POTENTIAL MINE PLANS FOR BARKLEY-ESTES PROPERTY
WITHIN AGUA FRIA BETWEEN INDIAN SCHOOL & CAMELBACK RDS.

SUMMARY REPORT

DEVELOPMENT OF POTENTIAL MINE PLANS FOR THE BARKLEY-ESTES PROPERTY WITHIN THE AGUA FRIA RIVER BETWEEN INDIAN SCHOOL ROAD AND CAMELBACK ROAD

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SUMMARY REPORT

DEVELOPMENT OF POTENTIAL MINE PLANS FOR THE BARKLEY-ESTES PROPERTY WITHIN THE AGUA FRIA RIVER BETWEEN INDIAN SCHOOL ROAD AND CAMELBACK ROAD

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Flood Control District of Maricopa County

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Date signed 10/22/93
ARIZONA, U.S.A.

October 22, 1993

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I. INTRODUCTION

1.1 Authorization and Scope

Simons, Li & Associates, Inc. (SLA), was retained by the Flood Control District of Maricopa County (FCD) to review a mine plan previously developed by ACCELS/Keegan Consulting Engineers for the Barkley-Estes property within the Agua Fria River. SLA was directed to use the previously developed plan as a base, and to modify the plan or develop improvements deemed necessary to mitigate potential channel stability impacts associated with the plan.

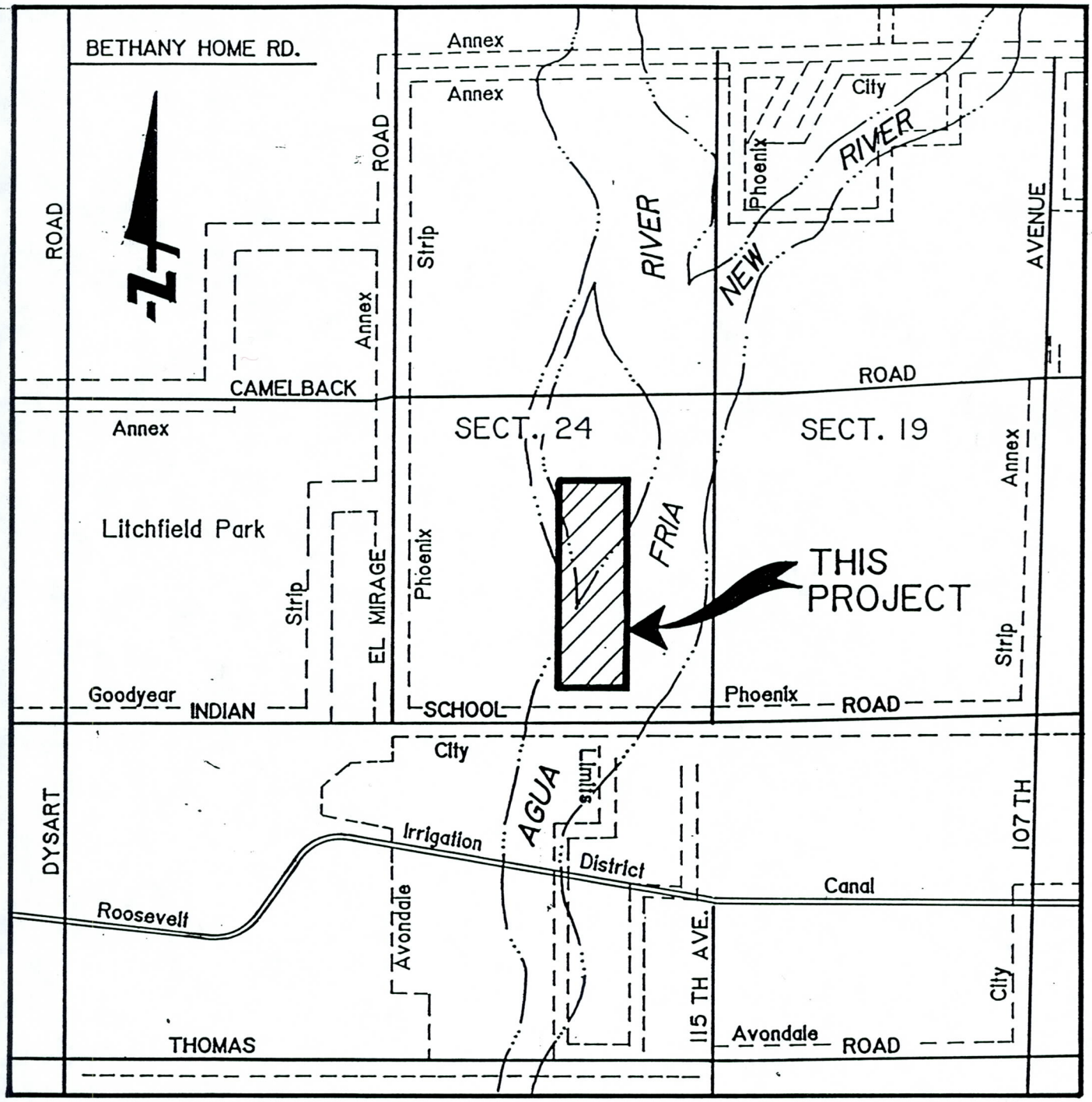
This report presents the results of SLA's review and analyses. A modified in-channel mining plan is presented. In addition, two options are presented for a proposed off-channel pit. The estimated potential channel stability effects associated with the modified plans are presented and discussed.

1.2 Study Reach

The Barkley-Estes (B-E) property is located within the 100-year floodplain of the Agua Fria River, between the Camelback Road and Indian School Road crossings (see **Figure 1**). The property directly east of the B-E site is owned by the Johnson-Stewart-Johnson (JSJ) Mining Company, and the original plan for the subject site was proposed as an expansion of the previously permitted (December 1987) JSJ operation.

1.3 Data Base

The channel geometry information used for this study was provided by FCD. The most recent floodplain-floodway work map for the local vicinity (1"=400', 4-foot contour interval) and the 1989 HEC-2 floodway deck for the Agua Fria River were used as a basis for the hydraulic and sediment transport analyses presented herein. Hydrologic and sediment size information was obtained from SLA's 1983 report entitled, "Hydraulic and Geomorphic Analysis of the Agua Fria River."



LOCATION MAP

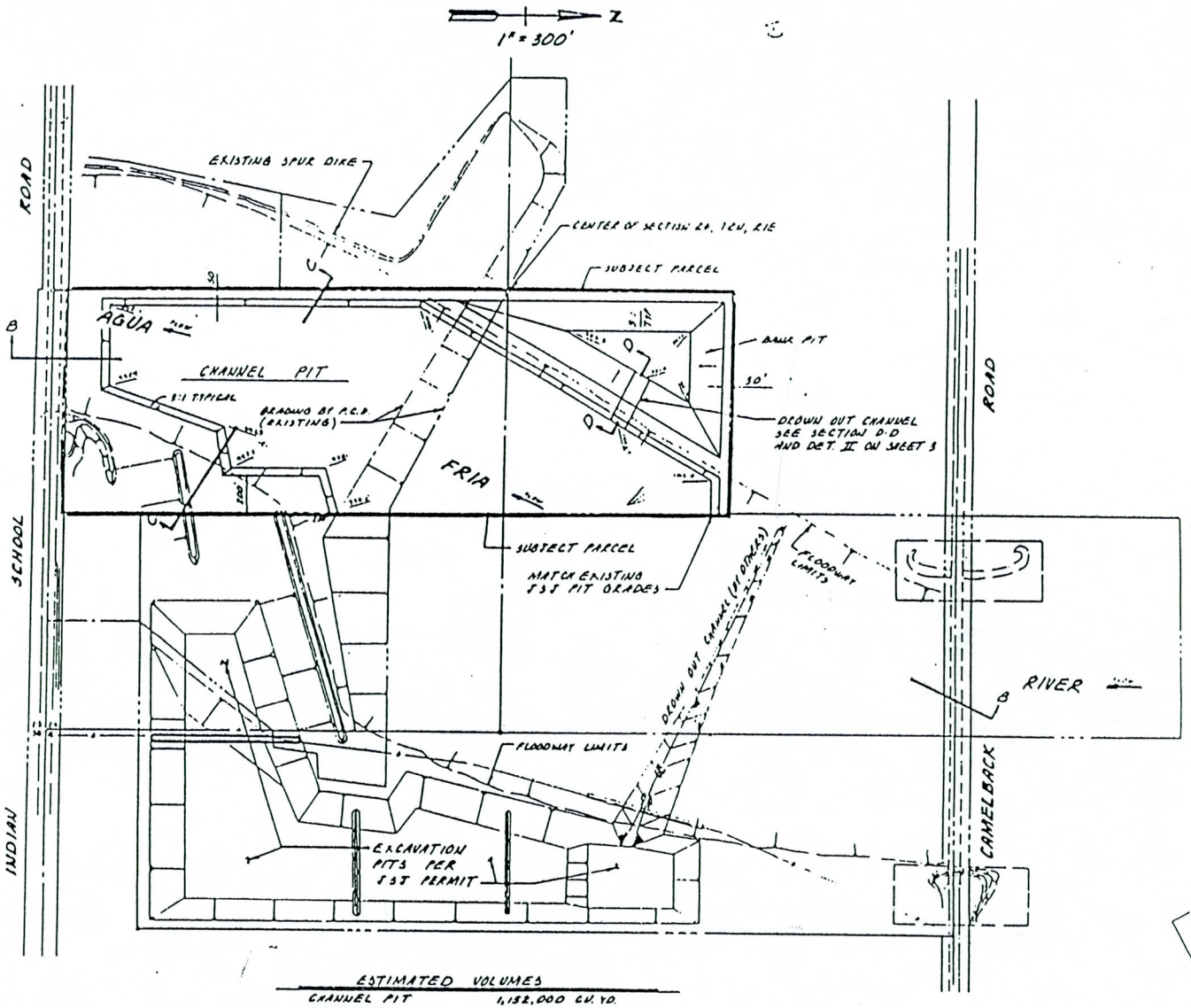
N.T.S.

