Aug. 25, 1997
23048-APA

Bridge Scour Investigation
and Design of Corrective Measures

Work Order No. 80407
Maricopa County Department of Transportation

FINAL REPORT

Structure Number 9145
Indian School Road Bridge over the Agua Fria River

Submitted to
Maricopa County Department of Transportation

Registered Professional Engineer (Civil)
Certificate No. 21674
Robert L. Davies
Date Signed 8-26-97
Arizona, U.S.A.

Submitted by

Baker

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Introduction

Maricopa County Department of Transportation (MCDOT) has completed an initial scour investigation of all Maricopa County bridges. Of the bridges studied, ten scour critical bridges are being considered for countermeasure design. The Baker team is investigating and performing the final design required to retrofit five of these bridges. Existing data/reports were reviewed, site investigations made, countermeasure alternative reports developed, and PS&E packages completed for each structure.

Bridge Location and Description

The Indian School Road Bridge over the Agua Fria River is an 18 span AASHTO type 3 girder bridge (1623 feet in length), built in 1970 under Project S-225(12). The bridge was widened to clear a roadway width of 74 feet under Project No. 60300 in 1978. The piers in the west portion of the bridge are supported on spread footings about 15 feet below the channel bed. The east portion of the bridge was reconstructed under Project No. 68074 in 1983 after 6 spans failed during the 1980 floods. The newer 5 piers on the east end of the bridge are supported on drilled shafts.

In 1986, the Maricopa County Flood Control District constructed flood control improvements to the Agua Fria River channel in the vicinity of the Indian School Bridge. The applicable features include a grade-control structure about 150 feet downstream and soil-cement bank protection on both banks at the bridge abutments. Directly under the bridge, the banks consist of a soil-cement lower layer and a grouted riprap upper section.

Report Review

Cannon and Associates, Inc. (Cannon) evaluated this bridge for scour risk under a previous contract with the MCDOT.

Cannon determined that the bridge is scour critical due to local scour depths below the shallow spread footings at the piers. The 5 drilled shaft piers and the abutments are not scour critical.

Cannon's report, completed in November 1996, has been reviewed and the following comments are made.

Comments:

1. The Report indicates that there is a broken grade control structure; however, the existing grade control structure downstream of the bridge appears to be in good condition.
2. The regulatory discharges used by Cannon for scour calculations are now outdated, since they were related to the old Waddell Dam. The new regulatory discharges with the New Waddell Dam, soon to be official, are much lower than that used previously.
3. Even with the new regulatory discharges, the spread footings are still scour vulnerable.
4. Baker concurs with Cannon's structural evaluation based on the parameters they used. The new regulatory discharges will cause the depths and velocities to vary. We agree that the piers are both vertically and laterally stable for Q500 flow conditions, however, the foundation is still vulnerable to being undercut.
5. Baker concurs with the geotechnical findings in Cannon's report. The contractor will be responsible to perform soil cement mix design depending on the material excavated and used.
6. Overall, the Cannon Report's findings are reasonable.

Site Inspection

The site inspection was made on June 19, 1997 with the following present: Bob Davies, John Misik, Anthony Pisano, and Richard Bruesch of Baker, Ken Ricker of RAM, Mark Larson of Larson & Company, and Tom Sonneman of MCDOT.

Observations:

1. Both banks are in sound condition, each consisting of a soil-cement section.
2. There is no visible evidence of a broken grade-control structure.
3. The channel bed material appears to be well suited for soil cement.
4. The river bed was dry with no standing or running water.
5. The existing vegetation of creosote, salt bush, and scattered low grasses is sparse, highly disturbed, and shows no evidence of near surface water sources. The closest economic land uses are agriculture, light industrial, residential, and gravel mining upstream of the bridge. A small population of cliff swallows, rock doves, house finches, and house sparrows inhabits the underside of the bridge. It is unlikely that the vegetation in the vicinity of the bridge supports any avian species in its disturbed and sparse condition.
6. There is a large area on the east upstream over bank that would be suitable for material storage, processing of soil cement, and contractor staging. This area appears to have been previously used for similar operations.

7. A local gravel mining operation has a haul road crossing under the bridge to transport material between processing facilities on both sides of Indian School Road. The haul road is depressed under one of the spans in the newer section of drilled shaft piers.
8. Review of existing site surface condition and subsurface data indicates that river bed contains fine to medium sands and silty sands with a trace to some gravel. The soils are generally loose at the surface, medium dense below and typically extend to depths of 15 to 25 feet. Below these depths, the soils are composed of sand, gravel and cobble deposits with various amounts of silt and clay fines.
9. A proposed resistant layer countermeasure could be composed of soil cement, cement stabilized alluvium or roller compacted concrete.
10. Material reuse considerations indicate that the materials excavated, probably sands and silty sands, may be used as the primary constituent of soil cement. The soil cement will probably require about 11 percent cement. The deeper materials could be used to make cement stabilized alluvium or roller compacted concrete.
11. Groundwater levels in the summer months are typically low and are anticipated to be well below the excavation depth. During and for some time after heavy rains or flows in the river, groundwater can be near the surface. Dewatering may be required.
12. Due to the sandy nature of the near surface soils, access to the site may require track equipment or the use of gravel or cement to stabilize the surface materials so that rubber-tired vehicles can readily service the construction activities.
13. The initial report by Cannon is complete enough to use, notwithstanding the difference in regulatory discharge. Since the bridge failed in 1980 during a flood, the finding of scour critical by Cannon should not be in question.

