FREQUENCY AND DURATION OF FLOODING OF GROVE CREEK NEAR KENANSVILLE, NORTH CAROLINA, FOR PRESENT AND PROPOSED RESTORED CHANNEL CONDITIONS

By T. C. Stamey

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CONVERSION FACTORS

The following factors may be used to convert inch-pound units published herein to the International System of Units (SI).

Multiply inch-pound unit	By	To obtain SI unit
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Gradient	
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
acre	0.4047	hectare (ha)
	Flow	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

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ABSTRACT

The Grove Creek basin includes an area of about 42 square miles in Duplin County, southeastern North Carolina. The North Carolina Department of Human Resources (DHR) proposes to implement a channel restoration project on about an eight-mile reach of Grove Creek. The purpose of the restoration program is to improve drainage, thereby reducing frequency and duration of overbank flooding and reducing the opportunity for mosquito breeding in frequently flooded areas adjacent to Grove Creek. This study evaluates the effects of the restoration on the frequency and duration of flooding within the study reach for present (1984) and proposed restored channel conditions.

The proposed restored channel is estimated to increase the carrying capacity of the main channel from 10 to 19 times. The greatest reduction in areas of flooded land immediately adjacent to the study reach would be west of North Carolina Highway 11 (between sites 4 and 6) and would be reduced by an average of 29 percent during floods up through the 10-year flood level and reduced by an average of 5 percent for the 25- to 100-year flood levels. An average reduction of 1 percent is indicated for areas inundated east of North Carolina Highway 11 (for sites 1 through 3) for the 2-, 5-, 10-, 25-, 50-, and 100-year floods; while reductions in inundated area of the total study reach of 13, 5, 4, and 1.5 percent are indicated for the 2-, 5-, 10-, and 100-year floods, respectively.

Overbank flooding during 1983 and 1984 water years occurred 32 times and persisted from a few hours up to about 3 months. For proposed restored-channel conditions, overbank flooding would have been reduced to 5 occurrences, and areal flooding would have persisted from a few hours to about 2 days.

Flooding on the Northeast Cape Fear River causes variable backwater conditions on the lower Grove Creek study reach. A 100-year flood on the Northeast Cape Fear River would create backwater for about 1.5 miles upstream on Grove Creek.

INTRODUCTION

The North Carolina Department of Human Resources (DHR), Division of Health Services, Vector Control Branch, proposes to implement a channel restoration project in the Grove Creek basin in Duplin County to improve drainage, reduce the frequency and duration of overbank flooding, and thereby enhance mosquito control programs in the area.

Stream-channel restoration is based on the premise that present channels have aggraded primarily as a result of the activities of man. In low-relief coastal streams such as Grove Creek, sediment-laden runoff from farm fields and roadway construction, along with limbs, logs, and other debris from logging operations is believed to have caused the pre-existing unaggraded channel to fill in, thereby reducing the carrying capacity of the stream channel and causing frequent overbank flooding (Nelson and Weaver 1981). The DHR restoration technique involves removal of deposited sediments and debris along the apparent natural pre-existing watercourse (as defined by probing along the existing channel in order to find the firm bed of the pre-existing channel) with no widening or straightening of the pre-existing channel. Minimal amounts of channel materials and few living trees are removed, and spoil piles are small and scattered.

The effects of proposed channel restoration on the environment, particularly mosquito populations, are largely unknown. The degree to which stream-channel characteristics develop as a result of man's activities or by natural processes is also uncertain. In 1982, the U. S. Geological Survey, in cooperation with the Department of Human Resources, initiated a program of studies to aid the NCDHR in it evaluation of these and other effects of channel restoration on the hydrology of the Grove Creek basin.

Purpose and Scope

The proposed stream channel restoration would be undertaken to control mosquito population by limiting both breeding areas and the length of time water is available in the flood plain for hatching of mosquito eggs. The duration and frequency of overbank flooding on Grove Creek that occurred during the 1983 and 1984 water years (hereafter referred to as present conditions) and that are estimated to occur with the proposed restored channel were computed to allow assessment of the need for, and to predict the effectiveness of, the restoration program.

This report describes the results of a special study, which started in January 1984, of lower Grove Creek, in the vicinity of Kenansville, to evaluate:

1. The frequency and duration of overbank flooding, and the size of the inundated area in the study reach for present and proposed restored channel conditions;
2. The upstream extent and frequency of flooding by backwater from the Northeast Cape Fear River; and
3. The age of the channel sediments to establish possible correlation of the source and thickness of channel sediments with man's activities.

Study Area

Grove Creek, in central Duplin County, is located in the Southeastern Coastal Plain province of North Carolina; it is a tributary to the Northeast Cape Fear River (fig. 1). The Grove Creek basin is approximately 42 mi^2 in size; major tributaries include Marsh Branch (5.7 mi^2), Buckskin Swamp (3.2 mi^2), and Tea Swamp (3.7 mi^2).

The study reach extends from the confluence with the Northeast Cape Fear River about 8 miles upstream to a point about 2 miles northwest of Kenansville (site 6, fig. 2). Land-surface elevations range from approximately 40 to 90 feet above sea level. Channel braiding occurs throughout most of the study reach, except north of Secondary Road 1376 and near the mouth (fig. 2). The average stream gradient is about 0.8 ft/1,000 ft, or 4.1 ft/mi (fig. 3). The flood plain ranges in width from about 1,000 to 2,000 feet and is typically swampy. The lower reach of Grove Creek is subject to flooding from backwater during floods on the Northeast Cape Fear River.

Most of the basin is sparsely populated except for the town of Kenansville which had a population of 931 according to the 1980 census. Major land-use activities in the basin are predominately agricultural and include forests and row crops. Several swine and turkey farms are scattered throughout the basin. Most farm fields are located as close to the streams as the swampy flood plains will allow. Average rainfall is 52 inches per year.

Data Collected

Stage records for six sites and discharge records for one site are available in the study reach (fig. 2). Continuous records of stage and discharge are available for site 4 since October 1982; continuous-stage records are available for site 2 since October 1983. Crest-stage records are available at sites 1, 3, 5, and 6 since February 1984.

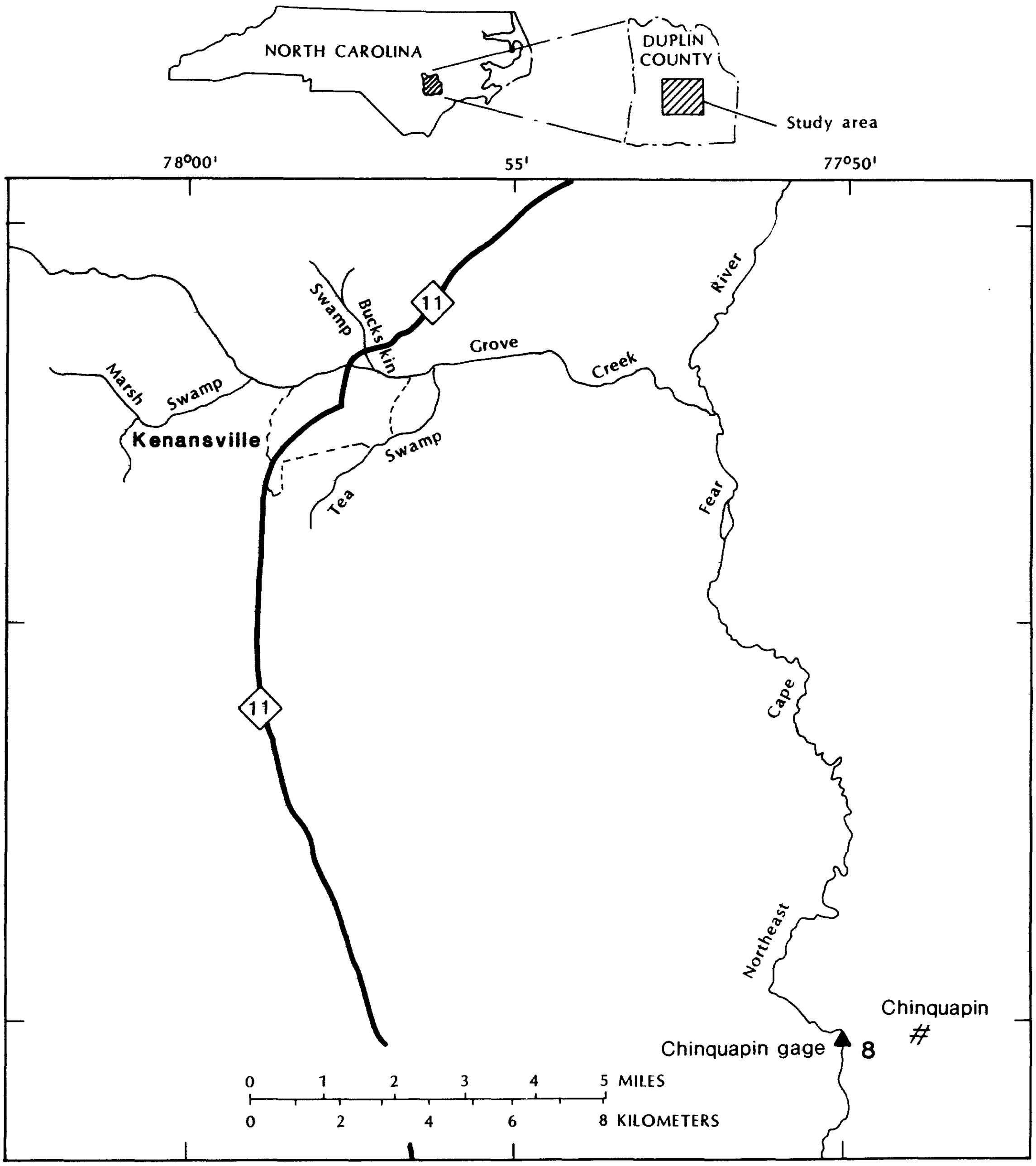

Figure 1.--Location of study area and gage near Chinquapin.

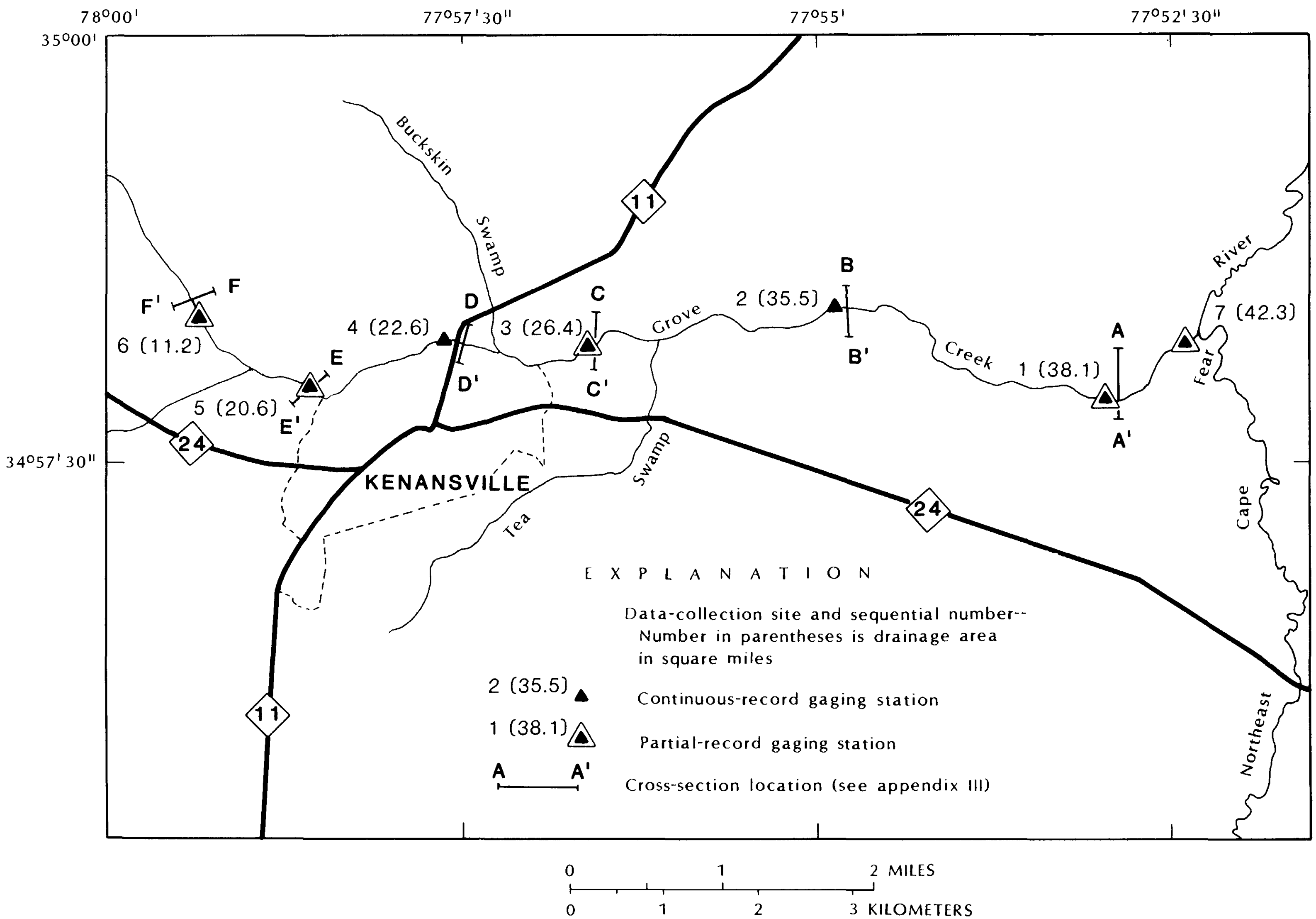

Figure 2.--Location of data-collection sites.

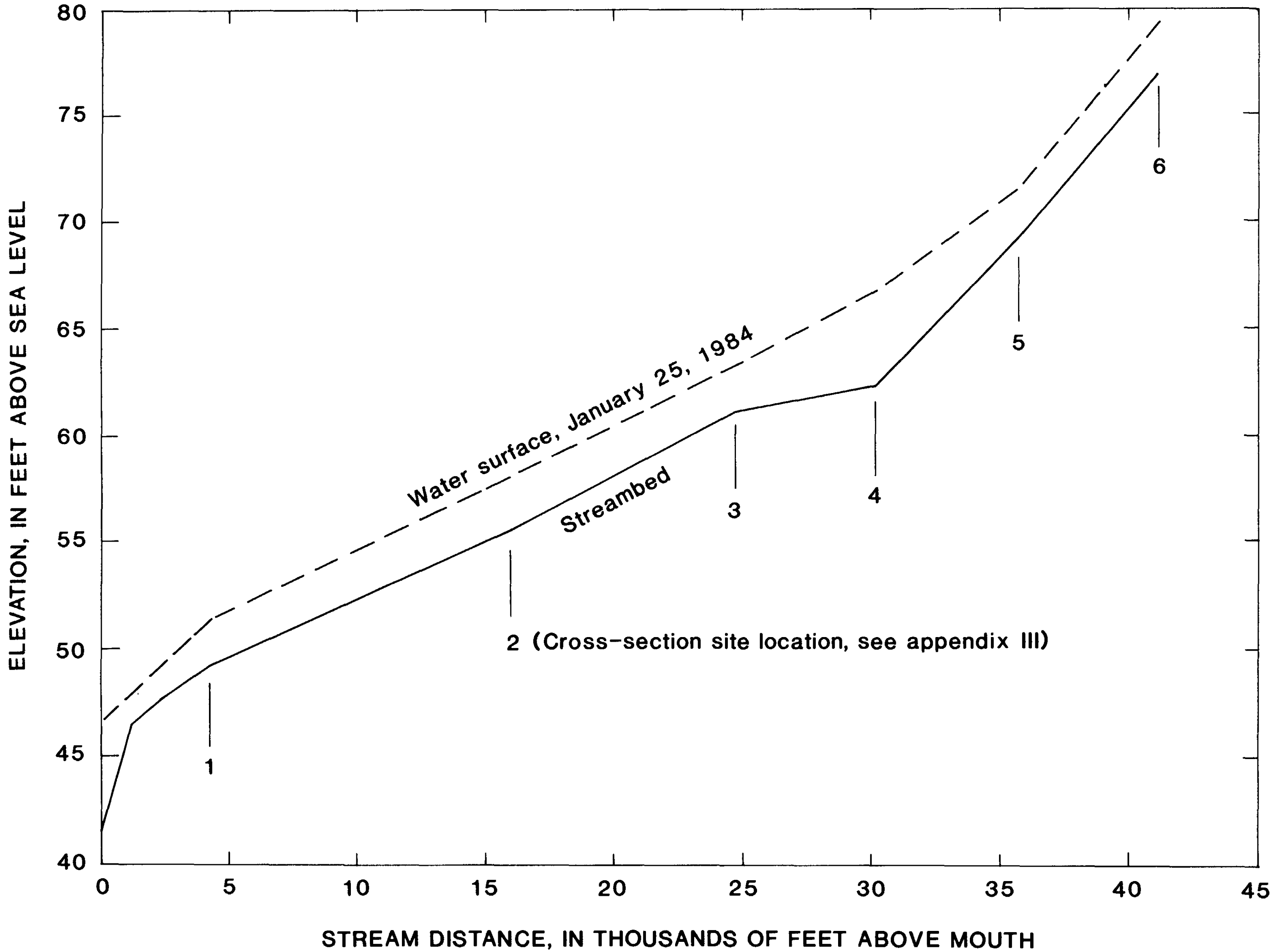

Figure 3.--Present streambed and water-surface profiles of study reach.