Figure 1

II. ORIGINAL MINE PLAN

A plan view of the original mine plan for the subject site is presented in Figure 2. The following description is taken from the ACCELS/Keegan narrative report submitted with the original mine plan:

> "The proposed Channel Pit mining operation consists of a shallow pit beginning at the east property line of the subject parcel, connecting the Phase I excavation of the JSJ permit and extends downstream to 200 feet upstream from the Indian School Road right-of-way line, or 275 feet from the monument line of the Indian School Road. The west boundary parallels the west floodway limits as defined by the Army Corps of Engineers, (COE) 1984 ... The east boundary follows the east line of the subject parcel to a point 200 feet from the existing FCD dikes. It maintains a minimum 200 feet separation from the dikes."
>
> "The proposed Bank Pit mining operation consists of a 60 foot pit beginning approximately 2,200 feet north of Indian School Road. The pit boundaries follow the limits of the subject parcel and the west floodway limit line to form a large, right triangle, and maintains a minimum 50-feet set back from each."
>
> "The Channel Pit will be 10-feet deep from a grade line connecting the Camelback Road Bridge and Indian School Road Bridge."
>
> "The Bank Pit will be separated from the Channel Pit by a dike of insitu material, 100 feet wide at the top with 3:1 side slopes. This pit will be excavated to a depth of 60 feet. It will be connected to the Channel Pit via a drown-out channel. This channel will allow controlled filling of the Bank Pit, reducing the possibility of a destructive failure of the channel side slopes."
>
> "Assuming a regular channel bed and constant slope, these pits will yield 1,152,000 cubic yards (Channel Pit), 1,001,000 cubic yards (Bank Pit) and 15,000 cubic yards (Drown-out channel) for a total of 2,167,000 cubic yards of aggregate."



ESTIMATED VOLUMES	
CHANNEL PIT	1,152,000 CU. YD.
BANK PIT	1,001,000 CU. YD.
DROWN OUT CHANNEL	15,000 CU. YD.
	2,168,000 CU. YD.

Figure 2

III. MODIFIED MINE PLAN

3.1 Channel Pit

SLA performed several studies of the Agua Fria River in the mid 1980's. Portions of the bank protection and invert stabilization project that exists along the Agua Fria River were designed by SLA.

The channel improvement structures immediately downstream of the proposed B-E mining site were designed using the concept of dynamic equilibrium slope. The channel structures were designed considering the sediment supply characteristics under "existing" conditions, estimated using the channel geometry data base that was available at the time of the project. The structures were designed using a somewhat short-term outlook, with the understanding that, if future changes to the upstream reaches were to occur, additional grade control measures could be added.

The previous SLA reports indicate that significant river bed armoring has occurred within the Agua Fria River between Bethany Home Road (approx. 1 mile upstream of Camelback Road) and Waddell Dam. The armoring condition was expected to continue to grow in the downstream direction, due to cut off in sediment supply in the upstream watershed. Armoring reduces the amount of sediment the river carries during floods, which reduces supply to downstream reaches and increases scour potential.

Even without mining occurring in the immediately upstream reaches, the trend identified in the previous reports was for sediment supply to decrease, which would necessitate the addition of grade stabilization measures in the channelized portion of the Agua Fria River. Mining within the reach immediately upstream of the Indian School Road will further decrease this supply, resulting in an acceleration of the sediment deficit trend predicted for the downstream reaches.

The top elevation of the grade control structure below the Indian School Road bridge is 1000.0 feet. The in-stream mining plan which was originally proposed will extend approximately 5 feet below this elevation, causing a depression within the river upstream of the bridge. This depression will trap sediment, reducing downstream sediment supply, and increasing the potential for downstream scour. A slight alteration of this plan, which would limit the excavation depth to elevation 1000 feet or greater, would smoothly daylight the mining area with the channel downstream, reducing to some degree the sediment trapping effect. This modified plan will also reduce the potential flow redistribution effect that may be associated with the plan as originally presented -- the one-side excavation of the channel near the Indian School Road bridge could potentially concentrate flood flows along one side of the bridge, increasing the likelihood of bridge undermining or failure.

The proposed plan modification will reduce the potential mining volume for the Channel Pit to an estimated 780,000 cubic yards. Plan and sectional views of the proposed channel pit are presented in the accompanying oversize sheets.

3.2 Bank Pit Concerns and Options

A drown-out channel has been proposed as part of the original plan which will connect the Channel Pit to the Bank Pit, allowing the Bank Pit to safely fill after the water surface elevation in the Channel Pit reaches a certain level, and prior to the arrival of the 100-year flood peak. However, the drown-out channel and the berm separating the Channel and Bank pits are composed of erodible materials. Upstream and downstream reaches along the river in the vicinity of the Bank Pit are also unlined and erodible. Therefore, the drown-out channel will only increase -- not guarantee -- the likelihood of the filling of the bank pit occurring at a desired location.

There are numerous potential locations for flow entry into the Bank Pit, and headcutting upstream of any entry point would be expected. Thus, unless an adequately armored berm is provided to surround the proposed bank pit, headcutting erosion has the potential to occur at any location around the perimeter of the pit.

SLA's PIT model was applied to the proposed Bank Pit configuration to estimate the amount of headcutting that would occur as the pit began filling due to an unexpected breach. Several scenarios were analyzed, considering various breaching modes, depths and widths. The maximum predicted immediate headcut is expected to occur considering a 10-ft wide breach of the levee proposed between the in-channel and off-channel pits. The headcut which will occur under these conditions could potentially travel approximately 382 feet upstream prior to the pit being drowned out. The headcut distances associated with other pit depths were also estimated, and the results are summarized below:

Table 1
Estimated Headcut Distance for Various Pit Depths

Pit Depth feet	Estimated Headcut Distance feet
60	382
50	243
40	222
30	216
20	174
10	124

The above results were used to evaluate an optimum configuration for the Bank Pit, under the condition that a setback equivalent to the estimated headcut distance would be required along the northern and western boundaries of the Bank Pit. The resulting volume vs. pit depth relationship is presented in **Figure 3**. As indicated in this figure, a 40-foot deep pit will provide nearly optimum use of the proposed Bank Pit area under these setback conditions. The volume of material associated with this alternative pit configuration is approximately 370,000 cubic yards.

In summary, two options are available for treatment of the Bank Pit area. The first option would follow that originally presented: a 60-foot deep pit with 50-

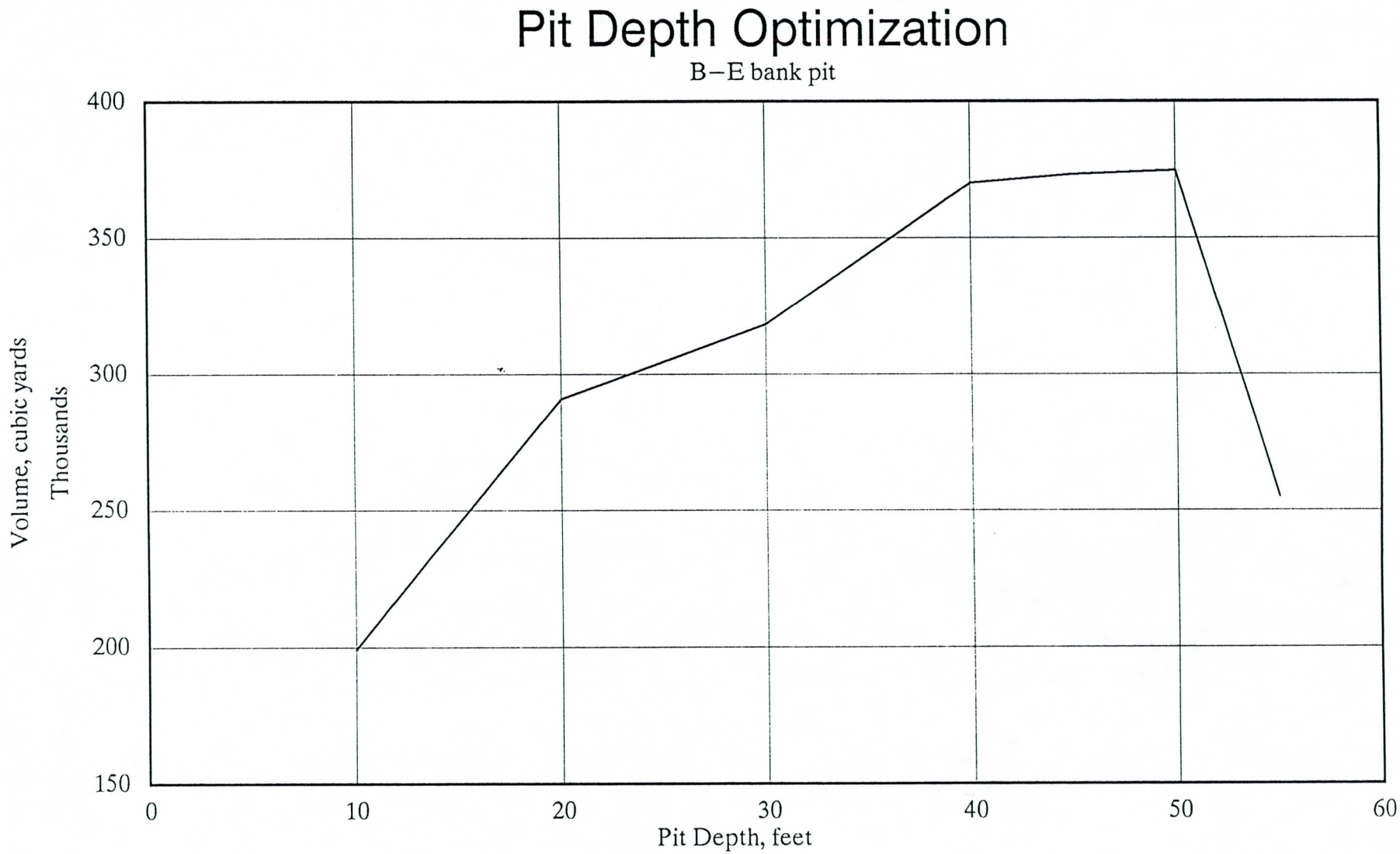

Pit Depth Optimization
B–E bank pit
Volume, cubic yards
Thousands
400
350
300
250
200
150
0
10
20
30
40
50
60
Pit Depth, feet

