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HYDRAULIC ANALYSIS, SEDIMENT TRANSPORT ANALYSIS, AND DEVELOPMENT OF BANK PROTECTION ALTERNATIVES FOR THE SALT RIVER NEAR THE TRI-CITY AND CENTER STREET LANDFILLS

sla

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HYDRAULIC ANALYSIS, SEDIMENT TRANSPORT ANALYSIS, AND DEVELOPMENT OF BANK PROTECTION ALTERNATIVES FOR THE SALT RIVER NEAR THE TRI-CITY AND CENTER STREET LANDFILLS

Submitted to:

Salt River Pima-Maricopa Indian Community
Route 1, P.O. Box 216
Scottsdale, Arizona 85256

Submitted by:

Simons, Li & Associates, Inc.
4600 South Mill Avenue - Suite 200
Tempe, Arizona 85282

May 10, 1993

sla Simons, Li & Associates, Inc.
Water Resources & Civil Engineering Consultants

May 10, 1993

Mr. Bryan D. Meyers, P.E.
Civil Engineer
Salt River Pima-Maricopa Indian Community
Route 1, Box 216
Scottsdale, Arizona 85256

RE: DRAFT REPORT - HYDRAULIC ANALYSIS, SEDIMENT TRANSPORT ANALYSIS, AND DEVELOPMENT OF BANK PROTECTION ALTERNATIVES

Dear Bryan:

Enclosed with this letter are twelve copies of our draft summary report, "Hydraulic Analysis, Sediment Transport Analysis, and Development of Bank Protection Alternatives for the Salt River near the Tri-City and Center Street Landfills." This report has been prepared for presentation and discussion at our May 10, 1993 coordination meeting.

If you have any questions or need any additional information regarding this report, please feel free to contact me.

Sincerely,

SIMONS, LI & ASSOCIATES, INC.

Dennis L. Richards

Dennis L. Richards, P.E.
Vice President

Enclosures

4600 South Mill Avenue, Suite 200 • Tempe, AZ 85282 • Phone: (602) 491-1393 • Fax: (602) 491-1396
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Summary Report

Hydraulic Analysis, Sediment Transport Analysis, and Development of Bank Protection Alternatives for the Salt River near the Tri-City and Center Street Landfills

May 10, 1993

The Tri-City and Center Street landfills are positioned along opposite banks of the Salt River, in the reach between the Horne Road and County Club Drive crossings. **Figure 1** shows the position of these landfill sites in relation to the most recent estimate of the 100-year floodplain, the current low flow channel alignment, and the ultimate channelization alignment previously presented by BRW.

The floodplain limits shown in Figure 1 were determined using a HEC-2 deck developed from 1992 topographic information for the immediate study reach (Horne to Country Club), incorporated within a previously developed HEC-2 deck which used 1986 topographic maps for generation of the cross-sectional descriptions. **Figure 2** illustrates the cross-sections used in the hydraulic analysis, and indicates the reach breakdown that will be used throughout this report for reference to various portions of the study reach.

Four sets of topographic maps were used to evaluate the changes that have occurred along the study reach in recent history: (1) USGS quadrangle maps, developed from photographs taken in 1951; (2) FEMA floodplain maps which utilize 1982 topography; (3) 1986 topographic maps, supplied by ADOT; and, (4) the 1992 topographic maps supplied by the County. The channel low point profiles along the study reach associated with each of these surveys are compared in **Figure 3.** The channel profile has dropped since 1951, due perhaps to the effects of in-stream mining and upstream regulation. Reach 10 has experienced significant scour in recent years, while the in-stream pits in Reaches 7, 8 and 9 have apparently filled.

The hydraulic characteristics of the study reach were analyzed over a range of flood conditions, including the 2-, 5-, 10-, 25-, 50-, and 100-year floods. The peak discharge associated with each of these events is shown in **Figure 4. Figures 5, 6 and 7** illustrate the variation in the channel velocity, flow depth, and flow width, respectively, along the study channel, for the 100-year and 10-year events. Maximum velocities are located within Reaches 9 and 10 under both flood events. The computed flow depths show less variation except downstream of Country Club Drive (another mining area). The flow width shows wide variation from reach to reach, with maximum widths occurring upstream of Horne Road (Reaches 11 and 12) and minimum widths near the locations of the crossings (Reaches 5-6, and Reach 10).

A qualitative indicator of the sediment transport capacity of a given river section is given by the product of the width and the velocity to the third power. **Figure 8** illustrates the variation in this parameter along the study channel under both 100-year and 10-year conditions. Maximum sediment transport capacity

is indicated within Reaches 9 and 10, while the upstream and downstream reaches seem somewhat balanced.

Sediment transport capacity calculations were performed using the results of the steady state hydraulic analyses (averaged over each reach), and a typical Salt River grain size distribution (**Figure 9**). The size distribution shown in Figure 9 was developed for a previous study of the Salt River between McClintock Drive and Dobson Road, and is judged to be a conservative (biased on the fine side) approximation of the bed material along the study reach for this project. The steady state sediment transport analysis used the Meyer-Peter, Mueller bedload equation and Einstein's procedure for integration of the suspended load to determine the bed material sediment transport capacity of each reach over a range of flow conditions. A discharge-vs-sediment transport relation was developed for each reach, and was integrated over a 10-day hydrograph for each of the 2-year through 100-year flood events to obtain the n-year sediment transport capacity volume. (The 100-year hydrograph used in this procedure, developed from the most-recent COE hydrologic analysis, is shown in **Figure 10**. Lesser magnitude floods used scaled versions following this same pattern.) The results of the n-year events were probability weighted to obtain the reach-by-reach transport capacity variation for an average annual event.

Figure 11 illustrates the variation in the steady state bed material transport capacity along the study channel under both 100-year and average annual conditions. These results confirm those of the qualitative analysis, with Reaches 9 and 10 showing much greater capacity for transport of sediment that the reaches up- or downstream.

An approximation of the amount of scour or deposition that could potentially occur within a given reach throughout the passage of a flood event may be determined through application of the sediment transport continuity concept. The change (scour or deposition) that may occur within a given reach will depend on the difference between its sediment transport capacity and the amount supplied by the upstream reach. Excessive supply in relation to transport capacity will result in deposition, whereas insufficient supply will result in scour. The scour or deposition volume, spread over the length and width of the reach of concern, gives an indication of the potential scour or deposition depth. This continuity concept was applied to the study channel, and the computed depths of potential change for the 100-year and average annual events are presented in **Figure 12**. As indicated in this figure, Reach 10 has the potential of scouring over 25 feet under 100-year flood conditions. Reach 6, which is downstream of depositional reaches, also has the potential for significant scour. Reaches 8 and 5, both previously mined, have high depositional tendencies.

The steady state analyses discussed above give an approximation of the scour and deposition trends likely in a given reach, but may over- or underestimate the actual channel change, due to the changes in hydraulics and bed material composition that occur as the channel adjusts during the coarse of a flood event. The QUASED quasi-unsteady hydraulic and sediment transport model was applied to the study reach to provide a more realistic estimate of the extent of scour and deposition likely along the length of the study channel during the passage of a 100-year flood event. The QUASED model uses the same general procedures for computation of sediment transport and channel adjustment as used in the steady state analysis, except that the channel condition is updated after each time step of the analyzed hydrograph, and the hydraulics and bed material composition are

updated. A six-hour time step was used for this analysis -- thus, 40 time steps of analysis were required for modeling the entire 100-year, 10-day hydrograph.

Figures 13 through 16 illustrate the results of the channel profile changes predicted by the QUASED model. Figure 13 compares the beginning and ending channel profile, while Figures 14 and 15 compare the starting profile to the maximum scour and maximum deposition profile (minimum and maximum elevations over all time steps), respectively. Figure 16 shows the predicted total range of the channel invert elevation at each location along the study channel throughout the course of the 100-year event. **Figures 17 through 20** indicate the changes in the bed material composition predicted to occur at several locations during the design event. In Reaches 10 and 11, the bed material becomes significantly coarser as scour occurs. Reach 10 (Figure 18) is coarsest at the peak, with some deposition occurring during the recession limb of the hydrograph, while Reach 11 (Figure 17) continues to coarsen, indicating an upstream advance of the scour from Reach 10. Reach 7 (Figure 19) aggrades prior and up to the peak, and then re-scours during the recession limb. In Reach 5 (Figure 20), the deposition continues throughout the passage of the hydrograph, filling the previously mined pit.

Cross-sectional views of the pre- and predicted post-flood channels are illustrated in **Figures 21 through 24**. Cross-section 316 (Figure 21), which is in Reach 10, shows significant scour, as does cross-section 109 (Figure 22) in Reach 9. Note however, that the scour is not uniform throughout each of these sections. Cross-section 107 (Figure 23), which is also in Reach 9, shows slight scour in the deepest portions of the channel, with deposition predicted on the gravel bar. Cross-section 106 (Figure 24), in Reach 8, shows aggradation occurring throughout the width of the submerged section.

In general, the QUASED results confirm the general tendencies indicated through the steady state analysis, with less extreme changes. **Figure 25** compares the results of both analyses, with the QUASED results shown as a range to indicate the variability with time and distance.

The conclusions that have be drawn as a result of the above analyses are listed as follows:

1> The historic profile analysis indicates that the channel is, in general, dropping, or increasing in capacity, as time proceeds. Contributing factors include the upstream regulation and the extensive in-stream mining.

2> The hydraulic analyses indicates that the 100-year flood is contained within the major banks of the channel along the study reach. Comparison of the 100-year flood levels shown on the current FEMA map with those computed in this study indicate that the channel floodplain has lowered in elevation since 1982.

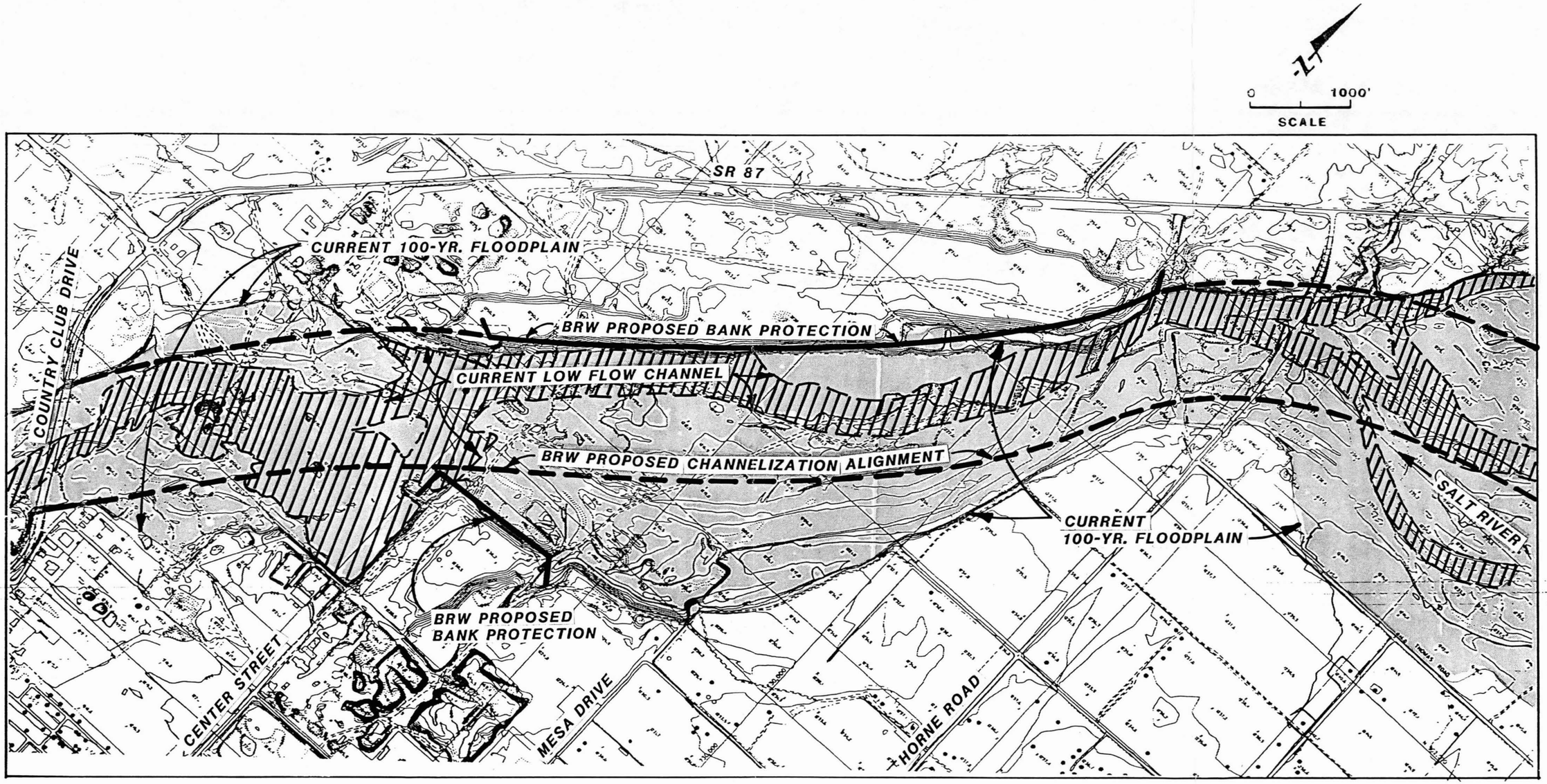
3> The qualitative, steady state and QUASED sediment transport analyses indicate that significant erosion potential exists near the upstream end of the Tri-City Landfill, with deposition likely near the Center Street Landfill. The channel reaches upstream (Reaches 11 and 12) and downstream (Reach 6) of these landfills have similar sediment transport capacities, and, ignoring the reaches in between, are

basically in balance. Excessive scour is limited by coarsening of the channel bed.

Four alternatives have been developed for protection of the Tri-City and Center Street landfills from the destabilizing effects of the Salt River flows. Alternative 1, presented in **Figure 26** is the alternative previously presented by BRW -- soil-cement stabilization along the river side boundary of each landfill. Due to the sharp bend located in the Salt River at the upstream end of the Tri-City landfill, and due to the erosive tendencies of this reach of the channel, it is evident that this alternative will require adjustment at the upstream end to avoid back-cutting and failure of the proposed bank protection. Alternative 2 (**Figure 27**) is one means of adjustment -- extension of the channel improvement measures. Extension of the bank protection and smoothing of the major channel bend would reduce the danger of failure at this upstream, most critical location. Alternative 3 (**Figure 28**), is another means of achieving the same objective -- through the use of groins. The proposed groins would redirect the channel flow while providing several buffers or layers of protection at the upstream terminus of the Tri-City landfill.

In each of these alternatives, the protection plan for the Center Street Landfill is the same -- a soil-cement cap along the river side of the landfill. Since the floodplain upstream of the Center Street landfill is very wide, major upstream work would be required to adjust this cap to an alignment which would more correspond to the ultimate alignment proposed for this reach by BRW. Alternative 4 (**Figure 29**) is an ultimate-improvement plan which would provide full-reach bank and invert stabilization. This alternative would connect the reaches upstream and downstream of the existing landfills with an excavated 1200-ft wide channel, which follows the general alignment of the existing low flow channel. The channel would better balance the sediment transport characteristics of the study reaches, would provide protection to both the Tri-City and Center Street Landfill, and would also protect the cemetery upstream of the Horne Road crossing. In addition, this alternative would remove approximately 179 acres of land from the current 100-year floodplain.

Typical sections of the proposed bank (all alternatives) and groin (Alternative 3) are illustrated in **Figure 30**. The estimated construction costs associated with each plan are summarized in **Table 1**.



