US Army Corps
of Engineers
Buffalo District

# Buffalo River Sedimentation Study

## Buffalo and West Seneca, NY

1988

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Buffalo River Sedimentation Study

## 1. Introduction

The Buffalo River and its tributaries drain a watershed of approximately 408.6 square miles. Sediment erosion from the uplands as well as the stream channels results in a continuous filling of the lower Buffalo River including the Federal navigation channel. Sediment deposition in the lower reaches of the river is also influenced by the level of Lake Erie.

The purpose of this analysis is to study shoaling of the navigation channel if dredging is no longer performed. The computer model HEC-6, "Scour and Deposition in Rivers and Reservoirs", developed by the Hydrologic Engineering Center, Davis California was used for this analysis. The study resulted in two useful products: (1) New thalweg elevations to be used in other studies for HEC-2 backwater analysis to determine the associated water surface elevations upstream of the navigation channel, and to compute average annual damages resulting from these water surface elevations. (2) A general procedure for evaluating the impact of modifying dredging programs or analyzing other district streams. (Appendix A)

## 2. Procedure

Sediment gradation analyses were performed from samples collected at representative cross-sections throughout the Federal navigation channel in 1981. Results from these analyses were assumed to be representative of the existing channel bottom. Figure 1 shows the sampling locations and Table 1 summarizes the gradation analysis for three samples at each site. These were averaged for input to the model. The gradation results obtained at the uppermost section were assumed to be characteristic of the input gradation of the inflowing sediment.

Cross-sections were developed from the 1986 "after dredging" soundings using actual survey points. Of the 36 cross-sections used for dredging purposes, only the 17 sections shown on Figure 2 that are representative sections were used for the sediment model. Analysis for sensitivity to various lake levels were performed using elevations of ; 569.15, 571.15, 571.9, 572.7 and 574.9 feet (NGVD) National Geodetic Vertical Datum), corresponding to level frequencies of 100%, 75%, 50%, 25% and 0% respectively. Note: Lake levels were converted from IGLD (International Great Lakes Datum) 1955 to NGVD by the formula NGVD=IGLD 1955 + 1.3 feet.

A comparison was made between soundings taken after the 1986 dredging and before the 1987 dredging to determine specifically where sediment accumulates in the channel. The purpose of this comparison was to identify visually how much sediment scours or deposits during one season. The information obtained from this analysis was to verify the shoaling rates that were calculated by using the computer simulation. Figures 3, 4, and 5 show the results at typical cross-sections through the study area.

TABLE 1. BUFFALO HARBOR GRAIN SIZE DATA (from 1981 study)

| Sample # | %VC Sand | %C Sand | %M Sand | %F Sand | %VF Sand | %Silt & Clay |
|---|---|---|---|---|---|---|
| BH-1 | 0.00 | 0.03 | 0.16 | 4.69 | 19.40 | 75.72 |
| BH-2 | 0.00 | 0.01 | 0.16 | 3.52 | 21.36 | 74.95 |
| BH-3 | 0.00 | 0.02 | 0.17 | 4.58 | 23.03 | 72.19 |
| BH-16 1 | 0.01 | 0.07 | 0.76 | 3.29 | 6.28 | 89.66 |
| BH-16 2 | 0.00 | 0.03 | 0.26 | 1.68 | 4.19 | 98.84 |
| BH-16 3 | 0.06 | 0.10 | 0.42 | 2.20 | 4.42 | 92.80 |
| BH-19 1 | 0.09 | 1.90 | 3.54 | 4.69 | 4.14 | 84.83 |
| BH-19 2 | 0.14 | 0.27 | 0.86 | 2.20 | 3.68 | 92.85 |
| BH-19 3 | 0.18 | 0.35 | 0.75 | 1.58 | 2.94 | 94.20 |
| BH-21 1 | 0.01 | 0.05 | 0.29 | 0.78 | 2.23 | 96.64 |
| BH-21 2 | 0.00 | 0.06 | 0.30 | 1.91 | 1.59 | 97.14 |
| BH-21 3 | 0.03 | 0.10 | 0.58 | 1.07 | 1.60 | 96.62 |
| BH-24 1 | 0.08 | 0.37 | 1.60 | 4.68 | 7.66 | 85.61 |
| BH-24 2 | 0.01 | 0.23 | 0.79 | 2.87 | 5.71 | 90.39 |
| BH-24 3 | 0.00 | 0.01 | 0.28 | 2.63 | 5.88 | 91.20 |
| BH-27 1 | 0.04 | 0.10 | 0.22 | 0.72 | 2.78 | 86.14 |
| BH-27 2 | 0.21 | 0.24 | 0.66 | 2.18 | 4.46 | 82.26 |
| BH-27 3 | 0.00 | 0.04 | 0.13 | 0.52 | 1.78 | 97.53 |
| BH-29 1 | 0.34 | 0.63 | 0.93 | 1.31 | 2.52 | 94.27 |
| BH-29 2 | 0.01 | 0.08 | 0.20 | 0.56 | 2.13 | 97.02 |
| BH-29 3 | 0.03 | 0.06 | 0.13 | 0.64 | 3.01 | 96.19 |
| BH-31 1 | 0.05 | 0.19 | 0.60 | 2.22 | 5.03 | 91.91 |
| BH-31 2 | 0.26 | 0.60 | 1.64 | 4.31 | 7.14 | 86.05 |
| BH-31 3 | 0.01 | 0.11 | 0.72 | 2.76 | 5.95 | 90.40 |
| BH-34 1 | 0.06 | 0.17 | 0.49 | 3.29 | 4.56 | 91.43 |
| BH-34 2 | 0.00 | 0.02 | 0.26 | 3.16 | 4.26 | 92.30 |
| BH-34 3 | 0.00 | 0.07 | 0.72 | 4.97 | 4.94 | 89.30 |
| BH-43 1 | 0.01 | 0.05 | 0.23 | 3.95 | 5.81 | 89.95 |
| BH-43 2 | 0.00 | 0.01 | 0.15 | 3.31 | 6.00 | 90.53 |
| BH-43 3 | 0.00 | 0.03 | 0.15 | 2.79 | 5.40 | 91.63 |
| BH-44 1 | 0.01 | 0.04 | 0.18 | 0.62 | 1.15 | 98.00 |
| BH-44 2 | 0.00 | 0.04 | 0.18 | 0.58 | 1.16 | 98.04 |
| BH-44 3 | 0.00 | 0.05 | 0.32 | 1.02 | 1.40 | 97.21 |
| BH-46 1 | 0.17 | 0.13 | 0.35 | 0.82 | 0.82 | 97.71 |
| BH-46 2 | 0.02 | 0.09 | 0.27 | 0.81 | 1.00 | 97.81 |
| BH-46 3 | 0.03 | 0.08 | 0.31 | 0.77 | 1.01 | 97.79 |

Three stream gaging stations in the Buffalo River Basin were used to calculate a total daily inflow to the Buffalo River: Buffalo Creek at Gardenville; Cayuga Creek at Lancaster; and Cazenovia Creek at Ebenezer. The water-stage recorder on Buffalo Creek at Gardenville provided daily discharge values for the period of October 1938 to September 1985. The water stage recorder on Cayuga Creek at Lancaster has provided data for the period October 1938 through September 1968 and May 1974 through September 1985. Only peak discharges were available for the period October 1971 through September 1974. The missing data was synthesized by Merideth and Rumer, 1987 using the available daily flows in Cayuga Creek and Buffalo Creek in a linear regression analysis to obtain a relationship for estimating flow in Cayuga Creek as a function of flow in Buffalo Creek. The daily discharge values obtained for Cazenovia Creek at Ebenezer cover the period June 1940 through September 1985. The total daily inflow to the Buffalo River was determined as the sum of the daily inflows from the three tributaries after the flows were prorated to their mouths by a drainage area relationship. The flow duration curve shown on Figures 6A and 6B, was adopted from a previous study by Meredith and Rumer, 1987. For this analysis, the flow distribution was approximated by breaking the flow duration curve up into discrete step functions which were repeated each year for 25 years.

The period of concurrent records is from 1940 through 1985. The average annual peak daily flow of the Buffalo River for this 45 year period of record was 12,300 cfs. The average annual suspended sediment yield for the drainage basin that was used for this study was 94,100 tons. This value was derived from the dredging records and does not reflect through flow of clays and silts. The inflowing sediment was then calibrated to agree with the approximate volume of sediment removed. The dredged volume is actually lower than the recorded inflowing suspended sediment data. However, to compensate for the model's inability to represent the scour of silt and clay, the dredged volume was used. The bedload was assumed to be negligible. The sediment discharge relationship that was used for this study is summarized in Table 2.

Table 2 Sediment Discharge Relationship

| | Flow | | |
|---|---|---|---|
| Sediment Discharge (Tons/day) | 46 (cfs) | 9,400 (cfs) | 21,800 (cfs) |
| Clay | .37 | 4,420 | 13,800 |
| VF Silt | .32 | 3,870 | 12,800 |
| F Silt | .32 | 3,870 | 12,800 |
| M Silt | .32 | 3,870 | 12,800 |
| C Silt | .32 | 3,870 | 12,800 |
| VF Sand | .09 | 1,100 | 3,450 |
| F Sand | .09 | 1,100 | 3,450 |

3. Limitations of the Model

Although the computer model HEC-6 can be used to predict the amount of expected sediment depositon, its limitations should be recognized. The main drawback for application on the Buffalo River is that once silt and clay sized particles are deposited, there is no means for erosion to occur during subsequent high flows. This can result in the apparent deposition of unrealistically high volumes of sediment. Knowing the limitations of the model, it is reasonable to assume that the resulting predicted values are unrealistically high when actual field data are used. In this particular study, the inflowing sediment to the lower reaches of the Buffalo River is primarily composed of silt and clay. In order to assess this apparent over deposition of silt and clay, the sediment gradation input data was modified. The gradation of the channel bottom sediment as well as the inflowing suspended sediment was changed to 100 percent very fine sand. This input data was not used to predict volumes of sediment but rather only to qualify how the sediment is transported through the system and to approximate the maximum channel bottom elevation that would be reached.

4. Results

The results of the HEC-6 model using a gradation of 100% very fine sand show that the maximum deposition occurs in the approximate vicinity of station 200+00. Channel scour occurs from about stations 40+00 to 80+00. In addition to a net scour between Stations 40+00 to 80+00, some sediment is also transported downstream and replaced with inflowing sediment resulting in little or no actual accumulation. To some extent, the level of the lake controls downstream erosion and deposition. At lake level 574.9 (NGVD), the maximum channel bottom elevation that was reached was 561 feet (15 feet of sediment deposition) at about station 27+00. In addition to this downstream peak, a second increase in elevation reaches about 556 feet (10 feet of sediment deposition) at station 95+00 then drops to approximately elevation 554 feet (7 feet to 11 feet of sediment deposition) from station 120+00 to station 220+00. Very similar patterns of deposition and erosion occur for lake levels 569.15, 571.15, 571.9 and 572.7 (NGVD). The maximum elevations between stations 95+00 and 220+00 are similar for lake levels 571.9 and 572.7 (NGVD) peaking at elevation 554 feet (10 feet of sediment deposition) and maintaining an approximate elevation of 552 (6 feet to 9 feet of sediment deposition). The primary difference with levels 571.15 and 569.15 (NGVD) is that the maximum elevations reached during these lower lake levels are between 1 to 2 feet lower.

The results using the actual field data show an overall increase in sediment accumulation for each of the five lake levels. The field data used were obtained in 1981 and indicate that the sediment is primarily comprised of silt with some clay and fine sand. The lowest lake level that was used for this analysis was 569.15 (NGVD) and resulted in the greatest sediment accumulation between stations 160+00 and 210+00 after 5 years of no dredging. The maximum channel bottom elevation that would be reached was between 548 and 549 (1 to 3 feet) from stations 220+00 to 270+00. A second peak accumulation occurred at approximately station 35+00. The maximum channel bottom elevation that would be reached after 25 years of no dredging was 554 and it occurred between Stations 200+00 and 290+00. The intermediate lake levels, 571.15, 571.9 and 572.7 (NGVD), showed similar patterns of deposition and erosion. The model predicted that after 5 years of no dredging, the greatest amount of deposition occurred at approximately Station 210+00. The model also showed that sediment continued to accumulate generally from the upper end of the Federal Navigation Channel, downstream toward the harbor resulting in a maximum channel bottom elevation of about 552 (7 to 9 feet) between Stations 90+00 and 220+00. The highest lake level used for this analysis was 574.9 (NGVD) with the maximum deposition occurring between stations 90+00 and 230+00. The maximum channel bottom elevation reached after 25 years of no dredging was approximately 555 (7 to 12 feet of sediment deposition between Stations 230+00 and 300+00).

The new channel bottoms have been lowered at some stations, based on the assumption that if very fine sand is being transported through the system, then silt and clay will also be transported. The maximum channel bottom elevations were developed by incorporating the results of the model using the 100% very fine sand gradation. Figures 7 through 11 show the thalweg elevation in the Federal navigation channel for 5 year increments for the 5 lake levels used in this analysis.

From these smoothed out curves, sediment increments were obtained at every station for each 5 year interval of no dredging. For this analysis, only the 571.15 (NGVD) lake level was used to develop shoaling rates because it was the closest to the long term (1900-1986) Lake Erie average of 571.12. For practical purposes, these curves were approximated by straight line segments. Figures 12 through 19 show the curves developed from this analysis. They were developed at every cross-section that will be used for the HEC-2 backwater analysis. The slopes of these curves also show the long term average rate at each station for the 5 year increment.

5. Hydraulics

Hydraulic modeling was conducted to derive flood profiles for the Buffalo River in Buffalo and West Seneca, New York. The study reach extends from Lake Erie to Harlem Road bridge or about 44,000 feet. The basic data for stream cross-sections was from "before" soundings done in July 1986 and "after" soundings done in October-November 1986. The cross-sections upstream of the Federal navigation project (Sta. 288+63) were from field surveys done by Corps personnel in February 1987. A location map is shown on Figure 20.

Backwater computations were performed using Computer Program 723-X6-L202A, HEC-2, "Water Surface Profiles," developed by the Hydrologic Engineering Center in Davis, CA. These computations were performed on Buffalo River for existing conditions and for conditions 25 years after eliminating dredging. For the reach, ten bridge sections and 61 stream cross-sections were used in the computations. From field investigtions, "N" values for the channel varied from 0.030 to 0.040. In overbank areas, "N" values varied from 0.050 to 0.090. Roughness coefficients varied according to channel conditions, brush in overbank areas, the presence of roads, buildings, and lawns, depths of flow, and other factors. Expansion and contraction coefficients of 0.4 and 0.2, respectively, were used in these computations. The starting level of these computations at Lake Erie was elevation 571.9 NGVD . The level of Lake Erie exceeds elevation 571.9 50 percent of the time. Backwater computations were performed for the 2- 25- 100- and 500- year floods. Peak discharges are shown on Table 3.

Table 3 Peak Discharges on Buffalo River

| Reach | 2-Yr Discharge (cfs) | 25-Yr Discharge (cfs) | 100-Yr Discharge (cfs) | 500-Yr Discharge (cfs) |
|---|---|---|---|---|
| Lake Erie to downstream mouth Cazenovia Creek | 14500 | 27600 | 34400 | 43200 |
| Upstream mouth Cazenovia Creek to Harlem Road Bridge | 11600 | 22000 | 27100 | 33600 |

Computed water surface and channel bottom profiles are shown on Figures 21 to 25. The changes in the 100-year water surface elevation at several locations are shown on Table 4.

Table 4 Changes in 100-Year Water Surface Elevation

| Station | Exist. Conds. 100-Yr W.S. Elev. (Ft-NGVD) | After 25 Years "No Dredging" 100-Yr. W.S. Elev. (Ft-NGVD) | Difference (Ft) |
|---|---|---|---|
| 110+67 | 575.0 (1) | 576.7 (1) | 1.7 |
| 361+10 | 585.0 | 586.4 | 1.4 |
| 390+11 | 589.5 | 590.1 | 0.6 |
| 416+60 | 591.7 | 592.0 | 0.3 |

(1) Based on Lake Erie water level at elevation 571.9 NGVD. The 100-year instantaneous level of Lake Erie is elevation 581.4 NGVD.

The study area was broken up into four reaches. Reach 1 is bounded by Hamburg Street, South Street, St. Clair Street, Louisiana Street, and Mackinaw Streets. Reach 2A is bounded by Seneca Street, Zittle Avenue, a set of railroad tracks, Southside Parkway, Bailey Avenue, the Buffalo River, and the Buffalo-West Seneca corporate limits. Reach 3A is bounded by the Conrail bridge, the Buffalo River, and the City of Buffalo-West Seneca corporate limits. A small area extends into West Seneca along Mineral Springs Road. This reach includes South Ogden Street, Polish Place, and Polish Court. Reach 3B is bounded by Spann Street, the Buffalo River, Casimar Street and Clinton Street. An index point for each reach was selected. Their locations are shown on Table 5.