Figure 3

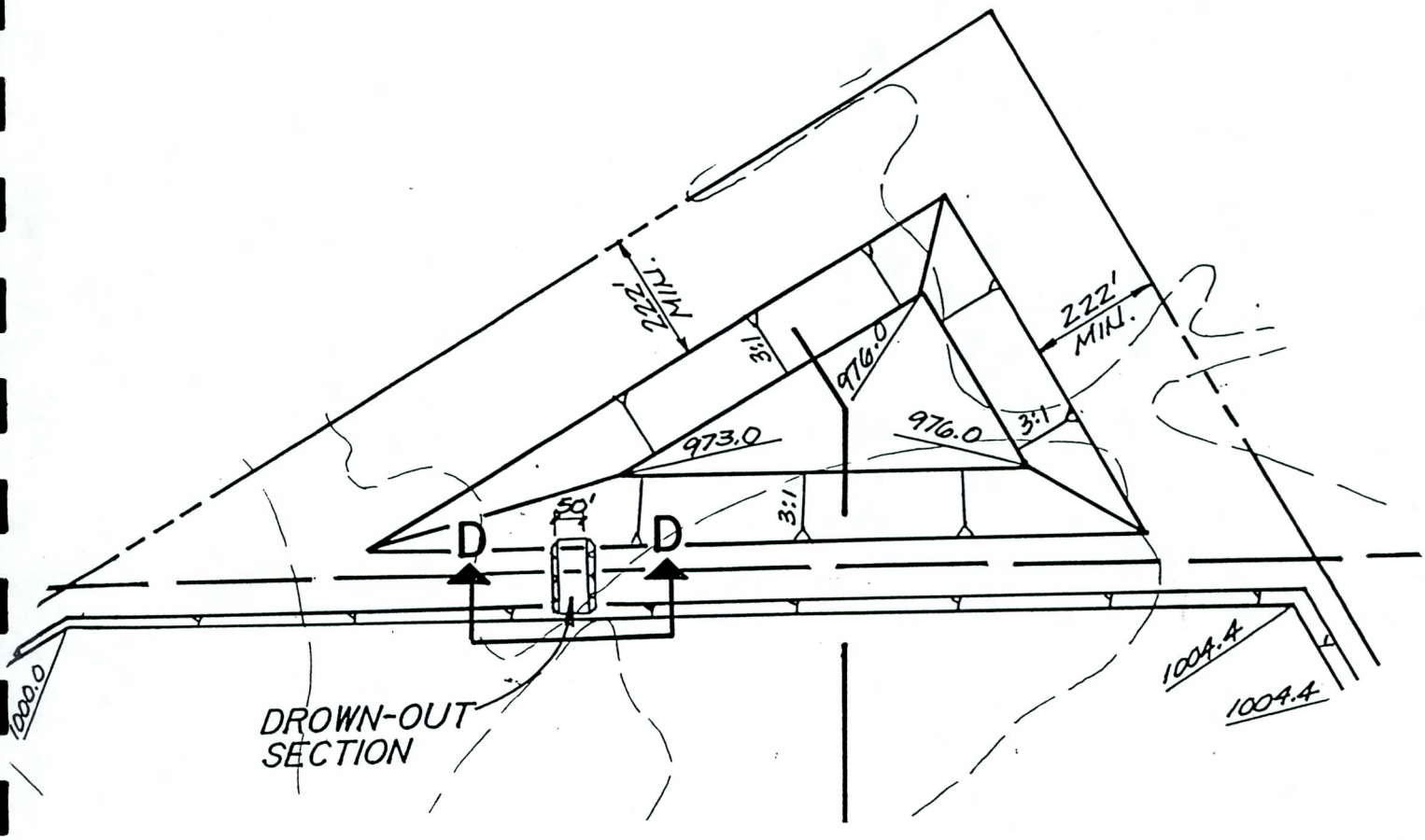
foot setbacks along the northern and western boundaries. This first option would require acquisition of erosion easements or agreements along the potentially affected boundaries in case the drown-out channel did not work as intended. The second option would provide additional setback around the northern and western boundaries of the Bank Pit, to allow room for potential uncontrolled headcut development on site. The optimum configuration under this option would be a 40-foot deep pit with 222-foot setbacks. The pertinent characteristics associated with each of these options is summarized below:

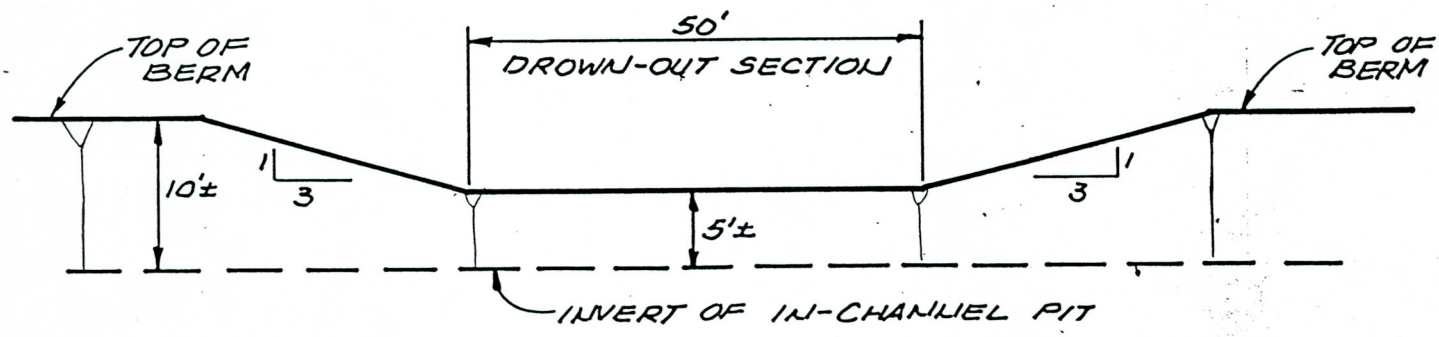
Table 2
Mining Option Characteristics and Volumes

Option	Bank Pit Depth feet	Bank Pit Setback feet	Bank Pit Volume cubic yards	Channel + Bank Pit Volume cubic yards
A	60	50	1,038,000	1,818,000
B	40	222	370,000	1,150,000

Under either option, it is recommended that the 100-foot wide erosion buffer be maintained between the Channel and Bank Pits. Additionally, it is suggested that the drown-out section be composed of a half-height section of the typical berm, as shown in **Figure 4**. This revised configuration will provide a greater degree of integrity to the Channel Pit - Bank Pit barrier during frequent low flow events, without decreasing its intended performance during events when the height of the drown out section is exceeded by the water surface.

Plan and sectional views of the proposed Channel Pit and Option A and Option B bank pits are provided in the accompanying oversized sheets.





SECTION D-D

N.T.S.

Figure 4

IV. PREDICTED CHANNEL STABILITY IMPACTS

Potential channel stability impacts associated with the modified mining plan were investigated through use of the QUASED quasi-unsteady sediment transport model. The Agua Fria River HEC-2 deck provided by FCD was modified to conform to several mining scenarios. These data were incorporated into the QUASED model, and the expected impacts to the river channel and local structures during the passage of a single design flood event were determined.

The scenarios analyzed included:

1. JSJ mining only -- adopted as the baseline condition.
2. Scenario 1 with the modified B-E mining plan added (Channel Pit only).
3. Scenario 2 with the proposed 60-ft deep Bank Pit captured by the river.
4. Scenario 2 with the optional 40-ft deep Bank Pit captured by the river.

Each of these scenarios were analyzed considering two different design flood events: (1) the currently adopted 100-year flood hydrograph (local peak discharge = 95,000 cfs); and, (2) a reduced 100-year event, with a local peak discharge of 75,000 cfs (a high estimate of the new 100-year discharge for the local reach, which has been reduced due the completion of Waddell Dam). The flood hydrographs considered are illustrated in **Figure 5**.

4.1 Potential Impacts Considering Currently Adopted Hydrology

Profile views of the Agua Fria River between the Thomas Road drop structure and the New River confluence, pre- and post-100-year flood, under baseline conditions (JSJ mining only) are presented in **Figure 6**. (Note that this profile presents results from consideration of the in-channel mining only.) A similar figure for the recommended in-channel mining plan is presented in **Figure 7**. It may be noted that under each of these conditions, the area of the JSJ operation fills during the passage of the flood hydrograph, while the channel reach immediately upstream of the JSJ operation degrades. **Figure 8** compares the post-flood channel invert profiles for each of these mining scenarios with the invert profile taken from the 1989 HEC-2 data. This figure indicates that the channel changes expected at each of the local bridges is very similar under each of these analysis conditions.

Additional QUASED runs were performed to evaluate the potential impact expected to occur if the river were to capture the Bank Pit during the course of the flood event. The results of this analysis, considering both the Option A and Option B Bank Pits, are presented in **Figure 9**. Under both conditions, the Bank Pit is expected to fill if captured, with little additional impact expected up- or downstream of the mining site.

The predicted variations in channel invert elevation at the location of the Camelback Road and Indian School Road bridges throughout the passage of the 100-year flood under each analysis condition are presented in **Figures 10 and 11**. (It should be noted that the figures indicate changes due to general scour only -- some additional scour due to the pier effects is also expected at these locations, but these local scour effects are not considered in the QUASED model.) Note that, at Camelback Road, the total amount of general scour and the variation with time changes very little with the analysis condition considered. Apparently, the processes occurring at this location are dominated by the effect

