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ANALYSIS OF

ALTERNATIVE ALIGNMENT FOR AGUA FRIA RIVER

CHANNELIZATION, INTERSTATE 10 TO BUCKEYE ROA

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ANALYSIS OF

ALTERNATIVE ALIGNMENT FOR AGUA FRIA RIVER

CHANNELIZATION, INTERSTATE 10 TO BUCKEYE ROAD

Prepared for:

Ball, Ball and Brosamer, Inc.
5821 West McDowell Road
Phoenix, Arizona 85043

For Submittal to:

Flood Control District of Maricopa County
3335 West Durango
Phoenix, Arizona 85009

Prepared by:

Simons, Li & Associates, Inc.
1225 East Broadway, Suite 200
Tempe, Arizona 85282

October 31, 1984

sla

SIMONS, LI & ASSOCIATES, INC.

1225 EAST BROADWAY ROAD
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TEMPE, ARIZONA 85282
TELEPHONE (602) 894-1771

Robert L. Ward, P.E.
Manager
Robert A. Mussetter, P.E.

November 2, 1984

Flood Control District of Maricopa County
3335 West Durango Street
Phoenix, AZ 85009

ATTENTION: Mr. Dick Perrault

Dear Dick:

SUBJECT: Alternative Alignment for Agua Fria River Channelization, Interstate 10 to Buckeye Road (SLA Project #PAZ-BBB-01)

Please find enclosed two copies of our preliminary analysis report for the above referenced project. As we discussed, the channelization costs for the alternative alignment will be approximatley $460,000 more than for the original alignment. Savings associated with shortening the Van Buren Street Bridge by 250 feet will be approximately $690,000, however, resulting in a net savings of approximately $230,000.

Based upon these findings, we believe that adopting the alternative alignment may be advantageous to your agency. Please review the attached reports and let us know your decision as soon as possible so that we can proceed with the final design plans. We are, of course, providing Ball, Ball and Brosamer with copies of the report. Unforttunately, Jim Martin will be out of the office until November 12. We hope that this will not delay a final decision on this matter.

If you have any questions, please feel free to call.

Sincerely,

Robert A. Mussetter

Robert A. Mussetter, P.E.
Senior Civil Engineer

RAM:ks
Enclosures
cc: Mr. John Lynch

I. INTRODUCTION

In May, 1984, Simons, Li & Associates, Inc. (SLA) submitted a report detailing a hydraulic and sediment transport analysis and provided a conceptual design for channelization at the Agua Fria River for Standard Project Flood (SPF) conditions (SLA, 1984). The reach considered in that study extended from Buckeye Road upstream to Camelback Road. The recommended design for the reach between Buckeye Road and the Interstate 10 (I-10) bridge called for a channel bottom width of 1410 feet at I-10, gradually narrowing to 1100 feet at the Southern Pacific Railroad Bridge (SPRR). Also included in the design was a drop structure to be located approximately 500 feet downstream of I-10 and scour-protection measures for the Buckeye Road, SPRR, and I-10 bridges and the existing electrical transmission towers located in the river channel.

Subsequent to submittal of the above report, Ball, Ball and Brosamer, Inc. (BBB), a firm having land development interest in the area, suggested an alternative alignment which narrowed the channel to 1100 feet at the drop structure downstream of the I-10 bridge and maintained a constant width through Buckeye Road. The alternative alignment would provide BBB with more usable land along the west side of the channel.

With the concurrence of the Maricopa County Flood Control District, (MCFCD) SLA contracted with BBB to evaluate the alternative alignment. The purpose of this report is to summarize the results of the analysis and provide recommendations for possible modifications to the original recommended alignment.

II. QUALITATIVE EVALUATION OF THE ALTERNATIVE ALIGNMENT

Prior to performing the detailed analysis, several considerations were qualitatively evaluated to eliminate obvious detrimental aspects of the alternative alignment proposed by Ball, Ball and Brosamer, Inc. The two primary considerations involved the need for an appropriate transition from the 1410 foot wide channel at the drop structure downstream of I-10 (see Plate 1) to 1100 feet in the downstream channel and the location of the electrical transmission towers in relation to the levee alignment along the east side of the channel. In considering these factors, it was found that realignment of the east levee to clear transmission tower #98 created an excessively sharp bend and constricted the flow, resulting in undesirable hydraulic conditions along the east side of the channel near and downstream of the drop structure. This constriction also raised the water surface sufficiently to pose a potential backwater problem at the outlet of the I-10 collector channel.

The alternative alignment selected for further evaluation, considering the above factors, is shown on Plate 1. This alignment provides an approximately 7:1 transition from the 1410 foot width at the drop structure to 1100 foot width approximately 300 feet upstream of Van Buren Street. The transition occurs from realignment of the west levee. The east level was maintained in the same location as the original recommended alignment.

