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Project No. 876191
Rio Salado Park
Channelization Design

FINAL REPORT

SALT RIVER HYDRAULIC DESIGN
GRADE CONTROL NO. 4 TO McCLINTOCK DRIVE BRIDGE

Prepared for

City of Tempe
Department of Public Works
Tempe, Arizona

By

CRSS Civil Engineers, Inc.
4041 North Central Avenue, Suite 650
Phoenix, Arizona 85012-3306

August 1991

FLOOD CONTROL DISTRICT
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C | HYDRO
ADMIN | LMGT
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ENGR
REMARKS

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August 1991

Registered Professional Engineer (Civil)
CERTIFICATE NO.
20207
GEORGE K.
COTTON
Date Signed 8.15.91
ARIZONA, U.S.A.

CRSS

August 17, 1991

City of Tempe
Department of Public Works
P.O. Box 5002
Tempe, Arizona 85281

Attn: Howard Hargis

Proj: Tempe Rio Salado
Salt River Channelization - Grade Control No. 4 to McClintock Drive
Final Hydraulics Report

Dear Howard:

This report presents results of the river and hydraulic design computations for the above-referenced project. The purpose of this report is to present the methods and approaches used in analyzing the hydraulic structures that are proposed as flood control features for the Salt River in the reach within the City limits of Tempe from approximately 1500 feet west of the Southern Pacific railroad bridge to the eastern city limits approximately one-quarter mile east of McClintock Drive. The hydraulic performance of these structures has been evaluated based on a range of hydrologic and hydraulic conditions.

Procedures have been used which are considered to provide reasonable estimates of channel hydraulic phenomenon. However, such is the nature of measured flood flow data on the Salt River, or similar rivers in Arizona, that it cannot be expected that these procedures provide a predictive accuracy with an error of less than ± 50 percent. To compensate for the error inherent in this analysis, a factor of safety has been applied to scour depth calculations and other hydraulic factors. Both the 100-year flood and maximum channel capacity discharges have been considered in the design. In addition, river scour phenomena are assumed to be cumulative and dependent on the most severe hydraulic conditions present in a given river reach.

The results of other investigators have been reviewed and a consistent use of methods has been made where possible. The results obtained by other investigators may vary due to the data used, assumptions made, procedures used and the engineering judgement exercised.

The analysis and recommendations presented in this report are based on a variety of information and the concurrent design of the East Papago Freeway by the Arizona Department of Transportation. We are available to review comments from these parties and Tempe's comments as soon as they become available.

Very truly yours,

CRSS COMMERCIAL GROUP, INC.

George K. Cotton

George K. Cotton, PE
Project Manager

cc: Don Rerick, FCD of Maricopa County

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4041 North Central Avenue
Phoenix, Arizona 85012-3306
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35,000 cfs Indian Bend Wash Inflow

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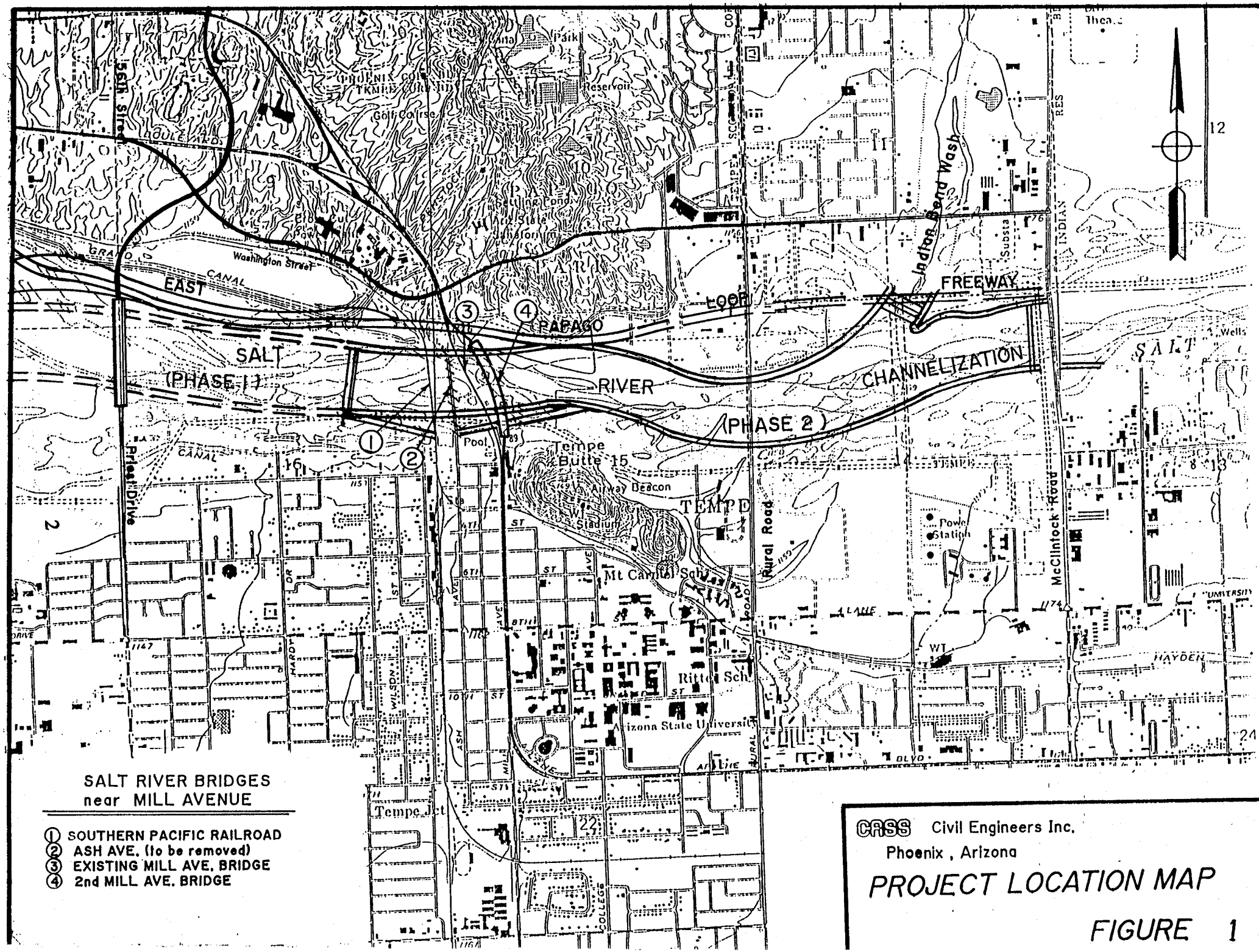
1.0 INTRODUCTION

1.1 Background

The proposed Rio Salado Park includes approximately 6.5 miles of floodway improvements to the Salt River through the City of Tempe (see Figure 1). This channel improvement established the basis for reclamation of the Salt River floodplain to higher valued land uses and the restoration of the in-stream habitat. The existing river channel has a 100-year flooded width of about 2,000 feet which inundates transportation routes, numerous utility routes and adjacent urban areas. The in-stream area has little habitat value and has been significantly disturbed during the past 50 years due to alterations in hydrology, in-stream mining and encroachments into the channel floodplain. Existing in-stream habitat is associated with storm drainage outfalls to the Salt River.

The Rio Salado Park channelization is being completed in two stages in conjunction with the construction of the East Papago Freeway. The first stage extends from the western city limit at 48th Street to the Souther Pacific Railroad bridge. Design was progressed by the Arizona Department of Transportation as part of the East Papago Freeway. At the time of this report, construction of this channel stage is underway. The second stage extends the channelization to the eastern city limit near the McClintock Drive bridge and is being designed by the City of Tempe. This report presents the analysis of river hydraulic design features for the second stage of channelization.

Two preliminary hydraulic studies of the second stage of channelization were completed for the Tempe Rio Salado channelization. The first study was completed in August 1988 by Simons, Li & Associates, Inc. This study identified the general alignment, profile and section of the river channel. A preferred channelization concept was derived from this study and used in the development of the Rio Salado Masterplan. The Masterplan identified the land use for the reclaimed portions of the Salt River floodplain. Areas adjacent to the channelization are to be protected by levees and bank protection works sufficient to contain a super flood event (approximately the 250-year flood) based on the hydrologic conditions which have


SALT RIVER BRIDGES
near MILL AVENUE
① SOUTHERN PACIFIC RAILROAD
② ASH AVE. (to be removed)
③ EXISTING MILL AVE. BRIDGE
④ 2nd MILL AVE. BRIDGE
CRSS Civil Engineers Inc.
Phoenix, Arizona
PROJECT LOCATION MAP
FIGURE 1
SALT RIVER
(PHASE 1)
(PHASE 2)
CHANNELIZATION
EAST
CANAL
PAPAGO
LOOP
FREEWAY
Washington Street
56th Street
Priest Drive
McClintock Road
Rural Road
Indian Bend Wash
Tempe Butte
Mt Carmel Sch
Ritter Sch
Arizona State University
TEMPE
Tempe Jct
Golf Course
Reservoir
Park
Stadium
Airway Beacon
Power Station
Substa
Pool
Wells
HAYDEN
UNIVERSITY
BLVD
COLLEGE
ASH
MILL
WILSON
HARDY
DR
ST
AVE
LANE
RURAL
12
13
15
16
21
22
24

been estimated for the period following completion of Roosevelt Dam improvements (USACE, Los Angeles District, October 1988). Areas within the channel are planned for recreational uses and riparian habitat. Since the in-channel area is subject to damaging floods, initial planning for the future development of riparian environments has emphasized features such as lakes and small channels with park areas on river terraces that can sustain significant innundation and high flow velocities with limited damage.

A second study on bridge hydraulics was completed by CRSS Commercial Group, Inc., for the Mill Avenue reach of the project in September 1989. This study identified the required levee alignments to improve hydraulic conditions at the Mill Avenue bridge and the effect on the downstream bridges at Ash Avenue and the Southern Pacific Railroad bridge.

Approval of the Rio Salado Masterplan was made by the Tempe City Council in March 1989. Design work for the channelization began October 1989 and was completed in August 1990. Construction plans and documents for the Rio Salado Salt River Channelization were broken down into three construction packages for inclusion with the East Papago Freeway construction plans.

1.2 Design Goals for Salt River Channel

The primary design goal is to construct a floodway capable of conveying a large magnitude flood event, in excess of the current 100-year flood (215,000 cfs) (i.e., pre-Roosevelt Dam improvements). The channel bed and bank should be stable for such a flood and have a protection systems for both the channel bed and channel banks adequate to prevent undue erosion or a change in the channel alignment. Key protection features for the Salt River floodway include the stabilized channel and levee banks, channel profile stabilization with a grade control structure near McClintock Drive, and a drop structure in Indian Bend Wash.

Design goals also focus on the need to create an aesthetically pleasing environment with opportunities for habitat restoration and development of in-stream recreational areas. These improvements will be established initially by grading the channel area

to provide a workable surface for further landscaping. In-channel terrace areas provide a continuous linear park above the elevation of frequent flooding along the north and south banks of the channel.

1.3 Reports by Others

Concurrent with the design of Salt River channel improvements, the Arizona Department of Transportation conducted design studies for the East Papago Freeway bridge across the Indian Bend Wash and for river hydraulic analysis of the Salt River for the Red Mountain Interchange. A number of design memos were exchanged between ADOT designers and the City of Tempe for East Papago freeway regarding drainage design issues along the north bank of the Salt River. Monthly coordination meetings between ADOT, Tempe, and the Maricopa County Flood Control District were conducted to identify and address the many interrelated aspects of the freeway and flood control projects.

Key design reports for the East Papago Freeway include: reports on the floodplain hydraulics of the Salt River (SLA, 1989; SLA, 1990), reports analyzing the Indian Bend Wash outlet (SLA, 1990) and drainage reports for the East Papago Freeway (JCE, 1990 and GF, 1990).

1.4 Description of the Project

The project consists of the following design elements:

- North levee for the Salt River beginning 1300 ± feet west of the Southern Pacific Railroad and ending at the McClintock Drive bridge.
- South levee for the Salt River beginning 1540 ± feet west of the Southern Pacific Railroad bridge and ending at the McClintock Drive bridge.
- Supplemental south overbank levee beginning at 1540 ± feet west of the SP railroad bridge and ending 500 ± feet east of the existing Mill Avenue bridge.
- Regrading of the Salt River floodway beginning 1420 ± feet west of the Southern Pacific Railroad bridge and ending 850 ± feet east of the McClintock Drive bridge.

- Construction of a temporary roadway fro Rio Salado Parkway from Farmer to east of Mill Avenue, and northbound Mill Avenue at grade crossing.
- Drop structure for the Indian Bend Wash channel located 1800 ± feet south of Curry Road.
- Channel grade control structure for the Salt River located 300 ± feet west of the McClintock Drive bridge.
- Sanitary sewer line relocation to an inverted siphon structure located immediately west of Rural Road.
- Relocation of an existing 30-inch water line located immediately east of Rural Road.
- Drainage penetration at seven locations on the north levee and seven locations on the south levee.

2.0 MAPPING AND SURVEY INFORMATION

The Rio Salado Project compiled a comprehensive computer database which consists of 14 datasets, including a variety of topographic and planimetric information. Information for this project was obtained largely from this computer database. Supplemental datasets for hydrology and channel bed material sediments were developed from separate sources.

2.1 Terrain Data

The Rio Salado District was aerially surveyed in December of 1988 and datasets of digitized planimetric features and terrain elevations were completed in Intergraph format in April 1989. The terrain dataset consists of an approximately uniform grid of spot elevations taken at 50-foot intervals. The approximate limits of aerial mapping data for the project are as follows:

West:	48th Street
East:	Evergreen Road
	(1/2 mile east of Price Road)
North:	Curry Road
South:	First Street

Accuracy of terrain data is such that 90 percent data points have a vertical accuracy of ± 0.25 feet and a horizontal accuracy of ± five feet.

2.2 Other Planimetric Information

The Rio Salado Database (CRSS, 1989) includes the following general categories of data:

- Survey Control - reference framework
- Parcel Identification
- Street and Road - centerline
- Utility Network - water, sewer, power, gas, storm drainage
- Physical Geography - soil, geology, hydrography
- Environmental - vegetation, habitat, air quality, water quality, noise
- Planimetric Details - building outlines, road features, etc.
- Topography
- Administrative - zoning, land use, tax districts, etc.

A set of reference files, provided in Table 1, for various planimetric information are included in the database in the above thematic categories. This files can be combined to display a combination of planimetric information in the Rio Salado Park project area.

Table 1
RIO SALADO DATABASE FILES

Extension	Contents	Thematic Type
LND	Control framework & parcel description	Control & Parcel
PLN	Planimetric features	Planimetric
TOP	Digital terrain data	Topography
TRN	Street, road & freeway	Transportation
WAT	Water transmission	Utility
SAN	Sanitary sewer	Utility
POW	Electrical power transmissions	Utility
GAS	Natural gas transmissions	Utility
TEL	Telephone	Utility
DRN	River control & storm drainage structures	Utility
GEO	Soil, geology & hydrography	Physical Geography
ENV	Vegetation types wildlife habitat boundaries	Environmental
ZON	Zoning boundaries	Administration
USE	Land use boundaries	Administration

2.3 Geotechnical Data

For the Rio Salado project, sampling of channel bed material was conducted at 21 locations by Thomas-Hartig & Associates (February 1990). Laboratory analysis of the portion of the material which was less than six inches in diameter was conducted. To estimate the fraction of oversized material, supplemental, large-volume samples were taken at six of the 21 locations. Figure 2 shows the location of field exploration sites conducted by Thomas-Hartig & Associates.

The design gradation was developed by plotting the measured gradation for 12 sediment samples along the channel invert (24, 25, 26, 27, 28, 29, 33, 35, 38, 39, 40, and 45). This includes six large volume samples for which the full distribution of sizes was measured (26, 29, 33, 39, 40, and 45). The fraction of oversized sediments (sizes greater than 3 inches) for sites without large volume samples was made visually. This visual estimate was adjusted downward, based on a comparison of the visual estimate for the measured sites, by 15 percent. Figure 3 shows the correlation between the visual assessment of oversized material and the adjusted/measured estimate of oversized material. Omitted from the design

gradation were channel samples 23, 34, 36, and 37. Samples 36 and 37 were taken at a depth of about four feet immediately downstream with the confluence with Indian Bend Wash (IBW). The IBW channel is composed of much finer sediments which have eroded and deposited in the Salt River Channel. This deposit is clearly evident in aerial photos of the channel. Sample 34 occurs at a greater depth, 13 feet, but is surrounded by samples that show substantially coarser sediments (samples 33, U-1, U-2, and U-3). Sample 34 was rejected as being inconsistent with the general spatial distribution of sediments near Rural Road. Finally, Sample 23 was also rejected as being uncharacteristic of the spatial distribution of sediments in the lower reach of the channel.

The spatial distribution of sediments along the channel invert is shown in Figure 4. No trend in the gradation of channel sediments over the length of the channel is believed to exist in the data. Figure 5 shows the variation in sample gradation by mean depth of sampling. The gradation of sediments appears to be in the range 10 mm to 50 mm regardless of the depth at which the sample was taken. No trend in the gradation of channel with depth is believed to exist in this data.

The lateral distribution of sediments is shown by three sites near Rural Road (see Figure 6). The average sediment size ranges from 14 mm to 43 mm in this cross-section. Sediment is slightly finer toward the center of the channel, possibly due to local deposition of Indian Bend Wash sediments.

Tables 2 and 3 summarize the gradation data used in developing the design gradation. Figure 7 charts the design gradation. The 90 percent confidence curve was used as the design gradation for all subsequent sedimentation calculations. Table 4 provides the design gradation in tabular form by geometrically increasing size intervals.

It is the considered opinion of the designer that this design gradation conservatively estimates the gradation of Salt River channel sediments over the full range of depths and scour that will occur for the Salt River channelization.

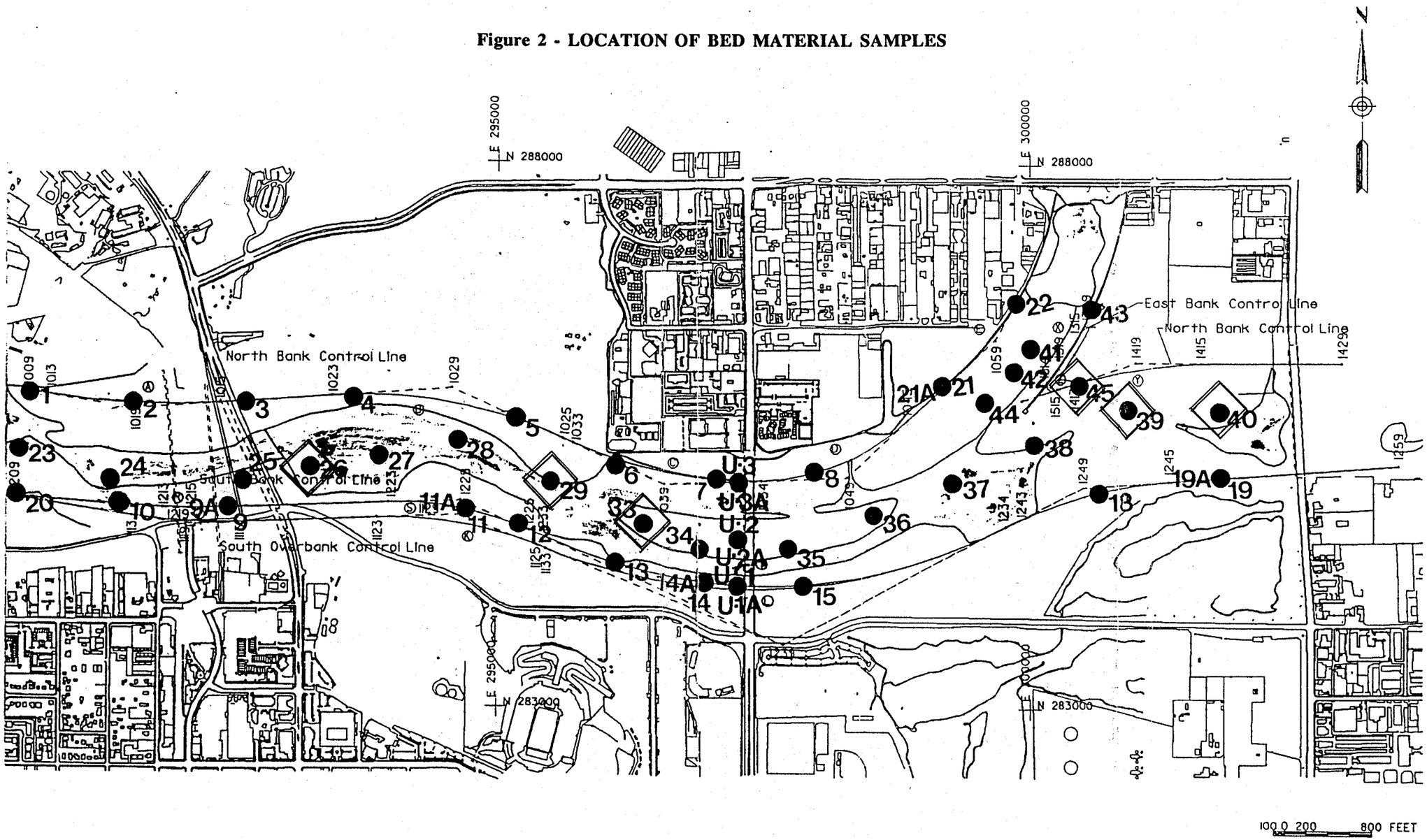
Table 2 - Sampled Bed Material Gradations along channel centerline

Boring no.	Location (sta.,offset)	Depth Range	200 0.075	100 0.150	50 0.300	30 0.600	16 1.00	8 2.36	4 4.76	3/4" 19.0	1" 25.0	2" 50.0	3" 75.0	Over Size	Over Size	D50 (mm)
			Sieve Size/Size(mm)													
23.0	400+00, 430' lt	0-6	5.0	31.0	71.0	82.0	87.0	89.0	90.0	94.0	95.0	100.0		35.0	20.0	0.3
24.0	409+00, 230' lt	0-16	12.0	24.0	33.0	35.0	36.0	36.0	37.0	42.0	47.0	73.0	95.0	0.0	0.0	27.9
25.0	421+00, 240' lt	0-11	1.0	2.0	5.0	13.0	25.0	34.0	41.0	61.0	68.0	87.0	100.0	55.0	40.0	45.2
26.0	428+00, 350' lt	8-17	2.0	3.0	5.0	14.0	27.0	36.0	43.0	67.0	74.0	87.0	100.0	35.0	19.0	15.9
27.0	434+00, 475' lt	0-8	1.0	2.0	5.0	17.0	36.0	44.0	51.0	71.0	77.0	94.0	100.0	35.0	20.0	12.9
28.0	440+00, 258' lt	8-18	2.0	3.0	6.0	11.0	18.0	26.0	34.0	59.0	66.0	83.0	100.0	40.0	25.0	26.0
29.0	448+00, 525' lt	0-8	1.0	2.0	4.0	12.0	24.0	31.0	37.0	53.0	59.0	71.0	100.0	45.0	31.0	51.3
33.0	458+00, 450' lt	0-8	1.0	1.0	4.0	11.0	25.0	34.0	42.0	63.0	69.0	85.0	100.0	45.0	33.0	33.8
34.0	464+00, 325' lt	9-17	5.0	7.0	12.0	22.0	35.0	43.0	49.0	68.0	74.0	91.0	100.0	0.0	0.0	5.5
35.0	474+00, 350' lt	0-8	1.0	3.0	7.0	17.0	29.0	37.0	44.0	69.0	77.0	93.0	100.0	35.0	20.0	15.3
36.0	482+00, 525' lt	0-7	1.0	4.0	20.0	68.0	91.0	95.0	96.0	98.0	98.0	100.0		0.0	0.0	0.5
37.0	490+00, 600' lt	0-10	0.0	2.0	14.0	41.0	68.0	80.0	84.0	94.0	95.0	98.0	100.0	0.0	0.0	0.7
38.0	498+00, 600' lt	8-17	2.0	3.0	7.0	13.0	23.0	32.0	39.0	60.0	68.0	90.0	100.0	55.0	40.0	42.4
39.0	508+00, 700' lt	0-8	1.0	3.0	12.0	27.0	39.0	46.0	52.0	70.0	77.0	91.0	100.0	35.0	17.0	11.3
40.0	516+00, 650' lt	8-17	1.0	2.0	6.0	15.0	27.0	36.0	43.0	63.0	70.0	90.0	100.0	45.0	30.0	26.8
45.0	207+00, 0' rt	0-8	4.0	8.0	15.0	23.0	32.0	40.0	48.0	69.0	76.0	92.0	95.0	25.0	27.0	18.7
avg			2.5	6.3	14.1	26.3	38.9	46.2	51.9	68.8	74.4	89.1	99.3	30.3	20.1	20.9

Table 3 - Sampled Bed Material Gradations at Rural Road Cross Section

Boring No.	Location	Range (ft)	200 0.075	100 0.150	50 0.300	30 0.600	16 1.00	8 2.36	4 4.76	3/4" 19.0	1" 25.0	2" 50.0	3" 75.0	Over-size	D50 (mm)
			Sieve Size/Size(mm)												
U-1	Rural Road, SB	0-3.5	1.0	2.0	6.0	17.0	29.0	34.0	37.0	54.0	62.0	89.0	94.0	20.0	25.9
U-2	Rural Road, CL	0-7	3.0	5.0	9.0	17.0	28.0	38.0	45.0	71.0	83.0	99.0	100.0	20.0	14.3
U-3	Rural Road, NB	0-2	3.0	5.0	6.0	7.0	9.0	10.0	12.0	31.0	42.0	77.0	87.0	25.0	42.6

Figure 2 - LOCATION OF BED MATERIAL SAMPLES



Field Exploration Location

Location with large volume sample of oversized material

Site Plan

Figure 2
LOCATION OF BED MATERIAL SAMPLES

Project No. 89-0919

THOMAS-HARTIG & ASSOCIATES, INC.

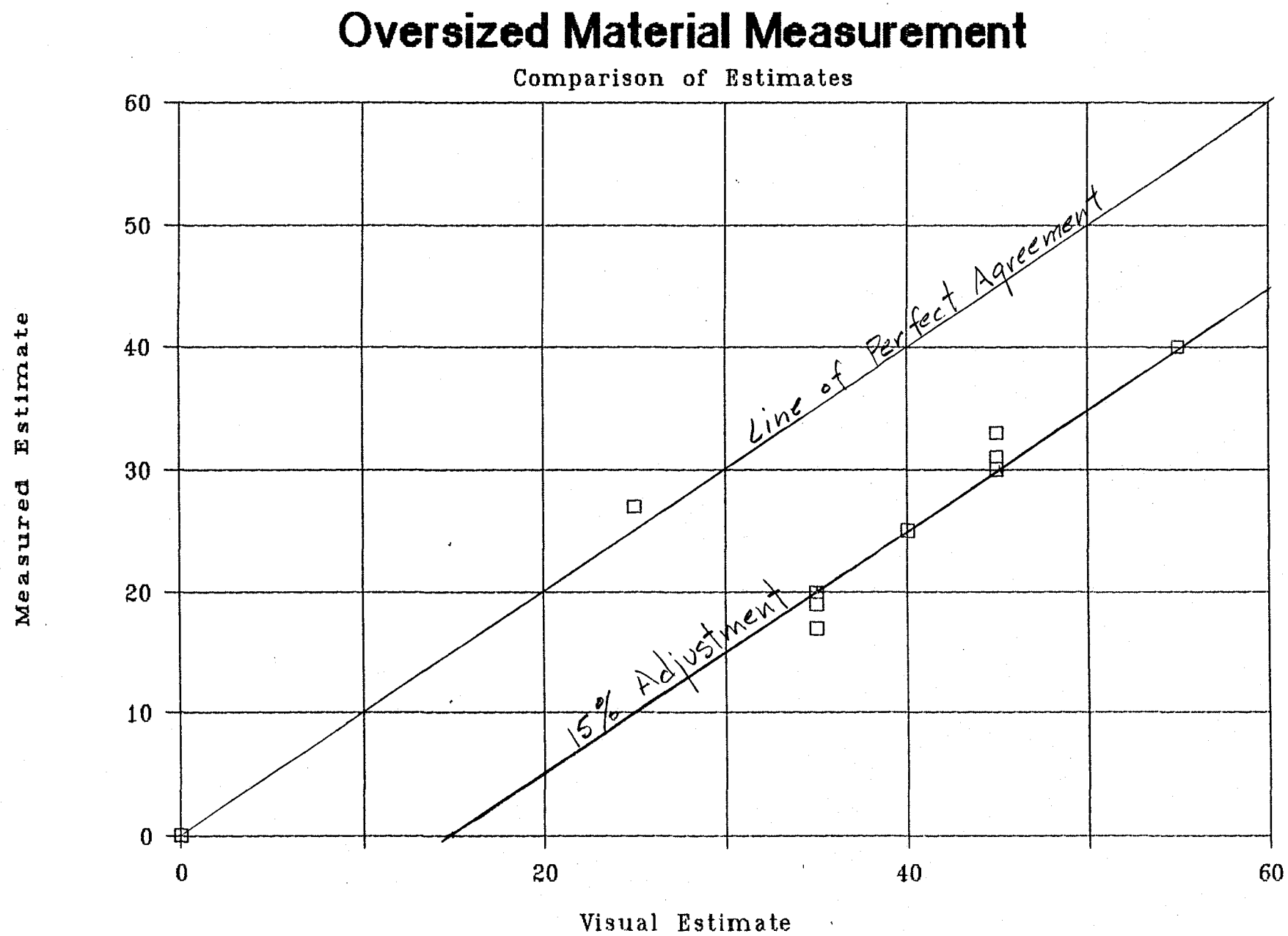

Oversized Material Measurement
Comparison of Estimates
Measured Estimate
Visual Estimate
0
10
20
30
40
50
60
0
20
40
60
Line of Perfect Agreement
15% Adjustment

Figure 3

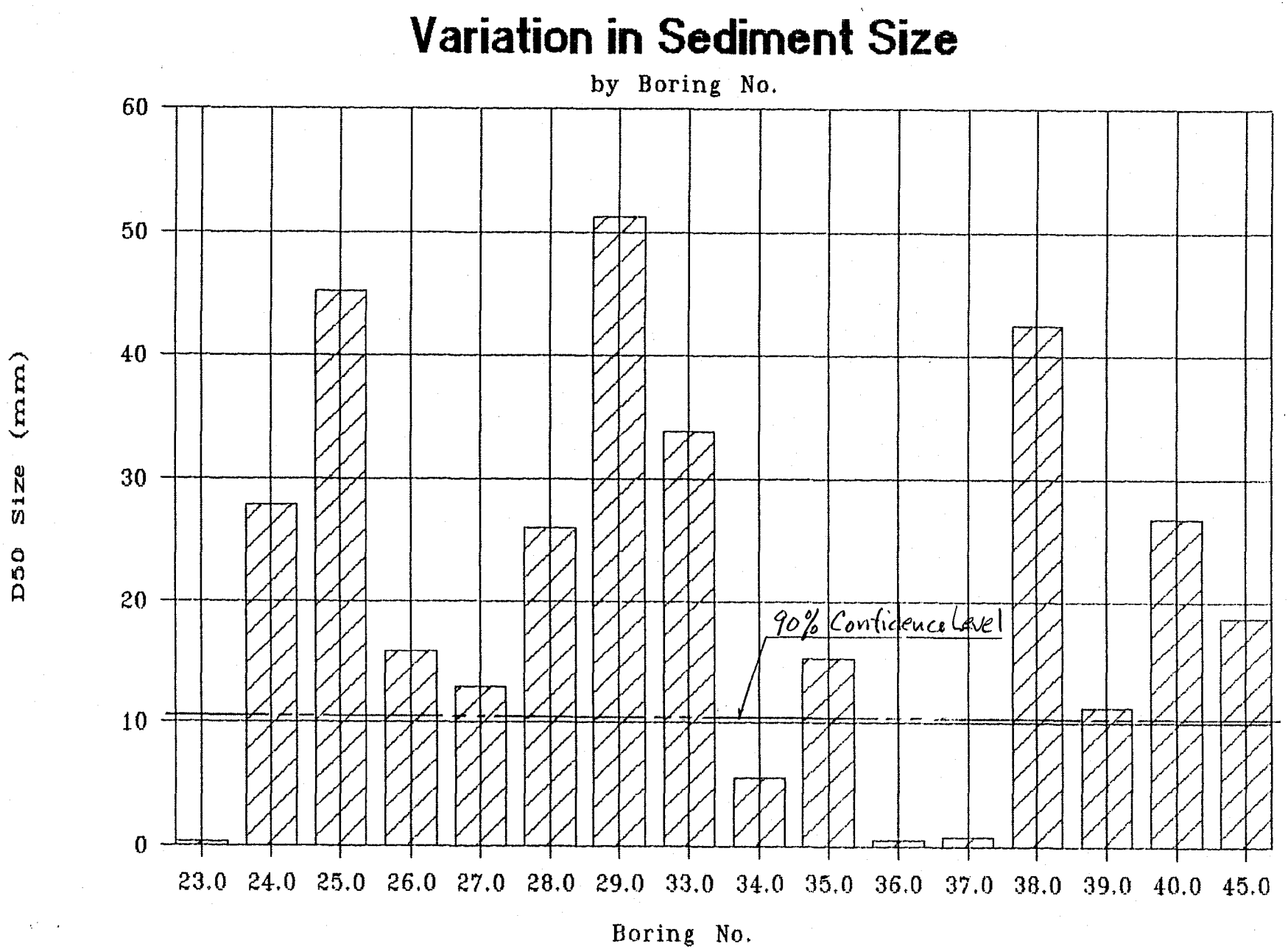

Variation in Sediment Size
by Boring No.
D50 Size (mm)
60
50
40
30
20
10
0
90% Confidence Level
23.0
24.0
25.0
26.0
27.0
28.0
29.0
33.0
34.0
35.0
36.0
37.0
38.0
39.0
40.0
45.0
Boring No.

Figure 4

SAMPLE DEPTH VERSUS MEAN SIZE

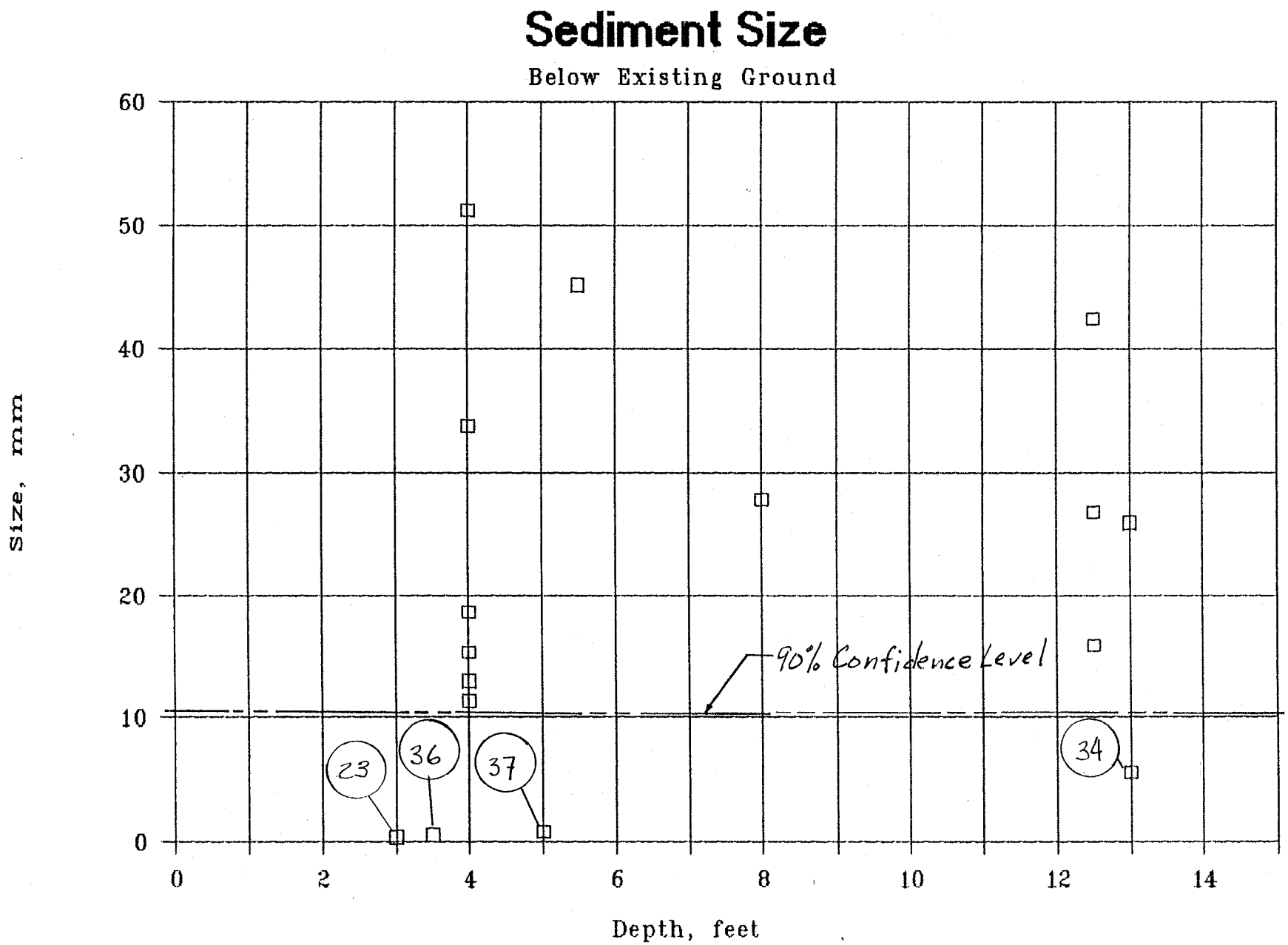


Figure 5

SEDIMENT SIZE VARIATION AT RURAL ROAD SECTION

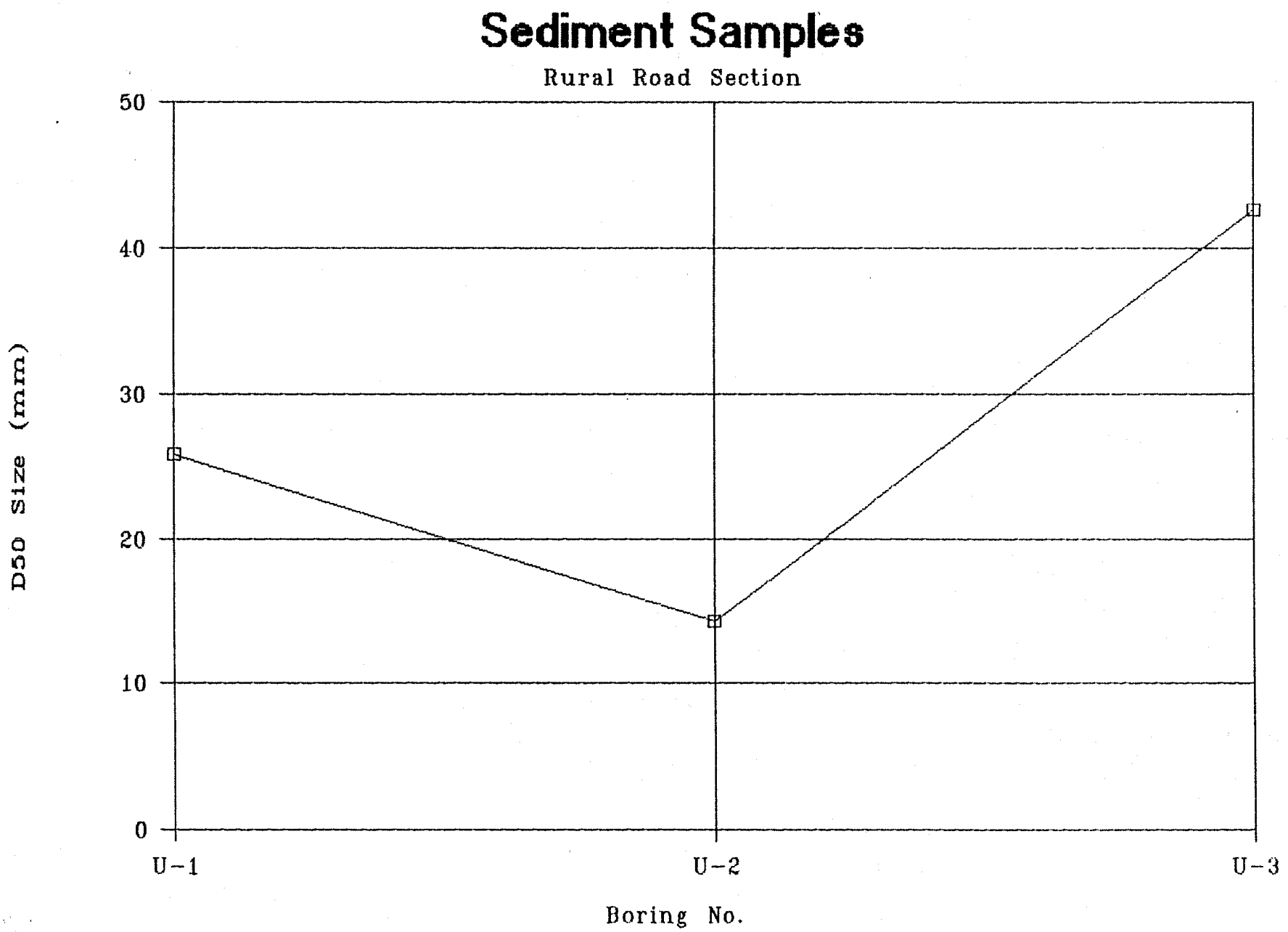


Figure 6

DESIGN BED MATERIAL GRADATION

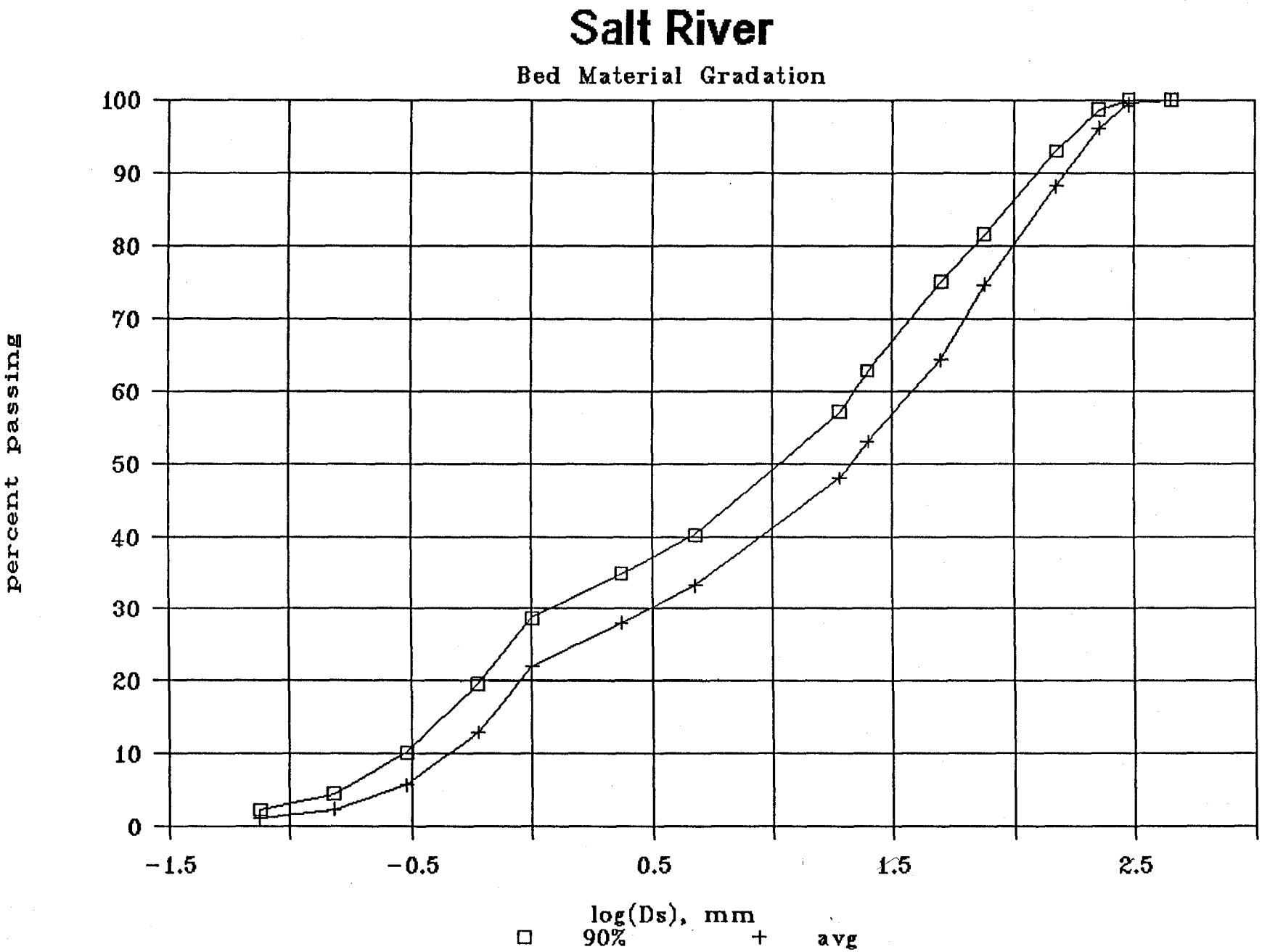


Figure 7

Table 4

DISCRETIZED DESIGN BED MATERIAL GRADATION

Size Range (mm)	Fraction (percent)	Cumulative (percent)
0.00 – 0.0625	1.9	1.9
0.0625 – 0.125	2.0	3.9
0.125 – 0.25	4.7	8.6
0.25 – 0.50	8.4	17.0
0.50 – 1.00	11.5	28.5
1.00 – 2.00	5.0	33.5
2.00 – 4.00	5.4	38.9
4.00 – 8.00	7.7	46.6
8.00 – 16.00	8.5	55.1
16.00 – 32.00	12.1	67.2
32.00 – 64.00	11.8	79.0
64.00 – 128.00	11.4	90.4
128.00 – 256.00	8.9	99.3
256.00 – 512.00	0.7	100.0

3.0 HYDROLOGIC ANALYSIS

The project hydrology is based on the revised analysis of Central Arizona Project features by the U.S. Army Corps of Engineers, Los Angeles District. This analysis was initiated in November of 1987, after it was determined that Plan 6 (one of nine alternatives to Orme Dam) would not include Cliff Dam (one of four structures which comprised Plan 6) or similar water conservation storage feature on the Verde River as an element of the recommended plan. The analysis was conducted in three parts; the future without project conditions were developed, alternatives for upstream storage were developed, and the benefits for upstream alternatives were evaluated.

The future without project condition was the current condition against which the feasibility of flood control was measured. Currently, there is no flood control storage on either the Salt or Verde Rivers. Under Plan 6, flood control storage would have been provided at two dams: 565,000 acre-feet of storage on the Salt River from a modified Roosevelt Dam and 465,000 acre-feet of storage on the Verde River from the new Cliff Dam. For future without project, the Corps analysis assumes Plan 6 will be constructed, but without Cliff Dam.

The future without project condition, Plan 6 minus Cliff Dam, was evaluated in the original CAWCS study as Plan 9. During the revised analysis, the Corps reevaluated the discharge frequency relationships developed for Plan 9 and found that the results supported most of the original CAWCS Plan 9 discharges, but that there would be a greater peak flow reduction for floods exceeding a 50-year event. Discharge frequency results for existing conditions (i.e., no flood control), Plan 6, the original CAWCS Plan 9, and the new Plan 9 values are given in Table 5. Under existing conditions, the 100-year flow at the Mill Avenue bridge is 215,000 cfs. The new Plan 9 reduces the 100-year flow to 160,000 cfs.

New Plan 9 hydrographs for the Salt River at Granite Reef Dam are shown in Figure 8 for the 50-, 100-, 200-, 300-, and 500-year flood events. A discretized version of these hydrographs is provided in Table 6.

Table 5
DISCHARGE FREQUENCY VALUE
SALT RIVER AT MILL AVENUE BRIDGE

Frequency (year)	Existing	CAWCS Plan 6	New Plan 9	Plan 9
5	40,000	40,000	44,000	44,000
10	93,000	50,000	84,000	84,000
20	135,000	50,000	110,000	110,000
50	160,000	50,000	140,000	135,000
100	215,000	55,000	170,000	160,000
200	275,000	92,000	215,000	190,000
500	330,000	170,000	265,000	250,000

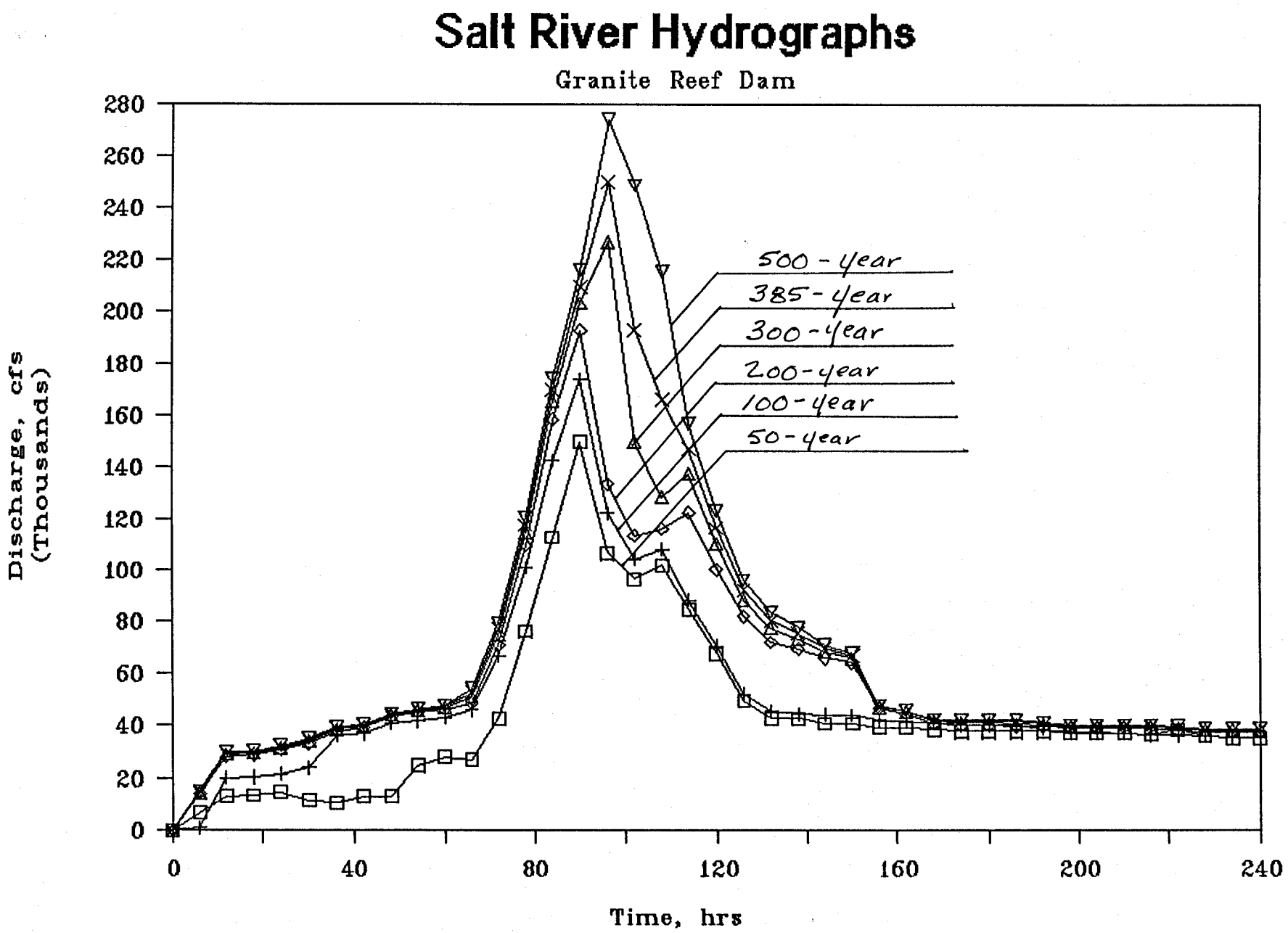

Salt River Hydrographs
Granite Reef Dam
Discharge, cfs
(Thousands)
Time, hrs
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
0
40
80
120
160
200
240
500 - year
385 - year
300 - year
200 - year
100 - year
50 - year

Figure 8

Table 6

SALT RIVER FLOOD HYDROGRAPHS LOCATION: GRANITE REEF DAM

New Plan 9

Volume:	V50 =	890578.5 acre-feet	Peak:	Q50 =	150000.0 cfs
	V100 =	1050534.8 acre-feet		Q100 =	174000.0 cfs
	V200 =	1224461.2 acre-feet		Q200 =	193000.0 cfs
	V300'=	1339654.3 acre-feet		Q300'=	227000.0 cfs
	V385 =	1418111.2 acre-feet		Q385 =	250000.0 cfs
	V500 =	1502320.7 acre-feet		Q500 =	274000.0 cfs
	V385'=	1418223.1			

Time step: dt = 6.0 hrs

Time	Flood Discharge, cfs					
(hr)	50-yr	100-yr	200-yr	300-yr'	385-yr	500-yr
0	0.0	0.0	0.0	0.0	0.0	0.0
6	6540.0	1008.5	14090.0	14514.4	14762.6	15015.0
12	13080.0	20170.0	28180.0	29028.8	29525.1	30030.0
18	13530.0	20670.0	28960.0	29582.4	29944.0	30310.0
24	14720.0	21630.0	30610.0	31441.8	31927.2	32420.0
30	11530.0	24110.0	33230.0	34062.8	34547.9	35040.0
36	10610.0	36000.0	37970.0	38740.4	39187.6	39640.0
42	13040.0	37000.0	39260.0	39838.5	40172.8	40510.0
48	13040.0	40870.0	43350.0	43970.3	44328.7	44690.0
54	24780.0	41610.0	45140.0	45742.1	46089.7	46440.0
60	28140.0	43170.0	46420.0	47003.8	47340.7	47680.0
66	27020.0	46060.0	48580.0	51231.9	52811.6	54440.0
72	42960.0	66880.0	70790.0	74650.4	76949.8	79320.0
78	76320.0	101060.0	109820.0	114787.7	117726.2	120740.0
84	112760.0	142850.0	158560.0	165853.8	170170.7	174600.0
90	150000.0	174000.0	193000.0	203500.2	209754.0	216200.0
96	106700.0	122240.0	133610.0	227000.0	250000.0	274000.0
102	96610.0	104490.0	113520.0	150000.0	193117.8	248630.0
108	101910.0	108170.0	116280.0	128500.0	166423.8	215540.0
114	84710.0	88210.0	122490.0	137689.4	147205.8	157380.0
120	67420.0	70650.0	100190.0	110313.6	116550.5	123140.0
126	49490.0	52440.0	81930.0	88292.5	92147.1	96170.0
132	42990.0	45610.0	72060.0	77366.4	80571.8	83910.0
138	42990.0	44590.0	69480.0	73193.3	75403.3	77680.0
144	40940.0	44260.0	65920.0	68302.2	69701.8	71130.0
150	40940.0	44030.0	64300.0	65955.7	66920.8	67900.0
156	39550.0	42370.0	46830.0	47257.1	47502.9	47750.0
162	39550.0	41300.0	44880.0	45394.7	45691.4	45990.0
168	38470.0	41300.0	41010.0	41712.5	42119.3	42530.0
174	38060.0	40270.0	40120.0	41227.3	41873.6	42530.0
180	38060.0	40270.0	40120.0	41227.3	41873.6	42530.0
186	38060.0	40110.0	39650.0	40969.0	41742.2	42530.0

Table 6, cont'd.

Time (hr)	Flood Discharge, cfs 50-yr	100-yr	200-yr	300-yr'	385-yr	500-yr
192	38060.0	38820.0	39650.0	40393.4	40824.4	41260.0
198	37290.0	37520.0	39370.0	39709.0	39904.0	40100.0
204	37290.0	37520.0	39370.0	39709.0	39904.0	40100.0
210	37290.0	37220.0	39370.0	39709.0	39904.0	40100.0
216	36580.0	36440.0	39370.0	39709.0	39904.0	40100.0
222	38580.0	36440.0	38240.0	39042.4	39508.4	39980.0
228	36030.0	36120.0	37870.0	38338.1	38608.1	38880.0
234	35180.0	35550.0	37870.0	38338.1	38608.1	38880.0
240	35180.0	35550.0	37870.0	38338.1	38608.1	38880.0

4.0 DESIGN CRITERIA

4.1 Design Discharge

The channel under construction by ADOT, west of Mill Avenue, was designed based on criteria provided by the Flood Control District of Maricopa County (FCDMC). This channel will safely convey and contain a flow of 215,000 cfs with four feet of freeboard and a maximum flow of 289,000 cfs with one foot of freeboard. The FCDMC has required that the channel east of Mill Avenue be compatible with the ADOT channel capacity and to the extent possible, provide the same maximum capacity.

Discussions with FCDMC lead to the recognition that the five existing bridges above the ADOT channelization physically limit the conveyance of this reach of the river. Also, future changes to upstream channel conditions that will affect the channel east of McClintock Drive, intense sand and gravel mining on Indian Community land, and modifications to the Roosevelt Dam. With these conditions in mind, the Flood Control District has required that the channel capacity achieve the maximum capacity possible for the existing bridge waterway openings. The operational channel design should be based on 215,000 cfs, with a maximum bridge capacity of 250,000 cfs. Levee heights should be based on four foot of freeboard for 215,000 cfs and a minimum of one foot of freeboard for 250,000 cfs, whichever is greater.

4.2 River Form

The new river channel form is established by the alignment of levees, the channel profile, and the channel section. The general criteria for design of the Salt River is to provide a plan form for the main channel that conforms with general geomorphic features of the natural Salt River channel. In addition, the channel alignment should conform to the location of various structures and facilities that presently exist in the Salt River channel. Some of these facilities would be extremely expensive to relocate and therefore are considered fixed constraints to the channel alignment. In

aligning the levees between these fixed constraints, the rates of curvature must be gradual because of the large size of the Salt River.

Historically, the Salt River east of Tempe was a braided, gravel bed channel that was wide and relatively shallow. Today, the upper reaches of the Salt River, east of Country Club Road, are all that remain of the natural form of the Salt River channel. In a braided channel, the individual braids are quite sinuous and tend to meander and intertwine. The reach of the Salt River through Tempe had several unique geomorphic features that resulted from the bed rock outcrop that exists in the river channel at the buttes, which was referred to as the Indian Bends. The channel profile grade was reduced upstream of the buttes due to deposition of sediments upstream of this natural constriction. The confluence of the Indian Bend Wash with the Salt River also imparted a prominent bend to the Salt River channel between Rural Road and McClintock Drive. This bend occurs in response to flow in Indian Bend Wash deflecting the main channel of the Salt River.

4.2.1 Levee Alignments

The levee alignments are constrained by the location of existing bridges. There are five existing bridges in the reach, including: Southern Pacific Railroad, Ash Avenue, Mill Avenue, Rural Road, and McClintock Drive bridges. The East Papago Freeway will introduce two new bridges into the reach: one structure across Indian Bend Wash, and another structure over McClintock Drive gradually crossing from the north bank of the Salt River to the Red Mountain Interchange on the south bank. The levee alignments have been set to guide the flow efficiently to each bridge opening. Because of the severe skew of the Mill Avenue bridge, a separate study of levee alignments and flow conditions was conducted during the planning phase for the project (CRSS Commercial Group, Inc., 1989).

4.2.2 River Profile

The design criteria for the channel profile are intended to meet three main objectives: (1) reduce flood elevations; (2) provide a stable channel invert that is not subject to substantial aggradation or degradation; and (3) provide borrow material that can be used by ADOT for construction of segments of the Easts Papago Freeway. The three objectives compliment one another and also create the opportunity to incorporate several planned in-stream features into the channelization project.

The deepening of the channel thalweg increases the capacity of the floodway, which reduces the stage in the adjacent floodplain. The deeper channel will have a flatter channel grade through the reach which will permit the formation of lake areas within the channel bed. The flatter channel grade will permit the circulation of water among a series of lakes along the channel bed with a minimum of pumping.

Since the prevailing grade of the Salt River throughout the City of Tempe is about 0.016 feet/foot (about eight feet per mile), a potential consequence of a reduced channel gradient is deposition of sediment. The chance of significant deposition in the Tempe reach is considered low because of the large volume of sand and gravel production that is occurring in the upper reaches of the Salt River at this time and because of the upper basin dams on both the Salt and Verde Rivers. The present condition of the river is such that it is actually sediment-deficient, and the river reach west of McClintock Drive is degrading. Reducing the river grade in this reach should arrest this process and provide a more stable river reach.

4.2.3 River Section

The design objective for the river cross section is to provide a section that conveys the design flood discharge through the site with approximately the same hydraulic characteristics as the existing channel. Locally, the section should include stable channel banks that will control any lateral erosion

during major flood flows. Hydraulic features of the cross section should include a low-flow channel capable of conveying typical annual SRP spills, a main floodway with the capacity for the maximum discharge and terraces set near the elevation of an intermediate discharge (about the ten-year flood) for riparian vegetation and habitat.

There are substantial opportunities for variation in channel section in the reach from Mill Avenue to McClintock Drive. Once the basic requirements of hydraulic capacity and channel stability have been met, enhancements have been made that are geared toward the planned recreational and land use development for the district.

4.3 River Stabilization Design

4.3.1 Levee Height

- The levee height is to provide four feet of freeboard for 215,000 cfs and a minimum of one foot of freeboard for 250,000 cfs, whichever is greater.
- Water surface profiles for the two design flows must be presented showing top of levee protection, freeboard for each, and low chords for all bridges in the project.
- Bank slope stability analysis calculations are to be submitted for District review. The analysis should consider pore pressures caused by rapid draw down. Minimum factors of safety should be 1.5 for 215,000 cfs and 1.3 for 250,000 cfs.
- All geotechnical testing and analyses are to be provided for District review.
- Degradation and aggradation analyses are to include the effect of dunes and antidunes.
- Scaled cross sections are to be provided showing velocity, depth, and energy slope for the two design flows. The depth of scour is to be determined from the thalweg invert elevation to determine the toedown

elevations for bank protection and grade control structures. The tabulated scour data must also be provided.

4.3.2 Bank Protection

- Minimum factor of safety for riprap design should be 1.5 for 215,000 cfs and 1.3 for 250,000 cfs.
- Cement stabilized bank protection should have a factor of safety consistent with the bank slope stability (see levee height criteria).

4.3.3 Grade Control and Drop Structure

- The foundation of the structure should be set below the depth of scour for the maximum channel discharge.
- The structure should have a factor of safety against overturning and sliding of 1.5 for 215,000 cfs and 1.3 for 250,000 cfs.

4.4 In-Channel Features

- In-channel features are to be limited to water conveyance features such as low flow channels and shallow water bodies.
- Water regulating structures such as check dams or gates are to be constructed so that during maximum channel flow, the structures will block less than five percent of the waterway area.

4.5 Off-Channel Areas

- Flood waters from overbank areas must return to the channel without causing erosion of channel banks.
- Velocity of water due to circulation of flow in off-channel areas should be less than the scour velocity for the natural ground cover.

5.0 HYDRAULIC ANALYSIS

5.1 Channel Hydraulics Conditions

The objective of the channel hydraulic analysis was to demonstrate for the planned configuration of levees and channel gradient, that the channel would have adequate capacity for the design events of 215,000 cfs and 250,000 cfs. The channel hydraulic analysis also became the basis for analysis of channel scour and the design of bank protection. Several iterations of the hydraulic analysis were progressed during the coarse of the channel design. Some of these intermediate steps are presented in this report because they were incorporated as alternatives in the environmental assessment for the project. Also, some of the early two-dimensional modeling results are presented since these served as a qualitative guide for later one-dimensional modeling of the channel.

5.1.1 Initial Two-Dimensional Hydraulic Analysis

Two-dimensional flow analysis was conducted using the Federal Highway Administration, Finite Element Surface Water Modeling System (FESWMS). The two-dimensional model was used to answer questions related to a number of more complex flow areas in the river including the Mill Avenue bridge and the confluence of Indian Bend Wash and the Salt River.

The two-dimensional model was run for two hypothetical inflow conditions occurring at the Indian Bend Wash confluence. In the first case, the entire 215,000 cfs discharge was confined to the main Salt River channel. In the second case, a flow of 35,000 cfs from Indian Bend Wash was combined with a Salt River flow of 180,000 cfs for a total discharge of 215,000 cfs below the confluence. The purpose of these two runs was to examine the way in which flow would impinge on the west bank of Indian Bend Wash.

The infinite element network used to describe the geometry of the Salt River is shown in Plate 1.

The graphic output for the FESWMS runs are provided in Plates 2 and 3. Plate 2 shows the effect of a 215,000 cfs discharge which occurs in the main channel of the Salt River. Plate 3 shows a combined flow of 35,000 cfs from Indian Bend Wash with 180,000 cfs on the main Salt River channel. Both outputs show the same backwater effect at the Mill Avenue bridge. The backwater created by this structure is approximately 3.0 feet and extends upstream to the Rural Road bridge. The model also shows that the curvature of the Salt River induces as much as one foot of super-elevation at the Rural Road bridge. For zero inflow from Indian Bend Wash, the main channel flow will impinge at about a 30-degree angle on the west bank of Indian Bend Wash. Approach velocities to the west bank are about five feet per second. With inflow from Indian Bend Wash, the main Salt River flow is deflected and does not impinge on the west bank. However, the convergence of the two flows causes an increased backwater which extends upstream to McClintock Drive.

The input dataset for the two-dimensional hydraulic model of the Salt River is provided in Appendix A. The input data includes three main blocks of data which are: 1) program control data, 2) network structure data, and 3) boundary condition data. The finite element network for the Salt River from Grade Control No. 4 to McClintock Drive is shown in Plate 1. The network actually consists of two models. Operationally, these models are combined by using the upstream water surface elevations of the lower model as an essential boundary condition at the downstream open boundary of the upper model. This approach was necessary because each of the two models approaches the maximum size of 500 elements permitted by the FESWMS model.

The boundary conditions for the model consist of a downstream rating relationship at Grade Control No. 4, summarized in Table 7, and the discharge of 215,000 cfs at the upstream open boundary.

Table 7
STAGE/DISCHARGE CHARACTERISTICS
GRADE CONTROL NO. 4

Discharge	Stage	Depth	Velocity
84,000	1144.5	12.1	7.90
135,000	1148.4	16.0	9.45
160,000	1150.1	17.3	10.07
215,000	1153.5	21.1	11.24
250,000	1154.7	22.3	12.31

5.1.2 Alternative Channel Designs

5.1.2.1 Existing Conditions

The capacity of the existing Salt River floodway through the City of Tempe is in range of 170,000 to 215,000 cfs. Five existing bridges span this floodway and provide waterways with a design capacity of about 210,000 cfs. Three bridges are located in the contraction formed by the Papago Buttes. The SPRR, Ash Avenue, and Mill Avenue Bridges span the Salt River at this location. Because the buttes force all flood flows through this contraction, the capacity of the existing Salt River is limited by the size of the waterway openings provided by those bridges. Two bridges upstream of the Papago Buttes are located at Rural Road and McClintock Drive. The existing floodplain is wider than the Salt River channel and both of these bridges have roadway approaches to the bridge that can be flooded while the super structure of bridge remains above the water surface.

The three bridges spanning the Salt River at Papago Buttes have withstood the larges magnitude flood since the construction of dams on the Salt River, 180,000 cfs in February 1980. Both the SPRR bridge and the Mill Avenue bridge remained operational through the flood. The Ash Avenue bridge was closed prior to any flooding because of structural deficiencies but did not fail due to hydraulic forces or scour in 1980. Crossings at Rural Road and McClintock Drive were destroyed. The present bridges date from 1983 and completely replace the previous structures.

All the bridges at the Papago Buttes owe their stability to the local outcropping of bedrock and the excellent foundation which it provides for each bridge substructure. Some scour occurred at the southern piers of the SPRR bridge which caused settlement of the

bridge after the 1980 flood. This settlement was corrected by the railroad by driving H-pile around the affected pier and then securing the pile to the pier. The potential for local scour is quite large, but is limited by the bedrock outcrop. Even with the proximity of bedrock, the general scour of the shallow alluvial material at the bridge has probably added sufficient area at the waterway to reduce the stage in the river during major floods.

Two-dimensional hydraulic analysis of the existing Mill Avenue bridge was conducted by CRSS (October 1989) for a discharge of 215,000 cfs. The water surface at the bridge opening was affected by the bridge skew and the size and orientation of the bridge piers. Flood levels in the bridge waterway extended ten feet above the spring line of the bridge arch. This stage is roughly 64 percent of the arch area and 83 percent of the total waterway area. The mean low chord of the bridge arches is 4.9 feet above the water surface.

5.1.2.2 Alternative Design Conditions

Design criteria for the Rio Salado channel (see Section 4.1, page 21) requires a design capacity of 250,000 cfs. Based on the existing capacity of bridges in Tempe across the Salt River, it was necessary to increase channel capacity by about 20 percent at these bridges.

There are two mechanisms to increase channel capacity: 1) to increase the waterway area by either widening or deepening the channel, and 2) by increasing the energy gradient by either reducing channel roughness or increasing the profile grade of the channel. Five alternative channel configurations were developed by varying channel geometry in these ways.

Alternative 1: This is the master-planned channel configuration based on the Rio Salado Master Plan. Additional channel capacity is

provided by lowering the profile of the Salt River. At Rural Road, on the inside of the channel bend, waterway area is removed to provide land for development. Overall, this channel has a capacity approximately equal to existing conditions of 215,000 cfs.

Alternative 2: This channel configuration widens the main channel at Rural Road. Otherwise it is the same as the configuration for Alternative 1. This change in waterway area at Rural Road results in no change in channel capacity. The velocity of flow is simply reduced at Rural Road.

Alternative 3: This channel configuration widens both the main channel at Rural Road and the low flow channel throughout the project. This configuration improves the velocity at Rural Road and increases channel capacity at 236,500 cfs.

Alternative 4: This channel configuration provides a terrace on the inside of the channel bend at Rural Road. The low flow channel is widened as well. This configuration further improves velocity at Rural Road and increases channel capacity to 240,700 cfs.

Alternative 5: This channel configuration provides a steeper channel grade by lowering the elevation of the downstream grade control structure (No. 4) by three feet. In all other respects, the channel configuration is the same as Alternative 4. The increase in channel gradient improves flow velocity and increases channel capacity to 250,000 cfs.

The channel alternatives show a range of hydraulic results. Table 7 → 8 shows water surface and energy grade line elevations for 215,000 cfs and 250,000 cfs. The behavior of the energy grade line and the water surface profile shows that widening the channel will generally reduce the energy grade line elevation. However, there can also be a concurrent decrease in velocity and velocity head which can actually

result in an increase in water surface elevation (Alternative 1 to Alternative 2). The most straightforward result is obtained by increasing the channel profile grade (Alternative 5). In this case, there is a lowering of the energy grade line elevation and a corresponding increase in velocity head. This results in a net decrease in water surface elevation.

Table 8
HYDRAULIC CONDITIONS AT RURAL ROAD (STA. 70+50)
LOW CHORD 1164.90

Alternative	Q=215,000 HEC - 2 WSEL	EG	Q= 250,000 HEC - 2 WSEL	EG	Q@1164.9
#1 Masterplan	1165.04	1166.45	1167.10	1168.69	~215,000
#2 Widened Channel	1165.32	1166.31	1167.42	1168.54	~210,000
#3 Widen w/o Low Flow	1163.56	1164.53	1165.70	1166.80	236,500
#4 No Low Flow	1163.33	1164.62	1165.43	1166.90	240,700
#5 Lower GC #4	1162.81	1164.23	1164.94	1166.54	250,000

To maximize the capacity of the channel, it was necessary to both increase the channel area and channel gradient. This was accomplished by lowering Grade Control No. 4 by three feet and then using a combination of profile lowering and gradient reduction upstream. The downstream ADOT channel has a gradient of 0.24 percent, while the Tempe channel with the lowered elevation at the Grade Control No. 4 will be 0.10 percent. The channel reach from Grade Control No. 3 to No. 4 now has a gradient of 0.16 percent. The lowering of Grade Control No. 4 provides additional conveyance in the Tempe reach and also provides a transition reach from the steeper grade of the ADOT channel to the milder channel grade of the Salt River upstream of the Papago Buttes.

5.1.3 Final Hydraulic Analysis

The final one-dimensional hydraulic analysis was conducted over a range of channel flows from 40,000 cfs to 250,000 cfs. The cross sections were set perpendicular to the south levee control line in most cases, with the exception of cross sections located immediately upstream and downstream of the five bridges which are parallel to the roadway. Plates 4 to 9 show the alignment of all channel sections. Stationing for the south levee begins at the downstream limit of the project and proceeds upstream. The stationing for channel sections is based on stationing for the south levee. The digital terrain modeling software used (Intergraph, InRoads) cuts sections oriented ahead along the control line stationing. The cross section is therefore oriented looking upstream, with stationing for the section profile beginning on the north bank. For each section, the distance 1500 corresponds to the south levee control line.

The downstream limit for 1-D modeling was set at grade control structure three (GC3) in the ADOT channelization reach, which is 4,300 feet downstream of the project limits. The downstream boundary condition was based on the channel rating curve at GC3, which is given in Table 9.

Table 9
DOWNSTREAM RATING RELATIONSHIP AT GRADE CONTROL NO. 3

Discharge	*Stage	Discharge	*Stage
40,000	1130.53	160,000	1138.56
80,000	1133.72	200,000	1140.48
93,000	1134.60	215,000	1141.29
120,000	1136.28	250,000	1142.88

*Invert 1122.50

The channel roughness was set at 0.035 for the determination of water surface elevation. The other loss coefficients included expansion, contraction, and bridge losses. Expansion and contraction loss coefficients were set at 0.3 and 0.1, respectively, which corresponds to gradual variation in channel section. The calculations conducted for determining bridge loss coefficients are discussed in Section 5.2.

The topographic data for the 1-D model was derived from the digital terrain model (DTM) for the channel grading plan. Cross sections were cut from the channel grading DTM and output in ASCII numerical format and then converted to HEC-2 format.

Results of the water surface profile computations are graphically shown in Figures 9 to 12. Appendix B provides input and summary output datasets that were used and were the product of computation by the program HEC-2 for the 100-year (215,000 cfs) and standard project flood (250,000 cfs) conditions. The water surface profile for both design flows shows a steady acceleration of the river flow from about one-half mile east of the Rural to Grade control No. 3. This is reflected in increasing channel velocity and shear stress, and decreasing depth of flow. Channel topwidth varies depending on the width of overbank terraces and is widest in the vicinity of Tempe Beach Park, where the SPRR, Ash Avenue, and Mill Avenue bridges cross the Salt River, and at the confluence with Indian Bend Wash. There is a pronounced deceleration of the river flow below Grade Control No. 5 to one-half mile above the Rural Road Bridge. In this reach, the river flow widens to include a portion of the Indian Bend Wash confluence area. The extent of the flow expansion in this area was determined from the initial two-dimensional modeling. There is also a vertical expansion of the flow immediately downstream of Grade Control No. 5, where the channel profile is five feet below the upstream channel profile.

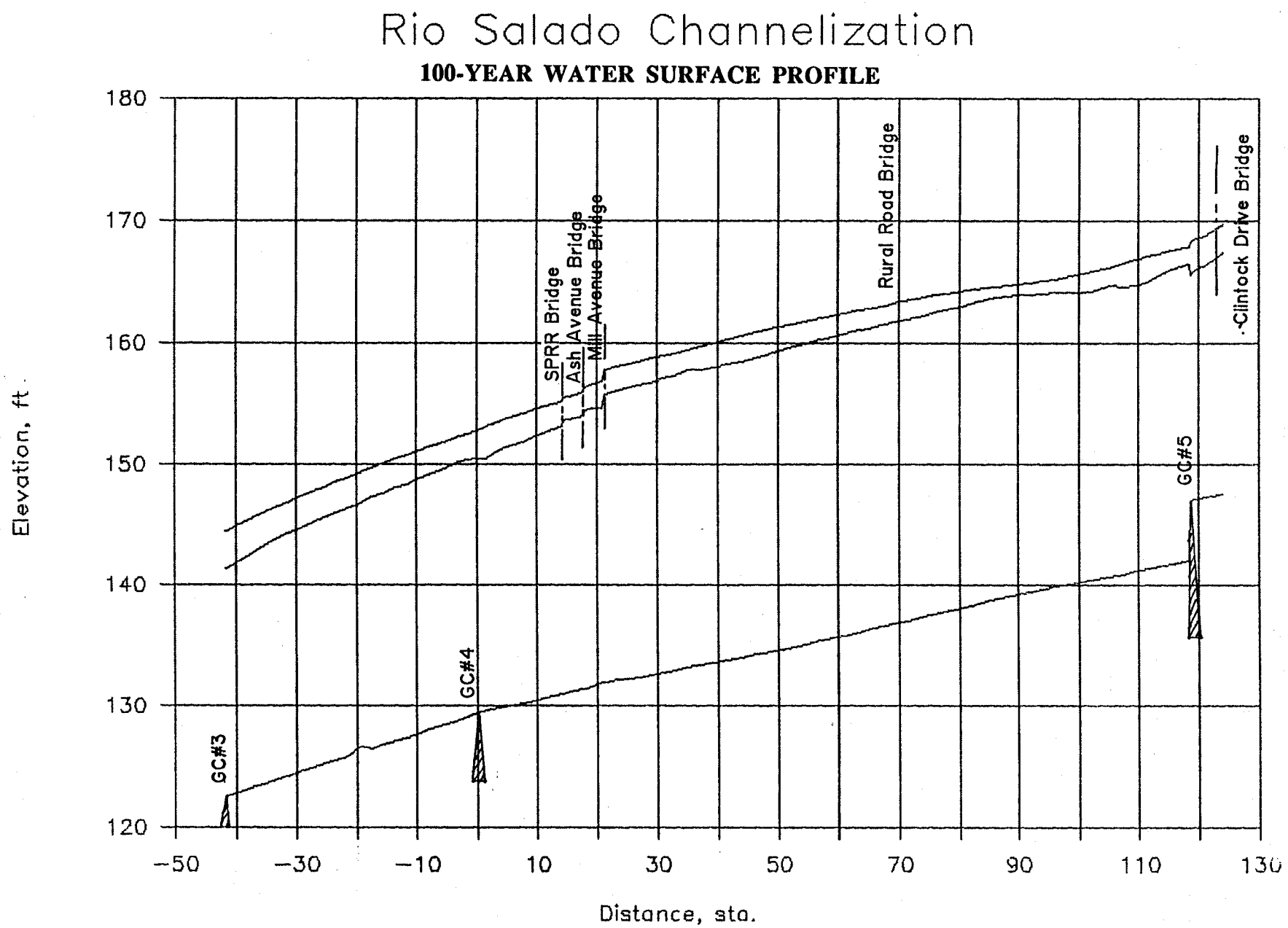

Rio Salado Channelization
100-YEAR WATER SURFACE PROFILE
Elevation, ft.
180
170
160
150
140
130
120
-50
-30
-10
10
30
50
70
90
110
130
Distance, sta.
GC#3
GC#4
GC#5
SPRR Bridge
Ash Avenue Bridge
Mill Avenue Bridge
Rural Road Bridge
Clintock Drive Bridge

Figure 9

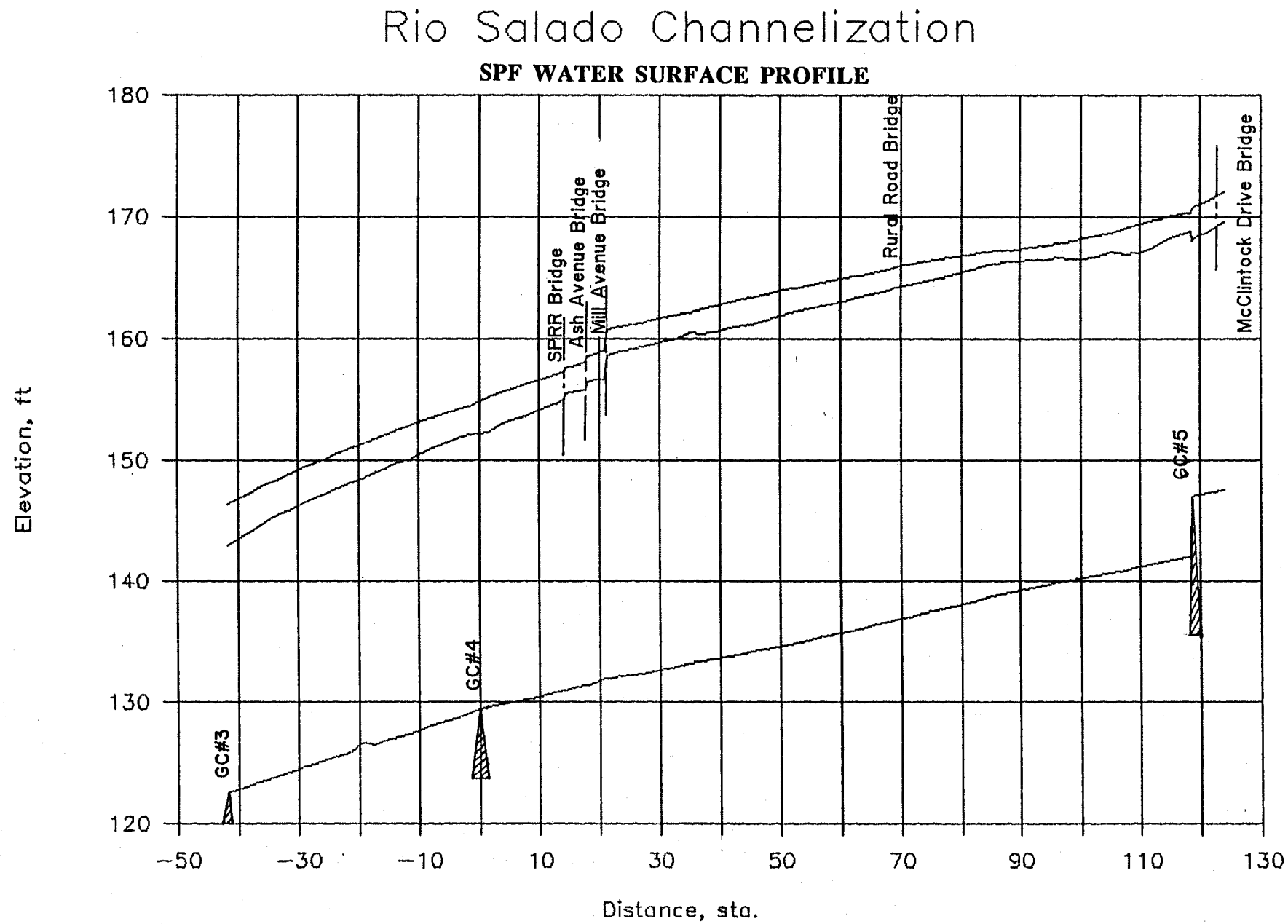

Rio Salado Channelization
SPF WATER SURFACE PROFILE
Elevation, ft
180
170
160
150
140
130
120
-50
-30
-10
10
30
50
70
90
110
130
Distance, sta.
GC#3
GC#4
GC#5
SPRR Bridge
Ash Avenue Bridge
Mill Avenue Bridge
Rural Road Bridge
McClintock Drive Bridge

Figure 10

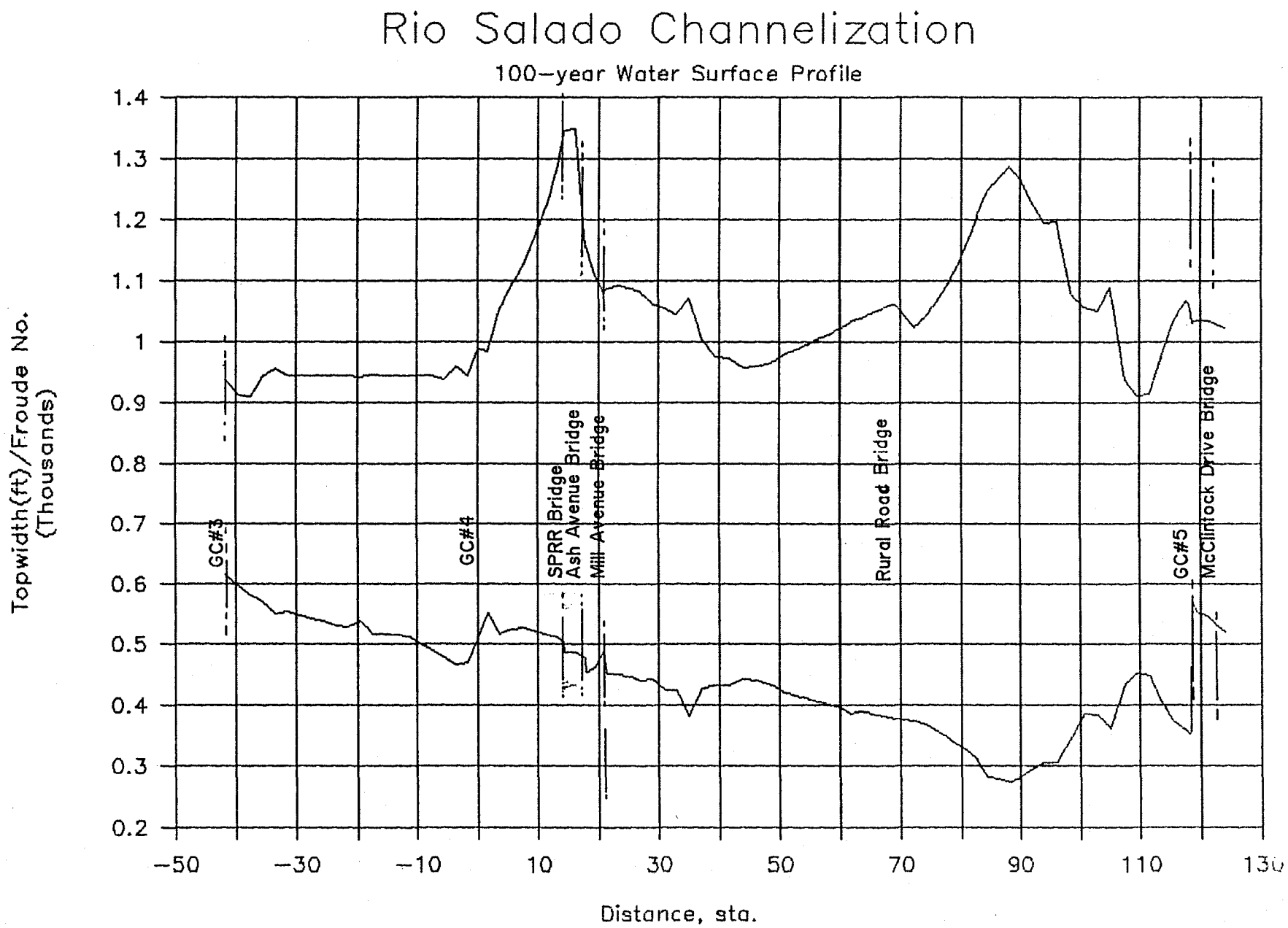

Rio Salado Channelization
100-year Water Surface Profile
Topwidth(ft)/Froude No.
(Thousands)
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
-50
-30
-10
10
30
50
70
90
110
130
Distance, sta.
GC#3
GC#4
SPRR Bridge
Ash Avenue Bridge
Mill Avenue Bridge
Rural Road Bridge
GC#5
McClintock Drive Bridge

Figure 11

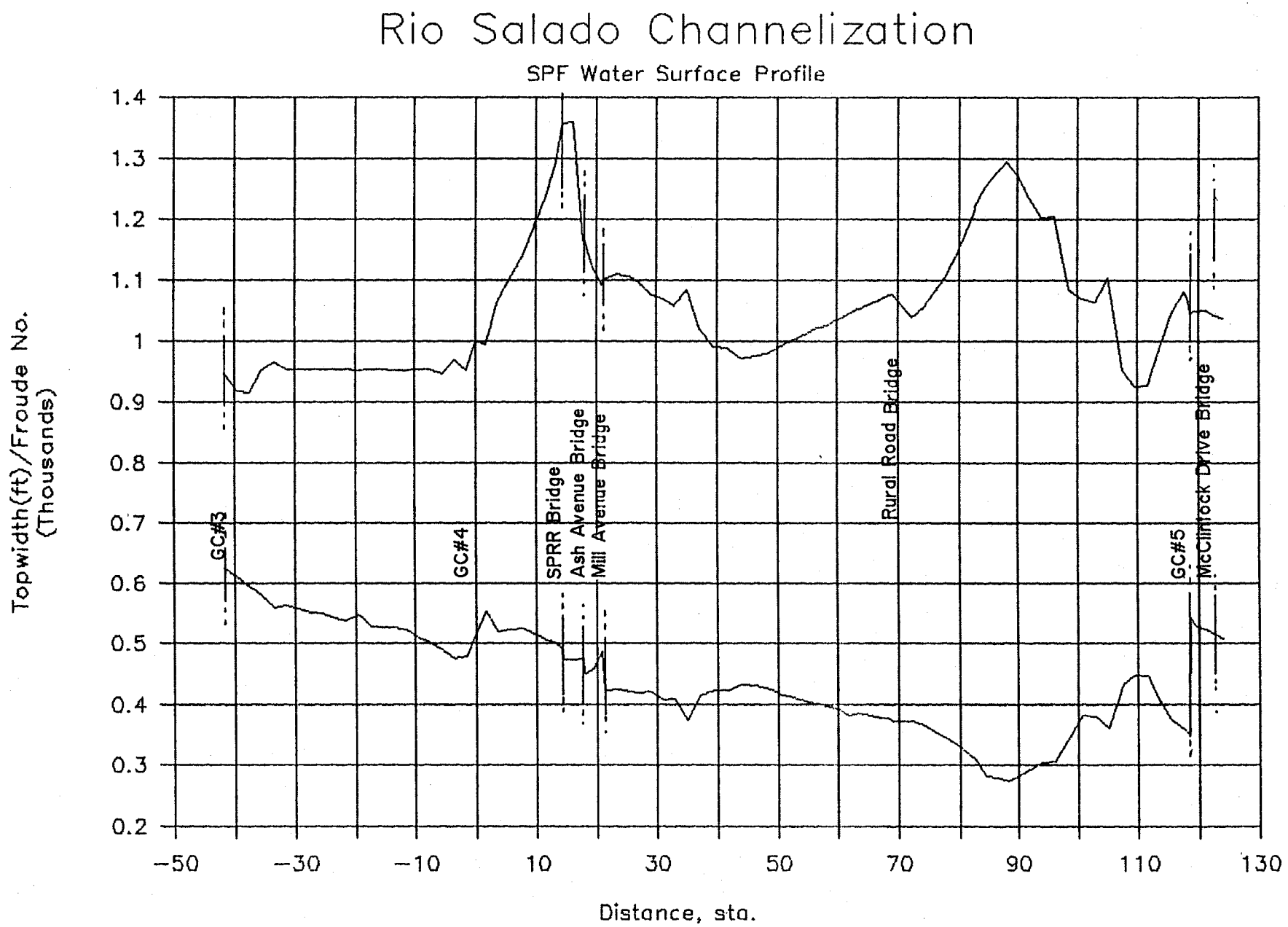

Rio Salado Channelization
SPF Water Surface Profile
Topwidth(ft)/Froude No.
(Thousands)
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
-50
-30
-10
10
30
50
70
90
110
130
Distance, sta.
GC#3
GC#4
SPRR Bridge
Ash Avenue Bridge
Mill Avenue Bridge
Rural Road Bridge
GC#5
McClintock Drive Bridge

Figure 12

5.2 Bridge Hydraulics

There are five existing bridges in the Rio Salado channelization, including the Southern Pacific Railroad bridge (c.1905), the abandoned Ash Avenue bridge (c. 1910), the Mill Avenue bridge (c. 1930), the Rural Road bridge (c. 1983), and the McClintock Drive bridge (c. 1984). Two of the older bridges, at Ash Avenue and Mill Avenue, have arched superstructures which are inundated during a major flood event. In addition, these structures use massive wall-type piers which obstruct a large amount of the waterway area. As a result, these structures cause a large hydraulic loss relative to the other more conventional bridge types.

To adequately analyze the various types of bridge losses in the channelized reach, the procedure provided in the report "Hydraulics of Bridge Waterways" (HDS No. 1, FHWA 1978) was used. Calculations were conducted without the aid of a computer program in order to account for the unusual geometric conditions that are present in the older bridges at various river stages. Table 10 summarizes the bridge losses for bridges located downstream of McClintock Drive. These losses were then entered directly into the HEC-2 program as externally computed bridge loss (record X2, field 6).

Table 10
BRIDGE LOSS COMPUTATIONS

	LOSS/FT			
Discharge	SPRR	Ash	Mill	Rural
40,000	0.11	0.18	0.31	0.06
80,000	0.21	0.33	0.57	0.10
120,000	0.28	0.39	0.81	0.14
160,000	0.26	0.48	1.01	0.19
215,000	0.38	0.52	1.16	0.21
250,000	0.42	0.66	2.05	0.28

5.3 Indian Bend Wash Drop Structure

5.3.1 Existing Geomorphic Setting

The confluence of the Indian Bend Wash and the Salt River is a major geomorphic feature of the project area. The outflow of water and sediments from Indian Bend Wash have significantly influenced the alignment of the Salt River channel and created a large radius channel bend, with a channel bar formation on the north bank downstream of the confluence. The profile of Indian Bend Wash is controlled upstream by roadway culverts at Curry Road. South of Gilbert Road, the Indian Bend Wash profile steepens abruptly as it enters the Salt River. This steepening of the channel profile is due in large part to a lowering of the Salt River profile which occurred during the last series of major floods.

For existing conditions, the base level lowering of the Salt River will induce a lowering of the Indian Bend Wash channel, resulting in significant channel erosion below Gilbert Road. A drop structure is therefore required to provide a stable transition between the profiles of the two rivers.

The estimated height of the drop structure consists of the sum of the following elevation differences:

Base level difference	8.5 feet
General scour	6.0 feet
Channelized profile difference	3.5 feet
Drop height	18.0 feet

5.3.2 Drop Structure Type, Size and Location

The axis of the structure is perpendicular to the banks of Indian Bend Wash in order to produce the shortest possible structure length. The drop structure is located immediately upstream of the Salt River confluence. This location for the drop structure was selected for two reasons. First, it

minimizes the amount of channel excavation and bank protection required on Indian Bend Wash, and second, it avoids a conflict with a major sanitary sewer trunkline (the 54-inch Four Cities Line), which is located along the Gilbert Road alignment. This location of the drop structure places it beneath the bridge planned for the East Papago Freeway crossing Indian Bend Wash.

This reach of Indian Bend Wash is spanned at the same location by east and westbound bridges for the East Papago Freeway. The bridge substructure uses six-foot diameter piers aligned parallel to the stream flow. The relative location of bridge piers and drop structure is showN in Figure 13. Piers that are within about 60 feet of the drop structure will produce a local scour capable of undermining the drop structure foundation. However, piers located within the structure will have a local scour which is limited by the structure. The drop structure itself will not produce any additional scour at the bridge structure (SLA, 1990). However, there were a number of other concerns and design issues related to the proximity of the two structures to each other, including: 1) a shifting or uplift of the stilling basin slab against the bridge piers, and 2) a variation in column length and embedment material which complicated substructure design.

Three drop structure types were considered, including: a baffle block spillway, a multiple drop/stilling basin, and a stepped drop (see Figure 14).

The first structure type, the baffle block structure, was considered for use in conjunction with the bridge structure. It has the advantage of being a relatively short structure; however, given the proposed location and alignment of the structure, it would still overlap the location of the bridge. Hydraulically, the structure has a number of disadvantages. First, because of the high unit discharge for the Standard Project Flood Condition (over 110 cfs/ft), the baffle height and downstream spacing become relatively large compared to the size of the drop (6 feet and 12 feet, respectively).

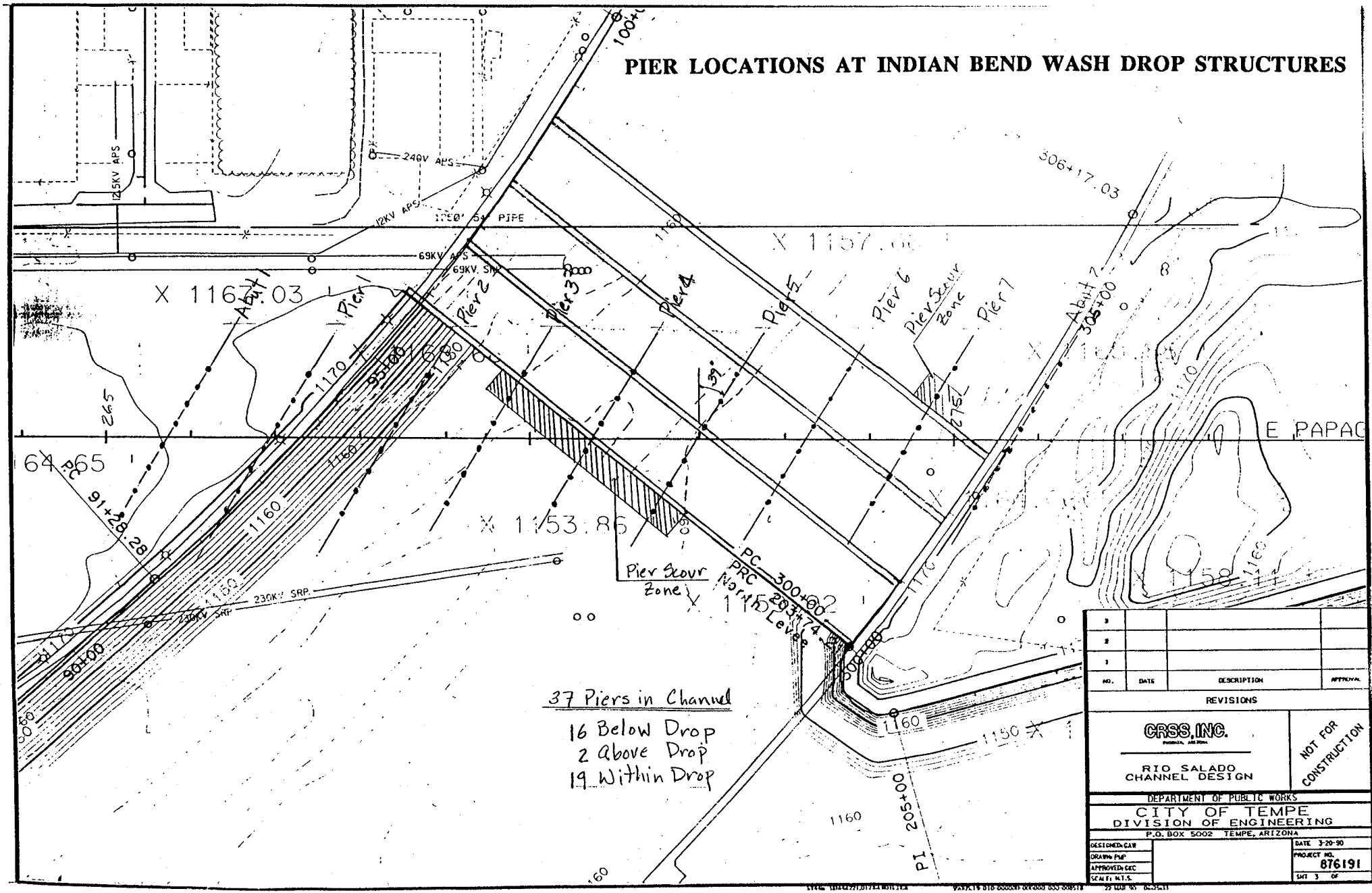
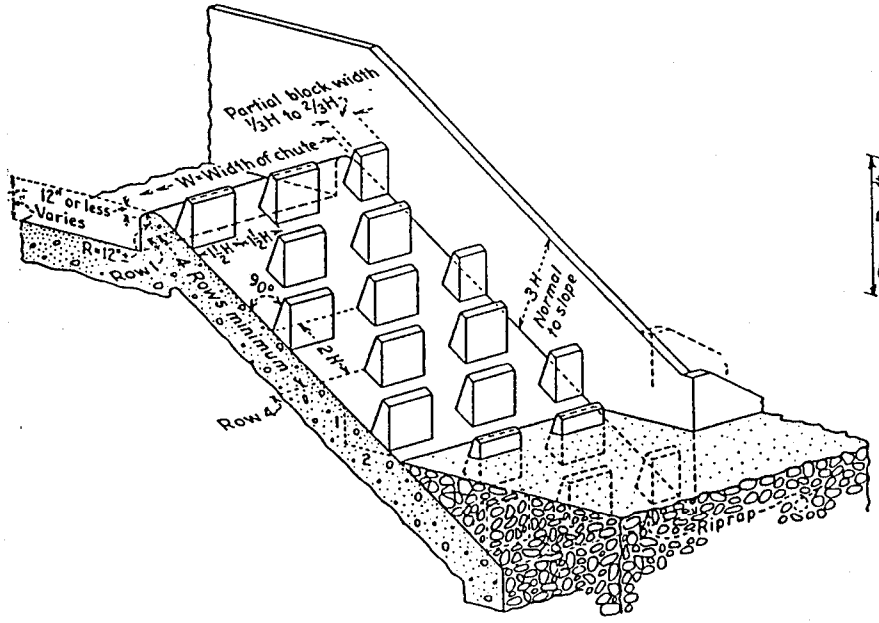
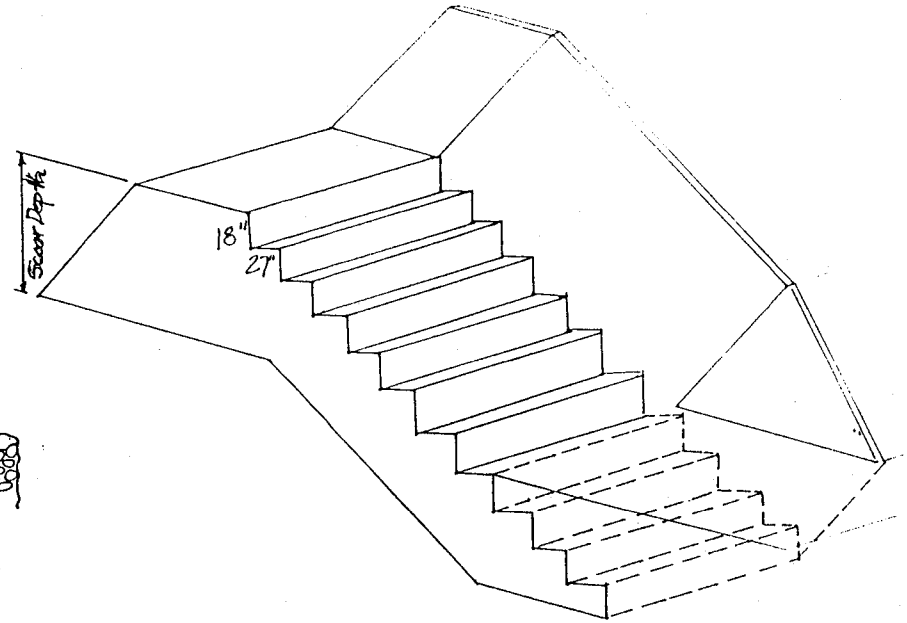

PIER LOCATIONS AT INDIAN BEND WASH DROP STRUCTURES
12.5KV APS
240V APS
12KV APS
1160' 54" PIPE
69KV APS
69KV SRP
X 1162.03
X 1157.08
X 1153.86
X 1158.11
Abut 1
Pier 1
Pier 2
Pier 3
Pier 4
Pier 5
Pier 6
Pier 7
Abut 7
Pier Scour Zone
Pier Scour Zone
PC 91+28.28
PRC 93+00
PC 300+00
PRC 303+74
North Levee
PT 305+00
306+17.03
230KV SRP
E PAPAGO
37 Piers in Channel
16 Below Drop
2 Above Drop
19 Within Drop
REVISIONS
NO. DATE DESCRIPTION APPROVAL
CRSS, INC.
RIO SALADO CHANNEL DESIGN
NOT FOR CONSTRUCTION
DEPARTMENT OF PUBLIC WORKS
CITY OF TEMPE
DIVISION OF ENGINEERING
P.O. BOX 5002 TEMPE, ARIZONA
DATE 3-20-90
PROJECT NO. 876191
SCALE: N.T.S.

Figure 13

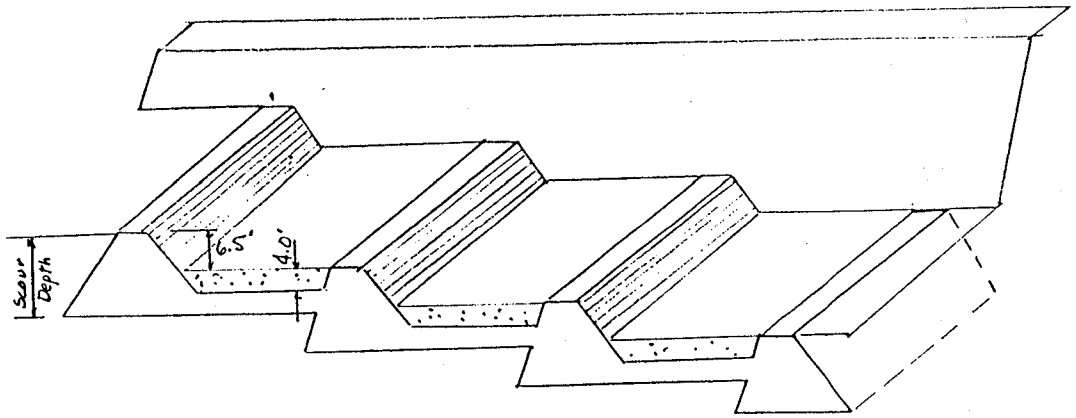
Figure 14 - DROP STRUCTURE TYPES



Baffle Block Spillway



Stepped Spillway
(skimming mode)



Stepped Spillway
(nappe mode)

This means it would be difficult to provide enough rows of baffles to fully control the flow. Second, the unit discharge exceeds the upper limit of 60 cfs/ft recommended for this type of structure (USBR, 1978).

The second structure type, a three-step drop structure, was a series of three 6.5 foot sloping drops with stilling basins at the base of each drop to dissipate energy. The stilling basins were assumed to function as USBR-type IV stilling basins, with a full hydraulic jump forming in the stilling basin. This approach was modified in the preliminary design phase to provide intermediate stilling basins of adequate length to impinge the drop jet but shortened to about 70 percent of the full length. For this size drop, energy dissipation will be roughly equivalent to that of a full stilling basin. The primary disadvantage of this structure type is that the flow velocity remains relatively high in the stilling basin at about 30 fps, which necessitates the use of a higher strength concrete. Roller compacted concrete (f'c=3000 psi) was selected for these conditions.

The third structure considered was a stepped spillway. The structure would consist of thirteen 1.5 foot steps set on an 8:1 (H:V) slope. Flow resistance for a stepped spillway is high due to turbulence created at each step. Energy dissipation is quite good as a result, and the flow velocity remains in an acceptable range. With a maximum velocity of 17.3 fps, cement stabilized alluvium should perform acceptably. One area of potential weakness in this structure is near the brink of each step. This area is typically difficult to compact on soil cement-type structures. To ensure that this portion of the structure remains in place, a reinforced concrete termination of the step was proposed.

Structure Type Two was selected based on hydraulic performance. Neither Type One nor Three was felt to have proven performance characteristics over the range of flows considered for this design. A more detailed analysis was then conducted to completely evaluated the stability of the structure. Computations are provided in Appendix F which address static and dynamic

uplift forces, scour near bridge piers, drop scour, and structure sliding and overturning.

5.4 McClintock Grade Control Structure

The combined affect of long-term and general scour for the profile of the Salt River is estimated to result in 5.0 feet of scour downstream of the McClintock bridge. If this scour were allowed to progress upstream through the bridge, it would threaten several utility lines which cross the Salt River channel at this location. A grade control structure is located at Station 520+50 of the south levee, which will maintain the grade of the channel at the design profile elevation.

A single drop with a downstream stilling basin is the recommended structure type. This structure type is able to operate over a wide range of discharge conditions without a large scour zone forming near the base of the structure. The scour process is completely controlled by the downstream stilling basin and endsill structure. The structure consists of an upstream drop of 5.0 feet, a 66-foot long stilling basin, with an 8.0 endsill.

The hydraulics condition at this structure are controlled by the relative elevation of the tailwater downstream of the endsill and critical depth at the drop. For discharges of less than 120,000 cfs, flow depth at the upper drop will reach critical depth and a hydraulic drop will occur. For discharges greater than 120,000 cfs, the downstream tailwater will drown out the drop at the structure and gradually varied backwater conditions will exist at the structure. Hydraulic conditions in the stilling basin remain relatively moderate and the energy dissipation required is minimal. Froude numbers in the stilling basin never exceed 1.0. The primary purpose of the stilling basin is to support the jet formed by the drop and provide an adequate transition distance. This transition distance was assumed equal to the maximum depth of flow.

6.0 SCOUR ANALYSIS

This section summarizes the scour calculations that have been made in order to get the foundation depths for various channel design elements. Consideration has been given to both existing conditions in the Salt River as well as the possible effects of future activities. Scour analysis at specific locations in the channel is also conducted. Finally, an analysis of bank protection stability is given.

6.1 River Conditions

The Salt River has undergone a rapid and profound change in channel form within the past decade. Major changes to the channel have occurred both upstream and downstream of the Tempe reach of the Salt River. Design criteria for the Rio Salado channelization dictate that improvements be made to the Salt River floodway so that stable channel conditions prevail in the future.

6.1.1 Upstream and Downstream Development

The single activity most affecting channel conditions on the Salt River is sand and gravel mining. In the past 30 years, since the mid-1960s, the Salt River channel in Tempe and immediately downstream in Phoenix has degraded on the order of 10 to 15 feet. Below Priest Drive to 40th Street, the Salt River has degraded an average of 12 feet. During this period, this reach of river was a productive mining area. Calculations indicate (SLA, 1987) that the production volume of sand and gravel nearly equals the volume of degradation in the river. However, after the floods of the later 1970s, gravel mining ceased operation in the reach from 24th Street to McClintock Drive.

In the past decade, mining has progressed upstream of McClintock Drive and is most heavily concentrated in the vicinity of Alma School Road. Downstream of Tempe, the City of Phoenix has completed channelization of the Salt River adjacent to Sky Harbor Airport in 1983. In 1981, ADOT completed a channel stabilization project at the I-10 crossing of the Salt

River that included a grade-control structure immediately downstream of the bridge. Currently, the Salt River is channelized from I-10 to 44th Street.

Within Tempe, channelization of the Salt River is being continued by ADOT for the reach from 44th Street to the Southern Pacific Railroad bridge in conjunction with the construction of the East Papago Freeway. This phase of channelization will be completed by the end of 1990. Upstream of Tempe, ADOT plans for construction of the Red Mountain Traffic Interchange, which will require encroachment of the south bank of the Salt River for about one mile in either direction from Price Road. A major bridge connecting the East Papago Freeway to this interchange will be located in the Salt River floodway just east of McClintock Drive. Further to the east, upstream of the Outer Loop Highway, mining operations on Indian lands are in production.

As can be seen from this discussion, the reach of the Salt River in Tempe, from the Southern Pacific Railroad bridge to McClintock, is in the middle of extensive modifications to the Salt River channel. Excluding the reach in Tempe, the Salt River will effectively be channelized from 24th Street to Dobson Road by the mid-1990s.

6.1.2 River Variables

River response can be assessed in general qualitative sense by reviewing the variables identified by Lane (1955). These include water and sediment discharge, Qs and Qw, respectively, the sediment size, Ds, and the channel energy slope Se. For equilibrium, Lane stated the following relationship:

$$Qs\ Ds \sim Qw\ Se$$

For the existing condition of the Salt River, both upstream and downstream of the Tempe reach, the following qualitative assessment can be made:

Qs: (-) Due to large dams on the Salt River watershed and intense sand and gravel mining in upstream reaches, the sediment supply to the Tempe reach has been greatly reduced.

Qw: (+) Although dams reduce the magnitude of major rare flood events on the Salt River, the magnitude of more frequent events has actually increased. The narrowing of the floodway due to channelization has likewise increased the amount of flood flow carried in the main channel.

Ds: (0) While armoring can locally increase the size of bed material, it is not anticipated that a significant change will occur in the surface layer sediments of the Salt River.

Se: (--) In response to the changes in other river variables, the energy gradient of the Salt River will need to decrease substantially. This could be accomplished by general scouring and transport of the channel bed sediments, or the construction of a milder channel profile and associated grade-control structures.

For the Salt River to be in equilibrium, the energy gradient of the channel would need to adjust to flatter grade that matches the reduced sediment supply and the increased water discharge. Channel bed armoring could moderate the effect; however, large floods can easily transport even the larges sediment sizes.

6.2 Long-Term Equilibrium Scour Analysis

6.2.1 Anticipated Salt River Profile

The natural profile of the Salt River channel had a grade approaching 0.2 percent. In the reach from the Souther Pacific Railroad bridge to Alma School Road, the average channel profile grade prior to mining was 0.166 percent. The existing profile of the Salt River in this reach is shown in Figure 15, prepared by Simon, Li & Associates for ADOT (1989). A simple profile no longer exists in the reach above McClintock Drive, but a rough approximation is that the river has been mined to half the previous profile grade. The Tempe reach of the Salt River from Grade Control No. 4 to McClintock Drive has a planned grade of 0.136%, which is intermediate to the mined profile east of McClintock Drive and the existing channel grade.

The long-term effects of mining are apparent at Alma School Road where the reduced profile grade of the Salt River has lowered the channel invert beneath the bridge. There is no grade control in the vicinity of the Alma School Road bridge and as a result, the foundation of the bridge is threatened by the profile lowering. It is unlikely that the Salt River will resume its natural profile. Nearly 20 million cubic yards of sand gravel has been mined from the channel bed in the McClintock to Alma School reach and intensive mining continues. It is likely that the average depth of mining will extend to 40 feet below the original profile. This is an additional sediment deficit of about 15 million cubic yards.

6.2.2 Equilibrium Conditions

For a river system to be in equilibrium, the bed of the channel should neither aggrade nor degrade over the long term. The principle of sediment continuity dictates that under conditions of equilibrium, the sediment transport rate into a river reach must equal the transport rate out of the reach.

INVERT PROFILE COMPARISONS

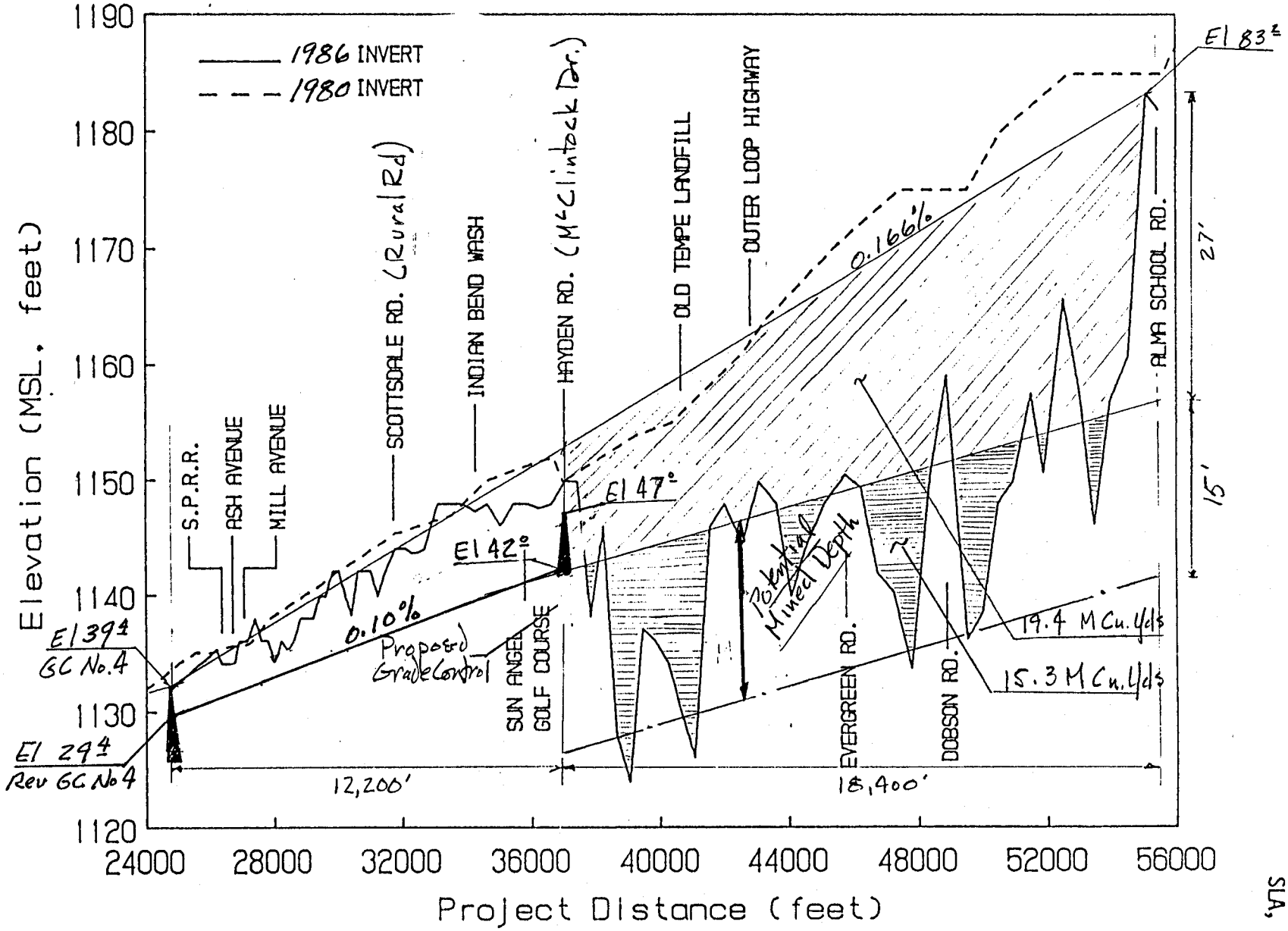


Figure 15

Table 11 shows the variation in sediment transport rates by river reach for existing and proposed conditions for an assumed dominant discharge of 84,000 cfs. The existing sediment transport rate for the Salt River upstream of Grade Control No. 4 averages 210,300 tons/day, compared to 232,100 tons/day for the Rio Salado channelization. In both cases, the supply of sediment from upstream transport into the reach is essentially zero due to upstream sand and gravel mining. Because of this deficit, the supply of sediment will be provided entirely from the channel bed. Since not all sediment sizes can be transported, an armor layer will eventually form that will curtail the supply of sediment. Under these condition, the transport capacity of the channel for the dominant discharge condition will be zero and equilibrium will exist based solely on channel armoring.

The supply of sediment available equals the product of depth to armoring, reach length, and width. The existing sediment supply totals 2.15 million tons, compared to 1.55 million tons for the Rio Salado channelization. The supply of sediment is substantially less, due to a reduction in channel width and a decrease in armor depths. The ratio of sediment supply to transport capacity ranges from 1.9 to 3.8 for the existing condition and 0.8 to 1.3 for channelized conditions. This indicated that channel armoring will occur roughly two to three times faster for channelized conditions compared to existing conditions.

From a water quality standpoint, the concentration of suspended sediments in the waters of the Salt River can be expected to average 930 ppm for the existing condition and 1030 ppm for channelized conditions. Given the accuracy of the available sediment transport equations, the ten percent difference in suspended sediment concentration is, for all practical purposes, negligible. Over the life of the project, the Rio Salado channelization will reduce the supply of sediment to downstream reaches of the Salt River by 1.2 million tons. This should benefit lower reaches of the Salt River that are essentially channelized and would be adversely effected by sediment deposition.

Table 11

COMPARISON OF EQUILIBRIUM SEDIMENT TRANSPORT

Dominant Discharge, Q = 84,000 cfs

Reach	Reach Length (ft)	Velocity Max/Min/Avg (fps)	Max Depth (ft)	Avg Width (ft)	Max Shear (lb/ft^2)	Armor Size (mm)	Coarse Fraction (%)	Sediment Transport (tons/day)	Depth to Armor (ft)	Sediment Supply (tons)
Existing Conditions:										
GC3-GC4	4018	9.6 7.7 8.6	12.5	892	1.51	95	21	405,900	3.5	627,200
GC4-Mill	2224	8.4 6.7 7.8	17.6	1185	1.59	100	20	272,600	3.9	513,900
Mill-Rural	4957	7.2 5.1 6.2	17.4	1381	1.12	71	28	164,300	1.8	616,100
Rural-IBW	2569	6.5 5.7 6.0	14.2	1747	0.99	62	30	141,500	1.4	314,200
IBW-McClintock	2786	8.2 5.3 6.4	17.6	1469	1.47	93	22	305,600	3.3	675,300
Proposed Conditions:										
GC3-GC4	4018	9.6 7.7 8.6	12.5	892	1.51	95	21	405,900	3.5	627,200
GC4-Mill	2224	8.3 7.2 7.8	13.5	993	1.06	67	29	235,600	1.6	176,700
Mill-Rural	4957	8.3 6.3 7.3	14.5	927	0.90	57	31	215,270	1.2	275,700
Rural-IBW	2569	7.7 5.8 6.6	14.0	1038	0.90	57	31	176,200	1.2	160,000
IBW-McClintock	2786	8.8 7.5 8.0	11.4	967	1.24	78	26	310,800	2.3	309,800

Armor Size: Da = Max shear/(1.65 x 62.4 x 0.047)*304.8

Sediment Transport: $Gs = 45.7\ V^{4.32} h^{-0.30} W$;(V, velocity; h, depth; W, width)

Depth to Armor: ya = 3*Da*(1/Pc-1)/(304.8 mm/ft)

Sediment Supply: Vs = Da x Lr x W*(0.05 flows/ft^3); (Lr, reach length)

6.2.3 Potential Impacts of Gravel Mining

As was presented at the beginning of this section, sand and gravel mining is probably the dominant morphologic influence on the upper reaches of the Salt River. If mining were to cease today, and the Salt River channel from McClintock Drive to Alma School Road were regraded to the mined depth, it would be many decades before equilibrium conditions for sediment transport could be established in the Tempe reach of the Salt River. Mining in the reach above Tempe will continue to reduce the supply of sediment to the Salt River in Tempe.

Because it is expected that mining will continue, the expected degradation in the Tempe reach must be controlled by providing grade stabilization for the Salt River channel. A grade-control structure is planned in the river immediately below the McClintock Drive bridge. This structure will maintain , to the extent possible, the proposed channel profile upstream of the bridge and provide protection of the existing bridge foundation and underground utilities crossing the channel above the bridge. However, the shallow burial depth of the Mesa gravity sewer line makes it vulnerable to continued channel scour.

6.3 Maximum Bed Scour

The principal of tractive force was applied channel section by channel section to estimate the maximum scour in the channel bed.

Figures 16 and 17 show the profile of tractive force along channelization for the 100-year and SPF conditions, respectively. More detailed shear distributions for the north and south levee banks are provided in Appendix I.

These shear stresses include factors that consider specific conditions at each channel section, such as the rate of channel curvature, the channel side slope, the distribution of shear on the channel bed, and impingement on a channel bank. The

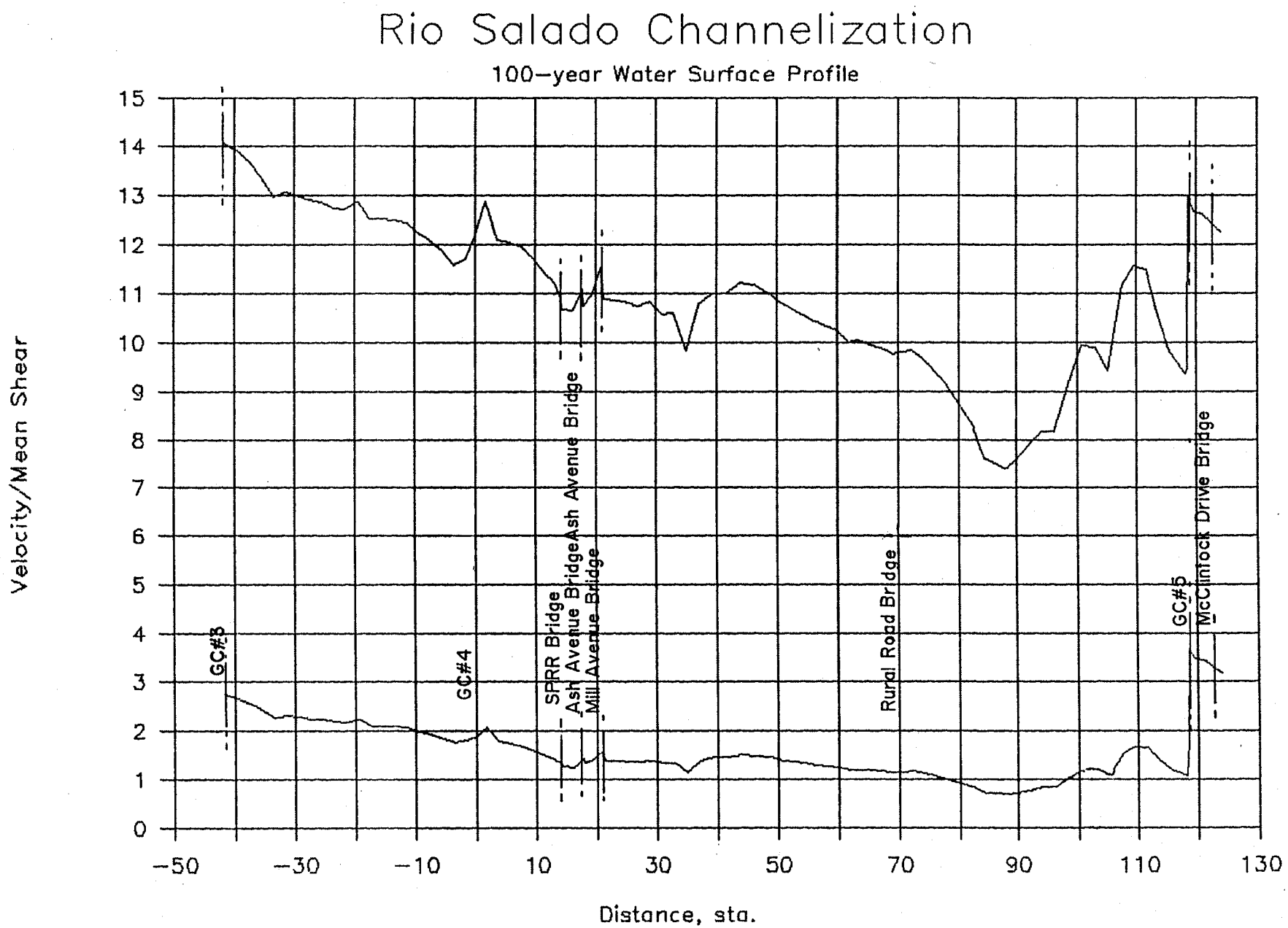

Rio Salado Channelization
100-year Water Surface Profile
Velocity/Mean Shear
Distance, sta.
GC#3
GC#4
SPRR Bridge
Ash Avenue Bridge
Ash Avenue Bridge
Mill Avenue Bridge
Rural Road Bridge
GC#5
McClintock Drive Bridge
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-50
-30
-10
10
30
50
70
90
110
130

Figure 16

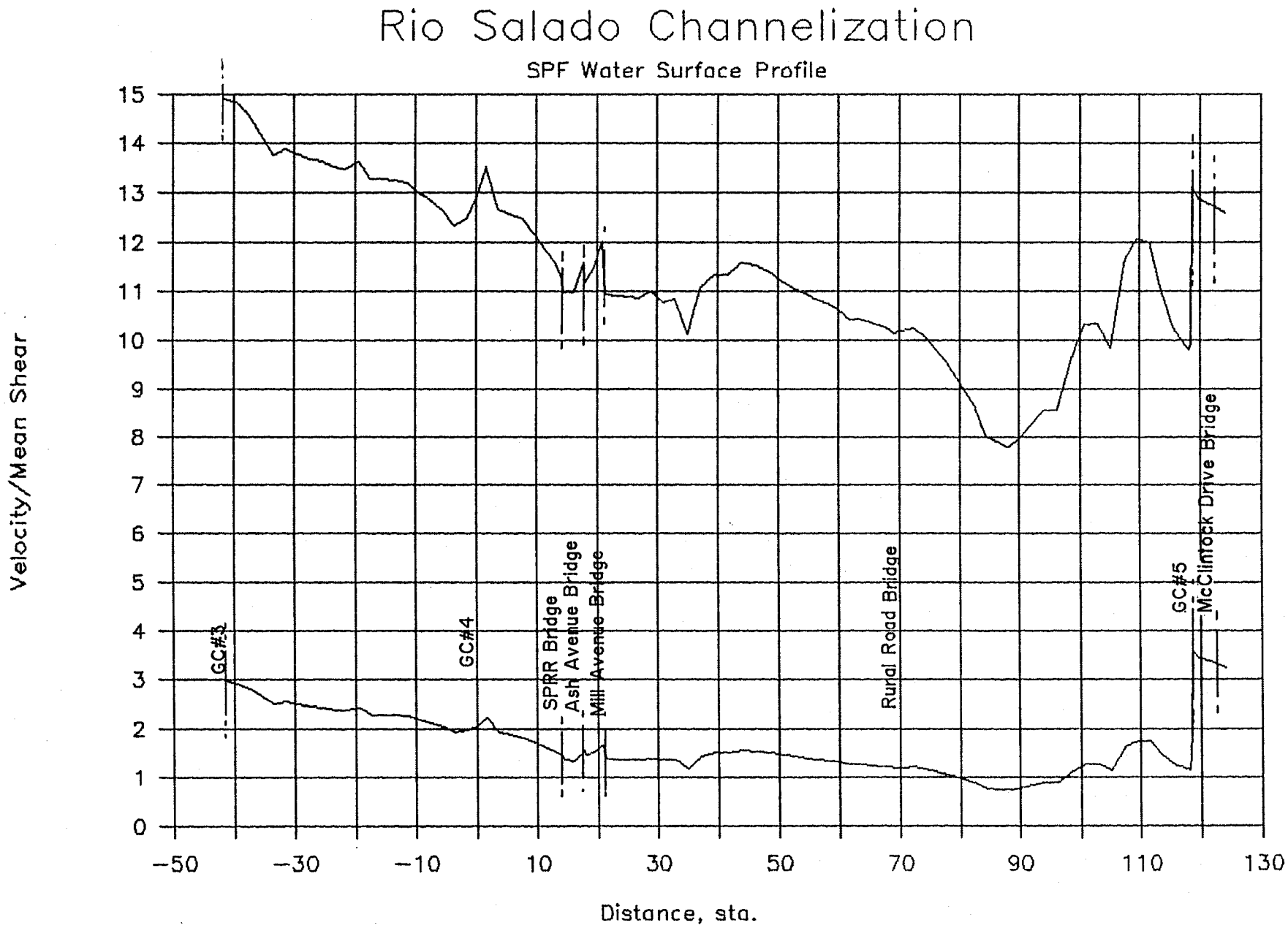

Rio Salado Channelization
SPF Water Surface Profile
Velocity/Mean Shear
Distance, sta.
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
-50
-30
-10
10
30
50
70
90
110
130
GC#3
GC#4
SPRR Bridge
Ash Avenue Bridge
Mill Avenue Bridge
Rural Road Bridge
GC#5
McClintock Drive Bridge

Figure 17

maximum bed scour calculation is the basis for establishing the profile of bank protection toedown.

Applying the tractive force to the channel bed results in a scour of sufficient depth to form an armor layer composed of sediment sizes whose critical shear stress equals the applied tractive force. Appendix I provides calculations of the channel bed scour for each channel section. Scour depths are determined based on armor layer thickness equal to three times the armoring size.

6.4 Bed Form Analysis

For the discharges of 215,000 and 250,000 cfs, hydraulic conditions on the Tempe reach of the Salt River are in a subcritical, lower regime mode. The larges bed form in lower regime flow is dunes. Calculations of the amplitude of the dune bed form height are provided in Appendix I.
The results obtained using Yalin's method were used since this equation predicted a greater bed form height. It is worth noting that the ratio of average boundary shear stress to critical shear stress for all reaches except the ADOT channelization is less than the critical value of 17.6 that Yalin indicated was the minimum required to initiate dunes. Following this argument, the bed of the Salt River will most likely remain in a plane-bed form without dunes during most flows.

One-half the dune height has been added to the scour depths to estimate the total bed scour depths.

6.5 Local Scour Analysis

Local scour in a channel bed results from an abrupt acceleration of the flow. In the Tempe reach of the Salt River, there are three features that can cause significant local scour. These features are the existing bridge piers, the planned drop structure on Indian Bend Wash, and the grade control structure below McClintock Drive. There are five existing bridges in the Tempe reach, with bridge piers of varying sizes and types. The Ash Avenue and Mill Avenue bridges are founded on bed rock that outcrops in this subreach. The Southern Pacific Railroad bridge has eight of eleven piers located on bedrock, and three piers near the south abutment on driven wooden piles in alluvial material. The Rural Road and McClintock Drive bridges are located in alluvial material. Local scour at bridge piers founded on bed rock will not affect the stability of the bridge. However, piers founded in alluvial material are vulnerable and need careful assessment. Grade control and drop structures can create a very large potential for scour. These structures have therefore been assigned to dissipate the excess energy developed by the change in grade at the structure.

6.5.1 Bridge Piers

A summary of the hydraulic conditions in the approach reach to each bridge in the Tempe reach are summarized in Table 12.

Table 12
APPROACH FLOW CONDITIONS
Q = 215,000 cfs

Location	Flow Depth (ft)	Vel (fps)	Pier Size Shape	Attack Angle
SPRR	22.2	9.4	8.0 circ	0°
Rural	24.7	9.6	6.0 circ	0°
McClintock	20.9	10.5	6.0 circ	0°

From the large number of pier scour equations, four were selected. Two clear water scour equations were used; one developed at Colorado State University (CSU) and the other developed by Laursen. Two live bed scour equations that consider the size of the bed material directly were used; one developed by Jain & Fisher and the other by Froehlich. Results of this analysis are shown in Table 13 for SPRR, Rural Road and McClintock Drive.

Table 13
ESTIMATED PIER SCOUR
Q = 215,000 cfs

Location	CSU	Laursen	Froehlich	Jain & Fisher
SPRR Pier 3	15.4	14.7	13.3	16.4
Rural	12.7	13.4	10.6	14.3
McClintock	12.9	12.3	10.4	14.1

All four scour calculations are in fairly close agreement, particularly if half the dune height of 4.3 feet is added to the Froehlich equation. If a debris accumulation of up to ten feet is considered at these locations, then scour depths increase about 20 percent at the SPRR bridge and about 40 percent at Rural and McClintock. Since this is within the range of the factor of safety used for foundation, no explicit accounting of debris accumulation has been made.

6.5.2 Grade Control Structures

The potential for scour at a grade control structure is quite large. Scour depths can easily exceed reasonable foundation depth for this type of structure. In a hydraulic drop, excess energy is produced profile - a jet forms that impinges on the channel bed, creating a plunge pool. If the jet can be supported and redirected, then scour can be significantly reduced. An energy dissipater structure accomplished this redirection, and this idea

has been incorporated into the design of the grade control structures for the Rio Salado project. By dissipating the excess energy before it leaves the structure, the foundation depths for the structure can be greatly reduced. Also, a more reliable estimate of the hydraulic performance can be made. The scour equations currently available for estimating scour below a sill structure, provide significantly different estimate of scour depth. For example, if the equation developed by Laursen is used (ADOT, 1983) scour depths can be expected to be extremely deep (over 100 feet), while equations developed by Bormann (CSU, 1988) indicated scour depths in the range of 20 to 25 feet. This raises important questions on the reliability of the available scour prediction equations that cannot be adequately assessed as part of this design. The method of energy dissipation is preferred to formation of a plunge pool because it will result in lower foundation depths and more reliable hydraulic performance.

The McClintock grade-control structure provides for a potential 5.0 feet of bed profile lowering at this location. A 20-foot stilling basin is provided below the drop to support the jet as it expands in the downstream direction. A four-foot end sill provides the means of producing increased pressure in the stilling basin and deflecting the jet away from the bed immediately downstream of the structure. The end sill is placed below the general scour depth and is toed-down to the maximum scour depth.

The Indian Bend Wash drop structure is a series of three drops of 6.5 feet each, for a total of 19.5 feet. There are four stilling basins, each 40 feet in length, ending with a 4-foot end sill. The last end sill will be toed-down to match the adjacent bank protection.

6.6 Bank Protection Stability Analysis

Two types of bank protection are used to provide a complete system for stabilizing the channel banks. The foundation of the bank protection is cement stabilized alluvium with a horizontal thickness of eight feet. The protection extends to on-half the bank height and is toed-down to below the

maximum estimated scour. This massive protection will prevent any lateral migration of the channel.

The upper portion of the bank is stabilized with rock riprap. The rock size has been determined based on a factor of safety approach using the maximum tractive force that can occur in a subreach of the river. The use of rounded stones was assumed in the riprap analysis. To account for this condition, the angle of repose was reduced to a minimum value and an additional riprap layer thickness was provided. Table 14 provides a summary of riprap sizes by levee location along the channel.

Table 14
RECOMMENDED RIPRAP SIZES
Q = 250,000

Location	D50 Size, Inches North Bank	South Bank
GC No. 4 - Mill	12	9
Mill - Rural	12	9
Rural - IBW	9	12
West Bank IBW	12	-
IBW - McClintock	12	6

7.0 DESIGN REQUIREMENTS

7.1 Top of Levee Profile

The top of levee profile was set for the north and south levees based on the height of the water surface adjacent to each levee. Both one- and two-dimensional hydraulic analyses were used to provide the water surface for the design discharge of 215,000 cfs. Four feet of freeboard was added to this surface to provide for a surcharge flow in excess of the design discharge. Table 15 summarizes the profile grade for each levee.

Table 15
TOP OF LEVEE PROFILES

Station	Water Surface Elevation Q=215,000 cfs	Levee Elevation at Control Line	Top of Levee
South Levee:			
400+00	1150.57	1147.40	1154.60*
424+00	1154.42	1151.50	1159.20*
426+00	1155.72	1153.50	1159.69*
431+00	1156.27	1153.95	1160.95*
432+00	1165.34	1151.20	1158.20
505+00	1164.33	1158.10	1164.40
507+50	1164.73	1158.10	1164.86
510+00	1165.00	1169.30	1169.30
524+00	1167.63	1171.80	1171.80

(*On South Overbank Levee)

South Overbank Levee:			
600+00	1150.57	1154.60	1154.60
616+52.76	1153.48	1157.50	1157.50
700+00	1153.76	1157.76	1157.76
702+00	1153.76	1157.96	1157.96
714+10.62	1156.27	1160.95	1160.95
North Levee:			
0+00	1150.57	1154.60	1154.60
16+00	1153.72	1158.60	1158.60
20+00	1156.66	1160.80	1160.80
70+00	1161.59	1166.00	1166.00
84+00	1163.43	1168.00	1168.00
96+00	1163.92	1169.32	1169.32
101+00	1164.00	1170.00	1170.00
300+00	1164.00	1169.30	1169.30
307+00	1164.00	1170.00	1170.00
203+74.2	1164.00	1169.33	1169.33
205+00	1164.05	1169.46	1169.46
227+92.01	1167.43	1171.80	1171.80

7.2 Toe of Levee Profile

The toe of levee profile was set for the north and south levees based on the conditions associated with a discharge of 250,000 cfs. The toe-down depths include a 30 percent factor of safety that provides increased protection against scour. Table 16 summarizes the foundation profile for each levee.

Table 16
LEVEE PROTECTION TOE-DOWN PROFILE

Station	Invert Elevation	Depth to Armoring	Bed Form	Total Scour	Toe-Down Depth
South Levee:					
400+00	1129.40	4.7	1.8	2.0	8.5
424+00	1132.33	6.0	1.9	2.4	10.3
472+00	1138.19	7.2	1.9	2.7	11.8
500+00	1142.70	7.2	1.9	2.7	11.8
524+00	1146.56	7.2	1.9	2.7	11.8
North Levee:					
0+00	1129.40	4.7	1.8	2.0	8.5
22+00	1132.14	6.0	1.9	2.4	10.3
70+00	1138.14	7.2	1.9	2.7	11.8
95+74.58	1142.30	7.2	1.9	2.7	11.8
203+74.21	1142.30	7.2	1.9	2.7	11.8
227+82.01	1146.36	7.2	1.9	2.7	11.8

8.0 REFERENCE MATERIAL

USACE, Los Angeles District, "Study for Flood Control Alternatives to Cliff Dam", October 1988.

