Maricopa County Department of Transportation

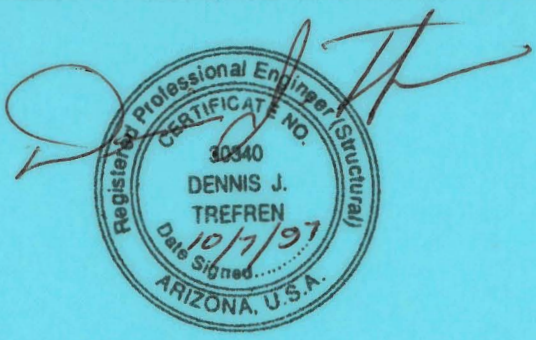
Bridge Scour Investigation and Design of Corrective Measures

Contract No. CY 1997-26
Work Order No. 80407

Final Report

51ST Avenue Bridge over Salt River

Submitted October 7, 1997



Prepared By:

INCA

INCA ENGINEERS, INC.
Wood/Patel & Associates
Maxim Technologies Inc.

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APPENDICES

Bridge Scour Investigation and Design of Corrective Measures

FINAL REPORT

INTRODUCTION

The Maricopa County Department of Transportation retained two consultants in 1995 under Work Order Number 80407 to evaluate the scour potential during 100 and 500 year flood events for existing bridges in their jurisdiction over waterways. The results of that study classified some of the bridges as scour critical.

INCA Engineers, Inc. was retained by the County to review the previous reports for five bridges classified as scour critical, determine the extent of scour damage, recommend methods to prevent scour damage, and prepare contract documents for scour countermeasures.

The 51st Avenue Bridge over Salt River was evaluated as scour critical by Parsons, Brinckerhoff, Quade, and Douglas and documented in their report dated February 1997.

Bridge Location and Description:

The 51st Avenue Bridge crossing of the Salt River is located in Southwestern Maricopa County at the intersection of Sections 20, 21, 28, and 29, T1N, R2E, Gila and Salt River Baseline and Meridian. It is located on 51st Avenue just south of Broadway Road near the town of Tolleson, Arizona. This location is a rural low density area surrounded by light industrial areas comprised of sand and gravel operations both upstream and downstream of the bridge along the Salt River.

REVIEW OF PREVIOUS REPORT

Parsons, Brinckerhoff, Quade, and Douglas (PBQ&D) performed a scour investigation and structural stability analysis of this site and submitted a report in February of 1997 documenting their findings. Wood/Patel has reviewed this report and offers the following comments:

The report makes the assumption that long-term scour has stabilized at this site.

"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."
(Page 16, Section 6.1, Paragraph 1)

It does not appear that the active gravel mining operations downstream were taken into account in formulating this statement. The most common estimate for the long-term degradation effect of sand and gravel mining is 20 feet, the absence of this number has significant impact on the calculated total scour.

SITE INVESTIGATION

On June 17, 1997, a review of the site conditions was conducted by Dennis Trefren, P.E., and Richard Bruesch, P.E. of INCA, Jeff Holzmeister, P.E. and Rick Hiner, P.E. of Wood/Patel, Dave Thomas, P.E. of Maxim Technologies and Tom Sonnemann, P.E. of MCDOT. Observations were noted as the following:

1. There are a number of active gravel mining operations in the area both downstream and upstream of the bridge. The low flow channel under the south end of the structure has degraded significantly since the bridge was constructed in 1981. There has been only one significant flow, the 1993 flood, that caused approximately ten feet of channel degradation.

2. There are two depth gauges painted on the columns at the south end of the bridge. They have a different datum probably due to channel degradation.

3. The south abutment protection consists of a layer of rounded stone (river run pit reject) with a fairly thin grout covering. This protection is currently damaged and is not suitable for long term protection.

4. There is an old abandoned sewer line downstream of the bridge that is totally exposed but was originally buried below the river bottom.

5. The south bank upstream of the bridge in the low flow channel is actively being eroded by higher flows.

6. The low flow channel along the south bank is approximately ten to twelve feet deeper than the rest of the channel. It appears that this low flow channel could migrate to any point in the river bottom.

7. There is active mining upstream on the south bank. This may alter the degradation pattern during larger flood flows. Gravel mining operations will likely cause significant changes in the flow direction and the angle of attack.

8. There is a ponded area at the north abutment being fed from agricultural and irrigation tail water. Algae and plant growth are thriving largely due to this nutrient rich tail water.

9. Direct observation of the channel invert at the north abutment was prevented due to the size of the ponded area.

HYDROLOGY RECOMMENDATIONS

Wood/Patel reviewed the hydrology from the Final Bridge Scour Assessment Report prepared by PBQ&D. The 100-year discharge of 190,000 cfs and 500-year discharge of 315,000 cfs are based on the pre-Roosevelt Dam analysis and do not take into account the flow reductions resulting from the Roosevelt Dam improvements. However, the controlling flow is the overtopping flow of 252,000 cfs.

HYDRAULICS RECOMMENDATIONS

The hydraulics performed in the Final Bridge Scour Assessment Report prepared by PBQ&D used multiple section HEC-2 and HEC-RAS models to determine the hydraulic characteristics of the bridge crossing. Using this data, a HEC-RAS analysis was conducted for the bridge site. The model extends from approximately 1700 feet downstream of the bridge to approximately 1300 feet upstream of the bridge.

PBQ&D provided the original HEC-2 computer model which was used to generate a HEC-RAS model for our analysis. PBQ&D chose to eliminate the low flow section at the south end of the bridge from their model because they believed it to be a localized hole. Field investigation showed that it is actually a continuous channel and for that reason, it remains in the model which was analyzed for this report. The water surface elevations and velocities resulting from this analysis are essentially the same as those resulting from the previous PBQ&D analysis.

The results of this analysis are presented in Appendix E.

SCOUR ANALYSIS

The most recent version of the HEC-RAS program (v. 2.0) has incorporated HEC-18 scour methodology into its programming. This feature was used to verify the scour results from the Final Bridge Scour Assessment Report prepared by PBQ&D. The assumption in the original bridge scour report that long-term/general scour had stabilized (estimate of 0.0 feet) apparently did not consider the effects of the sand & gravel mining operations downstream of the bridge structure. It is more likely that long-term scour values of 15 to 20 feet may occur at this bridge (this could occur during one or two major flood events). ADOT generally assumes that 20 feet of degradation will

occur due to sand & gravel mining and, therefore, our analysis assumes this value. The results of this analysis are presented below (and in a table in Appendix E):

	100-year	Overtopping
Contraction Scour	1.68 feet	2.82 feet
Pier Scour	18.33 feet	21.32 feet
Long-Term/General Scour	20.00 feet	20.00 feet
South Abutment Scour	26.51 feet	34.82 feet
North Abutment Scour	32.43 feet	38.25 feet

1.68
18.33
26.51
46.54

This yields a total scour at the piers of 40.01 feet for the 100-year event (vs. 20.9-ft in the prior analysis) and 44.14 feet for the overtopping event (vs. 24.3-ft in the prior analysis). The remaining embedment of the pier piles is 22 feet for the 100-year event and 18 feet for the overtopping event. The total scour at the abutments for the 100-year is 46.51 feet (south) and 52.43 feet (north) and for the overtopping event is 54.82 feet (south) and 58.25 feet (north) (abutment scour + contraction scour + long-term scour). The prior analysis did not predict any long-term scour at these locations. The remaining embedment of the abutment piles is 40.5 feet (south) and 35 feet (north) for the 100-year event and 32.2 feet (south) and 29 feet (north) for the overtopping event.

ALTERNATIVE COUNTERMEASURES

INCA Engineers, Inc. submitted a Candidate Assessment Report to MCDOT dated March 27, 1997, for the future widening of this bridge. All scour countermeasure alternatives must include the effects of the widening.

The following is a discussion of the most feasible countermeasures to protect the existing bridge or widened bridge from future scour damage.

Alternative 1: Soil Cement Floor

In addition to the bridge widening, this alternative consists of constructing 800 feet of spur dikes (an increase of 100 feet upstream from that proposed in INCA's C.A.R. dated March 27, 1997) and a soil cement floor across the full width of the river between the spur dikes to protect the pier foundations from local scour. The soil cement floor would be placed on top of the existing pier footings and be four feet thick. Therefore the top of the soil cement floor would be elevation 983 ± which is only four feet below the bottom of the existing low flow channel. A grade control structure needs to be incorporated in the soil cement floor on the downstream side in order to protect the floor from damage that could occur during the first future flood after construction of this countermeasure. This alternative would be good for approximately twelve feet of channel degradation. After this point, future grade control structures would be necessary until gravel mining and long term channel degradation has been eliminated. Refer to details of this countermeasure in Appendix C.

The advantages of this alternative are:

- Utilizes processed on site materials to manufacture soil cement.
- Resistant to abrasion damage.
- Provides integral initial grade control structure with the floor section.

The disadvantages of this alternative are:

- Initial soil placement sensitive to de-watering problems.
- The rigid soil cement floor structure is vulnerable to damage if undercut.
- Requires considerable site disturbance to excavate for countermeasure.
- Requires future grade control structures at approximately $1 million each after every major flood or loss of eight feet of channel bottom.

The estimated cost for this alternative (including bridge widening, longer spur dikes, floor system with integral grade control structure) is itemized as follows:

Item	Cost (million)
Widen Existing Bridge	$5.11*
Additional Spur Dikes	.07
Soil Cement Floor with Initial Grade Control Structure	5.79
Additional R/W	.01
Total =	**$10.98**

* Estimated cost reported in INCA's Final Candidate Assessment Report for the Full Cost Alternative dated March 27, 1997. Does not include approach roadway costs. (R/W, Utilities, Earthwork, etc.)

Note - Approximately two or three grade control structures will be required in the future.

Alternative 1A: Soil Cement Floor Modified

This alternative is similar to Alternative 1 except it is designed for a maximum long-term degradation at the piers of 12 feet rather than 20 feet. In a project meeting held on September 16, 1997, Kofi Awumah of the Flood Control District of Maricopa County (FCDMC) indicated that gravel mining permits in this area limit the pit depth to a maximum of 10 feet. Based on this point, FCDMC recommends using less than 20 feet for long-term degradation. The final recommendation resulting from this meeting was to use 12 feet for long-term degradation. This value represents Wood/Patel and Associates estimate of 11.6 feet without applying a factor of safety.

The downstream toe-down section of Alternative 1 is modified to be only 8 feet thick. The initial grade control structure for Alternative 1 is eliminated and replaced with a 6-foot thick by 40-foot wide apron placed at the bottom of the downstream cut-off wall to arrest the development of a scour hole due to local sill scour. Refer to details of this countermeasure in Appendix D.

The advantages of this alternative are:

- Utilizes processed on site materials to manufacture soil cement.
- Resistant to abrasion damage.
- The need for future grade control structures is eliminated.
- The least costly scour mitigation measure.

The disadvantages of this alternative are:

- Requires constant monitoring and enforcement of the requirements set forth in the gravel mining permits issued in the area in order to protect the assumption that maximum long-term degradation will not exceed 12 feet.
- Initial soil placement sensitive to de-watering problems.
- The rigid soil cement floor structure is vulnerable to damage if undercut.
- Requires considerable site disturbance to excavate for countermeasure.

The estimated cost for this alternative (including bridge widening, longer spur dikes, floor system) is itemized as follows:

Item	Cost (million)
Widen Existing Bridge	$5.11*
Additional Spur Dikes	.07
Soil Cement Floor	4.04
Additional R/W	.08
Total =	**$9.30**

* Estimated cost reported in INCA's Final Candidate Assessment Report for the Full Cost Alternative dated March 27, 1997. Does not include approach roadway costs. (R/W, Utilities, Earthwork, etc.)

Alternative 2: Wire Tied Riprap Floor

In addition to the bridge widening, this alternative consists of constructing spur dikes as discussed for Alternative 1 and constructing a wire tied riprap floor across the full width of the river between the spur dikes to protect the pier foundations from local scour. The

wire tied riprap floor would be placed on top of the existing pier footings and be three feet thick. Due to the shallow cover (± 4 feet) in the low flow channel, the wire tied floor is vulnerable to damage during the next flood. Therefore a grade control structure must be constructed with the wire tied floor. Subsequent grade control structures would be required until gravel mining, and long term channel degradation has been eliminated. Refer to details of this countermeasure in Appendix E.

The advantages of this alternative are:

- Utilizes readily available river cobble and pit reject material.
- Less sensitive to de-watering than soil cement.

The disadvantages of this alternative are:

- Wires are subject to abrasion and breakage.
- Construction is labor intensive.
- Requires a grade control structure in addition to the floor system.
- Requires considerable site disturbance to excavate for floor system and grade control structure.
- Most costly scour countermeasure.
- Highest initial plus long term costs.
- Requires future grade control structures at approximately $1 million each after every major flood or loss of eight feet of channel bottom.

The estimated cost for this alternative (including bridge widening, longer spur dikes, wire tied floor and initial grade control structure) is itemized as follows:

Item	Cost (million)
Widen Existing Bridge	$5.11*
Additional Spur Dikes	.07
Wire Tied Floor	7.31
Grade Control Structure	1.00
Additional R/W	.12
Total =	**$13.61**

* Estimated cost reported in INCA's Final Candidate Assessment Report for the Full Cost Alternative dated March 27, 1997. Does not include approach roadway costs. (R/W, Utilities, Earthwork, etc.)

Note - Approximately two or three grade control structures will be required in the future.

Alternative 2A: Wire Tied Riprap Floor Modified

This alternative is similar to Alternative 2 except it is designed for a maximum long-term degradation at the piers of 12 feet rather than 20 feet. In a project meeting held on September 16, 1997, Kofi Awumah of the Flood Control District of Maricopa County (FCDMC) indicated that gravel mining permits in this area limit the pit depth to a maximum of 10 feet. Based on this point, FCDMC recommends using less than 20 feet for long-term degradation. The final recommendation resulting from this meeting was to use 12 feet for long-term degradation. This value represents Wood/Patel and Associates estimate of 11.6 feet without applying a factor of safety.

The future grade control structure is eliminated and replaced with a 6-foot thick by 40-foot wide apron placed on the downstream side and at the bottom of the initial grade control structure to arrest the development of a scour hole due to local sill scour. Refer to details of this countermeasure in Appendix F.

The advantages of this alternative are:

- Utilizes readily available river cobble and pit reject material.
- Less sensitive to de-watering than soil cement.
- The need for future grade control structures is eliminated.

The disadvantages of this alternative are:

- Requires constant monitoring and enforcement of the requirements set forth in the gravel mining permits issued in the area in order to protect the assumption that maximum long-term degradation will not exceed 12 feet.
- Wires are subject to abrasion and breakage.
- Construction is labor intensive.
- Requires a grade control structure in addition to the floor system.
- Requires considerable site disturbance to excavate for floor system and grade control structure.
- Highest initial cost.