III. HYDRAULIC ANALYSIS

Hydraulic conditions for the alternative alignment were evaluated using the Corps of Engineers HEC-II program. Backwater profiles were computed for the standard project and 10-year floods. The study reach extended sufficiently far upstream to contain all of the area affected by the realignment. Discharges for those floods are 142,000 cfs and 31,000 cfs, respectively. As in the previous analysis conducted by SLA, a trapezoidal shaped channel with 3:1 side slopes was assumed. Manning's roughness coefficient for the main channel varies from 0.025 to 0.03. An average value of 0.03 was used to establish the water-surfaceelevations. For the sediment analysis, the coefficient was reduced to 0.025, providing more conservative flow velocities and sediment-transport rates.

Figure 3.1 shows the water-surface profiles for the original and alternative alignments for the SPF. As seen in the figure, the water-surface elevations are approximately 1.2 feet higher at Van Buren Street, and 0.8 feet higher at the I-10 bridge than for the original recommended alignment. The maximum increase of approximately 1.5 feet occurs between I-10 and Van Buren Street. Table 3.1 compares the average velocity, hydraulic depth and top width for the original and alternative alignments. The average velocities generally increase in the reach between Buckeye Road and Van Buren Street due to constriction of the channel. This constriction results in increased water-surface elevations and reduced velocities between Van Buren Street and McDowell Road.