Hydrology and Hydraulics

The critical flow for use in the scour analysis is the lesser of the 500-year flood and the flow that just reaches the low chord elevation of the bridge. A flow of 261,600 cfs would be required before the flow in the river would be deep enough to reach the maximum low chord elevation of the bridge. Since this discharge is much larger than the 500-year discharge, the 500-year flood was used in the scour computations.

The 100- and 500-year discharges used in the report were 95,000 cfs and 184,000 cfs, respectively. These discharges do not reflect the construction of the New Waddell Dam. After the construction of the dam, a new hydrologic analysis was performed for the Flood Control District of Maricopa County (FCDMC). This analysis was completed in October 1996. This new analysis shows that the new dam reduces the 100- and 500-year discharges to 52,000 and 125,000 cfs, respectively.

The analysis in the Cannon report shows that the bridge is scour critical for both the 100- and 500-year floods. These computations were done using the Pre-New Waddell Dam discharge, however the effect of the total discharge on the scour depths is not significant enough to remove the bridge from the scour critical list. Since the new 500-

year discharge is between the 100- and 500-year floods used in the Cannon report, the bridge is still scour critical.

Long Term Scour

The Cannon report cited a long-term scour of zero. There is an active gravel mining operation downstream of the bridge. There is a soil-cement grade control structure about 150 feet downstream of the bridge. It was constructed 18 feet deep below grade (elev. 1000) to an elevation of 982.00 according to the as-built drawings from the FCDMC. A copy of the typical section is included in Appendix A. To compensate for potential head-cutting, the proposed soil-cement section for the Indian School Road bridge is to be constructed to an elevation of 982.00 as shown in the following exhibit Typical Section Soil Cement Floor. Head-cutting would have to first take out the grade-control structure before damaging the Indian School soil-cement floor.

Research of Agua Fria River long-term scour studies has determined that the long term scour is about zero. This was established based on the Draft Final Sediment Transport Report done by Simons, Li and Associates, Inc. (SLA) for the Los Angeles Corps of Engineers (LACOE) dated July 16, 1984. Excerpts from this report are included in Appendix A. SLA also did the final design for the grade-control structure.

Scour Countermeasure Alternatives

Alternative No. 1

This alternative consists of constructing a soil-cement floor under the older portion of the bridge to protect the spread footings. The soil cement floor will have a sloping cut off wall on the upstream and the downstream side of the floor and will seal against the existing soil cement bank on the west bank. The east end of the floor will terminate past the last spread footing pier.

The estimated cost of this alternative is $870,700.

Alternative No. 2

This alternative is the same as Alternative No. 1, except that the soil-cement floor extends on through the newer piers and seals onto the east bank of the existing soil-cement bank protection.

The estimated cost for this alternative is $1,226,600.

Other Alternatives

There are several other potential alternatives such as bridge replacement and foundation underpinning. These concepts have not been explored further due to the substantially higher costs for replacing or underpinning.

There are also some other scour arresting layer concepts such as a wire-tied riprap floor or a reinforced concrete floor. A wire-tied system is more costly and is subject to some abrasion or corrosion damage. This site is not suitable for a reinforced concrete floor due to the width and length required. Interior cut off walls would be required for stability, a substantial increase in cost, for reinforced concrete floors of this size.

Recommended Alternative

Alternative No. 2 is the recommended scour countermeasure.

This is recommended because of the more uniform protection and appearance afforded as a result of its construction. Although Alternative No. 1 is less costly and it protects only a portion of the channel width.

