FINAL HYDRAULIC & SCOUR ANALYSIS REPORT

SALT RIVER
EAST PAPAGO FREEWAY
McCLINTOCK DRIVE TO SR 101L
MARICOPA COUNTY, ARIZONA

sla

Property of
Flood Control District of MC Library
Please Return to
2801 W. Durango
Phoenix, AZ 85009

FINAL HYDRAULIC & SCOUR ANALYSIS REPORT

SALT RIVER
EAST PAPAGO FREEWAY
McCLINTOCK DRIVE TO SR 101L
MARICOPA COUNTY, ARIZONA

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 200
Tempe, Arizona 85282
(602) 491-1393

Registered Professional Engineer (Civil)
CERTIFICATE NO.
28660
BART S.
BERGENDAHL
Date Signed 7-23-97
ARIZONA, U.S.A.

July, 1997

DMJM

Daniel, Mann, Johnson, & Mendenhall
300 West Clarendon Avenue, Suite 325
Phoenix, Arizona 85013-3499
Telephone: 602/277-1074
Fax: 602/241-0721

REGIONAL FREEWAY SYSTEM
ADOT GENERAL CONSULTANT

letter of transmittal

TO: ADOT VALLEY PROJECT MANAGEMENT
205 S. 17TH AVENUE, ROOM 295E
PHOENIX, AZ 85007

ATTENTION: TERRY BOURLAND

DATE: 8/26/97

DN: 37700
FN: 706.1.9, 500.11.1.2, 300.2, 300.11, 410.4, 410.8, 200.2, 800

We Transmit: ☒ herewith ☐ under separate cover ☐ as requested

Via: ☐ mail ☒ messenger ☐ federal express ☐ fax

For your: ☒ use ☐ review and comment ☒ information ☐ record ☐ distribution ☐ approval/acceptance ☐ signature ☐ other

The following: ☐ drawings ☐ specifications ☐ calculations ☒ report ☐ copy of letter ☐ shop drawing/product data ☐ diskettes ☐ change order ☐ originals ☐ other

copies	reference no.	description	action code
1		Final Hydraulic and Scour Analysis Report	
		Salt River from McClintock Drive to SR 101L	

FLOOD CONTROL DISTRICT
RECEIVED
AUG 26 1997
CH ENG | P & PM
DEI | HYDRO
ADMIN | LMOT
FINANCE | FILE
O & C
REMARKS

Action codes: A - Sign and return B - Forward as noted C - Resubmit D - Refer to remarks below

LS(RM) 3.9

Remarks:

This final report reflects the as-built conditions for the Salt River. It also includes extensive historical correspondence.

CC: EAR

Distribution of the report is shown below:

Joe Warren - ADOT Drainage (1)	Howard Hargis - Tempe (1)
Craig Cornwell - ADOT District Maintenance (1)	Tom Ankeny - Tempe (1)
Don Rerick - MCFCD (3)	Dennis Richards - SLA (1)
Chuck Reynolds - AGRA (1)	

Copies to:

Signed: Thomas Monchak

Thomas M. Monchak
Project Manager

Note: If enclosures are not as noted, please inform the sender immediately.

TABLE OF CONTENTS

Section		Page
LIST OF FIGURES		iii
LIST OF TABLES		iii
I.	INTRODUCTION	1
1.1	Authorization and Purpose	1
1.2	Scope of Work	1
1.3	Project Description	
1.4	Previous Work	1
II.	HYDROLOGY	3
2.1	Background Summary	3
2.2	Flood Insurance Study	3
2.3	Sand and Gravel Mining	5
III.	DESIGN HYDRAULIC ANALYSIS	6
3.1	Topographic Data Sets	6
3.2	Downstream Boundary Conditions	6
3.3	Energy-Loss Coefficients	6
3.4	Ineffective Flow Areas	6
3.5	Hydraulic Analysis Results	11
IV.	DESIGN SCOUR ANALYSIS	14
4.1	Long-Term Degradation	14
4.2	Low-Flow Incisement	14
4.3	General Scour	14
4.4	Bed-Form Scour	15
4.5	Factor of Safety	15
4.6	Mining Toe-Down	15
4.7	Recommended Toe-Down Depth	17
4.8	Scour Analysis Results	17

Registered Professional Engineer (Civil)
CERTIFICATE NO. 28660
BART S. BERGENDAHL
Date Signed 7-23-97
ARIZONA, U.S.A.

V. DESIGN RECOMMENDATIONS 20

5.1 Design Criteria Summary 20
5.2 Recommended Toe-Down Elevations 20
5.3 Recommended Top-of-Bank Elevations 20

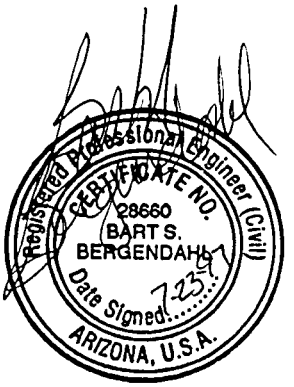
VI. AS-BUILT CONDITIONS 25

6.1 Description 25
6.2 Comparison with Design 25

VII. REFERENCES 28

VIII. APPENDICES

A. HEC-2 Design Data Files
B. HEC-2 As-Built Data Files
C. Historical Correspondence



LIST OF FIGURES

Figure No.		Page
1.1	Site Map	2
2.1	Corps Balanced Flood Hydrograph	4
3.1	Cross-Section Locations	7
4.1	Salt River Characteristic Grain Size Distribution	17
6.1	Typical Cross-Section	26

LIST OF TABLES

Table No.		Page
2.1	Salt River Discharge at Mill Avenue Bridge	5
3.1	Cross-Section Location by Bank Station	10
3.2	100-Year Design Hydraulics w/100-Year Bank Protection	12
3.3	100-Year Design Hydraulics w/10-Year Bank Protection	13
4.1	Salt River Bed Material Representative Gradations	17
4.2	North Bank Scour Analysis Results	18
4.3	South Bank Scour Analysis Results	19
5.1	North Bank Toe-Down Summary	21
5.2	South Bank Toe-Down Summary	22
5.3	Top of North Bank Summary	23
5.4	Top of South Bank Summary	24
6.1	Design vs. As-Built Hydraulics	27

I. INTRODUCTION

Bank protection was constructed along the Salt River, between McClintock Drive and the Pima Freeway crossing, to protect the East Papago Freeway (202L) and adjacent properties from the effects of floods up to the 100-year frequency. The bank protection was designed and constructed of cement stabilized alluvium (CSA) in conjunction with the freeway construction through the project reach.

1.1 Authorization and Purpose

This report was prepared by Simons, Li & Associates, Inc. (SLA), as authorized by the Arizona Department of Transportation (ADOT) under subcontract to Daniel, Mann, Johnson & Mendenhall, Inc. (DMJM). Its purpose is to: 1) summarize the hydraulic design and scour analyses, 2) compare the design recommendations to the as-built conditions for the bank protection, 3) draw qualitative conclusions regarding the adequacy of the protection, and 4) compile the various guidance and data transmittal documents used to direct the work.

1.2 Scope of Work

Between 1992 and 1994, SLA and DMJM analyzed and developed several design alternatives for both 10-year and 100-year levels of bank protection. Hydraulic and scour analyses were performed to set the design parameters after selection of the final alignments. The 10 and 100-year frequency flood events for the proposed design conditions were analyzed to determine channel hydraulic parameters. The results of the hydraulic analyses were then used to determine the various scour components which could impact the proposed bank protection. This report presents a discussion of the design criteria, assumptions, and engineering methodologies used in the analyses. The report summarizes the top-of-bank and toe-down design elevations for the 100-year flood event and compares them with the as-built conditions.

1.3 Project Description

A site map showing the study reach and the bank protection alignments is provided as Figure 1.1 of this report. The study reach begins at Grade Control Structure No. 5 (GCS#5) and ends approximately 1.25 miles upstream of the Pima Freeway crossing of the Salt River. The project reach begins at GCS #5 for the north bank and approximately 150 feet upstream of McClintock Drive for the south bank, ending approximately 200 feet upstream of the Pima Freeway (Loop 101).

1.4 Previous Work

Several hydraulic and sediment transport studies have been conducted within the project reach. In October of 1992, SLA completed an analysis for the proposed Salt River bridges associated with the Red Mountain Traffic Interchange (1). The analysis accounted for the proposed north and south bank protection around the structures. Additional hydraulic and sediment transport studies were conducted in 1994 for the East Papago Freeway bank protection design. The results are summarized in a July, 1994, letter from SLA to ADOT (2). This letter also transmitted various design memos from the 1992 East Papago bank protection analysis. These, along with other significant historical documents, are reproduced in Appendix C of this report.

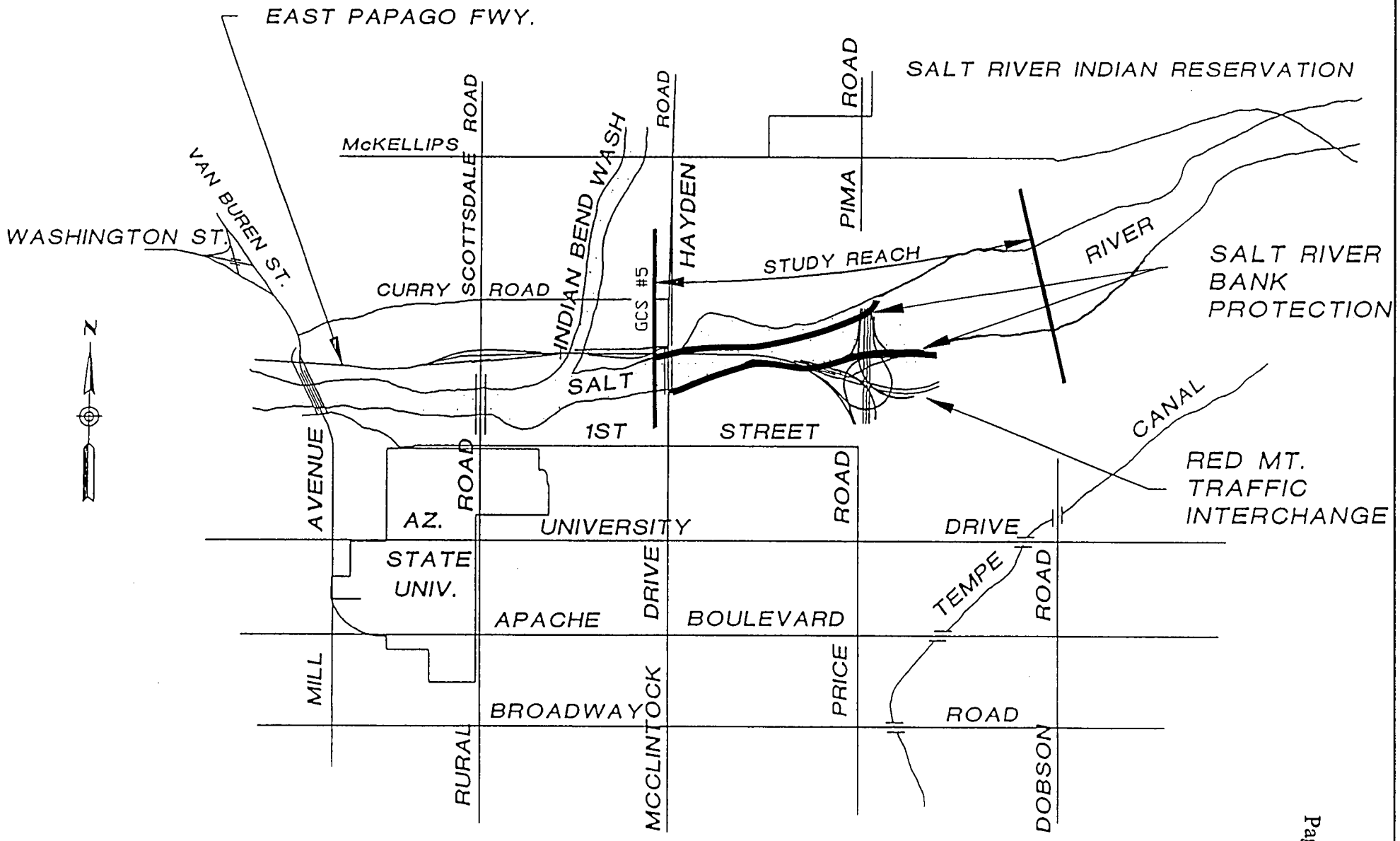


FIGURE 1.1 SITE MAP

II. HYDROLOGY

The following section describes the sources and development of hydrologic information used in the analyses of the Salt River within the study reach.

2.1 Background Summary

The Salt River has a contributing drainage area of approximately 1,000 square miles above the project reach. In 1982, the Los Angeles District Corps of Engineers (Corps) finalized a hydrologic study for the Gila River and tributaries, which includes the Salt River, as part of the Central Arizona Water Control Study (CAWCS) (3). One purpose of the CAWCS study was to develop discharge-frequency relationships at various points along the Gila River and tributaries for existing conditions. To develop existing conditions discharge-frequency relationships, recorded stream flow for the Salt and Gila Rivers had to be converted to a sequence of "standardized" existing conditions discharges. Standardization, converting all stream flow data to the same base existing conditions, was required because the recorded data was published for a non-homogeneous period of record. To standardize flow in the Salt River, Salt River Project (SRP) reservoirs were modeled using the HEC-5 computer program to simulate SRP operation under existing conditions. The HEC-5 model was calibrated using the December 1965 through January 1966 and March 1978 floods. Utilizing complex analysis procedures, resulting annual maximum values for the peak and various flow duration discharges were ordered and plotted on log-probability frequency paper.

A second study was performed by the Corps (4) which quantified the impact of the modified Roosevelt Dam on the discharge-frequency relationships at selected sites within the Gila River Basin. The Corps studies cited provide the best current estimate of existing and future hydrologic conditions (i.e., pre- and post-Roosevelt modifications) in the study reach.

The Mill Avenue bridge is approximately 2 miles downstream of the study area. Table 2.1 presents the results of the Corps hydrologic analyses for the Salt River at the Mill Avenue Bridge. These discharges were used to define the peak discharges for various frequency flood events within the project reach. The peak discharge-frequency data presented in Table 2.1 were developed from the Corps HEC-5 analyses.

A 100-year flood hydrograph for this study was developed from the Corps balanced flood hydrograph for the regulated 100-year flow routed through the existing SRP reservoir system. The design hydrograph is based on the most recent Corps hydrologic analyses (4). Different magnitude flood events utilized identical scaled versions of the Corps hydrograph. The design hydrograph, which was utilized for the estimation of sediment transport volumes and time dependent changes to the Salt River, is illustrated in Figure 2.1.

2.2 Flood Insurance Study

In 1983-84, the Corps performed a Flood Insurance Study (FIS) (5) encompassing 28 miles of the Salt River from the confluence with the Gila River to Country Club Drive. The study was performed for the Flood Control District of Maricopa County. The Corps Salt River FIS was adopted by the

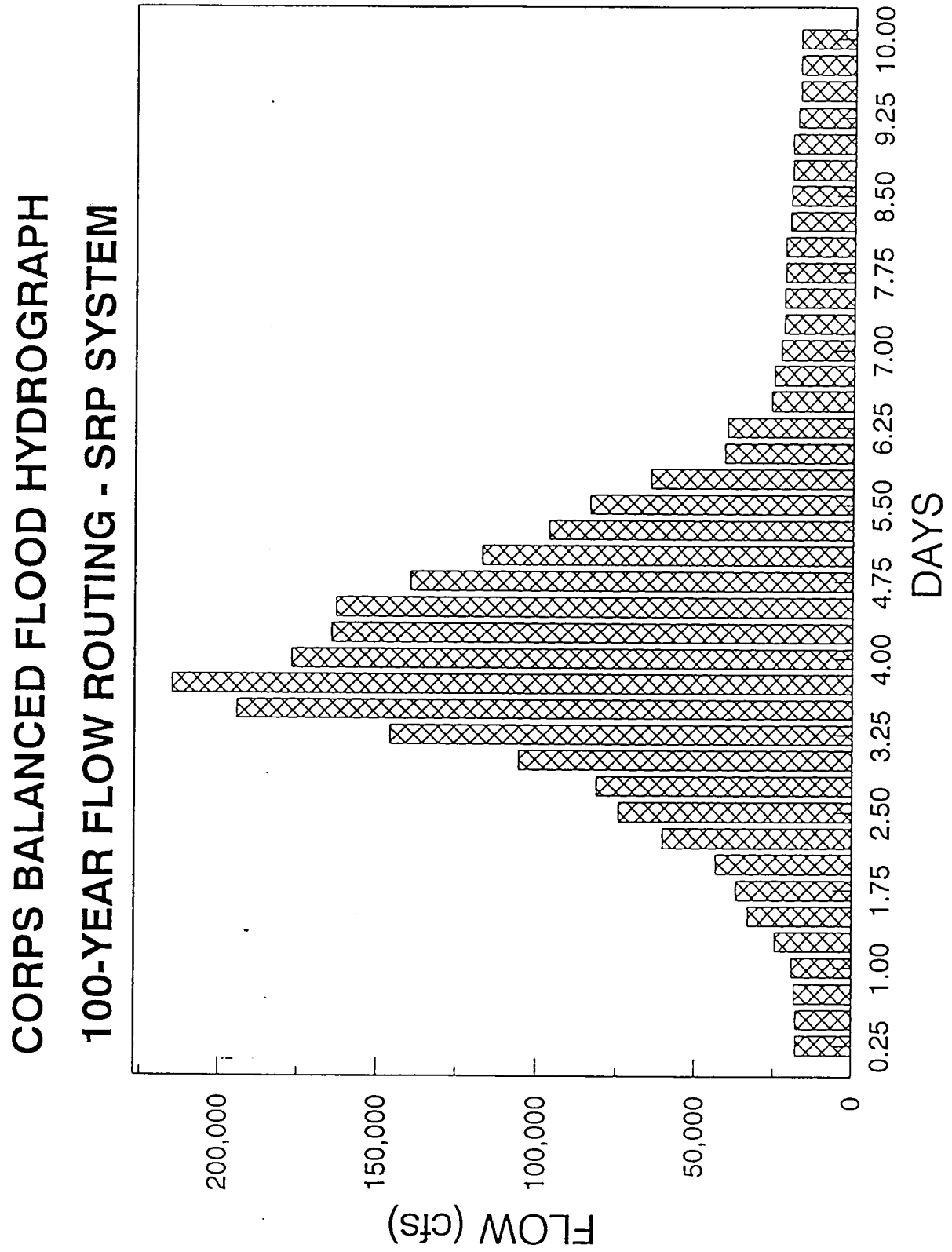

CORPS BALANCED FLOOD HYDROGRAPH
100-YEAR FLOW ROUTING - SRP SYSTEM
FLOW (cfs)
200,000
150,000
100,000
50,000
0
0.25
1.00
1.75
2.50
3.25
4.00
4.75
5.50
6.25
7.00
7.75
8.50
9.25
10.00
DAYS

Table 2.1 Salt River Discharge at Mill Avenue Bridge.

Return Period (years)	Discharge (cfs)
5	40,000
10	93,000
20	135,000
50	160,000
100	215,000
200	275,000
500	330,000

Federal Emergency Management Agency (FEMA) and the mapping was published as the regulatory floodplain and floodway. The Salt River FIS used the peak flood discharges developed by CAWCS (3) and are presented as existing conditions in Table 2.1. The FIS estimated a 100-year frequency peak discharge of 215,000 cfs through the project reach and 220,000 cfs upstream of the Pima Freeway Crossing.

2.3 Sand and Gravel Mining

The study limits are located within a reach of the Salt River which has historically been used as a source of sand and gravel for construction materials. A study by SLA for ADOT (5) has documented that extensive in-stream and floodplain mining operations can significantly impact the stability of a river system. The findings from this study were used to develop criteria for bank protection toe-down design in areas adjacent to sand and gravel mining pits.

III. DESIGN HYDRAULIC ANALYSIS

The final project design conditions include 100-year bank protection on both the north and south banks. The design channel invert was based on historical mapping which indicated a natural bed slope of approximately 0.1% extending upstream from GCS #5. The U.S. Army Corps of Engineers computer program "HEC-2 Water Surface Profiles" (6) was used to calculate the proposed hydraulic conditions for the Salt River through the project reach. Structures modeled within the study reach include the existing bridge at McClintock Drive, the East Papago Freeway structure, and the Red Mountain Traffic Interchange (RMTI) structures. The RMTI consists of three structures: the S-W/S-E ramp, Pima Freeway mainline bridge, and the E-N/W-N ramp. All bridges were modeled using the HEC-2 special bridge routine.

3.1 Topographic Data Sets

Three topographic data sets were combined to form the mapping for the study reach. The project reach was mapped in 1994 by Kenney Aerial Mapping, Inc. The June 1990 Cooper Aerial of Phoenix mapping and the March 1986 Kenney Aerial Mapping topography were used upstream of the project reach.

SLA developed the HEC-2 cross sections from the combined mapping data. Cross-sections were oriented perpendicular to the direction of flow and were spaced at approximately 400 foot intervals. Figure 3.1 presents the HEC-2 cross-section location maps for the study reach. Table 3.1 provides the approximate north and south bank stations for each cross-section location.

3.2 Downstream Boundary Conditions

Starting water-surface elevations of 1157.45 and 1166.59 feet were assumed for the 10 and 100-year rigid boundary analyses respectively. These elevations were based on the 10 and 100-year water-surface elevations of the CRSS Civil Engineers, Inc. HEC-2 output at GCS #5 (7).

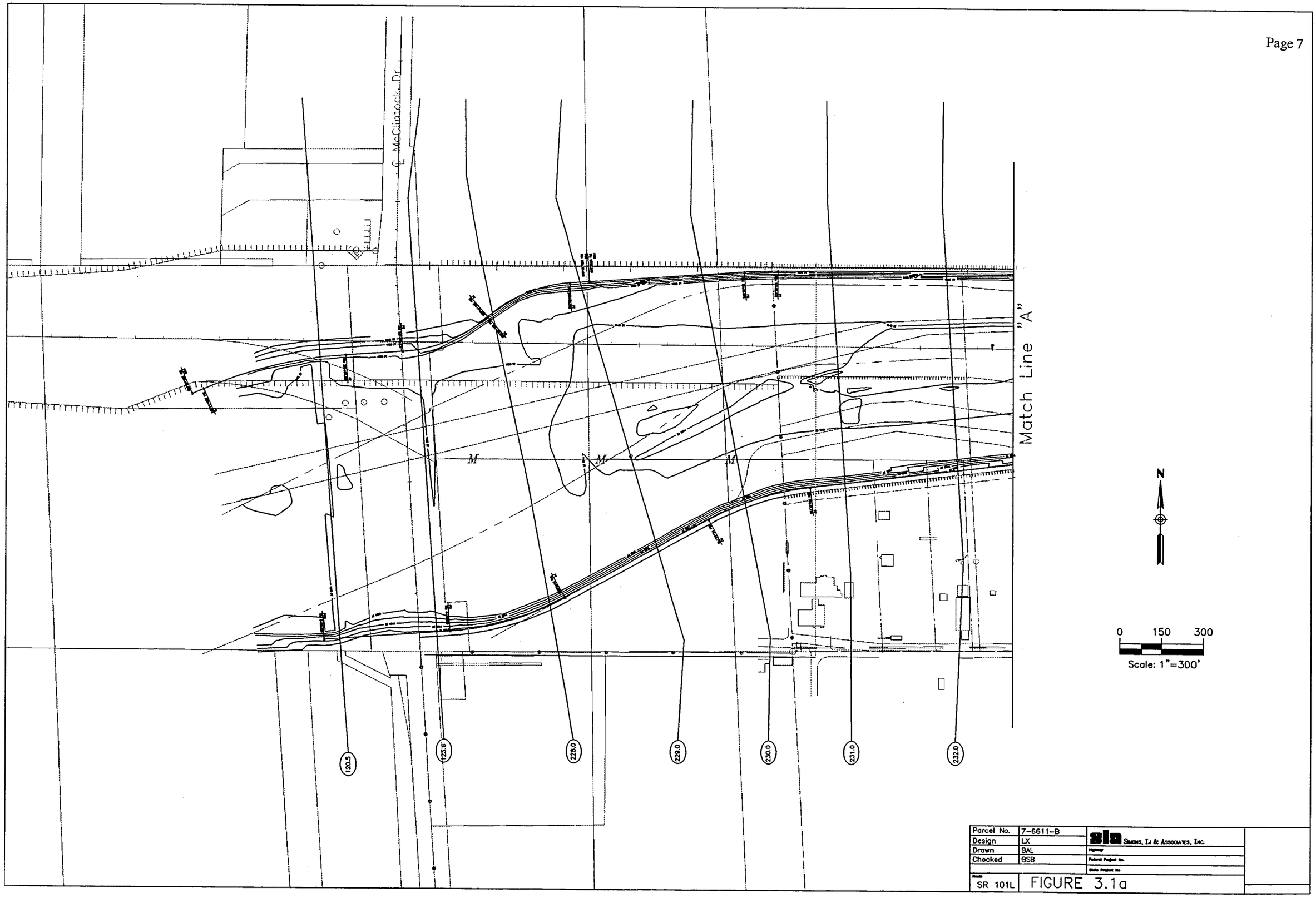
3.3 Energy-Loss Coefficients

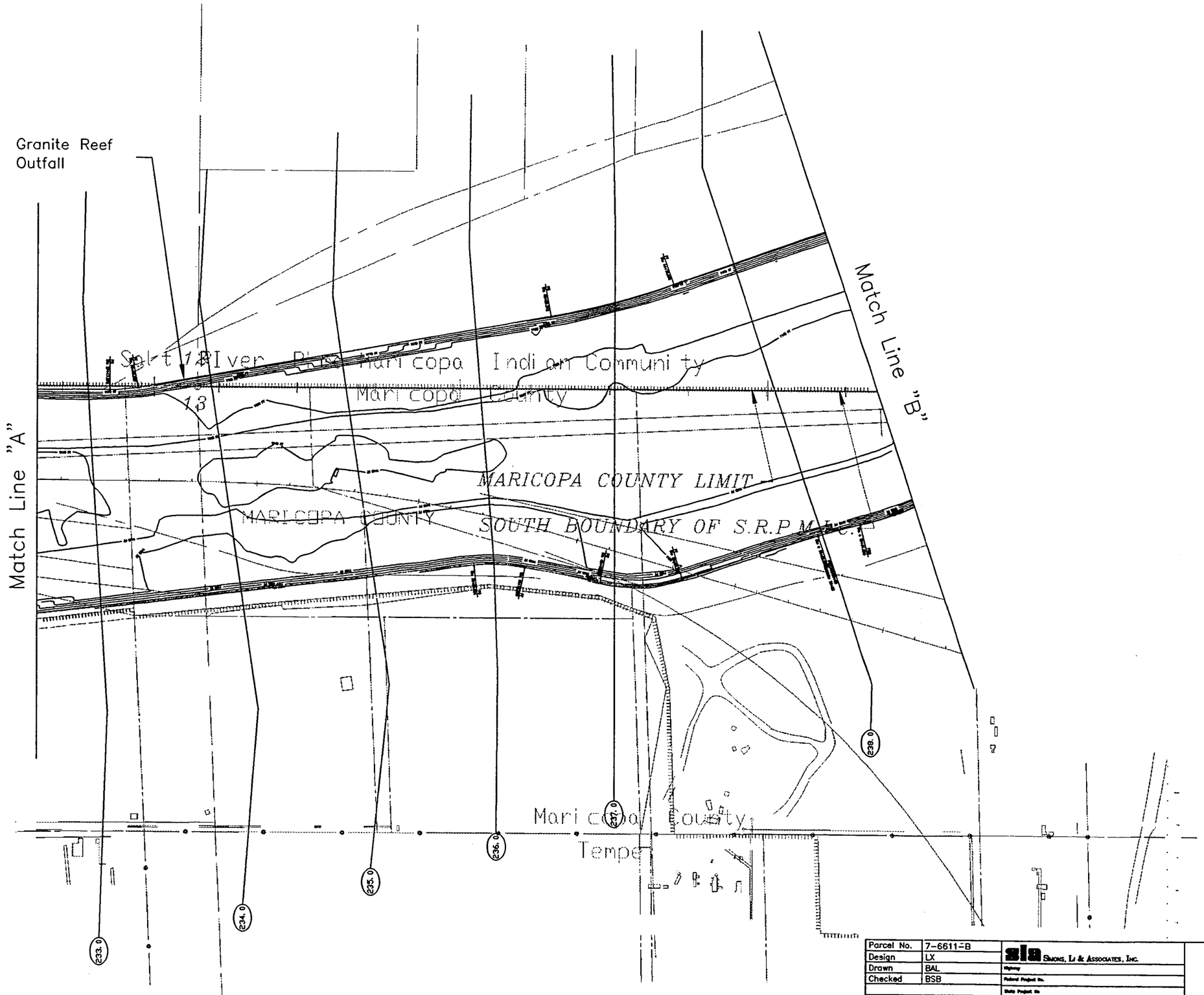
The roughness coefficients used in the HEC-2 analysis generally coincide with the 1983-84 FIS (8) values ranging from 0.033 to 0.040 for the main channel, and 0.040 to 0.050 for the overbanks. A main channel "n" value of 0.035 was used to provide water-surface elevations outside the project reach.

Expansion and contraction coefficients were set at 0.3 and 0.1, respectively. The expansion and contraction coefficients were modified to 0.5 and 0.3 through the various bridge crossings in the study reach. These values are consistent with recommendations provided in the HEC-2 Users Manual (6).

3.4 Ineffective Flow Areas

Encroachment stations were included upstream of the RMTI structures where the north floodplain is being actively mined. While the existing overbank pits will pond during a flood, the conveyance


℄ McCintock Dr.
Match Line "A"
N
0 150 300
Scale: 1"=300'
120.5
123.6
228.0
229.0
230.0
231.0
232.0
Parcel No. 7-6611-B
Design LX
Drawn BAL
Checked BSB
SR 101L
FIGURE 3.1a
Simons, Li & Associates, Inc.
Highway
Federal Project No.
State Project No.



Parcel No.	7-6611-B	SIA Simons, Li & Associates, Inc.
Design	LX	Highway
Drawn	BAL	Federal Project No.
Checked	BSB	State Project No.
Route SR 101L	FIGURE 3.1b	

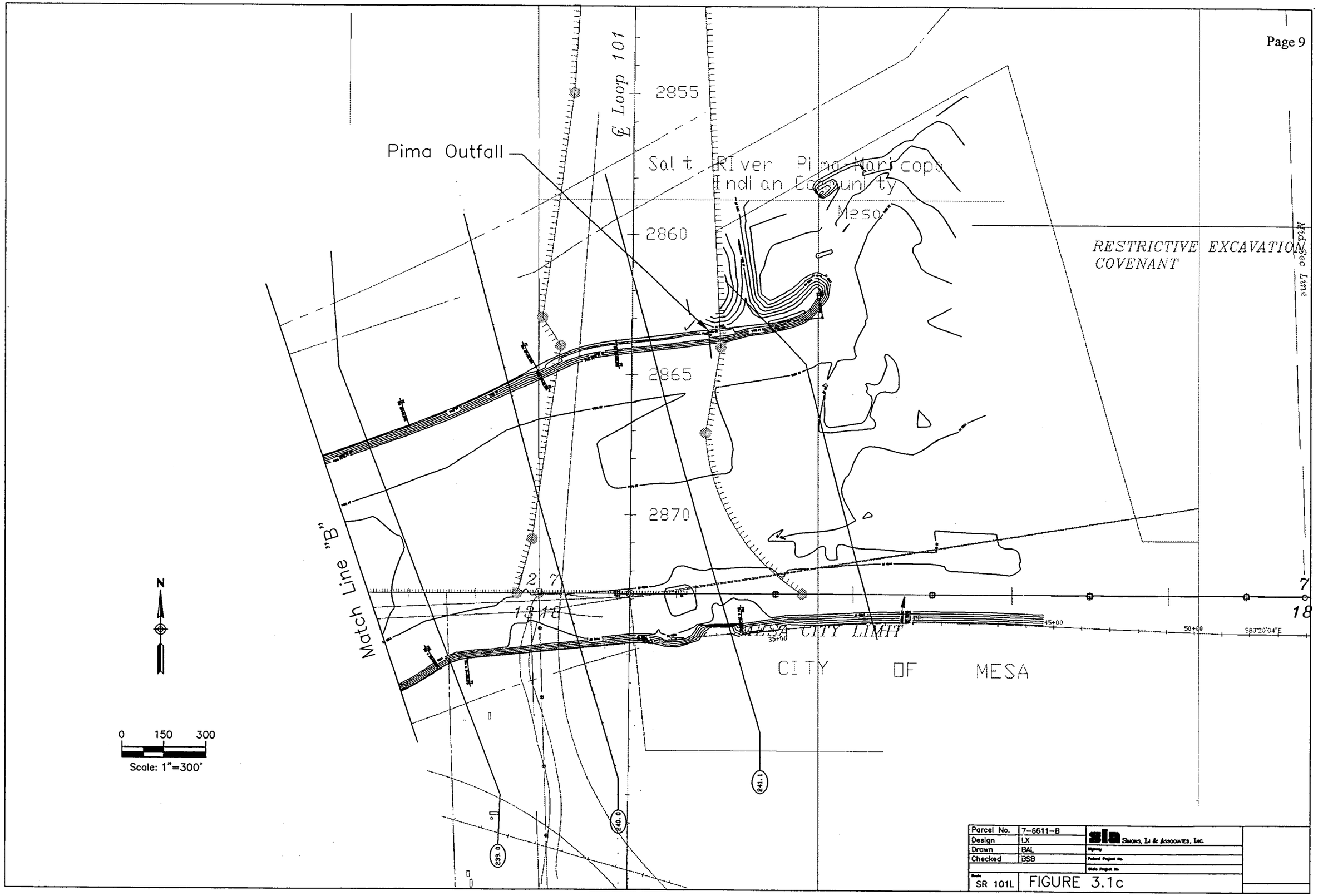

Pima Outfall
℄ Loop 101
2855
2860
2865
2870
Salt River Pima-Maricopa Indian Community
Mesa
RESTRICTIVE EXCAVATION COVENANT
Mid Sec Line
Match Line "B"
MESA CITY LIMIT
CITY OF MESA
45+00
50+00
S89°20'04"E
35+00
241.1
240.0
239.0
N
0 150 300
Scale: 1"=300'
Parcel No. 7-6611-B
Design LX
Drawn BAL
Checked BSB
SR 101L
FIGURE 3.1c
SIMONS, LI & ASSOCIATES, INC.

Table 3.1 Cross-Section Location by Bank Station

HEC-2 Cross-Section	North Bank Station	South Bank Station
120.5	224+84	0+60
122	226+36	2+10
122.65	227+24	2+80
123.55	228+14	4+00
228	230+58	8+30
229	234+65	12+60
230	13+85	16+10
231	18+40	19+70
232	22+50	23+60
233	26+35	27+60
234	30+15	31+90
235	34+20	35+95
236	38+45	39+46
237	42+80	43+51
238	48+96	46+70
239	51+20	22+01
240	56+70	27+74
241	62+18	32+92

capacity was conservatively considered to be negligible. Therefore, the north overbank, upstream of the RMTI, was eliminated from the total effective flow area.

All cross-sections were reviewed and encroachment stations inserted to comply with HEC-2's limitations and maintain reasonable section-to-section conveyance continuity. The ineffective flow encroachments were determined for the 100-year flood event and may not be applicable for different frequency flood events.

3.5 Hydraulic Analysis Results

Hydraulic parameters were developed for the 10- and 100-year frequency flood events for the entire study reach. Within the project reach, the average channel velocities range from 7.8 to 16.7 fps, depths vary between 19.5 and 27.0 feet, and top widths range from 607 feet to 1068 feet for the 100-year event with 100-year bank protection. Tables 3.2 and 3.3 present a summary of the HEC-2 design hydraulics for the 100-year flood with 100-year bank protection and with 10-year bank protection, respectively. The 1992 hydraulic analysis for 10-year bank protection generated the worst-case scour at some cross-sections and, therefore, was used for the final design at those locations. Appendix A contains the HEC-2 hydraulic input and output data for the 100-year bank protection constructed.

Table 3.2 100-Year Design Hydraulics w/100-Year Bank Protection

HEC-2 CROSS-SECTION	WATER SURFACE ELEVATION (feet)	VELOCITY (fps)	DEPTH (feet)	TOP WIDTH (feet)
120.5	1166.6	11.1	19.6	1037
122	1166.7	11.5	19.5	1009
122.65	1166.8	11.5	19.6	1007
123.55	1168.5	10.5	21.2	1061
228	1169.0	10.3	21.3	1003
229	1169.2	11.3	21.1	923
230	1169.1	13.9	20.7	768
231	1169.7	15.0	20.9	701
232	1170.5	15.8	21.3	654
233	1171.3	16.7	21.7	609
234	1172.8	16.2	22.8	607
235	1174.5	14.7	24.1	630
236	1175.8	13.6	25.0	657
237	1177.6	10.5	26.4	802
238	1178.3	9.7	26.6	863
239	1178.5	10.3	26.3	840
240	1179.3	8.8	26.6	969
241	1180.2	7.8	27.0	1068

Table 3.3 100-Year Design Hydraulics w/10-Year Bank Protection

HEC-2 CROSS-SECTION	WATER SURFACE ELEVATION (feet)	VELOCITY (fps)	DEPTH (feet)	TOP WIDTH (feet)
120.5	1166.5	11.9	19.5	1073
122	1166.7	12.1	19.5	1051
122.65	1166.8	12.2	19.6	1051
123.55	1168.4	11.0	21.1	1060
228	1169.0	10.7	21.3	952
229	1169.4	11.3	21.3	893
230	1169.4	14.4	21.0	740
231	1167.6	22.9	18.8	594
232	1172.6	18.7	23.4	811
233	1176.5	13.3	26.9	1811
234	1177.4	12.1	27.4	1712
235	1178.1	11.6	27.7	1675
236	1178.5	11.3	27.7	1491
237	1179.4	9.7	28.2	1319
238	1180.0	8.5	28.3	1496
239	1180.2	8.6	28.0	1453
240	1180.4	9.8	27.6	845
241	1182.0	7.3	28.8	1081

IV. DESIGN SCOUR ANALYSIS

This section of the report presents the procedures, methodology, assumptions, and results of the scour analysis for the proposed bank protection. Several scour components were considered in determining the total scour potential. These are described below. With the exception of long-term degradation, the scour depths used to establish the design toe-down elevations were estimated for the 100-year design flood.

4.1 Long-Term Degradation

The procedures described by the Bureau of Reclamation (9) were utilized to quantify the long-term degradation component of total potential scour. Long-term degradation was computed using the concepts of equilibrium slope and stream bed armoring.

The dominant discharge was used for the long-term degradation analysis. The dominant discharge is defined as the discharge which, if allowed to flow constantly, would have the same overall channel shaping effect as the natural fluctuating discharges. The dominant discharge is typically between a 5-year and 10-year event for ephemeral channels (10). The design hydraulic conditions for the 10-year event were used in determining the long-term degradation response for the project reach of the Salt River.

The analysis resulted in an estimated armor depth of 4.8 feet, and an equilibrium slope of 0.037%. The potential long-term degradation component at each cross-section location was computed as the smaller of: 1) the estimated armoring depth, or 2) depth to the equilibrium slope. GCS #5 was used as the pivot point for the equilibrium slope analysis.

4.2 Low-Flow Incisement

The large width-depth ratios for the design project reach of the Salt River require that consideration be given to the development of a low-flow channel. There are no rigorous methodologies for the prediction of low-flow channel incisement. A review of existing field conditions and experience from previous projects along the Salt River indicate a low-flow incisement depth of 2 feet is reasonable for the project reach.

4.3 General Scour

General scour refers to the vertical lowering of the channel bed over relatively short time periods, typically during the passage of a single flood event. General scour occurs because of an increase in slope or decrease in channel width, which causes the average velocity and bed shear stress to increase. This produces an increase in stream power (τV). Therefore, more bed material is transported through the contracted section than is transported into it. As the bed level is lowered, velocity decreases, and shear stress decreases and equilibrium is restored when the transport rate through the contracted section is equal to the incoming rate. Contraction scour can be defined as a special case of general scour that occurs at a specific location such as a bridge crossing or a relatively short, natural contraction of the channel cross-section.

The QUASED (QUAsi-dynamic hydraulic and SEDiment routing) and GFLUVIAL computer programs were applied to the study reach to quantify the local imbalance between sediment supply and transport capacity along the project reach. The hydrologic data used to simulate the 100-year design flood event was the Corps balanced hydrograph for the regulated 100-year flow routed through the existing Salt River Project system (4). The QUASED sediment transport calculations are performed using the balanced hydrograph and the characteristic Salt River grain size distributions presented in Figure 4.1. The QUASED sediment transport calculations were performed using the Meyer-Peter, Muller bedload equation and Einstein's procedure for integration of the suspended load to determine the bed material sediment transport capacity. During the QUASED analysis, the channel geometry is adjusted, and the hydraulics and bed material transport is updated after each time step of the discretized 100-year flood hydrograph. A six-hour time step was used in the analysis requiring 40 time steps to model the entire 100-year, 10-day event. The maximum scour at each cross-section was used for the estimated general scour component.

Two bed-material sediment populations are typically present in the Salt River. One represents a surface armor layer, while the other represents a subsurface parent material. Figure 4.1 presents a plot of the composite surface and subsurface gradations used in the sediment transport analyses. The composite gradations illustrated in Figure 4.1 are discretized in Table 4.1. These representative gradations are consistent with composite sediment routing gradations used by SLA on several reaches of the Salt River.

4.4 Bed-Form Scour

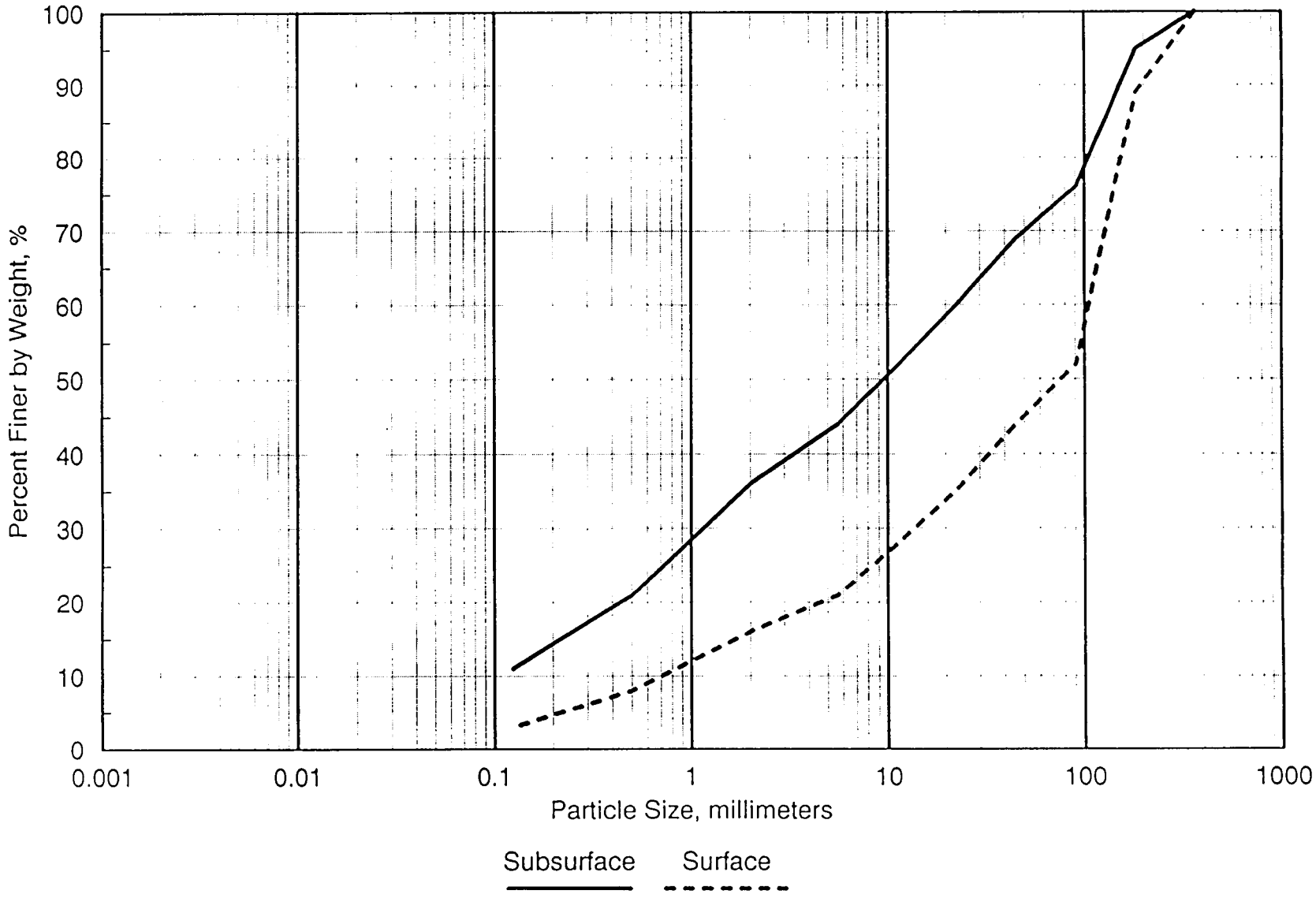
The bed-form scour component was estimated to be one-half of the dune and antidune heights. The dune height was calculated using a relationship developed by Allen (11). The antidune height was calculated using relationships developed by Kennedy (10). The actual type of bed form present in the project reach is a function of the flow regime. Since the flow regime will change with the fluctuating discharges of the flood hydrograph, both bed forms could occur during a single flood event. The maximum scour depth calculated from the above two relationships was utilized as the bed-form scour component.

4.5 Factor of Safety

A factor of safety was included to account for non-uniform flow distributions typical of alluvial channels. This factor of safety is calculated as 30 percent of the sum of the general scour, long-term scour, and bed-form scour as directed in the Letter Of Intent, Salt River South Bank Stabilization (13).

4.6 Mining Toe-Down

The mining toe-down depth is the depth that must be added to the standard toe-down depth to protect against lateral migration of mine pits. This scour component was determined based on the conditions and criteria outlined in the July 29, 1992, letter from SLA to DMJM (14) regarding bank protection toe-down depths in the vicinity of sand and gravel mining pits. The 1992 mining toe-down recommendations were approved by the Flood Control District Of Maricopa County (15). Depths of mining pits were estimated based on the available topographic mapping and the design



Salt River Composite Gradations

Figure 4.1 Salt River Characteristic Grain Size Distribution

channel invert. According to the 1992 recommendations, one quarter (1/4) of the pit depth is used for the lateral migration scour component if the pit is located within 150 feet of the bank invert.

Figure 4.1 Salt River Characteristic Grain Size Distribution

Particle Size (mm)	Surface Material (Percent Finer)	Subsurface Material (Percent Finer)
362.0	100	100
181.0	89	95
90.5	52	76
45.2	44	69
22.6	35	60
11.31	28	52
5.66	21	44
2.00	16	36
0.500	8	21
0.125	3	11

4.7 Recommended Toe-Down Depth

The total calculated toe-down is the sum of the long-term degradation, general scour, low-flow incisement, bed form components, and the factor of safety, plus the mining toe-down when applicable. However, based on engineering judgement and previous experience on the Salt River, a minimum total toe-down depth of 10 feet was recommended. In addition to the previously mentioned scour components, bend scour and local scour were also investigated and the recommended toe-down depth was adjusted accordingly. Since the Salt River does not contain any significant bends in the project reach, this component did not contribute to the toe-down depth. Local scour is due to flow obstructions such as bridge piers and abutments in the flow path, drop structures, or storm drain outfalls. Adjustments due to local scour are listed in Tables 4.2 and 4.3.

4.8 Scour Analysis Results

A summary of the scour analysis results for the north and south bank are presented in Tables 4.2 and 4.3, respectively. Examples of detailed calculations can be found in the historical correspondence of Appendix C.

Table 4.2 North Bank Scour Analysis Results

HEC-2 Cross-Section	LongTerm	Low Flow	General	Bed Form	Factor of Safety	Total Calculated Toe-Down	Mining	Recom. Depth	Local Scour Adj.
*120.5	0.0	2.0	0.3	2.0	0.7	5.0		10.0	
*122	0.1	2.0	0.3	2.0	0.7	5.1		10.0	
*122.65	0.1	2.0	0.3	2.0	0.7	5.1		10.0	
*123.55	0.2	2.0	0.3	2.0	0.8	5.3		10.0	
*228	0.4	2.0	0.3	2.0	0.8	5.5		10.0	25.6
229	0.7	2.0	0.0	1.7	0.7	5.2	1.3	10.0	
230	0.9	2.0	3.1	2.6	2.0	10.5	1.4	11.9	
*231	1.1	2.0	4.6	5.0	3.2	15.9	11.9	27.8	
*232	1.4	2.0	4.6	5.0	3.3	16.3	11.9	28.2	
233	1.6	2.0	6.7	3.8	3.6	17.7	4.1	21.9	
Granite Reef Wash	1.6	2.0	6.7	3.8	3.6	17.7	4.1	21.9	5.0
234	1.9	2.0	7.9	3.5	4.0	19.3	3.8	23.0	
235	2.1	2.0	7.4	2.9	3.7	18.2	3.4	21.5	
236	2.4	2.0	4.4	2.5	2.8	14.1	3.5	17.5	
237	2.6	2.0	3.7	1.7	2.4	12.4	1.5	15.0	
238	2.9	2.0	2.7	1.7	2.3	11.4	1.7	15.0	
239	3.3	2.0	2.9	1.7	2.3	12.1	1.3	15.0	
240	3.6	2.0	1.4	1.7	1.8	10.5	1.9	15.0	
241	3.9	2.0	2.5	2.0	2.5	12.9		12.9	

* Some components calculated from hydraulics for 10-year bank protection

Table 4.3 South Bank Scour Analysis Results

HEC-2 Cross-Section	Long-Term	Low-Flow	General	Bed-Form	Factor Safety	Total Calculated Toe-Down	Mining	Recom. Depth	Local Scour Adj.
123.55	0.2	2.0	0.0	1.5	0.5	4.1		10.0	
228	0.4	2.0	0.0	1.4	0.6	4.4		10.0	
229	0.7	2.0	0.0	1.7	0.7	5.2		10.0	
230	0.9	2.0	3.1	2.6	2.0	10.6		10.6	
231	1.1	2.0	3.5	3.1	2.3	12.0	2.5	14.5	
232	1.4	2.0	6.1	3.4	3.3	16.2	2.5	18.6	
233	1.6	2.0	6.7	3.8	3.6	17.7	2.5	20.3	
234	1.9	2.0	7.9	3.5	4.0	19.3	2.5	21.8	
235	2.1	2.0	7.4	2.9	3.7	18.1		18.2	
*236	2.4	2.0	4.6	2.0	2.7	13.7		13.7	33.8
*237	2.6	2.0	2.5	2.0	2.1	11.2		11.2	33.2
*238	3.0	2.0	2.5	2.0	2.3	11.8	10.6	22.2	
*239	3.2	2.0	2.5	2.0	2.3	12	1.9	13.9	
*240	3.5	2.0	2.5	2.0	2.4	12.4		12.4	
*241	3.9	2.0	2.5	2.0	2.5	12.9		12.9	

* Some components calculated from hydraulics for 10-year bank protection

V. DESIGN RECOMMENDATIONS

This section summarizes the design criteria used for the Salt River bank protection and provides the design recommendations for toe-down and top-of-bank elevations. The bank locations were set according to alignments determined in 1992 and 1994. The typical channel section is trapezoidal with 1:1 bank slopes above the design channel invert (re: Figure 6.1).

5.1 Design Criteria Summary

The key information and criteria used to develop the bank protection design parameters are summarized below:

Design Hydrology: Discharge = 215,000 cfs (current 100-year flood).

Design Topography: Based on 1" = 200' topographic maps (2-foot contour interval) developed by Kenney Aerial Mapping (1994 and 1986) and Cooper Aerial of Phoenix (1990).

Channel Roughness: Manning's "n" = 0.035 for the channel.

Sediment Gradation: Based on composite gradation curve developed from various geotechnical analyses performed along the Salt River.

Toe-Down Depth: Based on the estimated sum of long-term degradation, general scour, low-flow incisement, bed-form scour and a mining component. A factor of safety of 30 percent is applied to the general scour, long-term scour and bed-form scour components.

Protection Height: Freeboard of 3 feet over the 100-year water-surface elevation.

5.2 Recommended Toe-Down Elevations

By subtracting the total recommended toe-down depth from the design channel invert elevation, the minimum recommended toe-down elevation was obtained. The actual design toe-down elevations were obtained by rounding down to the nearest one foot from the recommended toe-down elevations at each HEC-2 cross-section. An additional adjustment (smoothing) was also applied, as appropriate, in consideration of construction efficiency. The recommended design toe-downs included adjustments to tie into existing CSA structures at the downstream end of the project reach. The recommended design toe-down elevations for the north and south banks are summarized in Tables 5.1 and 5.2, respectively.

5.3 Recommended Top-of-Bank Elevations

The recommended top-of-bank elevations were specified as a minimum of three feet above the water-surface elevation for the 100-year design flood with 100-year bank protection. These minimum elevations were increased, where necessary, to achieve a smooth, easily constructible design. The final design top-of-bank elevations and freeboard for the north and south banks are summarized in Tables 5.3 and 5.4, respectively.