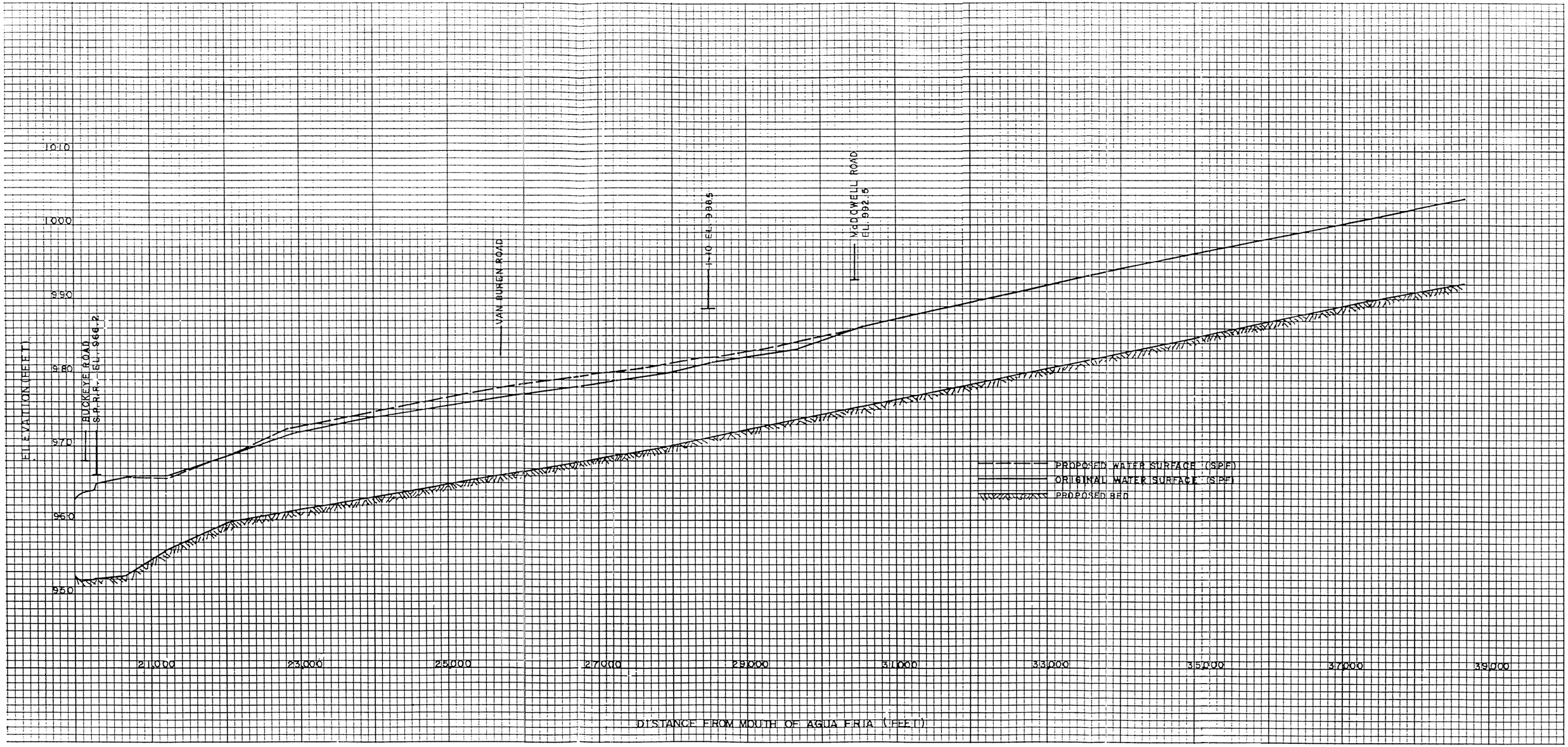


Figure 3.1 Water surface profiles for Standard Project Flood

TABLE 3.1

COMPARISON OF AVERAGE HYDRAULIC CONDITIONS

Reach	Velocity (FPS)			Hydraulic Depth			Top Width (FT)		
	Orig.	Altern.	Change	Orig.	Altern.	Change	Orig.	Altern.	Change
Standard Project Flood (Q=142,000 cfs)									
McDowell Road--I-10	11.3	11.2	-0.1	10.6	10.6	0.0	1190	1190	0
I-10 to Van Buren Street	9.6	9.4	-0.2	10.1	11.0	+0.9	1470	1385	-85
Van Buren Street to Buckeye Road	10.7	11.3	+0.6	10.7	10.9	+0.2	1240	1160	-80
10-Year Flood (Q=31,000 cfs)									
McDowell Road--I-10	6.7	6.2	-0.5	3.9	4.2	+0.3	1180	1185	+5
I-10 to Van Buren Street	6.1	5.4	-0.8	3.6	4.2	+0.7	1435	1365	-90
Van Buren Street to Buckeye Road	5.4	6.2	+0.8	4.7	4.4	-.03	1230	1125	-125

IV. SEDIMENT ANALYSIS

Design of the channelization is based upon the expected long-term aggradation/degradation response of the channel bed, local scour at obstructions within the channel such as bridge piers, bridge abutments, transmission towers, etc. as well as the water-surface elevations, and required freeboard. From the previous analyses performed by SLA, it was determined that the controlling design criteria for the channel bed was the equilibrium slope for the dominant discharge (estimated to be the 10-year flood of 31,000 cfs) and local scour for the design (Standard Project) flood.

4.1 Equilibrium Slopes

The dynamic equilibrium slope for the 10-year flood was recomputed for the reaches affected by the proposed alternative alignment. Tables 4.1 and 4.2 summarize the results of these calculations. The alternative alignment results in a degradational tendency in the reach between Van Buren Street and Buckeye Road. For the original alignment, this reach was approximately in equilibrium. The reduced velocities caused by the constriction result in a slight aggradational tendency between Van Buren Street and I-10. The reach between I-10 and McDowell Road remains degradational for the alternative alignment; however, the magnitude is reduced by the backwater effect from the downstream constriction.

4.2 Location of Grade Controls

The degradational tendency associated with the alternative alignment between Buckeye Road and Van Buren Street indicates a need for some form of grade control within that reach. Considering the existing channel profile, it is recommended that a drop structure be constructed at approximately 1850 feet upstream of Buckeye Road (see Plate 1). The crest of this structure should be at elevation 959.1 feet MSL. With the drop structure in this location, the equilibrium slopes indicate general degradation of approximately 2.1 feet at Van Buren Street reducing to slightly less than 1-foot at the originally proposed drop structure located 500 feet downstream of I-10.

Although the degradation potential downstream of I-10 has been reduced, it is sufficient when coupled with the local scour associated with the bridge

TABLE 4.1

SUMMARY OF EQUILIBRIUM SLOPE ANALYSIS FOR 10-YEAR FLOOD (Q=31,000 cfs)

Reach	Top Width (TW) (ft)	Velocity (V) (fps)	Hydraulic Depth (HY) (ft)	Sediment Discharge (Q_s) (cfs)	Concentration (ppm by wght)	Existing Thalweg Slope	Equilibrium Slope
McDowell Road--I-10	1185	6.2	4.2	138.8	11,865	.0021	.0016
I-10--Van Buren Street	1365	5.4	4.2	95.9	7,600	.0023	.0025
Van Buren Street--Buckeye Road	1125	6.2	4.4	133.8	11,440	.0016	.0013

TABLE 4.2

COMPARISON OF EQUILIBRIUM SLOPES FOR 10-YEAR FLOOD

Reach	Existing Slope	Equilibrium Slope	
		Original	Alternative
McDowell Road--I-10	.0021	.0012	.0016
I-10--Van Buren Street	.0023	.0017	.0025
Van Buren--Buckeye Road	.0016	.0017	.0013

and the channel bend to require construction of the originally recommended drop structure. The design height can, however, be reduced from 4 feet to 3 feet.

The altered hydraulic conditions result in minimal impact on the potential degradation upstream of I-10. No change in the location of the drop structures in these reaches is recommended.

4.3 Local Scour

Local-scour depths around the transmission towers and at the I-10 bridge were re-evaluated based upon the hydraulics for the alternative alignment. Flow velocity at the I-10 bridge is approximately 0.8 feet per second less for the alternative alignment which reduces the local-scour potential around the piers by approximately 0.5 feet. A similar reduction in scour associated with the channel bend will also occur. Due to the inherent uncertainty in these calculations and the relatively small change in flow conditions, scour protection at the bridge and levee toe down recommended in the original design should be maintained.