Table 5 Index Points

| Identification | Station | Location |
|---|---|---|
| 1 | 110+67 | 1193 feet upstream Ohio Street bridge |
| 2A | 361+10 | 514 feet downstream Conrail bridge |
| 3A | 390+11 | 100 feet upstream South Ogden Street bridge |
| 3B | 416+60 | 2749 feet upstream South Ogden Street bridge |

Lozier Architects/Engineers conducted a damage survey in study area in July-August 1987. Stage-damage curves were developed at each index point. Expected average annual damages were computed using HEC computer program "Expected Annual Flood Damage Computation - EAD." The results are shown on Table 6.

Table 6 Expected Annual Flood Damages

| Index Point | Exist. Conds. Damages (1) ($1000) | After 25 Years "No Dredging" Damages ($1000) | Flood Control Benefits Attributable to Dredging ($1000) |
|---|---|---|---|
| 1 | 34.85 (2) | 34.85 (2) | 0.00 |
| 2A | 3.87 | 17.87 | 14.0 |
| 3A | 19.85 | 26.53 | 6.68 |
| 3B | 47.86 | 60.30 | 12.44 |
| | | | 33.12 |

(1) All damages are based on July 1987 price levels.

(2) Damages are based on instantaneous levels of Lake Erie.

6. Conclusions

1. Based upon the results of the sedimentation analysis using the model HEC-6, it has been concluded that the lower Buffalo River from the upper limit of the Federal navigation channel to the mouth would continue to accumulate sediment for the next 25 years if dredging were no longer performed. It should be noted that the 25 year time period was arbitrarily chosen for the project life.

2. The total increase in deposition for that 25 year period varies from 1 to 10 feet throughout the navigation channel and indicates an overall average rate of accumulation of 0.3 ft/year. The actual elevation increments at each station for the 5, 10, 15, 20, and 25 years are summarized on Table 7.

3. These elevation increments can be added the "existing condition" having thalweg elevations in order to determine the new conditions for the HEC-2 backwater analysis which calculates the water surface elevations if dredging were eliminated.

4. The value of dredging to maintain "existing" cross sections on Buffalo River is approximately $33,000 annually in flood damage reduction.

Table 7. Summary of Shoaling Rates

| Station | $\overline{X}$ | 5 YRS | $\overline{X}$ | 10 YRS | $\overline{X}$ | 15 YRS | $\overline{X}$ | 20 YRS | $\overline{X}$ | 25 YRS |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | .85 | 1.50 | 2.55 | 2.60 | 4.20 | 4.50 | 5.59 | 6.20 | 7.70 | 9.5 |
| 418 | .75 | 1.50 | 2.25 | 2.50 | 3.80 | 3.90 | 5.30 | 5.70 | 6.80 | 8.7 |
| 1022 | .65 | 1.50 | 1.95 | 2.50 | 3.25 | 3.10 | 4.60 | 5.00 | 5.90 | 7.5 |
| 1729 | .60 | 1.10 | 2.15 | 2.50 | 3.60 | 3.60 | 5.05 | 6.30 | 6.50 | 8.0 |
| 2817 | .60 | 0.50 | 2.60 | 2.50 | 3.90 | 4.40 | 5.40 | 8.00 | 7.00 | 9.0 |
| 3458 | .55 | 0.50 | 1.75 | 2.00 | 3.00 | 3.30 | 4.20 | 6.00 | 5.45 | 7.0 |
| 4003 | .35 | 0.50 | 1.05 | 1.50 | 1.75 | 2.00 | 2.50 | 2.50 | 3.20 | 4.0 |
| 5725 | .35 | 0.50 | 1.05 | 1.50 | 1.75 | 2.00 | 2.50 | 2.60 | 3.20 | 3.7 |
| 7581 | .35 | 0.50 | 1.05 | 1.60 | 1.75 | 2.10 | 2.50 | 2.80 | 3.20 | 3.5 |
| 9148 | .55 | 1.30 | 1.55 | 2.80 | 2.65 | 2.90 | 3.65 | 4.50 | 4.70 | 5.1 |
| 9671 | .80 | 1.60 | 2.30 | 3.20 | 3.85 | 4.60 | 4.80 | 5.00 | 5.25 | 5.6 |
| 10215 | .75 | 1.40 | 2.15 | 2.90 | 3.60 | 4.20 | 4.45 | 4.70 | 5.15 | 5.6 |
| 10635 | .65 | 1.20 | 1.95 | 2.60 | 3.60 | 4.00 | 4.30 | 4.60 | 5.15 | 5.6 |
| 11067 | .60 | 1.00 | 1.80 | 2.30 | 3.00 | 3.80 | 4.10 | 4.50 | 5.00 | 5.5 |
| 11610 | .55 | 0.70 | 1.65 | 2.00 | 2.15 | 3.50 | 3.85 | 4.20 | 4.95 | 5.7 |
| 12188 | .45 | 0.50 | 1.50 | 1.70 | 2.50 | 3.20 | 3.55 | 4.00 | 4.60 | 5.5 |
| 12602 | .55 | 0.60 | 1.65 | 2.00 | 2.75 | 3.50 | 3.90 | 4.40 | 5.05 | 6.0 |
| 14036 | .75 | 1.10 | 2.15 | 3.00 | 3.60 | 4.50 | 5.00 | 5.60 | 6.45 | 7.3 |
| 14361 | .75 | 1.20 | 2.15 | 3.10 | 3.65 | 4.60 | 5.10 | 5.80 | 6.60 | 7.5 |
| 14980 | .80 | 1.40 | 2.35 | 3.40 | 3.90 | 5.00 | 5.45 | 6.10 | 7.05 | 8.0 |
| 15823 | .90 | 1.70 | 2.70 | 4.10 | 4.50 | 5.60 | 6.30 | 7.00 | 8.15 | 9.0 |
| 16233 | 1.0 | 2.00 | 3.00 | 4.30 | 5.10 | 5.80 | 6.75 | 7.30 | 8.35 | 9.2 |
| 17695 | 1.25 | 2.90 | 3.90 | 5.00 | 5.80 | 6.70 | 7.60 | 8.50 | 9.25 | 10 |
| 18295 | 1.15 | 3.20 | 3.45 | 5.20 | 5.75 | 7.10 | 8.00 | 8.80 | 10.3 | 10 |
| 19557 | 1.65 | 3.30 | 4.25 | 5.50 | 6.40 | 7.10 | 7.55 | 8.22 | 8.65 | 9.5 |
| 20057 | 1.65 | 3.30 | 4.25 | 5.60 | 6.40 | 7.10 | 7.55 | 8.10 | 8.65 | 9.0 |
| 20855 | 1.60 | 3.40 | 5.00 | 5.70 | 6.35 | 7.00 | 7.30 | 7.70 | 8.30 | 8.7 |
| 21350 | 1.60 | 3.40 | 5.00 | 5.80 | 6.35 | 7.00 | 7.30 | 7.50 | 8.30 | 8.8 |
| 22680 | 1.40 | 3.30 | 4.50 | 5.60 | 5.90 | 6.50 | 6.65 | 6.70 | 7.30 | 7.6 |
| 23828 | 1.70 | 3.30 | 5.00 | 5.30 | 5.50 | 5.90 | 6.00 | 6.10 | 6.50 | 6.7 |
| 24915 | 1.70 | 3.20 | 4.90 | 5.20 | 5.30 | 5.40 | 5.45 | 5.50 | 5.75 | 6.0 |
| 25775 | 1.35 | 3.10 | 4.10 | 5.00 | 5.00 | 5.00 | 5.00 | 5.00 | 5.30 | 5.5 |
| 26545 | 1.50 | 3.30 | 4.50 | 4.70 | 4.80 | 4.90 | 4.95 | 5.00 | 5.10 | 5.3 |
| 26985 | 1.50 | 3.30 | 4.50 | 4.70 | 4.80 | 4.90 | 4.95 | 5.00 | 5.10 | 5.2 |
| 28863 | .10 | 0.00 | 0.35 | 0.50 | 0.55 | 0.70 | 0.75 | 1.00 | 0.95 | 1.0 |

Appendix A. General Procedure for Evaluating the Impact of Various Dredging Options

A general procedure for evaluating the impact of modifying existing dredging programs has been developed for application to future studies. The computer model HEC-6 "Scour and Deposition in Rivers and Reservoirs", developed by the Hydrologic Engineering Center in Davis, California has the capability to predict the channel thalweg elevation for various specified conditions. Sensitivity to lake elevations can also be tested. This model requires actual field data for more accurate results. The necessary input data include gradation analysis of the channel bottom sediments. In addition, the gradation and the sediment rating curve of the inflowing suspended sediment are required to use the model. The sediment rating curves can be obtained from the available stream gage records. The gradation of the inflowing sediment can be estimated using channel bottom sediment data. A reconnaissance field investigation of the study area provides valuable insight to the actual river processes which can be useful especially when analyzing the data.

Surveyed cross sections of the channel along the entire study area are necessary input data to establish the existing channel geometry. Stream gage data are required. For the period of record, a flow duration curve can be developed and used to select representative flows.

The output from the HEC-6 model consists of a summary of accumulated flow and sediment transport from the starting time. For each time period and for each section, the water surface and thalweg elevations are given with the sediment transport in tons/day by sediment type. The results that are obtained from the computer simulation should be compared to known values for verification. For example, in studies that involve the prediction of dredged quantities, previous dredging records are useful to calibrate the model. If soundings are available for the interval between "after dredging" and "before dredging", an approximation can be made of how much sediment accumulates and where it deposits in the channel during a particular interval. Plots of the sediment increments at each cross section for the period of analysis provide useful data. The slopes of these curves represent the shoaling rates at each cross-section.

References

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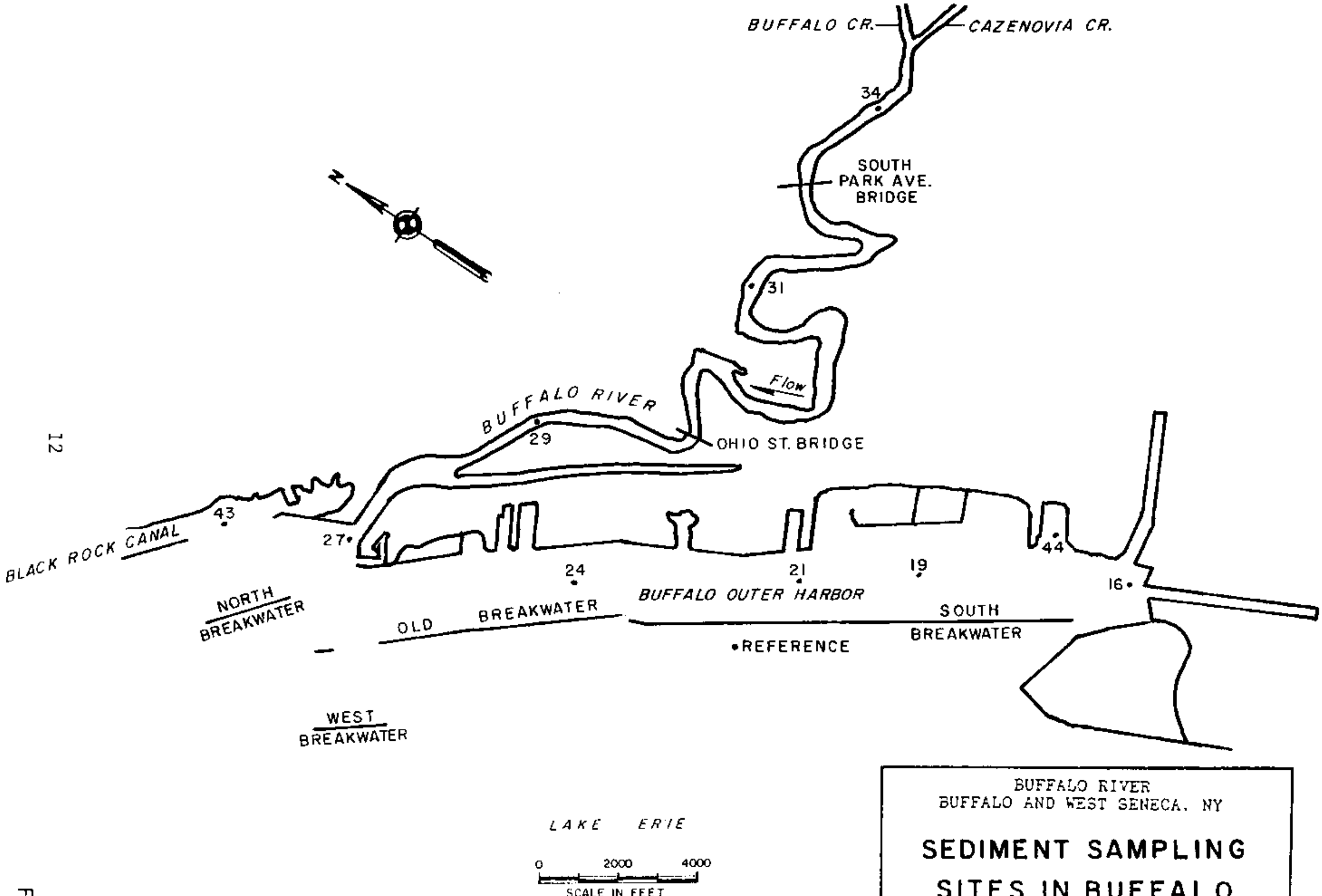
3. USAED, Hydrologic Engineering Center, Davis California, "HEC-2 Water Surface Profiles," Program # 723-X6-L202A, September 1982.