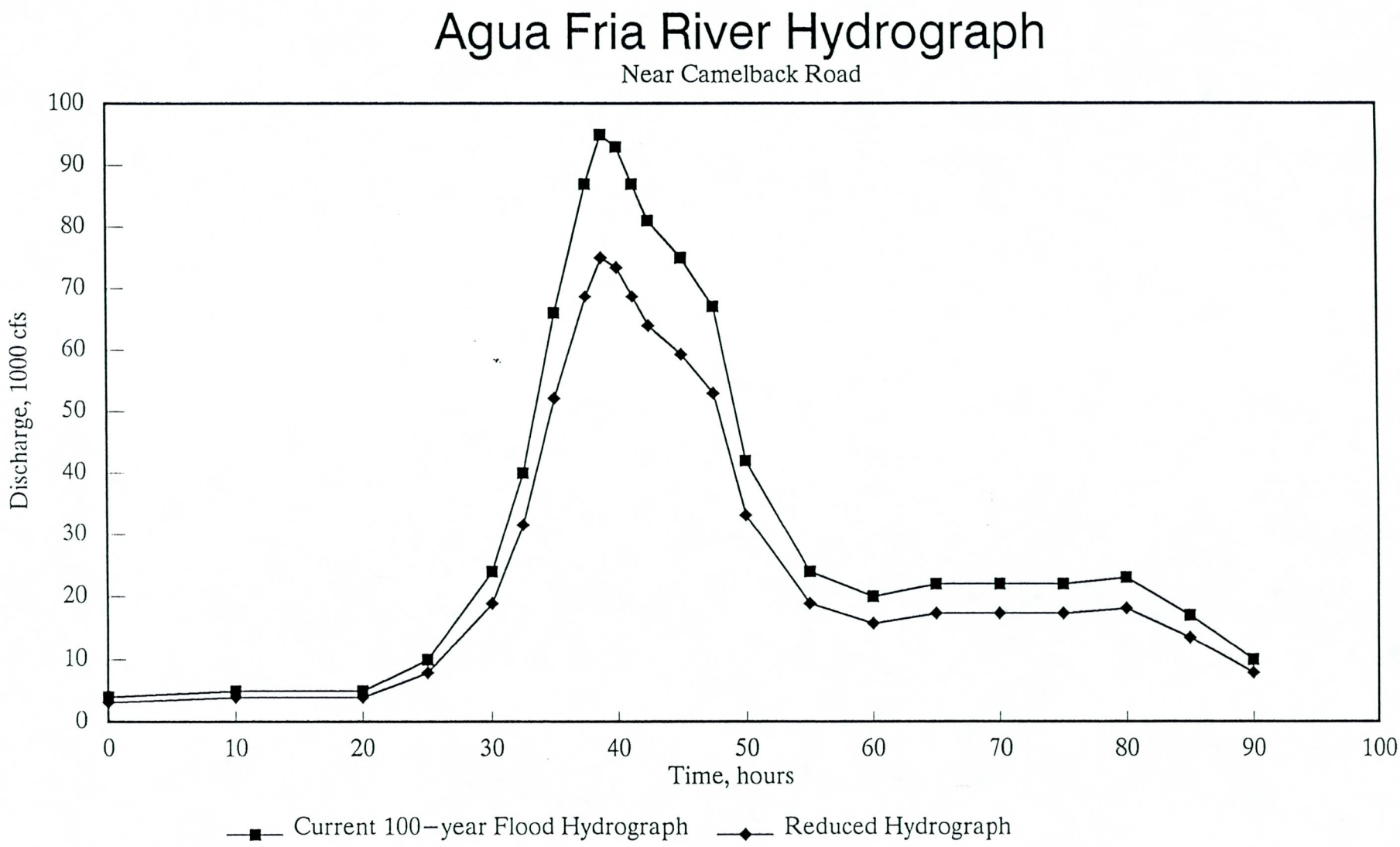
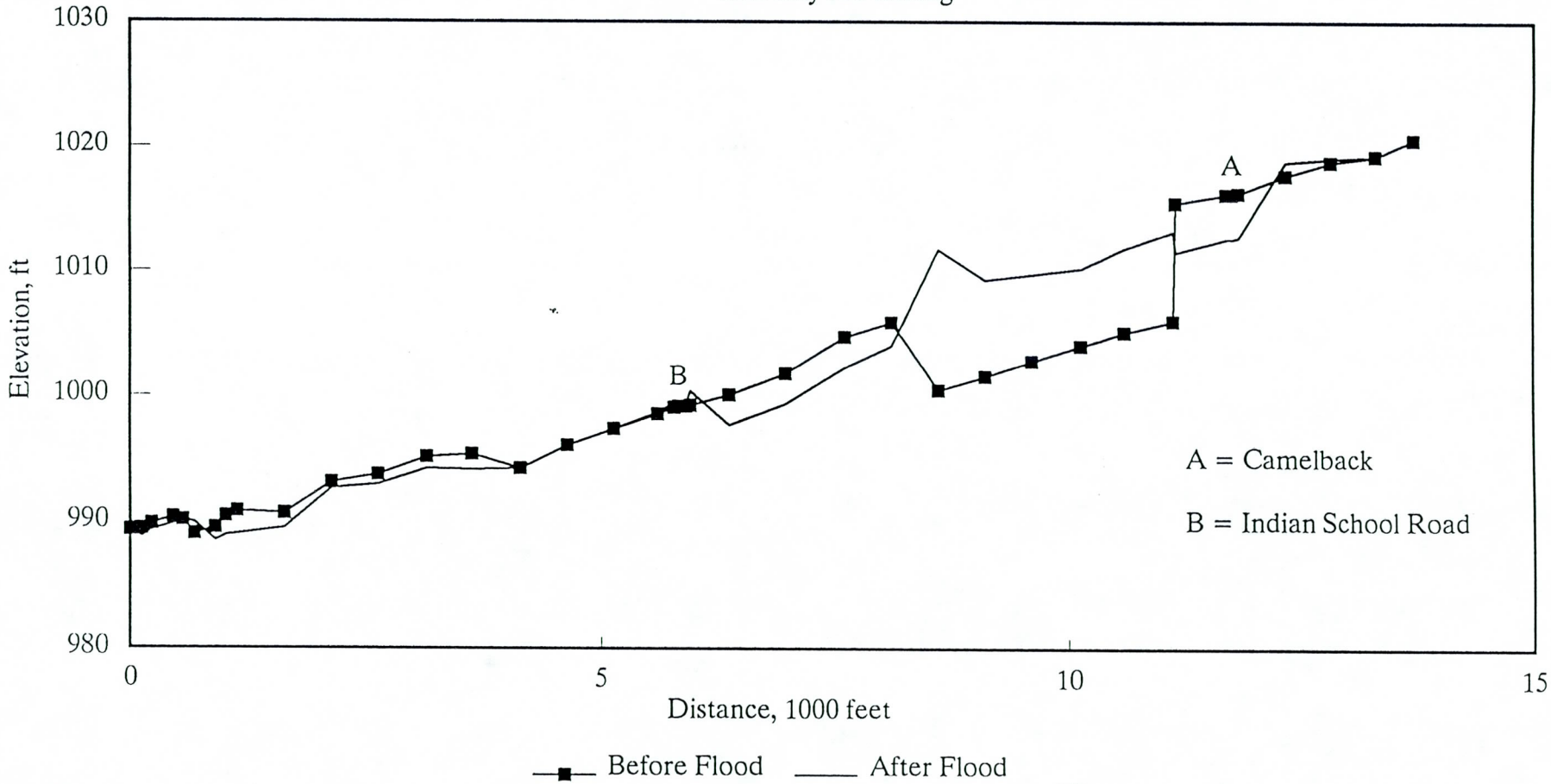

Agua Fria River Hydrograph
Near Camelback Road
Discharge, 1000 cfs
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
Time, hours
Current 100-year Flood Hydrograph
Reduced Hydrograph

Figure 5

Agua Fria River Profiles

with only JSJ mining

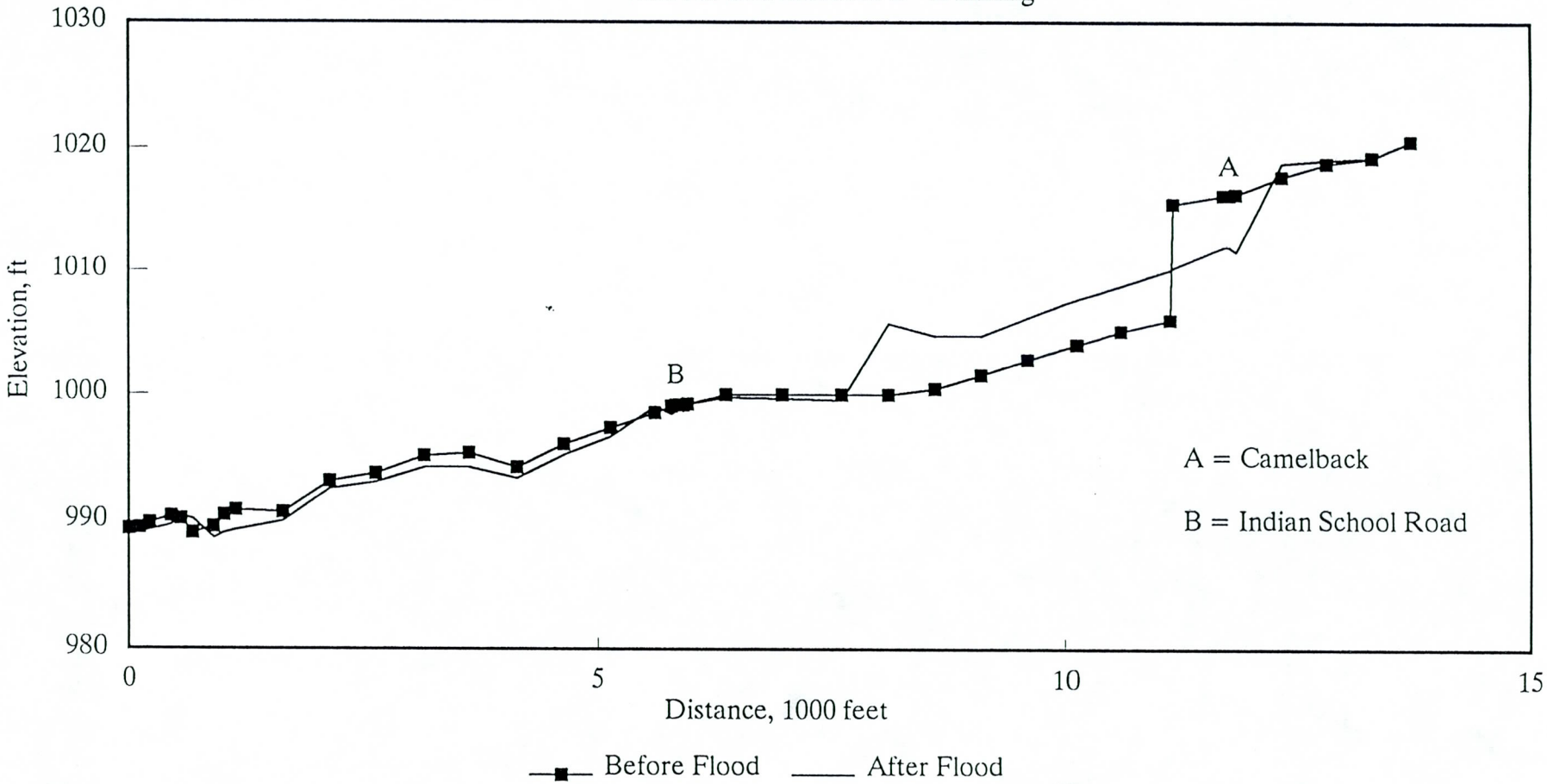


100–year flood peak = 95,000 cfs, SIDE PITS NOT CONSIDERED
Distance is measured from the Thomas Road drop structure