Table 5.1 North Bank Toe-Down Summary

HEC-2 Cross-Section	Design Invert Elevation (feet)	Total Recom. Depth (feet)	Recom. Toe-down Elevation (feet)	Design Toe-down Elevation (feet)	As-Built Toe-down Elevation (feet)
120.5	1147.0	10.0	1137.0	GCS	GCS
122	1147.2	10.0	1137.2	1137.1	1137.1
122.65	1147.2	10.0	1137.2	1137.2	1137.2
123.55	1147.3	10.0	1137.3	1137.3	1137.3
228	1147.7	35.6	1112.1	1112.1	1112.1
229	1148.1	10.0	1138.1	1138.0	1138.0
230	1148.4	11.9	1136.5	1136.5	1136.5
231	1148.8	27.8	1121.0	1122.0	1122.0
232	1149.2	28.2	1121.0	1122.0	1122.0
233	1149.6	21.9	1127.7	1122.0	1122.0
Granite Reef Wash	1149.9	26.9	1123.0	1123.0	1123.0
234	1150.0	23.0	1127.0	1127.0	1127.0
235	1150.4	21.5	1128.9	1128.7	1128.7
236	1150.8	17.5	1133.3	1133.0	1133.0
237	1151.2	15.0	1136.2	1136.2	1136.2
238	1151.7	15.0	1136.7	1136.6	1136.6
239	1152.2	15.0	1137.2	1137.1	1137.1
240	1152.7	15.0	1137.7	1134.8	1134.8
Cutoff Wall	1152.9	33.7	1119.2	1119.2	1119.2
241	1153.2	12.9	1140.3	1134.0	1134.0

Table 5.2 South Bank Toe-Down Summary

HEC-2 Cross-Section	Design Invert Elevation (feet)	Total Recom. Depth (feet)	Recom. Toe-down Elevation (feet)	Design Toe-down Elevation (feet)	As-Built Toe-down Elevation (feet)
123.55	1147.0	12.0	1135.0	1135.0	1135.0
228	1147.7	10.7	1137.0	1137.0	1137.0
229	1148.1	11.1	1137.0	1137.0	1137.0
230	1148.4	11.4	1137.0	1137.0	1137.0
231	1148.8	14.8	1134.0	1134.0	1134.0
232	1149.2	19.2	1130.0	1130.0	1130.0
233	1149.6	21.6	1128.0	1128.0	1128.0
234	1150.0	22.0	1128.0	1128.0	1128.0
235	1150.4	22.4	1128.0	1128.0	1128.0
236	1150.8	47.5	1103.3	1103.1	1103.1
237	1151.2	44.4	1106.8	1103.5	1103.57
238	1151.7	22.2	1129.5	1118.4	1118.4
239	1152.2	13.9	1138.3	1132.4	1132.4
240	1152.7	12.4	1140.3	1137.6	1137.6
241	1153.2	12.9	1140.3	1138.0	1138.0

Table 5.3 Top of North Bank Summary

HEC-2 Cross-Section	Design Water Surface (feet)	Design Bank Elevation (feet)	Design Freeboard (feet)	As-Built Water Surface (feet)	*As-Built Bank Elevation (feet)	As-Built Freeboard (feet)
120.5	1166.6	1171.4	4.8	1166.6	1171.8	5.2
122	1166.7	1171.8	5.1	1166.7	1170.3	3.6
122.65	1166.8	1171.9	5.1	1166.8	1169.4	2.6
123.55	1168.5	1172.1	3.6	1168.5	1170.2	1.7
228	1169.0	1172.6	3.6	1168.9	1172.4	3.5
229	1169.2	1173.4	4.2	1169.2	1173	3.8
230	1169.1	1172.5	3.4	1169.1	1172.8	3.7
231	1169.7	1172.8	3.1	1169.7	1172.6	2.9
232	1170.5	1173.6	3.1	1170.4	1173.8	3.4
233	1171.3	1174.4	3.1	1171.4	1174	2.6
234	1172.8	1176.3	3.5	1173.1	1177	3.9
235	1174.5	1177.8	3.3	1174.6	1177.9	3.3
236	1175.8	1179.0	3.2	1176.1	1179	2.9
237	1177.6	1180.6	3.0	1177.9	1181	3.1
238	1178.3	1181.3	3.0	1178.6	1181.5	2.9
239	1178.5	1181.7	3.2	1178.8	1180.6	1.8
240	1179.3	1182.4	3.1	1179.6	1183	3.4
241	1180.2	1184.0	3.8	1180.4	1182.6	2.2

* Information provided by DMJM

Table 5.4 Top of South Bank Summary

HEC-2 Cross-Section	Design Water Surface (feet)	Design Bank Elevation (feet)	Design Freeboard (feet)	As-Built Water Surface (feet)	*As-Built Bank Elevation (feet)	As-Built Freeboard (feet)
123.55	1168.5	1171.8	3.3	1168.5	1172.1	3.6
228	1169	1172	3.0	1168.9	1172.3	3.4
229	1169.2	1172.2	3.0	1169.2	1172.2	3.0
230	1169.1	1172.2	3.1	1169.1	1172.3	3.2
231	1169.7	1172.8	3.1	1169.7	1172.6	2.9
232	1170.5	1173.6	3.1	1170.4	1173.4	3.0
233	1171.3	1174.5	3.2	1171.4	1175.1	3.7
234	1172.8	1176.1	3.3	1173.1	1176.4	3.3
235	1174.5	1178.4	3.9	1174.6	1178.7	4.1
236	1175.8	1182.1	6.3	1176.1	1182.1	6.0
237	1177.6	1182.5	4.9	1177.9	1182.5	4.6
238	1178.3	1183.0	4.7	1178.6	1183.2	4.6
239	1178.5	1183.5	5.0	1178.8	1183.9	5.1
240	1179.3	1184.1	4.8	1179.6	1184.6	5.0
241	1180.2	1184.6	4.4	1180.4	1184.5	4.1

* Information provided by DMJM

VI. AS-BUILT CONDITIONS

6.1 Description

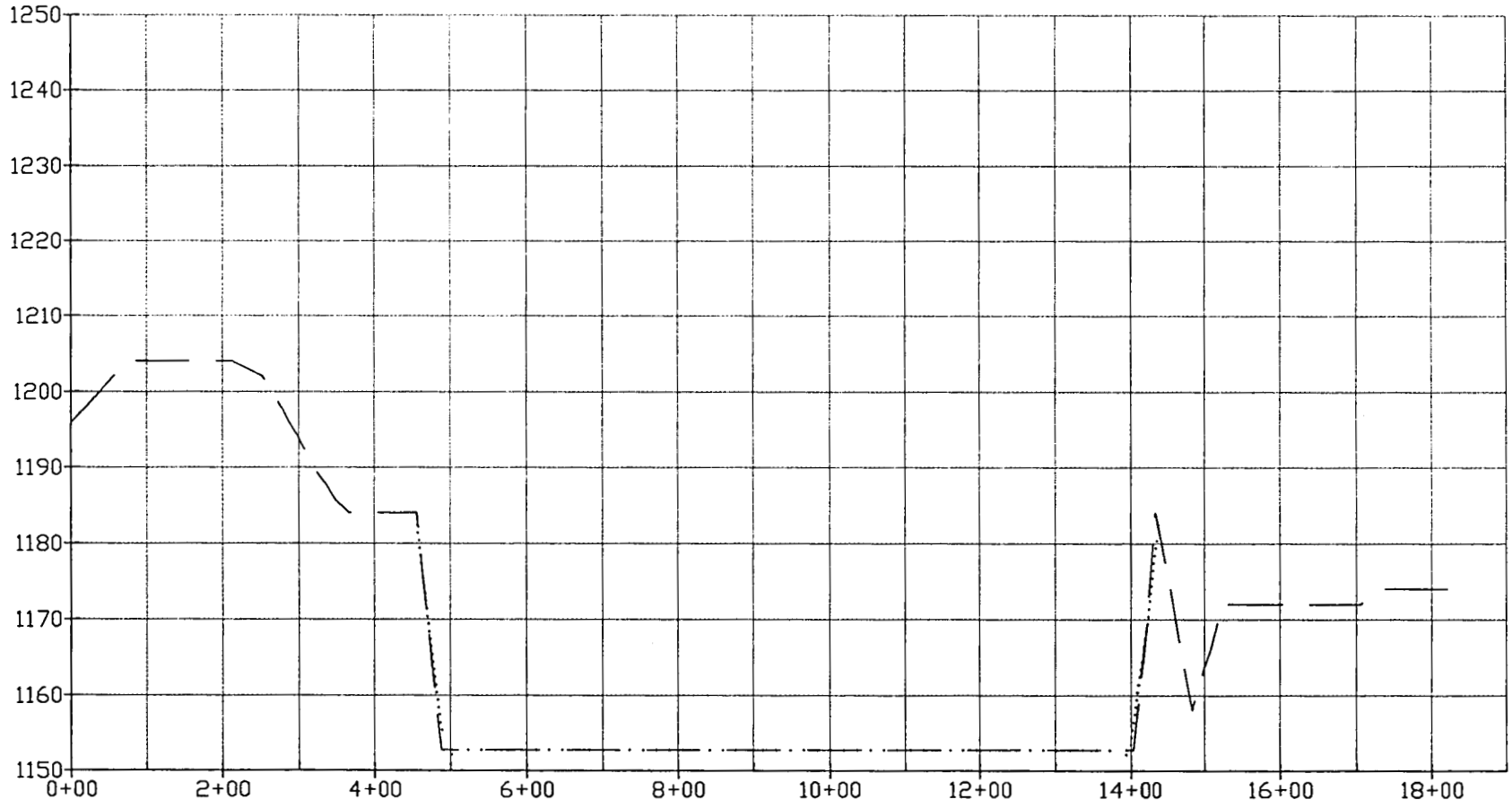
After the completion of construction in 1996, a ground survey was conducted by Urban Engineering to map the as-built geometry of the both the north and south bank protection. A digital terrain model (DTM) was generated from the survey and used as the basis to verify the as-built conditions and hydraulics. Figure 3.1 reflects the as-built contour DTM.

6.2 Comparison with Design

The location of the design cross-sections was digitized onto the DTM and BOSS HEC-2 was used to determine the as-built channel geometry and generate the as-built hydraulics. Figure 6.1 compares a typical as-built cross-section with a design cross-section for the same location. Table 6.1 provides a comparison between as-built velocity, depth, and top width and the respective design parameters. The parameters compare very well at all cross-sections. The maximum differences are as follows: velocity -- 0.7 fps, depth -- 0.3 feet, and top width -- 27 feet.

Tables 5.1 and 5.2 provide the as-built toe-down elevations for the north and south banks, respectively. As shown in the tables, the as-built elevations match the design elevations section by section. ADOT has certified that the bank protection toe-down was built in accordance with the design plans at all locations along the north and south banks (re: letter in Appendix C).

Tables 5.3 and 5.4 provide the as-built top-of-bank elevations and freeboard for the north and south banks, respectively. The top-of-bank elevations were developed from the ground survey of as-built conditions and provided by DMJM. As shown in the tables, the as-built freeboard varies from the design freeboard at most locations. At some locations the variance is significant with the freeboard less than the minimum three-foot required. This is especially true along the north bank where the freeboard is reduced to 1.7 feet upstream of the McClintock Drive Bridge and 1.8 feet just downstream of the Red Mountain Traffic Interchange.



..... As-Built with Design Invert

— — — Design

sla SIMONS, LI & ASSOCIATES, INC.

Federal Project No.

State Project No

FIGURE 6.1 TYPICAL CROSS-SECTION

Table 6.1 Design Versus As-Built Hydraulics

HEC-2 Cross-Section	As-Built Velocity (fps)	Design Velocity (fps)	As-Built Depth (feet)	Design Depth (feet)	As-Built Top Width (feet)	Design Top Width (feet)
120.5	11.0	11.1	19.6	19.6	1063	1037
122	11.5	11.5	19.5	19.5	1036	1010
122.65	11.5	11.5	19.6	19.6	1038	1007
123.55	10.5	10.5	21.2	21.2	1059	1061
228	10.4	10.3	21.2	21.3	999	1003
229	11.4	11.3	21.1	21.1	922	923
230	13.9	13.9	20.7	20.7	770	768
231	15.3	15.0	20.9	20.9	698	701
232	16.5	15.8	21.2	21.3	648	654
233	17.0	16.7	21.8	21.7	605	609
234	16.1	16.2	23.2	22.8	608	607
235	15.1	14.7	24.2	24.1	624	630
236	13.5	13.6	25.4	25.0	656	657
237	10.4	10.5	26.7	26.4	805	802
238	9.6	9.7	26.9	26.6	865	863
239	10.2	10.3	26.6	26.3	840	840
240	8.7	8.8	26.9	26.6	973	969
241	7.9	7.8	27.2	27.0	1054	1068

VII. REFERENCES

1. Simons, Li & Associates, Inc. "Bridge Hydraulics Report Pima Freeway Crossing of the Salt River", Tempe, Arizona, October, 1992.

2. Letter from Richards, D.L. (SLA) to Jimenez, S. (ADOT), "Compilation of Hydraulic and Sediment Transport Data for Bank Protection Design, East Papago Freeway, Section 6", July 8, 1994.

3. U.S. Army Corps of Engineers, Los Angeles District, "Gila River and Tributaries, Central Arizona Water Control Study, Hydrology Report," May, 1982.

4. U.S. Army Corps Of Engineers, "Study For Flood Control Alternatives To Cliff Dam", Los Angeles District, October, 1988.

5. Simons, Li & Associates, Inc. "Effects on In-Stream Mining on Channel Stability," Report No. FHWA-AZ88-250, Prepared for the Arizona Department of Transportation, Arizona Transportation Research Center, June, 1989.

6. U.S. Army Corps of Engineers, Hydrologic Engineering Center, "HEC-2 Water Surface Profiles", Users Manual, September, 1990.

7. CRSS Civil Engineers, Inc., "Salt River Hydraulic Design Grade Control No. 4 to McClintock Drive Bridge" Prepared for City of Tempe Department of Public Works, Tempe, Arizona, August, 1991.

8. U.S. Army Corps of Engineers, Los Angeles District, "Salt River Flood Insurance Study, Agua Fria River to Country Club Drive," Performed for the Federal Emergency Management Agency, 1983-1984.

9. U.S. Department of the Interior, Bureau of Reclamation, Computing Degradation and Local Scour, Technical Guideline, Denver, Colorado, January, 1984.

10. Simons, Li & Associates, Inc., "Design Manual for Engineering Analysis of Fluvial Systems," Prepared for the Arizona Department of Water Resources, Phoenix, Arizona, March, 1985.

11. Simons, Daryl B. and Fuat Senturk, Sediment Transport Technology, Water Resources Publications, Ft. Collins, Colorado, 1992.

12. Federal Highway Administration. "Highways in the River Environment," Publication No. FHWA-HI-90-016, February, 1990.

13. Flood Control District Of Maricopa County, "Letter Of Intent For Salt River South Bank Stabilization, Attachment A - Analytical Approach For Determining Required Toe Depths For Bank Protection Along Salt River Upstream Of McClintock Drive", February 18, 1992.

14. Letter from Richards, D.L. (SLA) to Monchak, T.M. (DMJM), "Bank Protection Toe-Down Depths In The Vicinity Of Sand And Gravel Mining Pits", July 29, 1992.

15. Letter from Rerick, D.J. (FCDMC) to Monchak, T.M. (DMJM), "Salt River Channel East of McClintock Drive - Bank Protection Toe-Down Depths", August 11, 1992.

APPENDIX A

HEC-2 Design Data Files

```
1*****************************************
 *  HEC-2 WATER SURFACE PROFILES          *
 *                                        *
 *  Version   4.6.2;  May 1991            *
 *                                        *
 *  RUN DATE    19JUN97    TIME   14:34:14 *
 *****************************************
```

```
*************************************
 *  U.S. ARMY CORPS OF ENGINEERS
 *  HYDROLOGIC ENGINEERING CENTER
 *  609 SECOND STREET, SUITE D
 *  DAVIS, CALIFORNIA 95616-4687
 *          (916) 756-1104
*************************************
```

```
X     X  XXXXXXX   XXXXX              XXXXX
X     X  X        X     X            X     X
X     X  X        X                        X
XXXXXXX  XXXX     X          XXXXX    XXXXX
X     X  X        X                   X
X     X  X        X     X             X
X     X  XXXXXXX   XXXXX              XXXXXXX
```

1

19JUN97 14:34:14 PAGE 1

THIS RUN EXECUTED 19JUN97 14:34:14

```
*************************************
 HEC-2 WATER SURFACE PROFILES

 Version   4.6.2;  May 1991
*************************************
```

```
T1      SIMONS, LI & ASSOCIATES, INC. (PAZ-DMJM-07)
T2      RED MOUNTAIN FREEWAY SALT RIVER BANK PROTECTION
T3

        FILE NAME : DESIGN.DAT
        Hydraulic Analysis for the 100-year design

J1  ICHECK    INQ      NINV     IDIR     STRT     METRIC   HVINS    Q        WSEL     FQ

                2                                                   215000   1166.59

J2  NPROF     IPLOT    PRFVS    XSECV    XSECH    FN       ALLDC    IBW      CHNIM    ITRACE

    -1                 -1

J3  VARIABLE CODES FOR SUMMARY PRINTOUT

    38        1        8        26       43       4        5        42       25

NC    0.035     0.035     0.035     0.1       0.3
X1    120.5     52        368.02    1432.2
X3    10
GR    1168      0         1164      17.95     1162      24.38     1162      36.95     1164      71.76
```

GR	1166	79.6	1168	87.26	1170	92.47	1170	100.79	1168	107.04
GR	1166	136.7	1164	170.55	1162	202.59	1162	204.03	1162	212.06
GR	1162	223.18	1162	256.79	1164	263.99	1166	271.92	1168	283.83
GR	1168	291.26	1168	333.54	1170	336.78	1172	341.62	1172	368.02
GR	1170	372.86	1168	379.02	1166	385.07	1164	391.96	1162	401.29
GR	1160	405.15	1147	417.51	1147	1383.8	1158.7	1396.8	1170.5	1432.2
GR	1164	1551.12	1166	1561.25	1168	1567.58	1170	1573	1172	1579.74
GR	1174	1587.59	1178	1595.63	1178	1606.62	1180	1659.93	1180	1677.36
GR	1180	1685.5	1180	1687.62	1170	1702.87	1168	1855.51	1168	1880.71
GR	1168	1915.94	1168	1966						
X1	122	50	371.86	1409.5	155	150	150			
X3	10									
GR	1168	0	1168	20.19	1168	48.23	1170	61.53	1170	84.4
GR	1168	99.93	1166	110.69	1166	185.25	1166	203.64	1166	250.93
GR	1168	294.27	1170	299.9	1172	350.11	1172	371.86	1170	379.7
GR	1168	385.29	1166	390.3	1164	395.63	1162	399.98	1160	403.29
GR	1158	407.35	1156	413.82	1154	422.34	1152	437.43	1147.2	450.69
GR	1147.2	1361.5	1159	1375	1170.5	1409.5	1158	1410.41	1160	1415.57
GR	1166	1509.56	1168	1519.96	1170	1527.06	1172	1531.57	1174	1536.19
GR	1178	1539.48	1178	1542.37	1178	1568.19	1176	1630.46	1174	1666.03
GR	1172	1673.42	1170	1679.79	1168	1691.14	1168	1700.35	1170	1704.62

1

GR	1172	1711.58	1174	1724.44	1174	1766.22	1172	1775.51	1170	1791.57
NC				0.3	0.5					
X1	122.65	27	188.7	1216.3	65	65	65			
X3	10									
GR	1172	0	1172	125.08	1170	188.7	1168	194.75	1166	201.16
GR	1164	205.95	1162	210.26	1160	216.37	1158	219.98	1156	227.72
GR	1154	232.41	1152	238.19	1147.2	264.91	1147.2	1169	1159.4	1183
GR	1170.5	1216.3	1168	1312.31	1170	1319.07	1172	1322.27	1174	1329.19
GR	1178	1333.2	1178	1338.91	1178	1378.93	1176	1435.77	1174	1496.03
GR	1172	1540.96	1170	1558.53						
SB	1.05	1.56	3	500	790	193	27088	6.5	1147.31	1147.2
X1	123.55	28	247.63	1335.6	120	120	120			
X2			1	1180.61	1181.8					
X3	10									
GR	1172	0	1172	247.63	1170	253.99	1168	273.55	1166	281.4
GR	1166	283.76	1166	310.92	1164	317.04	1162	322.63	1160	328.49
GR	1158	333.83	1156	339.53	1154	346.19	1152	354.31	1147.3	375.38
GR	1147.3	1288.2	1159.4	1302.3	1170.5	1335.6	1170	1419.47	1172	1429.2
GR	1174	1432.5	1176	1434.98	1178	1461.34	1178	1512.09	1176	1579.09
GR	1174	1678.33	1172	1755.73	1170	1861.49				
NC				0.1	0.3					
X1	228	44	90.9	1152.8	420	300	360			
X3	10									
GR	1170	0	1172	6.43	1172	14.35	1172	22.93	1172	27.9
GR	1170	31.53	1168	39.25	1166	45.63	1164	50.41	1162	58.03
GR	1160	66.41	1158	76.71	1172	90.9	1147.7	111.9	1147.7	999
GR	1184	999.1	1184	1052.9	1147.7	1053	1147.7	1131.8	1172	1152.8
GR	1164	1153.31	1166	1206.5	1168	1211.92	1168	1223.69	1168	1264.35
GR	1170	1276.64	1172	1283.33	1174	1291.14	1176	1295.99	1178	1316.09
GR	1178	1326.38	1178	1333.75	1180	1337.72	1180	1344.25	1178	1347.49
GR	1176	1351.78	1174	1355.53	1172	1359.44	1170	1363.26	1168	1378.57

GR	1168	1398.94	1168	1429.84	1166	1529.46	1166	1620.11		
X1	229	44	330.6	1314.7	440	330	380			
X3	10									
GR	1170	0	1160	21.56	1158	28.38	1158	53.44	1160	66.58
GR	1160	79.87	1158	116.07	1158	146.8	1158	153.74	1158	181.54
GR	1158	187.08	1158	202.48	1156	220.79	1154	247.95	1152	262.65
GR	1152	269.13	1152	301.61	1150	315.44	1172.2	330.6	1148.1	354.7
GR	1148.1	1060	1184	1060.1	1184	1113.9	1148.1	1114	1148.1	1288.9
GR	1173.5	1314.7	1172	1323.39	1174	1327.38	1176	1330.97	1178	1334.68
GR	1180	1337.95	1182	1343.55	1184	1364.4	1184	1386.7	1182	1391.21
GR	1180	1395.48	1178	1398.88	1176	1401.89	1174	1405.57	1172	1409.33
GR	1170	1415.5	1170	1520.41	1170	1537.44	1170	1644.45		
X1	230	32	481.5	1309.78	350	430	390			
X3	10									
GR	1174	14.68	1172	34.2	1170	69.37	1168	74.89	1166	92.61
GR	1164	163.09	1162	258.68	1160	329.81	1158	342.99	1156	346.62
GR	1154	353.18	1152	370.82	1150	394	1150	405.61	1152	440
GR	1152	467.1	1172.1	481.5	1148.4	505.2	1148.4	1156	1181	1156.1

GR	1181	1209.9	1148.4	1210	1148.4	1286.1	1172.1	1309.78	1168	1321.25
GR	1170	1339.03	1172	1352.5	1172	1462.29	1172	1490.22	1174	1509.85
GR	1174	1535.71	1172	1542.61						
X1	231	22	160.5	919.6	360	460	400			
X3	10									
GR	1178	0	1176	141.91	1172.7	160.5	1148.8	184.4	1148.8	765
GR	1181.5	765.1	1181.5	818.9	1148.8	818.9	1148.8	907.7	1172.7	919.6
GR	1158	1051.56	1160	1069.76	1162	1080.98	1164	1093.09	1166	1105.46
GR	1168	1115.59	1170	1123.76	1172	1128.42	1174	1133.06	1174	1152.4
GR	1174	1275.9	1174	1320.61						
X1	232	24	315.3	1027.6	400	410	400			
X3	10									
GR	1176	0	1176	39.97	1176	247.56	1173.5	315.3	1149.2	339.6
GR	1149.2	873	1182.5	873.1	1182.5	926.9	1149.2	927	1149.2	1015.5
GR	1173.5	1027.6	1152	1064.89	1154	1074.27	1156	1084.6	1158	1093.29
GR	1160	1106.57	1162	1113.87	1164	1118.12	1166	1121.69	1168	1131.52
GR	1170	1141.67	1172	1247.51	1172	1279.79	1172	1295.2		
X1	233	26	314.4	981.3	390	390	390			
X3	10									
GR	1176	0	1174	141.81	1172	247.49	1172	261.66	1174.3	314.4
GR	1149.6	339.1	1149.6	827	1182.5	827.1	1182.5	880.9	1149.6	881
GR	1149.6	969	1174.3	981.3	1154	984.4	1156	994.26	1158	1004.77
GR	1160	1015.49	1162	1023.59	1164	1032.43	1166	1038.61	1168	1046.29
GR	1168	1165.91	1168	1178.41	1170	1213.47	1170	1234.96	1168	1257.86
GR	1168	1265.33								
X1	234	39	351.3	1017.95	435	370	405			
X3	10									
GR	1172	0	1172	55.13	1170	131.34	1170	133.81	1170	148.48
GR	1168	156.75	1168	159.9	1170	177.68	1170	264.01	1170	280.92
GR	1172	285.13	1174	287.34	1176	291.37	1178	293.5	1178	300.48
GR	1176	308.6	1174	313.89	1172	317.53	1170	320.96	1168	324.38
GR	1166	330.13	1164	334.17	1162	339.95	1160	348.17	1175.8	351.3

GR	1150	377.1	1150	863	1183	863.1	1183	916.9	1150	917
GR	1150	992.2	1175.8	1017.95	1160	1028.08	1162	1056.1	1164	1100.41
GR	1166	1117.08	1168	1148.31	1170	1244.36	1170	1260.5		
X1	235	31	323.7	1013.6	400	405	400			
X3	10									
GR	1188	0	1188	5.95	1186	83.48	1184	109.91	1184	136.66
GR	1184	148.7	1182	181.29	1180	198.09	1180	208.53	1180	208.78
GR	1170	225.2	1160	240.93	1158	250.29	1156	268.18	1154	278.68
GR	1152	285.78	1177.5	323.7	1150.4	350.8	1150.4	859	1183	859.1
GR	1183	912.9	1150.4	913	1150.4	986.5	1177.5	1013.6	1166	1019.94
GR	1168	1036.82	1168	1047.05	1168	1118.89	1168	1129.18	1168	1142.62
GR	1170	1201.92								

X1	236	29	327.1	1044.5	380	430	405			
X3	10									
GR	1186	0	1186	33.09	1186	88.98	1186	158.59	1186	165.74
GR	1184	175.14	1182	179.03	1180	182.87	1170	197.46	1160	209.76
GR	1158	212.84	1156	218.12	1154	222.17	1179	327.1	1150.8	355.3
GR	1150.8	890	1184	890.1	1184	943.9	1150.8	944	1150.8	1016.5
GR	1178.8	1044.5	1168	1058.28	1166	1062.4	1166	1086.32	1166	1092.55
GR	1168	1106.08	1170	1228.32	1172	1295.79	1172	1304.29		
X1	237	27	275.3	1137.7	390	435	410			
X3	10									
GR	1188	0	1188	37.05	1186	162.09	1184	167.16	1182	170.9
GR	1180	173.01	1170	186.94	1160	203.56	1158	207.56	1156	209.33
GR	1154	215.62	1180.6	275.3	1151.2	304.7	1151.2	983	1184	983.1
GR	1184	1036.9	1151.2	1037	1151.2	1108.3	1180.6	1137.7	1166	1154.04
GR	1168	1163.43	1170	1182.53	1172	1319.78	1172	1366.54	1172	1385.84
GR	1172	1392.66	1172	1400.59						
X1	238	41	474.12	1344.58	650	380	510			
X3	10									
GR	1178	0	1178	42.14	1180	60.75	1182	68.52	1184	76.58
GR	1186	86.57	1188	95.67	1190	150.75	1190	278.24	1188	296.12
GR	1186	364.44	1184	398.62	1182	403.49	1180	406.14	1170	421.07
GR	1164	430.09	1162	437.35	1160	440.69	1183.1	474.12	1151.7	505.5
GR	1151.7	1315	1181.3	1344.58	1160	1363.15	1162	1374.46	1170	1381.24
GR	1172	1383.52	1174	1385.56	1174	1389.66	1172	1397.64	1170	1409.81
GR	1170	1439.22	1170	1456.49	1170	1463.91	1170	1467.53	1170	1476.98
GR	1170	1482.89	1170	1508.53	1172	1563.28	1174	1601.93	1176	1654.88
GR	1176	1666.64								
QT	1	220000								
X1	239	50	489.54	1337.7	500	450	480			
X3	10									
GR	1180	0	1180	60.86	1180	63.23	1180	73.46	1180	78.65
GR	1182	84.86	1184	87.46	1186	92.65	1188	95.53	1190	98.93
GR	1192	103.69	1194	105.79	1196	114.23	1198	170.87	1198	205.37
GR	1196	210.54	1194	216.61	1192	219.62	1190	226.22	1188	232.28
GR	1186	236.97	1184	244.01	1182	251.76	1180	257.61	1178	265.63
GR	1178	280.87	1178	286.25	1180	309.24	1180	384	1178	424.52
GR	1176	427.51	1174	430.65	1172	434	1170	436.74	1160	451.98
GR	1183.6	489.54	1152.2	520.94	1152.2	1308.4	1181.5	1337.7	1164	1340.92
GR	1166	1356.24	1168	1357.68	1170	1411.73	1172	1417.7	1172	1423.78

GR	1170	1427.2	1170	1461.02	1172	1519.9	1174	1610.18	1176	1629.91
X1	240	37	455.69	1433.84	470	550	500			
X3	10									
GR	1196	0	1198	18.94	1200	36.94	1202	54.89	1204	79.33
GR	1204	212.11	1202	252.1	1200	266.97	1198	275.7	1196	286.94
GR	1194	298.58	1192	308.25	1190	318.42	1188	333.62	1186	345.76
GR	1184	366.15	1184	390.9	1184	455.69	1152.7	487	1152.7	1402.54
GR	1184	1433.84	1158	1482.09	1160	1486.58	1162	1494.69	1164	1499.88
GR	1166	1506.5	1168	1511.89	1170	1516.8	1172	1520.97	1172	1535.67
GR	1172	1580.43	1172	1679.49	1172	1704.99	1174	1731.13	1174	1765.93

1

GR	1174	1769.16	1174	1819.84						
NC				0.3	0.5					
X1	240.1	4	5000	5979	58	37	57			
X3	10									
GR	1184.1	5000	1152.8	5031.3	1152.8	5947.7	1184.1	5979		
SB	1.05	1.56	2.6	500	923.4	106	33579	1	1152.8	1152.8
X1	240.2	4	5000	5986	32	32	32			
X2			1	1192	1206					
X3	10									
GR	1184.1	5000	1152.8	5031.3	1152.8	5954.7	1184.1	5986		
X1	240.3	4	5000	6009.2	106	106	106			
X3	10									
GR	1184.2	5000	1152.9	5031.3	1152.9	5977.9	1184.2	6009.2		
X1	240.4	4	5000	6032.4	106	106	106			
X3	10									
GR	1184.3	5000	1153	5031.3	1153	6001.1	1184.3	6032.4		
SB	1.05	1.56	2.6	500	988.4	104	28283	1	1153.1	1153.1
X1	240.5	4	5000	6051	85	85	85			
X2			1	1184	1199					
X3	10									
GR	1184.4	5000	1153.1	5031.3	1153.1	6019.7	1184.4	6051		
X1	240.6	4	5000	6063.7	58	58	58			
X3	10									
GR	1184.5	5000	1153.1	5031.4	1153.1	6032.4	1184.5	6063.7		
X1	241.1	4	5000	6076.7	59	59	59			
X3	10									
GR	1184.6	5000	1153.2	5031.4	1153.2	6045.2	1184.6	6076.7		
SB	1.05	1.5	2.6	500	1019.9	106	29097	1	1153.2	1153.2
X1	241.2	4	5000	6083	29	29	29			
X2			1	1184	1192					
X3	10									
GR	1185	5000	1153.2	5031.8	1153.2	6051.2	1185	6083		

1

```
   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST


*PROF 1
0

CCHV=     .100 CEHV=     .300
*SECNO 120.500

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=      1172.00 ELREA=      1170.50

  120.500     19.59   1166.59       .00   1166.59   1168.49      1.90       .00       .00   1172.00
 215000.0        .0  215000.0        .0        .0   19429.9        .0        .0        .0   1170.50
      .00       .00     11.07       .00      .000      .035      .000      .000   1147.00    383.29
  .001387        0.        0.        0.         0         0         0       .00   1037.18   1420.47


*SECNO 122.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=      1172.00 ELREA=      1170.50

  122.000     19.50   1166.70       .00       .00   1168.75      2.05       .22       .04   1172.00
 215000.0        .0  215000.0        .0        .0   18707.5        .0      65.7       3.5   1170.50
      .00       .00     11.49       .00      .000      .035      .000      .000   1147.20    388.54
  .001512      155.      150.      150.         2         0         0       .00   1009.57   1398.11


CCHV=     .300 CEHV=     .500
*SECNO 122.650

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=      1170.00 ELREA=      1170.50

  122.650     19.61   1166.81       .00       .00   1168.85      2.04       .10       .00   1170.00
 215000.0        .0  215000.0        .0        .0   18755.5        .0      93.6       5.0   1170.50
      .01       .00     11.46       .00      .000      .035      .000      .000   1147.20    198.58
  .001493       65.       65.       65.         1         0         0       .00   1006.63   1205.21


SPECIAL BRIDGE

5227 DOWNSTREAM ELEV IS    1156.29 , NOT    1166.81 HYDRAULIC JUMP OCCURS DOWNSTREAM (IF LOW FLOW CONTROLS)

1
```



```
   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST


SB  XK        XKOR      COFQ      RDLEN     BWC       BWP       BAREA     SS        ELCHU     ELCHD
```

1.05	1.56	3.00	500.00	790.00	193.00	27088.00	6.50	1147.31	1147.20

*SECNO 123.550
CLASS B LOW FLOW

3420 BRIDGE W.S.= 1162.28 BRIDGE VELOCITY= 20.60 CALCULATED CHANNEL AREA= 10393.

EGPRS	EGLWC	H3	QWEIR	QLOW	BAREA	TRAPEZOID AREA	ELLC	ELTRD	WEIRLN
.00	1170.17	.00	0.	215000.	27088.	27088.	1180.61	1181.80	0.

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1172.00 ELREA= 1170.50

123.550	21.18	1168.48	.00	.00	1170.17	1.69	1.32	.00	1172.00
215000.0	.0	215000.0	.0	.0	20580.1	.0	147.8	7.9	1170.50
.01	.00	10.45	.00	.000	.035	.000	.000	1147.30	268.86
.001174	120.	120.	120.	0	0	0	.00	1060.68	1329.54

CCHV= .100 CEHV= .300
*SECNO 228.000

3265 DIVIDED FLOW

3280 CROSS SECTION 228.00 EXTENDED 2.96 FEET

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1172.00 ELREA= 1172.00

228.000	21.25	1168.95	.00	.00	1170.59	1.64	.41	.01	1172.00
215000.0	.0	215000.0	.0	.0	20926.7	.0	319.3	16.4	1172.00
.02	.00	10.27	.00	.000	.035	.000	.000	1147.70	93.53
.001104	420.	360.	300.	0	0	0	.00	1002.76	1150.17

*SECNO 229.000

3265 DIVIDED FLOW

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1172.20 ELREA= 1173.50

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST
229.000	21.07	1169.17	.00	.00	1171.16	1.99	.47	.11	1172.20
215000.0	.0	215000.0	.0	.0	18995.6	.0	493.4	24.8	1173.50
.03	.00	11.32	.00	.000	.035	.000	.000	1148.10	333.63
.001369	440.	380.	330.	2	0	0	.00	922.79	1310.30

*SECNO 230.000

3265 DIVIDED FLOW

3301 HV CHANGED MORE THAN HVINS

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1172.10 ELREA= 1172.10

230.000	20.73	1169.13	.00	.00	1172.12	2.99	.66	.30	1172.10
215000.0	.0	215000.0	.0	.0	15502.8	.0	647.9	32.4	1172.10
.04	.00	13.87	.00	.000	.035	.000	.000	1148.40	484.47
.002142	350.	390.	430.	2	0	0	.00	768.48	1306.82

*SECNO 231.000

3265 DIVIDED FLOW

3301 HV CHANGED MORE THAN HVINS

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1172.70 ELREA= 1172.70

231.000	20.90	1169.70	.00	.00	1173.20	3.50	.93	.15	1172.70
215000.0	.0	215000.0	.0	.0	14317.2	.0	784.8	39.1	1172.70
.04	.00	15.02	.00	.000	.035	.000	.000	1148.80	163.50
.002513	360.	400.	460.	2	0	0	.00	700.77	918.11

*SECNO 232.000

3265 DIVIDED FLOW

1

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1173.50 ELREA= 1173.50

232.000	21.28	1170.48	.00	.00	1174.37	3.90	1.05	.12	1173.50
215000.0	.0	215000.0	.0	.0	13572.1	.0	912.8	45.3	1173.50
.05	.00	15.84	.00	.000	.035	.000	.000	1149.20	318.32
.002766	400.	400.	410.	2	0	0	.00	653.90	1026.09

*SECNO 233.000

3265 DIVIDED FLOW

3280 CROSS SECTION 233.00 EXTENDED 3.29 FEET

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1174.30 ELREA= 1174.30

233.000	21.69	1171.29	.00	.00	1175.64	4.35	1.13	.14	1174.30
215000.0	.0	215000.0	.0	.0	12846.4	.0	1031.1	51.0	1174.30
.06	.00	16.74	.00	.000	.035	.000	.000	1149.60	317.41
.003053	390.	390.	390.	2	0	0	.00	608.53	979.80

*SECNO 234.000

3265 DIVIDED FLOW

3280 CROSS SECTION 234.00 EXTENDED 2.78 FEET

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1175.80 ELREA= 1175.80

234.000	22.77	1172.77	.00	.00	1176.83	4.06	1.16	.03	1175.80
215000.0	.0	215000.0	.0	.0	13299.4	.0	1152.7	56.6	1175.80
.06	.00	16.17	.00	.000	.035	.000	.000	1150.00	354.32
.002703	435.	405.	370.	2	0	0	.00	606.75	1014.93

*SECNO 235.000

3265 DIVIDED FLOW

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

3280 CROSS SECTION 235.00 EXTENDED 4.48 FEET

3301 HV CHANGED MORE THAN HVINS

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1177.50 ELREA= 1177.50

235.000	24.08	1174.48	.00	.00	1177.85	3.37	.95	.07	1177.50
215000.0	.0	215000.0	.0	.0	14588.2	.0	1280.7	62.3	1177.50
.07	.00	14.74	.00	.000	.035	.000	.000	1150.40	326.72
.002092	400.	400.	405.	2	0	0	.00	630.01	1010.58

*SECNO 236.000

3265 DIVIDED FLOW

3280 CROSS SECTION 236.00 EXTENDED 3.78 FEET

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1179.00 ELREA= 1178.80

236.000	24.98	1175.78	.00	.00	1178.66	2.88	.76	.05	1179.00
215000.0	.0	215000.0	.0	.0	15795.7	.0	1421.9	68.3	1178.80
.08	.00	13.61	.00	.000	.035	.000	.000	1150.80	330.32
.001697	380.	405.	430.	2	0	0	.00	657.32	1041.48

*SECNO 237.000

3265 DIVIDED FLOW

3280 CROSS SECTION 237.00 EXTENDED 5.57 FEET

3301 HV CHANGED MORE THAN HVINS

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1180.60 ELREA= 1180.60

237.000	26.36	1177.56	.00	.00	1179.28	1.71	.50	.12	1180.60
215000.0	.0	215000.0	.0	.0	20460.5	.0	1592.6	75.2	1180.60
.09	.00	10.51	.00	.000	.035	.000	.000	1151.20	278.33
.000919	390.	410.	435.	2	0	0	.00	802.49	1134.67

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*SECNO 238.000
3280 CROSS SECTION 238.00 EXTENDED 2.25 FEET

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1183.10 ELREA= 1181.30

238.000	26.55	1178.25	.00	.00	1179.71	1.46	.41	.03	1183.10
215000.0	.0	215000.0	.0	.0	22200.4	.0	1842.3	84.9	1181.30
.10	.00	9.68	.00	.000	.035	.000	.000	1151.70	478.96
.000708	650.	510.	380.	2	0	0	.00	862.57	1341.54

*SECNO 239.000
3280 CROSS SECTION 239.00 EXTENDED 2.49 FEET

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1183.60 ELREA= 1181.50

239.000	26.29	1178.49	.00	.00	1180.13	1.64	.36	.06	1183.60
220000.0	.0	220000.0	.0	.0	21391.4	.0	2082.5	94.3	1181.50
.12	.00	10.28	.00	.000	.035	.000	.000	1152.20	494.65
.000810	500.	480.	450.	2	0	0	.00	840.03	1334.69

*SECNO 240.000
3280 CROSS SECTION 240.00 EXTENDED 5.32 FEET

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1184.00 ELREA= 1184.00

240.000	26.62	1179.32	.00	.00	1180.51	1.19	.34	.04	1184.00
220000.0	.0	220000.0	.0	.0	25079.0	.0	2349.2	104.7	1184.00
.13	.00	8.77	.00	.000	.035	.000	.000	1152.70	460.37
.000574	470.	500.	550.	2	0	0	.00	968.79	1429.16

CCHV= .300 CEHV= .500
*SECNO 240.100

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1184.10 ELREA= 1184.10

240.100	26.55	1179.35	.00	.00	1180.55	1.20	.03	.00	1184.10
220000.0	.0	220000.0	.0	.0	25038.3	.0	2382.0	105.9	1184.10
.13	.00	8.79	.00	.000	.035	.000	.000	1152.80	5004.75
.000578	58.	57.	37.	0	0	0	.00	969.51	5974.25

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

SPECIAL BRIDGE

SB	XK	XKOR	COFQ	RDLEN	BWC	BWP	BAREA	SS	ELCHU	ELCHD
	1.05	1.56	2.60	500.00	923.40	106.00	33579.00	1.00	1152.80	1152.80

*SECNO 240.200
CLASS A LOW FLOW

3420 BRIDGE W.S.= 1178.97 BRIDGE VELOCITY= 9.97 CALCULATED CHANNEL AREA= 22075.

EGPRS	EGLWC	H3	QWEIR	QLOW	BAREA	TRAPEZOID AREA	ELLC	ELTRD	WEIRLN
.00	1180.77	.26	0.	220000.	33579.	33579.	1192.00	1206.00	0.

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1184.10 ELREA= 1184.10

240.200	26.81	1179.61	.00	.00	1180.77	1.16	.22	.00	1184.10
220000.0	.0	220000.0	.0	.0	25472.7	.0	2400.5	106.7	1184.10
.14	.00	8.64	.00	.000	.035	.000	.000	1152.80	5004.49
.000551	32.	32.	32.	0	0	0	.00	977.02	5981.51

*SECNO 240.300

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1184.20 ELREA= 1184.20

240.300	26.84	1179.74	.00	.00	1180.84	1.10	.06	.02	1184.20
220000.0	.0	220000.0	.0	.0	26126.2	.0	2463.3	109.1	1184.20
.14	.00	8.42	.00	.000	.035	.000	.000	1152.90	5004.46
.000523	106.	106.	106.	2	0	0	.00	1000.28	6004.74

*SECNO 240.400

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1184.30 ELREA= 1184.30

240.400	26.86	1179.86	.00	.00	1180.91	1.05	.05	.02	1184.30
220000.0	.0	220000.0	.0	.0	26771.3	.0	2527.7	111.5	1184.30
.14	.00	8.22	.00	.000	.035	.000	.000	1153.00	5004.44
.000496	106.	106.	106.	2	0	0	.00	1023.52	6027.96

1

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

SPECIAL BRIDGE

SB	XK	XKOR	COFQ	RDLEN	BWC	BWP	BAREA	SS	ELCHU	ELCHD
	1.05	1.56	2.60	500.00	988.40	104.00	28283.00	1.00	1153.10	1153.10

*SECNO 240.500
CLASS A LOW FLOW

3420 BRIDGE W.S.= 1179.58 BRIDGE VELOCITY= 9.12 CALCULATED CHANNEL AREA= 24125.

EGPRS	EGLWC	H3	QWEIR	QLOW	BAREA	TRAPEZOID AREA	ELLC	ELTRD	WEIRLN
.00	1181.06	.19	0.	220000.	28283.	28283.	1184.00	1199.00	0.

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1184.40 ELREA= 1184.40

240.500	26.95	1180.05	.00	.00	1181.06	1.00	.15	.00	1184.40
220000.0	.0	220000.0	.0	.0	27368.0	.0	2580.5	113.5	1184.40
.15	.00	8.04	.00	.000	.035	.000	.000	1153.10	5004.35
.000472	85.	85.	85.	0	0	0	.00	1042.31	6046.65

*SECNO 240.600

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1184.50 ELREA= 1184.50

240.600	27.02	1180.12	.00	.00	1181.09	.97	.03	.01	1184.50
220000.0	.0	220000.0	.0	.0	27774.9	.0	2617.2	114.9	1184.50
.15	.00	7.92	.00	.000	.035	.000	.000	1153.10	5004.38

.000457	58.	58.	58.	2	0	0	.00	1054.95	6059.33

*SECNO 241.100

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1184.60 ELREA= 1184.60

241.100	26.97	1180.17	.00	.00	1181.13	.95	.03	.01	1184.60
220000.0	.0	220000.0	.0	.0	28073.4	.0	2655.0	116.4	1184.60
.15	.00	7.84	.00	.000	.035	.000	.000	1153.20	5004.43
.000448	59.	59.	59.	2	0	0	.00	1067.83	6072.26

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

SPECIAL BRIDGE

SB	XK	XKOR	COFQ	RDLEN	BWC	BWP	BAREA	SS	ELCHU	ELCHD
	1.05	1.50	2.60	500.00	1019.90	106.00	29097.00	1.00	1153.20	1153.20

*SECNO 241.200
CLASS A LOW FLOW

3420 BRIDGE W.S.= 1179.92 BRIDGE VELOCITY= 8.75 CALCULATED CHANNEL AREA= 25136.

EGPRS	EGLWC	H3	QWEIR	QLOW	BAREA	TRAPEZOID AREA	ELLC	ELTRD	WEIRLN
.00	1181.27	.17	0.	220000.	29097.	29097.	1184.00	1192.00	0.

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1185.00 ELREA= 1185.00

241.200	27.14	1180.34	.00	.00	1181.27	.93	.14	.00	1185.00
220000.0	.0	220000.0	.0	.0	28400.9	.0	2673.8	117.1	1185.00
.15	.00	7.75	.00	.000	.035	.000	.000	1153.20	5004.66
.000434	29.	29.	29.	0	0	0	.00	1073.68	6078.34

THIS RUN EXECUTED 19JUN97 14:34:15

****
HEC-2 WATER SURFACE PROFILES

Version 4.6.2; May 1991
****

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

SUMMARY PRINTOUT

	SECNO	CWSEL	DEPTH	VCH	Q	TOPWID	10*KS	ELMIN	AREA
	120.500	1166.59	19.59	11.07	215000.00	1037.18	13.87	1147.00	19429.93
	122.000	1166.70	19.50	11.49	215000.00	1009.57	15.12	1147.20	18707.49
	122.650	1166.81	19.61	11.46	215000.00	1006.63	14.93	1147.20	18755.49
*	123.550	1168.48	21.18	10.45	215000.00	1060.68	11.74	1147.30	20580.07
	228.000	1168.95	21.25	10.27	215000.00	1002.76	11.04	1147.70	20926.65
	229.000	1169.17	21.07	11.32	215000.00	922.79	13.69	1148.10	18995.57
	230.000	1169.13	20.73	13.87	215000.00	768.48	21.42	1148.40	15502.77
	231.000	1169.70	20.90	15.02	215000.00	700.77	25.13	1148.80	14317.18
	232.000	1170.48	21.28	15.84	215000.00	653.90	27.66	1149.20	13572.10
	233.000	1171.29	21.69	16.74	215000.00	608.53	30.53	1149.60	12846.37
	234.000	1172.77	22.77	16.17	215000.00	606.75	27.03	1150.00	13299.43
	235.000	1174.48	24.08	14.74	215000.00	630.01	20.92	1150.40	14588.24
	236.000	1175.78	24.98	13.61	215000.00	657.32	16.97	1150.80	15795.73
	237.000	1177.56	26.36	10.51	215000.00	802.49	9.19	1151.20	20460.53
	238.000	1178.25	26.55	9.68	215000.00	862.57	7.08	1151.70	22200.39
	239.000	1178.49	26.29	10.28	220000.00	840.03	8.10	1152.20	21391.37
	240.000	1179.32	26.62	8.77	220000.00	968.79	5.74	1152.70	25078.99

1

SECNO	CWSEL	DEPTH	VCH	Q	TOPWID	10*KS	ELMIN	AREA
240.100	1179.35	26.55	8.79	220000.00	969.51	5.78	1152.80	25038.34
240.200	1179.61	26.81	8.64	220000.00	977.02	5.51	1152.80	25472.70
240.300	1179.74	26.84	8.42	220000.00	1000.28	5.23	1152.90	26126.24
240.400	1179.86	26.86	8.22	220000.00	1023.52	4.96	1153.00	26771.28

240.500	1180.05	26.95	8.04	220000.00	1042.31	4.72	1153.10	27367.97
240.600	1180.12	27.02	7.92	220000.00	1054.95	4.57	1153.10	27774.93
241.100	1180.17	26.97	7.84	220000.00	1067.83	4.48	1153.20	28073.44
241.200	1180.34	27.14	7.75	220000.00	1073.68	4.34	1153.20	28400.89

1

SUMMARY OF ERRORS AND SPECIAL NOTES

CAUTION SECNO= 123.550 PROFILE= 1 HYDRAULIC JUMP D.S.

APPENDIX B

HEC-2 As-Built Files

```
1*******************************************
*  HEC-2 WATER SURFACE PROFILES            *
*                                          *
*  Version   4.6.2;  May 1991              *
*                                          *
*  RUN DATE    19JUN97    TIME   14:58:52  *
*******************************************
```

```
************************************
*  U.S. ARMY CORPS OF ENGINEERS
*  HYDROLOGIC ENGINEERING CENTER
*  609 SECOND STREET, SUITE D
*  DAVIS, CALIFORNIA 95616-4687
*          (916) 756-1104
************************************
```

```
X     X  XXXXXXX   XXXXX              XXXXX
X     X  X        X     X            X     X
X     X  X        X                        X
XXXXXXX  XXXX     X         XXXXX    XXXXX
X     X  X        X                  X
X     X  X        X     X            X
X     X  XXXXXXX   XXXXX             XXXXXXX
```

1

19JUN97 14:58:52 PAGE 1

THIS RUN EXECUTED 19JUN97 14:58:52

```
************************************
 HEC-2 WATER SURFACE PROFILES

 Version   4.6.2;  May 1991
************************************
```

```
T1   SIMONS, LI & ASOCIATES, INC. (PAZ-DMJM-07)
T2   RED MOUNTAIN FREEWAY SALT RIVER BANK PROTECTION
T3

      FILE NAME: ASB_D.DAT
      Hydraulic Analysis for the As-Built conditions with design invert
```

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
		2						215000	1166.59	

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	-1		-1					-6		

J3 VARIABLE CODES FOR SUMMARY PRINTOUT

38	1	8	26	43	4	5	42

NC	0.035	0.035	0.035	0.1	0.3					
X1	120.5	51	1000	2093.03						
X3	10									
GR	1172.3	1000	1171	1002.81	1170	1005.62	1169	1008.43	1168	1011.26
GR	1167	1014.09	1166	1016.94	1165	1019.81	1164	1022.79	1163	1025.82
GR	1162	1028.93	1161	1032.09	1160	1034.81	1159	1036.19	1158	1037.56
GR	1157	1038.94	1156	1040.31	1155	1041.69	1154	1043.06	1153	1044.44
GR	1152	1045.83	1151	1047.22	1150	1048.61	1149	1050.01	1148	1051.41
GR	1147	1052.81	1147	2009.06	1148	2011.89	1149	2013.19	1150	2014.51
GR	1151	2015.81	1152	2017.15	1153	2018.51	1154	2019.85	1155	2021.2
GR	1156	2022.54	1157	2023.88	1158	2025.22	1159	2053.49	1160	2056.79
GR	1161	2060.08	1162	2063.38	1163	2066.68	1164	2069.98	1165	2073.27
GR	1166	2076.57	1167	2079.86	1168	2083.15	1169	2086.45	1170	2089.74
GR	1171.8	2093.03								
X1	122	39	1000	2052.87	155	150	150			
X3	10									
GR	1171.8	1000	1170	1002.23	1169	1004.46	1168	1006.69	1167	1008.93
GR	1166	1011.16	1165	1013.39	1164	1015.78	1163	1018.25	1162	1020.8
GR	1161	1023.43	1160	1026.95	1159	1031.01	1158	1035.07	1157	1039.13
GR	1156	1043.18	1155	1047.24	1154	1051.3	1153	1055.36	1152	1059.42
GR	1147.2	1074.56	1147.2	1975.57	1153	1978.27	1154	1980.97	1155	1983.69
GR	1156	1986.49	1157	1989.44	1158	1992.62	1159	2020.79	1160	2023.99
GR	1161	2027.19	1162	2030.4	1163	2033.6	1164	2036.81	1165	2040.02
GR	1166	2043.23	1167	2046.44	1168	2049.66	1170.3	2052.87		

1

NC				0.3	0.5					
X1	122.65	41	1000	2056.29	65	65	65			
X3	10									
GR	1172	1000	1170	1002.61	1169	1005.23	1168	1007.88	1167	1010.56
GR	1166	1013.27	1165	1016.12	1164	1019.15	1163	1022.32	1162	1025.64
GR	1161	1028.97	1160	1032.7	1159	1037.19	1158	1041.68	1157	1046.11
GR	1156	1050.49	1155	1054.81	1154	1059.08	1153	1063.33	1152	1067.57
GR	1151	1071.81	1150	1076.04	1149	1080.27	1147.2	1084.49	1147.2	1969.74
GR	1151	1971.02	1151	1973.67	1151	1973.74	1152	1977.44	1158	1993.89
GR	1159	2014.39	1160	2027.12	1161	2030.36	1162	2033.6	1163	2036.84
GR	1164	2040.08	1165	2043.32	1166	2046.57	1167	2049.81	1168	2053.05
GR	1169.4	2056.29								
SB	1.05	1.56	3	500	790	193	27098	6.5	1147.30	1147.2
X1	123.55	37	1000	2076.63	120	120	120			
X2			1	1180.61	1181.8					
X3	10									
GR	1172.1	1000	1171	1002.85	1170	1005.73	1169	1008.64	1168	1011.59
GR	1167	1014.48	1163	1027.51	1162	1030.78	1161	1034.05	1160	1037.32
GR	1159	1040.59	1158	1043.86	1157	1047.12	1156	1050.36	1155	1053.62
GR	1154	1056.88	1153	1060.15	1152	1063.43	1151	1066.71	1147.3	1075.15
GR	1147.3	1986.19	1155	1987.71	1156	1989.24	1157	1990.77	1158	1992.34
GR	1159	1993.98	1160	2013.14	1161	2036.96	1162	2041.23	1163	2045.51
GR	1164	2049.79	1165	2054.08	1166	2058.38	1167	2062.66	1168	2066.95
GR	1169	2071.7	1170.2	2076.63						
NC				0.1	0.3					
X1	228	51	1000	2078.02	420	300	360			
X3	10									
GR	1172.3	1000	1171	1001.4	1170	1002.8	1169	1004.19	1168	1005.59

GR	1167	1006.99	1166	1008.39	1165	1009.79	1164	1011.2	1163	1012.6
GR	1162	1014	1161	1015.41	1160	1016.81	1159	1018.21	1158	1019.61
GR	1157	1021.01	1156	1022.42	1155	1023.82	1154	1025.22	1153	1026.62
GR	1152	1028.09	1151	1029.58	1150	1031.08	1147.7	1032.58	1147.7	1908.1
GR	1184	1908.2	1184	1962	1147.7	1962.1	1147.7	2030.08	1152	2036.68
GR	1153	2037.89	1154	2039.1	1155	2040.31	1156	2041.53	1157	2042.74
GR	1158	2043.95	1159	2045.16	1160	2046.37	1161	2047.58	1162	2048.8
GR	1163	2050.01	1164	2051.23	1165	2052.44	1166	2053.66	1167	2054.89
GR	1168	2056.11	1169	2057.34	1170	2058.57	1171	2059.8	1172	2064.99
GR	1172.4	2078.02								
X1	229	48	1000	1983.79	440	330	380			
X3	10									
GR	1172.2	1000	1171	1001.25	1170	1002.5	1169	1003.75	1168	1005
GR	1167	1006.25	1166	1007.5	1165	1008.74	1164	1010	1163	1011.24
GR	1162	1012.48	1161	1013.72	1160	1014.96	1159	1016.2	1158	1017.43
GR	1157	1018.67	1156	1019.91	1155	1021.14	1154	1022.38	1153	1023.62
GR	1152	1024.85	1151	1026.09	1148.1	1027.33	1148.1	1729.4	1184	1729.5
GR	1184	1783.3	1148.1	1783.4	1148.1	1953.42	1153	1954.96	1154	1956.49
GR	1155	1958.02	1156	1959.55	1157	1961.07	1158	1962.6	1159	1964.12
GR	1160	1965.64	1161	1967.16	1162	1968.68	1163	1970.19	1164	1971.71
GR	1165	1973.22	1166	1974.73	1167	1976.24	1168	1977.76	1169	1979.26
GR	1170	1980.77	1171	1982.28	1173	1983.79				

1

X1	230	41	1000	1829.34	350	430	390			
X3	10									
GR	1172.3	1000	1171	1001.26	1170	1002.52	1169	1003.78	1168	1005.04
GR	1167	1006.3	1166	1007.56	1165	1008.82	1164	1010.09	1163	1011.35
GR	1162	1012.61	1161	1013.88	1160	1015.14	1150	1027.76	1148.4	1029.03
GR	1148.4	1674.5	1181	1674.6	1181	1728.4	1148.4	1728.5	1148.4	1806.21
GR	1151	1807.32	1152	1808.43	1153	1809.55	1154	1810.66	1155	1811.77
GR	1156	1812.88	1157	1813.99	1158	1815.1	1159	1816.2	1160	1817.3
GR	1161	1818.4	1162	1819.5	1163	1820.6	1164	1821.69	1165	1822.79
GR	1166	1823.88	1167	1824.97	1168	1826.06	1169	1827.16	1170	1828.25
GR	1172.8	1829.34								
X1	231	52	1000	1757.27	360	460	400			
X3	10									
GR	1172.6	1000	1171	1001.27	1170	1002.54	1169	1003.82	1168	1005.1
GR	1167	1006.38	1166	1007.66	1165	1008.97	1164	1010.27	1163	1011.58
GR	1162	1012.88	1161	1014.19	1160	1015.49	1159	1016.8	1158	1018.1
GR	1157	1019.41	1156	1020.71	1155	1022.02	1154	1023.32	1153	1024.63
GR	1152	1025.93	1151	1027.23	1150	1028.54	1148.8	1029.84	1148.8	1604.5
GR	1181.5	1604.6	1181.5	1658.4	1148.8	1658.5	1148.8	1734.21	1150	1735.21
GR	1151	1736.21	1152	1737.21	1153	1738.2	1154	1739.2	1155	1740.2
GR	1156	1741.2	1157	1742.2	1158	1743.2	1159	1744.21	1160	1745.21
GR	1161	1746.21	1162	1747.22	1163	1748.22	1164	1749.22	1165	1750.23
GR	1166	1751.23	1167	1752.24	1168	1753.24	1169	1754.25	1170	1755.26
GR	1171	1756.26	1172.6	1757.27						
X1	232	45	1000	1710.96	400	410	400			
X3	10									
GR	1173.4	1000	1172	1001.08	1171	1002.16	1169	1015.18	1168	1016.59
GR	1167	1018	1166	1019.41	1165	1020.82	1164	1022.23	1163	1023.64
GR	1162	1025.05	1161	1026.46	1160	1027.88	1159	1029.29	1158	1030.7
GR	1157	1032.11	1156	1033.52	1154	1036.34	1153	1037.73	1152	1039.1