Problems With Soil Cement Around Piers

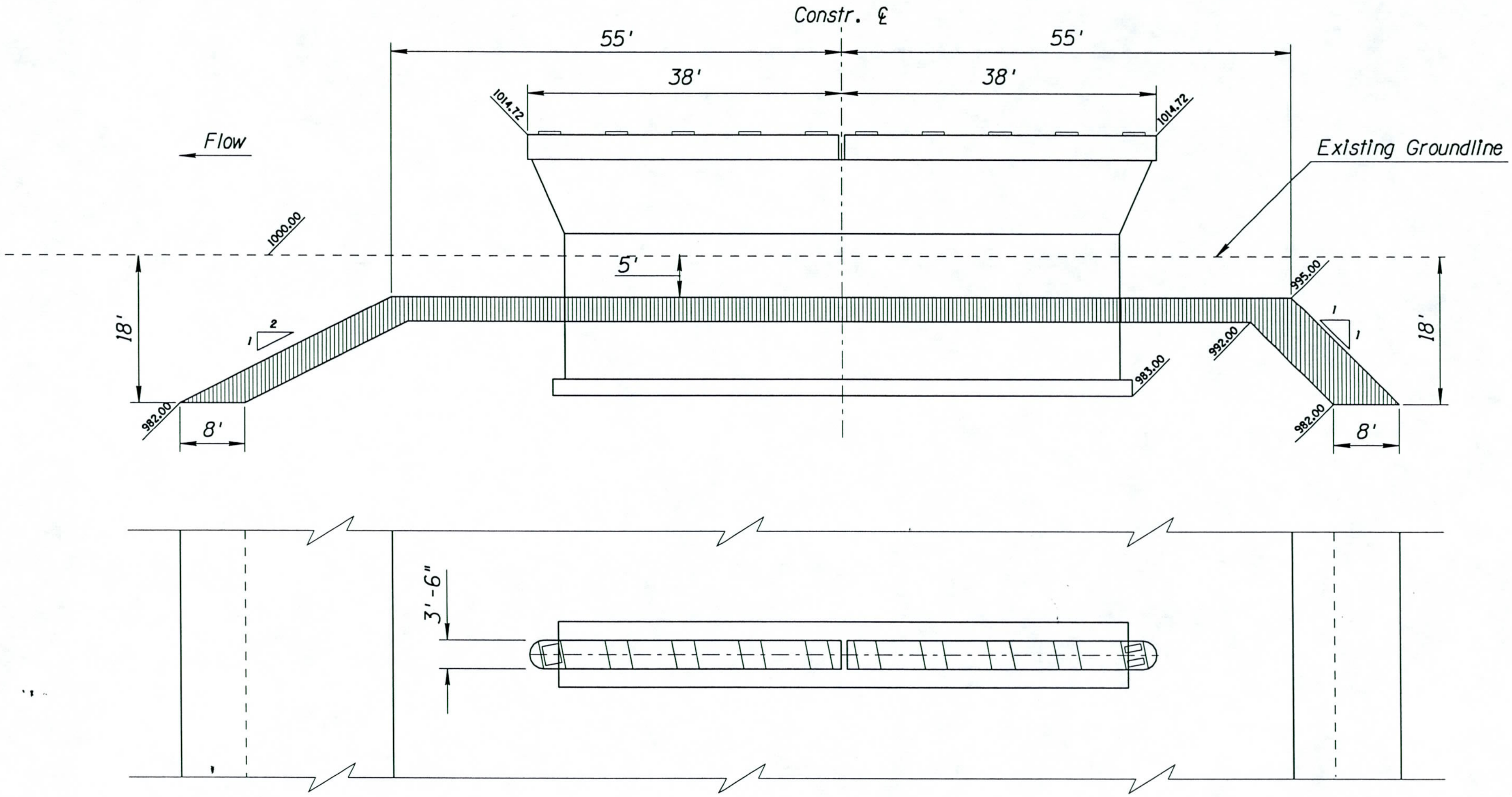
The soil cement layer will be placed in a continuous operation. The contractor will place the soil cement in layers using large equipment to dump the soil cement mixture and compact it using a vibratory compactor. So for the large open areas between the piers and on the upstream and downstream sides of the piers placement in layers will be fairly straightforward.

This bridge has two types of pier bents. The western eleven piers in the channel are solid piers while the eastern five piers are supported on drilled shafts. Placement of the soil cement around the piers requires special attention and equipment. The long solid piers can most likely have the soil cement placed correctly along the pier sides using the larger equipment. Compaction at the ends will require hand compaction equipment. The drilled shafts present a problem to compact correctly. It is expected that the contractor will use hand compaction equipment here also. Shallower lifts may also make correct placement of the soil cement easier around the piers. The specifications will point out to the contractor that lighter equipment may be required and special care must be taken around the piers.

Another consideration about using soil cement around piers is lateral movement of piers. Baker expects this impact to be small for this project. Lateral movement of the piers could result in a gap along one side of the pier and a crushed area along the other side. The crushed soil-cement area would be weakened and the gap side could increase the erosion potential. The solid piers are expected to have minimal lateral movement. The drilled shafts could have some lateral movement. The top of the soil-cement layer will have five feet of fill placed on top of it. This fill will, in effect, help to minimize the any lateral movement of the drilled shafts. This occurs due to the point of fixity of the drilled shafts being very close to the soil cement layer.

LIST OF FIGURES

Typical Section Soil Cement Floor
Alternate 1 Plan and Profile
Alternate 2 Plan and Profile



MARICOPA COUNTY
DEPARTMENT OF TRANSPORTATION

TYPICAL SECTION
SOIL CEMENT FLOOR

Baker
Michael Baker Jr., Inc.

