SCOUR ANALYSIS
OF THE
AGUA FRIA RIVER
BETWEEN
LOWER BUCKEYE ROAD AND BROADWAY BOULEVARD

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I. INTRODUCTION

1.1 Study Location and Purpose

This study pertains to a portion of the Agua Fria River which is located within the city of Avondale, Arizona. More specifically, the study reach is defined as that portion of the river located between Lower Buckeye Road and Broadway Boulevard. The downstream limit of the study reach (Broadway Blvd.) is located approximately 1.5 miles upstream of the Gila River confluence.

The purpose of this study is to provide design parameters for the placement of a new interceptor sewer across and beneath the river. The proposed interceptor sewer, which will provide a link between Avondale's existing wastewater treatment facility and a new treatment facility, will cross the Agua Fria River approximately one-half mile downstream of Lower Buckeye Road. The location and approximate alignment of the proposed interceptor sewer is shown on Figure 1.

1.2 Previous Studies

The study reach, as defined in the previous section, was included in a hydraulic and geomorphic analysis of the Agua Fria River that extended from the Gila River confluence to the New River confluence (Reference 1). This analysis divided its study reach into ten subreaches. The study reach as defined for the present investigation (see Section 1.1) was identified as Reach 9 in the previous study. The primary purpose of the previous analysis was to describe the channel and floodplain characteristics as they existed in 1983. This analysis was performed for the 10-, 25-, 50-, and 100-year events. The secondary purpose was to recommend conceptual flood-control measures and review proposed construction plans along selected subreaches. The study included a three-level geomorphic analysis. The first level involved a qualitative evaluation of the river. Although the qualitative analysis assessed historic trends, both natural and man-made, it was limited to general descriptions of the entire study reach (Reaches 1 - 10), with more specific descriptions of those selected subreaches where improvements were proposed.

The second level of analysis involved an engineering-geomorphic study which identified short-term and long-term aggradation and degradation tendencies, considering the mechanics of sediment-transport theory. Within Reach 9, there was neither a short-term tendency toward aggradation nor toward degradation, since the reach was considered to be in equilibrium. In the long-term, Reach 9 demonstrated a slight tendency toward aggradation.

The third level of analysis, as presented within Reference 1, involved a computer simulation of the river's response (i.e., depth of general scour with respect to the channel bed) to the 100-year flood hydrograph. The results indicated that the anticipated response within Reach 9 was less than one-half of a foot.

The geomorphic characteristics of the Agua Fria River, as identified in Reference 1, were used as a basis for comparison to the results obtained in a conceptual channelization study (Reference 2). The purpose of the second study was to evaluate the effects of channelization from I-10 downstream to Buckeye Road, and to provide design requirements to pass the 100-year peak discharge beneath various bridged crossings. In addition to the 100-year event, this concept channelization study also included an analysis of the 10-, 25-, and 50-year events. A three-level geomorphic analysis was again performed as part of this second study. In addition to defining the impact of channelization, the study defined the impact on those reaches located immediately upstream and downstream of the channelized reach of the river.

A third study (Reference 3), which was similar to the second study, was also performed to analyze the effects of channelization. However, the channelized reach was extended upstream to Camelback Road, and the impact and design requirements associated with the Standard Project Flood were also assessed. Again, a three-level geographic analysis was performed.

As a result of the latter two studies, the Agua Fria River was channelized from Indian School Road, downstream to Buckeye Road. According to the results obtained in these studies, the impact of channelization on the study reach, as defined for the present analysis (Lower Buckeye Road to Broadway Blvd), was considered insignificant.

1.3 Study Description

In order to establish the required design parameters for the interceptor sewer, a site-specific hydraulic and geomorphic analysis of the study reach, as defined in Section 1.1, was performed. The hydraulic analysis was performed using the cross-sectional information associated with both Reach 8 and Reach 9, as provided in Reference 1. Reach 8 applies to that portion of the Agua Fria River located between Buckeye Road and Lower Buckeye Road, and Reach 9 applies to that portion of the river located between Lower Buckeye Road and Broadway Boulevard (the study reach). However, the cross sections provided in Reference 1 were revised to account for the construction of a new levee along both the east and west banks of Reach 8, and along part of the west bank of Reach 9.

A two-level geomorphic analysis was performed to define the scour potential in the immediate vicinity of the proposed crossing. This two-level analysis involved (1) a qualitative evaluation of historic bank erosion, lateral migration, and aggradation/degradation potentials within Reach 8 and Reach 9; and (2) a quantitative analysis, which was subsequently used to estimate the total scour depth during the 100-year event. The individual scour components evaluated as part of the quantitative analysis were general scour, antidune scour, local scour, and the formation of an incised low-flow channel.

GENERAL SCOUR results in the lowering of the streambed by the entrainment of channel bed sediments. ANTIDUNE SCOUR results from the development of a sinusoidal bed-form that acts in phase with gravity water-surface waves. LOCAL SCOUR results from local disturbances in the flow path due to obstructions such as bridge piers and abutments, transmission towers, pipelines, and similar pile- or non-pile-supported structures. The accumulation of debris on the respective structures was also considered, since the effective width of the obstruction is significantly increased by the accumulation of debris; thereby increasing the local scour.

Whenever a large width-to-depth ratio exists for a given alluvial channel, the formation of a low-flow channel must also be considered in evaluating potential scour depths and lateral-migration distances. In some instances, flows confined to a low-flow channel will develop higher velocities than the primary channel will develop---even during the high, less-frequent, flow events.

II. DISCUSSION AND RESULTS

2.1 Qualitative Response

A qualitative analysis in the immediate vicinity of the proposed crossing was performed using (1) flow records which date back to 1960; (2) photographic records which date back to 1976; (3) topographic information which dates back to 1957; (4) the results of sediment-distribution analyses which were performed on various samples taken within the study reach and adjacent reaches; and (5) observations from a field investigation of the study reach. Collectively, this information was used to determine the aggradation or degradation potential with respect to the bed profile and the erodibility of the channel banks (ie., bank erosion and/or lateral migration) along the study reach.

The results of the field investigation indicate that the study reach exists as a wide, braided, alluvial channel. The banks and bed material consist mostly of cohesionless sands and gravels. This fact was confirmed by several sediment-distribution analyses of material collected at varying depths along the study reach. The banks of either the main channel or low-flow channel are poorly defined, and lack stabilizing vegetation. For the most part, it appears that the existing banks are either the result of agricultural encroachment with uncompacted, fill material; or, are the result of bars formed during relatively small flow events. It also appears that no geologic controls exist along the study reach to limit bed or bank erosion during a single flood event.

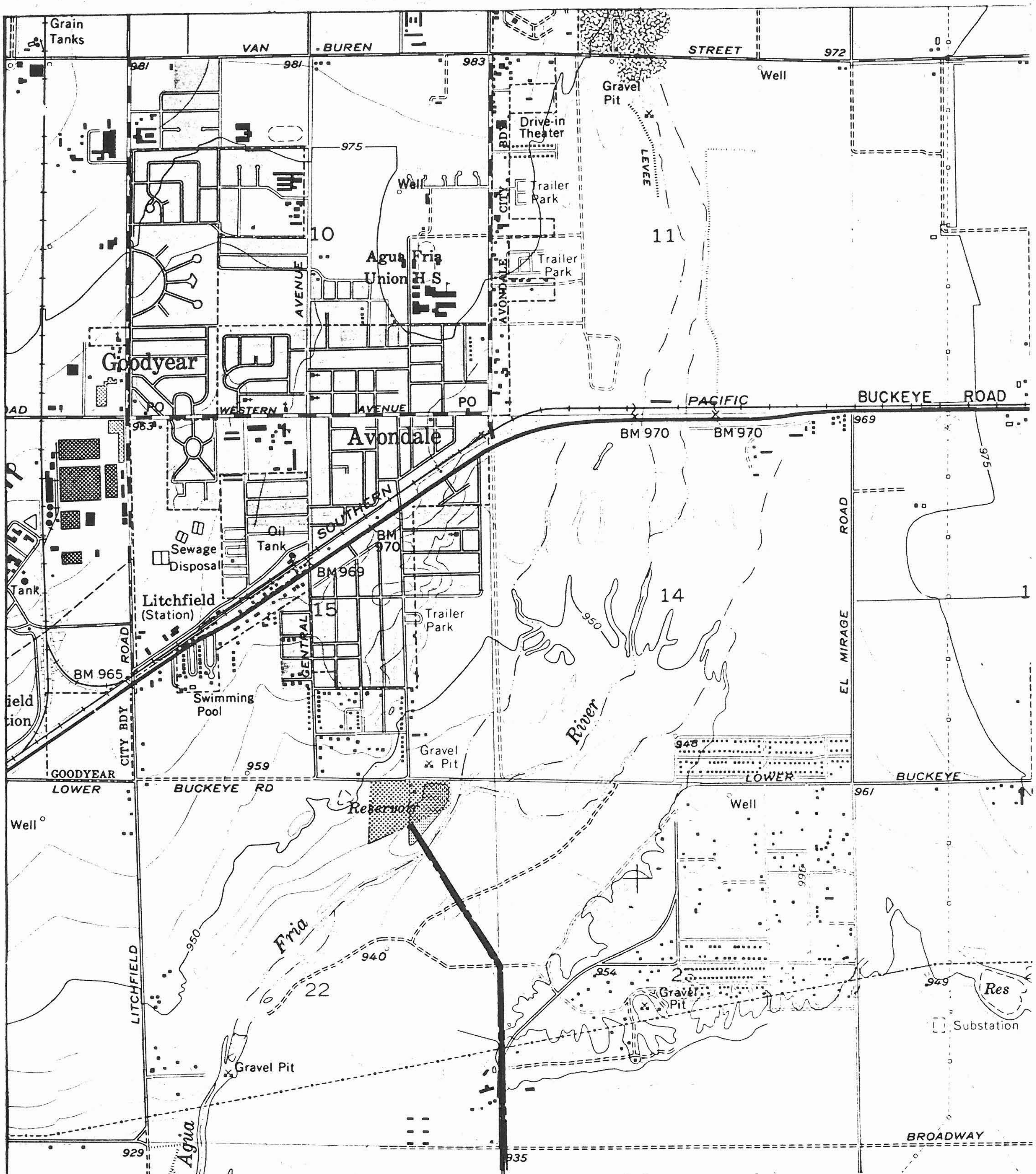
The type, density, and age of the vegetation (mostly shrubs and grasses) within and along the bars indicate that the bars are probably overtopped with sufficient frequency to prevent the formation of a more stabilizing type of vegetation (i.e., trees). The bars also contained evidence of migrating low-flow channels. In addition, there was no evidence of degradation along the study reach. The distribution of sediment sizes with respect to depth would seem to indicate a slight tendency for aggradation. Therefore, the profile along the study reach could probably be considered as either stable or slightly aggrading in the long term.

A comparison of the topographic information shown on Figure 1 and Figure 2 seems to indicate that the profile along the study reach is either stable or demonstrating a slight tendency toward aggradation. The topographic information on Figure 1 was prepared in 1957. The information on Figure 2 was obtained in 1981. The approximate thalweg elevation in the vicinity of the proposed crossing, as shown on Figure 1 and Figure 2, is 935.0 and 938.0, respectively. Although the accuracy of the mapping shown on the figures is 5 feet and ± 2 feet, respectively, there is no significant change noted when comparing these two maps.

A review of the flow records indicates that the study reach is not subjected to flow events on a regular basis. This is primarily due to the existence of the Waddell Dam which controls approximately 1457 square miles of the 2340-square-mile watershed (with respect to the Gila River confluence). In addition, the large storage capacity of the channel along the approximately 30-mile-long course between Waddell Dam and the study reach, coupled with relatively large infiltration rates, insignificant lateral inflows, and in-channel sand-and-gravel pits, have combined to eliminate most annual flow events. When notable flows do occur, the magnitude is such that they either create incised low-flow channels, or cause significant changes in the alignment and geometry of a low-flow channel that may have remained dormant for several years.

Between 1960 and 1977, the study reach was subjected to two sizeable flow events that approximated 20,000 cfs. One event, estimated to be approximately 20,000 cfs, occurred in December of 1967; and the other event, estimated to be approximately 20,600 cfs, occurred in September of 1971. These events were less than the 10-year event, which was defined in Reference 1 to be approximately 28,000 cfs. However, since historic photographs were not available to record the changes that occurred during each of these events, it was not possible to define the response of the channel.

However, it should be noted that during this seventeen-year period, records were not available for two years (1973 and 1974) while the Buckeye Road bridge was under construction. In addition, there were six years when no flows were recorded. With the exception of the two flow events that approximated 20,000 cfs, only four flows exceeded 1,000 cfs. The magnitude of these four flows were 4700 cfs in 1960, 3000 cfs in 1964, 8200 cfs in 1971, and 5180 cfs



sla

LEGEND

APPROXIMATE ALIGNMENT OF PROPOSED INTERCEPTOR

EXISTING WASTEWATER TREATMENT FACILITY

N

1" = 2000 FT.
Contour Interval 5ft.

