BRIDGE SCOUR EVALUATIONS

Work Order No. 80407
Contract No. CY 1995-11

51st Avenue Bridge over the Salt River

(SN9692)

Final Report

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Submitted to:

Maricopa County
Department of Transportation

Submitted by:

PARSONS BRINCKERHOFF

FINAL REPORT

BRIDGE SCOUR EVALUATION FOR THE 51ST AVENUE BRIDGE OVER THE SALT RIVER

MARICOPA COUNTY, ARIZONA

February, 1997

Submitted by:

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1.0 INTRODUCTION

The 51st Avenue Bridge carries vehicular traffic over the Salt River in Maricopa County, Arizona. Construction plans for the bridge were prepared by the firms of Nicholas-Cowie & Associates, and E.M. Plummer, dated January, 1980. The present bridge replaced a previous structure which was removed in 1982-83. The bridge length is approximately 1,602 feet, and is composed of sixteen concrete spans supported by concrete piers. The middle spans are 100 feet, while the two abutment spans are 99 feet 1.5 inches. Each pier consists of five 48 inch diameter concrete columns. The piers are supported by driven steel H-piles piles with pile caps at elevation 975, and are founded on sand and gravel mixtures with cobbles at elevation 925. The plan channel bed elevation is approximately 995.8. Each pile cap has 5 ft thick riprap protection. The abutments are supported by steel H-piles driven 90 ft deep to elevation 925. Both abutments have grouted riprap protection. The bridge carries two lanes of traffic and is approximately 53 feet wide. The roadway is oriented in a north-south direction and the profile is a vertical curve, except for the bridge approaches. The south approach roadway has a 2.7 percent grade, while the north approach roadway has a 1.8 percent grade. The bridge is on a 0° skew (e.g. normal to the stream flow.)

Evaluating scour potential of the existing bridge is the primary goal of the project. This report provides data on Salt River hydrology and hydraulics in the bridge vicinity. Using the hydraulic data, a complete scour analysis is performed for the 51st Avenue Bridge.

Total scour depths for the 100-year flood are estimated to be 28 feet at the south abutment, 34 feet at the north abutment, and 20 feet for all piers. An overtopping discharge was estimated and used in the scour calculations because the roadway is overtopped before the 500-year flood. Total scour for the overtopping flood is estimated to be 38 feet at the south abutment, 42 feet at the north abutment, and 24 feet for all piers. These total scour depths include contraction scour. Long term degradation/aggradation is zero. It is expected that actual

abutment scour will be less than the calculated depths, due to the inherent conservativeness of the Froehlich equation for abutment scour.

Section 2.0 describes data collection followed by the site description in section 3.0. Section 4.0 summarizes the results of the hydraulic HEC-2 modeling. Section 5.0 explains scour processes and procedures for calculating bridge scour. Section 6.0 provides the results of the scour calculations. Section 7.0 provides an initial evaluation of the bridge and lists any deficiencies. No recommendations are provided in this report, they will be deferred to the final report.

2.0 DATA COLLECTION

Data was supplied by Maricopa County Department of Transportation in the form of final plans for the 51st Avenue Bridge at the Salt River, project number 11501 dated 1980. U.S. Army Corps of Engineers HEC-2 data files for the 100-year flood was supplied by the Maricopa County Flood Control District. Floodplain maps prepared by the U.S. Army C.O.E. for the Flood Control District were obtained along with USGS topographic maps for the bridge site.

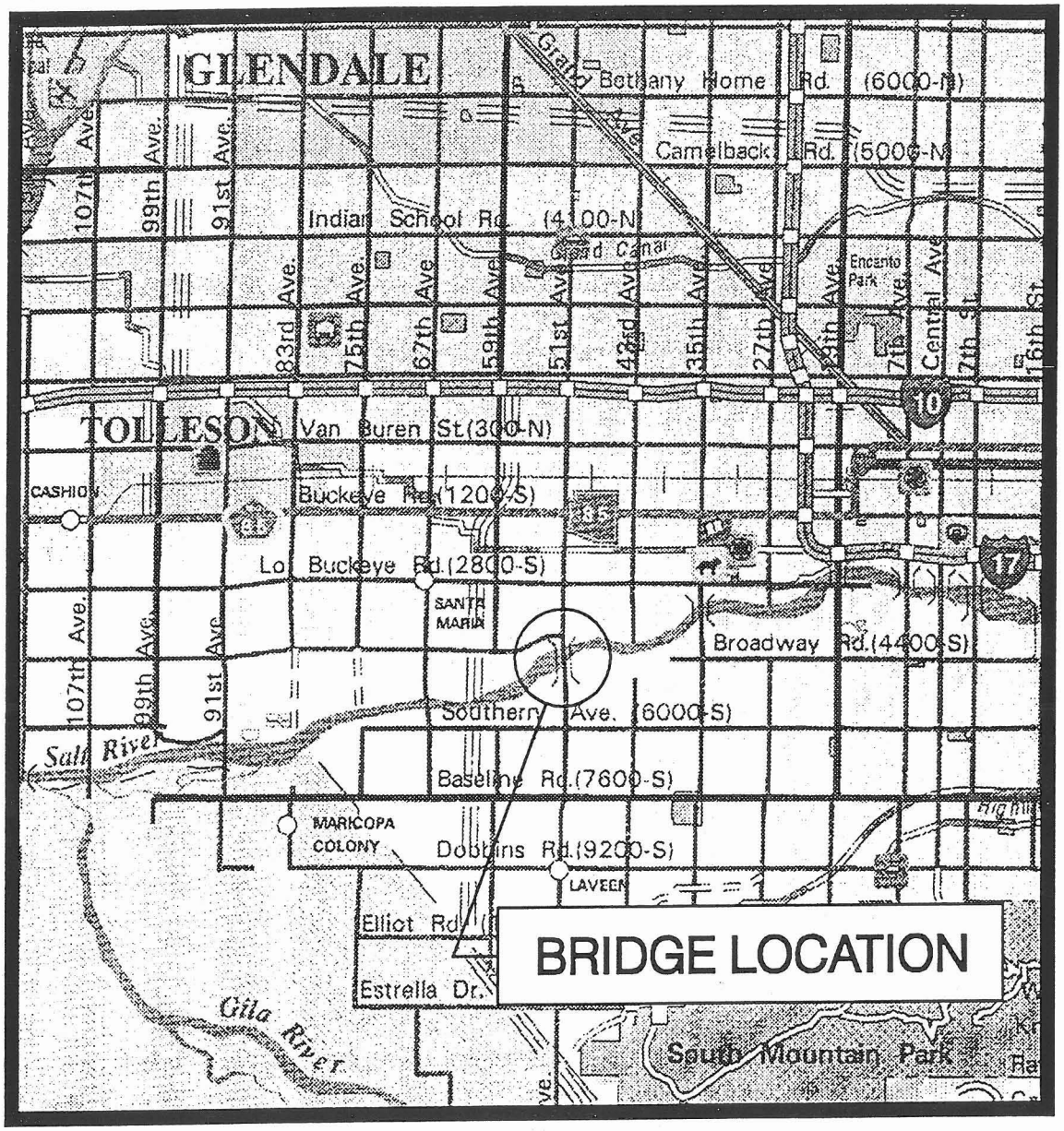
Parsons Brinckerhoff conducted a site visit on April 20, 1995. Extensive photographs of the site were taken and a visual survey of the bridge and surrounding area was made. A survey of the channel cross section was performed on May 18, 1995.

The scour screening procedure for the National Bridge Inventory System is completed for the 51st Avenue Bridge. The screening forms are included in the Appendix. The 51st Avenue Bridge is evaluated as a potential high risk with a recommended rating of 3C requiring a detailed scour and structural stability analysis. A scour analysis was performed for the 51st Avenue Bridge in order to verify the screening results and demonstrate the validity of the screening procedures. This information was used in the structural stability analysis to verify the bridge was scour critical.

3.0 SITE DESCRIPTION

As shown in Figure 1, the site lies in the south-west portion of the Phoenix metropolitan area. The bridge crosses the Salt River which is relatively dry during the majority of the year. A sand and gravel mine, located immediately downstream from the bridge site, is operated by the Arizona Crushing Company, Incorporated.

Figure 1


GLENDALE
Bethany Home Rd. (6000-N)
Camelback Rd. (5000-N)
Indian School Rd. (4100-N)
Encanto Park
TOLLESON
Van Buren St.(3000-N)
CASHION
Buckeye Rd.(1200-S)
Lower Buckeye Rd.(2800-S)
SANTA MARIA
Broadway Rd.(4400-S)
Southern Ave. (6000-S)
Salt River
Baseline Rd.(7600-S)
MARICOPA COLONY
Dobbins Rd.(9200-S)
LAVEEN
Elliot Rd.
Estrella Dr.
BRIDGE LOCATION
Gila River
South Mountain Park
107th Ave.
99th Ave.
91st Ave.
83rd Ave.
75th Ave.
67th Ave.
59th Ave.
51st Ave.
43rd Ave.
35th Ave.
27th Ave.
19th Ave.
7th Ave.
Central Ave.
7th St.
16th St.
10
17

The terrain in the immediate area is relatively flat. Due to flat topography, the 100-year floodplain at the bridge is approximately 4000 feet wide. The Salt River has a low flow width of approximately 40 to 50 feet. During low flow the Salt River runs along its thalweg, which was observed to be located approximately 160 feet north from the south abutment. Along the north abutment is a localized typical wetland with tall marsh grasses. Since no flow is observed into or out of the marsh area, it is assumed the origin is from tailwater from the nearby mining operation. This tailwater has eroded the north abutment and cracked the grouted riprap protection. This can be seen in the pictures enclosed. The floodplain is made up of sandy soil with some low level vegetation. The middle third of the bridge is covered with cobbles, that are assumed to be bed load deposited from previous floods. Vegetation, composed of grasses, shrubs, and small trees covers the channel near the marsh and the low flow area. The pictures also display minor evidence of scour depressions at the piers.

3.1 Geotechnical Evaluation

The geotechnical investigation for the old bridge which was replaced in 1982-83 was performed by Sergent Hauskins & Beckwith in 1968. Because of poor plan sheet copies and absence of other information, it was not possible to determine the name of the geotechnical engineering firm for the replacement bridge. The 51st Avenue bridge is located over the Salt River. The stream bed is uneven with antidunes 6-8 feet high. The bed load consists of sandy gravely silt. The South bank shows some degradation at upstream side of the bridge. Boring logs show sand and gravel mixtures with cobbles to the full depth of investigation at about elevation 930. The estimated D_{50} particle size, based on plan review and field reconnaissance, is 25 mm for bed, banks and overbanks.

During the field reconnaissance on 20 April 1995, a previously buried natural gas pipeline was exposed upstream of the bridge, indicating recent local scour in the channel. In addition, erosion was noted at the base of the grouted riprap at the south abutment. Vegetation was very

heavy in the bed and bank near the north abutment, where a consistent supply of water is provided from the concrete batch plant nearby. Surficial soils are considerably more fine grained in this wet area near the north abutment. Vegetation elsewhere in the bed, and on banks and overbanks, was sparse.

3.2 Structural Evaluation

There are scour protection measures at the piers and abutments. The five column piers are resting on 50-foot long H-piles. There is a five foot thick layer of riprap protection on top of the pile caps. The abutments are protected by a three foot layer of riprap and concrete slurry at 1:1 and ¾:1 sideslopes.

There is minor damage to the North abutment riprap protection. At the South abutment, there is a gravel mining operation which has affected the river bed configuration. The river flow during low water is through the south five spans of the bridge.

There is visible debris blockage around the piers at the structure. The local degradations at the base of the columns are minor and indicate a local temporary scour of about one foot.

The superstructure has two expansion joints at the piers. The total expansion of superstructure has exceeded the capacity of the joints and there is a gap of about six inches at these expansion joints.

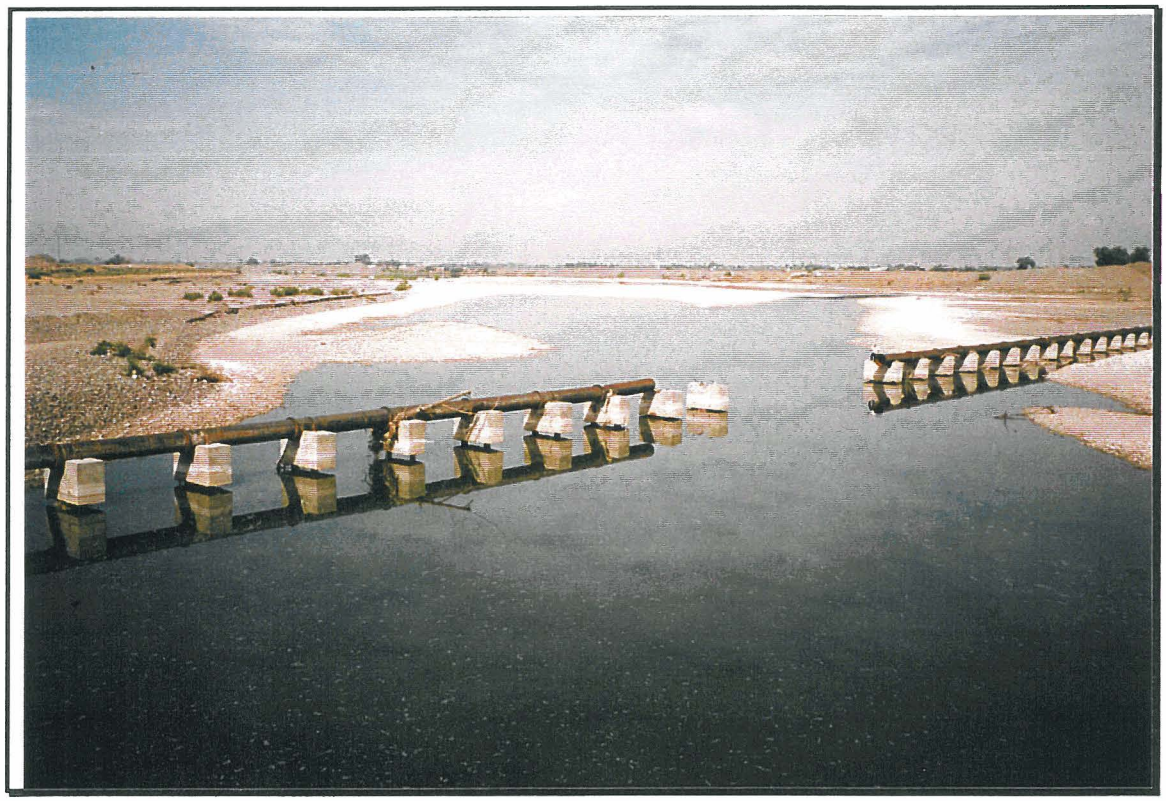
Due to the scour depths computed the work will proceed to a structural stability analysis, conducted in Section 7.1 to follow.

Looking upstream near middle of bridge.

Looking upstream; south end of bridge.

51st. AVENUE

Looking downstream near middle and north end of bridge.



Looking downstream near south end of bridge.

51st. AVENUE

Upstream face looking south.

Upstream face looking north.

51st. AVENUE

Downstream face looking North.

North abutment; downstream side.

51st. AVENUE

4.0 HYDRAULIC ANALYSIS

Although the Salt River is dry for most of the year, it is subject to heavy seasonal flood flows throughout the year. During low flow, approximately 300-400 cfs flows in the Salt River. The majority of the low flow is supplied from wastewater treatment, mining operations, and irrigation tailwater. As shown in Table 1, during flood conditions flow levels increase dramatically. The 100-year design flood flow for the existing conditions is 190,000 cfs. The 500-year superflood of 315,000 cfs overtops the approach roadway in the vicinity of the bridge. The flow was reduced to 252,000 cfs to approximate the flow to overtop the roadway. The U.S. Army Corps of Engineers has recently completed an operational plan for the improvements constructed to Roosevelt Dam. It is outside the scope of services for this project to analyze what effect it would have on future scour potential.

As displayed in Table 1, the HEC-2 output for the existing conditions calculates the maximum velocity at the bridge to be 12.4 fps for the 100-year flood event. Water surface elevation at the bridge is 1012.7 feet for the 100-year flood at existing conditions. The freeboard for the bridge slightly exceeds the minimum 3 foot requirement for the 100-year flood event. The average velocity at the bridge is calculated as 13.8 fps for the overtopping flood. Computed water surface elevation at the bridge is 1014.7 feet for the overtopping flood.

Table 1

	100-Year Flood Existing Conditions	Overtopping Flood Existing Conditions
Discharge (cfs)	190,000	252,000
Velocity (fps)	12.4	13.8
WSEL (feet)	1012.7	1014.7

5.0 SCOUR ANALYSIS

A scour analysis is performed for the conditions for both the 100-year flood scenario and the 500 year overtopping flood. The potential for scour damage to the bridge piers and abutments is evaluated using the guidelines and procedures presented in Hydraulic Engineering Circular Number 18 (HEC-18). Total scour is comprised of four components: long-term trends, contraction scour, bend scour (if applicable), and local scour.
(general)

5.1 Long-Term Trends

Long-term trends in channel aggradation, degradation, and lateral migration are predicted qualitatively based on available sources of information including mapping, field observations, history of flooding and erosion, previous inspection reports, geomorphology, soil characteristics, land uses, flow patterns, control works, and any other factors which may have an influence on the river. The prediction of long-term trends is given in section 6.1. It is beyond the Scope of Work for this project to compute equilibrium/stable slope analysis. That work is best left to the next contract designing corrective measures.

5.2 Contraction Scour

Contraction scour is caused by the channel width decreasing at the bridge crossing. Contraction scour occurs when the area of flow is decreased, resulting in increases in both velocity and bed shear stress in the contracted area. There are two basic forms of contraction scour, live-bed and clear-water, both of which are based on the principle of conservation of sediment transport. Live-bed is the condition where bed material upstream of the crossing is being transported. For live-bed scour, material is removed until equilibrium is reached between sediment transported into and out of the contracted section. Clear-water is the condition where there is no transportation of upstream bed material.

Live bed conditions exist at the site because the critical velocity for beginning sediment motion is less than the average channel velocity. As displayed in the contraction scour computations located in the Appendix, critical velocities for the flood conditions are well below the average flow velocities calculated in the hydraulic analysis.

FHWA recommends the modified version of Laursen's 1960 equation for estimating live-bed contraction scour. Input parameters for the equation include average depth, discharge, bottom width, and D_{50} of the bed material. It should be noted that Laursen's equation will overestimate scour if the contraction is the result of bridge piers and abutments. Using the median grain size, k_1 conservatively assumes transported sediment is mostly suspended bed material discharge. The equation is

$$\frac{Y_2}{Y_1} = \left(\frac{Q_2}{Q_1}\right)^{\frac{6}{7}} \left(\frac{W_1}{W_2}\right)^{k_1}$$

where

Y_1 = average depth in the upstream main channel
Y_2 = average depth in the contracted section
W_1 = bottom width of the upstream main channel
W_2 = bottom width of the contracted section
Q_1 = flow in the upstream channel transporting sediment
Q_2 = flow in the contracted channel
k_1 = relates to the mode of bed material transport (contact bed material vs. suspended bed load.
$Y_S = Y_2 - Y_1$ = average scour depth.

5.3 Local Scour

Local scour is the result of water flowing around a pier, abutment, or other obstruction. These obstructions induce the formation of vortex systems caused by the acceleration of the flow around the obstruction. A horseshoe vortex is formed by water hitting the upstream surface of

the obstruction and then traveling down the pier. In addition, piers have horizontal vortices, referred to as wake vortices, acting transverse to the pier downstream of the obstruction. Both vortices remove material from the base of the obstruction. However, the intensity of the vortices diminishes downstream from the obstruction.

The Colorado State University (CSU) equation is recommended for both live-bed and clear water pier scour. The basic input parameters are flow depth, pier shape, Froude number, pier width, and angle of attack. The angle of attack at the 51st Avenue Bridge over the Salt River is 0 degrees, i.e. the flow is normal to the bridge. Maps of the area show the Salt River flowing in a relatively straight line both upstream and downstream of the bridge, thereby indicating that the flow is parallel with the channel and normal to the bridge. Since the angle of attack is 0 degrees and because the columns are arranged in a straight line longitudinally, the pier width is the width of a single column plus an amount for debris accumulation. The pier width used for scour calculations is 8.0 feet. Four feet was added for debris blockage, for a total of 8.0 feet

The CSU equation estimates equilibrium scour depths. Depending on the bed configuration, adding a recommended correction factor to the equilibrium scour yields the estimated maximum scour. The CSU equation is

$$\frac{Y_s}{Y_1} = 2.0 K_1 K_2 K_3 \left(\frac{a}{Y_1}\right)^{0.65} Fr_1^{0.43}$$

where

Y_s = scour depth
Y_1 = flow depth just upstream of the pier
K_1 = correction for pier nose shape
K_2 = correction for angle of attack
K_3 = correction for bed configuration
a = pier width
Fr_1 = Froude number; $Fr_1 = V_1/(gY_1)^{1/2}$
V_1 = Mean Velocity of flow directly upstream of the pier.

Froehlich's live-bed equation, shown below, is used for estimating live-bed and clear-water scour at abutments. The equation is based entirely on laboratory data and provides very conservative estimates of scour. The basic input parameters are Froude number, shape, and projection of abutment, skew, and depth of flow. The use of engineering judgment is recommended in using these estimates of abutment scour depth, because cost will be the deciding factor between greater foundation depth or protection of the abutment area.

$$\frac{Y_s}{Y_a} = 2.27 K_1 K_2 \left(\frac{a'}{Y_a}\right)^{0.43} Fr^{0.61} + 1$$

Where

K_1 = coefficient for abutment shape
K_2 = coefficient for angle of embankment to flow
$a' = A_e/Y_a$ = length of abutment projected normal to flow
A_e = flow area of the approach cross section obstructed by the embankment
$Fr_e = V_e/(gY_a)$ = Froude number of approach flow upstream of the abutment
$V_e = Q_e/A_e$
Q_e = flow obstructed by the abutment and approach embankment
Y_a = average depth of flow on the floodplain
Y_s = scour depth.

No bend scour is predicted to occur at the 51st Avenue Bridge. The Salt River flows in a relatively straight line and does not flow around any bends in the bridge vicinity.

5.4 Total Scour

Total scour at any location is estimated as the sum of any long term trends, contraction scour, and local scour. The total scour is then plotted on a cross section view of the bridge. Any estimated scour depth due to long-term trend predictions is plotted below the existing channel bottom. The estimated scour depth due to contraction scour is then plotted a computed distance below the revised channel bottom. Local scour is finally plotted for each pier and abutment in the shape of a scour hole. The top width of a scour hole is estimated to be 2.8

times the predicted scour depth. Debris blockage will add to the effective width of the piers and thus increase the scour depth. This increase in the scour depth has a direct result on the width of the scour hole as noted above. If the estimated limits of scour holes overlap, the resulting scour may be deeper than originally estimated.

6.0 RESULTS

6.1 Long-Term Trends

Wrong - 6' Present

It is a reasonably safe prediction that any long-term aggradation or degradation of the channel bottom is nearly complete. No further degradation of the channel bottom by the thalweg is predicted to occur during the service life of the bridge. The recent field survey indicated aggradation of 4 to 6 feet has occurred since the bridge was built in 1980. This aggradation is evident across the whole channel except on the south end where the thalweg is currently located. The aggradation was not used in calculating scour depths because the thalweg could migrate across the channel. Thalweg movement is common for rivers such as the Salt River, which experience heavy flows infrequently and are usually relatively dry. The wide, flat floodplain, along with the sandy soil combine to create a condition where extensive lateral migration may occur with each flood event.

Because the thalweg is constantly shifting to different points in the floodway, a constant elevation equal to the invert is used for the entire cross section. The thalweg elevation of 987.2 obtained in the field survey is used for the invert elevation in all scour calculations.

6.2 Contraction Scour

Contraction scour occurs at the bridge site. As shown in Table 2, contraction scour is estimated at approximately 3 feet for the 100-year flood event and 6 feet for the 500 year overtopping flood. The upstream width is taken as approximately 2082 feet, which represents the distance across the floodway upstream from the bridge outside of backwater influences. The two flood

events have similar contraction scour depths, because flow through the contracted section is less than the total main channel flow for the existing 100-year and overtopping floods.

Table 2

100-Year Flood Existing Conditions	South Abutment	Pier	North Abutment
Local Scour	25.2 feet	17.5 feet	31.0 feet
Contraction	3.4 feet	3.4 feet	3.4 feet
Total Scour	**28.6 feet**	**20.9 feet**	**34.4 feet**
Scour Elevation	962.4 feet	970.1 feet	956.6
Remaining Pile Embedment	37.4 feet	45.1 feet	31.6
Overtopping Flood Existing Conditions	**South Abutment**	**Pier**	**North Abutment**
Local Scour	32.4 feet	18.5 feet	35.8 feet
Contraction	5.8 feet	5.8 feet	5.8 feet
Total Scour	**38.2 feet**	**24.3 feet**	**41.6 feet**
Scour Elevation	952.8 feet	966.7 feet	949.4
Remaining Pile Embedment	27.8 feet	41.7 feet	24.4

Assumes an average thalweg at Elevation 991.0 and bottom of Pile Tips at 925.0.

Note: Long term degradation/aggradation is zero for this evaluation.

6.3 Pier Scour

Local pier scour is predicted to occur at the bridge site for each of the flood events. The effective width of the piers used in the scour calculations was 8 feet. This width accounts for debris accumulation of approximately twice the pier width. Maximum pier scour is estimated to be approximately 18 feet for the 100-year flood scenario. Maximum pier scour is estimated to be approximately 19 feet for the overtopping check flood. The maximum estimated pier scour

may occur at any of the piers. Calculations for pier scour are included in the Appendix. For total scour at the piers the contraction scour component must be added to it as is shown in Table 2.

6.4 Abutment Scour

The south abutment scour estimates for each of the floods are shown in Table 2. The existing topography is expected to reduce flow velocity and angle of attack at the south abutment. Figure 2 shows a small mound located approximately 300 feet west of the abutment. The mound extends above the high water for all flood events and will effectively reduce velocities at the south abutment. A pointed ridge begins approximately 1000 feet west of the south abutment. It is believed that the ridge will deflect flow back into the channel and away from the abutment. A two-dimensional analysis may be used to analyze the flow patterns at the south abutment.

The south abutment scour depths shown in Table 2 are less than those calculated at the north abutment.

Please note that the abutment scour equation recommended by HEC-18 is inherently conservative and includes a large factor of safety. The grouted riprap should help protect the abutments and help prevent the predicted maximum scour depth from occurring. In 1992, the 51st Avenue bridge experienced a flood approaching the 10-year event and no significant damage was observed at either abutment.

Abutment scour is not expected to be as severe as predicted in the scour computations or as shown in Figure 2. HEC-18 recommends placing abutment footings at least 6 feet below the depth reached by long-term degradation and contraction scour.

6.5 Total Scour

Table 2 summarizes the total scour predicted at each pier and abutment for the 100-year and 500-year overtopping flood event. It is possible for the maximum pier scour depth to occur at each pier, therefore only one representative pier is displayed in the table. Figure 3 shows the plotted scour holes associated with the 100-year flood. The overtopping flood is not plotted, because values are given in Table 2. Debris accumulation is not shown in figure 3, however, it is accounted for in the scour calculations. Scour computations are included in the appendix.

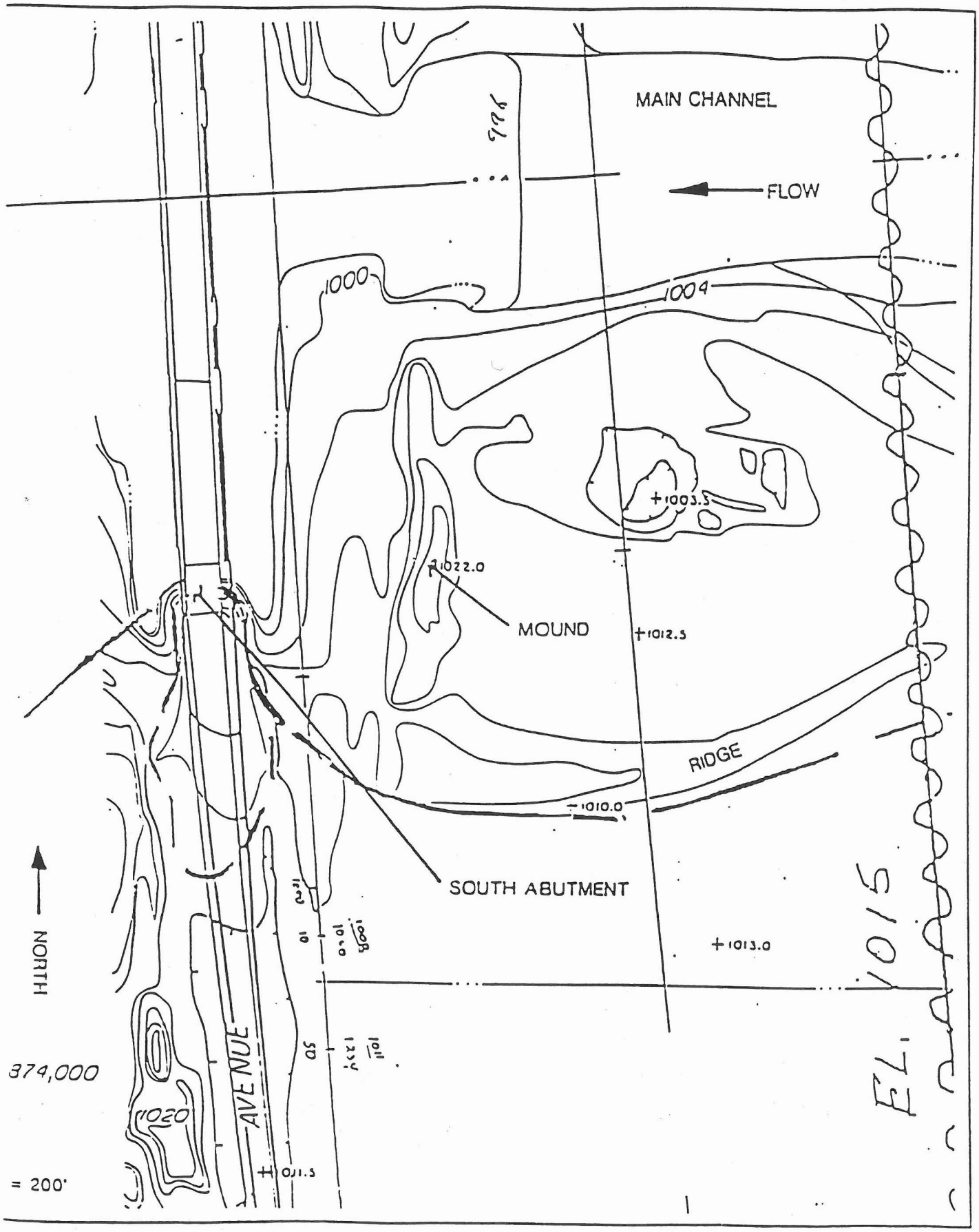
Maximum total scour is predicted to go below the pier pile caps. There is riprap protection placed above each pile cap but the gradation is unknown and it is beyond the scope of this evaluation to predict the Armoring benefit derived from this riprap.

7.0 INITIAL EVALUATION

The 51st Avenue Bridge is scour critical and rated 3C. Section 7.1 describes the results of a structural stability analysis. Deep scour depths are calculated at both abutments. Some benefit will be derived from the riprap protection but the extent is not known at this time. The scour depths reach below the top of the pile caps and table 2 shows the remaining pile depths for both the 100-year and 500-year overtopping floods. During the field inspection debris accumulation was observed at the piers. The accumulation should be removed from around the piers because it creates a larger obstruction to the flow and may cause deeper scour depths to occur.

The north abutment has been eroded by the tailwater from the Arizona Crushing Company. This situation should be corrected before further damage occurs.

FIGURE 2


MAIN CHANNEL
FLOW
1000
1004
+1003.5
+1022.0
MOUND
+1012.5
RIDGE
+1010.0
SOUTH ABUTMENT
+1013.0
NORTH
374,000
1020
AVENUE
+1011.5
= 200'

Scour countermeasures are recommended for the 51st Avenue Bridge. Riprap at the abutments should be inspected after each major flood event and replaced or repaired if necessary. If replaced PB would recommend a larger graded riprap (possibly D_{50}=18") and not use grouting so that individual particles may settle in future possible scour holes rather than wash away as larger grouted conglomerate sections.

7.1 Structural Analysis

Stability analysis is based on the original bridge plans and scour data provided by the PB's Drainage Section.

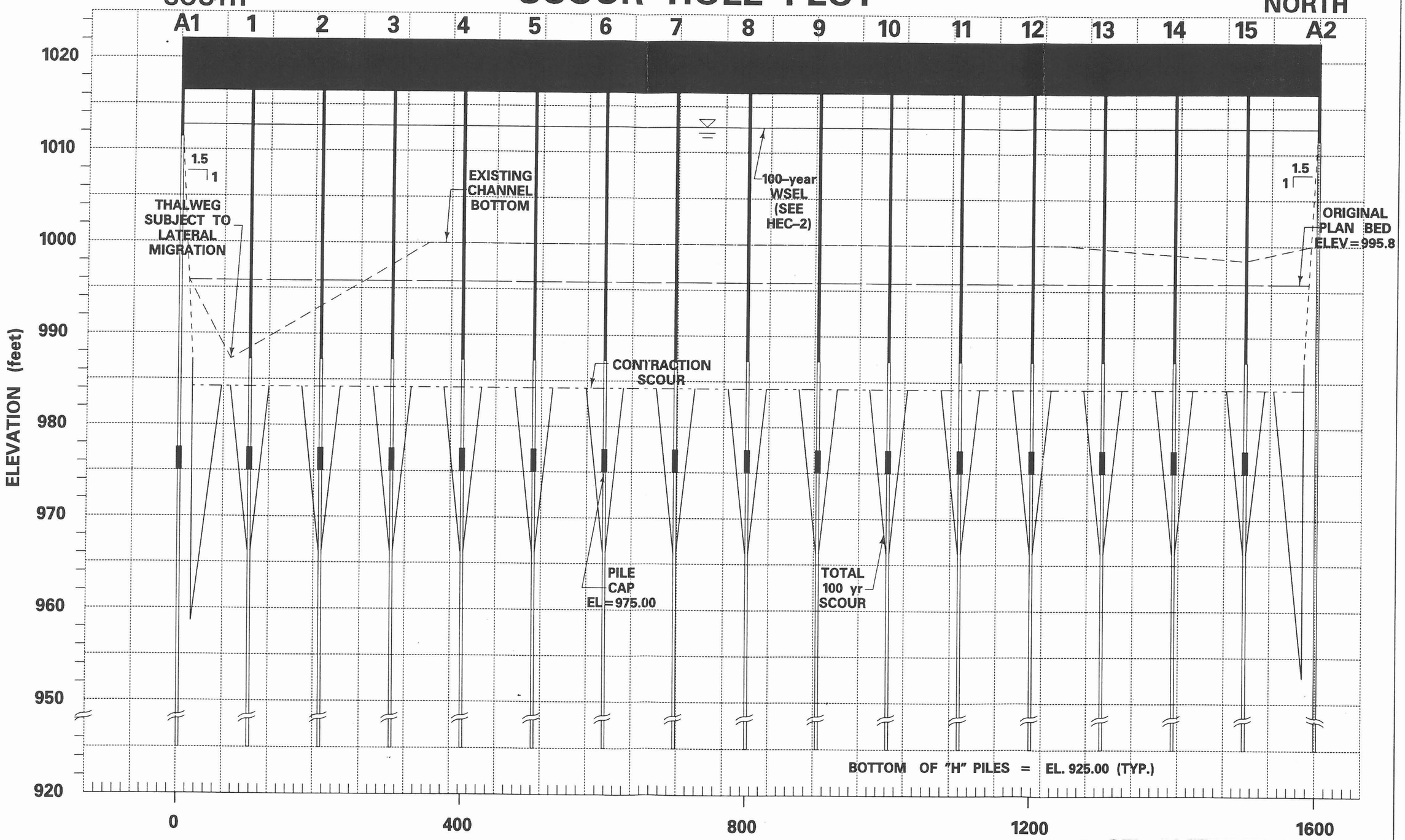
Abutment No. 1 (South) – Based on assumption that scour elevation is below the riprap protection and abutment scour protection will fail at 100-year storm event, exposed length of piles will be about 49 feet and piles will not pass the slenderness test under axial load. Similar situation exists at 500-year flood event.

Piers – Our analysis indicates pier foundations will perform satisfactorily under 100-year storm event. For 500 year storm, pier foundation piles fail strength (stress) test.

Abutment No. 2 (North) – Scour depth on Abutment No. 2 is longer than Abutment No. 1; therefore, this abutment fail the stability (pile slenderness) test.

Therefore, 51st Avenue bridge over Salt River **is scour critical**.