Other available data are as follows:

1. Measured land-surface elevations of the stream channel and flood plain (cross sections) at each of the six data-collection sites (fig. 2);
2. Estimated dimensions of the stream channel at each of the six data-collection sites for proposed restored conditions (provided by North Carolina Department of Human Resources);
3. Surveyed streambed profile from site 1 to mouth of Grove Creek; and
4. Concurrent flood stages for Northeast Cape Fear River near Chinquapin (site 8, fig. 1) and at the confluence with Grove Creek (site 7, fig. 2).

Measured land-surface elevation data and all gages were referred to sea level. Horizontal distances between sites were scaled from Soil Conservation Service aerial photographs. Drainage areas for each site were planimetered on U. S. Geological Survey 7.5 minute quadrangle topographic maps.

ANALYTICAL APPROACH

Because this investigation focuses on the likely outcome of proposed changes in the Grove Creek basin, the approach to the study was divided into four major topics. These topics are: (1) definition of flood profiles, (2) determination of the areal extent of the inundated area, (3) evaluation of the duration of overbank flooding, and (4) investigation of channel sediments. The first three topics were divided into two parts, one for the channel conditions as they existed during the study period (1983-84 water years) and one for the channel conditions as they are conceived to exist after the North Carolina Department of Human Resources' proposed channel restoration program.

The lower reach of Grove Creek is subject to flooding from backwater during floods on the Northeast Cape Fear River and separately from discharges of the Grove Creek drainage basin. The inundation from the Northeast Cape Fear River backwater was evaluated independently of Grove Creek discharges. In the lower reach of Grove Creek, such flooding will occur for all conditions of Grove Creek channels because the changes in hydraulic efficiency of Grove Creek have negligible effects on the major flooding of the Northeast Cape Fear River. For this analysis, the continuous record for the Northeast Cape Fear River near Chinquapin (site 8, figure 1) and the stage data at the mouth of Grove Creek (site 7, figure 2) were analyzed to help determine the upstream limits of backwater on Grove Creek. Maximum stage data at the Chinquapin gage and at the mouth of Grove Creek for the floods of February 1, September 14, and September 25, 1984, were plotted to establish a graphical relation (figure 4).

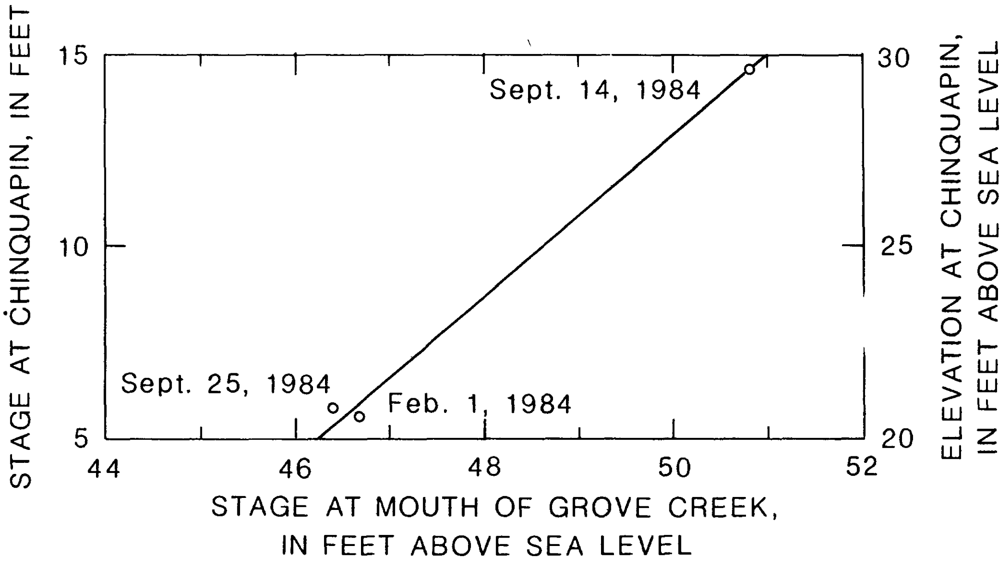

Figure 4.--Relation of flood stages on Northeast Cape Fear River near Chinquapin and at mouth of Grove Creek.

The 2- through 100-year peak discharges for the Northeast Cape Fear River near Chinquapin were determined from a flood-frequency analysis of the station data. The corresponding 2- through 100-year flood stages for the Chinquapin gage were determined for these discharges from the gaging station stage-discharge relation and were used with figure 4 to estimate flood stages at the mouth of Grove Creek. These data are presented in table 1 and the limits of backwater from Northeast Cape Fear River are shown on figure 5.

Flood Profiles

The step-backwater model described by Shearman (1976) was selected for the definition of the water-surface profiles in this study. The procedure requires a beginning stage and discharge at the initial downstream cross section. After a successful energy balance is attained between the first two cross sections, the procedure steps to the next upstream cross section in the same manner. The procedure continues in this way until the full study reach is completed.

There are three highway bridges across Grove Creek in the study reach. However, data describing these bridges were not included in the analyses for the definition of the flood profiles. Because Grove Creek is considered a fairly flat-sloped stream and field observations indicate that the bridges would have adequate conveyance characteristics, such effects on the water-surface profiles for large floods were considered to be within the accuracy limits of the step-backwater model.

Table 1.--Flood stages of Northeast Cape Fear River, and upstream extent of backwater, and inundated areas on Grove Creek study reach

	Recurrence interval in years					
Type of data	2	5	10	25	50	100
Flood stage, feet above sea level, on Northeast Cape Fear River near Chinquapin 1/	30.52	32.39	33.72	35.32	36.42	37.28
Flood stage, feet above sea level, on Northeast Cape Fear River at confluence with Grove Creek 2/	50.4	51.1	51.7	52.3	52.7	53.0
Grove Creek backwater, feet above mouth	3,000	3,800	4,500	5,500	6,500	7,000
Inundated area, in acres	172	218	258	316	373	459

1/ Site 8, fig. 1.
2/ Site 7, fig. 2.

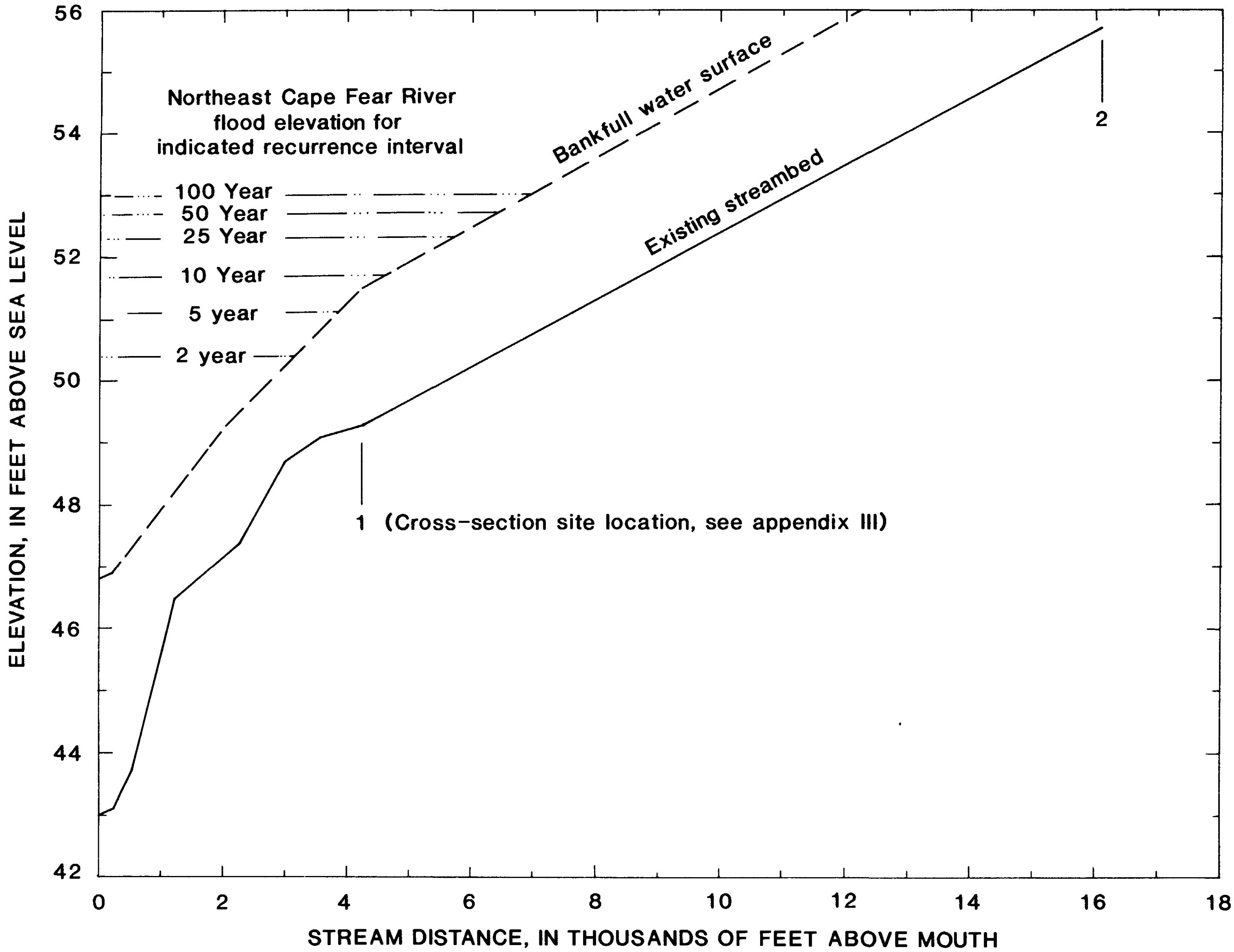

Figure 5.--Upstream extent of backwater from the Northeast Cape Fear River on the study reach.

Present Channel Conditions

The beginning stage and discharge values for the step-backwater analysis for the present channel conditions were determined from an analysis of the observed flood data. At site 4, the stage-discharge relation was well defined by discharge measurements made in the range of 1 to 1,380 ft^3/s. Stage-discharge relations for the remaining sites were based on flood stages recorded at each of the sites and discharges transferred from site 4. The transfer of discharges was based on a correlation of concurrent data collected at a partial-record site located upstream and out of the study reach. The flood stages and estimated discharges are presented in table 2. The stage-discharge relation for each site on Grove Creek is provided in Appendix II.

Manning's n-value, roughness coefficients were estimated for the study reach using the results of field observations and published reports (Barnes, 1967; Arcement and Schneider, 1984). Each cross section was divided into three subareas: left flood plain, main channel, and right flood plain. Roughness coefficients were assigned for each subarea. Channel roughness coefficients ranged from 0.060 to 0.180, and those for the flood plains ranged from 0.060 to 0.200. The roughness coefficients were varied with depth in the step-backwater analysis as described by Shearman (1976).

Of the four observed floods which were analyzed (table 2), the most significant occurred on September 14, 1984, during hurricane Diana and had a recurrence interval of about 15 years. The data for the September 14, 1984, flood were used to calibrate the step-backwater model for the present channel conditions. Minor adjustments in the roughness coefficients were necessary to make the simulated and observed flood stages match within acceptable limits. The adjusted roughness coefficients compared favorably with those reported by Arcement and Schneider (1984). The simulated and observed profiles for the flood of September 14, 1984, are shown in figure 6.

Discharges for the 2-, 5-, 10-, 25-, 50-, and 100-year floods for Grove Creek were determined from the regional flood-frequency relations reported by Jackson (1976). These data are shown in table 3. The calibrated step-backwater model was employed, and these discharges were substituted with corresponding beginning stages at site 1 taken from the stage-discharge relation discussed previously. The computed flood profile data are shown in table 4.

Table 2.--Observed flood stages and computed discharges for study reach

Date	Site 1/ number	Stage, in feet above sea level	Discharge, in cubic feet per second
02-15-84	1	52.12	176
02-15-84	2	58.68	163
02-15-84	3	64.02	122
02-15-84	4	67.16	104*
02-15-84	5	72.67	95
02-15-84	6	80.22	52
02-24-84	1	52.24	309
02-24-84	2	58.67	287
02-24-84	3	63.95	214
02-24-84	4	67.46	183*
02-24-84	5	72.97	166
02-24-84	6	80.77	92
03-14-84	1	52.18	267
03-14-84	2	58.62	248
03-14-84	3	63.90	185
03-14-84	4	67.38	158*
03-14-84	5	72.83	144
03-14-84	6	80.44	79
09-14-84	1	53.00	1,980
09-14-84	2	59.61	1,900
09-14-84	3	64.96	1,600
09-14-84	4	69.02	1,470*
09-14-84	5	75.11	1,390
09-14-84	6	82.55	975

1/ Site locations shown on fig. 2.

* From stage-discharge relation based on discharge measurements.

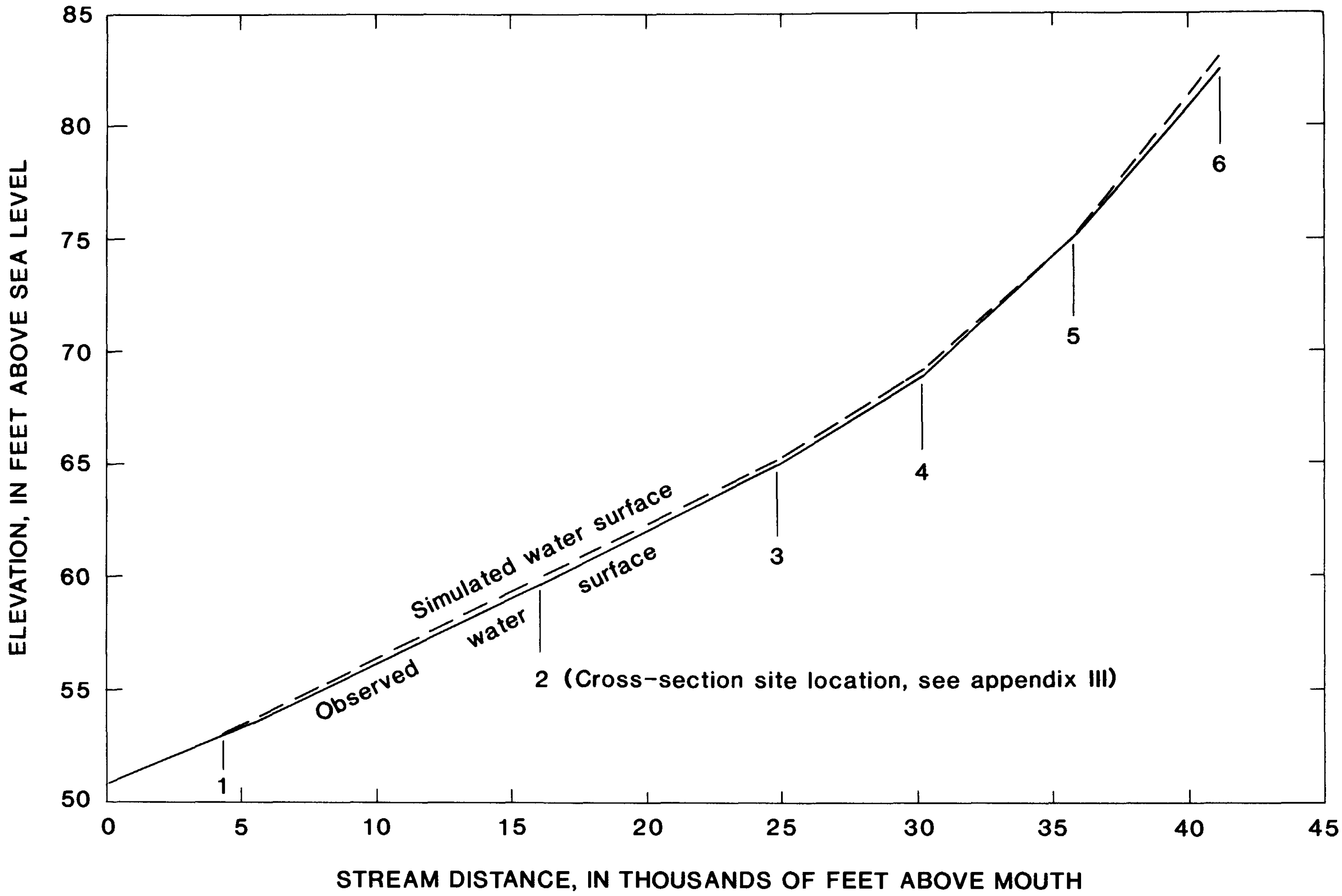

Figure 6.--Simulated and observed flood profiles of the study reach for September 14, 1984.