FIGURE I

LOCATION MAP–A PORTION OF THE TOLLESON ARIZONA QUADRANGLE, 7.5 MINUTE SERIES

(TOPO BASE, 1957, PHOTO REVISED, 1974)

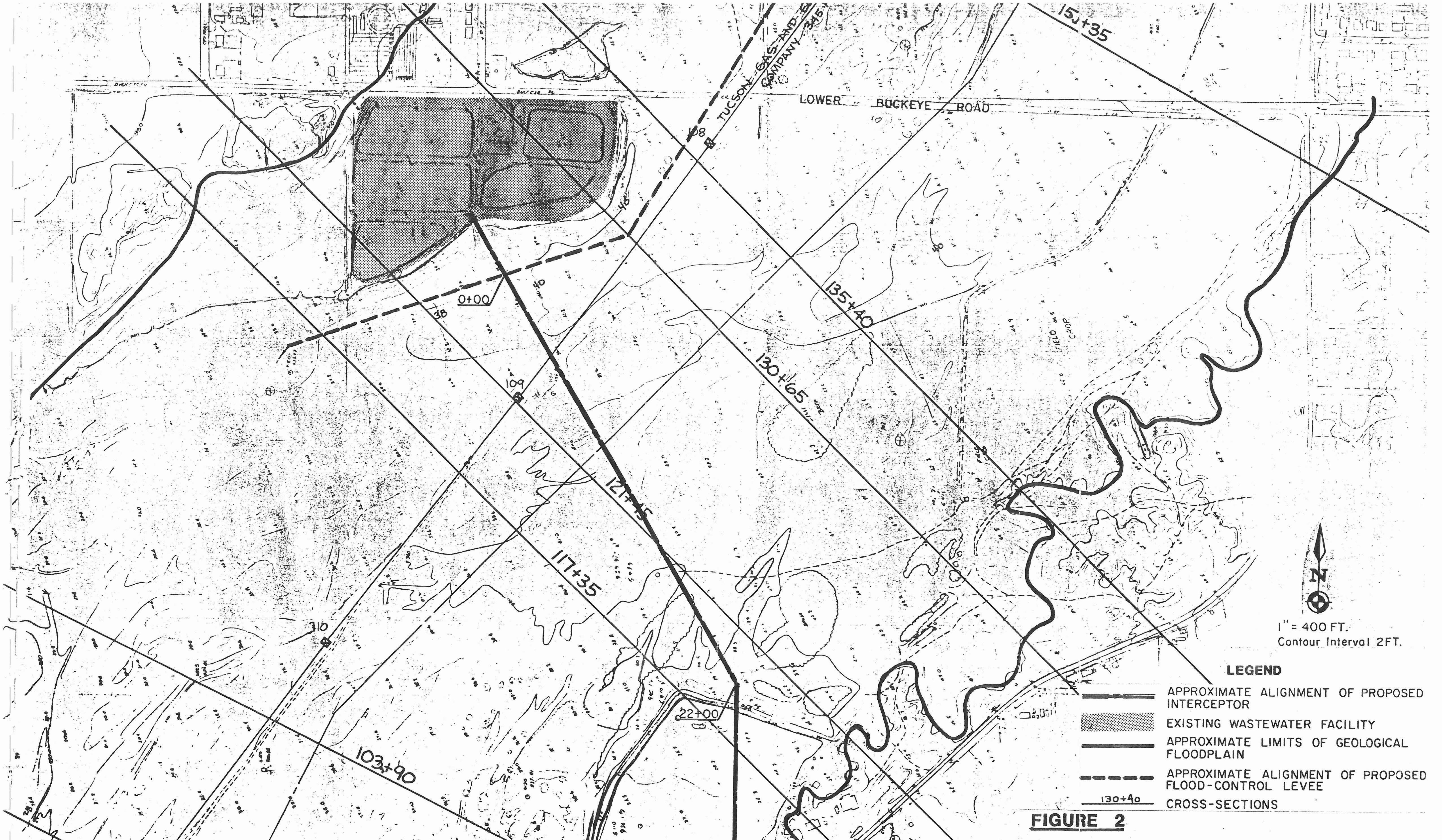


FIGURE 2

TOPOGRAPHIC MAP OF THE AQUA FRIA RIVER IN THE IMMEDIATE VICINITY OF INTERCEPTOR CROSSING (1981)

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in 1972. Therefore, it is likely that the low-flow channel shown on the December 1976, aerial photograph (Figure 3) was created in part by the two 20,000 cfs events that occurred in 1967 and 1971.

Between December 1976 and December 1978 (Figure 4), the study reach was subjected to one flow event that was estimated to be approximately 13,100 cfs. However, the relatively low magnitude associated with this event still caused channel widening on the order of 200 feet within the relatively straight reach located immediately upstream of Lower Buckeye Road. Downstream of Lower Buckeye Road, the southeastern bank (outside bend) of the low-flow channel migrated in excess of 360 feet.

Between December 1978 and December 1980 (Figure 5), the study reach was subjected to two flow events that were estimated to be 29,300 cfs and 44,200 cfs. These discharge magnitudes, which occurred in December of 1978 and December of 1980, respectively, approximated the 10-year (28,000 cfs) and 25-year (47,000 cfs) event, as defined in Reference 1. The established pre-flood, low-flow channel that appears on the 1978 photo was essentially eliminated when 180 feet of the west overbank area in the immediate vicinity of Lower Buckeye Road was removed. At the same location, approximately 930 feet of the east overbank area was also removed. The average widening between Lower Buckeye Road and Buckeye Road was 720 feet. This seems to confirm that the study reach is aggrading, since aggrading channels tend to widen---in contrast to degrading channels, which tend to narrow.

Between December 1980 and December 1983 (Figure 6), no significant flows occurred along the study reach. However, it is apparent that a definable low-flow channel is once again forming within the boundary of the 100-year floodplain. To date, most bank erosion within the study reach and the immediate upstream reach (Buckeye Road to Lower Buckeye Road) has occurred as a combination of channel widening and lateral migration. This response is a typical characteristic of aggrading reaches of an alluvial channel. However, continued urbanization of the upstream watershed, coupled with channelization and attempts to limit peak discharges through the construction of larger dams, could reverse the current tendency of slight aggradation to one of degradation. This transition, coupled with the sinusoidal alignment of the newly-formed low-flow channel, could increase the potential for channel instabilities and/or lateral migration for flows that equal or exceed approximately 10,000 cfs.

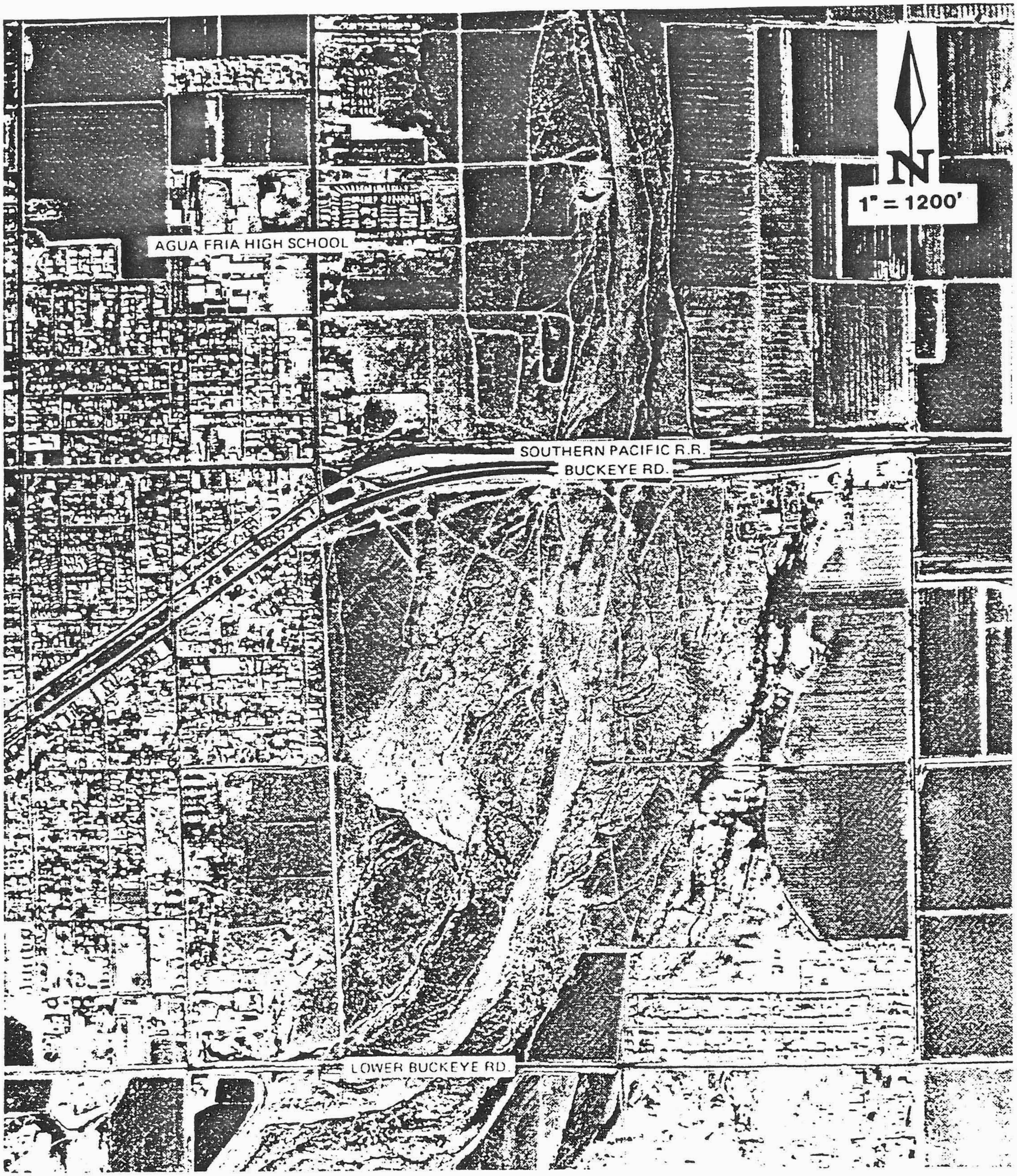

FIGURE 3

1976 AERIAL PHOTOGRAPH

(12-28-76)

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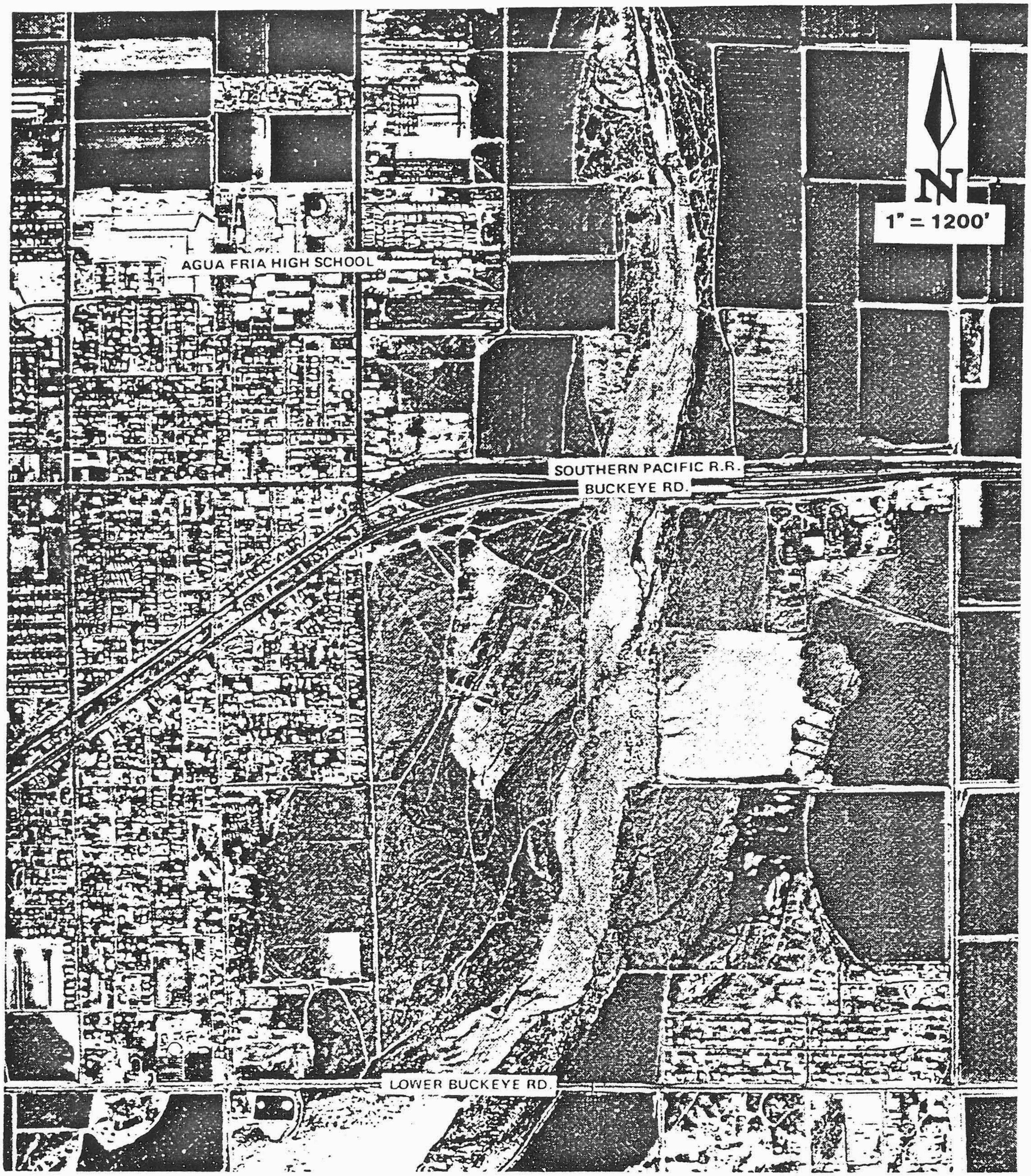
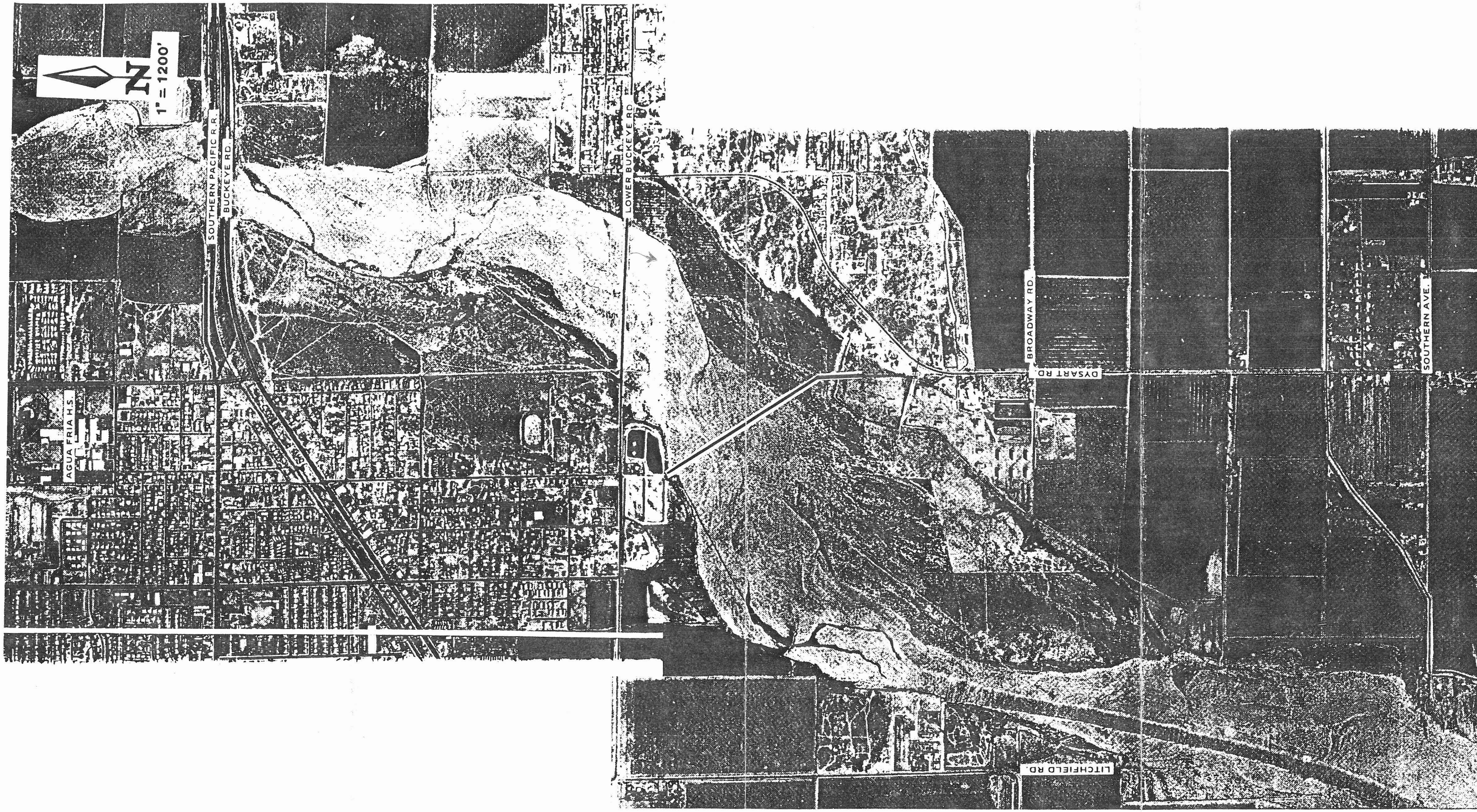