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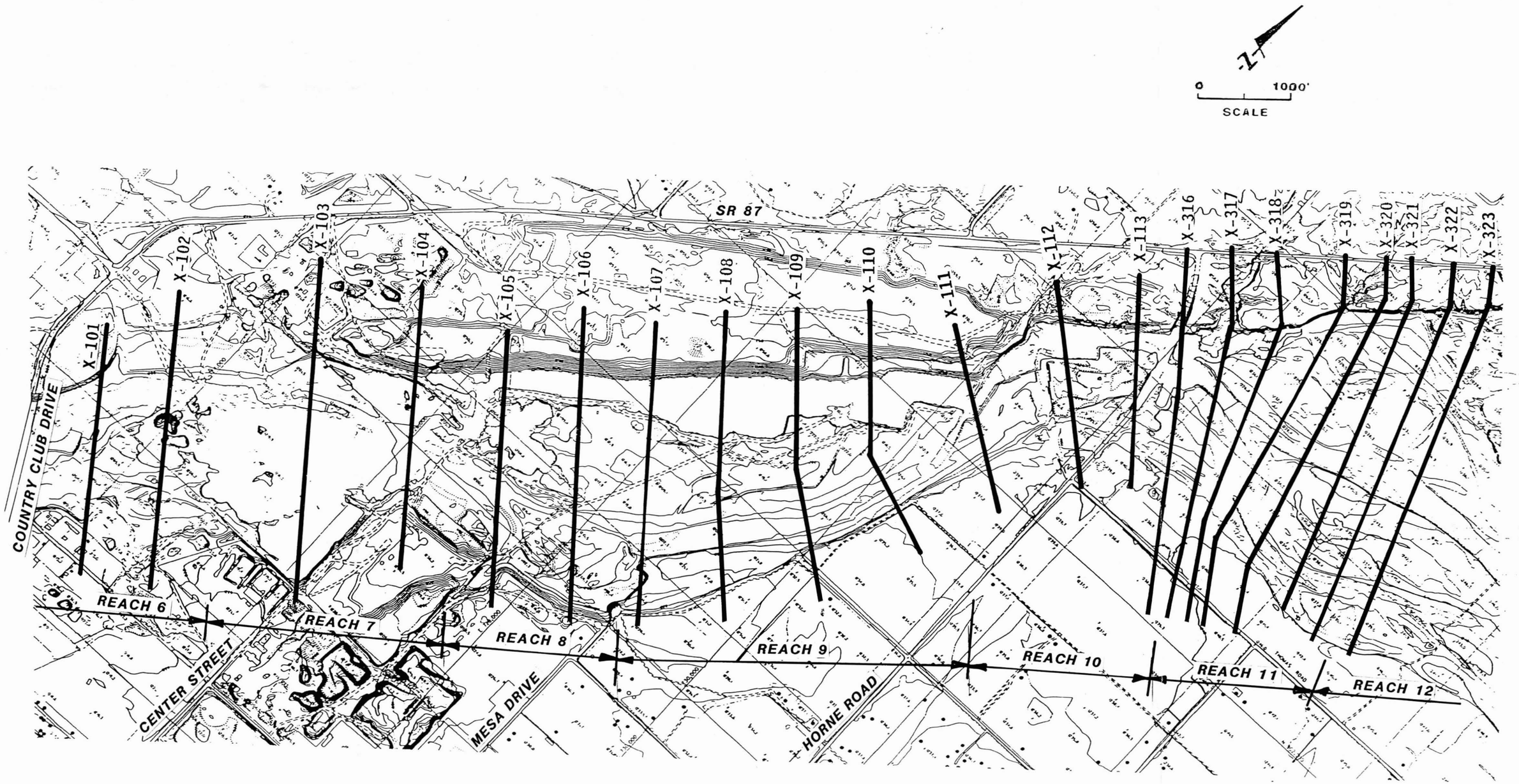
1992 TOPOGRAPHY SHOWING CURRENT LOW FLOW CHANNEL AND 100-YR FLOODPLAIN

FIGURE 1.



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REACH AND CROSS-SECTION LOCATION MAP

FIGURE 2.

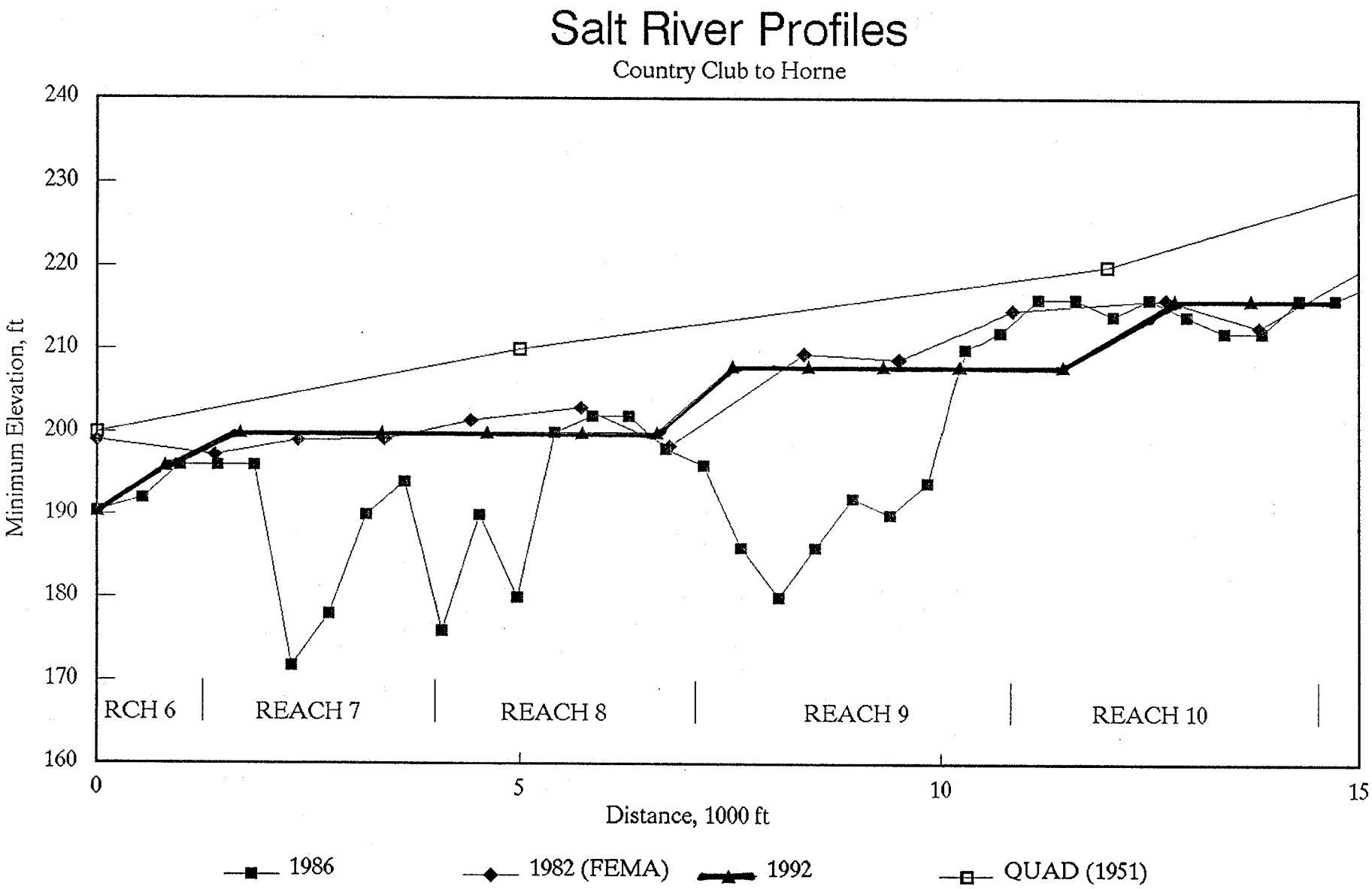
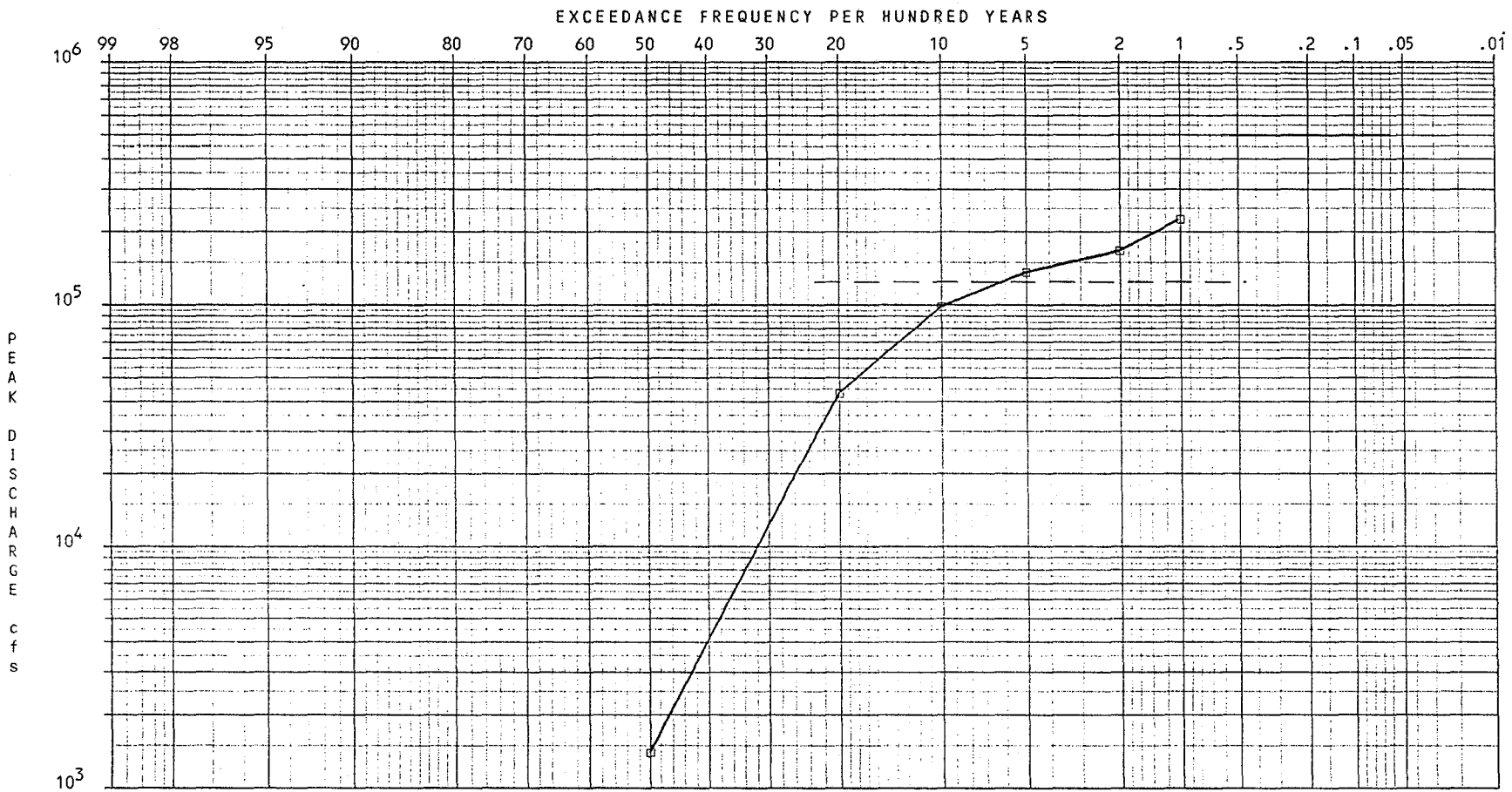

Salt River Profiles
Country Club to Horne
Minimum Elevation, ft
240
230
220
210
200
190
180
170
160
RCH 6
REACH 7
REACH 8
REACH 9
REACH 10
0
5
10
15
Distance, 1000 ft
1986
1982 (FEMA)
1992
QUAD (1951)

FIGURE 3.



SALT RIVER FLOW FREQUENCY

COUNTRY CLUB to GILBERT ROAD

FREQUENCY CURVE

JANUARY 1993 EVENT

Note:
2-year value estimated from Log Pearson Type III fit to available 5-, 10-, 20- and 50-year data.

FIGURE 4.

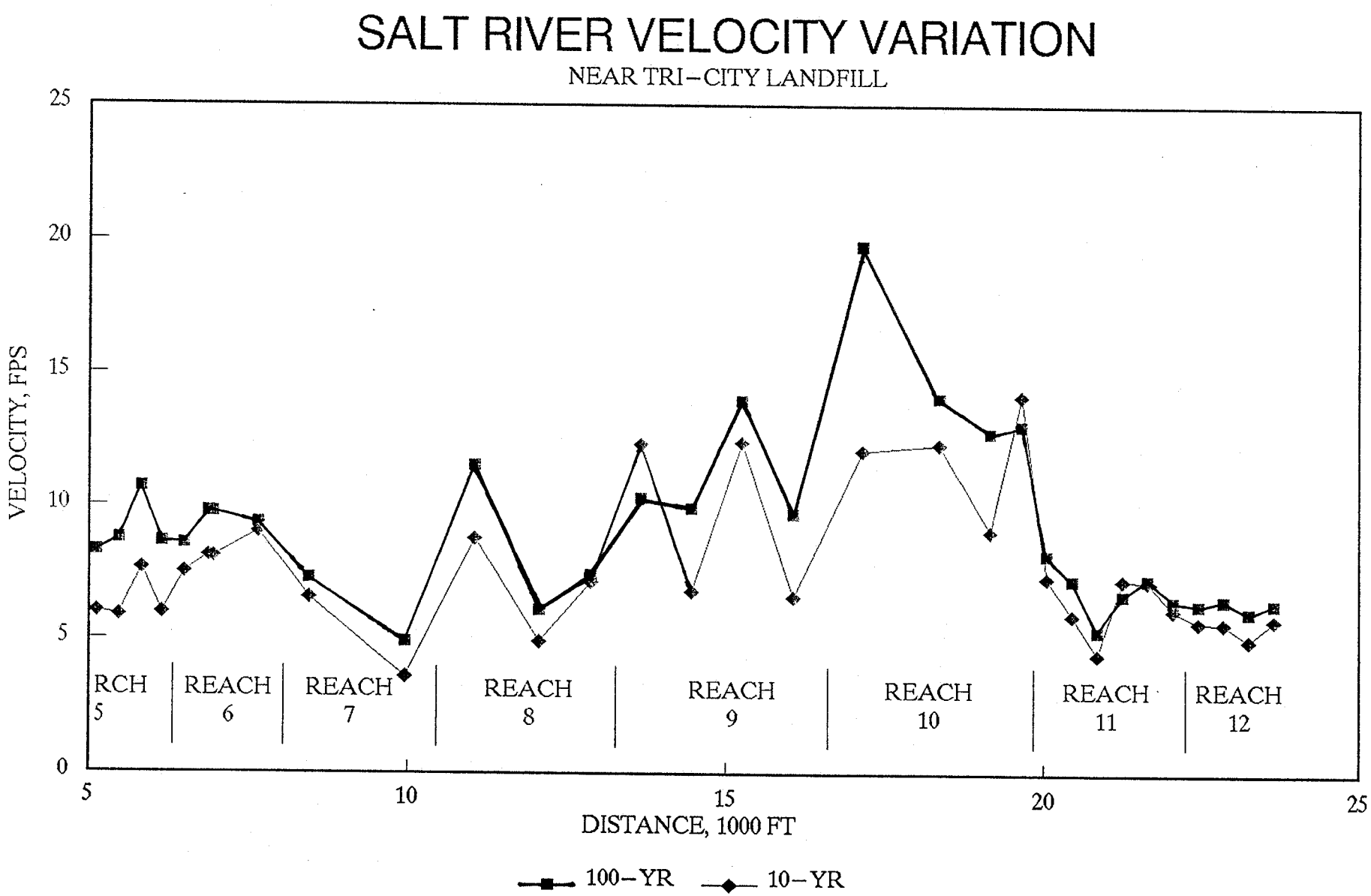

SALT RIVER VELOCITY VARIATION
NEAR TRI-CITY LANDFILL
VELOCITY, FPS
25
20
15
10
5
0
RCH 5
REACH 6
REACH 7
REACH 8
REACH 9
REACH 10
REACH 11
REACH 12
5
10
15
20
25
DISTANCE, 1000 FT
100-YR
10-YR

FIGURE 5.