The estimated cost for this alternative (including bridge widening, longer spur dikes, wire tied floor and initial grade control structure) is itemized as follows:

Item	Cost (million)
Widen Existing Bridge	$5.11*
Additional Spur Dikes	.07
Wire Tied Floor	7.31
Grade Control Structure	1.58
Additional R/W	.13
Total =	**$14.20**

* Estimated cost reported in INCA's Final Candidate Assessment Report for the Full Cost Alternative dated March 27, 1997. Does not include approach roadway costs. (R/W, Utilities, Earthwork, etc.)

Alternative 3: Remove and Replace Bridge

Due to the high costs of the initial scour countermeasures and the on going future costs of grade control structures in addition to the bridge widening and other improvements, the concept of a new bridge should be considered. The new bridge can be designed for a 500 year flood event and the existing and long term site conditions. The piers, for example, can be large ten foot diameter shafts placed deep enough to allow for thirty feet of scour and an additional forty feet of long term loss.

The advantages of this alternative are:

- Does not require a large area to be excavated and de-watered.
- All scour mitigation and future long term degradation allowances can be incorporated in the new bridge foundation design.
- Does not require costly future grade control, or having the risk and uncertainty of maintaining grade control structures over many decades.
- Lower long term cost.

The disadvantages of this alternative are:

- Greater disruption of traffic.
- Requires detour road.
- Longer initial construction period.
- Highest initial cost.

The estimated cost for this alternative is itemized as follows:

Item	Cost (million)
New 1602' x 88' Bridge (@ $70 psf)	$9.87
Construct and Armor Spur Dikes	.53
All Other Costs (R/W, Utilities, Environmental, etc.)	1.50
Scour Countermeasures, Piers	.00
Grade Control Structure	.00
Remove Existing Bridge (@ $20 psf)	1.70
Detour Road	.20
*** Total =**	**$13.80**

* Estimated cost does not include approach roadway costs. (R/W, Utilities, Earthwork, etc.)

Alternative 4: New Bridge 100 feet Upstream

This alternative is similar to Alternative 3 except traffic is maintained on the existing bridge until completion of a new bridge built 100 feet upstream.

The advantages of this alternative are:

- Minimal disruption to traffic.
- Does not require immediate removal of existing bridge.
- The horizontal roadway alignment between Southern Avenue and Broadway Road can be improved.
- Does not require costly future grade control, or the maintenance of grade control structures over many decades.
- Reduced environmental issues associated with wetlands at the North abutment.
- The lowest long term cost.

The disadvantages of this alternative are:

- Requires the most additional Right-of-Way.
- Requires longer spur dikes than any other alternative.
- Additional cost to remove existing bridge.
- Highest cost of approach roadways.

The estimated cost for this alternative is itemized as follows:

Item	Cost (million)
New 1602' x 86' Bridge (@ $70 psf)	$9.64
Construct and Armor Spur Dikes	.67
All Other Costs (Utilities, Environment, etc.)	1.50
Additional Right-of-Way	.15
Scour Countermeasures, Piers	.00
Grade Control Structure	.00
Remove Existing Bridge (@ $20 psf)	1.70
*** Total =**	**$13.66**

* Estimated cost does not include approach roadway costs. (R/W, Utilities, Earthwork, etc.)

PREFERRED ALTERNATIVE

We recommend Alternative 4 to be constructed since it offers the least long term cost, eliminates the need for future expenditures for construction and maintenance of grade control structures, eliminates monitoring and enforcement of gravel mining permits and is the least disruptive to the traffic and the environment.

Appendix A
Photographs

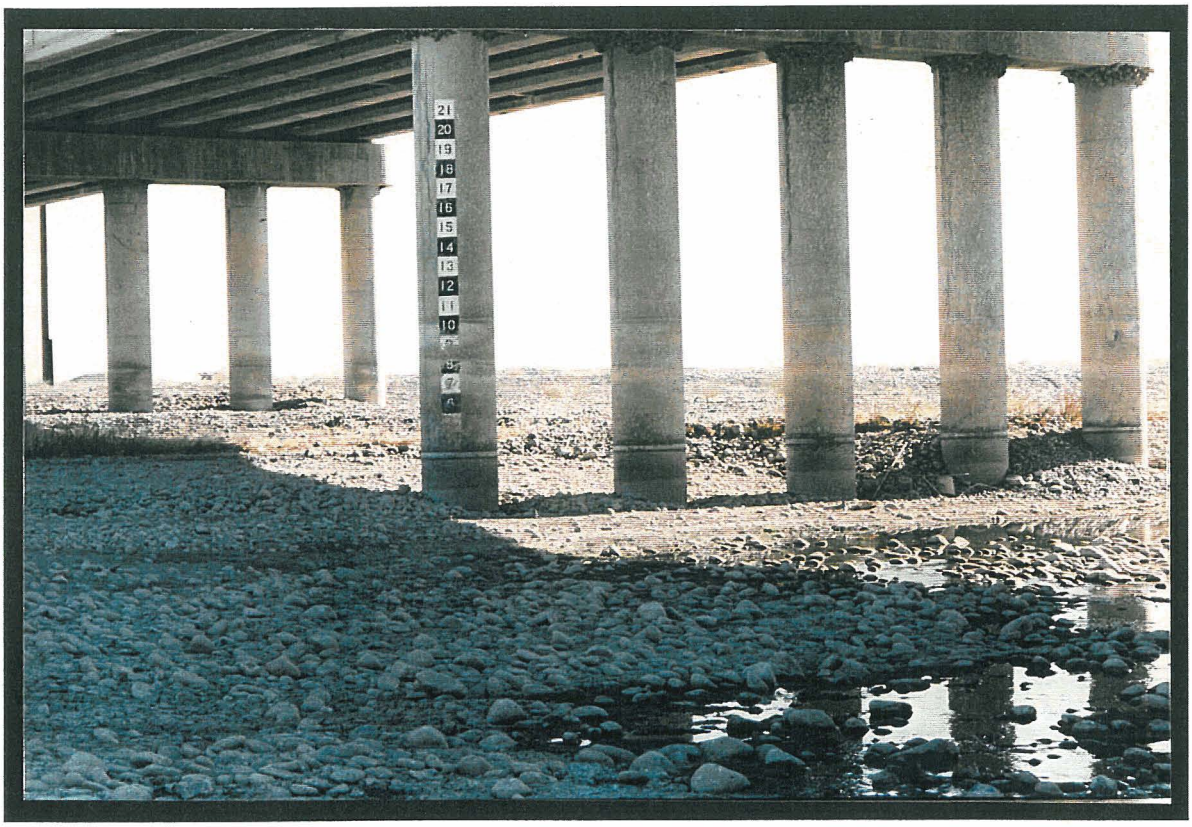
Upstream Side of Bridge Looking Northwest

Erosion of Upstream South Bank

Grouted Riprap Failure at South Abutment

Looking Upstream at Low Flow Channel at South Abutment

Abandoned Sewer Line Downstream (Was Previously Buried Below River Bottom)

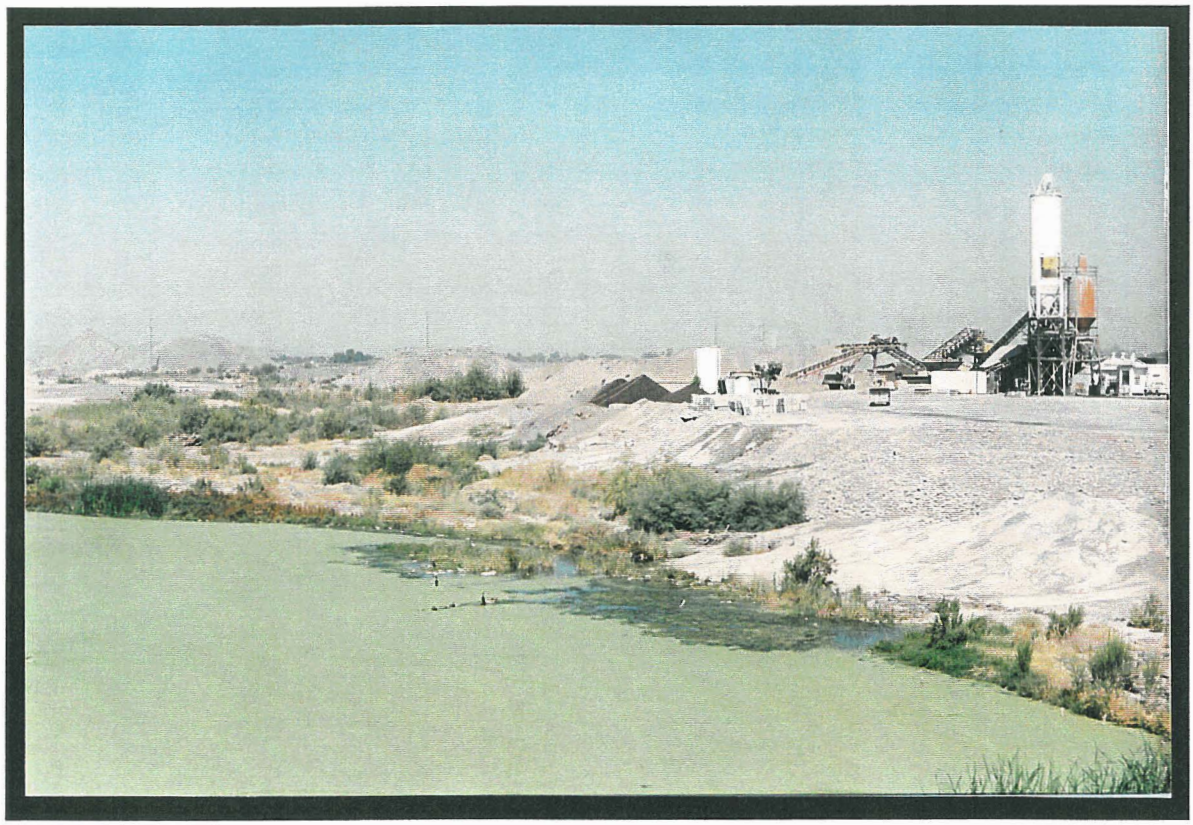


Depth Gauge on Pier 1 Column

Upstream Near North Abutment

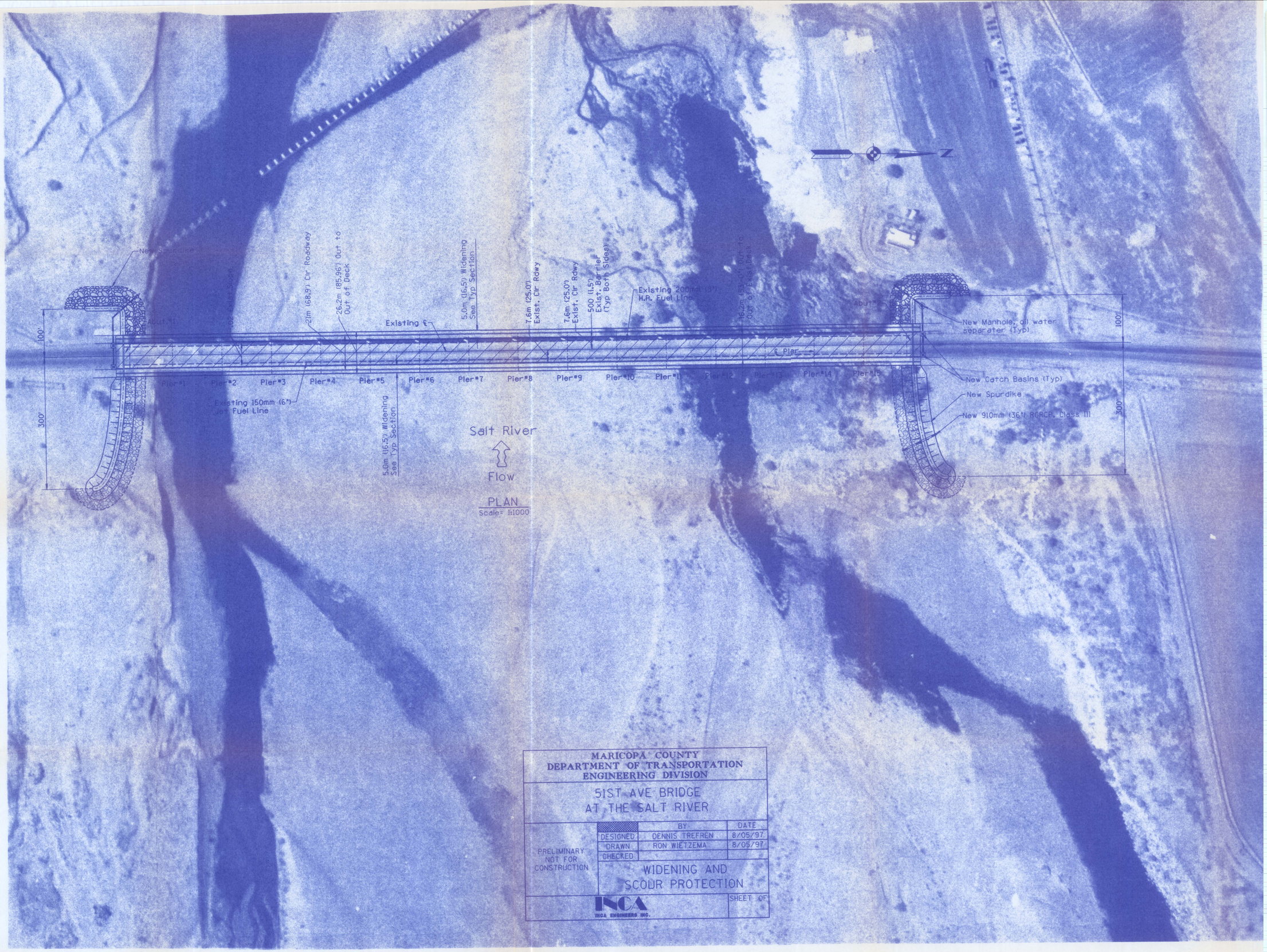
South Bank Erosion and Gravel Mining Upstream