SCOUR HOLE PLOT



51ST AVENUE BRIDGE
(at Salt River)

PREPARED BY D. BRIDGES DATE 7-95
CHECKED BY B. BATTISTELLO DATE 2-97
APPROVED BY DATE

JOB NO. 11026C

$$DGN$$
$$DATE$$

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Wed Feb 19 08:17:48 1997

VIEW NAME:

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51st AVENUE BRIDGE OVER THE SALT RIVER

CONTRACTION SCOUR

CASE 1 - LIVE BED	SEE NOTE	100-YEAR	OVER-TOPPING
Y1 - AVE. DEPTH IN UPSTREAM MAIN CHANNEL(FT)	1	9.92	12.59
W1 - WIDTH OF UPSTREAM MAIN CHANNEL(FT)		2082	2082
W2 - WIDTH OF CONTRACTED SECTION(FT)	2	1534	1534
N1 - AT MAIN CHANNEL		0.032	0.032
N2 - AT CONTRACTED SECTION		0.032	0.032
Q_1 - FLOW IN UPSTREAM MAIN CHANNEL (CFS)		167,000	200,700
Q_2 - FLOW IN CONTRACTED SECTION (CFS)		190,000	252,000
(Q_2/Q_1)^6/7		1.12	1.22
S1 - SLOPE OF ENERGY GRADE LINE IN US CHANNEL (FT/FT)	3	0.00131	0.00087
V*c - SHEAR VELOCITY(FPS) = [32.2(Y1)(S1)]^0.5		0.65	0.59
K1	4	0.59	0.59
(W1/W2)^K1		1.20	1.20
Y2/Y1 = Q_2/Q_1^(6/7)(W1/W2)^K1		1.34	1.46
Ys = Y2-Y1 = SCOUR (FT)	5,6	3	6

NOTES:

1. Y1 IS AVE. DEPTH IN MAIN CHANNEL.

2. W2=(BOTTOM WIDTH)-(SUM OF EFFECTIVE PIER WIDTHS). 1594'-(15x4')=1534'

3. ENERGY GRADE LINE (USED TO OBTAIN K1).TAKEN FROM HEC-2.

4. K1 VALUE ASSUMES MOSTLY CONTACT BED MATERIAL DISCHARGE.

5. EQ. ASSUMES SEDIMENT TRANSPORT IN CHANNEL UPSTRM = SEDIM. TRANSP. AT CONTRACTED SECTION.

6. ASSUMES LIVE BED CONTRACTION SCOUR BECAUSE Vc<Vmean.

51st AVENUE BRIDGE OVER THE SALT RIVER

PIER SCOUR - EXISTING CONDITIONS

		100-YEAR			OVERTOPPING		
FIVE COLUMN BENT	SEE NOTE	LEFT OVERBANK	MAIN CHANNEL	RIGHT OVERBANK	LEFT OVERBANK	MAIN CHANNEL	RIGHT OVERBANK
PIER NUMBER(S)			1-15			1-15	
SKEW ANGLE (DEGREES)			0			0	
a - PIER WIDTH (FT)	1		8			8	
K1	2		1.0			1.0	
K2	2		1.0			1.0	
K3	2		1.1			1.1	
V1 - VELOCITY, UPSTREAM FACE OF PIER (FT)	3		13.35			14.40	
Y1 - DEPTH OF FLOW UPSTRM. FACE OF PIER (FT)	4		13.74			16.21	
Fr1 - FROUDE NUMBER = V1/(32.2*Y1)^1/2			0.63			0.63	
[a/Y1]^0.65			0.70			0.63	
Ys/Y1= 2K1K2K3(a/Y1)^.65(Fr1)^.43	5		1.27			1.14	
Ys SCOUR DEPTH (FT)			17			18	

NOTES:

1. TWICE THE PIER WIDTH IS USED FOR THE EFFECTIVE PIER WIDTH TO ACCOUNT FOR DEBRIS ACCUMULATION.

2. K1=1.0 SINCE CIRCULAR CYLINDER PIERS.
   K2=1.0 SINCE ANGLE OF ATTACK IS 0.
   K3=1.1 FOR PLANE BED

3. THE MAXIMUM VELOCITY IS USED BECAUSE THE THALWEG MAY MOVE TO ANY PIER IN THE CHANNEL. vELOCITY OBTAINED FROM HEC-2 OUTPUT.

4. DEPTH VARIES AT DIFF. PIERS. MAX VALUE IS OBTAINED FROM HEC-2 OUTPUT TO. ACCOUNT FOR POSSIBLE THALWEG MOVEMENT.

5. THE C.S.U. EQ. ESTIMATES EQUILIBRIUM SCOUR.

51st AVENUE BRIDGE OVER THE SALT RIVER

ABUTMENT SCOUR

SPILLTHROUGH	SEE NOTE	100-YEAR NORTH ABUTMENT	100-YEAR SOUTH ABUTMENT	OVERTOPPING NORTH ABUTMENT	OVERTOPPING SOUTH ABUTMENT
Ya - DEPTH AT ABUT. (FT)		10.66	5.54	13.15	8.40
a'- ABUT. LENGTH NORMAL TO FLOW (FT)		100	250	100	250
(a'/Ya)^0.43		2.62	5.15	2.39	4.38
Ve = Qe/Ae	1	7.65	5.04	8.36	6.11
Fre = Ve/(32.2*Ya)^(1/2) = FROUDE NO.		0.41	0.38	0.41	0.37
Fre^0.61		0.58	0.55	0.58	0.55
(THETA)= ANGLE BTWN. ABUT. AND FLOW	2	90	90	90	90
K2 = ((THETA)/90)^0.13		1	1	1	1
K1	3	0.55	0.55	0.55	0.55
Ys/Ya=2.27K1K2* (a'/Ya)^0.43(Fre^0.61)+1		2.9	4.5	2.7	4.0
Ys SCOUR (FT)		31.0	25.2	35.8	33.5

NOTES:

1. Ve TAKEN FROM HEC-2 VELOCITY IN MAIN CHANNEL.

2. THETA < 90 IF POINTED DOWNSTREAM, > 90 IF POINTED UPSTREAM.
   THETA = 90 FOR NORTH ABUTMENT, 90 FOR SOUTH ABUTMENT.

3. K1 = 0.55 FOR SPILLTHROUGH ABUTMENT.

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1*****************************************
 *  HEC-2 WATER SURFACE PROFILES          *
 *                                        *
 *  Version   4.6.2;  May 1991            *
 *  \                                     *
 *  RUN DATE    12JUL95    TIME   03:02:54 *
 *****************************************
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*************************************
*  U.S. ARMY CORPS OF ENGINEERS     *
*  HYDROLOGIC ENGINEERING CENTER    *
*  609 SECOND STREET, SUITE D       *
*  DAVIS, CALIFORNIA 95616-4687     *
*          (916) 756-1104           *
*************************************
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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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1

12JUL95 03:02:54 PAGE 1

THIS RUN EXECUTED 12JUL95 03:02:54

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

 Version   4.6.2;  May 1991
 ************************************
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51st AVENUE BRIDGE OVER THE SALT RIVER
FILE NAME 51AVE
PARSONS BRINCKERHOFF - TEMPE, ARIZONA
The HEC-2 run for this bridge from the Maricopa County
Flood Control District was utilized using the sections
that pertain to the 51st Avenue bridge. The ground data
at the bridge was changed to correlate with data collected
in the field survey in April 1995.
The 100-yr discharge is 190,000 cfs. The 500-yr flood
overtopped so trial runs of lesser flows were used to
get an approximate discharge of 252000 cfs.
An effective pier width of twice the pier width was used for
all piers to estimate debris accumulation.

T1 MCDOT HYDRAULIC ANALYSIS
T2 100-yr SUB-CRITICAL RUN FOR 51st AVENUE BRIDGE
T3 SALT RIVER

T1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0	2	0	0	0	0	0	0	1007.04	0

T2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	1	0	-1	0	0	0	0	0	0	15

J3 VARIABLE CODES FOR SUMMARY PRINTOUT

	100	105	150	0	0	0	0	0	0	0
NC	.032	.032	.032	0.1	0.3	0	0	0	0	0
QT	2	190000	252000	0	0	0	0	0	0	0
NH	5	0.025	17204.5	0.043	18605.9	0.032	19521.4	0.032	20734.5	0.032
NH	21998	0	0	0	0	0	0	0	0	0

EXIT SECTION - 1672.2' FROM DOWNSTREAM FACE OF BRIDGE

X1	207.16	96	19521.4	20734.5	0	0	0	0	0	0
X3	0	0	0	18570.4	0	20734.5	0	0	0	0
GR	1011.7	16210.1	1011.9	16309.9	1012.7	16344.7	1011.8	16358.1	1013.5	16364.1
GR	1011.6	16438.5	1011.9	16493.9	1010.7	16557.8	1008.3	16585.8	1008.1	16700.8
GR	1008.6	16756.6	1008.6	16852.6	1008.6	16969	1008.4	17076	1008.7	17204.5
GR	1008.1	17321.8	1007.7	17421.3	1007.5	17541.4	1007.7	17638.7	1007.6	17755.6
GR	1007.2	17773.4	1009.2	17787.5	1007.5	17904.3	1006.5	17925	1007.4	18023.9
GR	1008	18085.4	1009.4	18140	1007.7	18201.1	1008.1	18218.4	1005	18321.4
GR	1005.4	18342.3	1003.8	18407.3	1009.9	18456.1	1008.2	18484.8	1005.3	18498.7
GR	1008.7	18523.8	1008.4	18528.7	1007.2	18529.5	1003.7	18545.1	1008.1	18570.4
GR	1007.9	18605.9	1000.3	18638.7	997.6	18663.3	997.7	18680.3	996.2	18717
GR	994.8	18733.2	996.9	18778.6	999.5	18811.7	1002.3	18924.2	1002.4	19046.2

GR	1000.2	19107	1000.7	19209.6	1002.2	19329.8	1003.5	19395.2	1002.1	19404.5
GR	1003.2	19419.4	1003.3	19521.4	1002	19614.6	1001.4	19721.9	999.6	19815.6
GR	996.2	19920.9	994.9	19994.2	992.7	20008.7	992.7	20062.5	994.3	20094.8
GR	993.1	20106.3	993	20160.3	993	20395.5	995	20413	997.1	20418.4
GR	1001.5	20436.9	996.6	20463.3	995.2	20488.6	995.2	20609.4	996	20655.2
GR	995.4	20660.9	996.6	20697	1007.6	20734.5	1008.7	20838.6	1010.1	20985.3
GR	1009.9	21116.5	1009.3	21223.5	1008.4	21316.4	1007.6	21471.6	1007.5	21595.3
GR	1007.5	21624	1009.3	21725.6	1008.9	21731.8	1010.9	21782.9	1010.3	21783
GR	1010	21812.5	1013.5	21872.1	1012.7	21911.2	1006	21930.8	1011.3	21952.5
GR	1010.9	21998								

Eliminate vertical ineffective area in lt. overbank by coding out GR data between and below sta,elev 18033.8,1009.3 and sta,elev 18634.4,1008.2 and between and below sta,elev 18686.7,1008.6 and sta,elev 18936.9,1006.8

END 4:1 EXPANSION FROM 51ST BRIDGE

NH	5	0.025	17640.8	0.043	19008.8	0.032	19428.8	0.032	20597.9	0.032
H	21463									
X1	207.27	73	19428.8	20597.9	575	585	572.72			
X3				18686.7		20662.2				
R	1012.6	16209.3	1013.2	16252.8	1012	16284.2	1012.6	16383.8	1012.9	16415.5
R	1009.2	16480.2	1009.4	16601.8	1009.3	16722.1	1009.1	16901.6	1008.9	17028
GR	1008.9	17034.7	1008.7	17132.7	1008.5	17256.4	1009.7	17345.1	1009	17477.8
R	1008.9	17574.2	1008.9	17623.2	1010.6	17640.8	1009.2	17654.3	1009.2	17776.8
R	1009.9	17890	1009.2	18017.7	1009.3	18033.8	1009.8	18373.9	1009.8	18428.4
GR	1009.9	18529.9	1008.2	18634.4	1008.6	18686.7	1006.8	18936.9	1004.2	18965
GR	1000.1	18981	999.5	18990.9	996.4	19008.8	989.6	19021	988.8	19047.9
R	996.4	19072	995	19107.5	989.3	19123.5	987.6	19162.8	994.7	19190
R	1002.1	19301.3	1005	19428.8	1003.7	19561.5	1002	19676.8	999.3	19820.6
GR	998.8	19940.6	997.8	19971.8	993.8	19986.7	993.3	20109.9	995.5	20119.1
R	998.5	20215.4	998.8	20300.7	1000.2	20305.8	1001.4	20322.6	998.6	20345.1

GR	998.7	20382.4	1000.7	20402.9	1000.4	20414.9	1001.7	20429.2	1000.4	20526.1
GR	1002.6	20597.9	1037.1	20662.2	1034	20670.6	1003.5	20727.4	1006.4	20805.4
GR	1010.3	20813.3	1008.4	20822.2	1009.6	20916.8	1009.2	21025	1010.2	21122.8
GR	1010.9	21233.4	1011	21356.4	1011.1	21463				

Eliminate vertical ineffective area in lt. overbank by coding out GR data
between and below sta,elev 17971.8,1008.9 and sta,elev 19089.4,1009.3

NC				.3	.5					
NH	5	0.025	17693.3	0.043	19196.9	0.032	19214.8	0.032	20847.7	0.032
NH	20997									
X1	207.34	63	19214.8	20847.7	370	530	393.75			
X3				19214.8		20996.7				
GR	1011.8	16035.2	1012.1	16177.7	1013	16280.1	1013.3	16403.9	1012	16481.2
GR	1009.6	16521.9	1009.6	16702.7	1009.5	16804.9	1009.4	16839.4	1010.3	16942.2
GR	1010.3	16976.4	1008.9	17093.8	1008.8	17125.8	1008.6	17242.3	1008.4	17266.9
GR	1008.6	17385.6	1008.6	17409.9	1008.8	17524	1009.1	17624.3	1009.2	17632.4
GR	1011.1	17642.3	1011.4	17673.2	1008.6	17693.3	1009	17801.9	1008.1	17911.5
GR	1007.7	17944	1008.9	17970.8	1010.8	18420.5	1010.2	18468.8	1009.3	18518.8

GR	1009.3	19089.4	1010.6	19158.1	1009.1	19180.5	1003.1	19194.8	1003.1	19196.9
GR	1010.1	19214.8	1005.7	19221.2	1002.1	19228.6	1001.1	19238.7	1002.5	19249
GR	997	19288.5	995.9	19326.4	999.5	19381	1002.2	19392.5	999	19404.7
GR	1000.9	19437.8	1002.4	19593.3	1001.8	19706.7	1000.3	19842	998.7	19946.7
GR	998.9	20191.8	998.8	20302.5	998.4	20382.5	996.5	20416.2	998.7	20521.3
GR	998.6	20631.1	998.2	20696.7	1000.8	20735.2	1007.9	20761.1	1010.6	20824.2
GR	1013.3	20847.7	1014.8	20977	1014.1	20997				

Eliminate vertical ineffective area in lt. overbank by coding out GR data
between and below sta,elev 18156.2,1012 and sta,elev 19012,1011.9

NH	5	0.025	17611.5	0.043	19012	0.032	19250.8	0.032	21053.7	0.032
NH	21985									
X1	207.43	77	19250.8	21053.7	450	575	461.19			
X3				19250.8		21380.1				
GR	1012.1	16001	1012.2	16131.4	1013.1	16228.7	1013.5	16320.3	1012.9	16407.2
GR	1013	16462.7	1009.5	16534.7	1009.9	16622	1010.1	16771.3	1010.1	16811.7
GR	1009.9	16903.6	1009.7	17000.5	1009.5	17064.3	1009.6	17157.6	1009.6	17168
GR	1009.5	17254.7	1009.1	17423.7	1009.1	17535	1010	17611.5	1011.6	17646.2
GR	1009.4	17670.8	1009.7	17760.3	1010.1	17874.6	1011.6	17964.8	1012	17984.9
GR	1016.3	17997.8	1011.1	18045.8	1010.8	18059.4	1019.1	18090.3	1011.8	18104.6
GR	1012.3	18153.8	1012	18156.2	1012.4	18391.4	1016.3	18596.1	1014.9	18654.3
GR	1012	18908.3	1011.9	19012	1014.5	19027.1	1014.7	19083.8	1012.4	19094.4
GR	1018.1	19147.4	1017.8	19153.2	1012.1	19176.4	1010.4	19237.2	1011.8	19250.8
GR	1006	19268.1	1006.3	19370.6	1005	19448.3	1000.2	19562.2	999.2	19660.1
GR	999	19729.8	999.1	19896.9	999.2	20054.8	999.3	20143.1	1000.1	20241.9
GR	1000.3	20361.6	1000.3	20453.3	999.9	20539.4	1001.1	20632.9	1003.1	20689.8
GR	1003	20747.1	999.4	20818	1000.8	20892	1002.3	20911.4	1001.5	20940.1
GR	1009.2	20958.5	1010.9	21053.7	1011.2	21146.5	1013	21244.1	1013.7	21380.1
GR	1010.1	21490.2	1011	21618.6	1013.6	21731	1014.2	21751.5	1011.3	21777.8
GR	1011.5	21912.6	1012.4	21985						

NH	3	0.032	19437	0.032	21080.9	0.032	21790.2
X1	207.47	84	19437	21080.9	250	315	244.54

X3				19335.9		21080.9				
GR	1010	19021.7	1010	19022.9	1011.1	19061	1012.8	19121	1012.8	19122.3
GR	1014.6	19177.8	1014.6	19179.1	1016.1	19232.9	1016.1	19233.6	1017.7	19287.5
GR	1017.6	19290.6	1018.8	19335.9	1018.7	19337.3	1018.2	19396.5	1017.7	19402
GR	1017.5	19434.1	1017.8	19437	1017.6	19440.4	1016.9	19443	1014.3	19450.2
GR	1013.3	19470.0	998.55	19503.0	996.61	19505.0	990.43	19544.0	989.31	19562.3
GR	989.87	19612.3	990.07	19662.3	993.21	19696.3	996.37	19762.3	997.75	19862.3
GR	997.46	19876.3	1000.08	19901.3	1000.71	19962.3	1002.11	20062.3	1003.51	20072.3
GR	1001.1	20162.3	999.87	20202.3	1000.73	20210.3	1000.48	20262.3	1003.22	20362.3
GR	1001.8	20369.3	1004.43	20462.3	1003.53	20562.3	1001.63	20573.3	1000.59	20662.3
GR	998.59	20762.3	998.57	20862.3	999.99	20962.3	1001.58	21033.0	1014.09	21053.0
GR	1018.2	21074.4	1018.5	21075.2	1019.2	21080.9	1019	21083	1019.2	21103.3
GR	1019.8	21110.1	1019	21133.4	1019	21134.2	1018.5	21178	1018.5	21178.3
GR	1017.1	21212.9	1017.1	21213.5	1016	21272.9	1015.9	21274	1015.1	21317.9
GR	1015.1	21318.4	1014.6	21366.5	1014.5	21366.9	1013.8	21410.7	1013.6	21459.5
GR	1013.8	21476.1	1013.8	21497.2	1013.7	21499.9	1013.6	21539.4	1013.6	21549.4
GR	1013.6	21578.3	1013.6	21597.4	1013.6	21609.3	1013.6	21644.1	1013.6	21686
GR	1013.5	21699.9	1013.5	21746.3	1013.4	21764.8	1013.4	21790.2		

1

Downstream face of 51st Avenue bridge

All data used to model this bridge was taken from the As-built plans and the survey notes.

NH	3	0.032	19455	0.032	21059.4	0.032	21875			
		APPROX. ALIGNMENT OF 51ST AVENUE BRIDGE - DOWNSTREAM FACE								
X1	207.48	87	19465.3	21059.4	1	1	1			
X3	10									
BT	-17	19465.3	1020.4	1014.70	19558.3	1023.40	1017.77	19658.3	1025.18	1019.47
BT		19758.3	1026.58	1020.87	19858.3	1027.68	1022.0	19958.3	1028.58	1022.87
BT		20058.3	1029.28	1023.60	20158.3	1029.68	1023.99	20258.3	1029.78	1024.09
BT		20358.3	1029.68	1024	20458.3	1029.28	1023.59	20558.3	1028.68	1023.01
BT		20658.3	1027.88	1022.21	20758.3	1026.68	1021.00	20858.3	1025.41	1019.67
BT		20958.3	1023.68	1017.96	21059.4	1020.6	1014.92			
GR	1008	18935	1012	19105	1016	19235	1020.2	19455	1020.4	19465.2
GR	1014.7	19465.3	1013.26	19470.0	998.55	19503.0	996.61	19505.0	990.43	19544.0
GR	989.31	19558.3	1017.77	19558.3	1017.77	19566.3	989.31	19566.3	989.87	19612.3
GR	990.07	19658.3	1019.47	19658.3	1019.47	19666.3	990.07	19666.3	993.21	19696.3
GR	996.37	19758.3	1020.87	19758.3	1020.87	19766.3	996.37	19766.3	997.75	19858.3
GR	1022.0	19858.3	1022.0	19866.3	997.75	19866.3	997.46	19876.3	1000.08	19901.3
GR	1000.7	19958.3	1022.87	19958.3	1022.87	19966.3	1000.70	19966.3	1002.11	20058.3
GR	1023.6	20058.3	1023.60	20066.3	1002.11	20066.3	1003.51	20072.3	1001.11	20158.3
GR	1024.0	20158.3	1024.00	20166.3	1001.11	20166.3	999.87	20202.3	1000.73	20210.3
GR	1000.5	20258.3	1024.1	20258.3	1024.1	20266.3	1000.48	20266.3	1003.22	20358.3
GR	1024.0	20358.3	1024.0	20366.3	1003.22	20366.3	1001.84	20369.3	1004.43	20458.3
GR	1023.6	20458.3	1023.68	20466.3	1004.43	20466.3	1003.53	20558.3	1023.01	20558.3
GR	1023.0	20566.3	1003.53	20566.3	1001.63	20576.3	1000.59	20658.3	1022.21	20658.3
GR	1022.2	20666.3	1000.59	20666.3	998.59	20758.3	1021.0	20758.3	1021.0	20766.3
GR	998.59	20766.3	998.57	20858.3	1019.7	20858.3	1019.7	20866.3	998.57	20866.3
GR	999.99	20958.3	1018.0	20958.3	1018.0	20966.3	999.99	20966.3	1001.58	21033.0
GR	1014.1	21053.0	1014.7	21059.4	1020.4	21059.5	1020.7	21080	1020	21115
GR	1016	21280	1013.8	21875						

Upstream face of 51st Avenue bridge

```
NH        3     0.032     19455     0.032    21059.4     0.032     21875
                APPROX. ALIGNMENT OF 51ST AVENUE BRIDGE - UPSTREAM FACE
X1   207.49        81   19465.3   21059.4        50        35     50.71
X3       10
BT      -16   19465.3    1020.4    1014.7   19558.3   1023.40   1017.77   19658.3   1025.18   1019.47
BT            19758.3   1026.58   1020.87   19858.3   1027.68    1022.0   19958.3   1028.58   1022.87
BT            20058.3   1029.28   1023.60   20158.3   1029.68   1023.99   20258.3   1029.78   1024.09
BT            20358.3   1029.68      1024   20458.3   1029.28   1023.59   20558.3   1028.68   1023.00
BT            20658.3   1027.88   1022.20   20758.3   1026.68   1021.00   20858.3   1025.41   1019.67
BT            21059.4    1020.6   1014.92
GR    1008      18935      1012     19105      1016     19235    1020.2     19455    1020.4   19465.2
GR  1014.7    19465.3    1013.3   19470.0    998.88   19490.0    998.85   19507.0    993.12   19532.0
GR  987.15    19558.3   1017.77   19558.3   1017.77   19566.3    987.15   19566.3    989.37   19586.0
GR  991.70    19658.3   1019.47   19658.3   1019.47   19666.3    991.70   19666.3    993.42   19675.0
GR  995.78    19758.3   1020.87   19758.3   1020.87   19766.3    995.78   19766.3    997.26   19822.0
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GR  999.43    19830.0    999.98   19858.3    1022.0   19858.3    1022.0   19866.3    999.98   19866.3
GR  1000.5    19958.3   1022.87   19958.3   1022.87   19966.3   1000.50   19966.3   1002.97   20058.3
GR  1023.6    20058.3   1023.59   20066.3   1002.97   20066.3   1002.38   20158.3    1024.0   20158.3
GR  1024.0    20166.3   1002.38   20166.3    1000.4   20258.3    1024.1   20258.3    1024.1   20266.3
GR  1000.4    20266.3   1002.13   20358.3    1024.0   20358.3    1024.0   20366.3   1002.13   20366.3
GR  1004.9    20458.3    1023.6   20458.3   1023.68   20466.3   1004.94   20466.3   1003.54   20558.3
GR  1023.0    20558.3    1023.0   20566.3   1003.54   20566.3    999.76   20610.0   1000.32   20658.3
GR  1022.2    20658.3    1022.2   20666.3   1000.32   20666.3    997.92   20740.0   1000.18   20758.3
GR  1021.0    20758.3    1021.0   20766.3    1000.2   20766.3    998.65   20774.0   1000.17   20858.3
GR  1019.7    20858.3    1019.7   20866.3   1000.17   20866.3    998.28   20943.0    1000.2   21035.0
GR  1013.7    21059.4    1020.4   21059.5    1020.7     21080      1020     21115      1016     21280
GR  1013.8      21875

NH        3     0.032    19438.9     0.032    21078.4     0.032    21996.7
X1   207.50        85    19438.9   21078.4         1         1          1
X3                                 19299.6               21078.4
GR  1010.3    19041.1    1010.3   19041.3    1012.2   19102.8    1012.2     19105   1013.7   19185.1
GR  1016.9    19241.1    1016.8   19244.3      1018   19299.6    1017.1   19306.3   1017.9   19363.8
GR  1017.9    19365.1    1017.6   19403.5    1017.6   19406.2    1017.3   19438.9     1017   19442.1
GR  1015.8    19448.2    1013.3   19470.0    998.88   19490.0    998.85   19507.0    993.12   19532.0
GR  987.15    19562.3    989.37   19586.0    991.70   19662.3    993.42   19675.0    995.78   19762.3
GR  997.26    19822.0    999.43   19830.0    999.98   19862.3    1000.5   19962.3   1002.97   20062.3
GR  1002.3    20162.3   1000.42   20262.3   1002.13   20362.3   1004.94   20462.3   1003.54   20562.3
GR  999.76    20610.0   1000.32   20662.3    997.93   20740.0   1000.18   20762.3    998.65   20774.0
GR  1000.2    20862.3    998.28   20943.0   1001.58   21033.0   1014.09   21053.0    1013.7   21060.0
GR  1017.9    21075.9    1018.4   21077.3    1018.9   21078.4    1019.3   21101.7    1019.6   21110.7
GR  1019.1    21131.7    1018.9   21135.1    1019.1     21139    1018.7   21177.4    1018.4   21183.2
GR  1017.2    21212.3      1017   21222.4      1016   21271.8    1015.9   21280.3    1015.1   21316.6
GR    1015    21327.7    1014.6   21365.8    1014.4   21378.4    1013.8   21409.4    1013.8   21418.9
GR  1013.6    21457.8    1013.9   21474.3    1012.8   21497.3    1012.7   21524.8    1012.7   21554.6
GR  1012.7    21565.9    1012.9   21603.4    1012.9     21609    1013.2     21639    1013.3   21652.7
GR  1013.5    21706.4    1013.5   21706.9    1013.6   21788.7    1013.6   21801.2    1013.8   21857.6
GR  1013.8    21861.9    1014.1   21919.1    1014.1   21949.6    1014.2   21988.1    1014.2   21996.7

NH        5     0.025    17620.2     0.043    19124.1     0.032    19502.9     0.032     21336     0.032
NH    21798
1    207.53        96    19502.9     21336       230       200     228.73
X3                                 19027.1               21336
GR  1011.1    16022.7    1011.7   16143.3    1011.5   16215.8    1014.1   16221.1    1013.9   16232.7
GR  1012.7    16241.1    1013.7   16266.4    1014.9   16266.5    1013.2   16268.8    1014.2   16273.6
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GR	1014.1	16372.5	1014.9	16429	1013.6	16432.3	1013	16526.5	1012.9	16542.7
GR	1012.9	16638.5	1012.6	16738.7	1012.8	16828.5	1014.1	16854.4	1014.1	16891.5
GR	1014.8	16896.5	1011.1	17034.3	1009.6	17122	1009.7	17238.3	1009.9	17332.6
GR	1010.1	17423.9	1010.4	17511.1	1010.7	17604.5	1013.7	17620.2	1010.7	17629.7
GR	1009.3	17643.4	1010	17724	1010.1	17812.5	1010	17954	1010.1	18065.4
GR	1010.1	18155.9	1010.5	18267.1	1010.5	18354.5	1011.5	18454.3	1011.5	18527.2
GR	1010	18611.5	1010	18724.9	1010.5	18789.3	1011.3	18796.9	1007.4	18812.1
GR	1008.9	18898.8	1010	18986.9	1010.7	18999.5	1017.5	19027.1	1011.3	19046.3
GR	1011.5	19124.1	1010.3	19133.7	1008.4	19137.2	1008.1	19148.2	1009.9	19240.4
GR	1010.8	19257.7	1009.2	19302.9	1008.3	19305.5	1008.5	19314.2	1010.3	19319
GR	1007.9	19329.6	1006.6	19386.1	1006.4	19502.9	1004.2	19603.8	1002.8	19684.4
GR	1001.2	19763.2	999.1	19791	1000.3	19817.3	1000.3	19986.4	1000.3	20057
GR	1000.3	20190.1	1001.2	20256.8	999.8	20303.8	999.9	20452.2	1000.2	20549.1
GR	1000.2	20636.9	1000.1	20732.4	1000.7	20823	1001.5	20885.5	1004.8	20917.4

1

GR	1001.4	20933.9	1004	20947	1000.8	20965	1002.6	21002.6	1002.9	21159.7
GR	1009.8	21269.1	1012.1	21336	1015.8	21366.8	1013.2	21376.8	1013.3	21407.7
GR	1014.6	21446.9	1014.3	21511.1	1017.7	21572.1	1014	21609.7	1013.1	21754.4
GR	1013.8	21798								

Eliminate vertical ineffective area in lt. overbank by coding out GR data
between and below sta,elev 18263.6,1011.9 and sta,elev 18647.5,1012.1

NH	5	0.025	17591.1	0.043	19005.5	0.032	19518.1	0.032	21484	0.032
NH	21786									
1	207.62	84	19518.1	21484	460	515	461.71			
3				18991.8		21785.6				
GR	1013	16251.6	1013.5	16315.4	1014.7	16374.7	1015.5	16377.5	1014.6	16395.5
GR	1015.7	16421.5	1014.7	16422	1013.9	16556.1	1014	16632.1	1014	16716.9
GR	1014.3	16809.1	1014.3	16813.5	1014.4	16896.9	1014.4	16907.1	1014.6	16991.8
GR	1013.2	17078.6	1009.6	17168.3	1010.1	17287	1010.3	17414.8	1010.6	17522.4
GR	1013.4	17591.1	1011.4	17609.8	1012.1	17662	1013.9	17679.1	1011.8	17688.4
GR	1010.9	17788.8	1012.4	17868.6	1011.6	17910.4	1008.9	17996.3	1010.7	18009.6
GR	1010.4	18035.1	1011.9	18045.1	1012.6	18138.2	1012.3	18185.4	1014.2	18195
GR	1011.9	18263.6	1012.1	18647.5	1011.6	18732.3	1006.9	18815.2	1011.1	18891.8
GR	1011	18961.7	1015.9	18978.7	1016.8	18991.8	1010.9	19005.5	1011.1	19115.1
GR	1010.9	19173.3	1009.2	19236.3	1010.9	19351.7	1010.7	19441.1	1010.9	19518.1
GR	1005.8	19536.8	1003.6	19551.7	1011.7	19572.3	1007	19592.2	1009.2	19618.9
GR	1005.5	19629.6	1008.7	19641.4	1006.2	19649.6	1010.9	19667.1	1009	19710.7
GR	1007.5	19801.1	1000.9	19885.1	1000.7	20012.8	1000.2	20210.2	1002.1	20295.5
GR	1005.1	20395.7	1005.7	20429.1	1011.5	20464.4	1010.6	20549.3	1007.1	20664.2
GR	1006	20756.4	1004.1	20844.7	1003.4	20964.8	1002.5	21097.7	1001.6	21189.6
GR	1002.2	21272.9	1003.4	21361.2	1003.8	21445.5	1003.9	21449.7	1017.3	21484
GR	1018	21597.8	1017.5	21670.5	1018.4	21682.6	1017.2	21786		

Eliminate vertical ineffective area in lt. overbank by coding out GR data
between and below sta,elev 17556.4,1015 and sta,elev 18768.1,1013.7

NC	0	0	0	0.1	0.3	0	0	0	0	0
NH	5	0.025	17556.4	0.043	18981.8	0.032	19360	0.032	21725.4	0.032
NH	22157									

APPROACH SECTION - 1178.35' FROM UPSTREAM FACE OF BRIDGE

1	207.71	68	19360	21725.4	485	485	487.91			
3				18932.9		21725.4				
GR	1015.3	16626.2	1016.9	16668.1	1017.7	16690.7	1016.4	16699.2	1017.7	16733.9
GR	1016.3	16740.2	1017.3	16747.5	1015.6	16818.1	1015.4	16927.6	1015.3	17021

GR	1014.4	17153.4	1014.4	17242.5	1014.7	17313.4	1012.2	17424.4	1011	17499
GR	1013	17545	1015	17556.4	1013.7	18768.1	1011.6	18795	1011.4	18818.9
GR	1012.5	18826.3	1011	18837.7	1010.8	18904.5	1017.1	18932.9	1016.5	18948.7
GR	1012.7	18965.2	1010.9	18981.8	1010.4	19105.3	1010.5	19195.8	1010.8	19272.7
GR	1012.7	19360	1012.3	19373.3	1010.3	19388.1	1009.8	19485.7	1007.5	19579.6
GR	1005.9	19626	1007	19656.3	1004.1	19724.1	1001.9	19825	1001.1	19865.5
GR	1000.7	20033.4	1000.3	20147.9	1001.7	20249.8	1005	20337.9	1009.8	20425.2
GR	1011	20449	1008.9	20553.3	1006.4	20639.2	1004.5	20687.9	1010.7	20738.5
GR	1011.2	20781.1	1010.6	20925.4	1010.5	21010.9	1007.8	21099.7	1007.3	21189.9
GR	1004.6	21251.6	1006.6	21350.8	1006	21434.6	1002.4	21545.1	1004.3	21640.9
GR	1006	21652.1	1004.2	21660.7	1019.4	21725.4	1016.6	21784.6	1018.1	21889.9
GR	1019.3	21992.7	1018.7	22114.5	1018.7	22157				

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

PROF 1

CHV= .100 CEHV= .300
.490 NH CARD USED
*SECNO 207.160

3470 ENCROACHMENT STATIONS= 18570.4 20734.5 TYPE= 1 TARGET= 2164.100
EXIT SECTION - 1672.2' FROM DOWNSTREAM FACE OF BRIDGE

207.160	14.34	1007.04	.00	1007.04	1008.83	1.79	.00	.00	1003.30
190000.0	47210.7	142789.3	.0	5540.0	12538.1	.0	.0	.0	100000.00
.00	8.52	11.39	.00	.032	.032	.000	.000	992.70	18609.61
.002675	0.	0.	0.	0	0	0	.00	2122.98	20732.59

FLOW DISTRIBUTION FOR SECNO= 207.16 CWSEL= 1007.04

TA=	18610.	18717.	18779.	18924.	19107.	19210.	19395.	19521.	20734.
PER Q=	4.4	4.4	4.5	3.4	3.0	3.6	1.5	75.2	
AREA=	827.0	695.0	983.3	921.2	676.1	945.9	491.4	12538.1	
VEL=	10.0	12.1	8.7	7.1	8.4	7.2	6.0	11.4	
DEPTH=	7.7	11.3	6.8	5.0	6.6	5.1	3.9	10.4	

1490 NH CARD USED
SECNO 207.270

3301 HV CHANGED MORE THAN HVINS

3470 ENCROACHMENT STATIONS= 18686.7 20662.2 TYPE= 1 TARGET= 1975.500

207.270	20.70	1008.30	.00	.00	1010.76	2.46	1.73	.20	1005.00
190000.0	76037.4	113809.9	152.6	5346.1	10006.3	30.3	220.3	26.4	1002.60
.01	14.22	11.37	5.03	.033	.032	.032	.000	987.60	18727.48
.003432	575.	573.	585.	2	0	0	.00	1881.05	20608.54

FLOW DISTRIBUTION FOR SECNO= 207.27 CWSEL= 1008.30