Figure 6

Agua Fria River Profiles

with JSJ and modified B–E mining

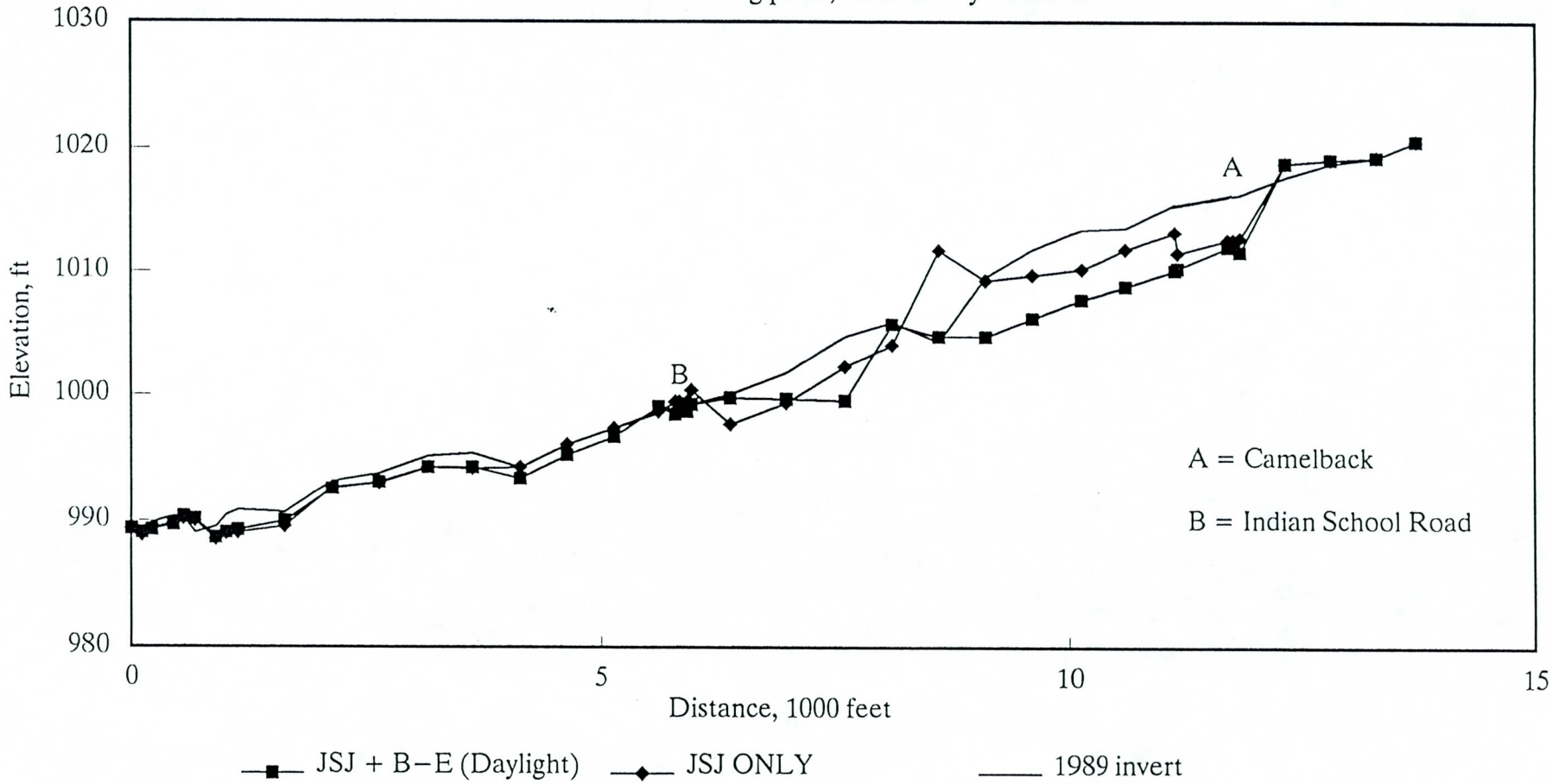


100–year flood peak = 95,000 cfs, SIDE PITS NOT CONSIDERED.
Distance is measured from the Thomas Road drop structure