Gravel Mining Downstream Near North Abutment



Wetlands and Gravel Mining Downstream Near North Abutment

Appendix B
Plan View of Widened Bridge and Spur Dikes



PLAN
Scale= 1:1000

MARICOPA COUNTY
DEPARTMENT OF TRANSPORTATION
ENGINEERING DIVISION

51ST AVE BRIDGE
AT THE SALT RIVER

	BY	DATE
DESIGNED	DENNIS TREFREN	8/05/97
DRAWN	RON WIETZEMA	8/05/97
CHECKED		

PRELIMINARY
NOT FOR
CONSTRUCTION

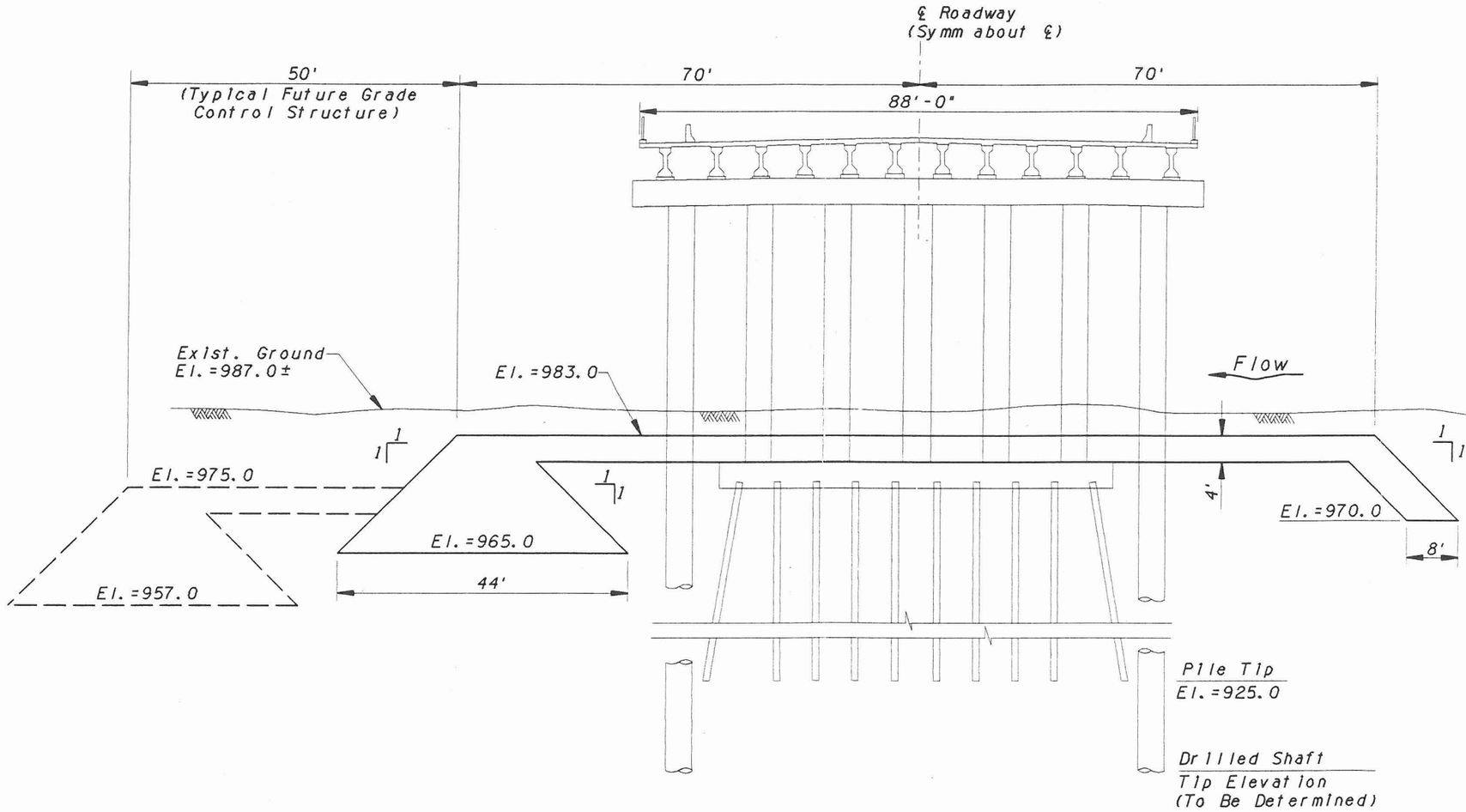
WIDENING AND
SCOUR PROTECTION

INCA
INCA ENGINEERS INC.

SHEET OF

Appendix C
Alternative 1 Details

F.W.H.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	RECORD DRAWING
9	AZ.				



(TYPICAL SECTION AT PIER)
NTS

SOIL CEMENT ALTERNATIVE

MARICOPA COUNTY
DEPARTMENT OF TRANSPORTATION
ENGINEERING DIVISION

51ST AVE BRIDGE @ SALT RIVER

	BY	DATE
DESIGNED	DENNIS TREFREN	10/2/97
DRAWN	RON WIETZEMA	10/2/97
CHECKED		

PRELIMINARY
NOT FOR
CONSTRUCTION

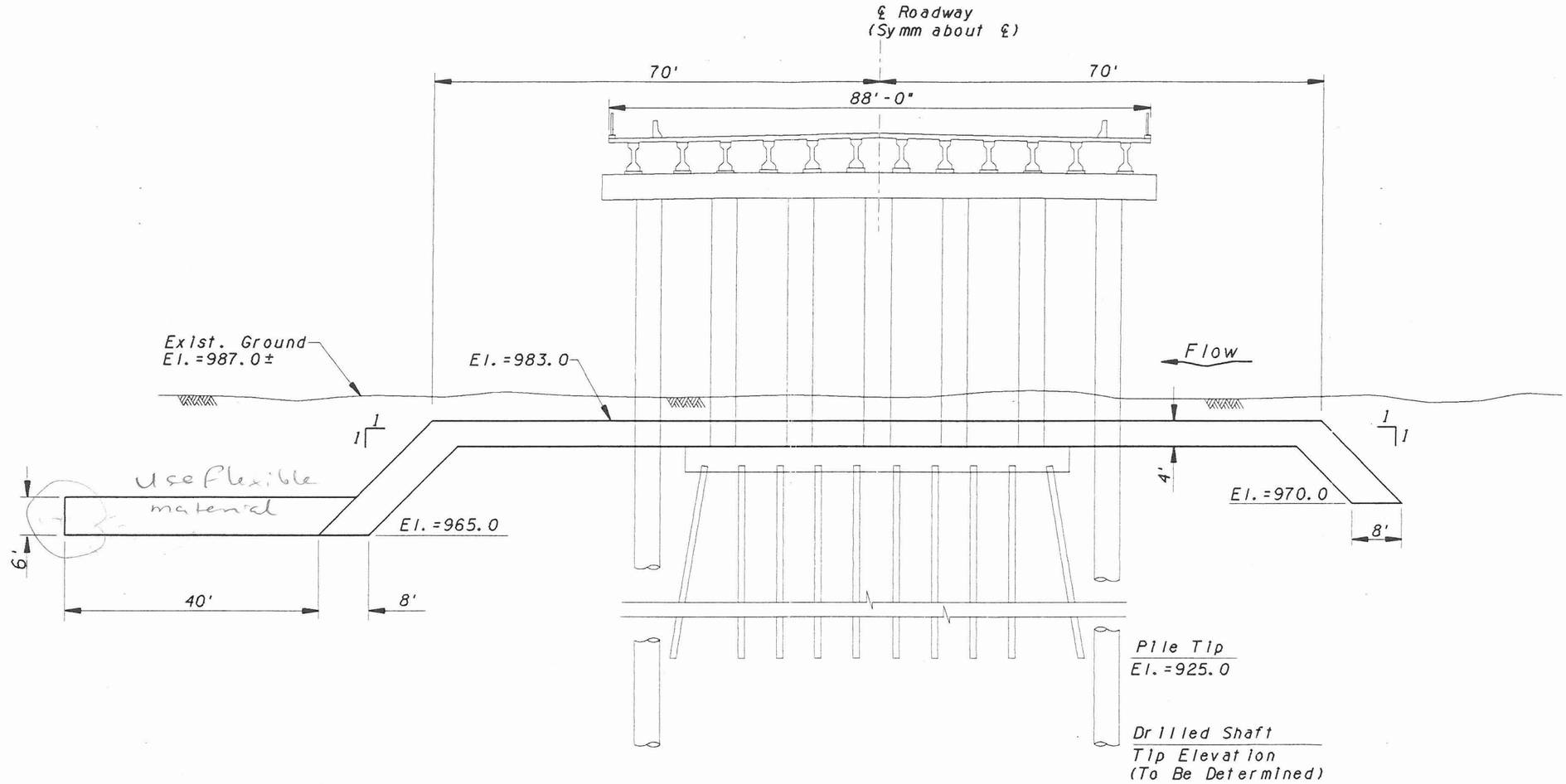
INCA
INCA ENGINEERS INC.

ALTERNATE NO. 1

SHEET OF

Appendix D
Alternative 1A Details

F.W.H.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	RECORD DRAWING
9	AZ.				.



(TYPICAL SECTION AT PIER)
NTS

SOIL CEMENT ALTERNATIVE MODIFIED

MARICOPA COUNTY
DEPARTMENT OF TRANSPORTATION
ENGINEERING DIVISION

51ST AVE BRIDGE @ SALT RIVER

	BY	DATE
DESIGNED	DENNIS TREFREN	10/2/97
DRAWN	RON WIETZEMA	10/2/97
CHECKED		

PRELIMINARY
NOT FOR
CONSTRUCTION

INCA ENGINEERS INC.

ALTERNATE NO. 1A

SHEET OF

Appendix E
Alternative 2 Details

F.W.H.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	RECORD DRAWING
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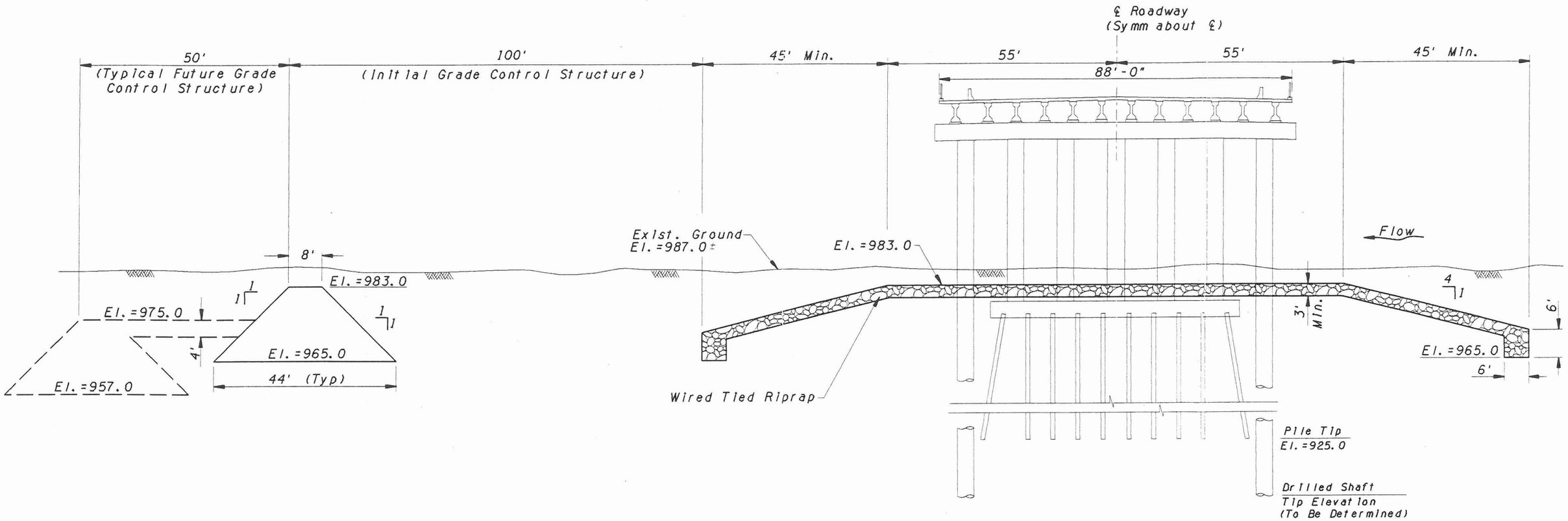

(TYPICAL SECTION AT PIER)
NTS

WIRE TIED RIPRAP ALTERNATIVE

MARICOPA COUNTY
DEPARTMENT OF TRANSPORTATION
ENGINEERING DIVISION

51ST AVE BRIDGE @ SALT RIVER

PRELIMINARY
NOT FOR
CONSTRUCTION

	BY	DATE
DESIGNED	DENNIS TREFREN	10/2/97
DRAWN	RON WIETZEMA	10/2/97
CHECKED		

INCA
INCA ENGINEERS INC.

ALTERNATE NO. 2

SHEET OF

Appendix F
Alternative 2A Details

F.W.H.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	RECORD DRAWING
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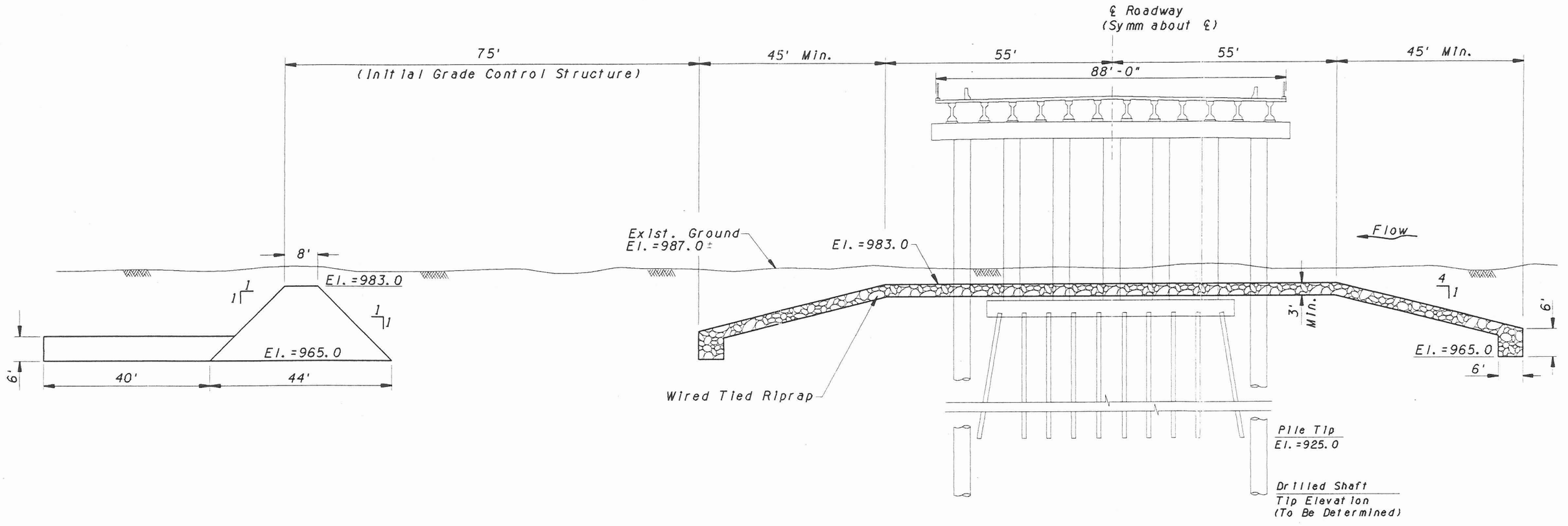


(TYPICAL SECTION AT PIER)
NTS

WIRE TIED RIPRAP ALTERNATIVE MODIFIED

MARICOPA COUNTY
DEPARTMENT OF TRANSPORTATION
ENGINEERING DIVISION

51ST AVE BRIDGE @ SALT RIVER

	BY	DATE
DESIGNED	DENNIS TREFREN	10/2/97
DRAWN	RON WIETZEMA	10/2/97
CHECKED		

PRELIMINARY
NOT FOR
CONSTRUCTION

INCA
INCA ENGINEERS INC.

