DICK PETRIBAUCH

HYDRAULIC ANALYSIS FOR TRANSITION REACH OF SALT RIVER CHANNELIZATION EAST PAPAGO FREEWAY

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HYDRAULIC ANALYSIS FOR TRANSITION REACH OF SALT RIVER CHANNELIZATION EAST PAPAGO FREEWAY

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January 1989

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I. INTRODUCTION

This report presents the hydraulic analysis of the upstream transition reach of the Salt River channelization project that will be constructed in conjunction with the East Papago and Hohokam Freeways. The effects of the transition on the river's hydraulic characteristics, not only in the transition, but on the upstream structures and floodplain as well, are described in the report. Design plans for the transition area were provided to Simons, Li & Associates, Inc. (SLA) by Daniel, Mann, Johnson, & Mendenhall, (DMJM), management consultants to the Arizona Department of Transportation.

The information in this report supplements the information presented in the concept design report for the Salt River Channelization prepared by SLA in May, 1988. In the initial study, existing conditions were assessed and a baseline condition established. Backwater analyses were conducted for the 10-year, 50-year, 100-year, and Standard Project (SPF) floods for both the existing and channelized conditions. The SPF is the design event for the channelization project.

This study was conducted to address the termination point of the transition guide banks and the impacts on the existing structures and the floodplain immediately upstream of the channelization. A rigid-boundary backwater analysis was conducted, along with a moveable-bed analysis. The 100-year flood (215,000 cfs) is used in this analysis, since the impacts on the regulatory floodplain and floodway are the primary concern. The effects of channelization are compared to the baseline conditions. Figure 1 is a location map of the reach of interest.

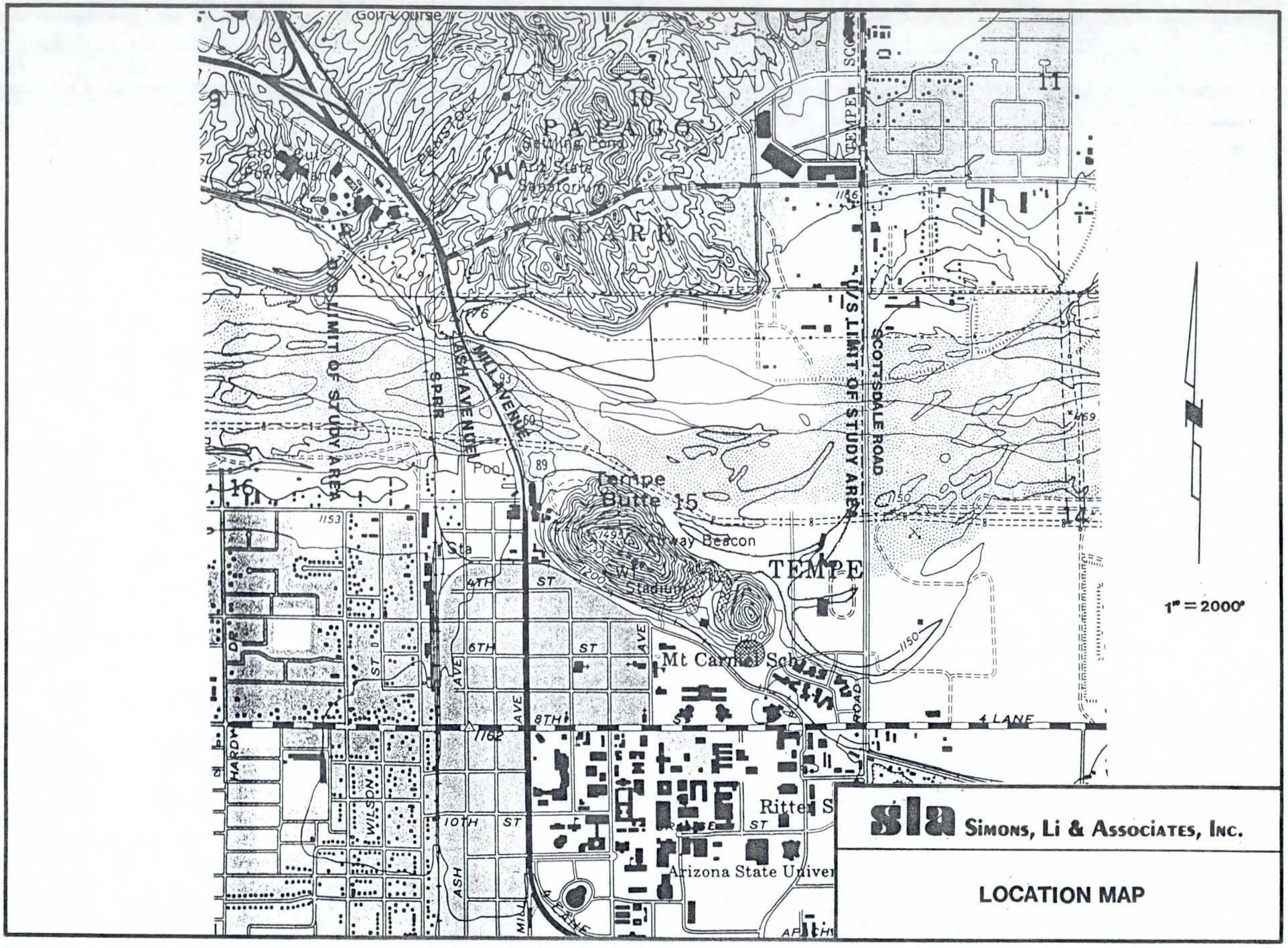


Figure 1. Transition Reach of the Salt River Channelization Location Map

II. CHANNEL ANALYSIS

2.1 Reach Investigated

The reach of interest for this study is from Grade Control No. 4, located at the upstream end of the channelization, Station 249+55, to Scottsdale Road. This reach includes the transition area, the Southern Pacific Railroad (SPRR) bridge, the Ash Avenue bridge, and the Mill Avenue bridge. These three existing bridges are located immediately upstream of the transition. Figure 2 is an aerial photo of the three bridges and the downstream channel. This photo was taken in February 1980 during a flow of approximately 170,000 cfs.

2.2 Rigid-Boundary Analysis

The concept hydraulic design study prepared by SLA in May, 1988, used two water-surface profile programs in combination with the rigid-boundary analysis of the Salt River. The Federal Highway Administration's WSPRO program was used at each bridge location, and the Corps of Engineers HEC-2 program was used for the intervening reaches of the river. The analysis consisted of running HEC-2 to a section downstream of each bridge, then running WSPRO through the bridge, using the upstream calculated water-surface elevation from the most upstream HEC-2 section as the starting water-surface elevation. Upstream of the bridge, the procedure was reversed with the HEC-2 run continuing from the approach section of the bridge, using a starting water-surface elevation calculated by WSPRO.

For this supplemental analysis, two procedures were used for the rigid-boundary analysis. The first procedure used HEC-2 to model the entire reach, including the bridges. The special bridge routine was used at the bridges. This procedure was used since the 1983-84 Salt River Flood Insurance Study used the HEC-2 program for the entire reach. In addition, the distance between bridges is less than is recommended for proper application of WSPRO. The second procedure used the combination of the HEC-2 program and the WSPRO program, as was done in the concept

SALT RIVER CHANNEL DOWNSTREAM OF MILL AVENUE

(COURTESY OF MARICOPA COUNTY FLOOD CONTROL DISTRICT)

Figure 2. Photograph of Salt River Channel Downstream of Mill Avenue

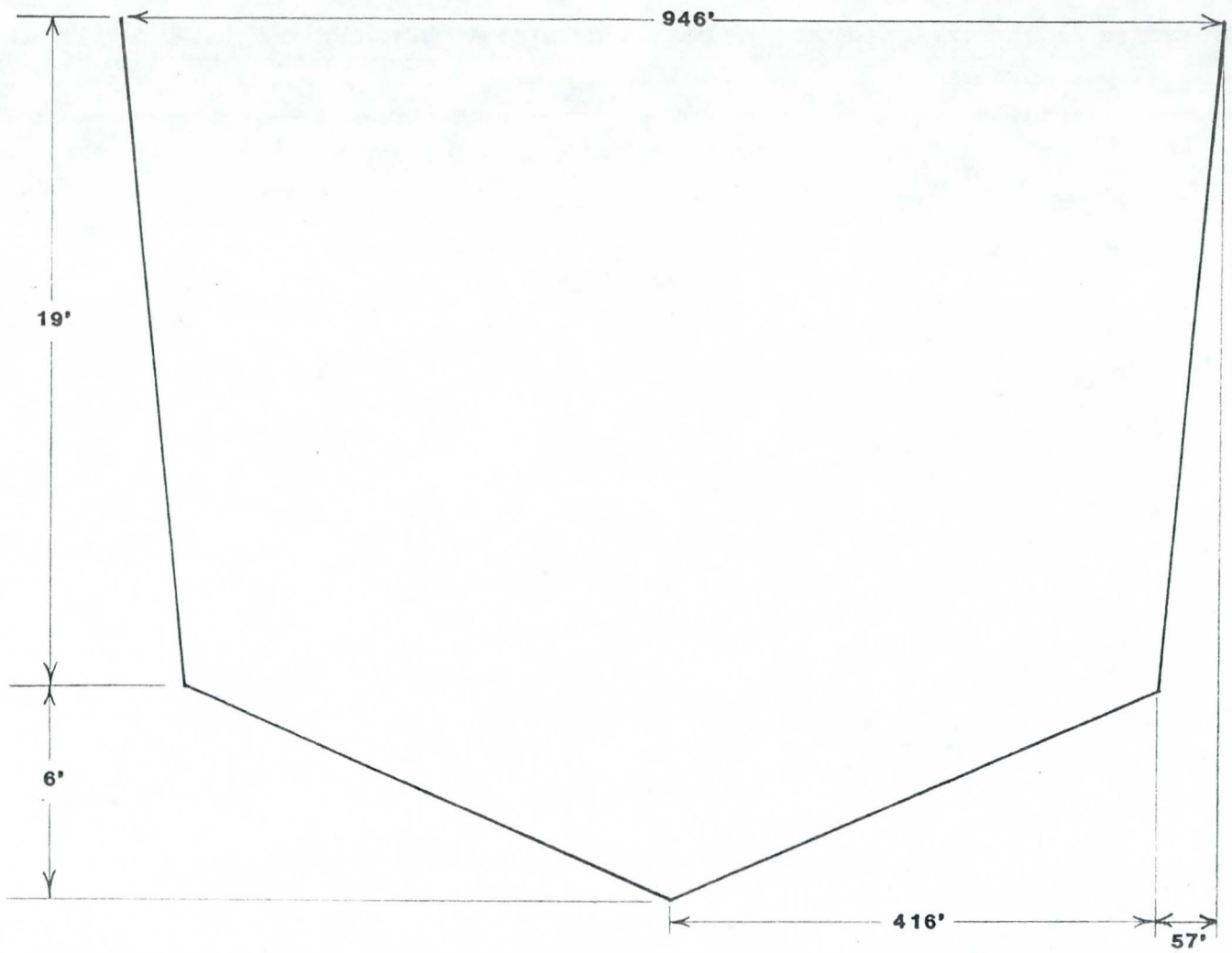
hydraulic design study. This procedure was used in order to compare results of this analysis with results presented in the concept design report. In both procedures, the low ground south of the bridge abutments was considered to be an ineffective flow area.

2.3 Concept Hydraulic Analysis

In the concept design, a five-point channel cross-section with a V-shaped invert was used for the channelized reach. A typical five-point cross-section is shown in Figure 3. The slope of that channel was 0.0022 ft/ft, with an invert elevation of 1131.87 at Grade Control No. 4. Upstream of the grade-control structure, the slope increased to 0.0028 ft/ft.

For the concept design, the transition guide-banks were aligned to gradually contract the flow from the natural section to the channelized section. The north guide-bank was deflected 12 degrees left at the upstream end of the channelization, and tied in with the north abutment of the Ash Avenue Bridge (see Figure 4). The south guide-bank transitioned smoothly from the channelized section to the south embankment of the SPRR. The concept analysis assumed the transition reach would not be graded. The n-value used for the transition reach was 0.040.

The channelization produces a general lowering of the 100-year-flood elevations, and a corresponding increase in flow velocities, as compared to the baseline conditions. Figure 5 provides plots of the 100-year-flood elevations from downstream of Grade Control No. 4 to Scottsdale Road for both baseline and channelized conditions, as configured in the concept design. Figure 6 provides an expanded view of the reach from downstream of Grade Control No. 4 to the upstream end of the transition. For channelized conditions, the water-surface elevations increase upstream of the channelization, and exceed the elevations for baseline conditions. This increase is created by the contraction of flow in the transition reach. Flow velocities were little changed in the reach upstream of the channelization.



sla Simons, Li & Associates, Inc.