Figure 7

Agua Fria River Profiles

Various mining plans, after 100–year flood



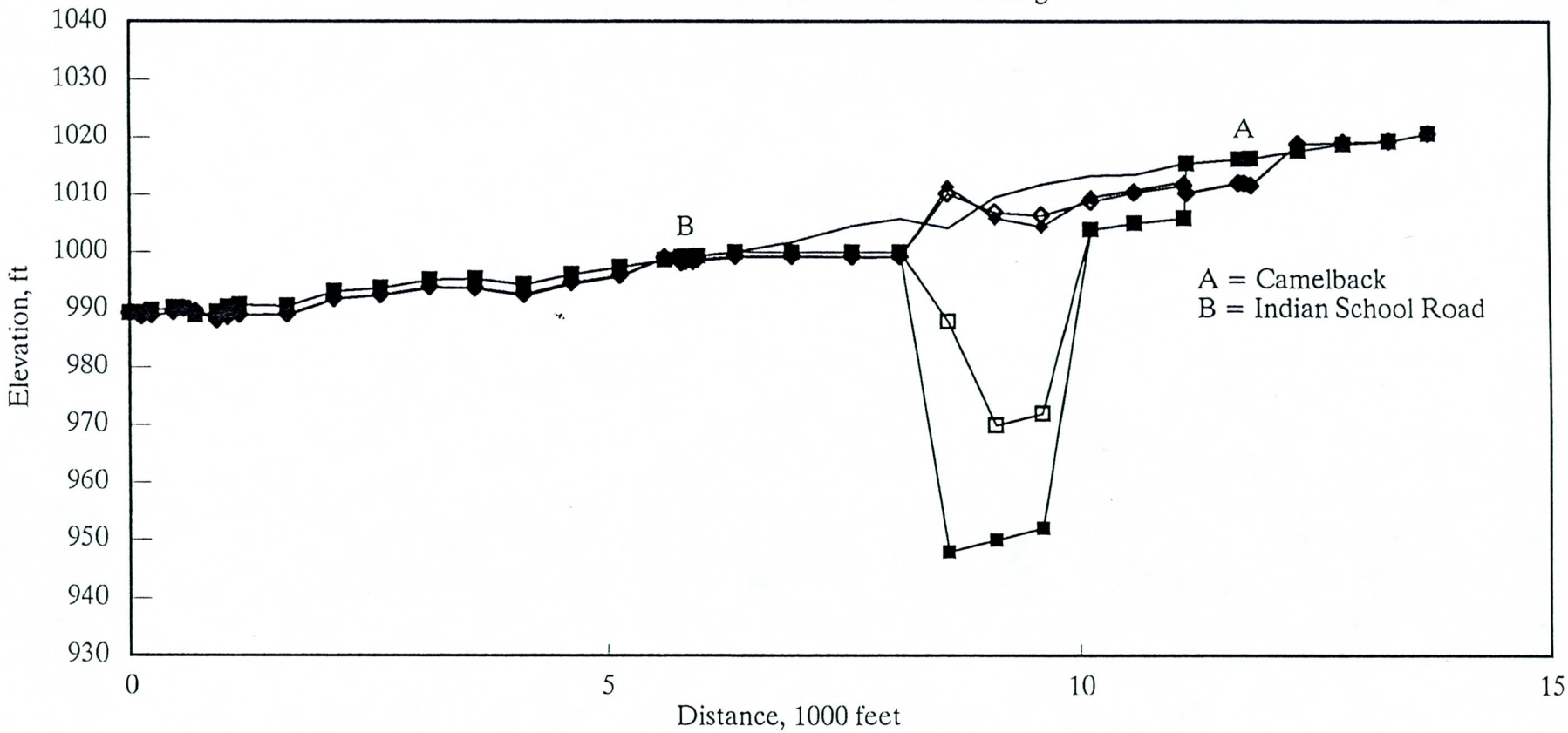
100–year flood peak = 95,000 cfs

Distance is measured from the Thomas Road drop structure

Figure 8

Agua Fria River Profiles

with JSJ and modified B–E mining



Option A — Option A (end) — Option B — Option B (end) — 1989 invert

100–year flood peak = 95,000 cfs

Distance is measured from the Thomas Road drop structure

Figure 9

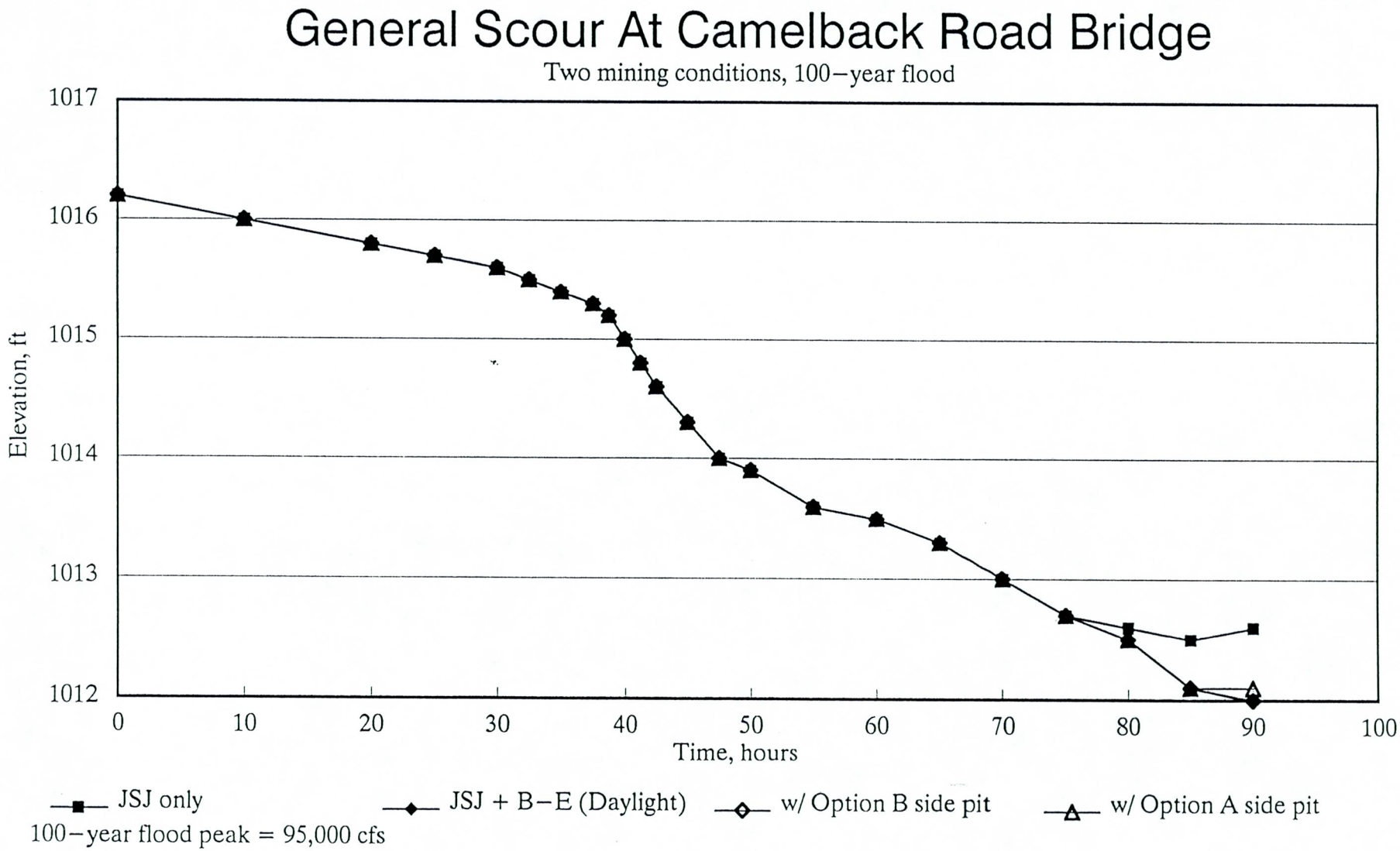
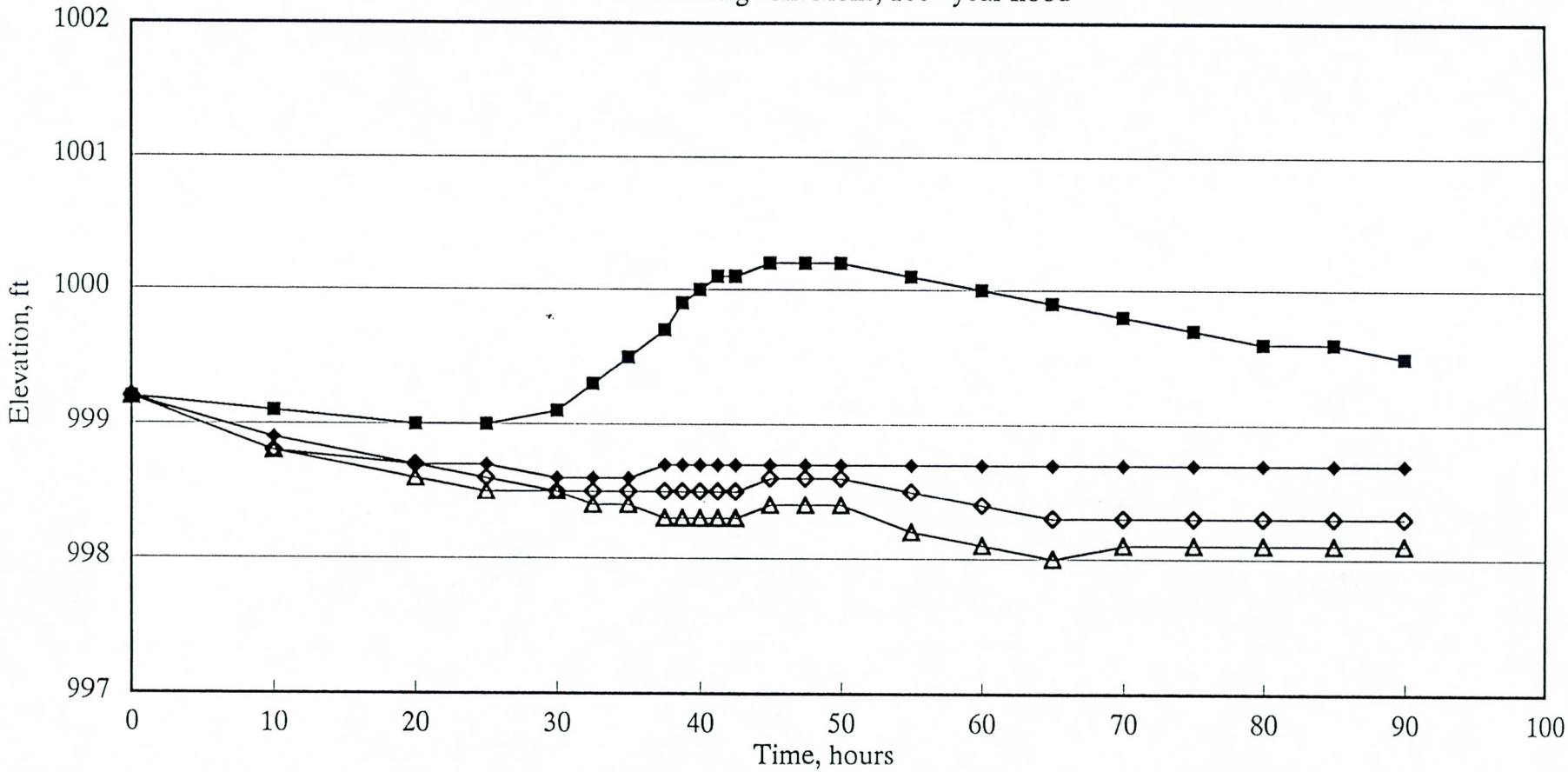

General Scour At Camelback Road Bridge
Two mining conditions, 100−year flood
Elevation, ft
1017
1016
1015
1014
1013
1012
0
10
20
30
40
50
60
70
80
90
100
Time, hours
JSJ only
JSJ + B−E (Daylight)
w/ Option B side pit
w/ Option A side pit
100−year flood peak = 95,000 cfs

Figure 10

General Scour At Indian School Road Bridge

Two mining conditions, 100−year flood



JSJ only

JSJ + B−E (Daylight)

w/ Option B side pit

w/ Option A side pit

100−year flood peak = 95,000 cfs

Figure 11

of the JSJ operation. Only at the tail end of the hydrograph is any difference noted between the cases. The JSJ-only (baseline) case begins to recover slightly, as the pit downstream returns to an equilibrium level. The other cases considered entail more extensive mining than this baseline condition, and thus, take longer to achieve a "filled" condition.

At Indian School Road, more variation is noted between scenarios, with increased scour potential expected with increased mining activity. The total potential genreal scour depth at this location is within approximately one foot, however, for all conditions considered.

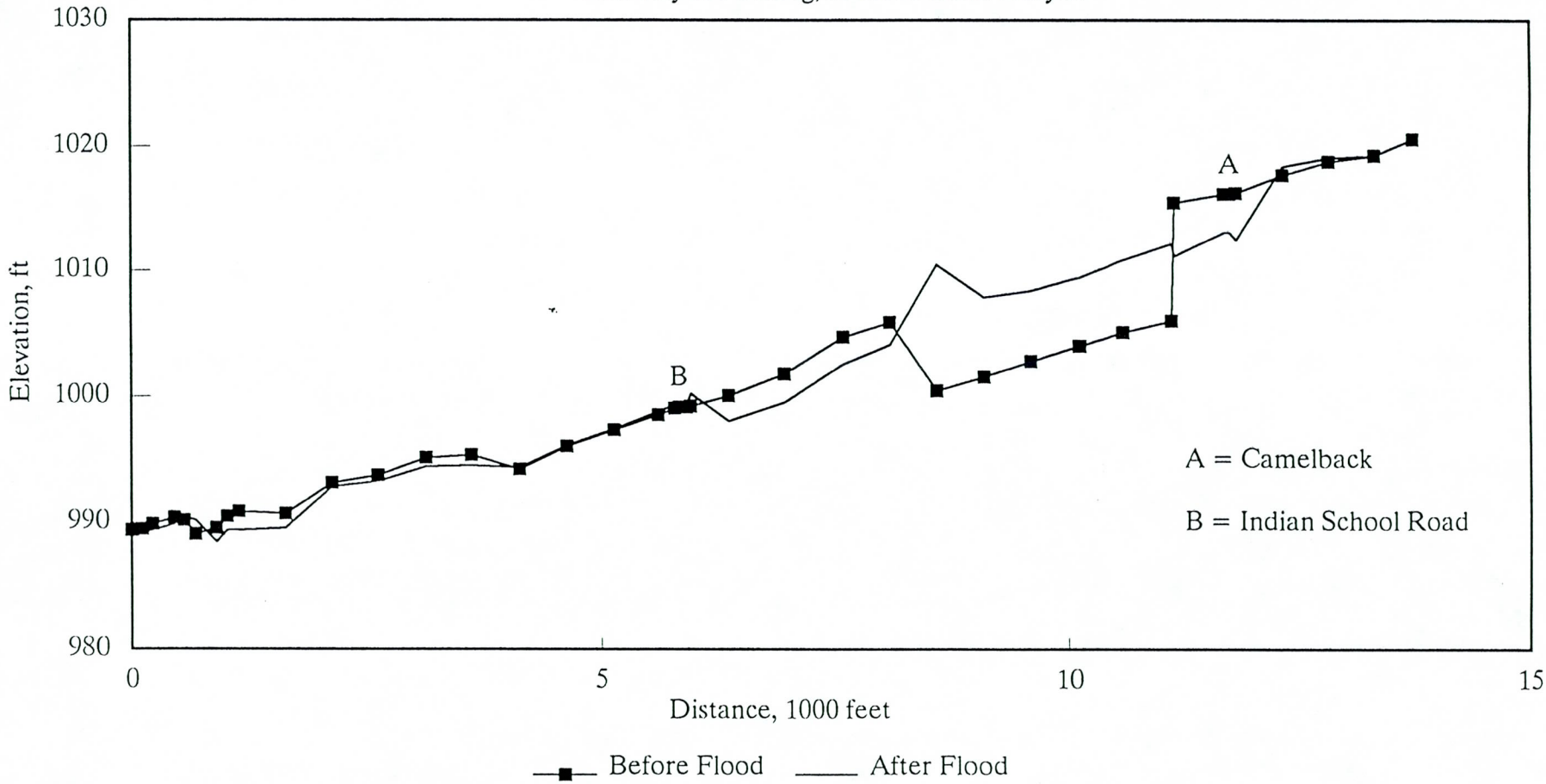
The QUASED analysis indicates that the channel stability impacts associated with the proposed mining within the B-E property are relatively minor.