Table 3.--Flood discharges used in computing flood profiles of study reach

Site 1/ number	Drainage area, in square miles	Discharge, in cubic feet per second, for indicated recurrence interval in years					
		2	5	10	25	50	100
1	38.1	2/665	2/1,170	2/1,660	2/2,470	2/3,240	2/4,050
2	35.5	635	1,120	1,590	2,370	3,120	3,900
3	26.4	520	935	1,330	2,000	2,650	3,350
4	22.6	470	850	1,210	1,830	2,430	3,090
5	20.6	440	800	1,150	1,740	2,310	2,940
6	11.2	295	550	800	1,230	1,660	2,140

1/ Site locations shown on fig. 2.

2/ Affected by backwater from Northeast Cape Fear River; recurrence interval unknown.

Table 4.--Computed flood stages of the study reach for present and proposed restored conditions

	Stage, in feet above sea level Recurrence interval, in years											
Site 1/ number	2 Present	2 Restored	5 Present	5 Restored	10 Present	10 Restored	25 Present	25 Restored	50 Present	50 Restored	100 Present	100 Restored
1	2/52.5	2/52.1	2/52.7	2/52.4	2/52.8	2/52.6	2/53.0	2/52.8	2/53.3	2/53.1	2/53.5	2/53.4
2	59.2	58.7	59.5	59.3	59.8	59.6	60.1	59.9	60.4	60.1	60.8	60.4
3	64.4	63.6	64.8	64.3	65.0	64.6	65.2	65.0	65.4	65.2	65.8	65.5
4	68.0	66.7	68.5	67.2	68.8	67.8	69.2	68.6	69.5	69.0	69.8	69.3
5	73.3	71.9	74.1	72.4	74.5	73.2	75.1	74.1	75.6	74.7	76.0	75.3
6	81.3	79.8	81.9	80.7	82.4	81.2	83.0	82.0	83.5	82.6	84.0	83.2

1/ Site locations shown on fig. 2.

2/ Affected by backwater from Northeast Cape Fear River; recurrence interval is unknown.

Proposed Restored Channel Conditions

Because the hydraulic efficiency of the stream channel will be changed with the completion of the channel restoration program, peak discharges may be different from those for the present conditions. However, it was assumed for this analysis that the 2- through 100-year peak flood discharges are the same as for the existing channel condition. A sensitivity test for this assumption will be discussed with the areal extent of inundated area.

New stage-discharge relations at section 1 for the proposed restored channel conditions were estimated based on slope-conveyance studies, and starting elevations for the 2- through 100-year peak flood discharges were selected from these relations. Cross-section width, streambed slope, and other dimensions of the proposed restored channel vary considerably along the study reach. The top width of the restored channel ranged from 45 feet at site 1 to 30 feet at site 6. A standard shape channel was used for computational purposes. Plots of the cross sections are presented in Appendix III. In the lower part of the study reach, streambed slopes for the restored channel were estimated to range from as steep as 0.0025 ft/ft to as flat as 0.0005 ft/ft. The observed water-surface slope for the peak discharge profile for the present channel during the flood of September 14, 1984, was 0.0005 ft/ft. Because the friction slope for flat-sloped streams, particularly under the potential influence of backwater, is generally no steeper than the water-surface slope, the friction slope for the slope-conveyance study was assumed to be 0.0005 ft/ft, the flattest slope observed or estimated.

The roughness coefficients of the proposed restored channel were estimated to be 0.040, based on observations of similar restored channels. The roughness coefficients for the flood plains were assumed to be the same as the adjusted roughness coefficients for the previously calibrated step-backwater model.

The described data for proposed restored channel sections and the lower roughness coefficients were substituted for the present conditions channel data in the calibrated step-backwater model. All other parts of the calibrated step-backwater model, including the 2- through 100-year discharges, remained the same as for the present channel conditions. The computed flood profile data for the proposed restored channel condition are also shown in table 4.

Areal Extent of Inundated Area

The input data for the step-backwater model and the computed water-surface profiles provided the data and information to determine the areal extent of inundated area. The cross sections used in the step-backwater models were assumed to be representative of the width of flooded area for a distance equal to the sum of one-half the distance between adjoining cross sections. These widths for inundated area at each cross section for the 2- through 100-year floods were taken from the step-backwater models. Scaled distances between cross sections were required input variables for the step-backwater models. The extent of the inundated area was computed as the product of cross-section width and representative reach distance. Areal extent of inundated areas are summarized in table 5.

The proposed restored channel program would result in a reduction of the total area inundated by all floods. The total inundated area in the study reach of Grove Creek for the 2-year flood would be reduced by about 13 percent. The reduction for the 100-year flood would be about 1.5 percent.

Because the proposed restored channel program would change the drainage characteristics for Grove Creek, a sensitivity test was performed to evaluate possible errors due to changes in discharges. If the discharges for Grove Creek were reduced by the proposed restored channel program, the reduction in inundated area would be greater than reported above. If the discharges were increased by the proposed restored channel program, the reduction in inundated area would be less than reported above. The 2- through 100-year flood discharges were increased by 25 percent, and the extent of inundated areas were determined for comparison with the previous areas. The results showed a 5-percent increase in inundated area for the Grove Creek study reach at the 2-year recurrence interval.

Sensitivity to errors associated with the assumed starting elevation for the proposed restored-channel step-backwater model were not directly investigated. However, a test with increased starting elevation and holding discharges constant should result in no greater area of inundation for the total study reach than that resulting from the increase of 25 percent in discharges and its associated higher starting elevations. Therefore, the computations using the same discharges for both the present and the proposed restored channel conditions are considered reliable for comparison purposes within these undefined accuracy limits of combining the errors in the data and the errors associated with the methods of the analyses.

Table 5.--Computed flooded acres adjacent to the study reach for present and proposed restored conditions

Site 1/ number	Area, in acres Recurrence interval, in years: 2		5		10		25		50		100	
	Present	Restored	Present	Restored	Present	Restored	Present	Restored	Present	Restored	Present	Restored
1	2/ 547	2/ 535	2/ 553	2/ 546	2/ 558	2/ 551	2/ 563	2/ 559	2/ 572	2/ 568	2/ 576	2/ 574
2	302	296	304	303	306	305	309	307	311	309	316	311
3	253	246	254	253	255	254	256	255	257	256	258	257
4	91	52	95	83	98	89	102	96	104	99	107	103
5	127	55	137	115	140	124	144	138	147	141	149	145
6	60	20	78	51	83	59	88	80	93	85	97	90
Total area	1,380	1,204	1,421	1,351	1,440	1,382	1,462	1,435	1,484	1,458	1,503	1,480

1/ Site locations shown on fig. 2.

2/ Affected by backwater from Northeast Cape Fear River; recurrence interval unknown.

Duration and Frequency of Overbank Flooding

The stream channel restoration program is to be undertaken by the North Carolina Department of Human Resources to control mosquito populations by limiting breeding areas and limiting the length of time water is available for hatching the mosquito eggs in the flood plain. Overbank flooding provides water for mosquito breeding whenever the capacity of the low-water channel, bankfull capacity, is exceeded. The cross-section data and the stage-discharge relations from the step-backwater models were used to evaluate the bankfull discharge at each cross section for both the present and the proposed restored channel conditions. Bankfull discharges are presented in table 6. For the proposed restored channel conditions, the bankfull discharges were determined to be 10 to 19 times greater than those for the present channel conditions. At all cross sections, the bankfull discharges will be exceeded by the 2- through 100-year flood discharges for both present and proposed restored channel conditions. Thus, the changes in the length of time water would be available on the flood plain, duration of overbank flooding, would be needed by NCDHR in an evaluation of the channel restoration program.

Present Channel Conditions

Hydrographs of the mean daily discharges were available for the 1983 and 1984 water years at site 4. The hydrographs are presented in figures 7 and 8. Although hydrographs of the mean daily discharges for the other study sites on Grove Creek were not available for this analysis, the continuous stage record at site 2 for the 1984 water year indicated that the results for the entire study reach would be similar to those for site 4. Duration of overbank flooding was estimated by applying the bankfull discharge to the hydrographs of mean daily discharge and determining the length of time the mean daily discharge exceeded bankfull discharge. The number of occurrences and lengths of time bankfull discharge was exceeded and the number of times overbank flooding lasted 7 days or longer (incubation period for mosquito eggs) are summarized in tables 7 and 8.

Overbank flooding at site 4 for the 1983 and 1984 water years occurred 32 times and lasted for a total of 374 days with the maximum individual duration of 3 months. There were 18 occurrences that lasted longer than 7 days each.

Because the instantaneous peak discharge for a given flood is generally greater than the mean daily discharge, the duration of overbank flooding for the present channel conditions at site 4 was also evaluated for a relation of instantaneous peak discharge and total time of overbank flooding.

Overbank floods for this relation were selected from single rainfall events that began when the stream discharge was at or below 20 ft^3/s, bankfull stage, and after the rainfall ceased with no additional rain occurring until the discharge returned to 20 ft^3/s, bankfull stage. Nineteen floods were selected for this analysis and ranged from 22 ft^3/s to 1,900 ft^3/s. The resulting curve in figure 9 showed that any flood during the present channel conditions and exceeding 340 ft^3/s would cause overbank flooding lasting longer than 168 hours, 7 days.

Table 6.--Bankfull discharges in the study reach for present and proposed restored conditions

Site 1/ number	Bankfull discharge, cubic feet per second	
	Present	Restored
1	40	380
2	35	380
3	25	370
4	20	350
5	20	350
6	15	290

1/ Site locations shown on fig. 2.

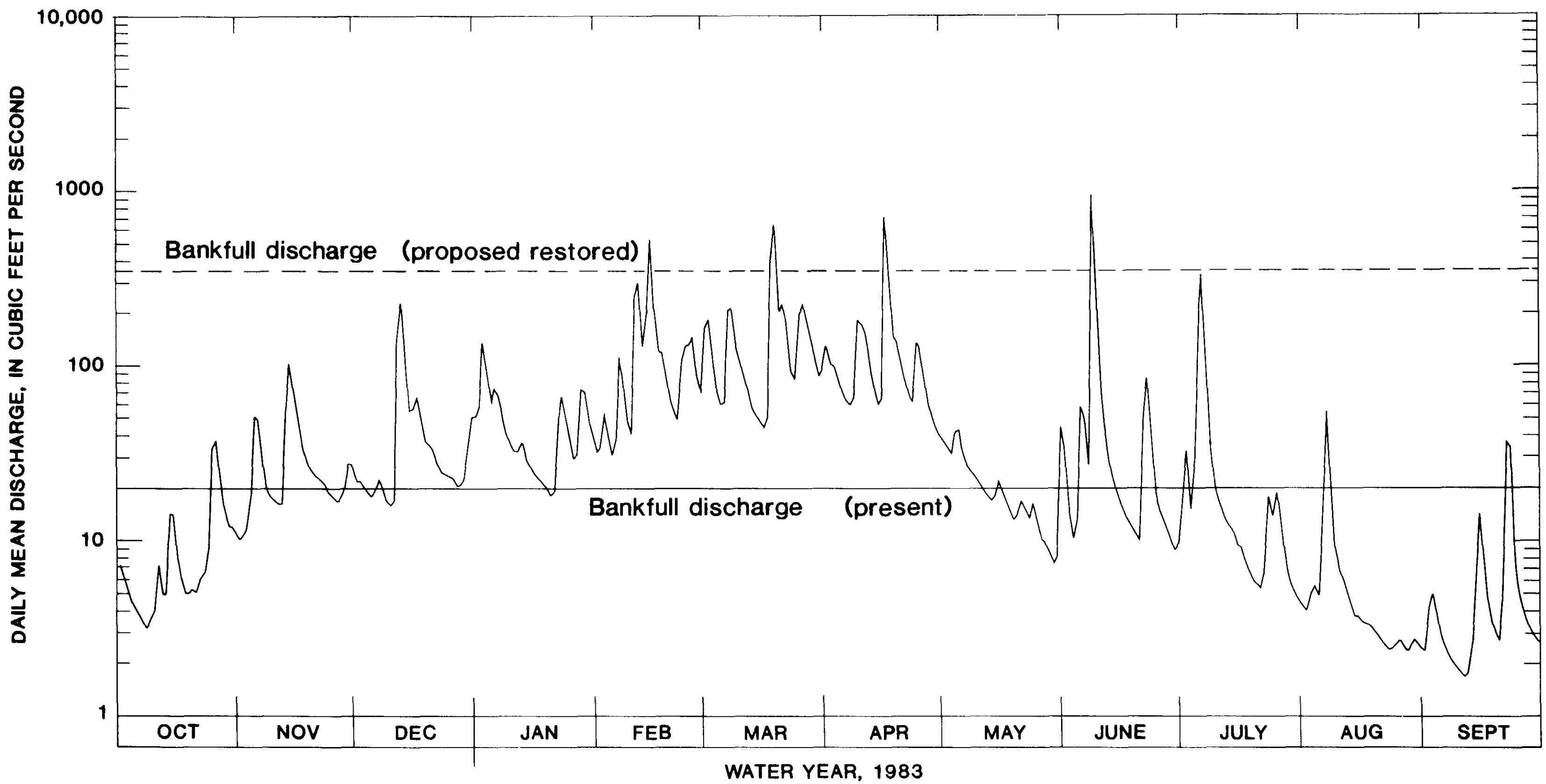

Figure 7.--Daily mean discharge in cubic feet per second, site 4.

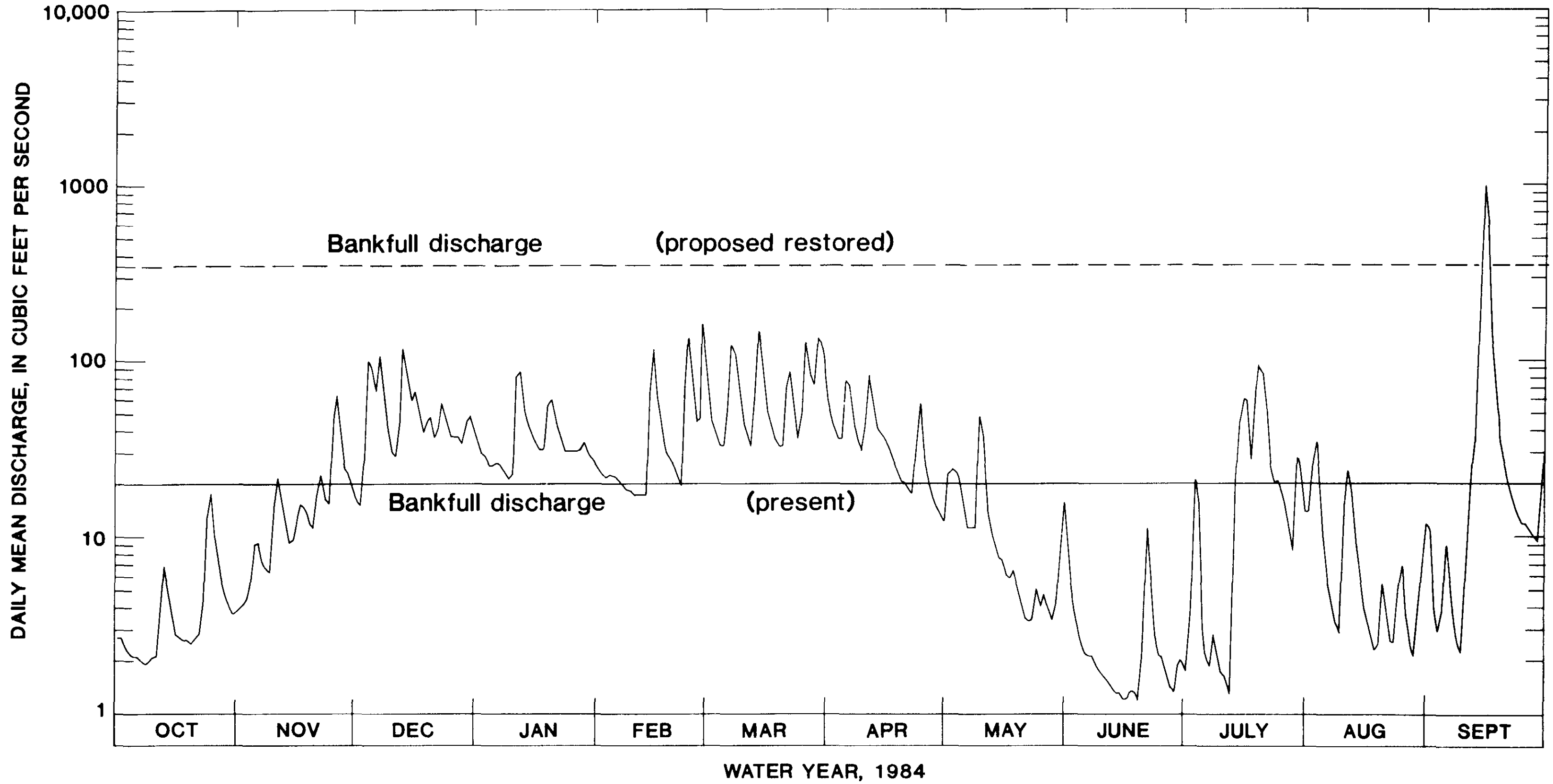

Figure 8.--Daily mean discharge in cubic feet per second, site 4.