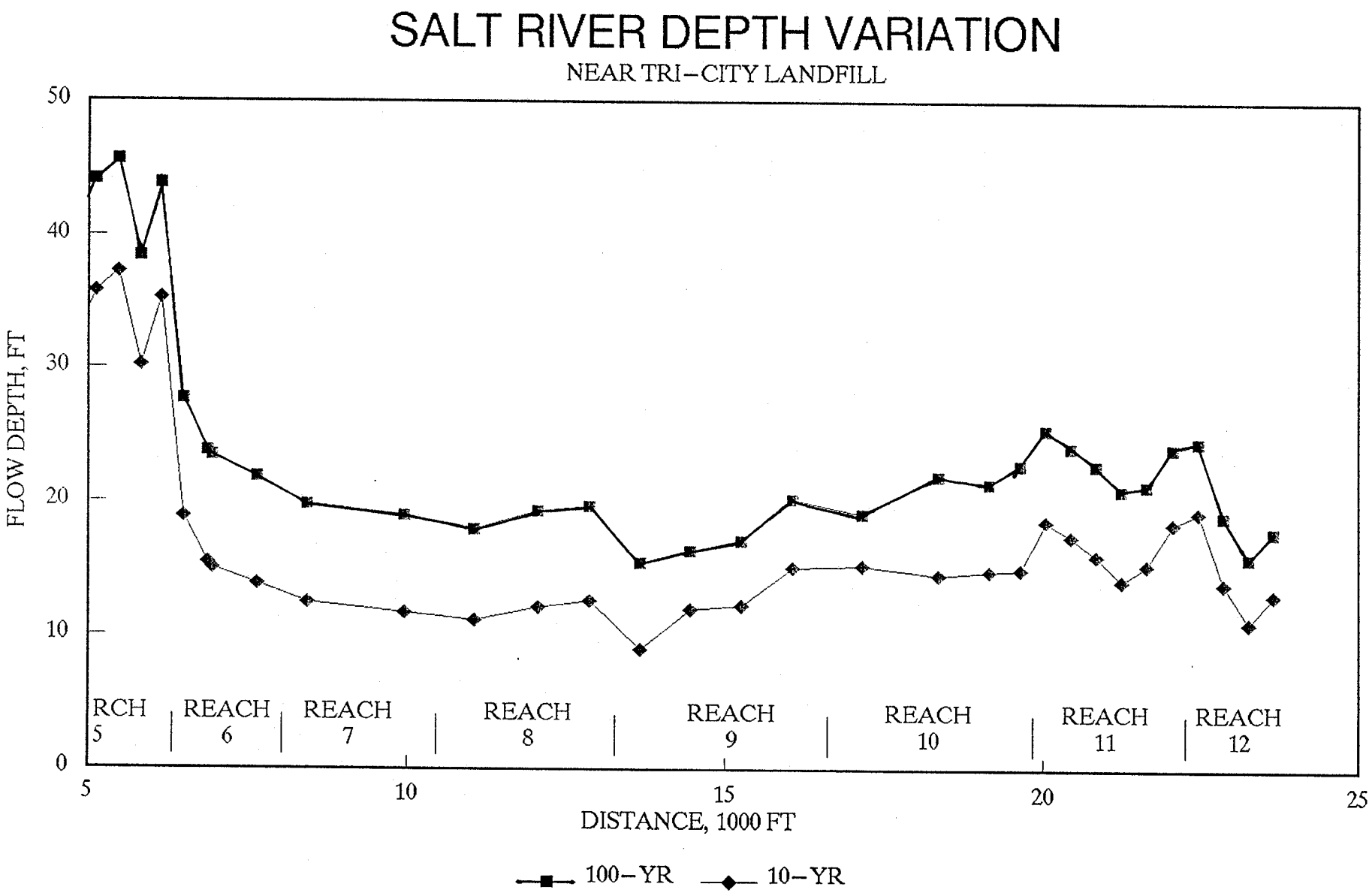

SALT RIVER DEPTH VARIATION
NEAR TRI-CITY LANDFILL
FLOW DEPTH, FT
50
40
30
20
10
0
RCH 5
REACH 6
REACH 7
REACH 8
REACH 9
REACH 10
REACH 11
REACH 12
5
10
15
20
25
DISTANCE, 1000 FT
100-YR
10-YR

FIGURE 6.

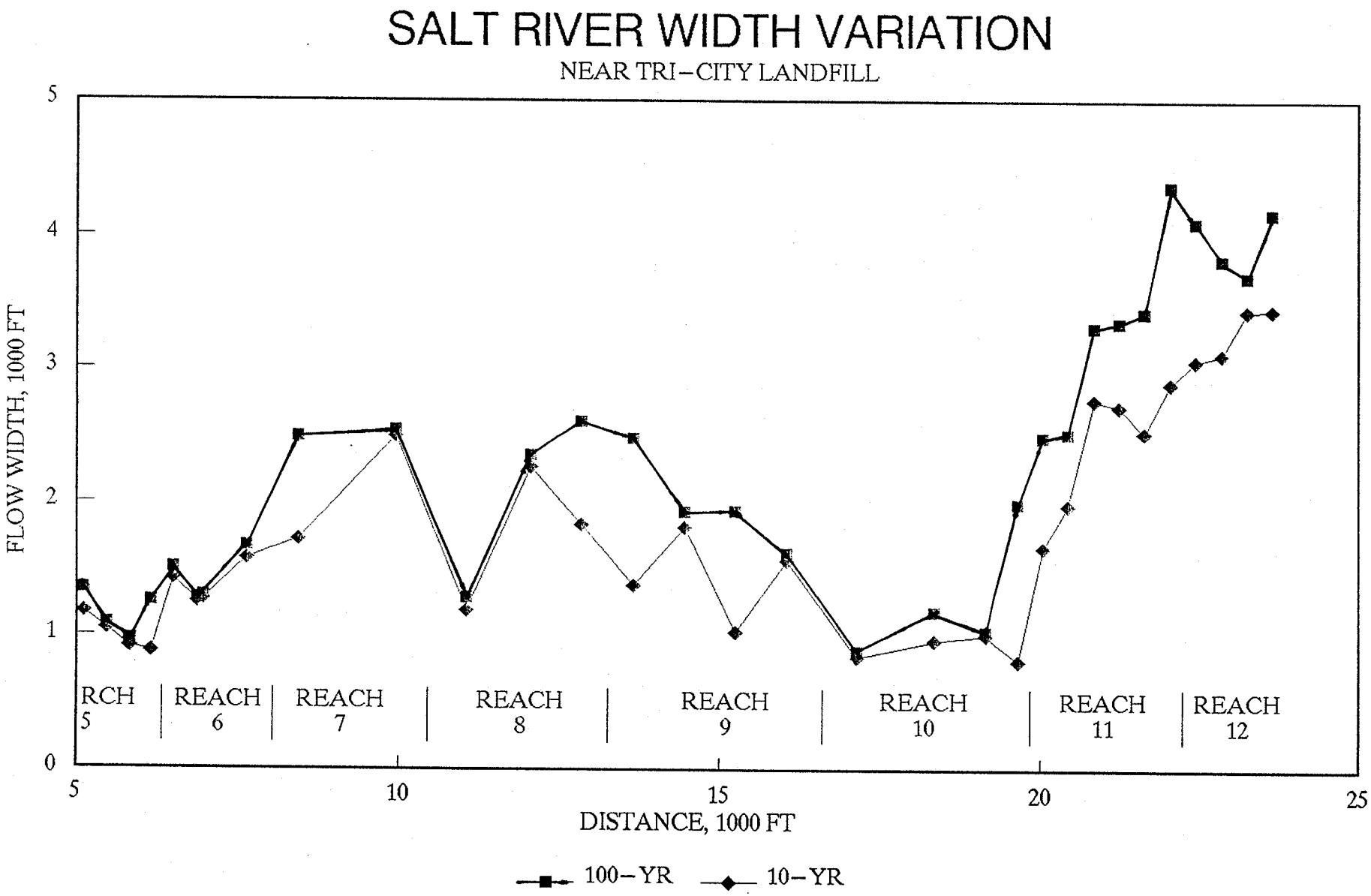

SALT RIVER WIDTH VARIATION
NEAR TRI-CITY LANDFILL
FLOW WIDTH, 1000 FT
0
1
2
3
4
5
RCH 5
REACH 6
REACH 7
REACH 8
REACH 9
REACH 10
REACH 11
REACH 12
5
10
15
20
25
DISTANCE, 1000 FT
100-YR
10-YR

FIGURE 7.

SALT RIVER SEDIMENT TRANSPORT CAPACITY VARIATION

NEAR TRI–CITY LANDFILL

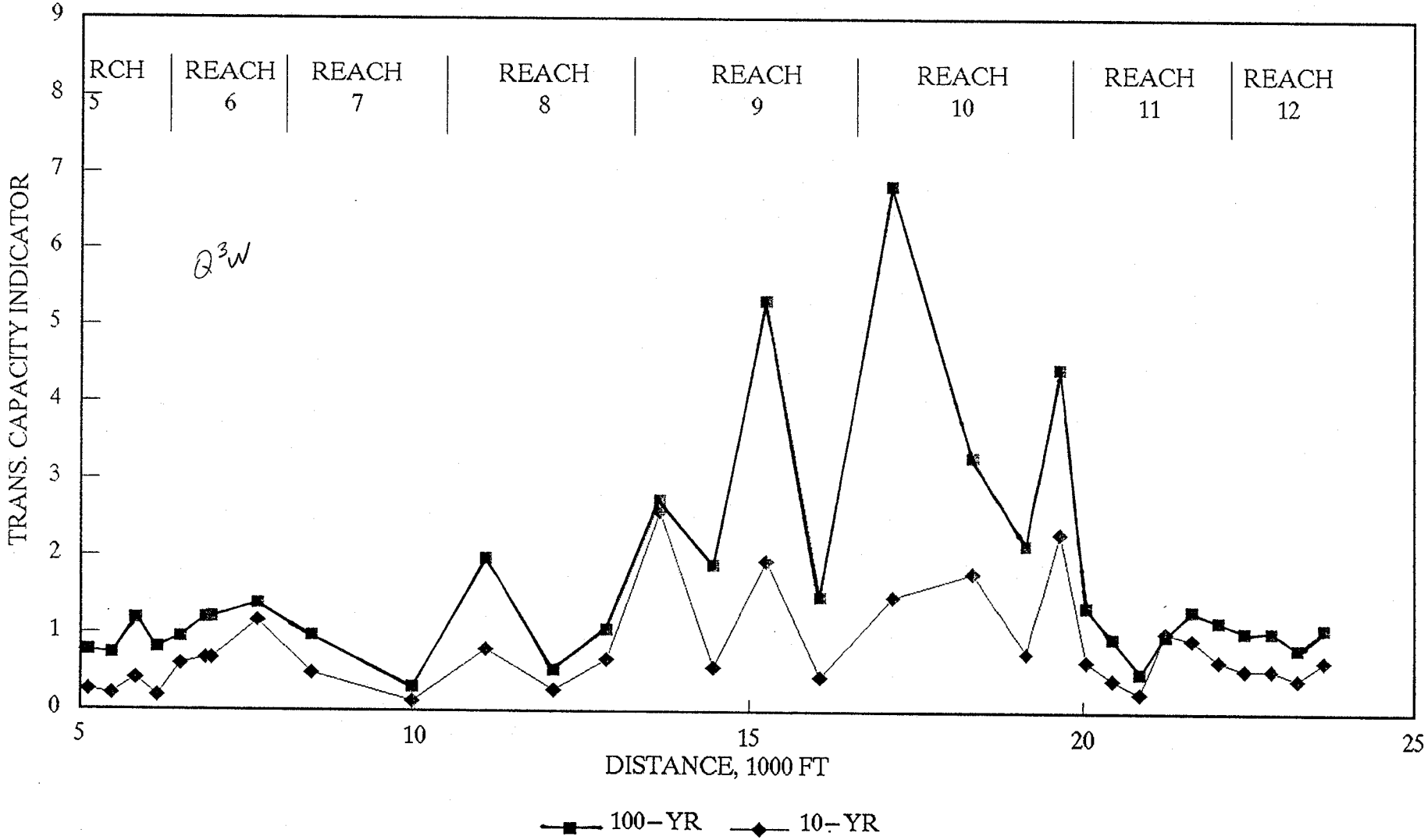


FIGURE 8.

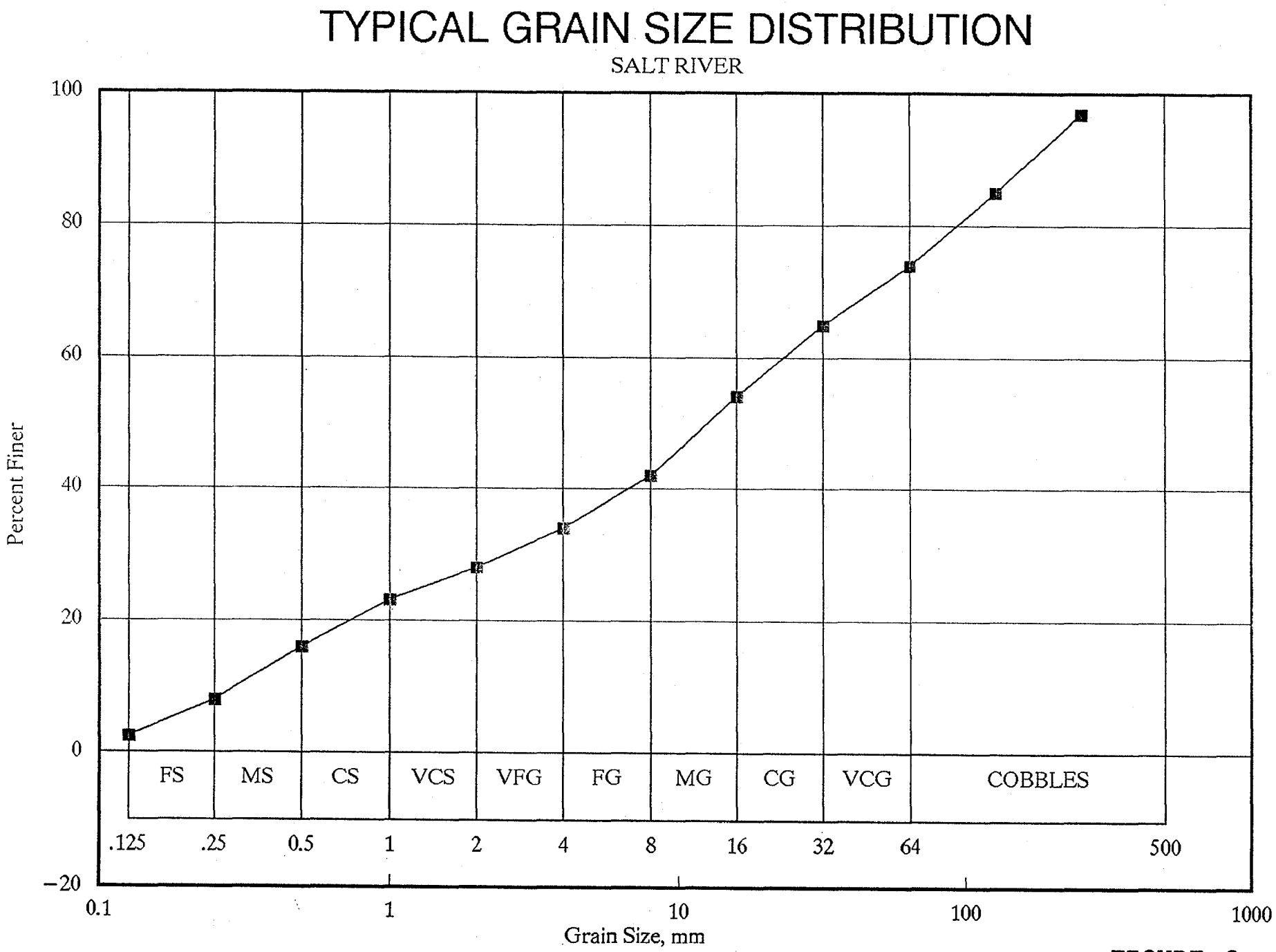

TYPICAL GRAIN SIZE DISTRIBUTION
SALT RIVER
Percent Finer
100
80
60
40
20
0
−20
FS
MS
CS
VCS
VFG
FG
MG
CG
VCG
COBBLES
.125
.25
0.5
1
2
4
8
16
32
64
500
0.1
1
10
100
1000
Grain Size, mm

FIGURE 9.

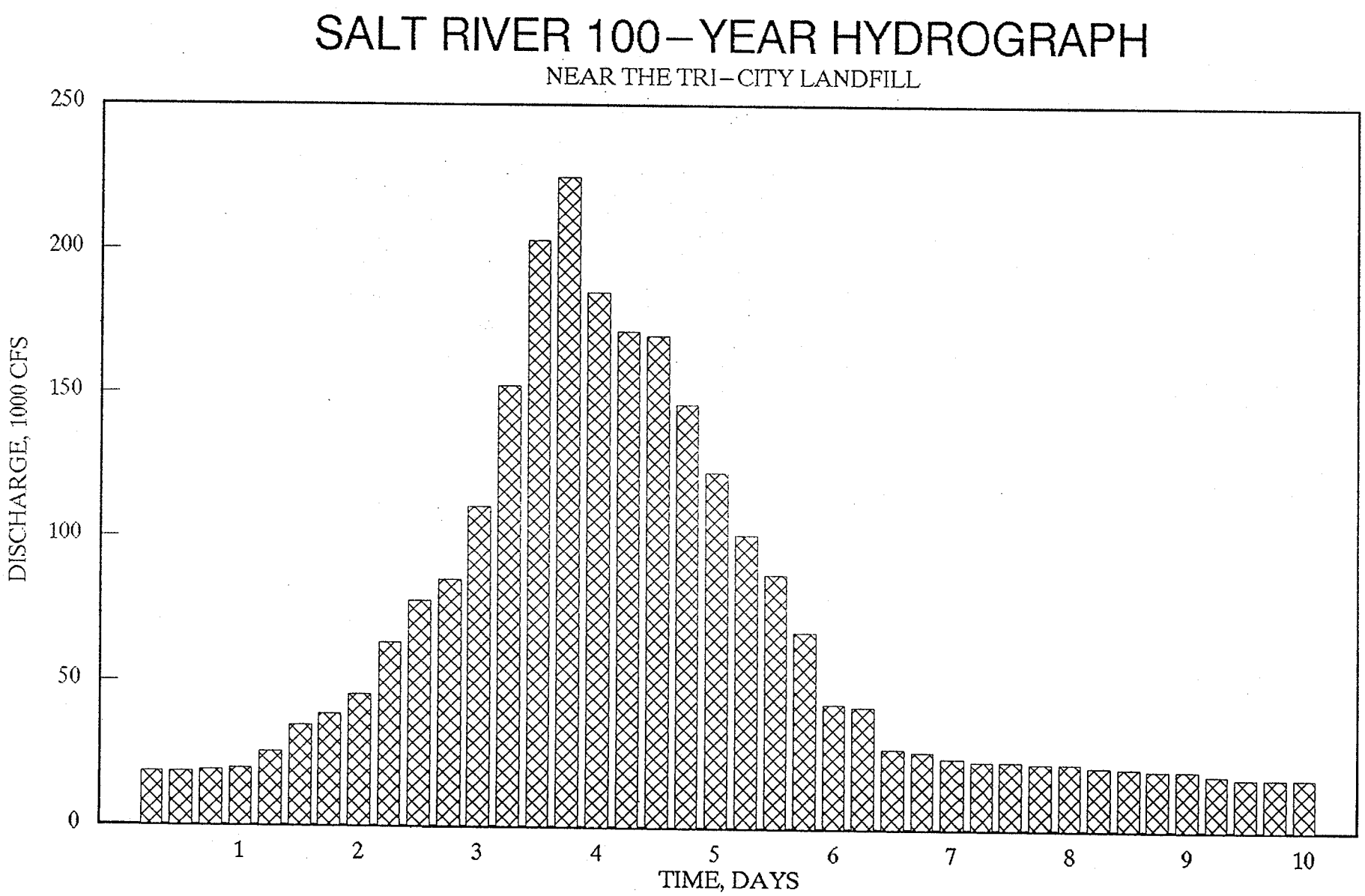

SALT RIVER 100–YEAR HYDROGRAPH
NEAR THE TRI–CITY LANDFILL
DISCHARGE, 1000 CFS
250
200
150
100
50
0
1
2
3
4
5
6
7
8
9
10
TIME, DAYS

FIGURE 10.