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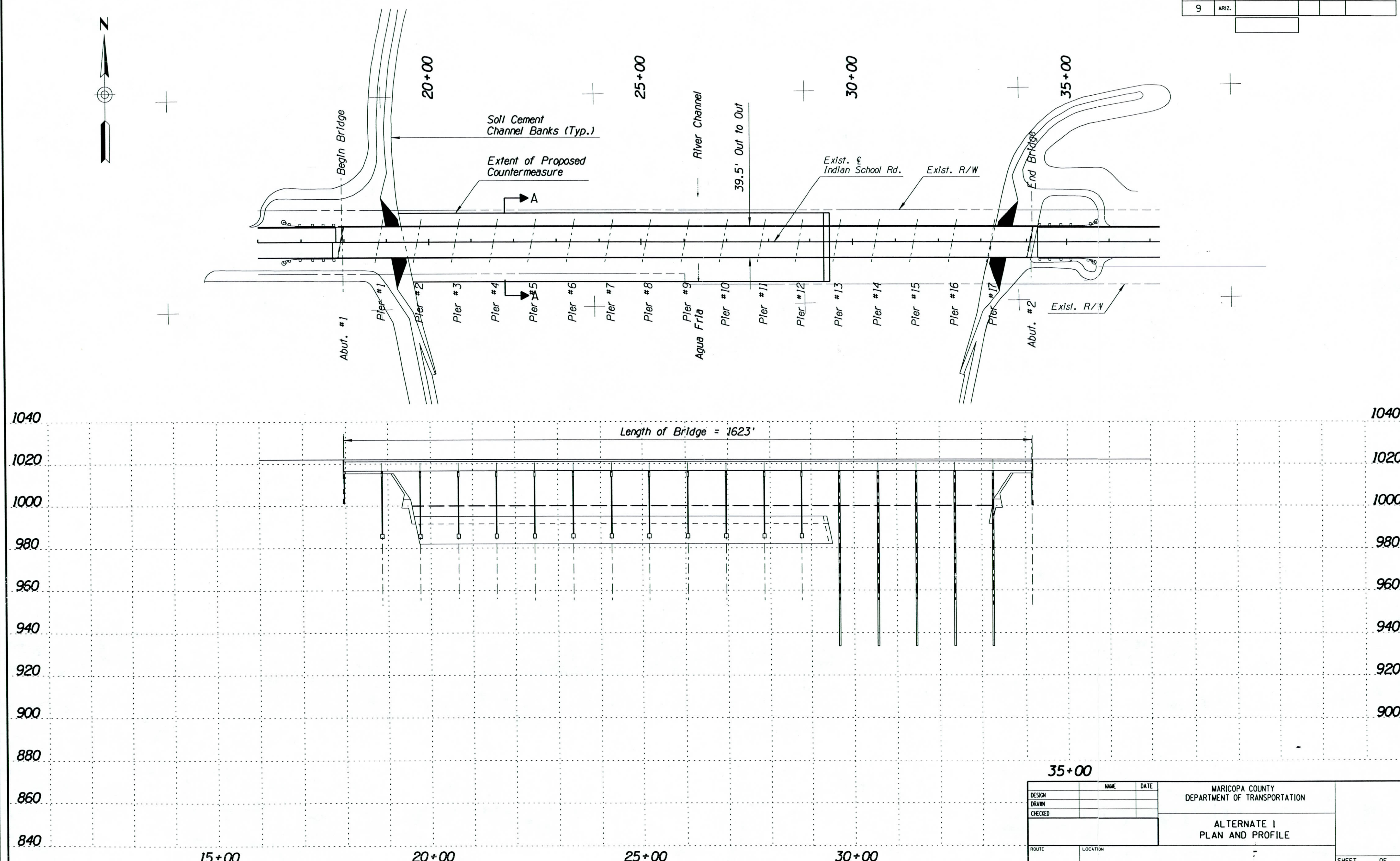
19 AUG 97 17:22:51

F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ.				



	NAME	DATE
DESIGN		
DRAWN		
CHECKED		

MARICOPA COUNTY
DEPARTMENT OF TRANSPORTATION

ALTERNATE 1
PLAN AND PROFILE

ROUTE | LOCATION | SHEET OF

TRACS NO. ___ OF ___

SURVEY NO. | FINISHED PLANS | REVISIONS | LOCATION | DATE

p:\proj\mcdot\cadd\isrpln1.dgn
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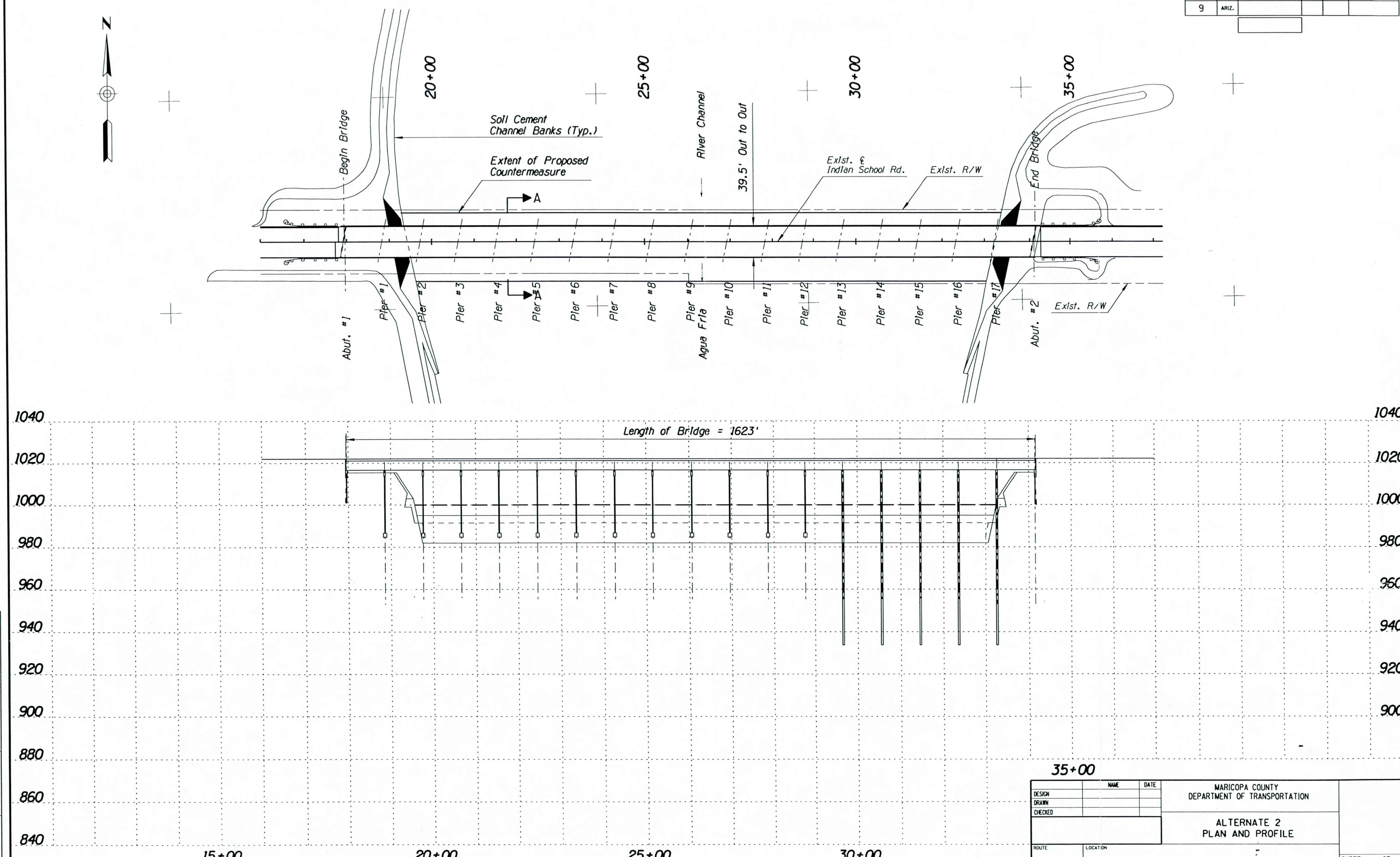
CONSTRUCTION DISPLAY ON