Simons, Li & Associates, "Concept Hydraulic Design, Salt River Channelization, East Papago Freeway", May 1988

Simons, Li & Associates, "Rio Salado Channel Improvement, Mill Avenue to Hayden Road", August 1988.

CRSS, Inc., "Channel Improvement Study, Mill Avenue Reach", October 1989.

Thomas-Hartig & Associates, "Geotechnical Services, Rio Salado Improvement, Near Farmer Avenue to McClintock Drive, Tempe, Arizona", February 1990.

Simons, Li & Associates, "Preliminary Hydraulic Analysis of the Salt River for the East Papago Freeway and Red Mountain Interchange", September 1989.

Simons, Li & Associates, "Interim Summary Report: Hydraulic Investigation of the Salt River for the East Papago Freeway and Red Mountain Interchange", September 1990.

John Carollo Engineers, "Final Drainage Design, East Papago Freeway, Priest Drive to Indian Bend Wash, Design Segment 5", Project No RAM-600-5-308, 202 MA 0861 01D, January 1990.

Simons, Li & Associates, "Draft Report - Hydraulic and Scour Analysis for the East Papago Crossing of the Indian Bend Wash", March 1990.

Gannett Fleming, "Final I Drainage Report, East Papago Freeway - Section 6", Project No. RAM-600-5-301D, 202L-MA-OH-0855-01D, May 1990.

CRSS, Inc., "Tempe Rio Salado Park, Project Database User Documentation", September 1989.

APPENDIX A

INPUT DATA FOR TWO-DIMENSIONAL MODEL

FILE A1.DAT
10/27/89 12:1

Grade Control No 4
to Rural Road

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SWMS              1          :
RID SALADO * MILL AVE. BRDG * A1 ALIGNMENT * SEPT 20.1989
   0   3   1   0   0   1   0  -1
PLOT
SALT RIVER MILL AVE. BRIDGE REACH (A1 ALIGNMENT)
   0   0
      .100      .070      .105      .105     5.000
  290000.0  283500.0      .000      .000     200.0     200.0      .000
ELEM
   10  334  991   36   64   67   63    0    0    0    1    0
   11  334  985  336  992  337  997   36  991    0    1    0
   12    5   62  334   63   67   66    0    0    0    1    0
   13   67   64   36   65   37   68    0    0    0    1    0
   14    5   66   67   68   37   71   70   69    0    0    0
   15    6   72    5   69   70   73    0    0    0    1    0
   16   70   71   37   75   38   74    0    0    0    1    0
   17    6   73   70   76   82   78    0    0    0    1    0
   18   82   76   70   74   38   79    0    0    0    1    0
   19    7   77    6   78   82   81    0    0    0    1    0
   20   82   79   38   80   39   83    0    0    0    1    0
   21    7   81   82   83   39   86   85   84    0    0    0
   22    8   87    7   84   85   88    0    0    0    1    0
   23   85   86   39   90   40   89    0    0    0    1    0
   24    8   88   85   91   97   93    0    0    0    1    0
   25   97   91   85   89   40   94    0    0    0    1    0
   26    9   92    8   93   97   96    0    0    0    1    0
   27   97   94   40   95   41   98    0    0    0    1    0
   28    9   96   97   98   41  101  100   99    0    0    0
   29   10  102    9   99  100  103    0    0    0    1    0
   30  100  101   41  105   42  104    0    0    0    1    0
   31   10  103  100  106  112  108    0    0    0    1    0
   32  112  106  100  104   42  109    0    0    0    1    0
   33   11  107   10  108  112  111    0    0    0    1    0
   34  112  109   42  110   43  113    0    0    0    1    0
   35   11  111  112  113   43  116  115  114    0    0    0
   36   12  117   11  114  115  118    0    0    0    1    0
   37  115  116   43  120   44  119    0    0    0    1    0
   38   12  118  115  121  127  122    0    0    0    1    0
   39  127  121  115  119   44  123    0    0    0    1    0
   40   13  125   12  122  127  126    0    0    0    1    0
   41  127  123   44  124   45  128    0    0    0    1    0
   42   13  126  127  128   45  131  130  129    0    0    0
   43   14  132   13  129  130  133    0    0    0    1    0
   44  130  131   45  135   46  134    0    0    0    1    0
   45   14  133  130  136  142  137    0    0    0    1    0
   46  142  136  130  134   46  138    0    0    0    1    0
   47   15  139   14  137  142  141    0    0    0    1    0
   48  142  138   46  140   47  143    0    0    0    1    0
   49   15  141  142  143   47  146  145  144    0    0    0
   50  323  147   15  144  145  148    0    0    0    1    0
   51  145  146   47  150  333  149    0    0    0    1    0
   52  323  148  145  149  333  989    0    0    0    1    0
   54  322  983  323  989  333  995  332  988    0    1    0
   55  321  982  322  988  332  994  331  987    0    1    0
   56  320  981  321  987  331  993  330  986    0    1    0
  101  200  700  201  711  211  722  210  710    0    0    0
  102  201  701  202  712  212  723  211  711    0    1    0
  103  202  702  203  713  213  724  212  712    0    1    0
  104  203  703  204  714  214  725  213  713    0    1    0
  105  204  704  205  715  215  726  214  714    0    1    0
```

106	205	705	206	716	216	727	215	715	0	1	0
107	206	706	207	717	217	728	216	716	0	1	0
108	207	707	208	718	218	729	217	717	0	0	0
111	210	722	211	733	221	743	220	732	0	1	0
112	211	723	212	734	222	744	221	733	0	1	0
113	212	724	213	735	223	745	222	734	0	1	0
114	213	725	214	736	224	746	223	735	0	1	0
115	214	726	215	737	225	747	224	736	0	1	0
116	215	727	216	738	226	748	225	737	0	1	0
117	216	728	217	739	227	749	226	738	0	1	0
118	217	729	218	740	228	750	227	739	0	1	0
121	220	743	221	754	231	764	230	753	0	1	0
122	221	744	222	755	232	765	231	754	0	1	0
123	222	745	223	756	233	766	232	755	0	1	0
124	223	746	224	757	234	767	233	756	0	1	0
125	224	747	225	758	235	768	234	757	0	1	0
126	225	748	226	759	236	769	235	758	0	1	0
127	226	749	227	760	237	770	236	759	0	1	0
128	227	750	228	761	238	771	237	760	0	1	0
131	230	764	231	775	241	785	240	774	0	1	0
132	231	765	232	776	242	786	241	775	0	1	0
133	232	766	233	777	243	787	242	776	0	1	0
134	233	767	234	778	244	788	243	777	0	1	0
135	234	768	235	779	245	789	244	778	0	1	0
136	235	769	236	780	246	790	245	779	0	1	0
137	236	770	237	781	247	791	246	780	0	1	0
138	237	771	238	782	248	792	247	781	0	1	0
141	240	785	241	796	251	806	250	795	0	1	0
142	241	786	242	797	252	807	251	796	0	1	0
143	242	787	243	798	253	808	252	797	0	1	0
144	243	788	244	799	254	809	253	798	0	1	0
145	244	789	245	800	255	810	254	799	0	1	0
146	245	790	246	801	256	811	255	800	0	1	0
147	246	791	247	802	257	812	256	801	0	1	0
148	247	792	248	803	258	813	257	802	0	1	0
151	250	806	251	817	261	827	260	816	0	1	0
152	251	807	252	818	262	828	261	817	0	1	0
153	252	808	253	819	263	829	262	818	0	1	0
154	253	809	254	820	264	830	263	819	0	1	0
155	254	810	255	821	265	831	264	820	0	1	0
156	255	811	256	822	266	832	265	821	0	1	0
157	256	812	257	823	267	833	266	822	0	1	0
158	257	813	258	824	268	834	267	823	0	1	0
161	260	827	261	838	271	848	270	837	0	1	0
162	261	828	262	839	272	849	271	838	0	1	0
163	262	829	263	840	273	850	272	839	0	1	0
164	263	830	264	841	274	851	273	840	0	1	0
165	264	831	265	842	275	852	274	841	0	1	0
166	265	832	266	843	276	853	275	842	0	1	0
167	266	833	267	844	277	854	276	843	0	1	0
168	267	834	268	845	278	855	277	844	0	1	0
171	270	848	271	859	281	869	280	858	0	2	0
172	271	849	272	860	282	870	281	859	0	2	0
173	272	850	273	861	283	871	282	860	0	2	0
174	273	851	274	862	284	872	283	861	0	2	0
175	274	852	275	863	285	873	284	862	0	2	0
176	275	853	276	864	286	874	285	863	0	2	0
177	276	854	277	865	287	875	286	864	0	2	0
178	277	855	278	866	288	876	287	865	0	2	0
181	280	869	281	880	291	890	290	879	0	1	0

182	281	870	282	881	292	891	291	880	0	1	0
183	282	871	283	882	293	892	292	881	0	1	0
184	283	872	284	883	294	893	293	882	0	1	0
185	284	873	285	884	295	894	294	883	0	1	0
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187	286	875	287	886	297	896	296	885	0	1	0
188	287	876	288	887	298	897	297	886	0	1	0
191	290	890	291	901	301	911	300	900	0	3	0
192	291	891	292	902	302	912	301	901	0	3	0
193	292	892	293	903	303	913	302	902	0	3	0
194	293	893	294	904	304	914	303	903	0	3	0
195	294	894	295	905	305	915	304	904	0	3	0
196	295	895	296	906	306	916	305	905	0	3	0
197	296	896	297	907	307	917	306	906	0	3	0
198	297	897	298	908	308	918	307	907	0	3	0
201	300	911	301	922	311	932	310	921	0	1	0
202	301	912	302	923	312	933	311	922	0	1	0
203	302	913	303	924	313	934	312	923	0	1	0
204	303	914	304	925	314	935	313	924	0	1	0
205	304	915	305	926	315	936	314	925	0	1	0
206	305	916	306	927	316	937	315	926	0	1	0
207	306	917	307	928	317	938	316	927	0	1	0
208	307	918	308	929	318	939	317	928	0	1	0
211	310	932	311	943	321	981	320	942	0	1	0
212	311	933	312	944	322	982	321	943	0	1	0
213	312	934	313	945	323	983	322	944	0	1	0
215	313	935	314	947	323	945	0	0	0	1	0
216	314	948	15	147	323	947	0	0	0	1	0
217	314	949	14	139	15	948	0	0	0	1	0
218	314	950	324	951	14	949	0	0	0	1	0
219	314	936	315	954	324	950	0	0	0	1	0
220	324	952	13	132	14	951	0	0	0	1	0
221	324	953	12	125	13	952	0	0	0	1	0
222	324	963	325	969	12	953	0	0	0	1	0
223	315	955	325	963	324	954	0	0	0	1	0
224	325	970	11	117	12	969	0	0	0	1	0
225	325	971	10	107	11	970	0	0	0	1	0
226	325	964	326	972	10	971	0	0	0	1	0
227	315	956	326	964	325	955	0	0	0	1	0
228	315	937	316	957	326	956	0	0	0	1	0
229	316	958	327	965	326	957	0	0	0	1	0
230	326	973	9	102	10	972	0	0	0	1	0
231	326	965	327	974	8	92	9	973	0	1	0
232	327	975	7	87	8	974	0	0	0	1	0
233	327	966	328	976	7	975	0	0	0	1	0
234	316	959	328	966	327	958	0	0	0	1	0
235	316	938	317	960	328	959	0	0	0	1	0
236	317	961	329	967	328	960	0	0	0	1	0
237	328	977	6	77	7	976	0	0	0	1	0
238	328	967	329	978	5	72	6	977	0	1	0
239	329	979	334	62	5	978	0	0	0	1	0
240	317	939	318	962	335	968	329	961	0	1	0
241	329	968	335	980	336	985	334	979	0	1	0
247	330	993	331	999	341	1025	340	998	0	1	0
248	331	994	332	1000	342	1026	341	999	0	1	0
249	332	995	333	1001	343	1027	342	1000	0	1	0
251	333	150	47	1003	343	1001	0	0	0	1	0
252	47	140	46	1004	343	1003	0	0	0	1	0
253	46	1005	344	1028	343	1004	0	0	0	1	0
254	46	135	45	1006	344	1005	0	0	0	1	0

255	45	124	44	1007	344	1006	0	0	0	1	0
256	44	120	43	1008	344	1007	0	0	0	1	0
257	43	1009	345	1029	344	1008	0	0	0	1	0
258	43	110	42	1010	345	1009	0	0	0	1	0
259	42	105	41	1011	345	1010	0	0	0	1	0
260	41	95	40	1012	345	1011	0	0	0	1	0
261	40	1013	346	1030	345	1012	0	0	0	1	0
262	40	90	39	1014	346	1013	0	0	0	1	0
263	39	80	38	1015	346	1014	0	0	0	1	0
264	38	75	37	1016	346	1015	0	0	0	1	0
265	37	1017	347	1031	346	1016	0	0	0	1	0
266	37	65	36	1018	347	1017	0	0	0	1	0
267	36	997	337	1019	348	1032	347	1018	0	1	0
281	340	1025	341	1036	351	1046	350	1035	0	1	0
282	341	1026	342	1037	352	1047	351	1036	0	1	0
283	342	1027	343	1038	353	1048	352	1037	0	1	0
284	343	1028	344	1039	354	1049	353	1038	0	1	0
285	344	1029	345	1040	355	1050	354	1039	0	1	0
286	345	1030	346	1041	356	1051	355	1040	0	1	0
287	346	1031	347	1042	357	1052	356	1041	0	1	0
288	347	1032	348	1043	358	1053	357	1042	0	1	0
291	350	1046	351	1057	361	1067	360	1056	0	1	0
292	351	1047	352	1058	362	1068	361	1057	0	1	0
293	352	1048	353	1059	363	1069	362	1058	0	1	0
294	353	1049	354	1060	364	1070	363	1059	0	1	0
295	354	1050	355	1061	365	1071	364	1060	0	1	0
296	355	1051	356	1062	366	1072	365	1061	0	1	0
297	356	1052	357	1063	367	1073	366	1062	0	1	0
298	357	1053	358	1064	368	1074	367	1063	0	1	0
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302	361	1068	362	1079	372	1089	371	1078	0	1	0
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305	364	1071	365	1082	375	1092	374	1081	0	1	0
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315	374	1092	375	1103	385	1113	384	1102	0	1	0
316	375	1093	376	1104	386	1114	385	1103	0	1	0
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328	387	1116	388	1127	398	1137	397	1126	0	1	0
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403	462	1279	463	1290	473	1300	472	1289	0	1	0
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405	464	1281	465	1292	475	1302	474	1291	0	1	0
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408	467	1284	468	1295	478	1305	477	1294	0	1	0
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413	472	1300	473	1311	483	1321	482	1310	0	1	0

414	473	1301	474	1312	484	1322	483	1311	0	1	0
415	474	1302	475	1313	485	1323	484	1312	0	1	0
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417	476	1304	477	1315	487	1325	486	1314	0	1	0
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441	500	1361	501	1372	511	1382	510	1371	0	1	0
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37	292928.1	284947.6	1132.74	0		
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47	292619.6	285568.7	1132.70	0		
67	292906.2	284934.9	1132.74	0		
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268	291705.9	284831.4	1162.19	0
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281	292062.8	285727.9	1149.87	0
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401	294113.9	285804.0	1150.27	0
402	294116.2	285704.1	1150.27	0
403	294117.0	285664.2	1132.91	0
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405	294123.7	285302.9	1132.92	0
406	294128.8	285104.9	1132.92	0
407	294131.6	284950.4	1132.92	0
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411	294337.0	285783.7	1150.31	0
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413	294331.8	285641.0	1132.94	0
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415	294319.1	285292.4	1132.95	0
416	294313.2	285090.9	1132.95	0
417	294307.3	284940.5	1132.95	0
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420	294568.4	285784.0	1162.75	0
421	294566.5	285748.5	1150.35	0
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424	294537.9	285470.6	1132.97	0
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426	294497.0	285067.5	1132.98	0
427	294483.7	284925.9	1132.98	0
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431	294791.2	285699.9	1150.39	0
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453	295181.3	285446.6	1133.06	0
454	295150.8	285342.2	1133.06	0
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456	295038.5	284962.4	1133.06	0
457	294991.3	284811.1	1133.05	0
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467	295178.4	284748.6	1133.09	0
468	295154.1	284678.9	1162.91	0
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471	295615.8	285422.3	1150.55	0
472	295583.6	285332.4	1150.55	0
473	295569.0	285293.4	1133.11	0
474	295530.0	285187.0	1133.11	0
475	295460.2	284993.0	1133.11	0
476	295394.1	284809.3	1133.12	0
477	295349.7	284678.8	1133.12	0
478	295326.8	284612.0	1162.95	0
480	295817.9	285383.0	1162.99	0
481	295805.3	285346.8	1150.59	0
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483	295758.6	285221.6	1133.14	0
484	295714.9	285106.1	1133.14	0
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486	295577.2	284728.9	1133.14	0
487	295534.3	284605.9	1133.14	0
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490	295983.5	285323.2	1163.03	0
491	295971.7	285283.8	1150.63	0
492	295942.6	285193.6	1150.63	0
493	295931.5	285156.8	1133.18	0
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495	295833.7	284848.9	1133.18	0
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497	295735.8	284533.3	1133.17	0
498	295712.0	284461.5	1163.03	0
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502	296121.5	285135.3	1150.67	0
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504	296077.8	284982.1	1133.20	0
505	296025.1	284786.4	1133.20	0
506	295970.5	284588.8	1133.20	0
507	295937.2	284467.5	1133.20	0
508	295917.2	284394.1	1163.07	0
510	296335.2	285219.3	1163.11	0
511	296326.8	285179.7	1150.71	0
512	296303.2	285089.6	1150.71	0
513	296294.1	285048.7	1133.23	0
514	296265.1	284927.9	1133.23	0
515	296217.9	284725.1	1133.23	0
516	296172.6	284527.5	1133.23	0
517	296144.6	284406.7	1133.23	0
518	296127.5	284337.8	1163.11	0

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RESE
    1  100
  102  103  104  105  106  107   -1

LAST
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Flomod
FILE: A1.DAT
10/27/89 12:33 F

Grade Control No 4
Rural Road

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SWMS              1         1
TEMPE RIO SALADO * SALT RIVER * MILL AVE. REACH * Q=215,000 CFS
    0    1    0    0    0    0    0    1    1    0    1
    1    1    1    1    0    0   98   99
         9         0         1         1      .000      .000      .000     1.000
  1162.000      .000     1.937     1.000      .000  1.00E+35     0.500     1.000
      .000      .000  .237E-02     1.000      .000      .000
PROP
         1     .0450         8     .0350        15      .000        50      0.60
         2     .0470         8     .0370        15      .000        50      0.60
         3     .0490         8     .0390        15      .000        50      0.60

QSEC
         1    215000
  510 1382  511 1383  512 1384  513 1385  514 1386  515 1387  516 1388  517 1389
  518   -1

ZSEC
         1    1153.5                   1
  201  701  202  702  203  703  204  704  205  705  206  706  207   -1


LAST
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File R10.DAT
11/1/89 11:00a

Rural Road
to McClintock Dr.

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SWMS              1         1
RIO SALADO * EAST OF MILL AVE. BRDG * OCTOBER 20,1989
   0   3   1   0   0   1   0  -1
PLOT
SALT RIVER MILL AVE. BRIDGE REACH (A1 ALIGNMENT)
   0   0
     .100      .070      .105      .105     5.000
  290000.0  283500.0      .000      .000     200.0     200.0      .000
ELEM
   1   1   2   3  19  29  28  27  18   0   0   0
   2   3   4   5  20  31  30  29  19   0   1   0
   3   5   6   7  21  33  32  31  20   0   1   0
   4   7   8   9  22  35  34  33  21   0   1   0
   5   9  10  11  23  37  36  35  22   0   1   0
   6  11  12  13  24  39  38  37  23   0   1   0
   7  13  14  15  25  41  40  39  24   0   1   0
   8  15  16  17  26  43  42  41  25   0   0   0
  11  27  28  29  45  55  54  53  44   0   1   0
  12  29  30  31  46  57  56  55  45   0   1   0
  13  31  32  33  47  59  58  57  46   0   1   0
  14  33  34  35  48  61  60  59  47   0   1   0
  15  35  36  37  49  63  62  61  48   0   1   0
  16  37  38  39  50  65  64  63  49   0   1   0
  17  39  40  41  51  67  66  65  50   0   1   0
  18  41  42  43  52  69  68  67  51   0   1   0
  21  53  54  55  71  81  80  79  70   0   1   0
  22  55  56  57  72  83  82  81  71   0   1   0
  23  57  58  59  73  85  84  83  72   0   1   0
  24  59  60  61  74  87  86  85  73   0   1   0
  25  61  62  63  75  89  88  87  74   0   1   0
  26  63  64  65  76  91  90  89  75   0   1   0
  27  65  66  67  77  93  92  91  76   0   1   0
  28  67  68  69  78  95  94  93  77   0   1   0
  31  79  80  81  97 107 106 105  96   0   1   0
  32  81  82  83  98 109 108 107  97   0   1   0
  33  83  84  85  99 111 110 109  98   0   1   0
  34  85  86  87 100 112 894 111  99   0   1   0
  35  87  88  89 101 114 113 112 100   0   1   0
  36  89  90  91 102 115 895 114 101   0   1   0
  37  91  92  93 103 116 898 115 102   0   1   0
  38  93  94  95 104 118 117 116 103   0   1   0
  41 105 106 107 120 130 129 128 119   0   1   0
  42 107 108 109 121 131 896 130 120   0   1   0
  43 109 110 111 122 132 899 131 121   0   1   0
  44 111 894 112 123 134 133 132 122   0   1   0
  45 112 113 114 124 136 135 134 123   0   1   0
  46 114 895 115 125 138 137 136 124   0   1   0
  47 115 898 116 126 140 139 138 125   0   1   0
  48 116 117 118 127 142 141 140 126   0   1   0
  51 128 129 130 144 154 153 152 143   0   1   0
  52 130 896 131 145 156 155 154 144   0   1   0
  53 131 899 132 146 158 157 156 145   0   1   0
  54 132 133 134 147 160 159 158 146   0   1   0
  55 134 135 136 148 162 161 160 147   0   1   0
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  62 154 155 156 171 182 181 180 170   0   1   0
  63 156 157 158 172 184 183 182 171   0   1   0
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84	210	211	212	224	237	236	235	223	0	1	0
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94	235	236	237	250	263	262	261	249	0	1	0
95	237	238	239	251	265	264	263	250	0	1	0
96	239	240	241	252	266	900	265	251	0	1	0
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217	562	563	564	582	607	606	605	581	0	1	0
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247	605	606	607	620	646	645	644	619	0	1	0
251	632	633	634	654	893	673	672	653	0	1	0
252	634	635	636	655	675	674	893	654	0	1	0
253	636	637	638	656	677	676	675	655	0	1	0
254	638	639	640	657	679	678	677	656	0	1	0
255	640	641	642	658	681	680	679	657	0	1	0
256	642	643	644	659	683	682	681	658	0	1	0
257	644	645	646	660	685	684	683	659	0	1	0
261	672	673	893	693	713	712	711	692	0	1	0
262	893	674	675	694	715	714	713	693	0	1	0
263	675	676	677	695	717	716	715	694	0	1	0
264	677	678	679	696	719	718	717	695	0	1	0
265	679	680	681	697	721	720	719	696	0	1	0
266	681	682	683	698	723	722	721	697	0	1	0
267	683	684	685	699	725	724	723	698	0	1	0
271	711	712	713	727	736	735	734	726	0	1	0
272	713	714	715	728	738	737	736	727	0	1	0
273	715	716	717	729	740	739	738	728	0	1	0
274	717	718	719	730	742	741	740	729	0	1	0

275	719	720	721	731	744	743	742	730	0	1	0
276	721	722	723	732	746	745	744	731	0	1	0
277	723	724	725	733	748	747	746	732	0	1	0
281	734	735	736	750	760	759	758	749	0	1	0
282	736	737	738	751	760	750	0	0	0	1	0
283	738	752	762	761	760	751	0	0	0	1	0
284	738	739	740	753	762	752	0	0	0	1	0
285	740	741	742	754	764	763	762	753	0	1	0
286	742	743	744	755	766	765	764	754	0	1	0
288	744	745	746	756	768	767	766	755	0	1	0
289	746	747	748	757	770	769	768	756	0	1	0
291	758	759	760	772	780	779	778	771	0	1	0
292	760	761	762	773	782	781	780	772	0	1	0
293	762	763	764	774	784	783	782	773	0	1	0
294	764	765	766	775	786	785	784	774	0	1	0
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296	768	769	770	777	790	789	788	776	0	1	0
301	778	779	780	792	800	799	798	791	0	1	0
302	780	781	782	793	802	801	800	792	0	1	0
303	782	783	784	794	804	803	802	793	0	1	0
304	784	785	786	795	806	805	804	794	0	1	0
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306	788	789	790	797	810	809	808	796	0	1	0
311	798	799	800	812	820	819	818	811	0	1	0
312	800	801	802	813	822	821	820	812	0	1	0
313	802	803	804	814	824	823	822	813	0	1	0
314	804	805	806	815	826	825	824	814	0	1	0
315	806	807	808	816	828	827	826	815	0	1	0
316	808	809	810	817	830	829	828	816	0	1	0
321	818	819	820	832	840	839	838	831	0	1	0
322	820	821	822	833	842	841	840	832	0	1	0
323	822	823	824	834	844	843	842	833	0	1	0
324	824	825	826	835	846	845	844	834	0	1	0
325	826	827	828	836	848	847	846	835	0	1	0
326	828	829	830	837	850	849	848	836	0	1	0
331	838	839	840	852	860	859	858	851	0	1	0
332	840	841	842	853	862	861	860	852	0	1	0
333	842	843	844	854	864	863	862	853	0	1	0
334	844	845	846	855	866	865	864	854	0	1	0
335	846	847	848	856	868	867	866	855	0	1	0
336	848	849	850	857	870	869	868	856	0	1	0
341	858	859	860	872	880	879	878	871	0	1	0
342	860	861	862	873	882	881	880	872	0	1	0
343	862	863	864	874	884	883	882	873	0	1	0
344	864	865	866	875	886	885	884	874	0	1	0
345	866	867	868	876	888	887	886	875	0	1	0
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NODE	1	1	1	0	0	0
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3	296320.5	285167.5	1150.71	0		
5	296293.5	285071.3	1150.71	0		
7	296284.2	285031.9	1133.23	0		
9	296258.1	284911.1	1133.23	0		
11	296211.5	284716.5	1133.23	0		
13	296168.1	284521.3	1133.23	0		
15	296140.5	284393.0	1133.23	0		
17	296126.4	284325.1	1163.11	0		
27	296510.5	285169.8	1163.14	0		
29	296502.4	285127.7	1150.74	0		

31	296481.6	285032.2	1150.74	0
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35	296449.7	284868.1	1133.26	0
37	296409.6	284671.7	1133.26	0
39	296368.3	284475.9	1133.27	0
41	296342.4	284346.8	1133.28	0
43	296328.9	284278.4	1163.14	0
53	296708.2	285132.9	1163.19	0
55	296700.1	285095.2	1150.78	0
57	296679.4	284997.1	1150.78	0
59	296672.1	284956.4	1133.30	0
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63	296603.1	284636.4	1133.29	0
65	296562.8	284437.8	1133.29	0
67	296536.4	284309.6	1133.29	0
69	296521.6	284240.5	1163.18	0
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83	296869.2	284972.6	1150.81	0
85	296861.7	284933.5	1133.33	0
87	296840.3	284811.2	1133.32	0
89	296804.2	284610.6	1133.32	0
91	296768.5	284415.0	1133.32	0
93	296740.6	284288.3	1133.32	0
95	296731.3	284209.9	1163.21	0
105	297076.7	285100.0	1163.23	0
107	297072.0	285059.2	1150.83	0
109	297058.1	284959.8	1150.83	0
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112	297035.9	284789.3	1133.35	0
114	297009.0	284584.5	1133.35	0
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116	296965.1	284259.5	1133.36	0
118	296954.6	284183.9	1163.23	0
128	297226.3	285091.1	1163.26	0
130	297224.7	285051.5	1150.86	0
131	297221.7	284948.8	1150.86	0
132	297220.6	284910.5	1133.38	0
134	297216.3	284774.5	1133.38	0
136	297210.1	284569.9	1133.38	0
138	297205.7	284369.6	1133.38	0
140	297201.6	284239.6	1133.38	0
142	297201.2	284166.0	1163.26	0
152	297413.3	285094.0	1163.31	0
154	297413.1	285046.9	1150.91	0
156	297412.5	284952.7	1150.91	0
158	297412.4	284914.8	1133.43	0
160	297412.3	284766.9	1133.44	0
162	297410.5	284568.7	1133.43	0
164	297412.3	284362.5	1133.43	0
166	297411.4	284232.9	1133.43	0
168	297410.3	284160.1	1163.31	0
178	297595.5	285106.0	1163.47	0
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182	297599.1	284966.4	1151.07	0
184	297601.2	284926.7	1133.59	0
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188	297611.9	284572.2	1133.58	0
190	297613.7	284365.0	1133.57	0
192	297617.2	284238.0	1133.57	0

194	297619.2	284164.2	1163.47	0
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208	297787.2	284993.4	1151.21	0
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214	297809.5	284581.6	1133.72	0
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218	297826.4	284243.5	1133.71	0
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229	297921.2	285166.0	1163.74	0
231	297928.9	285123.1	1151.34	0
233	297946.4	285027.0	1151.34	0
235	297953.4	284985.0	1133.86	0
237	297985.1	284796.8	1133.87	0
239	298010.3	284599.5	1133.87	0
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245	298059.8	284192.7	1163.74	0
255	298089.2	285213.7	1163.89	0
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261	298130.3	285037.2	1134.01	0
263	298179.4	284821.6	1134.02	0
265	298210.1	284625.1	1134.02	0
266	298241.4	284424.2	1134.02	0
268	298263.9	284294.3	1134.01	0
270	298276.1	284219.4	1163.89	0
280	298241.5	285270.3	1164.03	0
282	298251.8	285233.2	1151.63	0
284	298281.1	285140.0	1151.63	0
286	298293.8	285098.0	1134.15	0
288	298368.3	284855.5	1134.16	0
290	298405.0	284660.3	1134.16	0
292	298445.1	284460.3	1134.16	0
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316	298510.3	285042.7	1134.30	0
318	298557.8	284898.1	1134.31	0
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353	298890.3	284431.1	1134.44	0
355	298909.0	284362.4	1164.30	0
366	298637.9	285489.1	1164.42	0
368	298662.4	285456.3	1152.02	0
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372	298736.5	285344.2	1134.54	0
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376	298917.8	285002.0	1134.59	0
378	298987.4	284814.5	1134.60	0
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414	299294.0	284552.1	1134.74	0
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436	299289.7	285136.0	1134.89	0
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442	299496.6	284631.8	1134.88	0
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866	302274.2	285420.0	1137.14	0
868	302284.8	285244.5	1137.14	0
870	302287.8	285174.4	1167.02	0
878	302433.4	286108.8	1167.17	0
880	302437.9	286032.1	1137.28	0
882	302451.7	285822.2	1137.28	0
884	302462.3	285621.6	1137.29	0
886	302473.7	285425.6	1137.30	0
888	302484.4	285260.3	1137.30	0
890	302488.3	285192.9	1167.17	0
892	300075.0	285886.9	1165.52	0

```
      893  300554.8  285940.8   1135.94        0

RESE
    1  100
    2    3    4    5    6    7   -1

LAST
```

```
SWMS                1         1
TEMPE RIO SALADO * SALT RIVER * MILL AVE. REACH EAST * Q=215,000 CFS (SPF)
    0    1    0    0    0    0    0    1    1    0    1
    1    1    1    1    0    0   98   99
         3         0         1         1      .000      .000      .000     1.000
  1170.000      .000     1.937     1.000      .000  1.00E+35     0.500     1.000
      .000      .000  .237E-02     1.000      .000      .000
PROP
         1     .0450         8     .0350        15      .000        50      0.60

BOUN
         3       111    -4.812     1.365   1162.50
         4       111    -5.069     1.329   1161.97
         5       111    -6.625     1.658   1161.44
         6       111    -7.995     1.777   1161.89
         7       111    -9.559     2.250   1162.35
         8       111   -10.306     2.474   1162.24
         9       111   -10.354     2.437   1162.13
        10       111   -10.285     2.393   1162.35
        11       111   -10.213     2.360   1162.57
        12       111   -10.216     2.343   1162.57
        13       111   -10.212     2.351   1162.56
        14       111   -10.100     2.341   1162.89
        15       111    -9.859     2.890   1163.21