4.2 Potential Impacts Considering Reduced Hydrology

The results of the QUASED analysis using the reduced hydrology provide results very similar to those discussed above, with slightly smaller magnitudes of channel changes indicated (as is to be expected with a flood of lesser peak and volume). The results of the reduced discharge analyses are presented in **Figures 12 through 17**. One result of note is indicated in Figure 16 -- at Camelback Road, the anticipated changes in channel invert elevation are practically identical for each mining condition considered. Apparently, the reduced discharge event is not of sufficient magnitude to cause the initiation of recovery within the reaches upstream of the mining area, under any of the conditions considered.

Agua Fria River Profiles

with only JSJ mining, reduced flood analysis

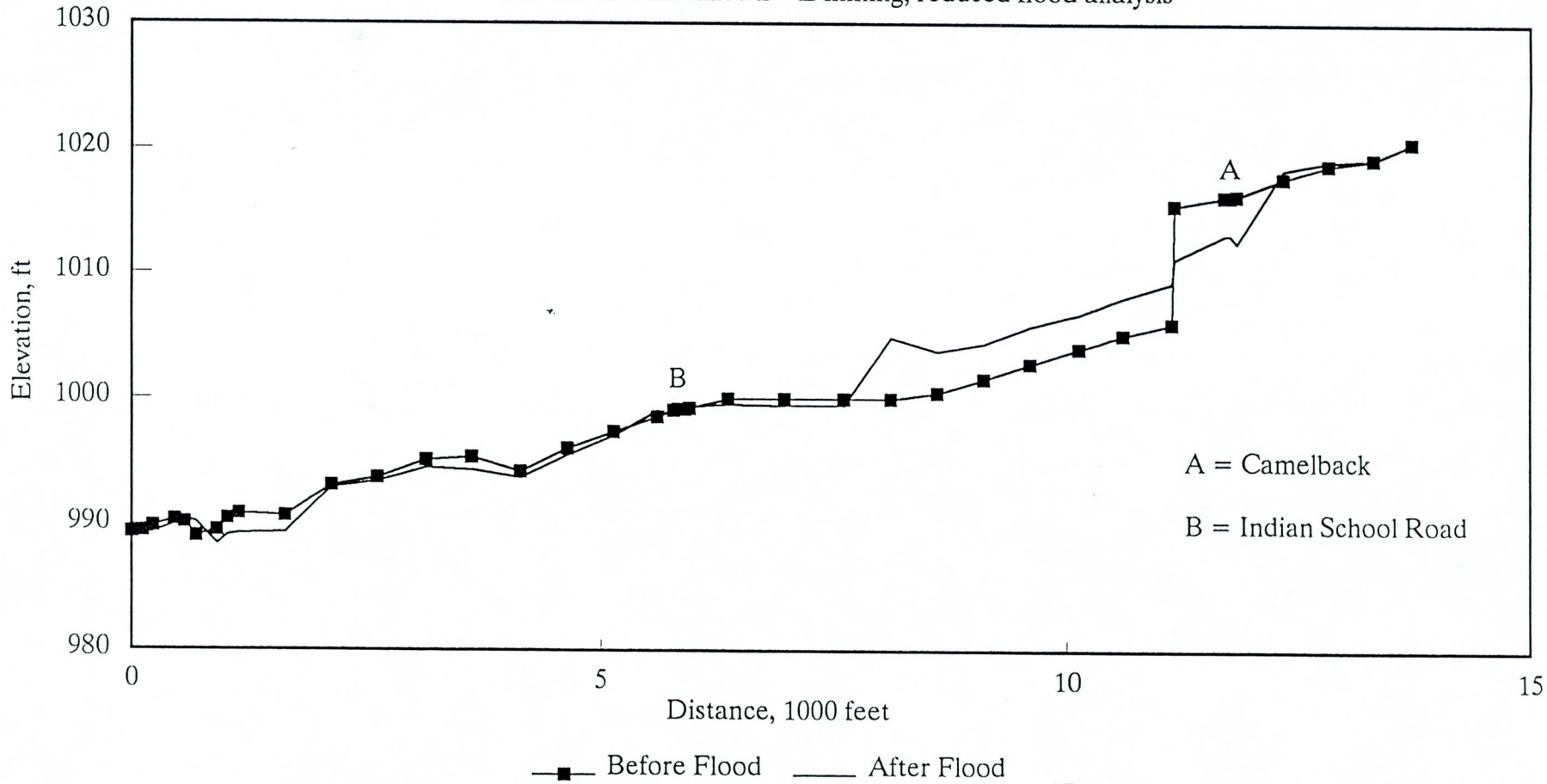


100–year flood peak = 75,000 cfs, no side pits considered
Distance is measured from the Thomas Road drop structure

Figure 12

Agua Fria River Profiles

with JSJ and modified B–E mining, reduced flood analysis

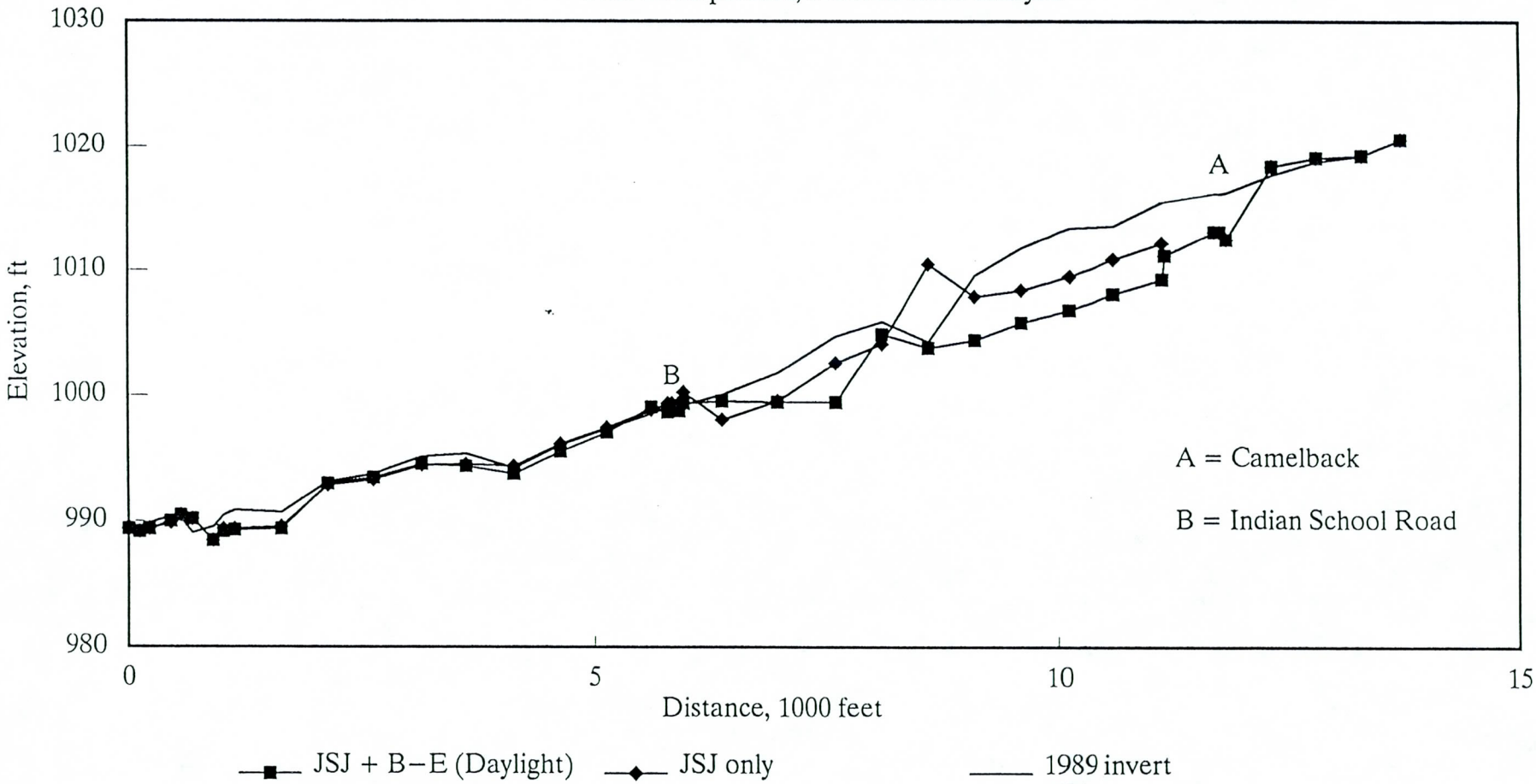


100–year flood peak = 75,000 cfs, side pit not considered
Distance is measured from the Thomas Road drop structure