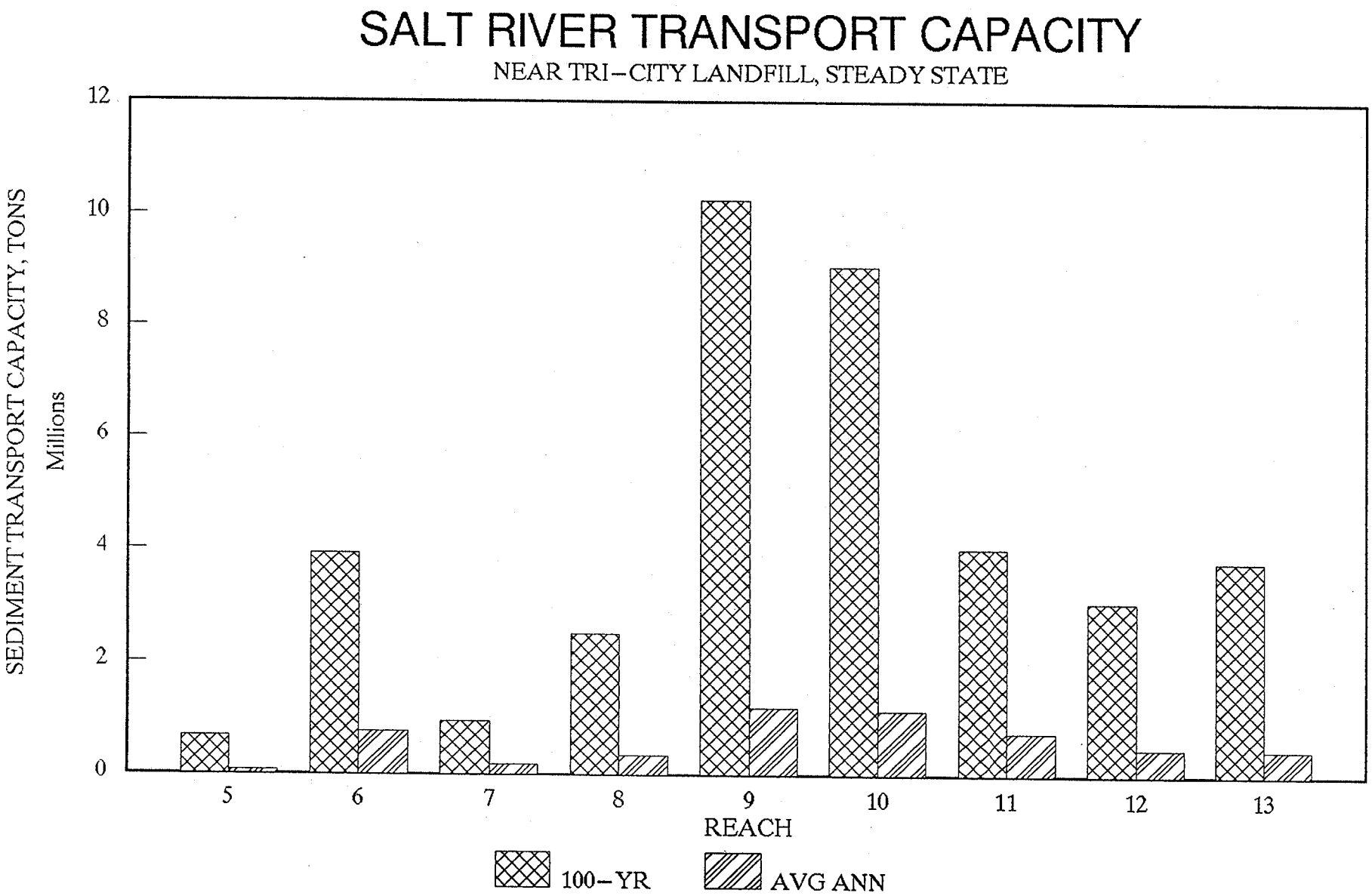

SALT RIVER TRANSPORT CAPACITY
NEAR TRI-CITY LANDFILL, STEADY STATE
SEDIMENT TRANSPORT CAPACITY, TONS
Millions
12
10
8
6
4
2
0
5
6
7
8
9
10
11
12
13
REACH
100-YR
AVG ANN

FIGURE 11.

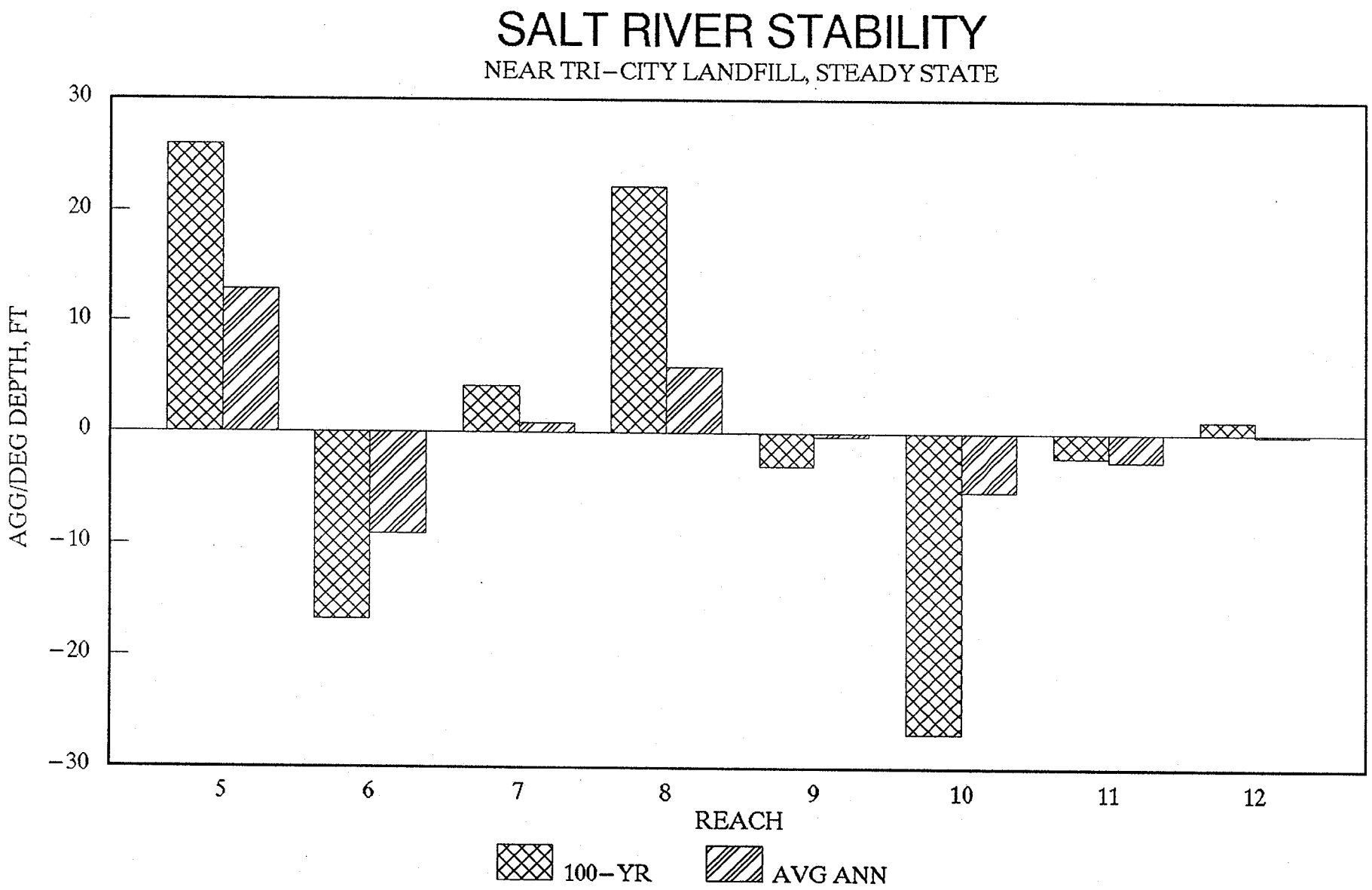

SALT RIVER STABILITY
NEAR TRI–CITY LANDFILL, STEADY STATE
AGG/DEG DEPTH, FT
30
20
10
0
−10
−20
−30
5
6
7
8
9
10
11
12
REACH
100–YR
AVG ANN

FIGURE 12.

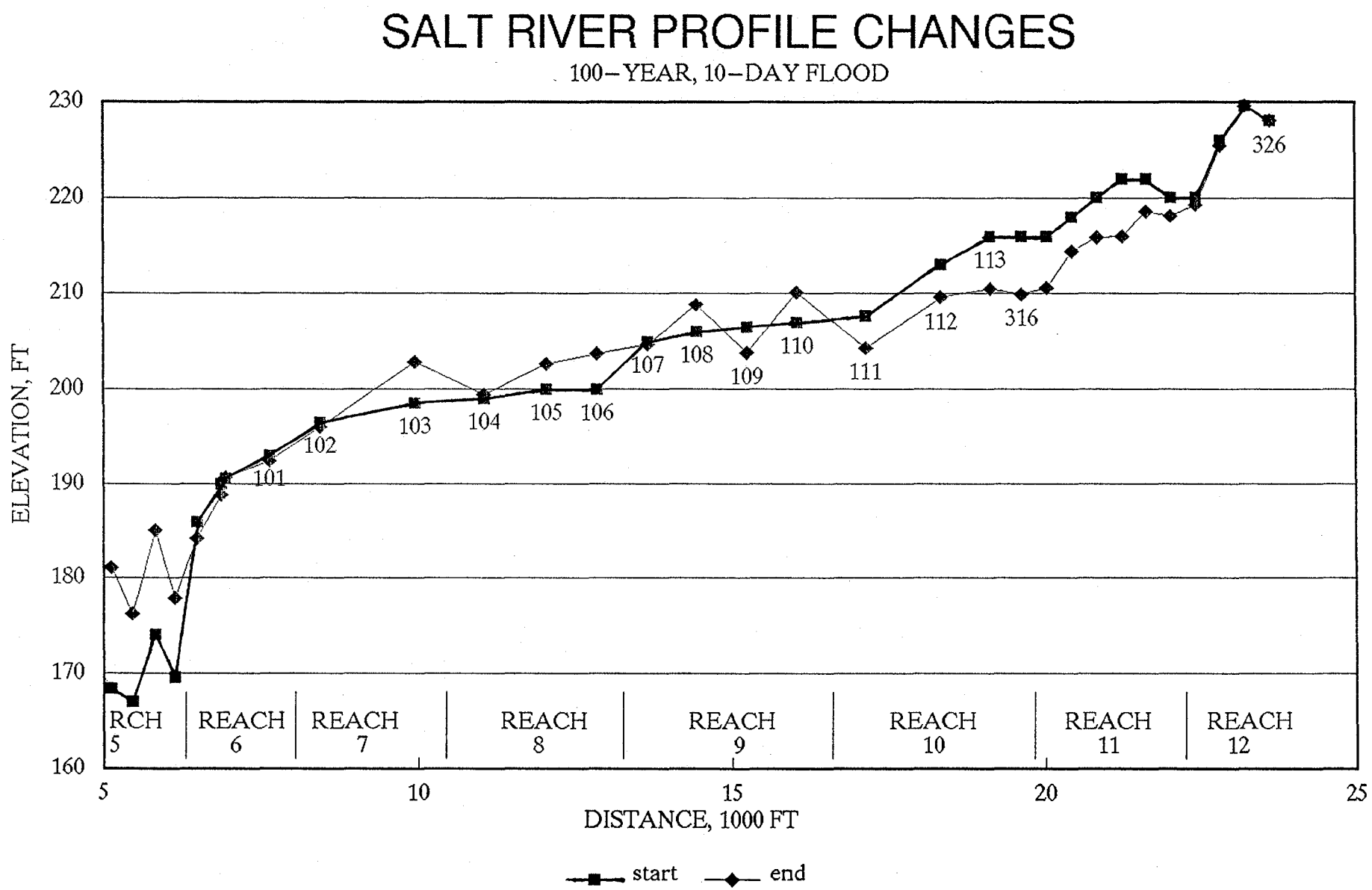

SALT RIVER PROFILE CHANGES
100-YEAR, 10-DAY FLOOD
ELEVATION, FT
230
220
210
200
190
180
170
160
5
10
15
20
25
DISTANCE, 1000 FT
RCH 5
REACH 6
REACH 7
REACH 8
REACH 9
REACH 10
REACH 11
REACH 12
101
102
103
104
105
106
107
108
109
110
111
112
113
316
326
start
end

FIGURE 13.

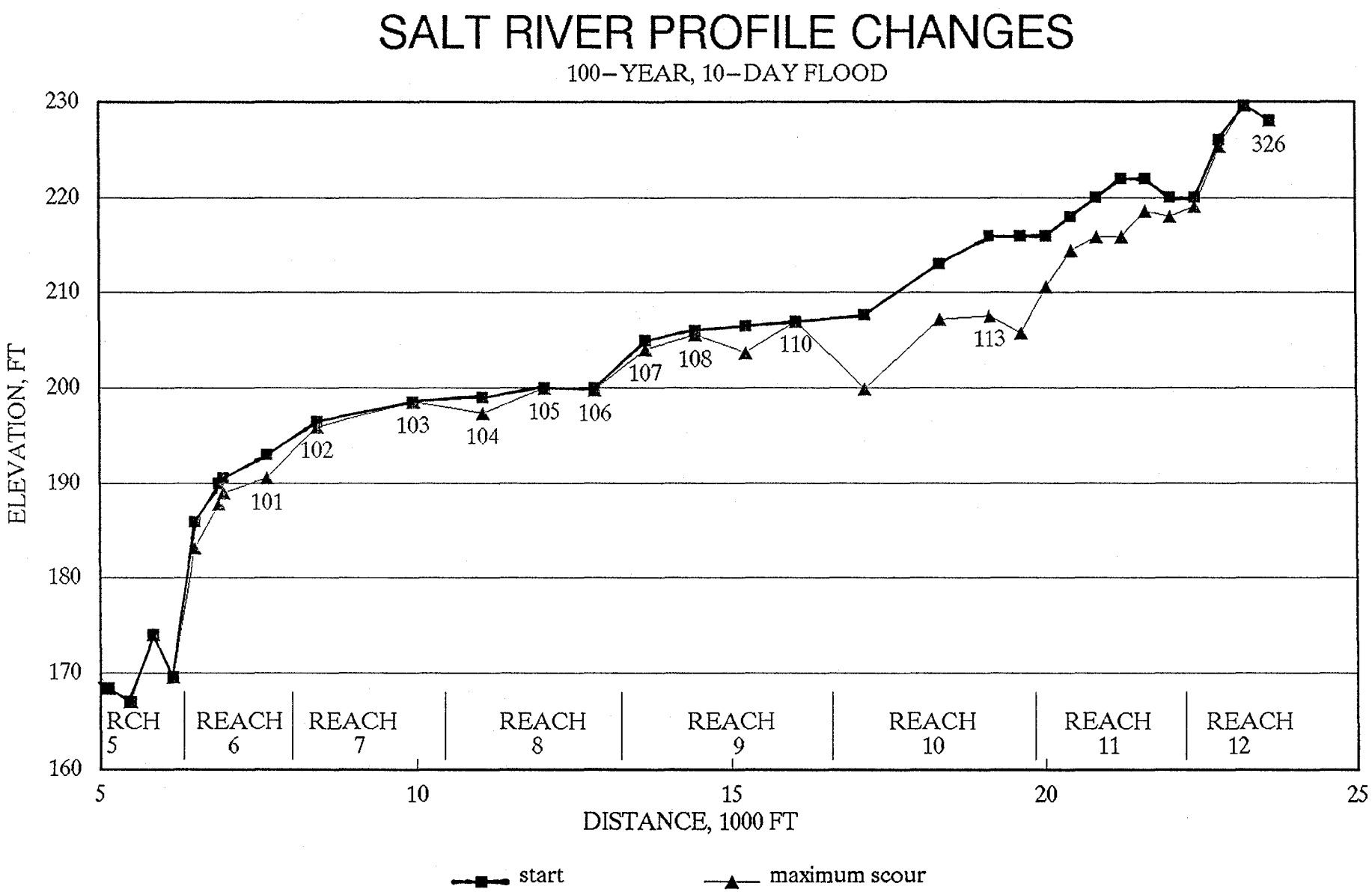

SALT RIVER PROFILE CHANGES
100-YEAR, 10-DAY FLOOD
ELEVATION, FT
230
220
210
200
190
180
170
160
5
10
15
20
25
DISTANCE, 1000 FT
RCH 5
REACH 6
REACH 7
REACH 8
REACH 9
REACH 10
REACH 11
REACH 12
101
102
103
104
105
106
107
108
110
113
326
start
maximum scour

FIGURE 14.