TYPICAL FIVE-POINT

CHANNEL CROSS-SECTION

Figure 3. Typical Five-point Channel Cross-Section

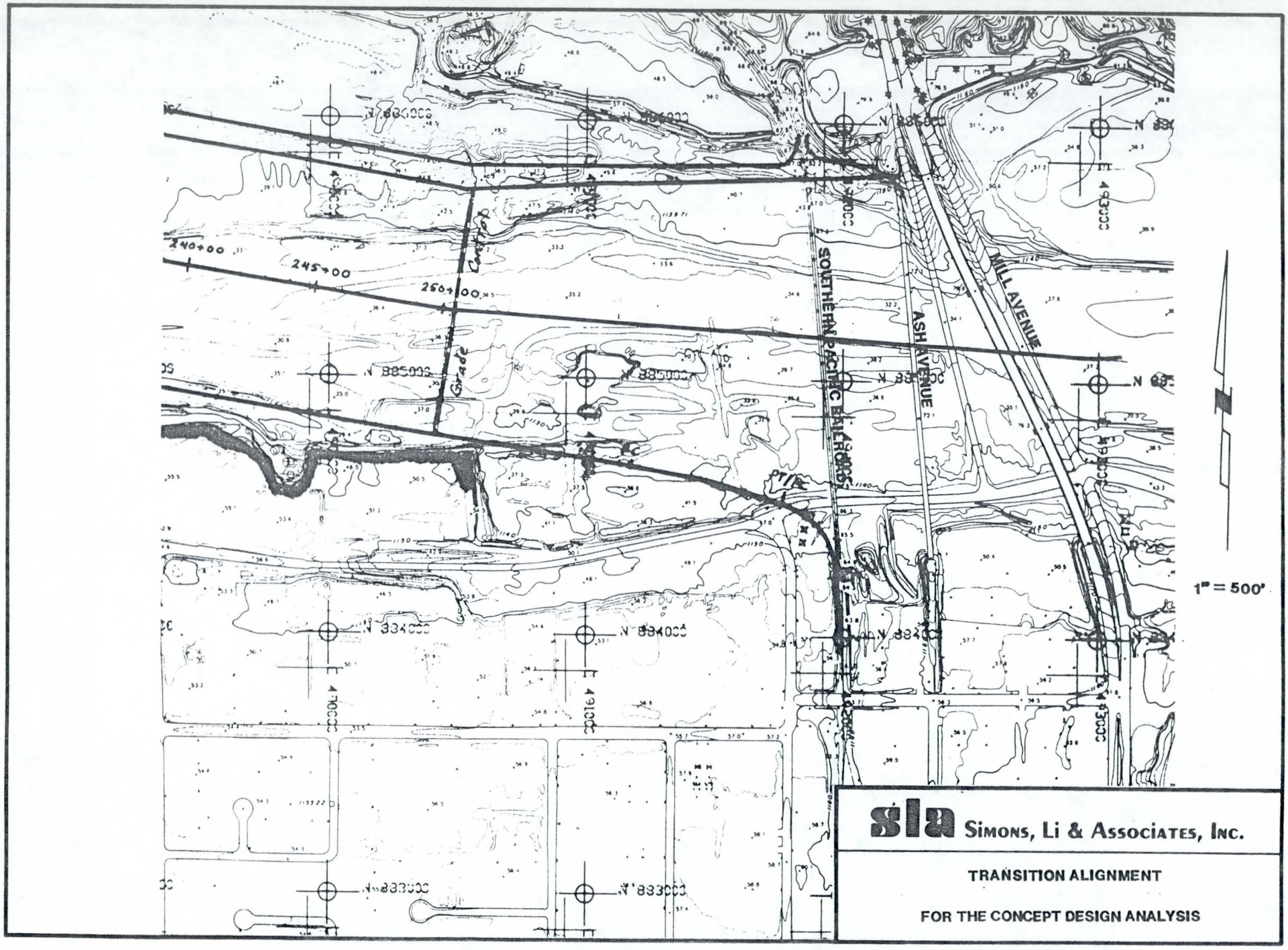


Figure 4. Transition Alignment from the Concept Design Study

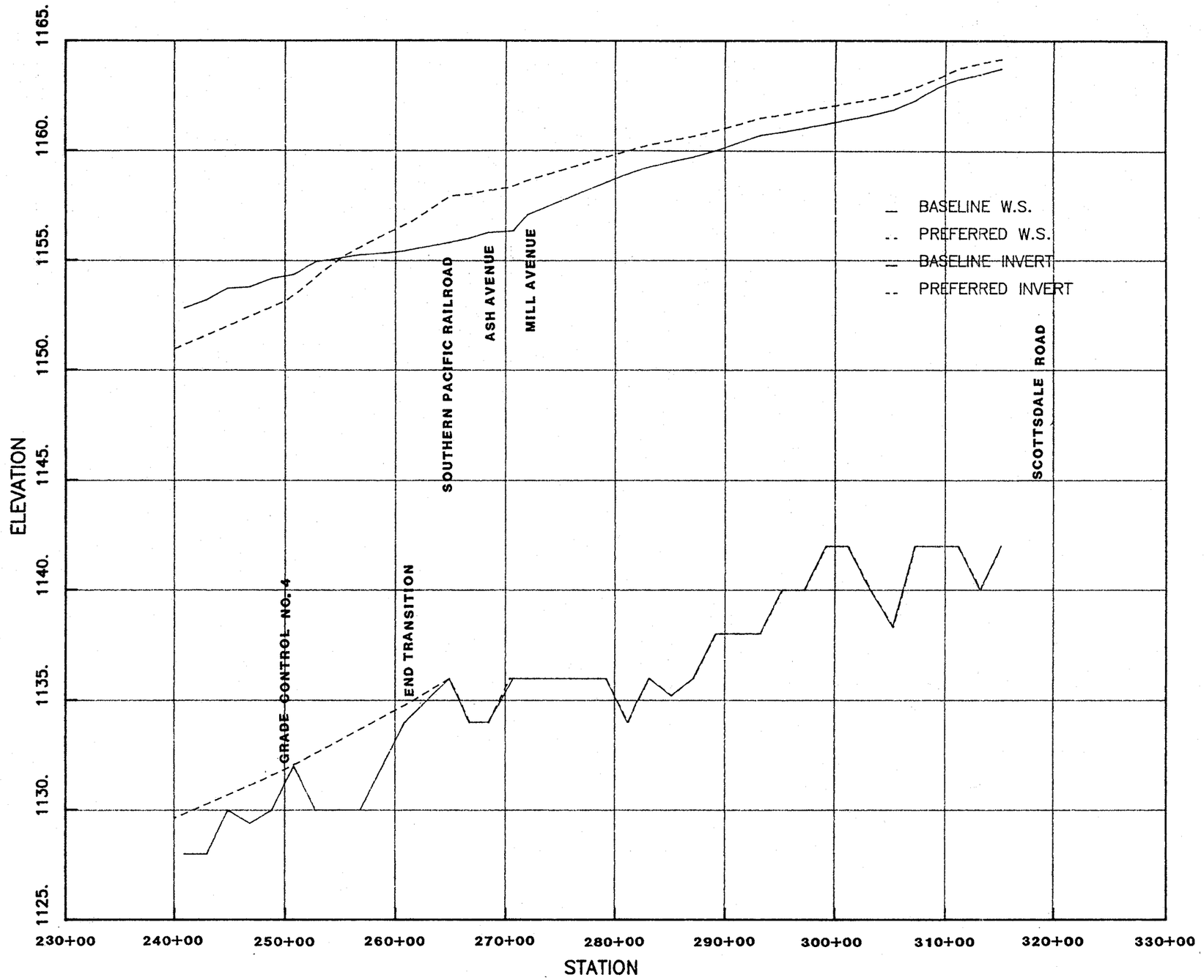


Figure 5. Comparison of Water-Surface Profiles for Baseline and Channelized Conditions from the Concept Design Study

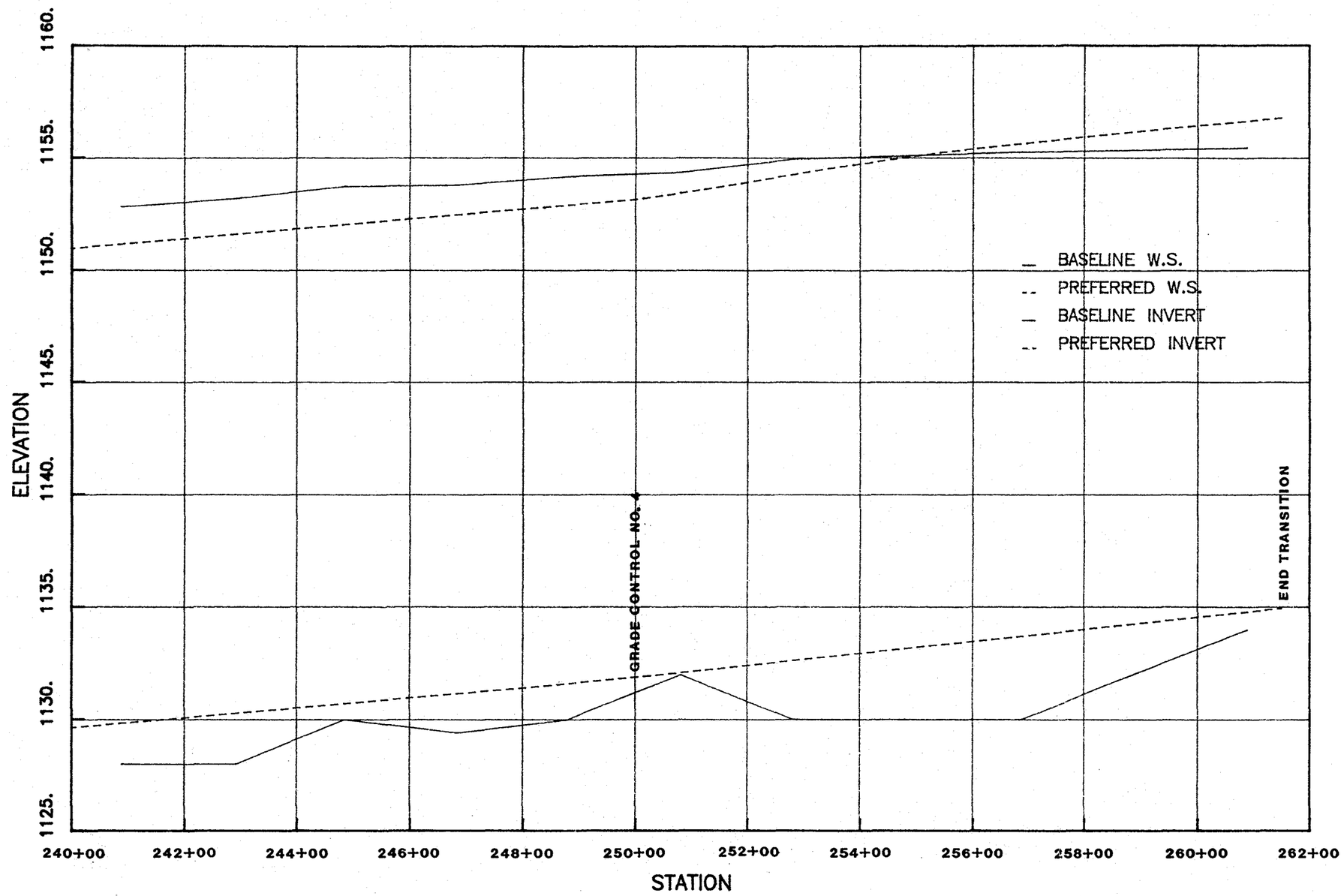


Figure 6. Comparison of Water-Surface Profiles for Baseline and Channelized Conditions from the Concept Design Study, Transition Reach

2.4 Supplemental Analysis

This study is an in-depth analysis to determine the impact of channelization on the floodplain and existing structures upstream of the channelization. The analysis is for a reach of the Salt River beginning at Grade Control No. 3 (Station 207+82), and continuing to Scottsdale Road. The starting water-surface elevation was based on SLA's concept design study. The water-surface elevation at Grade Control No. 3 is 1143.34 feet for the 100-year flood. The invert elevation at Grade Control No. 3 is 1122.58 feet.

For the supplemental analysis, the slope was adjusted to match the invert elevations provided on DMJM's channelization plans. Plan sheets are contained in Appendix A. This new slope is 0.0024 ft/ft. The invert elevation at Grade Control No. 4 is 1132.48 feet. Guide-banks on both the north bank and south bank extend eastward from the upstream end of the channelization to tie into the SPRR abutments. There are two breaks in the south guide-bank for First Street and Farmer Avenue.

The five-point cross section was maintained in the transition reach, except for a narrow bench at the toe of each bank. A roughness value of 0.035 was used for the transition reach. The n-value changes to 0.040 just upstream of the transition. The channel slope in the transition reach is 0.0028 ft/ft.

A rigid-boundary analysis was conducted for two conditions. For the first condition, a channel slope of 0.0024 ft/ft, the initial bed slope, was assumed between Grade Control No. 3 and Grade Control No. 4. For the other condition, a long-term degradational (equilibrium) slope of 0.00136 ft/ft was used. The water-surface-profile computations began at Grade Control No. 3, using the 100-year-flood elevation computed in the concept design study.

For the equilibrium-slope condition, there is a vertical drop of 4.2 feet at Grade Control No. 4. Critical-flow conditions were investigated at this structure, and it was determined that for the

100-year flood, the structure would be submerged and the flow would be affected by downstream conditions. Submergence calculations are included in Appendix B. Therefore, the water-surface profile was calculated from Grade Control No. 3 to just downstream of Grade Control No. 4. The elevation calculated at the downstream side of Grade Control No. 4 was then used as the starting elevation for water-surface-profile computations upstream of this structure.

Prior to conducting the submergence calculations, runs were also made beginning at both critical depth and normal depth at Grade Control No. 3 to determine the effects of the water-surface elevation at Grade Control 4. It was found that the differences in the two runs become smaller with increasing distance upstream of Grade Control No. 3 and are virtually gone at Grade Control No. 4. The difference in water-surface elevations 365 feet upstream (Station 211+65) of Grade Control No. 3 was 1.49 feet, while 4000 feet upstream the difference was 0.24 feet.