```
STA=   18727.   19021.   19048.   19072.   19108.   19163.   19190.   19301.   19429.   20598.   20609.
  PER Q=      3.5      5.3      3.3      3.5     10.5      4.3      7.3      2.5     59.9       .1
   AREA=    791.5    514.0    378.5    447.5   1038.9    466.6   1102.6    606.5  10006.3     30.3
    VEL=      8.3     19.4     16.5     14.7     19.1     17.7     12.5      7.7     11.4      5.0
  DEPTH=      2.7     19.1     15.7     12.6     18.8     17.2      9.9      4.8      8.6      2.9
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   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST

CHV=     .300 CEHV=     .500
1490 NH CARD USED
*SECNO 207.340

3470 ENCROACHMENT STATIONS=    19214.8   20996.7  TYPE=      1  TARGET=     1781.898
   207.340     14.00   1009.90       .00       .00   1012.10      2.21      1.26       .08   1010.10
  190000.0        .0  190000.0        .0        .0   15943.4        .0     360.4      41.9   1013.30
       .02       .00     11.92       .00      .000      .032      .000      .000    995.90  19215.09
   .003065      370.      394.      530.         2         0         0       .00   1592.76  20807.85

FLOW DISTRIBUTION FOR SECNO=    207.34          CWSEL=   1009.90

STA=   19215.   20824.
  PER Q=    100.0
   AREA=  15943.4
    VEL=     11.9
  DEPTH=     10.0

1490 NH CARD USED
*SECNO 207.430

3301 HV CHANGED MORE THAN HVINS

3470 ENCROACHMENT STATIONS=    19250.8   21380.1  TYPE=      1  TARGET=     2129.299
   207.430     12.85   1011.85       .00       .00   1013.45      1.60      1.17       .18   1011.80
  190000.0        .0  189851.1     148.9        .0   18695.6      85.9     544.4      60.7   1010.90
       .03       .00     10.15      1.73      .000      .032      .032      .000    999.00  19250.80
   .002119      450.      461.      575.         2         0         0       .00   1931.04  21181.84

FLOW DISTRIBUTION FOR SECNO=    207.43          CWSEL=   1011.85

TA=   19251.   21054.   21147.   21182.
  PER Q=     99.9       .1       .0
   AREA=  18695.6     74.4     11.5
    VEL=     10.2      1.8      1.0
  DEPTH=     10.4       .8       .3
```

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

1490 NH CARD USED
*SECNO 207.470

3470 ENCROACHMENT STATIONS= 19335.9 21080.9 TYPE= 1 TARGET= 1745.000

207.470	23.33	1012.64	.00	.00	1013.93	1.29	.39	.09	1017.80
190000.0	.0	190000.0	.0	.0	20841.1	.0	655.7	70.7	100000.00
.04	.00	9.12	.00	.000	.032	.000	.000	989.31	19471.47
.001244	250.	245.	315.	2	0	0	.00	1579.21	21050.68

FLOW DISTRIBUTION FOR SECNO= 207.47 CWSEL= 1012.64

STA= 19471. 21053.
PER Q= 100.0
AREA= 20841.1
VEL= 9.1
DEPTH= 13.2

1490 NH CARD USED
*SECNO 207.480

3265 DIVIDED FLOW

3280 CROSS SECTION 207.48 EXTENDED 4.51 FEET

3370 NORMAL BRIDGE, NRD= 17 MIN ELTRD= 1020.40 MAX ELLC= 1024.09

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1014.70 ELREA= 1014.70

APPROX. ALIGNMENT OF 51ST AVENUE BRIDGE - DOWNSTREAM FACE

207.480	23.20	1012.51	.00	.00	1014.06	1.55	.00	.13	1014.70
190000.0	.0	190000.0	.0	.0	19026.6	.0	656.1	70.7	1014.70
.04	.00	9.99	.00	.000	.031	.000	.000	989.31	19471.67
.002006	1.	1.	1.	2	0	0	.00	1458.79	21050.47

FLOW DISTRIBUTION FOR SECNO= 207.48 CWSEL= 1012.51

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

STA=	19472.	19566.	19666.	19766.	19866.	19966.	20066.	20166.	20266.	20366.	20466.	20566.	20666.
PER Q=	7.3	14.0	10.5	8.0	6.0	4.8	4.2	5.4	4.5	3.7	3.2	5.0	
AREA=	1313.2	2091.5	1725.1	1421.8	1183.8	1022.0	935.8	1101.7	981.1	864.7	785.1	1034.5	
VEL=	10.6	12.8	11.6	10.6	9.6	9.0	8.5	9.4	8.8	8.2	7.8	9.1	

```
  DEPTH=     15.2     22.7     18.8     15.5     12.9     11.1     10.2     12.0     10.7      9.4      8.5     11.2

STA=   20666.   20766.   20866.   20966.   21053.
  PER Q=      6.1      6.8      6.3      4.1
   AREA=   1189.0   1281.9   1217.5    877.8
    VEL=      9.7     10.1      9.8      8.9
  DEPTH=     12.9     13.9     13.2     10.4

3490 NH CARD USED
SECNO 207.490

3265 DIVIDED FLOW

3280 CROSS SECTION    207.49 EXTENDED      4.66 FEET


3370 NORMAL BRIDGE, NRD=  16 MIN ELTRD=  1020.40 MAX ELLC=  1024.09


3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA=      1014.70 ELREA=      1013.70

             APPROX. ALIGNMENT OF 51ST AVENUE BRIDGE - UPSTREAM FACE
   207.490     25.51   1012.66       .00       .00   1014.17      1.51       .10       .01   1014.70
  190000.0        .0  190000.0        .0        .0   19242.0        .0     678.4      72.4   1013.70
       .04       .00      9.87       .00      .000      .031      .000      .000    987.15  19470.89
   .001916       50.       51.       35.         2         0         0       .00   1474.63  21057.52


FLOW DISTRIBUTION FOR SECNO=    207.49          CWSEL=   1012.66

STA=   19471.   19566.   19666.   19766.   19866.   19966.   20066.   20166.   20266.   20366.   20466.   20566.   20666.
  PER Q=      7.5     13.5      9.9      7.4      5.6      4.6      4.0      4.8      4.9      3.5      3.1      5.3
   AREA=   1375.3   2080.1   1679.1   1380.0   1142.5   1004.9    918.5   1036.7   1048.2    841.2    774.5   1090.5
    VEL=     10.4     12.4     11.2     10.3      9.3      8.7      8.3      8.8      8.9      7.9      7.5      9.2
  DEPTH=     15.7     22.6     18.3     15.0     12.4     10.9     10.0     11.3     11.4      9.1      8.4     11.9

STA=   20666.   20766.   20866.   21059.
  PER Q=      6.5      6.2     13.2
   AREA=   1246.8   1218.7   2405.1
    VEL=      9.8      9.7     10.4
  DEPTH=     13.6     13.2     12.6


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


.490 NH CARD USED
SECNO 207.500

3470 ENCROACHMENT STATIONS=    19299.6   21078.4  TYPE=      1  TARGET=     1778.801
   207.500     25.85   1013.00       .00       .00   1014.25      1.25       .00       .08   1017.30
  190000.0        .0  190000.0        .0        .0   21150.1        .0     678.9      72.4 100000.00
       .04       .00      8.98       .00      .000      .032      .000      .000    987.15  19470.41
   .001188        1.        1.        1.         2         0         0       .00   1580.85  21051.26
```

```
FLOW DISTRIBUTION FOR SECNO=    207.50          CWSEL=   1013.00

STA=   19470.   21053.
  PER Q=    100.0
   AREA=  21150.1
    VEL=      9.0
  DEPTH=     13.4

1490 NH CARD USED
*SECNO 207.530

3470 ENCROACHMENT STATIONS=    19027.1   21336.0  TYPE=      1  TARGET=     2308.900
   207.530     14.44   1013.54       .00       .00   1014.59      1.05       .28       .06   1006.40
  190000.0   10894.4  179105.7        .0    2209.8   21398.4        .0     796.4      82.6 100000.00
       .05      4.93      8.37       .00      .032      .032      .000      .000    999.10  19039.35
   .001229      230.      229.      200.         2         0         0       .00   2296.65  21336.00


FLOW DISTRIBUTION FOR SECNO=    207.53          CWSEL=   1013.54

STA=   19039.   19386.   19503.   21336.
  PER Q=      3.1      2.6     94.3
   AREA=   1387.1    822.7  21398.4
    VEL=      4.3      6.0      8.4
  DEPTH=      4.0      7.0     11.7

1490 NH CARD USED
*SECNO 207.620

3470 ENCROACHMENT STATIONS=    18991.8   21785.6  TYPE=      1  TARGET=     2793.799
   207.620     13.90   1014.10       .00       .00   1015.49      1.39       .73       .17   1010.90
  190000.0    8959.9  181040.1        .0    1810.3   18807.4        .0    1030.7     107.9   1017.30
       .06      4.95      9.63       .00      .032      .032      .000      .000   1000.20  18998.04
   .002115      460.      462.      515.         1         0         0       .00   2477.80  21475.84


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


FLOW DISTRIBUTION FOR SECNO=    207.62          CWSEL=   1014.10

STA=   18998.   19352.   19518.   21484.
  PER Q=      3.3      1.4     95.3
   AREA=   1259.1    551.2  18807.4
    VEL=      5.0      4.7      9.6
  DEPTH=      3.6      3.3      9.6

CHV=      .100 CEHV=      .300
1490 NH CARD USED
*SECNO 207.710
```

```
3470 ENCROACHMENT STATIONS=    18932.9   21725.4  TYPE=      1  TARGET=     2792.500
             APPROACH SECTION - 1178.35' FROM UPSTREAM FACE OF BRIDGE
   207.710     15.09   1015.39       .00       .00   1016.44      1.05       .91       .03   1012.70
  190000.0    9198.3  180801.7        .0    1792.6   21700.7        .0    1277.6     137.2 100000.00
       .08      5.13      8.33       .00      .032      .032      .000      .000   1000.30  18953.49
   .001662      485.      488.      485.         2         0         0       .00   2754.87  21708.36


FLOW DISTRIBUTION FOR SECNO=    207.71          CWSEL=   1015.39

STA=   18953.   19196.   19360.   21725.
  PER Q=      3.1      1.8     95.2
   AREA=   1109.3    683.3  21700.7
    VEL=      5.2      4.9      8.3
  DEPTH=      4.6      4.2      9.2
```



```
T1          MCDOT HYDRAULIC ANALYSIS
T2          OVERTOPPING SUB-CRITICAL RUN FOR 51st AVENUE BRIDGE
T3          SALT RIVER

J1  ICHECK    INQ      NINV     IDIR     STRT     METRIC   HVINS    Q        WSEL     FQ

      0        3        0        0    0.0017       0        0        0    1008.50      0

J2  NPROF     IPLOT    PRFVS    XSECV    XSECH    FN       ALLDC    IBW      CHNIM    ITRACE

      2        0       -1        0        0        0        0        0        0        15
```



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


*PROF 2

CHV=     .100 CEHV=     .300
1490 NH CARD USED
 SECNO 207.160

3470 ENCROACHMENT STATIONS=    18570.4   20734.5  TYPE=      1  TARGET=     2164.100
             EXIT SECTION - 1672.2' FROM DOWNSTREAM FACE OF BRIDGE
   207.160     17.54   1010.24       .00   1008.50   1011.87      1.63       .00       .00   1003.30
  252000.0   73773.8  178226.2        .0    8544.2   16415.4        .0        .0        .0 100000.00
       .00      8.63     10.86       .00      .032      .032      .000      .000    992.70  18570.40
   .001706        0.        0.        0.         0         0         3       .00   2164.10  20734.50


LOW DISTRIBUTION FOR SECNO=    207.16          CWSEL=   1010.24
```

```
STA=   18570.   18717.   18779.   18924.   19107.   19210.   19330.   19521.   20735.
  PER Q=      4.6      4.0      5.1      4.7      3.5      3.4      3.9     70.7
   AREA=   1259.9    891.9   1448.8   1505.5   1004.1   1056.2   1377.9  16415.4
    VEL=      9.2     11.4      8.9      7.8      8.8      8.2      7.1     10.9
  DEPTH=      8.6     14.5     10.0      8.2      9.8      8.8      7.2     13.5

1490 NH CARD USED
*SECNO 207.270

3301 HV CHANGED MORE THAN HVINS


3470 ENCROACHMENT STATIONS=    18686.7   20662.2  TYPE=      1  TARGET=     1975.500
   207.270     23.32   1010.92       .00       .00   1013.30      2.39      1.21       .23   1005.00
  252000.0   95079.3  156552.6     368.2    7280.4   13063.1      64.5     298.7      26.9   1002.60
       .01     13.06     11.98      5.71      .033      .032      .032      .000    987.60  18686.70
   .002670      575.      573.      585.         2         0         0       .00   1926.71  20613.41


FLOW DISTRIBUTION FOR SECNO=    207.27          CWSEL=   1010.92

STA=   18687.   19009.   19048.   19108.   19163.   19190.   19301.   19429.   20598.   20613.
  PER Q=      3.3      5.6      6.0      8.6      3.7      7.1      3.4     62.1       .1
   AREA=   1440.9    802.9    981.9   1183.5    537.8   1393.6    939.8  13063.1     64.5
    VEL=      5.7     17.7     15.4     18.4     17.2     12.9      9.1     12.0      5.7
  DEPTH=      4.5     20.5     16.5     21.4     19.8     12.5      7.4     11.2      4.2

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   12JUL95      03:02:54                                                                                    PAGE   15


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


CCHV=     .300 CEHV=     .500
.490 NH CARD USED
SECNO 207.340

'470 ENCROACHMENT STATIONS=    19214.8   20996.7  TYPE=      1  TARGET=     1781.898
   207.340     15.97   1011.87       .00       .00   1014.57      2.70      1.11       .16   1010.10
  252000.0        .0  252000.0        .0        .0   19102.7        .0     475.4      42.8   1013.30
       .02       .00     13.19       .00      .000      .032      .000      .000    995.90  19214.80
   .003024      370.      394.      530.         0         0         0       .00   1620.39  20835.19


'LOW DISTRIBUTION FOR SECNO=    207.34          CWSEL=   1011.87

STA=   19215.   20848.
  PER Q=    100.0
   AREA=  19102.7
    VEL=     13.2
  DEPTH=     11.8

_490 NH CARD USED
*SECNO 207.430
280 CROSS SECTION    207.43 EXTENDED      1.64 FEET
```

3301 HV CHANGED MORE THAN HVINS

3470 ENCROACHMENT STATIONS= 19250.8 21380.1 TYPE= 1 TARGET= 2129.299

207.430	15.04	1014.04	.00	.00	1015.92	1.88	1.11	.25	1011.80
252000.0	.0	250069.0	1931.0	.0	22638.9	560.3	700.0	63.1	1010.90
.03	.00	11.05	3.45	.000	.032	.032	.000	999.00	19250.80
.001946	450.	461.	575.	3	0	0	.00	2129.30	21380.10

FLOW DISTRIBUTION FOR SECNO= 207.43 CWSEL= 1014.04

STA=	19251.	21054.	21147.	21244.	21380.
PER Q=	99.2	.5	.2	.1	
AREA=	22638.9	277.4	189.2	93.7	
VEL=	11.0	4.3	3.2	1.6	
DEPTH=	12.6	3.0	1.9	.7	

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

1490 NH CARD USED
*SECNO 207.470
3280 CROSS SECTION 207.47 EXTENDED 1.27 FEET

3470 ENCROACHMENT STATIONS= 19335.9 21080.9 TYPE= 1 TARGET= 1745.000

207.470	25.36	1014.67	.00	.00	1016.37	1.70	.40	.05	1017.80
252000.0	.0	252000.0	.0	.0	24071.8	.0	833.2	73.8	100000.00
.04	.00	10.47	.00	.000	.032	.000	.000	989.31	19449.17
.001386	250.	245.	315.	2	0	0	.00	1606.86	21056.03

FLOW DISTRIBUTION FOR SECNO= 207.47 CWSEL= 1014.67

STA=	19449.	21074.
PER Q=	100.0	
AREA=	24071.8	
VEL=	10.5	
DEPTH=	15.0	

.490 NH CARD USED
*SECNO 207.480

:265 DIVIDED FLOW

3280 CROSS SECTION 207.48 EXTENDED 6.50 FEET

3370 NORMAL BRIDGE, NRD= 17 MIN ELTRD= 1020.40 MAX ELLC= 1024.09

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1014.70 ELREA= 1014.70

APPROX. ALIGNMENT OF 51ST AVENUE BRIDGE - DOWNSTREAM FACE

207.480	25.19	1014.50	.00	.00	1016.55	2.05	.00	.17	1014.70
252000.0	.0	252000.0	.0	.0	21932.9	.0	833.7	73.9	1014.70
.04	.00	11.49	.00	.000	.031	.000	.000	989.31	19465.95
.002341	1.	1.	1.	2	0	0	.00	1471.31	21057.27

FLOW DISTRIBUTION FOR SECNO= 207.48 CWSEL= 1014.50

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

STA=	19466.	19566.	19666.	19766.	19866.	19966.	20066.	20166.	20266.	20366.	20466.	20566.	20666.
PER Q=	7.0	12.9	10.0	7.8	6.1	5.0	4.5	5.6	4.8	4.1	3.6	5.2	
AREA=	1490.4	2274.3	1907.8	1604.5	1366.5	1204.8	1118.5	1284.5	1163.8	1047.4	967.9	1217.2	
VEL=	11.9	14.3	13.1	12.2	11.2	10.6	10.1	10.9	10.4	9.9	9.4	10.7	
DEPTH=	16.1	24.7	20.7	17.4	14.9	13.1	12.2	14.0	12.7	11.4	10.5	13.2	

STA=	20666.	20766.	20866.	20966.	21059.
PER Q=	6.1	6.8	6.3	4.2	
AREA=	1371.7	1464.6	1400.3	1048.8	
VEL=	11.3	11.7	11.4	10.2	
DEPTH=	14.9	15.9	15.2	11.5	

1490 NH CARD USED
*SECNO 207.490

3265 DIVIDED FLOW

280 CROSS SECTION 207.49 EXTENDED 6.70 FEET

370 NORMAL BRIDGE, NRD= 16 MIN ELTRD= 1020.40 MAX ELLC= 1024.09

3495 OVERBANK AREA ASSUMED NON-EFFECTIVE, ELLEA= 1014.70 ELREA= 1013.70

APPROX. ALIGNMENT OF 51ST AVENUE BRIDGE - UPSTREAM FACE

207.490	27.55	1014.70	.00	.00	1016.68	1.99	.11	.02	1014.70
252000.0	.0	251862.0	138.0	.0	22254.5	108.6	859.5	75.7	1013.70
.04	.00	11.32	1.27	.000	.032	.032	.000	987.15	19465.31
.002197	50.	51.	35.	2	0	0	.00	1724.41	21875.00

FLOW DISTRIBUTION FOR SECNO= 207.49 CWSEL= 1014.70

STA=	19465.	19566.	19666.	19766.	19866.	19966.	20066.	20166.	20266.	20366.	20466.	20566.	20666.
PER Q=	7.2	12.4	9.3	7.3	5.7	4.8	4.3	5.0	5.1	3.8	3.5	5.4	
AREA=	1558.3	2267.6	1866.6	1567.4	1329.9	1192.4	1105.9	1224.1	1235.6	1028.6	961.9	1278.0	
VEL=	11.6	13.8	12.6	11.7	10.8	10.2	9.8	10.3	10.4	9.4	9.1	10.7	

```
 DEPTH=     16.8     24.6     20.3     17.0     14.5     13.0     12.0     13.3     13.4     11.2     10.5     13.9

:TA=   20666.   20766.   20866.   21059.   21875.
 PER Q=      6.4      6.2     13.5       .1
  AREA=   1434.3   1406.2   2797.6    108.5
   VEL=     11.3     11.2     12.2      1.3
 DEPTH=     15.6     15.3     14.5       .1
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   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS     L-BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA       R-BANK ELEV
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN     SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST


1490 NH CARD USED
 SECNO 207.500
280 CROSS SECTION    207.50 EXTENDED       .97 FEET


470 ENCROACHMENT STATIONS=    19299.6   21078.4  TYPE=      1  TARGET=     1778.801
  207.500     28.01   1015.16       .00       .00   1016.79      1.63       .00       .11   1017.30
 252000.0        .0  252000.0        .0        .0   24608.2        .0     860.0      75.7 100000.00
      .04       .00     10.24       .00      .000      .032      .000      .000    987.15  19453.71
 .001295        1.        1.        1.         2         0         0       .00   1611.85  21065.56


'LOW DISTRIBUTION FOR SECNO=    207.50          CWSEL=   1015.16

:TA=   19454.   21076.
 PER Q=    100.0
  AREA=  24608.2
   VEL=     10.2
 DEPTH=     15.3

1490 NH CARD USED
 SECNO 207.530
 280 CROSS SECTION    207.53 EXTENDED      2.21 FEET


470 ENCROACHMENT STATIONS=    19027.1   21336.0  TYPE=      1  TARGET=     2308.900
  207.530     16.90   1016.00       .00       .00   1017.20      1.19       .27       .13   1006.40
 252000.0   19503.6  232496.5        .0    3360.2   25910.2        .0    1001.5      86.0 100000.00
      .05      5.80      8.97       .00      .033      .032      .000      .000    999.10  19031.73
 .001097      230.      229.      200.         2         0         0       .00   2304.27  21336.00


LOW DISTRIBUTION FOR SECNO=    207.53          CWSEL=   1016.00

'TA=   19032.   19306.   19503.   21336.
 PER Q=      3.0      4.7     92.3
  AREA=   1584.2   1776.0  25910.2
   VEL=      4.8      6.7      9.0
 DEPTH=      5.8      9.0     14.1
```

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

1490 NH CARD USED
*SECNO 207.620

3470 ENCROACHMENT STATIONS= 18991.8 21785.6 TYPE= 1 TARGET= 2793.799

207.620	16.29	1016.49	.00	.00	1017.95	1.46	.62	.13	1010.90
252000.0	18881.6	233118.4	.0	3051.9	23463.9	.0	1297.0	111.4	1017.30
.06	6.19	9.94	.00	.032	.032	.000	.000	1000.20	18992.53
.001685	460.	462.	515.	2	0	0	.00	2489.39	21481.92

FLOW DISTRIBUTION FOR SECNO= 207.62 CWSEL= 1016.49

STA=	18993.	19236.	19441.	19518.	21484.
PER Q=	3.3	3.2	1.1	92.5	
AREA=	1362.6	1251.3	437.9	23463.9	
VEL=	6.0	6.4	6.1	9.9	
DEPTH=	5.6	6.1	5.7	11.9	

CHV= .100 CEHV= .300
1490 NH CARD USED
*SECNO 207.710

3470 ENCROACHMENT STATIONS= 18932.9 21725.4 TYPE= 1 TARGET= 2792.500
APPROACH SECTION - 1178.35' FROM UPSTREAM FACE OF BRIDGE

207.710	17.27	1017.57	.00	.00	1018.73	1.16	.75	.03	1012.70
252000.0	16309.5	235690.5	.0	2697.2	26821.0	.0	1610.6	140.9	100000.00
.08	6.05	8.79	.00	.032	.032	.000	.000	1000.30	18932.90
.001402	485.	488.	485.	2	0	0	.00	2784.72	21717.62

FLOW DISTRIBUTION FOR SECNO= 207.71 CWSEL= 1017.57

STA=	18933.	19196.	19360.	21725.
PER Q=	4.0	2.5	93.5	
AREA=	1656.6	1040.6	26821.0	
VEL=	6.1	6.0	8.8	
DEPTH=	6.3	6.3	11.4	

THIS RUN EXECUTED 12JUL95 03:02:57

****
HEC-2 WATER SURFACE PROFILES

Version 4.6.2; May 1991
****

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

SALT RIVER

SUMMARY PRINTOUT TABLE 100

SECNO	EGLWC	ELLC	EGPRS	ELTRD	QPR	QWEIR	CLASS	H3	DEPTH	CWSEL	VCH	EG

1

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SALT RIVER

SUMMARY PRINTOUT TABLE 105

SECNO	CWSEL	HL	OLOSS	TOPWID	QLOB	QCH	QROB

1

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SALT RIVER

SUMMARY PRINTOUT TABLE 150

SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10*KS	VCH	AREA	.01K
207.160	.00	.00	.00	992.70	190000.00	1007.04	.00	1008.83	26.75	11.39	18078.10	36732.90
207.160	.00	.00	.00	992.70	252000.00	1010.24	.00	1011.87	17.06	10.86	24959.63	61004.13
207.270	572.72	.00	.00	987.60	190000.00	1008.30	.00	1010.76	34.32	11.37	15382.73	32433.12
207.270	572.72	.00	.00	987.60	252000.00	1010.92	.00	1013.30	26.70	11.98	20408.00	48765.40
207.340	393.75	.00	.00	995.90	190000.00	1009.90	.00	1012.10	30.65	11.92	15943.43	34321.96
207.340	393.75	.00	.00	995.90	252000.00	1011.87	.00	1014.57	30.24	13.19	19102.71	45827.41
207.430	461.19	.00	.00	999.00	190000.00	1011.85	.00	1013.45	21.19	10.15	18781.52	41275.89
207.430	461.19	.00	.00	999.00	252000.00	1014.04	.00	1015.92	19.46	11.05	23199.20	57131.45
207.470	244.54	.00	.00	989.31	190000.00	1012.64	.00	1013.93	12.44	9.12	20841.07	53858.86
207.470	244.54	.00	.00	989.31	252000.00	1014.67	.00	1016.37	13.86	10.47	24071.76	67677.95
207.480	1.00	1020.40	1024.09	989.31	190000.00	1012.51	.00	1014.06	20.06	9.99	19026.55	42426.41
207.480	1.00	1020.40	1024.09	989.31	252000.00	1014.50	.00	1016.55	23.41	11.49	21932.93	52087.64
207.490	50.71	1020.40	1024.09	987.15	190000.00	1012.66	.00	1014.17	19.16	9.87	19242.02	43405.88
207.490	50.71	1020.40	1024.09	987.15	252000.00	1014.70	.00	1016.68	21.97	11.32	22363.10	53768.91
207.500	1.00	.00	.00	987.15	190000.00	1013.00	.00	1014.25	11.88	8.98	21150.11	55117.62
207.500	1.00	.00	.00	987.15	252000.00	1015.16	.00	1016.79	12.95	10.24	24608.23	70014.77
207.530	228.73	.00	.00	999.10	190000.00	1013.54	.00	1014.59	12.29	8.37	23608.26	54190.38
207.530	228.73	.00	.00	999.10	252000.00	1016.00	.00	1017.20	10.97	8.97	29270.39	76095.63
207.620	461.71	.00	.00	1000.20	190000.00	1014.10	.00	1015.49	21.15	9.63	20617.73	41312.88

207.620	461.71	.00	.00	1000.20	252000.00	1016.49	.00	1017.95	16.85	9.94	26515.82	61389.32
207.710	487.91	.00	.00	1000.30	190000.00	1015.39	.00	1016.44	16.62	8.33	23493.30	46599.58
207.710	487.91	.00	.00	1000.30	252000.00	1017.57	.00	1018.73	14.02	8.79	29518.19	67306.77

SALT RIVER

SUMMARY PRINTOUT TABLE 150

SECNO	Q	CWSEL	DIFWSP	DIFWSX	DIFKWS	TOPWID	XLCH
207.160	190000.00	1007.04	.00	.00	.00	2122.98	.00
207.160	252000.00	1010.24	3.20	.00	1.74	2164.10	.00
207.270	190000.00	1008.30	.00	1.26	.00	1881.05	572.72
207.270	252000.00	1010.92	2.62	.68	.00	1926.71	572.72
207.340	190000.00	1009.90	.00	1.59	.00	1592.76	393.75
207.340	252000.00	1011.87	1.97	.95	.00	1620.39	393.75
207.430	190000.00	1011.85	.00	1.95	.00	1931.04	461.19
207.430	252000.00	1014.04	2.19	2.17	.00	2129.30	461.19
207.470	190000.00	1012.64	.00	.79	.00	1579.21	244.54
207.470	252000.00	1014.67	2.03	.63	.00	1606.86	244.54
207.480	190000.00	1012.51	.00	-.13	.00	1458.79	1.00
207.480	252000.00	1014.50	1.99	-.17	.00	1471.31	1.00
207.490	190000.00	1012.66	.00	.14	.00	1474.63	50.71
207.490	252000.00	1014.70	2.04	.20	.00	1724.41	50.71
207.500	190000.00	1013.00	.00	.34	.00	1580.85	1.00
207.500	252000.00	1015.16	2.17	.47	.00	1611.85	1.00
207.530	190000.00	1013.54	.00	.54	.00	2296.65	228.73
207.530	252000.00	1016.00	2.46	.84	.00	2304.27	228.73
207.620	190000.00	1014.10	.00	.56	.00	2477.80	461.71
207.620	252000.00	1016.49	2.38	.49	.00	2489.39	461.71
207.710	190000.00	1015.39	.00	1.29	.00	2754.87	487.91
207.710	252000.00	1017.57	2.18	1.08	.00	2784.72	487.91

SUMMARY OF ERRORS AND SPECIAL NOTES

```
 Z
Bad command or file name

  \HYDRO\HEC-2>HEC2
ENTER THE FILENAME FOR INPUT [CON]
 .ST
 ITER THE FILENAME FOR OUTPUT [CON]
51ST.OUT
ENTER THE FILENAME FOR TAPE95 [TAPE95]


    SALT RIVER

 Starting profile number  1

      CWSEL for cross section    207.160 is  1007.04
      CWSEL for cross section    207.270 is  1008.30
      CWSEL for cross section    207.340 is  1009.90
      CWSEL for cross section    207.430 is  1011.85
      CWSEL for cross section    207.470 is  1012.64
      CWSEL for cross section    207.480 is  1012.51
      CWSEL for cross section    207.490 is  1012.66
      CWSEL for cross section    207.500 is  1013.00
      CWSEL for cross section    207.530 is  1013.54
      CWSEL for cross section    207.620 is  1014.10
      CWSEL for cross section    207.710 is  1015.39

    SALT RIVER

 Starting profile number  2

      CWSEL for cross section    207.160 is  1010.24
      CWSEL for cross section    207.270 is  1010.92
      CWSEL for cross section    207.340 is  1011.87
      CWSEL for cross section    207.430 is  1014.04
      CWSEL for cross section    207.470 is  1014.67
      CWSEL for cross section    207.480 is  1014.50
      CWSEL for cross section    207.490 is  1014.70
      CWSEL for cross section    207.500 is  1015.16
      CWSEL for cross section    207.530 is  1016.00
      CWSEL for cross section    207.620 is  1016.49
      CWSEL for cross section    207.710 is  1017.57

 rmal program termination


 \HYDRO\HEC-2>EXIT
```

HEC-RAS WAS USED ONLY FOR FLOW DISTRIBUTION – USING MCDOT PROVIDED HEC-2 RUN

Plan: Imported Pla Reach: 1 Riv Sta: 207.53 Profile: 1 2/10/97 Q100

W.S. Elev (ft)	1013.54	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.05	Wt. n-Val.	0.032	0.032	
E.G. Elev (ft)	1014.59	Reach Len. (ft)	230.00	228.73	200.00
E.G. Slope (ft/ft)	0.001236	Flow Area (sq ft)	2209.11	21395.52	
Q Total (cfs)	190000.00	Flow (cfs)	10502.76	179497.20	
Top Width (ft)	2417.24	Top Width (ft)	584.14	1833.10	
Vel Total (ft/s)	8.05	Avg. Vel. (ft/s)	4.75	8.39	
Max Chl Dpth (ft)	14.44	Hydr. Depth (ft)	3.78	11.67	
Crit W.S. (ft)		Wetted Per. (ft)	3349.09	1836.09	
Conv. Total (cfs)	5405257.0	Conv. (cfs)	298790.0	5106467.0	

SEC 207.53 IS 230' U.S OF BRIDGE

THE ROADWAY PROFILE WAS CONSTRUCTED WITH OVER FLOW SECTION AT BOTH ROADWAY APPROACHES, THE SOUTH OVERFLOW SECTION IS LOWER & LONGER (~ELEV. 1011 ±)

MOST LIKELY OVERFLOW OCCURS AT A FLOW BETWEEN Q50 & Q100 NOT 252,000 cfs

ALSO Q'S NEED TO BE ASSESSED W/ NEW ROOSEVELT

EXIST FEMA RUN W/ ENCROACHMENTS IS CONSERVATIVE FOR ABOUT SCOUR / HYDRAULICS, IF BRIDGE IS SCOUR CRITICAL HYDRAULICS SHOULD BE REVISED FOR MITIGATION DESIGN

ABUTMENT SCOUR
DATA Q100

Plan: Imported Pla Reach: 1 Riv Sta: 207.53 Profile: 1 2/10/97

Left Sta (ft)	Right Sta (ft)	%Q	Area (sq ft)	W.P. (ft)	Conv. (cfs)	Hydr D. (ft)	Velocity (ft/s)
18804.86	19154.88	0.30	308.64	116.44	16427.6	2.67	1.87
19154.88	19502.90	5.04	1900.46	348.85	273223.3	5.46	5.04
19502.90	19576.22	1.93	582.32	73.34	107616.9	7.94	6.30
19576.22	19649.55	2.59	694.91	73.34	144490.3	9.48	7.09
19649.55	19722.87	3.23	792.15	73.34	179740.0	10.80	7.74
19722.87	19796.20	4.20	927.97	73.42	233815.1	12.66	8.60
19796.20	19869.52	4.61	981.12	73.34	256727.3	13.38	8.93
19869.52	19942.84	4.53	970.99	73.32	252368.7	13.24	8.87
19942.84	20016.17	4.53	970.99	73.32	252368.7	13.24	8.87
20016.17	20089.49	4.53	970.99	73.32	252368.7	13.24	8.87
20089.49	20162.82	4.53	970.99	73.32	252368.7	13.24	8.87
20162.82	20236.14	4.42	956.68	73.33	246194.4	13.05	8.78
20236.14	20309.46	4.36	948.69	73.35	242735.0	12.94	8.73
20309.46	20382.79	4.80	1005.56	73.32	267520.8	13.71	9.08
20382.79	20456.11	4.77	1001.89	73.32	265900.8	13.66	9.05
20456.11	20529.44	4.69	991.10	73.32	261142.1	13.52	8.99
20529.44	20602.76	4.59	978.92	73.32	255812.5	13.35	8.92
20602.76	20676.08	4.59	979.12	73.32	255902.1	13.35	8.92
20676.08	20749.41	4.63	983.03	73.32	257607.3	13.41	8.94
20749.41	20822.73	4.44	959.59	73.33	247446.7	13.09	8.80
20822.73	20896.06	4.01	902.45	73.39	223257.8	12.31	8.44
20896.06	20969.38	3.12	780.41	74.33	173761.2	10.64	7.60
20969.38	21042.70	3.47	827.20	73.36	193146.3	11.28	7.97
21042.70	21116.03	3.22	791.59	73.32	179548.5	10.80	7.74
21116.03	21189.35	2.97	754.44	73.38	165634.4	10.29	7.49
21189.35	21262.68	1.37	473.66	73.47	76188.1	6.46	5.49
21262.68	21336.00	0.32	198.77	74.82	17705.1	2.71	3.04

72.8%

13.6%
50.7%

GOES to South OVERFLOW SEC

19253 obstructed by South Abut FROM FIELD Obs

19503

South Abut.

$a_1 \sim 250'$

$A_R = 1384 ft^2$

$Q_R = 3.67\%$

$= 6973$ cfs

$V_R = 5.04$ fps

$Y_R = 5.54$

BRIDGE

21053 obstructed by North Abut FROM FIELD Obs

21153

GOES TO South OVERFLOW SEC.