Table 7.--Frequency and duration of overbank flooding at site 4 for present and proposed restored conditions for 1983 water year

	Number of times out of banks		Number of times out of banks more than 7 days		Longest duration (days)		Total time out of banks (days)	
Month	Present	Restored	Present	Restored	Present	Restored	Present	Restored
October	1	0	0	0	2.5	0	2.5	0
November	3	0	1	0	11.5	0	17	0
December	3	0	1	0	20	0	24	0
1982-1983 January	2	0	2	0	19	0	29	0
February	1	1	1	0	28	1	28	1
March	1	1	1	0	31	1.5	31	1.5
April	1	1	1	0	30	1.5	30	1.5
May	2	0	1	0	10.5	0	12	0
June	3	1	1	0	9.5	1	13	1
July	2	0	1	0	7	0	8.5	<1
August	1	0	0	0	2	0	2	0
September	1	0	0	0	2	0	2	0
Total or average	21[1/]	4	10	0	14.4	0.4	199.0	6

1/ This value is from cumulative monthly occurrences; actual total times that out-of-bank flooding occurred is 15.

Table 8.--Frequency and duration of overbank flooding at site 4 for present and proposed restored conditions for 1984 water year

	Number of times out of banks		Number of times out of banks more than 7 days		Longest duration (days)		Total time out of banks (days)	
Month	Present	Restored	Present	Restored	Present	Restored	Present	Restored
October	0	0	0	0	0	0	0	0
November	3	0	0	0	6	0	7	0
December	1	0	1	0	28.5	0	28.5	0
1983-1984 January	1	0	1	0	31	0	31	0
February	3	0	2	0	9	0	22	0
March	1	0	1	0	31	0	31	0
April	2	0	1	0	20	0	24	0
May	2	0	0	0	3	0	5	0
June	0	0	0	0	0	0	0	0
July	3	0	1	0	11	0	13	0
August	2	0	0	0	2	0	3	0
September	2	1	1	0	9.5	2	10.5	2
Total or average	20 1/	1	8	0	12.6	0.2	175	2

1/ This value is from cumulative monthly occurrences; actual total times that out-of-bank flooding occurred is 17.

Proposed Restored Channel Conditions

As discussed in the sections on Flood Profiles and Areal Extent of Inundated Area, it was also assumed for this analysis that discharges for the proposed restored channel conditions will be the same as those for the present channel conditions. However, the proposed restored channel should increase the hydraulic efficiency of Grove Creek and thus decrease the traveltime of a flood wave through the study reach. Using the hydrographs as presented in figures 7 and 8 and the bankfull discharge, 350 ft^3/s, for the proposed restored channel conditions was considered to be a tendency toward the maximum duration of overbank flooding that might reasonably be expected for the proposed restored channel. The number of occurrences and the lengths of time bankfull discharge was exceeded and the number of times overbank flooding lasted 7 days or longer for the proposed restored channel conditions are also summarized in tables 7 and 8.

Overbank flooding at site 4 for the 1983 and 1984 water years would have occurred 5 times and lasted for a total of 8 days with the maximum individual duration of 2 days. There would obviously have been no occurrences that lasted as long as 7 days.

The instantaneous peak discharge analysis for the present channel conditions presented in figure 9 are not directly applicable for the proposed restored channel conditions. In figure 9, the time that bankfull discharge was exceeded started at 20 ft^3/s, continued through the instantaneous peak discharge, and ended when the 20 ft^3/s was reached on the flood recession. The maximum observed time for this analysis was about 240 hours. For the proposed restored channel condition, 350 ft^3/s would be substituted for the start and end of the analysis; thus, indicating a shift of the curve in figure 9 to the left. This shift would most likely be more than 168 hours because of the shape of flood hydrographs which tend to have steeper slopes and more linear proportions nearer the peak discharge. Thus, instantaneous peak discharges less than about 2,000 ft^3/s would probably cause no overbank flooding lasting as long as 7 days.

The duration and areal extent of one important source of water available for mosquito breeding was beyond the scope of this study. That source is residual overbank flooding, that which remains in depressions and low-lying areas of the flood plain after the flood discharge has receded below bankfull stage. The duration of such residual overbank flooding depends upon a number of influences among which are depth of depression, soil type and characteristics, ground-water levels, season of the year, and the condition, type, and density of flood-plain vegetation. However, it can be deduced that this type of inundation would be no greater than that for the present channel conditions, particularly if restoration spoil is disposed of so that the depths of depressions and low-lying areas are not increased.

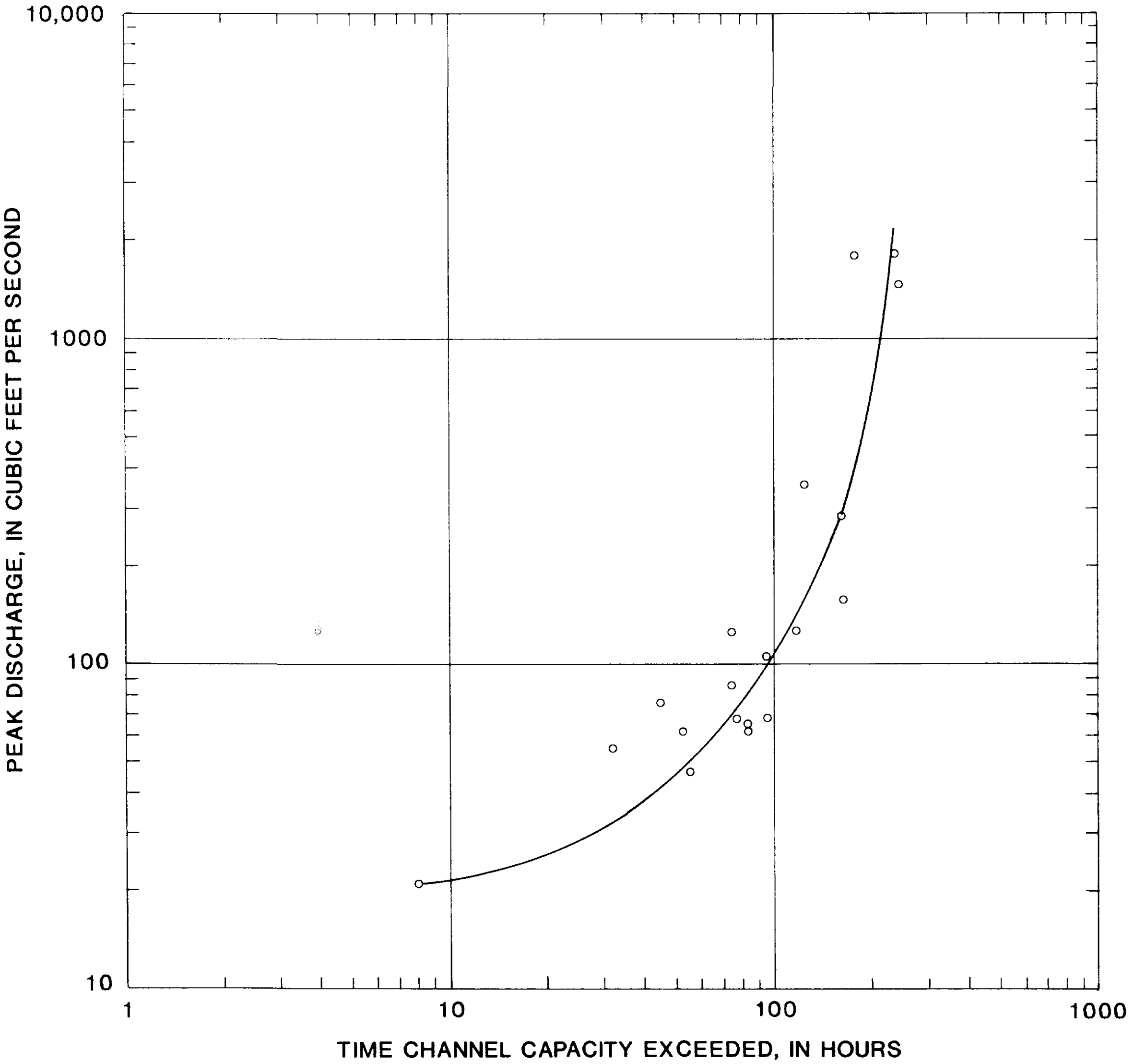

Figure 9.--Relation of flood-peak discharge to duration of overbank flooding for present conditions, site 4.

AGE OF CHANNEL SEDIMENTS

Some local scientists believe that the present stream channels are not in a natural state but have aggraded due to the activities of man (Nelson and Weaver, 1981). Sediment-laden runoff from farms and roadways, along with limbs, logs, and other debris from lumbering operations is believed to have caused the stream channel to fill in, thus reducing the carrying capacity of the channel and thereby increasing the frequency and extent of overbank flooding. Some environmental groups feel present channels are in a natural state but agree that the relative age of sediments at different depths in the channel may show a correlation with development activities of man. Determination of the relative ages of channel sediments would allow identification of development-associated materials and substantiate the channel design for restoration to predevelopment conditions.

Several radioisotope-dating methods have been used successfully to date materials deposited under almost undisturbed conditions, such as in lakes and reservoirs (Martin and Rice, 1981). The vertical distribution and the detectable amounts of the different radioisotopes can be used as a means of establishing sediment chronology. Sediments deposited in stream channels are subject to scour, redeposit, and possible intermixing of recent and older sediments; therefore, the applicability of the methods is uncertain. However, to test the methods, a total of eight channel-sediment cores were collected.

Four cores were collected in a fairly uniform reach above site 2 and below the mouth of Tea Swamp, and four cores were taken above site 4 (fig. 2). The cores were spaced across the channel to obtain a representative cross section. Core lengths ranged from 3.2 to 3.6 feet. Several thin lenses (1 to 2 inches thick), of sand and organic material, were found to be intermixed throughout with black silt, sand, peat, and wood fragments.

Two complete cores and the top segment of one core were analyzed by 3 different dating-analysis procedures. The laboratory analyses showed no detectable amounts of Lead-210 or Radium-226 in the core samples; however, small amounts of Cesium-137 were detectable in the top 6 to 8 inches of the samples. Cesium-137 results from above-ground testing of atomic bombs and is found only in post-1952 sediment (Robbins and Edgington, 1975). Therefore, all sediments below the top 6 to 8 inches have been deposited prior to 1952.

SUMMARY AND CONCLUSIONS

This study evaluates the effects of proposed channel restoration on overbank flooding for an 8-mile reach of Grove Creek near Kenansville. The channel restoration process is the removal of accumulated sediment and debris that are presumed to have been deposited in the stream channel as the result of development activities in the basin by man. Any reduction in the frequency and duration of overbank flooding that may be afforded by restored channels is expected to aid in minimizing the opportunity for mosquito breeding in areas adjacent to Grove Creek. The lower study reach is subject to flooding from Grove Creek and from backwater of the Northeast Cape Fear River. Therefore, flood-frequency data were not defined for the area between sites 1 and 2.

Results of analyses indicate that the capacity of the proposed restored channel may be 10 to 19 times greater than the capacity of the present channel. Therefore, the proposed restored channel was estimated to reduce the area of inundation by an average of 29 percent for sites 4-6 (west of NC Hwy 11) up through the 10-year flood; reduction in inundated areas for the 25- to 100-year floods will average 5 percent. Only a 1 percent average reduction in the area inundated is indicated for sites 1-3 (east of NC Hwy 11) for the 2- to 100-year floods.

Reduction in area flooded in the total study reach, from present to proposed restored conditions, are 13, 5, 4, and 1.5 percent for the 2-, 5-, 10-, and 100-year floods respectively.

Under present conditions, overbank flooding occurred in the study reach 32 times during the 1983 and 1984 water years and remained on the flood plain from a few hours to 2 or 3 months. For the proposed channel conditions, overbank flooding would have occurred 5 times during the 1983 and 1984 water years and lasted from a few hours to 1 or 2 days. Flooding in low-lying areas and residual overbank flooding will persist for undetermined lengths of time for present and proposed restored conditions after streamflow recedes to bankfull stage or below.

The results of the channel sediment dating analyses, Cesium-137 indicated that the top 6 to 8 inches of the channel sediment were deposited after 1952.

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GLOSSARY

Some of the technical terms frequently used in this report are defined in this section. See Dalrymple (1960) and Langbein and Iseri (1960) for additional information regarding flood-frequency analysis and associated terminology.

Crest-stage partial record station is a site on a stream where systematic records on maximum discharge and stage are obtained.

Discharge is the volume of water (or more broadly, total flow[s]) that moves past a given point within a specified period of time.

Drainage area of a stream at a specified location is the area measured in a horizontal plane, which is enclosed by a topographic divide. Upstream from the specified location, direct surface runoff normally drains by gravity into the stream.

Flood-frequency analysis is a procedure to determine flood magnitude that will, on the average, be exceeded once within a specified number of years. The Geological Survey uses the log-Pearson Type III distribution for analyzing annual maximum floods for gaged sites on streams. The distribution and procedure are described by the Water Resources Council (1976).

Flood profile is a graph showing the variation in stage along a stream reach for a specified flood discharge.

Flood stage is the water-surface elevation above a selected datum. Sea level datum is used in this study.

Manning's roughness coefficient, n, is a factor used with open channel flow equations and is a measure of channel boundary roughness. Typical values of roughness are tabulated for various boundary conditions in a variety of open-channel hydraulic texts. Value of roughness coefficient are estimated from aerial photographs, streamflow records, and field-site surveys.

100-year flood is a flood that is expected to be equaled or exceeded, on the average, once every 100 years and has a one percent chance of occurring each year. Percentage is determined by dividing one by the recurrence interval and multiplying by 100.

Recurrence intervals as applied to floods is the average time interval within which a flood of a specified magnitude is expected to be exceeded at least once.

Stage-discharge rating is an empirical relation between stream stage and discharge. Ratings are normally developed from concurrent field measurements of discharge and stage and may change with time due to changes in physical characteristics of the stream channel, such as scouring or deposition of sediment and debris.

Step-backwater analysis is a procedure used by the U. S. Geological Survey to determine water-surface elevation (or stages) for specified discharge at points along a stream reach where dimensions of channel geometry are known. The procedure is based upon the principle of conservation of energy between adjacent cross sections. The technique is similar to the standard step method described by Chow (1959) and Posey (1950).

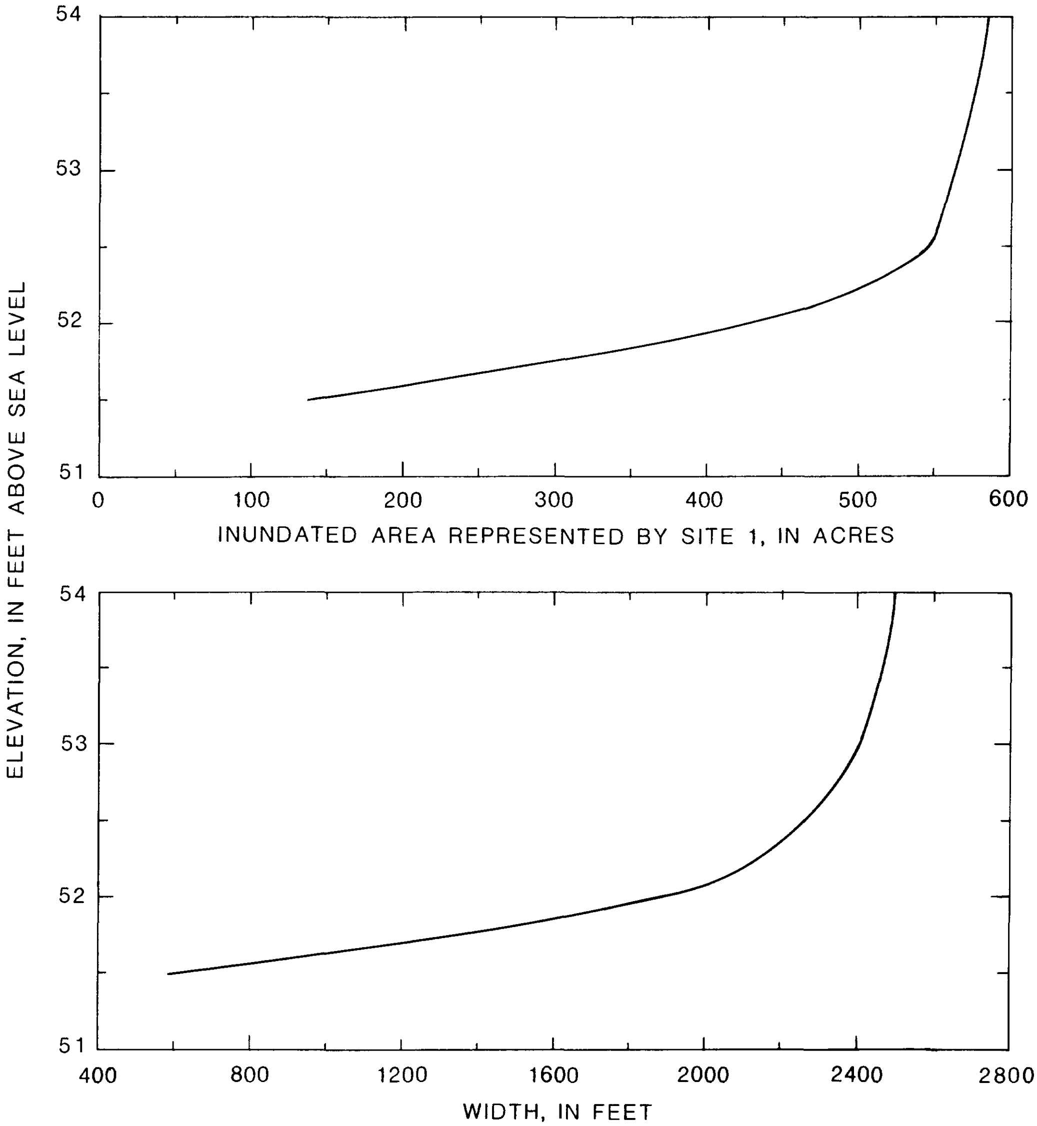
Streamflow station is a site on a stream where systematic records of stage and discharge are obtained. Stage records are normally collected by means of continuous recorders.