4. USAED, Hydrologic Engineering Center, Davis California, "Expected Annual Flood Damage Computation," February 1984.

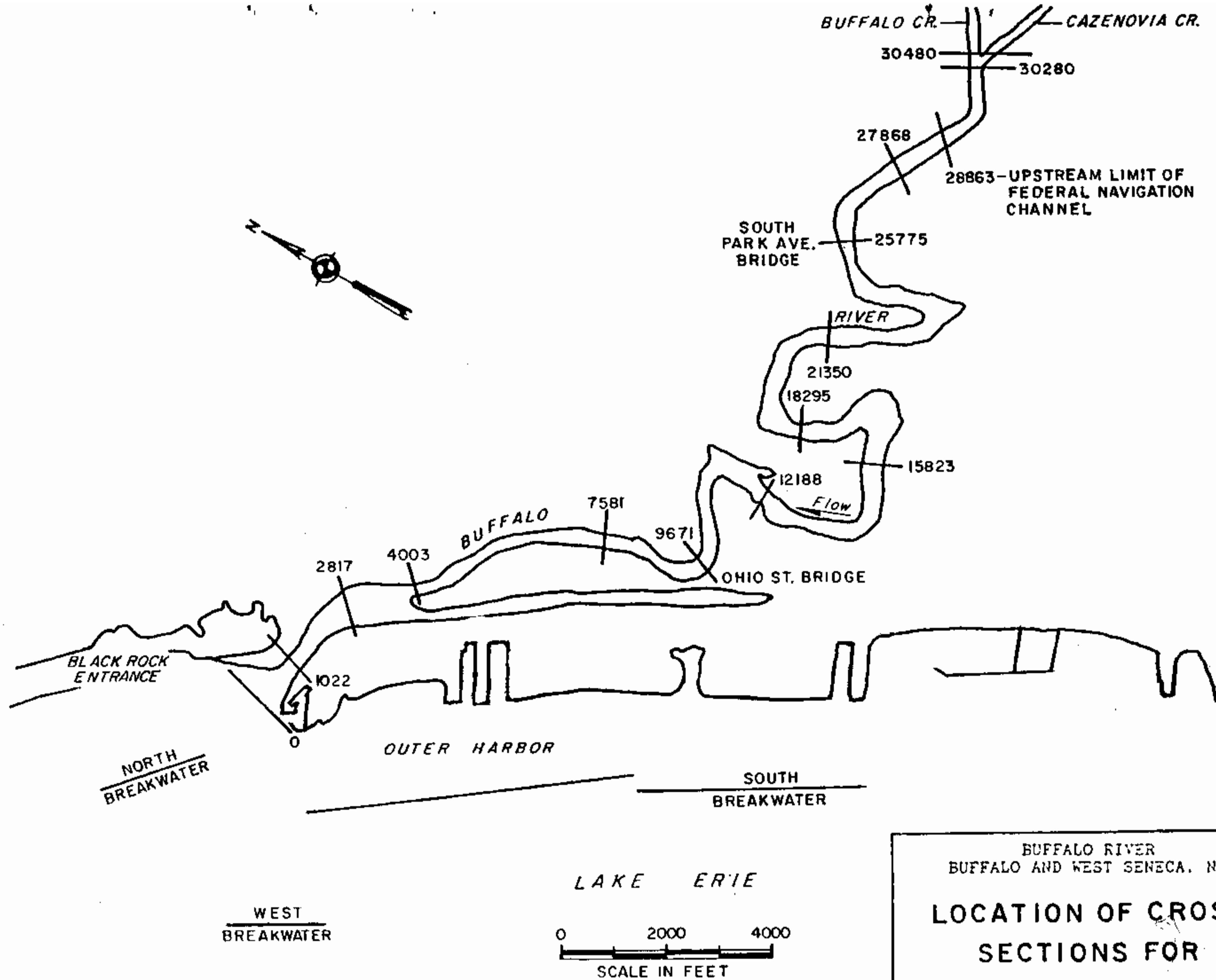



BUFFALO RIVER
BUFFALO AND WEST SENECA, NY

**SEDIMENT SAMPLING SITES IN BUFFALO RIVER AND HARBOR**

U.S. ARMY ENGINEER DISTRICT, BUFFALO

FIGURE

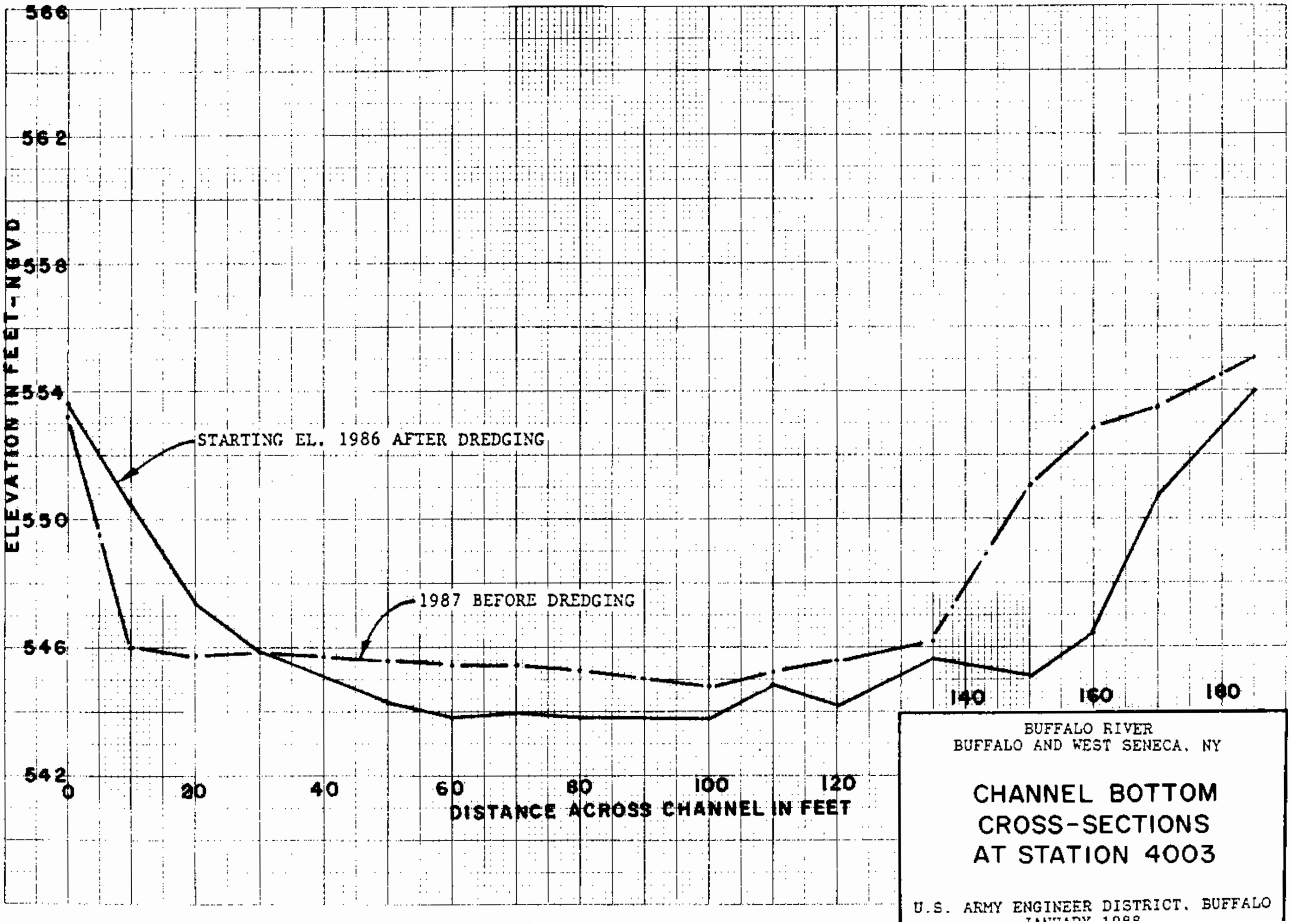



BUFFALO RIVER
BUFFALO AND WEST SENECA, NY

**LOCATION OF CROSS SECTIONS FOR SEDIMENTATION ANALYSIS**

U.S. ARMY ENGINEER DISTRICT, BUFFALO

FIGURE



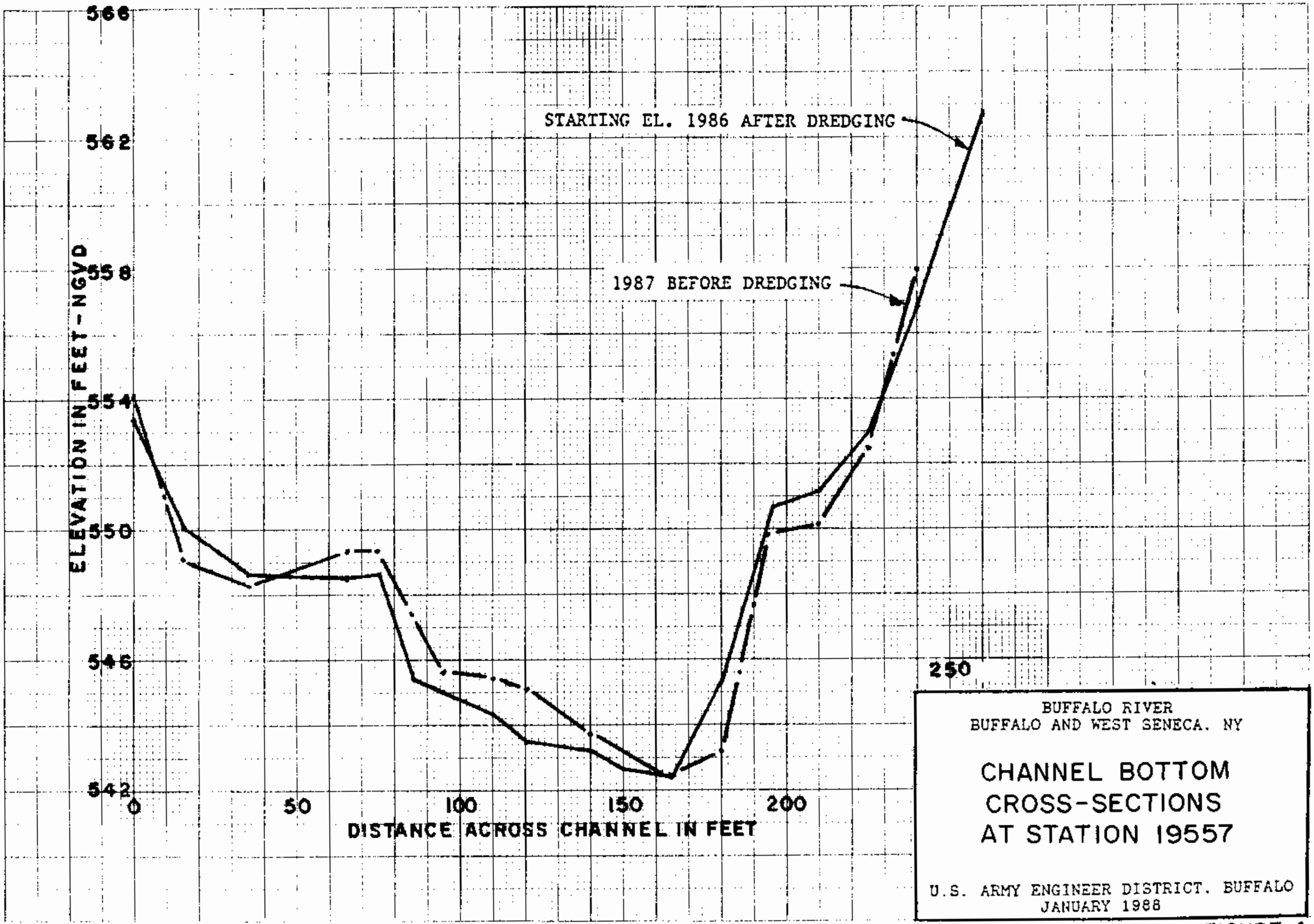

BUFFALO RIVER
BUFFALO AND WEST SENECA, NY

CHANNEL BOTTOM CROSS-SECTIONS AT STATION 4003

U.S. ARMY ENGINEER DISTRICT, BUFFALO



FIGURE




BUFFALO RIVER
BUFFALO AND WEST SENECA, NY

**CHANNEL BOTTOM CROSS-SECTIONS AT STATION 19557**

U.S. ARMY ENGINEER DISTRICT, BUFFALO
JANUARY 1988

FIGURE 4

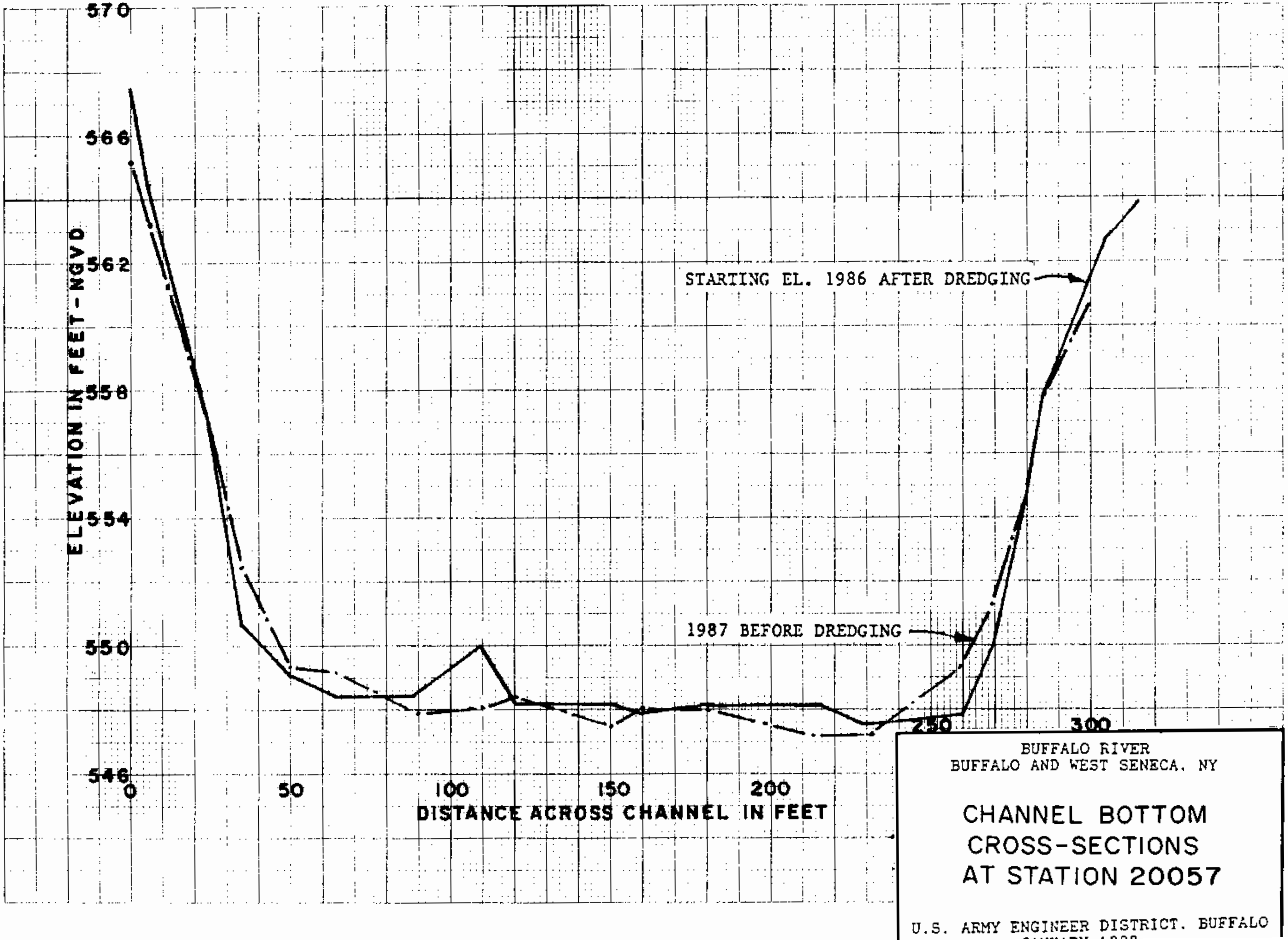
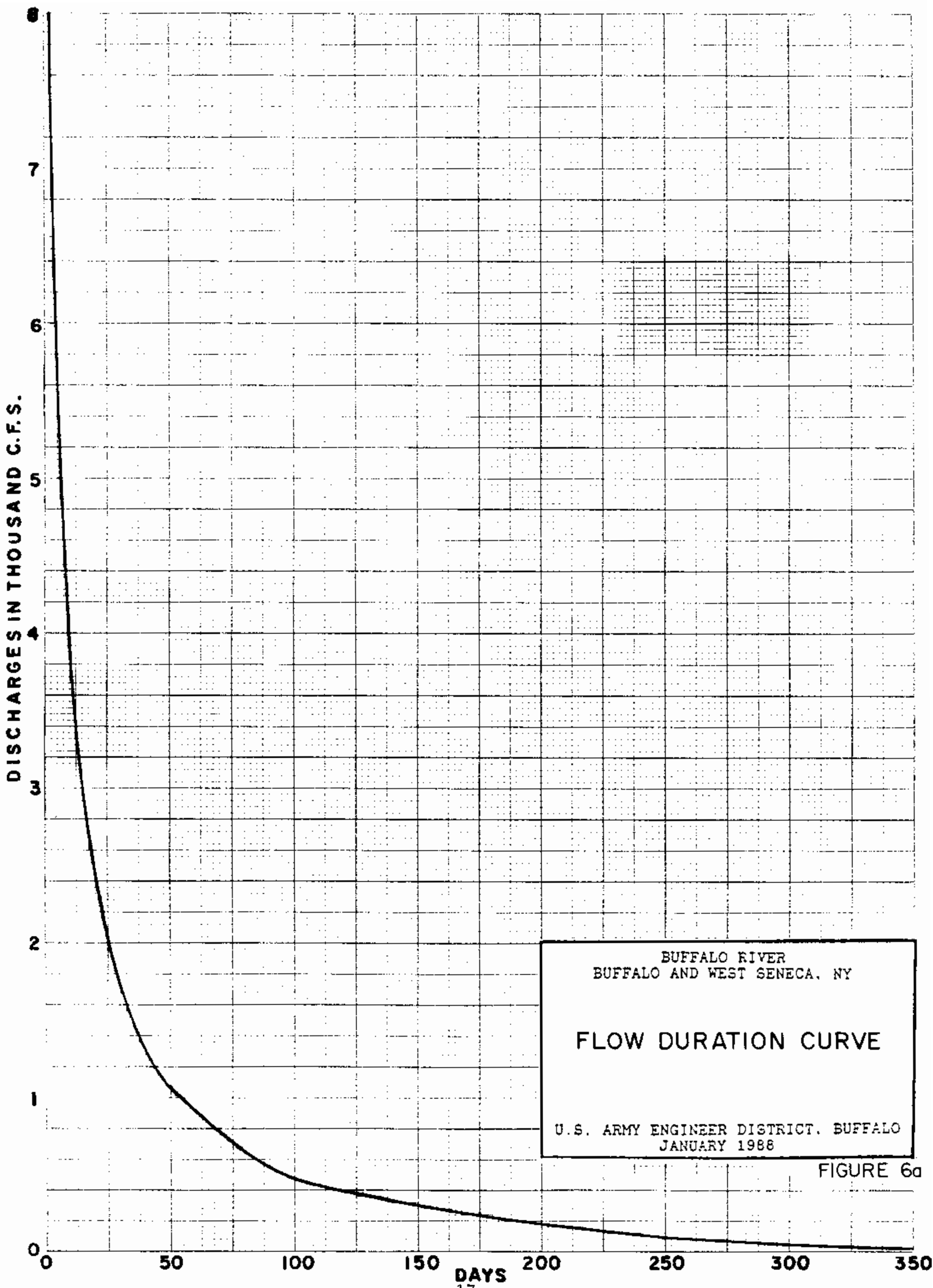

570
566
562
558
554
550
546
ELEVATION IN FEET-NGVD
0
50
100
150
200
250
300
DISTANCE ACROSS CHANNEL IN FEET
STARTING EL. 1986 AFTER DREDGING
1987 BEFORE DREDGING
BUFFALO RIVER
BUFFALO AND WEST SENECA, NY
CHANNEL BOTTOM
CROSS-SECTIONS
AT STATION 20057
U.S. ARMY ENGINEER DISTRICT, BUFFALO