NORTH ABUT

$a_1 \sim 100'$ $Q_R = 4.29\%$

$A_R = 1066 ft^2$ $= 8151$ cfs

$V_R = 7.65$ fps

$Y_R = 10.66$ ft

Plan: Imported Pla Reach: 1 Riv Sta: 207.53 Profile: 2 2/10/97 Q0T

W.S. Elev (ft)	1016.02	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.19	Wt. n-Val.	0.033	0.032	
E.G. Elev (ft)	1017.21	Reach Len. (ft)	230.00	228.73	200.00
E.G. Slope (ft/ft)	0.001097	Flow Area (sq ft)	3365.33	25930.38	
Q Total (cfs)	252000.00	Flow (cfs)	19180.31	232819.70	
Top Width (ft)	2424.90	Top Width (ft)	591.80	1833.10	
Vel Total (ft/s)	8.60	Avg. Vel. (ft/s)	5.70	8.98	
Max Chl Dpth (ft)	16.92	Hydr. Depth (ft)	5.69	14.15	
Crit W.S. (ft)		Wetted Per. (ft)	3357.14	1838.56	
Conv. Total (cfs)	7607727.0	Conv. (cfs)	579042.0	7028685.0	

ABUTMENT SCOUR
DATA Q_{OT}

GOES TO
South OVER FLOW SEC

Plan: Imported Pla Reach: 1 Riv Sta: 207.53 Profile: 2 2/10/97

Left Sta (ft)	Right Sta (ft)	%Q	Area (sq ft)	W.P. (ft)	Conv. (cfs)	Hydr D. (ft)	Velocity (ft/s)
18806.86	19154.88	0.46	603.91	124.49	34747.3	4.90	1.90
19154.88	19502.90	6.69	2761.42	348.85	509299.1	7.93	6.10
19502.90	19576.22	2.18	763.71	73.34	169107.8	10.42	7.18
19576.22	19649.55	2.74	876.30	73.34	212675.4	11.95	7.87
19649.55	19722.87	3.26	973.55	73.34	253449.6	13.28	8.44
19722.87	19796.20	4.05	1109.37	73.42	314852.0	15.13	9.21
19796.20	19869.52	4.38	1162.51	73.34	340614.4	15.85	9.50
19869.52	19942.84	4.32	1152.38	73.32	335743.3	15.72	9.45
19942.84	20016.17	4.32	1152.38	73.32	335743.3	15.72	9.45
20016.17	20089.49	4.32	1152.38	73.32	335743.3	15.72	9.45
20089.49	20162.82	4.32	1152.38	73.32	335743.3	15.72	9.45
20162.82	20236.14	4.23	1138.08	73.33	328814.8	15.52	9.37
20236.14	20309.46	4.18	1130.09	73.35	324920.4	15.41	9.33
20309.46	20382.79	4.54	1186.95	73.32	352697.0	16.19	9.64
20382.79	20456.11	4.52	1183.28	73.32	350885.9	16.14	9.62
20456.11	20529.44	4.45	1172.50	73.32	345567.2	15.99	9.56
20529.44	20602.76	4.37	1160.31	73.32	339602.0	15.82	9.49
20602.76	20676.08	4.37	1160.52	73.32	339702.3	15.83	9.49
20676.08	20749.41	4.40	1164.43	73.32	341611.5	15.88	9.52
20749.41	20822.73	4.25	1140.98	73.33	330221.8	15.56	9.39
20822.73	20896.06	3.90	1083.84	73.39	302956.7	14.78	9.07
20896.06	20969.38	3.17	961.81	74.33	246164.8	13.12	8.30
20969.38	21042.70	3.46	1008.59	73.36	268778.0	13.76	8.64
21042.70	21116.03	3.26	972.99	73.32	253235.5	13.27	8.44
21116.03	21189.35	3.05	935.83	73.38	237196.9	12.76	8.22
21189.35	21262.68	1.68	655.06	73.47	130789.1	8.93	6.48
21262.68	21336.00	0.66	380.17	77.29	51055.8	5.18	4.36

72.8%

13.6% ↑
50.7%

19253 South Abut obstruction
19503

South Abut
$a' \sim 250'$
$Q_e = 4.87\%$
$= 12272$ cfs
$A_e = 2010 ft^2$
$V_e = 6.11$ fps
$Y_e = 8.04$ ft

BRIDGE

21053 North Abut obstruction
21153
GOES TO
NORTH OVER FLOW SEC

$a' = 100'$
North Abut
$Q_e = 4.36\% = 10987$ cfs
$A_e = 1315 ft^2$ $V_e = 8.36$ fps
$Y_e = 13.15$ ft

— Used for Contraction and Pier Scour —

HEC-RAS Version 1.2 April 1996
U.S. Army Corp of Engineers
Hydrologic Engineering Center
609 Second Street, Suite D
Davis, California 95616-4687
(916) 756-1104

```
X   X XXXXXX  XXXX    XXXX    XX   XXXX
X   X X    X  X   X X   X X  X
X   X X    X      X X  X  X X
XXXXXXX XXXX   X   XXX XXXX  XXXXXX  XXXX
X   X X    X      X X  X  X    X
X   X X    X  X   X X  X  X    X
X   X XXXXXX  XXXX    X  X X  X XXXXX
```

****

PROJECT DATA
Project Title: 51St Ave. @ salt R.A2
Project File : 51st2a2.prj
Run Date and Time: 2/11/97 9:43:00 AM

Project in English units

****

PLAN DATA

Plan Title: Imported Plan 01
Plan File : c:\hec\ras\51st2a2.p01

Geometry Title: Imported Plan 01
Geometry File : c:\hec\ras\51st2a2.p01

Flow Title : Imported Plan 01
Flow File : c:\hec\ras\51st2a2.p01

Plan Summary Information:
Number of: Cross Sections = 11 Mulitple Openings = 0
Culverts = 0 Inline Weirs = 0
Bridges = 1

Computational Information
Water surface calculation tolerance = .01
Critical depth calculaton tolerance = .01
Maximum number of interations = 20
Maximum difference tolerance = .3
Flow tolerance factor = .001

Computational Flow Regime: Subcritical Flow

Encroachment Data: None

Flow Distribution Locations

Reach	RS Start	RS End	LOB	Channel	ROB
1	207.71	207.16	10	25	1

****

FLOW DATA

Flow Title: Imported Flow 01
Flow File : c:\hec\ras\51st2a2.f01

Flow Data (cfs)

Reach	Riv Sta	PF#1	PF#2
1	207.71	190000	252000

Boundary Conditions

Reach	Profile	Upstream	Downstream
1	1	Normal S = .0017	Known WS = 1007.04
1	2	Normal S = .0017	Normal S = .0017

****

GEOMETRY DATA

Geometry Title: Imported Geom 01
Geometry File : c:\hec\ras\51st2a2.g01

CROSS SECTION INPUT Reach: 1 River Station: 207.71
Description: 207.71

Station Elevation Data, num = 68

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
16626.2	1015.3	16668.1	1016.9	16690.7	1017.7	16699.2	1016.4	16733.9	1017.7
16740.2	1016.3	16747.5	1017.3	16818.1	1015.6	16927.6	1015.4	17021	1015.3
17153.4	1014.4	17242.5	1014.4	17313.4	1014.7	17424.4	1012.2	17499	1011
17545	1013	17556.4	1015	18768.1	1013.7	18795	1011.6	18818.9	1011.4
18826.3	1012.5	18837.7	1011	18904.5	1010.8	18932.9	1017.1	18948.7	1016.5
18965.2	1012.7	18981.8	1010.9	19105.3	1010.4	19195.8	1010.5	19272.7	1010.8
19360	1012.7	19373.3	1012.3	19388.1	1010.3	19485.7	1009.8	19579.6	1007.5
19626	1005.9	19656.3	1007	19724.1	1004.1	19825	1001.9	19865.5	1001.1
20033.4	1000.7	20147.9	1000.3	20249.8	1001.7	20337.9	1005	20425.2	1009.8
20449	1011	20553.3	1008.9	20639.2	1006.4	20687.9	1004.5	20738.5	1010.7
20781.1	1011.2	20925.4	1010.6	21010.9	1010.5	21099.7	1007.8	21189.9	1007.3
21251.6	1004.6	21350.8	1006.6	21434.6	1006	21545.1	1002.4	21640.9	1004.3
21652.1	1006	21660.7	1004.2	21725.4	1019.4	21784.6	1016.6	21889.9	1018.1
21992.7	1019.3	22114.5	1018.7	22157	1018.7				

Manning's n Values, num = 5

Sta.	Value	Sta.	Value	Sta.	Value	Sta.	Value	Sta.	Value
16626.2	.025	17556.4	.043	18981.8	.032	19360	.032	21725.4	.032

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
19360 21725.4 485 487.91 485 .1 .3

CROSS SECTION INPUT Reach: 1 River Station: 207.62
Description: 207.62

Station Elevation Data, num = 84

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
16251.6	1013	16315.4	1013.5	16374.7	1014.7	16377.5	1015.5	16395.5	1014.6
16421.5	1015.7	16422	1014.7	16556.1	1013.9	16632.1	1014	16716.9	1014
16809.1	1014.3	16813.5	1014.3	16896.9	1014.4	16907.1	1014.4	16991.8	1014.6
17078.6	1013.2	17168.3	1009.6	17287	1010.1	17414.8	1010.3	17522.4	1010.6
17591.1	1013.4	17609.8	1011.4	17662	1012.1	17679.1	1013.9	17688.4	1011.8
17788.8	1010.9	17868.6	1012.4	17910.4	1011.6	17996.3	1008.9	18009.6	1010.7
18035.1	1010.4	18045.1	1011.9	18138.2	1012.6	18185.4	1012.3	18195	1014.2
18263.6	1011.9	18647.5	1012.1	18732.3	1011.6	18815.2	1006.9	18891.8	1011.1
18961.7	1011	18978.7	1015.9	18991.8	1016.8	19005.5	1010.9	19115.1	1011.1
19173.3	1010.9	19236.3	1009.2	19351.7	1010.9	19441.1	1010.7	19518.1	1010.9
19536.8	1005.8	19551.7	1003.6	19572.3	1011.7	19592.2	1007	19618.9	1009.2
19629.6	1005.5	19641.4	1008.7	19649.6	1006.2	19667.1	1010.9	19710.7	1009
19801.1	1007.5	19885.1	1000.9	20012.8	1000.7	20210.2	1000.2	20295.5	1002.1
20395.7	1005.1	20429.1	1005.7	20464.4	1011.5	20549.3	1010.6	20664.2	1007.1
20756.4	1006	20844.7	1004.1	20964.8	1003.4	21097.7	1002.5	21189.6	1001.6
21272.9	1002.2	21361.2	1003.4	21445.5	1003.8	21449.7	1003.9	21484	1017.3
21597.8	1018	21670.5	1017.5	21682.6	1018.4	21786	1017.2		

Manning's n Values, num = 5

Sta.	Value	Sta.	Value	Sta.	Value	Sta.	Value	Sta.	Value
16251.6	.025	17591.1	.043	19005.5	.032	19518.1	.032	21484	.032

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
19518.1 21484 460 461.71 515 .3 .5
Blocked Obstructions, num = 2

Sta L	Sta R	Elev	Sta L	Sta R	Elev
16251.6	18991.8	1018.4	21785.6	21786	1018.4

CROSS SECTION INPUT Reach: 1 River Station: 207.53
Description: 207.53

Station Elevation Data, num = 96

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
16022.7	1011.1	16143.3	1011.7	16215.8	1011.5	16221.1	1014.1	16232.7	1013.9
16241.1	1012.7	16266.4	1013.7	16266.5	1014.9	16268.8	1013.2	16273.6	1014.2
16372.5	1014.1	16429	1014.9	16432.3	1013.6	16526.5	1013	16542.7	1012.9
16638.5	1012.9	16738.7	1012.6	16828.5	1012.8	16854.4	1014.1	16891.5	1014.1
16896.5	1014.8	17034.3	1011.1	17122	1009.6	17238.3	1009.7	17332.6	1009.9
17423.9	1010.1	17511.1	1010.4	17604.5	1010.7	17620.2	1013.7	17629.7	1010.7
17643.4	1009.3	17724	1010	17812.5	1010.1	17954	1010	18065.4	1010.1
18155.9	1010.1	18267.1	1010.5	18354.5	1010.5	18454.3	1011.5	18527.2	1011.5
18611.5	1010	18724.9	1010	18789.3	1010.5	18796.9	1011.3	18812.1	1007.4
18898.8	1008.9	18986.9	1010	18999.5	1010.7	19027.1	1017.5	19046.3	1011.3
19124.1	1011.5	19133.7	1010.3	19137.2	1008.4	19148.2	1008.1	19240.4	1009.9
19257.7	1010.8	19302.9	1009.2	19305.5	1008.3	19314.2	1008.5	19319	1010.3
19329.6	1007.9	19386.1	1006.6	19502.9	1006.4	19603.8	1004.2	19684.4	1002.8
19763.2	1001.2	19791	999.1	19817.3	1000.3	19986.4	1000.3	20057	1000.3

20190.1 1000.3 20256.8 1001.2 20303.8 999.8 20452.2 999.9 20549.1 1000.2
20636.9 1000.2 20732.4 1000.1 20823 1000.7 20885.5 1001.5 20917.4 1004.8
20933.9 1001.4 20947 1004 20965 1000.8 21002.6 1002.6 21159.7 1002.9
21269.1 1009.8 21336 1012.1 21366.8 1015.8 21376.8 1013.2 21407.7 1013.3
21446.9 1014.6 21511.1 1014.3 21572.1 1017.7 21609.7 1014 21754.4 1013.1
21798 1013.8

Manning's n Values, num = 5
Sta. Value Sta. Value Sta. Value Sta. Value Sta. Value
16022.7 .025 17620.2 .043 19124.1 .032 19502.9 .032 21336 .032

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
19502.9 21336 230 228.73 200 .3 .5
Blocked Obstructions, num = 2
Sta L Sta R Elev Sta L Sta R Elev
****
16022.7 19027.1 1017.7 21336 21798 1017.7

CROSS SECTION INPUT Reach: 1 River Station: 207.5
Description: 207.5

Station Elevation Data, num = 85
Sta. Elev. Sta. Elev. Sta. Elev. Sta. Elev. Sta. Elev.
19041.1 1010.3 19041.3 1010.3 19102.8 1012.2 19105 1012.2 19185.1 1013.7
19241.1 1016.9 19244.3 1016.8 19299.6 1018 19306.3 1017.1 19363.8 1017.9
19365.1 1017.9 19403.5 1017.6 19406.2 1017.6 19438.9 1017.3 19442.1 1017
19448.2 1015.8 19470 1013.3 19490 999 19507 999 19532 999
19562.3 999 19586 999 19662.3 999 19675 999 19762.3 999
19822 999 19830 999.43 19862.3 999.98 19962.3 1000.5 20062.3 1002.97
20162.3 1002.3 20262.3 1000.42 20362.3 1002.13 20462.3 1004.94 20562.3 1003.54
20610 999.76 20662.3 1000.32 20740 999 20762.3 1000.18 20774 999
20862.3 1000.2 20943 999 21033 1001.58 21053 1014.09 21060 1013.7
21075.9 1017.9 21077.3 1018.4 21078.4 1018.9 21101.7 1019.3 21110.7 1019.6
21131.7 1019.1 21135.1 1018.9 21139 1019.1 21177.4 1018.7 21183.2 1018.4
21212.3 1017.2 21222.4 1017 21271.8 1016 21280.3 1015.9 21316.6 1015.1
21327.7 1015 21365.8 1014.6 21378.4 1014.4 21409.4 1013.8 21418.9 1013.8
21457.8 1013.6 21474.3 1013.9 21497.3 1012.8 21524.8 1012.7 21554.6 1012.7
21565.9 1012.7 21603.4 1012.9 21609 1012.9 21639 1013.2 21652.7 1013.3
21706.4 1013.5 21706.9 1013.5 21788.7 1013.6 21801.2 1013.6 21857.6 1013.8
21861.9 1013.8 21919.1 1014.1 21949.6 1014.1 21988.1 1014.2 21996.7 1014.2

Manning's n Values, num = 3
Sta. Value Sta. Value Sta. Value
19041.1 .032 19438.9 .032 21078.4 .032

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
19438.9 21078.4 1 1 1 .3 .5
Blocked Obstructions, num = 2
Sta L Sta R Elev Sta L Sta R Elev
****
19041.1 19299.6 1019.6 21078.4 21996.7 1019.6

CROSS SECTION INPUT Reach: 1 River Station: 207.49
Description: 207.49

Station Elevation Data, num = 81

```
  Sta.  Elev.   Sta.  Elev.   Sta.  Elev.   Sta.  Elev.   Sta.  Elev.
 18935   1008  19105   1012  19235   1016  19455  1020.2 19465.2  1020.4
19465.3  1014.7  19470  1013.3  19490    999  19507    999  19532    999
19558.3    999 19558.3 1017.77 19566.3 1017.77 19566.3    999  19586    999
19658.3    999 19658.3 1019.47 19666.3 1019.47 19666.3    999  19675    999
19758.3    999 19758.3 1020.87 19766.3 1020.87 19766.3    999  19822    999
 19830  999.43 19858.3  999.98 19858.3   1022 19866.3   1022 19866.3  999.98
19958.3  1000.5 19958.3 1022.87 19966.3 1022.87 19966.3  1000.5 20058.3 1002.97
20058.3  1023.6 20066.3 1023.59 20066.3 1002.97 20158.3 1002.38 20158.3   1024
20166.3   1024 20166.3 1002.38 20258.3  1000.4 20258.3  1024.1 20266.3  1024.1
20266.3  1000.4 20358.3 1002.13 20358.3   1024 20366.3   1024 20366.3 1002.13
20458.3  1004.9 20458.3  1023.6 20466.3 1023.68 20466.3 1004.94 20558.3 1003.54
20558.3   1023 20566.3   1023 20566.3 1003.54  20610  999.76 20658.3 1000.32
20658.3  1022.2 20666.3  1022.2 20666.3 1000.32  20740    999 20758.3 1000.18
20758.3   1021 20766.3   1021 20766.3  1000.2  20774    999 20858.3 1000.17
20858.3  1019.7 20866.3  1019.7 20866.3 1000.17  20943    999  21035  1000.2
21059.4  1013.7 21059.5  1020.4  21080  1020.7  21115   1020  21280   1016
 21875  1013.8

Manning's n Values,  num = 3
  Sta.  Value   Sta.  Value   Sta.  Value
 18935   .032  19455   .032 21059.4   .032

Bank Sta: Left   Right   Lengths: Left Channel   Right   Coeff Contr.   Expan.
     19465.3 21059.4            50   50.71     35          .3      .5
Ineffective Flow Areas,  num = 2
  Sta L   Sta R   Elev   Sta L   Sta R   Elev
*********************************************
  18935 19465.3  1014.7 21059.4  21875  1013.7

BRIDGE INPUT          Reach: 1            River Station: 207.485
Description: Bridge # 1
Distance from Upstream XS =      0
Deck/Roadway Width       =  50.71
Weir Coefficient         =    2.6
Bridge Deck/Roadway Skew  =
Upstream Deck/Roadway Coordinates,  num = 16
   Sta. Hi Cord Lo Cord    Sta. Hi Cord Lo Cord    Sta. Hi Cord Lo Cord
*********************************************************************
 19465.3  1020.4  1014.7 19558.3  1023.4 1017.77 19658.3 1025.18 1019.47
 19758.3 1026.58 1020.87 19858.3 1027.68   1022 19958.3 1028.58 1022.87
 20058.3 1029.28  1023.6 20158.3 1029.68 1023.99 20258.3 1029.78 1024.09
 20358.3 1029.68   1024 20458.3 1029.28 1023.59 20558.3 1028.68   1023
 20658.3 1027.88 1022.2 20758.3 1026.68   1021 20858.3 1025.41 1019.67
 21059.4  1020.6 1014.92
Downstream Deck/Roadway Coordinates,  num = 17
   Sta. Hi Cord Lo Cord    Sta. Hi Cord Lo Cord    Sta. Hi Cord Lo Cord
*********************************************************************
 19465.3  1020.4  1014.7 19558.3  1023.4 1017.77 19658.3 1025.18 1019.47
 19758.3 1026.58 1020.87 19858.3 1027.68   1022 19958.3 1028.58 1022.87
 20058.3 1029.28  1023.6 20158.3 1029.68 1023.99 20258.3 1029.78 1024.09
 20358.3 1029.68   1024 20458.3 1029.28 1023.59 20558.3 1028.68 1023.01
 20658.3 1027.88 1022.21 20758.3 1026.68   1021 20858.3 1025.41 1019.67
 20958.3 1023.68 1017.96 21059.4  1020.6 1014.92
Elevation at which weir flow begins       =
Maximum allowable submergence for weir flow =    .95
```

Submergence criteria :Broad Crested

Number of Bridge Coefficient Sets = 1

Low Flow Methods
Energy
Momentum Cd = 0
Yarnell KVal =
W.S. Pro Method CVal =
Selected Low Flow Methods = Energy

High Flow Method
Energy Only

Additional Bridge Parameters
Add Friction component to Momentum
Do not add Weight component to Momentum
Class B flow critical depth computations use critical depth
inside the bridge at the downstream end
Criteria to check for pressure flow = Upstream water surface

CROSS SECTION INPUT Reach: 1 River Station: 207.48
Description: 207.48

Station Elevation Data, num = 87

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
18935	1008	19105	1012	19235	1016	19455	1020.2	19465.2	1020.4
19465.3	1014.7	19470	1013.26	19503	999	19505	999	19544	999
19558.3	999	19558.3	1017.77	19566.3	1017.77	19566.3	999	19612.3	999
19658.3	999	19658.3	1019.47	19666.3	1019.47	19666.3	999	19696.3	999
19758.3	999	19758.3	1020.87	19766.3	1020.87	19766.3	999	19858.3	999
19858.3	1022	19866.3	1022	19866.3	999	19876.3	999	19901.3	1000.08
19958.3	1000.7	19958.3	1022.87	19966.3	1022.87	19966.3	1000.7	20058.3	1002.11
20058.3	1023.6	20066.3	1023.6	20066.3	1002.11	20072.3	1003.51	20158.3	1001.11
20158.3	1024	20166.3	1024	20166.3	1001.11	20202.3	999.87	20210.3	1000.73
20258.3	1000.5	20258.3	1024.1	20266.3	1024.1	20266.3	1000.48	20358.3	1003.22
20358.3	1024	20366.3	1024	20366.3	1003.22	20369.3	1001.84	20458.3	1004.43
20458.3	1023.6	20466.3	1023.68	20466.3	1004.43	20558.3	1003.53	20558.3	1023.01
20566.3	1023	20566.3	1003.53	20576.3	1001.63	20658.3	1000.59	20658.3	1022.21
20666.3	1022.2	20666.3	1000.59	20758.3	999	20758.3	1021	20766.3	1021
20766.3	999	20858.3	999	20858.3	1019.7	20866.3	1019.7	20866.3	999
20958.3	999.99	20958.3	1018	20966.3	1018	20966.3	999.99	21033	1001.58
21053	1014.1	21059.4	1014.7	21059.5	1020.4	21080	1020.7	21115	1020
21280	1016	21875	1013.8						

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
18935	.032	19455	.032	21059.4	.032

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
19465.3	21059.4	1	1	1	.3	.5

Ineffective Flow Areas, num = 2

Sta L	Sta R	Elev	Sta L	Sta R	Elev
18935	19465.3	1014.7	21059.4	21875	1014.7

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CROSS SECTION INPUT Reach: 1 River Station: 207.47
Description: 207.47

Station Elevation Data, num = 84

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
19021.7	1010	19022.9	1010	19061	1011.1	19121	1012.8	19122.3	1012.8
19177.8	1014.6	19179.1	1014.6	19232.9	1016.1	19233.6	1016.1	19287.5	1017.7
19290.6	1017.6	19335.9	1018.8	19337.3	1018.7	19396.5	1018.2	19402	1017.7
19434.1	1017.5	19437	1017.8	19440.4	1017.6	19443	1016.9	19450.2	1014.3
19470	1013.3	19503	999	19505	999	19544	999	19562.3	999
19612.3	999	19662.3	999	19696.3	999	19762.3	999	19862.3	999
19876.3	999	19901.3	1000.08	19962.3	1000.71	20062.3	1002.11	20072.3	1003.51
20162.3	1001.1	20202.3	999.87	20210.3	1000.73	20262.3	1000.48	20362.3	1003.22
20369.3	1001.8	20462.3	1004.43	20562.3	1003.53	20573.3	1001.63	20662.3	1000.59
20762.3	999	20862.3	999	20962.3	999.99	21033	1001.58	21053	1014.09
21074.4	1018.2	21075.2	1018.5	21080.9	1019.2	21083	1019	21103.3	1019.2
21110.1	1019.8	21133.4	1019	21134.2	1019	21178	1018.5	21178.3	1018.5
21212.9	1017.1	21213.5	1017.1	21272.9	1016	21274	1015.9	21317.9	1015.1
21318.4	1015.1	21366.5	1014.6	21366.9	1014.5	21410.7	1013.8	21459.5	1013.6
21476.1	1013.8	21497.2	1013.8	21499.9	1013.7	21539.4	1013.6	21549.4	1013.6
21578.3	1013.6	21597.4	1013.6	21609.3	1013.6	21644.1	1013.6	21686	1013.6
21699.9	1013.5	21746.3	1013.5	21764.8	1013.4	21790.2	1013.4		

Manning's n Values, num = 3

Sta.	Value	Sta.	Value	Sta.	Value
19021.7	.032	19437	.032	21080.9	.032

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
19437	21080.9	250	244.54	315	.3	.5

Blocked Obstructions, num = 2

Sta L	Sta R	Elev	Sta L	Sta R	Elev
19021.7	19335.9	1019.8	21080.9	21790.2	1019.8

CROSS SECTION INPUT Reach: 1 River Station: 207.43
Description: 207.43

Station Elevation Data, num = 77

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
16001	1012.1	16131.4	1012.2	16228.7	1013.1	16320.3	1013.5	16407.2	1012.9
16462.7	1013	16534.7	1009.5	16622	1009.9	16771.3	1010.1	16811.7	1010.1
16903.6	1009.9	17000.5	1009.7	17064.3	1009.5	17157.6	1009.6	17168	1009.6
17254.7	1009.5	17423.7	1009.1	17535	1009.1	17611.5	1010	17646.2	1011.6
17670.8	1009.4	17760.3	1009.7	17874.6	1010.1	17964.8	1011.6	17984.9	1012
17997.8	1016.3	18045.8	1011.1	18059.4	1010.8	18090.3	1019.1	18104.6	1011.8
18153.8	1012.3	18156.2	1012	18391.4	1012.4	18596.1	1016.3	18654.3	1014.9
18908.3	1012	19012	1011.9	19027.1	1014.5	19083.8	1014.7	19094.4	1012.4
19147.4	1018.1	19153.2	1017.8	19176.4	1012.1	19237.2	1010.4	19250.8	1011.8
19268.1	1006	19370.6	1006.3	19448.3	1005	19562.2	1000.2	19660.1	999.2
19729.8	999	19896.9	999.1	20054.8	999.2	20143.1	999.3	20241.9	1000.1
20361.6	1000.3	20453.3	1000.3	20539.4	999.9	20632.9	1001.1	20689.8	1003.1
20747.1	1003	20818	999.4	20892	1000.8	20911.4	1002.3	20940.1	1001.5
20958.5	1009.2	21053.7	1010.9	21146.5	1011.2	21244.1	1013	21380.1	1013.7
21490.2	1010.1	21618.6	1011	21731	1013.6	21751.5	1014.2	21777.8	1011.3
21912.6	1011.5	21985	1012.4						

Manning's n Values, num = 5

Sta.	Value	Sta.	Value	Sta.	Value	Sta.	Value	Sta.	Value
16001	.025	17611.5	.043	19012	.032	19250.8	.032	21053.7	.032

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
19250.8	21053.7	450	461.19	575	.3	.5

Blocked Obstructions, num = 2

Sta L	Sta R	Elev	Sta L	Sta R	Elev
16001	19250.8	1019.1	21380.1	21985	1019.1

CROSS SECTION INPUT Reach: 1 River Station: 207.34
Description: 207.34

Station Elevation Data, num = 63

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
16035.2	1011.8	16177.7	1012.1	16280.1	1013	16403.9	1013.3	16481.2	1012
16521.9	1009.6	16702.7	1009.6	16804.9	1009.5	16839.4	1009.4	16942.2	1010.3
16976.4	1010.3	17093.8	1008.9	17125.8	1008.8	17242.3	1008.6	17266.9	1008.4
17385.6	1008.6	17409.9	1008.6	17524	1008.8	17624.3	1009.1	17632.4	1009.2
17642.3	1011.1	17673.2	1011.4	17693.3	1008.6	17801.9	1009	17911.5	1008.1
17944	1007.7	17970.8	1008.9	18420.5	1010.8	18468.8	1010.2	18518.8	1009.3
19089.4	1009.3	19158.1	1010.6	19180.5	1009.1	19194.8	1003.1	19196.9	1003.1
19214.8	1010.1	19221.2	1005.7	19228.6	1002.1	19238.7	1001.1	19249	1002.5
19288.5	999	19326.4	999	19381	999	19392.5	1002.2	19404.7	999
19437.8	1000.9	19593.3	1002.4	19706.7	1001.8	19842	1000.3	19946.7	999
20191.8	999	20302.5	999	20382.5	999	20416.2	999	20521.3	999
20631.1	999	20696.7	999	20735.2	1000.8	20761.1	1007.9	20824.2	1010.6
20847.7	1013.3	20977	1014.8	20997	1014.1				

Manning's n Values, num = 5

Sta.	Value	Sta.	Value	Sta.	Value	Sta.	Value	Sta.	Value
16035.2	.025	17693.3	.043	19196.9	.032	19214.8	.032	20847.7	.032

Bank Sta: Left	Right	Lengths: Left	Channel	Right	Coeff Contr.	Expan.
19214.8	20847.7	370	393.75	530	.3	.5

Blocked Obstructions, num = 2

Sta L	Sta R	Elev	Sta L	Sta R	Elev
16035.2	19214.8	1014.8	20996.7	20997	1014.8

CROSS SECTION INPUT Reach: 1 River Station: 207.27
Description: 207.27

Station Elevation Data, num = 73

Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.	Sta.	Elev.
16209.3	1012.6	16252.8	1013.2	16284.2	1012	16383.8	1012.6	16415.5	1012.9
16480.2	1009.2	16601.8	1009.4	16722.1	1009.3	16901.6	1009.1	17028	1008.9
17034.7	1008.9	17132.7	1008.7	17256.4	1008.5	17345.1	1009.7	17477.8	1009
17574.2	1008.9	17623.2	1008.9	17640.8	1010.6	17654.3	1009.2	17776.8	1009.2
17890	1009.9	18017.7	1009.2	18033.8	1009.3	18373.9	1009.8	18428.4	1009.8
18529.9	1009.9	18634.4	1008.2	18686.7	1008.6	18936.9	1006.8	18965	1004.2
18981	1000.1	18990.9	999.5	19008.8	996.4	19021	989.6	19047.9	988.8
19072	996.4	19107.5	995	19123.5	989.3	19162.8	987.6	19190	994.7
19301.3	1002.1	19428.8	1005	19561.5	1003.7	19676.8	1002	19820.6	999.3
19940.6	998.8	19971.8	997.8	19986.7	993.8	20109.9	993.3	20119.1	995.5

20215.4 998.5 20300.7 998.8 20305.8 1000.2 20322.6 1001.4 20345.1 998.6
20382.4 998.7 20402.9 1000.7 20414.9 1000.4 20429.2 1001.7 20526.1 1000.4
20597.9 1002.6 20662.2 1037.1 20670.6 1034 20727.4 1003.5 20805.4 1006.4
20813.3 1010.3 20822.2 1008.4 20916.8 1009.6 21025 1009.2 21122.8 1010.2
21233.4 1010.9 21356.4 1011 21463 1011.1

Manning's n Values, num = 5
Sta. Value Sta. Value Sta. Value Sta. Value Sta. Value
16209.3 .025 17640.8 .043 19008.8 .032 19428.8 .032 20597.9 .032

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
19428.8 20597.9 575 572.72 585 .1 .3
Blocked Obstructions, num = 2
Sta L Sta R Elev Sta L Sta R Elev
****
16209.3 18686.7 1037.1 20662.2 21463 1037.1

CROSS SECTION INPUT Reach: 1 River Station: 207.16
Description: 207.16

Station Elevation Data, num = 96
Sta. Elev. Sta. Elev. Sta. Elev. Sta. Elev. Sta. Elev.
16210.1 1011.7 16309.9 1011.9 16344.7 1012.7 16358.1 1011.8 16364.1 1013.5
16438.5 1011.6 16493.9 1011.9 16557.8 1010.7 16585.8 1008.3 16700.8 1008.1
16756.6 1008.6 16852.6 1008.6 16969 1008.6 17076 1008.4 17204.5 1008.7
17321.8 1008.1 17421.3 1007.7 17541.4 1007.5 17638.7 1007.7 17755.6 1007.6
17773.4 1007.2 17787.5 1009.2 17904.3 1007.5 17925 1006.5 18023.9 1007.4
18085.4 1008 18140 1009.4 18201.1 1007.7 18218.4 1008.1 18321.4 1005
18342.3 1005.4 18407.3 1003.8 18456.1 1009.9 18484.8 1008.2 18498.7 1005.3
18523.8 1008.7 18528.7 1008.4 18529.5 1007.2 18545.1 1003.7 18570.4 1008.1
18605.9 1007.9 18638.7 1000.3 18663.3 997.6 18680.3 997.7 18717 996.2
18733.2 994.8 18778.6 996.9 18811.7 999.5 18924.2 1002.3 19046.2 1002.4
19107 1000.2 19209.6 1000.7 19329.8 1002.2 19395.2 1003.5 19404.5 1002.1
19419.4 1003.2 19521.4 1003.3 19614.6 1002 19721.9 1001.4 19815.6 999.6
19920.9 996.2 19994.2 994.9 20008.7 992.7 20062.5 992.7 20094.8 994.3
20106.3 993.1 20160.3 993 20395.5 993 20413 995 20418.4 997.1
20436.9 1001.5 20463.3 996.6 20488.6 995.2 20609.4 995.2 20655.2 996
20660.9 995.4 20697 996.6 20734.5 1007.6 20838.6 1008.7 20985.3 1010.1
21116.5 1009.9 21223.5 1009.3 21316.4 1008.4 21471.6 1007.6 21595.3 1007.5
21624 1007.5 21725.6 1009.3 21731.8 1008.9 21782.9 1010.9 21783 1010.3
21812.5 1010 21872.1 1013.5 21911.2 1012.7 21930.8 1006 21952.5 1011.3
21998 1010.9

Manning's n Values, num = 5
Sta. Value Sta. Value Sta. Value Sta. Value Sta. Value
16210.1 .025 17204.5 .043 18605.9 .032 19521.4 .032 20734.5 .032

Bank Sta: Left Right Lengths: Left Channel Right Coeff Contr. Expan.
19521.4 20734.5 0 0 0 .1 .3
Blocked Obstructions, num = 2
Sta L Sta R Elev Sta L Sta R Elev
****
16210.1 18570.4 1013.5 20734.5 21998 1013.5

****

SUMMARY OF MANNING'S N VALUES

Reach	River Sta.	n1	n2	n3	n4	n5
1	207.71	.025	.043	.032	.032	.032
1	207.62	.025	.043	.032	.032	.032
1	207.53	.025	.043	.032	.032	.032
1	207.5	.032	.032	.032		
1	207.49	.032	.032	.032		
1	207.485	Bridge				
1	207.48	.032	.032	.032		
1	207.47	.032	.032	.032		
1	207.43	.025	.043	.032	.032	.032
1	207.34	.025	.043	.032	.032	.032
1	207.27	.025	.043	.032	.032	.032
1	207.16	.025	.043	.032	.032	.032

SUMMARY OF REACH LENGTHS

Reach	River Sta.	Left	Channel	Right
1	207.71	485	487.91	485
1	207.62	460	461.71	515
1	207.53	230	228.73	200
1	207.5	1	1	1
1	207.49	50	50.71	35
1	207.485	Bridge		
1	207.48	1	1	1
1	207.47	250	244.54	315
1	207.43	450	461.19	575
1	207.34	370	393.75	530
1	207.27	575	572.72	585
1	207.16	0	0	0

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS

Reach	River Sta.	Contr.	Expan.
1	207.71	.1	.3
1	207.62	.3	.5
1	207.53	.3	.5
1	207.5	.3	.5
1	207.49	.3	.5
1	207.485	Bridge	
1	207.48	.3	.5
1	207.47	.3	.5
1	207.43	.3	.5
1	207.34	.3	.5