F.H.W.A. REGION	STATE	PROJECT NO.	SHEET NO.	TOTAL SHEETS	AS BUILT
9	ARIZ.				



	NAME	DATE
DESIGN		
DRAWN		
CHECKED		

MARICOPA COUNTY
DEPARTMENT OF TRANSPORTATION

ALTERNATE 2
PLAN AND PROFILE

ROUTE | LOCATION | SHEET OF

SURVEY NO. | FINISHED PLANS | REVISIONS | LOCATION | DATE

p:\proj\mcdot\cadd\isrpln2.dgn
19 AUG 97 16:42:04

TRACS NO.

___ OF ___

CONSTRUCTION DISPLAY ON

FIELD PHOTOS

Westward view of structure from upstream bank.
Note: Drilled shaft piers in foreground and solid piers on spread footings in background. Sand and gravel haul road under bridge.

Westward view under bridge of sandy channel bottom in drilled shaft pier section.

Scour at nose of solid pier.

East bank, at downstream face, showing transition interface between grouted riprap and soil cement.

Northward view of deflector dikes on east bank upstream from bridge.
This area would be a good potential location to store and process material for compliance to US Corps Engineers 404 requirements.

APPENDIX A

As-builts Grade Control Structure

1. TYPICAL RIPRAP & SOIL CEMENT SECTIONS TO REFLECT TOE DOWN DEPTH 8.6' FROM EQUILIBRIUM LINE.
   RIPRAP & SOIL CEMENT WEST, STATION REVISIONS.
   SOIL CEMENT EAST, TRANSVERSE DIKE NO 2 LENGTH CHANGE.
   TYPICAL SECTION GRADE CONTROL STRUCTURE STATION CHANGE TO 50' SOUTH.
   TYPICAL SECTION OF TRANSVERSE DIKE TO REFLECT TOE DOWN DEPTH FROM EQUILIBRIUM LINE.

2. Revised toe down depths for Transverse Dike.

RECORD DRAWING

Certificate No. 7661
WAKEFIELD
5/21/86

FLOOD CONTROL DISTRICT OF MARI

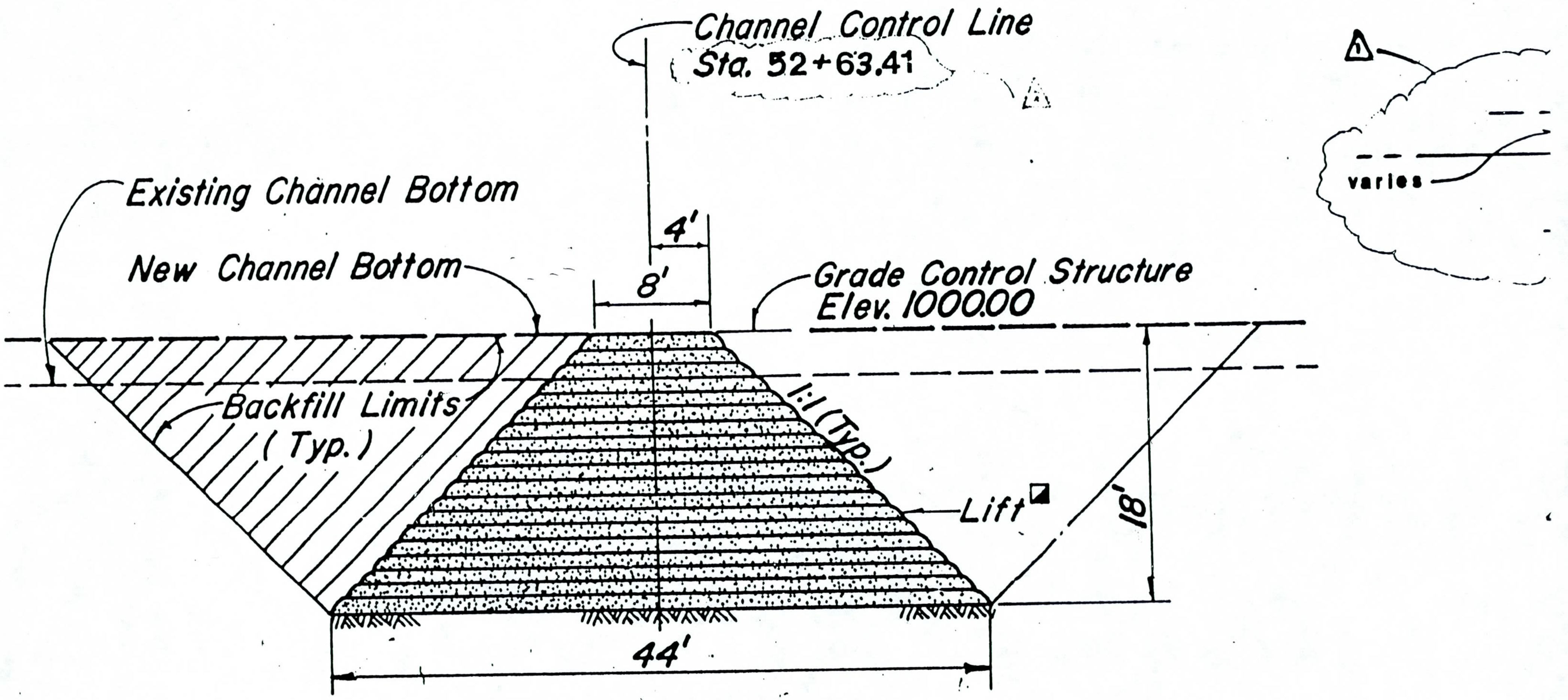
3335 West Durango Street · Phoenix Arizona 85009 · Tel. 602