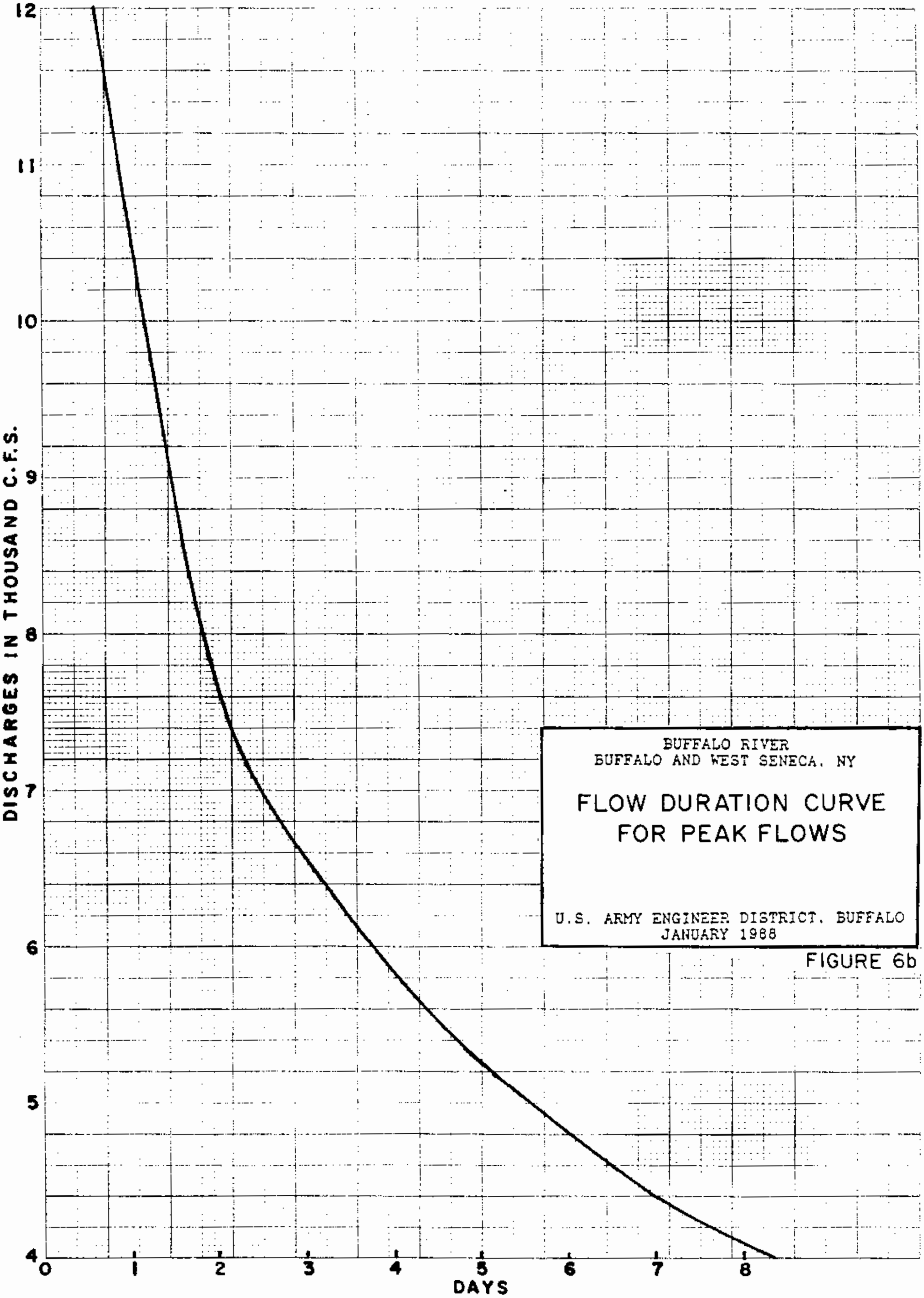


FIGURE 5



DISCHARGES IN THOUSAND C.F.S.
DAYS
0
1
2
3
4
5
6
7
8
0
50
100
150
200
250
300
350
BUFFALO RIVER
BUFFALO AND WEST SENECA, NY
FLOW DURATION CURVE
U.S. ARMY ENGINEER DISTRICT, BUFFALO
JANUARY 1988


FIGURE 6a



DISCHARGES IN THOUSAND C.F.S.
12
11
10
9
8
7
6
5
4
0
1
2
3
4
5
6
7
8
DAYS
BUFFALO RIVER
BUFFALO AND WEST SENECA, NY
FLOW DURATION CURVE
FOR PEAK FLOWS
U.S. ARMY ENGINEER DISTRICT, BUFFALO
JANUARY 1988

FIGURE 6b

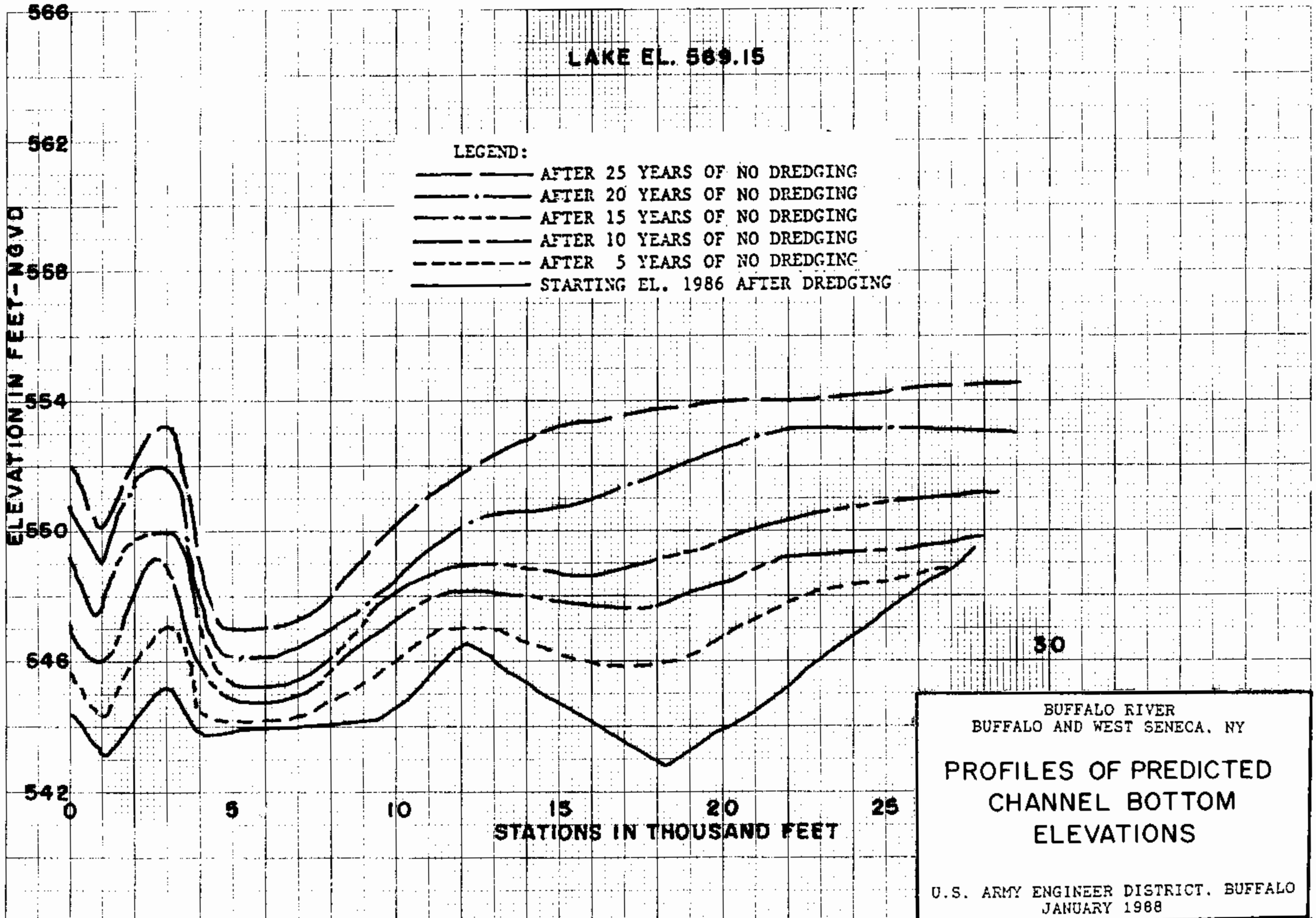



FIGURE 7



FIGURE 7

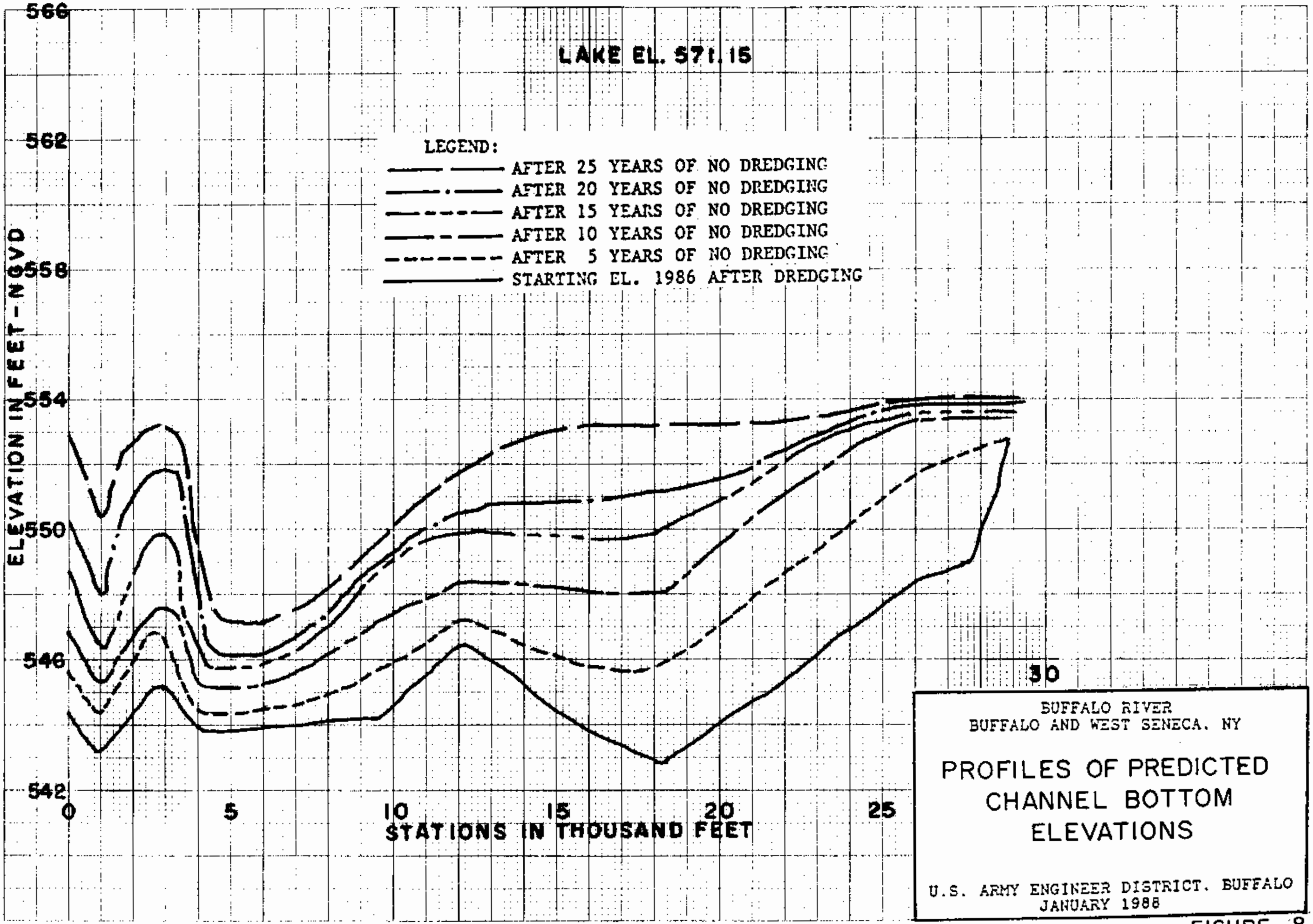



FIGURE 8

FIGURE 8

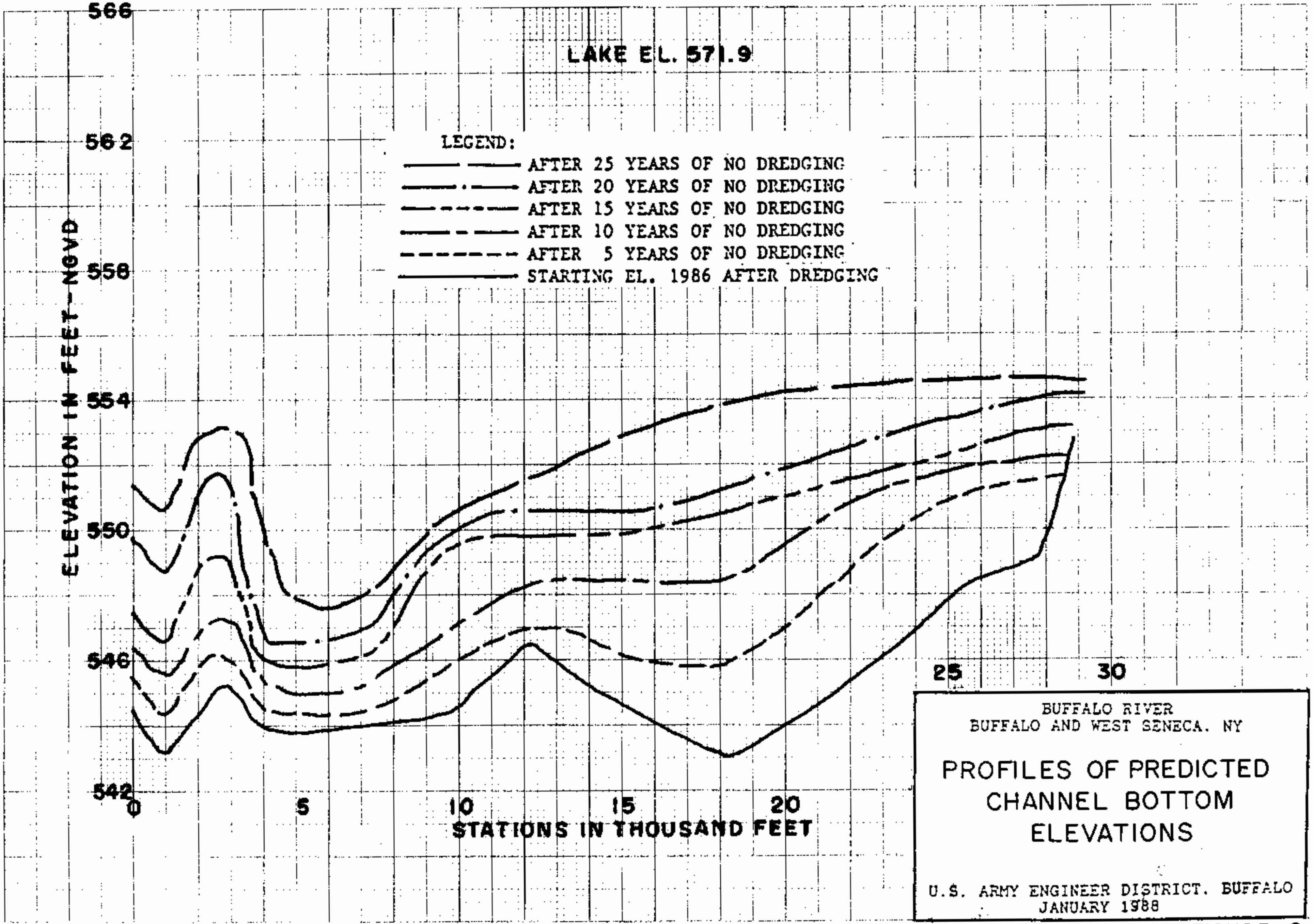
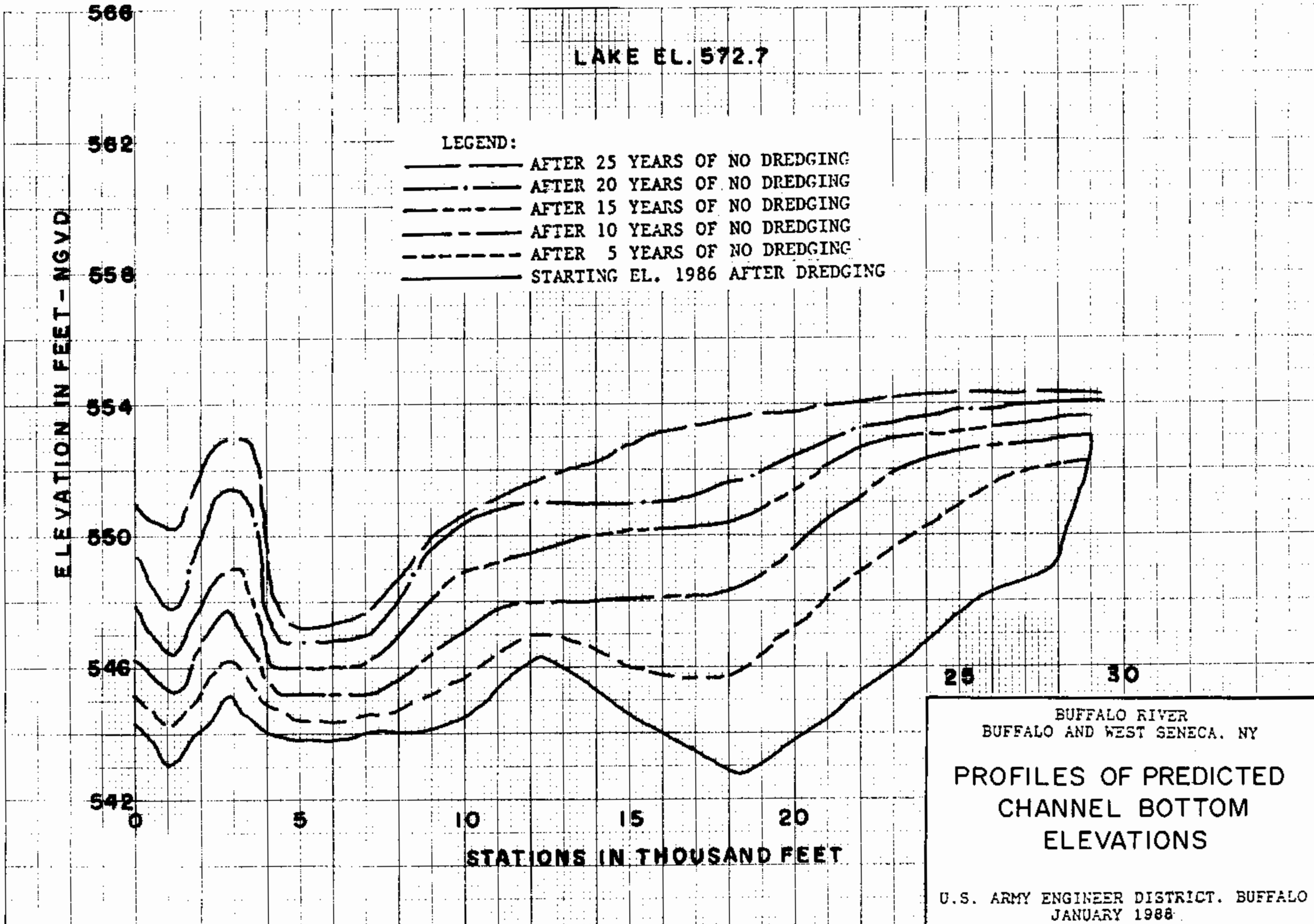