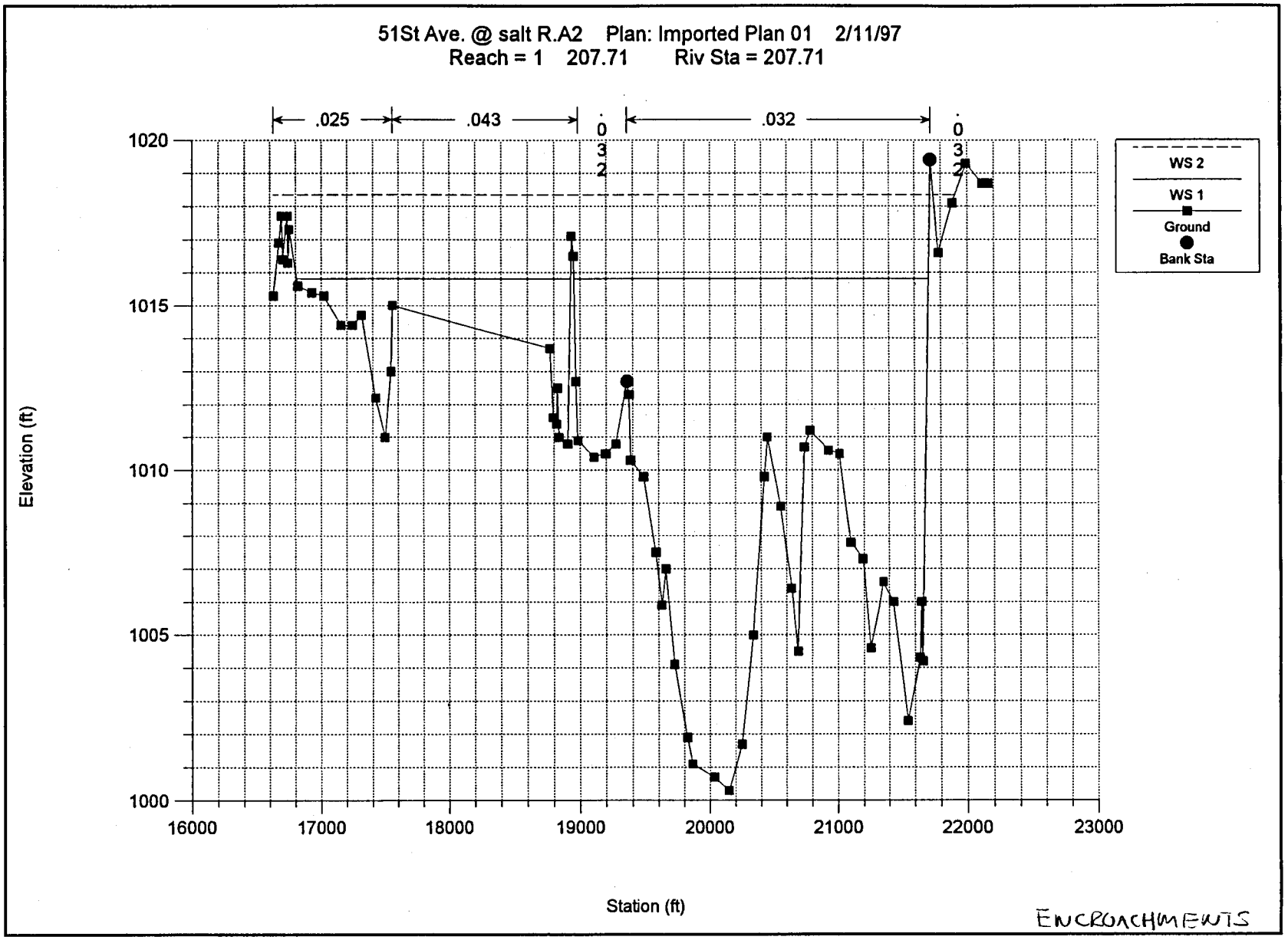
```
*1          *  207.27 *    .1*    .3*
*1          *  207.16 *    .1*    .3*
*********************************************
```

Profile Output Table - HEC-FDA

```
*********************************************
* River Sta. *  Q Total *Min Ch El *W.S. Elev *
*          *   (cfs) *    (ft) *    (ft) *
*********************************************
* 207.71    *190000.000 * 1000.300 * 1015.815 *
* 207.71    *252000.000 * 1000.300 * 1018.338 *
*          *          *          *          *
* 207.62    *190000.000 * 1000.200 * 1014.651 *
* 207.62    *252000.000 * 1000.200 * 1017.164 *
*          *          *          *          *
* 207.53    *190000.000 *  999.100 * 1014.194 *
* 207.53    *252000.000 *  999.100 * 1016.762 *
*          *          *          *          *
* 207.5     *190000.000 *  999.000 * 1013.189 *
* 207.5     *252000.000 *  999.000 * 1015.471 *
*          *          *          *          *
* 207.49    *190000.000 *  999.000 * 1012.744 *
* 207.49    *252000.000 *  999.000 * 1015.214 *
*          *          *          *          *
* 207.485   *  Bridge *          *          *
*          *          *          *          *
* 207.48    *190000.000 *  999.000 * 1012.425 *
* 207.48    *252000.000 *  999.000 * 1014.520 *
*          *          *          *          *
* 207.47    *190000.000 *  999.000 * 1012.591 *
* 207.47    *252000.000 *  999.000 * 1014.734 *
*          *          *          *          *
* 207.43    *190000.000 *  999.000 * 1012.200 *
* 207.43    *252000.000 *  999.000 * 1014.426 *
*          *          *          *          *
* 207.34    *190000.000 *  999.000 * 1009.823 *
* 207.34    *252000.000 *  999.000 * 1011.952 *
*          *          *          *          *
* 207.27    *190000.000 *  993.300 * 1008.519 *
* 207.27    *252000.000 *  993.300 * 1011.047 *
*          *          *          *          *
* 207.16    *190000.000 *  992.700 * 1007.040 *
* 207.16    *252000.000 *  992.700 * 1010.310 *
*********************************************
```

HEC-RAS Plan: Imported Pla Reach: 1 2/11/97

River Sta.	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
	(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
207.71	190000.00	1000.30	1015.82		1016.65	0.001310	7.61	28270.04	4889.89	0.43
207.71	252000.00	1000.30	1018.34		1019.04	0.000869	7.22	41067.70	5257.17	0.37
207.62	190000.00	1000.20	1014.65		1015.87	0.001741	9.05	21951.71	2544.23	0.50
207.62	252000.00	1000.20	1017.16		1018.45	0.001385	9.34	28199.53	2555.65	0.46
207.53	190000.00	999.10	1014.19		1015.12	0.001018	7.89	25102.64	2419.26	0.40
207.53	252000.00	999.10	1016.76		1017.83	0.000914	8.48	31015.38	2427.21	0.39
207.5	190000.00	999.00	1013.19		1014.67	0.001571	9.77	19446.07	1581.61	0.49
207.5	252000.00	999.00	1015.47		1017.32	0.001604	10.91	23094.71	1615.83	0.51
207.49	190000.00	999.00	1012.74	1008.82	1014.57	0.002637	10.83	17538.10	1669.06	0.55
207.49	252000.00	999.00	1015.21	1010.50	1017.26	0.002479	11.59	22516.19	2138.86	0.54
207.485	Bridge									
207.48	190000.00	999.00	1012.42	1008.85	1014.38	0.002985	11.23	16922.76	1642.20	0.58
207.48	252000.00	999.00	1014.52	1010.56	1016.99	0.003186	12.61	19987.92	1918.07	0.60
207.47	190000.00	999.00	1012.59		1014.21	0.001814	10.21	18603.64	1580.17	0.52
207.47	252000.00	999.00	1014.73		1016.77	0.001866	11.45	22012.49	1608.55	0.55
207.43	190000.00	999.00	1012.20		1013.70	0.001896	9.82	19456.73	2080.30	0.53
207.43	252000.00	999.00	1014.43		1016.19	0.001752	10.70	24022.91	2259.70	0.52
207.34	190000.00	999.00	1009.82		1012.25	0.003579	12.49	15210.00	1590.84	0.71
207.34	252000.00	999.00	1011.95		1014.79	0.003280	13.52	18637.20	1763.67	0.70
207.27	190000.00	993.30	1008.52	1006.71	1010.78	0.003529	11.72	15785.57	1910.98	0.70
207.27	252000.00	993.30	1011.05	1008.37	1013.36	0.002742	12.23	20650.03	1926.94	0.64
207.16	190000.00	992.70	1007.04	1005.10	1008.87	0.002761	11.57	18078.11	2122.98	0.63
207.16	252000.00	992.70	1010.31	1006.44	1011.93	0.001701	10.88	25117.88	2164.10	0.52



ENCROACHMENTS
REMOVED FOR
CONTRACTION SCOUR

CONTRACTION SCOUR
DATA Q100

Plan: Imported Pla Reach: 1 Riv Sta: 207.71 Profile: 1 2/11/97

Left Sta (ft)	Right Sta (ft)	%Q	Area (sq ft)	W.P. (ft)	Conv. (cfs)	Hydr D. (ft)	Velocity (ft/s)
16626.20	16899.58	0.01	28.02	104.43	692.9	0.27	0.82
16899.58	17172.96	0.18	209.80	273.38	10452.4	0.77	1.66
17172.96	17446.34	0.87	533.80	273.41	49561.0	1.95	3.10
17446.34	17719.72	0.08	574.87	273.60	4758.3	2.10	0.28
17719.72	17993.10	0.21	310.82	273.38	11700.0	1.14	1.26
17993.10	18266.48	0.30	391.00	273.38	17151.7	1.43	1.46
18266.48	18539.86	0.41	471.18	273.38	23406.0	1.72	1.66
18539.86	18813.24	0.65	618.21	273.46	36797.9	2.26	1.98
18813.24	19086.62	1.30	1109.97	249.99	74202.4	4.46	2.23
19086.62	19360.00	3.14	1338.06	273.40	179103.4	4.89	4.46
19360.00	19454.62	1.21	489.08	94.76	67828.0	5.17	4.70
19454.62	19549.23	1.78	616.09	94.64	99741.8	6.51	5.48
19549.23	19643.85	2.95	835.33	94.66	165635.9	8.83	6.72
19643.85	19738.46	3.85	979.09	94.69	215779.9	10.35	7.47
19738.46	19833.08	5.67	1235.59	94.64	318120.4	13.06	8.72
19833.08	19927.70	6.87	1386.50	94.62	385522.0	14.65	9.42
19927.70	20022.31	7.13	1416.98	94.62	399764.0	14.98	9.56
20022.31	20116.93	7.34	1442.15	94.62	411676.3	15.24	9.67
20116.93	20211.54	7.31	1438.49	94.62	409912.3	15.20	9.65
20211.54	20306.16	6.06	1286.06	94.66	340023.7	13.59	8.96
20306.16	20400.78	3.55	933.46	94.73	199221.1	9.87	7.23
20400.78	20495.39	1.41	537.24	94.69	79356.7	5.68	5.00
20495.39	20590.01	1.90	640.12	94.64	106305.1	6.77	5.63
20590.01	20684.63	3.32	895.86	94.67	186108.0	9.47	7.04
20684.63	20779.24	1.95	651.18	95.00	109110.5	6.88	5.68
20779.24	20873.86	1.07	454.56	94.62	60097.5	4.80	4.48
20873.86	20968.47	1.21	489.00	94.62	67874.6	5.17	4.70
20968.47	21063.09	1.44	543.24	94.64	80868.9	5.74	5.04
21063.09	21157.71	2.45	747.31	94.64	137608.8	7.90	6.24
21157.71	21252.32	3.27	888.02	94.67	183396.7	9.39	7.00

SOUTH
OVERBANK

19549

MAIN CH.

$A_c = 20662\ ft^2$

$Y_1 = \frac{20662}{2082}$

$= 9.92\ ft$

Plan: Imported Pla Reach: 1 Riv Sta: 207.71 Profile: 1 2/11/97 (continued)

Left Sta (ft)	Right Sta (ft)	%Q	Area (sq ft)	W.P. (ft)	Conv. (cfs)	Hydr D. (ft)	Velocity (ft/s)
21252.32	21348.94	3.79	969.50	94.63	212354.2	10.25	7.42
21348.94	21441.55	3.36	902.15	94.62	188356.0	9.53	7.07
21441.55	21538.17	4.64	1095.91	94.67	260421.5	11.58	8.05
21538.17	21630.79	5.37	1195.19	94.64	300972.7	12.63	8.53
21630.79	21725.40	1.97	616.21	81.02	110663.3	7.77	6.08

MAIN CH

21631

NORTH OVERBANK

$Q_o = 12.11\%$
$= 23000$

$W_1 = 2082$

$Q_c = Q_T - Q_o$
$= 190{,}000 - 23000$
$= 167{,}000$ cfs

Plan: Imported Pla Reach: 1 Riv Sta: 207.71 Profile: 1 2/11/97

W.S. Elev (ft)	1015.82	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.83	Wt. n-Val.	0.034	0.032	
E.G. Elev (ft)	1016.65	Reach Len. (ft)	485.00	487.91	485.00
E.G. Slope (ft/ft)	0.001310	Flow Area (sq ft)	5585.72	22684.32	
Q Total (cfs)	190000.00	Flow (cfs)	17335.37	172664.60	
Top Width (ft)	4889.89	Top Width (ft)	2539.75	2350.14	
Vel Total (ft/s)	6.72	Avg. Vel. (ft/s)	3.10	7.61	
Max Chl Dpth (ft)	15.52	Hydr. Depth (ft)	2.20	9.65	
Crit W.S. (ft)		Wetted Per. (ft)	2541.83	2353.03	
Conv. Total (cfs)	5250338.0	Conv. (cfs)	479034.4	4771304.0	

CONTRACTION SCOUR
(QOT) DATA

Plan: Imported Pla Reach: 1 Riv Sta: 207.71 Profile: 2 2/11/97

Left Sta (ft)	Right Sta (ft)	%Q	Area (sq ft)	W.P. (ft)	Conv. (cfs)	Hydr D. (ft)	Velocity (ft/s)
16826.20	16899.58	0.60	555.10	276.83	52464.7	2.03	2.70
16899.58	17172.96	1.34	899.64	273.38	118300.7	3.29	3.76
17172.96	17446.34	2.24	1223.64	273.41	197515.2	4.48	4.62
17446.34	17719.72	0.50	1264.71	273.60	43942.6	4.63	0.99
17719.72	17993.10	0.93	1000.66	273.38	82127.9	3.66	2.35
17993.10	18266.48	1.06	1080.84	273.38	93386.7	3.95	2.47
18266.48	18539.86	1.19	1161.02	273.38	105215.9	4.25	2.59
18539.86	18813.24	1.46	1308.05	273.46	128322.8	4.78	2.81
18813.24	19086.62	1.64	1779.50	274.79	144579.4	6.51	2.33
19086.62	19360.00	4.07	2027.90	273.40	358142.7	7.42	5.05
19360.00	19454.62	1.47	727.83	94.76	131570.2	7.69	5.11
19454.62	19549.23	1.93	854.84	94.64	172166.9	9.03	5.69
19549.23	19643.85	2.82	1074.08	94.66	251836.3	11.35	6.62
19643.85	19738.46	3.48	1217.84	94.69	310427.2	12.87	7.20
19738.46	19833.08	4.79	1474.34	94.64	427035.4	15.58	8.18
19833.08	19927.70	5.63	1625.25	94.62	502400.3	17.18	8.73
19927.70	20022.31	5.81	1655.73	94.62	518221.5	17.50	8.84
20022.31	20116.93	5.96	1680.90	94.62	531424.0	17.77	8.93
20116.93	20211.54	5.93	1677.24	94.62	529468.6	17.73	8.92
20211.54	20306.16	5.06	1524.81	94.66	451613.0	16.12	8.37
20306.16	20400.78	3.26	1172.21	94.73	291196.0	12.39	7.02
20400.78	20495.39	1.64	776.00	94.69	146464.6	8.20	5.33
20495.39	20590.01	2.02	878.87	94.64	180299.0	9.29	5.79
20590.01	20684.63	3.09	1134.62	94.67	275916.9	11.99	6.87
20684.63	20779.24	2.06	889.93	95.00	183636.1	9.41	5.83
20779.24	20873.86	1.36	693.31	94.62	121455.0	7.33	4.95
20873.86	20968.47	1.48	727.75	94.62	131674.7	7.69	5.11
20968.47	21063.09	1.66	781.99	94.64	148410.5	8.26	5.36
21063.09	21157.71	2.45	986.07	94.64	218434.1	10.42	6.26
21157.71	21252.32	3.06	1126.77	94.67	272738.2	11.91	6.84

South OVERBANK

19549

MAIN CH

$A_c = 26215$

$Y_1 = \frac{26215}{2082}$

$= 12.59$ ft

Plan: Imported Pla Reach: 1 Riv Sta: 207.71 Profile: 2 2/11/97 (continued)

Left Sta (ft)	Right Sta (ft)	%Q	Area (sq ft)	W.P. (ft)	Conv. (cfs)	Hydr D. (ft)	Velocity (ft/s)
21252.32	21346.94	3.44	1208.25	94.63	306484.6	12.77	7.17
21346.94	21441.55	3.12	1140.91	94.62	278567.1	12.06	6.90
21441.55	21536.17	4.05	1334.66	94.67	361689.7	14.11	7.65
21536.17	21630.79	4.57	1433.94	94.64	407711.4	15.16	8.03
21630.79	21725.40	1.87	830.00	92.05	166966.0	9.21	5.68
21725.40	22187.00	0.07	138.47	162.54	5778.4	0.85	1.23

MAIN CH

21631

North OVERBANK

$Q_0 = 20.37\%$ $W_1 = 2081$

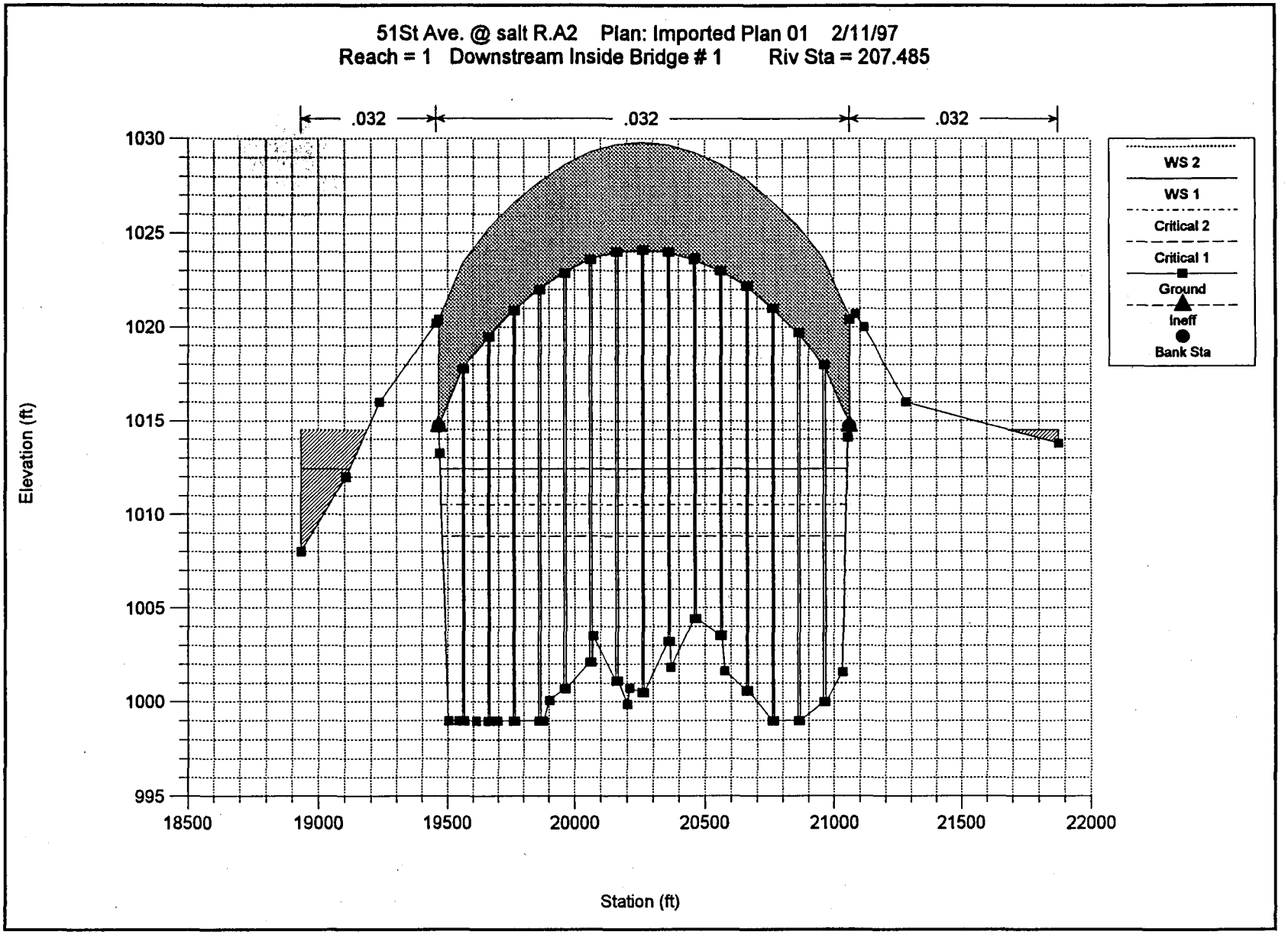
$= 51,300$ cfs

$Q_1 = 252,000 - 51,300$

$= 200,700$ cfs

Plan: Imported Pla Reach: 1 Riv Sta: 207.71 Profile: 2 2/11/97

W.S. Elev (ft)	1018.34	Element	Left OB	Channel	Right OB
Vel Head (ft)	0.70	Wt. n-Val.	0.034	0.032	0.032
E.G. Elev (ft)	1019.04	Reach Len. (ft)	485.00	487.91	485.00
E.G. Slope (ft/ft)	0.000869	Flow Area (sq ft)	12301.06	28628.17	138.47
Q Total (cfs)	252000.00	Flow (cfs)	45126.64	206703.00	170.38
Top Width (ft)	5257.17	Top Width (ft)	2733.80	2360.88	162.48
Vel Total (ft/s)	6.14	Avg. Vel. (ft/s)	3.67	7.22	1.23
Max Chl Dpth (ft)	18.04	Hydr. Depth (ft)	4.50	12.13	0.85
Crit W.S. (ft)		Wetted Per. (ft)	2739.02	2364.06	162.54
Conv. Total (cfs)	8546391.0	Conv. (cfs)	1530436.0	7010176.0	5778.4


51St Ave. @ salt R.A2 Plan: Imported Plan 01 2/11/97
Reach = 1 Downstream Inside Bridge # 1 Riv Sta = 207.485
.032
.032
.032
1030
1025
1020
1015
1010
1005
1000
995
Elevation (ft)
18500
19000
19500
20000
20500
21000
21500
22000
Station (ft)
WS 2
WS 1
Critical 2
Critical 1
Ground
Ineff
Bank Sta

PIER SCOUR
DATA Q100

Plan: Imported Pla Reach: 1 Riv Sta: 207.485 BU Profile: 1 2/11/97

Left Sta (ft)	Right Sta (ft)	%Q	Area (sq ft)	W.P. (ft)	Conv. (cfs)	Hydr D. (ft)	Velocity (fps)
19448.30	19525.06	3.97	668.98	62.69	150559.9	11.48	11.27
19525.06	19582.83	4.12	766.39	83.25	156315.7	13.74	10.22
19582.83	19648.89	6.16	876.34	63.76	233479.6	13.74	13.35
19648.89	19720.34	4.12	766.42	83.25	156322.4	13.74	10.22
19720.34	19764.12	4.12	766.39	83.25	156315.7	13.74	10.22
19764.12	19847.88	6.01	863.82	63.78	227911.8	13.55	13.22
19847.88	19911.85	3.66	706.98	81.29	138832.4	12.68	9.84
19911.85	19975.41	3.53	687.78	80.25	133746.0	12.33	9.74
19975.41	20039.18	4.34	710.52	63.79	164556.9	11.14	11.60
20039.18	20102.94	2.57	554.24	75.32	97365.5	9.94	8.80
20102.94	20166.71	2.65	568.08	76.49	100412.8	10.19	8.86
20166.71	20230.47	4.28	705.12	63.78	162494.0	11.06	11.54
20230.47	20294.23	3.39	672.65	80.46	128656.4	12.06	9.58
20294.23	20358.00	4.39	715.35	63.77	166447.3	11.22	11.66
20358.00	20421.76	2.46	545.55	77.02	93435.6	9.78	8.58
20421.76	20485.53	1.95	459.54	71.43	73812.4	8.24	8.05
20485.53	20549.29	2.81	547.17	63.77	106488.2	8.58	9.75
20549.29	20613.05	3.01	606.68	74.34	114195.9	10.88	9.43
20613.05	20676.82	3.67	705.64	80.62	139167.7	12.65	9.88
20676.82	20740.58	5.74	840.58	63.78	217791.0	13.18	12.98
20740.58	20804.34	4.00	744.59	81.00	151719.8	13.35	10.21
20804.34	20868.11	3.80	721.40	80.92	144026.0	12.94	10.00
20868.11	20931.87	5.67	834.50	63.77	215184.3	13.09	12.92
20931.87	20995.64	5.93	857.32	63.77	225084.2	13.45	13.15
20995.64	21059.40	3.65	646.05	65.28	138287.0	10.41	10.72

$Y_1 = 13.74$ ft
$V_1 = 13.35$ fps

HIGHEST

GR FILLED TO ELEV. 999 OC

Plan: Imported Pla Reach: 1 Riv Sta: 207.485 BU Profile: 1 2/11/97

W.S. Elev (ft)	1012.74	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.82	Wt. n-Val.		0.032	
E.G. Elev (ft)	1014.57	Reach Len. (ft)	50.71	50.71	50.71
E.G. Slope (ft/ft)	0.002637	Flow Area (sq ft)		17538.09	
Q Total (cfs)	190000.00	Flow (cfs)		190000.00	
Top Width (ft)	1474.89	Top Width (ft)		1474.89	
Vel Total (ft/s)	10.83	Avg. Vel. (ft/s)		10.83	
Max Chl Dpth (ft)	13.74	Hydr. Depth (ft)		11.89	
Crit W.S. (ft)	1008.81	Wetted Per. (ft)		1810.84	
Conv. Total (cfs)	3700237.0	Conv. (cfs)		3700237.0	

PIER SCOUR
DATA QOT

Plan: Imported Pla Reach: 1 Riv Sta: 207.485 BU Profile: 2 2/11/97

Left Sta. (ft)	Right Sta. (ft)	%Q	Area (sq ft)	W.P. (ft)	Conv. (cfs)	Hydr D. (ft)	Velocity (ft/s)
19485.36	19529.06	3.83	820.35	68.55	199291.9	12.87	11.76
19529.06	19592.83	3.81	904.13	88.19	198129.1	16.21	10.61
19592.83	19656.59	5.91	1033.84	63.76	307528.4	16.21	14.40
19656.59	19720.36	3.81	904.16	88.19	198137.8	16.21	10.61
19720.36	19764.12	3.81	904.13	88.19	198129.1	16.21	10.61
19764.12	19847.88	5.79	1021.32	63.78	301300.2	16.02	14.28
19847.88	19911.65	3.45	844.73	86.23	179578.1	15.15	10.29
19911.65	19975.41	3.35	825.52	85.19	174227.5	14.80	10.22
19975.41	20029.18	4.41	868.02	63.79	229742.2	13.61	12.81
20029.18	20192.94	2.60	691.99	80.26	135106.7	12.41	9.45
20192.94	20166.71	2.66	705.83	81.43	138296.2	12.66	9.49
20166.71	20230.47	4.37	862.63	63.78	227387.3	13.53	12.76
20230.47	20294.23	3.24	810.39	85.40	168664.0	14.53	10.08
20294.23	20358.00	4.46	872.85	63.77	231906.8	13.69	12.86
20358.00	20421.76	2.51	683.29	81.96	130456.2	12.25	9.24
20421.76	20485.53	2.10	597.29	76.37	109277.7	10.71	8.86
20485.53	20549.29	3.12	704.67	63.77	162333.9	11.05	11.15
20549.29	20613.06	2.96	744.42	79.28	153857.8	13.35	10.01
20613.06	20676.82	3.46	843.38	85.56	180047.1	15.12	10.34
20676.82	20740.58	5.57	998.08	63.78	289969.6	15.65	14.07
20740.58	20804.35	3.72	882.34	85.94	193534.8	15.82	10.62
20804.35	20868.11	3.56	859.15	85.86	185254.3	15.41	10.44
20868.11	20931.87	5.51	992.01	63.77	287047.5	15.56	14.01
20931.87	20995.64	5.73	1014.83	63.77	298141.7	15.92	14.22
20995.64	21059.40	3.74	802.73	67.25	194678.2	12.59	11.74

GR FILLED TO ELEV. 999 OC

HIGHEST $Y_1 = 16.21$ ft
$V_1 = 14.40$ fps

Plan: Imported Pla Reach: 1 Riv Sta: 207.485 BU Profile: 2 2/11/97

W.S. Elev (ft)	1015.21	Element	Left OB	Channel	Right OB
Vel Head (ft)	2.04	Wt. n-Val.	0.032	0.032	0.032
E.G. Elev (ft)	1017.26	Reach Len. (ft)	50.71	50.71	50.71
E.G. Slope (ft/ft)	0.002531	Flow Area (sq ft)	1054.14	21186.24	270.25
Q Total (cfs)	252000.00	Flow (cfs)	5934.93	245565.40	499.70
Top Width (ft)	2110.91	Top Width (ft)	274.45	1454.11	382.35
Vel Total (ft/s)	11.19	Avg. Vel. (ft/s)	5.63	11.59	1.85
Max Chl Dpth (ft)	16.21	Hydr. Depth (ft)	3.84	14.57	0.71
Crit W.S. (ft)	1010.50	Wetted Per. (ft)	282.78	1917.06	386.83
Conv. Total (cfs)	5008933.0	Conv. (cfs)	117967.0	4881033.0	9932.3

MARYLAND SHA CODING GUIDE FOR ITEM 113
SCOUR CRITICAL BRIDGES

CODE		DESCRIPTION
1ST DIGIT	2ND DIGIT	
N	-	BRIDGE NOT OVER WATERWAY
9	-	BRIDGE FOUNDATIONS (INCLUDING PILES) WELL ABOVE FLOOD WATER ELEVATIONS (SEE NOTE 1)
8	P	BRIDGE IS A STRUCTURE WITH A FULL LENGTH PAVED BOTTOM
8	L	BRIDGE HAS BEEN EVALUATED/ASSESSED IN THE FIELD AND OFFICE AS A LOW RISK STRUCTURE; NO FURTHER STUDY IS PLANNED
7	-	COUNTERMEASURES HAVE BEEN INSTALLED SINCE THE ORIGINAL CONSTRUCTION TO CORRECT A PROBLEM WITH SCOUR; BRIDGE IS NO LONGER SCOUR CRITICAL
6	-	BRIDGE HAS NOT BEEN EVALUATED FOR SCOUR
6	R	BRIDGE IS SCHEDULED FOR MAJOR REHABILITATION OR REPLACEMENT WITHIN THE NEXT 5 YEARS; THE SCOUR STUDY IS DEFERRED TO THE LOCATION/DESIGN PHASE OF THE BRIDGE PROJECT
6	T	TIDAL FLOW PREDOMINATES FOR WORST SCOUR CONDITIONS; THE ITEM 113 RATING IS DEFERRED WHERE THERE IS NO INDICATION OF SEVERE SCOUR CONDITIONS
6	U	THE BRIDGE FOUNDATIONS ARE UNKNOWN. THE BRIDGE SITE CONDITIONS HAVE BEEN EVALUATED/ASSESSED WITH CURSORY STUDY IN THE FIELD AND OFFICE AND THE RISK OF POTENTIAL DAMAGE FROM SCOUR IS JUDGED TO BE MODERATE OR MILD. STRUCTURE HAS NO HISTORY OF SCOUR PROBLEMS. FURTHER EVALUATION IS DEFERRED. (SEE NOTE 1)
5	-	A DETAILED SCOUR STUDY (ANALYSIS) HAS BEEN MADE AND THE STRUCTURE IS RATED AS STABLE.
4	-	BRIDGE FOUNDATIONS DETERMINED TO BE STABLE ON THE BASIS OF A FIELD AND OFFICE SCOUR EVALUATION OR ANALYSIS; BRIDGE INSPECTION REVEALS THAT ACTION IS REQUIRED TO PROTECT EXPOSED PILES FROM EFFECTS OF ADDITIONAL EROSION AND CORROSION.

3	A	BRIDGE IS RATED AS SCOUR CRITICAL ON THE BASIS OF A FIELD AND OFFICE EVALUATION OR AN ANALYSIS; THE POTENTIAL RISK IS JUDGED TO BE MILD, AND NO ACTIONS ARE PLANNED OTHER THAN MONITORING.
3	B	BRIDGE IS RATED AS SCOUR CRITICAL ON THE BASIS OF A FIELD AND OFFICE EVALUATION OR AN ANALYSIS; THE POTENTIAL RISK IS JUDGED TO BE MODERATE AND NO ACTIONS ARE PLANNED OTHER THAN MONITORING.
3	C	BRIDGE IS RATED AS SCOUR CRITICAL ON THE BASIS OF A FIELD AND OFFICE EVALUATION OR AN ANALYSIS; THE POTENTIAL RISK IS JUDGED TO BE SEVERE AND SCOUR COUNTERMEASURES ARE PLANNED. MONITORING IS TO BE UTILIZED UNTIL SCOUR COUNTERMEASURES ARE IN PLACE.
2	-	BRIDGE IS SCOUR CRITICAL; FIELD REVIEW INDICATES THAT EXTENSIVE SCOUR HAS OCCURRED AT A BRIDGE FOUNDATION. IMMEDIATE ACTION IS REQUIRED TO PROVIDE SCOUR COUNTERMEASURES.
1	-	BRIDGE IS SCOUR CRITICAL; FIELD REVIEW INDICATES THAT FAILURE OF PIERS/ABUTMENTS IS IMMINENT. BRIDGE IS CLOSED TO TRAFFIC.
0	-	BRIDGE IS SCOUR CRITICAL; BRIDGE HAS FAILED AND IS CLOSED TO TRAFFIC.

NOTE 1: IF THE RISK OF DAMAGE FROM POTENTIAL OR ACTUAL SCOUR DAMAGE IS JUDGED TO BE SEVERE, ADDITIONAL SCOUR STUDIES WILL BE UNDERTAKEN INCLUDING BORINGS OR OTHER MEANS OF SUBSURFACE EXPLORATION TO ASCERTAIN FOUNDATION AND SUPPORTING SOIL CONDITIONS.