FIGURE 4

1978 AERIAL PHOTOGRAPH

(12-14-78)



LEGEND

ALIGNMENT OF PROPOSED INTERCEPTOR

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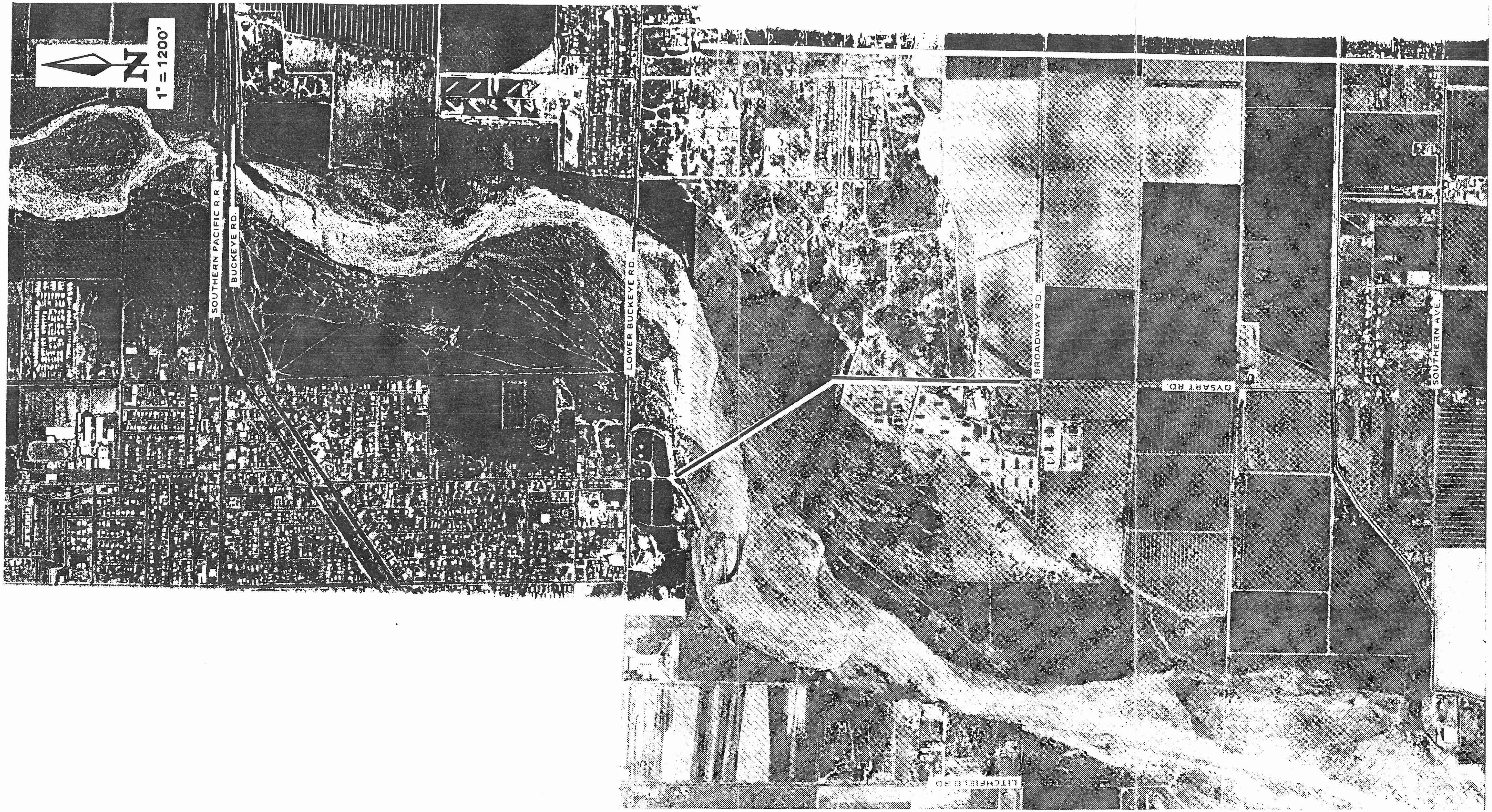
FIGURE 5

1980 AERIAL PHOTOGRAPH

(12-15-80)



LEGEND

ALIGNMENT OF PROPOSED INTERCEPTOR

FIGURE 6

1983 AERIAL PHOTOGRAPH

(12-7-83)

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2.2 Quantitative Response

A geomorphic analysis was performed to determine approximate scour depths within the study reach during the 100-year event. The 100-year peak discharge used for the hydraulic analysis (95,000 cfs) was obtained from Reference 1. As previously mentioned, the study reach as defined for this analysis corresponds to Reach 9, as identified in Reference 1. Therefore, the cross sections which were used for the hydraulic analyses of Reach 9 within Reference 1 were also used to establish the hydraulic parameters associated with the study reach for this analysis, under the assumption that the future construction of a flood-control levee would occur within the project limits.

The location of the cross sections used in this analysis are shown on Figure 2. The plotted cross sections are contained in Appendix A. As previously stated, the topographic information shown on Figure 2 was obtained in 1981. Since there have been no significant flows along the study reach since 1980, this information is adequate to establish the associated hydraulic parameters. Figure 2 also shows the approximate location and alignment of the proposed interceptor sewer and flood-control levee. In addition, the approximate limits of the geologic floodplain are shown on Figure 2.

As with Reference 1, the hydraulic parameters within the study reach were established using the U.S. Army Corps of Engineers HEC-2 backwater model. The input/output listings are contained in Appendix B. The average hydraulic parameters along the study reach, for both existing and leveed conditions, are provided as follows:

Existing Conditions

Maximum depth:	10.01 ft.
Hydraulic depth:	5.08 ft.
Channel velocity:	6.19 fps
Channel topwidth:	2787.50 ft.
Energy slope:	0.0025 ft./ft.

Leveed Conditions

Maximum depth:	9.44 ft.
Hydraulic depth:	5.54 ft.
Channel velocity:	6.90 fps
Channel topwidth:	2495.00 ft.
Energy slope:	0.0027 ft./ft.

As previously mentioned, the average hydraulic parameters associated with the leveed conditions were used to estimate all scour components, with the exception of general scour. The general-scour component, as determined by the Level-III analysis in Reference 1, was less than 0.5 feet. For design purposes, a minimum general-scour depth of one foot would be used for existing conditions. Since the HEC-2 analysis indicates that average hydraulic conditions within the study reach will not change significantly under leveed conditions, a minimum value of one foot for general scour is also valid for use in this analysis.

Both the antidune-scour component and the local-scour component were determined using the equations and relationships provided in Reference 4. Antidune scour is assumed to be one-half the antidune height, which is measured from the crest of the antidune to the trough of the antidune. Equation 4.25, as provided in Reference 4, can be used to compute the antidune height. For this study, the equation was modified to allow for the computation of antidune scour directly. Local scour was computed using Equation 5.15b, as provided in Reference 4. The associated computations are contained in Appendix C. The resulting scour depths associated with the antidune component of the flow and the local scour at the footings which support Transmission Tower #109, as shown on Figure 2, are approximately 0.65 feet and approximately 13.8 feet, respectively.

The average depth of the low-flow channel was determined to be approximately two feet. This value represents measured heights of existing and historic low-flow channels, as observed during field investigations which were conducted along the study reach.

Normally, the sum of the computed single-event scour components, with the exception of local scour, are multiplied by a safety factor of 1.3 to account for variations in the alignment of flow and non-uniform flow velocities and sediment distributions. Local scour is then added, if applicable, to define the total scour depth. However, due to the wide and shallow nature of the Agua Fria River along the study reach, it was felt that the individual components, as computed, may not actually represent the total scour potential associated with the study reach during a design flow event.

As was observed during field investigations, and noted during the qualitative analysis, that the width of the low-flow channel is such that intermediate flows concentrating in the low-flow channel section may produce above-average flow velocities. This would, in turn, create larger scour depths than those computed using the average hydraulic parameters associated with the 100-year event. Therefore, the individual scour components were multiplied by a 1.5 safety factor before they were summed, in order to account for this possibility. In addition, the 1.3 safety factor was also increased to 1.5 before it was applied to the total scour computed.

Based on the conditions described above, the depth of general scour increases to approximately 1.5 feet, the antidune scour increases to approximately 1.0 feet, the depth of the low-flow channel increases to approximately 3.0 feet, and the local scour increases to approximatley 20.7 feet. Therefore, the total scour depth, excluding local scour, is estimated to be approximately 8.2 feet. When the local-scour component is added, the total scour depth becomes approximately 28.9 feet.

To determine if local scour associated with a transmission tower will affect the interceptor sewer, it was first necessary to determine if the pipeline would be located within the zone of influence of the local scour. The lateral extent of the scour hole was determined using Equation 18, as presented in Reference 5. The associated calculations are contained in Appendix C. The results indicate that the extent of the local scour hole extends approximately 97 feet upstream of Transmission Tower #109. However, since the transmission tower is located approximately 240 feet downstream of the proposed crossing of the interceptor sewer, the effect of local scour at the tower will not impact the interceptor sewer. Therefore, the local-scour component may be eliminated. As a result, the depth of total scour, for design purposes, is approximately 8.2 feet.

III. DESIGN RECOMMENDATIONS

As noted in Reference 3, the design toe-down depth of 8.5 feet was applied to the bank protection which was recently constructed along that portion of the Agua Fria River located immediately upstream of Buckeye Road. In our opinion, construction of levees along a portion of the study reach, as proposed by the U.S. Army Corps of Engineers, is just the first step toward the ultimate channelization of the study reach. Therefore, in anticipation that the study reach would ultimately be leveed and channelized from its present width of 2600 feet to a much narrower width of 1200 feet, the design toe-down depth applied to the channelized reach located immediately upstream of Buckeye Road should also be applied to the study reach. Therefore, we recommend that the crown of the interceptor sewer be placed a minimum of 8.5 feet below the existing thalweg elevation within the main channel of the Agua Fria River. However, since a channelized width of 1200 feet does not currently exist, nor will it likely exist within the immediate future, the recommended burial depth should be applied to the entire 3200-foot-long segment of the interceptor sewer that will be located within in the geologic floodplain of the Agua Fria River.

Since the thalweg elevation varies for different segments of the proposed interceptor sewer, the following crown elevations should be applied to different points along the proposed alignment. To reference the various points where the crown elevation will change, reference stations were established along the proposed alignment, as shown on Figure 2.

The stationing begins at the approximate location where the Corps of Engineers plan to install a protected flood-control levee adjacent to the southeast of the existing treatment facility. Since the proposed alignment extends in a southeasterly direction from the existing facility and the proposed levee, the first bend in the interceptor sewer will be located approximately 2200 feet (Station 22+00) from the proposed levee. The location where the interceptor sewer exits the geologic floodplain is approximately 3200 feet (Station 32+00) from the proposed levee.

The thalweg elevation in the immediate vicinity of the proposed levee is approximately 936.5. Therefore, the maximum crown elevation at the levee should be approximately 928.0. The thalweg elevation associated with Station 22+00 is approximately 934.5. Therefore, the maximum crown elevation at this

8.5
926.0

station should be approximately 926.0. The thalweg elevation associated with Station 32+00 is approximately 932.5. Therefore, the maximum crown elevation at this station is approximately 924.0.

It is recognized that an attempt will be made to design the pipeline for gravity flow, unless excessive burial depths require that a siphon be provided. Since the toe-down depth for the proposed levee is approximately 14 feet below the adjacent ground elevation, the proposed flow-line elevation on the channel side of the levee for the new interceptor sewer will be approximately 920.3. This elevation is well below the maximum crown elevations discussed in the preceding paragraphs. Therefore, it appears that the toe-down elevation for the levee will control the design profile and/or establish whether or not a siphon will need to be provided along a portion of the alignment. If a gravity-flow design can be established starting at this elevation, the design profile will be well below the computed scour depths. However if a gravity-flow design can not be established, due to the controlling elevation at the levee, a siphon could be provided beneath the levee. An attempt could then be made to design the remaining portion of the interceptor sewer for gravity flow.

IV. SUMMARY

1. This hydraulic and geomorphic analysis pertains to a portion of the Agua Fria River within Avondale, Arizona. The study reach is defined as extending from Lower Buckeye Road, downstream to Broadway Boulevard.