Water year is the hydrologic year which begins October 1 and ends the following September 30.

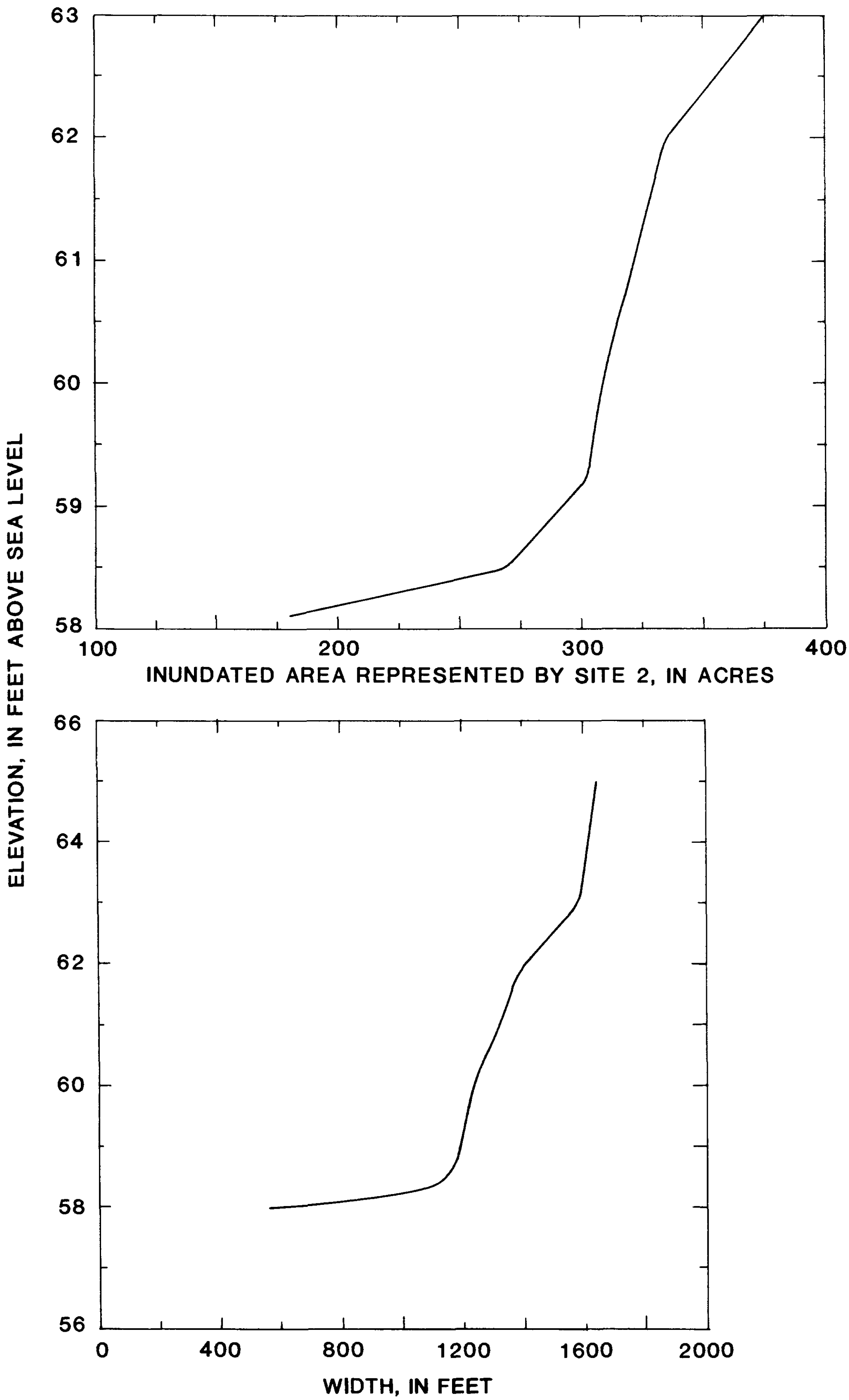
APPENDIX I

Stage-Area and Stage-Width Curves

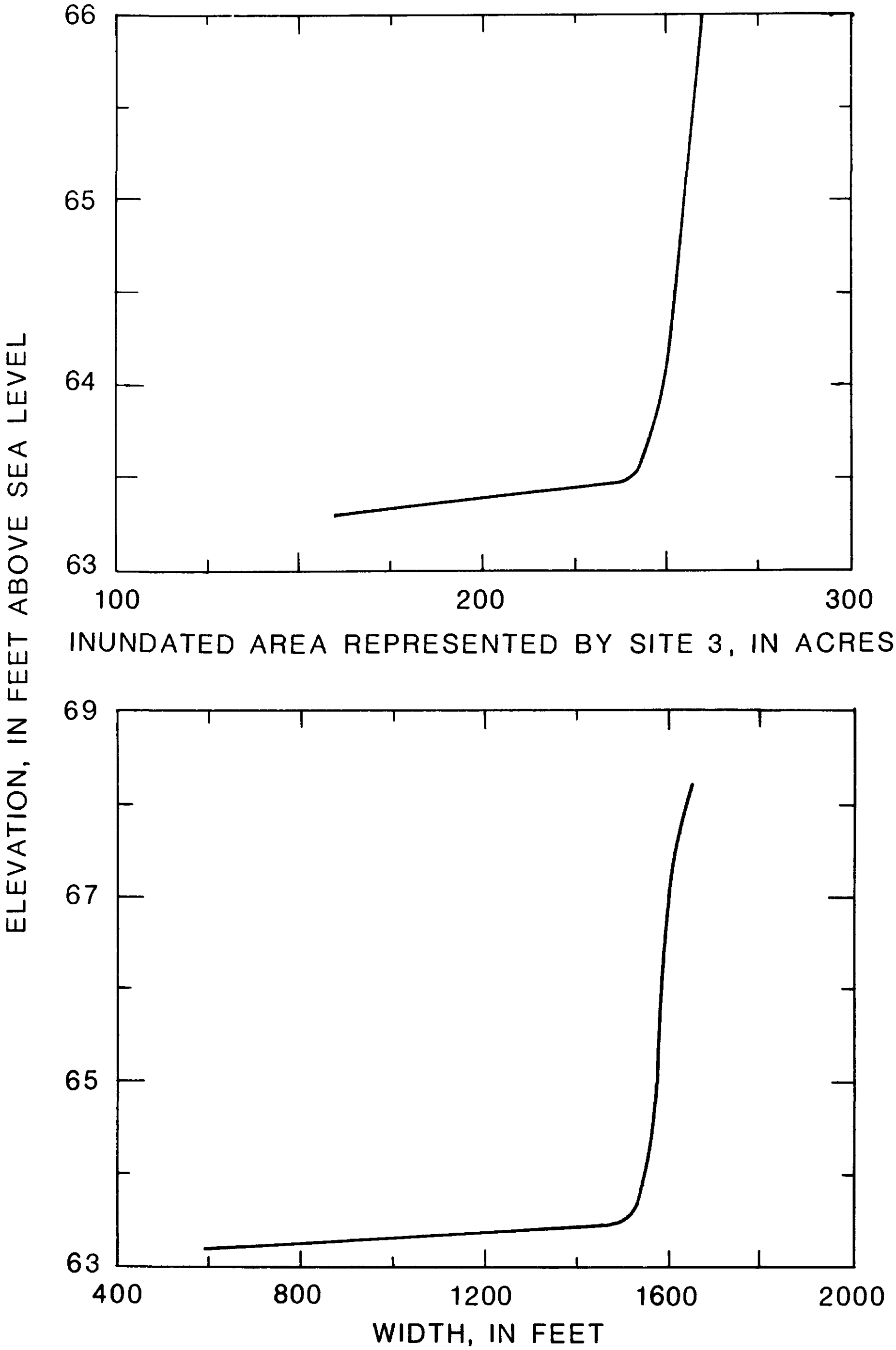
(Present Conditions)



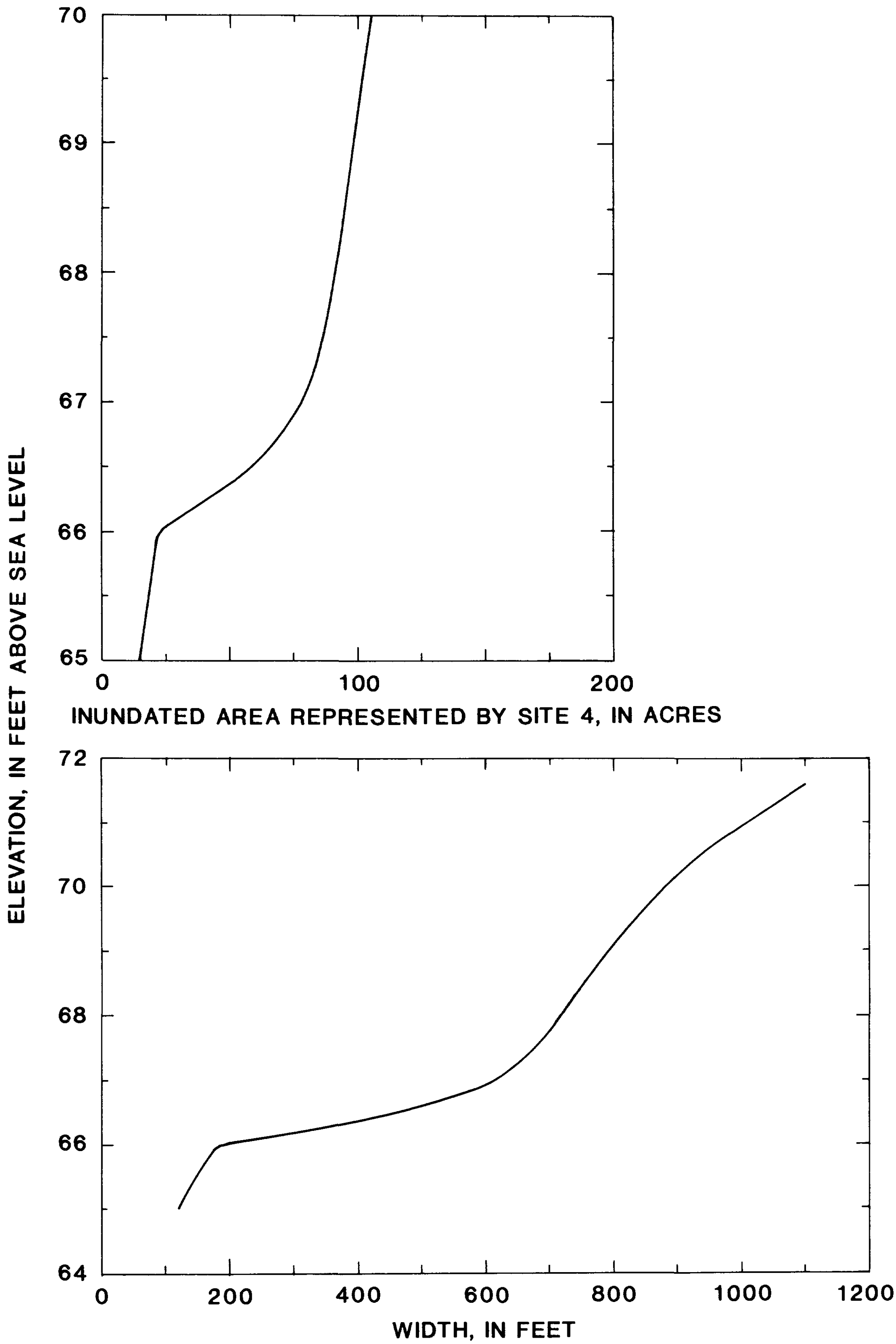
Stage-area and stage-width relations at site 1



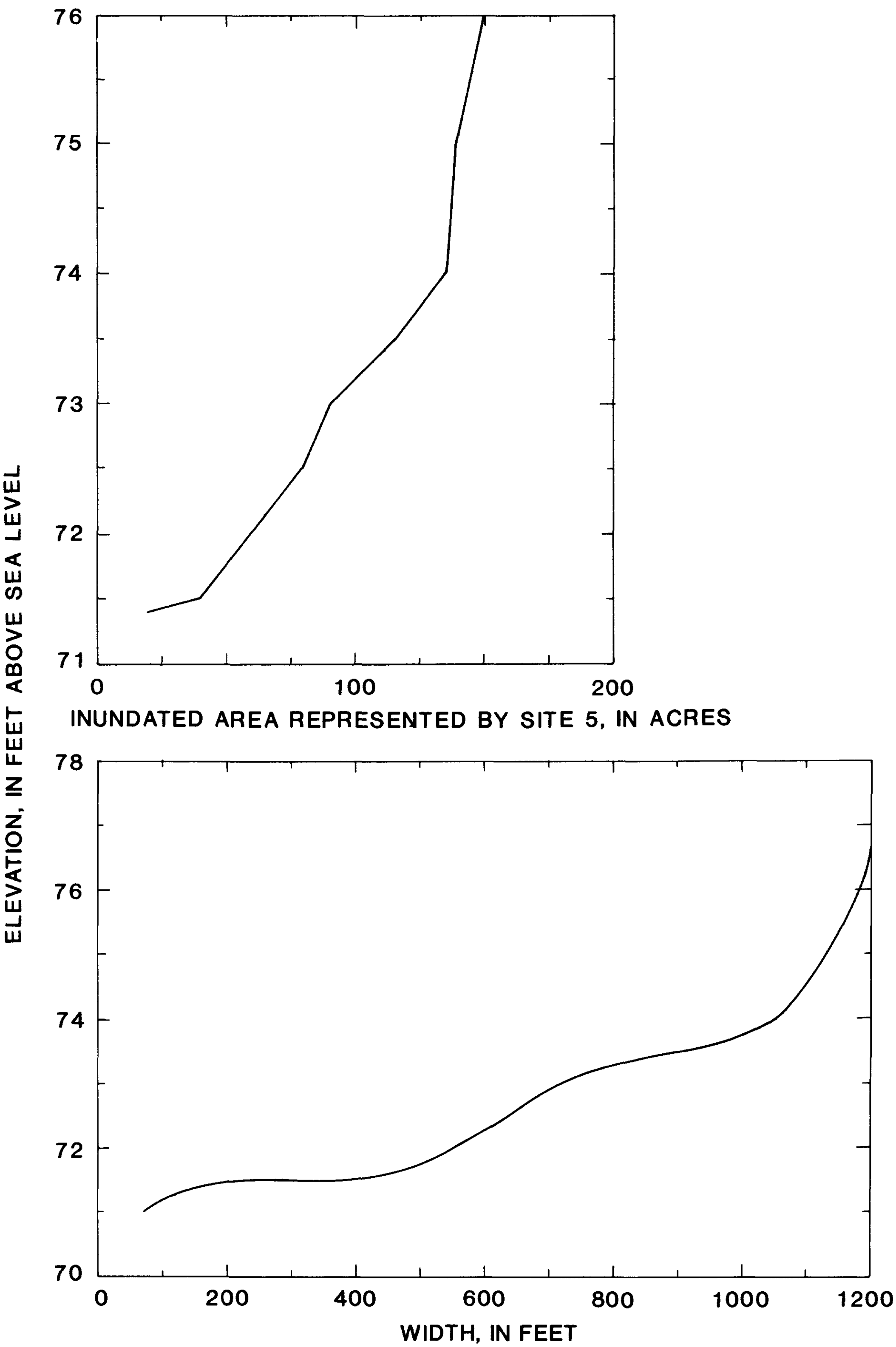
Stage-area and stage-width relations at site 2