Hydraulic results of the rigid-boundary analyses for the baseline conditions, initial slope, and equilibrium slope are shown in Tables 1 through 3. Figures 7 and 8 provide plots of the water-surface elevation for baseline conditions versus channelized conditions. Figure 7 is for channelized conditions using the initial bed slope, and Figure 8 is for channelized conditions using the equilibrium slope.

A moveable-bed analysis was conducted for the 100-year flood event to evaluate the effects that contraction scour would have upon the channel-bed profile, water-surface elevations, and flow velocities in the study reach. QUASED-WSPR, a quasi-dynamic sediment routing program developed by SLA, was the program used to determine the amount of material either transported or deposited in the river reach. This analysis was conducted using the channel and transition cross-sections from SLA's concept design study. The bed-gradation data used for this study is included in the concept design report (SLA, 1988).

HYDRAULIC INFORMATION
BASELINE CONDITIONS
100-YEAR FLOOD
HEC-2

NOTE: STATIONING IS MEASURED ALONG THE CHANNELIZATION CONTROL LINE.

STATION	WSEL	DEPTH	VELOCITY	INVERT
241+10	1152.83	10.14	10.06	1128.00
243+10	1153.22	10.65	9.57	1128.00
245+10	1153.75	10.86	8.62	1130.00
247+07	1153.81	13.58	9.31	1129.40
249+06	1154.19	10.66	8.92	1130.00
251+05	1154.37	11.74	9.26	1132.00
253+03	1154.95	10.64	7.50	1130.00
255+08	1155.10	11.23	7.31	1130.00
257+09	1155.27	12.65	7.11	1130.00
259+10	1155.34	14.05	7.70	1132.00
261+12	1155.49	12.16	8.25	1134.00

Table 1. Hydraulic Information for Baseline Conditions Below the Upstream End of the Transition

HYDRAULIC INFORMATION
PREFERRED CONDITIONS
INITIAL SLOPE
D/S OF GRADE CONTROL NO. 4 TO U/S END OF TRANSITION
100-YR FLOOD
SLA HEC-2

NOTE: STATIONING IS MEASURED ALONG THE
CHANNELIZATION CONTROL LINE.

STATION	WSEL	DEPTH	VELOCITY	INVERT
240+00	1151.15	17.01	13.51	1130.13
242+00	1151.61	17.00	13.51	1130.60
244+00	1152.08	17.00	13.51	1131.07
246+00	1152.54	16.99	13.52	1131.54
248+00	1153.01	16.99	13.52	1132.01
250+00	1153.48	16.99	13.52	1132.48
251+07	1154.38	18.03	11.94	1132.74
253+02	1155.28	18.53	10.30	1133.20
255+08	1155.87	18.70	9.18	1133.68
257+08	1156.25	18.66	8.50	1134.15
259+14	1156.59	18.62	7.86	1134.64
261+19	1156.79	18.35	7.61	1135.12

Table 2. Hydraulic Information for Channelized (Initial Slope) Conditions Below the Upstream End of the Transition

HYDRAULIC INFORMATION
PREFERRED CONDITIONS
EQUILIBRIUM SLOPE
D/S OF GRADE CONTROL NO. 4 TO U/S END OF TRANSITION
100-YR FLOOD
SLA HEC-2

NOTE: STATIONING IS MEASURED ALONG THE
CHANNELIZATION CONTROL LINE.

STATION	WSEL	DEPTH	VELOCITY	INVERT
240+00	1150.26	19.05	11.88	1126.93
242+00	1150.58	19.09	11.85	1127.20
244+00	1150.90	19.12	11.83	1127.48
246+00	1151.21	19.16	11.80	1127.75
248+00	1151.53	19.20	11.77	1128.02
249+98	1151.83	20.29	11.75	1128.29
250+00	1151.83	15.51	14.97	1132.48
251+07	1153.12	16.83	12.85	1132.74
253+02	1154.24	17.55	10.91	1133.20
255+08	1154.95	17.82	9.65	1133.68
257+08	1155.39	17.83	8.91	1134.15
259+14	1155.77	17.82	8.22	1134.64
261+19	1156.01	17.59	7.95	1135.12

Table 3. Hydraulic Information for Channelized (Equilibrium Slope) Conditions Below the Upstream End of the Transition

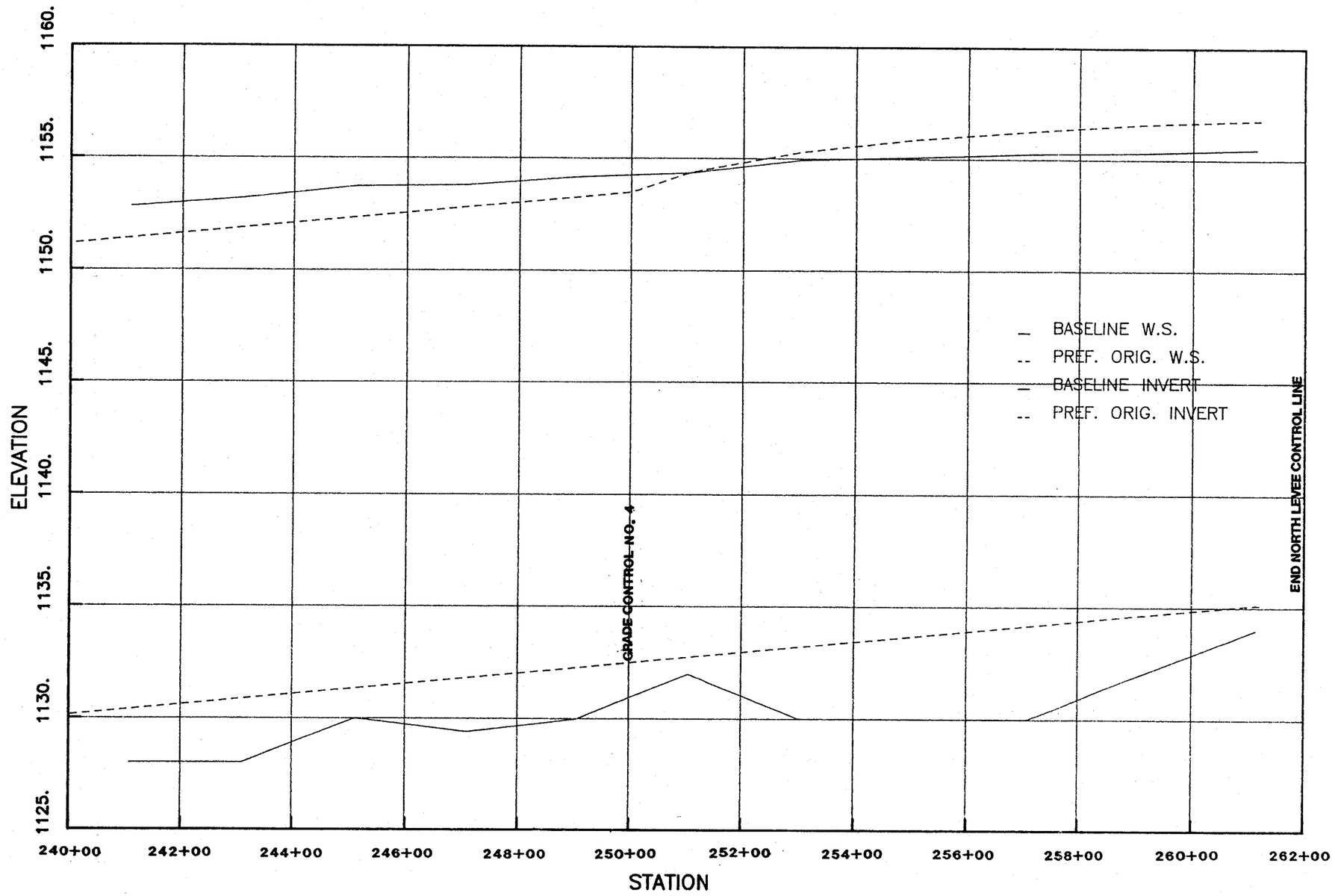


Figure 7. Comparison of Water-Surface Profiles for Baseline and Channelized (Initial Slope) Conditions, Transition Reach

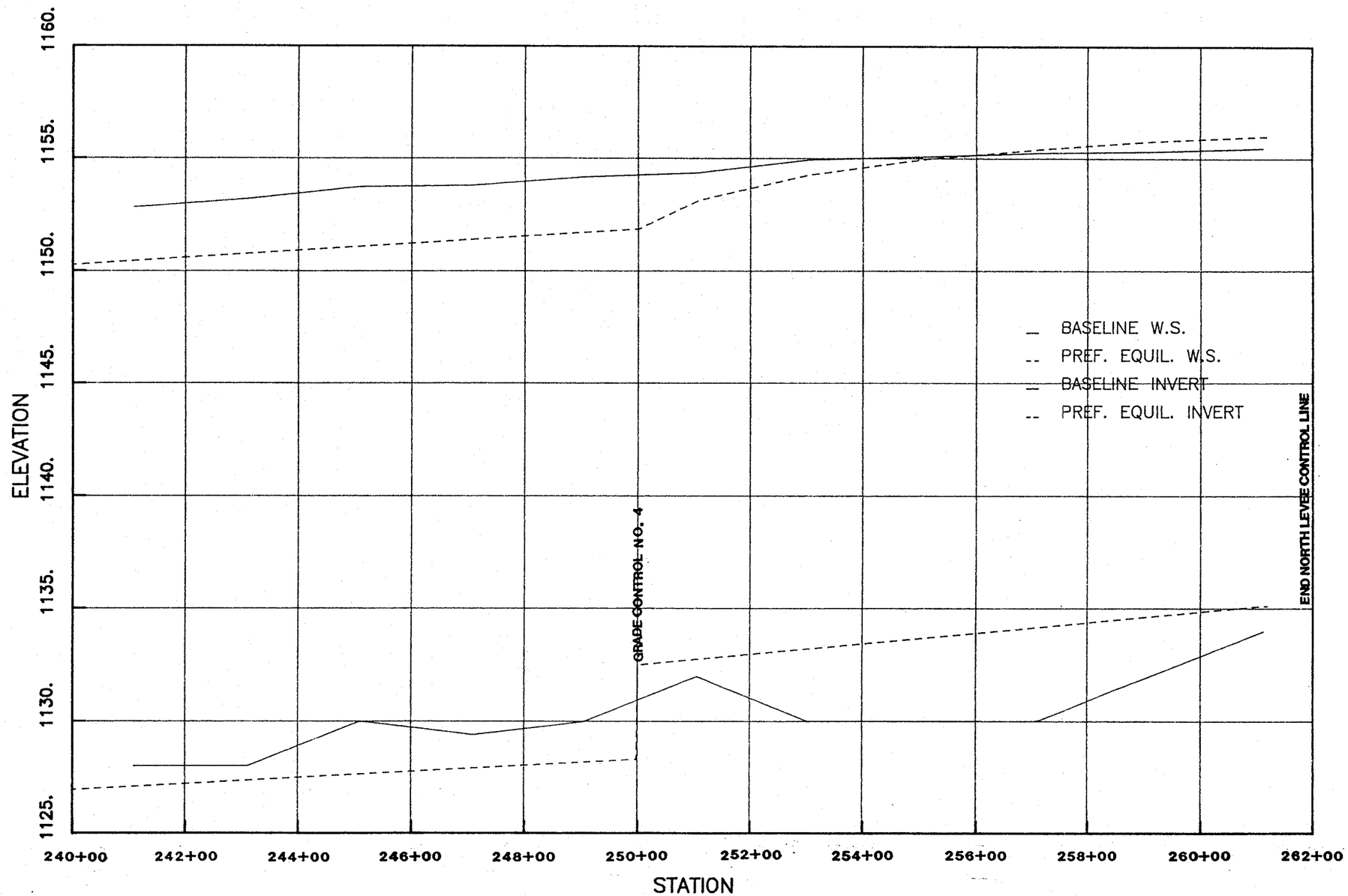


Figure 8. Comparison of Water-Surface Profiles for Baseline and Channelized (Equilibrium Slope) Conditions, Transition Reach

The results of the moveable-bed simulations for the baseline and channelized conditions are summarized in Tables 4 and 5, respectively. The initial, maximum, minimum, and final bed elevations are given. Figure 9 shows the water-surface elevations for channelized conditions for both the rigid-boundary analysis using the equilibrium slope and the moveable-bed analysis.