Increased flow depth and velocities around the transmission towers will require some modification in the height and depth of the scour protection at those locations (scour calculations are summarized in Table 4.3). Comparison of the results with those for the original alternative indicates relatively minor differences. The scour depth increases by less than 1-foot at the towers downstream of Van Buren Street and the water-surface elevation increases by 1 to 1.5 feet between Van Buren Street and I-10.

TABLE 4.3

LOCAL SCOUR AROUND TOWERS - TUCSON GAS & ELECTRIC CO. FOR WITH-SIPHON CHANNELIZATION ALTERNATIVE

Tower Number	w Obstruction Width	V Flow Velocity (ft/sec)	Elevation at Bottom of Footing (ft)	d Flow Depth (ft)	F_r	Local Scour Shen (ft)	Neil (ft)	L/w	Approximate Adopted Scour (ft)	Channelized Ground Elevation	Elevation After Scour	SPF Water-Surface Elevation
87	5'	11.1	977	11.2		12.5	12.8		12.7	990.0	977.4	**
88 (R)	10'	11.1	*	10.9		19.2	20.0		19.6	984.8	965.2	**
89 (R)	10'	11.1	971	10.9		19.2	20.0		19.6	983.5	963.9	**
94	5'	10.6	961.8	10.8		12.2	12.5	13.3	12.7	974.1	961.7	987.4
95 (R)	5'	11.1	953.5	10.5		12.5	12.7		12.6	973.6	961.0	**
96	10'	11.7	958.3	9.9	.983	19.9	20.2	12.7	20.1	972.1	952.0	983.4
97	5'	8.9	*	10.8		10.9	11.6	12.5	11.3	967.0	955.7	981.6
98	5'	9.0	*	11.5		11.0	11.7		11.4	964.6	953.2	979.6
99 (R)	10'	9.6	*	12.0		17.6	19.1	13.0	18.4	944.3	944.3	977.4
100 (R)	10'	10.1	947.3	11.6		18.2	19.4		18.8	960.4	941.6	975.0
101 (R)	10'	10.2	944.5	11.2		18.3	19.4		18.9	958.3	939.5	972.4
102 (R)	10'	13.3	938.8	9.7		21.5	21.2		21.4	956.1	934.7	967.5
103 (R)	10'	9.8	*	12.5		17.8	19.3		18.6	953.7	935.1	**

R = Reinforced

* = Elevation unknown

** = Not in Study Reach

SHEN: $S = .00073\left(\frac{V'w}{\nu}\right)^{.619}$ $\nu = 1\times10^{-5}\ ft^2/sec$

NEIL: $S = 2.21\left(\frac{W}{d}\right)^{.65}\left(\frac{V'}{\sqrt{dg}}\right)^{.43}$ $V' = 1.25V$

V. CONCEPTUAL DESIGN AND COSTS FOR ALTERNATIVE ALIGNMENT

The alternative channelization design analyzed in this report incorporates, to the extent possible, the alignment suggested by BBB. Their proposed alignment has been modified to provide for an appropriate transition at the drop structure downstream of I-10 and to accommodate the electrical transmission towers within the affected reach. A plan view of the alternative alignment reflecting these modifications is shown on Plate 1. Figures 5.1 and 5.2 show the channel, water surface, and levee profiles for this alignment for the east and west banks, respectively. As indicated in these figures, the alternative alignment differs from the original alignment by narrowing to 1100 feet within a distance of 2100 feet downstream of the drop structure below I-10.

The alternative alignment reduces the amount of excavation required to construct the channelization by approximately 126,500 yd^3. It also shortens the proposed Van Buren Street bridge by approximately 250 feet and reduces the land area occupied by the channel by approximately 23.8 acres.

Because of the narrower channel, the flow velocities increased sufficiently in the reach between Buckeye Road and Van Buren Street to induce degradation in the channel. To insure the stability of the levees and bridges, an additional drop structure located approxiamtely 1850 feet upstream of Buckeye Road (see Plate 1) is necessary. Water-surface elevations for the alternative alignment, when compared to the original alignment, increased from the location of the new drop structure upstream to McDowell Road. Maximum difference is approximately 1.5 feet between Van Buren Street and I-10. The increased water-surface elevations will require greater levee heights which will increase the soil-cement volumes required for construction of the channelization. Adequate freeboard is available at the I-10 bridge to accommodate the higher water surface and the elevations are low enough to prevent interference with the outlet of the I-10 collector channel.