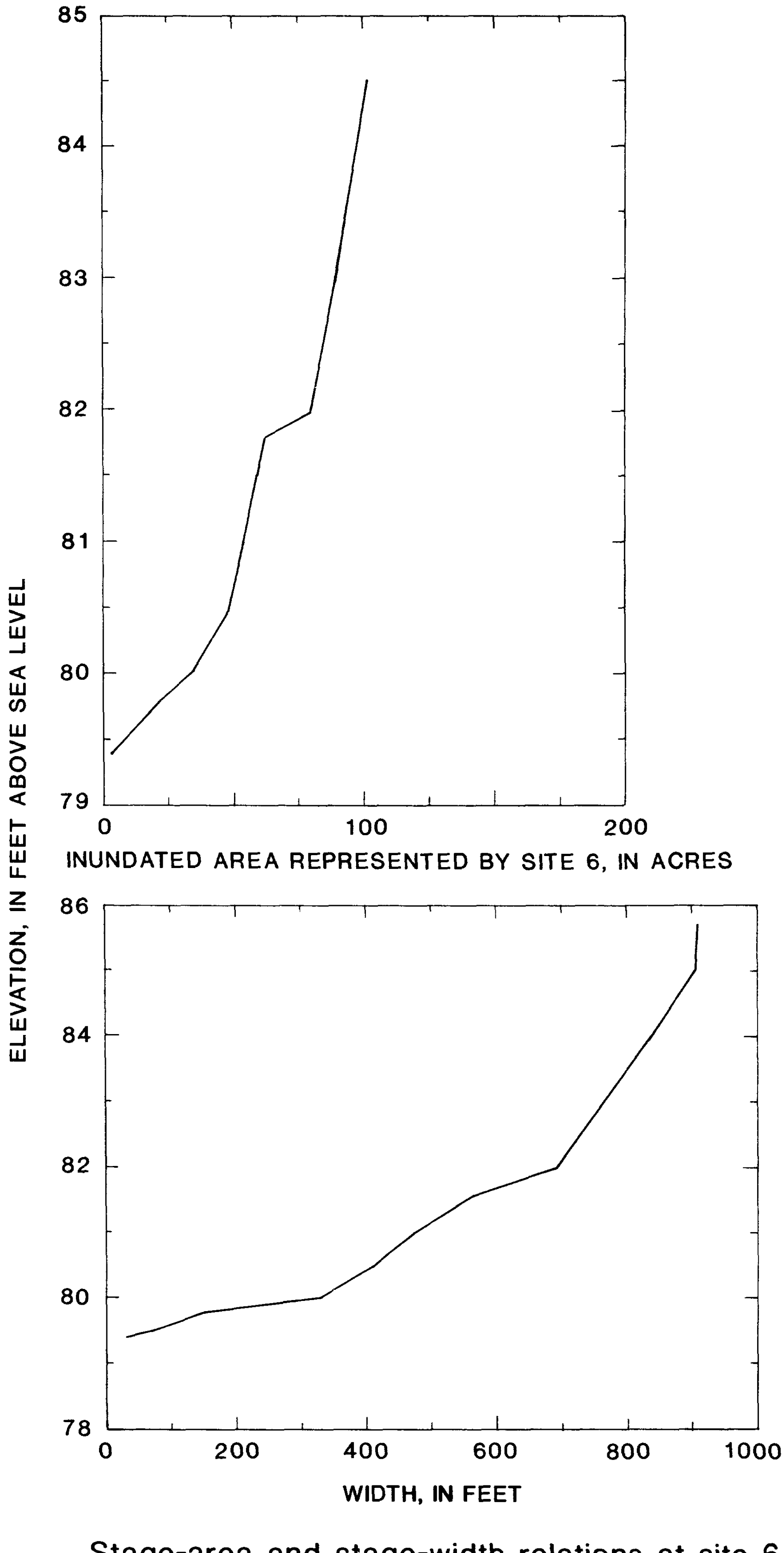
Stage-area and stage-width relations at site 3



Stage-area and stage-width relations at site 4



Stage-area and stage-width relations at site 5

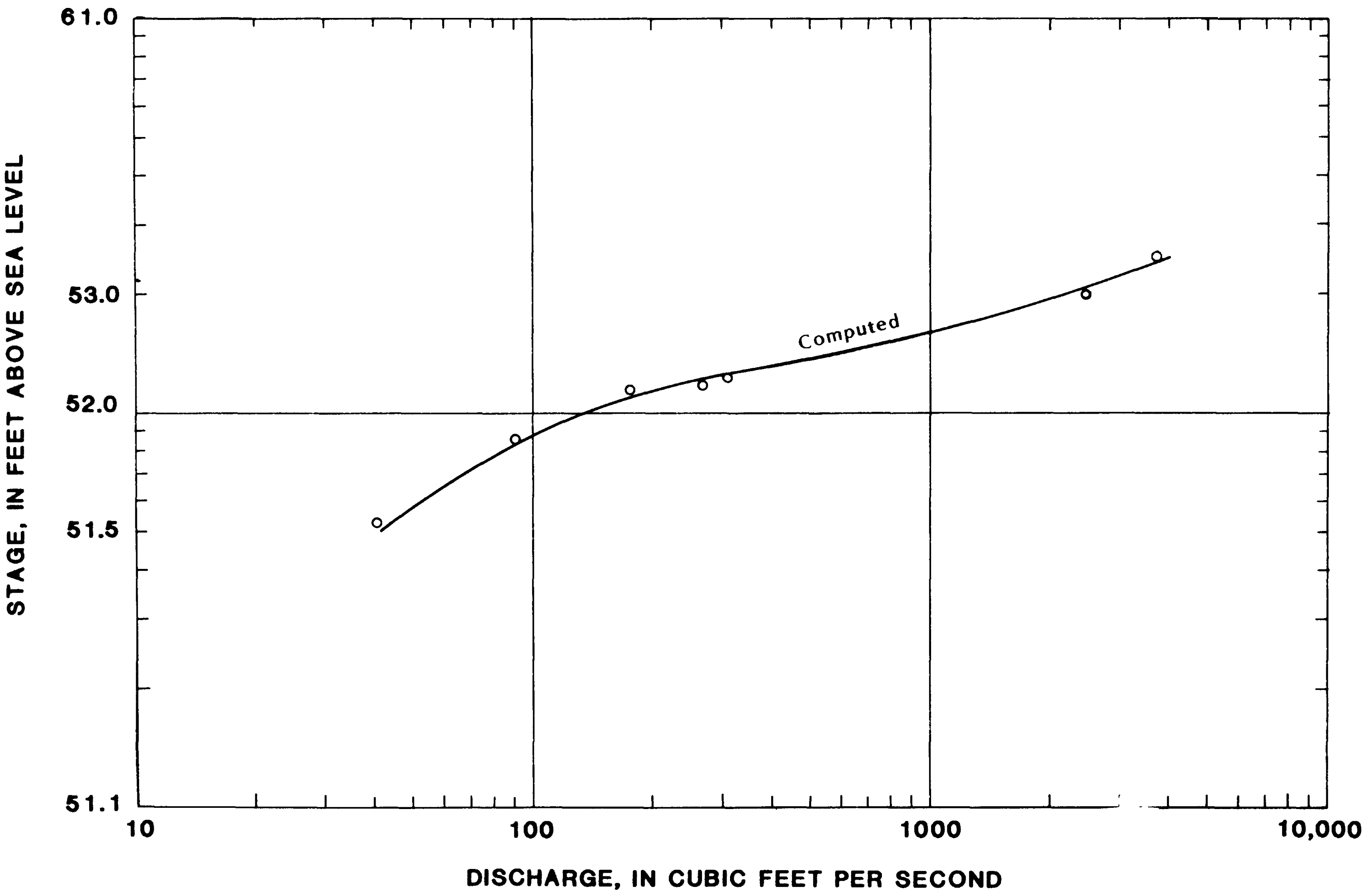


Stage-area and stage-width relations at site 6

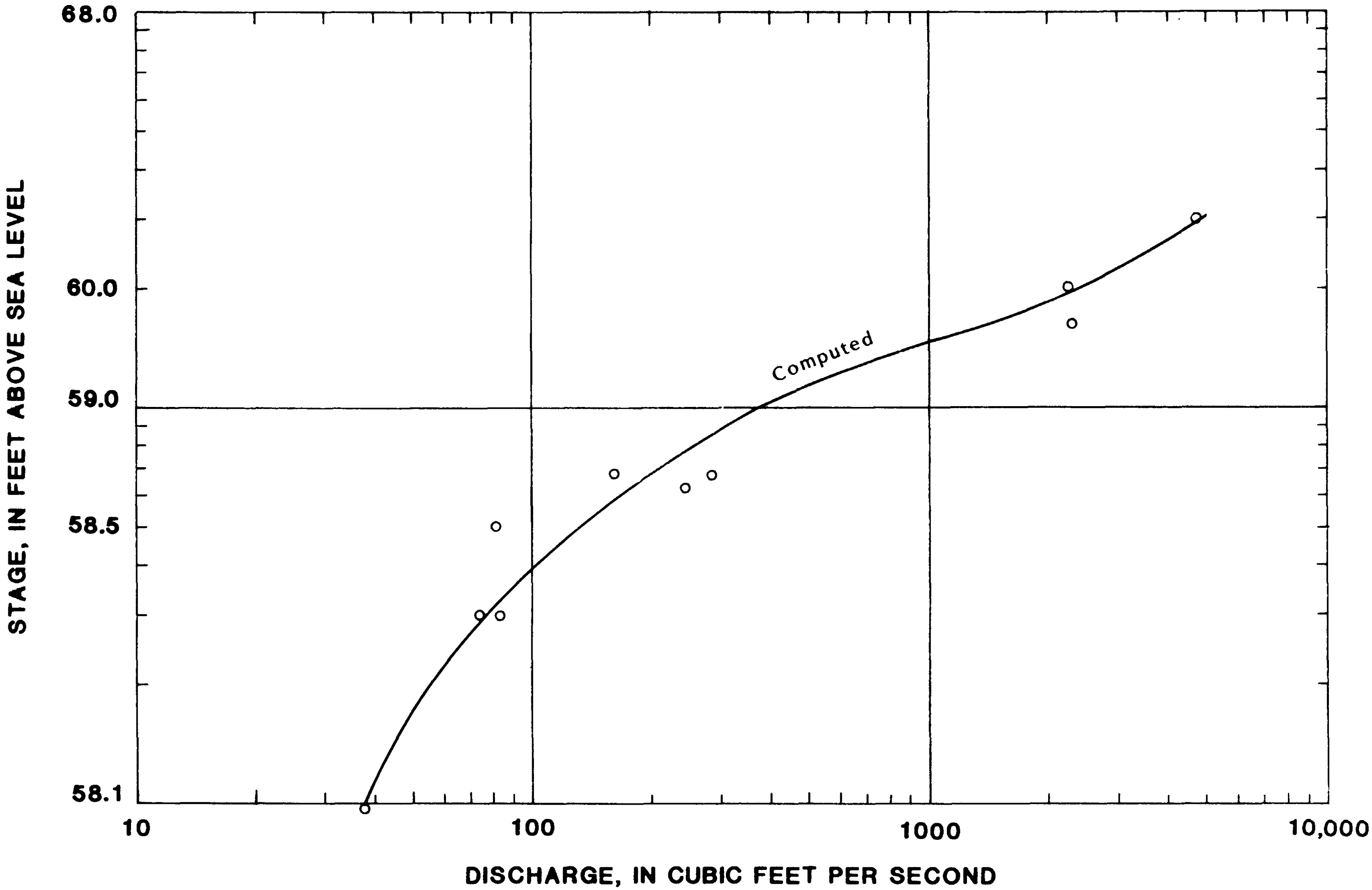
APPENDIX II

Rating Curves

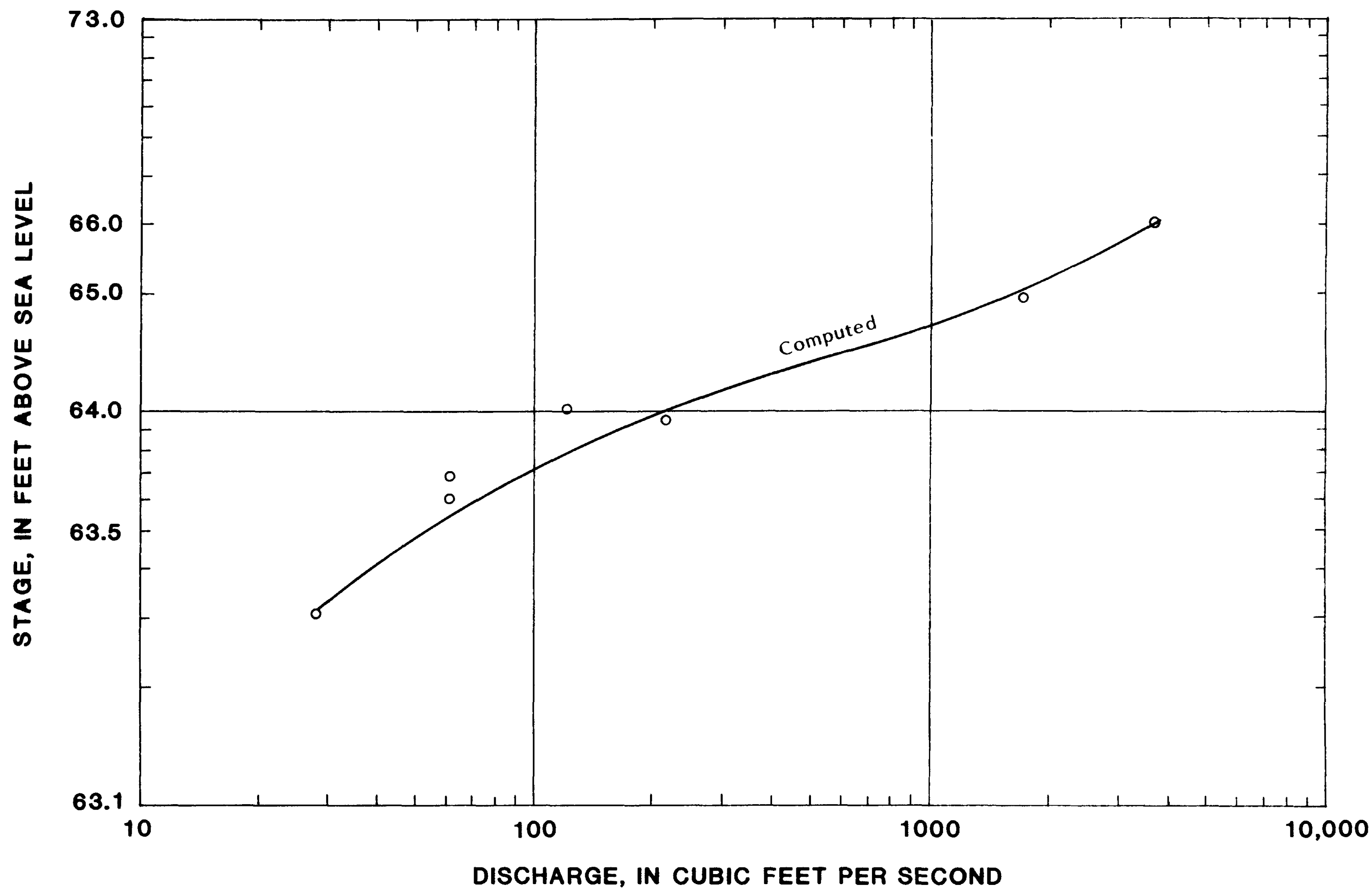
(Present Conditions)