GR	1151	1040.46	1150	1041.81	1149.2	1043.14	1149.2	1557.7	1182.5	1557.8
GR	1182.5	1611.6	1149.2	1611.7	1149.2	1691.93	1157	1693.04	1158	1694.16
GR	1159	1695.28	1160	1696.39	1161	1697.51	1162	1698.63	1163	1699.75
GR	1164	1700.87	1165	1701.99	1166	1703.11	1167	1704.23	1168	1705.35
GR	1169	1706.48	1170	1707.6	1171	1708.72	1172	1709.84	1173.8	1710.96
X1	233	57	1000	1666.46	390	390	390			
X3	10									
GR	1175.1	1000	1174	1001.26	1173	1002.52	1172	1003.78	1171	1005.03
GR	1170	1006.28	1169	1007.54	1168	1008.78	1167	1010.03	1166	1011.28
GR	1165	1012.52	1164	1013.76	1163	1015	1162	1016.24	1161	1017.47
GR	1160	1018.71	1159	1019.94	1158	1021.18	1157	1022.41	1156	1023.65
GR	1155	1024.88	1154	1026.11	1153	1027.35	1152	1028.58	1151	1029.82
GR	1149.6	1031.05	1149.6	1512.6	1182.5	1512.7	1182.5	1566.5	1149.6	1566.6
GR	1149.6	1637.69	1149.6	1638.97	1150	1640.08	1151	1641.19	1152	1642.29
GR	1153	1643.4	1154	1644.5	1155	1645.61	1156	1646.71	1157	1647.81
GR	1158	1648.91	1159	1650.01	1160	1651.11	1161	1652.21	1162	1653.31
GR	1163	1654.4	1164	1655.5	1165	1656.6	1166	1657.69	1167	1658.79
GR	1168	1659.88	1169	1660.98	1170	1662.08	1171	1663.17	1172	1664.27
GR	1173	1665.36	1174	1666.46						

X1	234	56	1000	1668.36	435	370	405			
X3	10									
GR	1176.4	1000	1175	1001.3	1174	1002.61	1173	1003.91	1172	1005.21
GR	1171	1006.51	1170	1007.82	1169	1009.12	1168	1010.42	1167	1011.72
GR	1166	1013.03	1165	1014.33	1164	1015.63	1163	1016.93	1162	1018.24
GR	1161	1019.54	1160	1020.84	1159	1022.14	1158	1023.45	1157	1024.75
GR	1156	1026.05	1155	1027.36	1154	1028.66	1153	1029.96	1152	1031.26
GR	1150	1032.57	1150	1511.7	1183	1511.8	1183	1565.6	1150	1565.7
GR	1150	1640.05	1152	1641.18	1153	1642.31	1154	1643.45	1155	1644.58
GR	1156	1645.71	1157	1646.84	1158	1647.98	1159	1649.11	1160	1650.24
GR	1161	1651.37	1162	1652.51	1163	1653.64	1164	1654.77	1165	1655.91
GR	1166	1657.04	1167	1658.17	1168	1659.3	1169	1660.43	1170	1661.57
GR	1171	1662.7	1172	1663.83	1173	1664.97	1174	1666.1	1175	1667.23
GR	1177	1668.36								
X1	235	56	1000	1690.33	400	405	400			
X3	10									
GR	1178.7	1000	1176	1001.32	1175	1002.65	1174	1003.97	1173	1005.3
GR	1172	1006.62	1171	1007.95	1170	1009.27	1169	1010.6	1168	1011.92
GR	1167	1013.25	1166	1014.57	1165	1015.9	1164	1017.22	1163	1018.55
GR	1162	1019.87	1161	1021.2	1160	1022.52	1159	1023.84	1158	1025.17
GR	1157	1026.49	1156	1027.81	1155	1029.14	1154	1030.46	1153	1031.78
GR	1150.4	1033.11	1150.4	1535.3	1183	1535.4	1183	1589.2	1150.4	1589.3
GR	1150.4	1650.24	1153	1651.33	1154	1652.41	1155	1653.49	1156	1654.58
GR	1157	1655.66	1158	1656.74	1159	1657.82	1160	1658.91	1161	1659.99
GR	1162	1661.07	1163	1662.16	1164	1663.24	1165	1664.32	1166	1665.4
GR	1167	1666.49	1168	1667.57	1169	1668.65	1170	1669.74	1171	1670.82
GR	1172	1671.9	1173	1672.98	1174	1674.07	1175	1684.85	1176	1689.08
GR	1177.9	1690.33								
X1	236	62	1000	1717.88	380	430	405			
X3	10									
GR	1182.1	1000	1181	1001.14	1180	1002.28	1179	1003.43	1178	1004.57
GR	1177	1005.71	1176	1006.85	1175	1007.99	1174	1009.13	1173	1010.27
GR	1172	1011.4	1171	1012.54	1170	1013.68	1169	1014.82	1168	1015.97

GR	1167	1017.11	1166	1018.25	1165	1019.39	1164	1020.53	1163	1021.68
GR	1162	1022.82	1161	1023.96	1160	1025.1	1159	1026.25	1158	1027.39
GR	1157	1028.53	1156	1029.67	1155	1030.81	1154	1031.96	1153	1033.1
GR	1150.8	1034.24	1150.8	1562.9	1184	1563	1184	1616.8	1150.8	1616.9
GR	1150.8	1688.26	1152	1689.87	1153	1690.99	1154	1692.11	1155	1693.23
GR	1156	1694.35	1157	1695.47	1158	1696.59	1159	1697.71	1160	1698.83
GR	1161	1699.95	1162	1701.07	1163	1702.19	1164	1703.31	1165	1704.43
GR	1166	1705.55	1167	1706.67	1168	1707.79	1169	1708.92	1170	1710.04
GR	1171	1711.16	1172	1712.28	1173	1713.4	1174	1714.52	1175	1715.64
GR	1176	1716.76	1179	1717.88						
X1	237	65	1000	1863.05	390	435	410			
X3	10									
GR	1182.5	1000	1181	1001.11	1180	1002.22	1179	1003.33	1178	1004.43
GR	1177	1005.54	1176	1006.65	1175	1007.76	1174	1008.87	1173	1009.98
GR	1172	1011.09	1171	1012.2	1170	1013.3	1169	1014.41	1168	1015.52
GR	1167	1020.34	1167	1022.87	1167	1023.78	1166	1025.76	1165	1026.98
GR	1164	1028.2	1163	1029.42	1162	1030.64	1161	1031.87	1160	1033.09

1

GR	1159	1034.31	1158	1035.53	1157	1036.75	1156	1037.97	1155	1039.2
GR	1154	1040.42	1153	1041.64	1152	1042.86	1151.2	1044.09	1151.2	1707.7
GR	1184	1707.8	1184	1761.6	1151.2	1761.7	1151.2	1837.61	1152	1838.6
GR	1153	1839.58	1154	1840.57	1155	1841.56	1156	1842.54	1157	1843.53
GR	1158	1844.52	1159	1845.5	1160	1846.49	1161	1847.48	1162	1848.46
GR	1163	1849.45	1164	1850.43	1165	1851.42	1166	1852.4	1167	1853.39
GR	1168	1854.37	1169	1855.35	1170	1856.33	1171	1857.3	1172	1858.27
GR	1173	1859.24	1174	1860.2	1175	1861.15	1176	1862.1	1181	1863.05
X1	238	63	1000	1871.44	650	380	510			
X3	10									
GR	1183.2	1000	1182	1000.94	1181	1001.88	1180	1002.82	1179	1003.77
GR	1178	1004.71	1177	1005.65	1176	1006.59	1175	1007.53	1174	1008.47
GR	1173	1009.41	1172	1010.36	1171	1011.3	1170	1012.24	1169	1013.18
GR	1168	1014.12	1167	1015.06	1166	1016	1165	1016.94	1164	1017.89
GR	1163	1018.82	1162	1019.75	1161	1020.69	1160	1021.62	1159	1022.57
GR	1158	1023.54	1157	1024.52	1156	1025.5	1155	1026.48	1154	1027.46
GR	1151.7	1028.45	1151.7	1119.5	1151.7	1838.78	1152	1839.87	1153	1840.96
GR	1154	1842.06	1155	1843.15	1156	1844.24	1157	1845.32	1158	1846.41
GR	1159	1847.5	1160	1848.59	1161	1849.68	1162	1850.77	1163	1851.86
GR	1164	1852.95	1165	1854.03	1166	1855.12	1167	1856.21	1168	1857.3
GR	1169	1858.38	1170	1859.47	1171	1860.56	1172	1861.65	1173	1862.73
GR	1174	1863.82	1175	1864.91	1176	1866	1177	1867.09	1178	1868.17
GR	1179	1869.26	1180	1870.35	1181.5	1871.44				
QT	1	220000								
X1	239	57	1000	1842.66	500	450	480			
X3	10									
GR	1183.9	1000	1179	1001	1178	1002	1177	1003	1176	1004.01
GR	1175	1005.01	1174	1006.01	1173	1007.01	1172	1008.02	1171	1009.02
GR	1170	1010.02	1169	1011.03	1168	1012.03	1167	1013.03	1166	1014.04
GR	1165	1015.04	1164	1016.05	1163	1017.05	1162	1018.05	1161	1019.06
GR	1160	1020.07	1159	1021.07	1158	1022.07	1157	1023.08	1156	1024.08
GR	1155	1025.08	1154	1026.09	1152.2	1027.09	1152.2	1811.48	1153	1812.6
GR	1154	1813.71	1155	1814.82	1156	1815.94	1157	1817.05	1158	1818.16
GR	1159	1819.28	1160	1820.39	1161	1821.5	1162	1822.62	1163	1823.73
GR	1164	1824.85	1165	1825.96	1166	1827.07	1167	1828.19	1168	1829.3
GR	1169	1830.42	1170	1831.53	1171	1832.64	1172	1833.76	1173	1834.87

GR	1174	1835.98	1175	1837.1	1176	1838.21	1177	1839.32	1178	1840.44
GR	1179	1841.55	1180.6	1842.66						
X1	240	60	1000	1981.82	470	550	500			
X3	10									
GR	1184.6	1000	1183	1001.16	1182	1002.31	1181	1003.46	1180	1004.62
GR	1179	1005.77	1178	1006.93	1177	1008.08	1176	1009.23	1175	1010.38
GR	1174	1011.53	1173	1012.68	1172	1013.83	1171	1014.98	1170	1016.12
GR	1169	1017.27	1168	1018.41	1167	1019.55	1166	1020.7	1165	1021.84
GR	1164	1022.98	1163	1024.12	1162	1025.26	1161	1026.4	1160	1027.54
GR	1159	1028.67	1158	1029.81	1157	1030.95	1156	1033.29	1152.7	1045.88
GR	1152.7	1937.63	1154	1943.18	1155	1944.56	1156	1945.94	1157	1947.33
GR	1158	1948.71	1159	1950.09	1160	1951.47	1161	1952.85	1162	1954.23
GR	1163	1955.61	1164	1956.99	1165	1958.37	1166	1959.76	1167	1961.14
GR	1168	1962.52	1169	1963.9	1170	1965.28	1171	1966.66	1172	1968.05
GR	1173	1969.43	1174	1970.81	1175	1972.17	1176	1973.55	1177	1974.93

1

GR	1178	1976.31	1179	1977.69	1180	1979.06	1181	1980.44	1183	1981.82
NC	0.035	0.035	0.035	0.3	0.5					
X1	240.1	47	1000	2001.12	57.85	56.87	59.59			
X3	10									
GR	1184.6	1000	1179	1001.16	1178	1002.32	1177	1003.48	1176	1004.65
GR	1175	1005.81	1174	1006.97	1173	1008.13	1172	1009.3	1171	1010.46
GR	1170	1011.62	1169	1012.78	1168	1013.94	1167	1015.11	1166	1016.27
GR	1152.8	1042.64	1152.8	1951.16	1154	1957.31	1155	1958.71	1156	1960.12
GR	1157	1961.54	1158	1962.98	1159	1964.43	1160	1965.88	1161	1967.34
GR	1162	1968.82	1163	1970.3	1164	1971.8	1165	1973.35	1166	1974.9
GR	1167	1976.45	1168	1977.99	1169	1979.54	1170	1981.09	1171	1982.64
GR	1172	1984.18	1173	1985.73	1174	1987.28	1175	1988.83	1176	1990.37
GR	1177	1991.91	1178	1993.41	1179	1994.91	1180	1996.41	1181	1997.91
GR	1182	1999.41	1183.1	2001.12						
SB	1.05	1.56	2.6	500	923.4	106	33579	1	1152.8	1152.8
X1	240.2	49	1000	1997.69	36.58	37.46	39.84			
X2			1	1192	1206					
X3	10									
GR	1184.6	1000	1176	1001.17	1175	1002.34	1174	1003.51	1173	1004.68
GR	1172	1005.85	1171	1007.02	1170	1008.19	1169	1009.35	1168	1010.52
GR	1167	1011.69	1166	1012.86	1165	1014.04	1164	1015.2	1163	1016.36
GR	1162	1017.53	1161	1018.69	1160	1019.85	1159	1021.02	1158	1022.18
GR	1157	1023.34	1156	1024.51	1155	1025.67	1152.8	1026.83	1152.8	1959.71
GR	1154	1966.28	1155	1967.49	1156	1968.7	1157	1969.92	1158	1971.14
GR	1159	1972.37	1160	1973.6	1161	1974.84	1162	1976.08	1163	1977.33
GR	1164	1978.59	1165	1979.93	1166	1981.29	1167	1982.66	1168	1984.05
GR	1169	1985.46	1170	1986.89	1171	1988.34	1172	1989.81	1173	1991.3
GR	1174	1992.9	1175	1994.49	1176	1996.09	1183.3	1997.69		
X1	240.3	63	1000	2054.96	101.4	101.93	94.65			
X3	10									
GR	1184.4	1000	1183	1001.29	1182	1002.59	1181	1003.88	1180	1005.18
GR	1179	1006.48	1178	1007.77	1177	1009.07	1176	1010.36	1175	1011.66
GR	1174	1012.96	1173	1014.26	1172	1015.56	1171	1016.86	1170	1018.15
GR	1169	1019.45	1168	1020.75	1167	1022.04	1166	1023.34	1165	1024.64
GR	1164	1025.93	1163	1027.23	1162	1028.53	1161	1029.82	1160	1031.12
GR	1159	1032.42	1158	1033.68	1157	1034.94	1156	1036.18	1155	1037.43
GR	1154	1038.67	1152.9	1039.9	1152.9	1997.16	1154	2005.85	1155	2007.2

GR	1156	2008.53	1157	2009.87	1158	2011.2	1159	2012.53	1160	2013.87
GR	1161	2015.2	1162	2016.54	1163	2017.87	1164	2019.21	1165	2020.51
GR	1166	2021.82	1167	2023.12	1168	2024.42	1169	2025.71	1170	2027
GR	1171	2028.28	1172	2029.56	1173	2030.84	1174	2032.12	1175	2033.4
GR	1176	2034.77	1177	2048.45	1178	2049.54	1179	2050.62	1180	2051.71
GR	1181	2052.79	1182	2053.88	1183.5	2054.96				
X1	240.41	46	1000	2100.68	120.77	110.03	108.67			
X3	10									
GR	1184.7	1000	1182	1001.18	1181	1002.35	1180	1003.53	1179	1004.7
GR	1178	1005.87	1177	1007.03	1176	1008.18	1175	1009.33	1174	1010.47
GR	1173	1011.6	1172	1012.7	1171	1013.75	1170	1014.81	1169	1015.9
GR	1168	1017.15	1167	1018.39	1166	1019.64	1165	1020.88	1164	1022.12
GR	1163	1023.37	1162	1024.65	1161	1026	1160	1027.34	1159	1028.69

GR	1158	1030.03	1157	1031.38	1153.0	1032.72	1153.0	2067.79	1161	2069.06
GR	1162	2070.32	1163	2071.59	1164	2072.86	1165	2074.13	1166	2075.4
GR	1167	2076.66	1168	2077.94	1169	2079.21	1170	2080.5	1171	2081.79
GR	1172	2095.62	1173	2096.64	1174	2097.65	1175	2098.66	1176	2099.67
GR	1182.7	2100.68								
SB	1.05	1.56	2.6	500	1002.9	104	28731	1	1153.1	1153.0
X1	240.5	52	1000	2103.09	87.84	87.86	89.17			
X2			1	1184	1199					
X3	10									
GR	1184.4	1000	1176	1000.98	1174	1002.96	1173	1003.95	1172	1004.96
GR	1171	1005.97	1170	1006.99	1169	1008.02	1168	1009.06	1167	1010.12
GR	1166	1011.24	1165	1012.46	1164	1013.72	1163	1015	1162	1016.32
GR	1161	1017.75	1160	1019.21	1159	1020.67	1158	1022.13	1157	1023.59
GR	1153.1	1029.2	1153.1	2055.24	1153.1	2056.49	1154	2057.74	1155	2058.98
GR	1156	2060.23	1157	2061.48	1158	2062.73	1159	2063.98	1160	2065.22
GR	1161	2066.47	1162	2067.72	1163	2068.97	1164	2070.22	1165	2071.47
GR	1166	2072.72	1167	2073.97	1168	2075.23	1169	2076.48	1170	2077.73
GR	1171	2092.24	1172	2093.24	1173	2094.22	1174	2095.21	1175	2096.19
GR	1176	2097.17	1177	2098.15	1178	2099.14	1179	2100.13	1180	2101.12
GR	1181	2102.11	1182.9	2103.09						
X1	240.6	59	1000	2086.49	50.36	51.9	49.5			
X3	10									
GR	1185.1	1000	1182	1002.06	1181	1004.12	1180	1006.17	1179	1008.22
GR	1178	1010.26	1177	1012.26	1176	1014.24	1175	1016.17	1174	1018.05
GR	1173	1019.8	1172	1021.41	1171	1023.04	1170	1024.71	1169	1026.4
GR	1168	1027.99	1167	1029.59	1166	1031.22	1165	1032.88	1164	1034.46
GR	1163	1035.98	1162	1037.49	1161	1038.38	1160	1039.18	1159	1039.93
GR	1158	1040.62	1157	1041.27	1156	1041.88	1153.1	1042.79	1153.1	2040.63
GR	1154	2041.85	1155	2043.07	1156	2044.28	1157	2045.48	1158	2046.66
GR	1159	2047.84	1160	2049	1161	2050.15	1162	2051.28	1163	2052.41
GR	1164	2053.55	1165	2054.68	1166	2055.81	1167	2056.94	1168	2058.07
GR	1169	2059.2	1170	2060.33	1171	2075.27	1172	2076.3	1173	2077.32
GR	1174	2078.33	1175	2079.35	1176	2080.36	1177	2081.38	1178	2082.4
GR	1179	2083.42	1180	2084.44	1181	2085.47	1182.5	2086.49		
X1	241.1	45	1000	2054.29	64.69	60.7	62.34			
X3	10									
GR	1184.5	1000	1176	1000.5	1175	1000.99	1174	1001.49	1173	1001.98
GR	1172	1002.48	1171	1002.97	1170	1003.46	1169	1003.96	1168	1004.45
GR	1167	1004.94	1166	1005.43	1164	1006.41	1163	1006.9	1162	1007.39

```
GR      1161    1007.88      1160    1008.37      1159    1008.85      1158    1009.34      1157    1009.82
GR    1153.2    1015.09    1153.2    2013.32      1155    2016.47      1156    2017.58      1157    2018.69
GR      1158    2019.79      1159     2020.9      1160    2022.01      1161    2023.12      1162    2024.22
GR      1163    2025.33      1164    2026.44      1165    2027.55      1166    2028.65      1167    2029.76
GR      1168    2030.87      1169    2031.98      1170     2033.1      1171    2040.04      1172     2049.2
GR      1173    2050.22      1174    2051.24      1175    2052.26      1176    2053.27    1182.6    2054.29
1
   19JUN97      14:58:52                                                                          PAGE     8


SB      1.05        1.5        2.6        500    1019.9        106      29097          1    1153.2    1153.2
X1     241.2         48       1000    2061.16      27.5      29.63      27.91
X2                                1       1184       1192
X3        10
GR    1184.5       1000       1176    1000.53      1175    1001.06      1174    1001.59      1173    1002.12
GR      1172    1002.66       1171     1003.2      1170    1003.73      1169    1004.27      1168    1004.81
GR      1167    1005.36       1166     1005.9      1165    1006.44      1164    1006.99      1163    1007.53
GR      1162    1008.08       1161    1008.62      1159    1009.72      1158    1010.27    1153.2    1011.12
GR    1153.2    2018.86       1156       2020      1157    2021.14      1158    2022.28      1159    2023.42
GR      1160    2024.56       1161    2025.69      1162    2026.82      1163    2027.94      1164    2029.06
GR      1165    2030.18       1166    2031.29      1167     2032.4      1168    2033.51      1169    2034.62
GR      1170    2035.73       1171    2042.83      1172    2051.44      1173    2052.41      1174    2053.38
GR      1175    2054.35       1176    2055.33      1177     2056.3      1178    2057.27      1179    2058.24
GR      1180    2059.21       1181    2060.18    1182.6    2061.16


1
   19JUN97      14:58:52                                                                          PAGE     9


    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST


 *PROF 1
0

 CCHV=     .100 CEHV=     .300
 *SECNO 120.500

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=      1172.30 ELREA=      1171.80

   120.500     19.59   1166.59       .00   1166.59   1168.46      1.87       .00       .00   1172.30
  215000.0        .0  215000.0        .0        .0   19592.1        .0        .0        .0   1171.80
       .00       .00     10.97       .00      .000      .035      .000      .000   1147.00   1015.26
   .001390        0.        0.        0.         0         0         0       .00   1063.25   2078.51


 *SECNO 122.000

 3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=      1171.80 ELREA=      1170.30

   122.000     19.49   1166.69       .00       .00   1168.73      2.04       .22       .05   1171.80
  215000.0        .0  215000.0        .0        .0   18759.8        .0      66.0       3.6   1170.30
       .00       .00     11.46       .00      .000      .035      .000      .000   1147.20   1009.62
   .001549      155.      150.      150.         2         0         0       .00   1035.83   2045.45
```

```
CCHV=     .300 CEHV=     .500
*SECNO 122.650

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=      1172.00 ELREA=      1169.40

   122.650     19.59   1166.79       .00       .00   1168.84      2.05       .10       .00   1172.00
  215000.0        .0  215000.0        .0        .0   18729.6        .0      94.0       5.2   1169.40
       .01       .00     11.48       .00      .000      .035      .000      .000   1147.20   1011.14
   .001560       65.       65.       65.         0         0         0       .00   1037.98   2049.12


SPECIAL BRIDGE

5227 DOWNSTREAM ELEV IS    1156.29 , NOT    1166.79 HYDRAULIC JUMP OCCURS DOWNSTREAM (IF LOW FLOW CONTROLS)

1
   19JUN97      14:58:52                                                                                    PAGE   10


    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST


SB  XK        XKOR      COFQ      RDLEN     BWC       BWP       BAREA     SS        ELCHU     ELCHD
     1.05      1.56      3.00    500.00    790.00    193.00  27098.00      6.50   1147.30   1147.20

*SECNO 123.550
CLASS B LOW FLOW

3420 BRIDGE W.S.=    1162.27 BRIDGE VELOCITY=      20.60     CALCULATED CHANNEL AREA=     10397.

 EGPRS      EGLWC       H3       QWEIR      QLOW      BAREA   TRAPEZOID      ELLC     ELTRD     WEIRLN
                                                                  AREA
       .00   1170.17      .00        0.   215000.    27098.    27098.     1180.61   1181.80        0.


3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=      1172.10 ELREA=      1170.20

   123.550     21.17   1168.47       .00       .00   1170.17      1.70      1.34       .00   1172.10
  215000.0        .0  215000.0        .0        .0   20526.6        .0     148.1       8.0   1170.20
       .01       .00     10.47       .00      .000      .035      .000      .000   1147.30   1010.20
   .001186      120.      120.      120.         0         0         0       .00   1058.98   2069.18


CCHV=     .100 CEHV=     .300
*SECNO 228.000

3265 DIVIDED FLOW


3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=      1172.30 ELREA=      1172.40

   228.000     21.20   1168.90       .00       .00   1170.60      1.69       .42       .00   1172.30
  215000.0        .0  215000.0        .0        .0   20589.1        .0     318.0      16.6   1172.40
```

.02	.00	10.44	.00	.000	.035	.000	.000	1147.70	1004.33
.001152	420.	360.	300.	2	0	0	.00	999.01	2057.22

*SECNO 229.000

3265 DIVIDED FLOW

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1172.20 ELREA= 1173.00

229.000	21.05	1169.15	.00	.00	1171.18	2.03	.48	.10	1172.20
215000.0	.0	215000.0	.0	.0	18815.3	.0	489.8	24.9	1173.00
.03	.00	11.43	.00	.000	.035	.000	.000	1148.10	1003.56
.001410	440.	380.	330.	2	0	0	.00	922.04	1979.49

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*SECNO 230.000

3265 DIVIDED FLOW

3301 HV CHANGED MORE THAN HVINS

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1172.30 ELREA= 1172.80

230.000	20.74	1169.14	.00	.00	1172.14	3.00	.67	.29	1172.30
215000.0	.0	215000.0	.0	.0	15463.4	.0	643.3	32.5	1172.80
.03	.00	13.90	.00	.000	.035	.000	.000	1148.40	1003.60
.002162	350.	390.	430.	2	0	0	.00	769.85	1827.32

*SECNO 231.000

3265 DIVIDED FLOW

3301 HV CHANGED MORE THAN HVINS

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1172.60 ELREA= 1172.60

231.000	20.85	1169.65	.00	.00	1173.29	3.63	.95	.19	1172.60
215000.0	.0	215000.0	.0	.0	14054.3	.0	778.8	39.2	1172.60
.04	.00	15.30	.00	.000	.035	.000	.000	1148.80	1002.99
.002633	360.	400.	460.	2	0	0	.00	698.05	1754.91

*SECNO 232.000

3265 DIVIDED FLOW

3301 HV CHANGED MORE THAN HVINS

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1173.40 ELREA= 1173.80

232.000	21.18	1170.38	.00	.00	1174.60	4.22	1.14	.18	1173.40
215000.0	.0	215000.0	.0	.0	13043.1	.0	903.2	45.4	1173.80
.05	.00	16.48	.00	.000	.035	.000	.000	1149.20	1006.17
.003100	400.	400.	410.	2	0	0	.00	647.99	1708.03

1

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*SECNO 233.000

3265 DIVIDED FLOW

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1175.10 ELREA= 1174.00

233.000	21.81	1171.41	.00	.00	1175.90	4.49	1.22	.08	1175.10
215000.0	.0	215000.0	.0	.0	12645.3	.0	1018.2	51.0	1174.00
.06	.00	17.00	.00	.000	.035	.000	.000	1149.60	1004.51
.003159	390.	390.	390.	2	0	0	.00	605.25	1663.63

*SECNO 234.000

3265 DIVIDED FLOW

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1176.40 ELREA= 1177.00

234.000	23.12	1173.12	.00	.00	1177.12	4.00	1.17	.05	1176.40
215000.0	.0	215000.0	.0	.0	13396.8	.0	1139.3	56.7	1177.00
.06	.00	16.05	.00	.000	.035	.000	.000	1150.00	1003.75
.002638	435.	405.	370.	2	0	0	.00	607.50	1665.11

*SECNO 235.000

3265 DIVIDED FLOW

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1178.70 ELREA= 1177.90

235.000	24.20	1174.60	.00	.00	1178.13	3.54	.97	.05	1178.70
215000.0	.0	215000.0	.0	.0	14247.5	.0	1266.2	62.3	1177.90

.07	.00	15.09	.00	.000	.035	.000	.000	1150.40	1003.18
.002232	400.	400.	405.	2	0	0	.00	623.50	1680.53

*SECNO 236.000

3265 DIVIDED FLOW

1

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

3301 HV CHANGED MORE THAN HVINS

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1182.10 ELREA= 1179.00

236.000	25.34	1176.14	.00	.00	1178.98	2.84	.77	.07	1182.10
215000.0	.0	215000.0	.0	.0	15909.2	.0	1406.4	68.3	1179.00
.08	.00	13.51	.00	.000	.035	.000	.000	1150.80	1006.68
.001653	380.	405.	430.	2	0	0	.00	656.28	1716.81

*SECNO 237.000

3265 DIVIDED FLOW

3301 HV CHANGED MORE THAN HVINS

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1182.50 ELREA= 1181.00

237.000	26.69	1177.89	.00	.00	1179.58	1.69	.49	.11	1182.50
215000.0	.0	215000.0	.0	.0	20618.5	.0	1578.3	75.1	1181.00
.09	.00	10.43	.00	.000	.035	.000	.000	1151.20	1004.55
.000898	390.	410.	435.	2	0	0	.00	804.08	1862.46

*SECNO 238.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1183.20 ELREA= 1181.50

238.000	26.89	1178.59	.00	.00	1180.00	1.42	.40	.03	1183.20
215000.0	.0	215000.0	.0	.0	22516.0	.0	1830.8	84.9	1181.50
.10	.00	9.55	.00	.000	.035	.000	.000	1151.70	1004.16
.000678	650.	510.	380.	2	0	0	.00	864.65	1868.81

*SECNO 239.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1183.90 ELREA= 1180.60

239.000	26.60	1178.80	.00	.00	1180.41	1.61	.35	.06	1183.90
220000.0	.0	220000.0	.0	.0	21600.3	.0	2073.9	94.3	1180.60
.12	.00	10.19	.00	.000	.035	.000	.000	1152.20	1001.20
.000784	500.	480.	450.	2	0	0	.00	840.13	1841.33

1

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*SECNO 240.000

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1184.60 ELREA= 1183.00

240.000	26.91	1179.61	.00	.00	1180.78	1.18	.33	.04	1184.60
220000.0	.0	220000.0	.0	.0	25257.0	.0	2342.8	104.7	1183.00
.13	.00	8.71	.00	.000	.035	.000	.000	1152.70	1005.07
.000561	470.	500.	550.	2	0	0	.00	973.45	1978.52

CCHV= .300 CEHV= .500
*SECNO 240.100

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1184.60 ELREA= 1183.10

240.100	26.90	1179.70	.00	.00	1180.83	1.14	.03	.01	1184.60
220000.0	.0	220000.0	.0	.0	25729.8	.0	2377.7	106.1	1183.10
.13	.00	8.55	.00	.000	.035	.000	.000	1152.80	1001.02
.000542	58.	60.	57.	2	0	0	.00	994.94	1995.95

SPECIAL BRIDGE

SB	XK	XKOR	COFQ	RDLEN	BWC	BWP	BAREA	SS	ELCHU	ELCHD
	1.05	1.56	2.60	500.00	923.40	106.00	33579.00	1.00	1152.80	1152.80

*SECNO 240.200
CLASS A LOW FLOW

3420 BRIDGE W.S.= 1179.34 BRIDGE VELOCITY= 9.82 CALCULATED CHANNEL AREA= 22401.

EGPRS	EGLWC	H3	QWEIR	QLOW	BAREA	TRAPEZOID AREA	ELLC	ELTRD	WEIRLN
.00	1181.02	.24	0.	220000.	33579.	33579.	1192.00	1206.00	0.

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1184.60 ELREA= 1183.30

240.200	27.13	1179.93	.00	.00	1181.02	1.09	.19	.00	1184.60
220000.0	.0	220000.0	.0	.0	26298.7	.0	2401.5	107.0	1183.30
.14	.00	8.37	.00	.000	.035	.000	.000	1152.80	1000.64
.000509	37.	40.	37.	0	0	0	.00	996.32	1996.95

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*SECNO 240.300

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1184.40 ELREA= 1183.50

240.300	27.17	1180.07	.00	.00	1181.09	1.02	.05	.02	1184.40
220000.0	.0	220000.0	.0	.0	27200.9	.0	2459.6	109.2	1183.50
.14	.00	8.09	.00	.000	.035	.000	.000	1152.90	1005.09
.000482	101.	95.	102.	2	0	0	.00	1046.70	2051.79

*SECNO 240.410

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1184.70 ELREA= 1182.70

240.410	27.28	1180.28	.00	.00	1181.17	.90	.05	.04	1184.70
220000.0	.0	220000.0	.0	.0	28964.9	.0	2529.7	111.9	1182.70
.14	.00	7.60	.00	.000	.035	.000	.000	1153.00	1003.20
.000420	121.	109.	110.	2	0	0	.00	1097.11	2100.31

SPECIAL BRIDGE

SB	XK	XKOR	COFQ	RDLEN	BWC	BWP	BAREA	SS	ELCHU	ELCHD
	1.05	1.56	2.60	500.00	1002.90	104.00	28731.00	1.00	1153.10	1153.00

*SECNO 240.500
CLASS A LOW FLOW

3420 BRIDGE W.S.= 1180.08 BRIDGE VELOCITY= 8.79 CALCULATED CHANNEL AREA= 24976.

EGPRS	EGLWC	H3	QWEIR	QLOW	BAREA	TRAPEZOID AREA	ELLC	ELTRD	WEIRLN
.00	1181.31	.15	0.	220000.	28731.	28731.	1184.00	1199.00	0.

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1184.40 ELREA= 1182.90

240.500	27.33	1180.43	.00	.00	1181.31	.89	.14	.00	1184.40
220000.0	.0	220000.0	.0	.0	29138.3	.0	2589.1	114.1	1182.90
.15	.00	7.55	.00	.000	.035	.000	.000	1153.10	1000.46
.000412	88.	89.	88.	0	0	0	.00	1101.08	2101.54

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	L-BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	R-BANK ELEV
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST

*SECNO 240.600

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1185.10 ELREA= 1182.50

240.600	27.32	1180.42	.00	.00	1181.36	.94	.02	.03	1185.10
220000.0	.0	220000.0	.0	.0	28223.9	.0	2621.7	115.4	1182.50
.15	.00	7.79	.00	.000	.035	.000	.000	1153.10	1005.31
.000445	50.	50.	52.	2	0	0	.00	1079.56	2084.87

*SECNO 241.100

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1184.50 ELREA= 1182.60

241.100	27.24	1180.44	.00	.00	1181.40	.96	.03	.01	1184.50
220000.0	.0	220000.0	.0	.0	28020.3	.0	2662.0	116.9	1182.60
.15	.00	7.85	.00	.000	.035	.000	.000	1153.20	1000.24
.000447	65.	62.	61.	0	0	0	.00	1053.72	2053.96

SPECIAL BRIDGE

SB	XK	XKOR	COFQ	RDLEN	BWC	BWP	BAREA	SS	ELCHU	ELCHD
	1.05	1.50	2.60	500.00	1019.90	106.00	29097.00	1.00	1153.20	1153.20

*SECNO 241.200
CLASS A LOW FLOW

3420 BRIDGE W.S.= 1180.19 BRIDGE VELOCITY= 8.66 CALCULATED CHANNEL AREA= 25399.

EGPRS	EGLWC	H3	QWEIR	QLOW	BAREA	TRAPEZOID AREA	ELLC	ELTRD	WEIRLN
.00	1181.55	.17	0.	220000.	29097.	29097.	1184.00	1192.00	0.

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1184.50 ELREA= 1182.60

241.200	27.40	1180.60	.00	.00	1181.55	.94	.15	.00	1184.50
220000.0	.0	220000.0	.0	.0	28264.8	.0	2680.0	117.6	1182.60
.15	.00	7.78	.00	.000	.035	.000	.000	1153.20	1000.24
.000438	28.	28.	30.	0	0	0	.00	1059.55	2059.80

1

THIS RUN EXECUTED 19JUN97 14:58:53

****

HEC-2 WATER SURFACE PROFILES

Version 4.6.2; May 1991
****

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

SUMMARY PRINTOUT

	SECNO	CWSEL	DEPTH	VCH	Q	TOPWID	10*KS	ELMIN
	120.500	1166.59	19.59	10.97	215000.00	1063.25	13.90	1147.00
	122.000	1166.69	19.49	11.46	215000.00	1035.83	15.49	1147.20
	122.650	1166.79	19.59	11.48	215000.00	1037.98	15.60	1147.20
*	123.550	1168.47	21.17	10.47	215000.00	1058.98	11.86	1147.30
	228.000	1168.90	21.20	10.44	215000.00	999.01	11.52	1147.70
	229.000	1169.15	21.05	11.43	215000.00	922.04	14.10	1148.10
	230.000	1169.14	20.74	13.90	215000.00	769.85	21.62	1148.40
	231.000	1169.65	20.85	15.30	215000.00	698.05	26.33	1148.80
	232.000	1170.38	21.18	16.48	215000.00	647.99	31.00	1149.20
	233.000	1171.41	21.81	17.00	215000.00	605.25	31.59	1149.60
	234.000	1173.12	23.12	16.05	215000.00	607.50	26.38	1150.00
	235.000	1174.60	24.20	15.09	215000.00	623.50	22.32	1150.40
	236.000	1176.14	25.34	13.51	215000.00	656.28	16.53	1150.80
	237.000	1177.89	26.69	10.43	215000.00	804.08	8.98	1151.20
	238.000	1178.59	26.89	9.55	215000.00	864.65	6.78	1151.70
	239.000	1178.80	26.60	10.19	220000.00	840.13	7.84	1152.20
	240.000	1179.61	26.91	8.71	220000.00	973.45	5.61	1152.70

1

SECNO	CWSEL	DEPTH	VCH	Q	TOPWID	10*KS	ELMIN
240.100	1179.70	26.90	8.55	220000.00	994.94	5.42	1152.80
240.200	1179.93	27.13	8.37	220000.00	996.32	5.09	1152.80

240.300	1180.07	27.17	8.09	220000.00	1046.70	4.82	1152.90
240.410	1180.28	27.28	7.60	220000.00	1097.11	4.20	1153.00
240.500	1180.43	27.33	7.55	220000.00	1101.08	4.12	1153.10
240.600	1180.42	27.32	7.79	220000.00	1079.56	4.45	1153.10
241.100	1180.44	27.24	7.85	220000.00	1053.72	4.47	1153.20
241.200	1180.60	27.40	7.78	220000.00	1059.55	4.38	1153.20

1

SUMMARY OF ERRORS AND SPECIAL NOTES

CAUTION SECNO= 123.550 PROFILE= 1 HYDRAULIC JUMP D.S.

APPENDIX C

Historical Correspondence

APPENDIX C
Historical Correspondence

DATE	TITLE	CONTENT
2/18/92	Letter of Intent for Salt River South Bank Stabilization	Outlines terms among ADOT, City of Tempe and FCDMC, as well as analytical approach and criteria for the design and contruction of south bank protection.
5/19/92	Salt River HEC-2 Models for the East Papago Freeway	List of HEC-2 models for the proposed design hydraulic conditions of the Salt River between McClintock Drive and the Pima Freeway.
6/3/92	Salt River Channelization East of McClintock - HEC-2 Analysis	Submittal comments regarding HEC-2 and GFLUVIAL models.
6/26/92	Characteristic Sediment Gradation for the Salt River - McClintock Drive to Dobson Road	Summary of twelve geotechnical data sets.
7/2/92	Salt River Channel East of McClintock Drive - Characteristic Sediment Gradation	Flood Control District acceptance of recommended sediment gradation analysis of 6/26/92.
7/29/92	Bank Protection Toe-Down Depths in the Vicinity of Sand and Gravel Mining Pits	Toe-Down recommendations with regard to lateral migration of sand and gravel mining pits.

DATE	TITLE	CONTENT
8/10/92	Bank Protection Toe-Down Depths along the Salt River Upstream of McClintock Drive	Summary table for the recommended toe-down depths, HEC-2 and GFLUVIAL results and the scour calculations for each of the various scour components for bank protection from McClintock Drive to the Pima Freeway (south bank).
8/11/92	Bank Protection Toe-Down Depths	Letter correspondence clarifying the difference between the north hardbank plans and the recommendation for the toe-down depths.
8/11/92	Salt River Channel East of McClintock Drive - Bank Protection Toe-Down Depths	Flood Control District acceptance of recommendations and criteria for bank protection toe-down depths near sand and gravel pits.
9/8/92	Calculations to Support Salt River Bank Protection Design (for north and south banks)	Bank stability and additional scour calculations for the reach from McClintock Drive to upstream of the Pima Freeway. Supplemental calculations to those submitted on August 10th for the north and south banks.
9/21/92	Salt River Channel - East of McClintock Drive - Slope Stability Calculations Submittal	Flood Control District acceptance of slope stability calculations.
10/9/92	Responses to FCD Comments - Salt River Channel	Comments specific to the following: backslope toe-down; levee embankment backslope protection; south levee maintenance roads and ramps; and, extension of the south levee.

DATE	TITLE	CONTENT
5/19/94	North Bank Termination	Toe-down depth recommendations in the vicinity of the cutoff wall and the north bank termination.
7/8/94	Compilation of Hydraulic and Sediment Transport Data for Bank Protection Design, East Papago Freeway, Section 6	Correspondence and data pertaining to hydraulic and sediment transport analyses.
8/10/94	South Bank Toe-Down Depths for the East Papago Levee Between McClintock and Price Road	Preliminary scour analysis and recommended toe-down depths.
11/3/94	Evaluation of Salt River Protection Toe-Down Depths East of McClintock Drive	SLA response to several issues raised by ADOT concerning: CSA slope along the north bank; raising the bank protection toe-down depths along the north and south banks; a table for the north bank scour components and the recommended toe-down elevations.
11/5/94	East Papago South Bank Levee Analysis	HEC-2 Section and Control Line correlations for the north and south banks of the 1992 and 1994 studies.

DATE	TITLE	CONTENT
1/6/95	Salt River Channel Improvements East of McClintock Drive - Adjustment of North Bank Toe-Down Depths	Includes four exhibits: FCD's 12/21/94 review letter; figures showing pier scour influence on the toe-downs at sections 228 and 229, an SLA letter, dated 11/3/94, summarizing the revised toe-down depths for the north bank between stations 231+25 and 56+89 (north revision for the south bank); and, sample hand computations for scour components shown in item 3 and local scour components in item 2.
2/20/95	CSA Toe-Down Elevation at Granite Reef Outfall	Hand computation for the toe-down elevation at Granite Reed Outfall (north bank).
5/1/97	Surveyed Top of Bank Elevation	Information provided by DMJM along the north and south banks for the as-built top of bank elevations.
6/16/97	FW: Salt River Channelization (Grade Control Str. #5 to McClintock	Confirmation that the toe-down elevations for the CSA hardbank are those as shown on the plans. As-built plans show only elevations indicated in Change Order #35. Request for written confirmation that as-built specifications meet plan elevation requirements.

FLOOD CONTROL DISTRICT
of
Maricopa County

2801 West Durango Street • Phoenix, Arizona 85009
Telephone (602) 506-1501
Fax (602) 506-4601

DMJM
31802
300.11
500.11.1, 800

BOARD OF DIRECTORS
P. Ben Arredondo
Betsey Bayless
James D. Bruner
Carole Carpenter
Tom Freestone

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

RECEIVED FEB 25 1992

FEB 18 1992

EAST PAPAGO - Otto St.
SHB
SLA
RS
AU
EW
DM
AW
JD ME CH FILE (1)
TM

Mr. Gary Robinson, P.E.
State Engineer
Arizona Department of Transportation
206 South 17th Avenue
Phoenix, Arizona 85007-3213

SUBJECT: Letter of Intent for Salt River South Bank Stabilization

Dear Mr. Robinson:

Enclosed are three copies of the Letter of Intent for the Salt River South Bank Stabilization with Exhibits A and B. Please sign all three copies and keep one copy for your records. We will provide one copy to the City of Tempe and keep the last copy for our records.

We appreciate all of the work and cooperation that ADOT's staff has provided in the channelization of the Salt River. Now that the Letter of Intent has been signed, we need to write the Intergovernmental Agreement to allow the transfer of funds to ADOT for the field exploration work. I've been told that ADOT staff is preparing this document.

Should you have any questions, please contact me or Dick Perreault at 506-1501.

Sincerely,

Stanley L. Smith, Jr., P.E.
Acting Chief Engineer and General Manager

Enclosures

RECEIVED
FEB 20 1992
Urban Highways Section
DMJM
EAST PAPAGO PROJECT

FEB 24 1992
RECEIVED ☐ SENT ☐

LETTER OF INTENT

SALT RIVER SOUTH BANK STABILIZATION

The Arizona Department of Transportation (ADOT) has been closely coordinating with the City of Tempe and the Flood Control District of Maricopa County (FCDMC) for the design and construction of the East Papago Freeway. Cooperative agreements have been implemented and the majority of the freeway and associated Salt River Channelization features, west of the Indian Bend Wash Outlet Channel, have been constructed or will be completed in the near future. The challenge that now requires all of our efforts involves that portion of the freeway east of McClintock Drive, lying predominantly outside of Tempe corporate boundaries.

During the last year, ADOT has negotiated an "Agreement and Covenant Not to Sue" (Region 9 Docket No. 91-23) with the Environmental Protection Agency (EPA) that allows ADOT to construct the freeway through the South Indian Bend Wash Superfund Site without incurring future liability beyond the freeway rights-of-way. In accordance with guidance and direction from EPA, ADOT has applied for a Section 404 Permit with the U.S. Army Corps of Engineers (COE). The permit application included 100-year level protection for the north and south river banks east of the Price Road alignment; 10-year protection along the north bank between Price Road and McClintock Drive, and no protection to the south bank west of the Pima/Red Mountain Freeway Traffic Interchange (T.I.) to McClintock Drive. Tempe and the FCDMC have provided written responses to the COE expressing concerns that the proposed construction does not provide any protection to approximately 4000 linear feet of the south bank and does not preclude the potential of a 100-year flood from overtopping McClintock Drive.

ADOT, the City of Tempe, and the FCDMC agree to work together to resolve the concerns for construction in the Salt River east of McClintock Drive and agree to support the timely construction of the East Papago Freeway to the Pima/Red Mountain T.I. An agreed upon goal of the three parties is the construction of 100-year protection for the north and south banks between McClintock Drive and the T.I. (See Exhibit "A", attached hereto and made a part hereof). The parties understand that ADOT's participation in this effort is subject to the EPA's written concurrence, and that ADOT's liability will be no greater than that specified in the "Covenant Not to Sue", and the parties agree to aggressively pursue such concurrence. The parties further acknowledge that participation by the FCDMC and the City of Tempe will be subject to ratification and agreement by the FCDMC Board of Directors and the Tempe City Council, respectively.

ADOT, at its own expense, has conducted extensive geotechnical testing and analyses of an alignment along the south bank that would be sufficient to construct 10-year level flood protection. In order to be able to construct 100-year level protection, additional geotechnical testing and environmental investigation is necessary. ADOT is willing to have this additional work performed under its direction. The terms included in this Letter of Intent define general provisions and responsibilities that the parties agree to in order to conduct the additional testing and analysis. An Intergovernmental Agreement shall be negotiated which defines the specific responsibilities of each party when the results of the additional testing and analysis have been reviewed. The present estimated costs of the approximately 4000 linear feet of 10-year to 100-year flood protection range from $3.8 million to $14.0 million.

TERMS OF THE LETTER OF INTENT:

1. ADOT will:

   a. Have additional geotechnical testing and environmental investigations performed which will provide the necessary information required to construct increased south bank flood protection from the 10-year to the 100-year level of protection. ADOT agrees to pay for up to one-third of the costs associated with the additional testing, which shall be deducted from ADOT's maximum $2.5 million commitment for south bank protection.

   b. Design the bank protection using criteria as shown on Exhibit "B", attached hereto and made a part hereof. The desired level of protection is 100-year; however, ADOT will design and construct a minimum of 10-year level of protection with 100-year toe-down protection, should higher levels of protection be impossible due to landfill considerations. The design shall include such features as necessary to create conditions such that the 100-year flood will not overtop McClintock Drive.

   c. Fund up to one-third of the additional testing costs, and the costs to acquire rights-of-way, design and construct the south bank protection subsequent to the date of this letter in an amount not to exceed $2.5 million.

   d. Construct the south bank protection with the earliest ADOT project possible, preferably with the adjacent south bank protection and/or the north bank protection.

   e. Acquire all necessary rights-of-way to construct the south bank protection and for operation and maintenance of the completed bank protection, provided that such purchases are covered under the provisions of the "Covenant Not to Sue". After construction has been accepted by the FCDMC, ADOT shall grant access to the FCDMC for operation and maintenance purposes. EPA cooperation shall be solicited such that the FCDMC will assume no responsibility for any existing contamination under the provisions of EPA's "Covenant Not to Sue".

   f. Coordinate with and seek the approval for all design and construction plans for all proposed channel/bank protection work with the jurisdiction having floodplain regulatory responsibility.

   g. Pay for the design and construction of the north bank levee between McClintock Drive and Loop 101L to the 100-year flood level of protection, when and if the corresponding south bank improvements are constructed. Costs for the design and construction of the north bank to the 100-year level of protection are in addition to ADOT's $2.5 million commitment for the south bank work.

2. The FCDMC staff will recommend to its Board of Directors the following. The FCDMC will:

   a. Support ADOT's Section 404 Permit Application based on ADOT's intentions stated above. The FCDMC will work closely with ADOT and the City of Tempe to achieve the desired 100-year level of protection for the Salt River east of McClintock Drive.

b. Reimburse ADOT for up to one-third of the additional costs incurred by ADOT for the additional geotechnical testing and environmental investigation necessary to increase the south bank protection from 10-year to 100-year.

c. Review, comment on and have right of approval on flood control features to be operated and maintained by FCDMC. The flood control features will be designed and constructed using FCDMC-provided criteria, as shown in Exhibit "B", attached hereto and made a part hereof, with the understanding that certain portions of the bank protection between McClintock Drive and Loop 101L may only be constructed to approximately the 10-year flood frequency elevation. The FCDMC will assist ADOT in the creation of conditions such that the 100-year flood will not overtop McClintock Drive.

d. Accept the operation and maintenance responsibility for flood control features constructed using FCDMC criteria between McClintock Drive and Dobson Road upon acceptance of easements or permits provided by ADOT or others that are clear of EPA Superfund liability.

e. Jointly cost-share with ADOT in the construction of 100-year protection for the approximately 4000 linear feet of south bank east of McClintock Drive. It is understood that ADOT's maximum commitment is $2.5 million. FCDMC cost-share may be as much as $11.0 million. If less than 100-year level of protection is the only feasible option, the FCDMC will match up to ADOT's maximum cost-share of $2.5 million for 10-year level of protection. Higher levels of protection will be paid for by FCDMC to a maximum commitment of $11.0 million.

f. Not hold ADOT or Tempe responsible for any future flood control operation and maintenance costs associated with the south bank protection or enhancements between McClintock Drive and Loop 101L once FCDMC has accepted operation and maintenance access.

g. Assist the City of Tempe in its application to the Federal Emergency Management Agency for revising the floodplain delineations of the Salt River through Tempe.

3. The staff of the City of Tempe will recommend to the City Council the following. Tempe will:

a. Support ADOT's Section 404 Permit Application based on ADOT's intentions, stated above.

b. Tempe's sole contribution towards the undertaking described in this LOI and any related obligations or requirements will be $250,000 to be used by ADOT for the additional geotechnical testing and environmental investigation necessary to increase the south bank protection from 10-year to 100-year.

c. Have the right to review and comment on all geotechnical testing results, environmental investigations and flood control features that could impact the Salt River Floodplain within the City. Tempe agrees to closely coordinate with ADOT and the FCDMC and shall provide any technical or environmental data that it has developed to the two entities.

This LOI will be incorporated into an Intergovernmental Agreement (IGA), ADOT File No. JPA 91-117, to be negotiated once conditions, costs, and design constraints are better defined, and the FCDMC staff and the City of Tempe staff will recommend to the Board of Directors and the City Council, respectively, that such an agreement be approved if it is consistent with this Letter of Intent. After this LOI is signed, ADOT will proceed with preliminary plans for geotechnical, and environmental investigations, concurrent with the preparation of an IGA. ADOT shall proceed and conduct the field investigation once all the parties have signed an IGA committing funds for the field investigation. The parties agree and understand that a second future IGA will be more comprehensive, and that in the event of conflict between the LOI and IGA, the terms of the IGA executed by the Board of Directors and the City Council will control.

I concur with the terms stated above in this Letter of Intent.

Robert P. Mikelson for 2/20/92	Gary R. Brown Acting City Manager 2/20/92
Gary Robinson, P.E. Date	Terry L. Zerkle Date
State Engineer	City Manager
Arizona Department of Transportation	City of Tempe

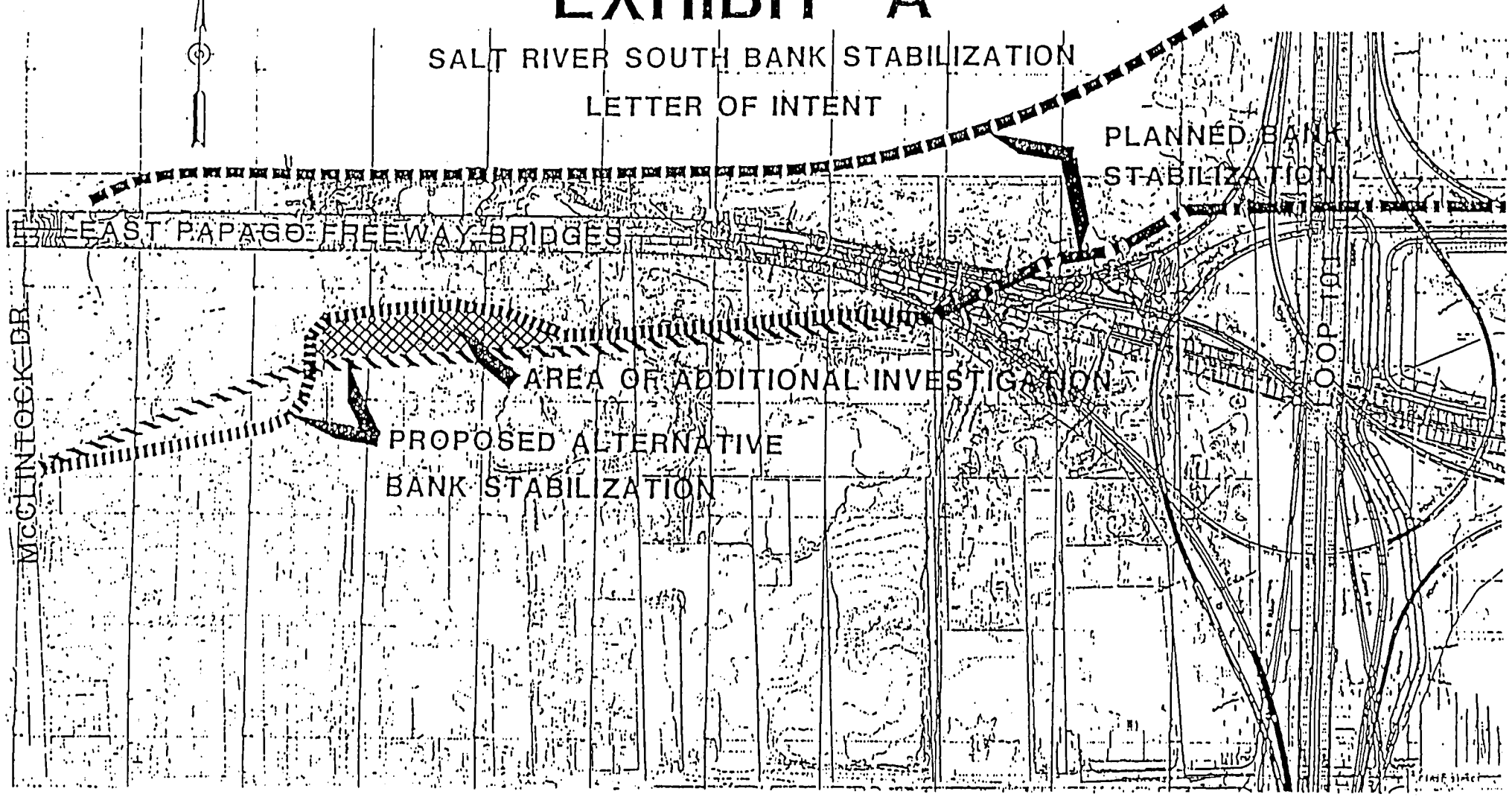
Stanley L. Smith 2-18-92

Stanley L. Smith, Jr., P.E. Date
Acting Chief Engineer and General Manager
Flood Control District of Maricopa County

EXHIBIT A

SALT RIVER SOUTH BANK STABILIZATION

LETTER OF INTENT



LEGEND

PROPOSED ALTERNATIVE SALT RIVER BANK STABILIZATION)

10 YEAR PROTECTION

100 YEAR PROTECTION

LEGEND

(PLANNED SALT RIVER BANK STABILIZATION)

10 YEAR PROTECTION

100 YEAR PROTECTION

EXHIBIT B

SALT RIVER CHANNEL DESIGN CRITERIA
UPSTREAM OF McCLINTOCK DRIVE

1. All geotechnical test results must be provided for District review. Gradation data should be available that is representative of the full depth of the moveable bed in this reach. The District's rule of thumb for bore hole/test pit intervals is one per 500 lineal feet. If an armoring analysis is to be presented for review, gradation test results for the channel bed samples should include the percentages of the 3 inch plus material encountered.

2. The geotechnical exploration must determine if landfill deposits are present within the channel alignment, and if so, their impacts on channel design and costs.

3. If the existing gravel pits are to be filled, gradation specs will be needed for the material that is to be placed in the moveable bed zone.

4. The channel should be designed with capacity for the current 100-year frequency peak flow with three feet of freeboard. The 100-year peak flow rate for this reach is 215,000 cfs. (This rate is 220,000 cfs upstream of Price Road). The freeboard requirement will provide a capacity in the channel approaching that of the Standard Project Flood peak flow with Modified Roosevelt Dam improvements in place and result in a consistent design with channelization immediately downstream. If design for 215,000 cfs is achievable only through unacceptably large impacts to known landfill wastes, the reach between McClintock Drive and the Pima Freeway is to be designed for, as a minimum, a flow rate that is necessary to contain a 10-year frequency flow along the south bank, and that precludes the 100-year frequency flow from overtopping McClintock Drive.