ALTERNATE NO. 2A

SHEET OF

Appendix G
Flood Plain Use Permit #FA88-026

ROBBINS & GREEN

PHILIP A. ROBBINS
WAYNE A. SMITH
WILLIAM H. SANDWEG III
JEFFREY P. BOSHES
JANET B. HUTCHISON
BRADLEY J. STEVENS
ALFRED W. RICCIARDI
PETER W. SORENSEN
JAMES O. EHINGER
JOHN P. AGER
SANDRA J. ROGERS

RICHARD W. ABBUHL
EDMUND F. RICHARDSON
JACK N. RUDEL
BRIAN IMBORNONI
RONALD G. WILSON
DWAYNE ROSS
SARAH N. McGIFFERT
BRUCE M. PHILLIPS
IRA M. SCHWARTZ
HEIDI M. CALVERT
MICHAEL A. CORDIER

25 YEARS OF LEGAL SERVICE

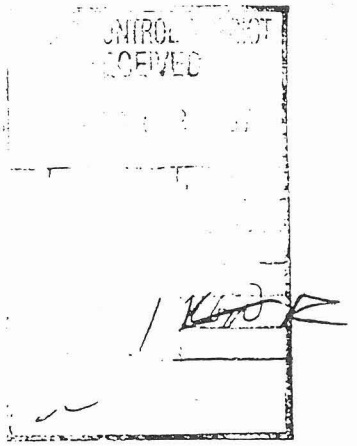
LAW OFFICES
A PROFESSIONAL ASSOCIATION
1800 NORWEST TOWER
3300 NORTH CENTRAL AVENUE
PHOENIX, ARIZONA 85012-2578
TELEPHONE (602) 248-7600
FACSIMILE (602) 266-5369

HENRY JACOBOWITZ
OF COUNSEL

ROBERT H. GREEN
RETIRED

Direct Line: 248-7677
e-mail: jmw@rglaw.com

September 3, 1997



Hand-Delivered

Mr. Ron Nebit
FLOOD CONTROL DISTRICT OF MARICOPA COUNTY
2801 West Durango Street
Phoenix, AZ 85009

RE: Floodplain Use Permit #FA88-026

Dear Mr. Nebit:

This letter is to notify you that Pioneer Concrete of Arizona, Inc. ("Pioneer") has acquired the operating assets of Cashway Concrete & Materials Corporation ("Cashway"). I have enclosed a letter from Ms. Therese A. Sanders, President of Cashway, confirming the transfer of ownership.

We are requesting that you transfer to Pioneer Concrete of Arizona, Inc. the Floodplain Use Permit #FA88-026 previously held by Cashway. Please also change your records to reflect the new ownership as follows:

Pioneer Concrete of Arizona, Inc.
Charles O. Wallace, Senior Vice-President/
Regional Manager
P. O. Box 20370
Mesa, AZ 85277-0370
Telephone number: 654-3000.

1997-26651-1

If you should have any questions or require additional information in order to transfer the Floodplain Use Permit, please contact me at 248-7677.

Sincerely,

Janet Williams, CLA
Legal Assistant to
Jack N. Rudel

JW
Enclosure

Cashway Concrete & Materials Corporation

August 29, 1997

Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009

Re: Floodplain Use Permit # FA88-026

Dear Sirs:

Effective August 29, 1997 the operating assets of Cashway Concrete Materials & Corporation have been be sold to Pioneer Concrete of Arizona, Inc.. Please amend your records to reflect this change of ownership. The address and telephone number shall remain unchanged.

Sincerely,

Therese A. Sanders

Therese A. Sanders
President

3450 N. Higley Road • Mesa • AZ 85215-9702 ❖ P.O. Box 20370 • Mesa • AZ 85277-0370 ❖ (602) 654-3000 • FAX (602) 654-3067

FLOOD CONTROL DISTRICT
of
Maricopa County

2801 West Durango Street • Phoenix, Arizona 85009
Telephone (602) 506-1501
Fax (602) 506-4601
TT (602) 506-5859

July 31,1996

Joe Moody, Compliance Officer
Cashway Concrete & Materials
700 W. McKellips Rd.
Mesa, Arizona 85211-0639

SUBJECT: Floodplain Use Permit # FA85-043

Dear Mr. Moody,

Your request to renew the above sand and gravel operation in the floodway/floodplain of the Salt River has been received. The review revealed the same plan of development for this permit, FA85-043 and for FA88-026. We have combined both permits into one, FA88-026, which expires March 31, 1999. Please forward copies of the 401-404 permits, when they are approved, to us so we can put them in the FA88-026 file.

We have also changed the names on permits FA85-043 and FA88-026 to Cashway Concrete & Materials Corporation.

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

Sincerely,

James Stewart
Floodplain Management

FLOOD CONTROL DISTRICT
of
Maricopa County

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

Neil S. Erwin, P.E., Chief Engineer and General Manager

April 06,1994

Joe Moody
Property Owner Representative
E.J.C. Investments
P.O. Box 1363
Mesa, Arizona 85211-1363

SUBJECT: Renewal Floodplain Use Permit FA88-26, sand and gravel extraction.

Dear Mr. Moody,

The renewal of Floodplain Use Permit FA88-26 you have requested has been approved, effective March 31,1994. The renewal is for a five year period from the effective date. The stipulations from the original permit are still in effect. Enclosed is a copy of those stipulations. Please forward a copy of your 404 permit renewal when you receive it from the Corps of Engineers.

If you have any questions, please contact us at the above address or telephone number.

Sincerely,

James Stewart
Floodplain Management

Enclosures

INFO: ~~RGNR~~
~~SRY~~ SRY

FILE: FA88-026

FLOOD CONTROL DISTRICT
of
Maricopa County

3335 West Durango Street • Phoenix, Arizona 85009
Telephone (602) 262-1501

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

MAR 01 1989

Mr. Joe Moody
Arizona Crushing Co.
P.O. Box 3184
Tempe, Arizona 85281

Re: FA88-26

Dear Mr. Moody:

This is to acknowledge receipt of the Section 26 clearance from the U.S. Army Corps of Engineers which was stipulation number 5 of the approval for the above referenced floodplain use permit.

We advise you that the permit expires 1-11-94, that prior to that date you may apply for a renewal or submit a plan of reclamation to restore the land to a more natural condition and that approval from the State Department of Environmental Quality may also be required. We require that we be provided a copy of clearance, if required, from that agency. And also, that a status report on development activity be submitted to us in January, 1991.

If you have any questions, please let me know.

Sincerely,

D. E. Sagramoso, P.E.
Floodplain Administrator

Ron Nevitt

Ron Nevitt,
Floodplain Representative

F. /c:

FA88-26 (R-)

FLOODPLAIN USE PERMIT
FA88-26

STIPULATIONS:

1. Development shall be in conformance with the plan of development submitted with the application dated April 11, 1988 and revised August 30, 1988.

2. The floodplain use permit shall be limited to five (5) years from the date of approval, subject to post-flood review and possible modification if necessary due to flood related changes to river morphology.

3. The applicant shall be responsible for being informed of any flooding that may be imminent and for removing portable equipment and structures.

4. The applicant shall submit a Warning and Disclaimer of Liability Notice provided by the District.

5. Proof of clearance or approval of a Section 404 Permit from the U.S. Army Corps of Engineers shall be obtained prior to commencement of further sand and gravel operations.

6. Proof of compliance with State water quality standards adopted by the State Water Quality Control Council shall be obtained from the Arizona Department of Environmental Quality.

7. The applicant shall be required to submit biennial status reports to the District including the anticipated extent of activity to the next required status report.

8. The applicant agrees to submit to the District a plan of reclamation to return the property to as near a natural condition as possible or to an improved condition at least six months prior to the permit expiration date.

9. Approval of FA88-26 does not convey any property rights, either real estate or material, and is not to be construed as consent, approval or authorization to cause any injury to property or invasion of rights or the infringement of any Federal, State or other local laws, rules or regulations nor does it obviate the requirement to obtain other permits. Furthermore, the plan review by the District has been soley for the purpose of determining that your application conforms with the written requirements of the Floodplain Regulation for Maricopa County and is not to be taken as a warranty that structural plans and specifications meet engineering requirements or standards or are free from failure to perform as described or designed in the application, reports or plans as submitted.

X _____ 12/15/88
Applicant Date

_____ 1-11-89
STANLEY L. SMITH JR., P.E.
DEPUTY CHIEF ENGINEER
Floodplain Administrator Date

MEMO TO: D. F. Sagramoso, Floodplain Administrator

FROM: Ron Nevitt, Floodplain Representative

SUBJECT: FA88-76 F. J. Cyr - Staff Report

This is a request for a floodplain use permit for an existing sand and gravel operation within the floodway district of the Salt River downstream of the 51st Avenue bridge. The operation was begun without prior approval required from the District.

The applicant initially requested excavation pit depths of 16 feet. Stockpiling and material processing is to be in the floodplain fringe portion of the property along the north overbank area.

A recent site inspection noted activity has been halted as ordered by staff pending the applicant obtaining the required permits. Although extraction operations have been discontinued, sufficient stockpiles have been accumulated to meet material orders for the immediate future.

Technical review by staff of the plans submitted by Simons, Li, Associates has been completed and approval is recommended with a maximum pit depth of 10 feet.

Recommendation: Staff recommends approval of FA88-76 subject to the attached stipulations.

	Initials	Date
(JJT) TRAM		1-9-89
(DRJ) JOHNSON		1/9/89
(SLS) SMITH		1/11/89
~~(DES) SAGRAMOSO~~		

Appendix H
Hydraulic/Hydrology Calculations

100 yr Discharge

HEC-RAS Scour Calculation Output

Contraction Scour

	Left	Channel
Input Data		
Average Depth (ft):	4.63	11.54
Approach Velocity (ft/s):	4.78	8.50
Br Average Depth (ft):		13.05
BR Opening Flow (cfs):		190000.0
BR Top WD (ft):		1519.85
Grain Size D50 (ft):	0.0833	0.0833
Approach Flow (cfs):		190000.0
Approach Top WD (ft):		2299
K1 Coefficient:	0.590	0.590
Results		
Scour Depth Ys (ft):		**1.68**
Critical Velocity (ft/s):		
Equation:		Live

Pier Scour

All piers have the same scour depth

Input Data	
Pier Shape:	Group of Cylinders
Pier Width (ft):	8.00
Grain Size D50 (ft):	0.08330
Depth Upstream (ft):	23.10
Velocity Upstream (ft/s):	12.64
K1 Nose Shape:	1.00
Pier Angle:	0.00
Pier Length (ft):	50.71
K2 Angle Coef:	1.00
K3 Bed Cond Coef:	1.10
Grain Size D90 (ft):	0.50000
K4 Armouring Coef:	1.00
Results	
Scour Depth Ys (ft):	**18.33**
Froude #:	0.46
Equation:	CSU equation

Abutment Scour

	Left	Right
Input Data		
Station at Toe (ft):	19465.30	21059.40
Toe Sta at appr (ft):	19529.30	21317.00
Abutment Length (ft):	250.00	100.00
Depth at Toe (ft):	5.33	10.41
K1 Shape Coef:	0.55 – Spill-through abutment	
Degree of Skew (degrees):	90.00	90.00
K2 Skew Coef:	1.00	1.00
Projected Length L' (ft):	250.00	100.00
Avg Depth Obstructed Ya (ft):	5.33	10.41
Flow Obstructed Qe (cfs):	6741.00	8056.00
Area Obstructed Ae (sq ft):	1331.38	1040.93
Results		
Scour Depth Ys (ft):	**24.82**	**30.74**
Qe/Ae = Ve:	5.06	7.74
Froude #:	0.39	0.42
Equation:	Froehlich	Froehlich

Long-Term Degradation/Scour **20.00**

Combined Scour Depths

Pier + Contraction + Long-Term (ft): **40.01**

Left abutment + Contraction + Long-Term (ft): **46.51**
Right abutment + Contraction + Long-Term (ft): **52.43**

Overtopping Discharge

HEC-RAS Scour Calculation Output

Contraction Scour

	Left	Channel
Input Data		
Average Depth (ft):	6.98	13.98
Approach Velocity (ft/s):	5.74	9.10
Br Average Depth (ft):		14.87
BR Opening Flow (cfs):		252000.0
BR Top WD (ft):		1545.45
Grain Size D50 (ft): 0.0833		0.0833
Approach Flow (cfs):		252000.0
Approach Top WD (ft):		2304
K1 Coefficient:	0.590	0.590
Results		
Scour Depth Ys (ft):		**2.82**
Critical Velocity (ft/s):		7.44
Equation:		Live

Pier Scour

All piers have the same scour depth

Input Data	
Pier Shape:	Group of Cylinders
Pier Width (ft):	8.00
Grain Size D50 (ft):	0.08330
Depth Upstream (ft):	24.91
Velocity Upstream (ft/s):	17.55
K1 Nose Shape:	1.00
Pier Angle:	0.00
Pier Length (ft):	50.71
K2 Angle Coef:	1.00
K3 Bed Cond Coef:	1.10
Grain Size D90 (ft):	0.50000
K4 Armouring Coef:	1.00
Results	
Scour Depth Ys (ft):	**21.32**
Froude #:	0.62
Equation:	CSU equation

Abutment Scour

	Left	Right
Input Data		
Station at Toe (ft):	19465.30	21059.40
Toe Sta at appr (ft):	19529.30	21317.00
Abutment Length (ft):	250.00	100.00
Depth at Toe (ft):	7.77	12.83
K1 Shape Coef:	0.55 – Spill-through abutment	
Degree of Skew (degrees):	90.00	90.00
K2 Skew Coef:	1.00	1.00
Projected Length L' (ft):	250.00	100.00
Avg Depth Obstructed Ya (ft):	7.77	12.83
Flow Obstructed Qe (cfs):	11919.60	10937.00
Area Obstructed Ae (sq ft):	1941.33	1283.44
Results		
Scour Depth Ys (ft):	**32.00**	**35.62**
Qe/Ae = Ve:	6.14	8.52
Froude #:	0.39	0.42
Equation:	Froehlich	Froehlich

Long-Term Degradation/Scour **20.00**

Combined Scour Depths

Pier + Contraction + Long-Term (ft): **44.14**

Left abutment + Contraction + Long-Term (ft): **54.82**
Right abutment + Contraction + Long-Term (ft): **58.25**

100 yr

Plan: 51stAveBrdge River: RIVER-1 Reach:Reach-1 Riv Sta: 207.485 BR U Profile: PF#1