QUASED-WSPR
100-YR FLOOD
BASELINE CONDITIONS
NO GRADE CONTROLS

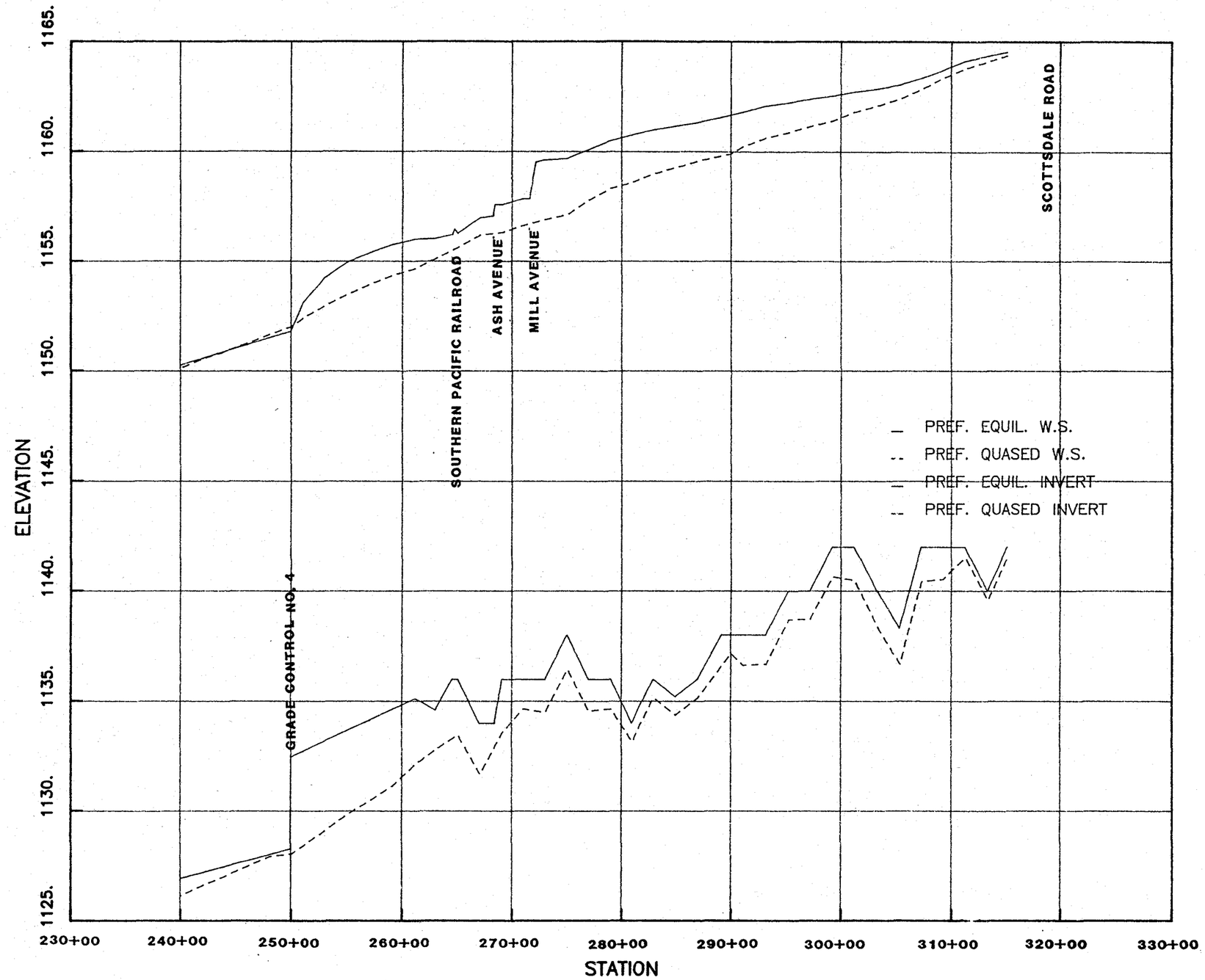
STATION	BED ELEVATION INITIAL	MAX.	MIN.	FINAL	WSEL	VELOCITY
241+10	1128.00	1128.00	1126.32	1126.66	1152.68	8.11
243+10	1128.00	1128.00	1126.42	1126.76	1153.12	7.75
245+10	1130.00	1130.00	1129.03	1129.03	1153.53	7.36
247+07	1129.40	1129.40	1128.23	1128.23	1153.69	8.20
249+06	1130.00	1130.00	1129.03	1129.03	1154.14	7.53
251+05	1132.00	1132.00	1131.02	1131.02	1154.44	7.65
253+03	1130.00	1130.00	1129.18	1129.18	1154.98	6.20
255+08	1130.00	1130.11	1129.28	1129.28	1155.17	6.60
257+09	1130.00	1130.07	1129.25	1129.25	1155.40	6.67
259+10	1132.00	1132.03	1131.06	1131.06	1155.52	7.29
261+12	1134.00	1134.08	1133.18	1133.18	1155.74	7.53
263+11	1134.00	1134.00	1132.57	1132.57	1155.97	7.71
265+04	1134.00	1134.00	1132.47	1132.47	1156.15	8.21
267+04	1134.00	1134.00	1132.44	1132.44	1156.39	8.33
269+06	1136.00	1136.00	1134.35	1134.35	1156.51	9.04
271+07	1136.00	1136.02	1134.91	1135.00	1156.81	9.01
273+02	1136.00	1136.01	1134.77	1134.90	1157.06	9.46
275+03	1138.00	1138.02	1136.75	1136.89	1157.28	10.32
276+98	1136.00	1136.02	1134.80	1134.94	1157.93	9.49
278+98	1136.00	1136.02	1134.91	1135.01	1158.45	8.69
280+98	1134.00	1134.05	1133.43	1133.43	1158.71	8.92
282+98	1136.00	1136.06	1135.44	1135.44	1159.09	8.65
284+98	1135.20	1135.26	1134.66	1134.66	1159.39	8.65
286+98	1136.00	1136.04	1135.42	1135.42	1159.68	8.69
289+98	1138.00	1138.04	1137.46	1137.46	1160.02	8.49
291+10	1138.00	1138.10	1136.70	1136.70	1160.35	8.16
293+21	1138.00	1138.09	1136.81	1136.81	1160.73	7.63
295+26	1140.00	1140.06	1138.86	1138.86	1160.98	7.66
297+19	1140.00	1140.08	1138.90	1138.90	1161.24	7.67
299+24	1142.00	1142.08	1140.91	1140.91	1161.50	7.84
301+23	1142.00	1142.00	1140.51	1140.51	1161.90	7.38
303+24	1140.00	1140.00	1138.46	1138.46	1162.19	7.51
305+25	1138.30	1138.30	1136.77	1136.77	1162.49	7.79
307+21	1142.00	1142.00	1140.50	1140.50	1162.92	7.48
309+18	1142.00	1142.00	1140.68	1140.68	1163.41	6.81
311+23	1142.00	1142.12	1141.52	1141.57	1163.84	6.13
313+29	1140.00	1140.10	1139.54	1139.59	1164.16	5.87
315+20	1142.00	1142.07	1141.52	1141.57	1164.43	5.98

Table 4. Moveable-boundary Bed Elevations and Hydraulic Information for Baseline Conditions

QUASED-WSPR
100-YR FLOOD
PREFERRED CONDITIONS
NO GRADE CONTROLS

STATION	BED ELEVATION INITIAL	MAX.	MIN.	FINAL	WSEL	VELOCITY
240+00	1129.67	1129.67	1126.13	1126.13	1150.11	11.80
242+00	1130.12	1130.12	1126.60	1126.60	1150.54	11.64
244+00	1130.56	1130.56	1127.02	1127.02	1150.87	11.88
246+00	1131.01	1131.01	1127.47	1127.47	1151.26	11.91
248+00	1131.45	1131.45	1127.91	1127.91	1151.66	11.94
250+00	1131.87	1131.87	1128.03	1128.03	1152.02	12.21
251+07	1132.22	1132.22	1128.41	1128.41	1152.41	11.95
253+02	1132.76	1132.76	1129.08	1129.08	1152.97	11.45
255+08	1133.31	1133.31	1129.83	1129.83	1153.48	10.99
257+08	1133.84	1133.84	1130.45	1130.45	1153.94	10.64
259+14	1134.39	1134.39	1131.13	1131.13	1154.35	10.34
261+19	1134.94	1134.94	1132.13	1132.13	1154.65	10.59
263+04	1135.46	1135.46	1132.80	1132.80	1155.11	10.15
265+04	1136.00	1136.00	1133.46	1133.46	1155.62	9.55
267+04	1134.00	1134.00	1131.67	1131.67	1156.17	8.43
269+06	1136.00	1136.00	1133.55	1133.55	1156.29	9.18
271+07	1136.00	1136.05	1134.62	1134.65	1156.62	9.09
273+02	1136.00	1136.04	1134.45	1134.47	1156.88	9.53
275+03	1138.00	1138.05	1136.43	1136.45	1157.11	10.41
276+98	1136.00	1136.05	1134.51	1134.54	1157.77	9.55
278+98	1136.00	1136.05	1134.63	1134.66	1158.30	8.74
280+98	1134.00	1134.01	1133.15	1133.15	1158.57	8.99
282+98	1136.00	1136.01	1135.15	1135.15	1158.96	8.71
284+98	1135.20	1135.22	1134.37	1134.37	1159.26	8.71
286+98	1136.00	1136.00	1135.13	1135.13	1159.56	8.74
289+98	1138.00	1138.00	1137.16	1137.16	1159.90	8.54
291+10	1138.00	1138.12	1136.61	1136.61	1160.23	8.23
293+21	1138.00	1138.07	1136.67	1136.67	1160.63	7.66
295+26	1140.00	1140.06	1138.67	1138.67	1160.88	7.71
297+19	1140.00	1140.06	1138.69	1138.69	1161.15	7.70
299+24	1142.00	1142.04	1140.65	1140.65	1161.41	7.86
301+23	1142.00	1142.00	1140.49	1140.49	1161.81	7.45
303+24	1140.00	1140.00	1138.37	1138.37	1162.10	7.57
305+25	1138.30	1138.30	1136.67	1136.67	1162.41	7.84
307+21	1142.00	1142.00	1140.42	1140.42	1162.85	7.53
309+18	1142.00	1142.00	1140.53	1140.53	1163.35	6.83
311+23	1142.00	1142.13	1141.51	1141.52	1163.79	6.17
313+29	1140.00	1140.11	1139.56	1139.56	1164.11	5.92
315+20	1142.00	1142.09	1141.54	1141.54	1164.39	6.01

Table 5. Moveable-boundary Bed Elevations and Hydraulic Information for Channelized Conditions from the Concept Design Analysis



SLA, INC.

Figure 9. Comparison of Water-Surface and Bed Profiles for the Rigid Boundary Analysis (Equilibrium Slope) and the Moveable-bed Analysis for Channelized Conditions

III. BRIDGE ANALYSES

Analyses through the three existing structures were conducted by both the HEC-2 program, to be consistent with the Flood Insurance Study, and by the WSPRO program, for comparison with the concept design study. The analyses were conducted for the equilibrium-slope conditions. Table 6 includes the results for both the HEC-2 analysis through the bridges and the WSPRO analysis. Figures 10 and 11 show the water-surface elevations for baseline versus channelized conditions using HEC-2 and WSPRO, respectively. Figures 12 and 13 plot the velocities for same sets of conditions.

The SPRR, Ash Avenue, and Mill Avenue bridges were analyzed by the WSPRO fixed-bridge routine and the HEC-2 special-bridge routine. For HEC-2, two different sets of bridge input data were used in the analysis.

1. Bridge input data developed by SLA.
2. Bridge input data developed by the Corps of Engineers. The Corps of Engineers data was obtained from their 1984 flood-insurance study.

The two different sets of bridge input data for HEC-2 give results that are quite different. Using SLA's bridge input data, water-surface elevations upstream of the bridges are significantly higher than elevations obtained using the Corps' bridge input data, particularly upstream of Mill Avenue. These differences are due primarily to the different channel geometries, pier widths, etc., coded in for the bridges. For instance, the pier widths used for Ash Avenue were 140 square-feet in SLA's input data, and 90 square-feet in the Corps' data. However, the difference in water-surface elevations between baseline and channelized conditions was essentially the same for each of the analyses. Hydraulic results for both set of bridge input data are included in Tables 7 and 8. Table 7 contains the results for baseline conditions and Table 8 contains the results for channelized conditions.

HYDRAULIC INFORMATION
BASELINE VS. PREFERRED CONDITIONS
THROUGH THE SPRR, ASH AVENUE, AND MILL AVENUE BRIDGES
100-YR FLOOD

NOTE: STATIONING IS MEASURED ALONG THE
CHANNELIZATION CONTROL LINE.

BASELINE CONDITIONS
HEC-2

STATION	WSEL	DEPTH	VELOCITY	INVERT
261+12	1155.49	12.16	8.25	1134.00
263+11	1155.61	14.21	8.59	1134.00
264+55	1155.72	14.14	9.00	1136.00
264+74	1155.96	14.36	8.85	1136.00
265+04	1155.98	14.33	9.11	1136.00
267+04	1156.34	15.87	8.73	1134.00
268+26	1156.44	16.11	9.10	1134.00
268+41	1156.97	16.60	8.81	1134.00
269+06	1156.97	16.05	9.23	1136.00
271+07	1157.36	13.47	9.21	1136.00
271+61	1157.27	16.52	9.99	1136.00
272+21	1159.19	18.17	8.94	1136.00
273+02	1159.48	14.52	8.41	1136.00
275+03	1159.50	13.07	9.57	1138.00
276+98	1159.86	13.35	9.29	1136.00
278+98	1160.24	14.13	8.99	1136.00

PREFERRED CONDITIONS
EQUILIBRIUM SLOPE
HEC-2

STATION	WSEL	DEPTH	VELOCITY	INVERT
261+19	1156.01	17.59	7.95	1135.12
263+04	1156.05	15.62	8.85	1134.60
264+55	1156.22	14.61	8.89	1136.00
264+74	1156.45	14.83	8.76	1136.00
265+04	1156.27	15.58	9.86	1136.00
267+04	1156.98	16.49	8.58	1134.00
268+26	1157.07	16.69	8.95	1134.00
268+41	1157.57	17.15	8.69	1134.00
269+06	1157.58	16.60	9.10	1136.00
271+07	1157.85	15.24	9.32	1136.00
271+61	1157.83	16.95	9.66	1136.00
272+21	1159.53	18.48	8.78	1136.00
273+02	1159.63	16.55	8.81	1136.00
275+03	1159.70	15.50	9.77	1138.00
276+98	1160.10	16.15	9.39	1136.00
278+98	1160.51	16.63	9.05	1136.00