5. Tributary (side) drainage to the Salt River channel must be addressed consistent with ADOT criteria which state that the more severe of the following two conditions govern; (1) 100-year frequency peak in the main channel with 10-year frequency peak tributary drainage or (2) 10-year frequency peak in the main channel with 100-year frequency peak tributary drainage.

6. Consideration must be given to the upstream river and floodplain conditions and how those conditions may impact the proposed channel. Existing and potential material extraction and landfill operations must be addressed in this context. Overbank flooding upstream of the channelization must be analyzed to ensure that those flows enter and are contained within the improved channel.

7. Maintenance access and channel invert access ramps must be incorporated into the design.

8. The design and analysis will address the potential impacts of known future modifications that may be proposed by the City of Tempe and/or the Salt River Indian Community.

9. The location of cross sections used in the water surface profile calculations must be provided on a scaled map. Computer files must also be provided such that velocity, depth, HGL and EGL can be verified for each cross section.

10. The final plans shall include profiles showing the top of levee protection, HGL, invert, and the low chords for all bridges.

11. The scour analysis should be performed using an analytical approach, based on the velocity associated with the 100-year frequency peak flow of 215,000/220,000 cfs, the depth of the thalweg, and the D_{50} of the channel bed materials.

12. Degradation and aggradation analyses should include factors for dunes and antidunes.

13. The depth of scour, measured from the low-flow thalweg invert elevation, should be used to determine the toe-down elevations for bank protection and grade control structures based on the 100-year frequency peak flow of 215,000/220,000 cfs.

14. Local scour calculations shall be provided for District review if structures that are to be maintained by the District are affected by scour. These calculations are to be tabulated at all critical design locations and presented with a map showing the locations.

15. Levee slope stability analysis calculations must be submitted for District review. The analysis should consider pore pressures caused by rapid draw down.

16. All calculations performed in the design of riprap and filter materials for slope stabilization must be provided for District review.

17. All calculations should be independently checked by a person at least as competent as the designer before submitting them to the District. Both the designer and checker must initial and date each page of calculations that is submitted.

18. Minimum factors of safety for the project should be 1.5 based on the 100-year frequency peak flow of 215,000/220,000 cfs. If a tractive shear approach is used, the safety factor should be applied to the calculated tractive shear.

ATTACHMENT A

ANALYTICAL APPROACH FOR DETERMINING REQUIRED TOE DEPTHS FOR BANK PROTECTION ALONG SALT RIVER UPSTREAM OF McCLINTOCK DRIVE

The following analytical approach shall be utilized for determining required toe depths for bank protection along the Salt River upstream of McClintock Drive:

1. Contraction Scour (includes General Scour), in the vicinity of bridge crossings and river sections that have been contracted due to landfill encroachment shall be computed by methods described in Federal Highway Administration, FHWA, Hydraulic Engineering Circular Nos. 18 and 20, and other publications deemed appropriate for the 100-year frequency peak flow of 215,000/220,000 cfs. General scour for uncontracted reaches, is to be quantified by computer models for flows representing a hydrological history, as described in Item 3 below, and must be supplemented with hand calculations. For hand calculations, the 100-year frequency peak flow of 215,000/220,000 cfs is to be used.

2. Bed-form Scour, due to the passage of dunes or anti-dunes, shall be computed from analytical relationships developed by investigators such as Yalin and Kennedy, as described in textbooks on sediment/transport technology. The maximum hydraulic parameters associated with the passage of a 100-year frequency peak will be used to establish the quantitative values for this scour component.

3. Long-term Aggradation/Degradation shall be computed by using either the concept of equilibrium slope or the concept of streambed armoring, depending upon which approach controls the long-term channel profile of the Salt River upstream of McClintock Drive. The equilibrium-slope concept shall utilize a sediment/transport relationship which incorporates the D_{50} and gradation of the streambed sediments. The streambed-armoring concept shall utilize the critical-tractive-stress approach and the representative (armor) particle size. A series of flood frequency hydrographs from 10 to 100-year, should be used to represent the hydrologic history that the structure may experience in its life as a basis for determining these long-term trends. The "dominant" discharge will be the 10-year frequency discharge.

4. Once the scour components are quantified, as described in Items 1 through 3, they will be added together (i.e., as if they each act independently) to inherently incorporate a factor of safety of 1.2 to 1.3 in the estimate of Total Scour. This

value for the summed Total Scour will then be multiplied by an appropriate factor (approximately 1.3) to assure a final minimum factor of safety of 1.5 in accordance with Item 18 of Exhibit B.

5. Finally, the bank-protection toe depth shall be based on the scour depth established in Item 4 and shall everywhere be measured from the low-flow thalweg invert elevation in accordance with Item 13 of Exhibit B.

Any sediment analysis will have to consider the sediment load entering the study reach. If the hydraulic parameters are known upstream, flow depth, velocity and tractive shear, and the gradation of the streambed can be determined upstream, a practical estimate of the sediment load entering the study reach can be made.

Coding files as well as model documentation are to be made available to the District for review.

MEMORANDUM

DATE: May 19, 1992 **PROJECT NO:** AZ-DMJM-03.24

TO: Jay Kim (FCDMC)

FROM: Jeff Minch (SLA) JRM

RE: **SALT RIVER HEC-2 MODELS FOR THE EAST PAPAGO FREEWAY (Submitted May 18, 1992)**

The HEC-2 analysis referenced above has been submitted for review as the proposed design hydraulic conditions of the Salt River between McClintock Drive and the Pima Freeway. The hydraulic parameters from these models will be used to determine the bank protection toe-down depths. Three HEC-2 models have been provided for the 100-year leveed and interim 10-year design concepts. The corresponding hydraulic models are outlined below:

1. The 100-year leveed conditions with three feet of freeboard (LEVEE.DAT).

2. The main channel hydraulic model for 10-year level of bank protection with one foot of freeboard (10YRBANK.DAT).

3. The hydraulic model for the north overbank corresponding to the 10-year level of protection and the 100-year discharge (N10YR.DAT).

The hydraulic analysis of the Salt River for the reach from the Pima Freeway to Dobson Road will be finalized once the 1986 topographic mapping is validated or a decision is reached regarding whether the mapping is representative of existing conditions. This reach of the Salt River is actively mined for sand and gravel and questions have been raised regarding the validity of the river geometry.

A dialog has been initiated between the District and SLA to develop a detailed approach to the scour analysis for the bank protection toe-down design. Due to this project's design and construction scheduling time constraints, it would be a tremendous help if your review of the final hydraulic analysis could be completed prior to finalizing the toe-down design procedure.

cc: DLR
FILE

Simons, Li & Associates, Inc.
Water Resources & Civil Engineering Consultants

June 26, 1992

Mr. Thomas M. Monchak
Daniel, Mann, Johnson, & Mendenhall
300 West Clarendon Avenue, Suite 335
Phoenix, Arizona 85013-3499

RE: CHARACTERISTIC SEDIMENT GRADATION FOR THE SALT RIVER - McCLINTOCK DRIVE TO DOBSON ROAD

Dear Tom:

SLA has reviewed the twelve geotechnical data sets, labeled A through L, compiled by SH&B for the Salt River between 40th Street and Dobson Road. The twelve geotechnical data sets are summarized in Attachment A as they relate to the Salt River sediment gradation.

To finalize the bank protection toe-down depths, a representative sediment gradation must be developed so that the long-term and general scour depths can be quantified. Two of the geotechnical data sets indicate that 20 to 30% of the Salt River sediment is larger than 3 inches (3"+). Since samples and visual estimates indicate that a significant portion of the channel sediment is 3"+ material, it is recommended that the 3"+ material be considered in the development of the representative sediment gradation for the design reach.

A total of 25 samples within the Salt River Channel from Data Sets D, G, H, J, and L were utilized to develop the characteristic sediment gradation for the design reach. Data Set J supplements Data Set H with sieve analysis data for 3"+ material at six identical sample locations. Therefore, Data Sets H and J were combined as a single data set for the characteristic sediment gradation analysis. The grain size distributions for Data Sets D and H&J were corrected for the percentage of material greater than 3 inches. For example, if 20 percent of the total sample is 3"+ material, then the grain size distribution for the 3 inch minus material represents only 80 percent of the total sample. Therefore, if 30% passes the No. 16 sieve for the minus 3 inch grain size distribution, 24% passes the No. 16 sieve for the total sample. Attachment B presents grain size distribution plots of each sample included in the analysis along with an average grain size distribution for all the samples comprising the data set.

The average grain size distributions from the resulting four data sets were used to develop the characteristic sediment gradation. The recommended characteristic sediment gradation for the design reach of the Salt River is the average of the individual data set average gradations. Averaging the data set average grain size distributions to define the characteristic sediment gradation prevents weighting by the differing number of samples comprising the four data sets. Attachment B includes a plot comparing the average of the four data sets with the recommended characteristic sediment gradation of the Salt River. The Salt River characteristic sediment gradation has been discretized in the following table:

4600 South Mill Avenue, Suite 190 • Tempe, AZ 85282 • Phone: (602) 491-1393 • Fax: (602) 491-1396
An Equal Opportunity Employer

Salt River Characteristic Sediment Gradation
(McClintock Drive to Dobson Road)

Particle Size (mm)	Cumulative Percent Passing (%)
0.15	5
0.30	10
0.60	18
1.18	25
2.36	30
4.75	36
12.5	46
25.0	62
50.0	70
75.0	78
152.4	88
228.6	96
304.8	100

The recommended sediment gradation should provide conservative scour depths since it is skewed towards smaller sediment sizes representative of Data Sets G and L. If you have any questions regarding this analysis, please feel free to call.

Sincerely,

SIMONS, LI & ASSOCIATES, INC.

Dennis L. Richards

Dennis L. Richards, P.E.
Vice President

cc: Steve Jimenez/Ray Jordan, ADOT
Don Rerick, FCD

Attachments

ATTACHMENT A

Data Set A

Data Set A was performed for the ADOT downstream channelization (40th Street to Mill Avenue). No map was provided identifying the sample locations. The samples are located using ADOT State Plane Coordinates. No estimates were made regarding the percentage of material greater than 3 inches.

Data Set B

Data Set B was performed for the foundation design of the East Papago Salt River Bridges. The boring logs indicate that the bed material at most sample locations consist of sand, gravel & cobbles (SGC) for a considerable depth. The generalized soil profile along the Salt River Bridges indicates the Salt River bed material is SGC from the existing invert to an elevation of 1055 feet. No estimates were made regarding the percentage of material greater than 3 inches. The sieve analyses were performed on samples at depths of 89 feet and greater. A boring log at the north bank indicates the bank consists of gravelly sand over SGC (sample N2). Boring logs within the abandoned in-stream pits indicate shallow deposits (clayey sand and gravel, silty clay) over SGC indicating a potential sediment supply to the design reach.

Data Set C

Data Set C consists of borings performed at the Red Mountain Traffic Interchange (RMTI). Only three of the samples are within the Salt River Channel. Borings T-10 and C-2 indicate the surface material is man-made fill over SGC. The surface material for boring C-3 consists entirely of SGC. No sieve analyses were provided for any of the borings that comprise this data set.

Data Set D

Data Set D was performed for the RMTI south bank protection from the Pima Freeway to Dobson Road. Sieve analyses were provided on three borings (HB series). Sieve analyses were not performed for the test pits (HP series). Visual corrections were noted for the percentage of material greater than 3 inches.

Data Set E

Data Set E was developed for the RMTI 11A Contract bridge structures. None of these structures are within the Salt River Channel.

Data Set F

Data Set F contains geotechnical data around the RMTI. Only two of the borings within the Salt River Channel (15B-4, 16B-2) include a sieve analysis of the surface material. Both samples indicate the surface material to be sand, gravel with some cobbles. Most of the sieve analyses were performed on samples at great depths for structure foundation design. Estimates of the maximum particle size are noted on some of the boring logs.

Data Set G

Data Set G was performed for the foundation design of the Pima Freeway structures crossing the Salt River. No estimates were noted regarding the percentage of material greater than 3 inches. However, three of the sieve analyses do not indicate 100% passing the 3 inch sieve.

Data Set H & J

Data Sets H & J were performed for the Rio Salado Channelization. Data Set H provides sieve analyses of 6 samples within the Salt River Channel for material less than 3 inches. Visual estimates were performed for the percentage of material greater than 3 inches. Data Set J supplements H with sieve analysis data of material greater than 3 inches for the identical 6 Salt River Channel locations.

Data Set I

Data Set I supplements Data Set H with two sieve analyses of the material larger than 3 inches. However, these two samples correspond to bank station locations and not samples within the Salt River Channel.

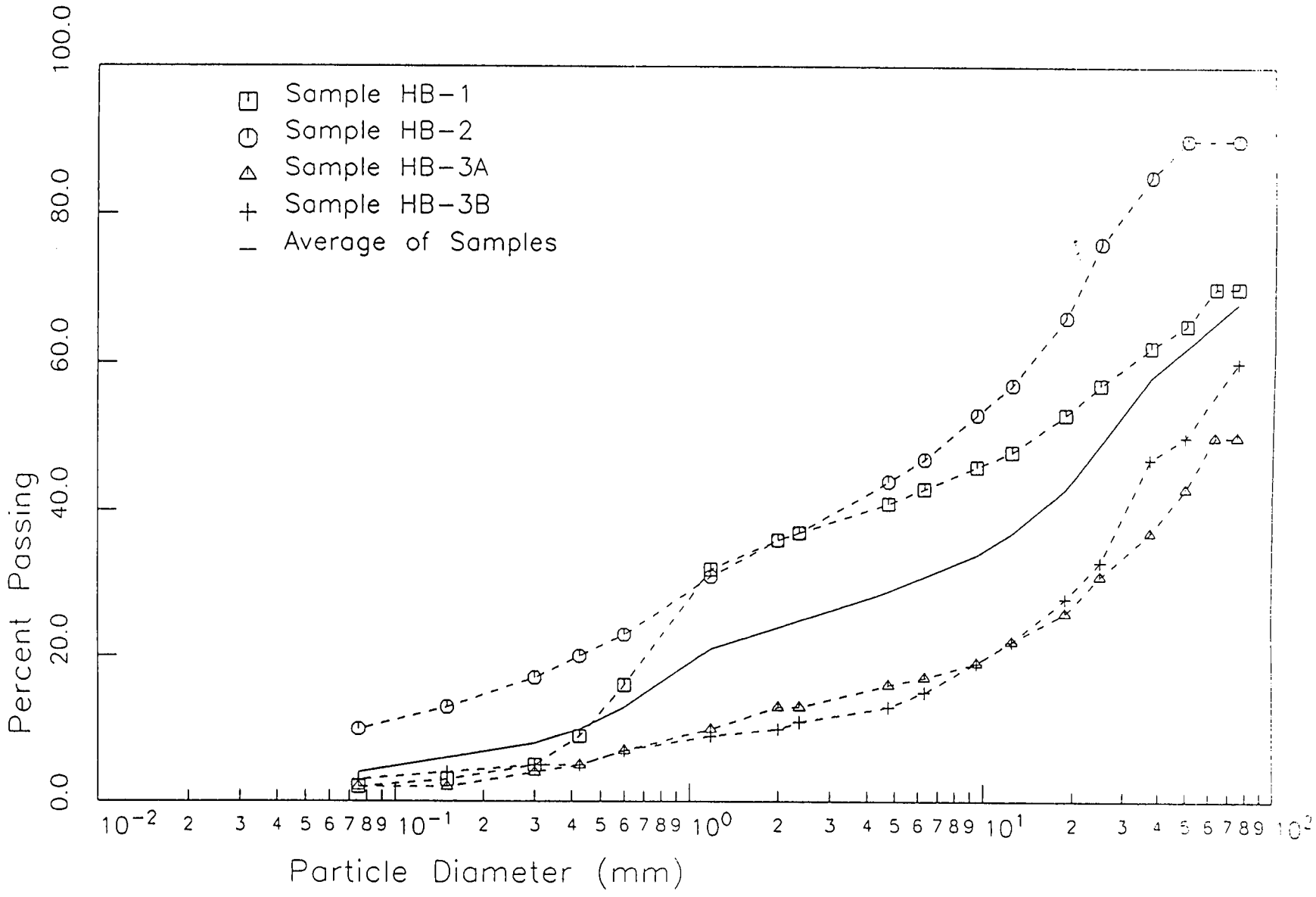
Data Set K

Data Set K consists of boring logs for the East Papago Salt River Bridges original northern alignment. No sieve analyses were included with this data set.

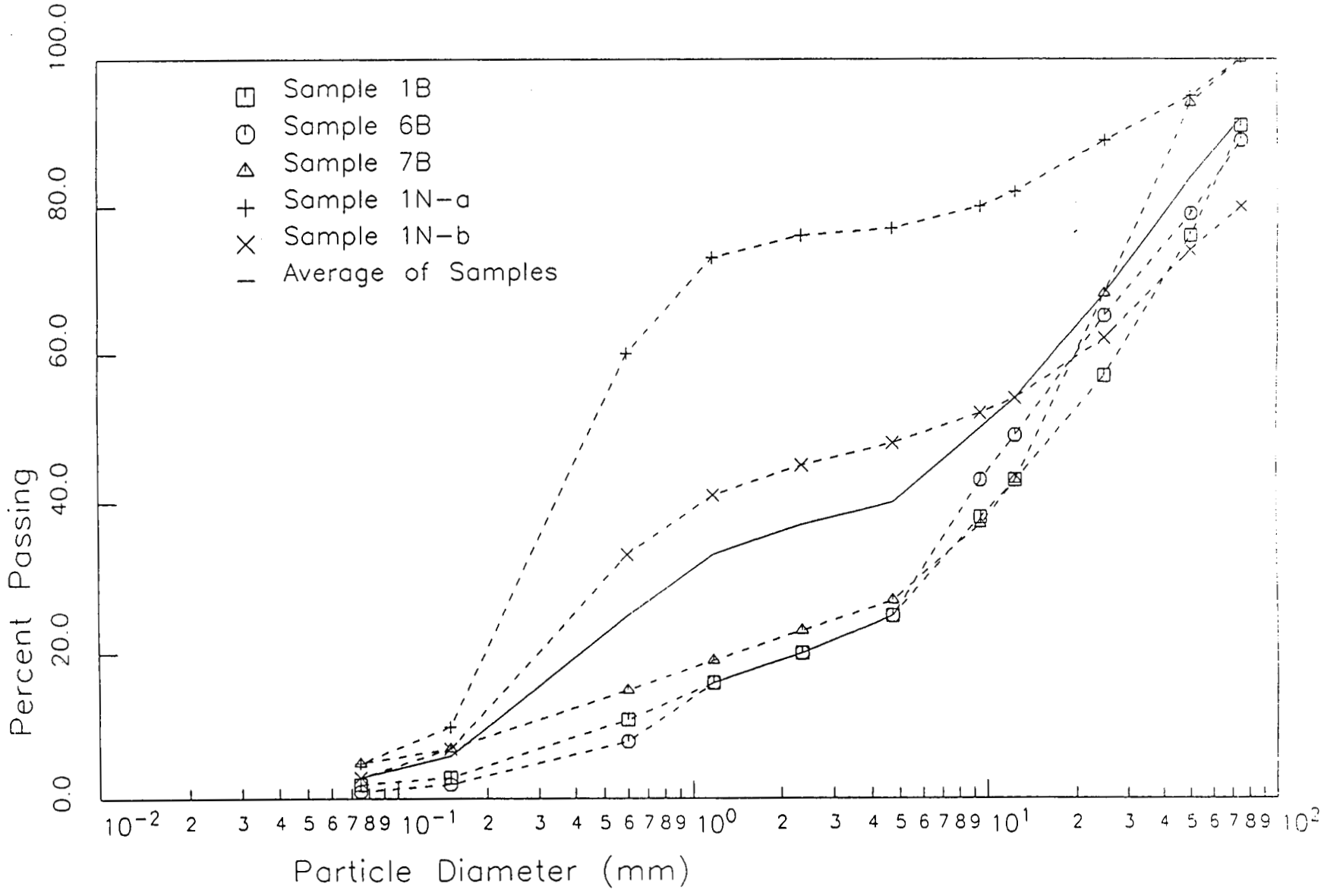
Data Set L

Data Set L provides additional geotechnical data for the current alignment of the East Papago Salt River Bridges. A majority of the sieve analyses were performed on deep samples for the structure foundation design. Twelve sieve analyses were performed on material within the scour zone (ie. above El. 1130 ft.). No estimates were provided regarding the percentage of material greater than 3 inches.

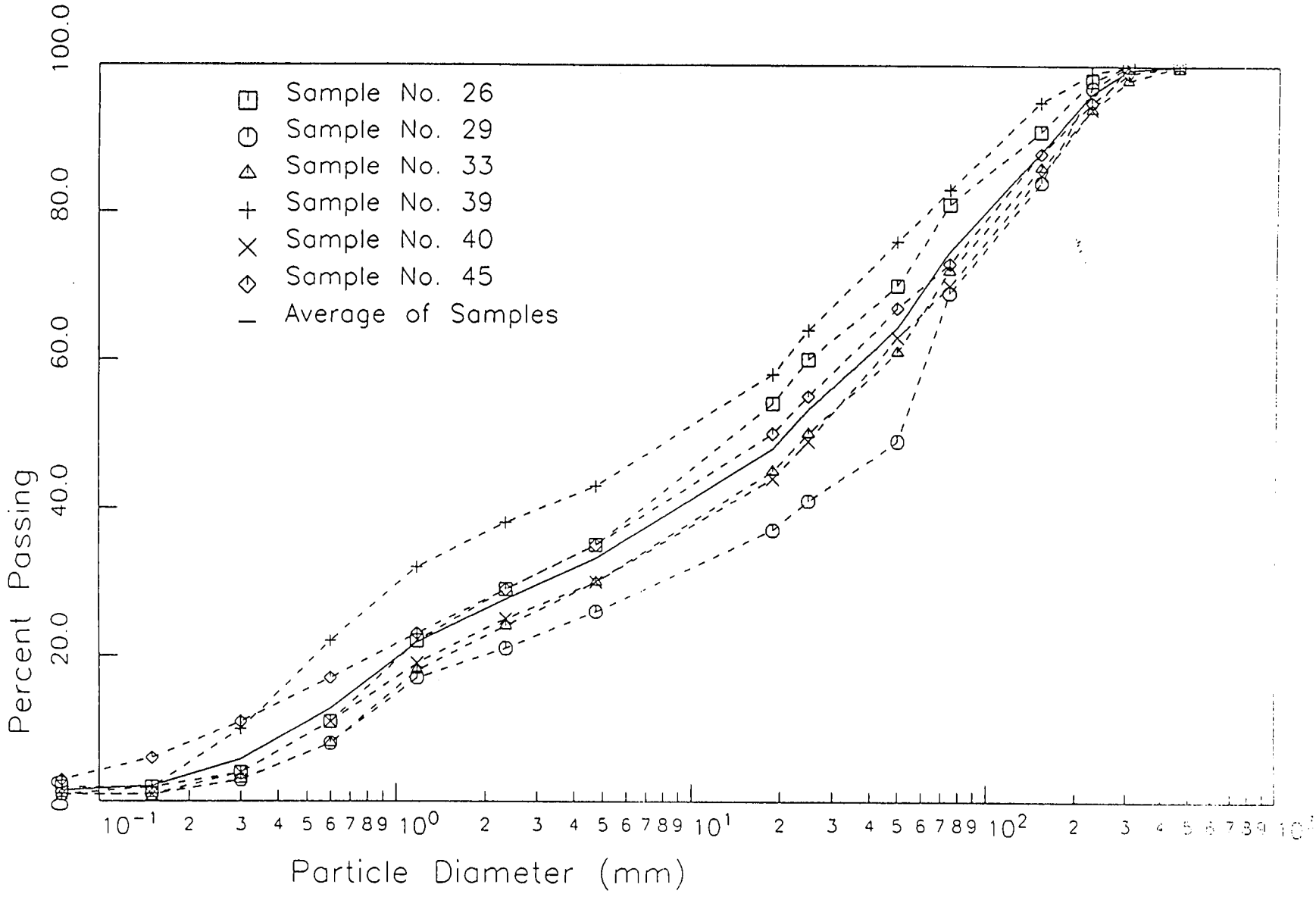
ATTACHMENT B


Sample HB-1
Sample HB-2
Sample HB-3A
Sample HB-3B
Average of Samples
Percent Passing
0.0
20.0
40.0
60.0
80.0
100.0
Particle Diameter (mm)
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}

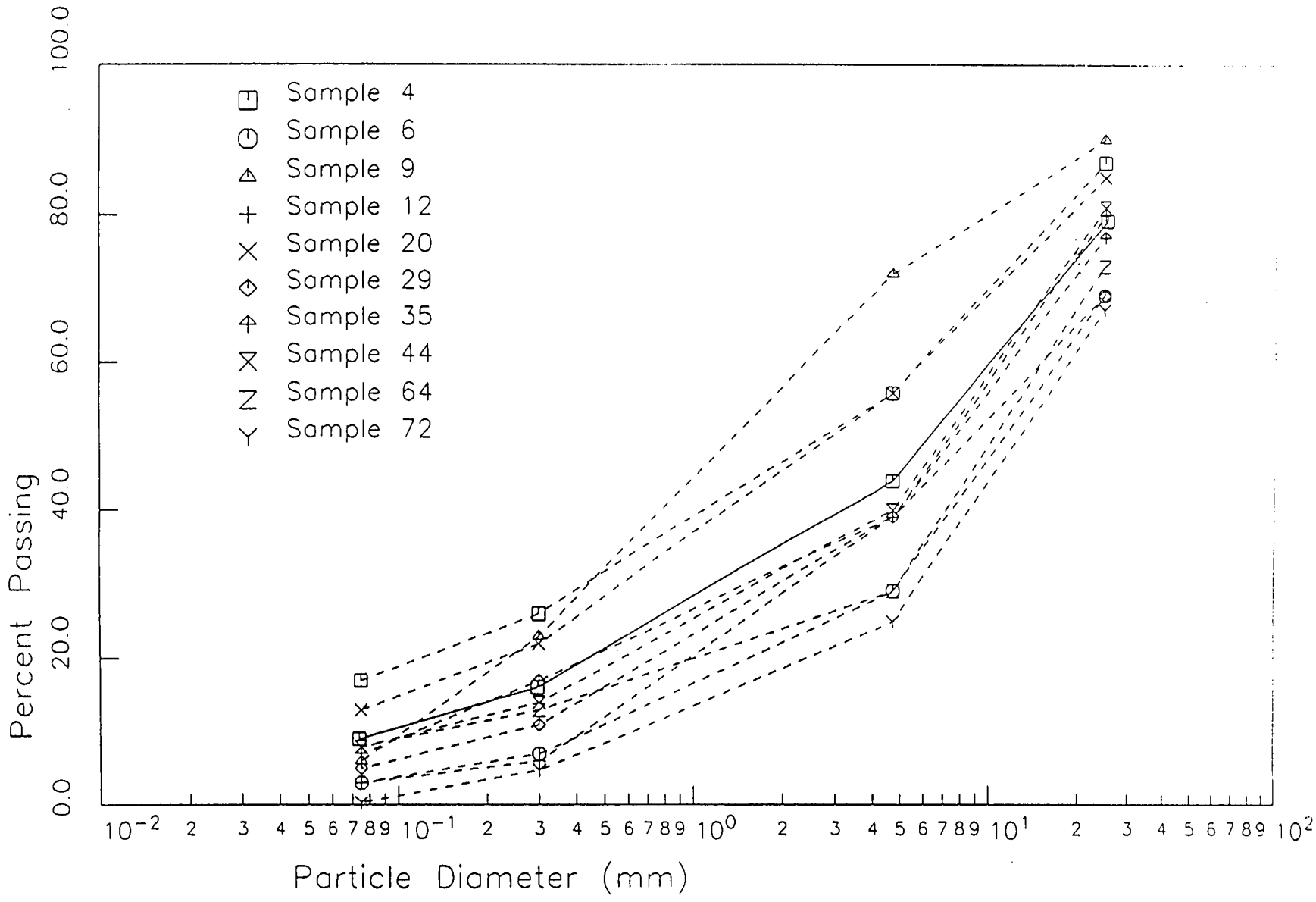
DATA SET D


Sample 1B
Sample 6B
Sample 7B
Sample 1N-a
Sample 1N-b
Average of Samples
Percent Passing
0.0
20.0
40.0
60.0
80.0
100.0
10^{-2} 2 3 4 5 6 7 8 9 10^{-1} 2 3 4 5 6 7 8 9 10^{0} 2 3 4 5 6 7 8 9 10^{1} 2 3 4 5 6 7 8 9 10^{2}
Particle Diameter (mm)

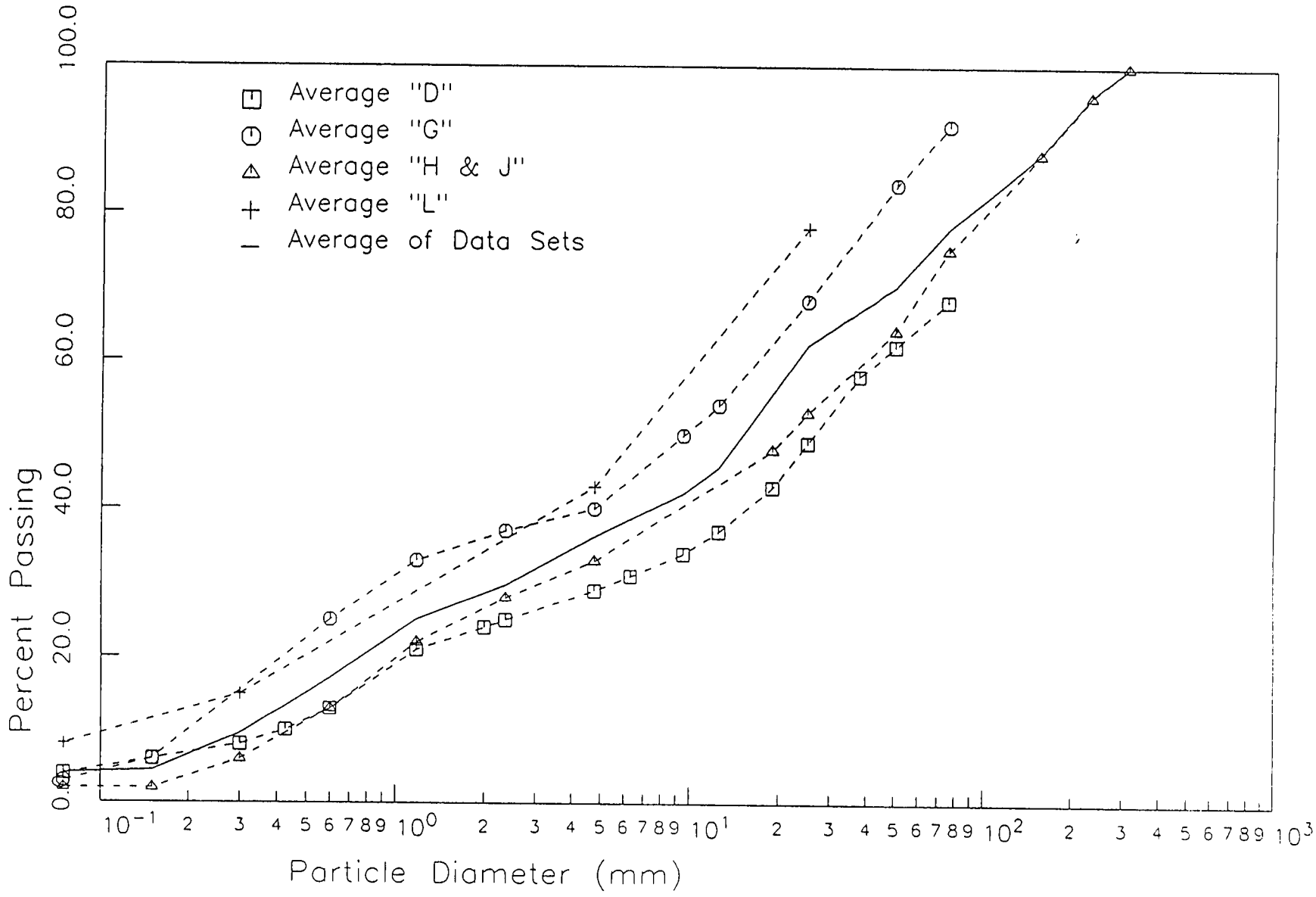
DATA SET G


Sample No. 26
Sample No. 29
Sample No. 33
Sample No. 39
Sample No. 40
Sample No. 45
Average of Samples
Percent Passing
100.0
80.0
60.0
40.0
20.0
0
Particle Diameter (mm)

DATA SET H&J


Sample 4
Sample 6
Sample 9
Sample 12
Sample 20
Sample 29
Sample 35
Sample 44
Sample 64
Sample 72
Percent Passing
0.0
20.0
40.0
60.0
80.0
100.0
Particle Diameter (mm)
10^{-2} 2 3 4 5 6 7 8 9 10^{-1} 2 3 4 5 6 7 8 9 10^{0} 2 3 4 5 6 7 8 9 10^{1} 2 3 4 5 6 7 8 9 10^{2}

DATA SET L



AVERAGE GRAIN SIZE DISTRIBUTION OF DATA SETS D, G, H&J, AND L

FLOOD CONTROL DISTRICT
of
Maricopa County

2801 West Durango Street • Phoenix, Arizona 85009
Telephone (602) 506-1501
Fax (602) 506-4601

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

RECEIVED JUN 0 4 1992

BOARD OF DIRECTORS
P. Ben Arredondo
Betsey Bayless
James D. Bruner
Carole Carpenter
Tom Freestone

JUN 3 1992

Mr. Jeffrey R. Minch, P.E.
Simons, Li & Associates, Inc.
4600 South Mill Avenue, Suite 190
Tempe, Arizona 85282

Subject: Salt River Channelization East of McClintock - HEC-2 Analysis

Dear Mr. Minch:

The Flood Control District has reviewed the HEC-2 submittal and the GFLUVIAL model provided to us on May 18, 1992 for the subject project. The District has the following comments regarding these submittals:

1. It is recommended that the GFLUVIAL model be used for the general scour analysis in the river.

2. The levee toedown depth must be calculated for the 100-yr discharge. Modeling the split flow of the 100-yr discharge with 10-yr leveed condition will result in a smaller discharge downstream of the split region. Therefore, for the design of levee toedown depths, 100-yr leveed condition should be used (Input file LEVEE.DAT among 3 input files submitted).

3. A decision whether to excavate the Perry Lane Landfill should be made before the final HEC-2 and GFLUVIAL results are obtained. This is because the worst case (no excavation) should be used in the levee elevation and toedown depth calculations.

4. The HEC-2 input files show the channel reach upstream of the Pima Freeway T.I. (Price Road) with a natural invert condition instead of graded constant slope. The natural channel invert condition may cause a significant sedimentation problem downstream. Also, as stated in previous meetings, if the District is to maintain the channel, the invert must be graded to create a uniform channel bottom. This condition should be reflected in the HEC-2 analysis.

5. The HEC-2 input files show cross-sections up to XS#245, which is located approximately 1,500 to 2,000 feet downstream from the end location of the north levee protection. Apparently this is because the new topo for this channel reach is not yet available. The final HEC-2 and GFLUVIAL results must include the missing reach.

Please proceed to incorporate these comments into the HEC-2 analysis. The District suggests that these comments be resolved before proceeding with the final levee design. If you have any questions, please call Jay Kim or me at 506-1501.

Sincerely,

Donald J. Rerick
Project Manager

Copies to: Thomas Monchak, DMJM
Steve Jimenez, ADOT/UHS

FLOOD CONTROL DISTRICT
of
Maricopa County

2801 West Durango Street • Phoenix, Arizona 85009
Telephone (602) 506-1501
Fax (602) 506-4601
TDD (602) 506-5897

RECEIVED JUL 0 7 1992

BOARD OF DIRECTORS

P. Ben Arredondo
Betsey Bayless
James D. Bruner
Carole Carpenter
Tom Freestone

JUL 0 2 1992

Mr. Dennis L. Richards, P.E.
Vice President
Simons, Li & Associates, Inc.
4600 South Mill Avenue, Suite 190
Tempe, Arizona 85282

SUBJECT: Salt River Channel East of McClintock Drive - Characteristic Sediment Gradation

Dear Mr. Richards:

The Flood Control District has reviewed the geotechnical data and gradation analysis provided in your letter of June 26, 1992.

The District finds the recommended sediment gradation acceptable as a representative gradation for this reach of the river channel project. The safety factor to be used in the scour analysis will need to reflect the local variations in sediment gradations that are evident in the geotechnical data sets.

It should be noted that the statement in Attachment A, indicating that the sample locations in Data Set I are not "... within the Salt River Channel.", is not correct. The sample materials are designated as "River Bed" at the top of the sieve analysis report.

If you have any questions, please call me or Warren Rosebraugh at 506-1501.

Sincerely,

Donald J. Rerick
Project Manager

Copies to: Thomas M. Monchak, DMJM
Ray Jordan, ADOT
Steve Jimenez, ADOT/UHS

Simons, Li & Associates, Inc.
Water Resources & Civil Engineering Consultants

July 29, 1992

Mr. Thomas M. Monchak
Daniel, Mann, Johnson & Mendenhall
300 West Clarendon Avenue, Suite 335
Phoenix, Arizona 85013

RE: BANK PROTECTION TOE-DOWN DEPTHS IN THE VICINITY OF SAND AND GRAVEL MINING PITS

Dear Tom:

The recommendations presented herein relate to the establishment of bank protection toe-down depths for Section 6 of the East Papago Freeway, and the Red Mountain Traffic Interchange. Since there has been extensive in-stream sand and gravel mining in the reach of the Salt River between McClintock Drive and Dobson Road, longitudinal and lateral migration of the existing pits must be considered.

Upstream of the Pima Freeway crossing of the Salt River, sand and gravel mining setbacks have been established. No sand and gravel mining will be allowed within these setback distances. The recommended setback distances were developed utilizing results from 1) a research study completed in 1989 for the Arizona Transportation Research Center by SLA titled "Effects of In-stream Mining on Channel Stability"; and 2) a physical model study prepared for Anderson-Nichols by the Colorado State University (CSU) Engineering Research Center in 1980 titled "Investigation of Gravel Mining Effects, Salt River Channelization Project at Sky Harbor International Airport". The sand and gravel mining setback distance from the Pima Freeway structures is 1300 feet. The sand and gravel mining setback distance measured perpendicular to each bank of the proposed bank protection system is 300 feet.

For the reach of the Salt River between McClintock Drive and the Pima Freeway, no additional mining will be allowed. Grade-control Structure No. 5, located immediately downstream of the McClintock Drive bridge, will help provide vertical stability to this reach. Based on the available topography, the existing sand and gravel mining pits in this reach have depths as great as 40 feet (the depth of pit is the depth measured from the design channel invert to the low point in the pit). Bank protection toe-down depths must consider lateral migration of the pits where pits are located within 300 feet of the bank. It is expected that over time the

4600 South Mill Avenue, Suite 190 • Tempe, AZ 85282 • Phone: (602) 491-1393 • Fax: (602) 491-1396
An Equal Opportunity Employer

existing pits will be filled by sediment supplied from upstream reaches. In those areas where there are existing pits adjacent to the bank, the design concept is to fill the pits to the design invert elevation for a horizontal distance of 150 feet measured perpendicular to the bank.

For this reach of the Salt River, there are three conditions to address with regards to lateral migration of sand and gravel mining pits. These three conditions are as follows:

1) Sand and gravel mining pits located within 150 feet of the bank (i.e., fill required adjacent to the bank). See Figure 1.
2) No sand and gravel mining pits located within 150 feet (i.e., fill not required adjacent to the bank), but sand and gravel mining pits located within 300 feet of the bank. See Figure 2.
3) No sand and gravel mining pits located within 300 feet of the bank. See Figure 3.

For the above outlined conditions, toe-downs will be based on the following:

1) Total Scour depth, as determined by the procedure outlined in Attachment A of the Letter of Intent, plus a lateral migration depth component. The toe-down depths will, at a minimum, extend three (3) feet below the point where the fill meets the existing channel invert.
2) Total Scour depth, as determined by the procedure outlined in Attachment A of the Letter of Intent, plus a lateral migration depth component.
3) Total Scour depth as determined by the procedure outlined in Attachment A of the Letter of Intent.

The criteria recommended for predicting the lateral migration depth is based on data from the CSU physical model study. This study indicates that the long-term lateral migration length for 40-foot pit depths are in the order of 300 feet. The CSU study found that for a 40-foot pit depth, the lateral migration depth was approximately 12.5 feet for a channel in which the low flow channel follows the natural thalweg. This depth is approximately 31% of the pit depth. The lateral migration depth decreases as the distance from the pit increases. As stated previously, the design concept for the proposed project is to fill the pits to the design invert for a horizontal distance of 150 feet. Based on this design concept and the data presented in the CSU report, it is recommended that the lateral migration scour component used for establishing toe-down depths be 1/4 the pit depth. Where fill is placed within 150 feet of the bank, the toe-down depths shall in all cases extend a minimum of three feet below the point where the fill slope meets the existing channel invert.

Should you have any questions regarding the recommended criteria for toe-downs, please feel free to contact me.

Registered Professional Engineer (Civil)
CERTIFICATE NO. 21560
DENNIS L. RICHARDS
Date Signed 7-29-92
ARIZONA, U.S.A.

Sincerely,

SIMONS, LI & ASSOCIATES, INC.

Dennis L. Richards

Dennis L. Richards, P.E.
Vice President

DLR:cia

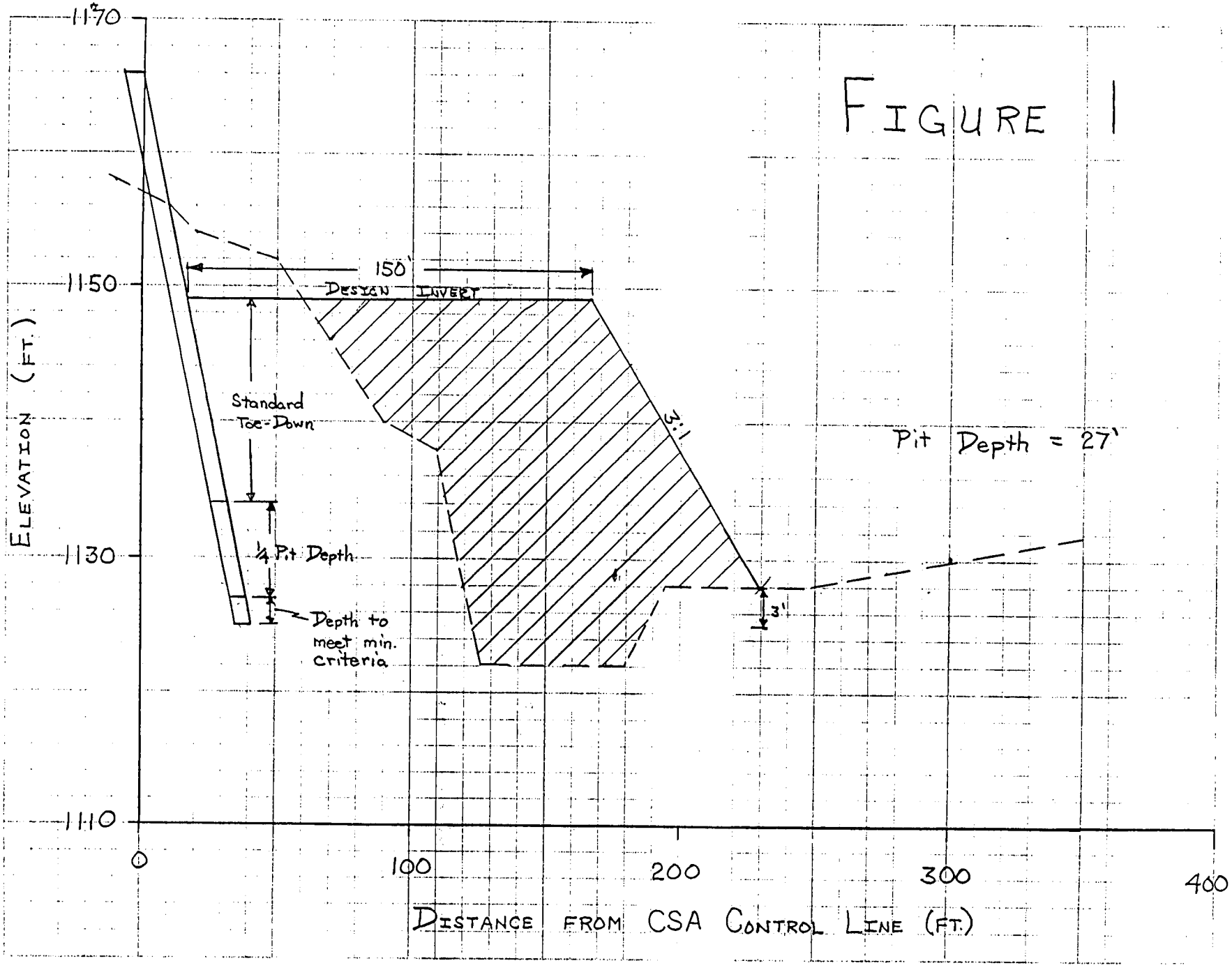
Attachments

cc: Ray Jordan, ADOT
Don Rerick, FCD

(PAZ-DMJM-03)

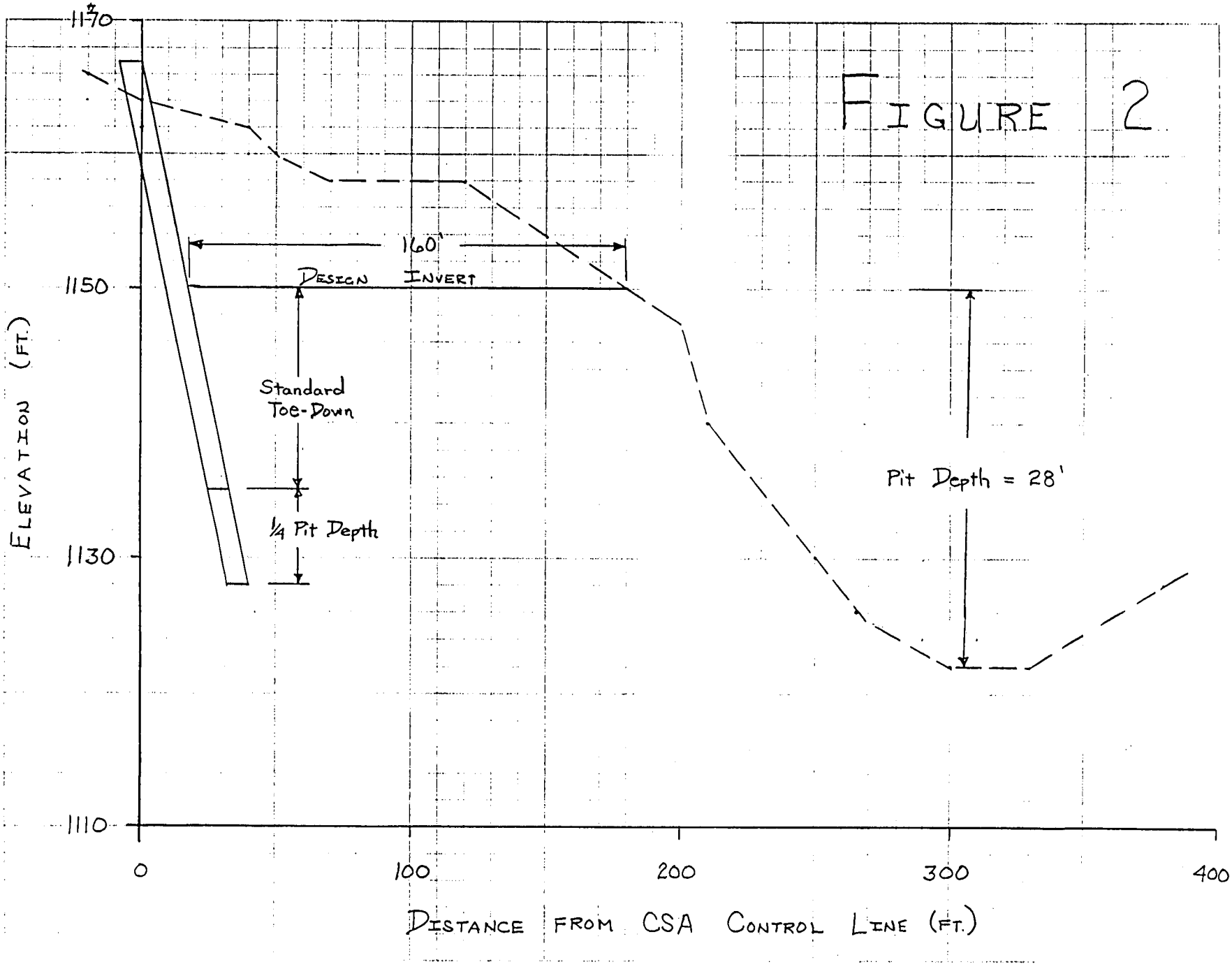
SIMONS, LI & ASSOCIATES, INC.

CLIENT
PROJECT PAZ-DMJM-03
DETAIL
JOB NO.
DATE CHECKED
CHECKED BY
PAGE
DATE 7-28-92
COMPUTED BY



SIMONS, LI & ASSOCIATES, INC.

CLIENT
PROJECT PAZ-DMJM-03
DETAIL
JOB NO.
DATE CHECKED
CHECKED BY
PAGE
DATE 7-28-92
COMPUTED BY

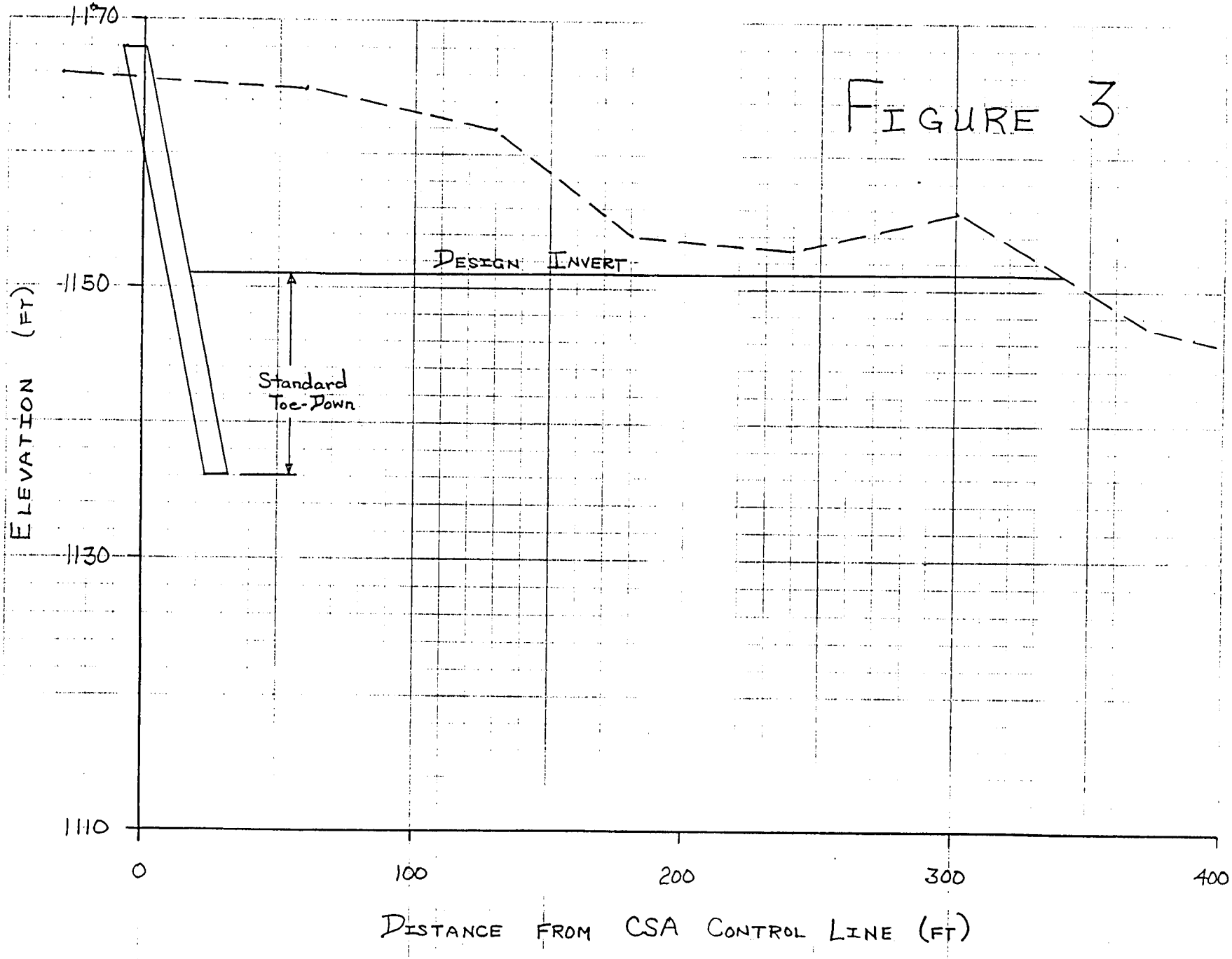


SIMONS, LI & ASSOCIATES, INC.

CLIENT
PROJECT PAZ-DMJM-03
DETAIL

JOB NO.
DATE CHECKED
CHECKED BY

PAGE
DATE 7-28-92
COMPUTED BY



Simons, Li & Associates, Inc.
Water Resources & Civil Engineering Consultants

August 10, 1992

Mr. Donald Rerick
Project Manager
Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009

RE: BANK PROTECTION TOE-DOWN DEPTHS ALONG THE SALT RIVER UPSTREAM OF McCLINTOCK DRIVE

Dear Don:

Enclosed are the HEC-2 files and the GFLUVIAL files for the design conditions of the proposed Salt River bank protection for the reach from McClintock Drive to upstream of the Pima Freeway. Also enclosed are the scour calculations for each of the various scour components.

The hydraulic and scour conditions were determined for two south bank conditions. The first alternative (10-yr. bank) considered was for the alignment of the south bank should only a 10-year bank be feasible. The second alternative (100-yr. levee) was for the alignment of the south bank for a 100-year bank. The alternative providing the largest scour was used to determine each of the scour components. The recommended toe-down depths are summarized in Table 1. - Recommended Bank Protection Toe-Down Depths. The following paragraphs provide information regarding the individual scour components and the procedure for obtaining the values included in the table.

Long-Term Degradation

Long-term aggradation/degradation was computed using the concepts of equilibrium slope or streambed armoring, depending upon which approach controlled the long-term channel profile of the Salt River upstream of McClintock Drive. The procedures in the publication titled, "Computing Degradation and Local Scour," Technical Guideline for Bureau of Reclamation, (January, 1984) have been utilized to quantify the long-term degradation. With Grade-Control Structure No. 5 providing a pivot point, the equilibrium slope was the controlling factor throughout the reach of interest.

4600 South Mill Avenue, Suite 190 • Tempe, AZ 85282 • Phone: (602) 491-1393 • Fax: (602) 491-1396
An Equal Opportunity Employer

The dominant discharge was used for the long-term degradation analysis. The dominant discharge is defined as the discharge which, if allowed to flow constantly, would have the same overall channel shaping effect as the natural fluctuating discharges. The dominant discharge is typically between a 5-year and 10-year event for ephemeral channels (ADWR, 1985). Often the dominant discharge is equal to the bankfull discharge. For this reach of the Salt River, the 10-year event approximates the bankfull discharge. Therefore, the design hydraulic conditions for the 10-year event were used in determining the long-term degradational response for the design reach of the Salt River upstream of McClintock Drive.

General/Contraction Scour

General scour refers to the vertical lowering of the channel bed over relatively short time periods, for example, the general scour in a given reach after passage of a single flood event. Contraction scour can be defined as a special case of general scour. General scour from a contraction occurs because the flow area becomes smaller than the normal channel and the average velocity and bed shear stress increase, hence there is an increase in stream power (τV) at the contraction and more bed material is transported through the contracted section than is transported into the section. As the bed level is lowered, velocity decreases, shear stress decreases and equilibrium is restored when the transport rate through the contracted section is equal to the incoming rate. The GFLUVIAL (Chang, 1990) sediment routing computer model has been used to quantify the local imbalance between sediment supply and transport capacity. The general scour depths included in Table 1 are average depths for given sub-reaches (i.e., cross-sections with similar hydraulic conditions) rather than the actual depth computed at a given cross-section.

The hydrologic data used with GFLUVIAL to simulate the 100-year design flood event was the U.S. Army Corps of Engineers (COE) balanced hydrograph for the regulated 100-year flow routed through the existing SRP system. This flood hydrograph was obtained from the Salt River hydrologic analysis titled, "Study for Flood Control Alternatives to Cliff Dam" (October 1988). This hydrograph was normalized with respect to peak discharge and transposed to the project reach for use as the design flood hydrograph in the GFLUVIAL model.

Low-Flow Incisement

The large width-depth ratios for the design reach of the Salt River require that consideration be given to the development of low-flow channels. There are no rigorous methodologies for the prediction of low-flow channel incisement. A review of existing field conditions and experience from previous projects along the Salt River indicate a low-flow incisement depth of 2 feet is reasonable for the design reach.