W.S. Elev (ft)	1012.67	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.43	Wt. n-Val.		0.032	
E.G. Elev (ft)	1014.09	Reach Len. (ft)	50.71	50.71	50.71
Crit W.S. (ft)	1007.44	Flow Area (sq ft)		19827.74	
E.G. Slope (ft/ft)	0.001904	Area (sq ft)		19827.74	
Q Total (cfs)	190000.00	Flow (cfs)		190000.00	
Top Width (ft)	1519.85	Top Width (ft)		1519.85	
Vel Total (ft/s)	9.58	Avg. Vel. (ft/s)		9.58	
Max Chl Dpth (ft)	25.33	Hydr. Depth (ft)		13.05	
Conv. Total (cfs)	4354541.0	Conv. (cfs)		4354541.0	
Length Wtd. (ft)	50.71	Wetted Per. (ft)		1927.69	
Min Ch El (ft)	987.34	Shear (lb/sq ft)		1.22	
Alpha	1.00	Stream Power (lb/ft s)		11.71	
Frctn Loss (ft)	0.10	Cum Volume (acre-ft)	96.20	585.34	1.28
C & E Loss (ft)	0.01	Cum SA (acres)	13.95	57.39	1.44

100 yr

Plan: 51stAveBrdge River: RIVER-1 Reach:Reach-1 Riv Sta: 207.53 Profile: PF#1

W.S. Elev (ft)	1013.41	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.08	Wt. n-Val.	0.032	0.032	
E.G. Elev (ft)	1014.49	Reach Len. (ft)	230.00	228.73	200.00
Crit W.S. (ft)	1008.69	Flow Area (sq ft)	2146.44	21147.58	
E.G. Slope (ft/ft)	0.001288	Area (sq ft)	2146.44	21147.58	
Q Total (cfs)	190000.00	Flow (cfs)	10255.10	179744.90	
Top Width (ft)	2296.22	Top Width (ft)	463.13	1833.10	
Vel Total (ft/s)	8.16	Avg. Vel. (ft/s)	4.78	8.50	
Max Chl Dpth (ft)	14.31	Hydr. Depth (ft)	4.63	11.54	
Conv. Total (cfs)	5294221.0	Conv. (cfs)	285751.5	5008470.0	
Length Wtd. (ft)	228.76	Wetted Per. (ft)	464.85	1835.96	
Min Ch El (ft)	999.10	Shear (lb/sq ft)	0.37	0.93	
Alpha	1.05	Stream Power (lb/ft s)	1.77	7.87	
Frctn Loss (ft)	0.29	Cum Volume (acre-ft)	101.87	696.27	1.28
C & E Loss (ft)	0.06	Cum SA (acres)	15.17	66.39	1.44

100 yr

Plan: 51stAveBrdge River: RIVER-1 Reach:Reach-1 Riv Sta: 207.53 Profile: PF#1

Left Sta (ft)	Right Sta (ft)	Flow (cfs)	Area (sq ft)	W.P. (ft)	% Conv.	Hydr D. (ft)	Velocity (ft/s)
18806.86	19154.88	870.52	293.05	116.00	0.46	2.55	2.97
19154.88	19502.90	9384.58	1853.39	348.85	4.94	5.33	5.06
19502.90 LB	19576.22	3640.23	572.40	73.34	1.92	7.81	6.36
19576.22	19649.55	4910.39	684.99	73.34	2.58	9.34	7.17
19649.55	19722.87	6126.42	782.24	73.34	3.22	10.67	7.83
19722.87	19796.20	7994.23	918.06	73.42	4.21	12.52	8.71
19796.20	19869.52	8786.18	971.20	73.34	4.62	13.25	9.05
19869.52	19942.84	8635.47	961.07	73.32	4.54	13.11	8.99
19942.84	20016.17	8635.47	961.07	73.32	4.54	13.11	8.99
20016.17	20089.49	8635.47	961.07	73.32	4.54	13.11	8.99
20089.49	20162.82	8635.47	961.07	73.32	4.54	13.11	8.99
20162.82	20236.14	8422.03	946.77	73.33	4.43	12.91	8.90
20236.14	20309.46	8302.47	938.77	73.35	4.37	12.80	8.84
20309.46	20382.79	9159.35	995.64	73.32	4.82	13.58	9.20
20382.79	20456.11	9103.34	991.97	73.32	4.79	13.53	9.18
20456.11	20529.44	8938.80	981.19	73.32	4.70	13.38	9.11
20529.44	20602.76	8754.53	969.00	73.32	4.61	13.22	9.03
20602.76	20676.08	8757.63	969.20	73.32	4.61	13.22	9.04
20676.08	20749.41	8816.58	973.11	73.32	4.64	13.27	9.06
20749.41	20822.73	8465.32	949.67	73.33	4.46	12.95	8.91
20822.73	20896.06	7629.39	892.53	73.39	4.02	12.17	8.55
20896.06	20969.38	5920.75	770.50	74.33	3.12	10.51	7.68
20969.38	21042.70	6589.27	817.28	73.36	3.47	11.15	8.06
21042.70	21116.03	6119.81	781.67	73.32	3.22	10.66	7.83
21116.03	21189.35	5639.67	744.52	73.38	2.97	10.15	7.57
21189.35	21262.68	2560.07	463.75	73.47	1.35	6.32	5.52
21262.68	21336.00 RB	566.58	188.86	74.68	0.30	2.58	3.00

North Overflow

19253 Obst. by
19503 South Abut.

$q_1 = 250'$

$Q_e = 3.56\%$
$= 6741$

$Ae = 1331.38$

$Ve = 5.06$

$Y_a = 5.33$

Bridge

21053 Obst. by
21153 N. Abut.

$q_1 = 100'$

South Overflow

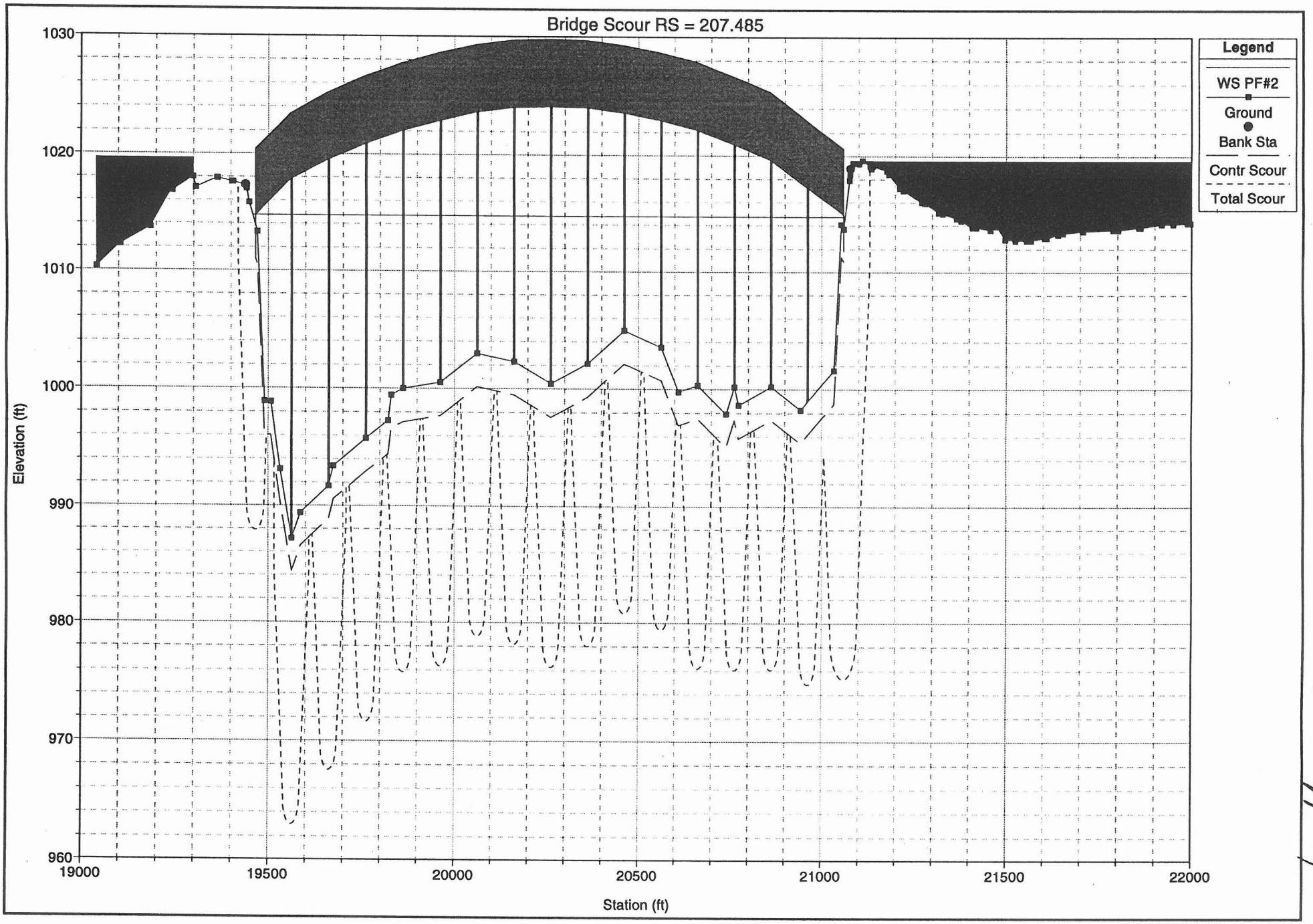
$Q_e = 4.23\%$
$= 8056$

$Ae = 1040.93$

$Ve = 7.74$

$Y_a = 10.41$

51st Avenue



Overtopping

OT

Plan: 51stAveBrdge River: RIVER-1 Reach:Reach-1 Riv Sta: 207.485 BR U Profile: PF#2

W.S. Elev (ft)	1014.73	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.87	Wt. n-Val.		0.032	
E.G. Elev (ft)	1016.60	Reach Len. (ft)	50.71	50.71	50.71
Crit W.S. (ft)	1009.06	Flow Area (sq ft)		22984.18	
E.G. Slope (ft/ft)	0.002181	Area (sq ft)	194038.10	22984.18	358303.80
Q Total (cfs)	252000.00	Flow (cfs)		252000.00	
Top Width (ft)	1545.45	Top Width (ft)		1545.45	
Vel Total (ft/s)	10.96	Avg. Vel. (ft/s)		10.96	
Max Chl Dpth (ft)	27.39	Hydr. Depth (ft)		14.87	
Conv. Total (cfs)	5396289.0	Conv. (cfs)		5396289.0	
Length Wtd. (ft)	50.71	Wetted Per. (ft)		2021.61	
Min Ch El (ft)	987.34	Shear (lb/sq ft)		1.55	
Alpha	1.00	Stream Power (lb/ft s)		16.97	
Frctn Loss (ft)	0.11	Cum Volume (acre-ft)	364.95	723.41	427.92
C & E Loss (ft)	0.01	Cum SA (acres)	14.33	57.81	3.54

O.T.

Plan: 51stAveBrdge River: RIVER-1 Reach:Reach-1 Riv Sta: 207.485 BR U Profile: PF#2

Left Sta (ft)	Right Sta (ft)	Flow (cfs)	Area (sq ft)	W.P. (ft)	% Conv.	Hydr D. (ft)	Velocity (ft/s)
19437.00 LB	19502.76	1849.97	299.81	57.76	0.73	5.61	6.17
19502.76	19568.51	14835.02	1370.19	113.57	5.89	22.19	10.83
19568.51	19634.27	28747.78	1637.72	65.76	11.41	24.91	17.55
19634.27	19700.02	16626.07	1452.92	110.83	6.60	23.53	11.44
19700.02	19765.78	13454.69	1220.21	98.41	5.34	19.76	11.03
19765.78	19831.54	16354.85	1167.55	65.76	6.49	17.76	14.01
19831.54	19897.29	10398.16	1033.81	95.70	4.13	16.74	10.06
19897.29	19963.05	9533.96	899.48	76.97	3.78	14.28	10.60
19963.05	20028.80	8854.49	866.80	78.40	3.51	13.44	10.22
20028.80	20094.56	6503.11	749.60	86.63	2.58	12.14	8.68
20094.56	20160.32	8144.19	827.90	79.24	3.23	12.59	9.84
20160.32	20226.07	9194.20	872.99	75.43	3.65	14.13	10.53
20226.07	20291.83	7950.18	858.64	90.00	3.15	13.90	9.26
20291.83	20357.58	9034.33	817.85	65.78	3.59	12.44	11.05
20357.58	20423.34	6506.93	744.75	85.16	2.58	12.06	8.74
20423.34	20489.10	5368.31	654.39	82.24	2.13	10.60	8.20
20489.10	20554.85	7069.72	705.86	65.76	2.81	10.73	10.02
20554.85	20620.61	7346.04	798.17	84.41	2.92	12.92	9.20
20620.61	20686.37	8018.94	862.56	89.86	3.18	13.97	9.30
20686.37	20752.12	12589.12	997.93	65.77	5.00	15.18	12.62
20752.12	20817.88	9800.51	989.72	93.79	3.89	16.03	9.90
20817.88	20883.63	9772.61	988.25	93.84	3.88	16.00	9.89
20883.63	20949.39	12744.29	1005.26	65.76	5.06	15.29	12.68
20949.39	21015.14	8122.71	873.75	91.03	3.22	14.15	9.30
21015.14	21080.90 RB	3179.78	373.16	44.30	1.26	9.18	8.52

O.T.

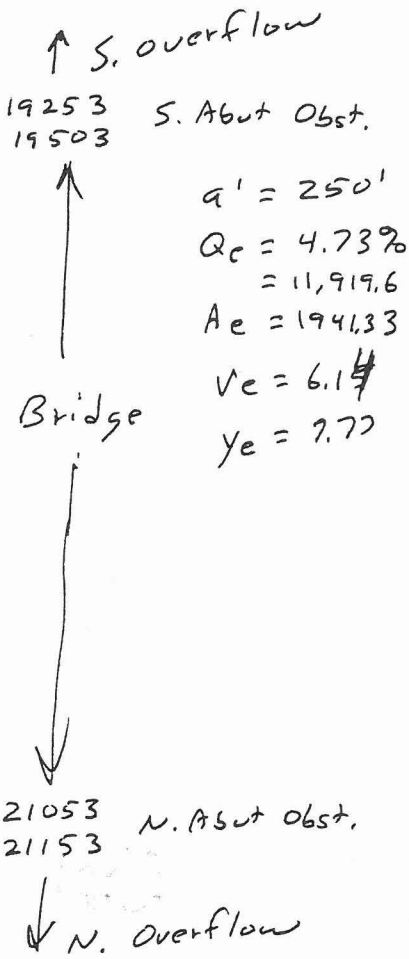
Plan: 51stAveBrdge River: RIVER-1 Reach:Reach-1 Riv Sta: 207.53 Profile: PF#2

W.S. Elev (ft)	1015.85	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.23	Wt. n-Val.	0.033	0.032	
E.G. Elev (ft)	1017.07	Reach Len. (ft)	230.00	228.73	200.00
Crit W.S. (ft)	1010.19	Flow Area (sq ft)	3285.57	25619.90	
E.G. Slope (ft/ft)	0.001145	Area (sq ft)	3285.57	25619.90	
Q Total (cfs)	252000.00	Flow (cfs)	18863.69	233136.30	
Top Width (ft)	2303.78	Top Width (ft)	470.68	1833.10	
Vel Total (ft/s)	8.72	Avg. Vel. (ft/s)	5.74	9.10	
Max Chl Dpth (ft)	16.75	Hydr. Depth (ft)	6.98	13.98	
Conv. Total (cfs)	7446847.0	Conv. (cfs)	557440.4	6889406.0	
Length Wtd. (ft)	228.78	Wetted Per. (ft)	472.79	1838.40	
Min Ch El (ft)	999.10	Shear (lb/sq ft)	0.50	1.00	
Alpha	1.04	Stream Power (lb/ft s)	2.85	9.07	
Frctn Loss (ft)	0.28	Cum Volume (acre-ft)	375.85	855.08	432.03
C & E Loss (ft)	0.13	Cum SA (acres)	15.57	66.88	3.54

O.T.