Cost estimates for the original and alternative alignments were prepared. The estimate for the original alignment has been modified slightly to reflect the excavation quantities based upon the 1983 mapping (the original estimate was based on 1981 mapping). The cost estimates are shown in Tables 5.1 and

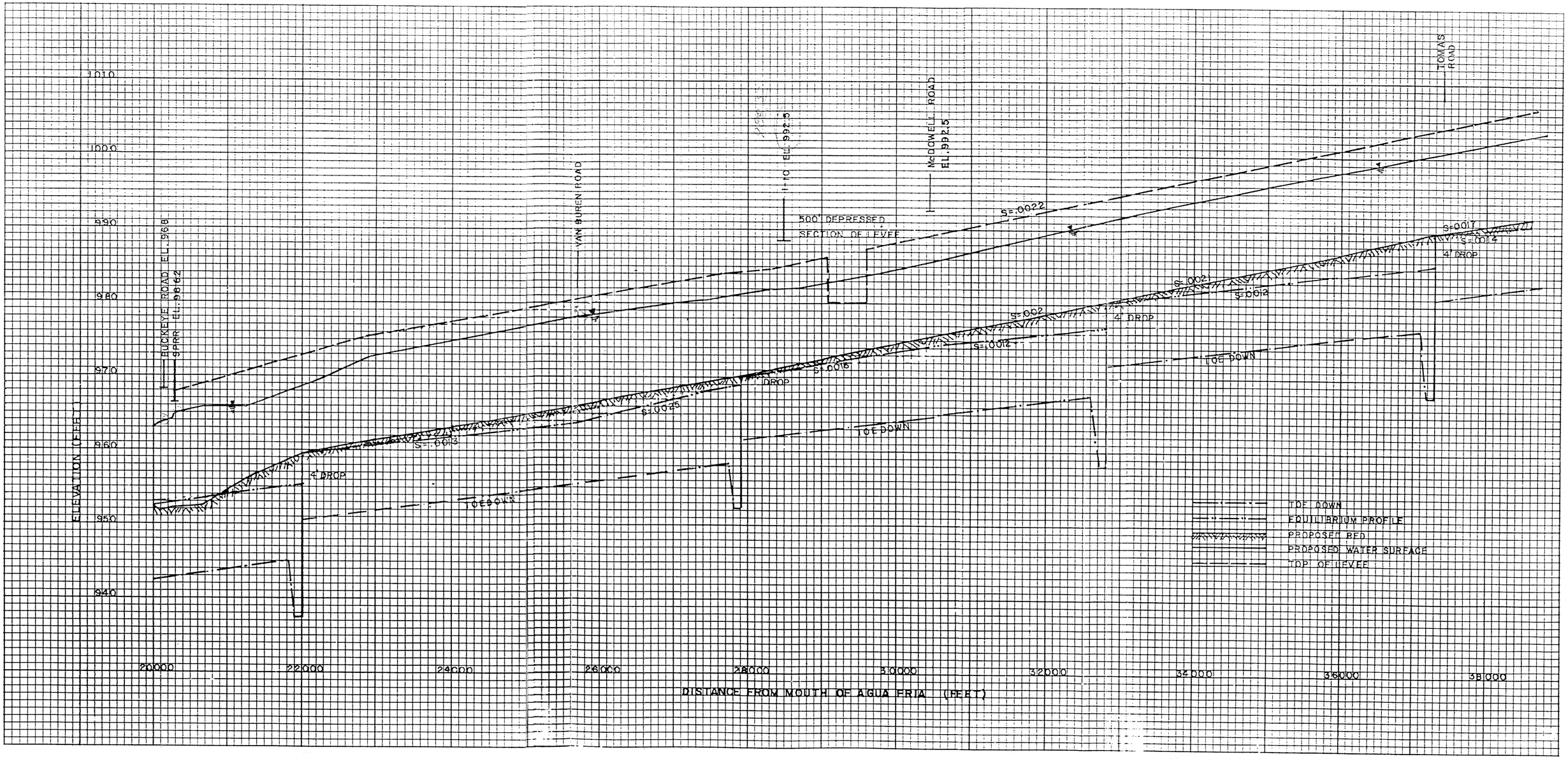


Figure 5.1 Design Profiles for SPF Channelization, East Bank

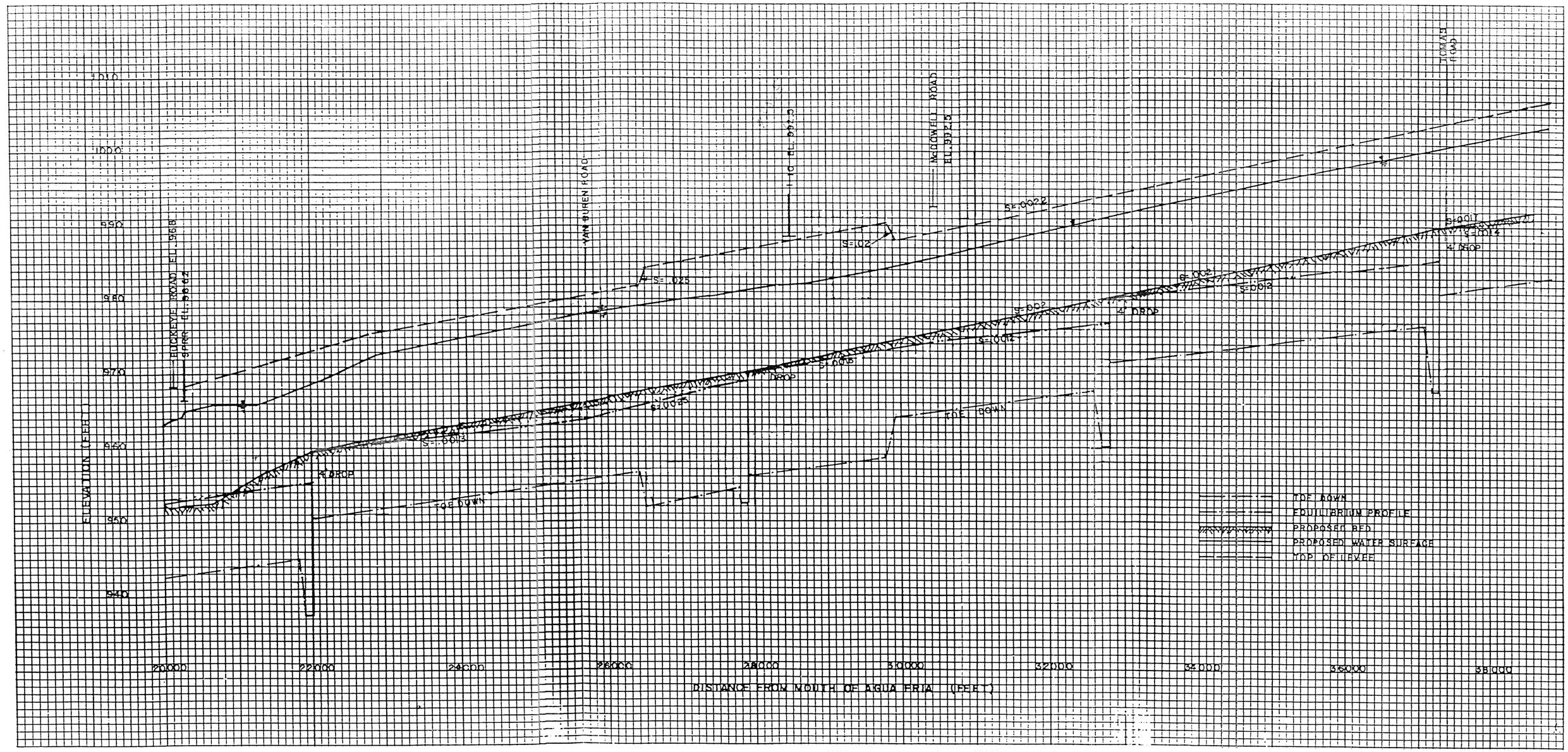


Figure 5.2 Design Profiles for SPF Channelization, West Bank

TABLE 5.1

PRELIMINARY COST AND QUANTITY ESTIMATE BETWEEN BUCKEYE ROAD AND I-10 FOR ORIGINAL ALIGNMENT

Item	Channelization	Levees	Drop Structure	I-10 Bridge Pier Protection	SPRR Bridge Pier Protection	Buckeye Rd Bridge Pier Protection	Gravel Pit Restoration	Total	Unit Cost	Total Cost
Common Fill		152,475 yd^3	20,900 yd^3				170,000 yd^3	343,375 yd^3	\$ 1.25/yd^3	\$ 429,220
Drainage Excavation	715,550 yd^3			26,890 yd^3	11,195 yd^3	11,690 yd^3		765,325 yd^3	0.90/yd^3	688,790
Structural Excavation			71,020 yd^3					71,020 yd^3	2.00/yd^3	142,040
Special Backfill			20,900 yd^3					20,900 yd^3	2.00/yd^3	41,800
Riprap			3,130 yd^3	17,930 yd^3	7,465 yd^3	7,790 yd^3		36,315 yd^3	22/yd^3	798,930
Gravel Filter Material			1,570 yd^3	8,960 yd^3	3,730 yd^3	3,900 yd^3		18,160 yd^3	15/yd^3	272,400
Filter Fabric (includes 6" soil cover)								---	1.50/yd^2	---
Soil Cement		130,605 yd^3	29,250 yd^3					159,855 yd^3	22.50/yd^3	3,596,735
Transmission Tower Protection								7 towers	100,000/tower	700,000
									Subtotal	\$6,669,915
									10% Contingencies and Construction Supervision	\$ 666,990
									Land Acquisition (150 acres)	\$ 750,000
									Total	\$8,086,905

5.2, and indicate that the channelization for the alternative alignment will cost approxiamtely $460,400 more than for the original alignment. The cost savings associated with shortening the Van Buren Street bridge, however, is approximately $690,000, indicating a net savings of $229,600 for the alternative alignment. A summary of these costs is shown in Table 5.3.