LAKE EL. 571.9
LEGEND:
AFTER 25 YEARS OF NO DREDGING
AFTER 20 YEARS OF NO DREDGING
AFTER 15 YEARS OF NO DREDGING
AFTER 10 YEARS OF NO DREDGING
AFTER 5 YEARS OF NO DREDGING
STARTING EL. 1986 AFTER DREDGING
566
562
558
554
550
546
542
ELEVATION IN FEET - NGVD
0
5
10
15
20
25
30
STATIONS IN THOUSAND FEET
BUFFALO RIVER
BUFFALO AND WEST SENECA, NY
PROFILES OF PREDICTED CHANNEL BOTTOM ELEVATIONS
U.S. ARMY ENGINEER DISTRICT, BUFFALO
JANUARY 1988

FIGURE 9




BUFFALO RIVER
BUFFALO AND WEST SENECA, NY

PROFILES OF PREDICTED CHANNEL BOTTOM ELEVATIONS

U.S. ARMY ENGINEER DISTRICT, BUFFALO
JANUARY 1988

FIGURE 10



FIGURE 10

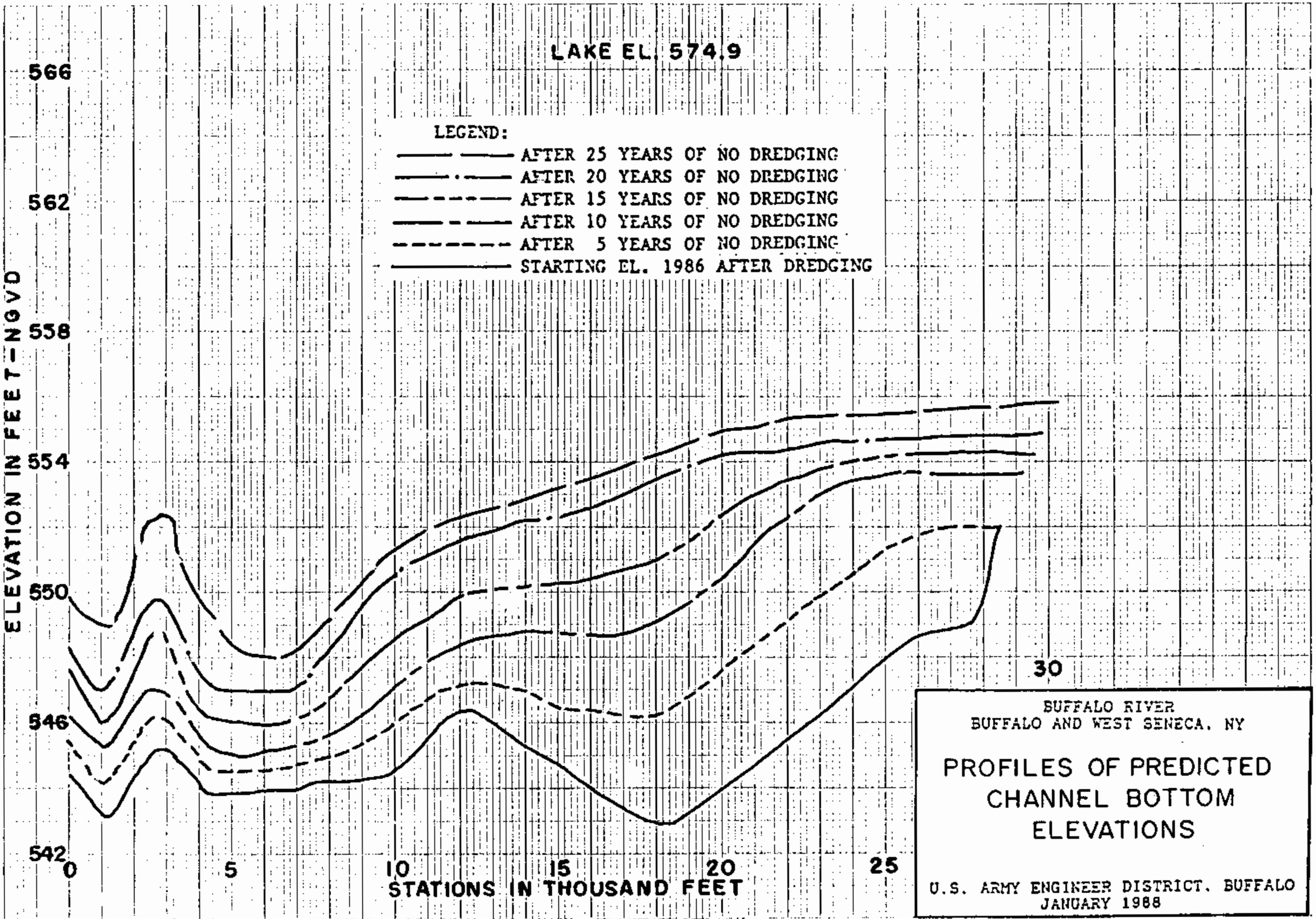
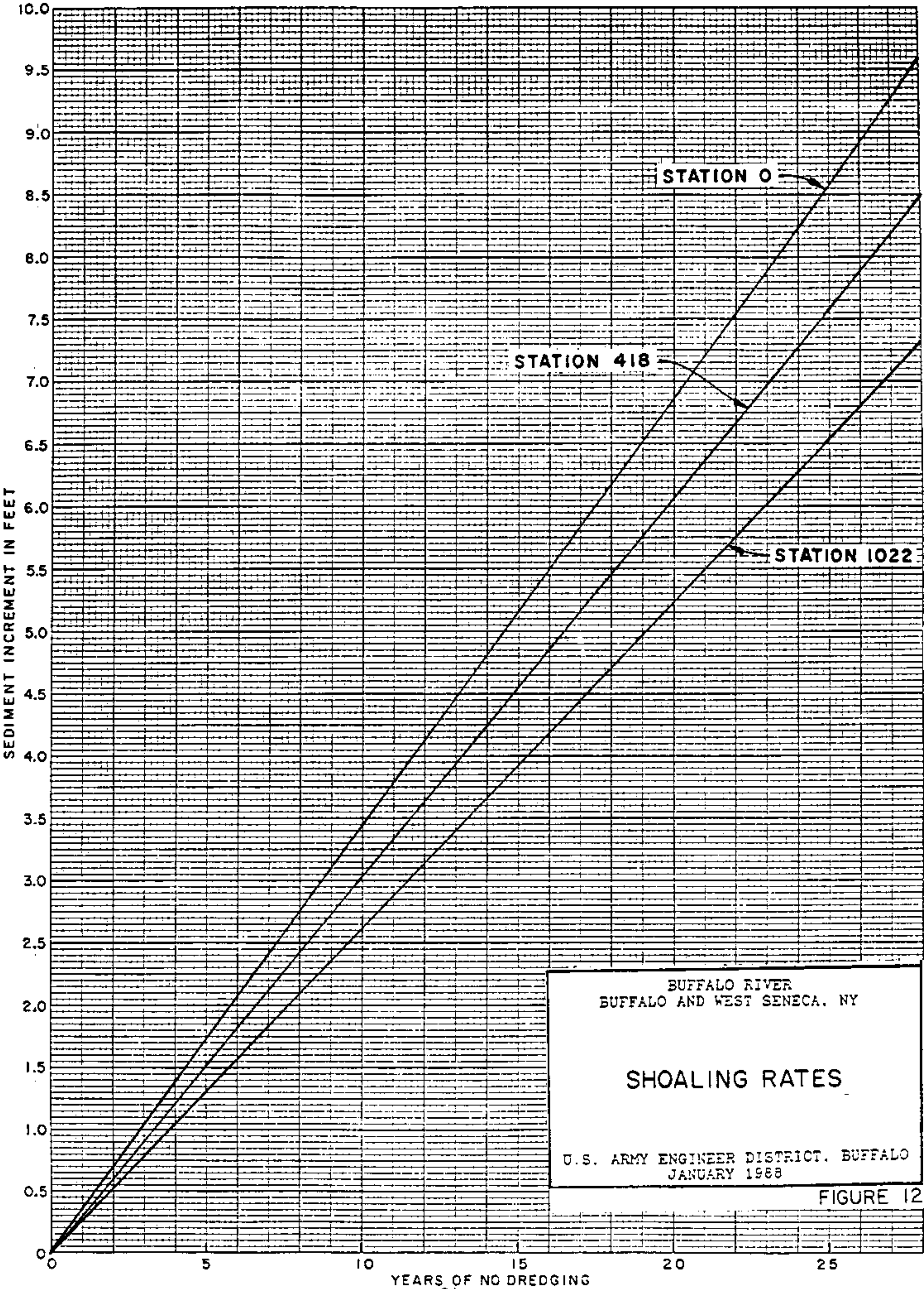

LAKE EL. 574.9
LEGEND:
AFTER 25 YEARS OF NO DREDGING
AFTER 20 YEARS OF NO DREDGING
AFTER 15 YEARS OF NO DREDGING
AFTER 10 YEARS OF NO DREDGING
AFTER 5 YEARS OF NO DREDGING
STARTING EL. 1986 AFTER DREDGING
ELEVATION IN FEET-NGVD
566
562
558
554
550
546
542
0
5
10
15
20
25
30
STATIONS IN THOUSAND FEET
BUFFALO RIVER
BUFFALO AND WEST SENECA, NY
PROFILES OF PREDICTED CHANNEL BOTTOM ELEVATIONS
U.S. ARMY ENGINEER DISTRICT, BUFFALO
JANUARY 1988