BASELINE CONDITIONS
WSPRO

STATION	WSEL	DEPTH	VELOCITY	INVERT
261+12	1155.49	12.15	7.73	1134.00
264+55	1155.92	14.32	9.08	1136.00
266+41	1156.17	15.06	9.28	1134.00
268+26	1156.47	16.13	9.43	1134.00
270+01	1156.71	14.78	10.89	1136.00
271+61	1157.33	16.58	9.95	1136.00
278+98	1158.85	14.97	9.00	1136.00

PREFERRED CONDITIONS
EQUILIBRIUM SLOPE
WSPRO

STATION	WSEL	DEPTH	VELOCITY	INVERT
261+19	1156.01	17.60	7.95	1135.12
264+55	1156.26	14.65	8.87	1136.00
266+41	1156.49	15.36	9.09	1134.00
268+26	1156.76	16.40	9.26	1134.00
270+01	1156.97	15.00	10.70	1136.00
271+61	1157.56	16.74	9.82	1136.00
278+98	1159.01	15.13	8.91	1136.00

Table 6. Comparison of Hydraulic Information at the Bridges for Baseline and Channelized (Equilibrium Slope) Conditions using HEC-2 and WSPRO

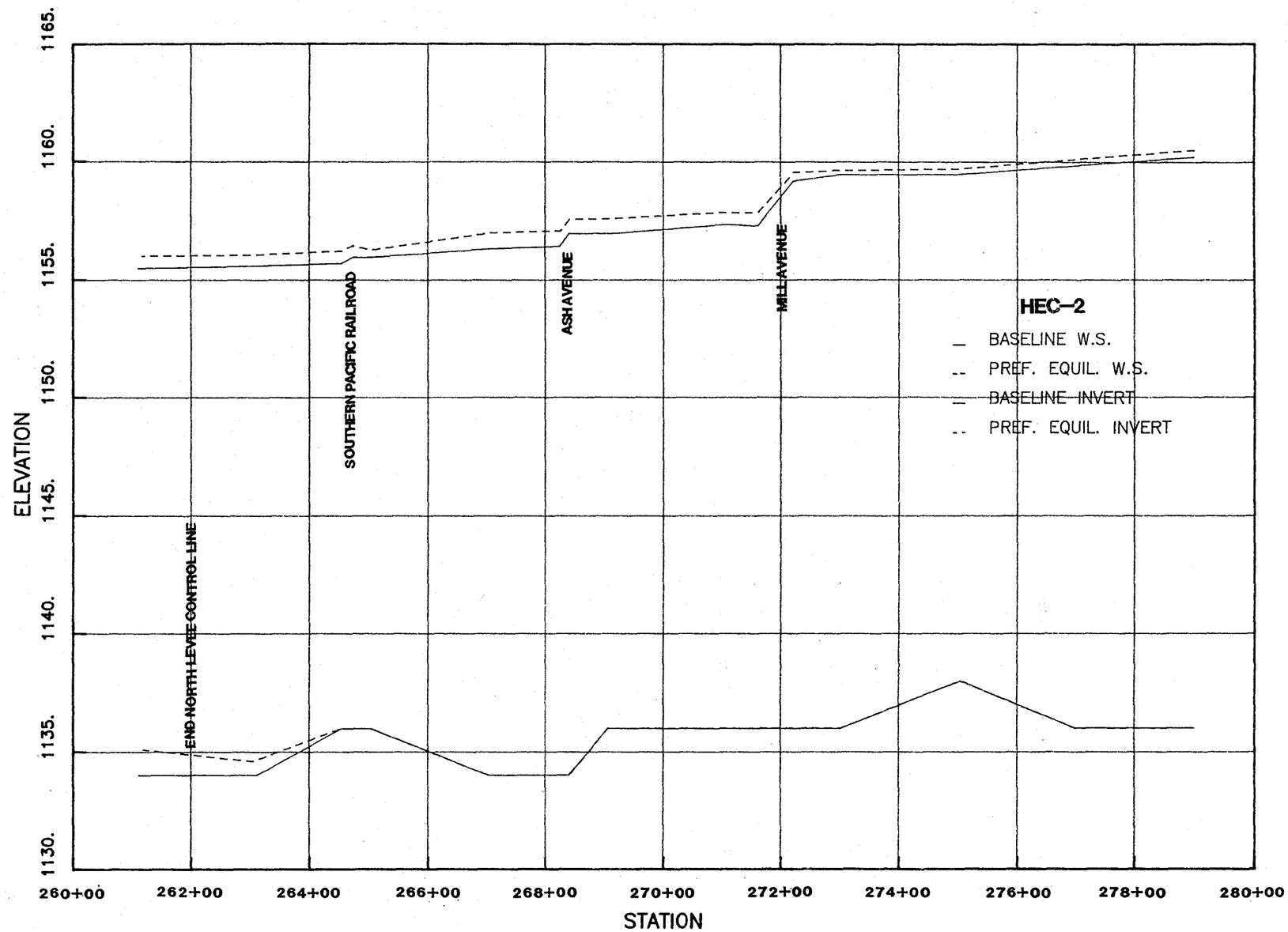


Figure 10. Comparison of Water-Surface Profiles at the Bridges for Baseline and Channelized (Equilibrium Slope) Conditions using HEC-2

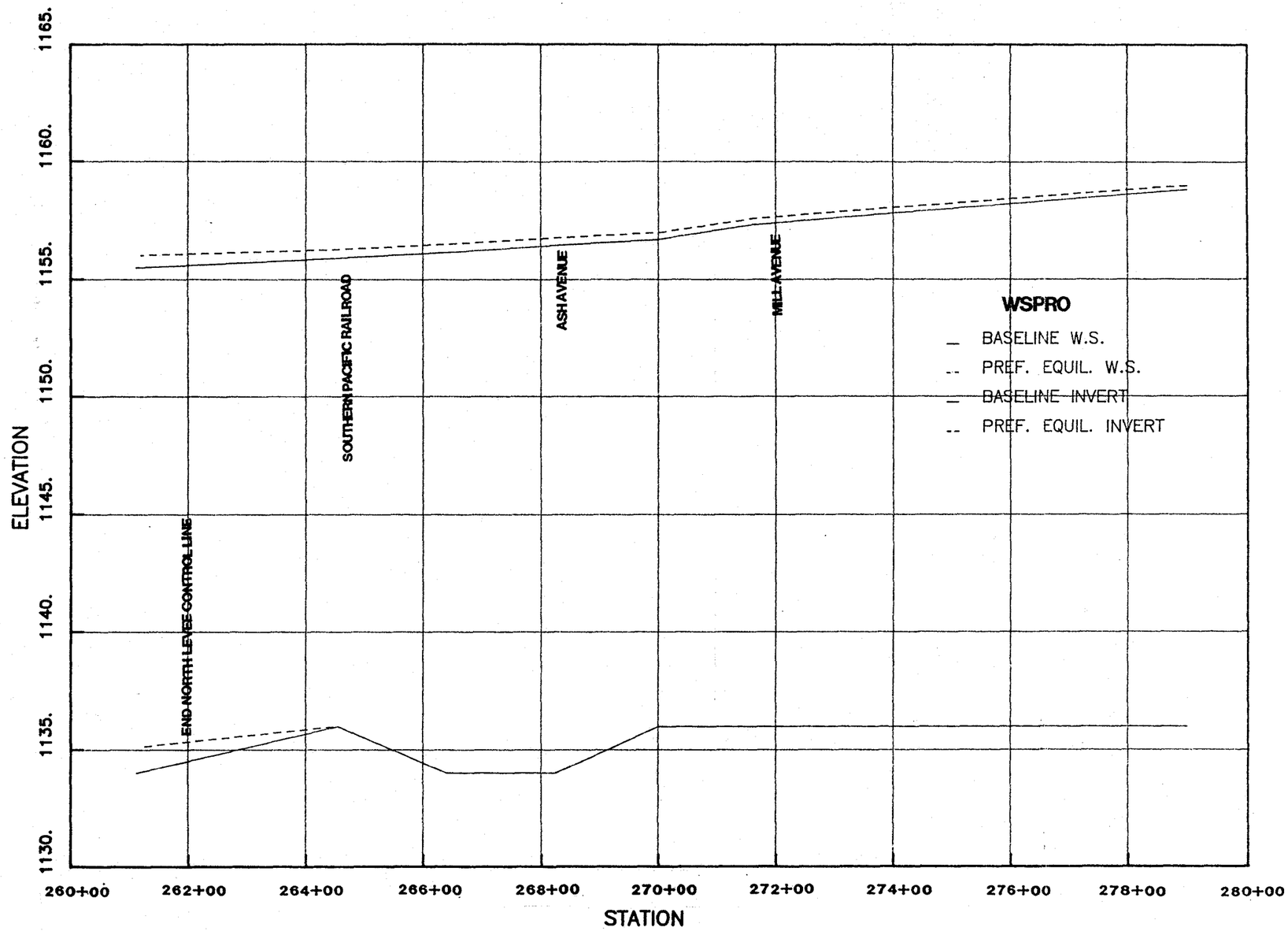


Figure 11. Comparison of Water-Surface Profiles at the Bridges for Baseline and Channelized (Equilibrium Slope) Conditions Using WSPRO

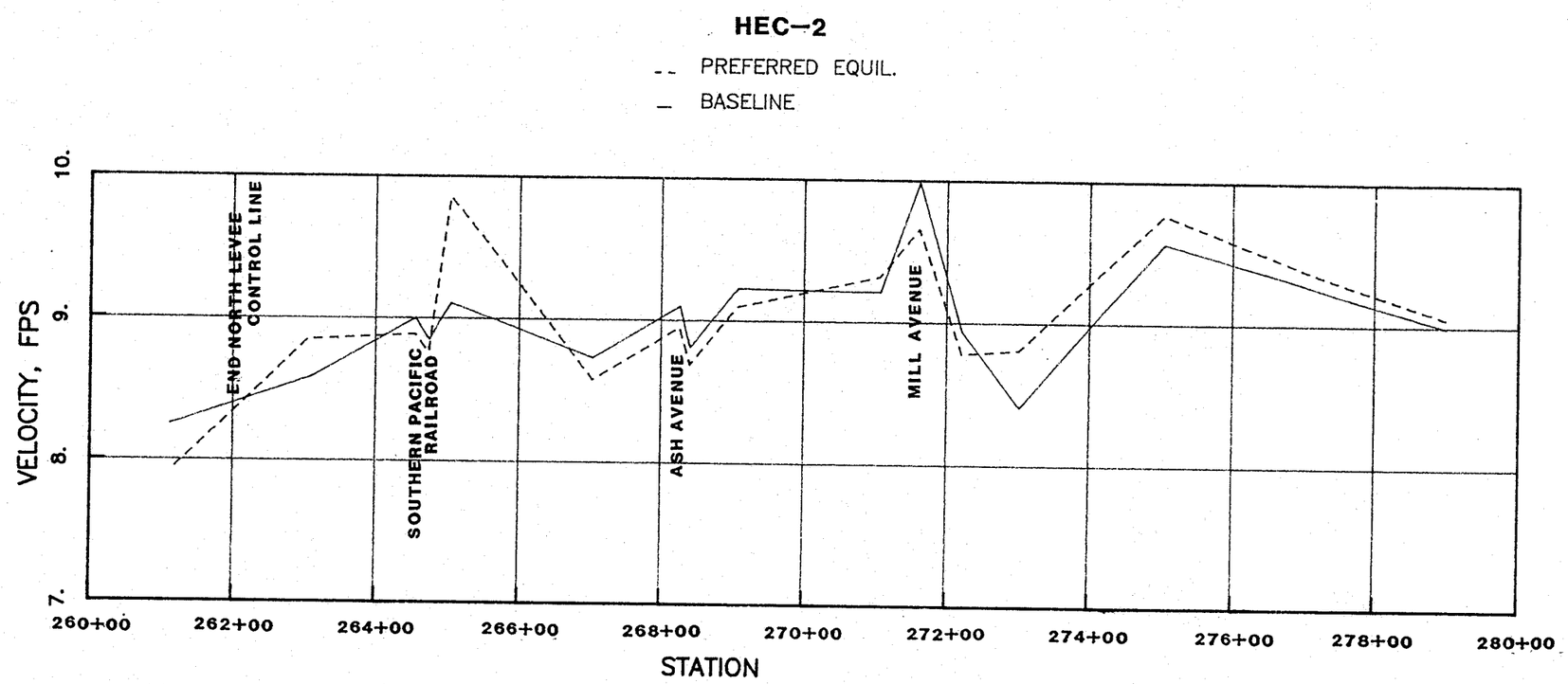


Figure 12. Comparison of Velocities at the Bridges for Baseline and Channelized (Equilibrium Slope) Conditions using HEC-2