QSEC
         1    215000
  878  879  880  881  882  883  884  885  886  887  888  889  890   -1

LAST
```

Flomod

File Rio.DAT

11/20/89 2.32p

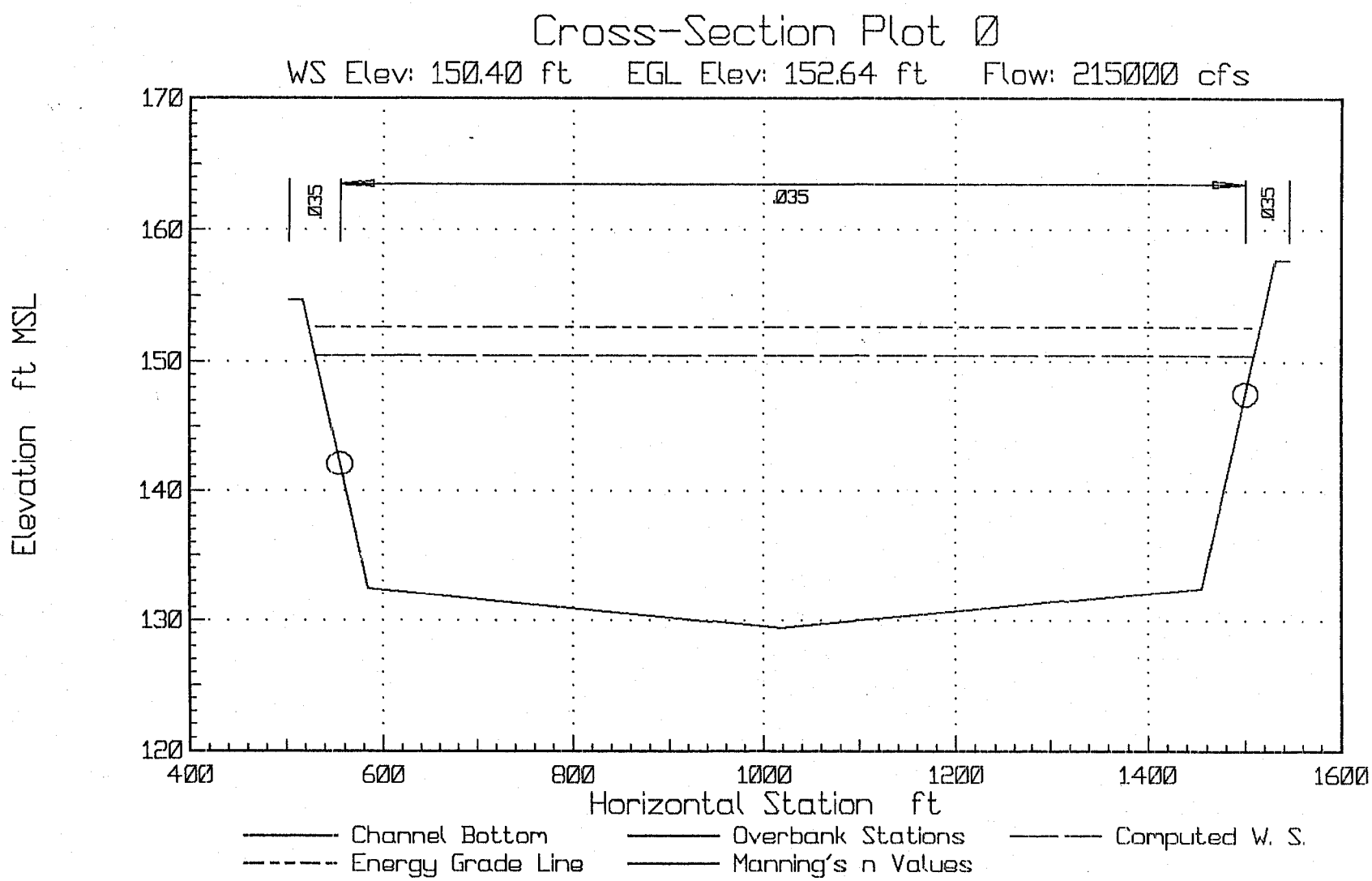
Rural Road
to McClintock Dr.

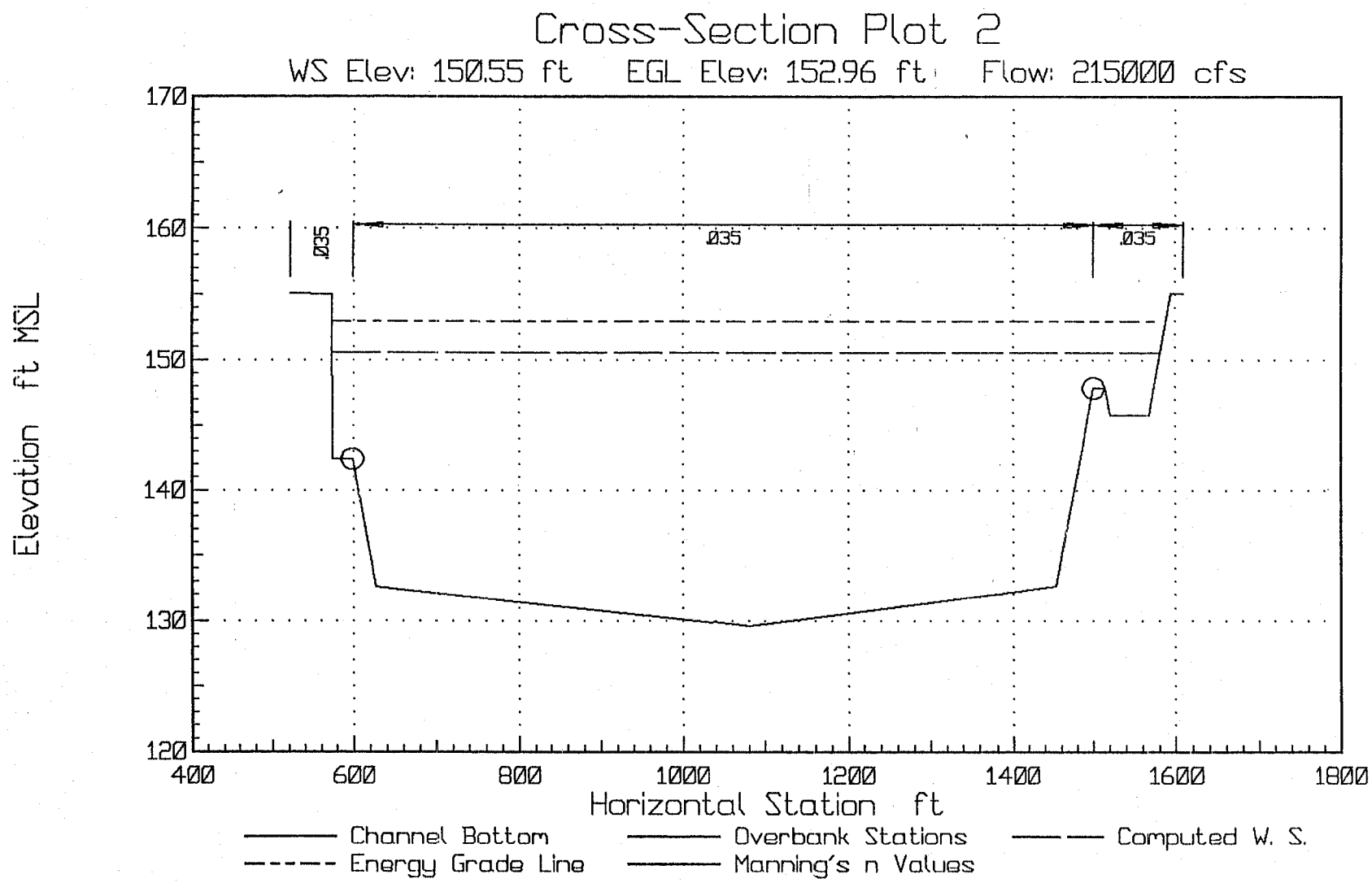
APPENDIX B

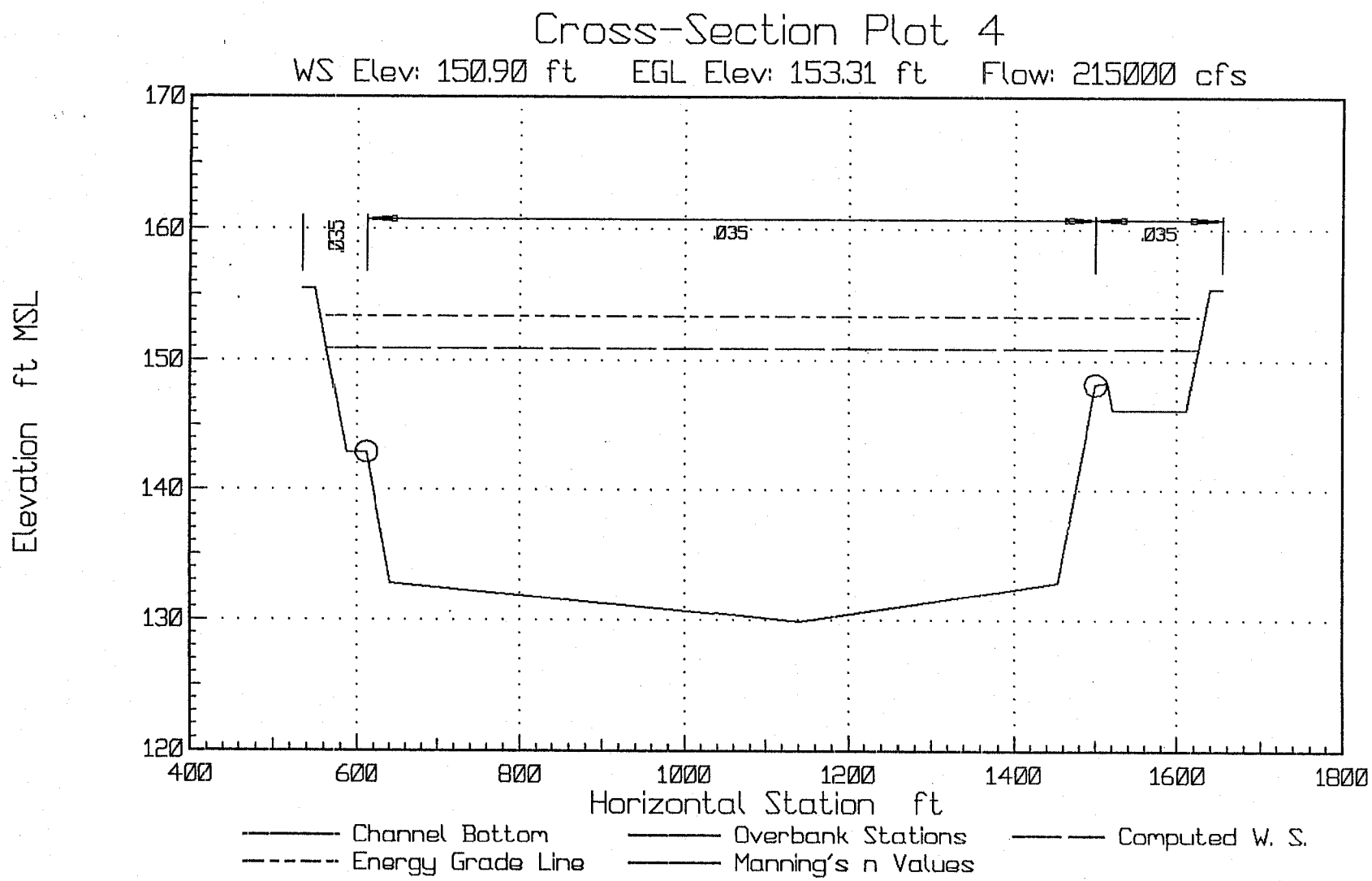
CHANNEL CROSS SECTIONS

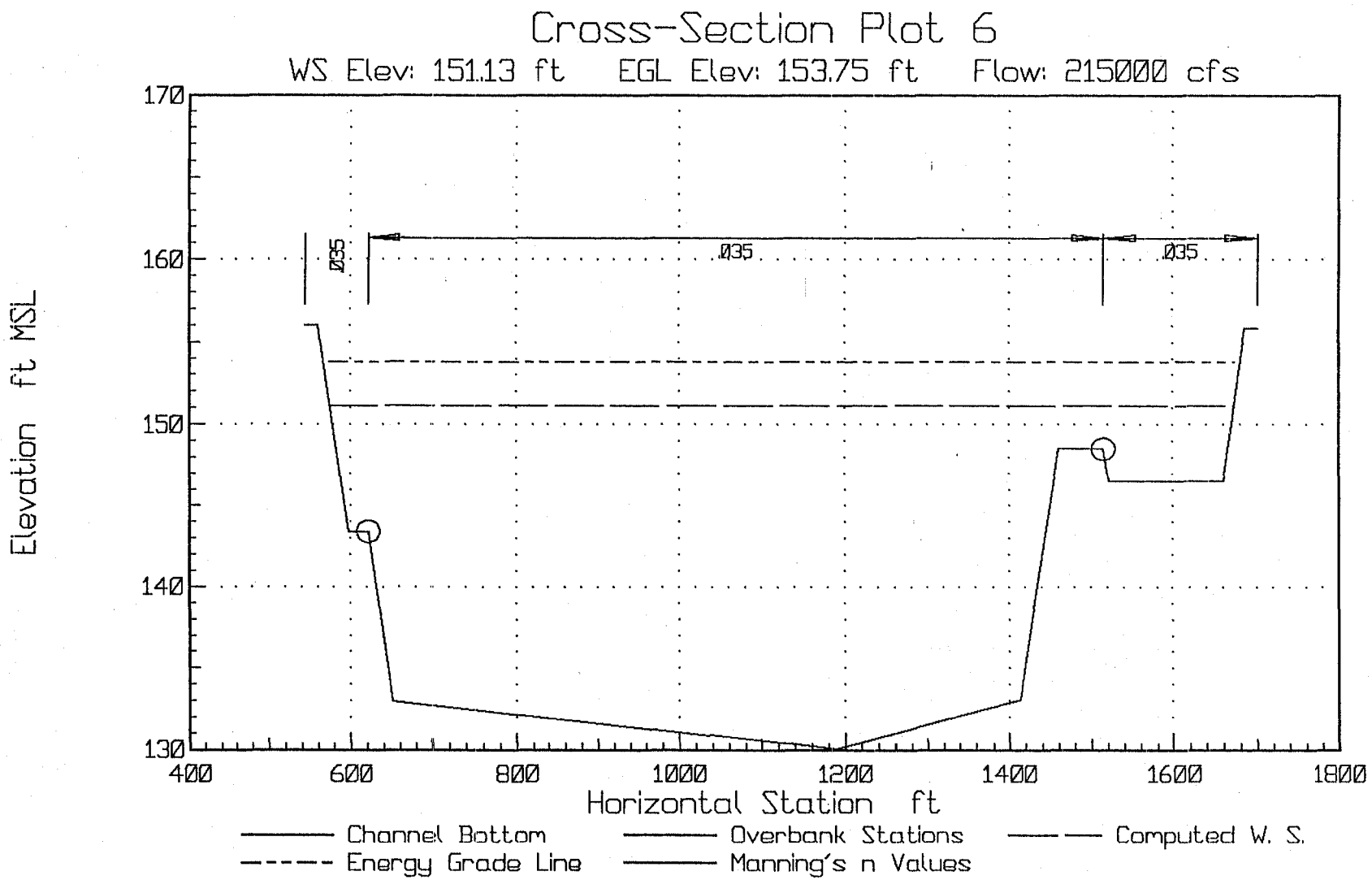
APPENDIX B

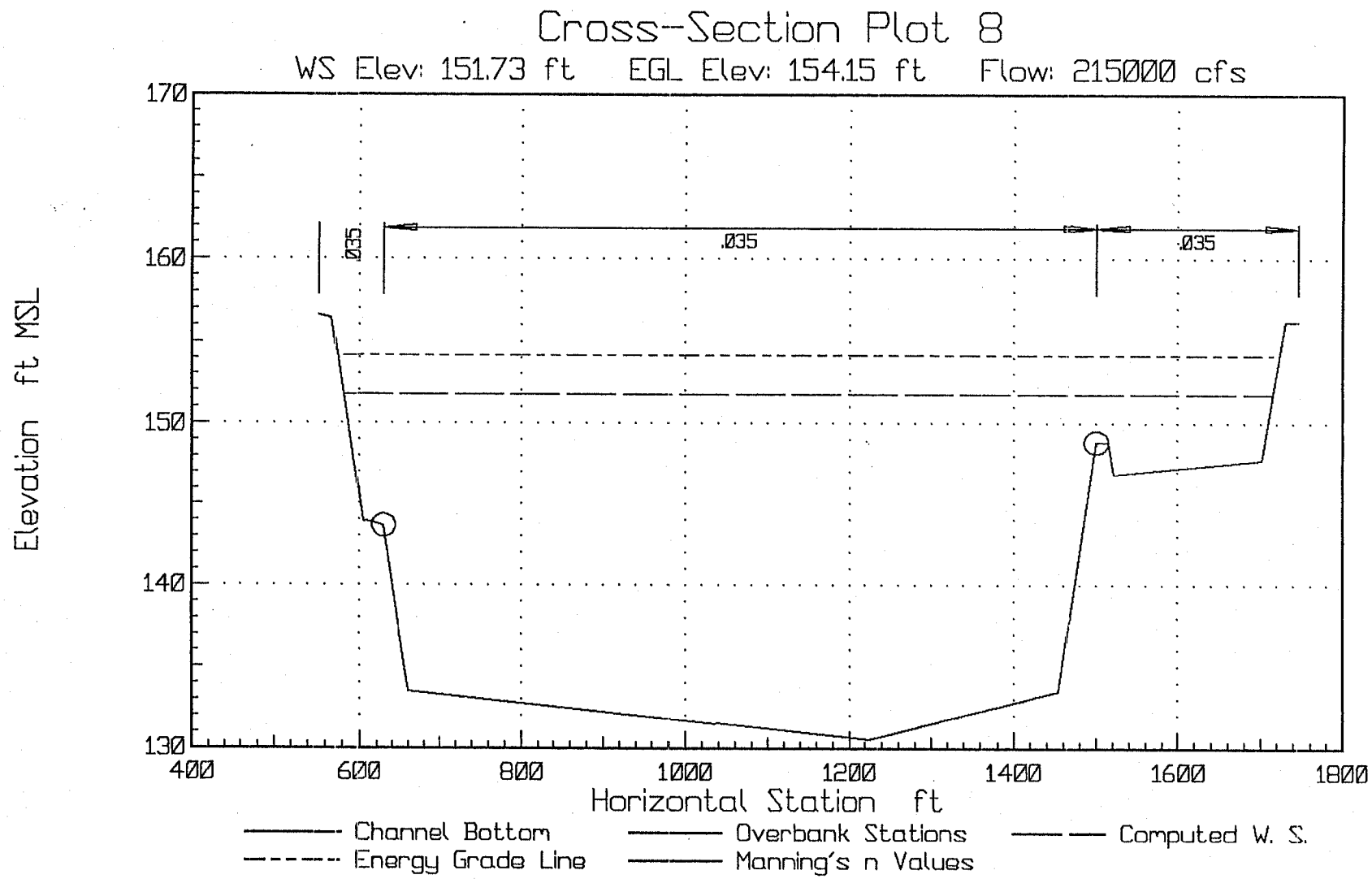
CHANNEL CROSS SECTIONS

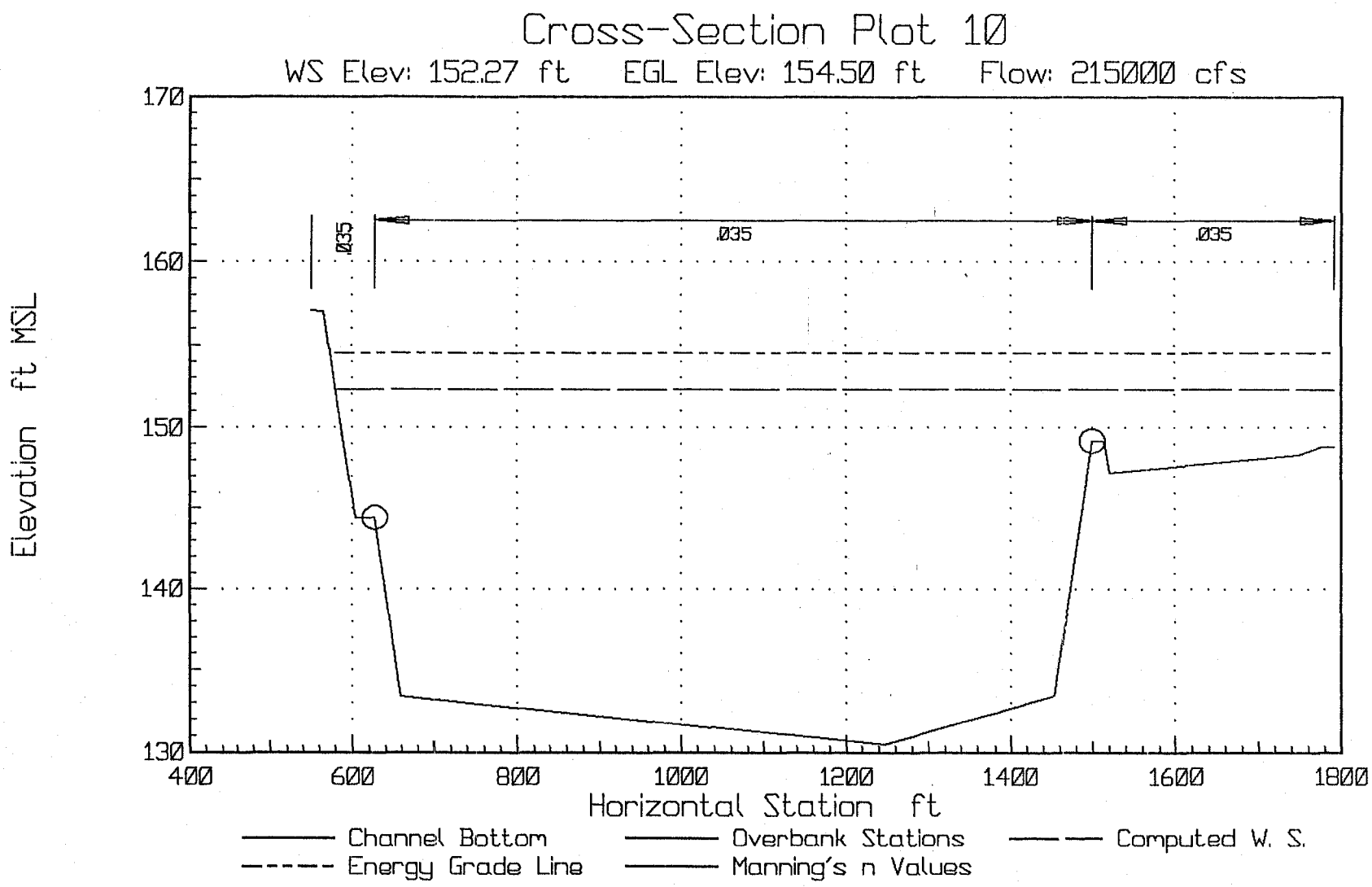

Cross-Section Plot 0
WS Elev: 150.40 ft
EGL Elev: 152.64 ft
Flow: 215000 cfs
170
160
150
140
130
120
Elevation ft MSL
.035
.035
.035
400
600
800
1000
1200
1400
1600
Horizontal Station ft
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

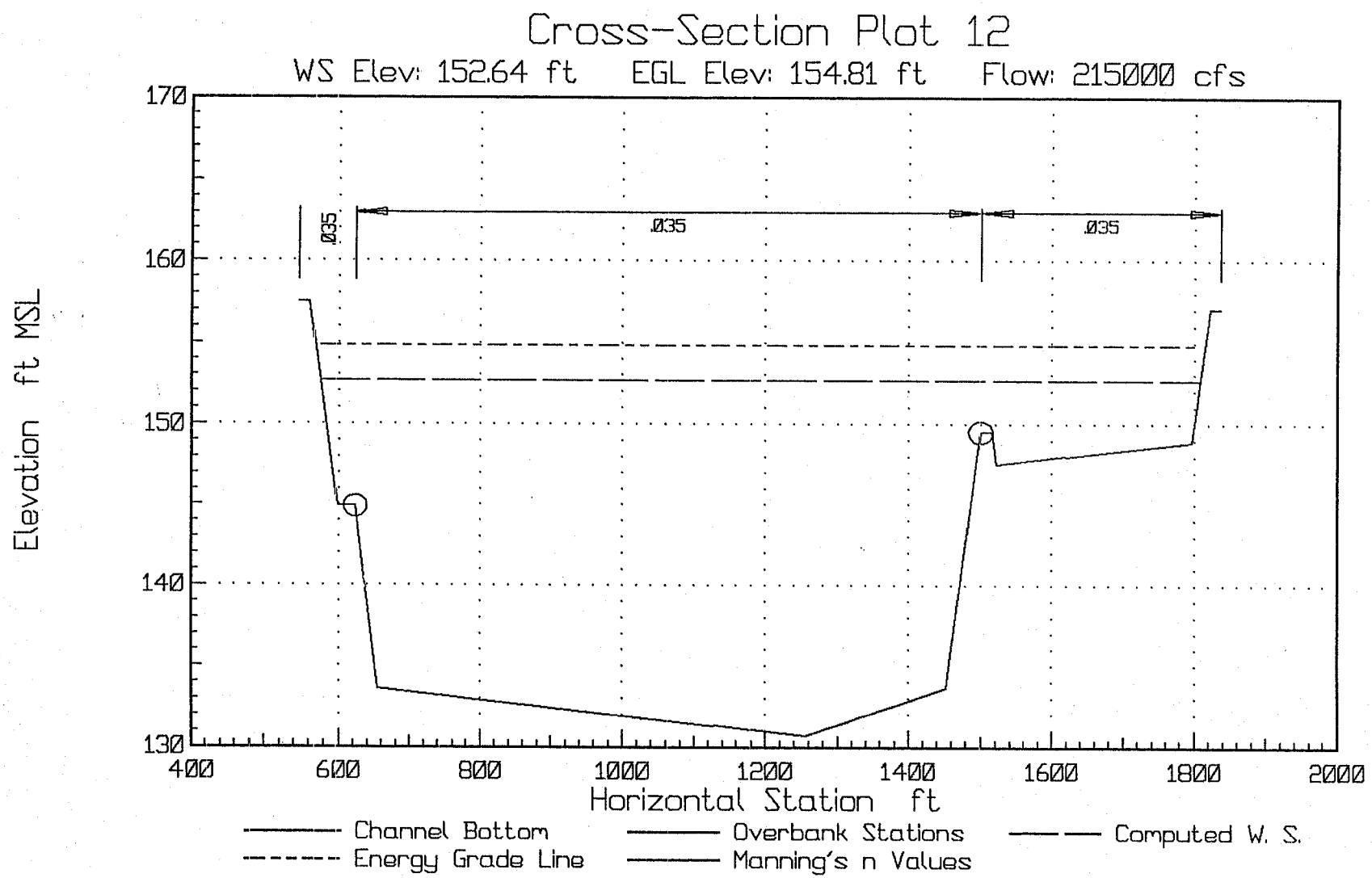

Cross-Section Plot 2
WS Elev: 150.55 ft
EGL Elev: 152.96 ft
Flow: 215000 cfs
Elevation ft MSL
170
160
150
140
130
120
.035
.035
.035
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values

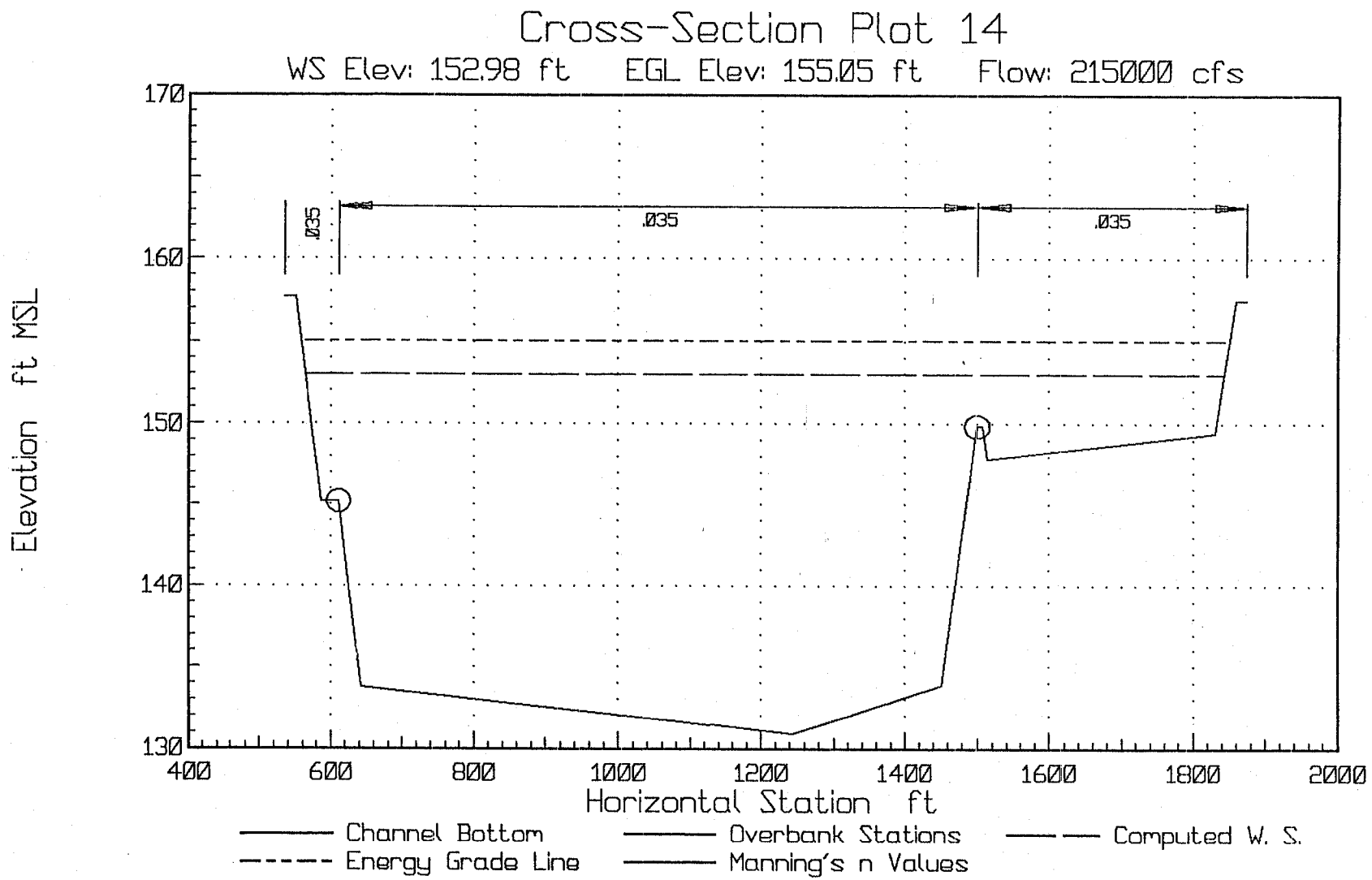

Cross-Section Plot 4
WS Elev: 150.90 ft
EGL Elev: 153.31 ft
Flow: 215000 cfs
Elevation ft MSL
170
160
150
140
130
120
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
.035
.035
.035
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

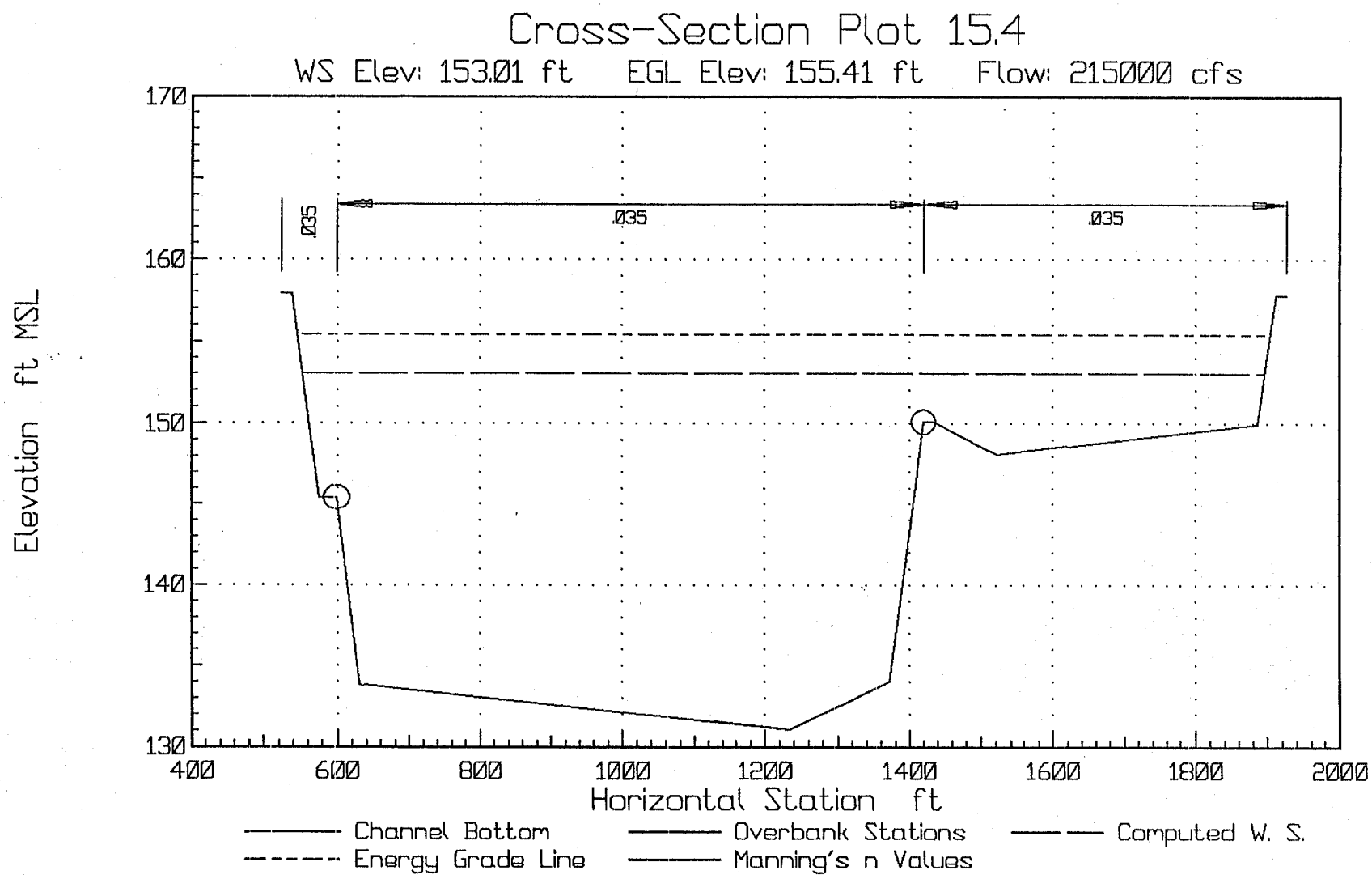

Cross-Section Plot 6
WS Elev: 151.13 ft EGL Elev: 153.75 ft Flow: 215000 cfs
Elevation ft MSL
170
160
150
140
130
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
.035
.035
.035
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

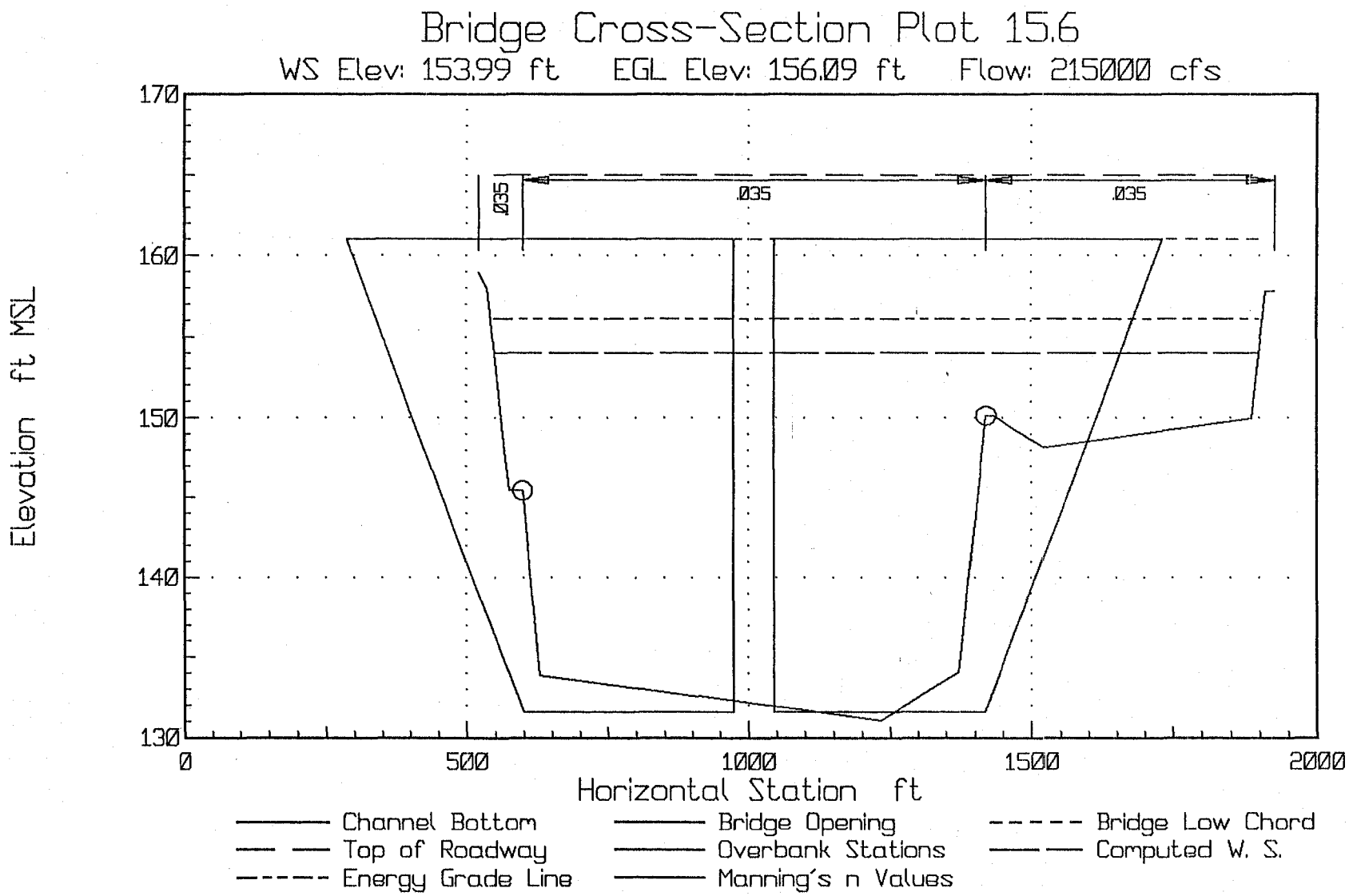

Cross-Section Plot 8
WS Elev: 151.73 ft
EGL Elev: 154.15 ft
Flow: 215000 cfs
170
160
150
140
130
Elevation ft MSL
.035
.035
.035
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values

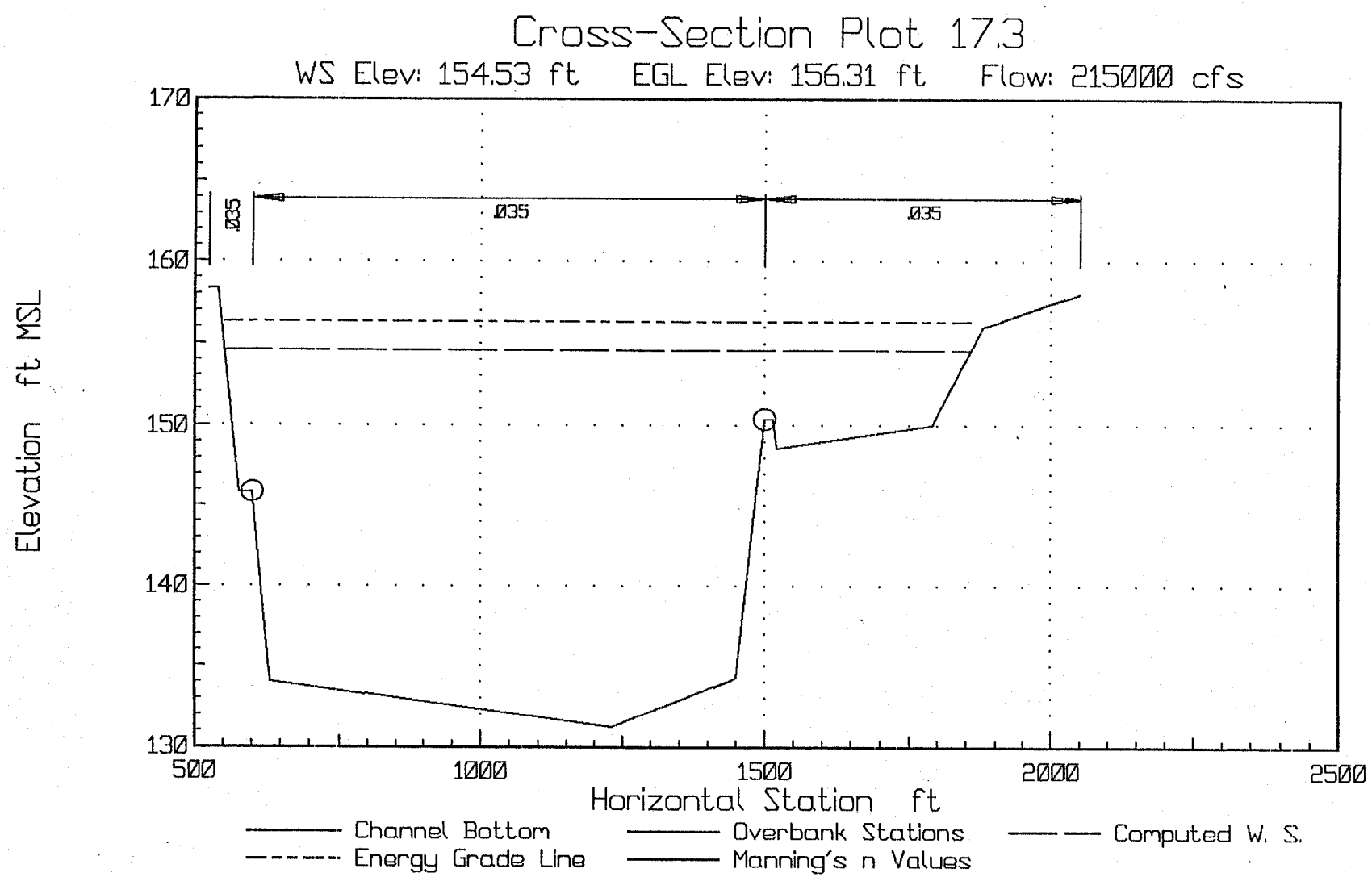

Cross-Section Plot 10
WS Elev: 152.27 ft
EGL Elev: 154.50 ft
Flow: 215000 cfs
170
160
150
140
130
Elevation ft MSL
.035
.035
.035
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values

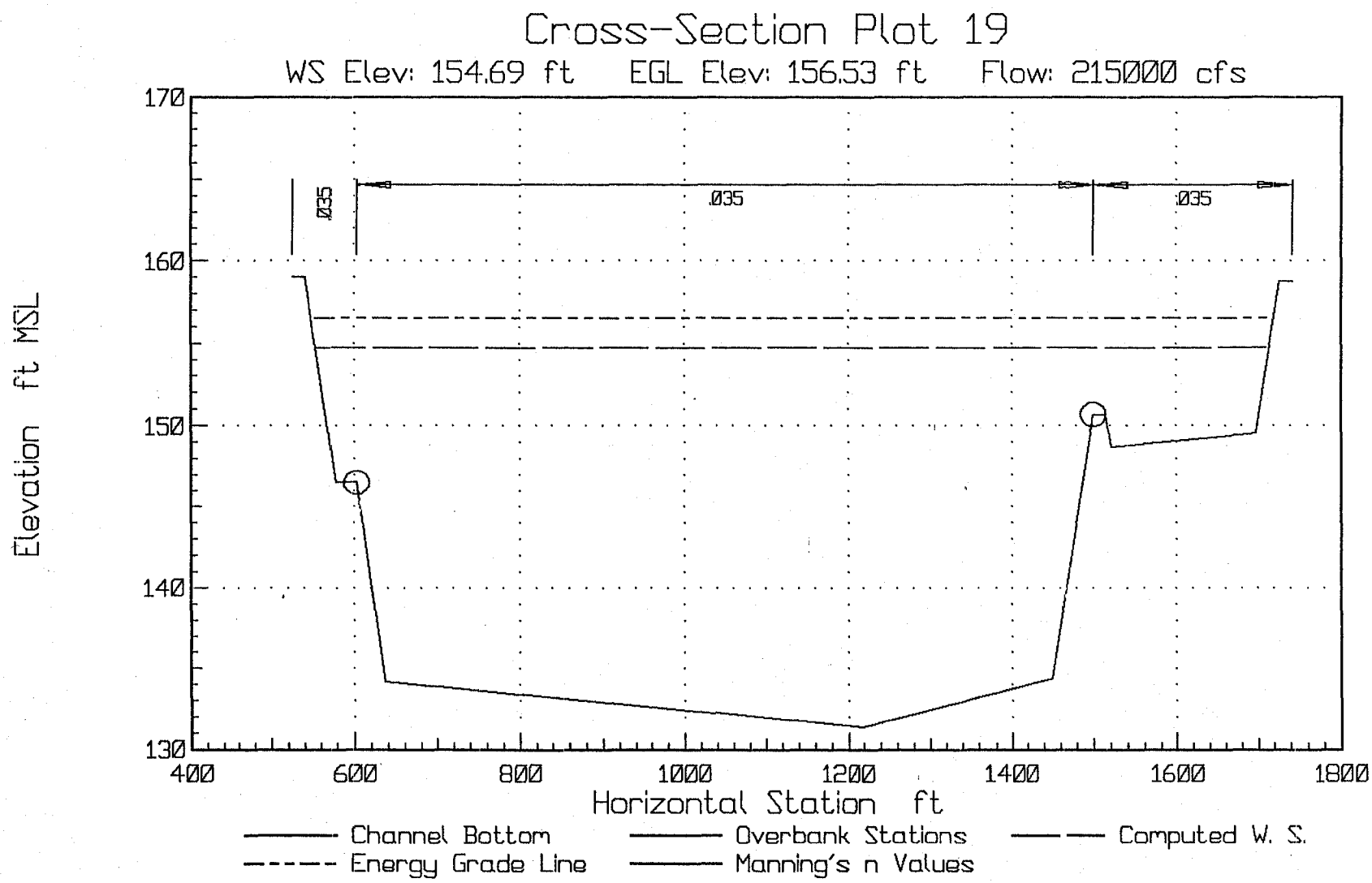

Cross-Section Plot 12
WS Elev: 152.64 ft
EGL Elev: 154.81 ft
Flow: 215000 cfs
Elevation ft MSL
170
160
150
140
130
400
600
800
1000
1200
1400
1600
1800
2000
Horizontal Station ft
.035
.035
.035
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

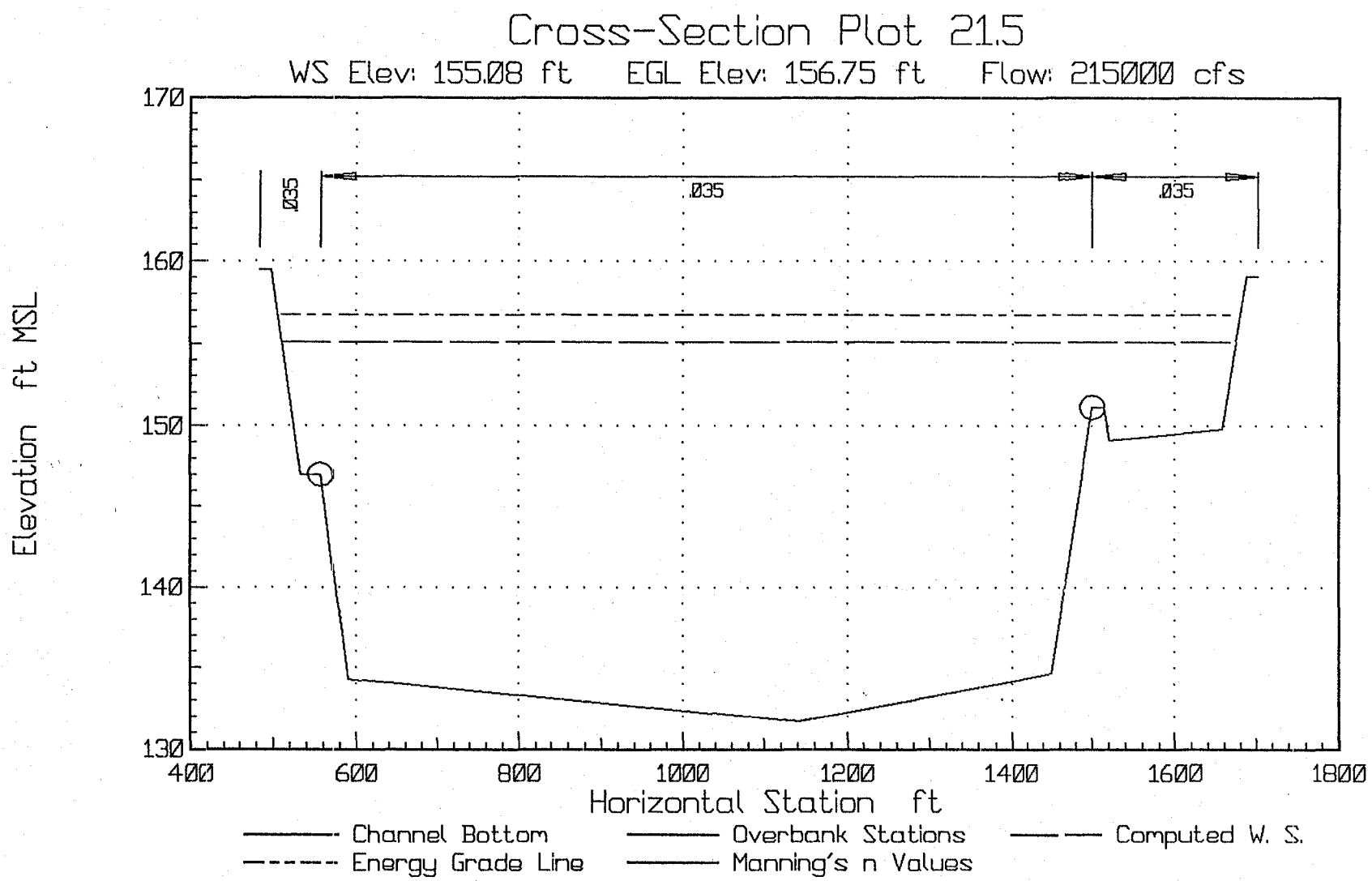

Cross-Section Plot 14
WS Elev: 152.98 ft
EGL Elev: 155.05 ft
Flow: 215000 cfs
170
160
150
140
130
Elevation ft MSL
.035
.035
.035
400
600
800
1000
1200
1400
1600
1800
2000
Horizontal Station ft
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

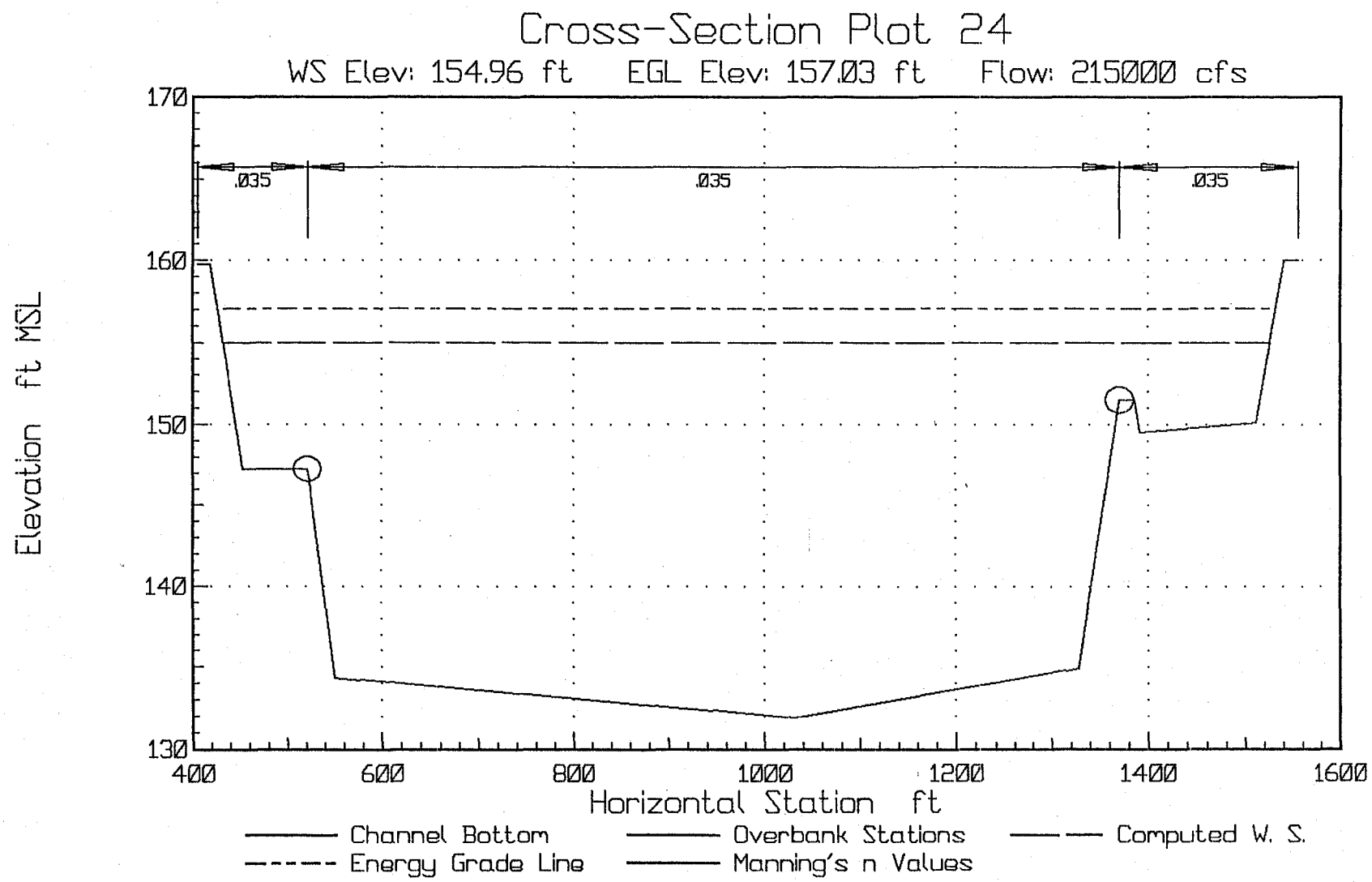

Cross-Section Plot 15.4
WS Elev: 153.01 ft
EGL Elev: 155.41 ft
Flow: 215000 cfs
170
160
150
140
130
Elevation ft MSL
.035
.035
.035
400
600
800
1000
1200
1400
1600
1800
2000
Horizontal Station ft
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

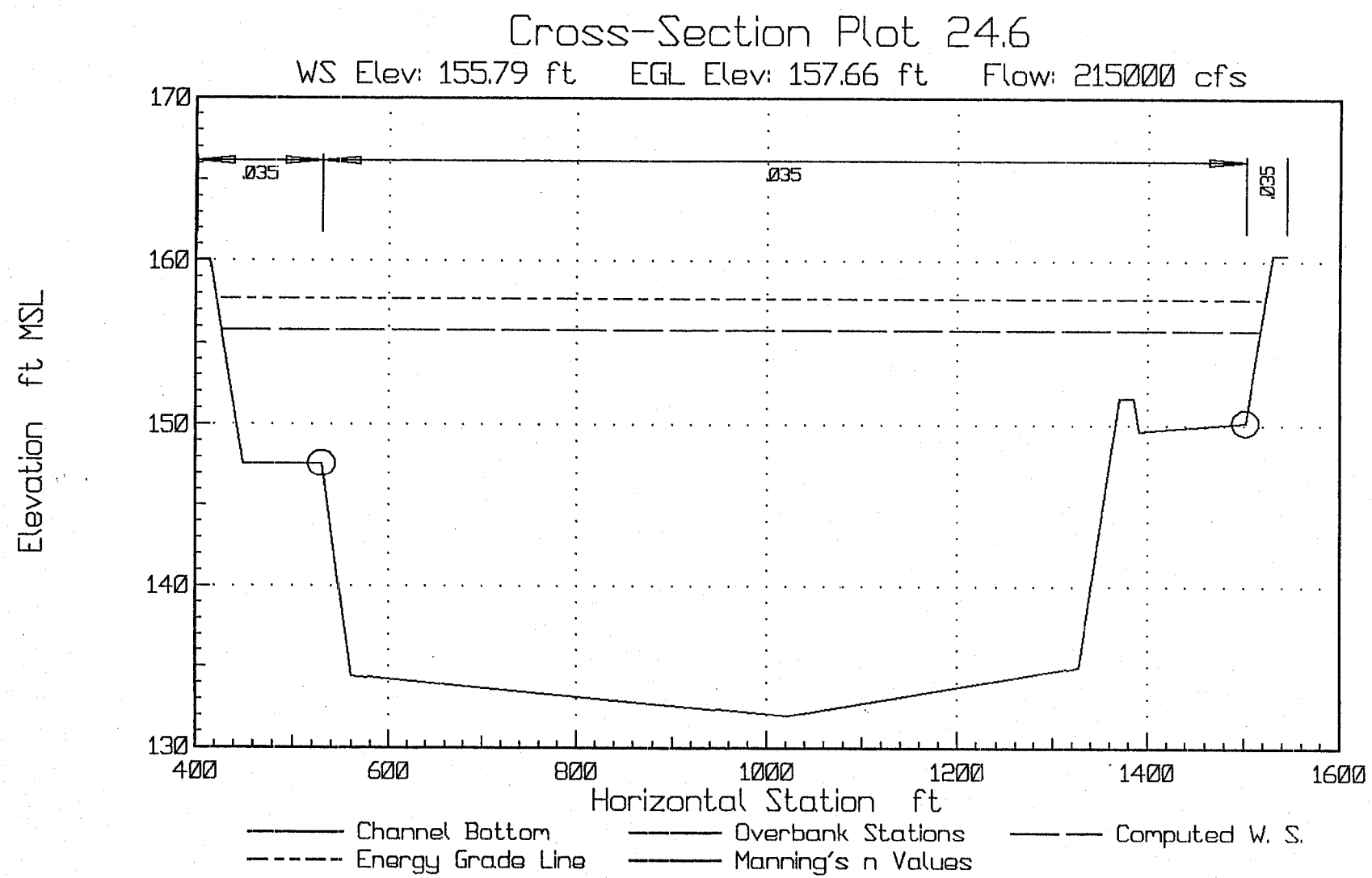

Bridge Cross-Section Plot 15.6
WS Elev: 153.99 ft EGL Elev: 156.09 ft Flow: 215000 cfs
Elevation ft MSL
170
160
150
140
130
0
500
1000
1500
2000
Horizontal Station ft
.035
.035
.035
Channel Bottom
Top of Roadway
Energy Grade Line
Bridge Opening
Overbank Stations
Manning's n Values
Bridge Low Chord
Computed W. S.

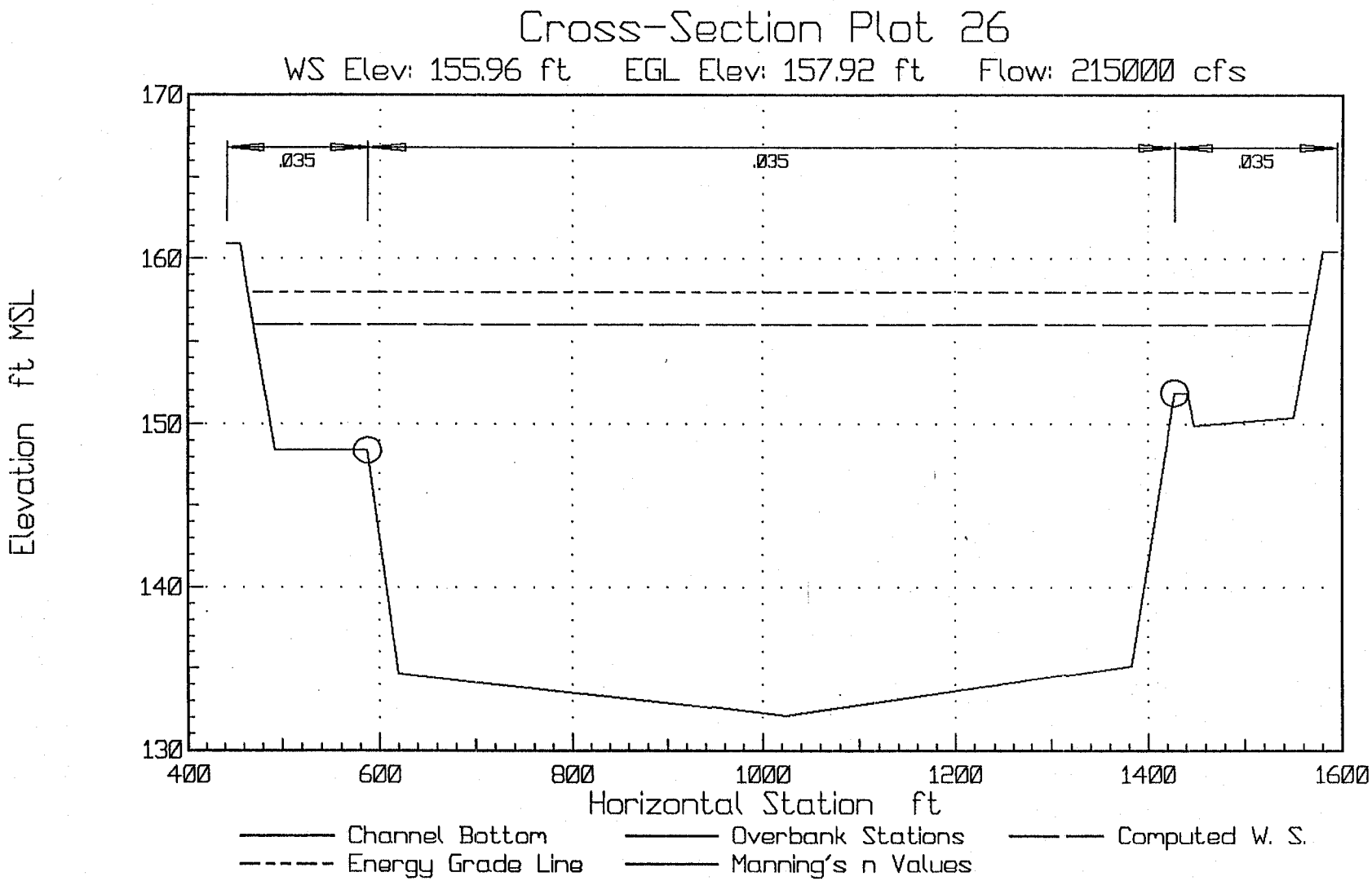

Cross-Section Plot 17.3
WS Elev: 154.53 ft
EGL Elev: 156.31 ft
Flow: 215000 cfs
170
160
150
140
130
Elevation ft MSL
.035
.035
.035
500
1000
1500
2000
2500
Horizontal Station ft
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

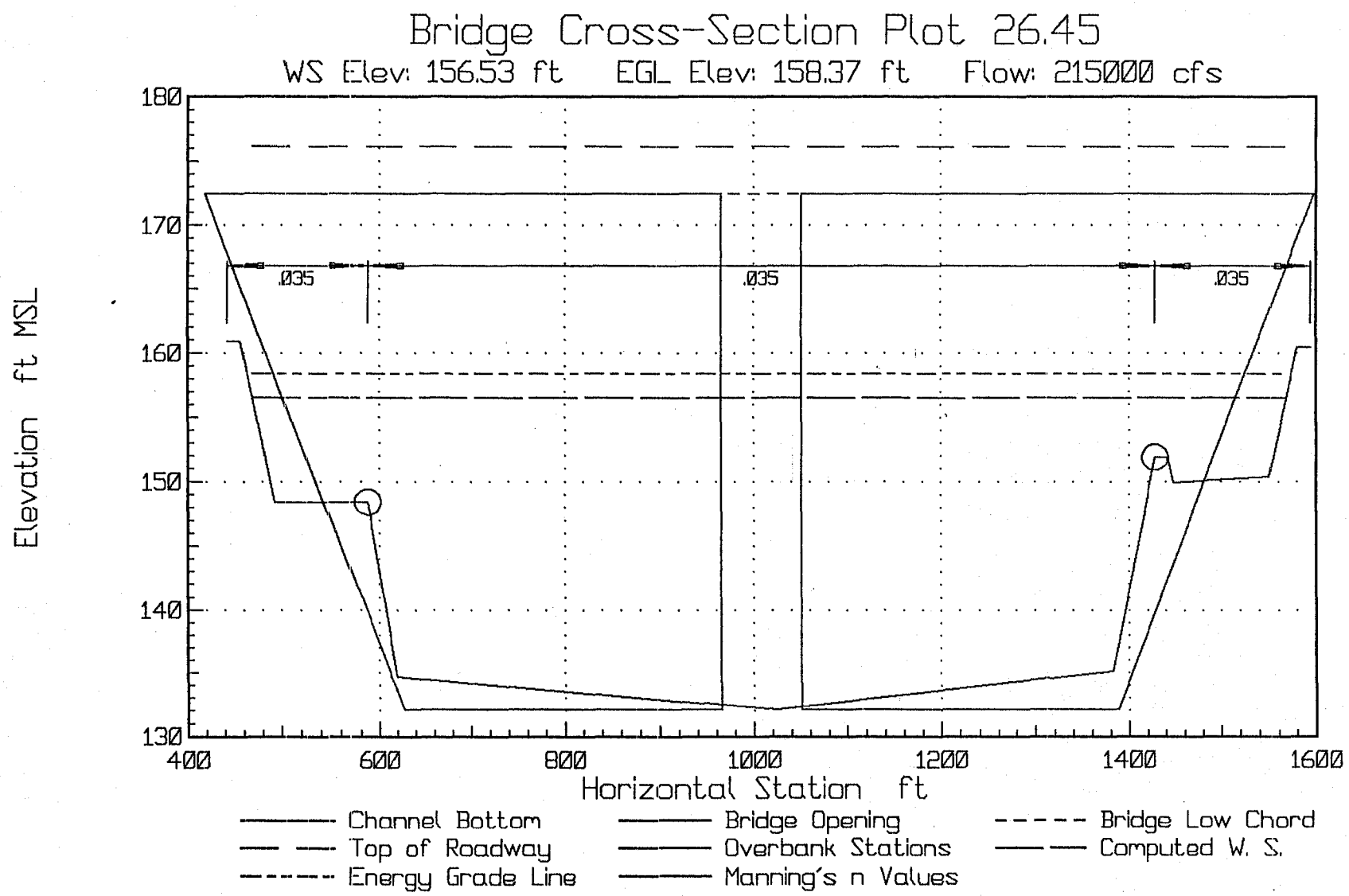

Cross-Section Plot 19
WS Elev: 154.69 ft EGL Elev: 156.53 ft Flow: 215000 cfs
170
160
150
140
130
Elevation ft MSL
.035
.035
.035
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

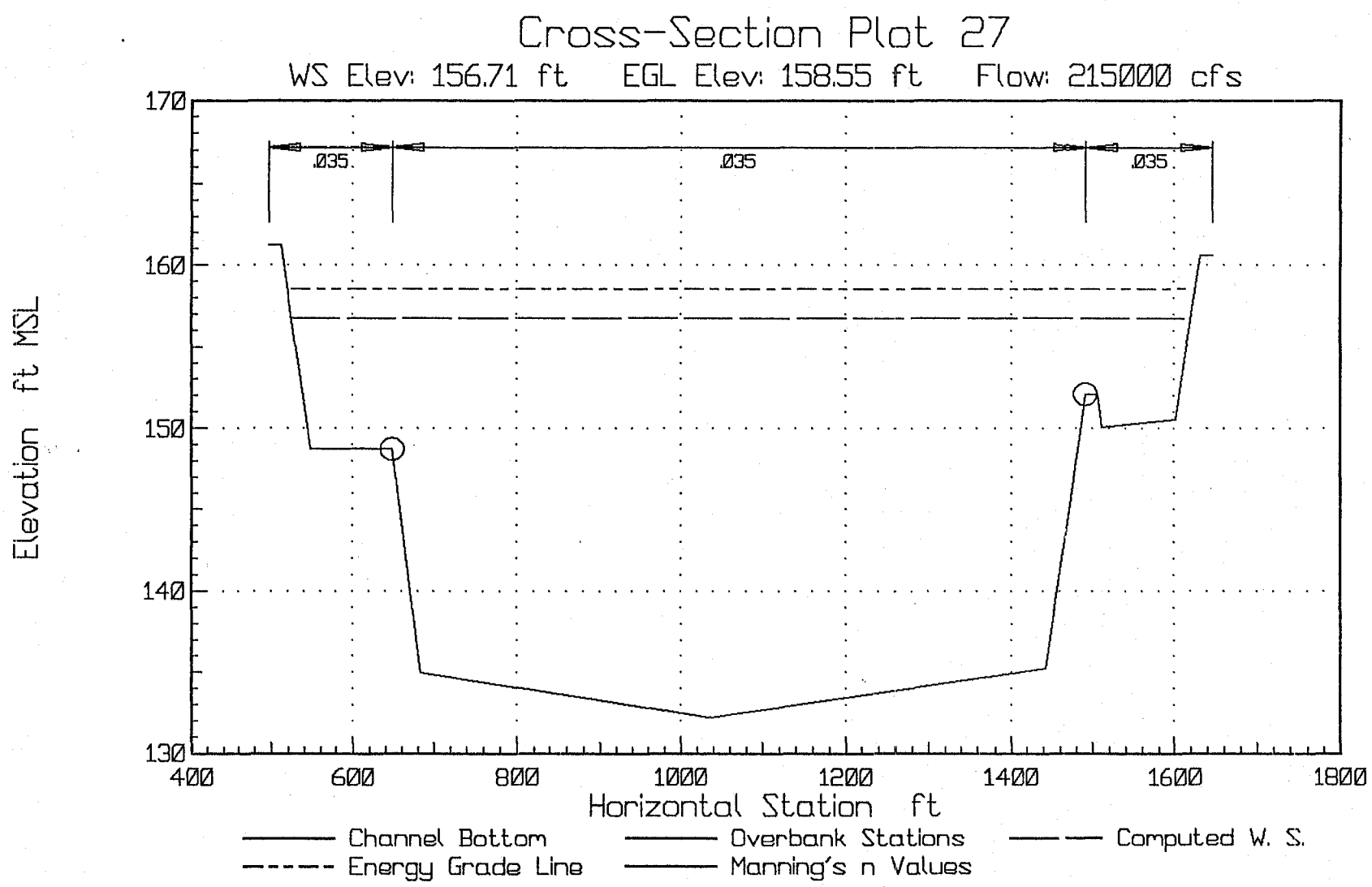

Cross-Section Plot 21.5
WS Elev: 155.08 ft
EGL Elev: 156.75 ft
Flow: 215000 cfs
170
160
150
140
130
Elevation ft MSL
.035
.035
.035
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values

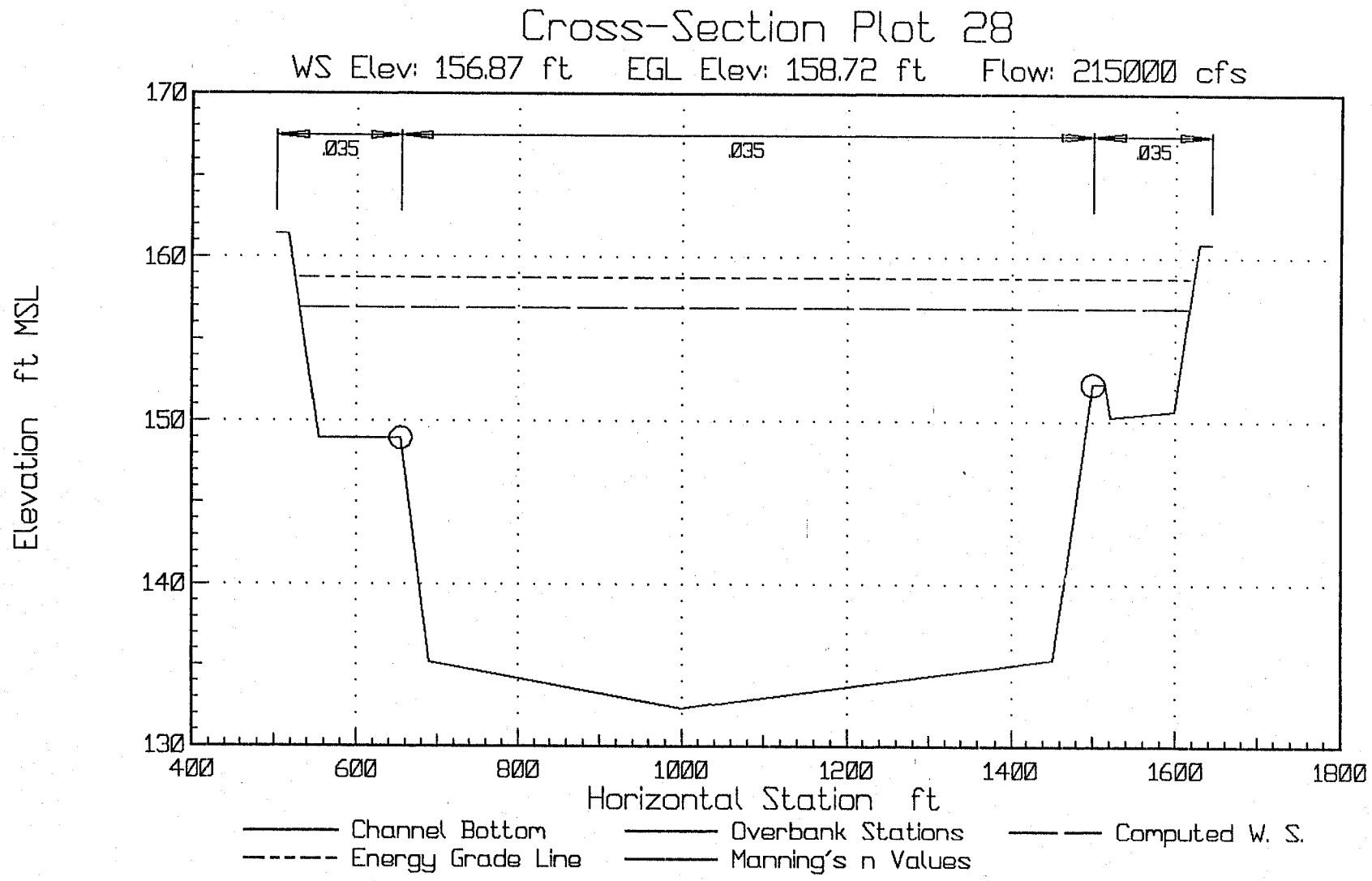

Cross-Section Plot 24
WS Elev: 154.96 ft
EGL Elev: 157.03 ft
Flow: 215000 cfs
.035
.035
.035
170
160
150
140
130
Elevation ft MSL
400
600
800
1000
1200
1400
1600
Horizontal Station ft
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

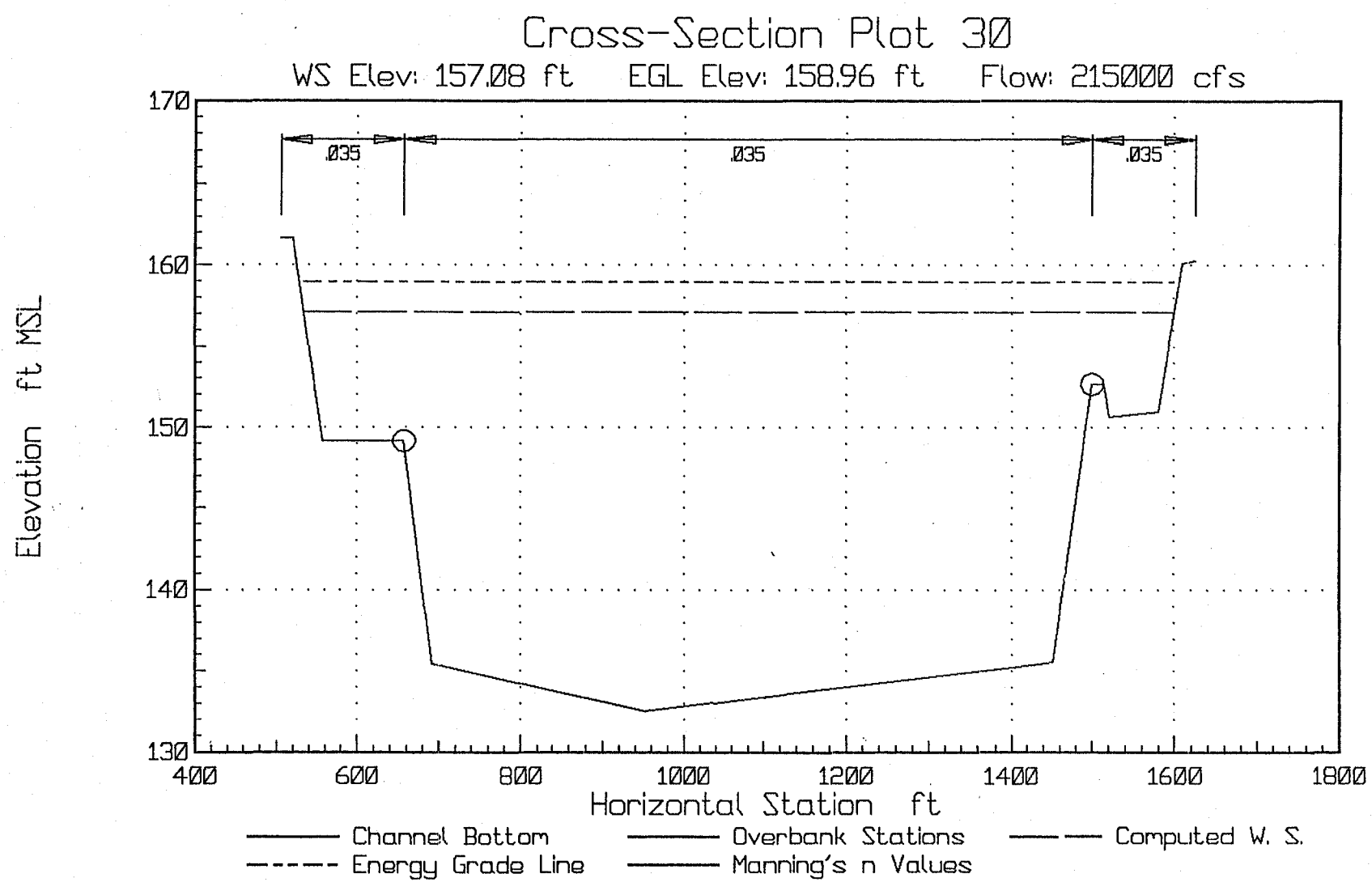

Cross-Section Plot 24.6
WS Elev: 155.79 ft
EGL Elev: 157.66 ft
Flow: 215000 cfs
170
160
150
140
130
Elevation ft MSL
.035
.035
.035
400
600
800
1000
1200
1400
1600
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values

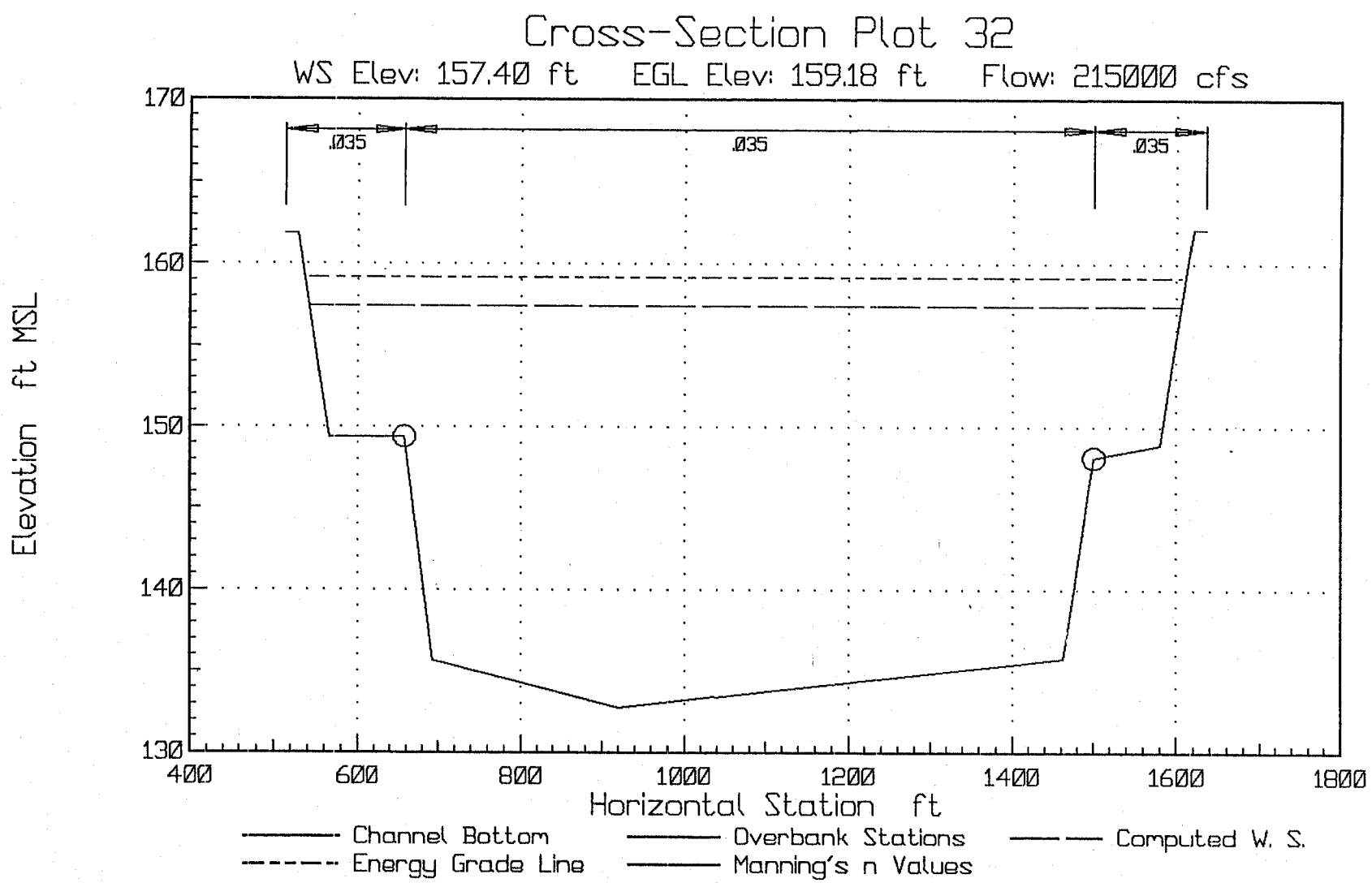

Cross-Section Plot 26
WS Elev: 155.96 ft
EGL Elev: 157.92 ft
Flow: 215000 cfs
.035
.035
.035
170
160
150
140
130
Elevation ft MSL
400
600
800
1000
1200
1400
1600
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values

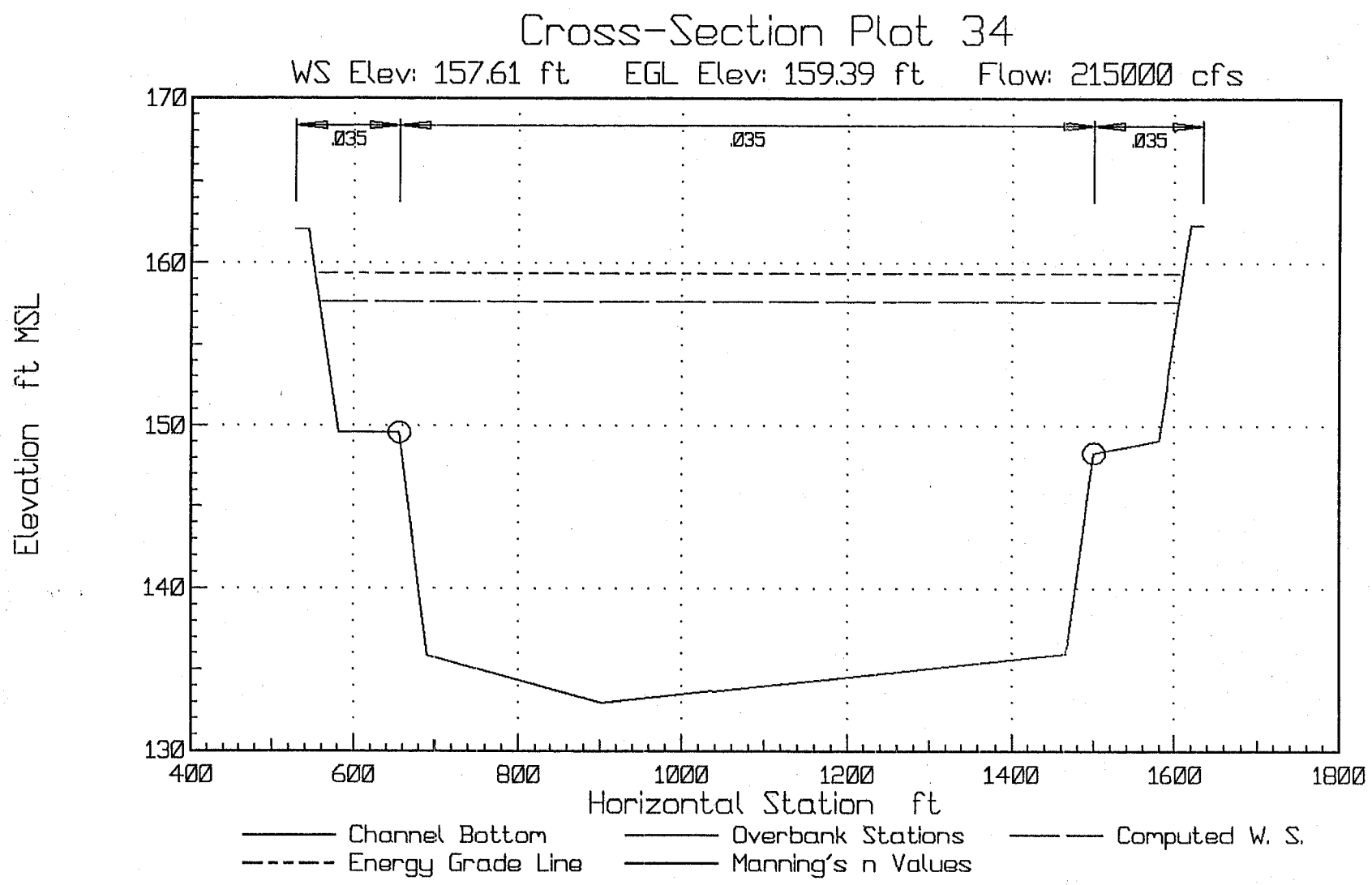

Bridge Cross-Section Plot 26.45
WS Elev: 156.53 ft
EGL Elev: 158.37 ft
Flow: 215000 cfs
Elevation ft MSL
180
170
160
150
140
130
.035
.035
.035
400
600
800
1000
1200
1400
1600
Horizontal Station ft
Channel Bottom
Top of Roadway
Energy Grade Line
Bridge Opening
Overbank Stations
Manning's n Values
Bridge Low Chord
Computed W. S.

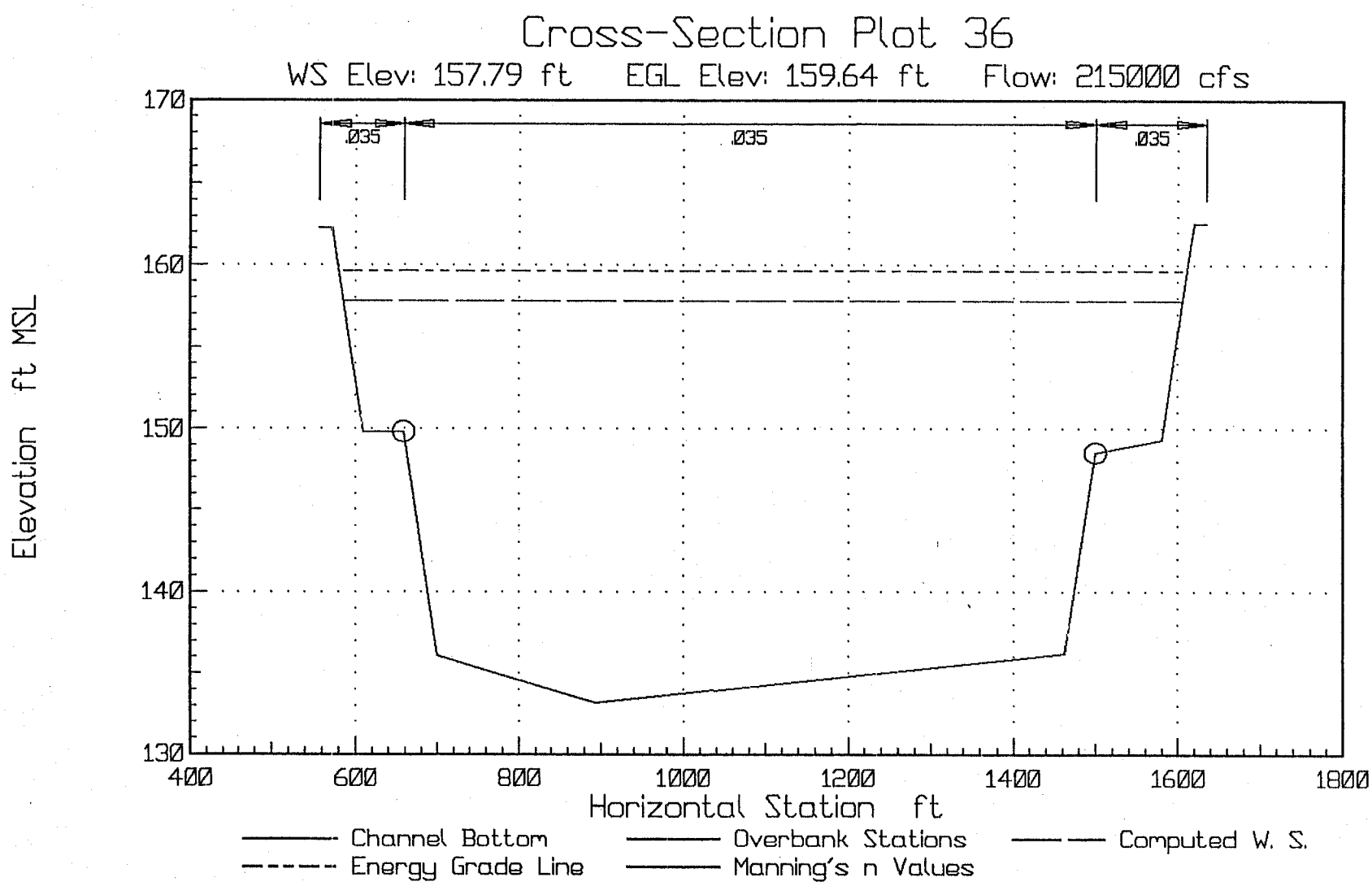

Cross-Section Plot 27
WS Elev: 156.71 ft
EGL Elev: 158.55 ft
Flow: 215000 cfs
.035
.035
.035
170
160
150
140
130
Elevation ft MSL
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

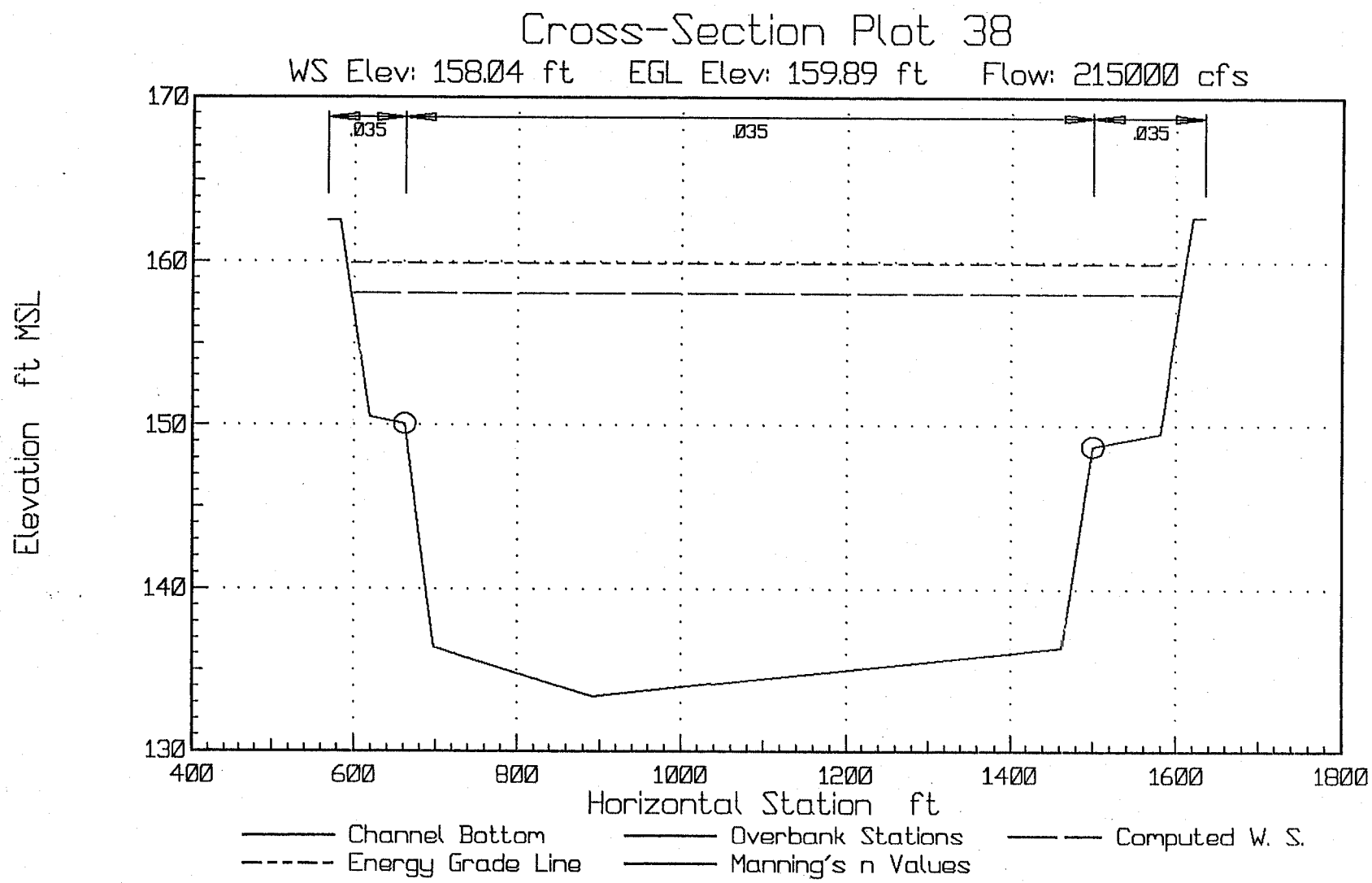

Cross-Section Plot 28
WS Elev: 156.87 ft
EGL Elev: 158.72 ft
Flow: 215000 cfs
.035
.035
.035
170
160
150
140
130
Elevation ft MSL
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values

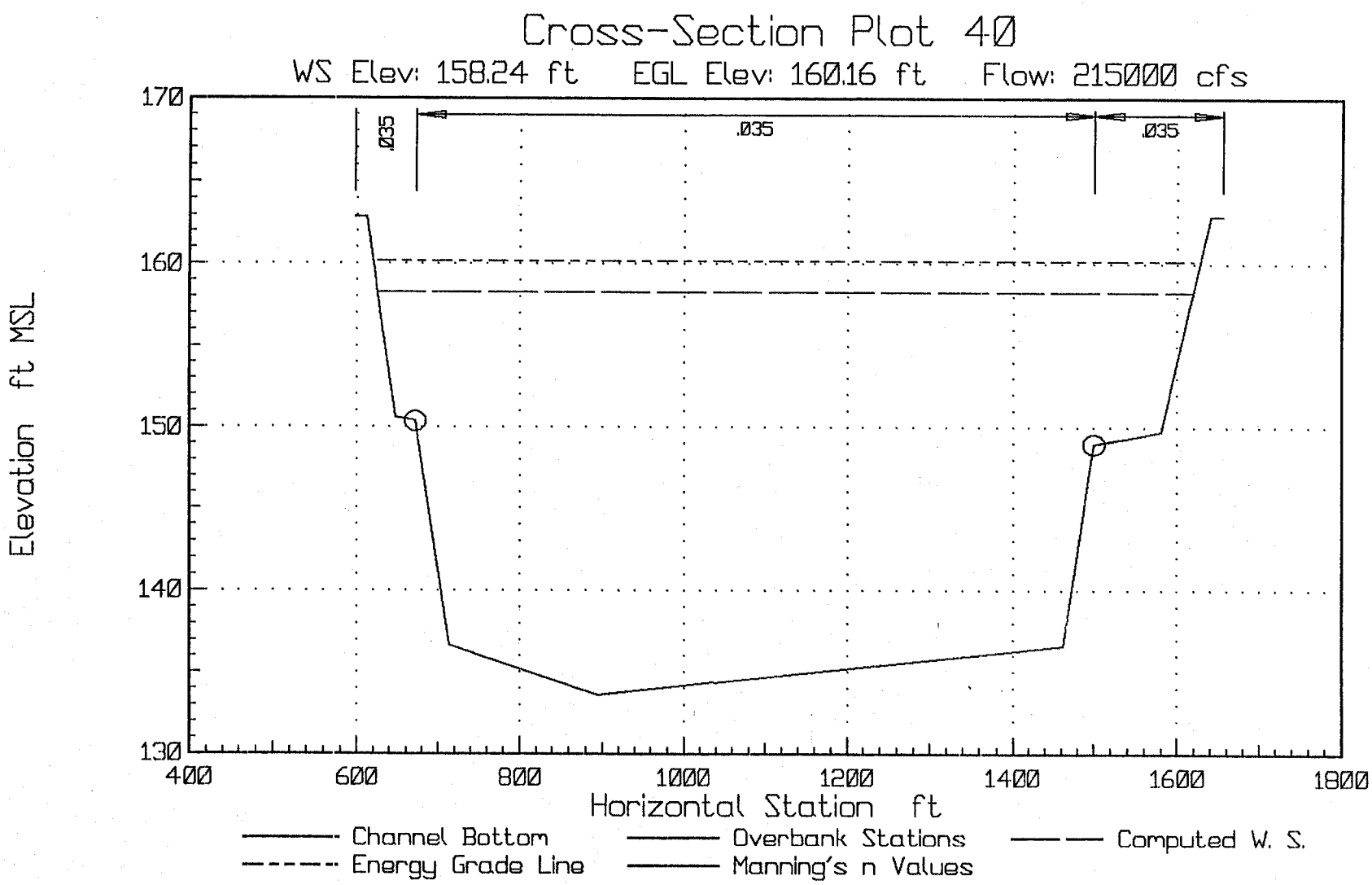

Cross-Section Plot 30
WS Elev: 157.08 ft
EGL Elev: 158.96 ft
Flow: 215000 cfs
.035
.035
.035
170
160
150
140
130
Elevation ft MSL
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values

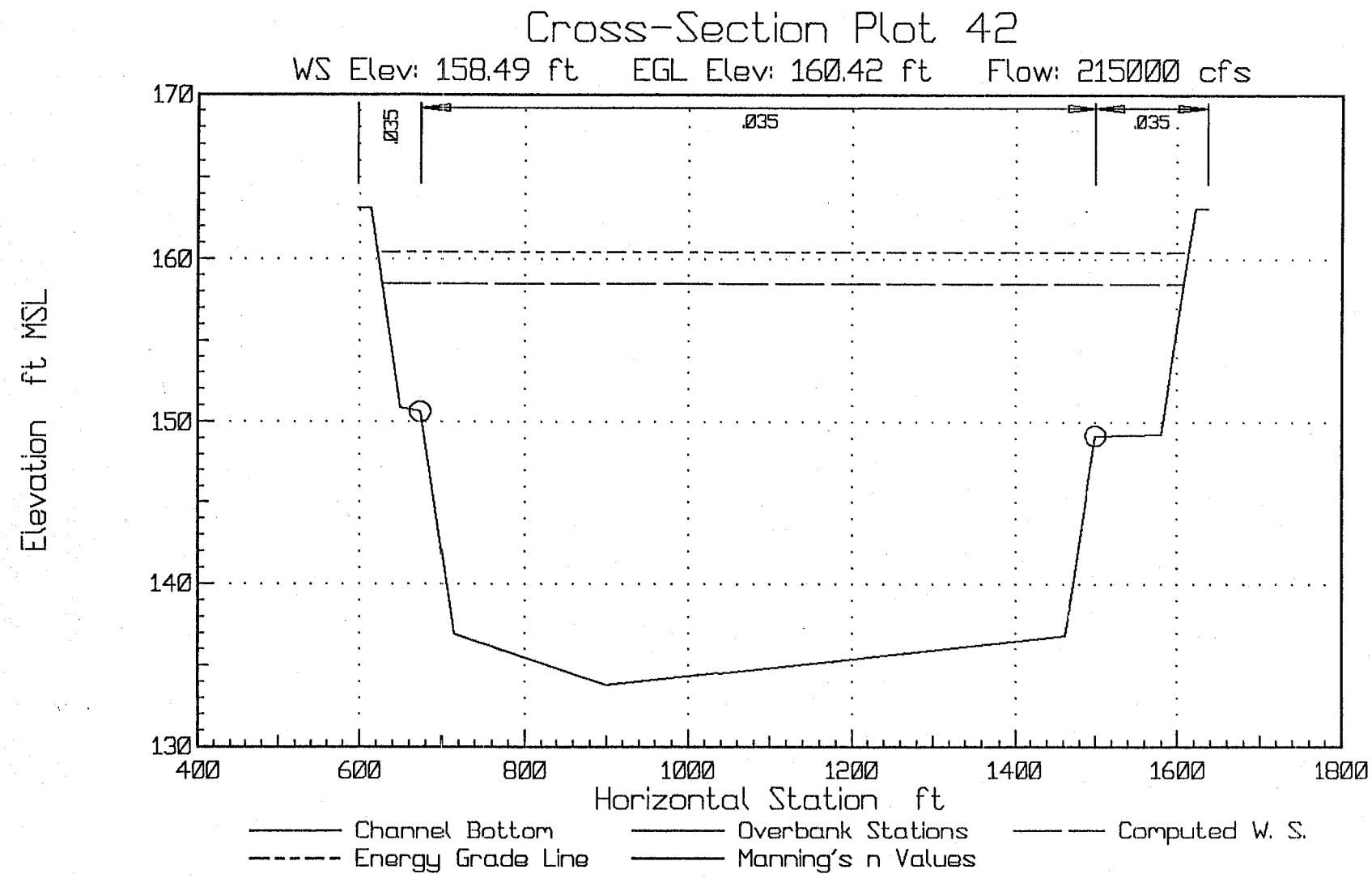

Cross-Section Plot 32
WS Elev: 157.40 ft
EGL Elev: 159.18 ft
Flow: 215000 cfs
.035
.035
.035
170
160
150
140
130
Elevation ft MSL
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

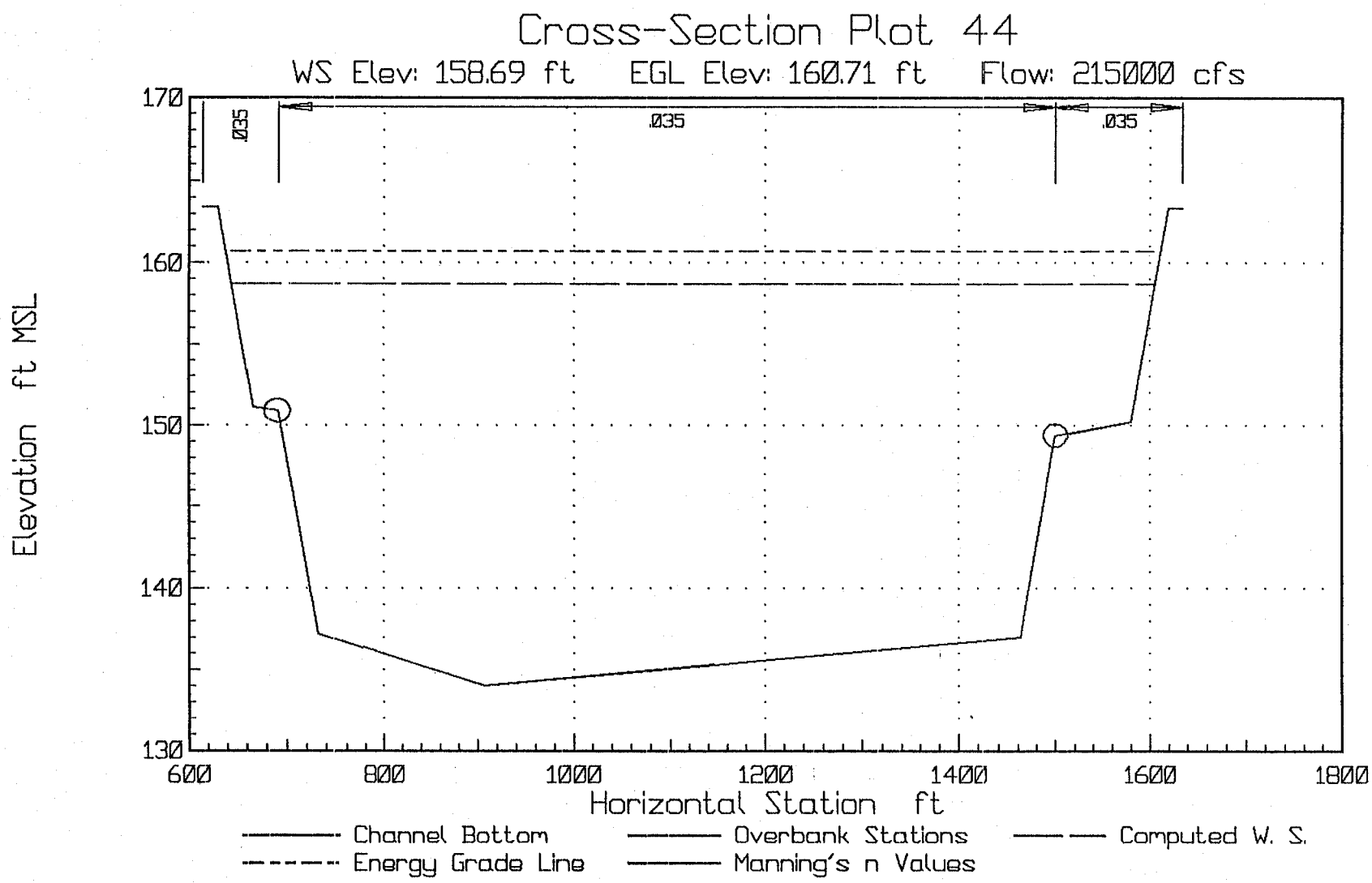

Cross-Section Plot 34
WS Elev: 157.61 ft
EGL Elev: 159.39 ft
Flow: 215000 cfs
.035
.035
.035
170
160
150
140
130
Elevation ft MSL
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values

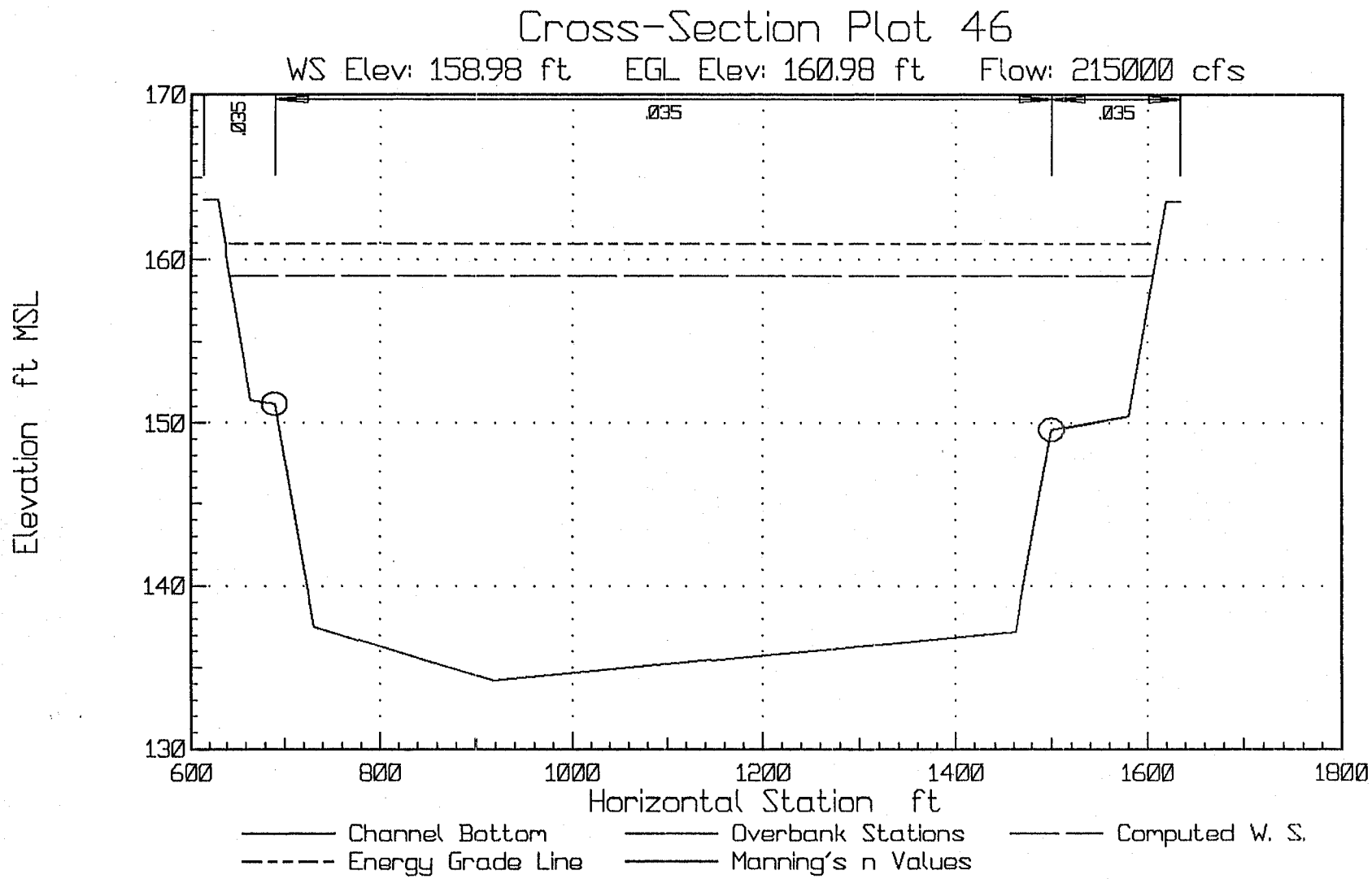

Cross-Section Plot 36
WS Elev: 157.79 ft
EGL Elev: 159.64 ft
Flow: 215000 cfs
.035
.035
.035
170
160
150
140
130
Elevation ft MSL
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

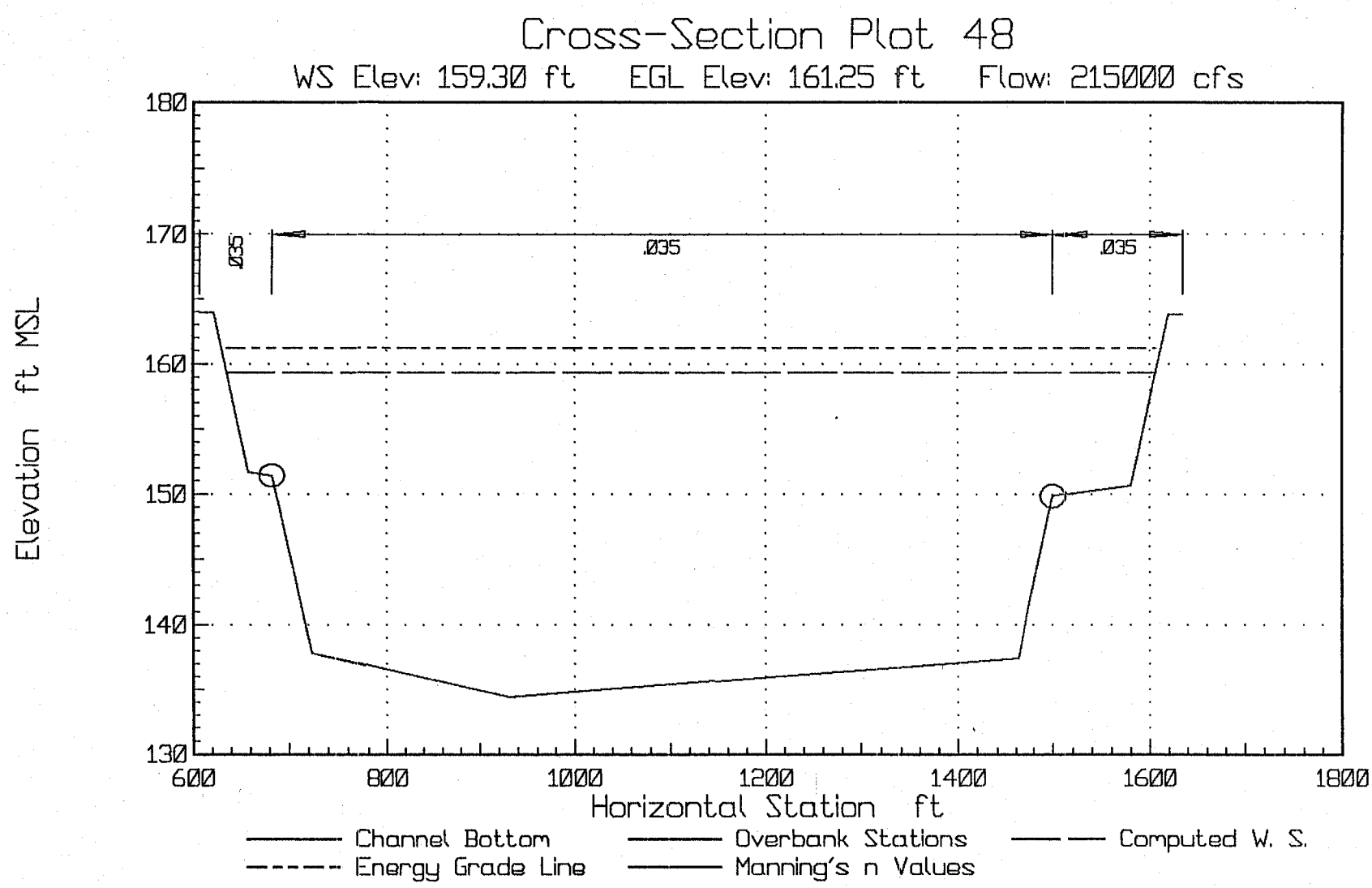

Cross-Section Plot 38
WS Elev: 158.04 ft
EGL Elev: 159.89 ft
Flow: 215000 cfs
.035
.035
.035
170
160
150
140
130
Elevation ft MSL
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

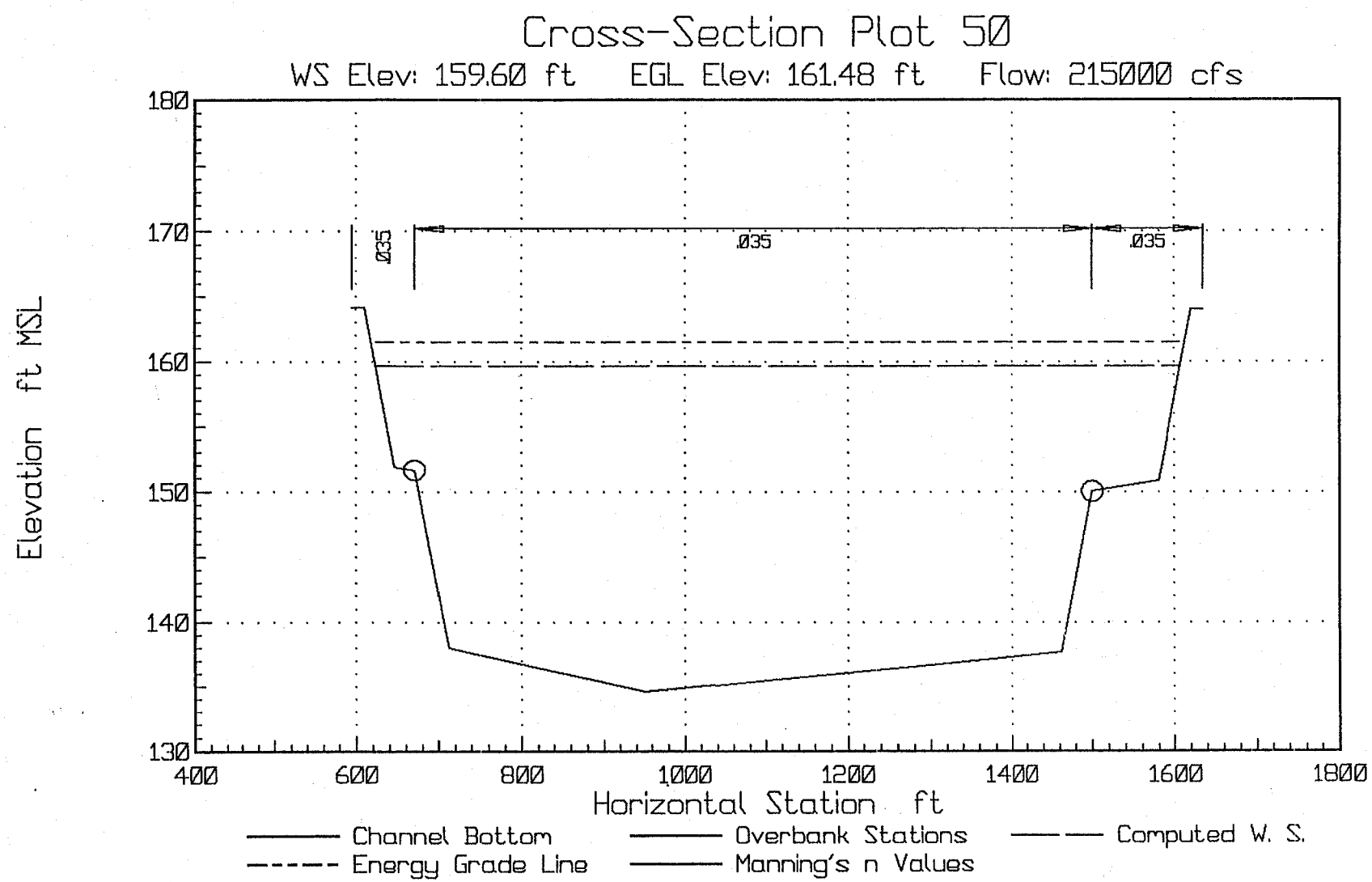

Cross-Section Plot 40
WS Elev: 158.24 ft
EGL Elev: 160.16 ft
Flow: 215000 cfs
.035
.035
.035
170
160
150
140
130
Elevation ft MSL
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

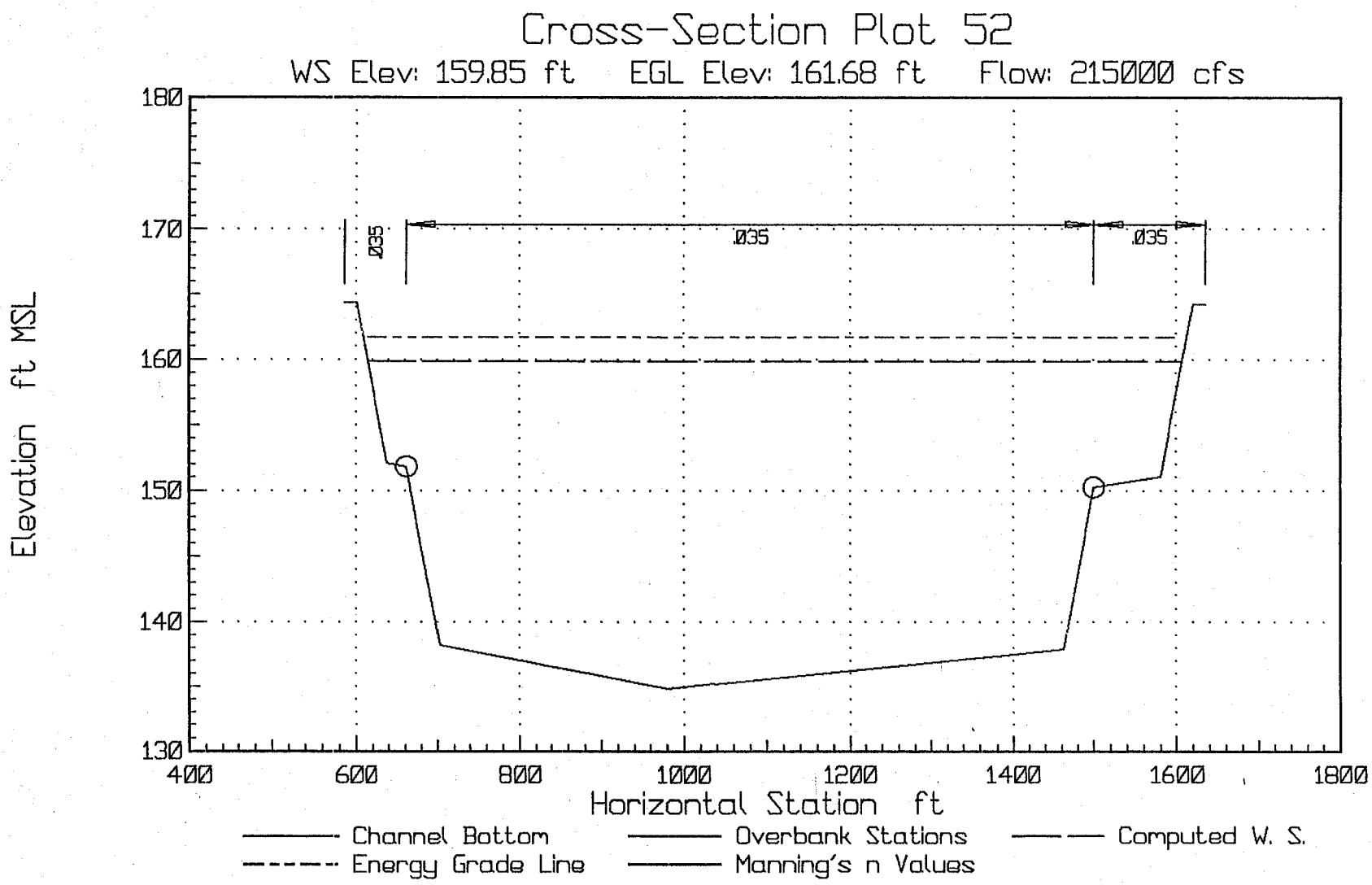

Cross-Section Plot 42
WS Elev: 158.49 ft
EGL Elev: 160.42 ft
Flow: 215000 cfs
.035
.035
.035
170
160
150
140
130
Elevation ft MSL
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values

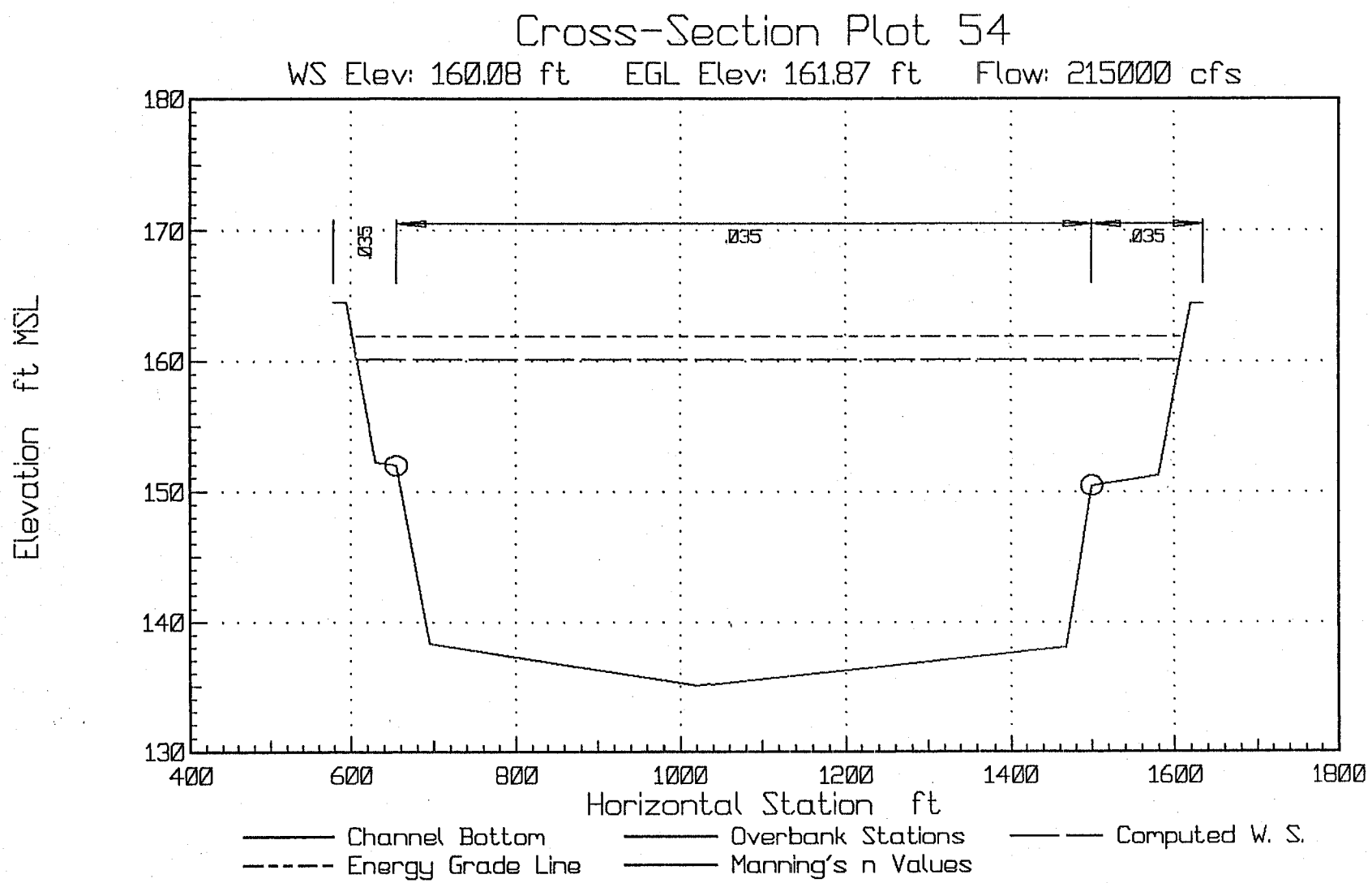

Cross-Section Plot 44
WS Elev: 158.69 ft EGL Elev: 160.71 ft Flow: 215000 cfs
.035
.035
.035
170
160
150
140
130
Elevation ft MSL
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values

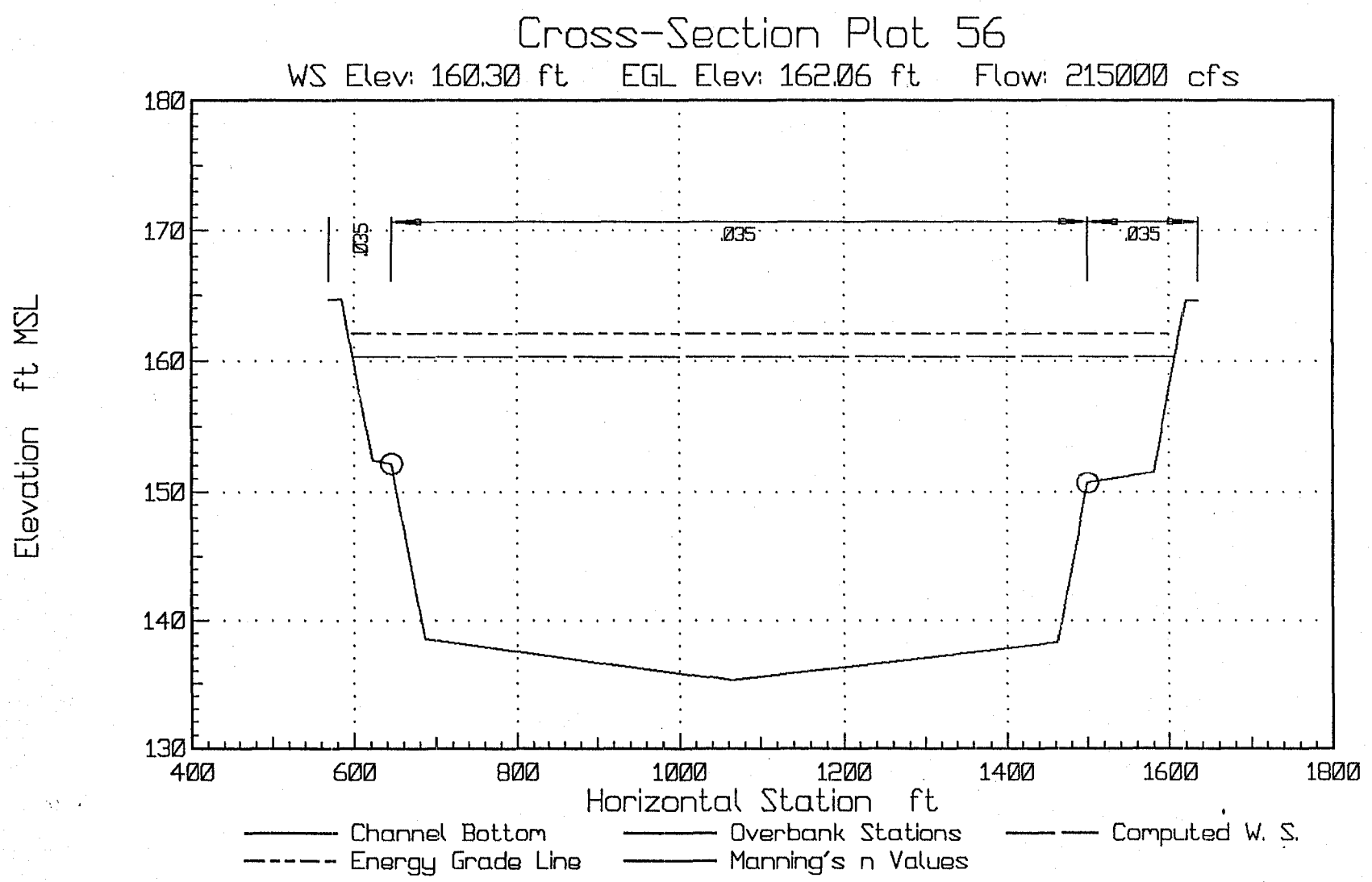

Cross-Section Plot 46
WS Elev: 158.98 ft
EGL Elev: 160.98 ft
Flow: 215000 cfs
.035
.035
.035
170
160
150
140
130
Elevation ft MSL
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

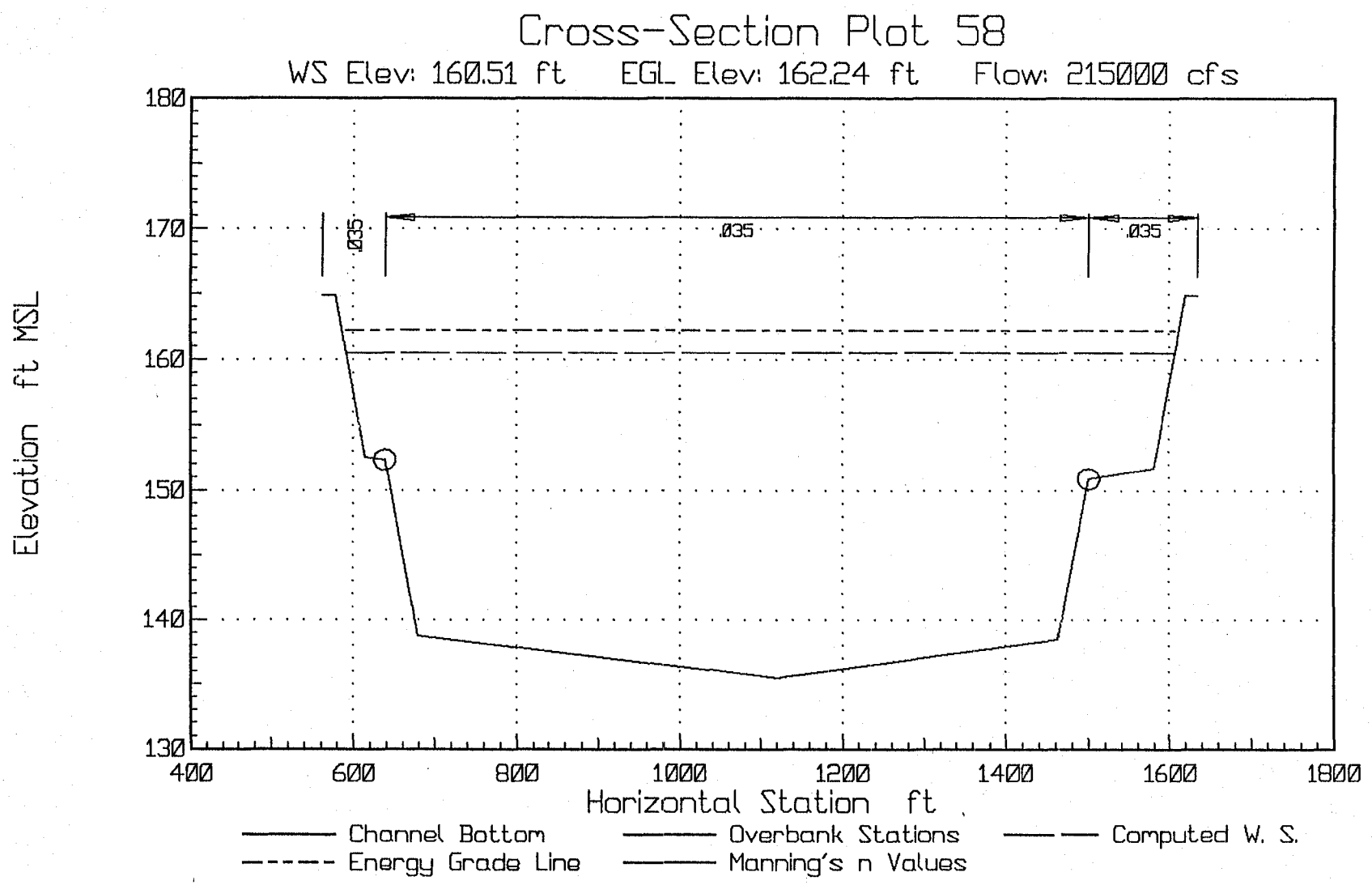

Cross-Section Plot 48
WS Elev: 159.30 ft
EGL Elev: 161.25 ft
Flow: 215000 cfs
Elevation ft MSL
180
170
160
150
140
130
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
.035
.035
.035
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

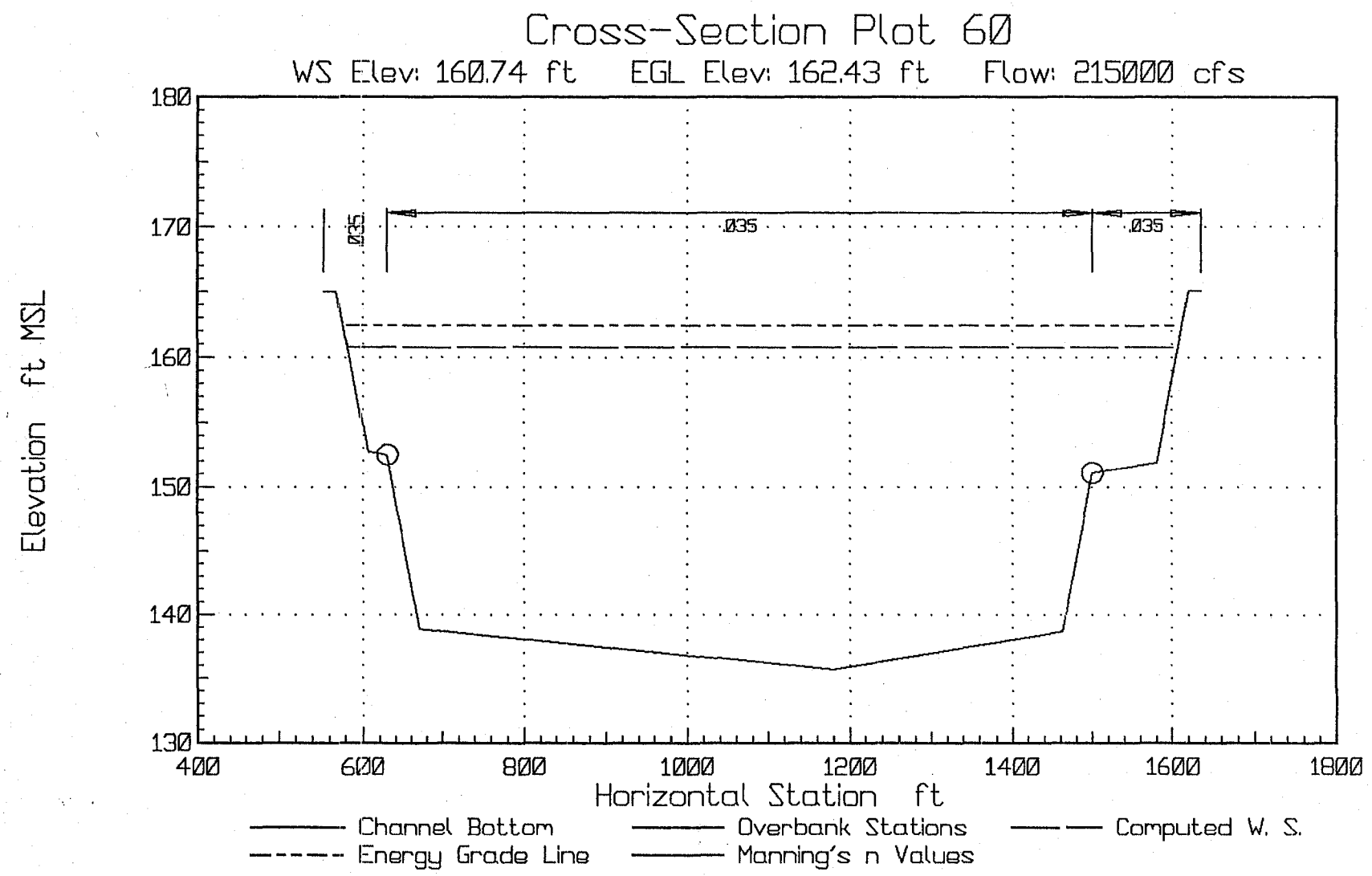

Cross-Section Plot 50
WS Elev: 159.60 ft
EGL Elev: 161.48 ft
Flow: 215000 cfs
Elevation ft MSL
180
170
160
150
140
130
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
.035
.035
.035
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

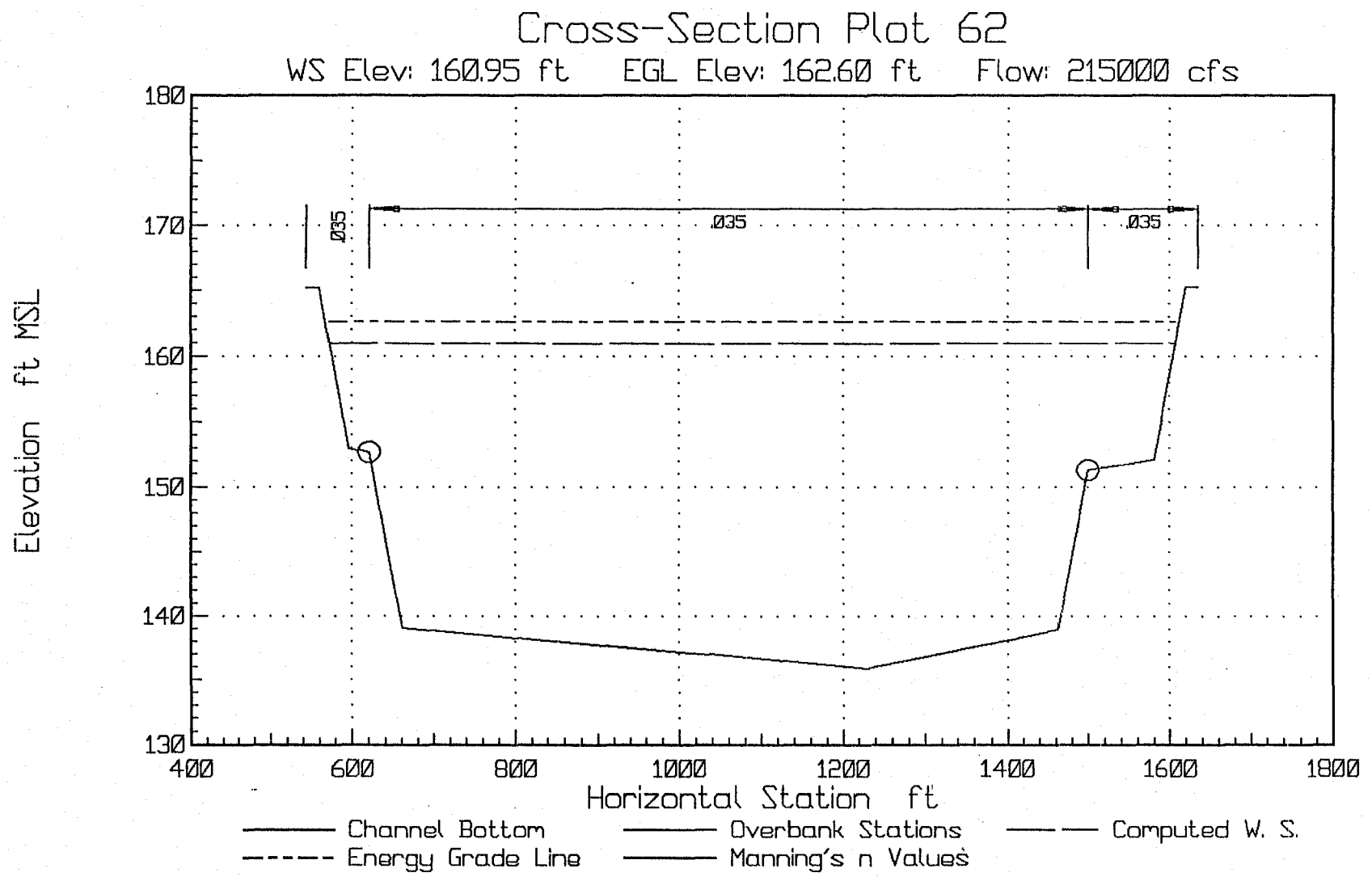

Cross-Section Plot 52
WS Elev: 159.85 ft
EGL Elev: 161.68 ft
Flow: 215000 cfs
Elevation ft MSL
180
170
160
150
140
130
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
.035
.035
.035
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values

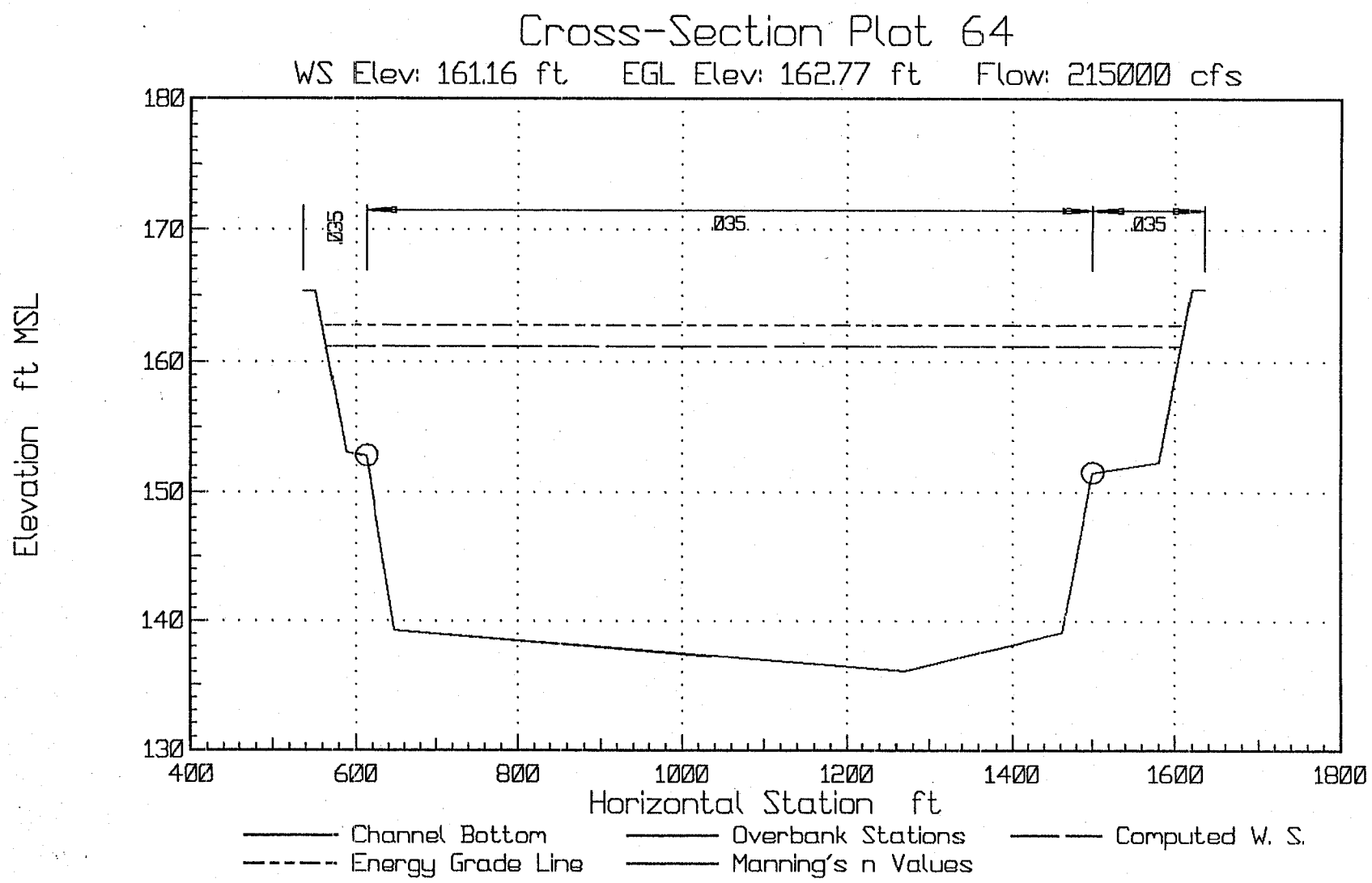

Cross-Section Plot 54
WS Elev: 160.08 ft
EGL Elev: 161.87 ft
Flow: 215000 cfs
Elevation ft MSL
180
170
160
150
140
130
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
.035
.035
.035
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

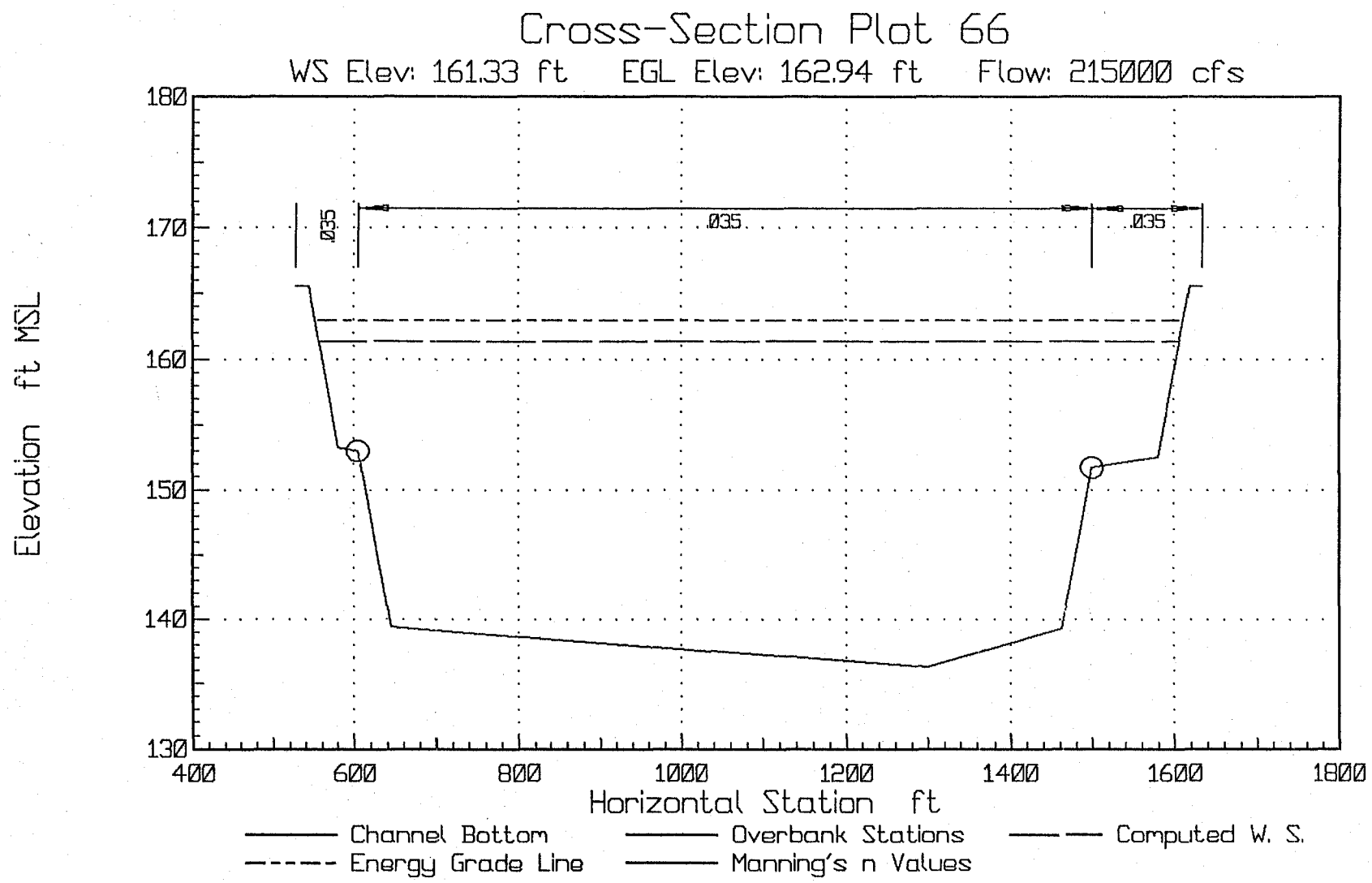

Cross-Section Plot 56
WS Elev: 160.30 ft EGL Elev: 162.06 ft Flow: 215000 cfs
Elevation ft MSL
180
170
160
150
140
130
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
.035
.035
.035
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

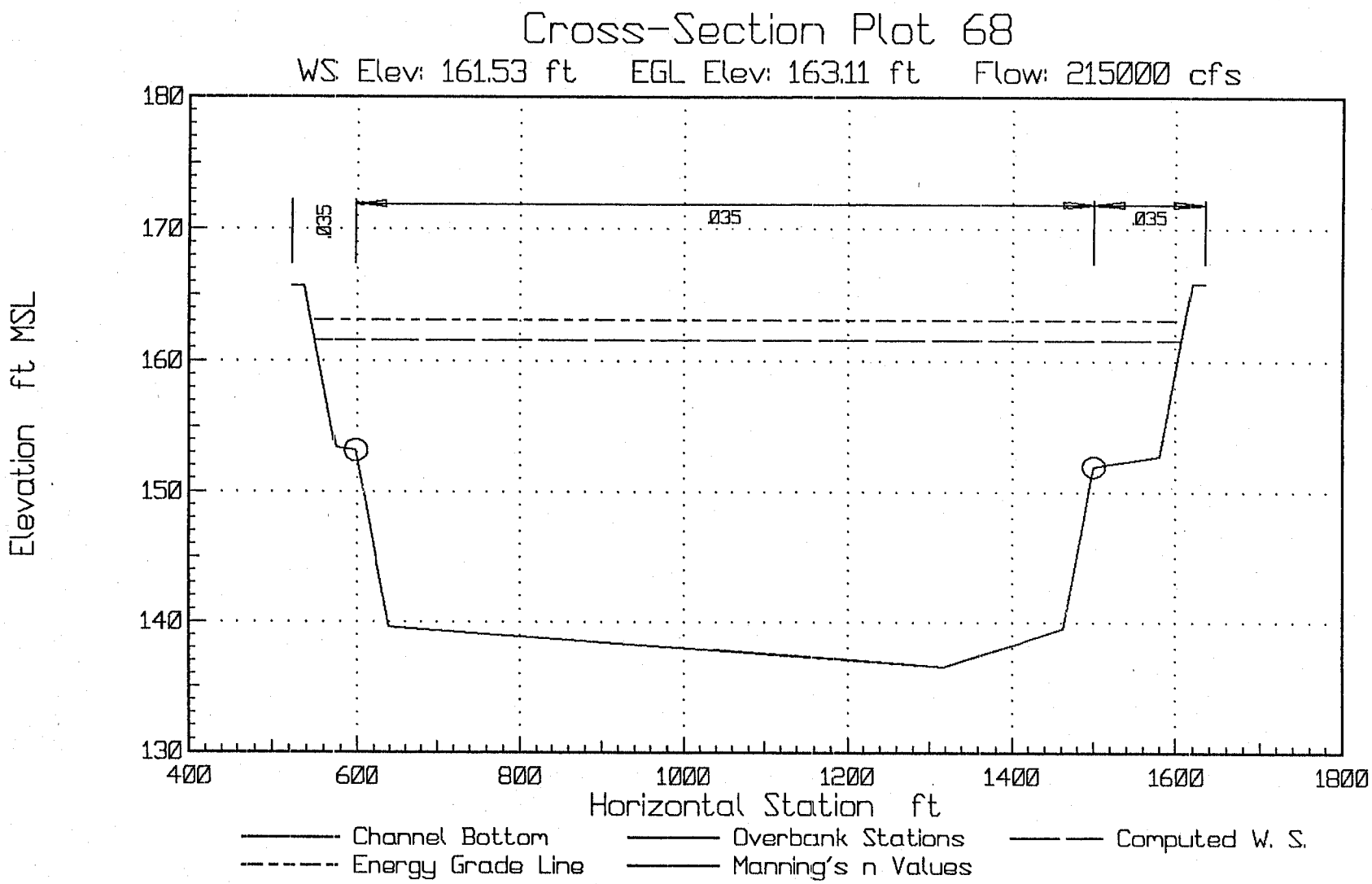

Cross-Section Plot 58
WS Elev: 160.51 ft
EGL Elev: 162.24 ft
Flow: 215000 cfs
Elevation ft MSL
180
170
160
150
140
130
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
.035
.035
.035
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values

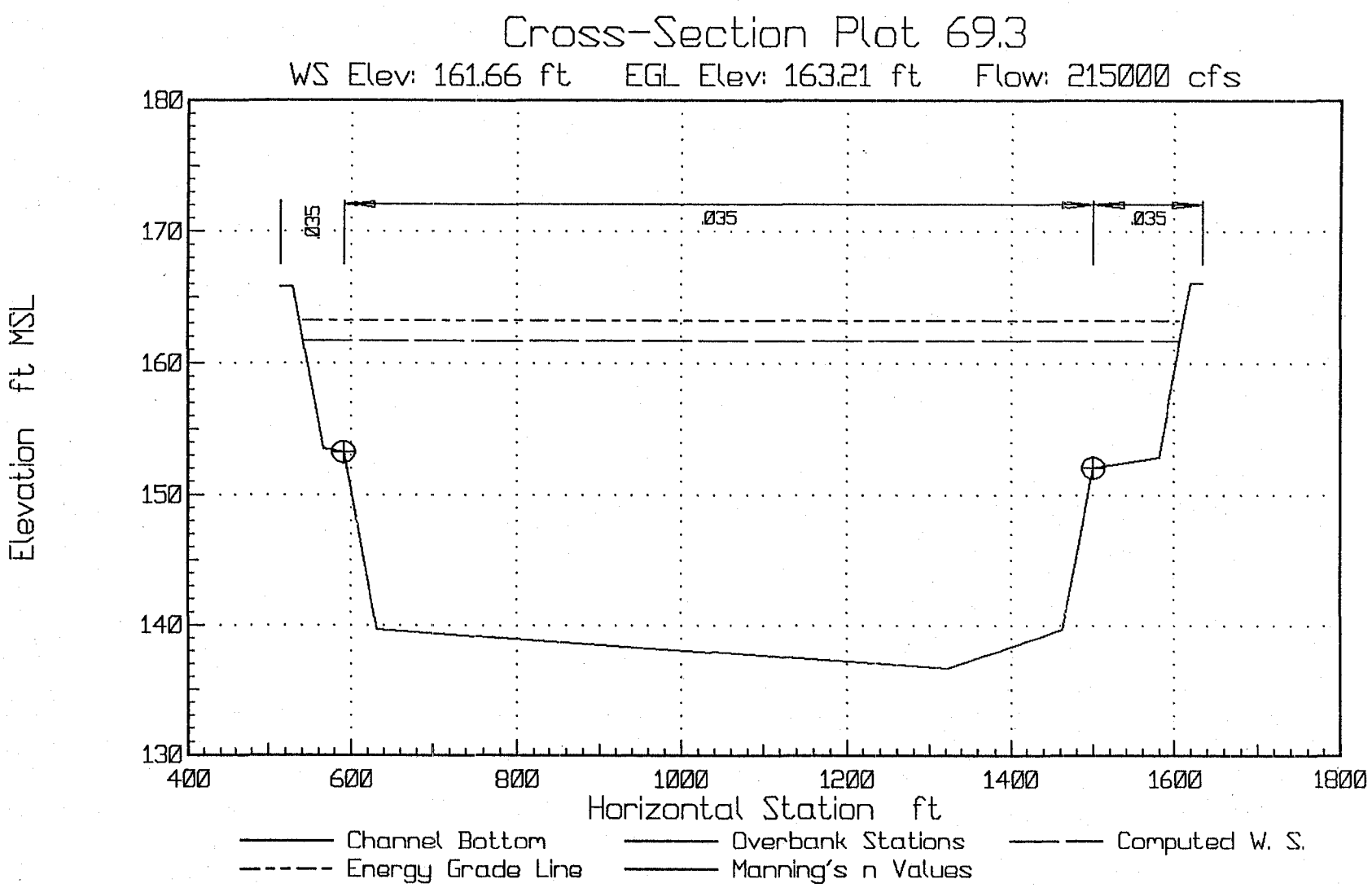

Cross-Section Plot 60
WS Elev: 160.74 ft
EGL Elev: 162.43 ft
Flow: 215000 cfs
Elevation ft MSL
180
170
160
150
140
130
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
.035
.035
.035
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

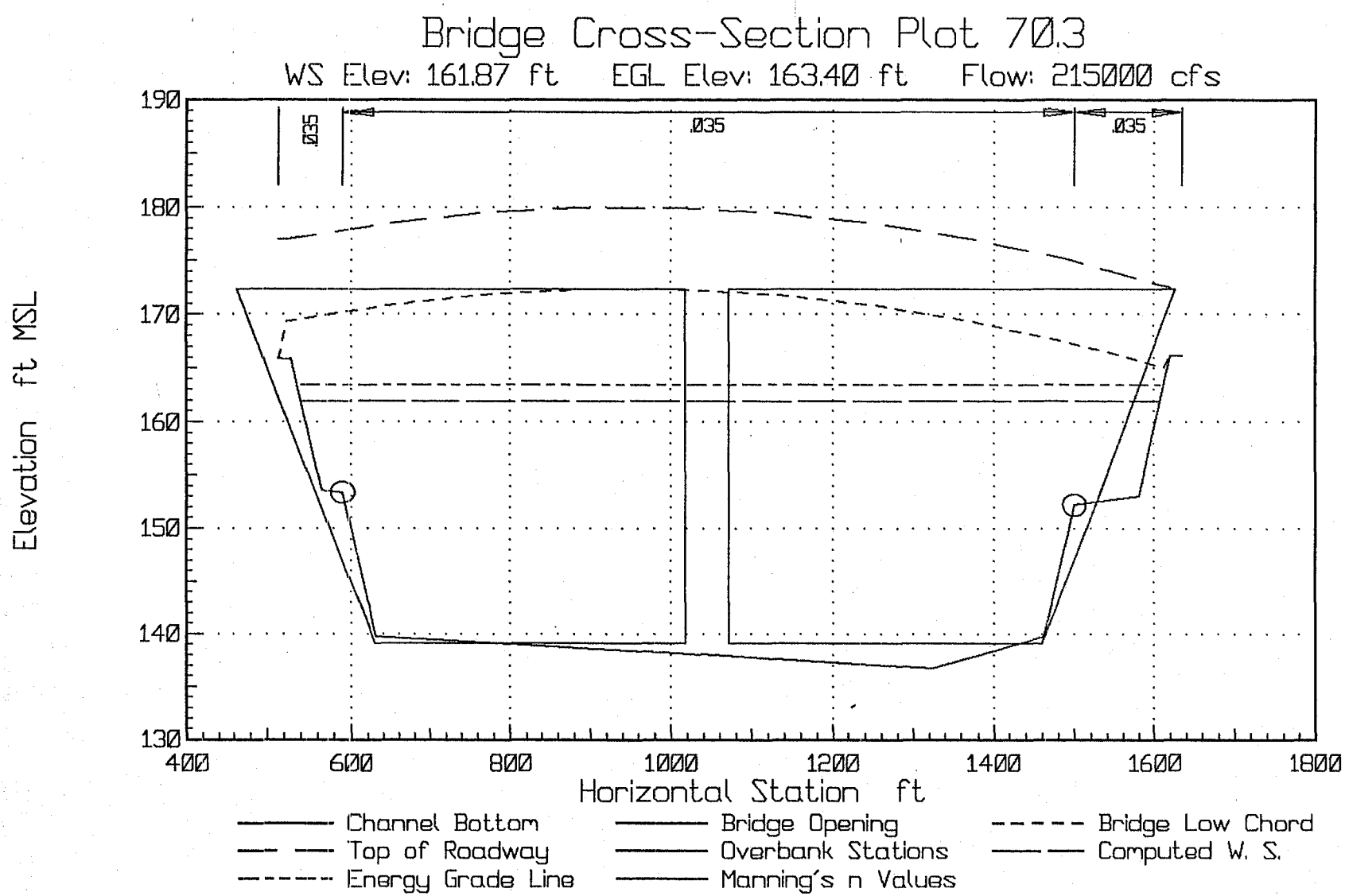

Cross-Section Plot 62
WS Elev: 160.95 ft
EGL Elev: 162.60 ft
Flow: 215000 cfs
Elevation ft MSL
180
170
160
150
140
130
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
.035
.035
.035
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values

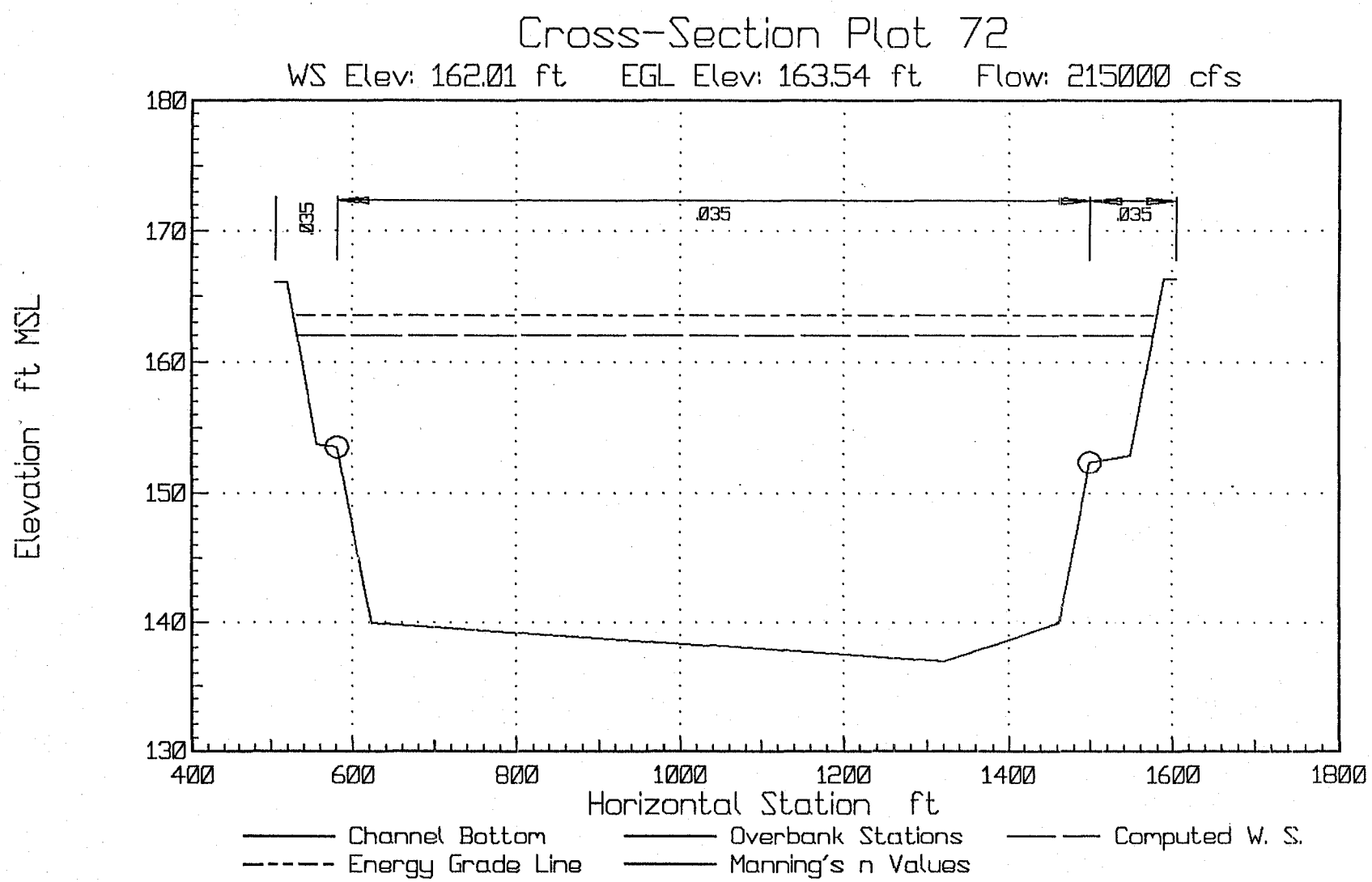

Cross-Section Plot 64
WS Elev: 161.16 ft
EGL Elev: 162.77 ft
Flow: 215000 cfs
Elevation ft MSL
180
170
160
150
140
130
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
.035
.035
.035
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

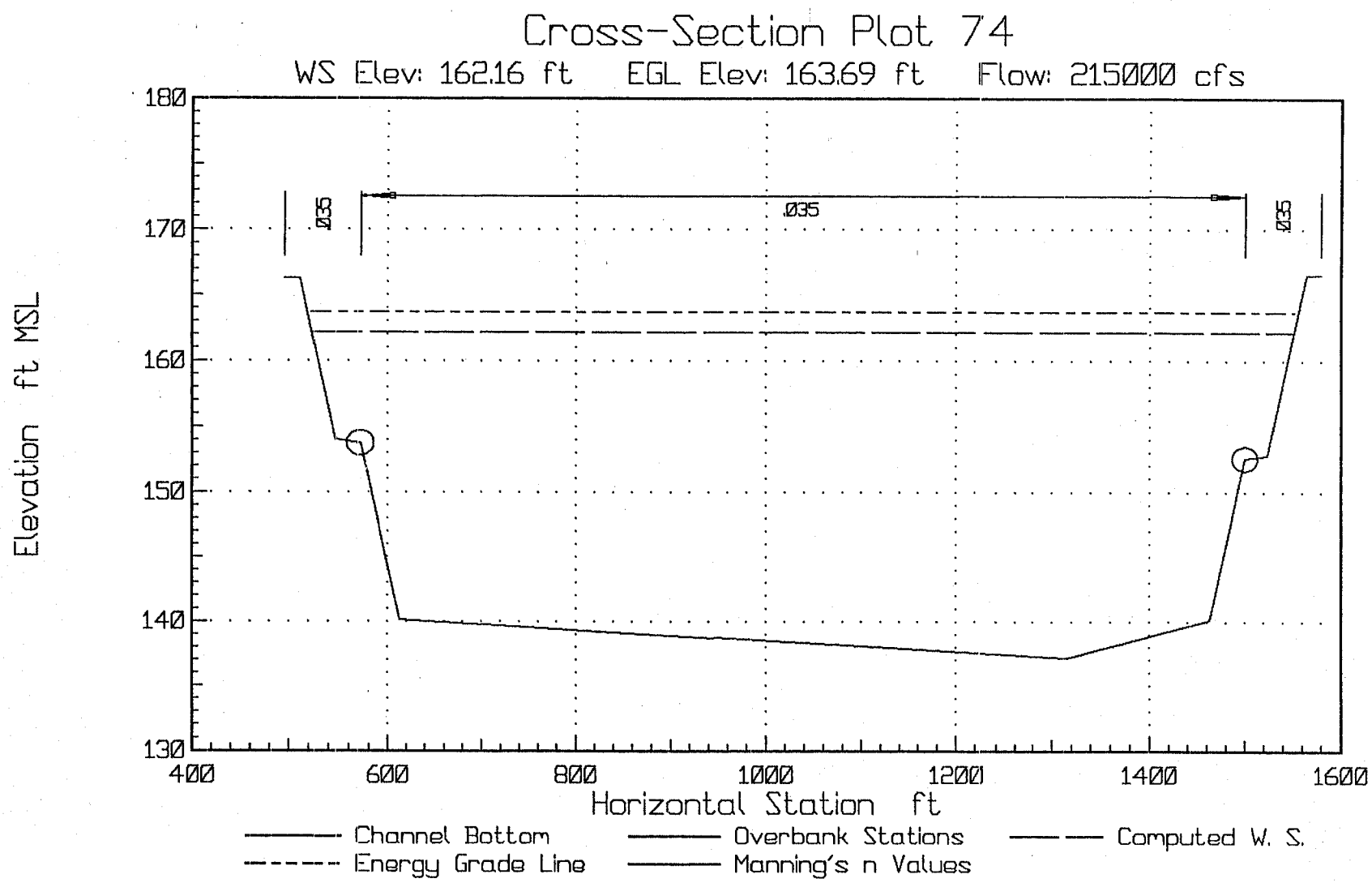

Cross-Section Plot 66
WS Elev: 161.33 ft
EGL Elev: 162.94 ft
Flow: 215000 cfs
Elevation ft MSL
180
170
160
150
140
130
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
.035
.035
.035
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values

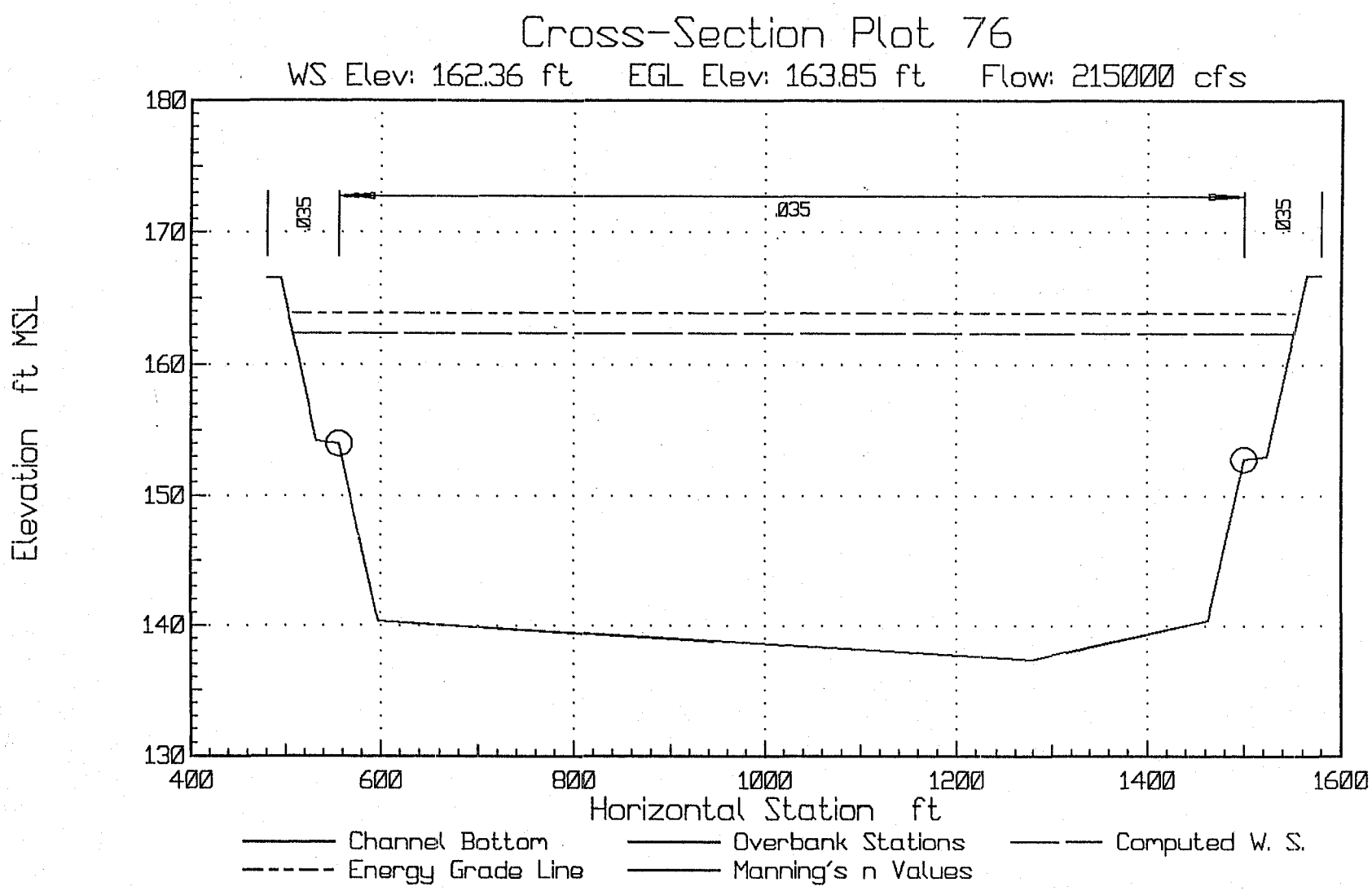

Cross-Section Plot 68
WS Elev: 161.53 ft
EGL Elev: 163.11 ft
Flow: 215000 cfs
Elevation ft MSL
180
170
160
150
140
130
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
.035
.035
.035
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

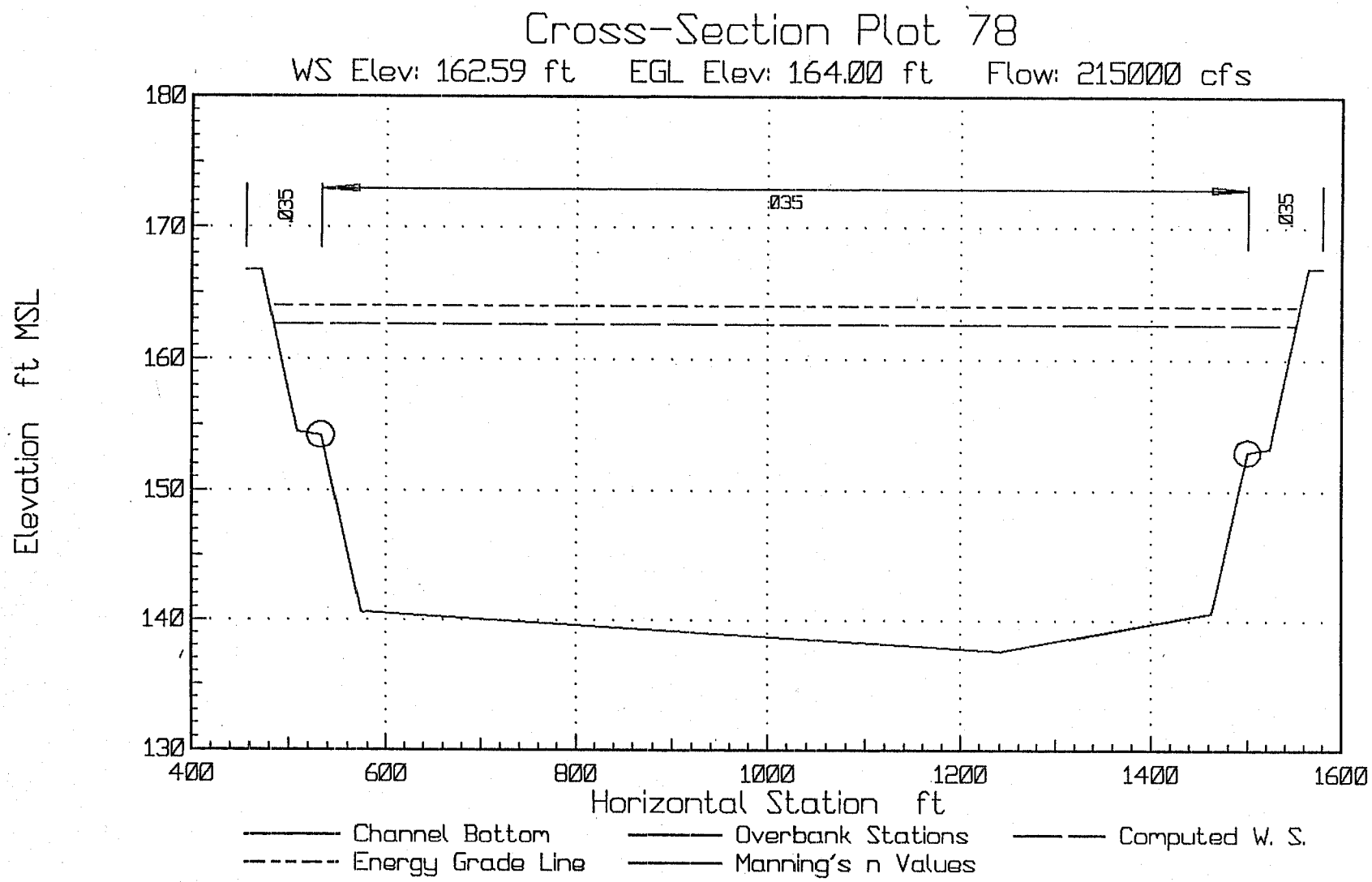

Cross-Section Plot 69.3
WS Elev: 161.66 ft
EGL Elev: 163.21 ft
Flow: 215000 cfs
Elevation ft MSL
180
170
160
150
140
130
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
.035
.035
.035
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

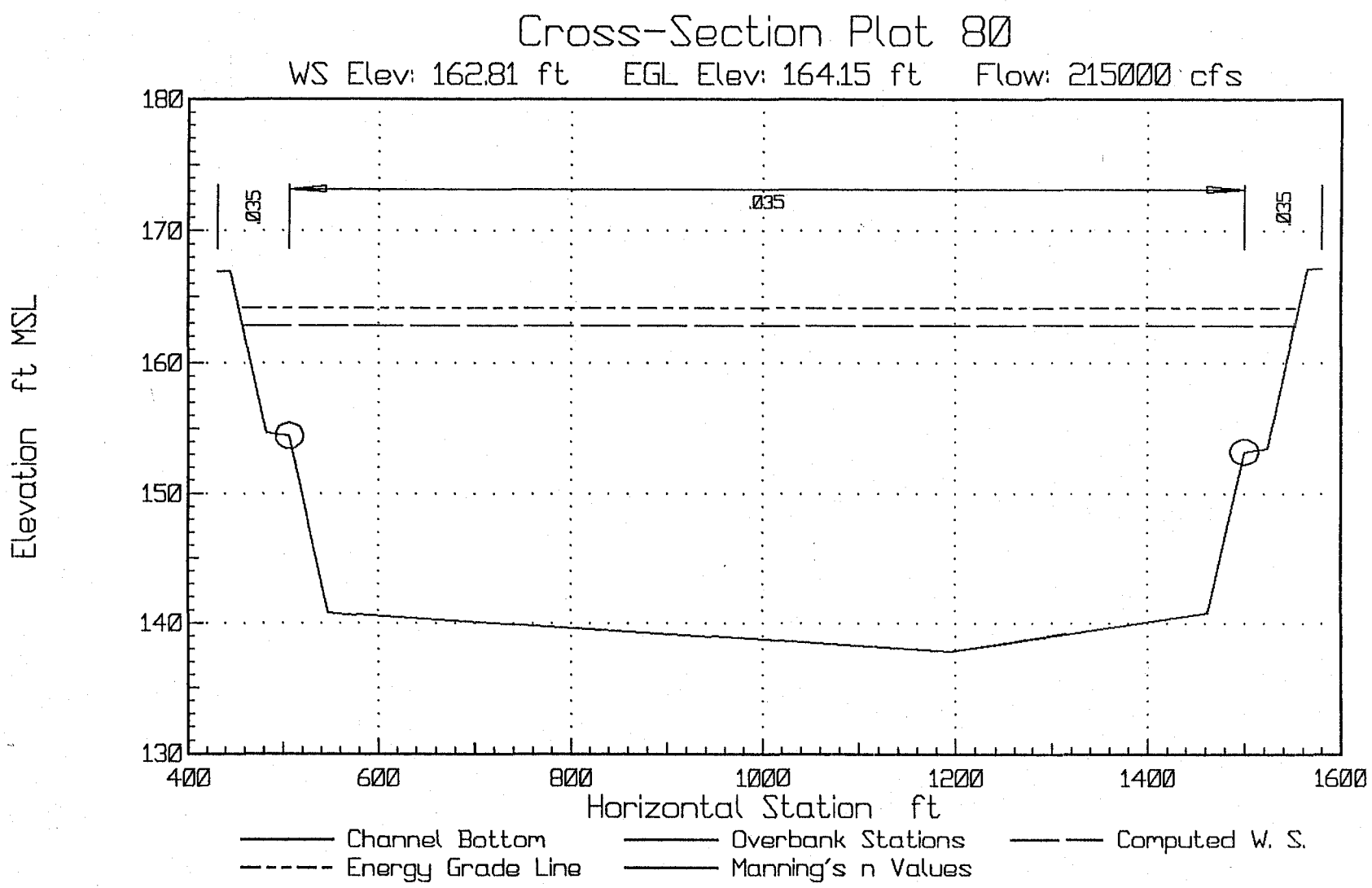

Bridge Cross-Section Plot 70.3
WS Elev: 161.87 ft
EGL Elev: 163.40 ft
Flow: 215000 cfs
.035
.035
.035
190
180
170
160
150
140
130
Elevation ft MSL
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
Channel Bottom
Top of Roadway
Energy Grade Line
Bridge Opening
Overbank Stations
Manning's n Values
Bridge Low Chord
Computed W. S.

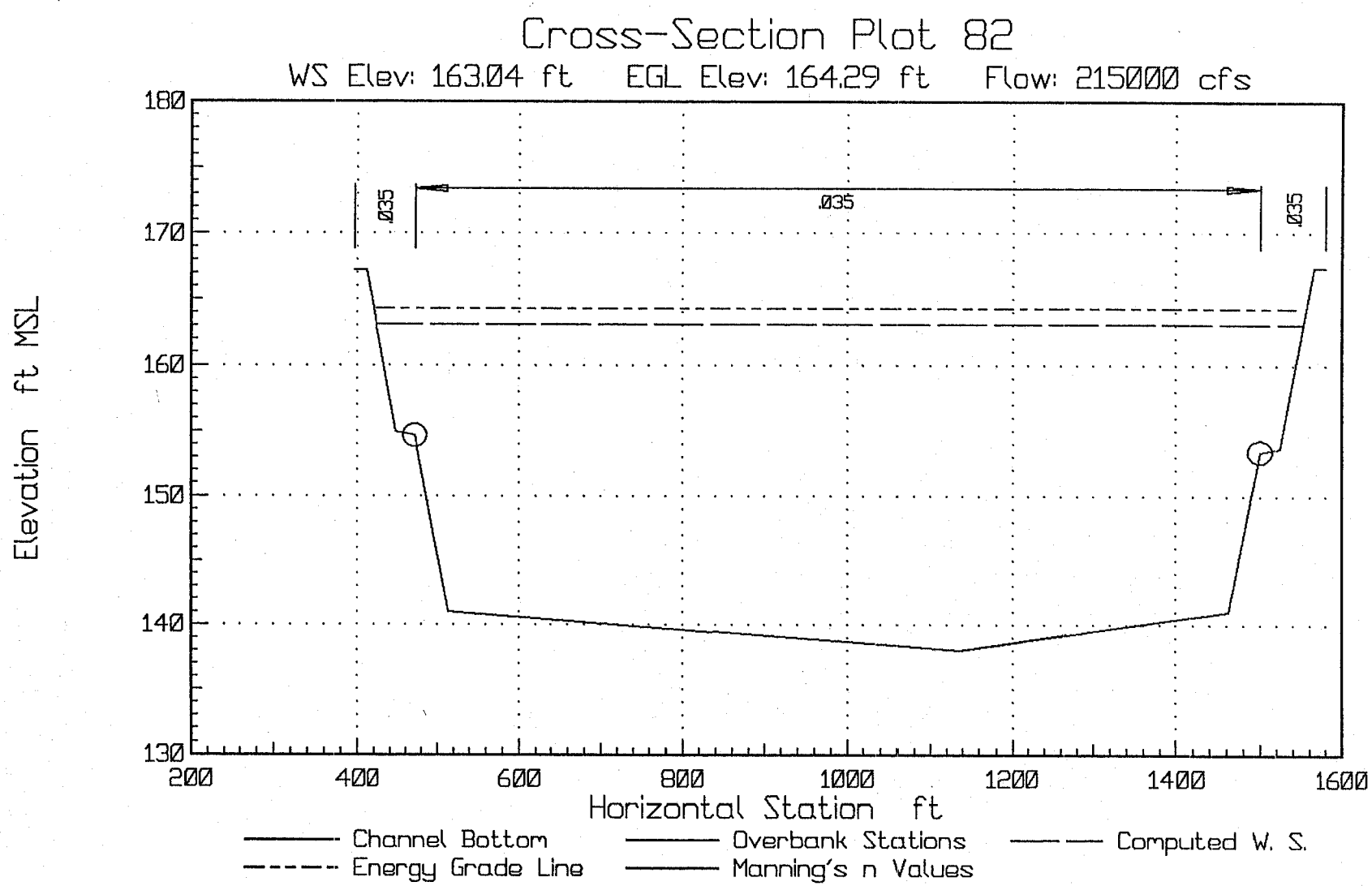

Cross-Section Plot 72
WS Elev: 162.01 ft
EGL Elev: 163.54 ft
Flow: 215000 cfs
Elevation ft MSL
180
170
160
150
140
130
400
600
800
1000
1200
1400
1600
1800
Horizontal Station ft
.035
.035
.035
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values

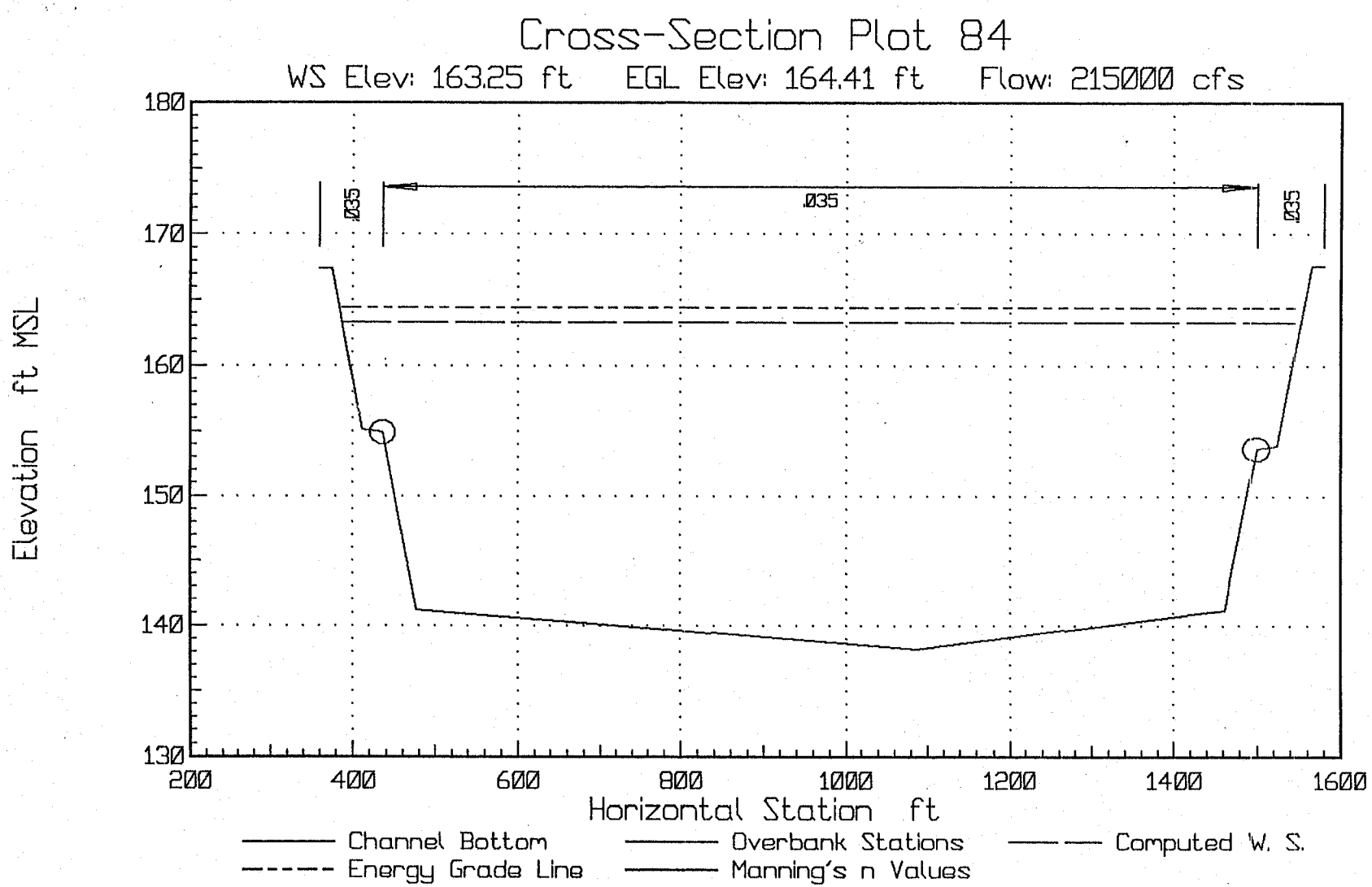

Cross-Section Plot 74
WS Elev: 162.16 ft
EGL Elev: 163.69 ft
Flow: 215000 cfs
Elevation ft MSL
180
170
160
150
140
130
400
600
800
1000
1200
1400
1600
Horizontal Station ft
.035
.035
.035
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

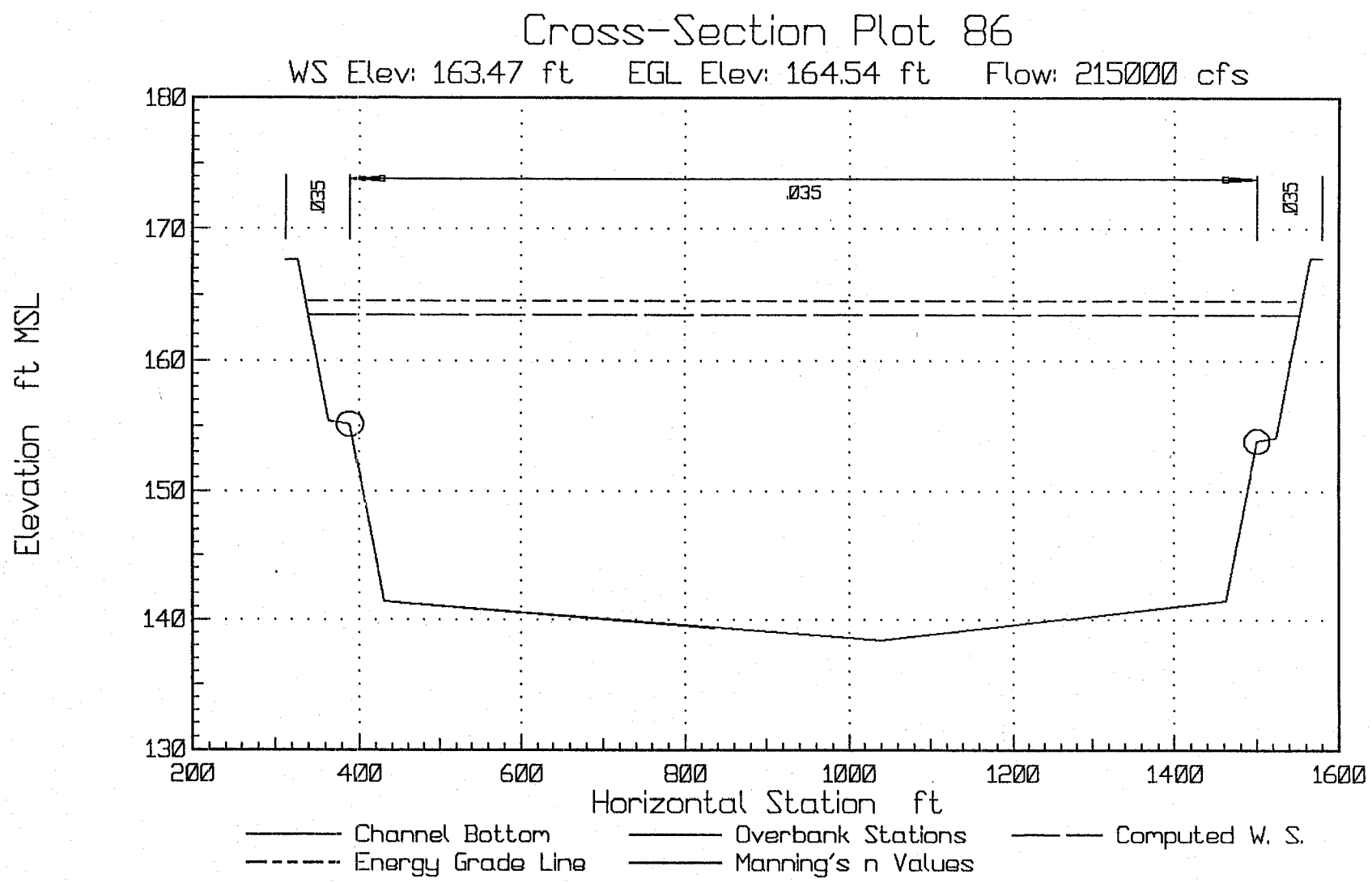

Cross-Section Plot 76
WS Elev: 162.36 ft
EGL Elev: 163.85 ft
Flow: 215000 cfs
.035
.035
.035
180
170
160
150
140
130
Elevation ft MSL
400
600
800
1000
1200
1400
1600
Horizontal Station ft
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

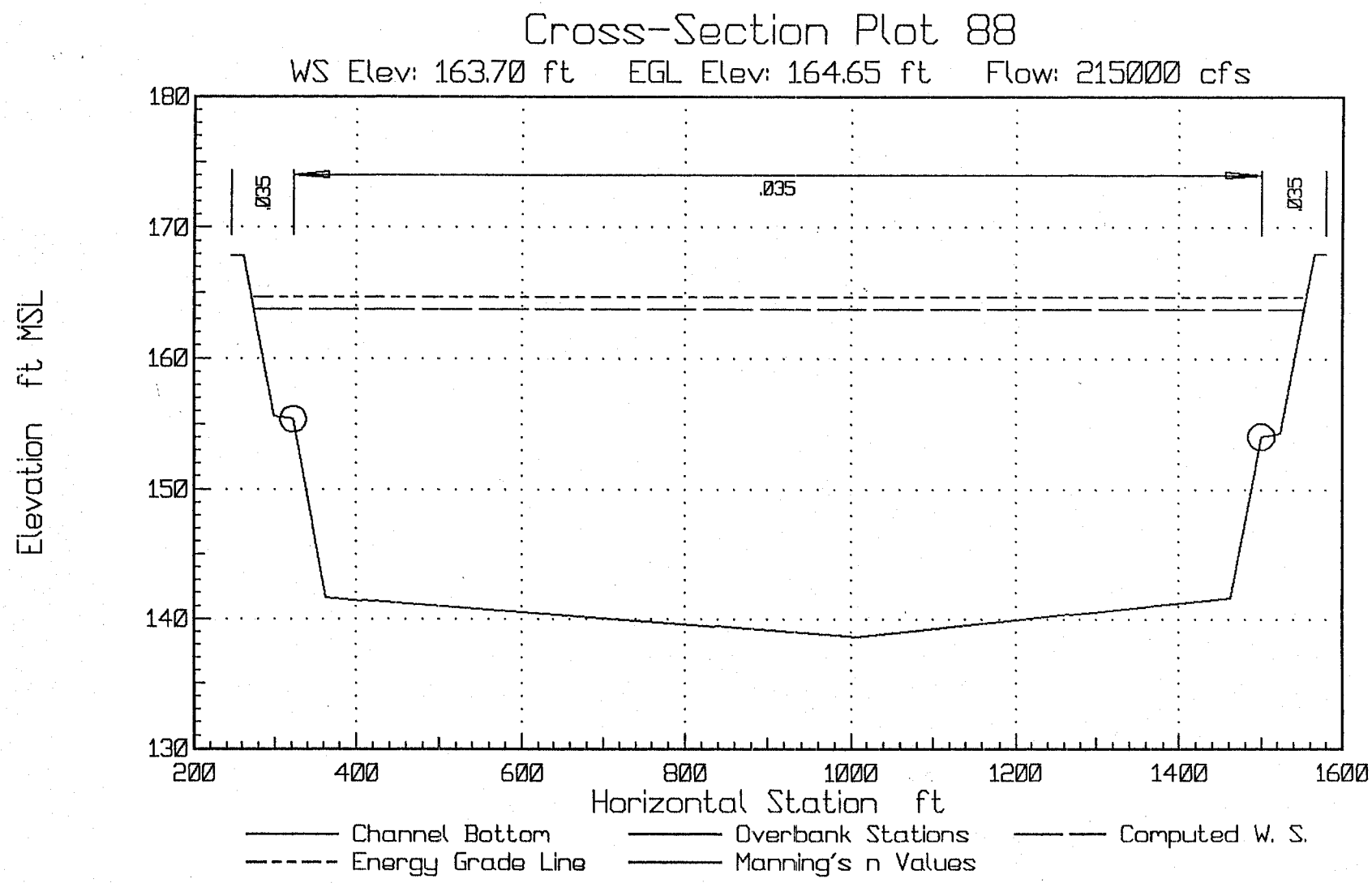

Cross-Section Plot 78
WS Elev: 162.59 ft
EGL Elev: 164.00 ft
Flow: 215000 cfs
.035
.035
.035
180
170
160
150
140
130
Elevation ft MSL
400
600
800
1000
1200
1400
1600
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values

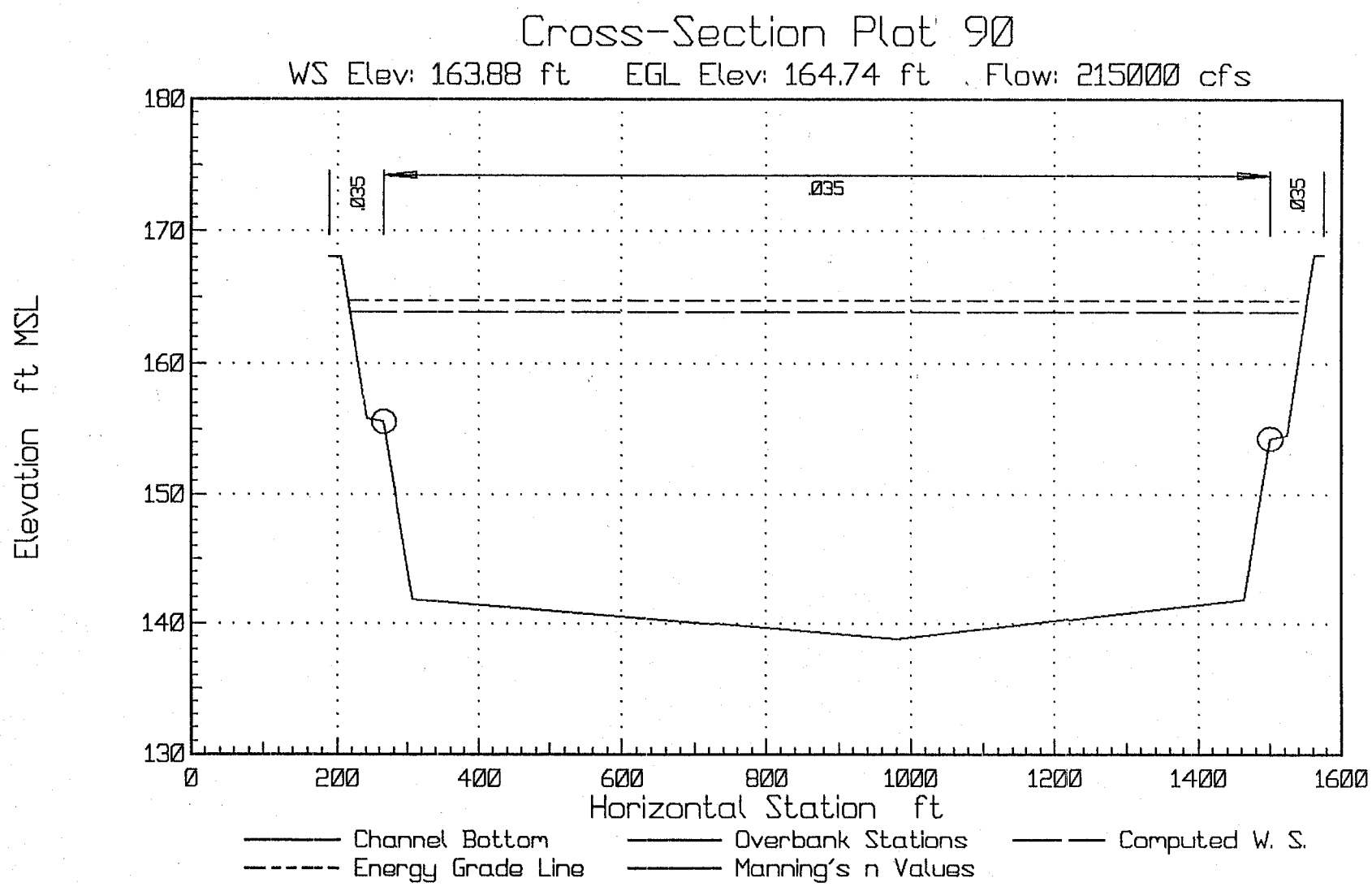

Cross-Section Plot 80
WS Elev: 162.81 ft
EGL Elev: 164.15 ft
Flow: 215000 cfs
Elevation ft MSL
180
170
160
150
140
130
400
600
800
1000
1200
1400
1600
Horizontal Station ft
.035
.035
.035
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

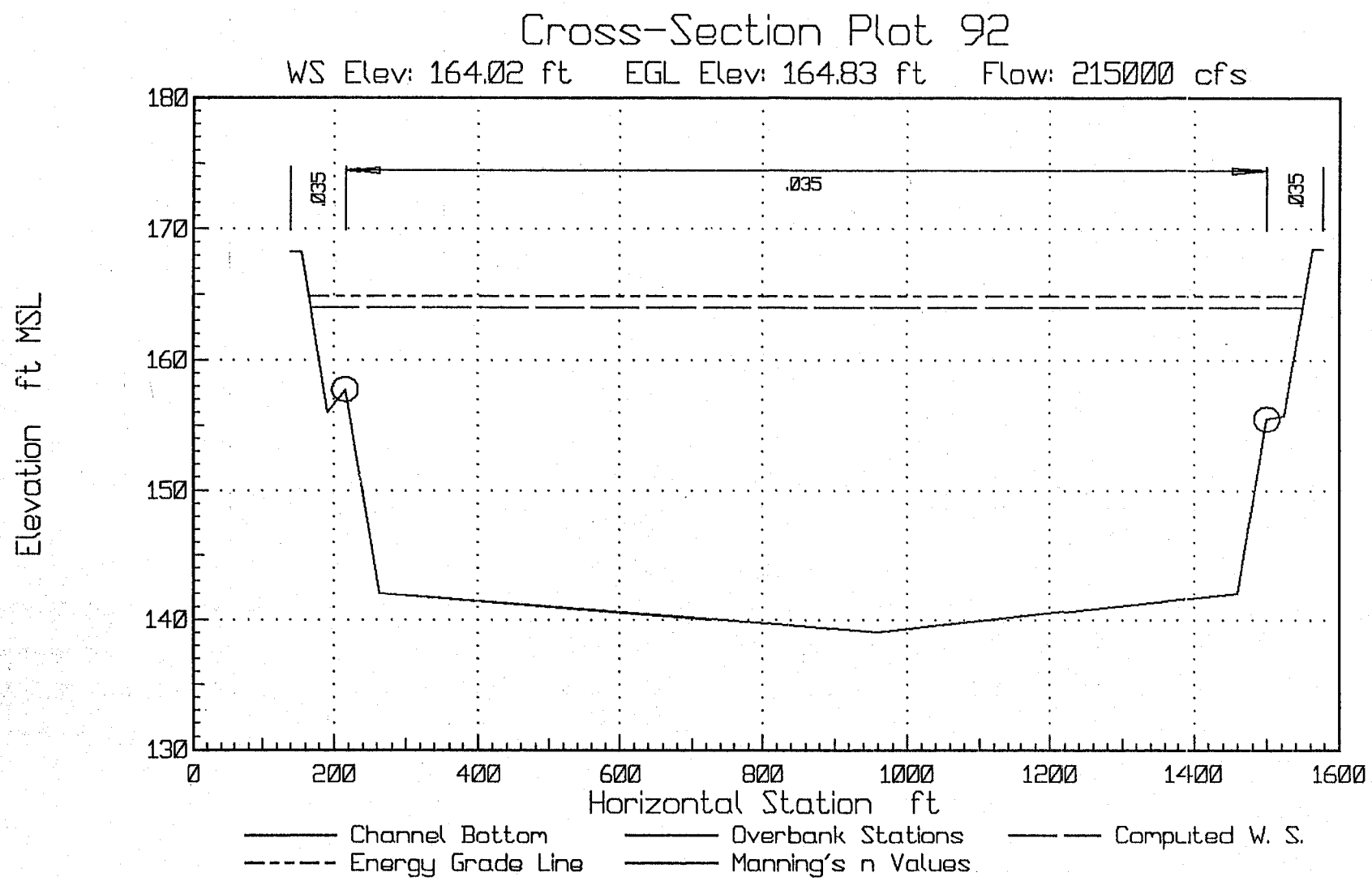

Cross-Section Plot 82
WS Elev: 163.04 ft
EGL Elev: 164.29 ft
Flow: 215000 cfs
Elevation ft MSL
180
170
160
150
140
130
200
400
600
800
1000
1200
1400
1600
Horizontal Station ft
.035
.035
.035
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

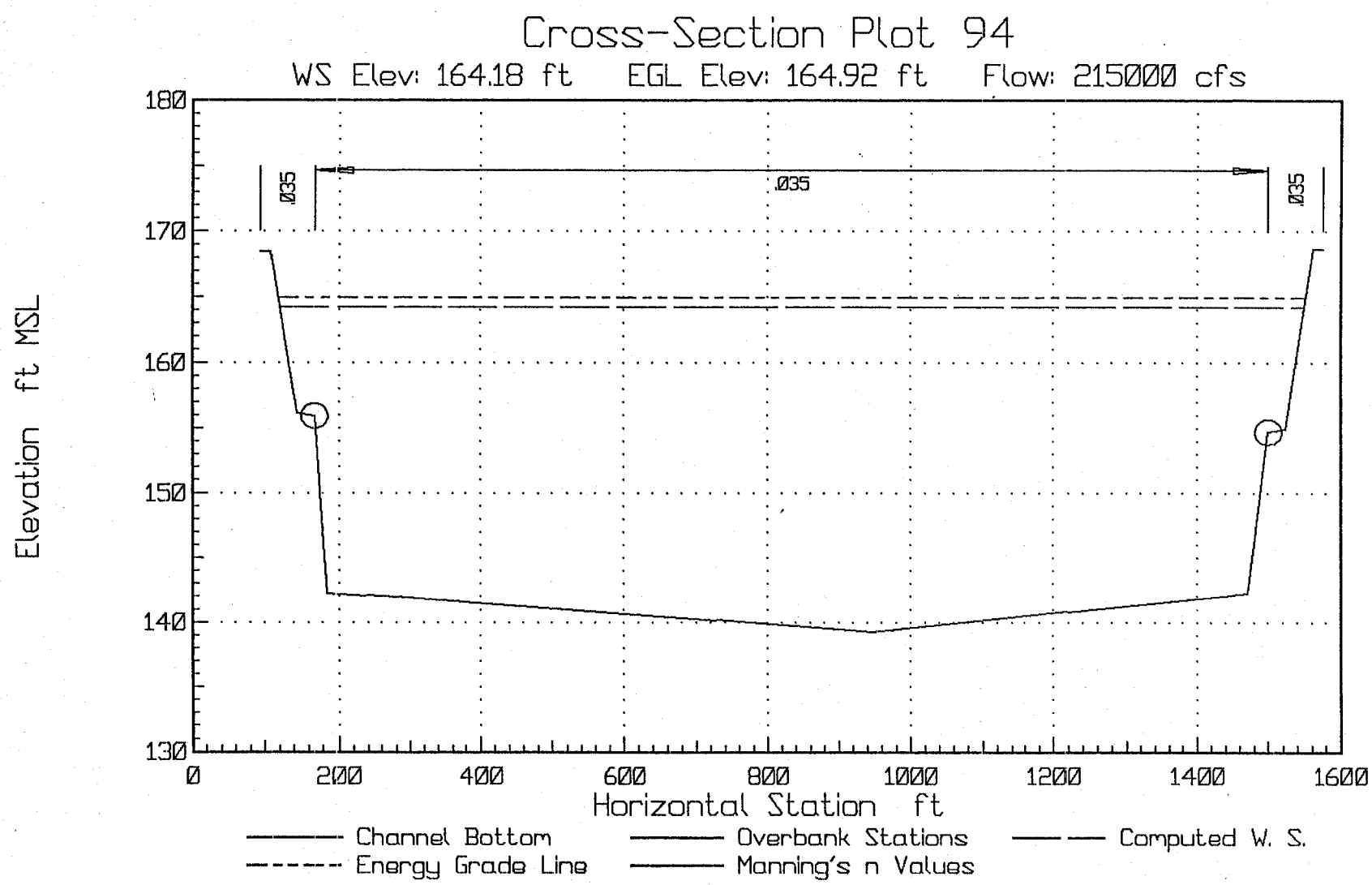

Cross-Section Plot 84
WS Elev: 163.25 ft EGL Elev: 164.41 ft Flow: 215000 cfs
Elevation ft MSL
180
170
160
150
140
130
200
400
600
800
1000
1200
1400
1600
Horizontal Station ft
.035
.035
.035
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

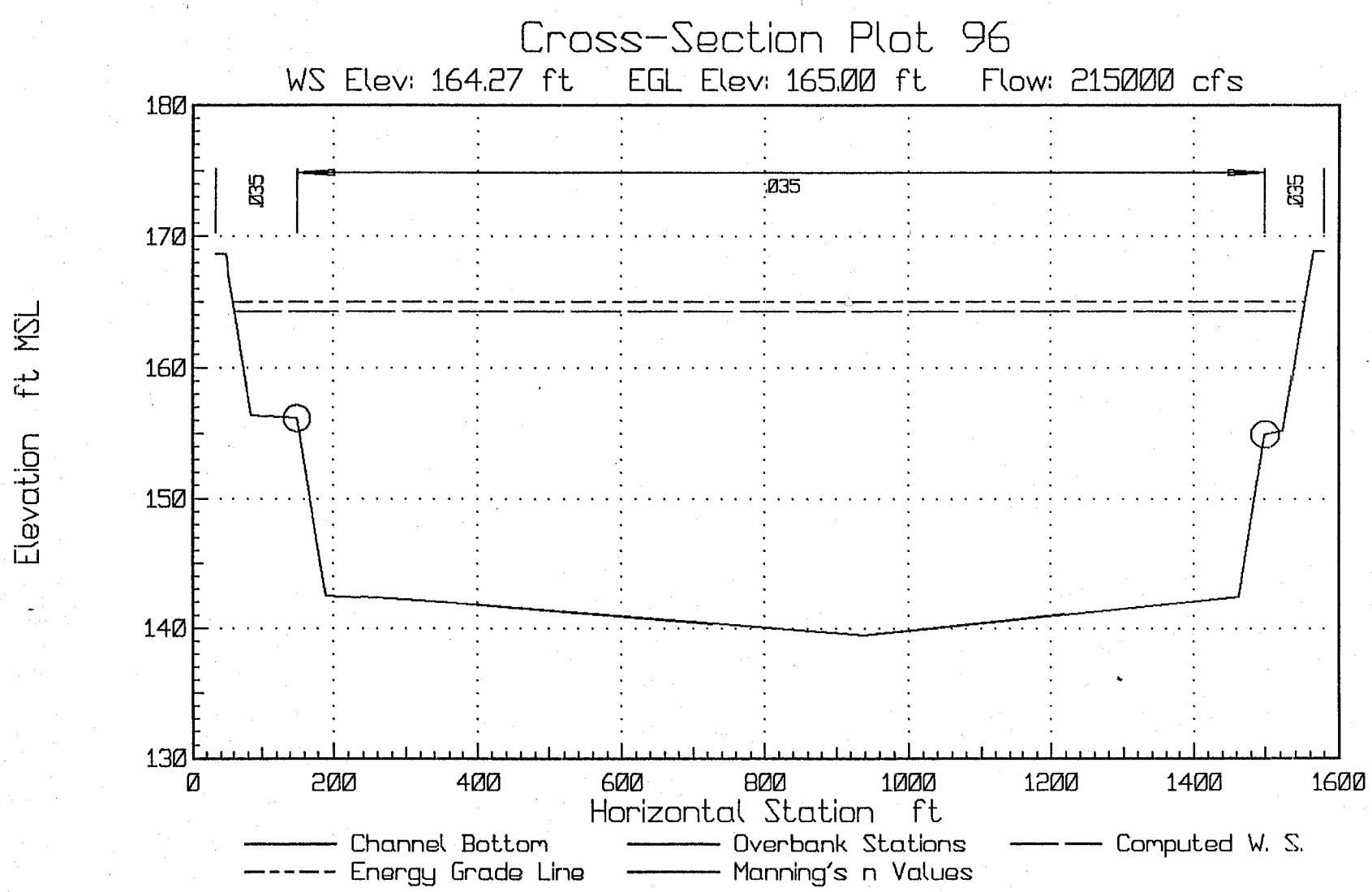

Cross-Section Plot 86
WS Elev: 163.47 ft
EGL Elev: 164.54 ft
Flow: 215000 cfs
Elevation ft MSL
180
170
160
150
140
130
200
400
600
800
1000
1200
1400
1600
Horizontal Station ft
.035
.035
.035
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

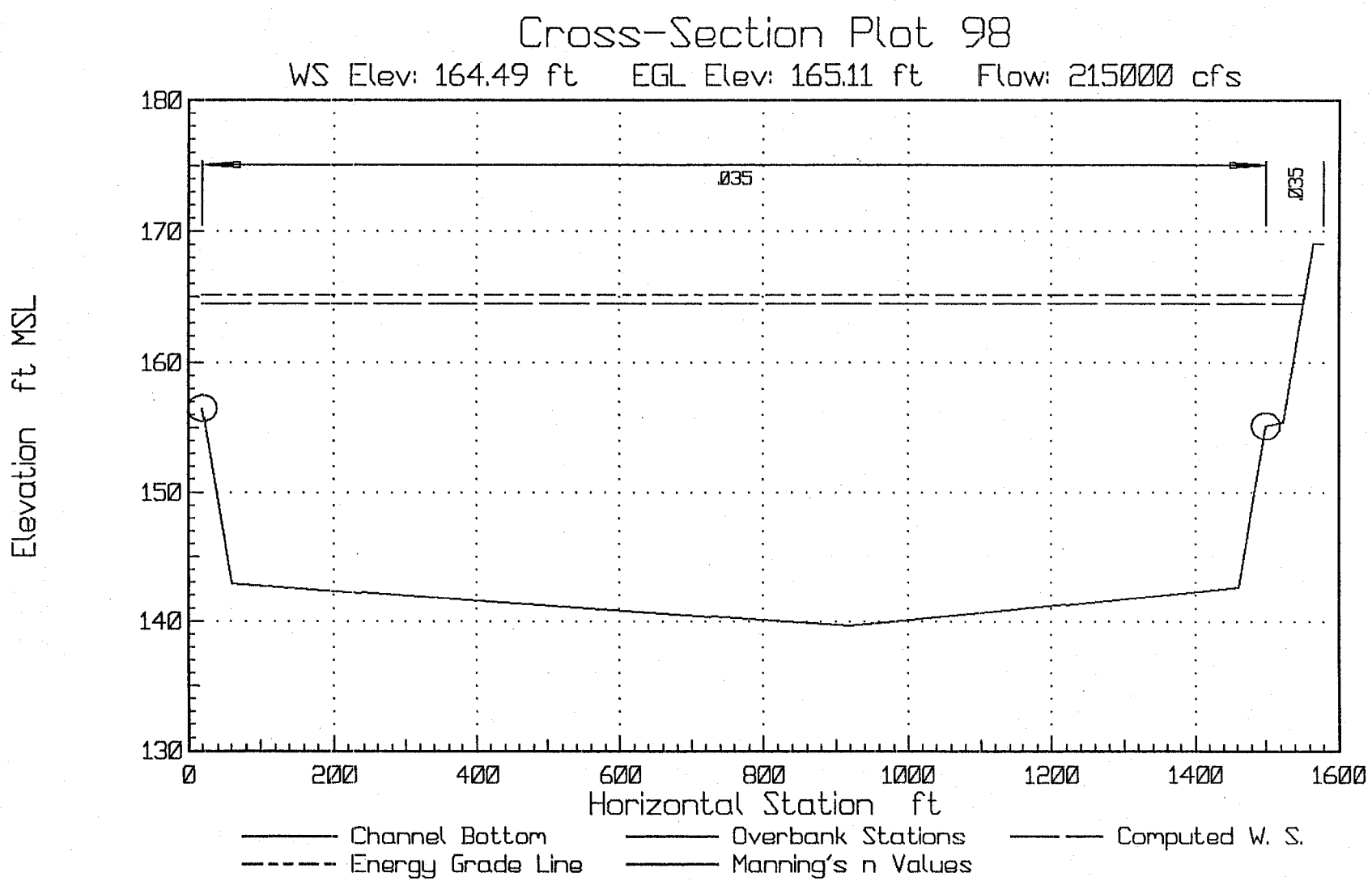

Cross-Section Plot 88
WS Elev: 163.70 ft
EGL Elev: 164.65 ft
Flow: 215000 cfs
.035
.035
.035
180
170
160
150
140
130
Elevation ft MSL
200
400
600
800
1000
1200
1400
1600
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values

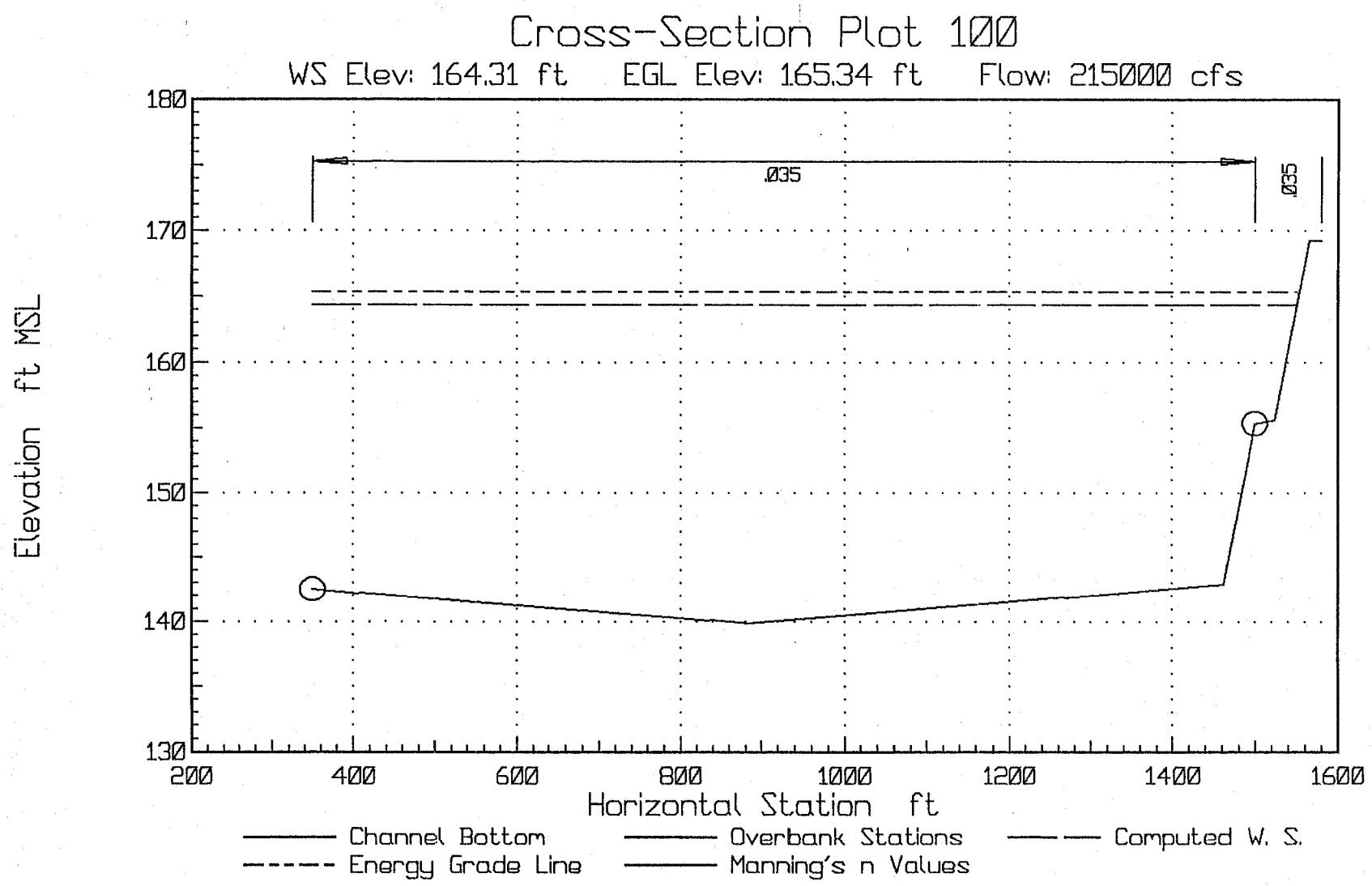

Cross-Section Plot 90
WS Elev: 163.88 ft
EGL Elev: 164.74 ft
Flow: 215000 cfs
.035
.035
.035
Elevation ft MSL
180
170
160
150
140
130
0
200
400
600
800
1000
1200
1400
1600
Horizontal Station ft
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

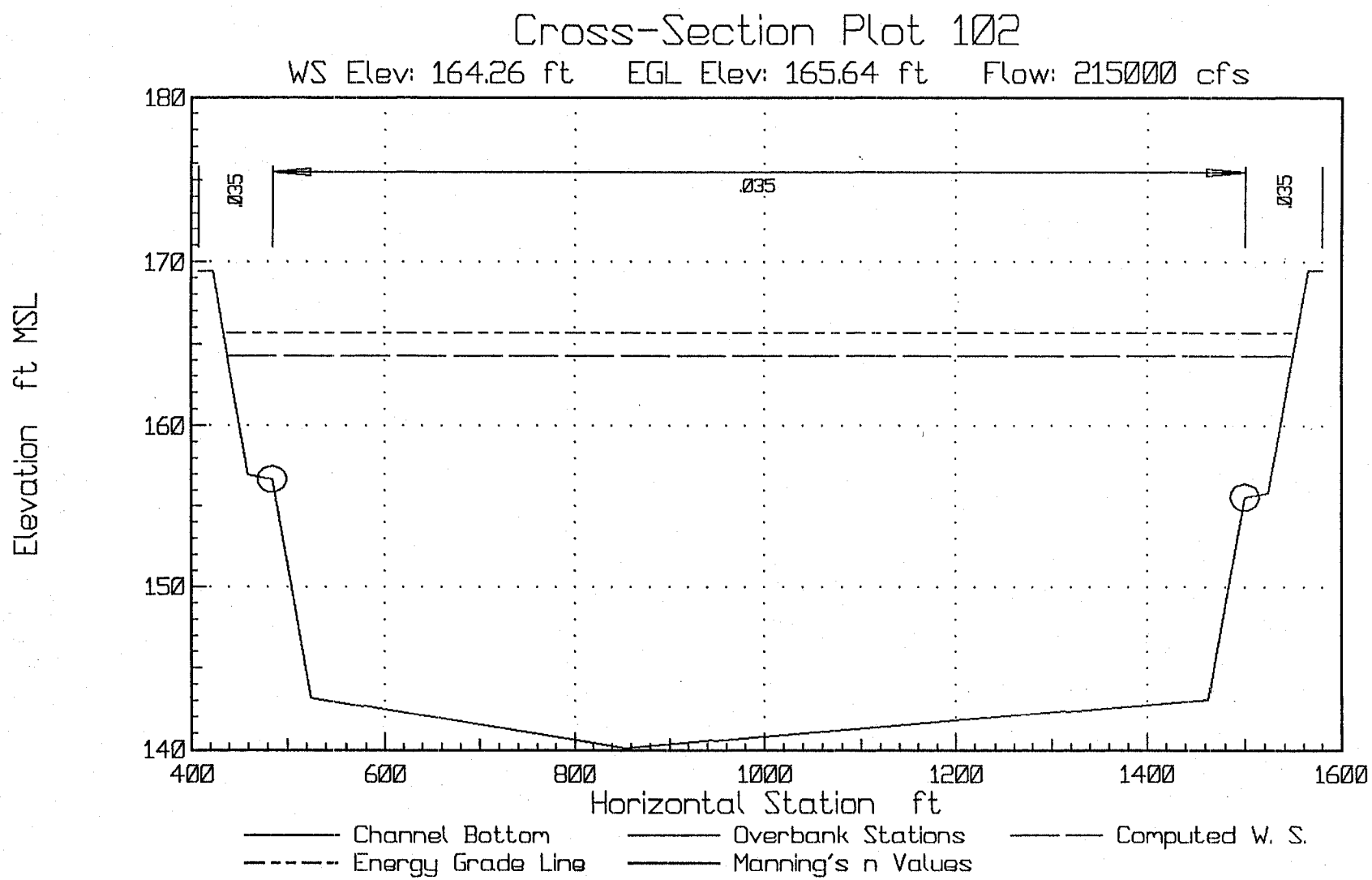

Cross-Section Plot 92
WS Elev: 164.02 ft
EGL Elev: 164.83 ft
Flow: 215000 cfs
.035
.035
.035
Elevation ft MSL
180
170
160
150
140
130
0
200
400
600
800
1000
1200
1400
1600
Horizontal Station ft
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

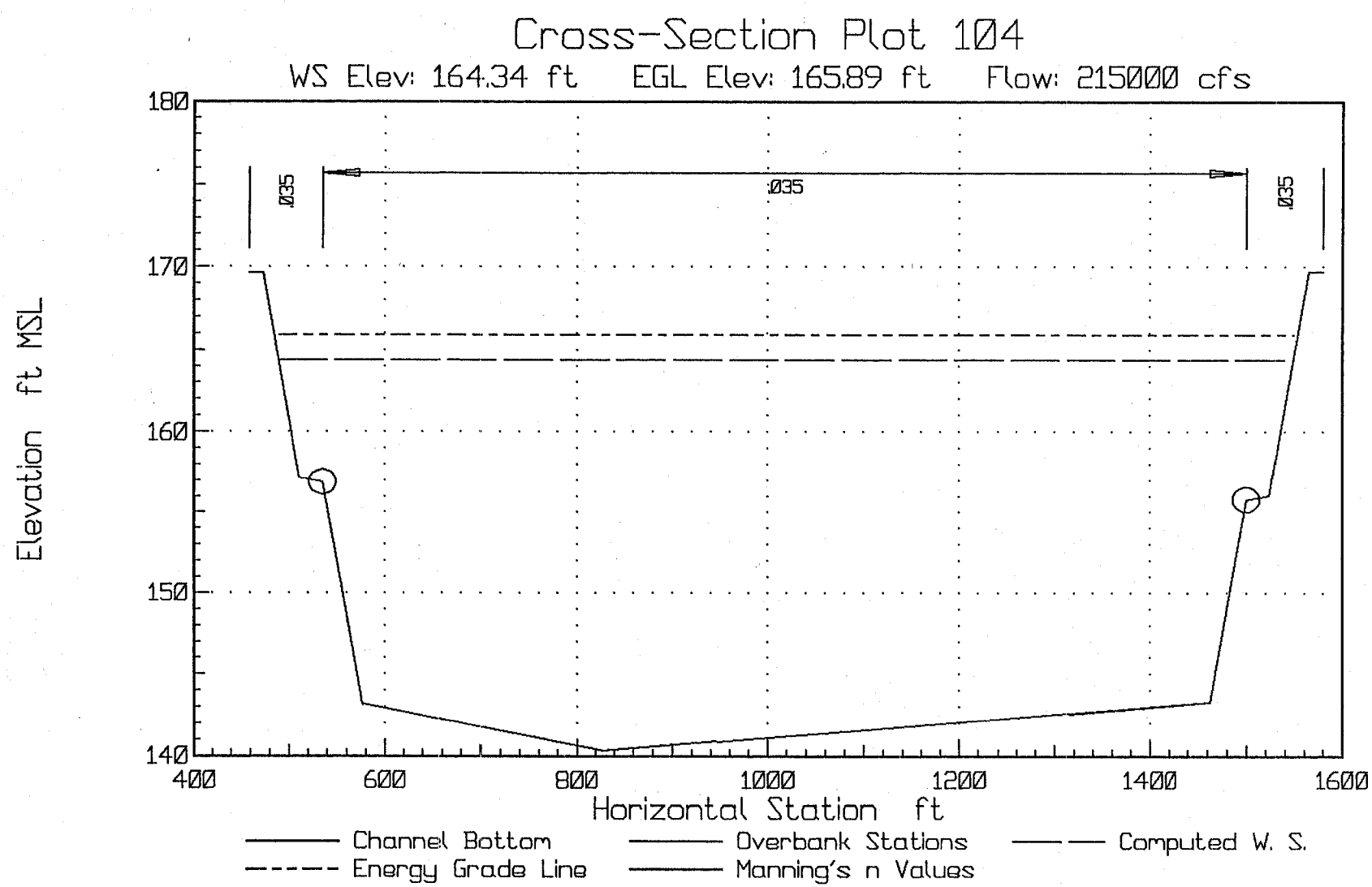

Cross-Section Plot 94
WS Elev: 164.18 ft
EGL Elev: 164.92 ft
Flow: 215000 cfs
Elevation ft MSL
180
170
160
150
140
130
0
200
400
600
800
1000
1200
1400
1600
Horizontal Station ft
.035
.035
.035
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

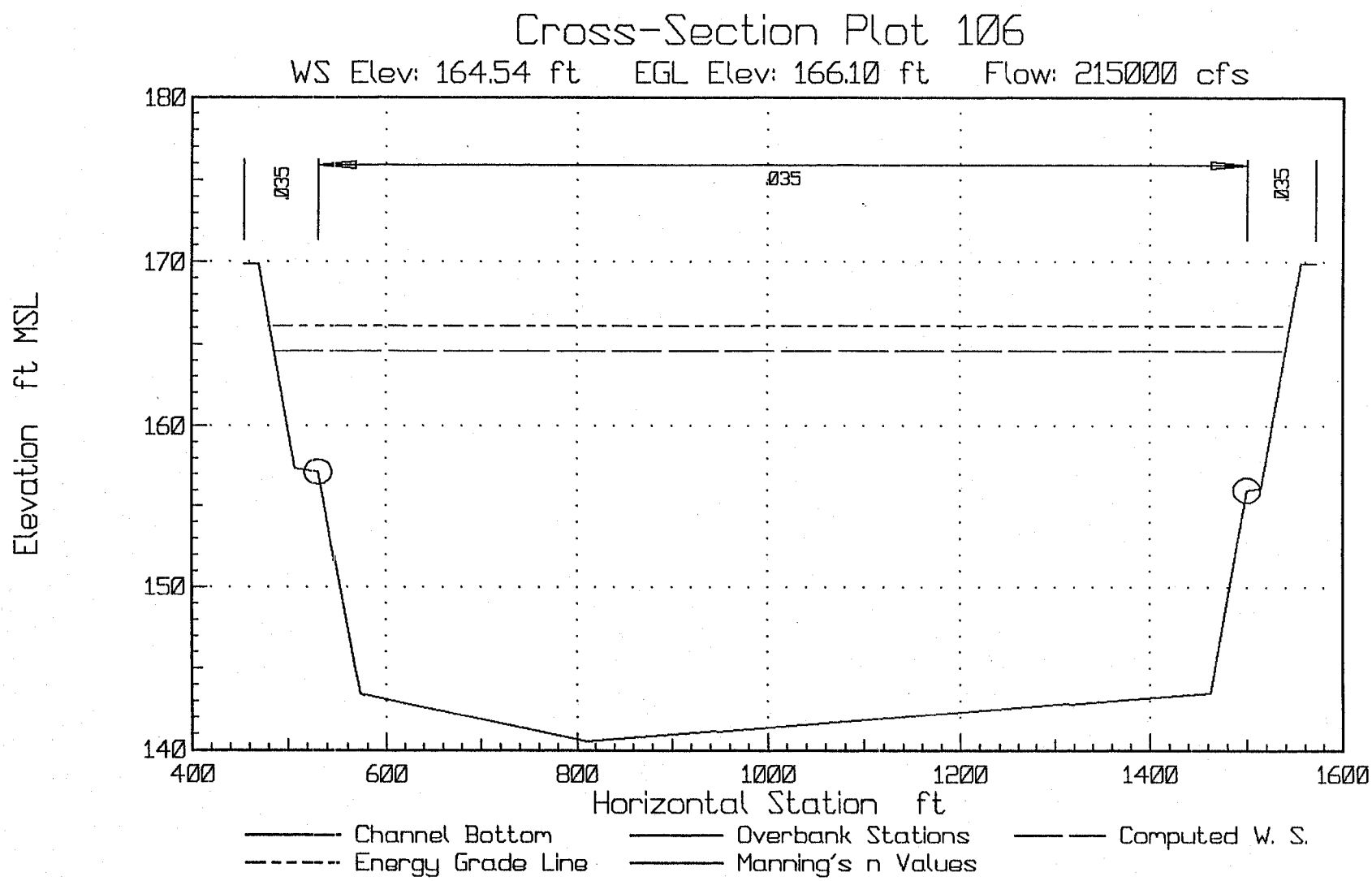

Cross-Section Plot 96
WS Elev: 164.27 ft
EGL Elev: 165.00 ft
Flow: 215000 cfs
Elevation ft MSL
180
170
160
150
140
130
0
200
400
600
800
1000
1200
1400
1600
Horizontal Station ft
.035
.035
.035
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

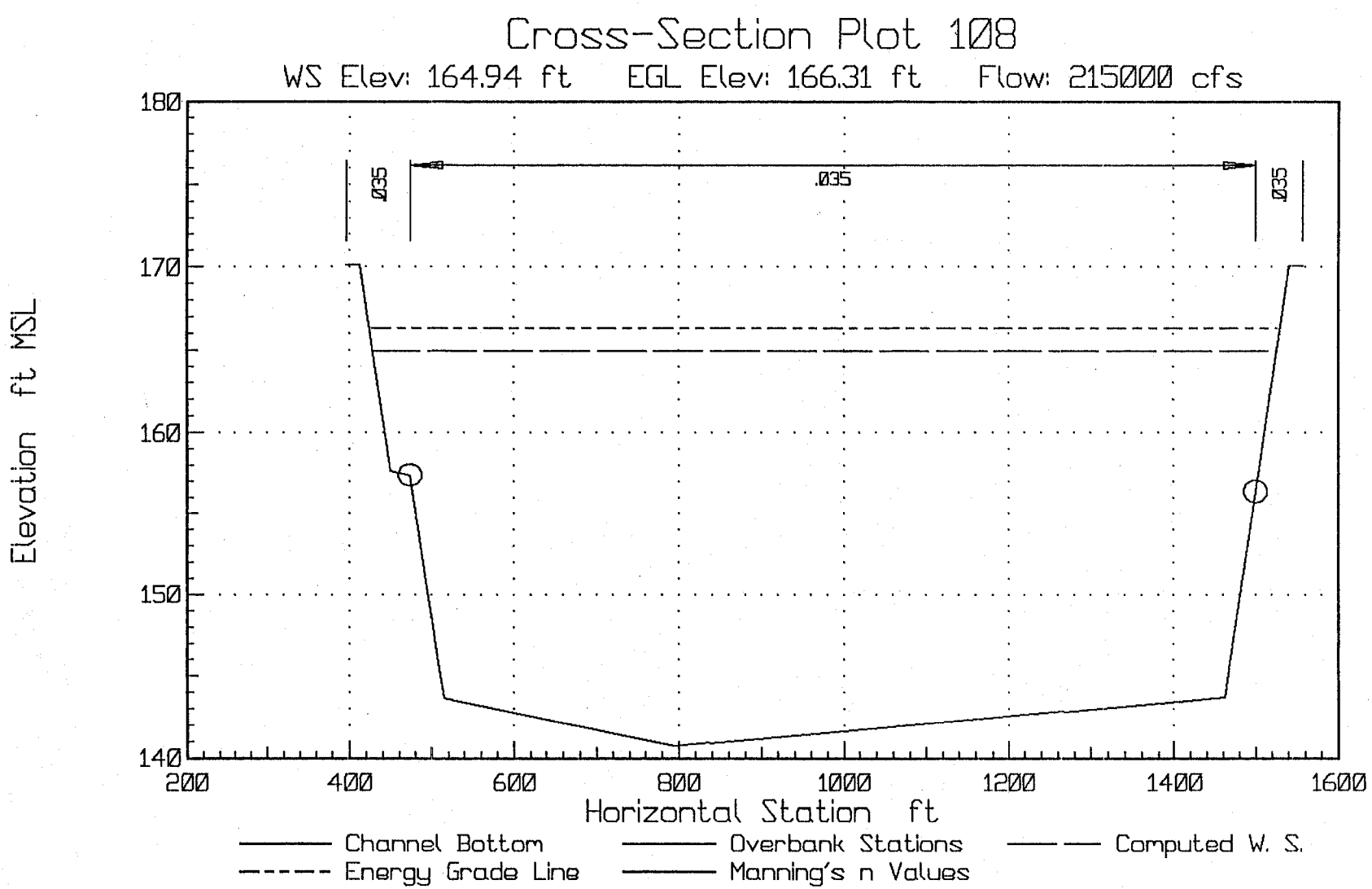

Cross-Section Plot 98
WS Elev: 164.49 ft
EGL Elev: 165.11 ft
Flow: 215000 cfs
Elevation ft MSL
180
170
160
150
140
130
0
200
400
600
800
1000
1200
1400
1600
Horizontal Station ft
.035
.035
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

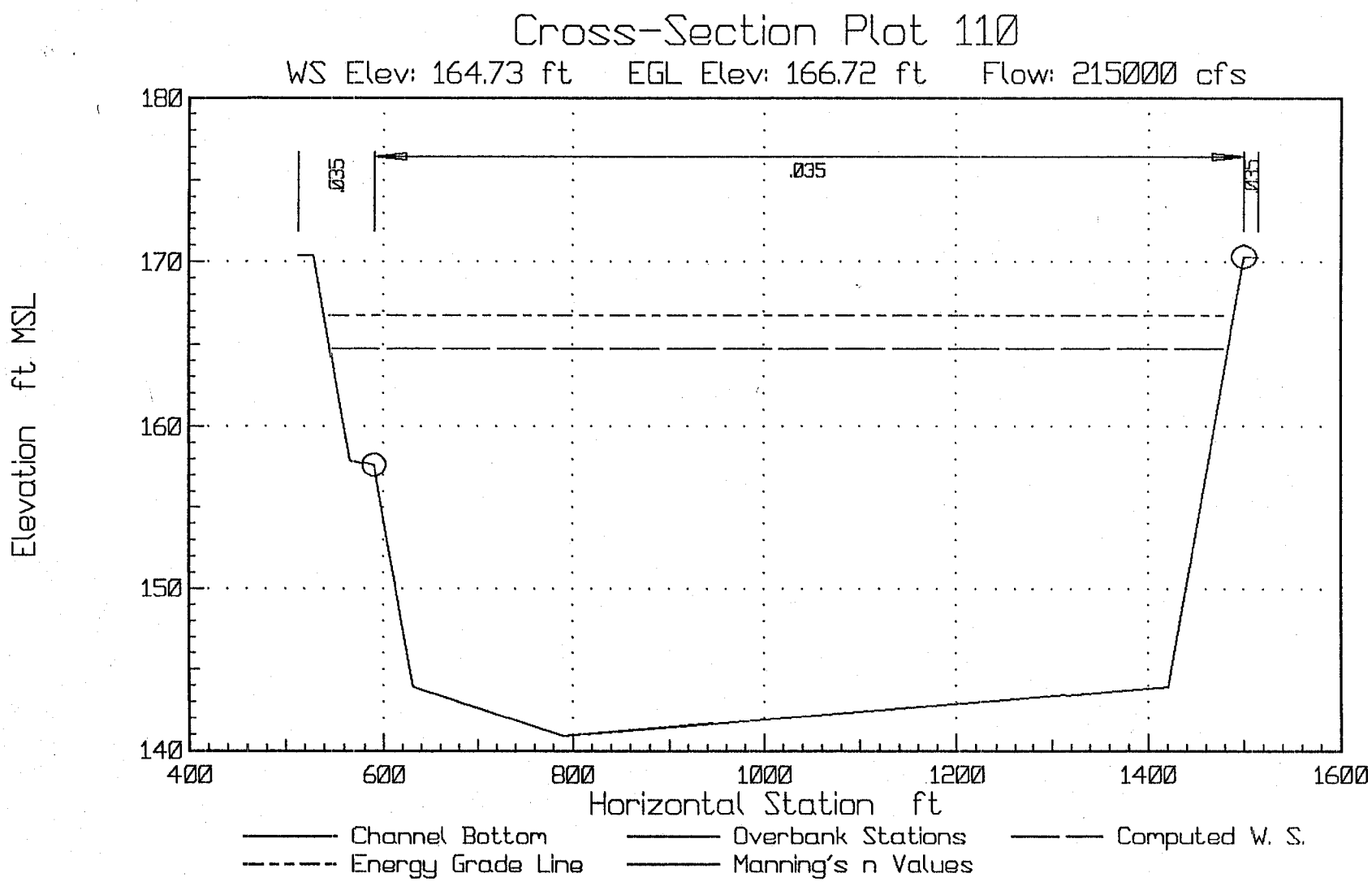

Cross-Section Plot 100
WS Elev: 164.31 ft
EGL Elev: 165.34 ft
Flow: 215000 cfs
.035
.035
180
170
160
150
140
130
Elevation ft MSL
200
400
600
800
1000
1200
1400
1600
Horizontal Station ft
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

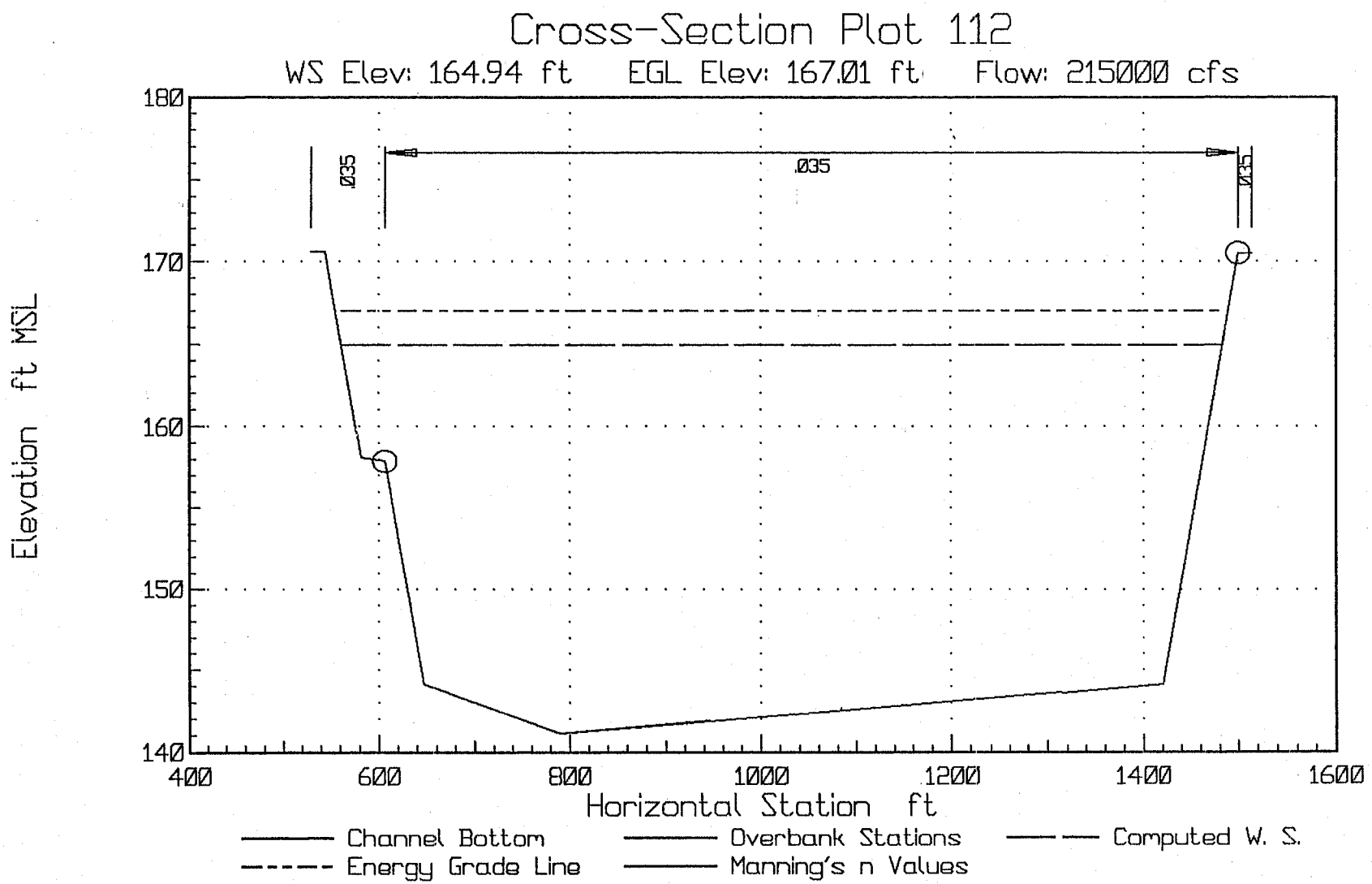

Cross-Section Plot 102
WS Elev: 164.26 ft
EGL Elev: 165.64 ft
Flow: 215000 cfs
.035
.035
.035
180
170
160
150
140
Elevation ft MSL
400
600
800
1000
1200
1400
1600
Horizontal Station ft
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

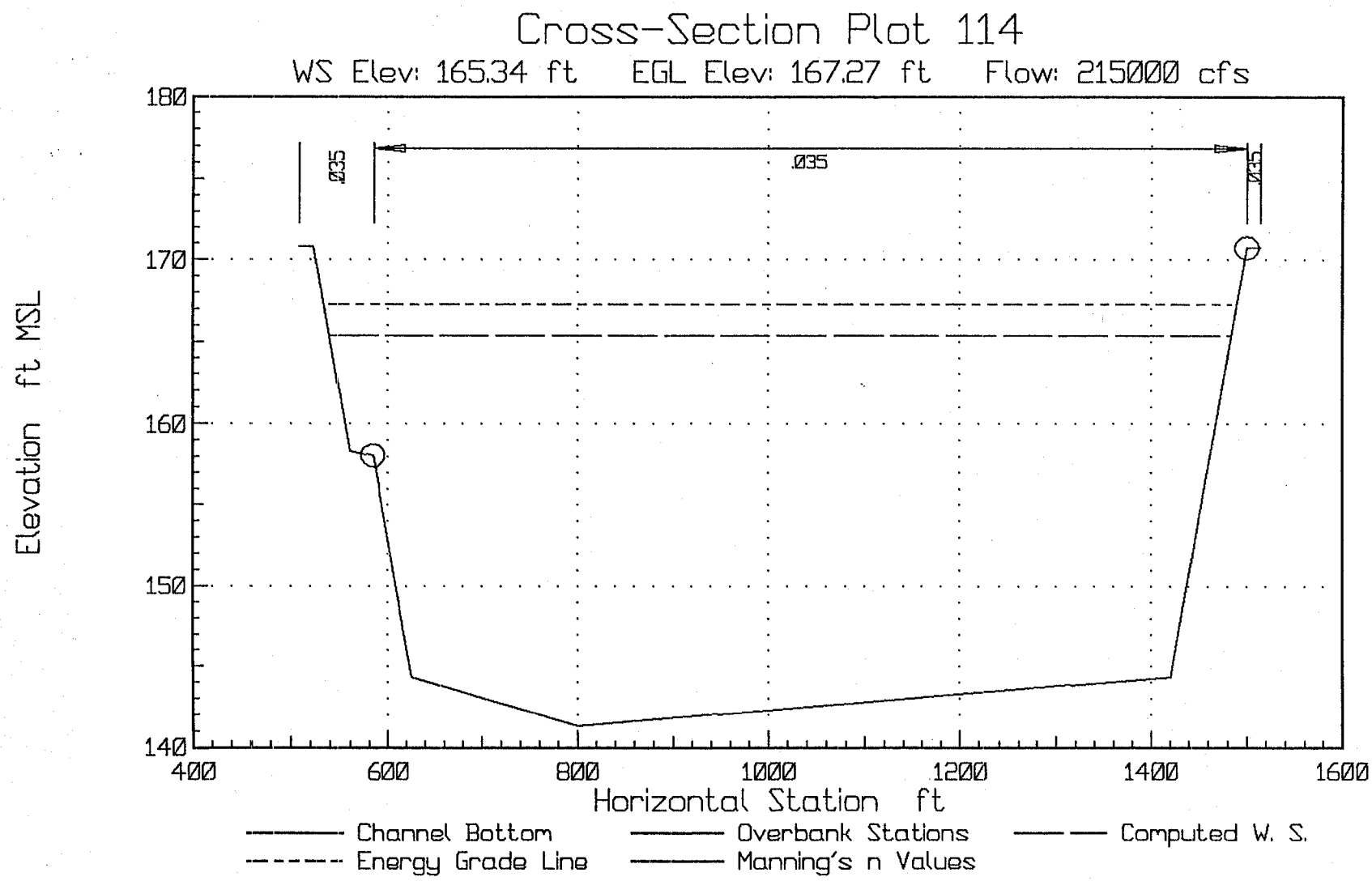

Cross-Section Plot 104
WS Elev: 164.34 ft
EGL Elev: 165.89 ft
Flow: 215000 cfs
.035
.035
.035
180
170
160
150
140
400
600
800
1000
1200
1400
1600
Elevation ft MSL
Horizontal Station ft
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

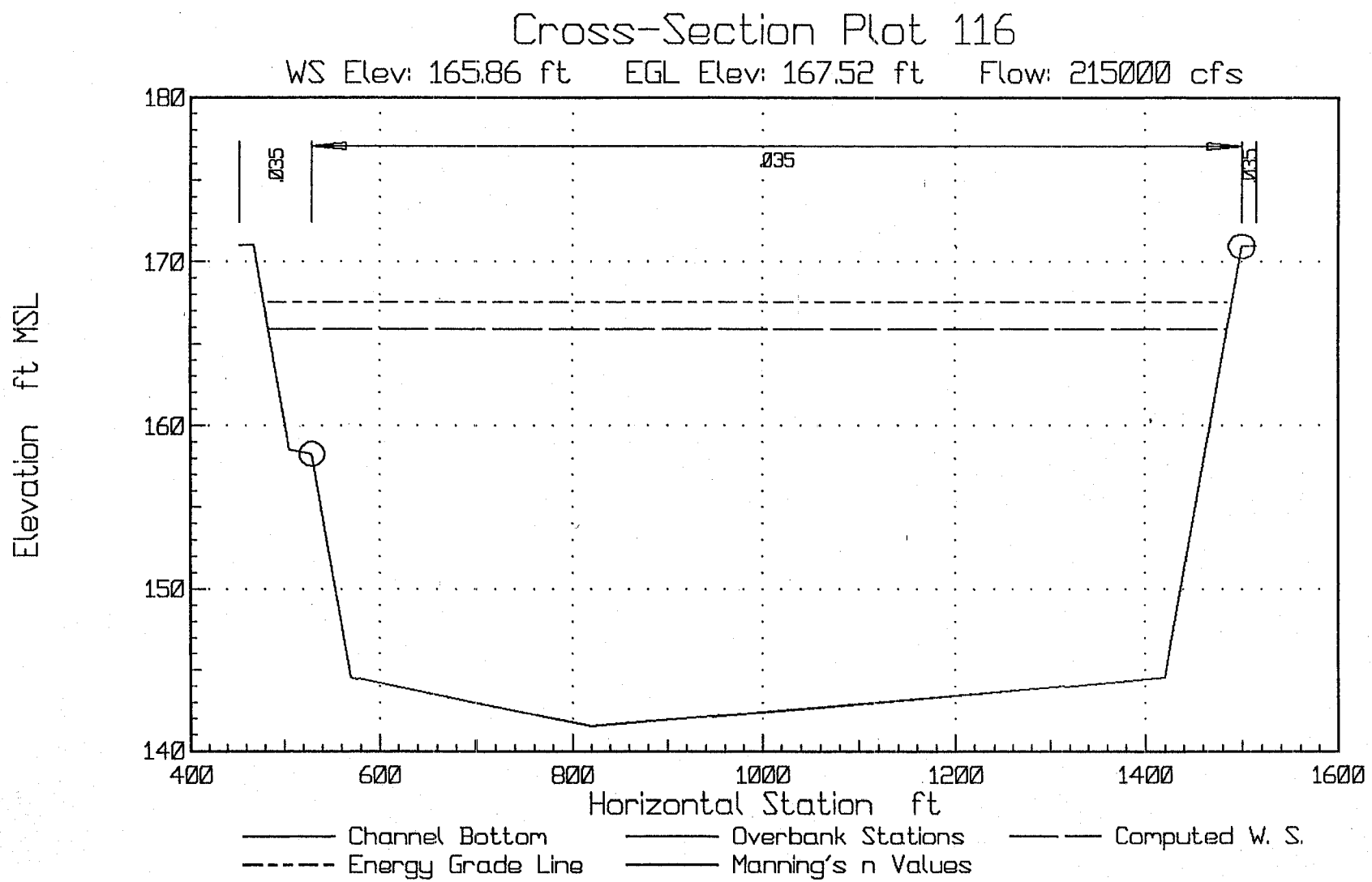

Cross-Section Plot 106
WS Elev: 164.54 ft
EGL Elev: 166.10 ft
Flow: 215000 cfs
.035
.035
.035
180
170
160
150
140
Elevation ft MSL
400
600
800
1000
1200
1400
1600
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values

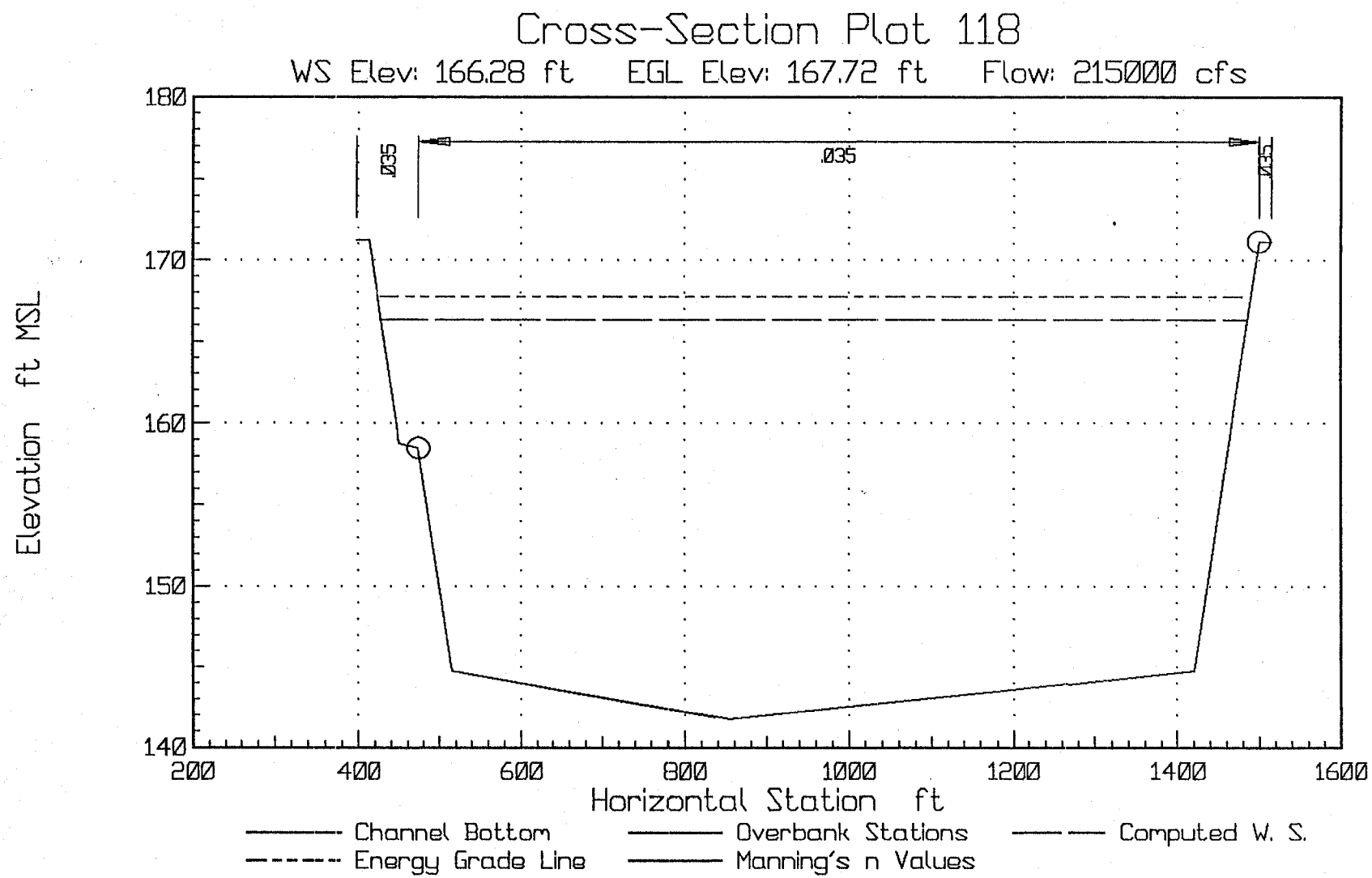

Cross-Section Plot 108
WS Elev: 164.94 ft
EGL Elev: 166.31 ft
Flow: 215000 cfs
.035
.035
.035
Elevation ft MSL
180
170
160
150
140
200
400
600
800
1000
1200
1400
1600
Horizontal Station ft
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

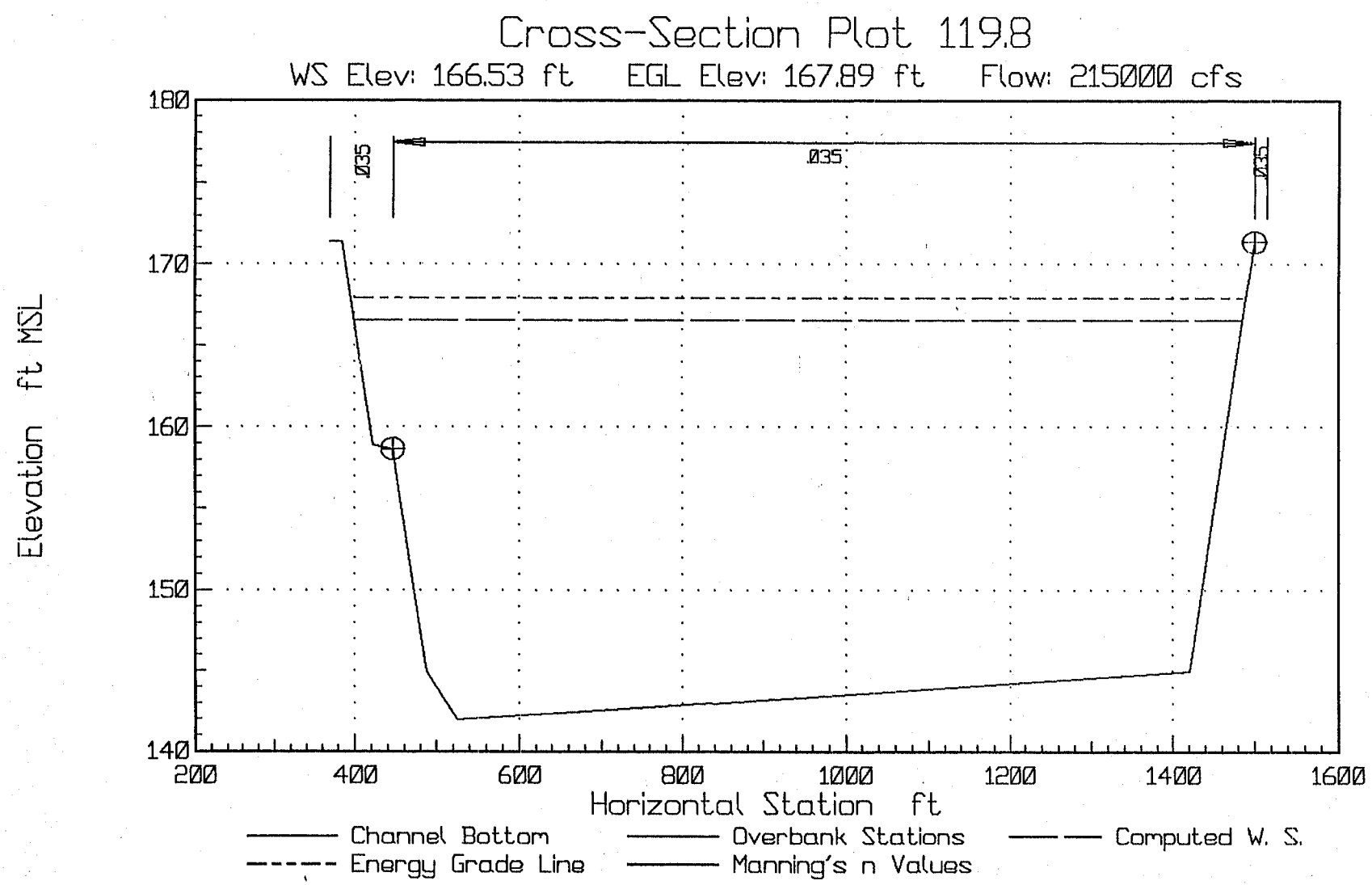

Cross-Section Plot 110
WS Elev: 164.73 ft
EGL Elev: 166.72 ft
Flow: 215000 cfs
.035
.035
.035
180
170
160
150
140
Elevation ft MSL
400
600
800
1000
1200
1400
1600
Horizontal Station ft
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

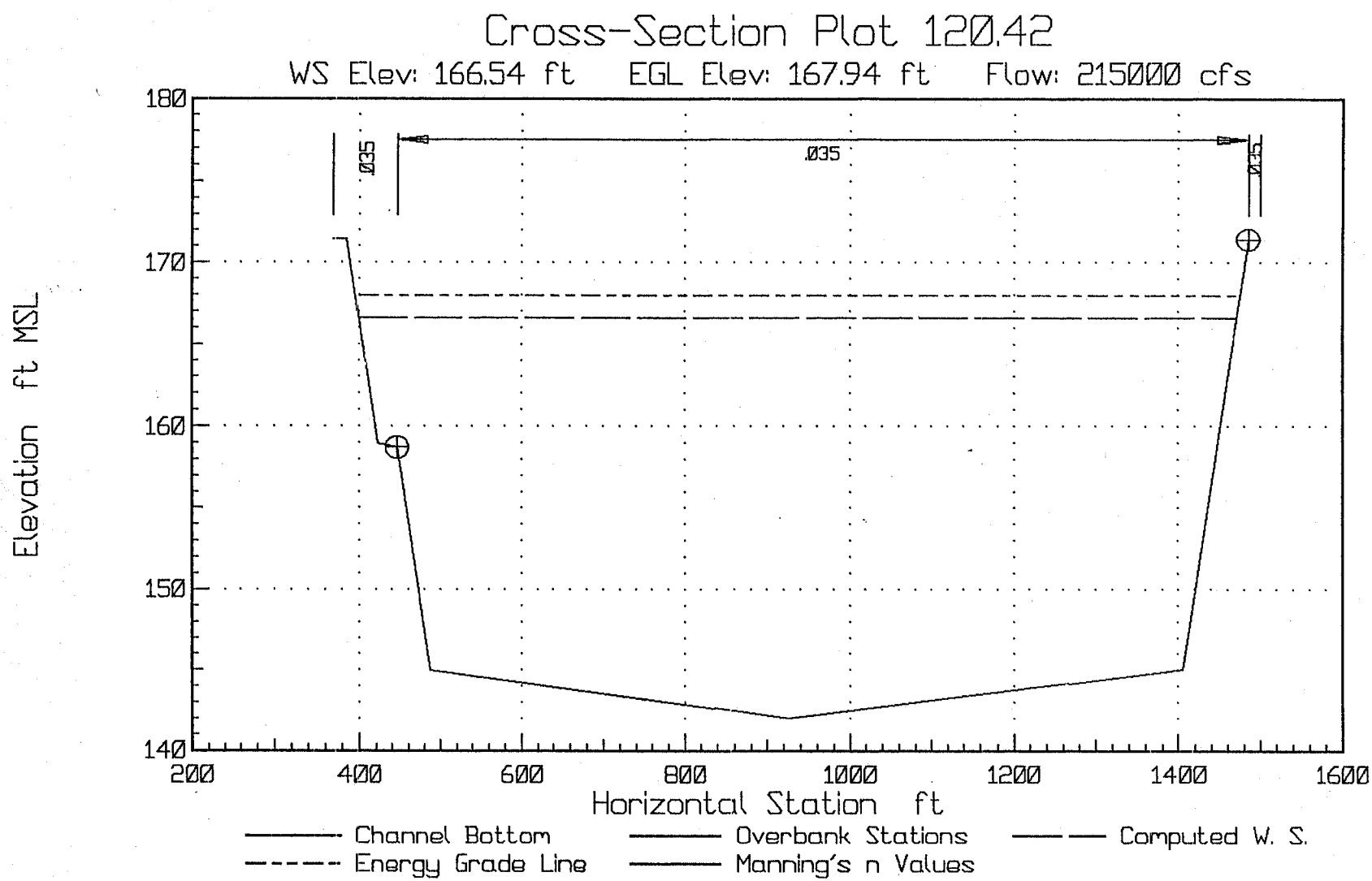

Cross-Section Plot 112
WS Elev: 164.94 ft
EGL Elev: 167.01 ft
Flow: 215000 cfs
.035
.035
.035
180
170
160
150
140
400
600
800
1000
1200
1400
1600
Elevation ft MSL
Horizontal Station ft
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

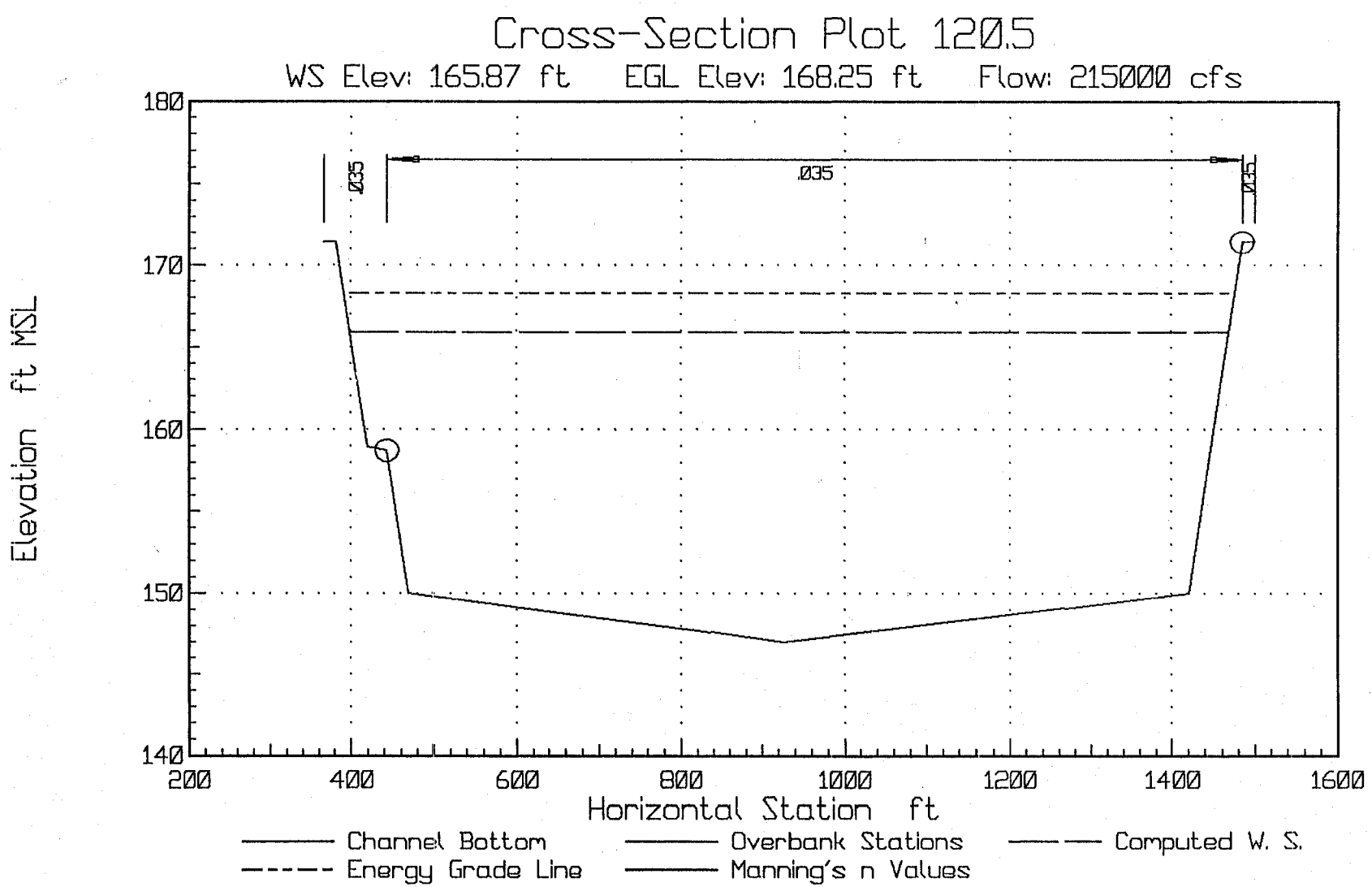

Cross-Section Plot 114
WS Elev: 165.34 ft
EGL Elev: 167.27 ft
Flow: 215000 cfs
.035
.035
.035
180
170
160
150
140
Elevation ft MSL
400
600
800
1000
1200
1400
1600
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values

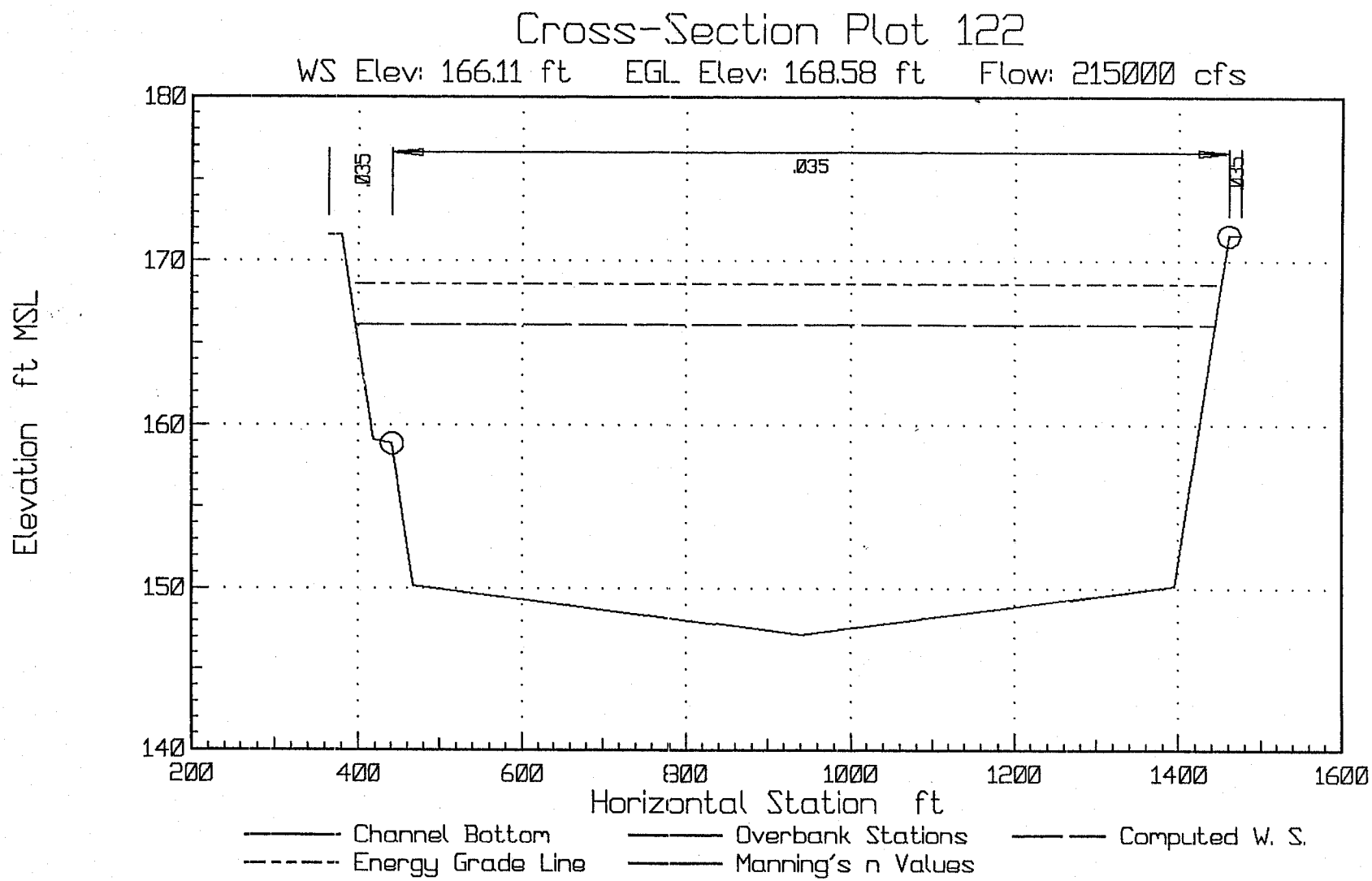

Cross-Section Plot 116
WS Elev: 165.86 ft
EGL Elev: 167.52 ft
Flow: 215000 cfs
.035
.035
.035
180
170
160
150
140
400
600
800
1000
1200
1400
1600
Elevation ft MSL
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values

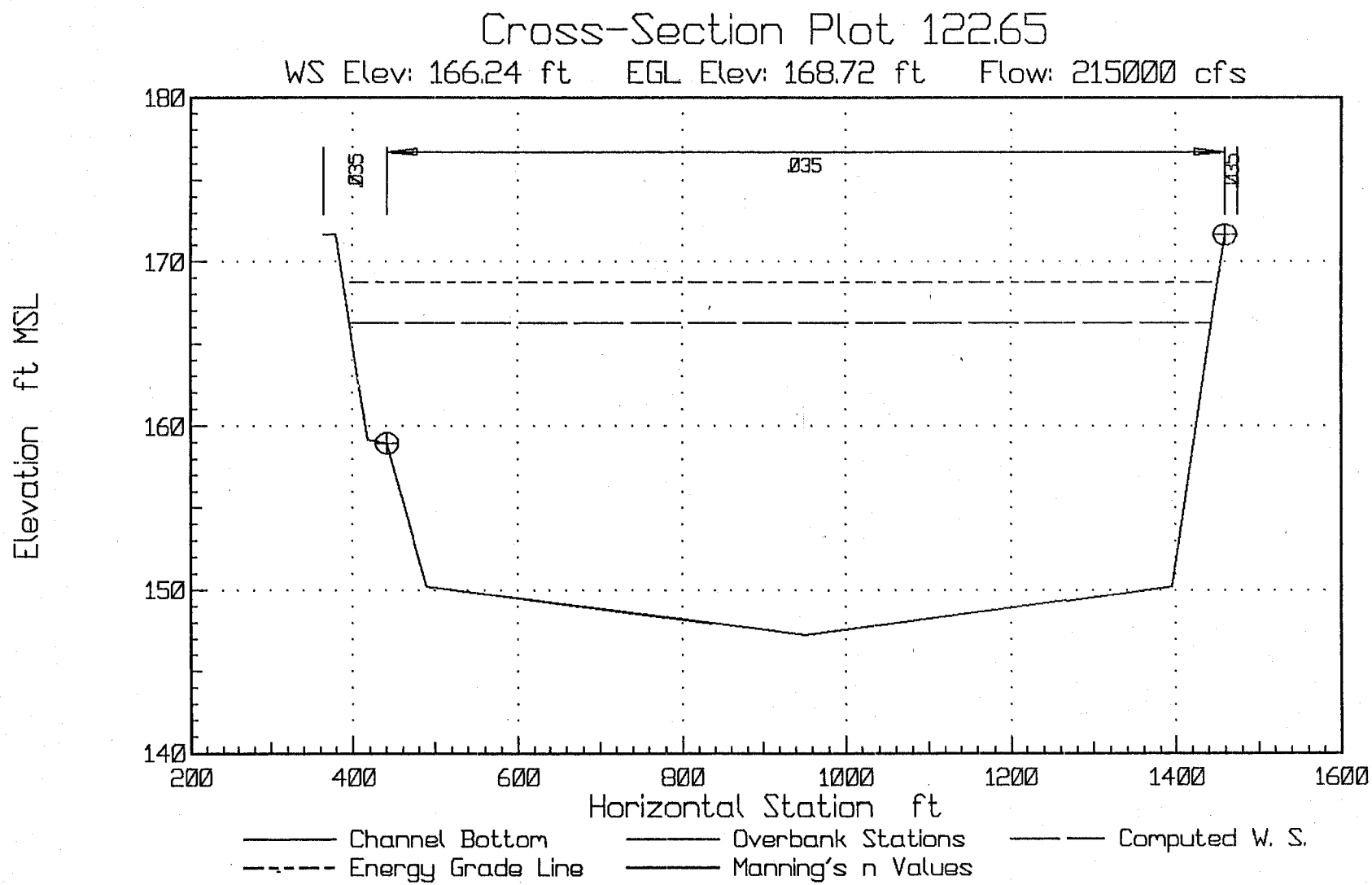

Cross-Section Plot 118
WS Elev: 166.28 ft
EGL Elev: 167.72 ft
Flow: 215000 cfs
Elevation ft MSL
180
170
160
150
140
200
400
600
800
1000
1200
1400
1600
Horizontal Station ft
.035
.035
.035
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

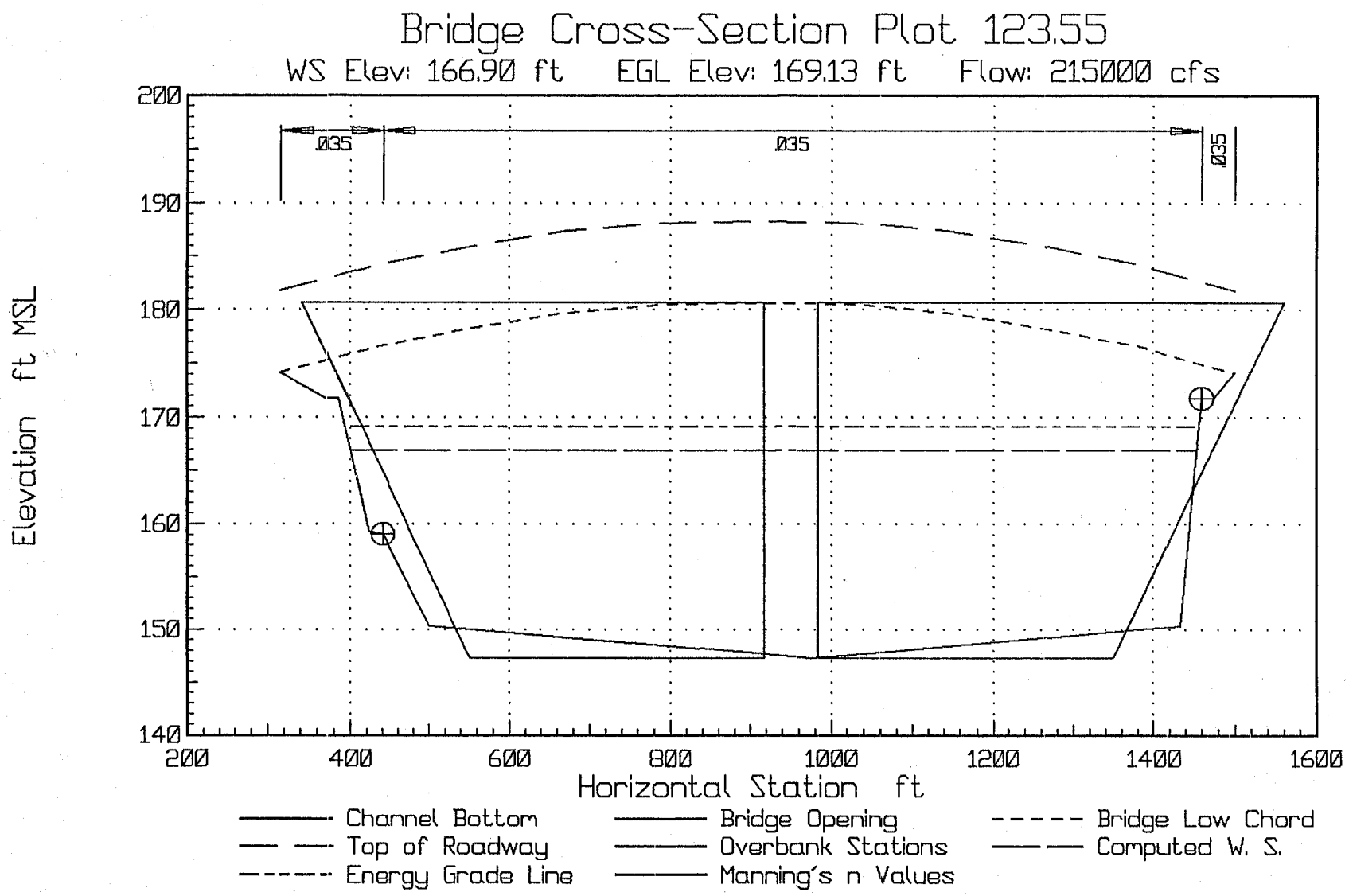

Cross-Section Plot 119.8
WS Elev: 166.53 ft EGL Elev: 167.89 ft Flow: 215000 cfs
Elevation ft MSL
180
170
160
150
140
200
400
600
800
1000
1200
1400
1600
Horizontal Station ft
035
035
035
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

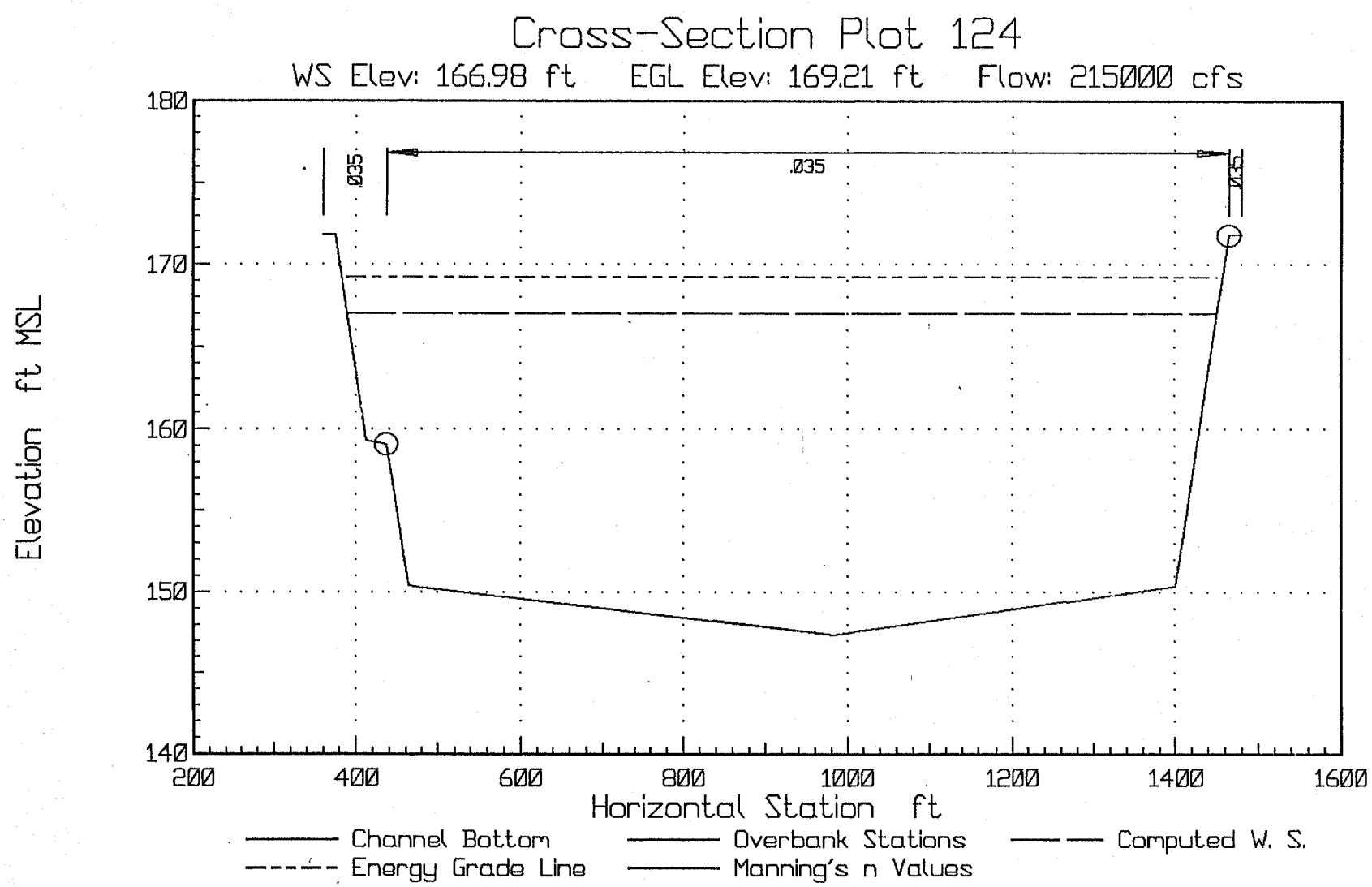

Cross-Section Plot 120.42
WS Elev: 166.54 ft EGL Elev: 167.94 ft Flow: 215000 cfs
.035
.035
.035
180
170
160
150
140
Elevation ft MSL
200
400
600
800
1000
1200
1400
1600
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values

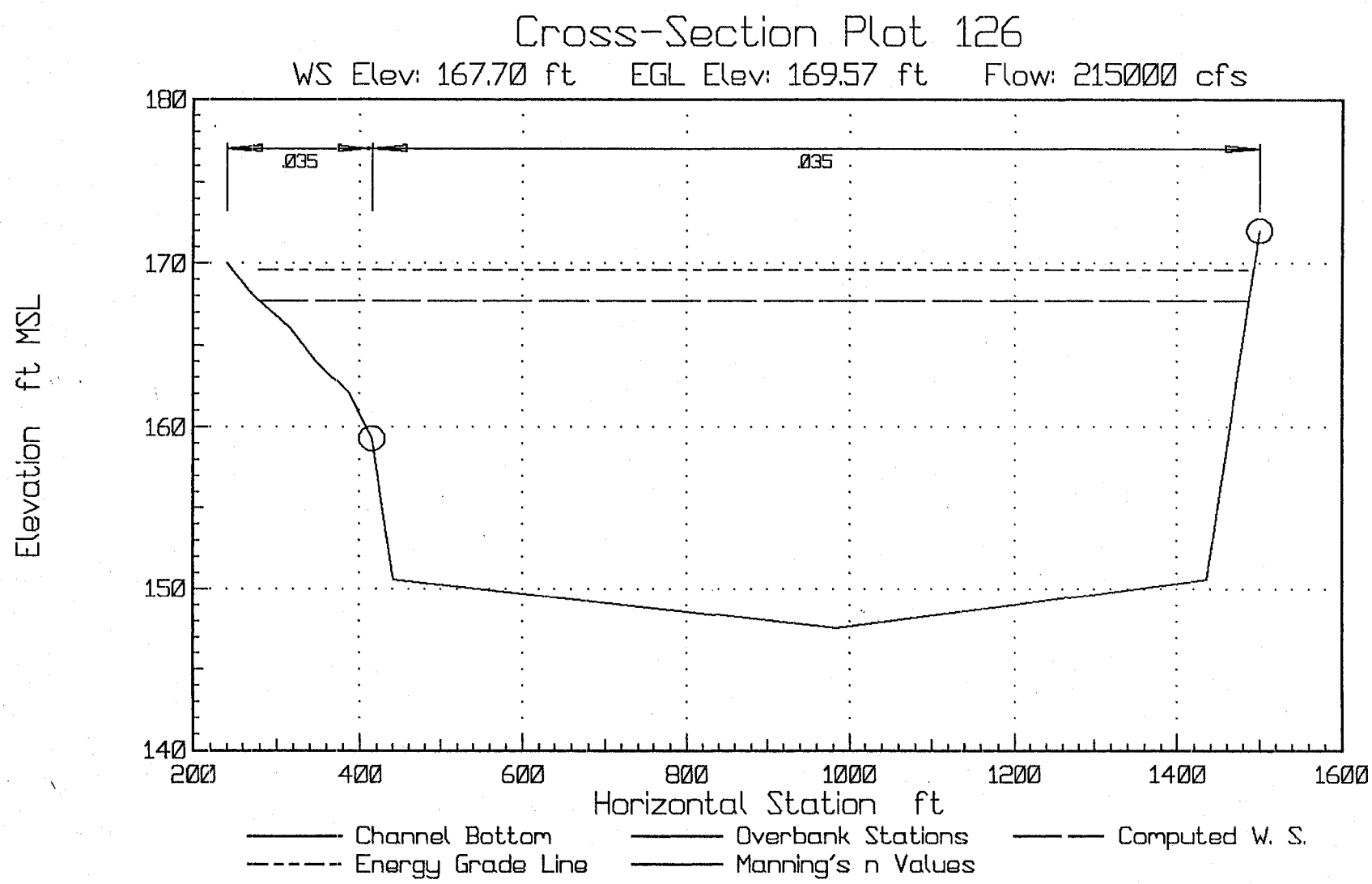

Cross-Section Plot 120.5
WS Elev: 165.87 ft EGL Elev: 168.25 ft Flow: 215000 cfs
Elevation ft MSL
180
170
160
150
140
200
400
600
800
1000
1200
1400
1600
Horizontal Station ft
.035
.035
.035
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values

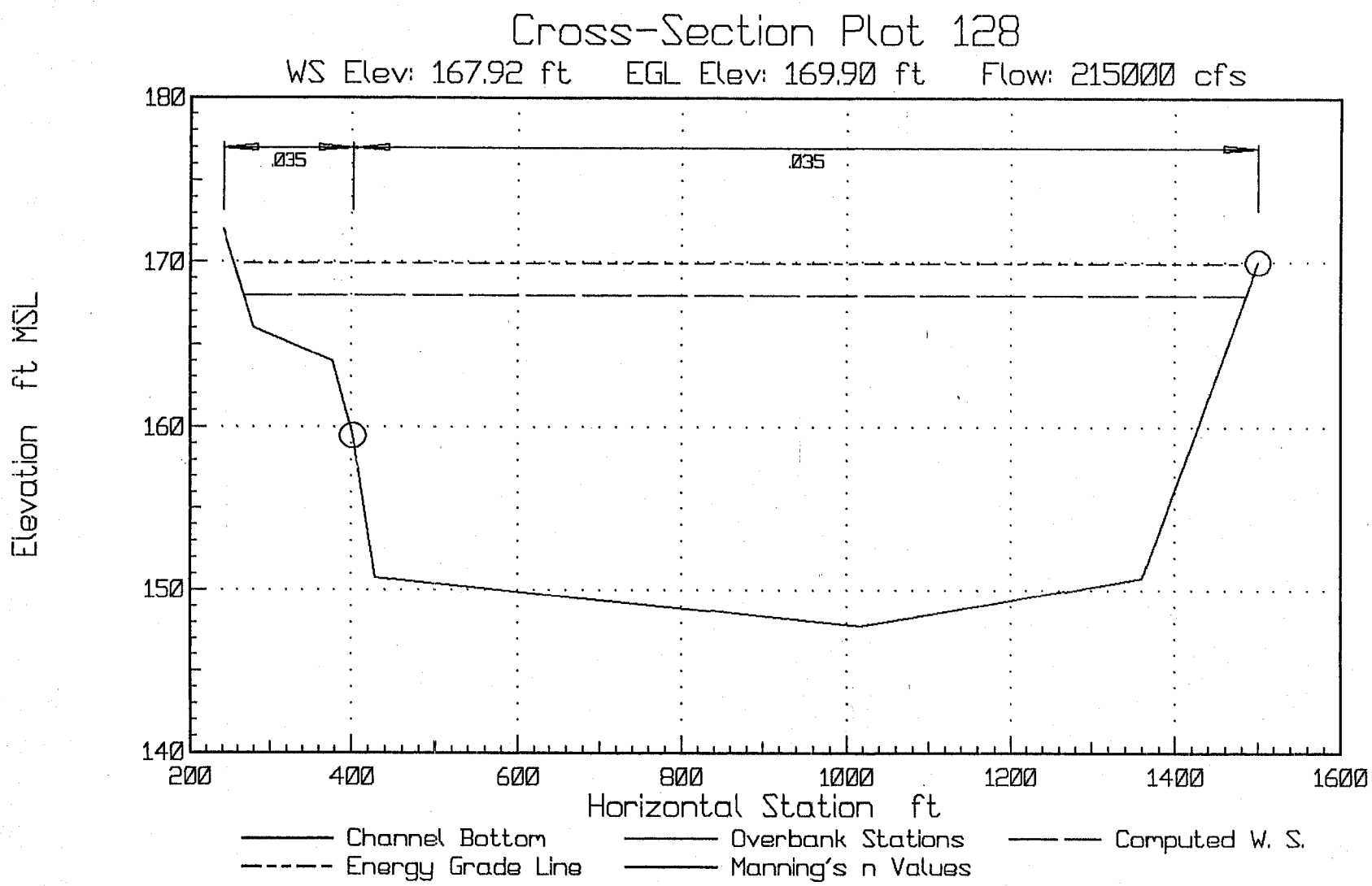

Cross-Section Plot 122
WS Elev: 166.11 ft
EGL Elev: 168.58 ft
Flow: 215000 cfs
.035
.035
.035
180
170
160
150
140
Elevation ft MSL
200
400
600
800
1000
1200
1400
1600
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values


Cross-Section Plot 122.65
WS Elev: 166.24 ft EGL Elev: 168.72 ft Flow: 215000 cfs
Elevation ft MSL
180
170
160
150
140
200
400
600
800
1000
1200
1400
1600
Horizontal Station ft
.035
.035
.035
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.


Bridge Cross-Section Plot 123.55
WS Elev: 166.90 ft
EGL Elev: 169.13 ft
Flow: 215000 cfs
Elevation ft MSL
Horizontal Station ft
035
035
035
200
190
180
170
160
150
140
200
400
600
800
1000
1200
1400
1600
Channel Bottom
Top of Roadway
Energy Grade Line
Bridge Opening
Overbank Stations
Manning's n Values
Bridge Low Chord
Computed W. S.


Cross-Section Plot 124
WS Elev: 166.98 ft EGL Elev: 169.21 ft Flow: 215000 cfs
.035
.035
.035
180
170
160
150
140
Elevation ft MSL
200
400
600
800
1000
1200
1400
1600
Horizontal Station ft
Channel Bottom
Overbank Stations
Computed W. S.
Energy Grade Line
Manning's n Values


Cross-Section Plot 126
WS Elev: 167.70 ft
EGL Elev: 169.57 ft
Flow: 215000 cfs
.035
.035
180
170
160
150
140
Elevation ft MSL
200
400
600
800
1000
1200
1400
1600
Horizontal Station ft
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.


Cross-Section Plot 128
WS Elev: 167.92 ft
EGL Elev: 169.90 ft
Flow: 215000 cfs
.035
.035
180
170
160
150
140
Elevation ft MSL
200
400
600
800
1000
1200
1400
1600
Horizontal Station ft
Channel Bottom
Energy Grade Line
Overbank Stations
Manning's n Values
Computed W. S.

APPENDIX C

HEC-2 INPUT DATASET