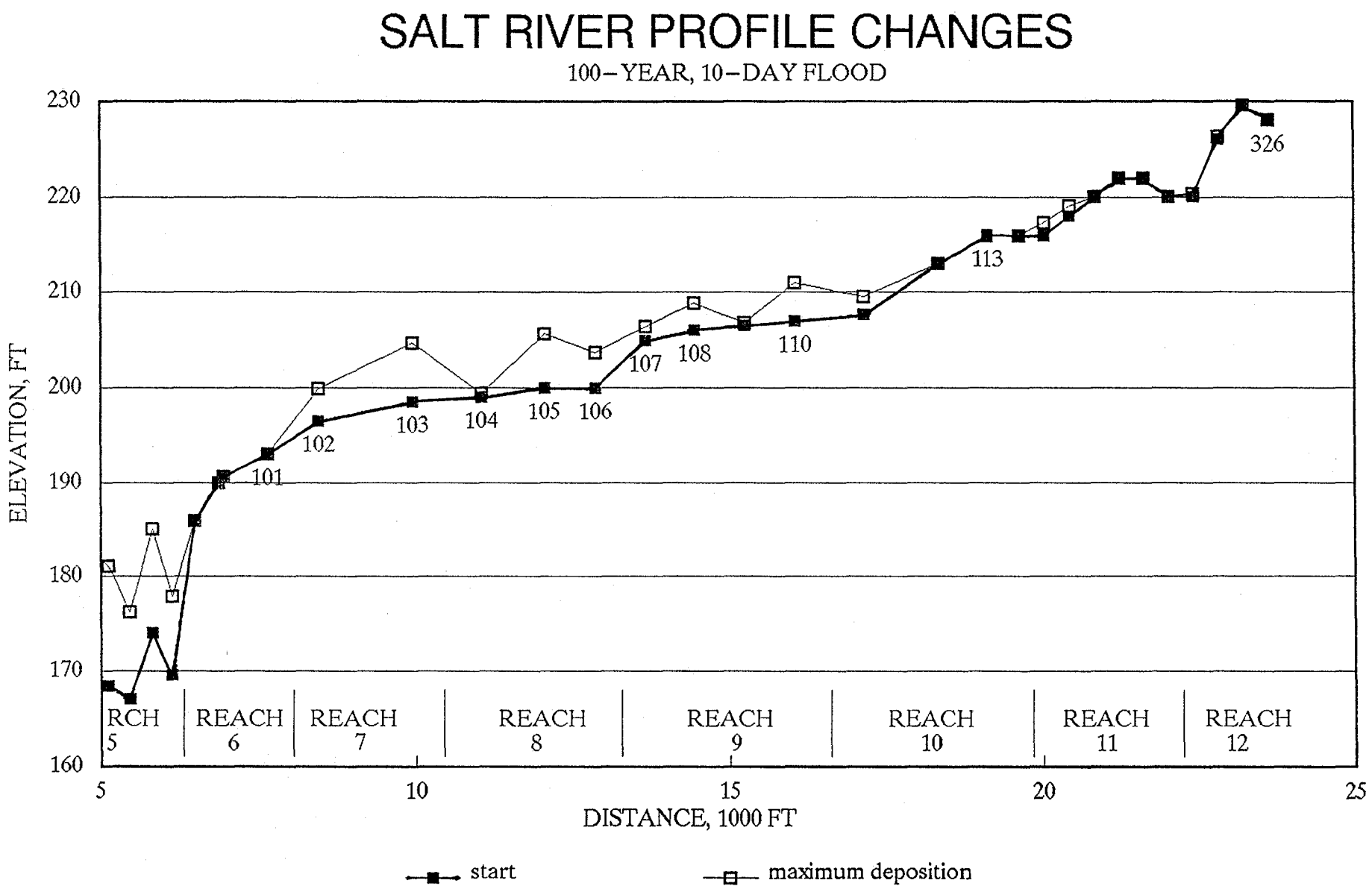

SALT RIVER PROFILE CHANGES
100-YEAR, 10-DAY FLOOD
ELEVATION, FT
230
220
210
200
190
180
170
160
5
10
15
20
25
DISTANCE, 1000 FT
RCH 5
REACH 6
REACH 7
REACH 8
REACH 9
REACH 10
REACH 11
REACH 12
101
102
103
104
105
106
107
108
110
113
326
start
maximum deposition

FIGURE 15.

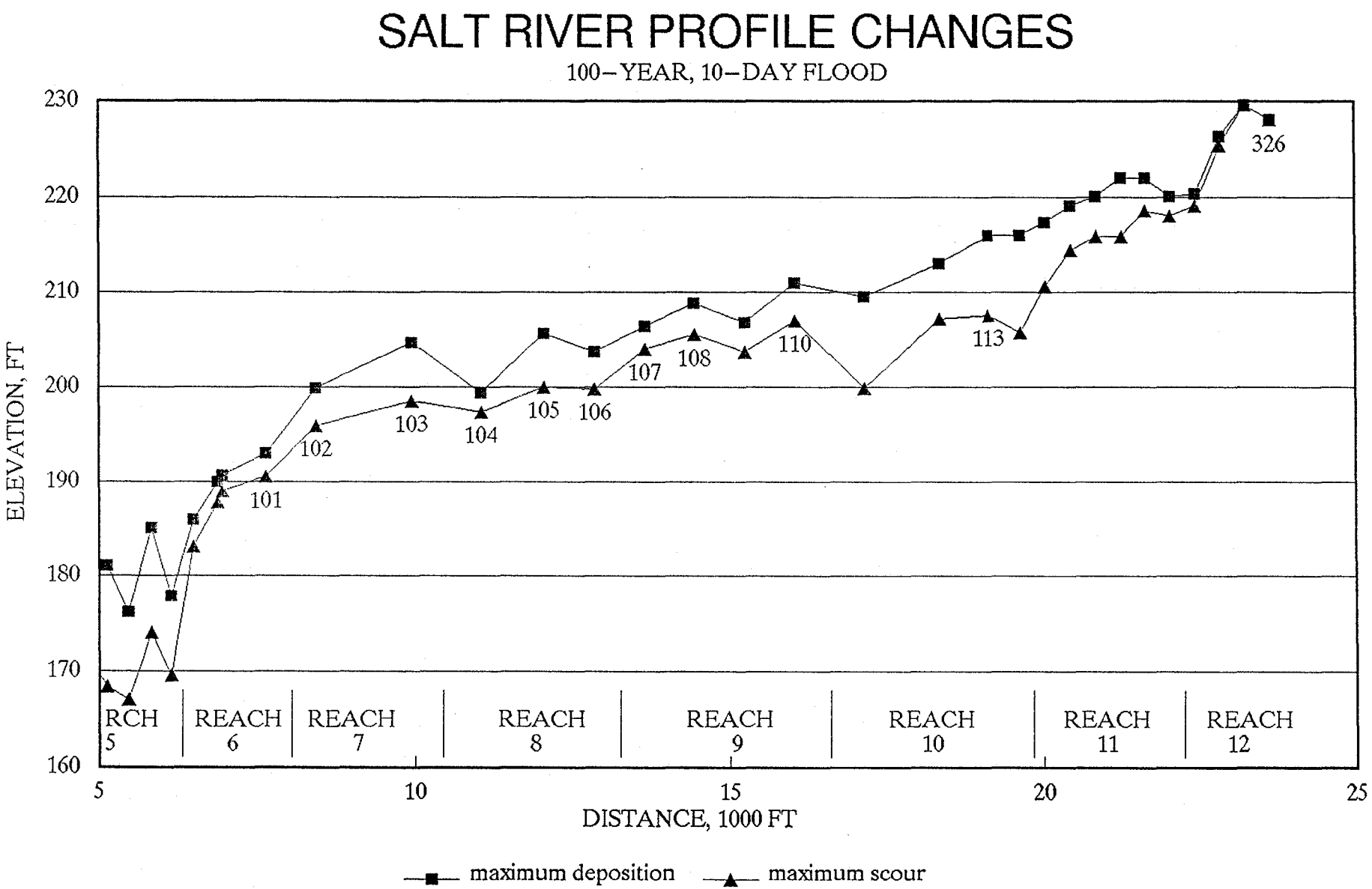

SALT RIVER PROFILE CHANGES
100–YEAR, 10–DAY FLOOD
ELEVATION, FT
230
220
210
200
190
180
170
160
5
10
15
20
25
DISTANCE, 1000 FT
RCH 5
REACH 6
REACH 7
REACH 8
REACH 9
REACH 10
REACH 11
REACH 12
101
102
103
104
105
106
107
108
110
113
326
maximum deposition
maximum scour

FIGURE 16.

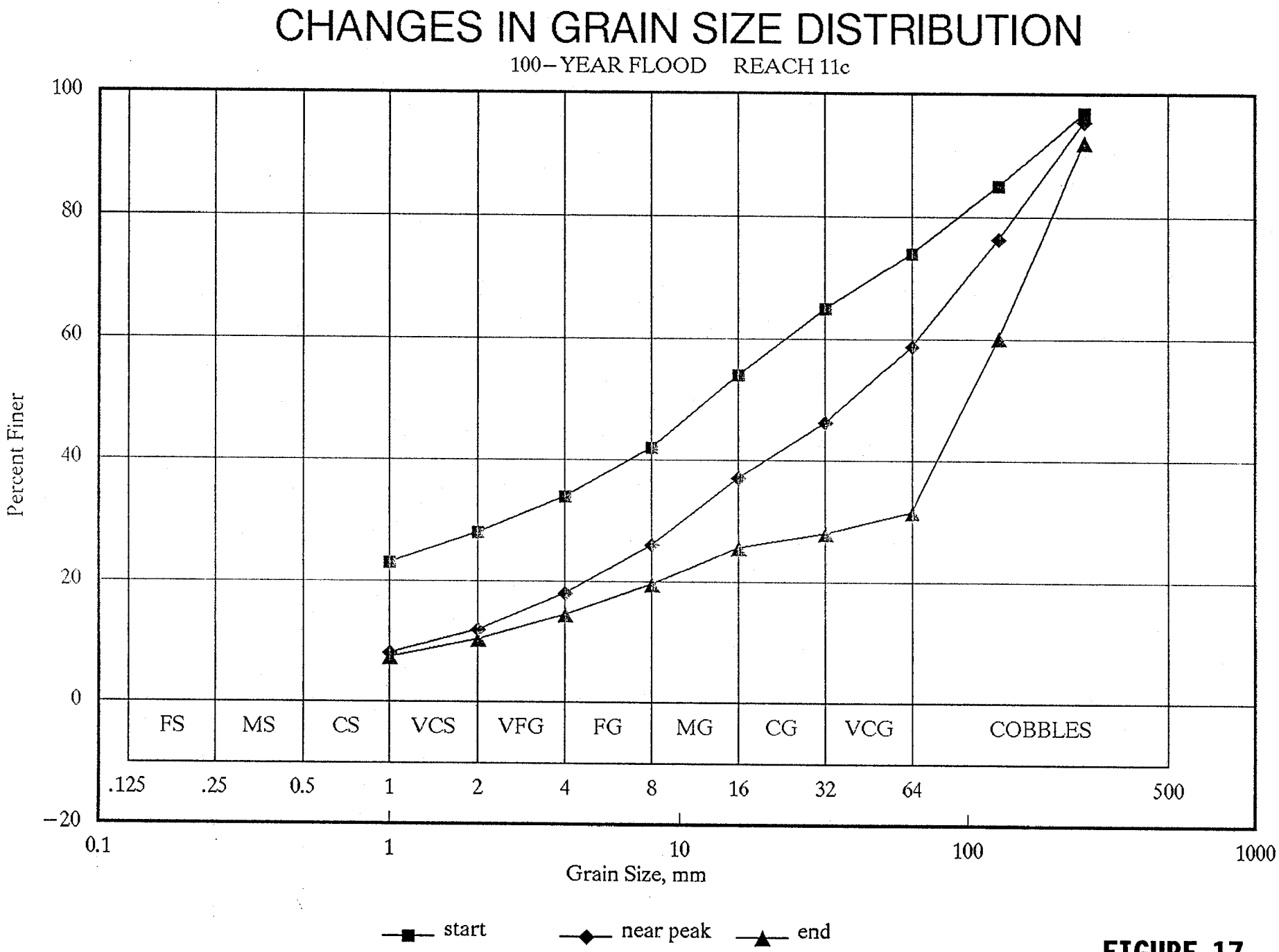

CHANGES IN GRAIN SIZE DISTRIBUTION
100-YEAR FLOOD REACH 11c
Percent Finer
100
80
60
40
20
0
-20
FS
MS
CS
VCS
VFG
FG
MG
CG
VCG
COBBLES
.125
.25
0.5
1
2
4
8
16
32
64
500
0.1
1
10
100
1000
Grain Size, mm
start
near peak
end

FIGURE 17.

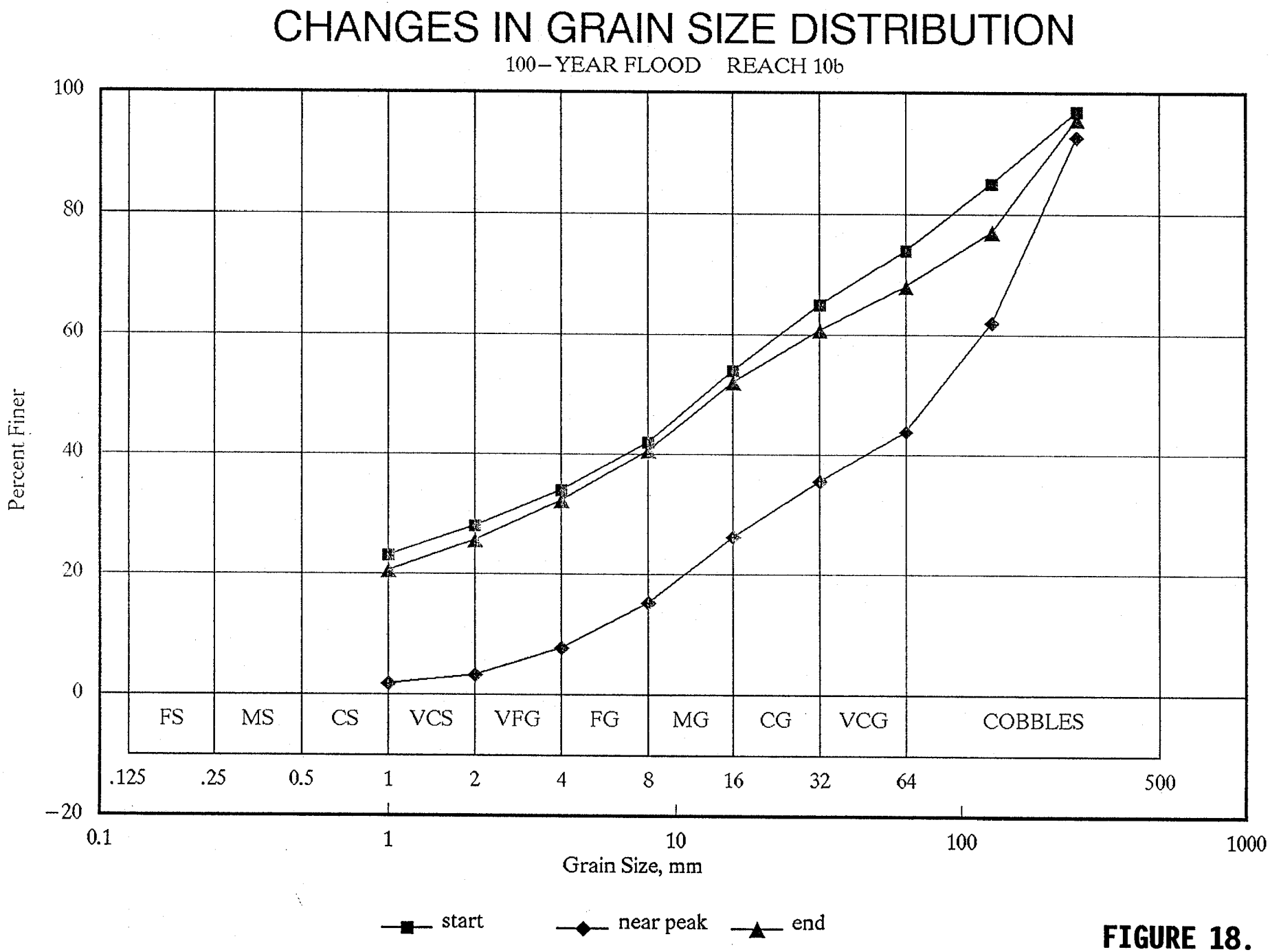

CHANGES IN GRAIN SIZE DISTRIBUTION
100-YEAR FLOOD REACH 10b
Percent Finer
100
80
60
40
20
0
-20
FS
MS
CS
VCS
VFG
FG
MG
CG
VCG
COBBLES
.125
.25
0.5
1
2
4
8
16
32
64
500
0.1
1
10
100
1000
Grain Size, mm
start
near peak
end

FIGURE 18.