Plan: 51stAveBrdge River: RIVER-1 Reach:Reach-1 Riv Sta: 207.53 Profile: PF#2

Left Sta (ft)	Right Sta (ft)	Flow (cfs)	Area (sq ft)	W.P. (ft)	% Conv.	Hydr D. (ft)	Velocity (ft/s)
18806.86	19154.88	2254.35	583.09	123.94	0.89	4.75	3.87
19154.88	19502.90	16609.34	2702.48	348.85	6.59	7.77	6.15
19502.90 LB	19576.22	5450.13	751.30	73.34	2.16	10.25	7.25
19576.22	19649.55	6878.54	863.88	73.34	2.73	11.78	7.96
19649.55	19722.87	8216.93	961.13	73.34	3.26	13.11	8.55
19722.87	19796.20	10234.54	1096.95	73.42	4.06	14.96	9.33
19796.20	19869.52	11081.53	1150.09	73.34	4.40	15.69	9.64
19869.52	19942.84	10921.32	1139.96	73.32	4.33	15.55	9.58
19942.84	20016.17	10921.32	1139.96	73.32	4.33	15.55	9.58
20016.17	20089.49	10921.32	1139.96	73.32	4.33	15.55	9.58
20089.49	20162.82	10921.32	1139.96	73.32	4.33	15.55	9.58
20162.82	20236.14	10693.50	1125.66	73.33	4.24	15.35	9.50
20236.14	20309.46	10565.48	1117.67	73.35	4.19	15.24	9.45
20309.46	20382.79	11478.87	1174.53	73.32	4.56	16.02	9.77
20382.79	20456.11	11419.31	1170.86	73.32	4.53	15.97	9.75
20456.11	20529.44	11244.38	1160.08	73.32	4.46	15.82	9.69
20529.44	20602.76	11048.21	1147.89	73.32	4.38	15.66	9.62
20602.76	20676.08	11051.51	1148.10	73.32	4.39	15.66	9.63
20676.08	20749.41	11114.30	1152.01	73.32	4.41	15.71	9.65
20749.41	20822.73	10739.76	1128.56	73.33	4.26	15.39	9.52
20822.73	20896.06	9843.50	1071.42	73.39	3.91	14.61	9.19
20896.06	20969.38	7978.65	949.39	74.33	3.17	12.95	8.40
20969.38	21042.70	8720.41	996.17	73.36	3.46	13.59	8.75
21042.70	21116.03	8209.89	960.57	73.32	3.26	13.10	8.55
21116.03	21189.35	7683.34	923.41	73.38	3.05	12.59	8.32
21189.35	21262.68	4195.92	642.64	73.47	1.67	8.76	6.53
21262.68	21336.00 RB	1602.32	367.75	77.12	0.64	5.02	4.36



$a' = 250'$

$Q_c = 4.73\%$
$= 11,919.6$

$A_e = 194.33$

$V_e = 6.1$

$y_e = 7.77$

$a' = 100'$

$Q_c = 4.34\%$
$= 10937 \text{ cfs}$

$A_e = 1283.44$

$V_e = 8.52$

$y_c = 12.834$

HEC-RAS Version 2.0 April 1997
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 Avenue Bridge Scour Analysis
Project File : 51avescr.prj
Run Date and Time: 6/9/97 1:52:28 PM

Project in English units

Project Description:
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.

MCDOT HYDRAULIC ANALYSIS

100-yr SUB-CRITICAL RUN FOR 51st AVENUE BRIDGE

SALT RIVER

PLAN DATA

Plan Title: 51st Avenue Bridge over the Salt River
Plan File : c:\hec\ras\51avescr.p02

Geometry Title: Modified MCFCD FIS HEC-2 DATA
Geometry File : w:\mcdotb~1\51stav~1\51avescr.g02

Flow Title : 100-year and Overtopping Flow Data
Flow File : w:\mcdotb~1\51stav~1\51avescr.f01

Plan Summary Information:
Number of: Cross Sections = 9 Mulitple Openings = 0
Culverts = 0 Inline Weirs = 0
Bridges = 1

Computational Information
Water surface calculation tolerance = 0.01
Critical depth calculaton tolerance = 0.01
Maximum number of interations = 20
Maximum difference tolerance = 0.3
Flow tolerance factor = 0.001

Computational Flow Regime: Subcritical Flow

FLOW DATA

Flow Title: 100-year and Overtopping Flow Data
Flow File : w:\mcdotb~1\51stav~1\51avescr.f01

Flow Data (cfs)

River	Reach	RS	PF#1	PF#2
RIVER-1	Reach-1	207.71	190000	252000

Boundary Conditions

River	Reach	Profile	Upstream	Downstream
RIVER-1	Reach-1	PF#1	Critical	Known WS = 1007.04
RIVER-1	Reach-1	PF#2	Critical	Normal S = 0.0017

GEOMETRY DATA

Geometry Title: Modified MCFCD FIS HEC-2 DATA
Geometry File : w:\mcdotb~1\51stav~1\51avescr.g02

CROSS SECTION RIVER: RIVER-1
REACH: Reach-1 RS: 207.71

INPUT
Description: APPROACH SECTION - 1178.35' FROM UPSTREAM FACE OF BRIDGE

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

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	n Val	Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val
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 OUTPUT Profile #PF#1

			Left OB	Channel	Right OB
W.S. Elev (ft)	1015.43	Element			
Vel Head (ft)	0.94	Wt. n-Val.	0.033	0.032	
E.G. Elev (ft)	1016.37	Reach Len. (ft)	485.00	487.91	485.00
Crit W.S. (ft)	1012.14	Flow Area (sq ft)	4623.24	21782.10	
E.G. Slope (ft/ft)	0.001542	Area (sq ft)	4623.24	21782.10	
Q Total (cfs)	190000.00	Flow (cfs)	14805.44	175194.60	
Top Width (ft)	4773.36	Top Width (ft)	2424.85	2348.51	
Vel Total (ft/s)	7.20	Avg. Vel. (ft/s)	3.20	8.04	
Max Chl Dpth (ft)	15.13	Hydr. Depth (ft)	1.91	9.27	
Conv. Total (cfs)	4838379.0	Conv. (cfs)	377022.7	4461357.0	
Length Wtd. (ft)	487.73	Wetted Per. (ft)	2426.44	2351.35	
Min Ch El (ft)	1000.30	Shear (lb/sq ft)	0.18	0.89	
Alpha	1.17	Stream Power (lb/ft s)	0.59	7.17	
Frctn Loss (ft)	0.89	Cum Volume (acre-ft)	157.93	1132.87	1.28
C & E Loss (ft)	0.05	Cum SA (acres)	36.75	110.60	1.44

Warning - Divided flow computed for this cross-section.
Warning - The cross-section end points had to be extended vertically for the computed water surface.

CROSS SECTION OUTPUT Profile #PF#2

			Left OB	Channel	Right OB
W.S. Elev (ft)	1017.76	Element			
Vel Head (ft)	0.82	Wt. n-Val.	0.034	0.032	0.032
E.G. Elev (ft)	1018.58	Reach Len. (ft)	485.00	487.91	485.00
Crit W.S. (ft)	1013.37	Flow Area (sq ft)	10727.42	27269.89	61.76
E.G. Slope (ft/ft)	0.001071	Area (sq ft)	10727.42	27269.89	61.76
Q Total (cfs)	252000.00	Flow (cfs)	40269.15	211665.50	65.35
Top Width (ft)	5198.45	Top Width (ft)	2733.80	2358.43	106.22
Vel Total (ft/s)	6.62	Avg. Vel. (ft/s)	3.75	7.76	1.06
Max Chl Dpth (ft)	17.46	Hydr. Depth (ft)	3.92	11.56	0.58

Conv. Total (cfs)	7702011.0	Conv. (cfs)	1230768.0	6469246.0	1997.3
Length Wtd. (ft)	487.57	Wetted Per. (ft)	2738.45	2361.54	106.25
Min Ch El (ft)	1000.30	Shear (lb/sq ft)	0.26	0.77	0.04
Alpha	1.21	Stream Power (lb/ft s)	0.98	5.99	0.04
Frctn Loss (ft)	0.66	Cum Volume (acre-ft)	485.28	1396.56	432.37
C & E Loss (ft)	0.07	Cum SA (acres)	38.97	111.21	4.13

Warning - Divided flow computed for this cross-section.
Warning - The cross-section end points had to be extended vertically for the computed water surface.
Warning - The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.

CROSS SECTION RIVER: RIVER-1
REACH: Reach-1 RS: 207.62

INPUT
Description:

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

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	n Val	Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val
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 OUTPUT Profile #PF#1

W.S. Elev (ft)	1014.00	Element	Left OB	Channel	Right OB	
Vel Head (ft)	1.43	Wt. n-Val.	0.032	0.032		
E.G. Elev (ft)	1015.43	Reach Len. (ft)	460.00	461.71	515.00	
Crit W.S. (ft)	1011.32	Flow Area (sq ft)	1750.34	18581.59		
E.G. Slope (ft/ft)	0.002211	Area (sq ft)	1750.34	18581.59		
Q Total (cfs)	190000.00	Flow (cfs)	8596.87	181403.10		
Top Width (ft)	2477.24	Top Width (ft)	519.79	1957.45		
Vel Total (ft/s)	9.34	Avg. Vel. (ft/s)	4.91	9.76		
Max Chl Dpth (ft)	13.80	Hydr. Depth (ft)	3.37	9.49		

Conv. Total (cfs)	4040751.0	Conv. (cfs)	182830.5	3857920.0	
Length Wtd. (ft)	461.63	Wetted Per. (ft)	520.47	1965.37	
Min Ch El (ft)	1000.20	Shear (lb/sq ft)	0.46	1.31	
Alpha	1.05	Stream Power (lb/ft s)	2.28	12.74	
Frctn Loss (ft)	0.76	Cum Volume (acre-ft)	122.45	906.82	1.28
C & E Loss (ft)	0.17	Cum SA (acres)	20.36	86.48	1.44

CROSS SECTION OUTPUT Profile #PF#2

			Left OB	Channel	Right OB
W.S. Elev (ft)	1016.36	Element			
Vel Head (ft)	1.50	Wt. n-Val.	0.032	0.032	
E.G. Elev (ft)	1017.86	Reach Len. (ft)	460.00	461.71	515.00
Crit W.S. (ft)	1012.70	Flow Area (sq ft)	2983.61	23208.62	
E.G. Slope (ft/ft)	0.001753	Area (sq ft)	2983.61	23208.62	
Q Total (cfs)	252000.00	Flow (cfs)	18501.89	233498.10	
Top Width (ft)	2488.76	Top Width (ft)	525.27	1963.49	
Vel Total (ft/s)	9.62	Avg. Vel. (ft/s)	6.20	10.06	
Max Chl Dpth (ft)	16.16	Hydr. Depth (ft)	5.68	11.82	
Conv. Total (cfs)	6018117.0	Conv. (cfs)	441851.3	5576266.0	
Length Wtd. (ft)	461.58	Wetted Per. (ft)	526.43	1971.86	
Min Ch El (ft)	1000.20	Shear (lb/sq ft)	0.62	1.29	
Alpha	1.04	Stream Power (lb/ft s)	3.85	12.96	
Frctn Loss (ft)	0.65	Cum Volume (acre-ft)	408.95	1113.86	432.03
C & E Loss (ft)	0.14	Cum SA (acres)	20.83	87.00	3.54

CROSS SECTION RIVER: RIVER-1
REACH: Reach-1 RS: 207.53

INPUT
Description:
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	n Val	Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val
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 OUTPUT Profile #PF#1

			Left OB	Channel	Right OB
W.S. Elev (ft)	1013.41	Element			
Vel Head (ft)	1.08	Wt. n-Val.	0.032	0.032	
E.G. Elev (ft)	1014.49	Reach Len. (ft)	230.00	228.73	200.00
Crit W.S. (ft)	1008.69	Flow Area (sq ft)	2146.44	21147.58	
E.G. Slope (ft/ft)	0.001288	Area (sq ft)	2146.44	21147.58	
Q Total (cfs)	190000.00	Flow (cfs)	10255.10	179744.90	
Top Width (ft)	2296.22	Top Width (ft)	463.13	1833.10	
Vel Total (ft/s)	8.16	Avg. Vel. (ft/s)	4.78	8.50	
Max Chl Dpth (ft)	14.31	Hydr. Depth (ft)	4.63	11.54	
Conv. Total (cfs)	5294221.0	Conv. (cfs)	285751.5	5008470.0	
Length Wtd. (ft)	228.76	Wetted Per. (ft)	464.85	1835.96	

Min Ch El (ft)	999.10	Shear (lb/sq ft)	0.37	0.93	
Alpha	1.05	Stream Power (lb/ft s)	1.77	7.87	
Frctn Loss (ft)	0.29	Cum Volume (acre-ft)	101.87	696.27	1.28
C & E Loss (ft)	0.06	Cum SA (acres)	15.17	66.39	1.44

CROSS SECTION OUTPUT Profile #PF#2

W.S. Elev (ft)	1015.85	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.23	Wt. n-Val.	0.033	0.032	
E.G. Elev (ft)	1017.07	Reach Len. (ft)	230.00	228.73	200.00
Crit W.S. (ft)	1010.19	Flow Area (sq ft)	3285.57	25619.90	
E.G. Slope (ft/ft)	0.001145	Area (sq ft)	3285.57	25619.90	
Q Total (cfs)	252000.00	Flow (cfs)	18863.69	233136.30	
Top Width (ft)	2303.78	Top Width (ft)	470.68	1833.10	
Vel Total (ft/s)	8.72	Avg. Vel. (ft/s)	5.74	9.10	
Max Chl Dpth (ft)	16.75	Hydr. Depth (ft)	6.98	13.98	
Conv. Total (cfs)	7446847.0	Conv. (cfs)	557440.4	6889406.0	
Length Wtd. (ft)	228.78	Wetted Per. (ft)	472.79	1838.40	
Min Ch El (ft)	999.10	Shear (lb/sq ft)	0.50	1.00	
Alpha	1.04	Stream Power (lb/ft s)	2.85	9.07	
Frctn Loss (ft)	0.28	Cum Volume (acre-ft)	375.85	855.08	432.03
C & E Loss (ft)	0.13	Cum SA (acres)	15.57	66.88	3.54

CROSS SECTION RIVER: RIVER-1
REACH: Reach-1 RS: 207.5

INPUT
Description:
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	998.88	19507	998.85	19532	993.12
19562.3	987.15	19586	989.37	19662.3	991.7	19675	993.42	19762.3	995.78
19822	997.26	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	997.93	20762.3	1000.18	20774	998.65
20862.3	1000.2	20943	998.28	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	n Val	Sta	n Val	Sta	n Val
19041.1	.032	19438.9	.032	21078.4	.032

Bank Sta: Left	Right	Lengths: Left Channel	Right	Coeff Contr.	Expan.
19438.9	21078.4	52 52.71	37	.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 OUTPUT Profile #PF#1

W.S. Elev (ft)	1012.86	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.28	Wt. n-Val.		0.032	
E.G. Elev (ft)	1014.14	Reach Len. (ft)	1.00	1.00	1.00
Crit W.S. (ft)	1007.22	Flow Area (sq ft)		20926.09	
E.G. Slope (ft/ft)	0.001231	Area (sq ft)		20926.09	
Q Total (cfs)	190000.00	Flow (cfs)		190000.00	
Top Width (ft)	1580.42	Top Width (ft)		1580.42	
Vel Total (ft/s)	9.08	Avg. Vel. (ft/s)		9.08	
Max Chl Dpth (ft)	25.71	Hydr. Depth (ft)		13.24	
Conv. Total (cfs)	5415201.0	Conv. (cfs)		5415201.0	
Length Wtd. (ft)	1.00	Wetted Per. (ft)		1590.62	
Min Ch El (ft)	987.15	Shear (lb/sq ft)		1.01	
Alpha	1.00	Stream Power (lb/ft s)		9.18	
Frctn Loss (ft)	0.00	Cum Volume (acre-ft)	96.20	585.80	1.28
C & E Loss (ft)	0.04	Cum SA (acres)	13.95	57.43	1.44

Warning - The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant method to find critical depth.