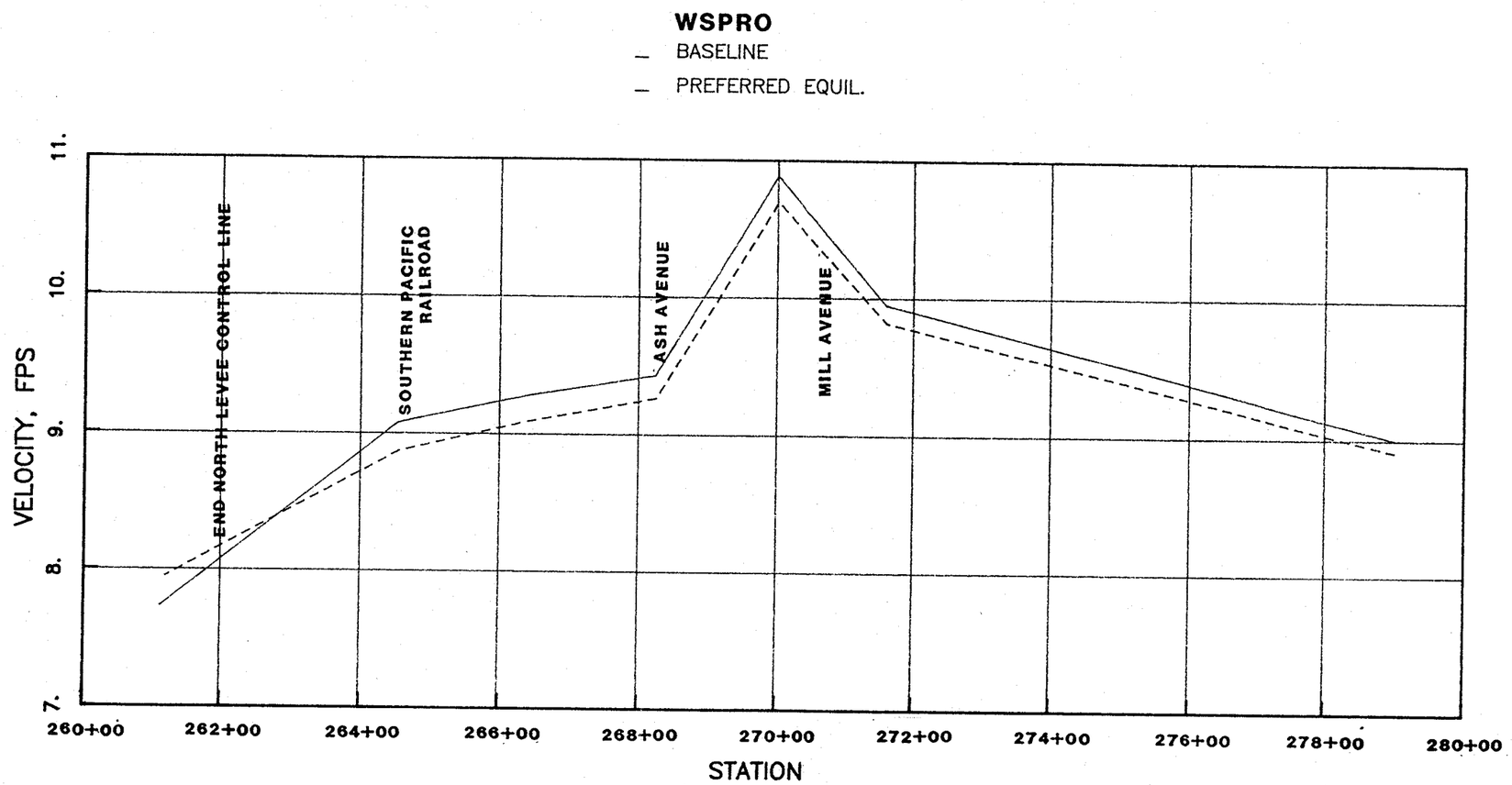


Figure 13. Comparison of Velocities at the Bridges for Baseline and Channelized (Equilibrium Slope) Conditions using WSPRO

SALT RIVER
HYDRAULIC INFORMATION
THROUGH THE SPRR, ASH AVENUE, AND MILL AVENUE BRIDGES
BASELINE CONDITIONS
100-YEAR FLOOD

SLA HEC-2

STATION	WSEL	DEPTH	VELOCITY	INVERT
263+11	1155.61	14.21	8.59	1134.00
264+55	1155.72	14.14	9.00	1136.00
264+74	1155.96	14.36	8.85	1136.00
265+04	1155.98	14.33	9.11	1136.00
267+04	1156.34	15.87	8.73	1134.00
268+26	1156.44	16.11	9.10	1134.00
268+41	1156.97	16.60	8.81	1134.00
269+06	1156.97	16.05	9.23	1136.00
271+07	1157.36	13.47	9.21	1136.00
271+61	1157.27	16.52	9.99	1136.00
272+21	1159.19	18.17	8.94	1136.00
273+02	1159.48	14.52	8.41	1136.00
275+03	1159.50	13.07	9.57	1138.00
276+98	1159.86	13.35	9.29	1136.00
278+98	1160.24	14.13	8.99	1136.00

SLA/CORPS HEC-2

STATION	WSEL	DEPTH	VELOCITY	INVERT
263+11	1155.61	14.21	8.59	1134.00
264+48	1155.71	14.49	9.05	1135.40
264+88	1155.83	14.59	8.98	1135.40
268+09	1156.27	15.80	9.27	1135.60
268+49	1156.71	16.20	9.02	1135.60
271+42	1157.33	16.86	8.36	1135.70
272+12	1157.43	16.94	8.50	1135.70
274+18	1157.53	13.57	9.13	1136.00
279+83	1158.08	16.00	10.86	1138.00

Table 7. Comparison of HEC-2's Hydraulic Results at the Bridges for Baseline Conditions using SLA's Input and the Corps of Engineers' Input

SALT RIVER
HYDRAULIC INFORMATION
THROUGH THE SPRR, ASH AVENUE, AND MILL AVENUE BRIDGES
PREFERRED CONDITIONS
EQUILIBRIUM SLOPE
100-YEAR FLOOD

SLA HEC-2

STATION	WSEL	DEPTH	VELOCITY	INVERT
263+04	1156.05	15.62	8.85	1134.60
264+55	1156.22	14.61	8.89	1136.00
264+74	1156.45	14.83	8.76	1136.00
265+04	1156.27	15.58	9.86	1136.00
267+04	1156.98	16.49	8.58	1134.00
268+26	1157.07	16.69	8.95	1134.00
268+41	1157.57	17.15	8.69	1134.00
269+06	1157.58	16.60	9.10	1136.00
271+07	1157.85	15.24	9.32	1136.00
271+61	1157.83	16.95	9.66	1136.00
272+21	1159.53	18.48	8.78	1136.00
273+02	1159.63	16.55	8.81	1136.00
275+03	1159.70	15.50	9.77	1138.00
276+98	1160.10	16.15	9.39	1136.00
278+98	1160.51	16.63	9.05	1136.00

SLA/CORPS HEC-2

STATION	WSEL	DEPTH	VELOCITY	INVERT
263+04	1156.05	15.62	8.85	1134.60
264+48	1156.21	15.62	8.95	1135.40
264+88	1156.32	14.90	8.88	1135.40
268+09	1156.73	16.22	9.22	1135.60
268+49	1157.16	16.60	8.98	1135.60
271+42	1157.76	17.22	8.34	1135.70
272+12	1157.85	17.30	8.29	1135.70
274+18	1157.96	13.98	8.87	1136.00
279+83	1158.43	16.35	10.63	1138.00

Table 8. Comparison of HEC-2's Hydraulic Results at the Bridges for Channelized (Equilibrium Slope) Conditions using SLA's Input and the Corps of Engineers' Input

IV. RESULTS

The increase in water-surface elevation that occurs upstream of the river channelization is due primarily to the flow constriction in the transition reach. The results of the hydraulic analyses for the transition reach and the bridges are summarized below.

4.1 Transition

The flow constriction in the transition has a major impact on the water-surface elevation and velocity. The results for the transition reach (Station 249+55 to Station 261+19) for baseline conditions are summarized in Table 1. The results for channelized conditions for initial slope and equilibrium slope are summarized in Tables 2 and 3, respectively.

Using the initial slope for the channelized reach, the water-surface elevations at the downstream end of the transition are about 0.8 foot lower and the velocities 2.5 fps higher than for baseline conditions. If the equilibrium slope is used, the water-surface elevations at the downstream end of the transition are about 2.5 feet lower and the velocities approximately 4.5 fps higher than for baseline conditions. The velocities are nearly 10 fps higher at Grade Control No. 4, but reduce to approximately 4.6 fps higher than for baseline conditions one-hundred feet upstream of this structure.

At the upstream end of the transition, the water-surface elevations are greater, and the velocities are generally less, than for baseline conditions. For initial-slope conditions, the water-surface elevations are 1.3 feet higher and the velocities are 0.6 fps less than baseline. For the equilibrium slope, the water-surface elevations are 0.5 feet higher and the velocities are about the same as baseline conditions.

The moveable-bed analysis indicates up to two feet more scour will occur in the transition reach for channelized conditions than for baseline conditions. This additional scour is due primarily

to the contraction that takes place as the flow goes from the natural channel to the channelized reach. Immediately upstream and downstream of the constriction, the water-surface elevations and flow velocities obtained from the moveable-bed analysis compare favorably with the results obtained from the HEC-2 rigid-boundary analysis. The final invert elevations just downstream of the constriction (Grade Control No. 4) are similar to those invert elevations using the long-term degradational (equilibrium) slope. The moveable-bed analysis calculates a final invert elevation of 1128.03 feet (Table 5) and the equilibrium-slope condition gives an invert elevation of 1128.29 feet (Table 3).

In addition to investigating channelized flow conditions for both the initial-slope and equilibrium-slope conditions, alternatives were investigated for reducing water-surface elevations within and upstream of the contraction. These included:

1. Extending the north guide-bank westward to tie into the channelized river at Station 244+00 rather than at Station 250+00.
2. Paving the transition reach, thereby reducing the roughness value from 0.035 to 0.020.
3. Lowering Grade Control No. 4 by one foot.

These alternatives were investigated independently, and results compared to the channelized conditions using the initial channel slope. Alternative No. 1 reduces the contraction losses, and thereby reduces the increase in water-surface elevation over baseline conditions in the transition. One disadvantage of this alternative is that the extension of the guide-bank conflicts with the highway alignment, the proposed strip park, and various utilities along the north bank. Alternative No. 3 gave slightly better results than Alternative No. 1; however, lowering the grade-control structure may not be a feasible alternative, as this will change both the slope and the vertical drop at the grade-control structure. For the alternatives investigated, the largest decrease in water-surface elevations for channelized conditions occurs by paving the invert in the transition reach (i.e., Alternative No. 2). The disadvantage of this alternative is that it is unlikely, in a river with a highly mobile bed, that the paving would remain in place. A comparison of water-surface elevations for the alternatives and baseline conditions is given in Table 9.

BASELINE CONDITIONS VS. TRANSITION ALTERNATIVES
100-YR FLOOD

BASELINE CONDITIONS			PAVED TRANSITION		EXTENDED TRANSITION		LOWERED G.C. (1 FT)	
STATION	WSEL	INVERT	STATION	WSEL	INVERT	WSEL	INVERT	WSEL	INVERT
23099	1150.40	1128	23000	1148.84	1127.77	1148.84	1127.77	1148.73	1127.24
23300	1150.77	1128	23200	1149.30	1128.24	1149.30	1128.24	1149.16	1127.67
23500	1151.61	1126	23400	1149.76	1128.71	1149.76	1128.71	1149.59	1128.09
23698	1152.52	1128	23600	1150.22	1129.19	1150.22	1129.19	1150.02	1128.51
23910	1152.53	1128	23800	1150.68	1129.66	1150.68	1129.66	1150.44	1128.94
24110	1152.83	1128	24000	1151.15	1130.13	1151.15	1130.13	1150.87	1129.36
24310	1153.22	1128	24200	1151.61	1130.60	1151.61	1130.60	1151.30	1129.78
24510	1153.75	1130	24400	1152.08	1131.07	1152.08	1131.07	1151.72	1130.21
24707	1153.81	1129.40	24600	1152.54	1131.54	1152.79	1131.54	1152.15	1130.63
24906	1154.19	1130	24800	1153.01	1132.01	1153.41	1132.01	1152.57	1131.06
25105	1154.37	1132	25000	1153.48	1132.48	1153.94	1132.48	1153.00	1131.48
25303	1154.95	1130	25107	1154.23	1132.74	1154.56	1132.74	1153.78	1131.83
25508	1155.10	1130	25302	1154.92	1133.20	1155.20	1133.20	1154.60	1132.46
25709	1155.27	1130	25508	1155.36	1133.68	1155.66	1133.68	1155.16	1133.13
25910	1155.34	1132	25708	1155.62	1134.15	1155.98	1134.15	1155.53	1133.78
26112	1155.49	1134	25914	1155.86	1134.64	1156.28	1134.64	1155.86	1134.45
26311	1155.61	1134	26119	1155.97	1135.12	1156.46	1135.12	1156.06	1135.12
			26304	1155.91	1134.60	1156.50	1134.60	1156.11	1134.60

Table 9. Comparison of Water-Surface Elevations for Baseline Conditions and Various Transition Alternatives

4.2 Bridges

When comparing the hydraulic results of the channelized conditions to those of the baseline conditions, it appears that the increase in water-surface elevations in the vicinity of the bridges are mainly due to the presence of the flow constriction downstream, rather than because of any effects caused by the bridges. The increase in water-surface elevations lessens with increasing distance upstream of the transition reach. Therefore, the compared results of the channelized and baseline conditions are more nearly the same at the Mill Avenue bridge than they are at the SPRR bridge. For channelized conditions, the results presented use the equilibrium-slope values.

In analyzing the flow through the bridges, the HEC-2 run using SLA's cross-section information and bridge parameters along with the equilibrium slope shows that the water-surface elevation is 0.50 feet higher than for baseline conditions at the Southern Pacific Railroad bridge (Station 264+55). Just upstream of the Mill Avenue bridge (Station 272+21), there is only a 0.34-foot increase. The velocities are correspondingly lower for the channelized condition. The velocity is 0.11 fps less for channelized conditions at the Southern Pacific Railroad bridge, and 0.16 fps less at the Mill Avenue bridge.