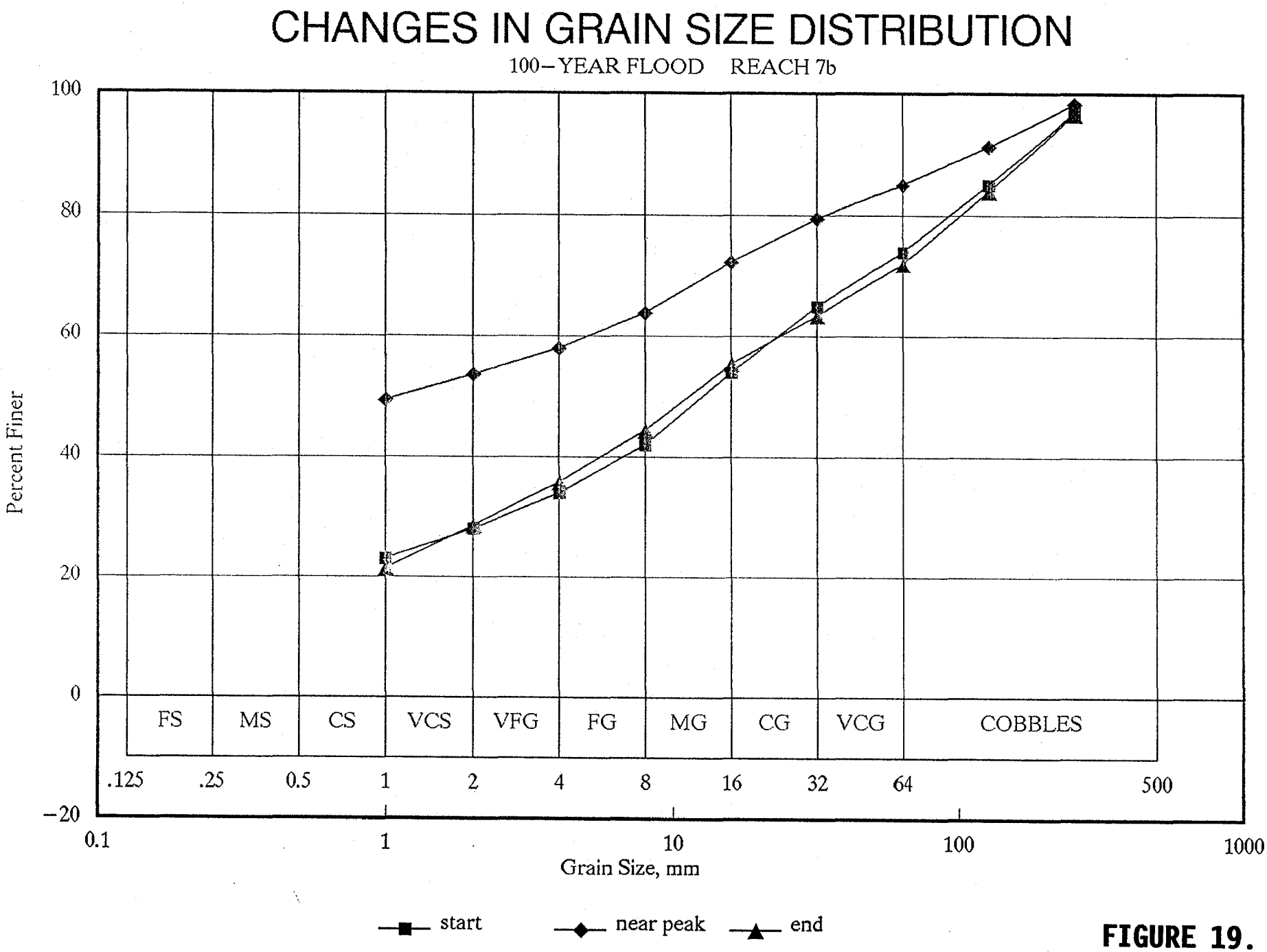

CHANGES IN GRAIN SIZE DISTRIBUTION
100-YEAR FLOOD REACH 7b
Percent Finer
100
80
60
40
20
0
-20
FS
MS
CS
VCS
VFG
FG
MG
CG
VCG
COBBLES
.125
.25
0.5
1
2
4
8
16
32
64
500
0.1
1
10
100
1000
Grain Size, mm
start
near peak
end

FIGURE 19.

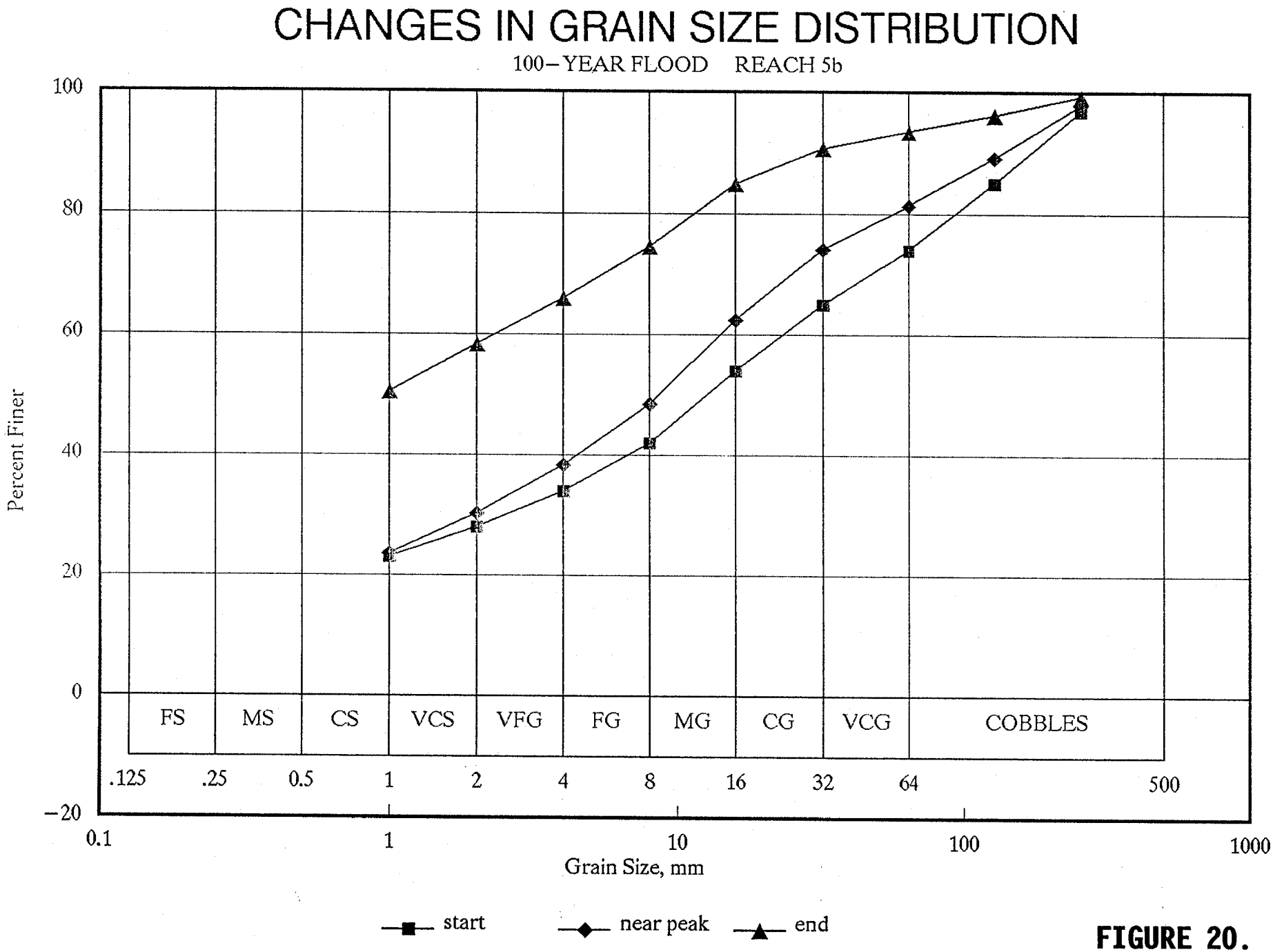
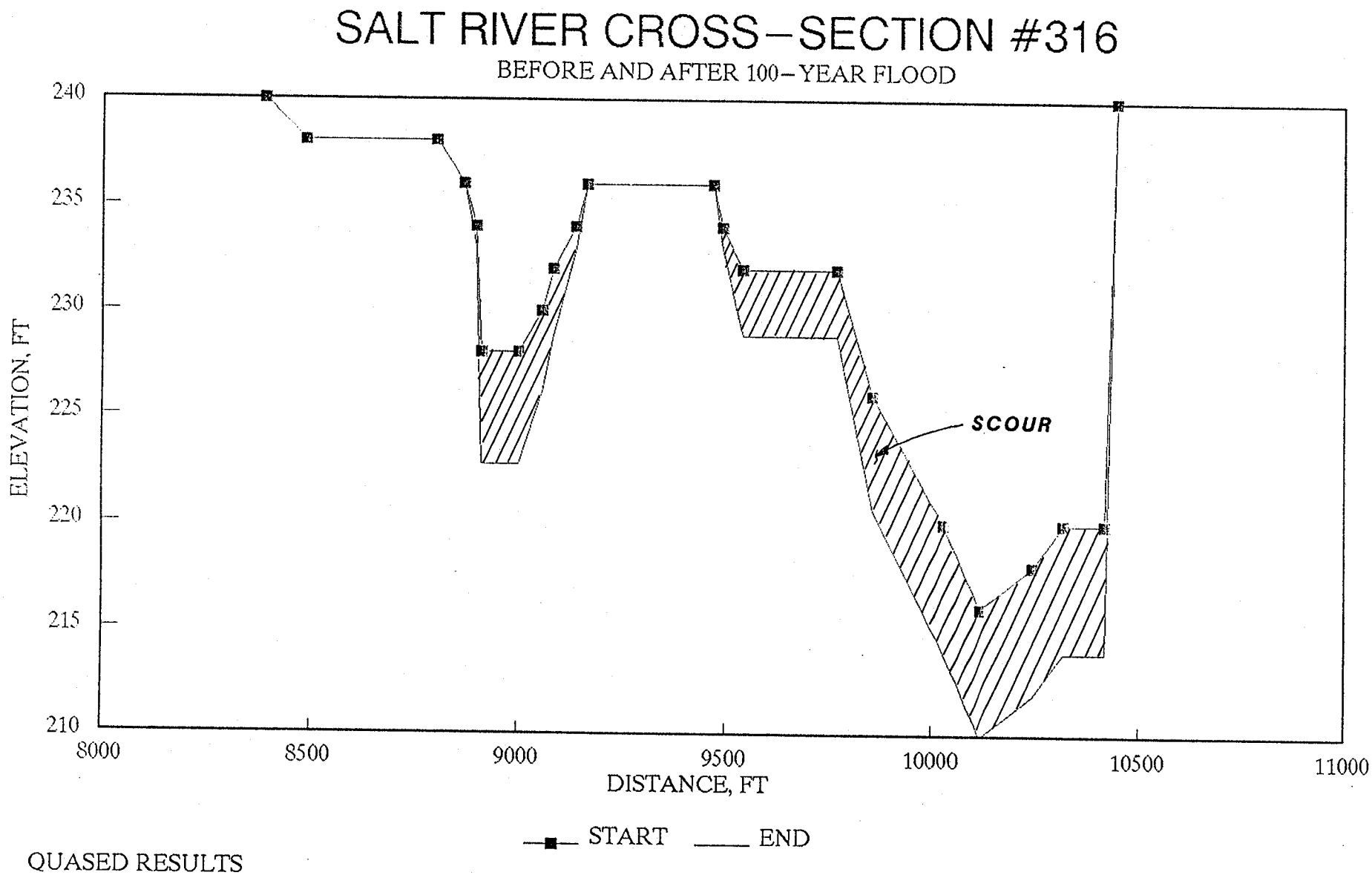

CHANGES IN GRAIN SIZE DISTRIBUTION
100-YEAR FLOOD REACH 5b
Percent Finer
100
80
60
40
20
0
-20
FS
MS
CS
VCS
VFG
FG
MG
CG
VCG
COBBLES
.125
.25
0.5
1
2
4
8
16
32
64
500
0.1
1
10
100
1000
Grain Size, mm
start
near peak
end

FIGURE 20.



QUASED RESULTS

FIGURE 21.