2. The purpose of this analysis is to provide the design parameters for the placement of a new interceptor sewer beneath the river. The interceptor sewer will cross the Agua Fria River approximately one-half mile downstream of Lower Buckeye Road.

3. Certain hydraulic and geomorphic characteristics of the study reach were defined in previous studies (References 1-3). However, these studies did not compile enough site-specific information to provide the required design parameters associated with the study reach.

4. The hydraulic analysis for this study was performed using the cross-sectional data provided in Reference 1. However, the data was modified to account for future construction of a flood-control levee within the study reach. This levee was designed by the U.S. Army Corps of Engineers.

5. A two-level geomorphic analysis was performed along the study reach. The two levels were (1) a qualitative analysis, which established the historic trends of the river when subjected to various flow events; and (2) a quantitative analysis, which was used to determine the various single-event scour components (ie. general scour, antidune scour, and local scour).

6. The results of the qualitative analysis indicates that study reach exhibits the characteristics of a aggrading channel, which compliments the formation of an incised meandering low-flow channel. Flow magnitudes significantly less than the 10-year peak discharge are capable of causing channel widening and/or migration distances in excess of 200 feet. In addition, there appear to be no geologic controls within the geologic floodplain which can limit either lateral-migration distances or scour

floodplain which can limit either lateral-migration distances or scour depths.

7. The results of the quantitative analysis indicate that the total single-event scour depth under leveed conditions, excluding local scour, would be approximately 8.2 feet. Local scour is excluded since the interceptor sewer will not be located close enough to TEP Transmission Tower #109 to be influenced by its resulting scour hole.

8. Since it is likely that the study reach will ultimately be channelized from its existing width of 2600 feet to a much narrower width of 1200 feet, the general toe-down depth associated with the bank-protected levees which were recently constructed between Buckeye Road and Van Buren Boulevard becomes the recommended burial depth associated with the crown of the proposed interceptor sewer. This burial depth is 8.5 feet. Also, because the bank-protected levees will not likely be constructed within the immediate future, this burial depth should extend for the entire 3200-foot-long segment of the interceptor sewer that will be located within the geologic floodplain of the Agua Fria River.

9. The recommended burial depth (i.e., 8.5 feet) is applied from the thalweg elevation to the crown of the interceptor sewer. Since the thalweg elevation varies along the alignment of the intercept, three maximum crown elevations were provided to assist in establishing the design profile for that portion of the pipeline that will be located with the geologic floodplain.

10. It appears that the toe-downs for the bank-protected levee (which are to be 14 feet below the adjacent ground elevation, and which will be constructed adjacent to the existing treatment facility) will determine the requirement for a siphon, as opposed to the minimum design burial depth associated with the interceptor sewer.

V. REFERENCES

1. Simons, Li & Associates, Inc., "Hydraulic and Geomorphic Analysis of the Agua Fria River", September, 1983.

2. Simons, Li & Associates, Inc., "System Analysis and Conceptual Design of Channelization in the Agua Fria River", October, 1983.

3. Simons, Li & Associates, Inc., "Standard Project Flood Analysis and Conceptual Design of Channelization in the Agua Fria River", February, 1984.

4. Simons, Li & Associates, Inc., "Design Manual for Engineering Analysis of Fluvial Systems", March, 1985.

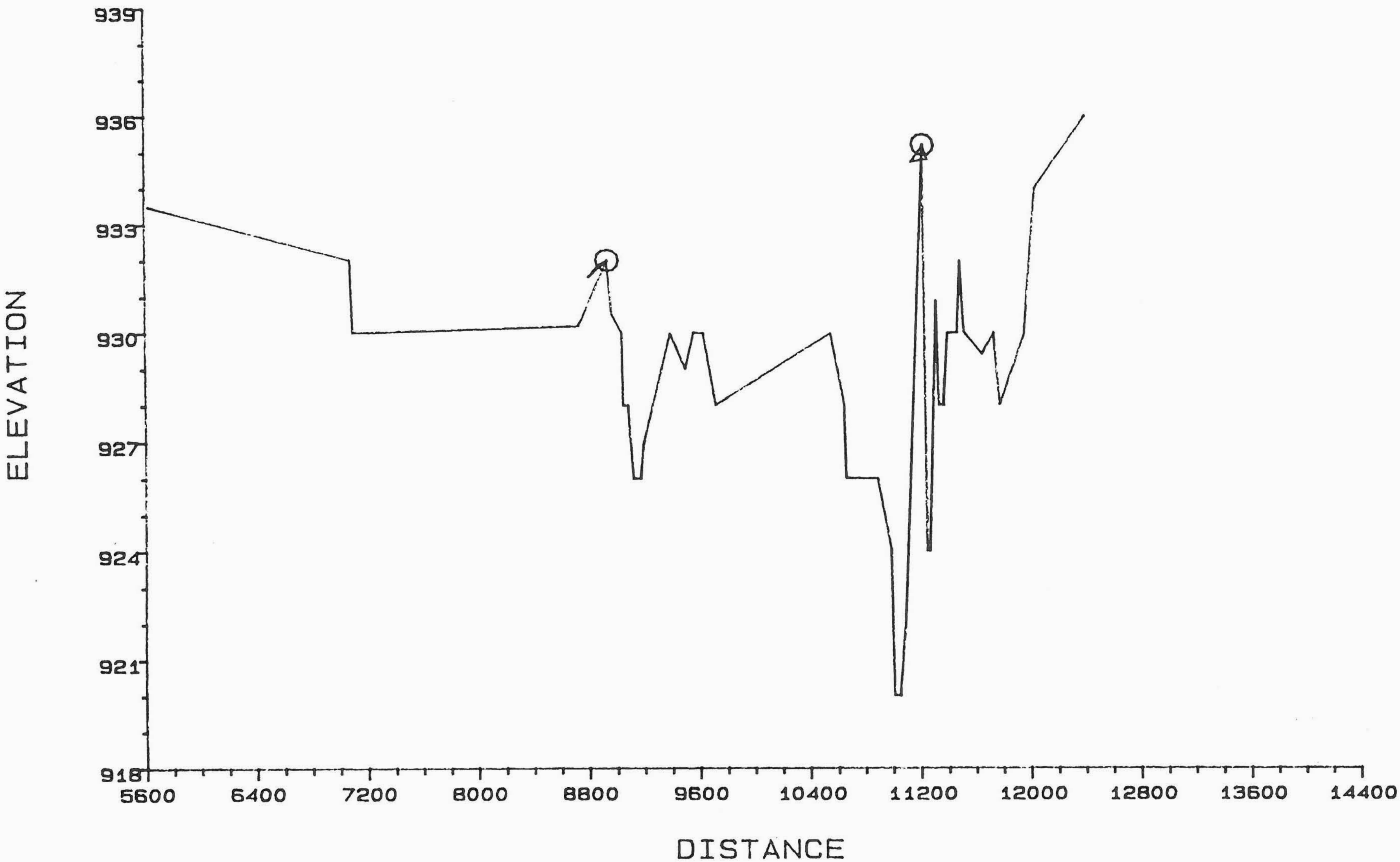
5. Simons, Li & Associates, Inc., "Simplified Step-by-Step Hydraulic Design Procedure for the Placement of Pipelines Across and/or Parallel to Alluvial Drainage Channels", December, 1984.