```
T1      RIOMR.00 PHASE 2
T2      TEMPE RIO SALADO - SPRR ENCROACHMENT
T3      GC#4 TO MCCLINTOCK DRIVE

J1  ICHECK    INQ      NINV     IDIR     STRT     METRIC   HVINS    Q        WSEL     FQ

      0        2        0        0       0.0        0      0.0   40000.0   137.89

J2  NPROF     IPLOT    PRFVS    XSECV    XSECH    FN       ALLDC    IBW      CHNIM    ITRACE

     1         0       0.0      0.0      0.0      0.0      0.0      0.0      0.0

USER-DEFINED SUMMARY TABLES (J3) :
---------------------------------

     38       42       39       43        1        3       25        4        5

REQUESTED CROSS-SECTION PRINTOUTS (J5) :
----------------------------------------

    -10      -10

 NC   0.035     0.035     0.035       0.1       0.3
Grade Control Str. No. 4

 X1     0.0        9    555.72   1500.00       0.0       0.0       0.0       1.0       0.0         0
 GR  154.70   502.92    154.70    517.92    142.10    555.72    132.40    584.82    129.40   1017.91
 GR  132.40  1454.70    147.50   1500.00    157.70   1530.60    157.70   1545.60

 X1     2.0       13    598.50   1500.00     120.0     200.0     160.0       1.0       0.0         0
 GR  155.05   522.00    154.98    573.00    142.40    574.50    142.40    598.50    132.53    626.94
 GR  129.61  1082.00    132.61   1454.55    147.83   1500.00    147.83   1515.00    145.83   1521.00
 GR  145.83  1568.00    155.04   1594.00    155.04   1609.00

 X1     4.0       13    611.50   1500.00     200.0     200.0     200.0       1.0       0.0         0
 GR  155.48   535.00    155.48    550.00    142.90    587.50    142.90    611.50    132.74    640.63
 GR  129.82  1141.00    132.82   1454.34    148.17   1500.00    148.32   1515.00    146.17   1521.00
 GR  146.17  1611.00    155.44   1639.00    155.44   1654.00

 X1     6.0       13    621.50   1515.00     200.0     200.0     200.0       1.0       0.0         0
 GR  155.98   545.00    155.98    560.00    143.40    597.50    143.40    621.50    132.96    651.29
 GR  130.03  1190.00    133.03   1413.59    148.50   1460.00    148.50   1515.00    146.50   1521.00
 GR  146.50  1660.00    155.83   1686.00    155.83   1701.00

 X1     8.0       13    629.50   1500.00     200.0     200.0     200.0       1.0       0.0         0
 GR  156.55   553.00    156.40    568.00    143.90    605.50    143.66    629.50    133.50    659.98
 GR  130.50  1225.00    133.50   1454.01    148.83   1500.00    148.83   1515.00    146.83   1521.00
 GR  147.73  1701.83    156.22   1730.00    156.22   1745.00

 X1    10.0       13    627.50   1500.00     200.0     200.0     200.0       1.0       0.0         0
 GR  157.05   551.00    156.98    566.00    144.40    603.50    144.40    627.50    133.38    658.64
 GR  130.45  1247.00    133.45   1453.86    149.17   1500.00    149.17   1515.00    147.17   1521.00
 GR  148.31  1748.00    148.83   1777.00    148.83   1792.00
```

X1	12.0	13	623.50	1500.00	200.0	200.0	200.0	1.0	0.0	0
GR	157.48	547.00	157.48	562.00	144.90	599.50	144.90	623.50	133.60	655.15
GR	130.66	1255.00	133.66	1453.65	149.50	1500.00	149.50	1515.00	147.50	1521.00
GR	148.88	1796.00	157.04	1822.00	157.04	1837.00				
X1	14.0	13	611.43	1500.00	115.0	200.0	158.0	1.0	0.0	0
GR	157.69	535.31	157.69	550.24	145.19	587.55	145.19	611.43	133.72	643.13
GR	130.86	1243.75	133.86	1452.09	149.83	1500.00	149.83	1507.43	147.83	1513.40
GR	149.42	1830.74	157.47	1859.66	157.47	1874.58				
NC	0.0	0.0	0.0	0.3	0.5					
X1	15.4	13	599.49	1420.00	85.0	160.0	122.0	1.0	0.0	0
GR	157.90	523.37	157.90	538.30	145.40	575.61	145.40	599.49	133.81	630.71
GR	131.03	1233.8	134.03	1371.79	150.10	1420.00	150.10	1435.00	148.10	1521.00
GR	149.93	1886.52	157.79	1911.32	157.79	1926.32				
SB	1.48	1.56	2.67	1388.0	816.0	72.0	29800.0	10.7	131.58	131.55

SPRR bridge

X1	15.6	13	598.49	1420.00	15.0	20.0	18.0	1.0	0.0	0
X2	0.0	0.0	1	161.0	165.0	0.0	0	2.0	0.0	
GR	158.94	522.38	157.94	537.30	145.44	574.61	145.44	598.49	133.83	629.75
GR	131.05	1232.81	134.05	1371.76	150.13	1420.00	150.13	1435.00	148.13	1521.00
GR	149.96	1886.52	157.79	1911.40	157.79	1926.32				
NC	0.0	0.0	0.0	0.1	0.3					
X1	17.3	13	602.29	1500.00	155.0	150.0	152.0	1.0	0.0	0
GR	158.33	525.95	158.33	540.92	145.83	578.34	145.83	602.29	133.99	634.21
GR	131.21	1229.54	134.21	1450.17	150.38	1500.00	150.38	1515.00	148.57	1521.00
GR	150.00	1790.00	156.00	1880.00	158.00	2050.00				

Old Ash Bridge alignment

X1	19.0	13	602.90	1500.00	180.0	165.0	172.0	1.0	0.0	0
GR	158.99	526.47	158.99	541.46	146.49	578.42	146.49	602.90	134.19	636.64
GR	131.38	1218.78	134.38	1450.88	150.66	1500.00	150.66	1515.00	148.66	1521.00
GR	149.55	1698.30	158.76	1726.27	158.76	1741.26				
X1	21.5	13	557.48	1500.00	90.0	275.0	182.0	1.0	0.0	0
GR	159.48	483.50	159.48	498.01	146.98	534.27	146.98	557.48	134.28	590.08
GR	131.67	1142.03	134.67	1450.65	151.12	1500.00	151.12	1515.00	149.12	1521.00
GR	149.81	1658.02	159.08	1688.10	159.08	1702.60				
X1	24.0	13	522.05	1371.00	50.0	230.0	140.0	1.0	0.0	0
GR	159.76	405.82	159.76	419.53	147.26	453.80	147.26	522.05	134.34	551.50
GR	131.91	1031.91	134.91	1327.70	151.50	1371.00	151.50	1386.00	149.50	1392.00
GR	150.10	1511.75	159.99	1541.00	159.99	1556.00				

Mill Avenue bridge

X1	24.6	13	530.00	1501.65	60.0	60.0	60.0	1.0	0.0	0
RC	7	40000.0	141.84	93000.0	147.51	135000.0	151.04	160000.0	152.84	215000.0
RC	156.12	250000.0	158.80	296000.0	162.00					
GR	160.09	402.16	160.09	415.87	147.59	450.15	147.59	530.00	134.40	560.00
GR	131.97	1021.85	134.97	1327.65	151.62	1370.00	151.62	1385.00	149.62	1391.00
GR	150.17	1501.65	160.36	1530.00	160.36	1545.00				

```
X1    26.0        13    587.86   1428.00    230.0    140.0    185.0      1.0     0.0       0
GR  160.90    442.68    160.90    456.96   148.40   492.66   148.40   587.86   134.65  620.48
GR  132.12   1024.35    135.12   1382.59   151.88  1428.00   151.88  1442.28   149.88 1447.99
GR  150.39   1550.00    160.46   1580.32   160.46  1594.60

SB    1.11      1.56      2.67    1040.0    760.0     85.0  30000.0      5.2   132.12  132.22
Second Mill Avenue bridge

X1    26.45       13    587.86   1428.00     45.0     45.0     45.0      1.0     0.0       0
X2      0.0      0.0         1    172.51   176.14      0.0        0      2.0     0.0
GR  160.90    442.68    160.90    456.96   148.40   492.66   148.40   587.86   134.65  620.48
GR  132.12   1024.35    135.12   1382.59   151.88  1428.00   151.88  1442.28   149.88 1447.99
GR  150.39   1550.00    160.46   1580.32   160.46  1594.60

X1    27.0        13    648.59   1491.00    255.0     55.0    155.0      1.0     0.0       0
GR  161.22    497.00    161.22    511.91   148.72   549.19   148.72   648.59   134.97  683.18
GR  132.22   1034.75    135.22   1443.40   152.08  1491.00   152.08  1505.91   150.08 1511.87
GR  150.53   1601.21    160.58   1631.00   160.58  1646.00

X1    28.0        13    654.50   1500.00    220.0    100.0    160.0      1.0     0.0       0
GR  161.44    502.00    161.44    517.00   148.94   554.50   148.94   654.50   135.20  689.57
GR  132.33    999.00    135.33   1451.97   152.27  1500.00   152.27  1515.00   150.27 1521.00
GR  150.66   1598.00    160.86   1628.00   160.86  1643.00

X1    30.0        13    657.50    1500.0    200.0    200.0    200.0      1.0     0.0       0
GR  161.65    505.00    161.65    520.00   149.15   557.50   149.15   657.50   135.42  692.39
GR  132.54    952.00    135.54   1451.64   152.65  1500.00   152.65  1515.00   150.65 1521.00
GR  150.95   1580.00    160.14   1610.00   160.29  1625.00

X1    32.0        11    658.06    1500.0    200.0    200.0    200.0      1.0     0.0       0
GR  161.86    514.00    161.86    529.00   149.37   566.50   149.37   658.06   135.63  692.98
GR  132.75    920.00    135.75   1462.92   148.11  1500.00   148.91  1580.00   162.11 1619.60
GR  162.11   1634.60

X1    34.0        11    656.17   1500.00    200.0    200.0    200.0      1.0     0.0       0
GR  162.07    529.00    162.07    544.00   149.57   581.50   149.57   656.17   135.85  691.45
GR  132.96    902.00    135.96   1466.01   148.32  1500.00   149.12  1580.00   162.32 1619.60
GR  162.32   1634.60

X1    36.0        11    658.78   1500.00    230.0    200.0    215.0      1.0     0.0       0
GR  162.31    557.00    162.31    572.00   149.81   609.50   149.81   658.78   136.09  699.94
GR  133.17    894.00    136.17   1462.89   148.54  1500.00   149.34  1580.00   162.53 1619.57
GR  162.53   1634.57

X1    38.0        11    661.39   1500.00    260.0    200.0    230.0      1.0     0.0       0
GR  162.58    568.00    162.58    583.00   150.49   619.27   150.08   661.39   136.37  697.57
GR  133.37    892.00    136.37   1462.86   148.75  1500.00   149.55  1580.00   162.74 1619.57
GR  162.74   1634.57

X1    40.0        11    671.78   1500.00    260.0    200.0    230.0      1.0     0.0       0
GR  162.85    596.00    162.85    611.00   150.59   647.78   150.35   671.78   136.65  712.88
GR  133.58    895.00    136.58   1462.86   148.96  1500.00   149.76  1580.00   162.95 1639.57
GR  162.95   1654.57

X1    42.0        11    673.78   1500.00    260.0    200.0    230.0      1.0     0.0       0
GR  163.12    598.00    163.12    613.00   150.86   649.78   150.62   673.78   136.93  714.85
GR  133.79    900.00    136.79   1462.83   149.18  1500.00   149.24  1580.00   163.16 1621.76
GR  163.16   1636.76
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X1    44.0       11   690.78  1500.00   260.0   200.0   230.0     1.0     0.0       0
GR  163.39   615.00   163.39   630.00  151.13  666.78  150.89  690.78  137.20  731.85
GR  134.00   908.00   137.00  1462.83  149.39 1500.00  150.19 1580.00  163.37 1619.54
GR  163.37  1634.54

X1    46.0       11   689.78  1500.00   260.0   200.0   230.0     1.0     0.0       0
GR  163.66   614.00   163.66   629.00  151.40  665.78  151.16  689.78  137.48  730.82
GR  134.21   919.00   137.21  1462.83  149.60 1500.00  150.40 1580.00  163.58 1619.54
GR  163.58  1634.54

X1    48.0       11   682.78  1500.00   260.0   200.0   230.0     1.0     0.0       0
GR  163.93   607.00   163.93   622.00  151.67  658.78  151.43  682.78  137.76  723.79
GR  134.42   931.00   137.42  1462.80  149.82 1500.00  150.62 1580.00  163.79 1619.51
GR  163.79  1634.51

X1    50.0       11   670.78  1500.00   210.0   200.0   205.0     1.0     0.0       0
GR  164.15   595.00   164.15   610.00  151.89  646.78  151.65  670.78  137.99  711.76
GR  134.63   951.00   137.63  1462.80  150.03 1500.00  150.83 1580.00  164.00 1619.51
GR  164.00  1634.51

X1    52.0       11   661.78  1500.00   175.0   200.0   188.0     1.0     0.0       0
GR  164.33   586.00   164.33   601.00  152.07  637.78  151.83  661.78  138.17  702.76
GR  134.84   981.00   137.84  1462.80  150.24 1500.00  151.04 1580.00  164.21 1619.51
GR  164.21  1634.51

X1    54.0       11   654.78  1500.00   160.0   200.0   180.0     1.0     0.0       0
GR  164.50   579.00   164.50   594.00  152.24  630.78  152.00  654.78  138.34  695.76
GR  135.05  1020.00   138.05  1467.87  150.46 1500.00  151.26 1580.00  164.42 1619.48
GR  164.42  1634.48

X1    56.0       11   645.78  1500.00   160.0   200.0   180.0     1.0     0.0       0
GR  164.67   570.00   164.67   585.00  152.41  621.78  152.17  645.78  138.52  686.73
GR  135.26  1065.00   138.26  1462.77  150.67 1500.00  151.47 1580.00  164.63 1619.48
GR  164.63  1634.48

X1    58.0       11   638.78  1500.00   165.0   200.0   182.0     1.0     0.0       0
GR  164.84   563.00   164.84   578.00  152.58  614.78  152.34  638.78  138.69  679.73
GR  135.47  1121.00   138.47  1462.77  150.88 1500.00  151.68 1580.00  164.84 1619.48
GR  164.84  1634.48

X1    60.0       11   629.78  1500.00   170.0   200.0   185.0     1.0     0.0       0
GR  165.01   554.00   165.01   569.00  152.75  605.78  152.51  629.78  138.87  670.70
GR  135.68  1180.00   138.68  1462.77  151.09 1500.00  151.89 1580.00  165.05 1619.48
GR  165.05  1634.48

X1    62.0       11   620.78  1500.00   160.0   200.0   180.0     1.0     0.0       0
GR  165.18   545.00   165.18   560.00  152.92  596.78  152.68  620.78  139.04  661.70
GR  135.89  1230.00   138.89  1462.74  151.31 1500.00  152.11 1580.00  165.26 1619.45
GR  165.26  1634.45

X1    64.0       11   612.78  1500.00   160.0   200.0   180.0     1.0     0.0       0
GR  165.34   537.00   165.34   552.00  153.08  588.78  152.84  612.78  139.22  647.88
GR  136.09  1270.00   139.09  1462.71  151.52 1500.00  152.32 1580.00  165.47 1619.45
GR  165.47  1634.45
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X1     66.0        11    604.78   1500.00     160.0     200.0     180.0       1.0       0.0         0
GR   165.51    529.00    165.51    544.00    153.25    580.78    153.01    604.78    139.39    645.64
GR   136.30   1300.00    139.30   1462.71    151.73   1500.00    152.53   1580.00    165.51   1618.94
GR   165.51   1633.94

X1     68.0        11    597.78   1500.00     170.0     200.0     185.0       1.0       0.0         0
GR   165.69    522.00    165.69    537.00    153.43    573.78    153.19    597.78    139.57    638.64
GR   136.51   1318.00    139.51   1462.68    151.95   1500.00    152.75   1580.00    165.89   1619.42
GR   165.89   1634.42

X1     69.3        11    590.78   1500.00      85.0     130.0     108.0       1.0       0.0         0
X3       10       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
GR   165.78    515.00    165.78    530.00    153.52    566.78    153.28    590.78    139.66    631.64
GR   136.65   1322.00    139.65   1462.68    152.09   1500.00    152.89   1580.00    166.03   1619.42
GR   166.03   1634.42

SB     1.05      1.56      2.63       0.0     831.0      54.0   34820.0       5.0    139.08    138.97
Rural Road bridge

X1     70.3        21    589.78   1500.00      85.0     100.0      92.0       1.0       0.0         0
X2      0.0       0.0         1    172.28    176.98       0.0         0       2.0       0.0
BT      -12    514.00    176.98    165.86    524.00    177.02    169.35    645.00    178.49    170.82
BT             766.00    179.49    171.79    887.00    179.95    172.28   1008.00    179.95    172.28
BT            1129.00    179.46    171.79   1250.00    178.49    170.82   1371.00    177.02    169.35
BT            1492.00    175.07    167.40   1612.00    172.65    164.98   1619.42    172.50    166.13
GR   165.86    514.00    165.78    524.00    165.86    529.00    153.60    565.78    153.36    589.78
GR   139.75    630.61    139.69    645.00    139.17    766.00    138.64    887.00    138.12   1008.00
GR   137.60   1129.00    137.07   1250.00    136.75   1325.00    137.76   1371.00    139.75   1462.68
GR   149.52   1492.00    152.19   1500.00    152.99   1580.00    163.66   1612.00    166.13   1619.42
GR   166.13   1634.42

X1     72.0        11    581.78   1500.00     150.0     170.0     160.0       1.0       0.0         0
GR   166.03    506.00    166.03    521.00    153.77    557.78    153.53    581.78    139.91    622.64
GR   136.93   1321.00    139.93   1462.68    152.37   1500.00    152.86   1549.00    166.31   1589.35
GR   166.31   1604.35

X1     74.0        11    571.78   1500.00     160.0     200.0     180.0       1.0       0.0         0
GR   166.26    496.00    166.26    511.00    154.00    547.78    153.76    571.78    140.12    612.70
GR   137.14   1315.00    140.14   1462.65    152.59   1500.00    152.83   1524.00    166.52   1565.07
GR   166.52   1580.07

X1     76.0        11    556.78   1500.00     160.0     200.0     180.0       1.0       0.0         0
GR   166.49    481.00    166.49    496.00    154.23    532.78    153.99    556.78    140.33    597.76
GR   137.35   1279.00    140.35   1462.65    152.80   1500.00    153.04   1524.00    166.73   1565.07
GR   166.73   1580.07

X1     78.0        11    532.75   1500.00     160.0     200.0     180.0       1.0       0.0         0
GR   166.71    457.00    166.71    472.00    154.46    508.75    154.22    532.75    140.54    573.79
GR   137.56   1241.00    140.56   1462.65    153.01   1500.00    153.25   1524.00    166.94   1565.07
GR   166.94   1580.07

X1     80.0        11    506.78   1500.00     165.0     200.0     182.0       1.0       0.0         0
GR   166.95    431.00    166.95    446.00    154.69    482.78    154.45    506.78    140.76    547.85
GR   137.77   1194.00    140.77   1462.62    153.23   1500.00    153.47   1524.00    167.15   1565.04
GR   167.15   1580.04
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X1	82.0	11	471.78	1500.00	160.0	200.0	180.0	1.0	0.0	0
GR	167.18	396.00	167.18	411.00	154.92	447.78	154.68	471.78	140.97	512.91
GR	137.98	1136.00	140.98	1462.62	153.44	1500.00	153.68	1524.00	167.36	1565.04
GR	167.36	1580.04								
X1	84.0	11	435.78	1500.00	160.0	200.0	180.0	1.0	0.0	0
GR	167.41	360.00	167.41	375.00	155.15	411.78	154.91	435.78	141.19	476.94
GR	138.19	1088.00	141.19	1462.62	153.65	1500.00	153.89	1524.00	167.57	1565.04
GR	167.57	1580.04								
X1	86.0	11	388.78	1500.00	165.0	200.0	182.0	1.0	0.0	0
GR	167.64	313.00	167.64	328.00	155.38	364.78	155.14	388.78	141.39	430.03
GR	138.40	1040.00	141.40	1462.59	153.87	1500.00	154.11	1524.00	167.78	1565.01
GR	167.78	1580.01								
X1	88.0	11	322.78	1500.00	160.0	200.0	180.0	1.0	0.0	0
GR	167.87	247.00	167.87	262.00	155.61	298.78	155.37	322.78	141.60	364.09
GR	138.60	1008.00	141.60	1462.56	154.08	1500.00	154.32	1524.00	167.99	1565.01
GR	167.99	1580.01								
X1	90.0	12	265.78	1500.00	155.0	200.0	178.0	1.0	0.0	0
GR	168.07	190.00	168.07	205.00	155.81	241.00	155.57	265.78	149.50	284.00
GR	141.80	307.09	138.81	980.00	141.81	1462.56	154.29	1500.00	154.53	1524.00
GR	168.20	1561.01	168.20	1576.01						
X1	92.0	11	215.78	1500.00	155.0	200.0	178.0	1.0	0.0	0
GR	168.24	140.00	168.24	155.00	155.98	191.78	157.74	215.78	142.01	262.97
GR	139.02	960.00	142.02	1459.53	155.51	1500.00	155.75	1524.00	168.41	1561.98
GR	168.41	1576.98								
X1	94.0	12	168.75	1500.00	155.0	200.0	178.0	1.0	0.0	0
GR	168.41	93.00	168.41	108.00	156.16	144.75	155.92	168.75	142.21	185.88
GR	141.96	282.00	139.23	948.00	142.23	1471.62	154.72	1500.00	154.96	1524.00
GR	168.62	1561.05	168.62	1576.05						
X1	96.0	12	150.00	1500.00	225.0	200.0	212.0	1.0	0.0	0
GR	168.66	33.00	168.66	48.00	156.41	84.75	156.17	150.00	142.51	190.98
GR	142.16	319.00	139.44	939.00	142.44	1462.53	154.93	1500.00	155.17	1524.00
GR	168.83	1564.98	168.83	1579.98						
X1	98.0	9	20.00	1500.00	290.0	200.0	245.0	1.0	0.0	0
GR	156.49	20.00	142.89	60.80	141.79	353.00	139.65	920.00	142.65	1462.50
GR	155.15	1500.00	155.39	1524.00	169.04	1564.95	169.04	1579.95		
X1	100.0	7	350.00	1500.00	310.0	200.0	255.0	1.0	0.0	0
GR	142.51	350.00	139.86	885.00	142.86	1462.50	155.36	1500.00	155.60	1524.00
GR	169.25	1564.95	169.25	1579.95						
X1	102.0	11	484.41	1500.00	370.0	200.0	285.0	1.0	0.0	0
GR	169.42	407.91	169.42	422.91	156.92	460.41	156.68	484.41	143.15	525.00
GR	140.07	853.00	143.07	1462.50	155.57	1500.00	155.81	1524.00	169.46	1564.95
GR	169.46	1579.95								

X1	104.0	11	535.50	1500.00	260.0	200.0	230.0	1.0	0.0	0
GR	169.62	459.00	169.62	474.00	157.12	511.50	156.88	535.50	143.15	576.69
GR	140.28	828.00	143.28	1462.47	155.79	1500.00	156.03	1524.00	169.67	1564.92
GR	169.67	1579.92								
X1	106.0	11	531.50	1500.00	250.0	200.0	225.0	1.0	0.0	0
GR	169.87	455.00	169.87	470.00	157.37	507.50	157.13	531.50	143.40	572.69
GR	140.49	810.00	143.49	1462.47	156.00	1500.00	156.14	1514.40	169.88	1555.62
GR	169.88	1570.62								
X1	108.0	10	473.50	1500.00	250.0	200.0	225.0	1.0	0.0	0
GR	170.12	397.00	170.12	412.00	157.62	449.50	157.38	473.50	143.65	514.69
GR	140.70	795.00	143.70	1462.02	156.36	1500.00	170.09	1541.19	170.09	1556.19
X1	110.0	9	590.50	1500.00	255.0	200.0	228.0	1.0	0.0	0
GR	170.37	514.00	170.37	529.00	157.87	566.50	157.63	590.50	143.91	631.66
GR	140.91	790.00	143.91	1420.83	170.30	1500.00	170.30	1515.00		
X1	112.0	9	606.50	1500.00	225.0	200.0	212.0	1.0	0.0	0
GR	170.60	530.00	170.60	545.00	158.10	582.50	157.86	606.50	144.13	647.69
GR	141.12	790.00	144.12	1420.83	170.51	1500.00	170.51	1515.00		
X1	114.0	9	584.50	1500.00	200.0	200.0	200.0	1.0	0.0	0
GR	170.80	508.00	170.80	523.00	158.30	560.50	158.06	584.50	144.33	625.69
GR	141.32	800.00	144.32	1420.77	170.73	1500.00	170.73	1515.00		
X1	116.0	9	529.50	1500.00	205.0	200.0	202.0	1.0	0.0	0
GR	171.00	453.00	171.00	468.00	158.50	505.50	158.26	529.50	144.54	570.66
GR	141.53	820.00	144.53	1420.77	170.94	1500.00	170.94	1515.00		
X1	118.0	9	474.50	1500.00	210.0	200.0	205.0	1.0	0.0	0
GR	171.21	398.00	171.21	413.00	158.71	450.50	158.47	474.50	144.75	515.66
GR	141.74	854.00	144.74	1420.77	171.15	1500.00	171.15	1515.00		
X1	119.8	9	446.50	1500.00	180.0	200.0	190.0	1.0	0.0	0
X3	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
GR	171.39	370.00	171.39	385.00	158.89	422.50	158.65	446.50	144.95	487.60
GR	141.95	525.00	144.95	1420.74	171.37	1500.00	171.37	1515.00		
X1	120.42	9	446.22	1485.00	57.0	42.0	50.0	1.0	0.0	0
X3	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
GR	171.45	370.00	171.45	385.00	158.95	422.50	158.71	446.22	144.98	487.69
GR	142.00	926.50	145.00	1405.77	171.41	1485.00	171.41	1500.00		

Grade Control Str. No. 5

X1	120.5	9	443.50	1485.00	8.0	8.0	8.0	1.0	0.0	0
GR	171.46	367.00	171.46	382.00	158.96	419.50	158.72	443.50	150.00	469.66
GR	147.00	926.50	150.00	1420.74	171.42	1485.00	171.42	1500.00		
X1	122.0	9	441.50	1460.00	155.0	150.0	152.0	1.0	0.0	0
GR	171.61	365.00	171.61	380.00	159.11	417.50	158.87	441.50	150.16	467.63
GR	147.15	941.00	150.15	1395.71	171.58	1460.00	171.58	1475.00		

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X1   122.65        9    441.50   1460.00      65.0      65.0      65.0       1.0       0.0         0
X3       10      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
GR   171.68   365.00    171.68    380.00    159.18    417.50    158.94    441.50    150.22    490.27
GR   147.22   952.00    150.22   1395.71    171.65   1460.00    171.65   1475.00

SB     1.05      1.56      2.63       0.0     798.0      66.0   24246.0       6.3    147.31    147.22
McClintock Drive Bridge

X1   123.55       20     441.5   1460.00      90.0      90.0      90.0       1.0       0.0         0
X2      0.0      0.0         1    180.61     181.8       0.0         0       2.0       0.0
X3       10      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
BT      -11   316.00    181.80    174.13    436.00    184.23    176.56    554.00    185.93    178.26
BT            672.00    187.37    179.70    790.00    188.15    180.48    908.00    188.28    180.61
BT           1026.00    188.15    180.48   1144.00    187.37    179.70   1262.00    185.93    178.26
BT           1380.00    184.23    176.56   1500.00    181.80    174.13
GR   174.13   316.00    171.77    371.00    171.77    386.00    159.27    423.50    159.10    436.00
GR   159.03   441.50    150.31    500.09    149.97    554.00    149.22    672.00    148.48    790.00
GR   147.73   908.00    147.31    975.00    147.64   1026.00    148.42   1144.00    149.19   1262.00
GR   149.96  1380.00    150.31   1433.31    171.75   1460.00    171.75   1475.00    174.13   1500.00

X1    124.0        9    436.50   1465.00      45.0      45.0      45.0       1.0       0.0         0
GR   171.81   360.00    171.81    375.00    159.31    412.50    159.07    436.50    150.36    464.22
GR   147.35   983.00    150.35   1400.68    171.79   1465.00    171.79   1480.00

X1    126.0       10    415.00   1500.00     200.0     200.0     200.0       1.0       0.0         0
X3        0      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
GR   170.00   240.00    168.00    272.00    166.00    317.00    164.00    348.00    162.00    388.00
GR   159.27   415.00    150.56    441.13    147.55    985.00    150.55   1435.62    172.01   1500.00

X1    128.0        8    402.00   1500.00     200.0     200.0     200.0       1.0       0.0         0
X3        0      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
GR   172.00   242.00    166.00    280.00    164.00    377.00    159.47    402.00    150.76    428.13
GR   147.75  1017.00    150.75   1359.75    170.00   1500.00
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T1 RIOMR.00 PHASE 2
T2 TEMPE RIO SALADO - SPRR ENCROACHMENT
T3 GC#4 TO MCCLINTOCK DRIVE

JOB PARAMETERS :

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0	3	0	0	0.0	0	0.0	93000.0	142.70	

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	2	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

T1 RIOMR.00 PHASE 2
T2 TEMPE RIO SALADO - SPRR ENCROACHMENT
T3 GC#4 TO MCCLINTOCK DRIVE

JOB PARAMETERS :

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0	4	0	0	0.0	0	0.0	135000.0	145.73	

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	3	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

T1 RIOMR.00 PHASE 2
T2 TEMPE RIO SALADO - SPRR ENCROACHMENT
T3 GC#4 TO MCCLINTOCK DRIVE

JOB PARAMETERS :

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0	5	0	0	0.0	0	0.0	160000.0	147.30	

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	4	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

T1 RIOMR.00 PHASE 2
T2 TEMPE RIO SALADO - SPRR ENCROACHMENT
T3 GC#4 TO MCCLINTOCK DRIVE

JOB PARAMETERS :

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0	6	0	0	0.0	0	0.0	215000.0	150.40	

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	5	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

T1 RIOMR.00 PHASE 2
T2 TEMPE RIO SALADO - SPRR ENCROACHMENT
T3 GC#4 TO MCCLINTOCK DRIVE

JOB PARAMETERS :

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0	7	0	0	0.0	0	0.0	250000.0	152.20	

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	6	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

T1 RIOMR.00 PHASE 2
T2 TEMPE RIO SALADO - SPRR ENCROACHMENT
T3 GC#4 TO MCCLINTOCK DRIVE

JOB PARAMETERS :

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0	8	0	0	0.0	0	0.0	296000.0	154.39	

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	15	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

APPENDIX D

HEC-2 OUTPUT

==========
B O S S H E C - 2 (tm)
==========

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Serial Number : 0010149.200

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PROJECT DESCRIPTION :

PROJECT TITLE : TEMPE RIO SALADO - SPRR ENCROACHMENT
PROJECT NUMBER : RIOMR.00 PHASE 2
DESCRIPTION : GC#4 TO MCCLINTOCK DRIVE
ENGINEER : GK COTTON, PE
DATE OF RUN : 8/14/1991
TIME OF RUN : 11:01 am

T1 RIOMR.00 PHASE 2
T2 TEMPE RIO SALADO - SPRR ENCROACHMENT
T3 GC#4 TO MCCLINTOCK DRIVE

JOB PARAMETERS :

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0	2	0	0	0.0	0	0.0	40000.0	137.89	
J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	1	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

USER-DEFINED SUMMARY TABLES (J3) :

38 42 39 43 1 3 25 4 5

REQUESTED CROSS-SECTION PRINTOUTS (J5) :

-10 -10

NC 0.035 0.035 0.035 0.1 0.3

Grade Control Str. No. 4

X1	0.0	9	555.72	1500.00	0.0	0.0	0.0	1.0	0.0	0
GR	154.70	502.92	154.70	517.92	142.10	555.72	132.40	584.82	129.40	1017.91
GR	132.40	1454.70	147.50	1500.00	157.70	1530.60	157.70	1545.60		
X1	2.0	13	598.50	1500.00	120.0	200.0	160.0	1.0	0.0	0
GR	155.05	522.00	154.98	573.00	142.40	574.50	142.40	598.50	132.53	626.94
GR	129.61	1082.00	132.61	1454.55	147.83	1500.00	147.83	1515.00	145.83	1521.00
GR	145.83	1568.00	155.04	1594.00	155.04	1609.00				
X1	4.0	13	611.50	1500.00	200.0	200.0	200.0	1.0	0.0	0
GR	155.48	535.00	155.48	550.00	142.90	587.50	142.90	611.50	132.74	640.63
GR	129.82	1141.00	132.82	1454.34	148.17	1500.00	148.32	1515.00	146.17	1521.00
GR	146.17	1611.00	155.44	1639.00	155.44	1654.00				
X1	6.0	13	621.50	1515.00	200.0	200.0	200.0	1.0	0.0	0
GR	155.98	545.00	155.98	560.00	143.40	597.50	143.40	621.50	132.96	651.29
GR	130.03	1190.00	133.03	1413.59	148.50	1460.00	148.50	1515.00	146.50	1521.00
GR	146.50	1660.00	155.83	1686.00	155.83	1701.00				

```
X1      8.0        13    629.50   1500.00     200.0     200.0     200.0       1.0       0.0         0
GR   156.55    553.00    156.40    568.00    143.90    605.50    143.66    629.50    133.50    659.98
GR   130.50   1225.00    133.50   1454.01    148.83   1500.00    148.83   1515.00    146.83   1521.00
GR   147.73   1701.83    156.22   1730.00    156.22   1745.00

X1     10.0        13    627.50   1500.00     200.0     200.0     200.0       1.0       0.0         0
GR   157.05    551.00    156.98    566.00    144.40    603.50    144.40    627.50    133.38    658.64
GR   130.45   1247.00    133.45   1453.86    149.17   1500.00    149.17   1515.00    147.17   1521.00
GR   148.31   1748.00    148.83   1777.00    148.83   1792.00

X1     12.0        13    623.50   1500.00     200.0     200.0     200.0       1.0       0.0         0
GR   157.48    547.00    157.48    562.00    144.90    599.50    144.90    623.50    133.60    655.15
GR   130.66   1255.00    133.66   1453.65    149.50   1500.00    149.50   1515.00    147.50   1521.00
GR   148.88   1796.00    157.04   1822.00    157.04   1837.00

X1     14.0        13    611.43   1500.00     115.0     200.0     158.0       1.0       0.0         0
GR   157.69    535.31    157.69    550.24    145.19    587.55    145.19    611.43    133.72    643.13
GR   130.86   1243.75    133.86   1452.09    149.83   1500.00    149.83   1507.43    147.83   1513.40
GR   149.42   1830.74    157.47   1859.66    157.47   1874.58

NC      0.0       0.0       0.0       0.3       0.5
X1     15.4        13    599.49   1420.00      85.0     160.0     122.0       1.0       0.0         0
GR   157.90    523.37    157.90    538.30    145.40    575.61    145.40    599.49    133.81    630.71
GR   131.03    1233.8    134.03   1371.79    150.10   1420.00    150.10   1435.00    148.10   1521.00
GR   149.93   1886.52    157.79   1911.32    157.79   1926.32

SB     1.48      1.56      2.67    1388.0     816.0      72.0   29800.0      10.7    131.58    131.55
SPRR bridge

X1     15.6        13    598.49   1420.00      15.0      20.0      18.0       1.0       0.0         0
X2      0.0       0.0         1     161.0     165.0       0.0         0       2.0       0.0
GR   158.94    522.38    157.94    537.30    145.44    574.61    145.44    598.49    133.83    629.75
GR   131.05   1232.81    134.05   1371.76    150.13   1420.00    150.13   1435.00    148.13   1521.00
GR   149.96   1886.52    157.79   1911.40    157.79   1926.32

NC      0.0       0.0       0.0       0.1       0.3
X1     17.3        13    602.29   1500.00     155.0     150.0     152.0       1.0       0.0         0
GR   158.33    525.95    158.33    540.92    145.83    578.34    145.83    602.29    133.99    634.21
GR   131.21   1229.54    134.21   1450.17    150.38   1500.00    150.38   1515.00    148.57   1521.00
GR   150.00   1790.00    156.00   1880.00    158.00   2050.00

Old Ash Bridge alignment

X1     19.0        13    602.90   1500.00     180.0     165.0     172.0       1.0       0.0         0
GR   158.99    526.47    158.99    541.46    146.49    578.42    146.49    602.90    134.19    636.64
GR   131.38   1218.78    134.38   1450.88    150.66   1500.00    150.66   1515.00    148.66   1521.00
GR   149.55   1698.30    158.76   1726.27    158.76   1741.26

X1     21.5        13    557.48   1500.00      90.0     275.0     182.0       1.0       0.0         0
GR   159.48    483.50    159.48    498.01    146.98    534.27    146.98    557.48    134.28    590.08
GR   131.67   1142.03    134.67   1450.65    151.12   1500.00    151.12   1515.00    149.12   1521.00
GR   149.81   1658.02    159.08   1688.10    159.08   1702.60
```

X1	24.0	13	522.05	1371.00	50.0	230.0	140.0	1.0	0.0	0
GR	159.76	405.82	159.76	419.53	147.26	453.80	147.26	522.05	134.34	551.50
GR	131.91	1031.91	134.91	1327.70	151.50	1371.00	151.50	1386.00	149.50	1392.00
GR	150.10	1511.75	159.99	1541.00	159.99	1556.00				

Mill Avenue bridge

X1	24.6	13	530.00	1501.65	60.0	60.0	60.0	1.0	0.0	0
RC	7	40000.0	141.84	93000.0	147.51	135000.0	151.04	160000.0	152.84	215000.0
RC	156.12	250000.0	158.80	296000.0	162.00					
GR	160.09	402.16	160.09	415.87	147.59	450.15	147.59	530.00	134.40	560.00
GR	131.97	1021.85	134.97	1327.65	151.62	1370.00	151.62	1385.00	149.62	1391.00
GR	150.17	1501.65	160.36	1530.00	160.36	1545.00				
X1	26.0	13	587.86	1428.00	230.0	140.0	185.0	1.0	0.0	0
GR	160.90	442.68	160.90	456.96	148.40	492.66	148.40	587.86	134.65	620.48
GR	132.12	1024.35	135.12	1382.59	151.88	1428.00	151.88	1442.28	149.88	1447.99
GR	150.39	1550.00	160.46	1580.32	160.46	1594.60				
SB	1.11	1.56	2.67	1040.0	760.0	85.0	30000.0	5.2	132.12	132.22

Second Mill Avenue bridge

X1	26.45	13	587.86	1428.00	45.0	45.0	45.0	1.0	0.0	0
X2	0.0	0.0	1	172.51	176.14	0.0	0	2.0	0.0	
GR	160.90	442.68	160.90	456.96	148.40	492.66	148.40	587.86	134.65	620.48
GR	132.12	1024.35	135.12	1382.59	151.88	1428.00	151.88	1442.28	149.88	1447.99
GR	150.39	1550.00	160.46	1580.32	160.46	1594.60				
X1	27.0	13	648.59	1491.00	255.0	55.0	155.0	1.0	0.0	0
GR	161.22	497.00	161.22	511.91	148.72	549.19	148.72	648.59	134.97	683.18
GR	132.22	1034.75	135.22	1443.40	152.08	1491.00	152.08	1505.91	150.08	1511.87
GR	150.53	1601.21	160.58	1631.00	160.58	1646.00				
X1	28.0	13	654.50	1500.00	220.0	100.0	160.0	1.0	0.0	0
GR	161.44	502.00	161.44	517.00	148.94	554.50	148.94	654.50	135.20	689.57
GR	132.33	999.00	135.33	1451.97	152.27	1500.00	152.27	1515.00	150.27	1521.00
GR	150.66	1598.00	160.86	1628.00	160.86	1643.00				
X1	30.0	13	657.50	1500.0	200.0	200.0	200.0	1.0	0.0	0
GR	161.65	505.00	161.65	520.00	149.15	557.50	149.15	657.50	135.42	692.39
GR	132.54	952.00	135.54	1451.64	152.65	1500.00	152.65	1515.00	150.65	1521.00
GR	150.95	1580.00	160.14	1610.00	160.29	1625.00				
X1	32.0	11	658.06	1500.0	200.0	200.0	200.0	1.0	0.0	0
GR	161.86	514.00	161.86	529.00	149.37	566.50	149.37	658.06	135.63	692.98
GR	132.75	920.00	135.75	1462.92	148.11	1500.00	148.91	1580.00	162.11	1619.60
GR	162.11	1634.60								
X1	34.0	11	656.17	1500.00	200.0	200.0	200.0	1.0	0.0	0
GR	162.07	529.00	162.07	544.00	149.57	581.50	149.57	656.17	135.85	691.45
GR	132.96	902.00	135.96	1466.01	148.32	1500.00	149.12	1580.00	162.32	1619.60

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GR   162.32    1634.60

X1     36.0        11    658.78   1500.00     230.0     200.0     215.0       1.0       0.0         0
GR   162.31    557.00    162.31    572.00    149.81    609.50    149.81    658.78    136.09    699.94
GR   133.17    894.00    136.17   1462.89    148.54   1500.00    149.34   1580.00    162.53   1619.57
GR   162.53   1634.57

X1     38.0        11    661.39   1500.00     260.0     200.0     230.0       1.0       0.0         0
GR   162.58    568.00    162.58    583.00    150.49    619.27    150.08    661.39    136.37    697.57
GR   133.37    892.00    136.37   1462.86    148.75   1500.00    149.55   1580.00    162.74   1619.57
GR   162.74   1634.57

X1     40.0        11    671.78   1500.00     260.0     200.0     230.0       1.0       0.0         0
GR   162.85    596.00    162.85    611.00    150.59    647.78    150.35    671.78    136.65    712.88
GR   133.58    895.00    136.58   1462.86    148.96   1500.00    149.76   1580.00    162.95   1639.57
GR   162.95   1654.57

X1     42.0        11    673.78   1500.00     260.0     200.0     230.0       1.0       0.0         0
GR   163.12    598.00    163.12    613.00    150.86    649.78    150.62    673.78    136.93    714.85
GR   133.79    900.00    136.79   1462.83    149.18   1500.00    149.24   1580.00    163.16   1621.76
GR   163.16   1636.76

X1     44.0        11    690.78   1500.00     260.0     200.0     230.0       1.0       0.0         0
GR   163.39    615.00    163.39    630.00    151.13    666.78    150.89    690.78    137.20    731.85
GR   134.00    908.00    137.00   1462.83    149.39   1500.00    150.19   1580.00    163.37   1619.54
GR   163.37   1634.54

X1     46.0        11    689.78   1500.00     260.0     200.0     230.0       1.0       0.0         0
GR   163.66    614.00    163.66    629.00    151.40    665.78    151.16    689.78    137.48    730.82
GR   134.21    919.00    137.21   1462.83    149.60   1500.00    150.40   1580.00    163.58   1619.54
GR   163.58   1634.54

X1     48.0        11    682.78   1500.00     260.0     200.0     230.0       1.0       0.0         0
GR   163.93    607.00    163.93    622.00    151.67    658.78    151.43    682.78    137.76    723.79
GR   134.42    931.00    137.42   1462.80    149.82   1500.00    150.62   1580.00    163.79   1619.51
GR   163.79   1634.51

X1     50.0        11    670.78   1500.00     210.0     200.0     205.0       1.0       0.0         0
GR   164.15    595.00    164.15    610.00    151.89    646.78    151.65    670.78    137.99    711.76
GR   134.63    951.00    137.63   1462.80    150.03   1500.00    150.83   1580.00    164.00   1619.51
GR   164.00   1634.51

X1     52.0        11    661.78   1500.00     175.0     200.0     188.0       1.0       0.0         0
GR   164.33    586.00    164.33    601.00    152.07    637.78    151.83    661.78    138.17    702.76
GR   134.84    981.00    137.84   1462.80    150.24   1500.00    151.04   1580.00    164.21   1619.51
GR   164.21   1634.51

X1     54.0        11    654.78   1500.00     160.0     200.0     180.0       1.0       0.0         0
GR   164.50    579.00    164.50    594.00    152.24    630.78    152.00    654.78    138.34    695.76
GR   135.05   1020.00    138.05   1467.87    150.46   1500.00    151.26   1580.00    164.42   1619.48
GR   164.42   1634.48
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X1     56.0        11    645.78   1500.00     160.0     200.0     180.0       1.0       0.0         0
GR   164.67    570.00    164.67    585.00    152.41    621.78    152.17    645.78    138.52    686.73
GR   135.26   1065.00    138.26   1462.77    150.67   1500.00    151.47   1580.00    164.63   1619.48
GR   164.63   1634.48

X1     58.0        11    638.78   1500.00     165.0     200.0     182.0       1.0       0.0         0
GR   164.84    563.00    164.84    578.00    152.58    614.78    152.34    638.78    138.69    679.73
GR   135.47   1121.00    138.47   1462.77    150.88   1500.00    151.68   1580.00    164.84   1619.48
GR   164.84   1634.48

X1     60.0        11    629.78   1500.00     170.0     200.0     185.0       1.0       0.0         0
GR   165.01    554.00    165.01    569.00    152.75    605.78    152.51    629.78    138.87    670.70
GR   135.68   1180.00    138.68   1462.77    151.09   1500.00    151.89   1580.00    165.05   1619.48
GR   165.05   1634.48

X1     62.0        11    620.78   1500.00     160.0     200.0     180.0       1.0       0.0         0
GR   165.18    545.00    165.18    560.00    152.92    596.78    152.68    620.78    139.04    661.70
GR   135.89   1230.00    138.89   1462.74    151.31   1500.00    152.11   1580.00    165.26   1619.45
GR   165.26   1634.45

X1     64.0        11    612.78   1500.00     160.0     200.0     180.0       1.0       0.0         0
GR   165.34    537.00    165.34    552.00    153.08    588.78    152.84    612.78    139.22    647.88
GR   136.09   1270.00    139.09   1462.71    151.52   1500.00    152.32   1580.00    165.47   1619.45
GR   165.47   1634.45

X1     66.0        11    604.78   1500.00     160.0     200.0     180.0       1.0       0.0         0
GR   165.51    529.00    165.51    544.00    153.25    580.78    153.01    604.78    139.39    645.64
GR   136.30   1300.00    139.30   1462.71    151.73   1500.00    152.53   1580.00    165.51   1618.94
GR   165.51   1633.94

X1     68.0        11    597.78   1500.00     170.0     200.0     185.0       1.0       0.0         0
GR   165.69    522.00    165.69    537.00    153.43    573.78    153.19    597.78    139.57    638.64
GR   136.51   1318.00    139.51   1462.68    151.95   1500.00    152.75   1580.00    165.89   1619.42
GR   165.89   1634.42

X1     69.3        11    590.78   1500.00      85.0     130.0     108.0       1.0       0.0         0
X3       10       0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
GR   165.78    515.00    165.78    530.00    153.52    566.78    153.28    590.78    139.66    631.64
GR   136.65   1322.00    139.65   1462.68    152.09   1500.00    152.89   1580.00    166.03   1619.42
GR   166.03   1634.42

SB     1.05      1.56      2.63       0.0     831.0      54.0   34820.0       5.0    139.08    138.97
Rural Road bridge

X1     70.3        21    589.78   1500.00      85.0     100.0      92.0       1.0       0.0         0
X2      0.0       0.0         1    172.28    176.98       0.0         0       2.0       0.0
BT      -12    514.00    176.98    165.86    524.00    177.02    169.35    645.00    178.49    170.82
BT             766.00    179.49    171.79    887.00    179.95    172.28   1008.00    179.95    172.28
BT            1129.00    179.46    171.79   1250.00    178.49    170.82   1371.00    177.02    169.35
BT            1492.00    175.07    167.40   1612.00    172.65    164.98   1619.42    172.50    166.13
GR   165.86    514.00    165.78    524.00    165.86    529.00    153.60    565.78    153.36    589.78
GR   139.75    630.61    139.69    645.00    139.17    766.00    138.64    887.00    138.12   1008.00
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GR   137.60   1129.00   137.07   1250.00   136.75   1325.00   137.76   1371.00   139.75   1462.68
GR   149.52   1492.00   152.19   1500.00   152.99   1580.00   163.66   1612.00   166.13   1619.42
GR   166.13   1634.42

X1     72.0        11   581.78   1500.00     150.0      170.0     160.0       1.0       0.0        0
GR   166.03    506.00   166.03    521.00   153.77    557.78   153.53    581.78    139.91   622.64
GR   136.93   1321.00   139.93   1462.68   152.37   1500.00   152.86   1549.00   166.31   1589.35
GR   166.31   1604.35

X1     74.0        11   571.78   1500.00     160.0      200.0     180.0       1.0       0.0        0
GR   166.26    496.00   166.26    511.00   154.00    547.78   153.76    571.78    140.12   612.70
GR   137.14   1315.00   140.14   1462.65   152.59   1500.00   152.83   1524.00   166.52   1565.07
GR   166.52   1580.07

X1     76.0        11   556.78   1500.00     160.0      200.0     180.0       1.0       0.0        0
GR   166.49    481.00   166.49    496.00   154.23    532.78   153.99    556.78    140.33   597.76
GR   137.35   1279.00   140.35   1462.65   152.80   1500.00   153.04   1524.00   166.73   1565.07
GR   166.73   1580.07

X1     78.0        11   532.75   1500.00     160.0      200.0     180.0       1.0       0.0        0
GR   166.71    457.00   166.71    472.00   154.46    508.75   154.22    532.75    140.54   573.79
GR   137.56   1241.00   140.56   1462.65   153.01   1500.00   153.25   1524.00   166.94   1565.07
GR   166.94   1580.07

X1     80.0        11   506.78   1500.00     165.0      200.0     182.0       1.0       0.0        0
GR   166.95    431.00   166.95    446.00   154.69    482.78   154.45    506.78    140.76   547.85
GR   137.77   1194.00   140.77   1462.62   153.23   1500.00   153.47   1524.00   167.15   1565.04
GR   167.15   1580.04

X1     82.0        11   471.78   1500.00     160.0      200.0     180.0       1.0       0.0        0
GR   167.18    396.00   167.18    411.00   154.92    447.78   154.68    471.78    140.97   512.91
GR   137.98   1136.00   140.98   1462.62   153.44   1500.00   153.68   1524.00   167.36   1565.04
GR   167.36   1580.04

X1     84.0        11   435.78   1500.00     160.0      200.0     180.0       1.0       0.0        0
GR   167.41    360.00   167.41    375.00   155.15    411.78   154.91    435.78    141.19   476.94
GR   138.19   1088.00   141.19   1462.62   153.65   1500.00   153.89   1524.00   167.57   1565.04
GR   167.57   1580.04

X1     86.0        11   388.78   1500.00     165.0      200.0     182.0       1.0       0.0        0
GR   167.64    313.00   167.64    328.00   155.38    364.78   155.14    388.78    141.39   430.03
GR   138.40   1040.00   141.40   1462.59   153.87   1500.00   154.11   1524.00   167.78   1565.01
GR   167.78   1580.01

X1     88.0        11   322.78   1500.00     160.0      200.0     180.0       1.0       0.0        0
GR   167.87    247.00   167.87    262.00   155.61    298.78   155.37    322.78    141.60   364.09
GR   138.60   1008.00   141.60   1462.56   154.08   1500.00   154.32   1524.00   167.99   1565.01
GR   167.99   1580.01

X1     90.0        12   265.78   1500.00     155.0      200.0     178.0       1.0       0.0        0
GR   168.07    190.00   168.07    205.00   155.81    241.00   155.57    265.78    149.50   284.00
GR   141.80    307.09   138.81    980.00   141.81   1462.56   154.29   1500.00   154.53   1524.00
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GR   168.20    1561.01    168.20    1576.01

X1     92.0         11    215.78    1500.00     155.0     200.0     178.0       1.0       0.0         0
GR   168.24     140.00    168.24     155.00    155.98    191.78    157.74    215.78    142.01    262.97
GR   139.02     960.00    142.02    1459.53    155.51   1500.00    155.75   1524.00    168.41   1561.98
GR   168.41    1576.98

X1     94.0         12    168.75    1500.00     155.0     200.0     178.0       1.0       0.0         0
GR   168.41      93.00    168.41     108.00    156.16    144.75    155.92    168.75    142.21    185.88
GR   141.96     282.00    139.23     948.00    142.23   1471.62    154.72   1500.00    154.96   1524.00
GR   168.62    1561.05    168.62    1576.05

X1     96.0         12    150.00    1500.00     225.0     200.0     212.0       1.0       0.0         0
GR   168.66      33.00    168.66      48.00    156.41     84.75    156.17    150.00    142.51    190.98
GR   142.16     319.00    139.44     939.00    142.44   1462.53    154.93   1500.00    155.17   1524.00
GR   168.83    1564.98    168.83    1579.98

X1     98.0          9     20.00    1500.00     290.0     200.0     245.0       1.0       0.0         0
GR   156.49      20.00    142.89      60.80    141.79    353.00    139.65    920.00    142.65   1462.50
GR   155.15    1500.00    155.39    1524.00    169.04   1564.95    169.04   1579.95

X1    100.0          7    350.00    1500.00     310.0     200.0     255.0       1.0       0.0         0
GR   142.51     350.00    139.86     885.00    142.86   1462.50    155.36   1500.00    155.60   1524.00
GR   169.25    1564.95    169.25    1579.95

X1    102.0         11    484.41    1500.00     370.0     200.0     285.0       1.0       0.0         0
GR   169.42     407.91    169.42     422.91    156.92    460.41    156.68    484.41    143.15    525.00
GR   140.07     853.00    143.07    1462.50    155.57   1500.00    155.81   1524.00    169.46   1564.95
GR   169.46    1579.95

X1    104.0         11    535.50    1500.00     260.0     200.0     230.0       1.0       0.0         0
GR   169.62     459.00    169.62     474.00    157.12    511.50    156.88    535.50    143.15    576.69
GR   140.28     828.00    143.28    1462.47    155.79   1500.00    156.03   1524.00    169.67   1564.92
GR   169.67    1579.92

X1    106.0         11    531.50    1500.00     250.0     200.0     225.0       1.0       0.0         0
GR   169.87     455.00    169.87     470.00    157.37    507.50    157.13    531.50    143.40    572.69
GR   140.49     810.00    143.49    1462.47    156.00   1500.00    156.14   1514.40    169.88   1555.62
GR   169.88    1570.62

X1    108.0         10    473.50    1500.00     250.0     200.0     225.0       1.0       0.0         0
GR   170.12     397.00    170.12     412.00    157.62    449.50    157.38    473.50    143.65    514.69
GR   140.70     795.00    143.70    1462.02    156.36   1500.00    170.09   1541.19    170.09   1556.19

X1    110.0          9    590.50    1500.00     255.0     200.0     228.0       1.0       0.0         0
GR   170.37     514.00    170.37     529.00    157.87    566.50    157.63    590.50    143.91    631.66
GR   140.91     790.00    143.91    1420.83    170.30   1500.00    170.30   1515.00

X1    112.0          9    606.50    1500.00     225.0     200.0     212.0       1.0       0.0         0
GR   170.60     530.00    170.60     545.00    158.10    582.50    157.86    606.50    144.13    647.69
GR   141.12     790.00    144.12    1420.83    170.51   1500.00    170.51   1515.00
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X1	114.0	9	584.50	1500.00	200.0	200.0	200.0	1.0	0.0	0
GR	170.80	508.00	170.80	523.00	158.30	560.50	158.06	584.50	144.33	625.69
GR	141.32	800.00	144.32	1420.77	170.73	1500.00	170.73	1515.00		
X1	116.0	9	529.50	1500.00	205.0	200.0	202.0	1.0	0.0	0
GR	171.00	453.00	171.00	468.00	158.50	505.50	158.26	529.50	144.54	570.66
GR	141.53	820.00	144.53	1420.77	170.94	1500.00	170.94	1515.00		
X1	118.0	9	474.50	1500.00	210.0	200.0	205.0	1.0	0.0	0
GR	171.21	398.00	171.21	413.00	158.71	450.50	158.47	474.50	144.75	515.66
GR	141.74	854.00	144.74	1420.77	171.15	1500.00	171.15	1515.00		
X1	119.8	9	446.50	1500.00	180.0	200.0	190.0	1.0	0.0	0
X3	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
GR	171.39	370.00	171.39	385.00	158.89	422.50	158.65	446.50	144.95	487.60
GR	141.95	525.00	144.95	1420.74	171.37	1500.00	171.37	1515.00		
X1	120.42	9	446.22	1485.00	57.0	42.0	50.0	1.0	0.0	0
X3	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
GR	171.45	370.00	171.45	385.00	158.95	422.50	158.71	446.22	144.98	487.69
GR	142.00	926.50	145.00	1405.77	171.41	1485.00	171.41	1500.00		

Grade Control Str. No. 5

X1	120.5	9	443.50	1485.00	8.0	8.0	8.0	1.0	0.0	0
GR	171.46	367.00	171.46	382.00	158.96	419.50	158.72	443.50	150.00	469.66
GR	147.00	926.50	150.00	1420.74	171.42	1485.00	171.42	1500.00		
X1	122.0	9	441.50	1460.00	155.0	150.0	152.0	1.0	0.0	0
GR	171.61	365.00	171.61	380.00	159.11	417.50	158.87	441.50	150.16	467.63
GR	147.15	941.00	150.15	1395.71	171.58	1460.00	171.58	1475.00		
X1	122.65	9	441.50	1460.00	65.0	65.0	65.0	1.0	0.0	0
X3	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
GR	171.68	365.00	171.68	380.00	159.18	417.50	158.94	441.50	150.22	490.27
GR	147.22	952.00	150.22	1395.71	171.65	1460.00	171.65	1475.00		
SB	1.05	1.56	2.63	0.0	798.0	66.0	24246.0	6.3	147.31	147.22

McClintock Drive Bridge

X1	123.55	20	441.5	1460.00	90.0	90.0	90.0	1.0	0.0	0
X2	0.0	0.0	1	180.61	181.8	0.0	0	2.0	0.0	
X3	10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
BT	-11	316.00	181.80	174.13	436.00	184.23	176.56	554.00	185.93	178.26
BT		672.00	187.37	179.70	790.00	188.15	180.48	908.00	188.28	180.61
BT		1026.00	188.15	180.48	1144.00	187.37	179.70	1262.00	185.93	178.26
BT		1380.00	184.23	176.56	1500.00	181.80	174.13			
GR	174.13	316.00	171.77	371.00	171.77	386.00	159.27	423.50	159.10	436.00
GR	159.03	441.50	150.31	500.09	149.97	554.00	149.22	672.00	148.48	790.00
GR	147.73	908.00	147.31	975.00	147.64	1026.00	148.42	1144.00	149.19	1262.00
GR	149.96	1380.00	150.31	1433.31	171.75	1460.00	171.75	1475.00	174.13	1500.00

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X1    124.0        9    436.50   1465.00      45.0      45.0      45.0       1.0       0.0         0
GR   171.81   360.00    171.81    375.00    159.31    412.50    159.07    436.50    150.36    464.22
GR   147.35   983.00    150.35   1400.68    171.79   1465.00    171.79   1480.00

X1    126.0       10    415.00   1500.00     200.0     200.0     200.0       1.0       0.0         0
X3        0      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
GR   170.00   240.00    168.00    272.00    166.00    317.00    164.00    348.00    162.00    388.00
GR   159.27   415.00    150.56    441.13    147.55    985.00    150.55   1435.62    172.01   1500.00

X1    128.0        8    402.00   1500.00     200.0     200.0     200.0       1.0       0.0         0
X3        0      0.0       0.0       0.0       0.0       0.0       0.0       0.0       0.0
GR   172.00   242.00    166.00    280.00    164.00    377.00    159.47    402.00    150.76    428.13
GR   147.75  1017.00    150.75   1359.75    170.00   1500.00
T1      RIOMR.00 PHASE 2
T2      TEMPE RIO SALADO - SPRR ENCROACHMENT
T3      GC#4 TO MCCLINTOCK DRIVE
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JOB PARAMETERS :

```
J1  ICHECK    INQ      NINV     IDIR     STRT    METRIC    HVINS      Q       WSEL      FQ

       0        3         0        0      0.0         0      0.0  93000.0    142.70

J2  NPROF    IPLOT     PRFVS    XSECV    XSECH       FN    ALLDC     IBW     CHNIM   ITRACE

       2        0       0.0      0.0      0.0      0.0      0.0     0.0       0.0

T1      RIOMR.00 PHASE 2
T2      TEMPE RIO SALADO - SPRR ENCROACHMENT
T3      GC#4 TO MCCLINTOCK DRIVE
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JOB PARAMETERS :

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J1  ICHECK    INQ      NINV     IDIR     STRT    METRIC    HVINS      Q       WSEL      FQ

       0        4         0        0      0.0         0      0.0 135000.0    145.73

J2  NPROF    IPLOT     PRFVS    XSECV    XSECH       FN    ALLDC     IBW     CHNIM   ITRACE

       3        0       0.0      0.0      0.0      0.0      0.0     0.0       0.0

T1      RIOMR.00 PHASE 2
T2      TEMPE RIO SALADO - SPRR ENCROACHMENT
T3      GC#4 TO MCCLINTOCK DRIVE
```

JOB PARAMETERS :

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0	5	0	0	0.0	0	0.0	160000.0	147.30	

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	4	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

T1 RIOMR.00 PHASE 2
T2 TEMPE RIO SALADO - SPRR ENCROACHMENT
T3 GC#4 TO MCCLINTOCK DRIVE

JOB PARAMETERS :

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0	6	0	0	0.0	0	0.0	215000.0	150.40	

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	5	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

T1 RIOMR.00 PHASE 2
T2 TEMPE RIO SALADO - SPRR ENCROACHMENT
T3 GC#4 TO MCCLINTOCK DRIVE

JOB PARAMETERS :

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0	7	0	0	0.0	0	0.0	250000.0	152.20	

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	6	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

T1 RIOMR.00 PHASE 2
T2 TEMPE RIO SALADO - SPRR ENCROACHMENT
T3 GC#4 TO MCCLINTOCK DRIVE

PROJECT TITLE : TEMPE RIO SALADO - SPRR ENCROACHMENT
PROJECT NUMBER : RIOMR.00 PHASE 2 8/14/1991

JOB PARAMETERS :

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0	8	0	0	0.0	0	0.0	296000.0	154.39	
J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	15	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

SPECIAL NOTE :

An asterisk (*) to the left of the cross-section number indicates a special note is present in the SUMMARY OF WARNING AND STATUS MESSAGES section.

SUMMARY PRINTOUT : TEMPE RIO SALADO - SPRR ENCROACHMENT
GC#4 TO MCCLINTOCK DRIVE
RIOMR.00 PHASE 2

Cross-Section Number SECNO	Minimum C. S. Elevation (ft MSL) ELMIN	Channel Reach Length (ft) XLCH	Discharge Flow (cfs) Q	Computed W. S. Elevation (ft MSL) CWSEL	Energy Gradient Elevation (ft MSL) EG	Cross-Section Area (sq ft) AREA	Water Surface Top Width (ft) TOPWID	Energy Gradient Slope * 10,000 10K*S
.000	129.40	.00	40000.00	137.89	138.54	6170.89	902.82	18.01
.000	129.40	.00	93000.00	142.70	143.90	10582.86	931.68	16.81
.000	129.40	.00	135000.00	145.73	147.30	13433.39	949.86	16.28
.000	129.40	.00	160000.00	147.30	149.09	14932.07	959.28	16.24
.000	129.40	.00	215000.00	150.40	152.65	17934.66	977.88	16.10
.000	129.40	.00	250000.00	152.20	154.72	19704.57	988.68	16.02
.000	129.40	.00	296000.00	154.39	157.27	21884.17	1001.82	16.00
2.000	129.61	160.00	40000.00	138.15	138.86	5936.69	860.35	19.22
2.000	129.61	160.00	93000.00	142.90	144.22	10098.69	910.83	18.52
2.000	129.61	160.00	135000.00	145.90	147.62	12845.73	967.52	18.00
2.000	129.61	160.00	160000.00	147.46	149.41	14367.92	981.47	17.89
2.000	129.61	160.00	215000.00	150.56	152.96	17471.05	1007.82	17.47
2.000	129.61	160.00	250000.00	152.36	155.03	19295.08	1013.13	17.23
2.000	129.61	160.00	296000.00	154.56	157.57	21530.16	1019.60	17.02

PROJECT TITLE : TEMPE RIO SALADO - SPRR ENCROACHMENT
PROJECT NUMBER : RIOMR.00 PHASE 2 8/14/1991

Cross-Section Number SECNO	Minimum C. S. Elevation (ft MSL) ELMIN	Channel Reach Length (ft) XLCH	Discharge Flow (cfs) Q	Computed W. S. Elevation (ft MSL) CWSEL	Energy Gradient Elevation (ft MSL) EG	Cross-Section Area (sq ft) AREA	Water Surface Top Width (ft) TOPWID	Energy Gradient Slope * 10,000 10K*$
4.000	129.82	200.00	40000.00	138.54	139.23	5983.83	847.30	18.35
4.000	129.82	200.00	93000.00	143.26	144.59	10057.33	898.92	18.40
4.000	129.82	200.00	135000.00	146.24	147.99	12774.91	1007.10	18.05
4.000	129.82	200.00	160000.00	147.80	149.77	14360.79	1025.46	17.94
4.000	129.82	200.00	215000.00	150.91	153.31	17616.71	1061.63	17.41
4.000	129.82	200.00	250000.00	152.74	155.38	19583.11	1072.69	16.98
4.000	129.82	200.00	296000.00	154.98	157.92	22000.57	1086.13	16.58
6.000	130.03	200.00	40000.00	138.87	139.63	5716.92	796.70	19.68
6.000	130.03	200.00	93000.00	143.54	145.03	9500.34	848.02	20.53
6.000	130.03	200.00	135000.00	146.46	148.44	12008.16	865.53	20.48
6.000	130.03	200.00	160000.00	148.00	150.23	13564.44	1022.45	20.39
6.000	130.03	200.00	215000.00	151.14	153.75	16949.49	1098.49	20.53
6.000	130.03	200.00	250000.00	152.97	155.80	18976.30	1109.08	19.61
6.000	130.03	200.00	296000.00	155.22	158.31	21485.53	1122.05	18.70
8.000	130.50	200.00	40000.00	139.31	140.02	5903.41	828.87	18.64
8.000	130.50	200.00	93000.00	144.06	145.43	9920.92	880.70	18.73
8.000	130.50	200.00	135000.00	147.04	148.85	12577.14	942.39	18.50
8.000	130.50	200.00	160000.00	148.61	150.64	14234.50	1097.08	18.36
8.000	130.50	200.00	215000.00	151.73	154.15	17738.63	1133.12	17.53
8.000	130.50	200.00	250000.00	153.56	156.19	19813.66	1144.63	17.02
8.000	130.50	200.00	296000.00	155.80	158.69	22397.84	1158.81	16.45
10.000	130.45	200.00	40000.00	139.74	140.36	6331.64	831.66	14.83
10.000	130.45	200.00	93000.00	144.55	145.79	10397.62	883.36	16.08
10.000	130.45	200.00	135000.00	147.54	149.21	13082.65	975.86	16.31
10.000	130.45	200.00	160000.00	149.12	151.00	14835.92	1187.25	16.32
10.000	130.45	200.00	215000.00	152.28	154.50	18649.35	1211.98	15.58
10.000	130.45	200.00	250000.00	154.12	156.53	20893.98	1217.49	15.10
10.000	130.45	200.00	296000.00	156.40	159.02	23672.80	1224.27	14.56
12.000	130.66	200.00	40000.00	140.05	140.65	6438.67	835.28	14.11
12.000	130.66	200.00	93000.00	144.90	146.11	10549.36	863.01	15.40
12.000	130.66	200.00	135000.00	147.91	149.53	13268.63	987.82	15.66
12.000	130.66	200.00	160000.00	149.49	151.33	15055.92	1197.10	15.69
12.000	130.66	200.00	215000.00	152.64	154.81	18904.94	1231.57	15.06
12.000	130.66	200.00	250000.00	154.49	156.83	21185.04	1242.94	14.62
12.000	130.66	200.00	296000.00	156.76	159.31	24028.54	1256.97	14.10
14.000	130.86	158.00	40000.00	140.30	140.87	6577.81	846.40	13.37
14.000	130.86	158.00	93000.00	145.20	146.35	10802.44	898.58	14.49
14.000	130.86	158.00	135000.00	148.23	149.78	13570.24	997.65	14.79
14.000	130.86	158.00	160000.00	149.82	151.57	15406.53	1250.97	14.83

PROJECT TITLE : TEMPE RIO SALADO - SPRR ENCROACHMENT
PROJECT NUMBER : RIOMR.00 PHASE 2 8/14/1991

Cross-Section Number SECNO	Minimum C. S. Elevation (ft MSL) ELMIN	Channel Reach Length (ft) XLCH	Discharge Flow (cfs) Q	Computed W. S. Elevation (ft MSL) CWSEL	Energy Gradient Elevation (ft MSL) EG	Cross-Section Area (sq ft) AREA	Water Surface Top Width (ft) TOPWID	Energy Gradient Slope * 10,000 10K*S
14.000	130.86	158.00	215000.00	152.99	155.06	19425.55	1279.29	14.21
14.000	130.86	158.00	250000.00	154.84	157.07	21808.37	1291.48	13.77
14.000	130.86	158.00	296000.00	157.13	159.55	24782.32	1306.54	13.24
15.400	131.03	122.00	40000.00	140.42	141.10	6034.59	778.06	15.94
15.400	131.03	122.00	93000.00	145.28	146.65	9881.72	805.72	17.48
15.400	131.03	122.00	135000.00	148.27	150.13	12394.05	889.87	17.93
15.400	131.03	122.00	160000.00	149.84	151.95	14097.74	1280.38	18.04
15.400	131.03	122.00	215000.00	153.01	155.41	18315.76	1343.35	16.86
15.400	131.03	122.00	250000.00	154.88	157.40	20831.95	1354.81	16.01
15.400	131.03	122.00	296000.00	157.18	159.85	23972.17	1368.96	15.04
15.600	131.05	18.00	40000.00	140.69	141.33	6233.02	780.38	14.37
15.600	131.05	18.00	93000.00	145.86	147.11	10353.10	833.81	15.09
15.600	131.05	18.00	135000.00	149.07	150.74	13171.75	1081.33	15.14
15.600	131.05	18.00	160000.00	150.75	152.60	15277.30	1330.27	14.90
15.600	131.05	18.00	215000.00	153.99	156.09	19626.42	1350.26	13.98
15.600	131.05	18.00	250000.00	155.87	158.10	22172.36	1361.83	13.43
15.600	131.05	18.00	296000.00	158.19	160.56	25346.45	1392.69	12.80
17.300	131.21	152.00	40000.00	141.02	141.53	6985.17	855.91	11.11
17.300	131.21	152.00	93000.00	146.34	147.34	11634.55	910.76	11.54
17.300	131.21	152.00	135000.00	149.65	150.97	14795.87	1138.43	11.55
17.300	131.21	152.00	160000.00	151.35	152.83	16868.92	1248.50	11.46
17.300	131.21	152.00	215000.00	154.54	156.32	20933.84	1305.77	11.36
17.300	131.21	152.00	250000.00	156.37	158.31	23358.94	1364.42	11.25
17.300	131.21	152.00	296000.00	158.65	160.77	26689.03	1524.05	10.96
19.000	131.38	172.00	40000.00	141.21	141.72	6976.66	854.11	11.12
19.000	131.38	172.00	93000.00	146.54	147.54	11610.01	909.29	11.57
19.000	131.38	172.00	135000.00	149.85	151.17	14786.65	1110.84	11.58
19.000	131.38	172.00	160000.00	151.54	153.03	16696.12	1140.87	11.55
19.000	131.38	172.00	215000.00	154.69	156.53	20318.06	1159.74	11.69
19.000	131.38	172.00	250000.00	156.49	158.54	22415.33	1170.53	11.75
19.000	131.38	172.00	296000.00	158.71	161.02	25031.02	1183.85	11.77
21.500	131.67	182.00	40000.00	141.46	141.92	7378.54	899.38	9.89
21.500	131.67	182.00	93000.00	146.86	147.74	12313.66	929.42	10.16
21.500	131.67	182.00	135000.00	150.21	151.38	15637.77	1113.93	10.16
21.500	131.67	182.00	160000.00	151.91	153.24	17563.50	1144.87	10.18
21.500	131.67	182.00	215000.00	155.08	156.75	21225.82	1164.37	10.40
21.500	131.67	182.00	250000.00	156.89	158.76	23343.73	1175.49	10.52
21.500	131.67	182.00	296000.00	159.12	161.24	25981.95	1203.56	10.61

PROJECT TITLE : TEMPE RIO SALADO - SPRR ENCROACHMENT
PROJECT NUMBER : RIOMR.00 PHASE 2 8/14/1991

Cross-Section Number SECNO	Minimum C. S. Elevation (ft MSL) ELMIN	Channel Reach Length (ft) XLCH	Discharge Flow (cfs) Q	Computed W. S. Elevation (ft MSL) CWSEL	Energy Gradient Elevation (ft MSL) EG	Cross-Section Area (sq ft) AREA	Water Surface Top Width (ft) TOPWID	Energy Gradient Slope * 10,000 10K*S
24.000	131.91	140.00	40000.00	141.53	142.11	6558.45	809.88	12.75
24.000	131.91	140.00	93000.00	146.85	147.98	10936.52	835.90	13.11
24.000	131.91	140.00	135000.00	150.15	151.64	13963.97	1043.49	13.08
24.000	131.91	140.00	160000.00	151.83	153.51	15738.97	1075.62	13.09
24.000	131.91	140.00	215000.00	154.96	157.04	19134.11	1093.46	13.27
24.000	131.91	140.00	250000.00	156.75	159.06	21097.23	1103.65	13.35
24.000	131.91	140.00	296000.00	158.95	161.56	23541.85	1116.20	13.40
24.600	131.97	60.00	40000.00	141.84	142.40	6679.83	802.05	11.84
24.600	131.97	60.00	93000.00	147.51	148.56	11304.88	829.36	11.62
24.600	131.97	60.00	135000.00	151.04	152.38	14671.59	1045.17	13.04
24.600	131.97	60.00	160000.00	152.84	154.32	16584.99	1073.33	12.70
24.600	131.97	60.00	215000.00	156.12	157.93	20135.22	1091.45	12.33
24.600	131.97	60.00	250000.00	158.80	160.67	23080.14	1106.25	10.77
24.600	131.97	60.00	296000.00	162.00	163.96	26690.47	1142.84	9.53
26.000	132.12	185.00	40000.00	142.06	142.62	6659.38	798.50	11.89
26.000	132.12	185.00	93000.00	147.72	148.78	11266.79	827.31	11.71
26.000	132.12	185.00	135000.00	151.24	152.62	14592.41	1050.19	11.48
26.000	132.12	185.00	160000.00	153.02	154.56	16490.55	1078.45	11.36
26.000	132.12	185.00	215000.00	156.28	158.18	20038.50	1097.58	11.49
26.000	132.12	185.00	250000.00	158.93	160.89	22971.93	1113.15	10.26
26.000	132.12	185.00	296000.00	162.12	164.16	26578.63	1151.92	9.22
26.450	132.12	45.00	40000.00	142.20	142.74	6769.48	799.21	11.27
26.450	132.12	45.00	93000.00	148.01	149.02	11497.23	828.72	10.97
26.450	132.12	45.00	135000.00	151.62	152.93	14990.10	1054.51	10.64
26.450	132.12	45.00	160000.00	153.44	154.90	16947.42	1080.94	10.48
26.450	132.12	45.00	215000.00	156.81	158.61	20623.95	1100.71	10.53
26.450	132.12	45.00	250000.00	159.45	161.31	23546.78	1116.18	9.52
26.450	132.12	45.00	296000.00	162.63	164.58	27165.14	1151.92	8.63
27.000	132.22	155.00	40000.00	142.37	142.92	6768.58	799.07	11.27
27.000	132.22	155.00	93000.00	148.18	149.19	11496.88	830.06	10.99
27.000	132.22	155.00	135000.00	151.78	153.09	14972.44	1048.33	10.68
27.000	132.22	155.00	160000.00	153.60	155.07	16917.17	1075.75	10.52
27.000	132.22	155.00	215000.00	156.97	158.77	20578.26	1095.80	10.57
27.000	132.22	155.00	250000.00	159.59	161.46	23462.64	1111.34	9.59
27.000	132.22	155.00	296000.00	162.75	164.72	27048.89	1149.00	8.71
28.000	132.33	160.00	40000.00	142.56	143.10	6815.12	801.66	11.06
28.000	132.33	160.00	93000.00	148.37	149.37	11559.15	832.93	10.85
28.000	132.33	160.00	135000.00	151.97	153.27	15019.22	1039.58	10.57
28.000	132.33	160.00	160000.00	153.78	155.24	16938.57	1067.15	10.45

PROJECT TITLE : TEMPE RIO SALADO - SPRR ENCROACHMENT
PROJECT NUMBER : RIOMR.00 PHASE 2 8/14/1991

Cross-Section Number SECNO	Minimum C. S. Elevation (ft MSL) ELMIN	Channel Reach Length (ft) XLCH	Discharge Flow (cfs) Q	Computed W. S. Elevation (ft MSL) CWSEL	Energy Gradient Elevation (ft MSL) EG	Cross-Section Area (sq ft) AREA	Water Surface Top Width (ft) TOPWID	Energy Gradient Slope * 10,000 10K*S
28.000	132.33	160.00	215000.00	157.15	158.94	20569.05	1087.18	10.53
28.000	132.33	160.00	250000.00	159.74	161.62	23417.03	1102.63	9.58
28.000	132.33	160.00	296000.00	162.88	164.86	26956.76	1141.00	8.74
30.000	132.54	200.00	40000.00	142.78	143.32	6798.15	798.44	11.09
30.000	132.54	200.00	93000.00	148.58	149.59	11518.63	829.57	10.92
30.000	132.54	200.00	135000.00	152.17	153.48	14927.99	1017.85	10.66
30.000	132.54	200.00	160000.00	153.98	155.45	16801.04	1046.91	10.58
30.000	132.54	200.00	215000.00	157.34	159.16	20344.86	1067.91	10.72
30.000	132.54	200.00	250000.00	159.91	161.82	23109.64	1084.01	9.81
30.000	132.54	200.00	296000.00	163.02	165.06	26564.68	1120.00	8.99
32.000	132.75	200.00	40000.00	143.02	143.54	6906.54	810.48	10.73
32.000	132.75	200.00	93000.00	148.83	149.81	11742.60	912.58	10.49
32.000	132.75	200.00	135000.00	152.45	153.69	15392.49	1033.36	9.97
32.000	132.75	200.00	160000.00	154.27	155.66	17280.66	1044.27	9.87
32.000	132.75	200.00	215000.00	157.64	159.38	20840.31	1064.53	10.04
32.000	132.75	200.00	250000.00	160.18	162.02	23566.72	1079.79	9.28
32.000	132.75	200.00	296000.00	163.27	165.24	26964.01	1120.60	8.58
34.000	132.96	200.00	40000.00	143.24	143.75	6952.16	813.56	10.56
34.000	132.96	200.00	93000.00	149.05	150.02	11792.54	914.89	10.37
34.000	132.96	200.00	135000.00	152.65	153.89	15390.64	1018.36	9.91
34.000	132.96	200.00	160000.00	154.46	155.86	17249.67	1029.25	9.84
34.000	132.96	200.00	215000.00	157.84	159.58	20755.82	1049.49	10.05
34.000	132.96	200.00	250000.00	160.36	162.21	23424.13	1064.64	9.33
34.000	132.96	200.00	296000.00	163.43	165.42	26741.06	1105.60	8.68
36.000	133.17	215.00	40000.00	143.46	143.99	6881.04	806.97	10.80
36.000	133.17	215.00	93000.00	149.26	150.25	11687.79	912.28	10.63
36.000	133.17	215.00	135000.00	152.85	154.12	15177.06	990.19	10.19
36.000	133.17	215.00	160000.00	154.65	156.09	16963.48	1000.96	10.17
36.000	133.17	215.00	215000.00	158.02	159.82	20366.13	1021.15	10.41
36.000	133.17	215.00	250000.00	160.51	162.44	22935.48	1036.14	9.72
36.000	133.17	215.00	296000.00	163.56	165.64	26147.96	1077.57	9.06
38.000	133.37	230.00	40000.00	143.71	144.23	6913.82	806.66	10.63
38.000	133.37	230.00	93000.00	149.51	150.49	11712.13	912.37	10.53
38.000	133.37	230.00	135000.00	153.08	154.35	15143.17	979.08	10.17
38.000	133.37	230.00	160000.00	154.88	156.32	16917.60	989.90	10.15
38.000	133.37	230.00	215000.00	158.25	160.06	20288.26	1010.12	10.42
38.000	133.37	230.00	250000.00	160.73	162.67	22813.45	1025.01	9.76
38.000	133.37	230.00	296000.00	163.75	165.85	25968.83	1066.57	9.15

Cross-Section Number SECNO	Minimum C. S. Elevation (ft MSL) ELMIN	Channel Reach Length (ft) XLCH	Discharge Flow (cfs) Q	Computed W. S. Elevation (ft MSL) CWSEL	Energy Gradient Elevation (ft MSL) EG	Cross-Section Area (sq ft) AREA	Water Surface Top Width (ft) TOPWID	Energy Gradient Slope * 10,000 10K*S
40.000	133.58	230.00	40000.00	143.95	144.48	6814.29	794.04	10.92
40.000	133.58	230.00	93000.00	149.73	150.75	11537.58	904.73	10.88
40.000	133.58	230.00	135000.00	153.29	154.61	14861.56	956.24	10.58
40.000	133.58	230.00	160000.00	155.08	156.58	16590.44	969.73	10.57
40.000	133.58	230.00	215000.00	158.44	160.33	19892.36	994.99	10.86
40.000	133.58	230.00	250000.00	160.90	162.92	22358.48	1013.45	10.21
40.000	133.58	230.00	296000.00	163.90	166.09	25463.44	1058.57	9.58
42.000	133.79	230.00	40000.00	144.20	144.74	6810.97	792.00	10.90
42.000	133.79	230.00	93000.00	149.98	151.00	11552.68	906.52	10.89
42.000	133.79	230.00	135000.00	153.53	154.85	14868.94	951.07	10.57
42.000	133.79	230.00	160000.00	155.32	156.82	16585.77	961.84	10.57
42.000	133.79	230.00	215000.00	158.69	160.58	19858.90	982.05	10.86
42.000	133.79	230.00	250000.00	161.13	163.16	22273.70	996.69	10.25
42.000	133.79	230.00	296000.00	164.11	166.32	25307.10	1038.76	9.65
44.000	134.00	230.00	40000.00	144.44	145.00	6683.59	775.06	11.28
44.000	134.00	230.00	93000.00	150.21	151.27	11280.67	887.22	11.38
44.000	134.00	230.00	135000.00	153.73	155.12	14510.54	931.66	11.11
44.000	134.00	230.00	160000.00	155.52	157.09	16185.58	942.39	11.11
44.000	134.00	230.00	215000.00	158.88	160.86	19385.07	962.54	11.43
44.000	134.00	230.00	250000.00	161.30	163.43	21726.92	977.03	10.81
44.000	134.00	230.00	296000.00	164.26	166.58	24670.05	1019.54	10.20
46.000	134.21	230.00	40000.00	144.70	145.26	6714.40	776.11	11.13
46.000	134.21	230.00	93000.00	150.48	151.53	11332.00	888.36	11.24
46.000	134.21	230.00	135000.00	154.00	155.37	14559.77	932.76	11.00
46.000	134.21	230.00	160000.00	155.79	157.34	16237.16	943.49	11.02
46.000	134.21	230.00	215000.00	159.16	161.12	19460.67	963.77	11.30
46.000	134.21	230.00	250000.00	161.55	163.68	21777.86	978.09	10.74
46.000	134.21	230.00	296000.00	164.50	166.82	24708.99	1020.54	10.16
48.000	134.42	230.00	40000.00	144.97	145.51	6813.98	783.27	10.73
48.000	134.42	230.00	93000.00	150.76	151.79	11496.89	895.65	10.85
48.000	134.42	230.00	135000.00	154.29	155.62	14753.46	940.07	10.65
48.000	134.42	230.00	160000.00	156.08	157.60	16449.05	950.83	10.67
48.000	134.42	230.00	215000.00	159.47	161.38	19704.54	971.16	10.96
48.000	134.42	230.00	250000.00	161.85	163.93	22037.35	985.46	10.44
48.000	134.42	230.00	296000.00	164.78	167.05	24976.85	1027.51	9.91
50.000	134.63	205.00	40000.00	145.21	145.73	6934.91	795.40	10.33
50.000	134.63	205.00	93000.00	151.02	152.01	11710.59	907.91	10.41
50.000	134.63	205.00	135000.00	154.55	155.84	15018.47	952.37	10.23
50.000	134.63	205.00	160000.00	156.35	157.82	16743.08	963.18	10.25

PROJECT TITLE : TEMPE RIO SALADO - SPRR ENCROACHMENT
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Cross-Section Number SECNO	Minimum C. S. Elevation (ft MSL) ELMIN	Channel Reach Length (ft) XLCH	Discharge Flow (cfs) Q	Computed W. S. Elevation (ft MSL) CWSEL	Energy Gradient Elevation (ft MSL) EG	Cross-Section Area (sq ft) AREA	Water Surface Top Width (ft) TOPWID	Energy Gradient Slope * 10,000 10K*S
50.000	134.63	205.00	215000.00	159.76	161.61	20062.40	983.64	10.51
50.000	134.63	205.00	250000.00	162.14	164.14	22416.99	997.90	10.04
50.000	134.63	205.00	296000.00	165.06	167.26	25387.59	1039.51	9.55
52.000	134.84	188.00	40000.00	145.41	145.92	7009.40	804.45	10.12
52.000	134.84	188.00	93000.00	151.24	152.20	11841.01	916.99	10.18
52.000	134.84	188.00	135000.00	154.78	156.04	15196.51	961.54	9.98
52.000	134.84	188.00	160000.00	156.58	158.01	16942.56	972.38	9.99
52.000	134.84	188.00	215000.00	160.01	161.81	20309.54	992.94	10.23
52.000	134.84	188.00	250000.00	162.38	164.34	22679.17	1007.15	9.78
52.000	134.84	188.00	296000.00	165.30	167.44	25671.07	1048.51	9.32
54.000	135.05	180.00	40000.00	145.61	146.10	7091.02	813.42	9.88
54.000	135.05	180.00	93000.00	151.45	152.39	11989.57	924.11	9.88
54.000	135.05	180.00	135000.00	154.98	156.22	15363.00	968.62	9.72
54.000	135.05	180.00	160000.00	156.79	158.19	17125.69	979.48	9.74
54.000	135.05	180.00	215000.00	160.23	162.00	20530.42	1000.12	9.97
54.000	135.05	180.00	250000.00	162.60	164.51	22910.06	1014.29	9.55
54.000	135.05	180.00	296000.00	165.51	167.61	25916.40	1055.48	9.12
56.000	135.26	180.00	40000.00	145.79	146.28	7119.25	820.41	9.86
56.000	135.26	180.00	93000.00	151.63	152.56	12056.33	933.06	9.83
56.000	135.26	180.00	135000.00	155.18	156.39	15465.40	977.59	9.63
56.000	135.26	180.00	160000.00	156.99	158.37	17258.07	988.53	9.61
56.000	135.26	180.00	215000.00	160.44	162.18	20707.73	1009.25	9.81
56.000	135.26	180.00	250000.00	162.80	164.69	23103.80	1023.39	9.40
56.000	135.26	180.00	296000.00	165.71	167.78	26131.97	1064.48	8.98
58.000	135.47	182.00	40000.00	145.97	146.46	7160.72	827.37	9.78
58.000	135.47	182.00	93000.00	151.83	152.74	12148.07	940.08	9.68
58.000	135.47	182.00	135000.00	155.37	156.57	15581.01	984.60	9.49
58.000	135.47	182.00	160000.00	157.19	158.54	17390.70	995.57	9.47
58.000	135.47	182.00	215000.00	160.65	162.36	20876.09	1016.36	9.64
58.000	135.47	182.00	250000.00	163.00	164.86	23282.75	1030.47	9.26
58.000	135.47	182.00	296000.00	165.91	167.94	26325.40	1071.48	8.84
60.000	135.68	185.00	40000.00	146.16	146.64	7223.22	836.35	9.64
60.000	135.68	185.00	93000.00	152.03	152.92	12269.87	949.12	9.49
60.000	135.68	185.00	135000.00	155.57	156.74	15751.50	993.73	9.28
60.000	135.68	185.00	160000.00	157.39	158.72	17570.12	1004.66	9.27
60.000	135.68	185.00	215000.00	160.87	162.54	21099.89	1025.52	9.42
60.000	135.68	185.00	250000.00	163.22	165.03	23522.93	1039.60	9.06
60.000	135.68	185.00	296000.00	166.11	168.11	26587.39	1080.48	8.66

