditions for both of the proposed northern alignments (Alternative 1 and Alternative 2), with debris buildup. Table 6 is a relative comparison between concept conditions of the proposed northern alignments 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 northern alignments show that the channelized concept condition will result in higher water-surface elevations upstream of the Old Scottsdale Landfill (cross-section 232.00). The maximum increase over Alternative 1 is 1.2 feet, which occurs at the Outer Loop crossing of the Salt River (cross-section 241.00). The increased water-surface elevations are a consequence of the reduction in channel width associated with concept channelized conditions.

Downstream of the Old Scottsdale Landfill, water-surface elevations generally decrease under channelized conditions. The effect of decreased water-surface elevations under these conditions is an increase in average channel velocities. The maximum increase in average velocity under channelized conditions is 2.0 feet per second, which occurs at the Old Scottsdale Landfill (cross-section 231.00 and 232.00). Average velocities upstream of the Outer Loop crossing are generally lower as a result of the backwater created from channelized conditions. However, the constriction created at the Outer Loop crossing causes minimal upstream inundation. Two factors, the effect of in-stream mining on channel geometry and the extension of the south hardbank to approximately Evergreen Road, mitigate impacts upstream of the Outer Loop crossing caused by the concept channelized conditions. As presented in Table 6, the comparison of calculated topwidths between channelized and existing north

TABLE 5. Hydraulic Information -- Concept Conditions for the Proposed Northern Alignment, 100-Year Event with Debris Buildup

		ALTERNATIVE 2				ALTERNATIVE 1				
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	21.5	8.8	1139	1173.2	21.4	8.7	1813	Hayden Road Bridge
37116	227.40	1173.6	21.8	8.6	1141	1173.9	22.2	8.4	1895	
37436	228.00	1174.3	23.3	7.7	1204	1174.7	21.8	7.1	2356	
37836	229.00	1174.3	23.4	9.7	942	1174.8	19.0	8.8	2206	
38236	230.00	1174.5	24.4	11.5	768	1175.0	16.9	10.1	2454	
38635	231.00	1175.1	25.1	12.8	668	1175.5	17.0	10.8	2335	Old Scottsdale
39042	232.00	1176.3	26.2	12.1	676	1176.4	18.8	10.2	2477	Landfill
39444	233.00	1177.2	27.0	11.8	672	1177.0	19.9	10.3	2094	
39840	234.00	1178.2	27.7	11.2	694	1177.7	21.6	9.8	1827	
40246	235.00	1178.8	27.2	10.9	725	1178.1	23.7	10.1	1628	
40647	236.00	1179.7	26.8	9.8	819	1178.8	23.5	9.4	1930	Old Tempe Landfill
41043	237.00	1180.4	26.0	9.2	899	1179.2	23.4	9.2	1391	
41553	238.00	1181.3	30.8	7.5	930	1180.2	29.3	7.3	1496	
42018	239.00	1181.5	29.5	7.7	970	1180.4	28.4	7.7	1458	
42568	240.00	1182.1	29.9	6.4	1161	1181.1	20.9	5.6	1883	Outer Loop Highway
43073	241.00	1182.5	30.3	5.3	1361	1181.4	21.0	5.6	1884	
43588	242.00	1182.7	25.4	5.2	1715	1181.6	25.1	5.2	2131	
44058	243.00	1183.0	26.5	4.0	2184	1181.9	26.0	4.1	2244	
44528	244.00	1183.0	20.4	4.4	2440	1181.9	19.4	5.0	2285	
45078	245.00	1183.2	17.4	4.6	2733	1182.1	16.3	5.2	2582	
45693	246.00	1183.5	18.1	3.9	3155	1182.5	17.2	4.1	3145	Evergreen Road
46197	247.00	1183.5	14.5	6.3	2434	1182.5	13.8	6.7	2390	
46736	248.00	1184.0	18.1	3.8	3189	1183.2	17.3	4.0	3179	
47237	249.00	1184.1	20.8	4.1	2586	1183.3	20.0	4.3	2578	
47757	250.00	1184.2	18.6	4.8	2469	1183.4	17.9	5.0	2454	
48364	251.00	1184.2	14.0	8.4	1867	1183.4	13.3	8.9	1862	
48862	252.00	1184.7	15.8	8.9	1564	1184.1	15.2	9.3	1559	Dobson Road
49506	253.00	1185.9	12.4	8.4	2125	1185.5	11.9	8.7	2122	
49980	254.00	1186.0	9.8	14.3	1577	1185.6	9.6	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	17.3	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 Elevations, Velocity, and Topwidth Comparisons -- Concept Conditions for Alternative 2 Minus Alternative 1, 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	0.6	-1153	
37836	229.00	-0.5	1.0	-1264	
38236	230.00	-0.5	1.4	-1686	
38635	231.00	-0.4	2.0	-1667	Old Scottsdale Landfill
39042	232.00	-0.1	2.0	-1801	
39444	233.00	0.3	1.5	-1422	
39840	234.00	0.5	1.4	-1133	
40246	235.00	0.7	0.8	-904	
40647	236.00	0.9	0.5	-1111	Old Tempe Landfill
41043	237.00	1.1	0.0	-492	
41553	238.00	1.1	0.2	-566	
42018	239.00	1.1	0.0	-488	
42568	240.00	0.9	0.8	-722	Outer Loop Highway
43073	241.00	1.2	-0.2	-523	
43588	242.00	1.1	0.0	-416	
44058	243.00	1.1	-0.1	-61	
44528	244.00	1.1	-0.5	155	
45078	245.00	1.1	-0.6	151	
45693	246.00	0.9	-0.2	9	Evergreen Road
46197	247.00	0.9	-0.4	44	
46736	248.00	0.8	-0.2	10	
47237	249.00	0.8	-0.2	8	
47757	250.00	0.8	-0.2	15	
48364	251.00	0.8	-0.5	5	
48862	252.00	0.7	-0.4	4	Dobson Road
49506	253.00	0.5	-0.3	3	
49980	254.00	0.4	-0.6	30	
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