FIGURE 1

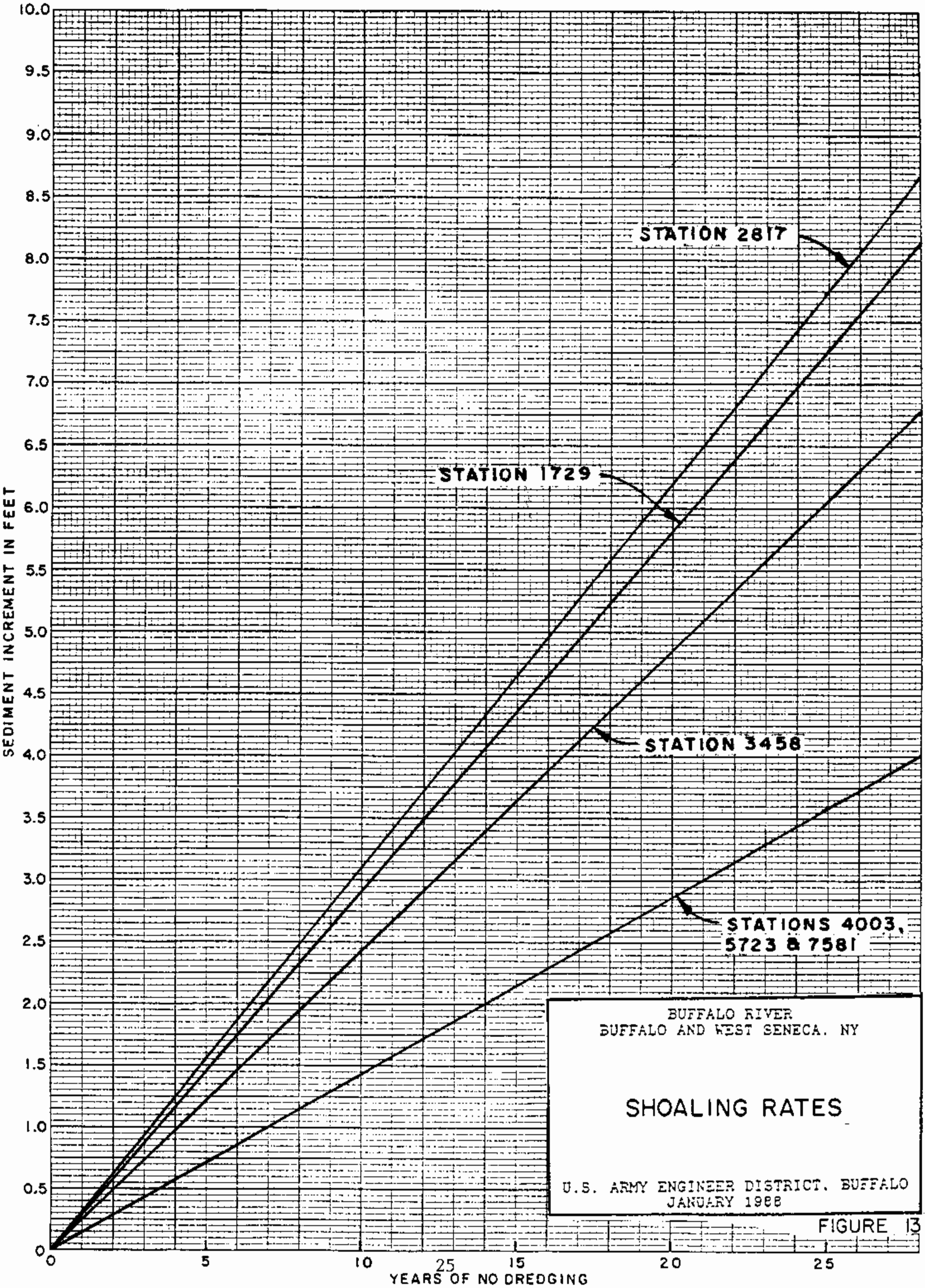



BUFFALO RIVER
BUFFALO AND WEST SENECA, NY

SHOALING RATES

U.S. ARMY ENGINEER DISTRICT, BUFFALO
JANUARY 1988

FIGURE 12




BUFFALO RIVER
BUFFALO AND WEST SENECA, NY

SHOALING RATES

U.S. ARMY ENGINEER DISTRICT, BUFFALO
JANUARY 1988

FIGURE 13

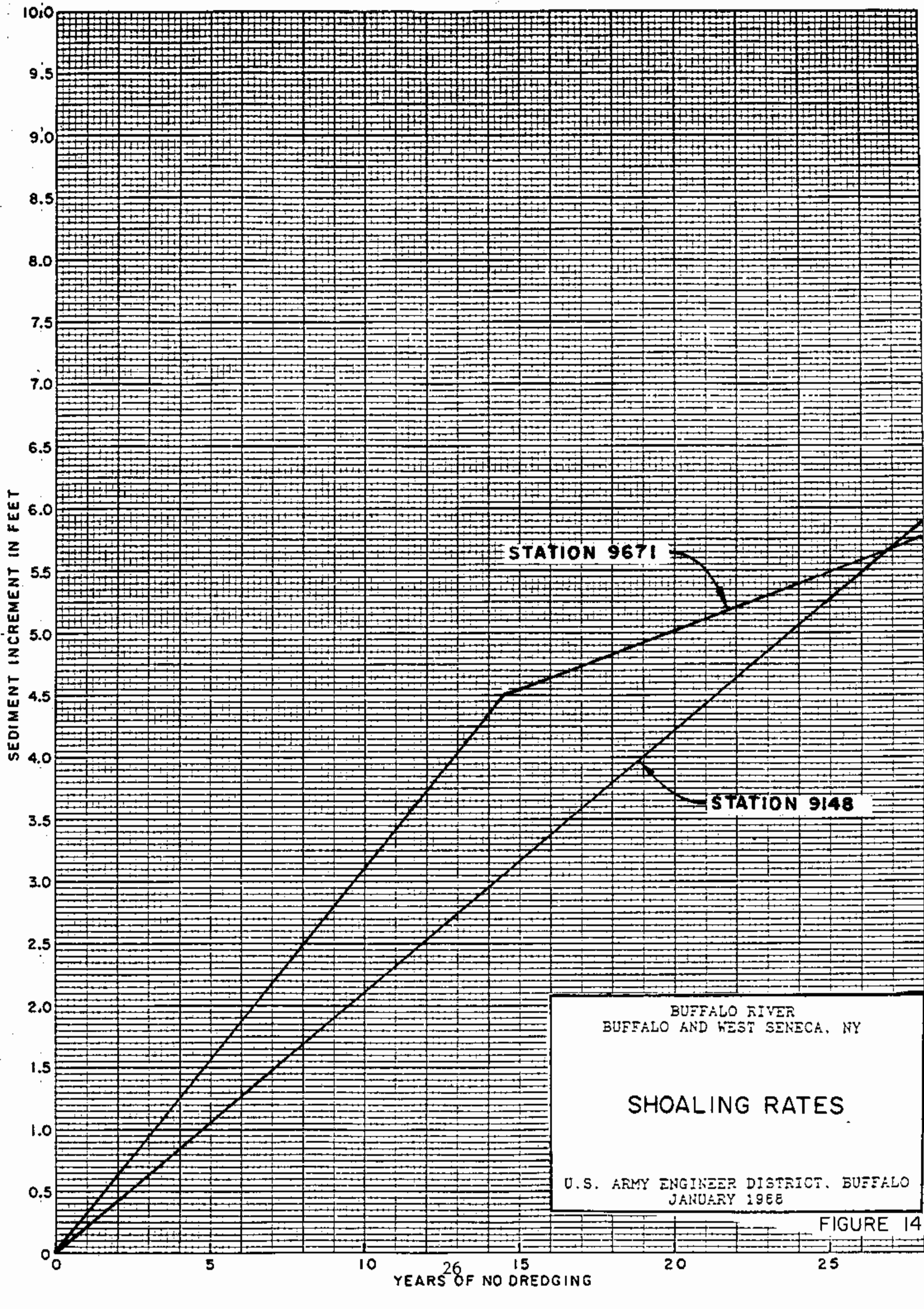

SEDIMENT INCREMENT IN FEET
YEARS OF NO DREDGING
STATION 9671
STATION 9148
BUFFALO RIVER
BUFFALO AND WEST SENECA, NY
SHOALING RATES
U.S. ARMY ENGINEER DISTRICT, BUFFALO
JANUARY 1988

FIGURE 14

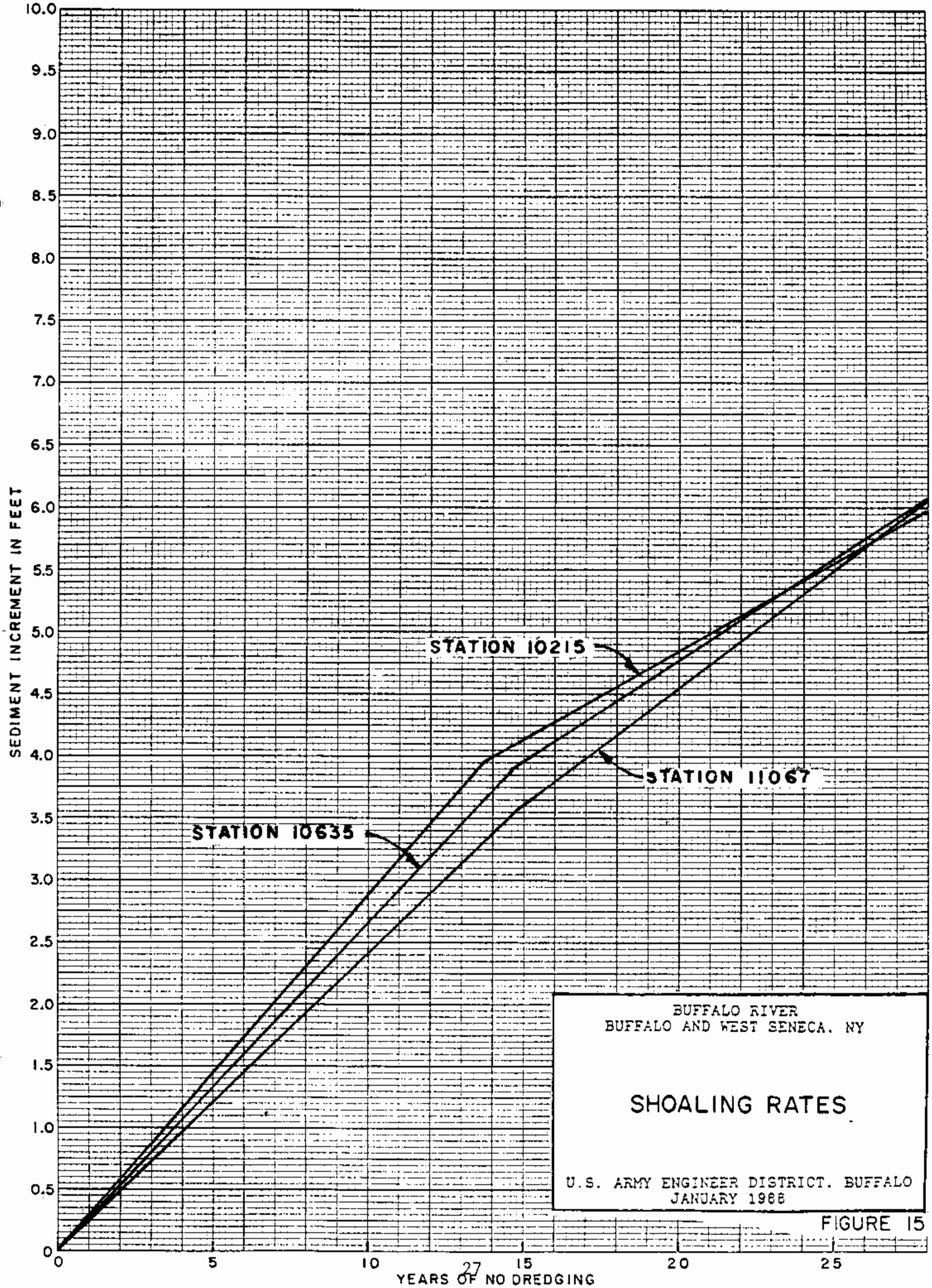

SEDIMENT INCREMENT IN FEET
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
0
5
10
15
20
25
YEARS OF NO DREDGING
STATION 10215
STATION 11067
STATION 10635
BUFFALO RIVER
BUFFALO AND WEST SENECA, NY
SHOALING RATES
U.S. ARMY ENGINEER DISTRICT, BUFFALO
JANUARY 1988

FIGURE 15

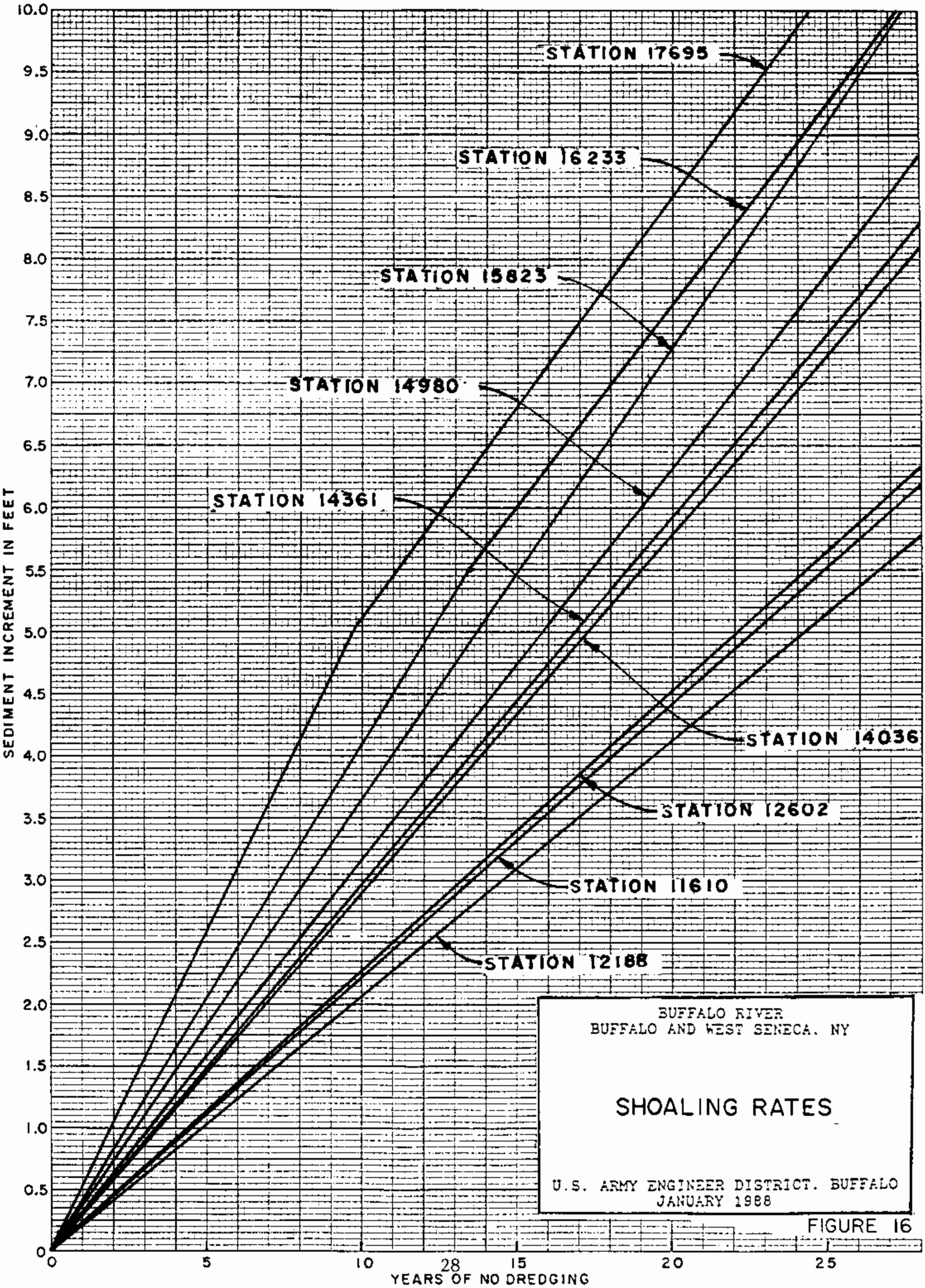
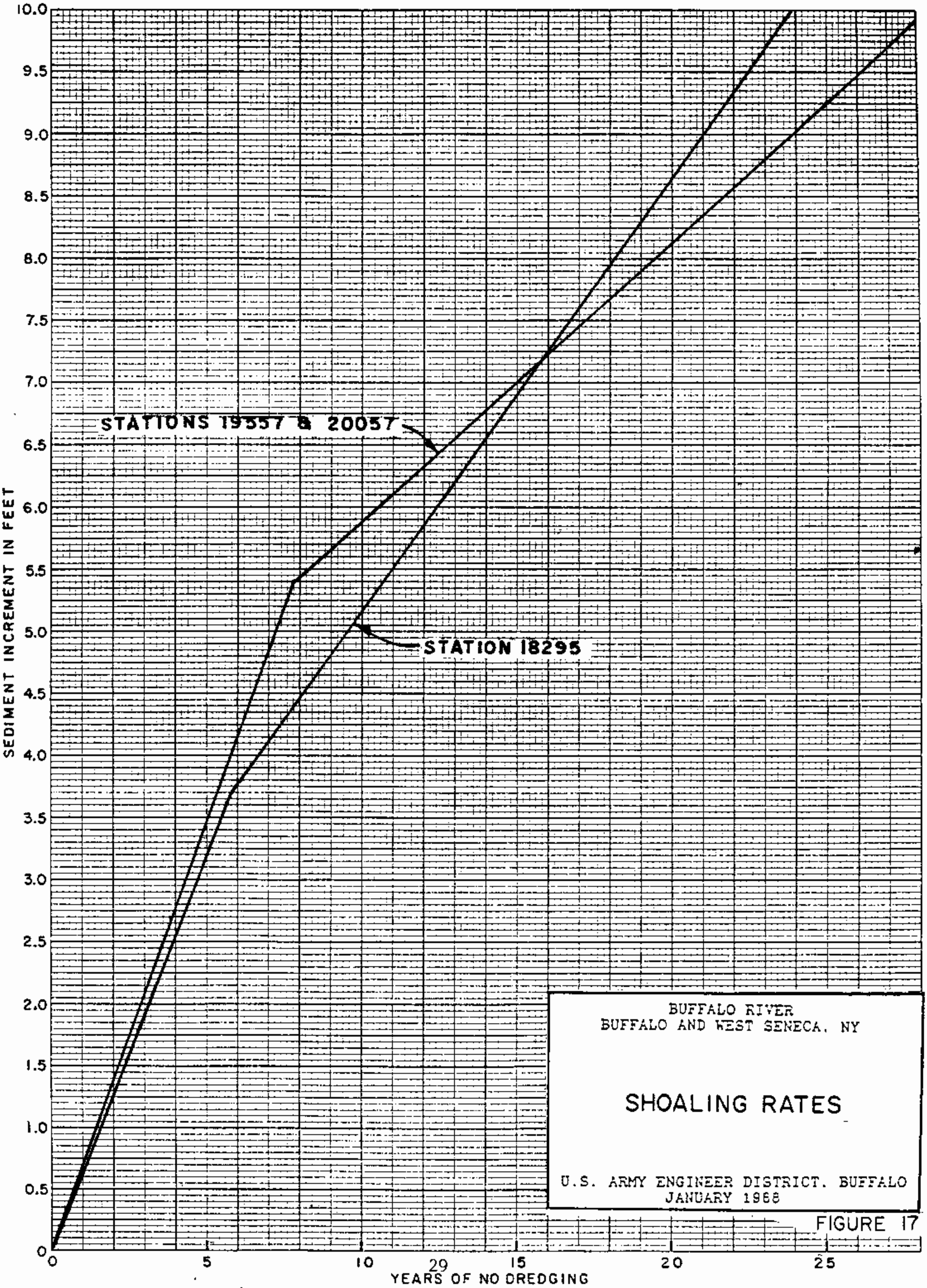

STATION 17695
STATION 16233
STATION 15823
STATION 14980
STATION 14361
STATION 14036
STATION 12602
STATION 11610
STATION 12188
SEDIMENT INCREMENT IN FEET
YEARS OF NO DREDGING
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
5
10
15
20
25
BUFFALO RIVER
BUFFALO AND WEST SENECA, NY
SHOALING RATES
U.S. ARMY ENGINEER DISTRICT, BUFFALO
JANUARY 1988

FIGURE 16



SEDIMENT INCREMENT IN FEET
YEARS OF NO DREDGING
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
5
10
15
20
25
STATIONS 19557 & 20057
STATION 18295
BUFFALO RIVER
BUFFALO AND WEST SENECA, NY
SHOALING RATES
U.S. ARMY ENGINEER DISTRICT, BUFFALO
JANUARY 1988