Using the same SLA cross-sections and bridge parameters, the WSPRO analysis indicates the water-surface elevation to be 0.34 feet higher than for baseline conditions at the railroad bridge, and 0.23 feet higher at the Mill Avenue bridge. The velocities are approximately 0.21 fps less for channelized conditions at the railroad bridge, and 0.13 fps lower at Mill Avenue.

The same pattern holds true for the HEC-2 results using the cross-section and bridge data obtained from the Corps of Engineers study. At the railroad bridge, the water-surface elevation is 0.49 feet higher, and the velocity is 0.10 fps less, than baseline conditions. Upstream of Mill Avenue, the water-surface elevation is 0.42 feet higher, and the velocity is 0.21 fps less than baseline conditions.

Each of the different analyses conducted through the bridges calculated different water-surface profiles. However, the difference between the baseline water-surface elevations and the channelized water-surface elevations are essentially the same in each of the three analyses.

The increased water-surface elevations upstream of the transition do not have a significant impact on the bridges for the 100-year event. The water-surface elevations are well below the low-chord elevations. At the railroad bridge, the water surface is approximately 3.7 feet below the low chord, while for the other two bridges, the difference is greater than 10 feet.

4.3 Study Reach

Table 10 provides a tabulation of the water-surface elevations and velocities for baseline and channelized conditions for the reach from Grade Control No. 3 to just downstream of Scottsdale Road. Upstream of the channelization, the increase in water-surface elevations lessens with increasing distance upstream. Figure 14 provides a comparison of the water-surface elevations for baseline and channelized conditions for this reach. Upstream of Mill Avenue, the slight increase in water-surface elevations as a result of downstream channelization will have little affect on the floodplain south of the river. The East Papago Freeway will provide a barrier on the river's north side.

HYDRAULIC INFORMATION
BASELINE VS. PREFERRED CONDITIONS
D/S OF GRADE CONTROL 4 TO D/S OF SCOTTSDALE ROAD
100-YR FLOOD
SLA HEC-2

NOTE: STATIONING IS MEASURED ALONG THE
CHANNELIZATION CONTROL LINE.

BASELINE CONDITIONS					PREFERRED CONDITIONS EQUILIBRIUM SLOPE				
STATION	WSEL	DEPTH	VELOCITY	INVERT	STATION	WSEL	DEPTH	VELOCITY	INVERT
					240+00	1150.26	19.05	11.88	1126.93
241+10	1152.83	10.14	10.06	1128.00					
					242+00	1150.58	19.09	11.85	1127.20
243+10	1153.22	10.65	9.57	1128.00					
					244+00	1150.90	19.12	11.83	1127.48
245+10	1153.75	10.86	8.62	1130.00					
					246+00	1151.21	19.16	11.80	1127.75
247+07	1153.81	13.58	9.31	1129.40					
					248+00	1151.53	19.20	11.77	1128.02
249+06	1154.19	10.66	8.92	1130.00					
					250+00	1151.83	15.51	14.97	1132.48
251+05	1154.37	11.74	9.26	1132.00					
					251+07	1153.12	16.83	12.85	1132.74
					253+02	1154.24	17.55	10.91	1133.20
253+03	1154.95	10.64	7.50	1130.00					
255+08	1155.10	11.23	7.31	1130.00	255+08	1154.95	17.82	9.65	1133.68
					257+08	1155.39	17.83	8.91	1134.15
257+09	1155.27	12.65	7.11	1130.00					
259+10	1155.34	14.05	7.70	1132.00					
					259+14	1155.77	17.82	8.22	1134.64
261+12	1155.49	12.16	8.25	1134.00					
					261+19	1156.01	17.59	7.95	1135.12
					263+04	1156.05	15.62	8.85	1134.60
263+11	1155.61	14.21	8.59	1134.00					
264+55	1155.72	14.14	9.00	1136.00	264+55	1156.22	14.61	8.89	1136.00
264+74	1155.96	14.36	8.85	1136.00	264+74	1156.45	14.83	8.76	1136.00
265+04	1155.98	14.33	9.11	1136.00	265+04	1156.27	15.58	9.86	1136.00
267+04	1156.34	15.87	8.73	1134.00	267+04	1156.98	16.49	8.58	1134.00
268+26	1156.44	16.11	9.10	1134.00	268+26	1157.07	16.69	8.95	1134.00
268+41	1156.97	16.60	8.81	1134.00	268+41	1157.57	17.15	8.69	1134.00
269+06	1156.97	16.05	9.23	1136.00	269+06	1157.58	16.60	9.10	1136.00
271+07	1157.36	13.47	9.21	1136.00	271+07	1157.85	15.24	9.32	1136.00
271+61	1157.27	16.52	9.99	1136.00	271+61	1157.83	16.95	9.66	1136.00
272+21	1159.19	18.17	8.94	1136.00	272+21	1159.53	18.48	8.78	1136.00
273+02	1159.48	14.52	8.41	1136.00	273+02	1159.63	16.55	8.81	1136.00
275+03	1159.50	13.07	9.57	1138.00	275+03	1159.70	15.50	9.77	1138.00
276+98	1159.86	13.35	9.29	1136.00	276+98	1160.10	16.15	9.39	1136.00

Table 10. Comparison of Hydraulic Information for Baseline and Channelized (Equilibrium Slope) Conditions for the Study Reach

278+98	1160.24	14.13	8.99	1136.00	278+98	1160.51	16.63	9.05	1136.00
280+98	1160.53	14.42	8.80	1134.00	280+98	1160.77	16.37	8.94	1134.00
282+98	1160.74	14.76	8.54	1136.00	282+98	1161.01	16.38	8.63	1136.00
284+98	1160.92	14.66	8.58	1135.20	284+98	1161.18	16.27	8.67	1135.20
286+98	1161.08	15.05	8.63	1136.00	286+98	1161.35	16.57	8.68	1136.00
289+18	1161.31	14.31	8.50	1138.00	289+18	1161.59	16.01	8.52	1138.00
291+10	1161.58	14.24	8.08	1138.00	291+10	1161.82	16.49	8.23	1138.00
293+21	1161.88	13.39	7.62	1138.00	293+21	1162.10	14.77	7.87	1138.00
295+26	1162.00	12.16	7.78	1140.00	295+26	1162.25	14.02	7.91	1140.00
297+19	1162.14	12.09	7.87	1140.00	297+19	1162.41	13.75	7.90	1140.00
299+24	1162.29	11.71	8.09	1142.00	299+24	1162.56	13.26	8.09	1142.00
301+23	1162.47	10.63	8.35	1142.00	301+23	1162.74	11.91	8.33	1142.00
303+24	1162.61	9.67	9.25	1140.00	303+24	1162.88	11.13	9.18	1140.00
305+25	1162.80	9.30	9.60	1138.30	305+25	1163.07	10.65	9.52	1138.30
307+21	1163.16	8.04	9.28	1142.00	307+21	1163.37	10.05	9.35	1142.00
309+18	1163.62	7.88	8.65	1142.00	309+18	1163.73	9.09	9.13	1142.00
311+23	1163.93	7.63	8.27	1142.00	311+23	1164.15	8.81	8.42	1142.00
313+29	1164.08	9.75	8.30	1140.00	313+29	1164.38	9.83	8.04	1140.00
315+20	1164.27	8.45	8.33	1142.00	315+20	1164.56	8.41	8.09	1142.00

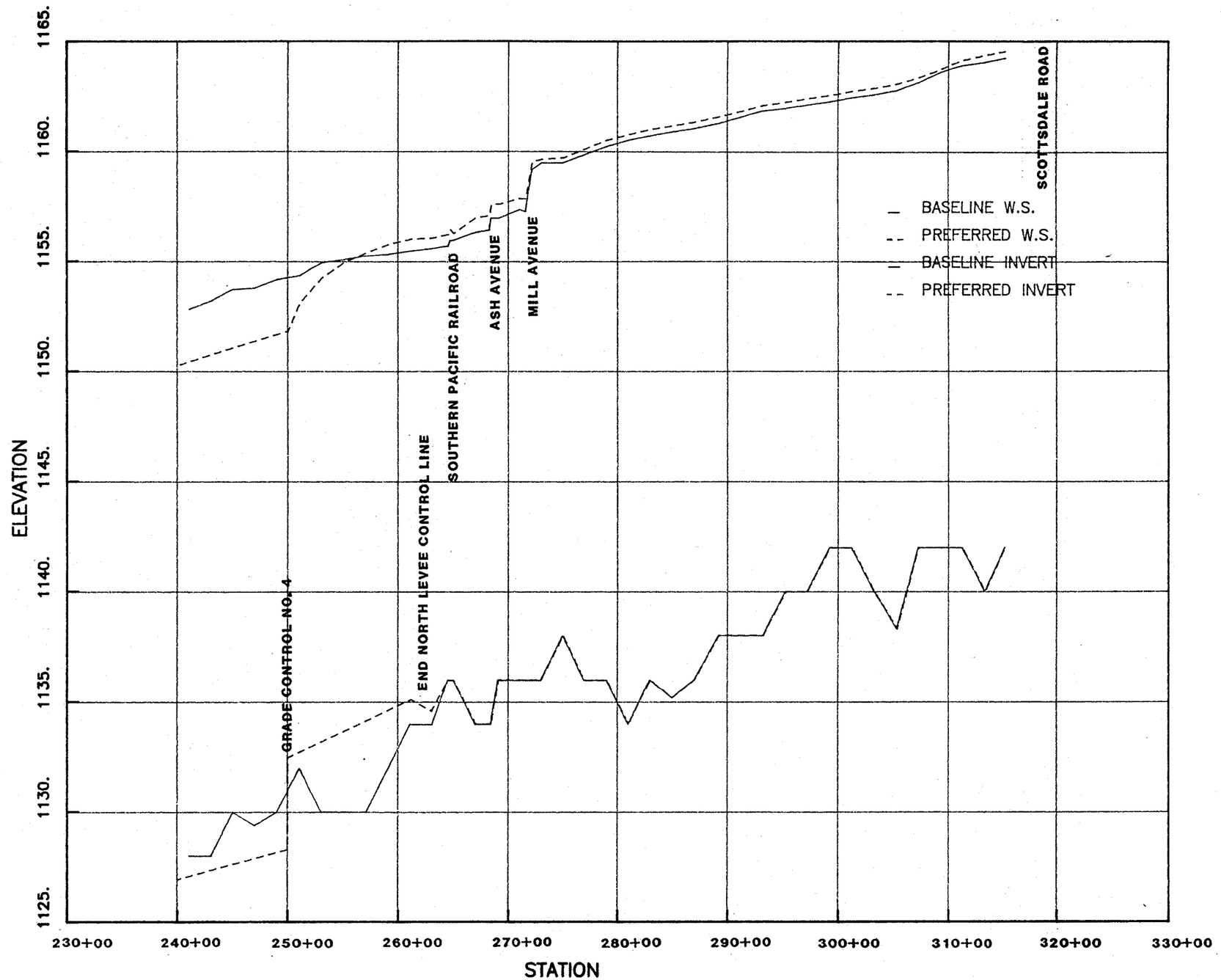


Figure 14. Comparison of Water-Surface Profiles for Baseline and Channelized Conditions

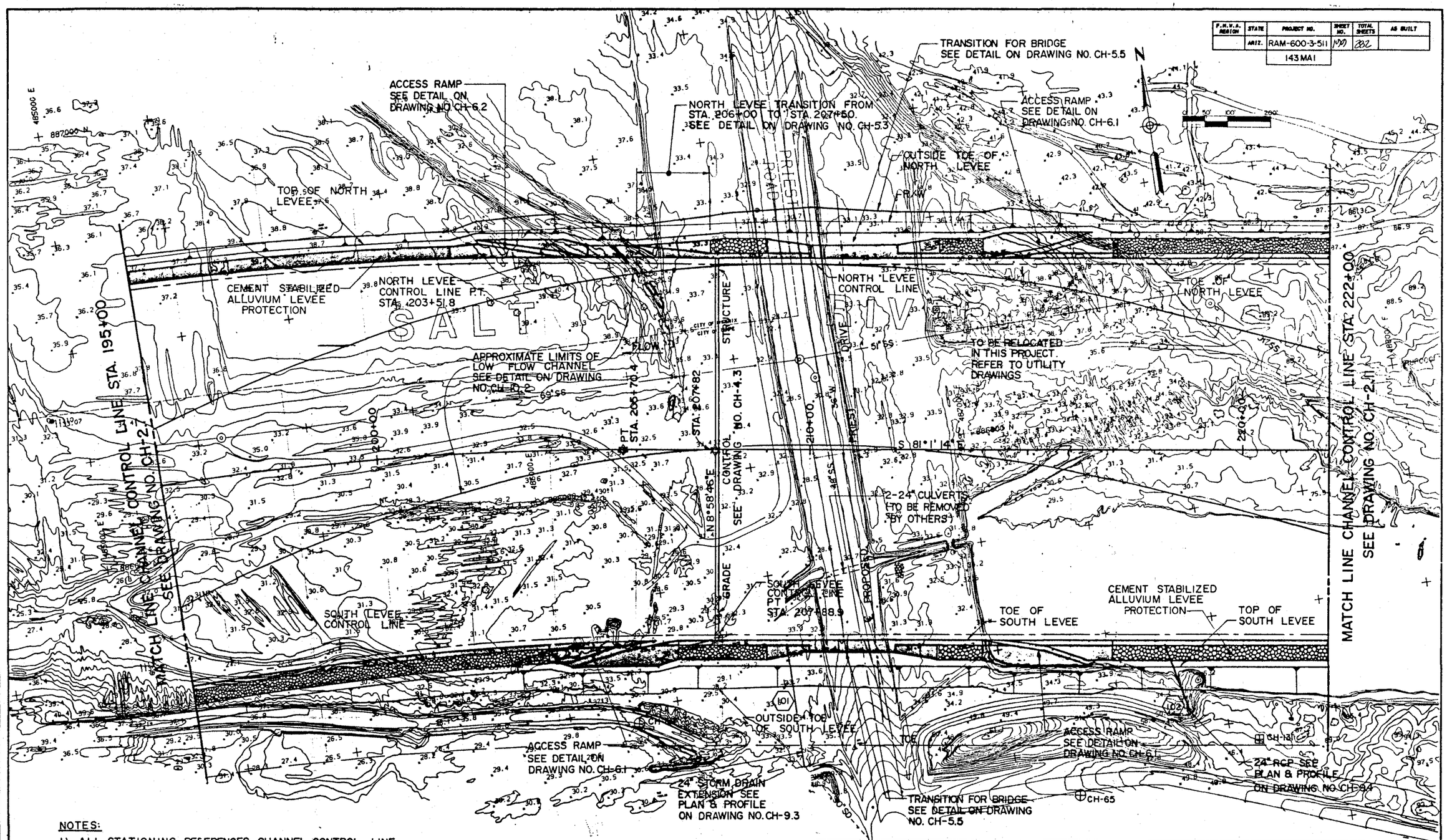
V. CONCLUSIONS

The hydraulic analyses for the transition reach are an in-depth analyses providing improved hydraulic results. The contraction of flow which occurs in the transition reach does have an affect on the water-surface elevations and velocities through the transition reach. The results of these analyses indicate there are no adverse impacts on the three existing structures located immediately upstream of the transition reach.