APPENDIX A

AGUA FRIA RIVER

LOWER BUCKEYE ROAD TO BROADWAY BOULEVARD

CROSS-SECTION NO. 75.000



AGUA FRIA RIVER
LOWER BUCKEYE ROAD TO BROADWAY BOULEVARD
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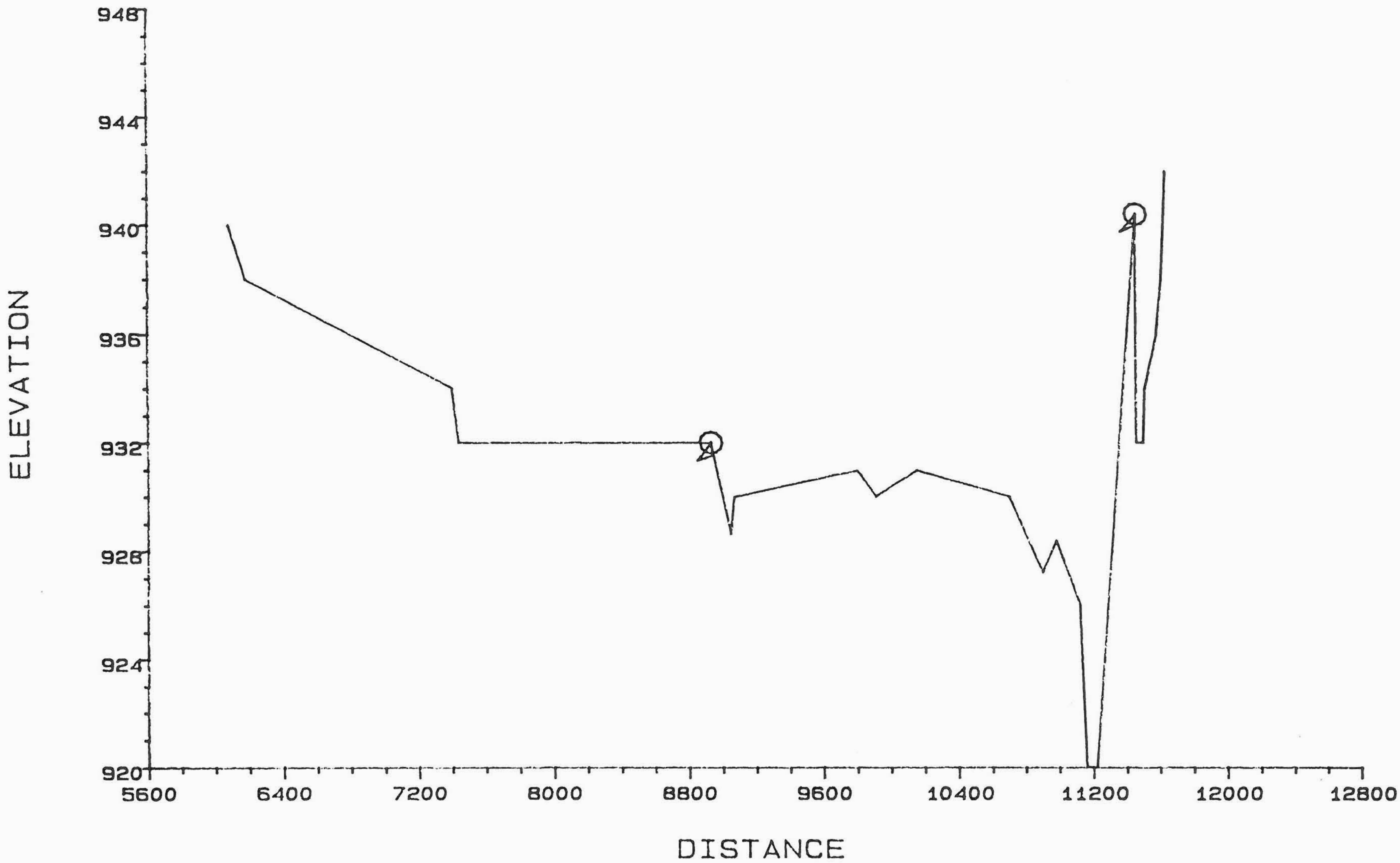
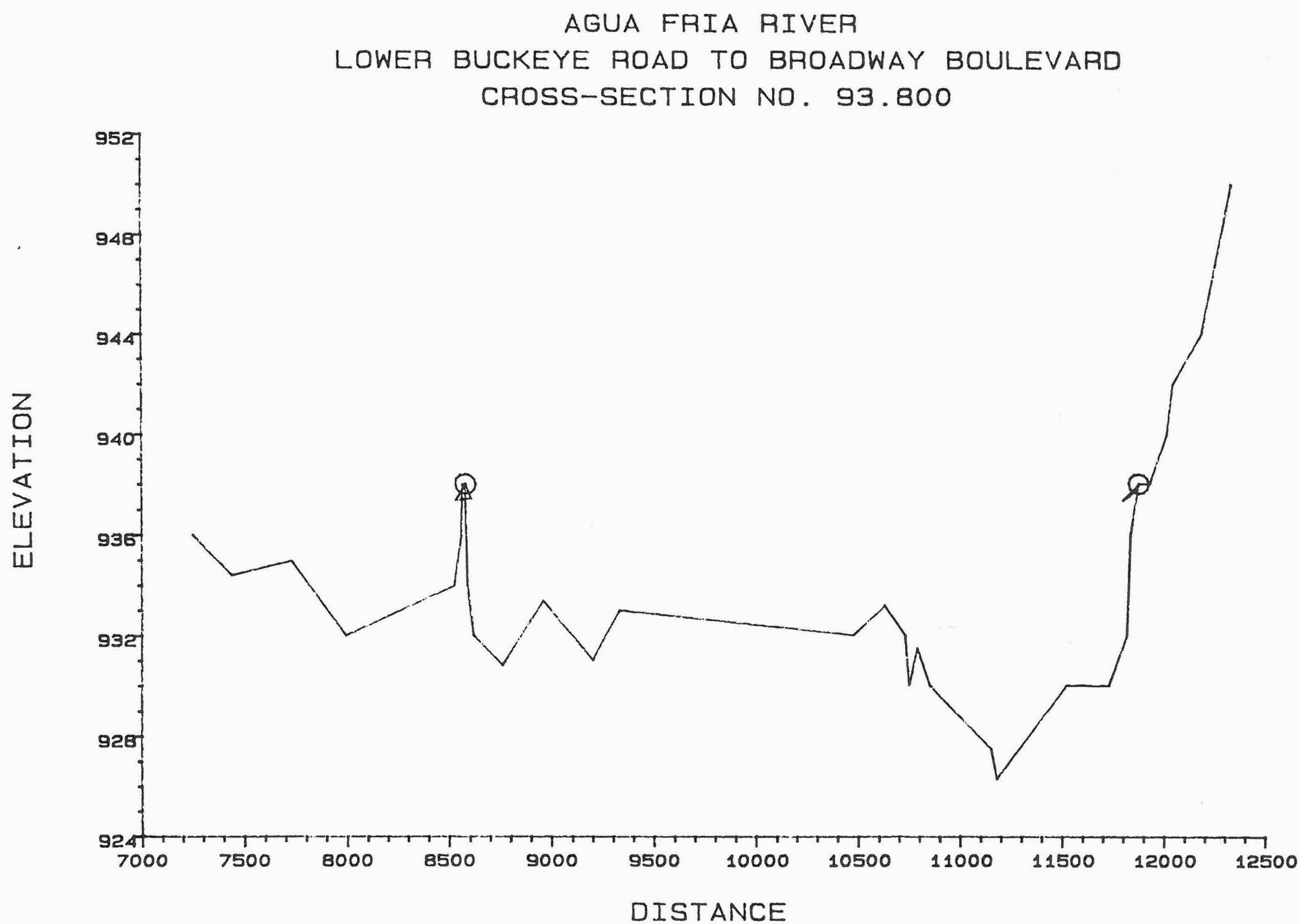
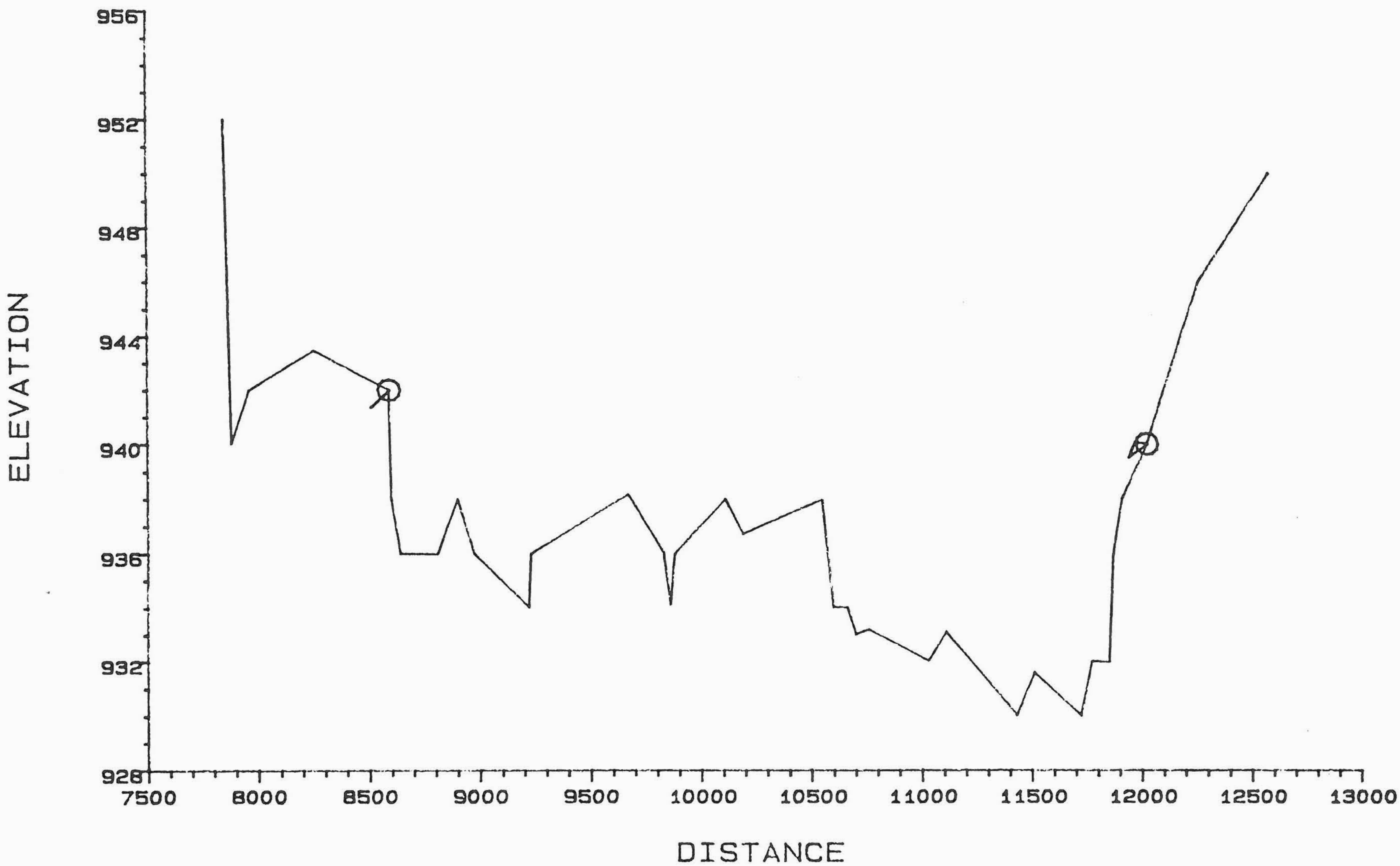
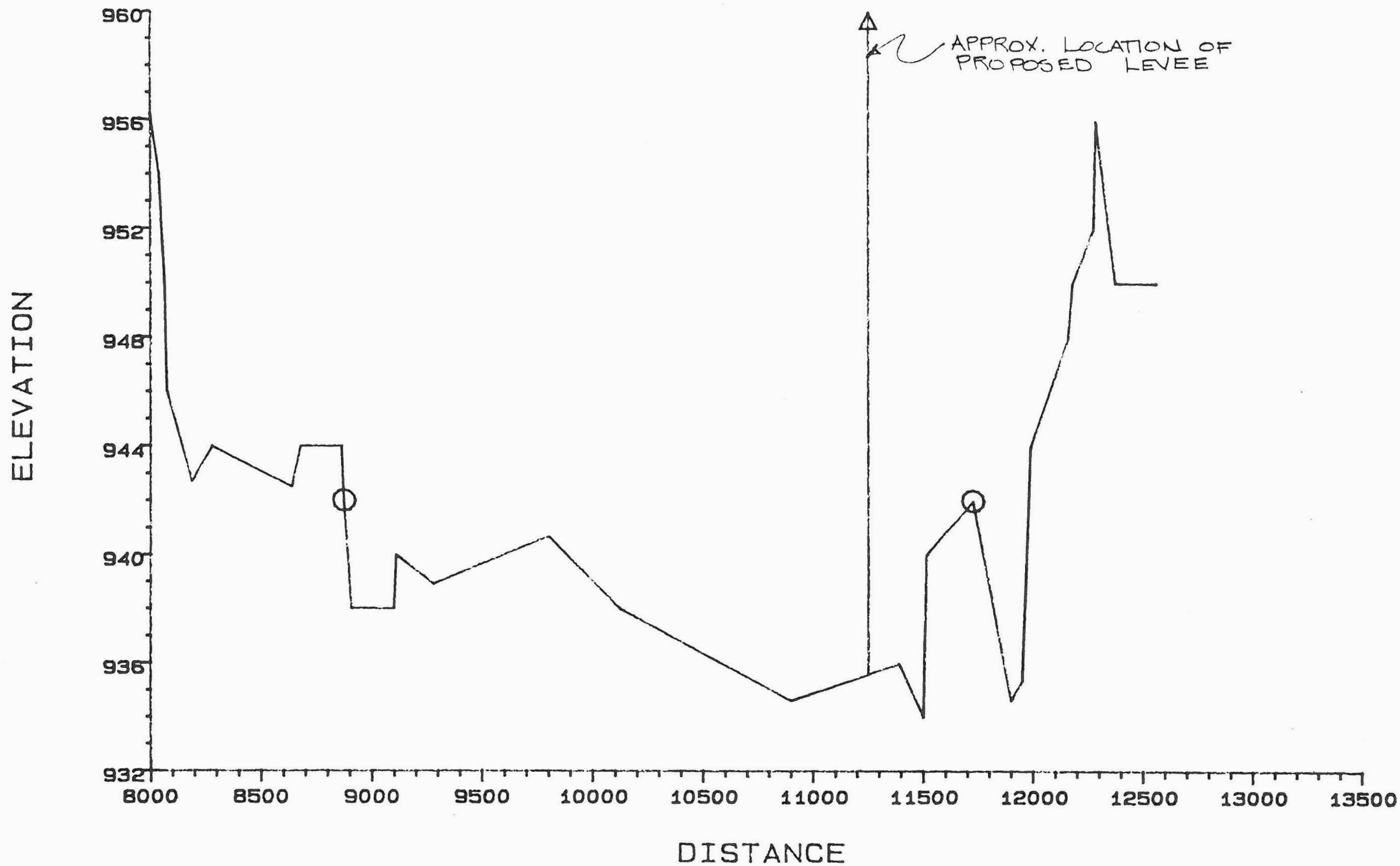



AGUA FRIA RIVER
LOWER BUCKEYE ROAD TO BROADWAY BOULEVARD
CROSS-SECTION NO. 93.800
ELEVATION
952
948
944
940
936
932
928
924
7000
7500
8000
8500
9000
9500
10000
10500
11000
11500
12000
12500
DISTANCE

AGUA FRIA RIVER
LOWER BUCKEYE ROAD TO BROADWAY BOULEVARD
CROSS-SECTION NO. 103.900



AGUA FRIA RIVER
LOWER BUCKEYE ROAD TO BROADWAY BOULEVARD
CROSS-SECTION NO. 117.300



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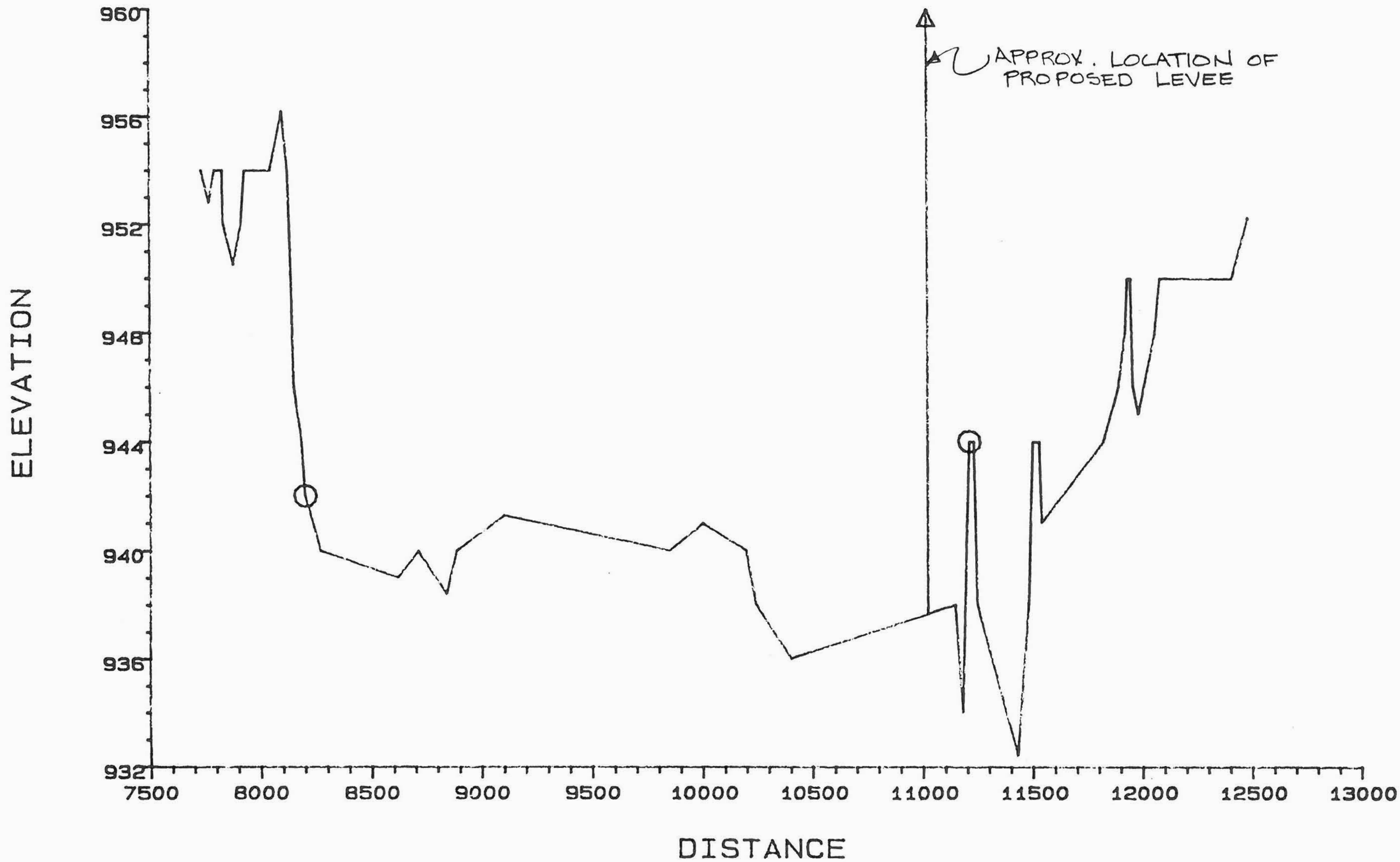
CROSS-SECTION NO. 121.400