PROJECT TITLE : TEMPE RIO SALADO - SPRR ENCROACHMENT
PROJECT NUMBER : RIOMR.00 PHASE 2 8/14/1991

Cross-Section Number SECNO	Minimum C. S. Elevation (ft MSL) ELMIN	Channel Reach Length (ft) XLCH	Discharge Flow (cfs) Q	Computed W. S. Elevation (ft MSL) CWSEL	Energy Gradient Elevation (ft MSL) EG	Cross-Section Area (sq ft) AREA	Water Surface Top Width (ft) TOPWID	Energy Gradient Slope * 10,000 10K*S
62.000	135.89	180.00	40000.00	146.34	146.81	7286.56	845.27	9.49
62.000	135.89	180.00	93000.00	152.21	153.09	12389.51	958.08	9.31
62.000	135.89	180.00	135000.00	155.76	156.91	15904.95	1002.71	9.10
62.000	135.89	180.00	160000.00	157.59	158.89	17743.47	1013.65	9.08
62.000	135.89	180.00	215000.00	161.08	162.71	21316.58	1034.58	9.22
62.000	135.89	180.00	250000.00	163.42	165.20	23756.22	1048.64	8.87
62.000	135.89	180.00	296000.00	166.31	168.27	26842.37	1089.45	8.49
64.000	136.09	180.00	40000.00	146.52	146.98	7382.95	855.90	9.24
64.000	136.09	180.00	93000.00	152.40	153.26	12558.68	966.35	9.01
64.000	136.09	180.00	135000.00	155.95	157.08	16096.06	1010.75	8.84
64.000	136.09	180.00	160000.00	157.78	159.05	17952.55	1021.71	8.83
64.000	136.09	180.00	215000.00	161.28	162.88	21564.90	1042.71	8.97
64.000	136.09	180.00	250000.00	163.62	165.36	24018.73	1056.73	8.65
64.000	136.09	180.00	296000.00	166.51	168.42	27123.59	1097.45	8.29
66.000	136.30	180.00	40000.00	146.69	147.15	7398.83	861.16	9.25
66.000	136.30	180.00	93000.00	152.57	153.42	12597.33	974.02	9.01
66.000	136.30	180.00	135000.00	156.12	157.24	16158.81	1018.58	8.82
66.000	136.30	180.00	160000.00	157.95	159.21	18029.40	1029.54	8.80
66.000	136.30	180.00	215000.00	161.46	163.04	21679.82	1050.60	8.91
66.000	136.30	180.00	250000.00	163.79	165.52	24146.57	1064.59	8.58
66.000	136.30	180.00	296000.00	166.68	168.58	27284.42	1104.94	8.21
68.000	136.51	185.00	40000.00	146.87	147.32	7436.66	867.98	9.19
68.000	136.51	185.00	93000.00	152.75	153.59	12675.93	980.42	8.91
68.000	136.51	185.00	135000.00	156.30	157.40	16264.14	1025.44	8.71
68.000	136.51	185.00	160000.00	158.13	159.38	18150.68	1036.42	8.69
68.000	136.51	185.00	215000.00	161.65	163.21	21843.94	1057.59	8.77
68.000	136.51	185.00	250000.00	163.98	165.68	24323.45	1071.56	8.45
68.000	136.51	185.00	296000.00	166.86	168.73	27460.38	1112.42	8.11
69.300	136.65	108.00	40000.00	146.97	147.42	7485.00	874.92	9.09
69.300	136.65	108.00	93000.00	152.86	153.69	12766.67	984.30	8.79
69.300	136.65	108.00	135000.00	156.41	157.50	16381.97	1032.42	8.59
69.300	136.65	108.00	160000.00	158.25	159.47	18296.18	1043.48	8.54
69.300	136.65	108.00	215000.00	161.77	163.30	22009.85	1064.62	8.63
69.300	136.65	108.00	250000.00	164.10	165.77	24504.03	1078.59	8.32
69.300	136.65	108.00	296000.00	166.98	168.82	27659.64	1119.42	7.99
70.300	136.75	92.00	40000.00	147.03	147.48	7465.20	875.77	9.18
70.300	136.75	92.00	93000.00	152.97	153.79	12800.35	986.99	8.73
70.300	136.75	92.00	135000.00	156.56	157.63	16458.31	1033.79	8.47
70.300	136.75	92.00	160000.00	158.41	159.62	18385.85	1044.91	8.42

PROJECT TITLE : TEMPE RIO SALADO - SPRR ENCROACHMENT
PROJECT NUMBER : RIOMR.00 PHASE 2 8/14/1991

Cross-Section Number SECNO	Minimum C. S. Elevation (ft MSL) ELMIN	Channel Reach Length (ft) XLCH	Discharge Flow (cfs) Q	Computed W. S. Elevation (ft MSL) CWSEL	Energy Gradient Elevation (ft MSL) EG	Cross-Section Area (sq ft) AREA	Water Surface Top Width (ft) TOPWID	Energy Gradient Slope * 10,000 10K*$
70.300	136.75	92.00	215000.00	161.98	163.49	22151.52	1066.31	8.47
70.300	136.75	92.00	250000.00	164.32	165.97	24665.99	1080.37	8.16
70.300	136.75	92.00	296000.00	167.21	169.03	27849.98	1120.42	7.82
72.000	136.93	160.00	40000.00	147.18	147.62	7513.67	883.59	9.09
72.000	136.93	160.00	93000.00	153.12	153.93	12889.23	966.74	8.62
72.000	136.93	160.00	135000.00	156.70	157.76	16457.48	1011.49	8.42
72.000	136.93	160.00	160000.00	158.55	159.76	18342.83	1022.61	8.39
72.000	136.93	160.00	215000.00	162.11	163.63	22030.08	1044.02	8.47
72.000	136.93	160.00	250000.00	164.44	166.11	24481.10	1058.01	8.20
72.000	136.93	160.00	296000.00	167.32	169.17	27576.76	1098.35	7.91
74.000	137.14	180.00	40000.00	147.35	147.79	7565.34	893.26	9.01
74.000	137.14	180.00	93000.00	153.29	154.09	12985.55	952.15	8.50
74.000	137.14	180.00	135000.00	156.86	157.92	16495.63	996.87	8.34
74.000	137.14	180.00	160000.00	158.71	159.91	18343.46	1007.93	8.34
74.000	137.14	180.00	215000.00	162.26	163.78	21971.25	1029.30	8.47
74.000	137.14	180.00	250000.00	164.58	166.26	24382.27	1043.26	8.22
74.000	137.14	180.00	296000.00	167.46	169.31	27434.29	1084.07	7.94
76.000	137.35	180.00	40000.00	147.53	147.95	7657.13	907.95	8.85
76.000	137.35	180.00	93000.00	153.47	154.24	13177.97	966.93	8.27
76.000	137.35	180.00	135000.00	157.05	158.07	16745.09	1011.68	8.09
76.000	137.35	180.00	160000.00	158.90	160.06	18627.61	1022.78	8.09
76.000	137.35	180.00	215000.00	162.46	163.94	22314.75	1044.19	8.20
76.000	137.35	180.00	250000.00	164.79	166.41	24756.87	1058.13	7.97
76.000	137.35	180.00	296000.00	167.66	169.46	27847.25	1099.07	7.71
78.000	137.56	180.00	40000.00	147.70	148.11	7834.65	931.73	8.48
78.000	137.56	180.00	93000.00	153.65	154.39	13504.36	990.75	7.87
78.000	137.56	180.00	135000.00	157.24	158.21	17167.28	1035.57	7.69
78.000	137.56	180.00	160000.00	159.10	160.21	19102.58	1046.73	7.68
78.000	137.56	180.00	215000.00	162.69	164.09	22897.03	1068.26	7.77
78.000	137.56	180.00	250000.00	165.02	166.56	25399.15	1082.22	7.55
78.000	137.56	180.00	296000.00	167.89	169.60	28564.64	1123.07	7.30
80.000	137.77	182.00	40000.00	147.87	148.26	8019.12	957.38	8.14
80.000	137.77	182.00	93000.00	153.83	154.53	13847.56	1016.45	7.50
80.000	137.77	182.00	135000.00	157.43	158.36	17612.85	1061.34	7.31
80.000	137.77	182.00	160000.00	159.30	160.35	19604.41	1072.53	7.28
80.000	137.77	182.00	215000.00	162.91	164.23	23513.01	1094.18	7.35
80.000	137.77	182.00	250000.00	165.24	166.70	26079.92	1108.17	7.14
80.000	137.77	182.00	296000.00	168.12	169.74	29325.89	1149.04	6.91

PROJECT TITLE : TEMPE RIO SALADO - SPRR ENCROACHMENT
PROJECT NUMBER : RIOMR.00 PHASE 2 8/14/1991

Cross-Section Number SECNO	Minimum C. S. Elevation (ft MSL) ELMIN	Channel Reach Length (ft) XLCH	Discharge Flow (cfs) Q	Computed W. S. Elevation (ft MSL) CWSEL	Energy Gradient Elevation (ft MSL) EG	Cross-Section Area (sq ft) AREA	Water Surface Top Width (ft) TOPWID	Energy Gradient Slope * 10,000 10K*$
82.000	137.98	180.00	40000.00	148.04	148.41	8275.30	992.06	7.68
82.000	137.98	180.00	93000.00	154.01	154.67	14325.96	1051.22	7.01
82.000	137.98	180.00	135000.00	157.63	158.49	18230.58	1096.19	6.81
82.000	137.98	180.00	160000.00	159.50	160.48	20297.78	1107.44	6.78
82.000	137.98	180.00	215000.00	163.13	164.37	24358.46	1129.23	6.83
82.000	137.98	180.00	250000.00	165.47	166.83	27014.17	1143.25	6.63
82.000	137.98	180.00	296000.00	168.36	169.87	30370.92	1184.04	6.42
84.000	138.19	180.00	40000.00	148.20	148.54	8527.79	1027.69	7.29
84.000	138.19	180.00	93000.00	154.18	154.79	14799.20	1086.91	6.58
84.000	138.19	180.00	135000.00	157.81	158.61	18845.14	1131.95	6.38
84.000	138.19	180.00	160000.00	159.69	160.61	20989.13	1143.25	6.34
84.000	138.19	180.00	215000.00	163.34	164.50	25203.76	1165.16	6.36
84.000	138.19	180.00	250000.00	165.69	166.96	27950.30	1179.22	6.18
84.000	138.19	180.00	296000.00	168.58	169.99	31419.62	1220.04	5.98
86.000	138.40	182.00	40000.00	148.36	148.67	8881.18	1074.33	6.75
86.000	138.40	182.00	93000.00	154.35	154.91	15435.79	1133.57	6.05
86.000	138.40	182.00	135000.00	157.99	158.73	19666.85	1178.70	5.85
86.000	138.40	182.00	160000.00	159.89	160.73	21910.52	1190.07	5.80
86.000	138.40	182.00	215000.00	163.56	164.62	26324.31	1212.11	5.81
86.000	138.40	182.00	250000.00	165.91	167.07	29190.05	1226.22	5.64
86.000	138.40	182.00	296000.00	168.82	170.11	32807.48	1267.01	5.46
88.000	138.60	180.00	40000.00	148.51	148.79	9379.71	1139.92	6.09
88.000	138.60	180.00	93000.00	154.52	155.02	16348.88	1199.27	5.39
88.000	138.60	180.00	135000.00	158.18	158.84	20840.78	1244.51	5.20
88.000	138.60	180.00	160000.00	160.09	160.83	23223.92	1255.95	5.15
88.000	138.60	180.00	215000.00	163.79	164.73	27914.67	1278.16	5.14
88.000	138.60	180.00	250000.00	166.15	167.18	30948.75	1292.33	4.99
88.000	138.60	180.00	296000.00	169.07	170.22	34775.33	1333.01	4.83
90.000	138.81	178.00	40000.00	148.64	148.90	9756.01	1196.41	5.70
90.000	138.81	178.00	93000.00	154.66	155.12	17085.01	1255.84	4.96
90.000	138.81	178.00	135000.00	158.33	158.93	21798.40	1300.70	4.76
90.000	138.81	178.00	160000.00	160.25	160.93	24298.70	1311.50	4.71
90.000	138.81	178.00	215000.00	163.97	164.82	29218.13	1332.50	4.69
90.000	138.81	178.00	250000.00	166.33	167.28	32388.45	1345.86	4.55
90.000	138.81	178.00	296000.00	169.26	170.31	36380.63	1386.01	4.40
92.000	139.02	178.00	40000.00	148.75	149.00	9976.68	1236.92	5.53
92.000	139.02	178.00	93000.00	154.77	155.21	17545.18	1273.10	4.74
92.000	139.02	178.00	135000.00	158.45	159.02	22379.94	1347.73	4.56
92.000	139.02	178.00	160000.00	160.37	161.01	24977.39	1359.24	4.50

PROJECT TITLE : TEMPE RIO SALADO - SPRR ENCROACHMENT
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Cross-Section Number SECNO	Minimum C. S. Elevation (ft MSL) ELMIN	Channel Reach Length (ft) XLCH	Discharge Flow (cfs) Q	Computed W. S. Elevation (ft MSL) CWSEL	Energy Gradient Elevation (ft MSL) EG	Cross-Section Area (sq ft) AREA	Water Surface Top Width (ft) TOPWID	Energy Gradient Slope * 10,000 10K*S
92.000	139.02	178.00	215000.00	164.10	164.91	30094.50	1381.65	4.45
92.000	139.02	178.00	250000.00	166.47	167.36	33388.36	1395.88	4.31
92.000	139.02	178.00	296000.00	169.41	170.39	37535.48	1436.98	4.16
94.000	139.23	178.00	40000.00	148.87	149.10	10503.15	1309.15	5.03
94.000	139.23	178.00	93000.00	154.90	155.29	18460.82	1347.80	4.25
94.000	139.23	178.00	135000.00	158.59	159.10	23545.63	1396.36	4.07
94.000	139.23	178.00	160000.00	160.51	161.09	26244.16	1407.36	4.02
94.000	139.23	178.00	215000.00	164.26	164.99	31558.43	1428.77	4.00
94.000	139.23	178.00	250000.00	166.63	167.44	34969.03	1442.34	3.89
94.000	139.23	178.00	296000.00	169.57	170.47	39257.82	1483.05	3.76
96.000	139.44	212.00	40000.00	148.97	149.21	10260.81	1310.59	5.43
96.000	139.44	212.00	93000.00	154.98	155.39	18248.50	1352.84	4.48
96.000	139.44	212.00	135000.00	158.67	159.19	23488.64	1456.58	4.21
96.000	139.44	212.00	160000.00	160.60	161.18	26301.88	1468.12	4.13
96.000	139.44	212.00	215000.00	164.35	165.08	31844.82	1490.60	4.04
96.000	139.44	212.00	250000.00	166.73	167.53	35407.75	1504.87	3.89
96.000	139.44	212.00	296000.00	169.68	170.55	39898.28	1546.98	3.73
98.000	139.65	245.00	40000.00	149.14	149.33	11213.57	1439.90	4.58
98.000	139.65	245.00	93000.00	155.16	155.49	19991.89	1476.83	3.73
98.000	139.65	245.00	135000.00	158.86	159.29	25569.13	1514.40	3.52
98.000	139.65	245.00	160000.00	160.79	161.28	28502.03	1520.20	3.47
98.000	139.65	245.00	215000.00	164.56	165.18	34255.78	1531.52	3.43
98.000	139.65	245.00	250000.00	166.94	167.62	37912.37	1538.66	3.33
98.000	139.65	245.00	296000.00	169.89	170.65	42466.83	1559.95	3.23
100.000	139.86	255.00	40000.00	149.20	149.52	8876.23	1131.52	7.29
100.000	139.86	255.00	93000.00	155.13	155.68	15637.69	1149.31	6.14
100.000	139.86	255.00	135000.00	158.77	159.49	19924.32	1183.52	5.88
100.000	139.86	255.00	160000.00	160.68	161.49	22183.12	1189.24	5.82
100.000	139.86	255.00	215000.00	164.39	165.41	26616.65	1200.37	5.81
100.000	139.86	255.00	250000.00	166.74	167.87	29443.65	1207.41	5.66
100.000	139.86	255.00	296000.00	169.64	170.91	32966.56	1229.95	5.51
102.000	140.07	285.00	40000.00	149.36	149.81	7409.62	975.01	10.85
102.000	140.07	285.00	93000.00	155.18	155.96	13186.57	1009.94	9.02
102.000	140.07	285.00	135000.00	158.78	159.77	16977.47	1078.09	8.44
102.000	140.07	285.00	160000.00	160.66	161.78	19017.34	1089.38	8.24
102.000	140.07	285.00	215000.00	164.33	165.71	23057.18	1111.41	8.03
102.000	140.07	285.00	250000.00	166.66	168.17	25659.64	1125.37	7.71
102.000	140.07	285.00	296000.00	169.54	171.21	28927.33	1172.04	7.38

PROJECT TITLE : TEMPE RIO SALADO - SPRR ENCROACHMENT
PROJECT NUMBER : RIOMR.00 PHASE 2 8/14/1991

Cross-Section Number SECNO	Minimum C. S. Elevation (ft MSL) ELMIN	Channel Reach Length (ft) XLCH	Discharge Flow (cfs) Q	Computed W. S. Elevation (ft MSL) CWSEL	Energy Gradient Elevation (ft MSL) EG	Cross-Section Area (sq ft) AREA	Water Surface Top Width (ft) TOPWID	Energy Gradient Slope * 10,000 10K*S
104.000	140.28	230.00	40000.00	149.58	150.08	7040.84	923.93	11.97
104.000	140.28	230.00	93000.00	155.34	156.20	12476.99	958.58	10.12
104.000	140.28	230.00	135000.00	158.90	160.02	16036.37	1026.47	9.54
104.000	140.28	230.00	160000.00	160.77	162.02	17962.99	1037.67	9.32
104.000	140.28	230.00	215000.00	164.41	165.96	21784.10	1059.54	9.08
104.000	140.28	230.00	250000.00	166.72	168.41	24245.92	1073.39	8.72
104.000	140.28	230.00	296000.00	169.58	171.45	27337.69	1090.53	8.35
106.000	140.49	225.00	40000.00	149.86	150.35	7138.85	928.28	11.51
106.000	140.49	225.00	93000.00	155.58	156.43	12540.16	962.56	10.01
106.000	140.49	225.00	135000.00	159.13	160.23	16082.50	1021.13	9.46
106.000	140.49	225.00	160000.00	160.99	162.23	17981.23	1032.23	9.28
106.000	140.49	225.00	215000.00	164.62	166.16	21775.26	1054.05	9.06
106.000	140.49	225.00	250000.00	166.92	168.61	24214.92	1067.85	8.73
106.000	140.49	225.00	296000.00	169.76	171.64	27276.78	1084.91	8.37
108.000	140.70	225.00	40000.00	150.17	150.59	7687.74	986.32	9.74
108.000	140.70	225.00	93000.00	155.91	156.65	13439.14	1020.71	8.59
108.000	140.70	225.00	135000.00	159.48	160.44	17167.63	1065.41	8.16
108.000	140.70	225.00	160000.00	161.35	162.44	19173.07	1076.65	8.01
108.000	140.70	225.00	215000.00	165.01	166.37	23157.88	1098.63	7.86
108.000	140.70	225.00	250000.00	167.32	168.81	25705.17	1112.45	7.60
108.000	140.70	225.00	296000.00	170.17	171.83	28908.52	1159.19	7.32
110.000	140.91	228.00	40000.00	150.31	150.92	6354.43	827.55	14.56
110.000	140.91	228.00	93000.00	155.90	156.99	11075.85	861.10	13.05
110.000	140.91	228.00	135000.00	159.39	160.80	14154.34	905.31	12.57
110.000	140.91	228.00	160000.00	161.22	162.82	15821.29	916.29	12.39
110.000	140.91	228.00	215000.00	164.80	166.78	19141.20	937.78	12.23
110.000	140.91	228.00	250000.00	167.06	169.23	21275.81	951.34	11.85
110.000	140.91	228.00	296000.00	169.86	172.26	23967.29	968.17	11.42
112.000	141.12	212.00	40000.00	150.61	151.23	6301.37	812.04	14.60
112.000	141.12	212.00	93000.00	156.15	157.28	10896.81	845.31	13.45
112.000	141.12	212.00	135000.00	159.62	161.09	13894.89	889.35	13.05
112.000	141.12	212.00	160000.00	161.44	163.10	15523.47	900.27	12.89
112.000	141.12	212.00	215000.00	165.01	167.06	18782.80	921.73	12.72
112.000	141.12	212.00	250000.00	167.25	169.51	20874.69	935.25	12.33
112.000	141.12	212.00	296000.00	170.04	172.54	23505.53	951.98	11.91
114.000	141.32	200.00	40000.00	150.94	151.52	6588.81	834.79	13.05
114.000	141.32	200.00	93000.00	156.50	157.55	11322.47	868.14	12.26
114.000	141.32	200.00	135000.00	159.99	161.35	14425.63	912.33	11.92
114.000	141.32	200.00	160000.00	161.82	163.36	16105.99	923.31	11.79

PROJECT TITLE : TEMPE RIO SALADO - SPRR ENCROACHMENT
PROJECT NUMBER : RIOMR.00 PHASE 2 8/14/1991

	Cross-Section Number SECNO	Minimum C. S. Elevation (ft MSL) ELMIN	Channel Reach Length (ft) XLCH	Discharge Flow (cfs) Q	Computed W. S. Elevation (ft MSL) CWSEL	Energy Gradient Elevation (ft MSL) EG	Cross-Section Area (sq ft) AREA	Water Surface Top Width (ft) TOPWID	Energy Gradient Slope * 10,000 10K*S
	114.000	141.32	200.00	215000.00	165.41	167.32	19459.33	944.85	11.69
	114.000	141.32	200.00	250000.00	167.66	169.76	21598.61	958.34	11.38
	114.000	141.32	200.00	296000.00	170.45	172.78	24298.31	975.10	11.02
	116.000	141.53	202.00	40000.00	151.28	151.76	7146.08	890.56	10.85
	116.000	141.53	202.00	93000.00	156.90	157.79	12244.35	924.27	10.27
	116.000	141.53	202.00	135000.00	160.42	161.59	15588.74	968.71	9.99
	116.000	141.53	202.00	160000.00	162.28	163.60	17396.70	979.85	9.89
	116.000	141.53	202.00	215000.00	165.92	167.57	21008.51	1001.72	9.81
	116.000	141.53	202.00	250000.00	168.19	170.00	23296.55	1015.33	9.56
	116.000	141.53	202.00	296000.00	171.01	173.02	26182.26	1062.00	9.28
	118.000	141.74	205.00	40000.00	151.55	151.98	7661.19	945.96	9.33
	118.000	141.74	205.00	93000.00	157.22	158.00	13115.60	979.94	8.82
	118.000	141.74	205.00	135000.00	160.78	161.80	16692.31	1024.58	8.58
	118.000	141.74	205.00	160000.00	162.65	163.80	18623.79	1035.83	8.50
	118.000	141.74	205.00	215000.00	166.34	167.77	22484.81	1057.95	8.42
	118.000	141.74	205.00	250000.00	168.62	170.20	24918.29	1071.67	8.22
	118.000	141.74	205.00	296000.00	171.46	173.22	27991.73	1117.00	7.98
	119.800	141.95	190.00	40000.00	151.75	152.15	7878.24	973.91	8.83
	119.800	141.95	190.00	93000.00	157.43	158.16	13511.51	1008.01	8.30
	119.800	141.95	190.00	135000.00	161.00	161.96	17200.74	1052.72	8.06
	119.800	141.95	190.00	160000.00	162.88	163.97	19192.55	1064.01	7.97
	119.800	141.95	190.00	215000.00	166.59	167.94	23176.10	1086.24	7.89
	119.800	141.95	190.00	250000.00	168.88	170.36	25680.05	1099.98	7.70
	119.800	141.95	190.00	296000.00	171.72	173.38	28842.62	1145.00	7.48
	120.420	142.00	50.00	40000.00	151.79	152.20	7759.67	959.05	9.10
	120.420	142.00	50.00	93000.00	157.45	158.21	13291.93	993.17	8.59
	120.420	142.00	50.00	135000.00	161.02	162.01	16910.00	1037.52	8.36
	120.420	142.00	50.00	160000.00	162.90	164.02	18869.74	1048.79	8.27
	120.420	142.00	50.00	215000.00	166.59	167.99	22789.95	1070.99	8.19
	120.420	142.00	50.00	250000.00	168.88	170.42	25254.52	1084.71	7.99
	120.420	142.00	50.00	296000.00	171.72	173.43	28366.74	1130.00	7.76
*	120.500	147.00	8.00	40000.00	152.28	154.19	3609.76	964.75	117.38
*	120.500	147.00	8.00	93000.00	156.38	158.69	7621.61	989.39	54.44
*	120.500	147.00	8.00	135000.00	160.22	162.37	11490.33	1035.67	30.23
*	120.500	147.00	8.00	160000.00	162.16	164.35	13521.90	1047.37	25.12
*	120.500	147.00	8.00	215000.00	165.93	168.29	17504.29	1069.94	19.76
*	120.500	147.00	8.00	250000.00	168.25	170.70	20008.78	1083.90	17.41
	120.500	147.00	8.00	296000.00	171.13	173.70	23151.46	1101.16	15.32

PROJECT TITLE : TEMPE RIO SALADO - SPRR ENCROACHMENT
PROJECT NUMBER : RIOMR.00 PHASE 2 8/14/1991

Cross-Section Number SECNO	Minimum C. S. Elevation (ft MSL) ELMIN	Channel Reach Length (ft) XLCH	Discharge Flow (cfs) Q	Computed W. S. Elevation (ft MSL) CWSEL	Energy Gradient Elevation (ft MSL) EG	Cross-Section Area (sq ft) AREA	Water Surface Top Width (ft) TOPWID	Energy Gradient Slope * 10,000 10K*S
* 122.000	147.15	152.00	40000.00	154.24	155.15	5239.71	952.62	33.36
122.000	147.15	152.00	93000.00	157.52	159.43	8388.97	972.25	38.65
122.000	147.15	152.00	135000.00	160.68	162.82	11533.11	1014.50	29.05
122.000	147.15	152.00	160000.00	162.52	164.74	13407.07	1025.53	25.12
122.000	147.15	152.00	215000.00	166.17	168.62	17195.08	1047.46	20.38
122.000	147.15	152.00	250000.00	168.45	171.00	19594.26	1061.11	18.14
122.000	147.15	152.00	296000.00	171.29	173.97	22630.72	1078.14	16.06
122.650	147.22	65.00	40000.00	154.47	155.36	5291.27	942.03	31.80
122.650	147.22	65.00	93000.00	157.81	159.68	8488.04	970.75	37.06
122.650	147.22	65.00	135000.00	160.87	163.01	11532.78	1015.27	29.06
122.650	147.22	65.00	160000.00	162.67	164.91	13372.40	1026.09	25.34
122.650	147.22	65.00	215000.00	166.29	168.76	17122.67	1047.79	20.66
122.650	147.22	65.00	250000.00	168.55	171.13	19509.63	1061.37	18.40
122.650	147.22	65.00	296000.00	171.37	174.08	22528.12	1078.30	16.30
123.550	147.31	90.00	40000.00	154.72	155.51	5593.63	968.34	27.44
123.550	147.31	90.00	93000.00	158.48	160.03	9287.65	998.26	28.55
123.550	147.31	90.00	135000.00	161.55	163.39	12425.29	1030.65	23.33
123.550	147.31	90.00	160000.00	163.33	165.30	14267.52	1038.21	20.88
123.550	147.31	90.00	215000.00	166.94	169.17	18043.66	1053.54	17.58
123.550	147.31	90.00	250000.00	169.19	171.54	20420.81	1063.07	15.92
123.550	147.31	90.00	296000.00	172.00	174.50	23430.01	1111.91	14.33
124.000	147.35	45.00	40000.00	154.87	155.64	5688.83	964.32	25.78
124.000	147.35	45.00	93000.00	158.63	160.16	9362.58	987.59	27.37
124.000	147.35	45.00	135000.00	161.66	163.50	12456.42	1029.22	22.94
124.000	147.35	45.00	160000.00	163.43	165.39	14284.46	1039.83	20.72
124.000	147.35	45.00	215000.00	167.02	169.25	18058.82	1061.38	17.62
124.000	147.35	45.00	250000.00	169.27	171.61	20448.52	1074.81	16.01
124.000	147.35	45.00	296000.00	172.07	174.57	23488.34	1120.00	14.42
126.000	147.55	200.00	40000.00	155.49	156.08	6476.07	1024.11	18.13
126.000	147.55	200.00	93000.00	159.46	160.66	10588.01	1049.23	19.65
126.000	147.55	200.00	135000.00	162.43	163.93	13766.73	1091.96	17.64
126.000	147.55	200.00	160000.00	164.16	165.79	15688.50	1130.98	16.37
126.000	147.55	200.00	215000.00	167.74	169.60	19866.61	1209.41	14.19
126.000	147.55	200.00	250000.00	169.99	171.94	22641.00	1253.86	12.89
126.000	147.55	200.00	296000.00	172.83	174.87	26211.53	1260.00	11.51
128.000	147.75	200.00	40000.00	155.84	156.47	6265.31	983.90	19.19
128.000	147.75	200.00	93000.00	159.81	161.09	10258.56	1025.65	21.16
128.000	147.75	200.00	135000.00	162.73	164.33	13307.23	1063.03	19.37
128.000	147.75	200.00	160000.00	164.43	166.17	15131.66	1103.05	18.13

PROJECT TITLE : TEMPE RIO SALADO - SPRR ENCROACHMENT
PROJECT NUMBER : RIOMR.00 PHASE 2 8/14/1991

Cross-Section Number SECNO	Minimum C. S. Elevation (ft MSL) ELMIN	Channel Reach Length (ft) XLCH	Discharge Flow (cfs) Q	Computed W. S. Elevation (ft MSL) CWSEL	Energy Gradient Elevation (ft MSL) EG	Cross-Section Area (sq ft) AREA	Water Surface Top Width (ft) TOPWID	Energy Gradient Slope * 10,000 10K*$
128.000	147.75	200.00	215000.00	167.96	169.93	19297.85	1217.56	15.79
128.000	147.75	200.00	250000.00	170.19	172.24	22046.54	1246.54	14.30
128.000	147.75	200.00	296000.00	173.00	175.14	25572.80	1258.00	12.57

SUMMARY OF WARNING AND STATUS MESSAGES :

Section 120.5, profile 1, critical depth assumed.

Section 120.5, profile 1, probable minimum specific energy.

Section 120.5, profile 1, 20 trials attempted to balance water surface elevation.

Section 120.5, profile 2, conveyance change outside acceptable range.

Section 120.5, profile 3, conveyance change outside acceptable range.

Section 120.5, profile 4, conveyance change outside acceptable range.

Section 120.5, profile 5, conveyance change outside acceptable range.

Section 120.5, profile 6, conveyance change outside acceptable range.

Section 122, profile 1, conveyance change outside acceptable range.

9 Warning and status message(s) generated

END OF OUTPUT

APPENDIX E

BRIDGE LOSS COMPUTATIONS

CRSS

CRS SIRRINE

PROJECT

CLIENT

SUBJECT Bridge Loss

JOB NO.		NO.
DESIGNED BY GKC	DATE 1/13/90	1
CHECKED BY JFM	DATE 2/5/90	OF 11

Summary

	Location			
Discharge	SPRR	Ash	Mill	Rural
40,000	0.11	0.18	0.31	0.06
80,000	0.21	0.33	0.57	0.10
120,000	0.28	0.39	0.81	0.14
160,000	0.26	0.48	1.01	0.19
215,000	0.38	0.52	1.16	0.21
250,000	0.42	0.66	2.05	0.28

CRS SIRRINE	PROJECT: Rio Salado	JOB NO.		NO. 2
	CLIENT: City of Tempe	DESIGNED BY: GKC	DATE: 1/13/90	OF 11
	SUBJECT: Bridge Loss Q=40,000	CHECKED BY: JFM	DATE: 2/5/90	

Location	Sec No	Area	Obst Area	J	K
SPRR	15.60	6841	404	0.059	0.14
Ash	19.20	6887	556	0.081	0.22
Mill	24.50	6906	979	0.142	0.40
Rural	70.50	7987	351	0.044	0.105

Location	h_v	K	Δh_1	TW	Δh_2	Loss
SPRR	0.53	0.14	0.096	849	0.016	0.11
Ash	0.53	0.22	0.15	852	0.025	0.18
Mill	0.52	0.40	0.27	834	0.042	0.31
Rural	0.39	0.105	0.053	921	0.006	0.06

$$\Delta h_1 = 1.3 h_v K$$

$$\Delta h_2 = 1.3 h_v \left[1 - (Area/(Area + \Delta h_1 TW))^2\right]$$

SPRR

$A_p = 6(8)(39.84 - 31.43)$

$= 404$

Ash

$A_p = 1282(40.26 - 32.81)/17.19$

$= 556$

Mill:

$A_p =$ Wall + Pier

Wall $= 2(40.67 - 32.2)16.8 +$
$4(40.67 - 32.2)13.1$

$= 728$

Pier $= 527(40.67 - 32.2)/17.8$

$= 251$

$A_p = 979$

Rural:

$A_p = 8 \times 5 \times (46.2 - 37.42)$

$= 351$

CRS SIRRINE	PROJECT: Rio Salado	JOB NO.		NO. 4
	CLIENT: City of Tempe	DESIGNED BY: GKC	DATE: 1/13/90	OF 11
	SUBJECT: Bridge Losses Q=89000	CHECKED BY: JFM	DATE: 2/5/90	

Location	Sec No	Area	Obst Area	J	K
SPRR	15.60	10303	596	0.058	0.14
Ash	19.20	10496	858	0.082	0.22
Mill	24.50	10341	1449	0.140	0.40
Rural	70.50	12307	536	0.044	0.105

Location	h_v	K	Δh_1	TW	Δh_2	Loss
SPRR	0.94	0.14	0.17	882	0.035	0.21
Ash	0.92	0.22	0.26	1187	0.067	0.33
Mill	0.93	0.40	0.48	854	0.090	0.57
Rural	0.66	0.105	0.09	951	0.012	0.10

$$\Delta h_1 = 1.3 K h_v$$

$$\Delta h_2 = 1.3 h_v [1 - (Area/(Area + \Delta h_1 TW))^2]$$

$$Loss = \Delta h_1 + \Delta h_2$$

CRS SIRRINE	PROJECT	JOB NO.		NO. 5
	CLIENT	DESIGNED BY GKC	DATE 1/13/90	OF 11
	SUBJECT	CHECKED BY JFM	DATE 2/5/90	

*

SPRR:

$A_p = 6(8)(43.84 - 31.43)$

$= 596$

Ash:

$A_p = 1282(44.31 - 32.81)/17.19$

$= 858$

Mill:

$A_p = \text{Wall} + \text{Pier} + \text{Super}$

$\text{Wall} = 2(44.74 - 32.2) + 16.8 +$
$4(44.74 - 32.2) + 13.1$

$= 1078$

$\text{Pier} = 527(44.74 - 32.2)/17.8$

$= 371$

$\text{Super} = 0$

$A_p = 1449$

Rural:

$A_p = 8 + 5(50.81 - 37.42)$

$= 536$

CRS SIRRINE	PROJECT: Rio Salado	JOB NO.		NO. 6
	CLIENT: City of Tempe	DESIGNED BY: GKC	DATE: 1/13/90	OF 11
	SUBJECT: Bridge Losses Q=120,000	CHECKED BY: JPM	DATE: 2/5/90	

Location	SecNo	Area	obst Area	J	K
SPRR	15.60	14397	822	0.057	0.14
Ash	19.20	14297	1095	0.077	0.20
Mill	24.50	13520	1848	0.137	0.39
Rural	70.50	15676	676	0.043	0.105

Location	h_v	K	Δh_1	TW	Δh_2	Loss
SPRR	1.21	0.14	0.22	1311	0.061	0.28
Ash	1.19	0.20	0.31	1204	0.078	0.39
Mill	1.29	0.39	0.65	1044	0.156	0.81
Rural	0.91	0.105	0.12	974	0.017	0.14

$$\Delta h_1 = K h_v 1.3$$

$$\Delta h_2 = 1.3\, h_v \left[1 - (\text{Area}/(\text{Area} - \Delta h_1 TW))^2\right]$$

$$\text{Loss} = \Delta h_1 + \Delta h_2$$

CRSS	PROJECT	JOB NO.		NO.
	CLIENT	DESIGNED BY 6KC	DATE 1/13/90	7
CRS SIRRINE	SUBJECT	CHECKED BY JFM	DATE 2/5/90	OF 11

*

SPRR:

$$A_p = 14(1)(47.04-44) + 2(5)(47.04-44) + 6(8)(47.04-31.43)$$
$$= 42.56 + 30.40 + 749.28$$
$$= 822.24$$

Ash: $A_p = 1282(47.49-32.81)/17.19$
$= 1095$

Mill:

A_p = Wall + Pier + Super

$$\text{Wall} = (47.86-45)*13.1 + 2(47.86-32.2)*16.8 + 4(47.86-32.2)*13.1$$
$$= 1384$$
$$\text{Pier} = 527(47.86-32.2)/17.8$$
$$= 464$$

Super = 0

$A_p = 1848$

Rural:

$$A_p = 8 \times 5 \times (54.31-37.42)$$
$$= 676$$

CRS SIRRINE	PROJECT: Rio Salado	JOB NO. R101N	NO. 8
	CLIENT: City of Tempe	DESIGNED BY GKC / DATE 1/13/90	OF 11
	SUBJECT: Bridge Losses Q = 160,000	CHECKED BY JFM / DATE 2/5/90	

Location	Sec No	Area	Obstr Area *	J	K
SPRR	15.60	18016	1020	0.057	0.14
Ash	19.20	17557	1282	0.073	0.195
Mill	24.50	16297	2206	0.135	0.39
Rural	70.50	18565	794	0.043	0.105

Location	h_v	K	Δh_1	TW	Δh_2	Loss
SPRR	1.40	0.14	0.25	1332	0.065	0.26
Ash	1.43	0.195	0.36	1218	0.089	0.48
Mill	1.60	0.39	0.81	1060	0.203	1.01
Rural	1.15	0.105	0.16	992	0.025	0.19

$$\Delta h_1 = K h_v 1.3$$

$$\Delta h_2 = 1.3 h_v [1 - (Area/(Area - \Delta h_1 TW))^2]$$

$$Loss = \Delta h_1 + \Delta h_2$$

*

SPRR:

$$A_p = 14(1)(49.78 - 44.00) + 2(5)(49.78 - 44.00) + 6(8)(49.78 - 31.43)$$
$$= 80.92 + 57.8 + 880.8$$
$$= 1019.52$$

Ash:

$$A_p = 1282$$

Mill:

$$A_p = \text{Wall} + \text{Pier} + \text{Superstructure}$$

$$\text{Wall} = (50.50 - 45) \times 13.1 + 2(50.50 - 32.2) \times 16.8 + 4(50.50 - 32.2)\,13.1$$
$$= 1645.85$$

$$\text{Pier} = 527$$

$$\text{Super} = 0.5(4 * 7.5 + 2 * 12) + 7(0.86)$$
$$= 33.02$$

$$A_p = 2205.87$$

Rural:

$$A_p = 8 \times 5(57.26 - 37.42)$$
$$= 793.60$$

CRS SIRRINE	PROJECT: Rio Salado	JOB NO.: R101N	NO. 10 / 11
	CLIENT: City of Tempe	DESIGNED BY: GKC / DATE: 1/13/90	
	SUBJECT: Bridge Losses Q = 215,000	CHECKED BY: JFM / DATE: 5 FEB 90	OF

Location	Sec No	Area	Obstr. Area *	J	K
SPRR	15.60	22,503	1256	0.056	0.14
Ash	19.20	22,312	1674	0.075	0.20
Mill	24.50	21,405	3239	0.151	0.435
Rural	70.50	22,659	956	0.042	0.10

* SPRR

$A_p = 14(1)(53.10 - 44.00) + 2(5)(53.10 - 44.00) + 6(8)(53.10 - 31.43)$

$= 124.4 + 91.0 + 1040.2$

$= 1255.6$

Ash

$A_p = 1282 + 8(49)$

$= 1674$

Mill

A_p = Wall + Pier + Superstr

Wall $= (55.2 - 45.0)13.1 + 2(55.2 - 32.2)16.8 + 4(55.2 - 32.2)13.1$

$= 2112$

Pier $= 7.4(50 - 45) + 2 \times 15.0(50 - 32.2) + 4 \times 8.2(50 - 32.2)$

$= 527$

Super $= 5.2(4 * 7.5 + 2 * 12) + 7(45.6)$

$= 600$

$A_p = 3239$

CRSS	PROJECT	JOB NO.		NO. 11
	CLIENT	DESIGNED BY BKL	DATE 1/13/90	
CRS SIRRINE	SUBJECT	CHECKED BY JFM	DATE 5 FEB 90	OF 11

Location	h_v	K	Δh_1	Δh_2	Loss	TW
SPRR	1.63	0.14	0.30	0.075	0.38	1361
Ash	1.61	0.20	0.42	0.095	0.52	1244
Mill	1.69	0.435	0.96	0.201	1.16	1096
Rural	1.40	0.10	0.18	0.029	0.21	1019

where $\Delta h_1 = h_v K 1.3$

$$\Delta h_2 = 1.3\left[1 - (Area/(Area + \Delta h_1 TW))^2\right] h_v$$

$$Loss = \Delta h_1 + \Delta h_2$$

Rural Obstruction

$$A_p = 8 \times 5(61.33 - 37.42) = 956.4$$

CRS SIRRINE	PROJECT: Rio Salado	JOB NO. R101N	NO. 1
	CLIENT: City of Tempe	DESIGNED BY GKC / DATE 1/31/90	
	SUBJECT: Bridge Loss Calculation SPR'R Bridge	CHECKED BY JFM / DATE 2/5/90	OF 3

Existing SPRR Bridge

Narrative: Calculation is based on normal stage. The bridge substructure consists of both timber bents and concrete-filled steel caisons. The timber bents are located on the south overbank terrace, and the caisons are located in the main channel. The bridge span between timber bents is 15 feet. The typical span between the caisons is 162 feet, and there are ten piers with a cummulative span of 1292 feet. The Rio Salado channel removes the ninth and tenth pier on the north bank of the channel.

Flow Conditions:

$Q = 250{,}000$ cfs
$WSEL = 1155.05$
$A_{n2} = 608$ Left Overbank
$20{,}210$ Main Channel
$4{,}345$ Right Overbank
$25{,}163$

$V_{n2} = 9.94$ fps (average)
3.95 fps LOB
11.12 CH
5.26 ROB

$h_e = EGL - WSEL = 1156.82 - 1155.05$
$= 1.77'$

$M = 1.0$; No flow contraction
assume $\alpha_1 = \alpha_2 = 1.3$; Large River, compound section

Skew $= 0°$; Bridge is aligned to flow

CRSS	PROJECT: Rio Salado	JOB NO. 12101N	NO. 2
CRS SIRRINE	CLIENT: City of Tempe	DESIGNED BY BKC / DATE 1/31/90	
	SUBJECT: SPRR Bridge Loss Calc.	CHECKED BY JPM / DATE 2/5/90	OF 3

Pier Loss Coef:

Terrace Elev 1144.0
Ave Channel Bed 1131.43
14 Timber Bents and 2 caisons on terrace
6 caisons in channel

$A_p = 14(1)(55.05 - 44.00) +$
$2(5)(55.05 - 44.00) +$
$6(8)(55.05 - 31.43)$
$= 154.70 + 110.50 + 1133.76$
$= 1398.96$

$J = A_p / A_{n2} = 1399/25163 = 0.056$

$\Delta K_p = 0.14$

Loss:

$$h_1 = \Delta K_p \alpha_2 h_e + \alpha_1 \left[\left(\frac{A_{n2}}{A_{n4}}\right)^2 - \left(\frac{A_{n2}}{A_1}\right)^2 \right] h_e$$

$= 0.14(1.3)1.77 + \alpha_1 [\quad]$

$= 0.32 + \alpha_1 [\quad]$

$= 0.32 + 1.3\left[1 - \left(25163/(25163 + 0.32(1347))\right)^2\right] 1.77$

$= 0.32 + 0.08 = 0.40$

$h_f = 0.02$ (Friction loss from section 15.4 to 15.6)

$h_L = h_1 + h_f$
$= 0.40 + 0.02$
$= 0.42$

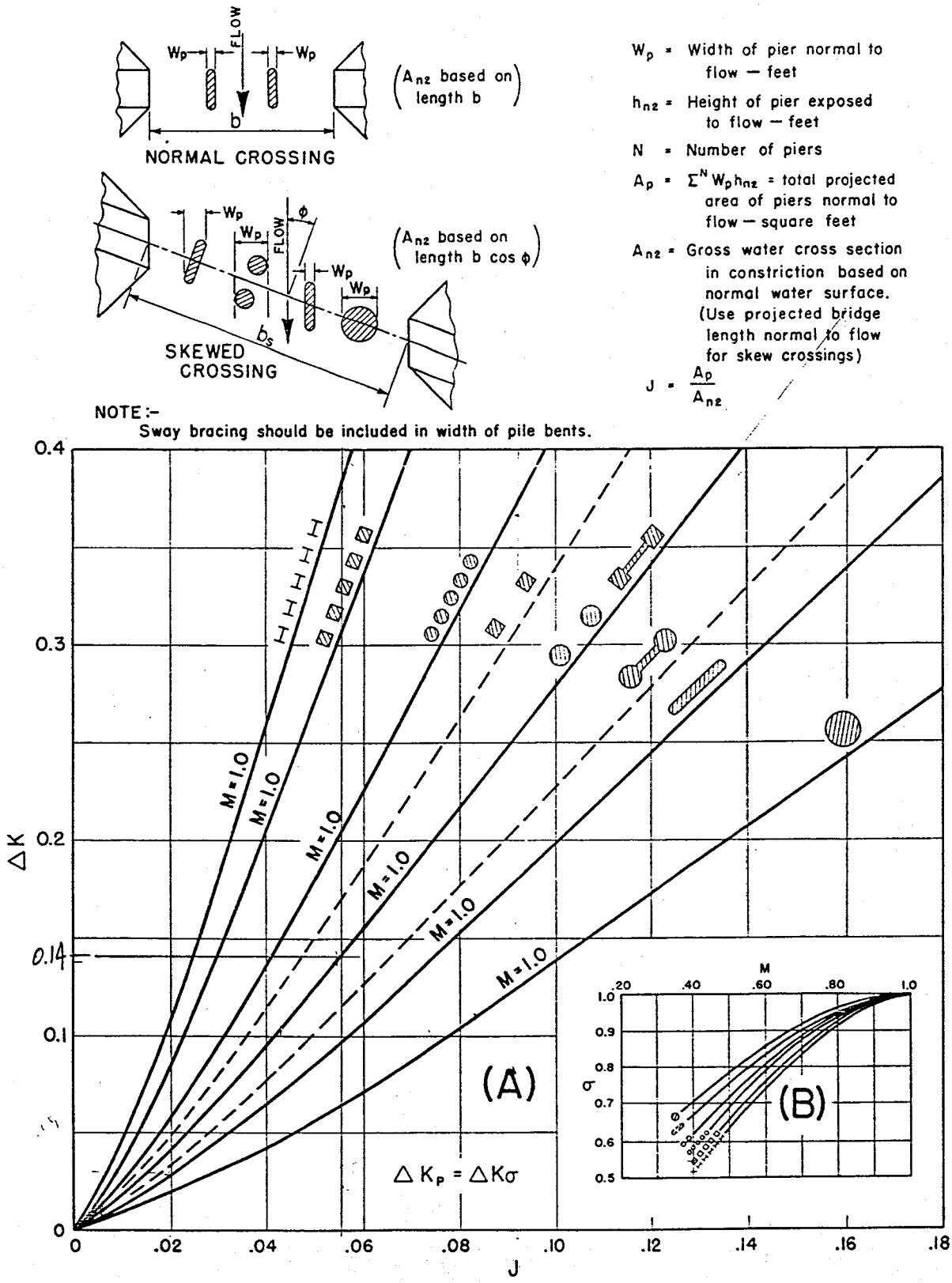

Figure 7.—Incremental backwater coefficient for piers.

```
****************************************************
* WATER SURFACE PROFILES                           *
* VERSION OF NOVEMBER 1976                         *
* UPDATED MAY 1984                                 *
* IBM-PC-XT VERSION AUGUST 1985                    *
* RUN DATE  01-26-90   TIME  11:23:34              *
****************************************************
```

```
*************************************
* U.S. ARMY CORPS OF ENGINEERS
* THE HYDROLOGIC ENGINEERING CENTER
* 609 SECOND STREET. SUITE D
* DAVIS, CALIFORNIA 95616
* (916) 440-2105 (FTS) 448-2105
*************************************
```

TEST.DAT
No widening @ 1212
No LOSSES
(straight HEC-2)

```
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
```

THIS RUN EXECUTED 01-26-90

```
**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
  ERROR CORR -  01,02,03,04,05,06
  MODIFICATION -  50,51,52,53,54,55,56
  IBM-PC-XT VERSION AUGUST 1985
**************************************************


C
T1              CRSS COMMERCIAL GROUP, INC.
T2      RIO SALADO * HEC2 * GRADE CONTROL STRUCTURE No. 3 TO HAYDEN ROAD
T3      JANUARY 25, 1990         FILE:TEST.DAT         Q = 250,000 CFS

J1  ICHECK    INQ       NINV      IDIR      STRT      METRIC    HVINS     Q         WSEL      FQ

    -10.       2.        0.        0.   .000000       .00       .0        0.   142.880      .000

J2  NPROF     IPLOT     PRFVS     XSECV     XSECH     FN        ALLDC     IBW       CHNIM     ITRACE

    -1.000     .000    -1.000     .000      .000      .000    -1.000     .000      .000      .000

J3  VARIABLE CODES FOR SUMMARY PRINTOUT

    38.000    1.000     8.000    13.000    14.000    15.000    55.000    26.000    56.000     3.000

J5  LPRNT    NUMSEC                    ********REQUESTED SECTION NUMBERS********

   -10.000  -10.000      .000      .000      .000      .000      .000      .000      .000      .000
```

THIS RUN EXECUTED 01-26-90

```
**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
  ERROR CORR -  01,02,03,04,05,06
  MODIFICATION -  50,51,52,53,54,55,56
  IBM-PC-XT VERSION AUGUST 1985
**************************************************
```

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

JANUARY 25, 1990

SUMMARY PRINTOUT

SECNO	CWSEL	DEPTH	QLOB	QCH	QROB	VLOB	VCH	VROB	EG
20782.000	142.88	20.38	.00	250000.00	.00	.00	14.91	.00	146.33
20800.000	142.94	20.41	.00	250000.00	.00	.00	14.90	.00	146.38
21000.000	143.50	20.64	.00	250000.00	.00	.00	14.81	.00	146.91
21200.000	144.12	20.93	.00	250000.00	.00	.00	14.58	.00	147.42
21400.000	144.78	21.26	.00	250000.00	.00	.00	14.19	.00	147.91
21600.000	145.43	21.58	.00	250000.00	.00	.00	13.76	.00	148.37
21800.000	145.82	21.64	.00	250000.00	.00	.00	13.89	.00	148.81
22000.000	146.29	21.78	.00	250000.00	.00	.00	13.79	.00	149.25
22200.000	146.75	21.91	.00	250000.00	.00	.00	13.71	.00	149.67
22400.000	147.19	22.01	.00	250000.00	.00	.00	13.66	.00	150.08
22600.000	147.65	22.14	.00	250000.00	.00	.00	13.52	.00	150.49
22800.000	148.06	22.22	.00	250000.00	.00	.00	13.49	.00	150.89
23000.000	148.41	21.71	.00	250000.00	.00	.00	13.65	.00	151.31
23200.000	148.97	22.47	.00	250000.00	.00	.00	13.30	.00	151.71
23400.000	149.34	22.51	.00	250000.00	.00	.00	13.29	.00	152.09
23600.000	149.72	22.56	.00	250000.00	.00	.00	13.27	.00	152.46
23800.000	150.11	22.65	.00	250000.00	.00	.00	13.23	.00	152.83

SECNO	CWSEL	DEPTH	QLOB	QCH	QROB	VLOB	VCH	VROB	EG	
24000.000	150.57	22.75	.00	250000.00	.00	.00	13.00	.00	153.20	
24200.000	150.98	22.83	.00	250000.00	.00	.00	12.85	.00	153.54	
24400.000	151.39	22.91	.00	250000.00	.00	.00	12.65	.00	153.88	
24600.000	151.83	23.02	.00	250000.00	.00	.00	12.34	.00	154.19	
24800.000	152.09	22.95	.00	250000.00	.00	.00	12.48	.00	154.51	
.000	152.39	22.99	552.66	249447.30	.08	3.21	12.34	.34	154.75	
2.000	152.69	23.12	2470.69	244805.20	2724.11	4.36	12.25	5.11	154.98	
4.000	152.86	23.08	1988.19	242888.30	5123.47	4.57	12.70	4.94	155.31	
6.000	153.16	23.16	2124.96	240447.10	7427.92	4.65	12.75	5.12	155.60	
8.000	153.50	23.29	2708.08	238052.90	9239.00	4.50	12.68	5.11	155.90	
10.000	153.88	23.46	2757.95	236743.90	10498.18	4.52	12.47	5.00	156.19	
12.000	154.47	23.83	2502.56	229582.50	17914.91	4.06	11.76	5.27	156.48	
14.000	154.79	23.99	2133.21	226738.30	21128.54	4.04	11.46	5.32	156.67	
15.400	155.03	24.13	2393.88	224823.00	22783.19	3.94	11.12	5.26	156.80	SPRR Bridge
	0.02									
15.600	155.05	24.12	2403.43	224739.30	22857.25	3.95	11.12	5.26	156.82	
17.500	155.23	24.11	2185.34	228087.20	19727.49	4.17	11.10	5.27	157.01	
19.000	155.33	24.04	2082.90	229813.60	18103.50	4.61	11.40	5.46	157.22	Ash Ave Bridge
	0.02									
19.200	155.35	24.04	2089.92	229756.10	18153.98	4.61	11.39	5.46	157.24	
21.500	155.37	23.89	2328.85	232029.30	15641.80	4.75	12.06	5.69	157.50	
24.000	155.49	23.86	1892.99	238604.30	9502.68	4.69	12.19	5.45	157.72	Mill Ave Bridge
	0.07									
24.500	155.56	23.88	1912.32	238502.90	9584.73	4.69	12.18	5.46	157.78	
26.000	155.75	23.85	2082.11	239314.30	8603.63	4.93	12.44	5.69	158.07	
27.000	155.83	23.72	7433.84	234473.00	8093.15	5.99	13.31	6.05	158.45	
28.000	156.08	23.81	7733.22	235424.70	6842.12	6.04	13.25	5.77	158.68	
30.000	156.45	23.96	8075.45	234154.30	7770.26	6.07	13.11	5.91	158.99	
32.000	156.65	23.95	7460.35	234860.10	7679.55	5.95	13.48	5.82	159.33	

SECNO	CWSEL	DEPTH	QLOB	QCH	QROB	VLOB	VCH	VROB	ES
34.000	156.99	24.08	7718.66	234726.00	7555.34	6.02	13.41	5.83	159.65
36.000	157.36	24.23	6681.53	236185.50	7132.97	5.92	13.20	6.05	159.95
38.000	157.69	24.33	3069.59	239746.80	7183.58	5.52	13.10	5.86	160.27
40.000	157.95	24.35	2379.59	242518.30	5102.12	5.19	13.29	5.19	160.63
42.000	158.15	24.30	2592.22	239821.50	7586.31	5.51	13.95	5.75	161.07
44.000	158.62	24.53	2733.15	240462.50	6804.33	5.55	13.69	5.60	161.44
46.000	159.04	24.70	2967.74	238971.40	8060.88	5.33	13.57	5.65	161.79
48.000	159.38	24.79	2660.94	240825.00	6514.09	5.25	13.56	5.63	162.15
50.000	159.89	25.08	2748.05	240562.60	6689.34	5.28	13.10	5.39	162.47
52.000	160.49	25.48	2781.17	243736.90	3481.90	4.97	12.15	4.40	162.73
54.000	160.94	25.74	.69	246703.40	3295.93	.52	11.48	4.35	162.96
56.000	161.17	25.77	1.25	246533.50	3465.23	.60	11.37	4.38	163.16
58.000	161.31	25.72	1.43	243916.60	6081.93	.64	11.65	4.93	163.38
60.000	161.70	25.92	2.28	247451.20	2546.53	.70	11.05	4.61	163.58
62.000	161.90	25.93	3.01	247387.80	2609.19	.74	10.98	4.61	163.76
64.000	162.11	25.95	3.98	247320.50	2675.51	.79	10.88	4.60	163.93
66.000	162.32	25.96	5.06	247258.50	2736.43	.83	10.77	4.59	164.11
68.000	162.54	25.98	7.28	247606.30	2386.42	.90	10.65	4.44	164.29
69.500	162.76	26.10	.33	249999.70	.00	.40	10.23	.00	164.39
70.500	162.82	26.06	.42	249999.60	.00	.43	10.33	.00	164.48
72.000	162.92	26.00	.62	249985.60	13.80	.48	10.49	1.04	164.63
74.000	162.99	25.80	.77	249977.70	21.53	.53	10.96	1.17	164.85
76.000	163.12	25.56	.00	249981.30	18.73	.00	11.20	1.19	165.06
78.000	163.17	25.23	1.15	249820.30	178.56	.65	11.84	2.25	165.35
80.000	163.82	25.50	2.71	249961.90	35.37	.72	10.65	1.32	165.58
82.000	164.11	25.41	.00	249967.40	32.65	.01	10.27	1.29	165.75

SECNO	CWSEL	DEPTH	QLOB	QCH	QROB	VLOB	VCH	VROB	EG
84.000	164.35	25.27	.05	249959.70	40.26	.24	10.03	1.33	165.91
86.000	164.65	25.19	44.11	249911.80	44.11	1.32	9.59	1.32	166.08
88.000	164.92	25.08	.57	249952.60	46.84	.43	9.14	1.29	166.22
90.000	165.14	24.92	.00	250000.00	.00	.00	8.82	.00	166.35
92.000	165.28	24.68	.00	250000.00	.00	.00	8.73	.00	166.47
94.000	165.36	24.38	.00	250000.00	.00	.00	8.96	.00	166.60
96.000	165.42	24.06	.00	250000.00	.00	.00	9.36	.00	166.78
98.000	165.49	23.76	.00	250000.00	.00	.00	9.80	.00	166.99
100.000	165.54	23.43	.00	250000.00	.00	.00	10.55	.00	167.27
102.000	165.61	23.12	.00	250000.00	.00	.00	11.37	.00	167.62
104.000	165.75	22.88	.00	249901.00	98.95	.00	11.90	1.99	167.95
106.000	166.07	22.82	6.48	249879.30	114.26	1.01	11.89	2.07	168.26
108.000	166.51	22.88	10.52	249856.30	133.24	1.11	11.53	2.09	168.58
110.000	166.67	22.66	.30	249848.80	150.92	.48	12.16	2.26	168.96
112.000	166.82	22.43	.53	249830.70	168.78	.58	12.76	2.42	169.34
114.000	167.20	22.43	1.63	249804.90	193.50	.75	12.61	2.49	169.67
116.000	167.75	22.60	4.62	249817.10	178.24	.93	12.03	2.38	169.99
118.000	168.25	22.72	7.04	249793.60	199.38	1.01	11.44	2.34	170.28
120.000	168.61	22.70	10.14	249922.80	67.11	1.08	11.17	1.69	170.54
120.500	168.67	22.67	10.82	249919.50	69.69	1.10	11.18	1.70	170.60
122.000	168.84	22.56	11.49	249911.10	77.44	1.13	11.20	1.76	170.79
122.650	169.04	22.63	13.54	249901.20	85.23	1.18	11.17	1.79	170.98
123.550	169.23	22.65	15.91	249890.10	93.98	1.22	11.15	1.84	171.16
124.000	169.44	22.78	18.70	249877.70	103.57	1.26	11.07	1.87	171.34

Existing Ash Avenue Bridge

Narrative: Calculation is based on abnormal stage with backwater from the SPRR bridge included. The bridge substructure consists of a wall-type pier on caisons. The bridge has ten piers. Channelization removes piers 1 and 10 from the flow and places pier 2 on the south overbank terrace.

Flow Conditions:

$Q = 250,000$ cfs
$WSEL = 1155.71$

$A_{n2} =$	476	LOB
	20,486	CH
	3,432	ROB
	24,394	

$V_{n2} =$	10.25	(average)
	4.54	LOB
	11.19	CH
	5.42	ROB

$h_e = EG - WSEL = 1157.53 - 1155.71 = 1.82$

$M = 1.0$; No flow contraction

Assume $\alpha_1 = \alpha_2 = 1.3$; Large River, compound section

Skew = 0° ; Bridge is aligned to flow

CRS SIRRINE	PROJECT: Rio Salado	JOB NO.: R101N	NO. 2 / 3
	CLIENT: City of Tempe	DESIGNED BY: GKC / DATE: 1/31/90	
	SUBJECT: Ash Ave	CHECKED BY: JFM / DATE: 2/5/90	

Pier Loss Coef:

Terrace Elev. 1144.00
Ave Channel Bed 1131.81
7 piers in the main channel
1 on the terrace

	Pier	Arch	
$A_p =$	$(50-44)8.4$ +	86.3 +	No. 2
	$(50.0-31.81)7.2$ +	86.3 +	No. 3
	272 +	86.3 +	No. 4
	$(50.0-31.81)7.2$ +	86.3 +	No. 5
	$(50.0-31.81)7.2$ +	86.3 +	No. 6
	259 +	86.3 +	No. 7
	$(50.0-31.81)7.9$ +	86.3 +	No. 8
	$(50.0-31.81)9.0$ +	86.3	No. 9
$=$	1281.7	690.4	
$=$	1972.1	with 4' of debris 2460	

$J = A_p/A_{n2} = 1972/24394 = 0.081 \quad (0.101)$

$\Delta K_p = 0.22 \quad (.28)$

Loss:

$$h_1 = \Delta K_p \alpha_2 h_c + \alpha_1 \left[(A_{n2}/A_{n4})^2 - (A_{n2}/A_{n1})^2 \right] h_c$$

$$h_1 = 0.22(1.3)1.82 + \alpha_1 [\quad] h_c$$

$$= 0.52 + 1.3\left[1 - \left(\frac{24394}{24394 + 0.52(1229.3)}\right)^2\right] 1.82$$

$$= 0.52 + 1.3(0.050)1.82 = 0.64 \quad (0.81)$$

$h_f = 0.02$ (Friction loss from sec 19.0 to 19.2)

$$h_e = h_1 + h_f$$

$$= 0.64 + 0.02 \quad (0.81 + 0.02)$$

$$= 0.66$$

3/3

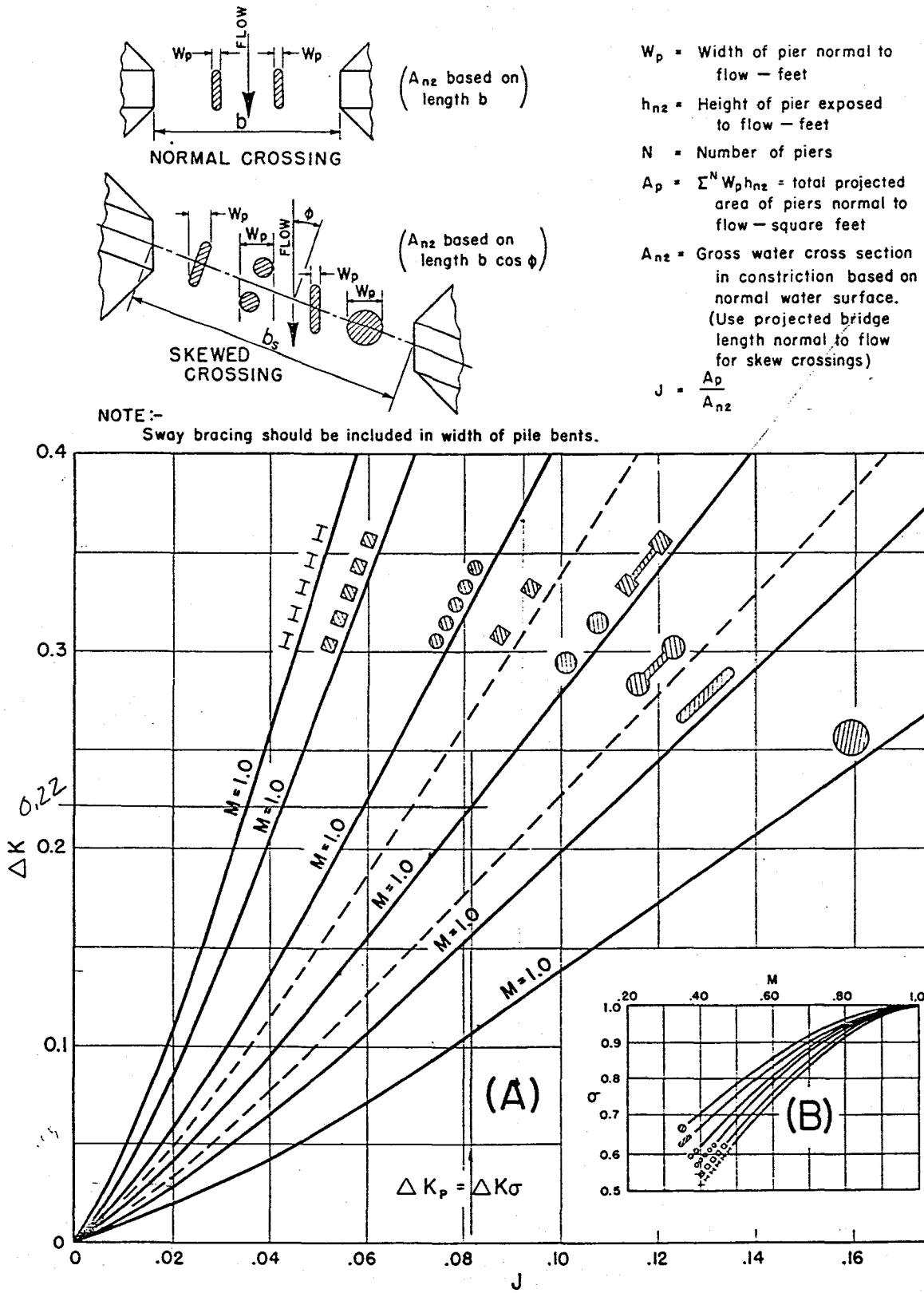

Figure 7.—Incremental backwater coefficient for piers.

```
****************************************************
*  WATER SURFACE PROFILES                          *
*  VERSION OF NOVEMBER 1976                        *
*  UPDATED MAY 1984                                *
*  IBM-PC-XT VERSION AUGUST 1985                   *
*  RUN DATE  01-31-90   TIME  13:09:45               *
****************************************************
```

```
*************************************
*  U.S. ARMY CORPS OF ENGINEERS     *
*  THE HYDROLOGIC ENGINEERING CENTER *
*  609 SECOND STREET. SUITE D       *
*  DAVIS, CALIFORNIA 95616          *
  *  (916) 440-2105 (FTS) 448-2105
*************************************
```

TEST.DAT

SPRR LOSS → 0.40'

No other losses

```
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
```

THIS RUN EXECUTED 01-31-90

```
**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
  ERROR CORR -  01,02,03,04,05,06
  MODIFICATION -  50,51,52,53,54,55,56
  IBM-PC-XT VERSION AUGUST 1985
**************************************************


C
T1              CRSS COMMERCIAL GROUP, INC.
T2      RIO SALADO * HEC2 * GRADE CONTROL STRUCTURE No. 3 TO HAYDEN ROAD
T3      JANUARY 25, 1990         FILE:TEST.DAT          Q = 250,000 CFS

J1  ICHECK    INQ       NINV      IDIR      STRT      METRIC    HVINS     Q         WSEL      FQ

    -10.        2.        0.        0.   .000000       .00        .0        0.   142.880      .000

J2  NPROF     IPLOT     PRFVS     XSECV     XSECH     FN        ALLDC     IBW       CHNIM     ITRACE

    -1.000      .000    -1.000      .000      .000      .000    -1.000      .000      .000      .000

J3  VARIABLE CODES FOR SUMMARY PRINTOUT

    38.000     1.000     8.000    13.000    14.000    15.000    55.000    26.000    56.000     3.000

J5  LPRNT     NUMSEC                    ********REQUESTED SECTION NUMBERS********

   -10.000   -10.000      .000      .000      .000      .000      .000      .000      .000      .000
```

THIS RUN EXECUTED 01-31-90

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*************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
  ERROR CORR -  01,02,03,04,05,06
  MODIFICATION -  50,51,52,53,54,55,56
  IBM-PC-XT VERSION AUGUST 1985
*************************************************
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NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

JANUARY 25, 1990

SUMMARY PRINTOUT

SECNO	CWSEL	DEPTH	QLOB	QCH	QROB	VLOB	VCH	VROB	EG
20782.000	142.88	20.38	.00	250000.00	.00	.00	14.91	.00	146.33
20800.000	142.94	20.41	.00	250000.00	.00	.00	14.90	.00	146.38
21000.000	143.50	20.64	.00	250000.00	.00	.00	14.81	.00	146.91
21200.000	144.12	20.93	.00	250000.00	.00	.00	14.58	.00	147.42
21400.000	144.78	21.26	.00	250000.00	.00	.00	14.19	.00	147.91
21600.000	145.43	21.58	.00	250000.00	.00	.00	13.76	.00	148.37
21800.000	145.82	21.64	.00	250000.00	.00	.00	13.89	.00	148.81
22000.000	146.29	21.78	.00	250000.00	.00	.00	13.79	.00	149.25
22200.000	146.75	21.91	.00	250000.00	.00	.00	13.71	.00	149.67
22400.000	147.19	22.01	.00	250000.00	.00	.00	13.66	.00	150.08
22600.000	147.65	22.14	.00	250000.00	.00	.00	13.52	.00	150.49
22800.000	148.06	22.22	.00	250000.00	.00	.00	13.49	.00	150.89
23000.000	148.41	21.71	.00	250000.00	.00	.00	13.65	.00	151.31
23200.000	148.97	22.47	.00	250000.00	.00	.00	13.30	.00	151.71
23400.000	149.34	22.51	.00	250000.00	.00	.00	13.29	.00	152.09
23600.000	149.72	22.56	.00	250000.00	.00	.00	13.27	.00	152.46
23800.000	150.11	22.65	.00	250000.00	.00	.00	13.23	.00	152.83

SECNO	CWSEL	DEPTH	QLOB	QCH	QROB	VLOB	VCH	VROB	EG
24000.000	150.57	22.75	.00	250000.00	.00	.00	13.00	.00	153.20
24200.000	150.98	22.83	.00	250000.00	.00	.00	12.85	.00	153.54
24400.000	151.39	22.91	.00	250000.00	.00	.00	12.65	.00	153.88
24600.000	151.83	23.02	.00	250000.00	.00	.00	12.34	.00	154.19
24800.000	152.09	22.95	.00	250000.00	.00	.00	12.48	.00	154.51
.000	152.39	22.99	552.66	249447.30	.08	3.21	12.34	.34	154.75
2.000	152.69	23.12	2470.69	244805.20	2724.11	4.36	12.25	5.11	154.98
4.000	152.86	23.08	1988.19	242888.30	5123.47	4.57	12.70	4.94	155.31
6.000	153.16	23.16	2124.96	240447.10	7427.92	4.65	12.75	5.12	155.60
8.000	153.50	23.29	2708.08	238052.90	9239.00	4.50	12.68	5.11	155.90
10.000	153.88	23.46	2757.95	236743.90	10498.18	4.52	12.47	5.00	156.19
12.000	154.47	23.83	2502.56	229582.50	17914.91	4.06	11.76	5.27	156.48
14.000	154.79	23.99	2133.21	226738.30	21128.54	4.04	11.46	5.32	156.67
15.400	155.03	24.13	2393.88	224823.00	22783.19	3.94	11.12	5.26	156.80
* 15.600	155.43	24.50	2503.21	224026.30	23470.52	3.90	10.90	5.22	157.13
17.500	155.59	24.47	2272.44	227483.20	20244.32	4.11	10.90	5.22	157.31
19.000	155.69	24.40	2155.42	229290.00	18554.60	4.54	11.20	5.41	157.51
19.200	155.71	24.40	2162.24	229234.70	18603.03	4.54	11.19	5.42	157.53
21.500	155.72	24.24	2413.32	231545.30	16041.34	4.68	11.86	5.63	157.78
24.000	155.83	24.20	1966.11	238250.40	9783.46	4.64	12.00	5.41	157.98
24.500	155.90	24.22	1984.97	238152.40	9862.65	4.64	11.99	5.42	158.04
26.000	156.09	24.19	2138.93	239091.60	8769.49	4.85	12.18	5.61	158.31
27.000	156.14	24.03	7624.19	234079.80	8295.96	5.95	13.11	6.01	158.68
28.000	156.37	24.10	7914.11	235071.90	7014.03	6.00	13.06	5.72	158.90
30.000	156.72	24.23	8241.02	233821.00	7938.04	6.03	12.94	5.87	159.19
32.000	156.91	24.21	7629.93	234510.10	7859.93	5.91	13.31	5.78	159.52

0.02

0.07

Ash Bridge

SECNO	CWSEL	DEPTH	QLOB	QCH	QROB	VLOB	VCH	VROB	EG
34.000	157.23	24.32	7872.59	234413.20	7714.26	5.99	13.25	5.79	159.82
36.000	157.59	24.46	6802.45	235941.10	7256.49	5.89	13.06	6.02	160.12
38.000	157.90	24.54	3127.80	239567.30	7304.85	5.49	12.98	5.82	160.43
40.000	158.15	24.55	2430.21	242368.40	5201.36	5.16	13.17	5.17	160.78
42.000	158.34	24.49	2643.38	239641.00	7715.68	5.47	13.83	5.72	161.20
44.000	158.79	24.70	2778.22	240314.80	6906.96	5.52	13.59	5.58	161.56
46.000	159.20	24.86	3014.69	238822.60	8162.73	5.30	13.48	5.62	161.91
48.000	159.53	24.94	2703.12	240694.50	6602.35	5.22	13.47	5.61	162.26
50.000	160.02	25.21	2783.37	240448.80	6767.87	5.26	13.02	5.37	162.57
52.000	160.61	25.60	2811.87	243663.40	3524.69	4.95	12.09	4.39	162.83
54.000	161.05	25.85	.93	246665.50	3333.51	.56	11.42	4.34	163.06
56.000	161.28	25.88	1.57	246496.50	3501.92	.64	11.32	4.37	163.25
58.000	161.42	25.83	1.75	243860.10	6138.17	.67	11.59	4.91	163.47
60.000	161.81	26.03	2.64	247427.50	2569.91	.72	11.00	4.60	163.67
62.000	162.00	26.03	3.42	247364.40	2632.14	.76	10.94	4.59	163.84
64.000	162.21	26.05	4.44	247297.80	2697.80	.81	10.83	4.59	164.01
66.000	162.41	26.05	5.58	247236.30	2758.09	.85	10.73	4.57	164.18
68.000	162.63	26.07	7.92	247586.40	2405.66	.92	10.61	4.43	164.36
69.500	162.85	26.19	.44	249999.60	.00	.43	10.20	.00	164.46
70.500	162.90	26.14	.52	249999.50	.00	.46	10.30	.00	164.55
72.000	163.00	26.08	.76	249984.50	14.72	.50	10.46	1.05	164.70
74.000	163.06	25.87	.93	249976.20	22.91	.55	10.93	1.18	164.92
76.000	163.19	25.63	.00	249980.20	19.85	.00	11.17	1.20	165.13
78.000	163.25	25.31	1.34	249816.10	182.56	.67	11.80	2.25	165.41
80.000	163.89	25.57	2.97	249960.10	36.87	.74	10.62	1.33	165.64
82.000	164.18	25.48	.00	249966.10	33.88	.01	10.24	1.29	165.81

SECNO	CWSEL	DEPTH	QLOB	QCH	QROB	VLOB	VCH	VROB	EG
84.000	164.41	25.33	.07	249958.30	41.64	.27	10.01	1.34	165.97
86.000	164.71	25.25	45.45	249909.10	45.45	1.32	9.56	1.32	166.13
88.000	164.98	25.14	.67	249951.20	48.13	.44	9.12	1.30	166.27
90.000	165.19	24.97	.00	250000.00	.00	.00	8.80	.00	166.40
92.000	165.34	24.74	.00	250000.00	.00	.00	8.71	.00	166.52
94.000	165.41	24.43	.00	250000.00	.00	.00	8.94	.00	166.65
96.000	165.48	24.12	.00	250000.00	.00	.00	9.34	.00	166.83
98.000	165.55	23.82	.00	250000.00	.00	.00	9.78	.00	167.03
100.000	165.59	23.48	.00	250000.00	.00	.00	10.53	.00	167.31
102.000	165.66	23.17	.00	250000.00	.00	.00	11.34	.00	167.66
104.000	165.80	22.93	.00	249899.10	100.86	.00	11.88	2.00	167.99
106.000	166.12	22.87	6.85	249877.00	116.19	1.02	11.86	2.07	168.30
108.000	166.56	22.93	10.97	249853.90	135.16	1.12	11.50	2.10	168.61
110.000	166.71	22.70	.35	249846.70	152.96	.50	12.13	2.26	169.00
112.000	166.86	22.47	.60	249828.50	170.91	.59	12.73	2.42	169.37
114.000	167.24	22.47	1.76	249802.60	195.62	.77	12.59	2.49	169.70
116.000	167.78	22.63	4.85	249815.30	179.85	.94	12.01	2.38	170.02
118.000	168.28	22.75	7.28	249791.80	200.91	1.01	11.42	2.34	170.31
120.000	168.64	22.73	10.42	249921.50	68.09	1.09	11.15	1.69	170.57
120.500	168.69	22.69	11.11	249918.20	70.69	1.11	11.16	1.71	170.63
122.000	168.87	22.59	11.77	249909.80	78.47	1.14	11.19	1.76	170.81
122.650	169.07	22.66	13.84	249899.90	86.28	1.18	11.15	1.80	171.00
123.550	169.26	22.68	16.23	249888.70	95.06	1.23	11.14	1.84	171.18
124.000	169.47	22.81	19.03	249876.30	104.65	1.27	11.06	1.87	171.37

SUMMARY OF ERRORS AND SPECIAL NOTES

NOTE SECNO= 15.600 PROFILE= 1 WSEL BASED ON X2 CARD

Existing Mill Ave Bridge

Narrative: Calculation is based on abnormal stage with backwater from the SPRR and Ash Ave bridges. The bridge substructure is a wall-type pier that is skewed to the direction of flow. A portion of the bridge superstructure in addition to the piers obstructs the flow. Channelization removes piers 2 and 10 from the flow and places pier 3 on the south overbank terrace.

Flow Conditions:

$Q = 250{,}000$ cfs

WSEL = 1155.90

A_{n2} =	428	LOB
	19,630	CH
	1,820	ROB
	21,878	

V_{n2} =	11.42 fps	(Average)
	4.64	LOB
	11.99	CH
	5.42	ROB

$h_e = 1158.04 - 1155.90 = 2.14$

$M = 1.0$; No flow contraction

assume $\alpha_1 = \alpha_2 = 1.3$; Large River, compound section

Skew = 15° ;

Pier Loss Coef:

Terrace Elev. 1145.0
Average channel bed 1132.18
1 pier on terrace
6 piers in channel

wall pier

$A_p = (55.90 - 45.00)(13.1) + 7.4(50 - 45) +$ No. 2
$(55.90 - 32.18)(16.8) + 15.0(50 - 32.18) +$ No. 3 *
$(55.90 - 32.18)(13.1) + 8.2(50 - 32.18) +$ No. 4
$(55.90 - 32.18)(13.1) + 8.2(50 - 32.18) +$ No. 5
$(55.90 - 32.18)(13.1) + 8.2(50 - 32.18) +$ No. 6
$(55.90 - 32.18)(16.8) + 15.0(50 - 32.18) +$ No. 7 *
$(55.90 - 32.18)(13.1) + 8.2(50 - 32.18) +$ No. 8

superstructure → $+ 5.9(7.5 + 12 + 7.5 + 7.5 + 7.5 + 12 + 7.5) +$
$7(58.8)$

$= \underset{\text{wall}}{2182.7} + \underset{\text{pier}}{1156.1} + \underbrace{362.9 + 411.6}_{\text{arch}} = 4113.3$

$J = A_p / A_{n2} = 4113/21878$
$= 0.188$

$\Delta K_p = 0.56$

Loss:

$h_1 = \Delta K_p \alpha_2 h_e + \alpha_1 [(A_{n2}/A_{n4})^2 - (A_{n2}/A_{n1})^2] h_e$
$= 0.56(1.3)2.14 + \alpha_1 [\quad] h_e$
$= 1.56 + 1.3[1 - (21878/(21878 + 1.56 \cdot 1190))^2] 2.14$
$= 1.56 + 1.3(0.15)2.14$
$= 1.98$

$h_f = 0.07$ (Friction loss from sec 24.0 to 24.5)

$h_l = h_1 + h_f$

$h_l = 1.98 + 0.07 = 2.05$

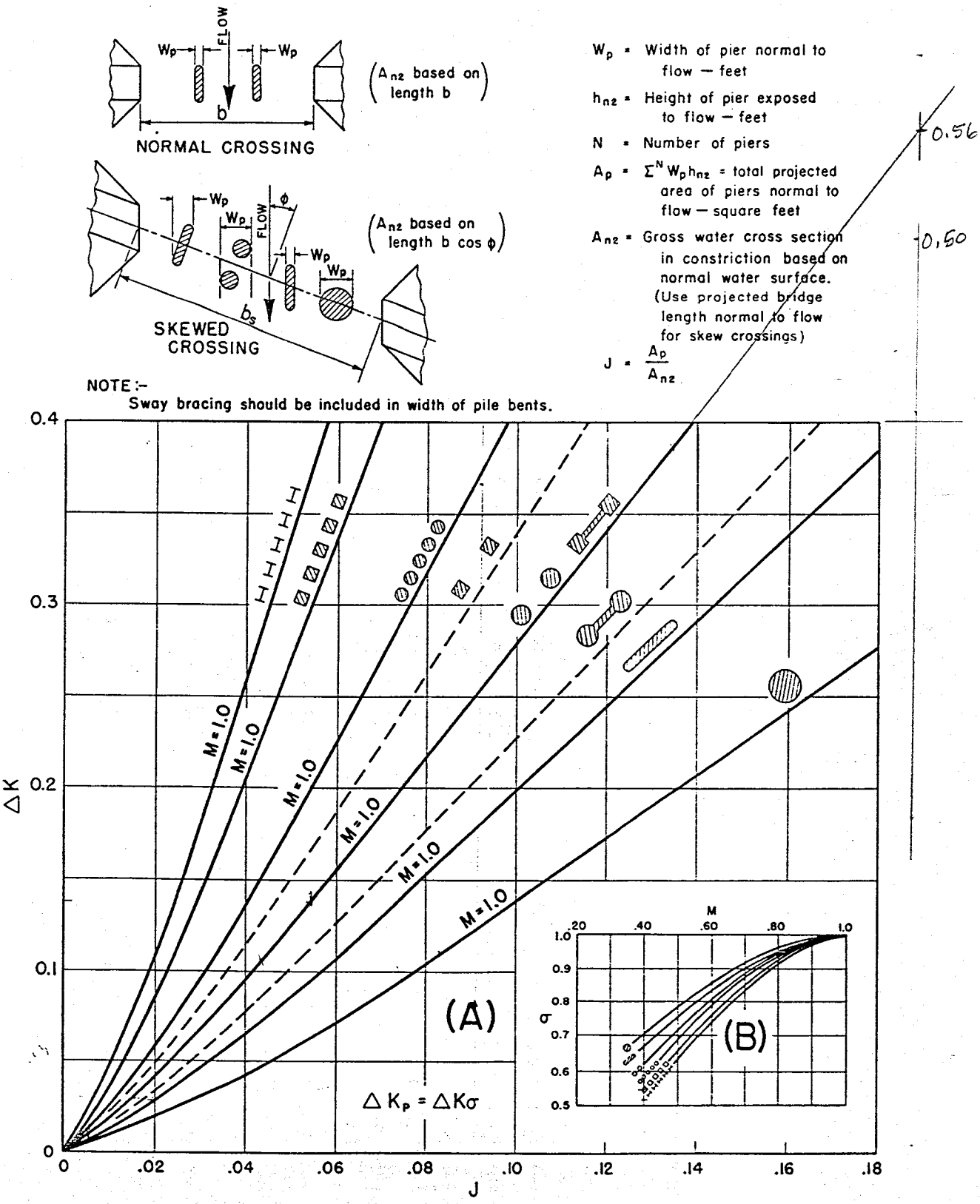

Figure 7.—Incremental backwater coefficient for piers.

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****************************************************
*  WATER SURFACE PROFILES                          *
*  VERSION OF NOVEMBER 1976                        *
*  UPDATED MAY 1984                                *
*  IBM-PC-XT VERSION AUGUST 1985                   *
*  RUN DATE  01-31-90   TIME  18:27:46               *
****************************************************
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*************************************
*  U.S. ARMY CORPS OF ENGINEERS     *
*  THE HYDROLOGIC ENGINEERING CENTER *
*  609 SECOND STREET. SUITE D       *
*  DAVIS, CALIFORNIA 95616          *
  *  (916) 440-2105 (FTS) 448-2105
*************************************
```


```
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
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THIS RUN EXECUTED 01-31-90

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**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
  ERROR CORR -  01,02,03,04,05,06
  MODIFICATION -  50,51,52,53,54,55,56
  IBM-PC-XT VERSION AUGUST 1985
**************************************************


C
T1              CRSS COMMERCIAL GROUP, INC.
T2      RIO SALADO * HEC2 * GRADE CONTROL STRUCTURE No. 3 TO HAYDEN ROAD
T3      JANUARY 25, 1990         FILE:TEST.DAT          Q = 250,000 CFS

J1  ICHECK    INQ       NINV      IDIR      STRT      METRIC    HVINS     Q         WSEL      FQ

    -10.       2.        0.        0.   .000000       .00        .0        0.   142.880      .000

J2  NPROF     IPLOT     PRFVS     XSECV     XSECH     FN        ALLDC     IBW       CHNIM     ITRACE

    -1.000     .000    -1.000     .000      .000      .000    -1.000     .000      .000      .000

J3  VARIABLE CODES FOR SUMMARY PRINTOUT

    38.000    1.000     8.000    13.000    14.000    15.000    55.000    26.000    56.000     3.000

J5  LPRNT    NUMSEC                    ********REQUESTED SECTION NUMBERS********

   -10.000  -10.000      .000      .000      .000      .000      .000      .000      .000      .000
```

THIS RUN EXECUTED 01-31-90

```
**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
  ERROR CORR -  01,02,03,04,05,06
  MODIFICATION -  50,51,52,53,54,55,56
  IBM-PC-XT VERSION AUGUST 1985
**************************************************
```

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

JANUARY 25, 1990

SUMMARY PRINTOUT

SECNO	CWSEL	DEPTH	QLOB	QCH	QROB	VLOB	VCH	VROB	EG
20782.000	142.88	20.38	.00	250000.00	.00	.00	14.91	.00	146.33
20800.000	142.94	20.41	.00	250000.00	.00	.00	14.90	.00	146.38
21000.000	143.50	20.64	.00	250000.00	.00	.00	14.81	.00	146.91
21200.000	144.12	20.93	.00	250000.00	.00	.00	14.58	.00	147.42
21400.000	144.78	21.26	.00	250000.00	.00	.00	14.19	.00	147.91
21600.000	145.43	21.58	.00	250000.00	.00	.00	13.76	.00	148.37
21800.000	145.82	21.64	.00	250000.00	.00	.00	13.89	.00	148.81
22000.000	146.29	21.78	.00	250000.00	.00	.00	13.79	.00	149.25
22200.000	146.75	21.91	.00	250000.00	.00	.00	13.71	.00	149.67
22400.000	147.19	22.01	.00	250000.00	.00	.00	13.66	.00	150.08
22600.000	147.65	22.14	.00	250000.00	.00	.00	13.52	.00	150.49
22800.000	148.06	22.22	.00	250000.00	.00	.00	13.49	.00	150.89
23000.000	148.41	21.71	.00	250000.00	.00	.00	13.65	.00	151.31
23200.000	148.97	22.47	.00	250000.00	.00	.00	13.30	.00	151.71
23400.000	149.34	22.51	.00	250000.00	.00	.00	13.29	.00	152.09
23600.000	149.72	22.56	.00	250000.00	.00	.00	13.27	.00	152.46
23800.000	150.11	22.65	.00	250000.00	.00	.00	13.23	.00	152.83

	SECND	CWSEL	DEPTH	QLOB	QCH	QROB	VLOB	VCH	VROB	EG
	24000.000	150.57	22.75	.00	250000.00	.00	.00	13.00	.00	153.20
	24200.000	150.98	22.83	.00	250000.00	.00	.00	12.85	.00	153.54
	24400.000	151.39	22.91	.00	250000.00	.00	.00	12.65	.00	153.88
	24600.000	151.83	23.02	.00	250000.00	.00	.00	12.34	.00	154.19
	24800.000	152.09	22.95	.00	250000.00	.00	.00	12.48	.00	154.51
	.000	152.39	22.99	552.66	249447.30	.08	3.21	12.34	.34	154.75
	2.000	152.69	23.12	2470.69	244805.20	2724.11	4.36	12.25	5.11	154.98
	4.000	152.86	23.08	1988.19	242888.30	5123.47	4.57	12.70	4.94	155.31
	6.000	153.16	23.16	2124.96	240447.10	7427.92	4.65	12.75	5.12	155.60
	8.000	153.50	23.29	2708.08	238052.90	9239.00	4.50	12.68	5.11	155.90
	10.000	153.88	23.46	2757.95	236743.90	10498.18	4.52	12.47	5.00	156.19
	12.000	154.47	23.83	2502.56	229582.50	17914.91	4.06	11.76	5.27	156.48
	14.000	154.79	23.99	2133.21	226738.30	21128.54	4.04	11.46	5.32	156.67
	15.400	155.03	24.13	2393.88	224823.00	22783.19	3.94	11.12	5.26	156.80
*	15.600	155.43	24.50	2503.21	224026.30	23470.52	3.90	10.90	5.22	157.13
	17.500	155.59	24.47	2272.44	227483.20	20244.32	4.11	10.90	5.22	157.31
	19.000	155.69	24.40	2155.42	229290.00	18554.60	4.54	11.20	5.41	157.51
	19.200	155.71	24.40	2162.24	229234.70	18603.03	4.54	11.19	5.42	157.53
	21.500	155.72	24.24	2413.32	231545.30	16041.34	4.68	11.86	5.63	157.78
	24.000	155.83	24.20	1966.11	238250.40	9783.46	4.64	12.00	5.41	157.98
	24.500	155.90	24.22	1984.97	238152.40	9862.65	4.64	11.99	5.42	158.04
	26.000	156.09	24.19	2138.93	239091.60	8769.49	4.85	12.18	5.61	158.31
	27.000	156.14	24.03	7624.19	234079.80	8295.96	5.95	13.11	6.01	158.68
	28.000	156.37	24.10	7914.11	235071.90	7014.03	6.00	13.06	5.72	158.90
	30.000	156.72	24.23	8241.02	233821.00	7938.04	6.03	12.94	5.87	159.19
	32.000	156.91	24.21	7629.93	234510.10	7859.93	5.91	13.31	5.78	159.52

0.07

Mill Ave.

SECNO	CWSEL	DEPTH	QLOB	QCH	QROB	VLOB	VCH	VROB	EG
34.000	157.23	24.32	7872.59	234413.20	7714.26	5.99	13.25	5.79	159.82
36.000	157.59	24.46	6802.45	235941.10	7256.49	5.89	13.06	6.02	160.12
38.000	157.90	24.54	3127.80	239567.30	7304.85	5.49	12.98	5.82	160.43
40.000	158.15	24.55	2430.21	242368.40	5201.36	5.16	13.17	5.17	160.78
42.000	158.34	24.49	2643.38	239641.00	7715.68	5.47	13.83	5.72	161.20
44.000	158.79	24.70	2778.22	240314.80	6906.96	5.52	13.59	5.58	161.56
46.000	159.20	24.86	3014.69	238822.60	8162.73	5.30	13.48	5.62	161.91
48.000	159.53	24.94	2703.12	240694.50	6602.35	5.22	13.47	5.61	162.26
50.000	160.02	25.21	2783.37	240448.80	6767.87	5.26	13.02	5.37	162.57
52.000	160.61	25.60	2811.87	243663.40	3524.69	4.95	12.09	4.39	162.83
54.000	161.05	25.85	.93	246665.50	3333.51	.56	11.42	4.34	163.06
56.000	161.28	25.88	1.57	246496.50	3501.92	.64	11.32	4.37	163.25
58.000	161.42	25.83	1.75	243860.10	6138.17	.67	11.59	4.91	163.47
60.000	161.81	26.03	2.64	247427.50	2569.91	.72	11.00	4.60	163.67
62.000	162.00	26.03	3.42	247364.40	2632.14	.76	10.94	4.59	163.84
64.000	162.21	26.05	4.44	247297.80	2697.80	.81	10.83	4.59	164.01
66.000	162.41	26.05	5.58	247236.30	2758.09	.85	10.73	4.57	164.18
68.000	162.63	26.07	7.92	247586.40	2405.66	.92	10.61	4.43	164.36
69.500	162.85	26.19	.44	249999.60	.00	.43	10.20	.00	164.46
70.500	162.90	26.14	.52	249999.50	.00	.46	10.30	.00	164.55
72.000	163.00	26.08	.76	249984.50	14.72	.50	10.46	1.05	164.70
74.000	163.06	25.87	.93	249976.20	22.91	.55	10.93	1.18	164.92
76.000	163.19	25.63	.00	249980.20	19.85	.00	11.17	1.20	165.13
78.000	163.25	25.31	1.34	249816.10	182.56	.67	11.80	2.25	165.41
80.000	163.89	25.57	2.97	249960.10	36.87	.74	10.62	1.33	165.64
82.000	164.18	25.48	.00	249966.10	33.88	.01	10.24	1.29	165.81

SECNO	CWSEL	DEPTH	QLOB	QCH	QROB	VLOB	VCH	VROB	EG
84.000	164.41	25.33	.07	249958.30	41.64	.27	10.01	1.34	165.97
86.000	164.71	25.25	45.45	249909.10	45.45	1.32	9.56	1.32	166.13
88.000	164.98	25.14	.67	249951.20	48.13	.44	9.12	1.30	166.27
90.000	165.19	24.97	.00	250000.00	.00	.00	8.80	.00	166.40
92.000	165.34	24.74	.00	250000.00	.00	.00	8.71	.00	166.52
94.000	165.41	24.43	.00	250000.00	.00	.00	8.94	.00	166.65
96.000	165.48	24.12	.00	250000.00	.00	.00	9.34	.00	166.83
98.000	165.55	23.82	.00	250000.00	.00	.00	9.78	.00	167.03
100.000	165.59	23.48	.00	250000.00	.00	.00	10.53	.00	167.31
102.000	165.66	23.17	.00	250000.00	.00	.00	11.34	.00	167.66
104.000	165.80	22.93	.00	249899.10	100.86	.00	11.88	2.00	167.99
106.000	166.12	22.87	6.85	249877.00	116.19	1.02	11.86	2.07	168.30
108.000	166.56	22.93	10.97	249853.90	135.16	1.12	11.50	2.10	168.61
110.000	166.71	22.70	.35	249846.70	152.96	.50	12.13	2.26	169.00
112.000	166.86	22.47	.60	249828.50	170.91	.59	12.73	2.42	169.37
114.000	167.24	22.47	1.76	249802.60	195.62	.77	12.59	2.49	169.70
116.000	167.78	22.63	4.85	249815.30	179.85	.94	12.01	2.38	170.02
118.000	168.28	22.75	7.28	249791.80	200.91	1.01	11.42	2.34	170.31
120.000	168.64	22.73	10.42	249921.50	68.09	1.09	11.15	1.69	170.57
120.500	168.69	22.69	11.11	249918.20	70.69	1.11	11.16	1.71	170.63
122.000	168.87	22.59	11.77	249909.80	78.47	1.14	11.19	1.76	170.81
122.650	169.07	22.66	13.84	249899.90	86.28	1.18	11.15	1.80	171.00
123.550	169.26	22.68	16.23	249888.70	95.06	1.23	11.14	1.84	171.18
124.000	169.47	22.81	19.03	249876.30	104.65	1.27	11.06	1.87	171.37

CRS SIRRINE	PROJECT: Rio Salado	JOB NO. R101N	NO. 1
	CLIENT: City of Tempe	DESIGNED BY GKC / DATE 2/1/90	OF 3
	SUBJECT: Rural Rd Bridge Loss	CHECKED BY JFM / DATE 2/5/90	

Existing Rural Road

Narrative: Calculation is based on abnormal stage with backwater from SPRR, Ash Ave and Mill Avenue bridges. The bridge substructure consists of a bent with three five-foot-diameter circular piers. The profile of the bridge super structure is arched with the the lowest point of bridge low chord at the bridge abutment. At mid-span the low chord is 7.3 higher than at the abutment. Channelization removes piers 9 and 10 from the flow.

Flow Conditions:

$Q = 250,000$ cfs

$WSEL = 1163.53$

$A_{n2} =$

3	LOB
24,900	CH
0	ROB
24,903	

$V_{n2} = 10.04$

0.62	LOB
10.04	CH
.00	ROB

$h_e = 1165.09 - 1163.53 = 1.56$

$M = 1.0$; No flow contraction

assume $\alpha_1 = \alpha_2 = 1.3$; Large river, compound section

Skew $= 0°$; Piers aligned to flow

CRS SIRRINE	PROJECT: Rio Salado	JOB NO. R101N		NO. 4
	CLIENT: City of Tempe	DESIGNED BY GKC	DATE 2/1/90	OF 3
	SUBJECT: Rural Rd Bridge	CHECKED BY JFM	DATE 2/5/90	

Pier Loss Coef.

Average bed elev 1137.42

8 piers in the channel

$A_p = 8.5(63.53 - 37.42) = 1044.4$

$J = 1044/24{,}903 = 0.042$

$\Delta K_p = 0.10$

Loss:

$h_1 = \Delta K_p \alpha_2 h_e + \alpha_1 [(A_{n2}/A_{n1})^2 - (A_{n2}/A_{n1})^2] h_e$

$= 0.10(1.3)1.56 + \alpha_1 [\quad] h_e$

$= 0.20 + 1.3[1.0 - (24903/(24903 + 0.20(1031)))^2]1.56$

$= 0.20 + 1.3(0.016)1.56$

$= 0.23$

$h_f = 0.05$ (Friction loss from Sec 69.5 to 70.5

$h_\ell = h_1 + h_f$

$= 0.23 + 0.05$

$= 0.28$

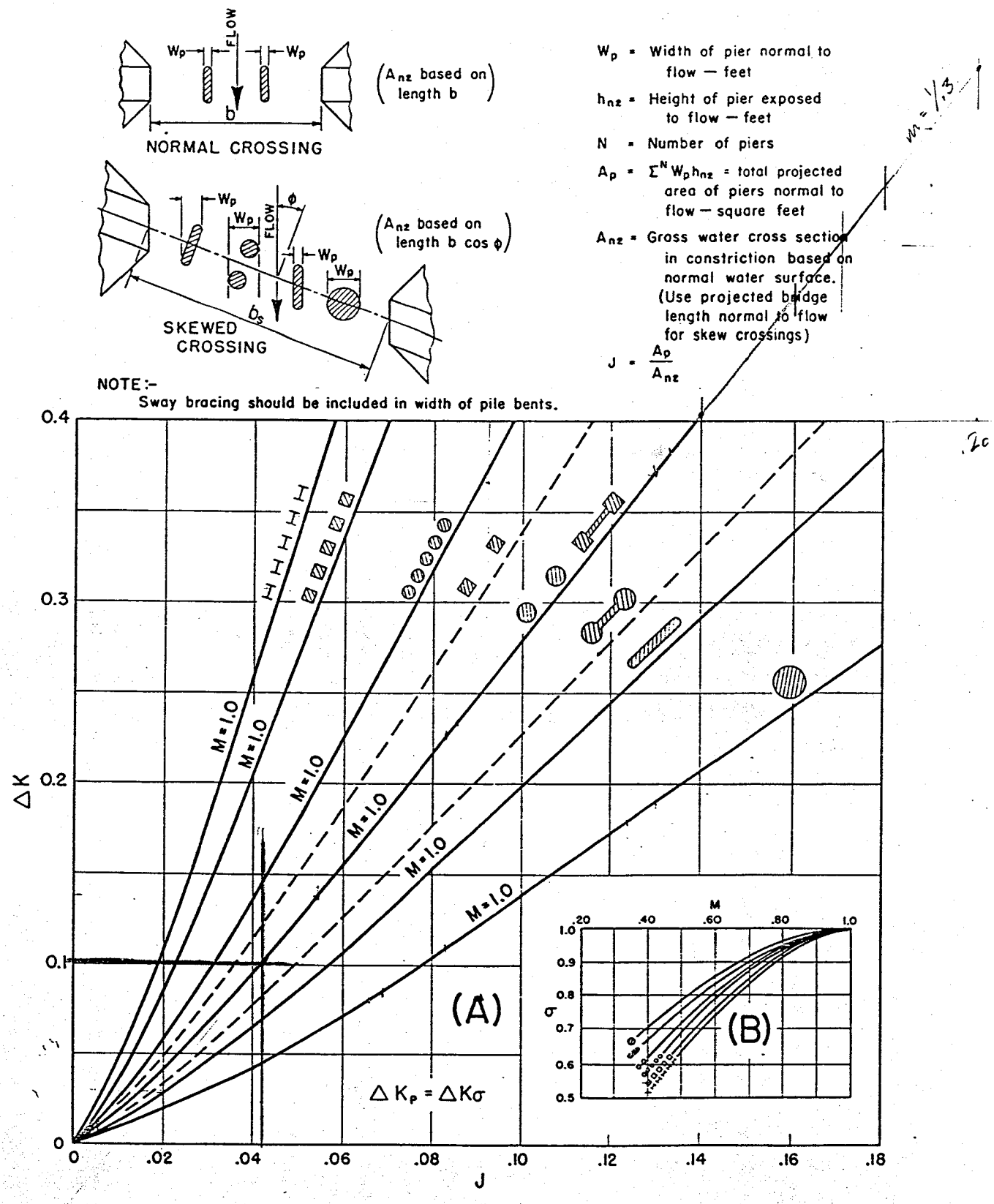

Figure 7.—Incremental backwater coefficient for piers.

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*****************************************************
*  WATER SURFACE PROFILES                           *
*  VERSION OF NOVEMBER 1976                         *
*  UPDATED MAY 1984                                 *
*  IBM-PC-XT VERSION AUGUST 1985                    *
*  RUN DATE  02-01-90   TIME  09:12:17               *
*****************************************************
```


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*************************************
*  U.S. ARMY CORPS OF ENGINEERS     *
*  THE HYDROLOGIC ENGINEERING CENTER *
*  609 SECOND STREET, SUITE D       *
*  DAVIS, CALIFORNIA 95616          *
*  (916) 440-2105 (FTS) 448-2105    *
*************************************
```


```
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
```

THIS RUN EXECUTED 02-01-90

```
**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
  ERROR CORR -  01,02,03,04,05,06
  MODIFICATION -  50,51,52,53,54,55,56
  IBM-PC-XT VERSION AUGUST 1985
**************************************************


C
T1            CRSS COMMERCIAL GROUP, INC.
T2      RIO SALADO * HEC2 * GRADE CONTROL STRUCTURE No. 3 TO HAYDEN ROAD
T3      JANUARY 25, 1990        FILE:TEST.DAT        Q = 250,000 CFS

J1  ICHECK    INQ      NINV     IDIR     STRT     METRIC   HVINS    Q        WSEL     FQ

     -10.       2.       0.       0.   .000000     .00       .0       0.   142.880    .000

J2  NPROF     IPLOT    PRFVS    XSECV    XSECH    FN       ALLDC    IBW      CHNIM    ITRACE

    -1.000     .000   -1.000     .000     .000     .000   -1.000     .000     .000     .000

J3  VARIABLE CODES FOR SUMMARY PRINTOUT

    38.000    1.000    8.000   13.000   14.000   15.000   55.000   26.000   56.000    3.000

J5  LPRNT    NUMSEC                   ********REQUESTED SECTION NUMBERS********

   -10.000  -10.000     .000     .000     .000     .000     .000     .000     .000     .000
```

THIS RUN EXECUTED 02-01-90

```
**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
  ERROR CORR -  01,02,03,04,05,06
  MODIFICATION -  50,51,52,53,54,55,56
  IBM-PC-XT VERSION AUGUST 1985
**************************************************
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NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

JANUARY 25, 1990

SUMMARY PRINTOUT

SECNO	CWSEL	DEPTH	QLOB	QCH	QROB	VLOB	VCH	VROB	EG
20782.000	142.88	20.38	.00	250000.00	.00	.00	14.91	.00	146.33
20800.000	142.94	20.41	.00	250000.00	.00	.00	14.90	.00	146.38
21000.000	143.50	20.64	.00	250000.00	.00	.00	14.81	.00	146.91
21200.000	144.12	20.93	.00	250000.00	.00	.00	14.58	.00	147.42
21400.000	144.78	21.26	.00	250000.00	.00	.00	14.19	.00	147.91
21600.000	145.43	21.58	.00	250000.00	.00	.00	13.76	.00	148.37
21800.000	145.82	21.64	.00	250000.00	.00	.00	13.89	.00	148.81
22000.000	146.29	21.78	.00	250000.00	.00	.00	13.79	.00	149.25
22200.000	146.75	21.91	.00	250000.00	.00	.00	13.71	.00	149.67
22400.000	147.19	22.01	.00	250000.00	.00	.00	13.66	.00	150.08
22600.000	147.65	22.14	.00	250000.00	.00	.00	13.52	.00	150.49
22800.000	148.06	22.22	.00	250000.00	.00	.00	13.49	.00	150.89
23000.000	148.41	21.71	.00	250000.00	.00	.00	13.65	.00	151.31
23200.000	148.97	22.47	.00	250000.00	.00	.00	13.30	.00	151.71
23400.000	149.34	22.51	.00	250000.00	.00	.00	13.29	.00	152.09
23600.000	149.72	22.56	.00	250000.00	.00	.00	13.27	.00	152.46
23800.000	150.11	22.65	.00	250000.00	.00	.00	13.23	.00	152.83

	SECNO	CWSEL	DEPTH	QLOB	QCH	QROB	VLOB	VCH	VROB	EG	
	24000.000	150.57	22.75	.00	250000.00	.00	.00	13.00	.00	153.20	
	24200.000	150.98	22.83	.00	250000.00	.00	.00	12.85	.00	153.54	
	24400.000	151.39	22.91	.00	250000.00	.00	.00	12.65	.00	153.88	
	24600.000	151.83	23.02	.00	250000.00	.00	.00	12.34	.00	154.19	
	24800.000	152.09	22.95	.00	250000.00	.00	.00	12.48	.00	154.51	
	.000	152.39	22.99	552.66	249447.30	.08	3.21	12.34	.34	154.75	
	2.000	152.69	23.12	2470.69	244805.20	2724.11	4.36	12.25	5.11	154.98	
	4.000	152.86	23.08	1988.19	242888.30	5123.47	4.57	12.70	4.94	155.31	
	6.000	153.16	23.16	2124.96	240447.10	7427.92	4.65	12.75	5.12	155.60	
	8.000	153.50	23.29	2708.08	238052.90	9239.00	4.50	12.68	5.11	155.90	
	10.000	153.88	23.46	2757.95	236743.90	10498.18	4.52	12.47	5.00	156.19	
	12.000	154.47	23.83	2502.56	229582.50	17914.91	4.06	11.76	5.27	156.46	
	14.000	154.79	23.99	2133.21	226738.30	21128.54	4.04	11.46	5.32	156.67	
	15.400	155.03	24.13	2393.88	224823.00	22783.19	3.94	11.12	5.26	156.80	SPRR Bridge
*	15.600	155.43	24.50	2503.21	224026.30	23470.52	3.90	10.90	5.22	157.13	
	17.500	155.59	24.47	2272.44	227483.20	20244.32	4.11	10.90	5.22	157.31	
	19.000	155.69	24.40	2155.42	229290.00	18554.60	4.54	11.20	5.41	157.51	Ash Ave.
	19.200	155.71	24.40	2162.24	229234.70	18603.03	4.54	11.19	5.42	157.53	
	21.500	155.72	24.24	2413.32	231545.30	16041.34	4.68	11.86	5.63	157.78	
	24.000	155.83	24.20	1966.11	238250.40	9783.46	4.64	12.00	5.41	157.98	Mill Ave
*	24.500	157.81	26.13	2408.59	236214.30	11377.06	4.33	10.98	5.19	159.60	
	26.000	157.94	26.04	2548.26	237441.70	10010.08	4.57	11.20	5.38	159.82	
	27.000	157.98	25.87	8699.24	231858.30	9442.47	5.69	12.02	5.74	160.10	
	28.000	158.14	25.87	8951.00	233034.50	8014.55	5.74	12.03	5.43	160.27	
	30.000	158.39	25.90	9212.14	231852.30	8935.59	5.77	11.97	5.57	160.49	
	32.000	158.53	25.83	8646.54	232410.30	8943.12	5.67	12.33	5.53	160.76	

SECNO	CWSEL	DEPTH	QLOB	QCH	QROB	VLOB	VCH	VROB	EG
34.000	158.76	25.85	8812.26	232499.30	8688.43	5.75	12.34	5.55	160.99
36.000	159.02	25.89	7557.26	234414.70	8028.02	5.68	12.23	5.79	161.23
38.000	159.26	25.90	3500.09	238431.20	8068.67	5.27	12.21	5.60	161.49
40.000	159.45	25.85	2770.66	241376.80	5852.58	4.93	12.43	5.00	161.78
42.000	159.59	25.74	2989.11	238446.50	8564.36	5.23	13.06	5.54	162.14
44.000	159.95	25.86	3085.98	239318.80	7595.24	5.31	12.90	5.40	162.44
46.000	160.28	25.94	3341.31	237805.80	8852.88	5.08	12.84	5.45	162.73
48.000	160.55	25.96	2995.26	239804.90	7199.80	5.03	12.87	5.45	163.04
50.000	160.97	26.16	3032.26	239652.30	7315.47	5.11	12.49	5.23	163.31
52.000	161.48	26.47	3031.63	243137.30	3831.02	4.81	11.65	4.28	163.54
54.000	161.87	26.67	4.09	246391.20	3604.78	.78	11.03	4.23	163.74
56.000	162.07	26.67	5.35	246227.30	3767.37	.83	10.94	4.26	163.91
58.000	162.20	26.61	5.30	243453.20	6541.55	.85	11.21	4.81	164.11
60.000	162.54	26.76	6.21	247252.90	2740.92	.86	10.67	4.49	164.29
62.000	162.71	26.74	7.33	247193.30	2799.41	.89	10.62	4.48	164.45
64.000	162.90	26.74	8.76	247129.40	2861.83	.93	10.52	4.47	164.60
66.000	163.08	26.72	10.26	247071.90	2917.87	.96	10.43	4.46	164.76
68.000	163.28	26.72	13.67	247439.70	2546.61	1.02	10.32	4.37	164.92
69.500	163.48	26.82	1.86	249998.10	.00	.60	9.93	.00	165.01
70.500	163.53	26.77	2.06	249997.90	.00	.62	10.04	.00	165.09
72.000	163.62	26.70	2.62	249974.10	23.29	.67	10.19	1.15	165.23
74.000	163.67	26.48	3.01	249961.30	35.73	.72	10.65	1.28	165.43
76.000	163.79	26.23	.00	249969.80	30.15	.00	10.88	1.29	165.63
78.000	163.84	25.90	3.64	249780.20	216.14	.83	11.48	2.28	165.89
80.000	164.43	26.11	5.59	249944.10	50.32	.84	10.37	1.40	166.10
82.000	164.70	26.00	.30	249955.00	44.76	.38	10.02	1.35	166.26

0.15

Rural Rd.

SECNO	CWSEL	DEPTH	QLOB	QCH	QROB	VLOB	VCH	VROB	EG
84.000	164.92	25.84	.57	249945.70	53.75	.45	9.79	1.39	166.41
86.000	165.20	25.74	57.19	249885.60	57.19	1.37	9.36	1.37	166.56
88.000	165.45	25.61	1.85	249938.80	59.35	.56	8.94	1.33	166.69
90.000	165.65	25.43	.00	250000.00	.00	.00	8.63	.00	166.81
92.000	165.79	25.19	.00	250000.00	.00	.00	8.55	.00	166.92
94.000	165.85	24.87	.00	250000.00	.00	.00	8.77	.00	167.05
96.000	165.92	24.56	.00	250000.00	.00	.00	9.16	.00	167.22
98.000	165.98	24.25	.00	250000.00	.00	.00	9.60	.00	167.41
100.000	166.02	23.91	.00	250000.00	.00	.00	10.33	.00	167.67
102.000	166.08	23.59	.00	250000.00	.00	.00	11.13	.00	168.00 — U/S IBW
104.000	166.21	23.34	.00	249882.80	117.23	.00	11.65	2.03	168.32
106.000	166.50	23.25	10.28	249857.40	132.34	1.11	11.65	2.09	168.61
108.000	166.92	23.29	15.16	249833.20	151.64	1.19	11.31	2.11	168.90
110.000	167.06	23.05	.97	249828.60	170.39	.63	11.93	2.28	169.27
112.000	167.19	22.80	1.41	249809.40	189.18	.72	12.53	2.44	169.63
114.000	167.55	22.78	3.13	249783.10	213.74	.87	12.40	2.50	169.93
116.000	168.06	22.91	7.05	249799.30	193.67	1.02	11.85	2.38	170.24
118.000	168.55	23.02	9.53	249776.50	214.00	1.07	11.28	2.34	170.52
120.000	168.88	22.97	12.98	249910.30	76.74	1.14	11.02	1.72	170.77
120.500	168.94	22.94	13.74	249906.80	79.44	1.15	11.03	1.73	170.83
122.000	169.11	22.83	14.28	249898.20	87.49	1.18	11.06	1.78	171.01
122.650	169.30	22.89	16.49	249888.10	95.44	1.22	11.03	1.82	171.19
123.550	169.48	22.90	19.03	249876.60	104.39	1.26	11.02	1.86	171.36
124.000	169.68	23.02	21.95	249864.10	114.00	1.30	10.95	1.89	171.54

SUMMARY OF ERRORS AND SPECIAL NOTES

NOTE SECND= 15.600 PROFILE= 1 WSEL BASED ON X2 CARD

NOTE SECND= 24.500 PROFILE= 1 WSEL BASED ON X2 CARD

CRSS

CRS SIRRINE

DESIGN SHEET

Job: Rio Salado
Structure: Mill Avenue
Live Load Per Square Foot:

Job No.: 12181N
Date: 1/15/90
Computed By: GKC
Working Stress:

JFM 1/19/90

Mill Avenue Bridge

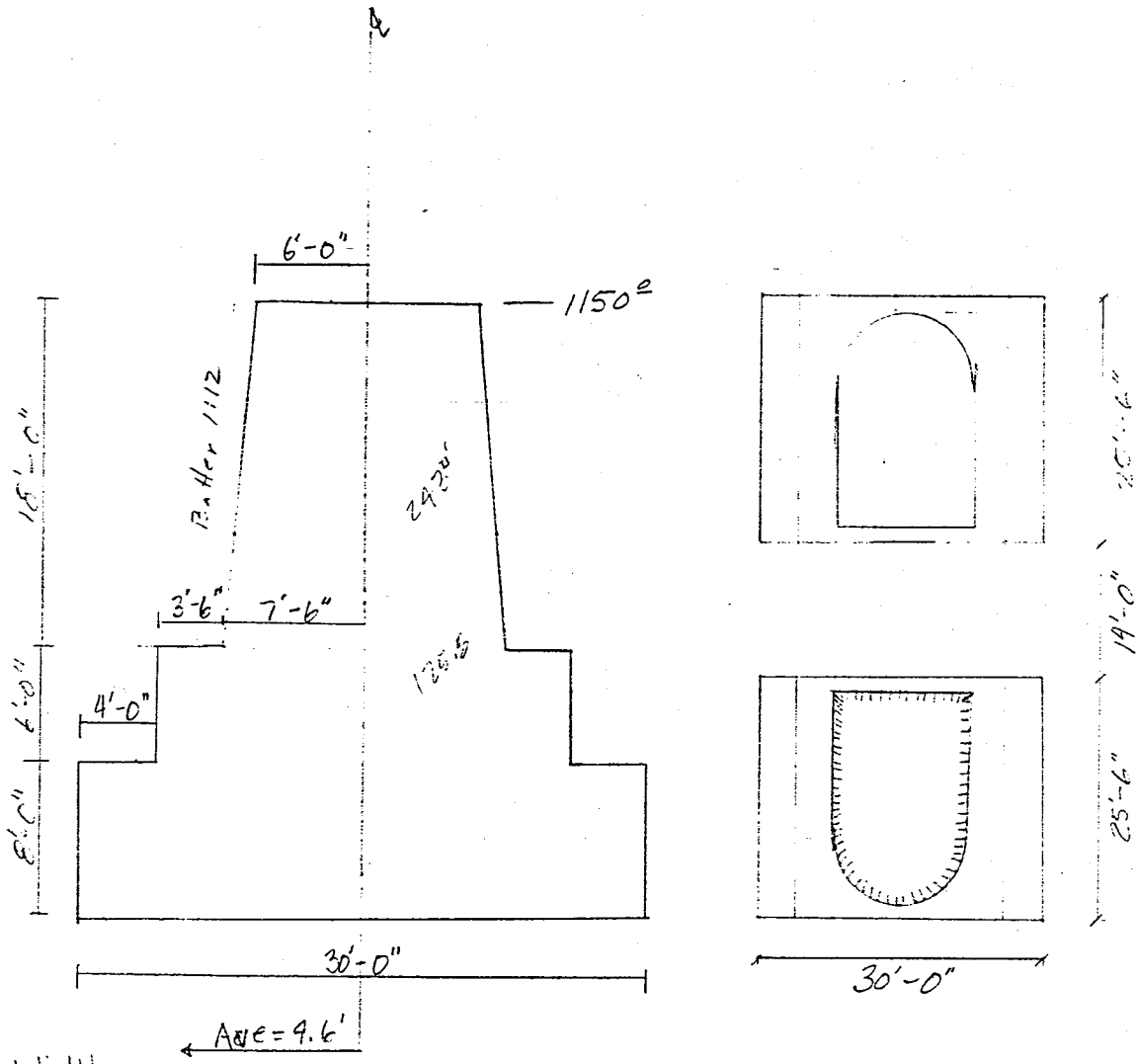
Location	Orig Plan Station	Span Length	Pier ⊙ Width	Foundation Footing Base*	Foundation Footing Top
No 1 South Abut	10+33.46	149.75	12.0	1114.80	1124.00
No 2 Inter. Pier	11+83.21	147.50	7.5	1117.00	1126.34
No. 3 Pier	13+30.71	149.75	7.5	1119.00	1128.00
No. 4 Abut Pier	14+80.46	149.75	12.0	1124.90	1138.00
No. 5 Inter. Pier	16+30.21	141.50	7.5	1120.95	1129.00
No 6 Pier	17+77.71	153.50	7.5	1120.30	1128.50
No 7 Pier	19+25.21	149.75	7.5	1119.90	[illegible]
No 8 Abut Pier	20+74.96	149.75	12.0	[illegible]	1136.00
No 9 Inter. Pier	22+24.71	147.50	7.5	1133.00	[illegible]
No 10 Pier	23+72.21	149.75	7.5	1119.40	1128.[illegible]
No 11 North Abut	25+21.96		12.0	1134.04	--
		1488.50			

* Piers extend 3 feet into solid rock.

⊙ At spring line

Channel Invert

CRSS	PROJECT: Rio Salado	JOB NO. RJC111	NO. 3
CRS SIRRINE	CLIENT: Mill Avenue Bridge	DESIGNED BY GKC / DATE 1/15/90	OF 5
	SUBJECT: Abutment Pier	CHECKED BY JFM / DATE 1/19/90	



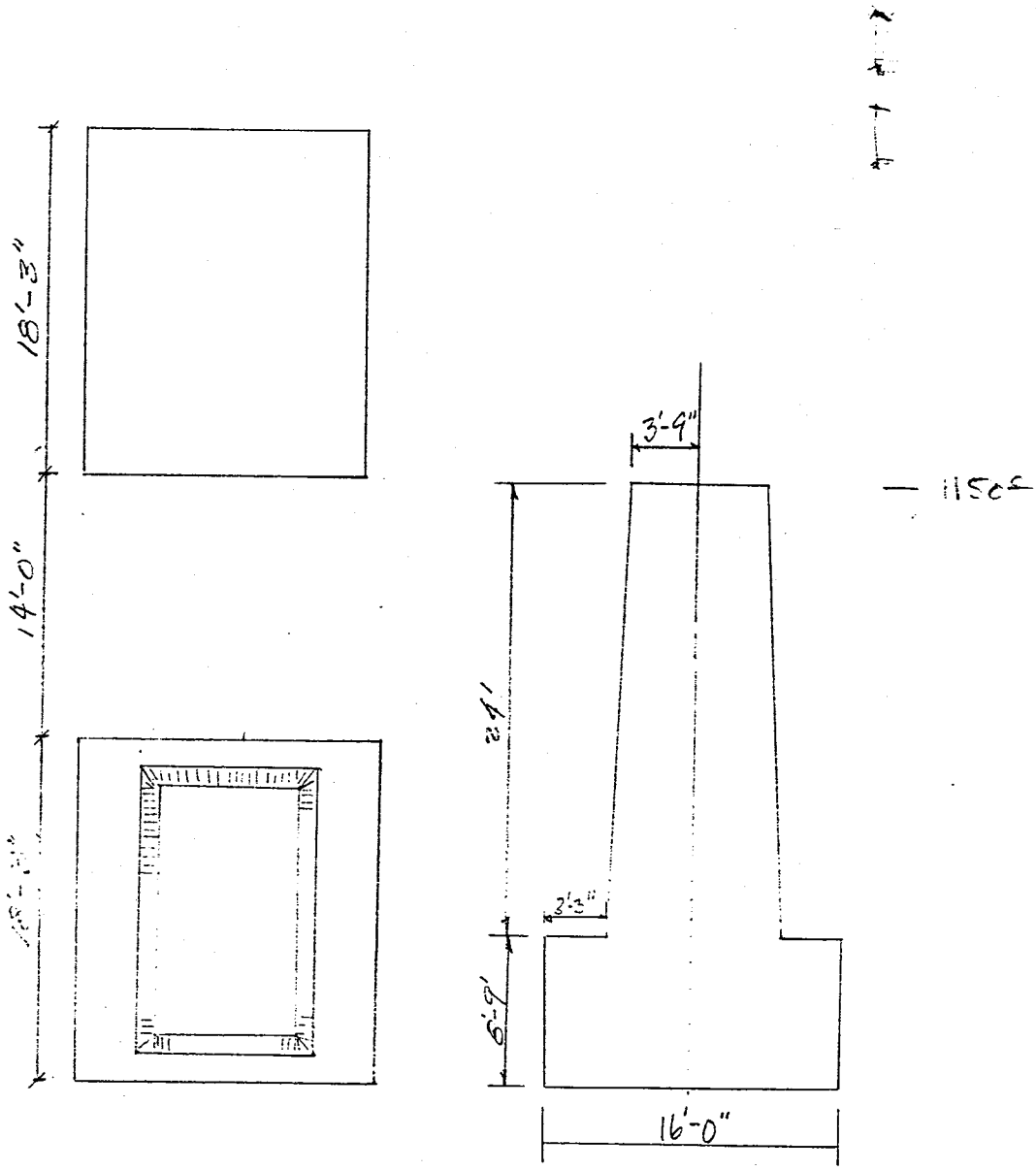
Ave Pier Width:

$$\frac{(6+7.5)/2 * 18 + 11 * 6 + 15 * 8}{32} = 9.61$$

Length:

32'-6"

CRS SIRRINE	PROJECT: Rio Salado	JOB NO.	NO. 3
	CLIENT: Mill Avenue Bridge	DESIGNED BY: GKC / DATE: 1/15/90	
	SUBJECT: Intermediate Pier	CHECKED BY: JFM / DATE: 1/19/90	OF 5



Ave Pier Width

$$\frac{4.25 \times 24 + 8 \times 8.75}{32} = 5.38$$

Length

25'-3"

CRSS

CRS SIRRINE

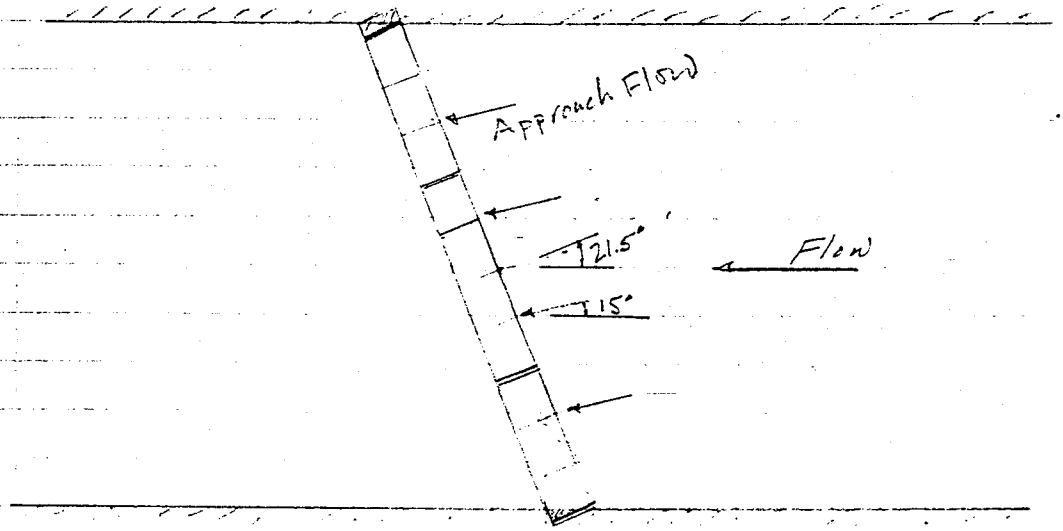
DESIGN SHEET

Job Second Mill Cove For.
Structure
Live Load Per Square Foot

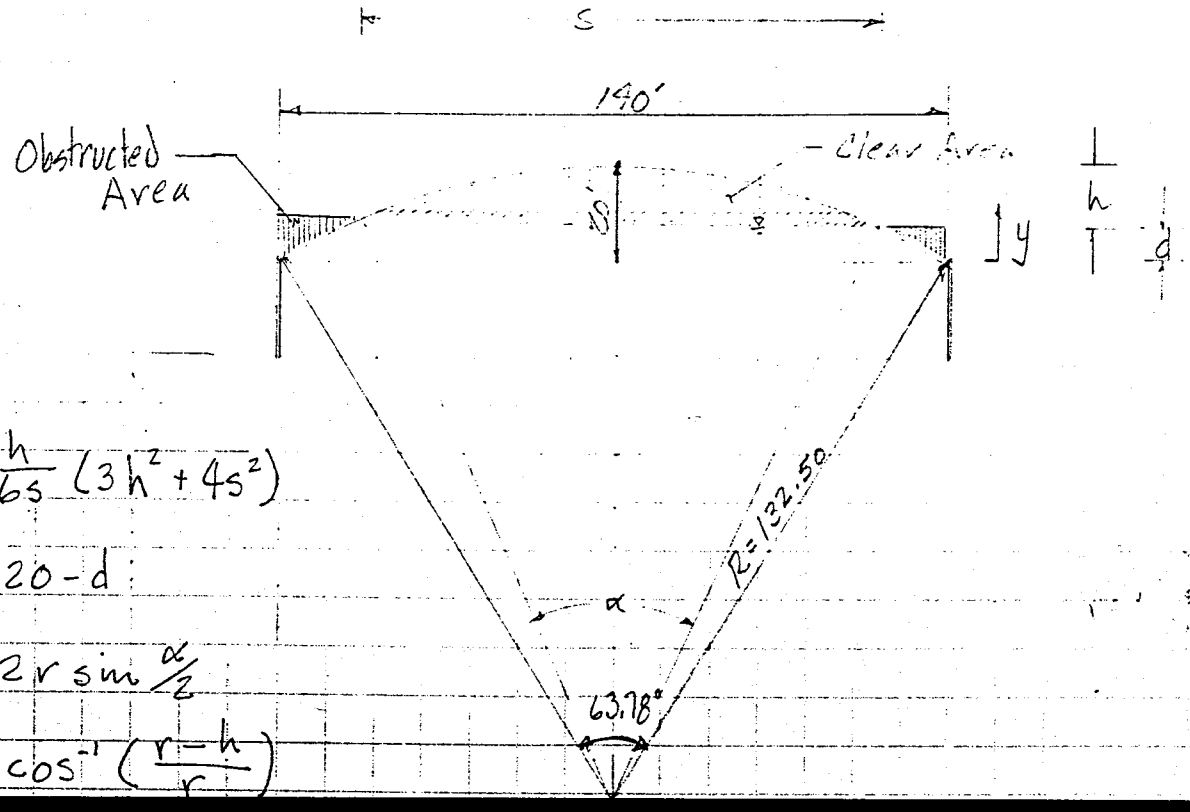
Job No. 1210EK Date 1/12/90
Computed By EKC
Working Stress
JFM 1/19/90

Computation of Mill Ave Waterway Area

Plan



Typical Span



$$\text{Area} = \frac{h}{6s}(3h^2 + 4s^2)$$

$$h = 20 - d$$

$$s = 2r\sin\frac{\alpha}{2}$$

$$\alpha = 2\cos^{-1}\left(\frac{r-h}{r}\right)$$

EKC 1/12/90 5/5

JFM 1/19/90

SPAN = 140.00 FT
RISE = 20.00 FT
AREA = 1895.24 SQ FT
RADIUS = 132.50 FT

FLOW DEPTH	CLEAR	CLEAR SPAN	CLEAR AREA	WETTED AREA	WITH 15° SKEW
0.00	20.00	140.00	1895.24	0.00	0.0
1.00	19.00	136.73	1757.04	138.20	133.5
2.00	18.00	133.36	1622.15	273.09	263.8
3.00	17.00	129.86	1490.68	404.56	390.8
4.00	16.00	126.24	1362.76	532.48	514.3
5.00	15.00	122.47	1238.52	656.71	634.3
6.00	14.00	118.56	1118.11	777.12	750.6
7.00	13.00	114.47	1001.69	893.55	863.1
8.00	12.00	110.20	889.44	1005.80	971.5
9.00	11.00	105.72	781.55	1113.69	1075.7
10.00	10.00	101.00	678.25	1216.99	1175.5
11.00	9.00	96.00	579.80	1315.44	1270.6
12.00	8.00	90.69	486.48	1408.76	1360.8
13.00	7.00	84.99	398.66	1496.58	1445.6
14.00	6.00	78.84	316.74	1578.50	1524.7
15.00	5.00	72.11	241.24	1654.00	1597.6
16.00	4.00	64.62	172.82	1722.42	[illegible]
17.00	3.00	56.07	112.38	1782.85	[illegible]
18.00	2.00	45.87	61.25	1833.99	[illegible]
19.00	1.00	32.50	21.68	1873.56	1809.7
20.00	0.00	0.00	0.00	1895.24	1830.7

CRSS

CRS SIRRINE

DESIGN SHEET

Job: Rio Salado
Structure: Ash Ave Bridge
Live Load Per Square Foot:

Job No.: R101N
Date: 1/16/90
Computed By: GKC
Working Stress:

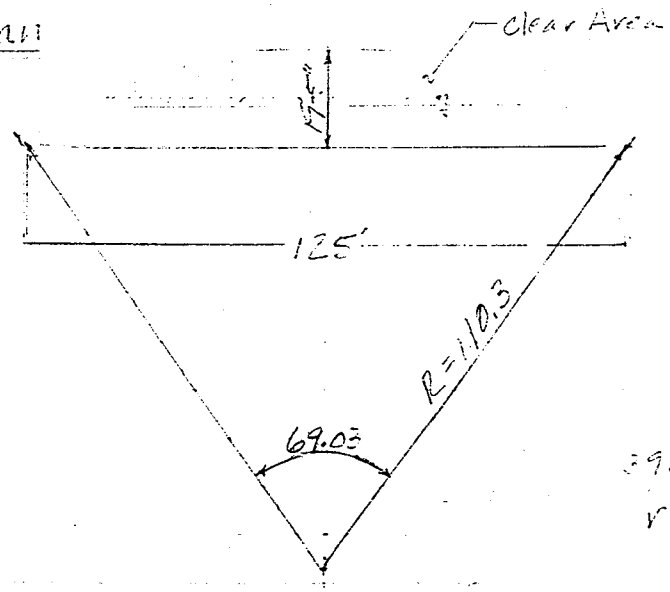
JFM 1/19/90

Ash Avenue Bridge

Location	Orig Plan Station	Span Length	Pier Width	Foundation Base	Foundation Top
So. Abutment	9+17.0	128.0	—	—	—
Pier No. 1	10+45.0	131.0	6.0	1121.0	1133.0
2	11+76.0	131.0	6.0	1123.5	1138.0
3	13+07.0	131.0	6.0	1122.0	1134.0
4	14+38.0	131.0	6.0	1120.0	1132.0
5	15+69.0	131.0	6.0	1120.0	1138.0
6	17+00.0	131.0	6.0	1124.0	1136.0
7	18+31.0	131.0	6.0	1125.0	1136.5
8	19+62.0	131.0	6.0	1105.0	1124.0
9	20+93.0	131.0	6.0	[illegible]	1125.0
10	22+24.0	128.0	6.0	1141.8	1146.5
No. Abutment	23+52.0		—	—	—

1435.0

Typical Span



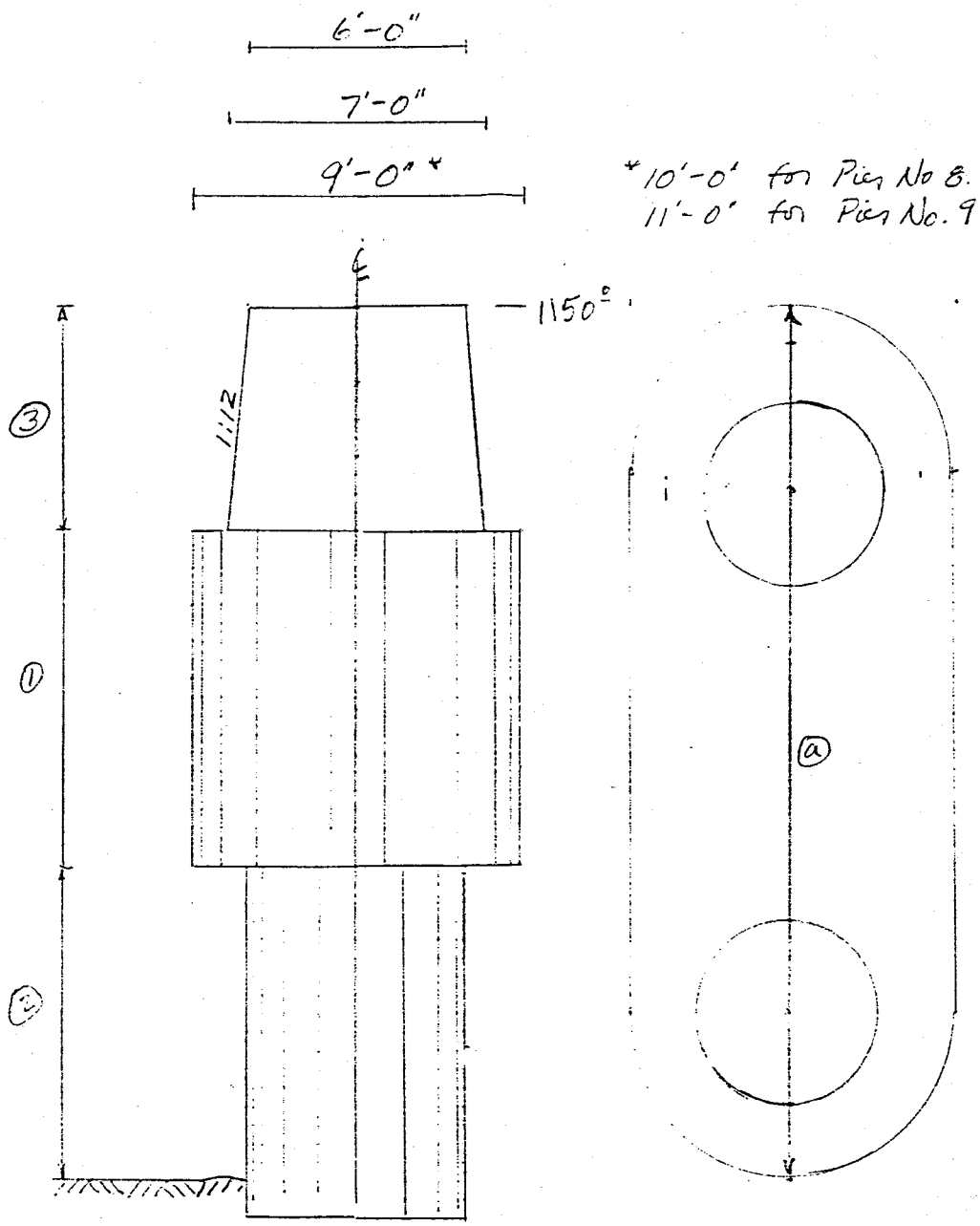
$62.5^2 + (r - 9.4)^2 =$

$3906.25 + r^2 - 38.83r + 377 =$

$r = (3906.25 + 377)/38.83$

$= 110.3$

CRS SIRRINE	PROJECT: Rio Salado	JOB NO. [illegible]	NO. 2
	CLIENT: Ash Avenue Bridge	DESIGNED BY: GKC / DATE: 1/16/90	
	SUBJECT: Intermediate Pier	CHECKED BY: JFN / DATE: 1/19/90	OF 3



Pier No	①	②	③	ⓐ
1	11.0	12.0	6.0	23.42
3	13.0	12.0	3.0	24.42
5	9.0	18.0	3.0	23.42
6	11.0	12.0	3.0	23.42
8	13.0	19.0	13.0	24.42
9	13.0	12.0	12.0	25.42
Typical	12.0	14.0	6.0	24.0

Ave Pier Width =

$(12 \cdot 9) + (14 \cdot 6) + (6 \cdot 6.5) / 32$

$= 7.2$

GKC 3/3
1/16/90

JFM. 1/19/90

ASH AVENUE ARCH

SPAN = 125.00
RISE = 19.42
AREA = 1647.63
RADIUS = 110.28

FLOW DEPTH	CLEAR HEIGHT	CLEAR SPAN	CLEAR AREA	WETTED AREA
0.00	19.42	125.00	1647.63	0.00
1.00	18.42	122.04	1524.27	123.36
2.00	17.42	118.98	1403.92	243.71
3.00	16.42	115.79	1286.68	360.95
4.00	15.42	112.49	1172.67	474.96
5.00	14.42	109.04	1062.02	585.61
6.00	13.42	105.45	954.88	692.75
7.00	12.42	101.69	851.41	796.22
8.00	11.42	97.74	751.77	895.86
9.00	10.42	93.59	656.17	991.45
10.00	9.42	89.20	564.84	1082.79
11.00	8.42	84.53	478.02	1169.61
12.00	7.42	79.54	396.01	1251.62
13.00	6.42	74.16	319.18	1328.45
14.00	5.42	68.30	247.94	1399.69
15.00	4.42	61.82	182.86	1464.77
16.00	3.42	54.50	124.63	1523.00
17.00	2.42	45.95	74.29	1573.34
18.00	1.42	35.28	33.44	1614.19
19.00	0.42	19.23	5.39	1642.24
19.42	0.00	0.00	0.00	1647.63

723.8 @ 6.3

CRSS

CRS SIRRINE

DESIGN SHEET

Job: Rio Salado
Structure: SPRR Bridge
Live Load Per Square Foot: _____

Job No.: R101N Date: 1/15/90
Computed By: EKC
Working Stress: _____
JFM 1/19/90

Southern Pacific RR Bridge

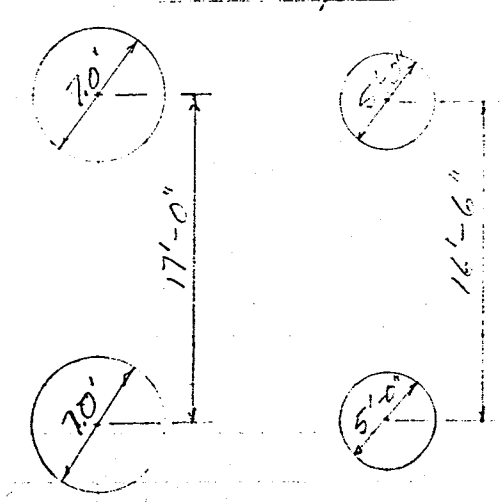
Location	Orig Plan Station	Span Length	Low Chord	No. Bents	Pile Tip Min	Pile Tip Max
South Abutment	17+73.5	330.0	1163.10	22 ①	1132.20	1133.70
Pier No. 1	21+02.5	101.9	1160.73	0	1125.39	1118.39
2	22+04.4	152.6	1160.73	0	1127.39	1113.39
3	23+57.0	152.5	1160.73	0	1126.39	1113.39
4	25+09.5	152.6	1160.73	0	1121.23	1114.23
5	26+62.1	152.5	1160.73	0	1120.06	[illegible]
6	28+14.6	152.6	[illegible]	0	1124.06	1122.23
7	29+77.2	152.6	1160.73	0	1119.73	[illegible]
8	31+29.8	152.6	1160.73	0	1115.64	1114.[illegible]
9	32+82.4	152.6	1160.73	0	1121.23	1117.[illegible]
10	34+34.3	101.9	1160.73	0	1126.89	1124.31
North Abutment	35+13.3	179.0	1163.10	12	1137.20	[illegible]
		3300.0				

① Only 13 bents built at the present time

* On bedrock

Location	Diameter	
Pier No. 1	5.0	46
2	7.0	46
3	7.0	31
4	7.0	31
5	7.0	31
6	7.0	31
7	7.0	31
8	7.0	43
9	7.0	Behind N. Levee
10	5.0	↓
Trestle Piles	1.0	

Pier Configuration



Piers 2-9 Piers 1, 10

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C     22
C       STARTING WATER SURFACE ELEVATION IS BASED UPON SLA's HEC-2
C                 MODEL AT GRADE-CONTROL STRUCTURE NO. 3
C
C       THE MODEL INCORPORATES SLA'S MODEL FROM GRADE CONTROL STRUCTURE 3 TO 4
C
C       THE MODEL'S INVERT PIVOTS AT GCS No. 3 AND IS LOWERED 3 FEET AT GCS No. 4
C             THE LOW FLOW CHANNEL IS REMOVED UPSTREAM FROM GCS No. 4
C
C       THIS MODEL HAS A SLOPE CHANGE IN THE INVERT JUST UPSTREAM OF RURAL ROAD
C             TO THE END OF THE MODEL JUST PAST THE McCLINTOCK BRIDGE.
C
C       LOSSES THROUGH THE SPRR. ASH, AND MILL BRIDGES WERE CALCULATED BY HAND
C             USING    HDS No. 1  "HYDRAULICS OF BRIDGE WATERWAYS"
C
C               STARTING WSEL
C                    Q =  40,000   1130.53      Q = 160,000   1138.56
C                    Q =  80,000   1133.72      Q = 200,000   1140.58
C                    Q =  93,000   1134.60      Q = 215,000   1141.29
C                    Q = 120,000   1136.28      Q = 250,000   1142.88
C
C       ENCROACHMENT PLACED AT RURAL ROAD TO REFLECT NO WIDENING CONDITIONS
C
T1              CRSS COMMERCIAL GROUP, INC.
T2      RIO SALADO * HEC2 * GRADE CONTROL STRUCTURE No. 3 TO HAYDEN ROAD
T3      JANUARY 25, 1990          FILE:TEST.DAT          Q = 250,000 CFS
J1   -10      2      0      0      0      0      0      0  142.88      0
J2    -1      0     -1      0      0      0     -1      0      0      0
J3    38      1      8     13     14     15     55     26     56      3      4
J5   -10    -10
QT     1 250000
NC  .035   .035   .035     .1     .3
X1 20782     14  10012.  10988.      0      0      0
GR147.67  10000.  147.67  10012.  136.66  10045.  136.66  10053.  125.56  10069.
GR125.56  10230.  122.50  10236.  122.50  10636.  125.56  10642.  125.56  10931.
GR136.66  10947.  136.66  10955.  147.67  10988.  147.67  10999.
X1 20800     14  10012.  10988.     18     18     18
GR147.70  10000.  147.70  10012.  136.69  10045.  136.69  10053.  125.59  10069.
GR125.59  10230.  122.53  10236.  122.53  10636.  125.59  10642.  125.59  10931.
GR136.69  10947.  136.69  10955.  147.70  10988.  147.70  10999.
X1 21000     10  10032.  10964.    200    200    200
GR148.20  10000.  148.20  10032.  125.94  10069.  125.94  10190.  122.86  10196.
GR122.86  10596.  125.94  10602.  125.94  10931.  148.20  10964.  148.20  10999.
X1 21200     10  10035.  10965.    200    200    200
GR148.90  10000.  148.90  10035.  126.20  10069.  126.20  10160.  123.19  10166.
GR123.19  10566.  126.20  10572.  126.20  10931.  148.90  10965.  148.90  11000.
X1 21400     14  10011.  10991.    200    200    200
GR149.60  10000.  149.60  10011.  137.86  10045.  137.86  10053.  126.56  10070.
GR126.56  10133.  123.52  10139.  123.52  10539.  126.56  10545.  126.56  10932.
GR137.86  10949.  137.86  10957.  149.60  10991.  149.60  11002.
X1 21600     10  10013.  11006.    200    200    200
GR150.00  10000.  150.00  10013.  126.91  10078.  126.91  10119.  123.85  10125.
GR123.85  10525.  126.91  10531.  126.91  10940.  150.50  11006.  150.50  11017.
X1 21800     14  10011.  10991.    200    200    200
GR150.50  10000.  150.50  10011.  138.47  10045.  138.47  10053.  127.17  10070.
GR127.17  10101.  124.18  10107.  124.18  10507.  127.17  10513.  127.17  10932.
GR138.47  10949.  138.47  10957.  150.50  10991.  150.50  11002.
X1 22000     14  10011.  10991.    200    200    200
GR151.00  10000.  151.00  10011.  138.82  10045.  138.82  10053.  127.52  10070.
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GR127.52  10104.  124.51  10110.  124.51  10510.  127.52  10516.  127.52  10932.
GR138.82  10949.  138.82  10957.  151.00  10991.  151.00  11002.
X1 22200      14  10010.  10990.     200     200     200
GR151.40  10000.  151.40  10010.  139.08  10044.  139.08  10052.  127.88  10069.
GR127.88  10123.  124.84  10129.  124.84  10529.  127.88  10535.  127.88  10931.
GR139.08  10948.  139.08  10956.  151.40  10990.  151.40  11000.
X1 22400      14  10010.  10990.     200     200     200
GR151.90  10000.  151.90  10010.  139.44  10044.  139.44  10052.  128.24  10069.
GR128.24  10160.  125.18  10166.  125.18  10566.  128.24  10572.  128.24  10931.
GR139.44  10948.  139.44  10956.  151.90  10990.  151.90  11000.
X1 22600      14  10010.  10990.     200     200     200
GR152.30  10000.  152.30  10010.  139.69  10044.  139.69  10052.  128.49  10069.
GR128.49  10205.  125.51  10211.  125.51  10611.  128.49  10617.  128.49  10931.
GR139.69  10948.  139.69  10956.  152.30  10990.  152.30  11000.
X1 22800      14  10010.  10990.     200     200     200
GR152.80  10000.  152.80  10010.  140.05  10044.  140.05  10052.  128.85  10069.
GR128.85  10260.  125.84  10266.  125.84  10666.  128.85  10672.  128.85  10931.
GR140.05  10948.  140.05  10956.  152.80  10990.  152.80  11000.
X1 23000      14  10011.  10989.     200     200     200
GR153.20  10000.  153.20  10011.  140.30  10045.  140.30  10053.  129.20  10069.
GR129.20  10325.  126.70  10331.  126.70  10731.  129.20  10737.  129.20  10931.
GR140.30  10947.  140.30  10955.  153.20  10989.  153.20  11000.
X1 23200      14  10010.  10990.     200     200     200
GR153.70  10000.  153.70  10010.  140.66  10044.  140.66  10052.  129.46  10069.
GR129.46  10390.  126.50  10396.  126.50  10796.  129.46  10802.  129.46  10931.
GR140.66  10948.  140.66  10956.  153.70  10990.  153.70  11000.
X1 23400      14  10011.  10989.     200     200     200
GR154.10  10000.  154.10  10011.  140.92  10045.  140.92  10053.  129.82  10069.
GR129.82  10440.  126.83  10446.  126.83  10846.  129.82  10852.  129.82  10931.
GR140.92  10947.  140.92  10955.  154.10  10989.  154.10  11000.
X1 23600      14  10011.  10989.     200     200     200
GR154.60  10000.  154.60  10011.  141.27  10045.  141.27  10053.  130.17  10069.
GR130.17  10480.  127.16  10486.  127.16  10886.  130.17  10892.  130.17  10931.
GR141.27  10947.  141.27  10955.  154.60  10989.  154.60  11000.
X1 23800      14  10011.  10989.     200     200     200
GR155.00  10000.  155.00  10011.  141.53  10045.  141.53  10053.  130.53  10069.
GR130.53  10500.  127.46  10506.  127.46  10906.  130.53  10912.  130.53  10931.
GR141.53  10947.  141.53  10955.  155.00  10989.  155.00  11000.
X1 24000      14  10011.  10989.     200     200     200
GR155.50  10000.  155.50  10011.  141.88  10045.  141.88  10053.  130.40  10069.
GR130.40  10510.  127.82  10516.  127.82  10916.  130.40  10922.  130.40  10931.
GR141.88  10947.  141.88  10955.  155.50  10989.  155.50  11000.
X1 24200      14  10011.  10989.     200     200     200
GR155.90  10000.  155.90  10011.  142.14  10045.  142.14  10053.  130.40  10069.
GR130.40  10507.  128.15  10513.  128.15  10913.  130.40  10919.  130.40  10931.
GR142.14  10947.  142.14  10955.  155.90  10989.  155.90  11000.
X1 24400      10  10014.  10981.     200     200     200
GR156.40  10000.  156.40  10014.  130.40  10066.  130.40  10487.  128.48  10493.
GR128.48  10893.  130.40  10899.  130.40  10928.  156.40  10981.  156.40  10994.
X1 24600      10  10010.  11004.     200     200     200
GR156.80  10000.  156.80  10010.  130.40  10076.  130.40  10465.  128.81  10471.
GR128.81  10871.  130.40  10877.  130.40  10938.  156.80  11004.  156.80  11019.
X1 24800      14  10011.  10989.     200     200     200
GR157.30  10000.  157.30  10011.  143.11  10045.  143.11  10053.  130.40  10069.
GR130.40  10410.  129.14  10416.  129.14  10816.  130.40  10822.  130.40  10931.
GR143.11  10947.  143.11  10955.  157.30  10989.  157.30  11000.
NC 0.045   0.045   0.035     0.1     0.3
X1   0.0       9    100.   1110.     155     155     155    .996       0       0
GR140.00   45.00  156.00   81.00  157.00  100.00  130.40  184.00  129.40  600.00
GR130.40 1020.00  160.00 1110.00  160.00 1125.00  152.00 1150.00
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X1  2.0      13  151.00   1060.     155     200     158       0       0       0
GR140.00   30.00  157.00   78.00  157.00  100.00  142.00  130.00  142.00  151.00
GR130.57  190.00  129.57  619.00  130.57 1007.00  142.00 1060.00  142.00 1094.00
GR160.00 1144.00  160.00 1162.00  150.00 1192.00
X1  4.0      13  164.00   1035.     200     200     200       0       0       0
GR146.00   48.00  158.00   83.00  158.00  100.00  143.00  140.00  143.00  164.00
GR130.78  201.00  129.78  630.00  130.78  992.00  144.00 1035.00  144.00 1130.00
GR160.00 1177.00  160.00 1195.00  146.00 1242.00
X1  6.0      13  165.00   1025.     200     200     200       0       0       0
GR146.00   48.00  158.00   82.00  158.00  100.00  143.00  141.00  143.00  165.00
GR131.00  210.00  130.00  640.00  131.00  979.00  144.00 1025.00  144.00 1156.00
GR160.00 1203.00  160.00 1225.00  144.00 1274.00
X1  8.0      13  166.00   1015.     200     200     200       0       0       0
GR142.00   33.00  158.00   81.00  158.00  101.00  143.00  142.00  143.00  166.00
GR131.21  210.00  130.21  644.00  131.21  972.00  144.00 1015.00  144.00 1163.00
GR160.00 1262.00  160.00 1282.00  144.00 1325.00
X1 10.0      13  162.00   1015.     200     200     200       0       0       0
GR142.00   33.00  158.00   80.00  158.00  102.00  143.00  138.00  143.00  162.00
GR131.42  212.00  130.42  636.00  131.42  972.00  144.00 1015.00  144.00 1166.00
GR159.00 1316.00  159.00 1338.00  145.00 1380.00
X1 12.0      13  161.00   1025.     200     200     200       0       0       0
GR142.00   32.00  158.00   80.00  158.00  100.00  144.00  139.00  144.00  161.00
GR131.64  210.00  130.64  641.00  131.64  978.00  144.00 1025.00  144.00 1320.00
GR159.00 1370.00  159.00 1390.00  145.00 1430.00
X1 14.0      13  161.00 1035.00     105     200     153    .995       0       0
GR146.00   39.00  158.00   80.00  158.00  100.00  144.00  139.00  144.00  161.00
GR131.80  210.00  130.80  644.00  131.80  988.00  144.00 1035.00  144.00 1390.00
GR162.00 1425.00  162.00 1442.00  146.00 1463.00
X1 15.4      13  162.00 1050.00      75     135     105    .995       0       0
GR144.00   37.00  158.00   80.00  158.00  100.00  144.00  139.00  144.00  162.00
GR131.90  211.00  130.90  653.00  131.90  997.00  144.00 1050.00  144.00 1433.00
GR162.00 1467.00  162.00 1487.00  152.00 1520.00
X1 15.6      13  162.00 1050.00      18      18      18    .995       0       0
X2                                        0.00
GR144.00   37.00  158.00   80.00  158.00  100.00  144.00  139.00  144.00  162.00
GR131.93  211.00  130.93  653.00  131.93  997.00  144.00 1050.00  144.00 1433.00
GR162.00 1467.00  162.00 1487.00  152.00 1520.00
X1 17.5      13  165.00 1060.00     176     172     174    .998       0       0
GR148.00   50.00  160.00   82.00  160.00   94.00  144.00  141.00  144.00  165.00
GR132.12  190.00  131.12  650.00  132.12 1000.00  144.00 1060.00  144.00 1380.00
GR162.00 1420.00  162.00 1440.00  152.00 1470.00
X1 19.0      13  165.00 1050.00     195     163     164    .999       0       0
GR152.00   58.00  160.00   81.00  160.00  100.00  144.00  141.00  144.00  165.00
GR132.29  210.00  131.29  652.00  132.29  993.00  144.00 1050.00  144.00 1328.00
GR162.00 1376.00  162.00 1398.00  157.00 1420.00
X1 19.2      13  165.00 1050.00      20      20      20    .999       0       0
X2                                        0.00
GR152.00   58.00  160.00   81.00  160.00  100.00  144.00  141.00  144.00  165.00
GR132.31  210.00  131.31  652.00  132.31  993.00  144.00 1050.00  144.00 1328.00
GR162.00 1376.00  162.00 1398.00  157.00 1420.00
X1 21.5      13  184.00 1050.00      56     248     152    .967       0       0
GR152.00   52.00  162.00   85.00  162.00  100.00  144.00  160.00  144.00  184.00
GR132.48  212.00  131.48  676.00  132.48 1020.00  144.00 1050.00  144.00 1280.00
GR163.00 1340.00  163.00 1360.00  152.00 1410.00
X1 24.0      13  185.00 1120.00      54     237     145    .914       0       0
GR154.00   52.00  163.00   80.00  163.00  100.00  145.00  161.00  145.00  185.00
GR132.63  215.00  131.63  710.00  132.63 1085.00  145.00 1120.00  145.00 1285.00
GR164.00 1345.00  164.00 1365.00  154.00 1400.00
X1 24.5      13  185.00 1120.00      48      48      48    .914       0       0
X2    0       0       0       0       0    0.00       0       0       0       0
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SPRR Bridge

Ash Avenue

131.3 1360.6

Mill Ave.