Bed-Form Scour

The bed-form scour component was estimated by calculating dune and antidune height. Dune height was calculated using a relationship developed by Allen (Simons & Senturk, 1977). The antidune height was calculated using relationships developed by Kennedy (ADWR, 1985). The actual type of bed form present in the design reach is a function of the flow regime. Since the flow regime will change with the fluctuating discharges of the flood hydrograph, both bed forms could be present in the design reach during the same flood event. The maximum scour depth calculated with the above relationships, for the 100-year design hydraulic conditions, has been used as the bed-form scour depth for the design reach. The bed-form scour depths included in Table 1 are average values for designated sub-reaches rather than the actual depth computed for a given cross-section.

Factor of Safety

A factor of safety was included to account for non-uniform flow distributions typical of alluvial channels. This factor of safety is calculated as 30% of the sum of general scour, low-flow incisement, and bed-form scour.

Standard Toe-Down Depth

The column labeled standard toe-down depth provides the sum of the long-term degradation, general scour, low-flow incisement, and bed form components plus the factor of safety.

Mining Impacts

The mining toe-down depth is the depth that must be added to the standard toe-down depth to protect against lateral migration of the pits. This scour component was determined based on the conditions and criteria outlined in our July 29, 1992 letter to Mr. Thomas M. Monchak regarding bank protection toe-down depths in the vicinity of sand and gravel mining pits.

Total Toe-Down Depth

This column contains the recommended toe-down depth for any point along the bank protection. This is the sum of the standard toe-down depth and the mining toe-down depth. This depth does not include the additional toe-down that may be required to extend 3 feet below the point where the fill meets the existing channel invert.

Toe-Down Elevation

This column provides the minimum elevation to which to extend the toe-down. It is obtained by subtracting the total toe-down depth from the concept invert elevation.

In addition to the above components, bend scour and local scour were also investigated. Since the main channel of the Salt River does not contain any significant bends within the subject reach, a column for bend scour was not included in Table 1. Local scour (pier scour) was estimated using the CSU equation as presented in HEC-18. The East Papago Freeway crossing and bank protection measures were located to prevent local pier scour from undermining the bank protection system upstream of McClintock Drive. The zone of influence for the total pier scour was determined to verify that scour due to piers does not endanger the bank protection stability.

If you have any questions regarding the recommended toe-down depths or the accompanying calculations, please feel free to call.

Sincerely,

SIMONS, LI & ASSOCIATES, INC.

Dennis L. Richards

Dennis L. Richards, P.E.
Vice President

Registered Professional Engineer (Civil) CERTIFICATE NO. 21560 DENNIS L. RICHARDS Date Signed 8-10-92 ARIZONA, U.S.A.

DLR

Enclosures

cc: Mr. Ray Jordan w/enclosures (ADOT)
Mr. Thomas Monchak w/enclosures (DMJM)

(PAZ-DMJM-03.25)

TABLE 1. RECOMMENDED BANK PROTECTION TOE-DOWN DEPTHS

NORTH BANK STATION	HEC-2 CROSS SECTION NUMBER	CONCEPT INVERT ELEV. (ft)	LONG-TERM DEGRADATION (ft)	GENERAL SCOUR (ft)	LOW-FLOW INCISEMENT (ft)	BED-FORM SCOUR (ft)	FACTOR OF SAFETY (ft)	STANDARD TOE-DOWN DEPTH (ft)	MINING TOE-DOWN DEPTH (ft)	TOTAL TOE-DOWN DEPTH (ft)	TOE-DOWN ELEVATION (ft)	REMARKS
	120.50	1147.0	0.0	0.3	2.0	2.0	1.3	5.6	0.0	5.6	1141.4	
	122.00	1147.2	0.1	0.3	2.0	2.0	1.3	5.7	0.0	5.7	1141.5	
	122.65	1147.2	0.1	0.3	2.0	2.0	1.3	5.7	0.0	5.7	1141.5	
	123.55	1147.3	0.2	0.3	2.0	2.0	1.3	5.8	0.0	5.8	1141.5	
	124.00	1147.4	0.2	0.3	2.0	2.0	1.3	5.8	0.0	5.8	1141.6	
230+58	228.00	1147.7	0.4	0.3	2.0	2.0	1.3	6.0	2.6	8.5	1139.2	
234+65	229.00	1148.1	0.7	0.3	2.0	2.0	1.3	6.3	2.8	9.1	1139.0	
14+15	230.00	1148.4	0.9	4.6	2.0	5.0	3.5	16.0	2.0	17.9	1130.5	
17+96	231.00	1148.8	1.1	4.6	2.0	5.0	3.5	16.2	8.2	24.4	1124.4	
22+70	232.00	1149.2	1.4	4.6	2.0	5.0	3.5	16.5	8.0	24.5	1124.7	Sta. 19+ to Sta. 25+ Added toe-down req. to be below fill catch pt.
26+60	233.00	1149.6	1.6	4.6	2.0	2.0	2.6	12.8	5.6	18.4	1131.2	
30+65	234.00	1150.0	1.9	4.6	2.0	2.0	2.6	13.1	5.4	18.4	1131.6	
34+71	235.00	1150.4	2.2	4.6	2.0	2.0	2.6	13.4	7.6	21.0	1129.4	
38+77	236.00	1150.8	2.4	4.6	2.0	2.0	2.6	13.6	6.7	20.3	1130.5	
42+85	237.00	1151.2	2.6	2.5	2.0	2.0	2.0	11.1	8.1	19.1	1132.1	
47+75	238.00	1151.7	3.0	2.5	2.0	2.0	2.0	11.5	6.9	18.4	1133.3	
52+57	239.00	1152.2	3.2	2.5	2.0	2.0	2.0	11.7	1.9	13.5	1138.7	
56+89	240.00	1152.7	3.5	2.5	2.0	2.0	2.0	12.0	2.4	14.3	1138.4	
62+06 ~~56+89~~	241.00	1153.2	3.9	2.5	2.0	2.0	2.0	12.4	2.1	14.4	1138.8	
66+11	242.00	1153.7	4.2	2.5	2.0	2.0	2.0	12.7	1.6	14.3	1139.4	
71+36	243.00	1154.2	4.5	2.5	2.0	2.0	2.0	13.0	3.6	16.6	1137.6	
76+70	244.00	1154.7	4.8	2.5	2.0	2.0	2.0	13.3	3.6	16.9	1137.9	
80+59	245.00	1155.2	5.2	2.5	2.0	2.0	2.0	13.7	1.9	15.5	1139.7	
85+19	246.00	1155.8	5.5	2.5	2.0	2.0	2.0	14.0	1.4	15.4	1140.4	
91+30	247.00	1156.3	5.8	2.5	2.0	2.0	2.0	14.3	2.2	16.5	1139.8	
100+65	248.00	1157.0	6.2	0.0	2.0	2.0	1.2	11.4	2.8	14.2	1142.8	

August 7, 1992

Simons, Li & Associates, Inc.
Water Resources & Civil Engineering Consultants

HEC-2 DATA

HEC-2 HYDRAULIC CONDITIONS

HEC-2 CROSS SECTION	QCH (cfs)	Q (cfs)	K*CHSL (ft/ft)	10*KS (ft/ft)	DEPTH (ft)	VCH (fps)	AREA (sq.ft)	TOPWIDTH (ft)
120.50	93000	93000	0.00	35.63	10.45	10.72	8678	996
122.00	93000	93000	1.32	32.00	10.85	10.46	8890	975
122.65	93000	93000	0.00	31.22	11.09	10.39	8951	975
123.55	92976	93000	1.22	17.43	12.67	8.61	10810	1024
124.00	92965	93000	2.00	17.32	12.66	8.64	10787	1020
228.00	93000	93000	0.94	17.54	12.81	9.34	9956	783
229.00	93000	93000	1.05	15.79	13.17	9.02	10313	790
230.00	93000	93000	0.80	26.16	13.23	11.51	8081	617
231.00	93000	93000	1.00	40.83	13.36	14.29	6507	501
232.00	93000	93000	0.95	31.40	14.90	13.34	6969	483
233.00	93000	93000	1.04	19.23	16.35	11.11	8374	529
234.00	93000	93000	1.00	12.39	17.19	9.27	10030	601
235.00	93000	93000	1.00	10.95	17.40	8.80	10563	625
236.00	93000	93000	1.00	9.90	17.53	8.42	11039	647
237.00	93000	93000	1.03	6.65	17.80	7.04	13208	760
238.00	93000	93000	1.00	4.67	17.79	6.10	15237	874
239.00	95300	95300	1.09	4.93	17.50	6.20	15367	896
240.10	95300	95300	0.96	6.21	17.20	6.87	13868	824
240.20	95300	95300	0.94	5.74	17.38	6.66	14319	841
240.30	95300	95300	1.04	4.93	17.45	6.20	15383	899
240.40	95300	95300	0.94	4.28	17.49	5.79	16457	958
240.50	95300	95300	1.06	3.90	17.58	5.55	17175	994
240.60	95300	95300	1.04	3.65	17.58	5.37	17735	1026
241.10	95300	95300	1.02	3.43	17.58	5.21	18301	1058
241.20	95300	95300	1.04	3.29	17.63	5.12	18627	1074
242.00	95300	95300	0.39	4.03	17.66	4.91	19415	1377
243.00	95300	95300	0.67	2.80	17.66	3.80	25056	1632
244.00	87757	95300	0.77	6.71	17.40	4.99	19403	1704
245.00	95300	95300	1.93	11.79	16.71	6.02	15842	1536
246.00	56020	95300	-0.35	25.00	17.75	7.37	7599	934
247.00	56020	95300	0.73	16.57	18.37	7.44	7525	671
248.00	56020	95300	2.60	118.00	17.72	15.01	3731	514
249.00	56020	95300	1.01	40.61	22.12	10.66	5255	543
250.00	56020	95300	0.99	53.93	23.87	11.85	4727	514
251.00	56031	95300	1.00	114.42	27.68	17.88	3134	319
252.00	63000	95300	11.13	9.29	27.75	6.94	9080	580
253.00	63000	95300	9.45	2.52	22.59	3.69	17063	1070

CALCULATED HYDRAULIC VARIABLES

HEC-2 CROSS SECTION	AVERAGE CHANNEL DEPTH (ft)	CHANNEL SLOPE (ft/ft)	ENERGY SLOPE (ft/ft)	CRITICAL SHEAR STRESS (psf)	EFFECTIVE CHANNEL WIDTH (ft)	(Q/QCH)	SHEAR VELOCITY	REYNOLD NUMBER	REYNOLD NUMBER CHECK
120.50	8.72	0.00000	0.00356	2.32	830	1.00	1.09	5389	OK
122.00	9.11	0.00132	0.00320	2.17	819	1.00	1.06	5203	OK
122.65	9.18	0.00000	0.00312	2.16	807	1.00	1.06	5196	OK
123.55	10.56	0.00122	0.00174	1.38	853	1.00	0.84	4150	OK
124.00	10.58	0.00200	0.00173	1.37	852	1.00	0.84	4135	OK
228.00	12.71	0.00094	0.00175	1.40	777	1.00	0.85	4186	OK
229.00	13.06	0.00105	0.00158	1.30	783	1.00	0.82	4027	OK
230.00	13.09	0.00080	0.00262	2.16	611	1.00	1.06	5195	OK
231.00	13.00	0.00100	0.00408	3.40	487	1.00	1.33	6522	OK
232.00	14.44	0.00095	0.00314	2.92	468	1.00	1.23	6040	OK
233.00	15.84	0.00104	0.00192	1.96	512	1.00	1.01	4952	OK
234.00	16.70	0.00100	0.00124	1.33	583	1.00	0.83	4075	OK
235.00	16.91	0.00100	0.00109	1.19	607	1.00	0.78	3855	OK
236.00	17.05	0.00100	0.00099	1.08	630	1.00	0.75	3679	OK
237.00	17.39	0.00103	0.00067	0.74	742	1.00	0.62	3038	OK
238.00	17.43	0.00100	0.00047	0.52	857	1.00	0.52	2545	OK
239.00	17.15	0.00109	0.00049	0.54	878	1.00	0.53	2594	OK
240.10	16.84	0.00096	0.00062	0.67	806	1.00	0.59	2886	OK
240.20	17.02	0.00094	0.00057	0.62	824	1.00	0.57	2789	OK
240.30	17.11	0.00104	0.00049	0.54	882	1.00	0.53	2590	OK
240.40	17.18	0.00094	0.00043	0.47	941	1.00	0.49	2416	OK
240.50	17.27	0.00106	0.00039	0.43	977	1.00	0.47	2312	OK
240.60	17.28	0.00104	0.00037	0.40	1009	1.00	0.45	2237	OK
241.10	17.29	0.00102	0.00034	0.38	1041	1.00	0.44	2169	OK
241.20	17.34	0.00104	0.00033	0.36	1057	1.00	0.43	2127	OK
242.00	14.10	0.00039	0.00040	0.44	1099	1.00	0.48	2356	OK
243.00	15.36	0.00067	0.00028	0.31	1419	1.00	0.40	1964	OK
244.00	11.39	0.00077	0.00067	0.73	1115	1.09	0.61	3017	OK
245.00	10.32	0.00193	0.00118	1.23	948	1.00	0.80	3920	OK
246.00	8.13	-0.00035	0.00250	2.77	428	1.70	1.20	5883	OK
247.00	11.21	0.00073	0.00166	1.90	410	1.70	0.99	4872	OK
248.00	7.26	0.00260	0.01180	13.05	211	1.70	2.59	12770	OK
249.00	9.68	0.00101	0.00406	5.61	238	1.70	1.70	8370	OK
250.00	9.19	0.00099	0.00539	8.03	198	1.70	2.04	10019	OK
251.00	9.81	0.00100	0.01144	19.76	113	1.70	3.19	15716	OK
252.00	15.65	0.01113	0.00093	1.61	327	1.51	0.91	4484	OK
253.00	15.95	0.00945	0.00025	0.36	755	1.51	0.43	2107	OK

HEC-2 HYDRAULIC CONDITIONS

HEC-2 CROSS SECTION	QCH (cfs)	Q (cfs)	K*CHSL (ft/ft)	10*KS (ft/ft)	DEPTH (ft)	VCH (fps)	AREA (sq ft)	TOPWIDTH (ft)
120.50	212131	215000	0.00	19.25	19.00	12.24	17578	1070
122.00	212070	215000	1.32	19.97	19.03	12.48	17237	1048
122.65	212042	215000	0.00	20.12	19.16	12.51	17196	1048
123.55	211978	215000	1.22	13.32	21.09	10.99	19580	1060
124.00	211580	215000	2.00	13.49	21.06	11.02	19554	1070
228.00	213630	215000	0.94	11.98	21.29	10.69	19981	952
229.00	212421	215000	1.05	13.61	21.26	11.32	18760	893
230.00	211746	215000	0.80	22.52	21.02	14.36	14906	740
231.00	211134	215000	1.00	68.20	18.75	22.91	9466	594
232.00	207018	215000	0.95	34.90	23.38	18.69	12190	811
233.00	186262	215000	1.04	14.73	26.93	13.32	20897	1811
234.00	196323	215000	1.00	11.75	27.40	12.13	21432	1712
235.00	196278	215000	1.00	10.46	27.67	11.55	22571	1675
236.00	199804	215000	1.00	9.96	27.73	11.31	22296	1491
237.00	204607	215000	1.03	7.11	28.17	9.68	24678	1319
238.00	208711	215000	1.00	4.97	28.28	8.53	27300	1495
239.00	213709	220000	1.09	5.11	28.00	8.60	27650	1453
240.10	220000	220000	0.96	6.85	27.61	9.75	22555	845
240.20	220000	220000	0.94	6.21	28.07	9.39	23420	863
240.30	220000	220000	1.04	5.28	28.26	8.72	25223	921
240.40	220000	220000	0.94	4.55	28.41	8.14	27039	980
240.50	220000	220000	1.06	4.07	28.70	7.76	28353	1017
240.60	220000	220000	1.04	3.80	28.74	7.51	29310	1049
241.10	220000	220000	1.02	3.55	28.77	7.27	30270	1081
241.20	220000	220000	1.04	3.39	28.91	7.13	30869	1097
242.00	220000	220000	0.39	3.02	29.11	6.24	35252	1389
243.00	220000	220000	0.67	2.36	29.15	5.01	43870	1643
244.00	197748	220000	0.77	3.62	28.85	5.65	41310	1943
245.00	213202	220000	1.93	5.17	27.94	6.21	37386	2212
246.00	72049	220000	-0.35	2.49	28.74	3.83	18806	1082
247.00	73878	220000	0.73	3.61	28.44	4.85	15241	822
248.00	73878	220000	2.60	13.74	26.88	8.29	8915	592
249.00	73878	220000	1.01	18.90	26.99	9.26	7980	572
250.00	74226	220000	0.99	33.36	27.39	11.25	6599	539
251.00	78543	220000	1.00	110.80	30.07	20.15	3898	320
252.00	96840	220000	11.13	11.28	31.31	8.69	11139	580
253.00	96840	220000	9.45	2.88	26.54	4.55	21277	1070

CALCULATED HYDRAULIC VARIABLES

HEC-2 CROSS SECTION	AVERAGE CHANNEL DEPTH (ft)	CHANNEL SLOPE (ft/ft)	ENERGY SLOPE (ft/ft)	CRITICAL SHEAR STRESS (psf)	EFFECTIVE CHANNEL WIDTH (ft)	(Q/QCH)	SHEAR VELOCITY	REYNOLD NUMBER	REYNOLD NUMBER CHECK
120.50	16.42	0.00000	0.00193	2.28	925	1.01	1.09	5341	OK
122.00	16.45	0.00132	0.00200	2.37	906	1.01	1.11	5444	OK
122.65	16.41	0.00000	0.00201	2.41	898	1.01	1.11	5483	OK
123.55	18.48	0.00122	0.00133	1.75	928	1.01	0.95	4681	OK
124.00	18.28	0.00200	0.00135	1.77	929	1.02	0.96	4707	OK
228.00	20.99	0.00094	0.00120	1.59	939	1.01	0.91	4460	OK
229.00	21.01	0.00105	0.00136	1.81	882	1.01	0.97	4750	OK
230.00	20.16	0.00080	0.00225	2.95	709	1.02	1.23	6076	OK
231.00	15.95	0.00100	0.00682	7.98	505	1.02	2.03	9986	OK
232.00	15.02	0.00095	0.00349	5.09	521	1.04	1.62	7977	OK
233.00	11.54	0.00104	0.00147	2.48	776	1.15	1.13	5562	OK
234.00	12.52	0.00100	0.00118	2.01	782	1.10	1.02	5011	OK
235.00	13.48	0.00100	0.00105	1.81	816	1.10	0.97	4751	OK
236.00	14.96	0.00100	0.00100	1.72	804	1.08	0.94	4641	OK
237.00	18.71	0.00103	0.00071	1.25	876	1.05	0.80	3952	OK
238.00	18.25	0.00100	0.00050	0.88	965	1.03	0.67	3311	OK
239.00	19.02	0.00109	0.00051	0.89	988	1.03	0.68	3340	OK
240.10	26.71	0.00096	0.00069	1.18	817	1.00	0.78	3840	OK
240.20	27.15	0.00094	0.00062	1.09	834	1.00	0.75	3687	OK
240.30	27.40	0.00104	0.00053	0.93	893	1.00	0.69	3411	OK
240.40	27.59	0.00094	0.00046	0.81	952	1.00	0.65	3175	OK
240.50	27.89	0.00106	0.00041	0.73	988	1.00	0.61	3018	OK
240.60	27.95	0.00104	0.00038	0.68	1020	1.00	0.59	2918	OK
241.10	28.01	0.00102	0.00035	0.64	1052	1.00	0.57	2822	OK
241.20	28.14	0.00104	0.00034	0.61	1068	1.00	0.56	2765	OK
242.00	25.39	0.00039	0.00030	0.55	1211	1.00	0.53	2618	OK
243.00	26.70	0.00067	0.00024	0.43	1505	1.00	0.47	2316	OK
244.00	21.26	0.00077	0.00036	0.65	1432	1.11	0.58	2854	OK
245.00	16.90	0.00193	0.00052	0.90	1338	1.03	0.68	3356	OK
246.00	17.39	-0.00035	0.00025	0.45	654	3.05	0.48	2362	OK
247.00	18.55	0.00073	0.00036	0.64	536	2.98	0.57	2830	OK
248.00	15.05	0.00260	0.00137	2.30	332	2.98	1.09	5367	OK
249.00	13.96	0.00101	0.00189	3.18	296	2.98	1.28	6307	OK
250.00	12.24	0.00099	0.00334	5.70	241	2.96	1.72	8441	OK
251.00	12.18	0.00100	0.01108	20.79	130	2.80	3.28	16119	OK
252.00	19.21	0.01113	0.00113	2.20	356	2.27	1.07	5248	OK
253.00	19.88	0.00945	0.00029	0.48	802	2.27	0.50	2441	OK

HEC-2 HYDRAULIC CONDITIONS

HEC-2 CROSS SECTION	QCH (cfs)	Q (cfs)	K*CHSL (ft/ft)	10*KS (ft/ft)	DEPTH (ft)	VCH (fps)	AREA (sq ft)	TOPWIDTH (ft)
120.50	93000	93000	0.00	35.63	10.45	10.72	8678	996
122.00	93000	93000	1.32	32.00	10.85	10.46	8890	975
122.65	93000	93000	0.00	31.22	11.09	10.39	8951	975
123.55	92976	93000	1.22	17.43	12.67	8.61	10810	1024
124.00	92965	93000	2.00	17.32	12.66	8.64	10787	1020
228.00	93000	93000	0.94	11.22	13.07	7.62	12200	946
229.00	93000	93000	1.05	11.20	13.10	7.63	12197	944
230.00	93000	93000	0.80	18.65	12.95	9.69	9600	754
231.00	93000	93000	1.00	23.15	13.13	10.82	8592	668
232.00	93000	93000	0.95	24.09	13.62	11.25	8266	621
233.00	93000	93000	1.04	25.28	14.06	11.70	7946	579
234.00	93000	93000	1.00	19.72	14.91	10.73	8665	596
235.00	93000	93000	1.00	15.93	15.51	9.90	9390	621
236.00	93000	93000	1.00	13.62	15.89	9.31	9984	644
237.00	93000	93000	1.03	8.73	16.39	7.67	12133	757
238.00	93000	93000	1.00	6.01	16.50	6.59	14109	871
239.00	95300	95300	1.09	6.28	16.27	6.68	14266	893
240.10	95300	95300	0.96	7.81	16.05	7.37	12925	821
240.20	95300	95300	0.94	7.11	16.30	7.11	13407	839
240.30	95300	95300	1.04	6.07	16.40	6.60	14439	897
240.40	95300	95300	0.94	5.23	16.47	6.16	15476	956
240.50	95300	95300	1.06	4.72	16.60	5.88	16197	992
240.60	95300	95300	1.04	4.42	16.61	5.70	16725	1024
241.10	95300	95300	1.02	4.14	16.61	5.52	17270	1056
241.20	95300	95300	1.04	3.96	16.68	5.41	17607	1072
242.00	95300	95300	0.39	5.04	16.74	5.25	18146	1376
243.00	95300	95300	0.67	3.39	16.80	4.03	23654	1631
244.00	87629	95300	0.77	8.35	16.58	5.35	18040	1627
245.00	95300	95300	1.93	14.83	16.00	6.46	14753	1528
246.00	56020	95300	-0.35	30.36	17.27	7.84	7142	926
247.00	56020	95300	0.73	17.99	18.08	7.64	7332	669
248.00	56020	95300	2.60	114.08	17.80	14.86	3771	514
249.00	56020	95300	1.01	40.91	22.09	10.69	5243	543
250.00	56020	95300	0.99	54.07	23.87	11.86	4723	514
251.00	56031	95300	1.00	114.42	27.68	17.88	3134	319
252.00	63000	95300	11.13	9.29	27.75	6.94	9080	580
253.00	63000	95300	9.45	2.52	22.59	3.69	17063	1070

CALCULATED HYDRAULIC VARIABLES

HEC-2 CROSS SECTION	AVERAGE CHANNEL DEPTH (ft)	CHANNEL SLOPE (ft/ft)	ENERGY SLOPE (ft/ft)	CRITICAL SHEAR STRESS (psf)	EFFECTIVE CHANNEL WIDTH (ft)	(Q/QCH)	SHEAR VELOCITY	REYNOLD NUMBER	REYNOLD NUMBER CHECK
120.50	8.72	0.00000	0.00356	2.32	830	1.00	1.09	5389	OK
122.00	9.11	0.00132	0.00320	2.17	819	1.00	1.06	5203	OK
122.65	9.18	0.00000	0.00312	2.16	807	1.00	1.06	5196	OK
123.55	10.56	0.00122	0.00174	1.38	853	1.00	0.84	4150	OK
124.00	10.58	0.00200	0.00173	1.37	852	1.00	0.84	4135	OK
228.00	12.89	0.00094	0.00112	0.92	933	1.00	0.69	3382	OK
229.00	12.91	0.00105	0.00112	0.92	931	1.00	0.69	3383	OK
230.00	12.73	0.00080	0.00187	1.51	741	1.00	0.88	4340	OK
231.00	12.87	0.00100	0.00232	1.90	654	1.00	0.99	4869	OK
232.00	13.32	0.00095	0.00241	2.05	607	1.00	1.03	5058	OK
233.00	13.71	0.00104	0.00253	2.22	565	1.00	1.07	5265	OK
234.00	14.54	0.00100	0.00197	1.83	581	1.00	0.97	4788	OK
235.00	15.13	0.00100	0.00159	1.54	605	1.00	0.89	4390	OK
236.00	15.50	0.00100	0.00136	1.35	628	1.00	0.83	4108	OK
237.00	16.03	0.00103	0.00087	0.89	740	1.00	0.68	3340	OK
238.00	16.19	0.00100	0.00060	0.62	855	1.00	0.57	2781	OK
239.00	15.97	0.00109	0.00063	0.64	877	1.00	0.57	2823	OK
240.10	15.74	0.00096	0.00078	0.78	805	1.00	0.64	3127	OK
240.20	15.98	0.00094	0.00071	0.72	823	1.00	0.61	3006	OK
240.30	16.10	0.00104	0.00061	0.62	880	1.00	0.57	2786	OK
240.40	16.19	0.00094	0.00052	0.54	940	1.00	0.53	2592	OK
240.50	16.32	0.00106	0.00047	0.49	976	1.00	0.50	2472	OK
240.60	16.33	0.00104	0.00044	0.46	1007	1.00	0.49	2393	OK
241.10	16.35	0.00102	0.00041	0.43	1040	1.00	0.47	2316	OK
241.20	16.42	0.00104	0.00040	0.41	1056	1.00	0.46	2270	OK
242.00	13.19	0.00039	0.00050	0.53	1084	1.00	0.52	2565	OK
243.00	14.50	0.00067	0.00034	0.36	1408	1.00	0.43	2107	OK
244.00	11.09	0.00077	0.00083	0.86	1088	1.09	0.67	3286	OK
245.00	9.66	0.00193	0.00148	1.48	922	1.00	0.87	4302	OK
246.00	7.71	-0.00035	0.00304	3.27	414	1.70	1.30	6394	OK
247.00	10.95	0.00073	0.00180	2.03	406	1.70	1.02	5036	OK
248.00	7.33	0.00260	0.01141	12.67	212	1.70	2.56	12584	OK
249.00	9.66	0.00101	0.00409	5.64	237	1.70	1.71	8395	OK
250.00	9.19	0.00099	0.00541	8.05	198	1.70	2.04	10032	OK
251.00	9.81	0.00100	0.01144	19.76	113	1.70	3.19	15716	OK
252.00	15.65	0.01113	0.00093	1.61	327	1.51	0.91	4484	OK
253.00	15.95	0.00945	0.00025	0.36	755	1.51	0.43	2107	OK

ARMORING AND EQUILIBRIUM SLOPE CALCULATIONS

HEC-2 CROSS SECTION	MEYER-PETER, MULLER (mm)	BOTTOM VELOCITY METHOD (mm)	SHIELD'S DIAGRAM (mm)	YANG INCIPIENT MOTION (mm)	AVERAGE ARMOR SIZE (mm)	SCHOK-LITSCH METHOD	MEYER-PETER, MULLER METHOD	SHIELD'S DIAGRAM METHOD	AVERAGE SLOPE (ft/ft)
120.50	88	216	115	231	162	0.00044	0.00061	0.00046	0.00050
122.00	82	206	107	220	154	0.00043	0.00059	0.00045	0.00049
122.65	82	203	107	217	152	0.00043	0.00057	0.00044	0.00048
123.55	52	139	68	149	102	0.00045	0.00050	0.00038	0.00045
124.00	52	140	68	150	102	0.00045	0.00050	0.00038	0.00045
228.00	35	109	45	117	76	0.00042	0.00049	0.00037	0.00043
229.00	35	109	45	117	77	0.00042	0.00049	0.00037	0.00043
230.00	57	177	75	189	124	0.00036	0.00049	0.00037	0.00041
231.00	72	220	94	235	155	0.00033	0.00048	0.00037	0.00039
232.00	77	238	101	254	168	0.00031	0.00047	0.00036	0.00038
233.00	84	257	110	275	181	0.00029	0.00045	0.00035	0.00036
234.00	69	216	91	231	152	0.00030	0.00043	0.00033	0.00035
235.00	58	184	76	197	129	0.00031	0.00041	0.00031	0.00034
236.00	51	163	67	174	114	0.00032	0.00040	0.00031	0.00034
237.00	34	111	44	118	77	0.00036	0.00039	0.00030	0.00035
238.00	23	82	31	87	56	0.00040	0.00039	0.00029	0.00036
239.00	24	84	32	90	57	0.00040	0.00039	0.00030	0.00036
240.10	30	102	39	109	70	0.00038	0.00040	0.00030	0.00036
240.20	27	95	36	102	65	0.00038	0.00039	0.00030	0.00036
240.30	23	82	31	87	56	0.00040	0.00039	0.00030	0.00036
240.40	20	71	27	76	49	0.00042	0.00039	0.00029	0.00037
240.50	18	65	24	69	44	0.00043	0.00038	0.00029	0.00037
240.60	17	61	23	65	42	0.00044	0.00038	0.00029	0.00037
241.10	16	57	21	61	39	0.00045	0.00038	0.00029	0.00038
241.20	16	55	20	59	37	0.00046	0.00038	0.00029	0.00038
242.00	20	52	26	55	38	0.00055	0.00038	0.00029	0.00041
243.00	13	31	18	33	24	0.00063	0.00038	0.00029	0.00043
244.00	33	54	43	57	47	0.00063	0.00042	0.00029	0.00045
245.00	56	78	73	84	73	0.00060	0.00040	0.00030	0.00043
246.00	124	116	162	123	131	0.00041	0.00063	0.00028	0.00044
247.00	77	110	100	117	101	0.00032	0.00060	0.00027	0.00040
248.00	479	415	627	444	491	0.00026	0.00061	0.00027	0.00038
249.00	213	215	279	230	234	0.00027	0.00049	0.00022	0.00033
250.00	304	264	399	283	313	0.00026	0.00045	0.00020	0.00031
251.00	747	601	979	642	742	0.00018	0.00039	0.00018	0.00025
252.00	61	91	80	97	82	0.00029	0.00035	0.00017	0.00027
253.00	13	26	18	27	21	0.00046	0.00043	0.00021	0.00037
AVERAGE	89	149	116	159	128	0.00040	0.00045	0.00031	0.00039

DLR 8-7-92

ASSUMED VALUES:

STREAMBED "n" =	0.040	
SHIELDS PARAMETER =	0.06	
D50 =	15	mm
D90 =	165	mm
SPECIFIC WEIGHT OF SEDIMENT =	165	pcf
SPECIFIC WEIGHT OF WATER =	62.4	pcf
KINEMATIC VISCOSITY =	0.00001	sq ft/s

HEC-2 HYDRAULIC CONDITIONS

HEC-2 CROSS SECTION	QCH (cfs)	Q (cfs)	K*CHSL (ft/ft)	10*KS (ft/ft)	DEPTH (ft)	VCH (fps)	AREA (sq ft)	TOPWIDTH (ft)
120.50	213345	215000	0.00	17.41	19.59	11.89	18210	1074
122.00	213288	215000	1.32	18.17	19.59	12.16	17822	1051
122.65	213262	215000	0.00	18.34	19.70	12.19	17770	1051
123.55	213320	215000	1.22	13.30	21.17	11.01	19666	1060
124.00	212917	215000	2.00	13.47	21.14	11.04	19641	1070
228.00	215000	215000	0.94	11.96	21.36	10.69	20106	963
229.00	215000	215000	1.05	11.91	21.41	10.69	20117	961
230.00	215000	215000	0.80	20.81	20.89	13.74	15653	770
231.00	215000	215000	1.00	27.23	20.86	15.56	13814	683
232.00	215000	215000	0.95	29.55	21.38	16.36	13141	636
233.00	215000	215000	1.04	31.98	21.87	17.15	12537	595
234.00	215000	215000	1.00	24.07	23.47	15.54	13837	613
235.00	215000	215000	1.00	19.02	24.58	14.24	15100	639
236.00	215000	215000	1.00	16.00	25.31	13.32	16137	663
237.00	215000	215000	1.03	9.83	26.41	10.85	19816	777
238.00	215000	215000	1.00	6.37	26.84	9.26	23221	892
239.00	220000	220000	1.09	6.50	26.62	9.31	23622	914
240.10	220000	220000	0.96	8.01	26.35	10.24	21489	842
240.20	220000	220000	0.94	7.16	26.90	9.82	22413	860
240.30	220000	220000	1.04	6.05	27.13	9.10	24183	918
240.40	220000	220000	0.94	5.19	27.31	8.47	25959	978
240.50	220000	220000	1.06	4.61	27.65	8.06	27290	1014
240.60	220000	220000	1.04	4.29	27.71	7.79	28224	1046
241.10	220000	220000	1.02	4.00	27.75	7.54	29161	1079
241.20	220000	220000	1.04	3.81	27.90	7.39	29766	1095
242.00	220000	220000	0.39	3.43	28.14	6.49	33899	1388
243.00	220000	220000	0.67	2.66	28.21	5.20	42333	1642
244.00	198201	220000	0.77	4.17	27.93	5.90	39517	1942
245.00	214331	220000	1.93	6.08	27.04	6.53	35399	2211
246.00	73571	220000	-0.35	3.03	27.92	4.11	17918	1076
247.00	74554	220000	0.73	4.20	27.64	5.11	14586	815
248.00	74554	220000	2.60	16.53	26.12	8.81	8462	590
249.00	74554	220000	1.01	22.22	26.37	9.78	7624	569
250.00	74687	220000	0.99	37.82	26.98	11.72	6375	539
251.00	78541	220000	1.00	108.37	30.16	20.01	3925	320
252.00	96968	220000	11.13	11.33	31.29	8.71	11131	580
253.00	96968	220000	9.45	2.89	26.53	4.56	21268	1070

CALCULATED HYDRAULIC VARIABLES

HEC-2 CROSS SECTION	AVERAGE CHANNEL DEPTH (ft)	CHANNEL SLOPE (ft/ft)	ENERGY SLOPE (ft/ft)	CRITICAL SHEAR STRESS (psf)	EFFECTIVE CHANNEL WIDTH (ft)	(Q/QCH)	SHEAR VELOCITY	REYNOLD NUMBER	REYNOLD NUMBER CHECK
120.50	16.96	0.00000	0.00174	2.13	930	1.01	1.05	5157	OK
122.00	16.95	0.00132	0.00182	2.22	910	1.01	1.07	5269	OK
122.65	16.90	0.00000	0.00183	2.25	902	1.01	1.08	5308	OK
123.55	18.55	0.00122	0.00133	1.76	929	1.01	0.95	4686	OK
124.00	18.35	0.00200	0.00135	1.78	929	1.01	0.96	4712	OK
228.00	20.88	0.00094	0.00120	1.59	941	1.00	0.91	4463	OK
229.00	20.93	0.00105	0.00119	1.59	940	1.00	0.91	4459	OK
230.00	20.33	0.00080	0.00208	2.71	749	1.00	1.18	5822	OK
231.00	20.22	0.00100	0.00272	3.54	662	1.00	1.35	6656	OK
232.00	20.66	0.00095	0.00296	3.94	615	1.00	1.43	7019	OK
233.00	21.07	0.00104	0.00320	4.36	573	1.00	1.50	7385	OK
234.00	22.57	0.00100	0.00241	3.53	590	1.00	1.35	6637	OK
235.00	23.63	0.00100	0.00190	2.92	614	1.00	1.23	6038	OK
236.00	24.34	0.00100	0.00160	2.53	638	1.00	1.14	5620	OK
237.00	25.51	0.00103	0.00098	1.62	750	1.00	0.91	4500	OK
238.00	26.03	0.00100	0.00064	1.07	865	1.00	0.74	3651	OK
239.00	25.84	0.00109	0.00065	1.08	887	1.00	0.75	3673	OK
240.10	25.52	0.00096	0.00080	1.32	816	1.00	0.82	4057	OK
240.20	26.06	0.00094	0.00072	1.20	833	1.00	0.79	3876	OK
240.30	26.33	0.00104	0.00061	1.02	891	1.00	0.73	3578	OK
240.40	26.55	0.00094	0.00052	0.88	951	1.00	0.68	3325	OK
240.50	26.90	0.00106	0.00046	0.80	987	1.00	0.64	3153	OK
240.60	26.97	0.00104	0.00043	0.74	1019	1.00	0.62	3045	OK
241.10	27.03	0.00102	0.00040	0.69	1051	1.00	0.60	2942	OK
241.20	27.19	0.00104	0.00038	0.66	1067	1.00	0.59	2879	OK
242.00	24.43	0.00039	0.00034	0.60	1205	1.00	0.56	2744	OK
243.00	25.77	0.00067	0.00027	0.47	1501	1.00	0.49	2419	OK
244.00	20.35	0.00077	0.00042	0.73	1415	1.11	0.61	3014	OK
245.00	16.01	0.00193	0.00061	1.03	1309	1.03	0.73	3581	OK
246.00	16.66	-0.00035	0.00030	0.53	642	2.99	0.52	2569	OK
247.00	17.90	0.00073	0.00042	0.72	528	2.95	0.61	3009	OK
248.00	14.35	0.00260	0.00165	2.69	324	2.95	1.18	5803	OK
249.00	13.41	0.00101	0.00222	3.66	289	2.95	1.37	6760	OK
250.00	11.84	0.00099	0.00378	6.37	236	2.95	1.81	8920	OK
251.00	12.27	0.00100	0.01084	20.40	130	2.80	3.24	15965	OK
252.00	19.19	0.01113	0.00113	2.21	356	2.27	1.07	5258	OK
253.00	19.88	0.00945	0.00029	0.48	802	2.27	0.50	2445	OK

LONG-TERM DEGRADATION/AGGRADATION

ARMORING AND EQUILIBRIUM SLOPE CALCULATIONS

HEC-2 CROSS SECTION	MEYER-PETER, MULLER (mm)	BOTTOM VELOCITY METHOD (mm)	SHIELD'S DIAGRAM (mm)	YANG INCIPIENT MOTION (mm)	AVERAGE ARMOR SIZE (mm)	SCHOK-LITSCH METHOD	MEYER-PETER, MULLER METHOD	SHIELD'S DIAGRAM METHOD	AVERAGE SLOPE (ft/ft)
120.50	88	216	115	231	162	0.00044	0.00061	0.00046	0.00050
122.00	82	206	107	220	154	0.00043	0.00059	0.00045	0.00049
122.65	82	203	107	217	152	0.00043	0.00057	0.00044	0.00048
123.55	52	139	68	149	102	0.00045	0.00050	0.00038	0.00045
124.00	52	140	68	150	102	0.00045	0.00050	0.00038	0.00045
228.00	53	164	69	175	115	0.00037	0.00050	0.00038	0.00041
229.00	49	153	64	163	107	0.00037	0.00048	0.00037	0.00041
230.00	82	249	107	266	176	0.00031	0.00048	0.00037	0.00039
231.00	129	384	169	410	273	0.00026	0.00048	0.00036	0.00037
232.00	110	335	145	357	237	0.00026	0.00043	0.00033	0.00034
233.00	74	232	97	248	163	0.00027	0.00039	0.00030	0.00032
234.00	50	162	66	173	113	0.00030	0.00037	0.00028	0.00032
235.00	45	146	59	156	101	0.00031	0.00037	0.00028	0.00032
236.00	41	133	54	142	93	0.00032	0.00036	0.00028	0.00032
237.00	28	93	37	100	64	0.00036	0.00036	0.00027	0.00033
238.00	20	70	26	75	47	0.00040	0.00036	0.00027	0.00034
239.00	20	72	27	77	49	0.00040	0.00036	0.00028	0.00035
240.10	25	89	33	95	60	0.00038	0.00037	0.00028	0.00034
240.20	24	83	31	89	57	0.00038	0.00037	0.00028	0.00034
240.30	20	72	27	77	49	0.00040	0.00036	0.00028	0.00035
240.40	18	63	23	67	43	0.00042	0.00036	0.00028	0.00035
240.50	16	58	21	62	39	0.00043	0.00036	0.00028	0.00036
240.60	15	54	20	58	37	0.00044	0.00036	0.00028	0.00036
241.10	14	51	19	55	35	0.00045	0.00036	0.00028	0.00036
241.20	14	49	18	53	33	0.00046	0.00036	0.00028	0.00037
242.00	17	45	22	48	33	0.00055	0.00036	0.00027	0.00040
243.00	12	27	15	29	21	0.00063	0.00036	0.00027	0.00042
244.00	28	47	36	50	40	0.00065	0.00040	0.00028	0.00044
245.00	46	68	61	73	62	0.00060	0.00038	0.00029	0.00042
246.00	105	102	137	109	113	0.00041	0.00061	0.00027	0.00043
247.00	72	104	94	111	95	0.00032	0.00059	0.00026	0.00039
248.00	493	424	646	453	504	0.00026	0.00061	0.00027	0.00038
249.00	212	214	278	228	233	0.00028	0.00049	0.00022	0.00033
250.00	304	264	398	282	312	0.00026	0.00045	0.00020	0.00031
251.00	747	601	979	642	742	0.00018	0.00039	0.00018	0.00025
252.00	61	91	80	97	82	0.00029	0.00035	0.00017	0.00027
253.00	13	26	18	27	21	0.00046	0.00043	0.00021	0.00037
AVERAGE	89	152	117	163	130	0.00039	0.00043	0.00030	0.00037

DLR 8-7-92

ASSUMED VALUES:

STREAMBED "n" =	0.040	
SHIELDS PARAMETER =	0.06	
D50 =	15	mm
D90 =	165	mm
SPECIFIC WEIGHT OF SEDIMENT =	165	pcf
SPECIFIC WEIGHT OF WATER =	62.4	pcf
KINEMATIC VISCOSITY =	0.00001	sq ft/s

DESIGN CONDITION	DOMINANT DISCHARGE (cfs)	ARMOR SIZE (mm) MEYER-PETER, MULLER	COMPETENT BOTTOM VELOCITY	SHIELD'S DIAGRAM	YANG INCIPIENT MOTION	STABLE SLOPE (ft/ft) SCHOKLITSCH METHOD	MEYER-PETER, MULLER	SHIELD'S DIAGRAM
10-YEAR BANK	93,000	89	152	117	163	0.00039	0.00043	0.00037
	215,000	88	221	115	236	0.00025	0.00034	0.00026
LEVEED 100-YEAR BANK	93,000	89	149	116	159	0.00040	0.00045	0.00031
	215,000	90	224	118	239	0.00022	0.00035	0.00025

DESIGN CONDITION	DOMINANT DISCHARGE (cfs)	MEAN ARMOR SIZE (mm)	MEAN STABLE SLOPE (ft/ft)
10-YEAR BANKS	93,000	130	0.00037
	215,000	165	0.00026
LEVEED 100-YEAR BANKS	93,000	128	0.00039
	215,000	168	0.00025
RECOMMENDED DESIGN	93,000	130	0.00037
	215,000	165	0.00025

ARMORING DEPTH:

ASSUMPTIONS: 1. 10% OF SEDIMENT GRADATION IS COARSER THAN ARMOR SIZE.

2. THE ARMOR LAYER IS COMPOSED OF TWO-LAYER THICKNESS OF NON-TRANSPORTABLE MATERIAL

DEPTH TO ARMOR:

$$Y_d = Y_a\left(\frac{1}{\Delta p} - 1\right)$$

Y_d = DEPTH OF DEGRADATION, DEPTH FROM ORIGINAL STREAMBED TO TOP OF ARMORING LAYER
Y_a = THICKNESS OF ARMOR LAYER = $2D_c$
Δp = DECIMAL PERCENTAGE OF ORIGINAL BED MATERIAL LARGER THAN ARMOR SIZE, D_c

Q = 93,000 cfs:

$$Y_d = 2\left(\frac{130}{304.8}\right)\left(\frac{1}{0.10} - 1\right)$$

$$Y_d = 1.68' \approx \underline{\underline{7.7\ ft}}$$

Q = 215,000 cfs:

$$Y_d = 2\left(\frac{165}{304.8}\right)\left(\frac{1}{0.10} - 1\right)$$

$$Y_d = 9.74' \approx \underline{\underline{9.7\ ft}}$$

REFERENCES: PEMBERTON E.L., LARA, J.M., BUREAU OF RECLAMATION, "COMPUTING DEGRADATION AND LOCAL SCOUR", TECHNICAL GUIDELINE, JANUARY 1984.

U.S. DEPARTMENT OF THE INTERIOR, BUREAU OF RECLAMATION, DESIGN OF SMALL DAMS, THIRD EDITION, 1987.

PROCEDURES: I) DEGRADATION LIMITED BY ARMORING —

1. MEYER-PETER, MULLER
2. COMPETENT BOTTOM VELOCITY
3. SHIELDS DIAGRAM
4. YANG INCIPIENT MOTION

II) DEGRADATION LIMITED BY STABLE SLOPE —

1. SCHOKLITSCH METHOD
2. MEYER-PETER, MULLER
3. SHIELDS DIAGRAM

MEYER-PETER, MULLER:

$$D_c = \frac{dS}{K\left(\frac{n_s}{D_{90}^{1/6}}\right)^{3/2}}$$

D_c = INDIVIDUAL PARTICLE SIZE (mm)
K = 0.19 (in-lb units)
d = DEPTH OVER CHANNEL BED @ DOMINANT DISCHARGE (ft)
S = SLOPE OF EGL (ft/ft)
n_s = MANNINGS "n" FOR STREAM BED
D_{90} = PARTICLE SIZE @ WHICH 90% OF BED MATERIAL IS FINER BY WEIGHT (mm)

$$D_c = \frac{17.19\,(0.00124)}{0.19\left(\frac{0.040}{(165)^{1/6}}\right)^{3/2}} = 50.3\text{ mm} \simeq \underline{\underline{50\text{ mm}}}$$

$$D_c = \frac{27.40\,(0.00118)}{0.19\left(\frac{0.040}{(165)^{1/6}}\right)^{3/2}} = 76.2\text{ mm} \simeq \underline{\underline{76\text{ mm}}}$$

COMPETENT BOTTOM VELOCITY:

$$D_c = 1.88\ V_m^2$$

D_c = ARMOR SIZE (mm)
V_m = MEAN CHANNEL VELOCITY (fps)

$$D_c = 1.88\ (9.27)^2 = 161.5$$

$$D_c \cong \underline{\underline{162\ mm}}$$

$$D_c = 1.88\ (12.13)^2 = 276.6$$

$$D_c \cong \underline{\underline{277\ mm}}$$

SHIELD'S DIAGRAM:

$$T_* = \frac{T_c}{(\gamma_s - \gamma_w) D_c} = 0.060$$

T_* = DIMENSIONLESS SHEAR STRESS
T_c = CRITICAL SHEAR STRESS = $\gamma_w d S$ (psf)
γ_s = SPECIFIC WEIGHT OF SEDIMENT (165 pcf)
γ_w = SPECIFIC WEIGHT OF WATER (62.4 pcf)
d = DEPTH OVER CHANNEL BED @ DOMINANT DISCHARGE (ft)

$$D_c = \frac{\gamma_w d S}{(\gamma_s - \gamma_w) T_*}$$

$$D_c = \frac{62.4\,(17.19)(0.00124)}{(165-62.4)(0.060)}$$

$$D_c = 0.22 \text{ ft} \approx \underline{\underline{66 \text{ mm}}}$$

$$D_c = \frac{62.4(27.40)(0.00118)}{(165-62.4)(0.060)}$$

$$D_c = 0.33 \text{ ft} \approx \underline{\underline{99 \text{ mm}}}$$

YANG INCIPIENT MOTION:

$$D_c = 0.00659\ V_{cr}^2$$

D_c = ARMOR SIZE (ft)
V_{cr} = CRITICAL AVERAGE WATER VELOCITY @ INCIPIENT MOTION (fps)

$$D_c = 0.00659(9.27)^2$$

$$D_c = 0.57\ ft \cong \underline{173\ mm}$$

$$D_c = 0.00659(12.13)^2$$

$$D_c = 0.97\ ft \cong \underline{296\ mm}$$

SCHOKLITSCH METHOD:

$$S_L = K\left(\frac{DB}{Q}\right)^{3/4}$$

S_L = STABLE SLOPE (ft/ft)
K = 0.00174 (in-lb units)
D = MEAN PARTICLE SIZE (mm)
B = CHANNEL WIDTH (ft)
Q = DOMINANT DISCHARGE (cfs)

$$S_L = 0.00174\left(\frac{15(601)}{93000}\right)^{3/4}$$

$$S_L = \underline{\underline{0.00030 \text{ ft/ft}}}$$

$$S_L = 0.00174\left(\frac{15(1712)}{215000}\right)^{3/4}$$

$$S_L = \underline{\underline{0.00035 \text{ ft/ft}}}$$

MEYER-PETER, MULLER METHOD:

$$S_L = \frac{K\left(\frac{Q}{Q_B}\right)\left(\frac{n_s}{D_{90}^{1/6}}\right)^{3/2} D}{d}$$

S_L = STABLE SLOPE (ft/ft)
K = 0.19 (IN-lb UNITS)
$\frac{Q}{Q_B}$ = RATIO OF TOTAL FLOW (cfs) TO FLOW OVER STREAM BED (cfs)
D_{90} = PARTICLE SIZE @ WHICH 90% OF BED MATERIAL IS FINER BY WEIGHT (mm)
n_s = MANNINGS "n" FOR STREAM BED
D = MEAN PARTICLE SIZE (mm)
d = DEPTH OVER CHANNEL BED @ DOMINANT DISCHARGE (ft)

$$S_L = \frac{0.19\,(1)\left(\frac{0.040}{165^{1/6}}\right)^{3/2}(15)}{17.19}$$

S_L = 0.00037 ft/ft

$$S_L = \frac{0.19\left(\frac{215000}{196323}\right)\left(\frac{0.040}{165^{1/6}}\right)^{3/2}(15)}{27.40}$$

S_L = 0.00025 ft/ft

SHIELD'S DIAGRAM METHOD:

$$R_* = \frac{U_* D}{\nu} \qquad T_* = \frac{T_c}{(\gamma_s - \gamma_w) D} = \frac{\gamma_w d S}{(\gamma_s - \gamma_w) D}$$

R_* = BOUNDARY REYNOLD'S NUMBER
U_* = SHEAR VELOCITY $(S_L R g)^{1/2}$ (ft/s)
S_L = SLOPE (ft/ft)
R = HYDRAULIC RADIUS OR DEPTH FOR WIDE CHANNELS (ft)
g = ACCELERATION DUE TO GRAVITY (32.2 ft/s²)
D = MEAN PARTICLE DIAMETER (ft)
ν = KINEMATIC VISCOSITY OF WATER (10^{-5} ft²/s)
T_* = DIMENSIONLESS SHEAR STRESS = 0.060
T_c = CRITICAL SHEAR STRESS (psf)
γ_s, γ_w = SPECIFIC WEIGHT OF SEDIMENT & PARTICLES (165, 62.4 pcf)
d = CHANNEL DEPTH @ DOMINANT DISCHARGE (ft)

$$R_* = \frac{[0.00124(17.19)32.2]^{1/2}\left(\frac{15}{304.8}\right)}{10^{-5}}$$

$$R_* = 4075 \checkmark$$

$$S_L = \frac{T_*(\gamma_s - \gamma_w)D}{\gamma_w d} = \frac{0.060(165-62.4)(15/304.8)}{62.4(17.19)}$$

$$S_L = \underline{0.00628 \text{ ft/ft}}$$

$$R_* = \frac{[0.001175(27.4)32.2]^{1/2}(15/304.8)}{10^{-5}}$$

$$R_* = 5011 \checkmark$$

$$S_L = \frac{0.060(165-62.4)(15/304.8)}{62.4(27.4)}$$

$$S_L = \underline{0.00018 \text{ ft/ft}}$$

GENERAL SCOUR

CROSS-SECTION NUMBER	INITIAL BED EL. (ft)	10-YR. BANKS MINIMUM BED EL. (ft)	10-YR. BANKS SCOUR DEPTH (ft)	100-YR. LEVEE MINIMUM BED EL. (ft)	100-YR. LEVEE SCOUR DEPTH (ft)	DESIGN MINIMUM BED EL. (ft)	DESIGN SCOUR DEPTH (ft)
120.5	1147.0	1147.00	0.00	1147.00	0.00	1147.0	0.0
122.0	1147.2	1147.95	0.75	1147.99	0.79	1148.0	0.8
122.6	1147.2	1146.93	-0.27	1146.92	-0.28	1146.9	-0.3
124.0	1147.4	1148.65	1.25	1148.96	1.56	1148.7	1.3
228.0	1147.7	1150.81	3.11	1150.42	2.72	1150.4	2.7
229.0	1148.1	1150.49	2.39	1150.50	2.40	1150.5	2.4
230.0	1148.4	1148.42	0.02	1148.30	-0.10	1148.3	-0.1
231.0	1148.8	1144.20	-4.60	1145.96	-2.84	1144.2	-4.6
232.0	1149.2	1144.73	-4.57	1145.73	-3.47	1144.7	-4.5
233.0	1149.6	1145.11	-4.49	1146.31	-3.29	1145.1	-4.5
234.0	1150.0	1145.40	-4.60	1146.02	-3.98	1145.4	-4.6
235.0	1150.4	1146.54	-3.86	1146.54	-3.86	1146.5	-3.9
236.0	1150.8	1147.38	-3.42	1147.28	-3.52	1147.3	-3.5
237.0	1151.2	1149.53	-1.67	1148.66	-2.54	1148.7	-2.5
238.0	1151.7	1150.21	-1.48	1149.51	-2.19	1149.5	-2.2
239.0	1152.2	1151.91	-0.29	1152.20	0.00	1151.9	-0.3
240.0	1152.7	1152.70	0.00	1152.70	0.00	1152.7	0.0
241.0	1153.2	1153.20	0.00	1153.20	0.00	1153.2	0.0
242.0	1150.0	1150.05	0.05	1150.05	0.05	1150.1	0.0
243.0	1140.0	1145.30	5.30	1145.08	5.08	1145.1	5.1
244.0	1150.0	1147.71	-2.29	1147.67	-2.33	1147.7	-2.3
245.0	1148.0	1148.12	0.12	1148.14	0.14	1148.1	0.1
246.0	1150.0	1154.47	4.47	1154.45	4.45	1154.5	4.5
247.0	1150.0	1146.76	-3.24	1146.78	-3.22	1146.8	-3.2
248.0	1142.0	1142.03	0.03	1142.03	0.03	1142.0	0.0
249.0	1142.0	1142.25	0.25	1142.26	0.26	1142.3	0.3
250.0	1150.0	1152.34	2.34	1152.32	2.32	1152.3	2.3
251.0	1150.0	1154.27	4.28	1153.82	3.82	1153.8	3.8
252.0	1164.0	1156.30	-7.70	1156.12	-7.88	1156.1	-7.9
253.0	1170.0	1162.02	-7.98	1162.01	-7.99	1162.0	-8.0
254.0	1138.5	1143.00	4.50	1143.00	4.50	1143.0	4.5
255.0	1148.1	1148.10	0.00	1148.10	0.00	1148.1	0.0
256.0	1150.0	1151.22	1.22	1151.19	1.19	1151.2	1.2
257.0	1157.5	1153.09	-4.41	1153.24	-4.26	1153.1	-4.4

BED-FORM SCOUR

HEC-2 CROSS-SECTION NUMBER	10-YR. BANKS					100-YR. LEVEE					DESIGN BED-FORM SCOUR (ft)
	MAXIMUM CONCEPT CHANNEL DEPTH (ft)	AVERAGE CHANNEL VELOCITY (ft/sec)	DUNE SCOUR (ft)	ANTIDUNE SCOUR (ft)	BED-FORM SCOUR (ft)	MAXIMUM CONCEPT CHANNEL DEPTH (ft)	AVERAGE CHANNEL VELOCITY (ft/sec)	DUNE SCOUR (ft)	ANTIDUNE SCOUR (ft)	BED-FORM SCOUR (ft)	
120.50	19.0	12.2	1.2	2.0	2.0	19.6	11.9	1.2	1.9	1.9	2.0
122.00	19.0	12.5	1.2	2.1	2.1	19.6	12.2	1.2	2.0	2.0	2.1
122.65	19.2	12.5	1.2	2.1	2.1	19.7	12.2	1.2	2.0	2.0	2.1
123.55	21.1	11.0	1.3	1.6	1.6	21.2	11.0	1.3	1.7	1.7	1.7
124.00	21.1	11.0	1.3	1.7	1.7	21.1	11.0	1.3	1.7	1.7	1.7
228.00	21.3	10.7	1.3	1.6	1.6	21.4	10.7	1.3	1.6	1.6	1.6
229.00	21.3	11.3	1.3	1.7	1.7	21.4	10.7	1.3	1.6	1.6	1.7
230.00	21.0	14.4	1.3	2.8	2.8	20.9	13.7	1.3	2.6	2.6	2.8
231.00	18.8	22.9	1.1	7.2	7.2	20.9	15.6	1.3	3.3	3.3	7.2
232.00	23.4	18.7	1.5	4.8	4.8	21.4	16.4	1.3	3.7	3.7	4.8
233.00	26.9	13.3	1.8	2.4	2.4	21.9	17.2	1.4	4.0	4.0	4.0
234.00	27.4	12.1	1.8	2.0	2.0	23.5	15.5	1.5	3.3	3.3	3.3
235.00	27.7	11.6	1.8	1.8	1.8	24.6	14.2	1.6	2.8	2.8	2.8
236.00	27.7	11.3	1.8	1.7	1.8	25.3	13.3	1.6	2.4	2.4	2.4
237.00	28.2	9.7	1.9	1.3	1.9	26.4	10.9	1.7	1.6	1.7	1.9
238.00	28.3	8.5	1.9	1.0	1.9	26.8	9.3	1.7	1.2	1.7	1.9
239.00	28.0	8.6	1.8	1.0	1.8	26.6	9.3	1.7	1.2	1.7	1.8
240.10	27.6	9.8	1.8	1.3	1.8	26.4	10.2	1.7	1.4	1.7	1.8
241.10	28.8	7.3	1.9	0.7	1.9	27.8	7.5	1.8	0.8	1.8	1.9
242.00	29.1	6.2	1.9	0.5	1.9	28.1	6.5	1.9	0.6	1.9	1.9
243.00	29.2	5.0	1.9	0.3	1.9	28.2	5.2	1.9	0.4	1.9	1.9
244.00	28.9	5.7	1.9	0.4	1.9	27.9	5.9	1.8	0.5	1.8	1.9
245.00	27.9	6.2	1.8	0.5	1.8	27.0	6.5	1.8	0.6	1.8	1.8
246.00	28.6	4.7	1.9	0.3	1.9	27.9	4.2	1.8	0.2	1.8	1.9
247.00	28.5	4.3	1.9	0.3	1.9	27.6	5.2	1.8	0.4	1.8	1.9
248.00	26.9	7.3	1.8	0.7	1.8	26.1	8.9	1.7	1.1	1.7	1.8

I) 10-YEAR BANK HYDRAULIC CONDITIONS:

DEPTH = 27.4 ft
AVERAGE VELOCITY = 12.1 fps

DUNE SCOUR:

$$A = 0.0655\, d^{1.209} \quad \text{(ALLEN, 1963)}$$

$$A = 0.0655\,(27.4)^{1.209}$$

$$A = 3.6 \text{ ft}$$

$$Y_s = \tfrac{1}{2}(3.6') = \underline{1.8 \text{ ft}}$$

ANTIDUNE SCOUR:

$$Y_s = \left(\frac{V}{8.56}\right)^2 \quad \text{(ADWR, 1985)}$$

$$Y_s = \left(\frac{12.1}{8.56}\right)^2$$

$$Y_s = \underline{2.0 \text{ ft}}$$

II) 100-YEAR LEVEE HYDRAULIC CONDITIONS:

DEPTH = 23.5 ft
AVERAGE VELOCITY = 15.5 fps

DUNE SCOUR: $Y_s = \tfrac{1}{2}\left(0.0655(23.5)^{1.209}\right)$

$$Y_s = \underline{1.5 \text{ ft}}$$

ANTIDUNE SCOUR: $Y_s = \left(\frac{15.5}{8.56}\right)^2$

$$Y_s = \underline{3.3 \text{ ft}}$$

DESIGN FOR MAXIMUM BEDFORM SCOUR DEPTH = 3.3 ft

MINING COMPONENT

HEC-2 CROSS-SECTION NUMBER	DESIGN INVERT ELEV. (ft)	PIT INVERT ELEV. (ft)	PIT DEPTH (ft)	LATERAL MIGRATION COMPONENT (ft)
120.50	1147.0	N/A	N/A	0.0
122.00	1147.2	N/A	N/A	0.0
122.65	1147.2	N/A	N/A	0.0
123.55	1147.3	N/A	N/A	0.0
124.00	1147.4	N/A	N/A	0.0
228.00	1147.7	1137.5	10.2	2.5
229.00	1148.1	1136.8	11.3	2.8
230.00	1148.4	1140.6	7.8	2.0
231.00	1148.8	1116.0	32.8	8.2
232.00	1149.2	1117.2	32.0	8.0
233.00	1149.6	1127.3	22.3	5.6
234.00	1150.0	1128.6	21.4	5.4
235.00	1150.4	1119.9	30.5	7.6
236.00	1150.8	1123.9	26.9	6.7
237.00	1151.2	1119.0	32.2	8.1
238.00	1151.7	1123.9	27.8	7.0
239.00	1152.2	1144.7	7.5	1.9
240.00	1152.7	1143.3	9.4	2.3
241.00	1153.2	1145.0	8.2	2.0
242.00	1153.7	1147.2	6.5	1.6
243.00	1154.2	1139.7	14.5	3.6
244.00	1154.7	1140.3	14.4	3.6
245.00	1155.2	1147.7	7.5	1.9
246.00	1155.8	1150.1	5.7	1.4
247.00	1156.3	1147.4	8.9	2.2
248.00	1157.0	1145.8	11.2	2.8

sla
SIMONS, LI & ASSOCIATES, INC.