STRUCTURES INVENTORY AND APPRAISAL
(NATIONAL BRIDGE INVENTORY SYSTEM)

SCREENING PROCEDURE FOR
RATING BRIDGES FOR ITEM 113, SCOUR CRITICAL BRIDGE

AGENCY: *PARSONS BRINCKERHOFF* BRIDGE NO.: 9692
ROUTE: *51st AVENUE* STREAM: *SALT RIVER*

SCREEN 1 - BRIDGE INSPECTOR'S SCREEN

EVALUATOR'S NAME: DATE: *4/20/95*
RECOMMENDATION: ☐ RATE BRIDGE: 3C ☒ GO TO SCREEN 2

CRITERIA	RESPONSE		ITEM 113 RATING
	YES	NO	
1-1. BRIDGE OVER WATERWAY?	CONTINUE	RATE BRIDGE	N
1-2. BRIDGE INSPECTION REPORTS INDICATE:			
• BRIDGE FAILED/CLOSED DUE TO SCOUR	RATE BRIDGE	CONTINUE	O
• BRIDGE CLOSED; FAILURE IMMINENT DUE TO SCOUR	RATE BRIDGE	CONTINUE	1
• FOOTING EXPOSED; PROMPT ACTION REQUIRED TO PROTECT BRIDGE FROM SCOUR	NOTIFY OWNER; RATE BR.	CONTINUE	2
• SCOUR HOLES HAVE FORMED TO DEPTHS NEAR BOTTOM OF SPREAD FOOTINGS	NOTIFY OWNER; RATE BR.	CONTINUE	2
• EXPOSED PILES REQUIRE PROTECTION	NOTIFY OWNER; RATE BR.	CONTINUE	4
1-3. BRIDGE IS A CULVERT WITH A PAVED INVERT	RATE BRIDGE	CONTINUE	8C
1-4. TIDAL FLOWS GOVERN BRIDGE HYDRAULICS FOR WORST SCOUR CONDITIONS	RATE BRIDGE (INTERIM RATING)	CONTINUE	6T
1-5. BRIDGE IS ON THE 5 YEAR CAPITAL REPLACE. PROGRAM	RATE BRIDGE	CONTINUE	6R
1-6 BRIDGE IS ON THE 2 YEAR PROGRAM FOR REMEDIAL WORK	RATE BRIDGE	CONTINUE SCREEN 2	6R

SCOUR EVALUATION FORM FOR RATING BRIDGES FOR ITEM 113

SCREEN 2 - BRIDGE ENGINEER'S SCREEN

Agency: *PARSONS BRINCKERHOFF*

Date/Place Meeting: *4/20/95; 51st AVENUE BRIDGE*

Attendees:

Bridge No.: *9692* Date Built/Date on Bridge Plans: *1980*

Description of Bridge/Bridge Type: *16 SPAN PRE-CAST PRE-STRESSED AASHTO GIRDER BRIDGE*

Route: *51st AVENUE* Water Course: *SALT RIVER*

Underclearance at thalweg (ft): *36.9*

Elevation of stream thalweg (ft): *987.1*

Normal water elevation (ft): *993.4*

Reported high water elevation: *+-1012*

Description of flood: *Q100*

Description of approach and "getaway" conditions: *VEGETATION AND UNEVEN BED; UPSTREAM MOUNDS OF SOIL AS HIGH AS 12'*

Description of bed load: *SANDY-GRAVELY SILT*

Condition of banks; evidence of lateral movement, degradation or aggradation: *SOUTH BANK SHOWS SOME MINOR DEGRADATION UPSTREAM*

Overtopping Q (cfs)/Recurrence interval: *252,000 cfs/APPROX. 250-300 YR.*

Stage rise to overtopping:

Depth/velocity through bridge at overtopping: *24.6/13.8*

Confluences: *N/A*

BRIDGE NUMBER 9692

Description of flood plain: *THE TOPOGRAPHY IN THE IMMEDIATE AREA IS RELATIVELY FLAT. THE FLOODPLAIN IS APPROXIMATELY 4000' WIDE.*

Item 321 rating: 7
Item 71 rating: 9
Item 61 rating: 7

ABUTMENTS		
	LEFT	RIGHT
TYPE	*SPILL THROUGH*	*SPILL THROUGH*
SPREAD/PILES	*P*	*P*
EXPOSED FOOTINGS	*N*	*N*
FOOTING ELEVATION	*925*	*925*
ROCK ELEVATION AND DESCRIPTION	*N/A*	*N/A*
SOIL ELEVATION AND DESCRIPTION	*998.9* *25mm COBBLES*	*1000.2* *25mm COBBLES*
ANGLE OF ATTACK OF FLOOD FLOWS ON ABUTMENT	*0°*	*0°*
DESCRIPTION OF RIPRAP OR OTHER SCOUR PROTECTION	*RIPRAP WITH GROUT* *1:1*	*RIPRAP WITH GROUT* *1 3/4:1*
ITEM 113 RATING	*3C*	*3C*

GENERAL COMMENTS:

1.) *RIGHT ABUTMENT: GOOD CONDITION WITH STORM DRAIN ON THE WEST SIDE; GROUTED RIPRAP HAS PARTIAL DAMAGE AT WEST SIDE; NO EXPANSION JOINTS AT ABUTMENTS.*

2.) *LEFT ABUTMENT: WATER FROM THE GRAVEL MINING OPERATION HAS DAMAGED THE WEST END OF THE ABUTMENT. THE GROUTED RIPRAP HAS BEEN UNDERMINED AND BREAKS AND CRACKS ARE VISIBLE.; THERE IS A GRAVEL MINING OPERATION AT UPSTREAM NORTH END OF BRIDGE.*

BRIDGE NUMBER 9692

PIERS						
	ALL					
CHANNEL/FLOODPLAIN	*C*					
PIER WIDTH	*4'DIA*					
SPREAD/PILES	*P*					
EXPOSED FOOTINGS	*N/A*					
FOOTING HEIGHT	*5'*					
FOOTING ELEVATION AND WIDTH	*975'*					
ROCK ELEVATION/TYPE	*N/A*					
ELEVATION OF TOP OF GROUND OR CHANNEL; SOIL TYPE	*1000* *SAND GRAVEL COBBLE*					
ANGLE OF ATTACK (DEG)	*0*					
RIPRAP OR OTHER PROTECTION	*YES* *GROUT/ RIPRAP*					
ITEM 113 RATING	*3C*					

General Comments/Assessment:

1.) EXPANSION JOINT HAS OPENED UP 6"; MAIN CHANNEL FLOW IS AT PIER #1-5; THERE IS SOME DEGRADATION OF THE RIVER BED OF ABOUT 4'.

Recommended Item 113 and Risk Ratings:

3C

BRIDGE NUMBER 9692

SCREEN 3 - HYDRAULIC ENGINEER'S SCREEN

NAME: *51st AVENUE* DATE: *4/20/95*

AGENCY: *PARSONS BRINCKERHOFF*

THE RECOMMENDED ITEM 113 RATING FOR THIS STRUCTURE IS: *3C*

THIS RECOMMENDATION IS BASED ON:

☒ A SCOUR EVALUATION

☒ A FULL OR DETAILED SCOUR ANALYSIS

THE RECOMMENDATION HAS BEEN APPROPRIATELY COORDINATED WITH THE BRIDGE/FOUNDATION/GEOTECHNICAL ENGINEERS WHO HAVE PREPARED SCREENS 1, 2 AND 4.

COMMENTS ON SCREEN 3:

- USE OF SCREEN 3 IS RECOMMENDED WHEN THERE ARE QUESTIONS OR ISSUES WHICH HAVE NOT BEEN FULLY ADDRESSED DURING THE ITEM 113 BRIDGE SCOUR EVALUATION UTILIZING SCREEN 2.

- **AS A FIRST STEP, THE HYDRAULIC ENGINEER IS ENCOURAGED TO REVIEW APPROPRIATE AVAILABLE INFORMATION AND TO INSPECT THE BRIDGE SITE TO DETERMINE IF ADEQUATE INFORMATION CAN BE DEVELOPED TO RESPOND TO THE ISSUES ON SCOUR RAISED IN THE SCREEN 2 REVIEW WITHOUT CONDUCTING A FULL OR DETAILED SCOUR ANALYSIS.**

- SINCE THE ITEM 113 RATING REQUIRES THE EVALUATION OF THE STABILITY OF THE STRUCTURE UNDER WORST CASE SCOUR CONDITIONS, THE HYDRAULIC ENGINEER WILL GENERALLY NEED TO CONDUCT THE EVALUATION/ANALYSIS IN COOPERATION WITH A FOUNDATION/GEOTECHNICAL ENGINEER, AND SCREEN 4 SHOULD BE PREPARED AS APPROPRIATE.

- THE HYDRAULIC ENGINEER SHOULD DOCUMENT THE BASIS FOR HIS OR HER RECOMMENDATION OF THE ANTICIPATED EXTENT OF SCOUR TO BE EXPECTED AT THE BRIDGE. SCOUR ANALYSES SHOULD BE BASED ON THE PROCEDURES SET FORTH IN THE MARYLAND SHA PPM ON SCOUR EVALUATION OF BRIDGES DATED 6/17/91 AND IN THE FHWA HYDRAULIC ENGINEERING CIRCULARS 18 AND 20.

BRIDGE NUMBER 9692

SCREEN 4 - FOUNDATION/GEOTECHNICAL ENGINEER'S SCREEN

NAME: *51st AVENUE* Date: *4/20/95*

AGENCY: *AGRA - EARTH AND ENVIRONMENTAL INC.*

THE RECOMMENDED ITEM 113 RATING FOR THIS STRUCTURE IS: *3C*

THIS RECOMMENDATION IS BASED ON:

☒ A SCOUR EVALUATION

☐ A FULL OR DETAILED SCOUR AND STRUCTURAL STABILITY ANALYSIS

THE RECOMMENDATION HAS BEEN APPROPRIATELY COORDINATED WITH THE BRIDGE AND HYDRAULIC ENGINEERS WHO HAVE PREPARED SCREENS 1, 2 AND 3.

COMMENTS ON SCREEN 4:

- USE OF SCREEN 4 IS RECOMMENDED WHEN THERE ARE QUESTIONS OR ISSUES WHICH HAVE NOT BEEN FULLY ADDRESSED DURING THE ITEM 113 BRIDGE SCOUR EVALUATION UTILIZING SCREEN 2.
- **AS A FIRST STEP, THE FOUNDATION/GEOTECHNICAL ENGINEER IS ENCOURAGED TO REVIEW APPROPRIATE AVAILABLE INFORMATION AND TO INSPECT THE BRIDGE SITE TO DETERMINE IF ADEQUATE INFORMATION CAN BE DEVELOPED TO RESPOND TO THE ISSUES ON SCOUR RAISED IN THE SCREEN 2 REVIEW WITHOUT CONDUCTING A FULL OR DETAILED SCOUR ANALYSIS.**
- SINCE THE ITEM 113 RATING REQUIRES THE EVALUATION OF THE STABILITY OF THE STRUCTURE IN ACCORDANCE WITH AASHTO STABILITY CRITERIA UNDER WORST CASE SCOUR CONDITIONS, THE FOUNDATION/GEOTECHNICAL ENGINEER WILL GENERALLY NEED TO CONDUCT THE EVALUATION/ANALYSIS IN COOPERATION WITH A HYDRAULICS ENGINEER TO ADDRESS PERTINENT SCREEN ISSUES.
- THE FOUNDATION/GEOTECHNICAL ENGINEER SHOULD DOCUMENT THE BASIS FOR HIS OR HER RECOMMENDATION REGARDING THE STABILITY OF THE BRIDGE FOR THE ANTICIPATED WORST CASE SCOUR CONDITIONS AND THE EXTENT OF SCOUR TO BE EXPECTED AT THE BRIDGE. PARTICULAR ATTENTION SHOULD BE GIVEN TO:
  - FOUNDATIONS ON ROCK AND THE DEGREE TO WHICH THE ROCK IS SCOUR- RESISTANT.
  - THE STABILITY OF FOUNDATIONS ON PILES, IF THE PILING CAN BE EXPECTED TO BE EXPOSED BY SCOUR.
  - EVALUATION OF EXISTING INFORMATION TO DETERMINE OR ESTIMATE FOUNDATION CONDITIONS WHEN THE BRIDGE PLAN DETAILS ARE INCOMPLETE.

BRIDGE NUMBER 9692

SCREEN 5 - BRIDGE MANAGER'S SCREEN

NAME/SIGNATURE: *PARSONS BRINCKERHOFF* DATE: APRIL, 20, 1995

I HAVE REVIEWED SCREENS 1-4 AND CONCUR WITH THE FOLLOWING RATINGS:

- ITEM 113 RATING: *3C* DESCRIPTION:
- RISK RATING (FOR ITEM 113 RATING CODES 3 AND 6): *N/A*

COMMENTS ON SCREEN 5:

1. THE CODES SET FORTH IN TABLE 1, ARE TO BE USED IN RATING BRIDGES FOR ITEM 113.

2. EACH BRIDGE MANAGER/OWNER NEEDS TO DEVELOP AN ACTION PLAN FOR SCOUR CRITICAL BRIDGES (SEE FHWA HEC- 18, CHAPTER 7) THIS PLAN SHOULD ADDRESS MONITORING OF SCOUR CRITICAL BRIDGES DURING HIGH WATER AND SCHEDULING AND INSTALLATION OF SCOUR COUNTERMEASURES WHERE DETERMINED TO BE NECESSARY. IT IS RECOMMENDED THAT SCOUR CRITICAL BRIDGES BE PRIORITIZED (ACCORDING TO THE ENGINEER'S JUDGMENT AS TO THE RELATIVE RISK OF SUSTAINING DAMAGE DUE TO SCOUR IN A FUTURE FLOOD) AS SEVERE (3), MODERATE (2) OR MILD (1). BRIDGES CODED AS 6 U SHOULD ALSO BE GIVEN A RISK RATING AS DESCRIBED IN TABLE 1.

BRIDGE NUMBER 9692

REVIEW BY INTERDISCIPLINARY SCOUR EVALUATION TEAM

DATE: *February, 1997* ITEM 113 RATING: *3C*

RISK RATING: *Scour Critical - monitor until countermeasures are in place.*

PROPOSED ACTIONS:

1.) *Recommend that scour countermeasures be designed and constructed.*

Notes:

A.6 Structural Calculations

STRUCTURAL ANALYSIS & CONCLUSION

Stability analysis is based on the original bridge plans and scour data provided by the PB's Drainage Section.

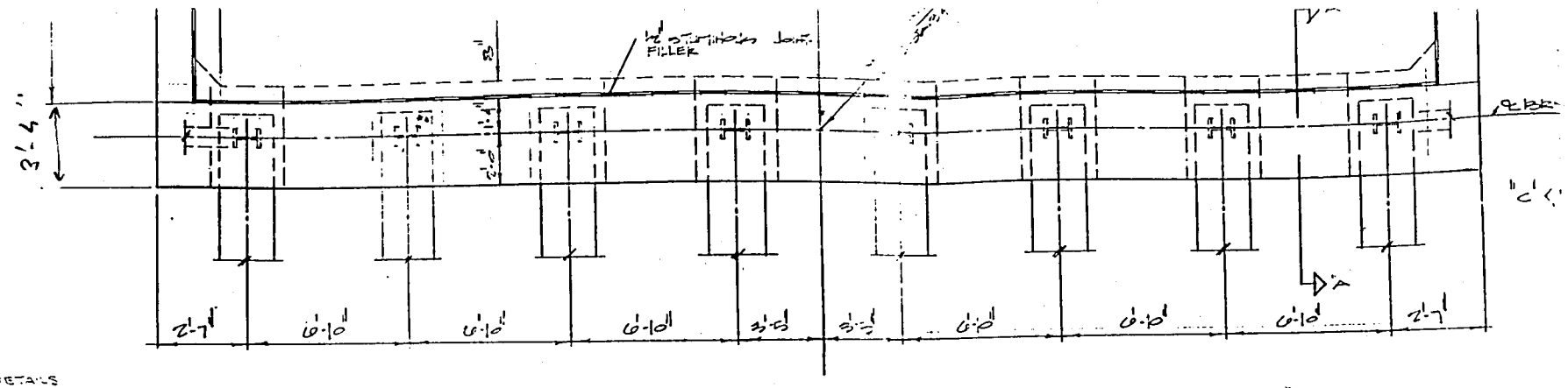
Abutment No. 1 (South) – Based on assumption that scour elevation is below the riprap protection and abutment scour protection will fail at 100-year storm event, exposed length of piles will be about 49 feet and piles will not pass the slenderness test under axial load. Similar situation exists at 500-year flood event.

Piers – Our analysis indicates pier foundations will perform satisfactorily under 100-year storm event. For 500 year storm, pier foundation piles fail strength (stress) test.

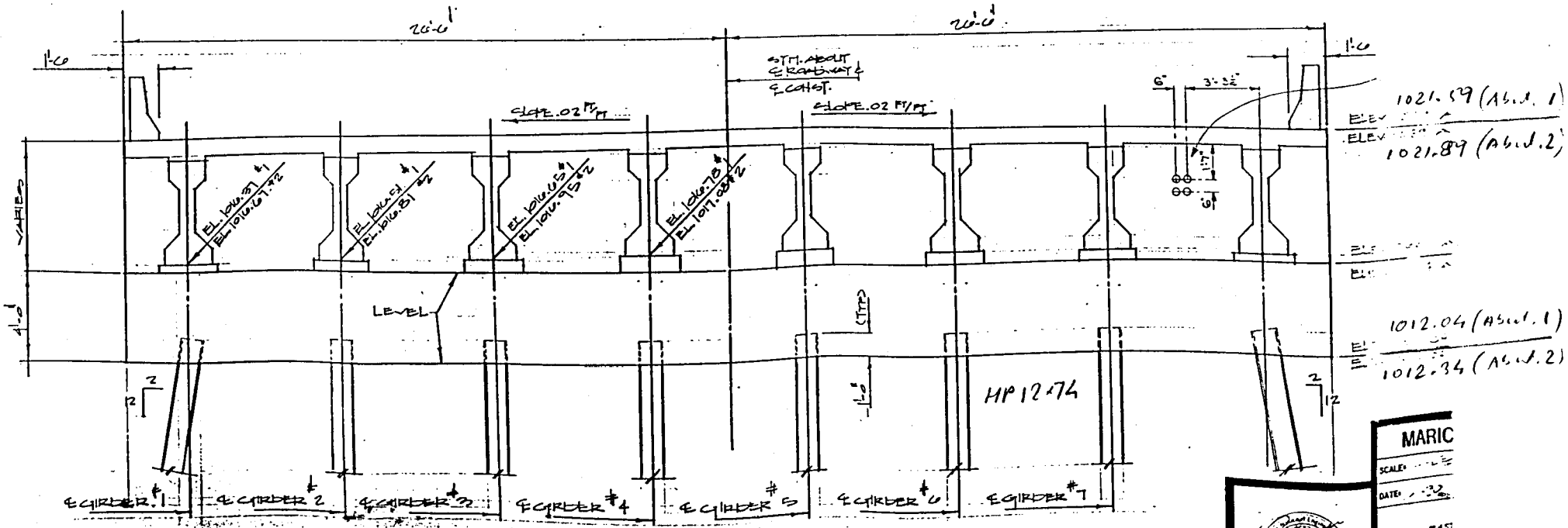
Abutment No. 2 (North) – Scour depth on Abutment No. 2 is longer than Abutment No. 1; therefore, this abutment fail the stability (pile slenderness) test.

Therefore, 51st Avenue bridge over Salt River **is scour critical**.

Feb. 18, 97



PLAN @ ABUTMENT



FRONT ELEVATION

(NOTE: ALL ELEV & BRNG')

DETAILS
AT FOR
PAGS

MARIC
SCALE:
DATE:
51
F.M. PLUMMER

51st Ave & Salt River

Table 2

100-Year Flood Existing Conditions	South Abutment	Pier	North Abutment
Local Scour	25.2 feet	17.5 feet	31.0 feet
Contraction	3.4 feet	3.4 feet	3.4 feet
Total Scour	**28.6 feet** ✓	**20.9 feet** ✓	**34.4 feet** ✓
Scour Elevation	~~967.0~~ 962.4	~~974.7~~ 970.1	~~961.2~~ 956.6
Remaining Pile Embedment	37.4 ~~42~~ feet	45.1 ~~50~~ feet	31.6 ~~36~~ feet

Overtopping Flood Existing Conditions	South Abutment	Pier	North Abutment
Local Scour	32.4 feet	18.5 feet	35.8 feet
Contraction	5.8 feet	5.8 feet	5.8 feet
Total Scour	**38.2 feet** ✓	**24.3 feet** ✓	**41.6 feet** ✓
Scour Elevation	952.8 ~~957.4~~	~~971.3~~ 966.7	~~954.0~~ 949.4
Remaining Pile Embedment	27.8 ~~32~~ feet	41.7 ~~46~~ feet	~~29~~ feet 24.4

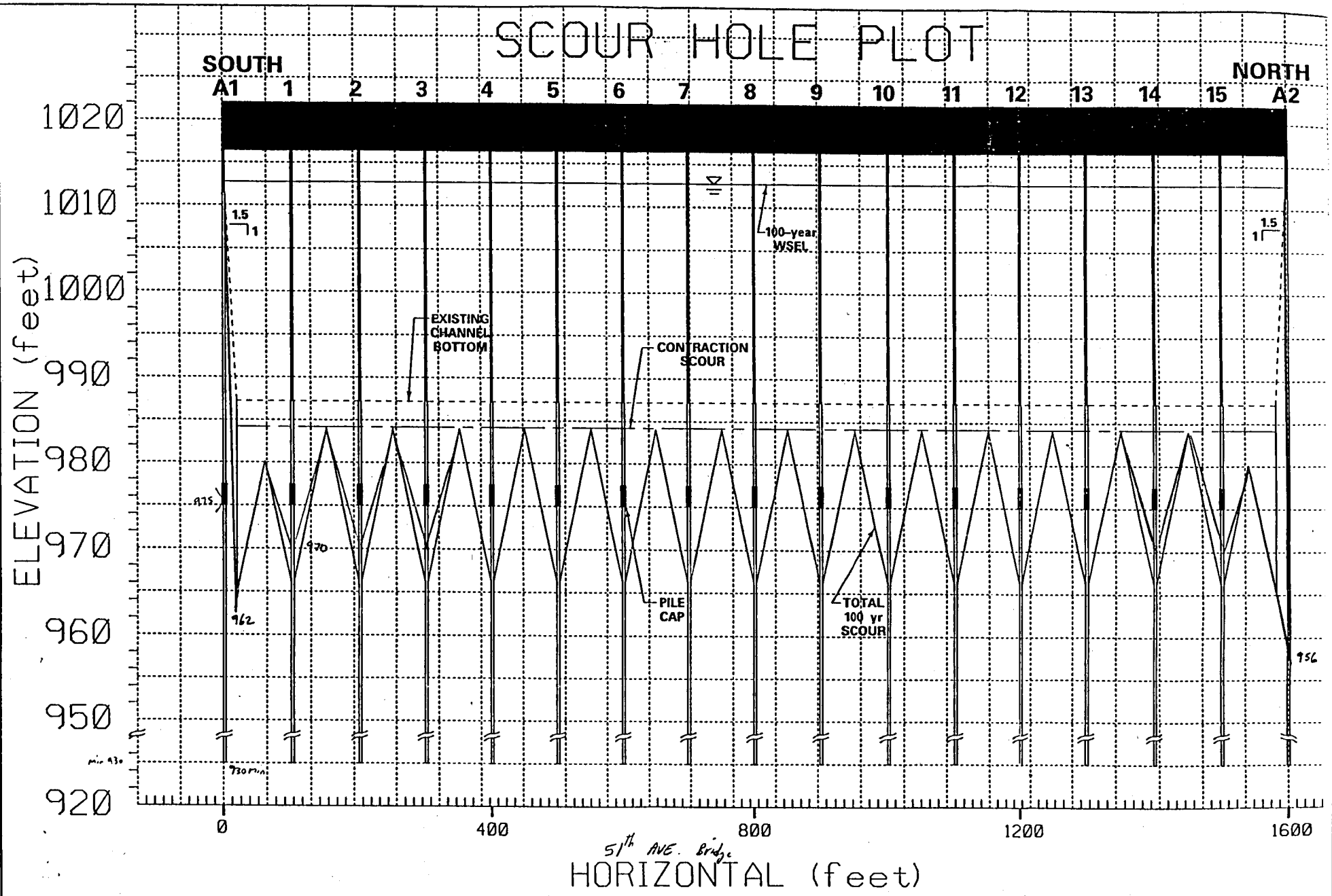
Assumes thalweg at Elevation ~~995.6~~ 991. 991.0 and Pile Tips at 925.0.

−4.6

Replace all by this amount (done In Red)

Rev's. – after speaking w/ Ray Jordan – FEB. 11, 97 (B.B.)

SCOUR HOLE PLOT



PREPARED BY ____ DATE ____
CHECKED BY ____ DATE ____
APPROVED BY ____ DATE ____

G:\PROJECTS\ARIZONA\SST.dgn
01/13/95

Parsons Brinckerhoff **Computation Sheet**

Subject 51th Ave Bridge

Page 1 of

Made by Ali

Date 7/9/96

Checked by

Date

- Superstructure 16-span Bridge AASHTO Type IV span length 100' max, 53' wide

  Consists of 4-span frames. $A = 790\ in^2$

- piers consists of 5-4'4 column on 20 HP 12X74 L=53± (2 Rows)

  Column Length 35'± To 41'±

- Pier cap 4'-6" wide x 4' Deep x 55' Long

- Pile cap 12' x 60' x 3'-9" Deep

Piers, appear to have the least depth of scour. Check pier stability. If pier is N.G., there is no need to check abutments;

Scour Elevations

	South Abutment	Pier	North Abutment
100-y storm	962.4	970.1	956.6
500-y storm	952.8	966.7	949.4

Parsons Brinckerhoff **Computation Sheet**

Subject: 51th Ave bridge

Page 2 of

Made by: Al

Date: 7-9-96

Checked by:

Date: 11. 3. 96

LOADS

DL : 8 - AASHTO IV

wt. = $8 \times \frac{790 in^2}{144} \times 0.15 \times 100' = 658^k$

Deck = $53' \times \frac{10''}{12} \times 0.15 \times 100' = 662^k$

CAP = $4.5 \times 4 \times 55 \times 0.15 = 150^k$

columns = $2^2 * \pi \times 41 \times 5 \times 0.15 = 390^k$

PileCAP = $12' \times 60 \times 3'9'' \times 0.15 = 405^k$

TOTAL = 2265^k per pier on Top of Piles

LIVE LOAD

No. of Lane $\frac{53'}{12 \; 14} = 4.4$ Lane Impact = 23%

Assume simple spans L = 100'

$R_{max} = 65.3^k * 4.4 \times 1.23 = \frac{353^k}{2 \; 4}$ Per AASHTO Page 643

Total: 2505 k per bent (ASW)

Parsons Brinckerhoff **Computation Sheet**

Subject: 51th Ave bridge

Page 3 of

Made by: Al

Date: 7-9-96

Checked by: [illegible]

Date: [illegible]

LOAD Cntd.

use: 0.3W + WL or W w/o LL

Wind Load = 50 PSF

$W = \frac{50}{1000} \times 100' \times (2'8" + 5.5') = 41^k$ per span $\times 0.3 = 12.3$

$WL = 100\ PLF * 100' = 10^k$ per span 10

51^k TOTAL WIND 22.3k

stream Force

$P_{avg} = k\ V_{avg}^2$ Assume V = 12 ft/sec For Salt river

k = 1.4 For Drift build up

$P = 1.4 \times 12^2 = 202$ PSF

$Force = \frac{202 \times 2}{2} \times \left(\frac{35'\ col.}{1000}\right)(4' + 8'\ Blk) = 85^k$

202 x 2

check per independent calculations, see next 3+3 = 6 pages = 89.3k

Disagreement is within the error of assumptions say OK. use Force = 85 k

PARSONS BRINCKERHOFF COMPUTATION SHEET

Page 30 of

Made by A. Wojaliesin

Date Nov. 3, 96

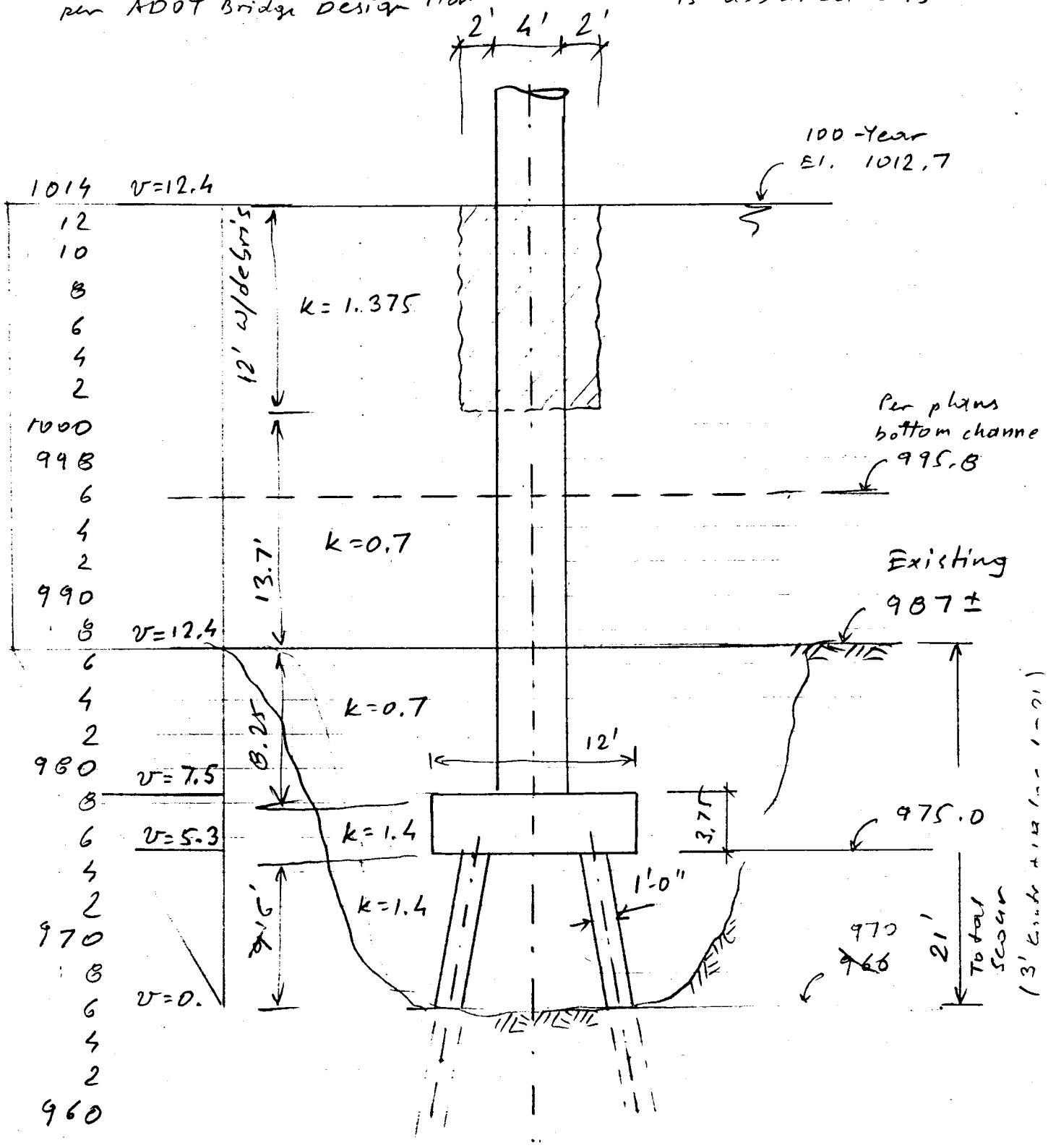
Checked by

Date

Subject Maricopa County DOT - scour analysis 51st Ave at Salt River

Stream Force per ADOT Bridge Design Manual

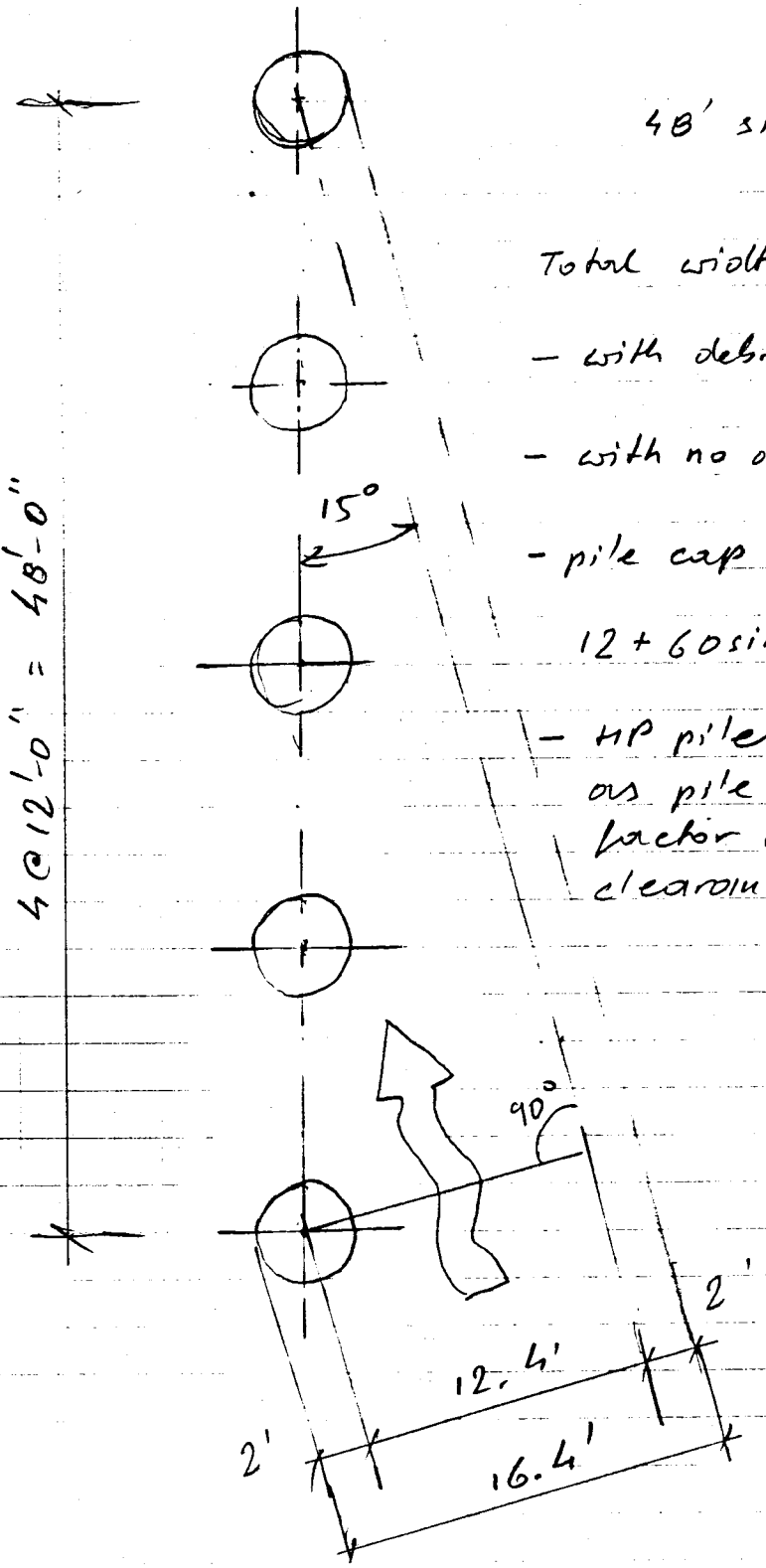
Minimum angle of attack is assumed = 15°



PARSONS BRINCKERHOFF COMPUTATION SHEET

Subject: Maricopa County DOT
Scour Analysis
51st Ave. @ Salt River

Page 3b of
Made by A. Wojalkevich
Date Nov. 3, 96
Checked by
Date



48' sin 15° = 12.4

Total width

- with debris 16.4+4 = 20.4'
- with no debris = 16.4'
- pile cap

12 + 60 sin 15° = 27.5'

- HP piles - assume same as pile cap with the factor of 0.5 for clearances between piles

= 13.8'

3

PARSONS BRINCKERHOFF COMPUTATION SHEET

Subject: Maricopa County DOT
Scour Analysis
51st Ave @ Salt River

Page 3c of
Made by A. Wojakiewicz
Date Nov. 3, 96
Checked by
Date

Total force acting in direction of flow (assumed 15° angle of attack)

a) Columns w/ debris

$$\overset{h}{12'} \times \overset{b}{20.4'} \times \overset{k}{1.375} \times 12.4^2 = \underline{51,756 \text{ lb}}$$

b) Columns w/o debris

$$13.7' \times 16.4 \times 0.7 \times 12.4^2 = \underline{24,183 \text{ lb}}$$

c) Columns w/o debris below channel bottom
average water velocity $= (12.4 + 7.5) \div 2 = 9.95$

$$8.25 \times 16.4 \times 0.7 \times 9.95^2 = \underline{9,377 \text{ lb}}$$

d) Pile caps $v_{av.} = (7.5 + 5.3) \div 2 = 6.4$ fps

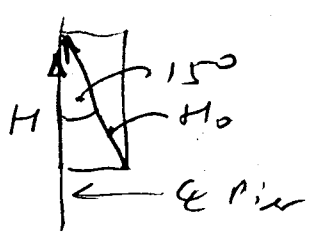
$$3.75 \times 27.5 \times 1.4 \times 6.4^2 = \underline{5,914 \text{ lb}}$$

e) HP piles $v_{av} = (5.3 + 0) \div 2 = 2.65$ fps

$$9.0 \times 13.8 \times 1.4 \times 2.65^2 = \underline{1,221 \text{ lb}}$$

Total stream force $H_o = \underline{92,451 \text{ lb}}$

Stream force acting along ℄ Pier



$$H = H_o \cos 15° = \underline{89.3 \text{ kip}}$$

1.2.1 TYPES OF LOADS (continued)

Stream Forces (AASHTO 3.18.1)

A Drainage Report shall be produced by Bridge Drainage Services or a consultant when appropriate for all stream crossings. The designer should review the Drainage Report for a full understanding of waterway considerations. The report should contain as a minimum the following information for both the critical flow and superflood conditions.

High water elevation
Mean Velocity
Scour Elevations (General and Local)
Angle of attack
Required bank protection
Special drainage considerations

For design for the most critical flow and the superflood condition, the following criteria shall be used unless more severe criteria is recommended in the Drainage Report.

Design calculations of stream forces on piers over natural water courses shall assume a 2 foot increase in pier width per side due to blockage by debris with a shape factor k = 1.375 for the first 12 feet of depth. For flows with depths greater than 12 feet, only the top 12 feet shall be assumed blocked by debris with lower sections using the actual pier width and a shape factor in accordance with AASHTO. For uncased drilled shafts, a 20% increase in diameter should be assumed to account for possible oversizing of the hole and any irregular shape. The force on the pier in the scour hole shall be assumed to vary linearly from the value at the channel floor to zero at the bottom of the scour hole.

When the clear distance between columns or shafts is 16 feet or greater, each column or shaft shall be treated as an independent unit for stream forces and debris. When the clear distance is less than 16 feet the greater of the two following criteria shall be used: 1) Each column or shaft acting as an independent unit or 2) All columns or shafts acting as one totally clogged unit with 2 foot of debris normal to the flow added on each end.

The mean main channel velocity for the appropriate flow condition shall be used in calculating the stream forces. The water surface elevation shall be the high water elevation for the appropriate flow condition. A minimum angle of attack of 15 degrees shall be assumed.