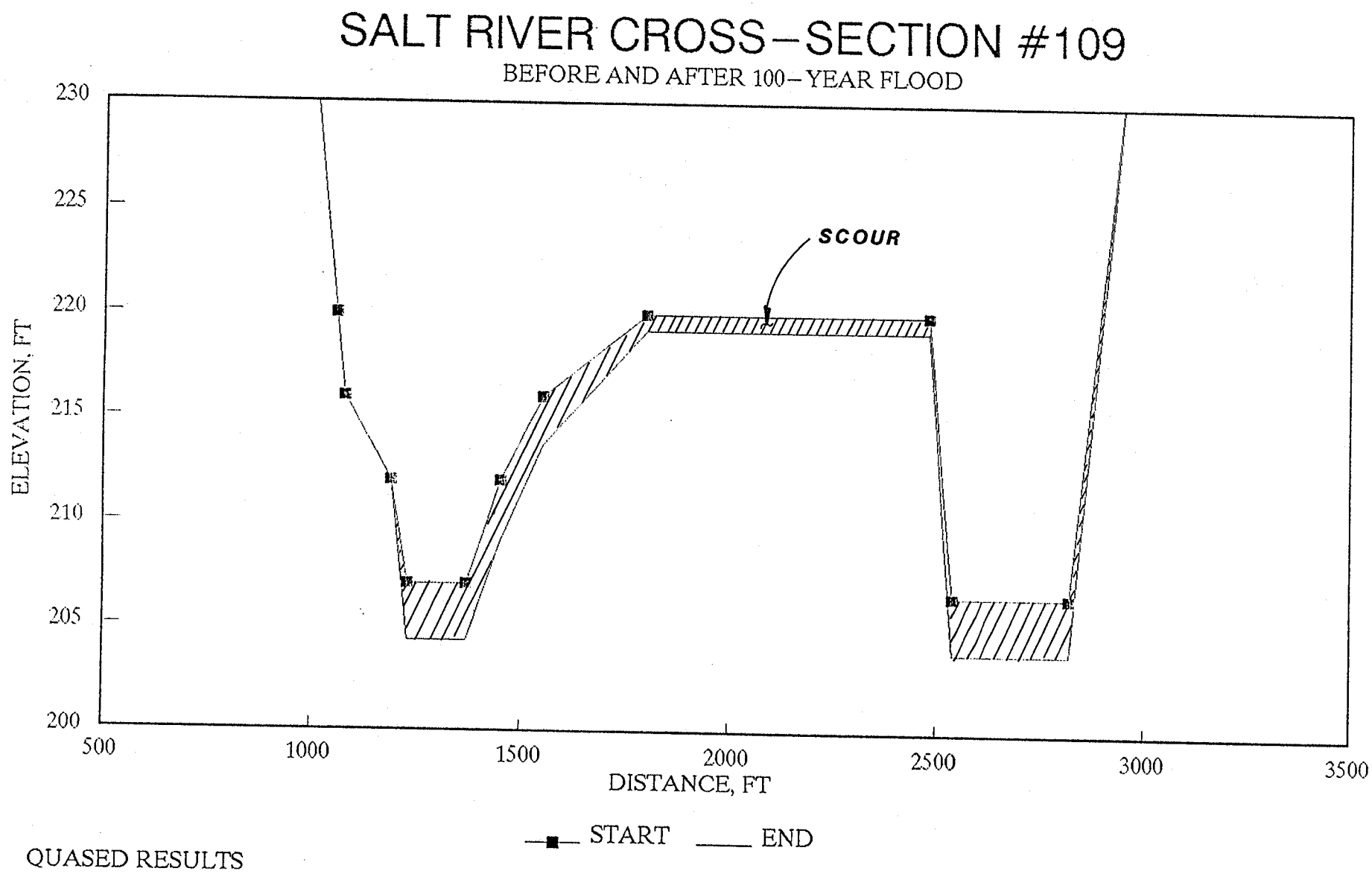
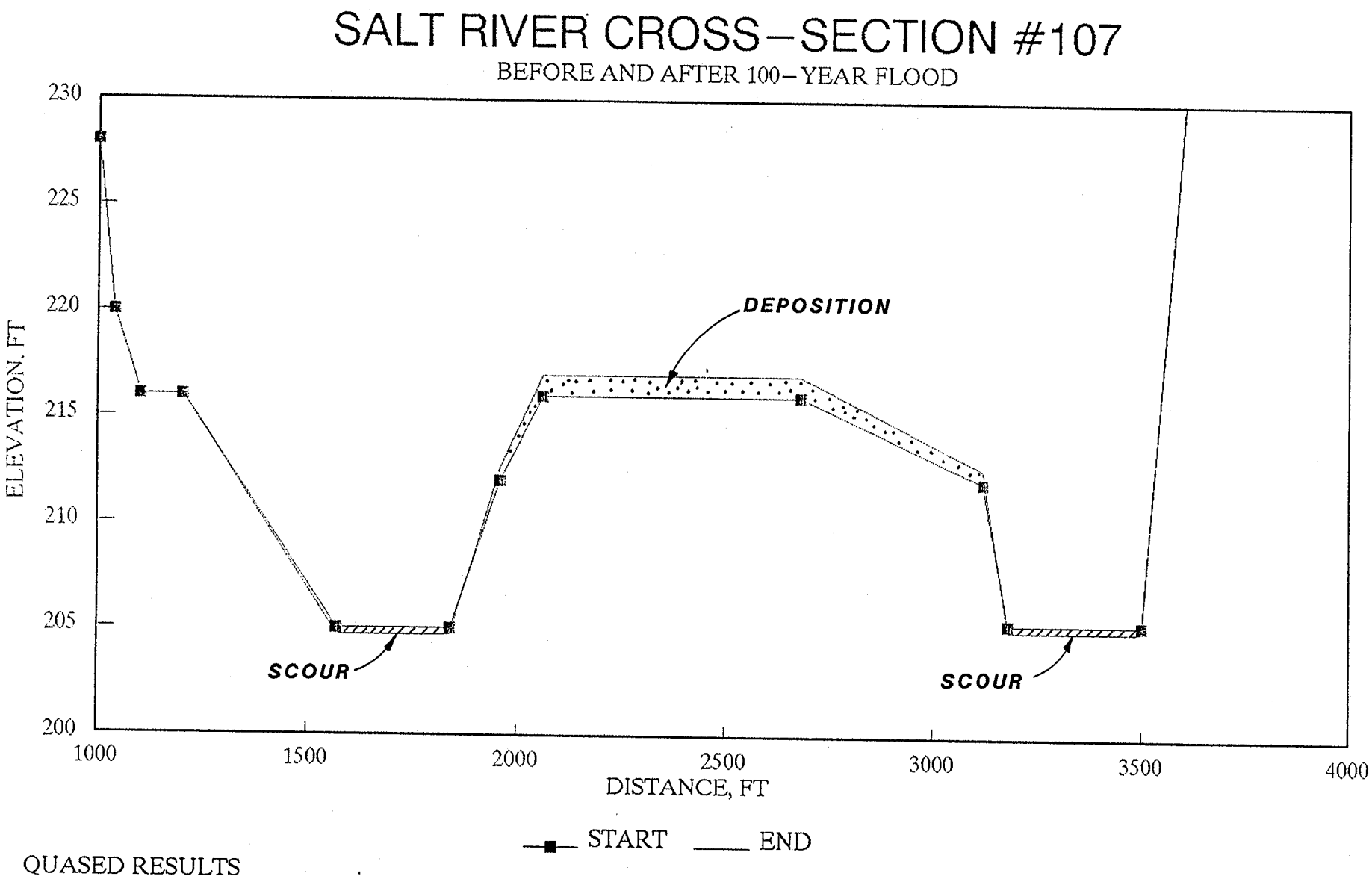
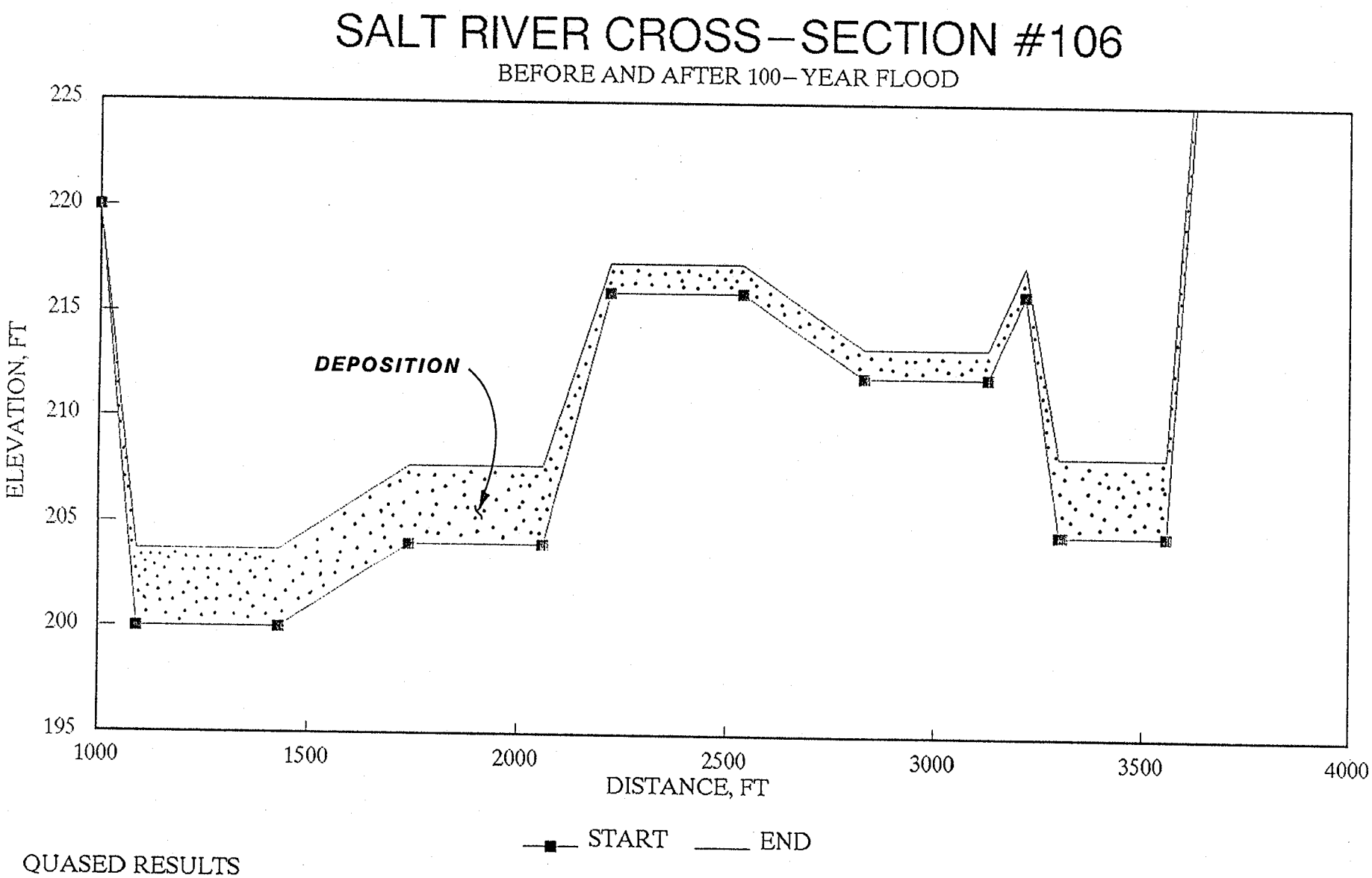

SALT RIVER CROSS–SECTION #109
BEFORE AND AFTER 100–YEAR FLOOD
SCOUR
ELEVATION, FT
230
225
220
215
210
205
200
500
1000
1500
2000
2500
3000
3500
DISTANCE, FT
START
END
QUASED RESULTS

FIGURE 22.



QUASED RESULTS

FIGURE 23.



QUASED RESULTS

FIGURE 24.

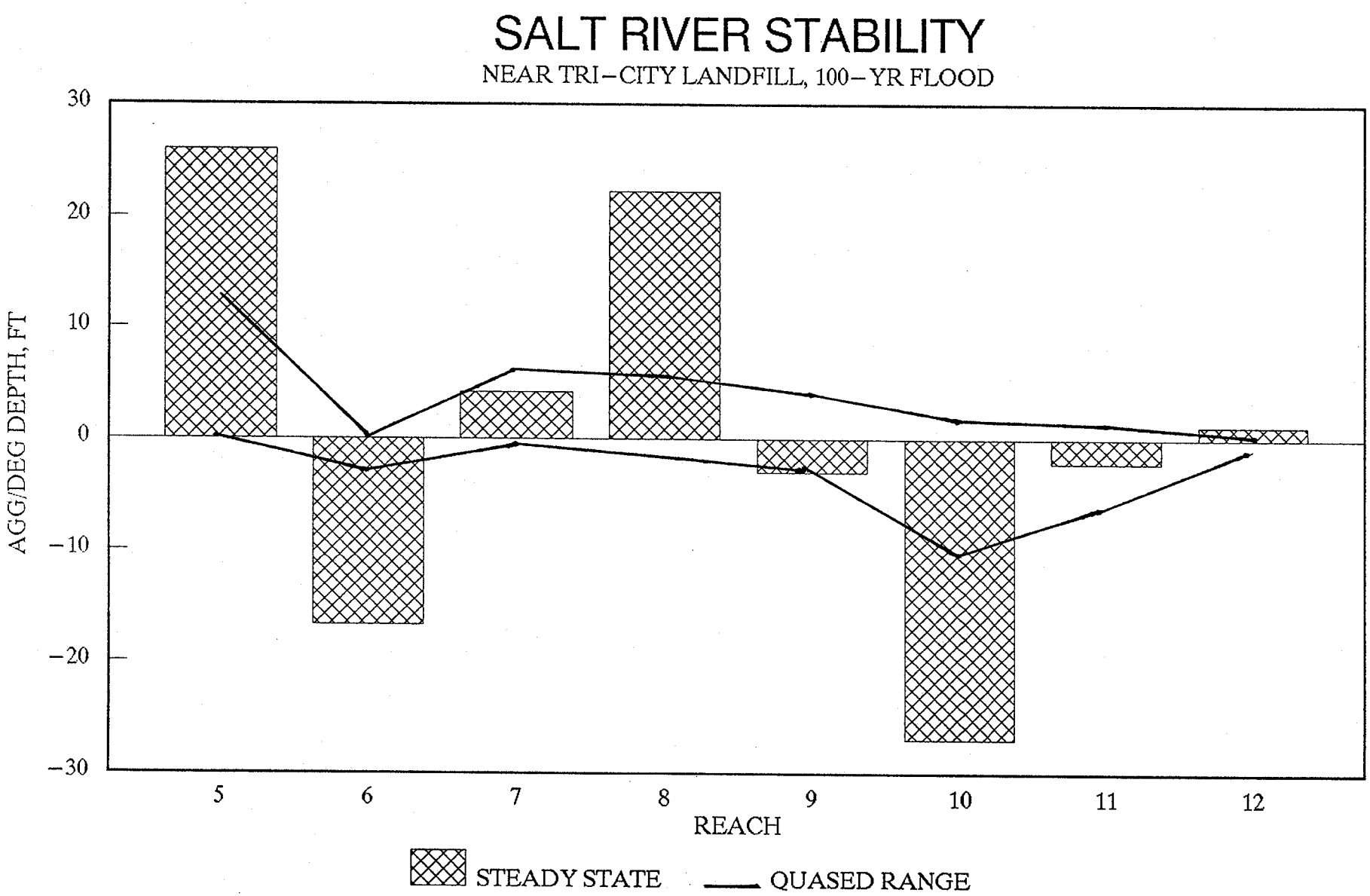
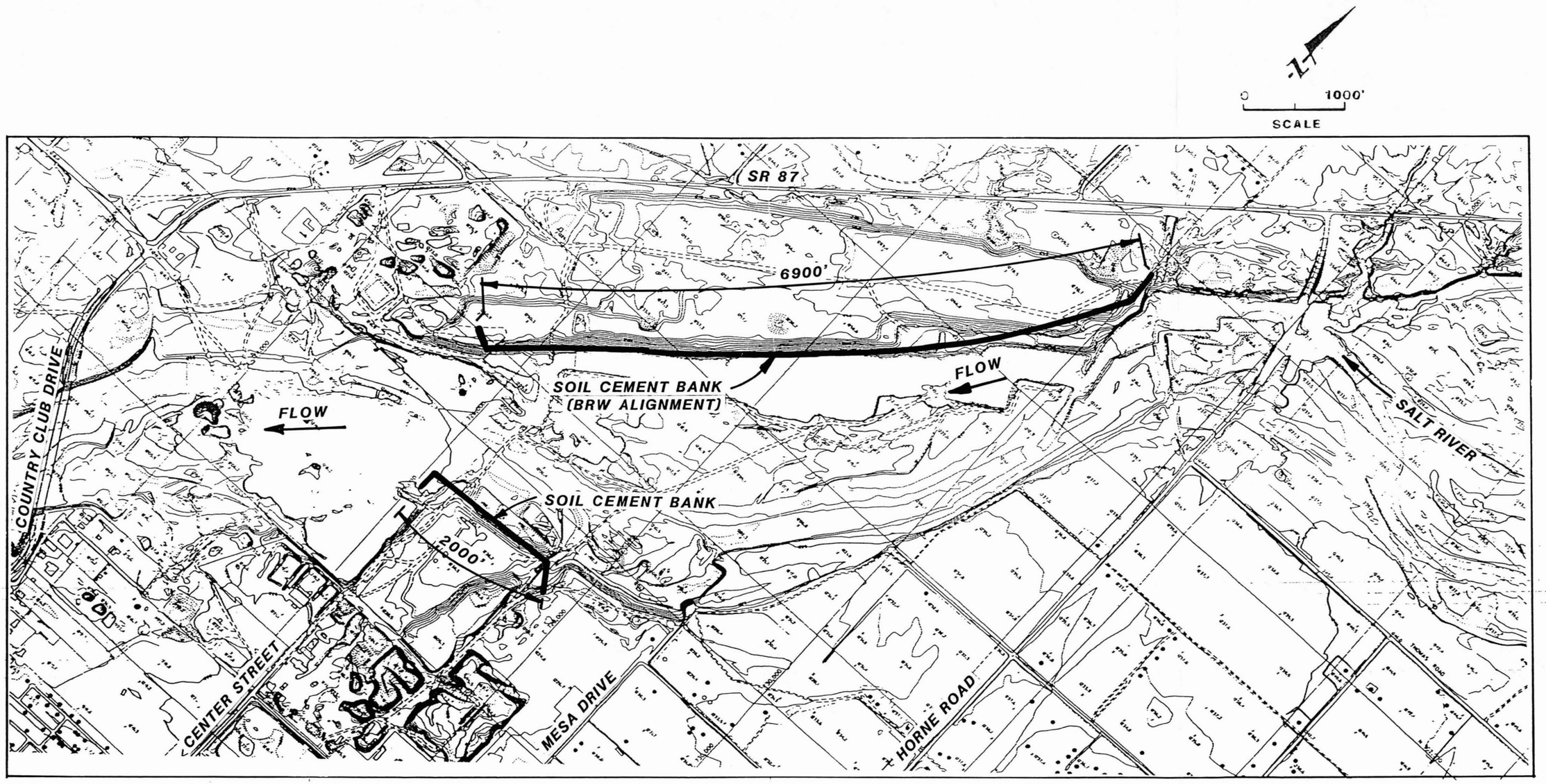

SALT RIVER STABILITY
NEAR TRI-CITY LANDFILL, 100-YR FLOOD
AGG/DEG DEPTH, FT
30
20
10
0
-10
-20
-30
5
6
7
8
9
10
11
12
REACH
STEADY STATE
QUASED RANGE

FIGURE 25.