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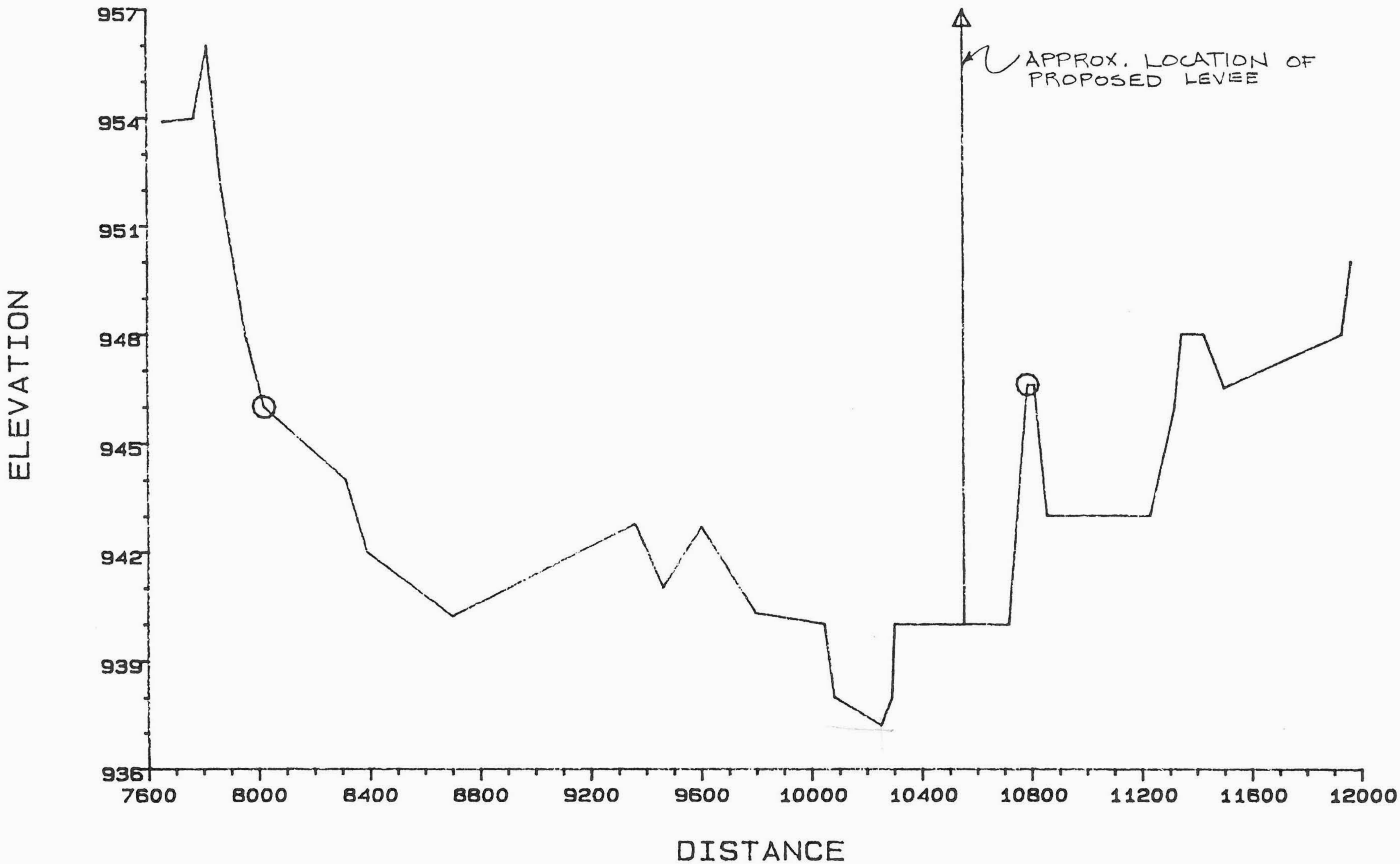
CROSS-SECTION NO. 130.600



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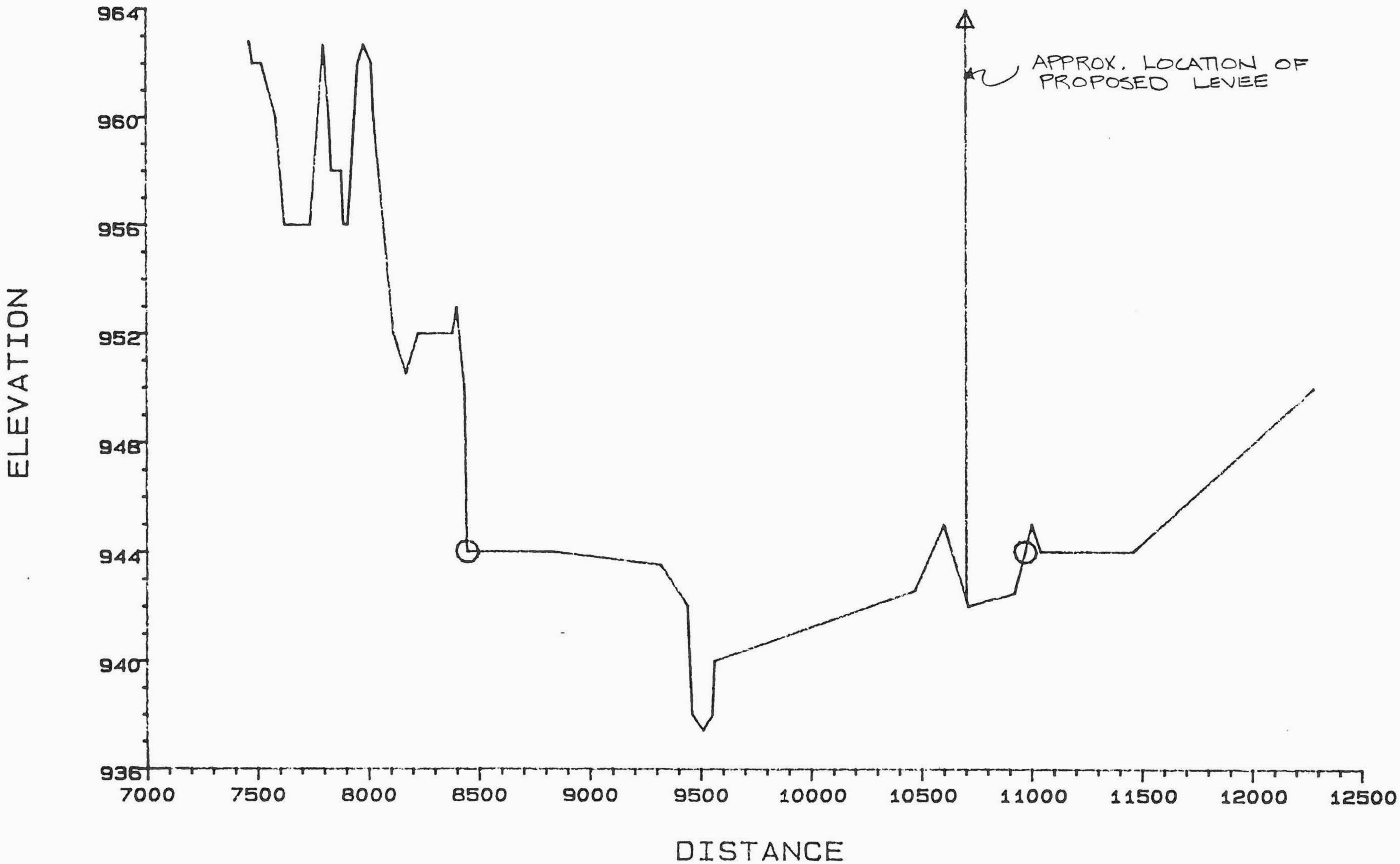
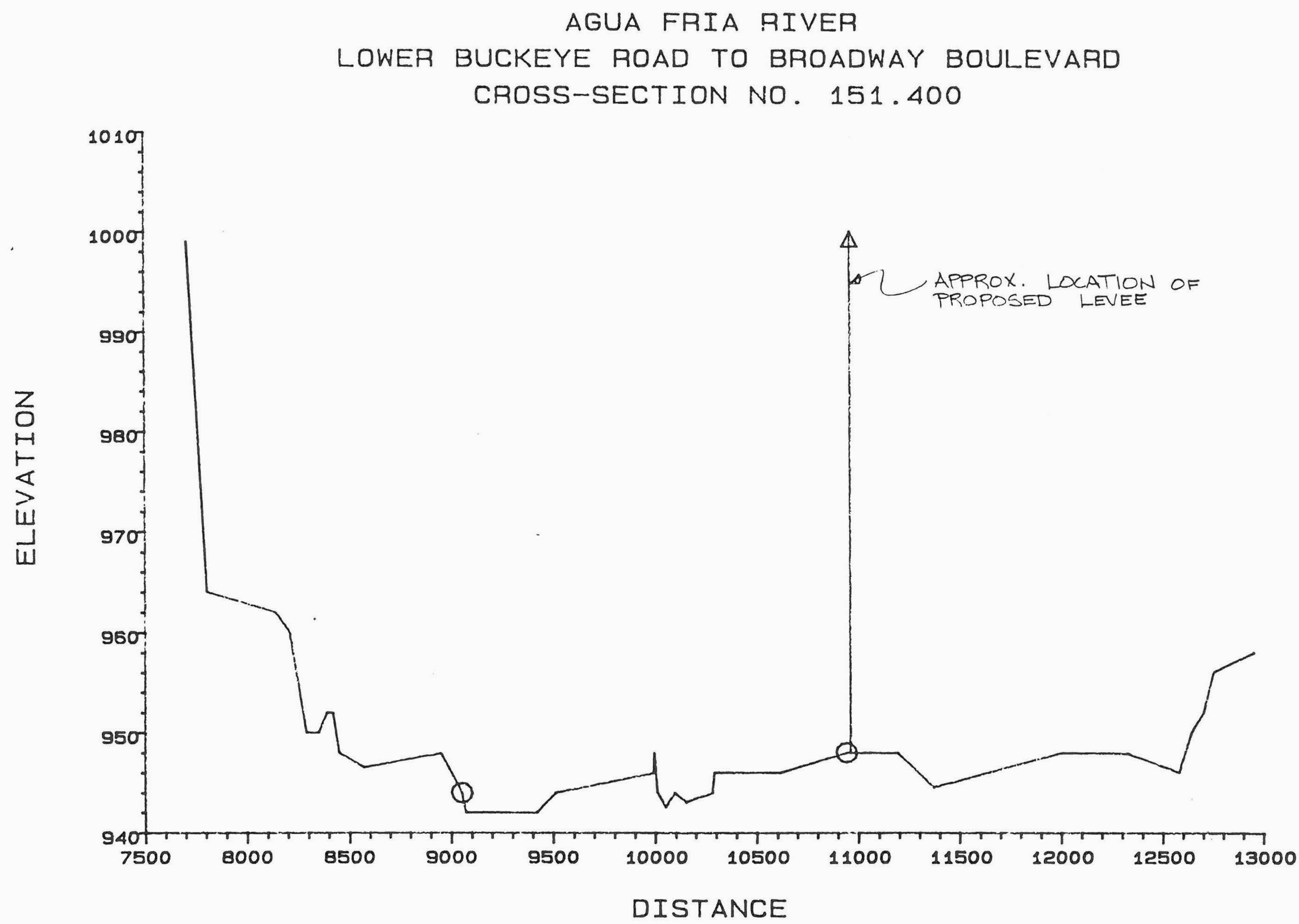
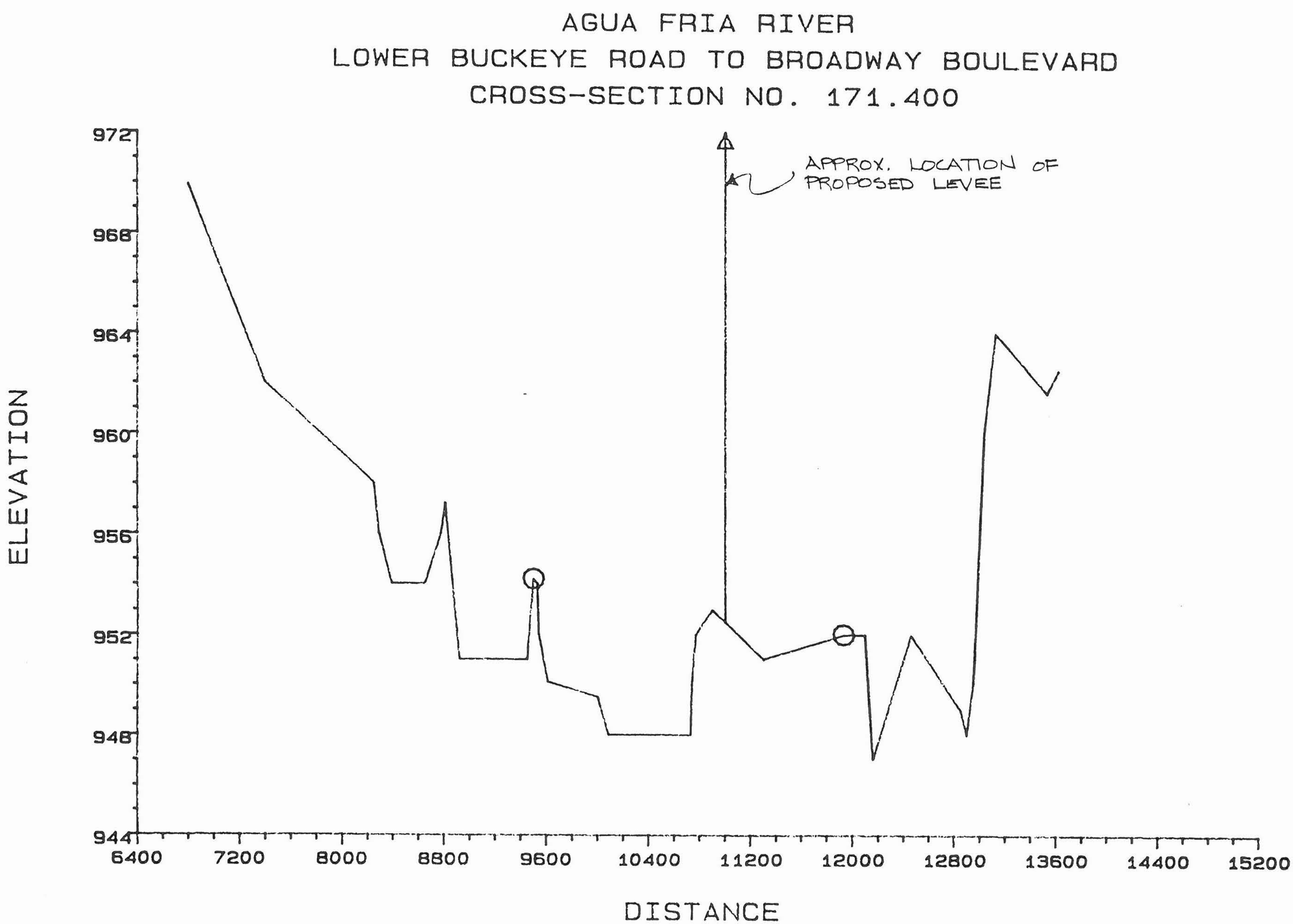
LOWER BUCKEYE ROAD TO BROADWAY BOULEVARD
CROSS-SECTION NO. 135.400