1.2.1 TYPES OF LOADS (continued)

Scour may be categorized into two types: general and local. General scour is the permanent loss of soil due to degradation or mining while local scour is the temporary loss of soil during a peak flow. Local scour may consist of two types: contraction scour and local pier or abutment scour. Contraction scour occurs uniformly across the bridge opening when the waterway opening of the bridge causes a constriction in the stream width. Local pier and abutment scour occurs locally at substructure units due to the turbulence caused by the presence of the substructure unit.

Bridges over natural water courses shall be investigated for four different streambed ground lines. Refer to Figure 2.1 for an illustration of these cases.

Case 1 is the as-constructed stream cross section. For this case, the bridge shall be designed to withstand the forces from the AASHTO Groups I to VII load combinations.

Case 2 represents the long term dry streambed cross section, i.e. the as-constructed stream cross section minus the depth of the general scour. For this case, the bridge shall be designed to withstand the same forces as for Case 1.

Case 3 represents the streambed cross section condition for the most critical design flow. Abutment protection is designed to withstand this event and abutments may be assumed to be protected from scour for this condition. Piers will experience the full general and critical flow local scour. For this case, the bridge shall be designed to withstand the forces from the AASHTO Groups I to VI load combinations.

Case 4 represents the streambed cross section conditions for the superflood condition. For this case, all bank protection and approach embankments are assumed to have failed. Abutments and piers should be designed for the superflood scour assuming all substructure units have experienced the maximum scour simultaneously. For this case, the bridge shall be designed to withstand the following forces: DL + SF + B + 0.5W. For members designed using the WSD Method an allowable overstress of 140% shall be used. For members designed using the LFD Method a gamma factor of 1.25 shall be used.

1.2.1 TYPES OF LOADS (continued)

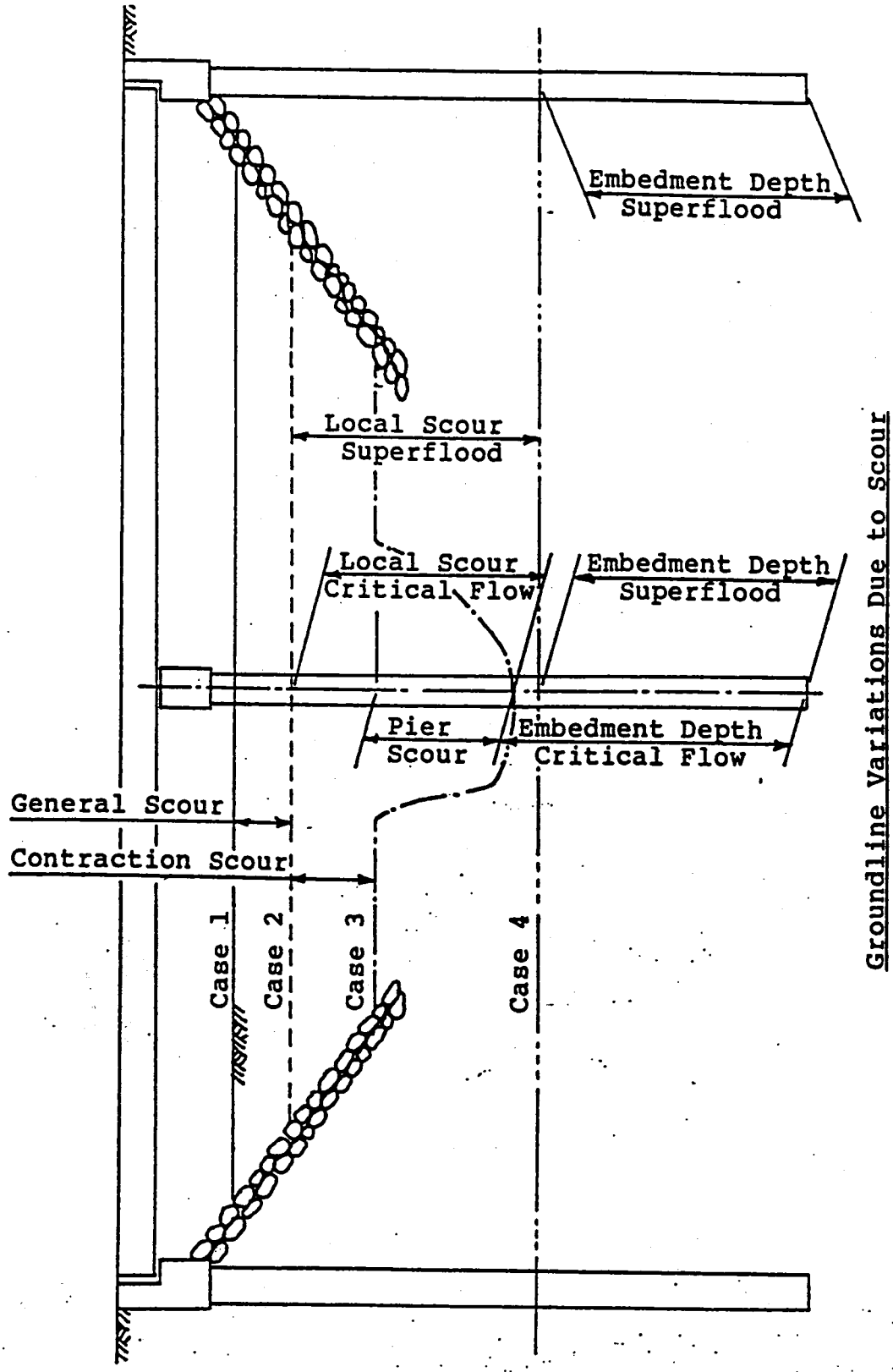


Figure 2.1

Parsons Brinckerhoff **Computation Sheet**

Subject: 51th Ave

Page 4 of

Made by: Ali

Date: 11-7-96

Checked by: ASLD

Date: Nov. 3, 96

Piles HP 12x74 $A = 21.8\ in^2$ $d = 12.12''$

$S_x = 93.4\ in^3$ $I_x = 566\ in^4$

$S_y = 30.2\ in^3$ $I_y = 185\ in^4$

Assume fixity point about 6' into ground

exposed pile length 9'±

TOTAL pile length ≈ 15'±

Revision Feb. 12, 97 per Drainage Section

5'

5+6 = 11' ±

ASLD 2/12/97

From strudl run

For a uniform load of 10 k/ft vertical &

concentrated load of 100 k/ft Horizontal

we have the following Forces on the two exterior piles each side of cap

AT point of Fixity $I = I_{CAP}$

LOAD 2 $P = 25.7^k$ $M = 0.166\ k\text{-}'$

LOAD 3 $P = \pm 206.5$ $M = \mp 103.5\ k\text{-}'$

results from run w/o KFY spring at pile tip - VOID.

Parsons Brinckerhoff **Computation Sheet**

Subject: 51th Ave bridge

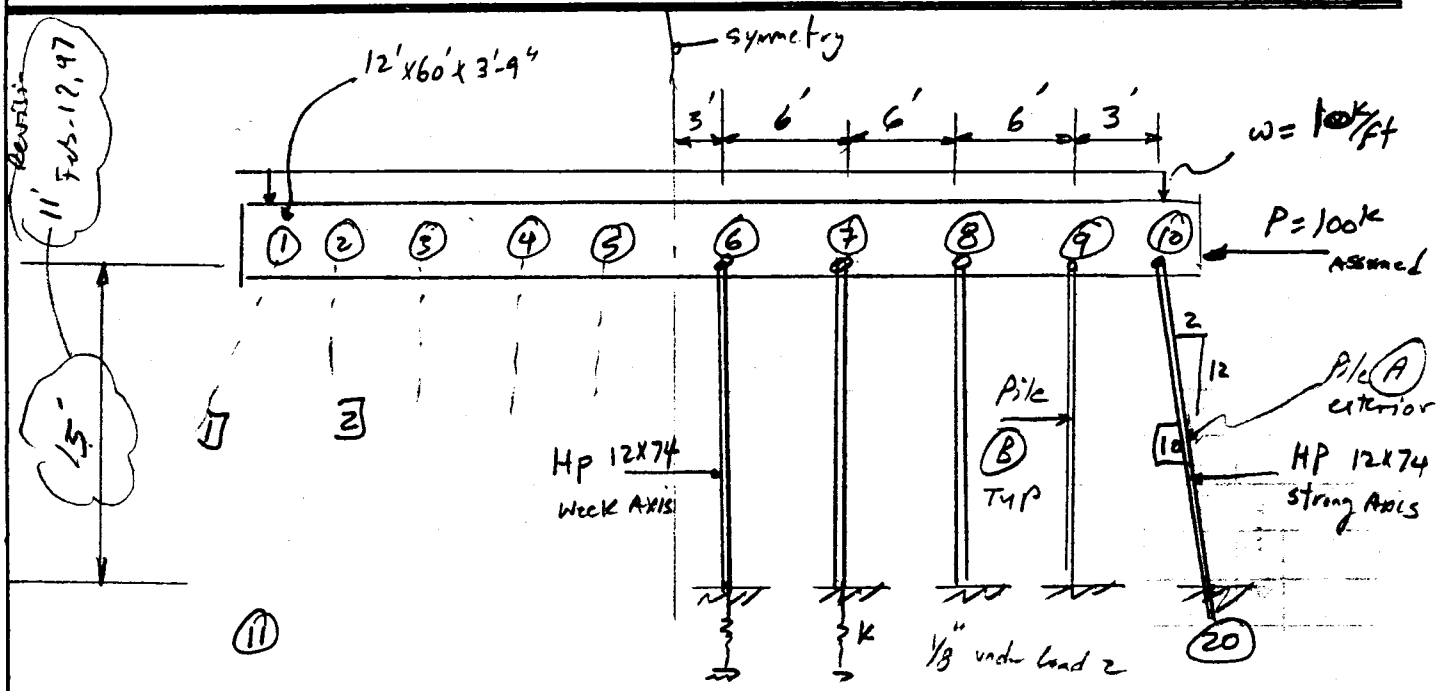
Page 5 of

Made by: Ali

Date

Checked by

Date



HP 12x74 $A = 21.8\ in^2$ $I_x = 566\ in^4$, $I_y = 185\ in^4$

CAP $A = 45\ ft^2 = 6480\ in^2$ $I = 52.73\ ft^4 = 1{,}093{,}500\ in^4$ (10000)

Pile A $A = 43.6\ in^2$ $I = 1132\ in^4$

Pile B $A = 43.6\ in^2$ $I = 370\ in^4$

PARSONS BRINCKERHOFF COMPUTATION SHEET

Page 5-1 of

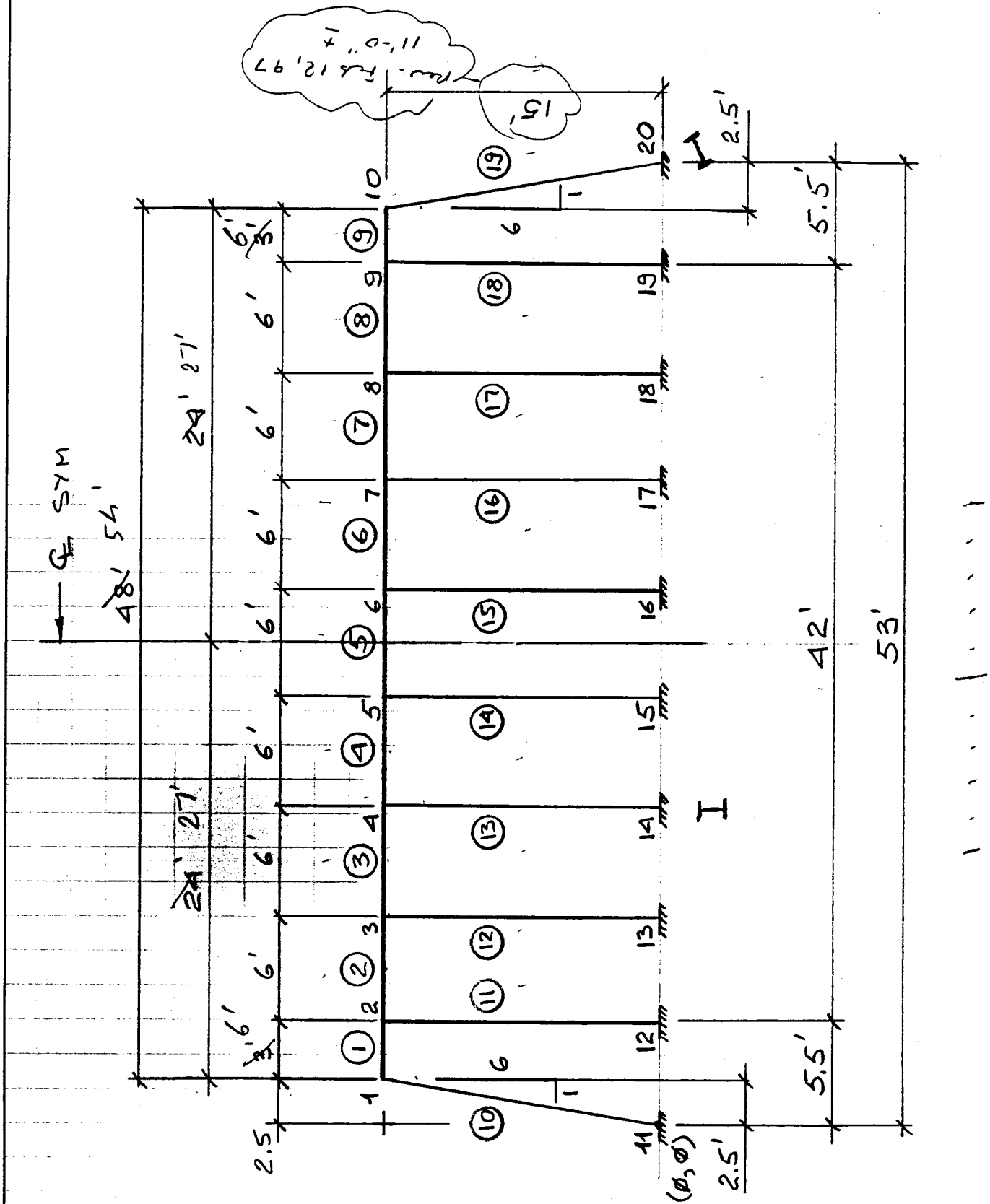
Made by A. MARSHTEYN

Date 11/06/96

Checked by

Date

Subject 51th AVE BRIDGE
Scour analysis



5-2

```
STRUDL 'P-CAP' '51AV BRIDGE PIER BENT SCOUR ANALYSIS'
*TITLE 'P-CAP:  51AV BRIDGE PIER BENT SCOUR ANALYSIS'

$*********************************************************************
$* PROBLEM DESCRIPTION:  HP 12x74 Piles & Pier Footing Cap Frame Model
$*                       at 51ave Bridge Pier Bent for Scour Ananlysis
$* File:    P-CAP.IN
$* Project:  51ave Bridge
$* Made by: A.Marshteyn
$* Date:    November 7, 1996
$*********************************************************************

UNITS KIP FT FAHRENHEIT

JOINT COORDINATES
   1        2.500        15.000        0.000
GENERATE 8 JOINTS  ID  2 INCR 1  X 5.500 INCR 6.000  Y 15.000
JOINT COORDINATES
  10       50.500        15.000        0.000
  11        0.000         0.000        0.000
GENERATE 8 JOINTS  ID 12 INCR 1  X 5.500 INCR 6.000  Y  0.000
JOINT COORDINATES
  20       53.000         0.000        0.000

STATUS SUPPORT JOINTS  11 TO 20
JOINT RELEASES
   11 TO 20  KFY  6000.0

TYPE PLANE FRAME

GENERATE  9 MEMBERS ID  1 INCR 1 FROM 1 INCR 1 TO 2 INCR 1
GENERATE 10 MEMBERS ID 10 INCR 1 FROM 11 INCR 1 TO 1 INCR 1

MEMBER RELEASES
 10 TO 19 END MOMENT Z

UNITS INCHES

MEMBER PROPERTIES
  1 TO  9   AX 6480.0  IZ 1093500.0
 11 TO 18   AX   43.6  IZ     370.0
 10 19      AX   43.6  IZ    1132.0

UNITS FT

CONSTANTS
   DENSITY 0.150    1 TO  9
   DENSITY 0.490   10 TO 19

UNITS INCHES

CONSTANTS
   E    3400.000    1 TO  9
   E   29000.000   10 TO 19

UNITS FT

LOAD 1 'VERTICAL UNIFORM LOAD ON CAP'
  MEMBER LOADS
   1 TO 9  FORCE Y GLOBAL UNIF W -10.000

LOAD 2 'HORIZONTAL LOAD ON CAP'
  JOINT LOADS
   1 FORCE X 100.000

STIFFNESS ANALYSIS

LOAD LIST ALL

OUTPUT DECIMAL 3
LIST REACTIONS FORCES
SECT FRA NS 3 0.00 0.50 1.00 MEMBERS  1 TO 19
```

```
LIST SECTION FORCES

OUTPUT DECIMAL 7
LIST DISPLACEMENTS

FINISH
```

5.3

5.4

```
{    2} > *TITLE 'P-CAP:  51AV BRIDGE PIER BENT SCOUR ANALYSIS'
{    3} >
{    4} > $*********************************************************************
{    5} > $* PROBLEM DESCRIPTION:  HP 12x74 Piles & Pier Footing Cap Frame Model
{    6} > $*                       at 51ave Bridge Pier Bent for Scour Ananlysis
{    7} > $* File:    P-CAP.IN
{    8} > $* Project:  51ave Bridge
{    9} > $* Made by: A.Marshteyn
{   10} > $* Date:    November 7, 1996
{   11} > $*********************************************************************
{   12} >
{   13} > UNITS KIP FT FAHRENHEIT
{   14} >
{   15} > JOINT COORDINATES
{   16} >    1          2.500          15.000          0.000
{   17} > GENERATE 8 JOINTS  ID  2 INCR 1  X 5.500 INCR 6.000  Y 15.000

  /-------   CARTESIAN COORDINATES      FREE, GLOBAL  -------/

      JOINT            X              Y              Z

        2            5.500          15.000          0.000
        3           11.500          15.000          0.000
        4           17.500          15.000          0.000
        5           23.500          15.000          0.000
        6           29.500          15.000          0.000
        7           35.500          15.000          0.000
        8           41.500          15.000          0.000
        9           47.500          15.000          0.000

{   18} > JOINT COORDINATES
{   19} >   10        50.500          15.000          0.000
{   20} >   11         0.000           0.000          0.000
{   21} > GENERATE 8 JOINTS  ID 12 INCR 1  X 5.500 INCR 6.000  Y  0.000

  /-------   CARTESIAN COORDINATES      FREE, GLOBAL  -------/

      JOINT            X              Y              Z

       12            5.500           0.000          0.000
       13           11.500           0.000          0.000
       14           17.500           0.000          0.000
       15           23.500           0.000          0.000
       16           29.500           0.000          0.000
       17           35.500           0.000          0.000
       18           41.500           0.000          0.000
       19           47.500           0.000          0.000

{   22} > JOINT COORDINATES
{   23} >   20        53.000           0.000          0.000
{   24} >
{   25} > STATUS SUPPORT JOINTS  11 TO 20
{   26} > JOINT RELEASES
{   27} >    11 TO 20  KFY  6000.0
{   28} >
{   29} > TYPE PLANE FRAME
{   30} >
```

5.5

```
{   31} > GENERATE  9 MEMBERS ID  1 INCR 1 FROM 1 INCR 1 TO 2 INCR 1

     /----------------  MEMBER INCIDENCES ----------------/

        MEMBER          INCIDENCES

       1            1         2
       2            2         3
       3            3         4
       4            4         5
       5            5         6
       6            6         7
       7            7         8
       8            8         9
       9            9         10

{   32} > GENERATE 10 MEMBERS ID 10 INCR 1 FROM 11 INCR 1 TO 1 INCR 1

     /----------------  MEMBER INCIDENCES ----------------/

        MEMBER          INCIDENCES

       10           11        1
       11           12        2
       12           13        3
       13           14        4
       14           15        5
       15           16        6
       16           17        7
       17           18        8
       18           19        9
       19           20        10

{   33} >
{   34} > MEMBER RELEASES
{   35} >  10 TO 19 END MOMENT Z
{   36} >
{   37} > UNITS INCHES
{   38} >
{   39} > MEMBER PROPERTIES
{   40} >   1 TO  9   AX 6480.0  IZ 1093500.0
{   41} >  11 TO 18   AX   43.6  IZ     370.0
{   42} >  10 19      AX   43.6  IZ    1132.0
{   43} >
{   44} > UNITS FT
{   45} >
{   46} > CONSTANTS
{   47} >    DENSITY 0.150    1 TO  9
{   48} >    DENSITY 0.490   10 TO 19
{   49} >
{   50} > UNITS INCHES
{   51} >
{   52} > CONSTANTS
{   53} >    E    3400.000    1 TO  9
{   54} >    E   29000.000   10 TO 19
{   55} >
{   56} > UNITS FT
```

5.6

```
{   57} >
{   58} > LOAD 1 'VERTICAL UNIFORM LOAD ON CAP'
{   59} >   MEMBER LOADS
{   60} >    1 TO 9  FORCE Y GLOBAL UNIF W -10.000
{   61} >
{   62} > LOAD 2 'HORIZONTAL LOAD ON CAP'
{   63} >   JOINT LOADS
{   64} >    1 FORCE X 100.000
{   65} >
{   66} > STIFFNESS ANALYSIS


BANDWIDTH INFORMATION BEFORE RENUMBERING.


THE MAXIMUM BANDWIDTH IS   10 AND OCCURS AT JOINT 11
THE AVERAGE BANDWIDTH IS                        5.450
THE STANDARD DEVIATION OF THE BANDWIDTH IS      4.555
                                           ----------
                                              10.005
                                           ==========


BANDWIDTH INFORMATION AFTER  RENUMBERING.


THE MAXIMUM BANDWIDTH IS    2 AND OCCURS AT JOINT 2
THE AVERAGE BANDWIDTH IS                        0.950
THE STANDARD DEVIATION OF THE BANDWIDTH IS      0.921
                                           ----------
                                               1.871
                                           ==========
TIME FOR CONSISTENCY CHECKS FOR     19 MEMBERS      0.00 SECONDS
TIME FOR BANDWIDTH REDUCTION                        0.00 SECONDS
TIME TO GENERATE     19 ELEMENT STIF. MATRICES      0.00 SECONDS
TIME TO PROCESS     10 MEMBER RELEASES              0.00 SECONDS
TIME TO PROCESS        9 MEMBER LOADS               0.00 SECONDS
TIME TO ASSEMBLE THE STIFFNESS MATRIX               0.06 SECONDS
TIME TO PROCESS     20 JOINTS                       0.00 SECONDS
TIME TO SOLVE WITH    5 PARTITIONS                  0.00 SECONDS
TIME TO PROCESS     20 JOINT DISPLACEMENTS          0.00 SECONDS
TIME TO PROCESS     19 ELEMENT DISTORTIONS          0.00 SECONDS
TIME FOR STATICS CHECK                              0.00 SECONDS
{   67} >
{   68} > LOAD LIST ALL
{   69} >
{   70} > OUTPUT DECIMAL 3
{   71} > LIST REACTIONS FORCES
```

5.7

****
RESULTS OF LATEST ANALYSES
****

PROBLEM - P-CAP TITLE - 51AV BRIDGE PIER BENT SCOUR ANALYSIS

ACTIVE UNITS FEET KIP RAD DEGF SEC

--- LOADING - 1 VERTICAL UNIFORM LOAD ON CAP ---

MEMBER FORCES

MEMBER	JOINT	FORCE AXIAL	FORCE SHEAR Y	FORCE SHEAR Z	MOMENT TORSIONAL	MOMENT BENDING Y	MOMENT BENDING Z
1	1	6.466	38.896				0.000
1	2	-6.466	-8.896				71.689
2	2	6.465	51.437				-71.689
2	3	-6.465	8.563				200.309
3	3	6.465	40.363				-200.309
3	4	-6.465	19.638				262.484
4	4	6.465	33.962				-262.484
4	5	-6.465	26.038				286.254
5	5	6.465	30.000				-286.254
5	6	-6.465	30.000				286.254
6	6	6.465	26.038				-286.254
6	7	-6.465	33.962				262.484
7	7	6.465	19.638				-262.484
7	8	-6.465	40.363				200.309
8	8	6.465	8.563				-200.309
8	9	-6.465	51.437				71.689
9	9	6.466	-8.896				-71.689
9	10	-6.466	38.896				0.000
10	11	39.430	0.017				0.255
10	1	-39.430	-0.017				0.000
11	12	42.540	0.000				0.006
11	2	-42.540	0.000				0.000
12	13	48.926	0.000				0.004
12	3	-48.926	0.000				0.000
13	14	53.599	0.000				0.003
13	4	-53.599	0.000				0.000
14	15	56.038	0.000				0.001
14	5	-56.038	0.000				0.000

15	16	56.038	0.000				-0.001
15	6	-56.038	0.000				0.000
16	17	53.599	0.000				-0.003
16	7	-53.599	0.000				0.000
17	18	48.926	0.000				-0.004
17	8	-48.926	0.000				0.000
18	19	42.540	0.000				-0.006
18	9	-42.540	0.000				0.000
19	20	39.430	0.017				0.255
19	10	-39.430	-0.017				0.000

RESULTANT JOINT LOADS SUPPORTS

JOINT		FORCE			MOMENT		
		X FORCE	Y FORCE	Z FORCE	X MOMENT	Y MOMENT	Z MOMENT
11	GLOBAL	6.466	38.896				0.255
12	GLOBAL	0.000	42.540				0.006
13	GLOBAL	0.000	48.926				0.004
14	GLOBAL	0.000	53.599				0.003
15	GLOBAL	0.000	56.038				0.001
16	GLOBAL	0.000	56.038				-0.001
17	GLOBAL	0.000	53.599				-0.003
18	GLOBAL	0.000	48.926				-0.004
19	GLOBAL	0.000	42.540				-0.006
20	GLOBAL	-6.466	38.896				-0.255

--- LOADING - 2 HORIZONTAL LOAD ON CAP ---

MEMBER FORCES

MEMBER	JOINT	FORCE			MOMENT		
		AXIAL	SHEAR Y	SHEAR Z	TORSIONAL	BENDING Y	BENDING Z
1	1	74.082	-46.461				0.000
1	2	-74.082	46.461				-139.382
2	2	68.054	-14.196				139.382
2	3	-68.054	14.196				-224.557
3	3	62.027	7.075				224.557
3	4	-62.027	-7.075				-182.105
4	4	56.001	18.941				182.105
4	5	-56.001	-18.941				-68.461
5	5	49.976	22.729				68.461
5	6	-49.976	-22.729				67.915
6	6	43.953	18.947				-67.915
6	7	-43.953	-18.947				181.596
7	7	37.929	7.092				-181.596

7	8	-37.929	-7.092	224.149
8	8	31.907	-14.160	-224.149
8	9	-31.907	14.160	139.186
9	9	25.885	-46.395	-139.186
9	10	-25.885	46.395	0.000
10	11	-50.089	17.927	272.614
10	1	50.089	-17.927	0.000
11	12	32.265	6.028	90.423
11	2	-32.265	-6.028	0.000
12	13	21.271	6.027	90.404
12	3	-21.271	-6.027	0.000
13	14	11.865	6.026	90.388
13	4	-11.865	-6.026	0.000
14	15	3.789	6.025	90.372
14	5	-3.789	-6.025	0.000
15	16	-3.783	6.024	90.359
15	6	3.783	-6.024	0.000
16	17	-11.855	6.023	90.347
16	7	11.855	-6.023	0.000
17	18	-21.253	6.022	90.337
17	8	21.253	-6.022	0.000
18	19	-32.235	6.022	90.328
18	9	32.235	-6.022	0.000
19	20	50.020	-17.906	-272.288
19	10	-50.020	17.906	0.000

RESULTANT JOINT LOADS SUPPORTS

JOINT		/----------FORCE----------//			----------MOMENT----------/		
		X FORCE	Y FORCE	Z FORCE	X MOMENT	Y MOMENT	Z MOMENT
11	GLOBAL	-25.918	-46.461				272.614
12	GLOBAL	-6.028	32.265				90.423
13	GLOBAL	-6.027	21.271				90.404
14	GLOBAL	-6.026	11.865				90.388
15	GLOBAL	-6.025	3.789				90.372
16	GLOBAL	-6.024	-3.783				90.359
17	GLOBAL	-6.023	-11.855				90.347
18	GLOBAL	-6.022	-21.253				90.337
19	GLOBAL	-6.022	-32.235				90.328
20	GLOBAL	-25.885	46.395				272.288

5.10

```
{   74} >
{   75} > OUTPUT DECIMAL 7
{   76} > LIST DISPLACEMENTS
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5.11

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****************************
*RESULTS OF LATEST ANALYSES*
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PROBLEM - P-CAP TITLE - 51AV BRIDGE PIER BENT SCOUR ANALYSIS

ACTIVE UNITS FEET KIP RAD DEGF SEC

--- LOADING - 1 VERTICAL UNIFORM LOAD ON CAP ---

RESULTANT JOINT DISPLACEMENTS SUPPORTS

JOINT		DISPLACEMENT X DISP.	Y DISP.	Z DISP.	ROTATION X ROT.	Y ROT.	Z ROT.
11	GLOBAL	0.0000000	-0.0064827				0.0000000
12	GLOBAL	0.0000000	-0.0070900				0.0000000
13	GLOBAL	0.0000000	-0.0081543				0.0000000
14	GLOBAL	0.0000000	-0.0089332				0.0000000
15	GLOBAL	0.0000000	-0.0093397				0.0000000
16	GLOBAL	0.0000000	-0.0093397				0.0000000
17	GLOBAL	0.0000000	-0.0089332				0.0000000
18	GLOBAL	0.0000000	-0.0081543				0.0000000
19	GLOBAL	0.0000000	-0.0070900				0.0000000
20	GLOBAL	0.0000000	-0.0064827				0.0000000

RESULTANT JOINT DISPLACEMENTS FREE JOINTS

JOINT		DISPLACEMENT X DISP.	Y DISP.	Z DISP.	ROTATION X ROT.	Y ROT.	Z ROT.
1	GLOBAL	0.0000070	-0.0069647				-0.0002118
2	GLOBAL	0.0000062	-0.0075947				-0.0002068
3	GLOBAL	0.0000044	-0.0087347				-0.0001682
4	GLOBAL	0.0000026	-0.0095691				-0.0001075
5	GLOBAL	0.0000009	-0.0100045				-0.0000367
6	GLOBAL	-0.0000009	-0.0100045				0.0000367
7	GLOBAL	-0.0000026	-0.0095691				0.0001075
8	GLOBAL	-0.0000044	-0.0087347				0.0001682
9	GLOBAL	-0.0000062	-0.0075947				0.0002068
10	GLOBAL	-0.0000070	-0.0069647				0.0002118

5.12

--- LOADING - 2 HORIZONTAL LOAD ON CAP ---

RESULTANT JOINT DISPLACEMENTS SUPPORTS

JOINT		DISPLACEMENT			ROTATION		
		X DISP.	Y DISP.	Z DISP.	X ROT.	Y ROT.	Z ROT.
11	GLOBAL	0.0000000	0.0077434				0.0000000
12	GLOBAL	0.0000000	-0.0053775				0.0000000
13	GLOBAL	0.0000000	-0.0035452				0.0000000
14	GLOBAL	0.0000000	-0.0019775				0.0000000
15	GLOBAL	0.0000000	-0.0006315				0.0000000
16	GLOBAL	0.0000000	0.0006304				0.0000000
17	GLOBAL	0.0000000	0.0019758				0.0000000
18	GLOBAL	0.0000000	0.0035421				0.0000000
19	GLOBAL	0.0000000	0.0053725				0.0000000
20	GLOBAL	0.0000000	-0.0077326				0.0000000

RESULTANT JOINT DISPLACEMENTS FREE JOINTS

JOINT		DISPLACEMENT			ROTATION		
		X DISP.	Y DISP.	Z DISP.	X ROT.	Y ROT.	Z ROT.
1	GLOBAL	0.0910227	-0.0068163				0.0003547
2	GLOBAL	0.0910126	-0.0057602				0.0003466
3	GLOBAL	0.0909941	-0.0037975				0.0003043
4	GLOBAL	0.0909772	-0.0021183				0.0002571
5	GLOBAL	0.0909620	-0.0006764				0.0002280
6	GLOBAL	0.0909484	0.0006753				0.0002279
7	GLOBAL	0.0909364	0.0021164				0.0002569
8	GLOBAL	0.0909261	0.0037942				0.0003040
9	GLOBAL	0.0909174	0.0057549				0.0003462
10	GLOBAL	0.0909138	0.0068098				0.0003543

5.13

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(   77) >
(   78) > FINISH
```

Parsons Brinckerhoff **Computation Sheet**

Subject: 51st Ave bridge
Center pile

Page 6 of
Made by: AL
Date: 11-7
Checked by:
Date:

AT point of Fixity $I_{CAP} \rightarrow \infty$

LOAD 2 $P = 39.4^{k}$ $M = 0.255^{k\text{-}'} \approx 0$

LOAD 3 $P = \mp 50^{k}$ $M = \pm 272.6^{k\text{-}'}$

see attached

Forces

AXIAL

$$DL = \frac{39.4^{k}}{10^{k/ft}} \times \frac{2265}{48'(2\ pile)} = 93^{k}$$

$$LL = \frac{39.4}{10} \times \frac{353}{48(2)} = 15^{k}$$

$$WIND = \frac{50^{k}}{100^{k}} \times \frac{51^{k}}{2\ pile} = 13^{k}$$

$$stream = \frac{50^{k}}{100^{k}} \times \frac{85^{k}}{2\ pile} = 21^{k}$$

MOMENT

$$WIND = \frac{273^{k\text{-}'}}{100^{k}} \times \frac{51}{2} = 70^{k\text{-}'}$$

$$stream = \frac{273^{k\text{-}'}}{100^{k}} \times \frac{85}{2} = 116^{k\text{-}'}$$

redo

PARSONS BRINCKERHOFF COMPUTATION SHEET

Page ____ of ____

Made by A. Wojtkiewicz

Date Nov. 8, 76

Checked by

Date

Subject Maricopa County DOT
Scour Analysis
51st Ave. over Salt River

Check HP piles by ASD method

Group I

Axial: $\frac{39.4}{10.0}\left(\frac{2265}{48\times2}+\frac{240}{48\times2}\right)+\frac{50}{100}\,\frac{85}{2} = 124.0\ k$

Moment: $\frac{273}{100}\left(0+0+\frac{85}{2}\right) = 116.0\ k\text{-}'$

Group II

Axial: $\frac{39.4}{10.0}\times\frac{2265}{48\times2}+\frac{50}{100}\left(\frac{85}{2}+\frac{41}{2}\right) = 124.5\ k$

Moment: $0+\frac{273}{100}\left(\frac{85}{2}+\frac{41}{2}\right) = 172.0\ k\text{-}'$

Group III

Axial: $\frac{39.4}{10.0}\left(\frac{2265}{48\times2}+\frac{240}{48\times2}\right)+\frac{50}{100}\left(.3\,\frac{41}{2}+\frac{10}{2}+\frac{85}{2}\right) = 129.6\ k$

Mom.: $0+0+\frac{273}{100}\left(0.3\,\frac{41}{2}+\frac{10}{2}+\frac{85}{2}\right) = 146.5\ k\text{-}'$

$$C_c=\sqrt{\frac{2\pi^2E}{F_y}}=\sqrt{\frac{2\pi^2\,29000}{36}}=126.1$$

$$\frac{Kl}{r}=\frac{0.8\times\cancel{15}^{\,11}\times12}{2.92}=\cancel{49.32}\ 34.17$$

$$\frac{\frac{Kl}{r}}{C_c}=0.3911$$

2

PARSONS BRINCKERHOFF COMPUTATION SHEET

Subject: Maricopa County DOT
Scour Analysis
51st. Ave over Salt River

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Made by: A. Najafi
Date: Nov. 8, 96
Checked by: ____
Date: ____

(E2-1)
$$F_a = \frac{\left[1 - \frac{(Kl/r)^2}{2C_c^2}\right]F_y}{\frac{5}{3} + \frac{3}{8}\frac{Kl/r}{C_c} - \frac{(Kl/r)^3}{8C_c^3}} =$$

$$= \frac{1 - \frac{1}{2}(0.3911)^2}{\frac{5}{3} + \frac{3}{8}(0.3911) - \frac{1}{8}(0.3911)^3} \cdot F_y = \frac{0.9235F_y}{1.8059} =$$

$$= 0.5114\ F_y = 18.41 \text{ ksi}$$

$$f_a = \frac{129.6}{21.8} = 5.95 \text{ ksi}$$

$$\frac{f_a}{F_a} = \frac{5.95}{18.41} = 0.32 > 0.15 \Rightarrow \text{use } H1\text{-}1 \ \& \ H1\text{-}2$$

$$F'_e = \frac{12\pi^2 E}{23\left(\frac{Kl}{r}\right)^2} = \frac{12\pi^2 \times 29\,000}{23\left(\frac{0.8 \times 15 \times 12}{5.11}\right)^2} = 188.0$$

find: F_b

$$L_c = \frac{76 b_f}{\sqrt{F_y}} = \frac{76 \times 12.2}{6} = 154''$$

$$L_c = \frac{20\,000}{\frac{d}{A_f} \cdot F_y} = \frac{20\,000}{\frac{12}{12 \times 0.61} \cdot 36} = 339$$

$$= 154''$$

$$L_b = 12 \times 15 = 180 > 154$$

3

PARSONS BRINCKERHOFF COMPUTATION SHEET

Subject: Maricopa County DOT
Scour Analysis
51st Ave over Salt River

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Made by: A. Wojalica
Date: Nov. 8, 96
Checked by: ____
Date: ____

(F1-8) $$F_b = \frac{12\times10^3\times C_b}{\frac{\ell d}{A_f}} = \frac{12\,000\times1.75}{\frac{12\times15\times12}{12\times0.61}} = 71.1 \text{ psi}$$

$$\frac{\ell}{r_T} = \frac{15\times12}{3.26} = 55.2$$

$$\sqrt{\frac{102\times1000\times1.75}{36}} = 70.4$$

$$F_b = \left(\frac{2}{3} - \frac{36(55.2)^2}{1530\times1000\times1.75}\right)F_y = 0.6257\,F_y$$

use $F_b = 0.6\,F_y$

Group I: $$f_a = \frac{124,000}{21.8} = 5.69 \text{ ksi}$$

$$f_b = \frac{12\times116}{93.8} = 14.84 \text{ ksi}$$

(H1-1) $$\frac{5.69}{18.41} + \frac{0.85\times14.84}{\left(1-\frac{5.69}{188}\right)0.6\times36} = 0.91 < 1.0$$

(H1-2) $$\frac{5.69}{0.6\times36} + \frac{14.86}{0.6\times36} = 0.95 < 1.0$$

PARSONS BRINCKERHOFF COMPUTATION SHEET

Subject: Maricopa County DOT
Scour Analysis
51st Ave. over Salt River

Page ____ of ____
Made by: A. Wojslaw
Date: Nov. 8, 96
Checked by: ____
Date: ____

Group II: $f_a = \frac{124.5}{21.8} = 5.71$ ksi

$$f_b = \frac{172.0 \times 12}{93.8} = 22.0 \text{ ksi}$$

(H1-1) $$\frac{5.71}{18.41} + \frac{0.85 \times 22.0}{\left(1 - \frac{5.71}{188}\right) 0.6 \times 36} = 1.203 > 1.0$$

(H1-2) $$\frac{5.71}{18.41} + \frac{22.0}{0.6 \times 36} = 1.33 > 1.0$$

Use provision A5.2 - divide ~~fore~~ stresses by 1.3

(H1-1) $$\ldots = \frac{1.203}{1.3} = 0.925 < 1.0$$

(H1-2) $$\ldots = \frac{1.33}{1.3} = 1.023 > 1.0$$

$0.975 < 1.0$ ~~No good~~

1.25 ← AASHTO Chapter 3

5

PARSONS BRINCKERHOFF COMPUTATION SHEET

Page ____ of ____

Made by A. Wojaliani

Date Nov-8, 96

Checked by ____

Date ____

Subject Maricopa County DOT
Scour Analysis
51st Ave over Salt River

Group III $\quad f_a = \dfrac{129.6}{21.8} = 5.95$ ksi

$$f_b = \frac{12 \times 146.5}{93.8} = 18.74 \text{ ksi}$$

(H1-1) $\quad \dfrac{5.95}{18.41} + \dfrac{0.85 \times 18.74}{\left(1 - \dfrac{5.95}{188}\right) 0.6 \times 36} = 1.08 \rightarrow 1.0$

0.66

(H1-2) $\quad \dfrac{5.95}{0.6 \times 36} + \dfrac{18.74}{0.6 \times 36} = 1.14 > 1.0$

0.66

Use provision A5.2 - divide stresses by 1.3

(H1-1) $\quad \dfrac{0.998}{1.3} = 0.77 < 1.0$

(H1-2) $\quad \dfrac{1.039}{1.3} = 0.80 < 1.0$

OK.