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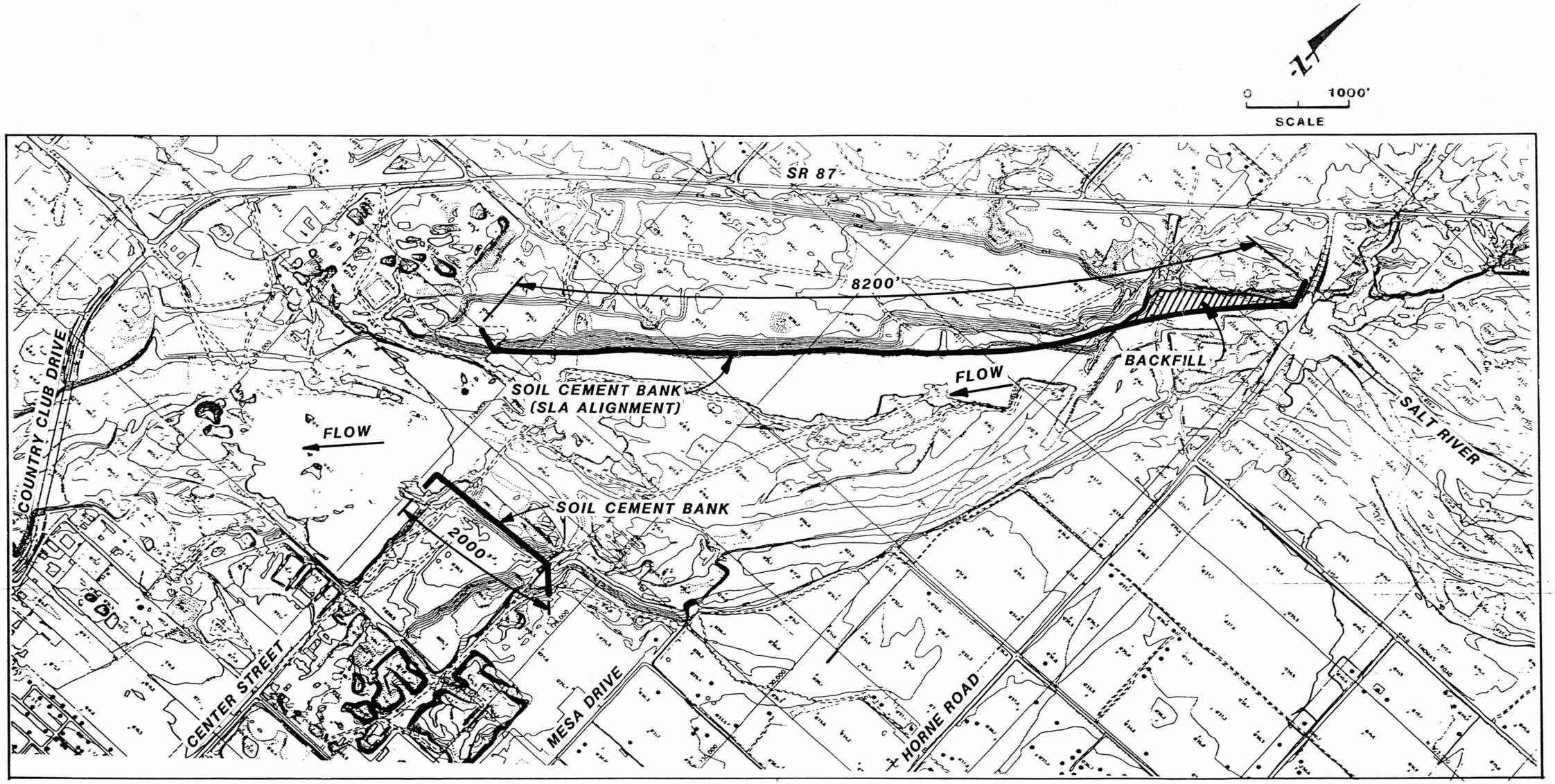
ALTERNATIVE 1 -- SOIL CEMENT BANKS (BRW ALIGNMENT)

FIGURE 26.



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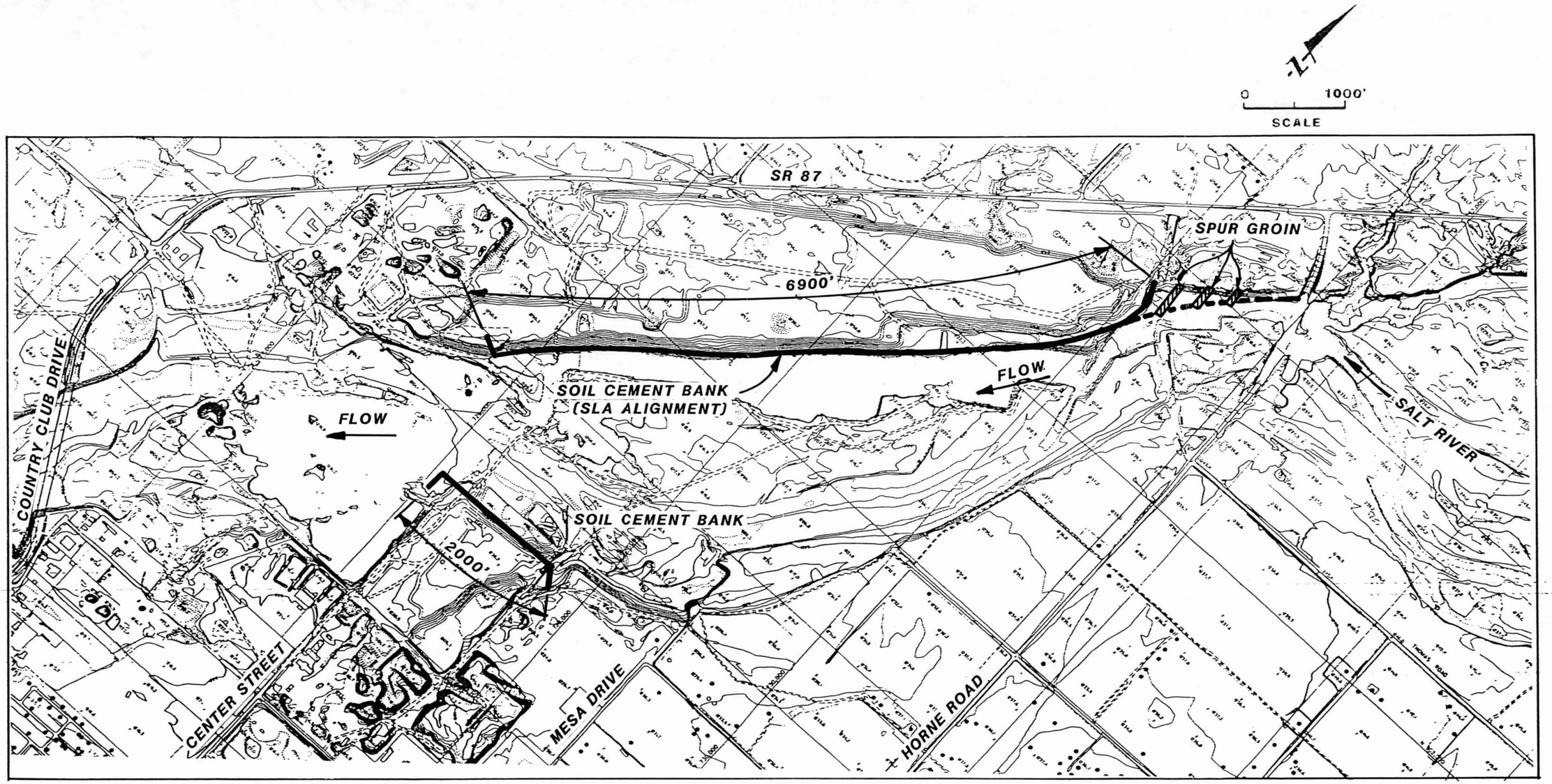
ALTERNATIVE 2 -- SOIL CEMENT BANKS (SLA ALIGNMENT)

FIGURE 27.



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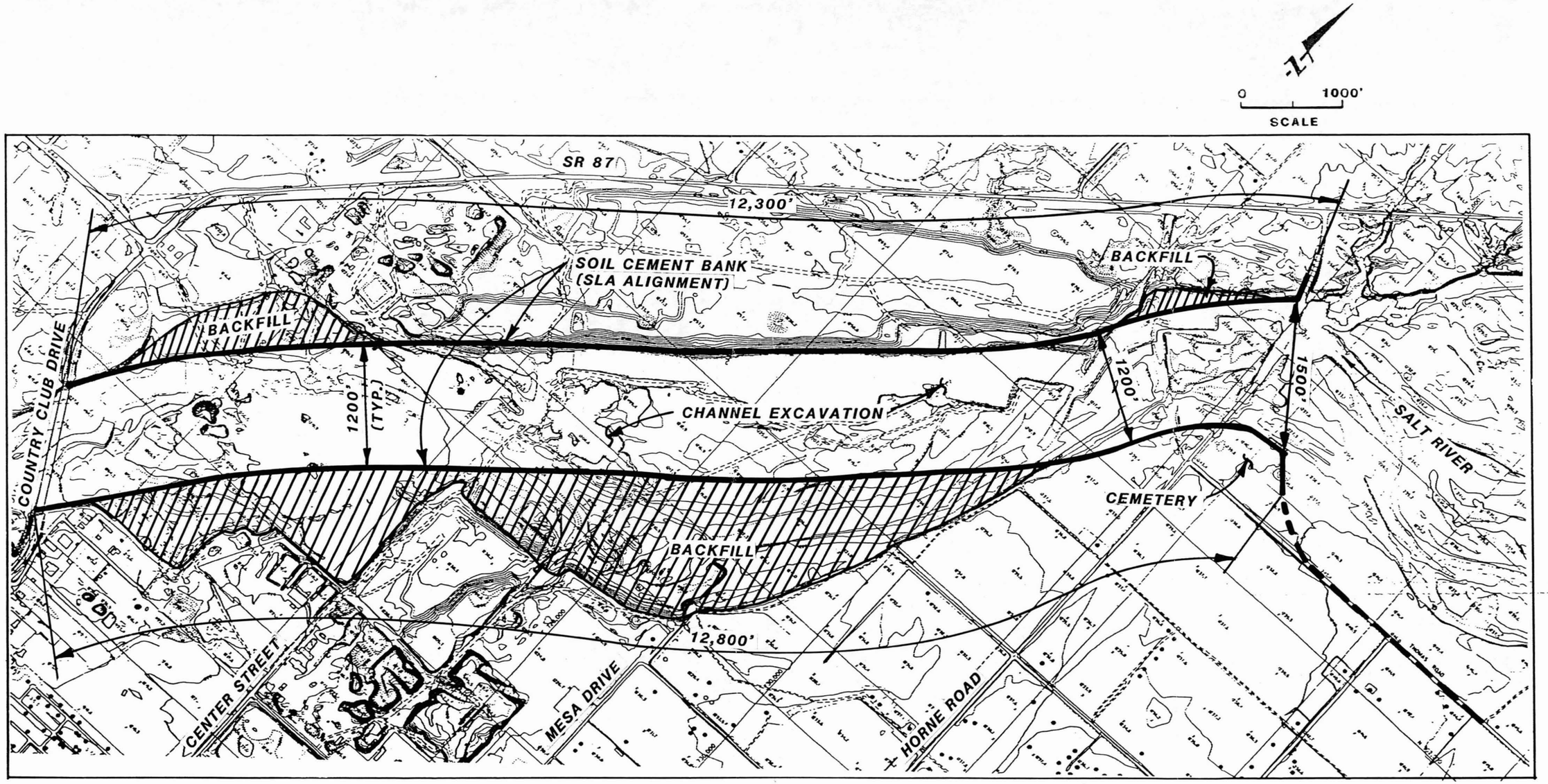
ALTERNATIVE 3 -- SOIL CEMENT BANKS WITH SPUR GROINS

FIGURE 28.



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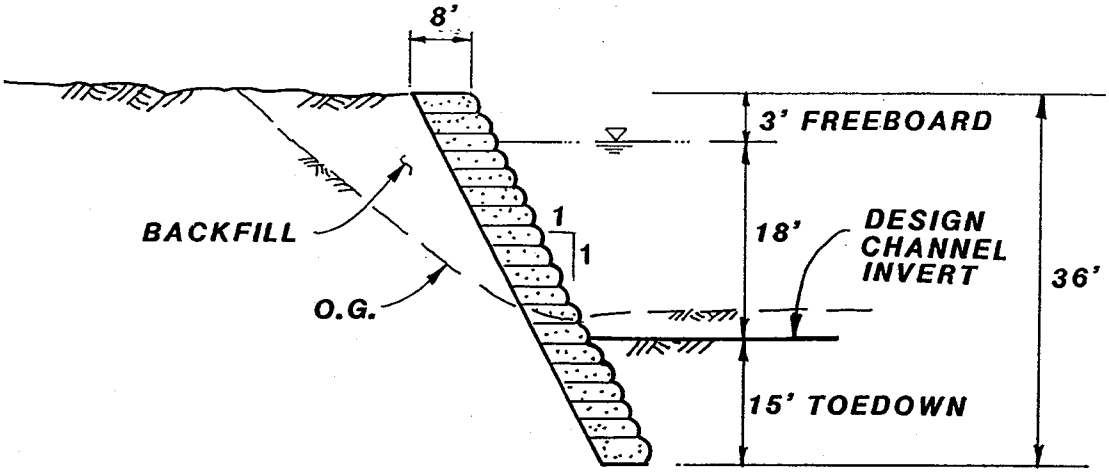
ALTERNATIVE 4 -- CHANNELIZATION WITH SOIL CEMENT BANKS

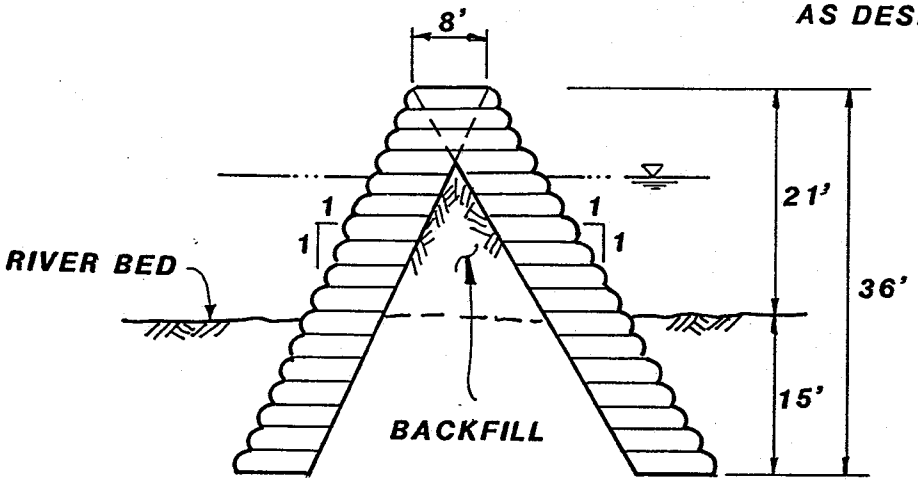
FIGURE 29.



TYPICAL SOIL CEMENT SECTION

N.T.S.

NOTE: ACTUAL DIMENSIONS WILL BE ADJUSTED AS DESIGN PROCEEDS.



TYPICAL SPUR GROIN SECTION

N.T.S.

FIGURE 30.

Table 1. Preliminary Cost Estimate of Flood Control Alternatives

MAJOR ITEM	QUANTITY		UNIT COST ($)	COST ($)
I. Alt. 1 -- Soil Cement Banks (BRW Alignment)				
Soil Cement Banks	8,900	lf	220	1,958,000
			Total	**$1,958,000**
II. Alt. 2 -- Soil Cement Banks (SLA Alignment)				
Soil Cement Banks	10,200	lf	220	2,244,000
Backfill	197,200	cy	1.5	296,000
			Total	**$2,540,000**
III. Alt. 3 -- Soil Cement Banks with Spur Groins				
Soil Cement Banks	8,900	lf	220	1,958,000
Spur Groins (Soil Cement)	900	ft	440	396,000
			Total	**$2,354,000**
IV. Alt. 4 -- Channelization with Soil Cement Banks				
Soil Cement Banks	25,100	lf	220	5,522,000
Channel Excavation	3,104,400	cy	1.2	3,725,000
			Total	**$9,247,000**

NOTES: 1. The soil cement banks were assumed to have a height of 36 ft. Actual dimensions will be adjusted as design proceeds.

2. The Alt.4 also removes about 179 ac land from current 100-year floodplain.