FIGURE 17

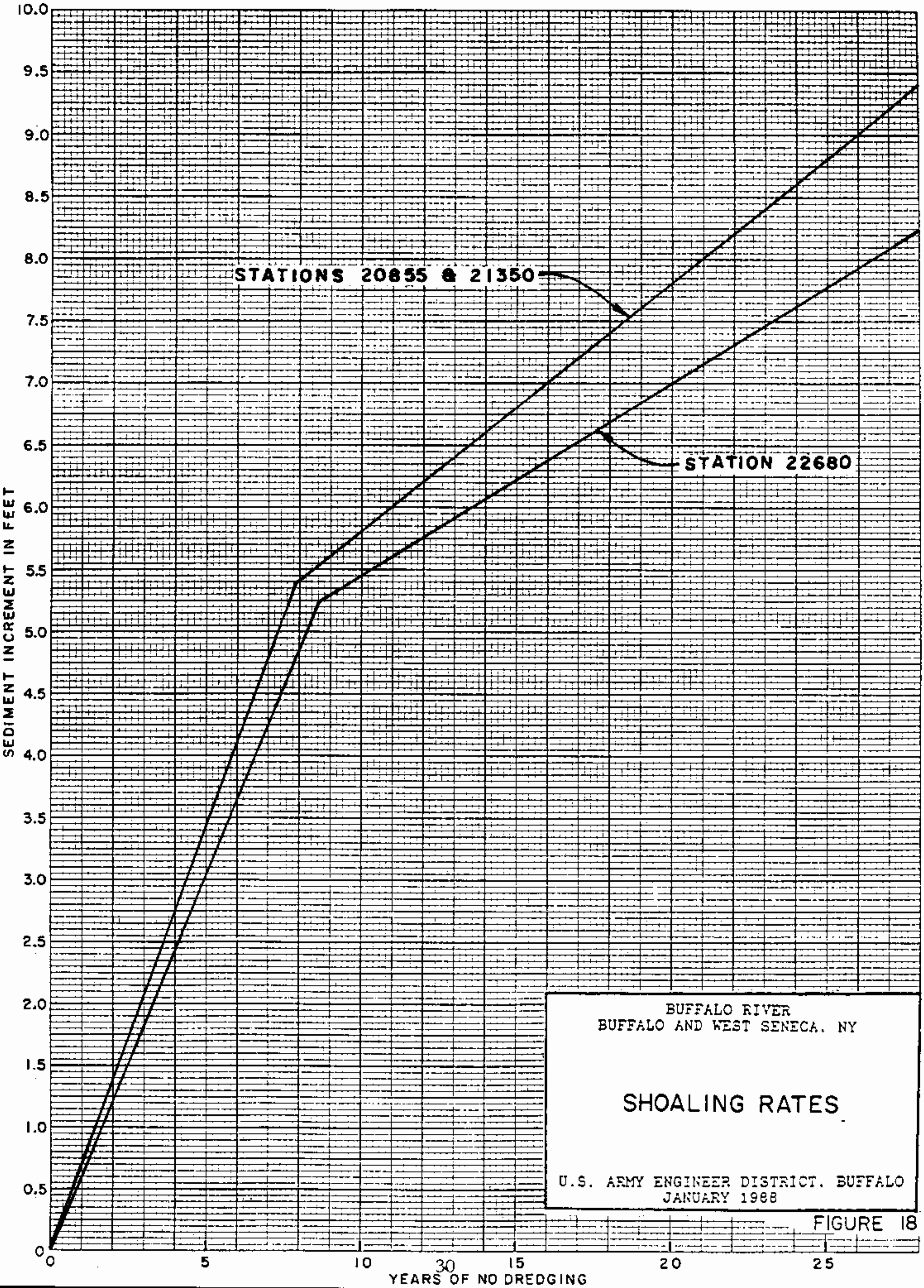
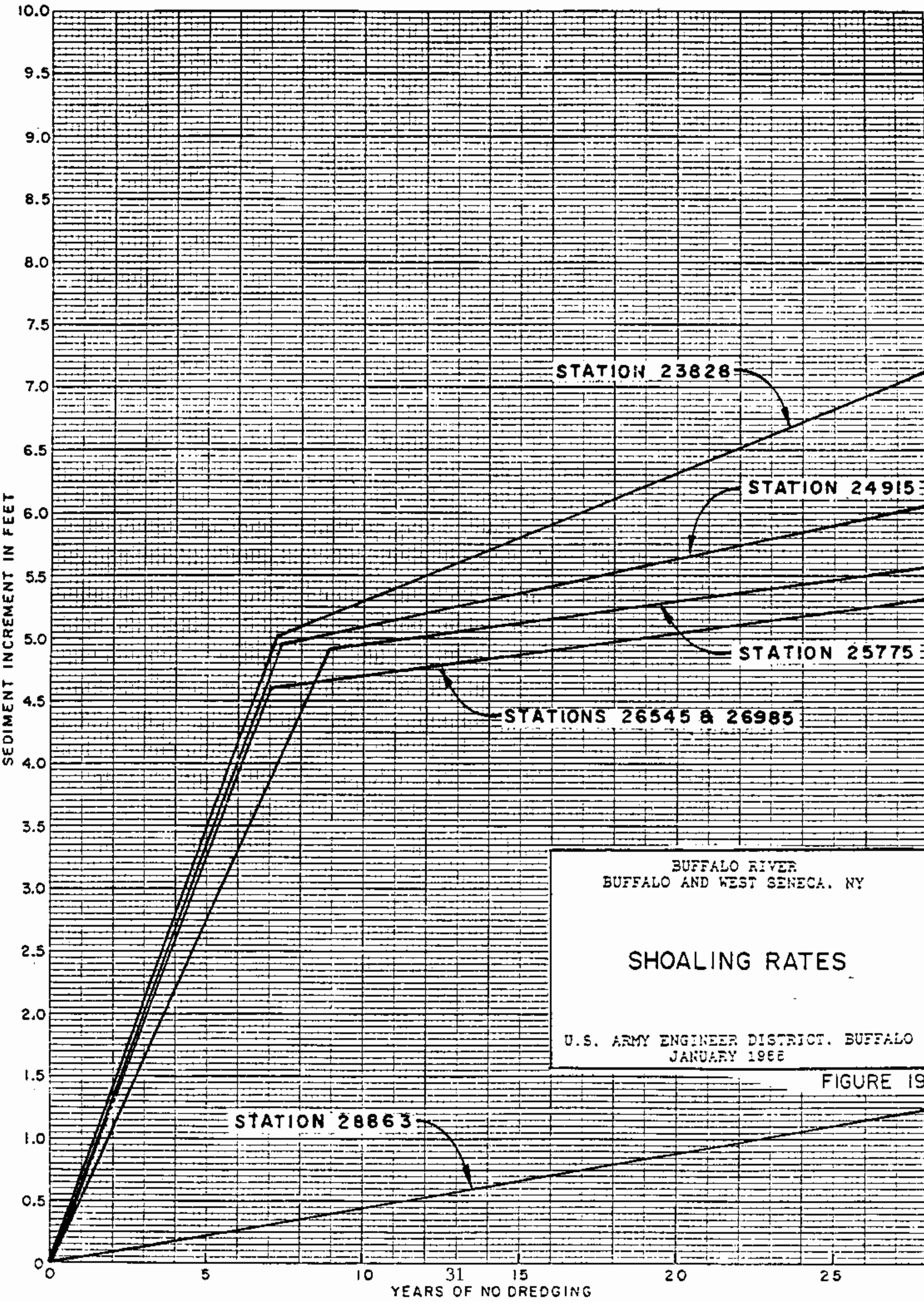
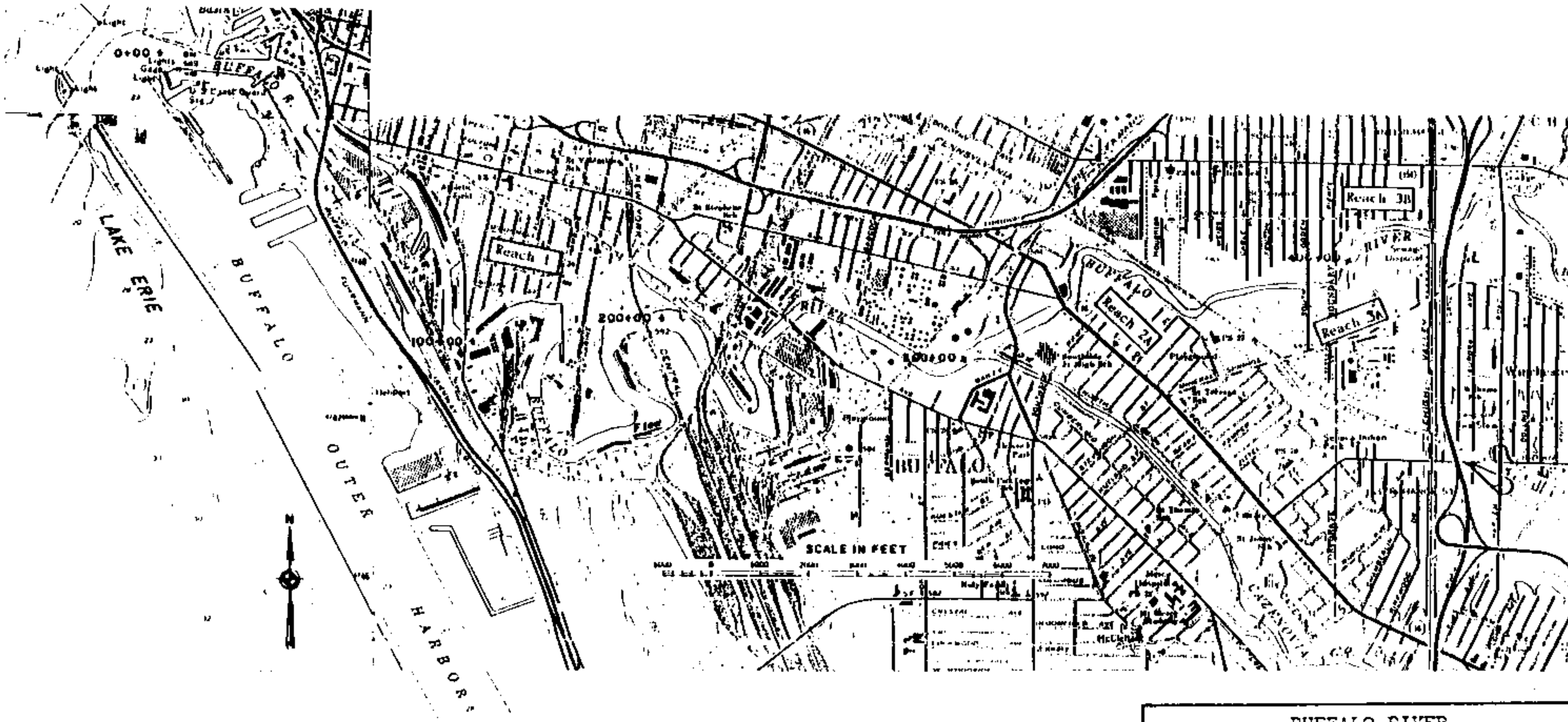

STATIONS 20855 & 21350
STATION 22680
SEDIMENT INCREMENT IN FEET
YEARS OF NO DREDGING
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
0
5
10
15
20
25
BUFFALO RIVER
BUFFALO AND WEST SENECA, NY
SHOALING RATES
U.S. ARMY ENGINEER DISTRICT, BUFFALO
JANUARY 1988

FIGURE 18


STATION 23828
STATION 24915
STATION 25775
STATIONS 26545 & 26985
STATION 28863
SEDIMENT INCREMENT IN FEET
YEARS OF NO DREDGING
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
5
10
15
20
25
BUFFALO RIVER
BUFFALO AND WEST SENECA, NY
SHOALING RATES
U.S. ARMY ENGINEER DISTRICT, BUFFALO
JANUARY 1966
FIGURE 19




NOTE: Reach 2B is Located On Cazenovia Creek.

BUFFALO RIVER
BUFFALO AND WEST SENECA. NY

## LOCATION MAP

U.S. ARMY ENGINEER DISTRICT. BUFFALO
JANUARY 1988



FIGURE 20

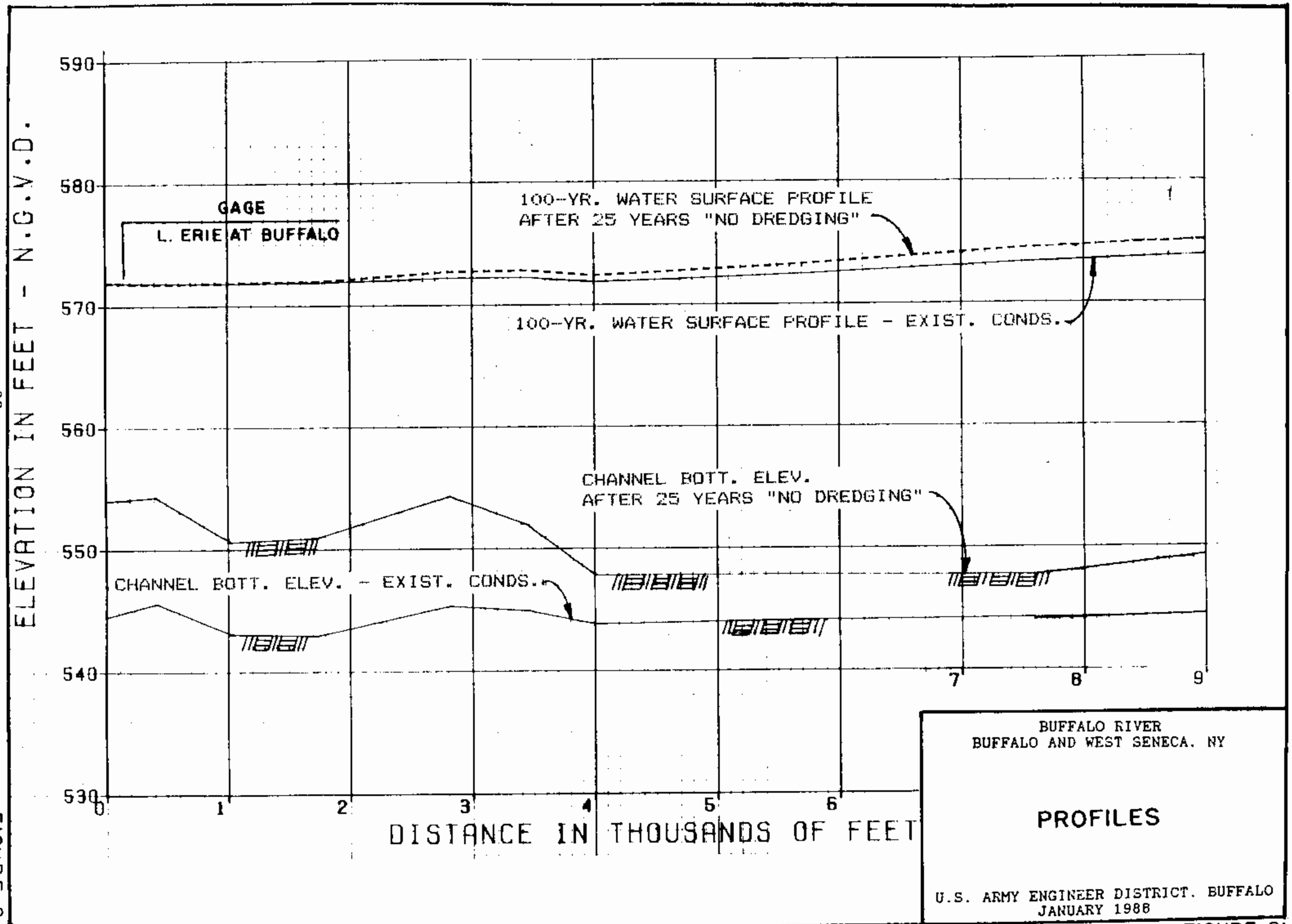
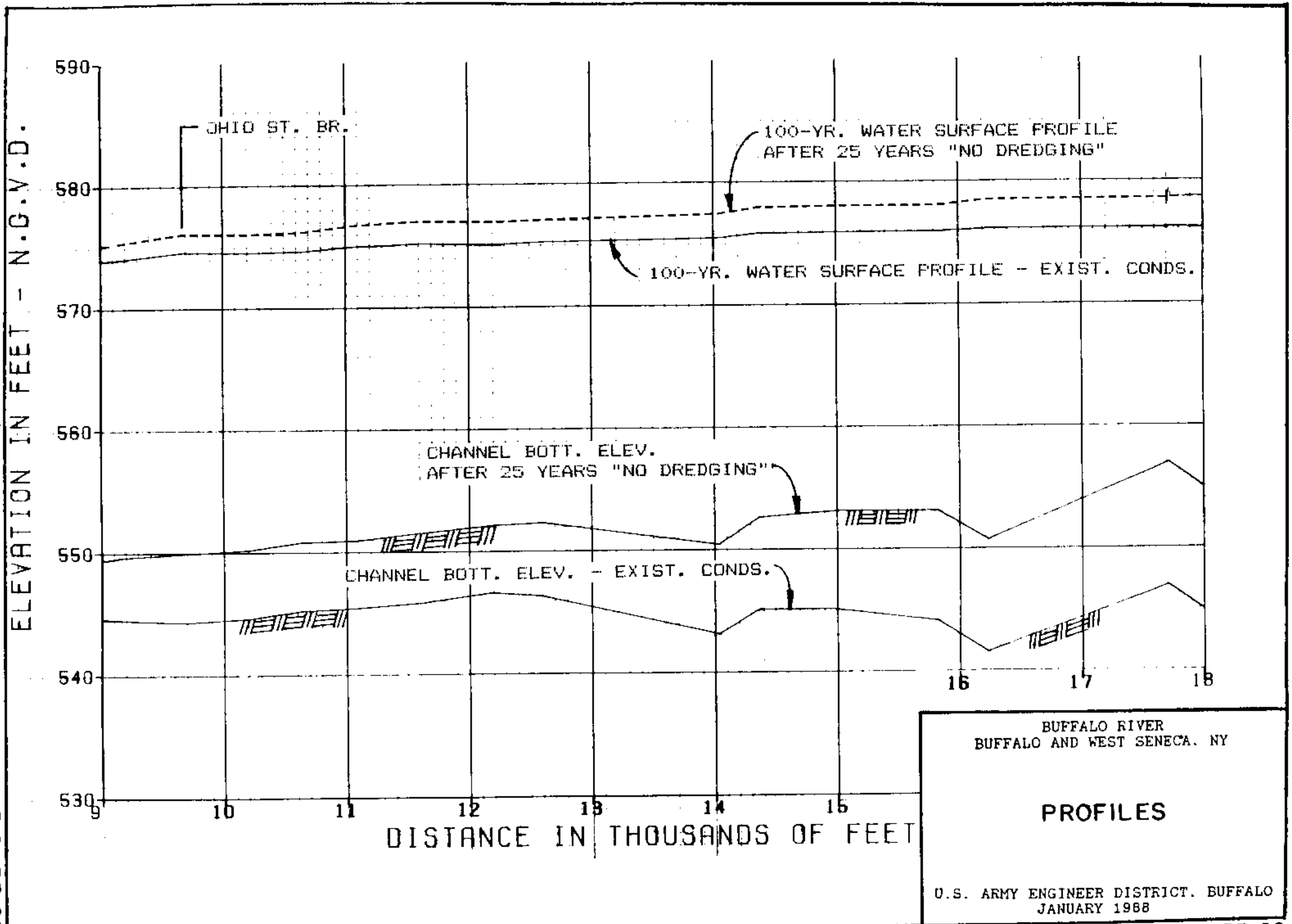