AGUA FRIA RIVER IMPROVEMENT

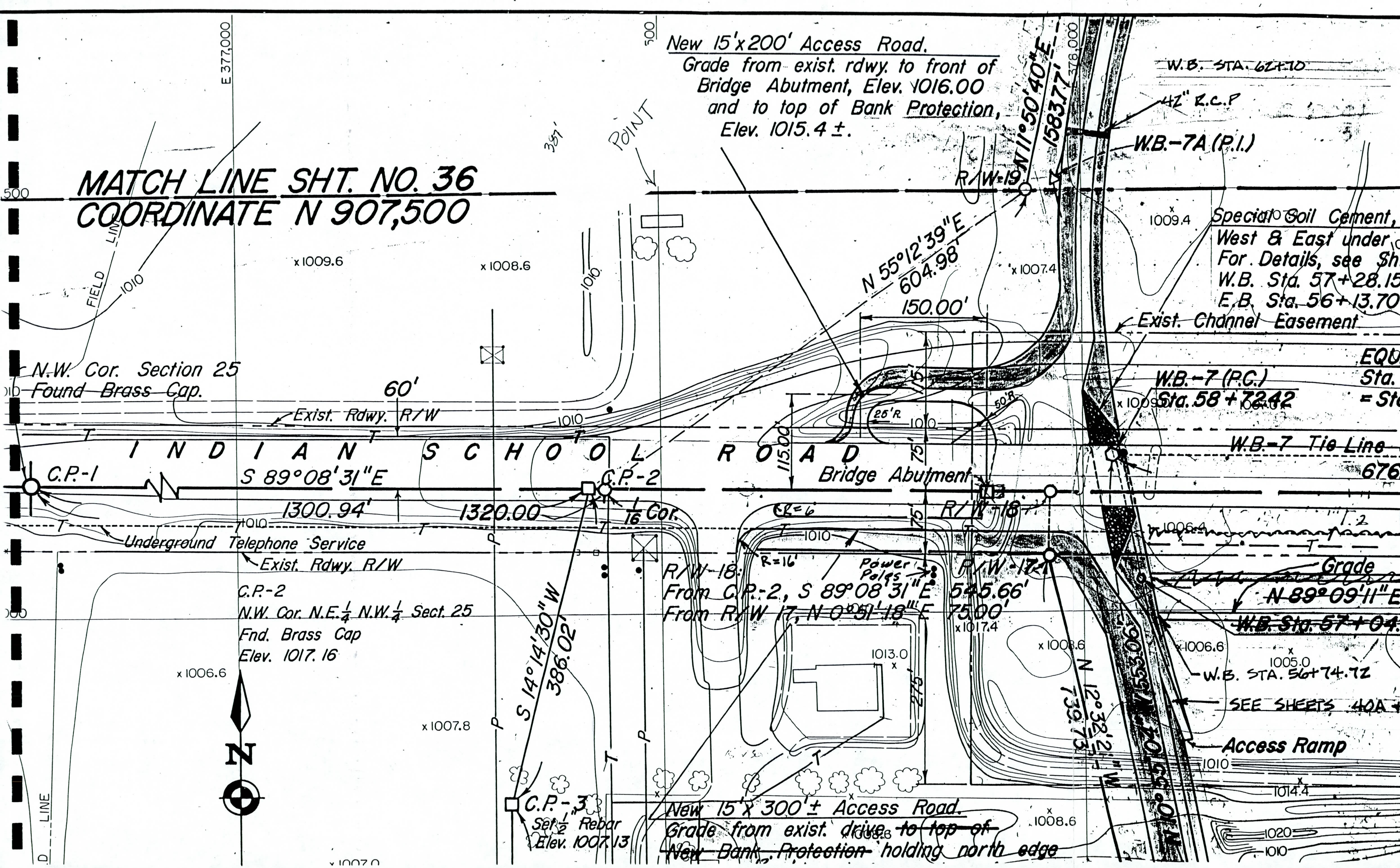
PHASE II – CHANNELIZATION & BANK PROTE

Project No.	AZ-MC-06
Date:	Dec., '84
Design:	R.N.B.
Drawn:	E.E.C.
Check:	J.K.L.
Revisions:	ERDMAN 10-11-85