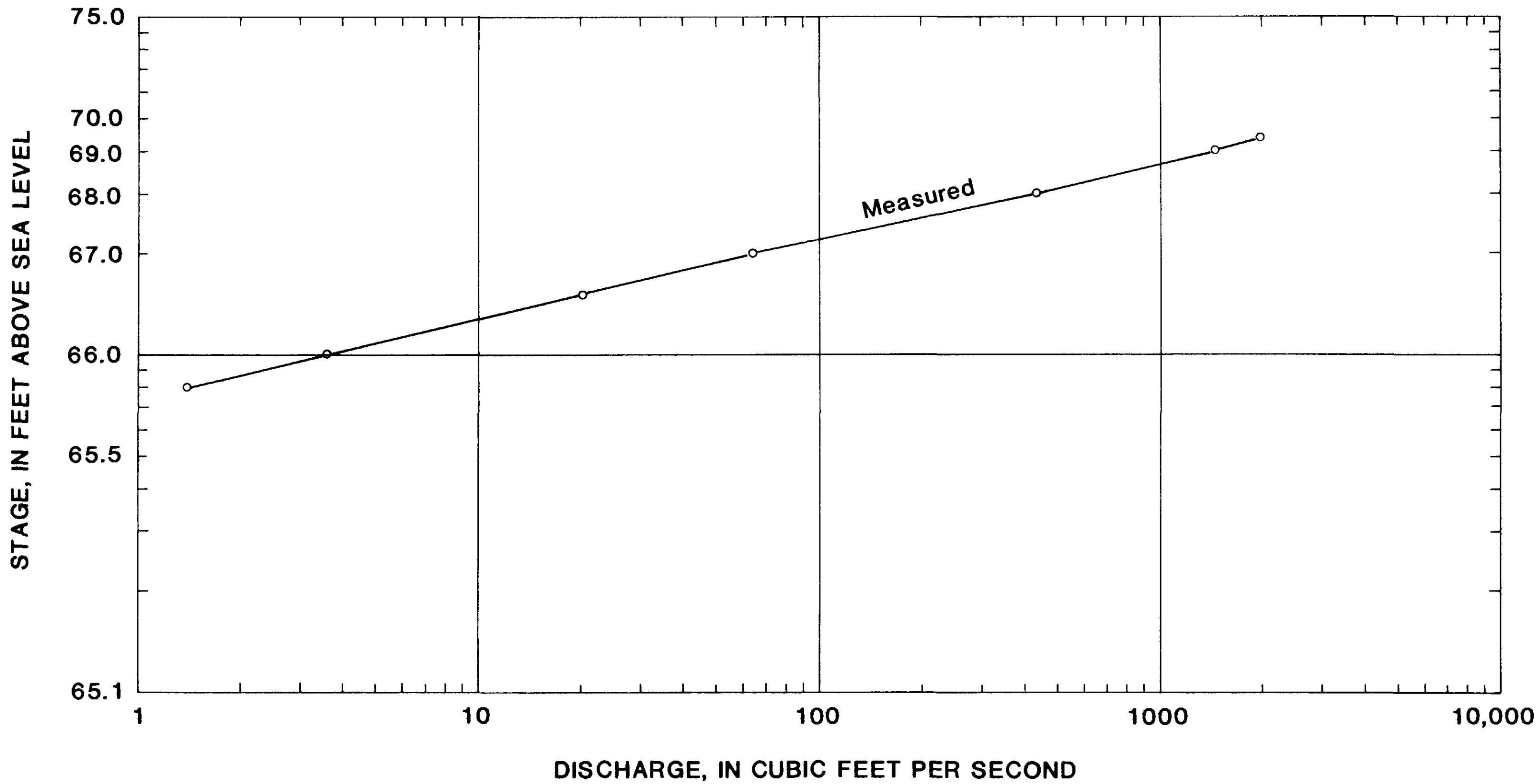
Stage-discharge relation for Grove Creek at site 1



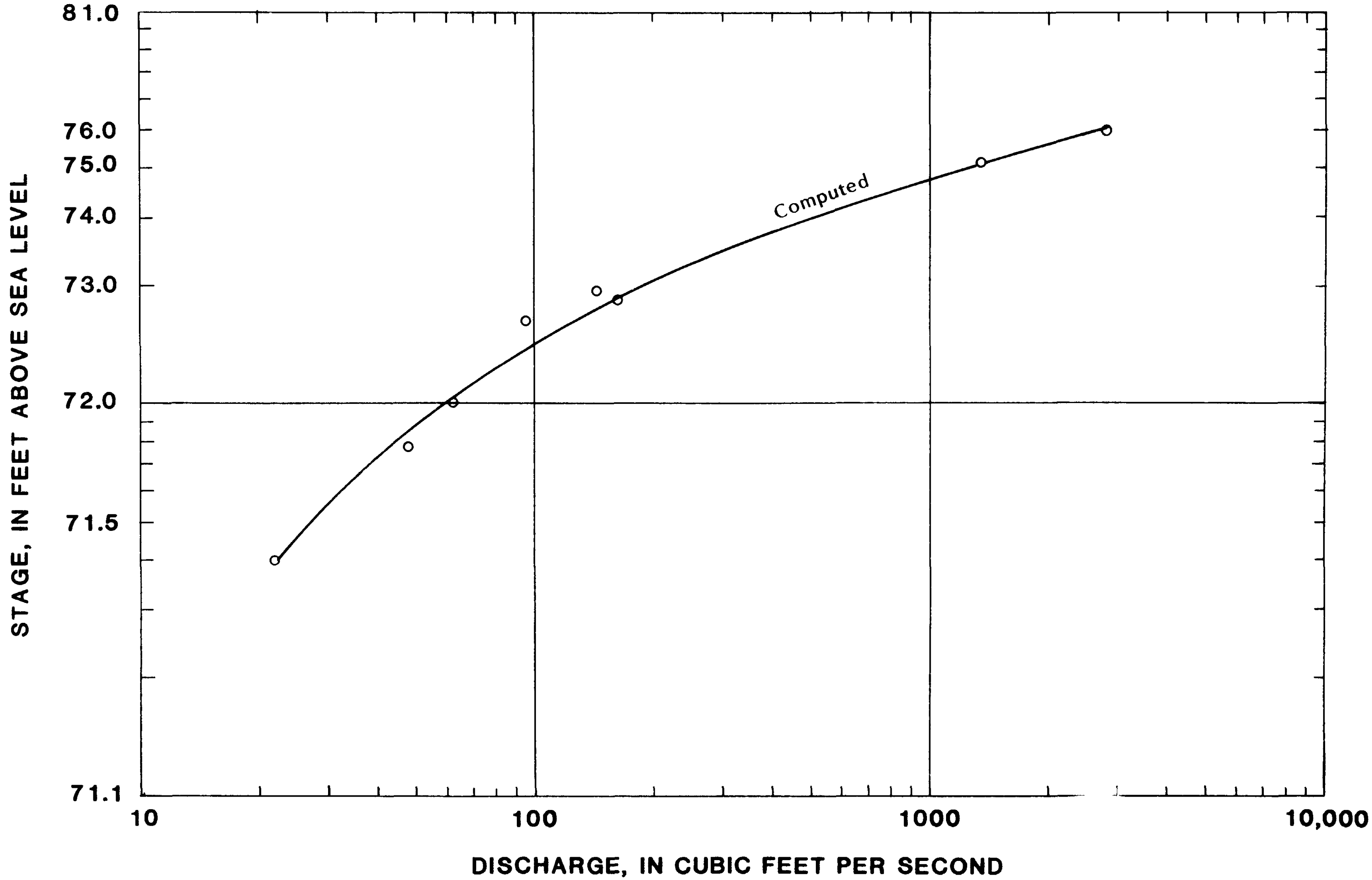
Stage-discharge relation for Grove Creek at site 2



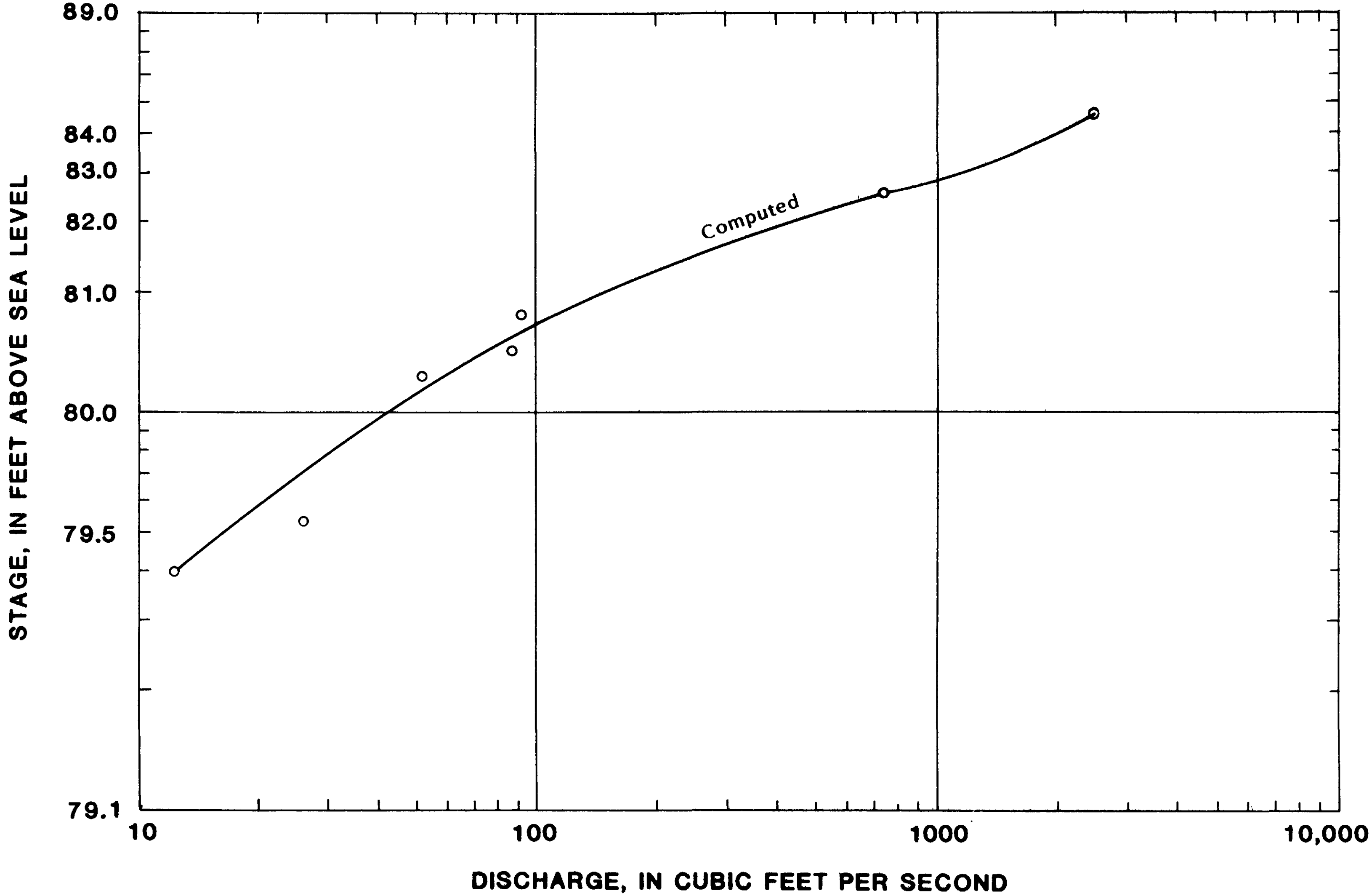
Stage-discharge relation for Grove Creek at site 3



Stage-discharge relation for Grove Creek at site 4



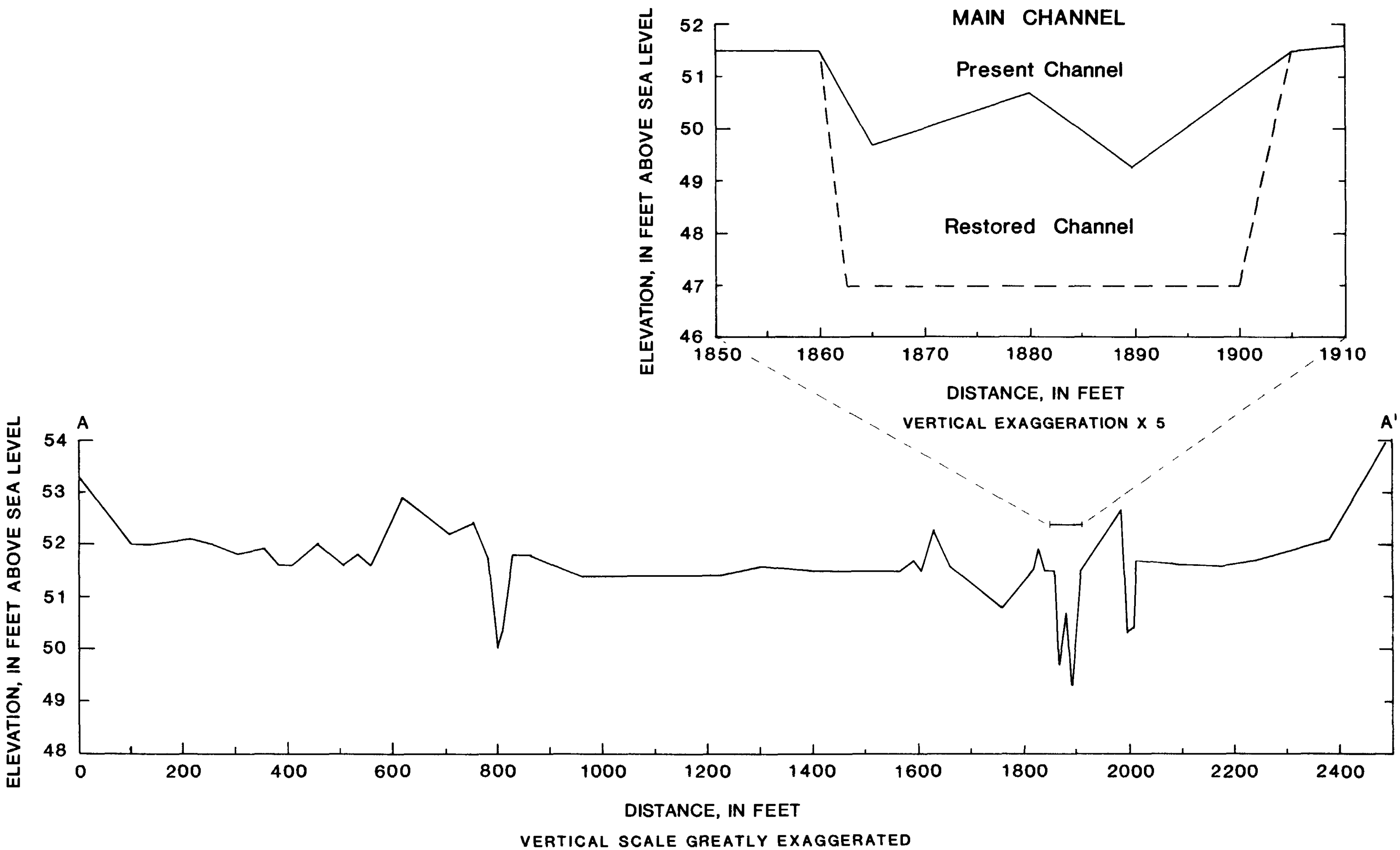
Stage-discharge relation for Grove Creek at site 5



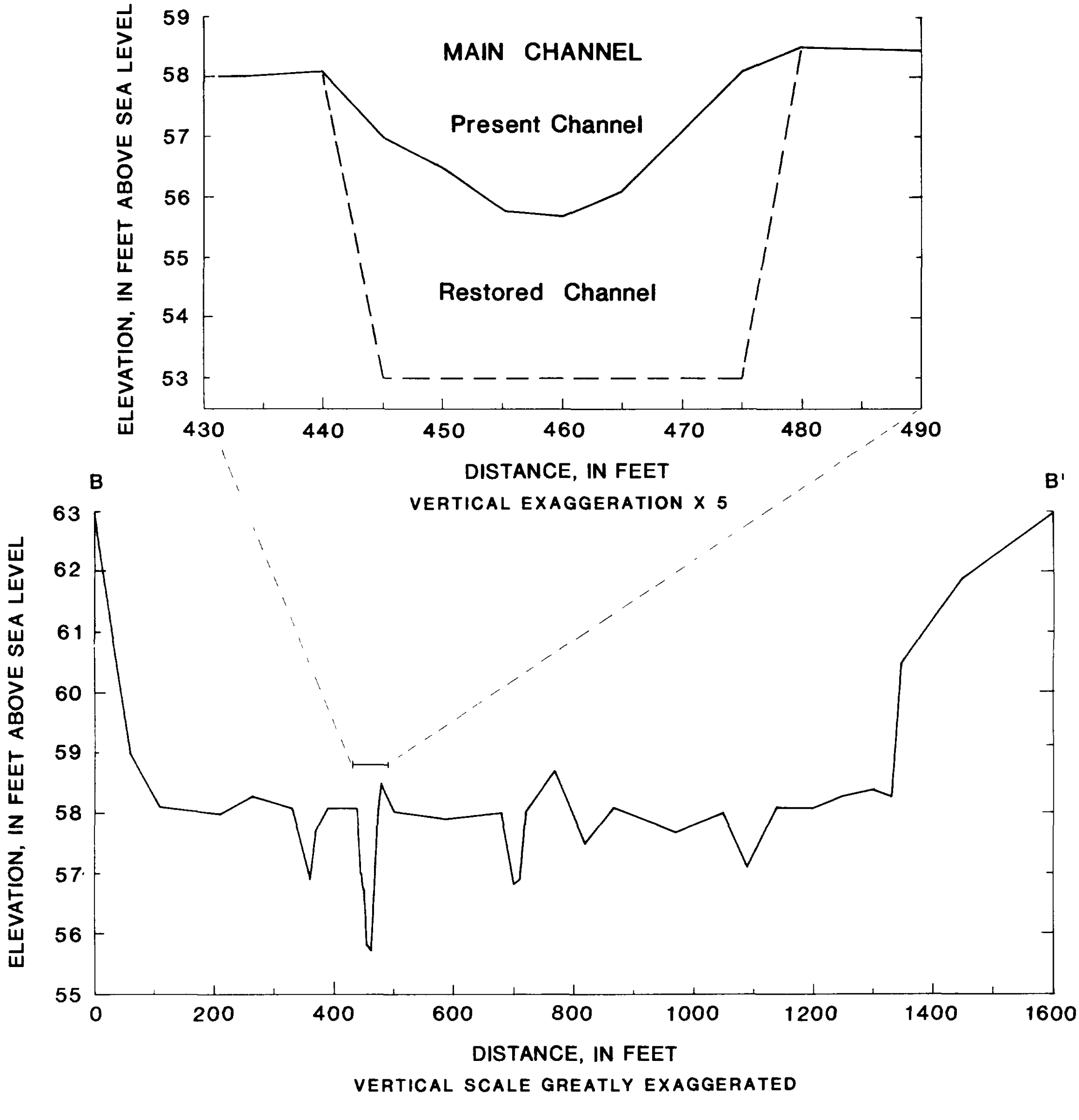
Stage-discharge relation for Grove Creek at site 6