590
580
570
560
550
540
530
ELEVATION IN FEET - N.G.V.D.
0
1
2
3
4
5
6
7
8
9
DISTANCE IN THOUSANDS OF FEET
GAGE
L. ERIE AT BUFFALO
100-YR. WATER SURFACE PROFILE
AFTER 25 YEARS "NO DREDGING"
100-YR. WATER SURFACE PROFILE - EXIST. CONDS.
CHANNEL BOTT. ELEV.
AFTER 25 YEARS "NO DREDGING"
CHANNEL BOTT. ELEV. - EXIST. CONDS.
BUFFALO RIVER
BUFFALO AND WEST SENECA, NY
PROFILES
U.S. ARMY ENGINEER DISTRICT, BUFFALO
JANUARY 1988

FIGURE 2



OHIO ST. BR.
100-YR. WATER SURFACE PROFILE AFTER 25 YEARS "NO DREDGING"
100-YR. WATER SURFACE PROFILE - EXIST. CONDS.
CHANNEL BOTT. ELEV. AFTER 25 YEARS "NO DREDGING"
CHANNEL BOTT. ELEV. - EXIST. CONDS.
590
580
570
560
550
540
530
9
10
11
12
13
14
15
16
17
18
ELEVATION IN FEET - N.G.V.D.
DISTANCE IN THOUSANDS OF FEET
BUFFALO RIVER
BUFFALO AND WEST SENECA, NY
PROFILES
U.S. ARMY ENGINEER DISTRICT, BUFFALO
JANUARY 1988


FIGURE 22

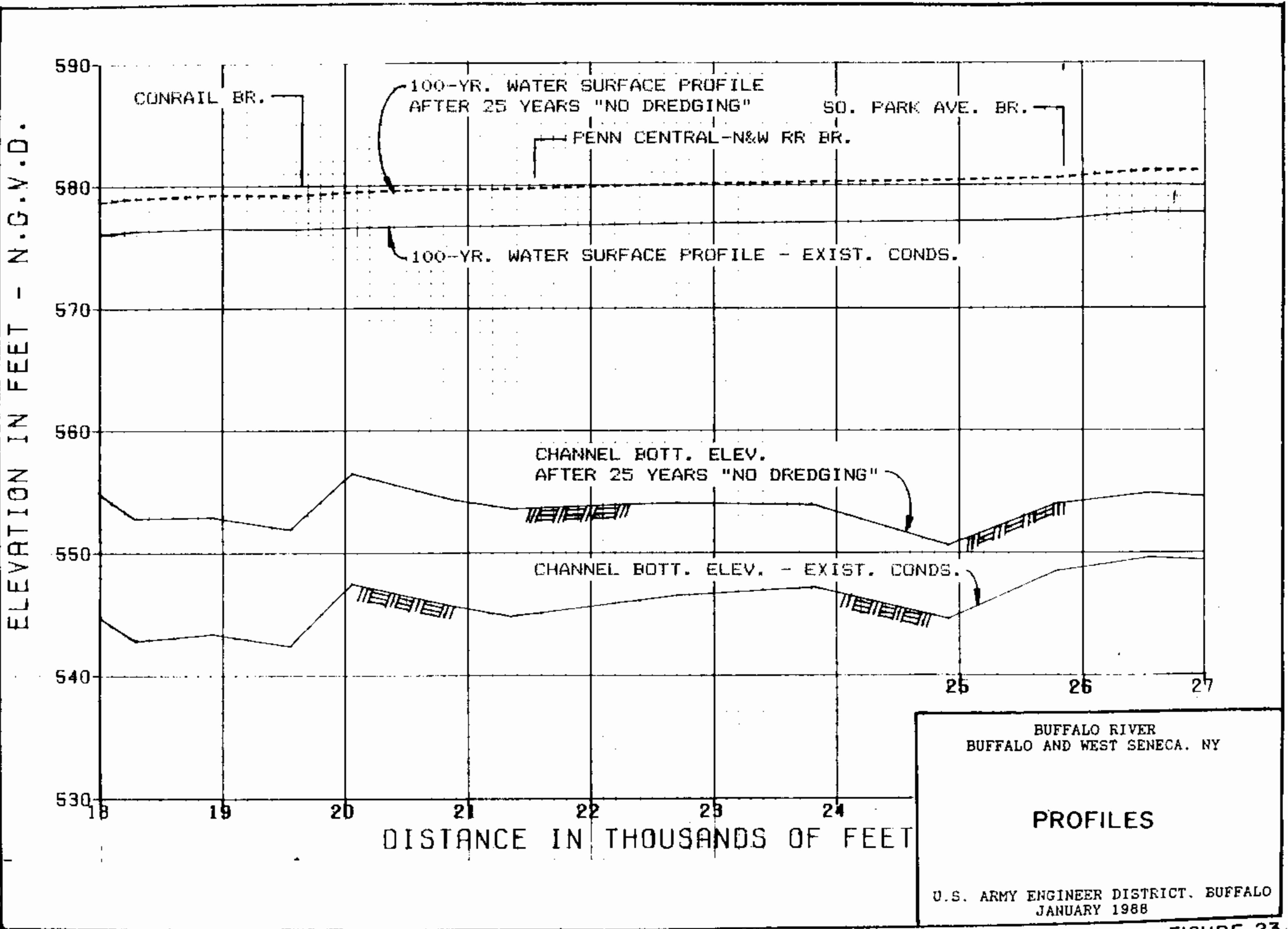

100-YR. WATER SURFACE PROFILE
AFTER 25 YEARS "NO DREDGING"
CONRAIL BR.
SO. PARK AVE. BR.
PENN CENTRAL-N&W RR BR.
100-YR. WATER SURFACE PROFILE - EXIST. CONDS.
CHANNEL BOTT. ELEV.
AFTER 25 YEARS "NO DREDGING"
CHANNEL BOTT. ELEV. - EXIST. CONDS.
ELEVATION IN FEET - N.G.V.D.
590
580
570
560
550
540
530
18
19
20
21
22
23
24
25
26
27
DISTANCE IN THOUSANDS OF FEET
BUFFALO RIVER
BUFFALO AND WEST SENECA, NY
PROFILES
U.S. ARMY ENGINEER DISTRICT, BUFFALO
JANUARY 1988

FIGURE 23

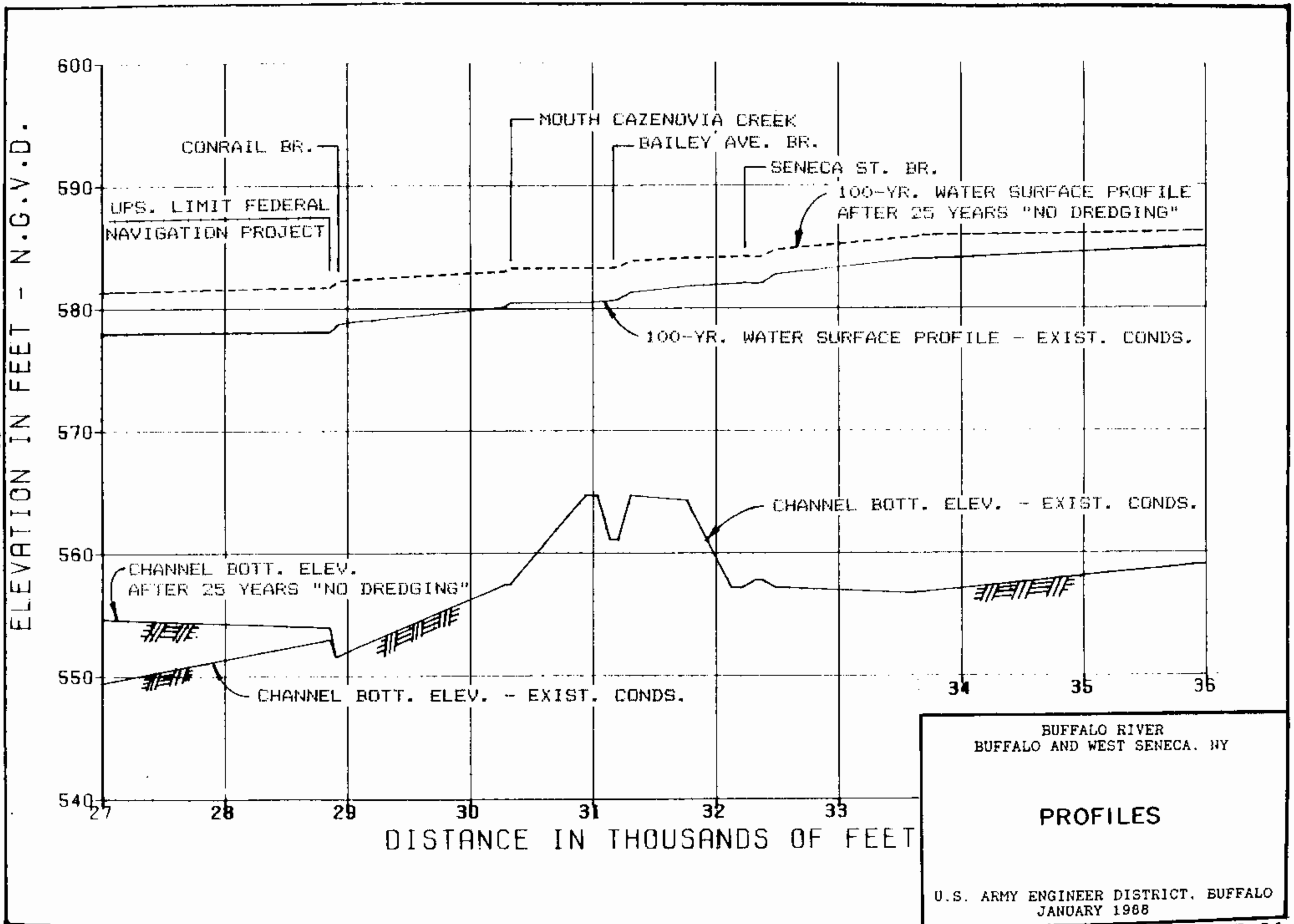

ELEVATION IN FEET - N.G.V.D.
600
590
580
570
560
550
540
27
28
29
30
31
32
33
34
35
36
DISTANCE IN THOUSANDS OF FEET
CONRAIL BR.
UPS. LIMIT FEDERAL
NAVIGATION PROJECT
MOUTH CAZENOVIA CREEK
BAILEY AVE. BR.
SENECA ST. BR.
100-YR. WATER SURFACE PROFILE
AFTER 25 YEARS "NO DREDGING"
100-YR. WATER SURFACE PROFILE - EXIST. CONDS.
CHANNEL BOTT. ELEV. - EXIST. CONDS.
CHANNEL BOTT. ELEV.
AFTER 25 YEARS "NO DREDGING"
CHANNEL BOTT. ELEV. - EXIST. CONDS.
BUFFALO RIVER
BUFFALO AND WEST SENECA, NY
PROFILES
U.S. ARMY ENGINEER DISTRICT, BUFFALO
JANUARY 1988



FIGURE 24

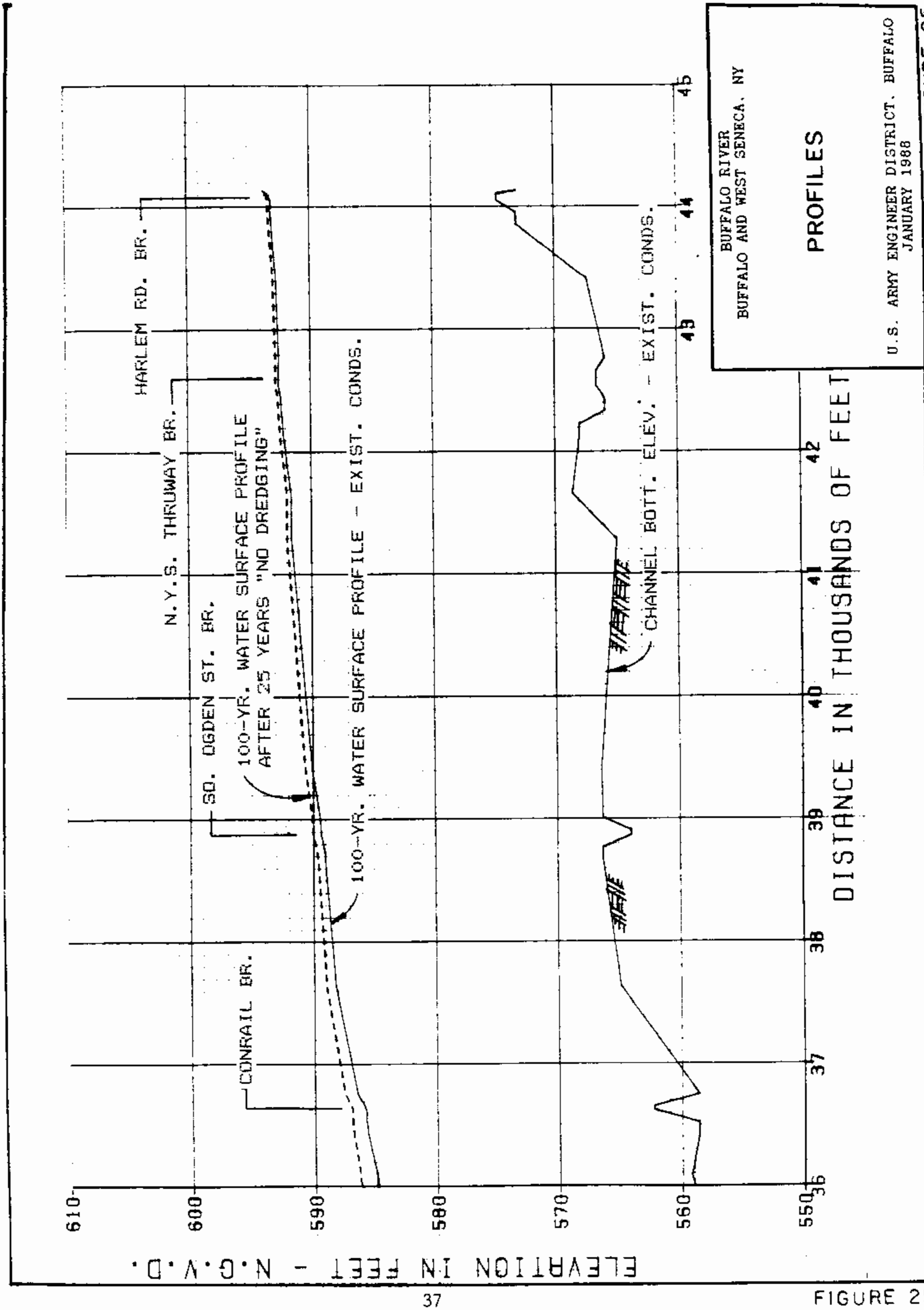

BUFFALO RIVER
BUFFALO AND WEST SENECA, NY
PROFILES
U.S. ARMY ENGINEER DISTRICT, BUFFALO
JANUARY 1988
HARLEM RD. BR.
N.Y.S. THRUWAY BR.
SO. OGDEN ST. BR.
CONRAIL BR.
100-YR. WATER SURFACE PROFILE
AFTER 25 YEARS "NO DREDGING"
100-YR. WATER SURFACE PROFILE - EXIST. CONDS.
CHANNEL BOTT. ELEV. - EXIST. CONDS.
DISTANCE IN THOUSANDS OF FEET
36
37
38
39
40
41
42
43
44
45
ELEVATION IN FEET - N.G.V.D.
550
560
570
580
590
600
610



FIGURE 2