TABLE 5.2

PRELIMINARY COST AND QUANTITY ESTIMATE BETWEEN BUCKEYE ROAD AND I-10 FOR ALTERNATIVE ALIGNMENT

Item	Channelization	Levees	Drop Structure (yd^3) I-10	Drop Structure (yd^3) Van Buren	I-10 Bridge Pier Protection	SPRR Bridge Pier Protection	Buckeye Rd Bridge Pier Protection	Gravel Pit Restoration	Total	Unit Cost	Total Cost
Common Fill		153,590 yd^3	16,920	19,900				170,000 yd^3	360,410 yd^3	\$ 1.25/yd^3	\$ 450,510
Drainage Excavation	589,100 yd^3				26,890 yd^3	11,195 yd^3	11,690 yd^3		638,875 yd^3	0.90/yd^3	574,990
Structural Excavation			58,280	66,930					125,210 yd^3	2.00/yd^3	250,420
Special Backfill			16,920	19,900					36,820 yd^3	2.00/yd^3	73,640
Riprap			3,130	2,470	17,930 yd^3	7,465 yd^3	7,790 yd^3		38,785 yd^3	22/yd^3	853,270
Gravel Filter Material			1,570	1,240	8,960 yd^3	3,730 yd^3	3,900 yd^3		19,400 yd^3	15/yd^3	291,000
Filter Fabric (includes 6" soil cover)									---	1.50/yd^2	---
Soil Cement		126,080 yd^3	24,440	27,140					177,660 yd^3	22.50/yd^3	3,997,350
Transmission Tower Protection			572,000						7 towers	100,000/tower	700,000
										Subtotal	\$7,191,180
										10% Contingencies and Construction Supervision	\$ 719,120
										Land Acquisition (126.2 acres)	\$ 631,000
										Design Fee and GeoTechnical for Additional Drop Structure	\$ 6,000
										Total	\$8,547,300

TABLE 5.3

COST SUMMARY AND COMPARISON

	Total Cost
Alternative Alignment	$8,547,300
Original Alignment	8,086,910
Difference	$ 460,390
Savings for Van Buren Street Bridge (250'x69'x$40/ft^2)	$ 690,000
Net Savings	**$ 229,610**

VI. CONCLUSIONS AND RECOMMENDATIONS

Analysis of an alternative channel alignment proposed by BBB for a reach of the Agua Fria River between Buckeye Road and I-10 has been performed. Modifications to their suggested alignment have been made to provide for an appropriate transition from the 1410-foot-wide channel at the drop structure downstream of I-10 to the 1100-foot-wide channel, and to accommodate the electrical transmission towers located along the east side of the channel. The recommended alignment for the alternative is shown on Plate 1.

The analysis consisted of an evaluation of the hydraulic conditions, assessment of the degradation and scour potential, and estimate of the projected construction costs associated with the alternative alignment. Based upon the analysis, the following conclusions can be drawn from a comparison of the original and alternative alignments:

1. The narrower channel results in increased flow velocities in the reach between Buckeye Road and approximately 1200 feet upstream of Van Buren Street.
2. Constriction of the channel increases the water-surface elevations from approxiamtely 1800 feet upstream of Buckeye Road to McDowell Road. The maximum increase is approximately 1.5 feet which occurs between Van Buren Street and I-10.
3. Water-surface elevations are still sufficiently low to prevent interference with the outlet of the I-10 collector channel. Maximum allowable water-surface elevation at that location is 983.7. For the alternative alignment, the water-surface elevation at the upstream side of the inlet is 983.4.
4. Due to the greater depths caused by the narrower channel, velocities from approximately 1200 feet upstream of Van Buren Street to McDowell Road are reduced.
5. The changes in flow velocity result in a degradational tendency in the reach between Buckeye Road and Van Buren Street. This reach was approximately in equilibrium for the original alignment.
6. Because of the potential degradation between Buckeye Road and Van Buren Street, an additional 4-foot drop structure should be provided. From the existing profile, the most advantageous location is