CLIENT ADOT/DMJM
PROJECT LATERAL MIGRATION COMPONENT
DETAIL EXAMPLE CALC @ 234

JOB NO. AZ-DMJM-03
DATE CHECKED
CHECKED BY

PAGE
DATE 8-7-92
COMPUTED BY JRM

DESIGN INVERT ELEV. = 1150.0 ft
PIT INVERT ELEV. = 1128.6 ft

PIT DEPTH = 21.4 ft

LATERAL MIGRATION COMPONENT = 1/4 (21.4)
= 5.4 ft

LOCAL SCOUR

10–YEAR BANK PROTECTION HYDRAULIC CONDITIONS

EFFECTIVE PIER WIDTH = 13 ft

HEC–2 CROSS–SECTION NUMBER	CONCEPT INVERT ELEV. (ft)	PIT INVERT ELEV. (ft)	MAXIMUM CONCEPT CHANNEL DEPTH (ft)	AVERAGE CHANNEL VELOCITY (ft/sec)	PIER SCOUR w/o PITS (ft)	PIT FLOW DEPTH (ft)	PIT FLOW VELOCITY (ft/sec)	PIER SCOUR w/ PITS (ft)
120.5	1147.0	N/A	19.0	12.2	24.1	N/A	N/A	N/A
122.0	1147.2	N/A	19.0	12.5	24.3	N/A	N/A	N/A
122.7	1147.2	N/A	19.2	12.5	24.4	N/A	N/A	N/A
123.6	1147.3	N/A	21.1	11.0	23.4	N/A	N/A	N/A
124.0	1147.4	N/A	21.1	11.0	23.4	N/A	N/A	N/A
228.0	1147.7	1137.5	21.3	10.7	23.1	31.5	7.2	20.6
229.0	1148.1	1136.8	21.3	11.3	23.7	32.6	7.4	20.9
230.0	1148.4	1140.6	21.0	14.4	26.2	28.8	10.5	23.9
231.0	1148.8	1116.0	18.8	22.9	31.5	51.5	8.3	23.4
232.0	1149.2	1117.2	23.4	18.7	29.8	55.4	7.9	23.1
233.0	1149.6	1127.3	26.9	13.3	26.2	49.2	7.3	22.0
234.0	1150.0	1128.6	27.4	12.1	25.3	48.8	6.8	21.3
235.0	1150.4	1119.9	27.7	11.6	24.8	58.2	5.5	19.9
236.0	1150.8	1123.9	27.7	11.3	24.6	54.6	5.7	20.1
237.0	1151.2	1119.0	28.2	9.7	23.0	60.4	4.5	18.4
238.0	1151.7	1123.9	28.3	8.5	21.8	56.1	4.3	17.8
239.0	1152.2	1144.7	28.0	8.6	N/A	N/A	N/A	N/A
240.1	1152.8	1143.3	27.6	9.8	23.0	37.1	7.3	21.1
241.1	1153.2	1145.0	28.8	7.3	20.4	37.0	5.7	18.9
242.0	1153.4	1147.2	29.1	6.2	19.1	35.3	5.1	18.1

100-YEAR LEVEED HYDRAULIC CONDITIONS

EFFECTIVE PIER WIDTH = 13 ft

HEC-2 CROSS-SECTION NUMBER	CONCEPT INVERT ELEV. (ft)	PIT INVERT ELEV. (ft)	MAXIMUM CONCEPT CHANNEL DEPTH (ft)	AVERAGE CHANNEL VELOCITY (ft/sec)	PIER SCOUR w/o PITS (ft)	PIT FLOW DEPTH (ft)	PIT FLOW VELOCITY (ft/sec)	PIER SCOUR w/ PITS (ft)
120.5	1147.0	N/A	19.6	11.9	23.9	N/A	N/A	N/A
122.0	1147.2	N/A	19.6	12.2	24.2	N/A	N/A	N/A
122.7	1147.2	N/A	19.7	12.2	24.2	N/A	N/A	N/A
123.6	1147.3	N/A	21.2	11.0	23.4	N/A	N/A	N/A
124.0	1147.4	N/A	21.1	11.0	23.4	N/A	N/A	N/A
228.0	1147.7	1137.5	21.4	10.7	23.1	31.6	7.2	20.6
229.0	1148.1	1136.8	21.4	10.7	23.1	32.7	7.0	20.4
230.0	1148.4	1140.6	20.9	13.7	25.7	28.7	10.0	23.4
231.0	1148.8	1116.0	20.9	15.6	27.1	53.7	6.0	20.5
232.0	1149.2	1117.2	21.4	16.4	27.8	53.4	6.6	21.2
233.0	1149.6	1127.3	21.9	17.2	28.4	44.2	8.5	23.1
234.0	1150.0	1128.6	23.5	15.5	27.5	44.9	8.1	22.7
235.0	1150.4	1119.9	24.6	14.2	26.7	55.1	6.4	21.0
236.0	1150.8	1123.9	25.3	13.3	26.0	52.2	6.5	21.0
237.0	1151.2	1119.0	26.4	10.9	24.0	58.6	4.9	18.9
238.0	1151.7	1123.9	26.8	9.3	22.4	54.6	4.5	18.2
239.0	1152.2	1144.7	26.6	9.3	N/A	N/A	N/A	N/A
240.1	1152.8	1143.3	26.4	10.2	23.4	35.8	7.5	21.3
241.1	1153.2	1145.0	27.8	7.5	20.6	36.0	5.8	19.1
	1153.4	1147.2	28.1	6.5	19.4	34.3	5.3	18.3

HYDRAULICS @ SECNO. 231: VCH = 22.9 fps (10YRBANK.DAT)
DEPTH = 18.8 ft

CSU EQN: (HEC-18)

$$Y_s = 2.2 \left(\frac{a}{Y_1}\right)^{0.65} F_r^{0.43} Y_1$$

WHERE: Y_s = LOCAL PIER SCOUR DEPTH, ft
a = EFFECTIVE PIER WIDTH, ft
Y_1 = FLOW DEPTH U/S OF PIER, ft
F_r = FROUDE NUMBER

a = 9' ϕ PIER + 4' DEBRIS = 13'

$$Y_s = 2.2 \left(\frac{13}{18.8}\right)^{0.65} \left[\frac{22.9}{(32.2(18.8))^{1/2}}\right]^{0.43} (18.8)$$

Y_s = 31.5 ft

CALCULATE PIER SCOUR USING PIT HYDRAULICS:

CONCEPT INVERT ELEV. = 1148.8'
PIT INVERT ELEV. = 1116.0'

PIT DEPTH = 32.8'
FLOW DEPTH = 18.8'

TOTAL PIT FLOW DEPTH = 51.6 ft

PIT FLOW VELOCITY = 22.9 fps (18.8/51.6) = 8.3 fps

$$Y_s = 2.2\left(\frac{13}{51.6}\right)^{0.65}\left[\frac{8.3}{(32.2(51.6))^{1/2}}\right]^{0.43}(51.6)$$

$$Y_s = \underline{\underline{23.4 \text{ ft}}}$$

CALCULATE PIER SCOUR ELEV:

TOTAL SCOUR @ PIER = 16.2' + 1.3(31.5) = 57.2 ft

CONCEPT INVERT ELEV. = 1148.8 ft
TOTAL SCOUR @ PIER = 57.2 ft

PIER SCOUR ELEV. = 1091.6 ft

FOR PIT HYDRAULIC CONDITIONS:

PIT INVERT ELEV. = 1116.0
TOTAL SCOUR @ PIER = 1.3(23.4) = 30.4

PIER SCOUR ELEV. = 1085.6 ft

BRIDGE GEOMETRY:

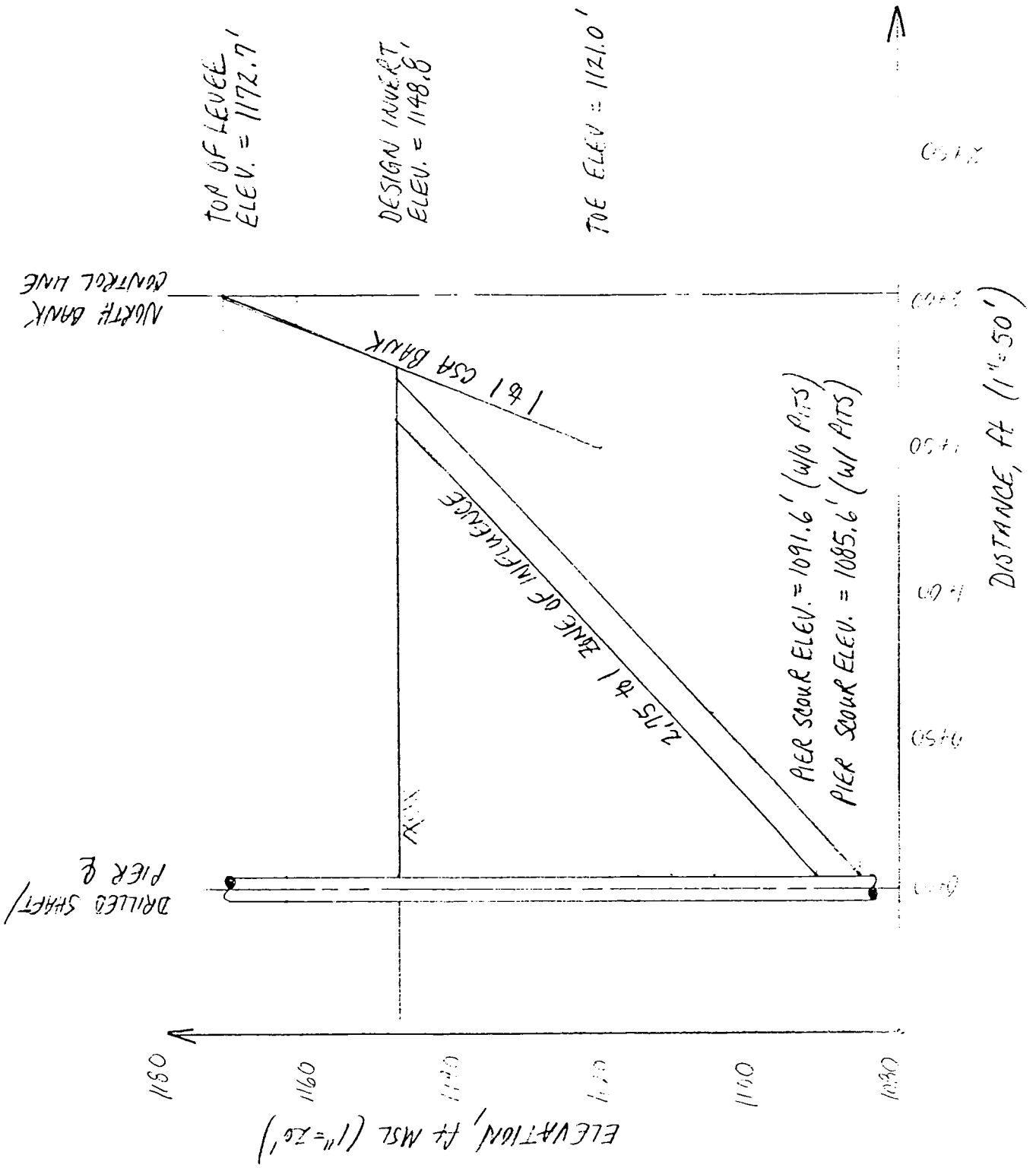
HEC-2 CROSS SECTION 231 = N. BRIDGE STA. 17+96

AASHTO ALTERNATE — STA. 17+82

W.B. PIER #17 (NORTH) IS 202 ft FROM THE CENTER OF THE PIER COLUMN TO THE NORTH LANE CENTERLINE.

sla
SIMONS, LI & ASSOCIATES, INC.

CLIENT ADOT / DMVM	JOB NO. AZ-DMVM-03	PAGE 3/3	
PROJECT EAST PAPAGO FWY	DATE CHECKED	DATE 8-9-92	
DETAIL PIER SCOUR @ XSEC 231	CHECKED BY	COMPUTED BY JRM	



HYDRAULICS @ SEC NO. 233: VCH = 17.2 fps (LEVEE.DAT)
DEPTH = 21.9 ft

CSU EQN: (HEC-18)

$$Y_S = 2.2 \left(\frac{a}{Y_1}\right)^{0.65} F_r^{0.43} Y_1$$

WHERE: Y_S = LOCAL PIER SCOUR DEPTH, ft
a = EFFECTIVE PIER WIDTH, ft
Y_1 = FLOW DEPTH UPSTREAM OF PIER, ft
F_r = FROUDE NUMBER

a = 9' ϕ PIER + 4' DEBRIS = 13 ft

$$Y_S = 2.2 \left(\frac{13}{21.9}\right)^{0.65} \left[\frac{17.2}{(32.2(21.9))^{1/2}}\right]^{0.43} (21.9)$$

Y_S = 28.4 ft

CALCULATE PIER SCOUR USING PIT HYDRAULICS:

CONCEPT INVERT ELEV. = 1149.6'
PIT INVERT ELEV. = 1127.3'

PIT DEPTH = 22.3'
FLOW DEPTH = 21.9

TOTAL PIT FLOW DEPTH = 44.2 ft

PIT FLOW VELOCITY = 17.2 fps (21.9/44.2)
= 8.5 fps

$$Y_s = 2.2\left(\frac{13}{44.2}\right)^{0.65}\left[\frac{8.5}{(32.2(44.2))^{1/2}}\right]^{0.43}(44.2)$$

$$Y_s = \underline{\underline{23.1\ ft}}$$

CALCULATE PIER SCOUR ELEV:

TOTAL SCOUR @ PIER = 12.8' + 1.3(28.4) = 49.7 ft

CONCEPT INVERT ELEV. = 1149.6'
TOTAL SCOUR @ PIER = − 49.7'

PIER SCOUR ELEV. = 1099.9 ft

FOR PIT HYDRAULIC CONDITIONS:

PIT INVERT ELEV. = 1127.3'
TOTAL SCOUR @ PIER = 1.3(23.1) = − 30.0

PIER SCOUR ELEV. = 1097.3 ft

BRIDGE GEOMETRY:

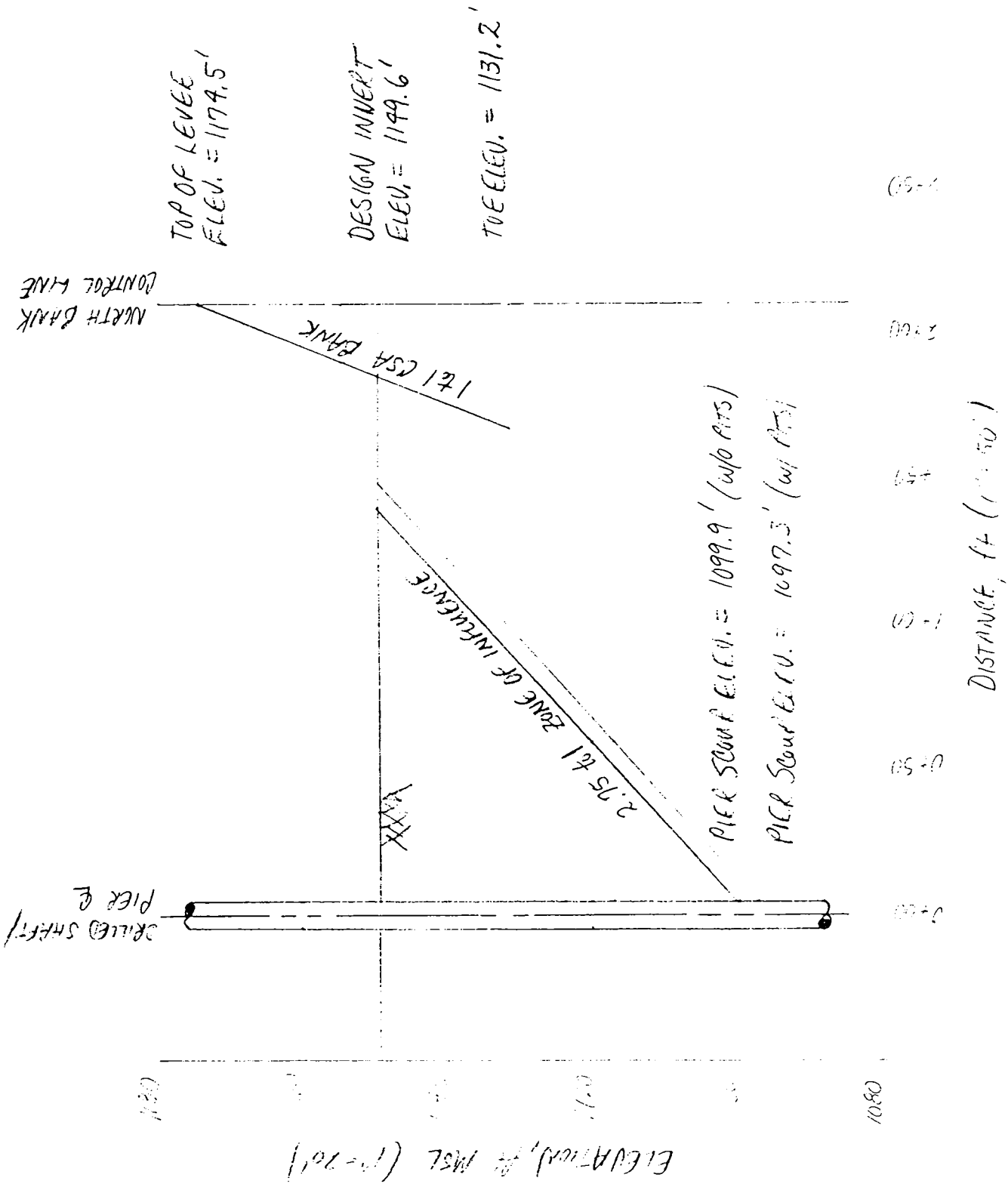
HEC-2 CROSS SECTION 233 = N. BANK STA. 26+60

AASHTO ALTERNATE — STA. 26+22

W.B. PIER # 23 (NORTH) IS 210 ft FROM THE CENTER OF THE PIER COLUMN TO THE NORTH BANK CONTROL LINE.

sla
SIMONS, LI & ASSOCIATES, INC.

CLIENT ADOT / DMJM	JOB NO. AZ-DMJM-03	PAGE 3/3	
PROJECT EAST PARAGO FWY.	DATE CHECKED	DATE 8-9-92	
DETAIL PIER SCOUR @ XSEC 233	CHECKED BY	COMPUTED BY JRM	



Simons, Li & Associates, Inc.
Water Resources & Civil Engineering Consultants

August 11, 1992

Mr. Thomas M. Monchak
Daniel, Mann, Johnson & Mendenhall
300 West Clarendon Avenue, Suite 335
Phoenix, Arizona 85013

RE: BANK PROTECTION TOE-DOWN DEPTHS

Dear Tom:

As you are aware the toe-down depths shown on the north hardbank plans are not as deep as the toe-down depths recommended for this reach of the Salt River. The differences can be attributed to the following factors. First, the toe-down depths included on the plans do not include a scour component to account for lateral migration of the pits. Secondly, the recommended toe-down depths, including a component for lateral migration of pits, were being finalized at the same time the plans were being prepared.

The north hardbank plans were prepared using toe-down depths of 15 feet below the proposed channel design invert for Station 30+65 through Station 100+65. The toe-down depths for the section from Station 17+00 through Station 25+00 were estimated to be deeper due to the existing pits near the bank. These depths were established in meetings between SLA and DMJM in late July, and were considered to be a conservative estimate of the total scour depth for standard scour components (i.e., long-term degradation, general scour, low-flow incisement, bed-forms, local scour, and a factor of safety). However, these estimates did not include the added toe-down depth required for lateral migration of pits.

The table of recommended toe-down depths furnished to DMJM on August 7, 1992 provided the total toe-down depth which is the sum of the standard toe-down depth and the mining (lateral migration) toe-down depth. Although the standard toe-down depth were less than 15 feet for Station 26+60 through Station 100+65, the total toe-down depth was greater for many of the stations due to the addition of mining toe-down depths. These recommended toe-down depths were established with the assumption that the criteria for toe-downs in the vicinity of sand and gravel mining pits was acceptable to the Flood Control District.

In addition to the above two factors, another factor contributed to some minor differences between the toe-downs shown on the plans and the recommended toe-down depths. It was our understanding that all pits within 150 feet of the bank would be filled to the design channel invert elevation with a 3:1 fill slope beyond that point. The criteria for establishing bank protection toe-down depths in the vicinity of sand and gravel mining pits was developed based on this concept. If this concept is not being used, the toe-down depths recommended must be reviewed.

4600 South Mill Avenue, Suite 190 • Tempe, AZ 85282 • Phone: (602) 491-1393 • Fax: (602) 491-1396
An Equal Opportunity Employer

For instance, at Station 32+00, the required toe-down elevation would be 1128 feet if fill extended 150 feet. If fill is not placed for this distance, the required toe-down would be approximately 130.8 feet. Furthermore, if this is not the concept being used, the criteria proposed in our July 29, 1992 letter for determining lateral migration toe-down depths must be re-examined.

Finally, the establishment of scour depths and preparation of bank protection plans is an iterative process. As alignments are shifted, bank configurations modified, or other concepts altered; the hydraulic conditions change which result in modifications to scour depths. This requires close coordination and good communication among the team members. I feel that our team (DMJM, SLA, GF, etc.) has done an excellent job of coordination and communication, especially when you consider the constraints, changing conditions, and tight schedule.

If you have any questions regarding the establishment of toe-down depths or need additional information, please feel free to call me.

Sincerely,

SIMONS, LI & ASSOCIATES, INC.

Dennis L. Richards

Dennis L. Richards, P.E.
Vice President

DLR:cia

(PAZ-DMJM-03.25)

PAZ - DMJM. AZ 25

FLOOD CONTROL DISTRICT
of
Maricopa County

2801 West Durango Street • Phoenix, Arizona 85009
Telephone (602) 506-1501
Fax (602) 506-4601
TDD (602) 506-5897

BOARD OF DIRECTORS

P. Ben Arredondo
Betsey Bayless
James D. Bruner
Carole Carpenter
Tom Freestone

AUG 1 1 1992

Mr. Thomas M. Monchak, P.E.
Project Manager
Daniel, Mann, Johnson & Mendenhall
300 West Clarendon Avenue, Suite 335
Phoenix, Arizona 85013

SUBJECT: Salt River Channel East of McClintock Drive - Bank Protection Toe-Down Depths

Dear Mr. Monchak:

The Flood Control District has reviewed its copy of the July 29, 1992 letter to you from Dennis L. Richards, of Simons, Li & Associates, Inc. (SLA), in which Mr. Richards presents recommendations and criteria for the establishment of bank protection toe-down depths in the vicinity of sand and gravel mining pits for the subject project.

The District is of the opinion that the recommendations and criteria presented by SLA are reasonable. They should be used in conjunction with the criteria outlined in Attachment A of the Letter of Intent for the final design of the levee protection being done by SLA.

If you have any questions, please call me or Warren Rosebraugh at 506-1501.

Sincerely,

Donald J. Rerick
Project Manager

Copies to: Dennis L. Richards, SLA
Michael Shapiro, DMJM
Steve Jimenez, ADOT/UHS

Simons, Li & Associates, Inc.
Water Resources & Civil Engineering Consultants

September 8, 1992

Mr. Thomas M. Monchak
Daniel, Mann, Johnson & Mendenhall
300 West Clarendon Avenue, Suite 335
Phoenix, Arizona 85013

RE: CALCULATIONS TO SUPPORT SALT RIVER BANK PROTECTION DESIGN

Dear Tom:

Enclosed are bank stability calculations and additional scour calculations for the proposed Salt River bank protection for the reach from McClintock Drive to upstream of the Pima Freeway. These calculations supplement the scour calculations transmitted with our August 10, 1992 letter.

Tables 1.0 and 2.0 provide the minimum bank protection toe-down elevation for the north and south banks, respectively. These tables provide the bank station, design invert elevation, the value for each of the standard scour components, the standard toe-down depth, the mining toe-down condition (i.e., 1, 2, or 3), the lateral migration component, the minimum toe-down depth, and the minimum toe-down elevation.

The local pier scour table was expanded to include the total pier scour expected at the bridge piers. Immediately upstream of McClintock Drive along the north bank and near the west end of the south bank, local scour due to bridge piers controls the minimum bank protection toe-down elevations. Pier scour calculations at HEC-2 cross section number 237.0 are provided.

We have also evaluated the 2' minimum toe-down depth of the backslope CSA shown on the north hardbank plans, and determined that a 2' minimum toe-down is sufficient. Although there is a length of bank that is approximately 18-feet in height on the back side, the majority of the bank with CSA on the backslope is much less in height. The estimated depth of scour due to overtopping is less than 2-feet. Scour due to overtopping was estimated using the Veronese Equation (from "Computing Degradation and Local Scour", Technical Guideline for Bureau of Reclamation, January 1984) and assuming no tailwater. Since the volume north of the bank and below the 10-year bank elevation is relatively small (approximately 33,300 cu. yd.), the tailwater elevation will increase and ponding will occur in a very short time period.

4600 South Mill Avenue, Suite 190 • Tempe, AZ 85282 • Phone: (602) 491-1393 • Fax: (602) 491-1396
An Equal Opportunity Employer

If you have any questions or need additional information regarding the enclosed calculations, please feel free to call me.

Sincerely,

SIMONS, LI & ASSOCIATES, INC.

Dennis L. Richards

Dennis L. Richards, P.E.
Vice President

DLR:cia
Enclosures

cc: Ray Jordan w/enclosures - ADOT
Don Rerick w/enclosures - FCD

(PAZ-DMJM-03.25)

Table 1.0 North Bank Protection Toe-Down Elevations

NORTH BANK STATION	HEC-2 CROSS SECTION NUMBER	DESIGN INVERT ELEV. (ft)	LONG-TERM DEGRADATION (ft)	GENERAL SCOUR (ft)	LOW-FLOW INCISEMENT (ft)	BED-FORM SCOUR (ft)	FACTOR OF SAFETY (ft)	STANDARD TOE-DOWN DEPTH (ft)
224+84	120.50	1147.0	0.0	0.3	2.0	2.0	0.7	5.0
226+36	122.00	1147.2	0.1	0.3	2.0	2.0	0.7	5.1
227+24	122.65	1147.2	0.1	0.3	2.0	2.0	0.7	5.1
228+14	123.55	1147.3	0.2	0.3	2.0	2.0	0.8	5.3
228+59	124.00	1147.4	0.2	0.3	2.0	2.0	0.8	5.3
230+58	228.00	1147.7	0.4	0.3	2.0	2.0	0.8	5.5
234+65	229.00	1148.1	0.7	0.3	2.0	2.0	0.9	5.9
14+15	230.00	1148.4	0.9	4.6	2.0	5.0	3.2	15.7
17+96	231.00	1148.8	1.1	4.6	2.0	5.0	3.2	15.9
22+70	232.00	1149.2	1.4	4.6	2.0	5.0	3.3	16.3
26+60	233.00	1149.6	1.6	4.6	2.0	2.0	2.5	12.7
30+65	234.00	1150.0	1.9	4.6	2.0	2.0	2.6	13.1
34+71	235.00	1150.4	2.2	4.6	2.0	2.0	2.6	13.4
38+77	236.00	1150.8	2.4	4.6	2.0	2.0	2.7	13.7
42+85	237.00	1151.2	2.6	2.5	2.0	2.0	2.1	11.2
47+75	238.00	1151.7	3.0	2.5	2.0	2.0	2.3	11.8
52+57	239.00	1152.2	3.2	2.5	2.0	2.0	2.3	12.0
56+89	240.00	1152.7	3.5	2.5	2.0	2.0	2.4	12.4
62+06	241.00	1153.2	3.9	2.5	2.0	2.0	2.5	12.9
66+11	242.00	1153.7	4.2	2.5	2.0	2.0	2.6	13.3
71+36	243.00	1154.2	4.5	2.5	2.0	2.0	2.7	13.7
76+70	244.00	1154.7	4.8	2.5	2.0	2.0	2.8	14.1
80+59	245.00	1155.2	5.2	2.5	2.0	2.0	2.9	14.6
85+19	246.00	1155.8	5.5	2.5	2.0	2.0	3.0	15.0
91+30	247.00	1156.3	5.8	2.5	2.0	2.0	3.1	15.4
100+65	248.00	1157.0	6.2	0.0	2.0	2.0	2.5	12.7

Table 1.0 North Bank Protection Toe-Down Elevations (cont.)

NORTH BANK STATION	HEC-2 CROSS SECTION NUMBER	STANDARD TOE-DOWN DEPTH (ft)	MINING TOE-DOWN CONDITION	LATERIAL MIGRATION COMPONENT (ft)	CATCH POINT ELEV. (ft)	CATCH POINT ELEV. STATION	MINIMUM ELEV. CRITERIA (ft)	MINIMUM TOE-DOWN DEPTH (ft)	MINIMUM TOE-DOWN ELEV. (ft)
224+84	120.50	5.0	3	0.0				5.0	1142.0
226+36	122.00	5.1	3	0.0				5.1	1142.1
227+24	122.65	5.1	3	0.0				5.1	1142.1
228+14	123.55	5.3	3	0.0				5.3	1142.0
228+59	124.00	5.3	3	0.0				5.3	1142.1
230+58	228.00	5.5	PIER	2.6			1112.1	35.6	1112.1
234+65	229.00	5.9	2	2.8				8.7	1139.4
14+15	230.00	15.7	2	2.0				17.7	1130.7
17+96	231.00	15.9	1	8.2	1124.0	19+00	1121.0	27.8	1121.0
22+70	232.00	16.3	1	8.0	1124.0	23+00	1121.0	28.2	1121.0
26+60	233.00	12.7	1	5.6	1139.0	27+00	1136.0	18.3	1131.3
30+65	234.00	13.1	1	5.4	1132.0	31+00	1129.0	21.0	1129.0
34+71	235.00	13.4	2	7.6				21.0	1129.4
38+77	236.00	13.7	2	6.7				20.4	1130.4
42+85	237.00	11.2	2	8.1				19.3	1131.9
47+75	238.00	11.8	2	6.9				18.7	1133.0
52+57	239.00	12.0	2	1.9				13.9	1138.3
56+89	240.00	12.4	1	2.4	1148.0	57+00	1145.0	14.8	1137.9
62+06	241.00	12.9	3	N/A				12.9	1140.3
66+11	242.00	13.3	2	1.6				14.9	1138.8
71+36	243.00	13.7	2	3.6				17.3	1136.9
76+70	244.00	14.1	2	3.6				17.7	1137.0
80+59	245.00	14.6	2	1.9				16.5	1138.7
85+19	246.00	15.0	2	1.4				16.4	1139.4
91+30	247.00	15.4	2	2.2				17.6	1138.7
100+65	248.00	12.7	2	2.8				15.5	1141.5

Table 2.0 South Bank Protection Toe-Down Elevations

SOUTH BANK STATION	HEC-2 CROSS SECTION NUMBER	DESIGN INVERT ELEV. (ft)	LONG-TERM DEGRADATION (ft)	GENERAL SCOUR (ft)	LOW-FLOW INCISEMENT (ft)	BED-FORM SCOUR (ft)	FACTOR OF SAFETY (ft)	STANDARD TOE-DOWN DEPTH (ft)
39+46	236.00	1150.8	2.4	4.6	2.0	2.0	2.7	13.7
43+51	237.00	1151.2	2.6	2.5	2.0	2.0	2.1	11.2
48+96	238.00	1151.7	3.0	2.5	2.0	2.0	2.3	11.8
22+01	239.00	1152.2	3.2	2.5	2.0	2.0	2.3	12.0
27+74	240.00	1152.7	3.5	2.5	2.0	2.0	2.4	12.4
32+80	241.00	1153.2	3.9	2.5	2.0	2.0	2.5	12.9

SOUTH BANK STATION	HEC-2 CROSS SECTION NUMBER	STANDARD TOE-DOWN DEPTH (ft)	MINING TOE-DOWN CONDITION	LATERIAL MIGRATION COMPONENT (ft)	CATCH POINT ELEV. (ft)	CATCH POINT ELEV. STATION	MINIMUM ELEV. CRITERIA (ft)	MINIMUM TOE-DOWN DEPTH (ft)	MINIMUM TOE-DOWN ELEV. (ft)
39+46	236.00	13.7	PIER	6.7			1103.3	47.5	1103.3
43+51	237.00	11.2	PIER	8.1			1106.8	44.4	1106.8
48+96	238.00	11.8	1	7.0	1132.5	49+00	1129.5	22.2	1129.5
22+01	239.00	12.0	1	1.9	1147.0	22+00	1144.0	13.9	1138.3
27+74	240.00	12.4	3	N/A				12.4	1140.3
32+80	241.00	12.9	3	N/A				12.9	1140.3

10-YEAR BANK PROTECTION HYDRAULIC CONDITIONS

EFFECTIVE PIER WIDTH = 13 ft

HEC-2 CROSS-SECTION NUMBER	CONCEPT INVERT ELEV. (ft)	PIT INVERT ELEV. (ft)	MAXIMUM CONCEPT CHANNEL DEPTH (ft)	AVERAGE CHANNEL VELOCITY (ft/sec)	PIER SCOUR w/o PITS (ft)	PIT FLOW DEPTH (ft)	PIT FLOW VELOCITY (ft/sec)	PIER SCOUR w/ PITS (ft)
120.5	1147.0	N/A	19.0	12.2	24.1	N/A	N/A	N/A
122.0	1147.2	N/A	19.0	12.5	24.3	N/A	N/A	N/A
122.7	1147.2	N/A	19.2	12.5	24.4	N/A	N/A	N/A
123.6	1147.3	N/A	21.1	11.0	23.4	N/A	N/A	N/A
124.0	1147.4	N/A	21.1	11.0	23.4	N/A	N/A	N/A
228.0	1147.7	1137.5	21.3	10.7	23.1	31.5	7.2	14.7
229.0	1148.1	1136.8	21.3	11.3	23.7	32.6	7.4	15.0
230.0	1148.4	1140.6	21.0	14.4	26.2	28.8	10.5	17.1
231.0	1148.8	1116.0	18.8	22.9	31.5	51.5	8.3	16.8
232.0	1149.2	1117.2	23.4	18.7	29.8	55.4	7.9	16.5
233.0	1149.6	1127.3	26.9	13.3	26.2	49.2	7.3	15.7
234.0	1150.0	1128.6	27.4	12.1	25.3	48.8	6.8	15.3
235.0	1150.4	1119.9	27.7	11.6	24.8	58.2	5.5	14.2
236.0	1150.8	1125.0	27.7	11.3	24.6	53.5	5.9	14.5
237.0	1151.2	1125.0	28.2	9.7	23.0	54.4	5.0	13.6
238.0	1151.7	1125.0	28.3	8.5	21.8	55.0	4.4	12.8
239.0	1152.2	1144.7	28.0	8.6	N/A	N/A	N/A	N/A
240.0	1152.7	1143.3	27.6	9.8	23.0	37.0	7.3	15.1
241.0	1153.2	1145.0	28.8	7.3	20.4	37.0	5.7	13.6
242.0	1153.7	1147.2	29.1	6.2	19.1	35.6	5.1	12.9

100-YEAR LEVEED HYDRAULIC CONDITIONS

EFFECTIVE PIER WIDTH = 13 ft

HEC-2 CROSS-SECTION NUMBER	CONCEPT INVERT ELEV. (ft)	PIT INVERT ELEV. (ft)	MAXIMUM CONCEPT CHANNEL DEPTH (ft)	AVERAGE CHANNEL VELOCITY (ft/sec)	PIER SCOUR w/o PITS (ft)	PIT FLOW DEPTH (ft)	PIT FLOW VELOCITY (ft/sec)	PIER SCOUR w/ PITS (ft)
120.5	1147.0	N/A	19.6	11.9	23.9	N/A	N/A	N/A
122.0	1147.2	N/A	19.6	12.2	24.2	N/A	N/A	N/A
122.7	1147.2	N/A	19.7	12.2	24.2	N/A	N/A	N/A
123.6	1147.3	N/A	21.2	11.0	23.4	N/A	N/A	N/A
124.0	1147.4	N/A	21.1	11.0	23.4	N/A	N/A	N/A
228.0	1147.7	1137.5	21.4	10.7	23.1	31.6	7.2	14.8
229.0	1148.1	1136.8	21.4	10.7	23.1	32.7	7.0	14.6
230.0	1148.4	1140.6	20.9	13.7	25.7	28.7	10.0	16.7
231.0	1148.8	1116.0	20.9	15.6	27.1	53.7	6.0	14.7
232.0	1149.2	1117.2	21.4	16.4	27.8	53.4	6.6	15.2
233.0	1149.6	1127.3	21.9	17.2	28.4	44.2	8.5	16.5
234.0	1150.0	1128.6	23.5	15.5	27.5	44.9	8.1	16.3
235.0	1150.4	1119.9	24.6	14.2	26.7	55.1	6.4	15.0
236.0	1150.8	1125.0	25.3	13.3	26.0	51.1	6.6	15.1
237.0	1151.2	1125.0	26.4	10.9	24.0	52.6	5.4	14.0
238.0	1151.7	1125.0	26.8	9.3	22.4	53.5	4.6	13.1
239.0	1152.2	1144.7	26.6	9.3	N/A	N/A	N/A	N/A
240.0	1152.8	1143.3	26.4	10.2	23.4	35.8	7.5	15.3
241.0	1153.2	1145.0	27.8	7.5	20.6	36.0	5.8	13.7
242.0	1153.4	1147.2	28.1	6.5	19.4	34.3	5.3	13.1

TOTAL PIER SCOUR DEPTHS & ELEVATIONS

HEC-2 CROSS-SECTION NUMBER	STANDARD TOE-DOWN DEPTH (ft)	10-YEAR BANK HYDRAULICS				100-YEAR LEVEE HYDRAULICS				DESIGN PIER SCOUR ELEVATION (ft)
		TOTAL PIER SCOUR W/O PITS (ft)	TOTAL PIER SCOUR W/ PITS (ft)	PIER SCOUR ELEVATION W/O PITS (ft)	PIER SCOUR ELEVATION W/ PITS (ft)	TOTAL PIER SCOUR W/O PITS (ft)	TOTAL PIER SCOUR W/ PITS (ft)	PIER SCOUR ELEVATION W/O PITS (ft)	PIER SCOUR ELEVATION W/ PITS (ft)	
120.5	5.0	36.4	N/A	1110.6	N/A	36.1	N/A	1110.9	N/A	1110.6
122.0	5.1	36.7	N/A	1110.5	N/A	36.5	N/A	1110.7	N/A	1110.5
122.7	5.1	36.8	N/A	1110.4	N/A	36.6	N/A	1110.6	N/A	1110.4
123.6	5.3	35.7	N/A	1111.6	N/A	35.7	N/A	1111.6	N/A	1111.6
124.0	5.3	35.7	N/A	1111.7	N/A	35.8	N/A	1111.6	N/A	1111.6
228.0	5.5	35.6	19.2	1112.1	1118.3	35.6	19.2	1112.1	1118.3	1112.1
229.0	5.9	36.7	19.4	1111.4	1117.4	36.0	19.0	1112.1	1117.8	1111.4
230.0	15.7	49.8	22.2	1098.6	1118.4	49.1	21.8	1099.3	1118.8	1098.6
231.0	15.9	56.9	21.8	1091.9	1094.2	51.1	19.1	1097.7	1096.9	1091.9
232.0	16.3	55.0	21.5	1094.2	1095.7	52.4	19.7	1096.8	1097.5	1094.2
233.0	12.7	46.8	20.4	1102.8	1106.9	49.7	21.5	1099.9	1105.8	1099.9
234.0	13.1	45.9	19.8	1104.1	1108.8	48.9	21.2	1101.1	1107.4	1101.1
235.0	13.4	45.6	18.5	1104.8	1101.4	48.1	19.6	1102.3	1100.3	1100.3
236.0	13.7	45.6	18.8	1105.2	1106.2	47.5	19.7	1103.3	1105.3	1103.3
237.0	11.2	41.1	17.6	1110.1	1107.4	42.3	18.2	1108.9	1106.8	1106.8
238.0	11.8	40.1	16.7	1111.6	1108.3	41.0	17.0	1110.7	1108.0	1108.0
239.0	12.0	12.0	N/A	1140.2	N/A	12.0	N/A	1140.2	N/A	1140.2
240.0	12.4	42.3	19.6	1110.4	1123.7	42.8	19.9	1110.0	1123.4	1110.0
241.0	12.9	39.4	17.6	1113.8	1127.4	39.7	17.8	1113.5	1127.2	1113.5
242.0	13.3	38.2	16.8	1115.5	1130.4	38.5	17.0	1114.9	1130.2	1114.9

HYDRAULICS @ SECNO. 237.0:

VCH = 10.9 fps (LEVEE.DAT)
DEPTH = 26.4 ft

CSU EQN: (HEC-18)

$$Y_S = 2.2\left(\frac{a}{Y_1}\right)^{0.65} F_r^{0.43}\, Y_1$$

WHERE: Y_S = LOCAL PIER SCOUR DEPTH, ft
a = EFFECTIVE PIER WIDTH
Y_1 = FLOW DEPTH U/S OF PIER
F_r = FROUDE NUMBER

a = 9' ø PIER + 4' DEBRIS = 13'

$$Y_S = 2.2\left(\frac{13}{26.4}\right)^{0.65}\left(\frac{10.9}{(32.2(26.4))^{1/2}}\right)^{0.43}(26.4)$$

Y_S = 24.0 ft

CALCULATE PIER SCOUR ELEV:

STANDARD TOE-DOWN DEPTH = 11.2'
TOTAL PIER SCOUR = 1.3(24) = 31.2'

TOTAL SCOUR @ PIER = 42.4'

DESIGN INVERT ELEV = 1151.2'
TOTAL SCOUR @ PIER = 42.4'

TOTAL PIER SCOUR ELEV. = 1108.8 ft

CALCULATE PIER SCOUR USING PIT HYDRAULICS:

DUE TO STRUCTURAL EXCAVATION FOR THE NUMEROUS PIER COLUMNS AND CHANNEL INVERT MODIFICATIONS TO ENABLE DRILLED SHAFT CONSTRUCTION, ASSUME THE MINIMUM PIT INVERT ELEV. TO BE 1125.0 ft.

DESIGN INVERT ELEV. = 1152.2'
PIT INVERT ELEV. = −1125.0'

PIT DEPTH = 27.2'
FLOW DEPTH = 26.4'

TOTAL PIT FLOW DEPTH = 53.6 ft

PIT FLOW VELOCITY = 10.9 fps (26.4/53.6) = 5.4 fps

IT IS NOT CONSIDERED REALISTIC THAT DEBRIS WOULD IMPACT PIER SCOUR FOR THE ENTIRE PIT FLOW DEPTH. THEREFORE, THE CSU EQUATION IS REVISED TO:

$$Y_S = 2.0 \left(\frac{a}{Y_1}\right)^{0.65} F_r^{0.43} Y_1$$

$$Y_S = 2.0 \left(\frac{a}{53.6}\right)^{0.65} \left[\frac{5.4}{(32.2(53.6))^{2}}\right]^{0.43} (53.6)$$

$$Y_S = \underline{\underline{14.0 \text{ ft}}}$$

CALCULATE PIER SCOUR ELEV:

TOTAL SCOUR @ PIER = (1.2)(14) = 18.2 ft

PIT INVERT ELEV. = 1125.0'
TOTAL SCOUR @ PIER = −18.2'

PIER SCOUR ELEV = 1106.8 ft

SUMMARY:

	W/ PITS	W/O PITS
PREDICTED TOTAL SCOUR ELEVATION @ THE PIERS	1106.8'	1108.8'

RECOMMENDED DESIGN PIER SCOUR ELEV. = 1106.8 ft

THE SOUTH BANK PROTECTION TOE-DOWN ELEVATION @ THE EAST ABUTMENT OF THE EAST PAPAGO FWY IS 1103.5 ft. THE CURRENT TOE-DOWN DESIGN WILL PROVIDE THE MINIMUM 1.5 FACTOR OF SAFETY AS REQUIRED IN ATTACHMENT A OF THE LETTER OF INTENT.

FLOOD CONTROL DISTRICT
of
Maricopa County

2801 West Durango Street • Phoenix, Arizona 85009
Telephone (602) 506-1501
Fax (602) 506-4601
TDD (602) 506-5897

RECEIVED SEP 2 3 1992

BOARD OF DIRECTORS

P. Ben Arredondo
Betsey Bayless
James D. Bruner
Carole Carpenter
Tom Freestone

SEP 2 1 1992

Mr. Dennis L. Richards, P.E.
Vice President
Simons, Li & Associates, Inc.
4600 South Mill Avenue, Suite 190
Tempe, Arizona 85282

SUBJECT: Salt River Channel - East of McClintock Drive;
Slope Stability Calculations Submittal

Dear Mr. Richards:

The Flood Control District has reviewed the slope stability calculations for the subject project and has found them to be acceptable.

The only comment we have pertains to the lack of checkers initials at the top of each page of the calculations. Given the urgency to complete our review in order to meet ADOT project schedule, the District reviewed the calculations in spite of this omission. In the future, submittals of calculations must have each page initialed and dated by the originator and the checker.

If you have any questions, please call me or Warren Rosebraugh at 506-1501.

Sincerely,

Donald J. Rerick
Project Manager

Copies to: Thomas Monchak, DMJM
Steve Jimenez, ADOT/UHS

sla Simons, Li & Associates, Inc.
Water Resources & Civil Engineering Consultants

October 9, 1992

Mr. Thomas M. Monchak
Daniel, Mann, Johnson & Mendenhall
300 West Clarendon Avenue, Suite 335
Phoenix, Arizona 85013

RE: RESPONSES TO FCD COMMENTS - SALT RIVER CHANNEL

Dear Tom:

This letter addresses four comments furnished by the Flood Control District of Maricopa County (FCD) regarding the Salt River channel plans, specifications, and calculations. They are as follows:

1. Two foot (2') minimum toe-down depth of the backslope CSA;
2. Treatment of levee embankment backslope;
3. Maintenance roads and ramps to the south levee; and
4. Extension of the south levee further west.

Backslope Toe-Down

We evaluated the 2' minimum toe-down depth of the backslope CSA shown on the north hardbank plans, and determined that a 2' minimum toe-down is sufficient. Although there is a length of bank that is approximately 18-feet in height on the back side, the majority of the bank with CSA on the backslope is much less in height. The estimated depth of scour due to overtopping is less than 2-feet. Scour due to overtopping was estimated using the Veronese Equation (from "Computing Degradation and Local Scour", Technical Guideline for Bureau of Reclamation, January 1984) and assuming no tailwater. Since the volume north of the bank and below the 10-year bank elevation is relatively small (approximately 33,300 cu. yd.), the tailwater elevation will increase and ponding will occur in a very short time period.

Levee Embankment Backslope Protection

Based on discussions with ADOT staff, it was concluded that for the 10-year north bank (Station 13+80 to Station 31+00) treatment of the levee embankment backslope would not be cost effective. It was recognized that should flows exceed the 10-year level, there may be some erosion of the backslope. However, maintenance should be minimal and the CSA structure would not be threatened.

For those sections of CSA bank with 100-year protection, the top of the bank slopes at a 1 percent slope toward the Salt River, and the main cause of erosion will be rain falling directly on the embankment. In addition, there is some uncertainty as to if and when the Indian

4600 South Mill Avenue, Suite 190 • Tempe, AZ 85282 • Phone: (602) 491-1393 • Fax: (602) 491-1396
An Equal Opportunity Employer

Community might fill behind the 100-year bank. The area east of the East Papago Freeway abutment and behind the south hardbank will be filled in conjunction with construction of the Red Mountain Traffic Interchange (RMTI).

South Levee Maintenance Roads and Ramps

We reviewed the possibility of including maintenance roads and ramps along the south bank between the RMTI and the west end of the bank protection and determined it would be very difficult to include any ramps in this section of bank protection. There are several bridge piers located along or near the bank as well as a curve in the bank alignment. We would recommend that a ramp be located just to the west of the current bank protection terminus. Concepts have previously been developed for maintenance roads along the south bank and were submitted to the Outer Loop (RMTI) design team for review and comment.

Extension of the South Levee

We evaluated extending the west end of the south levee an additional 800-feet. This would extend 100-year bank protection to a point where the 10-year bank protection alignment and the proposed 100-year bank alignment begin to diverge. This additional length of 100-year bank protection does not significantly reduce the quantity of flow which splits to the south.

If you have any questions or need additional information regarding the issues addressed herein, please feel free to call me.

Sincerely,

SIMONS, LI & ASSOCIATES, INC.

Dennis L. Richards

Dennis L. Richards, P.E.
Vice President

DLR:cia

cc: Steve Jimenez

(PAZ-DMJM-05)

HEC-2 CROSS-SECTION	PIMAZ.DAT CWSEL ①	NEW TOP OF LEVEE ELEV. ②	ORIGINAL LEVEE ELEV. ③	ADDITIONAL FREEBOARD REQUIRED	ORIGINAL LEVEE CURRENT FREEBOARD	NEW CST. ℄ STATION ④	ORIGINAL CST. ℄ STATION
239	1178.82	1181.8	1181.8	~~0~~	3.0	52+51	52+57
240	1179.36	1182.4	1182.1	+0.3'	2.7	56+89	56+89
241	1179.85	1182.9	1184.0	-1.1'	4.1	61+87	62+06
242	1180.01	1183.0	1184.5	-1.5'	4.5	66+72	66+11

NOTES:

① LEVEED NORTH AND SOUTH BANKS WHICH INCLUDES LANDFILL REMOVAL AT SOUTH BANK (LEVEE.DAT)

② PIMAZ.DAT CWSEL + 3' FREEBOARD

③ APRIL 1992 LEVEE ELEV'S PROVIDED TO DMJM FOR DESIGN. ASSUMES CHANNELIZED LEVEED NORTH AND SOUTH BANKS.

④ NEW NORTH BANK CST. ℄ ALIGNMENT PROVIDED 5-6-94 BY DMJM. (1ST REVISION).

⑤ D/S SIDE OF RAMP S-W IS AT STA. 58+86 ±. FEMA 4' FREEBOARD TO STA 57+86 ±.

61+87	1182.9
57+86 →	1182.5 + 1' = 1183.5'
56+89	1182.4

SIMONS, LI & ASSOCIATES, INC.

CLIENT ADOT/DMJM
PROJECT NORTH BANK TERMINATION
DETAIL LEVEE HEIGHT
JOB NO. AZ-DMJM-05
DATE CHECKED
CHECKED BY DEQ
PAGE
DATE 5-19-94
COMPUTED BY VRM

SIMONS, LI & ASSOCIATES, INC.