124.1 1313.6

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GR154.00   52.00  163.00   80.00  163.00  100.00  145.00  161.00  145.00  185.00
GR132.68  215.00  131.68  710.00  132.68 1085.00  145.00 1120.00  145.00 1285.00
GR164.00 1345.00  164.00 1365.00  154.00 1400.00
X1  26.0      13  185.00 1075.00     262     142     202    .952       0       0
GR156.00   55.00  164.00   80.00  164.00  100.00  145.00  161.00  145.00  185.00
GR132.90  221.00  131.90  688.00  132.90 1040.00  145.00 1075.00  145.00 1210.00
GR166.00 1260.00  166.00 1280.00  156.00 1320.00
X1  27.0      13  260.00 1040.00     301     103     202    .994       0       0
GR158.00   62.00  164.00   82.00  164.00  104.00  145.00  161.00  145.00  260.00
GR133.11  290.00  132.11  665.00  133.11 1010.00  145.00 1040.00  145.00 1150.00
GR166.00 1205.00  166.00 1225.00  156.00 1260.00
X1  28.0      13  260.00  1040.     211      92     151       0       0       0
GR158.00   62.00  164.00   80.00  164.00  104.00  145.00  161.00  145.00  260.00
GR133.27  295.00  132.27  660.00  133.27 1010.00  145.00 1040.00  145.00 1125.00
GR168.00 1180.00  168.00 1200.00  148.00 1260.00
X1  30.0      13  260.00  1040.     200     200     200       0       0       0
GR158.00   61.00  164.00   80.00  164.00  104.00  145.00  161.00  145.00  260.00
GR133.49  295.00  132.49  663.00  133.49 1005.00  145.00 1040.00  145.00 1135.00
GR168.00 1190.00  168.00 1210.00  150.00 1270.00
X1  32.0      13  260.00  1020.     200     200     200       0       0       0
GR156.00   53.00  164.00   80.00  164.00  100.00  146.00  160.00  146.00  260.00
GR133.70  280.00  132.70  652.00  133.70  980.00  146.00 1020.00  146.00 1123.00
GR168.00 1183.00  168.00 1200.00  150.00 1255.00
X1  34.0      13  260.00  1015.     200     200     200       0       0       0
GR156.00   52.00  166.00   85.00  166.00  100.00  146.00  160.00  146.00  260.00
GR133.91  270.00  132.91  650.00  133.91  980.00  146.00 1015.00  146.00 1111.00
GR168.00 1172.00  168.00 1192.00  150.00 1246.00
X1  36.0      13  240.00  1010.     200     200     200       0       0       0
GR158.00   60.00  166.00   85.00  166.00   92.00  146.00  160.00  146.00  240.00
GR134.13  260.00  133.13  640.00  134.13  970.00  146.00 1010.00  146.00 1100.00
GR168.00 1152.00  168.00 1172.00  156.00 1212.00
X1  38.0      13  190.00   975.     238     200     219       0       0       0
GR158.00   60.00  166.00   82.00  166.00  100.00  146.00  160.00  146.00  190.00
GR134.36  220.00  133.36  620.00  134.36  940.00  146.00  975.00  146.00 1060.00
GR170.00 1111.00  170.00 1131.00  150.00 1190.00
X1  40.0      13  184.00   966.     250     200     225       0       0       0
GR156.00   52.00  166.00   83.00  166.00  100.00  147.00  160.00  147.00  184.00
GR134.60  215.00  133.60  615.00  134.60  936.00  147.00  966.00  147.00 1020.00
GR172.00 1090.00  172.00 1110.00  146.00 1191.00
X1  42.0      13  186.00   925.     270     200     235       0       0       0
GR156.00   51.00  166.00   81.00  166.00  102.00  147.00  162.00  147.00  186.00
GR134.85  210.00  133.85  584.00  134.85  889.00  147.00  925.00  147.00 1005.00
GR172.00 1080.00  172.00 1094.00  146.00 1179.00
X1  44.0      13  186.00   933.     250     200     225       0       0       0
GR158.00   58.00  166.00   82.00  166.00  102.00  147.00  162.00  147.00  186.00
GR135.09  210.00  134.09  542.00  135.09  897.00  147.00  933.00  147.00  998.00
GR172.00 1073.00  172.00 1090.00  146.00 1174.00
X1  46.0      13  187.00   930.     260     200     230       0       0       0
GR154.00   45.00  166.00   82.00  166.00  103.00  147.00  163.00  147.00  187.00
GR135.34  210.00  134.34  542.00  135.34  894.00  147.00  930.00  147.00 1000.00
GR172.00 1075.00  172.00 1090.00  144.00 1181.00
X1  48.0      13  188.00   937.     268     200     234       0       0       0
GR156.00   52.00  166.00   82.00  166.00  104.00  148.00  164.00  148.00  188.00
GR135.59  218.00  134.59  548.00  135.59  901.00  148.00  937.00  148.00 1009.00
GR172.00 1081.00  172.00 1099.00  150.00 1170.00
X1  50.0      13  187.00   952.     210     200     205       0       0       0
GR160.00   62.00  166.00   81.00  166.00  103.00  148.00  163.00  148.00  187.00
GR135.81  217.00  134.81  553.00  135.81  916.00  148.00  952.00  148.00 1019.00
GR172.00 1091.00  172.00 1111.00  148.00 1190.00
X1  52.0      13  187.00  1007.     170     200     185       0       0       0
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GR160.00   61.00  166.00   80.00  166.00  103.00  148.00  163.00  148.00  187.00
GR136.01  217.00  135.01  560.00  136.01  971.00  148.00 1007.00  148.00 1031.00
GR172.00 1103.00  172.00 1121.00  148.00 1200.00
X1  54.0      11  100.00   1014.     170     200     185       0       0       0
GR160.00   64.00  166.00   82.00  166.00  100.00  136.20  190.00  135.20  566.00
GR136.20  978.00  148.00 1014.00  148.00 1038.00  172.00 1110.00  172.00 1130.00
GR150.00 1202.00
X1  56.0      11  200.00   1123.     160     200     180       0       0       0
GR160.00  164.00  166.00  182.00  166.00  200.00  136.40  295.00  135.40  674.00
GR136.40 1087.00  148.00 1123.00  148.00 1148.00  172.00 1220.00  172.00 1240.00
GR150.00 1311.00
X1  58.0      11  200.00   1094.     166     200     183       0       0       0
GR160.00  164.00  167.00  182.00  167.00  200.00  136.59  290.00  135.59  671.00
GR136.59 1058.00  149.00 1094.00  149.00 1159.00  172.00 1228.00  172.00 1249.00
GR150.00 1320.00
X1  60.0      11  200.00   1145.     160     200     180       0       0       0
GR160.00  164.00  168.00  182.00  168.00   200.0  136.78  290.00  135.78  680.00
GR136.78 1109.00  149.00 1145.00  149.00 1169.00  172.00 1238.00  172.00 1259.00
GR160.00 1300.00
X1  62.0      11  300.00   1249.     160     200     180       0       0       0
GR160.00  264.00  168.00  282.00  168.00  300.00  136.97  390.00  135.97  785.00
GR136.97 1215.00  149.00 1249.00  149.00 1273.00  172.00 1342.00  172.00 1362.00
GR160.00 1408.00
X1  64.0      11  552.00   1513.     152     200     176       0       0       0
GR160.00  518.00  168.00  536.00  168.00  552.00  137.16  649.00  136.16 1043.00
GR137.16 1477.00  149.00 1513.00  149.00 1537.00  172.00 1606.00  172.00 1623.00
GR160.00 1670.00
X1  66.0      11  543.00 1513.00     160     200     180       0       0       0
GR160.00  507.00  168.00  525.00  168.00  543.00  137.36  642.00  136.36 1036.00
GR137.36 1477.00  149.00 1513.00  149.00 1537.00  172.00 1606.00  172.00 1621.00
GR160.00 1668.00
X1  68.0      11  538.00 1517.00     188     200     194       0       0       0
GR160.00  500.00  168.00  520.00  168.00  538.00  137.56  633.00  136.56 1035.00
GR137.56 1481.00  150.00 1517.00  150.00 1541.00  172.00 1607.00  172.00 1624.00
GR164.00 1660.00
X1  69.5       9  533.00 1608.00      60     131      95       0       0       0
GR162.00  498.00  168.00  515.00  168.00  533.00  137.66  626.00  136.66 1033.00
GR137.66 1506.00  172.00 1608.00  172.00 1623.00  170.00 1634.00
X1  70.5       9  533.00 1608.00      90      90      90       0       0       0
X2                                          0.00
GR162.00  498.00  168.00  515.00  168.00  533.00  137.76  626.00  136.76 1033.00
GR137.76 1493.00  172.00 1608.00  172.00 1623.00  170.00 1634.00
X1  72.0       9  522.00 1572.00     166     140     153       0       0       0
GR162.00  486.00  168.00  504.00  168.00  522.00  137.92  617.00  136.92 1012.00
GR137.92 1476.00  170.00 1572.00  170.00 1593.00  160.00 1624.00
X1  74.0       9  512.00   1523.     158     200     179       0       0       0
GR162.00  480.00  168.00  498.00  168.00  512.00  138.19  607.00  137.19 1007.00
GR138.19 1433.00  168.00 1523.00  168.00 1540.00  160.00 1573.00
X1  76.0       9  500.00   1497.     160     200     180       0       0       0
GR164.00  466.00  168.00  482.00  168.00  500.00  138.56  593.00  137.56  995.00
GR138.56 1410.00  168.00 1497.00  168.00 1520.00  160.00 1546.00
X1  78.0       9  476.00   1498.     168     200     184       0       0       0
GR162.00  440.00  169.00  458.00  169.00  476.00  138.94  569.00  137.94  988.00
GR138.94 1308.00  168.00 1498.00  168.00 1518.00  156.00 1555.00
X1  80.0       9  450.00   1499.     148     200     174       0       0       0
GR162.00  414.00  170.00  432.00  170.00  450.00  139.32  543.00  138.32  979.00
GR139.32 1409.00  169.00 1499.00  169.00 1514.00  160.00 1547.00
X1  82.0       9  413.00   1501.     138     200     169       0       0       0
GR164.00  376.00  170.00  395.00  170.00  413.00  139.70  507.00  138.70  957.00
GR139.70 1411.00  170.00 1501.00  170.00 1516.00  160.00 1546.00
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Rural Rd

549 1580

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X1  84.0       9  372.00   1497.     150     200     175       0       0       0
GR164.00  336.00  170.00  354.00  170.00  372.00  140.08  480.00  139.08  944.00
GR140.08 1407.00  170.00 1497.00  170.00 1515.00  160.00 1547.00
X1  86.0       9  330.00   1499.     160     200     180       0       0       0
GR160.00  278.00  170.00  309.00  170.00  330.00  140.46  420.00  139.46  911.00
GR140.46 1400.00  170.00 1499.00  170.00 1517.00  160.00 1548.00
X1  88.0       9  280.00   1496.     137     200     169       0       0       0
GR164.00  240.00  170.00  259.00  170.00  280.00  140.84  367.00  139.84  885.00
GR140.84 1409.00  170.00 1496.00  170.00 1516.00  160.00 1546.00
ET           9.1                                                   270.   1496.
X1  90.0      10  227.00   1496.     160     200     180       0       0       0
X3    10                                                     1172    1172
GR164.00  183.00  170.00  202.00  170.00  227.00  156.00  270.00  141.22  314.00
GR140.22  879.00  141.22 1409.00  170.00 1496.00  170.00 1517.00  160.00 1547.00
ET           9.1                                                   262.   1496.
X1  92.0      10  175.00   1496.     158     200     179       0       0       0
X3    10                                                     1172    1172
GR166.00  140.00  170.00  151.00  170.00  175.00  141.65  259.00  141.60  262.00
GR140.60  888.00  141.60 1412.00  170.00 1496.00  170.00 1517.00  160.00 1547.00
ET           9.1                                                   278.   1496.
X1  94.0      10  121.00   1496.     150     200     175       0       0       0
X3    10                                                     1172    1172
GR166.00  100.00  170.00  111.00  170.00  121.00  142.10  205.00  141.98  278.00
GR140.98  903.00  141.98 1412.00  170.00 1496.00  170.00 1517.00  160.00 1547.00
ET           9.1                                                   313.   1496.
X1  96.0      10   80.00   1496.     200     200     200       0       0       0
X3    10                                                     1172    1172
GR166.00   46.00  170.00   59.00  170.00   80.00  142.60  161.00  142.36  313.00
GR141.36  935.00  142.36 1412.00  170.00 1496.00  170.00 1517.00  160.00 1547.00
ET           9.1                                                   352.   1496.
X1  98.0      10     11.   1496.     200     200     200       0       0       0
X3    10                                                     1172    1172
GR168.00    0.00  170.00    2.00  170.00   11.00  143.00   92.00  142.73  352.00
GR141.73  940.00  142.73 1415.00  170.00 1496.00  170.00 1517.00  160.00 1547.00
ET           9.1                                                   415.   1496.
X1 100.0      10     12.   1496.     250     200     225       0       0       0
X3    10                                                     1172    1172
GR169.00    0.00  170.00    2.00  170.00   12.00  143.80   90.00  143.11  415.00
GR142.11  978.00  143.11 1415.00  170.00 1496.00  170.00 1517.00  160.00 1547.00
ET           9.1                                                   470.   1496.
X1 102.0      10    419.   1496.     276     200     238       0       0       0
X3    10                                                     1172    1172
GR166.00  382.00  170.00  400.00  170.00  419.00  152.00  470.00  143.49  497.00
GR142.49  986.00  143.49 1415.00  170.00 1496.00  170.00 1517.00  160.00 1547.00
X1 104.0       9  466.00   1496.     230     200     215       0       0       0
GR168.00  450.00  170.00  458.00  170.00  466.00  143.87  544.00  142.87  985.00
GR143.87 1418.00  170.00 1496.00  170.00 1517.00  160.00 1547.00
X1 106.0       9  463.00   1496.     250     200     225       0       0       0
GR164.00  427.00  170.00  445.00  170.00  463.00  144.25  541.00  143.25  977.00
GR144.25 1418.00  170.00 1496.00  170.00 1517.00  160.00 1547.00
X1 108.0       9  441.00   1496.     250     200     225       0       0       0
GR164.00  402.00  170.00  420.00  170.00  441.00  144.63  516.00  143.63  964.00
GR144.63 1421.00  170.00 1496.00  170.00 1517.00  160.00 1547.00
X1 110.0       9  482.00   1494.     266     200     233       0       0       0
GR166.00  450.00  170.00  461.00  170.00  482.00  145.01  557.00  144.01  990.00
GR145.01 1422.00  170.00 1494.00  170.00 1520.00  160.00 1550.00
X1 112.0       9  522.00   1494.     200     200     200       0       0       0
GR166.00  480.00  170.00  491.00  170.00  522.00  145.39  587.00  144.39 1005.00
GR145.39 1422.00  170.00 1494.00  170.00 1520.00  160.00 1550.00
X1 114.0       9  509.00   1494.     200     200     200       0       0       0
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GR166.00  474.00  170.00  486.00  170.00  509.00  145.77  581.00  144.77 1000.00
GR145.77 1422.00  170.00 1494.00  170.00 1520.00  160.00 1550.00
X1 116.0       9  468.00   1494.     200     200     200       0       0       0
GR166.00  435.00  170.00  448.00  170.00  468.00  146.15  540.00  145.15  984.00
GR146.15 1416.00  172.00 1494.00  172.00 1520.00  160.00 1550.00
X1 118.0       9  430.00   1494.     200     200     200       0       0       0
GR166.00  398.00  170.00  409.00  170.00  430.00  146.53  499.00  145.53  960.00
GR146.53 1419.00  172.00 1494.00  172.00 1520.00  160.00 1550.00
X1 120.0       9  405.00   1494.     200     200     200       0       0       0
GR166.00  370.00  170.00  381.00  170.00  405.00  146.91  474.00  145.91  947.00
GR146.91 1419.00  172.00 1494.00  172.00 1520.00  164.00 1550.00
X1 120.5       9  405.00 1494.00      50      50      50       0       0       0
GR166.00  370.00  170.00  381.00  170.00  405.00  147.00  474.00  146.00  947.00
GR147.00 1419.00  172.00 1494.00  172.00 1520.00  164.00 1550.00
X1 122.0       9  403.00 1494.00     150     150     150       0       0       0
GR166.00  370.00  170.00  380.00  170.00  403.00  147.28  472.00  146.28  955.00
GR147.28 1419.00  172.00 1494.00  172.00 1520.00  164.00 1550.00
X1122.65       9  403.00 1494.00     150     150     150       0       0       0
X2                                       0.00
GR166.00  370.00  170.00  380.00  170.00  403.00  147.41  472.00  146.41  955.00
GR147.41 1419.00  172.00 1494.00  172.00 1520.00  164.00 1550.00
X1123.55       9  403.00 1494.00     150     150     150       0       0       0
GR166.00  370.00  170.00  380.00  170.00  403.00  147.58  472.00  146.58  955.00
GR147.58 1419.00  172.00 1494.00  172.00 1520.00  164.00 1550.00
X1 124.0       9  403.00 1494.00     150     150     150       0       0       0
GR166.00  370.00  170.00  380.00  170.00  403.00  147.66  472.00  146.66  955.00
GR147.66 1419.00  172.00 1494.00  172.00 1520.00  164.00 1550.00
EJ


ER
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APPENDIX F

DROP STRUCTURE SCOUR AND STABILITY

INDEX OF INDIAN BEND WASH DROP STRUCTURE CALCS

Set #1: Rating curves for drops

Set #2: Stilling basin size computations

Set #3: Static uplift pressures/creep ratio

Set #4: Dynamic uplift pressure

Set #5: Weep hole spacing determination

Set #6: Drop structure stability computations

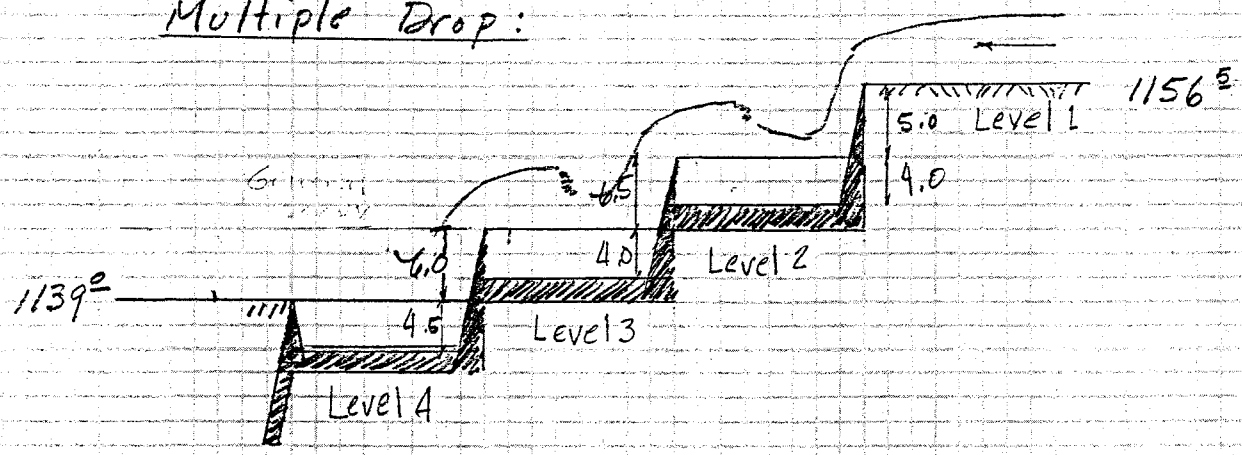
Set #7: Local scour from IBW Bridge Piers

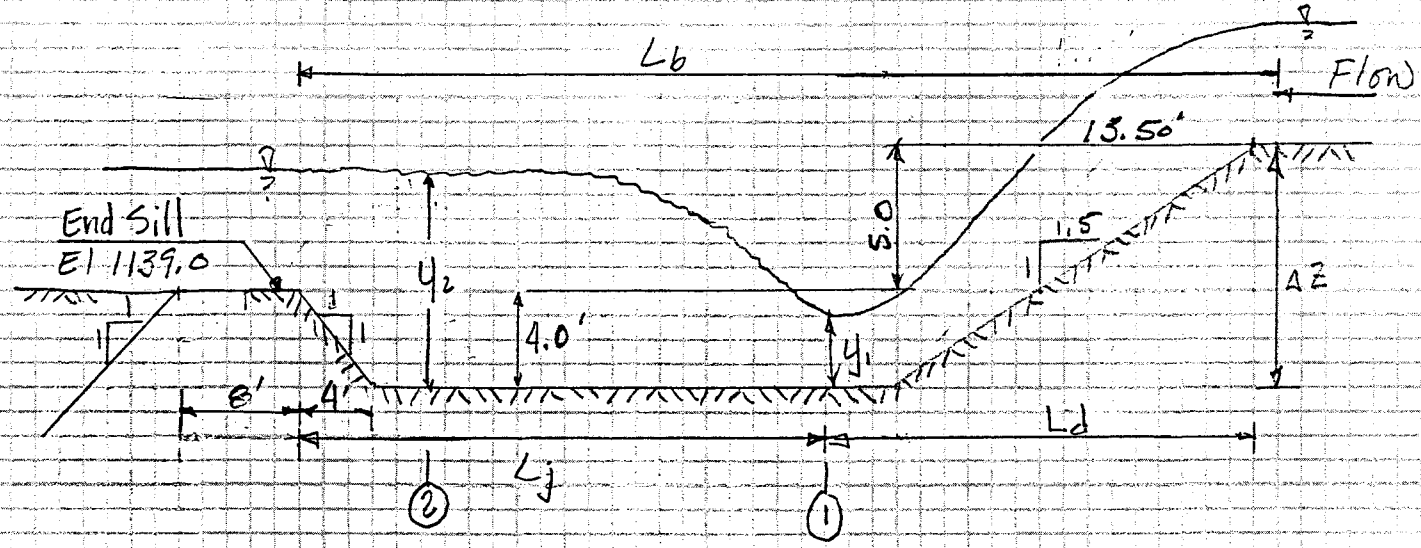
Set #8: Residual drop scour computation

Registered Professional Engineer (Civil)
CERTIFICATE NO.
20207
GEORGE K. COTTON
Date Signed 11/5/90
ARIZONA, U.S.A.

CRS SIRRINE	PROJECT: Rio Salado Channelization	JOB NO. R101N	NO. 1
	CLIENT: Tempe	DESIGNED BY GKC / DATE 5/27/90	OF 4
	SUBJECT: IBW Drop Structure	CHECKED BY JFM / DATE 5/27/90	

Multiple Drop:





Hydraulic Conditions: Level 1

Design Discharge, $Q_d = 63{,}000$ cfs
Axis Length, $L_a = 621.5$ ft
Unit discharge, $q = 101.4$ cfs/ft

Approach flow conditions

$y_c = 8.3$ ft
$V_c = 14.8$ fps
$H_c = 11.7$ ft

Conditions at base of drop

$$y_1 = 0.54\,(y_c/\Delta Z)^{0.275}\,y_c$$

$$L_d = 4.30\,(y_c/\Delta Z)^{0.09}\,\Delta Z$$

for $y_c = 8.3'$ $\Delta Z = 9.0$

$$y_1 = 0.54\,(8.3/9.0)^{0.275}\,8.3 = 4.4'$$

$$L_d = 4.30\,(8.3/9.0)^{0.09}\,9.0 = 38.4$$

$$V_1 = 101.4/4.4 = 23.1 \text{ fps}$$

Sequent Depth:

$$y_2 = \tfrac{1}{2}\left(\sqrt{1+8F_b^2} - 1\right) y_1 \qquad \text{where } F = \frac{V_1}{\sqrt{32.2\,y_1}}$$

$$y_2 = \tfrac{1}{2}\left(\sqrt{1+8(1.94)^2} - 1\right) 4.4$$

$$= 10.1$$

For USBR Type III Stilling Basin $(2.5 < F < 4.5)$

$$h_2 = 1.25\,y_1$$
$$= 1.25\,(4.4)$$
$$= 5.5'$$

$$L_j = 4.24\,y_2$$
$$= 4.24\,(10.1)$$
$$= 42.8'$$

From Henderson:

$$L_j = 6.9\,(y_2 - y_1)$$
$$= 6.9\,(10.1 - 4.4)$$
$$L_j = 39.3$$

(See attached chart from Design of Small Dams).

Total basin length level 2

$$L_b = L_d + L_j = 38 + 40 = 78'$$

CRSS	PROJECT: Rio Salado Channelization	JOB NO: R101N	NO. 3
	CLIENT: Tempe	DESIGNED BY: GKC / DATE: 11/1/90	
	SUBJECT: IBW Drop Structure	CHECKED BY: JFM / DATE: 11/2/90	OF 4

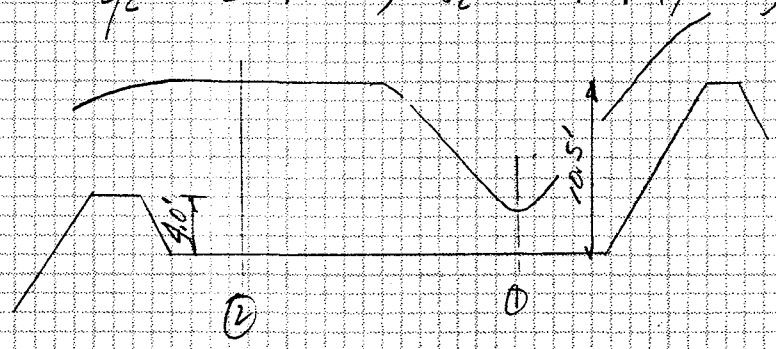
Level 2 Crest:

Design Q = 63000 cfs

Axis Length = 605 ft

Unit discharge = 104.1 cfs/ft

y_c = 8.4' ; V_c = 14.9 fps ; H_c = 11.9 ft



$$y_1 = 0.54(y_c/\Delta Z_0)^{0.275}\, y_c$$
$$= 0.54(8.4/10.5)^{0.275}\, 8.4$$
$$= 4.3'$$

$$L_d = 4.3(y_c/\Delta Z_0)^{0.09}\, \Delta Z_0$$
$$= 4.3(8.4/10.5)^{0.09}\, 10.5$$
$$= 44.3'$$

$$y_2 = 1.66(y_c/\Delta Z_0)^{0.81}\, \Delta Z_0$$
$$= 1.66(8.4/10.5)^{0.81}\, 10.5$$
$$= 14.6$$

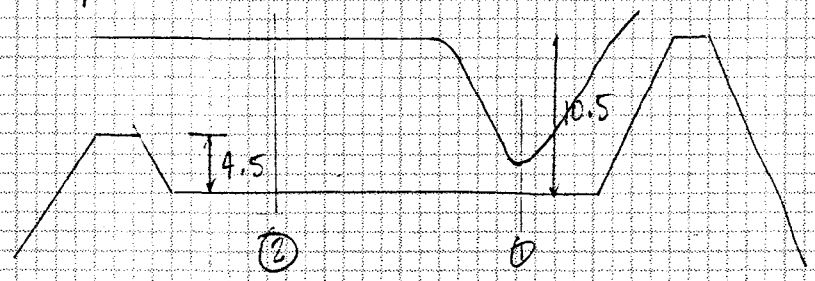
$$L_j = 6.9(y_2 - y_1)$$
$$= 6.9(14.6 - 4.3)$$
$$= 71.1$$

$$L_b = L_d + L_j = 44.3 + 71.1 = 115.4'$$

CRSS	PROJECT: Rio Salado Channelization	JOB NO: R101N		NO. 4
	CLIENT: Tempe	DESIGNED BY: GKC	DATE: 11/1/90	OF 4
	SUBJECT: IBW Drop structure	CHECKED BY: JFM	DATE: 11/1/90	

Level 3 Crest:

Design Q = 63,000 cfs
Axis Length = 612.2 ft
Unit Discharge = 102.9 cfs/ft
y_c = 8.9 ft; V_c = 14.9 fps; H_c = 12.4 ft.



$y_1 = 0.54(8.9/10.5)^{0.275}\ 8.9$
$= 4.6$

$y_2 = 1.66(8.9/10.5)^{0.81}\ 10.5$
$= 15.3$

$L_4 = 4.3(8.9/10.5)^{0.09}\ 10.5$
$= 44.5$

$L_j = 6.9(15.3 - 4.6)$
$= 73.8$

$L_b = 44.5 + 73.8$
$= 118.3$

with experiment is remarkably good considering the approximations that must be inherent in this formulation of the problem.

This analysis by White is commended to the reader as a good example of the way in which skilful formulation and a grasp of fundamentals can yield surprisingly exact solutions of problems which may at first glance appear intractable by theoretical methods. The details can be worked out by the reader as an exercise (Probs. 6.10 and 6.11).

The Drop Structure

Figure 6-17 shows that the energy loss E_L at the base of an overfall may be 50 percent or more of the initial energy, referred to the basin floor as datum. If, as in Fig. 6-16, there is a hydraulic jump downstream of section 1 dissipating further energy, the energy loss in the entire "drop structure" may be very substantial. The loss due to the hydraulic jump is readily calculated (Prob. 6.12) in terms of the parameters of Fig. 6-17, and a curve is plotted on that figure displaced to the left of the E_1/y_c curve by the amount E_J/y_c, where E_J is the loss in the jump. This left-hand curve then indicates the remaining specific energy E_2 downstream of the jump. It is seen that the ratio E_2/y_c does not vary greatly with $\Delta z_0/y_c$; this suggests that a value of 2.5 for E_2/y_c may form a satisfactory basis for a preliminary design (Probs. 6.13 and 6.14).

Rand [25] assembled the results of experimental measurements made by himself, by Moore [24], and others, and from them obtained the following exponential equations, which fit the data with errors of 5 percent or less:

$$\frac{y_1}{\Delta z_0} = 0.54\left(\frac{y_c}{\Delta z_0}\right)^{1.275} \tag{6-37a}$$

or

$$\frac{y_1}{y_c} = 0.54\left(\frac{y_c}{\Delta z_0}\right)^{0.275} \tag{6-37b}$$

$$\frac{y_2}{\Delta z_0} = 1.66\left(\frac{y_c}{\Delta z_0}\right)^{0.81} \tag{6-38}$$

$$\frac{L_d}{\Delta z_0} = 4.30\left(\frac{y_c}{\Delta z_0}\right)^{0.09} \tag{6-39}$$

$$L_j = 6.9(y_2 - y_1) \tag{6-40}$$

where L_d and L_j are the horizontal distances covered by the jet and the hydraulic jump respectively, as shown in Fig. 6-16. With the help of these equations the designer can proportion the simple drop structure completely. The upward step of $y_2/6$ at the end of the structure, shown in Fig. 6-16, is a standard design feature which helps to localize the jump immediately below the overfall.

Figure 6-18.

It has been assum
of the overfall is cri
of the drop structu
nel to be laid on a
occur, leading to su
the jet shape and b
The drop structu
and is the simples
practice; e.g., a bas
would indicate, em
as in Sec. 6.7. A
Fig. 6-18, which h

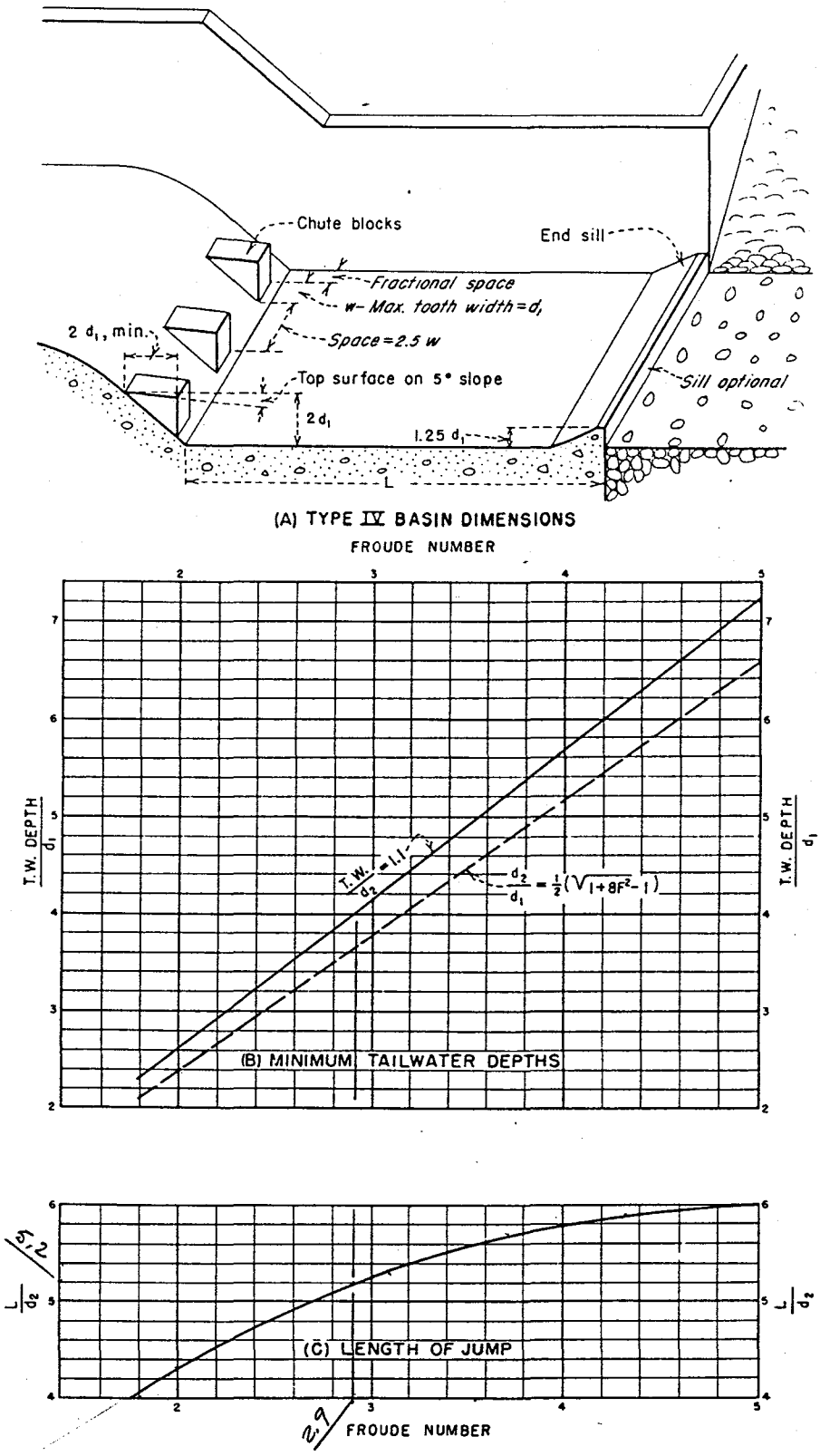
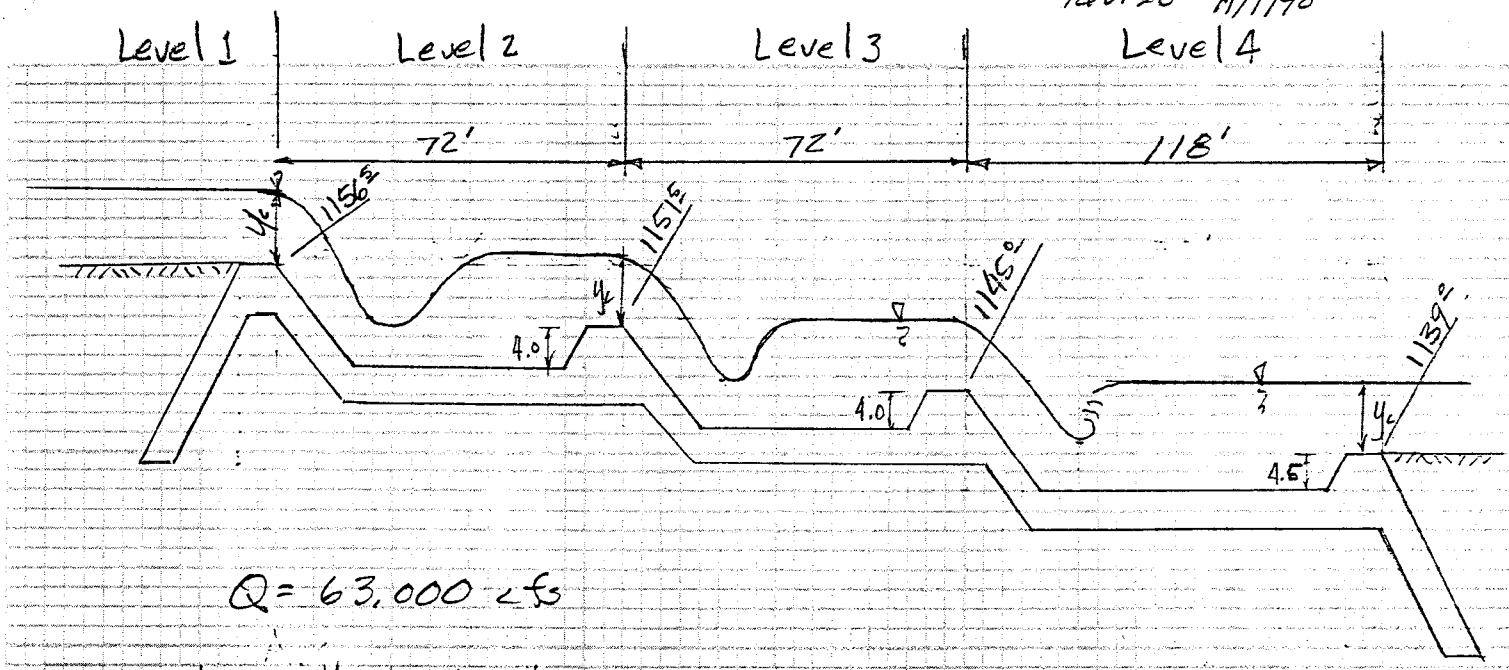


Figure 265. **Stilling basin characteristics for Froude numbers between 2.5 and 4.5. 288—D—2425.**

CRS SIRRINE	PROJECT: 12 Salado Channelization	JOB NO. 12101N	NO. 1 / 3
	CLIENT: City of Tempe	DESIGNED BY GRC / DATE 5/18/90	
	SUBJECT: IBW Drop WSP	CHECKED BY JFM / DATE 5/18/90	
		Revised 11/1/90	



Q = 63,000 cfs

Level	Crest Elev	Crest Length	q_{max}	y_c	Δz_o	WSEL
I	1156.5	621.5	135.7	8.3	—	1164.8
II	1151.5	605.0	138.2	8.4	9.0	1159.9
III	1145.0	555.5	150.7	8.9	10.5	1153.9
IV	1139.0	537.5	153.2	9.0	10.0	1148.0

Basin	y_1	V_1	F_1	y_2
I-II	4.4	30.8	2.6	10.1
II-III	4.3	32.1	2.7	14.6
III-IV	4.6	32.8	2.7	15.3

[Ref: Henderson, 1966 "Open Channel Flow" Chapter 6, pg 200]

CRSS			
PROJECT: Rio Salado	JOB NO: R10N		NO. 2
CLIENT: Tempe	DESIGNED BY: GKC	DATE: 5/25/90	OF 3
SUBJECT: Critical Depths IBW Drop	CHECKED BY: JFM	DATE: 5/18/90	
	Revised	11/1/90	

Crest Section Level 1

Sta	Elev
0.0	1170.0
15.75	1159.5
326.50	1156.5
637.25	1159.5
653.0	1170.0

Q	y_c	Area	TopWid	Vel
63,000	8.3	4268	637.4	14.8

$q_{max} = 135.7$

where $q_{max} = \sqrt{y_c^3 g}$

Crest Section Level 2

Sta	Elev
0.0	1170.0
23.25	1154.5
325.75	1151.5
628.25	1154.5
651.0	1170.0

Q	y_c	Area	TopWid	Vel
63,000	8.4	4216	621	14.9

$q_{max} = 138.2$

Crest Section Level 3

Sta	Elev
0.0	1170.0
23.25	1154.5
38.25	1154.5
48.0	1148.0
325.75	1145.0
603.50	1148.0
613.25	1154.5
628.25	1154.5
651.50	1170.0

Q	y_c	Area	TopWid	Vel
63,000	8.9	4219.6	612.2	14.9

$q_{max} = 150.7$

CRSS			
PROJECT: Rio Salado	JOB NO: R101N		NO. 3
CLIENT: Tempe	DESIGNED BY: GKC	DATE: 5/25/90	
SUBJECT: IBW Drop Rating	CHECKED BY: JFM	DATE: 5/25/90	OF 3

Elev	Depth	Area	TopWid	Q_c
1157.5	1.0	103.6	207.2	416
58.5	2.0	414.3	414.3	2351
59.5	3.0	932.3	621.5	6474
60.5	4.0	1555.3	624.5	13917
61.5	5.0	2181.3	627.5	23059
62.5	6.0	2810.3	630.5	33641
63.5	7.0	3442.3	633.5	45497
64.5	8.0	4077.3	636.5	58512
64.8	8.3	4268.0	637.4	63000

$$Q_c = \sqrt{g}\, A^{3/2} / T^{1/2}$$

Design Discharges:

Q	Elev	Design Event
30,000	1162.2	100-yr
43,000	1163.3	Bankfull
51,000	1163.9	Super Flood
63,000	1164.8	SPF

Coincident Stage: Salt Riv/IBW

Salt / IBW	10-year	100-yr	Qmax
100-yr			
Bank			
Super			
SPF			

CRS SIRRINE	PROJECT: Rio Salado Channelization	JOB NO. R101N	NO. 1
	CLIENT: Tempe	DESIGNED BY GRC / DATE 5/27/90	OF 1
	SUBJECT: IBW Drop Structure	CHECKED BY JFM / DATE 7/30/90	

A. Dynamic Uplift Force on Slab

Assume that $\Delta P_{max} \propto \tau_{max}$ where τ_{max} is the shear force on the stilling basin and ΔP_{max} is the differential pressure to uplift the slab.

$$\tau_{max} = 2.0 \frac{n^2}{2.21} 62.4 * d_a^{-1/3} V_a^2$$

assume $n = 0.024$

For stilling basins

$V_a = 30.8 - 32.8$ fps

Basin	q_{max}	y_1	V_1
2	135.7	4.4	30.8
3	138.2	4.3	32.1
4	150.7	4.6	32.8

$$\tau_{max} = 2 \frac{(0.024)^2}{2.21} 62.4 (4.6)^{-1/3} (32.8)^2$$

$$= 21.0 \text{ lb/ft}^2$$

B. Slab Thickness

For $SF = 1.3$

$\tau_c = 4.1 S$ (150 lb/ft³ density)

where S = slab thickness

$$S = SF(\tau_{max}/4.1)$$

$$= 1.3(21.0/4.1) = 6.7 \text{ ft}$$

Use 6.75' slab thickness (9-9" lifts)

Rio Salado Channelization
IBW Drop Structure
Seepage and Uplift Computation:
Lane's Weighted Creep Method

Job No.:
Dgn. By: GKC Date: 09/21/90
Chk. By: JFN Date: 9/24/90

Path	Dir	Length (ft)	Cumm Length (ft)	Weight Factor	Eff Length (ft)	Frac Length	Uplift Head Low (ft)	Uplift Head High (ft)
2-3	V	22.00	22.00	2.00	14.67	0.08	16.11	25.11
3-4	H	8.00	30.00	1.00	17.33	0.09	15.86	24.86
4-5	V	17.00	47.00	2.00	28.67	0.15	14.79	23.79
5-6	H	4.00	51.00	1.00	30.00	0.16	14.66	23.66
6-7	V	22.25	73.25	2.00	44.83	0.24	13.26	22.26
7-8	V	4.50	77.75	3.00	49.33	0.27	12.84	21.84
8-9	H	8.00	85.75	1.00	52.00	0.28	12.58	21.58
9-10	V	4.50	90.25	3.00	56.50	0.31	12.16	21.16
10-11	H	56.50	146.75	1.00	75.33	0.41	10.38	19.38
11-12	H	9.75	156.50	1.00	78.58	0.42	10.07	19.07
12-13	V	4.50	161.00	3.00	83.08	0.45	9.64	18.64
13-14	H	8.00	169.00	1.00	85.75	0.46	9.39	18.39
14-15	V	4.50	173.50	3.00	90.25	0.49	8.97	17.97
15-16	H	54.25	227.75	1.00	108.33	0.59	7.26	16.26
16-17	H	9.75	237.50	1.00	111.58	0.60	6.95	15.95
17-18	V	4.50	242.00	3.00	116.08	0.63	6.52	15.52
18-19	H	8.00	250.00	1.00	118.75	0.64	6.27	15.27
19-20	V	4.50	254.50	3.00	123.25	0.67	5.85	14.85
20-21	H	95.50	350.00	1.00	155.08	0.84	2.84	11.84
21-22	V	15.00	365.00	2.00	165.08	0.89	1.89	10.89
22-23	H	8.00	373.00	1.00	167.75	0.91	1.64	10.64
23-24	V	26.00	399.00	2.00	185.08	1.00	0.00	9.00

High Stage:
Upper = 1164.80 △1
Lower = 1148.00
Creep ratio = 11.02

Low Stage:
Upper = 1156.50 △1
Lower = 1139.00
Creep ratio = 10.58

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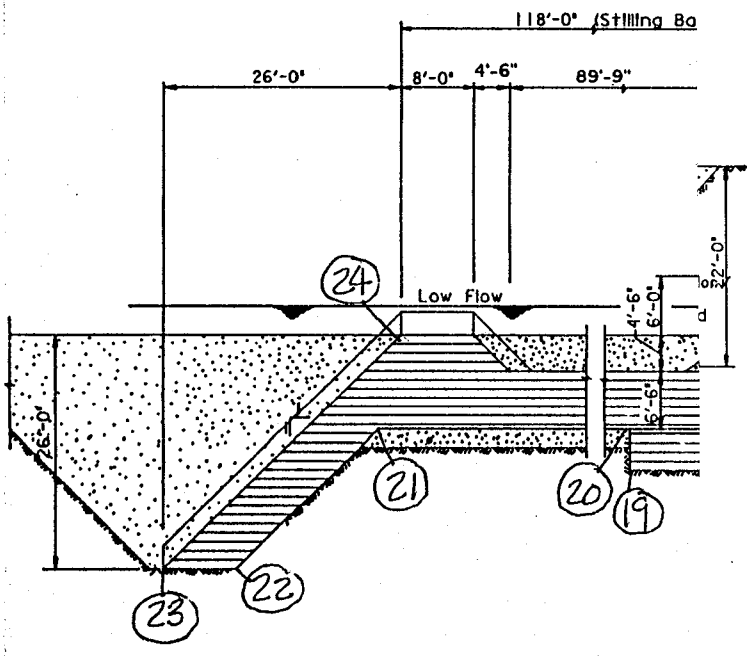
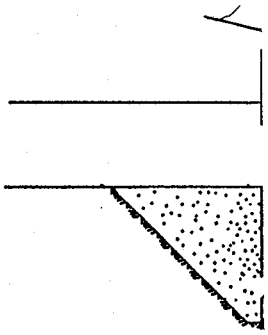
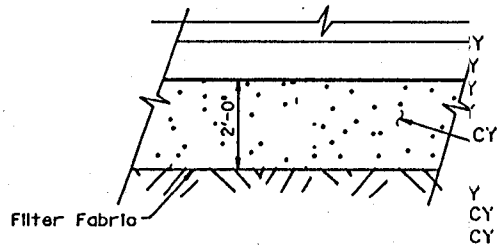
△1 revised 11/1/90 to conform to final structure dimensions and stage/discharge relationship







FILTER DRAIN DETAIL

CONSTRUCTION NOTES

-For McClintock Structure Additional Details Refer to Sht No. 573

-For Indian Bend Wash Structure Additional Details Refer to Sht No. 572

-All Work shall be done According to the Arizona Department of Transportation "Standard Specifications For Road and Bridge Construction." 1987 Edition Amended By Special Provisions.

Design:

In Accordance with ACI 318-83 and Arizona Department of Transportation Highway Division, Structures Section Drainage Manual, Edition August 1987.

Design Loads:

-Cement Stabilized Alluvium - 140 pcf
-Dry Alluvium - 110 pcf
-Hydraulic Uplift (Dynamic) - 21.2 psf
-Design Flow Velocity - 30fps

Materials:

-Cement Stabilized Alluvium - fc' = 1000 psi (7 days)
-Roller Compacted Concrete - fc' = 3000 psi (28 days)

-Granular Filter Bedding (1)
-Filter Fabric (2)

Miscellaneous:

-All Dimensions Shown on the Plans are Measured Horizontally or Vertically Unless Otherwise Noted.

(1) GRADING

Sieve Size	Percent by Weight passing Sieve
3"	100%
2"	70-85%
1"	40-60%
0.5"	8-15%
#200	0-5%

(2) Min Permeability 6.2×10^{-4} ft/sec
Max AOS 0.6
Type: Mirafi 140N
Typar 3401
Trivera Spunbound 1112
or Approved Equal

NO.	DATE	DESCRIPTION	APPROVAL
3			
2			
1			

REVISIONS

CRSS, INC.
PHOENIX, ARIZONA

RIO SALADO
CHANNEL DESIGN

DEPARTMENT OF PUBLIC WORKS
CITY OF TEMPE
DIVISION OF ENGINEERING
P.O. BOX 5002 TEMPE, ARIZONA

DESIGNED: JV	GRADE CONTROL STRUCTURES CROSS SECTIONS & DETAILS	DATE 8 1-90
DRAWN: CRS		PROJECT NO. 876191
APPROVED: GKC		
SCALE: NOTED		SHT 574 OF 585

CRS SIRRINE	PROJECT: Rio Salado Channel	JOB NO. 12101N	NO. 1
	CLIENT: City of Tempe	DESIGNED BY GRC / DATE 8/21/90	
	SUBJECT: IBW Structure Weep Holes	CHECKED BY JFM / DATE 8/22/90	OF 4

① The weep holes drain water that is dammed behind the drop. From the Lane's weighted creep analysis it was found that the largest uplift pressure will exist in the lowest stilling basin of the structure. The average uplift head on the slab is 8.9 feet. The average path length to the lower basin is 123 feet. Assuming that the weep holes will reduce the pressure head on the lower basin to zero, the ground water gradient is

$$i = (18.0 + 4.5)/123 \quad \text{(where 4.5 is the end sill height)}$$
$$= 0.183$$

The drainage path is through the existing fine sand material with a hydraulic conductivity of 3×10^{-3} cm/sec (from Morris & Johnson). or 9.8×10^{-5} ft/sec.

② Weep hole discharge

$$Q = kiA$$

for weep holes on 12' spacing

$$A = 144 \text{ sq. ft}$$

$$Q = 9.8 \times 10^{-5} (0.183) 144$$
$$= 2.5 \times 10^{-3} \text{ cfs/hole}$$

③ The influence of a single weep hole will extend radially from the hole. For a single hole

$$Q_e = k i A_e$$
$$= k i \pi r_e^2$$

where r_e = effective draw down radius

$$Q_e = 9.8 \times 10^{-5} (0.183) \pi r_e^2$$
$$= 1.8 \times 10^{-5} \pi r_e^2$$

④ For a radial drain

$$Q = \frac{\pi k h_e^2}{\ln(r_e/r_w)}$$

where r_e = weep hole radius (1")

⑤ Combining 3 & 4 gives

$$k i \pi r_e^2 = \frac{\pi k h_e^2}{\ln(r_e/r_w)}$$

$$r_e^2 \ln(r_e/r_w) = h_e^2 / i$$

⑥ For $h_e = 8.9'$ $\quad i = 0.183$

$r_w = 0.083'$

$$r_e^2 \ln(r_e/0.083) - 432.8 = 0$$

$$r_e = 9.5'$$

(7) At a radius of 6' the effective draw down can be found from eq. 4.

$$h = \left(\frac{Q \ln(r/r_w)}{\pi k}\right)^{1/2}$$

$$h = \left[\frac{2.5\times10^{-3}(\ln(6/0.083))}{\pi\ 9.8\times10^{-5}}\right]^{1/2}$$

$$= 5.9'$$

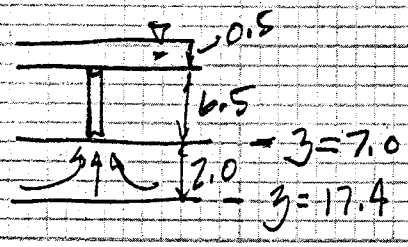
(8) By adding a granular filter layer the drawdown can be locally increased. For gravel, $k = 0.4$ cm/sec or 0.13×10^{-1} ft/sec.

$$h = \left[\frac{2.5\times10^{-3}(\ln(6/.083))}{\pi\ 0.013}\right]^{1/2}$$

$$= 0.51'$$

This is a 94% reduction in uplift pressure head.

(9) For a 2' thick granular bedding layer, the ground water gradient is $i = 10.4/2 = 5.2$



CRS SIRRINE	PROJECT Rio Salado Channel	JOB NO. 12101N	NO. 4
	CLIENT City of Tempe	DESIGNED BY GKC / DATE 8/21/90	
	SUBJECT IBW Weep Holes	CHECKED BY JFM / DATE 8/22/90	OF 4

(10) This gives an apparent velocity of for the granular layer of

$$V = ki$$

$$= 0.013(5.2) = 0.068$$

which is much larger than the velocity in the surrounding fine sand material.

(11) check Reynold No.

$$Re = \frac{q\bar{d}}{\nu} \quad \text{where } \bar{d} = \sqrt{0.6k}$$

$$= \frac{(2.5\times10^{-3}/144)0.09}{1\times10^{-5}} \qquad = 0.09' \sim 1''$$

$$\bar{d} \approx D_{50} \checkmark$$

$$= 0.16 \checkmark$$

For Darcy law to be valid $Re < 1$

(12) Velocity in weep hole

$$V = 2.5\times10^{-3}/\pi(0.083)^2$$

$$= 0.12 \text{ fps} \checkmark$$

Fall velocity of a 1/4" ϕ stone is about 0.9 fps

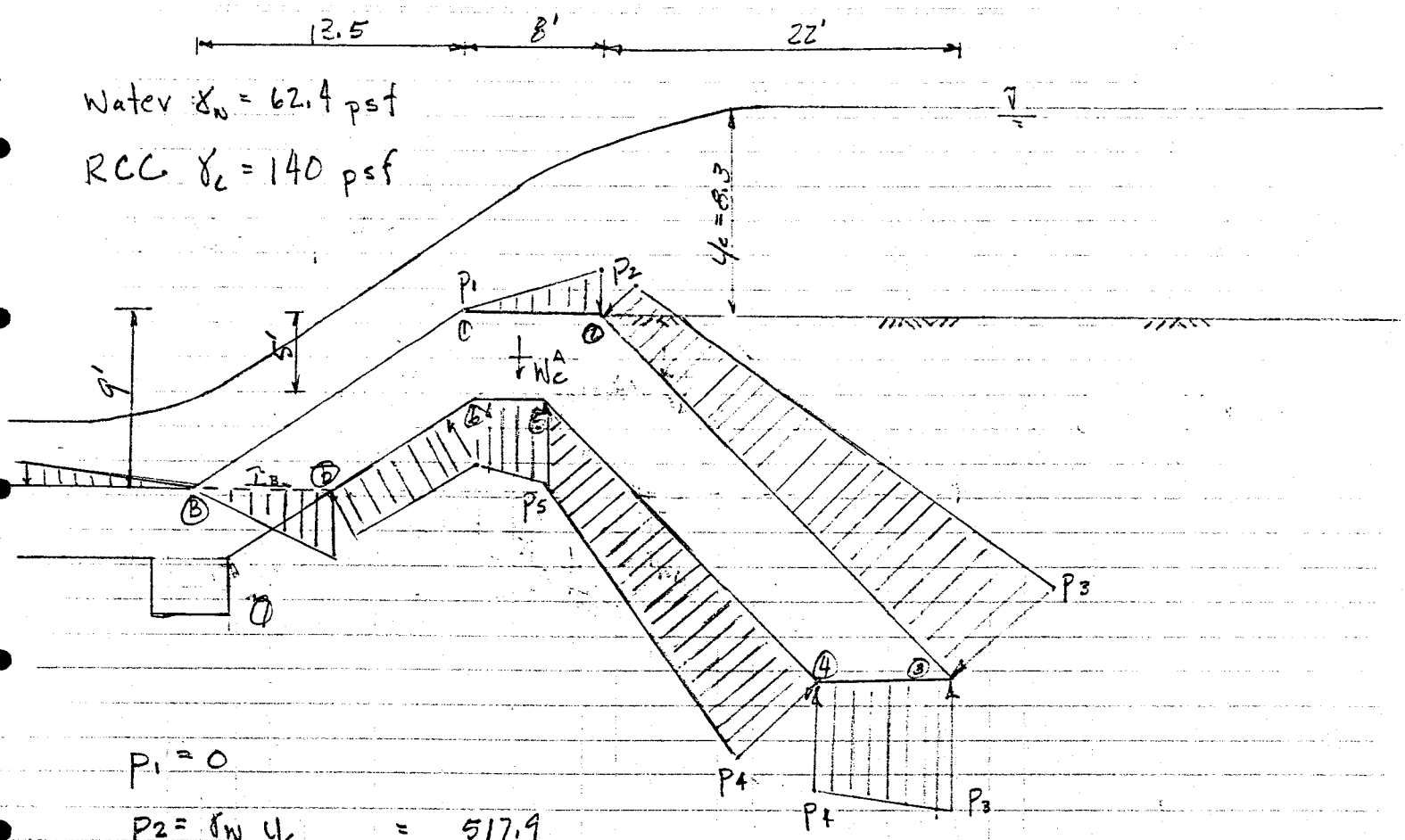
CRSS

CRS SIRRINE

DESIGN SHEET

Job R10 SALADO CHANNEL DGN
Structure INDIAN BEND WASH DROP
Live Load Per Square Foot _____

Job No. R10IN Date 10/15/90
Computed By JFM
Working Stress GKC 11/5/90



$P_1 = 0$

$P_2 = \gamma_w y_c = 517.9$

$P_3^* = \gamma_w 25.11 = 1566.9$

$P_4 = \gamma_w 24.86 = 1551.3$

$P_5 = \gamma_w 23.79 = 1484.5$

$P_6 = \gamma_w 23.66 = 1476.4$

$P_b = 1443.1$

$P_7 = \gamma_w 22.26 = 1389.0$

*Note: See computation of uplift pressures by weighted Creep Method.

Assumptions:

- Uplift pressures based on weighted creep methodology
- No scour in the approach reach
- Zero pressure on spillway face
- Friction factor $\mu = \tan(40°) = 0.84$
- Cracks in planes A'-A & B-B
- Sliding resisted: 20% Concrete Shear, 80% Friction Shear
- Calculations don't reflect weep-hole drains for pressure relief

CRSS

CRS SIRRINE

DESIGN SHEET

Job _____ Job No. _____ Date 10/15/90
Structure _____ Computed By JFM
Live Load Per Square Foot _____ Working Stress GKC 11/5/90

Moment Around B : Full Section

Forces:

$F_{1-2} = (0 + 0.518)/2 * 8 = 2.07$; $F^V_{1-2} = -2.07$; $F^H_{1-2} = 0.0$

$F_{2-3} = (0.518 + 1.567)/2 * 31.1 = 32.4$; $F^V_{2-3} = -22.9$; $F^H_{2-3} = -22.9$

$F_{3-4} = (1.567 + 1.551)/2 * 8 = 12.5$; $F^V_{3-4} = 12.5$; $F^H_{3-4} = 0.0$

$F_{4-5} = (1.551 + 1.485)/2 * 24.0 = 36.4$; $F^V_{4-5} = 25.8$; $F^H_{4-5} = 25.8$

$F_{5-6} = (1.485 + 1.476)/2 * 4.5 = 6.66$; $F^V_{5-6} = 6.66$; $F^H_{5-6} = 0.0$

$F_{6-b} = (1.476 + 1.443)/2 * 7.2 = 10.5$; $F^V_{6-B} = 5.83$; $F^H_{6-B} = -8.74$

$F_{b-B} = (1.443 + 0)/2 * 8 = 5.77$; $F^V_{b-B} = -5.77$; $F^H_{b-B} = 0.0$

$W_c = (4*8 + 14.3*5 + 17*8)/40 = 33.5$; $F_c^V = -33.5$; $F_c^H = 0.0$

Moment Arms:

Force	X	Y
F_{1-2}	18.83	–
F_{2-3}	34.34	-3.84
F_{3-4}	39.51	–
F_{4-5}	27.05	-4.55
F_{5-6}	16.25	–
F_{6-B}	11.0	2.0
F_{b-B}	3.33	–
W_c	23.60	–

CRSS

CRS SIRRINE

DESIGN SHEET

Job _____ Job No. _____ Date 10/15/90
Structure _____ Computed By GKC/JFM
Live Load Per Square Foot _____ Working Stress GKC 11/5/90

Sliding:

$\tau_s = 0.95\sqrt{3000}\ 8\ (12^2) = 59.9$

$\tau_f = 0.5(1.91) = 0.96$

$\tau_B = 0.8(0.96) + 0.2(59.9) = 12.75$

$SF = \dfrac{12.75 + 25.8}{22.9 + 8.74} = 1.2$

Overturning:

$\Sigma M\circlearrowright = 18.83(2.07) + 34.34(22.9) + 23.6(33.5) + 3.84(22.9)$

$= 1704$ k-ft

$\Sigma M\circlearrowleft = 39.51(12.5) + 27.05(25.8) + 16.25(6.66) +$

$11.0(5.83) + 4.55(25.8) + 2.0(8.74) + 3.33(5.77)$

$= 1518$ k-ft

$SF = \dfrac{\Sigma M\circlearrowright}{\Sigma M\circlearrowleft} = \dfrac{1704}{1518} = 1.1$

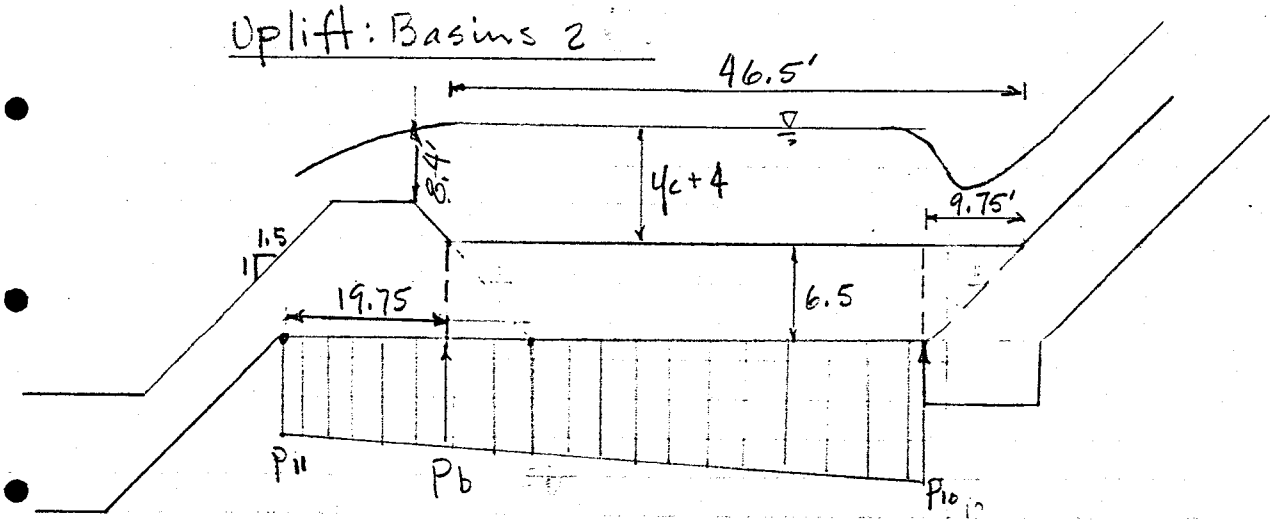
CRSS

CRS SIRRINE

DESIGN SHEET

Job _____ Job No. _____ Date 10/15/90
Structure _____ Computed By VFM
Live Load Per Square Foot _____ Working Stress ~~GKC~~ 11/5/90

Uplift: Basins 2



For basin 2:

Wet: $P_{10} = 21.2$ Dry: $P_{10} = 12.2$

$P_{11} = 19.4$ $P_{11} = 10.4$

Dry: $P_b = 20.0$ $P_b = 11.0$

$F^{u}_{10-b} = (21.2 + 20.0)/2 * 62.4 * 36.8 = 47.3\ k$ (wet)
$(12.2 + 11.0)/2 * 62.4 * 36.8 = 26.6\ k$ (dry)

$F^{d}_{10-b} = 12.4 * 62.4 * 36.8 = 28.5\ k$ (wet)
$= 0.0\ k$ (dry)

$W_c = 36.8 * 6.5 * 140 = 33.5\ k$ wet/dry

$SF_w = \frac{28.5 + 33.5}{47.3} = 1.4$ wet

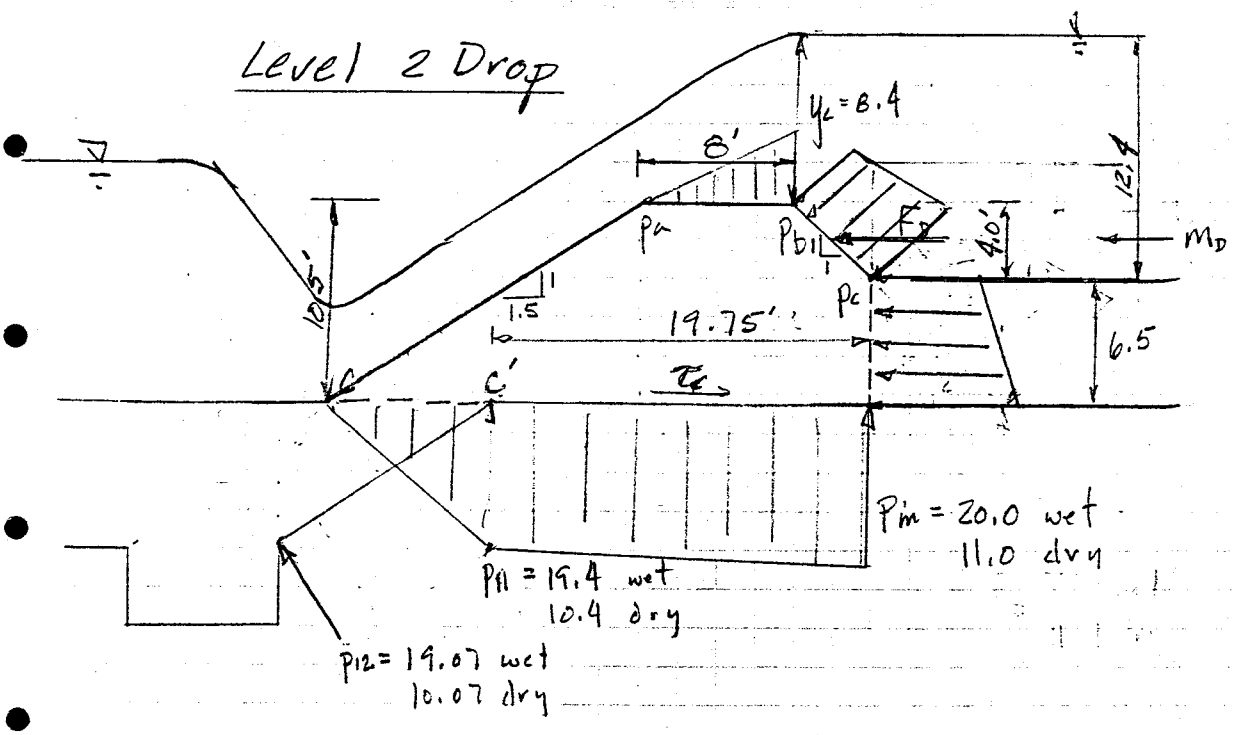
$SF_D = \frac{33.5}{26.6} = 1.3$ dry

CRSS

CRS SIRRINE

DESIGN SHEET

Job _____ Job No. _____ Date 10/15/90
Structure _____ Computed By JEM
Live Load Per Square Foot _____ Working Stress _____ GKC 11/5/90



$p_a = 0$

$p_b = 8.4 \times \gamma_w = 0.524$ ksf

$p_c = 12.4 \times \gamma_w = 0.774$ ksf

$p_m = 20.0 \times \gamma_w = 1.248$ k (wet)
$11.0 \times \gamma_w = 0.686$ k (dry)

$p_{11} = 19.4\ \gamma_w = 1.211$ k (wet)
$10.4\ \gamma_w = 0.649$ k (dry)

$p_{12} = 19.1\ \gamma_w = 1.192$ k (wet)
$10.1\ \gamma_w = 0.630$ k (dry)

$m_D = C_D\ \frac{1}{2} \rho V_0^2 = 1.5 \times (\frac{1}{2} \times 1.94 \times 11.2^2) = 0.18$ ksf

$C_D = 1.5$ for triangle. see Morris & Wiggert "Applied Hydraulic in Engineering" pg 93
See Table on Sheet 10/10.

CRSS

CRS SIRRINE

DESIGN SHEET

Job _____ Job No. _____ Date 10/15/90
Structure _____ Computed By JFM
Live Load Per Square Foot _____ Working Stress _____ 6/LL 11/5/90

For Section c-c'

$F_{a-b} = (0+0.524)/2 * 8 = 2.10$; $F^V_{a-b} = 2.10$; $F^H_{a-b} = 0.0$

$F_{b-c} = (0.524+0.774)/2 * 5.66 = 3.67$; $F^V_{b-c} = -2.60$; $F^H_{b-c} = -2.60$

$F_{c-m} = (0.774+1.248)/2 * 6.5 = 6.57$; $F^V_{c-m} = 0.0$; $F^H_{c-m} = -6.57$

$F_{m-11} = (1.248+1.211)/2 * 19.8 = 24.3$; $F^V_{m-11} = -24.3$; $F^H_{m-11} = 0.0$

$F_{11-c} = (1.211+0)/2 * 8 = 4.84$; $F^V_{11-c} = -4.83$; $F^H_{11-c} = 0.0$

$\tau_c = 0.8(0.5*3.67)+0.2(60) = 13.47$; $F^V_\tau = 0.0$; $F^H_\tau = 13.47$

$W_c = 200.7 * 140 = 28.1$; $F^V_c = 28.1$; $F^H_c = 0.0$

$F_D = 0.18 * 4 = 0.72$; $F^V_D = 0.0$; $F^H_D = -0.72$

Force	Moment Arm X	Y
F_{a-b}	21.1	–
F_{b-c}	25.9	8.37
F_{c-m}	–	3.00
F_{m-11}	17.9	–
F_{11-c}	5.33	–
W_c	17.0	–
F_D	–	8.5

CRSS

CRS SIRRINE

DESIGN SHEET

Job _____ Job No. _____ Date 10/15/90
Structure _____ Computed By JFM
Live Load Per Square Foot _____ Working Stress GKL 11/5/90

SF Overturning : Moment about C

$$\Sigma M_J = 2.10(21.1) + 2.60(25.9) + 28.1(17.0)$$

$$= 589.4$$

$$\Sigma M_J = 24.3(17.9) + 2.60(8.37) + 6.57(3.00) + 0.72(8.5) + 4.83(5.33)$$

$$= 508.3$$

$$\frac{\Sigma M_J}{\Sigma M_J} = \frac{589.4}{508.3} = 1.2$$

SF Sliding.

$$SF = \frac{13.47}{2.60 + 6.57 + 0.72} = 1.4$$

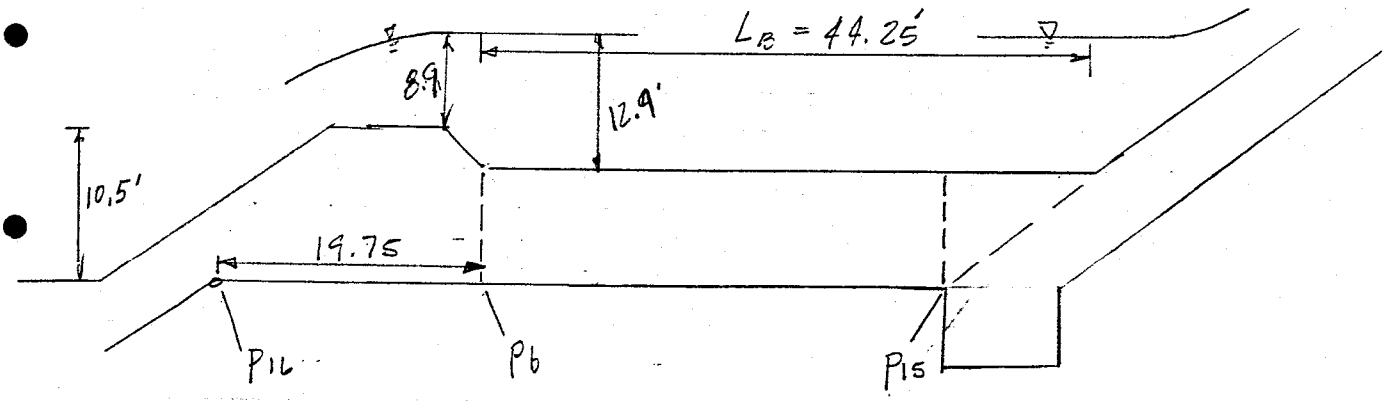
CRSS

CRS SIRRINE

DESIGN SHEET

Job _____ Job No. _____ Date 10/15/90
Structure _____ Computed By VFM
Live Load Per Square Foot _____ Working Stress _____ GLC 11/5/90

Level 3 Basin



Wet: $P_{15} = 18.0$ Dry: $P_{15} = 9.0$

$P_{1b} = 16.3$ $P_{1b} = 7.3$

$P_b = 16.9$ $P_b = 7.9$

$F^U_{15-b} = (18.0 + 16.9)/2 * 62.4 * 37.75 = 41.1$ kips (wet)

$(9.0 + 7.9)/2 * 62.4 * 37.75 = 19.9$ kips (dry)

$F^D_{15-b} = (12.9 * 62.4) * 37.75 = 30.4$ kips (wet)

$= 0.0$ kips (dry)

$W_c = 37.75 * 6.5 * 140 = 34.4$ kips (wet/dry)

$SF_w = \frac{34.4 + 30.4}{41.1} = 1.6$ wet

$SF_D = \frac{34.4}{19.9} = 1.7$ (dry)

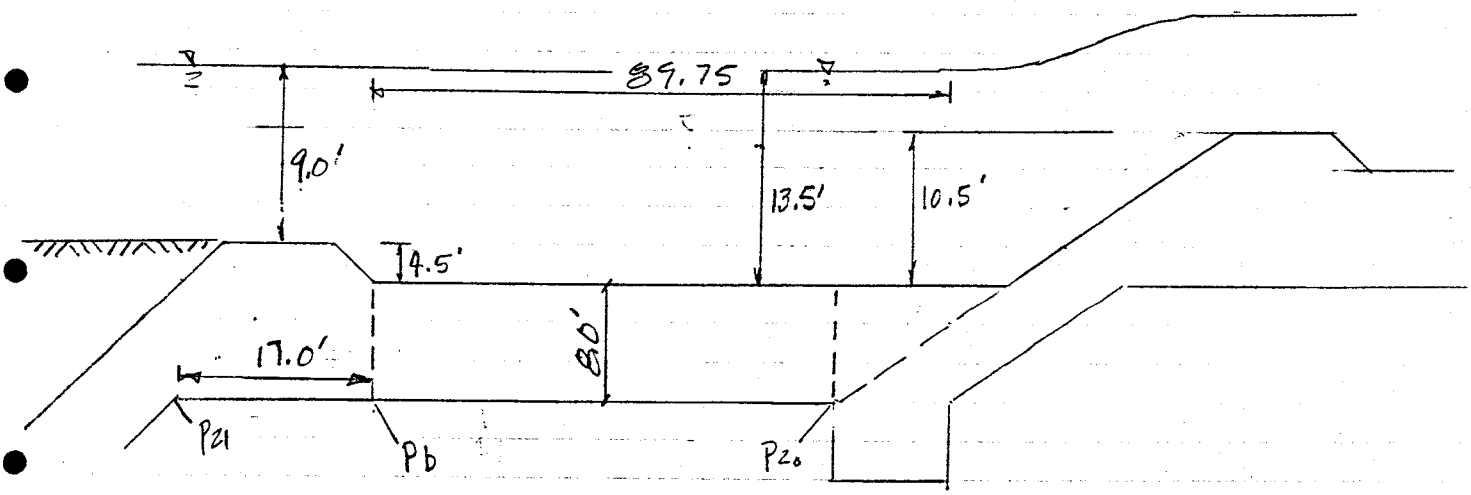
CRSS

CRS SIRRINE

DESIGN SHEET

Job _____ Job No. _____ Date 10/15/90
Structure _____ Computed By JFM
Live Load Per Square Foot _____ Working Stress GKC 11/5/90

Level 4 Basin



Wet: $P_{20} = 14.9$ Dry: $P_{20} = 5.9$

$P_{21} = 11.8$ $P_{21} = 2.8$

$P_b = 12.4$ $P_b = 3.4$

$$F^U_{20-b} = \begin{cases} (14.9 + 12.4)/2 * 62.4 * 77.8 = 66.3 \text{ kips (wet)} \\ (5.9 + 3.4)/2 * 62.4 * 77.8 = 22.6 \text{ kips (dry)} \end{cases}$$

$$F^D_{20-b} = (13.5 * 62.4) * 77.8 = 65.5 \text{ kips (wet)}$$
$$= 0. \text{ kips (dry)}$$

$$W_c = 77.8 * 8 * 140 = 87.1 \text{ kips (wet/dry)}$$

$$SF_W = \frac{65.5 + 87.1}{66.3} = 2.3 \text{ (wet)}$$

$$SF_D = \frac{87.1}{22.6} = 3.9 \text{ (dry)}$$

CRSS

CRS SIRRINE

10/10

DESIGN SHEET

Job _____ Job No. _____ Date 10/15/90 JFM

Computed By _____ GKL 11/5/9

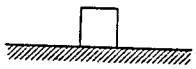
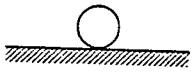
Spot Roughness	Type of Element	C_D
Sphere		0.5
Hemisphere		0.4
Cube		1.5
Cone		0.5
Strip Roughnesses		
Rectangular		1.9
Circular		1.2
Elliptical		0.5
Semi-circular		0.9
Triangular		1.5 ← Use
Depression Roughnesses		
Rectangular slot		1.0
Hemispherical pit		0.2

Fig. 3–11. Drag coefficients for roughness elements.

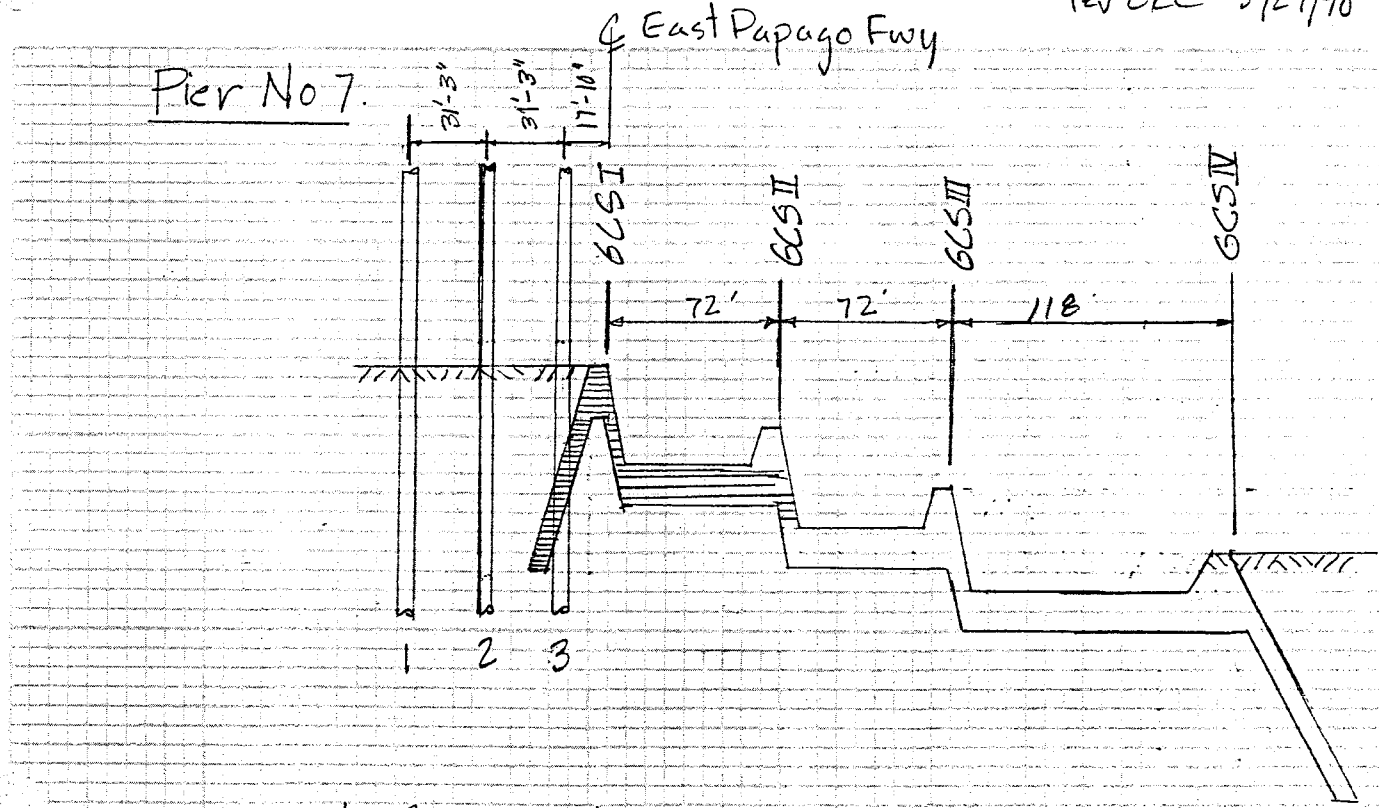
curves, define the entire transition from smooth flow to normal turbulent flow for corrugated surfaces. As noted before, this includes a segment of semi-smooth flow as well as the hyperturbulent regime proper.

Similar families of experimental curves are plotted on Figs. 3–14 and 3–15, for sharp-edged strip roughnesses and uniform spot roughnesses, respectively. The latter are identical with the Nikuradse test curves on uniform sand-coated surfaces, since the sand-grain diameter and roughness spacing are identical in this case.

Morris & Wiggert, Applied Hydraulics in Engineering

CRS SIRRINE	PROJECT: Salado Channel	JOB NO.: R101N	NO. 1
	CLIENT: City of Tempe	DESIGNED BY: GKC / DATE: 5/17/90	
	SUBJECT: Local Scour IBW Drop	CHECKED BY: JFM / DATE: 5/18/90	OF 10

REV GKC 5/27/90



Local Scour at Piers:

CSU equation $d_s/y = 2.0 K_1 K_2 (b/y)^{0.65} Fr^{0.4}$

$b = 6'$ Max debris size $= 10'$

Use $b_{eff} = 10'$

for round piers $K_1 = K_2 = 1.0$

$y_c = \left[\frac{(Q/T)^2}{g}\right]^{1/3}$ $Q = 63{,}000$ cfs

$T = 602'$

$y_c = \left[\frac{(63000/602)^2}{32.2}\right]^{1/3} = 6.98$ ✓

Assume that the flow is at critical vel. through all the piers.

$d_s = 2.0(1.0)(1.0)(10/7.0)^{0.65}(1.0)^{0.65}(7.0)$

$d_s = 17.7'$

CRS SIRRINE	PROJECT: Rio Salado Channel	JOB NO. R101N	NO. 2
	CLIENT: City of Tempe	DESIGNED BY GKC / DATE 5/18/90	OF 10
	SUBJECT: IBW Drop - Local Scour	CHECKED BY JFM / DATE 5/18/90	

rev GKC 5/27/90

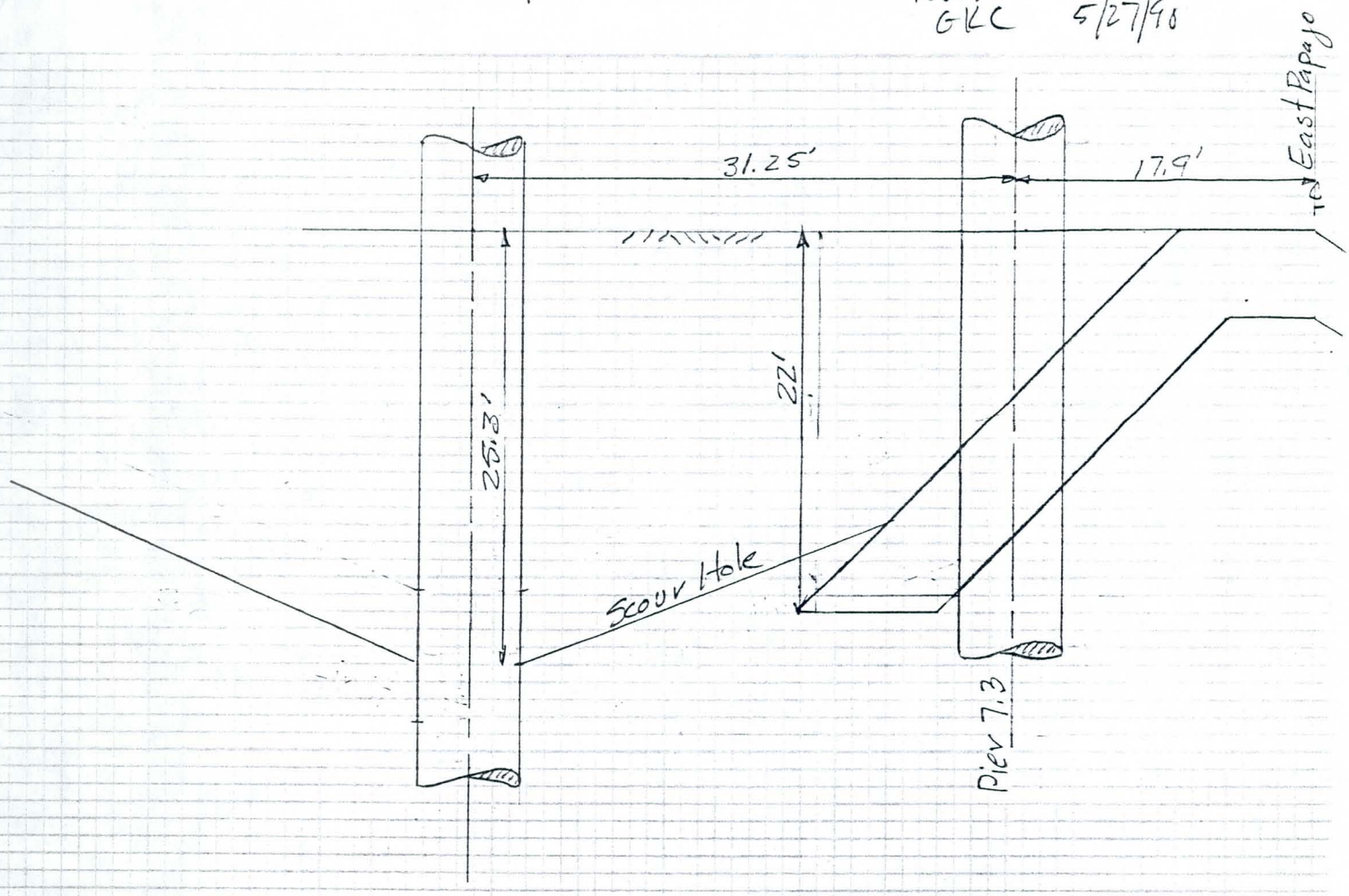
Total Pier Scour

$$d_{pt} = 1.3 \times 1.1 \times 17.7$$

$$= 25.3'$$

Pier Scour upstr

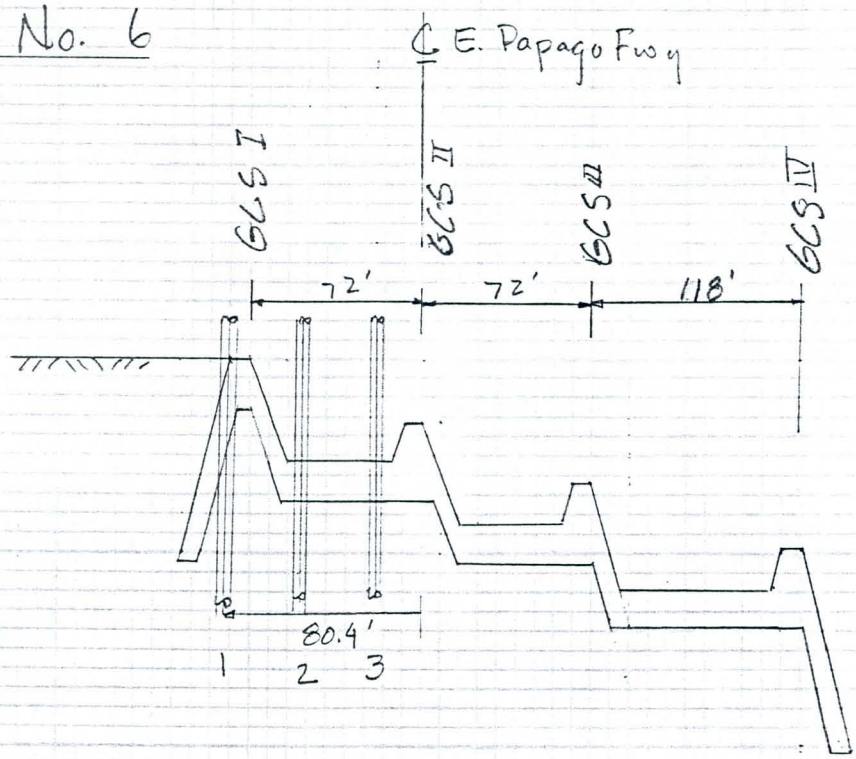
CRS SIRRINE	PROJECT: R. Salado Channel	JOB NO. R101N		NO. 3
	CLIENT: City of Tempe	DESIGNED BY GKC	DATE 5/18/90	OF 10
	SUBJECT: IBW Drop - Local Scour	CHECKED BY JFM	DATE 5/18/90	
		REVIEWED GKC	5/27/90	

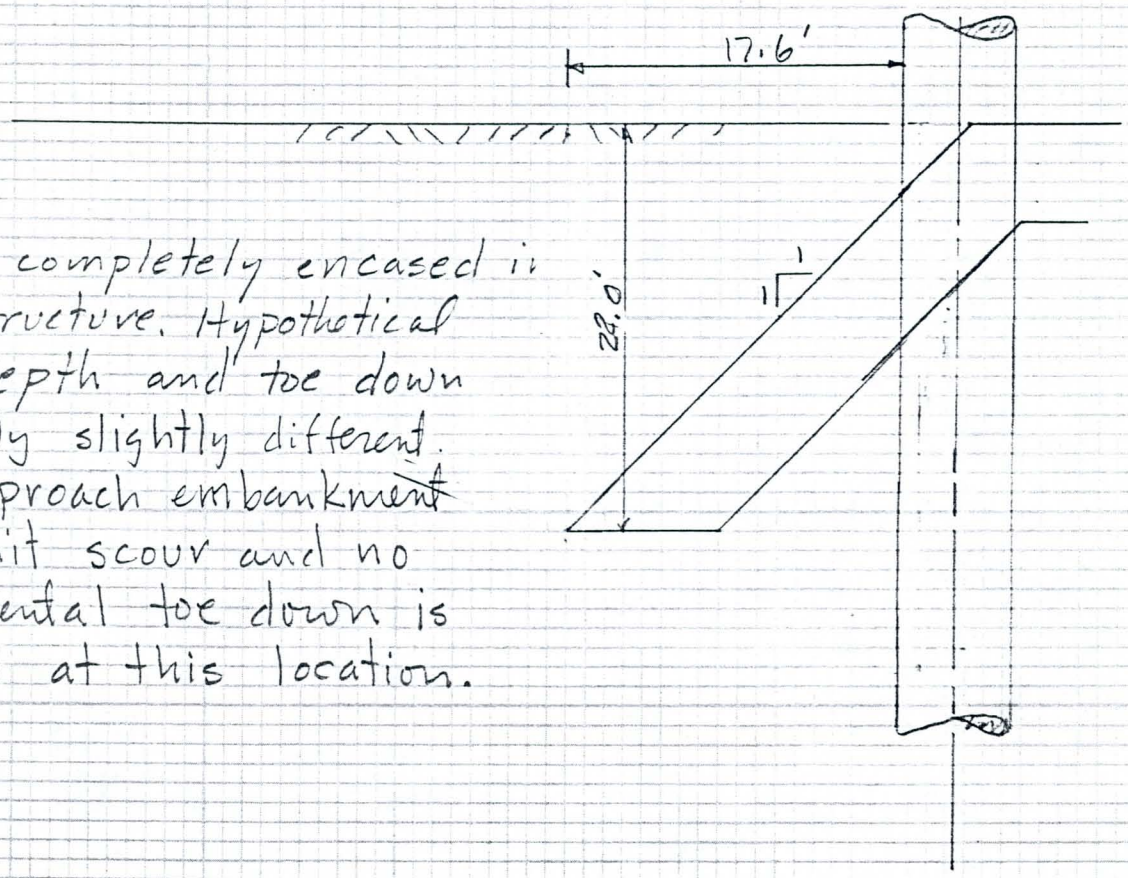


Section Along Pier 7

CRS SIRRINE	PROJECT: Ri Salado	JOB NO.: R101N	NO. 4
	CLIENT: Tempe	DESIGNED BY: GKC / DATE: 5/18/90	OF 10
	SUBJECT: IBW Drop Local Scour	CHECKED BY: JFM / DATE: 5/18/90	
		revised GKC 5/27/90	

Pier No. 6





Note:
Pier is completely encased in drop structure. Hypothetical scour depth and toe down are only slightly different. Drop approach embankment will limit scour and no supplemental toe down is required at this location.

CRSS	PROJECT: Rio Salado	JOB NO. R101N	NO. 5
CRS SIRRINE	CLIENT: Tempe	DESIGNED BY GKC / DATE 5/18/90	OF 10
	SUBJECT: IBW Drop Local Scour	CHECKED BY JFM / revised GKC / DATE 5/18/90 / 5/27/90	

Local Scour at Piers
Downstream of Level IV

Velocity at base of drop III

$V_b = 22.5$ fps $\quad y_b = 5.17'$

Critical Depth

$q = Q/T$

$= 63{,}000/537.5$

$= 117.2$ cfs/ft

$y_c = (q^2/g)^{1/3}$

$= (117.2^2/32.2)^{1/3}$

$= 7.53$

Design Velocity

$V_2 = q_2/y_2$

$= 117.2/7.53$

$= 15.6$ fps

Local Scour, CSU equation

$d_s = 2.0\, K_1 K_2 (b/y)^{0.65} F^{0.43}\, y$

$= 2.0(1.0)(1.0)(10/7.53)^{0.65}(1.0)^{0.43}\, 7.53$

$= 18.1$ ✓

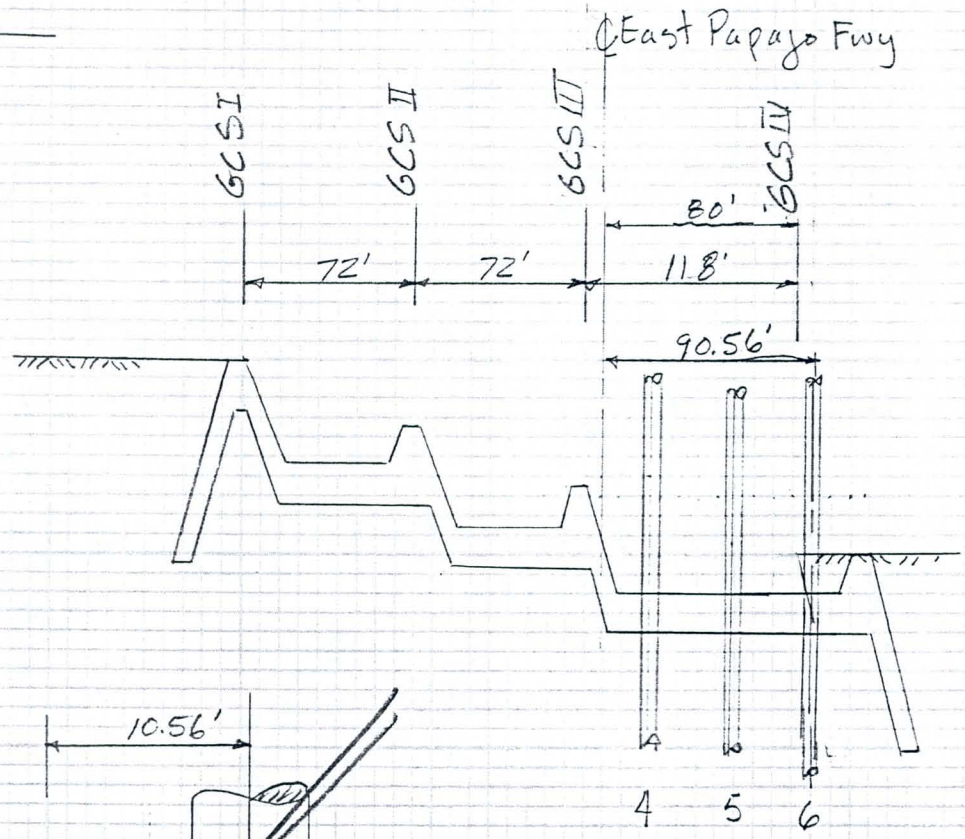
Total Pier Scour

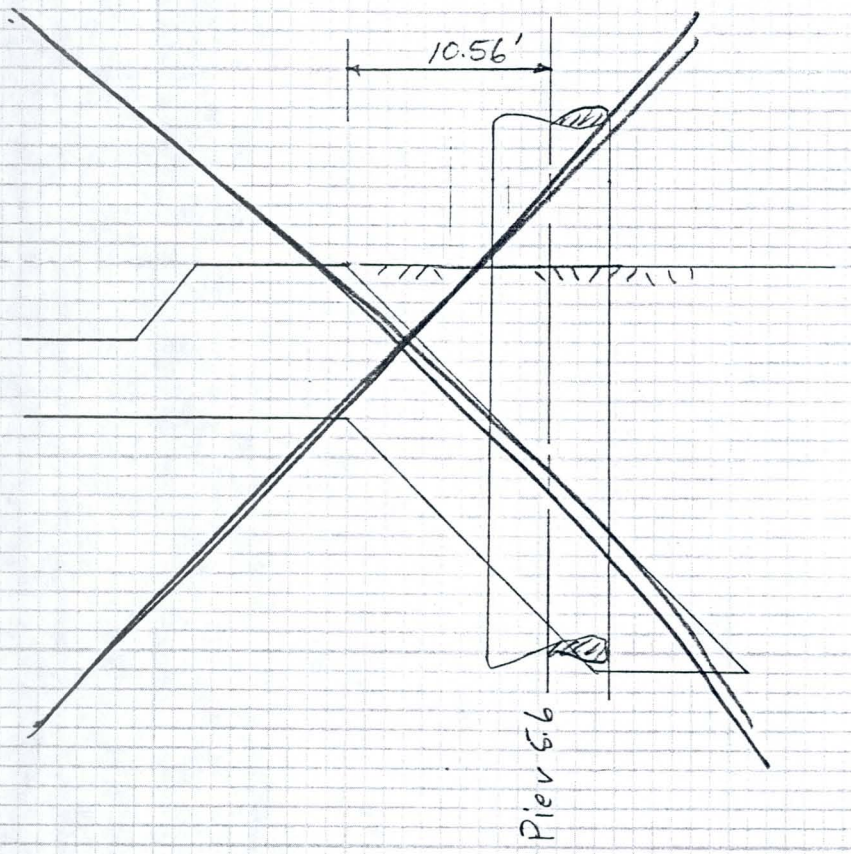
$d_{pf} = 1.3 \times 1.1 \times 18.1 = 25.9$

Pier downstream of GC

CRS SIRRINE	PROJECT: R. Salado	JOB NO.: R10IN		NO. 6 / 10
	CLIENT: City of Tempe	DESIGNED BY: GKC	DATE: 5/18/90	
	SUBJECT: Local Scour IBW Drop	CHECKED BY: JFM, revised GKC	DATE: 5/18/90, 5/27/90	

Pier 5

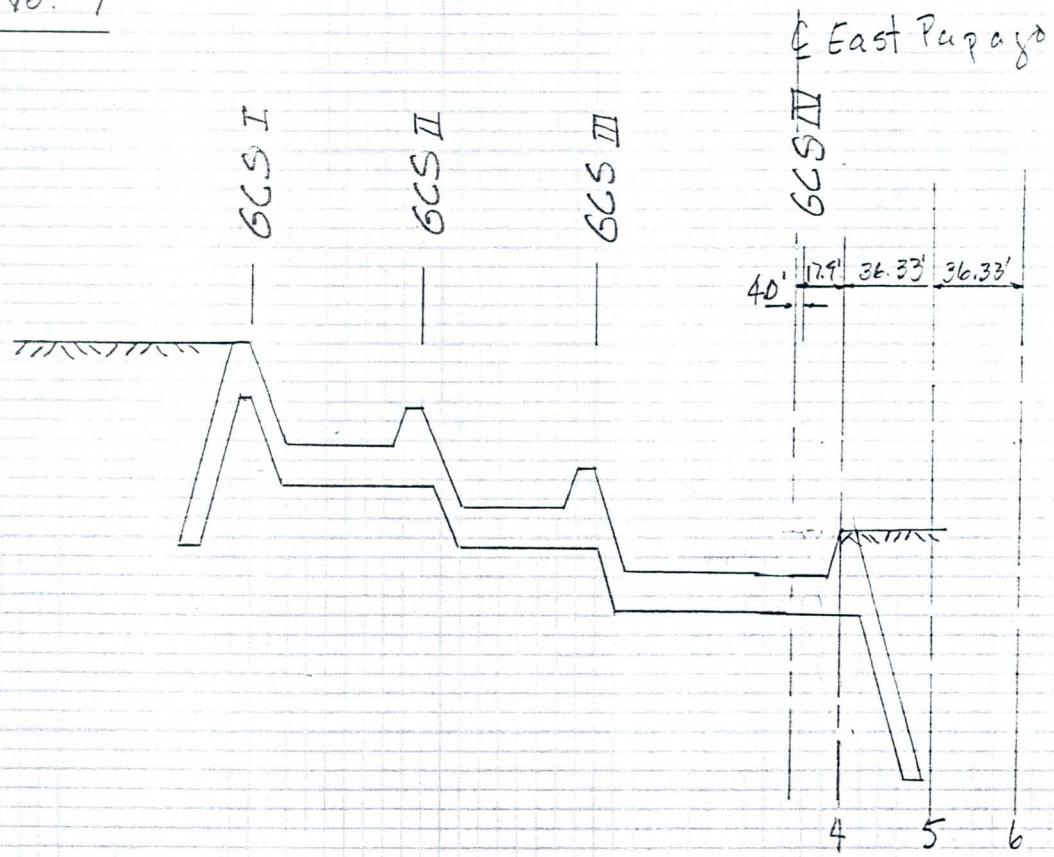


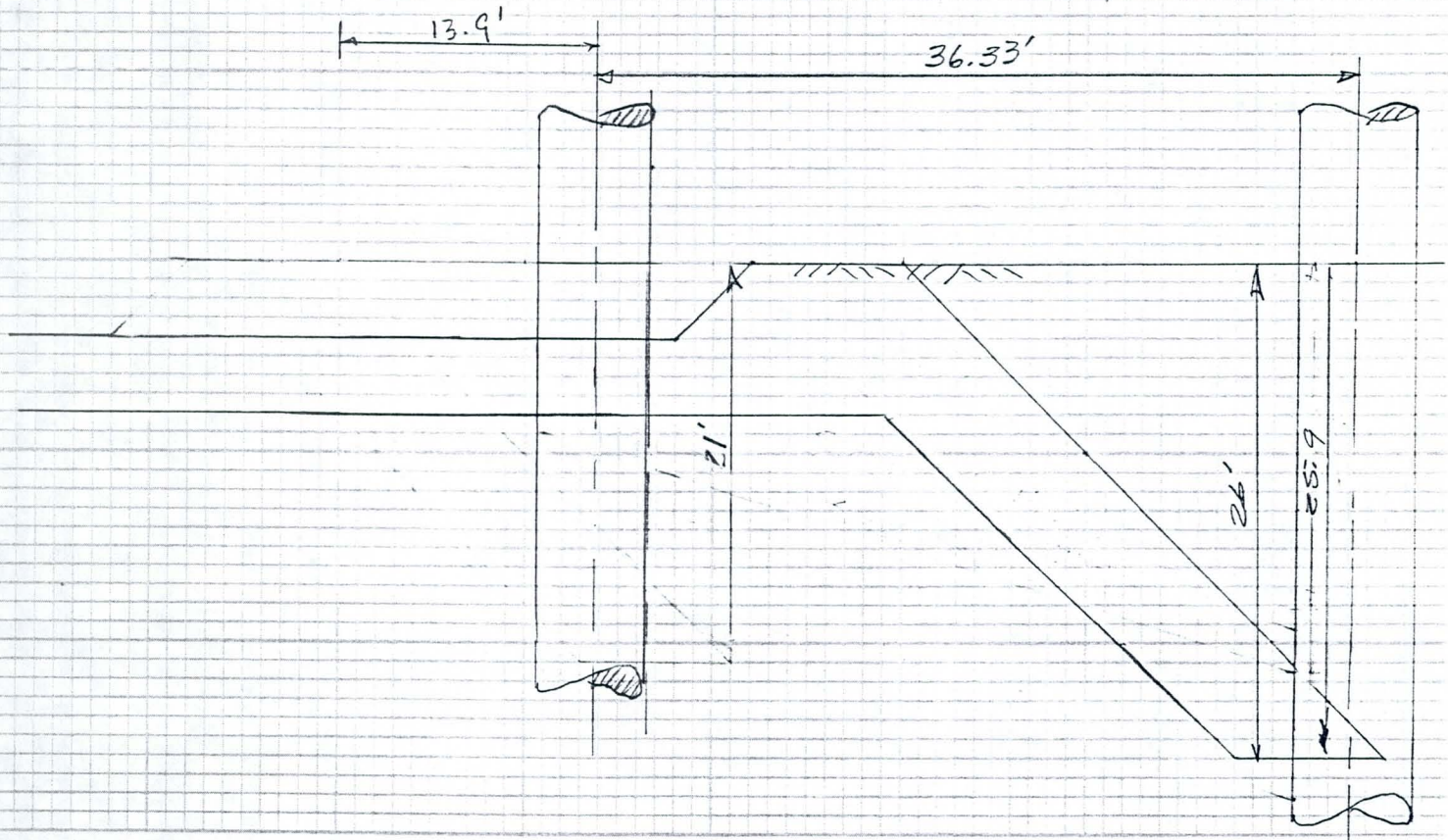


Note:
Scour is limited by encasement of pier in drop structure. No supplemental tie down is required.

CRS SIRRINE	PROJECT: R. Salado	JOB NO.: R101N	NO. 7 / 10
	CLIENT: City of Tempe	DESIGNED BY: GKC / DATE: 5/18/90	
	SUBJECT: Local Scour IBW Drop	CHECKED BY: JFM, revised GKC / DATE: 5/18/90, 5/21/90	

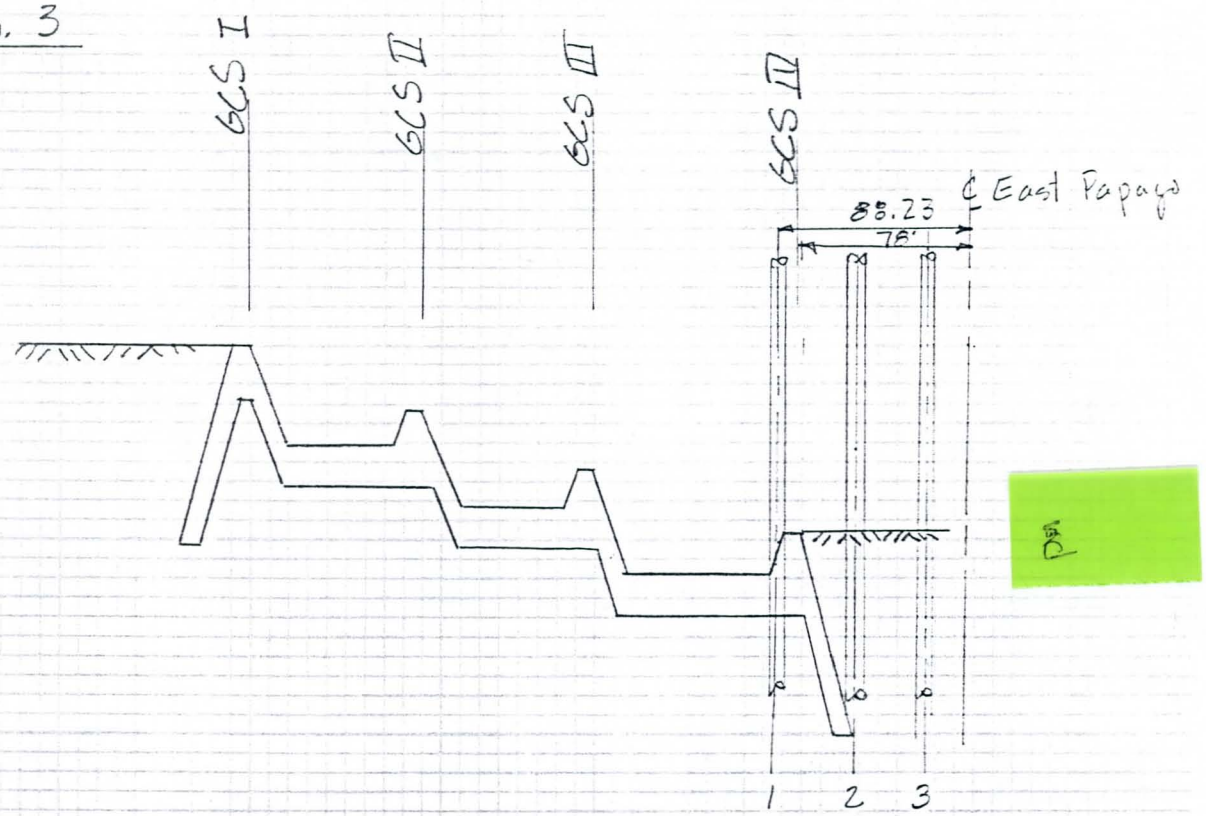
Pier No. 4

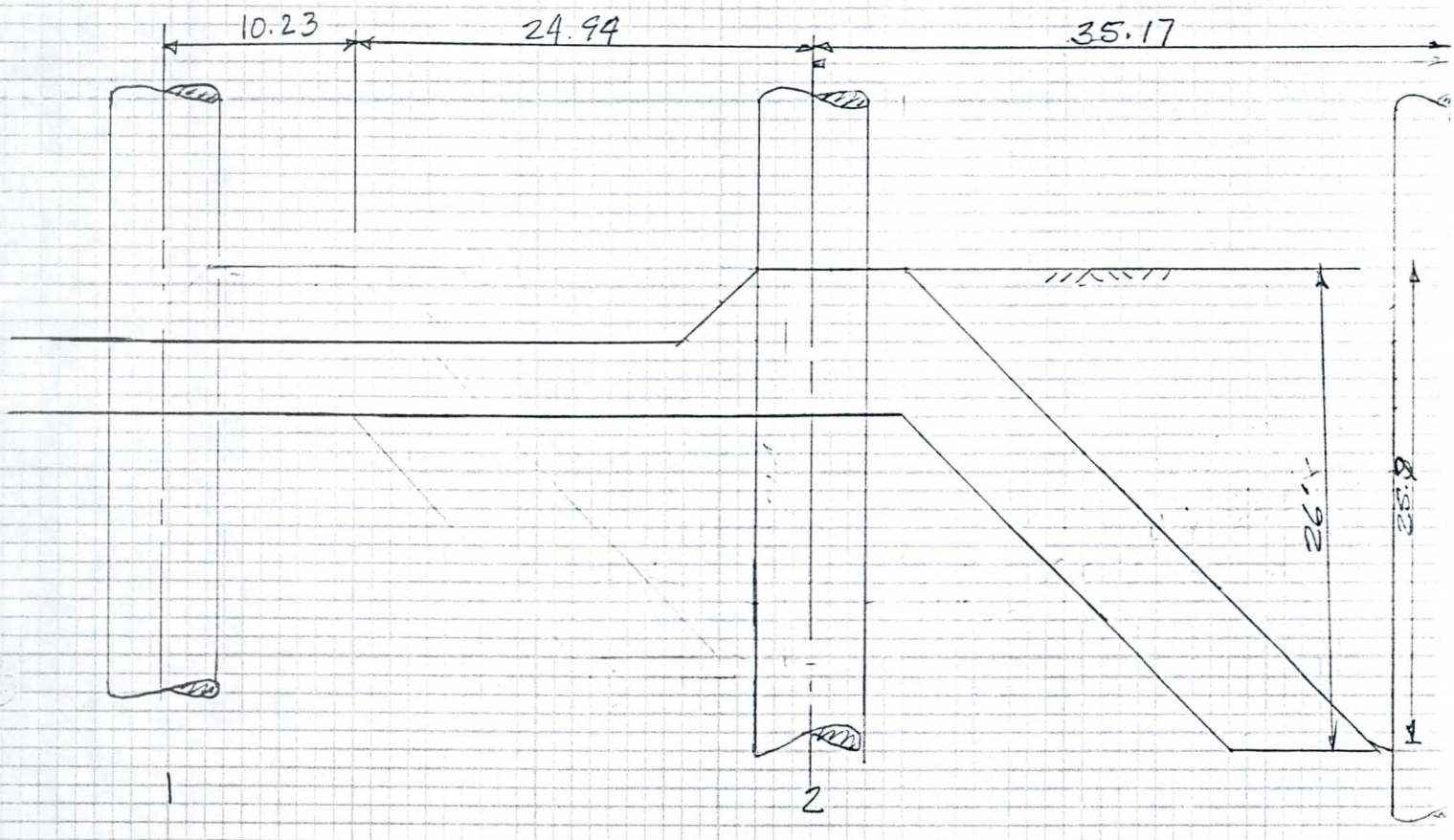




CRS SIRRINE	PROJECT: Rio Salado Channelization	JOB NO.: R101N	NO. 8 / 10
	CLIENT: City of Tempe	DESIGNED BY: GKC DATE: 5/18/90	
	SUBJECT: Local Scour IBW Drop	CHECKED BY: JFM DATE: 5/18/90	
		revised GKC 5/27/90	

Pier No. 3





Pier No 2.

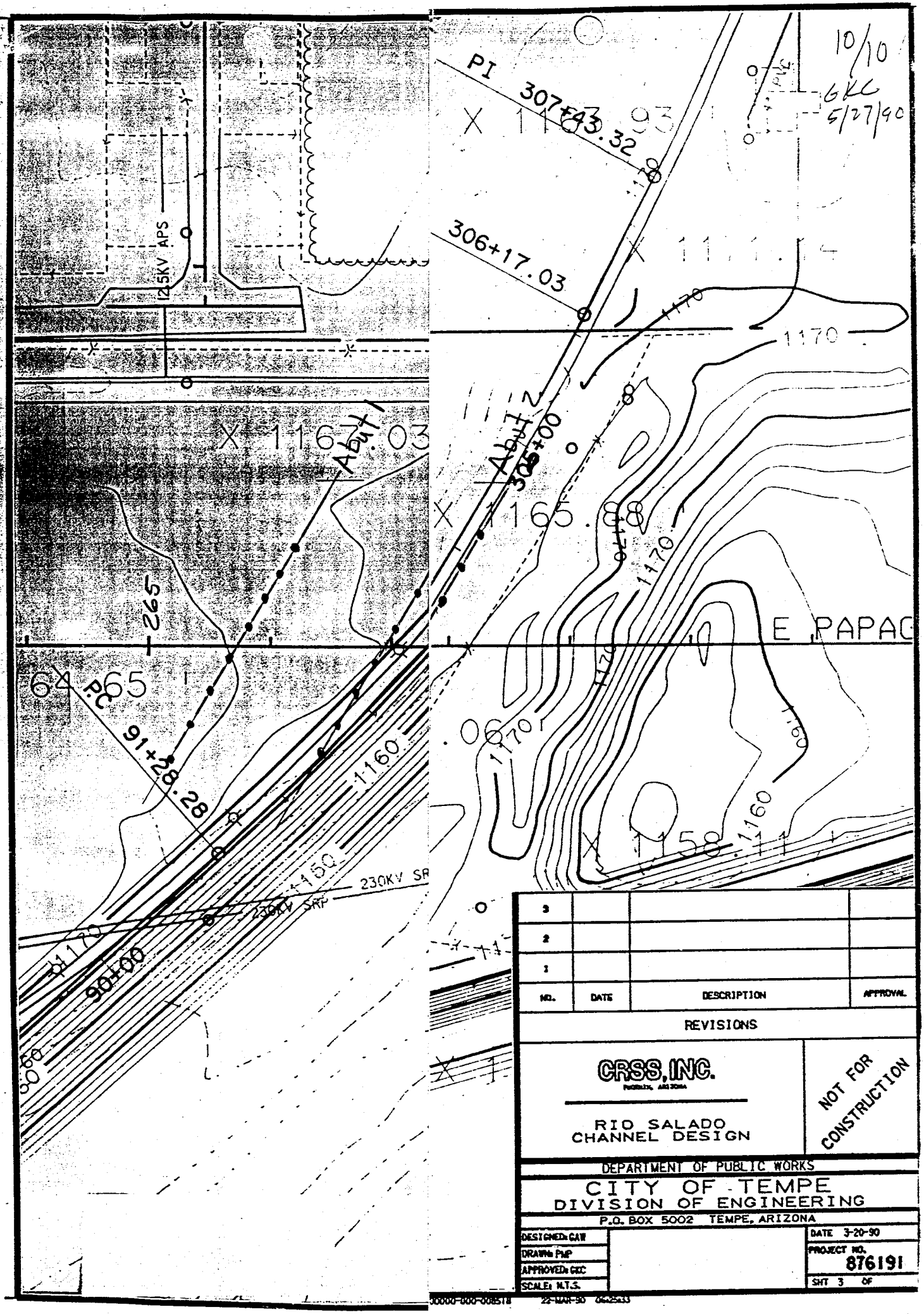
Pier 2.1 (most upstream pier) is 35 ft downstream of str 4. The local scour hole will be at 13.2 ft below the crest of str 4., i.e. local scour from pier No 2 will not effect on IBW structure.

Pier No 1

Pier 1 is located on the west bank of IBW and is unaffected by flow in either IBW or the Salt River.

Abutments 1 & 2

Both abutments are located on the banks of IBW and are unaffected by flows in either IBW or the Salt River.



NO.	DATE	DESCRIPTION	APPROVAL
3			
2			
1			

REVISIONS

CRSS, INC.
PHOENIX, ARIZONA

RIO SALADO
CHANNEL DESIGN

NOT FOR CONSTRUCTION

DEPARTMENT OF PUBLIC WORKS
CITY OF TEMPE
DIVISION OF ENGINEERING
P.O. BOX 5002 TEMPE, ARIZONA

DESIGNED: GAW
DRAWN: PMP
APPROVED: GKC
SCALE: N.T.S.

DATE 3-20-90
PROJECT NO. 876191
SHT 3 OF

30000-000-008518 22-MAR-90 06:25:33

CRSS	PROJECT: Rio Salado Channel	JOB NO: R10IN	NO. 1
	CLIENT: Tempe	DESIGNED BY: GKC / DATE: 8/27/90	OF 2
	SUBJECT: IBW Bridge Pier Protection	CHECKED BY: JFM / DATE: 8/29/90	

Flow at Gabion

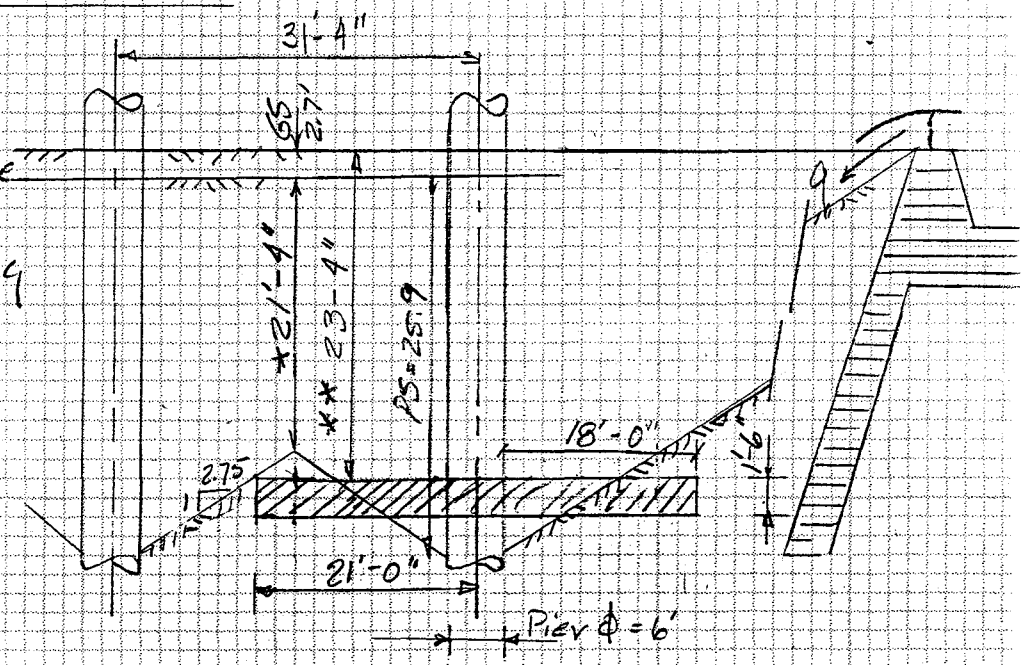
Assume:

Uniform flow down hole side slope

Note:

* Depth to overlapping pier scour

** Depth to gabion below adjacent pier scour



$$\tau_{max} = \gamma d S$$

$$= 62.4 (0.15) 0.34$$

$$= 3.2 \text{ psf}$$

$$\tau_c = 4.83 D_G$$

$$SF = \frac{\tau_c}{\tau_{max}} \quad ; \quad SF = 1.5$$

$$D_G = \frac{1.5 \times 3.2}{4.8}$$

$$= 1.0'$$

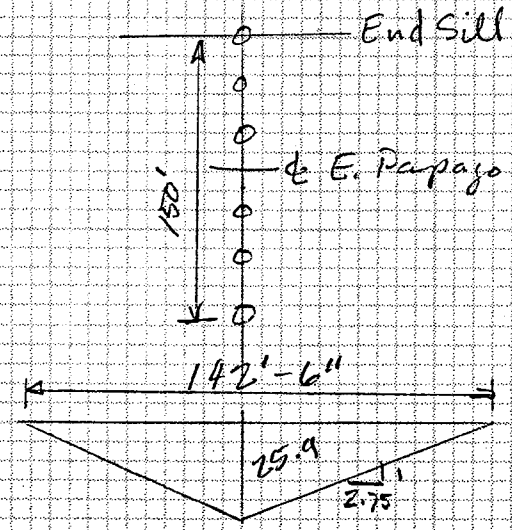
Fill Gradation: $D_{50} = 6''$

$D_{min} = 3''$

$D_{max} = 12''$

CRSS	PROJECT: Rio Salado Channel	JOB NO: R101N	NO. 2
	CLIENT: Tempe	DESIGNED BY: GKC / DATE: 8/27/90	OF 2
	SUBJECT: IBW Bridge Pier Protection	CHECKED BY: JFM / DATE: 8/29/90	

Scour Hole Volume



$$V_s = \tfrac{1}{2}(142.5)(25.9)(150) + \tfrac{1}{2}\,\frac{71.25^2\,\pi\,25.9}{3}$$

$$= 345650 \text{ cf}$$

$$= 7.9 \text{ acre-ft.}$$

Time to fill

1 cfs/ft

$$t_f = \frac{V_s}{Q} = \frac{345650}{142.5}\,\frac{1}{60}$$

$$= 40 \text{ min}$$

10 cfs/ft

$$t_f = \frac{V_s}{Q} = \frac{345650}{1425}\,\frac{1}{60}$$

$$= 4 \text{ min}$$

Assume critical depth at end sill

$$y_c = (q^2/g)^{1/3}$$

for

q	y_c	H
1	0.31	0.47
10	1.96	2.19

for side slope of scour hole

$$S = \sin(\operatorname{atan}(1/2.75)) = 0.34$$

$$q = \frac{1.49}{n}\,y^{5/3}\,S^{1/2}$$

$$y = \left(\frac{q\,n}{1.49\,S^{1/2}}\right)^{0.6} \quad ; \; n = 0.035$$

q	y_n	y_c	E	τ_o
1	0.15	6.9	0.89	3.18
10	0.58	17.3	5.23	12.3

Flow from end sill down scour hole will accelerate to normal depth

For $q = 1$ cfs the scour hole will be filled to 5' depth in $\frac{1}{33}\,t_f$ or 1.2 min

Since this depth is sufficient to dissipate energy and flow duration is brief, assume

$$\tau_{max} = \tau_{(1\,cfs)}$$

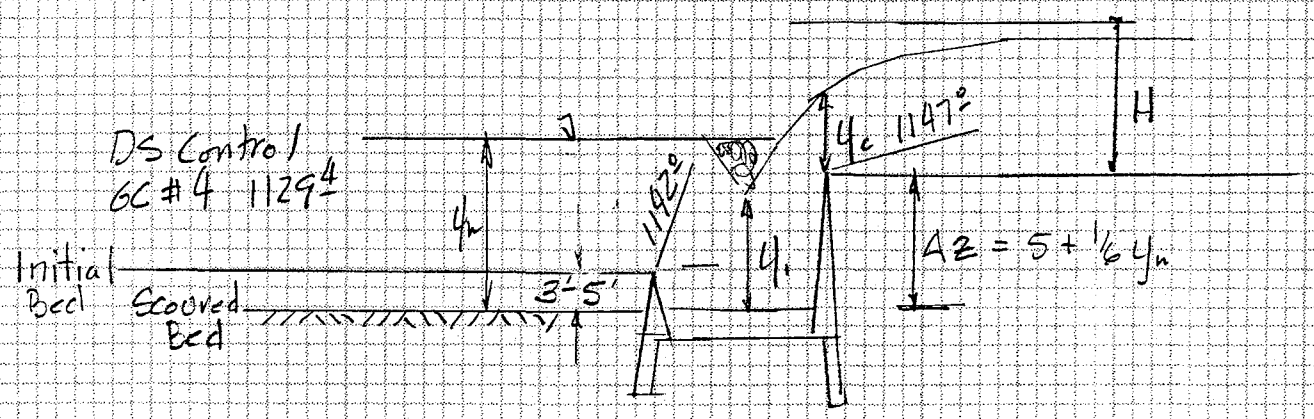
APPENDIX G

GRADE CONTROL STRUCTURE HYDRAULICS

CRSS			
PROJECT: Rio Salado Channel	JOB NO: 12101N		NO. 1
CLIENT: Tempe	DESIGNED BY: GKC	DATE: 8/27/90	OF 5
SUBJECT: Grade Control No. 5	CHECKED BY: JFM	DATE: 8/29/90	

McClintock Drive structure

A. Hydraulic Conditions



Reach length = 11,800' $n = 0.035$

Crest width = 950'

D/S channel S_o = 0.0814% for $y_s = 3'$

D/S channel S_o = 0.0644% for $y_s = 5'$

Q	q	y_{n3}	y_{n5}	y_c	H	σ_3	σ_5
1,000	1.1	0.94	1.01	0.33	0.50	0.27*	0.18
5,000	5.3	2.42	2.60	0.96	1.44	0.70*	0.40
10,000	10.5	3.65	3.91	1.51	2.27	0.69*	0.54
20,000	21.1	5.55	5.95	2.40	3.60	(d) 0.83*/0.48	0.69
40,000	42.1	8.39	9.00	3.80	5.70	0.61	(d) 0.84*/0
60,000	63.2	10.71	11.49	4.99	7.49	0.69	0.66
80,000	84.2	12.72	13.65	6.04	9.06	0.75	0.72
100,000	105.3	14.55	15.61	7.01	10.51	0.79	0.76
120,000	126.3	16.22	17.41	7.91	11.87	(d) 0.86	0.82

where $H = \frac{3}{2} y_c$

$\sigma = y_n / (H + (8 \text{ or } 10))$

* - hydraulic drop below end sill

(d) hydraulic drop submerged

B. Stilling Basin Size

Q = 120,000 cfs is the maximum unsubmerged flow that will occur at GC #5. At discharges greater than this, the drop will become a vertical expansion of the flow.