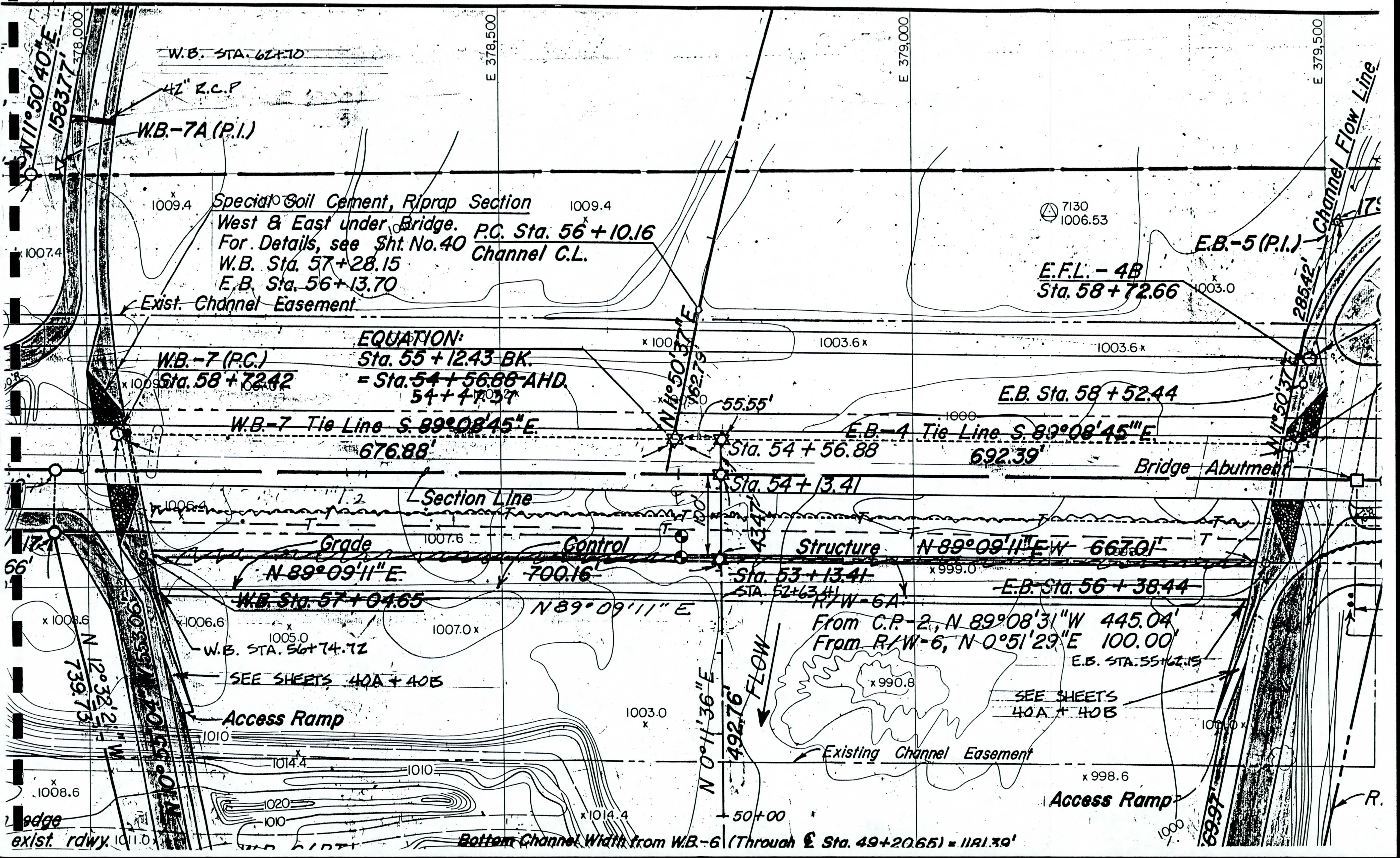
Typical Section
Sheet 30A of 62



TYPICAL SECTION
GRADE CONTROL STRUCTURE
N.T.S.