CROSS SECTION OUTPUT Profile #PF#2

			Left OB	Channel	Right OB
W.S. Elev (ft)	1014.99	Element			
Vel Head (ft)	1.67	Wt. n-Val.		0.032	
E.G. Elev (ft)	1016.66	Reach Len. (ft)	1.00	1.00	1.00
Crit W.S. (ft)	1008.81	Flow Area (sq ft)		24326.47	
E.G. Slope (ft/ft)	0.001344	Area (sq ft)		24326.47	
Q Total (cfs)	252000.00	Flow (cfs)		252000.00	
Top Width (ft)	1609.66	Top Width (ft)		1609.66	
Vel Total (ft/s)	10.36	Avg. Vel. (ft/s)		10.36	
Max Chl Dpth (ft)	27.84	Hydr. Depth (ft)		15.11	
Conv. Total (cfs)	6873651.0	Conv. (cfs)		6873651.0	
Length Wtd. (ft)	1.00	Wetted Per. (ft)		1620.63	
Min Ch El (ft)	987.15	Shear (lb/sq ft)		1.26	
Alpha	1.00	Stream Power (lb/ft s)		13.05	
Frctn Loss (ft)	0.00	Cum Volume (acre-ft)	367.18	723.95	432.03
C & E Loss (ft)	0.06	Cum SA (acres)	14.33	57.84	3.54

BRIDGE RIVER: RIVER-1
REACH: Reach-1 RS: 207.485

INPUT
Description: Bridge #1

Downstream face of 51st Avenue bridge

Distance from Upstream XS = 1
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						

Upstream Bridge Cross Section Data
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	998.88	19507	998.85	19532	993.12
19562.3	987.15	19586	989.37	19662.3	991.7	19675	993.42	19762.3	995.78
19822	997.26	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	997.93	20762.3	1000.18	20774	998.65
20862.3	1000.2	20943	998.28	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	n Val	Sta	n Val	Sta	n Val
19041.1	.032	19438.9	.032	21078.4	.032

Bank Sta: Left	Right	Coeff Contr.	Expan.
19438.9	21078.4	.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

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			

Downstream Bridge Cross Section Data
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	998.55	19505	996.61	19544	990.43	19562.3	989.31
19612.3	989.87	19662.3	990.07	19696.3	993.21	19762.3	996.37	19862.3	997.75
19876.3	997.46	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	998.59	20862.3	998.57	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	n Val	Sta	n Val	Sta	n Val
19021.7	.032	19437	.032	21080.9	.032

Bank Sta: Left	Right	Coeff Contr.	Expan.
19437	21080.9	.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

Upstream Embankment side slope = 2 horiz. to 1.0 vertical
Downstream Embankment side slope = 2 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow = .95
Elevation at which weir flow begins =
Energy head used in spillway design =
Spillway height used in design =
Weir crest shape = Broad Crested

Number of Piers = 15

Pier Data
Pier Station Upstream= 19562.3 Downstream= 19562.3
Upstream num= 2

Width	Elev	Width	Elev
4	986.95	4	1017.77

Downstream num= 2

Width	Elev	Width	Elev
4	986.95	4	1017.77

Pier Data
Pier Station Upstream= 19662.3 Downstream= 19662.3
Upstream num= 2

Width	Elev	Width	Elev
4	991.5	4	1019.47

Downstream num= 2

Width	Elev	Width	Elev
4	991.5	4	1019.47

Pier Data
Pier Station Upstream= 19762.3 Downstream= 19762.3
Upstream num= 2

Width	Elev	Width	Elev
4	995.58	4	1020.87

Downstream num= 2

```
    Width   Elev    Width   Elev
       4  995.58       4 1020.87

Pier Data
Pier Station     Upstream= 19862.3    Downstream= 19862.3
Upstream     num=        2
    Width   Elev    Width   Elev
       4  998.78       4    1022
Downstream     num=        2
    Width   Elev    Width   Elev
       4  998.78       4    1022

Pier Data
Pier Station     Upstream= 19962.3    Downstream= 19962.3
Upstream     num=        2
    Width   Elev    Width   Elev
       4  1000.3       4 1022.87
Downstream     num=        2
    Width   Elev    Width   Elev
       4  1000.3       4 1022.87

Pier Data
Pier Station     Upstream= 20062.3    Downstream= 20062.3
Upstream     num=        2
    Width   Elev    Width   Elev
       4 1002.77       4  1023.6
Downstream     num=        2
    Width   Elev    Width   Elev
       4 1002.77       4  1023.6

Pier Data
Pier Station     Upstream= 20162.3    Downstream= 20162.3
Upstream     num=        2
    Width   Elev    Width   Elev
       4 1002.18       4    1024
Downstream     num=        2
    Width   Elev    Width   Elev
       4 1002.18       4    1024

Pier Data
Pier Station     Upstream= 20262.3    Downstream= 20262.3
Upstream     num=        2
    Width   Elev    Width   Elev
       4  1000.2       4  1024.1
Downstream     num=        2
    Width   Elev    Width   Elev
       4  1000.2       4  1024.1

Pier Data
Pier Station     Upstream= 20362.3    Downstream= 20362.3
Upstream     num=        2
    Width   Elev    Width   Elev
       4 1001.93       4    1024
Downstream     num=        2
    Width   Elev    Width   Elev
       4 1001.93       4    1024

Pier Data
Pier Station     Upstream= 20462.3    Downstream= 20462.3
Upstream     num=        2
    Width   Elev    Width   Elev
       4  1004.7       4 1023.68
Downstream     num=        2
    Width   Elev    Width   Elev
       4  1004.7       4 1023.68

Pier Data
Pier Station     Upstream= 20562.3    Downstream= 20562.3
Upstream     num=        2
    Width   Elev    Width   Elev
       4 1003.34       4    1023
Downstream     num=        2
    Width   Elev    Width   Elev
       4 1003.34       4    1023

Pier Data
Pier Station     Upstream= 20662.3    Downstream= 20662.3
Upstream     num=        2
```

```
    Width   Elev     Width   Elev
       4 1000.12        4  1022.2
Downstream     num=         2
    Width   Elev     Width   Elev
       4 1000.12        4  1022.2

Pier Data
Pier Station     Upstream= 20762.3    Downstream= 20762.3
Upstream     num=         2
    Width   Elev     Width   Elev
       4    1000        4    1021
Downstream     num=         2
    Width   Elev     Width   Elev
       4    1000        4    1021

Pier Data
Pier Station     Upstream= 20862.3    Downstream= 20862.3
Upstream     num=         2
    Width   Elev     Width   Elev
       4  999.97        4  1019.7
Downstream     num=         2
    Width   Elev     Width   Elev
       4  999.97        4  1019.7

Pier Data
Pier Station     Upstream= 20962.3    Downstream= 20962.3
Upstream     num=         2
    Width   Elev     Width   Elev
       4  999.79        4    1018
Downstream     num=         2
    Width   Elev     Width   Elev
       4  999.79        4    1018

Number of Bridge Coefficient Sets =  1

Low Flow Methods and Data
       Energy
       Momentum               Cd   =     1.2
       Yarnell                KVal =    1.05
Selected Low Flow Methods = Highest Energy Answer

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

BRIDGE OUTPUT    Profile #PF#1
Opening : Bridge #1
```

			Inside BR US	Inside BR DS
E.G. US. (ft)	1014.14	Element		
W.S. US. (ft)	1012.86	E.G. Elev (ft)	1014.09	1013.99
Q Total (cfs)	190000.00	W.S. Elev (ft)	1012.67	1012.58
Q Bridge (cfs)	190000.00	Crit W.S. (ft)	1007.44	1007.25
Q Weir (cfs)		Max Chl Dpth (ft)	25.33	23.25
Weir Sta Lft (ft)		Vel Total (ft/s)	9.58	9.53
Weir Sta Rgt (ft)		Flow Area (sq ft)	19827.74	19935.59
Weir Submerg		Froude # Chl	0.47	0.46
Weir Max Depth (ft)		Specif Force (cu ft)	197593.50	199442.80
Min Top Rd (ft)	1013.70	Hydr Depth (ft)	13.05	13.12
Min El Prs (ft)	1024.09	W.P. Total (ft)	1927.69	1931.39
Delta EG (ft)	0.21	Conv. Total (cfs)	4354541.0	4388482.0
Delta WS (ft)	0.22	Top Width (ft)	1519.85	1518.97
BR Open Area (sq ft)	33007.61	Frctn Loss (ft)	0.10	0.00
BR Open Vel (ft/s)	9.58	C & E Loss (ft)	0.01	0.06
Coef of Q		Shear Total (lb/sq ft)	1.22	1.21
Br Sel Mthd	Energy only	Power Total (lb/ft s)	11.71	11.51

```
Note - Momentum answer is not valid if the water surface is above the low chord or if there is weir
               flow.  The momentum answer has been disregarded.
Warning - The parabolic search method failed to converge on critical depth.  The program will try the
               cross section slice/secant method to find critical depth.
Warning - The parabolic search method failed to converge on critical depth.  The program will try the
```

BRIDGE OUTPUT Profile #PF#2
Opening : Bridge #1

			Inside BR US	Inside BR DS
E.G. US. (ft)	1016.66	Element		
W.S. US. (ft)	1014.99	E.G. Elev (ft)	1016.60	1016.48
Q Total (cfs)	252000.00	W.S. Elev (ft)	1014.73	1014.63
Q Bridge (cfs)	251992.60	Crit W.S. (ft)	1009.06	1008.92
Q Weir (cfs)		Max Chl Dpth (ft)	27.39	25.30
Weir Sta Lft (ft)		Vel Total (ft/s)	10.96	10.92
Weir Sta Rgt (ft)		Flow Area (sq ft)	22984.18	23069.26
Weir Submerg		Froude # Chl	0.50	0.50
Weir Max Depth (ft)		Specif Force (cu ft)	271000.40	272716.10
Min Top Rd (ft)	1013.70	Hydr Depth (ft)	14.87	14.92
Min El Prs (ft)	1024.09	W.P. Total (ft)	2021.61	2022.16
Delta EG (ft)	0.26	Conv. Total (cfs)	5396289.0	5428638.0
Delta WS (ft)	0.29	Top Width (ft)	1545.45	1546.50
BR Open Area (sq ft)	33007.61	Frctn Loss (ft)	0.11	0.00
BR Open Vel (ft/s)	10.97	C & E Loss (ft)	0.01	0.08
Coef of Q		Shear Total (lb/sq ft)	1.55	1.53
Br Sel Mthd	Energy only	Power Total (lb/ft s)	16.97	16.76

Note - Momentum answer is not valid if the water surface is above the low chord or if there is weir flow. The momentum answer has been disregarded.
Warning - The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant method to find critical depth.
Warning - The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant method to find critical depth.

CROSS SECTION RIVER: RIVER-1
REACH: Reach-1 RS: 207.47

INPUT
Description:
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	998.55	19505	996.61	19544	990.43	19562.3	989.31
19612.3	989.87	19662.3	990.07	19696.3	993.21	19762.3	996.37	19862.3	997.75
19876.3	997.46	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	998.59	20862.3	998.57	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	n Val	Sta	n Val	Sta	n Val
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 OUTPUT Profile #PF#1

			Left OB	Channel	Right OB
W.S. Elev (ft)	1012.64	Element			
Vel Head (ft)	1.29	Wt. n-Val.		0.032	
E.G. Elev (ft)	1013.93	Reach Len. (ft)	250.00	244.54	315.00
Crit W.S. (ft)	1007.04	Flow Area (sq ft)		20835.00	
E.G. Slope (ft/ft)	0.001246	Area (sq ft)		20835.00	
Q Total (cfs)	190000.00	Flow (cfs)		190000.00	
Top Width (ft)	1579.20	Top Width (ft)		1579.20	
Vel Total (ft/s)	9.12	Avg. Vel. (ft/s)		9.12	
Max Chl Dpth (ft)	23.33	Hydr. Depth (ft)		13.19	
Conv. Total (cfs)	5382557.0	Conv. (cfs)		5382557.0	

Length Wtd. (ft)	244.57	Wetted Per. (ft)		1587.70	
Min Ch El (ft)	989.31	Shear (lb/sq ft)		1.02	
Alpha	1.00	Stream Power (lb/ft s)		9.31	
Frctn Loss (ft)	0.39	Cum Volume (acre-ft)	96.20	561.72	1.28
C & E Loss (ft)	0.09	Cum SA (acres)	13.95	55.59	1.44

Warning - The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant method to find critical depth.