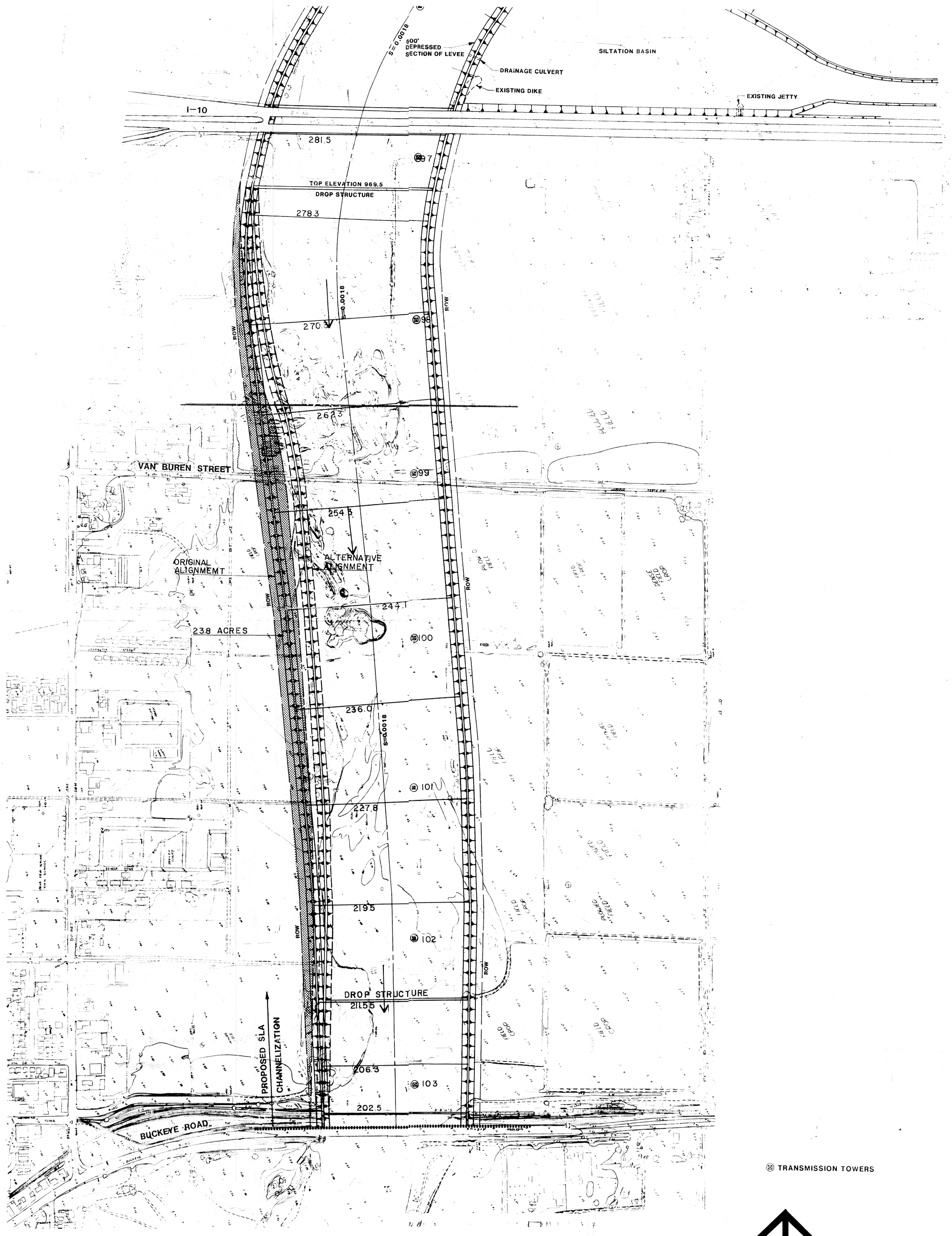
approximately 1850 feet upstream of Buckeye Road.

7. With the addition of the 4-foot drop structure upstream of Buckeye Road, the height for the drop structure downstream of I-10 can be reduced to 3 feet which results in less scour at the toe and a smaller structure.
8. Design heights for the levees must be increased from 1800 feet upstream of Buckeye Road to McDowell Road to provide sufficient freeboard.
9. As recommended for the original alignment, toe-down depths for the levees should be 8.5 feet. This toe down should be increased to 14 feet for 2000 feet downstream of I-10 on the west side of the channel to provide additional safety along the outside of the bend. Also, freeboard height should be increased from 3 feet to 5.5 feet in this area to account for the superelevation around the bend.
10. The alternative alignment will occupy approximately 23.8 acres less than the original alignment. All of the land area difference occurs along the west side of the channel.
11. The Van Buren Street bridge is approximately 250 feet shorter for the alternative alignment, reducing its cost by approximately $690,000.
12. Estimated cost to construct the original and alternative alignments is $8,086,900 and $8,547,300, respectively, indicating that the alternative alignment will cost approximately $460,400 more.
13. From Items 11 and 12 above, the net savings for the alternative alignment is $229,600.
14. Based upon the cost comparison and considering that detrimental hydraulic conditions associated with the alternative alignment can be mitigated by adding an additional drop structure and raising the levees, it is recommended that the alternative alignment shown on Plate 1 be used for the final design.

VII. REFERENCE

Simons, Li & Associates, Inc., February, 1984, revised May, 1984, "Standard Project Flood Analysis and Conceptual Design of Channelization in the Agua Fria River," prepared for Maricopa County Flood Control District.

R1/R662PH



⊗ TRANSMISSION TOWERS

NORTH

0 200' 400'
SCALE

NOTE: FROM PLATES 3 AND 4 OF AZ-MC-05 REPORT

Project No	AZ-MC-09
Date:	AUG. 1984
Design:	
Drawn:	
Check:	
Revisions:	

PLATE - 1

ORIGINAL AND ALTERNATIVE ALIGNMENTS

sla Simons, Li & Associates, Inc.
Cheyenne, WY • Colorado Springs, CO • Denver, CO • Fort Collins, CO
Newport Beach, CA • Pittsburgh, PA • Salt Lake City, UT • Tucson, AZ • Washington, D.C.