bank conditions for the proposed northern alignment of the East Papago Freeway indicates the potential for land which could be reclaimed from the 100-year floodplain.

As noted in Addendum No. 1, one disadvantage of Alternative 1 is that pier scour, and its resulting zone of influence, could potentially undermine the north bank and create bank stability problems for the section of the freeway located parallel to the north bank of the Salt River. The results presented in this addendum exhibit local increases in water-surface elevations and average channel velocities over Alternative 1 in exchange for defined channel banks and reclaimed floodplain. Additionally, under the assumption that sand and gravel mining would not be permitted under channelized conditions, the depth of bridge foundations required for Alternative 2 would be less.

VI. SUMMARY

This addendum has presented the preliminary results of a hydraulic and local-scour analysis for a northern alignment of the East Papago Freeway with bank protection on both the south and north banks of the Salt River from immediately downstream of Hayden Road through the Outer Loop Highway crossing. 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. Scour depths for piers, based upon preliminary total-scour estimates, have been provided as part of this addendum.

From a hydrologic, hydraulic, and erosion standpoint; the advantages/ disadvantages of Alternative 1 (proposed northern alignment with south bank protection) and of Alternative 2 (proposed northern alignment with both north and south bank protection) are as follows:

ALTERNATIVE 1

Advantages	Disadvantages
Lower water-surface elevations.	Greater impact from mining operations
Lower average velocities.	Greater erosion potential.
	Potential problems due to debris.
	Greater land inundation during 100-year flood event.

ALTERNATIVE 2

Advantages	Disadvantages
Less impact from gravel mining.	Higher water-surface elevations.
Less erosion potential.	Higher average velocities.
Potential for reclaimable land from the 100-year floodplain.	Potential problems due to debris.

In summary, the results presented in this addendum show that the proposed northern alignment with bank protection will increase water-surface elevations and average channel velocities. However, the impact associated with these increases is minimized, since the channel can effectively convey the design discharge within the channel banks. Concept conditions for the northern alignment with bank protection also provides potential for the removal of land from the 100-year floodplain.

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., Engineering Analysis of Fluvial Systems, published by Simons, Li & Associates, printed and bound by Bookcrafters, Inc., Chelsea, Michigan 1982.