CLIENT: ADOT / DMM
PROJECT:
DETAIL:
JOB NO. AZ-DMM-05
DATE CHECKED:
CHECKED BY:
PAGE 1/1
DATE 5-9-94
COMPUTED BY VRM

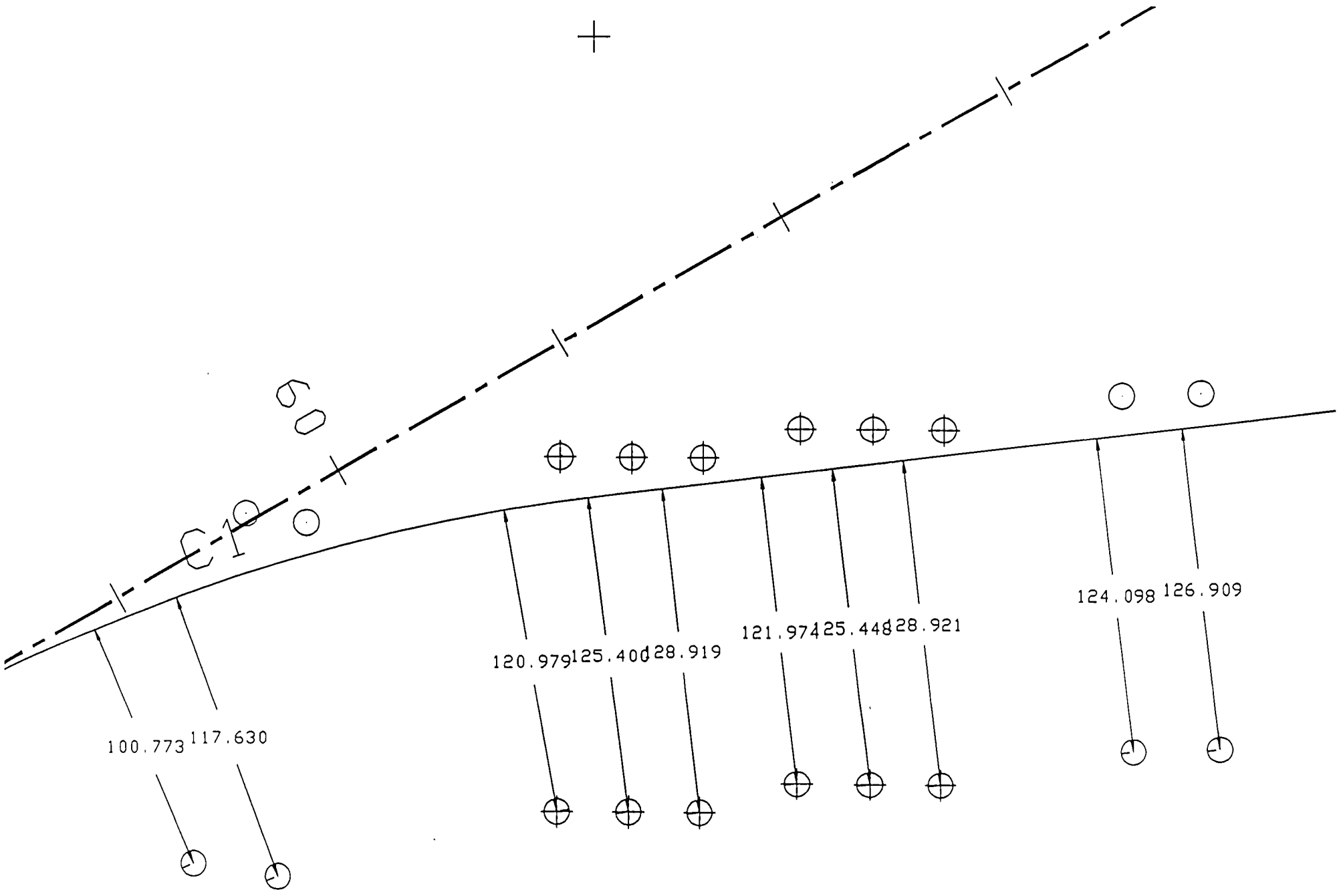
STRUCTURE	COLUMN	STATION	DIST. (a) ①	LEVEE ELEV. (ft)	DIST. (b)	INTERSECTION (x) ②	INTERSECTION ELEV. (ft)	
RAMP S-W	WEST	58+86	100.8	1182.82	67.52	59.9	1122.9	X
	EAST	59+21	117.6	1182.95	67.65	50.5	1132.4	
PIMA FWY S.B.	WEST	60+54	121.0	1183.44	68.14	49.4	1134.1	
	MIDDLE	60+87	125.4	1183.56	68.26	47.0	1136.5	X
	EAST	61+16	128.9	1183.67	68.37	45.2	1138.5	
PIMA FWY. E.B.	WEST	61+55	122.0	1183.81	68.51	49.4	1134.4	
	MIDDLE	61+83	125.5	1183.92	68.62	47.6	1136.4	
	EAST	62+11	128.9	1184.01	68.71	45.7	1138.3	X
RAMP E-W	WEST	62+87	124.1	1184.10	68.80	48.6	1135.5	
	EAST	63+20	126.9	1184.14	68.84	47.1	1137.1	X

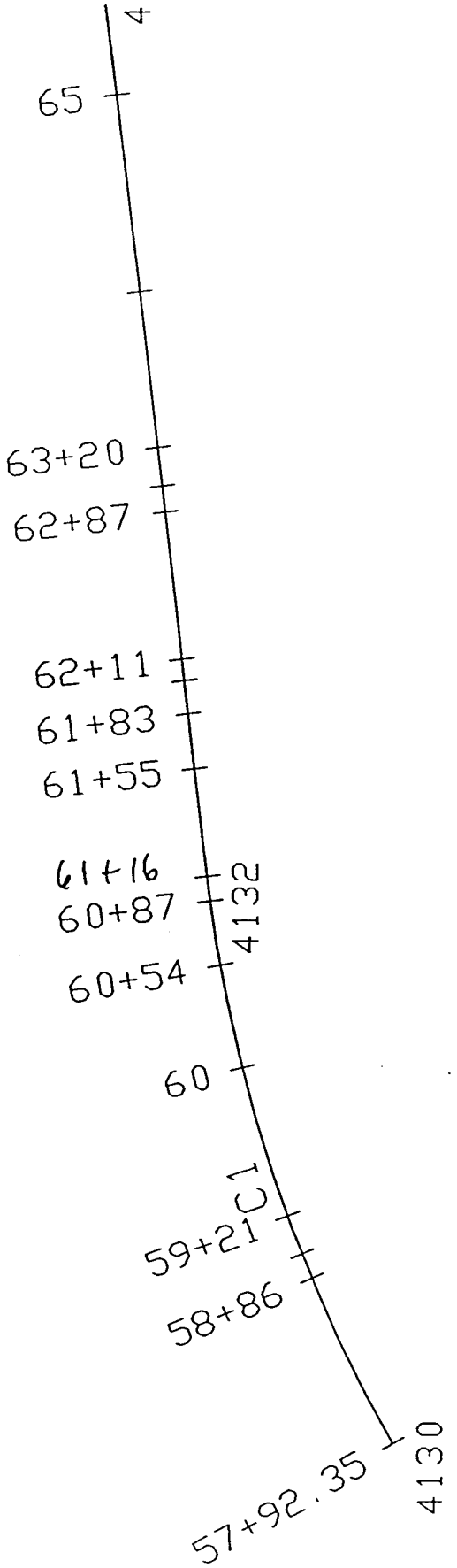
NOTES:

① ACCESS RAMP UNDER STRUCTURES REDUCES DIST (a) BY 15' (WIDTH OF RAMP).

② CONSERVATIVELY ASSUMES 10' Ø COLUMNS / DRILLED SHAFTS FOR ALL PIER COLUMNS.

DESIGN: TOE-DOWN ELEVATION OF 1134' THROUGH STRUCTURES.


60
C10
100.773
117.630
120.979
125.400
128.919
121.974
125.448
128.921
124.098
126.909


4
65
63+20
62+87
62+11
61+83
61+55
61+16
60+87
4132
60+54
60
C1
59+21
58+86
57+92.35
4130

$X = (T - Y)$ = HORIZONTAL DIST. TO TOE (1:1 Slope)

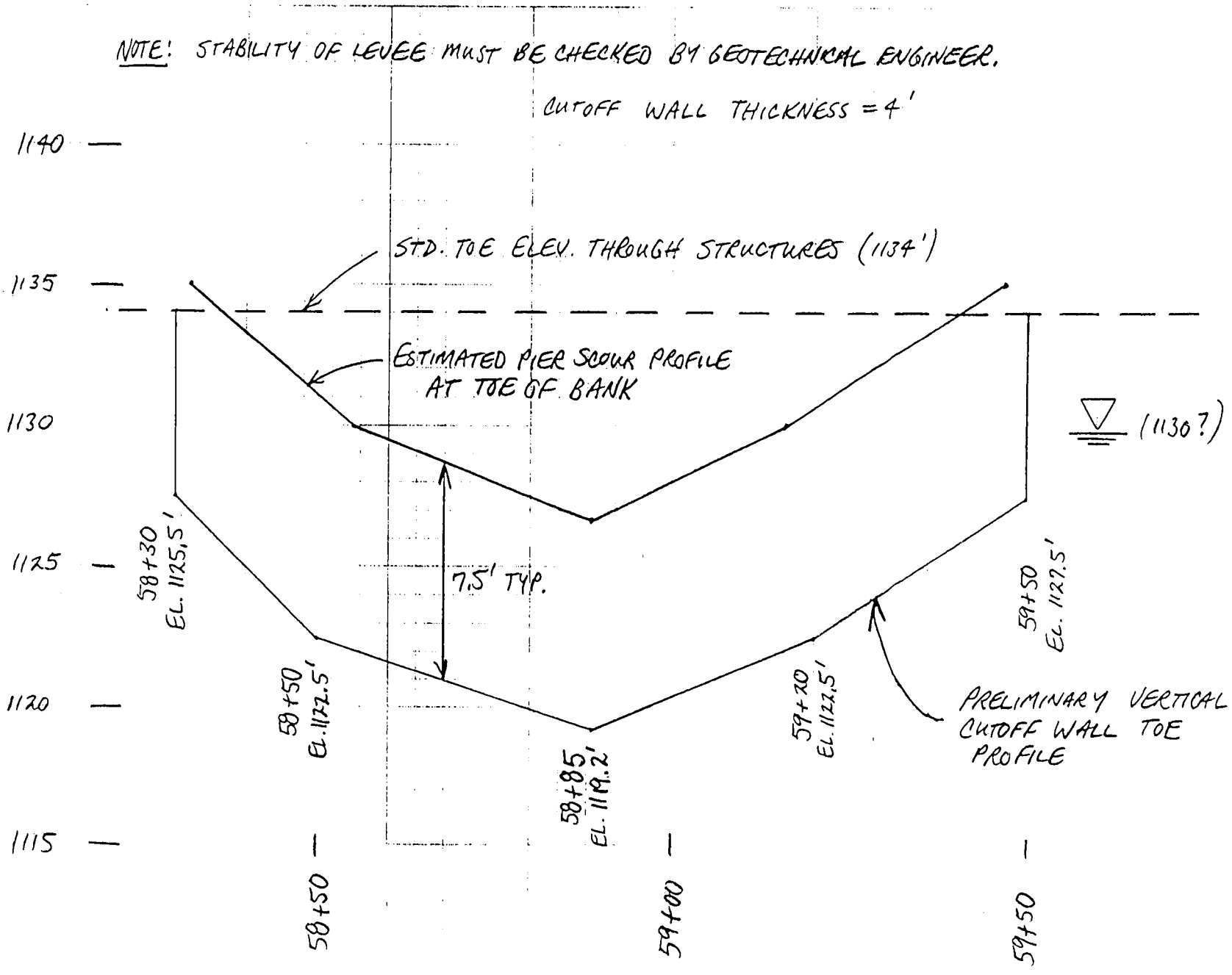
WHERE: T = TOP OF BANK ELEV.
Y = DESIGN TOE-DOWN ELEV.

① MUST INCLUDE RAMP WIDTH (15') ADDED TO X WHERE APPLICABLE

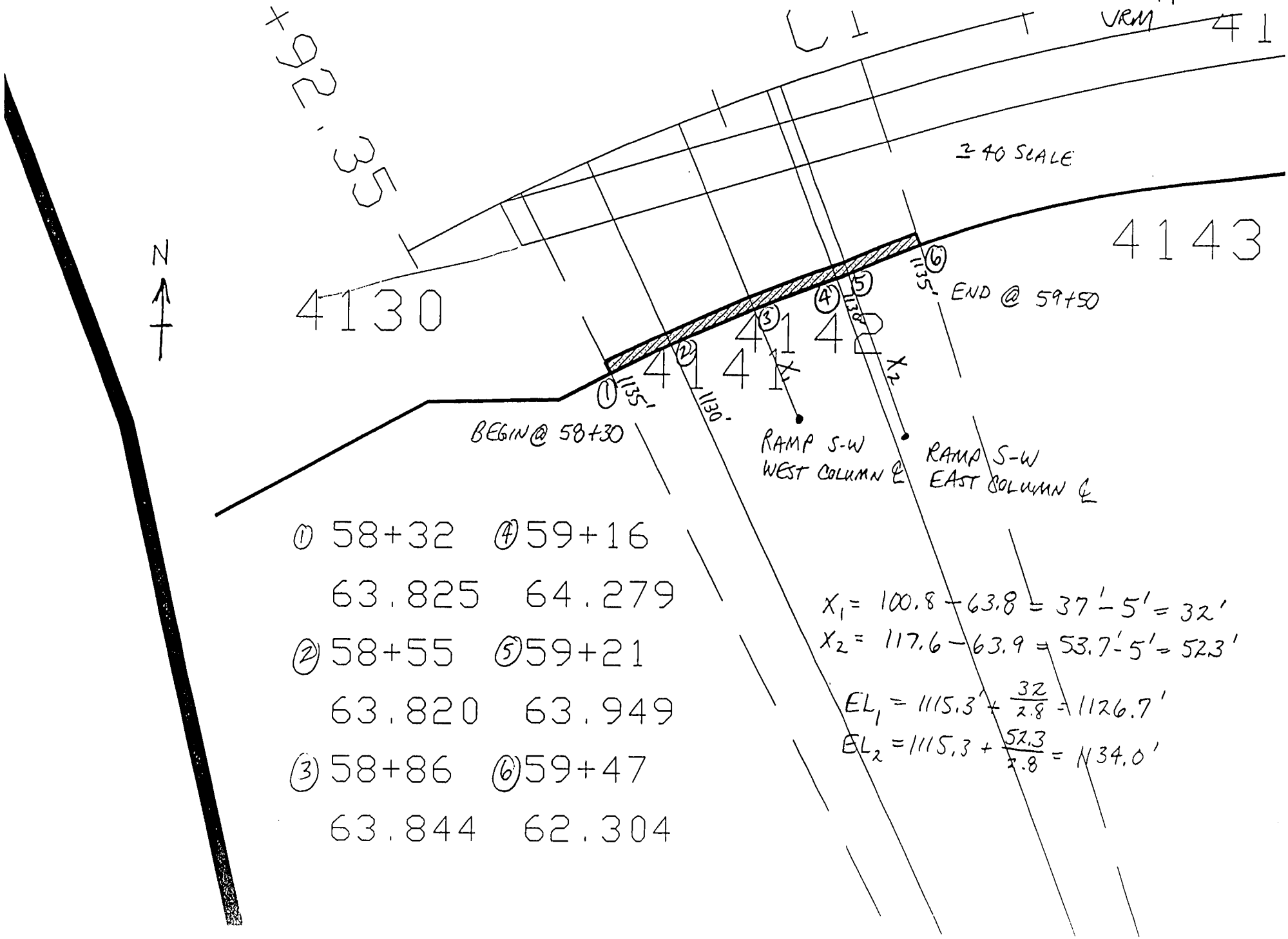
STATION	LEVEE ELEV. (ft)	DESIGN TOE ELEV. (ft)	X (ft)	PLAN DIST. ① FROM ℄ (ft)	
56+89	1182.10	1137.70	44.40	44.40	
58+86	1182.82	1134.00	48.82	63.82	←
59+21	1182.95	1134.00	48.95	63.95	
60+54	1183.44	1134.00	49.44	64.44	PLOT LIMITS
61+55	1183.81	1134.00	49.81	64.81	
62+06	1184.00	1134.00	50.00	65.00	←
62+87	1184.10	1135.00	49.10	64.10	

RAMP HORIZONTAL OFFSETS

STATION	LEVEE ELEV. (ft)	RAMP ELEV. (ft)	HORIZ. OFFSET (ft)
58+25	1182.60	1182.60	~~0~~
59+50	1183.06	1170.50	12.56
63+65	1184.20	1170.50	13.70
65+10	1184.38	1184.38	~~0~~
60+96 (PT)	1183.10	1170.50	12.60


NOTE: STABILITY OF LEVEE MUST BE CHECKED BY GEOTECHNICAL ENGINEER.
CUTOFF WALL THICKNESS = 4'
1140
1135
1130
1125
1120
1115
STD. TOE ELEV. THROUGH STRUCTURES (1134')
ESTIMATED PIER SCOUR PROFILE AT TOE OF BANK
(1130?)
7.5' TYP.
58+30 EL. 1125.5'
58+50 EL. 1122.5'
58+85 EL. 1119.2'
59+20 EL. 1122.5'
59+50 EL. 1127.5'
PRELIMINARY VERTICAL CUTOFF WALL TOE PROFILE
58+50
59+00
59+50

AZ-DMNM-05.8
5-19-94
VRM



① 58+32 ④ 59+16

63.825 64.279

② 58+55 ⑤ 59+21

63.820 63.949

③ 58+86 ⑥ 59+47

63.844 62.304

$X_1 = 100.8 - 63.8 = 37' - 5' = 32'$

$X_2 = 117.6 - 63.9 = 53.7' - 5' = 52.3'$

$EL_1 = 1115.3' + \frac{32}{2.8} = 1126.7'$

$EL_2 = 1115.3 + \frac{52.3}{2.8} = 1134.0'$

Simons, Li & Associates, Inc.
Water Resources & Civil Engineering Consultants

July 8, 1994

Mr. Steve Jimenez
Statewide Project Management
Arizona Department of Transportation
205 South 17th Avenue
Phoenix, AZ 85007

RE: COMPILATION OF HYDRAULIC AND SEDIMENT TRANSPORT DATA FOR BANK PROTECTION DESIGN, EAST PAPAGO FREEWAY, SECTION 6

Dear Steve:

We have assembled the correspondence and data pertaining to the hydraulic and sediment transport analyses conducted to support the Salt River bank protection design east of McClintock Drive. A listing of the information assesmbled is attached.

A copy of this correspondence and data is being provided to Stanley Consultants, the Flood Control District, and DMJM per their request. If you have any questions or need additional information regarding the information provided, please feel free to contact me.

Sincerely,

SIMONS, LI & ASSOCIATES, INC.

Dennis L. Richards

Dennis L. Richards, P.E.
Vice President

Attachment

cc: Mr. Steven D. Wilcox, Stanley Consultants
Mr. Thomas M. Monchak, DMJM
Mr. Dick Perreault, FCD

4600 South Mill Avenue, Suite 200 • Tempe, AZ 85282 • Phone: (602) 491-1393 • Fax: (602) 491-1396
An Equal Opportunity Employer

HYDRAULIC AND SEDIMENT TRANSPORT DATA

EAST PAPAGO FREEWAY, SECTION 6

SLA Memorandum	Salt River HEC-2 Models for the East Papago Freeway (05/19/92)
FCD Letter	Salt River Channelization East of McClintock -- HEC-2 Analysis (06/03/92)
SLA Letter	Characteristic Sediment Gradation for the Salt River - McClintock Drive to Dobson Road (06/26/92)
FCD Letter	Salt River Channel East of McClintock Drive - Characteristic Sediment Gradation (07/02/92)
SLA Letter	Bank Protection Toe-Down Depths in the Vicinity of Sand and Gravel Mining Pits (07/29/92)
SLA Letter	Bank Protection Toe-down Depths Along the Salt River Upstream of McClintock Drive (08/10/92)
FCD Letter	Salt River Channel East of McClintock Drive - Bank Protection Toe-Down Depths (08/11/92)
SLA Letter	Bank Protection Toe-Down Depths (08/11/92)
SLA Letter	Calculations to Support Salt River Bank Protection Design (09/08/92)
FCD Letter	Salt River Channel - East of McClintock Drive; Calculations to Support Bank Protection Design (09/10/92)
FCD Letter	Salt River Channel - East of McClintock Drive; Slope Stability Calculations Submittal (09/21/92)
SLA Letter	Responses to FCD Comments - Salt River Channel (10/09/92)
Appendix I	HEC-2 Cross Section Locations
Appendix II	Letter of Intent for Salt River South Bank Stabilization

c:\wp51\dmjm-07\trandata.rv

Simons, Li & Associates, Inc.
Water Resources & Civil Engineering Consultants

August 10, 1994

Mr. Donald J. Rerick
Project Manager
Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, AZ 85009

RE: SOUTH BANK TOE-DOWN DEPTHS FOR THE EAST PAPAGO LEVEE BETWEEN McCLINTOCK DRIVE AND PRICE ROAD

Dear Don:

Enclosed for your review is the preliminary scour analysis and recommended toe-down depths for the East Papago south bank levee between McClintock Drive and Price Road. We would request that your review of the scour analysis be completed by August 26, 1994.

The study reach for the analysis starts at Grade Control #5 (G.C. #5) and ends approximately 1.25 miles upstream of Price Road. The project reach starts approximately 150 feet upstream of McClintock Drive at the termination of the existing cement stabilized alluvium (CSA)/gabion levee. The project reach follows the south bank alignment upstream (See Exhibit A) for approximately 3400 feet to tie-in with the levee design completed in 1992. The project design conditions assume 100-year levees on the north and south banks. The project design channel invert was based on a 0.1% slope extending upstream from G.C. #5. The 0.1% slope is consistent with that used previously in the design of the north levee and the East Papago Freeway. The analysis utilized the 1994 topographic mapping supplied by DMJM.

The recommended toe-down depths are summarized in Table 1. The following paragraphs provide information regarding the individual scour components and procedures for obtaining the design toe-down elevations. Detailed calculations and spreadsheets are included in Exhibit B.

Long-Term Degradation

The procedures described by the Bureau of Reclamation (Exhibit C, #1) were utilized to quantify the long-term degradation component of total potential scour. Long-term degradation was computed using the concepts of equilibrium slope and stream bed armoring.

The dominant discharge was used for the long-term degradation analysis. The dominant discharge is defined as the discharge which, if allowed to flow constantly, would have the same overall channel shaping effect as the natural fluctuating discharges. The dominant discharge is typically between a 5-year and 10-year event for ephemeral channels (Exhibit C, #2). The design hydraulic conditions for the 10-year event were used in determining the long-term degradation response for the project reach of the Salt River upstream of McClintock Drive.

4600 South Mill Avenue, Suite 200 • Tempe, AZ 85282 • Phone: (602) 491-1393 • Fax: (602) 491-1396
An Equal Opportunity Employer

The analysis resulted in estimated armor depths of 4.8 feet, and an equilibrium slope of 0.037%. The potential long-term degradation component at each cross-section location was computed as the smaller of: 1) the estimated armoring depth, or 2) depth to the equilibrium slope. Grade Control #5 was used as the pivot point for the equilibrium slope analysis.

General Scour

General scour refers to the vertical lowering of the channel bed over relatively short time periods, for example, the general scour in a given reach after passage of a single flood event. Contraction scour can be defined as a special case of general scour. General scour from a contraction occurs because the flow area becomes smaller than the upstream channel and the average velocity and bed shear stress increase, hence there is an increase in stream power (τ V) at the contraction and more bed material is transported through the contracted section than is transported into the section. As the bed level is lowered, velocity decreases, and shear stress decreases and equilibrium is restored when the transport rate through the contracted section is equal to the incoming rate.

The SLA QUASED (QUAsi-unsteady hydraulic and SEDiment routing) computer program was applied to the study reach to quantify the local imbalance between sediment supply and transport capacity along the project reach. The hydrologic data used with QUASED to simulate the 100-year design flood event was the U.S. Army Corps of Engineers (COE) balanced hydrograph for the regulated 100-year flow routed through the existing Salt River Project system (Exhibit C, #3). The maximum scour profiles were obtained considering the entire 100-year, 10-day event. The estimated maximum scour depth at each cross-section was used for the general scour component of the total potential scour.

Low-Flow Incisement

The large width-depth ratios for the design project reach of the Salt River require that consideration be given to the development of low-flow channels. There are no rigorous methodologies for the prediction of low-flow channel incisement. A review of existing field conditions and experience from previous projects along the Salt River indicate a low-flow incisement depth of 2 feet is reasonable for the project reach.

Bed-Form Scour

The bed-form scour component was estimated to be one-half of the dune and antidune heights. The dune height was calculated using a relationship developed by Allen (Exhibit C, #4). The antidune height was calculated using relationships developed by Kennedy (Exhibit C, #2). The actual type of bed form present in the project reach is a function of the flow regime. Since the flow regime will change with the fluctuating discharges of the flood hydrograph, both bed forms could occur during a single flood event. The maximum scour depth calculated from the above two relationships was utilized as the bed-form scour component of the total potential scour.

Factor Of Safety

A factor of safety was included to account for non-uniform flow distributions typical of alluvial channels. This factor of safety is calculated as 30 percent of the sum of the general scour, long-term scour, and bed-form scour as recommended in the Letter Of Intent Salt River South Bank Stabilization (Exhibit C, #5).

Mining Toe-Down

The mining toe-down depth is the depth that must be added to the standard toe-down depth to protect against lateral migration of mine pits. This scour component was determined based on the conditions and criteria outlined in the July 29, 1992 letter from SLA to DMJM (Exhibit C, #6) regarding bank protection toe-down depths in the vicinity of sand and gravel mining pits. The 1992 mining toe-down recommendations were approved by the Flood Control District Of Maricopa County (Exhibit C, #7). Depths of mining pits were estimated based on the current topographic mapping and the design channel invert. Between south bank stations 19+70 and 31+90 several mine pits up to 10 feet deep were noted within 150 feet of the proposed alignment. According to the 1992 recommendations, one quarter (1/4) the pit depth was used for the lateral migration scour component if the pit is located within 150 feet of the bank invert.

Total Calculated Toe-Down Depth and Minimum Elevation

The total toe-down is the sum of the long-term degradation, general scour, low-flow incisement, bed form components, and the factor of safety, plus the mining toe-down. Based on engineering judgement and previous experience on the Salt River, a minimum total toe-down depth of 10 feet is recommended. In addition to the previously mentioned scour components, bend scour and local scour were also investigated. Since the south bank of the Salt River in the project reach does not contain any significant bends or local scour inducing structures, these two components do not contribute to the toe-down depth in the project reach. By subtracting the total calculated toe-down depth from the channel invert, the minimum toe-down elevation can be obtained.

Design Toe-Down Elevation

The design toe-down elevation was determined based on the total calculated toe-down elevation. By comparing the south bank stationing with each HEC-2 cross-section, the design toe-down elevations were determined. The design toe-down elevations were rounded down to the nearest one foot from the total calculated toe-down elevations. An additional adjustment (smoothing) was applied to the design values, in consideration of construction efficiency. The recommended design toe-downs include adjustments to tie-in to the existing CSA levee at the downstream terminus and the designed CSA levee at the upstream terminus. The recommended design toe-down elevations are summarized in Table 1. Detailed calculations are presented in Exhibit B.

Table 1 Summary of Design Toe-down Elevation

South Bank Station	Toe-down Elevation (feet)	Notes
6+96.31	1135.00	Match Existing Toe CSA Bank (Rio Salado Design Sta. 526+65) Slope = +3.7%
7+50	1137.00	Slope = 0.0%
16+00	1137.00	Slope = -6.0%
16+50	1134.00	Slope = 0.0%
19+70	1134.00	Slope = -4.6%
21+00	1128.00	Slope = 0.0%
35+90	1128.00	Slope = -10.0%
38+40.66	1102.94	Match Designed Toe CSA Bank, Lower Elevation Due To Local Scour from East Papago Piers

If you have any questions regarding the recommended toe-down depths or the accompanying calculations, please feel free to call.

Sincerely,

SIMONS, LI & ASSOCIATES, INC.

Dennis L. Richards

Dennis L. Richards, P.E.
Vice President

Registered Professional Engineer (Civil) CERTIFICATE NO. 21560 DENNIS L. RICHARDS Date Signed 8/10/94 ARIZONA, U.S.A.

DLR/CJP/rv

Enclosures - dist w/GVHSEI 1.B.

cc: Thomas M. Monchank (DMJM)

c:\wp51\dmjm-07\080994.101

EXHIBIT A

VICINITY MAP

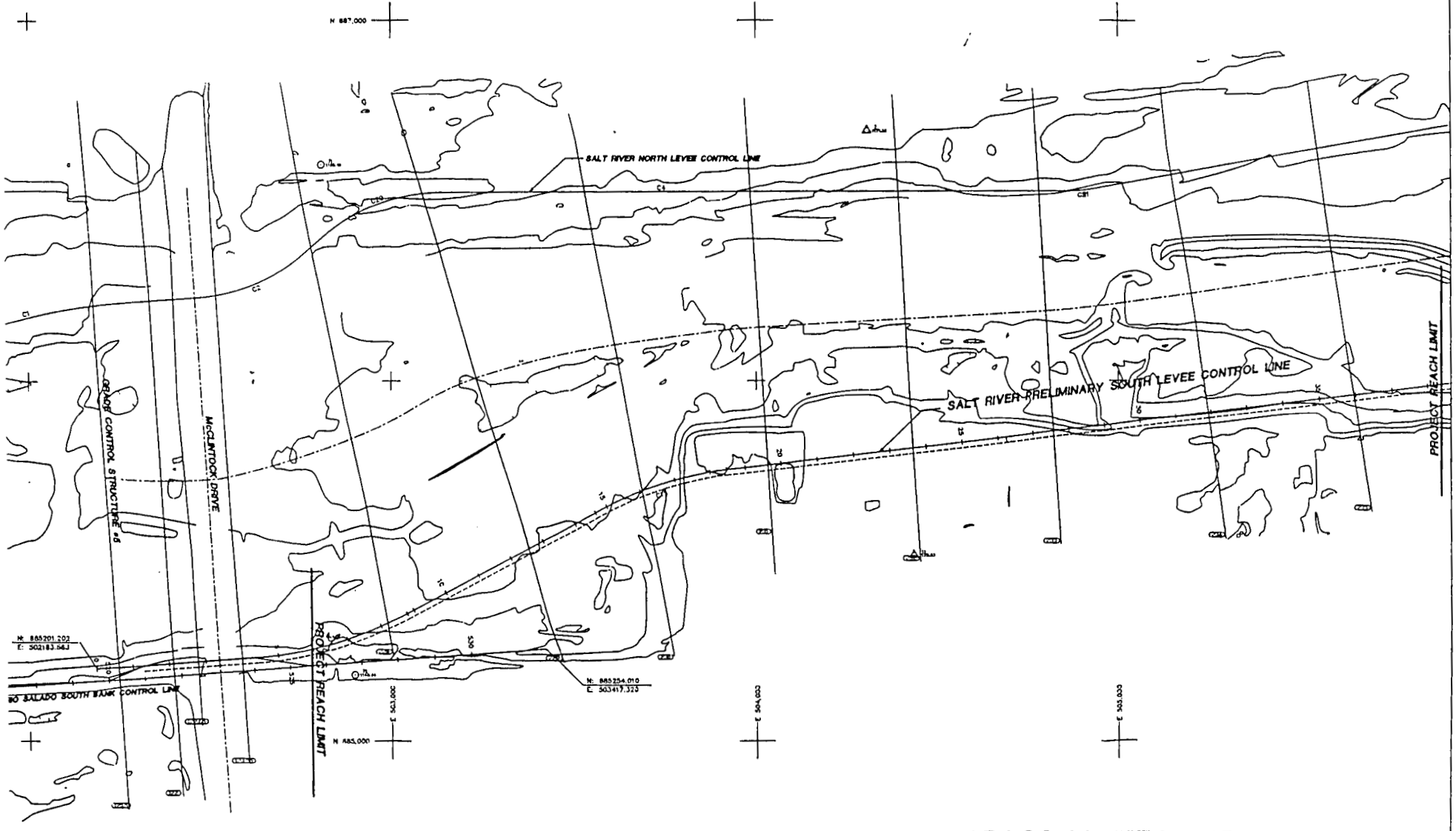


EXHIBIT A: VICINITY MAP OF EAST PAPAGO LEVEES - PROJECT REACH

EXHIBIT B

DETAILED CALCULATIONS

SALT RIVER BANK PROTECTION -- BETWEEN McCLINTOCK DRIVE AND PIMA FREEWAY (SOUTH BANK)

8/10/94 file: toeelev.wk3

HEC-2 X-SEC	DISTANCE UPSTREAM G.C. #5 (FEET)	DESIGN CHANNEL INVERT (FEET)	100-YR HYDRAULICS CALC. WATER SURFACE (FEET)	DEPTH (FEET)	CHAN. VEL. (FEET)	GENERAL SCOUR (QUASED) MAX. INVERT (FEET)	MIN. INVERT (FEET)	AGG. DEP. (FEET)	SCR. DEP. (FEET)	BEND SCOUR (FEET)	MAX. WATER SURFACE (FEET)	STABLE INVERT (FEET)	LONG-TERM SCOUR (FEET)	LOW-FLOW SCOUR (FEET)	BEDFORM SCOUR DUNE (FEET)	ANTIDUNE (FEET)	FACTOR OF SAFETY (30%) (FEET)	MINING TOE DOWN (FEET)	TOTAL CALC. TOE DOWN (FEET)	TOTAL CALC. TOE DOWN ELEV. (FEET)	RECOM. TOE DOWN (FEET)	RECOM. TOE DOWN ELEV. (FEET)	
123.55	335	1147.30	1168.48	21.18	10.45	1148.9	1147.3	1.6	0.0	0.0	1170.08	1147.12	0.2	2.0	1.3	1.5	0.5	0	4.1	1143.15	10.0	1137.00	
228	695	1147.70	1168.95	21.25	10.27	1149.3	1147.7	1.6	0.0	0.0	1170.55	1147.26	0.4	2.0	1.3	1.4	0.6	0	4.4	1143.27	10.0	1137.00	DIR
229	1075	1148.10	1169.17	21.07	11.34	1149.9	1148.1	1.8	0.0	0.0	1170.97	1147.40	0.7	2.0	1.3	1.7	0.7	0	5.2	1142.93	10.0	1138.00	
230	1465	1148.40	1169.12	20.72	13.93	1149.1	1145.3	0.7	3.1	0.0	1169.82	1147.54	0.9	2.0	1.3	2.6	2.0	0	10.6	1137.85	10.6	1137.00	
231	1865	1148.80	1169.70	20.90	15.04	1149.5	1145.3	0.7	3.5	0.0	1170.40	1147.69	1.1	2.0	1.3	3.1	2.3	2.5	14.5	1134.34	14.5	1134.00	
232	2265	1149.20	1170.49	21.29	15.85	1149.2	1143.1	0.0	6.1	0.0	1170.49	1147.84	1.4	2.0	1.3	3.4	3.3	2.5	18.6	1130.59	18.6	1130.00	DIR
233	2655	1149.60	1171.29	21.69	16.78	1149.6	1142.9	0.0	6.7	0.0	1171.29	1147.98	1.6	2.0	1.4	3.8	3.6	2.5	20.3	1129.35	20.3	1129.00	
234	3060	1150.00	1172.80	22.80	16.17	1150.0	1142.1	0.0	7.9	0.0	1172.80	1148.13	1.9	2.0	1.4	3.5	4.0	2.5	21.8	1128.21	21.8	1128.00	
235	3460	1150.40	1174.50	24.10	14.76	1150.4	1143.0	0.0	7.4	0.0	1174.50	1148.28	2.1	2.0	1.5	2.9	3.7	0	18.2	1132.20	18.2	1132.00	
236	3865	1150.80	1175.82	25.02	13.59	1150.8	1146.4	0.0	4.4	0.0	1175.82	1148.43	2.4	2.0	1.6	2.5	2.8	0	14.0	1136.76	14.0	1136.00	

236-24

HEC-2 X-SEC	DISTANCE UPSTREAM G.C. #5 (FEET)	DESIGN CONDITIONS DESIGN CHANNEL INVERT (FEET)	HIGH WATER SURFACE ELEV. (FEET)	MIN. TOE-DOWN ELEV. (FEET)	MIN. TOP BANK ELEV. (FEET)	MIN. BANK HEIGHT (FEET)
123.55	335	1147.30	1170.08	1137.00	1173.08	36.1
228	695	1147.70	1170.55	1137.00	1173.55	36.6
229	1075	1148.10	1170.97	1138.00	1173.97	36.0
230	1465	1148.40	1169.82	1137.00	1172.82	35.8
231	1865	1148.80	1170.40	1134.00	1173.40	39.4
232	2265	1149.20	1170.49	1130.00	1173.49	43.5
233	2655	1149.60	1171.29	1129.00	1174.29	45.3
234	3060	1150.00	1172.80	1128.00	1175.80	47.8
235	3460	1150.40	1174.50	1132.00	1177.50	45.5
236	3865	1150.80	1175.82	1136.00	1178.82	42.8

RECOMMENDED DESIGN SOUTH BANK STATION (FEET)	DESIGN TOEDOWN ELEVATION (FEET)
4+00	1135.00
8+30	1137.00
12+60	1137.00
16+10	1137.00
19+70	1134.00
23+60	1130.00
27+60	1128.00
31+90	1128.00
35+95	1128.00
39+70	1103.00

SALT RIVER BANK PROTECTION -- McClintock Drive to Pima Freeway (SOUTH BANK)

8/10/94

SOUTH BANK STATION	HEC-2 CROSS SECTION	10-YEAR DESIGN HYDRAULICS EGL	HDEPTH	VCH	TOPWID	ARMORING MEYER-PETER, MULLER (mm)	BOTTOM VELOCITY METHOD (mm)	SHIELD'S DIAGRAM (mm)	YANG INCIPIENT MOTION (mm)	EQUILIBRIUM SLOPE SCHOK-LITSCH METHOD	MEYER-PETER, MULLER METHOD	SHIELD'S DIAGRAM METHOD	BOUNDARY REYNOLD'S NUMBER	
4+00	123.55	0.001184	12.30	7.75	975	42	113	45	121	0.00043	0.00042	0.00039	3370	
8+30	228	0.001102	12.63	7.46	988	40	105	43	112	0.00044	0.00041	0.00038	3294	DKR
12+60	229	0.001354	12.52	8.21	905	49	127	52	135	0.00041	0.00042	0.00039	3636	
16+10	230	0.002014	12.48	9.94	750	72	186	78	198	0.00036	0.00042	0.00039	4427	
19+70	231	0.002213	12.82	10.54	688	82	209	88	223	0.00033	0.00041	0.00038	4703	
23+60	232	0.002327	13.20	10.98	641	88	227	95	242	0.00032	0.00039	0.00037	4894	DKR
27+60	233	0.002483	13.58	11.51	595	97	249	104	266	0.00030	0.00038	0.00036	5128	
31+90	234	0.002206	14.15	11.16	589	90	234	96	250	0.00030	0.00037	0.00034	4934	
35+95	235	0.001755	14.83	10.26	611	75	198	80	211	0.00031	0.00035	0.00033	4506	
39+70	236	0.001438	15.33	9.50	639	64	170	68	181	0.00032	0.00034	0.00032	4147	
					AVG	70	182	75	194	0.00035	0.00039	0.00036		

TOTAL AVG. SIZE 130 mm SLOPE 0.00037 ft/ft

References : 1. Pemberton, E.L. Lara, J.M., Bureau of Reclamation, "Computing Degradation and Local Scour", Technical Guideline, January 1984.

2. Arizona Department of Water Resources, "Design Manual for Engineering Analysis of Fluvial Systems", March 1985

Procedures : I) Degradation Limited By Armoring —

1 Meyer-Peter, Muller
2. Competent Bottom Velocity
3. Shields Diagram
4 Yang Incipient Motion

II) Degradation Limited By Stable Slope —

1. Schoklitsch Method
2. Meyer-Peter, Muller
3. Shield's Diagram

1. Meyer-Peter, Muller:

$$D_c = \frac{dS}{K\left(\frac{n_s}{D_{90}^{1/6}}\right)^{3/2}}$$

$$D_c = \frac{12.48 \times 0.002014}{0.19\left(\frac{0.035}{165^{1/6}}\right)^{3/2}}$$

$$= 72.04 \approx 72 \text{ mm}$$

D_c = Individual Particle Size (mm)
K = 0.19 (in-lb)
d = flow depth of Q_{10} (ft)
S = EGL slope (ft/ft)
n_s = Manning's "n" for Streambed (0.035)
D_{90} = particle size 90% finer (mm)

2. Competent Bottom Velocity:

$$D_c = 1.88\, V_m^2$$

$$D_c = 1.88(9.94)^2$$
$$= 186.0 \text{ mm}$$

D_c = Armor size (mm)
V_m = Mean ch. vel. (fps)

3. Shield's Diagram:

$$T_* = \frac{T_c}{(\gamma_s - \gamma_w) D_c} = 0.060$$

$$\text{or } D_c = \frac{\gamma_w d S}{(\gamma_s - \gamma_w)(0.060)}$$

$$D_c = \frac{62.4(12.48)(0.002014)}{(165-62.4)(0.060)}$$
$$= 0.25 \text{ ft} = 77.66 \approx 78 \text{ mm}$$

T_* = Dimensionless Shear Stress
T_c = Critical shear stress = $\gamma_w dS$ (psf)
γ_s = Specific wt. of Sediment (165 pcf)
γ_w = " water (62.4 pcf)
d = flow depth of Q_{10} (ft)

4. Yang Incipient Motion:

$$D_c = 0.00659\, V_{cr}^2$$

$$D_c = 0.00659(9.94)^2 = 0.65 \text{ ft} \approx 198 \text{ mm}$$

D_c = Armor Size (ft)
V_{cr} = Critical Avg. water velocity @ incipient Motion (fps)

5. Schoklitsch Method :

$$S_L = K\left(\frac{D_{50}B}{Q}\right)^{3/4}$$

$$S_L = 0.00174\left(\frac{15 \times 750}{93{,}000}\right)^{3/4}$$

$$= 0.00036$$

S_L = Stable slope (ft/ft)

K = 0.00174 (in-lb)

D_{50} = mean particle size (mm)

B = channel width (ft)

Q = Dominant Discharge Q_{10} (cfs)

6. Meyer-Peter, Muller Method :

$$S_L = \frac{K\left(\frac{Q}{Q_B}\right)\left(\frac{n_s}{D_{90}^{1/6}}\right)^{3/2} D}{d}$$

$$S_L = \frac{0.19(1)\left(\frac{0.035}{165^{1/6}}\right)^{3/2}(15)}{12.48}$$

$$= 0.00042$$

S_L = Stable Slope (ft/ft)

K = 0.19 (in-lb units)

$\frac{Q}{Q_B}$ = ratio of Total flow to flow in ch.

D_{90} = particle size 90% finer (mm)

n_s = Manning's "n" for streambed

D = D_{50} (mm)

d = flow depth of Q_{10} (ft)

7. Shield's Diagram Method :

$$R_* = \frac{u_* D}{\nu} \quad , \quad T_* = \frac{T_c}{(\gamma_s - \gamma_w)D} = \frac{\gamma_w d S_L}{(\gamma_s - \gamma_w)D}$$

$$R_* = \frac{[0.002014(12.48)32.2]^{1/2}(15/304.8)}{10^{-5}}$$

$$= 4427$$

$$S_L = \frac{T_*(\gamma_s - \gamma_w)D}{\gamma_w d}$$

$$= \frac{0.060(165-62.4)(15/304.8)}{62.4(12.48)}$$

$$= 0.00039$$

R_* = Boundary Reynold's No.

u_* = Shear Vel. $(S_L R g)^{1/2}$ (ft/s)

S_L = Slope (ft/ft)

R = Hydraulic Radius (ft)

g = 32.2 ft/s²

D = D_{50} (ft)

ν = Kinematic Viscosity of water (10^{-5} ft²/s)

T_* = Dimensionless shear stress (0.060)

T_c = Critical Shear Stress (psf)

γ_s, γ_w = Sp. wt. of sed. & water (165, 62.4 pcf)

d = flow depth @ Q_{10} (ft)

Armoring Depth

$$Y_d = Y_a\left(\frac{1}{\Delta P} - 1\right)$$

Y_d = depth of Armoring

Y_a = Thickness of Armoring Layer ($2D_c$)

ΔP = % of Original Bed Material larger than Armor Size, D_c

$D_c = 130$ mm, $\Delta P = 0.15$ (from gradation data, letter send to Mr. Monchak of DMJM, 6/26/92)

$$Y_d = 2 \times (130/304.8)\left(1/0.15 - 1\right)$$

$$= 4.8'$$

Bed-form Scour

Antidune Scour (higher Regime)

$$\Delta Z_{as} = \frac{1}{2} h_a = 0.0135\, V^2 \quad \text{(ADWR, 1985)}$$

ΔZ_{as} = bed-form Scour (ft)

h_a = antidune height (ft)

V = flow velocity (fps)

@ X-230

$V = 13.93$ fps

$$\Delta Z_{as} = 0.0135\,(13.93)^2$$

$$= 2.6'$$

Dune Scour (Lower Regime)

$$\Delta Z_{as} = \frac{1}{2}\left(0.0655\, d^{1.209}\right) \quad \text{(Allen, 1963)}$$

@ X-230 $d = 20.72$

$$\Delta Z_{as} = 0.0328\,(20.72)^{1.209}$$

$$= 1.3'$$

$\Rightarrow$ Antidune Scour governs $\Delta Z_{as} = 2.6'$

EXHIBIT C

REFERENCES

1. U.S. Bureau Of Reclamation, "Computing Degradation And Local Scour", Denver, Colorado, January, 1984.

2. A.D.W.R., "Design Manual For Engineering Analysis Of Fluvial Systems", Prepared by SLA, Tucson, Arizona, March, 1985.

3. U.S. Army Corps Of Engineers, "Study For Flood Control Alternatives To Cliff Dam", Los Angeles District, October, 1988.

4. Simons, D.B. & Senturk, F., "Sediment Transport Technology", Water Resources Publications, Fort Collins, Colorado, 1977.

5. Flood Control District Of Maricopa County, "Letter Of Intent For Salt River South Bank Stabilization, Attachment A - Analytical Approach For Determining Required Toe Depths For Bank Protection Along Salt River Upstream Of McClintock Drive", February 18, 1992.

6. Letter Richards, D.L. (SLA) to Monchak, T.M. (DMJM), "Bank Protection Toe-Down Depths In The Vicinity Of Sand And Gravel Mining Pits", July 29, 1992.

7. Letter Rerick, D.J. (FCDMC) to Monchak, T.M. (DMJM), "Salt River Channel East of McClintock Drive - Bank Protection Toe-Down Depths", August 11, 1992.

Simons, Li & Associates, Inc.
Water Resources & Civil Engineering Consultants

November 3, 1994

Mr. Thomas M. Monchak
Daniel, Mann, Johnson & Mendenhall
300 West Clarendon Avenue, Suite 400
Phoenix, Arizona 85013-3499

RE: EVALUATION OF SALT RIVER BANK PROTECTION TOE-DOWN DEPTHS EAST OF McCLINTOCK DRIVE

Dear Tom:

The following is Simons, Li & Associates, Inc. (SLA) response to several issues raised by the Arizona Department of Transportation (ADOT). The issues are as follows: 1.) flattening the cement stabilized alluvium (CSA) slope along the north bank to 1:1 below the channel design invert; 2.) identifying any locations where the channel should be graded to remove high spots and improve hydraulic conveyance; and 3.) raising the bank protection toe-down depths along both the north and south banks due to changes in the channel bed since the 1992 analysis (Reference 2) and design.

1. The 1/2:1 bank protection slope occurs between north bank stations 16+00 and 28+00. The bank protection can be flattened to 1:1 below the design channel invert shown on the design plans without affecting the hydraulics or the toe-down requirements.

2. Based on the October 14, 1994 topography, the majority of the existing Salt River channel falls below the channel design invert elevation. Other than a small area of the north bank, just upstream of McClintock Drive, SLA did not identify any locations where the existing channel elevation exceeded that of the design channel.

3. Since the 1992 analysis and design of the East Papago bank protection, many of th have been partially or completely filled. On October 27, 1994 complete s information was received by SLA from ADOT updating topographic conditions in th River channel. Table 1 presents the scour components for the minimum recomm toe-down elevations along the north bank of the East Papago bank protection. The components are based on the October, 1994 survey data and the August, 1994 hyd analysis (Reference 1). Table 1 revises the recommended design toe-downs be north bank stations 231+25 and 56+89.

   SLA also evaluated the south bank toe-down elevations, focusing on the area where the East Papago crosses the south bank protection. Toe-down depths between south bank stations 39+20.65 and 48+00 were governed by local scour depths of the nearby piers in a "without pits" condition in the 1992 analysis. After reviewing the August, 1994

4600 South Mill Avenue, Suite 200 • Tempe, AZ 85282 • Phone: (602) 491-1393 • Fax: (602) 491-1396
An Equal Opportunity Employer

hydraulic data and comparing it to the 1992 analysis, insignificant changes were observed and any adjustments to the toe-down elevations in this area are not recommended.

If you have any questions or need additional information regarding the review responses, please feel free to contact me.

Sincerely,

SIMONS, LI & ASSOCIATES, INC.

Dennis L. Richards

Dennis L. Richards, P.E.
Vice President

DLR/BSB/CJP/kb

Attachment - Table 1 and References

SALT RIVER BANK PROTECTION, BETWEEN McCLINTOCK DRIVE AND PIMA FREEWAY (NORTH BANK)

PAZ-DMJM-05

TABLE 1. NORTH BANK SCOUR COMPONENTS AND RECOMMENDED MINIMUM TOE-DOWN ELEVATIONS

10/31/94 FILE: NBNKTOES.WK3

References:				August 10, 1994 (1)			August 10, 1994 (1)		November 24, 1993 (3) August 10, 1994 (1)			August 10, 1994 (1)				October 14, 1994 ADOT Field Survey					
				100-YR HYDRAULICS			GENERAL SCOUR					BEDFORM SCOUR									
HEC-2 X-SEC	NORTH BANK STATION (FEET)	DISTANCE UPSTREAM G.C. #5 (FEET)	DESIGN CHANNEL INVERT (FEET)	CALC. WATER SURFACE (FEET)	DEPTH (FEET)	CHAN. VEL. (FPS)	MIN. INVERT (FEET)	DEPTH (QUASED) (FEET)	STABLE INVERT (FEET)	LONG-TERM SCOUR (FEET)	LOW-FLOW SCOUR (FEET)	DUNE (FEET)	ANTIDUNE (FEET)	FACTOR OF SAFETY (30%) (FEET)	10/31/94 STANDARD TOE DOWN	ELEV. LOW GRND. PT. WITHIN 300' CSA (FEET)	MINE TOE = 1/4 OF DIST. BELOW DESIGN INVERT (FEET)	TOTAL CALC. TOE DOWN (FEET)	TOTAL CALC. TOE DOWN ELEV. (FEET)	10/31/94 RECOM. TOE DOWN* (FEET)	10/31/94 RECOM. TOE DOWN ELEV. (FEET)
228	23125	695	1147.7	1168.95	21.25	10.27	1147.7	0.0	1147.3	0.4	2.0	1.3	1.4	0.6	4.4			4.4	1143.3	10.0	1137.7
229	23470	1075	1148.1	1169.17	21.07	11.32	1148.1	0.0	1147.4	0.7	2.0	1.3	1.7	0.7	5.2	1143	1.3	6.4	1141.7	10.0	1138.1
230	1360	1465	1148.4	1169.12	20.73	13.87	1145.3	3.1	1147.5	0.9	2.0	1.3	2.6	2.0	10.5	1143	1.4	11.9	1136.5	11.9	1136.5
231	1840	1865	1148.8	1169.70	20.90	15.02	1145.3	3.5	1147.7	1.1	2.0	1.3	3.0	2.3	12.0	1135	3.5	15.4	1133.4	15.4	1133.4
232	2250	2265	1149.2	1170.49	21.28	15.84	1143.1	6.1	1147.8	1.4	2.0	1.3	3.4	3.3	16.1	1132	4.3	20.4	1128.8	20.4	1128.8
233	2635	2655	1149.6	1171.29	21.69	16.74	1142.9	6.7	1148.0	1.6	2.0	1.4	3.8	3.6	17.7	1133	4.1	21.9	1127.7	21.9	1127.7
234	3015	3060	1150.0	1172.80	22.77	16.17	1142.1	7.9	1148.1	1.9	2.0	1.4	3.5	4.0	19.3	1135	3.6	23.0	1127.0	23.0	1127.0
235	3420	3460	1150.4	1174.60	24.06	14.74	1143.0	7.4	1148.3	2.1	2.0	1.5	2.9	3.7	18.2	1137	3.4	21.5	1128.9	21.5	1128.9
236	3845	3865	1150.8	1175.82	24.98	13.61	1146.4	4.4	1148.4	2.4	2.0	1.6	2.5	2.8	14.1	1137	3.6	17.5	1133.3	17.5	1133.3
237	4200	4275	1151.2	1177.56	26.36	10.61	1147.5	3.7	1148.6	2.6	2.0	1.7	1.5	2.3	12.4	1145	1.6	13.9	1137.3	15.0	1136.2
238	4775	4785	1151.7	1178.25	26.55	9.66	1149.0	2.7	1148.8	2.9	2.0	1.7	1.3	2.1	11.4	1145	1.7	13.1	1138.6	15.0	1136.7
239	5257	5265	1152.2	1178.49	26.29	10.28	1149.3	2.9	1148.9	3.3	2.0	1.7	1.4	2.3	12.1	1147	1.3	13.4	1138.8	15.0	1137.2
240	5669	5765	1152.7	1179.32	26.62	8.77	1151.3	1.4	1149.1	3.6	2.0	1.7	1.0	1.8	10.5	1145	1.9	12.4	1140.3	15.0	1137.7

NOTES: * 10' MINIMUM TOE-DOWN IN AGGRADING SECTIONS, 15' MINIMUM TOE-DOWN IN DEGRADING SECTIONS.

REFERENCES:

1. LETTER D.L. RICHARDS (SLA) TO D.J. RERICK (FCDMC) DATED AUGUST 10, 1994, "SOUTH BANK TOE-DOWN DEPTHS FOR EAST PAPAGO LEVEE BETWEEN McCLINTOCK DRIVE AND PRICE ROAD
2. LETTER D.L. RICHARDS (SLA) TO T.M. MONCHAK (DMJM) DATED SEPTEMBER 8, 1992, "CALCULATIONS TO SUPPORT SALT RIVER BANK PROTECTION DESIGN"
3. LETTER D.L. RICHARDS (SLA) TO T.M. MONCHAK (DMJM) DATED NOVEMBER 24, 1993, "REVISED PIER SCOUR ELEVATIONS FOR THE EAST PAPAGO FREEWAY SALT RIVER BRIDGES"
4. LETTER D.L. RICHARDS (SLA) TO D.J. RERICK (FCDMC) DATED JUNE 14, 1994, "BANK PROTECTION TOE-DOWN DEPTHS FOR THE NORTH BANK OF THE SALT RIVER AT THE PIMA FREEWAY"

References : 1. Pemberton, E.L. Lara, J.M., Bureau of Reclamation, "Computing Degradation and Local Scour", Technical Guideline, January 1984.

2. Arizona Department of Water Resources, "Design Manual for Engineering Analysis of Fluvial Systems", March 1985

Procedures : I) Degradation Limited By Armoring —

1 Meyer-Peter, Muller
2. Competent Bottom Velocity
3. Shields Diagram
4 Yang Incipient Motion

II) Degradation Limited By Stable Slope —

1. Schoklitsch Method
2 Meyer-Peter, Muller
3. Shield's Diagram

1. Meyer-Peter, Muller:

$$D_c = \frac{dS}{K\left(\frac{n_s}{D_{90}^{1/6}}\right)^{3/2}}$$

$$D_c = \frac{12.48 \times 0.002014}{0.19\left(\frac{0.035}{165^{1/6}}\right)^{3/2}}$$

$$= 72.04 \approx 72 \text{ mm}$$

D_c = Individual Particle Size (mm)
K = 0.19 (in-lb)
d = flow depth of Q_{10} (ft)
S = EGL slope (ft/ft)
n_s = Manning's "n" for Streambed (0.035)
D_{90} = particle size 90% finer (mm)

2. Competent Bottom Velocity:

$$D_c = 1.88\, V_m^2$$

$$D_c = 1.88\,(9.94)^2$$
$$= 186.0 \text{ mm}$$

D_c = Armor size (mm)
V_m = Mean ch. vel. (fps)

3. Shield's Diagram:

$$T_* = \frac{T_c}{(\gamma_s - \gamma_w) D_c} = 0.060$$

$$\text{or } D_c = \frac{\gamma_w d S}{(\gamma_s - \gamma_w)(0.060)}$$

$$D_c = \frac{62.4\,(12.48)(0.002014)}{(165 - 62.4)(0.060)}$$
$$= 0.25 \text{ ft} = 77.66 \approx 78 \text{ mm}$$

T_* = Dimensionless Shear Stress
T_c = Critical shear stress = $\gamma_w d S$ (psf)
γ_s = Specific wt. of Sediment (165 pcf)
γ_w = " water (62.4 pcf)
d = flow depth of Q_{10} (ft)

4. Yang Incipient Motion:

$$D_c = 0.00659\, V_{cr}^2$$

$$D_c = 0.00659\,(9.94)^2 = 0.65 \text{ ft} \approx 198 \text{ mm}$$

D_c = Armor Size (ft)
V_{cr} = Critical Avg. water velocity @ incipient Motion (fps)

5. Schoklitsch Method :

$$S_L = K\left(\frac{D_{50}B}{Q}\right)^{3/4}$$

$$S_L = 0.00174\left(\frac{15 \times 750}{93{,}000}\right)^{3/4}$$

$$= 0.00036$$

S_L = Stable slope (ft/ft)

K = 0.00174 (in-lb)

D_{50} = mean particle size (mm)

B = channel width (ft)

Q = Dominant Discharge Q_{10} (cfs)

6. Meyer-Peter, Muller Method :

$$S_L = \frac{K\left(\frac{Q}{Q_B}\right)\left(\frac{n_s}{D_{90}^{1/6}}\right)^{3/2} D}{d}$$

$$S_L = \frac{0.19(1)\left(\frac{0.035}{165^{1/6}}\right)^{3/2}(15)}{12.48}$$

$$= 0.00042$$

S_L = Stable Slope (ft/ft)

K = 0.19 (in-lb units)

$\frac{Q}{Q_B}$ = ratio of Total flow to flow in ch.