- For 100 year storm, Pier is OK
- By inspection, (see Group II loading), for 500 year storm, Pier is no good.

INCA ENGINEERS INC.

July 12, 1995

Simons, Li & Associates, Inc.
4600 South Mill Avenue
Suite 200
Tempe, Arizona 85282

Attention: Mr. Bart S. Bergendahl, P.E.

Subject: Local Government Bridge Scour Evaluation Study

Dear Mr. Bergendahl:

This letter is submitted in order to explain the assumptions and qualifications for Table 1, "Guidelines for Allowable Unsupported Length" in the Phase I report for the Local Government Bridge Scour Evaluation Study. This table gives the maximum unsupported length allowable based on the structural capacity of the pile for assumed axial loads. It should be emphasized that the pile material property, end conditions, and applied load assumptions are generic and should be superseded when site specific information is obtained.

1. ASSUMED END CONDITIONS

The allowable unsupported lengths are calculated for steel H-piles, steel pipe piles, steel fluted tapered piles, reinforced concrete piles, prestressed concrete piles, drilled shafts, and timber piles. The piles are conservatively assumed to be vertical, have 50% fixity at the top, not braced against sidesway, and fixed at the base of an equivalent cantilever as defined in CALTRANS Bridge Design Aids 12-33 (copy attached). Therefore, in the slenderness ratio, KL/r, K is assumed to be 1.5. An exception is made for timber piles where a pinned condition is assumed at the top and K equal 2.0 is used.

2. ASSUMED LOADS

The axial load, P, is assumed equal to the pile loads given in CALTRANS Bridge Design Specifications (BDS) Table 4.3.4.5 "Assumed Pile Loads" except that 9 ksi is used for the bearing capacity of rock for all steel piles (copy attached). Pile loads given in CALTRANS BDS are considered to be

1702 East Highland Avenue, Suite 207 Phoenix, AZ 85016 (602) 277-8161 (FAX) 277-8163

representative of pile loads that will be encountered during Phase II of the Scour Study. Lateral load on the piles is not included.

3. MAXIMUM UNSUPPORTED LENGTHS

The unbraced lengths are calculated using the assumed axial loads and AASHTO Standard Specifications for Highway Bridges except that a factor of safety for stress of 1.3 is used. The unbraced lengths given in Table 1 are for an equivalent free standing column as defined in CALTRANS Bridge Design Aid 12-33. The unbraced length calculations consider both slenderness and axial stresses.

In regions where the foundation design is governed by seismic loading, only half the maximum anticipated scour need be considered when determining the allowable unsupported pile length per AASHTO 4.4.5.2.

4. INTENDED USE OF TABLE 1

The allowable unsupported lengths given in Table 1 may be used to identify the most scour critical deep foundations. Foundations that do not satisfy the unsupported length criteria of Table 1 can be declared "scour critical". Deep foundations that do satisfy Table 1 requirements shall be subjected to further analysis to determine whether or not they are scour critical.

Sincerely,

INCA Engineers, Inc.

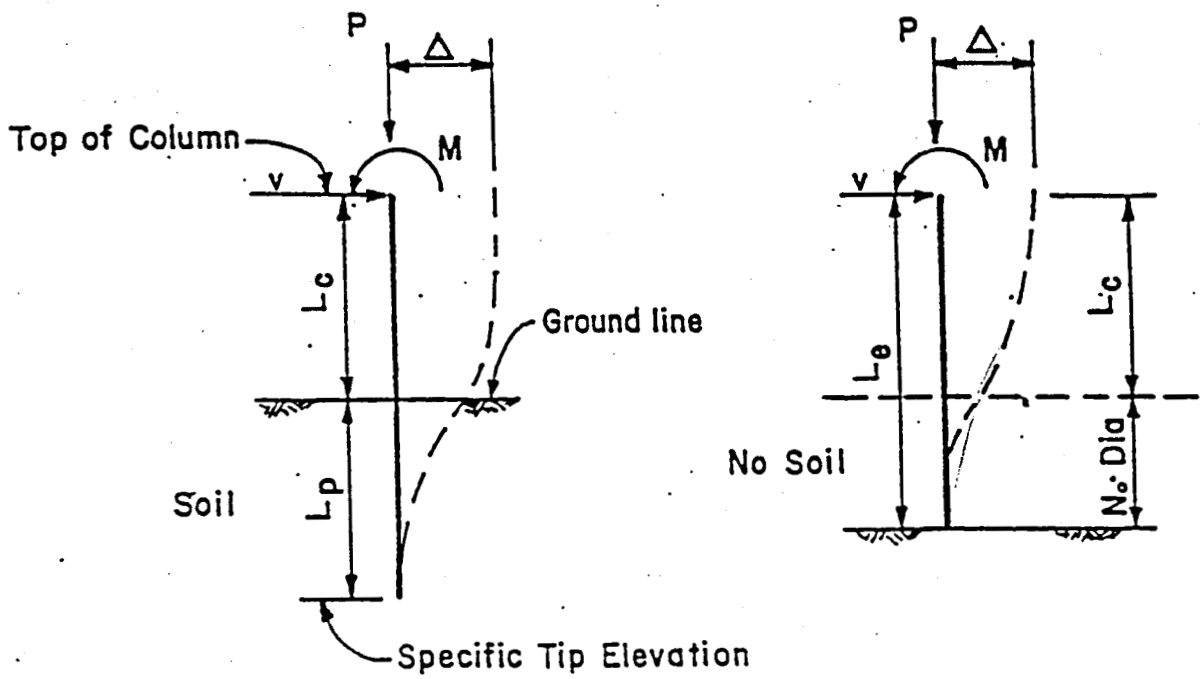
Mark E. Wavering

Mark Wavering, P.E.
Project Manager

Registered Professional Engineer (Civil)
CERTIFICATE No. 21872
MARK E. WAVERING
Date Signed 7/14/
ARIZONA, U.S.A.

enclosure: CALTRANS Bridge Design Aids 12-33
CALTRANS Bridge Design Specification Table 4.3.4.5
Table 1
Figure 2

1. Determine an equivalent column length. The equivalent length (Le) of a column/pile shaft member is defined as that length of column (Lc) plus pile shaft (Lp) which when fixed at the bottom will produce the same deflections at the top of the column for a given load as the actual column plus shaft surrounded by soil. The equivalent column has the same EI as the actual column. The analysis of the bridge supported by columns in the soil can be carried out if the columns of the bridge are adjusted to the equivalent length, thus eliminating the soil from the problem.



(d) For steel H-piles and unfilled tubular steel piles, 10,000 psi times the net cross section area of the pile tip, not including the area of any pile tip reinforcement. Net section = gross section less $1/16$ inch from all surfaces.

(e) For prestressed concrete piles fully embedded in soils providing lateral support, a stress of $0.33 f'_c - 0.27 f_{ce}$ times the gross cross sectional area of the concrete where f_{ce} is the concrete stress in the pile due to prestressing, after all losses.

4.3.4.3.2 Friction Piles

4.3.4.3.2.1 A pile shall be considered to be a friction pile if its point does not rest on or in material that is capable of developing the pile load by direct bearing at the point.

4.3.4.3.2.2 The load-carrying capacity of friction piles shall be determined by one or more of the following methods:

(a) Dynamic pile driving analysis.
(b) Pile load testing.
(c) Pile-driving experience in the vicinity. When piles are designed on the basis of experience in the vicinity, due consideration will be given to the variation in pile types and lengths, and to the variation of the soil strata. Where possible, the complete driving records of all piles in the vicinity shall be examined and compared with the driving records of the project piles.
(d) Adequate tests of the soil strata through which the pile is to be driven. These tests should be projected and compared, if possible, with tests of similar material through which piles of known capacity have been driven.

4.3.4.4 Case C – Capacity of the Ground to Support the Load Delivered by the Pile

4.3.4.4.1 For the evaluation of the capacity of the ground, preference shall be given to test loading or satisfactory subgrade investigation.

4.3.4.4.2 In the absence of pile tests, the capacity of the ground to support the load delivered by the pile shall be determined from the results of the applicable subsurface investigations.

4.3.4.4.2.1 Point-Bearing Piles

Sufficient borings shall be made to determine the thickness and quality of the stratum in which the point bearing is to be developed. If that stratum is of sufficient thickness and is underlain by a firm material, no reduction need be made for group action of piles. In general, piles should not rest on a thin stratum of hard material that is underlain by a thick stratum of soft or yielding material, but where this condition cannot be avoided, group action should be considered and the design loads reduced accordingly.

4.3.4.4.2.2 Friction Piles

4.3.4.4.2.2.1 Borings shall be carried well below the tips of the piles in order to determine the characteristics of the underlying material. In most cases a study of those borings will suffice to determine whether or not the underlying soil will support the loads to be delivered to it, but in doubtful or special cases, especially large foundation areas and important footings, the material should be investigated more thoroughly by soil mechanics methods.

4.3.4.4.2.2.2 A single row of piles shall not be considered as a group provided that they are not spaced closer center to center than $2\frac{1}{2}$ times the nominal diameter or dimension. In those cases where piles are driven in groups into plastic material, the design load shall be determined by the loading of a group of piles or an allowance shall be made according to Article 4.3.4.7 for the difference between the supporting capacity of a single pile and that of a group of piles.

4.3.4.5 Maximum Design Loads for Piles

4.3.4.5.1 In those cases where it is not feasible to make the required subsurface investigations or test loads, the maximum assumed design load for piles shall be as given in the Table 4.3.4.5. These values may be increased for certain combinations of loads as specified in Article 3.22.

4.3.4.5.2 The assumed allowable design loads for driven pile shall be substantiated by analysis of the actual driving of the pile.

Table 4.3.4.5 Assumed Pile Loads

Size or Diameter at Butt[a] (inches)	Type of Piles			
	Timber (tons)	Concrete (tons)	Steel (Friction) (tons)	Steel Point-Bearing
8	—	—	16	10,000 lb. per sq. in. of point area, not including the area of any pile reinforcement.
10	20	20	20	
12	24	24	24	
14	28	28	28	
16	32	32	—	
20	—	40	—	
24	—	50	—	

[a] Timber piles, diameter to be measured 3 feet from butt.

4.3.4.6 Uplift

4.3.4.6.1 Friction piles may be considered to resist an intermittent but not sustained uplift. Resistance may be equivalent to 40 percent of both the allowable and the ultimate compressive load capacity, except that for seismic loads it may be equivalent to 50 percent of the ultimate compressive load. Adequate pile anchorage, tensile strength, and skin friction must be provided. In no case shall the uplift exceed the weight of material (buoyancy considered) surrounding the embedded portion of the pile.

4.3.4.6.2 In seals, the bond between timber, steel, or concrete piles and surrounding concrete may be assumed to be 10 pounds per square inch. The total bond force used shall be no greater than the resistance of the pile to uplift.

4.3.4.7 Group Pile Loading

The capacity for a group of piles shall be determined by an analysis of subsurface conditions.

4.3.4.8 Lateral Resistance

Lateral resistance of piles fully embedded in soil with a standard penetration resistance value, *N*, of 10 and with a ¼ inch maximum horizontal deflection under Service Load shall be:

CIDH Concrete (16") ..... 13 kips
Driven Concrete (15") ..... 13 kips
Driven Concrete (12") ..... 5 kips
Steel (12" or 10" flange) ..... 5 kips
Steel (8" flange) ..... 4 kips
Timber ..... 5 kips

The lateral resistance of piles not within these criteria shall be determined by geotechnical analysis and structural adequacy of the pile.

At bent and pier footings the number of piles required for lateral pile resistance shall not be governed by Group VII loads.

The horizontal component of a battered pile's axial load may be added to the lateral resistance.

4.3.5 Required Subsurface Investigations

4.3.5.1 Point-Bearing Piles

Sufficient borings shall be made to determine the presence, position, and thickness of the material which is capable of developing point bearing, and the log of borings shall show the nature of the overlying strata in order that the extent of lateral support may be determined. If the point-bearing stratum is of doubtful thickness and quality, the borings shall be made to such sufficient depth below this stratum that the capacity of a friction pile may be determined.

4.3.5.2 Friction Piles

Borings shall be made to an elevation well below the expected elevation of the pile tips and accurate logs of these borings shall be made. In those cases where the piles are to be designed on the basis of soil tests, undisturbed samples shall be taken on all strata that will have appreciable influence on the capacity of the pile.

4.3.5.3 Combination Point-Bearing and Friction Piles

Piles shall classified as either (1) point-bearing or (2) friction. Those cases, in which adequate strength is developed by both point-bearing and friction, may be designed under either of these classifications.

4.3.5.4 Scour

Subsurface investigations shall be made that will determine the probable depth of scour or flotation of material and the condition of lateral support of the pile.

TABLE 1

GUIDELINES FOR ALLOWABLE UNSUPPORTED LENGTH

TYPE	ALLOWABLE UNSUPPORTED LENGTH	COMMENTS
HP 8 x 36 HP 10 x 42 HP 12 x 53 HP 14 x 73	16' 20' 24' 30'	Assumed P = 95.4 k Assumed P = 111.6 k Assumed P = 139.5 k Assumed P = 192.6 k
Pipe piles: 10" diam. 12" diam. 14" diam.	 29' 35' 41'	 Assumed P = 68.9 k Assumed P = 103.1 k Assumed P = 120.8 k
14" steel fluted tapered pile	38'	Assumed P = 56 k, Fy = 50 ksi
Prestressed or reinforced concrete piles	19 x width (square) 16 x dia. (round)	Limited to KL/r = 100
Drilled Shafts	16 x dia.	Limited to KL/r = 100
Timber: 12" butt 14" butt 16" butt 18" butt	 14' 17' 20' 24'	Douglas Fir, Coast Type or Southern Pine Assumed P = 48 k Assumed P = 56 k Assumed P = 64 k Assumed P = 72 k

Notes: 1) Unsupported length = bot. of pile cap - thalweg + dist. to point of pile fixity (equivalent cantilever) + anticipated scour

2) All axial loads, P, are service loads.

3) Allowable unsupported length is calculated for load or KL/r ratio given.

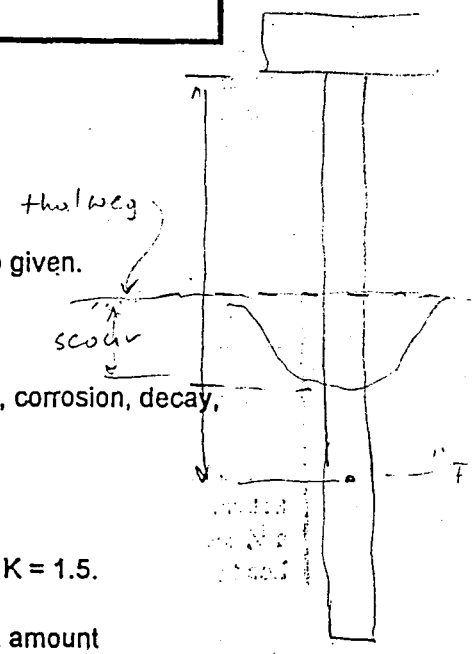
4) No lateral load is considered. F.S. = 1.3 (NOT per AASHTO).

5) No reduction is included for possible member degradation (e.g., corrosion, decay, damage).

6) Assumed Fy = 36 ksi unless noted otherwise.

7) Assumed K = 2.0 for timber piles. For all other piles, assumed K = 1.5.

8) Concrete piles and drilled shafts are assumed to have constant amount of reinforcing over their full lengths.



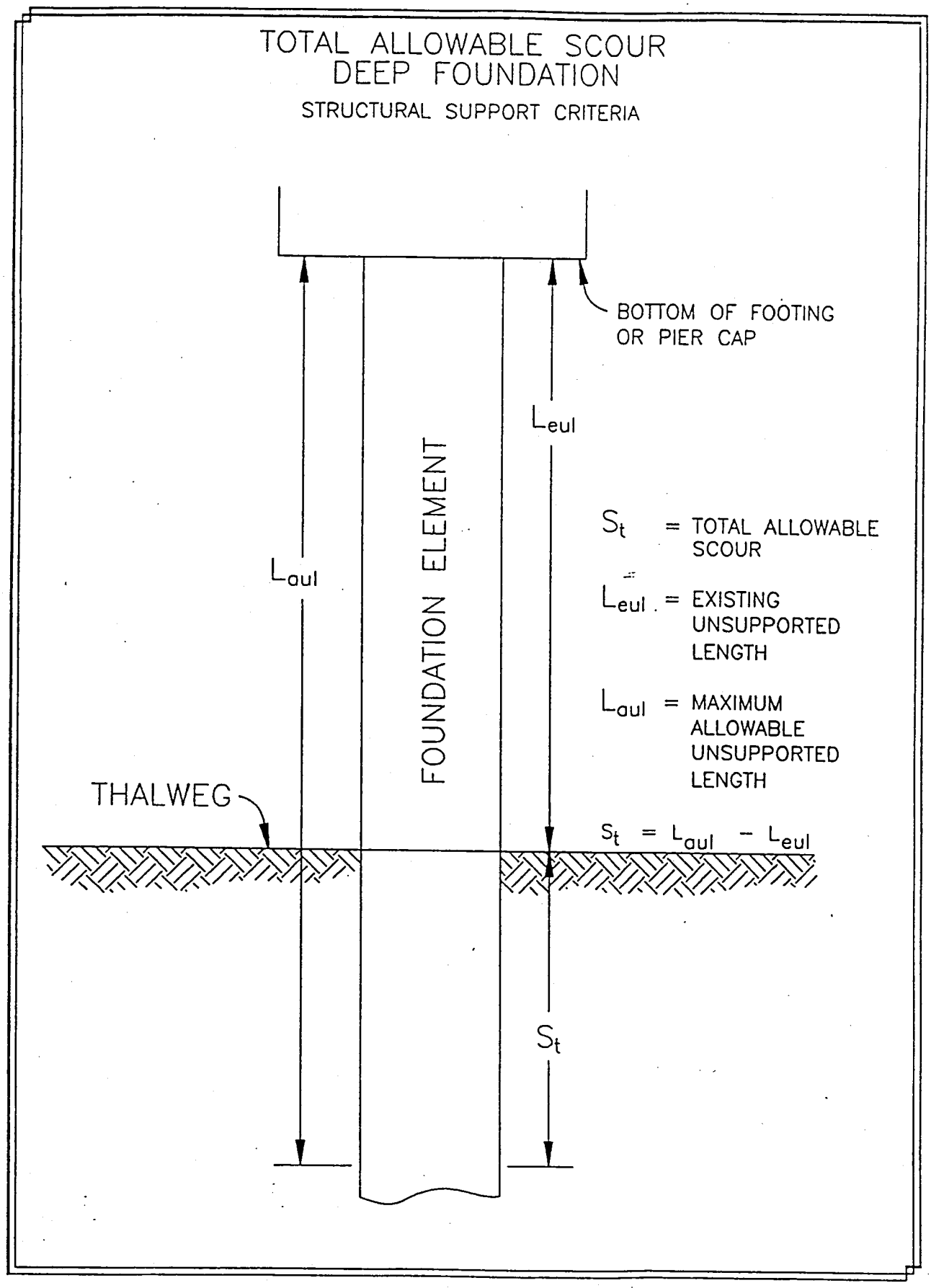


Figure 2
Total Allowable Scour – Deep Foundations (Criteria A)

PARSONS BRINCKERHOFF COMPUTATION SHEET

Subject: MC DOT - Scour Analysis
51 st Ave at Salt River

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Checked by: ____
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Abutment #1 (South check) 100-y storm

Loads

			kip
DL	girders	$8 \frac{790}{144} \times 0.155 \times \frac{100'}{2}$ =	340.1
	deck	$53' \times \frac{10}{12} \times 0.15 \frac{100}{2}$ =	331.3
	barriers	$2 \times 0.8 \times \frac{100}{2}$ =	80.0
	cap	$53' \times 4' \times 3.33' \times 0.15$ =	105.9
	End diaphragm	$53' \times 4.5' \times 1.5' \times 0.15$ =	53.7
			911 k

LL No of lanes

$\frac{50}{12} = 4.17 \Rightarrow 4$

$4 \times 0.75 = 3$ lanes for substructure design
no impact factor

$R_{max} = 3 \times 65.3$ = 195.9 k

Wind on superstructure (50 psf)

$W = 0.05 \times \frac{100'}{2} [(2'-8'') + (5'-6'')] = 20.4$ k

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Subject: MC DOT – Scour Analysis
51st Ave & Salt River

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Date:

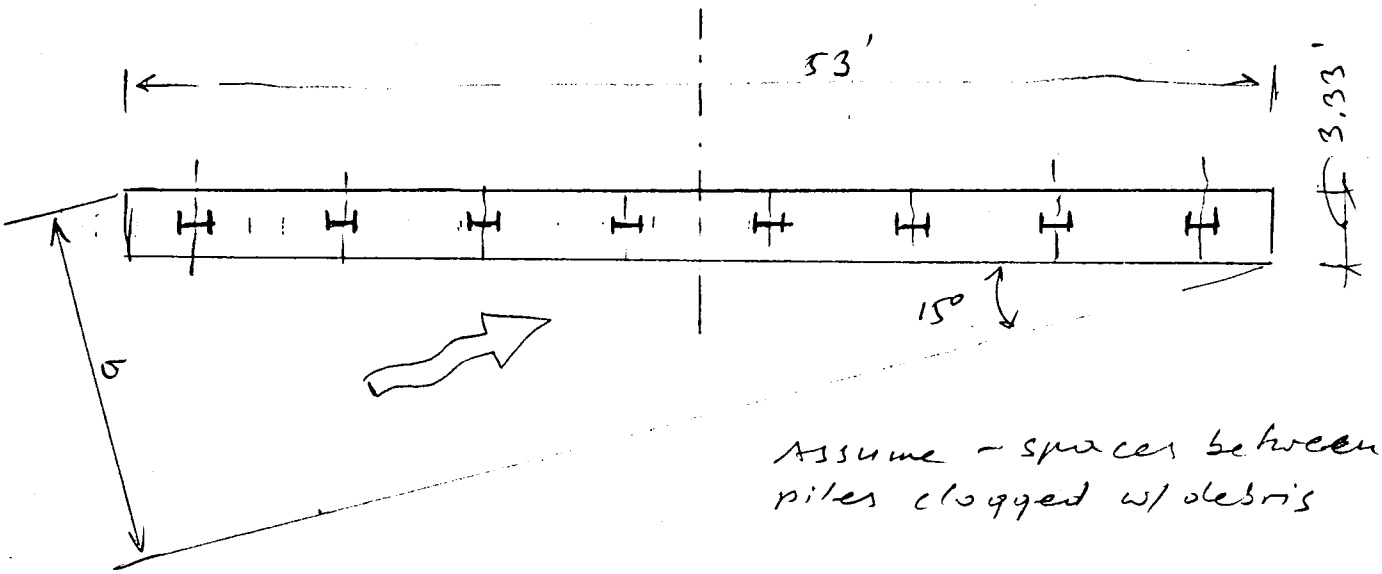
Wind on LL

$$WL = 0.1 \times \frac{100}{2} = 5\ k$$

LL braking force

$$LF = 5\%\ \text{of LL} = 0.05 \times 195.9 = 9.8\ k$$

Stream forces (per ADOT Bridge Design Manual)



Assume – spaces between piles clogged w/ debris

$$b = 53 \sin 15 + 3.33 \cos 15 = 13.72 + 3.22 = 16.94'$$

3

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51st Ave & Salt River

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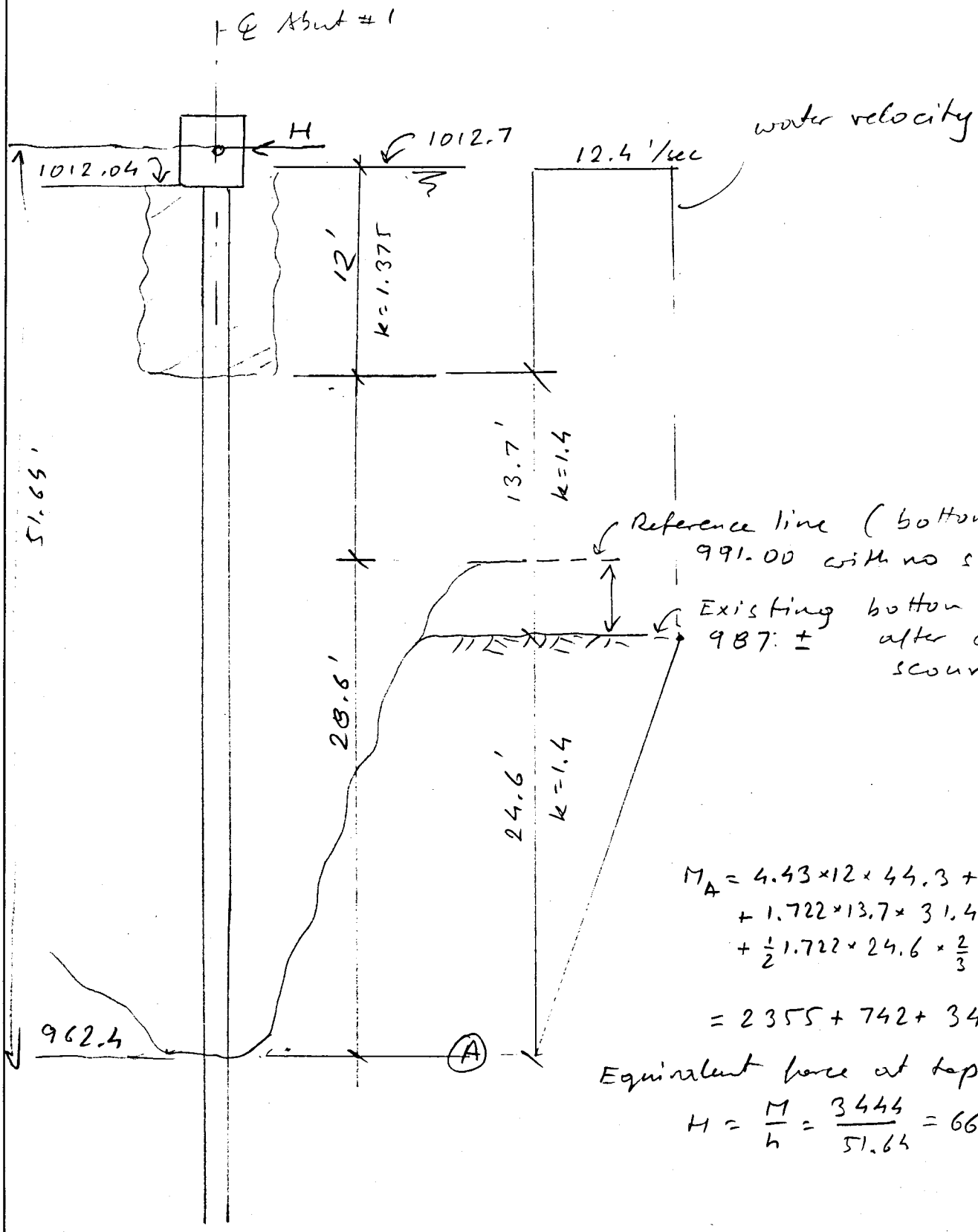

$$M_A = 4.43 \times 12 \times 44.3 + 1.722 \times 13.7 \times 31.45 + \frac{1}{2} 1.722 \times 24.6 \times \frac{2}{3} 24.6 =$$

$$= 2355 + 742 + 347 = 3444$$

Equivalent force at top

$$H = \frac{M}{h} = \frac{3444}{51.64} = 66.7 \text{ kN}$$

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PARSONS BRINCKERHOFF COMPUTATION SHEET

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51st Ave & Salt River

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top 12' (w/debris)

$$SF_1 = (2' + 16.94' + 2') \times 1.375 \times 12.4^2 = 4{,}430 \ \frac{lb}{ft}$$

mid 13.7' (no debris, full water velocity)

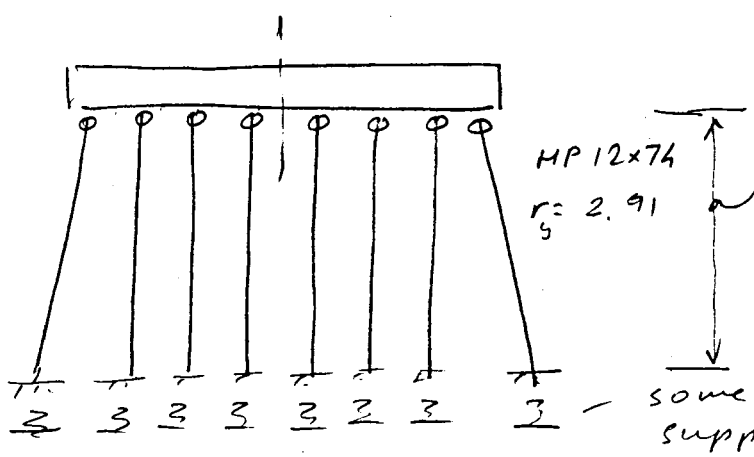
$$SF_2 = 1' \times 1.4 \times 12.4^2 \times 8 \text{ piles} = 1722 \ \frac{lb}{ft}$$

bottom 24.6'

SF_3 at top = 1722

SF_3 at bottom = 0

For structural analysis assume 5' to the point of fixity



$h = (1012.04 - 962.4 +$
$= 54.64'$

some arbitrary spring supports to get more realistic results

transv. $\frac{KL}{r} = \frac{2.1 \times 54.64 \times 12}{5.1} = 270 > 200$ N.G. no further analysis needed

longit.: assume $K = 0.65 \rightarrow \frac{KL}{r} = 146.5 < 200$ in long direction
$r = 2.91$

57th Ave.

1. Report did not consider degradation due to mining both upstream & d/s
2. Grade stabilization is crucial (GCS). Uneven flow distribution initiates severe scour problems at groups of piers & abutment.
   - GCS evens flows across the channel
   - GCS reduces general degradation & probably reduces pier scour as well
3. Cost of GCS may not be ~~too~~ high ($1M - 1.5M)
4. It will be difficult to blame one S&G company. All mines from ~~Atlantic~~ at least I-10 down are partly responsible.

TABLE 2-4. DISCHARGE FREQUENCY VALUES
SALT RIVER AND GILA RIVER
RECOMMENDED PLAN (P6OP2) VERSUS W/O PROJECT

LOCATION		RETURN PERIOD						
		500-YR	200-YR	100-YR	50-YR	20-YR	10-YR	5-YR
PEAK DISCHARGES (ft^3/s) IN SALT RIVER AT:								
CP-40	W/P	250,000	210,000	175,000	150,000	100,000	60,000	22,000
	WO/P	360,000	290,000	245,000	175,000	141,000	102,000	45,000
CP-109	W/P	246,000	207,000	172,000	145,000	95,000	58,000	21,000
	WO/P	345,000	285,000	230,000	170,000	139,000	100,000	44,000
CP-110	W/P	243,000	204,000	169,000	140,000	90,000	55,000	20,500
	WO/P	330,000	275,000	215,000	160,000	135,000	93,000	40,000
CP-111	W/P	240,000	202,000	166,000	135,000	87,000	53,000	20,200
	WO/P	325,000	265,000	200,000	155,000	130,000	91,000	39,000
CP-112	W/P	237,000	200,000	164,000	132,000	84,000	51,000	20,000
	WO/P	315,000	255,000	190,000	150,000	126,000	90,000	38,000
CP-113	W/P	235,000	198,000	162,000	130,000	82,000	49,000	19,500
	WO/P	310,000	250,000	185,000	145,000	125,000	85,000	36,000
PEAK DISCHARGES (ft^3/s) IN GILA RIVER AT:								
CP-1310	W/P	285,000	243,000	227,000	185,000	92,000	57,000	23,500
	WO/P	360,000	295,000	250,000	200,000	135,000	95,000	40,000
CP-1216	W/P	270,000	225,000	210,000	160,000	68,000	46,000	17,000
	WO/P	350,000	290,000	245,000	195,000	133,000	88,000	39,000
CP-1217	W/P	270,000	220,000	203,000	153,000	67,000	42,000	15,000
	WO/P	340,000	280,000	240,000	190,000	129,000	82,000	38,000
CP-1218	W/P	270,000	215,000	195,000	145,000	65,000	38,000	12,000
	WO/P	335,000	277,000	235,000	186,000	124,000	78,000	37,000

DEFINITIONS:
W/P = Recommended Plan, P6OP2. WO/P = without project/existing conditions per 1982 CAWCS Hydrology Report, Table 23.
CP-40, at Granite Reef Dam
CP-109, at Gilbert Road
CP-110, at Tempe Bridge
CP-111, at Central Avenue
CP-112, at 67th Avenue
CP-113, above confluence with Gila River
CP-1310, below confluence with Salt River
CP-1216, below confluence with Waterman Wash
CP-1217, below confluence with Hassayampa River
CP-1218, at Gillespie Dam