Dimensions:

$$L_d = 4.30\, y_c^{0.09}\, \Delta Z^{0.91}$$
$$= 4.30\,(7.91)^{0.09}\,(5 + \tfrac{1}{6}\,13.0)^{0.91}$$
$$= 31.1$$

$$y_1 = 0.54\, y_c^{1.275} / \Delta Z^{0.275}$$
$$= 0.54\,(7.91)^{1.275} / (5 + \tfrac{1}{6}\,13.0)^{0.275}$$
$$= 4.4$$

$$L_j = 6.9\,(13.0 - 4.4)$$
$$= 59.5$$

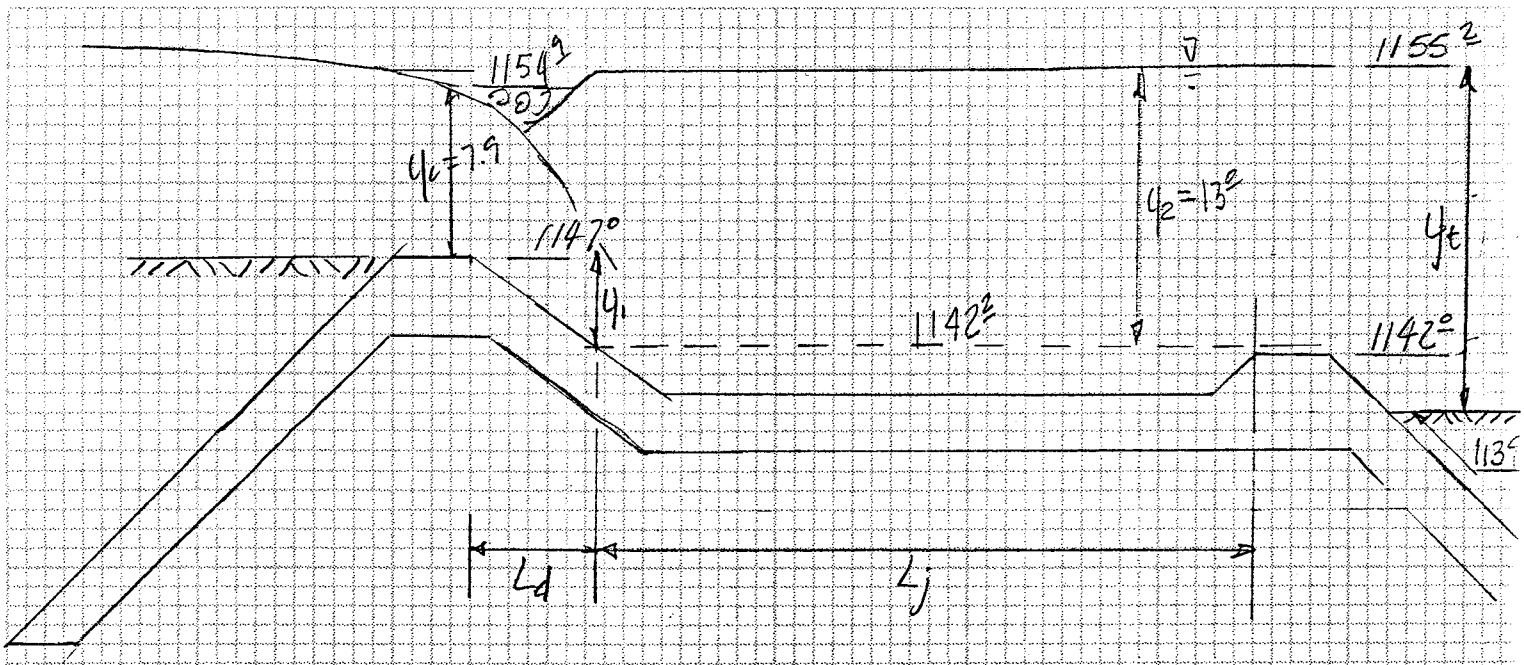
$$F_1 = q/\sqrt{g y_1^3}$$
$$= 126.3/\sqrt{32.2 \times 4.4^3}$$
$$= 2.41$$

$$y_2 = (y_1/2)\left(\sqrt{1 + 8F_1^2} - 1\right)$$
$$= 13.0'$$

$$\frac{y_{TW}}{y_2} = \frac{16.2}{13.0} = 1.25$$

$$\frac{y_{TW}}{y_1} = \frac{16.2}{4.4} = 3.7$$

CRSS	PROJECT: Rio Salado Channel	JOB NO: R10IN	NO. 3
	CLIENT: Tempe	DESIGNED BY: GKC / DATE: 8/28/90	OF 5
	SUBJECT: GC # 5	CHECKED BY: JFM / DATE: 8/29/90	



① Since the drop has a high submergence at this discharge the jump will actually begin on the drop slope.

② The drop length L_d is much shorter than given by the previous equation. Following Elevatorski's procedure

$$L_d = 1.5(1147.0 - (1139.0 + y_t - y_2))$$
$$= 1.5(1147.0 - (1139.0 + 16.2 - 13))$$
$$= 7.2$$

<u>Total Basin Length</u>

$$L_t = L_d + L_j$$
$$= 59.5 + 7.2$$
$$= 66.7'$$

CRSS	PROJECT: Rio Salado Channel	JOB NO: R101N	NO. 4
	CLIENT: Tempe	DESIGNED BY: GKC / DATE: 8/28/90	
	SUBJECT: GC #5	CHECKED BY: JFM / DATE: 8/29/90	OF 5

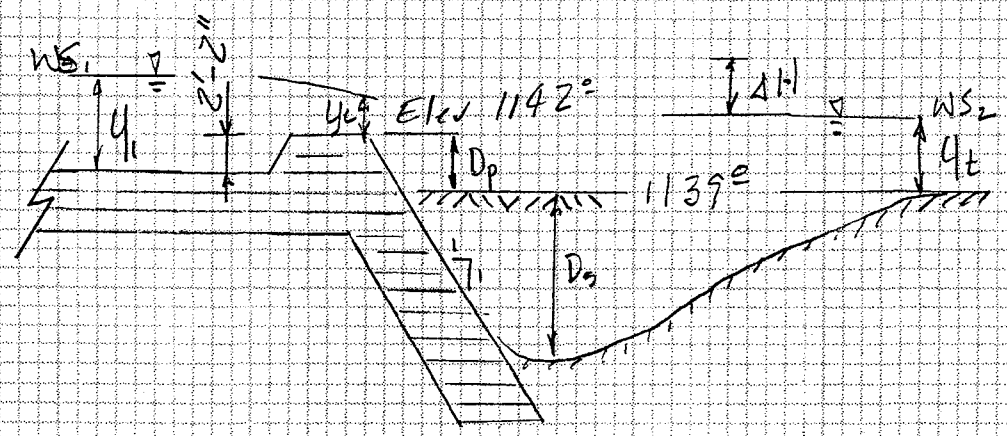
For other discharges*

Q	y_1	y_2	TW	L_j	L_d	L_t
120,000	4.4	13.0	16.2	59.3	7.2	66.7
100,000	3.8	11.8	14.6	55.4	7.8	63.2
80,000	3.1	10.5	12.7	50.7	8.6	59.3
60,000	2.4	8.9	10.7	44.9	9.4	54.3
40,000	1.7	7.2	8.4	37.7	10.2	47.9
20,000	1.0	4.9	5.6	27.3	11.0	38.3

* $\Delta Z_0 = 7.2$ for other Q's

CRSS			
PROJECT: Rio Salado Channel	JOB NO: R10IN		NO. 5
CLIENT: Tempe	DESIGNED BY: GKC	DATE: 8/28/90	OF 5
SUBJECT: GC #5	CHECKED BY: JFM	DATE: 8/29/90	

C. Scour Below End Sill



Q	q	WS1	WS2	ΔH*	yt	y1	Sr
1000	1.1	1142.5	1139.9	2.6	0.9	0.5	-
5000	5.3	1143.4	1141.4	2.0	2.4	1.4	-
10000	10.5	1144.3	1142.7	1.6	3.7	2.3	0.30
20000	21.1	1145.6	1144.6	1.0	5.6	3.6	0.7
40000	42.1	1147.7	1147.4	0.3	8.4	5.7	0.9

$\Delta H = WS_1 - WS_2$; $S_r = (y_t - D_p)/y_1$

where $D_p = 3.0'$

$$D_s = 1.36\, y_c\, (\Delta H / y_t)^{0.158}\, S_r^{-0.134}$$

Q	yc	ΔH/yt	Ds
1000	0.33	2.89	—
5000	0.96	0.83	—
10000	1.51	0.43	2.11
20000	2.40	0.18	2.60
40000	3.80	0.04	3.13

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HYDRAULIC ENERGY DISSIPATORS

EDWARD A. ELEVATORSKI
Head, Hydraulics Laboratory and
Assistant Professor of Civil Engineering
University of Arizona

McGRAW-HILL BOOK COMPANY, INC.
NEW YORK TORONTO LONDON
1959

By increasing the tailwater depth, it is possible for the designer to move the front of the hydraulic jump up on the sloping apron. There are, in general, three types of jump formations that can occur on a sloping floor. These are shown in Fig. 6-1*a*, *b*, and *c*.

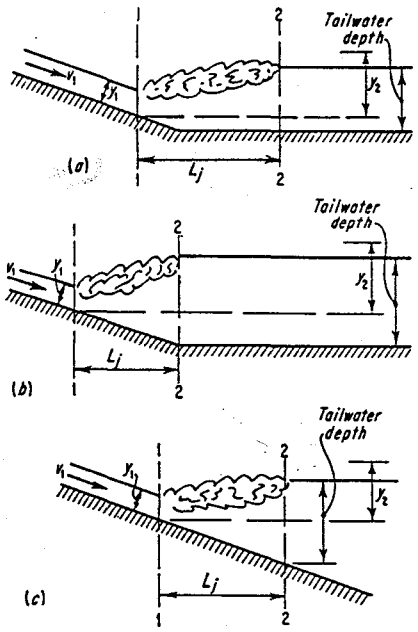


FIG. 6-1. Occurrence of the hydraulic jump on a sloping apron: (a) case I, (b) case II, (c) case III.

The different formations of the hydraulic jump depend primarily upon where the terminus of the jump falls. As shown in Fig. 6-1*a*, case I prevails when the toe of the hydraulic jump forms on the slope, while the terminus, or end, of the jump occurs on the horizontal apron.

In case II, illustrated by Fig. 6-1*b*, the toe of the hydraulic jump occurs on the slope as in case I, but the end of the jump occurs at the junction of the slope and the horizontal apron.

As shown in Fig. 6-1*c*, case III prevails when the hydraulic jump forms entirely on the sloping apron. Cases II and III are practically the same, and further analysis will be made only of cases I and III.

It will be noted that case II is virtually that of the hydraulic jump formed on a horizontal apron, operating with excessive tailwater. As the tailwater is further increased, the formation of the hydraulic jump can be changed progressively from case I to case II and finally to case III.

If the tailwater depth is increased by a vertical element Δy, the front of the hydraulic jump does not rise an equal amount vertically. Instead, the jump profile undergoes an immediate change as the slope becomes part of the stilling basin, as illustrated by Fig. 6-2.

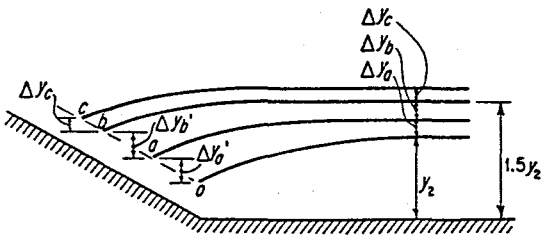


FIG. 6-2. Profile of the hydraulic jump on a sloping apron.

For an increase in tailwater
on the slope to point *a*, or mo
several times Δy_a. The same
front of the hydraulic jump is
of tailwater depth produce the
will continue until the tailwate
greater than this amount, the
tailwater depth Δy_c moves the
equal vertical distance Δy_c.

6-2. Historical Résumé. Ti
tion of the hydraulic jump was
of the Miami Conservancy Dis
Riegel were principally intere
apron upon the design of the (

In 1927, Ellms[5] conducted s
4 feet long, whose slope coul
Several erroneous results were
section of the flume he used w
Also, Ellms neglected to comp
bottom of the flume and to n
flume.

An analysis was attempted
apron-floor pressure under the
profile from the beginning to t
made in a glass-walled flume 2.
tigations were made on slopes c
tunately, Yarnell's work was i

In 1935, Rindlaub[9] conducte
of California hydraulic labora
walled flume 3 ft deep and 0
four slopes of 8.2, 12.5, 24.2, a
made on the slope of 12.5°.
the pressure component on th
term, which can be determi
external forces.

Experiments in a rectangula
14 were performed in 1936 at
Matzke.[1] In order to compen
floor, a dimensionless cubic ec
be dependent upon the shape
investigated were very small,
made from the results.

During 1941, Puls[8] presente

For an increase in tailwater depth Δy_a, the front of the jump moves up on the slope to point a, or moves a vertical distance $\Delta y'_a$, which may be several times Δy_a. The same effect occurs to a lesser degree when the front of the hydraulic jump is moved to point b. Additional increments of tailwater depth produce the same effect, only to a lesser degree. This will continue until the tailwater approaches $1.5y_2$. For tailwater depths greater than this amount, the relation is geometric, and an increase in tailwater depth Δy_c moves the front of the hydraulic jump on the slope an equal vertical distance Δy_c.

6-2. Historical Résumé. The effect of a sloping floor upon the formation of the hydraulic jump was first studied in 1917 by Beebe and Riegel[2] of the Miami Conservancy District, located in Dayton, Ohio. Beebe and Riegel were principally interested in studying the effect of a stepped apron upon the design of the Germantown Dam outlet works.

In 1927, Ellms[5] conducted several experiments in a rectangular flume 4 feet long, whose slope could be varied from approximately 9 to 17°. Several erroneous results were obtained by Ellms because the horizontal section of the flume he used was too small to contain the hydraulic jump. Also, Ellms neglected to compensate for the pressure force exerted on the bottom of the flume and to make allowances for the flaring sides of the flume.

An analysis was attempted by Yarnell, in 1934, to determine the apron-floor pressure under the hydraulic jump by assuming a straight-line profile from the beginning to the end of the jump. Over 600 tests were made in a glass-walled flume 2.5 ft wide, 3 ft deep, and 30 ft long. Investigations were made on slopes of 1 on 6, 1 on 3, 1 on 2, and 1 on 1. Unfortunately, Yarnell's work was interrupted by his death.

In 1935, Rindlaub[9] conducted a series of experiments at the University of California hydraulic laboratory. Experiments were made in a glass-walled flume 3 ft deep and 0.5 ft wide. Investigations were made on four slopes of 8.2, 12.5, 24.2, and 30°, with most of the experiments being made on the slope of 12.5°. In his analysis, Rindlaub compensated for the pressure component on the sloping floor by including a dimensionless term, which can be determined experimentally, to account for any external forces.

Experiments in a rectangular channel having a maximum slope of 1 on 14 were performed in 1936 at Columbia University by Bakhmeteff and Matzke.[1] In order to compensate for the weight of the jump on a sloping floor, a dimensionless cubic equation was developed which was found to be dependent upon the shape of the jump. Unfortunately, the slopes investigated were very small, and consequently no generalization can be made from the results.

During 1941, Puls[8] presented a method of routing stream flow through

CRSS	PROJECT: Rio Salado Channel	JOB NO. R101N	NO. 1
CRS SIRRINE	CLIENT: Tempe	DESIGNED BY GKC / DATE 8/28/90	OF 1
	SUBJECT: McClintock Grade Control	CHECKED BY JFM / DATE 8/29/90	

Slab Thickness

A. Local uplift on slab

$$\tau_{max} = 2.0 \frac{n^2}{2.21} 62.4 \cdot d_a^{-1/3} V_a^2$$

use $n = 0.024$

$V_a = 28.7$

$d_a = 4.4$

$$\tau_{max} = 2.0 \frac{(0.024)^2}{2.21} 62.4 (4.4)^{-1/3} (28.7)^2$$

$= 16.4$ psf

B. slab Thickness

For $SF = 1.5$

$\tau_c = 4.1\ S$ (150 lb/ft^3 density)

where S = slab thickness

$S = SF(\tau_{max}/4.1)$

$= 1.5(16.4/4.1)$

$= 6.0$ ft

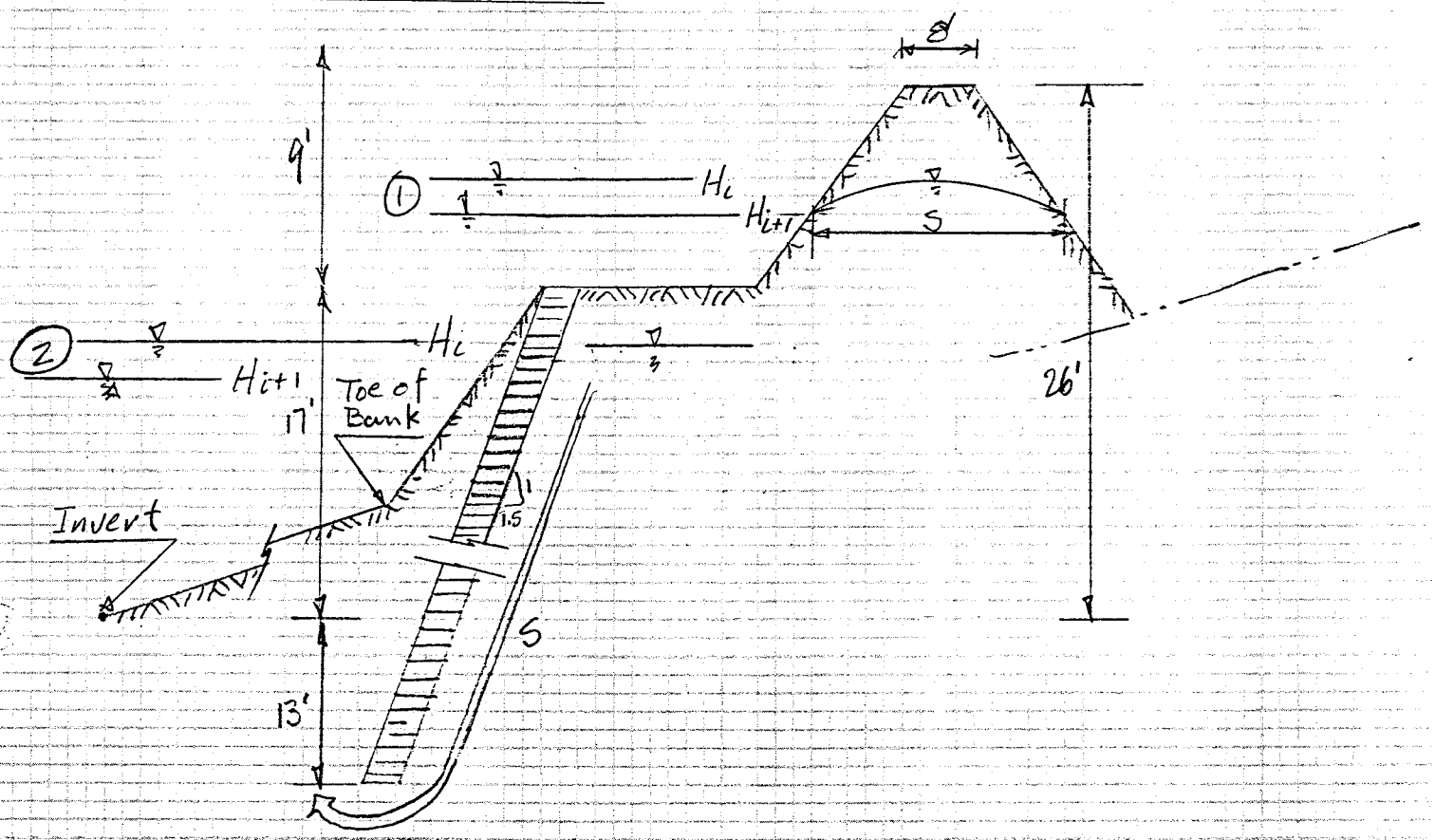
Use 6.0 ft slab thickness

APPENDIX H

BANK STABILITY

CRS SIRRINE	PROJECT: Rio Salado	JOB NO. R101N	NO. 1
	CLIENT: Tempe	DESIGNED BY GKC / DATE 8/24/90	OF 3
	SUBJECT: Bank Stability	CHECKED BY JEM / DATE 8/29/90	

Definition Sketch



① Case I: Water surface is above hard bank and drains laterally through levee banks.

② Case II: Water surface is below hard bank and drains to channel from beneath the hard bank.

For case I : $S = [3(26 - y_{i+1}) + 4]2 = 164 - 6y_{i+1}$

For case II : $S = 1.8y_i + 8 + 13 = 21 + 1.8y_i$

Draw Down Rate

Case I: This is similar to a condition of parallel drains where

$$S^2 = \frac{4kH}{v}(2d+H)$$

solving for unit inflow rate

$$v = \frac{4kH}{S^2}(2d+H)$$

For a large depth to aquiclude the effective depth to a barrier layer, d, is about

$$d = \frac{S}{12.5} + 3$$

Case II: The unit inflow rate is simply

$$v = ki$$

where $i = \Delta h / S$

where S is the path length through the embankment.

Conductivity

For coarse sand $k = 0.052$ cm/s
For gravel $k = 0.403$ cm/s

The outer envelope for Salt River bed material which describes the finest gradation of material gives $D_{50} = 10$ mm
This is medium to fine gravel use

$$k = \sqrt{0.052 \times 0.403} = 0.14 \text{ cm/sec}$$

CRS SIRRINE	PROJECT: Rio Salado	JOB NO. R101N	NO. 3
	CLIENT: Tempe	DESIGNED BY GKC / DATE 8/24/90	
	SUBJECT: Bank Stability	CHECKED BY JFM / DATE 8/29/90	OF 3

Spread Sheet Equations

2/7 $$y = \left[\frac{qn}{1.49\,S^{1/2}}\right]^{0.6}$$

where $n = 0.035$; $S = 0.105\%$

$$y = 0.82\,q^{0.6}$$

3/7 $\Delta h = y_{i+1} - y_i$

4/7 if $\Delta h < 0$

if $y_{i+1} > 17$

$S = 164 - 6\,y_{i+1}$

if $y_{i+1} < 17$

$S = 21. + 1.8\,y_i$

else no computation

5/7 if $\Delta h < 0$

if $y_{i+1} > 17$

$V = 4kH(1/6.25*S + 6/S^2 + H)$

if $y_{i+1} < 17$

$V = k\,\Delta h/S$

6/7 $\Delta h_d = V*(6*3600)$

$= 21{,}600\,V$

7/7 if $\Delta h < h_d$ then "drains" else "pools"

23-Aug-90 DATE

Job: R101M Date
Calc by: GRC 8/24/90
Checked by: JFM 8/29/90
Dwg Chk:

Salt River Flood Hydrographs
Location: Granite Reef Dam

Discharge Hydrograph:

Time	50-yr	100-yr	200-yr	300-yr	500-yr
0	0.0	0.0	0.0	0.0	0.0
6	6540.0	10085.0	14090.0	14514.4	15015.0
12	13080.0	20170.0	28180.0	29028.8	30030.0
18	13530.0	20670.0	28960.0	29582.4	30310.0
24	14720.0	21630.0	30610.0	31441.8	32420.0
30	11530.0	24110.0	33230.0	34062.8	35040.0
36	10610.0	36000.0	37970.0	38740.4	39640.0
42	13040.0	37000.0	39260.0	39838.5	40510.0
48	13040.0	40870.0	43350.0	43970.3	44690.0
54	24780.0	41610.0	45140.0	45742.1	46440.0
60	28140.0	43170.0	46420.0	47003.8	47680.0
66	27020.0	46060.0	48580.0	51231.9	54440.0
72	42960.0	66880.0	70790.0	74650.4	79320.0
78	76320.0	101060.0	109820.0	114787.7	120740.0
84	112760.0	142850.0	158560.0	165853.8	174600.0
90	150000.0	174000.0	193000.0	203500.2	216200.0
96	106700.0	122240.0	133610.0	227000.0	274000.0
102	96610.0	104490.0	113520.0	150000.0	248630.0
108	101910.0	108170.0	116280.0	128500.0	215540.0
114	84710.0	88210.0	122490.0	137689.4	157380.0
120	67420.0	70650.0	100190.0	110313.6	123140.0
126	49490.0	52440.0	81930.0	88292.5	96170.0
132	42990.0	45610.0	72060.0	77366.4	83910.0
138	42990.0	44590.0	69480.0	73193.3	77680.0
144	40940.0	44260.0	65920.0	68302.2	71130.0
150	40940.0	44030.0	64300.0	65955.7	67900.0
156	39550.0	42370.0	46830.0	47257.1	47750.0
162	39550.0	41300.0	44880.0	45394.7	45990.0
168	38470.0	41300.0	41010.0	41712.5	42530.0
174	38060.0	40270.0	40120.0	41227.3	42530.0
180	38060.0	40270.0	40120.0	41227.3	42530.0
186	38060.0	40110.0	39650.0	40969.0	42530.0
192	38060.0	38820.0	39650.0	40393.4	41260.0
198	37290.0	37520.0	39370.0	39709.0	40100.0
204	37290.0	37520.0	39370.0	39709.0	40100.0
210	37290.0	37220.0	39370.0	39709.0	40100.0
216	36580.0	36440.0	39370.0	39709.0	40100.0
222	38580.0	36440.0	38240.0	39042.4	39980.0
228	36030.0	36120.0	37870.0	38338.1	38880.0
234	35180.0	35550.0	37870.0	38338.1	38880.0
240	35180.0	35550.0	37870.0	38338.1	38880.0

23-Aug-90 DATE

Job: 240N Date
Calc by: GKC 8/24/90
Checked by: JFM 8/29/90
Dwg Chk:

Salt River Flood Hydrographs
Location: Granite Reef Dam

Stage Hydrograph:

Time	50-yr	100-yr	200-yr	300-yr	500-yr
0	0.0	0.0	0.0	0.0	0.0
6	2.5	3.3	4.0	4.1	4.2
12	3.9	5.0	6.1	6.2	6.3
18	3.9	5.1	6.2	6.3	6.4
24	4.1	5.2	6.4	6.5	6.6
30	3.6	5.6	6.7	6.8	7.0
36	3.4	7.1	7.3	7.4	7.5
42	3.8	7.2	7.5	7.5	7.6
48	3.8	7.6	7.9	8.0	8.1
54	5.7	7.7	8.1	8.2	8.2
60	6.1	7.9	8.2	8.3	8.4
66	6.0	8.2	8.5	8.7	9.1
72	7.9	10.3	10.6	11.0	11.4
78	11.1	13.2	13.8	14.2	14.6
84	14.0	16.2	17.2	17.7	18.3
90	16.7	18.2	19.4	20.0	20.8
96	13.6	14.7	15.5	21.4	23.9
102	12.8	13.4	14.1	16.7	22.6
108	13.2	13.7	14.3	15.2	20.7
114	11.8	12.1	14.8	15.8	17.2
120	10.3	10.6	13.1	13.9	14.8
126	8.6	8.9	11.6	12.1	12.8
132	7.9	8.2	10.7	11.2	11.8
138	7.9	8.0	10.5	10.8	11.2
144	7.6	8.0	10.2	10.4	10.7
150	7.6	8.0	10.0	10.2	10.4
156	7.5	7.8	8.3	8.3	8.4
162	7.5	7.7	8.1	8.1	8.2
168	7.4	7.7	7.7	7.7	7.8
174	7.3	7.6	7.6	7.7	7.8
180	7.3	7.6	7.6	7.7	7.8
186	7.3	7.6	7.5	7.7	7.8
192	7.3	7.4	7.5	7.6	7.7
198	7.2	7.3	7.5	7.5	7.6
204	7.2	7.3	7.5	7.5	7.6
210	7.2	7.2	7.5	7.5	7.6
216	7.1	7.1	7.5	7.5	7.6
222	7.4	7.1	7.3	7.4	7.5
228	7.1	7.1	7.3	7.4	7.4
234	7.0	7.0	7.3	7.4	7.4
240	7.0	7.0	7.3	7.4	7.4

where $\text{stage} = \left(\frac{qn}{1.49 S^{1/2}}\right)^{0.6}$

$n = 0.035$

$S = 0.105\%$

23-Aug-90 DATE

Job: 1210/N Date
Calc by: GLC 8/24/90
Checked by: JFM 8/29/90
Dwg Chk:

Salt River Flood Hydrographs
Location: Granite Reef Dam

Stage Fall (ft):

Time	50-yr	100-yr	200-yr	300-yr	500-yr
0	--	--	--	--	--
6	NA	NA	NA	NA	NA
12	NA	NA	NA	NA	NA
18	NA	NA	NA	NA	NA
24	NA	NA	NA	NA	NA
30	0.6	NA	NA	NA	NA
36	0.2	NA	NA	NA	NA
42	NA	NA	NA	NA	NA
48	NA	NA	NA	NA	NA
54	NA	NA	NA	NA	NA
60	NA	NA	NA	NA	NA
66	0.1	NA	NA	NA	NA
72	NA	NA	NA	NA	NA
78	NA	NA	NA	NA	NA
84	NA	NA	NA	NA	NA
90	NA	NA	NA	NA	NA
96	3.1	3.5	3.8	NA	NA
102	0.8	1.3	1.4	4.7	1.4
108	NA	NA	NA	1.5	1.9
114	1.4	1.6	NA	NA	3.6
120	1.5	1.5	1.7	2.0	2.3
126	1.7	1.7	1.5	1.7	2.0
132	0.7	0.7	0.9	0.9	1.0
138	NA	0.1	0.2	0.4	0.5
144	0.2	0.0	0.3	0.4	0.6
150	NA	0.0	0.2	0.2	0.3
156	0.2	0.2	1.7	1.8	2.0
162	NA	0.1	0.2	0.2	0.2
168	0.1	NA	0.4	0.4	0.4
174	0.0	0.1	0.1	0.1	NA
180	NA	NA	NA	NA	NA
186	NA	0.0	0.1	0.0	NA
192	NA	0.1	NA	0.1	0.1
198	0.1	0.1	0.0	0.1	0.1
204	NA	NA	NA	NA	NA
210	NA	0.0	NA	NA	NA
216	0.1	0.1	NA	NA	NA
222	NA	NA	0.1	0.1	0.0
228	0.3	0.0	0.0	0.1	0.1
234	0.1	0.1	NA	NA	NA
240	NA	NA	NA	NA	NA

where fall = $stage_{i+1} - stage_i$

if fall < 0 then na (not computed)

24-Aug-90 DATE

Salt River Flood Hydrographs
Location: Granite Reef Dam

Job: 1210/N Date
Calc by: GLC 8/29/90
Checked by: JFM 8/29/90
Dwg Chk:

Drainage Path Length:

Time	50-yr	100-yr	200-yr	300-yr	500-yr
0	--	--	--	--	--
6	NA	NA	NA	NA	NA
12	NA	NA	NA	NA	NA
18	NA	NA	NA	NA	NA
24	NA	NA	NA	NA	NA
30	28.5	NA	NA	NA	NA
36	27.4	NA	NA	NA	NA
42	NA	NA	NA	NA	NA
48	NA	NA	NA	NA	NA
54	NA	NA	NA	NA	NA
60	NA	NA	NA	NA	NA
66	32.0	NA	NA	NA	NA
72	NA	NA	NA	NA	NA
78	NA	NA	NA	NA	NA
84	NA	NA	NA	NA	NA
90	NA	NA	NA	NA	NA
96	51.0	53.8	55.9	NA	NA
102	45.5	47.5	49.0	59.5	28.6
108	NA	NA	NA	51.0	39.7
114	44.8	45.7	NA	NA	61.1
120	42.3	42.8	47.6	49.5	51.9
126	39.6	40.1	44.5	45.9	47.7
132	36.4	37.0	41.9	42.8	44.0
138	NA	35.7	40.3	41.2	42.2
144	35.2	35.5	39.9	40.5	41.2
150	NA	35.4	39.3	39.7	40.2
156	34.8	35.4	39.0	39.3	39.6
162	NA	35.1	35.9	36.0	36.1
168	34.5	NA	35.5	35.6	35.8
174	34.3	34.8	34.8	34.9	NA
180	NA	NA	NA	NA	NA
186	NA	34.6	34.6	34.8	NA
192	NA	34.6	NA	34.8	35.1
198	34.2	34.3	34.5	34.7	34.8
204	NA	NA	NA	NA	NA
210	NA	34.1	NA	NA	NA
216	34.0	34.0	NA	NA	NA
222	NA	NA	34.4	34.5	34.6
228	34.3	33.8	34.2	34.4	34.6
234	33.7	33.8	NA	NA	NA
240	NA	NA	NA	NA	NA

Job: 1101N
Calc by: GKC Date 8/24/90
Checked by: JFM 8/29/90
Dwg Chk:

Draw Down Rate (ft/sec):

Time	50-yr	100-yr	200-yr	300-yr	500-yr
0	--	--	--	--	--
6	NA	NA	NA	NA	NA
12	NA	NA	NA	NA	NA
18	NA	NA	NA	NA	NA
24	NA	NA	NA	NA	NA
30	-9.12E-05	NA	NA	NA	NA
36	-2.92E-05	NA	NA	NA	NA
42	NA	NA	NA	NA	NA
48	NA	NA	NA	NA	NA
54	NA	NA	NA	NA	NA
60	NA	NA	NA	NA	NA
66	-2.11E-05	NA	NA	NA	NA
72	NA	NA	NA	NA	NA
78	NA	NA	NA	NA	NA
84	NA	NA	NA	NA	NA
90	NA	NA	NA	NA	NA
96	-2.78E-04	-2.97E-04	-3.16E-04	NA	NA
102	-7.96E-05	-1.28E-04	-1.36E-04	-3.64E-04	-3.41E-02
108	NA	NA	NA	-1.33E-04	-6.35E-02
114	-1.43E-04	-1.59E-04	NA	NA	-2.34E-01
120	-1.65E-04	-1.62E-04	-1.62E-04	-1.83E-04	-2.08E-04
126	-2.03E-04	-1.99E-04	-1.54E-04	-1.74E-04	-1.97E-04
132	-8.77E-05	-8.87E-05	-9.44E-05	-9.93E-05	-1.05E-04
138	NA	-1.42E-05	-2.65E-05	-4.10E-05	-5.80E-05
144	-2.98E-05	-4.64E-06	-3.76E-05	-5.00E-05	-6.45E-05
150	NA	-3.25E-06	-1.76E-05	-2.50E-05	-3.35E-05
156	-2.08E-05	-2.37E-05	-2.05E-04	-2.16E-04	-2.29E-04
162	NA	-1.56E-05	-2.67E-05	-2.54E-05	-2.38E-05
168	-1.65E-05	NA	-5.51E-05	-5.20E-05	-4.84E-05
174	-6.34E-06	-1.53E-05	-1.32E-05	-7.13E-06	NA
180	NA	NA	NA	NA	NA
186	NA	-2.40E-06	-7.08E-06	-3.82E-06	NA
192	NA	-1.95E-05	NA	-8.56E-06	-1.85E-05
198	-1.20E-05	-2.01E-05	-4.24E-06	-1.03E-05	-1.72E-05
204	NA	NA	NA	NA	NA
210	NA	-4.71E-06	NA	NA	NA
216	-1.12E-05	-1.23E-05	NA	NA	NA
222	NA	NA	-1.73E-05	-1.01E-05	-1.80E-06
228	-3.98E-05	-5.12E-06	-5.74E-06	-1.08E-05	-1.67E-05
234	-1.37E-05	-9.18E-06	NA	NA	NA
240	NA	NA	NA	NA	NA

24-Aug-90 DATE

Job/ 2101N Date
Calc by: GLC 8/24/90
Checked by: JFM 8/29/90
Dwg Chk:

Draw Down Fall (ft):

Time	50-yr	100-yr	200-yr	300-yr	500-yr
0	--	--	--	--	--
6	NA	NA	NA	NA	NA
12	NA	NA	NA	NA	NA
18	NA	NA	NA	NA	NA
24	NA	NA	NA	NA	NA
30	-2.0	NA	NA	NA	NA
36	-0.6	NA	NA	NA	NA
42	NA	NA	NA	NA	NA
48	NA	NA	NA	NA	NA
54	NA	NA	NA	NA	NA
60	NA	NA	NA	NA	NA
66	-0.5	NA	NA	NA	NA
72	NA	NA	NA	NA	NA
78	NA	NA	NA	NA	NA
84	NA	NA	NA	NA	NA
90	NA	NA	NA	NA	NA
96	-6.0	-6.4	-6.8	NA	NA
102	-1.7	-2.8	-2.9	-7.9	-736.5
108	NA	NA	NA	-2.9	-1371.1
114	-3.1	-3.4	NA	NA	-5049.4
120	-3.6	-3.5	-3.5	-4.0	-4.5
126	-4.4	-4.3	-3.3	-3.7	-4.3
132	-1.9	-1.9	-2.0	-2.1	-2.3
138	NA	-0.3	-0.6	-0.9	-1.3
144	-0.6	-0.1	-0.8	-1.1	-1.4
150	NA	-0.1	-0.4	-0.5	-0.7
156	-0.4	-0.5	-4.4	-4.7	-4.9
162	NA	-0.3	-0.6	-0.5	-0.5
168	-0.4	NA	-1.2	-1.1	-1.0
174	-0.1	-0.3	-0.3	-0.2	NA
180	NA	NA	NA	NA	NA
186	NA	-0.1	-0.2	-0.1	NA
192	NA	-0.4	NA	-0.2	-0.4
198	-0.3	-0.4	-0.1	-0.2	-0.4
204	NA	NA	NA	NA	NA
210	NA	-0.1	NA	NA	NA
216	-0.2	-0.3	NA	NA	NA
222	NA	NA	-0.4	-0.2	-0.0
228	-0.9	-0.1	-0.1	-0.2	-0.4
234	-0.3	-0.2	NA	NA	NA
240	NA	NA	NA	NA	NA

24-Aug-90 DATE

Job: 140/N Date
Calc by: GKC 8/24/90
Checked by: JFM 8/29/90
Dwg Chk:

Draw Down Check:

Time	50-yr	100-yr	200-yr	300-yr	500-yr
0					
6	NA	NA	NA	NA	NA
12	NA	NA	NA	NA	NA
18	NA	NA	NA	NA	NA
24	NA	NA	NA	NA	NA
30	drains	NA	NA	NA	NA
36	drains	NA	NA	NA	NA
42	NA	NA	NA	NA	NA
48	NA	NA	NA	NA	NA
54	NA	NA	NA	NA	NA
60	NA	NA	NA	NA	NA
66	drains	NA	NA	NA	NA
72	NA	NA	NA	NA	NA
78	NA	NA	NA	NA	NA
84	NA	NA	NA	NA	NA
90	NA	NA	NA	NA	NA
96	drains	drains	drains	NA	NA
102	drains	drains	drains	drains	drains
108	NA	NA	NA	drains	drains
114	drains	drains	NA	NA	drains
120	drains	drains	drains	drains	drains
126	drains	drains	drains	drains	drains
132	drains	drains	drains	drains	drains
138	NA	drains	drains	drains	drains
144	drains	drains	drains	drains	drains
150	NA	drains	drains	drains	drains
156	drains	drains	drains	drains	drains
162	NA	drains	drains	drains	drains
168	drains	NA	drains	drains	drains
174	drains	drains	drains	drains	NA
180	NA	NA	NA	NA	NA
186	NA	drains	drains	drains	NA
192	NA	drains	NA	drains	drains
198	drains	drains	drains	drains	drains
204	NA	NA	NA	NA	NA
210	NA	drains	NA	NA	NA
216	drains	drains	NA	NA	NA
222	NA	NA	drains	drains	drains
228	drains	drains	drains	drains	drains
234	drains	drains	NA	NA	NA
240	NA	NA	NA	NA	NA

24-Aug-90 DATE

Worst Case
Use lowest possible
conductivity

5/7

Job: R101N Date
Calc by: GKC 8/24/90
Checked by: JFM 8/29/90
Dwg Chk:

Draw Down Rate (ft/sec):

Time	50-yr	100-yr	200-yr	300-yr	500-yr
0	--	--	--	--	--
6	NA	NA	NA	NA	NA
12	NA	NA	NA	NA	NA
18	NA	NA	NA	NA	NA
24	NA	NA	NA	NA	NA
30	-3.37E-05	NA	NA	NA	NA
36	-1.08E-05	NA	NA	NA	NA
42	NA	NA	NA	NA	NA
48	NA	NA	NA	NA	NA
54	NA	NA	NA	NA	NA
60	NA	NA	NA	NA	NA
66	-7.81E-06	NA	NA	NA	NA
72	NA	NA	NA	NA	NA
78	NA	NA	NA	NA	NA
84	NA	NA	NA	NA	NA
90	NA	NA	NA	NA	NA
96	-1.03E-04	-1.10E-04	-1.17E-04	NA	NA
102	-2.94E-05	-4.74E-05	-5.03E-05	-1.34E-04	-1.26E-02
108	NA	NA	NA	-4.92E-05	-2.35E-02
114	-5.27E-05	-5.88E-05	NA	NA	-8.64E-02
120	-6.09E-05	-6.00E-05	-5.99E-05	-6.77E-05	-7.69E-05
126	-7.50E-05	-7.37E-05	-5.68E-05	-6.41E-05	-7.28E-05
132	-3.24E-05	-3.28E-05	-3.49E-05	-3.67E-05	-3.88E-05
138	NA	-5.24E-06	-9.79E-06	-1.51E-05	-2.14E-05
144	-1.10E-05	-1.71E-06	-1.39E-05	-1.85E-05	-2.38E-05
150	NA	-1.20E-06	-6.52E-06	-9.24E-06	-1.24E-05
156	-7.67E-06	-8.75E-06	-7.56E-05	-7.98E-05	-8.46E-05
162	NA	-5.77E-06	-9.88E-06	-9.38E-06	-8.80E-06
168	-6.08E-06	NA	-2.04E-05	-1.92E-05	-1.79E-05
174	-2.34E-06	-5.64E-06	-4.89E-06	-2.63E-06	NA
180	NA	NA	NA	NA	NA
186	NA	-8.87E-07	-2.62E-06	-1.41E-06	NA
192	NA	-7.21E-06	NA	-3.16E-06	-6.83E-06
198	-4.44E-06	-7.42E-06	-1.57E-06	-3.80E-06	-6.36E-06
204	NA	NA	NA	NA	NA
210	NA	-1.74E-06	NA	NA	NA
216	-4.14E-06	-4.56E-06	NA	NA	NA
222	NA	NA	-6.39E-06	-3.74E-06	-6.67E-07
228	-1.47E-05	-1.89E-06	-2.12E-06	-3.99E-06	-6.15E-06
234	-5.07E-06	-3.39E-06	NA	NA	NA
240	NA	NA	NA	NA	NA

for K = 0.05 cm/sec
for coarse sand

24-Aug-90 DATE

Job: 1210N
Date
Calc by: GKC 8/24/90
Checked by: JFM 8/29/90
Dwg Chk:

Draw Down Fall (ft):

Time	50-yr	100-yr	200-yr	300-yr	500-yr	
0	--	--	--	--	--	
6	NA	NA	NA	NA	NA	
12	NA	NA	NA	NA	NA	
18	NA	NA	NA	NA	NA	
24	NA	NA	NA	NA	NA	
30	-0.7	NA	NA	NA	NA	
36	-0.2	NA	NA	NA	NA	
42	NA	NA	NA	NA	NA	
48	NA	NA	NA	NA	NA	
54	NA	NA	NA	NA	NA	
60	NA	NA	NA	NA	NA	
66	-0.2	NA	NA	NA	NA	
72	NA	NA	NA	NA	NA	
78	NA	NA	NA	NA	NA	
84	NA	NA	NA	NA	NA	
90	NA	NA	NA	NA	NA	
96	-2.2 +0.9	-2.4 1.1	-2.5 1.3	NA	NA	
102	-0.6 +0.2	-1.0 0.3	-1.1 0.3	-2.9 1.8	-272.2	
108	NA	NA	NA	-1.1 0.4	-506.7	
114	-1.1 +0.3	-1.3 0.3	NA	NA	-1866.1	
120	-1.3 +0.2	-1.3 0.2	-1.3 0.4	-1.5 0.5	-1.7	0.6
126	-1.6 +0.1	-1.6 0.1	-1.2 0.3	-1.4 0.3	-1.6	0.4
132	-0.7	-0.7	-0.8 0.1	-0.8 0.1	-0.8	0.2
138	NA	-0.1	-0.2	-0.3 0.1	-0.5	0
144	-0.2	-0.0	-0.3	-0.4	-0.5	0.3
150	NA	-0.0	-0.1	-0.2	-0.3	0.
156	-0.2	-0.2	-1.6	-1.7	-1.8	0.2
162	NA	-0.1	-0.2	-0.2	-0.2	0
168	-0.1	NA	-0.4	-0.4	-0.4	0
174	-0.1	-0.1	-0.1	-0.1	NA	
180	NA	NA	NA	NA	NA	
186	NA	-0.0	-0.1	-0.0	NA	
192	NA	-0.2	NA	-0.1	-0.1	
198	-0.1	-0.2	-0.0	-0.1	-0.1	
204	NA	NA	NA	NA	NA	
210	NA	-0.0	NA	NA	NA	
216	-0.1	-0.1	NA	NA	NA	
222	NA	NA	-0.1	-0.1	-0.0	
228	-0.3	-0.0	-0.0	-0.1	-0.1	
234	-0.1	-0.1	NA	NA	NA	
240	NA	NA	NA	NA	NA	
max ah	1.7	2.0	2.4	3.2	1.7	

24-Aug-90 DATE

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Job: 12101N
Date
Calc by: GKC 8/24/90
Checked by: JFM 8/29/90
Dwg Chk:

Draw Down Check:

Time	50-yr	100-yr	200-yr	300-yr	500-yr
0					
6	NA	NA	NA	NA	NA
12	NA	NA	NA	NA	NA
18	NA	NA	NA	NA	NA
24	NA	NA	NA	NA	NA
30	drains	NA	NA	NA	NA
36	drains	NA	NA	NA	NA
42	NA	NA	NA	NA	NA
48	NA	NA	NA	NA	NA
54	NA	NA	NA	NA	NA
60	NA	NA	NA	NA	NA
66	drains	NA	NA	NA	NA
72	NA	NA	NA	NA	NA
78	NA	NA	NA	NA	NA
84	NA	NA	NA	NA	NA
90	NA	NA	NA	NA	NA
96	pools	pools	pools	NA	NA
102	pools	pools	pools	pools	drains
108	NA	NA	NA	pools	drains
114	pools	pools	NA	NA	drains
120	pools	pools	pools	pools	pools
126	pools	pools	pools	pools	pools
132	drains	pools	pools	pools	pools
138	NA	drains	pools	pools	pools
144	drains	drains	pools	pools	pools
150	NA	drains	pools	pools	pools
156	drains	drains	pools	pools	pools
162	NA	drains	drains	drains	drains
168	drains	NA	drains	drains	drains
174	drains	drains	drains	drains	NA
180	NA	NA	NA	NA	NA
186	NA	drains	drains	drains	NA
192	NA	drains	NA	drains	drains
198	drains	drains	drains	drains	drains
204	NA	NA	NA	NA	NA
210	NA	drains	NA	NA	NA
216	drains	drains	NA	NA	NA
222	NA	NA	drains	drains	drains
228	drains	drains	drains	drains	drains
234	drains	drains	NA	NA	NA
240	NA	NA	NA	NA	NA

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troduction to Hydrology,

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Soil Engineering

Fourth Edition

Merlin G. Spangler • Richard L. Handy
Iowa State University

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Cambridge, Philadelphia, San Francisco,
London, Mexico City, São Paulo, Sydney
1817

proximately inverse to D^2. Then the flow per unit area is

$$nq = \frac{Q}{A} = C_1 D^2 i \frac{\gamma_w}{\eta} = ki$$

or

$$k = C_1 D^2 \frac{\gamma_w}{\eta} \tag{11.6a}$$

where C_1 is a constant and k is the coefficient of hydraulic conductivity of the soil.

Since the capillary diameter D is not known and is not readily measured, empirical investigations have for the most part attempted to relate fluid flow characteristics of soils to their particle size and void ratio. An empirical equation by Hazen (*4*) is

$$k = C_2 D_{10}^2 \tag{11.7}$$

where D_{10} is the soil effective size, $C_2 = 100$, and k is in centimeters per second. This of course does not account for variability in void ratio or influences from other grain sizes, and is unreliable for prediction. Other studies have shown that as an approximation with particle size constant,

$$k = C_3 \left(\frac{e^3}{1 + e} \right) \tag{11.8}$$

where C_3 is a constant and e is the void ratio. Thus the coefficient of hydraulic conductivity increases roughly as the square of both the particle size and the void ratio.

Typical ranges of k values are indicated in Table 11.1. Metric units in wide use are centimeters per second, and because of the extended range of values, the coefficient frequently is given in terms of the exponent, a permeability coefficient of "minus 1" signifying 10^{-1} cm/s. There are numerous types of problems in connection with engineering projects which require knowledge of the hydraulic conductivity characteristics of the soil involved, such as computations of seepage through earth dams and levees and losses from irrigation ditches. Estimates of pumpage-capacity requirements for dewatering cofferdams or excavations below a water table are familiar examples of such problems. The spacing and depth of underdrains for lowering the water table under a road or runway in order to improve subgrade stability

TABLE 11.1 Hydraulic Conductivity Values

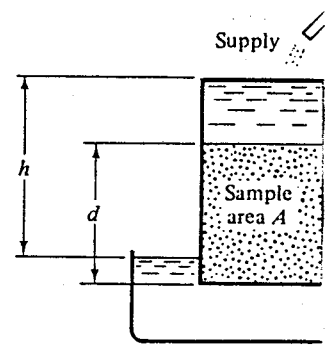
Range	k (cm/s)	Soils
Very high	$>10^0$ (>1.0)	Clean gravel
High	10^{-1}–10^0	Gravel, clean coarse sand
Medium	10^{-3}–10^{-1}	Graded sand, fine sand
Low	10^{-5}–10^{-3}	Silty sand, silt
Very low	10^{-7}–10^{-5}	Dense silt, clayey silt
Practically impermeable	$<10^{-7}$	Clay, silty clay

or for draining waterlogge
which the conductivity of
of settlement of a structu
rate at which water move

Several methods of m
able. Some methods invo
turbed samples, and other
of the soil in place below a
tages that are important in
most feasible and appropr
chosen. For example, in s
would be appropriate to m
to be used which would be
structure. On the other ha
appropriate in the case of s
In every case, the objecti
soil in its natural or norm
possible. Furthermore, sc
spect to flow; that is, the c
differ considerably from t
exists, it may be necessar

11.8. LABORATORY TE APPARATUS

A laboratory test that is p
cient of hydraulic conduc
which the hydraulic gradi
A typical arrangement of



Gr

Figure 11.4 Constant-hea
conductivity of coarse-grai

GEOHYDROLOGY

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Princeton University

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e solution, namely, $x_1 = 1, x_2 = -1$,

$$Cd^2\gamma/\mu \tag{4.18}$$

o K, such as effective permeability [5], seepage coefficient [7], and hydraulic nductivity, in view of the analogy with is gaining widespread use. It is used rinsic permeability for

$$= Cd^2 \tag{4.19}$$

haracteristic of the medium alone, and

$$= \frac{\gamma}{\mu} \tag{4.18*}$$

s the dimensions of a velocity. It may of consistent units, generally different oil mechanics, petroleum engineering, nt to continent (Europe, the United er-gram-second units are universally in this country are carried out with K in ²).

n petroleum engineering, has been pre- ic permeability k because of an incom- ndeed, for horizontal flow, Darcy's law

$$= -(k/\mu)(dp/dl)$$

in absolute value,

$$= \frac{\mu(Q/A)}{dp/dl} \tag{4.20}$$

n defined as

$$\frac{\text{ntipoise} \times 1\ \text{cm}^3/\text{sec}}{1\ \text{cm}^2}$$

1 atmosphere/cm

$[L]^2$. It may be expressed as such by

1 poise = 0.01 dyne sec/cm²

132 × 10⁶ dynes/cm²

Table 4.1 Average Values of K and k

Soil Class	K cm/sec	K darcys	K gpd/ft²
Gravel	1——10^2	10^3——10^5	10^4——10^6
Clean sands (good aquifers)	10^{-3}——1	1——10^3	10——10^4
Clayey sands, fine sands (poor aquifers)	10^{-6}——10^{-3}	10^{-3}——1	10^{-2}——10

This leads to

$$1 \text{ darcy} = 0.987 \times 10^{-8}\ \text{cm}^2$$

or

$$1 \text{ darcy} = 1.062 \times 10^{-11}\ \text{ft}^2$$

Because Eq. 4.18 may be written as

$$K = kg/\nu \tag{4.21}$$

in which $\nu = \mu/\rho$ is the kinematic viscosity of the fluid, and ρ is the density of the fluid. It is easy to convert from darcy units to gpd/ft². The knowledge of the temperature of the fluid makes it possible to read ν from tables of physical properties of fluids [11]. The U.S. Geological Survey uses the meinzer unit to measure the hydraulic conductivity, honoring the late Dr. O. E. Meinzer. The meinzer unit is defined as the flow of water in gallons per day through a cross-sectional area of 1 square foot under a hydraulic gradient of one at a temperature of 60°F.

A second coefficient, the field coefficient of hydraulic conductivity, is also used by the Water Resources Division of the Geological Survey.

Table 4.2 Representative Values for k and K

Geologic Classification		Darcys (k)	Meinzers (K)
Argillaceous limestone	2% porosity	1.0×10^{-4}	1.80×10^{-3}
Limestone	16% porosity	1.4×10^{-1}	2.50
Sandstone, silty	12% porosity	2.6×10^{-3}	4.74×10^{-2}
Sandstone, coarse	12% porosity	1.1	19.90
Sandstone	29% porosity	2.4	43.60
Very fine sand	well sorted	9.9	18.00×10
Medium sand	very well sorted	2.6×10^2	4.60×10^3
Coarse sand	very well sorted	3.1×10^3	5.80×10^4
Gravel	very well sorted	4.3×10^4	7.88×10^5
Montmorillonite clay		10^{-5}	10^{-4}
Kaolinite clay		10^{-3}	10^{-2}

For the clays only the order of magnitude is indicated.

K ≐ hydraulic conductivity

k ≐ permeability

GROUND-WATER HYDROLOGY AND HYDRAULICS

by

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and

Daniel K. Sunada

Water Resources Publications
P. O. Box 303
Fort Collins, Colorado 80522 USA

Table 3-1 contains values of hydraulic conductivity to water for several different porous materials. It is striking to note that the hydraulic conductivity of materials with which the hydrologist must deal range over 9 orders of magnitude.

Table 3-1. Hydraulic Conductivity of Porous Materials (Adapted from Morris & Johnson, 1967)

Material	No. of Analyses	Range cm/s	Arithmetic Mean cm/s
Igneous Rocks			
Weathered granite	7	$(3.3 - 52) \times 10^{-4}$	1.65×10^{-3}
Weathered gabbro	4	$(0.5 - 3.8) \times 10^{-4}$	1.89×10^{-4}
Basalt	93	$(0.2 - 4250) \times 10^{-8}$	9.45×10^{-6}
Sedimentary Materials			
Sandstone (fine)	20	$(0.5 - 2270) \times 10^{-6}$	3.31×10^{-4}
Siltstone	8	$(0.1 - 142) \times 10^{-8}$	1.9×10^{-7}
Sand (fine)	159	$(0.2 - 189) \times 10^{-4}$	2.88×10^{-3}
Sand (med.)	255	$(0.9 - 567) \times 10^{-4}$	1.42×10^{-2}
Sand (coarse)	158	$(0.9 - 6610) \times 10^{-4}$	5.20×10^{-2}
Gravel	40	$(0.3 - 31.2) \times 10^{-1}$	4.03×10^{-1}
Silt	39	$(0.09 - 7090) \times 10^{-7}$	2.83×10^{-5}
Clay	19	$(0.1 - 47) \times 10^{-8}$	9×10^{-8}
Metamorphic Rocks			
Schist	17	$(0.002 - 1130) \times 10^{-6}$	1.9×10^{-4}

3.2 NON-HOMOGENIETY AND ANISOTROPY

Non-homogeneous Aquifers

An aquifer is said to be *homogeneous* with respect to hydraulic conductivity if K is not a function of the space coordinates. If $K = K(x,y,z)$ the aquifer is *non-homogeneous*. Rarely is an aquifer actually homogeneous, but the practical and financial difficulties of establishing the function $K = K(x,y,z)$ in the field are substantial. Flow nets, a method of analysis to be discussed in Chapter IV, is one method by which non-homogeniety can be deduced quantitatively. Nevertheless, the hydrologist is often obliged to assign a constant value to K in full realization that doing so is only an approximation.

No modification of Darcy's Law is required for flow in non-homogeneous aquifers. Both Eqs. 3-10 and 3-20 apply because

$K = K(x,y,z)$ remains a scalar
with, but opposite in sense t
head just as in the case of c
homogeniety that must be deal
of the aquifer. The hydrauli
within individual stratum but
Such an aquifer can be regard
with discontinuities in K at
layers.

Treatment of block-wise
plished by defining a piezome
which K is constant. For exa
and b in which the hydraulic
the piezometric heads are h_a
the two regions is denoted by
velocity $\vec{q}_a$ at any point on C

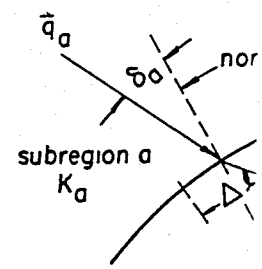


Figure 3-8. Refraction of th
between differer

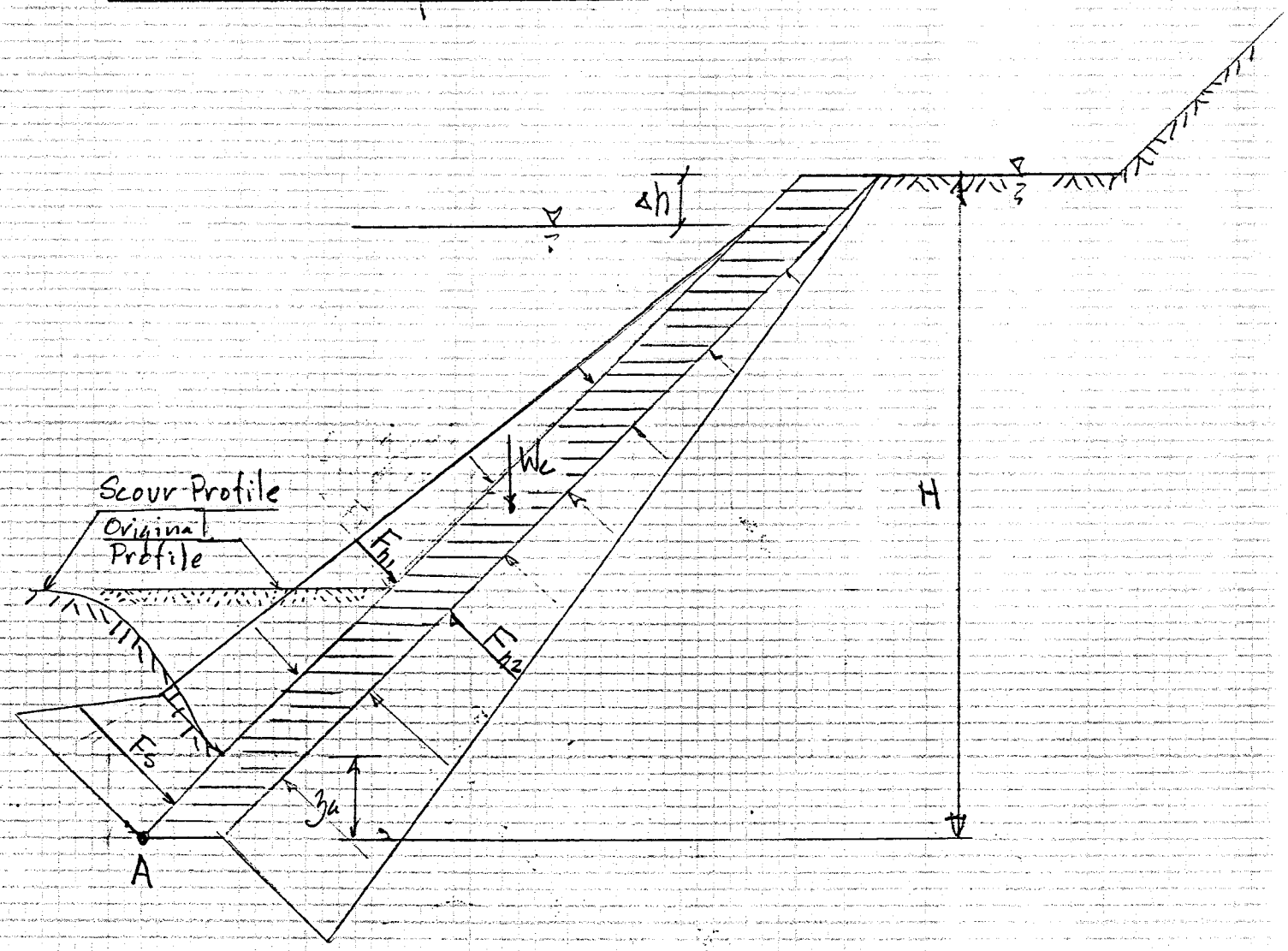
q_{an} normal to C and one tange
depth into the paper through
is the coordinate measured t
can be similarly decomposed.
ment $\Delta\ell$ must be the same reg
used to calculate it, the co
$\vec{q}_a$ and $\vec{q}_b$ normal to C must b

$q_a \cos \delta_a$

The fact that $(p/\rho g)_a =$
means that $h_a = h_b$ on C. Th

CRS SIRRINE	PROJECT: Rio Salado Channel	JOB NO.: R101N	NO. 1
	CLIENT: Tempe	DESIGNED BY: GKC / DATE: 8/24/90	OF 5
	SUBJECT: Bank Stability	CHECKED BY: JV / DATE: 8/29/90	

Overturning Condition



where H : bank protection height
Δh : drawdown depth
y_a : toe embedment depth
F_{h1} : hydrostatic force at center of pressure
F_{h2} : uplift force at center of pressure
F_s : soil pressure force at center of pressure

Forces:

Pressure (acting normal to submerge surface,

$$F_{h1} = \gamma_w (H - \Delta h - z_a)^2 / (2 \cos\theta)$$

$$F_{h2} = \gamma_w H^2 / (2 \cos\theta)$$

$$F_s = \tfrac{1}{2} (2 \gamma_w (H - \Delta h - z_a) + U_s z_a) z_a / \cos\theta$$

$$= \gamma_w (H - \Delta h + (\tfrac{1}{2} U_s / \gamma_w - 1) z_a) z_a / \cos\theta$$

Body (acting vertically)

$$W_{cy} = 8 (H * \gamma_c - (H - \tfrac{1}{2} \Delta h) \gamma_w)$$

Component Forces

$$F_{h1x} = \gamma_w (H - \Delta h - z_a)^2 / 2$$

$$F_{h1y} = \gamma_w (H - \Delta h - z_a)^2 \tan\theta / 2$$

$$F_{h2x} = \gamma_w H^2 / 2$$

$$F_{h2y} = \gamma_w H^2 \tan\theta / 2$$

$$F_{sx} = \gamma_w (H - \Delta h + (\tfrac{1}{2} U_s / \gamma_w - 1) z_a) z_a$$

$$F_{sx} = \gamma_w (H - \Delta h + (\tfrac{1}{2} U_s / \gamma_w - 1) z_a) z_a \tan\theta$$

Moments

$$d_{h1x} = z_a + \tfrac{1}{3}(H - \Delta h - z_a)$$

$$d_{h1y} = d_{h1x} \tan\theta$$

$$d_{h2x} = \tfrac{1}{3} H$$

$$d_{h2y} = 8 + d_{h2x} \tan\theta$$

$$d_{sx} = \tfrac{1}{3} z_a \left[\frac{(\gamma_w (H - \Delta h) + U_s z_a) + 2\gamma_w (H - \Delta h)}{(\gamma_w (H - \Delta h) + U_s z_a) + \gamma_w (H - \Delta h)} \right]$$

$$d_{sy} = d_{sx} \tan\theta$$

$$d_{cy} = 4 + \tfrac{3}{2}\,\tfrac{1}{2} H = 4 + \tfrac{3}{4} H$$

For: $H = 30'$ $H_o = 17'$

$z_a = \frac{1}{3}(H - H_o) = \frac{1}{3}(30-17) = 4.3'$

$\Delta h = 3.2'$

$\gamma_w = 62.4$ pcf

$\gamma_c = 150$ pcf

$\gamma_s = 180$ pcf

$F_{h1x} = 62.4(30 - 3.2 - 4.3)^2/2 = 15.8$ kips

$F_{h1y} = 1.5(F_{h1x}) = 23.7$ kips

$F_{h2x} = 62.4(30)^2/2 = 28.1$ kips

$F_{h2y} = 1.5(F_{h2x}) = 42.1$ kips

$F_{sx} = 62.4(30 - 3.2 + (\frac{1}{2}(180/62.4 - 1)4.3)4.3$
$= 7.7$ kips

$F_{sy} = 1.5(F_{sx}) = 11.6$ kips

$W_c = 8(150-62)(30 - \frac{1}{2}3.2) + \frac{1}{2}(50 \times 3.2) = 21.9$ k

$d_{h1x} = 4.3 + \frac{1}{3}(30 - 3.2 - 4.3) = 11.8'$

$d_{h1y} = 1.5\, d_{h1x} = 17.7'$

$d_{h2x} = \frac{1}{3}(30) = 10.0'$

$d_{h2y} = 8 + 1.5\, d_{h2x} = 23.0'$

$$d_{sx} = \frac{1}{3}4.3\left[\frac{62.4(30-3.2) + 180 \times 4.3 + 2 \times 62.4(30-3.2)}{62.4(30-3.2) + 180 \times 4.3 + 62.4(30-3.2)}\right]$$

$= 2.0$

$d_{sy} = 1.5\, d_{sx} = 3.0$

$$SF = \frac{(F_{h1x} d_{h1x} + F_{h2x} d_{h2x} + F_{sx} d_{sx} + F_{sy} d_{sy} + W_{cy} d_{cy})}{(F_{h2x} d_{h2x} + F_{h2y} d_{h2y})}$$

$$= \frac{(15.8(11.8) + 23.7(17.7) + 7.7(2.9) + 11.6(3.0) + 21.9(26.9}{(28.1(10.0) + 42.1(23.0))}$$

$$= \frac{1236.5}{1249.3}$$

$$= 0.99$$

<u>For Sliding:</u>

$$SF = \frac{F_{h1x} + F_{sx} + \tan\phi\, W_c}{F_{h2x}}$$

$$= \frac{28.1 + 7.7 + 0.7(21.9)}{28.1}$$

$$= 1.82$$

Rio Salado Channel
City of Tempe
Bank Stability Computation

Proj: RIOIN
Dgn: GKC 29-Aug-90
Chk: VV 8/29/90

H =	30.0 '	Uw =	62.0 pcf	Z =	1.50
dh =	3.2 '	Uc =	150.0 pcf	Az =	33.7 degrees
za =	4.3 '	Us =	180.0 pcf	Tc =	8.0

Force:	kips	Moment:	ft
Fh1x	15.7	d1x	11.8
Fh1y	23.5	d1y	17.7
Fh2x	27.9	d2x	10.0
Fh2y	41.9	d2y	23.0
Fsx	7.7	dsx	2.0
Fsy	11.5	dsy	3.0
Wc	21.9	dc	26.5

Factor of Safety:
Overturning:
SF = 0.99

Sliding:
SF = 1.82

Rio Salado Channel
City of Tempe
Bank Stability Computation

Proj: RIOIN
Dgn: GKC 29-Aug-90
Chk:

H =	30.0 '	Uw =	62.0 pcf	Z =	1.25
dh =	3.2 '	Uc =	150.0 pcf	Az =	38.7 degrees
za =	4.3 '	Us =	180.0 pcf	Tc =	8.0

Force:	kips	Moment:	ft
Fh1x	15.7	d1x	11.8
Fh1y	19.6	d1y	14.8
Fh2x	27.9	d2x	10.0
Fh2y	34.9	d2y	20.5
Fsx	7.7	dsx	2.0
Fsy	9.6	dsy	2.5
Wc	21.9	dc	26.5

Factor of Safety:
Overturning:
SF = 1.10

Sliding:
SF = 1.82

Rio Salado Channel
City of Tempe
Bank Stability Computation

Proj: RIOIN
Dgn: GKC 29-Aug-90
Chk: JV 8/29/90

H =	25.0 '	Uw =	62.0 pcf	Z =	1.50
dh =	3.2 '	Uc =	150.0 pcf	Az =	33.7 degrees
za =	4.3 '	Us =	180.0 pcf	Tc =	8.0

Force:	kips	Moment:	ft
Fh1x	9.5	d1x	10.1
Fh1y	14.2	d1y	15.2
Fh2x	19.4	d2x	8.3
Fh2y	29.1	d2y	20.5
Fsx	6.3	dsx	2.0
Fsy	9.5	dsy	3.0
Wc	18.4	dc	22.8

Factor of Safety:
Overturning:
SF = 1.02

Sliding:
SF = 1.99

Rio Salado Channel
City of Tempe
Bank Stability Computation

Proj: RIOIN
Dgn: GKC 29-Aug-90
Chk:

H =	25.0 '	Uw =	62.0 pcf	Z =	1.25
dh =	3.2 '	Uc =	150.0 pcf	Az =	38.7 degrees
za =	4.3 '	Us =	180.0 pcf	Tc =	8.0

Force:	kips	Moment:	ft
Fh1x	9.5	d1x	10.1
Fh1y	11.9	d1y	12.7
Fh2x	19.4	d2x	8.3
Fh2y	24.2	d2y	18.4
Fsx	6.3	dsx	2.0
Fsy	7.9	dsy	2.5
Wc	18.4	dc	22.8

Factor of Safety:
Overturning:
SF = 1.15

Sliding:
SF = 1.99

Rio Salado Channel
City of Tempe
Bank Stability Computation

Proj: RIOIN
Dgn: GKC 29-Aug-90
Chk: JV 8/29/90

H =	20.0 '	Uw =	62.0 pcf	Z =	1.50
dh =	3.2 '	Uc =	150.0 pcf	Az =	33.7 degrees
za =	4.3 '	Us =	180.0 pcf	Tc =	8.0

Force:	kips	Moment:	ft
Fh1x	4.8	d1x	8.5
Fh1y	7.3	d1y	12.7
Fh2x	12.4	d2x	6.7
Fh2y	18.6	d2y	18.0
Fsx	5.0	dsx	2.0
Fsy	7.5	dsy	2.9
Wc	14.9	dc	19.0

Factor of Safety:
Overturning:
SF = 1.07

Sliding:
SF = 2.24

Rio Salado Channel
City of Tempe
Bank Stability Computation

Proj: RIOIN
Dgn: GKC 29-Aug-90
Chk:

H =	20.0 '	Uw =	62.0 pcf	Z =	1.25
dh =	3.2 '	Uc =	150.0 pcf	Az =	38.7 degrees
za =	4.3 '	Us =	180.0 pcf	Tc =	8.0

Force:	kips	Moment:	ft
Fh1x	4.8	d1x	8.5
Fh1y	6.1	d1y	10.6
Fh2x	12.4	d2x	6.7
Fh2y	15.5	d2y	16.3
Fsx	5.0	dsx	2.0
Fsy	6.2	dsy	2.4
Wc	14.9	dc	19.0

Factor of Safety:
Overturning:
SF = 1.23

Sliding:
SF = 2.24

Rio Salado Channel
City of Tempe
Bank Stability Computation

Proj: RIOIN
Dgn: GKC 29-Aug-90
Chk: JV 8/29/90

H =	30.0 '	Uw =	62.0 pcf	Z =	1.50
dh =	0.0 '	Uc =	150.0 pcf	Az =	33.7 degrees
za =	0.0 '	Us =	180.0 pcf	Tc =	8.0

Force:	kips	Moment:	ft
Fh1x	27.9	d1x	10.0
Fh1y	41.9	d1y	15.0
Fh2x	27.9	d2x	10.0
Fh2y	41.9	d2y	23.0
Fsx	0.0	dsx	0.0
Fsy	0.0	dsy	0.0
Wc	21.1	dc	26.5

Factor of Safety:
Overturning:
SF = 1.18

Sliding:
SF = 1.53

Rio Salado Channel
City of Tempe
Bank Stability Computation

Proj: RIOIN
Dgn: GKC 29-Aug-90
Chk:

H =	30.0 '	Uw =	62.0 pcf	Z =	1.25
dh =	0.0 '	Uc =	150.0 pcf	Az =	38.7 degrees
za =	0.0 '	Us =	180.0 pcf	Tc =	8.0

Force:	kips	Moment:	ft
Fh1x	27.9	d1x	10.0
Fh1y	34.9	d1y	12.5
Fh2x	27.9	d2x	10.0
Fh2y	34.9	d2y	20.5
Fsx	0.0	dsx	0.0
Fsy	0.0	dsy	0.0
Wc	21.1	dc	26.5

Factor of Safety:
Overturning:
SF = 1.28

Sliding:
SF = 1.53

Rio Salado Channel
City of Tempe
Bank Stability Computation

Proj: RIOIN
Dgn: GKC 29-Aug-90
Chk: ✓ 8/29/90

H =	25.0 '	Uw =	62.0 pcf	Z =	1.50
dh =	0.0 '	Uc =	150.0 pcf	Az =	33.7 degrees
za =	0.0 '	Us =	180.0 pcf	Tc =	8.0

Force:	kips	Moment:	ft
Fh1x	19.4	d1x	8.3
Fh1y	29.1	d1y	12.5
Fh2x	19.4	d2x	8.3
Fh2y	29.1	d2y	20.5
Fsx	0.0	dsx	0.0
Fsy	0.0	dsy	0.0
Wc	17.6	dc	22.8

Factor of Safety:
Overturning:
SF = 1.22

Sliding:
SF = 1.64

Rio Salado Channel
City of Tempe
Bank Stability Computation

Proj: RIOIN
Dgn: GKC 29-Aug-90
Chk:

H =	25.0 '	Uw =	62.0 pcf	Z =	1.25
dh =	0.0 '	Uc =	150.0 pcf	Az =	38.7 degrees
za =	0.0 '	Us =	180.0 pcf	Tc =	8.0

Force:	kips	Moment:	ft
Fh1x	19.4	d1x	8.3
Fh1y	24.2	d1y	10.4
Fh2x	19.4	d2x	8.3
Fh2y	24.2	d2y	18.4
Fsx	0.0	dsx	0.0
Fsy	0.0	dsy	0.0
Wc	17.6	dc	22.8

Factor of Safety:
Overturning:
SF = 1.34

Sliding:
SF = 1.64

Rio Salado Channel
City of Tempe
Bank Stability Computation

Proj: RIOIN
Dgn: GKC 29-Aug-90
Chk: JV 8/29/90

H =	20.0 '	Uw =	62.0 pcf	Z =	1.50
dh =	0.0 '	Uc =	150.0 pcf	Az =	33.7 degrees
za =	0.0 '	Us =	180.0 pcf	Tc =	8.0

Force:	kips	Moment:	ft
Fh1x	12.4	d1x	6.7
Fh1y	18.6	d1y	10.0
Fh2x	12.4	d2x	6.7
Fh2y	18.6	d2y	18.0
Fsx	0.0	dsx	0.0
Fsy	0.0	dsy	0.0
Wc	14.1	dc	19.0

Factor of Safety:
Overturning:
SF = 1.28
Sliding:
SF = 1.79

Rio Salado Channel
City of Tempe
Bank Stability Computation

Proj: RIOIN
Dgn: GKC 29-Aug-90
Chk:

H =	20.0 '	Uw =	62.0 pcf	Z =	1.25
dh =	0.0 '	Uc =	150.0 pcf	Az =	38.7 degrees
za =	0.0 '	Us =	180.0 pcf	Tc =	8.0

Force:	kips	Moment:	ft
Fh1x	12.4	d1x	6.7
Fh1y	15.5	d1y	8.3
Fh2x	12.4	d2x	6.7
Fh2y	15.5	d2y	16.3
Fsx	0.0	dsx	0.0
Fsy	0.0	dsy	0.0
Wc	14.1	dc	19.0

Factor of Safety:
Overturning:
SF = 1.43
Sliding:
SF = 1.79

APPENDIX I

SCOUR CALCULATIONS

CRSS

CRS SIRRINE

DESIGN SHEET

Job _____ Job No. _____ Date _____
Structure _____ Computed By GKC 4/18/90
Live Load Per Square Foot _____ Working Stress JFM 4/27/90

Maximum Boundary Shear stress:

Channel Bed:

$$\tau_{max} = K_b K_r K_i \tau_o$$

revised 7/28/90 GKC

Channel Bank:

$$\tau_{max} = K_{ss} K_r K_i \tau_o$$

Q = 215,000

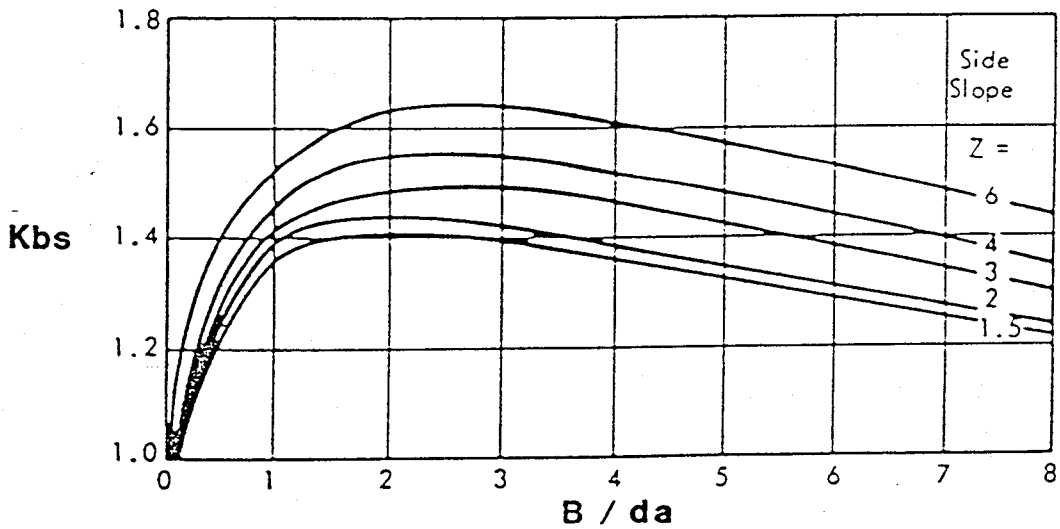
Rch	Bed	Banks North	Banks South
GC3-GC4	2.94	2.56	2.56
GC4-Mill	1.85	1.57	1.57
Mill-Rural	2.26	1.92 ✓	1.49
Rural-IBW	2.31	1.34	1.97 ✓
IBW-WestBank	—	2.01 ✓	—
IBW-McCl.	2.81	2.38 ✓	1.66

Q = 250,000

Rch	Bed	Banks North	Banks South
GC3-GC4	3.24	2.76	2.76
GC4-Mill	2.02	1.72	1.72
Mill-Rural	2.21	1.88	1.44
Rural-IBW	2.38	1.37	2.02
IBW-WestBank	—	2.06	—
IBW-McCl	2.87	2.44	1.69

See Attached worksheets: MESAZ15.WK1
MESAZ50.WK1

2/5



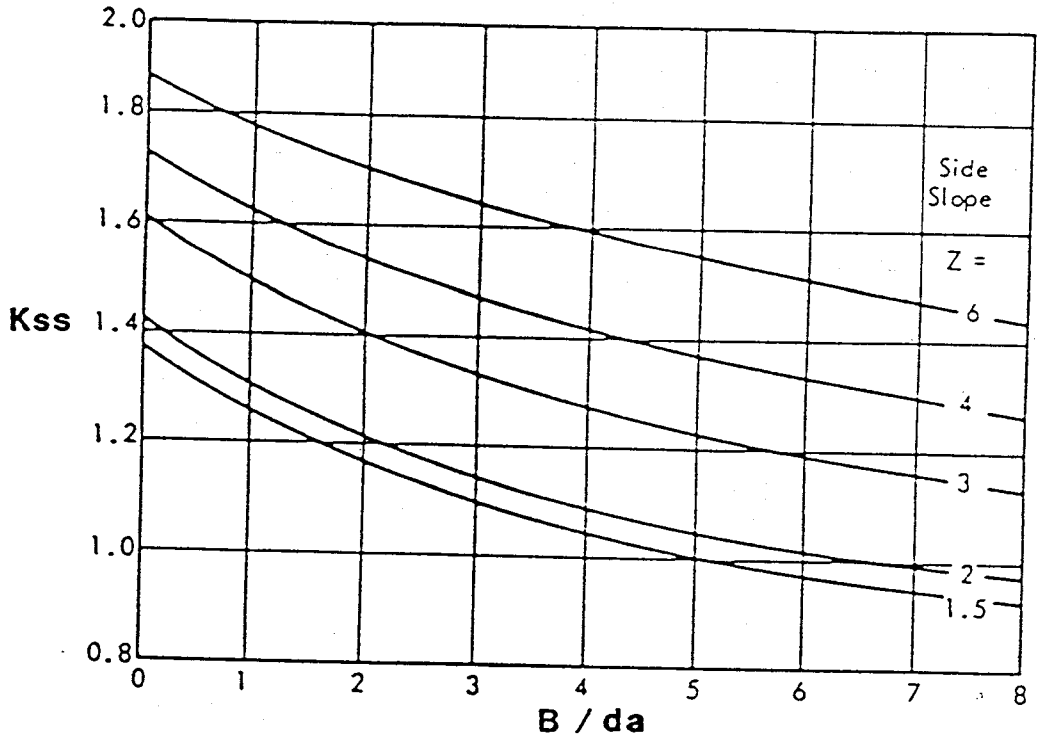
$$K_{bs} = \frac{\frac{B}{da} + 2\sqrt{Z^2 + 1}}{\frac{B}{da} + Z}$$

for $\frac{B}{da} > 8$

Chart 9. Boundary Shear Stress Adjustment Factor for Channel Bottom for a Symmetric Channel (Report 108, Tentative Design Procedure for Riprap Lined Channels)

ADOT Report No: FHWA-AZ89-26 Vol 2.

CHART 12



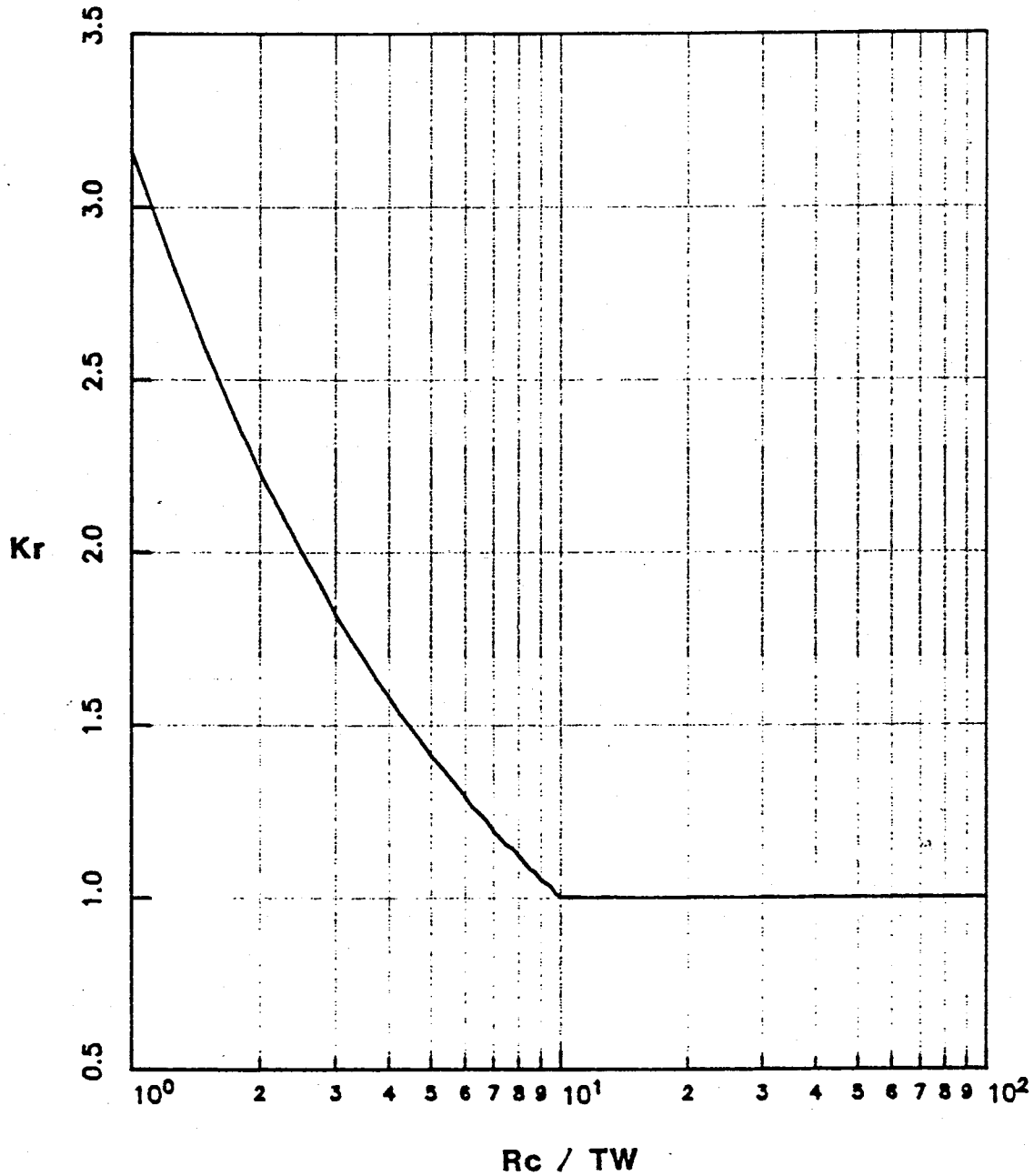
$$K_{ss} = C \left[\frac{\frac{B}{da} + 2\sqrt{Z^2 + 1}}{\frac{B}{da} + Z} \right]$$

for $\frac{B}{da} > 8$

Where

Z	C
1.5	0.76
2	0.785
3	0.85
4	0.935
6	0.97

Chart 12. Boundary Shear Stress Adjustment Factor for a Channel Side-Slope (Report 108, Tentative Design Procedure for Riprap-Lined Channels)



$Kr = 3.16 * (Rc/TW)^{-0.5}$ for $Rc/TW < 10.0$
$Kr = 1.0$ for $Rc/TW \geq 10.0$

Chart 14. Boundary Shear Stress Adjustment Factor, Kr, for a Channel Bend (EM1601 - Hydraulic Design of Flood Control Channels)

CRSS

CRS SIRRINE

DESIGN SHEET

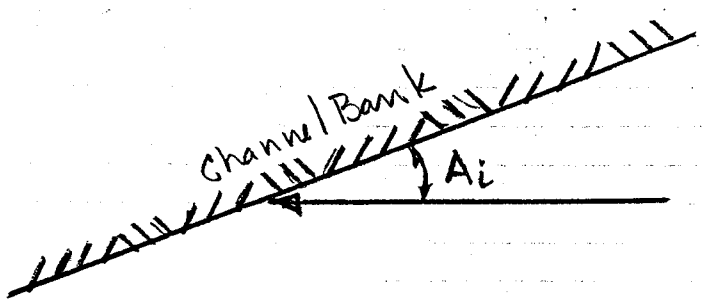
Job _____ Job No. _____ Date _____
Structure _____ Computed By _____
Live Load Per Square Foot _____ Working Stress _____

Boundary shear stress Adjustment Factor:

Impingment:

$K_i = 1 + \sin A_i$

where A_i = ∡ of impingment



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Job: R101N Date
Calc by: GKC 7/28/90
Checked by: JFM 7/30/90
Dwg Chk:

Channel Hydraulic Profiles
Salt River Channelization
Grade Control #4 to Grade Control #5

FILE: MESA215.WK1
DATE: 07/28/90

SECNO	ELMIN	XLCH	DIST	Q	CWSEL	EGL	AREA	TOPWID	10K*S	HYDDEP	MEAN SHEAR
0.00	129.40	155.00	0.00	215000	150.39	152.75	17607.77	989.45	17.03	17.80	1.89
2.00	129.61	158.00	158.00	215000	150.46	153.13	16700.71	985.15	19.52	16.95	2.06
4.00	129.82	200.00	358.00	215000	151.14	153.52	17796.17	1054.91	16.92	16.87	1.78
6.00	130.03	200.00	558.00	215000	151.47	153.86	17865.85	1091.55	16.94	16.37	1.73
8.00	130.24	200.00	758.00	215000	151.81	154.20	17975.88	1127.24	16.85	15.95	1.68
10.00	130.45	200.00	958.00	215000	152.22	154.54	18370.84	1176.37	16.17	15.62	1.58
12.00	130.65	200.00	1158.00	215000	152.63	154.86	18814.09	1228.75	15.44	15.31	1.48
14.00	130.86	153.00	1311.00	215000	152.93	155.10	19187.39	1287.18	14.93	14.91	1.39
15.40	131.01	105.00	1416.00	215000	153.18	155.26	19646.60	1341.97	14.25	14.64	1.30
15.60	131.03	18.00	1434.00	215000	153.56	155.55	20148.02	1346.58	13.32	14.96	1.24
17.50	131.23	174.00	1608.00	215000	153.79	155.78	20165.63	1347.97	13.26	14.96	1.24
19.00	131.39	164.00	1772.00	215000	153.97	156.02	19387.56	1153.39	13.57	16.81	1.42
19.20	131.41	20.00	1792.00	215000	154.49	156.42	20011.80	1156.34	12.41	17.31	1.34
21.50	131.65	152.00	1944.00	215000	154.64	156.63	19581.52	1110.81	12.79	17.63	1.41
24.00	131.91	145.00	2089.00	215000	154.68	156.89	18643.07	1080.61	14.47	17.25	1.56
24.50	131.96	48.00	2137.00	215000	155.84	157.84	19714.63	1086.32	12.24	18.15	1.39
26.00	132.12	202.00	2339.00	215000	156.10	158.08	19770.34	1093.44	12.18	18.08	1.37
27.00	132.22	202.00	2541.00	215000	156.37	158.33	19881.28	1087.83	11.92	18.28	1.36
28.00	132.33	151.00	2692.00	215000	156.58	158.51	19977.89	1082.34	11.70	18.46	1.35
30.00	132.54	200.00	2892.00	215000	156.79	158.76	19804.66	1061.26	11.82	18.66	1.38
32.00	132.75	200.00	3092.00	215000	157.13	158.99	20329.84	1055.11	11.02	19.27	1.32
34.00	132.96	200.00	3292.00	215000	157.35	159.21	20254.33	1043.73	11.02	19.41	1.33
36.00	133.16	200.00	3492.00	215000	157.85	159.44	21841.84	1071.23	8.93	20.39	1.14
38.00	133.37	219.00	3711.00	215000	157.84	159.75	19912.97	1004.85	11.19	19.82	1.38
40.00	133.58	225.00	3936.00	215000	158.05	160.03	19518.68	976.70	11.57	19.98	1.44
42.00	133.79	235.00	4171.00	215000	158.32	160.30	19516.16	974.78	11.54	20.02	1.44
44.00	134.00	225.00	4396.00	215000	158.53	160.59	19121.28	957.62	12.05	19.97	1.50
46.00	134.21	230.00	4626.00	215000	158.82	160.87	19223.59	961.34	11.87	20.00	1.48
48.00	134.42	234.00	4860.00	215000	159.16	161.15	19509.03	966.47	11.43	20.19	1.44
50.00	134.63	205.00	5065.00	215000	159.47	161.38	19891.16	979.04	10.91	20.32	1.38
52.00	134.84	185.00	5250.00	215000	159.73	161.59	20141.27	988.36	10.60	20.38	1.35
54.00	135.05	185.00	5435.00	215000	159.96	161.78	20342.80	995.62	10.37	20.43	1.32
56.00	135.26	180.00	5615.00	215000	160.19	161.97	20581.93	1004.94	10.10	20.48	1.29
58.00	135.46	183.00	5798.00	215000	160.41	162.16	20770.20	1012.06	9.90	20.52	1.27
60.00	135.67	180.00	5978.00	215000	160.63	162.34	21006.13	1021.25	9.65	20.57	1.24
62.00	135.88	180.00	6158.00	215000	160.88	162.52	21493.42	1033.10	9.16	20.80	1.19
64.00	136.09	176.00	6334.00	215000	161.04	162.68	21404.70	1038.43	9.28	20.61	1.19
66.00	136.30	180.00	6514.00	215000	161.23	162.85	21574.17	1046.48	9.14	20.62	1.18
68.00	136.51	194.00	6708.00	215000	161.44	163.03	21736.62	1053.52	8.99	20.63	1.16
69.50	136.67	95.00	6803.00	215000	161.54	163.12	21839.99	1060.38	8.93	20.60	1.15
70.50	136.77	90.00	6893.00	215000	161.75	163.30	21991.99	1062.11	8.75	20.71	1.13
72.00	136.93	153.00	7046.00	215000	161.88	163.44	21901.76	1044.79	8.71	20.96	1.14
74.00	137.14	179.00	7225.00	215000	162.05	163.59	21846.05	1024.76	8.66	21.32	1.15
76.00	137.35	180.00	7405.00	215000	162.26	163.75	22207.65	1040.46	8.37	21.34	1.11
78.00	137.56	184.00	7589.00	215000	162.49	163.91	22780.09	1064.37	7.93	21.40	1.06
80.00	137.77	174.00	7763.00	215000	162.71	164.05	23413.72	1090.32	7.49	21.47	1.00
82.00	137.97	169.00	7932.00	215000	162.93	164.18	24262.26	1125.36	6.95	21.56	0.93
84.00	138.18	175.00	8107.00	215000	163.14	164.31	25108.05	1161.42	6.47	21.62	0.87
86.00	138.39	180.00	8287.00	215000	163.36	164.43	26222.93	1208.30	5.91	21.70	0.80
88.00	138.60	169.00	8456.00	215000	163.63	164.54	28223.42	1247.67	5.06	22.62	0.71

Channel Hydraulic Profiles
Salt River Channelization
Grade Control #4 to Grade Control #5

FILE: MESA215.WK1
DATE: 07/28/90

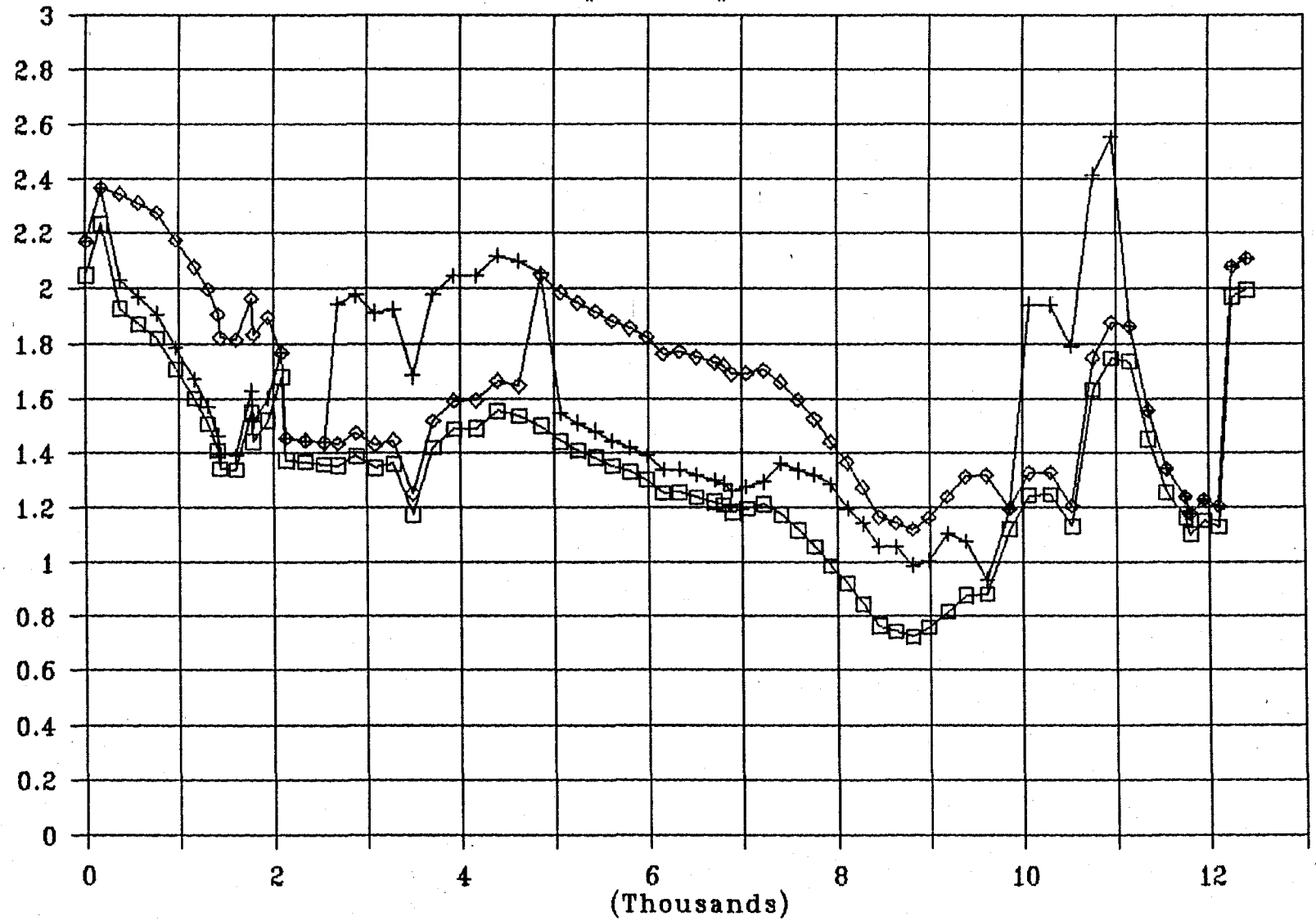
											MEAN
90.00	138.81	180.00	8636.00	215000	163.74	164.63	28569.22	1267.34	4.95	22.54	0.70
92.00	139.02	179.00	8815.00	215000	163.86	164.72	29011.21	1286.79	4.81	22.55	0.68
94.00	139.23	175.00	8990.00	215000	163.92	164.82	28353.70	1266.39	5.08	22.39	0.71
96.00	139.44	200.00	9190.00	215000	163.97	164.95	27308.57	1228.99	5.53	22.22	0.77
98.00	139.65	200.00	9390.00	215000	164.04	165.08	26353.18	1194.60	6.00	22.06	0.83
100.00	139.86	225.00	9615.00	215000	164.17	165.22	26327.22	1197.38	6.03	21.99	0.83
102.00	140.07	238.00	9853.00	215000	164.14	165.47	23377.54	1078.75	7.80	21.67	1.05
104.00	140.27	215.00	10068.00	215000	164.15	165.72	21661.18	1055.81	9.29	20.52	1.19
106.00	140.48	225.00	10293.00	215000	164.37	165.93	21677.09	1050.30	9.23	20.64	1.19
108.00	140.69	225.00	10518.00	215000	164.74	166.14	22778.89	1089.40	8.27	20.91	1.08
110.00	140.90	233.00	10751.00	215000	164.58	166.54	19229.12	939.47	12.12	20.47	1.55
112.00	141.11	200.00	10951.00	215000	164.73	166.83	18600.40	913.08	13.03	20.37	1.66
114.00	141.32	200.00	11151.00	215000	165.01	167.09	18684.87	914.42	12.86	20.43	1.64
116.00	141.53	200.00	11351.00	215000	165.61	167.36	20369.83	975.51	10.53	20.88	1.37
118.00	141.74	200.00	11551.00	215000	166.06	167.58	21882.31	1032.78	8.96	21.19	1.18
120.00	141.95	200.00	11751.00	215000	166.36	167.76	22749.22	1067.24	8.23	21.32	1.09
120.50	142.00	50.00	11801.00	215000	166.48	167.81	23388.98	1077.80	7.63	21.70	1.03
122.00	142.16	150.00	11951.00	215000	166.55	167.95	22851.33	1072.15	8.16	21.31	1.09
122.65	142.22	150.00	12101.00	215000	166.76	168.14	23011.47	1072.94	7.98	21.45	1.07
123.55	147.00	150.00	12251.00	215000	166.25	168.61	17552.96	1056.61	19.30	16.61	2.00
124.00	147.21	150.00	12401.00	215000	166.53	168.90	17491.73	1049.87	19.37	16.66	2.01

MAIN CHANNEL:		NORTH BANK:						SOUTH BANK:			
MAIN CHANNEL:		NORTH BANK:						SOUTH BANK:			
TW/da	Kb	Rc	Rc/TW	Kr	Ai	Ki	Tmax	Rc	Rc/TW	Kr	Tmax
55.60	1.06	*********	10.00	1.00	0.00	1.00	2.00	*********	10.00	1.00	2.00
58.11	1.05	*********	10.00	1.00	0.00	1.00	2.18	*********	10.00	1.00	2.18
62.53	1.05	*********	10.00	1.00	0.00	1.00	1.87	8000.00	7.58	1.15	2.15
66.69	1.05	*********	10.00	1.00	0.00	1.00	1.81	8000.00	7.33	1.17	2.12
70.69	1.05	*********	10.00	1.00	0.00	1.00	1.75	8000.00	7.10	1.19	2.08
75.33	1.04	*********	10.00	1.00	0.00	1.00	1.64	8000.00	6.80	1.21	1.99
80.25	1.04	*********	10.00	1.00	0.00	1.00	1.53	8000.00	6.51	1.24	1.90
86.35	1.04	*********	10.00	1.00	0.00	1.00	1.44	8000.00	6.22	1.27	1.83
91.66	1.04	*********	10.00	1.00	0.00	1.00	1.35	8000.00	5.96	1.29	1.74
90.00	1.04	*********	10.00	1.00	0.00	1.00	1.29	8000.00	5.94	1.30	1.67
90.10	1.04	*********	10.00	1.00	0.00	1.00	1.28	8000.00	5.93	1.30	1.66
68.62	1.05	*********	10.00	1.00	0.00	1.00	1.49	8000.00	6.94	1.20	1.79
66.82	1.05	*********	10.00	1.00	0.00	1.00	1.40	8000.00	6.92	1.20	1.69
63.01	1.05	*********	10.00	1.00	0.00	1.00	1.48	8000.00	7.20	1.18	1.74
62.64	1.05	*********	10.00	1.00	0.00	1.00	1.64	*********	10.00	1.00	1.64
59.86	1.05	*********	10.00	1.00	0.00	1.00	1.46	*********	10.00	1.00	1.46
60.47	1.05	*********	10.00	1.00	0.00	1.00	1.45	*********	10.00	1.00	1.45
59.52	1.05	*********	10.00	1.00	0.00	1.00	1.43	*********	10.00	1.00	1.43
58.64	1.05	6000.00	5.54	1.34	0.00	1.00	1.91	*********	10.00	1.00	1.42
56.87	1.06	6000.00	5.65	1.33	0.00	1.00	1.93	*********	10.00	1.00	1.45
54.76	1.06	6000.00	5.69	1.33	0.00	1.00	1.86	*********	10.00	1.00	1.40
53.78	1.06	6000.00	5.75	1.32	0.00	1.00	1.86	*********	10.00	1.00	1.41
52.54	1.06	6000.00	5.60	1.34	0.00	1.00	1.61	*********	10.00	1.00	1.20
50.71	1.06	6000.00	5.97	1.29	0.00	1.00	1.90	*********	10.00	1.00	1.47
48.87	1.06	6000.00	6.14	1.27	0.00	1.00	1.96	*********	10.00	1.00	1.53
48.69	1.06	6000.00	6.16	1.27	0.00	1.00	1.95	*********	10.00	1.00	1.53
47.96	1.07	6000.00	6.27	1.26	0.00	1.00	2.02	*********	10.00	1.00	1.60
48.08	1.07	6000.00	6.24	1.26	0.00	1.00	2.00	*********	10.00	1.00	1.58
47.88	1.07	6000.00	6.21	1.27	0.00	1.00	1.95	6030.00	6.24	1.27	1.94
48.19	1.06	*********	10.00	1.00	0.00	1.00	1.47	6030.00	6.16	1.27	1.88
48.50	1.06	*********	10.00	1.00	0.00	1.00	1.43	6030.00	6.10	1.28	1.84
48.73	1.06	*********	10.00	1.00	0.00	1.00	1.41	6030.00	6.06	1.28	1.81
49.07	1.06	*********	10.00	1.00	0.00	1.00	1.37	6030.00	6.00	1.29	1.77
49.31	1.06	*********	10.00	1.00	0.00	1.00	1.35	6030.00	5.96	1.29	1.75
49.65	1.06	*********	10.00	1.00	0.00	1.00	1.32	6030.00	5.90	1.30	1.71
49.66	1.06	*********	10.00	1.00	0.00	1.00	1.26	6030.00	5.84	1.31	1.65
50.38	1.06	*********	10.00	1.00	0.00	1.00	1.27	6030.00	5.81	1.31	1.66
50.76	1.06	*********	10.00	1.00	0.00	1.00	1.25	6030.00	5.76	1.32	1.64
51.06	1.06	*********	10.00	1.00	0.00	1.00	1.23	6030.00	5.72	1.32	1.62
51.48	1.06	*********	10.00	1.00	0.00	1.00	1.22	6030.00	5.69	1.33	1.61
51.29	1.06	*********	10.00	1.00	0.00	1.00	1.20	6030.00	5.68	1.33	1.59
49.84	1.06	*********	10.00	1.00	0.00	1.00	1.21	6030.00	5.77	1.32	1.59
48.07	1.07	*********	10.00	1.00	0.00	1.00	1.23	6030.00	5.88	1.30	1.60
48.75	1.06	*********	10.00	1.00	5.00	1.09	1.29	6030.00	5.80	1.31	1.56
49.73	1.06	*********	10.00	1.00	7.00	1.12	1.26	6030.00	5.67	1.33	1.49
50.77	1.06	*********	10.00	1.00	10.00	1.17	1.25	6030.00	5.53	1.34	1.43
52.20	1.06	*********	10.00	1.00	13.00	1.22	1.21	6030.00	5.36	1.37	1.35
53.72	1.06	*********	10.00	1.00	13.00	1.22	1.13	6030.00	5.19	1.39	1.28
55.68	1.06	*********	10.00	1.00	16.00	1.28	1.08	6030.00	4.99	1.41	1.20

MAIN CHANNEL:		NORTH BANK:						SOUTH BANK:			
55.16	1.06	*********	10.00	1.00	18.00	1.31	0.99	6030.00	4.83	1.44	1.09
56.22	1.06	*********	10.00	1.00	20.00	1.34	0.99	6030.00	4.76	1.45	1.07
57.08	1.06	*********	10.00	1.00	17.00	1.29	0.92	6030.00	4.69	1.46	1.04
56.56	1.06	*********	10.00	1.00	15.00	1.26	0.94	6030.00	4.76	1.45	1.09
55.31	1.06	*********	10.00	1.00	16.00	1.28	1.03	6030.00	4.91	1.43	1.16
54.15	1.06	*********	10.00	1.00	9.00	1.16	1.01	6030.00	5.05	1.41	1.23
54.46	1.06	*********	10.00	1.00	0.00	1.00	0.87	6030.00	5.04	1.41	1.23
49.78	1.06	*********	10.00	1.00	0.00	1.00	1.12	*********	10.00	1.00	1.12
51.46	1.06	5000.00	4.74	1.45	0.00	1.00	1.83	*********	10.00	1.00	1.26
50.89	1.06	5000.00	4.76	1.45	0.00	1.00	1.83	*********	10.00	1.00	1.26
52.10	1.06	5000.00	4.59	1.48	0.00	1.00	1.69	*********	10.00	1.00	1.14
45.90	1.07	5000.00	5.32	1.37	0.00	1.00	2.26	*********	10.00	1.00	1.65
44.82	1.07	5000.00	5.48	1.35	0.00	1.00	2.39	*********	10.00	1.00	1.77
44.75	1.07	*********	10.00	1.00	0.00	1.00	1.75	*********	10.00	1.00	1.75
46.72	1.07	*********	10.00	1.00	0.00	1.00	1.46	*********	10.00	1.00	1.46
48.74	1.06	*********	10.00	1.00	0.00	1.00	1.26	*********	10.00	1.00	1.26
50.07	1.06	*********	10.00	1.00	0.00	1.00	1.16	*********	10.00	1.00	1.16
49.67	1.06	*********	10.00	1.00	0.00	1.00	1.10	*********	10.00	1.00	1.10
50.30	1.06	*********	10.00	1.00	0.00	1.00	1.15	*********	10.00	1.00	1.15
50.03	1.06	*********	10.00	1.00	0.00	1.00	1.13	*********	10.00	1.00	1.13
63.60	1.05	*********	10.00	1.00	0.00	1.00	2.10	*********	10.00	1.00	2.10
63.01	1.05	*********	10.00	1.00	0.00	1.00	2.11	*********	10.00	1.00	2.11

Shear Stress Profile

GC#4 to GC#5



Mean Shear + Max North Bank ◇ Max South Bank

Job: 12101N	Date
Calc by: SKC	7/28/90
Checked by: JFM	7/29/90
Dwg Chk:	

5/5

Job: R101N
Date
Calc by: GKC 7/28/90
Checked by: JFM 7/30/90
Dwg Chk:

Channel Hydraulic Profiles
Salt River Channelization
Grade Control #4 to Grade Control #5

FILE: MESA250.WK1
DATE: 07/28/90

SECND	ELMIN	XLCH	DIST	Q	CWSEL	EGL	AREA	TOPWID	10K*S	HYDDEP	MEAN SHEAR
0.00	129.40	155.00	0.00	250000	152.18	154.82	19391.02	1000.16	16.92	19.39	2.05
2.00	129.61	158.00	158.00	250000	152.24	155.21	18460.61	995.81	19.32	18.54	2.23
4.00	129.82	200.00	358.00	250000	152.97	155.60	19729.64	1065.85	16.68	18.51	1.93
6.00	130.03	200.00	558.00	250000	153.30	155.93	19867.91	1102.50	16.65	18.02	1.87
8.00	130.24	200.00	758.00	250000	153.64	156.26	20037.55	1138.16	16.56	17.61	1.82
10.00	130.45	200.00	958.00	250000	154.07	156.60	20554.92	1187.46	15.80	17.31	1.71
12.00	130.65	200.00	1158.00	250000	154.49	156.92	21109.33	1239.01	15.05	17.04	1.60
14.00	130.86	153.00	1311.00	250000	154.80	157.15	21608.70	1295.02	14.49	16.69	1.51
15.40	131.01	105.00	1416.00	250000	155.07	157.31	22190.40	1352.42	13.79	16.41	1.41
15.60	131.03	18.00	1434.00	250000	155.49	157.63	22755.61	1358.20	12.87	16.75	1.35
17.50	131.23	174.00	1608.00	250000	155.71	157.85	22765.16	1359.60	12.83	16.74	1.34
19.00	131.39	164.00	1772.00	250000	155.84	158.10	21555.25	1163.73	13.42	18.52	1.55
19.20	131.41	20.00	1792.00	250000	156.50	158.61	22348.22	1167.30	12.09	19.15	1.44
21.50	131.65	152.00	1944.00	250000	156.64	158.82	21808.07	1121.54	12.52	19.44	1.52
24.00	131.91	145.00	2089.00	250000	156.66	159.09	20796.02	1093.52	14.13	19.02	1.68
24.50	131.96	48.00	2137.00	250000	158.71	160.74	22856.74	1102.90	10.63	20.72	1.37
26.00	132.12	202.00	2339.00	250000	158.93	160.95	22879.23	1110.18	10.64	20.61	1.37
27.00	132.22	202.00	2541.00	250000	159.16	161.17	22927.96	1105.26	10.51	20.74	1.36
28.00	132.33	151.00	2692.00	250000	159.33	161.33	22973.61	1098.18	10.39	20.92	1.36
30.00	132.54	200.00	2892.00	250000	159.52	161.55	22703.52	1076.91	10.57	21.08	1.39
32.00	132.75	200.00	3092.00	250000	159.81	161.76	23182.36	1069.47	9.97	21.68	1.35
34.00	132.96	200.00	3292.00	250000	160.00	161.97	23051.35	1058.81	10.02	21.77	1.36
36.00	133.16	200.00	3492.00	250000	160.48	162.17	24679.60	1086.13	8.29	22.72	1.18
38.00	133.37	219.00	3711.00	250000	160.45	162.47	22550.81	1019.62	10.30	22.12	1.42
40.00	133.58	225.00	3936.00	250000	160.62	162.74	22043.27	991.25	10.72	22.24	1.49
42.00	133.79	235.00	4171.00	250000	160.87	162.99	22025.10	989.27	10.72	22.26	1.49
44.00	134.00	225.00	4396.00	250000	161.05	163.26	21560.48	971.96	11.23	22.18	1.55
46.00	134.21	230.00	4626.00	250000	161.33	163.52	21650.93	976.37	11.11	22.17	1.54
48.00	134.42	234.00	4860.00	250000	161.65	163.78	21928.06	980.57	10.75	22.36	1.50
50.00	134.63	205.00	5065.00	250000	161.95	164.01	22329.34	993.08	10.30	22.48	1.45
52.00	134.84	185.00	5250.00	250000	162.19	164.20	22592.42	1002.35	10.04	22.54	1.41
54.00	135.05	185.00	5435.00	250000	162.41	164.39	22801.79	1009.56	9.83	22.59	1.39
56.00	135.26	180.00	5615.00	250000	162.64	164.57	23055.68	1018.85	9.59	22.63	1.35
58.00	135.46	183.00	5798.00	250000	162.85	164.74	23252.78	1025.90	9.42	22.67	1.33
60.00	135.67	180.00	5978.00	250000	163.06	164.91	23504.02	1035.06	9.20	22.71	1.30
62.00	135.88	180.00	6158.00	250000	163.31	165.08	24013.25	1045.46	8.75	22.97	1.25
64.00	136.09	176.00	6334.00	250000	163.46	165.24	23931.30	1052.22	8.86	22.74	1.26
66.00	136.30	180.00	6514.00	250000	163.65	165.40	24114.79	1060.21	8.73	22.75	1.24
68.00	136.51	194.00	6708.00	250000	163.84	165.57	24286.96	1067.20	8.60	22.76	1.22
69.50	136.67	95.00	6803.00	250000	163.94	165.66	24403.67	1074.05	8.54	22.72	1.21
70.50	136.77	90.00	6893.00	250000	164.22	165.91	24636.24	1076.18	8.30	22.89	1.19
72.00	136.93	153.00	7046.00	250000	164.35	166.03	24496.97	1059.33	8.29	23.12	1.20
74.00	137.14	179.00	7225.00	250000	164.49	166.18	24378.02	1038.57	8.28	23.47	1.21
76.00	137.35	180.00	7405.00	250000	164.70	166.33	24767.08	1054.42	8.01	23.49	1.17
78.00	137.56	184.00	7589.00	250000	164.93	166.49	25398.32	1078.27	7.60	23.55	1.12
80.00	137.77	174.00	7763.00	250000	165.15	166.62	26096.94	1104.23	7.17	23.63	1.06
82.00	137.97	169.00	7932.00	250000	165.38	166.75	27035.61	1139.30	6.66	23.73	0.99
84.00	138.18	175.00	8107.00	250000	165.59	166.87	27973.87	1175.41	6.20	23.80	0.92
86.00	138.39	180.00	8287.00	250000	165.82	166.99	29209.93	1222.28	5.66	23.90	0.84
88.00	138.60	169.00	8456.00	250000	166.09	167.09	31305.91	1254.30	4.89	24.96	0.76

Channel Hydraulic Profiles
Salt River Channelization
Grade Control #4 to Grade Control #5

FILE: MESA250.WK1
DATE: 07/28/90

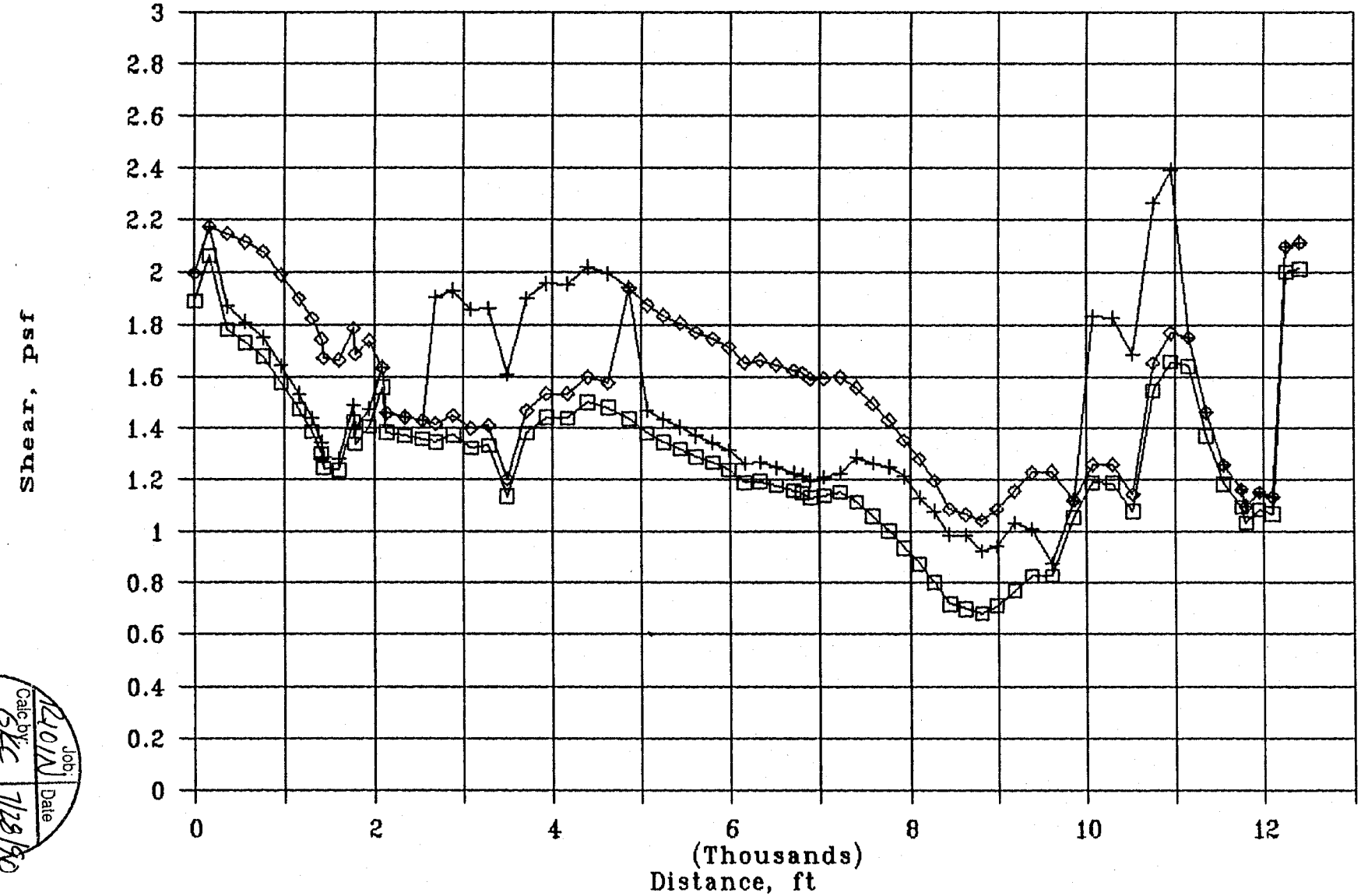
											MEAN
90.00	138.81	180.00	8636.00	250000	166.20	167.18	31698.51	1274.73	4.78	24.87	0.74
92.00	139.02	179.00	8815.00	250000	166.32	167.27	32190.31	1293.43	4.64	24.89	0.72
94.00	139.23	175.00	8990.00	250000	166.38	167.37	31475.84	1273.01	4.89	24.73	0.75
96.00	139.44	200.00	9190.00	250000	166.42	167.49	30328.57	1235.60	5.32	24.55	0.81
98.00	139.65	200.00	9390.00	250000	166.48	167.63	29278.36	1201.18	5.76	24.37	0.88
100.00	139.86	225.00	9615.00	250000	166.61	167.76	29253.28	1203.95	5.80	24.30	0.88
102.00	140.07	238.00	9853.00	250000	166.55	168.01	25987.18	1085.26	7.50	23.95	1.12
104.00	140.27	215.00	10068.00	250000	166.55	168.26	24208.47	1069.46	8.82	22.64	1.25
106.00	140.48	225.00	10293.00	250000	166.75	168.45	24184.93	1063.86	8.80	22.73	1.25
108.00	140.69	225.00	10518.00	250000	167.12	168.66	25395.39	1103.72	7.89	23.01	1.13
110.00	140.90	233.00	10751.00	250000	166.92	169.06	21445.47	952.29	11.61	22.52	1.63
112.00	141.11	200.00	10951.00	250000	167.05	169.35	20736.01	925.80	12.50	22.40	1.75
114.00	141.32	200.00	11151.00	250000	167.32	169.60	20812.03	927.09	12.38	22.45	1.73
116.00	141.53	200.00	11351.00	250000	167.94	169.86	22658.07	988.32	10.16	22.93	1.45
118.00	141.74	200.00	11551.00	250000	168.41	170.07	24320.08	1045.69	8.66	23.26	1.26
120.00	141.95	200.00	11751.00	250000	168.71	170.25	25273.65	1080.20	7.96	23.40	1.16
120.50	142.00	50.00	11801.00	250000	168.83	170.30	25935.84	1087.84	7.41	23.84	1.10
122.00	142.16	150.00	11951.00	250000	168.90	170.43	25383.51	1085.11	7.90	23.39	1.15
122.65	142.22	150.00	12101.00	250000	169.18	170.68	25621.59	1086.28	7.67	23.59	1.13
123.55	147.00	150.00	12251.00	250000	168.70	171.12	20156.65	1071.45	16.79	18.81	1.97
124.00	147.21	150.00	12401.00	250000	168.93	171.39	20030.69	1064.50	17.00	18.82	2.00

MAIN CHANNEL:		NORTH BANK:						SOUTH BANK:			
MAIN CHANNEL:		NORTH BANK:						SOUTH BANK:			
TW/da	Kb	Rc	Rc/TW	Kr	Ai	Ki	Tmax	Rc	Rc/TW	Kr	Tmax
51.59	1.06	*********	10.00	1.00	0.00	1.00	2.17	*********	10.00	1.00	2.17
53.72	1.06	*********	10.00	1.00	0.00	1.00	2.36	*********	10.00	1.00	2.36
57.58	1.05	*********	10.00	1.00	0.00	1.00	2.03	8000.00	7.51	1.15	2.34
61.18	1.05	*********	10.00	1.00	0.00	1.00	1.97	8000.00	7.26	1.17	2.31
64.65	1.05	*********	10.00	1.00	0.00	1.00	1.91	8000.00	7.03	1.19	2.27
68.60	1.05	*********	10.00	1.00	0.00	1.00	1.78	8000.00	6.74	1.22	2.17
72.72	1.04	*********	10.00	1.00	0.00	1.00	1.67	8000.00	6.46	1.24	2.08
77.61	1.04	*********	10.00	1.00	0.00	1.00	1.57	8000.00	6.18	1.27	2.00
82.42	1.04	*********	10.00	1.00	0.00	1.00	1.47	8000.00	5.92	1.30	1.91
81.07	1.04	*********	10.00	1.00	0.00	1.00	1.40	8000.00	5.89	1.30	1.82
81.20	1.04	*********	10.00	1.00	0.00	1.00	1.39	8000.00	5.88	1.30	1.82
62.83	1.05	*********	10.00	1.00	0.00	1.00	1.63	8000.00	6.87	1.21	1.96
60.97	1.05	*********	10.00	1.00	0.00	1.00	1.52	8000.00	6.85	1.21	1.83
57.68	1.05	*********	10.00	1.00	0.00	1.00	1.60	8000.00	7.13	1.18	1.90
57.50	1.05	*********	10.00	1.00	0.00	1.00	1.77	*********	10.00	1.00	1.77
53.22	1.06	*********	10.00	1.00	0.00	1.00	1.45	*********	10.00	1.00	1.45
53.87	1.06	*********	10.00	1.00	0.00	1.00	1.45	*********	10.00	1.00	1.45
53.28	1.06	*********	10.00	1.00	0.00	1.00	1.44	*********	10.00	1.00	1.44
52.49	1.06	6000.00	5.46	1.35	0.00	1.00	1.94	*********	10.00	1.00	1.44
51.08	1.06	6000.00	5.57	1.34	0.00	1.00	1.98	*********	10.00	1.00	1.47
49.34	1.06	6000.00	5.61	1.33	0.00	1.00	1.91	*********	10.00	1.00	1.43
48.63	1.06	6000.00	5.67	1.33	0.00	1.00	1.92	*********	10.00	1.00	1.45
47.80	1.07	6000.00	5.52	1.34	0.00	1.00	1.68	*********	10.00	1.00	1.25
46.10	1.07	6000.00	5.88	1.30	0.00	1.00	1.98	*********	10.00	1.00	1.52
44.57	1.07	6000.00	6.05	1.28	0.00	1.00	2.04	*********	10.00	1.00	1.59
44.43	1.07	6000.00	6.07	1.28	0.00	1.00	2.04	*********	10.00	1.00	1.59
43.82	1.07	6000.00	6.17	1.27	0.00	1.00	2.12	*********	10.00	1.00	1.66
44.03	1.07	6000.00	6.15	1.27	0.00	1.00	2.10	*********	10.00	1.00	1.64
43.85	1.07	6000.00	6.12	1.28	0.00	1.00	2.05	6030.00	6.15	1.27	2.05
44.17	1.07	*********	10.00	1.00	0.00	1.00	1.55	6030.00	6.07	1.28	1.98
44.47	1.07	*********	10.00	1.00	0.00	1.00	1.51	6030.00	6.02	1.29	1.95
44.70	1.07	*********	10.00	1.00	0.00	1.00	1.48	6030.00	5.97	1.29	1.92
45.02	1.07	*********	10.00	1.00	0.00	1.00	1.45	6030.00	5.92	1.30	1.88
45.26	1.07	*********	10.00	1.00	0.00	1.00	1.42	6030.00	5.88	1.30	1.86
45.58	1.07	*********	10.00	1.00	0.00	1.00	1.39	6030.00	5.83	1.31	1.82
45.52	1.07	*********	10.00	1.00	0.00	1.00	1.34	6030.00	5.77	1.32	1.76
46.26	1.07	*********	10.00	1.00	0.00	1.00	1.34	6030.00	5.73	1.32	1.77
46.61	1.07	*********	10.00	1.00	0.00	1.00	1.32	6030.00	5.69	1.33	1.75
46.89	1.07	*********	10.00	1.00	0.00	1.00	1.30	6030.00	5.65	1.33	1.73
47.27	1.07	*********	10.00	1.00	0.00	1.00	1.29	6030.00	5.61	1.33	1.72
47.01	1.07	*********	10.00	1.00	0.00	1.00	1.26	6030.00	5.60	1.33	1.69
45.81	1.07	*********	10.00	1.00	0.00	1.00	1.28	6030.00	5.69	1.32	1.69
44.25	1.07	*********	10.00	1.00	0.00	1.00	1.30	6030.00	5.81	1.31	1.70
44.89	1.07	*********	10.00	1.00	5.00	1.09	1.36	6030.00	5.72	1.32	1.66
45.78	1.07	*********	10.00	1.00	7.00	1.12	1.34	6030.00	5.59	1.34	1.59
46.72	1.07	*********	10.00	1.00	10.00	1.17	1.32	6030.00	5.46	1.35	1.53
48.01	1.07	*********	10.00	1.00	13.00	1.22	1.29	6030.00	5.29	1.37	1.44
49.39	1.06	*********	10.00	1.00	13.00	1.22	1.20	6030.00	5.13	1.40	1.37
51.15	1.06	*********	10.00	1.00	16.00	1.28	1.14	6030.00	4.93	1.42	1.27

MAIN CHANNEL:		NORTH BANK:						SOUTH BANK:			
50.25	1.06	*********	10.00	1.00	18.00	1.31	1.06	6030.00	4.81	1.44	1.17
51.26	1.06	*********	10.00	1.00	20.00	1.34	1.06	6030.00	4.73	1.45	1.14
51.97	1.06	*********	10.00	1.00	17.00	1.29	0.99	6030.00	4.66	1.46	1.12
51.49	1.06	*********	10.00	1.00	15.00	1.26	1.01	6030.00	4.74	1.45	1.16
50.34	1.06	*********	10.00	1.00	16.00	1.28	1.10	6030.00	4.88	1.43	1.24
49.28	1.06	*********	10.00	1.00	9.00	1.16	1.08	6030.00	5.02	1.41	1.31
49.55	1.06	*********	10.00	1.00	0.00	1.00	0.93	6030.00	5.01	1.41	1.32
45.32	1.07	*********	10.00	1.00	0.00	1.00	1.20	*********	10.00	1.00	1.20
47.25	1.07	5000.00	4.68	1.46	0.00	1.00	1.94	*********	10.00	1.00	1.33
46.80	1.07	5000.00	4.70	1.46	0.00	1.00	1.94	*********	10.00	1.00	1.33
47.97	1.07	5000.00	4.53	1.48	0.00	1.00	1.79	*********	10.00	1.00	1.21
42.29	1.07	5000.00	5.25	1.38	0.00	1.00	2.42	*********	10.00	1.00	1.75
41.33	1.07	5000.00	5.40	1.36	0.00	1.00	2.55	*********	10.00	1.00	1.88
41.30	1.08	*********	10.00	1.00	0.00	1.00	1.86	*********	10.00	1.00	1.86
43.11	1.07	*********	10.00	1.00	0.00	1.00	1.56	*********	10.00	1.00	1.56
44.96	1.07	*********	10.00	1.00	0.00	1.00	1.34	*********	10.00	1.00	1.34
46.17	1.07	*********	10.00	1.00	0.00	1.00	1.24	*********	10.00	1.00	1.24
45.63	1.07	*********	10.00	1.00	0.00	1.00	1.18	*********	10.00	1.00	1.18
46.39	1.07	*********	10.00	1.00	0.00	1.00	1.23	*********	10.00	1.00	1.23
46.06	1.07	*********	10.00	1.00	0.00	1.00	1.20	*********	10.00	1.00	1.20
56.95	1.06	*********	10.00	1.00	0.00	1.00	2.08	*********	10.00	1.00	2.08
56.57	1.06	*********	10.00	1.00	0.00	1.00	2.11	*********	10.00	1.00	2.11

Mean Shear Stress Profile

GC#4 to GC#5



Mean Shear + Max North Bank ◇ Max South Bank

Job:	Calc by:	Checked by:	Dwg Chk:
1R4010N	SKC	JFM	
Date	7/28/90	7/30/90	

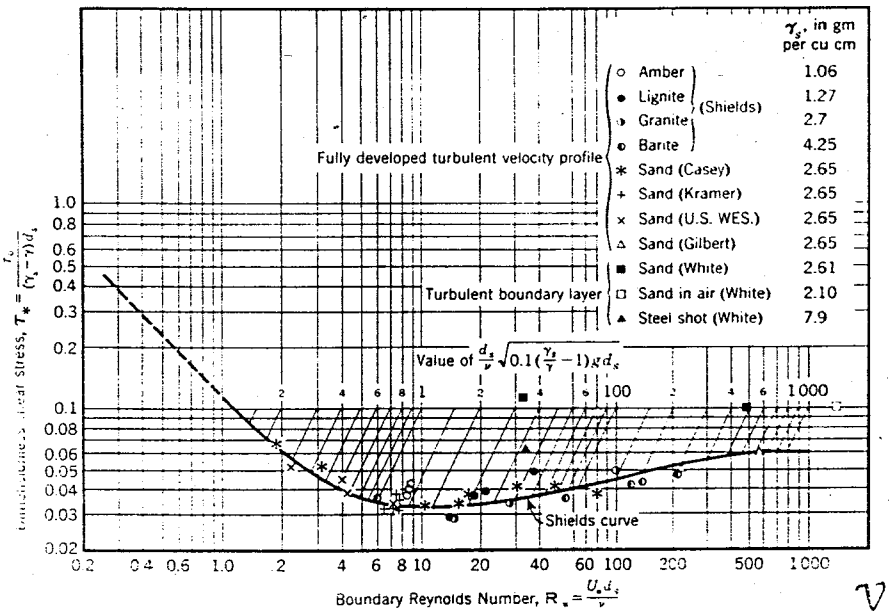
5/5

Maximum Bed Scour

$$y_s = 3 D_a (1/p_c - 1)$$

where $D_a = \tau_p / (\gamma_s - \gamma) \tau_*$

for boundary Reynolds number in excess of ≈ 500, $\tau_* = 0.060$



$\nu = 1 \times 10^{-5}$ ft²/sec

FIG. 2.43.—Shields Diagram with White Data Added

ASCE, Manual No. 54 pg. 96

Therefore $D_a = \tau_p / (0.06 \times 103)$

$$= \tau_p / 6.2 \qquad (1)$$

$$\tau_p = \left(\frac{n_p}{n}\right)^2 \cdot \tau_{max} \cdot SF \qquad (2)$$

$$n_p = 0.034 D_a^{1/6} \qquad (3)$$

where n_p is the roughness due to the partical

τ_p is the shear on the partical

SF = Safety factor : 1.5 for Q = 215,000 cfs
1.3 for Q = 250,000 cfs

Combining equations 1, 2 and 3 gives

$$D_a = \left(\frac{SF \cdot \tau_{max}}{5360\, n^2}\right)^{3/2} \qquad (4)$$

(see derivation pg. 3)

~~Q = 215,000 cfs $D_a = 0.11\, \tau_{max}^{3/2}$~~

Reach	τ_{max} North	τ_{max} South	D_a		P_c		y_s		R_*
GC3-GC4	2.46		0.42		~~17.0~~* 6.3		~~6.8~~ 18.7		67300
GC4-Mill	1.85	1.85	0.28		16.5		4.3		27300
Mill-Rural	2.26	1.75	0.37	0.26	11.7	17.5	8.4	3.7	24700
Rural-IBW	1.57	2.31	0.22	0.39	20.2	10.8	2.6	9.7	19,800
IBW-W. Bank	2.36	–	0.40	–	10.4	–	10.3	–	44,100
IBW-McCl	2.02	1.40	0.32	0.18	14.1	23.6	5.8	1.7	15,300

~~Q = 250,000 cfs $D_a = 0.088\, \tau_{max}^{3/2}$~~

Reach	τ_{max} North	τ_{max} South	D_a		P_c		y_s		R_*
GC3-GC4	2.70		0.39		~~18.5~~* 7.4		~~5.2~~ 14.6		46,000
GC4-Mill	2.02	2.02	0.25		18.4		3.3		25,500
Mill-Rural	2.32	1.77	0.31	0.21	14.6	21.0	5.4	2.4	20,000
Rural-IBW	1.63	2.43	0.18	0.33	23.6	13.5	1.7	6.3	16500
IBW-W. Bank	2.48	–	0.34	–	13.1	–	6.8	–	38,200
IBW-McCl.	2.25	1.54	0.30	0.17	15.1	24.6	5.1	1.6	15,100

~~*SLA Gradation would be 9.9% and 11.1% for CRSS gradation giving a y_s of 1.5 for the Q = 215~~

See Attached Worksheets
TOED215.WK1
TOED250.WK1

Derivation of Eq. 4

Combining eq 1, 2 and 3 gives

$$D_a = \frac{(n_p/h)^2 \, \tau_{max} \, SF}{6.2}$$

$$= \frac{(0.034 \, D_a^{1/6})^2 \, \tau_{max} \, SF}{6.2 \, n^2}$$

$$D_a^{2/3} = \frac{SF \, \tau_{max}}{6.2 \, (n/0.034)^2}$$

$$D_a = \left(\frac{SF \cdot \tau_{max}}{5360 \, n^2} \right)^{3/2} \qquad (4)$$

for $n = 0.035$ and $SF = 1.5$

equation 4 becomes

$$D_a = 0.11 \, \tau_{max}^{3/2}$$

for $n = 0.035$ and $SF = 1.3$

equation 4 becomes

$$D_a = 0.088 \, \tau_{max}^{3/2}$$

Design Gradation

Size (mm)	Percent Finer	ΔP
0.0625	2.0	
0.125	3.9	1.9
0.25	8.6	4.7
0.50	17.0	8.4
1.0	28.5	11.5
2.0	33.6	5.1
4.0	38.9	5.3
8.0	46.6	7.7
16.0	55.1	8.5
32.0	67.2	12.1
64.0	79.0	11.8
128.0	90.4	11.4
256.0	99.3	8.9
512.0	100.0	0.7