APPENDIX III

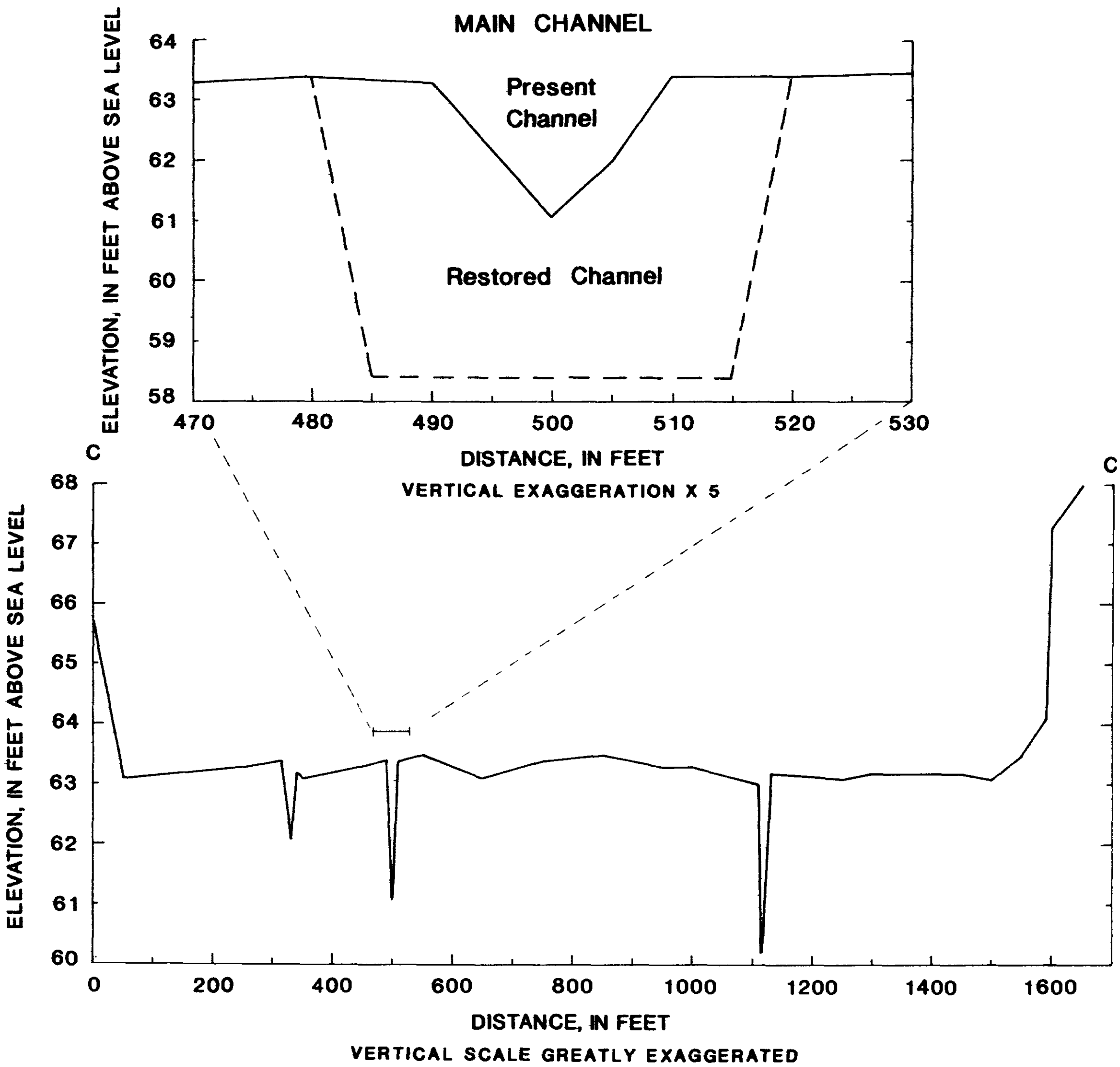
Cross-Section Plots for Present and Proposed Restored Conditions



Cross-section 1



Cross-section 2



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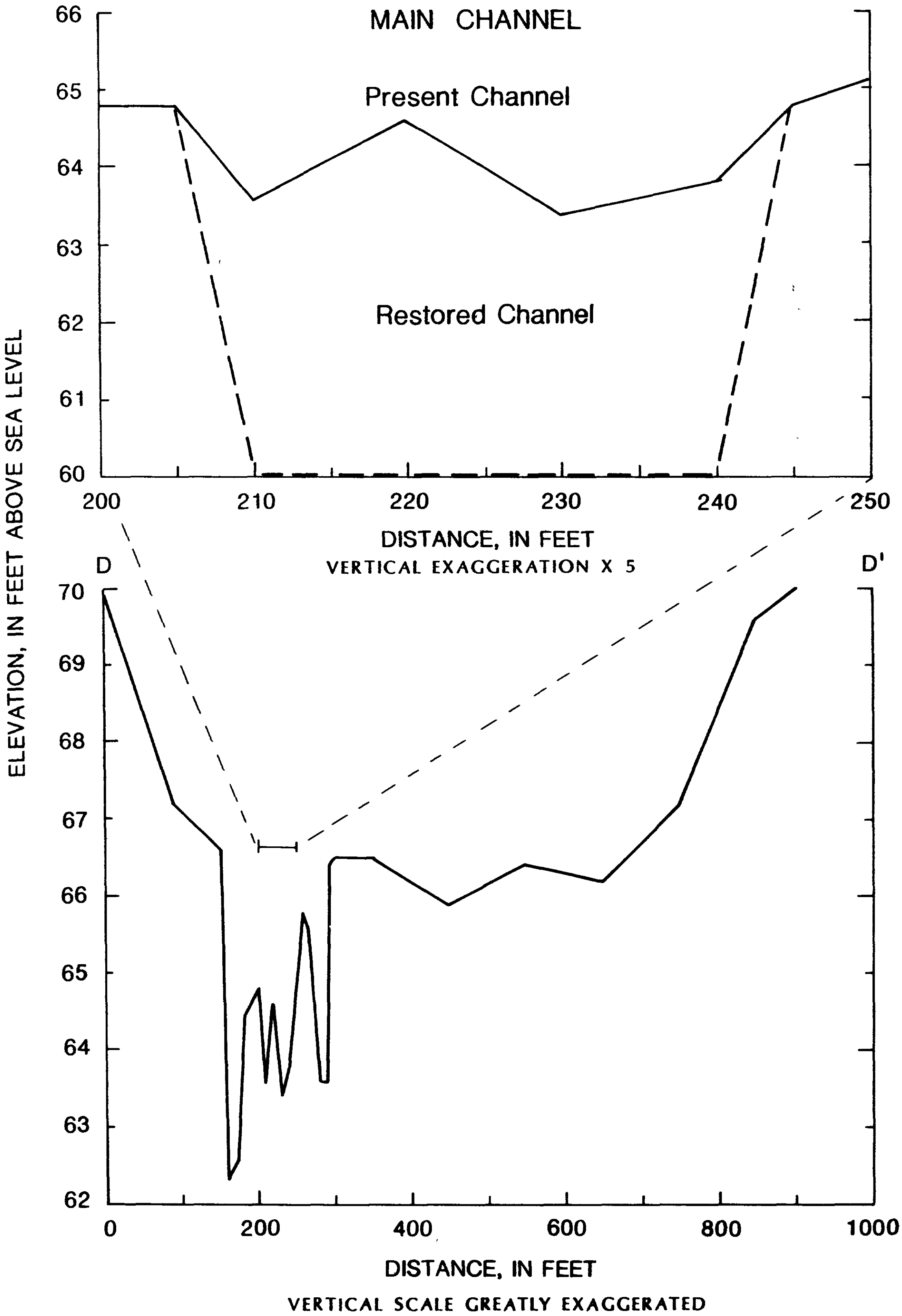
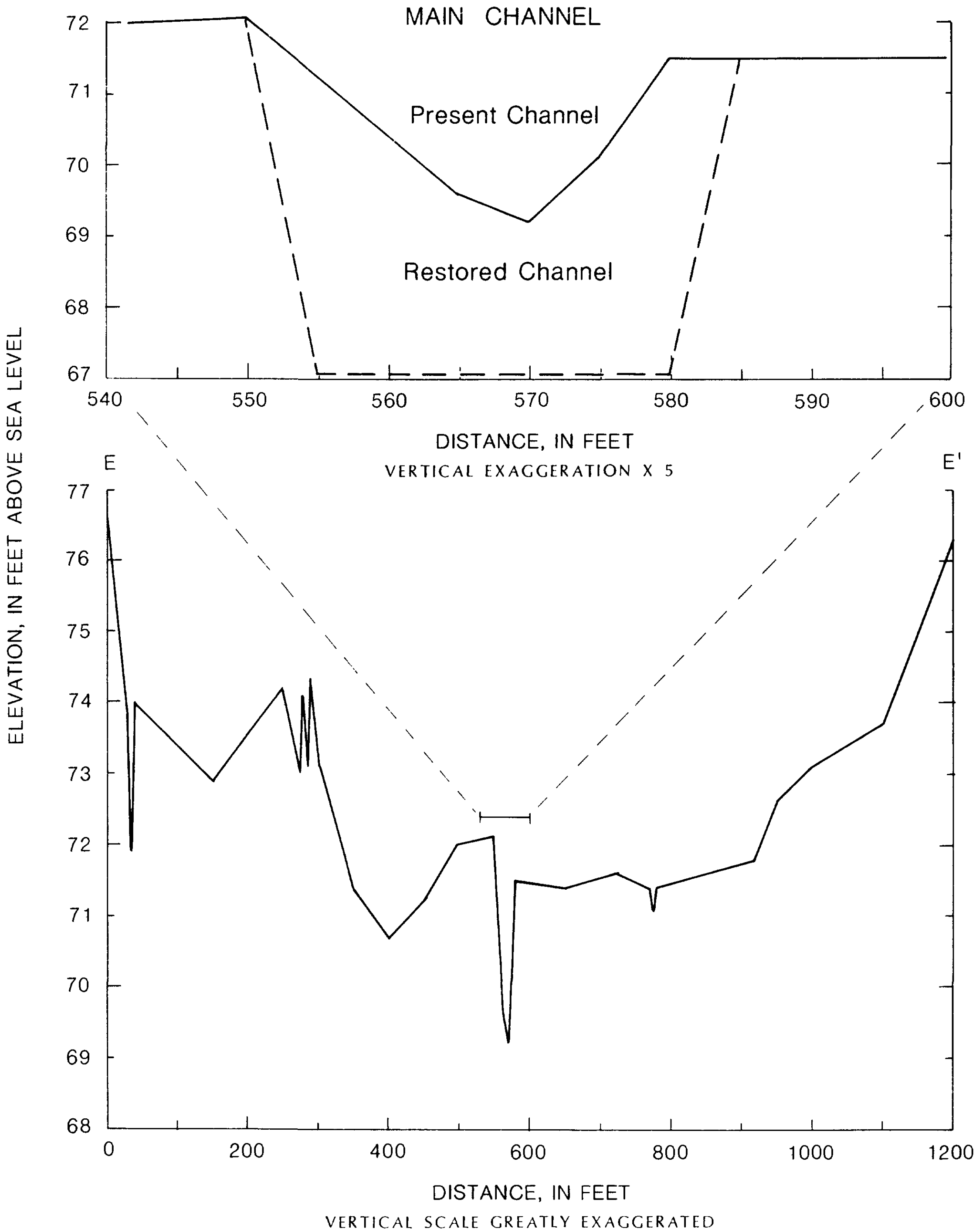
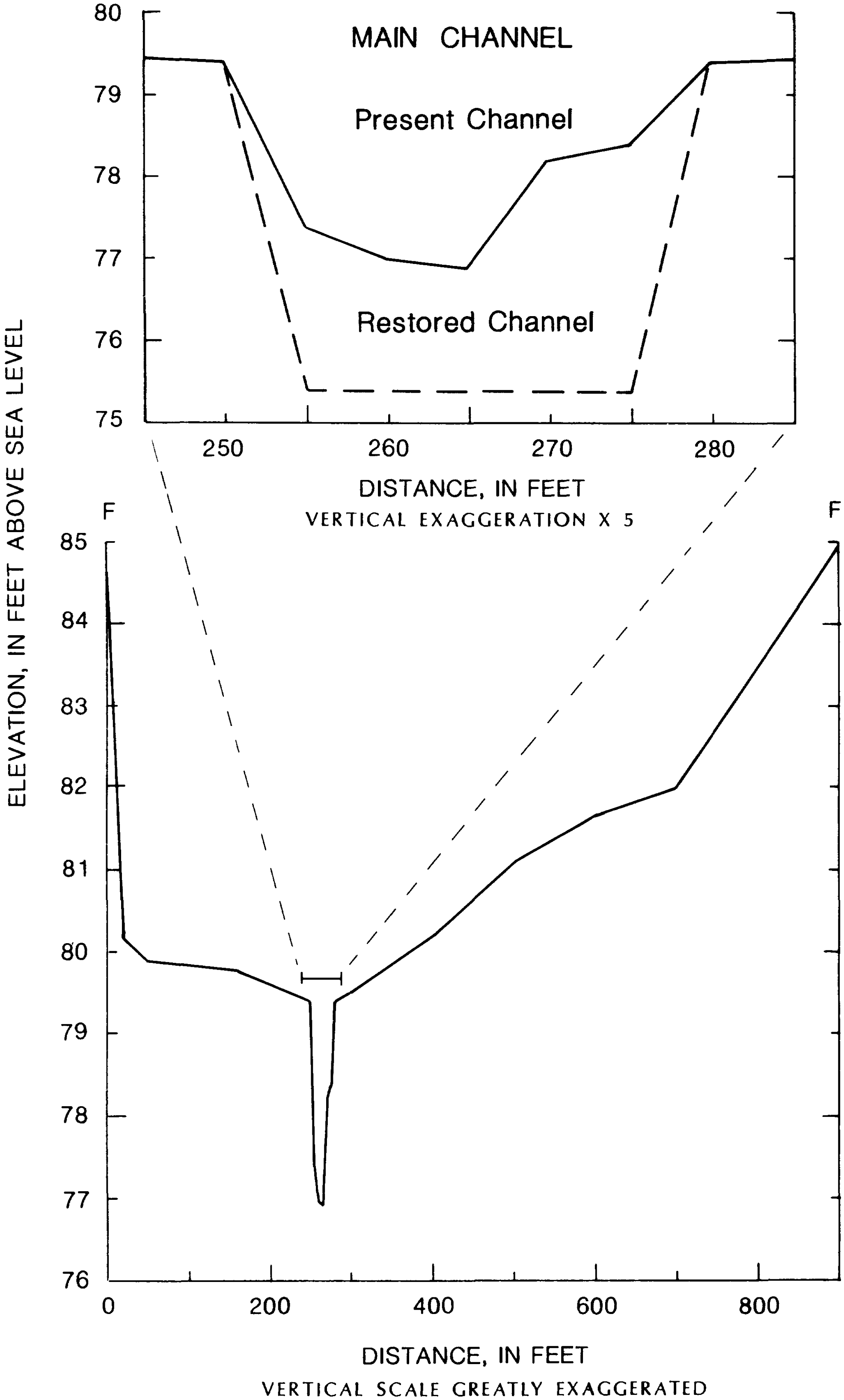


Cross-section 4



Cross-section 5



Cross-section 6

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