The bridge input data developed for this study provides water-surface elevations that are greater than the water-surface elevations obtained in using the bridge input data from the Corps of Engineers flood insurance study. The analysis for upstream reaches will require accurate description of the bridges, since the bridge configuration, pier width, etc., affects the water-surface elevations and velocities through and upstream of the bridges.

APPENDIX A

F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
	ARIZ.	RAM-600-3-511	149	282	
		143 MAI			



NOTES:

1.) ALL STATIONING REFERENCES CHANNEL CONTROL LINE UNLESS OTHERWISE NOTED.

2.) REFER TO DRAWING NO. CH-3.1 THRU CH-3.3 FOR DIMENSIONS AND ELEVATIONS OF CHANNEL CROSS SECTIONS.

KEY MAP

	NAME	DATE
DESIGN	DNJ	11/88
DRAWN	JCP	11/88
CHECKED	MAP	11/88

DMJM CONSULTING ENGINEERS PHOENIX ARIZONA

ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAYS DIVISION

CHANNEL ALIGNMENT

STA. 195+00 TO STA. 222+00

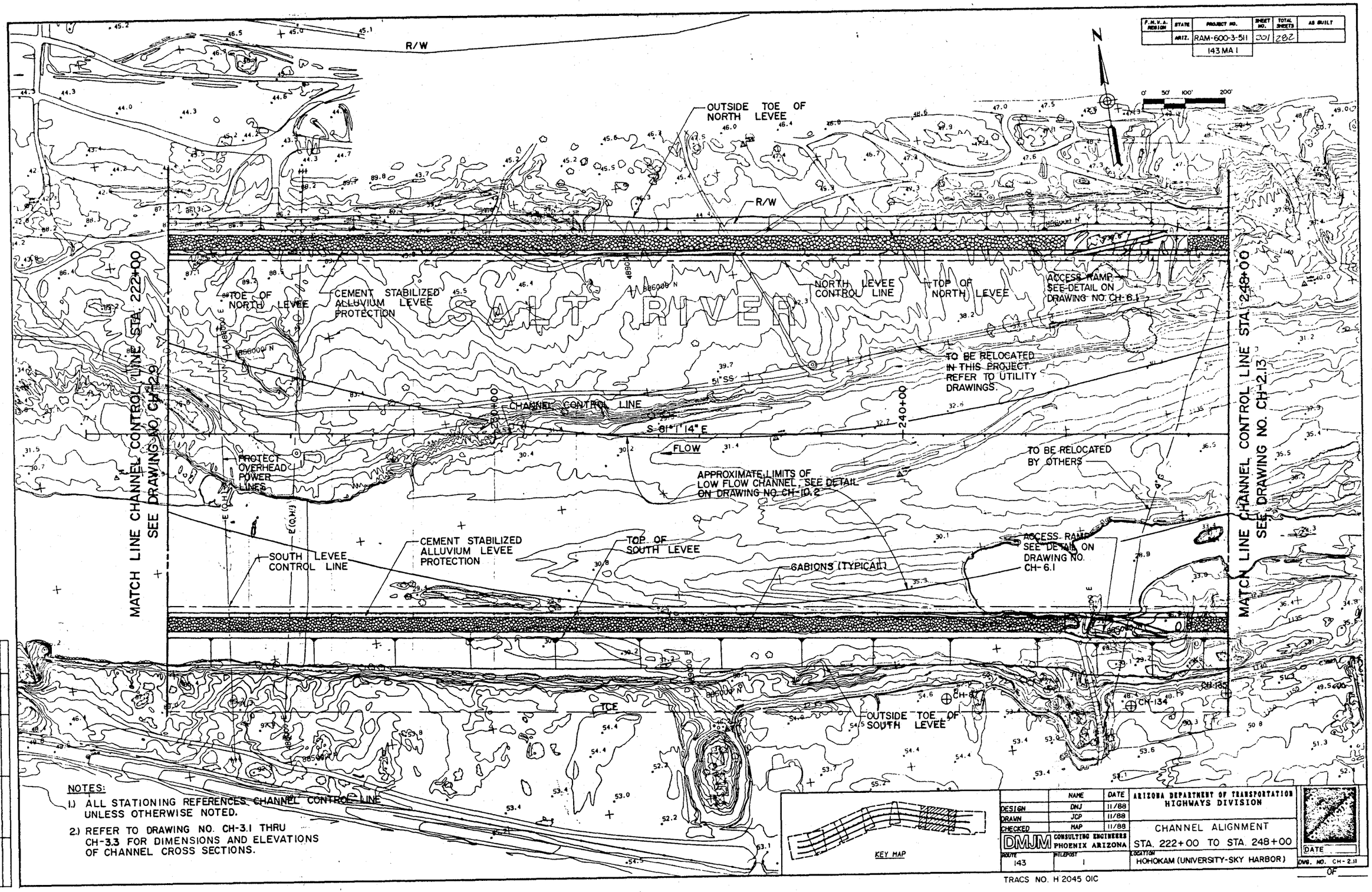
ROUTE 143 | MILEPOST 1 | LOCATION HOHOKAM (UNIVERSITY-SKY HARBOR)

DATE

DWG. NO. CH-2.9

TRACS NO. H 2045 OIC

OF



NOTES:

1.) ALL STATIONING REFERENCES CHANNEL CONTROL LINE UNLESS OTHERWISE NOTED.

2.) REFER TO DRAWING NO. CH-3.1 THRU CH-3.3 FOR DIMENSIONS AND ELEVATIONS OF CHANNEL CROSS SECTIONS.

	NAME	DATE
DESIGN	DNJ	11/88
DRAWN	JCP	11/88
CHECKED	MAP	11/88

DMJM CONSULTING ENGINEERS PHOENIX ARIZONA

ROUTE 143 | MILEPOST 1

ARIZONA DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION

CHANNEL ALIGNMENT
STA. 222+00 TO STA. 248+00

LOCATION HOHOKAM (UNIVERSITY-SKY HARBOR)

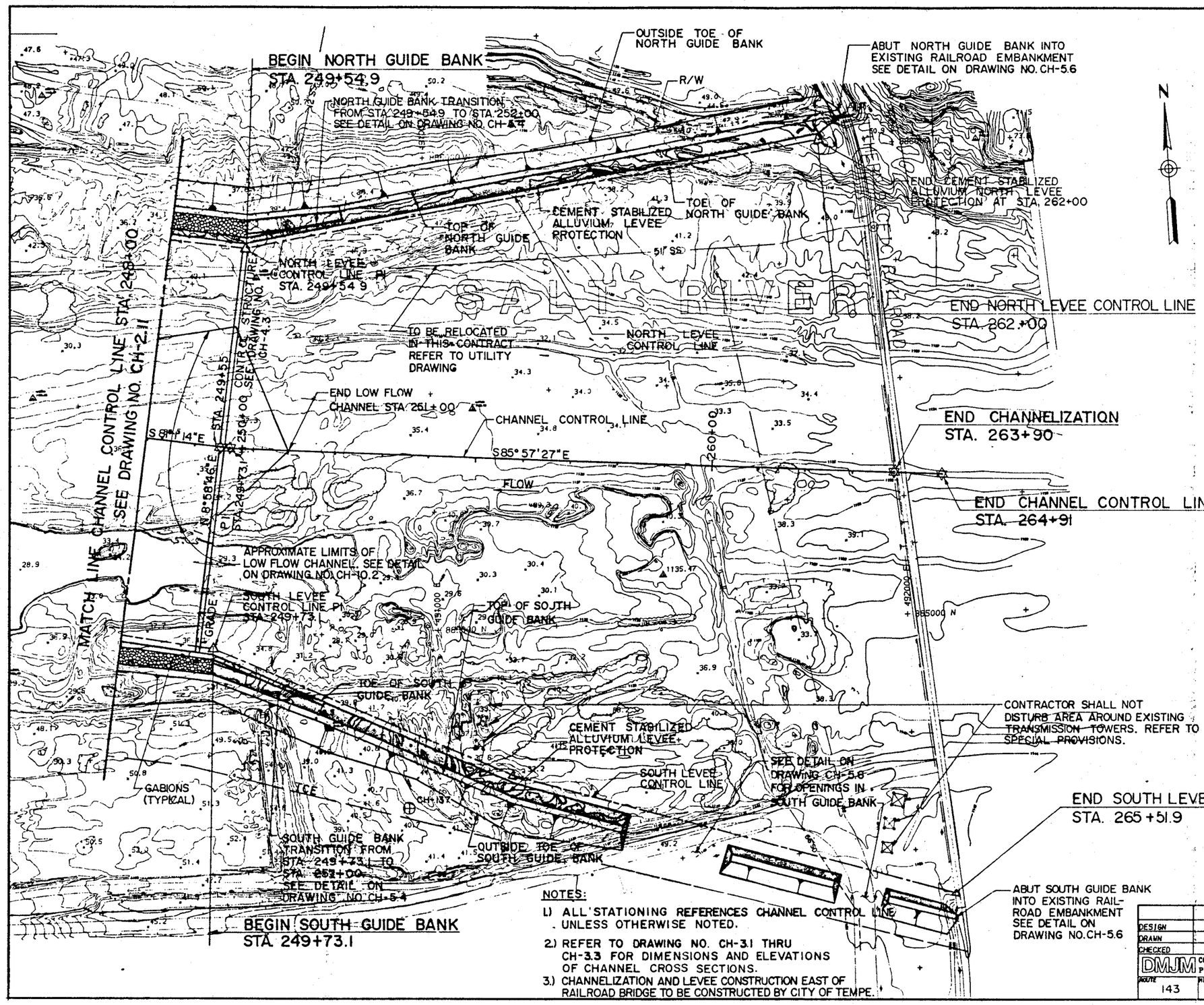
DATE

DWG. NO. CH-2.11

OF

TRACS NO. H 2045 01C

F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
	ARIZ.	RAM-600-3-511	103	082	
		143 MA 1			



NOTES:

1) ALL STATIONING REFERENCES CHANNEL CONTROL LINE UNLESS OTHERWISE NOTED.
2) REFER TO DRAWING NO. CH-3.1 THRU CH-3.3 FOR DIMENSIONS AND ELEVATIONS OF CHANNEL CROSS SECTIONS.
3) CHANNELIZATION AND LEVEE CONSTRUCTION EAST OF RAILROAD BRIDGE TO BE CONSTRUCTED BY CITY OF TEMPE.

KEY MAP

	NAME	DATE
DESIGN	DMJ	11/88
DRAWN	JCP	11/88
CHECKED	MAP	11/88

DMJM CONSULTING ENGINEERS PHOENIX ARIZONA

ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAYS DIVISION

CHANNEL ALIGNMENT
STA. 248+00 TO STA. 264+91

ROUTE 143 | MILEPOST 1 | LOCATION HOHOKAM (UNIVERSITY-SKY HARBOR)

DATE

DWG. NO. CH-2.13

OF

TRACS NO. H 2045 OIC

SURVEY NO.	FINISHED PLANS	REVISIONS	LOCATION	DATE

APPENDIX B

SUBMERGENCE CALCULATIONS

GRADE CONTROL No. 4 — STATION 249 + 55

$$\sigma = \frac{H_d}{H_u}$$

where:
σ = Submergence factor
H_u = Upstream head
H_d = Downstream head

Grade Control Invert Elev. = 1132.48 ft.

Upstream Section (Station 251 +07)
W.S. Elev. = 1153.12 ft.
Velocity = 12.85 fps

Downstream Section (Station 248 +00)
W.S. Elev. = 1151.53 ft.
Velocity = 11.77 fps

$$H_u = (1153.12 - 1132.48) + \frac{(12.85)^2}{2(32.2)} = 23.2 \text{ ft.}$$

$$H_d = (1151.53 - 1132.48) + \frac{(11.77)^2}{2(32.2)} = 21.2 \text{ ft.}$$

$$\sigma = \frac{21.2 \text{ ft.}}{23.2 \text{ ft.}} = 0.91$$

$\therefore$ Affected by downstream conditions