MATCH LINE SHT. NO. 36
COORDINATE N 907,500
E 377,000
New 15'x200' Access Road.
Grade from exist. rdwy. to front of Bridge Abutment, Elev. 1016.00 and to top of Bank Protection, Elev. 1015.4 ±.
POINT
N 11°50'40"E
1583.77'
W.B. STA. 62+10
42" R.C.P
W.B.-7A (P.I.)
R/W-19
x1009.4
Special Soil Cement,
West & East under
For. Details, see Sht.
W.B. Sta. 57+28.15
E.B. Sta. 56+13.70
x1009.6
x1008.6
x1007.4
N 55°12'39"E
604.98'
150.00'
Exist. Channel Easement
FIELD LINE
1010
N.W. Cor. Section 25
Found Brass Cap.
60'
Exist. Rdwy. R/W
W.B.-7 (P.C.)
Sta. 58+72.42
EQUA
Sta. 5
= Sta.
25'R.
50'R.
INDIAN SCHOOL ROAD
115.00'
75'
W.B.-7 Tie Line
676.
C.P.-1
S 89°08'31"E
C.P.-2
Bridge Abutment
1300.94'
1320.00
1/16 Cor.
R/W-18
R=16'
Underground Telephone Service
Exist. Rdwy. R/W
x1006.4
R/W-18:
From C.P.-2, S 89°08'31"E 545.66'
From R/W 17, N 0°51'18"E 75.00'
Power Poles
R/W-17
Grade
N 89°09'11"E
W.B. Sta. 57+04.6
C.P.-2
N.W. Cor. N.E. 1/4 N.W. 1/4 Sect. 25
Fnd. Brass Cap
Elev. 1017.16
S 14°14'30"W
386.02'
x1017.4
x1008.6
1013.0
x1006.6
x1005.0
W.B. STA. 56+74.72
N 12°32'2"W
739.73'
SEE SHEETS 40A +
x1006.6
x1007.8
275'
N
Access Ramp
C.P.-3
Set 1/2" Rebar
Elev. 1007.13
New 15'x300'± Access Road.
Grade from exist. drive to top of New Bank Protection holding north edge
x1008.6
1014.4
1020
1010
x1007.0


E 378,000
E 378,500
E 379,000
E 379,500
N 11°50'40" E
1583.77'
W.B. STA. 62+10
42" R.C.P.
W.B.-7A (P.I.)
1009.4
Special Soil Cement, Riprap Section
West & East under Bridge.
For. Details, see Sht. No. 40
W.B. Sta. 57+28.15
E.B. Sta. 56+13.70
P.C. Sta. 56+10.16
Channel C.L.
7130
1006.53
E.B.-5 (P.I.)
Channel Flow Line
1007.4
E.F.L. - 4B
Sta. 58+72.66
1003.0
285.42'
Exist. Channel Easement
EQUATION:
Sta. 55+12.43 BK.
= Sta. 54+56.88 AHD.
54+47.37
1003.6
W.B.-7 (P.C.)
Sta. 58+72.42
N 11°50'37" E
162.73'
55.55'
E.B. Sta. 58+52.44
1000
W.B.-7 Tie Line S. 89°08'45" E.
676.88'
E.B.-4 Tie Line S. 89°08'45" E.
692.39'
Sta. 54+56.88
Sta. 54+13.41
Bridge Abutment
Section Line
1006.4
43.47'
100'
1007.6
Grade
Control
Structure
N 89°09'11" E W
667.01'
N 89°09'11" E
700.16'
Sta. 53+13.41
STA. 52+63.41
x 999.0
W.B. Sta. 57+04.65
E.B. Sta. 56+38.44
R/W-6A:
From C.P.-2, N 89°08'31" W 445.04'
From R/W-6, N 0°51'29" E 100.00'
x 1008.6
1006.6
1005.0
1007.0
N 89°09'11" E
E.B. STA. 55+62.15
W.B. STA. 56+74.72
SEE SHEETS 40A + 40B
x 990.8
SEE SHEETS
40A + 40B
N 12°32'2" W
739.73'
Access Ramp
1003.0
FLOW
N 0°11'36" E
492.76'
1010
1014.4
Existing Channel Easement
x 998.6
1020
1008.6
Access Ramp
edge
exist. rdwy.
1011.0
x 1014.4
50+00
1000
R.
Bottom Channel Width from W.B.-6 (Through ℄ Sta. 49+20.65) = 1181.39'

DRAFT

FINAL SEDIMENT TRANSPORT REPORT

Submitted to

Los Angeles District
Corps of Engineers
P.O. Box 2711
Los Angeles, California 90053

By

Simons, Li and Associates, Inc.
4030 Birch Street
Suite 103
Newport Beach, California 92660

Project Number PAZ-COE-03
RDN/R439

July 16, 1984

Table 6.3. Average Annual Aggradation/Degradation Response for Study Reach.

Reach No.	Sediment Yield (ac-ft)	Degradation/ Aggradation (ac/ft)	Length (ft)	Average Depth * of Degradation/ Aggradation (ft)
New River	5.38	-	-	-
Agua Fria	68.20			
2	62.15	11.43	8,049	<0.1
3	70.46	3.12	2,301	0.1
4	61.60	11.98	3,580	0.2
5	76.39	-2.81	7,975	<-0.1
6	78.68	-5.10	4,632	-0.1
7	74.61	-1.03	5,470	-
8	73.97	-0.39	5,075	-
9	70.20	3.38	6,230	<0.1
10	85.04	-11.46	7,155	-0.1

Reach 1: Glendale Avenue to confluence of New River
Reach 2: Confluence of New River to ISRB
Reach 3: ISRB to the RID flume
Reach 4: RID flume to Thomas Road
Reach 5: Thomas Road to 1,500 ft upstream of I-10
Reach 6: 1,500 ft upstream of I-10 to Van Buren Street
Reach 7: Van Buren Street to Buckeye Road
Reach 8: Buckeye Road to Lower Buckeye Road
Reach 9: Lower Buckeye Road to Broadway Road
Reach 10: Broadway Road to the confluence with Gila River

*The degradation/aggradation responses are computed for initial conditions and as the bed responds toward equilibrium conditions, the net degradation/aggradation response tends toward zero. Therefore, this is just a measure of the direction in which each channel reach will respond.