CROSS SECTION OUTPUT Profile #PF#2

W.S. Elev (ft)	1014.71	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.69	Wt. n-Val.		0.032	
E.G. Elev (ft)	1016.40	Reach Len. (ft)	250.00	244.54	315.00
Crit W.S. (ft)	1008.64	Flow Area (sq ft)		24124.53	
E.G. Slope (ft/ft)	0.001377	Area (sq ft)		24124.53	
Q Total (cfs)	252000.00	Flow (cfs)		252000.00	
Top Width (ft)	1607.13	Top Width (ft)		1607.13	
Vel Total (ft/s)	10.45	Avg. Vel. (ft/s)		10.45	
Max Chl Dpth (ft)	25.40	Hydr. Depth (ft)		15.01	
Conv. Total (cfs)	6790799.0	Conv. (cfs)		6790799.0	
Length Wtd. (ft)	244.78	Wetted Per. (ft)		1616.34	
Min Ch El (ft)	989.31	Shear (lb/sq ft)		1.28	
Alpha	1.00	Stream Power (lb/ft s)		13.40	
Frctn Loss (ft)	0.40	Cum Volume (acre-ft)	136.83	696.06	6.69
C & E Loss (ft)	0.05	Cum SA (acres)	14.33	55.97	3.54

Warning - The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant method to find critical depth.

CROSS SECTION RIVER: RIVER-1
REACH: Reach-1 RS: 207.43

INPUT
Description:

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

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	n Val	Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val
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 OUTPUT Profile #PF#1

			Left OB	Channel	Right OB
W.S. Elev (ft)	1011.84	Element			
Vel Head (ft)	1.60	Wt. n-Val.		0.032	0.032
E.G. Elev (ft)	1013.44	Reach Len. (ft)	450.00	461.19	575.00
Crit W.S. (ft)	1008.26	Flow Area (sq ft)		18673.16	84.33
E.G. Slope (ft/ft)	0.002128	Area (sq ft)		18673.16	84.33
Q Total (cfs)	190000.00	Flow (cfs)		189862.90	137.14
Top Width (ft)	1930.36	Top Width (ft)		1802.90	127.46
Vel Total (ft/s)	10.13	Avg. Vel. (ft/s)		10.17	1.63
Max Chl Dpth (ft)	12.84	Hydr. Depth (ft)		10.36	0.66
Conv. Total (cfs)	4118552.0	Conv. (cfs)		4115579.0	2972.8
Length Wtd. (ft)	461.23	Wetted Per. (ft)		1805.78	127.47
Min Ch El (ft)	999.00	Shear (lb/sq ft)		1.37	0.09
Alpha	1.01	Stream Power (lb/ft s)		13.97	0.14
Frctn Loss (ft)	1.18	Cum Volume (acre-ft)	96.20	450.83	0.97
C & E Loss (ft)	0.19	Cum SA (acres)	13.95	46.10	0.98

Warning - The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
Warning - The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the need for additional cross sections.
Warning - The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant method to find critical depth.

CROSS SECTION OUTPUT Profile #PF#2

			Left OB	Channel	Right OB
W.S. Elev (ft)	1014.07	Element			
Vel Head (ft)	1.88	Wt. n-Val.		0.032	0.032
E.G. Elev (ft)	1015.95	Reach Len. (ft)	450.00	461.19	575.00
Crit W.S. (ft)	1009.83	Flow Area (sq ft)		22700.52	571.46
E.G. Slope (ft/ft)	0.001932	Area (sq ft)		22700.52	571.46
Q Total (cfs)	252000.00	Flow (cfs)		250306.90	1693.10
Top Width (ft)	2129.30	Top Width (ft)		1802.90	326.40
Vel Total (ft/s)	10.83	Avg. Vel. (ft/s)		11.03	2.96
Max Chl Dpth (ft)	15.07	Hydr. Depth (ft)		12.59	1.75
Conv. Total (cfs)	5732763.0	Conv. (cfs)		5694247.0	38516.5
Length Wtd. (ft)	461.57	Wetted Per. (ft)		1808.02	326.79
Min Ch El (ft)	999.00	Shear (lb/sq ft)		1.51	0.21
Alpha	1.03	Stream Power (lb/ft s)		16.70	0.62
Frctn Loss (ft)	1.09	Cum Volume (acre-ft)	136.83	564.63	4.62
C & E Loss (ft)	0.23	Cum SA (acres)	14.33	46.40	2.36

Warning - The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
Warning - The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the need for additional cross sections.
Warning - The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant method to find critical depth.

CROSS SECTION RIVER: RIVER-1
REACH: Reach-1 RS: 207.34

INPUT
Description:

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

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	997	19326.4	995.9	19381	999.5	19392.5	1002.2	19404.7	999
19437.8	1000.9	19593.3	1002.4	19706.7	1001.8	19842	1000.3	19946.7	998.7
20191.8	998.9	20302.5	998.8	20382.5	998.4	20416.2	996.5	20521.3	998.7
20631.1	998.6	20696.7	998.2	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	n Val	Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val
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 OUTPUT Profile #PF#1

W.S. Elev (ft)	1009.86	Element	Left OB	Channel	Right OB
Vel Head (ft)	2.22	Wt. n-Val.		0.032	
E.G. Elev (ft)	1012.08	Reach Len. (ft)	370.00	393.75	530.00
Crit W.S. (ft)	1007.36	Flow Area (sq ft)		15875.21	
E.G. Slope (ft/ft)	0.003107	Area (sq ft)		15875.21	
Q Total (cfs)	190000.00	Flow (cfs)		190000.00	
Top Width (ft)	1591.70	Top Width (ft)		1591.70	
Vel Total (ft/s)	11.97	Avg. Vel. (ft/s)		11.97	
Max Chl Dpth (ft)	13.96	Hydr. Depth (ft)		9.97	
Conv. Total (cfs)	3408842.0	Conv. (cfs)		3408842.0	
Length Wtd. (ft)	389.46	Wetted Per. (ft)		1596.45	
Min Ch El (ft)	995.90	Shear (lb/sq ft)		1.93	
Alpha	1.00	Stream Power (lb/ft s)		23.08	
Frctn Loss (ft)	1.29	Cum Volume (acre-ft)	96.20	267.94	0.42
C & E Loss (ft)	0.01	Cum SA (acres)	13.95	28.13	0.14

Warning - The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the need for additional cross sections.

CROSS SECTION OUTPUT Profile #PF#2

W.S. Elev (ft)	1011.99	Element	Left OB	Channel	Right OB
Vel Head (ft)	2.65	Wt. n-Val.		0.032	
E.G. Elev (ft)	1014.63	Reach Len. (ft)	370.00	393.75	530.00
Crit W.S. (ft)	1009.03	Flow Area (sq ft)		19301.87	
E.G. Slope (ft/ft)	0.002925	Area (sq ft)		19301.87	
Q Total (cfs)	252000.00	Flow (cfs)		252000.00	
Top Width (ft)	1621.46	Top Width (ft)		1621.46	
Vel Total (ft/s)	13.06	Avg. Vel. (ft/s)		13.06	
Max Chl Dpth (ft)	16.09	Hydr. Depth (ft)		11.90	
Conv. Total (cfs)	4659723.0	Conv. (cfs)		4659723.0	
Length Wtd. (ft)	389.61	Wetted Per. (ft)		1628.27	
Min Ch El (ft)	995.90	Shear (lb/sq ft)		2.16	
Alpha	1.00	Stream Power (lb/ft s)		28.26	
Frctn Loss (ft)	1.10	Cum Volume (acre-ft)	136.83	342.28	0.85
C & E Loss (ft)	0.16	Cum SA (acres)	14.33	28.27	0.20

Warning - The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the need for additional cross sections.

CROSS SECTION RIVER: RIVER-1
REACH: Reach-1 RS: 207.27

INPUT
Description:

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

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	n Val	Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val
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	1014.2	20662.2	21463	1014.2

CROSS SECTION OUTPUT Profile #PF#1

			Left OB	Channel	Right OB
W.S. Elev (ft)	1008.52	Element			
Vel Head (ft)	2.26	Wt. n-Val.	0.032	0.032	0.032
E.G. Elev (ft)	1010.78	Reach Len. (ft)	575.00	572.72	585.00
Crit W.S. (ft)	1006.71	Flow Area (sq ft)	5498.24	10254.68	32.65
E.G. Slope (ft/ft)	0.003529	Area (sq ft)	5498.24	10254.68	32.65
Q Total (cfs)	190000.00	Flow (cfs)	69619.61	120209.80	170.64
Top Width (ft)	1910.98	Top Width (ft)	730.85	1169.10	11.03
Vel Total (ft/s)	12.04	Avg. Vel. (ft/s)	12.66	11.72	5.23
Max Chl Dpth (ft)	20.92	Hydr. Depth (ft)	7.52	8.77	2.96
Conv. Total (cfs)	3198327.0	Conv. (cfs)	1171928.0	2023527.0	2872.4
Length Wtd. (ft)	573.41	Wetted Per. (ft)	736.97	1170.60	12.52
Min Ch El (ft)	993.30	Shear (lb/sq ft)	1.64	1.93	0.57
Alpha	1.01	Stream Power (lb/ft s)	20.81	22.62	3.00

Frctn Loss (ft)	1.78	Cum Volume (acre-ft)	72.85	149.84	0.22
C & E Loss (ft)	0.13	Cum SA (acres)	10.84	15.65	0.07

Warning - The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the need for additional cross sections.
Warning - The parabolic search method failed to converge on critical depth. The program will try the cross section slice/secant method to find critical depth.

CROSS SECTION OUTPUT Profile #PF#2

			Left OB	Channel	Right OB
W.S. Elev (ft)	1011.05	Element			
Vel Head (ft)	2.32	Wt. n-Val.	0.033	0.032	0.032
E.G. Elev (ft)	1013.36	Reach Len. (ft)	575.00	572.72	585.00
Crit W.S. (ft)	1008.37	Flow Area (sq ft)	7373.60	13209.83	66.49
E.G. Slope (ft/ft)	0.002742	Area (sq ft)	7373.60	13209.83	66.49
Q Total (cfs)	252000.00	Flow (cfs)	90018.68	161593.10	388.23
Top Width (ft)	1926.94	Top Width (ft)	742.10	1169.10	15.74
Vel Total (ft/s)	12.20	Avg. Vel. (ft/s)	12.21	12.23	5.84
Max Chl Dpth (ft)	23.45	Hydr. Depth (ft)	9.94	11.30	4.22
Conv. Total (cfs)	4812583.0	Conv. (cfs)	1719136.0	3086033.0	7414.3
Length Wtd. (ft)	573.46	Wetted Per. (ft)	750.66	1170.60	17.87
Min Ch El (ft)	993.30	Shear (lb/sq ft)	1.68	1.93	0.64
Alpha	1.00	Stream Power (lb/ft s)	20.53	23.63	3.72
Frctn Loss (ft)	1.22	Cum Volume (acre-ft)	105.52	195.34	0.45
C & E Loss (ft)	0.21	Cum SA (acres)	11.17	15.66	0.11

Warning - The velocity head has changed by more than 0.5 ft (0.15 m). This may indicate the need for additional cross sections.
Warning - The energy loss was greater than 1.0 ft (0.3 m). between the current and previous cross section. This may indicate the need for additional cross sections.

CROSS SECTION RIVER: RIVER-1
REACH: Reach-1 RS: 207.16

INPUT
Description: EXIT SECTION - 1672.2' FROM DOWNSTREAM FACE OF BRIDGE

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	n Val	Sta	n Val	Sta	n Val	Sta	n Val	Sta	n Val
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	.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

CROSS SECTION OUTPUT Profile #PF#1

			Left OB	Channel	Right OB
W.S. Elev (ft)	1007.04	Element			

Vel Head (ft)	1.83	Wt. n-Val.	0.032	0.032
E.G. Elev (ft)	1008.87	Reach Len. (ft)		
Crit W.S. (ft)	1005.10	Flow Area (sq ft)	5539.95	12538.16
E.G. Slope (ft/ft)	0.002761	Area (sq ft)	5539.95	12538.16
Q Total (cfs)	190000.00	Flow (cfs)	44962.80	145037.20
Top Width (ft)	2122.98	Top Width (ft)	911.79	1211.19
Vel Total (ft/s)	10.51	Avg. Vel. (ft/s)	8.12	11.57
Max Chl Dpth (ft)	14.34	Hydr. Depth (ft)	6.08	10.35
Conv. Total (cfs)	3615879.0	Conv. (cfs)	855684.5	2760194.0
Length Wtd. (ft)		Wetted Per. (ft)	913.19	1214.63
Min Ch El (ft)	992.70	Shear (lb/sq ft)	1.05	1.78
Alpha	1.07	Stream Power (lb/ft s)	8.49	20.58
Frctn Loss (ft)		Cum Volume (acre-ft)		
C & E Loss (ft)		Cum SA (acres)		

CROSS SECTION OUTPUT Profile #PF#2

W.S. Elev (ft)	1010.31	Element	Left OB	Channel	Right OB
Vel Head (ft)	1.63	Wt. n-Val.	0.032	0.032	
E.G. Elev (ft)	1011.93	Reach Len. (ft)			
Crit W.S. (ft)	1006.40	Flow Area (sq ft)	8613.66	16503.96	
E.G. Slope (ft/ft)	0.001701	Area (sq ft)	8613.66	16503.96	
Q Total (cfs)	252000.00	Flow (cfs)	72477.62	179522.40	
Top Width (ft)	2164.10	Top Width (ft)	951.00	1213.10	
Vel Total (ft/s)	10.03	Avg. Vel. (ft/s)	8.41	10.88	
Max Chl Dpth (ft)	17.61	Hydr. Depth (ft)	9.06	13.60	
Conv. Total (cfs)	6109817.0	Conv. (cfs)	1757242.0	4352575.0	
Length Wtd. (ft)		Wetted Per. (ft)	954.71	1219.32	
Min Ch El (ft)	992.70	Shear (lb/sq ft)	0.96	1.44	
Alpha	1.04	Stream Power (lb/ft s)	8.06	15.64	
Frctn Loss (ft)		Cum Volume (acre-ft)			
C & E Loss (ft)		Cum SA (acres)			

SUMMARY OF MANNING'S N VALUES

River:RIVER-1

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

SUMMARY OF REACH LENGTHS

River: RIVER-1

Reach	River Sta.	Left	Channel	Right
Reach-1	207.71	485	487.91	485
Reach-1	207.62	460	461.71	515
Reach-1	207.53	230	228.73	200
Reach-1	207.5	52	52.71	37
Reach-1	207.485	Bridge		
Reach-1	207.47	250	244.54	315
Reach-1	207.43	450	461.19	575
Reach-1	207.34	370	393.75	530
Reach-1	207.27	575	572.72	585
Reach-1	207.16	0	0	0

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS

River: RIVER-1

Reach	River Sta.		Contr.	Expan.
Reach-1	207.71		.1	.3
Reach-1	207.62		.3	.5
Reach-1	207.53		.3	.5
Reach-1	207.5		.3	.5
Reach-1	207.485	Bridge		
Reach-1	207.47		.3	.5
Reach-1	207.43		.3	.5
Reach-1	207.34		.3	.5
Reach-1	207.27		.1	.3
Reach-1	207.16		.1	.3