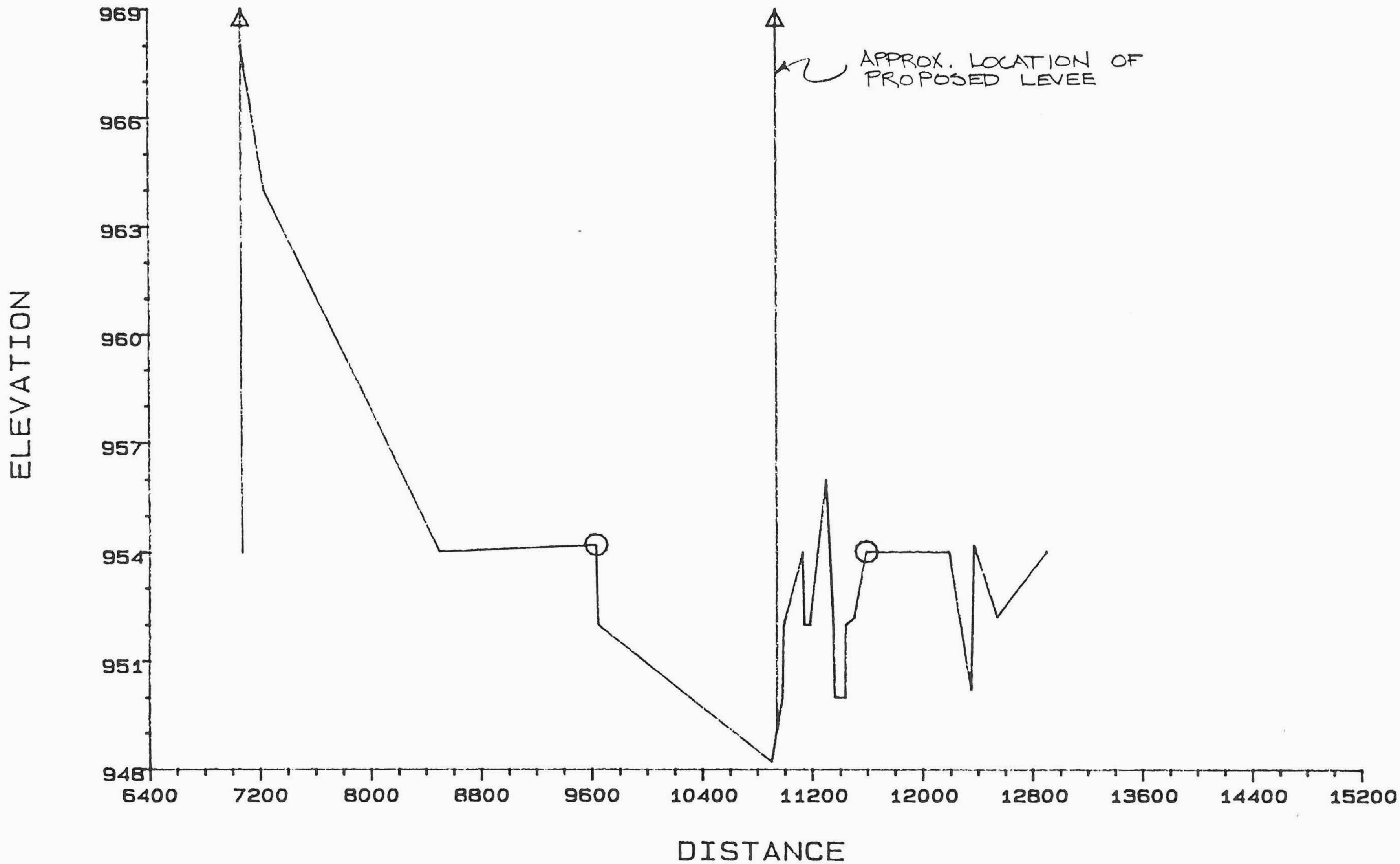

AGUA FRIA RIVER
LOWER BUCKEYE ROAD TO BROADWAY BOULEVARD
CROSS-SECTION NO. 151.400
ELEVATION
1010
1000
990
980
970
960
950
940
7500
8000
8500
9000
9500
10000
10500
11000
11500
12000
12500
13000
DISTANCE
APPROX. LOCATION OF
PROPOSED LEVEE


AGUA FRIA RIVER
LOWER BUCKEYE ROAD TO BROADWAY BOULEVARD
CROSS-SECTION NO. 171.400
ELEVATION
972
968
964
960
956
952
948
944
6400
7200
8000
8800
9600
10400
11200
12000
12800
13600
14400
15200
DISTANCE
APPROX. LOCATION OF
PROPOSED LEVEE

AGUA FRIA RIVER

LOWER BUCKEYE ROAD TO BROADWAY BOULEVARD

CROSS-SECTION NO. 181.600



APPENDIX B

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1*****************************************************
 * WATER SURFACE PROFILES                           *
 * VERSION OF NOVEMBER 1976                         *
 * UPDATED MAY 1984                                 *
 * IBM-PC-XT VERSION AUGUST 1985                    *
 * RUN DATE 01-12-88   TIME 16:47:37                  *
 *****************************************************

 **************************************
 * U.S. ARMY CORPS OF ENGINEERS       *
 * THE HYDROLOGIC ENGINEERING CENTER  *
 * 609 SECOND STREET, SUITE D         *
 * DAVIS, CALIFORNIA 95616            *
  * (916) 440-2105 (FTS) 448-2105
 **************************************
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X     X  XXXXXXX   XXXXX             XXXXX
X     X  X        X     X           X     X
X     X  X        X                       X
XXXXXXX  XXXX     X          XXXXX   XXXXX
X     X  X        X                 X
X     X  X        X     X           X
X     X  XXXXXXX   XXXXX            XXXXXXX
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 01-12-88     16:47:37
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THIS RUN EXECUTED 01-12-88

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

T1 PIPELINE-CROSSING SCOUR ANALYSIS FOR CITY OF AVONDALE

T2 AGUA FRIA RIVER: BROADWAY BLVD - LOWER BUCKEYE RD

T3 LEVEED 100-YR SUB (SEC. 117.3 - 181.6)

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0.	2.	0.	0.	.000000	.00	.0	0.	933.980	.000

J2	NPROF	IPLOT	PRFVS	XSECV	XSECH	FN	ALLDC	IBW	CHNIM	ITRACE
	-1.000	.000	-1.000	.000	.000	.000	.000	.000	.000	15.000

J3 VARIABLE CODES FOR SUMMARY PRINTOUT

38.000	1.000	55.000	26.000	56.000	13.000	14.000	15.000	8.000	4.000
25.000	53.000	54.000	.000	38.000	1.000	2.000	3.000	11.000	12.000

```
     42.000      5.000     33.000     21.000     22.000     39.000       .000       .000       .000       .000

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

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

NC        .040       .040       .035       .100       .300       .000       .000       .000       .000       .000
QT       1.000  95000.000       .000       .000       .000       .000       .000       .000       .000       .000
X1      75.000     41.000   8935.000  11225.000       .000       .000       .000       .000    500.000       .000
X3      10.000       .000       .000       .000       .000       .000       .000       .000       .000       .000
GR     433.500   5630.000    432.000   7080.000    430.000   7100.000    430.200   8730.000    432.000   8935.000
GR     430.500   8970.000    430.000   9040.000    428.000   9050.000    428.000   9085.000    426.000   9125.000
GR     426.000   9175.000    427.000   9200.000    430.000   9390.000    429.000   9500.000    430.000   9560.000
GR     430.000   9630.000    428.000   9720.000    430.000  10550.000    428.000  10650.000    426.000  10665.000
GR     426.000  10890.000    424.000  10990.000    420.000  11010.000    420.000  11050.000    422.000  11090.000
GR     435.200  11225.000    424.000  11250.000    424.000  11270.000    430.900  11320.000    428.000  11340.000
GR     428.000  11370.000    430.000  11400.000    430.000  11470.000    432.000  11490.000    430.000  11520.000
GR     429.400  11650.000    430.000  11735.000    428.000  11780.000    430.000  11960.000    434.000  12040.000
GR     436.000  12400.000       .000       .000       .000       .000       .000       .000       .000       .000

X1      82.600     23.000   8930.000  11455.000    750.000    720.000    760.000       .000    500.000       .000
X3      10.000       .000       .000       .000       .000       .000       .000       .000       .000       .000
GR     440.000   6080.000    438.000   6180.000    434.000   7490.000    432.000   7440.000    432.000   8930.000
GR     428.600   9050.000    430.000   9070.000    431.000   9800.000    430.000   9910.000    431.000  10150.000
GR     430.000  10700.000    427.200  10900.000    428.400  10980.000    426.000  11120.000    420.000  11160.000
GR     420.000  11220.000    440.400  11455.000    432.000  11460.000    432.000  11500.000    434.000  11510.000
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GR     436.000  11580.000    438.000  11610.000    442.000  11635.000       .000       .000       .000       .000

NC        .045       .045       .035       .100       .300       .000       .000       .000       .000       .000
X1      93.800     32.000   8580.000  11880.000   1200.000   1200.000   1120.000       .000    500.000       .000
X3      10.000       .000       .000       .000       .000       .000       .000       .000       .000       .000
GR     436.000   7250.000    434.400   7440.000    435.000   7730.000    432.000   7995.000    434.000   8525.000
GR     436.000   8560.000    438.000   8565.000    438.000   8580.000    434.000   8590.000    432.000   8620.000
GR     430.800   8760.000    433.400   8960.000    431.000   9200.000    433.000   9330.000    432.000  10480.000
GR     433.200  10630.000    432.000  10730.000    430.000  10750.000    431.500  10790.000    430.000  10850.000
GR     427.500  11150.000    426.300  11180.000    430.000  11520.000    430.000  11730.000    432.000  11820.000
GR     436.000  11840.000    438.000  11880.000    438.000  11935.000    440.000  12020.000    442.000  12050.000
GR     444.000  12190.000    450.000  12340.000       .000       .000       .000       .000       .000       .000

X1     103.900     35.000   8590.000  12025.000   1020.000   1020.000   1010.000       .000    500.000       .000
X3      10.000       .000       .000       .000       .000       .000       .000       .000       .000       .000
GR     452.000   7850.000    440.000   7880.000    442.000   7960.000    443.500   8250.000    442.000   8590.000
GR     438.000   8600.000    436.000   8640.000    436.000   8810.000    438.000   8900.000    436.000   8975.000
GR     434.000   9220.000    436.000   9230.000    438.200   9670.000    436.000   9830.000    434.100   9860.000
GR     436.000   9880.000    438.000  10110.000    436.700  10190.000    438.000  10550.000    434.000  10600.000
GR     434.000  10660.000    433.000  10700.000    433.200  10760.000    432.000  11030.000    433.100  11110.000
GR     430.000  11430.000    431.600  11510.000    430.000  11720.000    432.000  11770.000    432.000  11850.000
GR     436.000  11870.000    438.000  11910.000    440.000  12025.000    446.000  12260.000    450.000  12580.000
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X1	117.300	30.000	8875.000	11725.000	940.000	1960.000	1345.000	.000	500.000	.000
X3	.000	.000	.000	.000	.000	11250.000	.000	.000	.000	.000
GR	456.200	8000.000	454.000	8040.000	450.000	8065.000	446.000	8075.000	442.700	8190.000
GR	444.000	8280.000	442.500	8640.000	444.000	8680.000	444.000	8865.000	442.000	8875.000
GR	438.000	8910.000	438.000	9100.000	440.000	9110.000	438.900	9280.000	440.700	9800.000
GR	438.000	10120.000	434.600	10900.000	436.000	11390.000	434.000	11500.000	440.000	11515.000
GR	442.000	11725.000	434.600	11900.000	435.400	11950.000	444.000	11990.000	448.000	12160.000
GR	450.000	12180.000	452.000	12275.000	456.000	12285.000	450.000	12375.000	450.000	12560.000

X1	121.400	48.000	8200.000	11210.000	800.000	700.000	410.000	.000	500.000	.000
X3	.000	.000	.000	.000	.000	11020.000	.000	.000	.000	.000
GR	454.000	7735.000	452.800	7770.000	454.000	7795.000	454.000	7830.000	452.000	7835.000
GR	450.500	7880.000	452.000	7915.000	454.000	7930.000	454.000	8045.000	456.200	8100.000
GR	454.000	8125.000	450.000	8140.000	446.000	8150.000	444.000	8185.000	442.000	8200.000
GR	440.000	8270.000	439.000	8620.000	440.000	8710.000	438.400	8840.000	440.000	8885.000
GR	441.300	9100.000	440.000	9850.000	441.000	10000.000	440.000	10195.000	438.000	10240.000
GR	436.000	10400.000	438.000	11145.000	434.000	11180.000	440.000	11195.000	444.000	11210.000
GR	444.000	11230.000	438.000	11245.000	432.400	11430.000	438.000	11480.000	444.000	11500.000
GR	444.000	11530.000	441.000	11540.000	444.000	11820.000	446.000	11890.000	448.000	11920.000
GR	450.000	11930.000	450.000	11945.000	446.000	11955.000	445.000	11980.000	448.000	12055.000
GR	450.000	12080.000	450.000	12405.000	452.200	12480.000	.000	.000	.000	.000

X1	130.600	29.000	8020.000	10785.000	930.000	1000.000	920.000	.000	500.000	.000
X3	.000	.000	.000	.000	.000	10550.000	.000	.000	.000	.000
GR	453.900	7660.000	454.000	7770.000	456.000	7820.000	452.000	7870.000	448.000	7955.000
GR	446.000	8020.000	444.000	8315.000	442.000	8390.000	440.200	8700.000	442.800	9360.000
GR	441.000	9460.000	442.700	9600.000	440.300	9795.000	440.000	10045.000	438.000	10080.000
GR	437.200	10250.000	438.000	10290.000	440.000	10300.000	440.000	10715.000	446.600	10785.000
GR	446.600	10810.000	443.000	10855.000	443.000	11230.000	446.000	11320.000	448.000	11345.000
GR	448.000	11425.000	446.500	11500.000	448.000	11930.000	450.000	11965.000	.000	.000

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X1	135.400	39.000	8445.000	10970.000	640.000	500.000	475.000	.000	500.000	.000
X3	.000	.000	.000	.000	.000	10700.000	.000	.000	.000	.000
GR	462.800	7465.000	462.000	7480.000	462.000	7520.000	460.000	7585.000	456.000	7625.000
GR	456.000	7740.000	462.700	7800.000	460.000	7825.000	458.000	7835.000	458.000	7880.000
GR	456.000	7890.000	456.000	7910.000	462.000	7955.000	462.700	7980.000	462.000	8015.000
GR	460.000	8025.000	452.000	8115.000	450.500	8170.000	452.000	8225.000	452.000	8380.000
GR	453.000	8400.000	450.000	8435.000	444.000	8445.000	444.000	8810.000	443.500	9320.000
GR	442.000	9440.000	438.000	9460.000	437.400	9510.000	438.000	9550.000	440.000	9560.000
GR	442.600	10470.000	445.000	10600.000	442.000	10710.000	442.500	10920.000	444.000	10970.000
GR	445.000	11000.000	444.000	11040.000	444.000	11460.000	450.000	12280.000	.000	.000

X1	151.400	34.000	9050.000	10940.000	1930.000	1370.000	1595.000	.000	500.000	.000
X3	.000	.000	.000	.000	.000	10960.000	.000	.000	.000	.000
GR	499.000	7710.000	464.000	7805.000	462.000	8140.000	460.000	8210.000	450.000	8290.000
GR	450.000	8350.000	452.000	8390.000	452.000	8420.000	448.000	8450.000	446.500	8570.000
GR	448.000	8950.000	444.000	9050.000	442.000	9070.000	442.000	9420.000	444.000	9510.000
GR	446.000	9990.000	448.000	9995.000	444.000	10010.000	442.500	10050.000	444.000	10095.000
GR	443.000	10150.000	444.000	10280.000	446.000	10290.000	446.000	10615.000	448.000	10940.000

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 GR    448.000  11190.000    444.500   11370.000     448.000   12000.000     447.900   12325.000
 GR    450.000  12640.000    452.000   12700.000     456.000   12750.000     458.000   12950.000

 X1    171.400     32.000   9500.000   11930.000    2240.000    1630.000    2000.000        .000     500.000
 X3       .000       .000       .000        .000        .000   11000.000        .000        .000        .000        .000
 GR    469.900   6800.000    462.000    7400.000     458.000    8250.000     456.000    8290.000     454.000    8390.000
 GR    454.000   8650.000    456.000    8775.000     457.200    8810.000     451.000    8920.000     451.000    9450.000
 GR    454.200   9500.000    454.000    9530.000     452.000    9540.000     450.100    9610.000     449.500   10000.000
 GR    448.000  10085.000    448.000   10730.000     450.000   10740.000     452.000   10770.000     453.000   10900.000
 GR    451.000  11300.000    452.000   11930.000     452.000   12100.000     447.000   12160.000     452.000   12460.000
 GR    449.000  12850.000    448.000   12900.000     450.000   12950.000     460.000   13035.000     464.000   13125.000
 GR    461.600  13530.000    462.500   13620.000        .000        .000        .000        .000        .000        .000

 X1    181.600     23.000   9630.000   11590.000    1025.000    1060.000    1020.000        .000     500.000        .000
 X3       .000       .000       .000    7070.000        .000   10940.000        .000        .000        .000        .000
 GR    468.000   7070.000    464.000    7235.000     454.000    8500.000     454.200    9630.000     452.000    9645.000
 GR    448.200  10900.000    450.000   10980.000     452.000   10990.000     454.000   11130.000     452.000   11140.000
 GR    452.000  11180.000    456.000   11300.000     452.000   11350.000     450.000   11360.000     450.000   11435.000
 GR    452.000  11440.000    452.200   11500.000     454.000   11590.000     454.000   12190.000     450.200   12350.000
 GR    454.200  12370.000    452.200   12540.000     454.000   12900.000        .000        .000        .000        .000
 EJ       .000       .000       .000        .000        .000        .000        .000        .000        .000        .000
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    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN      SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID     ENDST


 FLOW DISTRIBUTION FOR SECNO=     75.00          CWSEL=    933.98

 STA=    5630.    7080.    7100.    8730.    8935.   11225.
   PER Q=      2.9        .2      22.5       1.7      72.7
    AREA=   1783.5      59.6    6324.4     590.4   13492.0
     VEL=      1.6       2.8       3.4       2.8       5.1

 FLOW DISTRIBUTION FOR SECNO=     82.60          CWSEL=    935.08

 STA=    7070.    7400.    7440.    8930.   11455.
   PER Q=       .2        .2      16.2      83.4
    AREA=    178.3      83.2    4591.0   13837.1
     VEL=      1.1       2.6       3.4       5.7

 FLOW DISTRIBUTION FOR SECNO=     93.80          CWSEL=    936.96

 STA=    8583.   11880.
   PER Q=    100.0
    AREA=  18441.2
     VEL=      5.2

 FLOW DISTRIBUTION FOR SECNO=    103.90          CWSEL=    939.04
```

```
STA=    8597.   12025.
  PER Q=     100.0
   AREA=  13807.9
    VEL=       6.9

FLOW DISTRIBUTION FOR SECNO=     117.30          CWSEL=    943.41

STA=    8165.    8240.    8640.    8664.    8875.   11725.
  PER Q=        .0        .1        .0        .0     99.8
   AREA=      26.7     100.8      11.2       5.0  13511.1
    VEL=        .9       1.0       1.0       1.3      7.0

FLOW DISTRIBUTION FOR SECNO=     121.40          CWSEL=    944.61

STA=    8174.    8200.   11210.
  PER Q=        .1      99.9
   AREA=      27.4   14982.7
    VEL=       2.0       6.3

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


FLOW DISTRIBUTION FOR SECNO=     130.60          CWSEL=    946.85

STA=    7993.    8020.   10785.
  PER Q=        .0     100.0
   AREA=      11.6   14057.4
    VEL=        .9       6.8

FLOW DISTRIBUTION FOR SECNO=     135.40          CWSEL=    948.08

STA=    8438.    8445.   10970.
  PER Q=        .0     100.0
   AREA=      13.9   12690.2
    VEL=       2.7       7.5

FLOW DISTRIBUTION FOR SECNO=     151.40          CWSEL=    951.83

STA=    8275.    8290.    8350.    8387.    8450.    8570.    8950.    9050.   10940.   10960.
  PER Q=        .0        .2        .0        .1       2.1       6.5       2.6      88.3        .2
   AREA=      13.4     110.0      33.6      55.1     549.9    1741.4     583.3   13610.1      76.7
    VEL=       1.2       1.9       1.2       2.0       3.5       3.5       4.2       6.2       2.8

FLOW DISTRIBUTION FOR SECNO=     171.40          CWSEL=    955.90

STA=    8295.    8390.    8650.    8769.    8920.    9450.    9500.   11930.
  PER Q=        .2       1.5        .2        .8      14.8        .7      81.9
```