Figure 13

Agua Fria River Profiles

Post flood profiles, reduced flood analysis

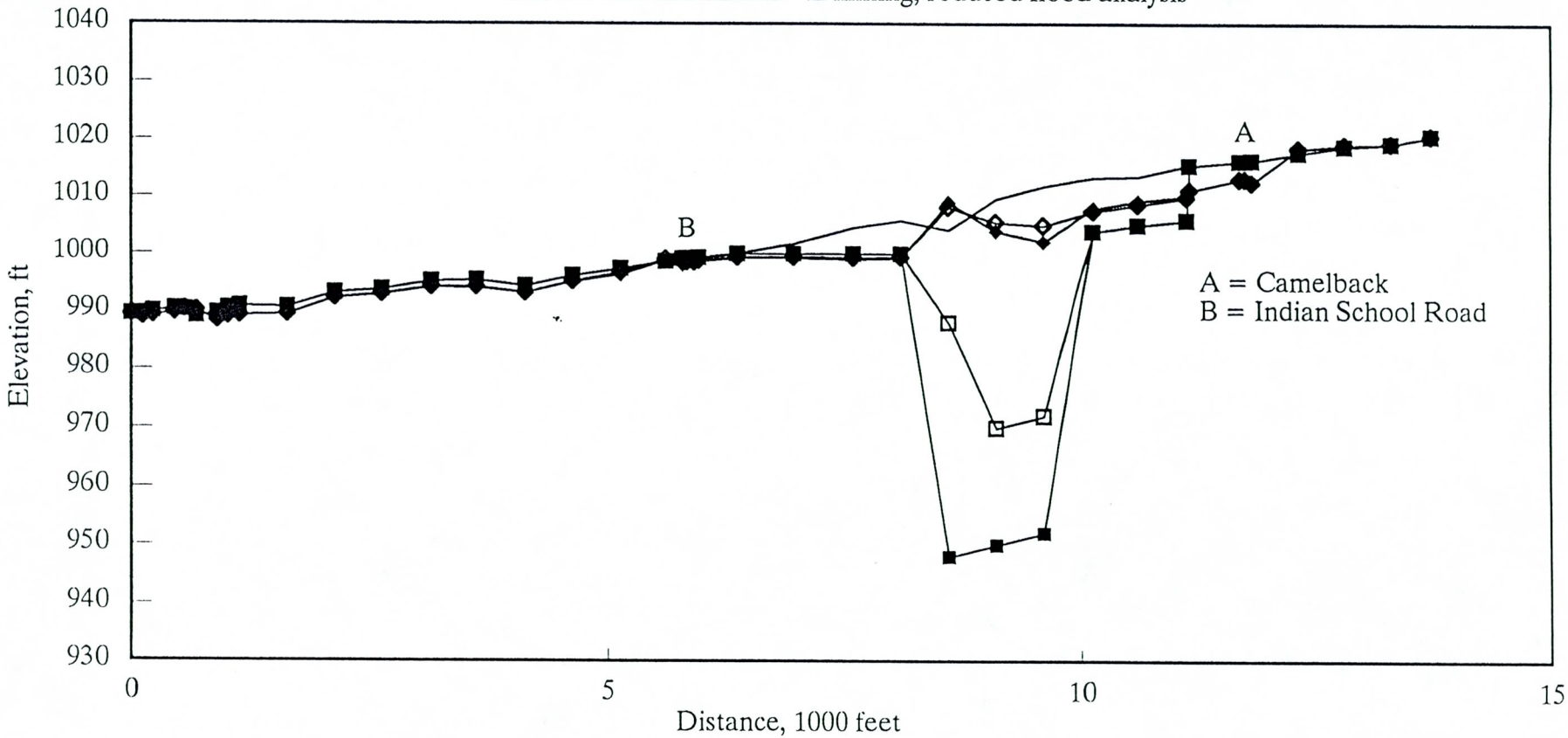


100–year flood peak = 75,000 cfs, no side pits considered
Distance is measured from the Thomas Road drop structure

Figure 14

Agua Fria River Profiles

with JSJ and modified B–E mining, reduced flood analysis



Option A — Option A (end) — Option B — Option B (end) — 1989 invert

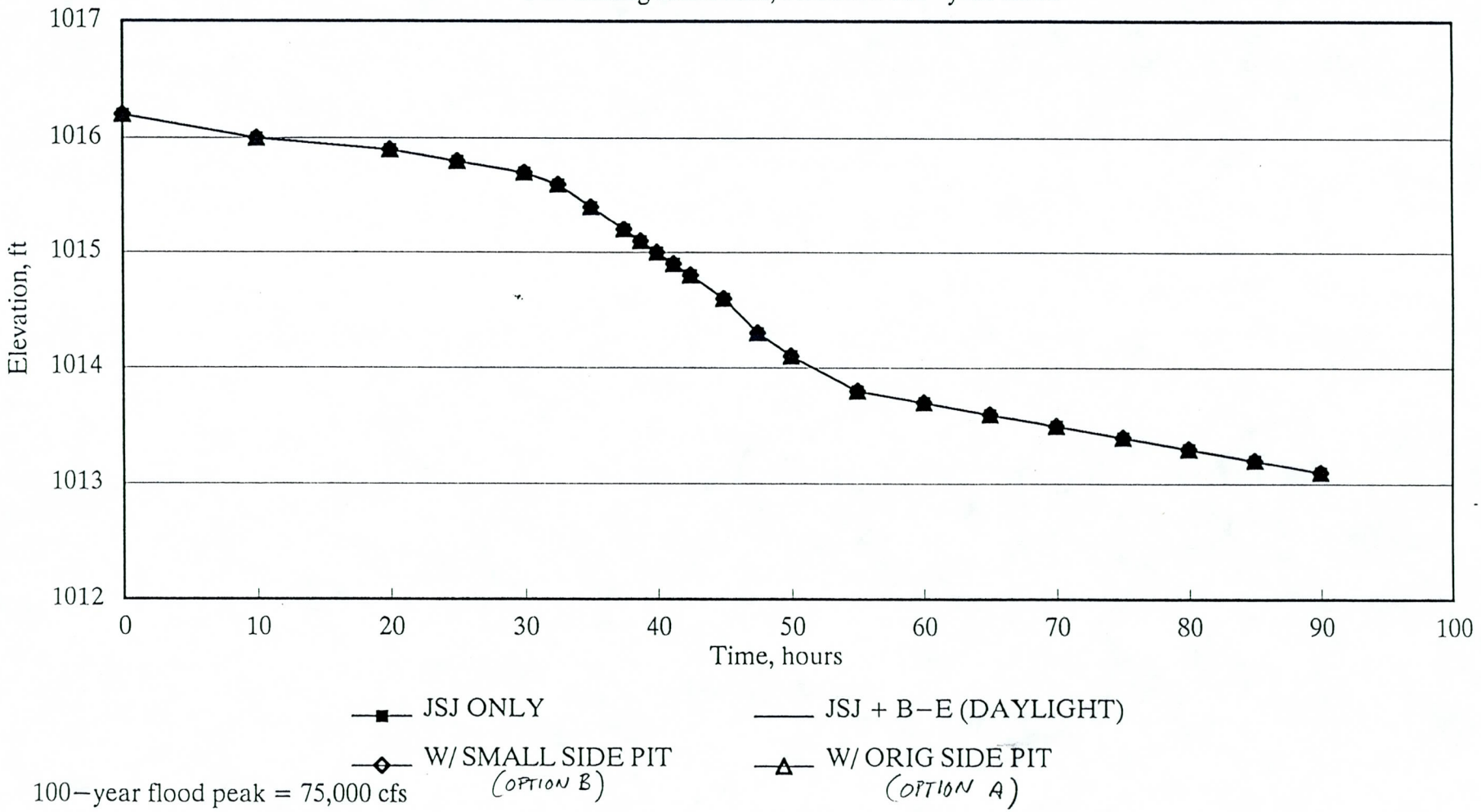
100–year flood peak = 75,000 cfs

Distance is measured from the Thomas Road drop structure

Figure 15

General Scour At Camelback Road Bridge

Two mining conditions, Reduced 100−year flood

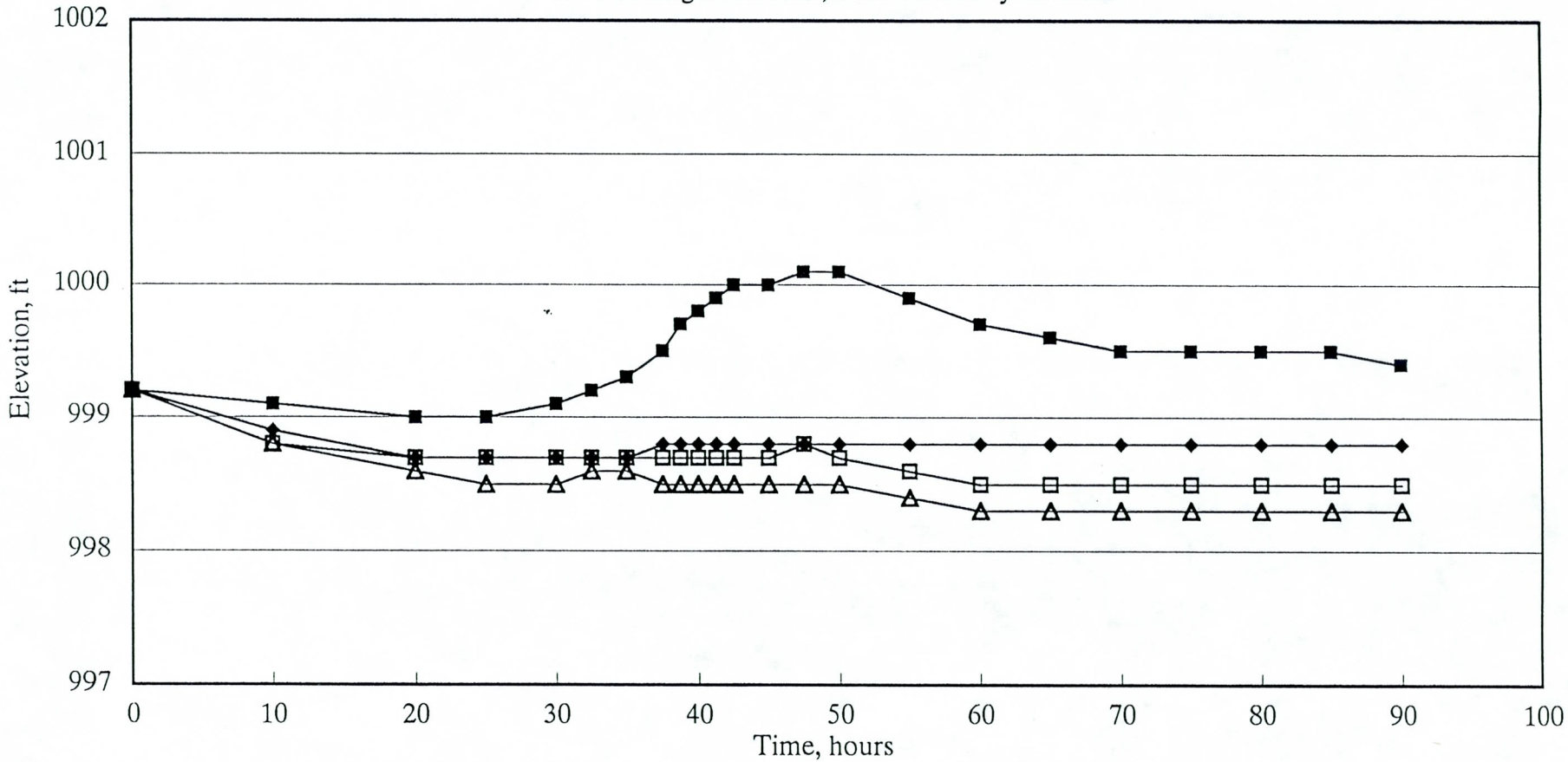


100−year flood peak = 75,000 cfs

Figure 16

General Scour At Indian School Road Bridge

Two mining conditions, reduced 100−year flood



JSJ only — JSJ + B−E (Daylight) — w/ Option B side pit — w/ Option A side pit

100−year flood peak = 75,000 cfs;

Figure 17