$D_{50} = 10.6$ mm

The percent coarser:

$$P_c = 100 - \left[P_L + (P_u - P_L)\left(\frac{\ln d_s - \ln d_L}{\ln d_u - \ln d_L}\right)\right]$$

where P is the cummulative percent finer
L is the index for the lower bound
U is the index for the upper bound
s is the index for a specific size

Job: 1210/N
Date
Calc by: GKC 7/28/90
Checked by: JFM 7/30/90
Dwg Chk:

Levee Toedown Computation
Salt River Channelization
Grade Control #4 to Grade Control #5

FILE: TOED215.WK1
DATE: 07/28/90

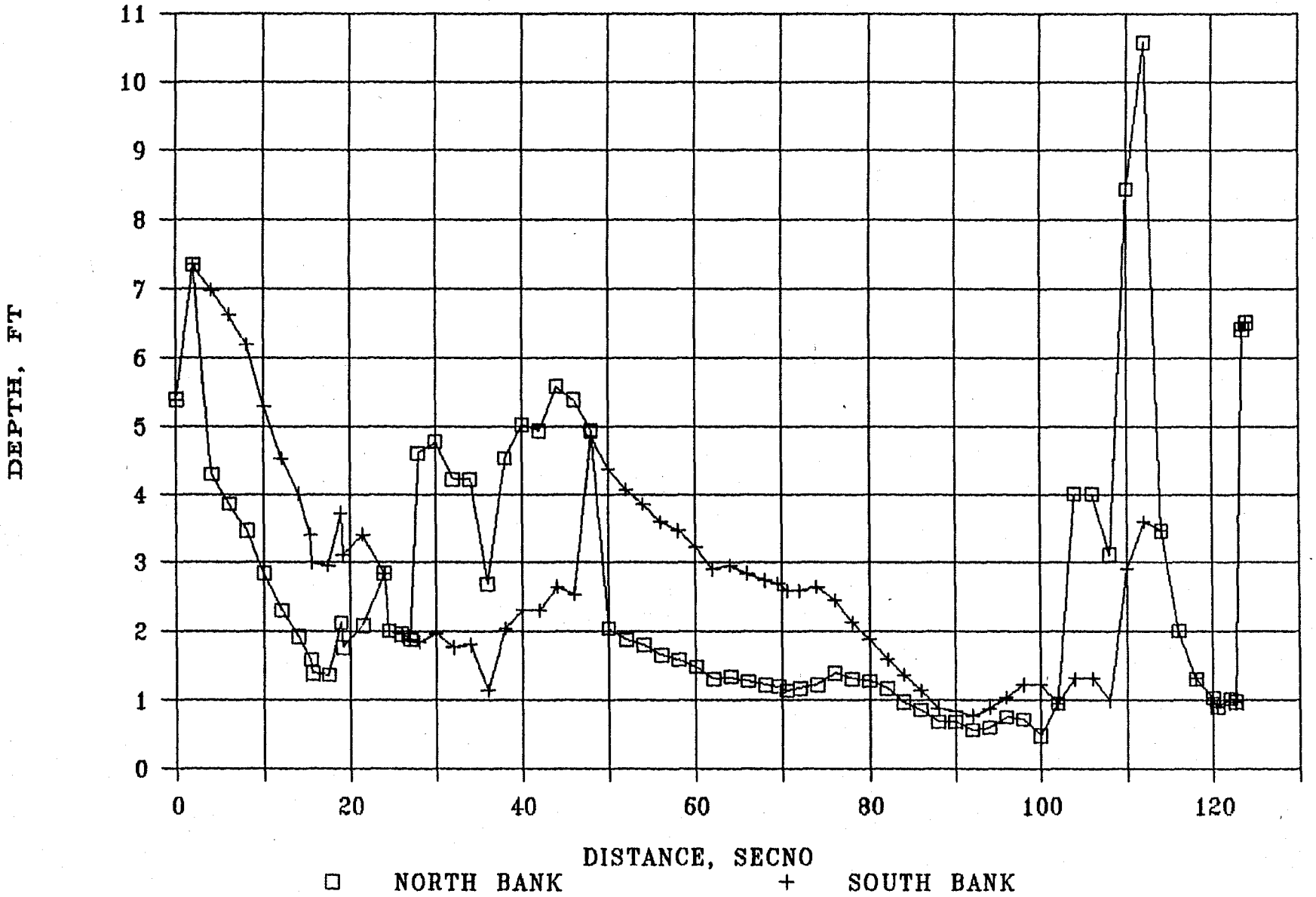
n = 0.035
SF = 1.50

	NORTH BANK:			ARMOR	SOUTH BANK:			ARMOR
SECND	TMAX	DA	%FINER	DEPTH	TMAX	DA	%FINER	DEPTH
0.00	2.00	94.13	85.35	5.40	2.00	94.13	85.35	5.40
2.00	2.18	107.12	87.47	7.36	2.18	107.12	87.47	7.36
4.00	1.87	85.11	83.69	4.30	2.15	104.92	87.13	6.99
6.00	1.81	81.04	82.88	3.86	2.12	102.73	86.78	6.64
8.00	1.75	77.05	82.05	3.47	2.08	99.84	86.31	6.20
10.00	1.64	69.90	80.45	2.83	1.99	93.43	85.22	5.30
12.00	1.53	62.99	78.73	2.29	1.90	87.16	84.08	4.53
14.00	1.44	57.51	77.18	1.91	1.83	82.39	83.15	4.00
15.40	1.35	52.20	75.53	1.59	1.74	76.39	81.91	3.40
15.60	1.29	48.76	74.37	1.39	1.67	71.82	80.90	2.99
17.50	1.28	48.20	74.17	1.36	1.66	71.18	80.75	2.94
19.00	1.49	60.53	78.05	2.12	1.79	79.70	82.61	3.73
19.20	1.40	55.13	76.46	1.76	1.69	73.12	81.19	3.11
21.50	1.48	59.92	77.88	2.08	1.74	76.39	81.91	3.40
24.00	1.64	69.90	80.45	2.83	1.64	69.90	80.45	2.83
24.50	1.46	58.71	77.53	1.99	1.46	58.71	77.53	1.99
26.00	1.45	58.11	77.36	1.95	1.45	58.11	77.36	1.95
27.00	1.43	56.91	77.00	1.88	1.43	56.91	77.00	1.88
28.00	1.91	87.85	84.21	4.61	1.42	56.32	76.82	1.84
30.00	1.93	89.24	84.47	4.78	1.45	58.11	77.36	1.95
32.00	1.86	84.42	83.56	4.22	1.40	55.13	76.46	1.76
34.00	1.86	84.42	83.56	4.22	1.41	55.72	76.64	1.80
36.00	1.61	67.99	79.99	2.68	1.20	43.75	72.52	1.14
38.00	1.90	87.16	84.08	4.53	1.47	59.32	77.71	2.03
40.00	1.96	91.32	84.85	5.03	1.53	62.99	78.73	2.29
42.00	1.95	90.63	84.72	4.95	1.53	62.99	78.73	2.29
44.00	2.02	95.55	85.59	5.59	1.60	67.36	79.84	2.63
46.00	2.00	94.13	85.35	5.40	1.58	66.10	79.53	2.53
48.00	1.95	90.63	84.72	4.95	1.94	89.93	84.59	4.86
50.00	1.47	59.32	77.71	2.03	1.88	85.79	83.82	4.37
52.00	1.43	56.91	77.00	1.88	1.84	83.07	83.29	4.07
54.00	1.41	55.72	76.64	1.80	1.81	81.04	82.88	3.86
56.00	1.37	53.37	75.91	1.65	1.77	78.37	82.33	3.59
58.00	1.35	52.20	75.53	1.59	1.75	77.05	82.05	3.47
60.00	1.32	50.47	74.96	1.49	1.71	74.42	81.48	3.22
62.00	1.26	47.07	73.77	1.30	1.65	70.54	80.60	2.88
64.00	1.27	47.63	73.97	1.33	1.66	71.18	80.75	2.94
66.00	1.25	46.51	73.57	1.27	1.64	69.90	80.45	2.83
68.00	1.23	45.40	73.15	1.22	1.62	68.62	80.15	2.73
69.50	1.22	44.85	72.95	1.19	1.61	67.99	79.99	2.68
70.50	1.20	43.75	72.52	1.14	1.59	66.73	79.69	2.58
72.00	1.21	44.30	72.74	1.16	1.59	66.73	79.69	2.58
74.00	1.23	45.40	73.15	1.22	1.60	67.36	79.84	2.63
76.00	1.29	48.76	74.37	1.39	1.56	64.85	79.22	2.43
78.00	1.26	47.07	73.77	1.30	1.49	60.53	78.05	2.12
80.00	1.25	46.51	73.57	1.27	1.43	56.91	77.00	1.88

82.00	1.21	44.30	72.74	1.16	1.35	52.20	75.53	1.59
84.00	1.13	39.98	70.99	0.96	1.28	48.20	74.17	1.36
86.00	1.08	37.35	69.83	0.85	1.20	43.75	72.52	1.14
88.00	0.99	32.78	67.61	0.67	1.09	37.87	70.07	0.87
90.00	0.99	32.78	67.61	0.67	1.07	36.84	69.60	0.83
92.00	0.92	29.37	65.70	0.55	1.04	35.30	68.87	0.77
94.00	0.94	30.33	66.27	0.59	1.09	37.87	70.07	0.87
96.00	1.03	34.79	68.62	0.75	1.16	41.58	71.66	1.03
98.00	1.01	33.78	68.12	0.71	1.23	45.40	73.15	1.22
100.00	0.87	27.01	64.24	0.48	1.23	45.40	73.15	1.22
102.00	1.12	39.45	70.76	0.94	1.12	39.45	70.76	0.94
104.00	1.83	82.39	83.15	4.00	1.26	47.07	73.77	1.30
106.00	1.83	82.39	83.15	4.00	1.26	47.07	73.77	1.30
108.00	1.69	73.12	81.19	3.11	1.14	40.51	71.21	0.99
110.00	2.26	113.07	88.36	8.45	1.65	70.54	80.60	2.88
112.00	2.39	122.97	89.74	10.59	1.77	78.37	82.33	3.59
114.00	1.75	77.05	82.05	3.47	1.75	77.05	82.05	3.47
116.00	1.46	58.71	77.53	1.99	1.46	58.71	77.53	1.99
118.00	1.26	47.07	73.77	1.30	1.26	47.07	73.77	1.30
120.00	1.16	41.58	71.66	1.03	1.16	41.58	71.66	1.03
120.50	1.10	38.40	70.30	0.89	1.10	38.40	70.30	0.89
122.00	1.15	41.04	71.44	1.01	1.15	41.04	71.44	1.01
122.65	1.13	39.98	70.99	0.96	1.13	39.98	70.99	0.96
123.55	2.10	101.28	86.55	6.41	2.10	101.28	86.55	6.41
124.00	2.11	102.01	86.67	6.53	2.11	102.01	86.67	6.53

ARMOR DEPTH

SALT RIVER CHANNELIZATION



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1/3

Job: R101N	Date
Calc by: GKC	7/28/90
Checked by: JFM	7/30/90
Dwg Chk:	

Levee Toedown Computation
Salt River Channelization
Grade Control #4 to Grade Control #5

FILE: TOED250.WK1
DATE: 07/28/90

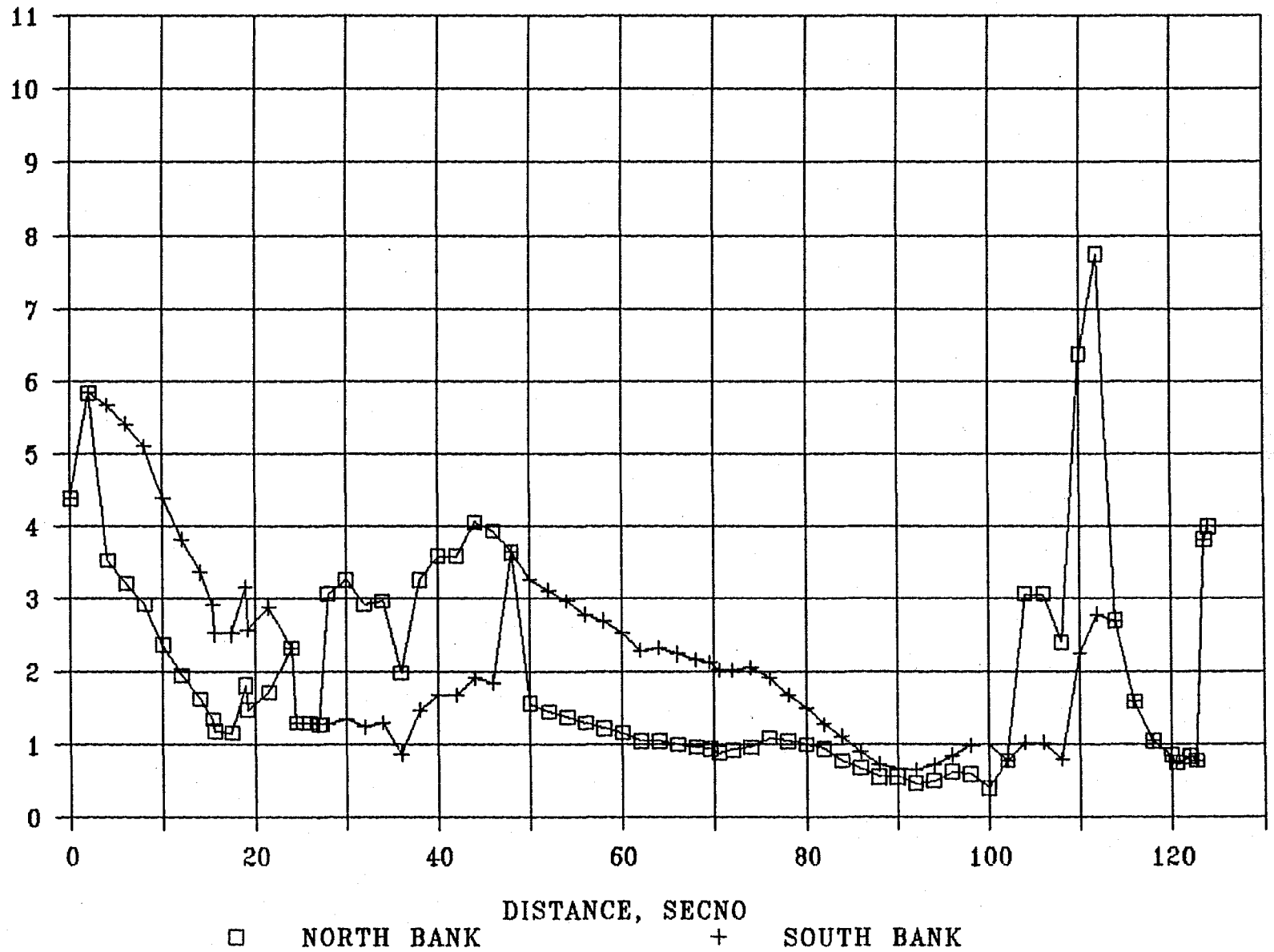
n = 0.035
SF = 1.30

	NORTH BANK:			ARMOR	SOUTH BANK:			ARMOR
SECND	TMAX	DA	%FINER	DEPTH	TMAX	DA	%FINER	DEPTH
0.00	2.17	85.84	83.83	4.38	2.17	85.84	83.83	4.38
2.00	2.36	97.35	85.90	5.84	2.36	97.35	85.90	5.84
4.00	2.03	77.66	82.18	3.53	2.34	96.12	85.69	5.66
6.00	1.97	74.25	81.44	3.21	2.31	94.28	85.37	5.41
8.00	1.91	70.88	80.68	2.91	2.27	91.84	84.94	5.10
10.00	1.78	63.77	78.94	2.35	2.17	85.84	83.83	4.38
12.00	1.67	57.95	77.31	1.94	2.08	80.55	82.78	3.81
14.00	1.57	52.82	75.73	1.62	2.00	75.95	81.82	3.36
15.40	1.47	47.86	74.05	1.34	1.91	70.88	80.68	2.91
15.60	1.40	44.48	72.81	1.17	1.82	65.93	79.49	2.51
17.50	1.39	44.00	72.62	1.15	1.82	65.93	79.49	2.51
19.00	1.63	55.88	76.69	1.81	1.96	73.68	81.32	3.16
19.20	1.52	50.32	74.91	1.48	1.83	66.47	79.62	2.56
21.50	1.60	54.34	76.22	1.71	1.90	70.32	80.55	2.87
24.00	1.77	63.23	78.79	2.31	1.77	63.23	78.79	2.31
24.50	1.45	46.88	73.70	1.29	1.45	46.88	73.70	1.29
26.00	1.45	46.88	73.70	1.29	1.45	46.88	73.70	1.29
27.00	1.44	46.40	73.53	1.27	1.44	46.40	73.53	1.27
28.00	1.94	72.56	81.06	3.06	1.44	46.40	73.53	1.27
30.00	1.98	74.81	81.57	3.26	1.47	47.86	74.05	1.34
32.00	1.91	70.88	80.68	2.91	1.43	45.92	73.35	1.24
34.00	1.92	71.44	80.81	2.96	1.45	46.88	73.70	1.29
36.00	1.68	58.47	77.46	1.98	1.25	37.53	69.91	0.86
38.00	1.98	74.81	81.57	3.26	1.52	50.32	74.91	1.48
40.00	2.04	78.24	82.30	3.58	1.59	53.84	76.06	1.68
42.00	2.04	78.24	82.30	3.58	1.59	53.84	76.06	1.68
44.00	2.12	82.89	83.25	4.06	1.66	57.43	77.16	1.91
46.00	2.10	81.72	83.02	3.93	1.64	56.40	76.85	1.84
48.00	2.05	78.82	82.42	3.64	2.05	78.82	82.42	3.64
50.00	1.55	51.82	75.41	1.56	1.98	74.81	81.57	3.26
52.00	1.51	49.82	74.74	1.45	1.95	73.12	81.19	3.11
54.00	1.48	48.35	74.23	1.37	1.92	71.44	80.81	2.96
56.00	1.45	46.88	73.70	1.29	1.88	69.22	80.29	2.78
58.00	1.42	45.44	73.17	1.22	1.86	68.12	80.03	2.69
60.00	1.39	44.00	72.62	1.15	1.82	65.93	79.49	2.51
62.00	1.34	41.65	71.69	1.04	1.76	62.70	78.65	2.27
64.00	1.34	41.65	71.69	1.04	1.77	63.23	78.79	2.31
66.00	1.32	40.72	71.30	1.00	1.75	62.16	78.50	2.23
68.00	1.30	39.80	70.91	0.96	1.73	61.10	78.21	2.16
69.50	1.29	39.34	70.72	0.94	1.72	60.57	78.06	2.12
70.50	1.26	37.98	70.12	0.88	1.69	58.99	77.61	2.01
72.00	1.28	38.89	70.52	0.92	1.69	58.99	77.61	2.01
74.00	1.30	39.80	70.91	0.96	1.70	59.52	77.76	2.05
76.00	1.36	42.59	72.07	1.08	1.66	57.43	77.16	1.91
78.00	1.34	41.65	71.69	1.04	1.59	53.84	76.06	1.68
80.00	1.32	40.72	71.30	1.00	1.53	50.82	75.07	1.51

82.00	1.29	39.34	70.72	0.94	1.44	46.40	73.53	1.27
84.00	1.20	35.30	68.87	0.77	1.37	43.06	72.25	1.10
86.00	1.14	32.68	67.56	0.67	1.27	38.43	70.32	0.90
88.00	1.06	29.30	65.66	0.55	1.17	33.98	68.22	0.72
90.00	1.06	29.30	65.66	0.55	1.14	32.68	67.56	0.67
92.00	0.99	26.45	63.88	0.46	1.12	31.83	67.11	0.64
94.00	1.01	27.26	64.40	0.49	1.16	33.55	68.00	0.70
96.00	1.10	30.98	66.63	0.61	1.24	37.08	69.71	0.84
98.00	1.08	30.14	66.15	0.58	1.31	40.26	71.11	0.98
100.00	0.93	24.08	62.24	0.39	1.32	40.72	71.30	1.00
102.00	1.20	35.30	68.87	0.77	1.20	35.30	68.87	0.77
104.00	1.94	72.56	81.06	3.06	1.33	41.19	71.50	1.02
106.00	1.94	72.56	81.06	3.06	1.33	41.19	71.50	1.02
108.00	1.79	64.31	79.08	2.39	1.21	35.74	69.08	0.79
110.00	2.42	101.09	86.52	6.38	1.75	62.16	78.50	2.23
112.00	2.55	109.34	87.81	7.75	1.88	69.22	80.29	2.78
114.00	1.86	68.12	80.03	2.69	1.86	68.12	80.03	2.69
116.00	1.56	52.32	75.57	1.59	1.56	52.32	75.57	1.59
118.00	1.34	41.65	71.69	1.04	1.34	41.65	71.69	1.04
120.00	1.24	37.08	69.71	0.84	1.24	37.08	69.71	0.84
120.50	1.18	34.42	68.44	0.73	1.18	34.42	68.44	0.73
122.00	1.23	36.63	69.50	0.82	1.23	36.63	69.50	0.82
122.65	1.20	35.30	68.87	0.77	1.20	35.30	68.87	0.77
123.55	2.08	80.55	82.78	3.81	2.08	80.55	82.78	3.81
124.00	2.11	82.30	83.14	3.99	2.11	82.30	83.14	3.99

ARMOR DEPTH

SALT RIVER CHANNELIZATION



Job: 1L10/N	Date
Calc by: GKC	7/28/90
Checked by: JFM	
Dwg Chk:	7/30/90

3/3

CRSS

CRS SIRRINE

DESIGN SHEET

Job Rio Salado Channel
Structure
Live Load Per Square Foot

Job No. R101N Date 12/15/89
Computed By GRC
Working Stress FM 12/20/89

Bed Form Analysis

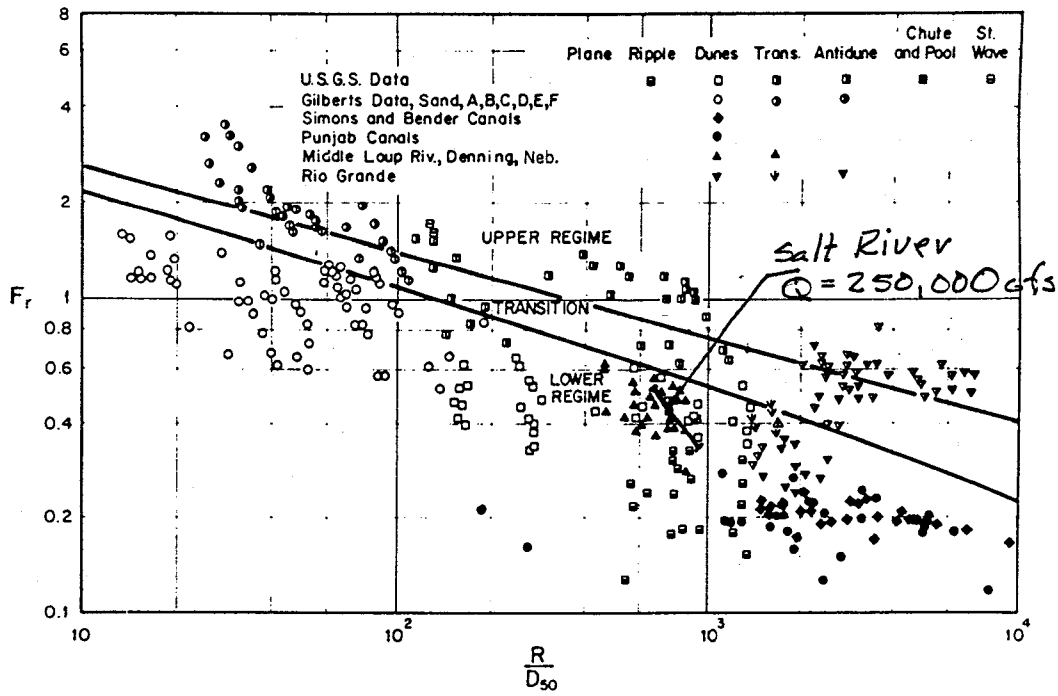


Fig. 5.23 Bed form prediction as a function of F_r and R/D_{50}.

from Simons & Senturk (1977) pg 262

Location	Q = 215,000 F	d_{max}	d/D_{50}	Q = 250,000 F	d_{max}	d/D_{50}
GC3 - GC4	0.62	21.2	646	0.62	23.0	701
GC4 - Mill	0.49	23.0	701	0.49	25.7	783
Mill - Rural	0.47	24.7	753	0.44	27.5	838
Rural - IBW	0.42	24.5	747	0.42	27.0	823
IBW - McClin	0.48	21.5	655	0.48	24.0	732

→ Channel is in lower regime
Bed form is dunes

See Attached worksheets: BEDF215.WK1
BEDF250.WK1

CRSS

CRS SIRRINE

DESIGN SHEET

Job Rio Salado Channel
Structure
Live Load Per Square Foot

Job No. R101N Date 12/15/89
Computed By
Working Stress JEM 12/20/89

Dune height - Method #1: Allen (1963)

$$A_D = 0.065 d^{1.21}$$

[from equation 5.13 Simons and Senturk (1977), page 266, converted to feet-units]

Reach	Q=215,000 dmax	Q=215,000 A_D	Q=250,000 dmax	Q=250,000 A_D
GC3-GC4	21.2	2.62	23.0	2.89
GC4-Mill	23.0	2.89	25.7	3.30
Mill-Rural	24.7	3.15	27.5	3.59
Rural-IBW	24.5	3.12	27.0	3.51
IBW-McClin	21.5	2.66	24.0	3.04

See Attached worksheets

Method #2: Yalin (1964)

$$A_d = \tfrac{1}{6}((\tau - \tau_c)/\tau)\, d$$

$$\tau_c = 4.83\,(10/304.8) \qquad D_{50} = 10 \text{ mm}$$
$$= 0.16 \text{ lb/ft}^2$$

Q=215,000

Location	τ	dmax	A_d	τ/τ_c	
GC3-GC4	2.94	21.2	3.34	18.4	*Dunes
GC4-Mill	1.85	23.0	3.50	11.6	Plane Bed
Mill-Rural	2.26	24.7	3.83	14.1	Plane Bed
Rural-IBW	2.31	24.5	3.80	14.4	Plane Bed
IBW-McClin	2.81	21.5	3.38	17.6	Dunes

See Attached worksheets

*According to Yalin sand waves, i.e. dunes, will disappear when $\tau/\tau_c < 17.63$

CRSS

CRS SIRRINE

DESIGN SHEET

Job _____ Job No. _____ Date _____
Structure _____ Computed By _____
Live Load Per Square Foot _____ Working Stress _____

Method # 2 : continued

Q = 250,000

Reach	τ	dmax	Ad	τ/τ_c	
6C3 - 6C4	3.24	23.0	3.64	20.3	Dunes
6C4 - Mill	2.02	25.7	3.94	12.6	Plane
Mill - Rural	2.21	27.5	4.25	13.8	Plane
Rural - IBW	2.38	27.0	4.20	14.9	Plane
IBW - MCT	2.87	24.0	3.78	17.9	Dunes

See Attached Worksheets

1/2

Job: 1210IN	Date
Calc by: GKC	7/28/90
Checked by: JFM	7/30/90
Dwg Chk:	

Bed Form Computation
Salt River Channelization
Grade Control #4 to Grade Control #5

FILE: BEDF215.WK1
DATE: 07/19/90

	NORTH BANK:				SOUTH BANK:		
SECND	TMAX	Dmax	YALIN	ALLEN	TMAX	YALIN	ALLEN
0.00	2.00	20.99	3.22	2.59	2.00	3.22	2.59
2.00	2.18	20.85	3.22	2.56	2.18	3.22	2.56
4.00	1.87	21.32	3.25	2.63	2.15	3.29	2.63
6.00	1.81	21.44	3.26	2.65	2.12	3.30	2.65
8.00	1.75	21.57	3.27	2.67	2.08	3.32	2.67
10.00	1.64	21.77	3.27	2.70	1.99	3.34	2.70
12.00	1.53	21.98	3.28	2.73	1.90	3.35	2.73
14.00	1.44	22.07	3.27	2.75	1.83	3.36	2.75
15.40	1.35	22.17	3.26	2.76	1.74	3.36	2.76
15.60	1.29	22.53	3.29	2.82	1.67	3.40	2.82
17.50	1.28	22.56	3.29	2.82	1.66	3.40	2.82
19.00	1.49	22.58	3.36	2.82	1.79	3.43	2.82
19.20	1.40	23.08	3.41	2.90	1.69	3.48	2.90
21.50	1.48	22.99	3.42	2.89	1.74	3.48	2.89
24.00	1.64	22.77	3.42	2.85	1.64	3.42	2.85
24.50	1.46	23.88	3.54	3.02	1.46	3.54	3.02
26.00	1.45	23.98	3.56	3.04	1.45	3.56	3.04
27.00	1.43	24.15	3.57	3.06	1.43	3.57	3.06
28.00	1.91	24.25	3.70	3.08	1.42	3.59	3.08
30.00	1.93	24.25	3.71	3.08	1.45	3.60	3.08
32.00	1.86	24.38	3.71	3.10	1.40	3.60	3.10
34.00	1.86	24.39	3.72	3.10	1.41	3.60	3.10
36.00	1.61	24.69	3.71	3.15	1.20	3.57	3.15
38.00	1.90	24.47	3.73	3.11	1.47	3.63	3.11
40.00	1.96	24.47	3.75	3.11	1.53	3.65	3.11
42.00	1.95	24.53	3.75	3.12	1.53	3.66	3.12
44.00	2.02	24.53	3.76	3.12	1.60	3.68	3.12
46.00	2.00	24.61	3.77	3.13	1.58	3.69	3.13
48.00	1.95	24.74	3.79	3.15	1.94	3.78	3.15
50.00	1.47	24.84	3.69	3.17	1.88	3.79	3.17
52.00	1.43	24.89	3.68	3.18	1.84	3.79	3.18
54.00	1.41	24.91	3.68	3.18	1.81	3.78	3.18
56.00	1.37	24.93	3.67	3.18	1.77	3.78	3.18
58.00	1.35	24.95	3.67	3.19	1.75	3.78	3.19
60.00	1.32	24.96	3.66	3.19	1.71	3.77	3.19
62.00	1.26	25.00	3.64	3.19	1.65	3.76	3.19
64.00	1.27	24.95	3.63	3.19	1.66	3.76	3.19
66.00	1.25	24.93	3.62	3.18	1.64	3.75	3.18
68.00	1.23	24.93	3.61	3.18	1.62	3.74	3.18
69.50	1.22	24.87	3.60	3.17	1.61	3.73	3.17
70.50	1.20	24.98	3.61	3.19	1.59	3.74	3.19
72.00	1.21	24.95	3.61	3.19	1.59	3.74	3.19
74.00	1.23	24.91	3.61	3.18	1.60	3.74	3.18
76.00	1.19	24.91	3.59	3.18	1.56	3.73	3.18
78.00	1.13	24.93	3.57	3.18	1.49	3.71	3.18
80.00	1.06	24.94	3.53	3.19	1.43	3.69	3.19
82.00	0.99	24.96	3.49	3.19	1.35	3.67	3.19
84.00	0.92	24.96	3.44	3.19	1.28	3.64	3.19

Job:
Date
Calc by:
Checked by: JFM 7/30/99
Dwg Chk:

86.00	0.85	24.97	3.38	3.19	1.20	3.61	3.19
88.00	0.75	25.03	3.28	3.20	1.09	3.56	3.20
90.00	0.73	24.93	3.24	3.18	1.07	3.53	3.18
92.00	0.71	24.84	3.21	3.17	1.04	3.50	3.17
94.00	0.75	24.69	3.24	3.15	1.09	3.51	3.15
96.00	0.81	24.53	3.28	3.12	1.16	3.52	3.12
98.00	0.87	24.39	3.32	3.10	1.23	3.54	3.10
100.00	0.87	24.31	3.31	3.09	1.23	3.52	3.09
102.00	1.12	24.07	3.44	3.05	1.12	3.44	3.05
104.00	1.83	23.88	3.63	3.02	1.26	3.47	3.02
106.00	1.83	23.89	3.63	3.02	1.26	3.48	3.02
108.00	1.69	24.05	3.63	3.05	1.14	3.45	3.05
110.00	2.26	23.68	3.67	2.99	1.65	3.56	2.99
112.00	2.39	23.62	3.67	2.98	1.77	3.58	2.98
114.00	1.75	23.69	3.59	2.99	1.75	3.59	2.99
116.00	1.46	24.08	3.57	3.05	1.46	3.57	3.05
118.00	1.26	24.32	3.54	3.09	1.26	3.54	3.09
120.00	1.16	24.41	3.51	3.10	1.16	3.51	3.10
120.50	1.10	24.48	3.49	3.11	1.10	3.49	3.11
122.00	1.15	24.39	3.50	3.10	1.15	3.50	3.10
122.65	1.13	24.54	3.51	3.12	1.13	3.51	3.12
123.55	2.10	19.25	2.96	2.33	2.10	2.96	2.33
124.00	2.11	19.32	2.98	2.34	2.11	2.98	2.34
		MAX Hbf =	3.79	3.20		3.79	3.20
		1/2 Hbf =	1.89	1.60		1.89	1.60

1/2

Job:	Date
12101N	
Calc by: GKC	7/28/9
Checked by: JFM	7/30/9
Dwg Chk:	

Bed Form Computation
Salt River Channelization
Grade Control #4 to Grade Control #5

FILE: BEDF250.WK1
DATE: 07/19/90

	NORTH BANK:				SOUTH BANK:		
SECND	TMAX	Dmax	YALIN	ALLEN	TMAX	YALIN	ALLEN
0.00	2.17	22.78	3.52	2.85	2.17	3.52	2.85
2.00	2.36	22.63	3.52	2.83	2.36	3.52	2.83
4.00	2.03	23.15	3.55	2.91	2.34	3.59	2.91
6.00	1.97	23.27	3.56	2.93	2.31	3.61	2.93
8.00	1.91	23.40	3.57	2.95	2.27	3.63	2.95
10.00	1.78	23.62	3.58	2.98	2.17	3.65	2.98
12.00	1.67	23.84	3.59	3.02	2.08	3.67	3.02
14.00	1.57	23.94	3.58	3.03	2.00	3.67	3.03
15.40	1.47	24.06	3.57	3.05	1.91	3.67	3.05
15.60	1.40	24.46	3.61	3.11	1.82	3.72	3.11
17.50	1.39	24.48	3.61	3.11	1.82	3.72	3.11
19.00	1.63	24.45	3.68	3.11	1.96	3.74	3.11
19.20	1.52	25.09	3.74	3.21	1.83	3.82	3.21
21.50	1.60	24.99	3.75	3.19	1.90	3.81	3.19
24.00	1.77	24.75	3.75	3.16	1.77	3.75	3.16
24.50	1.45	26.75	3.97	3.47	1.45	3.97	3.47
26.00	1.45	26.81	3.98	3.48	1.45	3.98	3.48
27.00	1.44	26.94	3.99	3.50	1.44	3.99	3.50
28.00	1.94	27.00	4.13	3.51	1.44	4.00	3.51
30.00	1.98	26.98	4.13	3.50	1.47	4.01	3.50
32.00	1.91	27.06	4.13	3.52	1.43	4.01	3.52
34.00	1.92	27.04	4.13	3.51	1.45	4.01	3.51
36.00	1.68	27.32	4.12	3.56	1.25	3.97	3.56
38.00	1.98	27.08	4.15	3.52	1.52	4.04	3.52
40.00	2.04	27.04	4.15	3.51	1.59	4.05	3.51
42.00	2.04	27.08	4.16	3.52	1.59	4.06	3.52
44.00	2.12	27.05	4.17	3.51	1.66	4.07	3.51
46.00	2.10	27.12	4.18	3.53	1.64	4.08	3.53
48.00	2.05	27.23	4.18	3.54	2.05	4.18	3.54
50.00	1.55	27.32	4.08	3.56	1.98	4.19	3.56
52.00	1.51	27.35	4.08	3.56	1.95	4.18	3.56
54.00	1.48	27.36	4.07	3.56	1.92	4.18	3.56
56.00	1.45	27.38	4.06	3.57	1.88	4.17	3.57
58.00	1.42	27.39	4.05	3.57	1.86	4.17	3.57
60.00	1.39	27.39	4.04	3.57	1.82	4.16	3.57
62.00	1.34	27.43	4.03	3.57	1.76	4.16	3.57
64.00	1.34	27.37	4.02	3.56	1.77	4.15	3.56
66.00	1.32	27.35	4.01	3.56	1.75	4.14	3.56
68.00	1.30	27.33	3.99	3.56	1.73	4.13	3.56
69.50	1.29	27.27	3.98	3.55	1.72	4.12	3.55
70.50	1.26	27.45	3.99	3.58	1.69	4.14	3.58
72.00	1.28	27.42	4.00	3.57	1.69	4.14	3.57
74.00	1.30	27.35	4.00	3.56	1.70	4.13	3.56
76.00	1.25	27.35	3.97	3.56	1.66	4.12	3.56
78.00	1.19	27.37	3.95	3.56	1.59	4.10	3.56
80.00	1.13	27.38	3.92	3.57	1.53	4.09	3.57
82.00	1.05	27.41	3.87	3.57	1.44	4.06	3.57
84.00	0.98	27.41	3.82	3.57	1.37	4.03	3.57

2/2

Date

Calc by:

Checked by: JFM 7/30/90

Dwg Chk:

86.00	0.90	27.43	3.76	3.57	1.27	4.00	3.57
88.00	0.81	27.49	3.68	3.58	1.17	3.96	3.58
90.00	0.79	27.39	3.64	3.57	1.14	3.92	3.57
92.00	0.76	27.30	3.59	3.55	1.12	3.90	3.55
94.00	0.80	27.15	3.62	3.53	1.16	3.90	3.53
96.00	0.87	26.98	3.67	3.50	1.24	3.92	3.50
98.00	0.93	26.83	3.70	3.48	1.31	3.93	3.48
100.00	0.93	26.75	3.69	3.47	1.32	3.92	3.47
102.00	1.20	26.48	3.82	3.42	1.20	3.82	3.42
104.00	1.94	26.28	4.02	3.39	1.33	3.85	3.39
106.00	1.94	26.27	4.02	3.39	1.33	3.85	3.39
108.00	1.79	26.43	4.01	3.42	1.21	3.82	3.42
110.00	2.42	26.02	4.05	3.35	1.75	3.94	3.35
112.00	2.55	25.94	4.05	3.34	1.88	3.96	3.34
114.00	1.86	26.00	3.96	3.35	1.86	3.96	3.35
116.00	1.56	26.41	3.95	3.41	1.56	3.95	3.41
118.00	1.34	26.67	3.91	3.45	1.34	3.91	3.45
120.00	1.24	26.76	3.88	3.47	1.24	3.88	3.47
120.50	1.18	26.83	3.87	3.48	1.18	3.87	3.48
122.00	1.23	26.74	3.88	3.47	1.23	3.88	3.47
122.65	1.20	26.96	3.89	3.50	1.20	3.89	3.50
123.55	2.08	21.70	3.34	2.69	2.08	3.34	2.69
124.00	2.11	21.72	3.35	2.69	2.11	3.35	2.69
		MAX Hbf =	4.18	3.58		4.19	3.58
		1/2 Hbf =	2.09	1.79		2.09	1.79

1/3

Job:	Date
R101N	
Calc by: GKC	7/28/90
Checked by: JFM	7/30/90
Dwg Chk:	

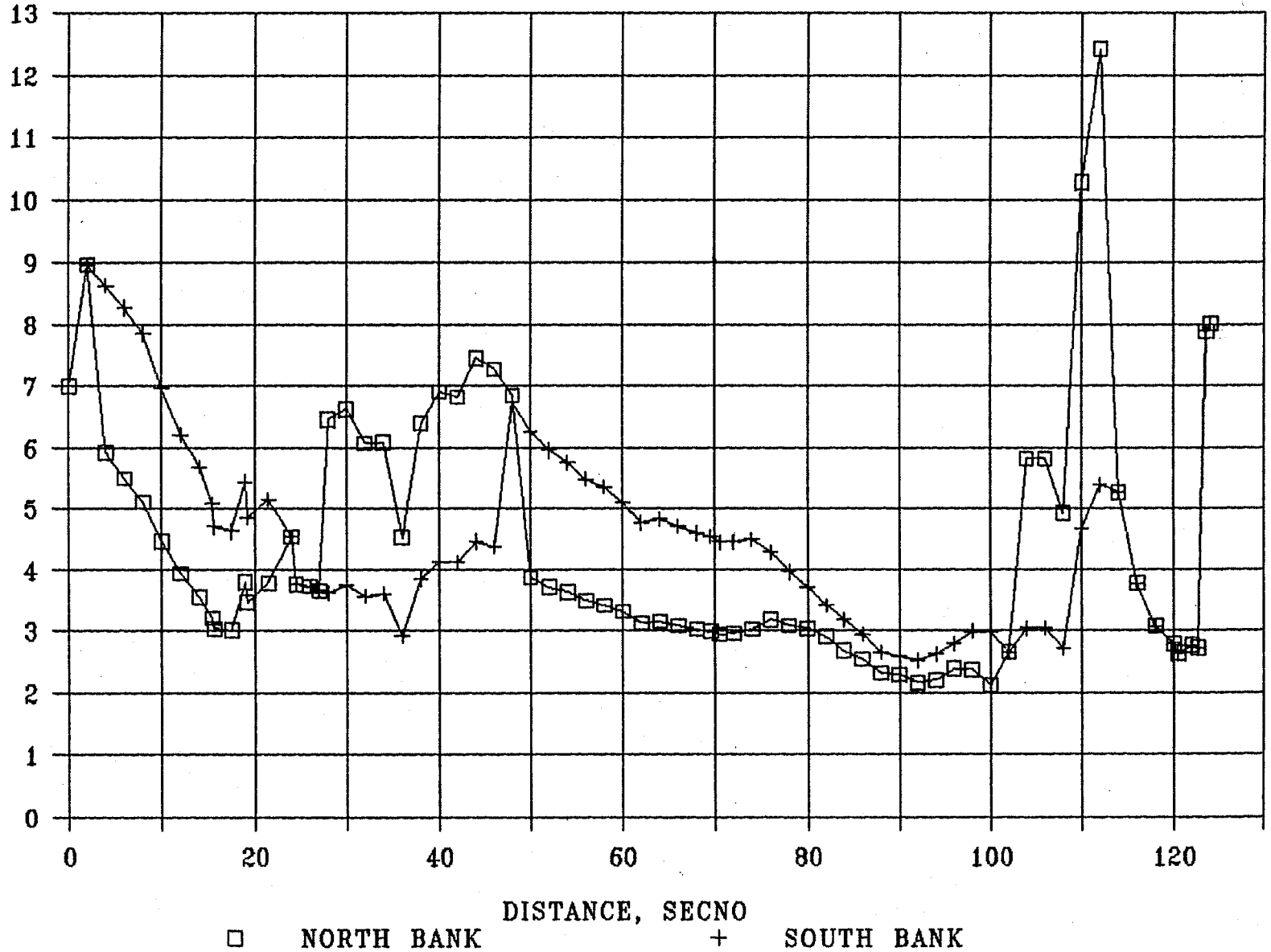
Levee Toedown Computation
Salt River Channelization
Grade Control #4 to Grade Control #5

	NORTH BANK:		SOUTH BANK:	
SECNO	BED FORM	TOEDOWN	BED FORM	TOEDOWN
0.00	3.22	7.01	3.22	7.01
2.00	3.22	8.97	3.22	8.97
4.00	3.25	5.92	3.29	8.64
6.00	3.26	5.49	3.30	8.29
8.00	3.27	5.10	3.32	7.86
10.00	3.27	4.47	3.34	6.97
12.00	3.28	3.93	3.35	6.21
14.00	3.27	3.55	3.36	5.68
15.40	3.26	3.22	3.36	5.08
15.60	3.29	3.04	3.40	4.69
17.50	3.29	3.01	3.40	4.64
19.00	3.36	3.80	3.43	5.44
19.20	3.41	3.47	3.48	4.85
21.50	3.42	3.79	3.48	5.14
24.00	3.42	4.54	3.42	4.54
24.50	3.54	3.76	3.54	3.76
26.00	3.56	3.73	3.56	3.73
27.00	3.57	3.66	3.57	3.66
28.00	3.70	6.46	3.59	3.63
30.00	3.71	6.63	3.60	3.75
32.00	3.71	6.08	3.60	3.56
34.00	3.72	6.08	3.60	3.60
36.00	3.71	4.53	3.57	2.92
38.00	3.73	6.40	3.63	3.85
40.00	3.75	6.91	3.65	4.12
42.00	3.75	6.82	3.66	4.12
44.00	3.76	7.47	3.68	4.47
46.00	3.77	7.28	3.69	4.37
48.00	3.79	6.84	3.78	6.75
50.00	3.69	3.88	3.79	6.27
52.00	3.68	3.72	3.79	5.97
54.00	3.68	3.64	3.78	5.75
56.00	3.67	3.49	3.78	5.48
58.00	3.67	3.42	3.78	5.36
60.00	3.66	3.32	3.77	5.11
62.00	3.64	3.12	3.76	4.76
64.00	3.63	3.15	3.76	4.82
66.00	3.62	3.08	3.75	4.71
68.00	3.61	3.02	3.74	4.60
69.50	3.60	2.99	3.73	4.54
70.50	3.61	2.94	3.74	4.45
72.00	3.61	2.97	3.74	4.45
74.00	3.61	3.02	3.74	4.50
76.00	3.59	3.19	3.73	4.30
78.00	3.57	3.09	3.71	3.97
80.00	3.53	3.04	3.69	3.72

82.00	3.49	2.91	3.67	3.42
84.00	3.44	2.68	3.64	3.18
86.00	3.38	2.54	3.61	2.94
88.00	3.28	2.31	3.56	2.65
90.00	3.24	2.29	3.53	2.59
92.00	3.21	2.16	3.50	2.52
94.00	3.24	2.21	3.51	2.63
96.00	3.28	2.39	3.52	2.79
98.00	3.32	2.37	3.54	2.99
100.00	3.31	2.13	3.52	2.98
102.00	3.44	2.66	3.44	2.66
104.00	3.63	5.82	3.47	3.04
106.00	3.63	5.82	3.48	3.04
108.00	3.63	4.92	3.45	2.71
110.00	3.67	10.28	3.56	4.66
112.00	3.67	12.42	3.58	5.38
114.00	3.59	5.26	3.59	5.26
116.00	3.57	3.78	3.57	3.78
118.00	3.54	3.07	3.54	3.07
120.00	3.51	2.79	3.51	2.79
120.50	3.49	2.64	3.49	2.64
122.00	3.50	2.76	3.50	2.76
122.65	3.51	2.72	3.51	2.72
123.55	2.96	7.89	2.96	7.89
124.00	2.98	8.02	2.98	8.02

TOEDOWN DEPTH

SALT RIVER CHANNELIZATION

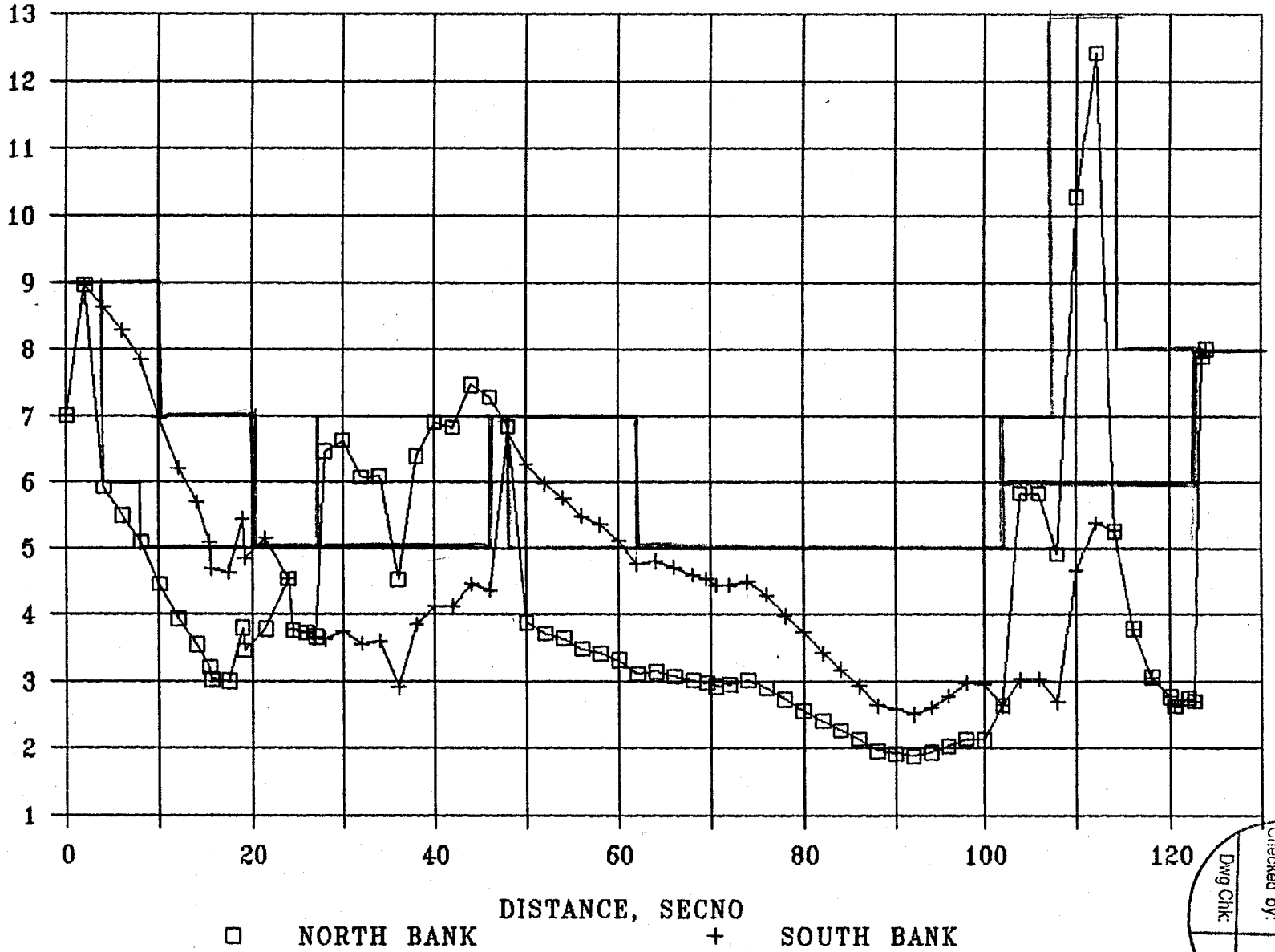


Job: 12101	
Calc by: GPC	Date 7/28/90
Checked by: JFM	
Dwg Chk:	7/30/90

3/3

TOEDOWN DEPTH

SALT RIVER CHANNELIZATION



Job:
Date
Calc by:
Checked by:
Dwg Chk:

Job:
Date
Calc by:
Checked by:
Dwg Chk:

APPENDIX J

REACH SCOUR CALCULATIONS

CRSS

CRS SIRRINE

DESIGN SHEET

Job _____ Job No. _____ Date _____
Structure _____ Computed By _____
Live Load Per Square Foot _____ Working Stress _____ JFM 4/27/90

Maximum Boundary Shear Computation
One-dimensional Hydraulics Summary

Q = 215,000 cfs

Rch	Vel Max	Vel Min	Vel Ave	Max Shear	Max Fr	Ave Width
GC3-GC4	14.1	11.6	12.8	2.75	0.62	942
GC4-Mill	11.6	9.4	10.4	1.73	0.49	1192
Mill-Rural	11.7	9.4	10.5	1.62	0.47	1004
Rural-IBW	10.5	8.1	9.2	1.47	0.42	1098
IBW-McCl	11.9	10.4	10.9	1.84	0.48	1037

Q = 250,000 cfs

Rch	Vel Max	Vel Min	Vel Ave	Max Shear	Max Fr	Ave Width
GC3-GC4	14.9	12.3	13.6	3.00	0.62	951
GC4-Mill	12.3	9.6	10.8	1.89	0.49	1216
Mill-Rural	11.7	9.7	10.6	1.56	0.44	1038
Rural-IBW	11.2	8.4	9.6	1.51	0.42	1119
IBW-McCl	12.3	10.8	11.3	1.88	0.48	1063

Reach Description

GC3-GC4: Grade Control No 3 to No 4
Sections 207+82 to 248+00
Length 4018, 22 sections

GC4-Mill: Grade Control No 4 to U/S Mill Ave bridge
Sections 0 to 24; Length 2244; 15 Sections

Mill-Rural: Mill Ave bridge to Rural Rd bridge
Sections 24+50 to 72+00; Length 4957; 26 Sec

Rural-IBW: Rural Rd bridge to Indian Band Wash
Sections 74+00 to 100+00; Length 2569; 14 Secs

IBW-McCl: Sections 100+00 to 124+00; Length 2786; 15 Secs

CRSS

CRS SIRRINE

DESIGN SHEET

Job _____ Job No. _____ Date _____
Structure _____ Computed By _____
Live Load Per Square Foot _____ Working Stress JFM 27 April 90

Continued...

Q = 215,000 cfs

Rch	Bend	Rc	TW	Depth	Rc/TW	TW/d
GC3-GC4	No	-	942	21.2	-	44.4
GC4-Mill	No	-	1192	23.0	-	51.8
Mill-Rural	Yes	6000	1004	24.7	6.0	40.6
Rural-IBW	Yes	5030	1098	24.5	4.6	44.8
IBW-McCl	Yes	5000	1037	21.5	4.8	48.2

Q = 250,000 cfs

Rch	Bend	Rc	TW	Depth	Rc/W	TW/d
GC3-GC4	No	-	951	23.0	-	41.3
GC4-Mill	No	-	1216	25.7	-	47.3
Mill-Rural	Yes	6000	1038	27.5	5.8	37.7
Rural-IBW	Yes	5030	1119	27.0	4.5	41.4
IBW-McCl	Yes	5000	1063	24.0	4.7	44.3

CRSS

CRS SIRRINE

DESIGN SHEET

Job _____ Job No. _____ Date _____
Structure _____ Computed By _____
Live Load Per Square Foot _____ Working Stress JFM 4/27/90

Maximum Boundary Shear Stress Factors

Condition	Factor	Equation/Chart
Max Bed	K_b	Chart 9
Max Bank	K_{ss}	Chart 12
Max Bend	K_r	Chart 14
High Froude	F_{sf}	Chart 13
Impingement	K_i	$K_i = 1 + \sin\theta$; θ = ∡ of impinge

Q = 215,000 cfs

Rch	K_b	K_{ss}	K_r	F_{sf}	K_i	
GC3-GC4	1.07	0.91	1.0	0.87	1.0	
GC4-Mill	1.07	0.91	1.0	0.84	1.0	
Mill-Rural	1.08	0.92	1.29	0.84	1.0	
Rural-IBW	1.07	0.91	1.47	0.83	1.0	
IBW West Bank	1.07	0.91	1.0	0.83	1.50	$\theta = 30°$
IBW-McCl	1.06	0.90	1.44	0.84	1.0	

Q = 250,000 cfs

Rch	K_b	K_{ss}	K_r	F_{sf}	K_i	
GC3-GC4	1.08	0.92	1.0	0.87	1.0	
GC4-Mill	1.07	0.91	1.0	0.84	1.0	
Mill-Rural	1.08	0.92	1.31	0.83	1.0	
Rural-IBW	1.07	0.91	1.49	0.83	1.0	
IBW-West Bank	1.07	0.91	1.0	0.83	1.50	$\theta = 30°$
IBW-McCl	1.07	0.91	1.46	0.84	1.0	

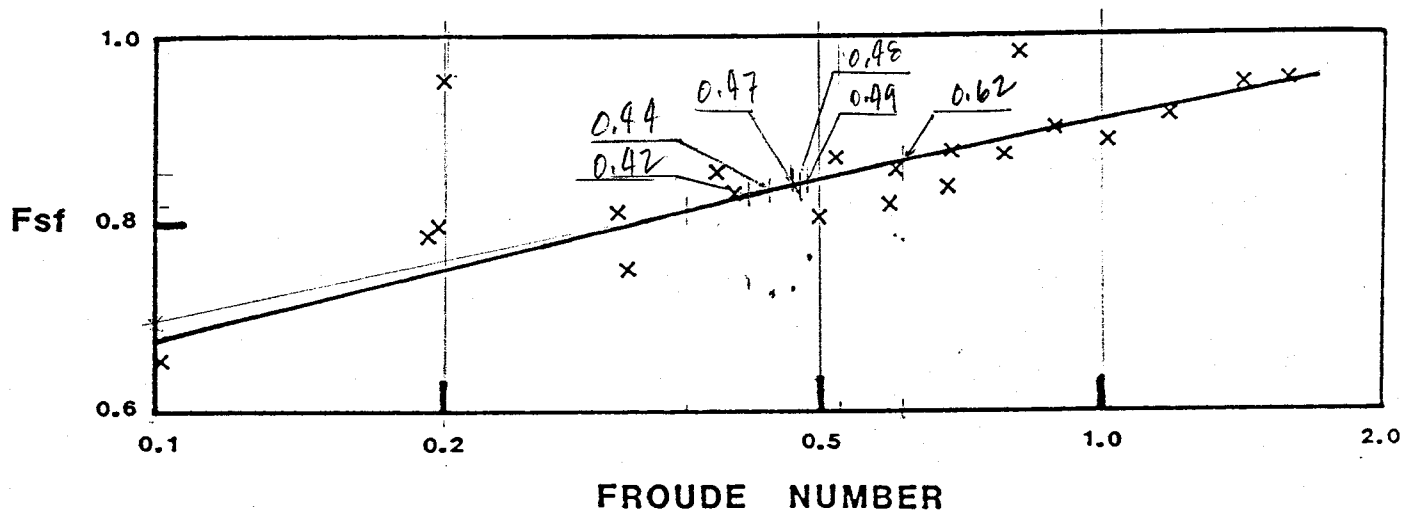


Chart 13. Coefficient for Effect of Froude Number on Boundary Shear Stress Adjustment Factor on Channel Side-Slope (Distribution of Shear in Rectangular Channels, Davidian, Cahal)

CRSS

CRS SIRRINE

DESIGN SHEET

Job Rio Salado Channel
Structure
Live Load Per Square Foot

Job No. R101N Date 12/15/89
Computed By GKC
Working Stress IFM 12/20/89

Maximum Bed Scour

$$d_s = y_a (1/\Delta p - 1)$$

$$y_a = 2 \cdot D_a$$

$$D_a = \tau_{max}/4.83$$

where $4.83 = 0.047(\gamma_s - \gamma)$
τ_{max} = max boundary shear, lb/ft²
D_a = armor size, ft
Δp = fraction larger than armor size

Q = 215,000

Reach	τ_{max}	D_a	% Pass	y_a	Δp	d_s
GC3-GC4	2.94	0.61	92.0	1.22	0.080	14.4
GC4-Mill	1.85	0.38	83.0	0.76	0.170	3.7
Mill-Rural	2.26	0.47	87.0	0.94	0.130	6.3
Rural-IBW	2.31	0.48	87.4	0.96	0.126	6.7
IBW-McC1	2.81	0.58	91.1	1.16	0.089	11.9

Q = 250,000

Reach	τ_{max}	D_a	% Pass	y_a	Δp	d_s
GC3-GC4	3.24	0.67	93.8	1.34	0.062	20.3
GC4-Mill	2.02	0.42	84.9	0.84	0.151	4.7
Mill-Rural	2.21	0.46	86.6	0.92	0.139	6.0
Rural-IBW	2.38	0.49	88.0	0.98	0.120	7.2
IBW-McC1	2.87	0.59	91.5	1.18	0.085	12.7

APPENDIX K

LOCAL SCOUR CALCULATIONS

CRSS

CRS SIRRINE

DESIGN SHEET

Job _____ Job No. _____ Date _____
Structure _____ Computed By _____
Live Load Per Square Foot _____ Working Stress _____

Comparison of Scour and Foundation Elevations
at Mill Ave Bridge
Maximum Scour

General:	3.6	
Local:	33.1	Abutment Pier
	26.2	Intermediate Pier

Foundation Elevations:		Theoretical Scour	Max Scour
South Abut	1114.80	–	–
Pier #2	1117.00	–	–
#3	1119.00	–	–
#4 (Abut)	1120.90	1095.0	1123.9 (R)
#5	1120.75	1101.9	1123.8 (R)
#6	1120.30	1101.9	1123.3 (R)
#7	1119.30	1101.9	1122.3 (R)
#8 (Abut)	1118.60	1095.0	1121.6 (R)
#9	1088.00	1101.9	1101.9
#10	1116.40	–	–
North Abut	1134.04	–	–

* Mill Ave Bridge Plans require piers to extend into solid rock 3 ft as minimum.

* Computed scour depths are greater than foundation depth for all piers except #9.

(R) Bed rock limits scour depth

– Indicates that channelization will place pier out of floodway

CRSS

CRS SIRRINE

DESIGN SHEET

Job Rio Salado Channel
Structure
Live Load Per Square Foot

Job No. 12101N Date 12/21/89
Computed By GKC
Working Stress JFM 12/20/89

Local Scour Analysis - Q = 215,000

Location	Flow Depth	Vel	Pier Size	Pier Shape	∡ Attack
SPRR	22.2	9.4	8	Circ	0°
Rural	24.7	9.6	6	Circ	0°
McClintock	20.9	10.5	6	Circ	0°
Mill Ave (A)	23.9	9.9	15×62	Wall	15°
Mill Ave (I)	23.9	9.9	9.5×45	Wall	15°

Debris: Scrubs & landfill debris
Characteristic size ~ 10'

Velocity distribution: For channelized conditions the velocity correction factor is ≈ 1.1. 2-D model indicates max vel about 10% higher than average velocity.

Pier Scour equations used:

1. CSU
2. Laursen
3. Froehlich
4. Jain & Fisher

CSU Eq.: $d_s/y = 2.0 K_1 K_2 (b/y)^{0.65} F_r^{0.43}$

Laursen Eq: $b/y = 5.5 (d_s/y)\left[(d_s/11.5/y + 1)^{1.7} - 1\right]$

Froehlich Eq: $d_s/b = 0.32 \phi (b'/b)^{0.62} (y/b)^{0.46} F_r^{0.20} (b/D)^{0.08} +$

Jain & Fisher Eq: $d_s/b = 1.86 (y/b)^{0.5} (F_r - F_{rc})^{0.25}$

CRSS

CRS SIRRINE

DESIGN SHEET

Job: Rio Salado Channel
Structure:
Live Load Per Square Foot:

Job No.: R101N
Computed By: GRC
Working Stress: JFM 12/20/89
Date: 12/21/89

CSU Eq.

Location	b	d_h	F_r	K_1	K_2	d_s
SPRR	8.0	16.8	0.40	1.0	1.0	15.4
Rural	6.0	22.3	0.36	1.0	1.0	12.7
McClintock	6.0	18.9	0.43	1.0	1.0	12.9
Mill (A)	15.0	19.8	0.39	1.0	1.5	33.1
Mill (I)	9.5	19.8	0.39	1.0	1.6	26.2

Laursen Eq:

Location	b	y	K_s	K_α	d_s
SPRR	8.0	22.2	~~0.9~~	~~1.0~~	14.7
Rural	6.0	24.7	0.9	1.0	13.4
McClintock	6.0	20.9	~~0.9~~	~~1.0~~	12.3

Froehlich Eq.

Location	b	b'	y	φ	F_r	D	d_s
SPRR	8.0	8.0	22.2	1.0	0.40	0.033	13.3
Rural	6.0	6.0	24.7	1.0	0.36	0.033	10.6
McClintock	6.0	6.0	20.9	1.0	0.43	0.033	10.4

$b' = b\cos\alpha + L\sin\alpha$: L = pier length

$D = 10\text{ mm} = 10/304.8 = 0.033'$

φ : shape factor - 1.3 square
1.0 circular

CRSS

CRS SIRRINE

DESIGN SHEET

Job: Rio Salado Channel
Structure:
Live Load Per Square Foot:

Job No.: R101N
Computed By: BKC
Working Stress: SFM 12/20/89

Date: 12/21/89

Jain & Fisher Eq:

Location	b	y	F_r	F_{rc}	d_s
SPRR	8.0	22.2	0.40	0.21	16.4
Rural	6.0	24.7	0.36	0.20	14.3
McClintock	6.0	20.9	0.43	0.22	14.1

$$F_{rc} = \frac{V_c}{\sqrt{gy}} \qquad \tau = \gamma y S$$

$$V = \frac{1.49}{n} y^{2/3} S^{1/2} = \frac{1.49}{\sqrt{\gamma} n} y^{1/6} \tau^{1/2}$$

$$n = 0.0395 D^{1/6}$$

$$V_c = \frac{1.49}{0.0395} \left(\frac{y}{D}\right)^{1/6} \left(\frac{\tau_c}{\gamma}\right)^{1/2}$$

$$F_{rc} = \frac{1.49}{0.0395} \frac{1}{\sqrt{gy}} \left(\frac{y}{D}\right)^{1/6} \left(\frac{\tau_c}{\gamma}\right)^{1/2} = 1.85 \left(\frac{D}{y}\right)^{1/3}$$

$$\tau_c = 4.83 * D$$

Summary of Pier Scour Equations - No Debris

Location	CSU	Laursen	Froehlich	Jain & Fisher
SPRR	15.4	14.7	13.3	16.4
Rural	12.7	13.4	10.6	14.3
McClintock	12.9	12.3	10.4	14.1

CRSS

CRS SIRRINE

DESIGN SHEET

Job _____ Job No. _____ Date _____
Structure _____ Computed By _____
Live Load Per Square Foot _____ Working Stress _____

JFM 4/27/90

Effect of Debris

Location	b"	d_s''/d_s CSU	Laursen	Froelich	Jain/Fish
SPRR	10	1.16	1.12	1.21	1.12
Rural	10	1.39	1.28	1.53	1.29
McClintock	10	1.39	1.29	1.54	1.29

b" pier width with debris

Dimensionless form:

CSU:

$$\frac{d_s''}{d_s} = \left(\frac{b''}{b}\right)^{0.65}$$

Laursen:

$$\frac{b''}{b} = \frac{d_s''}{d_s}\,\frac{[(d_s''/11.5/y)^{1.7}-1]}{[(d_s/11.5/y)^{1.7}-1]}$$

Froelich:

$$\frac{d_s''/b''-1}{d_s/b-1} = \left(\frac{b}{b''}\right)^{0.7}$$

Jain & Fisher:

$$\frac{d_s''}{d_s} = \left(\frac{b''}{b}\right)^{0.5}$$

CRSS

CRS SIRRINE

DESIGN SHEET

Job Rio Salado
Structure
Live Load Per Square Foot

Job No. R101N Date 7/24/90
Computed By
Working Stress

JFM 7/30/90

Comparison of Local Scour Elevations to Foundation Elevations at Bridges:

Foundation Elevations:

Mill Ave:

Location	Found. Elev	Rock (yes/no)	Pier Width	
So. Abut	1114.8	yes*	—	* 3' excav. into rock typical.
Pier #2	1117.0		9.5	
#3	1119.0		9.5	
#4 (Abut Type)	1120.9		15.0	
#5	1120.8		9.5	
#6	1120.3		9.5	
#7	1119.3		9.5	
#8 (Abut Type)	1118.6		15.0	
#9	1088.0		9.5	
#10	1116.4		9.5	
No. Abut	1134.0		—	

SPRR Salt River Bridge:

Location	Found. Elev.	Pier Diam.	Rock (yes/no)	Depth of Piles below Cyl.
Pier #1	1133.4/25.4*	5.0	no	10 to 16
#2	1133.4/23.4*	7.0	no	10 to 17
#3	1133.4/25.4	8.0	no	8 to 14
#4	1128.2/21.2	8.0	yes **	8 to 13
#5	1128.1/17.1	8.0	yes **	8 to 13
#6	1124.1	8.0	yes	—
#7	1119.6	8.0	yes	—
#8	1115.6	8.0	yes	—
#9	1121.2	7.0	yes	—
#10	1126.9	5.0	yes	—

* end of caison/max pile tip

** pile tips only on rock

CRSS

CRS SIRRINE

DESIGN SHEET

Job _____ Job No. _____ Date _____
Structure _____ Computed By _____
Live Load Per Square Foot _____ Working Stress _____

JFM 7/30/90

Rural Rd:

Location	Bott. of Col.	Pier Diam	Bott of Taper
So Abut	1100.0	—	—
Pier #1	1085.0	5.0	1140.0
2	1085.0	5.0	1140.0
3	1085.0	5.0	1140.0
4	1085.0	5.0	1140.0
5	1085.0	5.0	1140.0
6	1085.0	5.0	1140.0
7	1085.0	5.0	1140.0
8	1085.0	5.0	1140.0
9	1085.0	5.0	1140.0
10	1085.0	5.0	1140.0
No Abut	1100.0	—	

McClintock Drive:

Location	Bott. of Col.	Pier Diam.
So Abut	1055.0	-
Pier # 2	1042.0	6.0
3	↓	↓
4		
5		
6		
7		
8		
9		
10		
No Abut	1055.0	—

CRSS

CRS SIRRINE

DESIGN SHEET

Job _____ Job No. _____ Date _____
Structure _____ Computed By _____
Live Load Per Square Foot _____ Working Stress _____

JFM 7/30/90

Channel Invert Elevations:

Location	So. Levee Sta.	Invert Elev.	HEC-2 SEC NO
SPRR	415+60	1131.0	15.60
Mill	424+50	1132.0	24.50
Rural	470+30	1136.7	70.50
McClin	522+65	1142.2	122.65

Typical Debris Size:

Use 3* Pier Diam

Local Scour Equation:

CSU Eq: $d_s/y = 2.0\, K_1 K_2 (b/y)^{0.65} F_r^{0.93}$

where b is the pier diameter + debris

y is flow depth at pier

K_1 is pier shape factor

K_2 is a pier skew factor

F_r is the approach flow Froude number, where

$$F_r = \frac{V}{\sqrt{g d_h}}$$

where $d_h = A/T$ A = area, T = top width

CRSS

CRS SIRRINE

DESIGN SHEET

Job _____ Job No. _____ Date _____
Structure _____ Computed By _____
Live Load Per Square Foot _____ Working Stress _____

JFM 7/30/90

For Q = 215,000 cfs

Location	b	A	T	d_h	V	Fr
SPRR	24.0	20148	1346	15.0	10.7	0.49
Mill (Abut)	45.0	19715	1086	18.2	10.9	0.45
Mill (Int)	28.5	"	"	"	"	"
Rural	15.0	21992	1062	20.7	9.8	0.38
McClintock	18.0	23011	1073	21.5	9.3	0.35

WSEL	y	b/y	K_1	K_2	d_s/y
1153.6	22.6	1.06	1.0	1.0	1.53
1155.8	23.8	1.89	1.0	1.5	3.22
1155.8	23.8	1.20	1.0	1.6	2.56
1161.8	25.1	0.60	1.0	1.0	0.95
1166.8	24.6	0.73	1.0	1.0	1.04

d_s	Rock Depth	Armor Depth	½ Bed Form Height
34.6	10'-25'	3.0	1.6
76.6	11' to 44'	2.0	1.7
60.9	11' to 44'	2.0	1.7
23.9	n/a	2.6	1.9
25.6	n/a	1.0	1.8

Total Scour	Scour Elev	Unexposed Found.	
10-25'	varies	0.	(To be secured)
11-44'	"	0.	(Anchored to
11-44'	"	0.	bedrock)
27.8	1108.3	23.3	(Needs protection
28.4	1113.8	11.8	

CRSS

CRS SIRRINE

DESIGN SHEET

Job _____ Job No. _____ Date _____
Structure _____ Computed By _____
Live Load Per Square Foot _____ Working Stress _____

JFM 7/30/90

Q = 250,000 cfs

Location	b	A	T	d_h	V	F_r
SPRR	24.0	22756	1358	16.8	11.0	0.47
Mill: Abut	45.0	22856	1103	20.7	10.9	0.42
Int	28.5	"	"	"	"	"
Rural:	15.0	24636	1076	22.9	10.2	0.38
McClintock	18.0	25622	1086	23.6	9.8	0.36

WSEl	y	b/y	K_1	K_2	d_s/y
1155.5	24.5	0.98	1.0	1.0	1.43
1158.7	26.7	1.69	1.0	1.5	2.91
"	"	1.07	1.0	1.6	2.30
1164.2	27.5	0.55	1.0	1.0	0.89
1169.2	27.0	0.67	1.0	1.0	0.98

d_s	Rock Depth	Armor Depth	½ Bed Form Height
35.0	10-25'	2.5	1.9
77.7	11-44'	1.3	2.0
61.4	11-44'	1.3	2.0
24.5	n/a	2.0	2.1
26.5	n/a	0.8	1.9

Total Scour	Scour Elev	Unexposed Found.	
10-25'	varies	0.	(To be secured
11-44'	"	0.	(Anchored to
11-44'	"	0.	bed rock)
28.6	1107.5	22.5	(Needs protect)
29.2	1113.0	71.0	

CRSS

CRS SIRRINE

DESIGN SHEET

Job _____ Job No. _____ Date _____
Structure _____ Computed By _____
Live Load Per Square Foot _____ Working Stress _____

Note on Rural Road Bridge Pier Protection:

1. It is unlikely that the bridge foundation was initially designed to withstand 28 feet of scour.

2. The channelization will lower the channel invert from 1144.0 to 1136.7 or 7.3 feet. This is on the order of the predicted general scour for the reach. Therefore the total scour for existing and new conditions is unchanged.

3. Embedment of 22' to 23' below the maximum scour depth is not adequate.

4. Using the following alternative scour computation $b_{max} = 10$ ft, $V_{max} = 1.3\ V_a$ gives 86% of the local scour depth compared to $b_{max} = 3b$ approach. The difference is minor.

CRSS

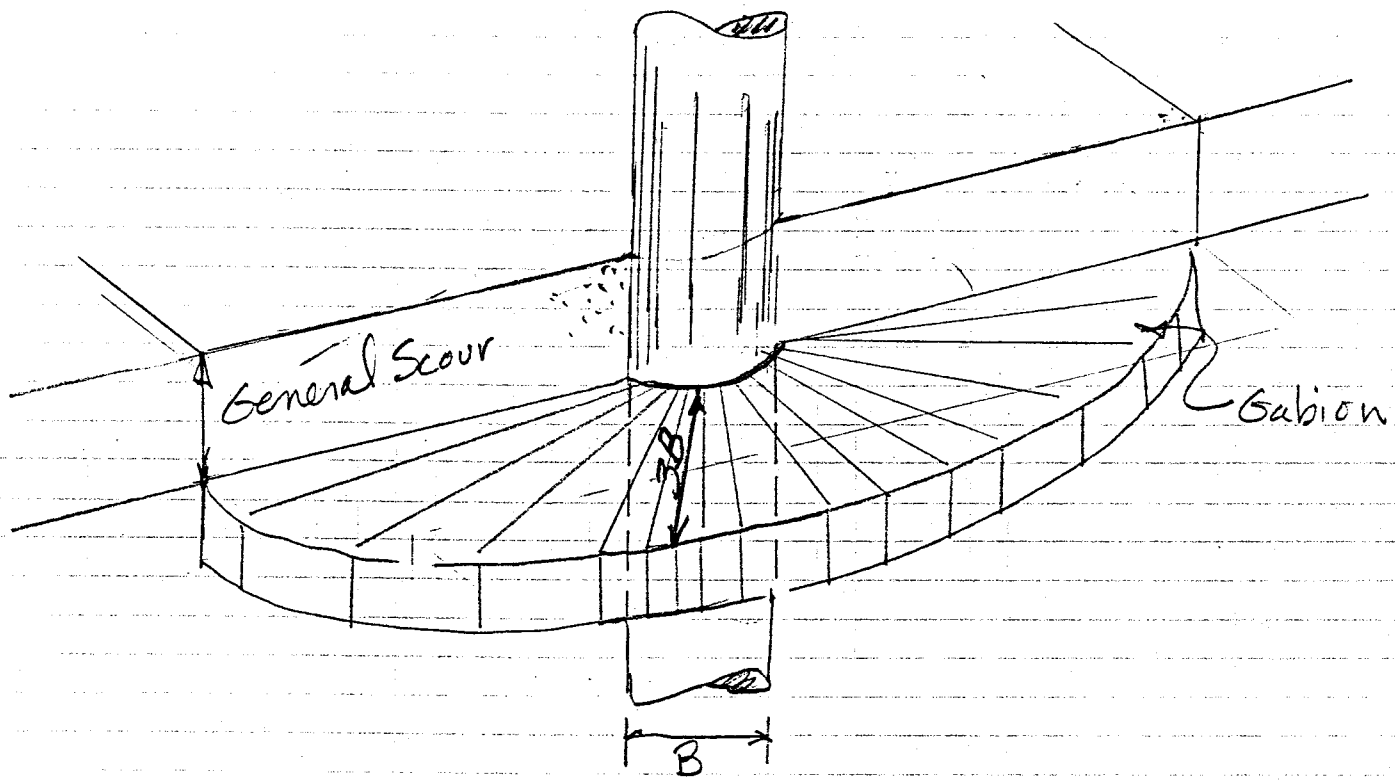
CRS SIRRINE

DESIGN SHEET

Job _____ Job No. _____ Date _____
Structure _____ Computed By _____
Live Load Per Square Foot _____ Working Stress _____

5. Protection of the piers at the general scour depth would provide 24.5 of additional embedment.

6. Pier protection method:



7. This replaces existing pier protection system at elevation 1140.0. New protection will be at elevation 1132.6, 7.4 feet lower than existing.

8. The commensurate reduction in skin friction on the column is 13%.

APPENDIX L

BANK PROTECTION

① The mean bed shear at the Rural Bridge is 1.13 psf. (see MESA215.WK1). Within 1000 ft upstream and downstream of the bridge the mean shear varies from 1.00 to 1.19 psf. To account for an adverse increase in mean shear at the bridge the highest mean shear of 1.19 psf will be used.

② The max bed shear correction factor,

$$K_b = 1.06$$

③ The correction factor for accelerated flow at a bridge pier,

$$K_p = 4.0 \quad \text{(ADOT, page 22)}$$

④ Max shear acting on bed at pier (So bank)

$$\tau_{max} = K_b K_r K_p \tau_o$$

$$= 1.06 \times 1.35 \times 4.0 \times 1.19$$

$$= 6.8 \text{ psf}$$

⑥ The design shear stress

$$\tau_d = C_a \tau_c$$

for horizontal bed $C_a = 1/SF$

$$\tau_c = 4.83 D_{50}$$

for $SF = 1.5$

$$\tau_d = 3.22 D_{50}$$

(7) Mean Riprap size or Gabion Thickness

$$T_G = \tau_{max}/3.22$$

$$T_G = 6.8/3.22$$

$$T_G = 2.1'$$

(8) Mean stone size for gabion fill

$$D_{50}^G = D_{50}^S/2.13$$

$$= 1.0'$$

(9) Recommendation 24" Gabion mattress on gravel bedding, for south bank

Fill Gradation: $D_{max} = 24''$

$D_{min} = 3''$

$D_{50} = 1.0$

(10) For north bank $K_r = 1.0$

- Thickness and stone size reduce proportionately

$$T_G = (1/1.35)\,2.1$$

$$= 1.56'$$

$$D_{50G} = (1/1.35)\,1.0$$

$$= 0.74'$$

For northbank use

18" Gabion mattress

$D_{50} = 9''$

Filter Gradation Design Procedure

1. Compare Riprap to bank material
2. If riprap cannot adequately perform as a filter then select a gravel filter or fabric filter.

Step One – Gabions

a. Assume levee embankment material is the same gradation as alluvial material

D85 (levee) = 92 mm
D50 (levee) = 11 mm
D15 (levee) = 0.42 mm

Note: This is based on the envelope gradation for the Salt River.

b. Assume gabion fill is composed of the coarse fraction (3"+) of the alluvial material.

For D50 (riprap) = 134 mm (5.3")
D85 (riprap) = 219 mm
D15 (riprap) = 89 mm

c. The filter gradation criteria are:

i. $\frac{D50\,(riprap)}{D50\,(bank)} < 40 \qquad \frac{134}{11} = 12.2$ OK

ii. $5 < \frac{D15\,(riprap)}{D15\,(bank)} < 40 \qquad \frac{89}{0.42} = 212$ NG

iii. $\frac{D15\,(riprap)}{D85\,(bank)} < 5 \qquad \frac{89}{92} = 1.0$ OK

Step One - Riprap

a. Same as gabions

b. Assume 9" stone is derived from the coarse fraction of the alluvial material.

D50 (riprap) = 230 mm (9" stone)
D85 (riprap) = 430 mm
D15 (riprap) = 115 mm

c. The filter gradation criteria are:

i. $\frac{D50\,(riprap)}{D50\,(bank)} < 40 \quad \frac{230}{11} = 20.9$ OK

ii. $5 < \frac{D15\,(riprap)}{D15\,(bank)} < 40 \quad \frac{115}{0.42} = 274$ NG

iii. $\frac{D15\,(riprap)}{D85\,(bank)} < 5 \quad \frac{115}{92} = 1.3$ OK

Step One - Results

The riprap or gabion stone gradation is not adequate to retain the fine fraction of the bed material. A gravel or fabric filter needs to be provided. The D15(filter) must be less than 17 mm. and greater than 2 mm. A logical choice for a filter then is a standard subbase material such as an ADOT class 4 or 5 aggregate subbase.

3"	100%
1/4"	30-75%
#200	0-10%

Step Two - Filter (Class 4 or 5 ADOT Subbase)

a. Assume levee embankment is the same gradation as alluvial material (see gabion calc)

b. Gradation for filter

D50 (filter) = 6.3 mm
D15 (filter) = 3.2 mm
D85 (filter) = 12.6 mm

c. Comparing to gradation criteria

i. $\frac{D50(\text{filter})}{D50(\text{bank})} < 40$ $\quad \frac{6.3}{11.0} = 0.57$ OK

$\frac{D50(\text{riprap})}{D50(\text{filter})} < 40$ $\quad \frac{230}{6.3} = 36.5$ OK

ii. $5 < \frac{D15(\text{filter})}{D15(\text{bank})} < 40$ $\quad \frac{3.2}{0.42} = 7.6$ OK

$5 < \frac{D15(\text{riprap})}{D15(\text{filter})} < 40$ $\quad \frac{89}{3.2} = 27.8$ OK

iii. $\frac{D15(\text{filter})}{D85(\text{bank})} < 5$ $\quad \frac{3.2}{92} = 0.03$ OK

$\frac{D15(\text{riprap})}{D85(\text{filter})} < 5$ $\quad \frac{11.5}{12.6} = 9.1$ NG

Step Two - Result

Works in all cases except gradation needs to be coarser than type subbase

Step Two – Filter (Special Gradation)

a. See previous trial

b. Gradation

D50 (filter) = 12.5 mm
D85 (filter) = 25 mm
D15 (filter) = 6.3 mm

c. Compare to gradation criteria:

i. $\frac{D50\,(filter)}{D50\,(bank)} < 40 \qquad \frac{12.5}{11.0} = 1.1$ OK

$\frac{D50\,(riprap)}{D50\,(filter)} < 40 \qquad \frac{230}{12.5} = 18.4$ OK

ii. $5 < \frac{D15\,(filter)}{D15\,(bank)} < 40 \qquad \frac{6.3}{0.42} = 15.0$ OK

$5 < \frac{D15\,(riprap)}{D15\,(filter)} < 40 \qquad \frac{89}{6.3} = 14.1$ OK

iii. $\frac{D15\,(filter)}{D85\,(bank)} < 5 \qquad \frac{6.3}{92} = 0.07$ OK

$\frac{D15\,(riprap)}{D85\,(filter)} < 5 \qquad \frac{115}{25} = 4.6$ OK

Step Two – Result

A course aggregate filter with a D50 of ½" with not more than 15% passing the ¼" sieve size.

CRS SIRRINE	PROJECT: Rio Salado	JOB NO.: R101N	NO. 5
	CLIENT: Tempe	DESIGNED BY: GKC / DATE: 7/24/90	OF 5
	SUBJECT: Filter	CHECKED BY: JFM / DATE: 7/30/90	

Alternative Filter Design: Filter Fabric

Task Force No 25 recommends the following criteria for filter fabric design. (see HEC-15, FHWA-IP-87-7, page 20).

1. The fabric must be able to transmit water faster than the soil.
2. The following criteria for the apparent opening size (AOS) must be met:
   a. For soil with less than 50 percent of the particles by weight passing a U.S. No. 200 sieve, AOS < 0.6 mm (0.024 in) (greater than #30 U.S. Std. Sieve).
   b. For soil with more than 50 percent of the particles by weight passing a U.S. No. 200 sieve, AOS < 0.297 mm (0.012 in) (greater that #50 U.S. Std. Sieve).

Criteria 1 and 2a will control
Soil permeability is estimated to be 5.2×10^{-2} cm/s for coarse sand.

Cost Analysis

Cost Comparison
Filter Fabric $3.00 sq yd
Gravel Bedding $14.00 sq. yd.
(Use 1.0 ft bedding thickness for riprap or rock, so 1 cu yd provides 3 sq yd
Gravel Bedding $12.00 cu. yd.)

Use filter fabric.

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DESIGN SHEET

Job Rio Salado Channel
Structure
Live Load Per Square Foot

Job No. R101N Date 12/18/89
Computed By GKC
Working Stress JFM 12/20/89

Bank Protection
Riprap Sizing:

Type: Very rounded stone: Angle of repose from Chart 12, HEC-15

Side Slope: 3:1 ($A_z = 18.4°$)

Oblique flow of 30° at west bank of IBW

Design Safety factor = 1.3 (250,000 cfs)
1.5 (215,000 cfs)

$\tau_d = C_a \tau_c$

$\tau_c = 4.83 D_{50}$ (specific gravity = 2.65)

$C_a = (1/SF) C_e C_z (1 - C_r C_b SF)$

$C_r = \tan(A_z)/\tan(A_r)$

Stone	A_r	C_r
8"	39°	0.41
12"	39.5°	0.40
18"	39.9°	0.40

$C_z = \cos(A_z) = 0.95$

$C_b = \cos(\tan^{-1}(1/E))$

$E = 2(\tau_c/\tau) C_z C_r$

for $C_r = 0.41$ then

$E = 3.76 (D_{50}/\tau)$

$C_b = 2/(1 + \sin(\tan^{-1}(1/E)))$

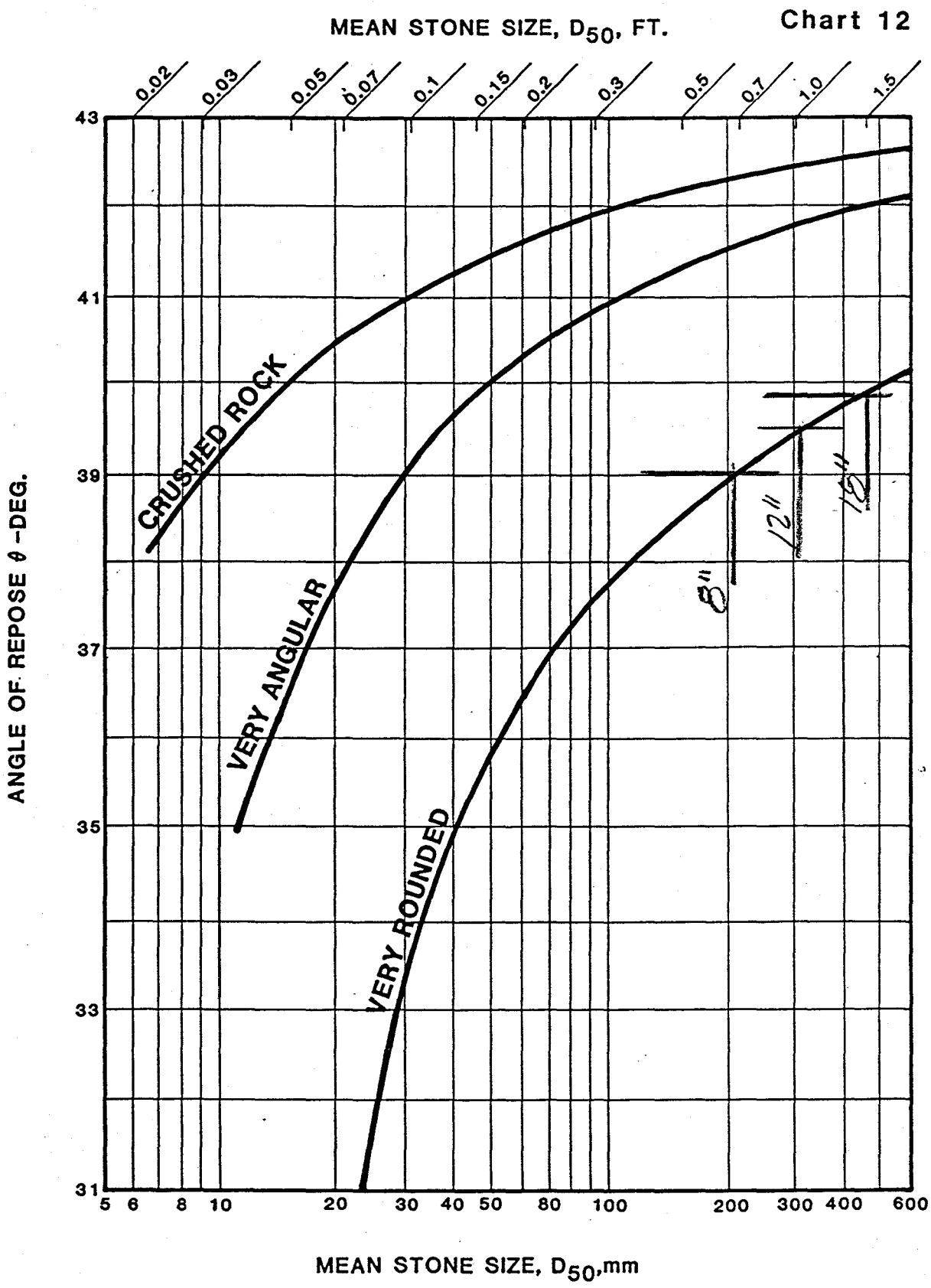


Chart 12. Angle of repose of riprap in terms of mean size and shape of stone.

CRSS

CRS SIRRINE

DESIGN SHEET

Job _____ Job No. _____ Date _____
Structure _____ Computed By _____
Live Load Per Square Foot _____ Working Stress JFM 4/27/90

For $C_r = 0.41$; $C_z = 0.95$ and $SF = 1.5$

$$C_a = 1.27/(1+\sin(\tan^{-1}(1/E))) * (1 - 0.62\cos(\tan^{-1}(1/E)))$$

For $C_r = 0.41$; $C_z = 0.95$ and $SF = 1.3$

$$C_a = 1.46/(1+\sin(\tan^{-1}(1/E))) * (1 - 0.53\cos(\tan^{-1}(1/E)))$$

$Q = 215{,}000$ cfs ; $SF = 1.5$

Location	τ_{max}	D_{50}	E	C_a	τ_c	τ_d
North Bank:						
GC4 - Mill	1.57	9"	1.80	0.46	3.62	1.6[illegible]
Mill - Rural	1.92	12"	1.96	0.46	4.83	2.2[illegible]
Rural - IBW	1.34	9"	2.10	0.46	3.62	1.6[illegible]
IBW W. Bank	2.01	12"	1.87	0.46	4.83	2.22
IBW - MCCI	2.38	12	1.58	0.46	4.83	2.22
South Bank						
GC4 - Mill	1.57	9"	1.80	0.46	3.62	1.6[illegible]
Mill - Rural	1.49	9"	1.89	0.46	3.62	1.67
Rural - IBW	1.97	12"	1.91	0.46	4.83	2.22
IBW - MCCI	1.66	9"	1.70	0.46	3.62	1.67

See Attached Worksheets: BANK215.WK1
BANK250.WK1

CRSS

CRS SIRRINE

DESIGN SHEET

Job _____ Job No. _____ Date _____
Structure _____ Computed By _____
Live Load Per Square Foot _____ Working Stress _____ JFM 4/27/90

Q = 250,000

Location	τ_{max}	D_{50}	E	C_a	τ_c	τ_d
North Bank						
GC4-Mill	1.72	12"	2.19	0.45	4.83	2.17
Mill-Rural	1.88	12"	2.00	0.45	4.83	2.17
Rural-IBW	1.37	9"	2.06	0.45	3.62	1.63
IBW W.Bank	2.06	12"	1.83	0.45	4.83	2.17
IBW-McCl	2.44	12"	1.54	0.45	4.83	2.17
South Bank						
GC4-Mill	1.72	9"	1.64	0.45	3.62	1.63
Mill-Rural	1.44	9"	1.96	0.45	3.62	1.63
Rural-IBW	2.02	12"	1.86	0.45	4.83	2.17
IBW-McCl	1.69	9"	1.67	0.45	3.62	1.63

Use North Bank	D_{50}	Thickness
GC4-Mill	12"	3.0'
Mill-Rural	12"	3.0'
Rural-IBW	9"	2.25'
IBW W Bank	12"	3.0
IBW-McCl	Cement Stabilized Alluvium	

South Bank		
GC4-Mill	9"	2.25'
Mill-Rural	9"	2.25'
Rural-IBW	12"	3.0'
IBW-McCl	9"	2.25'

See Attached Figure

Job: R101N
Date
Calc by: GKC 7/25/90
Checked by: JFM 7/30/90
Dwg Chk:

1/7

Levee Bank Protection Computation
Salt River Channelization
Grade Control #4 to Grade Control #5

FILE: BANK215.WK1
DATE: 07/25/90

SECNO	To	TOPWID	HYDDEP	Kss
0.00	1.89	989.45	17.80	0.90
2.00	2.06	985.15	16.95	0.90
4.00	1.78	1054.91	16.87	0.89
6.00	1.73	1091.55	16.37	0.89
8.00	1.68	1127.24	15.95	0.89
10.00	1.58	1176.37	15.62	0.89
12.00	1.48	1228.75	15.31	0.88
14.00	1.39	1287.18	14.91	0.88
15.40	1.30	1341.97	14.64	0.88
15.60	1.24	1346.58	14.96	0.88
17.50	1.24	1347.97	14.96	0.88
19.00	1.42	1153.39	16.81	0.89
19.20	1.34	1156.34	17.31	0.89
21.50	1.41	1110.81	17.63	0.89
24.00	1.56	1080.61	17.25	0.89
24.50	1.39	1086.32	18.15	0.89
26.00	1.37	1093.44	18.08	0.89
27.00	1.36	1087.83	18.28	0.90
28.00	1.35	1082.34	18.46	0.90
30.00	1.38	1061.26	18.66	0.90
32.00	1.32	1055.11	19.27	0.90
34.00	1.33	1043.73	19.41	0.90
36.00	1.14	1071.23	20.39	0.90
38.00	1.38	1004.85	19.82	0.90
40.00	1.44	976.70	19.98	0.90
42.00	1.44	974.78	20.02	0.90
44.00	1.50	957.62	19.97	0.91
46.00	1.48	961.34	20.00	0.91
48.00	1.44	966.47	20.19	0.91
50.00	1.38	979.04	20.32	0.91
52.00	1.35	988.36	20.38	0.90
54.00	1.32	995.62	20.43	0.90
56.00	1.29	1004.94	20.48	0.90
58.00	1.27	1012.06	20.52	0.90
60.00	1.24	1021.25	20.57	0.90
62.00	1.19	1033.10	20.80	0.90
64.00	1.19	1038.43	20.61	0.90
66.00	1.18	1046.48	20.62	0.90
68.00	1.16	1053.52	20.63	0.90
69.50	1.15	1060.38	20.60	0.90
70.50	1.13	1062.11	20.71	0.90
72.00	1.14	1044.79	20.96	0.90
74.00	1.15	1024.76	21.32	0.91
76.00	1.11	1040.46	21.34	0.90
78.00	1.06	1064.37	21.40	0.90
80.00	1.00	1090.32	21.47	0.90

Job:
Date
Calc by:
Checked by: JFM 7/30/90
Dwg Chk:

2/7

82.00	0.93	1125.36	21.56	0.90
84.00	0.87	1161.42	21.62	0.90
86.00	0.80	1208.30	21.70	0.90
88.00	0.71	1247.67	22.62	0.90
90.00	0.70	1267.34	22.54	0.90
92.00	0.68	1286.79	22.55	0.90
94.00	0.71	1266.39	22.39	0.90
96.00	0.77	1228.99	22.22	0.90
98.00	0.83	1194.60	22.06	0.90
100.00	0.83	1197.38	21.99	0.90
102.00	1.05	1078.75	21.67	0.90
104.00	1.19	1055.81	20.52	0.90
106.00	1.19	1050.30	20.64	0.90
108.00	1.08	1089.40	20.91	0.90
110.00	1.55	939.47	20.47	0.91
112.00	1.66	913.08	20.37	0.91
114.00	1.64	914.42	20.43	0.91
116.00	1.37	975.51	20.88	0.91
118.00	1.18	1032.78	21.19	0.90
120.00	1.09	1067.24	21.32	0.90
120.50	1.03	1077.80	21.70	0.90
122.00	1.09	1072.15	21.31	0.90
122.65	1.07	1072.94	21.45	0.90
123.55	2.00	1056.61	16.61	0.89
124.00	2.01	1049.87	16.66	0.89

Date 3/7
Calc by:
Checked by: JPM 7/30/90
Dwg Chk:

Levee Ba
Salt Riv
Grade Co

FILE: BANK215.N
DATE: 07/25/90

FILE:
DATE: SF = 1.50

NORTH BANK:

SECNO	Kr	Ai	Ki	Td	D50	E	Cb	Cl	Ca	Ta	CHCK
0.00	1.00	0.00	1.00	1.70	1.00	2.21	0.91	1.42	0.39	1.90	1.12
2.00	1.00	0.00	1.00	1.85	1.00	2.04	0.90	1.39	0.39	1.90	1.03
4.00	1.00	0.00	1.00	1.59	1.00	2.37	0.92	1.44	0.40	1.91	1.20
6.00	1.00	0.00	1.00	1.54	1.00	2.44	0.93	1.45	0.40	1.91	1.24
8.00	1.00	0.00	1.00	1.49	1.00	2.52	0.93	1.46	0.40	1.91	1.28
10.00	1.00	0.00	1.00	1.40	1.00	2.69	0.94	1.48	0.40	1.92	1.37
12.00	1.00	0.00	1.00	1.31	0.75	2.16	0.91	1.41	0.39	1.43	1.09
14.00	1.00	0.00	1.00	1.23	0.75	2.30	0.92	1.43	0.39	1.43	1.17
15.40	1.00	0.00	1.00	1.14	0.75	2.47	0.93	1.45	0.40	1.43	1.25
15.60	1.00	0.00	1.00	1.09	0.75	2.58	0.93	1.47	0.40	1.44	1.32
17.50	1.00	0.00	1.00	1.09	0.75	2.58	0.93	1.47	0.40	1.44	1.32
19.00	1.00	0.00	1.00	1.26	0.75	2.23	0.91	1.42	0.39	1.43	1.13
19.20	1.00	0.00	1.00	1.19	0.75	2.36	0.92	1.44	0.40	1.43	1.20
21.50	1.00	0.00	1.00	1.26	0.75	2.24	0.91	1.42	0.39	1.43	1.14
24.00	1.00	0.00	1.00	1.39	0.75	2.02	0.90	1.39	0.39	1.43	1.02
24.50	1.00	0.00	1.00	1.24	0.75	2.27	0.91	1.42	0.39	1.43	1.15
26.00	1.00	0.00	1.00	1.23	0.75	2.30	0.92	1.43	0.39	1.43	1.17
27.00	1.00	0.00	1.00	1.22	0.75	2.32	0.92	1.43	0.39	1.43	1.18
28.00	1.34	0.00	1.00	1.62	1.00	2.32	0.92	1.43	0.39	1.91	1.18
30.00	1.33	0.00	1.00	1.65	1.00	2.28	0.92	1.43	0.39	1.91	1.16
32.00	1.33	0.00	1.00	1.58	1.00	2.38	0.92	1.44	0.40	1.91	1.21
34.00	1.32	0.00	1.00	1.58	1.00	2.38	0.92	1.44	0.40	1.91	1.21
36.00	1.34	0.00	1.00	1.38	1.00	2.73	0.94	1.49	0.40	1.92	1.40
38.00	1.29	0.00	1.00	1.61	1.00	2.34	0.92	1.44	0.40	1.91	1.19
40.00	1.27	0.00	1.00	1.65	1.00	2.27	0.92	1.43	0.39	1.91	1.15
42.00	1.27	0.00	1.00	1.65	1.00	2.27	0.92	1.43	0.39	1.91	1.15
44.00	1.26	0.00	1.00	1.71	1.00	2.20	0.91	1.41	0.39	1.90	1.11
46.00	1.26	0.00	1.00	1.69	1.00	2.23	0.91	1.42	0.39	1.91	1.13
48.00	1.27	0.00	1.00	1.66	1.00	2.27	0.92	1.43	0.39	1.91	1.15
50.00	1.00	0.00	1.00	1.25	0.75	2.26	0.91	1.42	0.39	1.43	1.14
52.00	1.00	0.00	1.00	1.22	0.75	2.31	0.92	1.43	0.39	1.43	1.17
54.00	1.00	0.00	1.00	1.19	0.75	2.36	0.92	1.44	0.40	1.43	1.20
56.00	1.00	0.00	1.00	1.17	0.75	2.42	0.92	1.45	0.40	1.43	1.23
58.00	1.00	0.00	1.00	1.15	0.75	2.46	0.93	1.45	0.40	1.43	1.25
60.00	1.00	0.00	1.00	1.12	0.75	2.52	0.93	1.46	0.40	1.44	1.28
62.00	1.00	0.00	1.00	1.08	0.75	2.62	0.93	1.47	0.40	1.44	1.34
64.00	1.00	0.00	1.00	1.07	0.75	2.62	0.93	1.47	0.40	1.44	1.34
66.00	1.00	0.00	1.00	1.06	0.75	2.65	0.94	1.48	0.40	1.44	1.35
68.00	1.00	0.00	1.00	1.05	0.75	2.69	0.94	1.48	0.40	1.44	1.38
69.50	1.00	0.00	1.00	1.04	0.75	2.72	0.94	1.49	0.40	1.44	1.39
70.50	1.00	0.00	1.00	1.02	0.75	2.77	0.94	1.49	0.40	1.44	1.42
72.00	1.00	0.00	1.00	1.03	0.75	2.74	0.94	1.49	0.40	1.44	1.40
74.00	1.00	0.00	1.00	1.04	0.75	2.71	0.94	1.49	0.40	1.44	1.39
76.00	1.00	5.00	1.09	1.09	0.75	2.58	0.93	1.47	0.40	1.44	1.32
78.00	1.00	7.00	1.12	1.07	0.75	2.62	0.93	1.47	0.40	1.44	1.34
80.00	1.00	10.00	1.17	1.06	0.75	2.66	0.94	1.48	0.40	1.44	1.36

Date: 8/7
Calc by:
Checked by: JPM 7/30/90
Dwg Chk:

82.00	1.00	13.00	1.22	1.03	0.75	2.75	0.94	1.49	0.40	1.44	1.41
84.00	1.00	13.00	1.22	0.96	0.75	2.94	0.95	1.51	0.40	1.45	1.51
86.00	1.00	16.00	1.28	0.92	0.50	2.05	0.90	1.39	0.39	0.95	1.04
88.00	1.00	18.00	1.31	0.84	0.50	2.25	0.91	1.42	0.39	0.95	1.14
90.00	1.00	20.00	1.34	0.84	0.50	2.23	0.91	1.42	0.39	0.95	1.13
92.00	1.00	17.00	1.29	0.79	0.50	2.38	0.92	1.44	0.40	0.95	1.21
94.00	1.00	15.00	1.26	0.80	0.50	2.34	0.92	1.44	0.40	0.95	1.19
96.00	1.00	16.00	1.28	0.88	0.50	2.13	0.91	1.40	0.39	0.95	1.08
98.00	1.00	9.00	1.16	0.86	0.50	2.18	0.91	1.41	0.39	0.95	1.10
100.00	1.00	0.00	1.00	0.75	0.50	2.52	0.93	1.46	0.40	0.96	1.28
102.00	1.00	0.00	1.00	0.95	0.50	1.98	0.89	1.38	0.39	0.95	1.00
104.00	1.45	0.00	1.00	1.56	1.00	2.42	0.92	1.45	0.40	1.91	1.23
106.00	1.45	0.00	1.00	1.56	1.00	2.41	0.92	1.45	0.40	1.91	1.23
108.00	1.48	0.00	1.00	1.44	1.00	2.61	0.93	1.47	0.40	1.92	1.33
110.00	1.37	0.00	1.00	1.93	1.25	2.44	0.93	1.45	0.40	2.39	1.24
112.00	1.35	0.00	1.00	2.04	1.25	2.31	0.92	1.43	0.39	2.38	1.17
114.00	1.00	0.00	1.00	1.49	1.00	2.52	0.93	1.46	0.40	1.91	1.28
116.00	1.00	0.00	1.00	1.24	0.75	2.27	0.92	1.43	0.39	1.43	1.15
118.00	1.00	0.00	1.00	1.07	0.75	2.64	0.94	1.48	0.40	1.44	1.35
120.00	1.00	0.00	1.00	0.98	0.75	2.86	0.94	1.50	0.40	1.45	1.47
120.50	1.00	0.00	1.00	0.93	0.75	3.03	0.95	1.52	0.40	1.45	1.56
122.00	1.00	0.00	1.00	0.98	0.75	2.87	0.94	1.50	0.40	1.45	1.47
122.65	1.00	0.00	1.00	0.97	0.75	2.92	0.95	1.51	0.40	1.45	1.50
123.55	1.00	0.00	1.00	1.78	1.00	2.11	0.90	1.40	0.39	1.90	1.07
124.00	1.00	0.00	1.00	1.79	1.00	2.10	0.90	1.40	0.39	1.90	1.06

Sheet: 5/7
Date:
Calc by:
Checked by: JPM 7/30/90
Dwg Chk:

Levee BaKl
Salt Riv
Grade Co

FILE: BANK215.W
DATE: 07/25/90

FILE:
DATE:

SOUTH BANK:

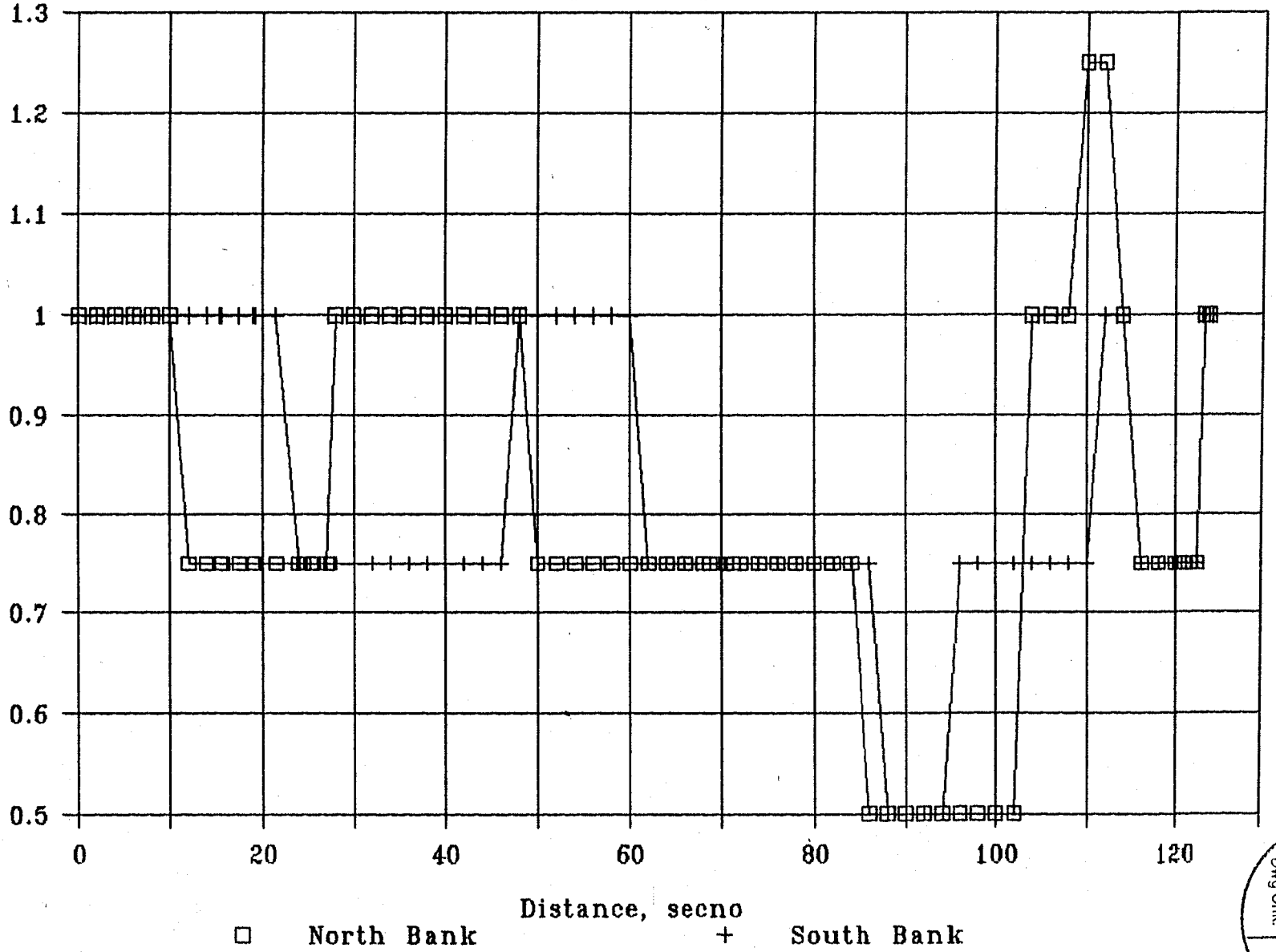
SECNO	Kr	Td	D50	E	Cb	Cl	Ca	Ta	CHCK
0.00	1.00	1.70	1.00	2.21	0.91	1.42	0.39	1.90	1.12
2.00	1.00	1.85	1.00	2.04	0.90	1.39	0.39	1.90	1.03
4.00	1.15	1.83	1.00	2.06	0.90	1.39	0.39	1.90	1.04
6.00	1.17	1.80	1.00	2.09	0.90	1.40	0.39	1.90	1.06
8.00	1.19	1.78	1.00	2.12	0.90	1.40	0.39	1.90	1.07
10.00	1.21	1.69	1.00	2.22	0.91	1.42	0.39	1.91	1.12
12.00	1.24	1.62	1.00	2.32	0.92	1.43	0.39	1.91	1.18
14.00	1.27	1.56	1.00	2.42	0.92	1.45	0.40	1.91	1.23
15.40	1.29	1.48	1.00	2.55	0.93	1.46	0.40	1.92	1.30
15.60	1.30	1.42	1.00	2.65	0.94	1.48	0.40	1.92	1.35
17.50	1.30	1.42	1.00	2.65	0.94	1.48	0.40	1.92	1.35
19.00	1.20	1.52	1.00	2.48	0.93	1.46	0.40	1.91	1.26
19.20	1.20	1.43	1.00	2.63	0.93	1.48	0.40	1.92	1.34
21.50	1.18	1.49	1.00	2.53	0.93	1.46	0.40	1.91	1.29
24.00	1.00	1.39	0.75	2.02	0.90	1.39	0.39	1.43	1.02
24.50	1.00	1.24	0.75	2.27	0.91	1.42	0.39	1.43	1.15
26.00	1.00	1.23	0.75	2.30	0.92	1.43	0.39	1.43	1.17
27.00	1.00	1.22	0.75	2.32	0.92	1.43	0.39	1.43	1.18
28.00	1.00	1.21	0.75	2.33	0.92	1.43	0.40	1.43	1.18
30.00	1.00	1.24	0.75	2.28	0.92	1.43	0.39	1.43	1.15
32.00	1.00	1.19	0.75	2.38	0.92	1.44	0.40	1.43	1.21
34.00	1.00	1.20	0.75	2.36	0.92	1.44	0.40	1.43	1.20
36.00	1.00	1.03	0.75	2.75	0.94	1.49	0.40	1.44	1.41
38.00	1.00	1.25	0.75	2.26	0.91	1.42	0.39	1.43	1.15
40.00	1.00	1.30	0.75	2.17	0.91	1.41	0.39	1.43	1.10
42.00	1.00	1.30	0.75	2.16	0.91	1.41	0.39	1.43	1.10
44.00	1.00	1.36	0.75	2.08	0.90	1.39	0.39	1.43	1.05
46.00	1.00	1.34	0.75	2.10	0.90	1.40	0.39	1.43	1.07
48.00	1.27	1.66	1.00	2.27	0.92	1.43	0.39	1.91	1.15
50.00	1.27	1.59	1.00	2.37	0.92	1.44	0.40	1.91	1.20
52.00	1.28	1.56	1.00	2.40	0.92	1.45	0.40	1.91	1.22
54.00	1.28	1.53	1.00	2.46	0.93	1.45	0.40	1.91	1.25
56.00	1.29	1.50	1.00	2.50	0.93	1.46	0.40	1.91	1.27
58.00	1.29	1.48	1.00	2.54	0.93	1.46	0.40	1.92	1.29
60.00	1.30	1.46	1.00	2.58	0.93	1.47	0.40	1.92	1.32
62.00	1.31	1.41	0.75	2.00	0.89	1.38	0.39	1.43	1.01
64.00	1.31	1.41	0.75	2.00	0.89	1.38	0.39	1.43	1.01
66.00	1.32	1.41	0.75	2.01	0.89	1.38	0.39	1.43	1.01
68.00	1.32	1.38	0.75	2.04	0.90	1.39	0.39	1.43	1.03
69.50	1.33	1.38	0.75	2.04	0.90	1.39	0.39	1.43	1.03
70.50	1.33	1.36	0.75	2.08	0.90	1.40	0.39	1.43	1.05
72.00	1.32	1.36	0.75	2.07	0.90	1.39	0.39	1.43	1.05
74.00	1.30	1.35	0.75	2.08	0.90	1.40	0.39	1.43	1.05
76.00	1.31	1.32	0.75	2.14	0.91	1.41	0.39	1.43	1.09
78.00	1.33	1.27	0.75	2.21	0.91	1.42	0.39	1.43	1.12
80.00	1.34	1.21	0.75	2.33	0.92	1.43	0.40	1.43	1.18

Job: 6/7
Date
Calc by:
Checked by: JFM 7/30/90
Dwg Chk:

82.00	1.37	1.15	0.75	2.46	0.93	1.45	0.40	1.43	1.25
84.00	1.39	1.09	0.75	2.59	0.93	1.47	0.40	1.44	1.32
86.00	1.41	1.01	0.75	2.78	0.94	1.49	0.40	1.44	1.43
88.00	1.44	0.92	0.50	2.05	0.90	1.39	0.39	0.95	1.04
90.00	1.45	0.91	0.50	2.06	0.90	1.39	0.39	0.95	1.04
92.00	1.46	0.89	0.50	2.11	0.90	1.40	0.39	0.95	1.07
94.00	1.45	0.92	0.50	2.03	0.90	1.39	0.39	0.95	1.03
96.00	1.43	0.99	0.75	2.85	0.94	1.50	0.40	1.45	1.46
98.00	1.41	1.05	0.75	2.68	0.94	1.48	0.40	1.44	1.37
100.00	1.41	1.05	0.75	2.68	0.94	1.48	0.40	1.44	1.37
102.00	1.00	0.95	0.75	2.97	0.95	1.52	0.40	1.45	1.53
104.00	1.00	1.07	0.75	2.63	0.93	1.48	0.40	1.44	1.34
106.00	1.00	1.07	0.75	2.63	0.93	1.48	0.40	1.44	1.34
108.00	1.00	0.97	0.75	2.90	0.95	1.51	0.40	1.45	1.49
110.00	1.00	1.41	0.75	2.00	0.89	1.38	0.39	1.43	1.01
112.00	1.00	1.51	1.00	2.49	0.93	1.46	0.40	1.91	1.27
114.00	1.00	1.49	1.00	2.52	0.93	1.46	0.40	1.91	1.28
116.00	1.00	1.24	0.75	2.27	0.92	1.43	0.39	1.43	1.15
118.00	1.00	1.07	0.75	2.64	0.94	1.48	0.40	1.44	1.35
120.00	1.00	0.98	0.75	2.86	0.94	1.50	0.40	1.45	1.47
120.50	1.00	0.93	0.75	3.03	0.95	1.52	0.40	1.45	1.56
122.00	1.00	0.98	0.75	2.87	0.94	1.50	0.40	1.45	1.47
122.65	1.00	0.97	0.75	2.92	0.95	1.51	0.40	1.45	1.50
123.55	1.00	1.78	1.00	2.11	0.90	1.40	0.39	1.90	1.07
124.00	1.00	1.79	1.00	2.10	0.90	1.40	0.39	1.90	1.06

Rock Riprap Size Profile

GC#4 to GC#5



Job:	210IN
Calc by:	GKC
Date	7/25/90
Checked by:	JRM
Dwg Chk:	7/30/90

Calc by:	
Date	
Checked by:	
Dwg Chk:	

1/5

Job: R101N
Date
Calc by: EKC 7/25/90
Checked by: JFM 7/30/90
Dwg Chk:

Levee Bank Protection Computation
Salt River Channelization
Grade Control #4 to Grade Control #5

FILE: BANK250.WK1
DATE: 07/25/90

SECNO	To	TOPWID	HYDDEP	Kss
0.00	2.05	1000.16	19.39	0.90
2.00	2.23	995.81	18.54	0.90
4.00	1.93	1065.85	18.51	0.90
6.00	1.87	1102.50	18.02	0.89
8.00	1.82	1138.16	17.61	0.89
10.00	1.71	1187.46	17.31	0.89
12.00	1.60	1239.01	17.04	0.89
14.00	1.51	1295.02	16.69	0.89
15.40	1.41	1352.42	16.41	0.88
15.60	1.35	1358.20	16.75	0.88
17.50	1.34	1359.60	16.74	0.88
19.00	1.55	1163.73	18.52	0.89
19.20	1.44	1167.30	19.15	0.89
21.50	1.52	1121.54	19.44	0.90
24.00	1.68	1093.52	19.02	0.90
24.50	1.37	1102.90	20.72	0.90
26.00	1.37	1110.18	20.61	0.90
27.00	1.36	1105.26	20.74	0.90
28.00	1.36	1098.18	20.92	0.90
30.00	1.39	1076.91	21.08	0.90
32.00	1.35	1069.47	21.68	0.90
34.00	1.36	1058.81	21.77	0.90
36.00	1.18	1086.13	22.72	0.91
38.00	1.42	1019.62	22.12	0.91
40.00	1.49	991.25	22.24	0.91
42.00	1.49	989.27	22.26	0.91
44.00	1.55	971.96	22.18	0.91
46.00	1.54	976.37	22.17	0.91
48.00	1.50	980.57	22.36	0.91
50.00	1.45	993.08	22.48	0.91
52.00	1.41	1002.35	22.54	0.91
54.00	1.39	1009.56	22.59	0.91
56.00	1.35	1018.85	22.63	0.91
58.00	1.33	1025.90	22.67	0.91
60.00	1.30	1035.06	22.71	0.91
62.00	1.25	1045.46	22.97	0.91
64.00	1.26	1052.22	22.74	0.91
66.00	1.24	1060.21	22.75	0.91
68.00	1.22	1067.20	22.76	0.91
69.50	1.21	1074.05	22.72	0.91
70.50	1.19	1076.18	22.89	0.91
72.00	1.20	1059.33	23.12	0.91
74.00	1.21	1038.57	23.47	0.91
76.00	1.17	1054.42	23.49	0.91
78.00	1.12	1078.27	23.55	0.91
80.00	1.06	1104.23	23.63	0.91

2/5

Job:
Date
Calc by:
Checked by: JFM 7/30/9
Dwg Chk:

82.00	0.99	1139.30	23.73	0.91
84.00	0.92	1175.41	23.80	0.90
86.00	0.84	1222.28	23.90	0.90
88.00	0.76	1254.30	24.96	0.90
90.00	0.74	1274.73	24.87	0.90
92.00	0.72	1293.43	24.89	0.90
94.00	0.75	1273.01	24.73	0.90
96.00	0.81	1235.60	24.55	0.90
98.00	0.88	1201.18	24.37	0.90
100.00	0.88	1203.95	24.30	0.90
102.00	1.12	1085.26	23.95	0.91
104.00	1.25	1069.46	22.64	0.91
106.00	1.25	1063.86	22.73	0.91
108.00	1.13	1103.72	23.01	0.91
110.00	1.63	952.29	22.52	0.91
112.00	1.75	925.80	22.40	0.91
114.00	1.73	927.09	22.45	0.91
116.00	1.45	988.32	22.93	0.91
118.00	1.26	1045.69	23.26	0.91
120.00	1.16	1080.20	23.40	0.91
120.50	1.10	1087.84	23.84	0.91
122.00	1.15	1085.11	23.39	0.91
122.65	1.13	1086.28	23.59	0.91
123.55	1.97	1071.45	18.81	0.90
124.00	2.00	1064.50	18.82	0.90

Levee Ba
Salt Riv
Grade Co

FILE: BANK250.W
DATE: 07/25/90

FILE:
DATE: SF = 1.30

NORTH BANK:

SECNO	Kr	Ai	Ki	Td	D50	E	Cb	Cl	Ca	Ta	CHCK
0.00	1.00	0.00	1.00	1.85	1.00	2.03	0.90	1.39	0.53	2.56	1.38
2.00	1.00	0.00	1.00	2.01	1.00	1.87	0.88	1.36	0.53	2.54	1.27
4.00	1.00	0.00	1.00	1.73	1.00	2.17	0.91	1.41	0.53	2.57	1.48
6.00	1.00	0.00	1.00	1.67	1.00	2.25	0.91	1.42	0.53	2.58	1.54
8.00	1.00	0.00	1.00	1.62	1.00	2.32	0.92	1.43	0.53	2.58	1.59
10.00	1.00	0.00	1.00	1.52	1.00	2.47	0.93	1.45	0.54	2.60	1.71
12.00	1.00	0.00	1.00	1.42	0.75	1.99	0.89	1.38	0.53	1.91	1.35
14.00	1.00	0.00	1.00	1.34	0.75	2.11	0.90	1.40	0.53	1.92	1.44
15.40	1.00	0.00	1.00	1.25	0.75	2.26	0.91	1.42	0.53	1.93	1.55
15.60	1.00	0.00	1.00	1.19	0.75	2.36	0.92	1.44	0.54	1.94	1.63
17.50	1.00	0.00	1.00	1.18	0.75	2.38	0.92	1.44	0.54	1.94	1.64
19.00	1.00	0.00	1.00	1.38	0.75	2.04	0.90	1.39	0.53	1.92	1.38
19.20	1.00	0.00	1.00	1.29	0.75	2.19	0.91	1.41	0.53	1.93	1.50
21.50	1.00	0.00	1.00	1.36	0.75	2.07	0.90	1.39	0.53	1.92	1.41
24.00	1.00	0.00	1.00	1.51	0.75	1.87	0.88	1.36	0.53	1.91	1.27
24.50	1.00	0.00	1.00	1.23	0.75	2.29	0.92	1.43	0.53	1.93	1.57
26.00	1.00	0.00	1.00	1.23	0.75	2.29	0.92	1.43	0.53	1.93	1.57
27.00	1.00	0.00	1.00	1.22	0.75	2.30	0.92	1.43	0.53	1.94	1.58
28.00	1.34	0.00	1.00	1.64	1.00	2.29	0.92	1.43	0.53	2.58	1.57
30.00	1.33	0.00	1.00	1.67	1.00	2.25	0.91	1.42	0.53	2.58	1.54
32.00	1.33	0.00	1.00	1.62	1.00	2.32	0.92	1.43	0.53	2.58	1.59

34.00	1.32	0.00	1.00	1.62	1.00	2.32	0.92	1.43	0.53	2.58	1.59
36.00	1.34	0.00	1.00	1.43	1.00	2.63	0.93	1.48	0.54	2.61	1.82
38.00	1.29	0.00	1.00	1.66	1.00	2.26	0.91	1.42	0.53	2.58	1.55
40.00	1.27	0.00	1.00	1.72	1.00	2.19	0.91	1.41	0.53	2.57	1.49
42.00	1.27	0.00	1.00	1.72	1.00	2.18	0.91	1.41	0.53	2.57	1.49
44.00	1.26	0.00	1.00	1.78	1.00	2.12	0.90	1.40	0.53	2.56	1.44
46.00	1.26	0.00	1.00	1.77	1.00	2.13	0.91	1.40	0.53	2.56	1.45
48.00	1.27	0.00	1.00	1.73	1.00	2.17	0.91	1.41	0.53	2.57	1.48
50.00	1.00	0.00	1.00	1.32	0.75	2.14	0.91	1.40	0.53	1.92	1.46
52.00	1.00	0.00	1.00	1.28	0.75	2.20	0.91	1.41	0.53	1.93	1.50
54.00	1.00	0.00	1.00	1.26	0.75	2.23	0.91	1.42	0.53	1.93	1.53
56.00	1.00	0.00	1.00	1.23	0.75	2.30	0.92	1.43	0.53	1.93	1.58
58.00	1.00	0.00	1.00	1.21	0.75	2.33	0.92	1.43	0.53	1.94	1.60
60.00	1.00	0.00	1.00	1.18	0.75	2.39	0.92	1.44	0.54	1.94	1.64
62.00	1.00	0.00	1.00	1.14	0.75	2.48	0.93	1.46	0.54	1.95	1.72
64.00	1.00	0.00	1.00	1.14	0.75	2.47	0.93	1.45	0.54	1.95	1.70
66.00	1.00	0.00	1.00	1.12	0.75	2.51	0.93	1.46	0.54	1.95	1.73
68.00	1.00	0.00	1.00	1.11	0.75	2.55	0.93	1.47	0.54	1.95	1.77
69.50	1.00	0.00	1.00	1.10	0.75	2.57	0.93	1.47	0.54	1.96	1.78
70.50	1.00	0.00	1.00	1.08	0.75	2.61	0.93	1.47	0.54	1.96	1.82
72.00	1.00	0.00	1.00	1.09	0.75	2.59	0.93	1.47	0.54	1.96	1.80
74.00	1.00	0.00	1.00	1.10	0.75	2.56	0.93	1.47	0.54	1.95	1.78
76.00	1.00	5.00	1.09	1.16	0.75	2.44	0.93	1.45	0.54	1.95	1.68
78.00	1.00	7.00	1.12	1.14	0.75	2.47	0.93	1.45	0.54	1.95	1.71
80.00	1.00	10.00	1.17	1.13	0.75	2.50	0.93	1.46	0.54	1.95	1.73
82.00	1.00	13.00	1.22	1.10	0.75	2.57	0.93	1.47	0.54	1.96	1.78
84.00	1.00	13.00	1.22	1.02	0.75	2.77	0.94	1.49	0.54	1.97	1.93
86.00	1.00	16.00	1.28	0.97	0.50	1.94	0.89	1.37	0.53	1.27	1.32
88.00	1.00	18.00	1.31	0.90	0.50	2.09	0.90	1.40	0.53	1.28	1.43
90.00	1.00	20.00	1.34	0.90	0.50	2.10	0.90	1.40	0.53	1.28	1.43
92.00	1.00	17.00	1.29	0.84	0.50	2.24	0.91	1.42	0.53	1.29	1.53
94.00	1.00	15.00	1.26	0.85	0.50	2.21	0.91	1.42	0.53	1.29	1.51
96.00	1.00	16.00	1.28	0.93	0.50	2.02	0.90	1.38	0.53	1.28	1.37
98.00	1.00	9.00	1.16	0.92	0.50	2.04	0.90	1.39	0.53	1.28	1.39
100.00	1.00	0.00	1.00	0.80	0.50	2.36	0.92	1.44	0.54	1.29	1.63
102.00	1.00	0.00	1.00	1.02	0.50	1.85	0.88	1.36	0.53	1.27	1.25
104.00	1.45	0.00	1.00	1.64	1.00	2.29	0.92	1.43	0.53	2.58	1.57
106.00	1.45	0.00	1.00	1.64	1.00	2.29	0.92	1.43	0.53	2.58	1.57
108.00	1.48	0.00	1.00	1.51	1.00	2.48	0.93	1.46	0.54	2.60	1.72
110.00	1.37	0.00	1.00	2.04	1.25	2.31	0.92	1.43	0.53	3.23	1.58
112.00	1.35	0.00	1.00	2.16	1.25	2.18	0.91	1.41	0.53	3.21	1.49
114.00	1.00	0.00	1.00	1.58	1.00	2.38	0.92	1.44	0.54	2.59	1.64
116.00	1.00	0.00	1.00	1.32	0.75	2.13	0.91	1.40	0.53	1.92	1.46
118.00	1.00	0.00	1.00	1.15	0.75	2.46	0.93	1.45	0.54	1.95	1.70
120.00	1.00	0.00	1.00	1.05	0.75	2.68	0.94	1.48	0.54	1.96	1.87
120.50	1.00	0.00	1.00	1.00	0.75	2.82	0.94	1.50	0.55	1.98	1.98
122.00	1.00	0.00	1.00	1.04	0.75	2.70	0.94	1.48	0.54	1.97	1.88
122.65	1.00	0.00	1.00	1.03	0.75	2.75	0.94	1.49	0.54	1.97	1.92
123.55	1.00	0.00	1.00	1.77	1.00	2.13	0.91	1.40	0.53	2.56	1.45
124.00	1.00	0.00	1.00	1.79	1.00	2.09	0.90	1.40	0.53	2.56	1.43

Job:	Date
Calc by:	
Checked by: JFM	7/30/90
Dwg Chk:	

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Job:	Date
Calc by:	
Checked by: JFM	7/30/90
Dwg Chk:	

Levee BaK1
Salt Riv
Grade Co

FILE: BANK250.W
DATE: 07/25/90

FILE:
DATE:

SOUTH BANK:

SECNO	Kr	Td	D50	E	Cb	Cl	Ca	Ta	CHCK
0.00	1.00	1.85	1.00	2.03	0.90	1.39	0.53	2.56	1.38
2.00	1.00	2.01	1.00	1.87	0.88	1.36	0.53	2.54	1.27
4.00	1.15	1.99	1.00	1.89	0.88	1.36	0.53	2.54	1.28
6.00	1.17	1.96	1.00	1.92	0.89	1.37	0.53	2.55	1.30
8.00	1.19	1.93	1.00	1.95	0.89	1.37	0.53	2.55	1.32
10.00	1.21	1.84	1.00	2.04	0.90	1.39	0.53	2.56	1.39
12.00	1.24	1.76	1.00	2.14	0.91	1.40	0.53	2.56	1.46
14.00	1.27	1.70	1.00	2.22	0.91	1.42	0.53	2.57	1.52
15.40	1.29	1.61	1.00	2.34	0.92	1.44	0.53	2.58	1.61
15.60	1.30	1.55	1.00	2.42	0.92	1.45	0.54	2.59	1.67
17.50	1.30	1.54	1.00	2.44	0.93	1.45	0.54	2.59	1.69
19.00	1.20	1.66	1.00	2.26	0.91	1.42	0.53	2.58	1.55
19.20	1.20	1.55	1.00	2.43	0.92	1.45	0.54	2.59	1.68
21.50	1.18	1.61	1.00	2.34	0.92	1.44	0.53	2.58	1.61
24.00	1.00	1.51	0.75	1.87	0.88	1.36	0.53	1.91	1.27
24.50	1.00	1.23	0.75	2.29	0.92	1.43	0.53	1.93	1.57
26.00	1.00	1.23	0.75	2.29	0.92	1.43	0.53	1.93	1.57
27.00	1.00	1.22	0.75	2.30	0.92	1.43	0.53	1.94	1.58
28.00	1.00	1.23	0.75	2.30	0.92	1.43	0.53	1.94	1.58
30.00	1.00	1.25	0.75	2.25	0.91	1.42	0.53	1.93	1.54
32.00	1.00	1.22	0.75	2.31	0.92	1.43	0.53	1.94	1.59
34.00	1.00	1.23	0.75	2.29	0.92	1.43	0.53	1.93	1.57
36.00	1.00	1.07	0.75	2.64	0.94	1.48	0.54	1.96	1.84
38.00	1.00	1.29	0.75	2.19	0.91	1.41	0.53	1.93	1.50
40.00	1.00	1.35	0.75	2.08	0.90	1.40	0.53	1.92	1.42
42.00	1.00	1.36	0.75	2.08	0.90	1.40	0.53	1.92	1.42
44.00	1.00	1.41	0.75	2.00	0.89	1.38	0.53	1.91	1.36
46.00	1.00	1.40	0.75	2.01	0.90	1.38	0.53	1.92	1.37
48.00	1.27	1.73	1.00	2.17	0.91	1.41	0.53	2.57	1.48
50.00	1.27	1.68	1.00	2.24	0.91	1.42	0.53	2.57	1.54
52.00	1.28	1.64	1.00	2.29	0.92	1.43	0.53	2.58	1.57
54.00	1.28	1.62	1.00	2.32	0.92	1.43	0.53	2.58	1.60
56.00	1.29	1.58	1.00	2.38	0.92	1.44	0.54	2.59	1.63
58.00	1.29	1.56	1.00	2.41	0.92	1.45	0.54	2.59	1.66
60.00	1.30	1.53	1.00	2.45	0.93	1.45	0.54	2.60	1.69
62.00	1.31	1.49	0.75	1.90	0.88	1.36	0.53	1.91	1.28
64.00	1.31	1.50	0.75	1.88	0.88	1.36	0.53	1.91	1.27
66.00	1.32	1.48	0.75	1.90	0.88	1.36	0.53	1.91	1.29
68.00	1.32	1.46	0.75	1.93	0.89	1.37	0.53	1.91	1.31
69.50	1.33	1.46	0.75	1.93	0.89	1.37	0.53	1.91	1.31
70.50	1.33	1.43	0.75	1.97	0.89	1.38	0.53	1.91	1.33
72.00	1.32	1.44	0.75	1.96	0.89	1.38	0.53	1.91	1.33
74.00	1.30	1.43	0.75	1.97	0.89	1.38	0.53	1.91	1.34
76.00	1.31	1.39	0.75	2.02	0.90	1.39	0.53	1.92	1.38
78.00	1.33	1.35	0.75	2.09	0.90	1.40	0.53	1.92	1.42
80.00	1.34	1.29	0.75	2.19	0.91	1.41	0.53	1.93	1.50

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Job:	Date
Calc by:	
Checked by: JFM	7/30/90
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82.00	1.37	1.23	0.75	2.30	0.92	1.43	0.53	1.93	1.58
84.00	1.39	1.16	0.75	2.44	0.93	1.45	0.54	1.95	1.68
86.00	1.41	1.07	0.75	2.64	0.94	1.48	0.54	1.96	1.84
88.00	1.44	0.99	0.50	1.90	0.89	1.36	0.53	1.27	1.29
90.00	1.45	0.97	0.50	1.94	0.89	1.37	0.53	1.27	1.32
92.00	1.46	0.95	0.50	1.98	0.89	1.38	0.53	1.28	1.35
94.00	1.45	0.98	0.50	1.92	0.89	1.37	0.53	1.27	1.30
96.00	1.43	1.05	0.75	2.70	0.94	1.48	0.54	1.97	1.88
98.00	1.41	1.12	0.75	2.51	0.93	1.46	0.54	1.95	1.74
100.00	1.41	1.12	0.75	2.51	0.93	1.46	0.54	1.95	1.74
102.00	1.00	1.02	0.75	2.77	0.94	1.49	0.54	1.97	1.94
104.00	1.00	1.13	0.75	2.49	0.93	1.46	0.54	1.95	1.72
106.00	1.00	1.13	0.75	2.49	0.93	1.46	0.54	1.95	1.72
108.00	1.00	1.02	0.75	2.76	0.94	1.49	0.54	1.97	1.93
110.00	1.00	1.49	0.75	1.90	0.88	1.36	0.53	1.91	1.28
112.00	1.00	1.60	1.00	2.35	0.92	1.44	0.54	2.59	1.62
114.00	1.00	1.58	1.00	2.38	0.92	1.44	0.54	2.59	1.64
116.00	1.00	1.32	0.75	2.13	0.91	1.40	0.53	1.92	1.46
118.00	1.00	1.15	0.75	2.46	0.93	1.45	0.54	1.95	1.70
120.00	1.00	1.05	0.75	2.68	0.94	1.48	0.54	1.96	1.87
120.50	1.00	1.00	0.75	2.82	0.94	1.50	0.55	1.98	1.98
122.00	1.00	1.04	0.75	2.70	0.94	1.48	0.54	1.97	1.88
122.65	1.00	1.03	0.75	2.75	0.94	1.49	0.54	1.97	1.92
123.55	1.00	1.77	1.00	2.13	0.91	1.40	0.53	2.56	1.45
124.00	1.00	1.79	1.00	2.09	0.90	1.40	0.53	2.56	1.43

This calculation is similar to the calculation for unconfined stone. The only difference is that the Shields parameter is increased from 0.047 to 0.100 to account for the confinement of the stone in the gabion basket.

The equation for stable stone on a slope is $\tau_d \leq C_a \tau_c$ where

$\tau_c = 10.3\, D_{50}$ for gabion
($\tau_c = 4.83\, D_{50}$ for stone)

The equivalent stone size for a gabion compared to loose stone is derived as follows

$$10.3\, D_{50}^{G} = 4.83\, D_{50}^{S}$$

$$\frac{D_{50}^{G}}{D_{50}^{S}} = \frac{4.83}{10.3} = 2.13$$

Equivalent sizes are:

Loose Stone	Gabion
6"	2.8"
9"	4.2"
12"	5.6"
15"	7.1"

For the proposed 1' gabion mattress thickness a 6" stone size will provide the equivalent stability as loose stone with $D_{50} = 12"$.

CRS SIRRINE	PROJECT: Rio Salado Channel	JOB NO. R101N	NO. 2
	CLIENT: City of Tempe	DESIGNED BY GKC / DATE 8/14/90	OF 2
	SUBJECT: Gabion Stone Fill	CHECKED BY JFM / DATE 8/15/90	

The gradation of the stone used to fill the mattress must be larger than the wire mesh opening and less than the mattress thickness. Use:

$D_{min} = 3''$

$D_{max} = 12''$

$D_{50} = 6''$

for 1' mattress thickness.

CRS SIRRINE	PROJECT: Ri Salado	JOB NO.: R101N	NO. 5
	CLIENT: Tempe	DESIGNED BY: GKC / DATE: 7/24/90	OF 5
	SUBJECT: Filter	CHECKED BY: JFM / DATE: 7/30/90	

Alternative Filter Design: Filter Fabric

Task Force No 25 recommends the following criteria for filter fabric design. (see HEC-15, FHWA-IP-87-7, page 20).

1. The fabric must be able to transmit water faster than the soil.
2. The following criteria for the apparent opening size (AOS) must be met:
   a. For soil with less than 50 percent of the particles by weight passing a U.S. No. 200 sieve, AOS < 0.6 mm (0.024 in) (greater than #30 U.S. Std. Sieve).
   b. For soil with more than 50 percent of the particles by weight passing a U.S. No. 200 sieve, AOS < 0.297 mm (0.012 in) (greater that #50 U.S. Std. Sieve).

Criteria 1 and 2a will control
Soil permeability is estimated to be 5.2×10^{-2} cm/s for coarse sand.

Cost Analysis

Cost Comparison

Filter Fabric	$3.00	sq yd
Gravel Bedding	$14.00	sq. yd.

(Use 1.0 ft bedding thickness for riprap or rock, so 1 cu yd provides 3 sq yd
Gravel Bedding $12.00 cu. yd.)

Use filter fabric.