D_{90} = particle size 90% finer (mm)

n_s = Manning's "n" for streambed

D = D_{50} (mm)

d = flow depth of Q_{10} (ft)

7. Shield's Diagram Method :

$$R_* = \frac{u_* D}{\nu} \quad . \quad T_* = \frac{T_c}{(\gamma_s - \gamma_w)D} = \frac{\gamma_w d S_L}{(\gamma_s - \gamma_w)D}$$

$$R_* = \frac{[0.002014(12.48)32.2]^{1/2}(15/304.8)}{10^{-5}}$$

$$= 4427$$

$$S_L = \frac{T_*(\gamma_s - \gamma_w)D}{\gamma_w d}$$

$$= \frac{0.060(165 - 62.4)(15/304.8)}{62.4(12.48)}$$

$$= 0.00039$$

R_* = Boundary Reynold's No.

u_* = Shear Vel. $(S_L R g)^{1/2}$ (ft/s)

S_L = Slope (ft/ft)

R = Hydraulic Radius (ft)

g = 32.2 ft/s²

D = D_{50} (ft)

ν = Kinematic Viscosity of water (10^{-5} ft²/s)

T_* = Dimensionless shear stress (0.060)

T_c = Critical Shear stress (psf)

γ_s, γ_w = Sp. wt. of sed. & water (165, 62.4 pcf)

d = flow depth @ Q_{10} (ft)

SALT RIVER BANK PROTECTION -- McClintock Drive to Pima Freeway (SOUTH BANK)

8/10/94

SOUTH BANK STATION	HEC-2 CROSS SECTION	10-YEAR DESIGN HYDRAULICS EGL	HDEPTH	VCH	TOPWID	ARMORING MEYER-PETER, MULLER (mm)	BOTTOM VELOCITY METHOD (mm)	SHIELD'S DIAGRAM (mm)	YANG INCIPIENT MOTION (mm)	EQUILIBRIUM SLOPE SCHOK-LITSCH METHOD	MEYER-PETER, MULLER METHOD	SHIELD'S DIAGRAM METHOD	BOUNDARY REYNOLD'S NUMBER
4+00	123.55	0.001184	12.30	7.75	975	42	113	45	121	0.00043	0.00042	0.00039	3370
8+30	228	0.001102	12.63	7.46	988	40	105	43	112	0.00044	0.00041	0.00038	3294
12+60	229	0.001354	12.52	8.21	905	49	127	52	135	0.00041	0.00042	0.00039	3636
16+10	230	0.002014	12.48	9.94	750	72	186	78	198	0.00036	0.00042	0.00039	4427
19+70	231	0.002213	12.82	10.54	688	82	209	88	223	0.00033	0.00041	0.00038	4703
23+60	232	0.002327	13.20	10.98	641	88	227	95	242	0.00032	0.00039	0.00037	4894
27+60	233	0.002483	13.58	11.51	595	97	249	104	266	0.00030	0.00038	0.00036	5128
31+90	234	0.002206	14.15	11.16	589	90	234	96	250	0.00030	0.00037	0.00034	4934
35+95	235	0.001755	14.83	10.26	611	75	198	80	211	0.00031	0.00035	0.00033	4506
39+70	236	0.001438	15.33	9.50	639	64	170	68	181	0.00032	0.00034	0.00032	4147
					AVG	70	182	75	194	0.00035	0.00039	0.00036	

TOTAL AVG. SIZE 130 mm SLOPE 0.00037 ft/ft

Armoring Depth

$$Y_d = Y_a\left(\frac{1}{\Delta P} - 1\right)$$

Y_d = depth of Armoring

Y_a = Thickness of Armoring Layer ($2D_c$)

ΔP = % of Original Bed Material larger than Armor Size, D_c

$D_c = 130$ mm, $\Delta P = 0.15$ (from gradation data, letter sent to Mr. Monchik of DMJM, 6/26/92)

$$Y_d = 2 \times (130/304.8)\left(1/0.15 - 1\right)$$

$$= 4.8'$$

Bed-form Scour

Antidune Scour (higher Regime)

$$\Delta Z_{as} = \frac{1}{2} h_a = 0.0135\, V^2 \quad \text{(ADWR, 1985)}$$

ΔZ_{as} = bed-form Scour (ft)

h_a = antidune height (ft)

V = flow velocity (fps)

@ X-230

$V = 13.93$ fps

$$\Delta Z_{as} = 0.0135\,(13.93)^2$$

$$= 2.6'$$

Dune Scour (Lower Regime)

$$\Delta Z_{as} = \frac{1}{2}\left(0.0655\, d^{1.209}\right) \quad \text{(Allen, 1963)}$$

@ X-230 $d = 20.72$

$$\Delta Z_{as} = 0.0328\,(20.72)^{1.209}$$

$$= 1.3'$$

$\Rightarrow$ Antidune Scour governs $\Delta Z_{as} = 2.6'$

Simons, Li & Associates, Inc.
Water Resources & Civil Engineering Consultants

January 6, 1995

Mr. Thomas M. Monchak, P.E.
Daniel, Mann, Johnson & Mendenhall
300 West Clarendon Avenue, Suite 400
Phoenix, Arizona 85013-3499

RE: SALT RIVER CHANNEL IMPROVEMENTS EAST OF McCLINTOCK DRIVE; ADJUSTMENT OF NORTH BANK TOE-DOWN DEPTHS

Dear Tom:

This letter contains Simons, Li & Associates, Inc.'s (SLA) response to the Flood Control District's (FCD) December 21, 1994 request for information regarding the above referenced project. Enclosed are figures and computations for the local pier scour influence on the north bank toe-downs near HEC-2 cross sections #228 and #229, as well as information supporting the recent toe-down elevation changes.

The following is a summary of the transmitted information:

Exhibit A: A copy of FCD's December 21, 1994 review letter.

Exhibit B: Two figures showing pier scour influence on the toe-downs near HEC-2 cross sections #228 and #229.

Exhibit C: SLA's November 3, 1994 letter summarizing the revised toe-down depths for the north bank between stations 231+25 and 56+89. (It should be noted that Table 1 does not include local scour influences.)

Exhibit D: Sample hand computations for the scour components shown in Exhibit C and the local scour component shown in Exhibit B.

If you have any questions or need additional information regarding this review response, please feel free to contact me.

Sincerely,

SIMONS, LI & ASSOCIATES, INC.

Dennis L. Richards

Dennis L. Richards, P.E.
Vice President

Registered Professional Engineer (Civil) CERTIFICATE NO. 21560 DENNIS L. RICHARDS Date Signed 1/6/95 ARIZONA, U.S.A.

DLR/BSB/CJP/kb

Enclosures

4600 South Mill Avenue, Suite 200 • Tempe, AZ 85282 • Phone: (602) 491-1393 • Fax: (602) 491-1396
An Equal Opportunity Employer

HYDRAULIC CONDITIONS @ SECNO 228:

VCH = 10.27 fps
DEPTH = 21.25 ft

10/31/94 Table 1. "Northbank Scour Components..." as Attachment to November 3, 1994 Letter "Evaluation of Salt River..." SLA to T. M. Monchak

CSU EQN.: (HEC-18)

$$y_s = 2.2\left(\frac{a}{y_1}\right)^{.65} F_R^{.43}\, y_1$$

WHERE: y_s = LOCAL PIER SCOUR DEPTH, ft
a = EFFECTIVE PIER WIDTH, ft
y_1 = FLOW DEPTH U/S OF PIER, ft
F_R = FROUDE NUMBER

a = 10' ϕ Pier + 4' Debris = 14'

$$y_s = 2.2\left(\frac{14'}{21.25'}\right)^{.65}\left[\frac{10.27}{(32.2(21.25))^{.5}}\right]^{.43}(21.25)$$

y_s = 23.84'

CALCULATE PIER SCOUR ELEVATION:

STANDARD TOE-DOWN DEPTH = 10.00'
TOTAL PIER SCOUR = 1.3 (23.84) = 30.99

TOTAL SCOUR @ PIER = 40.99'

DESIGN INVERT ELEV. = 1147.70
TOTAL SCOUR @ PIER = 40.99

TOTAL PIER SCOUR ELEV. = 1106.7'

HYDRAULIC CONDITIONS @ SECNO 229:

VCH = 11.32 fps
DEPTH = 21.07 ft

10/31/94 Table 2. "Northbank Scour Components..." as Attachment to November 3, 1994 Letter "Evaluation of Salt River..." SLA to T. M. Monchak

CSU EQN.: (HEC-18)

$$y_s = 2.2\left(\frac{a}{y_1}\right)^{.65} F_r^{.43}\, y_1$$

WHERE: y_s = LOCAL PIER SCOUR DEPTH, ft
a = EFFECTIVE PIER WIDTH, ft
y_1 = FLOW DEPTH u/s OF PIER, ft
F_R = FROUDE NUMBER

a = 10' Ø Pier + 4' Debris = 14'

$$y_s = 2.2\left(\frac{14'}{21.07}\right)^{.65}\left[\frac{11.32}{(32.2(21.07))^{1/2}}\right]^{.43}(21.07)$$

y_s = 24.84'

CALCULATE PIER SCOUR ELEVATION:

STANDARD TOE-DOWN DEPTH = 10.0'
TOTAL PIER SCOUR = 1.3(24.84) = 32.3'

TOTAL SCOUR @ PIER = 42.3'

DESIGN INVERT ELEV. = 1148.1'
TOTAL SCOUR @ PIER = 42.3'

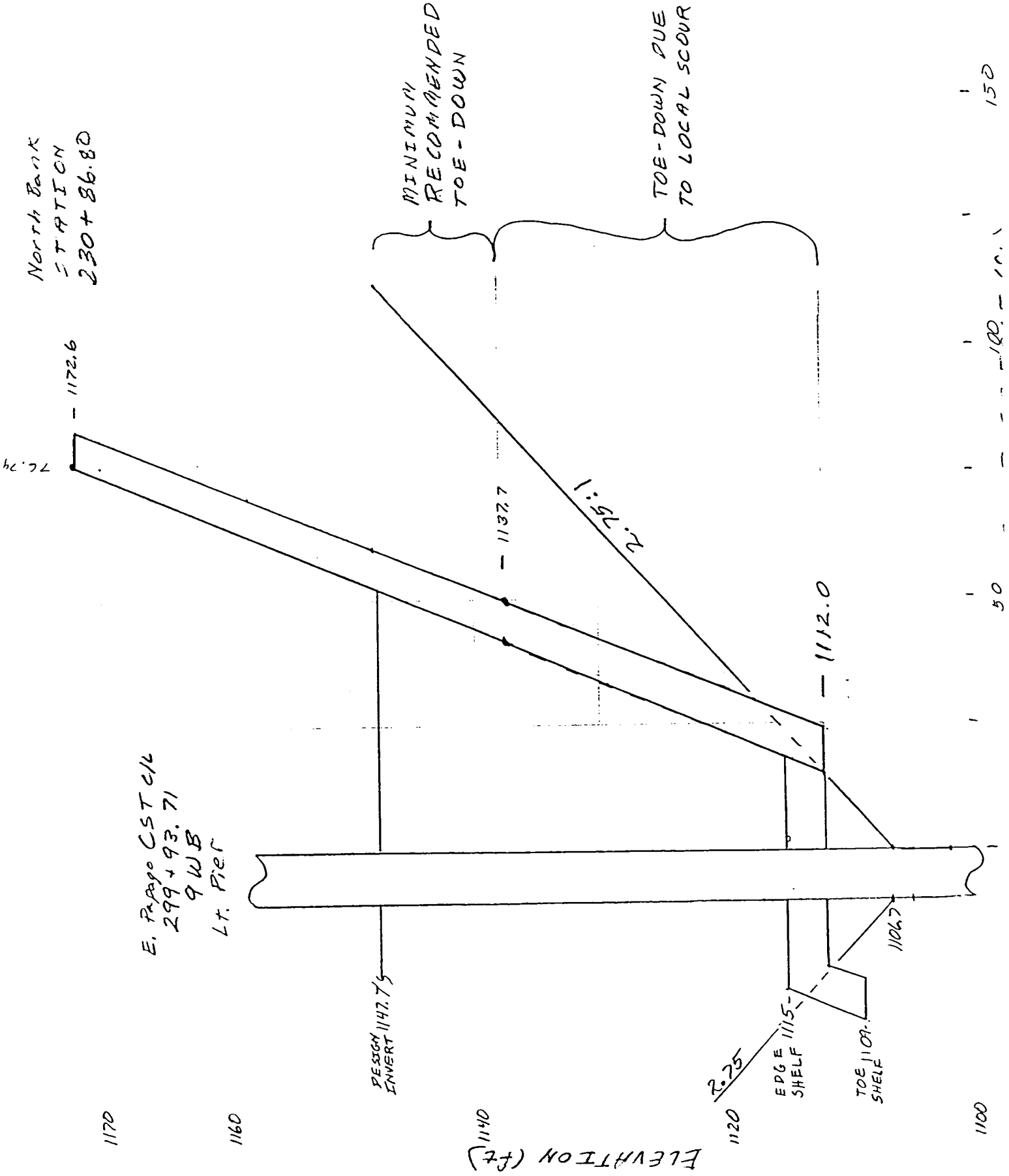
TOTAL PIER SCOUR ELEV. = 1105.8'

sla
SIMONS, LI & ASSOCIATES, INC.

CLIENT DMJV / ADOT
PROJECT Post Design Services
DETAIL Local Pier Scour Influence Near HEC-2 #228

JOB NO. AZ-DMJV-059
DATE CHECKED 1-5-95
CHECKED BY [illegible]

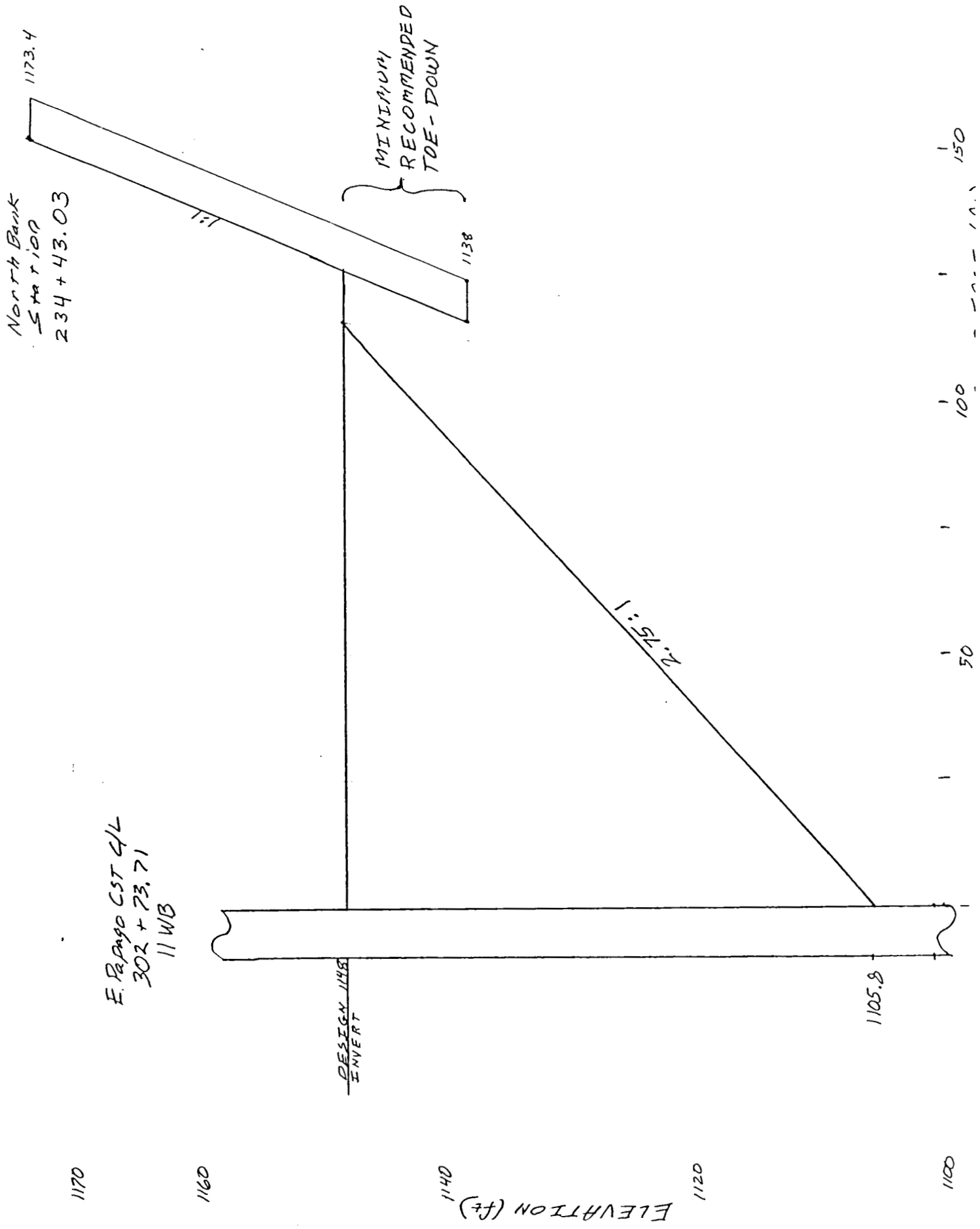
PAGE 1/4
DATE 1/4/95
COMPUTED BY CJP



sla
SIMONS, LI & ASSOCIATES, INC.

CLIENT DMJM/ADOT
PROJECT Post Design Services
DETAIL Local Pier Scour Influence Near HEC-2 #229

JOB NO AZ-DMJM-059 PAGE 2/4
DATE CHECKED 1-5-95 DATE 1/3/95
CHECKED BY [illegible] COMPUTED BY CJF



HYDRAULIC CONDITIONS @ SECNO 228:

VCH = 10.27 fps
DEPTH = 21.25 ft

10/31/94 Table 2. "Northbank Scour Components..." as Attachment to November 3, 1994 Letter "Evaluation of Salt River..." SLA to T. M. Monchak

CSU EQN.: (HEC-18)

$$y_s = 2.2\left(\frac{a}{y_1}\right)^{.65} F_R^{.43}\, y_1$$

WHERE: y_s = LOCAL PIER SCOUR DEPTH, ft
a = EFFECTIVE PIER WIDTH, ft
y_1 = FLOW DEPTH U/S OF PIER, ft
F_R = FROUDE NUMBER

a = 10' ϕ Pier + 4' Debris = 14'

$$y_s = 2.2\left(\frac{14'}{21.25'}\right)^{.65}\left[\frac{10.27}{(32.2(21.25))^{.5}}\right]^{.43}(21.25)$$

y_s = 23.84'

CALCULATE PIER SCOUR ELEVATION:

STANDARD TOE-DOWN DEPTH = 10.00'
TOTAL PIER SCOUR = 1.3 (23.84) = 30.99

TOTAL SCOUR @ PIER = 40.99'

DESIGN INVERT ELEV. = 1147.70
TOTAL SCOUR @ PIER = 40.99

TOTAL PIER SCOUR ELEV. = 1106.7'

HYDRAULIC CONDITIONS @ SECNO 229:

VCH = 11.32 fps
DEPTH = 21.07 ft

10/31/94 Table 2. "Northbank Scour Components..." as Attachment to November 3, 1994 Letter "Evaluation of Salt River..." SLA to T. M. Monchak

CSU EQN.: (HEC-18)

$$y_s = 2.2\left(\frac{a}{y_1}\right)^{.65} F_r^{.43}\, y_1$$

WHERE: y_s = LOCAL PIER SCOUR DEPTH, ft
a = EFFECTIVE PIER WIDTH, ft
y_1 = FLOW DEPTH u/s OF PIER, ft
F_R = FROUDE NUMBER

a = 10' Ø Pier + 4' Debris = 14'

$$y_s = 2.2\left(\frac{14'}{21.07}\right)^{.65}\left[\frac{11.32}{(32.2(21.07))^{1/2}}\right]^{.43}(21.07)$$

y_s = 24.84'

CALCULATE PIER SCOUR ELEVATION:

STANDARD TOE-DOWN DEPTH = 10.0'
TOTAL PIER SCOUR = 1.3(24.84) = 32.3'

TOTAL SCOUR @ PIER = 42.3'

DESIGN INVERT ELEV. = 1148.1'
TOTAL SCOUR @ PIER = 42.3'

TOTAL PIER SCOUR ELEV. = 1105.8'

SCALE: 1" = 100'
NORTH BANK CONSTRUCTION ℄
EAST PAPAGO CONSTRUCTION ℄
Scour Hole Zone
TOEDOWN
EDGE OF SHELF
STA. 232+60.01
STA. 234+43.03
STA. 235+82.66
STA. 230+86.80
STA. 299+93.71
STA. 302+73.11
STA. 305
STA. 230
STA. 228
STA. 229
STA. 232
C1
C2
C3
51
11
4
81.74
120.03
152.04
162.22
10WB
11WB
11EB
4'
3'
4'
Pier Scour Influence on N. Brk Backup for FLD Response
AZ-DYNM-05.9
10/6/95

FLOOD CONTROL DISTRICT
of
Maricopa County

2801 West Durango Street • Phoenix, Arizona 85009
Telephone (602) 506-1501
Fax (602) 506-4601
TT (602) 506-5859

BOARD OF DI
Betsey Ba
Ed Kin
Tom Raw
Don Stap
Mary Rose Garrido Wilcox

Dec. 21, 1994

Mr. Thomas M. Monchak, P.E.
Project Manager
Daniel, Mann, Johnson & Mendenhall
300 West Clarendon Avenue, Suite 400
Phoenix, Arizona 85-13-3499

Subject: Salt River Channel East of McClintock - Adjustment of North Levee Toedown Depths

Dear Mr. Monchak:

The Flood Control District has reviewed the revised plan sheets NH-1.2R and NH-3.3 as provided on December 20, 1994. These revisions represent an adjustment of the toedown elevations in the vicinity of the 0.5:1 CSA levee in accordance with the recommendations of AGRA and Dr. Hansen.

Other revisions to the toedowns as presented on plan sheets NH-3.2, 3.3, and 3.4, and submitted on December 1, 1994 show other reaches of the toedown raised due to the filling of the S&G pits. Based on our discussions with you in our meeting at the District on December 20, 1994, we have no objections to these toedown elevation changes.

(b/w x-section 228 & 229)

The District also understands that the (1) levee toedown east of Station 232+44.06 is not affected by the local scour from the bridge piers. Therefore, (2) the toedown adjustment does not extend to the west beyond Station 232+44.06.

The District requests for its files the following submittals -

1. An analysis of the influence of local pier scour on the north levee toedown at HEC-2 cross sections #228 and #229.

2. A memo sealed by a registered engineer summarizing the toedown elevation changes, and the basis of those changes as presented in the recent meetings and plan sheet submittals.

The District concurs with the toedown adjustments as presented in the above plan sheet submittals, and in accordance with our understanding of the changes as presented above.

If you have any questions, please call me or Raju Shah at 506-1501.

Sincerely,

Donald J. Renck
Project Manager

Copy to: Terry Bourland, ADOT

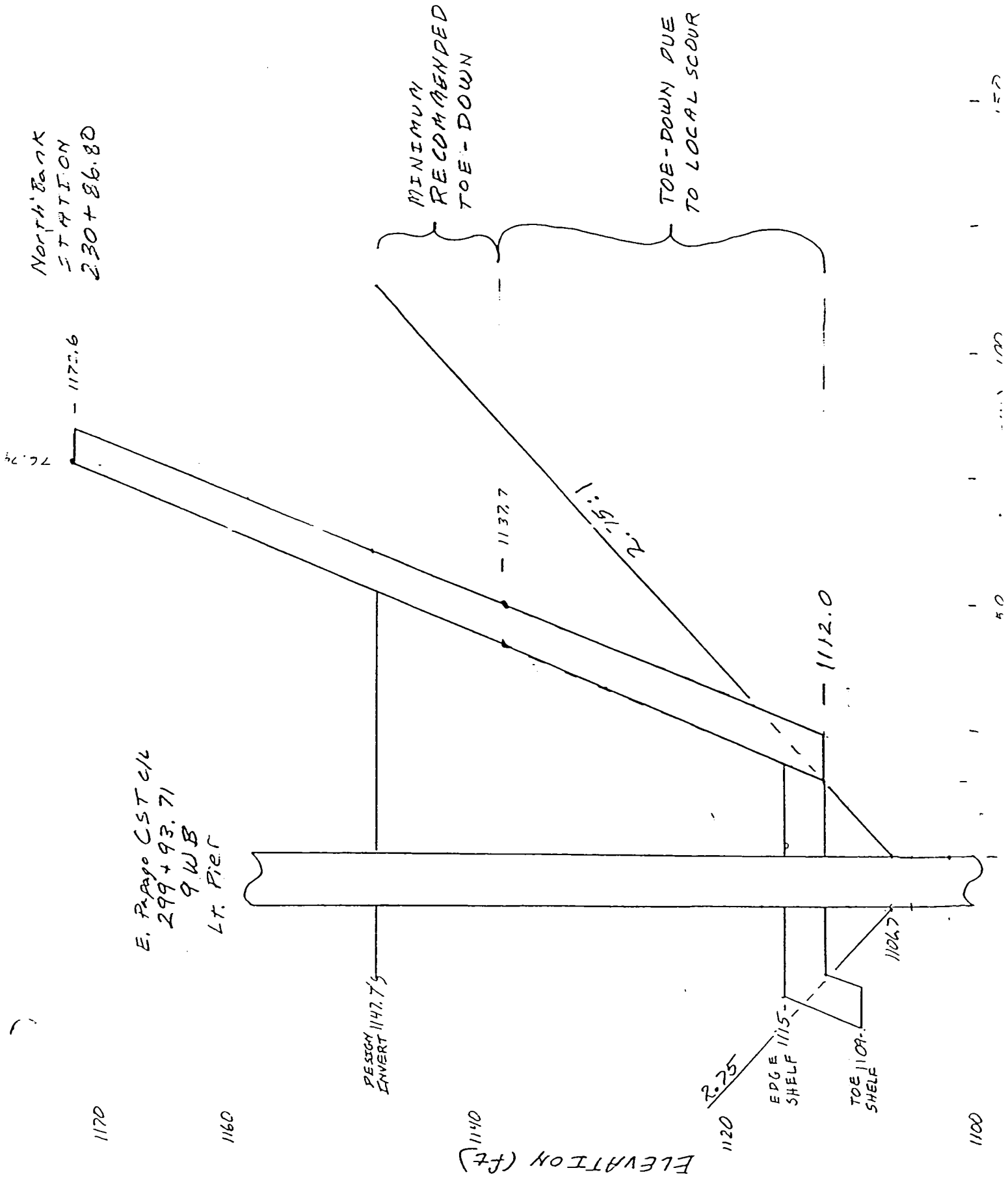
Post-it™ brand fax transmittal memo 7671	# of pages ▸ 1
To Tom Monchak	From Don Renck
Co. DMJM	Co. FCDMC
Dept. —	Phone # 506-1501
Fax # 285-1984	Fax # —

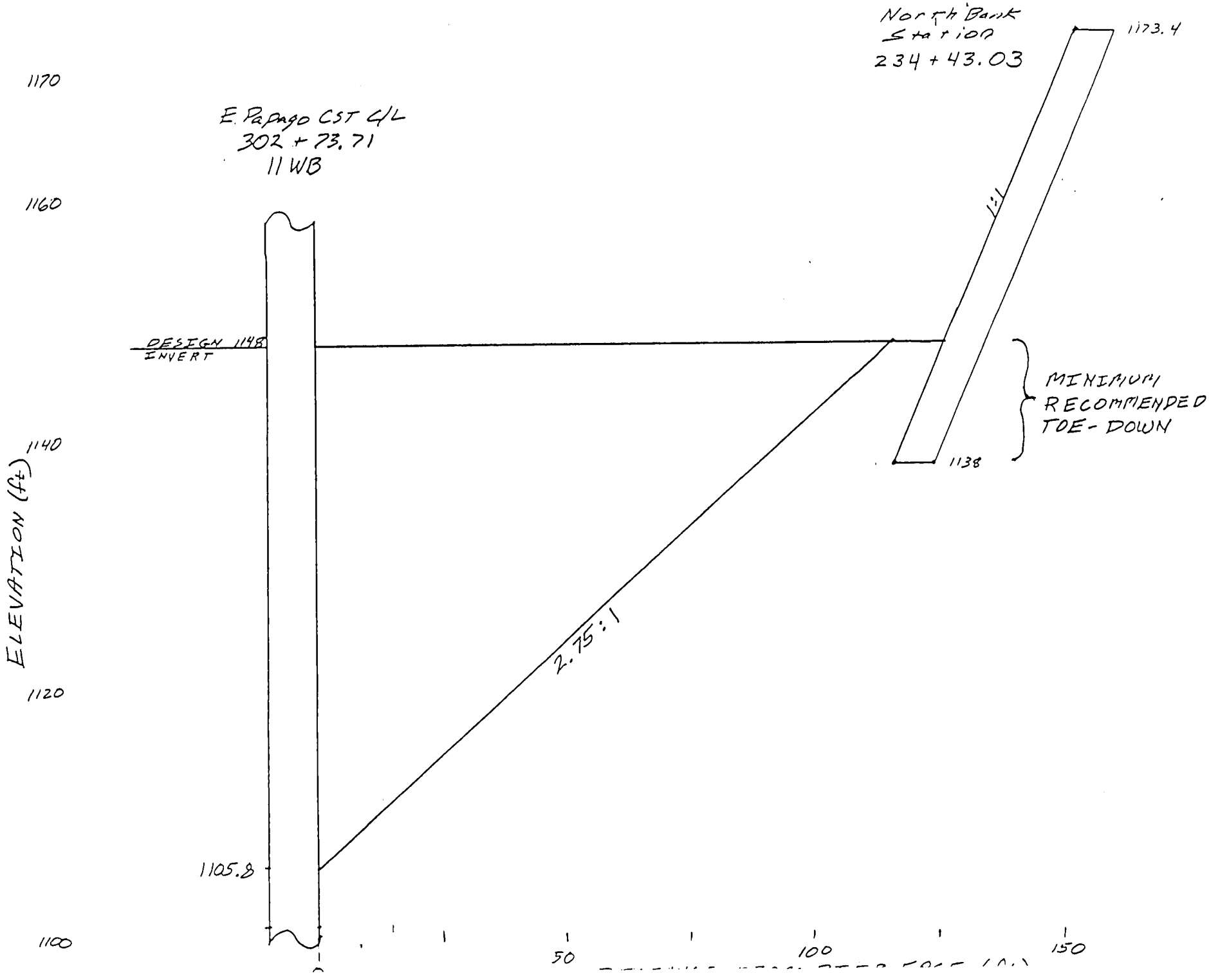
sla
SIMONS, LI & ASSOCIATES, INC.

CLIENT DPAN01/ADOT
PROJECT Post Design Services
DETAIL Local Pier Scour Influence
Near HEC-2 #228

JOB NO. AZ-DPAN-059
DATE CHECKED 1-5-95
CHECKED BY HR

PAGE 1/4
DATE 1/4/95
COMPUTED BY CJT





SIMONS, LI & ASSOCIATES, INC.

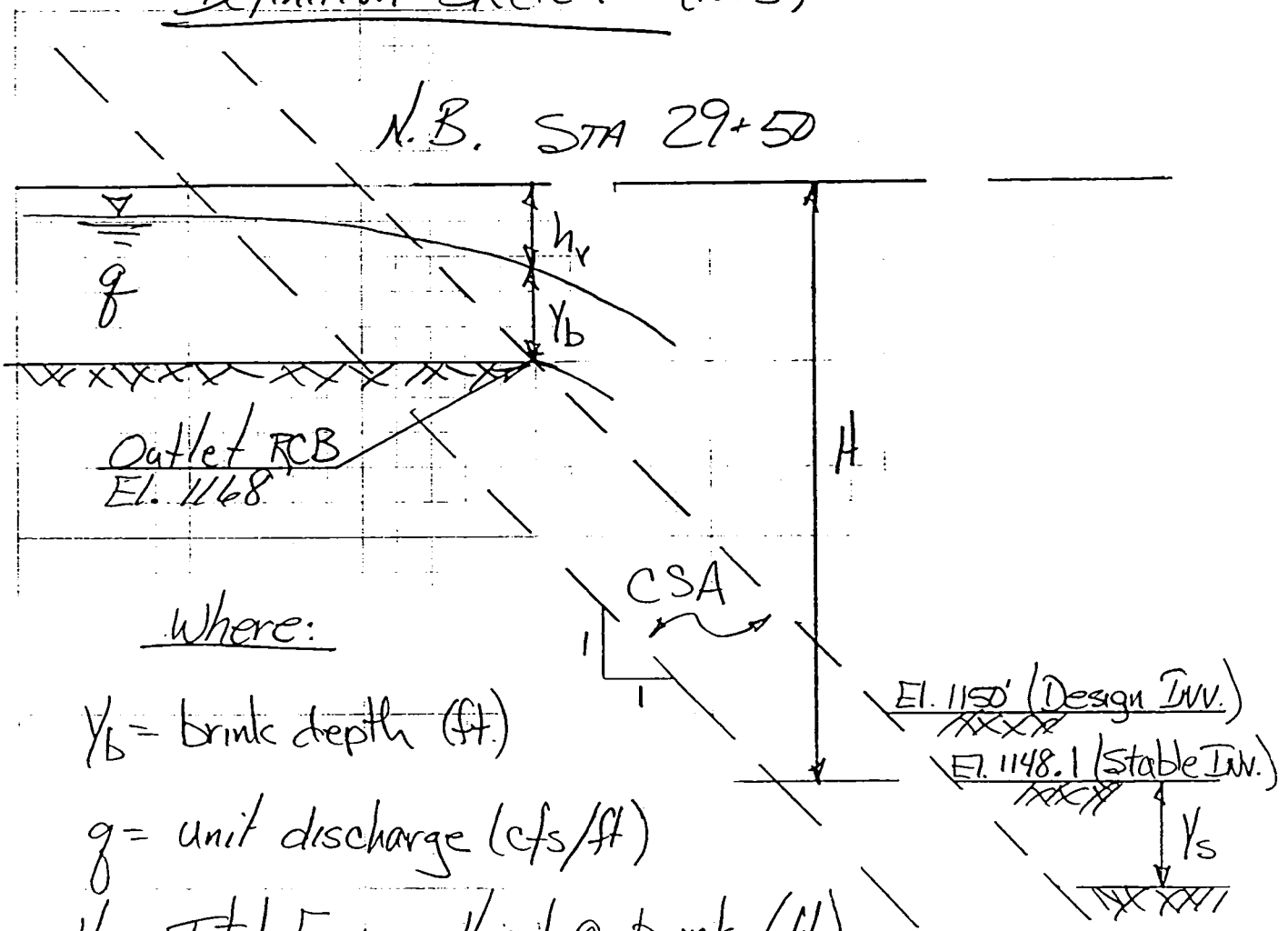
CLIENT PHOENIX/ADOT
PROJECT Post Design Services
DETAIL Local Pier Scour Influence Near HEC-2 #229

JOB No. A2-PHOTH-059 PAGE 2/4
DATE CHECKED 1-5-85 DATE 1/3/85
CHECKED BY [illegible] COMPUTED BY CJF

Assumptions

1. Q_{100} = 2000 cfs thru Dbl. 10'x10' RCB
2. Free overfall into Salt River
3. Brink depth at Outfall
4. No tailwater in Salt River
5. D_{50} = 15mm & D_{90} = 165 mm

Definition Sketch (NTS)



Where:

Y_b = brink depth (ft.)

q = unit discharge (cfs/ft)

H = Total Energy Head @ brink (ft.)

h_v = velocity head @ brink (ft.)

Y_s = depth of scour (ft.)

HEC-2 X-Sect	North Bank Station	Design Invert Elev	Long-Term Scour Depth	Stable Invert Elev
233	26+35	1149.6	1.6'	1148.0
sta → 29+50 234	30+15	1150.0	1.9'	1148.1

Calculate Hydraulic Parameters

$q = Q/b_w$ (where b_w = culvert width)

$= 2000\ cfs/20' = \underline{100\ cfs/ft}$

Y_b — ref. attached Fig. III-9 {FHWA, "HEC-14" 1983}

$TW/D = 0$ (No tailwater)

$Q/BD^{1.5} = 2000/20(10)^{1.5} = 3.16$

$Y_b/D = 0.52$

$Y_b = 0.52(10) = \underline{5.2\ ft}$

$V_b = q/Y_b = 100/5.2 = \underline{19.2\ fps}$

$H = z + Y_b + \frac{V_b^2}{2g}$

$= 19.9 + 5.2 + \frac{(19.2)^2}{2g} = \underline{30.8'}$

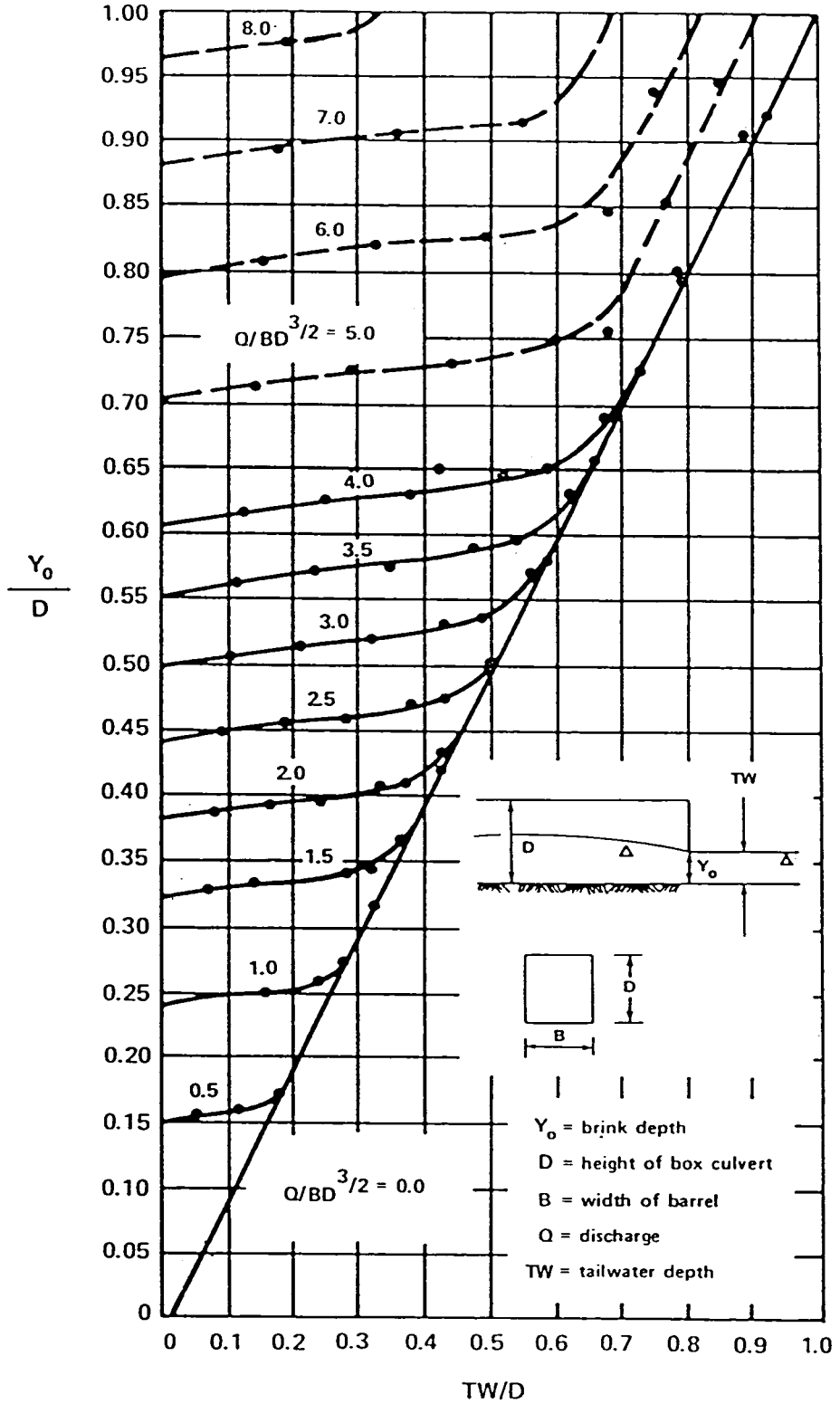


Figure III-9 Dimensionless Rating Curves for the Outlets of Rectangulars Culverts on Horizontal and Mild Slopes from Reference III-2

Schoklitsch Eqtn.

{Re: U.S. Bureau Reclamation, "Comp. Degrad. & L. Scour" 1984}

$$\cancel{Y_{tw}}^{0} + Y_s = \frac{3.15\,(H)^{0.2}\,(q)^{0.57}}{D_{90}^{0.32}}$$

$$Y_s = \frac{3.15\,(30.8)^{0.2}\,(100)^{0.57}}{(165)^{0.32}} = \underline{16.8\ ft}$$

Modified Veronese Eqtn.

$$\cancel{Y_{tw}}^{0} + Y_s = \frac{2.56}{D_{50}^{0.42}}\,H^{0.225}\,q^{0.54}$$

$$Y_s = \frac{2.56}{(15)^{0.42}}\,(30.8)^{0.225}\,(100)^{0.54}$$

$$Y_s' = \underline{21.3\ ft}$$

Recommendation

$$\overline{Y_s} = \frac{16.8 + 21.3}{2} = 19.1'$$

Add 30% Safety Factor for Bed-form scour 5.7'

use $Y_s = \boxed{24.8'}$

Recommendation (Con't)

Toe-Down Elev. –

Stable Inv El = 1148.1'

Less Scour -24.8'

Toe-Down El 1123.3'

Use El. 1123'

Min. Width of Scour Zone (w) –

Add. toe-down depth due to outfall (Δd_t)

El. toe-down w/o Outfall = 1127.0

El. toe-down w/ outfall = 1123.3

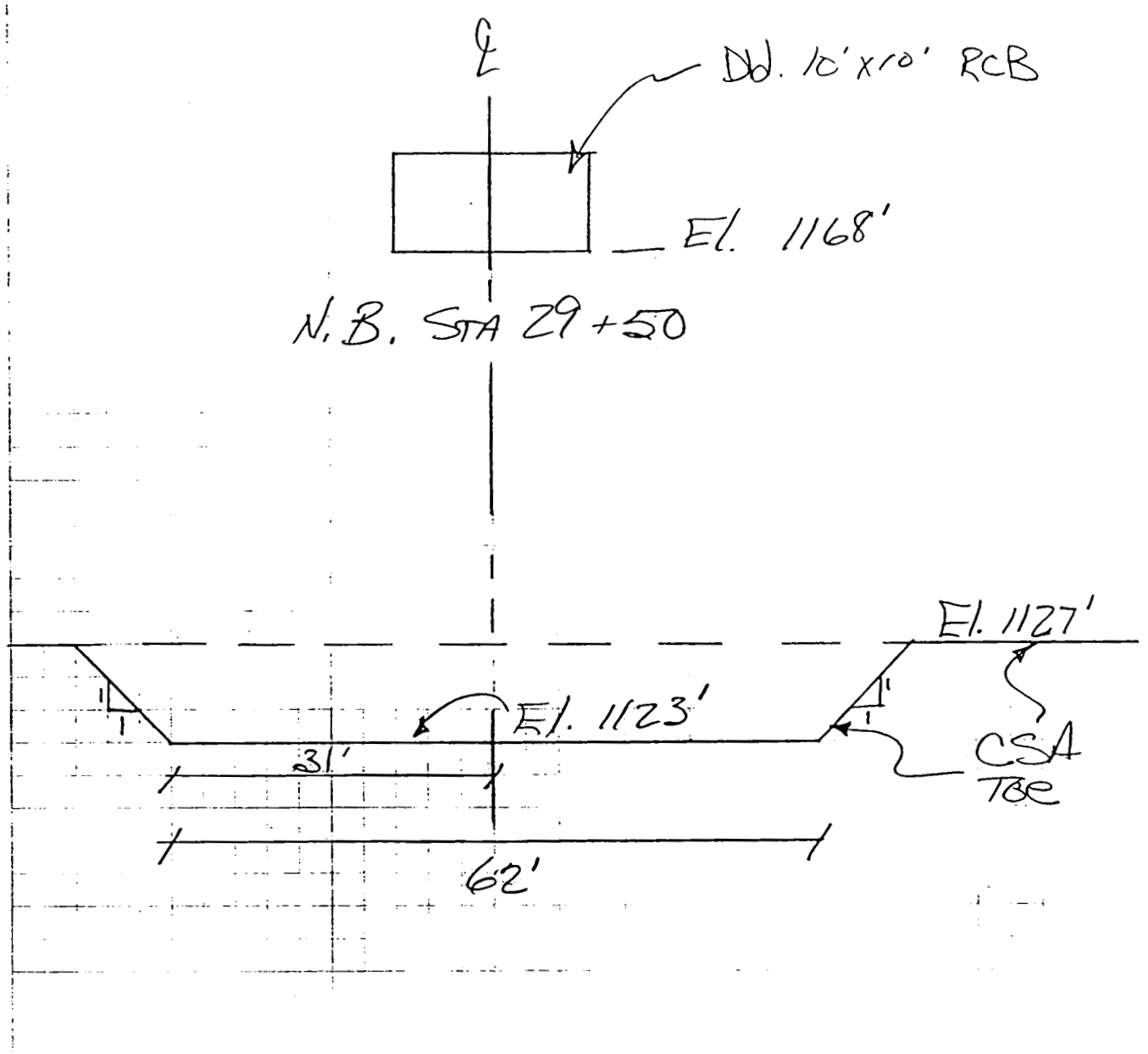
Δd = 3.7'

$$w = 2(2.75\,\Delta d + 2B)$$
$$= 2(2.75(3.7) + 2(10))$$
$$= 60.4\text{ ft.}$$

Use 62 ft.

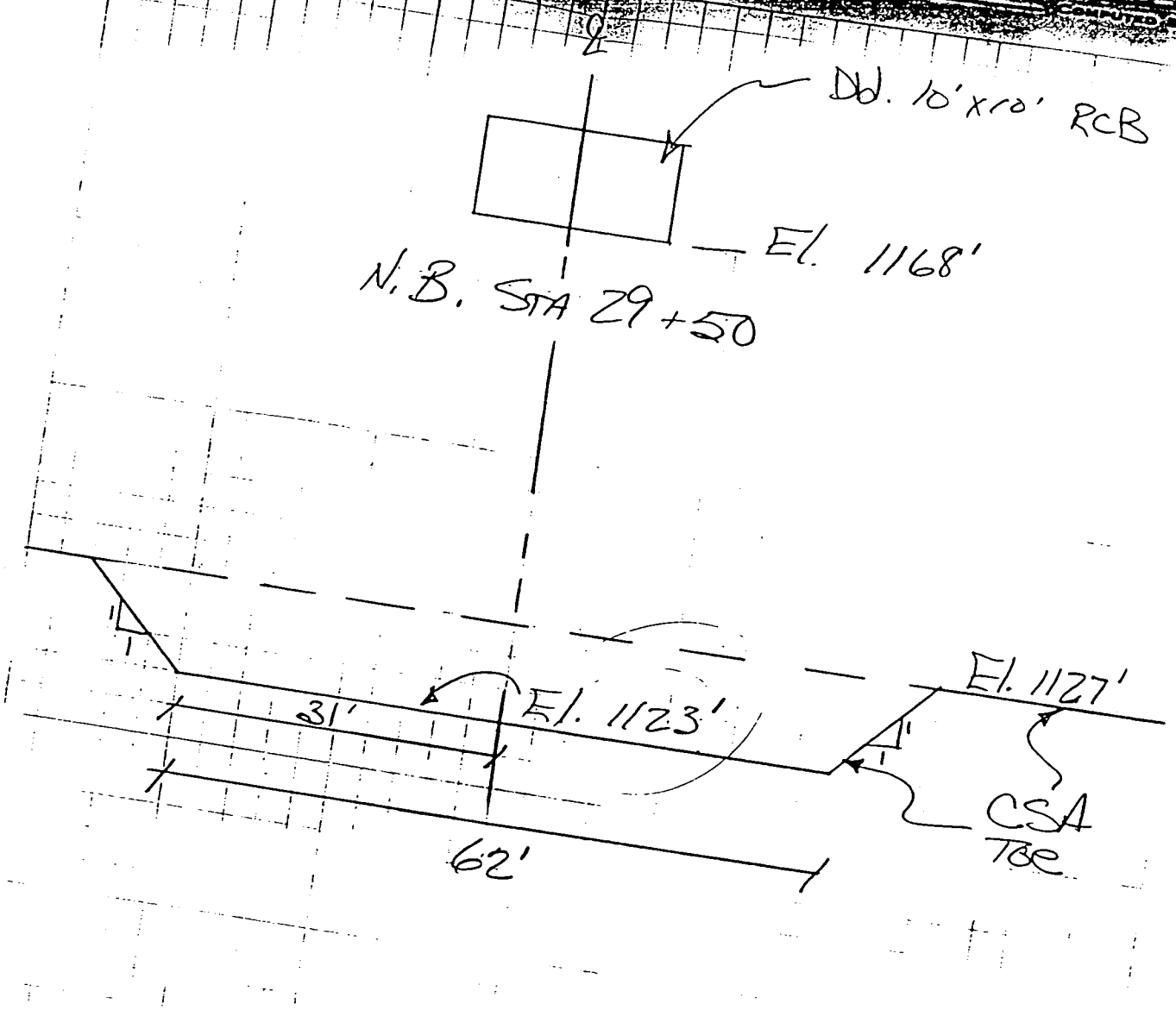
SIMONS, LI & ASSOCIATES, INC.

CLIENT DMJM / ADOT
PROJECT Granite Reef Outfall
DETAIL CSA Toe-Down Elev.
JOB NO.
DATE CHECKED
CHECKED BY
PAGE 5/5
DATE 2-20-95
COMPUTED BY



Design Recommendation

(NTS)



Design Recommendation
(NTS)

FACSIMILE
COVER SHEET

50 YEARS

Daniel, Mann, Johnson, & Mendenhall
300 West Clarendon, Suite 400
Phoenix, AZ 85013
(602) 264-0217

Automatic Facsimile Machine
Cannon L775
Compatible with Group I
Group II and Group III
FAX: 602 / 285-1984

Please call if problems occur or receipt confirmation is required. 602 / 264-0217

DATE OF TRANSMITTAL: 5-1-97 CHARGE NO. 5091.06

RECIPIENT'S FACSIMILE NUMBER: 491-1396

ATTENTION: M. Bart Bergendahl

FROM: Chip

INCLUDING COVER SHEET WE ARE SENDING 2 PAGE(S).

On your original Fax you indicated the ℄ of Pima @ 31+18 South 59+80 North
the ℄ of Pima North is ≈ 61+50±

DMJM

	Top of Bank	Urban's Survey Data Points - Top of Bank			
South Bank Station	Interpreted Elev.	Sta. West	Elev. West	Sta. East	Elev. East
+55.00	1172.3	+32.68	1172.4	+67.85	1172.3
2+09.00	1171.8	1+48.42	1171.9	2+28.05	1171.8
2+73.00	1172.0	2+29.23	1171.8	2+93.09	1172.1
4+00.00	1172.1	3+84.94	1172.1	4+26.76	1172.1
8+19.00	1172.3	8+05.75	1172.3	8+26.71	1172.4
12+17.00	1172.2	12+05.67	1172.2	12+26.58	1172.2
16+07.00	1172.3	15+26.75	1172.2	16+17.31	1172.3
19+72.00	1172.6	19+57.26	1172.5	20+26.69	1172.7
23+76.00	1173.4	23+26.69	1173.6	24+01.64	1173.2
27+69.00	1175.1	27+43.07	1175.0	28+26.62	1175.2
32+01.00	1176.4	31+90.74	1176.4	32+26.61	1176.5
36+09.00	1178.7	35+61.39	1178.3	36+26.61	1178.8
39+81.00	1182.1	39+78.00	1182.1	39+84.05	1182.2
43+56.00	1182.5	43+53.02	1182.6	44+24.76	1182.3
18+42.00	1183.2	18+36.08	1183.2	18+47.17	1183.3
23+43.00	1183.9	23+38.43	1184.0	23+47.40	1183.9
28+14.00	1184.6	27+81.64	1184.7	28+48.09	1184.6
28+76.00	1184.6	28+73.12	1184.6	29+48.04	1184.5
29+03.00	1184.6	28+73.12	1184.6	29+48.04	1184.5
30+08.00	1184.4	29+68.24	1184.5	30+10.09	1184.4
31+18.00	1184.7	31+09.02	1184.8	31+44.51	1184.3
32+00.00	1184.4	31+56.42	1184.1	32+42.41	1184.7
32+58.00	1185.1	32+44.64	1184.8	32+59.32	1185.1
33+20.00	1184.5	32+91.17	1184.4	33+24.20	1184.6
33+50.00	1184.6	33+24.20	1184.6	33+50.33	1184.6

	Top of Bank	Urban's Survey Data Points - Top of Bank			
North Bank Station	Interpreted Elev.	Sta. West	Elev.west	Sta. East	Elev. East
224+76.00	1171.8	224+22.47	1172.1	225+09.61	1171.6
226+32.00	1170.3	226+07.06	1170.7	227+01.34	1169.4
227+04.00	1169.4	227+01.34	1169.4	227+06.94	1169.4
228+25.00	1170.2	228+19.83	1170.2	229+26.46	1170.7
231+26.00	1172.4	230+36.76	1171.6	231+30.70	1172.5
234+66.00	1173.0	234+31.02	1173.1	235+31.25	1173.0
13+89.00	1172.8	13+46.99	1172.8	14+19.59	1172.8
18+52.00	1172.6	18+19.70	1172.6	19+16.88	1172.6
22+59.00	1173.8	22+19.59	1173.7	22+74.84	1173.8
26+50.00	1174.0	26+19.78	1174.0	27+00.81	1174.0
30+28.00	1177.0	30+19.09	1177.0	31+19.12	1177.2
34+34.00	1177.9	34+19.14	1177.8	34+42.53	1178.0
38+55.00	1179.0	38+19.03	1178.9	39+19.07	1179.2
42+89.00	1181.0	42+84.19	1181.0	42+99.87	1181.1
46+70.00	1181.5	46+18.78	1181.4	47+18.74	1181.6
51+31.00	1180.6	51+18.76	1180.6	51+40.39	1180.6
56+77.00	1183.0	56+18.42	1182.3	56+78.29	1183.0
57+39.00	1183.1	57+18.35	1183.1	57+54.75	1183.2
57+67.00	1183.3	57+54.67	1183.2	58+07.19	1183.6
58+72.00	1183.5	58+58.32	1183.8	59+13.31	1182.8
59+80.00	1182.7	59+64.94	1182.6	60+19.08	1183.2
60+61.00	1182.9	60+21.07	1183.2	60+74.11	1182.8
61+20.00	1182.5	61+19.44	1182.6	61+36.97	1182.4
61+81.00	1182.6	61+36.97	1182.4	61+91.47	1182.7
62+11.00	1182.7	61+91.47	1182.7	62+19.54	1182.7

DMJM
ADOT GENERAL CONSULTANT

JUN 16 1997

RECEIVED ☐ SENT ☐

37681
500.11.1.2, 300.11, 706.1.9, 706.4.9, 800

Thomas Monchak (DMJM)

From: Terry Bourland
To: Thomas Monchak (DMJM)
Subject: FW: Salt River Channelization (Grade Control Str. #5 to McClintock)
Date: Wednesday, May 28, 1997 8:37AM

Tom,
This is the confirmation on toe-down as-builts for the above subject area.

From: S. Alfred Kattan
To: Terry Bourland
Cc: John Hauskins
Subject: RE: Salt River Channelization (Grade Control Str. #5 to McClintock)
Date: Tuesday, May 27, 1997 3:55PM

This is to confirm that the Toe- Downs of the CSA hardbank between Mcklintock Drive and the Red Mountain T.I. have been built to the elevations that are shown on the project plans. The As-Built plans show only the changes from the Change Order No. 35 plans and are redlined as such; they do not show verify design elevations unless the construction phasing required such verification. This written confirmation is sufficient to proceed with the transfer of maintenance responsibility of the Salt River Channel to MCFCD.

From: Terry Bourland
To: S. Alfred Kattan
Cc: John Hauskins
Subject: Salt River Channelization (Grade Control Str. #5 to McClintock)
Date: Friday, May 23, 1997 8:37AM

In order to complete the as-builts we need verification in writing that the TOE-DOWNS were built to the plans elevation.

The department is still responsible for the maintenance of the channel until the as-builts are in the hands of the Flood Control District along with easements giving official authorization to maintain the flood control feature in ADOT Right-of-Way.

E. PAPAGO
TM
LB
RLB
RJS
RJ
DMB
CH
BW
DZ
CBB
MSS
SLA
FAX

Post-It® Fax Note 7671	Date 6/16	# of pages ▶ 1
To Bert Bergendahl	From	
Co./Dept.	Co.	
Phone #	Phone #	
Fax #	Fax #	