AREA=	90.4	494.5	113.0	213.1	2597.9	165.1	9480.4
VEL=	1.8	2.9	1.8	3.4	5.4	4.1	8.2

FLOW DISTRIBUTION FOR SECNO= 181.60 CWSEL= 958.45

STA=	7937.	8500.	9630.	11590.
PER Q=		2.9	17.9	79.1
AREA=		1250.7	4911.9	10947.3
VEL=		2.2	3.5	6.9

1

01-12-88 16:47:37

THIS RUN EXECUTED 01-12-88

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

LEVEED 100-YR SUB

SUMMARY PRINTOUT

SECNO	CWSEL	VLOB	VCH	VROB	QLOB	QCH	QROB	DEPTH	TOPWID	AREA	SSTA	ENDST
75.000	933.98	2.97	5.12	.00	25966.97	69033.04	.00	13.98	5582.52	22249.84	5630.00	11212.52
82.600	935.08	3.26	5.72	.00	15814.04	79185.97	.00	15.08	4323.51	18689.64	7070.22	11393.73
93.800	936.96	.00	5.15	.00	.00	95000.00	.00	10.66	3276.52	18441.24	8582.61	11859.13
103.900	939.04	.00	6.88	.00	.00	94999.99	.00	9.04	3372.57	13807.95	8597.39	11969.96
117.300	943.41	1.00	7.02	.00	144.29	94855.72	.00	8.81	2701.12	13654.92	8165.02	11250.00
121.400	944.61	2.04	6.34	.00	55.94	94944.06	.00	8.61	2845.69	15010.14	8174.31	11020.00
130.600	946.85	.94	6.76	.00	10.97	94989.03	.00	9.65	2557.47	14068.99	7992.53	10550.00
135.400	948.08	2.67	7.48	.00	37.07	94962.92	.00	10.68	2261.80	12704.04	8438.20	10700.00
151.400	951.83	3.54	6.16	2.80	10932.83	83852.46	214.71	9.83	2650.06	16773.40	8275.34	10960.00
171.400	955.90	4.69	8.21	.00	17213.61	77786.38	.00	7.90	2640.91	13154.38	8294.91	11000.00

REACH 9

REACH 8

181.600	958.45	3.22	6.87	.00	19825.78	75174.22	.00	10.25	3002.52	17109.81	7937.48	10940.00	

1
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LEVEED 100-YR SUB

SUMMARY PRINTOUT

SECNO	CWSEL	CRIWS	EG	HL	OLOSS	ELMIN	10K*S	K*CHSL	STCHL	STCHR	XLCH
75.000	933.98	.00	934.31	.00	.00	920.00	13.56	.00	8935.00	11225.00	.00
82.600	935.08	.00	935.53	1.18	.04	920.00	18.21	.00	8930.00	11455.00	760.00
93.800	936.96	.00	937.38	1.84	.00	926.30	14.71	5.62	8580.00	11880.00	1120.00
103.900	939.04	.00	939.78	2.31	.10	930.00	40.11	3.66	8590.00	12025.00	1010.00
117.300	943.41	.00	944.17	4.39	.01	934.60	27.05	3.42	8875.00	11725.00	1345.00
121.400	944.61	.00	945.23	1.05	.01	936.00	24.11	3.41	8200.00	11210.00	410.00
130.600	946.85	.00	947.55	2.30	.03	937.20	25.83	1.30	8020.00	10785.00	920.00
135.400	948.08	.00	948.95	1.34	.05	937.40	31.15	.42	8445.00	10970.00	475.00
151.400	951.83	.00	952.38	3.40	.03	942.00	15.15	2.88	9050.00	10940.00	1595.00
171.400	955.90	.00	956.82	4.33	.11	948.00	32.07	3.00	9500.00	11930.00	2000.00
181.600	958.45	.00	959.06	2.21	.03	948.20	15.57	.20	9630.00	11590.00	1020.00

REACH 9

REACH 8

1
01-12-88 16:47:37

SUMMARY OF ERRORS AND SPECIAL NOTES

1
01-12-88 16:47:54

THIS RUN EXECUTED 01-12-88

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HEC2 RELEASE DATED NOV 76 UPDATED MAY 1984

APPENDIX C

sla
SIMONS, LI & ASSOCIATES, INC.

CLIENT: BROWN & CALDWELL
PROJECT: AVONDALE INTERCEPTOR
DETAIL: SCOUR CALC.
JOB NO. BC-04
DATE CHECKED: 1-15-88
CHECKED BY: MEZ

DATE: 1-13-88
COMPUTED BY: RLS.

SCOUR COMPUTATIONS

I. GENERAL SCOUR DEPTH:

NOTE: THE GENERAL SCOUR DEPTH (G_S) AS DETERMINED IN REFERENCE 1 WAS LESS THAN 0.5 FEET. THE COMPUTED DEPTH IS VALID FOR THIS STUDY. HOWEVER, A MINIMUM OF ONE FOOT WILL BE USED AND A SAFETY FACTOR (S_f) OF 1.5 WILL BE APPLIED. THEREFORE,

$$G_S = S_f\,(1.0\,ft) = 1.5\,ft$$

II ANTIDUNE SCOUR DEPTH:

$$A_S = S_f\left(\frac{h_a}{2}\right) = S_f\left(\frac{0.0274V^2}{2}\right) = 0.0137\,S_f\,V^2$$

WHERE: A_S = ANTIDUNE SCOUR DEPTH, IN ft
h_a = ANTIDUNE HEIGHT, IN ft
V = AVE. CHANNEL VELOCITY, IN fps.
S_f = SAFETY FACTOR

FOR: $V = 6.90$ fps
$S_f = 1.5$

THEN: $A_S = 0.65\,S_f$ OR 0.98 ft

III DEPTH OF LOW-FLOW THALWEG

NOTE: BASED ON FIELD INVESTIGATIONS, THE AVERAGE DEPTH OF THE LOW-FLOW THALWEG (L_f) WAS DETERMINED TO BE 2.0 ft. HOWEVER, A SAFETY FACTOR OF 1.5 WILL BE APPLIED. THEREFORE,

$$L_f = S_f\,(2.0\,ft) = 3.0\,ft$$

IV LOCAL SCOUR DEPTH:

$$L_s = S_f \left[N_c Y \left(\frac{b_p}{Y} \right)^{0.65} F_R^{\,0.43} \right]$$

WHERE: L_s = LOCAL SCOUR DEPTH, IN ft
S_f = SAFETY FACTOR
N_c = PIER SHAPE COEFFICIENT
Y = DEPTH OF FLOW, IN ft
b_p = PIER OR BLOCKAGE WIDTH, IN ft
F_R = FROUDE NUMBER

FOR: S_f = 1.5
N_c = 2.0 (CIRCULAR CYLINDERS)
Y = 9.44 ft
b_p = 9.0 ft (5.0 ft PIER DIAMETER + 4.0 ft FOR DEBRIS ACCUMULATION)
F_R = 0.52

THEN: $L_s = S_f$ (13.82 ft) = 20.73 ft

V TOTAL DEPTH OF SCOUR (Y_s), IN FEET:

$$Y_s = 1.5\,(G_s + A_s + L_f) + L_s^{*}$$

* IF APPLICABLE

Y_s (INCLUDING L_s) = 28.93 ft

Y_s (EXCLUDING L_s) = 8.22 ft

VI LATERAL EXTENT OF LOCAL SCOUR (ZONE OF INFLUENCE):

$$Z = 3Y_s + 10\ ft$$

WHERE: Z = LATERAL EXTENT FROM PIER OR PILE, IN ft
Y_s = TOTAL SCOUR DEPTH, INCLUDING LOCAL SCOUR COMPONENT

FOR: $Y_s = 28.93$ ft

THEN: $Z = 96.79$ ft

NOTE: SINCE THE LOCATION OF THE PROPOSED INTERCEPTOR IS APPROXIMATELY 240 ft UPSTREAM OF THE CLOSEST TRANSMISSION TOWER (TOWER #109). THE LOCAL SCOUR COMPONENT MAY BE ELMINATED. THEREFORE, THE TOTAL SCOUR DEPTH IS 8.22 FT